LIVING SHORELINE CONCEPTUAL DESIGN

Bellamy River, Spur Road, Dover, NH

FINAL REPORT

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Prepared for

THE GREAT BAY
LIVING SHORELINE PROJECT

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LIST OF ABBREVIATIONS

CFA	coastal function value assessment
cfs	cubic feet per second
CVA	coastal vulnerability assessment
ft	foot
GBLS	Great Bay Living Shoreline
HTL	High Tide Line
MHHW	Mean Higher High Water
MHW	Mean High Water
MLLW	Mean Lower Low Water
MLW	Mean Low Water
mm	millimeter
MTL	Mean Tide Line
NAVD88	North American Vertical Datum of 1988
NERR	Great Bay National Estuarine Research Reserve
NHB	Natural Heritage Bureau
NHDES	New Hampshire Department of Environmental Services
OPCC	opinion of probable construction cost
RTK	real-time kinematic
SLR	Sea Level Rise
UNH	University of New Hampshire

1 Background

1.1 Project Background

The Great Bay Living Shoreline (GBLS) Project aims to create a pipeline of new living shoreline projects in the Great Bay Estuary that will protect salt marsh habitat and coastal communities from erosion, sea level rise, and flooding. The project is supported by the National Fish and Wildlife Foundation (funding partner), the Town of Durham, the New Hampshire Department of Environmental Services (NHDES) Coastal Program, the University of New Hampshire (UNH), the Great Bay National Estuarine Research Reserve (NERR), the Great Bay Stewards, the Strafford Regional Planning Commission, and the Piscataqua Region Estuaries Partnership. As part of this effort, four design teams comprised of restoration and shoreline management practitioners were assembled to develop conceptual designs for four unique sites around the Great Bay Estuary.

The Spur Road Design Team was tasked with the conceptual living shoreline design for the restoration of a private residential shoreline along the Bellamy River in Dover. Design team members included water resources engineers, environmental scientists, and environmental stewards.

The term living shoreline refers to a set of coastal erosion control practices, ranging from non-structural vegetated approaches to hybrid hard structural/restorative natural methods, that address erosion and inundation in a manner that improves or protects the ecological condition of the coastline[1].

1.2 Project Goals

Ecological Goals

The following ecological goals were identified for this project:

- Protect existing salt marsh from further erosion
- Restore salt marsh and shoreline functions that have already been lost to erosion
- Allow for some inland migration of salt marsh as sea level rises

Landowner Goals

The following landowner goals were identified through conversations with the property owner:

- Limit further shoreline erosion
- Protect lawn and property from flooding and erosion hazards
- Maintain some lawn for pets, open space, and field of view to river
- Provide for seasonal storage of several large docks on land accessible by barge-mounted crane

1.3 Project Scope

The scope of this project involved the development of a conceptual design of a living shoreline for the Spur Road site. Design deliverables include 1) drawings of plan and sectional views for the proposed

[1] Woods Hole Group. 2017. *Living Shorelines in New England: State of the Practice*. Prepared for The Nature Conservancy. East Falmouth, MA: Woods Hole Group. Retrieved from https://www.northeastoceancouncil.org/wp-content/uploads/2018/12/Final_StateofthePractice_7.2017.pdf.

improvements, 2) a list of recommended materials, 3) a planting plan, 4) a design basis report, and 5) a public presentation.

The physical scope includes approximately 150 linear feet of shoreline along the Bellamy River. The shoreline has two defined sections: a natural soil shoreline section (experiencing some erosion) and a stone retaining wall (experiencing structural issues). A structural analysis and design for the repair of the stone wall was beyond the scope of this project, but an alternative has been provided to replace the stone wall with living shoreline if desired.

Figures referenced in this report are contained in **Appendix A**. Representative photos are provided in **Appendix B**. The conceptual design plans are attached in **Appendix C**.

2 Site Assessment

2.1 Site Description

A location map of the site is provided in **Figure 2.1-1** in **Appendix A**, and an aerial image of the site is shown in **Figure 2.1-2**. The proposed project site is a 0.93-acre residential lot located on Spur Road in Dover, NH. The property includes an approximately 150-foot-long shoreline along the tidal portion of the Bellamy River. A pier extends from the shoreline to a set of several dock structures that are seasonally stored on- and offsite. The pier roughly divides the shoreline into two main sections: an approximately 100-foot-long section of natural shoreline extending to the southeast, and a stone retaining wall and armoring extending to the northwest.

The property contains a large, gently sloping, mowed lawn that extends to the edge of the retaining wall and near the eroding face of the natural shoreline. The remaining marsh is approximately 10 to 20 feet wide. The eroding faces of the banks are steep, with slopes ranging from 1 vertical to 5 horizontal (1V:5H) to 4V:1H. In the most significant area of erosion located about 40 feet south of the pier, the banks are undercut and pieces of marsh have sloughed off. Near the south end of the property, a section of shoreline has slumped down and the marsh is reestablishing at a lower elevation.

The retaining wall is approximately 40 feet long (30 feet on the property) and 4 to 5 feet high. It extends about 10 feet beyond the property line before meeting a perpendicular retaining wall section that extends waterward. The wall is primarily built of large, cut granite blocks. At the southeast end of the wall, a less structured formation of loose granite blocks and stones armors the shoreline under and adjacent to each side of the pier.

According to the landowner, the wall was rebuilt in recent years to address structural issues, but it appears to be currently out of alignment (leaning toward the water). A stormwater drainpipe from the yard outlets about halfway up the wall near its center. Additional stormwater from a swale through the yard flows over the top of the wall during storms.

2.2 Existing Information

Technical Assistance Program Report

A site visit was conducted and a summary report was prepared for the proposed project site in May 2021 under the New Hampshire Coastal Landowner Technical Assistance Program. The site visit included an assessment of existing conditions, an RTK GPS topographic survey, and an interview with the landowner.

The assessment found that the existing marsh is surprisingly healthy despite clear signs of erosion and the relatively small size of the remaining marsh platform (estimated at approximately 240 square yards based on the topographic survey data), containing the majority of native species commonly associated with salt marshes in New Hampshire. Smooth cordgrass dominated the low marsh, with prolific macroalgal patches of rockweed occupying the lower intertidal. Short-form smooth cordgrass was common particularly along the lower edge, but salt hay/meadow cordgrass, spikegrass, and blackgrass were also noted along with several halophytic (salt tolerant) forbs. A list of identified species is provided in **Table 2.2-1**. Common invasive species such as Common reed (*Phragmites australis*) were not observed despite their prevalence along nearby shoreline properties on the Bellamy River. Abundant native macroalgae on the seaward edge were noted to contribute to suitable conditions for a living shoreline.

Table 2.2-1: Plant Species Observed by in May 2021 by Technical Assistance Program

Habitat	Scientific Name	Common Name	Comment
Intertidal	*Ascophyllum nodosum*	rockweed	Relatively abundant
Low Marsh	*Spartina alterniflora*	smooth cordgrass	Dominant/common
High Marsh	*Spartina patens*	salt hay	Dominant
	Distichlis spicata	spikegrass	Common
	Juncus gerardii	blackgrass	Sparse
	Salicornia depressa	glasswort	Scattered throughout
	Limonium nashii	sea lavender	Scattered throughout
	Spartina alterniflora (s.f.)	smooth cordgrass	Short-form *S. alterniflora*
	Atriplex patula	orache	Sparse
Upland Edge/Lawn	*Spartina patens*	salt hay/saltmeadow	Not dominant, but present
	Poa annua	common lawn grass	Dominant
	Chenopodium alba	gooosefoot	In dry patches w/out grass
	Rumex acetosella	sorrel	In dry patches w/out grass
	Limonium nashii	sea lavender	In dry patches w/out grass
	Solidago sempervirens	seaside goldenrod	Very few

Living Shoreline Suitability Profile

A living shoreline suitability profile was prepared for the property based on information derived from the New Hampshire Living Shoreline Site Suitability Assessment (L3SA). This profile indicated that the property has a median living shoreline suitability index of 4.2 out of 6 (ranging from 3.7 to 4.7) and it may be suitable for a hybrid living shoreline approach with minimal structural components. The profile also indicated that the sea level rise (SLR) risk is approximately 1.3 feet to 2.3 feet by 2050.

Sea Level Rise Projections

Sea level rise predictions for 2050 and perhaps longer projections should be considered when designing a living shoreline project. The NH Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projections[2] includes a worksheet (Section E) that facilitates a seven-step process for using flood projections to plan projects, which must be completed for any shoreline project in New Hampshire. The specific guidance for a project depends on the project's sensitivity to inundation and the landowner's tolerance for flood risk as well as local sea level rise projections.

[2] NH Coastal Flood Risk Science and Technical Advisory Panel (2020). *New Hampshire Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projections*. Durham, NH: University of New Hampshire.

As part of the GBLS workshop feedback process, the New Hampshire Department of Environmental Services estimated the sea level rise for this project as 1.3 feet by 2050 and 2 feet by 2070. These projections were based on an assumption of a high tolerance for flood risk at the site, since no structures are currently threatened by flood waters. Both scenarios were considered by the design team, and the 2050 scenario (1.3 feet) was ultimately selected based on guidance from GBLS partners, landowner goals, and the desire to produce a cost-effective design that will be feasible for the landowner to construct while still meeting flood risk resiliency goals.

Rare Species / Exemplary Natural Communities

The New Hampshire Natural Heritage Bureau (NHB) was consulted in January 2022 by project partners to obtain information about potential rare species or exemplary natural communities near the project area. The species considered in the NHB database include those listed as Threatened or Endangered by either the state of New Hampshire or the federal government. It was determined that, although there was a NHB record (e.g., rare wildlife, plant, and/or natural community) present in the vicinity, NHB does not expect that it would be impacted by the proposed project.

2.3 Site Considerations

Sources of Impairment

According to the assessment in the Technical Assistance Report, the marsh platform at the site is clearly eroding, but is not as fragmented as that observed at similar properties in Great Bay. The exact causes of erosion at the site are unclear. Neither canopy shading nor boat wakes are likely a significant factor. Most likely, erosion is being driven by increasing inundation due to sea-level rise, compounded by winter storms, ice scouring, and ice rafting. The existing erosion also creates a positive feedback loop that leads to additional erosion, as the destabilized shoreline cannot hold itself in place as well as an intact shoreline.

Site Constraints

This site includes five distinct site constraints to be considered during the projects design. Each site constraint has been considered for a proposed modification, maintaining as is, or full removal.

Existing Irrigation System – A lawn irrigation system was installed below finished grade following the construction of the home in an effort to enhance the condition of the lawn. The system includes four zones of irrigation between the home and the river bank. Any proposed shoreline project must consider the physical extents of the irrigation system as well as its impacts on the natural salinity of the soil. The continuous fresh water in a marsh zone that would naturally have some salinity creates will affect the success of current and future marsh vegetation in the area.

Historic Bulkhead Remnants – This region is known for the historic use of its waterways for the transportation of goods to the Atlantic coast. Aerial imagery and site observation indicate a historic timber bulkhead that runs parallel to the existing shoreline and is partially buried in the mud flat (shown in **Figure 2.4-1**). This and other historic resources will need to be evaluated with regulatory agencies during future design and permitting phases, but is not expected to inhibit the feasibility of the proposed project.

Current Mowing Practices – Currently the landowner mows the entire lawn area regularly, including the area where high marsh vegetation was observed in the lawn within about 20 to 30 feet of the shoreline. The current mowing practices impact the health and landward extension of the marsh, which would make the shoreline more resilient to erosion.

Existing Retaining Wall – The existing failing stone retaining wall along the shoreline north of the pier is an important feature of the project and a concern for the landowner. A range of alternatives were considered for this structure, including removal, repair, or replacement with living shoreline.

Seasonal Dock Storage – The landowner has five docks seasonally installed in the river. Four of the five docks are typically moved into and out of the water over the property's shoreline, and some docks are stored in areas where marsh vegetation was observed or may be proposed for the restoration project. Dock storage is an important consideration for the health of current and future marsh vegetation onsite.

2.4 Data Collection & Analyses

Site visits were conducted on September 24 and October 28, 2021. A map showing key data collected during the site assessments is provided in **Figure 2.4-1** in **Appendix A**. Detailed information about the various data collection and analysis efforts are described below.

2.4.1 Topographic Survey

An initial topographic survey was conducted on September 24, 2021 by the design team using a survey level and prism. Four transects were surveyed through the property shoreline and retaining wall, and reference transects were surveyed at stable marsh sections of adjoining properties for reference. An updated survey was conducted on October 28, 2021 using a real-time kinematic (RTK) GPS unit. Surveyed transects are shown in **Figures 2.4.1-1** through **2.4.1-2** in **Appendix A**. The survey data was used along with LiDAR elevation data to inform the conceptual design and develop the design plans.

2.4.2 Water Level Monitoring / Tidal Statistics Analysis

A water level logger was installed in the river near the dock during the September 24, 2021 site visit and was retrieved on November 12, 2021. The logger measured water surface elevation of the river continuously during that approximately 50-day period in 5-minute increments. The resulting data were used to calculate tidal datums and delineate marsh zones for the site, as shown in **Table 2.4-1** below.

The sea level rise projection of 1.3 feet (determined in **Section 2.2** above) was then applied to the current tidal datums to estimate the predicted tidal datums for the year 2050, as shown in the right-most column of **Table 2.4-1**. Based on this information, it is anticipated that the High Tide Line (also known as the Spring Tide or King Tide) will be approximately 5 feet below the finished floor elevation of the residential house on the property by the year 2050.

Table 2.4-1: Tidal Datums and Sea Level Rise Projections

Approximate Tidal Zone	Tidal Datum	Elevation (ft, NAVD88)[1]	
		Current (Fall 2021)	*2050 Sea Level Rise Scenario (+1.3')*
Tidal Buffer	High Tide Line (HTL)[2]	5.77	7.07[3]
High Marsh	Mean Higher High Water (MHHW)	3.77	5.07
	Mean High Water (MHW)	3.42	4.72
Low Marsh	Mean Tide Line (MTL)	0.13	1.43
Subtidal	Mean Low Water (MLW)	-3.17	-1.87
	Mean Lower Low Water (MLLW)	-3.41	-2.11

[1] Elevations are relative to the North American Vertical Datum of 1988 (NAVD88)
[2] The High Tide Line is also known as the Spring Tide or King Tide and is the regulatory landward boundary of a salt marsh.
[3] For reference, the residential house on the property has a finished floor elevation of approximately 12 feet NAVD88.

2.4.3 Bank Erosion Monitoring

To assess current bank erosion trends, rebar pins were pounded horizontally into the bank until flush with the waterward edge at six locations during the September 24, 2021 site visit. The pins were then checked on October 28, 2021 and March 19, 2022 to measure the distance of rebar protruding from the edge of the bank (indicating the amount of bank that had eroded during that time). Average daily erosion rates were calculated for each pin. For most pins, the overall period from September to March was used to calculate the average rate. For pins #1 and #5, bank collapse or potential bank collapse was observed during the March visit, resulting in a zero reading, so only the period of September through October was used to calculate the average rates for those pins. The average daily rates were then used to project average annual erosion rates. These rates should be considered approximate, as there are typically seasonal fluctuations in bank erosion rates (with the most significant erosion often occurring during the spring ice thaw).

Lastly, the average annual erosion rates were used to predict the lateral distance of bank that is anticipated to erode away by the year 2050. The projected distances for each pin were averaged to determine an overall average for the site. This average 2050 bank erosion distance was found to be approximately 20 feet (using all data) to 24 feet (excluding the outliers of pins #1 and #5).

Additional bank erosion monitoring data (at least four years recommended) would be needed to analyze seasonal and/or spatial trends in the data.

Table 2.4.3-1: Summary of Bank Erosion Monitoring Results and Projected Erosion Distance

Pin No.	Dist. from S Edge of Pier (ft)	Protruding Distance (mm)[1]			Erosion Rate		2050 Erosion Distance (ft)
		9/24/2021	10/28/2021	3/19/2022	mm/day	mm/yr	
6	33	0	11	59	0.398	145	14
1	36	0	24	—[3]	0.706	258	25
2	55	0	33	163	1.114	406	39
3	67	0	33	147	1.023	373	36
5	83	0	2	0[4]	0.059	21	2
4	150	0	20[2]	15[5]	0.199	73	7
				Average *(all data)*	**0.583**	**213**	**20**
				Average *(excluding #1 & #5 outliers)*	**0.683**	**249**	**24**

[1] All pins were reset flush with the bank edge (0 mm) after readings (except where noted).
[2] Pin #4 was read on 10/30/21 and all pins were reset flush with the bank on that date.
[3] Bank collapsed. Metal detector picked up pin below the collapse, but pin was not visible.
[4] Possible bank collapse.
[5] Exposed through collapsed peat.

2.4.4 Salt Marsh Vegetation Survey

A survey of existing salt marsh vegetation was conducted during the September 24, 2021 site visit. Species identified at the site include the following:

- Low Marsh - *Spartina alterniflora* (smooth cord grass)
- High Marsh - *Juncus gerardii* (saltmarsh rush); *Spartina patens* (saltmeadow cordgrass); *Distichlis spicata* (salt grass)

Several high marsh species were identified in the mowed lawn area, as far as 25 feet landward of the edge of mowing. Additional species were observed during the initial *Technical Assistance Program Report* in May of 2021 (see **Table 2.2-1** for a listing of those species).

2.4.5 Hydrologic Analysis

Stormwater drainage of the site is a concern for the landowner. An existing stormwater swale runs about 100 feet from the north property/tree line to the top of the stone retaining wall. An underground stormwater drainpipe follows approximately the same path and outlets about midway up the retaining wall. These features should be taken into consideration during future phases of the living shoreline design.

A rainfall runoff model was developed for the site using HydroCAD software. A drainage area was delineated for the property. The model results provide peak runoff flow rates for various storm events. These results could be used to design an appropriate stormwater outfall (e.g., riprap protection) on the proposed living shoreline during future design phases.

3 Alternatives Analysis

Several alternatives were developed throughout the conceptual design process prior to selecting the recommended design presented in **Section 4**. Factors considered in the comparison of alternatives included, but were not limited to:

- Permitting requirements
- Construction considerations (e.g., access)
- Costs
- Maintenance requirements
- Performance monitoring needs

Alternatives considered included the following.

No Action Alternative – As sea levels change, salt marsh will migrate upland onto the property lawn as part of the natural ecosystem shift. If no action is taken, the natural shoreline will continue to erode landward. Assuming the erosion rate remains consistent with that measured during the study period (**Section 2.4.3**), the bank is expected to erode laterally a distance of approximately 24 feet. The Mean High Water line is anticipated to migrate landward by approximately 15-30 feet, while the High Tide Line (also known as the King Tide or Spring Tide) is expected to migrate landward by about 25-30 feet. These projections are depicted on a map of the site in **Figure 3-1** in **Appendix A**.

Full vs. Partial Living Shoreline – Two alternatives were initially developed: 1) a living shoreline along the 100-foot-long natural shoreline section only, and 2) a living shoreline along the full 150-foot-long property line. In the first scenario, the existing retaining wall could either be left as is (which may lead to it collapsing eventually) or could be assessed by a structural engineer and rebuilt to address structural issues. In the second scenario, the retaining wall would be shortened by removing approximately two courses of granite blocks, and the living shoreline would be built overtop it. The latter approach would likely be more cost effective and would offer longer-term protection than rebuilding the wall. After being presented with the options, the landowner selected the full living shoreline as the preferred approach.

Filling Seaward vs. Cutting Landward – Two options exist for flattening the slope of an existing eroding shoreline: adding fill and extending the toe of the bank seaward, and/or cutting back the top of the bank. A combination of approaches can be used. For this site, it was determined early in the design process that filling seaward would be the preferred approach due to available space in the mudflat, landowner preference, and the desire to not disturb the remaining existing high marsh to the extent feasible.

Sea Level Rise Scenario – Initially, a sea level rise projection of 2 feet by the year 2070 was assumed for this project to be conservative. However, after discussing further with the GBLS team and the landowner, it was decided to reduce the SLR projection to 1.3 feet by 2050 as this is more in line with targets used on similar projects and landowner goals for the site. This design choice will also make the project more cost effective (due to reduced fill requirements) and increase the feasibility of it being constructed by the landowner.

Slope Alternatives/Tiers – The GBLS team indicated that a slope of approximately 2% to 4% is ideal for living shorelines. Higher slopes can be accommodated with additional erosion protection materials. Another approach to mitigate steeper slopes is to install tiered marsh platforms separated by coir logs. Throughout the various iterations of SLR scenarios, stone toe elevations, and other design alternatives, the slope of the proposed living shoreline was adjusted several times. The design goals were to keep the slope of the low marsh at or below 4% and to limit the lateral seaward extent of the living shoreline to 50 feet or less due to permitting thresholds. Ultimately, the selected design required three tiers separated by coir logs to meet these goals.

Resilient Lawn Fill – One potential alternative that was proposed to the landowner as an added feature (to be permitting and constructed concurrently with the living shoreline but not dependent on it) was an area of raised lawn that would be resilient to sea level rise. This was proposed as an area of fill approximately 2 to 3 feet high in the northeast quadrant of the yard (north of the stone path) that would remain elevated above the landward advancement of higher tides. The landowner was interested in this idea, but did not wish to advance it to the next phase of design due to the high cost of the significant volume of fill that would be needed.

4 Conceptual Design

4.1 Design Narrative

A conceptual overview of the proposed design is provided in **Figure 4.1-1**. A schematic detail of a typical living shoreline cross-section is provided in **Figure 4.1-2**. Conceptual design plans and sections are attached in **Appendix C**.

The proposed design includes a living shoreline built outward from the top of the existing eroding bank along the entire 150-foot-length of the property line. In the design plans (**Appendix C**), typical sections are provided for three main areas: just south of the pier (Section A), near the southeast end of the property where existing slopes are shallowest (Section B), and at the existing retaining wall (Section C).

Living Shoreline Construction

A stone toe is proposed for the living shoreline to provide protection from erosion and form a sill for the proposed fill material. The crest of the stone toe will be set at an elevation equal to the projected 2050 Mean Tide Line (1.43 feet). The fill behind the stone toe will be set down approximately 2 inches from the crest. The fill will rise from there to tie into the existing top of bank near the extents of current mowing.

To achieve target slopes of 4% or lower for the proposed low marsh, two 16-inch-diameter coir logs will be used to divide the shoreline into three tiered sections. The lower two sections will comprise the low marsh and will have a target slope of 4%. The upper section will comprise the constructed portion of the high marsh, and will have slopes of approximately 7% to 17% to tie into the existing bank.

Retaining Wall

For the stone retaining wall section, approximately two courses of granite blocks will be removed from the wall to reduce its height below the target living shoreline elevation. The remaining wall will be left in place and the living shoreline will be constructed over it. The placed fill will likely stabilize any adjacent remaining sections of retaining wall (i.e., to the north on the abutting property), but this should be evaluated and confirmed by a structural engineer during final design. Erosion protection measures will be incorporated in future design phases for the stormwater outfall.

Unmowed/Future High Marsh Zone

Beyond the extent of the constructed high marsh where the proposed living shoreline ties into the existing bank, it is recommended that the landowner discontinue mowing for a distance of approximately 20 to 30 feet. This will allow the already present high marsh vegetation species to thrive and propagate and will begin to convert the lowermost section of the lawn to high marsh so that it is more resilient as sea level rises and the marsh migrates landward. It would be beneficial if the existing irrigation system could be modified to cut off this unmowed zone from further irrigation to restore the natural salinity of the soil and further support the growth of the salt marsh vegetation species.

Seasonal Dock Storage

Lastly, the success of the proposed living shoreline could be increased by avoiding seasonal storage of docks on the marsh. Storing docks on the marsh damages marsh vegetation by physically compressing it and reducing light transmission. The company that currently installs and removes the docks each spring and fall has indicated that it would be possible to transport some of the docks to a local marina for winter storage for a reasonable fee. It is recommended to store as many of the docks off-site and move any remaining docks onto the lawn beyond the extent of marsh vegetation to help minimize potential damage to the marsh.

Suggested Materials

Fill – Fill material will be needed to construct the living shoreline. Different fill compositions are recommended for the different low marsh and high marsh zones. A chart showing particle size distributions recommended by UNH for low and high marsh fill is provided in **Figure 4.1-3** in **Appendix A**. It is recommended that organic matter be added to the high marsh material in order to retain more water, as the high marsh zone is not inundated by the tides as frequently as the low marsh and therefore is more dependent on precipitation or other sources of water during the peak growing season. Approximately 3% organic matter by volume is specified, and the matter should be extremely refractory (unable to be broken down by microbes), such as wood products (e.g., coir).

Stone – Large stone will be needed to form the stone toe. The size of the stone necessary to withstand erosion and other forces will be determined during the next design phase. Granite blocks will be available from disassembling the top two courses of the stone retaining wall as proposed, but the landowner would prefer to apply these to other uses and instead utilize a consistent material for the entire stone toe.

Coir Logs – Coir logs should ideally be 16 inches in diameter and should be installed to provide 6 to 8 inches of lift. Some compression should be expected.

Geotextile Fabric – Geotextile fabric may be specified during the next design phase to prevent the loss of fill material through the filter stone. Geotextile fabric should be wrapped and overlapped appropriately to avoid gaps and slippage.

Oysters – The Eastern oyster (*Crassostrea virginica*) is an important ecological component of the Great Bay Estuary. The stone toe feature of the proposed living shoreline is a substrate on which these oysters could potentially be introduced to help boost the structural and ecological benefits of the project. Oysters help filter the water and provide essential fish habitat. Oyster reefs also help mitigate energy from wind and waves on the shoreline. When the final materials selection is made for the stone toe, consideration of products that would be conducive to the introduction of oysters should be considered. Additionally, the potential exists to partner with the New Hampshire chapter of The Nature Conservancy, (who has reintroduced over 3,500,000 oysters to the estuary and restored 28 acres of reef since 2009) to monitor success of the oysters over time.

4.2 Planting Plan

The ecological goal of the proposed planting plan is to plant native species that are likely to thrive in the constructed and near-future soil, hydrological, and salinity conditions found on the site. Landowner goals were also considered, including preference for species that are low in height and maximizing the area of turf lawn.

Species

The following species are proposed for planting at the site, as they are existing on-site, readily available, and are key components of low and high marsh plant communities:

<u>Low Marsh</u>

- *Spartina alterniflora* (Smooth cordgrass)

<u>High Marsh</u>

- *Juncus gerardii* (black grass)
- *Distichlis spicata* (saltgrass)
- *Spartina patens* (saltmeadow cordgrass)

Other plants were considered but not included in the final design (per landowner preference):

<u>Tidal Buffer</u>

- *Schyzachirium scoparium* (little bluestem grass) – Possibly use a nativar such as “Standing Ovation” for added landscape aesthetic benefit in certain areas
- *Panicum virgatum* (switchgrass) – Use a lower-growing variety
- *Clethra alnifolia* (summersweet clethra shrub) – use a cultivated variety such as Hummingbird to keep height low and add landscape aesthetic benefit
- *Solidago sempervirens* (seaside goldenrod) – Late season color and migrating monarch butterfly benefits

Other Recommendations

Plugs are recommended (rather than seeding) for the low and high saltmarsh graminoid species to improve plant establishment success. A spacing of 8 to 10 inches (on center) should be specified to maximize coverage and minimize erosion potential and open space for weed competition.

The small oak tree at the north end of the property shoreline will likely decline as the soils become more saline over time and may need to be removed in the future. A photo taken during the high high tide of January of 2022 (provided in **Appendix B**) shows that the trunk and root system are already inundated during these water levels.

Upland species such as seaside goldenrod and summersweet clethra could be planted around existing boulders at the edge of the high marsh/current lawn and in fringe areas near existing fences to add landscape interest and enhance pollinator benefits for the project. These species wouldn't create a visual barrier to the view of the docks and would eliminate the need for mowing around the rocks. However, upland plantings were not included in the proposed design at this time due to landowner preference.

Alternatives were also considered for protecting the proposed unmowed/future high marsh area from potential damage due to foot traffic, mowing, etc. by installing either protective boulders or fencing to roughly delineate this area. However, these features were not included in the proposed design at this time due to landowner preference.

The landowner was interested in potentially preserving portions of the intact marsh vegetation on the site for replanting following construction of the proposed living shoreline. The idea of cutting out some of the existing saltmarsh sod prior to regrading, and re-installing it after re-grading was considered. However, it would need to be watered daily until reinstallation, which could be a substantial cost. Additionally, a suitable site for storing the sod would need to be found during construction. Reinstallation would also have to take place prior to new vegetative growth beginning in the spring (prior to May 15), which could be logistically difficult to accomplish.

Proposed Renderings

Figures 4.2-2 through **4.2-6** in Appendix A provide renderings for possible variations of the above proposed planting plan. **Figure 4.2-1** provides the base image from which the renderings were created. The following scenarios are included:

- **Figure 4.2-2**: Salt Marsh with Low and High Marsh Grasses Only **(Selected Alternative)**
- **Figure 4.2-3**: Salt Marsh with Upland Grasses in Tidal Buffer
- **Figure 4.2-4**: Salt Marsh with Upland Grasses and Shrubs in Tidal Buffer
- **Figure 4.2-5**: Salt Marsh with Upland Grasses, Shrubs, and Protective Boulders in Tidal Buffer
- **Figure 4.2-6**: Salt Marsh with Protective Fencing in Tidal Buffer

The landowner prefers the first alternative presented in **Figure 4.2-2** with low and high marsh grasses only.

4.3 Anticipated Permitting Requirements

State Permitting

The proposed living shoreline project can be categorized by NHDES as a "Minimum Impact Tidal Shoreline Stabilization Project" (Env-Wt 609.10(b)) under the specifications that it remains under 200 linear feet and extends no greater than 50 feet seaward of the mean low water record (which the currently proposed design does). A minimum impact tidal shoreline stabilization project requires a coastal function value assessment (CFA) as well as a coastal vulnerability assessment (CVA). A CFA involves a New Hampshire Certified Wetland Scientist to complete a delineation and assessment data sheets. A CVA involves a water resource engineer to complete an assessment for the potential impact on the shoreline by sea level rise under different sea level rise scenarios. Filing under the Env-WT 609.10(b) also requires abutter approval for work within 50 feet of the property line. An extensive amount of coordination will be required with NHDES to file under the Env-Wt 609.10(b) and demonstrating avoidance and minimization of the wetland and tidal zones will be a large focus in their determination.

In addition to a state wetlands permit, a state shoreland permit is also required and this project can be filed under a "Shoreland Restoration" (Env-Wq 1412) project. A shoreland restoration permit requires a proposed planting plan, a plan of the waterfront buffer and a schedule of implementation and monitoring for at least two growing seasons.

An archeological assessment will also need to take place during the permitting phase. The Department of Historical Resources (DHR) requires a Phase IA Survey to be completed by a certified archeologist. A Phase IA Survey consists of a desktop and field review of the site. The archeologist will then compile a report with their findings and submit a Request for Project Review through DHR.

Local Permitting

The City of Dover zoning ordinance requires a conditional use permit within the conservation district (170-27.) and the wetland protection district (170-27.1). The conditional use permit application has an application fee of $300 with an additional $8 per abutter. Along with the fees, a permitting plan set is required containing the wetland delineation line, wetland impact square footage and erosion and sediment controls. Any supplemental information is always helpful on a local scale. The City of Dover requires an application to be submitted 21 days prior to the Planning Board meeting. Conservation Commission approval is necessary prior to the Planning Board presentation. The Conservation Commission meets on the second Monday of each month at 5:30 pm and the Planning Board meets the second and fourth Tuesday of each month.

4.4 Maintenance & Monitoring Considerations

The proposed living shoreline project will require some level of monitoring and maintenance to ensure its success. Monitoring of target parameters will also be required by the project permits. Parameters to be monitored should be determined in collaboration with regulatory agencies during future design and permitting phases, but a preliminary list may include the following:

- Initial and ongoing planting success (typically for two growing seasons per state regulations)
- Shoreline erosion rate
- Topographic survey to assess settlement/erosion (recommended one year post-construction)
- Biological indicators (e.g., wildlife, algae, fish surveys, oyster success, etc.)

5 Summary & Next Steps

In summary, this study found that the subject site along the Bellamy River on Spur Road in Dover, NH is a good candidate for a living shoreline per the proposed conceptual design. If the landowner wishes to continue pursuing a living shoreline for this site, the following next steps are recommended.

Preliminary Design & Permitting

An engineering consultant should be contracted to progress the project design plans to a level sufficient to initiate permitting. The consultant should have the following capabilities (either in-house or by subcontracting):

- Professional Engineer licensed in New Hampshire
- Civil or water resources engineer capable of designing the living shoreline
- Structural engineer capable of analyzing the stability of the retaining wall
- Certified Wetland Scientist capable of performing a wetland delineation
- Cultural resources specialist capable of performing a Phase IA survey

Prior to initiating permitting, a pre-application meeting should be held with regulatory agencies to discuss the proposed design and get early feedback on any design changes or requirements that may be needed. The wetland delineation, Phase IA cultural resources survey, and any additional field data collection will be conducted during this phase. The design will then be advanced to the preliminary (approximately 75% complete) level to submit with permit applications. Erosion and sedimentation best management practices, water control measures, proposed access routes, and other details will be added to the plans. Technical specifications and an opinion of probable construction cost (OPCC) will be developed. Permit applications will be prepared and submitted. Permit hearings will be held and questions from agencies or the public will be addressed.

Grant Application Assistance

The project consultant can also assist with the identification of funding opportunities and preparation of grant applications, as applicable. The GBLS team plans to provide additional guidance to landowners regarding potential grant or partnering opportunities as part of the GBLS design workshop.

Final Design & Bidding

Comments received from permitting agencies will be incorporated into the design and final design plans will be prepared and stamped by a Professional Engineer. The engineering consultant can then assist with the bidding of the project to contractors (e.g., preparation of bid documents, facilitation of a pre-bid meeting, contracting, etc.).

Construction & Post-Construction Monitoring

Following issuance of the final design plans and selection of a contractor, construction on the project will commence. Following construction, monitoring will be conducted to ensure the success of the project per permitting requirements.

Appendix A – Figures

Figure 2.1-1: Site Location Map

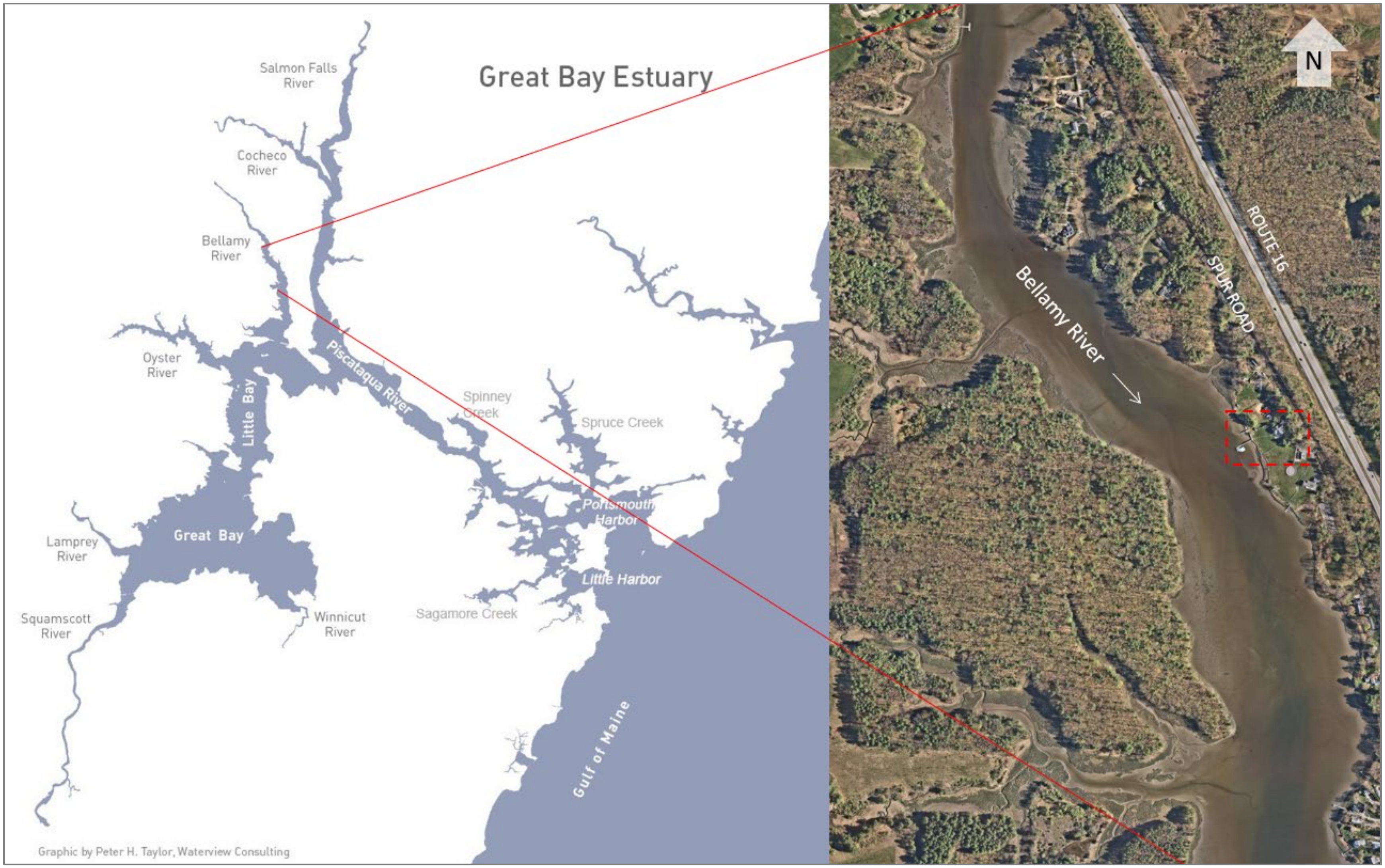


Figure 2.1-2: Aerial Map of Site

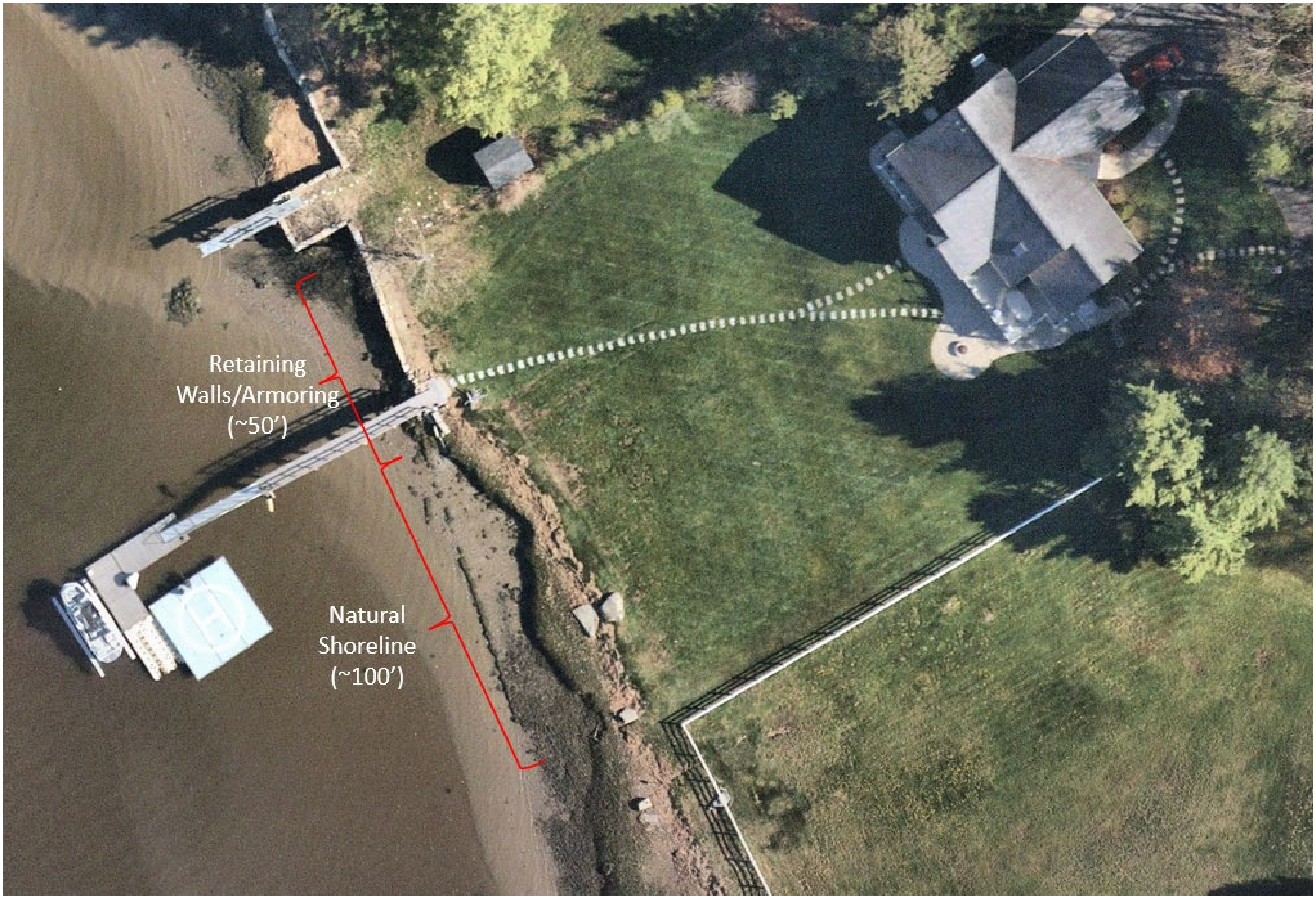


Figure 2.4-1: Summary of Site Assessment Data

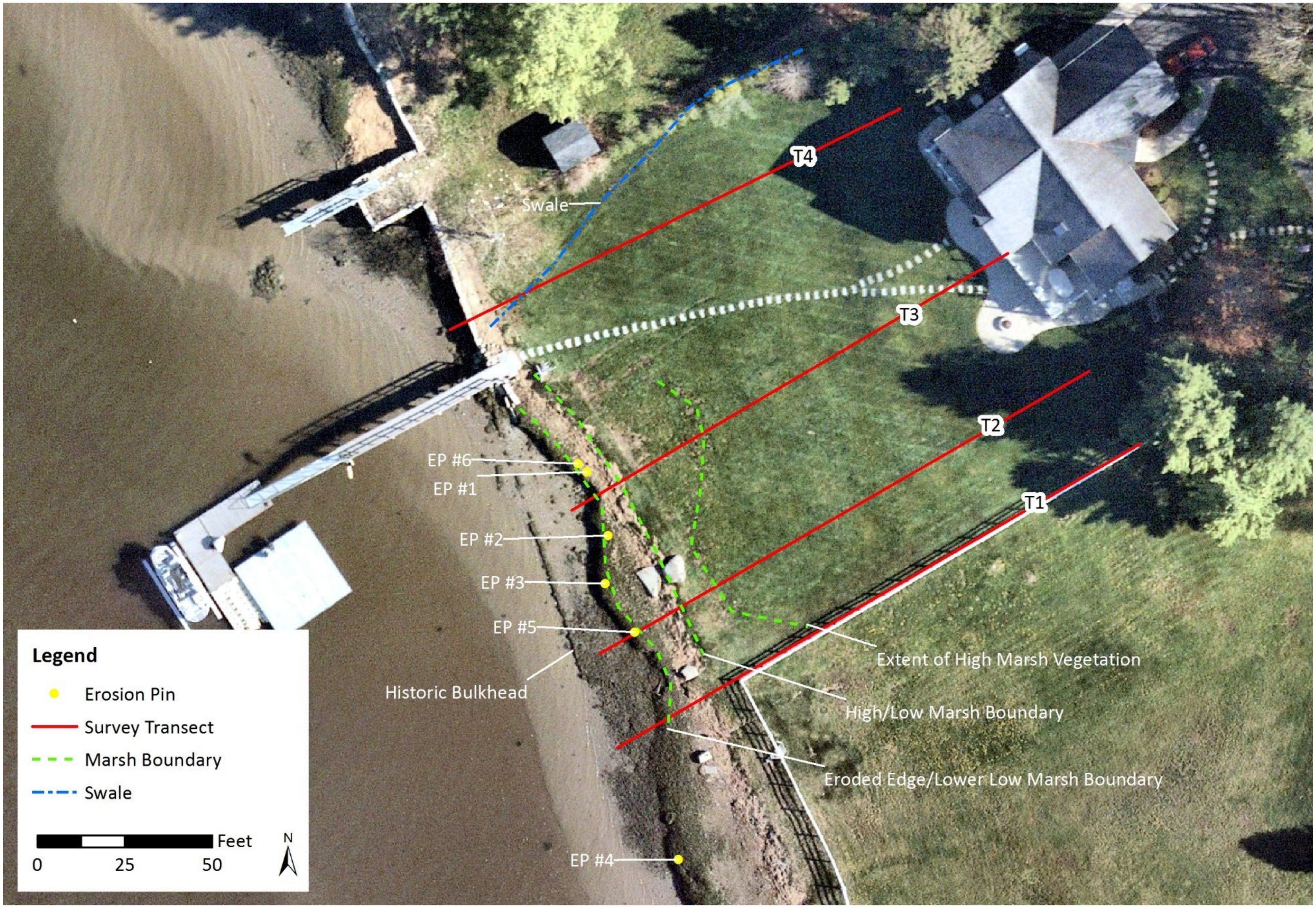


Figure 2.4.1-1: Survey Transect #1

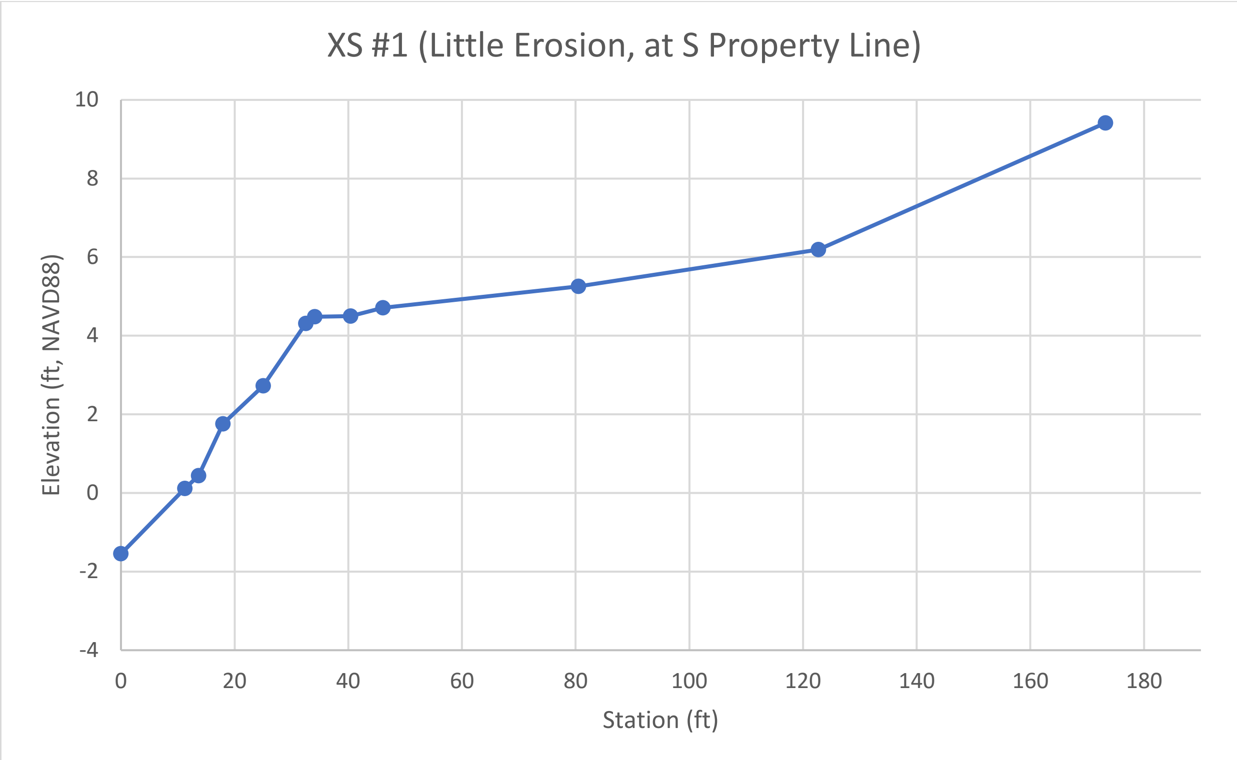


Figure 2.4.1-2: Survey Transect #2

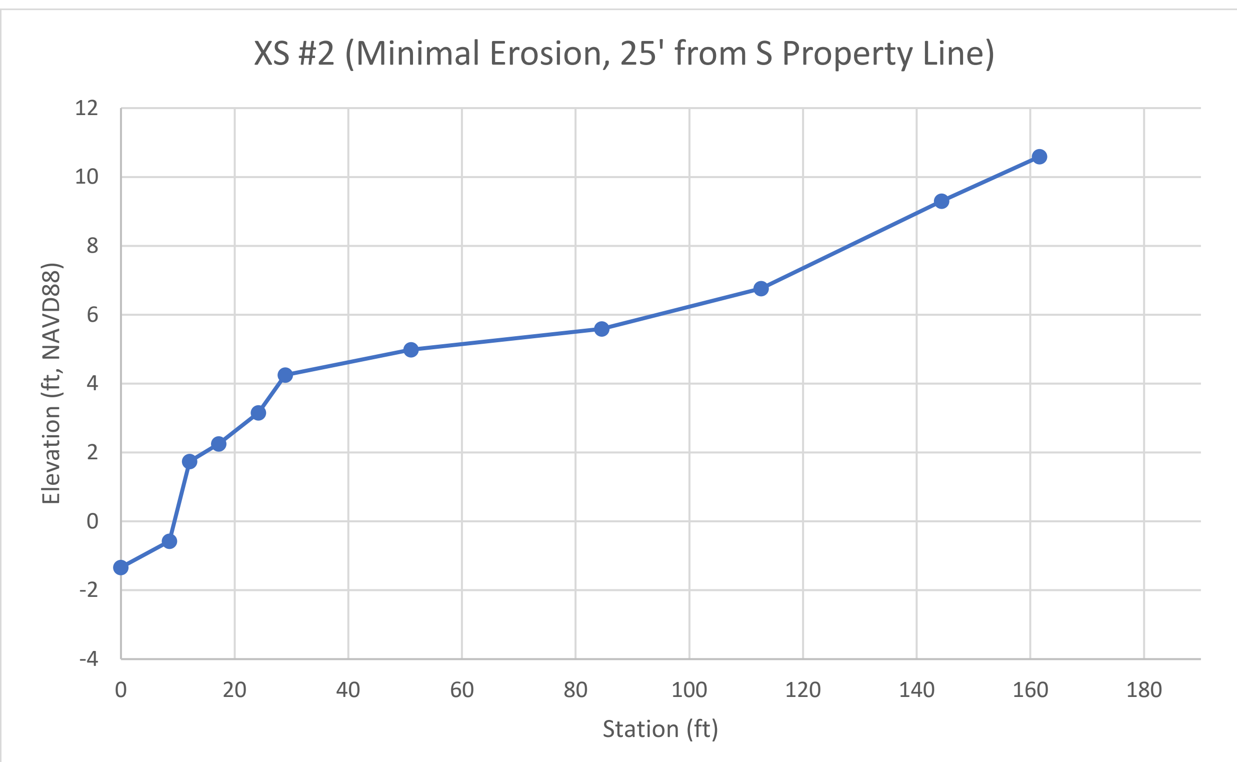


Figure 2.4.1-3: Survey Transect #3

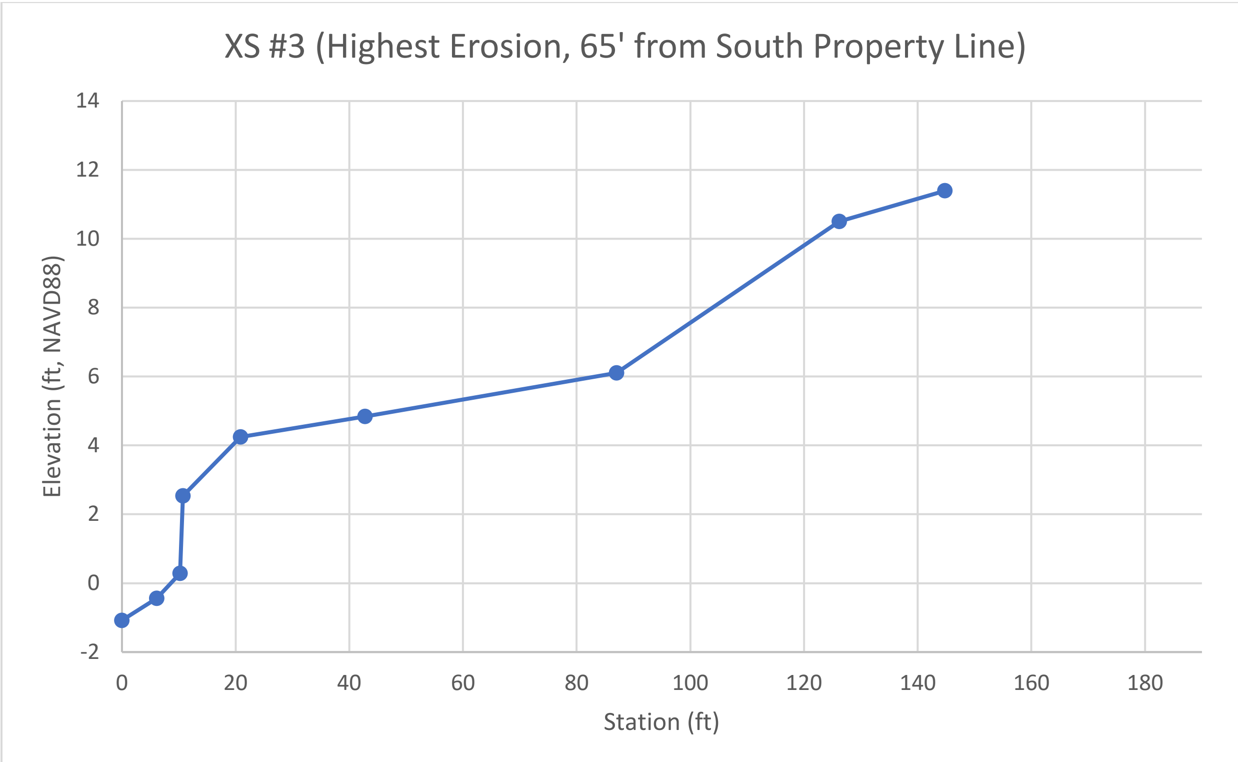


Figure 2.4.1-4: Survey Transect #4

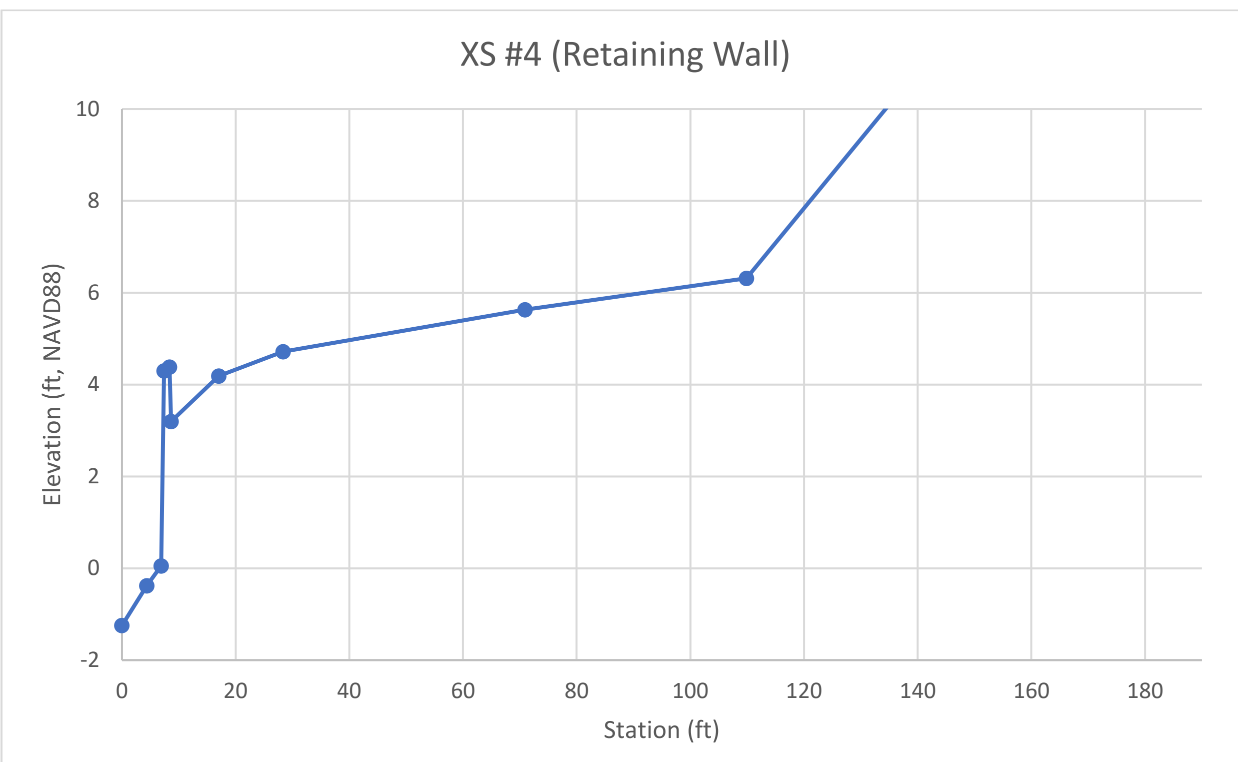
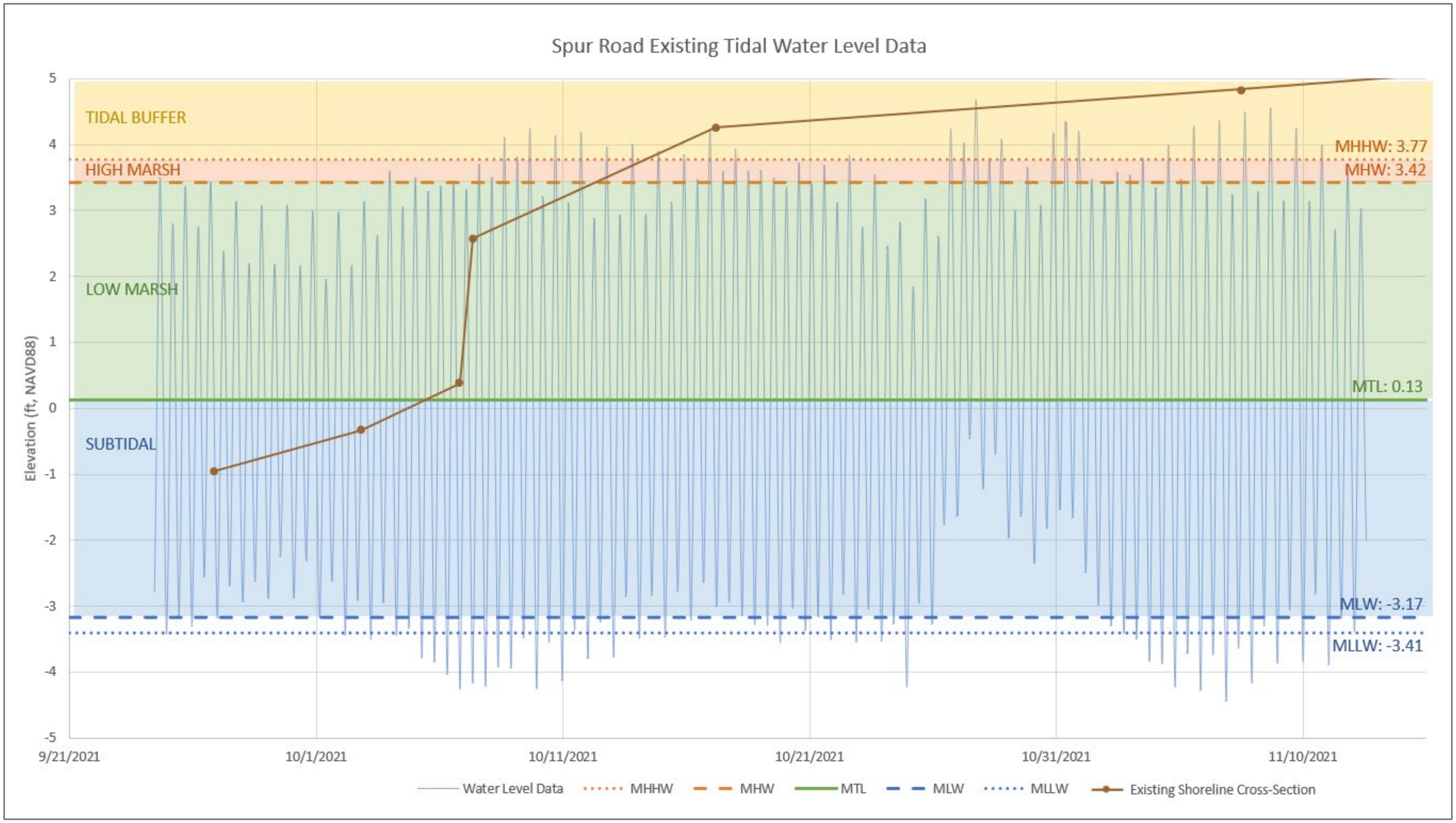


Figure 2.4.2-1: Tidal Water Level Data and Tidal Datums



Note: Existing shoreline Transect #3 (from Figure 2.4.1-3) in the area of the most significant erosion is shown for reference.

Figure 3-1: No Action Alternative (Approximate 2050 Projections)

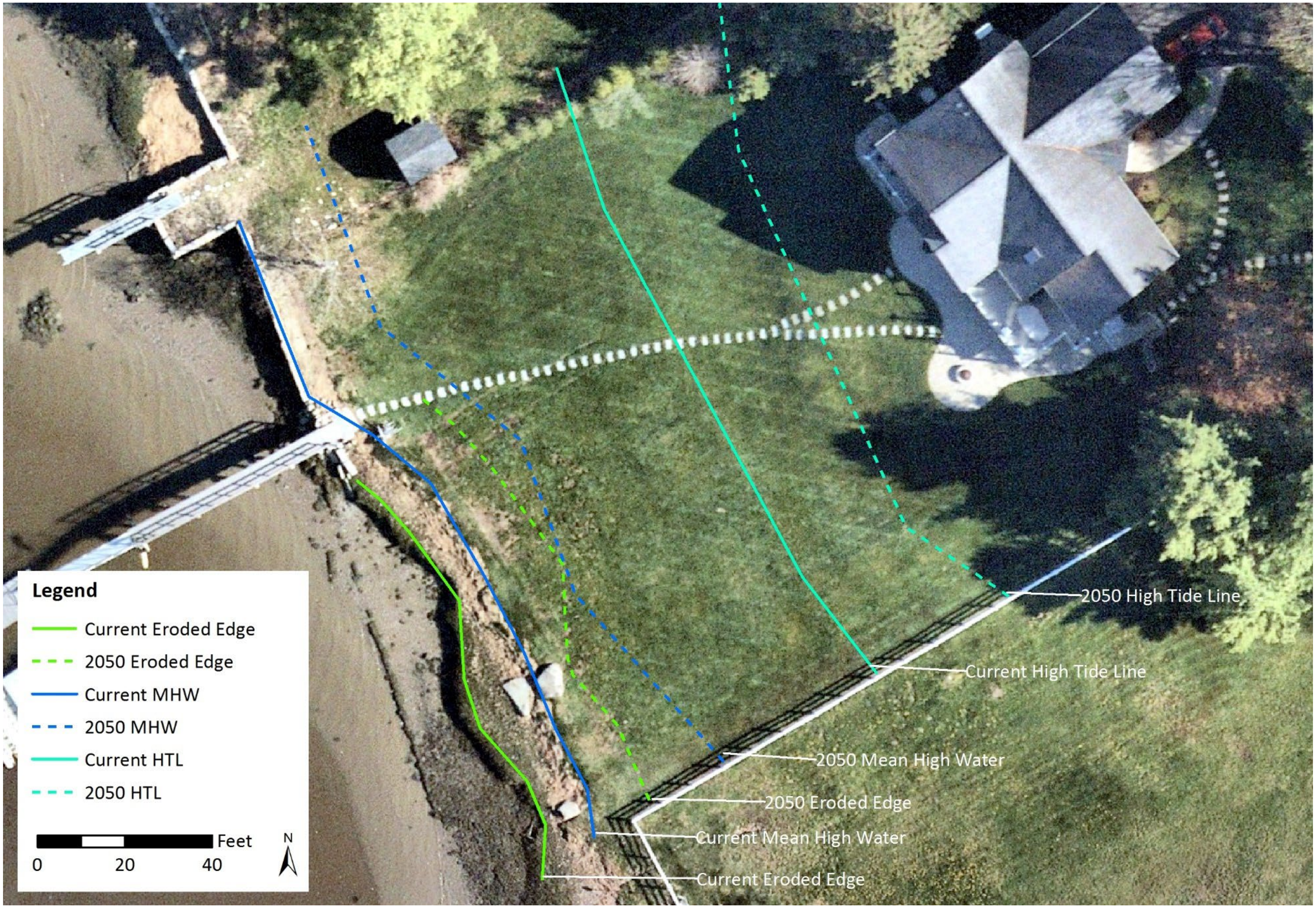


Figure 4.1-1: Schematic Overview of Proposed Concept Design

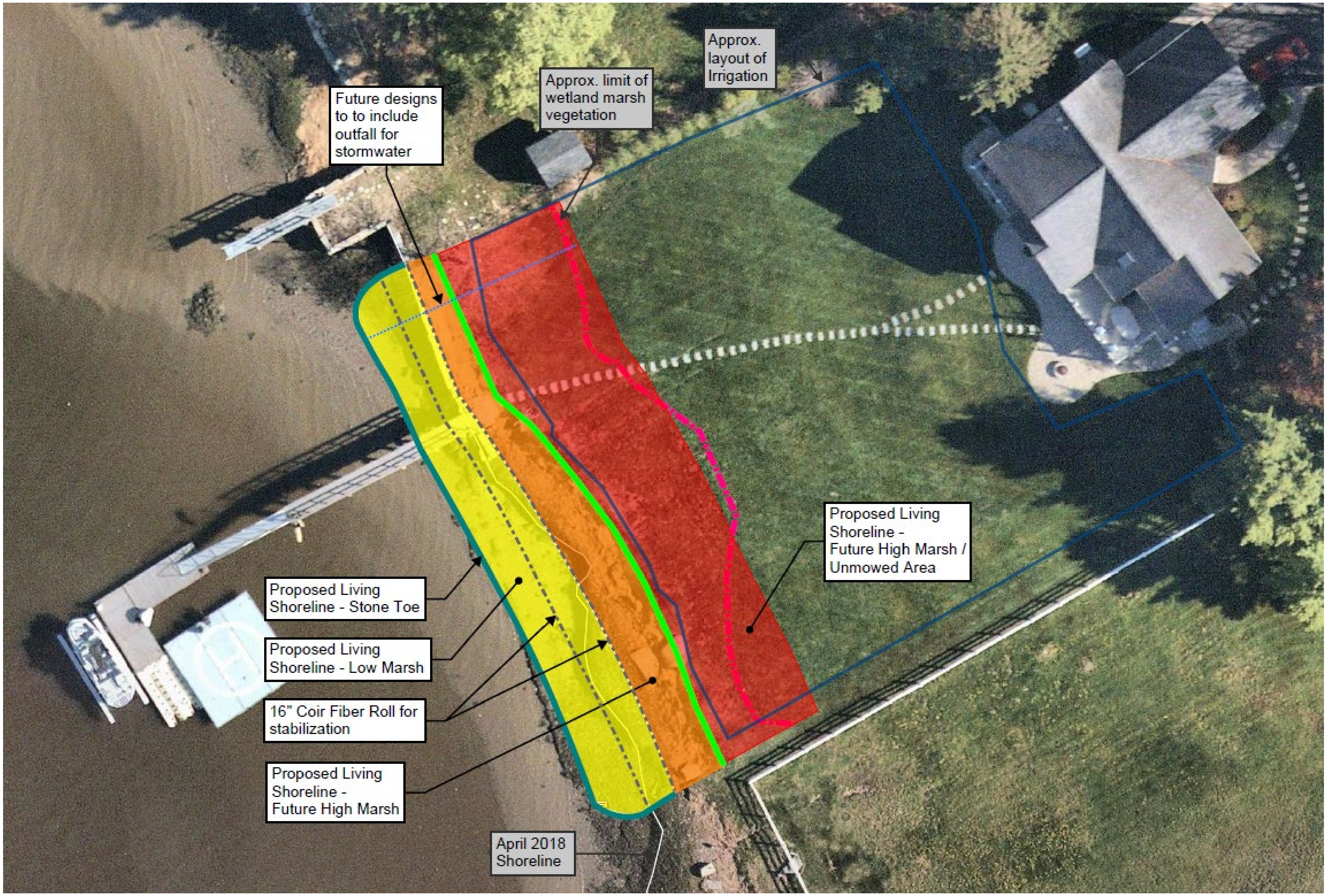
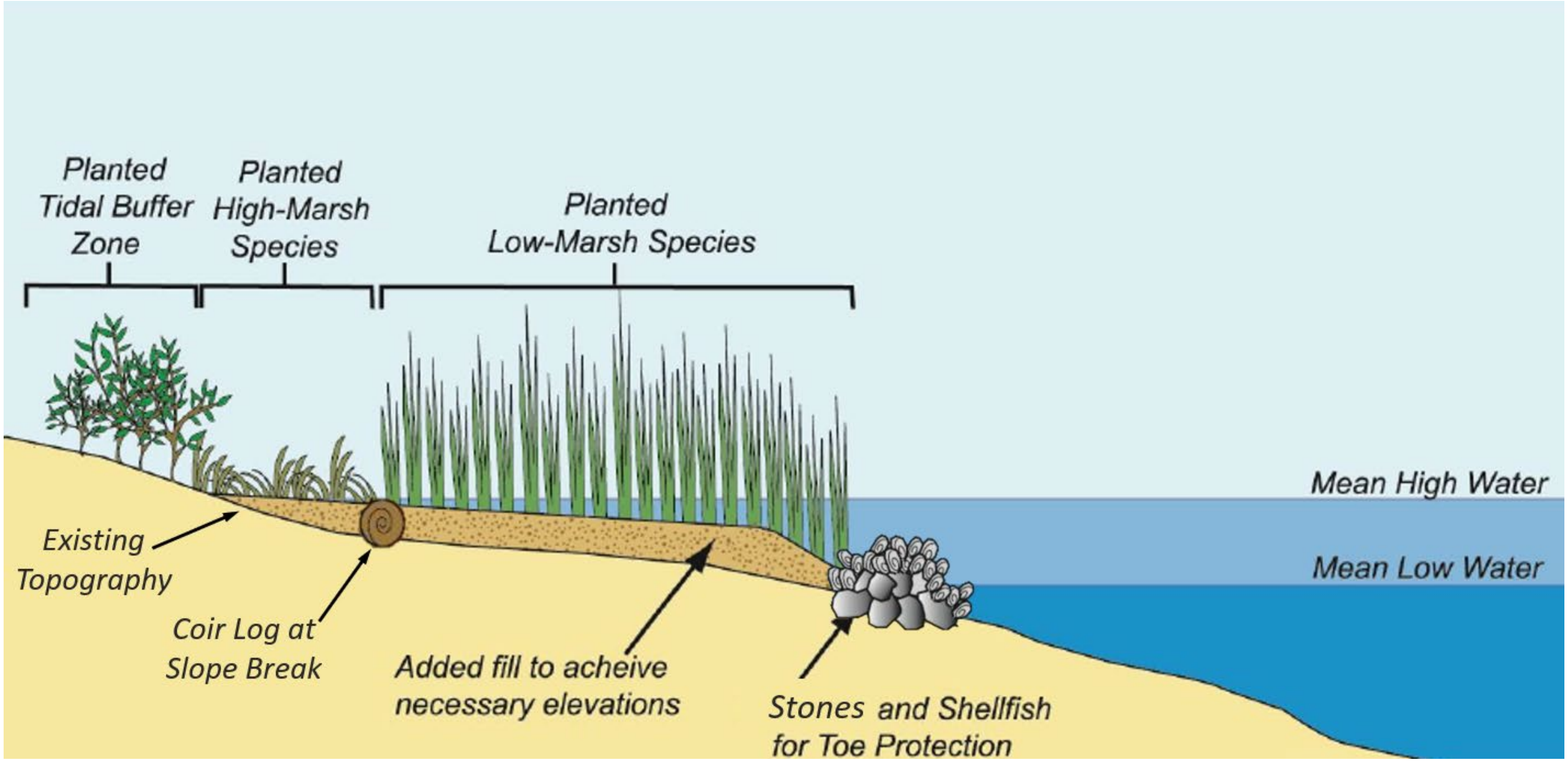


Figure 4.1-2: Schematic Typical Living Shoreline Section



Note: This schematic typical section is intended to convey elements of a living shoreline. It does not reflect the dimensions or exact features of the proposed concept design for this site (e.g., the proposed design includes a second coir log within the low marsh).

Figure 4.1-3: Recommended Living Shoreline Fill Particle Size Distributions

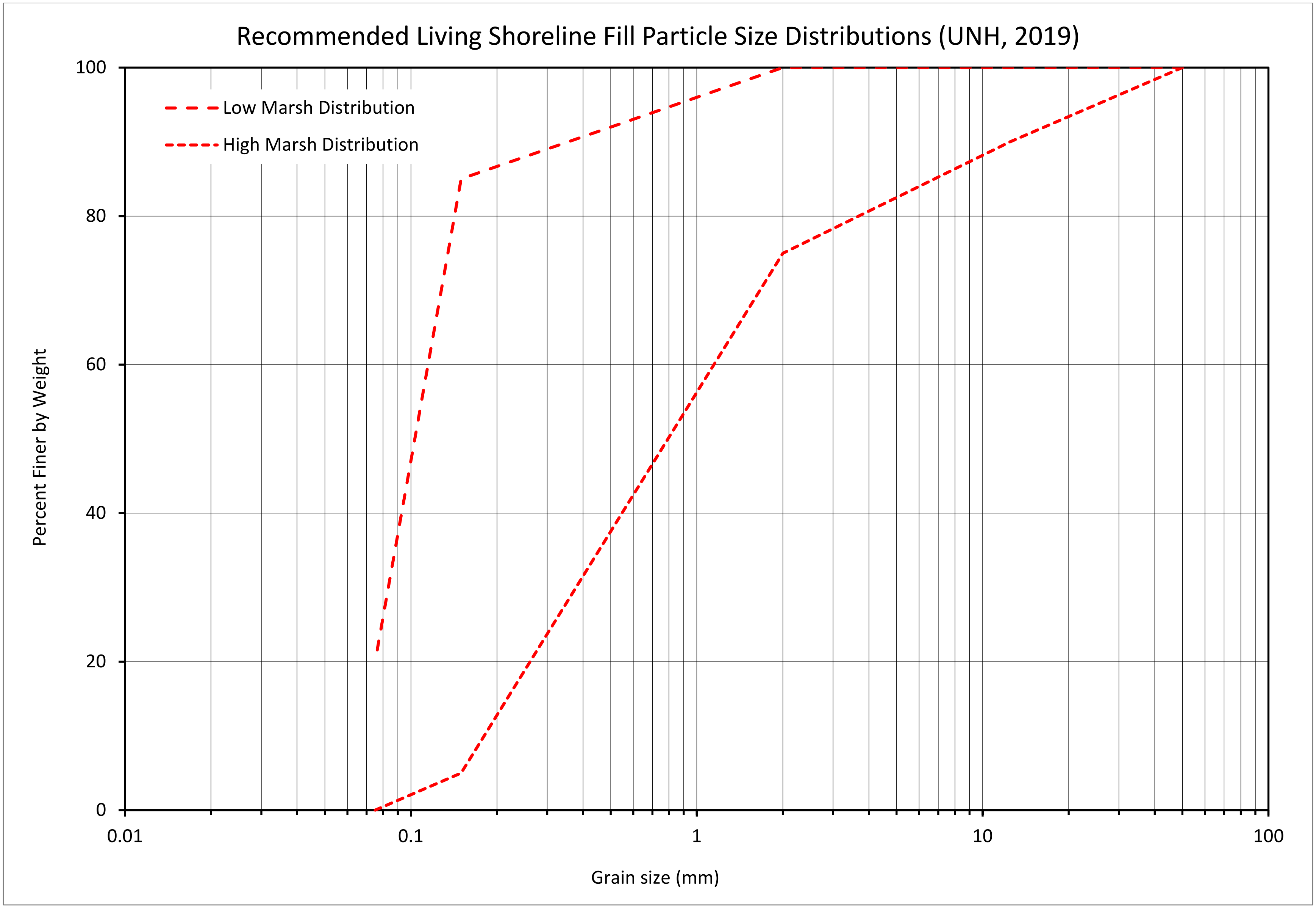


Figure 4.2-1: Existing Conditions (Base Image for Renderings)

Figure 4.2-2: Proposed Salt Marsh with Low & High Marsh Grasses Only (Selected Alternative)

Figure 4.2-3: Proposed Salt Marsh with Upland Grasses in Tidal Buffer

Figure 4.2-4: Proposed Salt Marsh with Upland Grasses and Shrubs in Tidal Buffer

Figure 4.2-5: Proposed Salt Marsh with Grasses, Shrubs, and Protective Boulders in Tidal Buffer

Figure 4.2-6: Proposed Salt Marsh with Protective Fencing in Tidal Buffer

Appendix B – Photographs

Natural shoreline south of pier

Retaining wall north of pier

Looking southeast along natural shoreline from pier armoring

Looking southeast along natural shoreline from large boulder (note boulder location in above photo)

Looking northwest from slumped/stabilized section of shoreline (near Transect #2)

Looking northwest from area of most significant erosion (near Transect #3)

Areas of undercut/sloughing bank near Transect #3

Undercut bank near Transect #3

Stone retaining wall (looking north from under pier)

Stone armoring under pier

King Tide (January 17, 2022). Observed to be approximately 2.65 feet higher than MHHW at Seavey Island Station.

High tide (fall 2021; date unknown)

SEE DESIGN PLANS LINK ON WEBPAGE