SMALL POINT ROAD (STATE ROUTE 216) TIDAL CROSSING ASSESSMENT

PHIPPSBURG, MAINE

PRELIMINARY DESIGN REPORT

ACADIA CIVIL WORKS
ENGINEERING DESIGN & CONSULTATION

December 4, 2021

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TIDAL CROSSING ASSESSMENT

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TIDAL CROSSING ASSESSMENT - PHIPPSBURG, ME

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

Small Point Road (State Route 216) extends southerly from its intersection with State Route 209 and travels along Small Point in the Town of Phippsburg to its termination at Head Beach adjacent to Hermit Island. Along its route, Small Point Road travels adjacent to a variety of tidal waters and wetlands adjacent to Totman Cove and Cape Small Harbor. Based upon Maine DOT traffic counts in 2013 and 2016, the roadway experiences annual average daily traffic (AADT) of 1000 and 1320 trips, respectively. Based upon its function and setting, including its dead-end nature, Small Point Road is classified as a Rural Minor Collector.

This study focuses on multiple tidal and potential tidal stream crossings of Small Point Road and adjacent roads (specifically, Flat Point Road and Morse Mountain Road) associated with an unnamed tidal marsh connected to Cape Small Harbor. A location map of the site is shown on the following page as Figure 1. The most significant of these crossings (referred to as the primary crossing) is a dry laid stone culvert, with variable dimensions and timber supported deck. The primary crossing is identified in the Maine Tidal Restriction Atlas created by the Maine Coastal Program (MeCP) as crossing ID #399.

Primary Crossing of Small Point Road – Dry Laid Stone Culvert w/ approx. 2' Span

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SITE LOCATION MAP
SMALL POINT ROAD (RT 216) CROSSING

PHIPPSBURG, ME | MAY 2020

FIGURE 1

Small Point Road is the sole means of access to Cape Small and the Small Point community to the south (emergency vehicles, evacuation). The primary crossing has been identified as a problem in prior studies, including NFWF Coastal Resilience Assessment of the Portland and MidCoast Watersheds (2019) and Maine DOT Coastal Wetland Tidal Restriction Study (2004).

Primary Crossing of Small Point Road (outlet) – Dry Laid Stone Culvert w/ Timber Deck Beams

The primary crossing of Small Point Road is located within the influence of current mean tides. While the exchange of tidal waters is restricted by the structure, the stream and wetland system upstream of the crossing is also tidally influenced. The primary crossing is founded directly on ledge (bedrock), which forms a grade control along the structure's invert at its outlet. The inlet of the structure is also founded on ledge, but the invert has been plugged by some additional loose rock. The ledge grade control, combined with the horizontal restriction of the structure has resulted in a persistent pool at low tides just upstream of the roadway.

The primary culvert varies in width anywhere from approximately 30 inches to 24 inches along the length of the crossing. Its height is also variable with a nearly 3.5 feet dimension at the structure outlet and an approximate 18 inch to 24 inch height at the inlet. It appears that the dry laid stone walls bear directly on ledge and support a series of timber beams along the structure roof/deck. Many of the timber components are deteriorating. Additionally, substantial organic material has collected around the timber deck members, which further restricts flow within the structure

Primary Crossing of Small Point Road (inlet) – Dry Laid Stone Culvert w/ Timber Deck Beams

The Maine DOT has recently inspected the structure as it is located along State Route 216. As identified by the Maine DOT, the "deck of this culvert is timber frame. The walls and base are granite stone. The timber is in very poor condition with many timber pieces missing. Displaced blocks and wall deformation." Overall, the Maine DOT indicates that this structure is in "Poor" condition.

Primary Crossing of Small Point Road – Interior view of Deteriorated Timber Deck

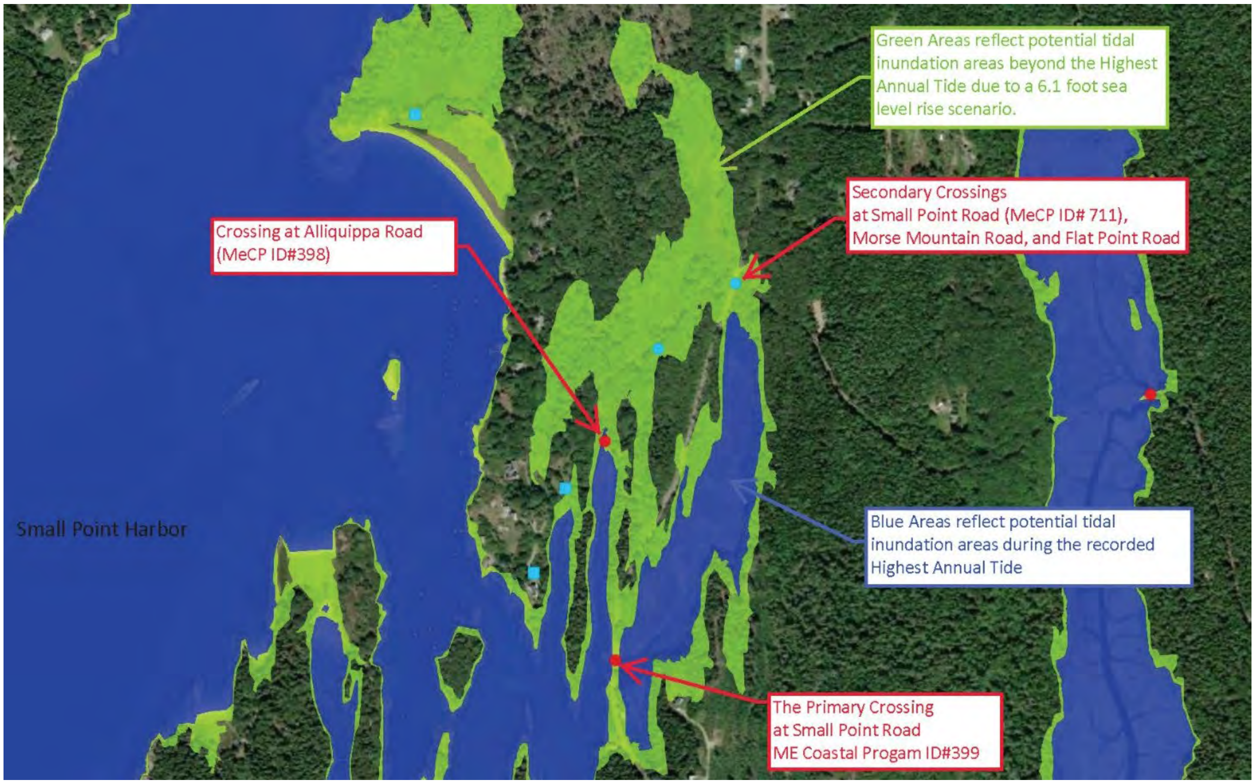
Three other crossings are also a focus of this assessment, as identified on Figure 1. This includes a Secondary Crossing of Small Point Road (12" corrugated metal pipe), which is in series with a crossing of Flat Point Road (15" high density polyethylene plastic pipe) located just upstream. The third crossing is located along Morse Mountain Road (24" corrugated metal pipe). These three crossings are all at the edge of current tidal influence and there is no exchange of tidal waters through these structures during mean tide conditions. A summary of the general information for each of the subject crossing structures is provided below in Table 1.1. This table includes the elevation of each structures inlet and outlet, as well as the lowest roadway elevation in proximity to the structure. Note that if water surface elevations exceed these road elevations, the roadways will flood/overtop.

TABLE 1.1
GENERAL CULVERT DATA

Primary Crossing					
Road	**Material**	**Size**	**Inv. In.**	**Inv. Out**	**Road Elev.**
Small Point Road (State Route 216)	Dry laid granite blocks with timber deck beams	highly variable (refer to narrative)	2.2	1.7	8.5
Secondary Crossings					
Road	**Material**	**Size**	**Inv. In.**	**Inv. Out**	**Road Elev.**
Small Point Road (State Route 216)	Corrugated Metal	12" Diameter	5.1	5.5	9.1
Flat Point Road	High Density Polyethylene	15" Diameter	6.9	6.6	9.6
Morse Mountain Road	Corrugated Metal	24" Diameter	8.7	7.3	10.9

Note: All elevations included in this table are in Feet and in relation to NAVD88.

A map of the project area is shown in the image below, as depicted by the Maine Coastal Program's Tidal Restriction Atlas. On the map, a blue shading has been used to highlight the areas of potential inundation during the observed Highest Astronomical Tide. A green shading has been used to depict the additional inundation footprint during the Highest Astronomical Tide with a 6.1 foot sea level rise scenario. The map shows a significant tidal inundation footprint between the east and west side of the primary crossing (ID #399) under the current Highest Astronomical High Tide. As shown by the green shaded area, a 6.1 foot sea level rise scenario expands the tidal inundation footprint and will cover several additional crossings in the immediate project area. This includes the crossing at Alliquippa Road (ID #398) and several crossings located at Small Point Road (ID #711), Morse Mountain Road, and Flat Point Road.



Map of Project Area produced with data from the Maine Coastal Program's Tidal Restriction Atlas

Note that the Tidal Restriction Atlas indicates that Small Point Road (Route 216) is not flooded during the Highest Astronomical Tide, but will be significantly inundated in a 6.1 foot sea level rise scenario.


Tidal Wetland and Stream Located just upstream of the Primary Crossing

Freshwater Wetland System Located Upstream of Flat Point Road

The Maine Coastal Program, in partnership with the Kennebec Estuary Land Trust (KELT) and the Casco Bay Estuary Partnership (CBEP) have all identified this location as a priority for restoration. As such, these organizations have contributed funding and/or technical expertise to assist the Town of Phippsburg in evaluating this crossing infrastructure.

Acadia Civil Works was retained by the Town of Phippsburg to work in partnership with the aforementioned group of cooperating organizations. A primary goal of this work is to provide preliminary engineering recommendations to improve the primary crossing at Small Point Road, while also providing guidance on future improvements at the three upstream crossings. Our scope of work included the requisite hydrologic, hydraulic, and engineering analysis, as well as a series of stakeholder meetings and discussions about the infrastructure.

1.2 PURPOSE OF REPORT

The purpose of this report is to provide preliminary design guidance on engineering solutions associated with improvements to the primary Small Point Road crossing. This includes a summary of pertinent hydrologic and hydraulic analyses of the tidal wetland system at the primary crossing and the three upstream crossings, as well as associated tidal effects and sea level rise projections within the area of study. The report concludes with multiple conceptual design recommendations that will provide for serviceable and dependable roadway infrastructure at the primary Small Point Road Crossing, as well as accommodate sea level rise and associated salt marsh migration.

1.3 PROJECT TEAM

Throughout the report there is reference to the Project Team. The following people comprise the group:

- Amber Jones, Town of Phippsburg
- Slade Moore, Maine Coastal Program
- Matt Craig, Casco Bay Estuary Partnership
- Ruth Indrick, Kennebec Estuary Land Trust
- Jamie Carter, NOAA Office for Coastal Management
- Joseph McLean, Acadia Civil Works

The project team articulated preliminary objectives for the study, which were discussed and refined during discussions with ACW. These objectives are as follows:

- The crossing is safe and maintains transportation access to Small Point for the design life of the structure.
- The culvert is cost-effective, can be feasibly installed
- The culvert's design life is 75 years (2100).
- The crossing will improve flow without causing flooding of adjacent roads or structures.
- Assuming a current (present day) 99% exceedance tide of 6.9' NAVD88, tidal flow restriction will be minimized.
- In an intermediate-high SLR projection (Portland, in NOAA et al 2017), tidal flow restriction will be minimized, as well as meeting Maine DOT bridge design criteria for flow capacity, structure stability, and other factors.
- The culvert bottom will be the existing natural bedrock/ledge profile.
- The crossing will optimize aquatic organism passage.

SECTION 2

SECTION 2
SURVEY AND EXISTING CONDITIONS DATA

2.1 INTRODUCTION

A variety of survey and data collection activities were undertaken to support this assessment. This includes new data collection, as well as a review of readily available data from GIS sources and record documents. Each of the substantive data collection efforts and data sets utilized in this assessment are described further in the following sections.

2.2 TOPOGRAPHIC (FIELD) SURVEY

Acadia Civil Works retained Plisga & Day Land Surveyors to perform existing conditions survey of Small Point Road at the primary crossing location. Field location was performed in early April of 2020. In addition to the topographic survey, Plisga & Day staff also performed research at the Sagadahoc County Registry of Deeds to identify and locate property boundaries adjacent to the crossing, as well as the associated right-of-way boundary. This survey information is depicted on the plan titled "Boundary & Topographical Survey Depicting a Portion of the Small Point Road aka State Route 216 at Little Marsh" (attached to this report at Appendix A).

In addition to the survey prepared by Plisga & Day, staff at the Maine Coastal Program in partnership with staff at the NOAA Office for Coastal Management also performed topographic data collection. This data collection effort covered was focused on each crossing, as well as within the marsh upstream of the primary crossing. This includes a focused profile of the stream channel through the marsh and several transects across the marsh surface. These points are depicted on the map attached to this report as Appendix B.

2.3 LiDAR DATA

Light detection and ranging (LiDAR) is a survey technique that uses focused light or lasers to rapidly scan and measure distances to a variety of fixed points. The resulting measurements create a "cloud" of points that describe the scanned object. There are a variety of LiDAR data collection methods, however aerial vehicles (airplanes) are a popular means of providing LiDAR devices with a good vantage of the landscape and effective collection of ground surface elevation data. Several governmental agencies have funded large scale LiDAR data collection efforts that span much of the state of Maine. In particular, the National Oceanic and Atmospheric Administration (NOAA) has collected multiple sets of LiDAR elevation data along the Gulf of Maine Coast. Additional LiDar data sets have also been collected by the State of Maine, USGS, and US Army Corps of Engineers.

For this study, staff at the NOAA Office for Coastal Management provided Acadia Civil Works with multiple terrain models of the project area. Each of these terrain models were based upon LiDar data collected in 2011 by the USGS. Two (2) of these terrain models were particularly useful in this study. One of the terrains represented the marsh surface as identified by the "ground" return elevations in the LiDAR data set (referred to as the unprocessed terrain). The second terrain was processed by NOAA staff to adjust for mapped vegetation and habitat types within the wetland areas, as well as to add the detail of the stream channel (from field data collection efforts). In general, the processed data lowered the elevation of the marsh surface (as compared to the unprocessed surface) and increased the stage-volume relationship across the marsh. For this study, the processed terrain data was utilized to describe the marsh surface. A map of the processed terrain topography within the study area has been shown on the map attached to this report as Appendix B.

2.4 SUBSURFACE EXPLORATION

Acadia Civil Works worked with Northern Test Boring, Inc. to explore subsurface conditions along Small Point Road in the vicinity of the primary crossing infrastructure. The primary goal of the explorations was to probe the roadway in various locations to determine the depth of the underlying ledge surface. In addition to the probes several split spoon samples were also recovered to characterize the underlying material. Associated field work was performed in July of 2020. The specific location of the probes, as well as the associated ledge elevations have been shown on the map included as Appendix C.

Boring/Probe Explorations being Performed on Small Point Road in July 2020

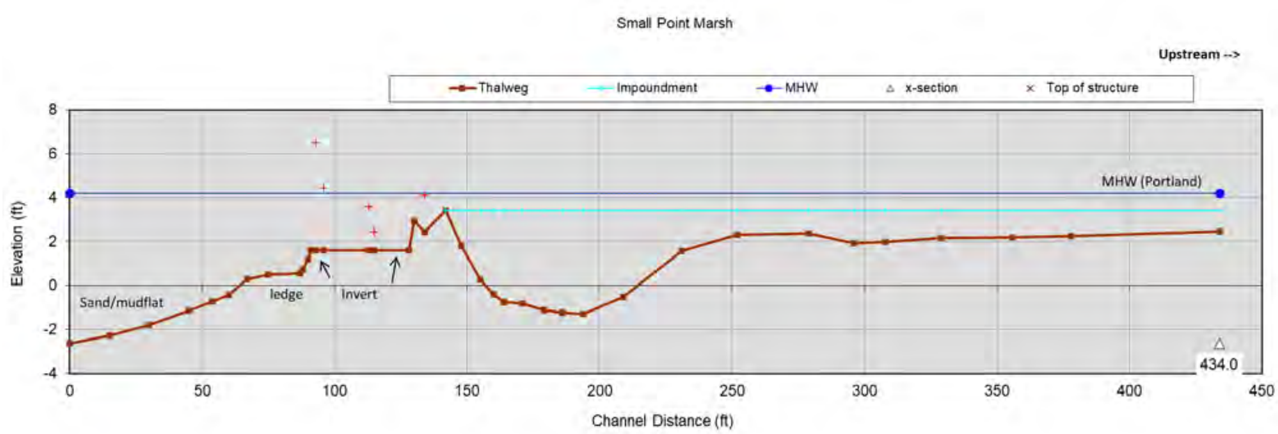
2.5 PRIOR INSPECTION REPORTS AND PLANS ON FILE

The primary crossing is located on State Route 216. As such, the Maine DOT has assigned the crossing structure with an identification number (XC-194616) and has inspected the site in recent years (January 2019). An excerpt of the structure data has been provided as Appendix G to this report. As identified by the Maine DOT, the "deck of this culvert is timber frame. The walls and base are granite stone. The timber is in very poor condition with many timber pieces missing. Displaced blocks and wall deformation." Overall, the Maine DOT indicates that this structure is in "Poor" condition.

Acadia Civil Works reviewed the Maine DOT online plan database in an effort to find plans on file withing the project area. While some plans associated with Small Point Road (State Route 216) were available, they did not cover the area of the project.

2.6 STREAM PROFILE AND WETLAND TRANSECTS

Casco Bay Estuary Partnership (CBEP) staff performed a variety of field data collection tasks in the project area. Of particular significance is a longitudinal profile of the stream through the primary crossing structure. In addition to the longitudinal stream profile, CBEP also surveyed a variety of transects (cross sections) within the marsh above the primary crossing. The longitudinal stream profile at the primary crossing is shown below.



Longitudinal Profile of the Primary Tidal Crossing (prepared by CBEP)

SECTION 3

SECTION 3
HYDROLOGIC DATA

3.1 INTRODUCTION

Hydrology is the science that encompasses the study of water on the Earth, both above and below the grounds surface. It is critical to understand the hydrologic conditions at a particular site when evaluating infrastructure options, as well as associated affects and impacts.

For the assessment at Small Point Road we have focused on two primary hydrologic conditions. One condition is the surface water hydrology driven by rainfall, runoff, and groundwater conditions. This flow is generally watershed driven and represents the flows (both normal and extreme) that will be generated upstream of the crossing and will flow down through the structure. The second condition is the hydrology of the tidal driven waters, which ebb and flow through the structure.

In addition to evaluating conditions that exist today, the project team recognizes that ocean levels are rising. New infrastructure at Small Point Road is likely to have design life of approximately 50 to 100 years. Over the course of that time, tidal hydrologic conditions are anticipated to change dramatically. This assessment also will look ahead to potential future tidal hydrologic conditions due to sea level rise.

3.2 WATERSHED HYDROLOGY

3.2.1 Watershed Characteristics

The primary crossing at Small Point Road has a tributary watershed of approximately 0.35 square miles. Of this area, approximately 0.04 square miles (11%) is mapped as wetland area as identified by the National Wetlands Inventory mapping. There are no substantial sand and gravel aquifers mapped in the watershed. Discharges from this watershed are directed immediately into the tidal waters of Cape Small Harbor, which is connected directly to Small Point Harbor and Casco Bay. There are no site-specific flow monitoring stations or data available within the watershed for this location.

3.2.2 Median Monthly Flows

If a person were to observe a stream on any given day, it is most probable that they would be witnessing the median flow condition (or something similar to the median condition). Certainly, periods of drought or periods of intense rainfall will influence those observations. However, statistically speaking, the median result is the one most likely to be experienced. These median flow rates are helpful to gauge the "typical" flow conditions at the site. The median condition for each month of an average year is provided below in Table 3.1.

TABLE 3.1
ESTIMATED MEDIAN MONTHLY FLOW RATES

Month	Median Flow (cfs)
January	0.4
February	0.3
March	1.5
April	1.0
May	0.3
June	0.2
July	0.05
August	0.01
September	0.01
October	0.1
November	0.6
December	0.7

Acadia Civil Works utilized regression techniques via the USGS StreamStats webtool. This methodology follows the equations and procedures established in USGS Scientific Investigations Report 2015-5151 to determine monthly flow rates at the crossing location. This methodology utilizes a number of stream flow gauging stations located around the state with a substantive history of recorded streamflow data to develop predictive equations based upon several explanatory variables. These variables include drainage basin area, areal fraction of the drainage basin underlain by sand and gravel aquifers, distance from the coast to the drainage basin centroid, mean drainage basin annual precipitation, and mean drainage basin winter precipitation.

It should be noted that some of the watershed characteristics are outside of the suggested range of parameters, and therefore these median monthly conditions have been extrapolated. Regardless, this technique provides a simple and relatively accurate means of understanding normal flow rates in the stream throughout the year. If more accurate base flow estimates are required at this site, more advanced hydrologic monitoring of the site will be required.

3.2.3 Extreme Flow Events

During heavy rainfall and extreme events, flow freshwater discharges at the primary Small Point Road culvert will be much higher than the median conditions. An extreme event is something that doesn't happen very often, such as a hurricane event or a very heavy rain coupled with melting snow or frozen ground. The likelihood of these rare events is often expressed as a "recurrence interval", such as the 100 year storm. Statistically, the 100-year storm will be equaled or exceeded at least once (and perhaps more than once) every 100-years. Another way of thinking about the recurrence interval is as its chance of annual occurrence. For example, a 100-year event has a 1% chance of occurring in any given year. Similarly, the 2-year event has a 50% chance occurring in any given year, and so on. The estimated extreme flow rates for the primary Small Point Road crossing are shown below in Table 3.2.

TABLE 3.2
ESTIMATED EXTREME FLOW RATES

Recurrence Interval	Peak Flow (cfs)
1-year	5
2-year	17
5-year	25
10-year	32
25-year	41
50-year	48
100-year	55
250-year	62
500-year	74

To determine these extreme flow rates, Acadia Civil Works utilized regression techniques via the USGS StreamStats webtool. This methodology follows the equations and procedures established in USGS Scientific Investigations Report 2015-5049. Similar to the methodology outlined in section 3.1.2, this methodology utilizes a number of stream flow gauging stations located around the state with a substantive history of recorded streamflow data to develop predictive equations based upon several explanatory variables. These variables include drainage basin area, as well as the areal fraction of NWI mapped wetland area.

It should be noted that some of the watershed characteristics are outside of the suggested range of parameters, and therefore these extreme flow conditions have been extrapolated. Regardless, this technique provides a simple and relatively accurate means of understanding the magnitude of flows that can be generated during extreme events.

3.3 TIDAL HYDROLOGY

While the watershed hydrology is important to understand, tidal hydrology is more critical at Small Point Road. The proximity of the primary Small Point Road crossing to the open ocean, as well as the structure's invert elevation being below mean high tide levels, results in a substantial tidal influence at the crossing. As such, accuracy and understanding of tidal hydrology is a priority in this assessment.

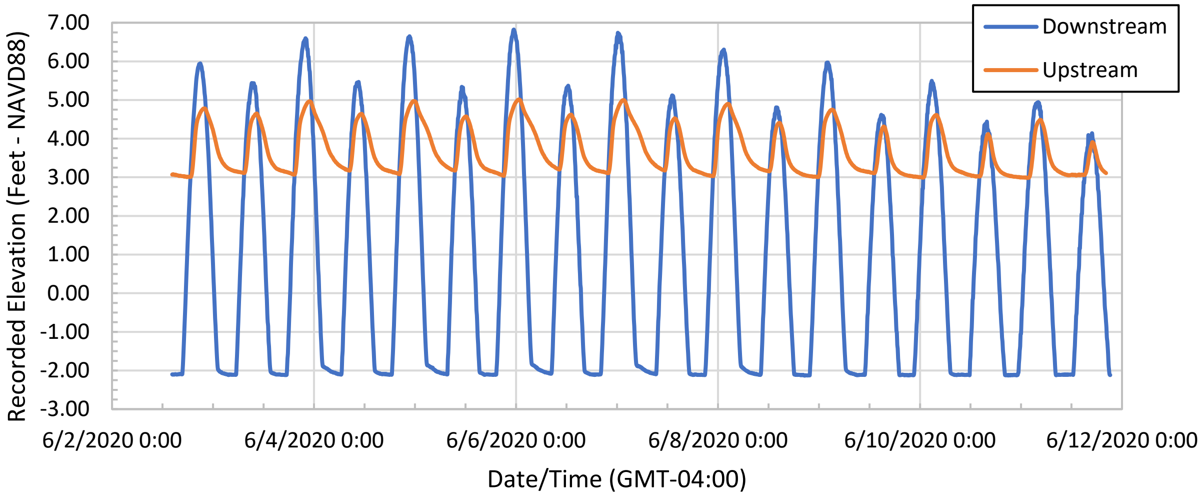
3.3.1 Local Tidal Monitoring

Staff at the Casco Bay Estuary Partnership (CBEP) deployed data loggers upstream and downstream of the primary crossing of Small Point Road to measure water surface elevations throughout the tidal cycle. These loggers were referenced to the North American Vertical Datum of 1988 (NAVD88) and tidal water surface elevations were recorded at six (6) minute intervals. Ten (10) days of the data is depicted below in Figure 9.

The Casco Bay Estuary Partnership completed the tidal monitoring in accordance with the protocols they have developed in their Quality Assurance Project Plan for tidal marsh assessment & monitoring. For this deployment, Onset HOBO titanium non-vented water level loggers were utilized. Additionally, barometric pressures were collected on-site and the water level data was post-processed to account for changes in atmospheric pressure.

It should be noted that the downstream water level logger was occasionally exposed to air at low-tide. This occurred when tide levels dropped below elevation -2 feet.

Figure 9 – Recorded Water Surface Elevations at Small Point Road



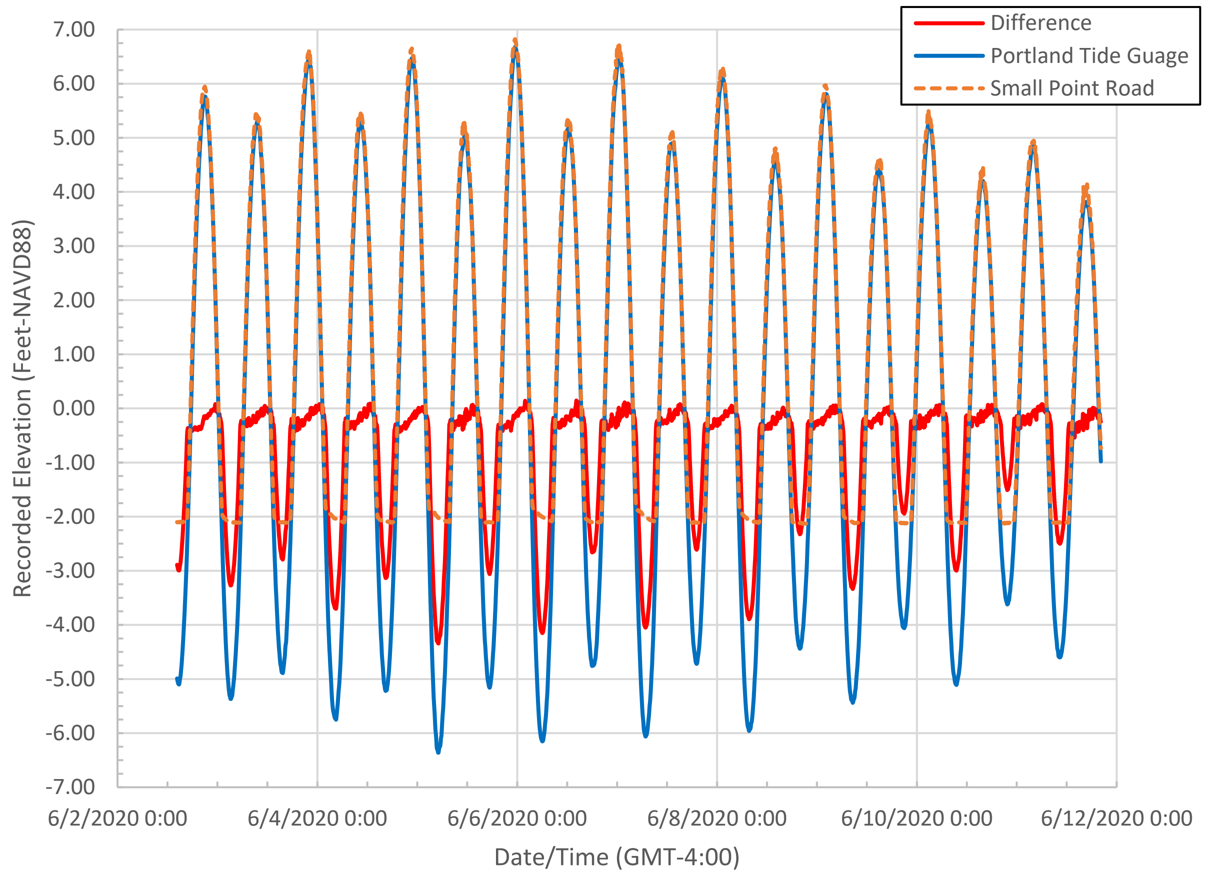
As shown in Figure 9, there is substantial difference between upstream and downstream tidal elevations at the primary crossing of Small Point Road. This is most pronounced at the lower end of the tide cycle when upstream elevations are "hung" by the culvert crossing and the upstream area is impounded at higher elevations. However, the higher end of the tide cycle is also affected, as the downstream water surface reaches higher elevations than the upstream areas.

3.3.2 NOAA Tide Gauge Correlation

Collecting localized tidal hydrology data (as described in Section 3.2.1) is an important step in the understanding of tidal influence at the project site. However, these local data collection efforts are only a small snapshot in time, representing only a few weeks of a single year. Determining normal tidal conditions, as well as extreme tidal events require a much more extensive set of tidal data. The most robust tidal information in close proximity to the project is at the NOAA Tide Station in Portland (Station ID: 8418150). The NOAA station in Portland was established in 1910 and the current installation of gauges have been in place since September of 1990. NOAA publishes a vast array of tidal statistics for the Portland Tide Gauge.

For the purposes of this assessment, a relationship between the local tide data collected by CBEP (described in Section 3.2.1) and the Portland Tide Gauge was developed. In particular, a correlation between the downstream data (downstream extent of the study area) and the Portland Tide Gauge was evaluated. A comparison between the Portland Tide Gauge and the localized data is shown below in Figure 10.

Figure 10– Comparison of Portland Tide Gauge to the Recorded data Downstream of Small Point Road (Overview)

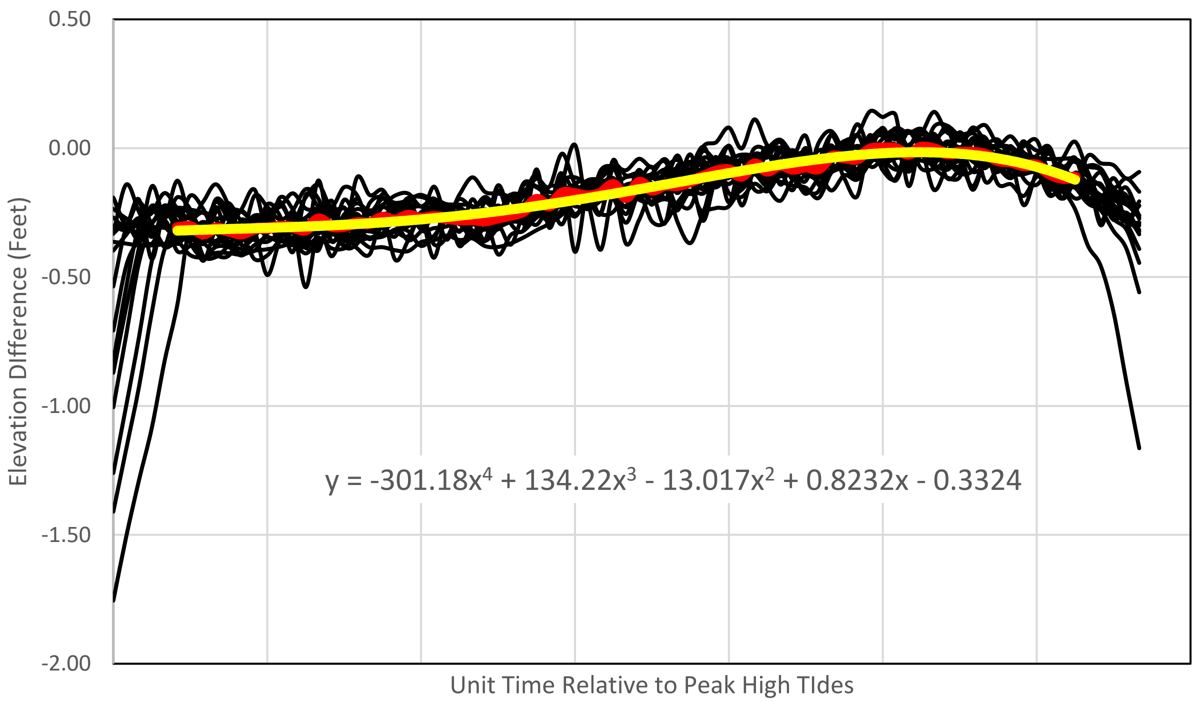


Note: The Portland Tide Station Data shown on this figure has been translated in time to align the high tide elevations to the local high tide measured by CBEP.

As shown in Figure 10, there is rather substantial difference in the comparison at low tides. This low tide difference is due to the thalweg channel elevations, which are located higher than the low tide. So, during low tides at the Portland Tide Gauge, the water surface elevation in the channel downstream of the crossing at Small Point Road is not driven by the tide, but rather by typical subcritical flows driven by watershed related discharge. These are two different processes that will not have a good correlation.

However, the higher portions of the tide offer more interesting differences. As shown in Figure 10, the peak high tide elevation varies significantly over the data collection period. However, the difference between the high tide recorded at the Portland Tide Gauge and at Small Point Road was remarkably similar. Note that the high tide portion of the red colored "difference" line is somewhat regular and exhibits the same general relationship during each high tide cycle. The positive portion of each difference curve (each high tide cycle during the monitoring period) were combined to develop a mean value. This average difference curve is shown below in Figure 11.

Figure 11 – Average High Tide Difference Between the Portland Tide Gauge and Localized Small Point Road Data

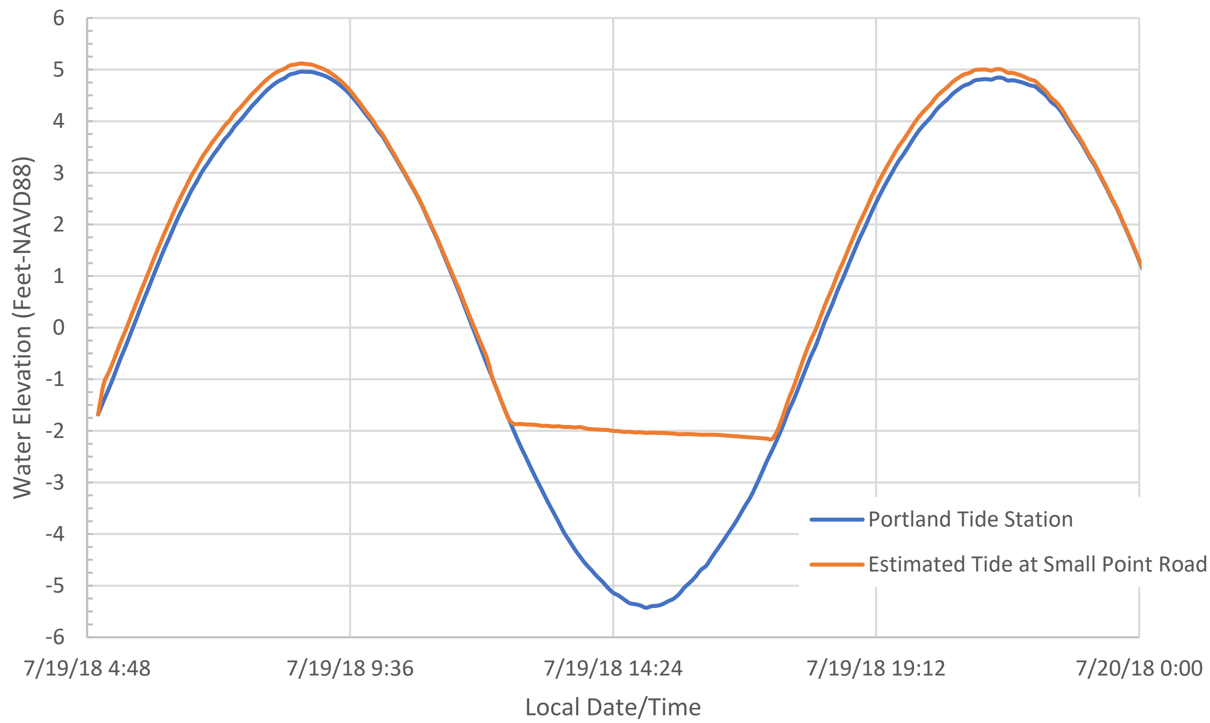


3.3.3 Regular Tide Events

NOAA reports that the Mean High Water (MHW) and Mean Higher-High Water (MHHW) elevations (2018-Figure 14) are 4.40 and 4.82 feet (NAVD88), respectively. Based upon a review of the data recorded at the Portland Tide Gauge for 2018, there was an event that occurred on July 19, 2018 which was quite similar to the reported MHHW elevation and was not influenced by any significant weather event. Using the July 19th data as a proxy for mean higher-high tidal condition, the curve shown in Figure 11 was applied to the Portland Tide Data to develop the approximated MHHW conditions downstream of the Small Point Road Crossing. Figure 12 depicts the estimated MHHW conditions downstream of Small Point Road and is overlain on the Portland Tide Station data for July 19, 2018.

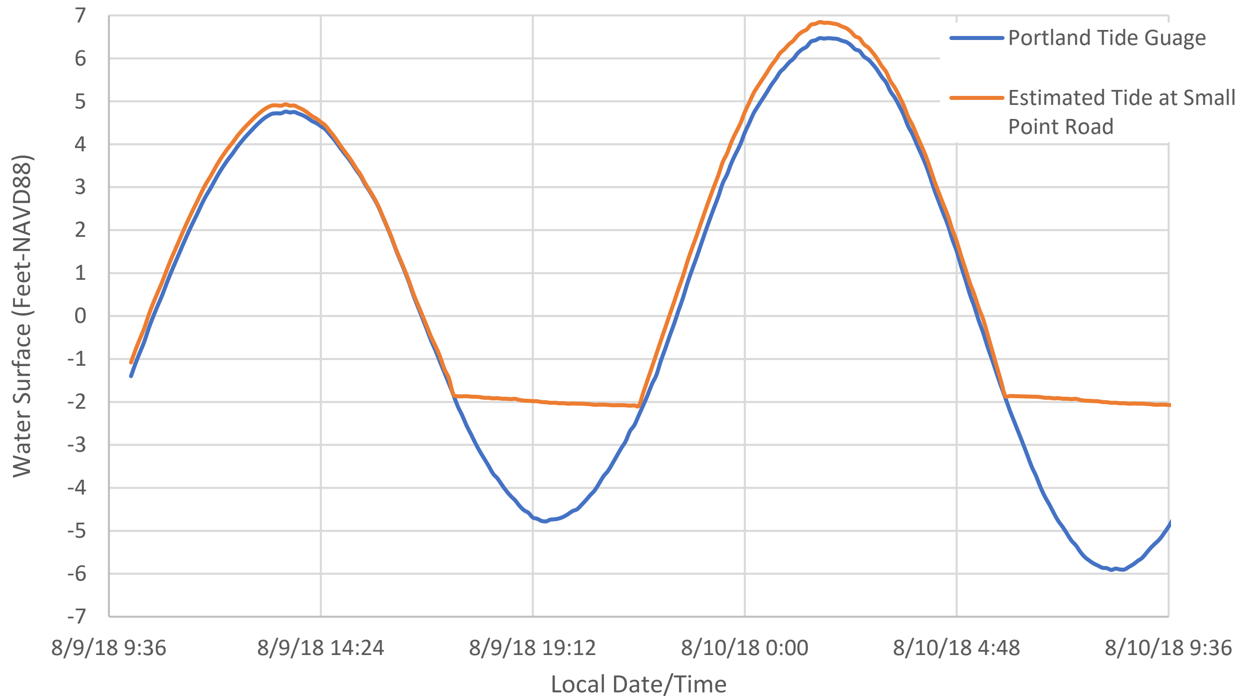
It is important to note that the application of the adjustment equation shown in Figure 11 is only applicable to the high tide portions of the curve. There is effectively no elevation correlation between the low tide curve downstream of Small Point Road and the Portland Tide Gauge. This is due primarily because the low tide portion of the curve is governed the by open channel hydraulics of the tidal stream system at the low portions of the tide, as opposed to the open ocean conditions. Additionally, it is important to recall that the tidal monitoring equipment at the site may also have been exposed to the open-air during portions of the low tide, which also impacted the low tide data.

Figure 12 – Estimated Mean Higher-High Tide Conditions at Small Point Road



In addition to the MHW and MHHW, NOAA also reports the general highest annual tide, also referred to as the 99% Annual Exceedance (1-year) tide elevation. At the Portand Tide Guage (2018-Figure 14), the 99% annual exceedance tide elevation is reported as 6.66 feet in relation to NAVD88 (2.12 meters station datum). After a review of the 2018 NOAA Portland Tide Gauge data, it was determined that the tide that occurred on August 10, 2018 was very similar to the HAT published by MeDEP. Using the August 10th data as a proxy for the 99% Exceedance condition, the curve shown in Figure 13 was applied to the Portland Tide Data to develop the approximated 99% exceedance tide condition downstream of Small Point Road.

Figure 13 – Estimated 99% Annual Exceedance Tide at Small Point Road

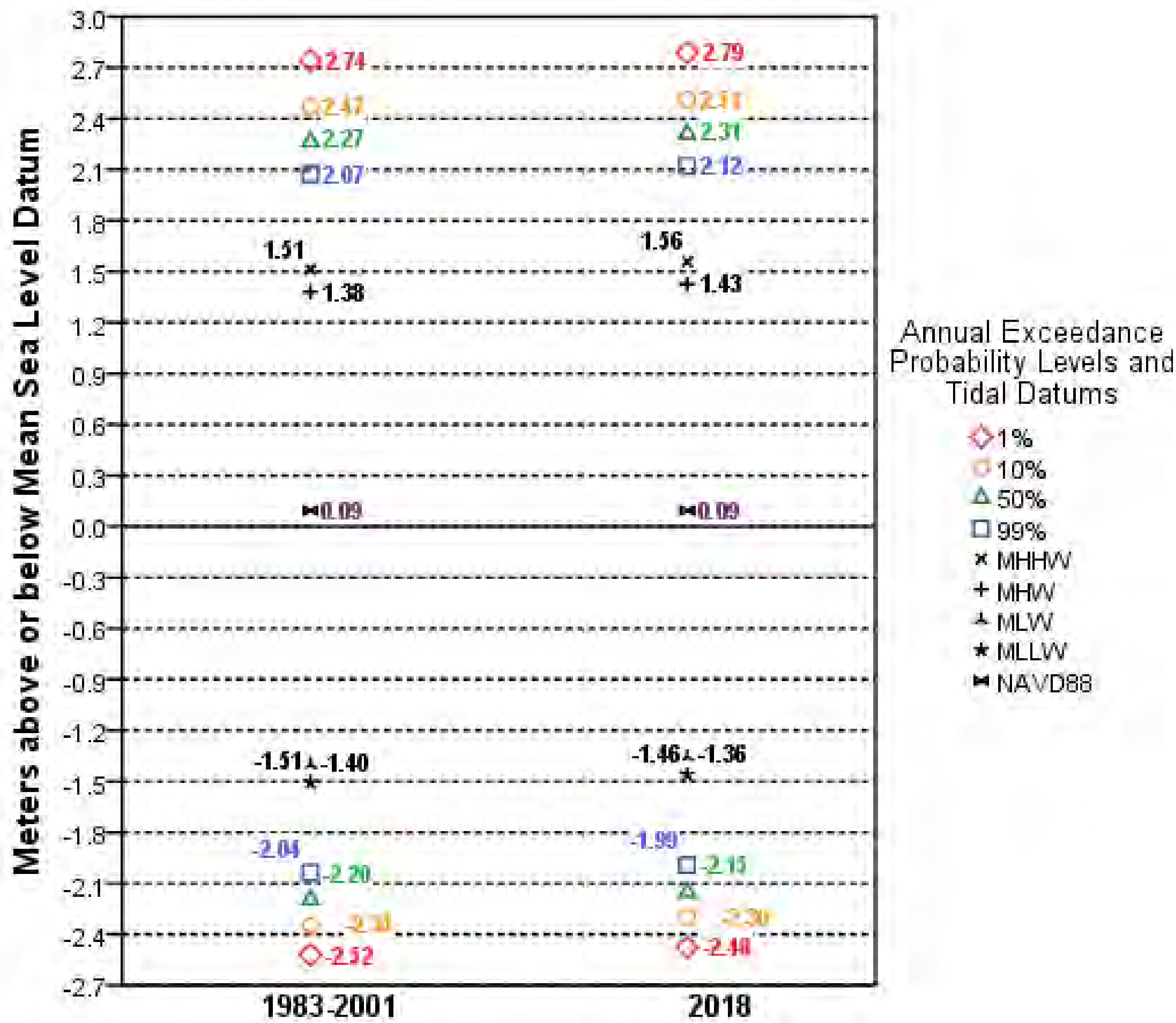


3.3.4 Extreme Tide Events

During large storms or other extreme conditions, tides will reach higher elevations that the HAT. NOAA has published the following data (See Figure 14) related to annual exceedance probability levels at the Portland Tide Gauge (ID# 8418150).

As shown in Figure 14, the 100-year tide elevation (1% annual exceedance) is estimated to be at an elevation of 2.79 meters above mean sea level (elevation 8.8 feet – NAVD88). The 10% exceedance (10-year) tide elevation is estimated to be at elevation 7.9 feet - NAVD 88 (2.51 meters above mean sea level). While the elevations are helpful for the purposes of comparison, they may not be representative of extreme tides located at the Small Point Site due to the distance from the tide gauge and location along the coast. It is also important to note that these tides are reported being reported for the year 2018.

Figure 14 – NOAA Portland Tide Station (8418150)



Note: This figure has been taken from the NOAA "Tides and Currents" website.

The Federal Emergency Management Agency (FEMA) has also published extreme tide information specific to Small Point Harbor in its Flood Insurance Study(FIS) for Sagadahoc County dated July 16, 2015. Specifically, Coastal Transect 10 is located at the approximate mouth of Cape Small Harbor, which is within 1000' or so of the primary crossing of Small Point Road. The southwest exposure of transect 10 is significant in the FEMA study and has resulted in fairly high flooding elevations due to the dynamics of wave action. However, those wave affects will be substantively muted at Small Point Road due to the protection offered by Hermit Island, as well as several smaller islands and ledge outcroppings between Transect 10 and the road crossing. This is reinforced by the change from a VE to and AE zone on the Flood Insurance Rate Map. Despite the wave dynamics being different, the stillwater flooding elevations should be quite similar between these locations and representative of the tidal flooding elevations to be anticipated in our study area.

The extreme flood elevations identified by FEMA in the FIS are included in Table 3.3 below. In addition, the MHHW and 99% Annual Exceedance tide elevations (from the Portland Tide gauge and adjusted as described in Section 3.3.2) are also included. Adjustment to these values due to sea level rise, (as described further in Section 3.4) is also included.

TABLE 3.3
ESTIMATED TIDAL ELEVATIONS[1]

Tide Event	Recurrence	Present Day	Potential Future[2]		Data Source
			2100 (Int)	2100 (High)	
MHHW	Average Daily	5.0	8.3	12.9	NOAA/ACW
1-year	99% Annual	6.9	10.2	14.8	NOAA/ACW
10-year	10% Annual	8.1	11.4	16.0	FEMA/ACW
50-year	2% Annual	9.1	12.4	17.0	FEMA/ACW
100-year	1% Annual	9.6	12.9	17.5	FEMA/ACW
500-year	0.2% Annual	11.0	14.3	18.9	FEMA/ACW

Notes:
1) All elevations are in feet and reference NAVD88
2) The SLR scenarios indicated in the "Potential Future" column is described further in Section 3.4

3.4 SEA LEVEL RISE

3.4.1 Corps Methodology

The US Army Corps of Engineers (Corps) has developed a web-based calculation tool for the prediction of future sea levels at a given site for a range of potential climate change scenarios. The tool is named the "Seal-Level Change Curve Calculator (Version 2019.21)" and is located on the Corps website. This web-tool utilizes localized land subsidence values, as well as local tidal information to determine potential future sea level rise values.

The Corps web tool relies heavily on work of other agencies to evaluate potential sea level rise scenarios. The most recent and comprehensive data related to potential sea level rise scenarios was published in 2017 as NOAA Technical Report NOS CO-OPS 083. This report was a collaboration of several institutional and governmental agencies, including the USGS, US EPA, and Rutgers University. The report provides regional guidelines for several potential sea level rise scenarios that range from "low" to "extreme." The variability in these scenarios are generally related to their assumptions associated with climate change and future carbon emissions. Refer to the full report for further details associated with these findings.

Using the Corps calculator and the recent NOAA (2017) climate change scenarios, Figure 15 was created, which depicts the potential relative sea level change at the Portland Tide Station.

Figure 15 – NOAA et al. 2017 Relative Sea Level Change Scenarios for Portland, ME

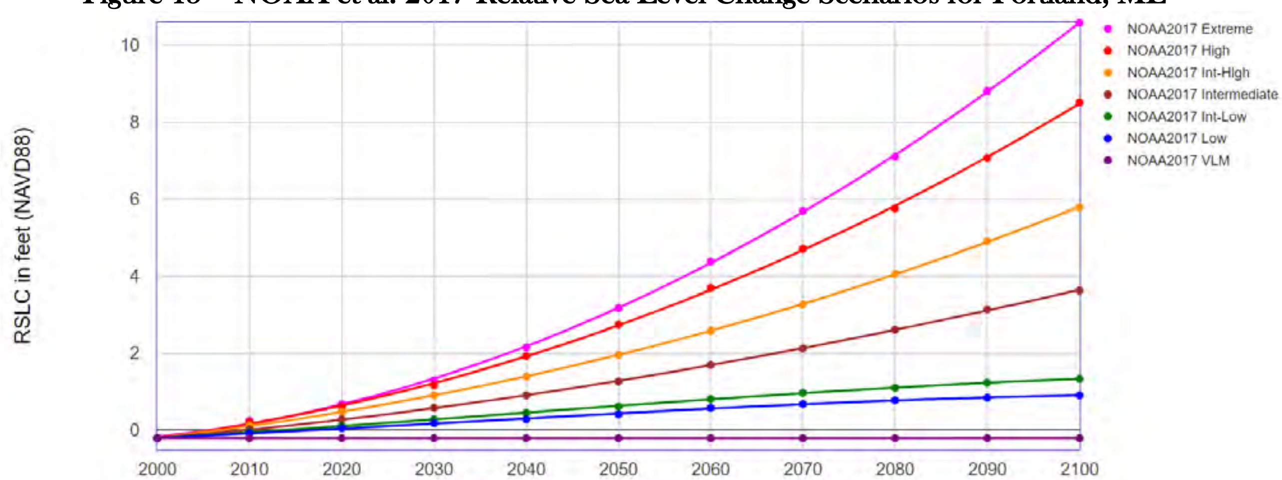


TABLE 3.4
NOAA et al. 2017 Relative Sea Level Change Scenarios for Portland Maine
Tabular Data that Correlates to Figure 15

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21
2010	-0.21	-0.08	-0.04	0.02	0.12	0.22	0.25
2020	-0.21	0.06	0.12	0.29	0.48	0.61	0.68
2030	-0.21	0.19	0.29	0.58	0.91	1.17	1.30
2040	-0.21	0.29	0.45	0.91	1.40	1.93	2.16
2050	-0.21	0.42	0.61	1.27	1.96	2.75	3.17
2060	-0.21	0.58	0.81	1.70	2.58	3.70	4.39
2070	-0.21	0.68	0.97	2.12	3.27	4.71	5.70
2080	-0.21	0.78	1.11	2.61	4.06	5.76	7.11
2090	-0.21	0.84	1.24	3.14	4.91	7.08	8.82
2100	-0.21	0.91	1.34	3.63	5.80	8.52	10.59

As identified in Figure 15, there are a range of potential sea level rise scenarios. These range from more than 10 feet of relative sea level change to minimal change over the course of the current century.

3.4.2 Anticipated Future Conditions

There was a consensus amongst the Project Team that the NOAA2017 Intermediate curve would be the minimum design assumption. It was also concluded that the NOAA2017 High curve should also be considered. While there is no established regulatory standard for this criterion, it is worth noting that the Maine Department of Transportation (MeDOT) has adopted an informal policy to use the NOAA2017 Intermediate curve as their initial baseline for infrastructure design.

Subsequent to our Project Team discussions, the Maine Climate Council issued their 2020 Draft Four Year Climate Action Plan Strategy. They recommended "that the State consider committing to manage for 1.5 feet of relative sea level rise by 2050, relative to the year 2000, and 3.9 feet of sea level rise by the year 2100. The Council also stated the importance of using the High scenario (3.0' of increase by 2050 and 8.8' of increase by 2100) for decisions about long-lifespan infrastructure and facilities that are critical for public safety and local economies."

As shown in Figure 15, there is approximately 3.34 feet of relative sea level change that will occur over the next 80 years (2020 to 2100) in the NOAA2017 Intermediate curve scenario. That change increases to 7.91 feet of change when considering the NOAA2017 High scenario. This calculated change was applied to the estimated MHHW and HAT conditions at Small Point

Road. These existing and anticipated future conditions downstream from Small Point Road are depicted on Figures 16 and 17.

Figure 16 – Estimated Current and Potential Future MHHW Conditions at Small Point Road

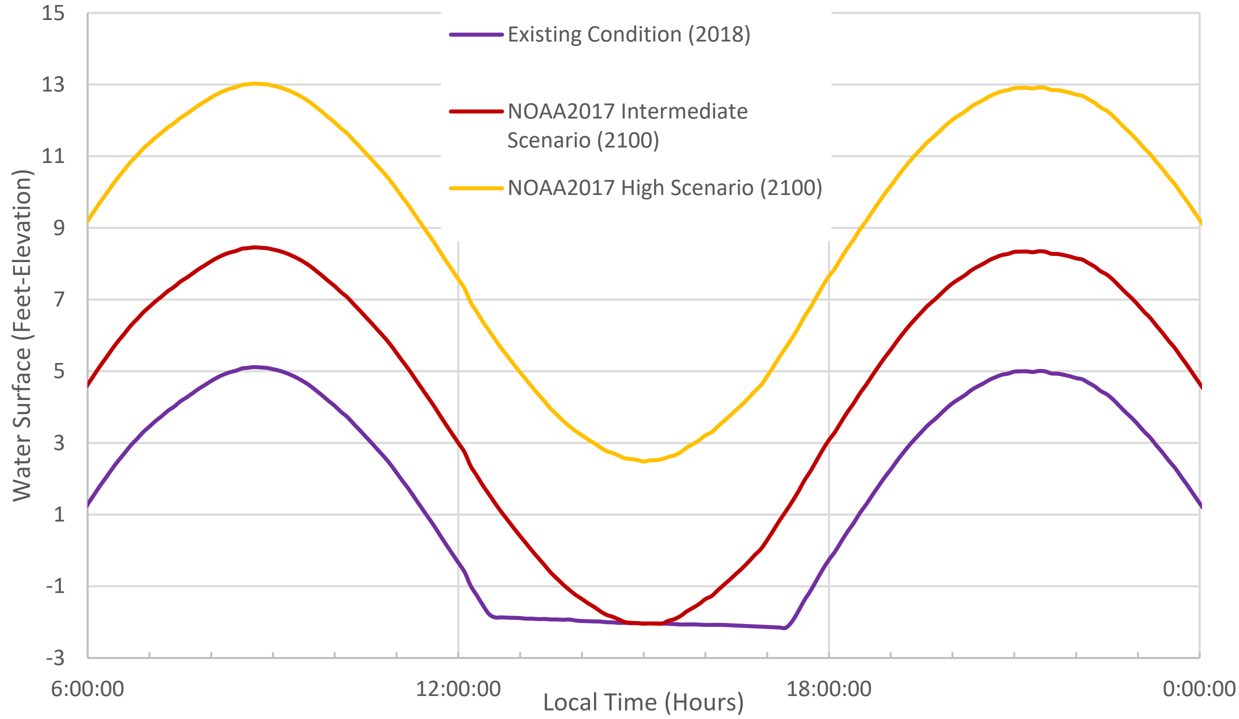
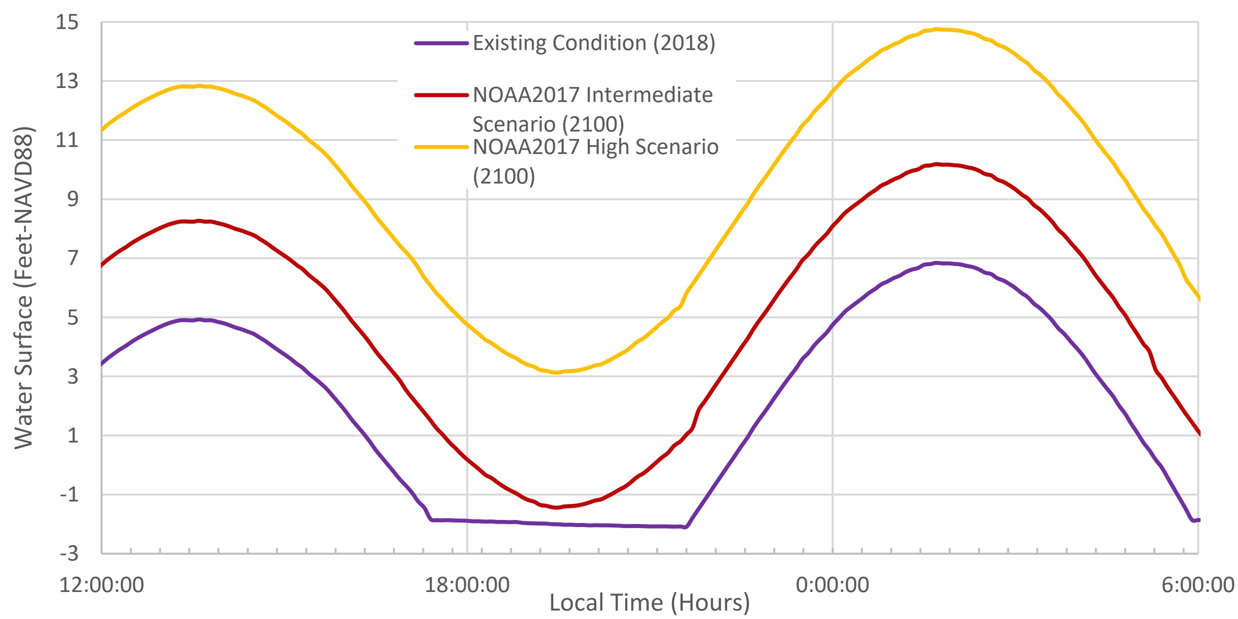


Figure 17 – Estimated Current and Potential Future 99% Exceedance Tide Conditions at Small Point Road



SECTION 4

SECTION 4
HYDRAULIC ANALYSIS

4.1 INTRODUCTION

Hydraulics is an applied science concerned principally with the practical applications of fluids in motion. In this assessment, a computer model was constructed to evaluate the hydraulic performance of the existing and proposed infrastructure in a variety of geometric and hydrologic conditions. Additional details regarding the computer model and associated hydraulic modeling techniques, as well as associated hydraulic performance results are contained in the following sections.

The primary purpose of this hydraulic analysis is to provide recommendations on infrastructure improvements at the four (4) subject crossing structures. These structures include the primary culvert crossing at Small Point road, the secondary crossing at Small Point Road, as well as the crossing at Flat Point Road and Morse Mountain Road. Refer to Figure 1 in Section 1 for a site location map that indicates the location of each of these crossing structures.

4.2 INITIAL HYDRAULIC ANALYSIS

The U.S Army Corps of Engineers (Corps) Hydraulic Engineering Center's (HEC) River Analysis System (RAS) computer modeling software (version 6.0.0) was utilized in the hydraulic analysis of this project. This software was developed by the Corps to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. Over the years, additional versions have added more detailed and advanced hydraulic assessment tools, most significantly is the development of two-dimensional modeling capabilities with the release of software version 5.

This section of the report (4.2) focuses on the initial hydraulic analysis that have been performed to determine the appropriate size of the crossing improvement structures. These initial calculations are generally centered around a one-dimensional hydraulic model, which has been run with a variety of improvement structure sizes to develop a sizing curve. Additional detail regarding the model assumptions and results are in the following sections.

4.2.1 Model Assumptions

The initial HEC-RAS modeling was developed utilizing a variety of data sources. The most significant of which, is the LiDAR dataset (Refer to Section 2.3). This LiDAR data formed the foundation of the model geometry construction, which was supplemented by field crew survey efforts (Section 2.2). The model was constructed as a network of reaches, pipe connections, and storage volumes. The primary crossing at Small Point Road was modeled as a reach with cross sections extend that extends up and downstream from the crossing structure. The other three crossings were modeled as pipe connections, which connect an associated storage volume that represents wetland areas.

As noted, the LiDAR dataset was used as the foundation of the model geometry. As described in Section2, LiDAR information is collected utilizing concentrated light (lasers) and measures surface data from an elevated location (in this case an airplane). LiDAR is incredibly accurate and measuring distances, however it has been questioned for its use in locations with dense vegetation as describing a ground surface that it too high. This is likely due to the lasers returning measurements that are from the dense vegetation, as opposed to the actual mineral ground surface. As noted in Section 2.3, NOAA staff processed this LiDAR surface to account for vegetation/habitat. Additionally, the field survey data (Section 2.2) was utilized as a basis to make adjustments to the LiDAR data.

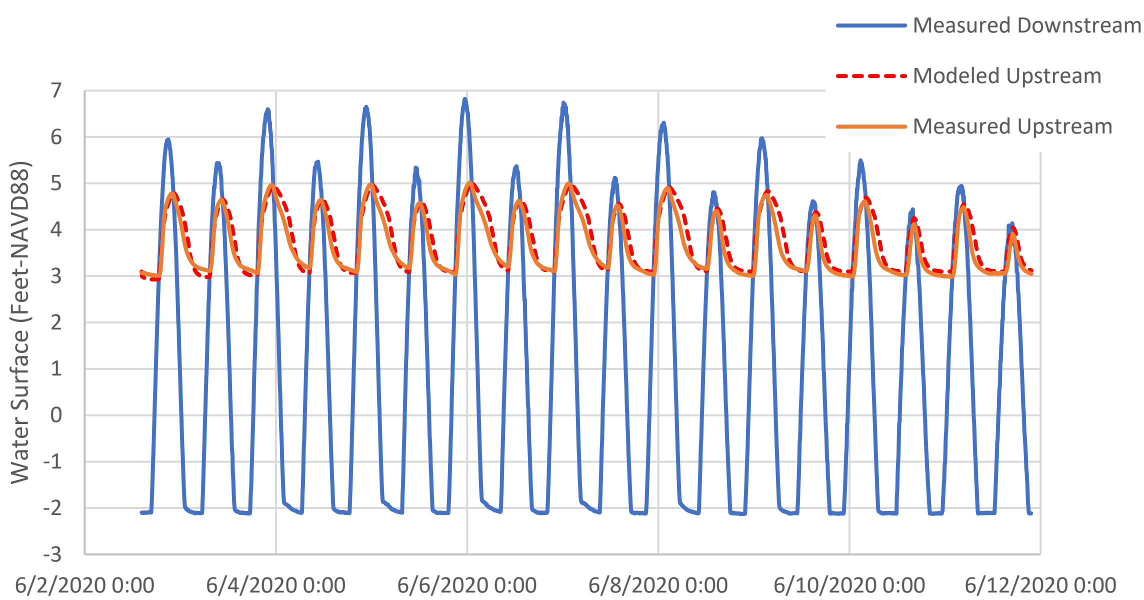
The existing conditions model was calibrated using the localized tide data collected by CBEP and described in Section 3. Values such as Mannings roughness (n) and hydraulic loss parameters were adjusted to provide results that mimic the observed existing performance. Figure 18, below, depicts an overlay of the modeled existing conditions results, with the measured results collected by CBEP.

As shown in Figure 18, the peak water surface elevations compare well between the modeled and measured results. However, modeled results reflect a somewhat extended ebb of the tide compared to the measured data. There are several challenges with model calibration at this site. Most particularly is the irregular nature of the dry laid stone culvert at the primary crossing, which has intricate hydraulic complexity that is difficult to capture with mathematical models.

The modeled conditions and measured upstream conditions are quite similar through the upstream flow of the tide. However, the ebb of the modeled tide extends out a bit further than the measured tide. This additional area under the curve indicates that slightly more volume is being discharged from the modeled condition during the immediate during ebb of tide, than what was measured. One explanation for this phenomena, is that a variety of pools and voids across the marsh surface (and subsurface) may be capturing volume during the incoming flow of the tide. Those volumes are then slowly released as baseflow during the ebbing cycles of the tide. The modeled condition does not consider these micro storage areas, nor does it attempt to model these factors. As such, the model immediately discharges all volume back through the crossing structure, which may account for the extended ebb shown.

Regardless, the modeled upstream tide correlates well to the measured incoming flow of the tide, as well as relative peak high tide elevations. The model calibration is generally acceptable and appropriate for this exercise.

Figure 18 – Comparison of Modeled versus Measured Results



As stated previously, the primary purpose of the hydraulic modeling assessment is to provide analysis and recommendations related to the sizing of infrastructure improvements the four (4) crossings within the study area. In the sizing analysis at each site, two significant assumptions were incorporated into the modeling to isolate each crossing structure and eliminate influences of other infrastructure factors, as follows:

- Eliminate Other Crossings: The model geometry utilized to assess a particular crossing included the removal of other crossing road fills and structures. This removal allows for the influence of these other roads and crossing to be eliminated from the assessment and isolates the specific infrastructure being assessed with the context of a restored wetland system. It is very possible (if not likely) these other crossings will be reconstructed or replaced in a substantive way over the life of the subject crossing. Utilizing this approach will ensure that the infrastructure has been sized adequately and will not be undersized in the future as a result of changes in other marsh infrastructure. For the purposes of the model geometry, all apparent roadway fills and crossing structures were removed.
- Eliminate Roadway Overtopping: As the current roadway infrastructure exists, certain tide events will overtop the roadways. The proposed model conditions all eliminate this overtopping of the roadways and require all tidal exchange to occur within the proposed crossing infrastructure.

4.2.2 Primary Crossing of Small Point Road (Route 216)

The proposed model was used to evaluate a range of proposed crossing infrastructure sizes at Small Point Road. The peak instantaneous head differential of the simulated tide surfaces (downstream subtracted from upstream) was recorded and plotted on a graph to generate a curve of the tide differential versus structure open area. This curve is intended to be used as a tool for decisions related sizing of the proposed crossing infrastructure. A separate curve was developed for each evaluated hydrologic condition.

Through discussion with the Project Team the NOAA 99% Annual Exceedance (1-year) tide and the Mean Higher-High Water (MHHW) published by NOAA were utilized as the design hydrologic conditions. The MHHW represents an average of the highest daily high tide. While the 99% exceedance tide is higher than average, it is essentially the 1-year tide, which has a statistical 99% chance of occurring in each calendar year. Sizing curves for each of these tidal conditions, as well as the conditions modified by future sea level rise was evaluated. The sizing curve for each of these hydrologic conditions is shown below as Figures 19 through 24.

The sizing curves relate the open area of a potential new crossing structure to the peak instantaneous head differential. The open area of the structure reflects the open cross-sectional area of the crossing structure hydraulically available for water to flow. The sizing curves shown in Figures 19 through 24 also include an approximate "span size" label at key data points. This "span size" should be considered approximate as there are a number of details associated with the final structural design, which will affect the actual span size (such as abutment configuration, location in the channel versus overbank, etc.). However, the span size should provide context and reference to the approximate magnitude of structures under consideration.

Figure 19 –MHHW (2018) Sizing Curve at Small Point Road (Primary)

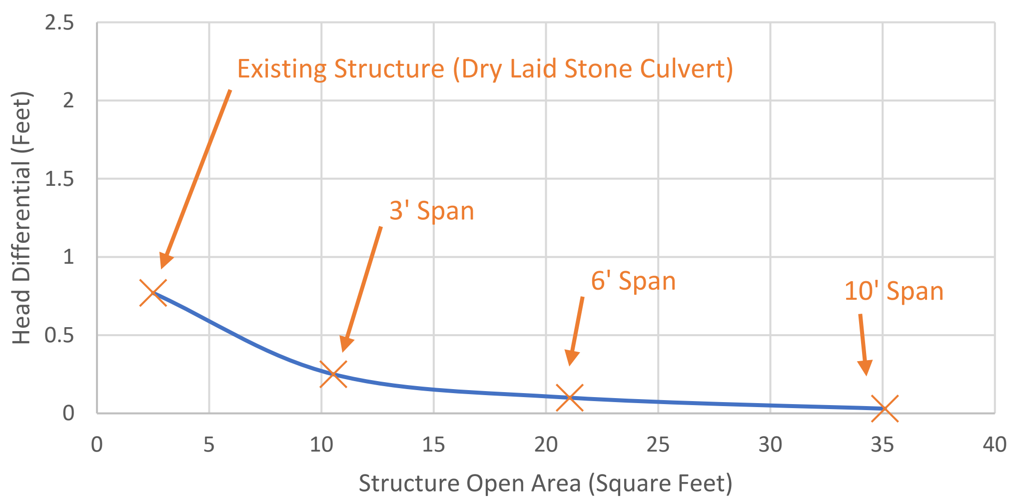


Figure 20 – 99% Exceedance Tide (2018) Sizing Curve at Small Point Road (Primary)

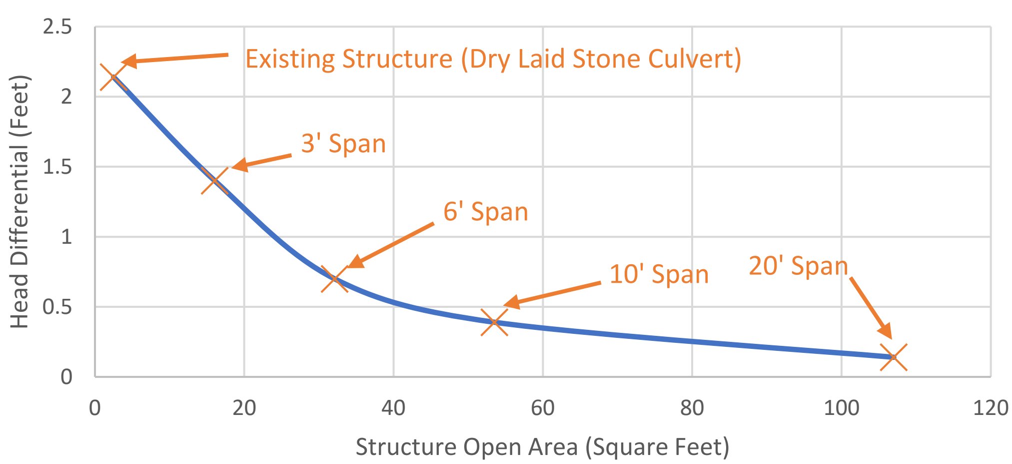


Figure 21 – Future MHHW (2100-Int) Sizing Curve at Small Point Road (Primary)

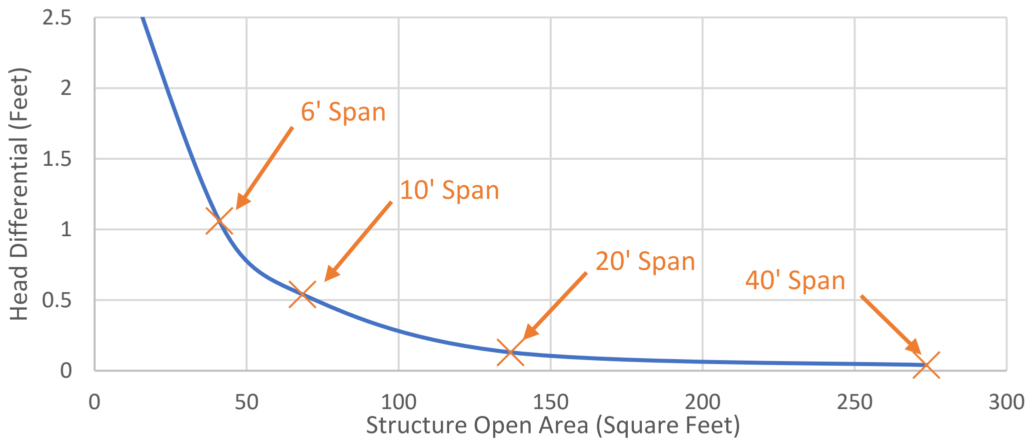


Figure 22 – Future 99% Exceedance Tide (2100-Int) Sizing Curve at Small Point Road (Primary)

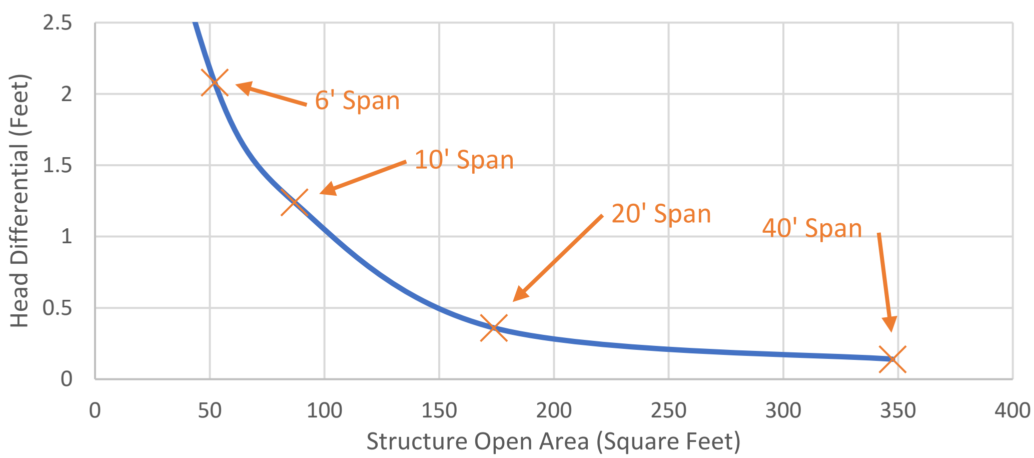


Figure 23 – Future MHHW (2100-High) Sizing Curve at Small Point Road (Primary)

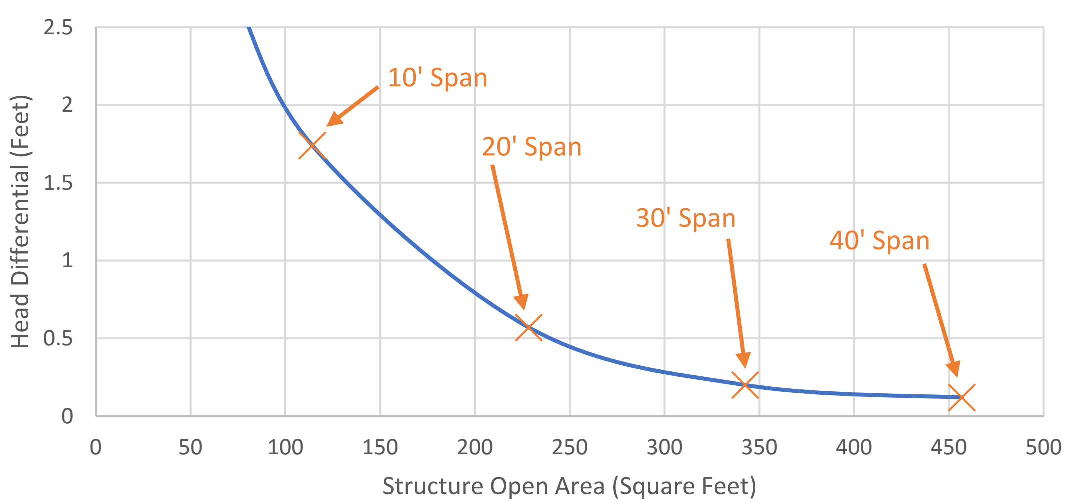
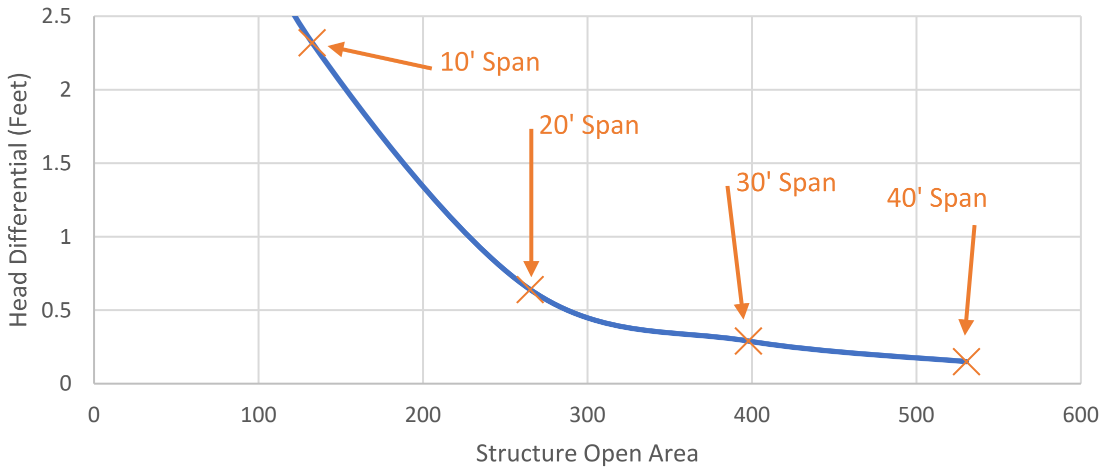


Figure 24 – Future 99% Exceedance Tide (2100-High) Sizing Curve at Small Point Road (Primary)



4.2.3 Secondary Crossing at Small Point Road (Route 216) and Flat Point Road

Similar to the primary crossing, the proposed model was used to evaluate a range of proposed crossing infrastructure sizes at the secondary crossing at Small Point Road and Flat Point Road. Due to their proximity, the two crossings have been evaluated as an identical pair. The peak differential of the tide surfaces (downstream subtracted from upstream) was recorded and plotted on a graph to generate a curve of the tide differential versus structure open area. A separate curve was developed for each evaluated hydrologic condition.

A significant difference between this secondary crossing at the primary crossing is related to elevation. The invert of these secondary crossings range from elevation 5.5 to 6.9 and are not significantly influenced by the existing tides. However, in the future, both the Intermediate and High sea level rise scenarios will influence the hydraulics at this location. As such, sizing curves for the secondary crossing have only been provided for future sea level rise conditions (Refer to Figures 25 through 28, below).

Figure 25 – Future MHHW (2100-Int) Sizing Curve at Small Point Road (Secondary) and Flat Point Road

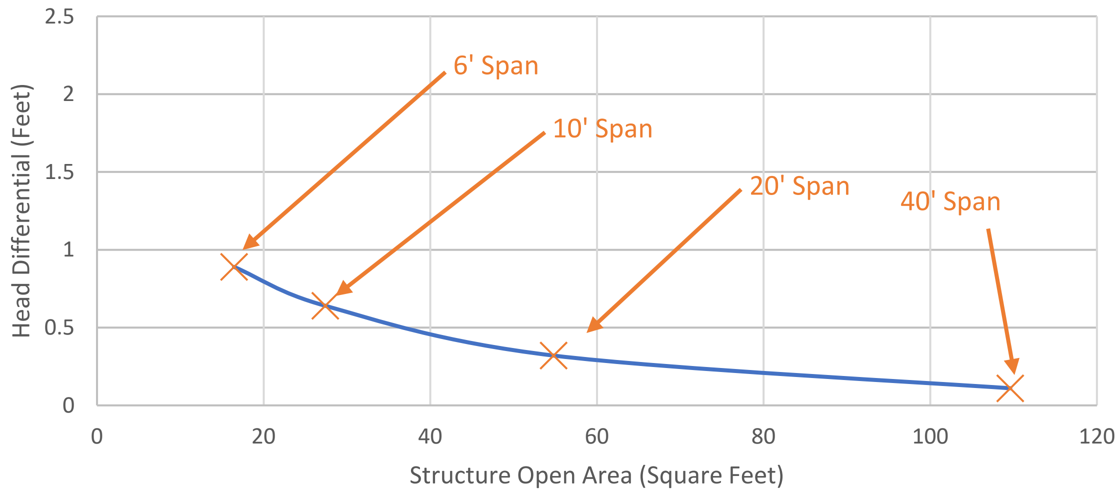


Figure 26 – Future 99% Exceedance Tide (2100-Int) Sizing Curve at Small Point Road (Secondary) and Flat Point Road

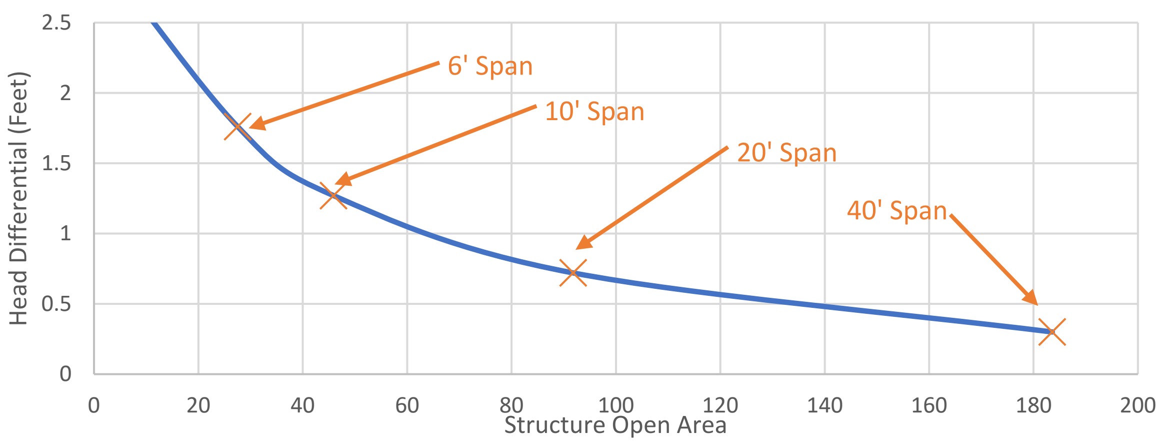


Figure 27 – Future MHHW (2100-High) Sizing Curve at Small Point Road (Secondary) and Flat Point Road

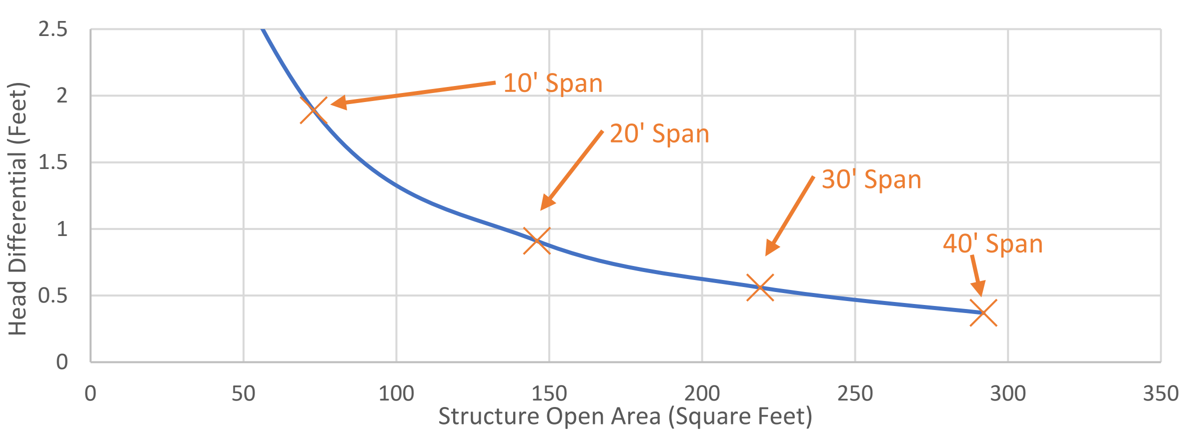
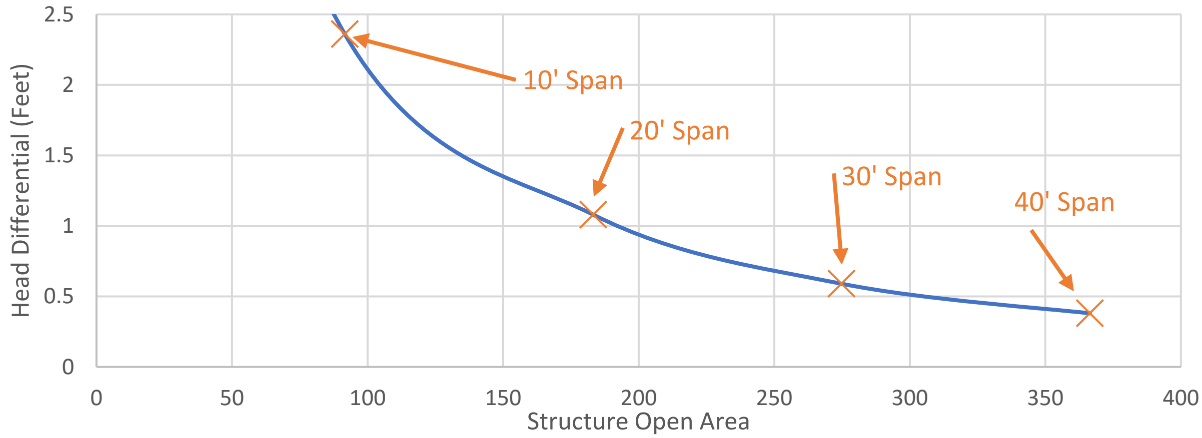


Figure 28 – Future 99% Exceedance Tide (2100-High) Sizing Curve at Small Point Road (Secondary) and Flat Point Road

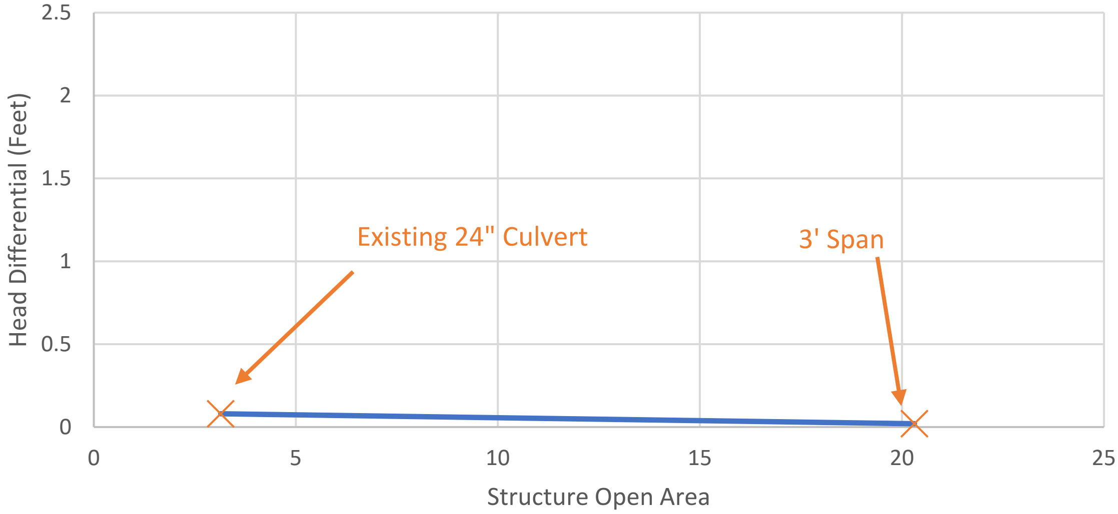


4.2.4 Secondary Crossing at Morse Mountain Road

Similar to the primary crossing, the proposed model was used to evaluate a range of proposed crossing infrastructure sizes at the secondary crossing at Morse Mountain Road. The peak differential of the tide surfaces (downstream subtracted from upstream) was recorded and plotted on a graph to generate a curve of the tide differential versus structure open area. A separate curve was developed for each evaluated hydrologic condition.

The crossing infrastructure at Morse Mountain Road is higher in elevation than the other three (3) crossing structures. The invert of this secondary crossing is in the range of 8 feet and is not significantly influenced by the existing tides, nor the tides anticipated in a future intermediate sea level rise scenario. So, only the future NOAA-2017 High sea level rise scenario for the HAT will meaningfully influence the sizing hydraulics at this location (Refer to Figure 29, below).

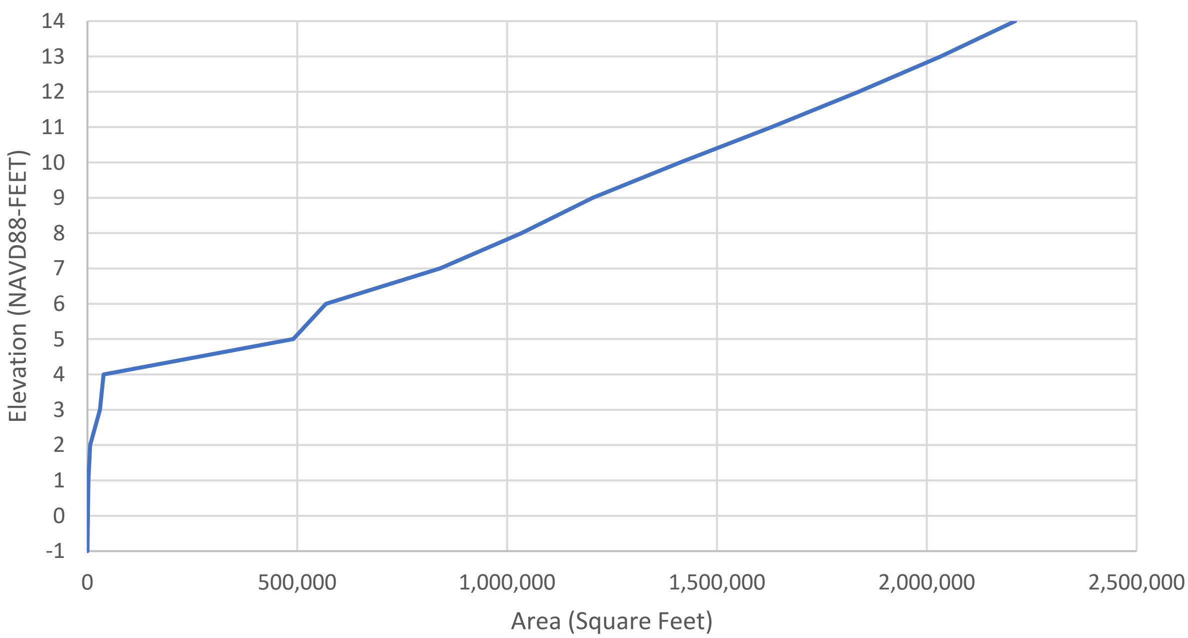
Figure 29 – Future 99% Exceedance Tide (2100-High) Sizing Curve at Morse Mountain Road



4.2.5 Elevation Acreage Relationship

Restoration practitioners are often interested in the relationship between tidal elevations and associated acreage of the landscape that is inundated by those tides. To put the footprint of these tidally influenced areas into context a plot of the correlation between elevation (stage) and the associated tidal influence footprint (area) has been provided on Figure 30, below.

Figure 30 – Hypsometric Curve for Area Upstream of the Primary Crossing of Small Point Road



The processed LiDAR terrain provided by NOAA staff (refer to Section 2.3) was used as the basis of the relationship in Figure 30. As shown, there is substantive variation in the area of inundation for elevations below elevation 6 feet (NAVD88). However, for elevations above 6, there is a somewhat linear increase area as it relates to elevation. This linear relationship is approximately 205,000 square feet per foot of elevation change. This is equivalent to 0.39 acres per inch.

SECTION 5

SECTION 5
IMPROVEMENT SCENARIOS

5.1 INTRODUCTION

The following sections of this report build upon the analysis provided in prior sections to outline several improvement scenarios. Note that a substantial factor in these improvement scenarios is related to judgment associated with the risks posed by future sea level rise, as well as appropriate investments to achieve restoration of tidal exchange across the associated crossings. These scenarios are an appropriate starting point to the conversation about these improvements and the information contained in prior sections can help to inform the associated impact of adjustments.

5.2 ROADWAY IMPROVEMENTS

Flooding of Small Point Road at the primary crossing is not related to the size of the crossing, but rather to the tidal elevations downstream of the roadway in Cape Small Harbor. Table 3.3 in Section 3.3.4 of this report outlines the array of extreme flood elevations to be anticipated at the site.

The roadway at the primary crossing will begin to flood around elevation 8.5' (NAVD88). As this roadway is a State Highway, as well as the sole point of access/egress to property on the southerly end of the Small Point peninsula, it is recommended that the roadway surface is raised to a level that maintains at least one foot of freeboard above the 100-year (1% annual recurrence) tidal event.

The existing 100-year tidal event (reported by FEMA) is approximately 9.6 feet (NAVD88). As such, the roadway should be raised to an elevation no lower than 10.6 feet (approximately 2 feet of fill height) to achieve this elevation. Based upon the topographic survey, this would require cover approximately 600 linear feet of roadway. Refer to the Map contained in Appendix I for a graphical depiction of this extent.

In future sea-level rise scenarios, the 100-year tide may reach 12.9 feet or 17.5 feet by 2100 in the NOAA 2017 Intermediate or High scenarios, respectively. Considering the Intermediate scenario, the roadway would need to be raised approximately 5.4 feet at the primary crossing location. This will require approximately 1,200 linear feet of roadway reconstruction. If the high scenario (NOAA

2017) sea level rise occurs by 2100, over three quarters of a mile of Small Point Road will require reconstruction (at a minimum). This scope of work extends outside the scope of this study and may warrant further investigation. It is likely that many other significant points of Small Point Road will also be inundated and impassable during this high scenario by 2100. If that level of protection is desired, it should be considered in the context of the entire Small Point Road corridor.

5.3 ADJACENT STRUCTURES

There are two (2) residential structures located within or adjacent to the scope of tidal inundation of this study. One is located approximately 200 feet to the south of the primary crossing on Small Point Road (Residence A). The other structure is located approximately 375 feet to the east of the crossing at the end of a long driveway that extends from Small Point Road. Each of these residential structures is identified on the topographic map of LiDAR data covering the project area included in Appendix B.

The residence in closest proximity to the primary crossing structure (Residence A), sits immediately adjacent to Small Point Road and the upstream marsh. The survey completed by Plisga & Day (refer to Section 2.2) located the ground surface elevations along the structure foundation. The lowest elevations are along the rear of the structure, which vary from 5.3 feet to 7.5 feet (NAVD88). It is notable that the tidal monitoring data collected by CBEP (Refer to Section 3.3.1) indicated that the water surface elevations within the marsh adjacent to the structure approached elevation 5 feet regularly. This structure (Residence A) is already within the flood plain of the marsh and experiences flooding below the 100-year event. Considering the elevation of this structure foundation any improvement to the primary crossing infrastructure at Small Point Road will increase the frequency and duration of flooding at this residence. The specific impacts of this flooding should be coordinated closely with the associated property owner.

While it is close in proximity, Residence B is located at a substantially higher elevation than Residence A. The scope of the Plisga & Day survey did not cover this structure, however LiDAR data is available around the residential property. It appears that the lowest ground surface around the structure is approximately 12 feet in elevation. Elevation 12 is significantly higher than the current 100-year flood elevation (9.6' by FEMA). However, it will be below potential future sea-level rise scenarios in the future. While this may occur, the existing Small Point Road infrastructure does not offer any flooding protection or reduction to Residence B. To put it another way, modifications and improvements to the Small Point Road infrastructure will not result in any new flood hazards at Residence B. In fact, Small Point Road improvements have the potential to benefit Residence B by increasing flooding protection.

5.4 CONCEPT A – 20 FOOT SPAN

Concept A represents an improvement scenario that will replace the existing dry laid stone culvert with a new 20' crossing structure. The configuration of this new structure is shown on the Conceptual Improvements Plan included as Appendix C.

In the existing tidal condition, the MHHW sizing curve (Figure 19) inflects at about a 3' span, whereas the 99% exceedance sizing curve (Figure 20) suggests an appropriate size should be in the range of 6' to 10' of total span. However, using a baseline of the 99% exceedance tide and a NOAA-2017 Intermediate sea level rise scenario (refer to Section 3.4), a 20' span is located just past the inflection point of the curve (Figure 22). Investment in a 20 foot span structure will provide excellent tidal exchange performance in the short term, and will remain serviceable through the year 2100 under an Intermediate sea-level rise scenario.

To visually demonstrate the extent of tidal inundation upstream of the crossing structures, a series of maps has been attached to the report. These maps include the inundation during the Mean Higher High Water (MHHW) (included as Appendix D) and the 99% exceedance tide (included as Appendix E). These maps depict a variety of tidal water surface elevations and footprints within the marsh upstream of the Small Point Road crossing under a variety of sea level rise scenarios. Numerical results of this performance is also included below in Table 5.1 and 5.2

TABLE 5.1
Concept A – Peak Tidal Water Surface Upstream of Small Point Road (Feet-NAVD88)

Tide Event	Recurrence	Present Tide	Potential Future	
			2100 (Int)	2100 (High)
MHHW	Average Daily	5.0	8.3	12.9
1-year	99% Annual	6.9	10.2	14.8

TABLE 5.2
Concept A – Area of Tidal Inundation Upstream of Small Point Road (Acres)

Tide Event	Recurrence	Present Day	Potential Future	
			2100 (Int)	2100 (High)
MHHW	Average Daily	11.2	16.4	28.0
1-year	99% Annual	14.5	19.9	32.3

5.5 CONCEPT B – 40 FOOT SPAN

Concept B represents an improvement scenario that will replace the existing dry laid stone culvert with 40' of new crossing structure. The configuration of this new structure is shown on the Concept B Improvement Plan included as Appendix F.

This concept is focused on maximizing tidal exchange and associated tidal restoration areas. In the short term, the 40 foot span may appear oversized for current tidal conditions, however it is well suited to perform in the future if sea levels rise towards the high end of predictions.

It should be noted that this concept may be implemented in phases. The nature of the ledge that underlies the roadway, provides for a stable base for foundation of the structure, as well as a non-erosive channel. It would certainly be possible to construct a 20 foot span (similar to Concept A), and then add an additional 10 foot span to each side of the crossing over time, as needed. This phased approach would reduce the upfront investment in the structure and allow for the crossing to adapt based upon the actual sea level rise that is experienced over time.

To visually demonstrate the extent of tidal inundation upstream of the crossing structures, a series of maps has been attached to the report. These maps include the inundation during the Mean Higher High Water (MHHW) (included as Appendix D) and the 99% exceedance tide (included as Appendix E). These maps depict a variety of tidal water surface elevations and footprints within the marsh upstream of the Small Point Road crossing under a variety of sea level rise scenarios. Numerical results of this performance is also included below in Table 5.3 and 5.4.

TABLE 5.3
Concept B– Peak Tidal Water Surface Upstream of Small Point Road (Feet-NAVD88)

Tide Event	Recurrence	Present Day	Potential Future	
			2100 (Int)	2100 (High)
MHHW	Average Daily	5.0	8.3	12.9
1-year	99% Annual	6.9	10.2	14.8

TABLE 5.4
Concept B – Area of Tidal Inundation Upstream of Small Point Road (Acres)

Tide Event	Recurrence	Present Day	Potential Future	
			2100 (Int)	2100 (High)
MHHW	Average Daily	11.2	16.4	28.0
1-year	99% Annual	14.5	19.9	32.3

5.6 SECONDARY CROSSING IMPROVEMENTS

Sections 5.6.1 and 5.6.2 are focused on improvement recommendations at each respective secondary area. An inherent assumption is that improvements are also being made at the primary crossing. However, it is also important to consider the potential conditions that may arise if improvements are made at the primary crossing, yet the secondary crossings remain as they exist.

Initially, there is minimal need to address these secondary crossings. As noted in Section 4.2.3 and discussed futher in the following sections, the secondary crossings are all located at the fringe of the current 99% exceedance tidal condition. The Small Point and Flat Point Road crossings would represent a tidal restriction in higher (extreme/storm) tide events, however they would be well outside the tidal influence during MHHW conditions.

Moving into the future, however, the secondary crossings will become a notable impact to tidal exchange. At some point between the year 2030 and 2050 (High and Int SLR scenarios, respectively) the secondary crossings structure inverts at the Small Point and Flat Point Road crossings will be submerged by approximately one foot of water during the peak of the 99% exceedance tide. Once this occurs, there will be noticeable restriction to tidal exchange. The restriction will certainly worsen over time.

Eventually, the secondary roadway surfaces at these secondary crossings will flood. The lowest elevation of the traveled way at Route 219 is approximately 9.1 feet in elevation, and similarly Flat Point Road's lowest elevation is approximately 9.6 feet. Above these elevations, the roadways will overtop, however impacts to the road structure will likely occur as tidal elevations regularly get within a foot of these grades. As such, roadway damage and overtopping will be notable between the year 2040 and 2060 (High and Int SLR scenarios, respectively).

5.6.1 Secondary Crossing at Small Point Road (Route 216) and Flat Point Road

These two crossing structures are located within close proximity, with the Flat Point Road Structure being only 80 feet upstream of the secondary crossing of Small Point Road. There is also very limited storage and wetland resources located between them. While the two structures have been modeled separately, these recommendations consider that they will require a common size moving forward.

As noted in Section 4.2.3, the invert of these secondary crossings range from elevation 5.5 to 6.9 and are not significantly influenced by the existing tides. As these structures are located on the upstream fringe of the 99% exceedance tide, existing freshwater stream crossing design considerations are likely to result in a larger crossing recommendation than tidal considerations. This includes the replacement of these round culverts, with new bottomless spans with natural channel inverts. The spans should also extend at least 1.2 times the bankful width of the existing freshwater stream channel. Based upon a review of aerial photos and the regional regression equations, it is anticipated that this would result in a crossing structure with approximately five (5) feet of span or more at each location.

This pair of crossings will experience a significant increase in tidal activity as sea levels rise. Figure 26 indicates that a span of at least twenty feet (if not thirty feet) would be required to reduce the head loss differential at this location. It is important to note that while the curve indicates that there is approximately 0.68 feet of head differential with a 20 span at each site, the individual head differentials at each crossing location is approximately half of that value. As such, it will be important from a tidal performance perspective, as well as investment in infrastructure to eliminate one of these crossings. Eliminating one of the crossing will substantially improve the hydraulic performance, as well as reducing the redundancy of the infrastructure investment.

In a High sea level rise scenario, these upper crossings would similarly need to expand. By comparison of the sizing curves (Figure 28 vs. Figure 24), it is notable that the 40 foot span recommendation under improvement Concept B for the primary crossing would also be applicable for this secondary crossing structure.

There are many possible combinations of improvements that may occur on this project. However, to provide an indication of performance, Concept A includes the improvement of this secondary crossing pair to a single 20 foot crossing span. Similarly, Concept B includes an improvement with a 40 foot span. The associated tidal inundation maps (included as Appendix D and E) depict this performance graphically. Tables 5.5, 5.6, 5.7 and 5.8 below provide numerical performance results.

TABLE 5.5
Concept A– Peak Tidal Water Surface Upstream of Flat Point Road (Feet-NAVD88)

		Potential Future	
Tide Event	Recurrence	2100 (Int)	2100 (High)
MHHW	Average Daily	8.3	12.9
1-year	99% Annual	10.2	14.8

TABLE 5.6
Concept A – Area of Tidal Inundation Upstream of Flat Point Road (Acres)

		Potential Future	
Tide Event	Recurrence	2100 (Int)	2100 (High)
MHHW	Average Daily	8.5	18.2
1-year	99% Annual	13.3	21.6

TABLE 5.7
Concept B– Peak Tidal Water Surface Upstream of Flat Point Road (Feet-NAVD88)

		Potential Future	
Tide Event	Recurrence	2100 (Int)	2100 (High)
MHHW	Average Daily	8.3	12.9
1-year	99% Annual	10.2	14.8

TABLE 5.8
Concept B – Area of Tidal Inundation Upstream of Flat Point Road (Acres)

Tide Event	Recurrence	Potential Future	
		2100 (Int)	2100 (High)
MHHW	Average Daily	8.5	18.2
1-year	99% Annual	13.3	21.6

5.6.2 Secondary Crossing at Morse Mountain Road

The secondary crossing at Morse Mountain Road is currently a 24" diameter corrugated metal culvert, with an upstream invert of 8.5 feet. There is also a relatively small available storage volume for tidal exchange on the upstream side of the roadway. While the culvert will be influenced by tidal conditions under both the Intermediate and High sea level rise scenarios, neither of these tidal conditions will drive the ultimate required span size. As shown in Figure 29, even the existing 24" diameter culvert will have a suitable tidal performance.

The design of improvements to this crossing structure should consider current freshwater stream crossing design standards. This includes the replacement of the 24" diameter culvert with a bottomless span. The span should also extend a minimum of 1.2 times the bankful width of the stream. Based upon a review of aerial photos and the regional regression equations, it is anticipated that this would result in a crossing structure with approximately four (4) feet of span or more.

5.7 CONSTRUCION COST ESTIMATES

The approximate magnitude of cost for each of these scenarios was estimated. The design options outlined in this report shall be considered conceptual. Substantive additional engineering and design work will be required to advance any of these concepts through design and construction. Significant unknown variables remain in the design process.

5.7.1 Road Fill and Reconstruction

As noted in Section 5.2, some element of roadway improvements are warranted at the site. An improvement scenario that raises the roadway based upon the current 100-year tidal flood will require approximately 600 feet of roadway reconstruction. Accommodating an Intermediate sea level rise scenario will require approximately 1,300 linear feet of roadway reconstruction.

Reconstructing Small Point Road to prevent flooding in a High Sea Level Rise scenario will require extensive roadway reconstruction, which is outside the scope of this assessment.

Unit quantities of materials for this work were estimated by Acadia Civil Works and past similar project unit prices were applied to generate the estimated value. Overall, we expect the road fill and reconstruction portion of the project (not including crossing structures) to be in the range of $400,000 to $600,000 for current tides, and $800,000 to $1,100,000 for an intermediate sea level rise scenario.

5.7.2 Primary Crossing Structure Improvements

The Primary crossing structure improvements were estimated based upon a review of past similar projects. This includes the bridge crossing and box culvert projects bid and awarded by the Maine DOT in recent years. Significant design work will be required to further refine these estimates, however based upon other similar structures and spans we estimate the following range of magnitudes:

Primary Crossing Structure
Concept A (20-foot Span) - $1,100,000 to $1,500,000
Concept B (40-foot Span) - $1,600,000 to $2,100,000

5.7.3 Project Cost Summary

The estimates above represent the cost to construct the bridge span structures, as well as the roadway improvements. To determine the total project cost, the scope of roadway fill and reconstruction should be added to the selected concept. A summary of each conceptual anticipated project cost is shown below in Table 5.9.

TABLE 5.9
CONSTRUCTION COST ESTIMATE SUMMARY

	Concept A 20 Foot Span	Concept B 40 Foot Span
Roadway Improvements	0.8 to 1.1	0.8 to 1.1
Structure Improvements	1.1 to 1.5	1.6 to 2.1
Total	**$1.9 to 2.6 Million**	**$2.4 to 3.2 Million**

SECTION 6

SECTION 6
CONCLUSION

Acadia Civil Works was retained by the Town of Phippsburg to evaluate the tidal crossing infrastructure located at Small Point Road (State Route 216) near Cape Small Harbor. The project is of interest to a diverse group of project partners, including the Maine Coastal Program, the Casco Bay Estuary Partnership, the Kennebec Estuary Land Trust, and the NOAA Office for Coastal Management.

A primary goal of this assessment is to provide recommendations for appropriate tidal crossing infrastructure at the primary tidal crossing of Small Point Road, which will provide improved and appropriate exchange of tides across the roadway while considering future sea level rise. The analysis also considered three (3) other secondary crossing structures upstream near Flat Point Road and Morse Mountain Road. Additionally, Small Point Road represents the only point of access and egress to the Small Point peninsula, and therefore it should have appropriate flood protection and serviceability in the event of an emergency.

Acadia Civil Works worked closely with project partners, to collect existing conditions information at the crossing location, including localized tide elevations and topographic survey. Additional existing conditions information was collected to assist in the processing of the publicly available LiDAR terrain data.

After a review and assessment of the hydrologic conditions, the 99% Exceedance (1-year) tide and the Mean Higher-High Water (MHHW) elevations calculated by NOAA were utilized as the primary crossing structure sizing conditions. The NOAA2017-Intermediate sea level rise scenario predicts an increase in ocean levels by 3.3 feet between 2020 and 2100, which is the anticipated design life of the improved infrastructure. The NOAA2017 High sea level rise scenario predicts a cooresponding increase of 7.9 feet.

Considering the design tides and sea level rise, two scenarios were developed. Option A consists of improvement to the primary crossing by replacing the existing dry laid stone structure with a new 20 foot bridge span. Option B consists of replacement of the existing structure with a 40' bridge span, which has the potential to be implemented in phases over time. Note that Option A would likely be appropriate for the NOAA2017-Intermediate sea level rise scenario, while Option B is sized to accommodated the NOAA2017-High sea level rise conditions through the year 2100 (the anticipated life of the structure).

At the secondary crossing with Flat Point Road and Small Point Road, it is recommended that one of these crossing structures is eventually eliminated over time (by rerouting the entrance to Flat Point Road). Additionally, the recommendation in span size should mimic the approach taken at the primary crossing structure. For example, if a 20 foot span is implemented at the primary crossing, a single 20 foot span should also be implemented at this secondary crossing.

The Morse Mountain Road crossing design is not driven by tidal hydraulics due to its elevation and relatively small tidal prism upstream. Overall, this structure should be improved utilizing current freshwater stream crossing standards, which would likely result in at least a four (4) foot bottomless span structure with a natural channel invert.

Improvement options would also be performed in conjunction with raising the road above tidal elevations to ensure it is serviceable and avoids annual flooding. This includes raising the road by 5.4 feet at the primary crossing to prevent flooding in during the 100-year event (including the NOAA2017-Intermediate sea level rise scenario). The total length of road reconstruction is approximately 1,300 linear feet. However, more substantial sea level rise (such as the NOAA2017-High scenario) will require much more roadway reconstruction (as much as 10 feet of fill or more) and should be considered as part of a more global planning study of Small Point Road flooding.

Project costs to construct Concept A (20-foot span) could range in the magnitude of $1.1 to $1.5 million dollars. Concept B (40-foot span) project costs could range in the magnitude of $1.6 to $2.1 million. Additionally, the cost to reconstruct and raise the existing roadway to prevent flooding in a 100-year Intermediate sea level rise scenario is likely is in the range of $0.8 to $1.1 million dollars.

APPENDIX A

NOTES

(1) DOCUMENTS REFERENCED ON THIS PLAN ARE RECORDED IN THE SAGADAHOC COUNTY REGISTRY OF DEEDS UNLESS OTHERWISE NOTED.

(2) THE DISTANCES PROVIDED ON THE PLAN ARE GRID DISTANCES. TO CONVERT GRID DISTANCES TO GROUND DISTANCES A COMBINED SCALE FACTOR OF 1.000024883 SHOULD BE APPLIED. THE PLAN IS ORIENTED TO GRID NORTH AND THE BEARINGS PROVIDED ARE GRID BEARINGS.

(3) THE NORTHERLY BOUNDARY LINE OF LAND OF MERLE E. GILLIAM AND JUNE E. GILLIAM IS DEFINED AS "A STRAIGHT LINE DRAWN FROM A BOLT IN A LEDGE NEAR THE SOUTHERN SIDE OF OF THE HOUSE OWNED BY THE GRANTORS EXTENDING WESTERLY TO THE FLOOD GATES, SO-CALLED" THE BOLT DESCRIBED COULD NOT BE RECOVERED, THE LOCATION DEPICTED ON THE DEPARTMENT OF TRANSPORTATION PLAN REFERENCED AS PLAN 1 HEREON WAS USED TO APPROXIMATE THE EASTERLY TERMINATION OF THE BOUNDARY LINE. THE LOCATION OF THE HISTORIC FLOOD GATES REFERENCED WAS LOCATED AND WAS USED FOR THE WESTERLY TERMINATION OF THE BOUNDARY LINE DEPICTED. THE EASTERLY BOUNDARY LINE OF GILLIAM ET UX. IS DESCRIBED AS "RUNNING SOUTHERLY BY THE SAID ROAD". THE BOUNDARY WAS ESTABLISHED PRIOR TO THE REALIGNMENT OF THE ROAD DEPICTED ON THE DEPARTMENT OF TRANSPORTATION PLAN REFERENCED AS PLAN 1, THE BOUNDARY FOLLOWS THE CENTERLINE OF THE ROAD RIGHT-OF-WAY AS DEFINED IN THE ORIGINAL SMALL POINT ROAD LAYOUT.

(4) THE HIGHEST ANNUAL TIDE (HAT) LINE IS DEPICTED AT AN ELEVATION OF 5.8' (NAVD88) AS DEFINED ON A PUBLICATION ENTITLED "*MAINE DEP HIGHEST ANNUAL TIDE (HAT) LEVELS FOR YEAR 2018, MAINE COAST FROM EASTPORT TO KITTERY*"

(5) RESEARCH AT THE SAGADAHOC COUNTY REGISTRY OF DEEDS FOUND NO RECORD OF A CONVEYANCE FOR THE EASEMENT AREAS DEPICTED AS PARCELS 7 AND 8 ON THE RIGHT OF WAY MAP REFERENCED AS PLAN REFERENCE 1 BELOW.

(6) HORIZONTAL AND VERTICAL COORDINATES WERE DERIVED FROM THE AVERAGE OF OPUS SOLUTIONS PROVIDED BY JAMIE CARTER, SENIOR REMOTE SENSING ANALYST AT LYNKER, LLC IN SUPPORT OF THE NOAA OFFICE FOR COASTAL MANAGEMENT. COORDINATES REFERENCE THE MAINE COORDINATE SYSTEM OF 1983, WEST ZONE (NAD_83 (2011)(EPOCH: 2010.0000). ELEVSATIONS PROVIDED REFERENCE THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) COMPUTED USING GEOID 18.

(7) THE SIDELINES OF STATE ROUTE 216 ARE DEPICTED AS SHOWN ON THE RIGHT OF WAY MAP REFERENCED IN PLAN REFERENCE 1. A SEARCH FOR A DESCRIPTION FOR THE ORIGINAL SMALL POINT ROAD LAYOUT WAS MADE THROUGH THE RECORDS OF THE TOWN OF PHIPPSBURG BY THE TOWN ADMINISTRATOR. THE SMALL POINT ROAD LAYOUT RECORDS COULD NOT BE LOCATED.

(8) FIELD LOCATION WAS SCHEDULED ON APRIL 3, 7, & 14, 2020. THE WATERLINES DEPICTED HEREON ARE BASED ON FIELD LOCATION AT LOW TIDE AND IN PART DIGITIZED FROM IMAGERY.

PLAN REFERENCES

(1) REFERENCE IS MADE TO A PLAN ENTITLED "*STATE OF MAINE DEPARTMENT OF TRANSPORTATION, BUREAU OF HIGHWAYS, RIGHT OF WAY MAP, STATE AID HIGHWAY NO. 1, PHIPPSBURG, SAGADAHOC CO.*" DATED JUNE 1939, RECORDED AS D.O.T. FILE NO. S-12-34.

(2) REFERENCE IS MADE TO A PLAN ENTITLED "*PLAN OF SUBDIVISION OF LAND OF HOOK ROCK PHIPPSBURG, MAINE*" DATED AUGUST 25 1976, PREPARED BY L.F. ROUILLARD, R.L.S., RECORDED IN THE SAGADAHOC COUNTY REGISTRY OF DEEDS IN PLAN BOOK 12, PAGE 35.

SCALE: 1"= 30'

30' 0 30' 60' 90' 120'

PLISGA & DAY
LAND SURVEYORS
72 MAIN STREET
BANGOR, MAINE
DATE: AUGUST 19, 2020
PROJ. NO. 20079
Email: info@WeMapIt.com
Phone: (207) 947-0019
Toll-Free: 1-800-734-0019
DRAWING FILE: 20079 JMW 20200819.dwg
www.WeMapIt.com

STATE OF MAINE
JULIAN M. WIGGINS
NO. 2537
PROFESSIONAL LAND SURVEYOR

SURVEY STANDARD

THIS PLAN WAS PREPARED FROM INFORMATION OBTAINED BY A SURVEY CONFORMING SUBSTANTIALLY TO THE REQUIREMENTS OF TECHNICAL STANDARDS CONTAINED IN CHAPTER 90, PART 2, OF THE RULES OF THE BOARD OF LICENSURE FOR PROFESSIONAL LAND SURVEYORS, EFFECTIVE APRIL 1, 2001.

Julian Wiggins
JULIAN M. WIGGINS, MAINE LICENSED
PROFESSIONAL LAND SURVEYOR No. 2537

BOUNDARY & TOPOGRAPHICAL SURVEY
DEPICTING A PORTION OF THE
SMALL POINT ROAD
AKA
STATE ROUTE 216
AT
LITTLE MARSH
PHIPPSBURG,
SAGADAHOC COUNTY,
MAINE

FOR
ACADIA CIVIL WORKS

APPENDIX B

ACADIA CIVIL WORKS

GRAPHIC SCALE

150 0 75 150 300 450

(IN FEET)
1 INCH = 150 FEET

(207) 212-9350
PO Box 212
Leeds, Maine
acadiacivilworks.com

ACW
ACADIA CIVIL WORKS
ENGINEERING DESIGN & CONSULTATION

NO.	REVISION	APP'D	DATE

SMALL POINT ROAD STRUCTURE
TIDAL STREAM CROSSING ASSESSMENT
PHIPPSBURG, ME
TOWN OF PHIPPSBURG

JAN 2021

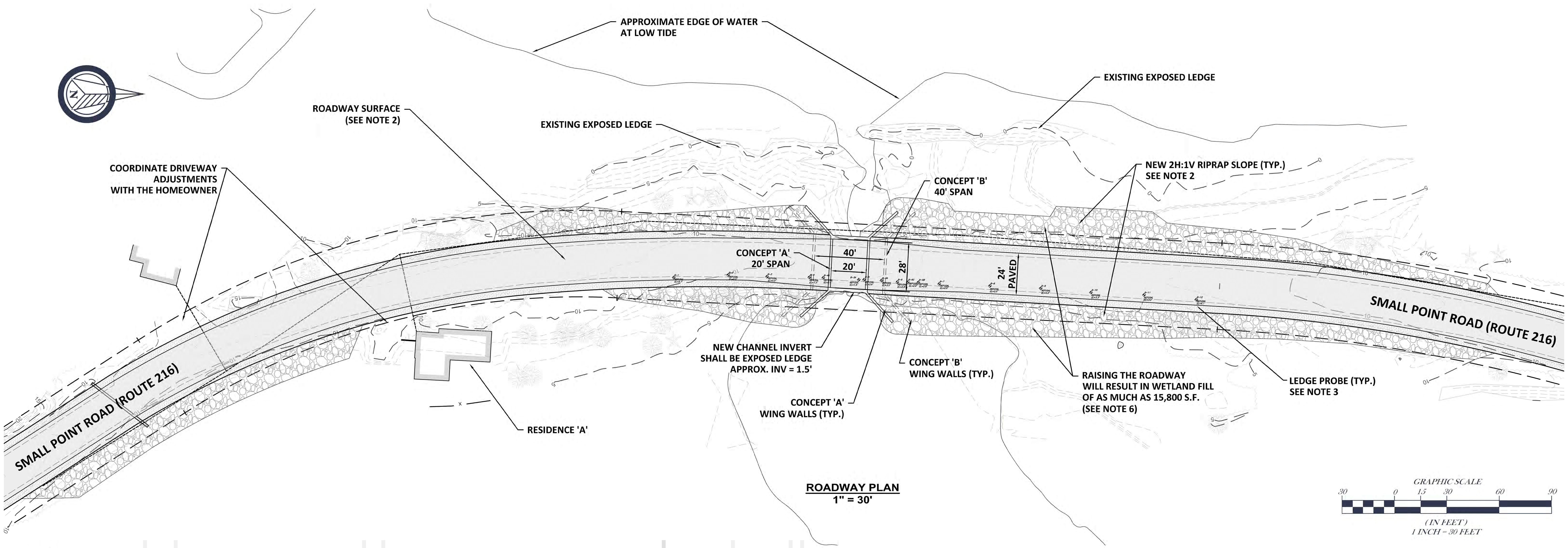
LiDAR AND EC SURVEY MAP

ACW

DRAWING
B

APPENDIX C

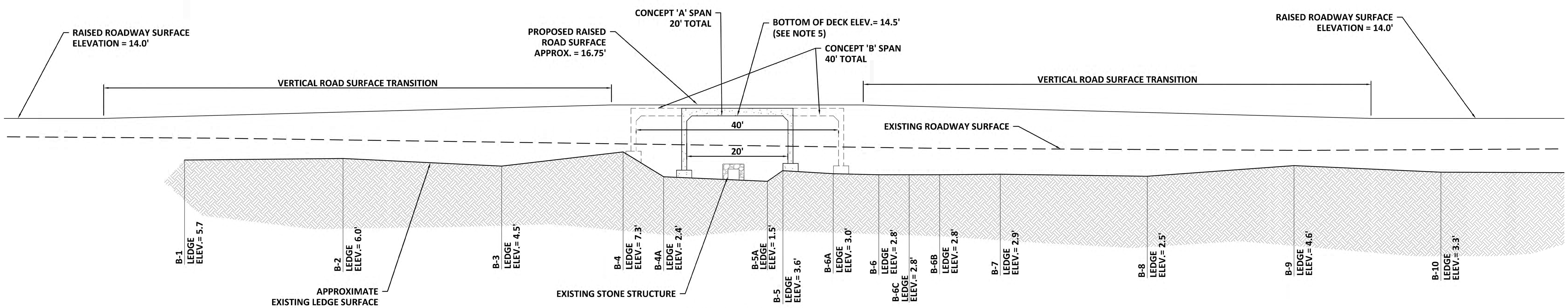
ACADIA CIVIL WORKS



ROADWAY PLAN
1" = 30'

NOTES

1. REFERENCE IS MADE TO A BOUNDARY AND TOPOGRAPHICAL SURVEY DEPICTING A PORTION OF THE SMALL POINT ROAD AT LITTLE MARSH IN PHIPPSBURG FOR ACADIA CIVIL WORKS PREPARED BY PLISGA & DAY LAND SURVEYORS. EXISTING CONDITIONS DEPICTED ON THIS PLAN HAVE BEEN TAKEN FROM THAT SURVEY.
2. THE EXTENT OF NEW RIPRAP SLOPES SHOWN ON THIS PLAN REFLECT RAISING THE ROADWAY TO APPROXIMATE ELEVATION 14 FEET (NAVD88). ELEVATION 14 REPRESENTS APPROXIMATELY ONE FOOT OF FREEBOARD AT THE ROADWAY SURFACE DURING THE 100-YEAR (1% EXCEEDANCE) PEAK TIDAL FLOOD (INCLUDING AN INTERMEDIATE SEA LEVEL RISE SCENARIO IN THE YEAR 2100). THIS REQUIRES APPROXIMATELY FIVE (5) FEET OF ROADWAY FILL AT THE EXISTING CROSSING STRUCTURE AND APPROXIMATELY 1,200 LINEAR FEET OF ROADWAY RECONSTRUCTION.
3. THE BORINGS/PROBES SHOWN ON THIS PLAN WERE PERFORMED BY ACADIA CIVIL WORKS AND NORTHERN TEST BORING IN JULY OF 2020.
4. THIS PLAN OF CONCEPTUAL IMPROVEMENTS HAS BEEN PREPARED AS AN ATTACHMENT TO THE SMALL POINT ROAD TIDAL CROSSING ASSESSMENT PREPARED BY ACADIA CIVIL WORKS IN JANUARY 2021. REFER TO THAT ASSESSMENT FOR ADDITIONAL INFORMATION.
5. THE BOTTOM OF THE STRUCTURE DECK IS SET AT A MINIMUM OF 14.5' IN ELEVATION. THIS EQUATES TO TWO (2) FEET OF FREEBOARD ABOVE THE 50-YEAR TIDE (NOAA INTERMEDIATE SLR SCENARIO IN 2100).
6. RAISING THE ROADWAY WILL RESULT IN SOME IMPACT TO WETLANDS, DUE TO THE EMBANKMENT FILL. BASED UPON THE MAINE DEP ELEVATION FOR THE HAT (APPROX. 6.5' IN ELEVATION) THIS PROJECT COULD FILL AS MUCH AS 15,800 SQUARE FEET OF WETLAND BELOW THE MAINE DEP HAT ELEVATION TO ARCHIVE THE ROADWAY GRADES SHOWN.



ROADWAY PROFILE
1" = 10'

ACW ACADIA CIVIL WORKS
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SMALL POINT ROAD STRUCTURE
TIDAL STREAM CROSSING ASSESSMENT
PHIPPSBURG, ME
TOWN OF PHIPPSBURG

CONCEPTUAL IMPROVEMENTS PLAN
JAN 2021

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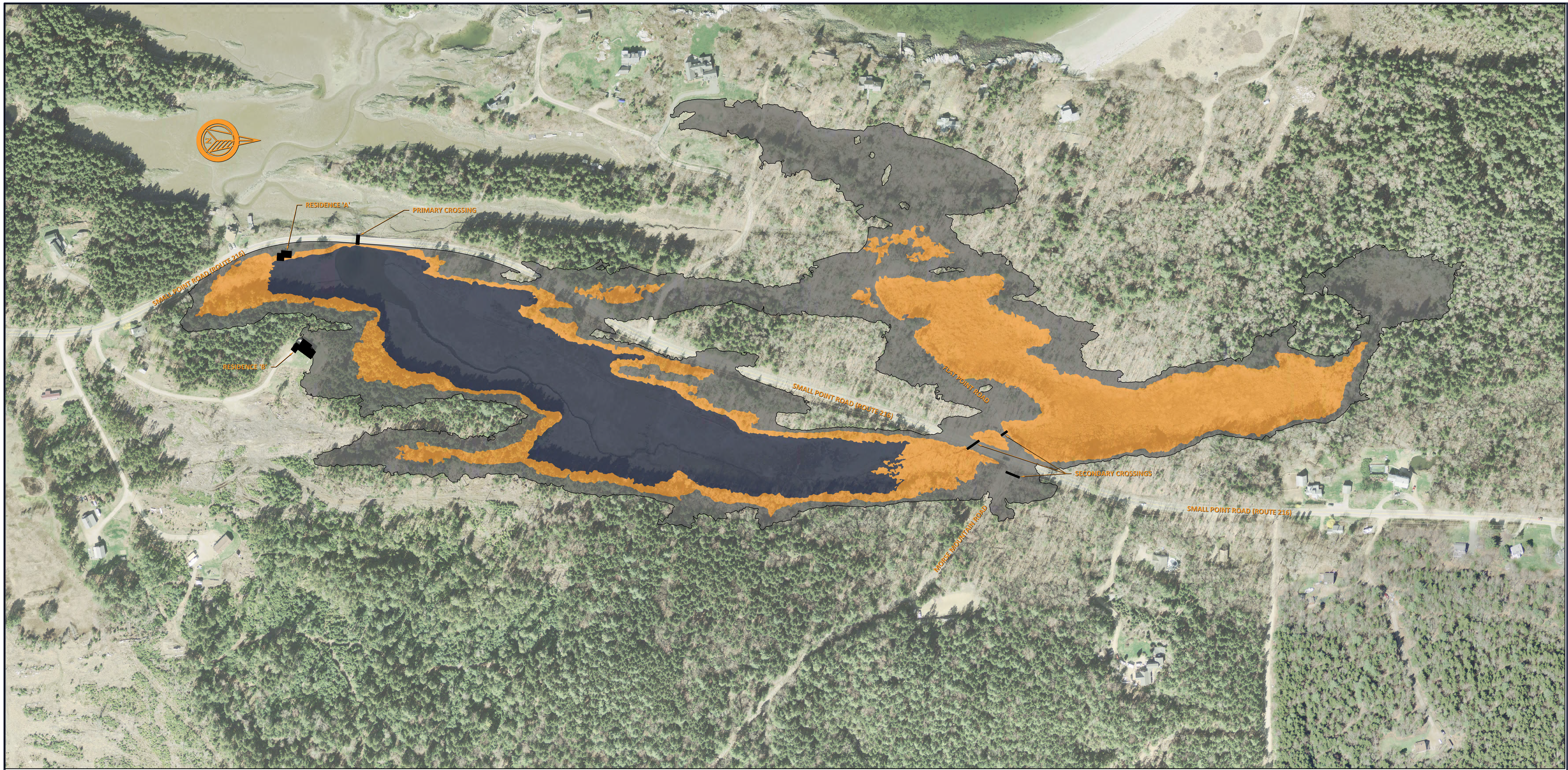
C

APPENDIX D

ACADIA CIVIL WORKS



NOTE: THE EXTENTS OF INUNDATION SHOWN ON THIS MAP ASSUME THAT THE PRIMARY CROSSING AND SECONDARY CROSSINGS HAVE BEEN IMPROVED IN ACCORDANCE WITH THE RECOMMENDATIONS OF THIS ASSESSMENT. AS SUCH, THEY SHOULD BE SEEN AS POTENTIAL INUNDATION AREAS UPON COMPLETION OF IMPROVEMENTS.

LEGEND

CURRENT (2018) - PEAK MEAN HIGHER HIGH WATER (MHHW) INUNDATION
APPROXIMATE ELEVATION = 5.0 FEET (NAVD88)
APPROXIMATE FOOTPRINT = 11.2 ACRES

FUTURE (2100 - INTERMEDIATE SEA LEVEL RISE) - PEAK MEAN HIGHER HIGH WATER (MHHW) INUNDATION
APPROXIMATE ELEVATION = 8.3 FEET (NAVD88)
APPROXIMATE TOTAL FOOTPRINT = 24.9 ACRES

FUTURE (2100 - HIGH SEA LEVEL RISE) - PEAK MEAN HIGHER HIGH WATER (MHHW) INUNDATION
APPROXIMATE ELEVATION = 12.9 FEET (NAVD88)
APPROXIMATE TOTAL FOOTPRINT = 46.2 ACRES

GRAPHIC SCALE
150 0 75 150 300 450
(IN FEET)
1 INCH = 150 FEET

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SMALL POINT ROAD STRUCTURE
TIDAL STREAM CROSSING ASSESSMENT
PHIPPSBURG, ME
TOWN OF PHIPPSBURG

MHHW INUNDATION MAPPING

JAN 2021

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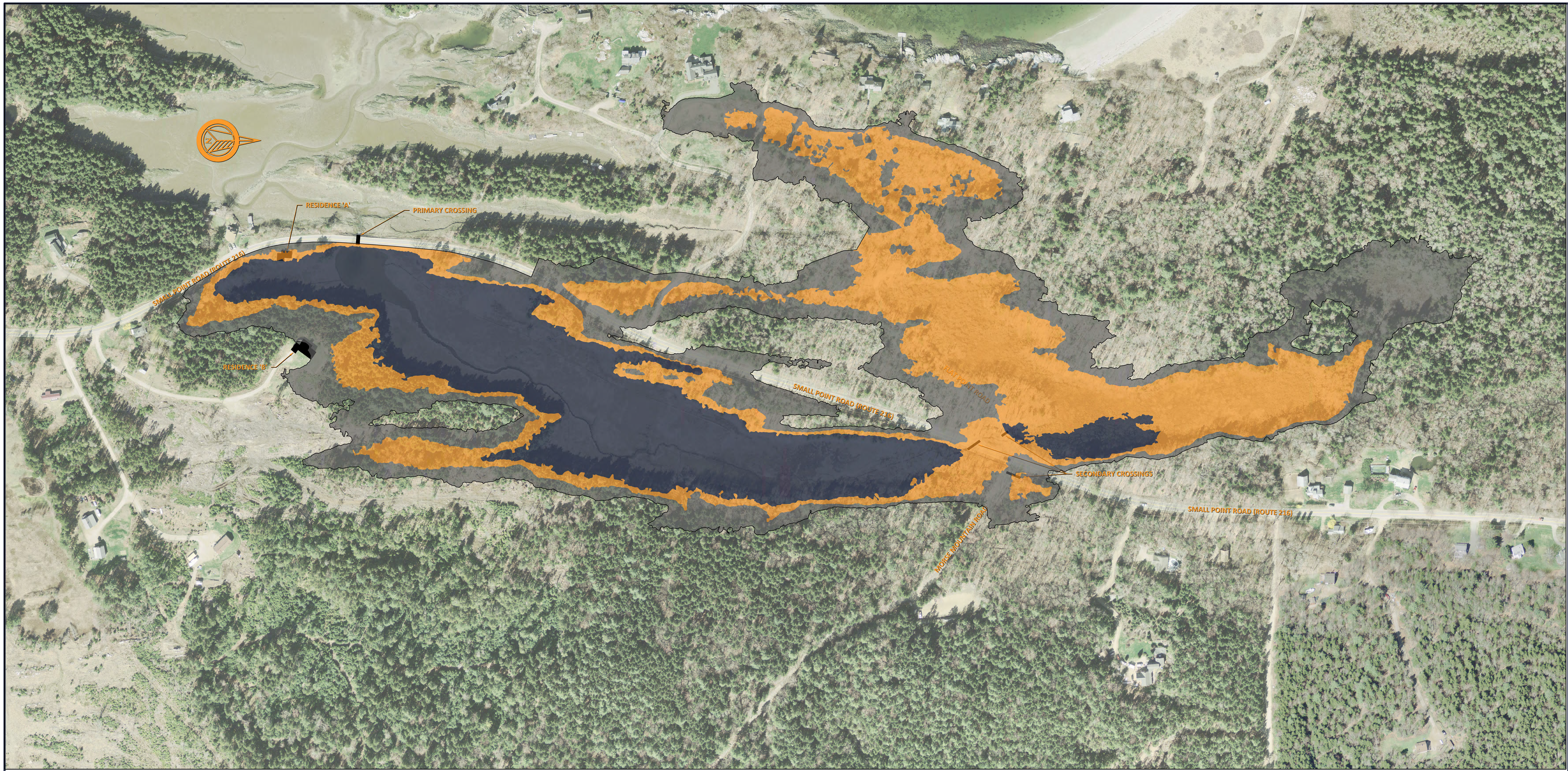
D

APPENDIX E



ACADIA CIVIL WORKS

NOTE: THE EXTENTS OF INUNDATION SHOWN ON THIS MAP ASSUME THAT THE PRIMARY CROSSING AND SECONDARY CROSSINGS HAVE BEEN IMPROVED IN ACCORDANCE WITH THE RECOMMENDATIONS OF THIS ASSESSMENT. AS SUCH, THEY SHOULD BE SEEN AS POTENTIAL INUNDATION AREAS UPON COMPLETION OF IMPROVEMENTS.

LEGEND

CURRENT (2018) - PEAK 99% EXCEEDANCE FLOOD INUNDATION
APPROXIMATE ELEVATION = 6.9 FEET (NAVD88)
APPROXIMATE FOOTPRINT = 14.5 ACRES

FUTURE (2100 - INTERMEDIATE SEA LEVEL RISE) - PEAK 99% EXCEEDANCE FLOOD INUNDATION
APPROXIMATE ELEVATION = 10.2 FEET (NAVD88)
APPROXIMATE TOTAL FOOTPRINT = 32.4 ACRES

FUTURE (2100 - HIGH SEA LEVEL RISE) - PEAK 99% EXCEEDANCE FLOOD INUNDATION
APPROXIMATE ELEVATION = 14.8 FEET (NAVD88)
APPROXIMATE TOTAL FOOTPRINT = 53.9 ACRES

GRAPHIC SCALE
150 0 75 150 300 450
(IN FEET)
1 INCH = 150 FEET

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SMALL POINT ROAD STRUCTURE
TIDAL STREAM CROSSING ASSESSMENT
PHIPPSBURG, ME
TOWN OF PHIPPSBURG

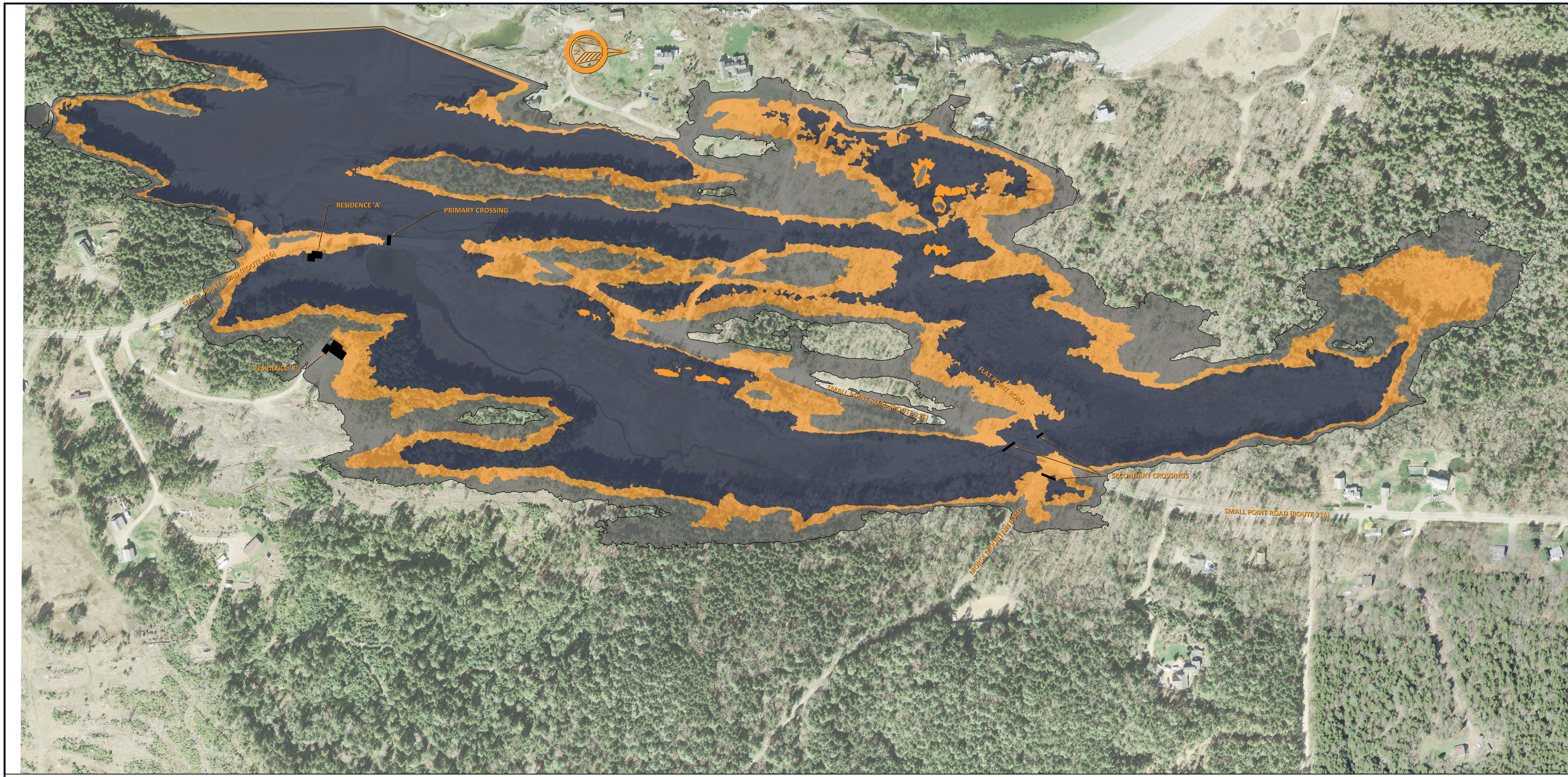
99% EX INUNDATION MAPPING

JAN 2021

DRAWING
E

APPENDIX F

ACADIA CIVIL WORKS



LEGEND

(dark blue)	CURRENT (2018) - 1% EXCEEDANCE (100-YEAR) INUNDATION APPROXIMATE ELEVATION = 9.6 FEET (NAVD88)
(orange)	FUTURE (2100 - INTERMEDIATE SEA LEVEL RISE) - 1% EXCEEDANCE (100-YEAR) INUNDATION APPROXIMATE ELEVATOIN = 12.9 FEET (NAVD88)
(grey)	FUTURE (2100 - HIGH SEA LEVEL RISE) - 1% EXCEEDANCE (100-YEAR) INUNDATION APPROXIMATE ELEVATION = 17.5 FEET (NAVD88)

GRAPHIC SCALE
150 0 75 150 300 450
(IN FEET)
1 INCH = 150 FEET

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SMALL POINT ROAD STRUCTURE
TIDAL STREAM CROSSING ASSESSMENT
PHIPPSBURG, ME
TOWN OF PHIPPSBURG

1% EXCEEDANCE INUNDATION MAPPING
JAN 2021

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F

APPENDIX G

Maine Department of Transportation

Managed Asset/Feature Inventory

Managed Roadside Hardware and Non-Transportation Facilities -
Friday - September 06, 2019

Report Description: Detail of **XC-194616** - Features by Element and Condition

MY PARENT

ELEMENT ID	DESCRIPTION	CREW NAME	ASSET TYPE	X LONG	Y LAT
MRA-173503	0216X .32 - 2.3 MRA-173503	REGION 1 ADMINISTRATION	USER ROUTE ASSETS		

ROUTE	ELEMENT ID	BEGIN MILE POINT/TOWN	END MILE POINT/TOWN	MAINTENANCE CREW	SIDE OF ROAD	ASSET GROUP
0216X	XC-194616	1.244 IN PHIPPSBURG	1.244 IN PHIPPSBURG	71105	ACROSS	CROSS CULVERT
(12) PICTURES AVAILABLE		(2) OWRS AVAILABLE	(2) WRS AVAILABLE	NO CHILD RECORDS		NO STOCKPILES

RLM DATE	INACTIVE DATE	CREW NAME	ASSET TYPE
14-JAN-19		REGION 1 TOPSHAM CREW	CULVERT -ARRAY

BEGIN DATE	END DATE	Y LATITUDE	X LONGITUDE	
20-AUG-09		43.74004	-69.841541	MDOT MAP GOOGLE MAP

SCORE	INSTALL DATE	NOTES
67		INSPECTION COMPLETE. 01-14-19 (SWH) TIMBER FRAME DECK WITH GRANITE BASE WALLS.

TAB_ASSET=2802

2802 - INSPECTION-SITE INFO(S) *TOTAL TAB ASSETS = 1*

DISPLAY CODE	DESCRIPTION	BEGIN DATE	END DATE
INSP-657587	INSPECTION #1 FOR XC-194616	09-OCT-10	

INSPECTOR	LAST INSPECTION DATE	REPAIRED DATE
TBM,SWH	14-JAN-19	

VISITATION TYPES	NEXT INSPECTION DATE	MODIFICATION DESCRIPTIONS	SINK HOLES
INFORMATIONAL	15-APR-19	THE DECK OF THIS CULVERT IS TIMBER FRAME. THE WALLS AND BASE ARE GRANITE STONE. THE TIMBER IS IN VERY POOR CONDITION WITH MANY TIMBER PIECES MISSING.DISLPACED BLOCKS AND WALL DEFORMATION.	MINOR

COMMENT: (NULL)

TAB_ASSET=1103

1103 - CULVERT - BARREL (S) *TOTAL TAB ASSETS = 1*

DISPLAY CODE	DESCRIPTION	BEGIN DATE	END DATE
BAR-657586	BARREL #1 FOR XC-194616	16-OCT-10	

BARREL STRUCTURE TYPE	BARREL CONDITION.	BARREL LENGTH(FT)	SPAN HEIGHT(IN)	SPAN WIDTH(IN)	SPAN NUMBER
04 TIMBER CULVERT	03 POOR	32	48	36	1

SMOOTH BORE	DEPTH(FT)	SKEW ANGLE	ADD LENGTH?	ROAD SETTLING?
NO	3	NO	1 TO 10 FEET NEEDED	NO

COMMENT: (NULL)

TAB_ASSET=1104

1104 - CULVERT INLET/OUTLET CONDITION *TOTAL TAB ASSETS = 1*

DISPLAY CODE	DESCRIPTION	BEGIN DATE	END DATE
CUL_IO-657585	DRAIN IN/OUTLET #1 FOR XC-194616	16-OCT-10	

DRAIN TYPE	FLOW CONDITION	EROSION
INLET/OUTLET	GOOD	MODERATE

COMMENT: (NULL)

258 Small Point Rd, Phippsburg
43.74004, -69.841533 (8.25 ft.)

1 Feature Found: Show Road Info

Cross Culverts 1

194616

Asset ID	194616
Condition	Poor
Crew	71105
Depth	3
Description	0216X 1.244 Culvert-194616
Element ID	XC-194616
Height	48
Last Inspection Date	1/14/2019 9:18:00 AM
Length	32
MP	1.244
Notes	Inspection Complete. 01-14-19 (SWH) Timber Frame Deck with Granite Base walls.
OFFSET	0
Region	1
RLM Date	1/14/2019
Route	0216X
Spans	1
Town	Phippsburg
Type	Timber Culvert
Width	36
X LONG	-69.841541
Y LAT	43.74004

APPENDIX H

ACADIA CIVIL WORKS

LEGEND

(magenta)	RAISE ROADWAY ABOVE CURRENT (2018) 100-YEAR (1% EXCEEDANCE) TIDE LEVELS TOTAL LENGTH OF ROADWAY RECONSTRUCTION = APPROXIMATELY 600 LINEAR FEET
(cyan)	RAISE ROADWAY ABOVE FUTURE T(2100) 100-YEAR (1% EXCEEDANCE) TIDE LEVELS ASSUMING A NOAA-2017 INTERMEDIATE SEA LEVEL RISE SCENARIO TOTAL LENGTH OF ROADWAY RECONSTRUCTION = APPROXIMATELY 1,200 LINEAR FEET
(red)	RAISE ROADWAY ABOVE FUTURE T(2100) 100-YEAR (1% EXCEEDANCE) TIDE LEVELS ASSUMING A NOAA-2017 HIGH SEA LEVEL RISE SCENARIO TOTAL LENGTH OF ROADWAY RECONSTRUCTION = APPROXIMATELY 3,100 LINEAR FEET

GRAPHIC SCALE
150 0 75 150 300 450
(IN FEET)
1 INCH = 150 FEET

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ENGINEERING DESIGN & CONSULTATION

NO.	REVISION	APP'D	DATE

SMALL POINT ROAD STRUCTURE
TIDAL STREAM CROSSING ASSESSMENT
PHIPPSBURG, ME
TOWN OF PHIPPSBURG

JAN 2021

ROADWAY EXTENTS MAP

DRAWING
H

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