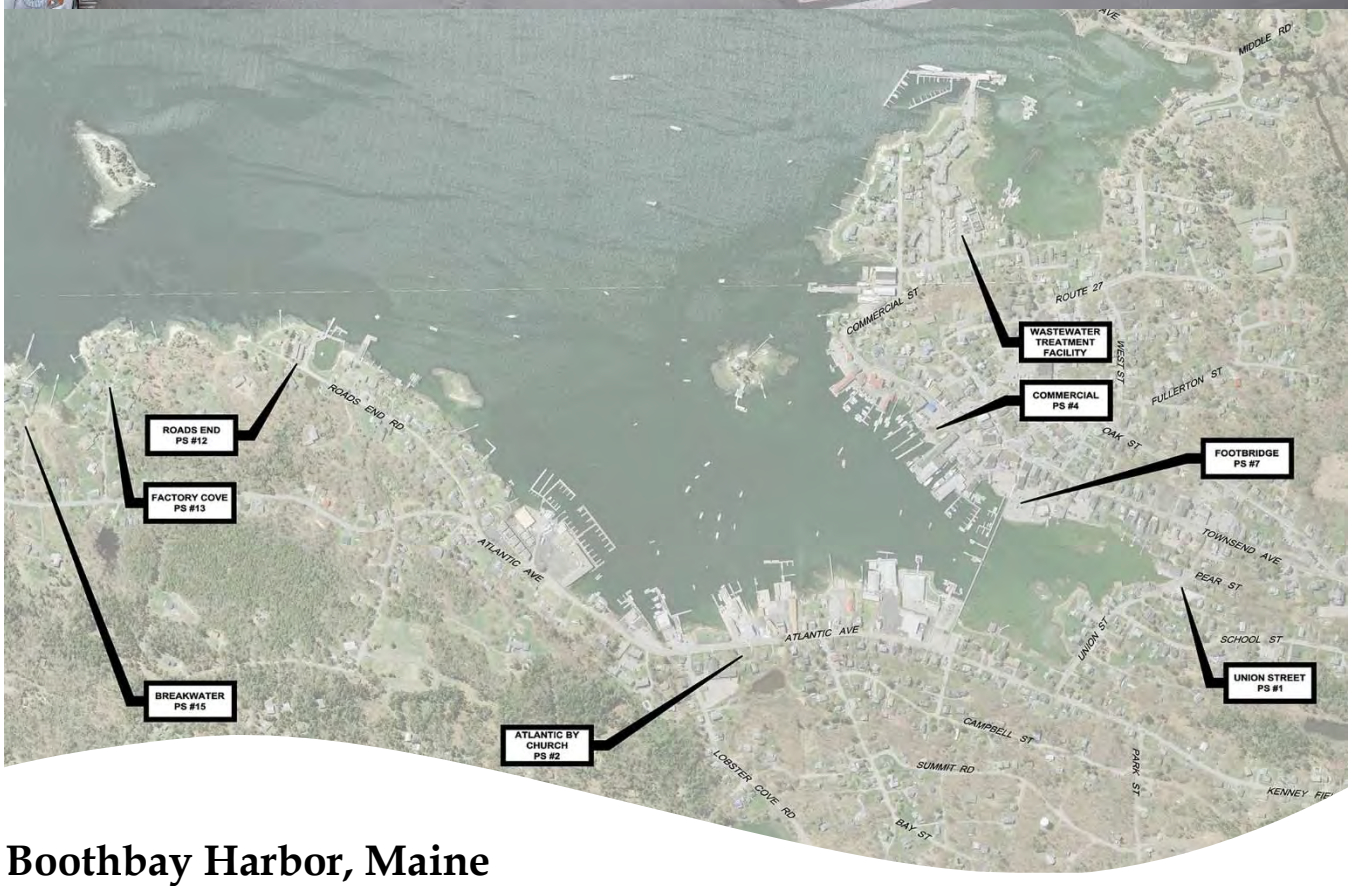


Boothbay Harbor, Maine

Wastewater Facilities Sea Level Rise & Storm Surge Impact Assessment

Date: January 2017

Prepared by Wright-Pierce

Table of Contents

	INTRODUCTION	Page
Acknowledgements		1
Section 1	Executive Summary	2
Section 2	Goals, Study Approach and Recommendations	3
Section 3	Discussion of Climate Change Parameters	8
Section 4	Description of Existing Facilities	17

	IMPACTS & MITIGATION OPTIONS	Page
Section 5	Potential Inundation Effects at the Wastewater Facilities	29
Section 6	Adaptation Strategies	59
Section 7	Potential Funding Sources	68

APPENDICES

A. Overview Map of Wastewater Facilities

B. Wastewater Treatment Facility Inundation Plan and Profile

C. Pump Station Inundation Plan and Profiles

D. Adaptation Strategies – Cost Considerations Matrix

E. FEMA Flood Insurance Rate Maps

F. Reference Resources

Acknowledgements

This report was prepared for the Lincoln County Regional Planning Commission and Boothbay Harbor under awards CZM NA14NOS4190066 and NA15NOS4190208 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.

Guidance and plan development assistance was provided by the following individuals:

Steering Committee

William Hamblen, Planning Board

Chris Higgins, Wastewater Superintendent

Deryl Kipp, Sewer District Trustee

Jim Stormont, Sewer District Trustee

Ted Tedeschi, Jr., Sewer District Trustee

Michael Tomko, Selectman

Thomas Woodin, Town Manager

Lincoln County Regional Planning Commission

Robert Faunce, County Planner

Maine Geological Survey

Peter Slovinski, Marine Geologist

Wright-Pierce

Travis Pryor, RLA – Project Manager

Jon Edgerton, PE – Principal-in-Charge

Bryanna Denis, PE – Lead Project Engineer

Thomas Hamill – GIS Technician

1 Executive Summary

The District is considering adaptation strategies for improvements to its wastewater facilities that could mitigate impacts to their infrastructure from predicted environmental climate change factors including coastal flooding, sea level rise, storm surge, and rainfall precipitation.

The Wastewater Treatment Facility (WWTF) and several Pump Stations along the perimeter of Boothbay Harbor have been identified by the District as having the potential to be impacted by these climate change factors. With the support of the State's Maine Coastal Program and federal funding from NOAA, the District retained Wright-Pierce to assess potential impacts to the wastewater treatment facilities, and to evaluate adaptation strategies for mitigation of the potential impacts.

A review of readily available data related to the wastewater facilities and environmental site conditions, along with input and guidance from the District, served as the basis for selection of (3) three planning scenario flood elevations to be utilized for this assessment. The results of the assessment are intended to provide the District with a cost / benefit matrix to guide them in making prioritized capital construction, maintenance and operations decisions. These decisions consider the District's near, mid- and long-term goals to provide continued sewer service to portions of the communities of Boothbay Harbor, Boothbay and Southport over an approximately 50-year planning horizon through 2070.

The District does not anticipate significant residential or commercial growth within the community, which would significantly impact the capacity of the current wastewater treatment facilities to serve the needs of the community by 2070.

The following timeframes for guiding prioritized coastal flooding mitigation improvements to the wastewater treatment facilities are recommended for the District to consider, along with capital costs:

- Near-term is considered within 20 years (2020 to 2040)
- Mid-term is considered from 20 to 40 years (2040 to 2060)
- Long-term is considered beyond 40 years to the planning horizon (2060 to 2070+)

It is also important to note that current federal regulations and funding agency supported guidelines are requiring that critical infrastructure be protected within Federal Emergency Management Agency (FEMA) 100-year coastal flood zones to an elevation of 3 feet above the 100-year base flood elevation (BFE). While this additional elevation above the 100-year BFE may address climate impacts due to increased flooding from sea level rise, or from greater storm surge events, the BFE plus 3 feet (BFE +3) of additional elevation may not account for impacts from both environmental factors combined.

The findings and recommendations of this assessment consider planning scenarios for flood elevations in excess of BFE +3 by adding 1 foot, 2 feet and 3 feet of additional flood elevation above the current this regulatory benchmark. The majority of the wastewater facilities assessed were found to be impacted by inundation in a similar manner under each of these three planning scenarios. Correspondingly, cost estimates for implementing adaptation measures to mitigate these impacts were generally found to be nominal between the three planning scenario elevations.

2 Goals, Study Approach and Recommendations

Goals

The District's goal of this assessment is to identify which of their wastewater facilities could be impacted by coastal flooding from potential climate change factors including, sea level rise, storm surge and rainfall precipitation. After the facilities prone to such impacts are identified the assessment should develop adaptation strategies to mitigate potential impacts to the District's wastewater treatment facilities from a cost / benefit standpoint, comparing impacts and associated mitigation costs for each of the three flood elevation planning scenarios selected by the District.

The State's goal in supporting this project is not only to develop sound planning for protection of the District's wastewater facilities from predicted coastal hazards, but to also develop a study that may have components which are transferable to other similar coastal Maine communities.

Approach

The assessment commenced with a review of readily available sources including:

- Topographic LiDAR data (Accurate to plus or minus 1.00 vertical foot of elevation).
- Record drawings of the wastewater treatment facilities.
- FEMA flood mapping identifying Special Flood Hazard Areas (SFHAs) over or in close proximity to the wastewater treatment facilities.
- Historic sea level rise data from NOAA and predicted sea level rise scenarios from the United States Army Corps of Engineers (ACOE).
- Historic data and predicted 100-year and 500-year 24-hour rainfall precipitation totals from the National Weather Service (NWS).
- Historic hurricane records and predicted storm surge inundation depths from NOAA and the NWS.
- Federal regulations, and guidelines of federal and state agency programs supporting operations and maintenance of critical wastewater infrastructure systems.

All elevation data was correlated to a common vertical datum for consistency. The geodetic vertical datum referenced for this study and all subsequent elevations denoted in this assessment (unless otherwise noted elsewhere) is the North American Vertical Datum of 1988 (NAVD88).

Based on the initial review of readily available data, the following wastewater facilities were identified as having potential to be impacted by coastal flooding from sea level rise and storm surge:

- Wastewater Treatment Facility (WWTF)
- Union Street Pump Station (PS #1)
- Atlantic by Church Pump Station (PS #2)
- Commercial Street Pump Station (PS#4)
- Footbridge Pump Station (PS #7)
- Roads End Pump Station (PS #12)
- Factory Cove Pump Station (PS #13)
- Breakwater Pump Station (PS #15)

These initial findings were reviewed by the District, who in turn provided additional wastewater facilities data based on their maintenance and operations experience with the facilities. Supplemental field observations were also made by Wright-Pierce.

A range of potential inundation elevations corresponding to regulatory requirements and additional predicted sea level rise and storm surge conditions through 2070 were discussed with the District. After these discussions, three planning scenario elevations were selected by the District for assessment of potential impacts to the wastewater facilities and for suggested adaptation strategies to mitigate the impacts at each of these inundation elevations. The three scenarios selected are as follows:

- FEMA 100-year base flood elevation (BFE) plus 3 feet, plus 1 foot of sea level rise (herein referenced as BFE +4)
- FEMA 100-year base flood elevation (BFE) plus 3 feet, plus 2 feet of sea level rise (herein referenced as BFE +5)
- FEMA 100-year base flood elevation (BFE) plus 3 feet, plus 3 feet of sea level rise (herein referenced as BFE +6)

(See Section 3 for more detail discussion supporting these elevations)

The three planning scenario elevations were applied to the existing wastewater facilities data. Mapped plans and profiles of the facilities were created to illustrate delineation of the potential limits of inundation to the wastewater treatment facilities.

Based on a review of the inundation limits at each of the wastewater facilities studied, impacts to the facilities were characterized in association with each of the three planning scenarios. The results of these potential impacts under each planning scenario were tabulated to illustrate relative level of inundation impacts by each of the three flood elevation planning scenarios.

A range of adaptation strategies and associated planning level cost estimates for each of the three planning scenarios were identified and discussed with the District and general public. Based on these discussions and in consideration of the District's goals stated above, the range of adaptation strategies and associated planning level cost estimates were further refined.

Recommendations

The District is concerned with the potential for negative impacts to the WWTF and several pump stations in the face of potential storm surges and sea level rise impacts to these facilities located within Boothbay Harbor. Wright-Pierce offers the following recommendations for the District's consideration to assist in prioritizing implementation the various suggested adaptation strategies:

- The District's wastewater facilities have provided consistent and reliable service to the Towns of Boothbay Harbor, Boothbay and Southport for many years, however, equipment and building systems will require upgrades in order to provide continued reliable service. Given the location and elevation of the wastewater treatment facilities, adaptation measures for BFE +3 or BFE +4 should be incorporated into near-term and mid-term capital improvements planning. For long-term planning, or where costs associated with additional materials to protect the facilities at higher planning scenario elevations are relatively small in increase, it may be prudent to consider adaptation measures of BFE +5 or BFE +6 in the near term as well. If those options are not feasible, relocation of the wastewater facilities to new sites may become reasonable to consider.
- The costs associated with the potential relocation of the WWTF and any of the pump stations are substantial. In addition, land that is currently available and may be suitable for relocation of the WWTF or any of the pump stations could be developed by other interests over time (and therefore would no longer be available). In order to proactively address the potential for long-term relocation, it would be appropriate for the District to consider potential sites for WWTF and pump station relocations in the near term. Once suitable parcels are identified, it may also be appropriate to consider purchase of some or all of those parcels. While relocation of pump stations would require minimal land area to purchase in fee ownership or be permanent easement, larger land area needed for relocation of the WWTF may be more difficult to find. Relocation of the WWTF may require a developable parcel between 2.2 to 10 acres, based on the current WWTF's 2.2 million gallon per day (MGD) full treatment capacity and the Water Environment Federation's "Design of Municipal Wastewater Treatment Plants – Manual and Reports on Engineering Practices Vol. 8, 1998" design guidelines of 1 acre/MGD to 4.5 acres/MGD.
- Going forward, the District should continue to engage agencies that provide grant funding for wastewater infrastructure in small communities as well as adaptation planning and/or implementation.
- The District should estimate the user rate impacts of these major capital projects and develop proposed adjustments to user rate system and reserve accounts to address the near-term, and long-term revenue needs, as they deem necessary and appropriate.
- Coordinate with the Town of Boothbay Harbor and abutting property owners where adaptation strategies include relocation of, or significant increases in elevation of the wastewater treatment facilities. This will likely be key to integrating upgrades of the Commercial Street and Footbridge pump stations within the context of the waterfront commercial districts aesthetic and functional needs.

- The District should identify the potential for 'floating' of tanks based on buoyancy of the WWTF structures under the three flood elevation planning scenarios when the structures are not overtopped. Wright-Pierce typically designs for groundwater equal to ground surface, so groundwater/floodwater at several feet above grade will add buoyancy which would involve into a greater level of structural "safety factor" assessment beyond the scope of this study.
- This assessment does not require that the District make any immediate, or long term decisions to act on any or all of the suggested adaptation strategies for mitigation of coastal flood impacts under any of the three planning scenarios. Some infrastructure improvements will likely be required as the wastewater facilities reach their normal life expectancies regardless of the assessment's adaptation mitigation strategies. When such upgrades of any of the wastewater treatment facilities become necessary, the District will likely need to comply with one or more of the New England Interstate Water Pollution Control Commission's (NEIWPCCs) TR-16 Guidelines as follows:

    - All systems should evaluate sewer lines that run cross country through easements located in a 100-year floodplain. The sewer manholes in these sections should be protected from I/I in flood conditions. Considerations to include water-tight manholes or manholes raised above the 100-year flood level. NEIWPCC
    - Underground fuel tanks for generators should be safeguarded against buoyancy and lateral movement by floods. Extra ballast can be added above the tank as needed.
    - Recognize the need for locating process units above potential flood levels to avoid possible process unit and equipment damage or process interruption. When eliminating the potential for process interference is not practical due to high receiving stream levels under flood conditions, provide emergency effluent pumping facilities.
    - Wastewater facilities susceptible to flooding should consider implementing a flood monitoring protocol to enable advance warning of rising water.
    - Backup Power Supply: Normal operation of the treatment processes should be maintained at all times. Furnish the backup power supply for critical equipment by using emergency power generation or an alternative power source of sufficient capacity. In addition, ensure that there is enough fuel to run under full load or peak flow for at least 48 hours, or under normal operating conditions for at least 96 hours, whichever requires the greater amount of fuel.
    - Any basement structure in a building located in a flood plain should consider including a flood alarm.
    - Potential emergencies should be considered in the design of wastewater treatment works. During emergencies as well as routine operations, primary concerns are personal safety and the ability to maintain the process equipment efficiently. Designs should include consideration of operations activities that may occur after daylight hours. Effective drainage inside and outside of buildings is key to avoiding icing issues and health impacts, and to ensuring safe working conditions.
    - Designs should avoid creating "confined space" conditions whenever possible. Emergency access and egress for emergency vehicles should be included in the engineering report as

well as recommendations for permanent safety features (e.g., sprinklers, fire hydrants, and alarm systems).

- In areas where hazardous chemicals are stored or used, provide appropriate emergency equipment such as eye wash stations and emergency showers. Ensure all areas where emergency equipment is located have appropriate signage and means of access and egress for emergency personnel. In areas of the plant where powdered or granular chemicals that can generate dust are handled, provide adequate ventilation.
- At plants that use chlorine gas, chlorine gas detection alarm systems should be provided with consideration for redundancy of the system.

(See Section 3 below for further detailed discussion regarding regulatory and potential funding agency requirements for protection of "Critical" wastewater treatment facility assets.)

3 Discussion of Sea Leve Rise / Storm Surge Parameters

This study considers the follow environmental factors and their potential impacts on the District's wastewater treatment facilities:

- Coastal flooding
- Sea level rise
- Storm surge
- Increased rainfall precipitation

Coastal Flooding:

FEMA has recently updated Flood Insurance Rate Maps (FIRMs) within the Town of Boothbay Harbor, effective as of July 16, 2015. These maps indicated that the WWTF and pump stations PS #15, PS #13, PS #12, PS #7, PS #4, PS #2 and PS#1 are within or in close proximity to Special Flood Hazard Areas (SFHA) identified by FEMA as 100-year AE and VE zones. These flood areas have a 1% annual change of being equaled or exceeded within any given year. FEMA defines AE zones as areas subject to inundation by the 1% annual chance flood event with a known BFE. FEMA defines VE zones as areas subject to inundation by the 1% annual chance flood event with a known BFE also due to additional hazards from storm induced velocity wave action. Known elevations for both of these SFHA are based on coastal flood studies that: analyze the effects of rainfall precipitation, tides, storm surges and waves; consider historical coastal flood events that have affected the study area; and use historical data to validate flood, wave and erosion analyses.

In addition to the defined FEMA 100-year flood zone elevations

Federal Executive Order 11988: Flood Plain Management (EO 11988) was amended as of January 30, 2015. Specifics of this amendment in relation to the District's wastewater treatment facilities require that this infrastructure be protected by adding an additional 3 feet to the 100-year BFE for "Critical" assets and 2 feet above the 100-year BFE for "Non-Critical" assets.

EO 11988 currently states:

(i) Section 6(c) is amended by striking ", including at a minimum, that area subject to a one percent or greater chance of flooding in any given year" and inserting in lieu thereof:

". The floodplain shall be established using one of the following approaches:

> *"(1) Unless an exception is made under paragraph (2), the floodplain shall be:*
>
> > *"(i) the elevation and flood hazard area that result from using a climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate*

> *science. This approach will also include an emphasis on whether the action is a critical action as one of the factors to be considered when conducting the analysis;*
>
> *"(ii) the elevation and flood hazard area that result from using the freeboard value, reached by adding an additional 2 feet to the base flood elevation for non-critical actions and by adding an additional 3 feet to the base flood elevation for critical actions;*
>
> *"(iii) the area subject to flooding by the 0.2 percent annual chance flood; or*
>
> *"(iv) the elevation and flood hazard area that result from using any other method identified in an update to the FFRMS.*

EO 11988 defines Critical as:

"(d) The term 'critical action' shall mean any activity for which even a slight chance of flooding would be too great."

The Environmental Protection Agency (EPA) has submitted draft regulations to the Federal Office of Management and Budget (OMB) describing how they will comply with EO 11988. Review by OMB has implied that the draft document was insufficient with no additional information offered to the public at this time.

The Maine Department of Environmental Protection who administers distribution of Federal Clean Water State Revolving Loan Funds (CWSRF) in support of sewer infrastructure needs in the state has no current requirement address the new FIRM elevations. With that said, FEMA has indicated that they are only willing to fund projects that address EO 11988. Furthermore, MaineDEP has long used NEIWPCC's TR-16 Guidelines for the Design of Wastewater Treatment Works and the latest revised version of this document as of May of 2016 generally follows the EO11988 definition of protecting infrastructure.

In short, EO 11988 mandates that any critical asset within the FEMA 100-year flood zone be protected to an elevation of 3 feet above the BFE, and while the regulations defining critical infrastructure are currently being defined, state and federal funding sources are likely to support this elevation benchmark for projects that they support.

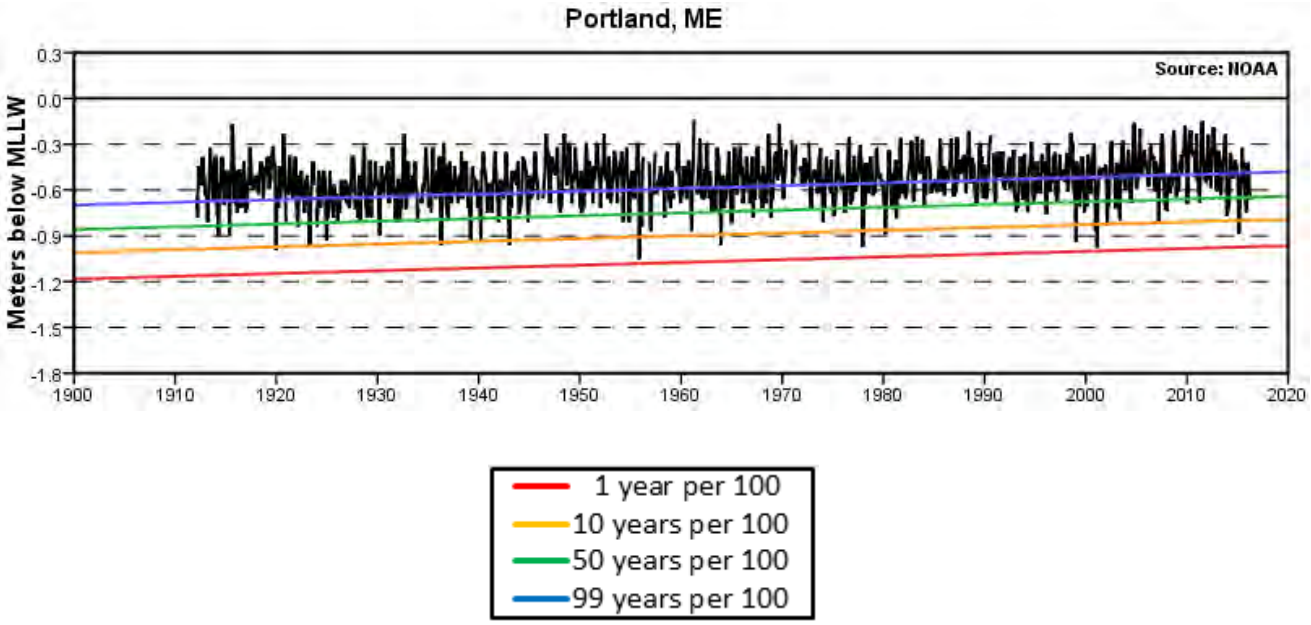
As noted above, FEMA SFHAs are based on analysis of historical flooding data and do not consider potential effects of climate change which may result increases to the 100-year BFEs. Discussions of potential increased impacts due to climate change factors including sea level rise, storm surge and rain fall precipitation follow below in this section of the assessment.

Sea Level Rise:

Advances in predictive scientific modeling and availability of historic sea level rise data for a period of greater than a century have led to development of future sea level rise scenarios that are receiving increased support from local, state and federal entities responsible for operating and maintaining our nation's infrastructure. Studies based on historic flood data alone do not consider effects of climate change on future flooding events and an increased importance has been placed on sea level rise scenarios and their potential impacts to public infrastructure.

Below is a chart of extreme water levels above the mean highest high water elevation as measured at the National Oceanic and Atmospheric Administration's (NOAA) nearest tidal station gauge nearest to Boothbay Harbor (Station 8418150 in Portland). The monthly extreme water levels include a Mean Sea Level (MSL) trend of 1.82 millimeters/year with a 95% confidence interval of +/- 0.17 millimeters/year based on monthly MSL data from 1912 to 2006 which is equivalent to a change of 0.60 feet in 100 years.

The plots below show the monthly highest water levels with the 1%, 10%, 50%, and 99% annual exceedance probability levels in red, orange, green, and blue. The plotted values are in meters relative to the Mean Higher High Water (MHHW) datum established by CO-OPS (1 foot = 0.3 meters). On average, the 1% level (red) will be exceeded in only one year per century, the 10% level (orange) will be exceeded in ten years per century, and the 50% level (green) will be exceeded in fifty years per century. The 99% level (blue) will be exceeded in all but one year per century, although it could be exceeded more than once in other years.



The United States Army Corps of Engineers (USACOE) Sea Level Change Curve Calculator was utilized for this project to illustrate a range of sea level rise planning scenarios for the District's consideration. The USACOE calculator includes historic NOAA tidal gauge data (as indicated above) and the U.S. National Climate Assessment sea level rise curve data in reference to local mean sea level (LMSL).

NAVD88 is 0.09 meters, or 0.30 feet above the LMSL tidal datum at NOAA's Portland Station.

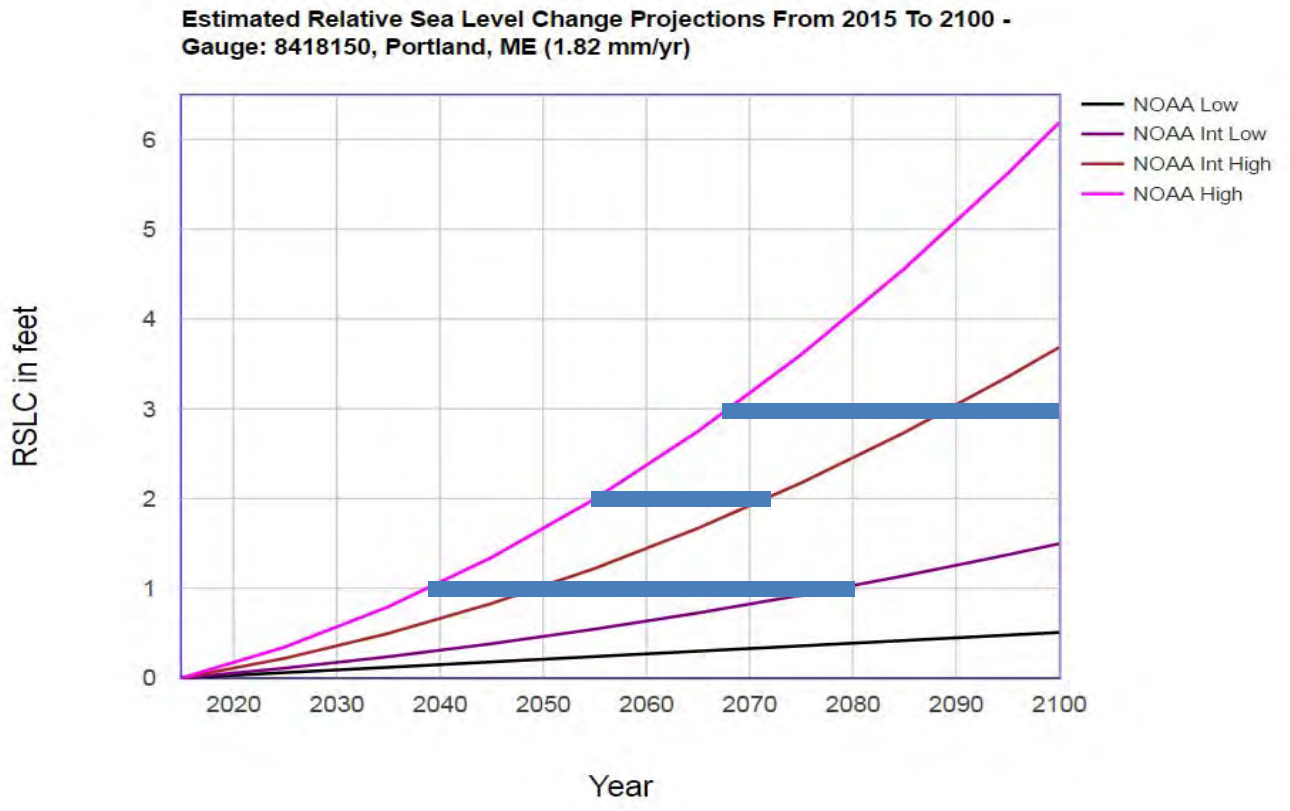
For reference, tidal datums are determined by averaging the water level at a tide gauge over a period of time (known as a national tidal datum epoch). The current epoch is from 1983 to 2001).

The curve data also takes into account predicted regional coastal subsidence and/or upward vertical land movement in relation to global sea level rise projections.

Estimated sea level rise scenarios by 2070 are based on the following:

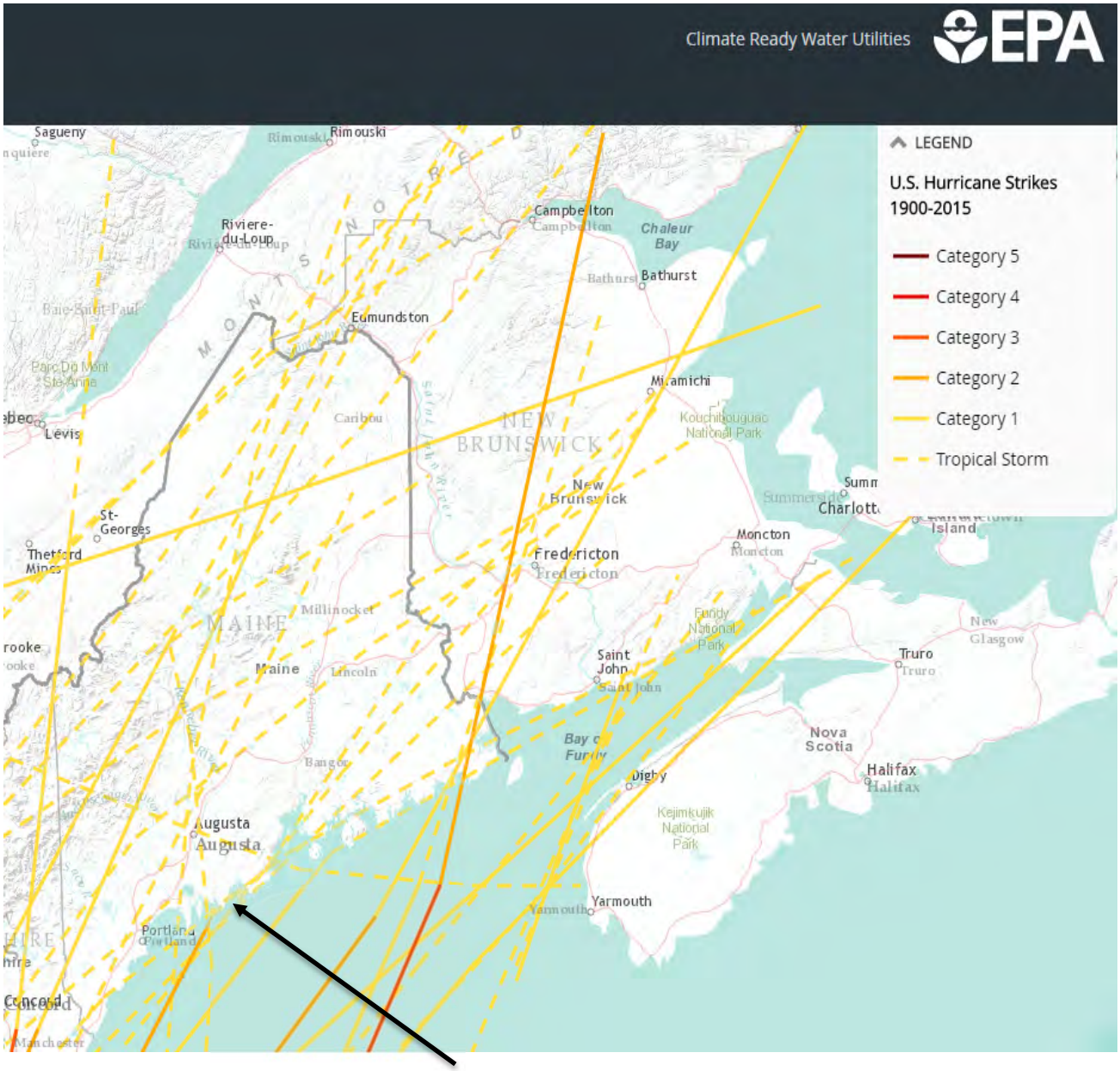
- Low Curve – Linear extrapolation of the historical sea level rise derived from NOAA tidal gauge records over the past century extended to 2070.
- Intermediate Low Curve – Linear extrapolation plus thermal expansion of the ocean waters. (As ocean temperatures increase, the water expands.)
- Intermediate High Curve – Linear extrapolation plus thermal expansion of the ocean waters, plus volumetric increase due to recent melting of land based ice sheets and glaciers.
- High Curve – Thermal expansion plus maximum potential melting of land based ice sheets and glaciers.

The following tables were generated from the USACOE curve calculator to further illustrate potential sea level rise scenarios through the 2070 assessment planning timeframe. (Again, note that the elevation data in the figure below is in relation to the local mean sea level datum and 0.30 feet are then added to adjust to NAVD88. Under the three planning scenarios selected, sea level rise estimates associated with BFE +4 and BFE + 5 are within the near and long range planning horizon of 2070 and BFE +6 sea level rise estimate begin around 2070.



Storm Surge

Over the past 100 plus years, NOAA records indicated that 9 hurricanes have passed through Maine's land borders with only 5 storms actually making landfall. 3 of these storms were Category 2 Hurricanes and 2 were Category 1 Hurricanes.



Boothbay Harbor

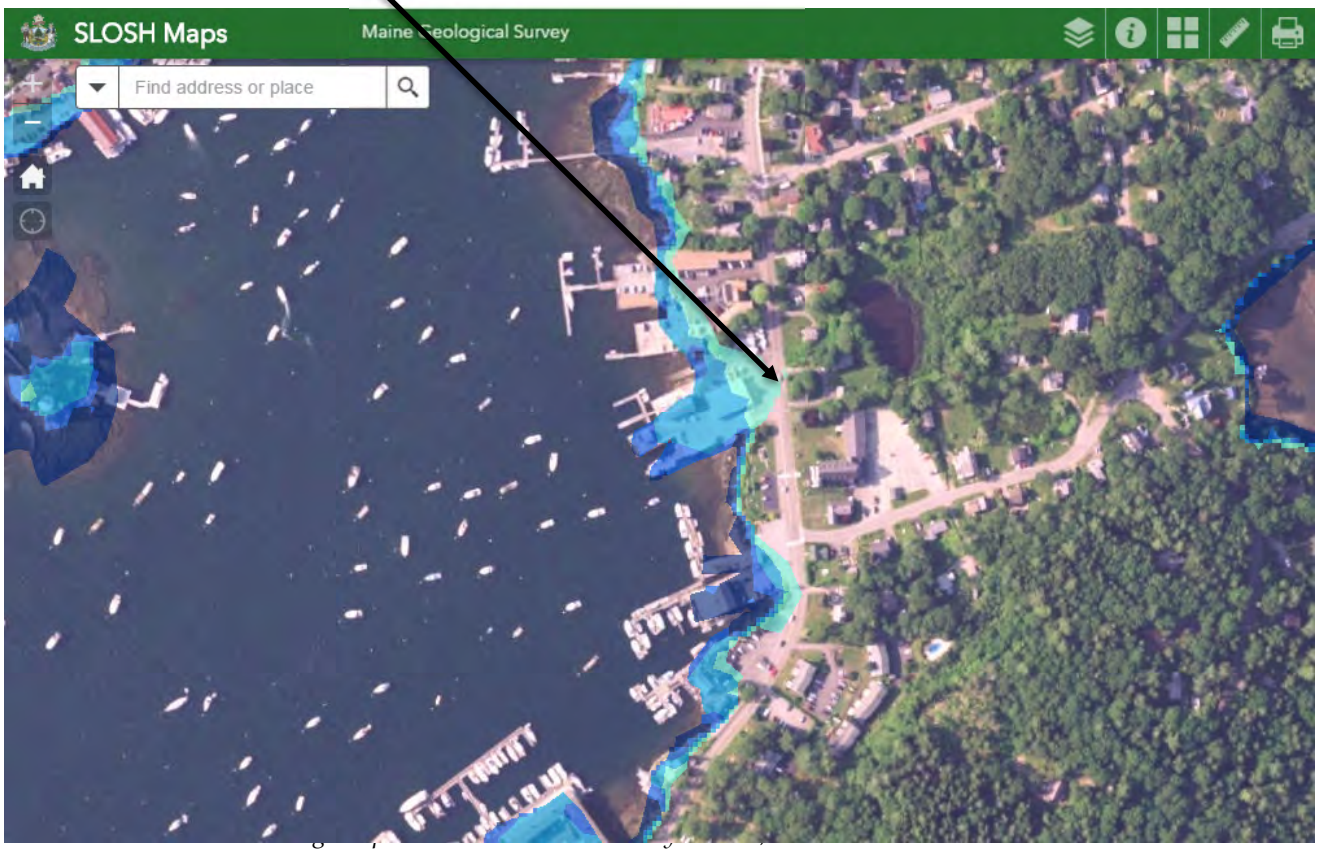
The National Weather Service (NWS) in coordination with NOAA, has developed the Sea, Lake and Overland Surges from Hurricanes (SLOSH) computerized numerical model to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data of the storm. These parameters are used to create a model of the wind field which drives the storm surge. NWS and NOAA uses this model to further look at predicted worst case storm surge scenarios by modeling the Maximum Envelop of Water

(MEOW). In addition to this scenario, NWS and NOAA further model the Maximum of the MEOWs (MOM), representing the most conservative storm surge scenario under these predictions. The MOM data set is the most widely used for insurance purposes in predicting areas where storm surge impacts will likely occur.

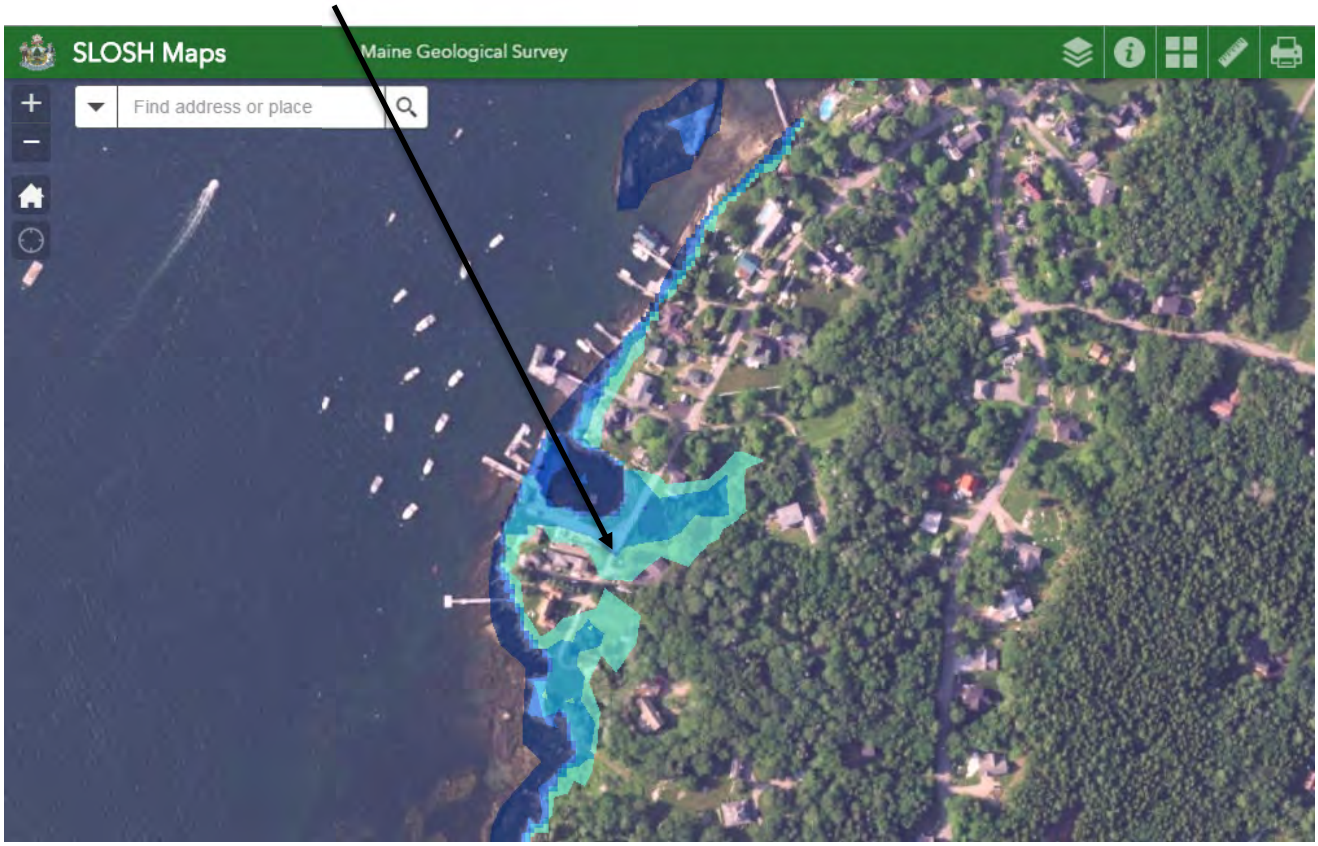
According to SLOSH model estimates under the MOM scenario for Boothbay Harbor, potential inundation depths for a Category 1 Hurricane are between 0 FT to 3 FT at all of the wastewater treatment facilities. Category 2 Hurricanes are either between 0 FT to 3 FT at the wastewater treatment facilities (represented in the maps below, as the lightest blue shading), or between 3 FT to 6 FT (represented in the maps below as the second lightest blue shading)

SLOSH maps are provided courtesy of the Maine Geological Survey.


PS #7
PS #1
SLOSH Maps
Maine Geological Survey
Find address or place
Boothbay Harbor
Mt Pisgah


PS #2
SLOSH Maps
Maine Geological Survey
Find address or place

PS #12 Wetwell



PS #13 Wetwell

Rainfall Precipitation

The NWS estimates that approximately 7.34 inches of rainfall will occur over a 24-hour during a 100-year event, and 9.73 inches of rainfall will occur over a 24-hour duration based on historic data collected from their nearest monitoring station in Newcastle, Maine. While this represents a significant amount of potential flood water, the inundation impacts of this onshore source is not estimated to be of significant concern to the District due to relatively steep topography of watershed areas along the shoreline, minimal low-lying coastal floodplain areas and tidal flushing of waters twice daily between low and high tide coastal conditions. Impacts often associated significant intensity of on-shore precipitation, often associated with coastal storms (hurricanes, tropical storms and blizzards) are of greater concern in southern coastal areas. The geography of these coastal floodplains is relative flat and the coastal region has less variation in daily tidal ranges, than conditions found in the northeast where onshore flood waters are conveyed seaward typically within the 6-hour period between high and low tides.

4 Description of Facilities

Wastewater Treatment Facility

- ***Location***

The WWTF is located on the east side of Mill Cove Harbor, off of Sea Street in Boothbay Harbor, Maine. The northern end of the WWTF is located adjacent to a FEMA 100-year flood AE zone at elevation 10.00 FT and the rest of the site is outside the flood zone. Mill Point and McFarland Point protect the site from nearby FEMA 100-year flood VE zones.

The site surrounding the WWTF varying in pattern of land development. Sea Street provides paved roadway access to the facility. The elevation of this roadway adjacent to the site is between 12.00 to 13.00 FT. Boothbay Harbor and commercial and residential coastal infrastructure (piers, floats, docks, etc.) are to the north of the site. Residential developments are to the east and west and a boatyard facility is to the south.

View of the WWTF Looking South from the top of the Sequencing Batch Reactors

- ***Construction / Upgrades***

The WWTF was originally built in 1963 and included only primary treatment and chlorination. The WWTF was later upgraded in 1995 to also include secondary treatment via sequencing batch reactors (SBRs).

- ***Capacity / Service Area***

The WWTF is operated by the District and provides secondary treatment for sanitary wastewater flow approximately 0.64 million gallons per day (MGD) average daily flow and up to 2.2 MGD during peak flow conditions.

The District serves the towns of Boothbay and Boothbay Harbor, along with municipal contracts with Southport for Squirrel and Capital Island. The WWTF receives wastewater from a collection system

comprised of approximately 25 miles of sewer mains and 21 pump stations located throughout the community.

- ***Infrastructure***

The WWTF consists of:

- The site within the WWTF infrastructure ranges in elevation between 8.00 FT to 12.00 FT and is predominantly paved. Some lawn and landscape areas are present throughout the site as well. The property abuts Boothbay Harbor on the northern side of the property and the shoreline there is covered with vegetation and somewhat eroded. A 6 -foot height chainlink fence with swing gates at the access drives off Sea Street surrounds the majority of the perimeter of the property. A wood stockade fence is located along the western side of the property.
- Electrical power supply from overhead utility lines. A transformer is mounted to a utility pole along the southern boundary of the property and electrical services is fed from the pole to an adjacent control panel with galvanized steel post and framing support. The approximately elevation of the bottom of the panel is 13.00 FT.
- Administration Building with a finish floor (FFE) elevation of 14.90 FT. This building is a wood framed, stick built structure supported by concrete foundation walls. The building is accessed by staircases and transition ramps leading to four doors. Two propane tanks are mounted on a concrete slab immediately adjacent to the building. Windows and vents are located at elevations of 17.00 FT and above.
- Garage with an FFE of 12.30 FT. This building is a wood framed, stick built structure supported by concrete foundation walls and slab. The building is accessed by three garage bay doors. Two propane tanks are mounted on a concrete slab immediately adjacent to the building. Windows and vents are located at elevations of 15.50 FT and above.
- Pump Station #6 with submersible pumps in a concrete wetwell structure with a top elevation of 13.90 FT. Electrical and control panels are mounted to a wood backboard supported by galvanized steel posts. The bottom elevation of the panels is 14.90 FT.
- Scum Well Pump Station with an elevation at the top of the concrete wetwell of 13.80 FT. Electrical and control panels are mounted on a wood backboard with galvanized steel supports. The bottom elevation of the panel is 14.80 FT
- (2) Concrete Sequencing Batch Reactors (SBRs) with a top elevation of 26.30 FT and a bottom floor elevation of 5.70 FT. A concrete septage inlet channel, with an elevation of 11.80 FT at the inlet grate, and subsurface concrete receiving tank are located immediately to the west of the structures. The SBRs are accessed by two aluminum staircases meeting existing site grade elevations of approximately 11.50 FT.
- Sludge Storage Tank with a top elevation of 24.20 FT and a base floor elevation at adjacent site grade of approximately 11.50 FT. The structure consists of a solid poured interior concrete wall, foam insulation and an exterior concrete masonry unit (CMU) block exterior wall which is partially deteriorated. The structure is accessed by a wood staircase meeting existing site grade elevations of approximately 11.50 FT.

- Concrete Chlorine Contact Tank with a top elevation of 16.00 FT and a bottom floor elevation of 5.80 FT. The structure is accessed by two concrete staircase meeting existing site grade elevations of approximately 11.50 FT.
- Concrete Metering Manhole with a top elevation of 11.10 FT flush with existing adjacent grade. An internal meter is at an elevation of 6.10 FT.
- The concrete pipe Outfall structure discharges into Boothbay Harbor south of the WWTF. The top of the concrete manhole (MH) accessing the Outfall before leaving the facility is at an elevation of 14.30 FT. The outfall elevation into the harbor is at 4.30 FT.
- Process Building with concrete floors and walls and a brick masonry wall façade. The basement is at elevation (-) 1.40 FT and contains the pump room, wet wetwell and blower room. The first floor sludge works loading area is at elevation 11.30 FT and is accessed by a single garage bay door. The headworks area is at elevation 11.70 FT and is accessed by an at grade door. The rest of the first floor is accessed by two doorways and a loading dock area and is at an elevation of 15.00 FT. The first floor contains a chlorine room, lime room, lockers, showers and storage areas, a mechanical room, electrical room and emergency generator. The second floor contains a dewatering room, control room and laboratory and is at an elevation of 27.00 FT. Windows and vents are at elevation 13.70 and above.

Sea Street Looking South from the WWTF Entrance

Sea Street Looking North from the WWTF Entrance. Admin. Building and Garage on the Left

Shoreline along the Northern Side of the WWTF

Breakwater Pump Station (PS #15)

- ***Location***

The Breakwater Pump Station (PS #15) is located on Breakwater Road along the south side of Factory Cove. PS #15 is located adjacent to a FEMA 100-year flood VE zone with an elevation 12.00 FT.

- ***Capacity / Service Area***

PS #15 collects sewage flows from eight (8) residential properties and one (1) commercial property. Flows are conveyed by force main to a gravity main along Atlantic Avenue, flowing to PS #2.

- ***Construction / Upgrades***

PS #15 was upgraded in 1996.

- ***Infrastructure***

PS #15 consists of:

  - Concrete wetwell with an elevation of 13.00 FT at the top of the structure.
  - (2) Submersible duplex grinder pumps.
  - Electrical service and control panels mounted on a wood backboard. The elevation of the bottom of the controls is at an approximate elevation of 14.00 FT. Electrical service is from overhead lines connected to a wood service pole. The backboard is mounted to the service pole and one additional wood pole.

PS #15 Looking West Towards Boothbay Harbor

Factory Cove Pump Station (PS #13)

- ***(Location)***

The Factory Cove Pump Station (PS #13) is located on Factory Cove Road on the west side of the southern Boothbay Harbor peninsula and on the north side of Factory Cove. PS #13 is located adjacent to a FEMA 100-year flood AE zone with an elevation of 12.00 FT and is also in close proximity to a FEMA 100-YR flood VE zone with an elevation of 12.00.

- ***Capacity / Service Area***

PS #13 collects sewage flows from 10 residential properties. Flows are conveyed by force main to a gravity main along Atlantic Avenue, flowing to PS #2.

- ***Construction / Upgrades***

PS #13 was upgraded in 1996.

- ***Infrastructure***

PS #13 consists of:

  - Concrete wetwell at grade with an elevation of 16.00 FT at the top of the structure.
  - (2) Submersible duplex grinder pumps.
  - Electrical service and control panels mounted on a wood backboard. The elevation of the bottom of the controls is at an approximate elevation of 19.00 FT. Electrical service is from overhead lines from a nearby wood service pole which includes a pole mounted transformer. The backboard is mounted to two wood posts.

PS #13 Wetwell Looking East Along Factory Cove Road

PS #13 Controls Looking East

Roads End Pump Station (PS #12)

- ***(Location)***

The Roads End Pump Station (PS #12) is located on Roads End Road on the west side of the southern Boothbay Harbor peninsula. PS #12 is located within the FEMA 100-year flood AE zone with an elevation of 10.00 FT and is adjacent to a FEMA 100-YR flood VE zone with an elevation of 12.00 FT.

- ***Capacity / Service Area***

PS #12 collects sewage flows from 19 residential properties. Flows are conveyed by force main to a gravity main along Atlantic Avenue, flowing to PS #2.

- ***Construction / Upgrades***

PS #12 was upgraded in 1996.

PS #12 Wetwell Looking East Along Roads End Road

PS #12 Controls West Towards Boothbay Harbor

- ***Infrastructure***

PS #12 consists of:

  - Concrete wetwell at grade with an elevation of 10.00 FT at the top of the structure.
  - (2) Submersible duplex grinder pumps.
  - Electrical service and control panels mounted on a wood backboard. The elevation of the bottom of the controls is at an approximate elevation of 14.00 FT. Electrical service is from overhead lines via a nearby wood service pole. The backboard is mounted to two wood posts.

Atlantic by Church Pump Station (PS #2)

- ***(Location)***

The Atlantic by Church Pump Station (PS #2) is located on Atlantic Avenue next to the Our Lady Queen of Peace Catholic Church. PS #2 is located adjacent to a FEMA 100-year flood AE zone with an elevation of 11.00 FT and adjacent to a FEMA 100-YR flood VE zone with an elevation of 12.00 FT.

- ***Capacity / Service Area***

PS #2 collects sewage flows from several residential neighborhoods in Boothbay Harbor, including from the pump stations noted above. There are approximately (10) properties, mostly commercial

PS #2 Looking South along Atlantic Avenue

developments, between Atlantic Avenue and Boothbay Harbor that contribute flows directly to PS #2. Flows are conveyed by force main to a gravity sewer main on Bay Street.

- ***Construction / Upgrades***

PS #2 was constructed in 1963.

- ***Infrastructure***

PS #2 consists of:

  - Concrete wetwell with an elevation of 13.50 FT at the top of the structure.
  - (2) Centrifugal duplex pumps in a package drywell with an elevation of 15.30 FT at the top of the pump enclosure.
  - Electrical service and control panels mounted on a wood backboard. The elevation of the bottom of the controls is at an approximate elevation of 16.50 FT. Electrical service is from overhead lines from a nearby wood service pole. The backboard is mounted to two wood posts.

Commercial Street Pump Station (PS #4)

- ***(Location)***

The Commercial Street Pump Station (PS #4) is located off of Commercial Street in downtown Boothbay Harbor on the west side of the harbor. PS #4 is located within a FEMA 100-year flood AE zone with an elevation of 11.00 FT.

- ***Capacity / Service Area***

PS #4 collects sewage flows from a significant portion of Boothbay Harbor's waterfront commercial district and surrounding inland residential and mixed use developments. Flows are conveyed by force main to a gravity sewer main on Commercial Street.

- ***Construction / Upgrades***

PS #4 was upgraded in 2011.

- ***Infrastructure***

PS #4 consists of:

  - Concrete wetwell at grade with an elevation of 10.40 FT at the top of the structure.
  - (2) Submersible duplex centrifugal pumps.

- Electrical service, control panels and emergency generator housed within a stick-built wood structure attached to the Town's public restroom building. Electrical service is from overhead power lines from a nearby utility service pole. The elevation of the bottom of the controls within the building enclosure is at an approximate elevation of 12.90 FT. The bottom of the emergency generator is at an elevation of 11.40 FT mounted above a fuel storage tank.

PS #4 Looking South from Commercial Street Towards Boothbay Harbor

Footbridge Pump Station

- ***(Location)***

The Footbridge Pump Station (PS #7) is located off of Townsend Avenue, in the Footbridge Parking Lot near downtown Boothbay Harbor on the west side of the harbor. PS #7 is located within a FEMA 100-year flood AE zone with an elevation of 11.00 FT.

- ***Capacity / Service Area***

PS #7 collects sewage flows from a significant portion of Boothbay Harbor's waterfront commercial district and surrounding inland residential and mixed use developments. Flows are conveyed by force main to a gravity sewer on Townsend Avenue. PS #7 is currently impacted by astronomical high tides throughout each year and the District has to shut down the pump station during these periods.

PS #7 Behind Shrubs on Right Looking Northeast Towards Boothbay Harbor

- ***Construction / Upgrades***

PS #7 was originally built in 1978.

- ***Infrastructure***

PS #7 consists of:

  - Concrete wetwell with an elevation of 9.50 FT at the top of the structure.
  - (3) Submersible triplex grinder pumps.
  - Electrical service and control panels mounted on a wood backboard. The elevation of the bottom of the controls is at an approximate elevation of 9.50 FT. Electrical service is from overhead lines from a nearby wood service pole. The backboard is mounted on galvanized steel posts and framing.

Union Street Pump Station (PS #1)

- ***(Location)***

The Union Street Pump Station (PS #1) is located at the head of the harbor, on Union Street. PS #1 is located adjacent to a FEMA 100-year flood VE zone within an elevation of 12.00 FT.

- ***Capacity / Service Area***

PS #1 collects sewage flows from a significant portion of the Town's waterfront commercial district and surrounding inland residential and mixed use developments. Flows are conveyed by force main to a sewer main on Oak Street.

- ***Construction / Upgrades***

PS #1 is anticipated to be upgraded during 2017. PS #1 upgrades are anticipated to consist of:

  - Concrete wetwell at grade with an elevation of 12.00 feet.
  - (3) new submersible triplex pumps.
  - Electrical service and control panels mounted on a stainless steel frame supported by stainless steel posts. The bottom of the panels are intended to be constructed with a bottom elevation of 16.00 FT.

- ***Infrastructure***

PS #1 consists of:

  - Concrete wetwell at grade with an elevation of 12.00 feet.
  - (3) Centrifugal triplex pumps in a package drywell with an elevation of 13.00 FT at the top of the pump enclosure.

- Emergency power generator with internal fuel storage mounted on top of a concrete slab at an elevation of 13.00 FT.
- Electrical service and control panels mounted on a wood backboard. The elevation of the bottom of the controls is at an approximate elevation of 15.00 FT. Electrical service is from overhead lines from a nearby wood service pole. The backboard is mounted to wood posts.

PS #1 Looking Across Union Street Towards Boothbay Harbor

5 Potential Inundation Effects

This section of the assessment describes of the nature of the impacts due to inundation from flooding to the District's wastewater treatment facilities. Tables for each of the facilities identify whether the specific infrastructure components of each facility could be inundated or not under the three planning scenario elevations follow the descriptions. Any of the structures that could be impacted by inundation under any of the three planning scenarios could also be impacted by storm surge tidal wave action and floating debris during the flood even, and until such debris could be cleared from the sites after inundation. These impacts are stated here and are not repeated for each structure below. Debris sources could include interior site materials such as external propane tanks, or materials from abutting properties.

Wastewater Treatment Facility

- ***Site Access***
  - Access to the WWTF from Sea Street could be limited during the period of inundation under all three planning scenarios.
- ***Interior Site***
  - Access throughout the entire site interior could be limited during the period of inundation under all three planning scenarios.
  - Shoreline erosion on the northern boundary of the site could occur under all three planning scenarios.
  - Perimeter fencing could be inundated during all three planning scenarios. Fenced gate systems are mechanically operated and should remain operational after inundation unless impacted by floating debris.
- ***Electrical Power Supply***
  - The electrical service and control panels serving the entire facility from overhead utilities could be impacted by inundation under all three planning scenarios.
  - It is likely that the pole mounted transformer would short out and electrical service to the WWTF would be unavailable until the transformer could be repaired/replaced and the electrical service and control panels could be also replaced.
- ***Administration Building***
  - Access to the Administration Building could be limited during the inundation period under all three planning scenarios.
  - The pad mounted propane tanks adjacent to the building could be displaced under all three planning scenarios.
  - The first floor could be inundated during BFE +5 and BFE +6 planning scenarios through doorway penetrations, impacting interior equipment and stored office materials requiring replacement.

- The structural integrity of the building structure could be compromised after the inundation period from the BFE +5 and BFE +6 planning scenarios.

- ***Garage***
  - Access to the Garage could be limited during the inundation period under all three planning scenarios.
  - The pad mounted propane tanks adjacent to the building could be displaced under all three planning scenarios.
  - The Garage interior could be inundated under all three planning scenarios through doorway penetrations, impacting interior equipment and stored materials requiring replacement.
  - The first floor could be inundated during BFE +5 and BFE +6 planning scenarios through window and vent penetrations, impacting interior equipment and stored office materials.
  - The structural integrity of the building structure could be compromised after the inundation period from all three planning scenarios.
- ***PS #6***
  - The wetwell could be impacted by flood water infiltration and inflow (I&I) entering this structure during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's process system, potentially exceeding treatment plant capacity and disrupting the biological digestion treatment process of the sewer effluent.
  - The electrical and control panels could be impacted by inundation during BFE +5 and BFE +6 planning scenarios.
- ***Scum Well Pump Station***
  - The wetwell could be impacted by flood water infiltration and inflow (I&I) entering this structure during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters.
  - The electrical and control panels could be impacted by inundation during BFE +5 and BFE +6 planning scenarios.
- ***SBRs***
  - Access to the SBRs via the staircases could be limited during the inundation period under all three planning scenarios.
  - The septage receiving area and subsurface receiving tank could be impacted by flood water I&I entering the structure during the inundation period. under all three planning scenarios. Inundation of these structures could cause stored sewage to mix with flood waters flowing throughout the site.

- ***Sludge Storage Tank***
  - Access to the Sludge Storage Tank via the staircase could be limited during the inundation period under all three planning scenarios.
- ***Chlorine Contact Tank***
  - Access to the Chlorine Contact Tank via the staircases could be limited during the inundation period under all three planning scenarios.
  - The tank could be inundated during the BFE +6 planning scenario. Inundation of this structure could introduce additional flows to the WWTF's process system, potentially exceeding treatment plant capacity and disrupting the biological digestion treatment process of the sewer effluent.
- ***Metering Manhole***
  - The MH and internal meter could be impacted by flood water infiltration and inflow (I&I) entering this structure during the inundation period under all three planning scenarios. Flood waters should not be able to flow into the process system as a result of this structure being compromised by flood waters.
- ***Outfall Structure (MH #1)***
  - MH #1 could be impacted by flood water infiltration and inflow (I&I) entering this structure during the inundation period under all three planning scenarios. Flood waters should not be able to flow into the process system as a result of this structure being compromised by flood waters.
- ***Process Building (Including Headworks Area and Sludge Loading Area)***
  - The entire basement floor area, first floor sludge loading area, and first floor headworks could be impacted by inundation under all three planning scenarios. Interior equipment and stored materials within these areas could be compromised requiring replacement.
  - The loading docks and first floor areas could be inundated under BFE +5 and BFE +6 planning scenarios. Interior equipment and stored materials within these areas could be compromised requiring replacement.
  - Access to the 2nd floor via internal stairwells could be limited during the inundation period.

WWTF Infrastructure	Base Elevation of Structure in Feet	BFE +4 (14-FT) Yes / No	BFE +5 (15-FT) Yes / No	BFE +6 (16-FT) Yes / No
Site Access – Sea Street	12.00 to 13.00	Y	Y	Y
Interior Site	8.00 to 10.00	Y	Y	Y
Electrical Power Supply – Electrical & Control Panels	13.00	Y	Y	Y
Administration Building – First Floor FFE	14.90	N	Y	Y
Administration Building – Windows & Vents	17.00 & Above	N	N	N
Garage - FFE	12.30	Y	Y	Y
Garage – Propane Tanks	12.30	Y	Y	Y
Garage – Windows & Vents	15.50 & Above	N	Y	Y
PS #6 – Wetwell	13.90	Y	Y	Y
PS #6 – Electrical & Control Panels	14.90	N	Y	Y
Scum Well PS – Concrete Vault	13.80	Y	Y	Y
Scum Well PS – Electrical & Control Panels	14.80	N	Y	Y
SBRs	26.30	N	N	N
SBR – Stairs	11.50	Y	Y	Y
SBR – Septage Inlet Channel	11.80	Y	Y	Y
Sludge Storage Tank	24.20	N	N	N
Sludge Storage Tank – Stairs	11.50	Y	Y	Y
Chlorine Contact Tank	16.00	N	N	Y
Chlorine Contact Tank - Stairs	11.50	Y	Y	Y

Metering Manhole	11.10	Y	Y	Y
Metering Manhole – Meter	6.10	Y	Y	Y
Outfall Manhole	14.30	N	Y	Y
Process Building – Basement FFE	(-) 1.40	Y	Y	Y
Process Building – Sludge Works Loading Area	11.30	Y	Y	Y
Process Building – Head Works FFE	11.70	Y	Y	Y
Process Building – Windows & Vents	13.70 & Above	Y	Y	Y
Process Building – 1st Floor FFE	15.00	N	Y	Y
Process Building – 2nd Floor FFE	27.00	N	N	N

WWTP Looking West at Process Building and Boothbay Harbor - BFE +4

WWTP Looking North Between the Process Building and SBRs – BFE +4

WWTP Looking West Past the Process Building - BFE +4

WWTP Looking West at Process Building and Boothbay Harbor - BFE +5

WWTP Looking North Between the Process Building and SBRs – BFE +5

WWTP Looking West Past the Process Building - BFE +5

WWTP Looking North Between the Process Building and SBRs – BFE +6

WWTP Looking West Past the Process Building - BFE + 6

WWTP Looking West at Process Building and Boothbay Harbor - BFE +5

Breakwater Pump Station (PS #15)

- ***Site Access***
  - Access to PS #15 from Breakwater Road could be limited during inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #15 from overhead utilities could be impacted by inundation under all three planning scenarios.
  - It is likely that the pole mounted transformer would short out under all three planning scenarios and electrical service to PS#15 would be unavailable until the transformer could be repaired/replaced and until the electrical service panels could be also replaced.
- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #15 during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #15 remains operational during any of the three of the planning scenarios.
- ***Controls***
  - PS #15 controls could be impacted by inundation under all three planning scenarios.

PS #15 Infrastructure	**Base Elevation of Structure in Feet**	**BFE +4 (16-FT) Yes / No**	**BFE +5 (17-FT) Yes / No**	**BFE +6 (18-FT) Yes / No**
Site Access – Breakwater Road	12.00 to 14.00	Y	Y	Y
Electrical Power Supply –	13.00	Y	Y	Y
Wetwell	12.30	Y	Y	Y
Controls	14.80	Y	Y	Y

PS #15 Looking West Towards Boothbay Harbor - BFE +4

PS #15 Looking West Towards Boothbay Harbor - BFE +5

PS #15 Looking West Towards Boothbay Harbor - BFE +6

Factory Cove Pump Station (PS #13)

- ***Site Access***
  - Access to PS #13 from Factory Cove Road could be limited during inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #13 from overhead utilities are not anticipated to be impacted by inundation under any of the three planning scenarios
- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #13 during the inundation period under BEF +5 and BFE +6 planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #13 remains operational during the BFE +5 and BFE +6 planning scenarios.
- ***Controls***
  - The PS #13 control panels are not anticipated to be impacted by inundation under any of the three planning scenarios.

PS #13 Infrastructure	Base Elevation of Structure in Feet	BFE +4 (16-FT) Yes / No	BFE +5 (17-FT) Yes / No	BFE +6 (18-FT) Yes / No
Site Access – Factory Cove Road	16.00 to 18.00	Y	Y	Y
Electrical Power Supply –	19.00	N	N	N
Wetwell	16.30	N	Y	Y
Controls	19.00	N	N	N

PS #13 Looking East Towards Atlantic Avenue Depicting Stillwater Flood Elevation BFE + 4-FT

PS #13 Looking East Towards Atlantic Avenue Depicting Stillwater Flood Elevation BFE + 5-FT

PS #13 Looking East Towards Atlantic Avenue Depicting Stillwater Flood Elevation BFE + 6-FT

PS #13 Electrical Service and Controls - BFE +6

Roads End Pump Station (PS #12)

- ***Site Access***
  - Access to PS #12 from Roads End Road could be limited during the period of inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #12 from overhead utilities could be impacted by inundation under the BFE +5 and BFE +6 planning scenarios.
  - It is likely that the pole mounted transformer would short out under the BFE +5 and BFE +6 planning scenarios and electrical service to PS#12 would be unavailable until the transformer could be repaired/replaced and until the electrical service panels could be also replaced.
- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #12 during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #4 remains operational during any of the three of the planning scenarios.
- ***Controls***
  - PS #12 controls could be impacted by inundation under the BFE +5 and BFE +6 planning scenarios.

PS #12 Infrastructure	**Base Elevation of Structure in Feet**	**BFE +4 (14-FT) Yes / No**	**BFE +5 (15-FT) Yes / No**	**BFE +6 (16-FT) Yes / No**
Site Access – Lands End Road	10.00 to 12.00	Y	Y	Y
Electrical Power Supply	14.00	N	Y	Y
Wetwell	10.00	Y	Y	Y
Controls	14.00	N	Y	Y

PS #12 Wetwell Looking North - BFE +4

PS #12 Electrical / Controls Panel Looking South - BFE +4

PS #12 Wetwell Looking North - BFE +5

PS #12 Electrical / Control Panels Looking South - BFE +5

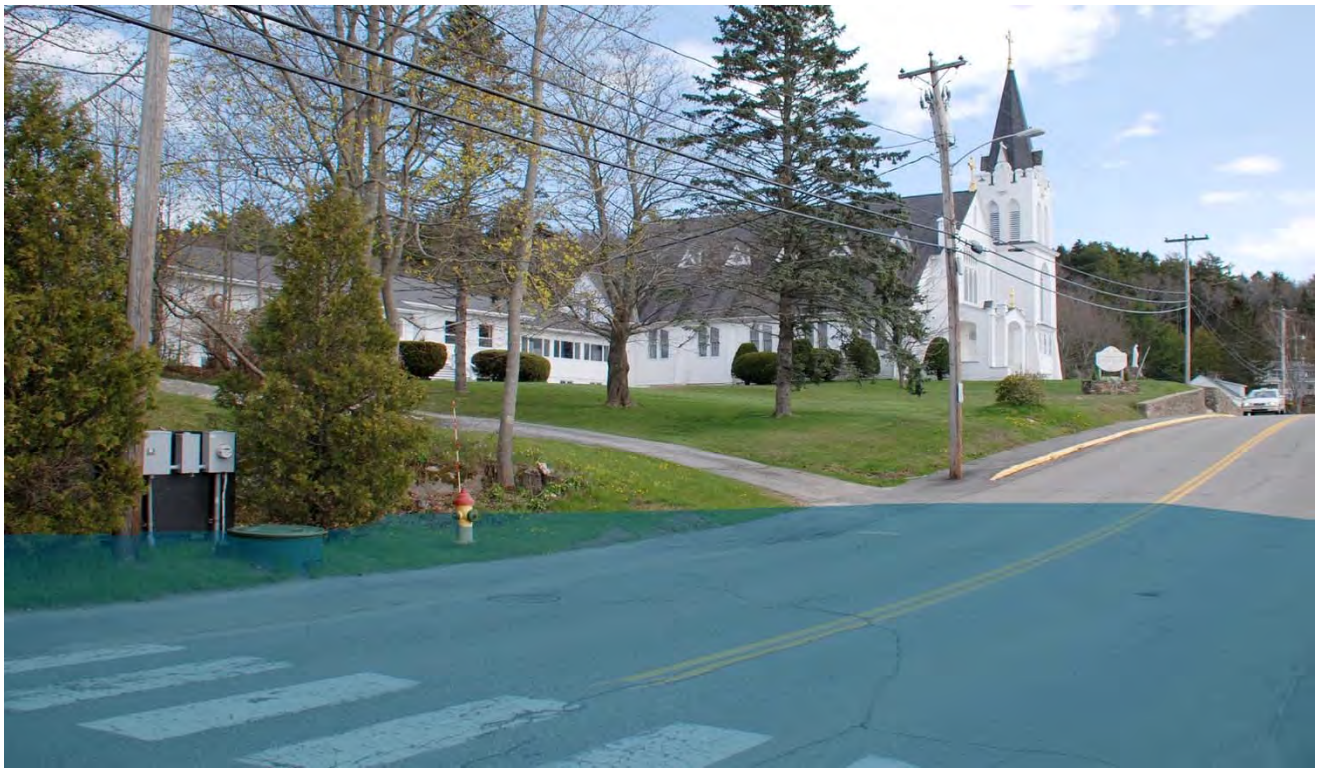
PS #12 Wetwell Looking North - BFE +6

PS #12 Electrical / Control Panels Looking South - BFE +6

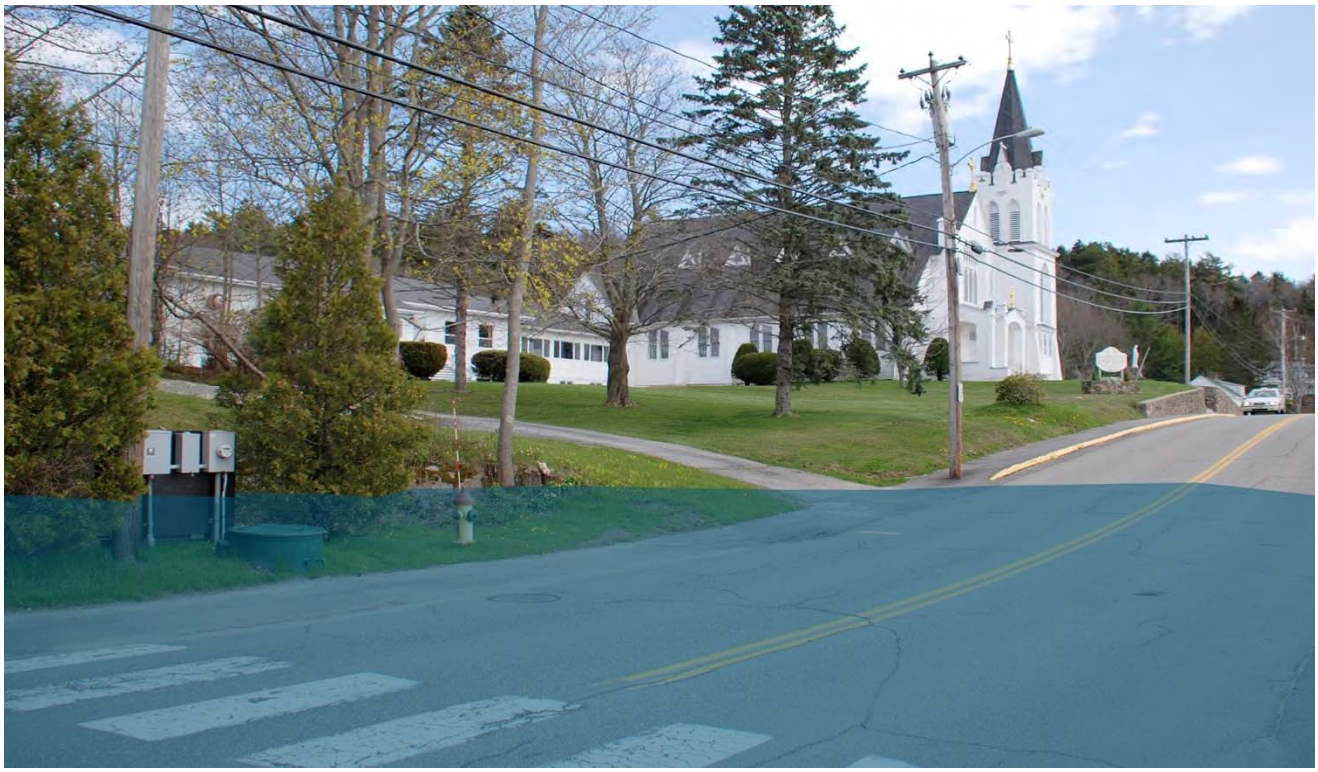
Atlantic By Church Pump Station (PS #2)

- ***Site Access***
  - Access to PS #2 from Atlantic Avenue could be limited during the period of inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #2 from overhead utilities could be impacted by inundation under the BFE +6 planning scenario.
  - It is likely that the pole mounted transformer would short out under the BFE +6 planning scenario and electrical service to PS#2 would be unavailable until the transformer could be repaired/replaced and until the electrical service panels could be also replaced.
- ***Controls***
  - PS #2 controls could be impacted by inundation under the BFE +6 planning scenario.
- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #2 during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #2 remains operational during the BFE +4 planning scenario where the pumps are protected in the drywell.
- ***Dry Well***
  - The drywell and enclosed pumps could be compromised by inundation during the BFE +5 and BFE +6 planning scenarios.

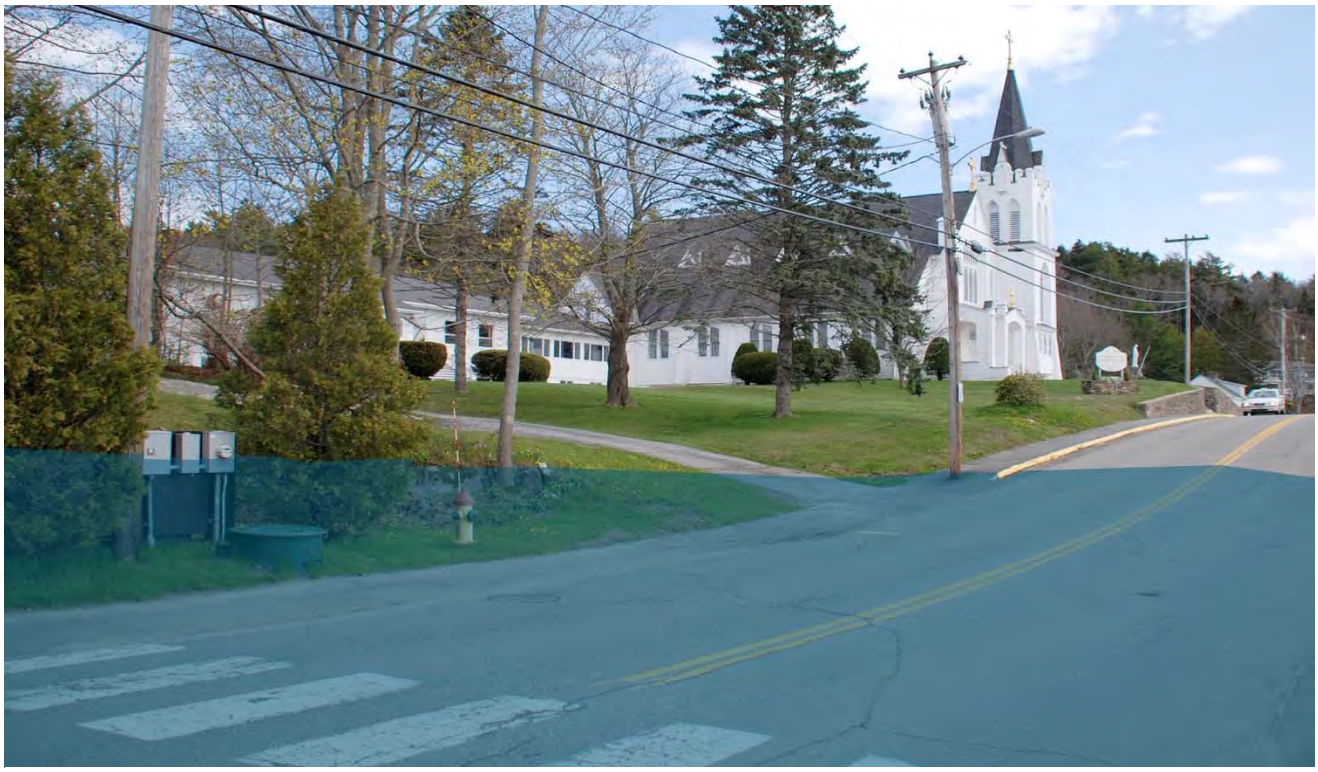
PS #2 Infrastructure	**Base Elevation of Structure in Feet**	**BFE +4 (15-FT) Yes / No**	**BFE +5 (16-FT) Yes / No**	**BFE +6 (17-FT) Yes / No**
Site Access – Atlantic Avenue	13.00 to 14.00	Y	Y	Y
Electrical Power Supply	16.50	N	N	Y
Wetwell	13.50	Y	Y	Y
Drywell	15.30	N	Y	Y
Controls	16.50	N	N	Y



PS #2 Looking South Towards the Adjacent Church - BFE +4



PS #2 Looking South Towards the Adjacent Church - BFE +5



PS #2 Wetwell Looking North - BFE +6

Commercial Street Pump Station (PS #4)

- ***Site Access***
  - Access to PS #4 from Commercial Street could be limited during the period of inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #4 from overhead utilities could be impacted by inundation under all three planning scenarios.
  - It is likely that the pole mounted transformer would short out under all three planning scenarios and electrical service to PS#4 would be unavailable until the transformer could be repaired/replaced and until the electrical service panels could be also replaced.
- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #4 during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #4 remains operational during any of the three of the planning scenarios.

- ***Controls***
  - PS #4 controls could be impacted by inundation under all three planning scenarios.
- ***Public Restroom Building***
  - Access to the building could be limited during the inundation period under all three planning scenarios.
  - The interior of the building could be inundated during all three planning scenarios, impacting equipment as noted above and below, along with any other interior equipment and stored materials.
  - The structural integrity of the building structure could be compromised after the inundation period from all three planning scenarios.

PS #4 Infrastructure	**Base Elevation of Structure in Feet**	**BFE +4 (15-FT) Yes / No**	**BFE +5 (16-FT) Yes / No**	**BFE +6 (17-FT) Yes / No**
Site Access – Commercial Street	10.00 to 12.00	Y	Y	Y
Electrical Power Supply	12.90	Y	Y	Y
Emergency Power Generator	11.40	Y	Y	Y
Wetwell	10.40	Y	Y	Y
Controls	12.90	Y	Y	Y
Public Restroom Building - FFE	10.40	Y	Y	Y

PS #4 Looking South Towards Boothbay Harbor from Commercial Street - BFE +4

PS #4 Looking South Towards Boothbay Harbor from Commercial Street - BFE +5

PS #4 Looking South Towards Boothbay Harbor from Commercial Street - BFE +6

Footbridge Pump Station (PS #7)

- ***Site Access***
  - Access to PS #7 from Townsend Avenue and the Footbridge Parking Lot could be limited during the period of inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #7 from overhead utilities could be impacted by inundation under all three planning scenarios.
  - It is likely that the pole mounted transformer would short out under all three planning scenarios and electrical service to PS#7 would be unavailable until the transformer could be repaired/replaced and until the electrical service panels could be also replaced.
- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #7 during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #7 remains operational during any of the three of the planning scenarios.

- ***Controls***
  - PS #7 controls could be impacted by inundation under all three planning scenarios.

PS #7 Infrastructure	Base Elevation of Structure in Feet	BFE +4 (15-FT) Yes / No	BFE +5 (16-FT) Yes / No	BFE +6 (17-FT) Yes / No
Site Access – Footbridge Parking Lot	8.00	Y	Y	Y
Electrical Power Supply	9.50	Y	Y	Y
Wetwell	9.50	Y	Y	Y
Controls	9.50	Y	Y	Y

PS #7 Looking North Towards Townsend Avenue from Boothbay Harbor - BFE +4

PS #7 Looking North Towards Townsend Avenue from Boothbay Harbor - BFE +5

PS #7 Looking North Towards Townsend Avenue from Boothbay Harbor - BFE +6

Union Street Pump Station (PS #1)

(Note: PS #1 is currently being designed for an upgrade to a submersible station and the impacts described below are in relation to the planned upgrades to the facility.)

- ***Site Access***
  - Access to PS #1 from Union Street could be limited during the period of inundation under all three planning scenarios.
- ***Power Supply***
  - The electrical service and panels serving PS #1 from overhead utilities could be impacted by inundation under BFE +5 and BFE +6 planning scenarios
  - It is likely that the pole mounted transformer would short out under BFE +5 and BFE +6 planning scenarios and electrical service to PS#1 would be unavailable until the transformer could be repaired/replaced and until the electrical service panels could be also replaced.
  - Emergency power generator with internal fuel storage mounted on top of a concrete slab could be compromised by inundation under all three planning scenarios requiring replacement.

- ***Wet Well***
  - The wetwell could be impacted by flood water I&I entering this structure directly and from other impacted properties contributing flows to PS #1 during the inundation period under all three planning scenarios. The wetwell and pumps are submersible and should not be damaged by flood waters, however, inundation of the wetwell could introduce additional flows to the WWTF's collection system if PS #1 remains operational during any of the three planning scenarios.
- ***Controls***
  - PS #1 controls could be impacted by inundation under BFE +5 and BFE +6 planning scenarios.

PS #1 Infrastructure	Base Elevation of Structure in Feet	BFE +4 (16-FT) Yes / No	BFE +5 (17-FT) Yes / No	BFE +6 (18-FT) Yes / No
Site Access – Union Street	12.00 to 14.00	Y	Y	Y
Electrical Power Supply	16.00	N	Y	Y
Emergency Power Generator	13.00	Y	Y	Y
Wetwell	12.00	Y	Y	Y
Controls	16.00	N	Y	Y

PS #1 Looking West Across Union Street and Towards Boothbay Harbor - BFE +4

PS #1 Looking West Across Union Street and Towards Boothbay Harbor - BFE +5

PS #1 Looking West Across Union Street and Towards Boothbay Harbor - BFE +6

Collection System

- There are several sewer manholes along multiple gravity sewer mains leading to the WWTF. Manholes within any of the areas inundated by the three planning scenarios which are not flood-proofed currently could be impacted by I&I entering directly into the structures during inundation of the surrounding sites, and from other impacted properties contributing flows to the collection system.

6 Adaptation Strategies

General Discussion

The District's wastewater treatment facilities are known to the community in terms of the value of the public utility service they provide and in terms of the capital construction costs in light of the Districts Charter requirement to go out to public vote for projects estimated to cost $150,000 or more. When considering the following adaptation strategies, suggested as technical design solutions below to address potential impacts from sea level rise and storm surge under the three planning scenarios assessed, it is important to consider the financial, visual and functional (social) wastewater utility service impacts to the community at large when making prioritized decisions to invest further in these facilities. At the most basic level, the District should consider whether to maintain the existing facility, employ adaptation strategies to mitigation potential increased sea level rise and storm surge impacts or to relocate from these coastal areas.

The following adaptation strategies for improvements to the wastewater treatment facilities assessed by this study to are offered as potential technical solutions to mitigate impacts from the planning elevation scenarios. Decisions regarding support of these structural adaptation strategies (e.g. non-structural means such as capital funding, emergency preparedness, impact ordinances, etc.) in combination with the structural adaptation measures provide a greater likelihood of success for maintaining these facilities over the long term.

As stated at the beginning of the assessment, the District's goal is to be able to make prioritized based on the findings and recommendations of this assessment for each of the wastewater treatment facilities that could potentially be impacted by climate change predicted sea level rise and storm surge factors. Not all of these measures need to be incorporated together, as there may be more than one way to address impacts to the facility components under each of the planning elevation scenarios.

The cost estimates included in the appendices for relocation of the WWTF or any of the pump stations for this assessment are conceptual planning-level estimates. Conceptual cost estimates are based on limited technical information and have a broad range of accuracy (+40% to -25%). Planning-level costs for all other adaptation strategies to the existing wastewater treatment facilities at their current locations are based on a greater level of technical information and have a narrower range of accuracy (+30% to -10%). These cost estimates should be refined as the District proceeds through this process and collects additional technical information.

(See Appendices for planning-level Construction Cost Considerations Matrix associated with the various adaptation strategies discussed below in relation to the three planning elevation scenarios assessed by this study discussed below)

Adaptation Strategies

The following are technical adaptation options for improvements to the various wastewater treatment facilities, either as individual infrastructure components, or in some cases for the entirety of each respective facility. Not all of these measures need to be incorporated together, as there may be more than one way to address impacts to protect the facility's various infrastructure components under each of the three planning elevation scenarios.

Shoreline Stabilization

The northern boundary of the WWTF shows evidence of erosion of the embankment. This erosion can be expected to continue and perhaps increase in relation to the higher planning elevation scenarios, especially due to impacts from increased storm surge tidal wave action. The full height of the embankment should be protected for the entire length of the shoreline. Careful consideration of how the stabilization is terminated or continues along the shoreline on abutting properties is also key to minimize potential erosion impacts from scouring due to wave deflection off the stabilized embankment onto adjacent shoreline areas that may not be protected.

Examples of Heavy Riprap Shoreline Stabilization in Richmond, Maine

Permanent Barrier Protection (Sea Walls and Flood Gates)

The District could consider surrounding the entire perimeter of the WWTF with a sea wall and flood gates at the two access drive entrances to the site. This strategy should be considered versus the option to relocate the WWTF, or to making individual improvements to any or all of the WWTF components. The substantial costs for this strategy should also be weighed versus potential sum of costs for improvements to multiple WWTF components. Costs for additional height of this structure are relatively nominal, and it is recommended that the top of the structure consider the higher planning elevation scenario of BFE +6 because if a lower elevation wall is over topped, then significant capital investment in this measure may prove unsuccessful in mitigating impacts and associated costs with replacement and repair of any or all of the WWTF components located within the perimeter of the wall. If the wall is designed to an elevation that is not overtopped, stormwater discharge pumps should still be located with the perimeter of the facility at a low point were stormwater can be readily conveyed. Significant storms (i.e. hurricanes) with potentially significant rainfall precipitation are estimated to increase in frequency, intensity and during on the future based on climate change modeling estimates and the wall would effectively trap that source of stormwater within the site during coinciding flood events were the stormwater cannot be conveyed off the site through more traditional pipe outfalls.

Example of a Barrier Wall and Flood Gates (sources from internet)

Temporary Flood Barriers (Building Doors and Windows)

The following building structures are recommended to consider installation of temporary flood barriers on doors and windows:

- ***Process Building***
  - There are (4) single person exterior doors, (3) double doors and (1) garage bay door that access the first floor of the Process Building. As an alternate to installing a temporary flood barrier on the garage door, the District could allow for this space to be inundated by flood waters and provide flood barrier protection on the internal single person door leading from the garage to the rest of the interior first floor area via the shower area and electrical room. This should be weighed in terms of cost of impacted materials, tools and equipment within the garage area. There are also (9) exterior wall windows that should be considered for protection by installing temporary flood barriers.
  - The concrete and masonry walls of this structure are estimated to be resistant to penetration of flood waters and to sustain impacts from storm surge.
  - This adaptation strategy is recommended in combination with providing additional flood proofing of building wall and floor penetrations.
  - This adaptation strategy is not recommended for existing stick built wooden frame building structures which are recommended to be replaced / reinforced to withstand impacts from storm surge, penetration by flood waters and potential floating prior to installation of this adaptation strategy on any of their doors and windows.

Examples of Temporary Flood Barriers for Doors
(source from internet)

Examples of Temporary Flood Barriers for Windows
(source from internet)

Flood Proof Building Penetrations (Vents and Wall/Floor Penetrations)

The following building structures are recommended to consider installation of temporary flood barriers on doors and windows:

- ***Process Building***
  - There are (4) vents through the first floor walls that could be inundated by flood waters. These vents should be raised higher on the walls where structurally feasible.
  - The buildings floor drain systems currently collect in the basement and a sump pump is in place to discharge water collected in these drains outside of the building. A check valve should be installed in the discharge line to prevent flood waters from back flowing into the basement area.
  - All floor penetrations from infrastructure such as subsurface electrical conduit and conductors to the building from the exterior electrical service control panel should be checked to make sure that they are still water tight.
  - The walls of this structure are estimated to be resistant to penetration of flood waters and to be able to structurally withstand impacts from storm surge.
  - This strategy is recommended in combination with providing temporary flood protection of the buildings doors and windows.
  - This adaptation strategy is not recommended for existing stick built wooden building structures which would be recommended to be replaced / reinforced to withstand impacts from storm surge, penetration by flood waters and potential floating prior to installation of this adaptation strategy on any of their doors and windows.

Reconstruction / Reinforcement of Buildings

The following building structures are recommended for consideration of reconstruction from stick built wood frame structures to concrete masonry buildings, or if maintained / rebuilt with wood materials, the structures should be elevated so that the first floor finish elevations are raised to the District's selected planning elevation scenario. Situations that may raise the consideration of this adaptation strategy could include when they have reached their useful life expectancy, or are in need of upgrade as may be necessary to accommodate additional building functions as may be desired by the District, or may be required by regulations governing the operation and maintenance of the wastewater treatment facilities:

- ***Administration Building***
  - If maintained as a stick built, wood frame structure, elevate this structure so that the finish first floor occupied space is at or above the District's selected planning elevation scenario. This would require addition of either a man lift or extensive ramp system for ADA compliance to the elevated structure. The structure would need to have openings on at least three sides (flood vents or supported on piles) for the space below the finish first floor and could be utilized for cold storage of items like grounds equipment and tools (lawn mowers, etc.)
  - Provision of safe space for administration needs and operations staff on-site during potential inundation conditions should be considered of high importance to the District for maintaining reliable operation of the facilities and minimizing impacts from flood impacts (e.g. placing temporary flood barriers prior to anticipated impacts from flooding with potential for a short emergency action warning timeframe
- ***Garage***
  - Reconstruction of the building should consider a concrete and masonry structure.
  - Operations and maintenance equipment and tools should be stored above the three flood event scenarios to the extent feasible.
  - Interior electrical and mechanical systems should also be raised above the selected planning elevation scenario to the extent feasible.
  - Flow through vents for this structure could potentially reduce impacts to the structural integrity of the building in combination with elevation of the other building components listed above.
- ***Public Restroom Building Enclosure at PS #4***
  - The same comments regarding coordination of elevation of this structure in a manner that is functionally and aesthetically compatible with the Town's waterfront commercial center and abutting property interests as noted for elevation of the PS #4 noted elsewhere in this section apply to this building structure should the adaptation strategy be selected by the District.
- ***Process Building***
  - Given the critical importance of this facility within the overall WWTF infrastructure operations, secondary considerations for elevation of critical equipment, materials and tools within the basement area and the first floor areas to the second floor should be considered where feasible.

Should temporary flood barriers fail, either structurally or by human error, the entire basement and first floor areas of this building would be susceptible to substantial impacts from flood waters and repairs / replacement would be costly.

Example of Building Elevated on Pile Supports (source from internet)

Elevate Structures, Tools and Equipment

The following wastewater treatment facilities, tools and equipment structures should be considered for elevation to the District's selected planning elevation scenario:

- ***Influent Pump Station (PS-6) electrical panels, controls***
- ***Scum Well Pump Station electrical panels, controls***
  - Primary concern for this structure would be to mitigate potential impacts from storm surge impacts. Otherwise this station could be shut down during periods of inundation under any of the planning elevation scenarios.
- ***Breakwater Pump Station (PS #15) electrical panels, controls***
- ***Factory Cove Pump Station (PS #13) electrical panels, controls***
- ***Roads End Pump Station (PS #12) electrical panels, controls***

- ***Atlantic By Church Pump Station (PS #2) electrical panels, controls***
- ***Footbridge Pump Station (PS #7) electrical panels, controls***
- ***Chlorine Contact Tank***
  - The top of this concrete tank structure is at the same elevation as the highest planning elevation scenario at the WWTF. The District should consider the costs for elevating this structure above BFE +6 versus cleanup efforts associated with inundation of the tanks by coastal flood waters and potential floating debris during the inundation period.

Flood Proof Structures

- ***Collection System***
  - Consider flood proofing manhole structures for areas of the collection system which fall within the three flood event planning scenarios. The District indicates that none of the sewer manhole structures have flood proof hatches and this is likely in consideration that I&I would likely get into the system from impacted properties with sewer services connected into the system near these manholes, making flood proof hatches for the manholes potentially unsuccessful in keeping I&I from flood waters out of the collection system.
- ***Metering Manhole***
  - Installation of a flood proof hatch on this could prevent I&I during the inundation period which could back flow into the wastewater treat process system under all three flood event planning scenarios.
- ***Atlantic by Church Pump Station (PS #2)***
  - Installation of a flood proof hatch on this could prevent I&I during the inundation period, protecting the dry well vault housing the pumps for this station. An alternative approach would be to reconstruct the facility with wetwell system and submersible pumps that could withstand potential impacts from inundation by flood waters.

Add / Improve Permanent Emergency Generator Capacity

New permanent emergency power generators are suggested at the following facilities:

- ***Breakwater Pump Station (PS #15)***
- ***Factory Cove Pump Station (PS #13)***
- ***Ends Road Pump Station (PS #12)***
- ***Atlantic By Church Pump Station (PS #2)***
- ***Footbridge Pump Station (PS #7)***

Improvements to existing permanent emergency generator capacity, in terms of added fuel storage capacity or elevation of existing structure to the planning elevation scenarios are suggested at the following facilities:

- ***Union Street Pump Station (PS #1)***
- ***Commercial Street Pump Station (PS #4)***
- ***Wastewater Treatment Facility Process Building***

Aesthetics and integrity of the structures to withstand impacts from storm surge should be considered at all pump station locations, and particularly at the Union Street Pump Station (PS #1) the Commercial Pump Station (PS #4) and the Footbridge Pump Station (PS #7).

Examples of Elevated Structures to House Electrical and Control Panel Systems, as well as Emergency Power Generators from Other Maine Communities

Relocate

The District may want to consider relocating or discontinuing any of the pump stations at a point where any of the three flood event planning scenarios creates scenarios where protection of the facilities is cost prohibitive or the surround areas that they serve are likely to become uninhabitable due to impacts from increased sea level rise and storm surge.

The District may also want to consider relocation of the WWTF at point where the cost of significant upgrade to the facility, either for needed replacement or to protect it from increased sea level rise and storm surge impacts become cost prohibitive, or when similar conditions arise as noted above for the pump stations, where a significant portion of the community served by this facility surrounding Boothbay Harbor may become uninhabitable to impacts from increased sea level rise and storm surge.

7 Potential Funding Sources

USDA Rural Development Emergency Community Water Assistance Grants (ECWAG)

The Department of Agriculture provides from $150,000 to $500,000 to assist a rural community that has experienced a significant decline in quantity or quality of drinking water due to an emergency. Grants cover projects to obtain or maintain adequate quantities of water that meet the standards set by the Safe Drinking Water Act. Eligible emergencies include drought, earthquake, flood, tornado, hurricane, disease outbreak or chemical spill, leakage, or seepage.

EPA Clean Water State Revolving Fund (CWSRF)

EPA provides grants to states under the Clean Water State Revolving Fund. States make low interest loans or other assistance to publicly owned wastewater collection and treatment systems, stormwater systems and nonpoint source pollution control and estuary management projects.

HUD CDBG and Section 108 Guaranteed Loans

HUD Community Development Block Grants (CDBGs) are for entitlement communities. CDBGs may also go to states to distribute to non-entitlement communities. Communities must spend at least 70% of these funds for activities that benefit low- and moderate-income persons. Utilities have used these block grants to develop new water sources, improve treatment and replace distribution system pipes.

SBA Disaster Loans

Through its Office of Disaster Assistance, the U.S. Small Business Administration (SBA) can provide low-interest, long term loans to businesses and private nonprofits of all sizes following a disaster. This includes infrastructure assistance to private for-profit (PFP) and private nonprofit (PNP) utilities to restore them to their pre-disaster operability.

Appendices

Overview Map of Wastewater Treatment Facilities

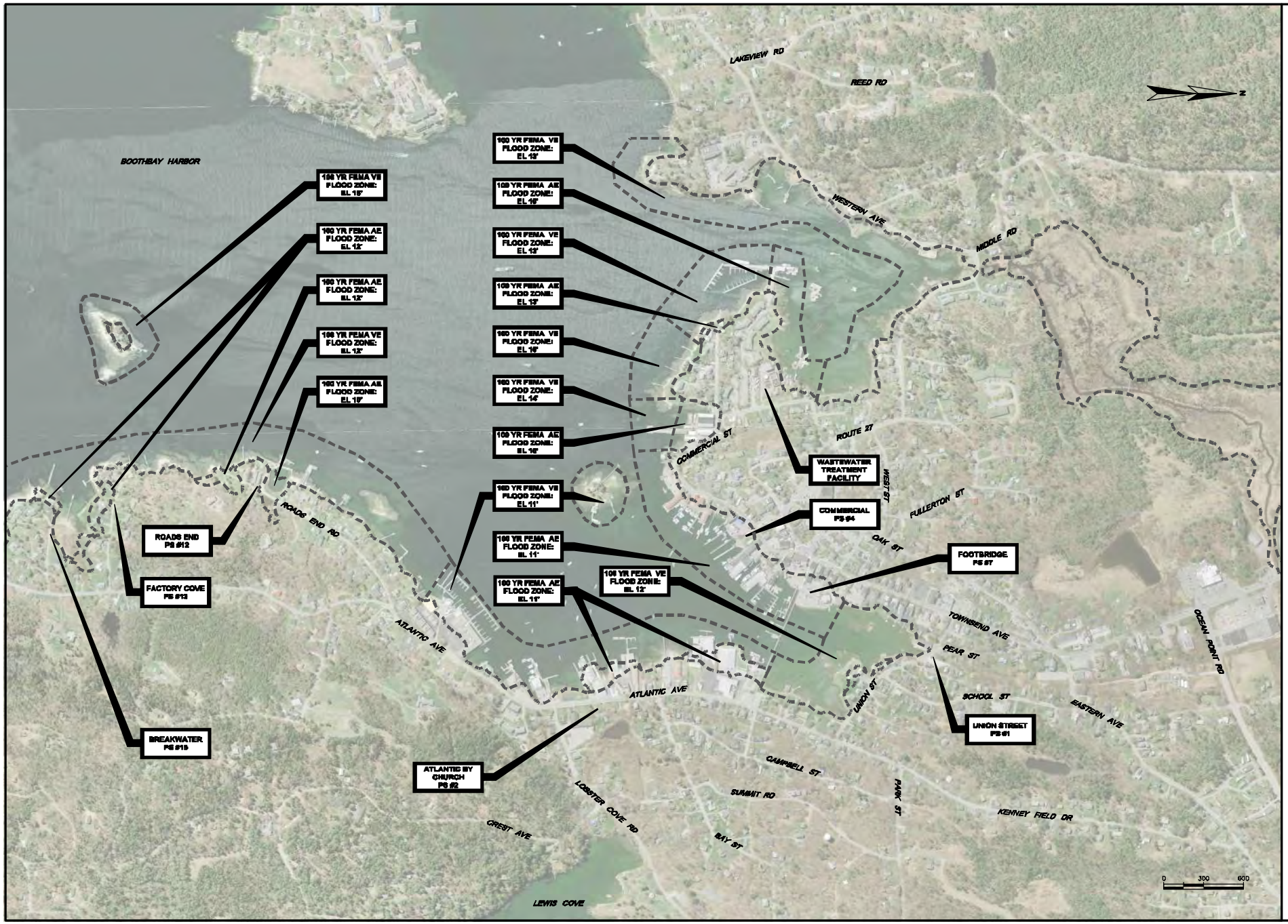
Wastewater Treatment Facility Plan and Profile

Pump Station Inundation Plan and Profile

Adaptation Strategies - Cost Considerations Matrix

FEMA Flood Insurance Rate Maps

Reference Resources



NO	SUBMISSIONS/REVISIONS	APP'D	DATE
1		TJP	5-16
2			
3			
4			
5			

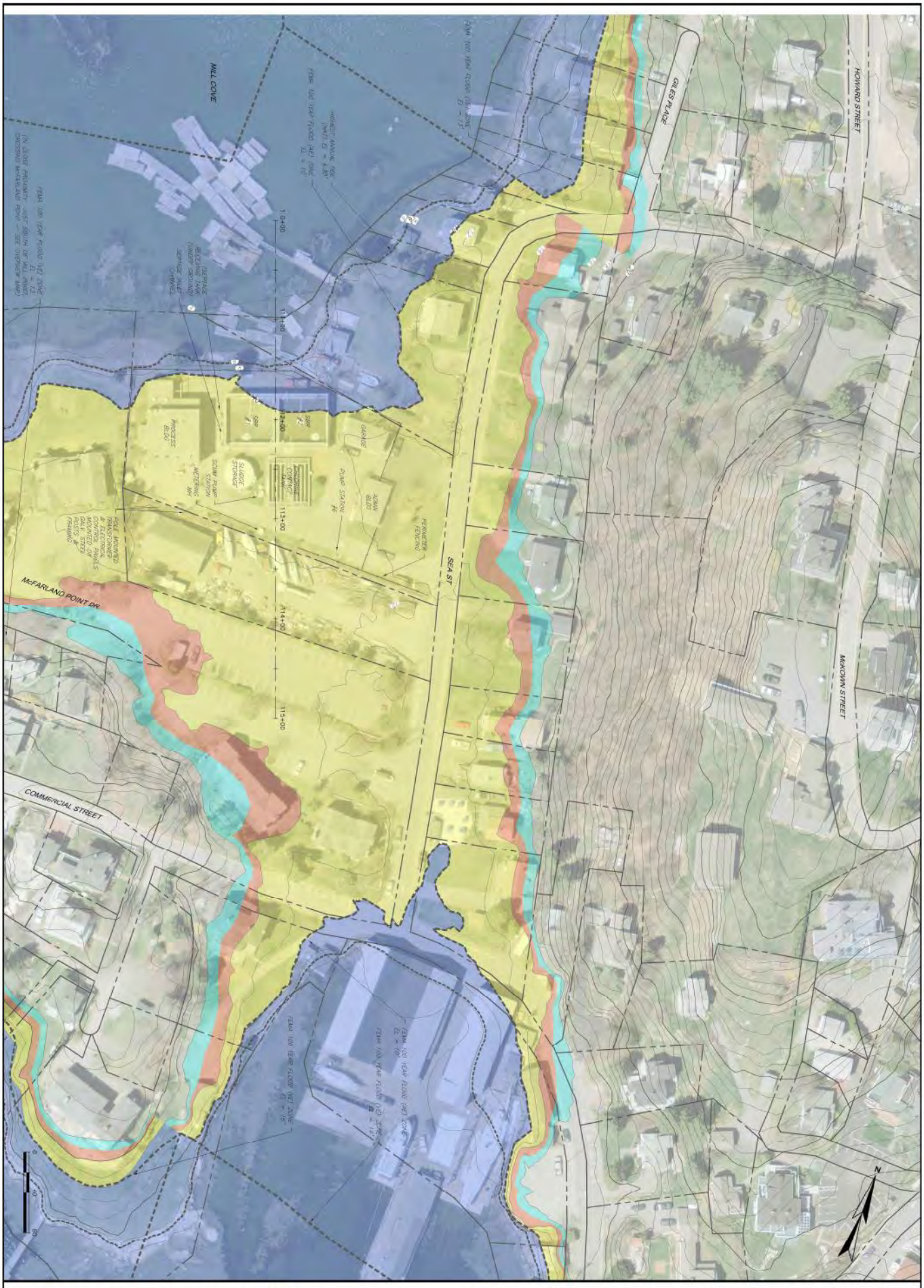
DESIGNED BY:
CAD CHKD:
QC CHKD:
CHECKED BY:
DATE:
APPROVED BY:
DATE:
PROJECT NO: 13358

WRIGHT-PIERCE
Engineering a Better Environment
Offices Throughout New England
800.521.7156 | www.wright-pierce.com

BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

PROJECT OVERVIEW MAP

DRAWING
FIG-1



BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

PLAN
WASTE WATER TREATMENT PLANT

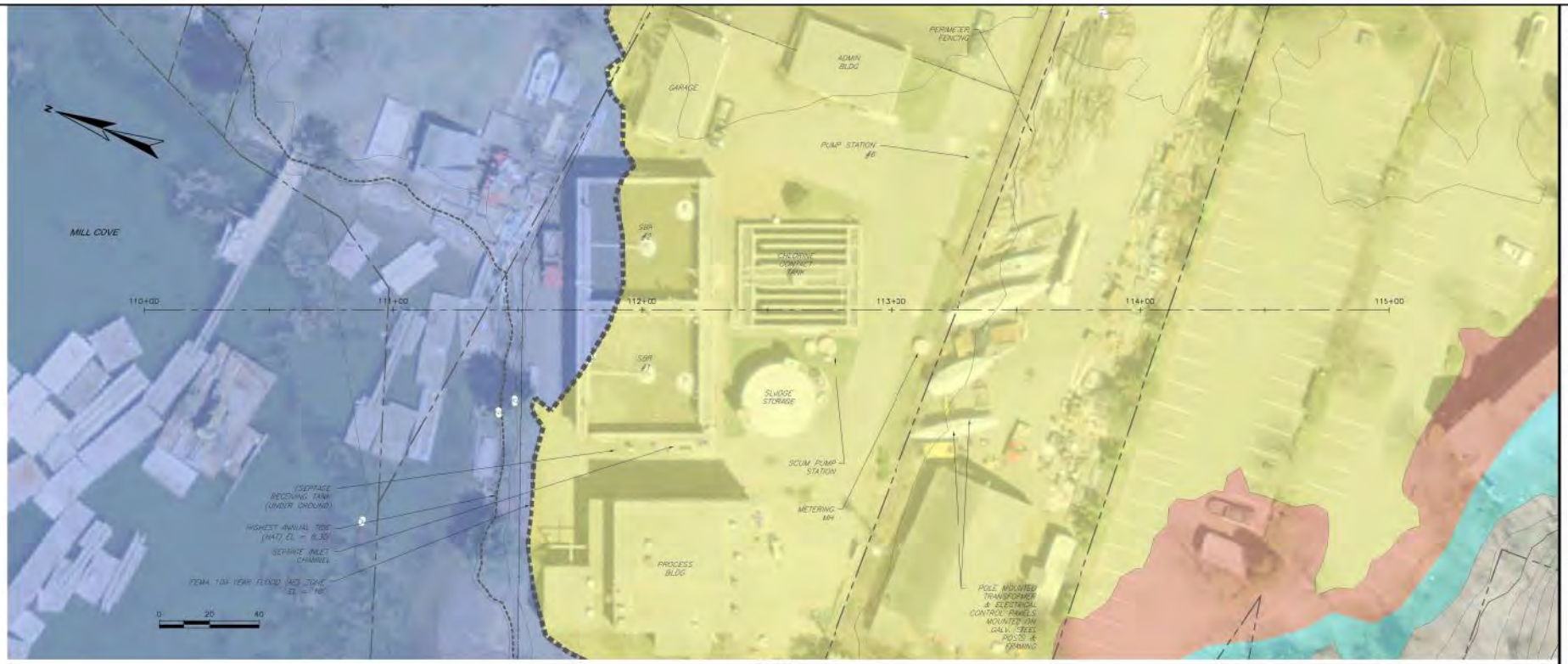
DRAWING
FIG-2

WRIGHT-PIERCE
Engineering a Better Environment

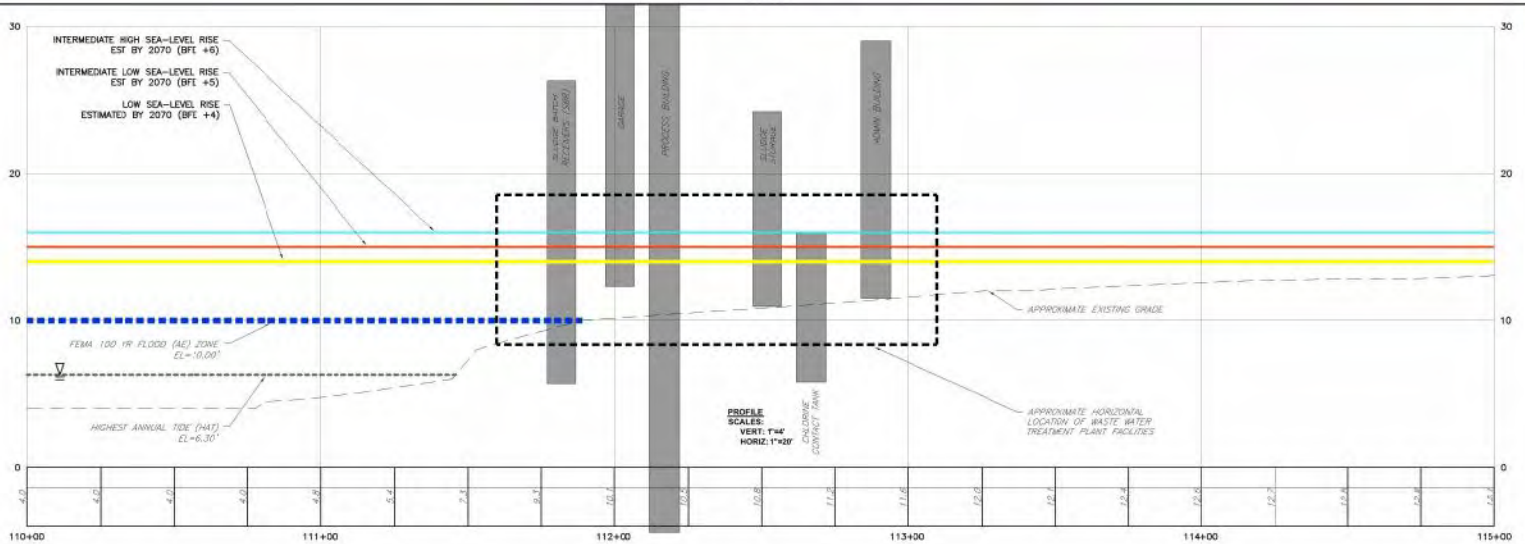
Offices Throughout New England
888.621.8156 | www.wright-pierce.com

DESIGNED BY:
CAD COMP: CMC
CAD:
CHECKED BY:
DATE:
APPROVED BY:
DATE:
PROJECT NO: 13358

NO	SUBMISSIONS/REVISIONS	APP'D	DATE
1			
2			
3			
4			



PLAN



NO.	DESCRIPTION	DRFT	DATE
		TJP	5-18
1			
2			
3			
4			

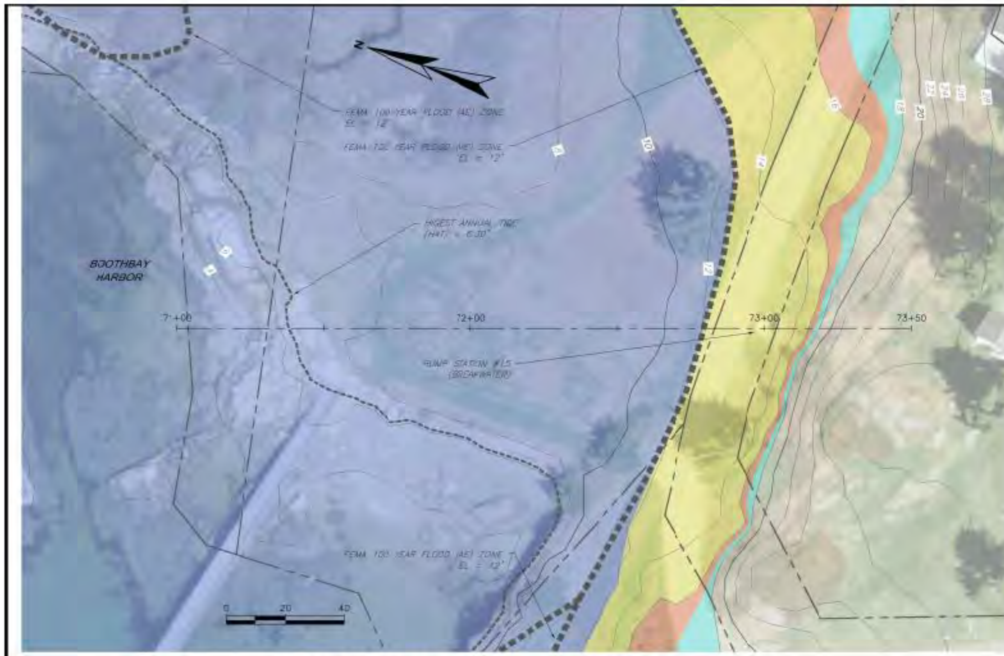
DESIGNED BY: CMC
DRAWN BY: CMC
CHECKED BY:
DATE:
APPROVED BY:
DATE:
PROJECT NO. 13358

WRIGHT-PIERCE
Engineering a Better Environment
Offices Throughout New England
888.621.8156 | www.wright-pierce.com

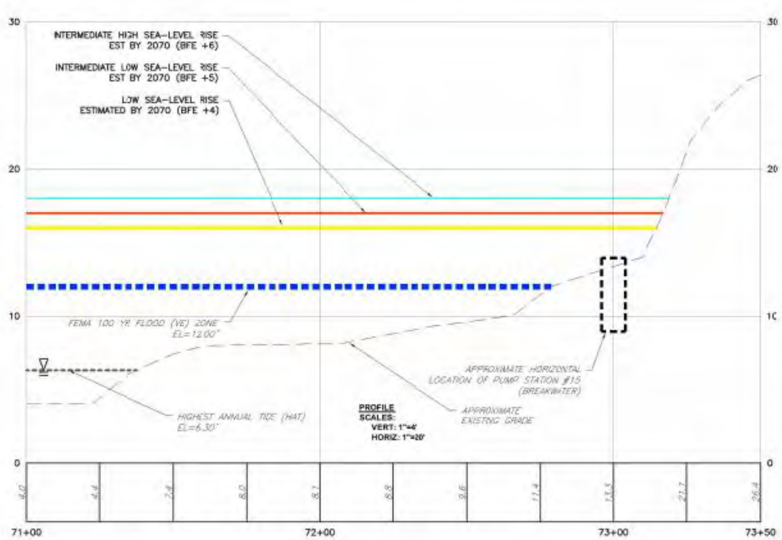
BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

PLAN & PROFILE
WASTE WATER TREATMENT FACILITY

DRAWING
FIG-3



PLAN: BREAKWATER PUMP STATION #15



BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

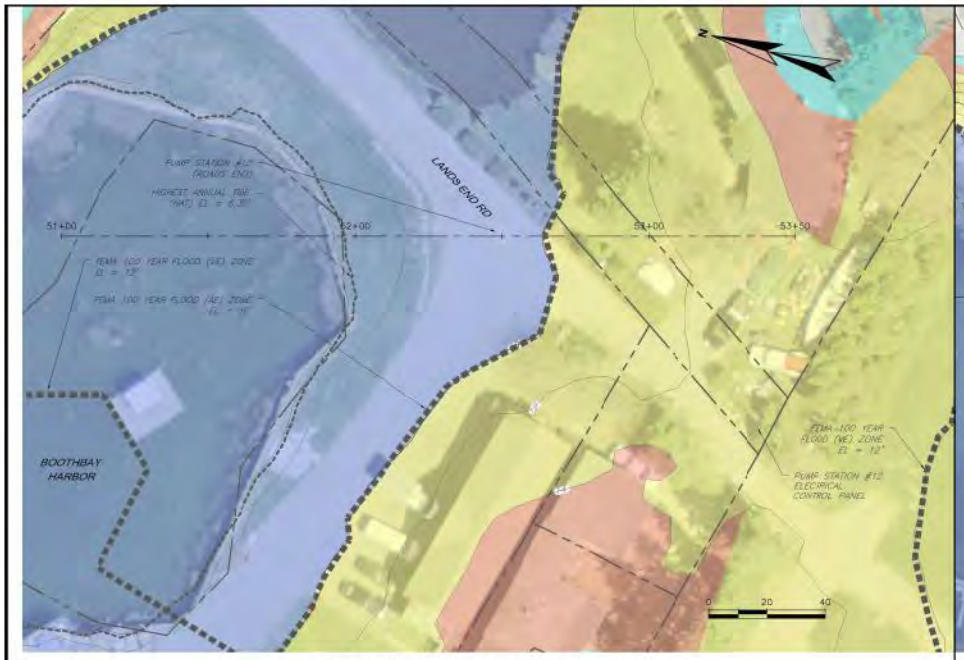
PLAN & PROFILE
PUMP STATION #15 & PUMP STATION #14

WRIGHT-PIERCE
Engineering a Better Environment
Offices Throughout New England
888.621.8156 | www.wright-pierce.com

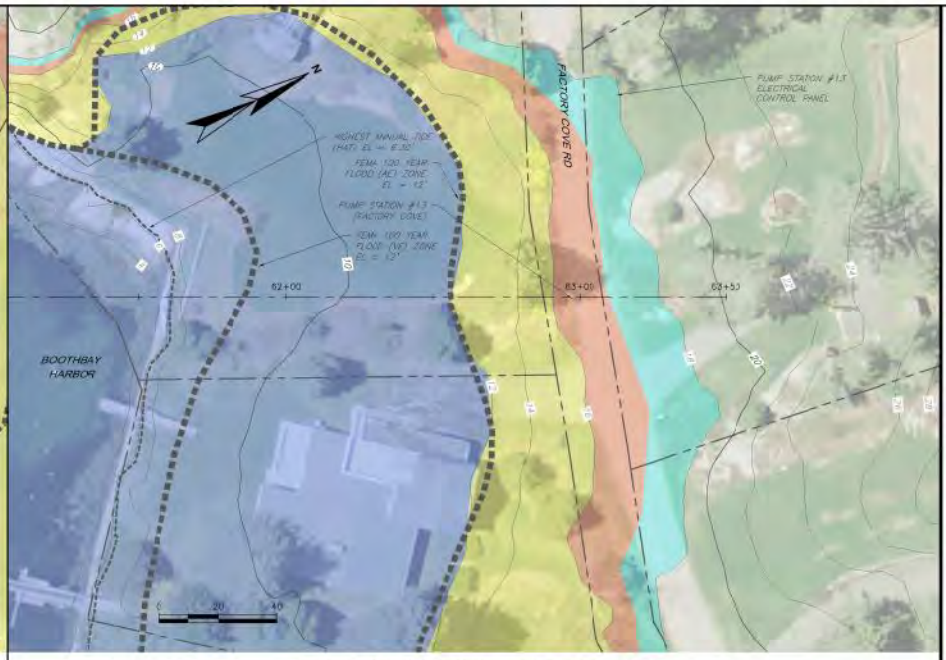
DESIGNED BY: CMC
CAD COORD: CMC
CAD: CMC
CHECKED BY:
DATE:
APPROVED BY:
DATE:
PROJECT NO. 13358

NO.	SUBMISSIONS/REVISIONS	APP'D	DATE

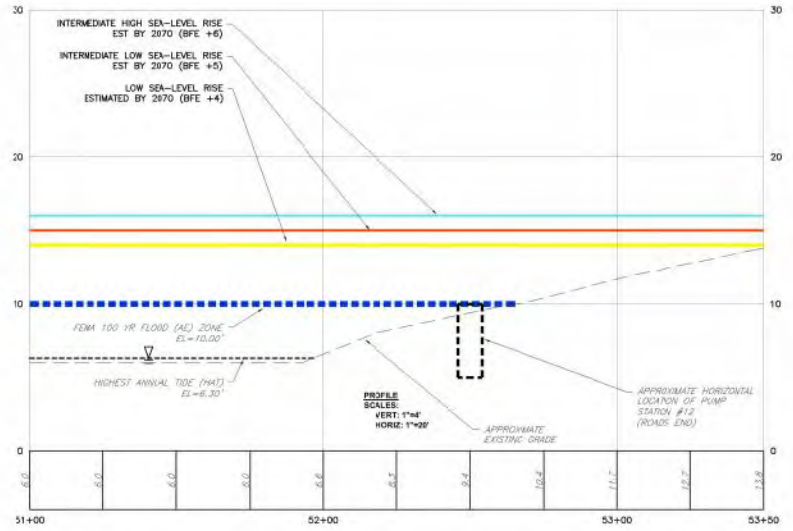
DRAWING
FIG-7

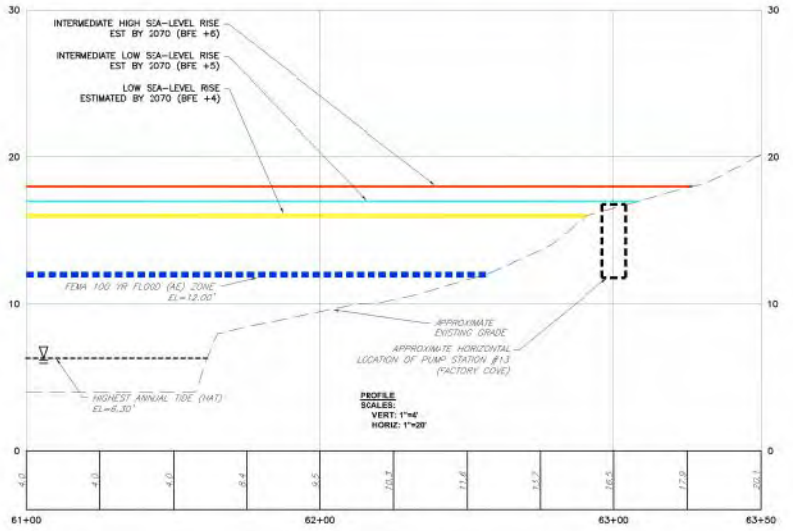


PLAN: ROADS END PUMP STATION #12



PLAN: FACTORY COVE PUMP STATION #13





NO.	DESCRIPTION	BY	DATE
1			

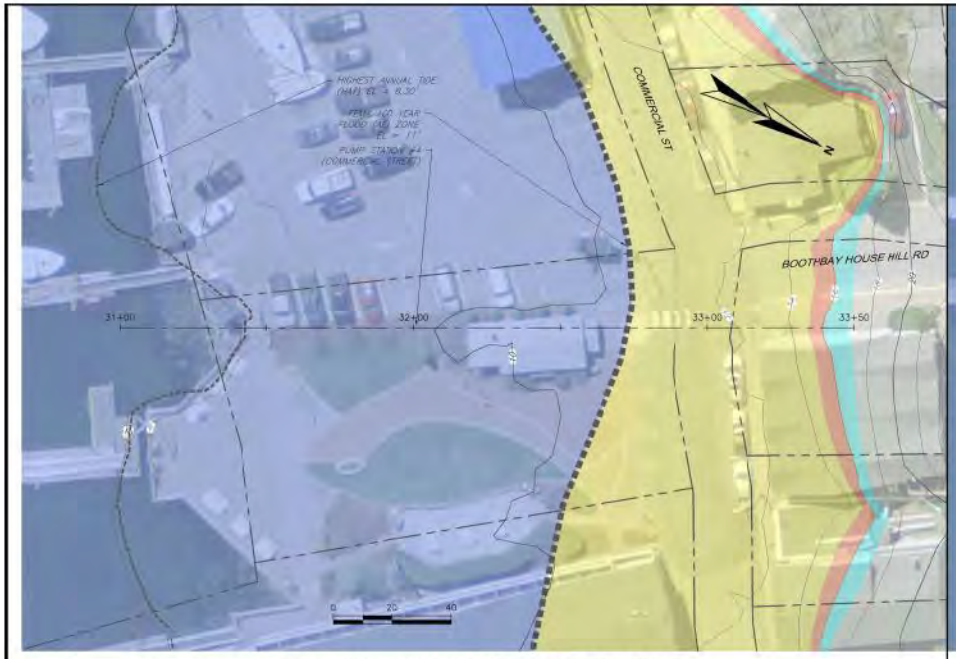
DESIGNED BY: CMC
DRAWN BY: CMC
CHECKED BY:
DATE:
APPROVED BY:
DATE:
PROJECT NO. 13358

WRIGHT-PIERCE
Engineering a Better Environment
Offices Throughout New England
888.621.8156 | www.wright-pierce.com

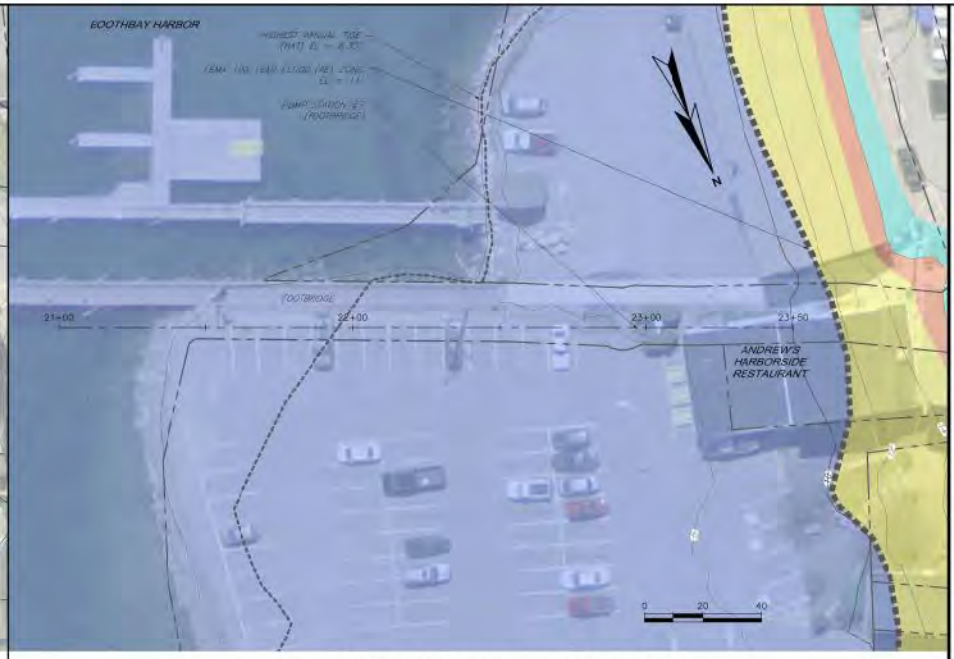
BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

PLAN & PROFILE
PUMP STATION #12 & PUMP STATION #13

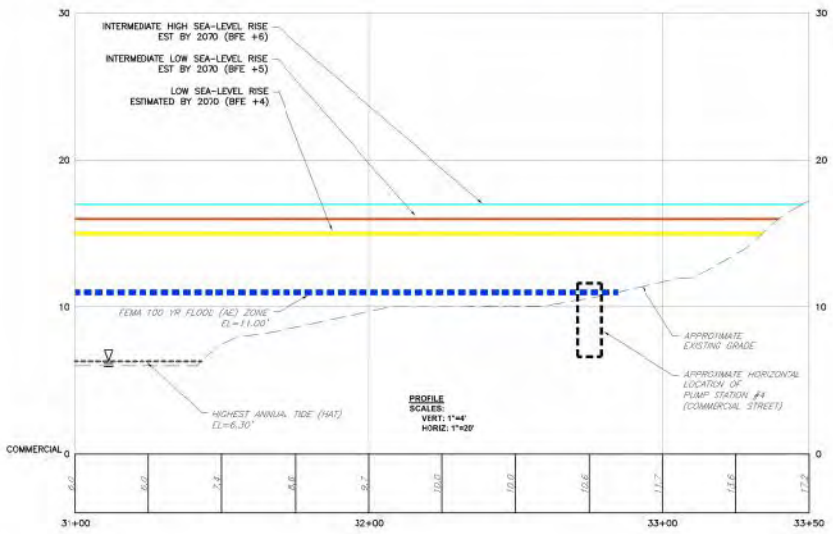
DRAWING
FIG-6

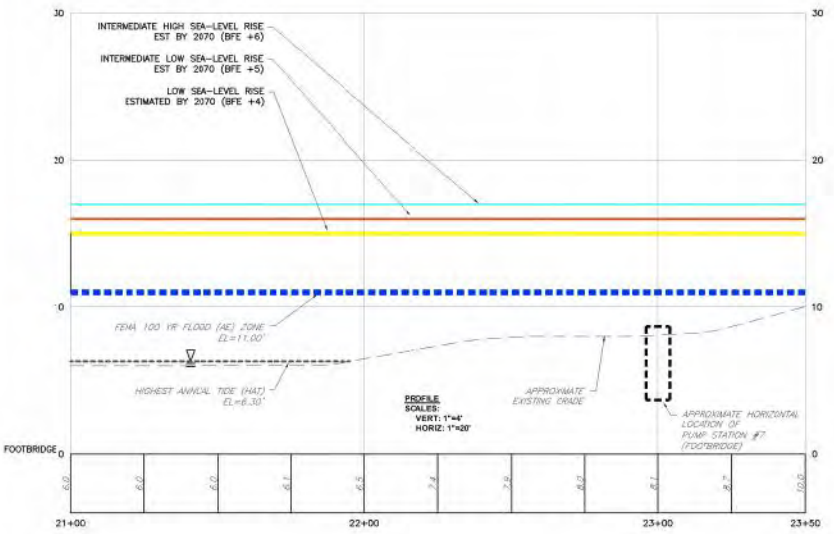


PLAN: COMMERCIAL STREET PUMP STATION #4



PLAN: FOOTBRIDGE PUMP STATION #7



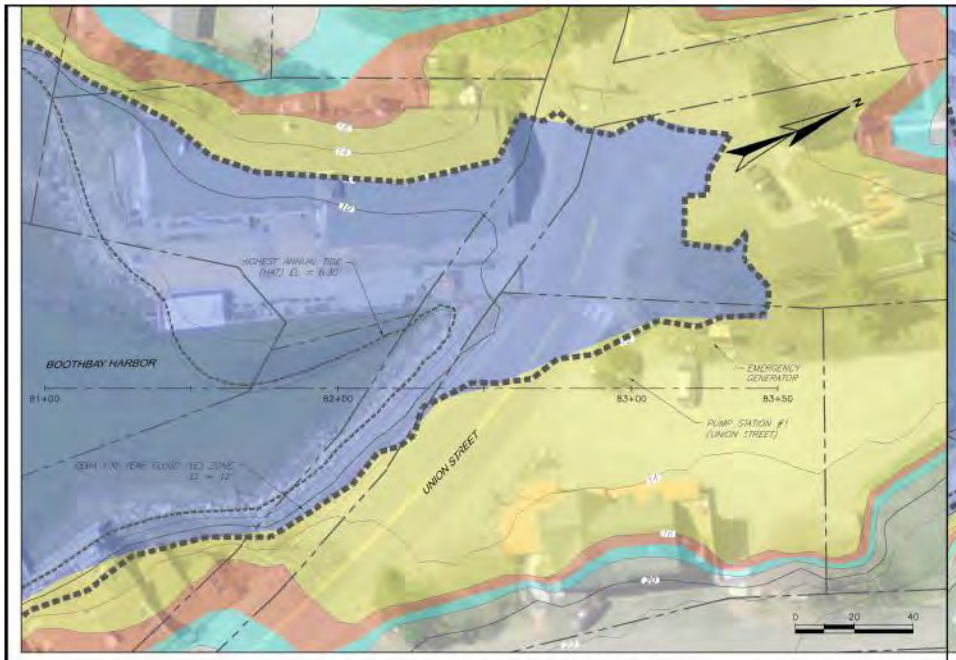


WRIGHT-PIERCE
Engineering a Better Environment
Offices Throughout New England
888.621.8156 | www.wright-pierce.com

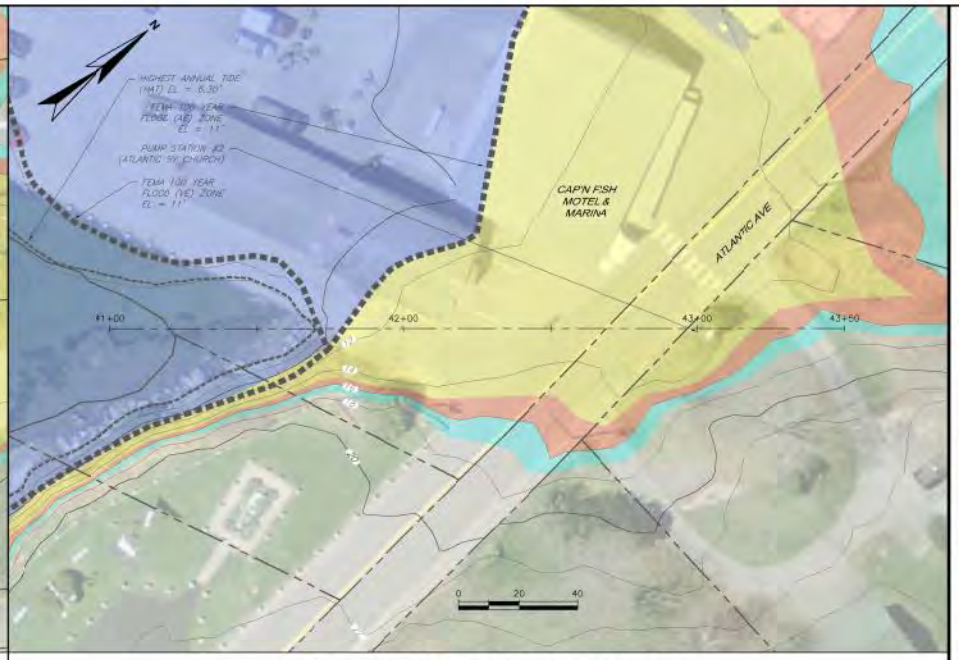
BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

PLAN & PROFILE
PUMP STATION #4 & PUMP STATION #7

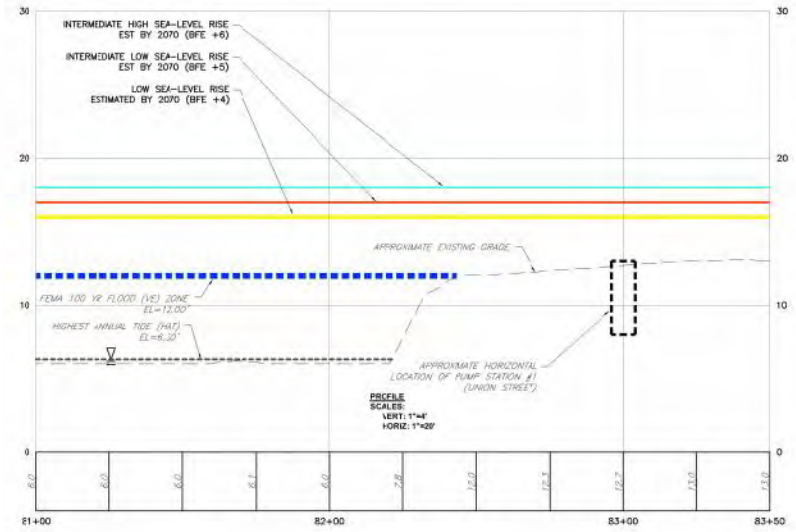
DRAWING
FIG–5

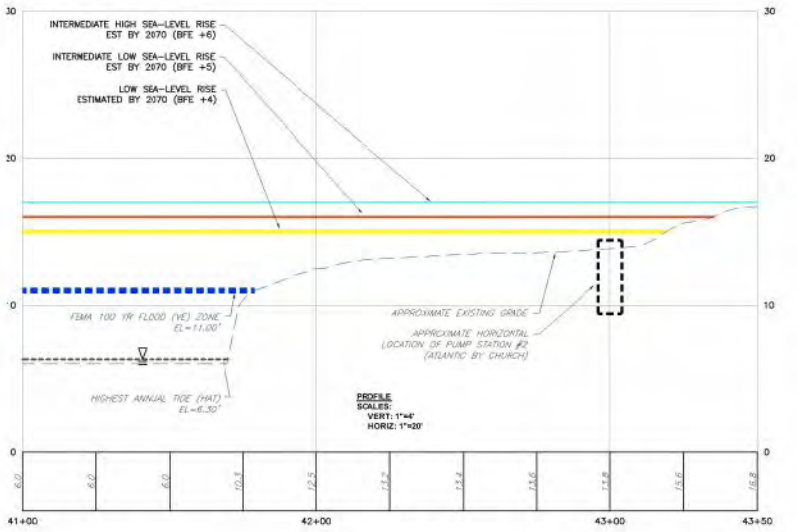


PLAN: PUMP STATION #1 (UNION STREET)



PLAN: PUMP STATION #2 (ATLANTIC BY CHURCH)





		DES'D	DATE
		TJP	5-18
		DESIGNED BY:	CMC
		DRAWN BY:	CMC
		CHECKED BY:	
		DATE:	
		APPROVED BY:	
		DATE:	
		PROJECT NO.	13358

WRIGHT-PIERCE
Engineering a Better Environment
Offices Throughout New England
888.621.8156 | www.wright-pierce.com

BOOTHBAY HARBOR SEWER DISTRICT
WWTF COASTAL RESILIENCY STUDY
BOOTHBAY HARBOR, MAINE

PLAN & PROFILE
PUMP STATION #1 & PUMP STATION #2

DRAWING
FIG–4

ADAPTATION STRATEGIES – COST CONSIDERATIONS MATRIX

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Shoreline Stabilization	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
WWTF Northern Shoreline	$75,000 - $100,000			The shoreline stabilization area is the same under all three of the planning elevation scenarios

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Permanent Barrier Projection	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
WWTF Perimeter	$1.25 M – 1.5 M	1.4 M - 1.65 M	1.55 M – 1.8M	Sheet Pile or Concrete Sea Wall with (2) Gates at the Entrance Drives Entering the Site from Sea St. This strategy should be considered versus the potential sum of costs for multiple infrastructures improvements within the WWTF

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Temporary Flood Barriers (Building Doors and Windows)	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
Individual Single Door	$5,000			Costs for this adaptation strategy are the same under all three of the planning elevation scenarios
Individual Double Door	$7,500 - $7,500			Costs for this adaptation strategy are the same under all three of the planning elevation scenarios
Individual Garage Door	$10,000 - $15,000			Costs for this adaptation strategy are the same under all three of the planning elevation scenarios
Individual Window	$2,500 - $5,000			Costs for this adaptation strategy are the same under all three of the planning elevation scenarios

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Flood Proof Building Penetrations Vents and Wall/Floor Penetrations	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
Process Building	$100,000 - $300,000			Costs for this adaptation strategy are the same under all three of the planning elevation scenarios

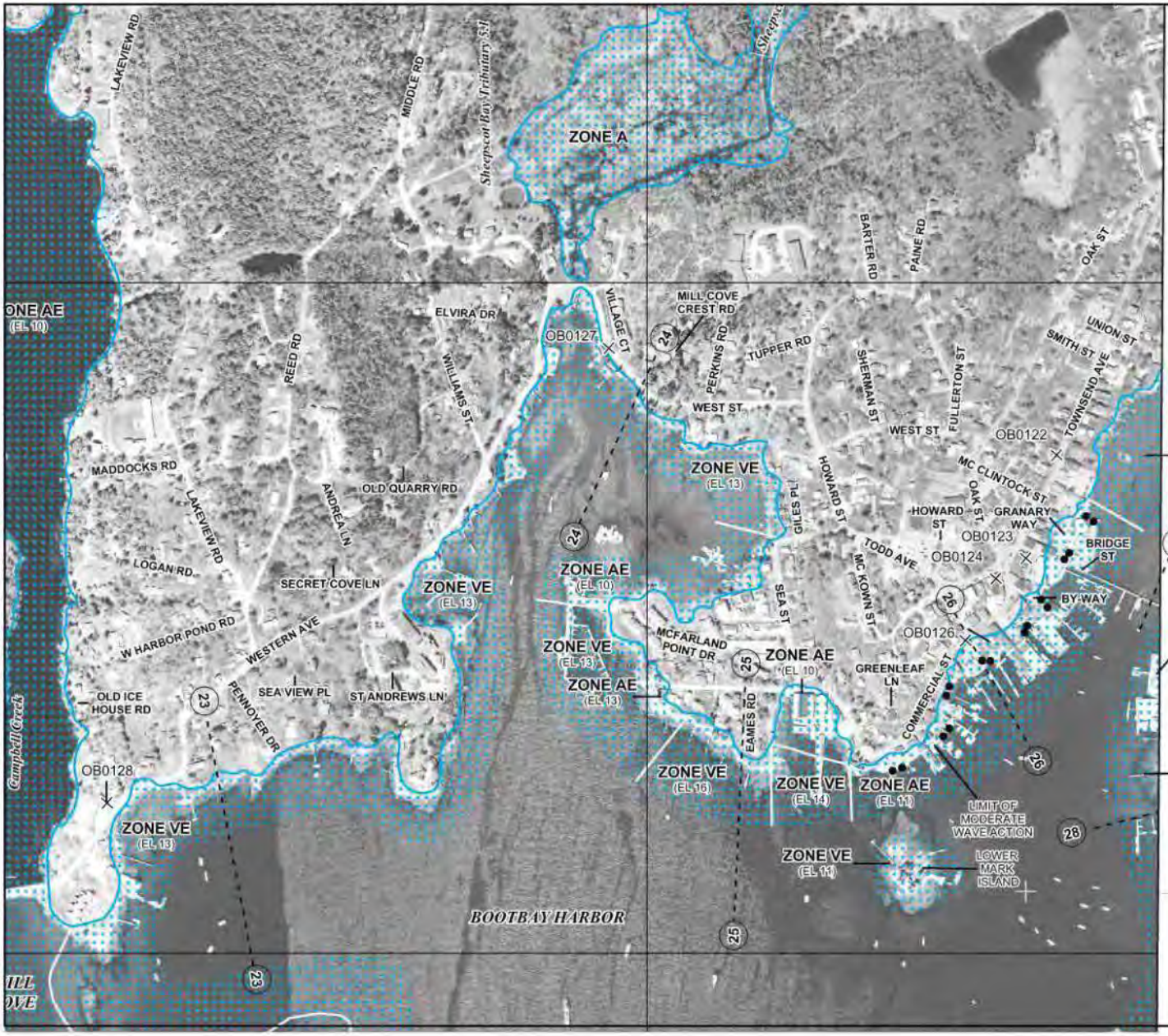
Adaptation Strategy	Planning Level Construction Costs			General Considerations
Reconstruction / Reinforcement of Buildings	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
Administration Building	$500,000 - $750,000	$600,000 - $850,000	$7500,000 - $1,000,000	
Garage	$350,000 - $500,000	$450,000 - $600,000	$550,000 - $700,000	
Public Restroom Building at PS #4	$125,000 - $175,000	$140,000 - $190,000	$175,000 - $225,000	
Process Building	$750,000 - $1,500,000			Costs for protection of basement and first floor interior infrastructure are the same under all three of the planning elevation scenarios
Footbridge PS #7	$100,000 - $150,000	$125,000 - $175,000	$150,000 - $200,000	

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Elevate Structures, Tools and Equipment	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
WWTF PS #6	$50,000 - $75,000	$60,000 - $85,000	$70,000 - $95,000	Assumes that the equipment will be mounted on stainless steel support posts and framing with a wooden back board in the same manner as the current Union Street PS #1 upgrades.
Scum Well PS	$50,000 - $75,000	$60,000 - $85,000	$70,000 - $95,000	Assumes that the equipment will be mounted on stainless steel support posts and framing with a wooden back board in the same manner as the current Union Street PS #1 upgrades.
Breakwater PS #15	$50,000 - $75,000	$60,000 - $85,000	$70,000 - $95,000	Assumes that the equipment will be mounted on stainless steel support posts and framing with a wooden back board in the same manner as the current Union Street PS #1 upgrades.
Factory Cove PS #13	$50,000 - $75,000	$60,000 - $85,000	$70,000 - $95,000	Assumes that the equipment will be mounted on stainless steel support posts and framing with a wooden back board in the same manner as the current Union Street PS #1 upgrades.
Roads End PS #12	$50,000 - $75,000	$60,000 - $85,000	$70,000 - $95,000	Assumes that the equipment will be mounted on stainless steel support posts and framing with a wooden back board in the same manner as the current Union Street PS #1 upgrades.
Atlantic By Church PS#2	$50,000 - $75,000	$60,000 - $85,000	$70,000 - $95,000	Assumes that the equipment will be mounted on stainless steel support posts and framing with a wooden back board in the same manner as the current Union Street PS #1 upgrades.
Footbridge PS #7	$100,000 - $150,000	$125,000 - $175,000	$150,000 - $200,000	Assumes that the equipment will be enclosed in a building structure to fit within the aesthetic setting of the Town's commercial waterfront area
Chlorine Contact Tank	$0	$0	$150,000 - $200,000	Top of existing structure is at the same elevation as BFE +6 at the WWTF.

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Flood Proof Structures	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
Collection System Individual Manhole	$2,500 - $5,000			Costs are expected to be on the same order of magnitude for each of the three flood event planning scenarios.
Metering Manhole	$4,000 - $6,000			Costs are expected to be on the same order of magnitude for each of the three flood event planning scenarios.
Temporary Flood Protection of Building Penetrations (Doors & Windows) – Admin. Bldg.	$5,000 - $7,500			Costs are expected to be on the same order of magnitude for each of the three flood event planning scenarios.

Adaptation Strategy	Planning Level Construction Costs			General Considerations
Add / Improve Permanent Emergency Generator Capacity	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
Individual Pump Station On Open Air Support Structure	$350,000	$375,000	$400,000	No pre-emptive capital improvement costs. Damage / Repair costs could be significant.
Individual Pump Station within Building Enclosure	$500,000	$550,000	$600,000	Costs are expected to be on the same order of magnitude for each of the three flood event planning scenarios. Costs most likely to vary depending on land acquisition needs and if a support structure is needed, which type is selected.

Adaptation Strategy	Conceptual Level Costs			General Considerations
Relocate	BFE +3-FT + 1-FT SLR	BFE + 3-FT + 2-FT SLR	BFE + 6 Ft + 3-FT SLR	Comments
WWTF	$12,000,000 to $17,000,000			If this option is considered, the WWTF should be relocated to a site that does not require protection from coastal flooding impacts. The conceptual level cost estimate for this scenario provided assumes such a relocation scenario.
Individual Pump Station	$750,000 to $950,000			If this option is considered, any of the pump stations relocated should be to a nearby site from the current location that does not require protection from coastal flooding impacts. The conceptual level cost estimate for this scenario provided assumes such a relocation scenario.



MAP SCALE 1" = 500'

250 0 500 1000 FEET METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0432D

FIRM

FLOOD INSURANCE RATE MAP

LINCOLN COUNTY, MAINE (ALL JURISDICTIONS)

PANEL 432 OF 525

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

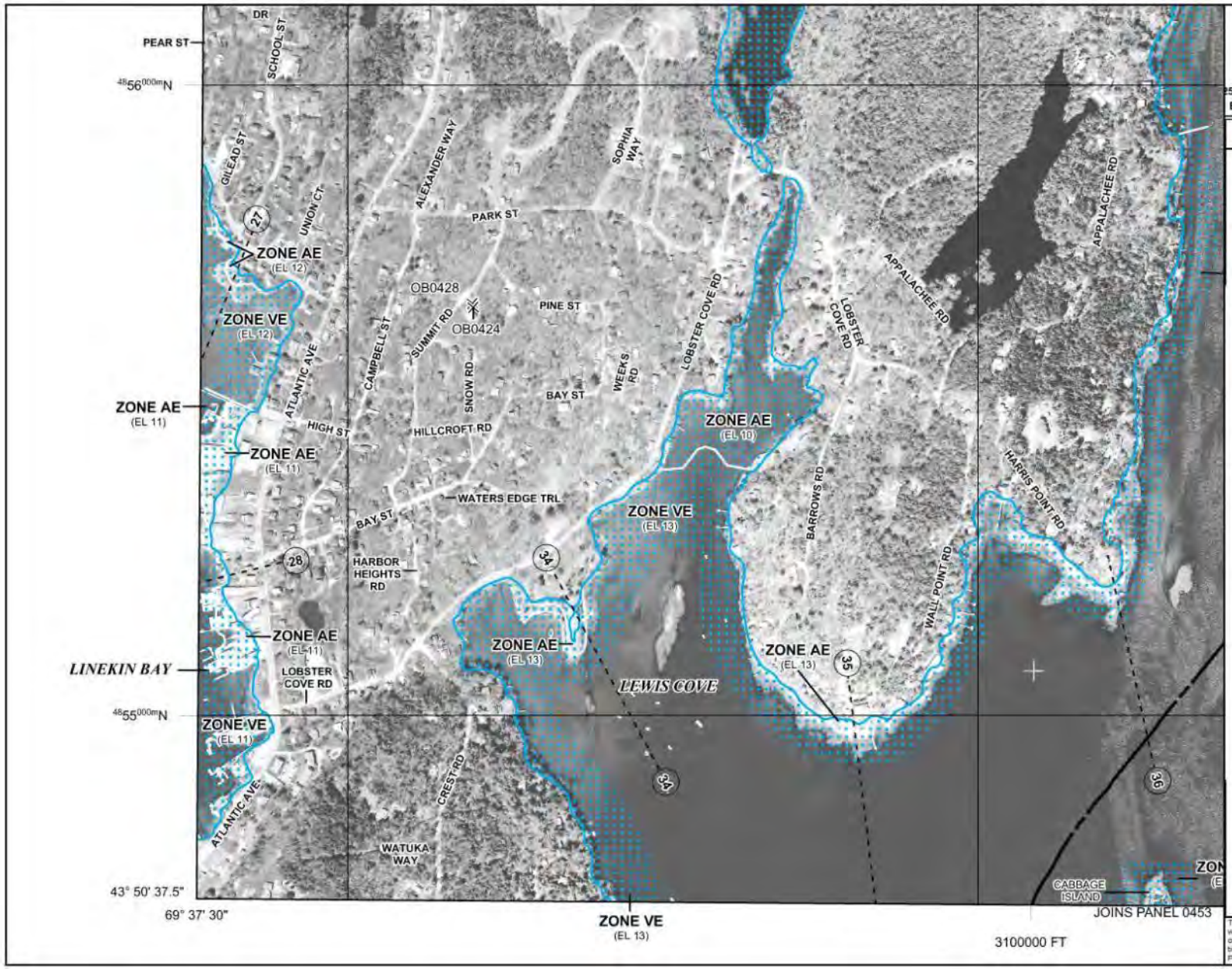
COMMUNITY	NUMBER	PANEL	SUFFIX
BOOTHBAY HARBOR, TOWN OF	230073	0432	D
BOOTHBAY, TOWN OF	230215	0432	D
SOUTHPORT, TOWN OF	230221	0432	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
23015C0432D

EFFECTIVE DATE
JULY 16, 2015

Federal Emergency Management Agency



MAP SCALE 1" = 500'

250 0 500 1000 FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0451D

FIRM

FLOOD INSURANCE RATE MAP

LINCOLN COUNTY, MAINE

(ALL JURISDICTIONS)

PANEL 451 OF 525

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

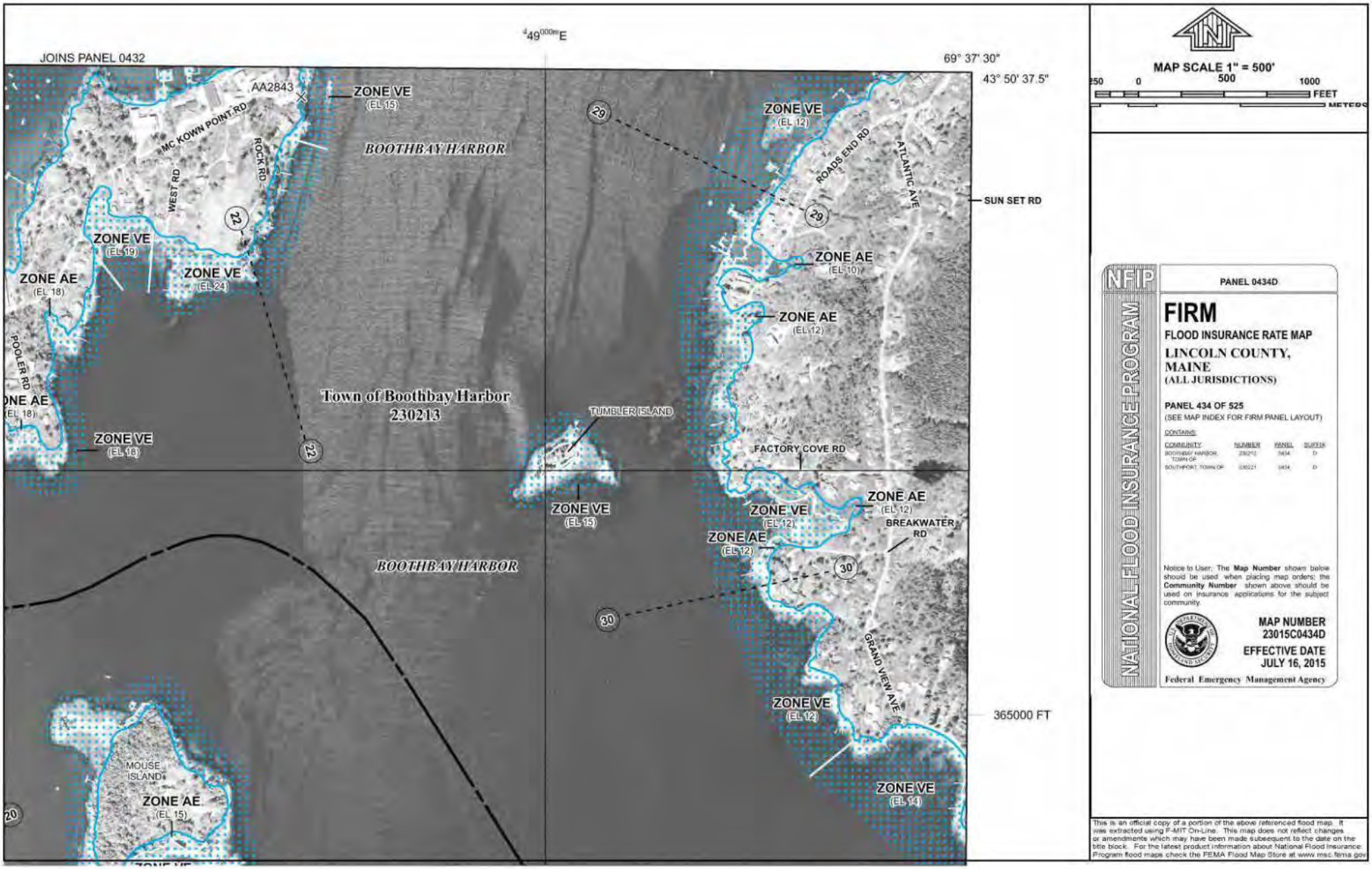
COMMUNITY	NUMBER	PANEL	SUFFIX
BOOTHBAY HARBOR, TOWN OF	230213	0451	D
BOOTHBAY, TOWN OF	230212	0451	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
23015C0451D

EFFECTIVE DATE
JULY 16, 2015

Federal Emergency Management Agency



MAP SCALE 1" = 500'

250 0 500 1000

FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0434D

FIRM

FLOOD INSURANCE RATE MAP

LINCOLN COUNTY, MAINE

(ALL JURISDICTIONS)

PANEL 434 OF 525

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BOOTHBAY HARBOR, TOWN OF	230213	0434	D
SOUTHPORT, TOWN OF	230221	0434	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
23015C0434D

EFFECTIVE DATE
JULY 16, 2015

Federal Emergency Management Agency

Reference Resources:
The following resource information supporting this report is as follows:

Sea, Lake, and Overland Surges for Hurricanes (SLOSH)

http://www.nhc.noaa.gov/surge/slosh.php
NOAA Tides and Currents

https://tidesandcurrents.noaa.gov/

USACOE Sea Level Rise Calculator

http://www.corpsclimate.us/ccaceslcurves.cfm

MaineDEP Highest Annual Tide Level for 2016

https://www1.maine.gov/dep/land/slz/predictions.pdf

FEMA Flood Zone

https://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping

New England Interstate Water Pollution Control Commission

http://www.neiwpcc.org/

Maine Geological Survey

http://www.maine.gov/dacf/mgs/

EPA Flood Resilience Guide

https://www.epa.gov/waterutilityresponse/flood-resilience-basic-guide-water-and-wastewater-utilities

EPA Climate Resilience Evaluation and Awareness Tool (CREAT)

https://www.epa.gov/sites/production/files/2016-05/documents/creat_3_0_methodology_guide_may_2016.pdf

WRIGHT-PIERCE
Engineering a Better Environment

Water
Wastewater
Infrastructure