Adaptation Strategies to Protect Areas of Increased Risk From Coastal Flooding Due to Climate Change

Seabrook, NH

Prepared by
Rockingham Planning Commission

for the
Town of Seabrook, N.H.

ROCKINGHAM PLANNING COMMISSION

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1. INTRODUCTION AND PROBLEM STATEMENT

The scientific community has reached a strong consensus that the Earth's climate is changing. The projected increase in temperature will cause sea level rise that will gradually inundate coastal areas and increase both beach erosion and flooding from coastal storms, changes in precipitation patterns, stronger hurricanes, and threats to biodiversity. Local governments must plan and act to address the impacts of climate change. This preparation includes risk assessments, prioritization of projects, and funding and allocation of both financial and human resources. Adaptation will require creativity, compromise, and collaboration across all levels of government, the private sector, and community residents.

The Rockingham Planning Commission (RPC) received funds from the Town of Seabrook and the New Hampshire Coastal Program to develop adaptation strategies to protect areas of Town at risk of flooding due to climate change. The elements of this project were to conduct research on present consensus estimates of sea level rise effecting the New England coast, the review approached taken by other states and communities in responding to this threat, to develop maps identifying the areas of increased risk to flooding from sea level rise specific to Seabrook, and finally to identify the various regulatory and non-regulatory options that should be considered by Seabrook to protect the Town from this potential risk.

2. RESEARCH AND FINDINGS

Research and information about the impacts of climate change in the Northeast are frequently revised and updated. The RPC reviewed findings and recommendations for Miami-Dade County, Florida and the State of Rhode Island to develop the maps and suggested land use regulations for this report. A list of resources and references can be found at the end of this report, and local decision makers are urged to review this information. The RPC will continue to provide communities with new information and scientific evidence regarding the impacts of climate change on New Hampshire's coastal communities.

Terms commonly used in discussions of climate change and adaptation planning are defined below.

- Climate is the long-term weather average observed within a geographic region.

- Climate change refers to fluctuations in the Earth's climate system as a result of both natural and man-made causes. The current long term climate change trend is evidenced by rising global temperatures, rising sea level, and increasing extremes within the hydrologic cycle resulting in more frequent floods and droughts.

- Sea level rise refers to the change in mean sea level over time in response to global climate and local tectonic changes. Sea level is the height of the sea with respect to a horizontal control point or benchmark. Sea level rise includes eustatic contributions – global changes responsible for worldwide variations in sea level (e.g., thermal expansion of seawater, melting glacial ice sheets), and isostatic effects – regional changes in land surface elevations that are related to the tectonic response to ice or sediment loading, and land subsidence due to extraction of water or oil. The combination of eustatic and isostatic effects at a particular location is known as relative sea level rise.

- Greenhouse gasses are gasses in the atmosphere that absorb and emit radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. Common greenhouse gasses in the earth's atmosphere include water vapor, carbon dioxide, methane, nitrous oxide and ozone.

- Greenhouse effect is the phenomenon whereby the Earth's atmosphere traps solar radiation, caused by the presence of such gasses as water vapor, carbon dioxide, nitrous oxide and methane that allow incoming sunlight to pass through but absorb heat radiated back from the Earth's surface.

Over the course of the geologic time scale, sea level naturally fluctuates in response to variations in astronomical configurations that cause changes in the Earth's climate. Global sea level has risen by almost 400 feet since the last Glacial Maximum, approximately 20,000 years ago. This rise in sea level was caused primarily by the melting of continental ice sheets.

Greenhouse gases being emitted into the atmosphere have increased surface warming, increasing the volume of the ocean due to thermal expansion and the acceleration of melting glacial ice. Human activities and increased concentrations of greenhouse gasses have accelerated the historic rate of eustatic sea level rise. Over the last 100 years, sea levels have risen 0.56 feet globally. The average rate of rise during the years between 1961 and 2003 was 0.071 inches per year, and between 1993 and 2003 the rate nearly doubled to 0.12 inches per year. (IPCC, 2007) For every inch of sea level rise, the sea moves inland by several feet, an effect amplified by high tides and storms. Low lying areas, such as land adjacent to Hampton-Seabrook Marsh and Seabrook Beach, are vulnerable to inundation.

In addition to rising global sea levels, the land surface in coastal New England is subsiding at a rate of approximately 6 inches per century. The combination of sea level rise and land subsidence is evident from the long term trend recorded by the Newport, RI tide gauge, which indicates a rate of approximately 10 inches of relative sea level rise over the last century.

Research projections indicate the rate of sea level rise is accelerating this century, with some models indicating a range of 4 inches to several feet of sea level rise by the year 2010. A 2007 report (Rahmstorf) correlates global sea level rise to global mean surface temperature, which is a good approximation for observations of the 20th century. When this correlation is applied to the 21st century, sea level rise is projected between 1.6 to 4.6 feet above 1990 levels. Accounting for regional subsidence, this estimate suggests that by 2100 sea level rise in New Hampshire could be approximately 2 to 5 feet.

Communities along New Hampshire's coast must begin now to proactively plan for sea level rise and integrate climate change and sea level rise scenarios into local planning and building regulations and policies. Examples of policies and programs adopted by other communities and regions are described below.

- Miami-Dade County Climate Change Advisory Task Force, April 2008 Recommendations – The Task Force identified recommendations for Built Environment Adaptation and Natural Systems Adaptation. The Built Environment Adaptation recommendations include planning for at least a 3-5 feet sea level rise over 100 years in all capital improvement projects. The Natural Systems Adaptation recommendations include protecting and restoring coastal ecosystems so that communities can be more resilient and better able to adapt to climate change.

- Rhode Island Coastal Resources Management Council, State Coastal Policy, 2007 – The Policy states the Council will proactively plan for and integrate climate change and sea level rise scenarios into its operations to accommodate a base rate of expected 3-5 foot rise in sea level by 2100. In May, 2009 the Council released to the public draft policies and standards for new and substantially improved buildings and structures, public infrastructure, and reconstruction of storm damaged buildings. These standards include coastal construction guidelines that recommend taking into account a 5 foot freeboard into the design of roads, bridges, wastewater treatment facilities, etc. to account for rising sea levels. The Policy will be revisited by the Council periodically to address new scientific evidence.

3. APPLICABILITY TO FUTURE LAND USE

Sea level rise will displace coastal populations, threaten infrastructure, intensify coastal flooding and ultimately lead to the loss of homes, businesses, public infrastructure, recreation areas, public space, coastal wetlands and salt marsh. Residential and commercial structures, roads, and bridges will be more prone to flooding. Sea level rise will also reduce the effectiveness and integrity of existing seawalls, which have been designed for historically lower water levels.

Higher sea levels along coastal New Hampshire will create changes in surface water and groundwater characteristics and disrupt important coastal ecological systems. Salt water intrusion into freshwater aquifers and wells will contaminate drinking water supplies. Higher water tables will directly impact wastewater treatment plants in the coastal zone.

Sea level rise will increase the extent of flood damage along the coast. Lower elevations along New Hampshire's coast will become increasingly susceptible to flooding as storm surges reach further inland due to sea level rise and the projected increase in storm frequency and intensity. Salt marshes are particularly vulnerable to the higher rise of sea level rise. The normal process of accretion, the build-up of live and decaying plants and sediments, will not keep pace. As salt marshes become submerged, they migrate inland. Existing development along the coast has decreased the amount of open space adjacent to salt marshes, limiting their ability to migrate landward. An increase in the rate of sea level rise will result in significant losses of coastal salt marsh habitat.

Flooding is a destructive natural hazard and results in significant economic loss to the New Hampshire businesses and residents. The 2005 Natural Hazard Mitigation Plan for the Town of Seabrook, prepared by the RPC, identified flooding as the primary hazard threat in Seabrook. The town is relatively flat with 95% of the land are under 60 feet above sea level. Tidal wetlands make up 30% of the land area, covering 1,734 acres. Seabrook's tidal wetlands are the largest expanse of this type of wetland in New Hampshire.

4. MAPPING THE EXTENDED COASTAL FLOOD HAZARD AREA

In order to model projected elevated sea level for Seabrook, NH, accurate and detailed digital elevation data was required. After reviewing the existing and available data, two sets of existing elevation data were chose for use in this project. The first set of data was acquired by the RPC in the spring of 2005 as part of the Natural Hazard Mitigation planning process. In 1998 the US Army Corps of Engineers (USACE) collected elevation data of the entire coast of New Hampshire. The data was collected for elevations from sea level to 20 feet above sea level, and was used to map the possible extent of hurricane storm surge events, by the National Hurricane Center, a division of the National Oceanic and Atmospheric Administration (NOAA). This elevation data was obtained by the RPC in

2005 as a set of mass point and breaklines, which required processing into a digital elevation model. The data was converted into a set of 5-foot contours by Complex Systems Research Center (CSRC) at the University of New Hampshire and delivered to the RPC in April, 2009.

The second set of data was generated from LiDAR (Light Detection And Ranging) imaging which is used to generated high resolution vertical terrain data. It was collected by USACE through the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX). The mission of JALBTCX[1] is to perform operations, research, and development in airborne LiDAR bathymetry and complementary technologies to support the coastal mapping and charting requirements of the USACE. Normally, LiDAR data from the USACE is made available to the public through the Coastal Services Center at NOAA[2]. At the time research was being done for this project, the 2007 LiDAR dataset for the coast of New Hampshire was not available. Working with the staff at the Coastal Services Center, the RPC was able to obtain the 2007 elevation data early June, 2009.

Comparison of the two sets of LiDAR data:

The two elevation datasets (1998 and 2007) both cover the entire coastline of Seabrook, but also have distinct difference. The 1998 data covers the entire area that was required for the project, meaning all of the area of Seabrook that is tidally influenced. As is mentioned above the contour interval for this data is 5 feet. The 2007 data has increased vertical resolution and can be used to create contours with intervals of 2 or 3 feet; however, the covered area only includes the coastline and approximately 2500 feet inland. The 2007 data thoroughly covers the Seabrook Beach area but not the inland extent of the salt marsh. The two datasets also differ in their vertical datum, being fixed reference points (benchmarks) by which to measure elevation. The 1998 data uses the National Geodetic Vertical Datum of 1929 (NGVD29). The 2007 data uses the North American Vertical Datum of 1988 (NAVD88). Both of these datums are attempting to represent mean sea level, but turn out to be vertically displaced from one another (see Table 1). Sea level is constantly tracked and recorded at tide stations operated by NOAA. The nearest station to Seabrook, NH, is Fort Point station in New Castle. According to the elevation information provided by NOAA for this station[3], the differences between the elevations of these two datums is 0.77 feet.

[1] http://shoals.sam.usace.army.mil/
[2] http://csc-s-maps-q.csc.noaa.gov/TCM/
[3] http:// www.ngs.noaa.gov/newsys-cgi-bin/ngs_opsd.prl?PID=OC0427&EPOCH=1983-2001

Table 1
Vertical Tidal Datum – Fort Point, New Castle, NH

Tidal Datum	Elevation in Feet
MHHW (Mean Higher High Water)	9.42
MHW (Mean High Water)	9.00
NAVD 88	5.02
MSL (Mean Sea Level)	4.72
MTL (Mean Tide Level)	4.69
NGVD29	4.25
MLW (Mean Low Water)	0.37
MLLW (Mean Lower Low Water)	0.00

Detailed Data Source Descriptions ("Metadata")

Excerpts from the technical metadata ("data about the data") on these two datasets follow:

1998 USACE Low Resolution LiDAR – The Army Corps of Engineers New England District contracted with EarthData International of Gaithersburg, MD, to fly the NH coast from the waterline up to approximately the 20 foot contour. The product was elevation data in the form of mass points and breaklines delivered in ArcInfo (GIS) point and line format. Although it is not explicitly stated in the metdata, this type of "raw" elevation data is often collected by LiDAR[4]. The study area was flown at 9,000 feet above-mean-terrain (AMT) to produce photography at a negative scale of 1 inch = 1,500 feet suitable for the production of 1 inch = 200 feet horizontal scale maps, and the generation of 5 foot contours meeting ASPRS Class 1 accuracy standards. The elevation data was referenced to the National Geodetic Vertical Datum of 1929 (NGVD29) and had vertical units of feet. The data was in a NH Stateplan NAD 83 horizontal coordinate system, with horizontal units of feet. The vertical accuracy of the elevation data is plus or minus 2.5 feet. The study area was flown in lead-off conditions on November 22, 1998.

2007 USACE Higher Resolution LiDAR – The U. S. Army Corps of Engineers collects (by themselves and via contractors) and maintains LiDAR data including orthophotos in coastal areas of the United States and its territories. The purpose of this survey was to obtain the existing conditions of the beach and near shore in support of the Joint Airborne LIDAR Bathyetric Technical Center of Expertise National Coastal Mapping Program. The Corps acquires this data in the course of performing its mission of Flood Control, Navigation, Environmental Engineering, and support for the Army and others. Hydrographic LIDAR datasets were collected using a SHOALS-1000T at 400m altitude, spot density of 5m x 5m and

[4] Nhrrp:// www.ndep.gov/glossary.html

sampling rate 1kHz. Topological data were also collected with a Leica ALS-50 sensor at 1600m altitude spot spacing of 1m x 1m spot spacing, and 133kHz sampling rate. These data depict the heights at the time of the survey and are only accurate for that time.

All data were processed in NAD83 horizontal and NVGD29 vertical datum. Data were later converted to the NAVD88 vertical datum using the GEOID03 model. Furgo in-house utilities were used to split the data in to pre-defined boxes, each covering approximately 5 km of shoreline. The product the RPC received was a bare earth model, created using Terrascan to define ground points. The ground points were then gridded using QT Modeler, to create a seamless model. The final Bare Earth Model is a 1m resolution GeoTIFF file. The LiDAR imaging was collected between 6th and 8th of June 2007.

Mapping of the Extended Coastal Flood Hazard Overlay

The adaptation planning project called for the creation of an "Extended Coastal Flood Hazard Overlay". In the Research and Findings section above, it is noted that predicted sea level rise varies, but, due to the apparent acceleration of the effects of climate change, is likely to be in the range of 3 to 5 feet in the next 100 years. It was determined that in order to account for the full extent of potential flooding impacts, the extended flood hazard area should encompass all of the land area that would be impacted at the upper end of that scenario – a 5 foot rise.

To create the Overlay, the existing flood information from Seabrook was reviewed. The existing DFIRM (Digital Flood Insurance Rate Map) for Seabrook has multiple special flood hazard zones identified, including an AE zone. Areas determined to be in the AE zone have 1% chance of receiving a 100-year flood each year, and also have base flood elevations determined. Base flood elevations are the computed elevation to which floodwater is anticipated to rise during the base flood, including wave height. The BFE is the regulatory requirement for the minimum elevation or flood proofing of structures. The BFE determined that Seabrook marsh area is 9 feet. So, at the current sea level a 100-year flood could be expected to inundate the AE zone in Seabrook to a depth of 9 feet above NGVD 29. The 9 foot BFE is based on the Flood Insurance Study for Rockingham County dated May 17, 2005.

In order to capture the areas that would be flooded during a 100-year storm event assuming the upper range of sea level rise (5 feet) in would be most appropriate to map the 14-foot contour (5 feet above the BFE for Seabrook, NH). Because of the variation in the two sets of digital elevation data used for this project is was not possible to create a 14 foot contour resolution. The closest we could produce using both data sets was at 15-feet of elevation or less. As such, the overlay includes areas that would be flooded at 6 feet above current base flood elevation. This overlay can be used to identify the outer boundary of land in Seabrook that is subject to increased risk from inundation, and where increased design flood elevations in the Town's regulations should apply. It is the suggestion of the RPC that this area be used as an overlay zoning district where extended flood regulations and standards would apply.

Project Maps

Five maps are included at the end of this report.

1. **Seabrook Existing Special Flood Hazard Zones.** This map displays the existing flood zones as developed by FEMA for use in Digital FIRMs.

2. **Seabrook Storm Surge Inundation.** This map displays the areas that would be inundated by storm surge during a range of hurricanes. This is the product that was developed from the 1998 elevation dataset used in this project.

3. **Seabrook Extended Coastal Flood Hazard Overlay.** This map depicts the areas of Seabrook that is at an elevation of 15 feet and below.

3a. **Seabrook Beach Extended Coastal Flood Hazard Overlay.** This map was added to help display the differences in the two sets of elevation data used to determine the Overlay.

4. **Town Owned Lands in Flood Prone Areas.** A map of the existing town-owned lands near the salt marsh that were recently deed restricted against development.

Acknowledgement of the Joint Airborne LIDAR Bathymetry Center of Expertise (JALBTCX) is requested in any publications or derived products.

5. POLICY OPTIONS

Climate Change will put coastal properties, infrastructure, and natural resources at risk due to rising sea levels. Communities need to review and revise regulatory and non-regulatory programs to accommodate the expected base rate of 2 to 5 foot rise in sea level by 2100.

A. Regulatory Recommendations:

- Utilize and/or establish base information that is provided by an agency that studies sea level rise in the region, trying to match information and models that are used within the New England region. This is important for keeping information up to date regarding sea level rise projections.

- Incorporate climate change/sea level rise impacts into all basic planning, zoning, and permitting. Assessments should utilize a minimum of a 50 year planning horizon and assume a 1.5 feet sea level rise in that period, and at least a 3 to 5 feet sea level rise of over 100 years.

- Establish a comprehensive planning and zoning policy such as development setbacks and limits on density and infrastructure in coastal and transitional zones to consider vulnerability to sea level rise and saltwater intrusion.

- Establish new street grade and building first floor elevation requirements and infrastructure elevation that exceed current Town, State and FEMA standards.

- As much as possible, locate future development, infrastructure and essential facilities outside coastal or flood hazard prone areas using projections of sea level rise to identify those areas.

- Define a transitions zone between the hazard area and built area to be protected and prohibit incompatible land uses that would convert open land in the transition zone.

The following recommendations are specific to the Town of Seabrook's Master Plan:

<u>Vision Statement</u> – Master Plan Vision statements guide existing and future land use decisions and policy. No current statements exist in Seabrook's Master Plan that pertain to the threat of climate change or sea level rise etc. It is indicative that the planning board incorporates statements related to climate change within their master plan goals and objectives section in order to develop effective policies related to the various threats that climate change may pose to the Town of Seabrook. Therefore, incorporating a set of statement(s) such as an objective(s) that reads like the following:

The Town of Seabrook recognizes that climate change and sea level rise is a possible threat to areas located along the seacoast and the Town seeks to minimize flood inundation to those areas in order to protect private, public, and Town interests or;

The Town of Seabrook seeks to mitigate impacts from future increases in relative sea level rise that may displace coastal populations, threaten infrastructure, intensify coastal flooding and ultimately lead to loss of recreation areas, public space, and coastal wetlands.

<u>Existing Land Use</u> – Areas of potential sea level rise inundation should be referred to within the existing land use section of the master plan. The areas should be delineated and existing land uses should be described within that area in order to give a current assessment of uses taking place within that defined area of town.

Future Lane Use – A section should be incorporated within the future land use section of the master plan that discusses areas within Town that are susceptible to current and future flood inundation and potential sea level rise scenarios. The incorporation of portions of this report and the accompanying maps would likely suffice. Incorporated within that section should be a map of the Future Extended Coastal Flood Hazard Overlay District and examples of policies that may help in reaching the goal protecting public safety, avoiding losses of infrastructure and facilities, and mitigating other effects of flooding.

The following recommendations are specific to the Town of Seabrook's Zoning Ordinance:

New Definitions may include the definitions provided on page 1 and 2 of this report.

Article III – Zoning Districts

Consider adopting an overlay district in which to apply higher standards for building freeboard height (desing flood elevation) and other provisions as described below:

Extended Coastal Flood Hazard Overlay District

The Extended Coastal Flood Hazard Overlay District would use Seabrook's existing Floodplain Regulations (Article XXII) as the framework for extending development and building regulations to lessen vulnerability of new buildings and facilities to flooding due to sea level rise.

The purpose of the Overlay District Ordinance would be to protect public and private property, buildings and infrastructure from undue risk from coastal inundation and flooding hazards arising from the projected rise in sea level expected to occur over the next 50 to 100 years. The extended risk area would encompass those areas subject to tidal flooding and storm related inundation that will occur if projected sea levels affecting the New England Coast rise to the degree expected, based on the best information available to the Town at the time of enactment. The area identified would encompass both the existing Flood Hazard Zones as identified by FEMA Digital Flood Insurance Rate Maps (DFIRM) adopted by the Town in May 2005, which assumes a present base flood elevation of 9 feet as well as areas mapped by the Rockingham Planning Commission using the best currently available elevation data that depict areas below 15 feet elevation NGVD 1929.

Since the existing FEMA flood maps have not been adjusted to reflect projected sea level rise, the Town of Seabrook is justified in using such information in further regulating development in vulnerable areas if it has good reason to believe that these area are at risk under existing standards. In doing so it is fulfilling the purposes of zoning (RSA 674:17) to secure public safety, promote general welfare, facilitate adequate infrastructure, conserving the value of buildings and encourage appropriate land use.

The regulatory standards included in this District seek to reduce the amount of damage and threats to health and safety that can be caused by moderate to major storm events, while protecting vital elements and beneficial functions (storm and flood damage reduction, wildlife habitat, recreational and aesthetic benefits) provided by coastal landforms, such as salt marches, coastal bank, barrier beaches, and dunes.

The recommended regulatory approach, adapted from the Rhode Island Coastal Resource Management Council's sea level rise policies, is to require all new construction and substantial reconstruction that occurs within the Overlay District to increase freeboard height for construction from 1 to 5 feet above the existing FIRM base flood elevation of 9 feet, depending on the type building or infrastructure. The suggested standards are shown in the following table:

Table 2
DESIGN FLOOD ELEVATION STANDARDS
EXTENDED COASTAL FLOOD OVERLAY DISTRICT

STRUCTURE TYPE	DESIGN FLOOD ELEVATION	RECONSTRUCTION THRESHOLD
Accessory Structures	10 ft. (9 ft. BFE + 1 ft.)	NA
Single Fam. Residential & Multi- family <5 Units	11 ft. (9 ft. BFE +2ft.)	50%
Multifamily 5+ units	12 ft. (9 ft. BFE + 3ft.)	40%
Commercial Development	12 ft. (9 ft.BFE + 3ft.)	40%
Essential Facilities (schools, hospitals, public safety buildings, etc.)	13 ft. (9ft. BFE + 4ft.)	33%
Public Infrastructure	14 ft. (9ft. BFE+ 5ft.)	25%

Property owners proposing construction or qualifying reconstruction within the Overlay District would be required to certify the elevation of their site and construction to prove compliance. Thus the overlay serves not as the definition of projected flood heights, but rather as indication that if certain development is undertaken here, it must meet specific DFE standards.

As a part of this project the RPC will prepare a model Extended Coastal Flood Hazard Overlay District incorporating these standards and assist the Planning Board to tailor it to the Town's needs should it decide to implement this recommendation.

B. Non-Regulatory Recommendations

- Current and future capital infrastructure projects should plan for sea level rise.

- Undeveloped land offers the greatest opportunities to provide for adaption to the effects of climate change. Different preservation and conservation tools should be explored and used in order to ensure the greatest amount of protection to existing open lands in public and private ownership.

- Increase funding and resources for land acquisition, land management programs, and land stewardship within Town. The retention of open land provides many critical public services, including replenishing drinking water supplies, protecting against salt water intrusion, conserving native wildlife and habitats, providing recreational opportunities, and sustaining agriculture and traditional harvesting.

- Permanently protect undeveloped coastal areas so the Town will be more resilient to climate change and be better able to adopt to sea level rise and increasing storm intensity. Permanently protecting these areas from development will also allow for coastal wetlands and marsh habitats to migrate and shift with rising sea level and give coastal species the ability to adjust as habitat changes occur.

- Identify fragmented habitats and work towards reconnecting habitat corridors. Fragmentation of coastal areas creates barriers to species movement. Isolated parcels of land that provide specific habitat are unable to provide all of the necessary components to support plant and animal populations. In addition, these isolated parcels are more susceptible to colonization by invasive species.

- Evaluate the impacts of salt water intrusion into all aquifers that support the local and regional population. Aquifers located underneath Collins Street and South Main Street, near the marsh, should be of significant importance given their proximity to sea level and high potential of inundation.

- Develop a Natural Hazards Chapter for the Town's Master Plan.

C. Emergency Management and Hazard Mitigation Recommendations

The following recommendations are specific to the Town of Seabrook's Hazard Mitigation Plan:

The Seabrook Hazard Mitigation Plan was compiled in 2007 to assist the Town of Seabrook in reducing and mitigating future losses from natural hazard events. Below are some recommendations the Town should consider in regards to revisiting certain sections within the document in order to not only mitigate future damage from sea level rise and storm events, but also to qualify for future hazard mitigation funding for mitigation projects that may help alleviate the burdensome effects of sea level rise and flood inundation.

Mapping the Hazards – This section of the plan contains areas that were identified where damage from historic natural disasters has occurred and areas where critical man-made facilities and other features may be at risk in the future for loss of life, property damage, environmental pollution and other risk factors. RPC generated a set of base maps with GIS (Geographic Information Systems) that were used in the process of identifying past and future hazards. This section should be updated to incorporate the newly identified areas within the "Extended Coastal Flood Hazard Zone". By adding this map to the plan the Town is delineating "potential" flood inundation areas due to sea level rise and storm surge.

Identify Critical Facilities and Areas of Concern – Critical Facilities are identified in the plan and are mapped out accordingly. These include buildings and areas that are considered to be important to the Town for emergency management purposes, were identified for provision of utilities and community services, evacuation routes, and for recreational and social value. The Town, while observing the "Extended Coastal Flood Hazard Zone" during the hazard mitigation plan update process, should include all facilities that are critical to the Town within this defined area. These facilities are grouped into four categories that include facilities/populations to protect, non emergency response services, emergency response services, and potential resources.

1. Facilities/Populations to Protect: includes, but is not limited to: daycare facilities, schools, special needs populations, elderly housing, other congregate care facilities, as well as access roads to these types of facilities.

2. Non-Emergency Response Facilities: includes, water and sewer infrastructure, culverts, alternative evacuation routes, bridges on the alternative evacuation route, etc.

3. Emergency Response Services: includes, the emergency operations center, emergency fuel facilities, police/fire station, hospital, ambulance/medical services, communications, shelters, primary evacuation routes, bridges on these routes, power plants, electrical power substations, dams, public works supplies, water and sewer department.
4. Potential Resources: includes, stores for supplies of food/fuel/etc., contractors, potential back-up shelters, etc.

Determining How Much will be Affected – The section entitled, "Determining how much will be affected" should be updated as well. This section (through analysis of where critical facilities are located) helps the Town determine what the most vulnerable areas of the Town of Seabrook are in relation to natural disasters, and to estimate (through a monetary value) their potential loss. The first step in this section is to identify the areas most likely to be damaged in a hazard event. To do this, locations of buildings and other structures are compared to the location of potential hazard areas identified using GIS (Geographic Information Systems). Again, the Town should utilize the mapped out "Extended Coastal Flood Hazard Zone" for determining how much could be effected within this area of Town.

Complete the Loss Estimation - The Town should then complete the loss estimation by assessing the level of damage from potential flooding due to sea level rise as a percentage of the buildings' assessed value within "Extended Coastal Flood Hazard Zone" for the purpose of calculating potential damage estimates. Damage estimates from hazards with a specific location are derived from the assessed values of the parcels within the hazard area. The GIS map should be used to determine which parcels are affected by sea level rise. After identifying the parcels and buildings that are at risk, the next step would be to calculate a damage estimate for the potential hazard area. FEMA provides a model for estimating damage for various flooding events, so the flood damage estimates provide information including: damage estimates for structures, contents of buildings, financial downtime and replacement time.

It is important to note that one purpose of mapping the critical facilities and accessing vulnerability to structures within the Extended Coastal Flood Hazard Zone would be to establish eligibility hazard mitigation grants to assist in floodproofing or even relocating emergency response services or structures outside of the zone, show infrastructure that could be negatively impacted by sea level rise and storm surge, as well as to show cost estimates of potential damage to structures located within the zone using FEMA's model for estimating damage and average replacement value.

Potential Mitigation Strategies – Lastly, a very important component within the plan is the section titled, "Potential Mitigation Strategies". By identifying potential mitigation strategies within the "Extended Coastal Flood Inundation Zone", such as but not limited to road elevation projects, or culvert replacement, the Town would then be able to pursue hazard mitigation monies through mitigation projects within the "Extended Coastal Flood Hazard Zone". If the Town can identify mitigation projects within this zone and list them accordingly in the hazards mitigation plan, then the Town will have ample grounds to apply for certain federal grants that may help alleviate any funding burden for hazard mitigation projects within this zone.

6. CONCLUSION

Sea level rise will significantly alter New Hampshire's coastal shoreline through increased severity and frequency of flooding, shoreline erosion and changes to coastal ecosystems. Science-based forecasts for accelerated sea level rise over the next 100 years due to global warming are as high as 5 feet. Important public infrastructure and critical wildlife habitat in Seabrook and the region are directly threatened by storms and costal inundation. Local decision makers need to develop and implement policies and regulations to plan for and mitigate the impacts of these changes. An important step for Seabrook at this point is to put regulations in place that increase the design flood elevation for buildings and infrastructure in the areas that will be subject to higher risk of flooding, as identified in this report.

APPENDIX 1

REFERENCES AND RESOURCES

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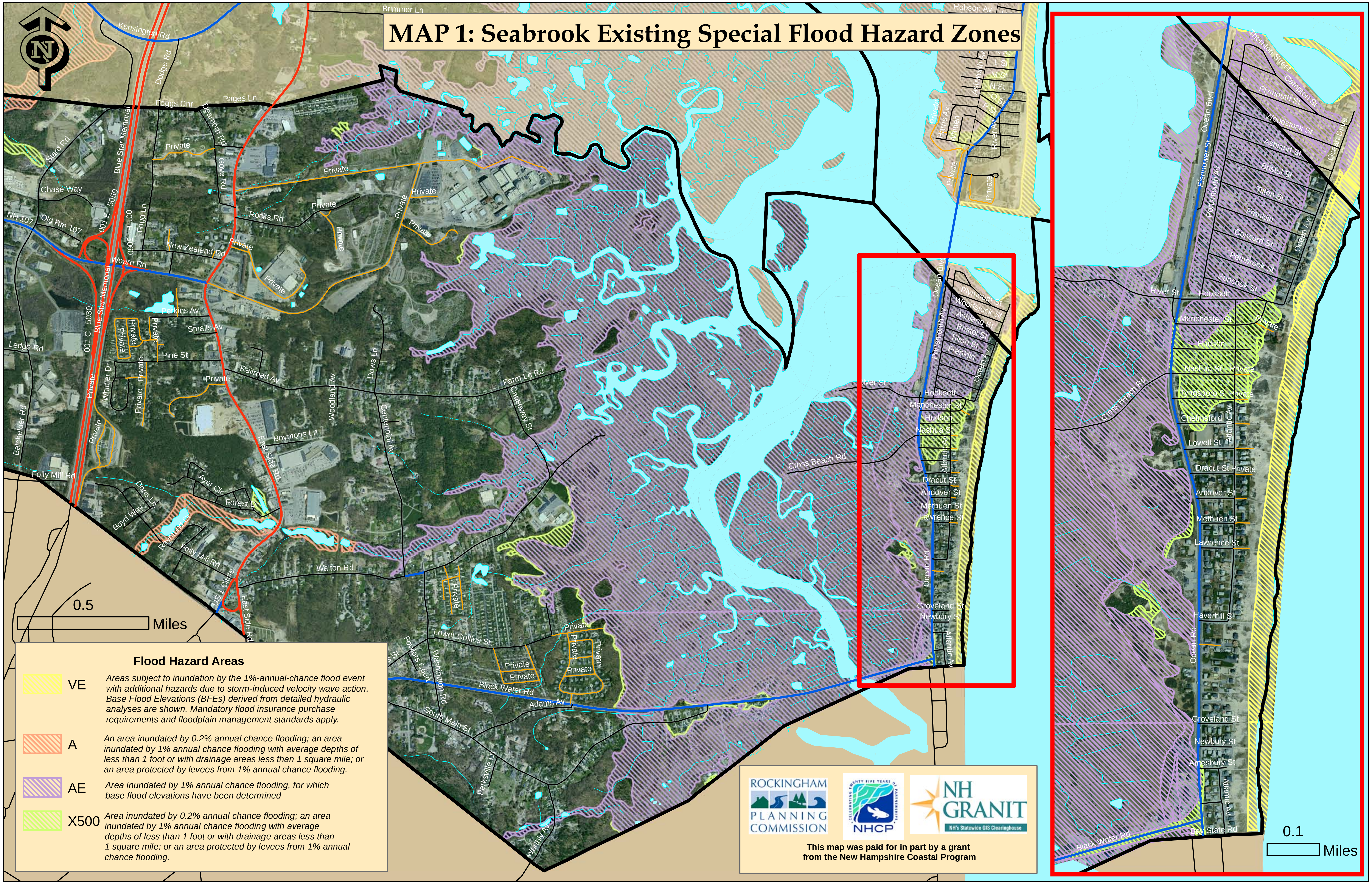
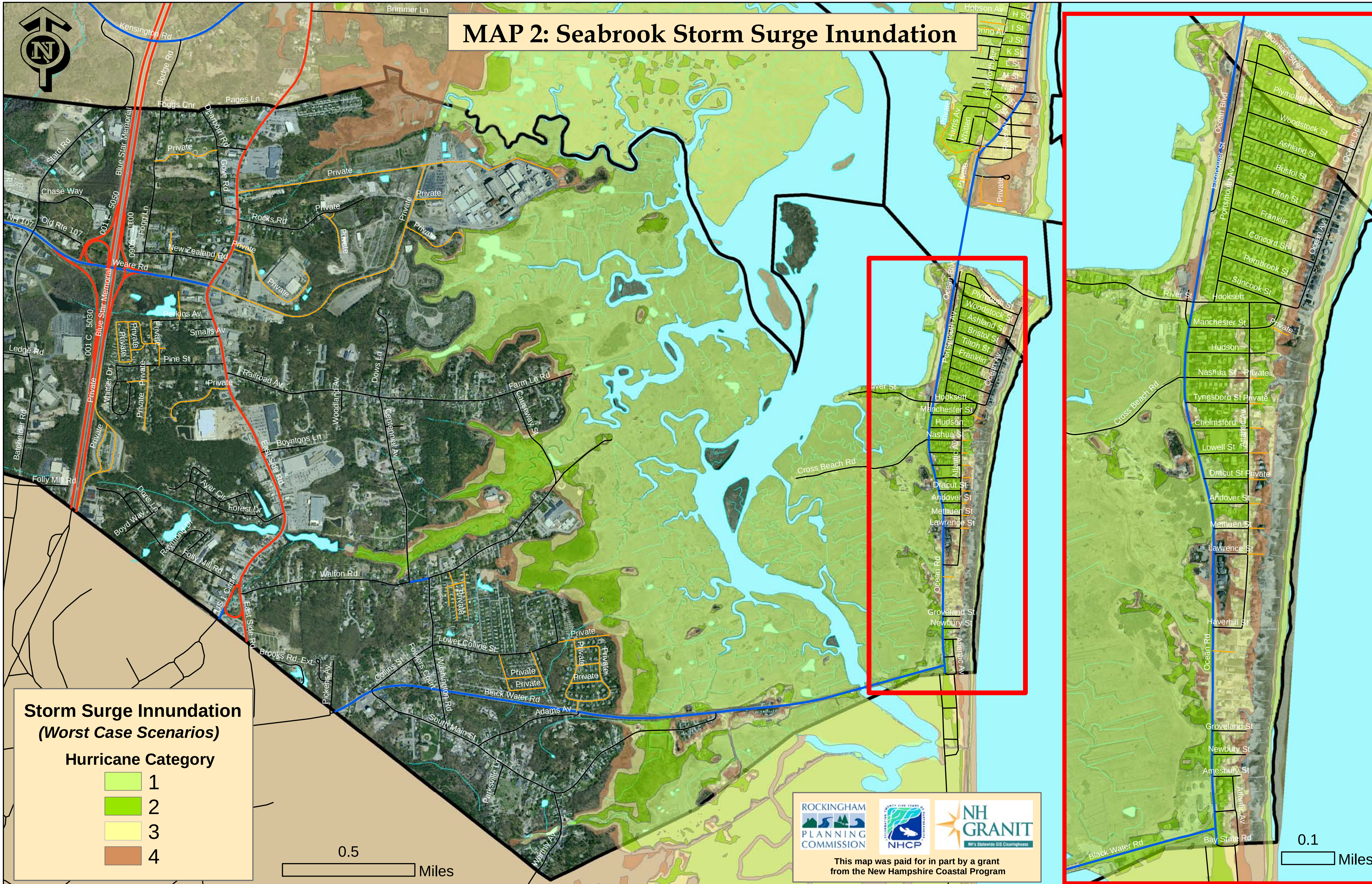
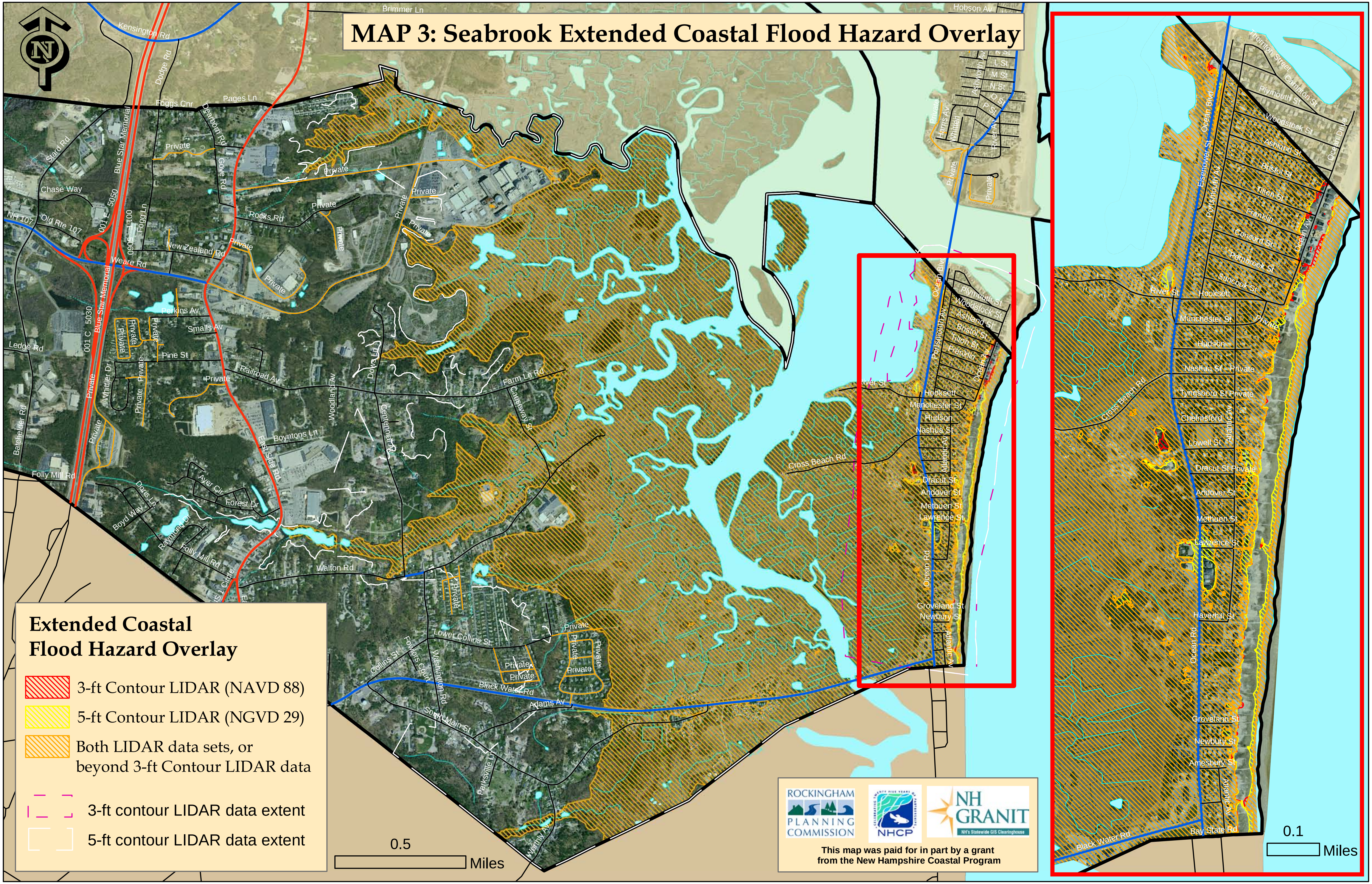
- www.ian.umces.edu/pdfs/ian_newsletter_20081002152303.pdf

- www.des.nh.gov/organization/divisions/air/tsb/tps/climate/index.htm

- http://curs.unc.edu/curs-pdf-downloads/climatechgsymp/Rubinoff.pdf


MAP 1: Seabrook Existing Special Flood Hazard Zones
Flood Hazard Areas
VE
Areas subject to inundation by the 1%-annual-chance flood event with additional hazards due to storm-induced velocity wave action. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.
A
An area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from 1% annual chance flooding.
AE
Area inundated by 1% annual chance flooding, for which base flood elevations have been determined
X500
Area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from 1% annual chance flooding.
0.5
Miles
0.1
Miles
ROCKINGHAM PLANNING COMMISSION
NHCP
NH GRANIT
NH's Statewide GIS Clearinghouse
This map was paid for in part by a grant from the New Hampshire Coastal Program


MAP 2: Seabrook Storm Surge Inundation
Storm Surge Innundation
(Worst Case Scenarios)
Hurricane Category
1
2
3
4
0.5
Miles
0.1
Miles
ROCKINGHAM PLANNING COMMISSION
NHCP
NH GRANIT
NH's Statewide GIS Clearinghouse
This map was paid for in part by a grant
from the New Hampshire Coastal Program
Brimmer Ln
Kensington Rd
Dodge Rd
Pages Ln
Foggs Cnr
Dearborn Rd
Stard Rd
Blue Star Memorial
Chase Way
NH 107
Old Rte 107
Weare Rd
New Zealand Rd
Rocks Rd
Perkins Av
Smalls Av
Pine St
Ledge Rd
Railroad Av
Farm Ln Rd
Causeway St
Dows Ln
Woodland Av
Centennial Av
Boyntons Ln
East Side Rd
Batchelder Rd
Folly Mill Rd
Ayer Cir
Forest Dr
Doris Ln
Boyd Way
Walton Rd
Brooks Rd. Ext.
Lower Collins St
Collins St
Washington Rd
Black Water Rd
Adams Av
South Main St
Pickens Av
Parksville Ln
Worthly Av
Cross Beach Rd
Private
Ocean Blvd
Portsmouth Av
Ocean Av
Ocean Drive
Plymouth St
Woodstock St
Ashland St
Bristol St
Tilton St
Franklin
Concord St
Pembrook St
Suncook St
Hooksett
River St
Manchester St
Hudson
Nashua St
Tyngsboro St
Chelmsford
Lowell St
Dracut St
Andover St
Methuen St
Lawrence St
Haverhill St
Groveland St
Newbury St
Amesbury St
Atlantic Av
Ocean Rd
Bay State Rd
Hobson Av
H St
I St
J St
K St
L St
M St
N St
O St
P St
Harris Av
Whitten
Eisenhower St
Brighton Street
Campton St



MAP 3: Seabrook Extended Coastal Flood Hazard Overlay
Extended Coastal Flood Hazard Overlay
3-ft Contour LIDAR (NAVD 88)
5-ft Contour LIDAR (NGVD 29)
Both LIDAR data sets, or beyond 3-ft Contour LIDAR data
3-ft contour LIDAR data extent
5-ft contour LIDAR data extent
0.5
Miles
0.1
Miles
ROCKINGHAM PLANNING COMMISSION
NHCP
NH GRANIT
NH's Statewide GIS Clearinghouse
This map was paid for in part by a grant from the New Hampshire Coastal Program
Brimmer Ln
Hobson Av
Kensington Rd
Dodge Rd
Pages Ln
Foggs Cnr
Dearborn Rd
Stard Rd
Blue Star Memorial
Chase Way
Cove Rd
Rocks Rd
NH 107
Old Rte 107
New Zealand Rd
Weare Rd
Perkins Av
Smalls Av
Pine St
Railroad Av
Ledge Rd
Farm Ln Rd
Woodland Av
Centennial St
Boyntons Ln
Batchelder Rd
Whittier Dr
Folly Mill Rd
Ayer Cir
Forest Dr
Boyd Way
Walton Rd
Lower Collins St
Collins St
Washington Rd
Black Water Rd
Adams Av
South Main St
Cross Beach Rd
Ocean Blvd
Portsmouth Av
Plymouth St
Woodstock St
Ashland St
Bristol St
Tilton St
Franklin
Concord St
Pembrook St
Suncook St
River St
Hooksett
Manchester St
Hudson
Nashua St
Tyngsboro St
Chelmsford
Lowell St
Dracut St
Andover St
Methuen St
Lawrence St
Haverhill St
Ocean Rd
Groveland St
Newbury St
Amesbury St
Atlantic Av
Bay State Rd
Private

MAP 3a: Seabrook Beach Extended Coastal Flood Hazard Overlay