



Boothbay Harbor, Maine  
Wastewater Treatment Facilities  
Sea Level Rise & Storm  
Surge Impact Assessment

DRAFT

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Prepared Wright-Pierce

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# 1 Description of Facilities

## Wastewater Treatment Plant

The Boothbay Harbor wastewater treatment facility (WWTP) is located on the east side of Mill Cove Harbor, off of Sea Street in Boothbay Harbor, Maine. The WWTP is operated by the Boothbay Harbor Sewer District and provides secondary treatment for sanitary wastewater flow approximately 0.64 mgd average daily flow and up to 2.2 mgd during peak flow conditions. The WWTP was originally built in 1963 and included only primary treatment and chlorination. The WWTP was later upgraded in 1995 to also include secondary treatment via sequencing batch reactors (SBRs).



*View of the WWTP Looking South from the Top of the Sequencing Batch Reactors*

The WWTP receives wastewater from a collection system comprised of approximately XX miles of sewers and XX pump stations located throughout the community

The Town does not anticipate significant residential or commercial development in the near future, nor is it expected that land use trends will drastically change such that the capacity of the plant would be exceeded during the study period through 2070.

WWTP facility components include:

- Overhead power supply
- Vegetated shoreline
- Perimeter chainlink fence
- Administration building
- Process building
- Garage
- Influent bar screens
- Grit chamber

- Influent pump station and wetwell
- (2) Sequencing batch reactor (SBR)
- Sludge storage tank
- Chlorine Contact Tank
- Metering manhole
- Predominantly paved site interior with some lawn areas and trees / shrubs
- Manhole #1 (outfall structure)
- 33-inch dia. reinforced concrete outfall pipe

The northern end of the WWTP is located at the FEMA 100-YR flood AE zone at elevation 10-FT and the rest of the site is outside the flood zone. Mill Point and McFarland Point protect the site from FEMA 100-YR flood VE zones. Ground elevation throughout the site ranges from elevation 8-FT to 12-FT, referenced to the North American Vertical Datum of 1988 (NAVD88).



*Sea Street Looking South from the WWTP Entrance*



*Sea Street Looking North from the WWTP Entrance. Administration Building on the Left*



*Shoreline along the Northern Side of the WWTF Looking Sea Street Looking North from the WWTP Entrance. Administration Building on the Left*

## Breakwater Pump Station (PS #15)

The Breakwater pump station (PS #15) is located on Breakwater Road along the south side of Factory Cove. PS #15 was upgraded along with several other pump stations in 1996.

PS #15 has a submersible duplex grinder pump station system consisting of:

- A 5-ft diameter concrete wetwell
- (2) 2 HP submersible pumps
- A control panel backboard

The pumps convey up to 30 gpm through a 2-inch diameter force main that discharges to a sewer manhole on Breakwater Road.

PS#15 is located adjacent to a FEMA 100-year flood VE zone at elevation 12. Ground elevation around the structure is approximately elevation 13-FT.



*PS #15 Looking West Towards Boothbay Harbor*

## Factory Cove Pump Station (PS #13)

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 was also upgraded in 1996.

PS #13 has a submersible duplex grinder pump station system consisting of:

- a 5-ft diameter concrete wetwell
- (2) 2 HP submersible pumps
- a control panel backboard

The pumps convey up to 32 gpm each through a 2-inch diameter force main to a sewer manhole on Atlantic Avenue.

The Factory Cove Station is located adjacent to a FEMA 100-year flood AE zone at elevation 12.10 and adjacent to a FEMA 100-YR flood VE zone at elevation 12. Ground elevation around the structure is approximately elevation 16-FT.



*PS #13 Wetwell Looking East Along Factory Cove Road*



*PS #13 Controls Looking East*

## Roads End Pump Station (PS #12)

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 was upgraded in 1996.

PS #12 has a submersible duplex grinder pump station system consisting of:

- A 5-ft diameter concrete wetwell
- (2) 3 HP submersible pumps
- A control panel backboard

The pumps convey up to 30 gpm each through a 2-inch diameter force main to a sewer manhole on Atlantic Avenue.

The Roads End Station is located within the FEMA 100-year flood zone AE at elevation 10 and adjacent to FEMA 100-YR flood VE zones at elevation 12. Ground elevation around the structure is approximately elevation 10-FT.



*PS #12 Wetwell Looking East Along Roads End Road*



*PS #12 Controls West Towards Boothbay Harbor*

## Atlantic by Church Pump Station (PS #2)

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 was constructed in 1963 and is a duplex tin-can drywell / wetwell pump station system consisting of:

- A 6-ft diameter wetwell
- (2) 3 HP centrifugal pumps
- A control panel backboard

The pumps convey up to 250 gpm through a 6-inch diameter force main that pumps to the gravity sewer on Bay Street.

The Atlantic by Church Station is located adjacent to a FEMA 100-year flood zone AE at elevation 11 and adjacent to a FEMA 100-YR flood VE zone at elevation 12. Ground elevation around the structure is approximately elevation 13-FT.



*PS #2 Looking South along Atlantic Avenue*

## Commercial Street Pump Station (PS #4)

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 station was upgraded in 2011 and is a duplex submersible station system with:

- An 8-ft diameter concrete wetwell,
- (2) 15 HP submersible centrifugal pumps,
- A small electrical / control room attached to a public restroom building that houses:
  - § Control equipment
  - § Electrical equipment
  - § A 40 kW diesel standby generator

The pumps convey up to 430 gpm each and pump into an existing 6-inch force main that discharges into a sewer manhole at the corner of Oak Street and Howard Street.

The Commercial Street Station is located within a FEMA 100-year flood AE zone at elevation 11. Ground elevation around the structure is approximately elevation 10.9-FT.



*PS #4 Looking South from Commercial Street Towards Boothbay Harbor*

## Footbridge Pump Station

The Footbridge Pump Station (PS #7) is located off of Townsend Avenue and near Commercial Avenue in downtown Boothbay Harbor on the west side of the harbor. PS #7 was originally built in 1978 and consists of a tin-can type wetwell / drywell duplex pump station system with:

- A 4-ft diameter concrete wetwell
- (2) grinder pumps
- A control panel backboard

The pumps convey up to 50 gpm each through a 3-inch diameter force main that pumps to a sewer manhole on Townsend Avenue.

The Footbridge Station is located within a FEMA 100-year flood AE zone at elevation 11. Ground elevation around the structure is approximately elevation 8-FT.



*PS #7 Behind Shrubs on Right Looking East Towards Boothbay Harbor*

## Union Street Pump Station (PS #1)

The Union Street Pump Station (PS #1) is located at the head of the harbor, on Union Street. PS #1 consists of a tin-can type wetwell / drywell triplex pump station system with:

- A 4-ft diameter concrete wetwell
- (3) centrifugal pumps
- A control panel backboard
- A 40kW diesel generator

The pumps convey up to 400 gpm each through an 8-inch diameter force main that pumps to a sewer manhole on Oak Street.

An upgrade of the existing station is currently in design, and it is expected to be constructed during 2017. The upgraded station will consist of:

- A 10-ft diameter concrete wetwell,
- (3) new submersible pumps, and
- New pump controls on a new backboard.

The existing generator will remain in place as is.

The Union Street Station is located close to, but outside a FEMA 100-year flood VE zone at elevation 12. Ground elevation around the structure is approximately elevation 12.1-FT.



*PS #1 Looking Across Atlantic Avenue Towards Boothbay Harbor*

# 2 Discussion of Sea Level Rise / Storm Surge Parameters

This study considers three primary environmental factors (coastal flooding, sea level rise and storm surge) and their predicted/regulated impacts on the Town's wastewater treatment facilities.

## Coastal Flooding:

The 100-year flood elevation as defined by the Federal Emergency Management Agency (FEMA) is the benchmark flood event considered in this study. FEMA has performed detailed coastal flood studies that:

- Include the effects of rainfall precipitation, tides, storm surges and waves.
- Consider historical coastal flood events that have affected the study area.
- Use historical data to validate flood, wave and erosion analyses.

Based on this assessment, FEMA has recently updated Flood Insurance Rate Maps (FIRMs) for the project areas, effective as of July 16, 2015. Both the WWTP and 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 AE zones with a known elevation of 10 feet, referenced to NAVD88. The Base Flood Elevation (BFE) represents the flood elevation for a calculated 100-year recurrence interval event. (I.e. a 1% annual chance of flooding.)

In terms of future climate change, it is important to note that FEMA SFHA's and corresponding BFE's are based on analysis of historical flooding data and do not consider potential effects of climate change which may increase currently identified flood risks due to increased precipitation, larger storm water surface run-off volumes, sea level rise and higher storm surges. While the 100-year flood elevation has been the standard benchmark elevation for projects located within flood zones as regulated by local, state and federal agencies, it is also increasingly becoming recognized by local, state and federal interests that future planning for critical infrastructure should also consider predicted increases in sea level rise and greater storm frequencies, rainfall intensities and increased storm surge levels.

### 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.

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

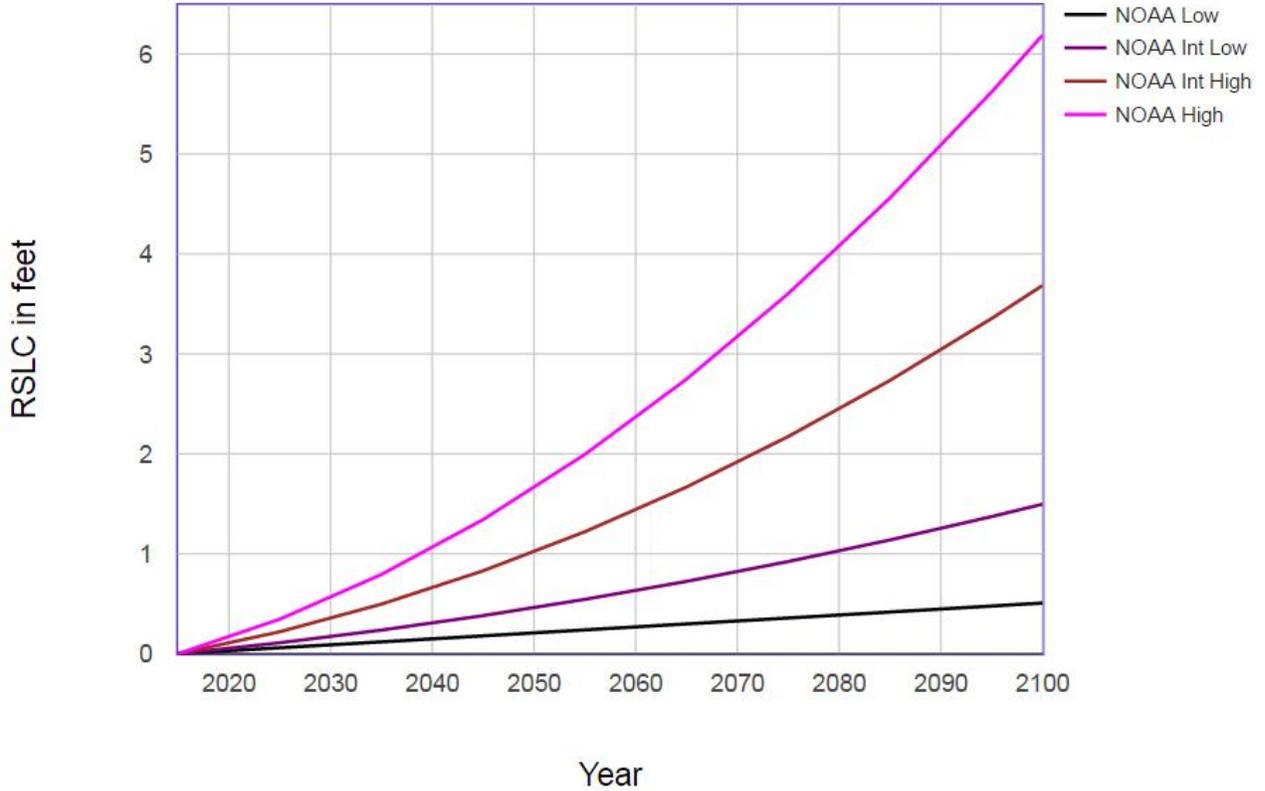
The curve data also takes into account predicted regional coastal subsidence and/or upward vertical land movement in relation to global sea level rise projections.

Tidal data recorded by NOAA in reference to Boothbay Harbor is from the Portland, ME gauge #8418150. Historical tidal data recorded at this gauge over the past century shows an average sea level rise rate of 7.3" per century.

Estimated sea level rise scenarios by 2100 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 2100.
- Intermediate Low Curve – Thermal expansion. (As ocean temperatures increase, the water expands.)
- Intermediate High Curve – Thermal expansion 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.

**Estimated Relative Sea Level Change Projections From 2015 To 2100 -  
Gauge: 8418150, Portland, ME (1.82 mm/yr)**



**Estimated Relative Sea Level Change  
from 2015 To 2100** Boothbay Harbor WWTF SLR &  
Storm Surge Impact Assessment  
8418150, Portland, ME  
NOAA's Published Rate: 0.00597 feet/yr  
All values are expressed in feet

Year	NOAA Low	NOAA Int Low	NOAA Int High	NOAA High
2015	0.00	0.00	0.00	0.00
2025	0.06	0.11	0.22	0.35
2035	0.12	0.24	0.50	0.79
2045	0.18	0.38	0.83	1.34
2055	0.24	0.55	1.22	2.00
2065	0.30	0.73	1.67	2.75
2075	0.36	0.92	2.18	3.61
2085	0.42	1.14	2.74	4.57
2095	0.48	1.37	3.36	5.63
2100	0.51	1.50	3.69	6.20

Storm Surge

In addition to factoring in storm surge based on historic data per FEMA 100-year flood zone calculations, predictive models are becoming more accepted by local stated and federal agencies as a planning tool for increased effects of storms due to potential climate change. The National Oceanic and Atmospheric Administration's (NOAA) National Hurricane Center utilizes the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model developed by the National Weather Service (NWS) to estimate storm surge heights resulting from historical, hypothetical or predicted hurricanes. SLOSH model elevations reference NAVD88.

According to SLOSH mapping data completed by the Maine Geological Survey, potential inundation depths for a category 1 hurricane at high tide are X to X feet above existing grade for the majority of the WWTP property and depths of approximate X feet at PS....

Potential inundation depths for a category 2 hurricane at high tide are X to X feet above existing grade for the majority of the WWTP property and depths of approximate X feet at PS....

(Coordinating info with MGS)

# 3 Goals and Study Approach

The overarching goal of this study is to identify a range of potential planning scenarios of coastal hazard resiliency impacts to Boothbay Harbor’s wastewater treatment facilities and assess a variety of mitigation measures to address the viability of maintaining this critical public infrastructure over the next 50 years. A 50-year planning horizon is considered a reasonable timeframe for wastewater infrastructure in terms of reasonable life cycle expectations of the treatment facilities.

The Town will have this study to reference and support in terms of addressing potential environmental health threats associated with handling of wastewaters, and in terms making cost / benefit capital expenditure decisions based on levels of planning risk that the town’s Committee has deemed reasonable to consider under this study.

This study does not require that the Town make any immediate, or long term decisions on any or all of the suggested mitigation options. Some infrastructure improvements will likely be required as the wastewater facilities reach their normal life expectancies regardless of the study’s recommendations and this assessment can be used to gauge where low cost solutions may be work the additional cost as part of these needed upgrades to mitigate high risk impacts to the community such as elevating pump station controls above required BFE+3-FT to account for predicted sea level rise. The minimum elevation endorsed by the New England Interstate Water Pollution Control Commission for critical infrastructure. NEIWPC recently issued planning guidance for storm resiliency and adaptation needs for wastewater conveyance and treatment facilities in support of FEMA recommends for consideration of protecting critical infrastructure to BFE plus 3 feet and non-critical infrastructure to BFE plus 2 feet to account for a 500-year flood event (0.2% annual chance of flood) and / or storm surge impacts from estimated hurricane events. Such an event includes predicted inundation estimates for a Category 1 hurricane which is on the high end of NOAA’s SLOSH model predictions for the Maine Coastline. The plan suggests mitigation measures in consideration of NEIWPC’s guidelines, which influence the availability of federal funds that assist communities in making essential wastewater infrastructure capital improvements.

The State’s goal in supporting this project is not only to develop sound planning for protection of the Town’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.

The study discusses the potential threat of climate change and flooding, identifies vulnerable assets and consequences of impacts due to these threats utilizing readily available infrastructure information in combination with environmental and regulatory parameters as described above.

The study also identifies and evaluates potential mitigation measures.

The study considers three planning scenarios to assist the Town in making informed decisions on wastewater infrastructure capital improvements supported by a plan that can be weighed in terms of a range of cost/benefit approached associated with various the various planning scenario risks of impact. After discussing planning scenarios with the Committee at the beginning of the study assessment process, from compliance with local regulatory and funding agency guidelines only, to the high estimated sea level rise scenario of 3 feet over the next 50 years, the Committee elected to consider

planning scenarios involving no sea level rise (BFE plus 3 feet), 1 foot of sea level rise (BFE plus 4 feet), and 3 feet of sea level rise (Base plus 6 feet).

It is important to note that the derivation of the water surface elevation associated with each of the planning scenarios for this project are assuming adding the delta from the sea level rise curves directly onto FEMA's BFE as a linear change in still water elevation which may not be directly applicable to storm surge scenarios. Water elevations for planning scenarios for this project were derived by adding the sea level rise scenarios (1, 2 and 3 feet) to the recommended NEIWPC standards (BFE + 3 feet).

# 4 Potential Inundation Effects

## General Considerations

Duration of flood impacts within the tide cycle and the likelihood of a flood event peak height of impact during a “King Tide” on the facilities is not certain.

Impacts due to increased frequency and intensity of storm events with significant on-shore precipitation are not estimated to be of significant concern to Boothbay Harbor 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 from often intense on-shore precipitation associated with coastal storms (hurricanes, tropical storms and blizzards) are of greater concern in southern coastal areas with less of a variety in daily high and low tide ranges, coupled with relatively flat and extensive coastal floodplains, than they are further north along the Atlantic seaboard as tidal daily ranges increase.

This study considers potential effects on the Wastewater Treatment Facilities due to coastal flooding from predicted sea level rise and storm surge reaching the maximum inundation planning scenario depths selected by the Committee, above the FEMA 100-year BFE.

## Wastewater Treatment Plant

The following is a summary of facilities at the Wastewater Treatment Plant that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (14.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - Between the WWTP and the nearest pump stations to the facility, there are several sewer manholes along multiple gravity sewer mains leading to the WWTP. Manholes within the 100-YR FEMA flood zone which are not flood-proofed currently could be impacted by infiltration and inflow (I&I) enter these at-grade structures during inundation of the surrounding sites.
  - Access to these structures could be limited for an extended period of time (days) due to impacts from deposit of floating debris.

- *Site Access*
  - Access to the site along Sea Street could be inundated by as much as 2-FT feet above approximate existing grade of 12.00-FT. The intersection of Sea Street and Commercial Street could be inundated by as much as 4-FT above approximate existing grade of 10.00-FT.
  - Vehicular access to the site could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.
- *Power Supply*
  - Impacts to the electrical power supply entering the site overhead from Sea Street and then distributed underground by service utility pole drop could be impacted by inundation.
  - Electrical power supply during flood events that may likely involve hurricane or tropical storm conditions may be impacted for an extended period of time (days or weeks) if power outages are be widespread throughout the town and surrounding region.
  - The industry standard for emergency generator capacity is to provide emergency power to the WWTP for a 24-hour period.
- *Shoreline and Interior Grounds*
  - The majority of the site could be inundated by as much as 6-FT to 9-FT above existing grades of 8.00-FT to 12-FT.
  - The majority of shoreline adjacent to the WWTP on the northerly boundary is comprised of embankment covered with scrub/shrub and small tree growth with lawn area at the top and adjacent to the paved interior of the site. Shoreline erosion of this area and slumping of the embankment could occur due to inundation and storm surge wave action.
  - The interior grounds of the site are predominantly covered in bituminous asphalt pavement and buildings, with some smaller areas of lawn. The interior of the site is not anticipated to be significantly impacted by inundation and storm surge wave action.
  - Floating debris from the adjacent harbor and on-shore storage hard (vegetation, marine structures, boats, tools, equipment, lumber materials, etc.) could potentially float around the site and be deposited within the site interior. This floating debris could also potentially cause structural damage from impacts with various facility structures listed below.
  - Perimeter chain link fencing should remain intact, however, it could be susceptible to damage from floating debris.

- *Influent Pump Station (PS-6)*
  - The top of the wetwell is at approximate elevation 11.30-FT and the bottom of the control panels are at approximate elevation 14.80-FT.
  - The wetwell could be impacted by flood water infiltration and inflow (I&I) entering this structure during inundation of the site. The wetwell and pumps should not be damaged by flood waters since they are rated to operate under water, however, inundation of the wetwell could introduce additional flows to the treatment process exceeding treatment plant capacity.
  - The control panels are on the verge of impacts from inundation, storm surge wave action and floating debris, and the support structures for the control panels could be impacted by inundation, storm surge wave action and floating debris.
- *Scum Well Pump Station*
  - The top of the concrete wetwell and concrete valve structure is at approximate elevation 13.8-FT, and the control panel is at approximate elevation 14.8-FT.
  - The wetwell is not anticipated to be impacted by flood conditions due to inundation or storm surge wave action. Flood water debris could also be deposited on top of the structure impacting access to the infrastructure.
  - The control panels are on the verge of impacts from inundation, storm surge wave action and floating debris, and the support structures for the control panels could be impacted by inundation, storm surge wave action and floating debris.
- *Process Building (Including Headworks Area and Sludge Loading Area)*
  - The basement finish floor elevation is approximately (-) 1.40-FT. The sludge loading level is approximately at 11.30-FT. The finish first floor elevation and door threshold entering the process building is approximately at 15.00-FT. The finish second floor elevation is approximately 27.00-FT. The interior of the building including the sludge loading area, headworks, influent channel and basement could be impacted by inundation.
  - Interior electrical and mechanical systems within 2.7-FT of above the finish floor elevation of the sludge loading area, and for the entire basement area could also be impacted by inundation.
  - The structural integrity of the masonry and concrete building itself is not anticipated to be impacted by inundation, storm surge wave action and floating debris.
- *Metering Manhole*
  - The top of the concrete manhole is flush with the adjacent access drive grade at approximate elevation 11.10-FT

- The structure and internal flow meter located at approximate elevation 6.10-FT within the manhole could be impacted by flood water infiltration and inflow (I&I) entering this structure during inundation of the site.
- Access to the manhole could also be impacted by deposit of floating debris on top of the structure
- *Sludge Storage Tank*
  - The top of the concrete tank is at approximate elevation 24.20-FT at 24.2-ft is located well above flood water scenarios.
  - The deteriorated state of the concrete/masonry structure as evidenced by visual spalling could be impacted by inundation, storm surge wave action and floating debris.
  - Access to the building could be limited due to inundation of the surrounding site.
- *Chlorine Contact Tanks*
  - The top of the concrete chlorine contact tanks are at elevation 16.10-FT. The elevation of the weir structure on the tanks is at elevation 11.60-FT.
  - The tanks could be impacted by inundation of the weir structure with flow backup into the tanks. Flood waters mixed with any sewage effluent in the tanks at the time of the 100-Yr flood event could then overtop the weir structure and flow freely across the site and back into Boothbay Harbor.
- *Sequencing Batch Reactors and Septage Receiving Area*
  - The top of the concrete sequencing batch reactors is approximately at elevation 26.30-FT. This structure is not expected to be directly impacted. Access to the building staircase could be limited due to inundation of the surrounding site.
  - The septage receiving area channel grate is approximately at elevation 11.80-FT and the control panel is approximately at elevation 14.30-FT. The receiving channel could be impacted by inundation and by floating debris deposited on top of the structure impacting access to the infrastructure. These flood waters could then cause I&I impact to other connected wastewater systems within the treatment process. The control panel is on the verge of being impacted by inundation.
- *Garage*
  - The finish floor elevation and door thresholds of the garage are at elevation 12.30-FT. Under these flood conditions, the interior of this building could be impacted by inundation.
  - Interior electrical and mechanical systems, stored tools and equipment within 1.70-FT of the finish floor elevation could be impacted by inundation.
  - The stick-built wooden structure could be impacted by inundation, storm surge wave action and floating debris.

- *Administration Building*
  - The finish floor elevation and door thresholds of the shed are at approximate elevation 14.90-FT. The interior of this building is on the verge of being inundated.
  - Access to the building could be limited due to inundation of the surrounding site.
- *Outfall Structure (MH #1)*
  - The top of concrete manhole is at approximate elevation of 14.30-FT and an internal overflow pipe in the manhole has an approximate elevation of 9.80-FT.
  - The manhole and connected WWTP system flows could be impacted by flood water infiltration and inflow (I&I) entering this structure during inundation of the site and backing up process water.
  - Access to the manhole could also be impacted by deposit of floating debris on top of the structure.



*WWTP Looking at Process Building Adjacent to Boothbay Harbor on Northern Side of the Site  
Depicting Stillwater Flood Elevation BFE + 4-FT*



*WWTP Looking North Between the Process Building and the Sequencing Batch Reactors  
Depicting Stillwater Flood Elevation BFE + 4-FT*



*WWTP Looking West Past the Process Building Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (15.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario, either by greater magnitude than noted above or under new inundation conditions:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - Access to the site along Sea Street could be inundated by as much as 3-FT feet above approximate existing grade of 12.00-FT. The intersection of Sea Street and Commercial Street could be inundated by as much as 5-FT above approximate existing grade of 10.00-FT.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Shoreline and Interior Grounds*
  - The majority of the site could be inundated by as much as 7-FT to 10-FT above existing grades of 8.00-FT to 12-FT.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Influent Pump Station (PS-6)*
  - The control panels could be impacted by inundation, storm surge wave action and floating debris.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Scum Well Pump Station*
  - The control panels could be impacted by inundation, storm surge wave action and floating debris.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Process Building (Including Headworks Area and Sludge Loading Area)*
  - Interior electrical and mechanical systems within 3.7-FT of above the finish floor elevation of the sludge loading area, and for the entire basement area could also be

impacted by inundation. The first floor area is on the verge of being impacted by inundation

- The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Metering Manhole*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Sludge Storage Tank*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Chlorine Contact Tanks*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Sequencing Batch Reactors and Septage Receiving Area*
  - The control panel is approximately at elevation 14.30-FT and could be impacted by inundation, storm surge wave action and floating debris.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Garage*
  - Interior electrical and mechanical systems, stored tools and equipment within 2.70-FT of the finish floor elevation could be impacted by inundation.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.
- *Administration Building*
  - The interior of the building could be impacted by inundation.
  - Interior electrical and mechanical systems, equipment and stored materials within 0.20-FT of the finish floor elevation could be impacted.
  - The stick-built wooden structure could be impacted inundation, storm surge wave action and floating debris.
- *Outfall Structure (MH #1)*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.



*WWTP Looking at Process Building Adjacent to Boothbay Harbor on Northern Side of the Site  
Depicting Stillwater Flood Elevation BFE + 5-FT*



*WWTP Looking North Between the Process Building and the Sequencing Batch Reactors  
Depicting Stillwater Flood Elevation BFE + 5-FT*



*WWTP Looking West Past the Process Building Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario, either by greater magnitude than noted above or under new inundation conditions:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Site Access*
  - Access to the site along Sea Street could be inundated by as much as 4-FT feet above approximate existing grade of 12.00-FT. The intersection of Sea Street and Commercial Street could be inundated by as much as 6-FT above approximate existing grade of 10.00-FT.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Shoreline and Interior Grounds*
  - The majority of the site could be inundated by as much as 8-FT to 11-FT above existing grades of 8.00-FT to 12-FT.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT and BFE+5 events.
- *Influent Pump Station (PS-6)*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Scum Well Pump Station*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Process Building (Including Headworks Area and Sludge Loading Area)*
  - The finish first floor elevation and door threshold entering the process building is approximately at 15.00-FT. The finish second floor elevation is approximately 27.00-FT. The interior of the first floor area could be impacted by inundation.
  - Interior electrical and mechanical systems within 1.00-FT of above the first floor finish elevation could be impacted by inundation.

- The second floor would not be directly impacted by inundation, however access to the second floor could be limited due to inundation of the surrounding site and first floor area.
- The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT and BFE+5 events.
- *Metering Manhole*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Sludge Storage Tank*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Chlorine Contact Tanks*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Sequencing Batch Reactors and Septage Receiving Area*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Garage*
  - Interior electrical and mechanical systems, stored tools and equipment within 2.70-FT of the finish floor elevation could be impacted by inundation.
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Administration Building*
  - Interior electrical and mechanical systems, equipment and stored materials within 1.20-FT of the finish floor elevation could be impacted.
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.
- *Outfall Structure (MH #1)*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5 events.



*WWTP Looking at Process Building Adjacent to Boothbay Harbor on Northern Side of the Site  
Depicting Stillwater Flood Elevation BFE + 6-FT*



*WWTP Looking North Between the Process Building and the Sequencing Batch Reactors  
Depicting Stillwater Flood Elevation BFE + 6-FT*



*WWTP Looking West Past the Process Building Depicting Stillwater Flood Elevation BFE + 6-FT*

## Breakwater Pump Station (PS #15)

The following is a summary of facilities at the Breakwater Pump Station (PS #15) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - (3) of the (9) residential properties contributing effluent flows to PS #15 could be impacted by inundation. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #15 along Breakwater Road could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.

- *Power Supply*
  - The power supply to PS #15 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are be widespread throughout the town and surrounding region.
  - The bottom of the electrical panel is at an approximate elevation of 13.00-FT and could be impacted by inundation, storm surge wave action and floating debris.
- *Wet Well*
  - The wetwell is a submersible pump system with the top of the concrete enclosure at an approximate elevation of 12.30-FT. This structure could be impacted by infiltration and inflow (I&I) entering the at-grade structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the wetwell.
  - The structure is not anticipated to be impacted by storm surge wave action. Floating debris could be deposited on top of the structure impacting access to the infrastructure.
- *Controls*
  - The bottom of control panel is at an approximate elevation of 14.8-FT. The control panel is not flood proofed and could be impacted by inundation, storm surge wave action and floating debris.



*PS #15 Looking West Towards Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.



*PS #15 Looking West Towards Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (18.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.



*PS #15 Looking West Towards Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 6-FT*

## Factory Cove Pump Station (PS #13)

The following is a summary of facilities at the Factory Cove Pump Station (PS #13) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - (3) of the (10) residential properties contributing effluent flows to PS #13 could be impacted by inundation. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #13 along Factory Cove Road is not expected to be impacted during this 100-YR event.
- *Power Supply*
  - The power supply to PS #13 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are be widespread throughout the town and surrounding region.
  - The bottom of the electrical panel is at an approximate elevation of 19.00-FT and is not estimated to be impacted by this 100-YR flood event.
- *Wet Well*
  - The wetwell is a submersible pump system with the top of the concrete enclosure at an approximate elevation of 16.30-FT. This structure is not expected to be impacted by this 100-YR event.
- *Controls*
  - The bottom of the control panel is at an approximate elevation of 19.0-FT. The control panel is not expected to be impacted by this 100-YR flood event.



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

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - Vehicular access to PS #13 along Factory Cove Road could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Wet Well*
  - The wetwell is a submersible pump system with the top of the concrete enclosure at an approximate elevation of 16.30-FT. This structure could be impacted by infiltration and inflow (I&I) entering the at-grade structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the pumps or enclosure.

- The structure is not anticipated to be impacted by storm surge wave action. Floating debris could be deposited on top of the structure impacting access to the infrastructure.
- *Controls*
  - The bottom of the control panel is at an approximate elevation of 19.0-FT. The control panel is not expected to be impacted by this 100-YR flood event.



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

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (18.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+5-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE 4 and BFE+5-FT events.

- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+5-FT event.
- *Controls*
  - The bottom of the control panel is at an approximate elevation of 19.0-FT. The control panel is not expected to be impacted by this 100-YR flood event.



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



*PS #13 Electrical Service and Controls Depicting Stillwater Flood Elevation BFE + 6-FT*

## Roads End Pump Station (PS #12)

The following is a summary of facilities at the Breakwater Pump Station (PS #12) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (14.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - (7) of the (19) residential properties contributing effluent flows to PS #12 could be impacted by inundation. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #12 along Roads End Road could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.
- *Power Supply*
  - The power supply to PS #12 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are be widespread throughout the town and surrounding region.
  - The bottom of the electrical panel is at an approximate elevation of 14.00-FT and could be impacted by inundation, storm surge wave action and floating debris.
- *Wet Well*
  - The wetwell is a submersible pump system with the top of the concrete enclosure at an approximate elevation of 10.30-FT. This structure could be impacted by infiltration and inflow (I&I) entering the at-grade structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the wetwell.
  - The structure is not anticipated to be impacted by storm surge wave action. Floating debris could be deposited on top of the structure impacting access to the infrastructure.
- *Controls*
  - The bottom of control panel is at an approximate elevation of 15.00-FT. The control panel is on the verge of being impacted and the support structure for the controls could be impacted by inundation, storm surge wave action and floating debris.



*PS #12 Wetwell Looking North Depicting Stillwater Flood Elevation BFE + 4-FT*



*PS #12 Electric / Control Panel Looking South Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Controls*
  - The bottom of control panel is at an approximate elevation of 15.00-FT. The control panel is not flood proofed and could be impacted by inundation, storm surge wave action and floating debris.



*PS #12 Wetwell Looking North Depicting Stillwater Flood Elevation BFE + 5-FT*



*PS #12 Electric / Control Panel Looking South Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (18.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Controls*

## IMPACTS & MITIGATION OPTIONS

- The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.



*PS #12 Wetwell Looking North Depicting Stillwater Flood Elevation BFE + 6-FT*



*PS #12 Electric / Control Panel Looking South Depicting Stillwater Flood Elevation BFE + 6-FT*

## Atlantic By Church Pump Station (PS #2)

The following is a summary of facilities at the Atlantic By Church Pump Station (PS #2) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (15.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - There are several areas contributing effluent flows to PS #2 including the pump stations noted above and several inland neighborhoods that are primarily residential. There are approximately (10) properties, mostly commercial developments between Atlantic Avenue and Boothbay Harbor, contributing effluent flows to PS #2 that could be impacted by inundation. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #2 along Atlantic Avenue could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days).
  - The power supply to PS #2 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are be widespread throughout the town and surrounding region.
  - The bottom of the electrical panel is at an approximate elevation of 16.50-FT. The electrical panel is not anticipated to be impacted directly by this 100-YR flood event, however the support structure for the electrical panel could be impacted by inundation, storm surge wave action and floating debris.
- *Wet Well / Dry Well*
  - The wetwell / drywell (tin can) pump station has a vault has an approximate top elevation of 15.30-FT and is not anticipated to be impacted by this 100-YR event. The wetwell has an approximate elevation of 13.50-FT and could be impacted by inundation.
  - Both structures could be impacted by storm surge wave action and floating debris during this event. Flooding of the vault could cause damage to its pumps. The wetwell could be impacted by infiltration and inflow (I&I) entering the at-grade structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the wetwell.

- *Controls*
  - The bottom of control panel is at an approximate elevation of 16.50-FT. The control panel is not anticipated to be impacted directly by this 100-YR flood event, however the support structure for the controls could be impacted by inundation, storm surge wave action and floating debris.



*PS #2 Looking South Towards the Adjacent Church Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.

- *Wet Well / Dry Well*
  - The wetwell / drywell (tin can) pump station has a vault has an approximate top elevation of 15.30-FT and could be impacted by inundation.
  - The infrastructure also could be impacted by other means as noted previously for the BFE+4-FT event.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.



*PS #2 Looking South Towards the Adjacent Church Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.

- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The bottom of the electrical panel is at an approximate elevation of 16.50-FT and could be impacted by inundation, storm surge wave action and floating debris.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Wet Well / Dry Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Controls*
  - The bottom of the control panel is at an approximate elevation of 16.50-FT and could be impacted by inundation, storm surge wave action and floating debris.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT and BFE+5-FT events.



*PS #2 Looking South Towards the Adjacent Church Depicting Stillwater Flood Elevation BFE + 6-FT*

## Commercial Street Pump Station (PS #4)

The following is a summary of facilities at the Commercial Street Pump Station (PS #4) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (15.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - PS #4 collects effluent flows from a significant portion of the Town's waterfront commercial district and surrounding inland residential and mixed use developments. The majority of the properties along the adjacent waterfront and Commercial Street, (mostly commercial developments) could be impacted by inundation, storm surge wave action and floating debris. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #4 along Commercial Street could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.
- *Power Supply*
  - The power supply to PS #4 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are widespread throughout the town and surrounding region.
  - The electrical panel is located within the public restroom building and has an approximate elevation of 12.90-FT at the bottom of the structure. The electrical panel could be impacted by inundation, storm surge wave action and floating debris.
  - An on-site generator is located within the public restroom building and has an approximate elevation of 11.40-FT set on top of a fuel storage tank. The generator and fuel storage tank could be impacted by inundation, storm surge wave action and floating debris.
- *Wet Well*
  - The wetwell is a submersible pump system with the top of the concrete enclosure at an approximate elevation of 10.40-FT. This structure could be impacted by infiltration and inflow (I&I) entering the at-grade structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the wetwell.

## IMPACTS & MITIGATION OPTIONS

- The structure is not anticipated to be impacted by storm surge wave action. Floating debris could be deposited on top of the structure impacting access to the infrastructure.
- *Controls*
  - The bottom of control panel is at an approximate elevation of 12.9-FT. The control panel is not flood proofed and could be impacted by inundation, storm surge wave action and floating debris.
- *Public Restroom Building*
  - The finish floor elevation and door thresholds of the public restroom building are at elevation 10.40-FT. Under these flood conditions, the interior of this building could be impacted by inundation.
  - Interior electrical and mechanical systems, stored tools and equipment within 4.60-FT of the finish floor elevation could be impacted by inundation.
  - The stick-built wooden structure could be impacted by inundation, storm surge wave action and floating debris.



*PS #4 Looking South Towards Boothbay Harbor from Commercial Street Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Public Restroom Building*
  - Interior electrical and mechanical systems, stored tools and equipment within 5.60-FT of the finish floor elevation could be impacted by inundation.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT event.



*PS #4 Looking South Towards Boothbay Harbor from Commercial Street Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.

- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Public Restroom Building*
  - Interior electrical and mechanical systems, stored tools and equipment within 6.60-FT of the finish floor elevation could be impacted by inundation.
  - The infrastructure could also be impacted by other means as noted previously for the BFE+4-FT and BFE+5-FT events.



*PS #4 Looking South Towards Boothbay Harbor from Commercial Street Depicting Stillwater Flood Elevation BFE + 6-FT*

## Footbridge Pump Station (PS #7)

The following is a summary of facilities at the Commercial Street Pump Station (PS #7) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (15.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - PS #7 collects effluent flows from a significant portion of the Town's waterfront commercial district and surrounding inland residential and mixed use developments. The majority of the properties along the adjacent waterfront, Townsend Avenue and Commercial Street (mostly commercial developments) could be impacted by inundation, storm surge wave action and floating debris. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #7 along Townsend Avenue and/or Commercial Street could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.
- *Power Supply*
  - The power supply to PS #7 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are be widespread throughout the town and surrounding region.
  - The electrical panel has an approximate elevation of 9.50-FT at the bottom of the structure. The electrical panel could be impacted by inundation, storm surge wave action and floating debris.
- *Wet Well*
  - The wetwell is a submersible pump system with the top of the concrete enclosure at an approximate elevation of 9.50-FT. This structure could be impacted by infiltration and inflow (I&I) entering structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the wetwell.
  - The structure could also be impacted storm surge wave action and floating debris.

- *Controls*
  - The bottom of control panel is at an approximate elevation of 9.50-FT. The control panel is not flood proofed and could be impacted by inundation, storm surge wave action and floating debris.



*PS #7 Looking North Towards Townsend Avenue from Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.

- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.



*PS #7 Looking North Towards Townsend Avenue from Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.

- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.



*PS #7 Looking North Towards Townsend Avenue from Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 6-FT*

## Union Street Pump Station (PS #1)

The following is a summary of facilities at the Union Street Pump Station (PS #1) that could potentially be impacted by the various study planning scenarios during 100-year flood events as previously discussed.

*(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.)*

### 100-YR Flood Event + 3-FT + 1-FT of Sea Level Rise (16.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - PS #1 collects effluent flows from a significant portion of the Town's waterfront commercial district and surrounding inland residential and mixed use developments. The majority of the properties between the adjacent waterfront and Union Street (mostly commercial developments) could be impacted by inundation, storm surge wave action and floating debris. I&I from the flood waters through these properties via sewer service lines to the pump station is possible.
- *Site Access*
  - Vehicular access to PS #1 along Union Street could be limited in the short term (inundation during the storm) and potentially for an extended period of time (days) due to impacts from deposit of floating debris.
- *Power Supply*
  - The power supply to PS #1 is from overhead powerlines.
  - Electrical power supply during flood events that may likely involve hurricane, tropical storm or blizzard conditions may be impacted for an extended period of time (days or weeks) if power outages are widespread throughout the town and surrounding region.
  - The electrical panel will be upgraded to an elevation of 16.00-FT or above. The control panel is not anticipated to be impacted by inundation, storm surge wave action and floating debris. The supporting structure at elevations below 16.00-FT could be impacted by storm surge wave action and floating debris.
  - An on-site generator is located has an approximate elevation of 13.00-FT. The generator could be impacted by inundation, storm surge wave action and floating debris.

- *Wet Well*
  - The wetwell pump station is being upgrade from a wetwell / drywell system to a wetwell only system. The top of the concrete wet well structure has an approximate elevation of 12.00-FT and is at-grade with the existing site. The wetwell could be impacted by infiltration and inflow (I&I) entering the at-grade structure during inundation of the surrounding site, but the flood waters should not cause permanent impacts to the wetwell.
  - Access to the wetwell could be limited for a short duration (days) due to deposit of debris.
- *Controls*
  - The bottom of control panel will be upgraded to an elevation of 16.0-FT or above. The control panel is not anticipated to be impacted by inundation, storm surge wave action and floating debris. The supporting structure at elevations below 16.00-FT could be impacted by storm surge wave action and floating debris.



*PS #1 Looking West Across Union Street and Towards Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 4-FT*

100-YR Flood Event + 3-FT + 2-FT of Sea Level Rise (17.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT event.



*PS #1 Looking West Across Union Street and Towards Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 5-FT*

100-YR Flood Event + 3-FT + 3-FT of Sea Level Rise (18.00-FT NAVD88)

The following facilities are anticipated to be impacted under this planning scenario:

- *Collection System*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Site Access*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Power Supply*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Wet Well*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.
- *Controls*
  - The infrastructure could be impacted by means as noted previously for the BFE+4-FT and BFE+5-FT events.



*PS #1 Looking West Across Union Street and Towards Boothbay Harbor Depicting Stillwater Flood Elevation BFE + 6-FT*

# 5 Adaptation Strategies

## General Discussion

Previous sections of this report identify the levels of risk due to potential sea level rise and storm surge scenarios to the Town's wastewater facilities as selected by the Committee. These wastewater treatment facilities are known to the community in terms of the public utility service they provide and in terms of the capital construction costs, and ongoing maintenance and operations associated with provision of the current level of service. 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 flood event planning scenarios considered, 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 Town should consider whether to maintain the existing facility, adapt to potential increased sea level rise and storm surge impacts (and to what level) or to abandon (flee) from these coastal areas.

The following are technical adaptation strategies for improvements to the Wastewater treatment facilities assessed by this study to potentially address these flood impact scenarios. The goal of this assessment is for the community to be able to make prioritized decisions regarding each of the specific facilities, within the context of what is of value to the entire community. 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 event scenarios.

Most of the adaptation strategies identified below are structural improvements to the WWTP and each of the seven pump stations as applicable. Decisions regarding support of these structural adaptation strategies (non-structural means such as capital funding, emergency preparedness, impact ordinances) in combination with the structural adaptation measures provide a greater likelihood of success for maintaining these facilities over the long term.

*(See Appendices for a Cost Considerations Matrix associated with the various adaptation strategies discussed below)*

## Wastewater Treatment Plant

The following are technical adaptation strategies for improvements to the various WWTP facilities, as individual components, or in some cases for the entire facility. Thusly, 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 planning event scenarios.

Do Nothing

Under this scenario, the WWTP will be left to function as is. When significant upgrades to any of the critical facilities at the site are needed for reasons other than to address potential threats to sea level rise and storm surge (i.e. equipment is beyond its useful life expectancy), local, state and federal regulatory or funding agency requirements may dictate that the improvements to the facility consider sea level rise or storm surge, such as the recently regulatory agency requirements to protect this critical infrastructure which is currently under guidance from FEMA and strong supporting financial influence from NEIWPC, the critical infrastructure would need to be elevated to BFE plus 3-FT or above, and an emergency power generator would need to be provided at or above this elevation. Non-critical infrastructure would need to be elevated to BFE plus 2-FT or above.

Critical Equipment as defined by NEIWPC is as follows:

*“Critical Equipment: Protect critical equipment, which includes conveyance and treatment system components identified for protection including, but not limited to, all electrical, mechanical, and control systems associated with pump stations and treatment facilities that are responsible for conveyance of wastewater to and through the treatment facility to maintain primary treatment and disinfection during the flood event. Other equipment that, if damaged by flood conditions, will prevent the facility from returning to pre-event operation after cessation of flood conditions is also critical equipment.*

*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.”*

Elevate Structures, Staff, Tools and Equipment

Strategies for adaptation of the WWTP of applicable facilities are as followings:

- *Influent Pump Station (PS-6)*
  - Elevate the electrical and control panels at or above the three flood event planning scenarios. It is recommended that the support structure for these facilities be designed to withstand impacts from storm surge wave action and floating debris to the extent feasible. A standalone power generator for this facility alone may not be necessary if adequate supply can be provided from the generator supplying power to other WWTP facilities.
- *Scum Well Pump Station*

- Elevate the electrical and control panels at or above the three flood event planning scenarios. It is recommended that the support structure for these facilities be designed to withstand impacts from storm surge wave action and floating debris to the extent feasible. A standalone power generator for this facility alone may not be necessary if adequate supply can be provided from the generator supplying power to other WWTP facilities.
- *Garage*
  - Equipment and tools could be stored above the three flood event scenarios to the extent feasible
  - Flood vents could be installed on three or more of the building walls to allow for free flow of flood waters through the unoccupied first floor garage space
  - Interior electrical and mechanical systems, stored tools and equipment within 1.70-FT of the finish floor elevation could be impacted by inundation.
  - The stick-built wooden structure could be impacted by inundation, storm surge wave action and floating debris.
- *Administration Building*
  - Elevation of this structure so that the finish first floor occupied space is at or above the three flood event planning scenarios. 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.)



*Example rendering by W-P of Administration Building Option at the Ogunquit Sewer District Facility*



*Example building on pile supports (source from internet)*

Waterproofing Structure Walls

All of the following concrete and masonry structures at the WWTP could receive waterproofing of the exterior walls, to not only combat penetration of flood waters into and through the walls, but to also improve the life expectancy of the concrete and masonry building exteriors.



*Example of Spray Coat Waterproofing of Concrete Structure (source from internet)*

- *Process Building (Including Headworks Area and Sludge Loading Area)*
- *Sludge Storage Tank*
- *Chlorine Contact Tanks*
- *Sequencing Batch Reactors and Septage Receiving Area*

Flood Proof Structures Susceptible to Inundation

- *Collection System*
  - Consider flood proofing manhole structures for areas of the collection system which fall within the three flood event planning scenarios. It is not known how many of those structures current are, or are not flood proofed. This would assist in minimizing impacts to the treatment plant from salt water entering the facility and disrupting the effluent treatment processes.



*Example of I&I Backing Impacts Through Sewer Collection System in Another Midcoast Maine Community*

- *Sequencing Batch Reactors and Septage Receiving Area*
  - A flood proof hatch could be provided over the septage receiving area channel grate. This structure may not be seen as critical to the adjacent reactors however. If too much salt water mixes with the effluent, then in may need to be pumped out and disposed of off-site.
- *Metering Manhole*
  - Flood proofing of the manhole under all three flood event planning scenarios.

Temporary Flood Proofing of Building Penetrations (Doors and Windows)

- *Process Building (Including Headworks Area and Sludge Loading Area)*
  - There are a variety of door and window flood proofing systems that could be adapted to the existing openings of the Process Building



*Example of Temporary Flood Barriers for Doors (source from internet)*

- Interior electrical and mechanical systems within 2.7-FT of above the finish floor elevation of the sludge loading area, and for the entire basement area could also be impacted by inundation.
- The structural integrity of the masonry and concrete building itself is not anticipated to be impacted by inundation, storm surge wave action and floating debris.
- *Garage*
  - If flow through vents allowing the first floor garage space to be inundated during any of the three flood event scenarios is not desired, there are a variety of building doors and window temporary flood gate systems

- These adaptation measures could be less effective when installed on this stick built structure, of which the structural integrity of the building could be compromised by flooding impacts elsewhere.



*Examples of Temporary Flood Barriers for Garage Doors (above) and Windows (below)  
(sources from internet)*

- *Administration Building*

- If elevation of the Administration Building structure is not desired, there are a variety of building doors and window temporary flood gate systems that could be customized to work with flood proofing of the building's doors and windows.



- These adaptation measures could be less effective when installed on this stick built structure, of which the structural integrity of the building could be compromised by flooding impacts elsewhere.

Increase Emergency Power Generation Capacity

The industry standard for emergency generator capacity is to provide emergency power to the WWTP for a 24-hour period. Additional capacity in terms of fuel storage could be added to the facility to provide standalone power for longer durations. We have started to see other treatment plants considering enough fuel storage for standalone power up to three days, mostly in locations where access to the facility could be compromised, preventing truck delivery to refuel the generators (*See also NEIWPCC Guidelines for provision of backup power at the top of this section of the report*). Space for additional fuel storage tanks may be available within paved parking and access drive areas, if it is not available within the building structures and in close proximity to existing emergency power generators.

Shoreline Stabilization

The northern boundary of the site continues to experience shoreline erosion from routine tidal wave action which could only be further impacted by any of the three flood event planning scenarios. Heavy riprap should be placed in round of the following barrier protection wall to stabilize the shoreline and prevent scouring and undermining of the site and it implemented, the barrier protection adaptation measure.



*Examples of Heavy Riprap Shoreline Stabilization in Richmond, Maine*

Barrier Protection (Sea Walls and Flood Gates)

Under this scenario the Town would surround the perimeter of the facility with a new seawall and gates at the access drives, versus making adaptation improvements to multiple WWTP facilities as noted elsewhere in this section of the assessment. The cost difference for a wall for each of the three flood event planning scenario elevations would be nominal relative to the overall adaptation strategy project costs. Installation of this barrier could eliminate the need for majority of the other adaption strategies, so long as the wall is not over topped. Discharge pumps should be planned for to pump out waters from the interior site should the wall be over topped and/or to address significant precipitation that could accumulate at the WWTP during significant storms (i.e. hurricanes) with potentially significant rainfalls during 100-YR flood events. The overall cost of such a structure is substantial but it could eliminate the costs associated with the majority of the other adaptation strategies mentioned elsewhere in this section of the assessment, including the estimated highest cost option of relocating the entire treatment facility.



*Examples of Sea Wall and Flood Gate Barriers (sources from internet)*

Relocation of the WWTP

The facility has more than enough capacity to handle anticipated development growth over the next 50 years within the sewer collection system area in Boothbay Harbor. Relocation of the WWTP would represent significant costs to the community. Alternate sites would have to be identified in terms of available land and feasibility to connect the existing collection system and likely add additional pump stations to redirect flows to the new plant. Relocation to avoid impacts from flood events is not recommended as a result of this report

**Pump Stations (General)**

Do Nothing

Under this scenario, the pump stations will be left to function as is. When significant upgrades to any of the critical facilities at the site are needed for reasons other than to address potential threats to sea level rise and storm surge (i.e. equipment is beyond its useful life expectancy), local, state and federal regulatory or funding agency requirements may dictate that the improvements to the facility consider sea level rise or storm surge, such as the recently regulatory agency requirements to protect this critical infrastructure which is currently under guidance from FEMA and strong supporting financial influence from NEIWPC, the critical infrastructure would need to be elevated to BFE plus 3-FT or above, and an emergency power generator would need to be provided at or above this elevation. Non-critical infrastructure would need to be elevated to BFE plus 2-FT or above.

Elevate Electrical Controls at PS and Add Backup Generator

A backup generator would need to be added at the following pump stations.

- *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)*

Projection of existing backup generators at Commercial Pump Station (#4) and Union Street Pump Station could be accommodated as noted below.

Under each of the three flood event planning scenarios, the Town could consider relocating the controls (and generator where present) to a higher point of elevation above any of the three flood event planning scenarios. This effort could be by means of building a structure to support the infrastructure at a higher elevation, or it could potentially be achieved by relocating the infrastructure to a nearby point of land with existing grades at or above the three flood event planning scenarios. Acquisition of property (deeded or by easement) may be necessary to place this equipment on nearby land at suitable elevations. Elevating the infrastructure by structural support measures can be in the form of a variety of construction types which the Town may want to consider in terms of visual impacts to the surrounding community.



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

### Abandon

The Town may also want to consider abandoning any of these pump stations at that point where any of the three flood event planning scenarios causes enough damage to the facility and surrounding development where redevelopment of these areas in the community are not likely.