Preparing for Coastal Flooding in Harpswell: A Plan for Basin Point Road and Its Wetlands

December 2018

Project Partners:

The Town of Harpswell
Conservation Commission
263 Mountain Road
Harpswell, Maine 04079

The Harpswell Heritage land Trust
153 Harpswell Neck Road
Harpswell, Maine 04079

Funded By:
The Maine Coastal Program
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Acknowledgements

The Study was completed by the Town of Harpswell in partnership with the Harpswell Heritage land Trust with reports completed by Gorrill Palmer Engineering, The Casco Bay Estuary Partnership, and submissions by the Town Planner, input from the Road Commissioner, Town Historian, Conservation Commission and Town Administration; under award CZM NA17NOS4190116 to the Maine Coastal Program from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce. Coastal Community Grants are awarded and administered by the Maine Department of Agriculture, Conservation and Forestry Municipal Planning Assistance Program.

Harpswell Conservation Commission

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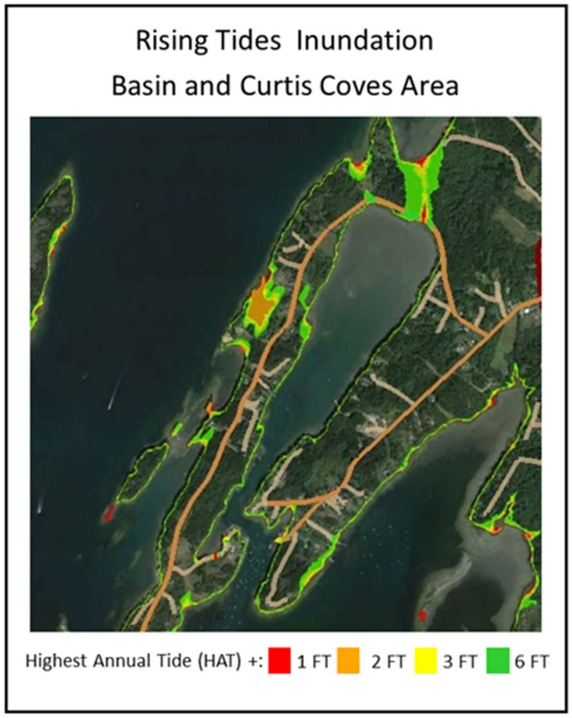
Background



The Town of Harpswell and the Harpswell Conservation Commission have become increasingly concerned about the potential impacts of sea level rise on the community. In 2014 the Casco Bay Estuary Project undertook an assessment of the impact of possible sea level rise on the wetlands of Casco Bay. This analysis identified a number of wetlands in Harpswell that will be impacted by sea level rise. As a follow-up to this report, the Conservation Commission worked with the MidCoast Council of Governments in 2015 to map the areas of the community that would potentially be inundated with a rise in sea level of one foot, two feet, three feet and six feet. This effort identified 16 public roads that could be inundated with six feet of sea level rise. Of these sixteen roads, thirteen could be flooded with three feet of rise while five could be impacted with as little as one foot of sea level rise.

With this information, the Conservation Commission began to question what the implications of sea level rise would be on these public roads and the wetlands associated with them. The Commission proposed undertaking a pilot study to look at one road to better understand the impacts of various levels of sea level rise on both the road infrastructure and the wetlands. The Commission selected Basin Point Road for this project for a number of reasons. The previous studies indicated that this road could become subject to periodic flooding with only one or two feet of sea level rise. The road is the only access to Basin Point which is developed with a number of both residential and commercial uses. The land inland of the road at its lowest elevation is owned by the Harpswell Heritage Land Trust which was interested in being a partner in the pilot project. And the area of the road that would potentially need to be raised is essentially undeveloped. These considerations led the Conservation Commission to believe this would be a good pilot to better understand the implications of sea level rise that would be useful in thinking about the other identified roads.

Study Objective

The analysis is designed to evaluate alternative plans for the elevation of Basin Point Road under differing scenarios of sea level rise (1.0, 2.0, 3.3 and 6.0 feet) considering both the physical infrastructure and the ecological impacts of increased flows of salt water into the pond and wetland upstream of the existing culvert. A key consideration in the analysis is the type, size and elevation of the culvert under Basin Point Road.

Existing Conditions

Basin Point Road is a two-lane paved town road running from Ash Point Road around the head of Basin Cove and extending down Basin Point. The low point in the road is at an existing 18-inch culvert that serves as an outlet for the pond and associated wetland on the northern side of the road. The culvert is a smooth-bore plastic pipe that has been replaced within the past few years. The outlet of the culvert is elevated above the bottom of the downstream stream channel by approximately 3.7 feet. During normal high tides salt water does not flow inland through the culvert but during extreme high tides and storm events, salt water enters the upstream pond. The low point in Basin Pont Road is approximately 2.5 feet above the Highest Annual Tide. There is no evidence that the road has been overtopped during extreme tidal conditions.

The land on the north or inland side of the road is part of the Curtis Farm Preserve owned by the Harpswell Heritage Land Trust. The land is undeveloped except for a small gravel parking lot and trails. There is an earthen berm just in front of the invert in to the culvert on the pond side of the road. The berm maintains the water level in the pond and prevents normal high tides from flowing back into the pond. This produces variable conditions in the water in the pond. During extreme high tides, the level of the salinity in the pond spikes and then drops as tidal exchange through the culvert is reduced or eliminated. There is also seasonal variation in the salinity of the pond with it tending toward fresh water in the spring and salt water in the summer as runoff from the watershed of the pond diminishes.

Scope of Work

The study involved two separate but interrelated components. Gorrill-Palmer, the Town's consulting engineer, developed conceptual designs for the elevation of the roadway at the head of Basin Cove to allow full mobility and safety with varying level of sea level rise. The initial scope of work envisioned that this would include alternatives for one foot, two feet, one meter (3.3 feet) and six feet of rise. However, during the study, Gorrill-Palmer determined that the one foot and two feet scenarios resulted in similar designs and costs as planning for a 3.3-foot rise, so the intermediate designs were dropped from further analysis. Appendix I includes Gorrill-Palmer's report on this component of the project.

The Casco Bay Estuary Partnership (CBEP) undertook a detailed examination of the pond and associated wetlands to develop an understanding of its likely history and ecological functioning. This included monitoring of the water in the pond, assessment of the surface water hydrology of the pond, vegetation, bottom sediments, and fish and wildlife. The overall ecological resilience has been degraded. There is a drowned marsh at the bottom of the pond. The pond has value for a subset of fish and wildlife but lacks the functions and values of a salt marsh. Marsh migration into low-lying upland areas is blocked and these areas are increasingly vulnerable to sudden change from increased flooding. Appendix II includes The Casco Bay Estuary Partnership's research and findings.

The interface of the two components of the study centered on the design of the replacement culvert as part of the elevation of the road. This facility is key to the future of the area upstream of the culvert as sea level rise results in more frequent inundation of the pond and wetlands with salt water. This evaluation is made more complex by the likely increasing frequency of inundation of the wetlands by salt water from the Curtis Cove end of the property.

Alternate Conceptual Designs

Gorrill-Palmer proposed three conceptual approaches for addresses potential sea level rise at the head of Basin Cove. One option would be to do nothing and adopt a wait and see attitude to evaluate how sea level rise is progressing and how it is impacting the roadway. A second option would be the reconstruction of a section of Basin Point Road at the head of Basin Cove to accommodate a 3.3-foot increase in sea level. The third option would be to reconstruct the larger section of the road to accommodate a six-foot increase in sea level.

The two options for the reconstruction and elevation of the roadway include installing a large box culvert under Basin Point Road that will facilitate full tidal interchange during the tide cycles as sea level rises. This capacity for tidal exchange will result in the pond and wetland transitioning to a salt water environment over time.

The Gorrill-Palmer report, Appendix A provides details for the conceptual design of the 3.3 foot and 6-foot improvement options. However, the option that addresses a six-foot increase in sea level raises other considerations that may make this an unrealistic alternative. With this level of sea level rise, the adjacent properties on the cove side of the road will be potentially flooded and inundation of the Curtis Farm Preserve from the Curtis Cove side of the property will also occur. These considerations may therefore raise different policy questions should this level of sea level rise occur.

The reconstruction of Basin Point Road needed to accommodate a 3.3-foot rise in sea level involves raising the road elevation for a length of approximately 682 feet and replacing the existing culvert with a four-sided precast concrete box culvert with a 14-foot span and a 10-foot rise. The design details are included in Appendix. The bottom two feet of the box culvert would be depressed below the channel invert to provide a natural channel bottom for improved fish passage and habitat improvements. The size of the culvert was selected to match the downstream channel width near the existing culvert and is set at an elevation that matches upstream and downstream thalweg elevations measured by CBEP. This culvert is intended to restore the natural hydrologic flow regime to the wetland and upstream channel and improve fish and other aquatic organism passage. It will also restore and improve sediment transport in and out of the upstream wetland while safely conveying fresh water flows from the upstream watershed into Basin Cove. The proposed size of the culvert will need to be confirmed by further hydrological modeling.

Gorrill-Palmer estimates that the cost for reconstructing the portion of Basin Point Road needed to accommodate a 3.3 sea level rise will be approximately $700,000 in 2018 dollars. This includes design and permitting costs in addition to the estimated construction costs. The construction costs include improvements necessary to retain vehicle access to home adjacent to the portion of the roadway that is being elevated.

Next Steps

The work completed as part of this study has produced conceptual designs for the elevation of Basin Point Road to accommodate sea level rise of 3.3 and 6 feet. If the Town desires to move forward with planning of the long-term improvement of this road, it will need to undertake additional work to allow the refinement of the conceptual designs into final engineering designs and updated costs. This work includes undertaking a hydrologic analysis of the area to allow a final determination to be made as to the sizing and elevation of the proposed box culvert. It also includes developing additional data about on-site conditions including detailed topography, soils information from borings, wetlands date, etc. The required information is laid out in Gorrill-Palmer's report.

Lessons Learned

The Basin Point Road study was undertaken to help the Town of Harpswell understand the potential implications of sea level rise on the Town's public roads that may become subject to more regular and intensive flooding. The following are some key take-aways from the project:

1. Dealing with sea level rise will be expensive. The estimated cost for improvement to Basin Point Road to deal with a 3.3-foot increase in sea level is approximately $700,000 in 2018 dollars. There are twelve other public roads in Harpswell that could be impacted with a 3.3-foot rise. While the cost for each road improvement is site-specific, the potential cost to the Town becomes very large even when considered over decades.
2. Damage to the road occurs before the roadway is overtopped. As sea level rises the sub-base of the roadbed becomes saturated with each high tide cycle. This results in damage to the road well below the elevation where flooding of the road occurs. As we look at existing situations and think about the implications of sea level rise, this is an important consideration.

3. There is an important policy issue involved in the design of a culvert as part of a road improvement project. The size and elevation of the culvert has the potential to change the ecology of the upstream habitat and the extent of the wetland area. Whether to plan for marsh migration with sea level rise and/or a transition from a freshwater to saltwater environment is a key decision point that is influenced by the specifics of each location and the viewpoints of the impacted property owners.
4. If sea level rise reaches six feet, the complexity of the issues involved will likely increase dramatically as the cost of improvements increases while the feasibility of actually making those improvements may decrease or become ineffective due to other factors. This may lead to the need to make hard choices about where and how to invest the public's resources.

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Appendices

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Appendix I

Gorrill Palmer Engineering – "*Final Road and Culvert Study*"
including Figures and Drawings

Preparing for Coastal Flooding in Harpswell: A Plan for Basin Point Road and its Wetlands
Final Road and Culvert Study

Date: November 20, 2018

View of Basin Point Road and Culvert, February 2018

Prepared for:
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Acknowledgements

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Appendices

Executive Summary

The primary objective of the feasibility study is to develop a long-term plan for managing the potential impacts of sea level rise (SLR) and storm surge on a portion of Basin Point Road and to develop options for managing the impact of increased salt water movement into the pond and wetlands beside the road. Gorrill Palmer (GP), the Town of Harpswell's engineering consultant firm, will be responsible for assessing the design options and costs for upgrading the road and culvert to withstand anticipated sea level rise. The Casco Bay Estuary Partnership (CBEP) will be responsible for developing a detailed assessment of current conditions and scenario planning for the impact of SLR and storm surge on the current habitat and ecosystems along the road.

The existing Basin Point Road and culvert located at the northerly end of Basin Cove are threatened by future sea level rise. Several of the Town's major businesses may become inaccessible to their patrons if sea level rise occurs, including the Dolphin Marina and Restaurant, which employs over 90 employees and served over 85,000 people in 2016. The Blue Door, an artist studio, gallery and site for art classes and the Brass Studio of Maine are also located on Basin Point Road beyond the head of the cove. Additionally, approximately 115 households could lose access to their homes from flooding if sea level rise and coastal flooding become more frequent.

Gorrill Palmer identified several possible options for addressing sea level rise scenarios of 1, 2, 3.3 and 6-feet. Option 1 is the do nothing alternative, which basically allows the road and culvert to remain the same with normal maintenance; Option 2 would raise the road profile in the vicinity of the culvert and head of cove to accommodate the 3.3-foot sea level rise scenario and increase the culvert size to a 14-foot span by 10-foot rise to improve fish and aquatic organism passage and accommodate the higher tidal flows into the adjacent wetland system; Option 3 would raise the road profile for over 1,800 linear feet to accommodate the 6-food sea level rise scenario and increase the culvert size to a 14-foot span by 12-foot rise.

Option 1 is the do nothing alternative will eventually result in additional annual maintenance and upkeep costs to repair more regular flooding and erosion that may eventually occur as sea levels rise. At some point the road will overtop making it unsafe for residents and business patrons from accessing homes and businesses located beyond the culvert location.

Option 2 will accommodate the 3.3-foot sea level rise and upgrade the existing culvert to accommodate higher tidal flows and improve aquatic organism passage and habitat. This option is anticipated to cost approximately $691,000, including design and permit application preparation costs.

Option 3 should accommodate the 6-foot sea level rise and upgrade the existing culver to accommodate higher tidal flows and improve aquatic organism passage and habitat. This option is anticipated to cost approximately $1,378,000, including design and permit application preparation costs.

Background

The primary objective of the feasibility study is to develop a long-term plan for managing the potential impacts of sea level rise (SLR) and storm surge on a portion of Basin Point Road and to develop options for managing the impact of increased salt water movement into the pond and wetlands beside the road. Gorrill Palmer (GP), the Town of Harpswell's engineering consultant firm, will be responsible for assessing the design options and costs for upgrading the road and culvert to withstand anticipated sea level rise. The Casco Bay Estuary Partnership (CBEP) will be responsible for developing a detailed assessment of current conditions and scenario planning for the impact of SLR and storm surge on the current habitat and ecosystems along the road.

Gorrill Palmer's scope of work included identifying needed improvements for a section of Basin Point Road to accommodate a possible sea level rise of 1, 2, 3.3 and 6 feet. This work included reviewing existing conditions along Basin Point Road and the culvert at the head of the cove and developing alternatives for elevating the road and increasing the culvert size if necessary. This report summarizes the findings and conceptual designs and costs to accommodate the possible sea level rise scenarios.

Vertical Datum

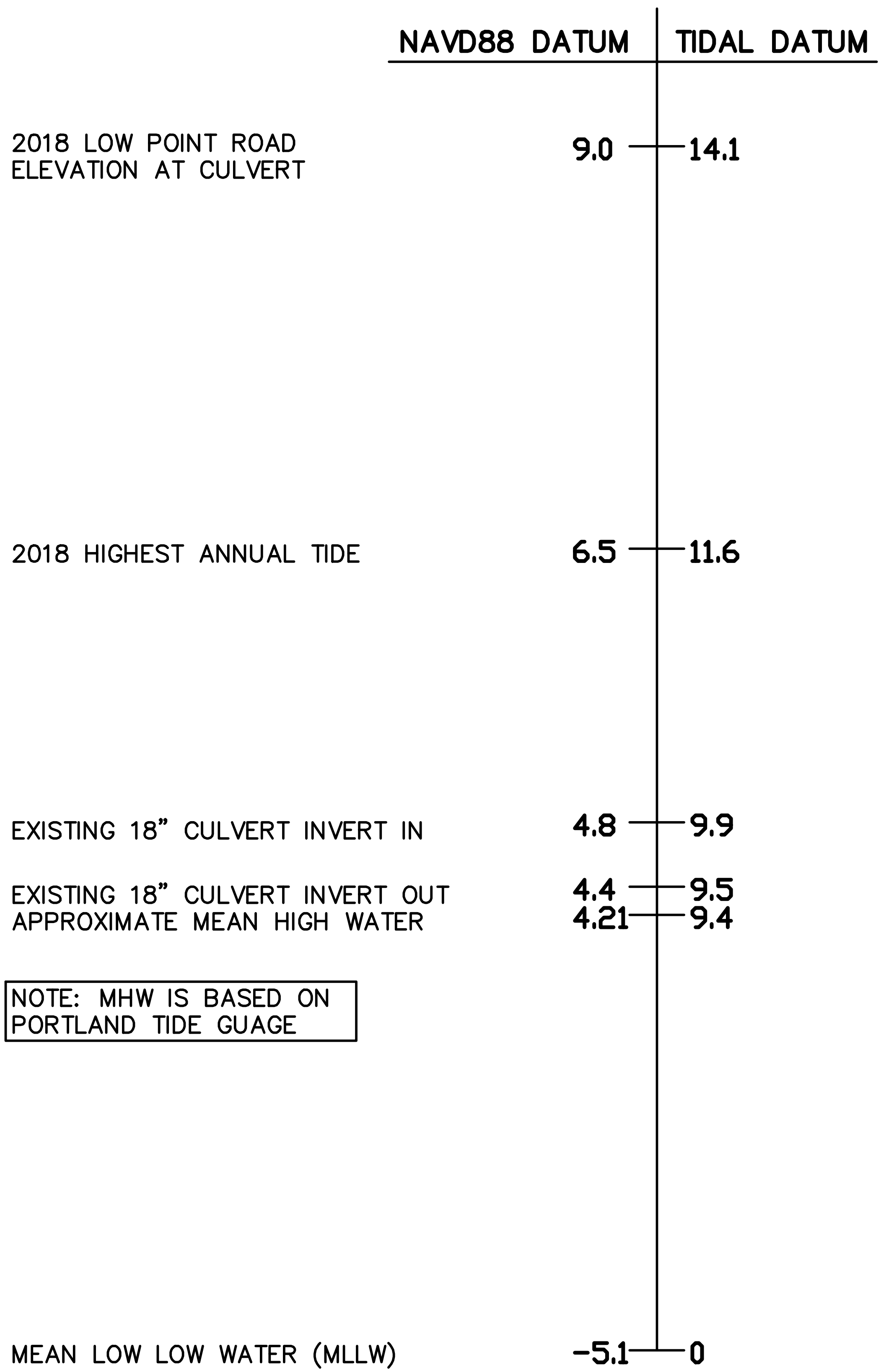
A datum is a reference from which measurements are made. In surveying and geodesy, a datum is a reference point on the earth's surface against which position measurements are made. Horizontal datums are used to describe a point on the earth's surface in latitude and longitude. A vertical datum is used to measure elevations above or below the earth's surface.

When referring to tidal elevations, there is often considerable confusion regarding the vertical datum that is being referenced. There are tidal datums that are referenced to the local tide station. For Basin Point Road in Harpswell, the closest local tide station is South Harpswell, Potts Harbor (Station ID 8417647). The tide station typically references Mean Low Low Water (MLLW) as the low water reference surface (elevation zero*). Mean High Water (MHW) is 4.21-feet based on the Portland Tide Gauge.*

The National Geodetic Survey (NGS) defines a geodetic datum as "a set of constants used for calculating coordinates of points on the Earth." The most common vertical reference datum in used today is the North American Vertical Datum of 1988 (NAVD 88). This is the datum that is referenced in this report and associated figures and plans. It appears to be the most common datum used in recent climate change and sea level rise studies, reports and research.

The Maine DEP publishes a table with Highest Annual Tide (HAT) levels along the Maine Coast. For 2018, the published elevations for South Harpswell are 11.6 (feet above MLLW) and 6.5 (NAVD 88). For the purposes of this report the sea level rise scenarios of 1, 2, 3.3 and 6 feet were added to the 2018 HAT elevations published by Maine DEP.

A comparison of the NAVD 88 and Tide datums is shown in Figure 1.



Datum Comparison

Basin Point Road - Harpswell, Maine

Design: OCC	Date: OCT 2018
Draft: LAN	Job No.: 2340.31
Checked: WCH	Scale: None
File Name: 2340.31–Figure1.dwg	

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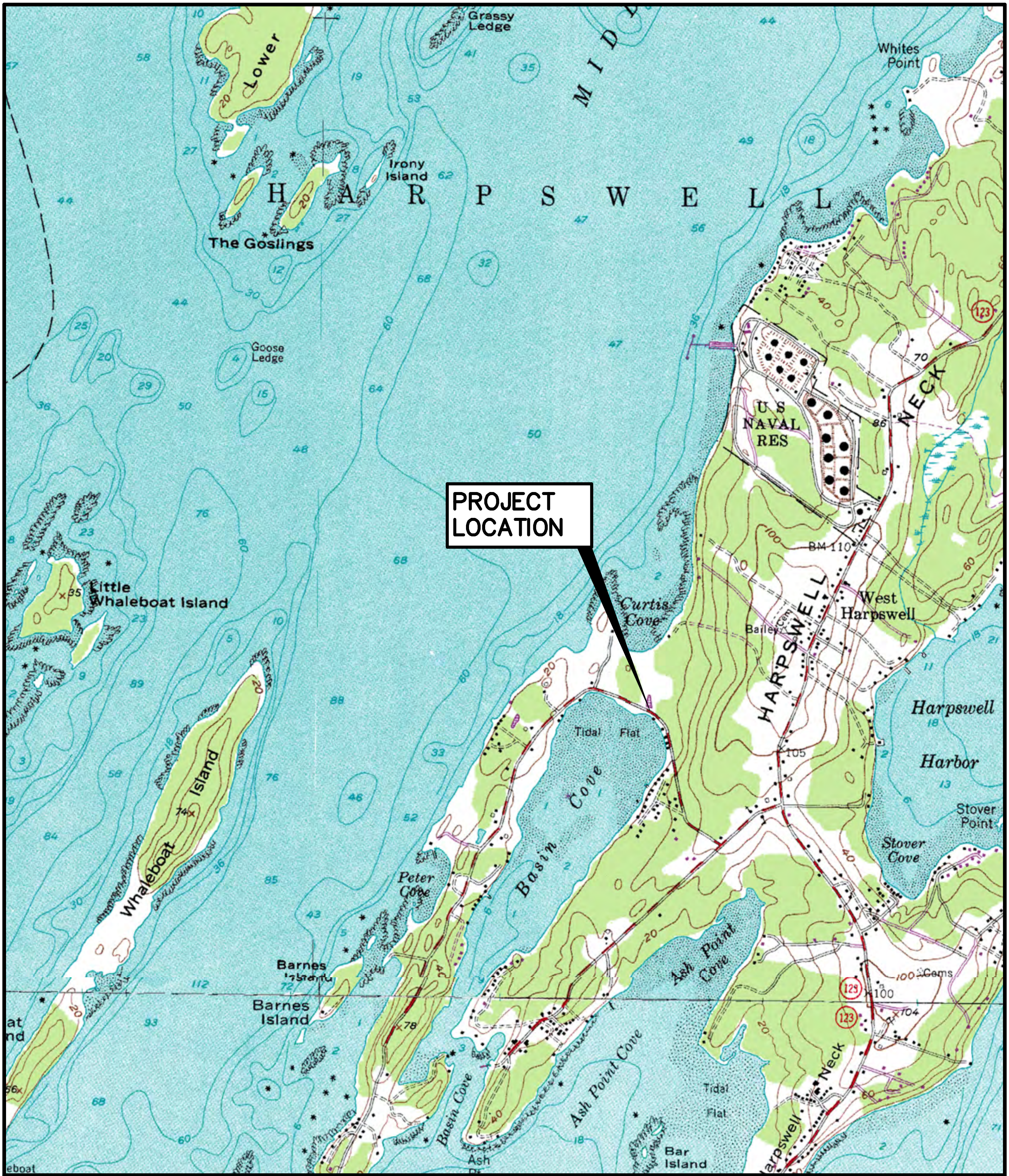
Figure

1



U.S.G.S. Location Map

Basin Point Road - Harpswell, Maine

U.S.G.S. Freeport & South Harpswell , State-7.5 Minute Series (Topographic)

Design: OCC	Date: OCT 2018
Draft: LAN	Job No.: 2340.31
Checked: WCH	Scale: None
File Name: 2340.31–LocMap.dwg	

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Figure

2

Road and Culvert Study

Gorrill Palmer was retained to identify needed improvements to Basin Point Road and the culvert at the head of Basin Cove to accommodate possible sea level rise scenarios of 1, 2, 3.3 and 6 feet. Our scope was limited and included feasibility/conceptual level work. If the Town decides to advance any of the options outlined in this report, additional survey, design, modeling and permitting will be required.

Data Collection & Document Review

Gorrill Palmer participated in various data collection and document review efforts for this project, including:

- Retained a surveyor to collect basic survey elevations along a portion of Basin Point Road in the vicinity of the project site. This included roadway centerline elevations, culvert invert elevations and nearby building finish floor elevations.
- Reviewed historic USGS topographic maps and nautical charts to better understand how the natural landscape and manmade features at the head of Basin Cove have changed over time.
- Review of FEMA Flood Insurance Rate Maps, including current map dated 7/20/1998 and new preliminary map dated 4/14/2017 (revised preliminary).
- Site visit to observe existing conditions and topography.
- Site visit to observe King Tide event on 12/4/2017
- Site visit to gather additional elevation and cross-section data of the natural tidal channel below the Basin Point Road culvert out to the mud flats.

Existing Conditions

Basin Point Road, located in South Harpswell, skirts the northerly edge, or head of Basin Cove (see Figure 2). The upstream side of the road in this vicinity is bounded by land owned by Harpswell Heritage Land Trust's Curtis Farm Preserve, which includes a state significant fresh water wetland and includes walking trails and nearly 2,000 feet of shoreline on Curtis Cove and Basin Cove.

Figure 3 Downstream End of Culvert & Tidal Channel

As Basin Point Road approaches the head of Basin Cove, the road dips to a distinct low point at an existing 18-inch diameter culvert that serves as an outlet to the pond on the northerly side of the road. This culvert is located approximately 2,400 linear feet from the intersection of Basin Point Road and Ash Point Road. The culvert is a smooth-bore, plastic pipe and has been replaced within the past few years. The culvert outlet invert (Basin

Cove side) is elevated above the bottom of the tidal channel invert by approximately 3.7-feet. Under normal high tide conditions (2018), the tide does not flow through the culvert into the pond. The low point of Basin Point Road centerline at the culvert is approximately 9-feet, which is about 2.5-feet above the current highest annual tide (HAT) of 6.5-feet. There is no anecdotal evidence that historic high tides have overtopped the road, however, the tides have flowed backward through the culvert and into the pond on the northerly side of the road.

Figure 4 Upstream End of Culvert & Berm

On December 4, 2017, there was an extreme high tide event where tidal water levels on the cove side of the road were measured at approximately elevation 6.5-feet (current HAT) at the time of peak high tide. The winds during this event were minimal, therefore, there were no observed impacts to the road.

There is what appears to be a man-made earthen berm just in front of the invert in to the culvert on the pond side of the road. The elevation of the top of the berm is about 6.2-feet, but it appears to have been breached so its current effective height is about 0.5-feet lower. Therefore, the current berm effectively maintains the water level in the pond at or below elevation 5.7-feet and generally prevents normal high tides from flowing back into the pond. It is unclear when the berm was constructed and whether it served any other purpose.

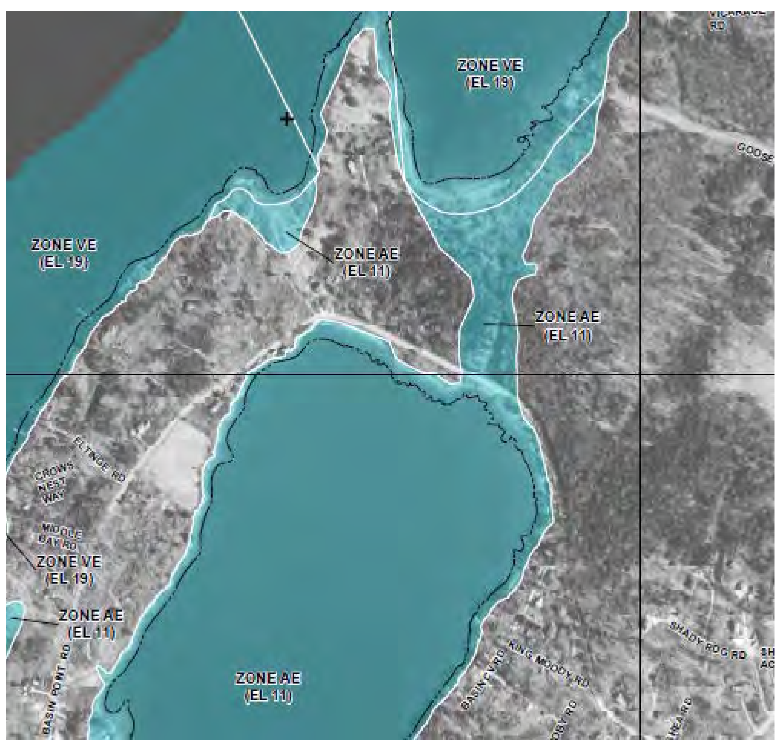


Figure 5 FEMA Revised Preliminary Firm Dated 4/14/17

The pond located on the northerly side of Basin Point Road has a tributary watershed of approximately 33 acres. The watershed is comprised almost entirely of undeveloped land owned by the Harspwell Heritage Land Trust's (HHLTs) Curtis Farm Preserve; however, there appears to be one residence and a short section Gooseledge Road within the watershed limits. Under normal conditions, the freshwater peak flows from the watershed are conveyed to the ocean through the existing 18-inch culvert under Basin Point Road. There is no anecdotal evidence that freshwater runoff peak flows overtop Basin Point Road.

The topography between Basin Point Road and Curtis Cove is quite flat and generally ranges between 8- and 16-feet.

The Federal Emergency Management Agency (FEMA) is in the process of updating their Flood Insurance Rate Maps (FIRMs) for many coastal towns in Maine, including Harpswell. The current official FEMA Firm is dated July 20, 1998 and shows the head of Basin Cove as Zone A2 with a base flood elevation of 9 (NGVD 1929), which converts to elevation 8.35 (NAVD 88). FEMA has issued a revised preliminary map dated April 14, 2017 that shows the head of Basin Cove as Zone AE with a 100-year base flood elevation of 11 (NAVD 88). This latest map shows the extent of flooding overtopping Basin Point Road and inundating the Harpswell Land Trust land between Basin Cove and Curtis Cove.

Public Participation

Gorrill Palmer participated in two public workshops to present the project to the public and obtain public input. Additionally, Gorrill Palmer attended a site visit on December 4, 2017 to observe a King Tide event and meet with members of the committee and interested public.

Workshop 1 was held on November 16, 2017 at the Harpswell Town Office and was attended by Committee members, property owners in the immediate vicinity of the Basin Point Road culvert, residents of Basin Point Road beyond the culvert, the Town historian, the Town Road Commissioner and other interested parties. Will Haskell of Gorrill Palmer described how they would explore ways to mitigate sea level rise flooding of the road and culvert improvements to enhance environmental and ecological aspects of the adjacent pond. Local anecdotal knowledge was documented

A King Tide event occurred on December 4, 2017 and a site visit was made to observe conditions at the Basin Cove culvert. Members of the Project Advisory Committee, Will Haskell from Gorrill Palmer, neighborhood residents and David Hackett of the Harpswell Historical Society were present. The peak tide elevation at this event essentially matched the published highest annual tide for Harpswell (6.5 feet based on NAVD 88). Gorrill Palmer marked the peak tide elevation on a grade stake to compare the elevation with existing road and culvert elevations. The peak tide elevation was measured at approximately 2.5 feet below the low elevation of the road at the culvert.

Workshop 2 was held on November 7, 2018 at the Harpswell Town Office and was attended by the Committee members, Will Haskell of Gorrill Palmer, Matt Craig of Casco Bay Estuary Project, property owners and other interested members of the public. Will Haskell of Gorrill Palmer and Matt Craig of CBEP made presentations of their reports and findings.

Notes from the public workshops are included in Appendix C.

Road & Culvert Improvement Options

It is clear, given that the existing highest annual tide elevation (HAT) of 6.5-feet, which is only 2.5 feet below the elevation of Basin Point Road, that any increase in sea level or storm surge will begin to impact the road and access beyond the culvert at the head of the cove. The existing road section (gravel and pavement) is assumed to be approximately 2-feet thick. Once tide elevations begin to regularly encroach into the pavement section, the road condition will begin to deteriorate more quickly because the daily influx of water into the base gravels will degrade the structural support of the road causing additional costs for regular operation and maintenance.

As sea level continues to increase and begins to inundate and overtop the road, the impacts will become more severe as the road will have to be closed during periods of flooding which will impact commerce and residential access beyond the culvert.

The *Basin Point Road Assessment* (CBEP 2018) report provides a figure showing the extent of sea level rise flooding for the 1, 3.3 and 6-foot scenarios at the head of Basin Cove. At 6-feet of rise, the extent of flooding is substantial, with daily high tides regularly flooding the road at its existing elevation.

We developed and reviewed three possible options for addressing the impacts of sea level rise that may occur over the next century, including:

- Option 1 – Do Nothing Alternative
- Option 2 – Sea Level Rise of 3.3-Feet
- Option 3 – Sea Level Rise of 6-feet

These options will be reviewed in more detail below.

Option 1 – Do Nothing Alternative

As noted the current highest annual tide (HAT) of 6.5-feet is about 2.5-feet below the elevation of Basin Point Road at the culvert. With another 0.5-feet of sea level rise, the HAT will begin to infiltrate into the road gravels with the potential impact of expediting the deterioration of the gravels and pavement, which will cause additional operation and maintenance costs. Additionally, higher peak tides may increase erosion of the road embankment where it is exposed to direct wave impacts.

Table 1 shows the estimated mean high water (MHW) and HAT elevations in comparison to the existing road elevation (at the culvert) for the existing condition and the SLR scenarios.

Table 1 (Option 1 – Do Nothing Alternative) Impacts to Basin Point Road					
SLR Scenario	Estimated Mean High Water (MHW)	Estimated Highest Annual Tide (HAT)	Elevation of Road	Impact @ MHW	Impact @ HAT
Exist. Cond.	4.21 (Note 1)	6.5	9	-4.79	-2.5
1-foot	5.21	7.5	9	-3.79	-1.5
2-feet	6.21	8.5	9	-2.79	-0.5
3.3-feet	7.51	9.8	9	-1.49	+0.8
6-feet	10.21	12.5	9	+1.21	+3.5
Notes: 1. At Portland Tide Gauge					

The impact columns in Table 1 show the anticipated impacts or flooding of Basin Point Road. Negative impacts indicate that there is no flooding of the road (road not overtopped). As shown, neither the estimated MHW, nor HAT will inundate the road up to 2-feet of SLR. However, as noted above, any increase in tidal elevation above the existing condition will begin to flood the road gravels and will potentially increase road maintenance and repair costs. Once SLR exceeds 2.5-feet the HAT will begin to inundate the road surface and begin limiting access to businesses and residences located west of the culvert during extreme tide events. At approximately 4.8-feet of SLR the MHW (normal high tide) will begin to inundate the road.

The increase in operation and maintenance costs due to inundation of the road gravels at extreme tide events is difficult to quantity. The frequency and extent of these events is unknown. When these events occur is also a factor in potential cost increases. For example, if an extreme tide event occurs in the winter, the water could infiltrate the road gravels and freeze causing more damage than the same event would cause if it occurred during the summer months.

Actual overtopping and inundation of the road surface will result in significantly more disruption and lost dollars. At lower levels, residents and business customers may choose to cross through the inundated roadway. As the flooding levels increase, it becomes significantly less safe to drive through the section of flooded road and the road will be closed which will result in lost productivity (unable to get to work) and lost business. It is difficult to quantify the costs because of the many unknown factors involved.

<u>Option 2 – Sea Level Rise of 3.3 Feet</u>

Given that roads and culverts often have a design life of 20-years and 50- to 75-years respectively, it seemed prudent to look at improvement options that would extend well into the future, rather than incremental improvements that would first accommodate a 1-foot SLR scenario, followed by another improvement to accommodate a 2-foot SLR, shortly thereafter.

Therefore, we decided to look at one option that would include road and culvert improvements that would accommodate up to the 3.3-foot SLR scenario. This option would include raising the road elevation 3.3-feet for a length of about 682-feet and replacing the existing culvert with four-sided precast concrete box culvert with 14-foot span and 10-foot rise. The bottom two feet of the box would be depressed below the channel invert to provide a natural channel bottom for improved fish passage and habitat improvements (StreamSmart design).

There are several possible options for this culvert design. The regulatory agencies generally prefer culverts with natural channel bottoms, such as a three-sided box culvert or arch set on footings. In our experience, structures on footings are often more expensive and require additional geotechnical investigations for the footing design. Since our current scope did not include a subsurface investigation, we have recommended the four-sided box culvert with natural channel bed infill. This type of structure still provides many of the same benefits of a natural channel bottom, while also providing a solid foundation of support from the bottom slab of the box culvert. If the Town decides to proceed with further design and permitting, other culvert options can be considered. Generally, Stream Smart design principles call for culverts to be sized so the span is at least 1.2 times the bankfull width of the stream. At this site there is an existing pond located upstream of the road crossing, therefore there is no stream width immediately adjacent to the road culvert. The channel cross section at the northerly end of the pond is about 1 to 2-feet wide. The *Basin Point Road Assessment* (CBEP 2018) report and field work identified the natural channel thalweg elevation upstream of the existing culvert (in the pond), as well as the downstream channel inverts and cross sections. The down stream channel, from the existing culvert outlet to the mudflat appears to range from 15- to 22-feet wide, getting wider towards the mudflat. The culvert size we selected (14-foot span by 10-foot rise) must be confirmed by further modeling; however, the proposed size significantly exceeds the size needed to convey freshwater flows. The Stream Smart culvert span design criteria is not applicable to tidal culverts; therefore, we selected a culvert span that generally matched the downstream channel width near the existing culvert, set at an elevation that matches the upstream and downstream channel thalweg elevations measured by CBEP in their study. We selected the 10-foot culvert rise to allow for 2-feet of channel embedment. This culvert will provide 112-square feet of cross-sectional area. The propose culvert would:

- Restore the natural hydrologic flow regime to the wetland and upstream channel;
- Improve fish and other aquatic organism passage;
- Restore and improve sediment transport in and out of the upstream wetland and channel; and,
- Safely convey fresh water peak flows from the upstream watershed to Basin Cove.

Further engineering design and modeling is required to confirm the proposed culvert size.

This option would result in the Basin Point Road profile being raised by over 4-feet at the culvert location. Overall, the road profile would be raised for a total of approximately 682-feet. At the first residential driveway towards the southeast, the road would be raised by approximately 0.6-feet. This driveway is about one car length deep, therefore, there may need to be some offsite improvements on this residential property to accommodate the road profile changes.

This option is shown in Figures 6 and 7 following this page. Full size drawings of these figures are also included in Appendix A (folded plans).

Table 2 (Option 2 – Sea Level Rise of 3.3-feet) Impacts to Basin Point Road					
SLR Scenario	Estimated Mean High Water (MHW)	Estimated Highest Annual Tide (HAT)	Elevation of Road	Impact @ MHW	Impact @ HAT
Raise Road 4.3-feet	7.51	9.8	13.3	-5.79	-3.5

As shown in Table 2, by raising the road profile by approximately 4.3-feet, the impacts caused by the 3.3-foot SLR scenario are mitigated as the MHW and HAT elevations are located below the road surface and subgrade elevations of the proposed road.

The estimated total project costs for permitting, design and construction for Option 2 improvements are as follows (2018 dollars):

- Construction: $607,000
- Design & Permit Application Preparation: $ 84,000
- Total Project Cost: $691,000

Other possible, but unknown costs may include coastal wetland impact mitigation costs.

A more detailed conceptual opinion of probable construction cost, along with assumptions is included in Appendix B. Additional data collection efforts are described under the Next Steps section of the report. The design and permit application costs increased slightly from what was presented at Workshop 2. Estimated fees for survey, wetlands and geotechnical scope as added.

Option 3 – Sea Level Rise of 6 Feet

Sea level rise of 6 feet is difficult to contemplate. At this level, normal high tides would inundate the existing Basin Point Road and the extreme tidal events would inundate approximately 1,820 linear feet of the road. Much of the current upland area between Basin Cove and Curtis Cove would be inundated daily at high tide (see Figure 19 in *Basin Point Road Assessment*, CBEP 2018). This option would include raising the road elevation 6-feet at the culvert, which equates to an approximate elevation of 15-feet for a length of approximately 1,820-feet. The existing culvert would be replaced with a four-sided precast concrete box culvert with 14-foot span and 12-foot rise. The bottom two feet of the box would be depressed below the channel invert to provide a natural channel bottom for improved fish passage and habitat improvements (Stream Smart design).

Similar design criteria and considerations from Option 2 were used in selecting the culvert for Option 3. We opted to increase the culvert rise for Option 3 to better accommodate the increased tidal flows associated with the 6-foot sea level rise scenario.

As noted, this option would result in the Basin Point Road profile being raised by 6-feet over the culvert to an elevation of approximately 15-feet. This would raise the road by approximately 3.4-feet at the first residential driveway located to the southeast of the culvert. Note, however, that with this scenario the estimated HAT of 12.5 would exceed the finish floor of the house by 0.1-foot and the finish floor of the adjacent studio by 0.7-feet. The road profile change would also impact the driveway to the second residence and driveway located to the southeast of the culvert. At this driveway, the road profile would be raised about 0.55-feet above the existing driveway. Note, that this second residence has a finish floor elevation of 11.2-feet, which is 1.3 feet below the estimate HAT.

This option is shown in Figures 8 through 11 following this page. Full size drawings of these figures are also included in Appendix A (folded plans).

Table 3 (Option 3 – Sea Level Rise of 6-feet) Impacts to Basin Point Road					
SLR Scenario	Estimated Mean High Water (MHW)	Estimated Highest Annual Tide (HAT)	Elevation of Road	Impact @ MHW	Impact @ HAT
Raise Road 6-feet	10.3	12.5	15	-4.7	-2.5

As shown in Table 3, by raising the road profile by 6-feet, the impacts caused by the 6-foot SLR scenario are mitigated as the MHW and HAT elevations are located below the road surface and subgrade elevations of the proposed road.

The estimated total project costs for permitting, design and construction for Option 3 improvements are as follows (2018 dollars):

- Construction: $1,210,000
- Design & Permit Application Preparation: $ 168,000
- Total Project Cost: $1,378,000

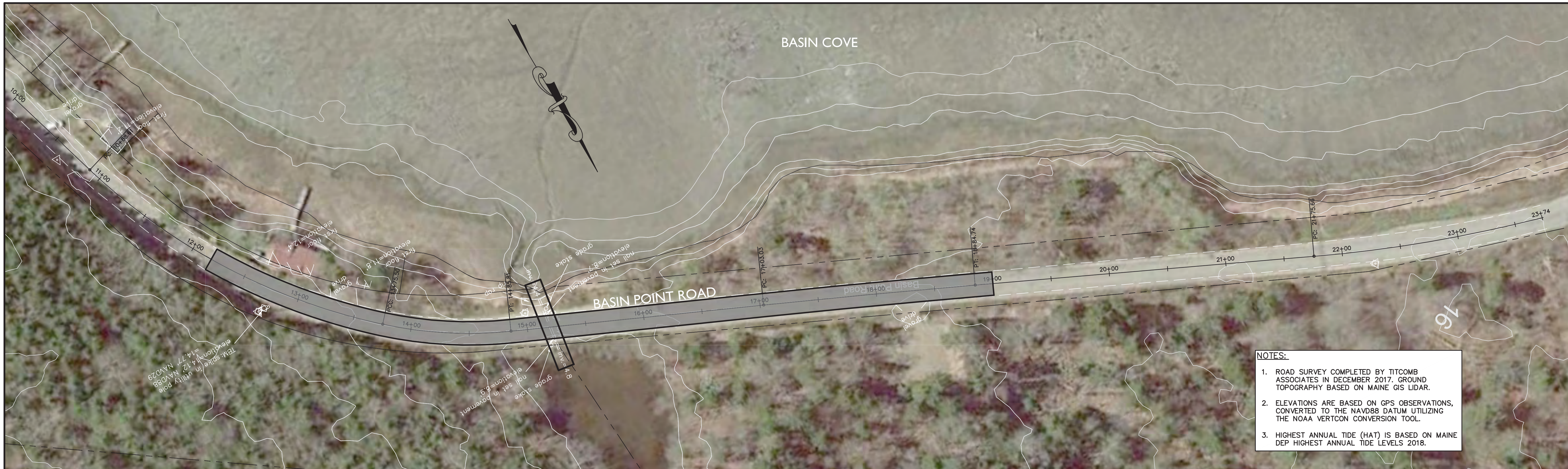
Other possible, but unknown costs may include coastal wetland impact mitigation costs.

A more detailed conceptual opinion of probable construction cost, along with assumptions is included in Appendix B. Additional data collection efforts are described in the following section (Next Steps). The design and permit application costs increased slightly from what was presented at Workshop 2. Estimated fees for survey, wetlands and geotechnical scope as added.

Next Steps

This feasibility study outlines several options for addressing several anticipates seal level rise scenarios that may occur over the coming century. The work outlined and discussed in this report along with the *Basin Point Road Assessment* report (CBEP 2018) provide some background and guidance to the Town on several options for mitigating sea level rise at Basin Cove and specifically on Basin Point Road near the head of the cove. The existing cross culvert at this location and the existing road profile will not accommodate anticipated sea level rise scenarios. However, this study and the CBEP study are only the starting point. The following next steps are suggested:

- Town to select Option 1 -3 outlined in this report;
- If Option 1 is selected, the next step would be a wait and see approach on how anticipated sea level rise affects the existing culvert and road.
- If Option 2 or 3 is selected, we anticipate the next steps to be:
    - Explore options for funding the design, permitting and construction of selected option;
    - Obtain proposal for design and permitting for selected option;
    - Obtain existing conditions, topographic and boundary survey along applicable portion of Basin Point Road;
    - Obtain geotechnical subsurface borings and report in vicinity of existing culvert;
    - Coordinate meetings with applicable regulatory agencies and stakeholder groups, including: Maine DEP, US Army Corps of Engineers (ACOE), NOAA, Casco Bay Estuary Project, Project Abutters;
    - Proceed with culvert and roadway design for selected option. As noted, there may be offsite property mitigation and design to accommodate the selected roadway improvements;
    - Complete culvert hydraulic modeling to determine optimum culvert size, type and configuration;
    - Submit permit applications to regulatory agencies. We anticipate that permit applications to Maine DEP and ACOE will be necessary;
    - Obtain required permits from regulatory agencies;
    - Solicit construction bids for selected design option;
    - Construct selected option;

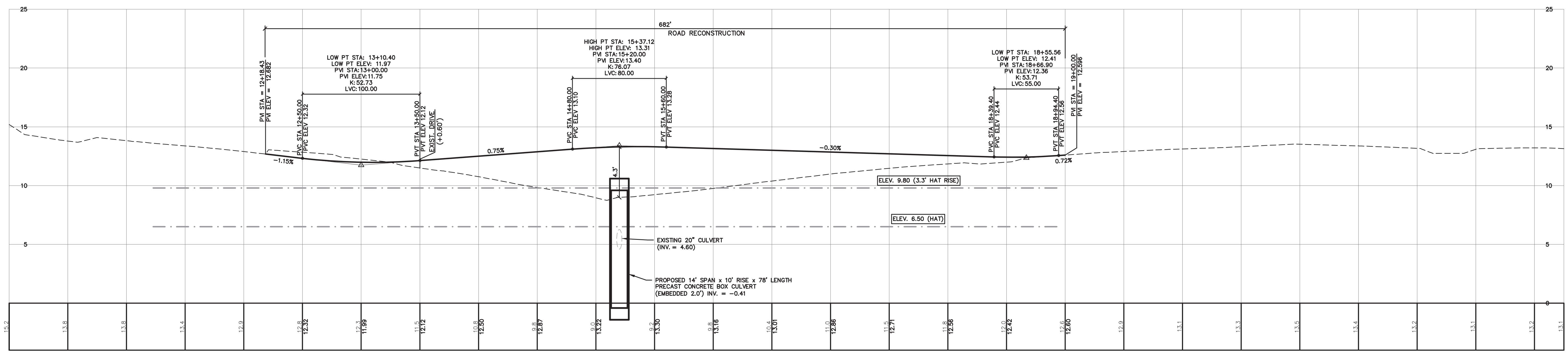


NOTES:

1. ROAD SURVEY COMPLETED BY TITCOMB ASSOCIATES IN DECEMBER 2017. GROUND TOPOGRAPHY BASED ON MAINE GIS LIDAR.
2. ELEVATIONS ARE BASED ON GPS OBSERVATIONS, CONVERTED TO THE NAVD88 DATUM UTILIZING THE NOAA VERTCON CONVERSION TOOL.
3. HIGHEST ANNUAL TIDE (HAT) IS BASED ON MAINE DEP HIGHEST ANNUAL TIDE LEVELS 2018.

PLAN

SCALE: 1"=40'



PROFILE

SCALE: 1"=40' HORIZ.
1"=4' VERT.

1 inch = 40 ft.

Rev.	Date	Revision
–	–	–

Issued For	Date	By
–	–	–

Design: OCC	Draft: LAN	Date: AUG 2018
Checked: WCH	Scale: AS SHOWN	Job No.: 2340.31
File Name: 2340.31-pbase_ALT1		

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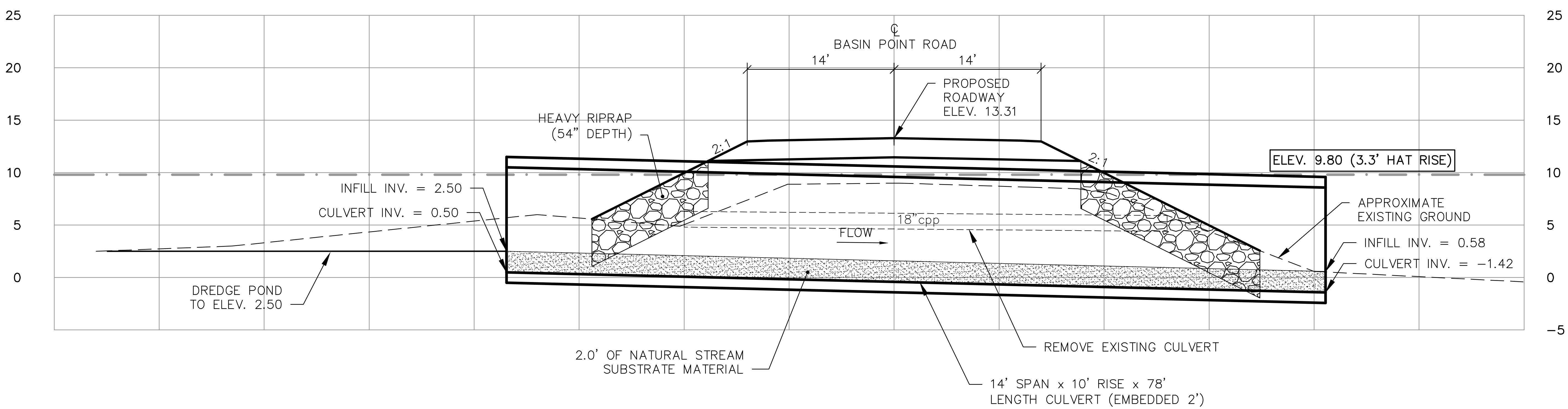
Drawing Name: **3.3' RISE PLAN AND PROFILE**

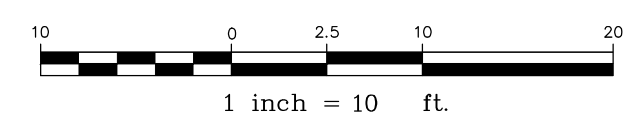
Project: **Basin Point Road Improvements**
Harpswell, Maine

Client: **Town of Harpswell**
Mountain Road, Harpswell, Maine

Figure 6



BASIN POINT ROAD CULVERT CROSS SECTION
(3.3' HAT RISE)
SCALE: 1"=10'



Rev.	Date	Revision
-	-	-

Design: OCC	Date: OCT 2018
Draft: LAN	Job No.: 2340.42
Checked: WCH	Scale: 1"=10'
File Name: 2340.31-CULV-ALT1.dwg	

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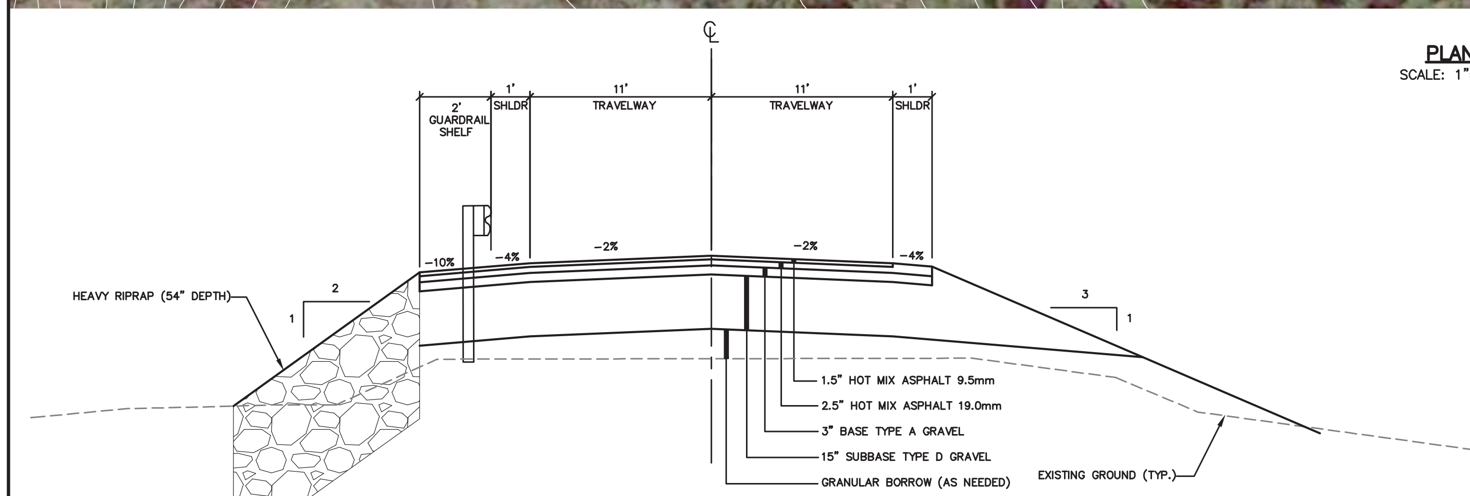
Drawing Name: Basin Point Road Section 3.3' HAT RISE
Project: Basin Point Roadway Improvements
Harpswell, Maine

Figure
7

PLAN

SCALE: 1"=60'



6' HAT RISE TYPICAL SECTION

NOT TO SCALE

60 0 30 60 120

1 inch = 60 ft.

Rev.	Date	Revision
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Issued For	Date	By
–	–	–

Design: OCC	Draft: LAN	Date: AUG 2018
Checked: WCH	Scale: AS SHOWN	Job No.: 2340.31
File Name: 2340.31-pbase_ALT2		

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GP GORRILL PALMER

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Drawing Name: 6.0' RISE OVERALL PLAN

Project: Basin Point Road Improvements
Harpswell, Maine

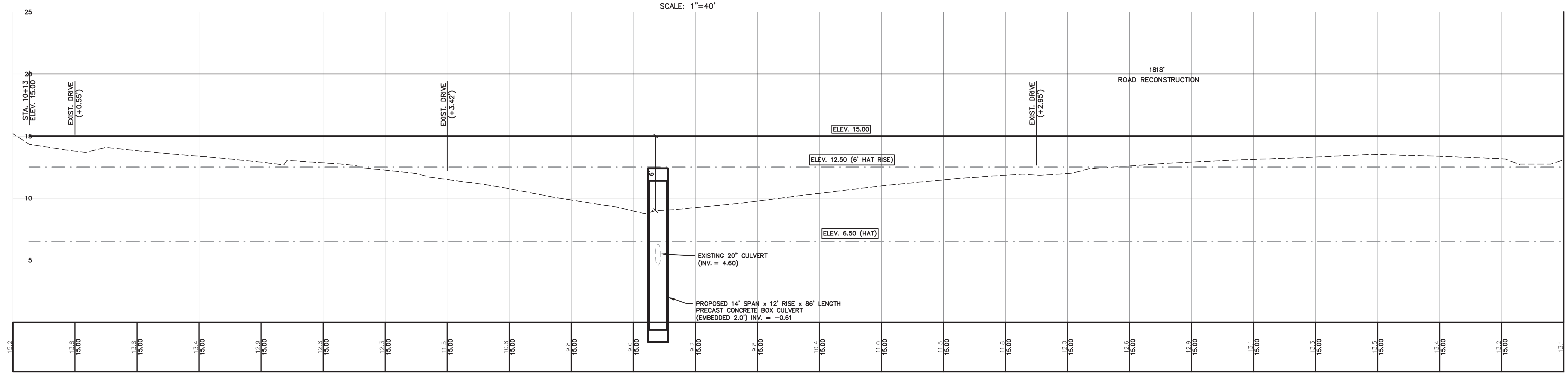
Client: Town of Harpswell
Mountain Road, Harpswell, Maine

Figure 8

NOTES:

1. ROAD SURVEY COMPLETED BY TITCOMB ASSOCIATES IN DECEMBER 2017. GROUND TOPOGRAPHY BASED ON MAINE GIS LIDAR.
2. ELEVATIONS ARE BASED ON GPS OBSERVATIONS, CONVERTED TO THE NAVD88 DATUM UTILIZING THE NOAA VERTCON CONVERSION TOOL.
3. HIGHEST ANNUAL TIDE (HAT) IS BASED ON MAINE DEP HIGHEST ANNUAL TIDE LEVELS 2018.

PLAN
SCALE: 1"=40'



PROFILE
SCALE: 1"=40' HORIZ.
1"=4' VERT.

1 inch = 40 ft.

Rev.	Date	Revision
–	–	–

Issued For	Date	By
–	–	–

Design: OCC	Draft: LAN	Date: AUG 2018
Checked: WCH	Scale: AS SHOWN	Job No.: 2340.31
File Name: 2340.31-pbase_ALT2		

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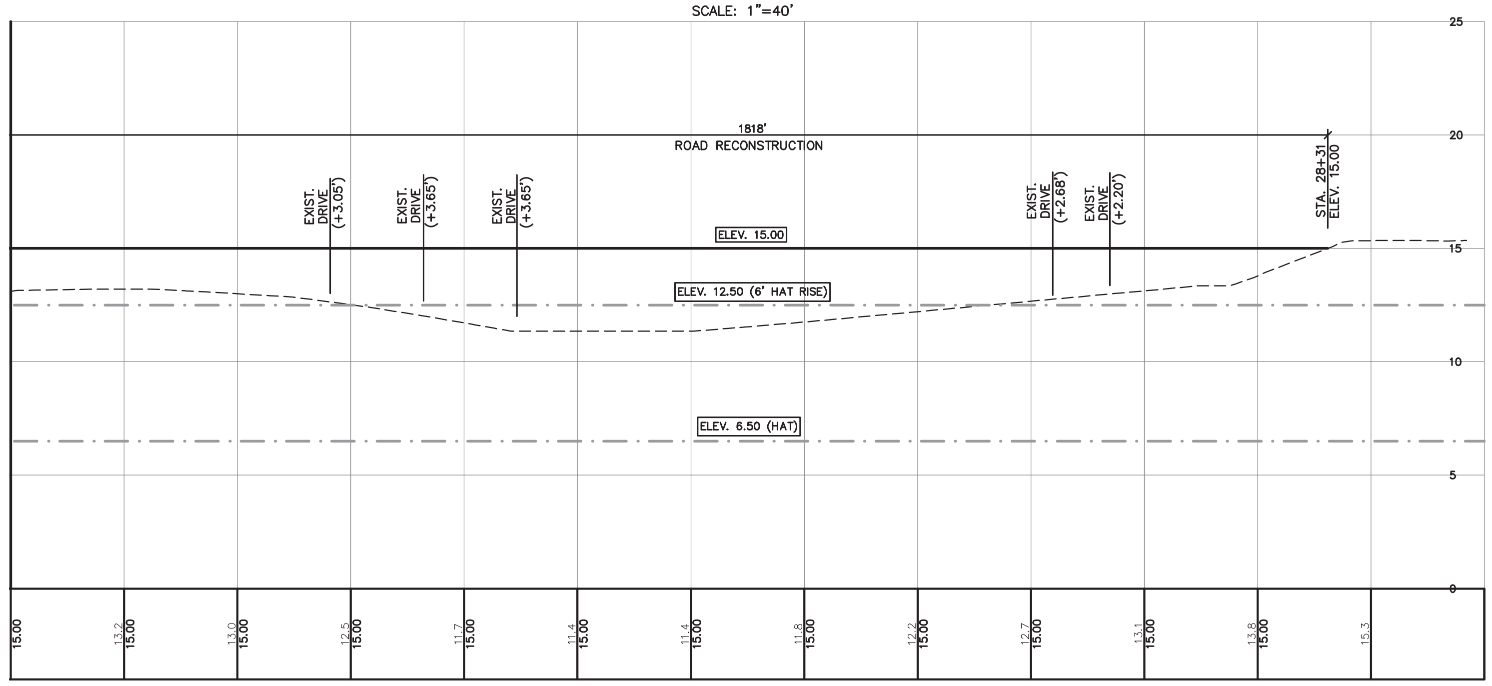
Drawing Name: **6.0' RISE PLAN AND PROFILE**
Project: **Basin Point Road Improvements**
Harpswell, Maine
Client: **Town of Harpswell**
Mountain Road, Harpswell, Maine

Figure
9

PLAN

SCALE: 1"=40'



PROFILE

SCALE: 1"=40' HORIZ.
1"=4' VERT.

1 inch = 40 ft.

Rev.	Date	Revision
–	–	–

Issued For	Date	By
–	–	–

Design: OCC	Draft: LAN	Date: AUG 2018
Checked: WCH	Scale: AS SHOWN	Job No.: 2340.31
File Name: 2340.31-pbase_ALT2		

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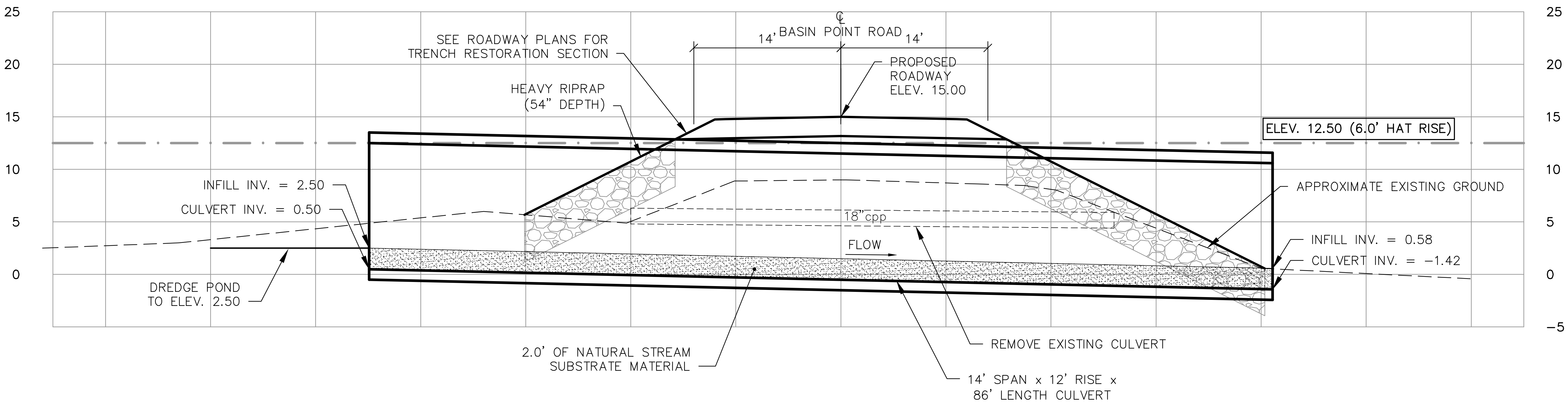
Drawing Name: **6.0' RISE PLAN AND PROFILE**

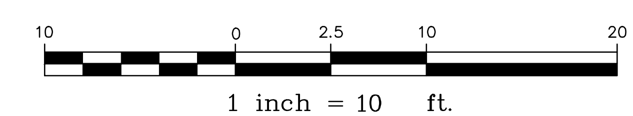
Project: **Basin Point Road Improvements**
Harpswell, Maine

Client: **Town of Harpswell**
Mountain Road, Harpswell, Maine

Figure
10



BASIN POINT ROAD CULVERT CROSS SECTION
(6.0' HAT RISE)
SCALE: 1"=10'



Rev.	Date	Revision
-	-	-

Design: OCC	Date: OCT 2018
Draft: LAN	Job No.: 2340.42
Checked: WCH	Scale: 1"=10'
File Name: 2340.31-CULV-ALT2.dwg	

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Drawing Name: Basin Point Road Section 6.0' HAT RISE

Project: Basin Point Roadway Improvements
Harpswell, Maine

Figure 11

References

Casco Bay Estuary Partnership. 2018. *Basin Point Road Assessment, Town of Harpswell.*

Maine Geological Survey Sea Level Rise/Storm Surge Viewer - https://www.maine.gov/dacf/mgs/hazards/slr_ss/index.shtml

NOAA. 2017. Global and Regional Sea Level Rise Scenarios for the United States.

Appendix A
Drawings for Basin Point Road Improvements
Figures 6, 8-10 – Full Size Folded Plans

Appendix B
Concept Opinions of Probable Construction Cost for Option 2 & Option 3

Gorrill-Palmer Consulting Engineers Inc.

Preliminary Opinion of Probable Construction Cost

11/19/2018

Project WIN: **2340.31**
Project Location: **Basin Cove Road - Sea Level Rise (3.3')**
Comments: **Conceptual OPCC**
Date: 11/19/2018
References: Unit pricing from MaineDOT average bid prices
Calculated By: Owen Chaplin
Checked By: Will Haskell

Notes:
1. Estimated engineering design and permitting fees are provided and include engineering design, survey, geotechnical investigations, wetlands delineation, and permitting (Maine DEP NRPA and Army Corps GP).
2. Opinion of cost does not include construction inspection services during the construction of the project.
3. Opinion of cost does not include legal, right of way, environmental or utility costs.
4. Opinion of cost does not include site work on private abutting properties, except for work within ROW.
5. Unit pricing based on historic MaineDOT average unit price bid results.
6. Opinion of cost is based on limited survey information.
7. Opinion of cost is based on a 3.3 foot increase in the 2018 Highest Annual Tide (HAT).
8. Opinion of cost assumes 15" of type D subbase gravel, 3" of type A base gravel, and 4" of total HMA pavement.
9. Opinion of cost does not include land acquisition or easement costs.

Item	Item Description	Unit	Unit Price	Quantity	Amount
202.20	REMOVE BITUMINOUS CONCRETE PAVEMENT	SY	$ 5.00	1400	$ 7,000.00
203.20	COMMON EXCAVATION	CY	$ 16.00	450	$ 7,200.00
304.10	AGGREGATE SUBBASE COURSE - TYPE D	CY	$ 24.00	850	$ 20,400.00
304.15	AGGREGATE BASE COURSE - TYPE A	CY	$ 30.00	150	$ 4,500.00
403.207	HOT MIX ASPHALT 19.0 MM NOMINAL MAXIMUM SIZE	T	$ 100.00	200	$ 20,000.00
403.210	HOT MIX ASPHALT 9.5 MM NOMINAL MAXIMUM SIZE	T	$ 100.00	130	$ 13,000.00
603.169	15 INCH STORM DRAIN PIPE OPTION III	LF	$ 70.00	30	$ 2,100.00
603.90	10' X 14' PRECAST CONCRETE BOX CULVERT (78 LF)	LS	$ 200,000.00	1	$ 200,000.00
606.17	GUARDRAIL TYPE 3B - SINGLE RAIL	LF	$ 22.00	250	$ 5,500.00
610.16	HEAVY RIPRAP	CY	$ 75.00	1600	$ 120,000.00
615.071	LOAM SEED MULCH	SY	$ 10.00	600	$ 6,000.00
652.36	MAINTENANCE OF TRAFFIC CONTROL	LS	$ 30,000.00	1	$ 30,000.00
656.75	TEMPORARY SOIL EROSION AND WATER POLLUTION CONTROL	LS	$ 30,000.00	1	$ 30,000.00
659.10	MOBILIZATION	LS	$ 40,000.00	1	$ 40,000.00
	SUB-TOTAL				**$ 505,700.00**
	DESIGN CONTINGENCY (10%)				**$ 50,570.00**
	CONSTRUCTION CONTINGENCY (10%)				**$ 50,570.00**
	TOTAL				**$ 606,840.00**
	ROUNDED TOTAL				**$ 607,000.00**
	ENGINEERING DESIGN / PERMITTING FEES				**$ 84,000.00**
				Total	**$ 691,000.00**

Gorrill-Palmer Consulting Engineers Inc.
Preliminary Opinion of Probable Construction Cost

Project WIN: **2340.31**
Project Location: **Basin Cove Road - Sea Level Rise (6')**
Comments: **Conceptual OPCC**
Date: 11/19/2018
References: Unit pricing from MaineDOT average bid prices
Calculated By: Owen Chaplin
Checked By: Will Haskell

Notes:
1. Estimated engineering design and permitting fees are provided and include engineering design, survey, geotechnical investigations, wetlands delineation, and permitting (Maine DEP NRPA and Army Corps GP).
2. Opinion of cost does not include construction inspection services during the construction of the project.
3. Opinion of cost does not include legal, right of way, environmental or utility costs.
4. Opinion of cost does not include site work on private abutting properties, except for work within ROW.
5. Unit pricing based on historic MaineDOT average unit price bid results.
6. Opinion of cost is based on limited survey information.
7. Opinion of cost is based on a 6 foot increase in the 2018 Highest Annual Tide (HAT).
8. Opinion of cost assumes riprap along the south side of Basin Cove Road.
9. Opinion of cost assumes guardrail along the south side of Basin Cove Road.
10. Opinion of cost assumes 15" of type D subbase gravel, 3" of type A base gravel, and 4" of total HMA pavement.
11. Opinion of cost does not include land acquisition or easement costs.

Item	Item Description	Unit	Unit Price	Quantity	Amount
202.20	REMOVE BITUMINOUS CONCRETE PAVEMENT	SY	$ 5.00	4700	$ 23,500.00
203.20	COMMON EXCAVATION	CY	$ 16.00	1300	$ 20,800.00
203.25	GRANULAR BORROW	CY	$ 30.00	1500	$ 45,000.00
304.10	AGGREGATE SUBBASE COURSE - TYPE D	CY	$ 24.00	3100	$ 74,400.00
304.15	AGGREGATE BASE COURSE - TYPE A	CY	$ 30.00	500	$ 15,000.00
403.207	HOT MIX ASPHALT 19.0 MM NOMINAL MAXIMUM SIZE	T	$ 100.00	700	$ 70,000.00
403.210	HOT MIX ASPHALT 9.5 MM NOMINAL MAXIMUM SIZE	T	$ 100.00	420	$ 42,000.00
603.169	15 INCH STORM DRAIN PIPE OPTION III	LF	$ 70.00	150	$ 10,500.00
603.90	12' X 14' PRECAST CONCRETE BOX CULVERT (86 LF)	LS	$ 250,000.00	1	$ 250,000.00
606.17	GUARDRAIL TYPE 3B - SINGLE RAIL	LF	$ 22.00	1700	$ 37,400.00
610.16	HEAVY RIPRAP	CY	$ 75.00	3600	$ 270,000.00
615.071	LOAM SEED MULCH	SY	$ 10.00	2000	$ 20,000.00
652.36	MAINTENANCE OF TRAFFIC CONTROL	LS	$ 30,000.00	1	$ 30,000.00
656.75	TEMPORARY SOIL EROSION AND WATER POLLUTION CONTROL	LS	$ 50,000.00	1	$ 50,000.00
659.10	MOBILIZATION	LS	$ 50,000.00	1	$ 50,000.00

SUB-TOTAL	**$ 1,008,600.00**
DESIGN CONTINGENCY (10%)	**$ 100,860.00**
CONSTRUCTION CONTINGENCY (10%)	**$ 100,860.00**
TOTAL	**$ 1,210,320.00**
ROUNDED TOTAL	**$ 1,210,000.00**
ENGINEERING DESIGN / PERMITTING FEES	**$ 168,000.00**
Rounded Total	**$ 1,378,000.00**

Appendix C
Notes from Workshops 1 & 2

Basin Point Road Project

11.16.17 Workshop Notes

<u>*Attendees:*</u>

Susan & Dixon Riley, Joan & Bob Dehetre, Terry Flanagan, Robert McIntyre and Selectman, Rick Daniel. Will Haskell (GP), Matt Craig (CBEP), Reed Coles (HHLT), Ron Ponziani, (Road Commissioner) Mark Eyerman, (Planner) (HCC) Mary Ann Nahf, Deirdre Strachan, and Wendy Batson.

<u>Workshop Objectives:</u>

- Introduce project scope, schedule and partners
- Present the current situation
- Collect information from stakeholders on pond and adjacent land

<u>Introduction:</u>

The Basin Point Rd Project will work to develop a long-term plan for managing potential impacts of coastal flooding due to sea level rise (SLR) and storm surge on the portion of the road near the head of Basin Cove. It will also develop options for managing the impact of increased salt water movement into the pond and wetland on Curtis Farm Preserve. The information developed in the study should be applicable to other areas of town so the town can use to plan and budget costs for future capital road projects on town roads and culverts.

As background and in answer to some questions from the attendees, Matthew Craig of the Casco Bay Estuary Partnership explained how the data for the models of projected rise have been established. Craig stated that tides in Portland harbor have been recorded for the last 100 years. These documented tides have shown a 7.5" rise, with a steeper rise in the last 30 years. Scientists are stating that the water in the Gulf of Maine is warming faster than 99% of the world's marine waters.

<u>Current Situation:</u>

The model developed by the Maine Geological Survey and Maine State Planning Office used historical records as a base and included current research data. From that they developed a conservative model of what we might expect in the next 30-40 years as well as in 100 years. The SLR coastal resilience model we are using shows how a 1, 2 and 3.3 feet of rise for that period would affect Harpswell.

Will Haskell of Gorrill Palmer Engineering explained they would be using current surveys and elevation maps. In addition, historical knowledge will be important as they begin studying options for raising the road profile and/or expanding the culvert at varying levels of rise.

Matt Craig stated that the pond is not completely fresh water as it receives salt water from inflow from culvert on extreme tides. It was confirmed by the presence of salt tolerant minnows and widgeon grass in the pond. He will use current knowledge for Curtis Farm Preserve[1] plus local knowledge and new field assessments to prepare conceptual alternatives to handle increased salt intrusion into the pond and adjoining freshwater wetland.

Historical Information from Stakeholders

- In 1879, Basin Point Road started at the ball field on Rt 123 and came down behind the pond and met the current road further south.
- Thought the road was re-routed to its present location sometime between 1900-1920
- Old map shows 2 parallel lines running down behind the pond. Thought may have been put in to enhance the replenishment of water at the tide mill.
- About 10 years ago the drainage ditch was scoured out by a contractor, then as wasn't properly reinforced, eroded away. As result snowplow went off road and the area was dug up and regraded so we are not looking at the natural terrain.

Next Steps

Field tests will be conducted in the spring and reports will be prepared. Both consultants will coordinate their findings as they prepare their final reports.

A 2nd workshop will be presented in the fall to present their findings. With the completion of the project, the town will be in a state to discuss how to address transportation access to accommodate rising seas and changing ecosystem and how the town might manage the impact of increased salt water movement into freshwater wetlands and ponds. The information compiled should also be applicable to other areas in town that may be affected by rising tides or migrating marshes.

King Tide Meet-Up – 11.6' ti***de***

A resident expressed interest in being to see how high the tide comes currently. Realizing December has one of the highest tides of the year, the group decided to meet for the King Tide **Monday 12/4/17 10:45am**. Meet at picnic bench, Basin Point Rd near pond and culvert. Park in Curtis Farm parking lot across the road. Bad weather Day Tuesday 12/5 11:45.

[1] *Maine Natural Areas Program Summary for Curtis Farm (*2009)
Curtis Farm Preserve Forest and Wildlife Habitat Management Plan (HHLT 2016)
Ecosystem Conditions and Benefits Assessment: Basin Cove/Curtis Cove Conservation Project (Forest Synthesis 2010)

Basin Point Road Assessment
Workshop II Notes
Nov. 7, 2018, 4:30 – 6:00 pm

Attendees: Basin Point Rd. residents, Dolphin Marina owner, Harpswell Heritage Land Trust Exec. Dir. & Trustees, Town Historian, Road Commissioner, Town Officials, Conservation Commission members and Town residents totaling approximately 24.

Presenters: Mary Ann Nahf, Conservation Commission; William Haskell, Gorrill Palmer Engineering; Mathew Craig, Casco Bay Estuary Partnership

Introduction:
In 2017, the Town of Harpswell initiated two studies to plan for the impacts of sea level rise (SLR) and storm surge on a low-lying road and adjacent ecosystems. The Town commissioned Gorrill Palmer Engineering (GP) to assess design options and costs for upgrading the road and culvert to withstand anticipated sea level rise, and the Casco Bay Estuary Partnership (CBEP) to develop a detailed assessment of current ecological conditions and scenario planning for the impact of culvert replacement and sea level rise on ecosystems adjacent to the road. Workshop II presents the consultants' findings and provides conceptual designs, costs and an evaluation of scenario-based ecological outcomes.

Background:
As Harpswell began gathering data to plan for the impact of sea level rise and storm surge on its road infrastructure and resource rich wetlands, it became evident that its 216 miles of shoreline, with its many coves would cause its roads and culverts to be vulnerable to rising tides.

Mary Ann Nahf (HCC) noted that Harpswell's culture and economy are tied to the water. Whether it be its fisheries or tourism the majority of the town's business income is marine related so the ability to reach these areas will be a top priority. There are 60 Town roads of which 13 will be affected with 1-3 feet of tide rise. The longest is Basin Point Road (2.43 miles).

Basin Point Road was chosen to study because the road has high traffic volume, has only one way in or out and services over 100 residents and several small home businesses.

- The high-volume Dolphin Marina and Restaurant, one of the Town's largest businesses is at the end of the road. It has over 90 employees and their restaurant served over 85,000 in 2016, most of whom came by road.

- Adjacent to the road at the head of Basin Cove is the Harpswell Heritage Land Trust's (HHLT) Curtis Farm Preserve. The pond and wetland presented an opportunity to assess present and future ecological conditions that will be affected with more tidal exchange.

It was explained that the elevations used in the presentation are given in feet relative to North American Vertical Datum 1988 (NAVD 88). Local tide tables, in contrast, typically provide tide predictions in feet relative to Mean Lower Low Water (MLLW) which would be 5.26 feet higher than a NAVD88 measurement.

<u>Existing Conditions</u>

Will Haskell (GP) explained that Basin Point Road dips to a distinct low point where an 18-inch culvert crosses the road at the head of Basin Cove. The culvert transports peak flows from the Curtis Farm Preserve's tributary watershed. Peak freshwater flows are conveyed via a stream into the pond and to the ocean through the existing culvert under Basin Point Road.

The culvert outlet invert (Basin Cove side) is elevated above the bottom of the pond's tidal channel invert approximately 3.7 feet. Under normal 2018 high tide conditions the tide does not flow through the culvert into the pond. There is no anecdotal evidence that historic high tides have overtopped the road; however, the tides have flowed backward though the culvert and into the pond.

The pond contains what appears to be an earthen berm just in front of the invert into the culvert. Currently, the elevation of the top of the berm is about 5.7 feet. It generally prevents normal high tides from flowing back into the pond and effectively maintains the water level in the pond at or below 5.7 feet.

Matt Craig (CBEP) explained they studied the existing ecological conditions by monitoring channel morphology/elevation, hydrology, and vegetation at ten stations adjacent to Basin Point Road. Monitoring stations were in place between April and August 2018 in the stream area between Basin and Curtis Coves.

Channel morphology: Data was collected from the downstream mudflats up to the head of the pond. The lowest point in the pond is immediately upstream of the road, it arcs to the west and follows the western shoreline and crosses to the east where it meets the freshwater stream that feeds the pond.

Craig stated the Study confirmed that the culvert is a sloped culvert that is atypical for tidal culverts as the inlet is higher than outlet. This "perched" condition contributes to a tidal restriction and presents a barrier to aquatic organism movement under the road. Immediately upstream of the culvert inlet, an artificial earthen dam (fill) further restricts the movement of salt water into the pond, and impounds water preventing it from draining out of the pond. The dam controls water levels in the pond. The elevation of the firm peat bottom indicates that prior to construction of the road and the dam, the pond was at one time a tidal marsh.

Hydrology and Salinity: The perched undersized culvert limits exchange of salt and freshwater. Surface pond water is further restricted by the earthen dam (berm) near the culvert that controls the pond's water level to a minimum of 5.7 feet. This results in a total lack of salt water intrusion for a month at a time severely restricting tidal exchange upstream.

In response to a question presented at the first workshop Craig stated that there are indications that the remnant gristmill structure does not currently affect tidal hydrology at the project site.

Vegetation:

The vegetation community downstream of Basin Point Road is starkly different from the vegetation community upstream. Transitions in the vegetation community of wetlands are often used as a visual indicator of altered hydrology. At this site, the abrupt community transition is indicative of altered tidal exchange. Throughout the pond and along the adacent edges, elevations are suitable for low marsh and high marsh salt marsh vegetation to grow, if the impoundment were to be removed and full tidal exchange restored to the area which is now a pond.

Fish & Wildlife: As previously stated, the existing perched and undersized culvert, combined with the earthen dam upstream of the culvert inlet, presents a severe barrier to aquatic organism passage. The presence of small fish in the pond indicates that some fish are able to enter the pond during astronomic high tides, similar to use of pools on the high marsh surface in a healthy marsh. Fish become trapped in the pond for weeks at a time during the summer dry season, as they would in a salt marsh pool. This attracts wading birds such as great blue heron and snowy egrets, as well as cormorants, which utilize the pond for feeding and were observed on multiple occasions. The presence of horseshoe crabs in the downstream channel indicates that they would likely utilize habitat upstream of the road, perhaps to mate, but are almost certainly unable to utilize the existing culvert.

<u>Proposal – Road and Culvert:</u>

Three options were presented for consideration by Gorrill Palmer

- Option 1 – Do nothing
- Option 2 – Raise road 4.3' over culvert to accommodate a 3.3' rise at an estimated construction cost of $607,000.

- Option 3 – Raise road 6' over culvert to accommodate 6' rise at an estimated construction cost of $1,210,000

Craig commented that its 2018 water level and vegetative assessment suggests that current conditions are periodically comparable to a 1 ft. sea level rise scenario. Sea level rise predictions indicate that Basin Point Road is at risk of overtopping between the 1’ and 3.3’ sea level rise scenarios, and in fact was probably close to overtopping during the 1/4/18 storm. If water were to spill into the pond from over the top of the road, the existing culvert would be grossly inadequate to drain the volume of water suddenly trapped upstream. As tide levels receded in Basin Cove, stored water upstream could cause scour, potentially undermining the road and threatening the pond.

<u>Next Steps and Conclusion:</u>

- If Option 2 or 3 is selected, anticipated next steps would be to explore options for funding for design, permitting and construction of selected option. Obtain geotechnical subsurface borings and report for the vicinity of the existing culvert and obtain topo and boundary survey along the applicable portion of the road.
- Develop a protocol to establish needs and costs for other Town roads and culverts.

Matt Craig stated at the conclusion that this site was useful as an in depth case study given its constrained but well defined issues pertaining to habitat impacts, threats to transportation infrastructure, and potential for residential and economic impacts over time.
Incorporation of ecological components to a plan is warranted due to the importance of these habitats to local economies, notably fisheries, as well as the values and services they provide, but also because coastal habitat restoration is a priority for several state and national entities that provide grant funding to promote ecological restoration and resilience. The Town’s multi-faceted approach to understanding existing conditions and planning for changes over time at this location can be transferred to similar sites around town.

The workshop ended at 6:15 pm.

Preparing for Coastal Flooding in Harpswell:
A Plan for Basin Point Road and Its Wetlands

Appendix II

Casco Bay Estuary Partnership -
"*Basin Point Road Assessment Report*"

Assessment of Existing & Future Ecological Conditions at Basin Point Road

Harpswell, Maine

November 2018

View of Curtis Farm Pond from Basin Point Road, Harpswell, July 2018

Prepared For:
Town of Harpswell
263 Mountain Road
Harpswell, Maine 04079

Prepared By:
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Funded By:
Maine Coastal Program
NOAA Coastal Zone Management Program

Table of Contents

Executive Summary

In 2017, the Town of Harpswell initiated two studies to plan for the impacts of sea level rise (SLR) and storm surge on a low-lying road and adjacent ecosystems. The Town commissioned Gorrill Palmer (GP) to assess design options and costs for upgrading the road and culvert to withstand anticipated sea level rise, and Casco Bay Estuary Partnership (CBEP) to assess current ecological conditions and scenario planning for the impact of culvert replacement and sea level rise on ecosystems adjacent to the road. This report summarizes findings of the ecological assessment, and references design options described in Gorrill Palmer's study.

CBEP assessed current conditions by monitoring hydrology, vegetation, channel morphology/elevation, and other parameters at ten stations adjacent to Basin Point Road. The study focused on fringing salt marsh downstream of the road and a pond upstream of the road, with additional data collected north of the pond, including low-lying upland and wetlands extending to the rocky beach at Curtis Cove. CBEP assessment found that two structures have altered upstream habitat: 1) an undersized and perched culvert beneath the road restricts tidal exchange and freshwater drainage out of the pond, while creating a severe barrier to aquatic organism passage; and 2) an artificial berm upstream of the culvert inlet further restricts water movement, forming a pond. This severe tidal restriction mutes tidal range. Salt water enters the pond during a handful of astronomic high tides each month but is otherwise cut off for four weeks at a time. As a result, salinity levels are highly variable, with low salinity levels during spring snowmelt, and higher salinity levels during the dry season. Widgeongrass covers most of the pond bottom, growing in an unconsolidated layer of organic matter. Remnant salt marsh peat forms a firm pond bottom. Small forage fish and wading birds and waterfowl were common.

GP option 1 is the no-action alternative. Existing habitat would likely be maintained but erosion is increasingly likely has higher flows are forced through the culvert. Over time, the existing road, culvert and berm/dam will leave upstream habitat increasingly vulnerable to unplanned changes resulting from flooding associated with sea level rise, large rain events, and storm surge. Projected increases in sea level would eventually result in overtopping the road, which came close to happening during the winter in 2018, as well as salt water moving into the area from Curtis Cove. At other areas in New England, this type of flooding combined with an undersized culvert has resulted in "blowouts" of infrastructure, and sudden unplanned changes in adjacent habitat. The level of risk at Basin Point Road is unclear given its relatively small size and watershed.

GP options for addressing either a 3.3-foot (option 2) or a 6-foot tidal increase in sea level (option 3) would have comparable effects on the current upstream habitat. Installation of either culvert option would immediately re-establish diurnal tidal exchange to upstream habitat, with a tidal range comparable to current conditions downstream. A new culvert would provide sufficient hydraulic capacity to drain the upstream watershed during spring snowmelt and large rain events. The sudden change in hydrology would create an immediate ecological disturbance, resulting in rapid / immediate loss of most vegetation in the pond and some vegetative mortality in low-lying adjacent uplands and wetlands, including some trees. Minor erosion is likely as accumulated organic matter exits the pond, and any remnant tidal creek channels upstream re-form. Restoration of natural hydrology would promote colonization of typical low marsh, high marsh, and brackish wetland species in the existing pond and low-lying uplands over the course of several years. Access to upstream habitat would be improved for fish and other aquatic organisms, and shellfish such as ribbed mussels would likely inhabit the restored salt marsh. Bird usage would likely shift, and restored salt marsh would potentially attract a wider variety of species typical to marshes, as well as many of the same wading birds and waterfowl.

Introduction

The Casco Bay Estuary Partnership (CBEP) is one of 28 National Estuary Programs nationwide funded by the U.S. Environmental Protection Agency and established under Section 320 of the Clean Water Act. CBEP is non-regulatory, and works with local, state, federal, academic, non-governmental, business, and other partners through collaborative networks to focus scientific expertise and financial resources on helping communities address regional challenges such as water pollution, habitat degradation, and adaptation to climate change. CBEP's work is guided by *The Casco Bay Plan* (CBEP 2016), which outlines four overarching goals for Casco Bay, including goal 1, "Protect, restore and enhance key habitats that sustain ecological health."

Coastal habitat restoration is a primary strategic focus of CBEP, and working with local partners, CBEP has contributed to several tidal wetland restoration projects in Harpswell dating back to 2014. CBEP's role in these 'tidal restoration' projects has varied, but all have shared a common objective of restoring tidal exchange beneath roads where undersized culverts have limited the movement of water (and other materials), resulting in degradation of adjacent habitat. The study site, where Basin Point Road crosses a small tidal creek at the head of Basin Cove, is one that CBEP identified as a tidal restriction during rapid assessment surveys in 2011-12. Subsequent conversations with the Town of Harpswell eventually led to a collaborative proposal for *Coastal Community Grant* program funding for a feasibility study at the site in 2017. The Maine Coastal Program awarded funding to the Town, the project commenced in the fall of 2017. The Town of Harpswell commissioned Gorrill Palmer to prepare engineering designs, and CBEP to conduct an ecological assessment of the site.

Location

The study site is located near the end of Harpswell Neck in West Harspwell, at the head of Basin Cove where Basin Point Road crosses a small tidal creek (Fig. 1, right) and a .9-acre pond, known locally as Curtis Farm Pond. Other than the road and the associated right of way, most of the study area lies within the Curtis Farm Preserve, owned and managed by the Harpswell Heritage Land Trust (HHLT) and accessible via a trailhead parking area off Basin Point Road. The 87-acre parcel was acquired by HHLT in 2010, with the majority of funding provided by the U.S. Fish and Wildlife Service through the *North American Wetlands Conservation Act* (NAWCA) grant program due to high value wetland habitat. CBEP provided HHLT with a $20,000 grant as seed funding for acquisition costs.

Basin Point Road is a Town-owned and maintained roadway that provides the sole overland access to residential and business properties along Basin Point, including Dolphin Marina.

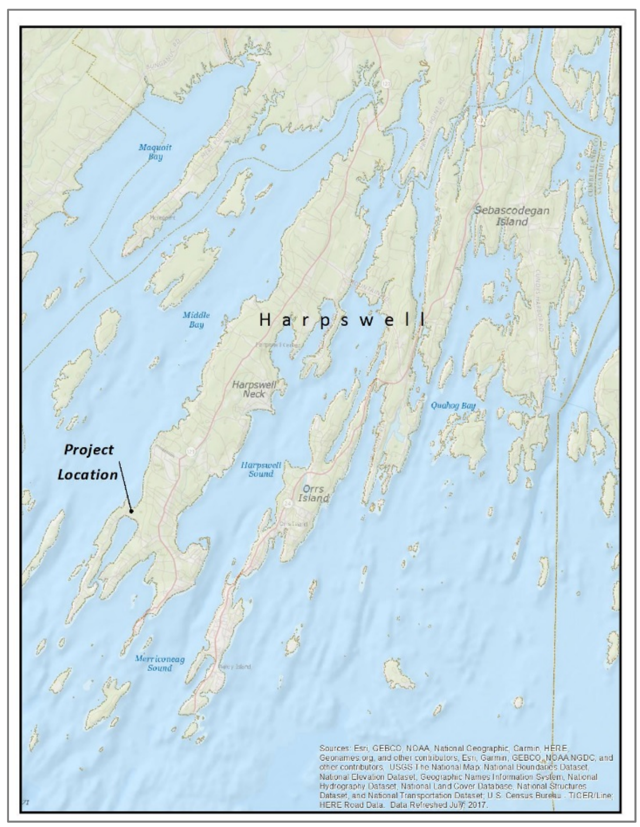

Figure 1. Map of Harpswell showing the project location.

Objectives

In conducting the ecological assessment, CBEP's objectives were to:

- Document existing conditions where Basin Point Road crosses a small tidal wetland;
- Assess how the road is impacting the adjacent ecosystem;
- Use assessment data to evaluate scenario-based ecological outcomes resulting from implementation of conceptual design alternatives; and,
- Support community-based climate adaptation efforts in order to build human and ecological resilience to predicted sea level rise and storm surge.

Approach

Between April and August 2018, CBEP surveyed low-lying, tidally influenced habitat upstream and downstream of Basin Point Road. The survey was designed to document existing ecological conditions, assess the impact of the road on the adjacent ecosystem, and collect data to understand likely ecological changes resulting from alterations to local site hydrology through culvert replacement and sea level rise. CBEP established monitoring stations, with one located downstream (south) of the road, in fringing salt marsh at the head of Basin Cove, and additional stations north of the road, including Curtis Farm Pond and the creek feeding into it. Figure 2 shows the locations of monitoring stations, and Table 1 shows monitoring activities by station. Monitoring parameters included surface water hydrology and salinity, vegetation community, marsh surface elevation, channel morphology, pore water salinity, invasive species, and aquatic organism passage. Incidental observations of the habitat by birds and nekton were also recorded. Monitoring and assessment methods followed widely accepted protocols described in *Quality Assurance Project Plan for Tidal Marsh Monitoring and Assessment* (CBEP 2018) and *Regional Standards to Identify and Evaluate Tidal Wetland Restoration in the Gulf of Maine* (Neckles and Dionne, 1999). Brief methods descriptions are provided in the results section.

Table 1. Location of monitoring activities by station.

	1	2	3	4	5	6	7	8	9	10	11	12
Hydrology	X	X										
Channel morphology	X	X	X	X	X	X	X	X	X	X	X	X
Vegetation	X	X	X	X	X	X	X	X	X	X	X	
Pore water salinity	X	X	X	X	X	X						
Fish and wildlife	X	X	X	X	X	X						
Invasive species	X	X	X	X	X	X						

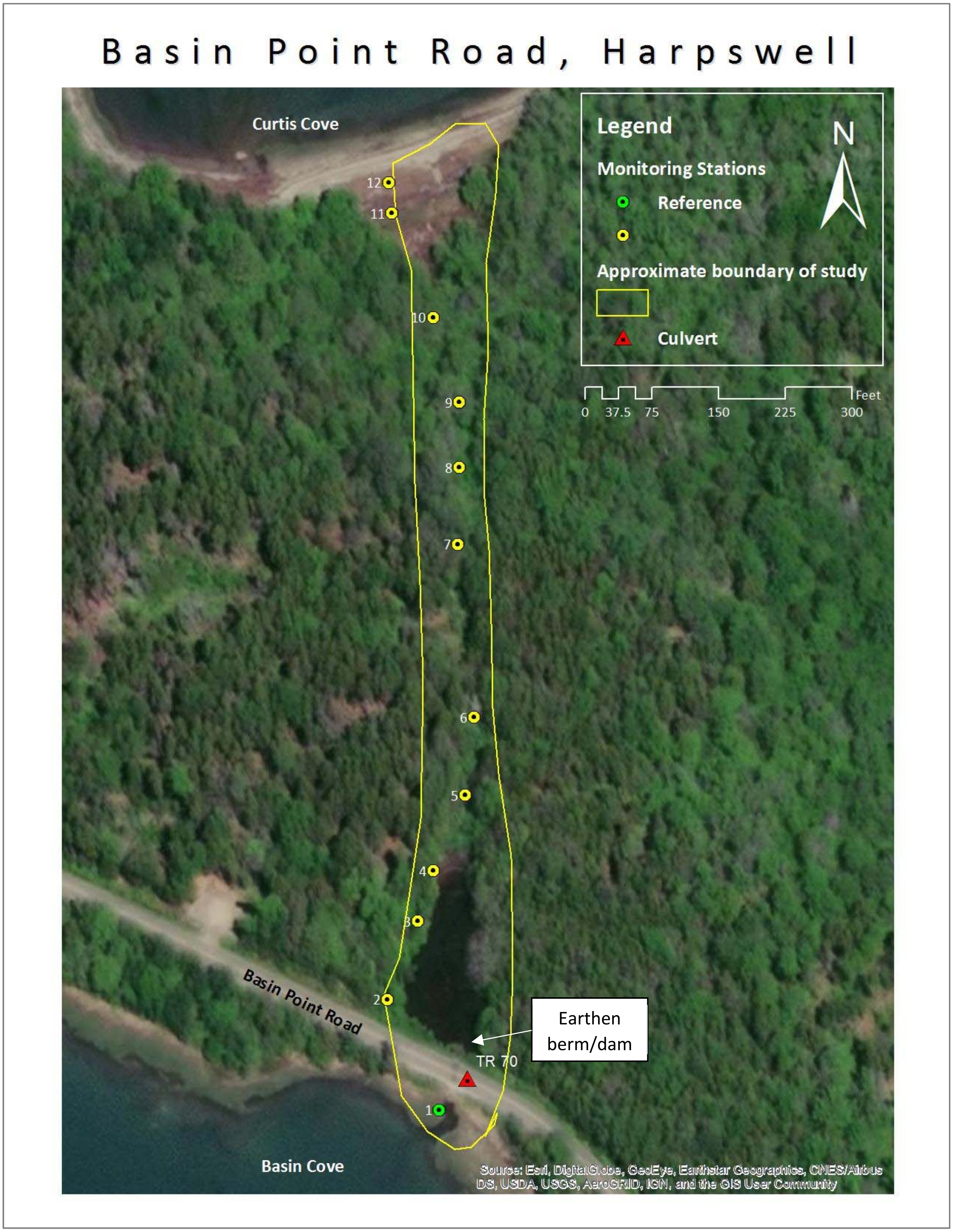

Figure 2. Map of monitoring stations and the general area studied adjacent to Basin Point Road.

Datums

Elevations throughout this document and the GP report are given in feet relative to North American Vertical Datum 1988 (NAVD 88). NAVD 88 is the standardized orthometric height for vertical surveying in the United States, and this approach is consistent with prevailing best practices for collecting elevation data using federal funds (NOAA 2012). Local tide tables, in contrast, typically provide tide predictions in feet relative to Mean Lower Low Water (MLLW). CBEP converted tidal datum elevations at the Portland Tide Station from MLLW to NAVD 88 by subtracting 5.26 from MLLW elevations, since in MLLW, NAVD 88 is equal to 5.26'.

Table 2 compares notable elevations in both MLLW and NAVD 88 at the Portland Tide Station.

Table 2. Tidal datums in Portland and Potts Harbor.

Tidal Datum	Significance	MLLW (ft.)	NAVD 88 (ft.)
Water level, Portland, 1/4/2018, 12:30	Highest observed water level for 2018 to date	13.68	8.43
HAT – Predicted Highest Annual Tide 2018, Potts Harbor (DEP)	Common elevation used to distinguish intertidal/upland for regulatory purposes	11.6	6.5
MHHW – Mean Higher High Water		9.91	4.65
MHW – Mean High Water	Approximately elevation corresponding with start of high marsh plant community	9.47	4.21
NAVD 88 – North American Vertical Datum 1988	Standard reference height	5.26	0.00
MSL – Mean Sea Level	Approximate elevation corresponding with start of low marsh plant community	4.94	-0.32
MLW – Mean Low Water		0.35	-4.91
MLLW – Mean Lower Low Water	Typically used for tide tables	0.00	-5.26

Project Area

CBEP defined the project area based on study objectives: areas that are either currently inundated with salt water or are predicted to be inundated with salt water under the 6-foot sea level rise scenario (see Fig. 20). In practice, this included the downstream fringing salt marsh, the road banks, the pond, and low-lying forested wetland upstream of the pond.

Site assessment

Mapped wetlands

National Wetland Inventory (NWI) maps of the wetlands adjacent to Basin Point Road (Fig. 3), prepared by the U.S. Fish and Wildlife Service, are coarse and provide limited detail. NWI classifies wetlands south of the road as M2US3N (Marine Intertidal Unconsolidated Shore Mud Regularly Flooded), commonly referred to as 'mudflat', and the wetlands north of the road as PUBHh (Palustrine Unconsolidated Bottom Permanently Flooded Diked/Impounded), or a 'freshwater pond'.

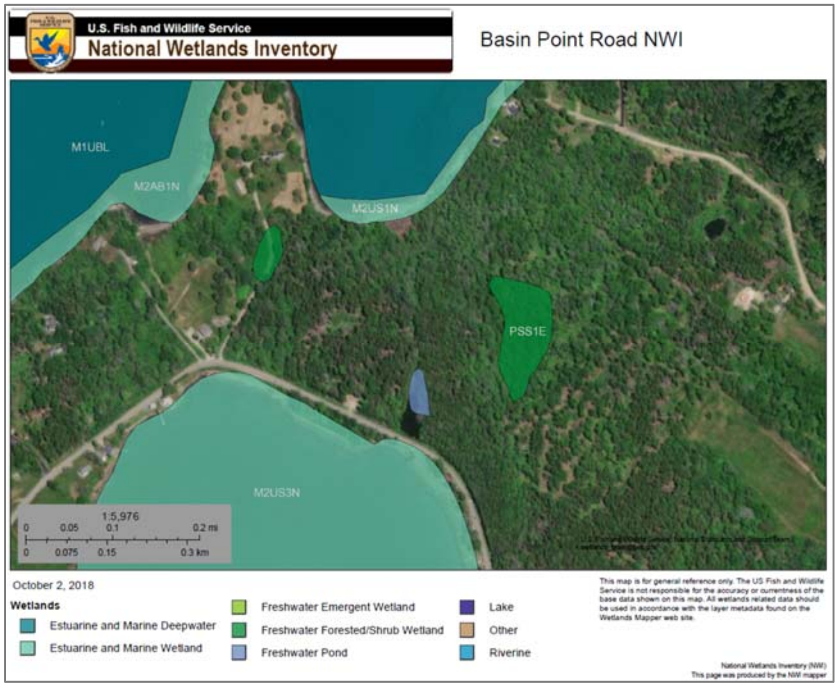

Figure 3. National Wetlands Inventory map of wetlands adjacent to Basin Point Road (source: NWI Mapper).

NWI classification of the wetlands south of Basin Point Road did not pick up the salt marsh that is visible when standing on the road and looking south toward the cove (Fig. 5a), most likely due to the scale of imagery used to develop NWI maps. Statewide maps of current tidal marsh area were developed using a 5 ac. minimum mapping unit, and therefore do not show salt marsh as present in this area. (Note: This 5 ac. screening process also results in the omission of the area from recently developed sea level rise prediction tools such as the Maine Coastal Resilience tool, *Future Habitat Explorer.*[1])

CBEP mapped fringing marsh in Casco Bay in 2007, commissioning the Wells National Estuarine Research Reserve to map fringing marsh using aerial photos and boat-based groundtruthing (Hayes *et al* 2008). Resulting data layers show a ribbon of fringing marsh (Fig. 4) along the perimeter of Basin Cove.

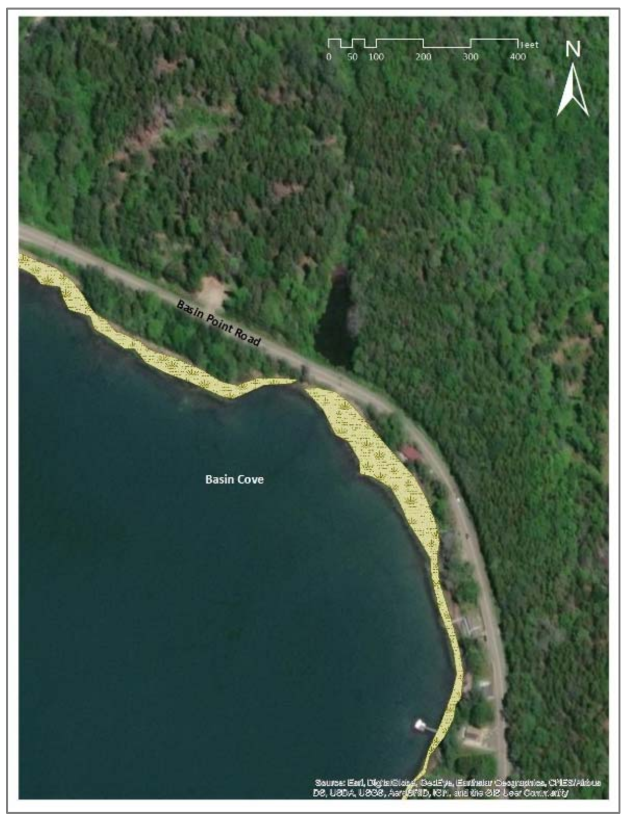

Figure 4. Fringing marsh at the head of Basin Cove (CBEP).

[1] http://maps.coastalresilience.org/maine/#

HHLT commissioned Robert Bryan of Forest Synthesis LLC to conduct a baseline survey of the two parcels that make up the current Curtis Farm Preserve in 2009. The subsequent report incorporated prior observations from the Maine Natural Areas Program (Puryear 2009), and included a map of wetlands (Fig. 5; Bryan 2010). Documented wetland types include marine intertidal mudflat in Basin Cove, as well as forested wetland and scrub/shrub wetland upstream of Basin Point Road. Although the map below does not specifically label the fringing tidal marsh south of Basin Point Road, both the MNAP and Forest Synthesis reports described tidal marsh at this location. The Forest Synthesis report also describes a small patch of salt marsh vegetation immediately downstream of the Curtis Farm Pond and adjacent to the Basin Point Road culvert inlet, which is not shown on the map. Forest Synthesis describes the pond as follows: “The pond currently provides freshwater feeding habitat for waterfowl and wading birds. While the pond could be restored to tidal wetland by placing a larger and lower-elevation culvert, the benefitted area is very small relative to the potential costs.” CBEP hydrology data and vegetation characterization (described in later sections) show that the pond currently receives salt water during astronomic high tides, resulting in highly variable salinity, and allowing widgeongrass to establish in loose unconsolidated organic matter on the pond bottom due to the minimal flow velocities.

For the purposes of this study, the pond and forested wetland at the head of the pond are of primary interest in terms of alteration resulting from proposed improvements at Basin Point Road.

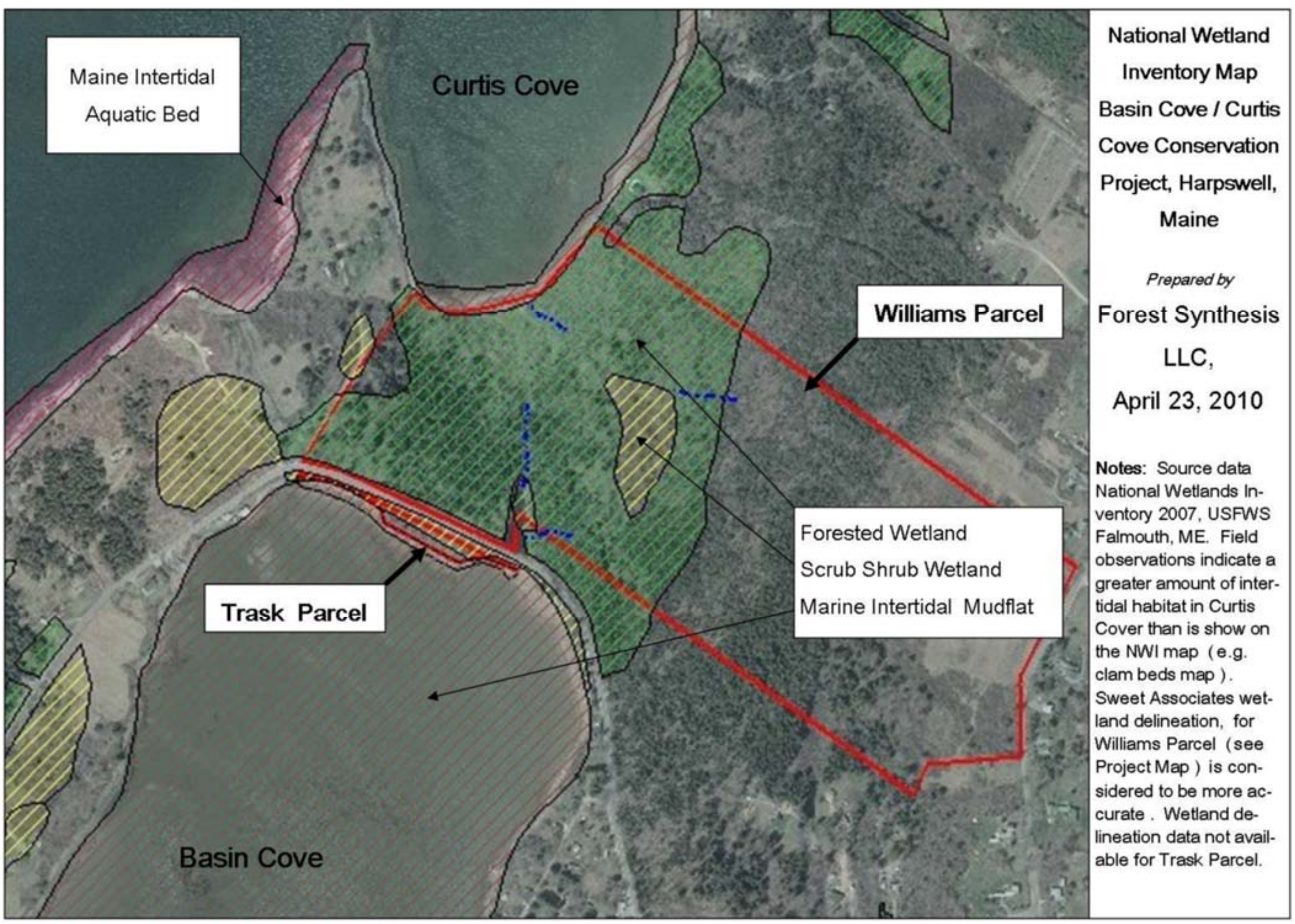

Figure 5. Wetlands map from the baseline survey for Curtis Farm Preserve (Bryan 2010).

Photo stations – Basin Point Road

Standard photo stations for stream/road crossing surveys (Fig. 6a-6f) include views: downstream, culvert outlet, upstream, culvert inlet, and road approach from each direction. The site was not surveyed in 2009/10 because of the lack of a perennial stream feeding into the pond, causing the site to be dropped during desktop screening.

Figure 6. Fig.6a-6f, from left to right. Top row: downstream channel; culvert outlet to channel (north). Middle row: upstream pond with berm/dam in foreground; culvert inlet with berm/dam in foreground. Bottom row: road approach (west); road approach (east).

Existing conditions

Channel morphology

CBEP used an auto level, 300’ tape reel, and a stadia rod to survey: 1) a longitudinal profile of the channel thalweg (the lowest point), from the downstream mudflats up to the head of the pond; 2) a longitudinal profile of the intermittent creek from the head of Curtis Farm Pond and Curtis Cove; 3) a cross section of the downstream creek channel; 4) four cross sections in the pond; and, 5) elevations of downstream tidal marsh community zonation.

Measurements were tied to NAVD88 by surveying into temporary benchmarks established on site by Gorrill Palmer. Methods followed protocols in the *Stream Barrier Removal Monitoring Guide* (Collins *et al* 2007).

Figure 7. Longitudinal profile of the channel thalweg.

Longitudinal profile

Figure 7 shows a plan view of the general location of the longitudinal profile survey, which started at the downstream channel transition from mudflat and continued to the head of the pond, following the lowest point.

The location of the lowest point (thalweg) in the pond was difficult to determine due to the presence of a layer of accumulated organic matter on the bottom, but was eventually located by testing different points perpendicular to the road. Immediately upstream of the road, the low point in the pond arcs to the west and follows the western shoreline before crossing back to the east, meeting the freshwater stream that feeds the head of the pond.

Figure 8 (below) plots the longitudinal profile. Mean High Water (MHW) of 4.21’ from the Portland Tide Gauge is shown for reference[2]. The start of the transect at zero lies at an elevation of approximately -1.0’. Cross section 1 is shown at 22.5’ along the transect, and is considered most representative of ‘natural’ creek channel conditions. Between XS1 and the culvert outlet, road fill and riprap defines the channel bottom and elevations are presumed to be artificially high. The culvert is sloped, which is atypical for tidal culverts, with the inlet higher than the outlet. Both the outlet invert (bottom elevation) and the inlet invert are set high in the tidal range, well above the natural channel bottom at XS1, and above the MHW line. This “perched” condition contributes to the tidal restriction shown in the hydrology data and presents a barrier to aquatic organism movement under the road. Immediately upstream of the culvert inlet, an artificial earthen dam (fill) further restricts the movement of salt water into the pond, and impounds water preventing it from draining out of the pond. The dam controls water levels in the pond. Within the pond, a layer of loose, mobile organic matter has accumulated over the true bottom. The bottom elevation was obtained by pushing the stadia rod down to refusal after measuring the surface of the organic matter. The bottom is presumed to be remnant salt marsh peat.

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[2] Low marsh plant assemblages typically occur below MHW, whereas high marsh assemblages occur between MHW and highest annual tide (HAT).

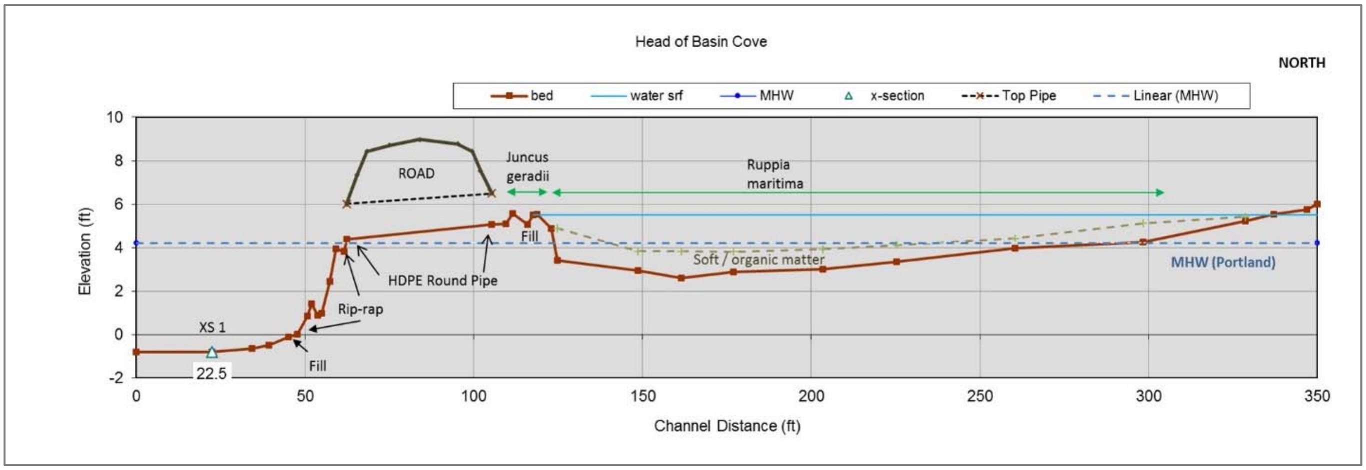

Figure 8. Longitudinal profile of the channel thalweg at Basin Point Rd., with 0' at downstream mudflats. Elevations in NAVD88.

Bottom elevations gradually increase moving north toward the head of the pond. All bottom elevations lie within the upper end of the tidal range (0' to 6'). A narrow band of high marsh (mostly blackgrass, *Juncus gerardii*) is growing atop the earthen dam, and widgeon grass (*Ruppia maritima*) is growing in lush beds rooted in the organic layer on the bottom of the pond. Widgeon grass is commonly found in salt marsh pools, and in restricted salt marsh creek channels. The elevation of the firm peat bottom indicates that prior to construction of the road and the dam, the pond was at one time a tidal marsh. Most of the organic matter is loose and would presumably wash away if the dam was removed and the culvert enlarged. Bottom elevations are suitable for a combination of low and high marsh communities to colonize the current pond if the existing impoundment were to be removed through culvert replacement.


Figure 9. Photo of St. 1 cross section. Yellow tape shows location of transect.

Cross sections

Station 1 served as a reference site[3] for comparison with upstream conditions and monitoring ecological response to future culvert replacement. The cross section transect started and ended on the marsh surface, perpendicular to the channel (Fig. 9). The channel bottom is soft mud with no indication that riprap or road fill are present.

Fig. 10 plots the cross section transect at St. 1. Measured from the top of the channel bank

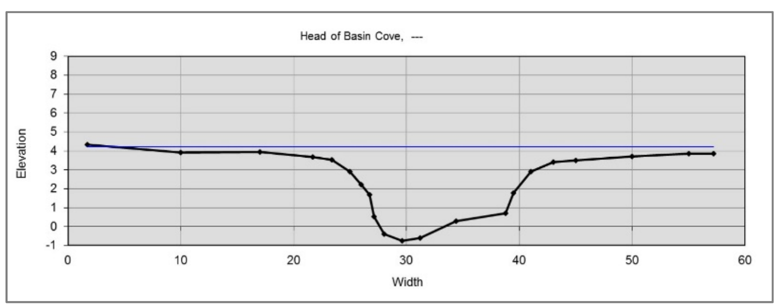

Figure 10. Plotted cross section at St. 1, downstream of the road.

[3] Note: Protocols for establishing reference conditions state that channel measurements be collected beyond the area of impact from an existing hydrological modification. At Station 1, the channel is assumed to be within the area of impact of the culvert, and therefore, not necessarily representative of upstream conditions likely to result from culvert replacement.

(3.5’ NAVD88), the U-shaped channel has an area of 49.3 ft.^{2}, a maximum depth of 4.3 ft., and is 22.4 ft. wide.

At St. 1, the U-shaped channel is rounded with no evidence of active scouring. The marsh surface is close to MHW (blue line), and vegetation consists of smooth cordgrass (*Spartina alterniflora*), typical of a low marsh community. During the highest observed tide captured during surface water monitoring, the marsh surface would have been under 3 ft. of water, and the bottom beneath nearly 8 ft. of water.

Figure 11. Photo of cross section at St. 2, with Jen standing atop the berm.

St. 2 was located immediately upstream of the road (Fig. 11). The cross section transected the pond parallel to the road, starting and ending at the upland edge. Most of the bottom was covered with widgeongrass. Fig. 12 plots the cross section with bottom elevations, but not the organic matter or water. The blue line shows pond water level at the time of the survey (5.8’). The deepest point on the transect was about 3 ft. below the water surface. Woody debris is evident between 26-30 feet.

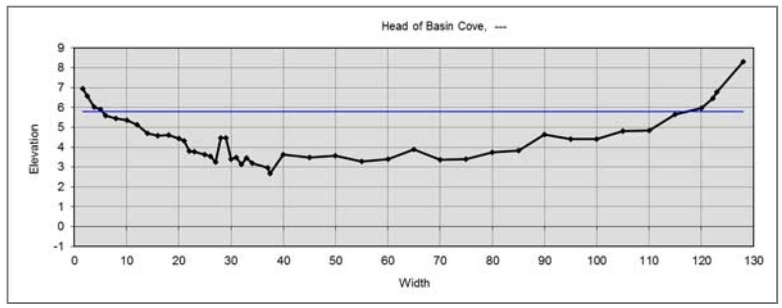

Figure 12. Cross section of the pond at St. 2.

The thalweg at 38’ corresponds with the longitudinal profile. The lowest elevations were found on the western side of the pond between 30-40’ on the tape. No clearly defined U-shaped channel was evident. Elevations are suitable for low marsh and high marsh salt marsh vegetation to grow, if the impoundment were to be removed.

Photo of a mid-pond cross section with lush widgeon grass.

The cross section at St. 3 more clearly shows a low point in the pond on the west side of the transect (Fig. 13). Again, the pond bottom was covered with widgeongrass. The thalweg at 28’ on the tape corresponded with the longitudinal profile, and is not quite as low as the thalweg at St. 2.

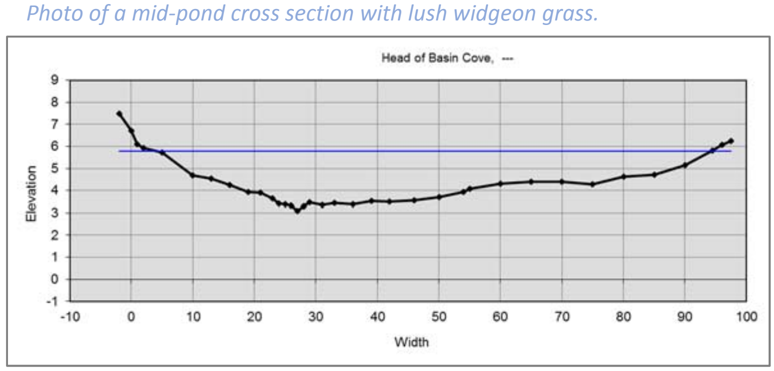

Figure 13. Cross section of the pond at St. 3.

Throughout the pond and along the adacent edges, elevations are suitable for low marsh and high marsh salt marsh vegetation to grow, if the impoundment were to be removed and full tidal exchange restored to the area which is now a pond.

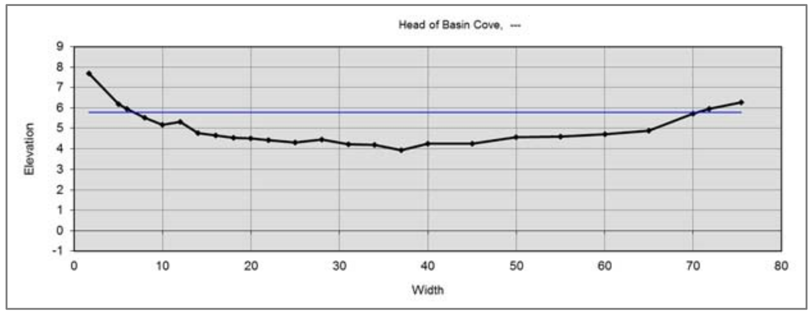

Figure 14. Cross section of the pond at St. 4.

The cross section at St. 4 (Fig. 14) shows that the head of the pond is shallower, with bottom elevations suitable for conversion to high marsh due to the expected exposure to salt water. At this location, widgeon grass was abundant and the thalweg was located toward the center of the pond. Additional cross sections were surveyed north of the pond, in the low-lying area between Curtis Farm Pond and Curtis Cove.

Figure 15 (below) plots the lowest elevations from Basin Cove to Curtis Cove in red. This plot includes the longitudinal profile shown previously, and extends it north to Curtis Cove. In addition to water levels in the pond, a reference elevation of 7.16', the highest observed water level during the 2018 water level monitoring downstream, is plotted. The transect was approximately 1,100 ft. long and ended at Curtis Cove's rocky beach.

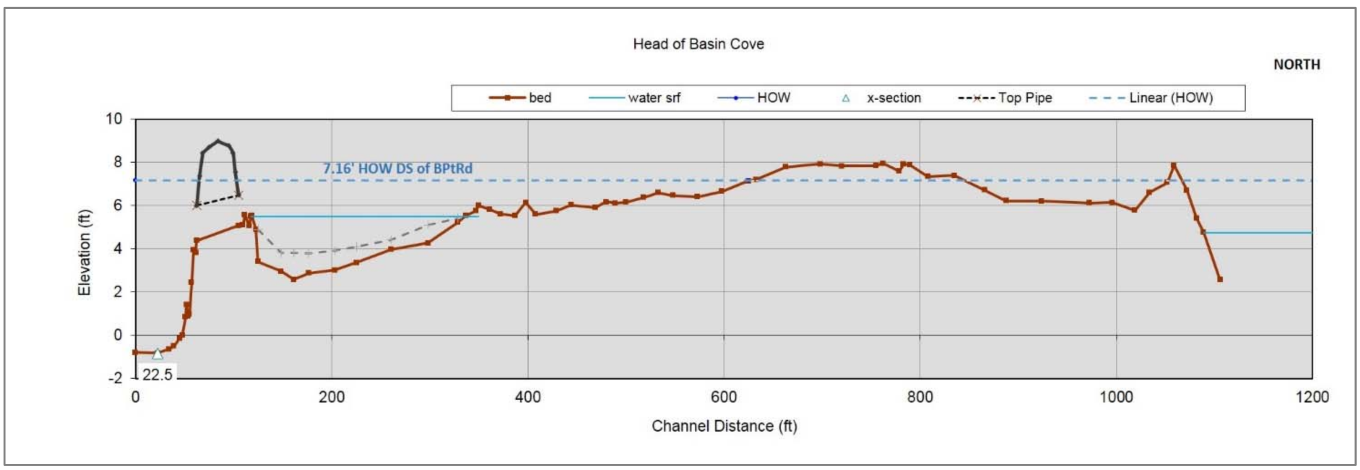

Figure 15. Longitudinal profile from Basin Cove (0') to Curtis Cove (1,100'). Elevations in NAVD88.

Previous public forums have suggested that a historic canal was dug between Curtis Cove and Basin Cove when the gristmill was operational, citing historic maps. CBEP was unable to locate documentation that support the historic presence of a canal. A review of available historic maps, including one dating to 1870, proved inconclusive on this matter. Some historic maps show a linear band of wetland between Basin Cove and Curtis Cove, but this same pattern was also used to map tidal wetlands generally and could also be interpreted as proving that prior to construction of Basin Point Road, there was a contiguous salt marsh between the two coves. Figure 15 does show a raised area around 700', which may have been the location of a historic road out to Basin Point. This elevated area may have been filled to improve access through wetlands. Investigations into soil characteristics may provide additional insights into the pre-development conditions of the land between Basin Cove and Curtis Cove.

Surface water hydrology & salinity

A perched, undersized culvert limits exchange of salt and freshwater beneath Basin Point Road. Surface water is additionally impounded upstream of Basin Point Road due to the presence of an artificial earthen dam. The dam appears to be comprised of road fill and 4-6” rock. A narrow nick point in the dam forms a small drainage out of the pond and down to the culvert. This lowest point on the dam controls water levels in the pond. Due to the high elevation of the dam relative to both sea level and the culvert, tidal exchange into the wetland upstream is severely restricted.

CBEP deployed continuous water level logging equipment adjacent to Basin Point Rd. from April 10 – June 26, 2018 with one instrument downstream and the other upstream. A separate barometric pressure logger was also deployed on site, allowing for post-processing of the data set for changes in atmospheric pressure. A conductivity logger was deployed in the pond to monitor salinity. Water level elevations were tied to NAVD88 by surveying into a temporary set of benchmarks established by Gorrill Palmer. Water level readings were logged at 6-minute intervals, concurrent with the Portland Tide Gauge. The downstream instrument was set in the tidal creek channel, which was dry at low tide, while the upstream instrument was continuously submerged and set in the pond.

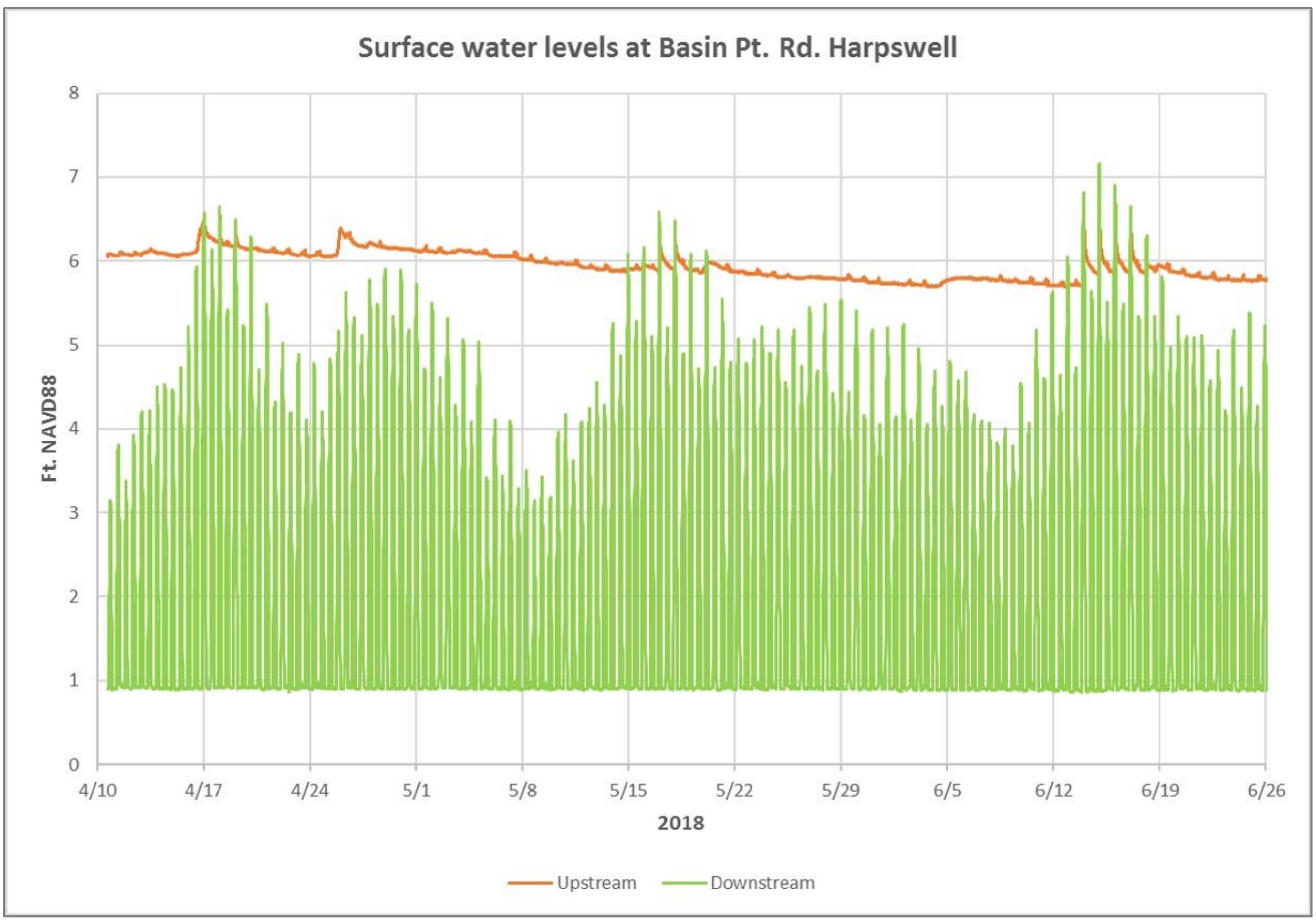

Figure 16. Plotted surface water elevations adjacent to Basin Point Road, April 10 - June 26, 2018.

The data set captured three astronomical high tide phases, in mid-April, mid-May, and mid-June, with neap tide phases in between (Fig. 16). The highest observed water levels for the deployment were recorded in the early morning of June 15 at 7.16' NAVD88 (12.42' relative to Mean Lower Low Water [MLLW, used on tide tables]) downstream, and 6.99' (12.25' MLLW) upstream. Note: These observed water levels exceeded 6.5' NAVD88/ 11.6' MLLW, which was Maine DEP's predicted highest annual tide level for 2018 at nearby Potts Harbor[4]. Water levels in Portland peaked at 7.10' during the same tide.

The maximum difference between highest and lowest water levels throughout the data set was 6.24' downstream, and 1.3' upstream. A 1.3" rain event (Portland Jetport, Weather Underground) occurred on 4/25 and is evident in a spike in upstream water levels during the neap tide phase. Tidewater enters the pond only during astronomic high tides. An artificial berm/dam upstream of the culvert inlet sits high in the tidal range and controls water levels in the pond at a minimum of about 5.7', resulting in a total lack of salt-water infiltration to the pond for a month at a time. During neap tides, and concurrent with the transition from spring runoff to drier summer conditions, water levels slowly dropped in the pond over the course of the deployment.

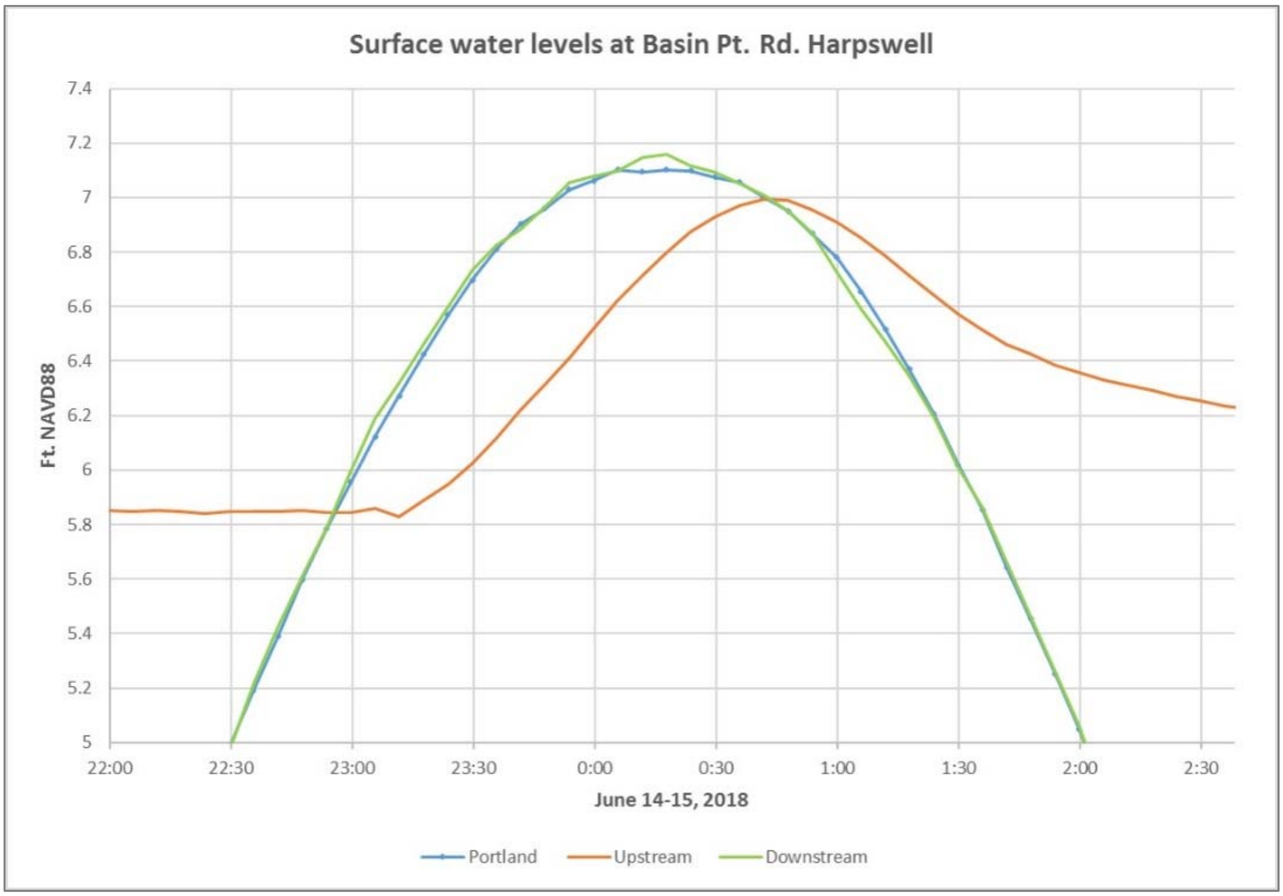

Figure 17. Detail of June 14-15 high tide water levels.

The effect of the culvert and road on tidal exchange is also evident over the course of an individual tide cycle. During upper phase of the June 14-15 high tide event, water levels were nearly identical at the downstream logger and Portland (Fig. 17). Meanwhile, a time lag upstream was evident, with salt water moving through the pipe but delayed in entering the pond due to the earthen dam. The restriction created by the undersized pipe and dam results in a lag of 30 minutes once tide levels reach about 6' NAVD88. The lag continues until the tide turns, and high tide upstream occurs about ½ hour after high tide downstream, while never getting as high. The

[4] https://www.maine.gov/dep/land/slz/hat18.pdf

difference in maximum tide height during this tide is about .2', a relatively small difference in water levels but one that results from the fact that upstream water levels are already high to begin with. The difference in tide heights would presumably increase with higher high tides associated with sea level rise and storm surge. A lag on the outgoing tide is evident upstream. In a tidal restoration scenario, we would expect nearly identical upstream and downstream water levels throughout the tide cycle.

The National Oceanic and Atmospheric Administration (NOAA) provides a Tidal Analysis Datum[5] calculator, useful for establishing tidal metrics for local data sets and comparing upstream and downstream water levels. Summary statistics from the 2018 data set are listed in Table 3.

Table 3. Locally derived tidal datums for CBEP's 2018 water level data set.

Datum	Downstream		Upstream		Difference (D/S - U/S)
	Feet NAVD88	Date time	Feet NAVD88	Date time	
MHHW	5.24		6.39		-1.15
MHW	4.87		6.38		-1.51
MTL	2.89		6.11		-3.22
DTL	3.07		6.15		-3.08
MSL	2.04		5.93		-3.89
MLW	0.09		5.84		-5.75
MLLW	0.90		5.90		-5.01
DHQ	0.37		0.01		0.36
DLQ	0.00		-0.07		0.07
MN	3.97		0.55		3.42
GT	4.34		0.49		3.85
HWL	7.14	6/15/18 0:18	6.97	6/15/18 0:42	0.17

Source: NOAA National Ocean Service Tidal Analysis Datums Calculator: https://access.co-ops.nos.noaa.gov/datumcalc/

At the mouth of the cove, about 1.15 miles south of the project site, remains from the historic Basic Cove gristmill tidal dam create a scenic "reversing falls". Detailed evaluation of the reversing falls and any potential impact on the project site was outside the scope of this study; however, there are indications that the remnant structure does not currently affect tidal hydrology at the project site, as evidenced by the nearly identical hydrographs from the logger downstream of Basin Point Road and the Portland Tide Station (Fig. 17).

[5] For more information on tidal datums see https://tidesandcurrents.noaa.gov/datums.html?id=8418150

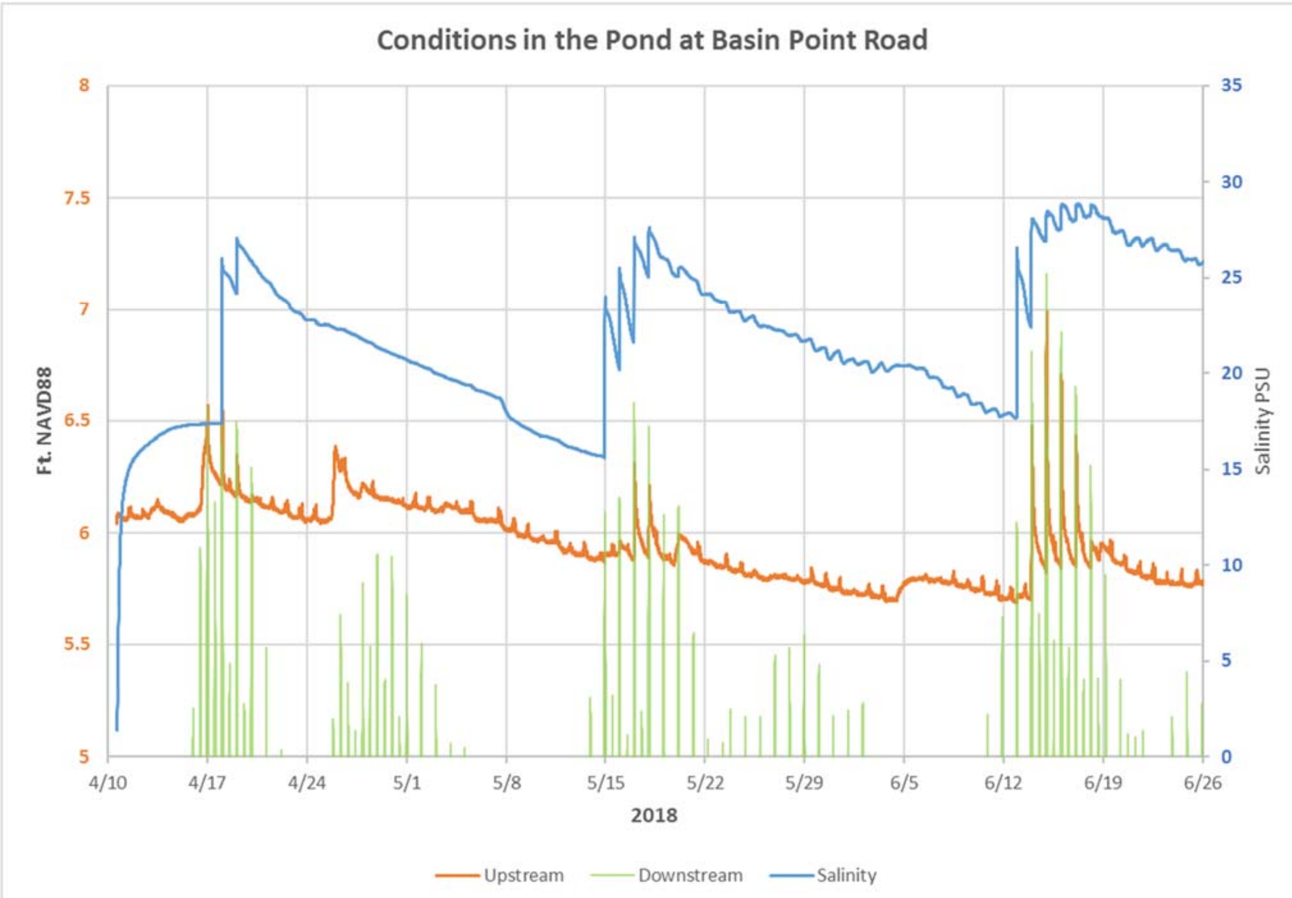

Figure 18. Surface water elevation and salinity in the pond, April 10 - June 26.

CBEP monitoring of salt marsh and tidal restoration projects in Harpswell indicate that salinity levels are a better prediction of vegetation that elevation. Salinity levels in the pond were relatively low (around 5 parts per thousand [PPT]) at the start of the deployment in early April, roughly consistent with NWI classification of the wetland as a freshwater pond (Fig. 18). By 4/17, salinity levels had risen considerably to 27 PPT during an astronomic high tide. Similar salinity spikes recurred monthly in conjunction with astronomic high tides. In between astronomic high tides, freshwater input to the pond from an intermittent stream gradually lowered salinity. This pattern repeated itself over the deployment and presumably recurs on a regular basis, at least when tides exceed 6.0' or so. For the remainder of the deployment, salinity levels remained at or above 15 PPT. Over the course of the deployment period, the pond grew increasingly salty as wet spring runoff conditions gave way to lower freshwater inputs and greater influence of spring tides. Spot salinity checks later in the summer confirm that salinity levels remained around 25 – 30 PPT throughout the summer. Presumably, salinity levels start to drop overall in the fall and winter, reaching lower highs and lower lows, in conjunction with increased precipitation and freshwater inputs to the pond. Minimum, maximum, and mean salinity levels over the entire data set were 1.4, 28.9, and 21.7 PSU (standard salinity units), respectively. Overall, salinity levels in the pond are best characterized as highly variable and dynamic. Salinity likely varies year to year from tides, storm surge, and precipitation.

During spring tides, salinity in the pond (blue) was observed to spike a day or two before a tidal signal was evident in the pond's water levels (orange). Downstream surface water elevations (green) suggest that high water levels are still resulting in salt water mixing in the pond somehow, possibly seeping through the berm, through the roadbed, or slightly over the top of the berm.

Vegetation community

Previous studies (Puryear 2009; Bryan 2010) documented habitat and wetland types on the Curtis Farm Preserve and provided limited species-specific data. For the current effort, CBEP sought to document species-specific vegetation within the project area. CBEP defined the project area as the downstream fringing salt marsh, the road banks, the pond, and low-lying forested wetland upstream of the pond that are either currently inundated with salt water or are predicted to be inundated with salt water under the 6-foot sea level rise scenario (see Fig. 20). CBEP Director Curtis Bohlen conducted species identification on 7/18/2018.

The vegetation community downstream of Basin Point Road is starkly different from the vegetation community upstream. Transitions in the vegetation community of wetlands are often used as a visual indicator of altered hydrology. At this site, the abrupt community transition is indicative of altered tidal exchange.

Below, vegetation is described moving from south (edge of Basin Cove) to north (edge of Curtis Cove).

Downstream

Downstream vegetation immediately adjacent to the culvert is dominated by smooth cordgrass (*Spartina alterniflora*). Cordgrass is typically found in the low marsh zone, closest to tidal creeks and open water, in areas that are subject to daily flooding. At this location, cordgrass is dominant across the marsh plain, where a high marsh community might be expected. This may be a legacy of impoundment from the Potts Harbor dam. Presumably, water was impounded in Basin Cove for long periods of time, potentially resulting in reduced sediment accretion at this location and consequently, a lower 'elevation capital' in relation to sea level. In effect, elevations are today more suitable to low marsh than high marsh communities.

A pocket of high marsh was found a few hundred feet away to the east, as well as brackish species, allowing for a survey of marsh community zonation tied to NAVD88. This information can be used to generally anticipate marsh community zonation in the pond if tidal exchange is fully restored. Fig. 19 and Table 4 summarize community elevations downstream of the road. Low marsh (cordgrass) was present starting at about -0.5' NAVD88, and as high as about 4.0'. High marsh vegetation was present starting between 3.8' up to about 5.0', up to the base of the road bank.

On the downstream road embankment immediately adjacent to the culvert, brackish and glycophytic species were present, including bayberry (*Myrica gale*), seaside goldenrod (*Solidago sempervirens*), red fescue (*Festuca rubra*), wild rye (*Elymus sp.*), wild carrot (*Daucus carota*), yarrow (*Achillea millefolia*), and other weedy plants and grasses in small quantities.

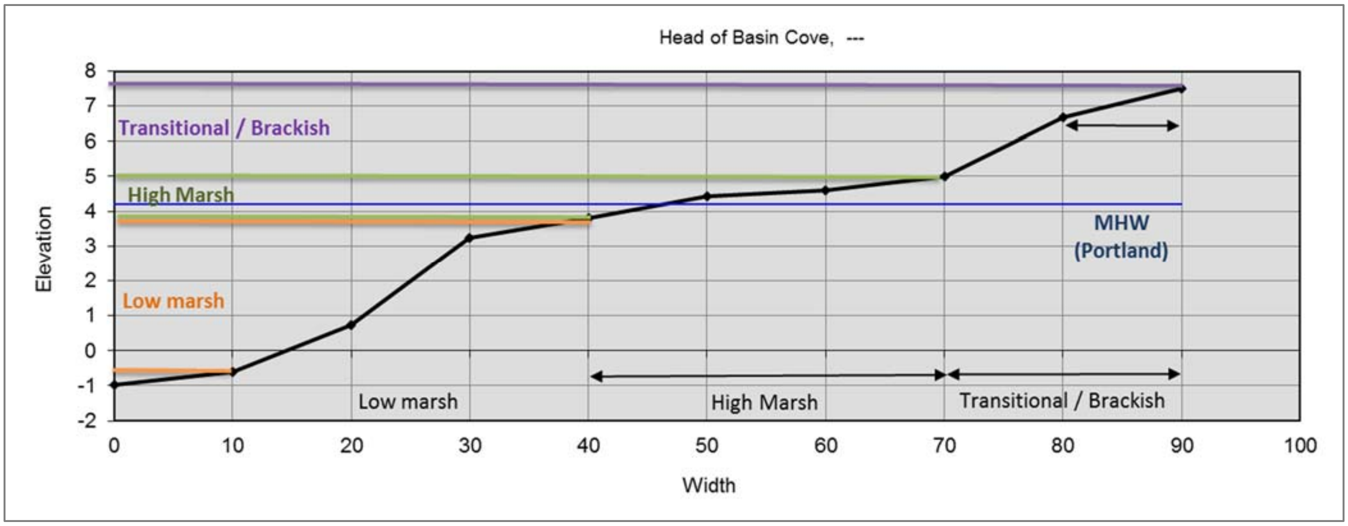

Figure 19. Plant community zonation downstream of Basin Point Road.

Table 4.Plant community elevations and indicator species downstream of the road.

Elevation (Feet, NAVD88)	Description
-.986	Mudflat
-.596	Start of low marsh (smooth cordgrass, *Spartina alterniflora*)
.744	Low marsh (*S. alterniflora*)
3.234	Low marsh (*S. alterniflora*)
3.794	Low to high marsh transition
4.444	High marsh (dominated by salt hay, *Spartina patens*)
4.594	High marsh (*S. patens*)
4.994	Brackish (*Bulboschoenus maritimus*)
6.674	Low end of wrack line on downstream road bank
7.514	Upper end of wrack line on downstream road bank

Upstream/Pond

CBEP collected upstream vegetation samples along the east side of the pond. Immediately upstream of the culvert inlet, atop the earthen berm/dam, a small area dominated by salt marsh species is present. Higher on the road embankment, the species are more varied, but are mostly species that occur on the edge of marshes, or on bluffs and beaches influenced by salt. Species present atop the earthen dam include blackgrass (*Juncus gerardii*), salt grass (*Distichlis spicata*), salt hay (*Spartina patens*), cordgrass, creeping bentgrass (*Agrostis stolonifera*), seaside goldenrod, and meadowsweet (*Spirea alba*).

On the upstream road embankment immediately adjacent to the culvert, species present included wild rye, beach rose (*Rosa rugosa*), bayberry, a cherry or beach plum (*Prunus* sp.), gray birch (*Betula populifolia*), and Canada goldenrod (*Solidago altissima*).

Widgeon grass (*Ruppia maritima*) is abundant in lush beds throughout the pond.

Species present along the immediate edge of the pond include New York aster (*Symphyotrichum novae-belgii*), sedge (*Carex scopari*), creeping bentgrass, red fescue, and *Viburnam* spp.

Species adjacent to the immediate edge, and in some cases overhanging the pond, include red oak (*Quercus rubrum*), red spruce (*Picea rubens*), red maple (*Acer rubrum*), winterberry (*Ilex verticellata*), bayberry, manna grass (*Glyceria Canadensis*), starflower (*Trientalis borealis*), sheep laurel (*Kalmia angustifolia*), lowbush blueberry (*Vaccinum angustifolium*), and highbush blueberry (*Vaccinum corymbosum*).

Moving north from pond to Curtis Cove

Species present adjacent to the low-lying area north of the pond, nearby or adjacent to the stream, include mosses (*Bryophyta spp.*), red spruce, gray birch, red oak, black cherry (*Prunus serotina*), honeysuckle, starflower, cinnamon fern (*Osmunda cinnamomeum*), and wood fern (*Dryopteris* sp.) and numerous grasses. Further north, vegetation is a dense wetland shrub mix with a complex understory. Species present include winterberry, gray birch, raspberry (*Rubus idaeus*), highbush blueberry, hay-scented fern (*Dennstaedtia punctilobula*), horsetail (*Equisetum pretense*), sensitive fern (*Onoclea sensibilis*), and a rush (*Juncus* sp.).

At the footbridge, numerous species were visible along a well-delineated swale of small stream channel. Vegetation in this area is typical of understory of Maine forested or shrub wetlands. There was no evidence of significant salt influence. Species present include red oak (~ 50% of canopy), red spruce (~ 30% of canopy), hay-scented fern (*Dennstaedtia punctilobula*), New York aster, marsh fern (*Thelypterus palustris*), *Carex scoparia*, *Carex lurida*, *Carex gynandra*, *Carex trisperma*, tear thumb (*Persicaria arifolium*), common rush (*Juncus effusus*), bluegrass (*Poa palustris*), and large patches of Sphagnum mosses.

North of the footbridge is a dense patch of vegetation surrounding downed trees. Shallow roots and composition suggest poorly drained soils and shallow depth to groundwater. Several open-grown oaks suggest the local forest is young, and established on cleared land. Species present include red maple, red spruce, red oak, poplar, high bush blueberry, low bush blueberry, sedges, starflower, dewberry (*Rubus hispidus*), cinnamon fern, and sphagnum moss in small patches.

Curtis Cove Salt Marsh

Approaching Curtis Cove, vegetation is adjacent to brackish-water dominated vegetation and is not quite a typical freshwater wetland, but close. Species present include red maple, high bush blueberry, winterberry, red spruce, white pine (*Pinus strobus*), wrinkle leaf goldenrod (*Solidago rugose*), late goldenrod, creeping bentgrass, New York aster, bluegrass, and dewberry. Adjacent uplands also include hay scented fern, *Carex intumescens*, and sensitive fern (*Onoclea sensibilis*).

At Curtis Cove, there is a triangular community of salt marsh vegetation formed in a shallow area behind a barrier dune of beach sand/gravel/cobble. Grades upslope away from beach to brackish water vegetation. Species present include salt hay, seaside goldenrod, marsh orache (*Atriplex prostrata*), quakgrass (*Elymus pycnanthus*), creeping bentgrass (abundant), arctic rush (*Juncus arcticus*), soft rush, prairie cordgrass (*Spartina pectinata*), apple (*Malus pumila*), beach rose, red maple, hedge bindweed (*Calystegia sepium*), winterberry, and New York aster.

Fish & Wildlife

Although initially CBEP hoped to engage local volunteers to monitor birds, and work with local schools to sample nekton in the pond and tidal creek channel, the availability of these resources proved to be limited. Therefore, CBEP recorded anecdotal observations of fish and wildlife use of these areas during site visits (Table 5).

As previously noted, the existing perched and undersized culvert, combined with the earthen dam upstream of the culvert inlet, presents a severe barrier to aquatic organism passage. The presence of small fish in the pond indicates that some fish are able to enter the pond during astronomic high tides, similar to use of pools on the high marsh surface in a healthy marsh. Fish become trapped in the pond for weeks at a time during the summer dry season, as they would in a salt marsh pool. This attracts wading birds such as great blue heron and snowy egrets, as well as cormorants, which utilize the pond for feeding and were observed on multiple occasions. The presence of horseshoe crabs in the downstream channel indicates that they would likely utilize habitat upstream of the road, perhaps to mate, but are almost certainly unable to utilize the existing culvert.

The pond seems to be excellent feeding habitat for waterfowl due to the abundance of widgeon grass. We observed two broods of 8-10 mallards each several times over the course of the 2018 field season.

Downstream of the road, in the tidal creek channel and adjacent flats, we observed ribbed mussel, softshell clam, quahog, and *Macoma sp.* No shellfish were present in the pond.

Table 5. Incidental observations of fish and wildlife during site visits.

Common name	Scientific name	Notes
Great blue heron	*Ardea herodias*	Pond, feeding
Snowy egret	*Egretta thula*	Pond, feeding
Black duck	*Anas rubripes*	Pond, feeding
Mallard	*Anas platyrhynchos*	Multiple broods; pond, feeding
Belted Kingfisher	*Megaceryle alcyon*	Pond, feeding
Double-crested cormorant	*Phalacrocorax auritus*	Pond, feeding
Soft shell clam	*Mya arenaria*	Downstream flats
Quahog	*Mercenaria mercenaria*	Downstream flats
Ribbed mussel	*Geukensia demissa*	Downstream marsh
Mud snail	*Hydrobiidae sp.*	Downstream channel
Macoma clams	*Macoma sp.*	Downstream flats
Horseshoe crab	*Limulus polyphemus*	Downstream channel
Striped killifish	*Fundulus majalis*	Pond
Mummichog	*Fundulus heteroclitus*	Pond
Green crab	*Carcinus maenas*	Downstream channel
American eel	*Anguilla rostrate*	Elver, entering Pond

Existing functions and values

Prior reports (Puryear 2009; Bryan 2010) documented functions and values associated with wetlands and habitat on Curtis Farm Preserve, including the project area defined for this study. Forest Synthesis, which referenced wetland delineation work by Sweet Associates, describes the property as, "…a mix of open field, early successional shrub/forest, intermediate-aged mixed deciduous-conifer forest, mature deciduous and conifer forest, and a variety of freshwater and coastal wetlands." The resources of interest for this section are those subject to alteration resulting from culvert replacement at Basin Point Road and/or a 6' sea level rise scenario. These include the pond and its immediate shoreline, and the low-lying freshwater forested wetlands between the pond and the high point (8') due north of the pond at about 650' on the longitudinal profile (Fig. 15). Other mapped resources, including those downstream of Basin Point Road, as well as low-lying forested wetland and tidal wetlands adjacent to Curtis Cove, are not expected to be impacted from road improvements and are anticipated to be impacted by sea level rise regardless of whether improvements are implemented.

Table 6 summarizes functions and values of the pond and freshwater forested wetlands as described by the Maine Natural Areas Program (Puryear 2009). The State classifies the Preserve's freshwater-forested wetlands, which are largely comprised of red maple swamp (Bryon 2010), as Wetlands of Special Significance due to their proximity to tidal waters.

Table 6. Functions and values of the wetlands affected by implementation of road improvements (Source: Puryear 2009).

Function/Value	PFO (red maple swamp)	PUB (pond on Basin Rd.)
Groundwater Recharge/Discharge	Y	N
Floodflow Alteration	N	Y
Fish and Shellfish Habitat	N	Y
Sediment/Toxicant Retention	Y	N
Nutrient Removal	Y	N
Production Export	Y	N
Sediment/Shoreline Stabilization	N	N
Wildlife Habitat	Y	Y
Recreation	Y	N
Educational/Scientific Value	Y	Y
Uniqueness/Heritage	Y	N
Visual Quality/Aesthetics	Y	Y
Endangered Species Habitat	N	N
MNAP Natural Community type	**Red Maple Sensitive Fern Swamp (S4)**	N/A
Acreage (based on field observation and NWI)	**28.5**	**.3**

The pond, which is fed by a freshwater stream but is also influenced by limited salt water exchange beneath Basin Point Road, currently provides feeding habitat for wading birds, which feed on schools of small saltwater forage fish (killifish) that are stranded in the pond for weeks at a time, and waterfowl, which feed on widgeongrass that grows in the unconsolidated organic matter on the pond's bottom, based on 2018 observations by CBEP. In prior years, CBEP observed cormorants feeding in the pond, presumably on killifish. CBEP also observed that the pond served as rearing habitat for a pair of mallard broods in 2018. Other than the description as a freshwater pond, these observations generally align with habitat attributes noted by Forest

Synthesis (Bryan 2010, p. 5). MNAP noted that the principle functions and values of the pond were floodflow alteration and aesthetics (Puryear 2009).

Red maple-sensitive fern swamp is an S4 ranked habitat (apparently secure in Maine) that is common in southern Maine. In some areas, these communities provide habitat for spotted and wood turtles, as well as four-toed salamanders. Birds associated with this community include northern water thrush and the yellow-throated vireo (Gawler and Cutko 2010). In describing the community at the Curtis Farm Preserve, Puryear noted, "Although this wetland does not quite meet the standards for being exemplary (due to its size), it is still a very nice example of this wetland type." MNAP ascribes the following functions and values to the parcel:

- Nutrient removal (wetland buffers for coastal marsh)
- Wildlife habitat (birds, mammals, amphibians, forested wetland area includes potential vernal pool)
- Uniqueness/heritage (nice example of wetland type, large unfragmented blocks uncommon in area, multiple functions and values present (listed in Table 6).

In a 2013 evaluation of sea level rise impacts on low-lying areas adjacent to Casco Bay, CBEP identified the head of Basin Cove as valuable for salt marsh migration due to the combination of low-lying coastal property and an absence of conflicts with built infrastructure, although the existing Basin Point Road crossing was noted as a barrier to marsh migration under current conditions (CBEP 2013). Sea level rise is anticipated to convert low-lying red maple swamp to tidally-influenced marsh (brackish and salt marsh) over time moving south from Curtis Cove, where the existing tidal marsh described by Puryear and Bryon will migrate upslope in conjunction with increased extent of tidal inundation. Existing sea level rise / storm surge predictions, such as those illustrated in Fig. 20, indicate that a low-lying corridor of forested wetland, part of which includes the freshwater stream and its banks, will be inundated in a 3.3' (1 m.) sea level rise scenario. These conditions are likely to result in localized mortality of existing trees and shrubs from exposure to salt water, a process that would migrate further upslope in a 6' sea level rise scenario. Although forested wetland values will be lost because of sea level rise, the expansion of salt marsh is important for maintaining a natural process of marsh migration into the undeveloped forest at Curtis Farm Preserve, particularly as lower elevation marsh is lost to erosion as part of normal marsh transgression processes.

Ecological resilience

Low-lying areas of Harpswell have been mapped several times, by different entities, to assess vulnerability to sea level rise and storm surge, and to identify salt marsh migration corridors (CBEP 2014, MCOG 2015). Figure 20 below is a snapshot of a 1-foot (blue), a 3.3-foot (green), and a 6-foot (yellow) depiction of sea level rise impacts between Basin Cove and Curtis Cove, as determined by the Maine Geological Survey's *Sea Level Rise/Storm Surge* online viewer.

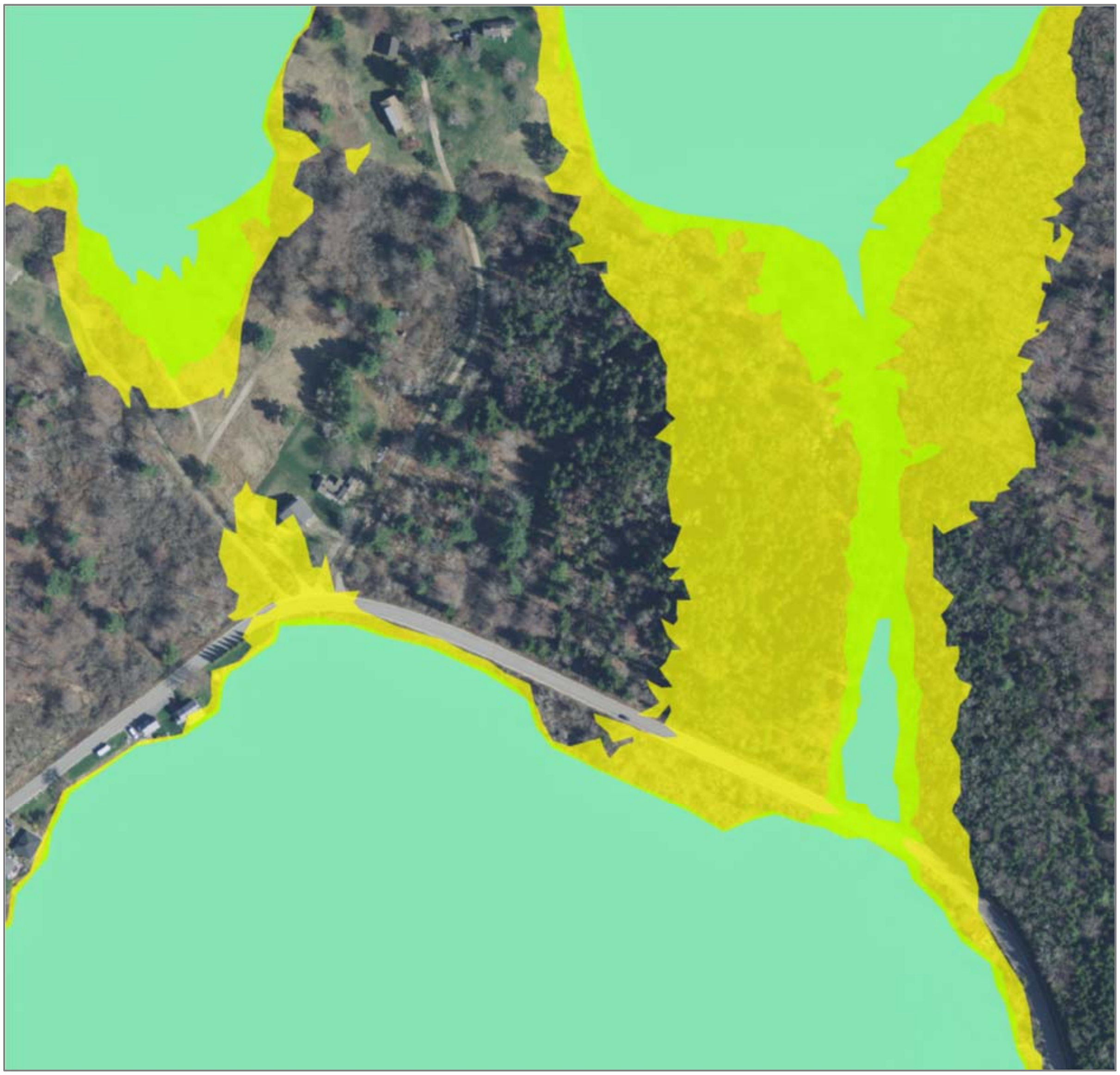

Figure 20. Modeled 1' (blue), 3.3' (green), and 6' (yellow) sea level rise scenarios near the study area (Maine Geological Survey Sea Level Rise/Storm Surge online viewer*).*

CBEP water level and vegetation assessment in 2018 suggests that current conditions are periodically comparable to the 1' SLR scenario, and several high water events accompanied winter storms in early 2018. On 1/4/2018, observed water levels at the Portland Tide Station reached a high of 8.43' NAVD88 (e.g., 13.68' based on MLLW = 0'), the second highest observed water levels on record following the blizzard of '78 (Fig. 21).

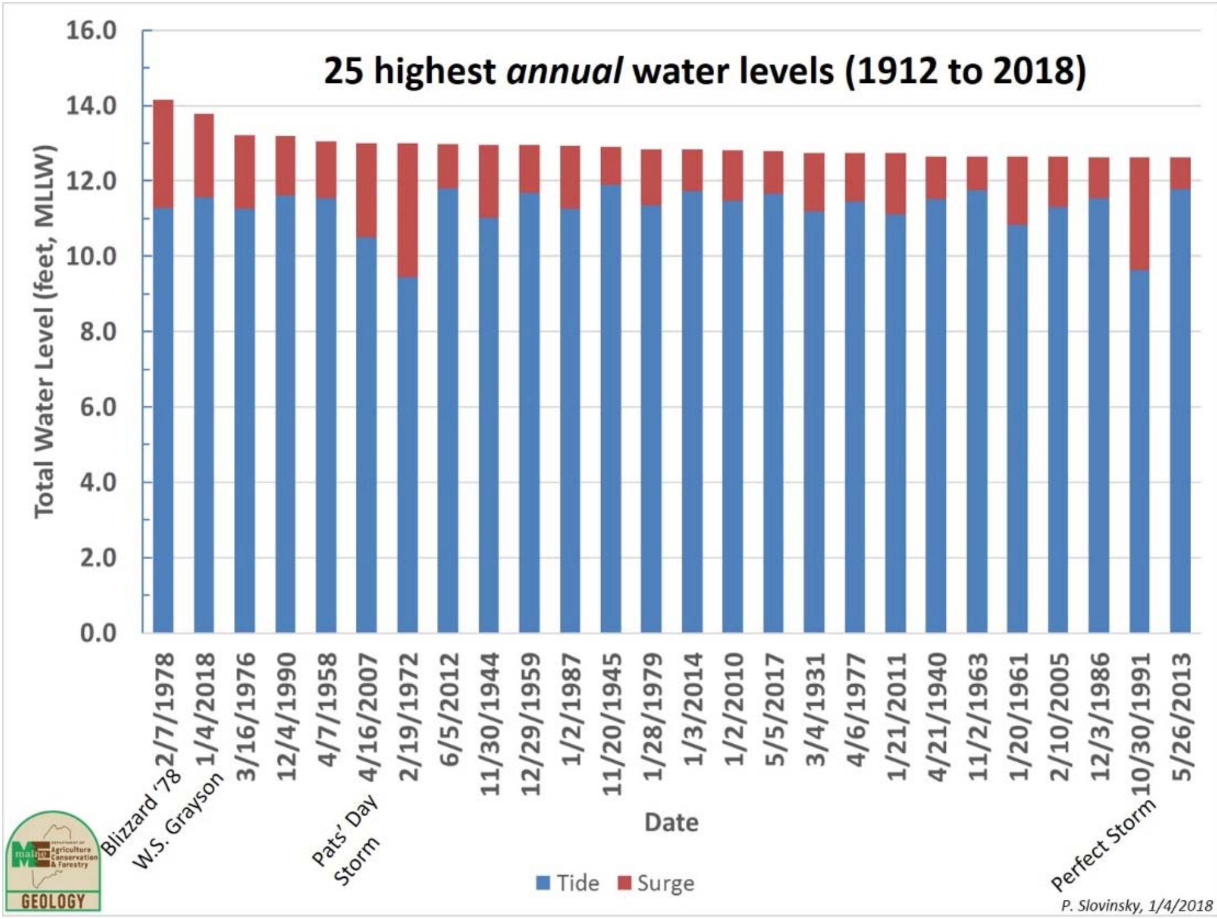

Figure 21. Highest annual water levels, 1912-2018 (Maine Geological Survey). Elevations are provided in feet relative to MLLW = 0'.

Sea level rise predictions indicate that Basin Point Road is at risk of overtopping between the 1' and 3.3' sea level rise scenarios, and in fact was probably close to overtopping during the 1/4/18 storm. If water were to spill into the pond from over the top of the road, the existing culvert would be grossly inadequate to drain the volume of water suddenly trapped upstream. As tide levels receded in Basin Cove, stored water upstream could cause scour, potentially undermining the road and threatening the pond. Prolonged exposure to salt-water inundation upstream of the road would almost certainly result in substantial mortality of the adjacent forest. Similar scenarios at larger wetland systems have resulted in "blowouts" of roads and dams. At Sherman Lake (now Sherman Marsh), adjacent to Route 1 in Newcastle, Maine[6], a dam blew out during a 2006 flood event, resulting in immediate conversion of a freshwater pond to a tidal wetland.

As sea level rises, the ecosystem will be increasingly vulnerable to sudden change from a flood event. A planned change, accomplished through raising the height of the road and adding hydraulic capacity beneath it through installation of larger culvert, would also result in a sudden change, but it would also increase ecological resilience over the long term through restoration of natural hydrology and associated ecological processes.

Overall resiliency of the system has been degraded because of altered hydrology created by the road crossing due to reduced depth, extent, and duration of tidal inundation, particularly during spring tides. The severe tidal

[6] For more information, see: http://www.gulfofmaine.org/times/spring2006/scienceinsights.html

restriction created by the culvert below Basin Point Road, and the earthen dam immediately upstream, have severed numerous natural processes in the upstream marsh. These include:

- Altering the hydrological regime of the wetland, thereby drowning former salt marsh by maintaining constant surface water levels above the marsh surface;
- Limiting the delivery of salt water upstream. CBEP monitoring of tidal restoration projects in Harpswell suggests that salt is a primary driver of vegetative community composition;
- Trapping fresh water in the system for long periods of time, which enables glycophytic species to invade areas that would otherwise support brackish and salt tolerant species typical of marshes;
- Preventing sediments from Basin Cove to move into the upstream area, leaving the drowned salt marsh below increasingly vulnerable to conversion to mudflat as sea levels rise;
- Altering nutrient cycling processes through the conversion of a salt marsh to a highly variable fresh/brackish/salt pond;
- Severely restricting the movement of aquatic organisms from Basin Cove into the pond;
- Interrupting dynamic natural processes through which marshes are maintained, including peat formation and sediment accumulation;
- Muting upstream water levels during astronomic tides, reducing area of inundation at low laying areas adjacent to the pond and blocking the natural process of marsh migration in response to sea level rise.

As the pace of sea level rise increases, it is increasingly important for these processes to be restored at drowned marshes, which is a primary reason why many tidal restoration projects have been undertaken throughout the Gulf of Maine in recent decades.

Salt marshes are built and maintained through regular inundation (and draining) of tidal water to deliver sediments onto the marsh surface. Through these natural processes, salt marshes have historically been able to maintain pace with sea level rise over time (although there is uncertainty about whether marshes will keep up with future rates of rise). The interruption of these processes often results in elevations of the marsh surface falling behind sea levels due to the lack of peat formation, the lack of sediment deposition, and other processes. Recent studies have shown that the subsequently formed low spots are vulnerable to pooling, and in some cases, conversion to mudflat, resulting in the permanent loss of salt marsh.

Additionally, through the natural process of transgression, salt marshes at the seaward edge covert to mudflat, while new marsh migrates inland where elevations are suitable. In the current condition, Basin Point Road prevents a gradual transition to salt marsh around the perimeter of the existing pond and adjacent freshwater wetlands.

Restoration and enhancement evaluation

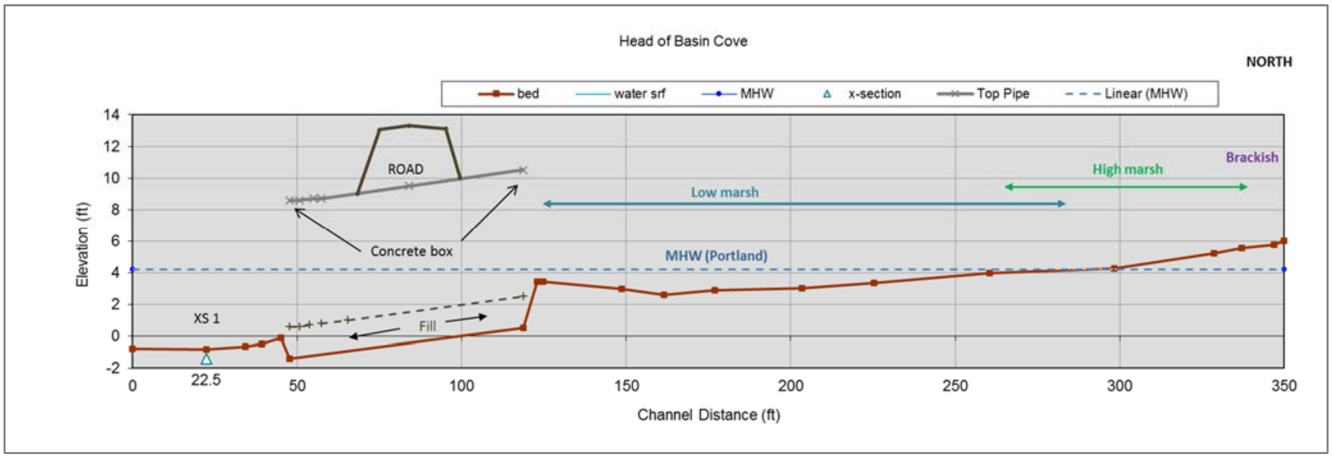

Figure 22. Predicted longitudinal profile following installation of new culvert.

As part of this project, GP developed three conceptual alternatives to improving culvert capacity beneath Basin Point Road. GP incorporated Stream Smart[7] principles into culvert replacement designs to the extent practicable, setting the culvert invert at an elevation that is at a similar slope to, and aligned with, the longitudinal profile of the creek channel downstream and the pond bottom upstream. GP's designs also raise the height of the structures to create ample capacity for future increases in sea level. These design components are consistent with CBEP recommendations for tidal restoration and salt marsh restoration based on the ecological assessment. However, Stream Smart principles have limited utility at this site for several reasons, including: a) it isn't possible to establish reference channel conditions due to proximity to the existing culvert; b) the Stream Smart approach does not directly translate to tidal crossings with their bidirectional flow; and, c) due to the upstream impoundment, it was difficult to determine whether a remnant creek channel is present upstream. Currently, there is no analog to Stream Smart for tidal culverts, and sizing is typically approached on a case-by-case basis. Therefore, additional data collection and studies, including hydraulic modeling, would be warranted at this site to refine culvert capacity needs, if the Town decides to proceed with culvert replacement.

GP's Option 1 was a 'no-action' alternative. Option 2 incorporated a 3.3' sea level rise scenario, and incorporated installation of a 10' tall by 14' wide concrete box culvert set at an elevation that matches the slope and depth of the downstream channel bottom and upstream bottom depth of the pond, while allowing for ample flow during 8'NAVD88 and above high tides. Option 3 studied a 6' sea level rise scenario, and incorporated installation of a similar concrete box culvert that is 12' tall and 14' wide. In terms of their effect on adjacent habitat, Options 2 and 3 are essentially identical, compared with existing conditions, and would be more than adequate for existing upstream resources. Figure 22 illustrates what the longitudinal profile would look like following installation of new culvert. Installation of either of these structures would:

- Restore natural hydrological regime to the wetland, allowing for daily inundation by the tides and nearly identical water levels upstream and downstream of the road;
- Increase delivery of salt water into upstream wetlands;

[7] For more information on Stream Smart culverts: https://www.maineaudubon.org/projects/stream-smart/

- Allow fresh water to drain out of the system during high water conditions such as spring snowmelt and extreme rain events. By improving freshwater drainage out of the system, salt tolerant vegetation will be more likely to establish and outcompete glycophytic species over time;
- These changes would create an abrupt ecological disturbance to the upstream ecosystem, which would cause the immediate die-off of freshwater vegetation and widgeon grass. Bare spots would become vegetated over the course of 1-3 years, as salt tolerant vegetation is established, and monitoring would be warranted, at least to prevent establishment by the invasive common reed (*Phragmites australis*);
- Sediment transport into and out of the upstream wetland would be restored, causing a) sediment deposition on the marsh surface, and b) potentially causing a new or remnant channel to form;
- Restore nutrient processes as marsh vegetation is established;
- Restore aquatic organisms passage, allowing for regular movement into and out of the upstream habitat during daily tides, and increasing the number of shellfish and nekton utilizing the upstream habitat;
- Bird use would likely shift to primary use by wading birds, who would still be able to feed during high tides. Use by waterfowl would likely be reduced, as food sources (widgeon grass) are reduced; and,
- Natural processes through which marshes are maintained, including peat formation and sediment accumulation, would be restored.

Monitoring of these changes would be warranted to identify any unanticipated changes resulting from the new hydrological regime. Based on the vegetation downstream, the proposed culverts would over time convert the existing pond to a mixed saltmarsh. This fringing marsh would include a mix of low marsh, (cordgrass), high marsh (salt hay, salt grass, black grass), and brackish species (seaside goldenrod, bulrush, quakgrass). Mixed saltmarsh are classified S3 ecological communities in Maine, relatively rare on a statewide basis (Gawler and Cutko 2010). Proposed functions and values resulting from installation of a new culvert are listed in Table 7.

Table 7. Proposed functions and values resulting from culvert replacement.

Function/Value	PFO (red maple swamp)	E2EM (coastal marsh)	PSS (scrub shrub)	E2EM (coastal marsh)
Groundwater Recharge/Discharge	Y	N	Y	N
Floodflow Alteration	N	N	N	N
Fish and Shellfish Habitat	N	Y	N	Y
Sediment/Toxicant Retention	Y	Y	Y	Y
Nutrient Removal	Y	Y	Y	Y
Production Export	Y	Y	N	Y
Sediment/Shoreline Stabilization	N	Y	N	Y
Wildlife Habitat	Y	Y	Y	Y
Recreation	Y	Y	N	Y
Educational/Scientific Value	Y	Y	N	Y
Uniqueness/Heritage	Y	Y	N	Y
Visual Quality/Aesthetics	Y	Y	N	Y
Endangered Species Habitat	N	Y	N	Y
MNAP Natural Community type	**Red Maple Sensitive Fern Swamp (S4)**	**Mixed Graminoid Forb Saltmarsh (S3)**	**Alder Shrub Thicket (S5)**	**Mixed Graminoid Forb Saltmarsh (S3)**
Acreage (based on field observation and NWI)	**28.5**	**.7**	**.2**	**1.0**

Salt marshes are highly productive ecosystems that provide a number of values: food for shellfish and finfish; nursery habitat for fish; clean water through nutrient uptake and sediment removal; foraging habitat for birds and mammals; recreational and educational opportunities; and flood protection.

In summary, re-establishing full tidal exchange through culvert replacement would expand the existing fringing salt marsh at the head of Basin Cove to the north of Basin Point Road, restoring former salt marsh allowing salt tolerant vegetation to migrate upslope as sea level rises. Upon culvert replacement, the altered hydrology would create an ecological disturbance, most likely resulting in mortality for much of the existing vegetation in and around the pond due to exposure to salt water and improved fresh water and salt-water drainage. Over a span of 1-5 years, low marsh, high marsh, and brackish marsh would establish in and around the existing pond. Over time, as sea level rises, this marsh footprint would slowly expand inland and grow in size, migrating into low-lying upland areas, killing woody vegetation, and promoting salt-tolerant plants to colonize areas inundated by the tides.

Planning for infrastructure improvements at this location should take into consideration the existing habitat values but also recognize that these values are fleeting, based on sea level rise predications. Even if the Town decided to raise the height of Basin Point Road but continue to maintain the existing impoundment, it would not be possible to maintain the pond and low-lying uplands and wetlands in their current state in perpetuity, since tidal water will eventually flood the area from the north, via Curtis Cove.

This site is useful as an in depth case study given its constrained but well defined issues pertaining to habitat impacts, threats to transportation infrastructure, and potential for residential and economic impacts over time. Resilience planning at coastal locations is complex, necessitating a phased approach to development of conceptual and final engineering designs, as well as decision-making. Incorporation of ecological components is warranted due to the importance of these habitats to local economies, notably fisheries, as well as the values and services they provide, but also because coastal habitat restoration is a priority for several state and national entities that provide grant funding to promote ecological restoration and resilience. The Town’s multi-faceted approach to understanding existing conditions and planning for changes over time at this location can be transferred to similar sites around town, as well as adjacent communities in Casco Bay and Midcoast Maine.

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Preparing for Coastal Flooding in Harpswell:
A Plan for Basin Point Road and Its Wetlands

Appendix III
Harpswell Roads Affected

Preparing for Coastal Flooding in Harpswell:
A Plan for Basin Point Road and Its Wetlands

Harpswell Roads Affected with 1, 2, 3.3 and 6-foot Rising Tides

Private Roads	1 foot	2 feet	3.3 feet	6 feet
Harpswell Neck:				
High Head Road – Bridge		x	x	x
Stucarro Drive (Lower end)			x	x
Interhaven Road				x
Great Island:	-	-	-	
Little Crow Point (past intersection with Tuttle Road)	x	x	x	x
Tuttle Road/Long Point Road/Little Crow Point		x	x	x
Gun Point Road (near intersection with Long Point Road)			x	x
East Harpswell/Cundy's Harbor				
Wallace Shore Road (both before and after bridge)	x	x	x	x
Shore Road		x	x	x
Hopkins Island Road			x	x
Cundy's Point Road				x
Sailor's Way				x
Orr's and Bailey Island:				
Johnson Point Road - Orr's Island				x
.				
.				

Public Roads	1 foot	2 feet	3.3 feet	6 feet
Harpswell Neck:				
Basin Point Road – Bridge	x	x	x	x
Lookout Point Road. (Lower End)	x	x	x	x
Windsor Lane (Stover's Point Area)	x	x	x	x
Route 123 – Bridge/Potts Point Road			x	x
Harpswell Neck Rd. Rte.123 – Skofield Cove, Near town Line			x	x
Great Island:				
Long Point Road – Near intersection with Little Crow Point	x	x	x	x
Long Point Road – Near intersection with Dirigo Lane			x	x
East Harpswell/Cundy's Harbor				
Dingley Island Road – Bridge		x	x	x
Bethel Point Road – Bridge		x	x	x
Oakhurst Island Road – Bridge		x	x	x
Bethel Point Road – Culvert near Little Ponds Road				x
Orr's and Bailey Island:				
Lowell's Cove Rd. - Orr's Island	x	x	x	x
Abner Point Rd./Lube La.- Bailey Island		x	x	x
Garrison Cove Road (near Cribstone Bridge)			x	x
Bridge between Great & Orr's Islands,at Eagle Bluff - Harpswell Islands Rd (Rte.24)				x
Harpswell Islands Road (Rte.24) – Beginning and end of Cribstone Bridge				x

Revised Oakhurst Is. Rd. 1.5.19

Preparing for Coastal Flooding in Harpswell:
A Plan for Basin Point Road and Its Wetlands

Appendix IV
Datums used in Project

	NAVD88 DATUM	TIDAL DATUM
2018 LOW POINT ROAD ELEVATION AT CULVERT	9.0	14.1
2018 HIGHEST ANNUAL TIDE	6.5	11.6
EXISTING 18" CULVERT INVERT IN	4.8	9.9
EXISTING 18" CULVERT INVERT OUT	4.4	9.5
APPROXIMATE MEAN HIGH WATER	4.21	9.4
MEAN LOW LOW WATER (MLLW)	-5.1	0

NOTE: MHW IS BASED ON PORTLAND TIDE GUAGE

Datum Comparison

Basin Point Road - Harpswell, Maine

Design: OCC	Date: OCT 2018
Draft: LAN	Job No.: 2340.31
Checked: WCH	Scale: None
File Name: 2340.31-Figure1.dwg	

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Figure 1

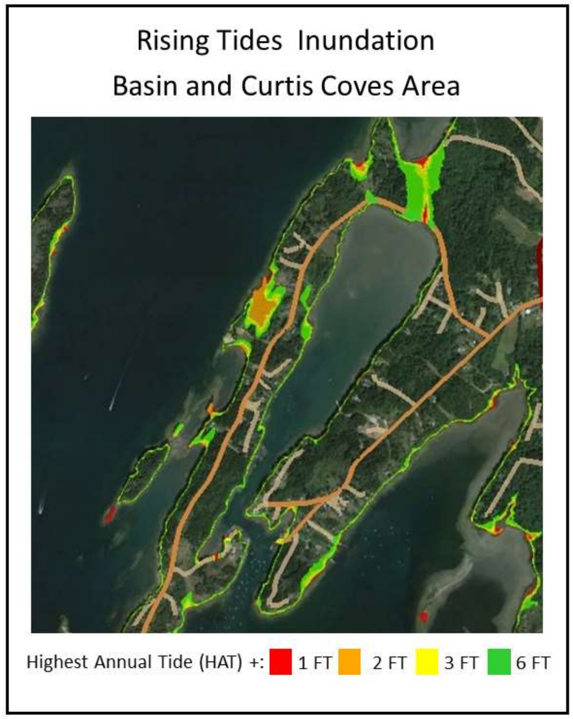
Preparing for Coastal Flooding in Harpswell:
A Plan for Basin Point Road and Its Wetlands

Appendix V

Case Study

Preparing for Coastal Flooding in Harpswell:
A Plan for Basin Point Road and Adjacent Wetlands

Case Study



- Project Description: In 2017, the Town of Harpswell awarded two studies to plan for the impacts of sea level rise (SLR) and storm surge on a low-lying road and adjacent ecosystems. The Town commissioned Gorrill Palmer Engineering (GP) to assess design options and costs for upgrading the road and culvert crossing to withstand anticipated sea level rise; and Casco Bay Estuary Partnership (CBEP) to assess current ecological conditions and scenario planning for the impact of culvert replacement and sea level rise on ecosystems adjacent to the road. This report summarizes findings of the ecological assessment, and references design options described in Gorrill Palmer's study.

- Project Partners: Harpswell Conservation Commission (HCC), Harpswell Heritage Land Trust (HHLT), The Dolphin Marina, and affected small businesses and households on Basin Point Road.

- Issue Area: Basin Point Road at the head of Basin Cove contains a culvert road crossing that drains the adjacent wetland and pond. On extremely high tides sea water begins to back flow into the pond. From the point of the crossing, approximately 115 households and a number of home businesses will lose access as extreme storm events become more frequent. One of Harpswell's largest businesses at the end of Basin Point Road would become inaccessible. The marina and restaurant employ over 90 people and served over 85,00 people in 2016.

- The Challenge and Approach Taken: Basin Point Road is predicted to be overtopped with as little as one (1) foot of sea level rise (SLR). As this is the only access point for a heavily traveled road, elevated sea levels will have impacts on local infrastructure, the local economy, and habitats of the adjacent wetland and pond. A feasibility study was performed to determine the present status of road infrastructure and determine how the existing culvert crossing is impacting the adjacent pond, wetland and marsh migration.

- The Results: Conceptual options are available to solve the problems of sea level rise and habitat impacts by raising the road but will require significant expenditures to implement. The study also highlighted that as we mitigate for a six (6) ft. SLR scenario there are flooding impacts on adjacent properties that may prompt a different solution.
    - Capital road improvements are designed to have a life expectancy of 20-50 years. Five of Harpswell's public roads currently experience overtopping when a high tide is accompanied with high winds and storm surge. Designing an infrastructure improvement of the magnitude to handle a one (1) or two (2) ft. sea level rise scenario would cost about the same as for a three (3) ft. rise, so it was determined to plan for rises of 3.3 ft. and 6 ft.
    - To Accommodate a 3.3 ft. rise: Raise the road 4.3 ft. over the culvert at an estimated construction cost of $607,000 plus 10% to cover design and permitting.
    - To accommodate a 6 ft. rise: Raise the road 6 ft. over the culvert at an estimated construction cost of $1,210,000 plus 10% to cover design and permitting.
    - The ecological study determined the existing pond is already tidal and provides habitat values for a limited range of birds and fish while drowning former salt marsh. Conceptual options above would restore tidal exchange and promote recovery of salt marsh communities in the pond and adjacent low-lying areas. These options would also promote marsh migration into low-lying freshwater wetlands and upland habitat as sea level rises.
    - The ecological report noted that its 2018 water level and vegetative assessment suggests that current conditions are periodically comparable to a one (1) ft. sea level rise scenario. Sea level rise predictions indicate that Basin Point Road is at risk of overtopping between the 1 ft. and 3.3 ft. sea level rise scenarios; and in fact, was probably close to overtopping during the January 4, 2018 storm. Road bed depth on a Class A road is between 15 and 18 inches so gravels could now be losing integrity. If water were to spill into the pond from over the top of the road, the existing culvert would be grossly inadequate to drain the volume of water suddenly trapped upstream. As tide levels receded in Basin Cove, stored water upstream could cause scour, potentially undermining the road and threatening the pond.

- Next steps/Opportunities:
    - Institute a program to monitor and track road deterioration, flooding damage and associated repair / maintenance costs on vulnerable Town roads.

- Harpswell has a number of high traffic roads that will be affected with 1 to 2 feet of sea level rise. Repeat comprehensive feasibility / conceptual design studies at these locations to provide important planning information to the Town.
- Provide information to the Town Roads Capital Improvements Program to start ranking vulnerable locations and prioritize mitigation on Town roads throughout Harpswell.
- Develop a capital improvement funding program to prepare for high costs of mitigating for sea level rise.

- Lessons Learned:
    - The project pointed out that a comprehensive approach of investigating transportation, economic, resiliency and ecological issues will facilitate informed decision making that addresses multiple priorities of the Town and the community.
    - This pilot study put numbers on what the Town is facing. There are (8) eight Town roads projected to be affected by one to two feet of rise, and if the cost for one road is extrapolated for 8 roads, what are the implications for a town of 5000 people?
    - When one thinks about SLR and coastal flooding, one envisions the water coming over road. However, the engineer noted that when the road base gravels begins to get wet, erosion and deterioration takes place and maintenance costs rise. A road base is usually between 15 and 18 inches below the road surface. Some of our most vulnerable roads are already getting seepage and degrading during king tides.
    - The study pointed out the benefits in opening flow and allowing salt marsh migration to replace the current fresh/brackish pond. The public presentation workshop promoted an exchange of thoughts regarding changes to the surrounding environment and pointed out that decisions regarding a final plan should take into account the viewpoints of the affected parties.

- Applicability For Other Municipalities:
    - Taking a comprehensive approach as part of a feasibility study for a specific location estimates the costs to remediate and will help in prioritization needed road improvements.
    - The Casco Bay Estuary Partnership stated at the study's conclusion that this site was useful as an in-depth case study given its constrained but well-defined issues pertaining to habitat impacts, threats to transportation infrastructure, and potential for residential and economic impacts over time. Incorporation of ecological components to a plan is warranted due to the importance of these habitats to local economies, notably fisheries, as well as the values and services they provide. And, in addition coastal habitat restoration is a priority for several state and national entities that provide grant funding to promote ecological restoration and resilience.

- Quote from a municipal official and project partner on the utility of the effort:
  - Selectboard Chair: "The usefulness of this project has and will continue to benefit the Town of Harpswell and will contribute to the increase in knowledge specific to this site and in the collective study of sea level rise, its effects and the planning for the future as a whole. Harpswell's 216 miles of coastline is an asset to us all. It can also be viewed as a potential liability by investors in the bond market because of sea level rise and storm surge. This year the Town of Harpswell issued for the first time its own bonds to finance the removal of a naval pier at Mitchell Field. The Town of Harpswell received a triple A bond rating resulting in significant interest savings for many factors, including Harpswell's recognition of sea level rise and specifically in its involvement in this project."
  - Project partner, The Harpswell Heritage Land Trust Executive Director: "The Assessment of Existing & Future Ecological Conditions at Basin Point Road conducted by the Casco Bay Estuary Partnership has produced very interesting and useful information about the wetlands and drainage on the Land Trust's Curtis Farm Preserve. The study will enable us to take an informed approach to the issue of Salt marsh resiliency at the preserve as the sea level rises in coming years."

- Recommendations to the Maine Coastal Program (MCP) for follow-up by state agencies to address identified municipal and regional needs and emerging coastal issues: As intense weather events continue to occur the amount of money needed by small municipalities to upgrade their roads will need to be supplemented with state and federal funds.

- For more information: www.harpswell.me.gov/Environment/Changingweatherandrisingtides
  Contact: Mary Ann Nahf, Commission Chair, Conservation@town.harpswell.me.us