



Project Report

Brooksville Climate Vulnerability Assessment: Coastal Flooding and Adaptation

Brooksville, Maine

Submitted to:

Town of Brooksville
Town House Road
Brooksville, ME 04617

Submitted by:

GEI Consultants, Inc
5 Milk Street
Portland, ME 04101
207.797.8901

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Leila A. Pike, P.E.
Senior Civil Engineer, Project Manager

Lissa Robinson, P.E., C.G.
Senior Civil Engineer and Hydrogeologist

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Acronyms and Abbreviations

1% annual chance storm	Also known as the “100-year storm,” this is a storm that has a 1% chance of being equaled or exceeded each year. It is the storm condition that FEMA uses to determine their flood insurance rate maps.
BFE	Base Flood Elevation. This is the water elevation that is expected to occur during a 1% annual chance storm. This elevation accounts for wave action (wave crests, wave setup, and wave runup) on top of the Stillwater Elevation (SWEL).
“Commit to Manage”	The Maine Climate Council’s (MCC) sea level rise recommendation, based on an intermediate rate of sea level rise.
DEM	Digital Elevation Model
EPA	Environmental Protection Agency
FEMA	The Federal Emergency Management Agency, responsible for distributing Flood Insurance Rate Maps (FIRMs) and determining present-day BFEs
FIRMs	Flood Insurance Rate Maps, or maps showing the flood extents and BFEs, distributed by FEMA
FIS	Flood Insurance Study, issued by FEMA to accompany the FIRMs and provide details regarding the basis of the BFEs and extents.
GIS	Geographic Information System
GMRI	Gulf of Maine Research Institute, a GEI partner on this project responsible for community engagement
GOPIF	Governor’s Office of Policy Innovation and the Future, a source of funding for this project through a Community Action Grant
HAT	Highest Astronomical Tide
ILF	In Lieu Fee
LiDAR	Light Detection and Ranging
Maine DACF	Maine Department of Agriculture, Conservation, and Forestry
Maine DMR	Maine Department of Marine Resources
Maine DOT	Maine Department of Transportation
Maine ECSB	Maine Emergency Services Communication Bureau
MCC	Maine Climate Council
MCFRM	Maine Coastal Flood Risk Model
MEDEP	Maine Department of Environmental Protection
MGS	Maine Geological Survey
MHHW	Mean Higher High Water, the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.
MHPC	Maine Historic Preservation Commission
NAVD88	The North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries
NOAA	The National Oceanic and Atmospheric Administration
NRPA	Natural Resources Protection Act

PBR	Permit-by-Rule
PCR	Pre-Construction Notification
“Prepare to Manage”	The Maine Climate Council’s (MCC) sea level rise recommendation, based on a high rate of sea level rise.
SLR	Sea Level Rise
SVNF	Self-Verification Notification Form
SWEL	Stillwater Elevation.
Town	Town of Brooksville, Maine
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish & Wildlife
VDATUM	Vertical Datum Transformation, a NOAA tool for converting between vertical datums

Executive Summary

This report presents the findings of the Brooksville Climate Vulnerability Assessment, which aims to evaluate the risks of coastal flooding, storm surge, and sea level rise to critical infrastructure and open spaces in the Town of Brooksville, Maine (the “Town”). This study was performed by GEI Consultants, Inc. (GEI) in partnership with the Gulf of Maine Research Institute (GMRI) and an oversight committee composed of representatives from the Towns of Blue Hill, Brooksville, and Surry. The assessment presented in this report provides an evaluation of the Town’s coastal flood vulnerability and offers recommendations for adaptation. The project was funded through a Community Action Grant from the Governor’s Office of Policy Innovation and the Future (GOPIF), with additional funding support from the Town of Brooksville.

The primary objective of this assessment was to identify vulnerable infrastructure within the town that could be impacted by coastal flooding due to increasing sea levels and more frequent storm events. The study utilized nine flood scenarios to model potential flooding impacts under present-day conditions, as well as future projections for 2050, 2070, and 2090, based on guidance from the Maine Climate Council (MCC). These scenarios accounted for both daily high tide levels and the 1% annual chance storm surge (commonly referred to as the “100-year storm”) under different sea level rise projections. This analysis was performed using Geographic Information System (GIS) tools, which allowed for mapping of flood extents and the identification of critical assets at risk.

E.S.1. Key Findings

The assessment identified several assets, including roads, culverts, bridges, buildings, and conservation lands, that would be vulnerable to flooding under both current and future conditions.

- **Roads:** Several roads would be particularly vulnerable to flooding, with Bagaduce Road, Bridge Road, Coastal Road, Back Road, Weir Cove Road, Dog Island Road, and Orcutts Harbor Road highlighted as high priority for further investigation and/or adaptation due to their potential flood exposure and importance as evacuation routes.
- **Culverts and Bridges:** We identified four state-owned culverts and two state-owned bridges, the Davis Narrows Bridge and Cape Rosier Bridge, as being at risk of inundation during coastal storm events. The bridges are critical for maintaining connectivity within the town and for emergency access.
- **Buildings and Critical Facilities:** We identified approximately 38 buildings that would be impacted by flooding. While most buildings in the town are not immediately at risk, some could experience daily flooding as early as 2050 in the absence of implementing adaptation measures.
- **Conservation Lands and Cemeteries:** Approximately 178 acres of conservation land and several cemeteries would likely experience flood inundation under present-day and future sea level rise scenarios.

E.S.2. Adaptation Strategies

The report outlines a range of adaptation strategies for the Town to consider that would help reduce the impacts of flooding on critical infrastructure. These strategies are designed to address both immediate risks (up to 2050) and longer-term threats (through 2090 and beyond). The adaptation options are grouped into structural and non-structural measures:

- **Structural Measures:**
 - **Road Elevation and Protection:** We recommend elevating key roads such as Coastal Road, Bridge Road, Weir Cove Road, Breezemere Road, Dog Island Road, and Orcutt's Harbor Road. We recommend studying further the risk of flood exposure along Back Road and Bagaduce Road. Where elevation is not feasible, the installation of protective structures such as sea walls, or relocation of the roadways (i.e., inland, upland), may be considered.
 - **Building Adaptations:** For buildings at risk of flooding, we recommend considering wet and dry floodproofing techniques, as well as the elevation of structures above predicted flood levels. In some cases, it may be necessary to consider retreat with the relocation of vulnerable structures away from flood-prone areas.
- **Non-Structural Measures:**
 - **Flood Monitoring Systems:** We suggest implementing a water level monitoring and alert system to provide real-time data on flood risks, allowing the town to respond more effectively to potential flooding events.
 - **Emergency Preparedness:** Developing emergency response plans would likely increase public safety during extreme storm events. Additionally, public awareness campaigns to educate residents about the dangers of driving or walking through floodwaters will help reduce risks during emergencies.
 - **Regulatory Improvements:** The Town could update local ordinances to enforce stricter building codes and floodplain management regulations. This could include adopting more stringent requirements for new developments in flood-prone areas and integrating climate change considerations into the Town's comprehensive planning efforts.

E.S.3. Cost Estimates and Funding Opportunities

The report provides preliminary cost estimates for implementing the recommended adaptation measures. Adapting critical infrastructure can be a significant investment, but the town may be able to leverage state and federal grant programs to offset costs. The report identifies several potential funding sources, which could support the town's efforts to build long-term flood resilience.

E.S.4. Next Steps

This vulnerability assessment is a high-level analysis designed to guide the Town's flood adaptation efforts. Future work should include conducting site-specific field investigations, implementing a monitoring program to provide real-time access to tidal and inlet water levels, refining coastal flood risk through wave modeling, refining flood risk along inlets that appear to be restricted by bridges and

resulting in attenuation with detailed hydraulic modeling, and preparing engineering designs for identified adaptation projects. The town should also continue engaging with the public and other stakeholders to build support for the necessary adaptation measures and to learn about stakeholder interests and preferences for improvements to communications regarding adaptation activities and during significant coastal events.

To enhance public access to the findings, the results of this study will be available online through an ArcGIS StoryMap, which will provide interactive maps of the flood risk scenarios and adaptation recommendations. This resource will be made available by the project closeout date of December 31, 2024.

In conclusion, this assessment underscores the importance of proactive adaptation planning to safeguard the Town of Brooksville against the increasing risks posed by coastal flooding. By implementing the recommended strategies, the town can enhance its resilience and protect critical infrastructure, natural resources, and the well-being of its residents.

1. Introduction

This report presents the method and findings of a vulnerability assessment for the Town of Brooksville (the “Town”) in Hancock County, Maine (Figure 1). The purpose of the project was to evaluate the vulnerability of infrastructure and open spaces to flood risk due to storm surge and sea level rise (SLR) and to provide adaptation strategies and timeframe recommendations for adaptation projects to increase the Town’s resiliency to flood inundation.

This work was based on our proposal dated August 4, 2023. The project team consisted of GEI Consultants, Inc. (GEI), the Gulf of Maine Research Institute (GMRI), and an Oversight Committee with several members from the Town of Blue Hill, the Town of Brooksville, and the Town of Surry. This project was funded with a Community Action Grant through the Governor’s Office of Policy Innovation and the Future (GOPIF) Community Resilience Partnership with additional funding support from the Town of Brooksville. This report provides a data review and data gap analysis, an overview of the flood exposure methodology, flood risk results which summarizes vulnerable infrastructure and places, general flood adaptation recommendations, and site-specific adaptation recommendations for select assets in the Town. Climate risks associated with heat, power outages, clean drinking water and drought, ocean acidification, shifts in plant hardiness zones, tick-borne diseases, and vulnerabilities to the working waterfront economy will be summarized separately as part of this project.

The flood scenarios included in this evaluation represent specific storm conditions and rates of sea level rise. Actual storms, sea level rise rates, and flood conditions will vary from conditions presented in this report. The purpose of this evaluation was to help the Town plan and prepare for resiliency projects. An important next step after this study would be to conduct site-specific detailed analysis for identified adaptation projects. The site-specific analyses could include wave modeling, site survey, permitting, and design, among other tasks.

The results of the flood vulnerability and adaptation study presented in this report will be available to view online as part of an ArcGIS StoryMap. The StoryMap will be available before the project closeout date of December 31, 2024.

Elevations in this report are references to the North American Vertical Datum of 1988 (NAVD88) unless otherwise specified.

2. Data Review

Data review was performed to evaluate previous work and available information to use for flood vulnerability and adaptation planning. This section summarizes the existing regional resiliency plans and policies related to climate and flood vulnerability for the Town of Brooksville.

Details of the data used for the flood vulnerability analysis, limitations of existing data, and next steps to improve upon available data, are provided throughout this report.

2.1. Existing Regional Resiliency Plans, Policies, and Data

The Town of Brooksville is on the Blue Hill Peninsula and within Hancock County. For these regions, we reviewed the Hancock County Hazard Mitigation Plan, planning efforts conducted by the group “Blue Hill Peninsula Tomorrow,” and the 2022 report by rbouvier consulting titled “Assessing the Carrying Capacity of the Blue Hill Peninsula.” In addition to a regional review, we have summarized Town-specific resiliency plans, policies, and data, such as the Town of Brooksville Comprehensive Plan, town-specific ordinances, and availability of Geographic Information System (GIS) data.

2.1.1. *Hancock County Hazard Mitigation Plan 2024 Update*

A hazard mitigation plan is a document that proposes ways to reduce loss of life and property by minimizing the impact of disasters. The 2024 Hancock County Hazard Mitigation Plan Update (Hancock County EMA, 2024) outlines four main hazards in the county: severe winter storms, flooding, severe summer storms, and wildfires. The plan specifies that these hazards were selected based on review of the Maine State Hazard Mitigation Plan 2023 Update (MEMA, 2023), past disaster declarations, mapped data, risk assessments, and input from residents and municipalities. Within each of the four hazard types, additional sub-types are defined, such as freezing fog as it pertains to severe winter storms, coastal flooding from storm surge as it pertains to flooding, and microbursts as they pertain to severe summer storms. Locations where hazards have occurred in the past are listed for each community. The following hazards and locations were identified for Brooksville in the Hancock County Hazard Mitigation Plan 2024 Update: coastal flooding, and flooding from winter and summer storms.

The plan notes opportunities for improvement on local plans and policies, including developing a town-specific zoning ordinance, and adopting building codes. Brooksville does not have a town zoning ordinance. Additionally, since the population of Brooksville is below 4,000, the town is not required to have an adopted building code. However, Brooksville could adopt a building code that conforms with the Maine Uniform Building and Energy Code (MUBEC).

2.1.2. *“Assessing the Carrying Capacity of the Blue Hill Peninsula” Report*

In August 2022, rbouvier consulting published a report on behalf of Blue Hill Heritage Trust (BHHT), that explored the carrying capacity of the Blue Hill Peninsula (rbouvier consulting, 2022). The purpose of the report was to examine population trends and projections related to climate-related migration and assess the physical, economic, and social carrying capacity of the peninsula to accommodate and increase in

population. The study found that there was an increase in temporary and permanent migration, likely due to the COVID-19 pandemic. The study results found that climate migration was voluntary and due to perceived dangers at the location people were moving from (e.g., wildfires, hurricanes, etc.).

2.1.3. Blue Hill Peninsula Tomorrow

In 2021, eight communities within the greater Blue Hill Peninsula formed Blue Hill Peninsula Tomorrow – a multi-town effort to identify the potential impact of climate change on the Blue Hill Peninsula and explore ways to maximize mitigation and adaptation opportunities through collaboration. In addition to virtual meetings, the group hosts a website for report and information compilation hosted on the Hancock County Planning Commission page.

2.1.4. Sea Level Rise and Climate Change Committee

There is a Sea Level Rise and Climate Change Committee in the Town of Brooksville. To date, there has not been a town-based assessment of climate-related vulnerabilities. However, both the Annual Town Report (Brooksville, 2022) and the Comprehensive Plan (Brooksville, 2021) acknowledge the threat of climate change and sea level rise. Funds were appropriated for the Sea Level Rise and Climate Change Committee, showing a commitment by the town to address sea level rise and climate change vulnerabilities. The Comprehensive Plan (2021) lists monitoring the threats and impacts of climate change as they relate to managing roads, marine resources, natural resources, agriculture and forested land, archaeological and historic sites, and land use planning as a climate change strategy for addressing climate change threats. The details of anticipated climate change impacts outlined within the comprehensive plan demonstrate the town's understanding of the breadth and depth climate-related impacts are likely to have on the town. In addition, many of the goals and objectives within each section identify the Sea Level Rise and Climate Change Committee as a collaboration partner, further integrating town objectives with acknowledgement of climate-related impacts.

2.1.5. Town Ordinances

Ordinances are pieces of legislation developed and enacted by a municipality. They are local laws for residents to follow, in addition to – and sometimes more restrictive than – federal or state laws. They are specific to each municipality and help communities maintain their character or goals for the future.

The Town of Brooksville maintains local floodplain management ordinances consistent with being a participant in the National Flood Insurance Program (NFIP) and the standards set forth by the National Flood Insurance Act of 1968. While this ordinance meets the necessary criteria for damage relief funding from flood hazards, outlined in the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Hancock County (FEMA, 2016), there are no additional or more stringent ordinances that account for risks related to sea level rise or increasing storm frequency/intensity.

In addition to the Floodplain Management Ordinance, the Town of Brooksville also has a Shoreland Environmental Protection Ordinance which regulates land use activities in the “shoreland zone.” As noted previously, the Town does not have a Building Ordinance or a Zoning Ordinance in place. These additional ordinances could offer avenues for more stringent regulations around infrastructure adaptation.

2.1.6. GIS Data

The Town of Brooksville does not maintain a GIS database of town-owned infrastructure, such as transportation infrastructure (i.e., road, sidewalks, etc.), drainage infrastructure (i.e., culverts, catch basins, drainage ditches, etc.), or sewer infrastructure (i.e., pump stations, outfalls, etc.). Additionally, infrastructure that is not town-owned but that is within the town, such as buildings and coastal structures (i.e., riprap, seawalls, etc.) could be possible data maintained by a municipality. GIS data used for this flood vulnerability study, and limitations of the data, is outlined in Section 3 of this report.

2.2. Opportunities for Policy, Plan, and Data Improvement

We have provided a summary of opportunities for improvement of the plans and data reviewed related to flood vulnerability. The following points are general opportunities for improvement. More detail on how to improve specific data sources is provided throughout this report.

- **Local Ordinances.** The Town of Brooksville could adopt building and zoning ordinances to enforce more restrictive infrastructure requirements and area where buildings or other infrastructure can be developed. Additionally, the existing floodplain management ordinance is based on FEMA Flood Insurance Rate Maps (FIRMs) which do not include sea level rise in the mapped hazard areas. The floodplain management ordinance could adopt more stringent rules accounting for sea level rise.
- **Collaboration with Maine DOT.** There are multiple vulnerable roads identified in this project that are owned by Maine Department of Transportation (Maine DOT). The Town of Brooksville could work collaboratively with Maine DOT to address these vulnerable roadways. An example of municipality working collaboratively with Maine DOT on a state-owned road adaptation project is the Route 1 and Route 9 resiliency project in the Town of Scarborough (Scarborough, 2024).
- **GIS Database of Assets.** Consider developing a process for cataloging data and maintaining a GIS database of assets. The GIS asset database should include the geographic coordinates of an asset and the asset type, at a minimum. However, a robust database includes details on the dimensions, elevations, and conditions of the asset and the date when the data entry was logged. There are readily available online databases with GIS data, many of which were used in this study, but there is a lack of data on infrastructure within the town, such as culverts and building footprints (the existing data is from 2018).

3. Flood Risk Assessment

Coastal flood risk for the Town was evaluated for nine flood scenarios. The scenarios included present-day sea levels and estimated sea levels in 2050, 2070, and 2090 based on sea level rise guidance provided by the Maine Climate Council (MCC) (2024). For present-day sea levels, flood risk due to 1% annual chance stillwater levels (“100-year storm surge”) was evaluated. For the 2050 and 2070 timeframes, flood risk was evaluated for average daily tide levels (represented as mean higher-high water [MHHW]) in addition to 1% annual chance storm surge elevations. Each scenario featured a water surface elevation representative of a timeframe, sea level rise value, and tide scenario (i.e., MHHW or 1% annual chance storm surge events).

The flood scenarios evaluated as part of this study represent static water levels (i.e., standing water or inundation without waves). The effect of wave action, including the flood extents due to wave runup and/or overtopping, was not included in the analysis. Thus, the flood depths and extents in this report likely underestimate those that would likely occur during the flood scenarios representative of coastal storm scenarios, where wave action is expected to occur. Additionally, flood risk due to rainfall events was not included as part of this study. The results from this evaluation should be used to identify and prioritize infrastructure at risk of flooding from coastal effects absent precipitation and/or wave impacts. Flood elevations included in this study should not be used in design. The data sources used for water levels and sea level rise estimates are described in further detail in the following sections.

A GIS-based analysis was performed using the nine flood elevations and a topographic surface of the study area to evaluate the extent of flooding for each scenario. A GIS database of “assets,” such as transportation infrastructure, building infrastructure, property parcels, and conservation lands, was compiled and used to identify infrastructure and areas at risk of flood inundation for the nine flood scenarios. The following sections describe the GIS analysis in more detail.

3.1. Methodology

3.1.1. Topography Data

A Digital Elevation Model (DEM) was developed by mosaicking multiple DEMs developed from LiDAR (Light Detection and Ranging) surveys (USGS, 2021). The original surveys have a resolution of 1-meter, meaning the terrain is divided into 1-meter grids with each grid cell being represented by a single elevation value. The elevations within each grid cell reference the NAVD88 datum.

3.1.2. GIS Asset Data

We compiled a GIS database of assets using primarily publicly-available data sources that were included as part of this vulnerability analysis using data from publicly available data sources. The GIS data included:

- Roads.
- Evacuation routes.

- Parcels.
- Conservation parcels.
- Building footprints.
- Critical facility locations (hospitals, government buildings, schools, and fire stations).
- Cemeteries.
- Boat launches.
- Large culvert and cross culvert locations on state-owned roads.
- Drinking water well locations.
- Bridges.

A detailed list of file names, sources, and dates data were accessed can be found in Appendix A. It is important to note that public GIS data accessed online can be updated over time. The data used in this study represents a snapshot in time. More details and limitations on the GIS data sources is provided within the results sections of this memo.

3.1.3. Water Levels

This study evaluated infrastructure and areas at risk of flooding during MHHW and 1% annual chance stillwater elevations (SWELs). MHHW is the average of the higher high-water height of each tide cycle, meaning that areas identified in the flood vulnerability results as inundated during MHHW would likely experience daily flooding. The MHHW elevation for the Towns was estimated for present-day sea levels using the National Oceanic and Atmospheric Association (NOAA) Vertical Datum Transformation (VDATUM) tool (NOAA, 2023). The average MHHW for the Towns is approximately 5.3 ft NAVD88.

The FEMA FIS for Hancock County was used to estimate the 1% annual chance stillwater elevations (FEMA, 2016). The FIS provides an estimated 1% annual chance SWEL for each shoreline transect included in the FEMA study. There are 3 FEMA transects in Surry, 9 in Blue Hill, and 12 in Brooksville. The average 1% annual chance SWEL for these transect locations is 9.4 ft NAVD88, representing approximately 4.1 ft of storm surge above MHHW conditions. Before 2016, the FEMA FIS for Hancock County was previously updated in 1990 (FEMA, 1990). There is no readily available information for when FEMA may next update the FIS for Hancock County.

Sea level rise estimates were added to present-day MHHW and 1% annual chance SWEL to estimate future MHHW and 1% annual chance storm surge elevations, described in further detail in the following section.

3.1.4. Sea Level Rise

The Maine Climate Council has recommended sea level rise estimates for Maine communities to consider when planning and designing for flood adaptation. The MCC has recommended that Maine communities “Commit to Manage” an intermediate rate of sea level rise and “Prepare to Manage” a high rate of sea level rise. The MCC sea level rise recommendations were first issued in 2020 and were based

on 2017 projections provided by NOAA (MCC, 2020a). This vulnerability assessment was performed in 2023 and used the MCC 2020 recommendations. However, the MCC updated the sea level rise recommendations for the “Prepare to Manage” scenarios following updated sea level rise projections issued by NOAA in 2022 (MCC, 2024). The “Prepare to Manage” sea level rise value of 3.0 ft has shifted from likely to occur by 2050 to likely to occur by 2070. The “Prepare to Manage” value of 5.0 ft has shifted from likely to occur by 2070 to likely to occur by 2090. We have updated the timeframes used in this study to reflect the recent changes to the MCC recommendations. The updated sea level rise scenarios for the Bar Harbor tide gauge for the years 2020 to 2150 are summarized in Table 3-1.

Table 3-1. Sea Level Rise Estimates

Timeframe	Sea Level Rise Amount (ft) Intermediate Rate Median (likely range)	Sea Level Rise Amount (ft) High Rate Median (likely range)
2020	0.4 (0.3-0.5)	0.4 (0.3-0.5)
2030	0.6 (0.4-0.8)	0.6 (0.4-0.9)
2040	0.9 (0.7-1.2)	1.0 (0.7-1.4)
2050	1.2 (0.9-1.5)	1.5 (1.0-2.0)
2060	1.5 (1.2-2.0)	2.1 (1.5-2.8)
2070	1.9 (1.5-2.4)	2.9 (2.2-3.7)
2080	2.4 (1.9-3.0)	3.9 (2.8-4.9)
2090	3.0 (2.3-3.6)	4.9 (3.5-6.2)
2100	3.6 (2.7-4.4)	6.0 (4.3-7.5)
2110	4.4 (3.1-5.4)	7.2 (5.2-8.9)
2120	5.0 (3.5-6.7)	8.3 (5.9-10.5)
2130	5.6 (4.0-8.4)	9.3 (6.5-12.4)
2140	6.2 (4.3-10.6)	10.2 (7.0-14.6)
2150	6.7 (4.7-13.1)	10.9 (7.6-16.9)

Source: Sea level rise estimates for the Bar Harbor, Maine, NOAA buoy taken from Table 3 in the 2024 Maine Climate Council report (MCC, 2024)

3.1.5. Flood and Mapping Scenarios

The nine flood scenarios used in this study and their respective flood elevations are summarized in Table 3-2.

Table 3-2. Summary of Flood Scenarios

MCC SLR Scenario	Timeframe	SLR Amount (ft)	Tidal Conditions	Flood Elevation (ft, NAVD88)
	Present Day	0.0	100-year	9.4
Commit to Manage	2050	1.5	MHHW	6.7
			100-year	10.8
	2070	2.4	MHHW	7.6
			100-year	11.7
	2070	3.0	MHHW	8.2

MCC SLR Scenario	Timeframe	SLR Amount (ft)	Tidal Conditions	Flood Elevation (ft, NAVD88)
Prepare to Manage	2090	5.0	100-year	12.3
			MHHW	10.2
			100-year	14.3

Note: Sea level rise estimates are based on relative increases from mean sea level in the year 2000, which is approximately 0.1 ft lower than present-day mean sea level. This difference in mean sea level was accounted for in the Flood Elevations used in this study.

For reporting purposes, the flood scenarios were arranged from lowest to highest water surface elevation and numbered from 1 to 9. Flood Scenario 1 would have the smallest inundation extent and lowest water surface elevation and Flood Scenario 9 would have the largest inundation extent and highest water surface elevation. Areas that would be inundated for lower scenario numbers would be considered more vulnerable while areas inundated under higher scenario numbers would be considered less vulnerable. Table 3-3 shows a description of the flood scenario with the corresponding scenario number to be used in the results summary tables. The flood scenario numbers table is also provided in Appendix B.

Table 3-3. Flood Scenario Numbers

Flood Scenario Description	Water Surface Elevation (NAVD88, ft)	Flood Scenario Number
2050, High Tide, Commit to Manage (1.5 ft SLR)	6.7	1
2070, High Tide, Commit to Manage (2.4 ft SLR)	7.6	2
2070, High Tide, Prepare to Manage (3.0 ft SLR)	8.2	3
Present Day, 100-year Storm	9.4	4
2090, High Tide, Prepare to Manage SLR (5.0 ft SLR)	10.2	5
2050, 100-year Storm, Commit to Manage (1.5 ft SLR)	10.8	6
2070, 100-year Storm, Commit to Manage (2.4 ft SLR)	11.7	7
2070, 100-year Storm, Prepare to Manage (3.0 ft SLR)	12.3	8
2090, 100-year Storm, Prepare to Manage (5.0 ft SLR)	14.3	9

Notes: “High Tide” refers to MHHW elevation. “100-year Storm” refers to the 1% annual chance stillwater elevation.

3.1.6. Asset Adaptation Prioritization

The water elevations for the nine flood scenarios were used to create nine flood inundation extents. The flood inundation extents for each scenario can be viewed on the corresponding ArcGIS StoryMap that will be developed as part of this project. The nine inundation extents were used to identify which GIS-based “assets” would be exposed to flooding for each scenario included in this study. Some assets, such as roads, were further categorized into “High,” “Medium,” and “Low Priority” in terms of prioritizing roads for flood adaptation.

Assets identified as being at risk of flood inundation for Flood Scenarios 1 through 4 were initially categorized as high priority for adaptation in terms of flood exposure. These assets would likely be inundated during 1% annual chance storm surge events for present-day water levels. Additionally, some of these assets would likely experience daily flooding by 2050 or 2070.

Assets identified as being at risk of flood inundation for Flood Scenarios 5 through 7 were initially categorized as medium priority for adaptation in terms of flood exposure. These assets would likely be inundated during 1% annual chance storm surge events in the years 2050 and 2070 for the “Commit to Manage” sea level rise scenario and would likely experience daily flooding in 2090 under the “Prepare to Manage” sea level rise scenario.

Assets identified as being at risk of flood inundation for Flood Scenarios 8 and 9 were initially categorized as low priority for adaptation in terms of flood exposure. These assets would likely experience flooding during 1% annual chance storm surge events in the years 2070 and 2090 for the “Prepare to Manage” sea level rise scenario.

After the initial prioritization based on flood exposure, assets were moved up or down in priority using input collected during the community mapping event, the potential use of the asset during emergencies (i.e., a road as an evacuation route), and the relative number of people who may be impacted if the asset were to be inundated.

The results of the flood exposure analysis have been summarized in the following sections of this report. The table of flood scenarios and the results summary tables included within this report are also included in Appendix B of this report.

3.2. Flood Risk Results

3.2.1. Roads

We have identified an initial list of eight roads in Brooksville that we suggest giving “High Priority” to in terms of flood adaptation. These roads were given high priority due to a combination of the estimated flood exposure, the potential use of these roads as evacuation routes, and the relative amount of people who may be impacted if the road were to be inundated. We recommend that the Town of Brooksville focus on “High Priority” roads first when considering flood adaptation measures. Using the same criteria, we identified an initial list of fourteen “Medium Priority” and nine “Low Priority” roads. A summary of the roads inundated and estimated length of inundation for each of the nine flood scenarios is provided in Table 3-4.

The road locations and lengths used in this analysis are based on a GIS shapefile of roads developed by Maine Emergency Services Communication Bureau (Maine ESCB, 2021). The digital data represents a snapshot in time and are based on road alignment developed by others. Actual road locations may differ. We based our inundation analysis on the digital road data described above and the terrain data compiled for this study. These results should be considered approximate.

Table 3-4. Roads Flood Risk Exposure Summary, Length of Inundation (ft)

Road Name	Ownership	1	2	3	4	5	6	7	8	9
High Priority Roads										
Bagaduce Rd	State	-	208	305	437	522	566	624	665	872
Back Rd	Town	-	122	196	290	339	363	401	422	477
Weir Cove Rd	Town	-	7	184	532	593	627	674	710	870
Breezemere Rd	Town	-	-	-	40	115	245	369	415	572
Bridge Rd	State	-	-	-	62	125	210	226	233	260
Coastal Rd	State	-	-	-	207	268	309	367	440	736
Dog Island Rd	Town	-	-	-	38	158	299	422	641	1,330
Orcutts Harbor Rd	Town	-	-	-	-	85	114	138	152	195
Medium Priority Roads										
Goose Falls Rd	Town	-	-	-	-	-	-	176	231	358
Cape Rosier Rd	Town	-	-	-	-	-	-	-	31	398
Harborside Rd	Town	-	-	-	-	-	-	-	-	106
S Wharf Rd	Town	6	13	19	25	32	36	39	45	62
Undercliff Rd	Town	-	12	178	245	476	553	623	711	925
Captain Eels Ln	Town	-	-	3	159	213	254	270	280	302
Indian Bar Rd	Town	-	-	49	171	208	232	264	284	313
Prentice Point Rd	Town	-	-	6	34	70	83	109	114	143
Hay Landing Rd	Town	-	-	-	28	58	65	103	125	175
Judy Point Ln	Town	-	-	-	66	147	166	196	212	270
Store Point Rd	Town	-	-	-	4	21	25	102	141	298
Burnt Marsh Ln	Town	-	-	-	-	5	30	128	190	237
Clifford Field Rd	Town	-	-	-	-	6	20	47	74	160
Eugenie Ln	Private	-	-	-	-	42	66	95	105	133
Low Priority Roads										
Norumbega Rd	Town	-	-	-	-	-	-	-	48	210
Abenaki Loop Rd	Town	-	-	-	-	-	-	-	-	149
Boatyard Rd	Private	-	-	-	-	-	-	-	-	144
Horseshoe Cove Rd	Town	-	-	-	-	-	-	-	-	362
Red Trl	Town	-	-	-	-	-	-	-	-	98
Condon Point Rd	Town	-	-	-	-	-	-	-	-	12
Bakemans Rd	Town	-	-	-	-	-	-	-	71	168
Perkins Ln	Private	-	-	-	-	-	-	-	8	38
Revere Way	Private	-	-	-	-	-	-	-	1	20

3.2.2. Culverts

We have identified four culvert crossing locations (one “large culvert” and three “cross culverts”) that were included in the Maine DOT culvert database for cross culverts (MaineDOT, 2021a) and large culverts (MaineDOT, 2021b) that would likely be fully submerged and the deck of the road at the culvert would be overtopped for one or more of the nine flood scenarios included in this study. We based this analysis on the Maine DOT culvert database locations and the terrain data compiled for this study. The

culvert crossings identified as being at risk of inundation, and an included descriptor of their location, are provided in Table 3-5.

Maine DOT defines a large culvert as “a pipe or structure with a total span width greater than 5 feet and less than 10 feet OR any multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening, and the total flow area is between 20 and 80 square feet” (MaineDOT, 2021b). Maine DOT defines a cross culvert as “a pipe or structure that has a span of less than 5 feet or multiple pipes or other structures with a combined opening of less than 20 square feet in area” (MaineDOT, 2021a).

Culverts on non-state roads, such as local or private roads, were not included in this evaluation due to lack of digital data. There are likely culvert crossing locations that would be overtopped for the flood scenarios included in this study that have not been captured in these results. Additionally, this study does not consider whether the size of the culvert is appropriate for present-day or future flood and flow scenarios, but instead identifies roads at culvert crossing locations that would likely be overtopped.

The culvert locations are based on the large culvert and cross culvert shapefiles maintained by MaineDOT. These results should be considered approximate.

Table 3-5. Maine DOT Culverts Flood Exposure Summary (Y/N)

Culvert Location	1	2	3	4	5	6	7	8	9
Large Culverts									
Bagaduce Road <i>Approx. 1.1 miles north of the intersection with Coastal Road</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cross Culverts									
Coastal Road <i>Approx. 150 ft south of Breezemere Farm Road</i>	-	-	-	Y	Y	Y	Y	Y	Y
Coastal Road <i>Near Stover Cove, approx. 0.1 miles west of Hawes Farm Road</i>	-	-	-	-	-	-	-	Y	Y
Bagaduce Road <i>Approx. 0.1 miles south of Parker Pond Road</i>	-	-	-	-	-	-	-	-	Y

3.2.3. Bridges

We have identified two bridges from the Maine DOT bridge database (MaineDOT, 2021c) with bridge approaches and bridge decks that would likely be overtopped due to the flood scenarios included as part of this study: the Davis Narrows Bridge located on Bridge Street over the Bagaduce River, and the Cape Rosier Bridge located on Goose Falls Road over Goose Falls. The flood scenarios that would likely inundate these bridges are summarized in Table 3-6. We based this analysis on the terrain compiled for this project and our review of aerial imagery. In the event the bridges were burned out of the terrain, we used the abutments and approaches to perform this analysis.

The Davis Narrows Bridge would likely be overtopped during 100-year storm surge conditions for present-day water levels and during high tide for 5.0 ft of sea level rise (the “Prepare to Manage” scenario for 2090). This bridge is located on a primary evacuation route for residents in the Town of Brooksville. There is a boat launch near the bridge that would also be at risk of flood inundation.

The Cape Rosier Bridge would likely be overtopped during 1% annual chance storm surge conditions for 2.4 ft of sea level rise (2070, “Commit to Manage”). An alternate route is possible to avoid this location during periods of inundation. The Goose Falls location was identified as a valuable asset during the community mapping event held at the beginning of this project.

The bridge location data used in this study were based on a MaineDOT shapefile of bridge locations provided by the MaineDOT Open Data Map Server. This digital data represents a snapshot in time and actual bridge locations may vary. Bridges that are not part of the Maine DOT database would not be included in this evaluation. These results should be considered approximate.

Table 3-6. Maine DOT Bridges Flood Exposure Summary (Y/N)

Bridge Name	1	2	3	4	5	6	7	8	9
Davis Narrows	-	-	-	Y	Y	Y	Y	Y	Y
Cape Rosier Bridge	-	-	-	-	-	-	Y	Y	Y

3.2.4. *Buildings*

We have identified approximately 38 buildings that would likely be at risk of flood inundation for one or more of the nine flood scenarios evaluated as part of this study, which represents approximately 3.3% of the total number of buildings in Brooksville. We base our analysis on the elevation of the ground surface adjacent to buildings using the terrain compiled for this study and the building footprint database used for this study (Microsoft, 2018). Approximately 14 buildings would likely be at risk of flood inundation for present-day sea levels and 1% annual chance coastal storms, without the addition of wave action. With 1.5 ft of sea level rise (i.e., the “Commit to Manage” scenario for 2050), approximately 10 buildings would be at risk of flood inundation during high tides. The flood exposure results for buildings in Brooksville for the nine scenarios included as part of this study are summarized in Table 3-7. This study does not refer to the structural integrity of buildings, but rather evaluates the potential for inundation.

These numbers are approximate and based on building footprint data generated using satellite imagery around the year 2012, according to the Microsoft building footprints layer for North America (Microsoft, 2018). From our review of the data, it appears that the building footprints for the study area were based on imagery taken prior to 2012. As a result, the number of building footprints used in this analysis is likely less than the actual number of buildings and represents a snapshot in time. In addition to representing residential structures, these building footprints also may include sheds, boathouses, or other appurtenant structures.

Table 3-7. Buildings Flood Exposure Summary

Buildings	1	2	3	4	5	6	7	8	9
# Impacted	10	11	12	14	15	19	22	22	38
% Impacted (%)	0.9	1.0	1.0	1.2	1.3	1.6	1.9	1.9	3.3

3.2.5. *Parcels*

We based our review of parcel inundation based on the Brooksville parcel layer obtained from the Maine Office of GIS (2021) and the elevation of the ground surface of the parcels using the terrain compiled for this study. There would be approximately 521 parcels at risk of being partially or fully inundated for one or more of the nine flood scenarios included as part of this study, representing approximately 41.3% of the total number of parcels in Brooksville. The area of parcels inundated (i.e., the area of land in the town limits of Brooksville) would be approximately 587 acres for Flood Scenario 9, which would represent approximately 3.0% of the total land area in Brooksville. Table 3-8 summarizes the flood exposure results for parcels in the Town of Brooksville.

These parcels include vacant lots in addition to parcels with buildings, such as residential houses. These numbers are approximate and based on digital parcel boundaries provided to the State by individual communities or residents. The parcels in Brooksville have a submission date of December 31, 2010 listed on the State's Geolibrary Parcel Viewer Application. As a result, these parcels represent a snapshot in time and may not include recent revisions to parcel boundaries.

Table 3-8. Parcels Flood Exposure Summary

Parcels	1	2	3	4	5	6	7	8	9
# of Parcels Partially or Fully Inundated	475	482	485	491	492	498	505	507	521
% of Total Parcels Partially or Fully Inundated (%)	37.7	38.3	38.5	39.0	39.0	39.5	40.1	40.2	41.3
Area of Parcels Inundated (acre)	73	127	161	225	272	311	374	418	587
% of Total Parcel Area Inundated (%)	0.4	0.7	0.8	1.2	1.4	1.6	1.9	2.2	3.0

3.2.6. *Cemeteries*

Cemetery locations were based on a digital dataset of cemetery locations for the State of Maine maintained by the Maine Old Cemetery Association and the Maine Office of GIS (2021). Our inundation analysis was based on the digital data of cemetery locations and the terrain data compiled for this study.

The flood vulnerability study results suggest that seven property boundaries that include cemeteries would likely experience flood inundation for one or more of the nine flood scenarios included in this study. Six of the properties with cemeteries would likely experience flooding for all nine of the flood scenarios included in this study. The flood exposure summary for properties in Brooksville that contain cemeteries is provided in Table 3-9.

This study has identified properties at risk of flood inundation that include cemeteries, but the boundaries of the cemeteries themselves may be outside of the likely flood extents. We recommend further review of the flood extents for these locations with the cemetery boundaries to refine the flood risk exposure for these cemeteries.

Table 3-9. Cemeteries Flood Exposure Summary (Y/N)

Cemetery	1	2	3	4	5	6	7	8	9
Dodges Point	Y	Y	Y	Y	Y	Y	Y	Y	Y
Indian Bar	Y	Y	Y	Y	Y	Y	Y	Y	Y
Indian Point	Y	Y	Y	Y	Y	Y	Y	Y	Y
Moses Blake	Y	Y	Y	Y	Y	Y	Y	Y	Y
Old Bakeman	Y	Y	Y	Y	Y	Y	Y	Y	Y
Valerius Black	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jesse Gray	-	-	-	-	-	-	-	-	Y

3.2.7. Conservation Areas

We evaluated the flood risk of land designated as conservation areas in the Town of Brooksville. Conservation areas were first identified using GIS data managed by Maine’s Department of Agriculture, Conservation and Forestry (Maine DACF, 2023). While the data is updated regularly, conservation organizations, land trusts, and municipalities must submit new or updated parcel easements to the State for them to be included in the data. GEI worked with George R. A. Fields, Associate Director at the Blue Hill Heritage Trust to obtain additional information on conservation parcels that were not reflected in the State’s shapefile.

The flood risk analysis results suggest that approximately 178 acres of land designated as conservation land would be at risk of flood inundation for one or more of the nine flood scenarios included in this study. Seventy-two acres of conservation land is at risk of experiencing flood inundation for present-day water levels and 1% annual chance coastal storm events. Twenty-five acres of conservation land would likely experience daily flood inundation during high tides for 1.5 ft of sea level rise (the “Commit to Manage” scenario for 2050). The flood exposure results for conservation land in Brooksville is summarized in Table 3-10.

Table 3-10. Conservation Land Flood Exposure Summary

Conservation Land	1	2	3	4	5	6	7	8	9
Conservation Land (acres inundated)	25	42	54	72	83	93	109	122	178

3.2.8. Wells

We evaluated the flood risk of water wells using the water well locations from the Maine Geological Survey (MGS) water well database (MGS, 2023). The Water Well Information Law, passed in 1987, requires that drilling companies submit information on new water wells to MGS. Data on wells drilled prior to 1987 were collected by a survey of well drillers in the 1970s and through a voluntary well driller reporting program in the mid-1980s. The database of wells drilled prior to 1987 is likely incomplete, and results from this analysis should be considered approximate. The database includes 311 well locations for the Town of Brooksville. It has been our experience that some of the wells may not be appropriately located. Work on this project did not include verifying that the wells were appropriately located (i.e., within a parcel, near a structure, etc.).

The flood vulnerability results suggest that the location of approximately 16 water wells in Brooksville would likely be at risk of flooding for one or more of the nine flood scenarios included in this study. Fifteen of these wells are private, and one provides water for the Seal Cove Boatyard, which is considered a public drinking water system. The Seal Cove Boatyard well location would likely experience flooding during Flood Scenario 9, which represents 100-year storm surge conditions and 5.0 ft of sea level rise (the “Prepare to Manage” amount for 2090). The flood exposure results for water wells in Brooksville are summarized in Table 3-11. The draft GEI memo summarizing the risk of clean drinking water and drought (GEI, 2023) provides more detail on the risk of flood inundation to drinking water wells.

Table 3-11. Water Wells Flood Exposure Summary

Wells	1	2	3	4	5	6	7	8	9
Wells (# of locations inundated)	1	1	3	4	6	7	9	9	16

3.2.9. Additional Assets

We have included an initial list of eleven additional assets in the Town of Brooksville that would likely experience flood inundation for the flood scenarios included in this study. These assets are primarily points of water access, such as boat ramps, beach parking, and beach access points. Several of these locations were identified by community members as valuable assets to the community during the community mapping event held on September 30, 2023. The assets and the flood scenarios that would likely inundate the asset locations are summarized in Table 3-12.

Table 3-12. Summary of Additional Assets at Risk of Flood Inundation (Y/N)

Asset	1	2	3	4	5	6	7	8	9
Town Landing <i>Top of Boat Ramp</i>	-	Y	Y	Y	Y	Y	Y	Y	Y
Town Landing <i>Parking Lot</i>	-	-	-	-	-	-	-	-	Y
Goose Falls <i>Top of Boat Ramp</i>	-	Y	Y	Y	Y	Y	Y	Y	Y
Boat Launch near Bridge Road <i>Top of Boat Ramp</i>	-	Y	Y	Y	Y	Y	Y	Y	Y
End of S. Wharf Road <i>Boat Ramp</i>	-	-	Y	Y	Y	Y	Y	Y	Y
Bakeman Beach Parking #1 <i>Seaward of Weir Cove Road</i>	-	-	Y	Y	Y	Y	Y	Y	Y
Bakeman Beach Parking #2 <i>Weir Cove Road Corner</i>	-	-	-	-	-	Y	Y	Y	Y
Bucks Harbor Yacht Club <i>Top of Pier</i>	-	-	-	Y	Y	Y	Y	Y	Y
Bucks Harbor Marina Parking <i>Top of Pier</i>	-	-	-	Y	Y	Y	Y	Y	Y
Bagaduce Lunch <i>Top of Pier / Parking Area</i>	-	-	-	-	Y	Y	Y	Y	Y
Seal Cove Boat Yard <i>Top of Launch</i>	-	-	-	-	-	-	-	-	Y

4. Flood Adaptation Recommendations

This report section summarizes our evaluation of adaptation options for infrastructure in the Town at risk of coastal flood inundation due to coastal storm surge and sea level rise. We have summarized general adaptation strategies for infrastructure such as roads, building, and piers; provided an overview of temporary and non-structural measures; and evaluated up to three adaptation options for assets identified as having high flood risk and/or critical to the community.

The adaptation options, such as road elevations and time horizons for flood risk, are based on the results of the flood risk analysis presented in Section 3.2. Elevations of infrastructure, such as roadways, are based on readily available LiDAR data, as outlined in Section 3.1.1.

4.1. Adaptation Options Overview

Broadly, there are four infrastructure-based adaptation approaches:

1. Protect – prevent inland propagation of water using a barrier, such as a sea wall.
2. Accommodate – reduce the impact of water by elevating structures and/or floodproofing the structure to reduce damage.
3. Retreat – move infrastructure to a new location away from the risk of flooding.
4. Do-Nothing – Leave the infrastructure as is.

In addition to infrastructure-based adaptation approaches, we have suggested several non-structural adaptation measures that the Towns could take to increase the resiliency of people and infrastructure to flood inundation. We have organized this report section to provide recommendations for both infrastructure-based and non-structural adaptation strategies.

The decision around which measure to take can depend on several factors, including the overall risk of flood exposure, the sensitivity to flooding for a particular asset, and the adaptive capacity. For example, electrical equipment constitutes an asset that is highly sensitive to flooding and would likely be damaged or inoperable if exposed to flood inundation. Assets like roads can usually withstand some level of flooding without damage and so are often considered not very sensitive to flooding in a structural sense. Infrastructure that could be easily relocated, elevated, or flood-proofed would be considered to have a high adaptive capacity. Infrastructure or assets that are not easy to relocate or flood-proof are often considered to have a low adaptive capacity.

We have explored these options as they relate to infrastructure located within the Towns that are vulnerable to flood inundation. We have provided a recommendation for adaptation to allow for increased vehicular access through the year 2050. For most infrastructure, it is our general recommendation to wait before adapting (i.e., elevating, relocating, etc.) for the 2090 and beyond timeframe until there is more certainty around the sea level rise projections and future storm surge values. The non-structural adaptation measures that we have suggested would likely increase resiliency to flood inundation for both near-term and long-term time horizons.

In most cases presented in this study, we have recommended an “accommodation” approach, such as elevating a roadway or asset above the height of anticipated water levels. However, in some cases, elevating the road to prevent inundation during the flood scenarios considered in this study is not practical. Instead, the Town could choose to elevate the road to a lower amount so that it would likely prevent flood inundation during typical high tides and 1% annual chance storm surge events in the near-term but would still likely experience flood inundation during the more extreme flood scenarios evaluated (1% annual chance coastal storm events in 2070/2090). Important topics such as emergency access would need to be addressed to ensure that emergency organizations have access to do their work, and to ensure that citizens can evacuate. In the future, when these more extreme flood scenarios are likely to become more common, other adaptation strategies, such as retreat, should be considered.

As a side note, FEMA community preparedness materials provide important information about the risks of driving or walking through flood waters (FEMA, 2024). It will be important, if the Town decides to “live with water,” that the Town educates citizens on the risks related to flooding and to properly block off areas that are unsafe for travel or access. It is never safe to drive through flood waters as the depth of water and velocity of flow are not always obvious.

Additionally, the Town could issue evacuation or shelter in place notices to occupants of buildings that would likely be without road access when extreme coastal storm events are anticipated to occur. It is up to the public safety and emergency response agencies whether building occupants should shelter in place or attempt to drive through inundated areas and this study does not intend to usurp the responsibility of public safety emergency response agencies.

Advancing infrastructure-based adaptation strategies will require additional phases of work before the recommendations can be implemented, such as site survey, preliminary design, permitting, and final design. The vulnerability analysis and adaptation recommendations provided in this report constitute a high-level assessment of risk and an introduction to adaptation options. The recommended adaptation elevations do not include information on “freeboard,” or the distance between top of flood waters and the sensitive infrastructure. Road elevation planning may warrant conversations about suitable freeboard to add a buffer to flood estimates and therefore provide additional protection. Additionally, wave action has not been considered in flood risk or adaptation recommendations. This report should be used as a guidance, but further investigation will be needed to advance engineering designs.

4.2. General Adaptation Strategies

4.2.1. Roads

Roads can be adapted to flood risk through elevation, relocation, abandonment, or protection via a sea wall system. The road infrastructure itself is often fairly resilient to flood inundation (i.e., small likelihood of infrastructure damage) – once flood waters recede, the roadway can typically be used. In some cases, floodwater can bring debris over roadways that should be cleared to allow for continued safe use of the roadway. Coastally exposed roadways that are subject to wave action have a higher likelihood of sustaining damage due to the impact of waves on the roadway infrastructure or shoreward facing revetment structure, if present.

Elevating a roadway is often the most cost-effective adaptation measure. However, in some cases, elevating may not be feasible due to topographic or regulatory constraints. In these instances, it may be worthwhile to examine relocating the roadway to avoid the area of flood inundation. Adaptation priority should be given to roads that would cut off emergency access to residents if they were inundated, such as roads that have no alternate route.

We have provided high-level concept drawings for road adaptation in the attached Figures 2 through 4. These concepts provide general cross sections of elevated roadways and roadways with sea walls.

4.2.2. *Buildings*

Several adaptation strategies for buildings at risk of flood inundation are provided below, including dry and wet floodproofing, conversion of the use of the first floor, elevation, and retreating.

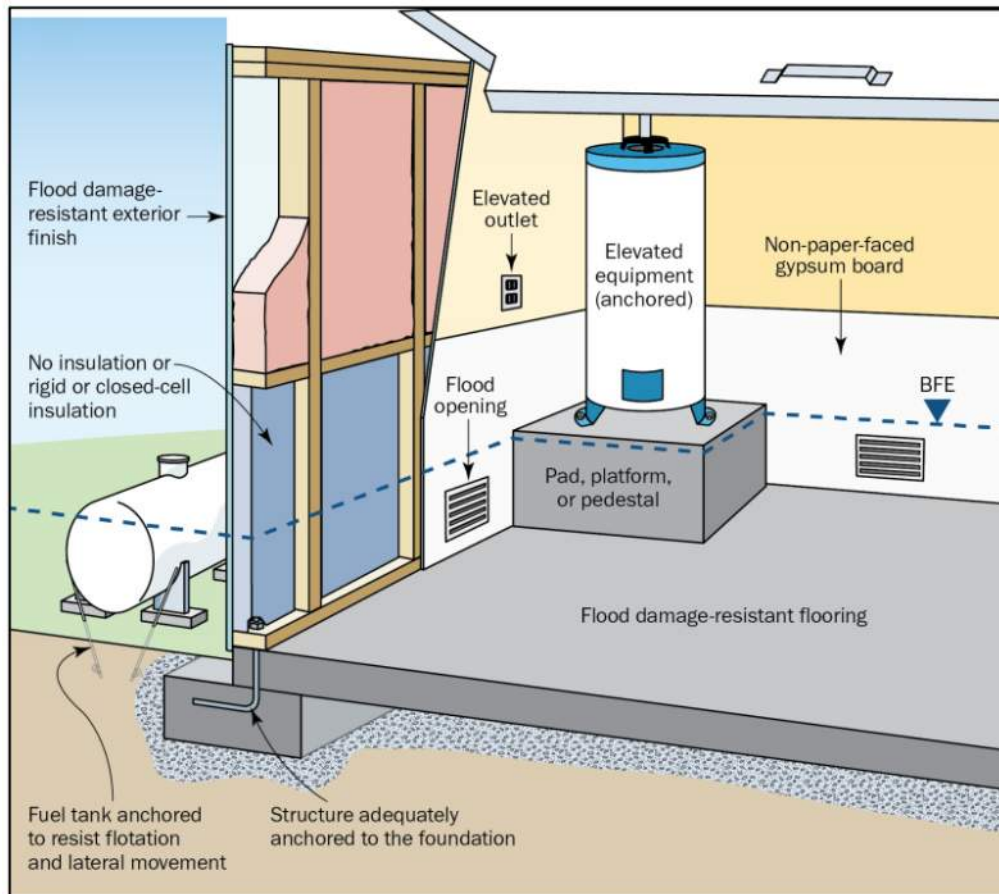
Dry Floodproofing

Dry floodproofing involves the installation of barriers and fortifying of the building structure and enclosure to limit intrusion of floodwaters. This can be accomplished by installing floodwalls or levees surrounding structures, installing temporary or permanent flood barriers in building openings, and sealing the building envelope to prevent floodwaters from entering enclosed spaces. Impervious coatings or coverings can be installed around the exterior of a building, typically to at least the height of anticipated flood risk. Dry floodproofing can require that structures be reinforced to withstand the force of water being restrained by the walls. Dry floodproofing may also require modification of building utilities such as the installation of backflow valves in sewer and drainage lines exiting buildings.

Wet Floodproofing

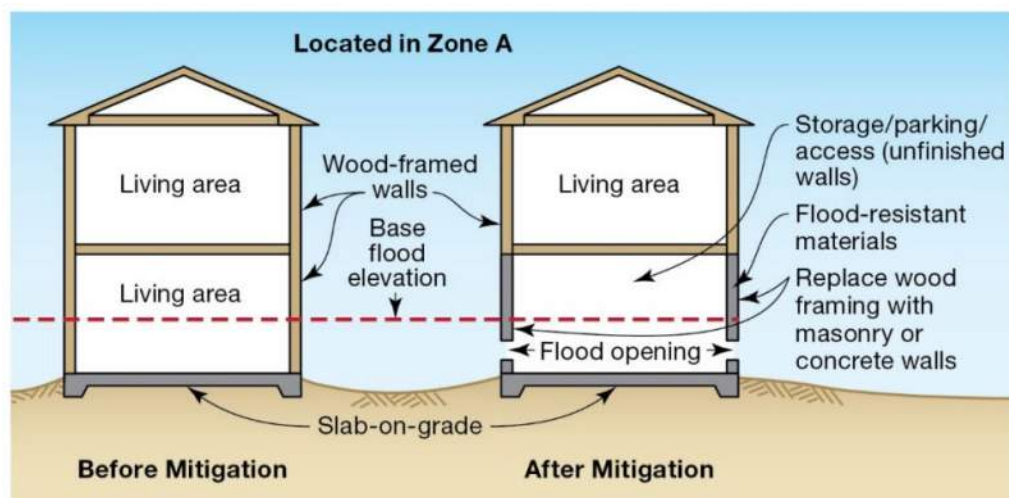
Wet floodproofing involves the adaptation of a building to accommodate exposure to floodwater while minimizing risk of damage to the structure and its contents. Refer to Figure 4-1 and Figure 4-2 for examples of wet floodproofing. Wet floodproofing measures can include providing flood openings in walls to allow water to pass into and out of the structure, elevating utilities and mechanical systems above the design flood elevation, use of flood-resistant materials for flooring and building envelope construction that minimize risk of damage if exposed to floodwaters and elevating internal building contents to minimize risk of exposure. Wet floodproofing can reduce risk of damage to buildings and contents from exposure to flooding but carries a greater risk of building serviceability and operability issues because water is able to enter structure during a flood event.

Figure 4-1. Example of Wet Floodproofing Measures



Source: FEMA (2022)

Figure 4-2. Example of Retrofitting Lowest Flood with Flood Resistant Materials and Flood Openings

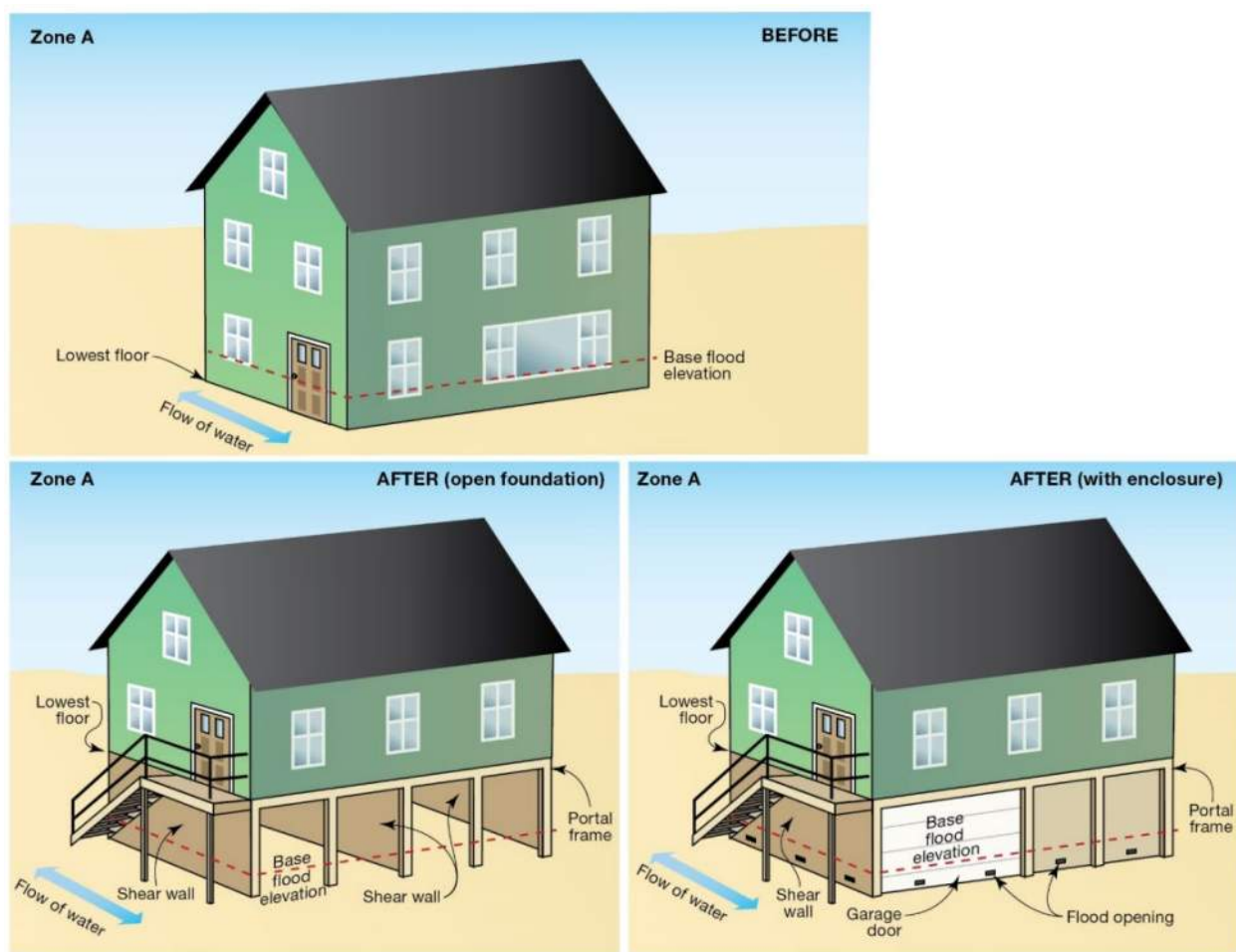


Source: FEMA (2019)

Conversion of Lowest Floor

Conversion of the lowest floor of a building from enclosed occupied space to open unoccupied space is an effective way to reduce risk of flood exposure and damage to the structure. This method is demonstrated in Figure 4-3. Using this method, the lowest floor is modified to include open, flow-through construction and the space formerly used by the first floor is converted for uses such as storage and parking. The second floor of the building becomes the lowest occupied space. The structure beneath the converted lowest floor may require reinforcement and addition/replacement of components with flood resistant materials to withstand anticipated exposure to floodwaters. While this method can be a lower impact than an entire building elevation project, it has the disadvantage of a reduction in the occupied space within the building.

Figure 4-3. Example of Lowest Floor Conversion



Source: FEMA (2019)

Elevation

One of the most effective ways to reduce risk of flooding is to elevate structures sufficiently above predicted flood elevations such that they are not impacted by water levels resulting from storm surge or sea level rise. The degree to which a building is potentially elevated would depend on the minimum code and regulatory requirements, as well as the owner's tolerance to risk, which may warrant the inclusion of additional freeboard above the minimum required values.

Retreat

In some cases, due to factors such as high risk of flood exposure, high cost of adaptation, and lack of functional dependence on a waterfront location, owners may consider retreating from locations of high flood risk. On properties with sufficient area outside of the flood zone, this can involve relocating buildings further away from the coast (often in combination with increased elevation). Retreat can also involve the removal of structures from flood-prone areas, and restoration of those properties to naturalized spaces that can be conserved in a natural form that is more resilient to flooding than developed land.

4.3. Non-Structural Adaptation Measures

There are several non-structural adaptation measures that the Town could take to adapt to flood inundation. These measures would not prevent inundation from occurring but would reduce the potential impact to people during flood events. Many of these adaptation measures could be implemented in the near-term and could help reduce the impact of present-day flood events.

4.3.1. Water Level Monitoring and Alert System

Water level monitors and alert systems could be used in critical areas alert (i.e., through a community emergency alert system) the residents of Brooksville when water levels rise above a threshold that would cause flood inundation. During these times, the Town of Brooksville could consider providing a shelter for residents stranded outside their home until the flood water recedes and residents can return safely to their homes.

A well-established water level monitoring company that works with municipalities is Hohonu. Hohonu provides water level monitors, installation support, a web browser to view up-to-date water levels, and alert services. Hohonu works with municipalities across the country, including with existing clients in Maine. There may also be other reliable systems the Town can consider.

Whether or not a water level monitoring system is established, the Town could implement an alert system for predicted astronomical high tides. NOAA publishes predicted high tides up to one year in advance on the "Monthly High Tide Flooding Outlook" website, specific to gauge stations across the country (NOAA, 2024). Leading up to these dates, the Town could remind residents to prepare to shelter in place by making sure they have adequate food and fuel in their homes and remind them to not attempt to drive through flooded water during these times. For residents who would likely need access to medical care during these tides, the Town could suggest that they shelter elsewhere during the predicted periods of high water.

4.3.2. Road Barricades

We suggest that the Town of Brooksville position road barricades near areas that experience flood inundation, such as Coastal Road, Breezemere Road, Bagaduce Road, Back Road, Bridge Road, Dog Island Road, and Weir Cove Road. When periods of high water are anticipated, Town staff should deploy the road barricades to prevent people from attempting to drive through flooded water. In addition to the risk of the vehicle flooding and people within the vehicle becoming stranded, it can be difficult to see the road condition under the flood inundation and during periods of heavy rain and/or storm surge, culverts along the roadways may become compromised and fail or “wash out.” Driving in flooded water and/or over a section of road with a washed-out culvert is very dangerous and not advised. The Town should develop a program to educate citizens about the risks of flooding and in particular to strongly discourage vehicular travel on inundated roads.

4.3.3. High-Water Rescue Vehicle

Access to residents in Brooksville who may be experiencing a medical emergency during periods of flood inundation could be evacuated through the use of a high-water rescue vehicle operated by emergency personnel. High-water rescue vehicles are able to travel through inundated roadways. Such a vehicle could be owned and operated by local or regional emergency response personnel.

4.4. Site-Specific Adaptation

We have provided site-specific adaptation recommendations for ten sites in the Town, identified from the flood vulnerability assessment. The ten sites included are:

- Bagaduce Road
- Back Road
- Weir Cove Road
- Bridge Road (Route 175) and Davis Narrows Bridge
- Norumbega Road
- Harborside Road
- Coastal Road
- Dog Island Road
- Cape Rosier Road
- Goose Falls Road

Information about road vulnerability refers to linear feet of road inundation, in the direction of travel. Additionally, the Town identified Breezemere Road as a Pilot Project for concept-level adaptation design. A separate report summarizes adaptation recommendations for Breezemere Road (GEI, 2024).

The following report sections summarize our adaptation recommendations for the above assets. In most cases, we recommend adapting to address near-term flood risk, i.e. flooding likely to occur during 1%

annual chance coastal events for the present-day timeframe or by 2050. There is more uncertainty around sea level rise projections for future time horizons, such as 2070 and beyond. We will have a better understanding of adaptation design elevations as we approach that timeframe.

Following the recommendations is a summary table with cost estimates for proposed adaptation methods.

4.4.1. Roads

4.4.1.1. Bagaduce Road

Figure 4-4. Bagaduce Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

The section of Bagaduce Road at risk of flood inundation is located near the upstream end of the tidally influenced Bagaduce River along the low dip in the road about 1 mile north of the center of Brooksville at intersection of Route 176 with Route 175. There is a hydraulic constriction along this river at the Davis Narrows Bridge that limits the tidal influence in the upper reach of the river. The constriction likely attenuates storm tides as they propagate up the river, meaning the tidally influenced peak water surface elevation near the upstream end of the river is likely lower than the tidally influenced peak water surface elevation downstream of the bridge closer to the mouth of the river. However, this flood vulnerability assessment assumed tidal transparency along the Bagaduce River (i.e., did not consider the impact of the constriction in peak tides) which likely overestimates the likelihood of flood inundation along Bagaduce Road upstream of the Davis Narrows Bridge. A more detailed analysis and/or water surface

observations along the Bagaduce River would help refine estimated peak water surface elevations during high tides and coastal storm events.

For present day sea levels, this flood vulnerability assessment suggests that approximately 437 ft of Bagaduce Road, about 0.5 miles south of Parker Pond Road, would likely be inundated during 1% annual chance coastal storm events. The road would likely be inundated by up to 2.3 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event.

By 2050, this flood vulnerability assessment suggests that approximately 566 ft of Bagaduce Road would likely be inundated during 1% annual chance coastal storm events, considering 1.5 ft of sea level rise (“commit to manage”). The road would likely be inundated by up to 3.7 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event.

This assessment suggests that the road would likely start to experience flood inundation due to typical daily high tides by 2070 for 2.4 ft of sea level rise (“commit to manage”). Flood inundation would likely be up to 0.5 ft and impact approximately 208 ft of the road. By 2090, daily high tide flooding would likely impact 522 ft of the road by depths of up to 3.1 ft during peak high tide for 5.0 ft of sea level rise (“prepare to manage”).

For present-day sea levels through sea level estimates by 2070, alternative access to Bagaduce Road would likely be available during periods of high-tide flood inundation. The alternative route could include Route 175, Snow Cove Road (Route 15), Southern Bay Road (Route 176), and Frank’s Flat (Route 176). Another route could include Coastal Road (Route 176) and Varnum Road. These detours add up to 11.0 and 12.7 miles, respectively.

During 1% annual chance coastal storm events for present-day and future sea levels and high tides in 2090 considering 5.0 ft of sea level rise (“prepare to manage”), flood inundation would likely be present along Bagaduce Road, Bridge Road (Rt 175), and Coastal Road near Orcutt Cove. If these three road sections are inundated, approximately 829 buildings located north of Orcutt Cove on Coastal Road and north of the area of flooding along Bagaduce Road would be prevented from traveling outside of Brooksville via Route 175. However, most buildings could still be accessed by emergency personnel originating from the Brooksville Volunteer Fire Department.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events for present day sea levels. Under this scenario, the 829 buildings impacted would likely be inaccessible from outside the town boundaries of Brooksville.

If the roadway remains as is, it would also likely be subject to flood inundation during typical daily high tide by 2070. Under this scenario, impacted buildings could be accessed via the two detours through Route 175, Snow Cove Road, and Route 176, and Coastal Road and Varnum Road. Alternate access would not be available during high tide in 2090.

We would encourage users of this roadway to plan travel around predicted periods of high tide and avoid travel during anticipated coastal storm events.

Adaptation Option 2: Elevate the Road

Elevating Bagaduce Road above elevation 8.2 ft (approximately 1.1 ft above the low point of the road) would likely reduce the risk of inundation during high tides by 2070. The road would still likely be inundated due to stillwater conditions by up to 1.2 ft in present day during 1% annual chance coastal storm events, and up to 2.0 ft during high tide by 2090, considering 5.0 ft of sea level rise (“prepare to manage”).

Elevating the road above elevation 10.8 ft (approximately 3.7 ft above the low point of the road) would likely reduce the risk of flood inundation during 1% annual chance coastal storms by 2050, considering 1.5 ft of sea level rise (“commit to manage”) and during typical daily high tides by 2090, considering 5.0 ft of sea level rise (“prepare to manage”). The road would still likely be inundated due to stillwater conditions during 1% annual chance coastal storms by 2070.

Recommendation

We recommend conducting a more detailed hydraulic study to understand tidally influenced peak water surface elevations at the upstream end of the Bagaduce River during coastal storm events. This will help refine the understanding of the effect of the Davis Narrows Bridge constriction on the propagation of storm surge up the river. The information presented in this report, which is based on constant peak tidal elevations, may be conservative given that the Davis Narrows Bridge likely reduces the extent of storm surge upstream of the bridge. A more detailed hydraulic analysis would help refine the risk of flood exposure of Bagaduce Road and help the Town prioritize infrastructure projects for adaptation. In lieu of a more detailed study, we recommend elevating this section of road by up to 3.7 ft to a minimum elevation of 10.8 ft. This would likely prevent coastal flooding along this stretch of road during 1% annual chance coastal storm events by 2050 with 1.5 ft of sea level rise.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.2. Back Road

Figure 4-5. Back Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

The section of road at risk of flood inundation is located alongside Goose Pond, upstream of the Cape Rosier Bridge. Similar to Bagaduce Road along upstream sections of the Bagaduce River, the constriction at the bridge location likely attenuates storm tides as they propagate into the pond which could result in lower tidal peak water surface elevations within the pond than on the downstream (coastal) side of the bridge. This flood vulnerability assessment assumed tidal transparency across the Cape Rosier Bridge (i.e., the assessment did not consider the impact of the bridge constriction on peak tides). A more detailed analysis, which could include detailed hydraulic modeling and/or a collection of water surface observations within the pond, would help refine the understanding of potential peak water surface elevations due to storm surge and sea level rise.

For present day sea levels, approximately 290 ft of Back Road, about 0.2 miles northeast of the Cape Rosier Bridge, would likely be inundated during 1% annual chance coastal storm events. The road would likely be inundated by up to 2.1 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event.

By 2050, approximately 363 ft of Back Road would likely be inundated during 1% annual chance coastal storm events, considering 1.5 ft of sea level rise (“commit to manage”). The road would likely be inundated by up to 3.5 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event.

By 2070, approximately 122 ft of Back Road would likely be inundated daily during typical high tides, considering 2.4 ft of sea level rise (“commit to manage”). Inundation depths would be approximately 0.3 ft during peak high tide. Inundation depths would increase during coastal storm events.

By 2090, approximately 339 ft of Back Road would likely be inundated during high tide, considering 5.0 ft of sea level rise (“prepare to manage”), and would be inundated by up to 2.9 ft during peak high tide.

There is approximately one building that would be inaccessible if both Back Road and the Cape Rosier Bridge are inundated, which is likely to occur during 1% annual chance coastal storms by 2070, consider 2.4 ft of SLR (“commit to manage”).

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events in present day, and during typical daily high tides by 2070. By 2070, during 1% annual chance coastal storm events, the building impacted would likely be inaccessible. We would encourage users of this roadway to plan travel around predicted periods of high tide and avoid travel during anticipated coastal storm events.

Adaptation Option 2: Elevate the Road

Elevating Back Road above elevation 9.4 ft (approximately 2.1 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events in the present day and high tides by 2070. The road would still likely be inundated by up to 1.4 ft during 1% annual chance coastal storm events by 2050, considering 1.5 ft of sea level rise (“commit to manage”), and by up to 0.8 ft during high tide in 2090, considering 5.0 ft of sea level rise (“prepare to manage”).

Elevating the road above elevation 10.8 ft (approximately 3.5 ft above the low point of the road) would likely reduce the risk of flood inundation during 1% annual chance coastal storm events by 2050, considering 1.5 ft of sea level rise (“commit to manage”), and due to high tide by 2090, considering 5.0 ft of sea level rise (“prepare to manage”). The road would still likely be inundated due to stillwater conditions during 1% annual chance coastal storm events by 2070.

Adaptation Option 3: Relocate the Road

The section of Back Road vulnerable to flooding could be relocated inland outside of the approximate extents of the inundation boundary. The land north of the roadway is part of the Holbrook Island Sanctuary, owned and operated as a State Park by the State of Maine. The land immediately northward of the roadway is topographically steep and unlikely to support a new road alignment. The new possible roadway would likely need to travel approximately 150 ft inland of its existing location along an area of mild topographic slopes. A more detailed study is needed to understand if this area could support a new road development. Right of way access would need to be granted through coordination with the State of Maine.

Recommendation

We recommend conducting a more detailed study to understand peak water surface elevations within Goose Pond during coastal storm surge events to better understand the effect of the Cape Rosier Bridge constriction on the propagation of storm surge into the pond. A more detailed study would help quantify in more detail the risk of flood inundation along this stretch of roadway. Town staff or volunteers could also take visual observations of peak water surface elevations near the road during forecasted coastal storm events to evaluate whether present-day coastal storms are causing inundation along the roadway.

There appears to be one building between the Cape Rosier Bridge and the vulnerable area along Back Road. We recommend road barricades to prevent travel eastward across the Cape Rosier Bridge and westward along Back Road during periods of anticipated coastal storm surge.

In lieu of a more detailed study, we recommend elevating this section of road by up to 2.1 ft to a minimum elevation of 9.4 ft, which would likely prevent coastal flooding along this stretch of during 1% annual chance coastal storm events for present-day sea levels. Road re-alignment or further elevation of the roadway should be studied in more detail before being pursued further.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.3. Weir Cove Road

Figure 4-6. Weir Cove Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

Weir Cove Road travels alongside Bakeman Beach. Bakeman Beach was highlighted by community members during an outreach event in September 2023 as a valuable asset to the community. Parking for beach access appears to be available alongside the southern portion of the road.

Maine Geological Survey has delineated a Frontal and Back Sand Dune system at Bakeman Beach, which includes Weir Cove Road (MGS, 2023). A figure of the mapped dune system at Bakeman Beach is provided in Appendix C. Maine sand dunes are subject to Coastal Sand Dune Rules which could make certain infrastructure-related adaptation projects more challenging to permit.

For present-day sea levels, approximately 532 ft of Weir Cove Road near Bakeman Beach would likely experience flood inundation due to stillwater conditions (i.e., no wave action) during 1% annual chance coastal storm events. The road would likely be inundated by up to 1.9 ft due to standing water during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

By 2050, approximately 627 ft of Weir Cove Road would likely be inundated during 1% annual chance coastal storm events, considering 1.5 ft of sea level rise (“commit to manage”). The road would likely be

inundated by up to 3.3 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

By 2070, a small portion of the road (less than 10 feet) would start to experience one to two inches of daily flooding during typical daily high tides, considering 2.4 ft of sea level rise (“commit to manage”).

By 2090, daily inundation would span up to 593 ft of Weir Cove Road near Bakeman Beach for 5.0 ft of sea level rise (“prepare to manage”). Inundated depths would be up to 2.7 ft during peak high tide.

There are approximately 64 buildings that would be impacted during periods of inundation. An alternate route of up to 6.6 miles is available via Cape Rosier Road and Harborside Road. This detour would likely be at risk of flood inundation along Harborside Road and northeast along Weir Cove Road by 2090 during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”). If the detour becomes impassible due to flood inundation, the buildings would be inaccessible to emergency vehicles and building occupants would not be able to evacuate to Cape Rosier Road.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events in present day and during high tide by 2070. During times of inundation, accessibility to 64 buildings could be impacted. Impacted buildings could be accessed via the Cape Rosier Road and Harborside Road detour, until these roads become inundated (likely during 1% annual chance coastal storm events by 2090). We would encourage users of this roadway to plan travel around anticipated coastal storm events. By 2070, users should avoid travel during periods of high tide.

Adaptation Option 2: Re-Align and Elevate the Road

The roadway could be re-aligned approximately 50 ft to 100 ft inland of its current location alongside Bakeman Beach to move it outside of the designated sand dune. This would likely enable the road to be elevated above the existing grade to reduce the risk of flood inundation. A new road design should include a site-specific coastal analysis to understand wave action in the area. If the road were to be re-aligned and elevated, the Town would need to work closely with the regulatory agencies to ensure the potential project meets permitting requirements.

Designing a re-aligned Weir Cove Road to an elevation above 9.4 ft (approximately 1.9 ft above the topographic elevation in the area) would likely reduce the risk of inundation during 1% annual chance coastal storm events in the present day and high tides by 2070. The road would still likely be inundated by up to 1.4 ft during 1% annual chance coastal storm events by 2050, considering 1.5 ft of sea level rise (“commit to manage”), and by up to 0.8 ft during high tide in 2090, considering 5.0 ft of sea level rise (“prepare to manage”).

Elevating the road above 10.8 ft (approximately 3.4 ft above the topographic elevation in the area) would likely reduce the risk of flood inundation during 1% annual chance coastal storm events by 2050, considering 1.5 ft of sea level rise (“commit to manage”), and due to high tide by 2090, considering 5.0 ft

of sea level rise (“prepare to manage”). The road would still likely be inundated due to stillwater conditions during 1% annual chance coastal storm events by 2070.

Recommendation

We recommend engaging with the Maine Department of Environmental Protection (MEDEP) and the MGS around possible project constraints given the identification of a sand dune in the area. We believe the road could be re-aligned inland of its existing location by approximately 100 ft to allow for road elevation to reduce the risk of flood inundation. We suggest elevating a re-aligned roadway to a minimum elevation of 10.8 ft to reduce the risk of flood inundation due to stillwater conditions during 1% annual chance coastal storm events by 2050, considering 1.5 ft of sea level rise. However, we recommend pursuing a more detailed coastal analysis to refine this elevation with the consideration of wave action.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.4. Bridge Road (Rt 175) and Davis Narrows Bridge

Figure 4-7. Bridge Road and Davis Narrows Bridge Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

Bridge Road in Brooksville connects Coastal Road to the Davis Narrows Bridge as it crosses over the Bagaduce River into the Town of Sedgwick and becomes Franks Flat Road. This stretch of road is part of the state-owned and maintained Route 175. Included in this area is a parking area and pier located behind Bagaduce Lunch on the eastern side of the bridge and a boat launch located on the river of the western side of the bridge.

For present-day sea levels, approximately 62 ft of Bridge Road would likely experience inundation, and the Davis Narrows Bridge would likely be overtopped during 1% annual chance coastal storm events. The road would likely be inundated by up to 0.3 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. The top of the boat ramp to the west of the bridge would also likely be inundated under these conditions. During periods of wave action, inundation depths would likely be higher.

By 2050, approximately 210 ft of Bridge Road would likely experience flood inundation during 1% annual chance coastal storm events, considering 1.5 ft of sea level rise (“commit to manage”), and the Davis Narrows Bridge would likely be overtopped. The road would likely be inundated by up to 1.7 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. The pier and parking area behind Bagaduce Lunch would likely be inundated as well as the top of the boat ramp west of the bridge. During periods of wave action, and during 1% annual chance coastal storm events in 2070 and 2090, inundation depths would likely be higher.

By 2090, approximately 125 ft of Bridge Road would likely experience flood inundation daily during high tide considering 5.0 ft of sea level rise (“prepare to manage”). The Davis Narrows Bridge would likely be overtopped, and the pier and parking area behind Bagaduce Lunch would likely be inundated during high tide. Additionally, the top boat ramp to the west of the bridge would likely be inundated during high tide.

During 1% annual chance coastal storm events for present-day and future sea levels, this study suggests that flood inundation would likely be present along Bagaduce Road, Bridge Road (Rt 175), and Coastal Road near Orcutt Cove. However, the risk of flooding along Bagaduce Road may be lower than reported in this study due to the tidal constriction at the Davis Narrows Bridge. If these three locations are inundated, approximately 829 buildings located north of Orcutt Cove on Coastal Road and north of the area of flooding along Bagaduce Road would be prevented from traveling outside of Brooksville via Route 175. However, most of these buildings would still likely be accessible by emergency personnel originating from the Brooksville Volunteer Fire Department.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway, bridge, and boat ramp remain as they are, they would likely be subject to flood inundation during 1% annual chance coastal storm events for present-day sea levels. During times when the bridge and road are inundated, the 829 buildings impacted would likely be inaccessible from outside of the Town of Brooksville.

We would encourage users of this roadway to avoid travel during anticipated coastal storm events.

Adaptation Option 2: Elevate the Road and Davis Narrows Bridge

Elevating Bridge Road and the Davis Narrows Bridge above elevation 10.8 ft (approximately 1.7 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storms by 2050, considering 1.5 ft of sea level rise (“commit to manage”) and due to high tide by 2090, considering 5.0 ft of sea level rise (“prepare to manage”). The road would still likely be inundated due to stillwater conditions by up to 0.9 ft and 1.5 ft during 1% annual chance coastal storm events by 2070, considering 2.4 ft of sea level rise (“commit to manage”) and 3.0 ft of sea level rise (“prepare to manage”), respectively.

Elevating the road above elevation 12.3 ft (approximately 3.2 ft above the low point of the road) would likely reduce the risk of flood inundation due to 1% annual chance coastal storm events by 2070, considering 3.0 ft of sea level rise (“prepare to manage”). The road would still likely be inundated by up to 2.0 ft by 2090 during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”).

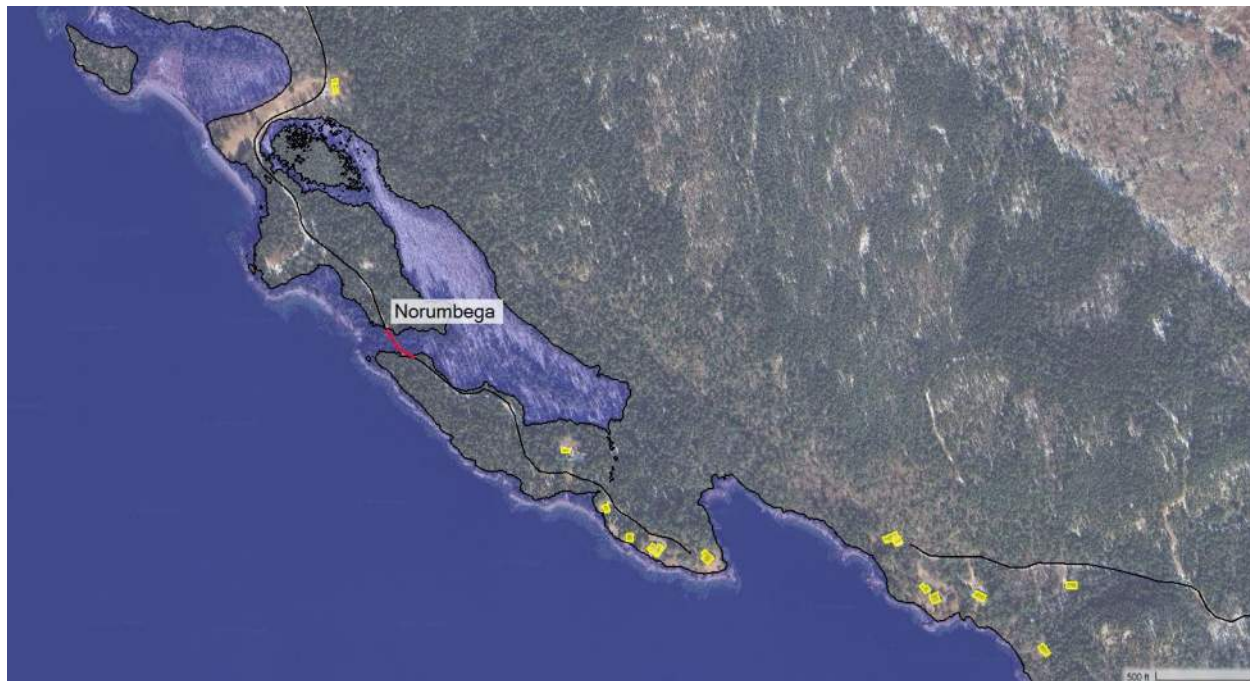
Recommendation

We recommend elevating the vulnerable section of this road, including the Davis Narrows Bridge, to a minimum elevation of 10.8 ft to increase the likelihood of continued vehicular access during 1% annual chance storm events by 2050.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.5. Norumbega Road

Figure 4-8. Norumbega Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

Norumbega Road was identified as an area of coastal flooding and flooding in Brooksville by the 2024 Hancock County Hazard Mitigation Plan (Hancock County EMA, 2024). This study suggests that coastal flooding is likely to occur by 2070 due to 1% annual chance coastal storm events, considering 3.0 ft of sea level rise (“prepare to manage”). For this scenario, approximately 48 ft of Norumbega Road, about 0.4 miles from its terminus, would likely experience flood inundation. The road would likely be inundated by up to 0.5 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

By 2090, approximately 210 ft of Norumbega Road would likely experience flood inundation during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”). The road would likely be inundated by up to 2.5 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

There are approximately five buildings that would be impacted during periods of inundation. If Norumbega Road becomes impassible due to flood inundation, the buildings would be inaccessible to emergency vehicles and building occupants would not be able to evacuate to Coastal Road.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events by 2070. During times of inundation, the five buildings impacted would likely be inaccessible. We would encourage users of this roadway to plan travel around anticipated coastal storm events.

Adaptation Option 2: Elevate the Road

Elevating Norumbega Road above elevation 14.3 ft (approximately 2.5 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events by 2090, considering 5.0 ft of sea level rise (“prepare to manage”).

Adaptation Option 3: Connect Norumbega Road to Winneganeke Way

Connecting the eastern terminus of Norumbega Road with the western terminus of Winneganeke Way would allow for travelers to avoid the low point along Norumbega Road and would keep the buildings accessible during periods of future coastal storm events. This would involve the design, permitting, and construction of approximately 1,800 ft of new roadway through a forested area.

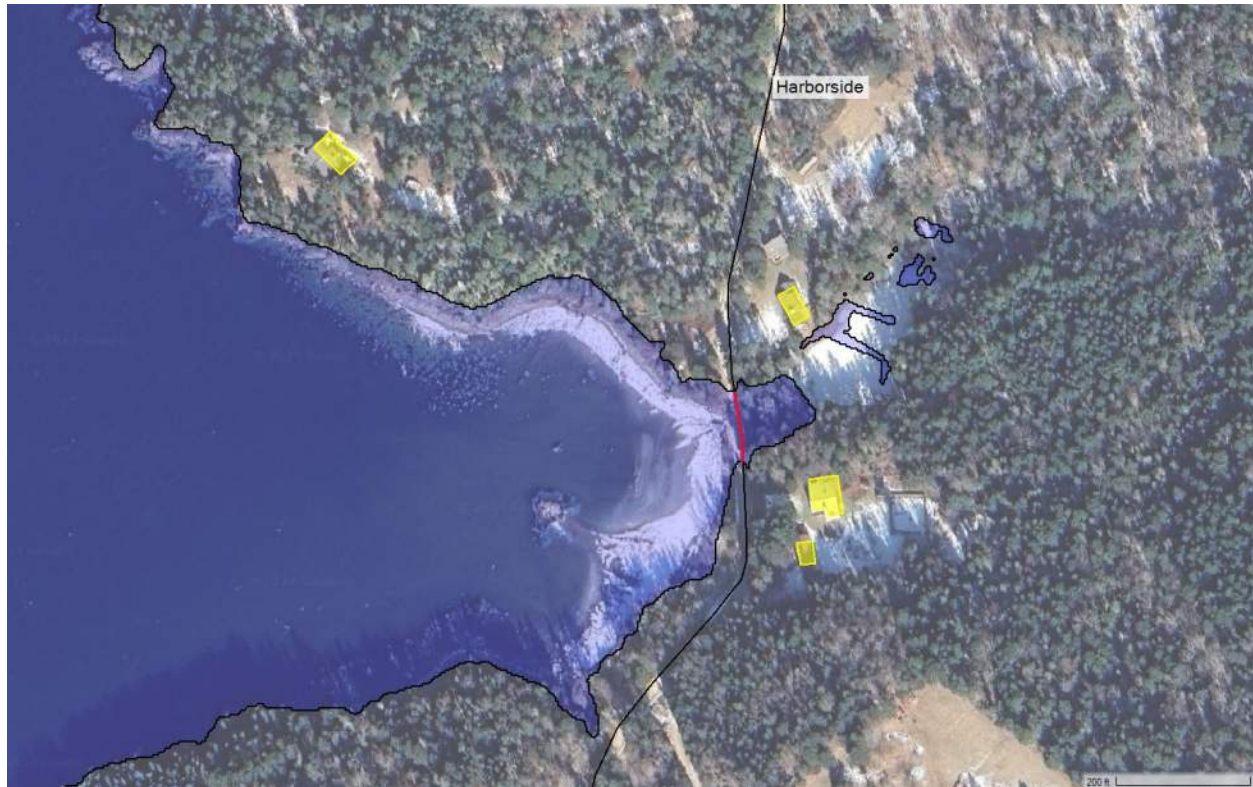
Recommendation

We recommend doing nothing at this location in the near-term. We suggest monitoring regional sea level rise and documenting the level of water in relation to the roadway during coastal storm events. By 2050, once there is less uncertainty around the rate of sea level rise by 2070, we suggest examining the risk of roadway inundation by 2070 during coastal storm events. If the risk of inundation by 2070 during coastal storm events remains, we recommend adapting this roadway either through elevation or through re-routing the road to connect to Winneganeke Way.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.6. Harborside Road

Figure 4-9. Harborside Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

Harborside Road dips to a low point elevation of approximately 12.3 ft, where a culvert is located that appears to restrict flow from a freshwater wetland, approximately 400 ft north of the access road for the Good Life Center. This section of roadway is coastally exposed and was subject to wave action during the coastal storm events in the early months of 2024. Figure 4-10 below shows the beach wrack line on the landward side of the road after the March 10, 2024, storm event, indicating wave splash over during the storm.

Figure 4-10. Harborside Road after Storm Event on March 10, 2024



Source: Town of Brooksville

The flood risk assessment undertaken as part of this project was based on stillwater elevations, or the elevation of water without the addition of wave action. The results of this study suggest that the road would not likely be inundated due to standing water during 1% annual chance coastal storm events until there is 5.0 ft of sea level rise, which is the “prepare to manage” estimate for 2090. Under this scenario, approximately 106 ft of Harborside Road would likely be inundated. The road would likely be inundated by up to 2.0 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

There are approximately 41 buildings located between the low point of Harborside Road and Weir Cove Road near Bakeman Beach that would likely be impacted during periods when both road sections are inundated. During periods of flood inundation, the buildings would be inaccessible to emergency vehicles and building occupants would not be able to evacuate to Cape Rosier Road.

A summary of the flood risk exposure for this road and other is provided in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to stillwater flood inundation during 1% annual chance coastal storm events by 2090. The road would likely experience flood inundation due to wave overtopping during major coastal storm events for present-day water levels, as evidenced by the 2024 storms that occurred in January and March. Town personnel would likely need to clear the road of debris to allow for safe vehicle passage after storm events. The road could become damaged due to repeated wave action. During times of inundation, the 41 buildings impacted would likely be inaccessible.

Adaptation Option 2: Elevate the Road

Elevating Harborside Road above elevation 14.3 ft (approximately 2.0 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events through 2090, considering 5.0 ft of sea level rise (“prepare to manage”). Elevating the roadway would also likely reduce road overtopping due to wave action for present-day storm events.

Adaptation Option 3: Abandon

The low-lying portion of this roadway could be abandoned and actively removed, which would allow for increased tidal transparency of the impacted wetland upstream of the culvert. Buildings to the south of the road would be accessed via Weir Cove Road. Buildings to the north of the low-lying portion of the road could be accessed from the north by Cape Rosier Road and Harborside Road or from across Cape Rosier Bridge. If Weir Cove Road near Bakeman Beach remains as is (i.e., is not adapted either through elevation or relocation), 41 buildings would likely be inaccessible during periods of flood inundation of Weir Cove Road.

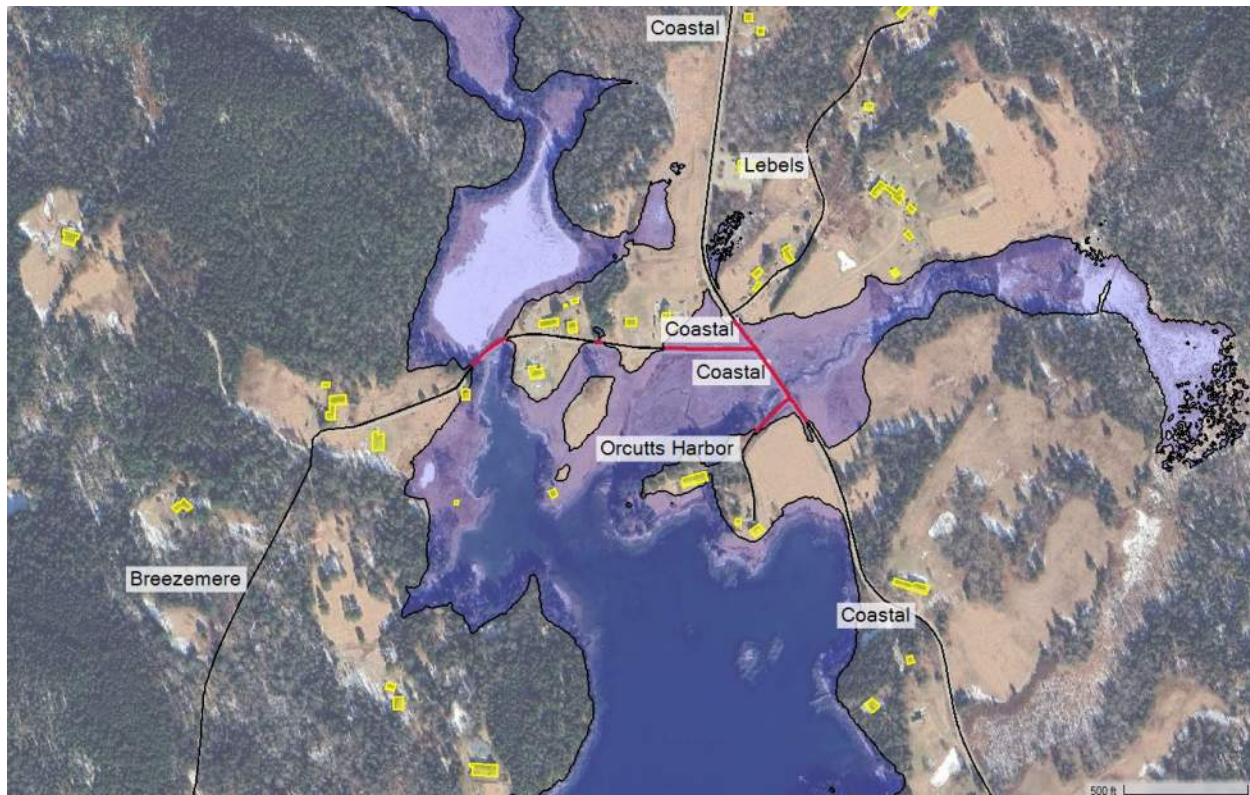
Recommendation

We recommend refining the flood risk at this location by performing a coastal wave analysis to evaluate flood risk due to wave runup for present-day and future sea levels and 1% annual chance coastal storm events. Information on wave heights due to sea level rise and storm events is anticipated to become available when the Maine Coastal Flood Risk Model (MCFRM) results are made publicly available. We recommend waiting on adaptation efforts until present-day flood risk due to wave action is better understood. We recommend documenting storm-induced road damage and evidence of road overtopping during and after coastal storm events. However, for reference, we have provided a high-level cost estimate for elevating the roadway to El. 14.3 ft, which would reduce the likelihood of stillwater flood inundation by 2090 due to 1% annual chance coastal storm events.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.7. Coastal Road

Figure 4-11. Coastal Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

There is a low-lying section of state-owned Coastal Road at the head of Orcutt Cove. This section of the road contains a cross culvert that has been identified as a restriction in the Maine Coastal Program Tidal Restriction Atlas (Maine DMR, 2020).

For present-day sea levels, approximately 207 ft of Coastal Road, between the intersection with Orcutt's Harbor Road and the intersection with Breezemere Road, would likely experience flood inundation during 1% annual chance coastal storm events. The road would likely be inundated by up to 0.9 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. Flood inundation depths during 1% annual chance coastal storm events in 2050 and 2070 for an intermediate rate of sea level rise ("commit to manage") would likely increase to 2.3 ft and 3.2 ft, respectively. During periods of wave action, inundation depths would likely be higher.

By 2090, approximately 268 ft of Coastal Road would likely experience flood inundation daily during high tide, considering 5.0 ft of sea level rise ("prepare to manage"). The road would likely be inundated by up to 1.7 ft during peak high tide.

During 1% annual chance coastal storm events for present-day and future sea levels, this study suggests that flood inundation would likely be present along Bagaduce Road, Bridge Road (Rt 175), and Coastal

Road near Orcutt Cove. However, the risk of flooding along Bagaduce Road may be lower than reported in this study due to the tidal constriction at the Davis Narrows Bridge. If these three locations are inundated, approximately 829 buildings located north of Orcutt Cove on Coastal Road and north of the area of flooding along Bagaduce Road would be prevented from traveling outside of Brooksville via Route 175. However, most of these buildings would still likely be accessible by emergency personnel originating from the Brooksville Volunteer Fire Department.

There are approximately 42 buildings that are accessed via Breezemere Road that would be impacted during periods of inundation on Coastal Road. There are approximately three buildings on Orcutt's Harbor Road that would be impacted during periods of inundation on Coastal Road. During periods of flood inundation, these 45 buildings would be inaccessible to emergency vehicles and building occupants would not be able to evacuate.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If Coastal Road remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events for present-day sea levels and during high tide by 2090. During times of inundation, up to approximately 829 buildings would be impacted, and in some instances, would likely be inaccessible from outside of Brooksville. The 45 buildings accessed from Coastal Road on Breezemere Road and Orcutt's Harbor Road would likely be inaccessible from within Brooksville as well. We would encourage users of this roadway to plan travel around predicted periods of high tide and avoid travel during anticipated coastal storm events.

Adaptation Option 2: Elevate the Roads

Elevating Coastal Road above elevation 10.8 ft (approximately 2.3 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events through 2050, considering 1.5 ft of sea level rise ("commit to manage") and during high tide through 2090, considering 5.0 ft of sea level rise ("prepare to manage"). The road would still likely be inundated due to stillwater conditions by up to 0.9 ft during 1% annual chance coastal storm events by 2070, considering 2.4 ft of sea level rise ("commit to manage").

Elevating the road above elevation 11.7 ft (approximately 3.2 ft above the low point of the road) would likely reduce the risk of flood inundation due to 1% annual chance coastal storm events by 2070, considering 2.4 ft of sea level rise ("commit to manage"). The road would still likely be inundated due to stillwater conditions during 1% annual chance coastal storms events in 2070 and 2090, considering 3.0 ft and 5.0 ft of sea level rise, respectively ("prepare to manage").

Recommendation

We recommend elevating the vulnerable section of this road to a minimum elevation of 10.8 ft to allow for the likelihood of continued vehicular access during 1% annual chance storm events for present-day sea levels and anticipated sea levels by 2050. Infrastructure adaptation work along this section of

roadway should be paired with a hydrologic and hydraulic evaluation of the tidally influenced culvert to assist with culvert re-sizing efforts.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.8. Dog Island Road

Figure 4-12. Dog Island Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

Dog Island Road travels south from Cape Roser Road towards Emerson Point. For present-day sea levels, approximately 38 ft of Dog Island Road, near its intersection with Store Point Road, would likely experience flood inundation during 1% annual chance coastal storm events. The road would likely be inundated by up to 0.1 ft due to stillwater conditions during the peak tide of the storm event. The low-lying section of roadway at risk of flood inundation is not likely exposed to wave action due to the protected area of Horseshoe Cove and narrow inlet leading to the roadway.

By 2050, approximately 299 ft of Dog Island Road would likely be inundated during 1% annual chance coastal storm events, considering 1.5 ft of sea level rise (“commit to manage”). The road would likely be

inundated by up to 1.5 ft, due to stillwater conditions during the peak tide of the storm event. By 2070, inundation depths during 1% annual chance coastal storm events would likely increase to 2.4 ft.

By 2090, approximately 158 ft of Dog Island Road would likely experience daily flood inundation during high tide, considering 5.0 ft of sea level rise (“prepare to manage”). The at-risk section of roadway would likely be inundated by up to 0.9 feet during peak high tide.

There are approximately 14 buildings that would be impacted during periods of inundation described above. If the road become impassible due to flood inundation, the buildings would be inaccessible to emergency vehicles and building occupants would not be able to evacuate.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events for present-day sea levels and during high tide by 2090. The present-day impact would likely be minor with flood depths likely under two inches and the inundated section approximately 50 ft. However, by 2050, inundation depths would likely increase to 1.5 ft during the peak tide of a 1% annual chance coastal event, which would likely make the 14 buildings inaccessible. We would encourage users of this roadway to plan travel around anticipated coastal storm events.

Adaptation Option 2: Elevate the Road

Elevating Dog Island Road above elevation 10.8 ft (approximately 1.5 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events by 2050, considering 1.5 ft of sea level rise (“commit to manage”) and during high tide by 2090, considering 5.0 ft of sea level rise (“prepare to manage”). The road would still likely be inundated due to stillwater conditions by up to 0.9 ft and 1.5 ft during 1% annual chance coastal storm events by 2070, considering 2.4 ft of sea level rise (“commit to manage”) and 3.0 ft of sea level rise (“prepare to manage”), respectively.

Elevating the road above elevation 12.3 ft (approximately 3.0 ft above the low point of the road) would likely reduce the risk of flood inundation due to 1% annual chance coastal storm events by 2070, considering 3.0 ft of sea level rise (“prepare to manage”). The road would still likely be inundated by up to 2.0 ft by 2090 during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”).

Adaptation Option 3: Re-route the road

The road could be re-routed inland of its current alignment to avoid areas of anticipated flood inundation. However, buildings accessed from Store Point Road would likely remain inaccessible during periods of flood inundation unless a new access road was created and elevated.

Recommendation

We recommend elevating the road to a minimum elevation of 10.8 ft to increase the likelihood for continued vehicular access during 1% annual chance storm events by 2050. By 2050, when sea level rise values for future timeframes (i.e., 2070, 2090, and beyond) are less uncertain, we recommended re-evaluating the risk of flood inundation along an elevated roadway for future timeframes.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.9. Cape Rosier Road

Figure 4-13. Cape Rosier Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft, 2018).

The section of road at risk of flood inundation is located at the northern end of Horseshoe Cove, approximately 2.6 miles from the entrance of Horseshoe Cove from the Atlantic Ocean. The configuration of this tidal inlet and the presence of bridge constrictions likely attenuate peak water surface elevations during storm tides as they propagate into the cove, meaning the peak water surface elevation at the northern end of the cove was conservatively assumed for this study to be the same as the peak water surface elevation at the entrance to Horseshoe Cove from the Atlantic Ocean. More detailed hydraulic analysis (outside the scope of this study) is likely to show that the peak water elevation in the northern end of the cove is lower than the peak water surface elevation at the entrance to Horseshoe Cove from the Atlantic Ocean. This flood vulnerability assessment did not include dynamic

modeling (i.e., did not consider the impact of storm attenuation), and likely is a conservative estimate of the peak water surface elevation at the northern end of Horseshoe Cove. A more detailed hydraulic analysis and/or water surface observations within Horseshoe Cove would help refine estimated water surface elevations due to storm surge and sea level rise.

The results of this flood risk assessment suggest that approximately 31 ft of Cape Rosier Road at the northern end of Horseshoe Cove, and between its intersections with Burnt Marsh Road and Bell Farm Road, would likely be at risk of flood inundation by 2070 during 1% annual chance coastal storm events, considering 3.0 ft of sea level rise (“prepare to manage”). The road would likely be inundated by up to 0.1 ft due to stillwater conditions during the peak tide of the storm event.

By 2090, approximately 398 ft of Cape Rosier Road would likely experience flood inundation during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”). The road would likely be inundated by up to 2.1 ft due to stillwater conditions during the peak tide of the storm event.

There are approximately 249 buildings that would be impacted during periods of inundation. Most of these buildings would likely be accessible to emergency vehicles originating from areas west of the inundated area along Cape Rosier Road and occupants would likely be able to move around the Cape Rosier area. However, flood inundation would likely prevent access to the 249 buildings from east of the inundated area.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to minor flood inundation during 1% annual chance coastal storm events by 2070. However, the attenuation effect of the long cove may reduce the peak storm tide below anticipated values from this study. By 2090, inundation depths would likely increase to 2.1 ft during the peak of 1% annual chance coastal events, which would likely make approximately 249 buildings inaccessible during periods of inundation. Under this future scenario, we would encourage users of this roadway to plan travel around predicted periods of coastal storm events.

Adaptation Option 2: Elevate the Road

Elevating Cape Rosier Road would reduce the risk of flood inundation during 1% annual chance coastal storm events for future time horizons (2070 and beyond). The suggested amount of elevation required to reduce flood risk depends on the measured and/or modeled attenuation effects of the Horseshoe Cove inlet. Elevating Cape Rosier Road above 14.3 ft (approximately 2.1 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events through 2090, considering 5.0 ft of sea level rise (“prepare to manage”).

Recommendation

In the near term, we recommend doing nothing in terms of infrastructure-based adaptation for this section of roadway. It is likely that this roadway would not need to be adapted before 2070. At a future

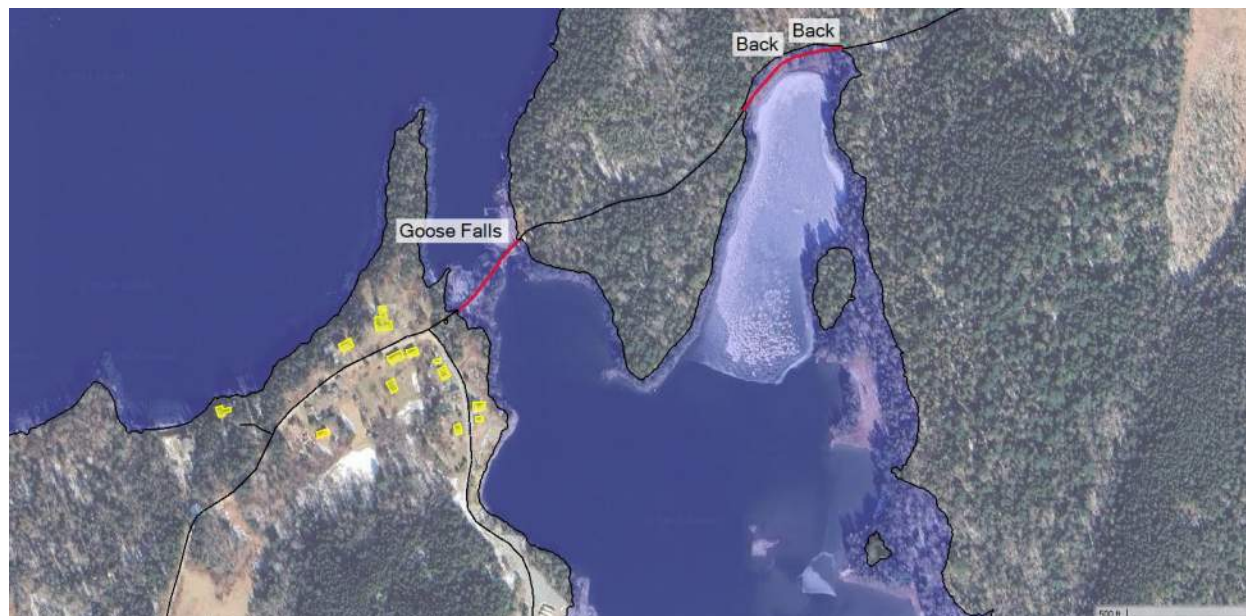
date (beyond 2050), when sea level rise estimates for 2070 and beyond are better understood, we recommend conducting a more detailed study to understand peak water surface elevations at the northern end of Horseshoe Cove during coastal storm surge events to better understand the attenuation effect of the long, narrow cove. A more detailed study would allow for a refined recommendation of roadway elevation.

In lieu of a more detailed study, we have provided a ballpark cost estimate for elevating the roadway to a minimum elevation of 14.3 ft, which would increase the likelihood for continued vehicular access during 1% annual chance storm events by 2090.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.4.1.10. Goose Falls Road and Cape Rosier Bridge

Figure 4-14. Goose Falls Road Inundation



Notes: Flood inundation boundary shown represents Flood Scenario Number 9 (Table 3-3): stillwater flooding during a 1% annual chance coastal storm event with 5.0 ft of sea level rise (2090, prepare to manage). Red lines represent likely inundated roadway sections. Yellow buildings based on GIS buildings data (Microsoft).

Goose Falls Road connects Harborside Road to the west of Goose Falls with Back Road to the east of Goose Falls and includes the Cape Rosier Bridge which spans over Goose Falls. There is a small dam located at the outlet of Goose Pond. By 2070, approximately 176 ft of Goose Falls Road, including the Cape Rosier Bridge, would likely be inundated during 1% annual chance coastal storm events, considering 2.4 ft of sea level rise (“commit to manage”). The road would likely be inundated by up to 0.3 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

By 2090, approximately 358 ft of Goose Falls Road, including the Cape Rosier Bridge, would likely experience flood inundation during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”). The road would likely be inundated by up to 2.9 ft due to stillwater conditions (i.e., without considering wave action) during the peak tide of the storm event. During periods of wave action, inundation depths would likely be higher.

There is approximately one building that would be impacted during periods of inundation. If the road becomes impassible due to flood inundation, the building would be inaccessible to emergency vehicles and building occupants would not be able to evacuate.

The estimated length of inundation along this roadway for the other flood scenarios is summarized in Table 3-4 within this report and in Appendix B.

Adaptation Option 1: Do Nothing

If the roadway remains as is, it would likely be subject to flood inundation during 1% annual chance coastal storm events by 2070. The Cape Rosier Bridge would likely be overtopped. During times of inundation, the building impacted would likely be inaccessible. We would encourage users of this roadway to plan travel around predicted periods of anticipated coastal storm events.

Adaptation Option 2: Elevate the Road

Elevating Goose Falls Road, including the Cape Rosier Bridge, above elevation 12.3 ft (approximately 0.9 ft above the low point of the road) would likely reduce the risk of inundation during 1% annual chance coastal storm events through 2070, considering both 2.4 and 3.0 ft of sea level rise (“commit to manage” and “prepare to manage”, respectively). The road would still likely be inundated by up to 2.0 ft by 2090 during 1% annual chance coastal storm events, considering 5.0 ft of sea level rise (“prepare to manage”).

Elevating the road above elevation 14.3 ft (approximately 2.9 ft above the low point of the road) would likely reduce the risk of flood inundation due to 1% annual chance coastal storm events through 2090, considering 5.0 ft of sea level rise (“prepare to manage”).

Adaptation Option 3: Abandon

This section of roadway could be abandoned, and the bridge and dam could be removed to allow for more tidal transparency at Goose Falls. The Cape Rosier Bridge and tidal dam is identified as a tidal barrier according to the Maine Coastal Program Tidal Restriction Atlas (Maine DMR, 2020). Removing the dam would help promote tidal action within Goose Pond.

Recommendation

We recommend taking a do nothing approach in terms of infrastructure adaptation at this location in the near term. We recommend evaluating a long-term plan to restore tidal transparency of Goose Pond, either through dam and road removal or increased hydraulic capacity of the structure. Vehicular drivers can use an alternate route via Cape Rosier Road and Back Road to access the other side of Goose Pond.

A summary of flood risk, number of impacted buildings, adaptation options, and estimated costs is provided in the attached Table 1. Additionally, estimated costs for elevating the roadway are summarized in Section 4.5 of this report.

4.5. Cost Estimates

We have prepared a cost estimate for road elevation adaptation options that were discussed in this report. Estimates were not provided for rerouting roadways due to the complexity of right of way access. It is recommended that a more detailed alternatives analysis be performed for individual road segments to evaluate road elevation versus road rerouting.

Estimated costs associated with the elevation scenarios described in the earlier sections of this report are summarized in Table 4-1 below. These cost estimates represent design, permitting, construction and oversight costs. The costs are based on 2024 dollars and should be considered approximate, ranging in accuracy by approximately +/- 30%. There are also costs associated with “no action” or not adapting infrastructure for increased flood risk. The National Institute of Building Sciences reported that every \$1 invested in pre-disaster risk reduction results in \$6 of avoided disaster damage (MCC, 2020a).

Table 4-1. Summary of Road Adaptation Cost Estimates

Road	Elevation Amount (ft)	Recommended Elevation (ft NAVD88)	Reduces Storm Surge Flooding During:	Reduces High Tide Flooding During:	Approximate Segment Length for Adaptation (ft)	Approximate Total Cost	Approximate Cost per Linear Foot of Roadbed
Bagaduce Road	1.1	8.2	N/A	2070	304	\$280,000	\$900
	3.7	10.8	2050	2090	568	\$680,000	\$1,200
Back Road	2.1	9.4	Present Day	2070	295	\$460,000	\$1,600
	3.5	10.8	2050	2090	367	\$680,000	\$1,900
Weir Cove Road ¹	1.9	9.4	Present Day	2070	545	\$850,000	\$1,600
	3.3	10.8	2050	2090	629	\$1,160,000	\$1,800
Bridge Road & Bridge ²	1.7	10.8	2050	2090	164	>\$2,000,000	>\$12,200
	3.2	12.3	2070	2090	309	>\$2,000,000	>\$6,500
Norumbega Road	2.5	14.3	2090	2090	213	\$160,000	\$800
Harborside Road	2.0	14.3	2090	2090	110	\$240,000	\$2,200
Coastal Road	2.3	10.8	2050	2090	310	\$930,000	\$3,000
	3.2	11.7	2070	2090	364	\$1,030,000	\$2,800
Dog Island Road	1.5	10.8	2050	2090	300	\$430,000	\$1,400
	3	12.3	2070	2090	496	\$840,000	\$1,700
Cape Rosier Road	2.1	14.3	2090	2090	426	\$780,000	\$1,800
Goose Falls Road and Bridge ²	0.9	12.3	2070	2090	180	>\$2,000,000	>\$11,100
	2.9	14.3	2090	2090	360	>\$2,000,000	>\$5,600

Notes:

1. The cost estimate for Weir Cove Road is for elevating the road in place; an estimate for relocating the roadway was not provided as part of this study.
2. Elevating these roads would likely require replacing a bridge. Due to the complexity of bridge replacements, we assume a rough estimate of greater than \$2,000,000 based on bridge replacement estimates from the MaineDOT 2024-2025-2026 workplan (MaineDOT, 2024).

4.6. Permitting Considerations

Infrastructure projects within the Town of Brooksville will likely be subject to a local, state, and/or federal regulatory process. In some cases, multiple permits may be required for a specific project. We have summarized some of the local, state, and federal permits that may be required for coastal adaptation projects in the Town of Brooksville. More detailed analysis and design would need to be developed to fully identify all permitting requirements.

Town of Brooksville

The Town of Brooksville participates in the National Flood Insurance Program and as such requires a Flood Hazard Development Permit for projects within Special Flood Hazard Areas (SFHAs). Improvements on wharves, piers, and bridges would fall within the Flood Hazard Development Permits for Minor Development or may be exempt depending on the scope of work proposed.

The Town of Brooksville's Shoreland Environmental Protection Ordinance applies to all land areas within 250 feet of the normal high-water line of any great pond or river, upland edge of a coastal wetland, or upland edge of a freshwater wetland and all land areas within 75 feet of the normal high-water line of a stream. Projects involving road construction, earthwork, and structures extending over or below the normal high-water line or within a wetland require a shoreland zoning permit issued by the Code Enforcement Officer and/or Planning Board. Table 1 of the Town of Brooksville's Shoreland Environmental Protection Ordinance outlines common land uses and the level of review required (i.e. CEO, Planning Board, or no review).

State of Maine

Under the Natural Resources Protection Act (NRPA), the MEDEP regulates activities in, on, and over protected natural resources that include coastal sand dune systems, coastal wetlands, significant wildlife habitat, fragile mountain areas, freshwater wetlands, great ponds, and rivers, stream, or brooks. In addition, activities within 75 feet of a coastal wetland, great pond, river, stream or brook, and specific freshwater wetlands area also subject to the NRPA. The goal of the NRPA is to avoid and minimize impacts to protected natural resources by regulating activities in, on, or adjacent to the resources.

In general, there are two permitting options for projects subject to the NRPA: a Permit-by-Rule (PBR) or an Individual NRPA permit. A PBR is an expedited permit review that applies to certain small, low-impact projects that present minimal risk of impact to environmental resources and must meet specific design standards. An Individual NRPA Permit is required for projects that do not meet PBR standards. This includes most projects that directly impact a coastal wetland, including upland areas with 25 feet of the highest annual tide line. The NRPA Individual permit application process requires that the natural resources impacted by the project be characterized, that the purpose for the project be demonstrated,

and that an alternatives analysis be undertaken to document that the option being proposed is the least impactful practical option that achieves the project objectives.

Depending on the amount of impact and type of protected natural resource, the MEDEP may require a functional assessment to determine if the project is anticipated to impact the functions and values of the resource. If so, the MEDEP may require mitigation for lost resource functions and values. For projects that impact less than 500 square feet of a coastal wetland, a functional assessment and/or compensation may not be required. For projects with greater impact, mitigation may be required in the form of in lieu fee (ILF), an on-site compensation project, or an off-site compensation project. For projects located within a mapped coastal sand dune, an Individual Coastal Sand Dune permit may be required. The timeframe for approval of applications under the NRPA is 2 weeks for PBR, and 4 -6 months for an Individual NRPA permit and Coastal Sand Dune application. Public notice is required for an Individual NRPA permit and Coastal Sand Dune application and projects subject to mitigation require a pre-application meeting with the DEP and a public information meeting prior to the submission of an application.

As a matter of consideration, certain projects may be eligible for a statutory exemption under the NRPA and may not require any permit. This can include maintenance and repair to less than 50% of an existing structure, including piers, wharves, and docks, public works projects, or the repair and maintenance or replacement of an existing crossing.

Federal

Under Section 404 of the Clean Water Act, the U.S. Army Corps of Engineers (USACE) regulates waters of the U.S., and, under Section 10 of the Rivers and Harbors Act, the USACE regulates navigable waters of the U.S. Projects that are subject to these regulations require a Maine General Permit. Similar to the MEDEP, there are generally two permit options: a Self-Verification Notification Form (SVNF) or a Pre-Construction Notification (PCN), depending on the scope of the project. In some cases, provided all proposed work is landward of the high tide line, these permits can be avoided. As an example, utilizing a vertical wall stabilization instead of a riprap slope may avoid structures below the high tide line. However, this activity may require MEDEP review and consideration needs to be given to the NRPA regulations. If a U.S. Army Corps of Engineers permit is required, several federal agencies will be involved in the review, including: US Fish & Wildlife (USFWS), the Environmental Protection Agency (EPA), and National Marine Fisheries (NMFS). Additionally, for either a SVNF or PCN, notification of the project must be submitted to the Maine Historic Preservation Commission (MHPC) and the five federally recognized tribes in the State of Maine. In cases where both an NRPA individual permit and Army Corps permit are required, an application can be made using the joint application form to both agencies; however, this process may be phased out in 2025 when the new USACE Maine General Permit is released.

For bridges in coastal locations, the lead agency for federal permitting is the US Coast Guard. The locations considered in this study do not involve crossings of navigable waterways, so it is anticipated that the scope of US Coast Guard permitting would likely be limited to Advance Approval for small crossings over tidal waters.

4.7. Funding Opportunities

There are several state and federal funding opportunities that coastal adaptation projects would be well suited for. These opportunities evolve over the years and new opportunities may become available in future years. Each funding source has different eligibility requirements, match requirements, and deadlines for funding. We have provided a list of some of the relevant grant programs, but this list should not be considered comprehensive as new grant funds are created frequently. A list of some of the grant programs available for coastal infrastructure projects in Maine is provided in Table 4-2.

Table 4-1. Flood Adaptation Grant Programs in Maine

Grantor	Grant Name	Description of Qualifying Grant Uses
Maine Coastal Program	Shore and Harbor Planning Grant	Shoreline access planning, waterfront and harbor planning, identification and resolution of waterfront use conflicts, and planning, feasibility, and design efforts for waterfront infrastructure.
Maine Department of Agriculture, Conservation, and Forestry	Coastal Communities Grant	Improve water quality, increase adaptation to erosion and flooding, restore coastal habitats, promote sustainable development, and enhance the coastal-dependent economy while preserving coastal natural resources within Maine's coastal zone.
Governor's Office of Policy Innovation and the Future (GOPIF)	Community Action Grants	Work supporting the List of Community Actions, which fall into the categories of: Embracing the Future of Transportation, Modernizing Maine's Buildings, Reducing Emissions through Clean Energy Innovation, Grow Jobs and Protect Natural Resource Industries, Protect the Environment & Promote Natural Climate Solutions, Build Healthy & Resilient Communities, Invest in Climate-Ready Infrastructure, and Engage Maine People.
Maine DOT	Small Harbor Improvement Program (SHIP)	Projects promoting economic development, public access, improved commercial fishing opportunities and works to preserve and create infrastructure at facilities in tidewater and coastal communities.
Maine DOT	Boating Infrastructure Grant (BIG)	Projects to construct, renovate, and maintain tie-up facilities with features for transient boaters in vessel 26 feet or more in length.
Maine DOT	Maine Infrastructure Adaptation Fund	Scoping, design, and/or construction of adaptation projects to adapt critical infrastructure to reduce vulnerability to climate change, specifically storm and flooding impacts.
Maine DOT	Municipal Stream Crossing Grant	Upgrading of municipal culverts at stream crossing, with the goal of creating infrastructure that is resilient to future climate conditions and that provides community, economic, and environmental benefits.
Northern Border Regional Commission	Catalyst Program	Economic development initiatives, such as: modernizing and expanding access to public water and wastewater services, revitalizing transportation infrastructure, establishing workforce development programs and facilities, growing outdoor recreation economy, and providing access to new childcare and healthcare facilities.
FEMA	Building Resilient Infrastructure in Communities (BRIC)	Hazard mitigation projects.

Grantor	Grant Name	Description of Qualifying Grant Uses
FEMA	Flood Mitigation Assistance (FMA)	Reduce or eliminate the risk of repetitive flood damage to buildings and structures insured under the National Flood Insurance Program.
FEMA	Hazard Mitigation Grant Program (HMGP)	Post-disaster grants to reduce disaster losses and protect life and property from future disaster damages in communities that have already experienced significant damages from a major natural disaster.
U.S. DOT	Bipartisan Infrastructure Law Grants	Several funding opportunities related to the transportation sector and improving public safety and climate resilience.
National Fish and Wildlife Foundation	Coastal Resilience Fund	Conservation projects that restore or expand natural features such as coastal marshes and wetlands, dune and beach systems, oyster and coral reefs, forests, coastal rivers and floodplains, and barrier islands that minimize the impacts of storms and other naturally occurring events on nearby communities.
U.S. Department of Agriculture	Community Facilities Direct Loan & Grant Program	Development of essential community facilities in rural areas, such as: health care facilities, public facilities, community support services, public safety services, and utility services.
Maine DEP	Municipal Wastewater Grants and SRF Loans	Multiple grant programs, such as: Clean Water State Revolving fund to plan, design, and construct wastewater infrastructure projects; and the State Municipal Wastewater Grant Program for design of wastewater infrastructure projects.

5. Next Steps for Adaptation

This report presents the findings and recommendations for coastal flood risk and adaptation in the Town of Brooksville. The analysis included gathering of background information, assessment of flood risk to assets within the Town based on nine flood scenarios, identification of critical assets for adaptation prioritization, an introduction of adaptation options, preliminary cost estimates for road elevation adaptation options, and an overview of funding options and permitting considerations. This was a high-level, planning-based study.

The vulnerabilities identified in this phase of study vary in severity and urgency for adaptation. For some assets, a phased implementation strategy is likely to be the most effective approach to completing priority projects while aligning with available grant funding programs. Adaptation projects could take years to fully implement.

We recommend that the Town of Brooksville continue with regional collaboration in order to leverage grant funding opportunities and increase overall resiliency to climate risk. While in some instances climate risk such as wave runup and overtopping is specific to one site, in many instances climate risk are best approached from a regional level. The impact of one closed roadway on the Blue Hill Peninsula could likely be felt by many surrounding communities. Approaching climate risk regionally is especially important in more rural areas throughout our state, such as the Blue Hill Peninsula, where there is a lack in capacity of Town staff to undertake planning efforts around climate risk. A regional collaboration would be in line with the Maine Climate Action Plan Strategy F: Build Healthy and Resilient Communities (MCC, 2020b).

We have provided a summary of recommended next steps in order for the Town to advance infrastructure-related adaptation to coastal flood risk:

- **Decide on adaptation projects to pursue.** This decision should be based on the risk of exposure to flooding as well as the impacts (i.e., consequences) that would likely occur if the area or infrastructure becomes inundated. The Town should consider their tolerance to “living with water” when making decisions. Infrastructure-based adaptation methods (i.e., elevating a roadway) could be supplemented with non-infrastructure-based adaptation methods (i.e., alert systems or road barriers) to increase the overall resiliency to flood risk. Furthermore, an understanding of the likelihood of inundation vs consequences (i.e., economic costs of damage such as those based on depth-damage functions) would help build a risk framework and guide prioritization of mitigation projects.
- **Pursue relevant funding options.** This could include a funding package that leverages grant awards as a match requirement for a separate grant award. Funding could be pursued regionally or for a particular piece of infrastructure. The Town should continue to explore grant opportunities focused on implementation of flood adaptation measures. Adapting a single piece of infrastructure through constructure may require support from multiple grants, over multiple funding cycles, to complete.

- **Contract with a consultant to develop preliminary and final designs, procure the necessary permits, and oversee construction.** Once assets have been identified for adaptation and funding has been received, we recommend contracting with one or more consultants to develop adaptation designs for the selected infrastructure and oversee construction. The consultant(s) should be responsible for several tasks. These tasks could be part of separate contracts, funded through various grant programs, and take several years to complete. The tasks that the consultant(s) could be responsible for include:
 - **Conducting field investigations.** This would include scope items such as coordinating surveys of areas, performing wetland delineation, and carrying out a geotechnical investigation, as applicable.
 - **Refining flood risk through a coastal and/or hydrologic and hydraulic analysis.** We recommend performing a site-specific coastal flood modeling analysis to understand wave conditions, such as wave runup heights, for assets that would likely be exposed to wave action. For infrastructure such as roadways with culverts, culverts themselves, or other drainage features, we recommend performing a hydrologic and hydraulic analysis to understand opening sizes that could adequately convey design flows following guidance from Maine DOT, the Federal Highway Administration, the CoastWise approach (Maine Coastal Program, 2023), or other applicable agencies and guidance manuals.
 - **Develop preliminary and final designs.** The adaptation measures identified would need to be advanced through preliminary and final phases of design development.
 - **Procure permits.** The consultant would help prepare and submit regulatory permits required for the selected design.
 - **Prepare construction bid documents.** The consultant could help prepare construction plans and bid documents and assist in the selection of a contractor for the construction of the project.
 - **Oversee construction.** The consultant could oversee the construction of the project.

Beyond infrastructure projects, it is imperative that the Town develop a plan for emergency preparedness around flooding. This might include, for example, developing forecasting methods and an emergency alert system, operating procedures for deploying road barricades in advance of major storm events, a program to educate the public about the dangers of flooding, and procedures for local emergency organizations to respond to emergencies during periods of inundation. A possible model to follow could be voluntary signup to receive text messages on cell phones or via email for significant events with the potential to cause flooding.

Emergency responders and public works officials should closely follow weather forecasts and extreme tides, separately and combined, and plan for road closures during significant events that pose a risk to roads. Residents who rely on stretches of road to travel to and from their home that are likely to inundate will need to be mindful of high tides and weather forecasts of significant events when planning for travel outside their home. Vulnerable populations who rely on emergency services may want to consider temporarily moving to a more accessible location during anticipated coastal storm events. Addressing inundation will require education by the Town, warnings about advancing storm events, and the development of, for example, emergency alert systems such as the Maine Citizen Alert System.

6. Limitations

This report summarizes our work for the Town of Brooksville. The project did not include field data collection and relied on readily available online information, published references, data gathered during the community mapping event, and our professional judgement. The purpose of this flood vulnerability and adaptation assessment was to identify areas and infrastructure at risk of flood inundation, prioritize infrastructure, and provide adaptation options.

The GIS data included in this study represent a snapshot in time of locations and configurations for assets, such as roads, parcels, and building footprints. Infrastructure not included in an existing GIS database, such as town-owned culverts, were not included in this study.

The flood extents were based on stillwater elevations representing 1% annual chance storm surge and MHHW elevations for present-day and future conditions for four values of sea level rise. The sea level rise values used were recommended by the Maine Climate Council (2024a) and the 1% annual chance storm surge SWEL was based on the FEMA coastal analysis for Hancock County (FEMA, 2016). There is no indicator for when FEMA will revise the coastal analysis for Hancock County to revise the 2016 maps. The previous coastal analyses and flood maps for Hancock County were completed and instated between the years 1987 and 1991. Actual storm surge elevations and rates of sea level rise will vary from what has been presented in this report. The numbers and cost estimates included in this study should be considered approximate. Additionally, the flood extents presented in this report do not include the effect of wave action. Wave runup and overtopping on coastal infrastructure would likely increase the flood extents and depths and may contribute to damage of coastal infrastructure.

This study does not include an evaluation of the structural integrity of roadways, culverts, bridges, dams, and other appurtenances. We recommend site survey and site-specific design be completed for any infrastructure projects the Town pursues. Because the methods, procedures, and assumptions used to develop the analysis are approximate, the results should be used only as guidance.

Reuse of this report for any purposes, in part or in whole, is at the sole risk of the user.

7. References

Brooksville, Town of (2022). 2022 Annual Report.

Brooksville, Town of (2021). Comprehensive Plan, December.

FEMA (2024). Community Preparedness. Accessed on 5/30/2024 from <https://community.fema.gov/ProtectiveActions/s/article/Flood-Vehicle-Do-Not-Drive-in-Floodwaters-Turn-Around-Don-t-Drown>.

FEMA (2022). Wet Floodproofing Requirements and Limitations. NFIP Technical Bulletin 7, May.

FEMA (2019). Second-Story Conversion – Elevation Project Design Considerations for Hazard Mitigation Assistance Applicants. Fact Sheet.

FEMA (2016). Flood Insurance Study. Hancock County, Maine. Effective July 20, 2016.

FEMA (1990). Flood Insurance Study. Town of Blue Hill, Maine. Hancock County, May 3.

GEI Consultants, Inc. (2024). Project Report. Brooksville Pilot Project, Breezemere Road. November.

GEI Consultants, Inc. (2023). Draft Clean Drinking Water and Drought Vulnerability Assessment. Climate Vulnerability Assessment. Towns of Blue Hill, Brooksville, and Surry, Maine, November.

Hancock County Emergency Management Agency (EMA) (2024). Hancock County, Maine. Hazard Mitigation Plan – 2024 Update.

Maine Climate Council (MCC) (2024). Scientific Assessment of Climate Change and its Effects in Maine, June.

Maine Climate Council (MCC) (2020a). Scientific Assessment of Climate Change and Its Effects in Maine, August.

Maine Climate Council (MCC) (2020b). Maine Won't Wait. A Four-Year Plan for Climate Action, December.

Maine Coastal Program (2023). The CoastWise Approach: Achieving Ecological Resilience and Climate-Ready Road Crossings in Tidal Environments. Maine Department of Agriculture, Conservation and Forestry (2023). "Maine Conserved Lands" layer databased. Accessed October 2023 from: <https://hub.arcgis.com/datasets/maine::maine-conserved-lands/about>.

Maine Department of Marine Resources (DMR) (2020). Tidal Restriction Access. Accessed August 2024 from: <https://www.arcgis.com/apps/webappviewer/index.html?id=8f7fc922c464482d8fe946ca5b17c7ea>

Maine Department of Transportation (DOT) (2024). Three-Year Work Plan, January.

Maine Department of Transportation (DOT) (2021a). “MaineDOT Cross Culverts” layer database. Accessed October 2023 from: https://gis.maine.gov/arcgis/rest/services/dot/MaineDOT_OpenData/MapServer/54.

Maine Department of Transportation (DOT) (2021b). “MaineDOT Large Culverts” layer database. Accessed October 2023 from: <https://data-hub.gpcog.org/datasets/maine::mainedot-large-culverts/about>.

Maine Department of Transportation (DOT) (2021c). “MaineDOT Bridges” layer database. Accessed October 2023 from: https://hub.arcgis.com/datasets/5c884800d36a44c1872ee7e5f195245f_0/explore.

Maine Emergency Management Agency (MEMA) (2023). 2023 State Hazard Mitigation Plan, September.

Maine Emergency Services Communication Bureau (ESCB). “Maine E911 NG_Roads” layer database. Accessed August 2023 from: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/Maine_E911_Roads_Feature/FeatureServer.

Maine Geological Survey (2023). “Water Well Database” layer database. October. Accessed November from: <https://www.maine.gov/dacf/mgs/explore/water/facts/water.htm>.

Maine Office of GIS (2021). “Brooksville,” “Blue Hill,” and “Surry” layer databases. Accessed August 2023 from: https://www.maine.gov/geolib/download_parcel_by_town.html.

Maine Old Cemetery Association and Maine Office of GIS (2021). “Cemeteries” layer database. Accessed September from: <https://services1.arcgis.com/RbMX0mRVOFNTdLzd/ArcGIS/rest/services/MaineSociety/FeatureServer/0>.

Microsoft (2018). United States Building Footprints. Accessed August 2023 from: <https://www.microsoft.com/en-us/maps/bing-maps/building-footprints>.

NOAA (2024). Tides and Currents. Monthly High Tide Flooding Outlook. Accessed variable dates from <https://tidesandcurrents.noaa.gov/high-tide-flooding/monthly-outlook.html>.

NOAA (2023). Vertical Datum Transformation (VDATUM) Online Tool. Accessed September 2023 from: <https://vdatum.noaa.gov/vdatumweb/vdatumweb?a=114202120230727>.

Rbouvier consulting (2022). “Assessing the Carrying Capacity of the Blue Hill Peninsula.” Prepared for Blue Hill Heritage Trust, August 26.

Scarborough Maine, Town of (2024). Route One/Pine Point Road Resiliency. Webpage accessed September 2024 from: <https://www.scarboroughmaine.org/stay-connected/municipal-projects/route-one-pine-point-road-resiliency>.

USGS (2021). “LiDAR: Midcoast Maine.” Accessed August 2023 from: <https://www.coast.noaa.gov/dataviewer/#/lidar/search/>.

Tables

Table 1. Brooksville Road Adaptation Summary

Table 1. Brooksville Road Adaptation Summary

Road	Approximate # of Buildings Impacted	Detour Length (mi)	Low Point Elevation of Road (ft)	Flood event that will cause standing water flooding in:				Adaptation Comparison						
				Present Day	2050 (1.5 ft SLR)	2070 (2.4 ft SLR)	2090 (5.0 ft SLR)	Elevation Amount (ft)	Recommended Elevation (ft NAVD88)	Reduces Storm Surge Flooding During:	Reduces High Tide Flooding During:	Approximate Segment Length for Adaptation (ft)	Approximate Total Cost ¹	Approximate Cost per Linear Foot of Roadbed ²
Bagaduce Road	17/829 ³	11	7.1	100-yr Storm	100-yr Storm	High Tide	High Tide	1.1	8.2	N/A	2070	304	\$280,000	\$900
								3.7	10.8	2050	2090	568	\$680,000	\$1,200
Back Road	1	5.1 ⁴	7.3	100-yr Storm	100-yr Storm	High Tide	High Tide	2.1	9.4	Present Day	2070	295	\$460,000	\$1,600
								3.5	10.8	2050	2090	367	\$680,000	\$1,900
Weir Cove Road	64	6.6	7.5	100-yr Storm	100-yr Storm	High Tide	High Tide	1.9	9.4	Present Day	2070	545	\$850,000	\$1,600
								3.3	10.8	2050	2090	629	\$1,160,000	\$1,800
Bridge Road (Rt 175)	829 ³	No Detour Available	9.1	100-yr Storm	100-yr Storm	100-yr Storm	High Tide	1.7	10.8	2050	2090	164	>\$2,000,000	>\$12,200
								3.2	12.3	2070	2090	309	>\$2,000,000	>\$6,500
Norumbega Road	5	No Detour Available	11.8	N/A	N/A	100-yr Storm ⁵	100-yr Storm	2.5	14.3	2090	2090	213	\$160,000	\$800
Harborside Road	41	No Detour Available	12.3	N/A	N/A	100-yr Storm ⁵	100-yr Storm	2.0	14.3	2090	2090	110	\$240,000	\$2,200
Coastal Road	45/829 ³	No Detour Available	8.5	100-yr Storm	100-yr Storm	100-yr Storm	High Tide	2.3	10.8	2050	2090	310	\$930,000	\$3,000
								3.2	11.7	2070	2090	364	\$1,030,000	\$2,800
Dog Island Road	15	No Detour Available	9.3	100-yr Storm	100-yr Storm	100-yr Storm	High Tide	1.5	10.8	2050	2090	300	\$430,000	\$1,400
								3.0	12.3	2070	2090	496	\$840,000	\$1,700
Cape Rosier Road	249	No Detour Available	12.2	N/A	N/A	100-yr Storm ⁵	100-yr Storm	2.1	14.3	2090	2090	426	\$780,000	\$1,800
Goose Falls Road	1	No Detour Available	11.4	N/A	N/A	100-yr Storm	100-yr Storm	0.9	12.3	2070	2090	180	>\$2,000,000	>\$11,100
								2.9	14.3	2090	2090	360	>\$2,000,000	>\$5,600

- Notes:
- 1. Total costs are rounded to the nearest \$10,000.
 - 2. Linear foot costs are rounded to the nearest \$100.
 - 3. Detour available through Scenario 3. From Scenario 4 onwards, there is access within Brooksville, but likely no route out of Brooksville for 829 buildings, due to flooding at Coastal Road and Bridge Road.
 - 4. No detour available during Flood Scenario 7 and beyond.
 - 5. 3.0 ft of SLR

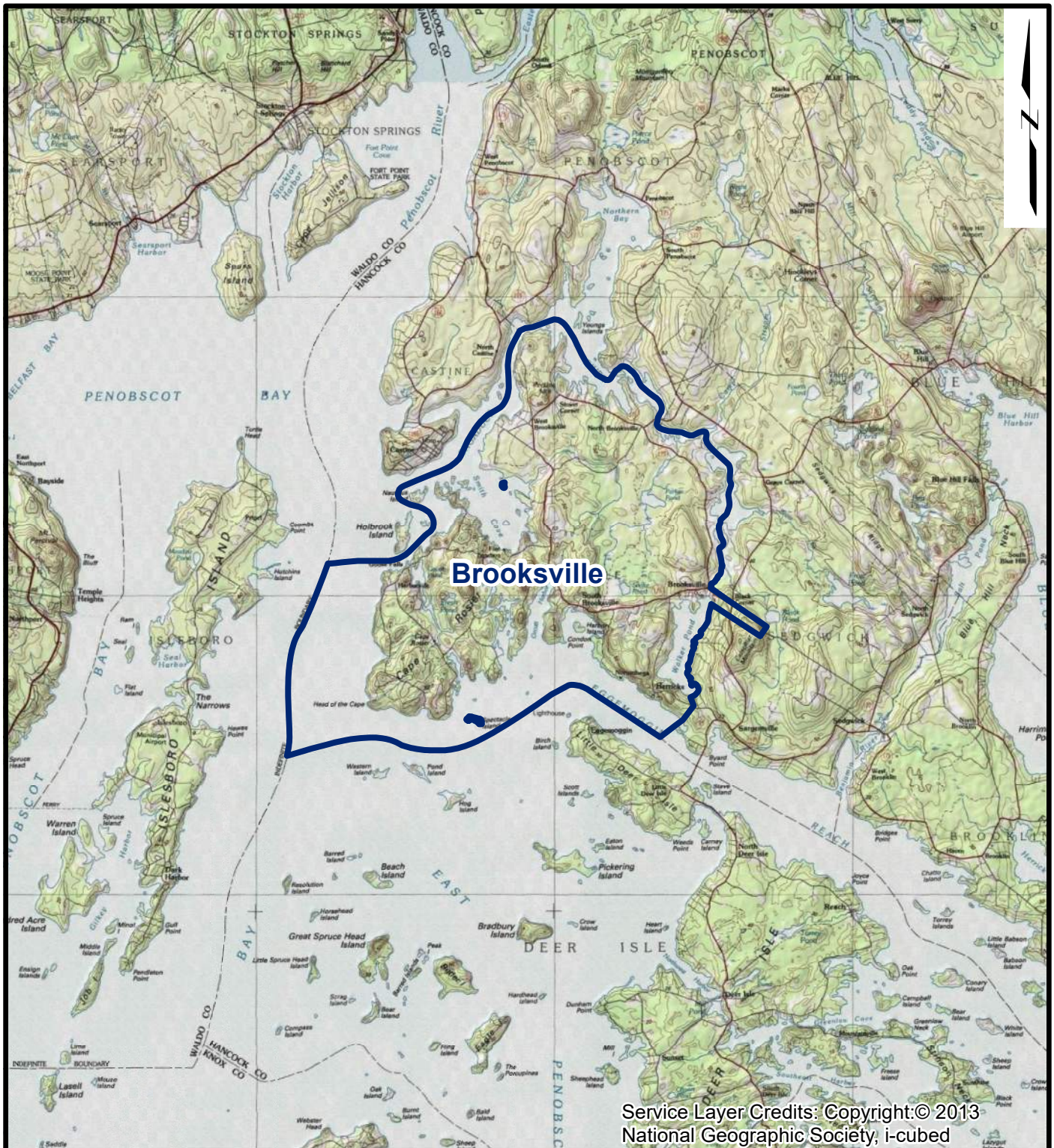
Figures

Figure 1. Town Boundary

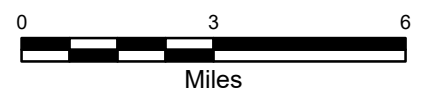
Figure 2. Road Adaptation Concepts A & B

Figure 3. Road Adaptation Concept C

Figure 4. Road Adaptation Concept D



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Brooksville Climate Vulnerability Assessment
Brooksville, Maine

Town of Brooksville, Maine

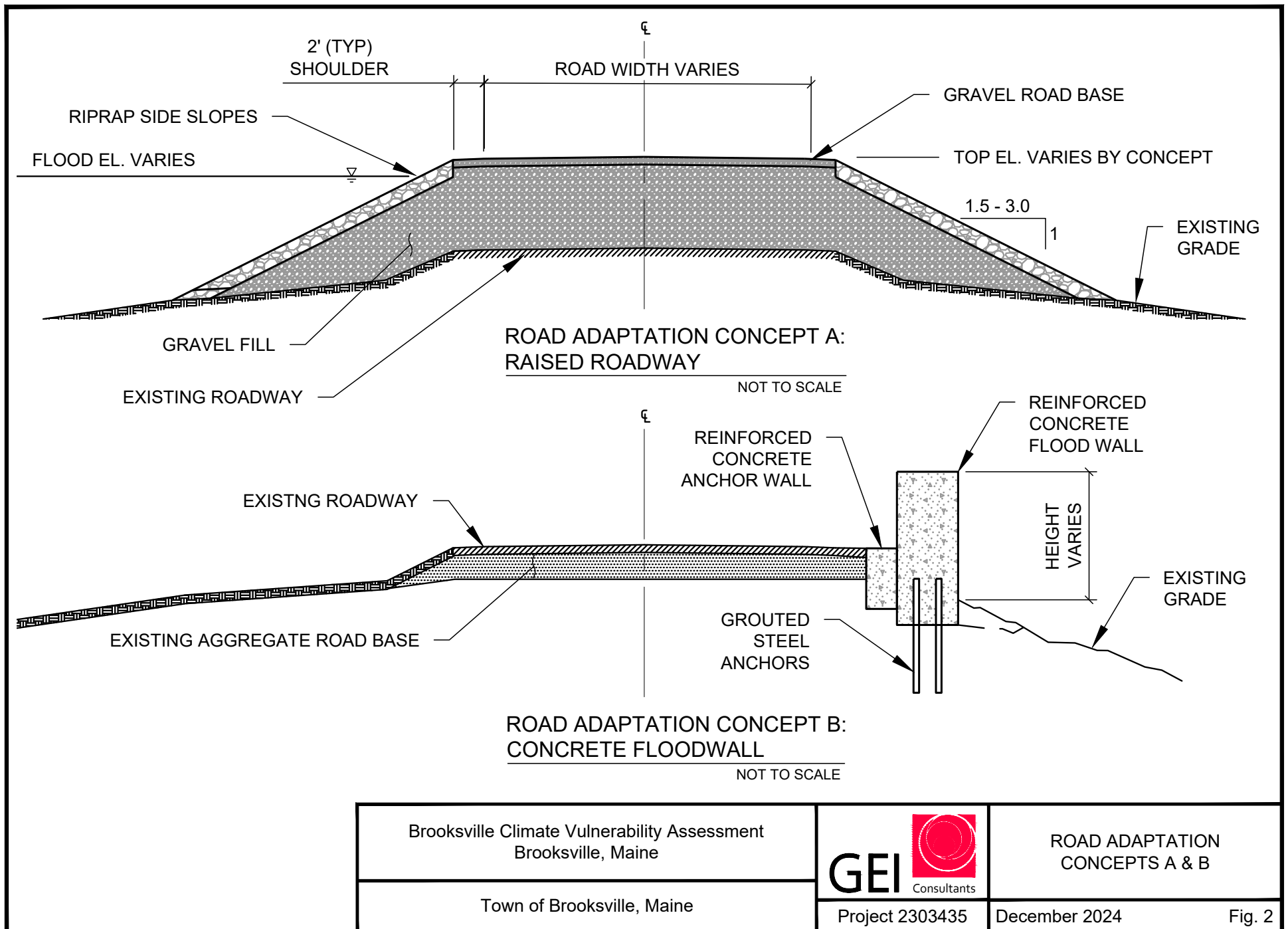


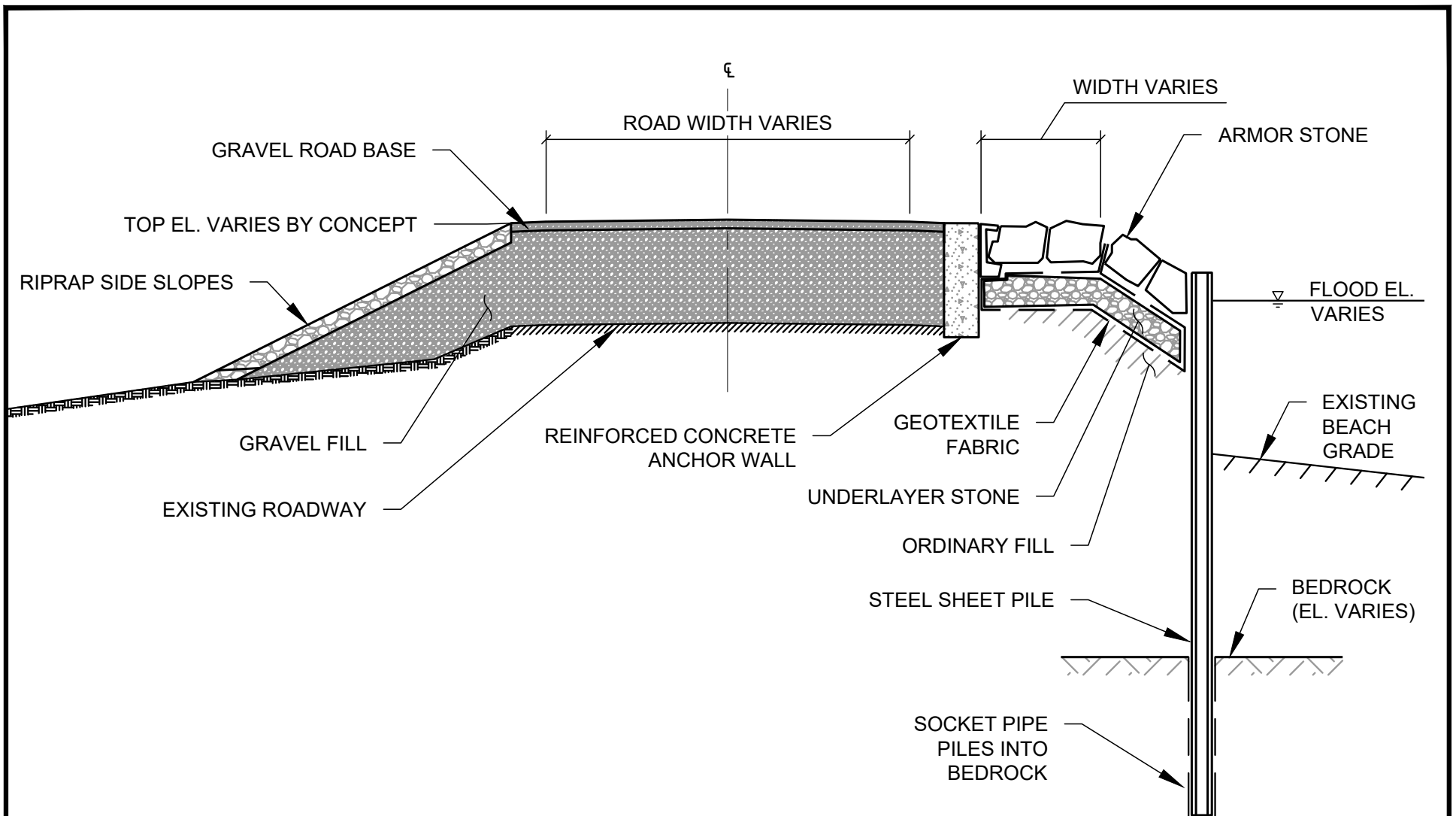
Project 2303435

TOWN BOUNDARY

December 2024

Fig. 1





ROAD ADAPTATION CONCEPT C:
RAISED ROADWAY & SHEET PILE FLOODWALL

NOT TO SCALE

Brooksville Climate Vulnerability Assessment
Brooksville, Maine

Town of Brooksville, Maine

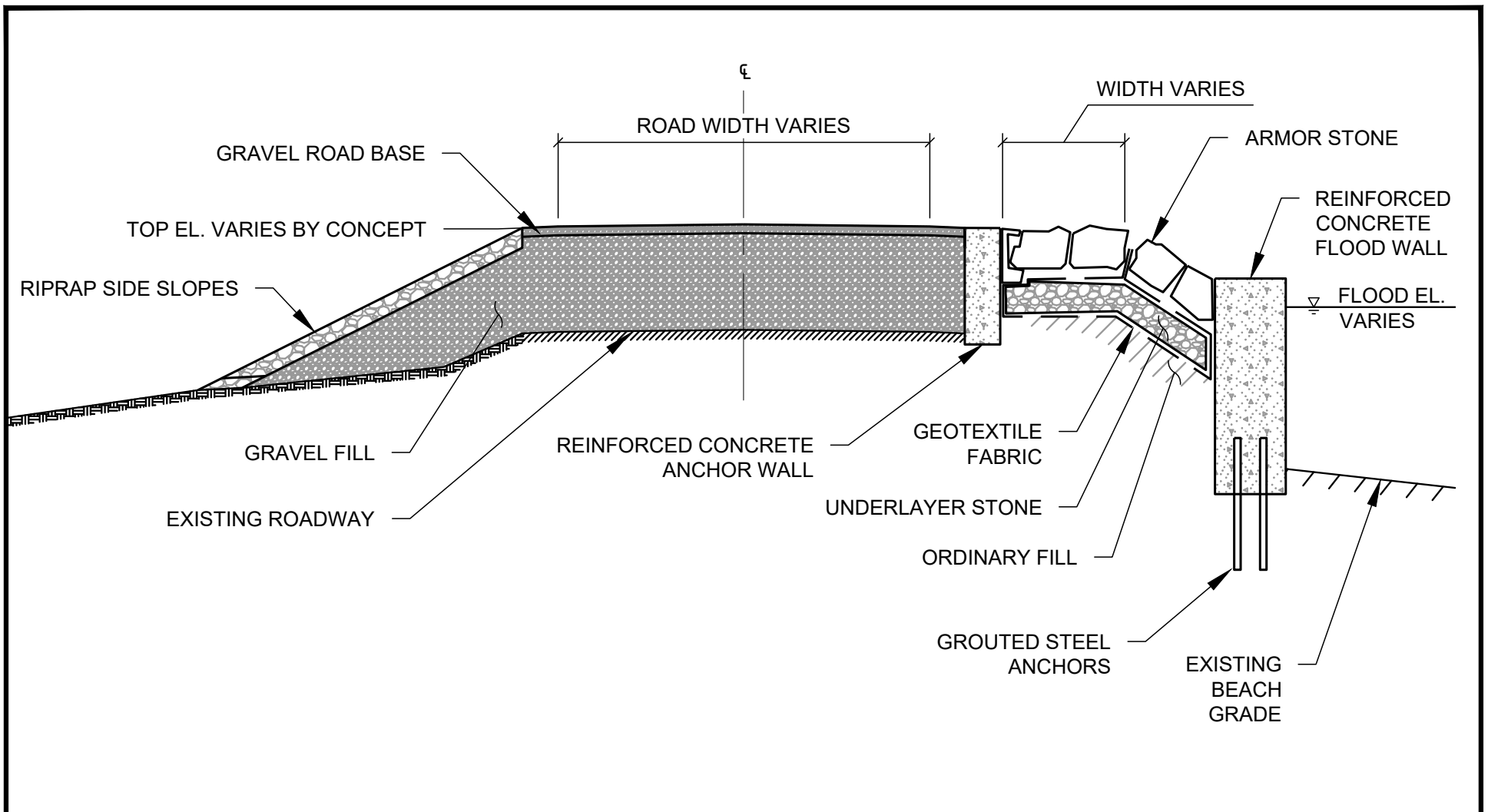


Project 2303435

ROAD ADAPTATION
CONCEPT C

December 2024

Fig. 3



ROAD ADAPTATION CONCEPT D:
RAISED ROADWAY & CONCRETE FLOODWALL
NOT TO SCALE

Brooksville Climate Vulnerability Assessment Brooksville, Maine		ROAD ADAPTATION CONCEPT D
Town of Brooksville, Maine		December 2024
Project 2303435		Fig. 4

Appendix A GIS Data Sources

Asset Name	Shapefile Name	Accessed
Roads source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/Maine_E911_Roads_Feature/FeatureServer	Maine_E911_NG_ROADS.shp	8/11/2023
Evacuation routes source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/Hurricane_Evacuation_Network/FeatureServer	Hurricane_Evacuation_Network	8/15/2023
Parcels source: https://www.maine.gov/geolib/download_parcel_by_town.html	Parcels_Blue_Hill, Parcels_Brooksville, Parcels_Surry	8/11/2023
Conservation parcels source: https://gis.maine.gov/arcgis/rest/services/acf/Conserved_Lands/MapServer/0	Maine_Conserved_Lands*	10/17/2023
Building footprints source: https://github.com/Microsoft/USBuildingFootprints	Maine.geojson	8/11/2023
Critical facilities:		
-Hospitals source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/Maine_E911_Addresses_Feature_Hospitals/FeatureServer	Maine_E911_Addresses_Feature_Hospitals	8/11/2023
-Government buildings source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/Maine_E911_Addresses_Feature_Government_Buildings/FeatureServer	Maine_E911_Addresses_Feature_Government_Buildings	8/11/2023
-Fire stations source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/Maine_E911_Addresses_Feature_Fire_Stations/FeatureServer	Maine_E911_Addresses_Feature_Fire_Stations	8/11/2023
-Schools source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/ArcGIS/rest/services/Maine_GeoLibrary_Structure/FeatureServer/8	Maine_Schools_Geolibrary	8/11/2023
Cemeteries source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/arcgis/rest/services/MaineSociety/FeatureServer	Cemeteries	9/6/2023
Boat launches source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/ArcGIS/rest/services/Maine_GeoLibrary_Structure/FeatureServer/1	Maine_Boat_Launches_GeoLibrary	8/11/2023
Large culverts source: https://gis.maine.gov/arcgis/rest/services/dot/MaineDOT_OpenData/MapServer/1	MaineDOT_Large_Culverts	8/11/2023
Cross culverts source: https://gis.maine.gov/arcgis/rest/services/dot/MaineDOT_OpenData/MapServer/54	MaineDOT_Cross_Culverts	8/11/2023
Wells source: https://services1.arcgis.com/RbMX0mRVOFNTdLzd/ArcGIS/rest/services/MGS_Wells_Database/FeatureServer	MGS_Wells	11/3/2023

Appendix B Flood Scenario and Results Tables

Flood Scenario Numbers

Flood Scenario Description	Water Surface Elevation (NAVD88, ft)	Flood Scenario Number
2050, High Tide, Commit to Manage (1.5 ft SLR)	6.7	1
2070, High Tide, Commit to Manage (2.4 ft SLR)	7.6	2
2070, High Tide, Prepare to Manage (3.0 ft SLR)	8.2	3
Present Day, 100-year Storm	9.4	4
2090, High Tide, Prepare to Manage SLR (5.0 ft SLR)	10.2	5
2050, 100-year Storm, Commit to Manage (1.5 ft SLR)	10.8	6
2070, 100-year Storm, Commit to Manage (2.4 ft SLR)	11.7	7
2070, 100-year Storm, Prepare to Manage (3.0 ft SLR)	12.3	8
2090, 100-year Storm, Prepare to Manage (5.0 ft SLR)	14.3	9

Notes: “High Tide” refers to MHHW elevation. “100-year Storm” refers to the 1% annual chance stillwater elevation.

Roads Flood Risk Exposure Summary, Length of Inundation (ft)

Road Name	Ownership	1	2	3	4	5	6	7	8	9
High Priority Roads										
Bagaduce Rd	State	-	208	305	437	522	566	624	665	872
Back Rd	Town	-	122	196	290	339	363	401	422	477
Weir Cove Rd	Town	-	7	184	532	593	627	674	710	870
Breezemere Rd	Town	-	-	-	40	115	245	369	415	572
Bridge Rd	State	-	-	-	62	125	210	226	233	260
Coastal Rd	State	-	-	-	207	268	309	367	440	736
Dog Island Rd	Town	-	-	-	38	158	299	422	641	1,330
Orcutts Harbor Rd	Town	-	-	-	-	85	114	138	152	195
Medium Priority Roads										
Goose Falls Rd	Town	-	-	-	-	-	-	176	231	358
Cape Rosier Rd	Town	-	-	-	-	-	-	-	31	398
Harborside Rd	Town	-	-	-	-	-	-	-	-	106
S Wharf Rd	Town	6	13	19	25	32	36	39	45	62
Undercliff Rd	Town	-	12	178	245	476	553	623	711	925
Captain Eels Ln	Town	-	-	3	159	213	254	270	280	302
Indian Bar Rd	Town	-	-	49	171	208	232	264	284	313
Prentice Point Rd	Town	-	-	6	34	70	83	109	114	143
Hay Landing Rd	Town	-	-	-	28	58	65	103	125	175
Judy Point Ln	Town	-	-	-	66	147	166	196	212	270
Store Point Rd	Town	-	-	-	4	21	25	102	141	298
Burnt Marsh Ln	Town	-	-	-	-	5	30	128	190	237
Clifford Field Rd	Town	-	-	-	-	6	20	47	74	160
Eugenie Ln	Private	-	-	-	-	42	66	95	105	133
Low Priority Roads										
Norumbega Rd	Town	-	-	-	-	-	-	-	48	210
Abenaki Loop Rd	Town	-	-	-	-	-	-	-	-	149
Boatyard Rd	Private	-	-	-	-	-	-	-	-	144
Horseshoe Cove Rd	Town	-	-	-	-	-	-	-	-	362
Red Trl	Town	-	-	-	-	-	-	-	-	98
Condon Point Rd	Town	-	-	-	-	-	-	-	-	12
Bakemans Rd	Town	-	-	-	-	-	-	-	71	168
Perkins Ln	Private	-	-	-	-	-	-	-	8	38
Revere Way	Private	-	-	-	-	-	-	-	1	20

Maine DOT Culverts Flood Exposure Summary (Y/N)

Culvert Location	1	2	3	4	5	6	7	8	9
Large Culverts									
Bagaduce Road <i>Approx. 1.1 miles north of the intersection with Coastal Road</i>	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cross Culverts									
Coastal Road <i>Approx. 150 ft south of Breezemere Farm Road</i>	-	-	-	Y	Y	Y	Y	Y	Y
Coastal Road <i>Near Stover Cove, approx. 0.1 miles west of Hawes Farm Road</i>	-	-	-	-	-	-	-	Y	Y
Bagaduce Road <i>Approx. 0.1 miles south of Parker Pond Road</i>	-	-	-	-	-	-	-	-	Y

Maine DOT Bridges Flood Exposure Summary

Bridge Name	1	2	3	4	5	6	7	8	9
Davis Narrows	-	-	-	Y	Y	Y	Y	Y	Y
Cape Rosier Bridge	-	-	-	-	-	-	Y	Y	Y

Buildings Flood Exposure Summary

Buildings	1	2	3	4	5	6	7	8	9
# Impacted	10	11	12	14	15	19	22	22	38
% Impacted (%)	0.9	1.0	1.0	1.2	1.3	1.6	1.9	1.9	3.3

Parcels Flood Exposure Summary

Parcels	1	2	3	4	5	6	7	8	9
# of Parcels Partially or Fully Inundated	475	482	485	491	492	498	505	507	521
% of Total Parcels Partially or Fully Inundated (%)	37.7	38.3	38.5	39.0	39.0	39.5	40.1	40.2	41.3
Area of Parcels Inundated (acre)	73	127	161	225	272	311	374	418	587
% of Total Parcel Area Inundated (%)	0.4	0.7	0.8	1.2	1.4	1.6	1.9	2.2	3.0

Cemeteries Flood Exposure Summary (Y/N)

Cemetery	1	2	3	4	5	6	7	8	9
Dodges Point	Y	Y	Y	Y	Y	Y	Y	Y	Y
Indian Bar	Y	Y	Y	Y	Y	Y	Y	Y	Y
Indian Point	Y	Y	Y	Y	Y	Y	Y	Y	Y
Moses Blake	Y	Y	Y	Y	Y	Y	Y	Y	Y
Old Bakeman	Y	Y	Y	Y	Y	Y	Y	Y	Y
Valerius Black	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jesse Gray	-	-	-	-	-	-	-	-	Y

Conservation Land Flood Exposure Summary

Conservation Land	1	2	3	4	5	6	7	8	9
Conservation Land (acres inundated)	25	42	54	72	83	93	109	122	178

Water Wells Flood Exposure Summary

Wells	1	2	3	4	5	6	7	8	9
Wells (# of locations inundated)	1	1	3	4	6	7	9	9	16

Summary of Additional Assets at Risk of Flood Inundation (Y/N)

Asset	1	2	3	4	5	6	7	8	9
Town Landing <i>Top of Boat Ramp</i>	-	Y	Y	Y	Y	Y	Y	Y	Y
Town Landing <i>Parking Lot</i>	-	-	-	-	-	-	-	-	Y
Goose Falls <i>Top of Boat Ramp</i>	-	Y	Y	Y	Y	Y	Y	Y	Y
Boat Launch near Bridge Road <i>Top of Boat Ramp</i>	-	Y	Y	Y	Y	Y	Y	Y	Y
End of S. Wharf Road <i>Boat Ramp</i>	-	-	Y	Y	Y	Y	Y	Y	Y
Bakeman Beach Parking #1 <i>Seaward of Weir Cove Road</i>	-	-	Y	Y	Y	Y	Y	Y	Y
Bakeman Beach Parking #2 <i>Weir Cove Road Corner</i>	-	-	-	-	-	Y	Y	Y	Y
Bucks Harbor Yacht Club <i>Top of Pier</i>	-	-	-	Y	Y	Y	Y	Y	Y
Bucks Harbor Marina Parking <i>Top of Pier</i>	-	-	-	Y	Y	Y	Y	Y	Y
Bagaduce Lunch <i>Top of Pier / Parking Area</i>	-	-	-	-	Y	Y	Y	Y	Y
Seal Cove Boat Yard <i>Top of Launch</i>	-	-	-	-	-	-	-	-	Y

Appendix C Bakeman Beach Sand Dune Geology



Maine Geological Survey

Address: 93 State House Station, Augusta, Maine 04333
Telephone: 207-287-2801 **E-mail:** mgs@maine.gov
Home page: www.maine.gov/dacf/mgs/

Coastal Sand Dune Geology Bakeman Beach, Brooksville, Maine

by Peter A. Slovinsky and Stephen M. Dickson
Open-File Map No. 23-331
2023

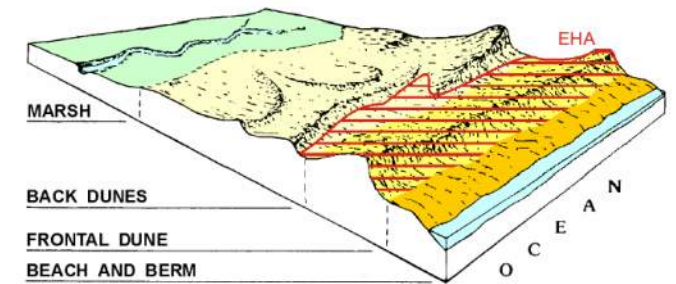
MAPPING MAINE'S DYNAMIC DUNES

"Coastal sand dune systems" are sand and gravel deposits within a marine beach system, including, but not limited to, beach berms, frontal dunes, dune ridges, back dunes and other sand and gravel areas deposited by wave or wind action. Coastal sand dune systems may extend into coastal wetlands. Coastal sand dune systems include dunes that may have been artificially created, dunes that may have been altered by development activity, and dunes supported by sand fencing or stabilization structures. Coastal sand dune systems naturally migrate landward through the process of overwash. For the purposes of this definition, a small windblown accumulation of sand within a street is not considered a dune. Maine's coastal beaches and dunes are constantly changing. Erosion or accretion can reshape the beach and dunes over time so remapping is needed for resource protection and coastal development. This map series updates and supersedes the previous Coastal Sand Dune Geology Maps of 2011 (Slovinsky and Dickson, 2011) and the Beach and Dune Geology Aerial Photo series maps (Dickson, 2001). The extent of coastal sand dunes were mapped using available aerial orthoimagery, lidar (light detection and ranging) topographic data, permit reviews, and field evaluations. Erosion Hazard Area boundaries were mapped according to the existing definition using historical shoreline change data, geomorphology, FEMA flood maps, and field evidence of storm washover in dunes.

COASTAL SAND DUNE RULES

The Maine Natural Resources Protection Act (NRPA: Title 38 Section 480-D) requires that new coastal development will not unreasonably (1) interfere with the natural supply or movement of sand or gravel within or to the sand dune system; (2) increase the erosion hazard to the sand dune system; (3) cause or increase the flooding of the dunes or adjacent properties; (4) interfere with the natural flow of any surface or subsurface waters; (5) inhibit the natural transfer of soil from the terrestrial to marine or freshwater environments; (6) harm any significant wildlife habitat, threatened or endangered plant habitat, travel corridor, freshwater, estuarine or marine life; or (7) interfere with existing scenic, aesthetic, recreational, or navigational uses. Permits are usually required for building projects located in Maine's coastal sand dune system. The Coastal Sand Dune Rules, Chapter 355, of the Maine Department of Environmental Protection clarify the criteria for obtaining a permit under NRPA (in regard to coastal sand dune systems). The rules outline classes of projects which are exempt from the requirement of obtaining a permit. For all other projects, the rules outline standards which must be met to satisfy the statutory criteria. The rules are based on the location of the project within the sand dune system.

EXPLANATION OF MAP UNITS



D1 Frontal dune. The frontal dune is the area consisting of the most seaward ridge of sand and gravel and includes former frontal dune areas modified by development. Where the dune has been altered from a natural condition, the dune position may be inferred from the present beach profile, dune positions along the shore, and regional trends in dune width. The frontal dune may or may not be vegetated with dune vegetation and may consist in part or in whole of artificial fill. In areas where smaller ridges of sand are forming in front of an established dune ridge, the frontal dune may include more than one ridge. The frontal dune includes former frontal dune areas modified by development. Where the dune has been modified by structures, the dune position may be inferred from the present beach profile, dune positions along the shore, and regional trends in dune width.

D2 Back dunes. Back dunes consist of sand dunes and eolian sand flats that lie landward of the frontal dune or a low energy beach. Back dunes include those areas containing artificial fill over back dune sands or over wetlands adjacent to the coastal sand dune system.

 **Erosion hazard area (EHA).** Any portion of the coastal sand dune system that can reasonably be expected to become part of a coastal wetland in the next 100 years due to cumulative and collective changes in the shoreline from: (1) historical long-term erosion; (2) short-term erosion resulting from a 100-year storm; or (3) flooding in a 100-year storm after a two-foot rise in sea level, or any portion of the coastal sand dune system that is mapped as an AO flood zone by the effective FEMA Flood Insurance Rate Map, which is presumed to be located in an Erosion Hazard Area unless the applicant demonstrates based upon site-specific information, as determined by the department, that a coastal wetland will not result from either (1), (2), or (3) occurring on an applicant's lot given the expectation that an AO-Zone, particularly if located immediately behind a frontal dune, is likely to become a V-Zone after 2 feet of sea level rise in 100 years (Ch. 355, Section 3.P.).

Additional Sources of Information

Contact the Maine Department of Environmental Protection, Bureau of Land and Water Quality, 17 State House Station, Augusta, ME 04333 for information regarding the Coastal Sand Dune Rules and the Natural Resources Protection Act.



Mapping of Maine's sand dune system is performed by the Maine Geological Survey with partial funding from the Maine Coastal Program/Maine Department of Marine Resources under the Coastal Zone Management Act of 1972 as amended, through the Office for Coastal Management/National Oceanic and Atmospheric Administration.