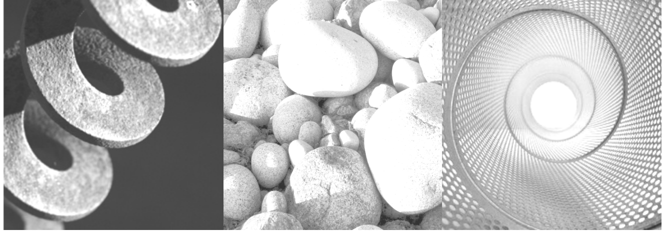

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Stonington Adaptation Report

Town of Stonington, Maine

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Project 1804859

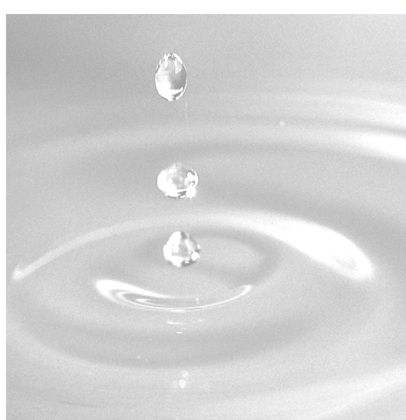

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Table of Contents

Figures

Appendices

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Acknowledgements

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We would also like to acknowledge the members of the Advisory Committee for their contributions to this project, including:

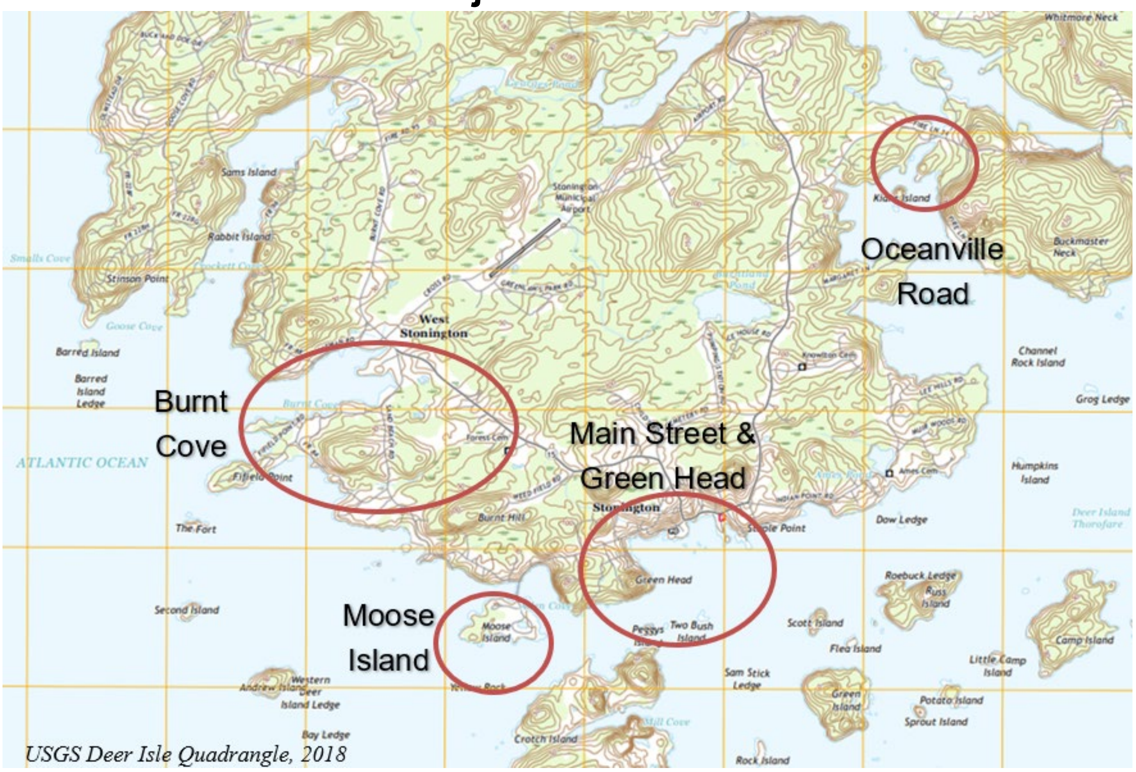
- Kathleen Billings, Stonington Town Manager
- Henry Teverow, Town of Stonington Economic Development Director
- Gay Atkinson, Stonington Sanitary District and Stonington Water Company Operator
- Benjamin Pitts, Former Stonington Water Company Superintendent
- Raelene Pert, Stonington Harbormaster
- Bill McDonnell, Stonington Resident
- Jeff Dworsky, Stonington Resident

Executive Summary

This report summarizes the work and findings of Phase II of a two-phase project to study coastal flooding in the Town of Stonington and identify ways to adapt infrastructure at risk, with Phase I being the vulnerability study (GEI, 2020), and Phase II addressing adaptation options. This adaptation report recommends timelines and heights to elevate roads and pump stations to reduce the risk of coastal flooding due to sea level rise and coastal storms. Additionally, we recommend actions for Hagen's Dock and the Rhode Island Avenue Outfall Pipe.

This study focused on four main areas in the Town of Stonington: Main Street and Green Head, Burnt Cove, Moose Island, and Oceanville Road.

Project Locations



Since the Vulnerability Report (GEI, 2020) was created, the Maine Climate Council released a four-year plan for climate action called "Maine Won't Wait" (Maine Climate Council, 2020) with guidance on sea level rise estimates to use for 2050 and 2100. The Scientific and Technical Subcommittee of the Maine Climate Council recommends planning for 1.5 ft of sea level rise by 2050 and 3.9 ft of sea level rise by 2100. These guidelines correlate closely with the estimates used for the Stonington Vulnerability Assessment, which were 1.6 ft for an Intermediate-Rate of SLR by 2050 and 4.0 ft for an Intermediate-Rate of SLR by 2100.

The Vulnerability Report (GEI, 2020) should be referred to for vulnerability assessment methodologies and results, such as sea level rise projections and maps showing flood extents.

The results of the Vulnerability Study were used to recommend adaptation actions. Each asset studied (road, pump station, etc.) was evaluated for vulnerability due to coastal storms and sea level rise in the "near-term" (2030), "intermediate-term" (2050), and "long-term" (2100). The recommended adaptation actions outlined in this report are primarily based on limiting flood exposure through 2050. Adaptation recommendations to address flood risk in the long-term (by 2100) are provided in the detailed sections of the comprehensive report for each asset, however, due to the uncertainty of sea level rise in the long-term, we recommend adapting for an earlier time horizon that has more certainty and reevaluating the 2100 flood risk at a later date. Elevation projects can be designed and constructed to be readily adaptable to further raising in the future to accommodate increased risk in the event the rate of sea level rise is accelerated above current predictions. Additionally, we have recommended cost-effective temporary adaptation actions that can be used to limit vehicular flood exposure along roads before longer-term adaptation actions are put in place, such as the warning signs seen below.

Town Roads

The following table provides a summary of the roads addressed in this project. The table is organized based on adaptation priority (i.e., roads most at risk from "no action"), with the highest priority at the top of the table and the lowest at the bottom. The table includes the approximate number of businesses and/or residences for which the road is the sole access; the detour length if the road were to be flooded or closed; the storm event that would cause flood inundation in 2030, 2050, and 2100; our recommended adaptation elevation amount to provide protection from most flooding scenarios through 2050; and the estimated cost of the adaptation for protection to 2050. Appendix B provides cost estimates for the other adaptation scenarios considered for each road. The costs provided in this report represent estimates to move forward with road adaptation, however, there are 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 (Maine Climate Council, 2020).

Higher Priority ↑ / Lower Priority ↓

Road	Approximate # of Residences/ Businesses for Which Road is Sole Access	Detour Length if Road Flooded or Closed	Minimum Elevation, ft NAVD88	Event That Will Cause Standing Water Flooding In:			Recommended Initial Amount to Raise Roads to Provide Protection from Most Flooding Scenarios Through 2050:	Approximate Segment Length for Recommended Elevation Action, ft	Total Cost	Estimated Costs to Elevate per Linear Foot of Roadbed
				2030	2050	2100				
Oceanville Road	100	No Detour Available	8.5	10-yr	HAT	MHW	2 ft	375	$260,000	$693
Whitman Road	28	No Detour Available	8.8	10-yr	10-yr	MHW	4 ft	780	$820,000	$1,051
Fifield Point Road	16	No Detour Available	9.1	10-yr	10-yr	MHW	4 ft	650	$360,000	$554
Ocean Street	8	No Detour Available	8.6	10-yr	HAT	MHW	3 ft	250	$180,000	$720
Moose Island Causeway	6	No Detour Available	8.1	10-yr	HAT	MHW	3 ft	475	$370,000	$779
Sand Beach Road	7	3+ miles	9	10-yr	10-yr	MHW	2 ft	600	$380,000	$633
Main Street	50	1.5 miles	11.3	NA	100-yr	HAT	3 ft	600	$340,000	$567
Atlantic Avenue	5	No Detour Available	13	NA	NA	10-yr	2 ft	200	$250,000	$1,250
Burnt Cove Road	3	5.5+	11	500-yr	50-yr	MHHW	2 ft	350	$220,000	$629
Bayview Avenue	5	No Detour Available	11.6	NA	500-yr	HAT	4 ft	500	$690,000	$1,380
West Main Street	25	0.2 miles	12.8	NA	NA	10-yr	2 ft	325	$250,000	$769
Colwell's Lane	NA	No Detour Available	8.4	10-yr	HAT	MHW	0 - 3 ft	0 - 100	$0 - $390,000	$0 - $3,900
Rhode Island Ave	3	No Detour Available	10	50-yr	10-yr	MHW	0 ft	0	$0	$0

We recommend that Oceanville Road, Whitman Road, Fifield Point Road, Ocean Street, and the Moose Island Causeway be given the highest priority due to the vulnerability to flooding, lack of alternate routes, and number of residences and businesses that rely on the roads as the sole access. This would amount to an estimated $2M in construction costs to elevate the highest priority roads to the recommended amount to provide protection from most flooding scenarios through 2050. These costs are approximate and are based on 2021 dollar amounts; the estimated costs do not account for complete permitting and design fees.

We recommend that West Main Street, Colwell's Lane, and Rhode Island Avenue be given the lowest priority due to lower risk in the near-term and/or fewer residences and businesses that rely on the roads or sole access. Sand Beach Road, Main Street, Atlantic Avenue, Burnt Cove Road, and Bayview Avenue would be considered moderate priority.

Plans for elevating these roads using both riprap and vertical wall stabilization are available in Fig. 11. A conceptual plan for protecting roads using a floodwall is included in Figs. 12 and 13.

Hagen's Dock

For Hagen's Dock, we recommend providing flood protection up to 4.0 ft to elevation 12.5 ft NAVD88 to prevent likely flooding through 2050. Protecting Hagen's Dock could be in the form of elevation by fill or by using a flood wall barrier. This location is also a good candidate for a temporary barrier to be employed during coastal storms to prevent flood inundation. While the Fire Station can be accessed via Atlantic Avenue, we recommend the that the Town of Stonington consider adapting both assets (Hagen's Dock and Atlantic Avenue) at the same time to benefit from cost efficiencies.

Rhode Island Avenue Outfall Pipe

For the Rhode Island Avenue Outfall Pipe, our main recommendations are to perform an updated survey of the outfall pipe invert and hire a wastewater systems design engineer to review the current use and storage capacity of the system and evaluate the potential implications that future sea water elevations might have on performance. In the short-term, we recommend consulting with a wastewater engineer to discuss the benefits of a backflow preventer.

Pump Stations

We recommend elevating the electrical equipment and controls of pump stations to prevent damage due to flooding. We have recommended elevation heights for the sensitive equipment for each pump station studied as part of this project in Section 4. The recommended elevation depends on the existing height of the equipment and the risk of flooding at each location. The next step would be to obtain survey to verify the existing elevation of electrical equipment and controls.

1. Introduction

This report documents Phase II of a two-phase project to identify and provide adaptation options for infrastructure at risk of coastal flooding for the Town of Stonington. Phase I consisted of a study to assess the vulnerability of public infrastructure to flooding from Sea Level Rise (SLR) and coastal storms. This report (Phase II) presents adaptation options for the vulnerable assets indicated in the Phase I study and is intended to be used as guidance for the Town of Stonington when performing resilience planning to protect assets from coastal flooding. The Phase I report should be referred to for recommended adaptation timelines and priorities among assets. Vulnerable assets and public infrastructure in this study refer to town-owned roads, pump stations, Hagen's Dock, and the Rhode Island Outfall Pipe.

GEI Consultants, Inc. was retained by the Town of Stonington to develop this study to address adaptation options aimed at helping the Town lessen the potential of inundated roads or infrastructure that could result in people being isolated during storm events, loss of emergency access during storm events, damage to infrastructure due to coastal storms and sea level rise, among other flood related risks to infrastructure and communities.

The vulnerability study used several flooding scenarios to evaluate risk, including three different projections of SLR, four storm surge scenarios without the effects of waves, one storm condition with the effects of waves, and six stages within the tide cycle. Flood vulnerability was assessed for existing sea levels (i.e., today) and for three future time horizons: near-term (2030), intermediate-term (2050), and long-term (2100). Sea level is understood in this study to represent the height of water measured at local tide stations relative to a specific point. This report often refers to different flood situations as "standing water flood inundation" or "flooding due to wave action or wave splash over during coastal storm events." We have differentiated the two since road infrastructure is often still useable during spray splash over from waves but may be impassable if there is standing water flood inundation due to coastal storm surge or sea level rise.

Together with Phase I, these reports will allow the Town to identify at-risk assets, prioritize adaptation timelines, and understand available adaptation alternatives.

All elevations in this report are referenced to the North American Vertical Datum of 1988 (NAVD88) unless otherwise specified.

While this study is robust there are areas that were outside the scope of work. Our study did not evaluate the structural integrity of the studied assets, including the roads, Hagen's Dock, Colwell's Ramp, the Rhode Island Ave Outfall pipe or the pump stations. For pump stations, we did not evaluate the current level of flood proofing that may exist. For pump stations, an assessment should be completed for structures before implementing flood proofing measures to ensure that flood proofing would be beneficial.

1.1 Overview of Adaptation Alternatives

There are a variety of adaptation strategies that are used in coastal settings when addressing risk of flooding due to coastal storms and sea level rise. These include protection, accommodation, policy changes, and retreat. These measures can also be thought of as regulatory measures (policy) versus infrastructure measures (protection, accommodation, retreat, etc.). It often makes sense to use a combination of these measures, such as both accommodation and policy changes. For the assets considered in this study, we have looked at adaptation through the lens of these options, with particular attention paid to infrastructure measures. Implementing policy changes was outside the scope of this study but an overview of this option is discussed in Section 1.1.3 below. We present the following strategies considered for this study.

1.1.1 Protection

Adapting to flooding due to coastal storms and sea level rise through protection measures involves implementing systems or structures to prevent floodwater from reaching the protected asset. Usually, physical barriers are used to keep flood waters away from areas to be protected. Flood walls, levees, and storm-surge barriers are examples of protective structures.

"Hard" engineered measures, such as floodwalls and levees, have traditionally been used to fortify areas against flood damage. However, "soft" measures, such as living shorelines, are becoming increasingly popular. Soft measures can be used to dampen wave energy as waves approach shorelines, thus reducing their damage potential for coastal structures.

1.1.2 Accommodation

Instead of physically preventing floodwater from reaching an area through protection, accommodation focuses on altering the asset to allow for continued usability during floods or reducing potential for structural damage. Accommodation measures include elevating assets like roads, pump stations, and buildings; increasing culvert sizes; and flood-proofing buildings and infrastructure.

When elevating a road, it is important to understand the impact to the surrounding environment, as well as to adjacent properties. For instance, elevating a road near a coastal wetland may require a vertical wall (e.g., sheet pile or concrete wall), or additional embankment protection. Alternatives that increase the footprint of impact into the coastal wetland may face challenges in permitting. Another alternative is to replace roads and causeways with bridges that allow free flow of water beneath. We have pointed out instances where vertical wall stabilization may be required to limit expansion into nearby coastal wetlands for roads in Stonington in Section 3.

1.1.3 Policy Changes

Policy changes can be implemented at municipal, state, or federal levels to reduce the impact flooding may have on people or infrastructure. By participating in the National Flood Insurance

Program (NFIP), the Town of Stonington has policies in place to reduce potential asset exposure to floods. Beyond the NFIP, policy changes can be implemented to further limit development in vulnerable coastal locations. For example, the Town's shoreland zoning ordinance could be revised to define a shoreland zone has the highest annual tide elevation plus 3 feet as the Town of Cape Elizabeth has done. Additionally, the Town could modify the Floodplain Management Ordinance to require more than NFIP minimum required freeboard as the Town of Bowdoinham has recently done.

1.1.4 Managed Retreat

Managed retreat is the coordinated movement of people and infrastructure out of areas with flood potential or danger. It is often used in low-lying areas with minimal development. Without other coordinated efforts for adaptation, some areas are forced to retreat due to frequent flooding and inaccessibility. Policy changes and regulations can facilitate a long-term managed retreat option in at-risk areas by limiting development within certain areas. In some instances, long-term managed retreat may be less costly than flood damage to infrastructure.

Some of the recommended adaptation alternatives presented for the Town of Stonington involve relocation of roadways farther inland from the shoreline. Road relocation can reduce the flood risk of a travelled route, however, relocation comes with several constraints. The Town would likely need to obtain property via eminent domain, otherwise undeveloped land would be subject to heavy construction and, depending on the topography and geology of the area, potential blasting and the associated ground velocities on water supply wells. These constraints should be evaluated when deciding upon adaptation alternatives.

1.1.5 Temporary Action

Temporary adaptation measures can be a cost-effective way to increase resilience in the near-term. Some temporary actions are listed below:

- Warning road signs indicating flooding, such as permanent road signs that flash when the street is flooded.
- Temporary road barriers blocking flooded roadways from travelers.
- A town-wide alert system to warn residents of high waters and areas prone to flooding via email, text or other methods.
- Temporary flood barriers to prevent flood water from entering an area.

2. Overview of Adaptation Measures for Roads

The dangers of flooded roads have been well studied and documented by Federal Highway Association, transportation agencies, and the National Weather Service (NWS). The NWS has developed the "Turn around Don't Drown" campaign to warn drivers against driving through roads inundated with flood water (NWS, 2020). Despite the warnings, deaths continue to occur each year due to motorists driving through flooded roads. The Centers for Disease Control and Prevention report that over half of all flood-related drownings occur when a vehicle is driven into hazardous flood water. The next highest percentage of flood-related deaths is due to walking into or near flood waters. The NWS warns drivers to never drive around the barriers blocking a flooded road. The road beneath the water may have collapsed. Furthermore, a mere 6 inches of fast-moving flood water can knock over an adult. It takes just 12 inches of rushing water to carry away most cars.

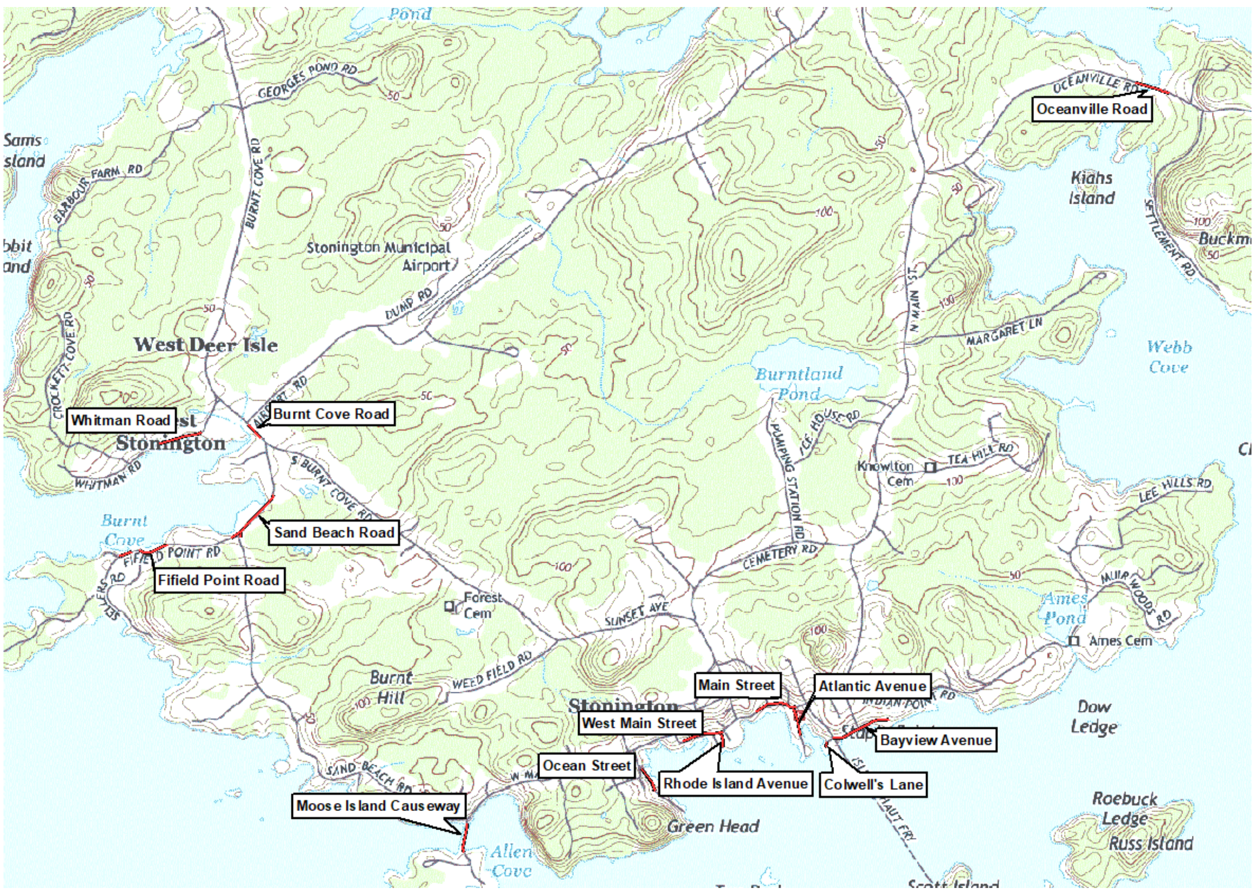
While riverine flood conditions may differ in some ways from coastal flood conditions, the risks of flooded roads are similar and real to motorists and pedestrians. It is never safe to drive or walk into flood waters whether along a river or at the coast. In addition to potential risk to human life from driving on a flooded road, there are risks from road impassibility for residents whose only means of access to emergency services may be the one flooded road. This is certainly the case for residents who live off Oceanville Road, Moose Island Causeway, Ocean Street, and Whitman Road in Stonington where only one road provides access. These important "sole access" roads are included in this study along with several other coastal roads that are at risk of flooding.

Several roads in Stonington were evaluated for their vulnerability to flooding and Section 3 of this report provides an overview of adaptation options for each of the studied roads. In addition, Appendix A provides conceptual design alternatives for adaptation options discussed in Section 3, including road elevation, flood barriers, bridges, causeways, and temporary measures, as well as an overview of regulatory constraints that might be encountered when elevating roads or considering bridges.

3. Adaptation Overview for Stonington Roads

The following subsections of Section 3 provide detailed descriptions of each road studied for this Adaptation Report, including an overview of each road's flood vulnerability, long-term adaptation alternatives, and our recommendations for adaptation. The attached Figs. 1-10 provide plan and profile drawings for the studied roads including the proposed elevation increases discussed in the following subsections. Appendix B provides order of magnitude cost estimates for the road adaptation options discussed in the following sections.

The location of the roads addressed in this study are called out in the figure below.



3.1 Main Street

Main Street is on the southern shore of Stonington and is considered the downtown region of the Town. Main Street is separated from West Main Street by the intersection with School Street and the Fish Pier Road. The portion of Main Street from School Street to Atlantic Ave is considered a long-term concern in terms of flood exposure. However, due to the economic importance of this section of road, an intermediate-term adaptation framework is recommended. The road has a close proximity and adjacency to the ocean which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues.

Main Street has a low elevation of 11.3 ft and is a long-term concern in terms of flood vulnerability. Flooding is likely to occur during 100-year and 500-year coastal storm events by 2050 and during highest annual tide by 2100, if 6.2 ft of SLR is realized.

3.1.1 Long Term Adaptation Alternatives

3.1.1.1 Elevate

Elevating Main Street would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Measures such as construction of a vertical wall may be required to provide the foundation and stability for elevating the road using fill. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Elevating the road would allow for continued vehicular use of the road during storm conditions, depending on the height of elevation. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 1:

- Elevate up to 3.0 ft (to elevation 14.3 ft NAVD88): Elevating Main Street up to 3.0 ft would likely provide flood protection from coastal storm surge and sea level rise through 2050. By 2100, flooding is likely to occur during coastal storm events.

- Elevate up to 4.0 ft (to elevation 15.3 ft NAVD88): Elevating the road up to 4.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. Flooding would be likely during 100-year and 500-year storm conditions in the year 2100 if an Intermediate rate of SLR (4.0 ft) or higher is realized.

- Elevate up to 6.0 ft (to elevation 17.3 ft NAVD88): Elevating the road up to 6.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2100, however splash over wave action may be likely in 2100 during extreme coastal storm events if 6.2 ft of SLR is realized.

3.1.1.2 Relocate

Due to the amount of businesses on Main Street, a complete relocation would be a large undertaking. However, the Town could consider relocating the through-street inland from its current location to maintain usability of a through-route during coastal storm events. A possible configuration could be created by linking Memorial Lane, off School Street, to Main Street near the intersection with Indian Point Road, or a point farther north along Route 15. This would allow access to Main Street at its current location but provide an alternate transportation route around downtown if inundation deems the road impassable.

3.1.1.3 Do Nothing

A "Do Nothing" approach to Main Street would allow inundation due to coastal storms and sea level rise on low portions of Main Street. Sections of Main Street may experience wave splash over during coastal storm events and inundation during storm events by the year 2050. By 2100, flooding would be likely during 10-year storm events and the highest annual tide. Standing flood water is estimated to have minimal damaging impact on the road itself but would likely damage businesses and structures along the route.

3.1.2 Recommendations

A long-term adaptation plan for Main Street is encouraged to allow for the continued vitality of Stonington's downtown district. We recommend elevating the road at least 3.0 ft to elevation 14.3 ft NAVD88. This would likely allow vehicular access through the year 2050 and under most coastal storm and sea level rise scenarios by 2100. However, if 6.2 ft of SLR is realized by 2100 than flooding would be likely during coastal storm events. We recommend initially elevating by 3.0 ft and reevaluating in the future for adaptation by 2100. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road. During times of impassability, users could avoid the low section of the road by bypassing the downtown area and traveling instead on Cemetery Road and School Street.

3.2 Atlantic Ave

Atlantic Ave is located in the downtown area of Stonington and provides access to the Fire Station and other business entities making it a critical road for day-to-day functionality of Stonington. The road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues. There are existing shoreline stabilization measures in place that may be at risk from future sea level rise and/or storm events.

This study focuses on the town-owned section of Atlantic Avenue, specifically from the intersection of Main Street to the southern end of the Fire Station, at which point the topography slopes downwards towards the southern end of the road. This section of Atlantic Ave has an approximate low elevation of 13.0 ft and is a long-term concern in terms of flood exposure. Note that this low elevation is approximately 2.0 ft higher than the low elevation reported in the Vulnerability Report (GEI, 2020) which is due to the change in extents of the road considered in this Phase of the project. This section of Atlantic Ave is considered a long-term concern in terms of flood exposure but due to the need to maintain access to the Fire Station, we recommend Atlantic Ave be a near-term priority.

3.2.1.1 Elevate

Elevating Atlantic Ave would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would likely require vertical wall stabilization to minimize impact on the surrounding resources. Increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Elevating the road would allow access to the residences and businesses on Atlantic Ave to be maintained, and due to the limitations related to the topography near Atlantic Ave, elevating by up to 2.0 ft was the only scenario considered, detailed below, and with conceptual plans provided in Fig. 1:

- <u>Elevate up to 2.0 ft (to elevation 15.0 ft NAVD88):</u> Elevating up to 2.0 ft would likely provide protection from standing water flood inundation due to coastal storms through 2050. By 2100, flooding would be likely during coastal storms if 6.2 ft of SLR is experienced (the Intermediate-High scenario). Raising the road higher than elevation 15.0 ft has not been considered since that would be higher than the elevation of the northern end of Atlantic Ave and such construction would need to be done in coordination with Main Street.

3.2.1.2 Build a Flood Barrier

A flood wall could be used to protect Atlantic Ave and Hagen's Dock from coastal flooding due to storm surge and sea level rise. Depending on the desired area to protect, the flood wall configuration could be such that Hagen's Dock and the town-owned portion of the road would be protected with continued access to the southern end of Atlantic Ave (south of the Fire Station). An alternate flood wall configuration could be worked out to provide protection to the end of Atlantic Ave.

3.2.1.3 Do Nothing

A "Do Nothing" approach to Atlantic Ave would likely mean flood inundation during 100-yr coastal storm events with wave action in the near-term, which may limit accessibility to the Fire Station during storm events. Standing flood water would have minimal damaging impact on the road, but wave action during coastal storm events may damage the existing revetment structure.

3.2.2 Recommendations

A long-term adaptation plan for Atlantic Ave is encouraged to allow for continued access to the Fire Station. We recommend protecting the road to 15.0 ft NAVD88 to allow access to the road and Fire Station through 2050. By 2100, flooding due to splash over from wave action and/or up to 6.0 inches of standing water flooding may occur in low sections of the road for 100-year coastal storm events if 6.2 ft of SLR is realized. Protection could be in the form of elevating, building a flood barrier, or a combination of the two. In the interim, short-term solutions can be utilized, such as housing a firetruck in an alternate location to be accessible during storm events. Temporary flashing light flood warning systems during storm events or temporary flood barriers can be used to reduce flood inundation at low-lying portions of the road. Maintaining access to the Fire Station is important in adapting Atlantic Ave. If the Town chooses to raise the roads to El. 15.0 ft, consideration should be given in the grading design to ensure emergency vehicles can access the Fire Station.

Due to the proximity of Hagen's Dock, it is recommended that Atlantic Ave and Hagen's Dock be addressed simultaneously. Recommendations for adapting Hagen's Dock are outlined in Section 5.

3.3 West Main Street

West Main Street is on the southern shore of Stonington and runs between Green Head Road and the intersection with Main Street at the Fish Pier Road and School Street. It is considered in the downtown region of the Town. West Main Street is a long-term concern in terms of flood exposure. It is elevated slightly higher than Main Street and subjected to less direct wave action. However, due to the density of houses and businesses along this road, an intermediate-term adaptation framework is recommended. The road has a close proximity and adjacency to the ocean which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues.

West Main Street has a low elevation of 12.8 ft and is a long-term concern in terms of flood vulnerability. Flood inundation due to coastal storms and sea level rise is likely by 2100 if an Intermediate rate of SLR (4.0 ft) is realized.

3.3.1 Long Term Adaptation Alternatives

3.3.1.1 Elevate

Elevating West Main Street would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Measures such as construction of a vertical wall may be required to provide the foundation and stability for elevating the road using fill. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Elevating the road would allow for continued vehicular use of the road during storm conditions, depending on the height of elevation. Two elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 2:

- Elevate up to 2.0 ft (to elevation 14.8 ft NAVD88): Elevating Main Street up to 2.0 ft would likely provide flood protection from coastal storm surge and sea level rise through 2050. Flooding may occur during coastal storm conditions for intermediate-high rates of SLR (6.2 ft) by 2100.

- Elevate up to 4.0 ft (to elevation 16.8 ft NAVD88): Elevating the road up to 4.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2100, however flooding due to wave splash over during a 100-year event may occur in the year 2100 of an intermediate-high rate of SLR (6.2 ft) is realized.

3.3.1.2 Build a Flood Barrier

A flood barrier along an approximate 200 ft low-lying section of the road west of the intersection with Rhode Island Ave could be used to lessen the effects of flood inundation along West Main Street. However, due to the proximity of buildings along this route, it would likely be difficult to position a floodwall in this area without impacting nearby businesses while also allowing for flood protection. While building a flood wall could reduce flood impacts, it is not our recommended action at this location.

3.3.1.3 Do Nothing

A "Do Nothing" approach to West Main Street would allow inundation due to coastal storms and sea level rise on low portions of the road. Sections of West Main Street may experience wave splash over during coastal storm events and inundation during storm events by the year 2050. By 2100, flood inundation would be likely during a 10-year storm event if an Intermediate-High rate of SLR (6.2 ft) is realized and during a 50-year storm event if an Intermediate rate of SLR (4.0 ft) is realized. During times of impassability, users could avoid the low section of the road by bypassing West Main Street altogether and traveling on neighboring streets.

3.3.2 Recommendations

A long-term adaptation plan for West Main Street is encouraged to allow for the continued vitality of Stonington's downtown district. We recommend elevating the road by a minimum of 2.0 ft to elevation 14.8 ft NAVD88 by 2050. This would likely allow for continued vehicular access during the coastal storm and sea level rise scenarios studied through the year 2050, and for most coastal storm and sea level rise scenarios studied by the year 2100. However, if 6.2 ft of SLR is realized by 2100, the road may be flooded by up to 9.0 inches during 100-year storms in 2100. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms, or road barriers to encourage alternate travel routes during times of flood inundation.

3.4 Rhode Island Avenue

Rhode Island Ave is a dead-end street off West Main Street in the downtown region of Stonington. Several residences and a U.S. Post Office are located along Rhode Island Avenue. Additionally, the outfall pipe for the wastewater treatment system is located at the end of the street. The end of the road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues. There are existing riprap revetments located near the end of the street.

Rhode Island Avenue is a long-term concern in terms of flood vulnerability. The southern end of the road is lowest in elevation, with a low elevation of approximately 10.0 ft. Flooding at the end of the road is likely during 100-year and 500-year events in the near term, during 50-year events by 2050, and during high tide conditions by 2100.

3.4.1 Long Term Adaptation Alternatives

3.4.1.1 Elevate

Elevating Rhode Island Avenue would lessen the risk of flooding due to coastal storms and sea level rise. Due to the surrounding topography of Rhode Island Ave, elevating the road can only occur with vertical wall stabilization on either side and at the southern extent. This would allow access to the end of the road, but access to driveways off of Rhode Island Ave would be difficult unless the driveways were also elevated. Additionally, there are two piers accessed from the end of the street which would also need to be elevated to continue to allow access from Rhode Island Ave. Depending on the access needs to driveways off Rhode Island Ave, the extent of elevation may be limited. Due to the end of the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 2:

- <u>Elevate up to 2.0 ft (to elevation 12.0 ft NAVD88):</u> Elevating the road up to 2.0 ft would likely provide protection from flood inundation due to standing water from coastal storms and sea level rise through 2050, however flooding due to wave splash over during 100-yr coastal events is still likely. By 2100, flooding is likely during coastal storms and sea level rise.

- Elevate up to 4.0 ft (to elevation 14.0 ft NAVD88): Elevating the road up to 4.0 ft would likely provide protection from standing water flood inundation due to coastal storms and sea level rise through the year 2050. However, splash over flooding due to wave action during 100-yr storm events is likely. By 2100, flooding would be likely during coastal storm events if 6.2 ft of SLR is realized.

3.4.1.2 Build a Flood Barrier

Building a flood barrier at the shoreline of Rhode Island Avenue would reduce the effects of flooding at Rhode Island Ave. Due to the topography of the area, a flood barrier would likely need to be located along most of the shoreline between the Fish Pier and West Main Street to the west of Rhode Island Ave. The height of the wall would determine the level of flood protection and designing a wall that could be built upon in the future as sea level rise increases flood risk would be recommended. Additionally, a combination of fill and a flood barrier could be used to lessen the visual impact of a wall.

3.4.1.3 Do Nothing

A “Do Nothing” approach to Rhode Island Ave would allow inundation due to coastal storms and sea level rise on the lower portion of the road. The lower section of Rhode Island Avenue, at the end of the road, would likely experience flooding during 100-year storm events in the near term, during 50-year storm events in 2050, and during highest annual tide conditions by 2100. Standing flood water is estimated to have minimal damaging impact on the road itself, but wave action during coastal storm events may damage the existing riprap revetment and wash out sections of the road. During periods of inundation, users may not be able to access the end of the street that is lower in elevation.

3.4.2 Recommendations

A long-term adaptation plan for Rhode Island Avenue is encouraged to allow for continued access of the private residences along Rhode Island Avenue. However, elevating Rhode Island Avenue or constructing a flood barrier would be major projects for the Town of Stonington and the road is currently considered a long-term concern. It is not a through street and several of the nearby residences have alternate access points. Additionally, elevating the road would prevent access to the two nearby piers. Because of this, we recommend holding off on adaptation measures until 2050 and reevaluating the flood risk and priorities for the Town of Stonington. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road.

3.5 Bayview Avenue

Bayview Avenue is located east of the downtown region, extending northeast from Seabreeze Ave and the intersection of Colwell's Lane to Little Bay Seafood. The road provides access to local businesses and residents but does not operate as a through street for vehicular traffic. The road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues. There is an existing revetment wall that stabilizes the road.

Bayview Avenue is a long-term concern in terms of flood vulnerability. The lowest elevation of the road is approximately 11.6 ft, with flooding likely due to splash over from storm events in the near term, and flood inundation due to coastal storms and sea level rise likely by the year 2100.

3.5.1 Long Term Adaptation Alternatives

3.5.1.1 Elevate

Elevating Bayview Avenue would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to the shoreline, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Extending upon the existing vertical wall would allow for minimal footprint increase and provide the foundation and stability for elevating the road using fill. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Consideration would need to be given to drainage on the northern side of the road to reduce the potential for ponding during rain events. Elevating the road would allow for access to the residences and businesses along Bayview Avenue to be maintained, depending on the height of elevation. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 3:

- Elevate up to 2.0 ft (to elevation 13.6 ft NAVD88): Elevating the road up to 2.0 ft would likely provide protection from flood inundation due to coastal storms and sea level rise through 2050, although flooding due to wave splash over would still be likely. By 2100, flood inundation due to coastal storms and sea level rise would be likely if an Intermediate-High rate of SLR (6.2 ft) is realized.

- Elevate up to 4.0 ft (to elevation 15.6 ft NAVD88): Elevating the road up to 4.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050, with a chance of wave splash over occurring by 2050 if an Intermediate-High rate of SLR (2.3 ft) is realized. Flooding due to wave splash over would be likely by 2100 for 100- and 500-year events.

- Elevate up to 6.0 ft (to elevation 17.6 ft NAVD88): Elevating the road up to 6.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. The road would remain at risk of flooding in the year 2100 due to wave splash over during storm conditions if an Intermediate-High rate of Sea Level Rise (6.2 ft) is realized.

3.5.1.2 Build a Flood Barrier

A flood barrier along Bayview Ave could be used to lessen the effects of flood inundation along the street. The height of the wall would determine the level of flood protection and designing a wall that could be built upon in the future as sea level rise increases flood risk would be recommended. Additionally, a combination of fill and a flood barrier could be used to lessen the visual impact of a wall.

3.5.1.3 Do Nothing

A “Do Nothing” approach to Bayview Avenue would allow inundation due to coastal storms and sea level rise on low portions of Bayview Avenue. Sections of Bayview Avenue may experience flooding due to wave splash over during 100-year storm events in the near term. The area most likely to experience flooding is northeast of the intersection with Granite Street. Access to the end of Bayview Avenue may be limited during coastal storm events. Standing flood water is estimated to have minimal damaging impact on the road itself, but wave action during coastal storm events may damage the revetment and wash out sections of the road.

3.5.2 Recommendations

A long-term adaptation plan for Bayview Avenue is encouraged to allow for continued access of the residences and businesses along Bayview Avenue. We recommend protecting the road to an elevation of 15.6 ft NAVD88, either through elevation or by building a barrier, by 2100. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road.

3.6 Colwell's Lane and Colwell's Ramp

Colwell's Lane is a dead-end street that stems from the intersection of Seabreeze Ave and Bayview Ave and provides access to the Colwell Ramp and the landing area next to the Isle au Haut Boat Service building. The landing currently has a vertical wall used to stabilize the shoreline.

Colwell's Lane has a low elevation of 8.4 ft and is a near-term concern in terms of flood vulnerability. Flooding is likely to occur during coastal storm events in the near term and during high tides by 2100. The following sections describe adaptation alternatives for Colwell's Lane and the landing area for Colwell's Ramp.

3.6.1 Long Term Adaptation Alternatives

3.6.1.1 Elevate

Elevating Colwell's Lane would lessen the risk of flooding due to coastal storms and sea level rise. Due to the limitations in topography of the area, elevating Colwell's Lane would require vertical wall stabilization, and elevating above 11.4 ft NAVD88 (up to 3.0 ft of raising) is the only scenario being considered. Beyond this height, elevating the road and landing becomes more impractical given the existing topography, coordinating use with the boat ramp, and the presence of nearby buildings. The flood protection that elevating by up to 3.0 ft would provide is detailed below, and conceptual plans are provided in Fig. 3:

- <u>Elevate up to 3.0 ft (to elevation 11.4 ft NAVD88):</u> Elevating Colwell's Lane up to 3.0 ft would likely provide flood protection from standing water flood inundation from coastal storms and sea level rise through the year 2050, however splash over due to wave action from coastal storms would remain likely in 2030 and 2050. By 2100, flooding would be likely during coastal storms and during highest annual tide conditions if 6.2 ft of SLR in realized.

3.6.1.2 Build a Flood Barrier

A flood wall could be used to lessen flood impact on Colwell's Lane and the Colwell Ramp landing area from coastal flooding due to storm surge and sea level rise. Depending on the desired area to protect, the flood wall configuration could be such that the landing area is protected, with an opening to access the boat ramp. The opening could be closed using temporary flood wall measures during coastal storm events. A flood wall could also be used in conjunction with elevating the road and landing area in order to lessen the visual impact of a floodwall.

3.6.1.3 Do Nothing

A "Do Nothing" approach to Colwell's Lane and the Colwell Ramp landing area would allow flood inundation during coastal storms and sea level rise on low portions of the road and landing area. During coastal storms the lower portions of the road and the landing may be unusable due to standing water flood inundation. Standing flood water is estimated to have minimal impact on the road and landing area, but wave action may damage the current revetment structure at the landing. By 2100, flooding would be likely on lower portions of the road during high tide conditions.

3.6.2 Recommendations

A long-term adaptation plan for Colwell's Lane would likely reduce overtopping flooding during coastal storms and sea level rise. However, Colwell's Lane is not a critical street for transportation and the existing structure will likely tolerate occasional flooding during coastal storm events and thus may not be a priority for the Town of Stonington. However, when or if the Town chooses to adapt this road, we recommend elevating the road by a minimum of 3.0 ft to elevation 11.4 ft NAVD88 by 2030. While splash over flooding due to wave action would still be likely, standing water flood inundation from most coastal storms studied would likely not impact the road and landing through the year 2050. However, if an intermediate-rate of SLR (2.3 ft) is realized by 2050, standing water flood inundation may occur during a 500-year storm event. In the interim, short-term solutions are recommended such as temporary barriers to prevent access to the landing area during periods of inundation.

3.7 Oceanville Road

Oceanville Road is the only road that connects Buckmaster Neck and Oceanville to the rest of Stonington. Every one of the approximately 100 residences on Buckmaster Neck and Oceanville rely on this road for vehicular access. The road is a near-term concern in terms of flood exposure and flooding has been observed in recent history.

The lowest elevation of the road is approximately 8.5 ft. Flooding is likely from coastal storms in the near term and during high tide conditions by 2100. The road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues. This road is a candidate for causeway or bridge consideration due to the length of the coastal wetland that it crosses over.

3.7.1 Long Term Adaptation Alternatives

3.7.1.1 Elevate

Elevating the Oceanville Road would transform the road into a causeway as seas continue rising. Due to the road's proximity to a coastal wetland, elevating the road would likely require vertical wall stabilization to minimize impact on the surrounding resources. Elevating the road would allow for access to the residences and businesses on Buckmaster Neck and Oceanville during future coastal storm events, depending on the height of elevation. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 4:

- <u>Elevate up to 2.0 ft (to elevation 10.5 ft NAVD88):</u> Elevating up to 2.0 ft would likely provide protection from standing water flood inundation due to coastal storms and sea level rise through the year 2050, although the road may experience flooding by 2030 from 500-year coastal events or due to wave action from 100-year events. By 2050, flooding would be likely due to 100-year storms. By 2100, flooding would be likely during high tide events.

- <u>Elevate up to 4.0 ft (to elevation 12.5 ft NAVD88):</u> Elevating the road up to 4.0 ft would likely provide flood protection from coastal storms and sea level rise through the year 2050. By 2100, flooding would be likely during coastal storm events and during highest annual tide if 6.2 ft of SLR is realized.

- <u>Elevate up to 6.0 ft (to elevation 14.5 ft NAVD88):</u> Elevating the road up to 6.0 ft would likely provide protection from flooding through 2050. By 2100, flooding due to coastal storms would be likely if 6.2 ft of SLR is realized.

3.7.1.2 Build a Bridge

Converting Oceanville Road into an open span bridge and elevating it above the current configuration would reduce the risk of flooding, increase the chances of maintained vehicular access to Buckmaster Neck and Oceanville, and improve ocean water flow. The risk reduction would be dependent on the height of the bridge. Maine DOT Bridge Design Guide standards (2003) require that the lowest structural member of a bridge be a minimum of 2 ft of freeboard above MHW plus an additional 4 ft to account for SLR. For Oceanville Road, this would mean the lowest structural member would need to be at 10.6 ft NAVD88 or higher. Depending on the design, the top of the road deck could be several feet higher. We would recommend the top of the road deck elevation to follow one of the three scenarios outlined above. A bridge would create hydraulic connectivity underneath the road, something not currently present, that would change the coastal hydrodynamics in the immediate vicinity of the bridge. It would be important to work with regulators at the beginning of the process if converting the road to a bridge is the adaptation option chosen in order to optimize environmental benefit and to ensure a successful permitting process.

3.7.1.3 Do Nothing

A "Do Nothing" approach to Oceanville Road would likely mean flood inundation during storm events in the near-term. By 2100, the road would likely be flooded during high tide events. Standing flood water is estimated to have minimal damaging impact on the road and causeway itself, but wave action during coastal storm events may erode the existing structure.

3.7.2 Recommendations

A long-term adaptation plan for Oceanville Road is encouraged to allow for continued vehicular access to Buckmaster Neck and Oceanville. We recommend elevating the road (either by elevating with fill or by converting to an open span bridge) by a minimum of 2.0 ft to elevation 10.5 ft NAVD88 by 2030 and an additional 2.0 ft to elevation 12.5 ft NAVD88 by 2050. Due to the cost and complexity of completing such a project and the lifespan associated with the improvements, we recommend that the road be elevated by 4.0 ft to 12.5 ft NAVD88 in the near-term. This would allow for continued vehicular access during coastal storm conditions and sea level rise scenarios studied through the year 2050, at which point the road can be reevaluated again for further elevation increases. There are many considerations to make when deciding on elevation using fill or converting to a bridge. Converting this road to a bridge would reduce the amount of infrastructure subject to flooding and wave action by elevating it above the water surface and would minimize the footprint of the structure within the coastal wetland. It would also create a hydraulic connection from either side of the road that would alter the existing wetland areas surrounding the road. A detailed environmental impact study and hydrologic and hydraulic analysis would be recommended to understand the full impacts of this decision. Additionally, design considerations, such as off-ramps, will need to be made to accommodate the existing driveways and access roads that stem from Oceanville Road near the low-lying areas. Due to the topography of the area and proximity to coastal wetlands, conversations with permitting regulators in the beginning of the process are encouraged to increase the likelihood of a successful permitting process. Converting this road to a bridge would be a more costly option but may provide increased resiliency and we encourage a more detailed study of this road when making a decision about elevating the road with a bridge versus using fill. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road.

3.8 Whitman Road

Whitman Road is located on the northern side of Burnt Cove and serves as the main connection from Route 15A, providing access to approximately 28 residential properties. The road has a close proximity and adjacency to the ocean and coastal wetlands, which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues. There is an existing riprap revetment that stabilizes the lowest portion of the road.

Whitman Road is a near-term concern in terms of flood vulnerability. The lowest elevation of the road is approximately 8.8 ft, with flooding likely during storm events by the year 2030 and during high tides by the year 2100.

3.8.1 Long Term Adaptation Alternatives

3.8.1.1 Elevate

Elevating Whitman Road would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Measures such as construction of a vertical wall may be required to provide the foundation and stability for elevating the road using fill. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Consideration would need to be given to drainage on the northern side of the road to reduce the potential for ponding during rain events. Elevating the road would allow for access to the residences on Whitman Road to be maintained, depending on the height of elevation. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 5:

- <u>Elevate up to 2.0 ft (to elevation 10.8 ft NAVD88):</u> Elevating Whitman Road up to 2.0 ft would provide likely provide flood protection from the coastal storm events and sea level rise amounts investigated in this study by the year 2030, with up to 5 inches of flooding possible during a 500 year storm if an Intermediate-High rate of SLR (1.2 ft). By 2050, flooding would be likely during 100-yr coastal storm events. By 2100, flooding would be likely during coastal storm events and during high tide conditions if an Intermediate-High rate of SLR (6.2 ft) is realized.

- <u>Elevate up to 4.0 ft (to elevation 12.8 ft NAVD88):</u> Elevating the road up to 4.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. Flooding would be likely during storm conditions by the year 2100.

- Elevate up to 6.0 ft (to elevation 14.8 ft NAVD88): Elevating the road up to 6.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. The road would remain at risk of flooding in the year 2100 during storm conditions if an Intermediate-High rate of SLR (6.2 ft) is experienced.

3.8.1.2 Relocate

Relocating Whitman Road by moving the road inland approximately 300 ft, allowing access to the residences from the north as opposed to the current alignment from the south, would reduce the risk of coastal flooding causing damage and/or inaccessibility to the residences. Depending on an alignment chosen, the road may be high enough in elevation or far enough inland that it would be removed from the projected flooding due to the worst-case-scenario event that we studied, a 1% annual chance storm with 6.2 ft of SLR.

3.8.1.3 Do Nothing

A “Do Nothing” approach to Whitman Road would allow inundation due to coastal storms and sea level rise on low portions of the road. Sections of Whitman Road may be inundated by up to 1.7 ft of water in 2030 during 1% annual chance coastal events and an Intermediate-High amount of SLR. Flooding would likely occur during 10-year storms under the three sea level rise scenarios studied for the years 2030, 2050, and 2100. Standing flood water is estimated to have minimal damaging impact on the road itself, but wave action during coastal storm events may damage the existing riprap revetment and wash out sections of the road.

3.8.2 Recommendations

A long-term adaptation plan for Whitman Road is encouraged to allow for continued access by the private residences who rely on this critical infrastructure for daily and emergency needs. We recommend elevating the road by 4.0 ft to elevation 12.8 ft NAVD88. This would likely provide protection from flooding from the estimated 500-yr coastal event through 2050. Alternately, the road could be elevated by 2.0 ft to 10.8 ft NAVD88 by 2030 and then by another 2.0 ft to elevation 12.8 ft NAVD88 by 2050. At that time, the road can be reevaluated for protection to 2100 based on the benefit of updated sea level and storm observations across the period from 2020 to 2050. Additionally, relocating the road is another adaptation option the Town could consider. Either option (elevation or relocating) is recommended since there are approximately 28 residences that rely on this road as their only access. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road.

3.9 Burnt Cove Road

Burnt Cove Road is located along Burnt Cove and is a critical travel route between the southern and western areas of Stonington. The low point of the road, near the Burnt Cove Market, and between the intersection of Sand Beach Road and Whitman Road, is expected to experience flooding by 2050 during a 50-year storm surge and an Intermediate-High (2.3 ft) amount of SLR.

Burnt Cove Road has a low elevation of 11.0 ft and is an intermediate-term concern in terms of flood vulnerability.

3.9.1 Long Term Adaptation Alternatives

3.9.1.1 Elevate

Elevating Burnt Cove Road would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Measures such as construction of a vertical wall may be required to provide the foundation and stability for elevating the road using fill. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Elevating the road would allow for continued vehicular use of the road during storm conditions, depending on the height of elevation. Two elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 6:

- <u>Elevate up to 2.0 ft (to elevation 13.0 ft NAVD88):</u> Elevating Burnt Cove Road up to 2.0 ft would likely provide flood protection from coastal storms and sea level rise through 2050. By 2100, flooding is likely during coastal storms if an intermediate (4.0 ft), or higher, amount of SLR is realized.

- <u>Elevate up to 4.0 ft (to elevation 15.0 ft NAVD88):</u> Elevating the road up to 4.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. Flooding would be likely during storm conditions in the year 2100 if an Intermediate-High rate of SLR (6.2 ft) is realized.

3.9.1.2 Relocate

Relocating Burnt Cove Road farther inland, or along the northeastern side of Burnt Cove Market, would likely reduce the risk of coastal flooding and maintain usability of the road during coastal storm events. If relocation of Burnt Cove Road is considered, a reconfiguration of Sand Beach Road should be considered concurrently to allow for a relocation of the intersection of Sand Beach Road with Burnt Cove Road.

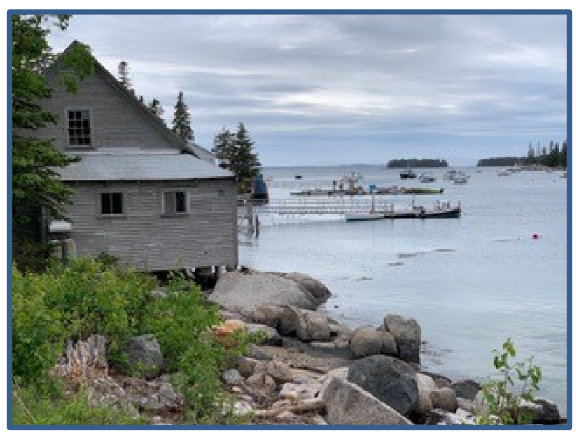
3.9.1.3 Do Nothing

A "Do Nothing" approach to Burnt Cove Road would allow inundation due to coastal storms and sea level rise on low portions of Burnt Cove Road. However, the road would likely only experience occasional wave splash over during coastal storm events in the near term. By 2050, the road may experience occasional inundation during coastal storm events if 2.3 ft of SLR is realized. If a portion of the road becomes impassable due to flood inundation, users can avoid the area by using the Airport Road.

3.9.2 Recommendations

Planning for long-term adaptation for Burnt Cove Road by 2050 is encouraged to allow for continued use of the road during coastal storms in the years 2050 through 2100. We recommend elevating by a minimum of 2.0 ft to elevation 13.0 ft NAVD88 by 2050. This would likely allow for continued vehicular access through the year 2050 for the coastal storm and sea level rise scenarios studied. The road should then be reevaluated in the future to see elevation requirements to protect through the year 2100. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme storm events when wave splash over may occur.

3.10 Fifield Point Rd



Fifield Point Rd is located on the southern side of Burnt Cove. Several residences and businesses, such as Fifield Lobster Co., are located alongside the road. Residences along Willie's Way and FR 85B are accessed via Fifield Point Rd. The road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues.

Fifield Point Rd is a near-term concern in terms of flood vulnerability as it is likely to experience flooding during coastal storm events in the near-term. The elevation of the lowest point of the road is approximately 9.1 ft. Note that this elevation is lower than what was reported in the Vulnerability Report (GEI, 2020) due to an adjustment of the road centerline location. It is important to note that the current BFE issued by FEMA is higher in elevation than the future 100-year flood levels determined during the Vulnerability Report (GEI, 2020). This is because FEMA's BFEs are based on shoreline transects and the results are coarser than the future 1% flood elevation determined for this study, meaning that the FEMA result from one transect will depict the flood elevation for a larger swath of land and flood elevations may be less accurate.

3.10.1 Long Term Adaptation Alternatives

3.10.1.1 Elevate

Elevating Fifield Point Rd would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would likely require vertical wall stabilization to minimize impact on the surrounding resources. Increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Elevating the road would allow for access to the residences, businesses, and private roads off Fifield Point Rd to be maintained, depending on the height of elevation. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 7:

- Elevate up to 2.0 ft (to elevation 11.1 ft NAVD88): Elevating up to 2.0 ft would likely provide protection from flooding due to coastal storm events and sea level rise in 2030. By 2050, flooding is likely during coastal storms if an Intermediate-High rate of SLR is realized (2.3 ft). Flooding would remain likely for coastal storms and sea level rise conditions in 2100.

- Elevate up to 4.0 ft (to elevation 13.1 ft NAVD88): Elevating the road up to 4.0 ft would likely provide protection from coastal storms and sea level rise in the 2030 and 2050 timeframe. By 2100, flooding would be likely during coastal storm events.

- Elevate up to 6.0 ft (to elevation 15.1 ft NAVD88): Elevating the road up to 6.0 ft would likely provide protection from the storm conditions and sea level rise scenarios studied in the 2030 and 2050 timeframes. Flooding is likely to occur in 2100 during 100-year storm events if 6.2 ft of SLR is realized.

3.10.1.2 Relocate

Relocating Fifield Point Road by moving it farther inland to a higher elevation would reduce the risk of coastal flooding causing damage and/or inaccessibility to residences, businesses, and residential streets located along Fifield Point Road. Depending on an alignment chosen, the road may be high enough in elevation, or far enough inland, that it would be removed from the projected flooding due to the worst-case-scenario event that we studied, a 1% annual chance storm with 6.2 ft of SLR.

3.10.1.3 Do Nothing

A "Do Nothing" approach to Fifield Point Road would likely mean flood inundation during storm events in the near term. Standing flood water would have minimal damaging impact on the road, but wave action during coastal storm events may damage the existing shoreline stabilization structures requiring repairs and continued maintenance.

3.10.2 Recommendations

A long-term adaptation plan for Fifield Point Road is encouraged to allow for continued access to the businesses and residences located alongside this road. We recommend adaptation measures to protect against most flooding scenarios through the year 2050. This could be either a relocation of the road or elevating the road by a minimum of 4.0 ft to elevation 13.1 NAVD88 to allow for vehicular access to continue for most conditions studied through the year 2050 under 100-year storm conditions. In the interim, short-term solutions can be utilized, such temporary flashing light flood warning systems during storm events.

3.11 Sand Beach Road

Sand Beach Road is located along Burnt Cove and provides access from Burnt Cove to Fifield Point and the southern side of Stonington, including Moose Island and Green Head. The stretch of Sand Beach Road between Fifield Point Road and Burnt Cove Road is the section of road addressed in this study. The road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues.

Sand Beach Road has a low elevation of 9.0 ft and is a near-term concern in terms of flood vulnerability. Flooding is likely to occur during coastal storm events in the near term and during high tides by 2100.

3.11.1 Long Term Adaptation Alternatives

3.11.1.1 Elevate

Elevating Sand Beach Road would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Measures such as construction of a vertical wall may be required to minimize impact to coastal resources while providing the foundation and stability for elevating the road. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Consideration would need to be given to maintain drainage from the marsh on the southern side of the road, such as increased culvert capacity. Elevating the road would allow for continued vehicular use of the road during storm conditions, depending on the height of elevation. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 8:

- Elevate up to 2.0 ft (to elevation 11.0 ft NAVD88): Elevating Sand Beach Road up to 2.0 ft would likely provide flood protection from coastal storms and sea level rise in 2030. By 2050, flooding would be likely during coastal storm events. By 2100, flooding would be likely during coastal storm events and for high tide conditions if an Intermediate-High rate of SLR (6.2 ft) is realized.

- Elevate up to 4.0 ft (to elevation 13.0 ft NAVD88): Elevating the road up to 4.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. Flooding would be likely during coastal storm events by the year 2100.

- Elevate up to 6.0 ft (to elevation 15.0 ft NAVD88): Elevating the road up to 6.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. Flooding would be likely during coastal storm events in the year 2100 if an Intermediate-High rate of SLR (6.2 ft) is realized.

3.11.1.2 Relocate

Relocating Sand Beach Road farther inland where it could intersect with South Burnt Cove Road southeast of the current intersection would likely reduce the risk of coastal flooding and maintain usability of the road during coastal storm events. In this configuration, the road would divert east from the intersection with Fifield Point Road instead of following the shoreline towards the Burnt Cove Market. To maintain access to the few residences located along this stretch of Sand Beach Road, the current alignment from Burnt Cove Market headed south could become a non-through street for those residences only.

3.11.1.3 Do Nothing

A “Do Nothing” approach to Sand Beach Road would allow inundation due to coastal storms and sea level rise on low portions of Sand Beach Road. Sections of Sand Beach Road may be inundated by up to 1.5 ft of water in 2030 during 1% annual chance coastal events and an Intermediate-High rate of SLR. Flooding would likely occur during 10-year storms under the three sea level rise scenarios studied for the years 2030, 2050, and 2100. By 2100, flooding would be likely during high tide events. Standing flood water is estimated to have minimal damaging impact on the road itself. During times of impassability, users could avoid the low section of the road by driving around through the downtown area of Stonington.

3.11.2 Recommendations

A long-term adaptation plan for Sand Beach Road is encouraged to allow for continued access of the private residences along Sand Beach Road. We recommend elevating the road up to 2.0 ft to 11.0 ft NAVD88 by 2030. This would allow for vehicular access to be maintained for most storm conditions through 2050, however, flooding would still be likely in 2050 during 500-year storm events or for 100-year storm events if an Intermediate-High rate of SLR (2.3 ft) is realized. The Town may opt for a relocation of the road which could also allow for continued vehicular access through 2050. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road. Road barriers and detours can be utilized during times of inundation and users could drive around through the downtown area of Stonington.

3.12 Moose Island Causeway

Moose Island Causeway connects Deer Isle to Moose Island and is the only way to access Moose island by vehicle. Moose Island is home to several residences and Billings Diesel and Marine.

Moose Island Causeway is a near-term concern in terms of flood vulnerability. The lowest elevation of the causeway is approximately 8.1 ft and flooding is expected in the near term for coastal storm conditions. As noted in the Vulnerability Report (GEI, 2020), obtaining a survey of the causeway would improve the understanding of risk at this asset.

3.12.1 Long Term Adaptation Alternatives

3.12.1.1 Elevate

Elevating the Moose Island Causeway would lessen the risk of flooding due to coastal storms and sea level rise. Elevating the causeway would allow for access to the residences and businesses on Moose Island to be maintained during coastal storm events and sea level rise, depending on the height of elevation. Two elevation scenarios have been considered and are discussed below. Elevating beyond 13.1 ft NAVD88 (raising by up to 5.0 ft) has not been considered due to the existing topography of the area. Conceptual plans are provided in Fig. 9.

- <u>Elevate up to 3.0 ft (to elevation 11.1 ft NAVD88):</u> Elevating up to 3.0 ft would likely provide protection from standing water flood inundation due to coastal storms and sea level rise though the year 2030, although the causeway would likely experience splash over flooding due to wave action during 100-year coastal storm events. By 2050, standing water flood inundation is likely during 100-year coastal storm events. By 2100, the causeway would likely experience flooding during coastal storm events and during highest annual tide if 6.2 ft of SLR is realized.

- Elevate up to 5.0 ft (to elevation 13.1 ft NAVD88): Elevating up to 5.0 ft would likely provide protection from standing water flood inundation due to coastal storms and sea level rise though the year 2050, although the causeway would likely experience splash over flooding due to wave action during 100-year coastal storm events. By 2100, the causeway would likely experience flooding during coastal storm events if 6.2 ft of SLR is realized.

3.12.1.2 Build a Bridge

Converting the Moose Island Causeway into a bridge and elevating it above the current configuration would reduce the risk of flooding and increase the chances of maintained vehicular access to Moose Island. The risk reduction would be dependent on the elevation of the road deck on the bridge; the two scenarios outlined above provide an overview of risk reductions for various elevations. Maine DOT Bridge Design Guide standards (2003) require that the lowest structural member of a bridge be a minimum of 2 ft of freeboard above MHW plus an additional 4 ft to account for SLR. For the Moose Island Causeway, this would mean the lowest structural member would need to be at 10.6 ft NAVD88 or higher. Depending on the design, the top of the road deck could be several feet higher (such as El. 11.1 ft or 13.1 ft as referenced above). An open span bridge would create hydraulic connectivity underneath the road, something not currently present with the causeway, which would change the coastal hydrodynamics in the immediate vicinity of the bridge and which should be studied in detail to understand the environmental value and potential local impacts.

3.12.1.3 Do Nothing

A "Do Nothing" approach to the Moose Island Causeway would likely mean flood inundation during storm events in the near-term. The causeway may be inundated during highest annual tide events by 2050 and by mean high water in the year 2100. Standing flood water is estimated to have minimal damaging impact on the road and causeway itself, but wave action during coastal storm events may damage the existing structure.

3.12.2 Recommendations

A long-term adaptation plan for the Moose Island Causeway is encouraged to allow for continued vehicular access of Moose Island for daily needs as well as emergency/safety. We recommend elevating the causeway at least 3.0 ft to elevation 11.1 NAVD88 by 2030, which would likely allow for vehicular access of Moose Island during coastal storm events through 2050. However, splash over from wave action, and/or up to 6.0 inches of flood inundation may occur on portions of the road during 100-year storm events in 2050. We recommend reevaluating the road by 2050 to determine if elevating the road further, or converting the road to a bridge, would allow for continued access by 2100. Similar to Oceanville Road, a detailed environmental impact study and hydrologic and hydraulic analysis should be performed for the Moose Island Causeway when making a decision about converting to a bridge. In the existing setup, the areas on either side of the bridge are used as lobster pens. These locations may have been selected historically due to the natural protection from waves that the existing topography and causeway creates and the existing substrates suitable for this use. If this road were to be converted to a bridge, the conditions that make this location work well for fishery storage would likely be lost due to the hydraulic connection created. To maintain fishery storage, the Town of Stonington may want to keep this as a causeway. The option of converting to a bridge is also anticipated to be more expensive, likely making the more feasible option to elevate the existing causeway. Before longer term solutions are put in place, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road.

3.13 Ocean Street

Ocean Street is located on the eastern shoreline of Green Head, stemming off from Allen Street and Green Head Road. The road has a close proximity and adjacency to the ocean and coastal wetlands which presents regulatory constraints to implementing adaptation measures, limits the potential to increase the road footprint, and introduces potential road construction stability issues. There is an existing riprap revetment that stabilizes the lowest portion of the road.

Ocean Street has a low elevation of 8.6 ft and is a near-term concern in terms of flood vulnerability due to likely flood inundation along portions of the road during 10-year storms in the near-term. However, impassable conditions due to flood depth and extents would likely not occur until 2050. Since the road is not a main thoroughfare or through-route, we suggest focusing on adaptation in the intermediate-term.

3.13.1 Long Term Adaptation Alternatives

3.13.1.1 Elevate

Elevating Ocean Street would lessen the risk of flooding due to coastal storms and sea level rise. Due to the road's proximity to a coastal wetland, elevating the road would need to balance the impact to (i.e., filling of) the adjacent coastal wetland resources. Measures such as construction of a vertical wall may be required to provide the foundation and stability for elevating the road using fill. These increased shoreline stabilization actions would reduce the likelihood of erosion or washout during storm events. Elevating the road would allow for access to the businesses and residences on Ocean Street and Richardson's Lane past the intersection with Allen Street. Three elevation scenarios have been considered, detailed below, and with conceptual plans provided in Fig. 10:

- Elevate up to 3.0 ft (to elevation 11.6 ft NAVD88): Elevating the road up to 3.0 ft would reduce flood risk, with standing water flood inundation due to coastal storms and sea level rise not likely until 2100. However, splash over flooding due to wave action during 100-year storm events is likely to occur within the 2030 and 2050 timeframes. By 2100, flooding is likely during coastal storm events.

- Elevate up to 6.0 ft (to elevation 14.6 ft NAVD88): Elevating the road up to 6.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. The road would remain at risk of flooding in the year 2100 storm surge conditions if an Intermediate-High rate of SLR (6.2 ft) is realized.

- Elevate up to 8.0 ft (to elevation 16.6 ft NAVD88): Elevating the road up to 8.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2100, with a chance of flooding in 2100 due to wave splash over during 100-yr storm events if 6.2 ft of SLR is realized.

3.13.1.2 Abandon/Reconfigure

The current configuration of Ocean Street between Allen Street and Richardson's Lane could be abandoned and a public route to access the southern end of Ocean Street could be reconfigured, possibly along existing nearby roads. The end of Ocean Street, past Richardson's Lane, would still be at risk but it is our understanding that this is not a town-owned portion of road.

3.13.1.3 Do Nothing

A "Do Nothing" approach to Ocean Street would allow inundation due to coastal storms and sea level rise on low portions of Ocean Street. The street would experience flood inundation due to coastal storms and sea level rise by 2030 but will likely remain passable during 10- and 50-year coastal storm events. Standing flood water is estimated to have minimal damaging impact on the road itself, but wave action during coastal storm events may damage the existing riprap revetment and wash out sections of the road.

3.13.2 Recommendations

A long-term adaptation plan for Ocean Street is encouraged to allow for continued access of the businesses and structures along Ocean Street. We recommend elevating the road by a minimum of 3.0 ft to elevation 11.6 ft NAVD88 by 2050. This would allow for continued vehicular access of the road during most coastal storm and sea level rise scenarios studied by 2050, with the exception of 500-year storms and splash over flooding due to wave action. The road can then be reevaluated for adaptation by 2100, which could include further elevation or a reconfiguration of the road. In the interim, short-term solutions are recommended such as flashing light flood warning systems during extreme high tides and storms or temporary flood barriers that can be used to reduce flood inundation at low-lying portions of the road.

3.14 Roads Summary

The following table provides a summary of the roads addressed in this project. The table is based on adaptation priority, with the highest priority roads at the top of the table and the lowest at the bottom. The table includes the approximate number of businesses and/or residences for which the road is the sole access; the detour length if the road were to be flooded or closed; the storm event that would cause flood inundation in 2030, 2050, and 2100; our recommended adaptation elevation amount to provide protection from most flooding scenarios through 2050; and the estimated cost of the adaptation for protection to 2050. Appendix B provides cost estimates for the other adaptation scenarios considered for each road. The costs provided in this report represent estimates to move forward with road adaptation, however, there are 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 (Maine Climate Council, 2020).

Higher Priority

Road	Approximate # of Residences/ Businesses for Which Road is Sole Access	Detour Length if Road Flooded or Closed	Minimum Elevation, ft NAVD88	Event That Will Cause Standing Water Flooding In:			Recommended Initial Amount to Raise Roads to Provide Protection from Most Flooding Scenarios Through 2050:	Approximate Segment Length for Recommended Elevation Action, ft	Total Cost	Estimated Costs to Elevate per Linear Foot of Roadbed
				2030	2050	2100				
Oceanville Road	100	No Detour Available	8.5	10-yr	HAT	MHW	2 ft	375	$260,000	$693
Whitman Road	28	No Detour Available	8.8	10-yr	10-yr	MHW	4 ft	780	$820,000	$1,051
Fifield Point Road	16	No Detour Available	9.1	10-yr	10-yr	MHW	4 ft	650	$360,000	$554
Ocean Street	8	No Detour Available	8.6	10-yr	HAT	MHW	3 ft	250	$180,000	$720
Moose Island Causeway	6	No Detour Available	8.1	10-yr	HAT	MHW	3 ft	475	$370,000	$779
Sand Beach Road	7	3+ miles	9	10-yr	10-yr	MHW	2 ft	600	$380,000	$633
Main Street	50	1.5 miles	11.3	NA	100-yr	HAT	3 ft	600	$340,000	$567
Atlantic Avenue	5	No Detour Available	13	NA	NA	10-yr	2 ft	200	$250,000	$1,250
Burnt Cove Road	3	5.5+	11	500-yr	50-yr	MHHW	2 ft	350	$220,000	$629
Bayview Avenue	5	No Detour Available	11.6	NA	500-yr	HAT	4 ft	500	$690,000	$1,380
West Main Street	25	0.2 miles	12.8	NA	NA	10-yr	2 ft	325	$250,000	$769
Colwell's Lane	NA	No Detour Available	8.4	10-yr	HAT	MHW	0 - 3 ft	0 - 100	$0 - $390,000	$0 - $3,900
Rhode Island Ave	3	No Detour Available	10	50-yr	10-yr	MHW	0 ft	0	$0	$0

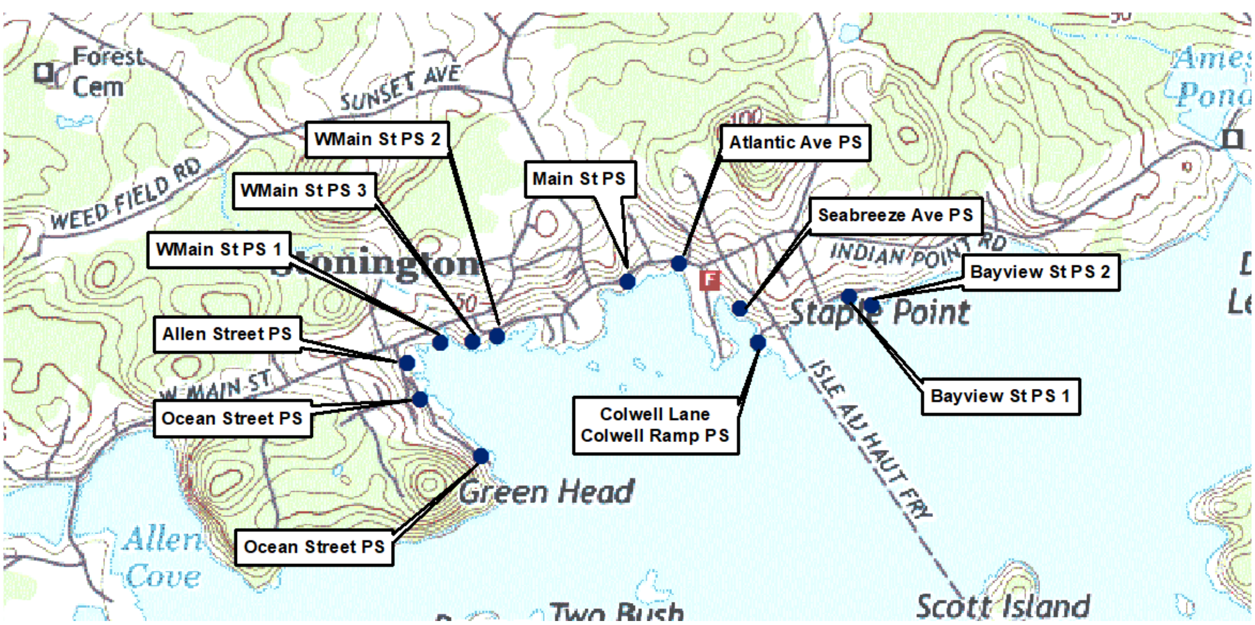
Lower Priority

4. Pump Stations

Our adaptation analysis included review of twelve pump station in the Town of Stonington that are potentially vulnerable to flooding from coastal storms and sea level rise by the year 2100 as indicated in the Vulnerability Report (GEI, 2020).

We performed a high-level review of overall risk and we have provided generalized adaptation options to consider for each pump station based on available elevation data. The elevation data was derived from existing grade elevations taken from LiDAR data (Maine, 2018) for the Town of Stonington. However, our recommendation for next steps would be to obtain survey for each pump station to understand the elevation at the ground surface and the elevation of sensitive equipment such as electrical panels, electrical and communication wiring, and controls. The survey would also include information on openings, wall seams, sills, doorways, or other avenues that would allow flood water to infiltrate and potentially damage sensitive equipment. Since our analyses are based on ground elevations and existing electrical panels and controls are likely higher, our recommendations may be conservative, provided electrical and communication wiring are not buried underground. A detailed survey should be completed prior to implementing adaptation measures.

When applicable, we recommend addressing pump station adaptation in coordination with the adaptation of the nearby road, so as not to elevate or flood-proof a pump station when the surrounding area may still be flooded. We will call out these specific locations as they apply to individual pump stations.



An overview of conceptual adaptation options and specific pump station recommendations is provided in the following sections.

4.1 Overview of Adaptation Alternatives for Pump Stations

4.1.1 Flood Proofing

Flood proofing is an adaptation measure that can be used to prevent sensitive infrastructure from damage or a decrease in performance if flooding were to occur. Dry floodproofing uses material to create watertight hatches or openings, whereas wet floodproofing allows water to access a structure and internal infrastructure that are designed to withstand flooding. For pump stations with dry well vaults, dry floodproofing the hatch would help prevent inundation. Dry floodproofing the door on facilities can prevent damaging floodwater from entering. Similarly, dry floodproofing manhole covers would help make them watertight. It is also important to evaluate the materials used in the construction of the buildings. In the event water intolerant materials, such as dry wall, are present at elevations at risk of inundation, consideration may be needed to modify to more tolerant materials.

4.1.2 Elevating

Elevating pump station features can reduce damage potential from floodwaters. Electrical panels and controls are at risk of being damaged if installed near ground surface and have the potential to be inundated by storm surge or sea level rise. Elevated such sensitive infrastructure helps to reduce risk. Other features that would benefit from elevating above flood risk levels include electrical and communications wiring, vent pipes and fill pipes for fuel tanks.

Without detailed survey of the Town of Stonington pump stations, the current elevation of the electrical and communications wiring, electrical panels, and controls are unknown. Instead of providing recommended elevation amounts (e.g. 2.0 ft, 4.0 ft, 6.0 ft, etc.), we have instead provided heights to elevate to (e.g. 10.0 ft NAVD88). In some instances, the electrical equipment may already be elevated to the recommended heights, but this would need to be verified with a site-specific survey. The following focuses primarily on elevating controls and electrical panels. Detailed information about electrical and communications wiring is not included in this study. Similarly, this study does not evaluate the potential impact of power outages on pump station infrastructure. We recommend the Town evaluate potential issues related to wiring and power outages under a separate work scope.

4.1.3 Do Nothing

A “Do Nothing” approach to pump stations may result in damage of electrical equipment, inundation of vent pipes (if present), inaccessibility to the pump station during coastal storm events and sea level rise, and flood damage to existing structures. In addition to damage potential, flood inundation may result in a decrease in system performance.

4.2 Recommendations for Stonington Pump Stations

4.2.1 Colwell Lane – Colwell Ramp Pump Station

The Colwell Lane – Colwell Ramp Pump Station is a near term concern in terms of flood vulnerability. Flooding is likely in the near term during coastal storm events. Since Colwell Lane and the landing area were considered as part of this study, we recommend addressing this pump station concurrently with the street. Recommended adaptation actions for Colwell's Lane included elevating the area or enclosing the area with a flood barrier. Both actions would reduce flood risk to the pump station.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 10.8 ft would likely protect it from standing water flood inundation due to coastal storms by 2030, although flooding due to wave action would still be likely.

- Elevating the electrical equipment to 12.0 ft would likely protect it from standing water flood inundation through 2050, although flooding due to wave action would still be likely.

- Elevating the electrical equipment to 14.0 ft would likely protect it from standing water flood inundation through 2100, although flooding due to wave action would still be likely.

4.2.2 Bayview Street Pump Station 1

This pump station, located west of Little Bay Seafood on Bayview Avenue, is a near term concern in terms of flood vulnerability. Flooding is likely in the near term due to coastal storm events. Since Bayview Avenue is being considered for adaptation measures as part of this study, we recommend addressing this pump station concurrently with the street. Recommended adaptation actions for Bayview Avenue include elevating and protecting with a flood barrier. Both actions would reduce flood risk to the pump station.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 11.0 ft would likely protect it from standing water flood inundation due to coastal storms by 2030, although flooding due to wave action would still be likely.

- Elevating the electrical equipment to 12.0 ft would likely protect it from standing water flood inundation through 2050, although flooding due to wave action would still be likely.

- Elevating the electrical equipment to 16.0 ft would likely protect it from standing water flood inundation through 2100, although flooding due to wave action would still be likely.

4.2.3 Bayview Street Pump Station 2

This pump station, located on the pier near Little Bay Seafood, is an intermediate term concern in terms of flood vulnerability. Flooding is likely by 2050 due to coastal storm events. The street nearby this pump station location is not being considered for adaptation as part of this study, therefore, adaptation of this pump station would be considered on its own.

While we recommend holding off on adaptation measures for this pump station until the near-term concern pump stations are addressed, we have provided elevations below that electrical equipment and controls could be raised to in order to increasing resilience to flood damage in the future:

- Elevating the electrical equipment and controls to 12.0 ft would likely provide protection from standing flood water through the year 2050, although flooding due to wave action may still be likely.

- Elevating the electrical equipment and controls to 14.0 ft would likely provide protection from standing flood water through the year 2050, although flooding due to wave action may still be likely. By 2100, flooding would be likely during coastal events if 6.2 ft of SLR is realized.

- Elevating the electrical equipment and controls to 16.0 ft would likely provide protection from flooding through the year 2100, although flooding may occur in 2100 due to wave action during coastal storm events.

4.2.4 Ocean Street Pump Station 1

This pump station is located along Ocean Street between the intersection with Allen Street and Richardson's Lane and is an intermediate-term concern in terms of flood vulnerability. Flooding is likely by 2050 due to coastal storm events and sea level rise. Since this section of Ocean Street is being considered for adaptation measures as part of this study, we recommend addressing this pump station concurrently with the street if the Town decides to move forward with elevating the street as an adaptation method.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 14.0 ft would likely protect it from flooding due to coastal storms and sea level rise through 2050, with flooding likely by 2100 if 6.2 ft of SLR is realized.

- Elevating the electrical equipment to 16.0 ft would likely protect it from flooding through 2100.

4.2.5 West Main Street Pump Station 1

This pump station is located of Green Head Road, west of West Main Street. It is a near-term concern in terms of flood vulnerability with flooding likely by 2030 due to coastal storm events. The street nearby this pump station location is not being considered for adaptation as part of this study, therefore, adaptation of this pump station would be considered on its own.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 11.0 ft would likely protect it from standing water flood inundation due to coastal storms by 2030, although flooding due to wave action would still be likely.

- Elevating the electrical equipment to 12.0 ft would likely protect it from standing water flood inundation due to coastal storms and sea level rise through 2050, although flooding due to wave action would still be likely.

- Elevating the electrical equipment to 14.0 ft would likely protect it from flooding due to coastal storms and sea level rise through 2050. In 2100, flooding would be likely during coastal storms if an Intermediate-High rate of SLR (6.2 ft) is realized.

4.2.6 West Main Street Pump Station 2

There are two pump stations located at the western end of West Main Street. This pump station is the eastern of the two. It is a near-term concern in terms of flood vulnerability, with flooding likely by 2030 due to coastal storm events. A nearby portion of West Main Street is being considered for adaptation measures as part of this study and we recommend addressing this pump station concurrently with the street if the Town decides to move forward with elevating the street as an adaptation method.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 11.0 ft would likely protect it from standing water flood inundation due to coastal storms by 2030, although minor flooding due to wave action may be likely.

- Elevating the electrical equipment to 12.0 ft would likely protect it from standing water flood inundation due to coastal storms and sea level rise through 2050, although minor flooding due to wave action may be likely.

- Elevating the electrical equipment to 16.0 ft would likely protect it from flooding due to coastal storms and sea level rise through 2100, although a chance of flooding due to wave action exists in 2100 for a 100-year coastal storm event.

4.2.7 West Main Street Pump Station 3

This pump station is the western of the two pump stations located on the western end of West Main Street. It is a long-term concern in terms of flood vulnerability, with flooding not likely until 2100 if 6.2 ft of SLR is realized. We recommend holding off on adaptation measures for this pump station location until a future timeframe when there is a better understanding of sea level rise potential, however, elevations have been provided below for future consideration:

- Elevating the electrical equipment to 16.0 ft would likely provide protection from standing water flood inundation through the year 2100, but a chance of flooding due to wave action if 6.2 ft of SLR is realized is still likely.

- Elevating the electrical equipment to 18.0 ft would likely provide protection from flooding through the year 2100.

4.2.8 Atlantic Avenue Pump Station

The Atlantic Avenue Pump Station is located near Hagen's Dock where it meets Main Street. It is an intermediate-term concern in terms of flood vulnerability, but it is recommended to address it while adaptation efforts are made at Hagen's Dock or Main Street, two assets also considered in this study. Flooding due to wave action during 100-year storms is likely in the near term and intermediate-term but standing water flood inundation due to coastal storms or sea level rise is not likely until 2100.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 14.0 ft would likely protect it from flooding through 2050, with standing water flood inundation likely by 2100 if 6.2 ft of SLR is realized.

- Elevating the electrical equipment to 16.0 ft would likely protect it flooding through the year 2100, with a chance of flooding due to wave action possible in 2100 if 6.2 ft of SLR is realized.

4.2.9 Ocean Street Pump Station 2

This pump station is located at the end of Ocean Street and is a near term concern in terms of flood vulnerability. Flooding is likely in the near term during coastal storm events.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 11.0 ft would likely protect it from standing water flood inundation due to coastal storms by 2030, although minor flooding due to wave action may be likely.

- Elevating the electrical equipment to 12.0 ft would likely protect it from flooding through 2050.

- Elevating the electrical equipment to 16.0 ft would likely protect it from standing water flood inundation through 2100, although a chance of flooding due to wave action exists for 100-year storm events if 6.2 ft of SLR is realized.

4.2.10 Main Street Pump Station

This pump station is located along Main Street, across from Town Hall. It is a long-term concern in terms of flood vulnerability, but we have recommended addressing the electrical equipment in the intermediate-term, or concurrently when adaptation measures are addressed for Main Street. Flooding is not expected at this pump station until 2100.

Consideration should be given to elevating the controls and electrical panels to prevent damage due to flooding:

- Elevating the electrical equipment to 16.0 ft would likely protect it from flooding through 2100, with flooding likely in 2100 due to wave action during a 100-yr storm event if 6.2 ft of SLR is realized.

- Elevating the electrical equipment to 17.0 ft would likely protect it from flooding due to coastal storms and sea level rise through 2100.

4.2.11 Seabreeze Ave Pump Station

This pump station is located along Seabreeze Avenue. It is a long-term concern in terms of flood vulnerability. Flooding is not likely until 2100 during 100-yr coastal storm events. We recommend holding off on adaptation measures for this pump station location until a future timeframe when there is a better understanding of sea level rise potential, however, elevations have been provided below for future consideration:

- Elevating the electrical equipment to 19.0 ft would likely provide protection from flooding through the year 2100.

4.2.12 Allen Street Pump Station

This pump station is located along Allen Street and is a long-term concern in terms of flood vulnerability. Flooding is not likely until 2100 during coastal storm events. We recommend holding off on adaptation measures for this pump station location until a future timeframe when there is a better understanding of sea level rise potential, however elevations have been provided below for future consideration:

- Elevating the electrical equipment to 16.0 ft would likely provide protection from flooding through the year 2100.

4.3 Pump Station Summary

Below is a table summarizing the recommended elevation scenarios for the pump stations studied as part of this adaptation analysis.

Pump Station	**Recommended Elevation (ft NAVD88) and Year that Will Provide Protection To, Scenario 1:**		**Recommended Elevation (ft NAVD88) and Year that Will Provide Protection To, Scenario 2:**		**Recommended Elevation (ft NAVD88) and Year that Will Provide Protection To, Scenario 3:**	
	El. ft NAVD88	**Year**	**El. ft NAVD88**	**Year**	**El. ft NAVD88**	**Year**
Colwell Lane – Colwell Ramp Pump Station	10.8	2030	12.0	2050	14.0	2100
Bayview Street Pump Station 1	11.0	2030	12.0	2050	16.0	2100
Bayview Street Pump Station 2	12.0	2050 without waves	14.0	2050 without waves	16.0	2100 without waves
Ocean Street Pump Station 1	14.0	2050	16.0	2100	NA	NA
West Main Street Pump Station 1	11.0	2030	12.0	2050	14.0	2100
West Main Street Pump Station 2	11.0	2030	12.0	2050	16.0	2100
West Main Street Pump Station 3	16.0	2050	18.0	2100	NA	NA
Atlantic Ave Pump Station	14.0	2050	16.0	2100	NA	NA
Ocean Street Pump Station 2	11.0	2030	12.0	2050	16.0	2100
West Main Pump Station	16.0	2100 without waves	17.0	2100 with wave action	NA	NA
Seabreeze Ave Pump Station	19.0	2100	NA	NA	NA	NA
Allen Ave Pump Station	16.0	2100	NA	NA	NA	NA

5. Fire Station and Hagen's Dock

5.1 Summary of Hagen's Dock

Hagen's Dock is located off Main Street in the downtown region of Stonington (Fig. 1). The dock serves as a public landing and includes public parking and a public restroom. The dock, including a seawall, greenspace, and pedestrian facilities, was rebuilt in 2017 to address ongoing erosion issues. The Fire Station is located along Hagen's Dock, which is accessed via Atlantic Ave and Main Street.

The lowest elevation of the dock is 8.5 ft and it is a near term concern in terms of flood vulnerability, with flooding likely by 2030 due to coastal storm events. Additionally, access to the Fire Station is considered vital to ensure the resiliency of the Town of Stonington into the future, especially during coastal storm events.

5.2 Long Term Adaptation Alternatives

5.2.1 Elevating Based on Fill

Elevating Hagen's Dock would lessen the risk of flooding due to coastal storms and sea level rise. Elevating Hagen's Dock should be coordinated with the elevation of Atlantic Avenue and consideration should be given to the buildings present along the dock to ensure the lower elevations of buildings are flood-proofed or elevated to avoid damage due to potential ponding in these locations. To elevate Hagen's Dock, the seawall would be extended vertically, and the parking lot would be elevated with fill. Elevating Hagen's Dock would allow access to the public landing and increase the resiliency of the Fire Station.

Three elevation scenarios have been considered, detailed below:

- Elevate up to 2.0 ft (to elevation 10.5 ft NAVD88): Elevating the dock up to 2.0 ft would likely provide protection from flood inundation due to standing water from coastal storms and sea level rise through 2030, however flooding due to wave splash over during 100-yr coastal events is still likely. By 2050, flooding is likely during coastal storm events, and by 2100, flooding would be likely during high tide events.

- Elevate up to 4.0 ft (to elevation 12.5 ft NAVD88): Elevating the dock up to 4.0 ft would likely provide protection from flood inundation due to standing water from coastal storms and sea level rise through 2050, however flooding due to wave splash over during 100-yr coastal storm events is still likely. By 2100, flooding due to coastal storm events and sea level rise is likely to occur.

- Elevate up to 7.0 ft (to elevation 15.5 ft NAVD88): Elevating the dock up to 7.0 ft would likely provide protection from coastal flooding due to the high tides and storm conditions considered in this study through the year 2050. By 2100, splash over flooding due to wave action during 100-year coastal storm events would be likely. Elevating to at least 15.0 ft NAVD88 would coincide with the recommended elevation for Atlantic Avenue.

5.2.1.1 Build a Flood Barrier

A flood wall could be used to protect Hagen's Dock and the Fire Station from coastal flooding due to storm surge and sea level rise. It is recommended to protect this area in conjunction with Atlantic Ave for surface elevation consistency and to facilitate gradual transition in elevations. Depending on the desired area to protect, the flood wall configuration could be such that Hagen's Dock and the town-owned portion of the road are protected. Additionally, a combination of a flood wall and fill could be used which may be more visually appealing.

5.2.1.2 Do Nothing

A "Do Nothing" approach to Hagen's Dock would allow inundation due to coastal storms and sea level rise. The dock would experience flooding during coastal storm events in the near-term and by 2100, flooding would be likely during high tide conditions. Standing flood water is estimated to have minimal damaging impact dock itself, but flood water may damage surrounding buildings and electrical features. Additionally, the Fire Station may become inaccessible during storm events would cause vulnerability concerns for the greater Stonington population.

5.2.2 Recommendations

We recommend prioritizing addressing flood risk at Hagen's Dock, the Fire Station, and Atlantic Avenue to ensure continued access to the vital services that the Fire Station provides to the Town of Stonington. At a minimum, protection up to 12.5 ft NAVD88, or 4.0 ft above the current low elevation of Hagen's Dock, should be considered. In the interim, short-term solutions such as barricades to the parking area during times of expected flooding, temporary flood barriers to prevent flooding, and/or relocation of the Fire Station facility should be considered.

6. Rhode Island Ave Outfall Pipe

6.1 Summary of Outfall Pipe

The Rhode Island Avenue Outfall Pipe is located off the end of Rhode Island Ave and serves as the outfall pipe for the Town's centralized treated wastewater (Fig. 2). The system was designed in 1990 by Wright-Pierce. A summary of the invert elevation and complications with datum conversions is included in section 3.2.12 of the Vulnerability Report (GEI, 2020). For this study, we are assuming the outfall pipe invert elevation is 5.9 ft NAVD88, but we recommend that this be surveyed by a licensed surveyor and a more current elevation and datum be established to more accurately evaluate the flood exposure and adaptation options.

With an outfall pipe invert elevation of 5.9 ft, the pipe invert is expected to experience flooding during highest annual tide conditions in 2030 and is considered a near-term concern in terms of flood vulnerability.

6.2 Outfall Pipe Adaptation Alternatives

Further investigation is needed for the outfall pipe to understand the level of risk and the current capacity of the system. Without a more complete understanding of the system, we are limiting our alternatives analysis to the two actions below. Our evaluation does not include information on the potential impact that salt water, the rise and fall of higher tides, or potential wave action may have on the piping and/or pipe bedding system.

6.2.1 Backflow Preventer

A backflow preventer can be used to prevent the movement of water into the pipe which would prevent flooding of the wastewater system and limit damage from saltwater on the system. A backflow preventer can be installed for the current system without doing a more involved redesign. We recommend consulting with a wastewater systems design engineer on the benefits of a backflow preventer on the wastewater system for the Town of Stonington.

6.2.2 Do Nothing

A "Do Nothing" approach to the Rhode Island Ave Outfall Pipe would lead to possible backflow into the outfall pipe during highest annual tide conditions by 2030. By 2050, backflow would be likely during high tide conditions under due to sea level rise. Backflow of seawater into the outfall pipe could lead to damage due to saltwater intrusion and/or a decrease in system performance. Prolonged water elevations above the outfall pipe invert elevation due to future sea level rise could lead to wastewater back-up in the wastewater treatment system, reducing capacity of the overall system.

6.3 Adaptation Recommendation

Our main recommendation for the outfall pipe is to perform an updated survey of the outfall pipe invert and hire a wastewater systems design engineer to review the current use and storage capacity of the system and potential implications future sea water elevations might have on performance. In the short-term, we recommend consulting with an engineer to discuss the benefits of a backflow preventer.

7. References

GEI Consultants, Inc. (2020). "Stonington Flood Vulnerability Study," Rev. March.

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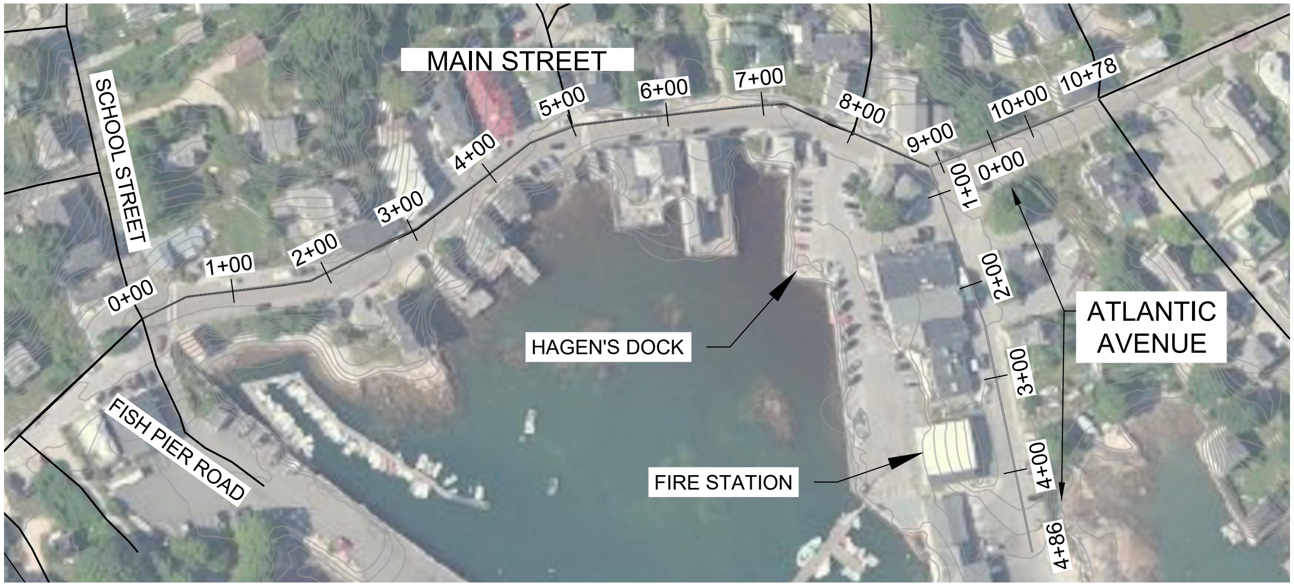
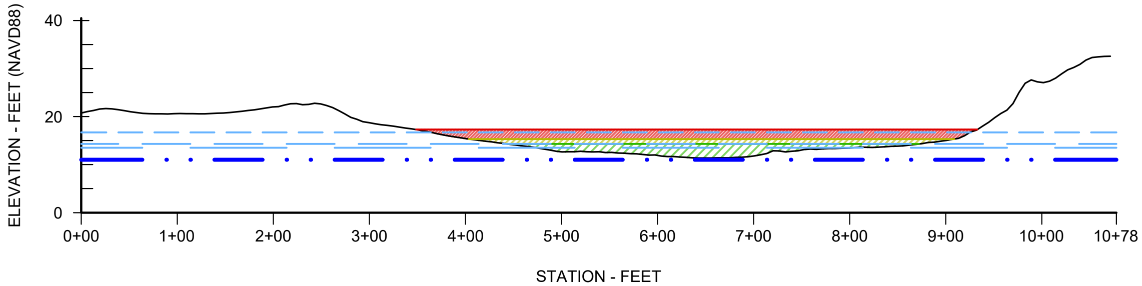
National Weather Service (NWS) (2020). "Turn Around Don't Drown," Accessed on December 23, 2020 from: https://www.weather.gov/safety/flood-turn-around-dont-drown.



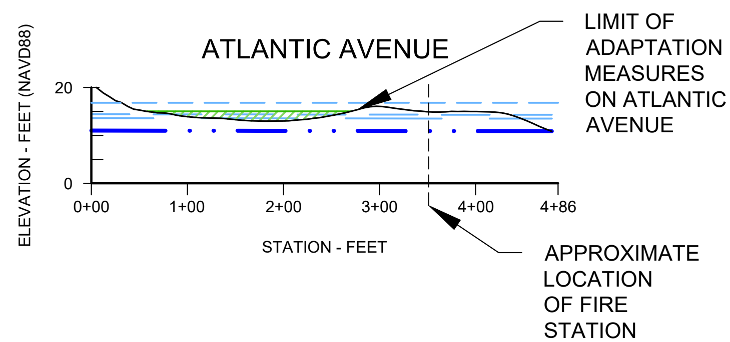
LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR

MAIN STREET



ATLANTIC AVENUE



MAIN STREET

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
6.0	17.3	(red hatch)
4.0	15.3	(yellow hatch)
3.0	14.3	(green hatch)

ATLANTIC AVENUE

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
2.0	15.0	(green hatch)

0 200 400

SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

Stonington Flood Vulnerability Study
Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

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MAIN STREET & ATLANTIC AVENUE
PLAN & PROFILES

MARCH 2021 | Fig. 1

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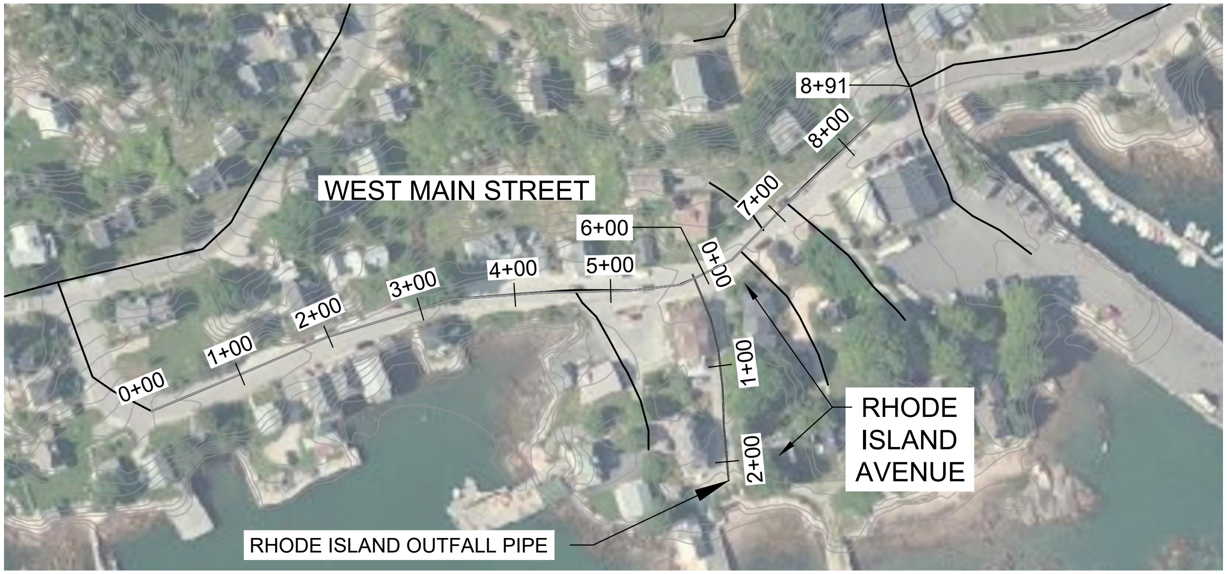
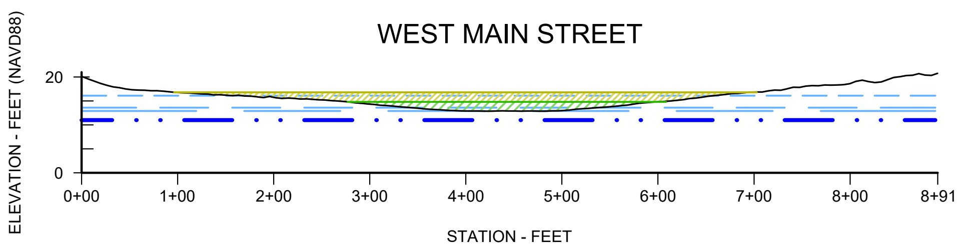
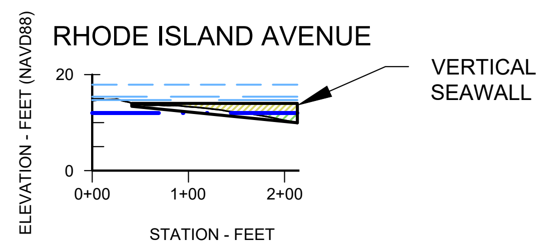


LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR





WEST MAIN STREET

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
4.0	16.8	
2.0	14.8	

RHODE ISLAND AVENUE

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
4.0	14.0	
2.0	12.0	

0 200 400

SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

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Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

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WEST MAIN STREET & RHODE ISLAND AVENUE PLAN & PROFILES

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Fig. 2

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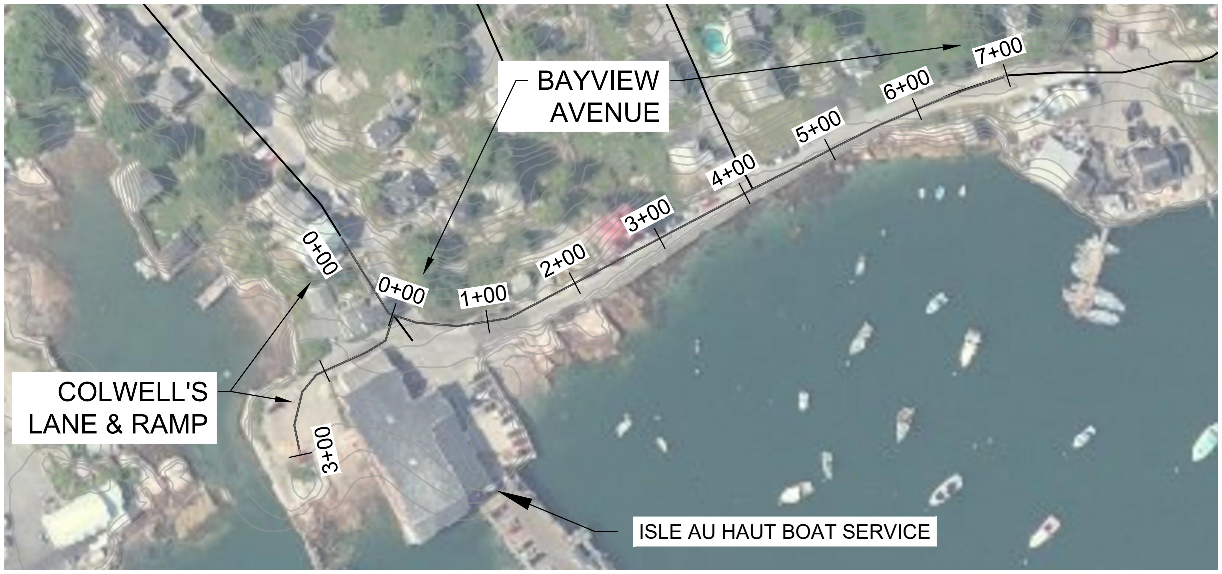
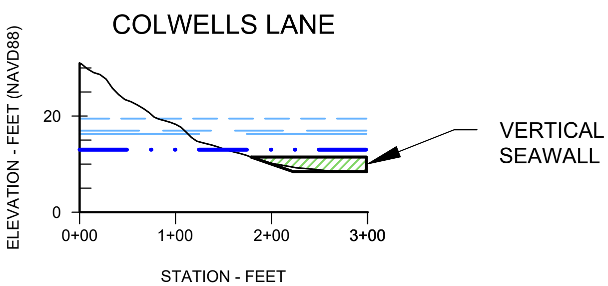
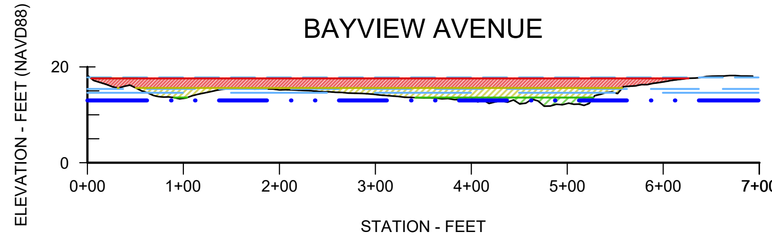


LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR





COLWELLS LANE

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
3.0	11.4	(green hatch)

BAYVIEW AVENUE

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
6.0	17.6	(red hatch)
4.0	15.6	(yellow hatch)
2.0	13.6	(green hatch)

0 200 400

SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

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Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

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BAYVIEW AVENUE & COLWELLS LANE
PLAN & PROFILE

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Fig. 3

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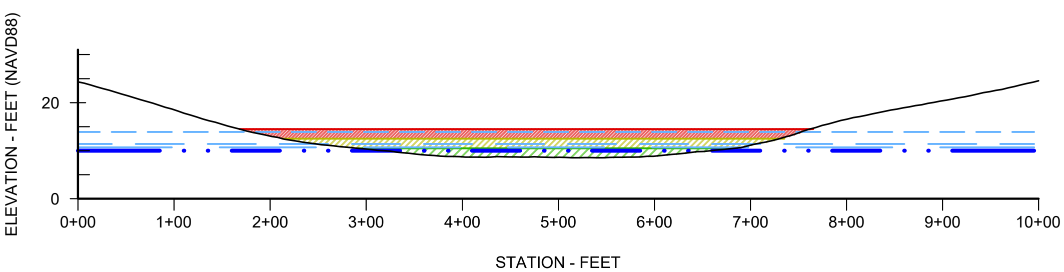
N

LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR



ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
6.0	14.5	(red hatch)
4.0	12.5	(yellow hatch)
2.0	10.5	(green hatch)

0 200 400

SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

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Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

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OCEANVILLE ROAD
PLAN & PROFILE

MARCH 2021

Fig. 4

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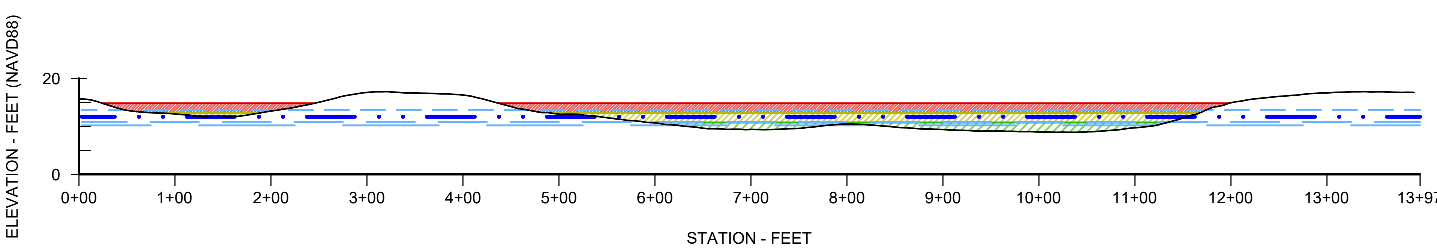
LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
6.0	14.8	red hatch
4.0	12.8	yellow hatch
2.0	10.8	green hatch



0 200 400

SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

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32 Main Street, Stonington, ME 04681

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WHITMAN ROAD
PLAN & PROFILE

MARCH 2021 | Fig. 5

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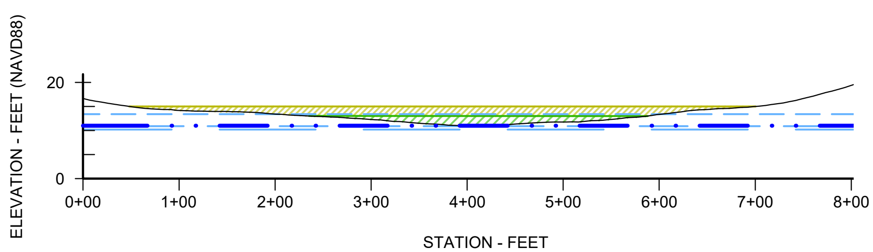
LEGEND:

EXISTING BFE
2030 FLOOD ELEVATION WITH INT-RATE OF SLR
2050 FLOOD ELEVATION WITH INT-RATE OF SLR
2100 FLOOD ELEVATION WITH INT-RATE OF SLR



ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
4.0	15.0	
2.0	13.0	

0 200 400
SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

Stonington Flood Vulnerability Study Stonington, Maine	GEI Consultants	BURNT COVE ROAD PLAN & PROFILE
Town of Stonington 32 Main Street, Stonington, ME 04681	Project 1804859	MARCH 2021 Fig. 6

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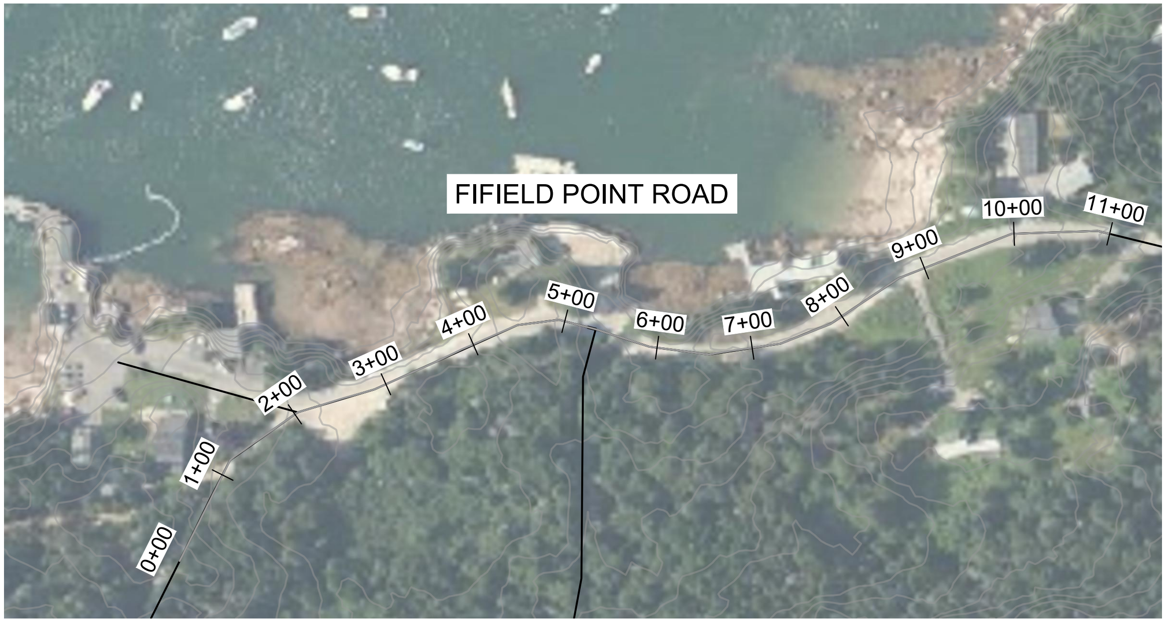
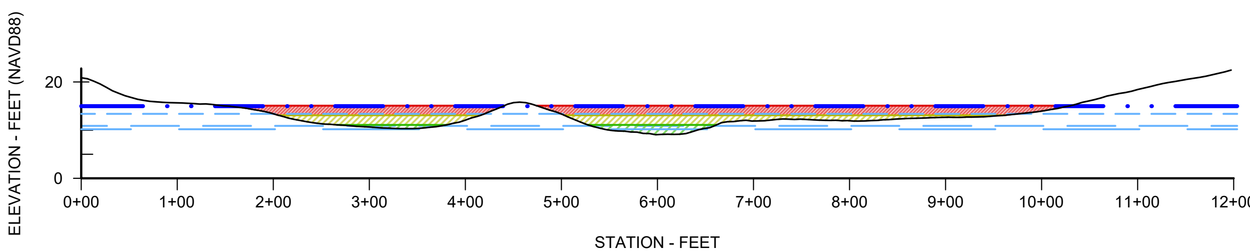


LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
6.0	15.1	red hatch
4.0	13.1	yellow hatch
2.0	11.1	green hatch



0 200 400
SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

Stonington Flood Vulnerability Study
Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

GEI Consultants

Project 1804859

FIFIELD POINT ROAD
PLAN & PROFILE

MARCH 2021

Fig. 7

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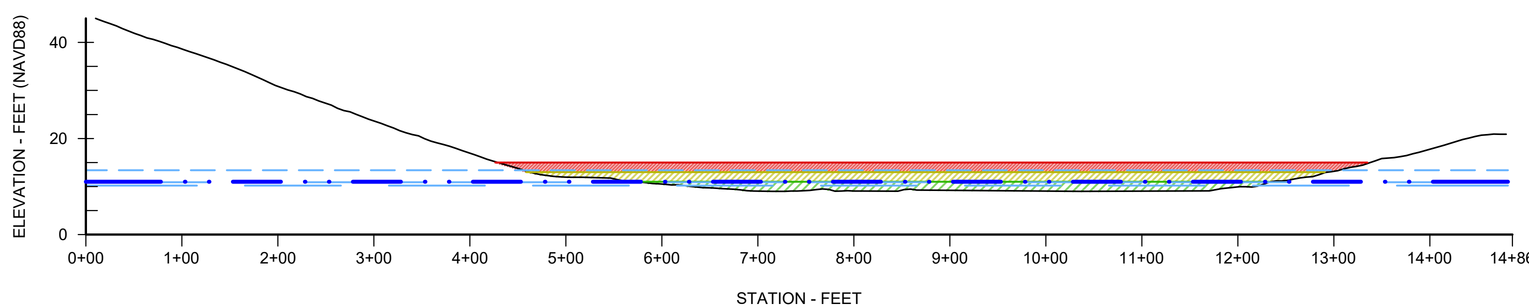
LEGEND:

- EXISTING BFE
- 2030 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2050 FLOOD ELEVATION WITH INT-RATE OF SLR
- 2100 FLOOD ELEVATION WITH INT-RATE OF SLR

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
6.0	15.0	
4.0	13.0	
2.0	11.0	



0 200 400

SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

Stonington Flood Vulnerability Study
Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

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Project 1804859

SAND BEACH ROAD
PLAN & PROFILE

MARCH 2021

Fig. 8

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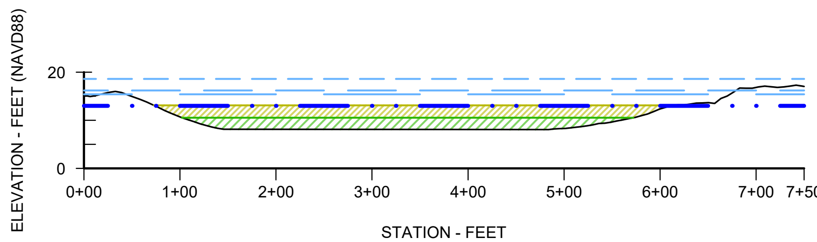
LEGEND:

EXISTING BFE
2030 FLOOD ELEVATION WITH INT-RATE OF SLR
2050 FLOOD ELEVATION WITH INT-RATE OF SLR
2100 FLOOD ELEVATION WITH INT-RATE OF SLR

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
5.0	13.1	
3.0	11.1	



0 200 400
SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

Stonington Flood Vulnerability Study
Stonington, Maine

Town of Stonington
32 Main Street, Stonington, ME 04681

GEI Consultants

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MOOSE ISLAND CAUSEWAY
PLAN & PROFILE

MARCH 2021 Fig. 9

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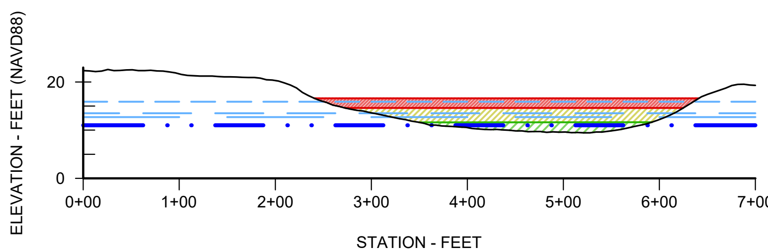
LEGEND:

(dash-dot line)	EXISTING BFE
(line)	2030 FLOOD ELEVATION WITH INT-RATE OF SLR
(line)	2050 FLOOD ELEVATION WITH INT-RATE OF SLR
(line)	2100 FLOOD ELEVATION WITH INT-RATE OF SLR

ELEVATION INCREASE (FT)	TO ELEVATION (NAVD88 FT)	KEY
8.0	16.6	(red)
6.0	14.6	(yellow)
3.0	11.6	(green)

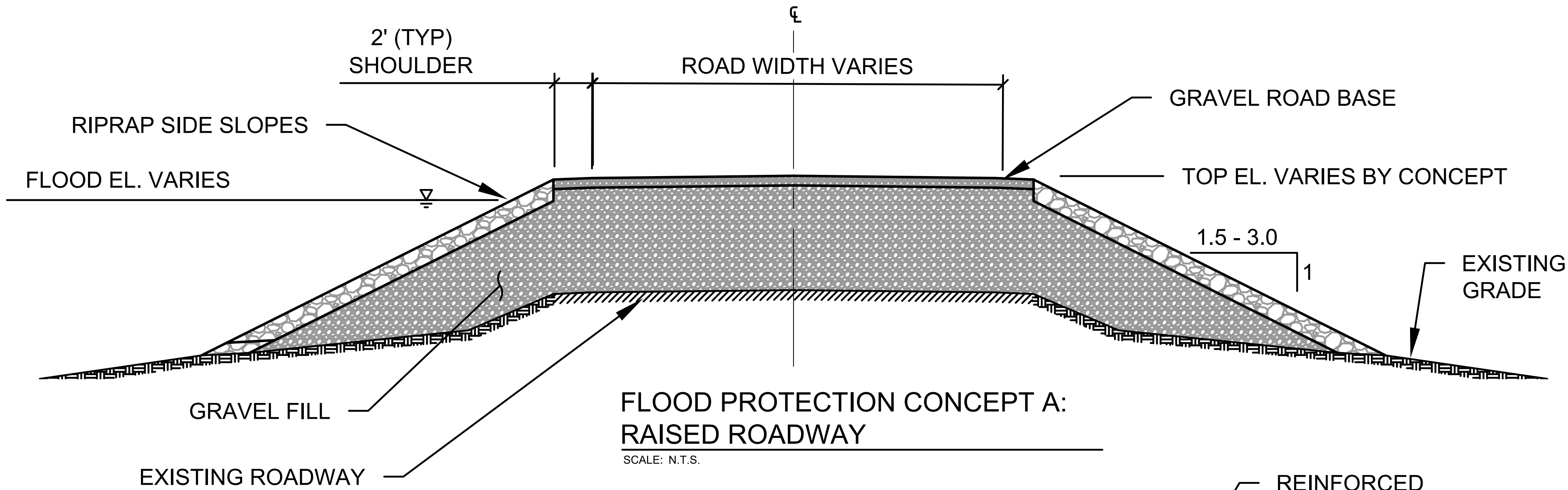


0 200 400
SCALE: 1" = 200'

AERIAL IMAGERY SOURCE: *Bing Maps*, 2020

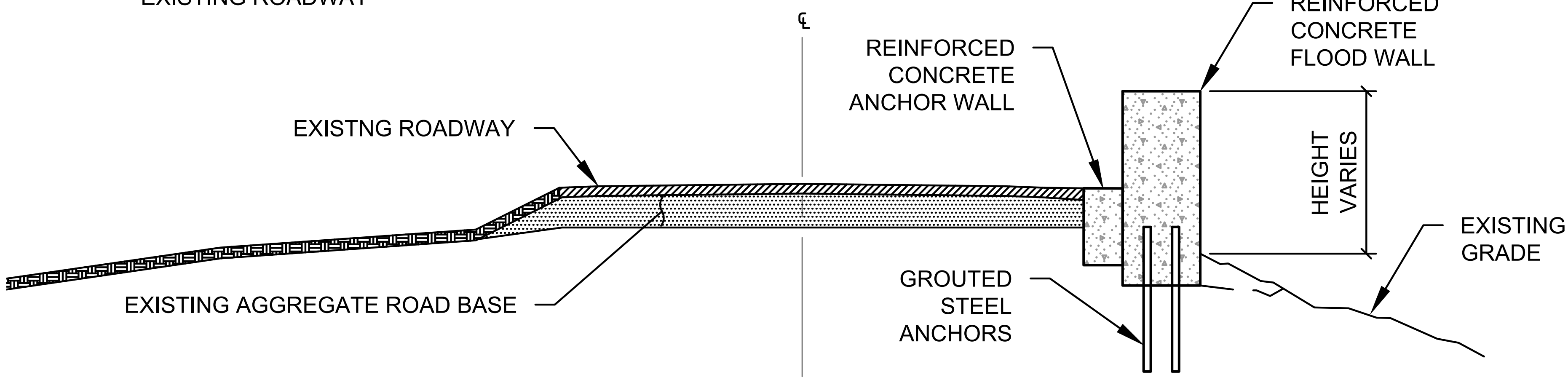
NOTE: PROFILES DEPICTED AT 5X VERTICAL SCALE

Stonington Flood Vulnerability Study Stonington, Maine	GEI Consultants	OCEAN STREET PLAN & PROFILE	
Town of Stonington 32 Main Street, Stonington, ME 04681	Project 1804859	MARCH 2021	Fig. 10



FLOOD PROTECTION CONCEPT A: RAISED ROADWAY

SCALE: N.T.S.



FLOOD PROTECTION CONCEPT B: CONCRETE FLOODWALL

SCALE: N.T.S.

Stonington Flood Vulnerability Study Stonington, ME	GEI Consultants	Flood Protection Concepts A & B
Town of Stonington 32 Main Street, Stonington, ME	Project 1804859	MARCH 2021 Fig. 11

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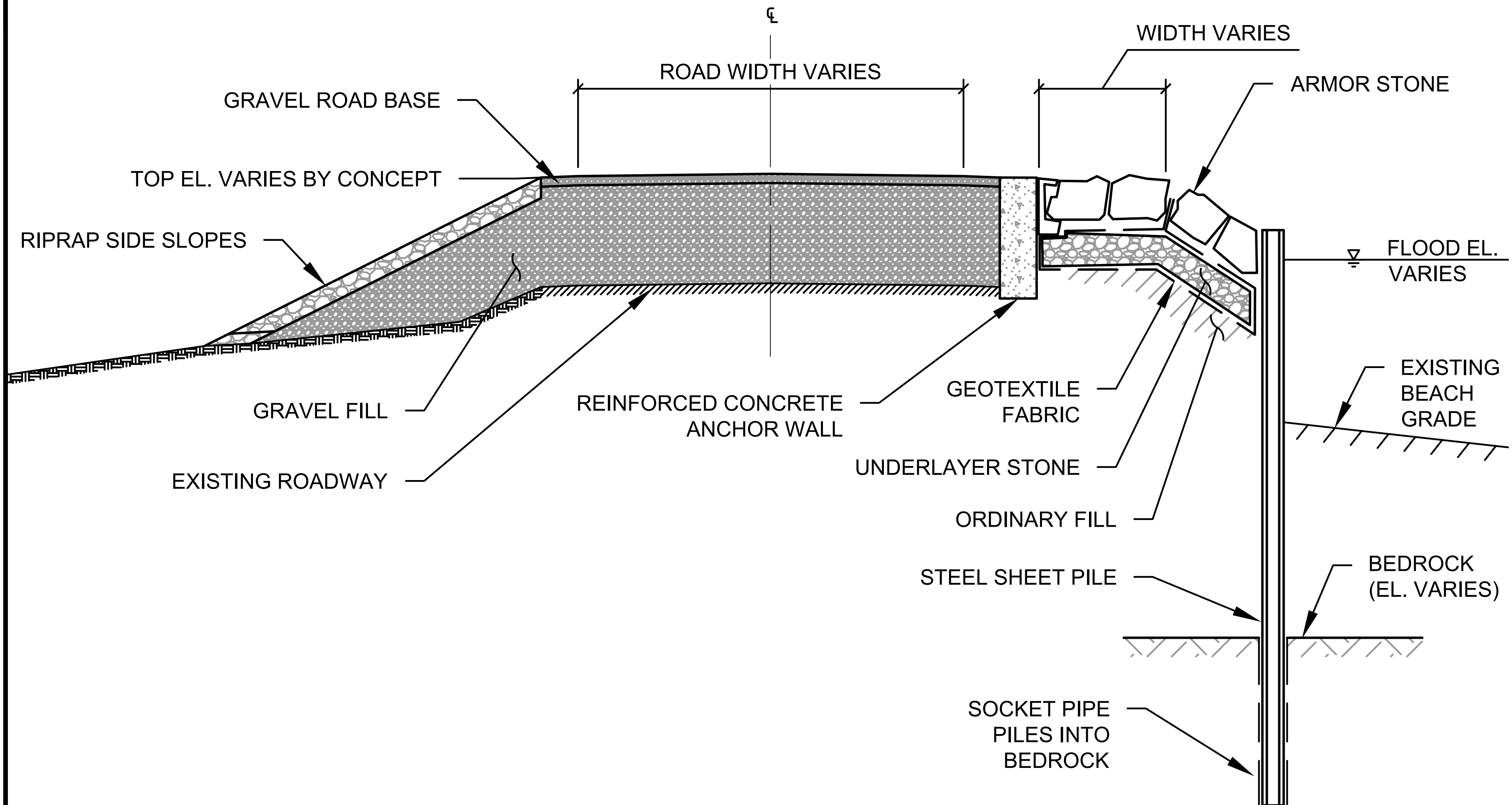
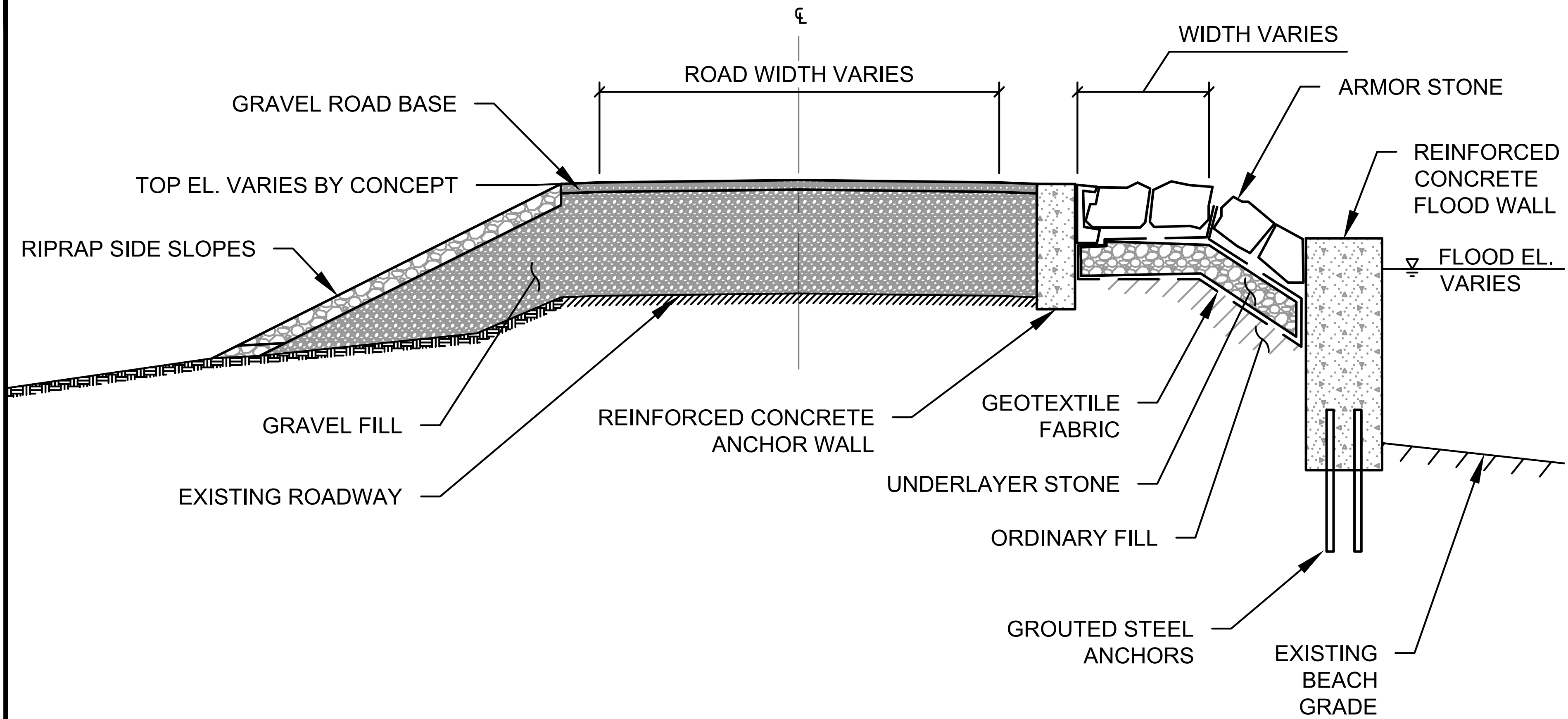


FLOOD PROTECTION CONCEPT C:
RAISED ROADWAY & SHEET PILE FLOODWALL

SCALE: N.T.S.

Stonington Flood Vulnerability Study Stonington, ME	GEI Consultants	Flood Protection Concepts C
Town of Stonington 32 Main Street, Stonington, ME	Project 1804859	MARCH 2021 Fig. 12



FLOOD PROTECTION CONCEPT D: RAISED ROADWAY & CONCRETE FLOODWALL

SCALE: N.T.S.

Stonington Flood Vulnerability Study Stonington, ME	GEI Consultants	Flood Protection Concept D
Town of Stonington 32 Main Street, Stonington, ME	Project 1804859	MARCH 2021 Fig. 13

\\POR1L-DPELL Y:\SHARED\PROJECTS\2018\1804859_StoningtonFloodVulnerability\GIS\Dan_2112021\RoadSections.dwg - 2/15/2021

Appendix A

Concept Plans and Regulatory Overview

Appendix A: Concept Plans and Regulatory Overview

1.1 Concept Plans

Conceptual plans for road adaptation are provided in the following subsections and attached Figures for temporary adaptation measures, elevated roads, and flood walls.

1.1.1 Temporary

Temporary solutions can be utilized to warn of flooded areas and prevent traffic flow from entering those areas. Temporary solutions can also be used to prevent flooding from occurring by using deployable flood barriers. Two examples of flood warning systems and two examples of temporary deployable barriers are shown below.

Flood Warning Systems:	
	
Deployable Flood Barriers:	
	

1.1.2 Elevated Roads

Concept A, C, and D in Figs. 11, 12, and 13 show three different ways road elevation can be accomplished in a coastal setting. Concept A is an elevated road based on fill which works well in settings with enough space on either side of the road to allow for the side slopes to not encroach upon coastal wetlands. Concept C and D are elevated roads based on fill with a riprap side slope on the upland side and a vertical flood wall on the coastal side of the road. Concept C uses a sheet pile wall and Concept D uses a reinforced concrete wall, both of which minimize the overall footprint of impact and can work well in coastal settings. The type of design that would be proposed for a specific site will depend on the site-specific conditions and design objectives.

1.1.3 Flood Wall

Concept B in Fig. 11 provides a conceptual design of a flood wall to be used in coastal settings. The wall is a reinforced concrete wall with grouted steel anchors. To be effective, the floodwall would need to extend to a point where the existing grades exceed the design flood elevations, or provided with gates at access openings.

1.2 Regulatory Overview

The following provides an overview of the regulatory permitting process that would likely be involved for coastal flood adaptation projects in Stonington.

1.2.1 Town of Stonington

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

The Town of Stonington Shoreland Zoning Ordinance stipulates that projects involving road construction, earthwork, and structures extending over or below the normal high-water line or within a wetland requires a shoreland zoning permit issued by the Code Enforcement Officer and/or Planning Board.

1.2.2 Maine Department of Environmental Protection (MeDEP)

The Maine Department of Environmental Protection requires a Natural Resource Protection Act (NRPA) permit for projects within or adjacent to a coastal or freshwater wetland or other protected natural resources. An NRPA Individual Permit will likely be required for projects that will directly or indirectly impact wetland areas, including projects that involve work beyond the highest annual tide line. However, the shorter Permit-By-Rule application may be used for certain small, low-impact projects that present minimal risk of impact to environmental resources. The goal of the NRPA is to prevent or mitigate adverse impacts to protected natural resources by regulating activities in, on, or adjacent to the resources to minimize and/or avoid associated impacts. Compensation for wetland impacts may be required depending on the extent and type of resources impacted. For small projects that impact less than 500 square feet of wetland, compensation may not be required. For projects with greater impact, compensation may be in the form of in lieu fee compensation (ILF), wetland creation, or other methods. The NRPA application process will require 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 lease impactful practical option that achieves the project objectives. The timeframe for approval of applications under the NRPA is 2 weeks for Permit-by-Rule, and 3-4 months for Individual Permit applications.

1.2.3 US Army Corps of Engineers

A U.S. Army Corps of Engineers permit is required for projects that extend seaward of the high water line. In some cases, these permits can be avoided by utilizing vertical wall stabilization instead of a riprap slope. If a U.S. Army Corps of Engineers permit is required, several federal agencies will be involved in the review, including: US Fish & Wildlife, the Environmental Protection Agency, and National Marine Fisheries. In some cases, a Public Hearing will be held by the U.S. Army Corps of Engineers' Maine Project Office. In cases where both an NRPA individual permit and Army Corps permit are required, application can be made using the joint application form to both agencies.

1.2.4 US Coast Guard

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.

Appendix B

Cost Estimates

Appendix B: Cost Estimates

Order of magnitude construction cost estimates in 2021 dollars have been provided for road elevation projects recommended in this study in the table below. These cost estimates are approximate, ranging in accuracy by approximately +/- 30%, and represent construction costs. They do not include design or permitting costs and are not meant to be fully comprehensive. Cost estimates for individual pump stations have not been included due to the imprecision of elevation data, however, included is a range of costs for elevating electrical equipment and controls.

These cost estimates below represent estimates to move forward with construction of adaptation measures, however, there is a cost to not adapting infrastructure to 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 (Maine Climate Council, 2020).

Road/Asset	Adaptation Option	Description	Cost Estimate
Whitman	1	Elevate up to 2 ft	$630,000
	2	Elevate up to 4 ft	$820,000
	3	Elevate up to 6 ft	$1,020,000
Moose Island Causeway	1	Elevate up to 3 ft	$370,000
	2	Elevate up to 5 ft	$510,000
	3	Elevate up to 8 ft	$770,000
Atlantic Ave	1	Elevate up to 2 ft	$250,000
Fifield Point Rd	1	Elevate up to 2 ft	$130,000
	2	Elevate up to 4 ft	$360,000
	3	Elevate up to 6 ft	$560,000
Sand Beach Rd	1	Elevate up to 2 ft	$380,000
	2	Elevate up to 4 ft	$610,000
	3	Elevate up to 6 ft	$780,000
Colwell's Rd	1	Elevate up to 3 ft	$390,000
	2	Elevate up to 8 ft	$710,000
	3	Elevate up to 11 ft	$930,000
Burnt Cove Rd	1	Elevate up to 2 ft	$220,000
	2	Elevate up to 4 ft	$420,000
Main St	1	Elevate up to 3 ft	$340,000
	2	Elevate up to 4 ft	$410,000
	3	Elevate up to 6 ft	$550,000
West Main St	1	Elevate up to 2 ft	$250,000
	2	Elevate up to 4 ft	$480,000

Road/Asset	Adaptation Option	Description	Cost Estimate
Ocean St	1	Elevate up to 3 ft	$180,000
	2	Elevate up to 6 ft	$300,000
	3	Elevate up to 8 ft	$390,000
Bayview Ave	1	Elevate up to 2 ft and raise vertical wall on along shoreline	$260,000
	2	Elevate up to 4 ft and raise vertical wall on along shoreline	$690,000
	3	Elevate up to 6 ft and raise vertical wall on along shoreline	$990,000
Rhode Island Ave	1	Elevate up to 2 ft with vertical wall stabilization along three sides	$100,000
	2	Elevate up to 4 ft with vertical wall stabilization along three sides	$210,000
Oceanville Rd	1	Elevate up to 2 ft	$260,000
	2	Elevate up to 4 ft	$410,000
	3	Elevate up to 6 ft	$550,000
	4	Elevate up to 2 ft and convert to a bridge	$2,790,000
	5	Elevate up to 4 ft and convert to a bridge	$3,910,000
	6	Elevate up to 6 ft and convert to a bridge	$4,470,000
Hagen's Dock	1	2 ft Floodwall	$150,000
	2	4 ft Floodwall	$340,000
	3	7 ft Floodwall	$740,000
Pump Stations	Elevate	Elevation Amount Varies	$50,000 - $100,000 per pump station