DRAFT
Technical Memorandum

City of Port Townsend Sea Level Rise Resiliency

Funded in part by Washington State Department of Ecology, Grant No. SEASPC-2325-PorToc-00020

Prepared for
City of Port Townsend

Prepared by
Herrera Environmental Consultants, Inc.

HERRERA
Science + Planning + Design

Technical Memorandum

City of Port Townsend Sea Level Rise Resiliency

Funded in part by Washington State Department of Ecology,
Grant No. SEASPC-2325-PorToc-00020

Prepared for
City of Port Townsend
250 Madison Street, Suite 1
Port Townsend, Washington 98368

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

DRAFT
February 26, 2025

Contents

Executive Summary iii
Project Introduction 1
Stakeholder and Community Engagement and Outreach 1
Existing Conditions Characterization 3
Review of Existing Sea Level Rise Information 3
Port Waterwalk Design Description 8
Discussion of Table 1 10
Recommended Actions to Improve Resiliency to Sea Level Rise 11
Temporary Measures 14
Green Strategies 14
Building Elevations 15
Permanent Structures 16
Retreat Strategy 17
Recommended Code Revisions 18
Port Waterwalk 18
Future Resiliency Actions 18
Summary 20
References 21

Tables

Table 1. Summary of Total Water Surface Elevation Analysis for Port Townsend Waterwalk. 7
Table 2. Summary of Shoreline Designations and Applicable Adaptive Measures. 20

Figures

Figure 1. City of Port Townsend Waterwalk SLR Study Area. 2
Figure 2. Illustration of the Components of a Marine High-Water Event and Total Water Level. 4
Figure 3. Port of Port Townsend Proposed Boat Haven Waterwalk Alignment. 6
Figure 4. Alternative Alignments for City Waterwalk. 12
Figure 5. Potential Climate Resiliency Tools 13

Executive Summary

In 2022, the City of Port Townsend (the City) conducted a Sea Level Rise Risk Assessment (Port Townsend 2022), which focused on impacts of coastal flooding that threaten *city* assets at low elevations. Coastal flooding probabilities and projections were developed using sea level rise projections and current coastal flooding impacts, such as storm surge, wave runup, and 100-year floods. This 2025 work builds on the 2022 assessment and discusses other recent analyses that similarly build on that work.

The Port of Port Townsend (the Port) has been in the process of developing a comprehensive design plan to build a structural Waterwalk along a portion of the city's southern shoreline (i.e., the Port's Waterwalk), which would consist of a public access pathway of varying construction types that would protect shoreline public access, water-oriented uses, and vital infrastructure in the Larry Scott Trail, Boat Haven, and Flats District portions of the city's shoreline. The design is robust for the short term (until 2075) and is proposed for construction landward of the regulatory (current) ordinary high water mark (OHWM). The proposed location of the structure and the highly developed nature of the shoreline in this area means that ecological impacts of the proposed structure are less than other less developed portions of the city's shoreline. The Port's proposed design elevations are compared to the City's recommendations coming out of Port Townsend (2022). They agree to a great extent, though the Port is using a shorter design life than the timeframes recommended by the City, which results in the Port using lower design elevations.

This document includes discussion of a variety of proposed measures to protect assets at risk of future coastal flooding along the city's entire southern shoreline located in five shoreline segments: the Larry Scott Trail, the Boatyard, the Flats District, the Historic District, and Point Hudson (see Figure 1 in the Project Introduction section). The Port's Waterwalk is proposed for the shoreline south of downtown Port Townsend from the beginning of the Larry Scott Trail where it emerges from the bluff on the south edge of the city to the base of the Ferry Terminal bluff in the Flats District (Figure 1). The current version of the plan of the Port's Waterwalk would not protect the northeast end of the Flats District, the Historic District, and Point Hudson (Figure 1), which are all at risk of future flooding. Each of the proposed Waterwalk protection methods for the City's Waterwalk (i.e., the remainder of the original Waterwalk alignment) are discussed in terms of cost, access considerations, permitting complexity, and efficacy. Recommendations are provided for the appropriateness of each measure to the five shoreline segments.

Finally, this technical memorandum includes a summary of recommended revisions to be made to update the City's Shoreline Master Program (SMP) to accommodate climate change resiliency actions. The document outlines several possible revisions to protect non-conforming historic structures and other key city infrastructure, encourage retreat, and encourage ecologically sensitive approaches to marine flood protection.

This page intentionally left blank

Project Introduction

The Waterwalk route, which spans Port Townsend's entire southern shoreline, originated in the Port Townsend Urban Waterfront Plan (Port Townsend 1990) and was formalized as Appendix G of its Shoreline Master Program (SMP) as "a coordinated system of connected pathways, sidewalks, passageways between buildings, and shoreline access points." The idea is currently central to the City's management of the five shoreline segments on its southern shoreline, as a part of its SMP. Unfortunately, the original idea did not consider sea level rise and subsequent increased storm damage caused from it.

The goal of this project is to continue the Waterwalk public access planning process along the city's southern shoreline. The objective of this report is to identify the anticipated gaps, both physical and regulatory, from future sea level rise (SLR) adaptation actions on the Waterwalk in Port Townsend, which comprises the study area (Figure 1). It is intended to identify which adaptive measures along the City's portion of the Waterwalk are or could be allowable by the City's SMP, the State's Shoreline Management Act (SMA) and Washington Administrative Code (WAC) and provide the scientific foundation for those decisions. The proposed conceptual design of the Port's Waterwalk (KPFF 2024) and its associated appendices identifies a broad array of conceptual design options at specific locations, alternative rankings, and priorities for future detailed assessment; and possible SMP revisions. These strategies are summarized here, in addition to several others that can be applicable to other portions of the City's Waterwalk.

Stakeholder and Community Engagement and Outreach

To be completed once the process is completed.

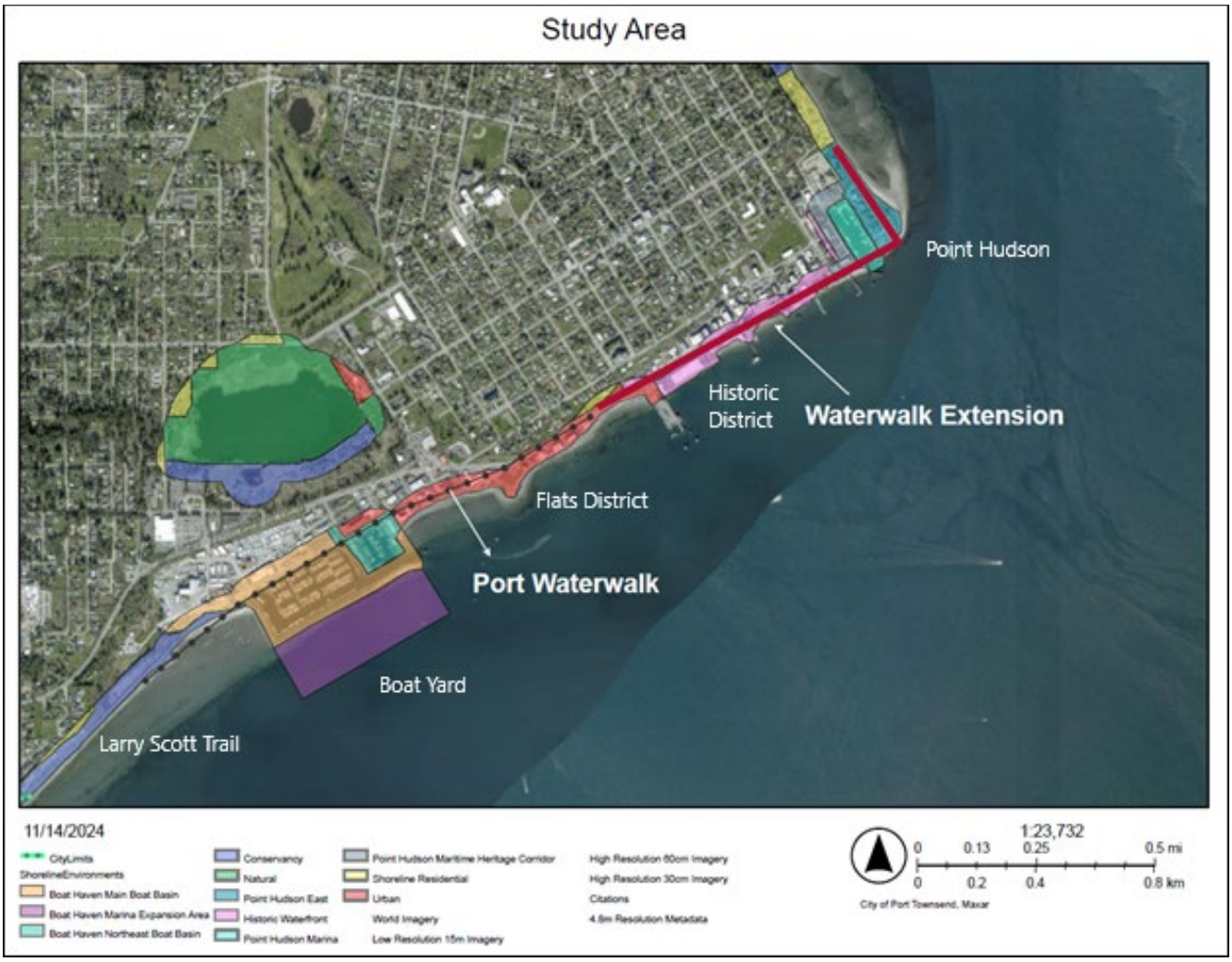


Figure 1. City of Port Townsend Waterwalk SLR Study Area.

Existing Conditions Characterization

The southern shoreline of Port Townsend is at risk of coastal flooding under existing conditions, though it is understood that primary impacts from marine processes are wave and debris damage and sea spray. The Existing Conditions Characterization relies on the analysis performed by Blue Coast Engineering (2024), as part of the basis of design document prepared for the Port's Waterwalk project (KPFF 2024) and the City's own sea level rise analysis (Port Townsend 2022). The City's analysis (Port Townsend 2022) provides the City's recommendations for assessments of sea level rise. These two studies (Blue Coast Engineering 2024; Port Townsend 2022) will be compared and described in detail below, along with context of other publicly available information. The City's analysis, which is less developed and more simplistic since it was developed for planning purposes only, will be presented to provide context in the section below. A more detailed description of the Port's analysis will be provided in a separate section.

Review of Existing Sea Level Rise Information

It is first helpful to establish terminology with regards to marine high-water events, in order to estimate their change with sea level rise. Often people will refer to "King Tides," which, strictly speaking, are an astronomical phenomenon that occurs when the alignment of the sun and moon create exceptionally high (tidally induced) water levels in marine waters. These events can be predicted years beforehand due to the accurate prediction of planetary alignments. Sometimes they can be distilled to a single value, referred to as the Highest Astronomical Tide (HAT). However, greatest storm damage typically occurs when high tides co-occur with an atmospheric low-pressure event (i.e., storms) which combines to generate a storm surge (through what is known as the inverse barometer effect—pulling water upwards) with strong winds, which generate large waves. This unique combination of conditions can occur during "King Tides" but does not require a King Tide (Figure 2). King Tides are a foot or two higher than mean higher high water (MHHW), whereas a storm surge can exceed 3 feet higher than astronomical tides would suggest. A storm event can add additional height to water levels from wave setup and runup. Wave setup, shown as overlapping in Figure 2, is the increase in mean water level due to the presence of breaking waves, while runup is the maximum onshore elevation reached by waves, relative to the shoreline position in the absence of waves. Total Water Level (TWL) represents this combined maximum water level from tides, storms, and waves. Though it is improbable that all contributing factors will peak at the same time, several simultaneous events occurred most recently in 2022 causing significant flooding along areas of the Waterwalk. TWL provides a valuable management tool for preparing for future inundation, planning, and design purposes. Figure 2 graphically displays the components common to this type of approach.

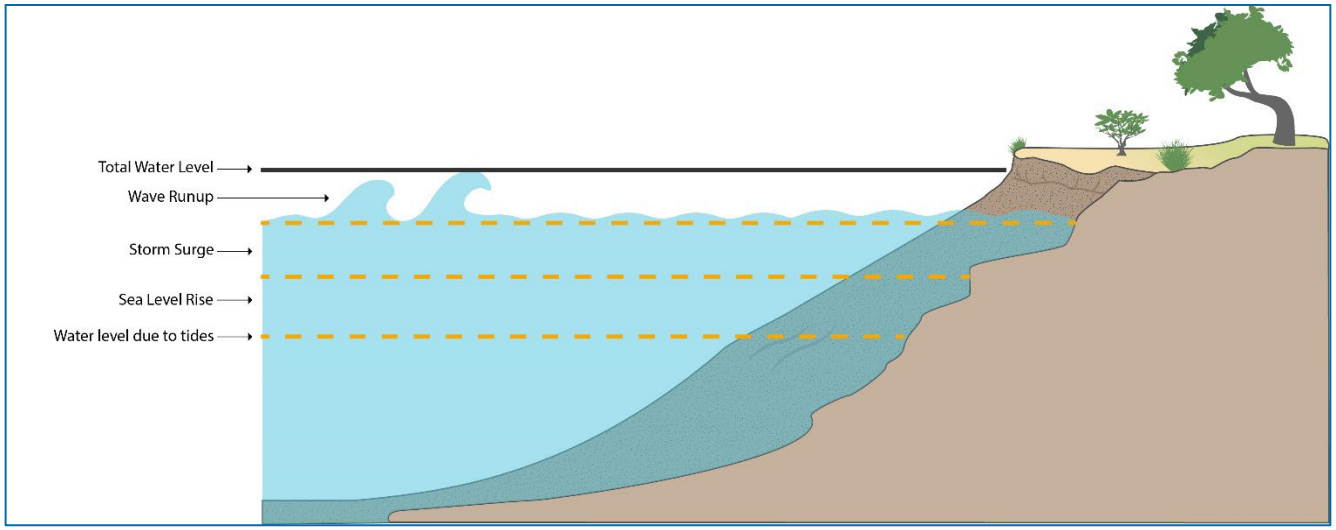


Figure 2. Illustration of the Components of a Marine High-Water Event and Total Water Level.

A total water level approach was used in the City's analysis of sea level rise (Port Townsend 2022). Over the short term (i.e., until 2050), the uncertainty associated with sea level rise projections is small, but so are the projections themselves (typically less than 1.5 feet). As water levels gradually rise over the next two decades, the risks to city assets are not significantly different than in current conditions, which, based on discussions with City public works staff, are generally confined to wave runup, battering from large woody debris, and sea spray. Stormwater infrastructure does not currently backwater (i.e., back up due to an inability to freely drain) routinely in a significant way due to stillwater marine levels (i.e., water level in the absence of waves; see Figure 2), as it does in other low-lying Puget Sound locales (Herrera 2020).

However, when looking beyond 2050, there is both far greater uncertainty and the potential for much larger increases in sea level, due to feedback mechanisms and cryogenic inputs from Greenland and the West Antarctic Ice sheet, among other contributing factors. This acceleration in sea level rise would produce significantly greater risk exposure to city assets. Finally, as mentioned above, sea level rise will persist beyond 2100, and is predicted to follow a path of increasing acceleration.

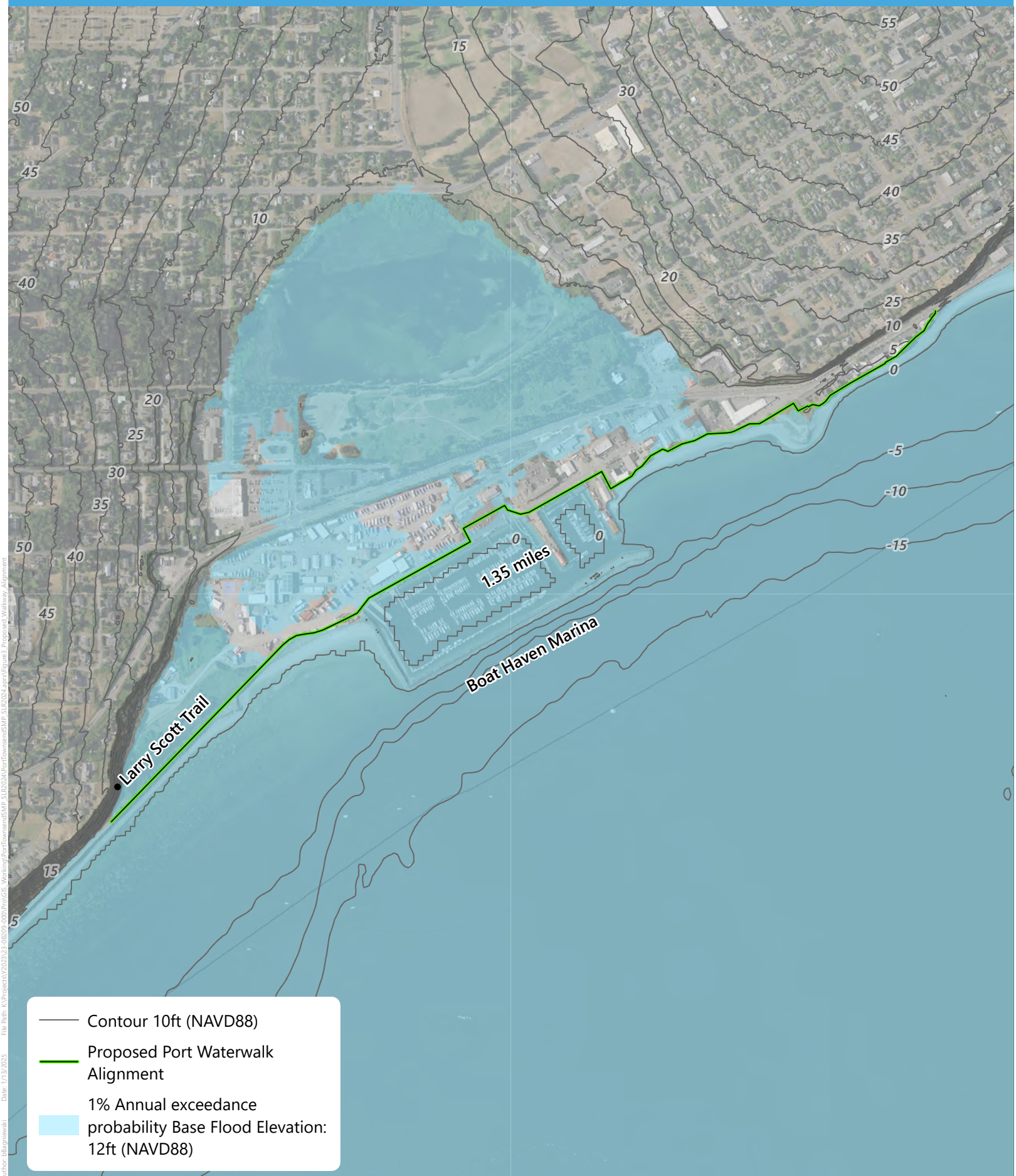
The city is currently subject to the risk of marine flooding of inundation of the 100-year marine flood event (i.e., an event that has a 1 percent chance of occurring in a given year) (see Figure 3), as assessed by the Federal Emergency Management Agency. The City (Port Townsend 2022) categorized sea level rise into two broad categories, the 17 percent probability of exceedance at 2100 (3.0 feet) and the 1 percent probability of exceedance at 2100 (5.0 feet). Larger values are possible and were noted, in particular the NOAA (2022) high projection of 6.5 feet. The City used the RCP 8.5 greenhouse gas emission scenario, the "business as usual" scenario. The analysis considered total water level, as described graphically above (Figure 2). Note that the storm surge and wave runup values in the City's sea level rise analysis (Port Townsend 2022) are not significantly different than the values calculated by Blue Coast Engineering (2024), even though the level of analysis applied in the City's analysis was limited. Caution should be used comparing wave runup in different portions of the city. There are numerous factors that can influence wave runup, such as wind direction, beach slope, offshore bathymetry, wave period, etc.

However, the comparison in Table 1 is valuable for assessing the level of risk the City's Waterwalk might be exposed to.

A key aspect to current marine flood risks in the city is storm surge combined with wave runup, contributing to wave and debris damage and sea spray. While reliable, predictive wave forecasting remains elusive, storm surge has been modeled accurately and effectively for Port Townsend (NOAA 2024). Local citizens have begun to use the NOAA Probabilistic Extra-Tropical Storm Surge tool (NOAA 2024) to forecast high water levels. A recent high-water event was accurately predicted by the tool (within 0.3 foot: Local 20/20 [2024]). Note that these predictions are more accurate than other locations within Puget Sound, likely due to the relative lack of baroclinicity (i.e., complications due to mixing in Admiralty Inlet and other Puget Sound sills, which contribution to tides in Port Townsend generally lacks) in the tidal predictions for Port Townsend. Sharing these predictions with the community, along with a high-resolution topographic map, should be considered to assist in preparation for these high-water events in the future.

HERRERA
Science + Planning + Design

Figure 3.
Port of Port Townsend Proposed Boat Haven Waterwalk Alignment.



Produced by Herrera Environmental Consultants (herrerainc.com) | Sources: FEMA, Jefferson County, Aerial (2022)

0 500 1,000 2,000 Feet

File Path: K:\Projects\Y2023\23-08209-000\ProjGIS_Working\PortTownsendSMP_SLR2024\PortTownsendSMP_SLR2024.aprx\Figure3_Proposed_Walkway_Alignment
Date: 1/13/2025
Author: bBagniewski

Table 1. Summary of Total Water Surface Elevation Analysis for Port Townsend Waterwalk.				
Item	**Port Waterwalk (Blue Coast Engineering 2024) King Tide Case**	**Port Waterwalk (Blue Coast Engineering 2024) Extreme Case**	**City of Port Townsend (2022) Higher Low Probability**	**City of Port Townsend (2022) Low Probability**
Tidal base (feet NAVD 88)	8.9 (HAT)	8.9 (HAT)	7.4 (MHHW)	7.4 (MHWW)
GHG Scenario	RCP 8.5	RCP 8.5	RCP 8.5	RCP 8.5
Level of Exceedance (%)	50	50	17	1
Design/Planning Horizon	2075	2075	2100	2100
Sea Level Rise (feet)	1.5	1.5	3.0	5.0
Storm Surge (feet)	0.0	2.2	3.1	3.1
Wave Runup (feet)	1.1 to 5.7	1.1 to 5.7	2.5	2.5
Total Water Surface Elevation (feet NAVD 88)	11.5. to 16.1	13.7 to 18.3	16.0	18.0

Port Waterwalk Design Description

The Port's Waterwalk design has been developed to protect the western portion of the city's southern shoreline and to increase and protect public access along the entire shoreline, consistent with the Port Townsend Urban Waterfront Plan (Port Townsend 1990) and the City's SMP. The design is intended to primarily protect Port assets in the vicinity of the Boat Haven boatyard and a modest portion of the city on either side. The design alignment can be divided into three primary stretches representing general shoreline conditions and land uses. Each stretch was further subdivided based on variability in shoreline and upland conditions (KPFF 2024); however, each stretch has generally similar conditions and will be amalgamated for simplicity of discussion. These are:

1. Larry Scott Trail, which is largely undeveloped other than the trail, approximately 1,800 feet.
2. Boat Haven boatyard, which is intensely developed, approximately 2,600 feet.
3. Flats District, a mix of developed properties, parking lots, and undeveloped properties backed by State Route 20 (Water Street), approximately 2,800 feet.

The design elevations are variable for the different parts of the Port's Waterwalk. However, none exceed 15 feet NAVD 88., which is less than the planning elevation set forth by the City (Table 1). That said, the various Waterwalk structures are expected to produce reliable, significant protection until 2075, according to KPFF (2024). It is important to note that none of the locations have sufficient freeboard to accommodate the city's own low probability total water level elevation (19.1 feet NAVD 88; Table 1) in 2100 or the highest total water levels in the "Extreme Case" in the Port's analysis (18.3 feet NAVD 88; Table 1).

Blue Coast Engineering (2024) used a Delft3D model to simulate waves in conjunction with storm surge and sea level rise (Table 1). The purpose of this modeling was to estimate a total water surface elevation to inform design elevations (Table 1). The analysis assumed two scenarios based on the highest astronomical tide (HAT) height:

1. A "King Tide" case that did not have an accompanying storm surge.
2. An extreme case with a storm.

Both scenarios assumed a 50 percent level of exceedance for sea level rise. This estimate of a total water level might be accurate for preliminary planning assessments of the remainder of the city's southern shoreline because the wave characteristics were modeled, though some further considerations need to be made as to its applicability to the City's Waterwalk since wave characteristics may be significantly different due to differing shoreline conditions (see the Recommended Actions to Improve Resiliency to Sea Level Rise section for a detailed recommendation in this regard).

For the extreme case, Blue Coast Engineering (2024) considered the following characteristics to develop their total water level: the tidal basis was a HAT, plus 2.2 feet of storm surge, estimated to be the annual exceedance event, with 1.5 feet of sea level rise (50 percent probability of exceedance in 2075 using the RCP 8.5 greenhouse gas scenario, the scenario that generates the largest sea level rise increases, approximately 50 years in the future). In the absence of sea level rise, these hydrodynamic conditions are

quite conservative because the probability of the highest astronomical tide occurring during a storm surge is low. However, the sea level rise estimate is modest, particularly when compared to the City's estimate of 5 feet, albeit for a different time interval (2075 [Blue Coast] versus 2100 [City]; Table 1). These conditions predicted by Blue Coast (2024) yielded a total water level of between 13.7 and 18.3 feet NAVD 88. Note that this is generally lower than the City's values in Table 1. However, Blue Coast Engineering's results (2024) are arguably more accurate, as wave conditions were modeled for the expected topographic conditions, not estimated.

For the Blue Coast Engineering (2024) "King Tide" case without a storm surge, a HAT was used with 1.5 feet of sea level rise (Table 1). No storm surge was included in this scenario. Waves were modeled according to these slightly lower water levels and varied depending on the shoreline conditions (Table 1). Further details about the approach can be found in Blue Coast Engineering (2024).

The Blue Coast Engineering report (2024) targets 2075 as the end of the design life of the Waterwalk structure. Its ultimate design elevations are lower than most of total water level estimates in Table 1. Design elevations were set to provide freeboard on still water elevations (i.e., elevations that do not include the influence of waves) and a minimum amount of overtopping. As a result, the design will account for some overtopping in the extreme case simulations (primarily from wave runup) towards the end of the design life. Finally, it is important to consider that sea level rise will continue and is predicted to accelerate after that time. In fact, as pointed out quite clearly in the City's sea level rise analysis (Port Townsend 2022), significant sea level rise is expected beyond this date and may exceed the elevations of the extreme design storm used to estimate inundation in the Blue Coast Engineering analysis (2024). Therefore, it is prudent to revisit observed sea level rise at regular intervals, and a phased approach to adapting to it is reasonable.

The alignment of the Port's Waterwalk is highly constrained by existing infrastructure and was developed with careful consideration of staying landward of the current OHWM. As such, the design alignment is appropriate and minimizes ecological impacts in the context of these largely already hardened and paved backshore environments.

Confluence Environmental (2024) summarized the applicable regulations relevant to the Port's Waterwalk. One key aspect of the Port's Waterwalk design is its avoidance of work below the ordinary high water mark. This may allow some parts of the project to proceed without state and federal permits, although there are other triggers for state and federal permits that may trigger greater outside scrutiny by regulatory agencies. Also, federal jurisdiction under Section 404 of the Clean Water Act has been defined at the High Tide Line, and recent clarity from USACE puts that elevation at 8.9 feet NAVD 88, slightly higher than the 8.7 feet NAVD 88 that is used by KPFF (2024). Also, the design is not advanced sufficiently to ensure that all work below these jurisdictional boundaries can be avoided. Cultural resource issues may also complicate construction and avoidance of in-water work, and they have not been investigated in detail yet. It is also important to note that although these structures are proposed to be located above current OHWM, water levels will be heightened over time, which may require re-engineering of structures to withstand increasing water level and wave impacts. A more detailed analysis of the implications for permitting the project is included below.

Discussion of Table 1

In comparing the City of Port Townsend (2022) total water level estimates to Blue Coast Engineering (2024), it is important to establish the differences between the purposes of the analyses performed by the two studies. The City of Port Townsend planning study (Port Townsend 2022) was intended to inform policy and facility planning. As a result, it did not have a site in mind, and therefore somewhat generically characterized wave runup (i.e., using a single observation of a storm in the Historic District for an estimate). While there are also differences in storm surge, they are minor (less than a foot). The Port's estimate was based on an analysis of water level, which suggests that 2.2 feet is the annual exceedance event. The Port's analysis modeled waves, which provides detailed conditions on how the waves will runup on the shoreline, based on local elevations and topography (albeit estimated from public sources and not licensed survey). The purpose of the Port's analysis was to provide specific location and context based guidance for a public works project. Their analysis also provides a variation in the final total water level. That said, as can be seen in Table 1, the final numbers fall within the same broad range, with the City's estimates being towards the upper end of the Blue Coast Engineering (2024) range.

However, probably the most significant difference in the analyses is the planning horizon or design life. Sea level rise estimates generally diverge around 2050 (Miller et al. 2018). This is because the acceleration in sea level rise is uncertain beyond 2050. The upper end of the range of predicted acceleration, as depicted in the City's "low probability" case, can be quite large. Since Blue Coast Engineering (2024) was interested in 2075, as opposed to 2100, the assumed sea level rise was much lower. It is also much more certain, which is important for design. The detailed assessment of waves, which produced larger estimates of wave runup (in some cases) than the single observation used by the City (Port Townsend 2024), raised the final total water level somewhat, but not enough to compensate for the higher assumed sea level rise assumed by the City (Port Townsend 2022).

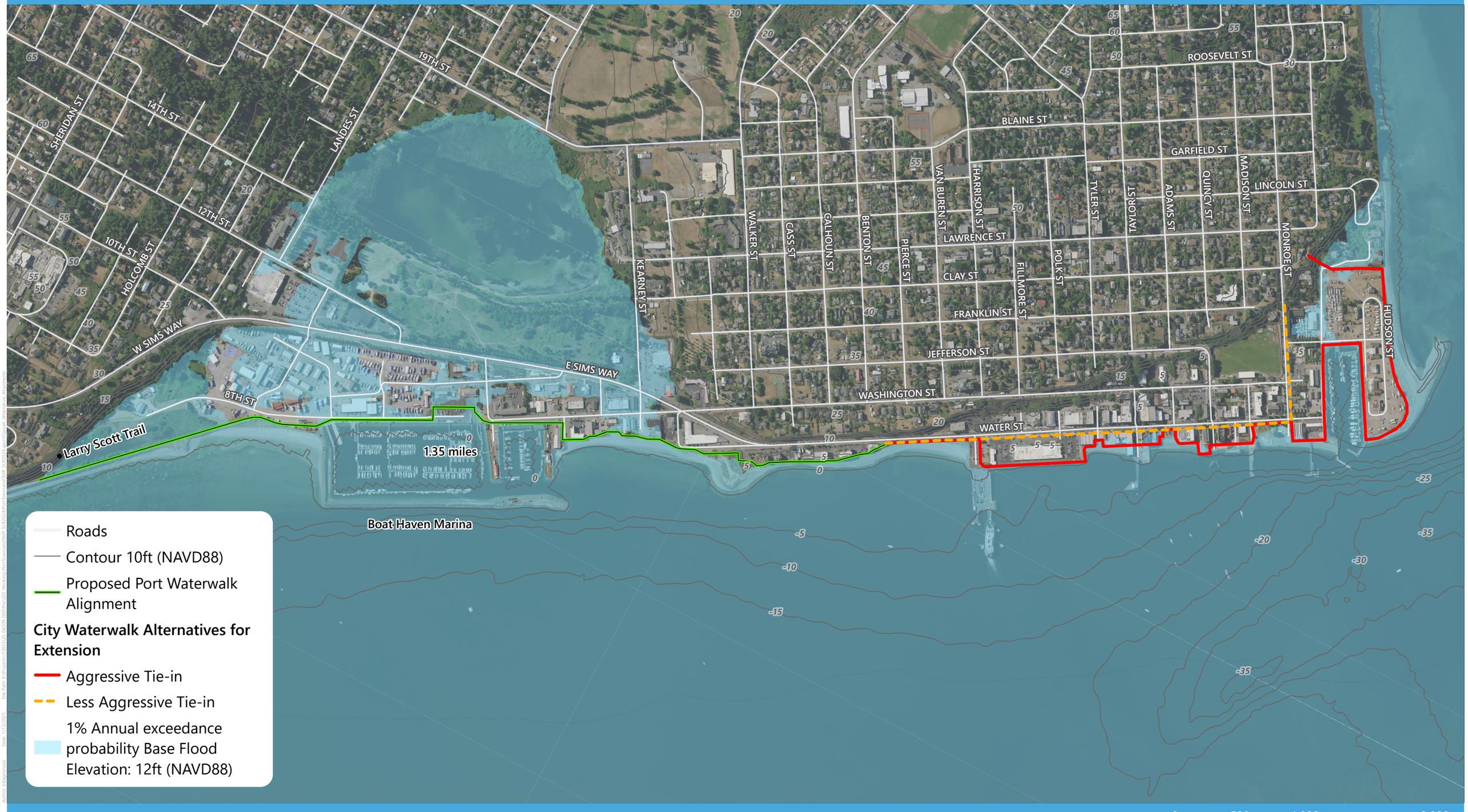
Recommended Actions to Improve Resiliency to Sea Level Rise

It is recommended that the City take actions to reduce potential damage from inundation that would impact assets that are not protected by the Port's Waterwalk project (Port Townsend 2022). Most of the high exposure properties and the Waterwalk itself, identified by the City's sea level rise analysis (Port Townsend 2022), will remain highly exposed to inundation, since the Port's Waterwalk will only protect low areas associated with the Boat Haven boatyard and Kai Tai Lagoon (KPFF 2024). That said, the City's protected Waterwalk could be extended from the east end of the Port's Waterwalk to Point Hudson. Figure 4 illustrates two potential alignments of protective actions to be taken to protect city assets, including the Waterwalk itself.

Figure 5 illustrates the possible tools available to provide that protection. Each tool will be discussed below with regards to relative efficacy, cost, access, and environmental impact. They are scored one to five with respect to each of these elements: the higher the scores, the more desirable the element (i.e., a cost score of a five means an inexpensive alternative). It is important to mention that many of these elements are highly project- and site-specific for each measure. The scoring is also mainly relative to the other measures. For instance, temporary measures might have very few environmental impacts, but they do not confer any environmental benefits, so they do not score a five because some of the green measures could provide environmental benefits. All the actions, including the no-action alternative, have a cost since sea level rise will eventually endanger more than $100 million in city and private assets (Port Townsend 2022). It is likely, just as with the Port's Waterwalk project, that the City will find a range of appropriate measures, depending on site-specific characteristics, which will further inform the development of strategies to protect the Historic District.

HERRERA
Science + Planning + Design

Figure 4.
Alternative Alignments for City Waterwalk.



Produced by Herrera Environmental Consultants (herrerainc.com) | Sources: FEMA, Jefferson County, Aerial (2021)

0 500 1,000 2,000 Feet

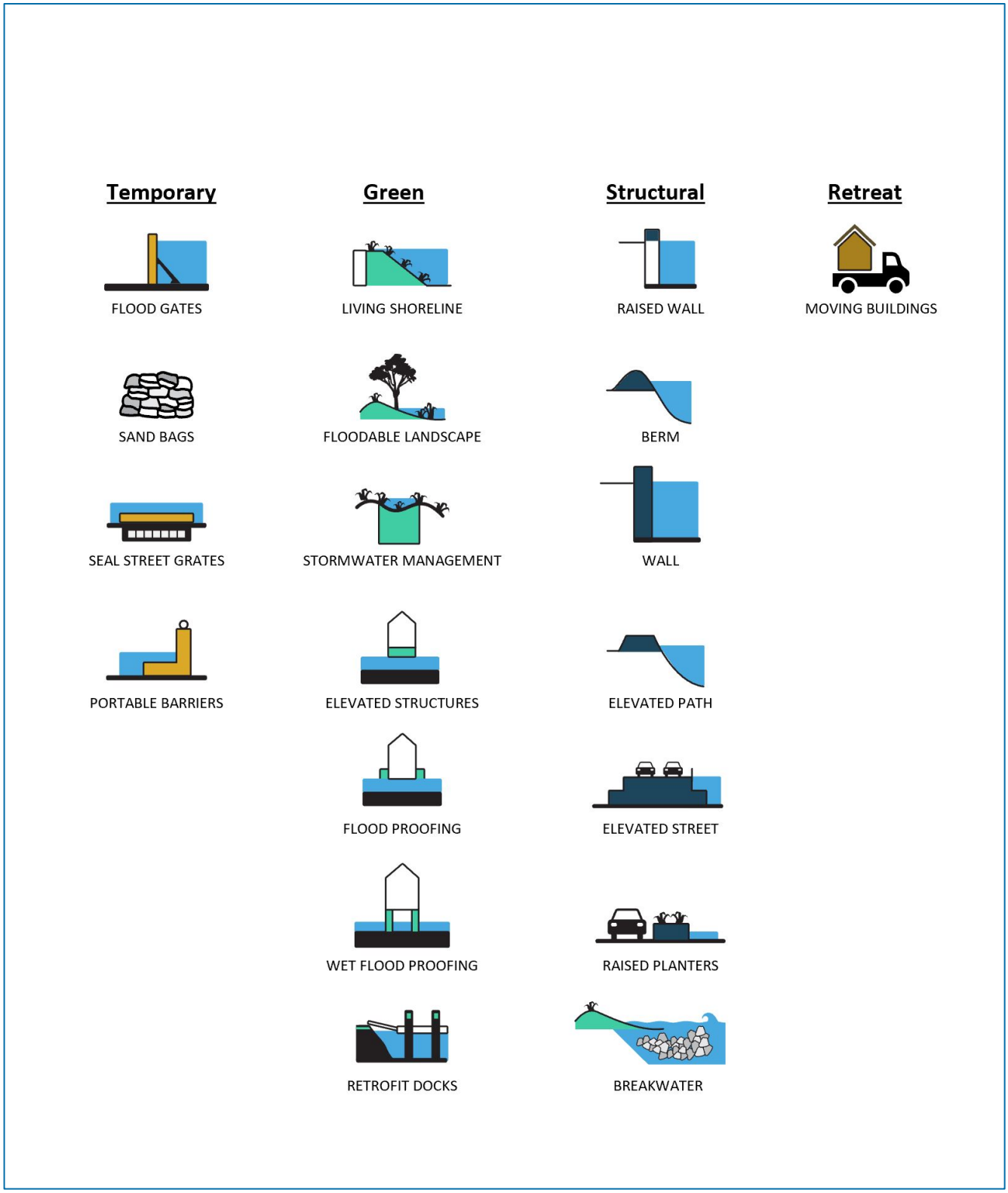


Figure 5. Potential Climate Resiliency Tools.

Temporary Measures

Portable Barriers and Temporary Flood Gates: The use of temporary flood gates and temporary flood gate manufacturers have proliferated due to the need caused by sea level rise and the intensity of tropical cyclones. Numerous manufacturers have been used effectively (e.g., during recent hurricane events in the southeastern United States) to prevent inundation of marine waters when sufficient advance notice is provided. The details of implementation for tidal flooding, as would be the case here, are less clear, though likely it will be dependent on judicious use of actionable inundation estimates (NOAA 2024), similar to what has begun to be used by the Port of Port Townsend. This would also require the development of a forecasting and implementation process that currently does not exist, but appears generally feasible. Upfront costs for such a system are likely significantly less than a permanent solution, although mobilization, demobilization, and storage costs over time could be significant as portable barriers and temporary flood gates are removed after each storm. These solutions also often require little space to deploy. Another advantage of this approach is that it would not impair access most of the time.

Efficacy: 4, Cost: 3, Access: 4, Environmental Impact: 3

Sandbags: Sandbags serve a similar purpose to portable barriers and temporary flood gates, and have been implemented in the past by the Port in particularly problematic locations in the city. Sandbags can be less expensive than portable barriers or temporary flood gates, but they can require more advance notice. Fortunately, the forecasting tools currently available can produce reasonable, actionable inundation estimates (NOAA 2024; Local 20/20 2024). Sandbags also could facilitate shoreline access when not in use, rather than more permanent structures.

Efficacy: 3, Cost: 4, Access: 4, Environmental Impact: 3

Sealed Street Grates: Backwater flooding from storm drains that drain to marine outfalls is a common mechanism for inundation, though less so at the current time in the city. This may not be true as sea level rise persists in the latter half of the 21st century. Simply sealing these storm drain grates can prevent it. Although sealing street grates takes some advance notice, like all the temporary measures, it requires much less time than barriers or sandbags. It is also a very inexpensive measure and does not impair access but does little to prevent wholesale marine flooding. However, under current conditions, backwater flooding is rare; and this method might be of limited use.

Efficacy: 1, Cost: 5, Access: 4, Environmental Impact: 4

Green Strategies

Living Shorelines: Living shorelines utilize natural materials and processes to protect coastlines from erosion caused from waves. Typically, these shorelines can use large woody materials combined with cobbles and vegetation to disperse wave energy. However, living shorelines require more area than hard armoring, such as a wall, and are not feasible in most locations due to the proximity of historic structures.

Efficacy: 3, Cost: 3, Access: 5, Environmental Impact: 5

Floodable Landscapes: Similar to living shorelines, this approach allows natural processes to persist to provide habitat for species that use the nearshore. The primary difference is that these areas would allow and accommodate inundation, rather than providing protection from inundation. While most locations are not amenable to this approach due to development, it may be possible to implement this approach in less developed areas around Point Hudson, particularly when made in conjunction with elevating remaining structures combined with beach nourishment to help prevent erosion and debris damage.

Efficacy: 3, Cost: 2, Access: 5, Environmental Impact: 5

Stormwater Management: Upland runoff drainage will be important to be maintained once sea level rises such that the existing stormwater system is frequently backwatered. Although stormwater management and insufficient drainage is not a significant currently, it is likely to be an important piece of any flood protection solution, no matter the means used to hold back marine waters. This likely would require a comprehensive strategy involving gates, infiltration galleries, cisterns, etc., in the Historic District and could be quite expensive. It may also be complicated by the local geology, which has extremely slow infiltration rates.

Efficacy: 1, Cost: 1, Access: 5, Environmental Impact: 5

Building Elevations

Elevated Structures and Floodproofing: For those structures waterward of Water Street, where space is limited between intertidal waters and the structures themselves, elevating the finished floors may be the only means of adaptation. Smaller elevations will likely be necessary to maintain the historic character of the structures, but they may be combined with selective abandonment of first floors (Eggleston et al. 2021). For other buildings further landward, it can also be a more reasonable approach to adaptation, particularly at the edges of the Historic District (i.e., in the Flats District and Point Hudson), where elevations only need to be modest (a few feet) and the structures are built of timber.

Efficacy: 4, Cost: 2, Access: 5, Environmental Impact: 3

Retrofit Docks: All of the docks along Water Street (approximately a dozen) will likely have to be retrofitted in the next century. This can be an expensive, complicated undertaking. However, if the existing pilings are creosote treated, it can become a multi-objective project that produces water quality and habitat benefits, improved shoreline use and access, and economic development. Currently, the City's code around these types of structures is limited in regard to adaptation measures. Recommendations for facilitating this work are described below in the Recommended Code Revisions section.

Efficacy: 4, Cost: 3, Access: 5, Environmental Impact: 4 (if replacement entails replacement of pollutant-generating structures)

Permanent Structures

Walls and Berms: Walls and berms are the primary means of protection used in the Port's Waterwalk design (KPFF 2024). They are also one of the most common permanent (i.e., immovable and structural) means to protect areas from flooding in other locales. They are highly effective if designed properly. They tend to be costly and can be difficult to permit if placed waterward of the ordinary high water mark and can produce deleterious geomorphic impacts on adjacent properties (Brucal and Lynham 2020). They can also present shoreline access limitations if they block common access routes. Walls are likely to be required for much of the more aggressive protection alignment due to the lack of space for other protective options (Figure 4). And even then, they may be difficult to implement due to disturbance and fill below the ordinary high water mark. Walls and berms should be designed to accommodate additional sea level rise that is anticipated in the coming decades, which may increase erosion and necessitate future beach nourishment and other habitat and geomorphic improvements. Berms can be constructed to resemble upper beach (foreshore) and backshore habitats and recover lost intertidal areas from development, erosion, and the coastal squeeze. Vegetation plantings can enhance resilience, where feasible.

Efficacy: 5, Cost: 1, Access: 1, Environmental Impact: 1

Raised Planters: Similar to wall and berms, this more modest type of structure can provide effective flood protection, provided total water level is not significantly above the existing land surface. It also adds green space, while providing reliable protection. It is important that raised planters are contiguous so that floodwaters are retained, although these can disrupt access. As such, they may contribute to access disruptions. However, raised planters could easily be used along Water Street (well above the current ordinary high water mark) in the less-aggressive alignment to protect more inland portions of the Historic District (Figure 4).

Efficacy: 5, Cost: 1, Access: 1, Environmental Impact: 1

Elevated Streets and Trails: Like walls and berms these features are common in Port's Waterwalk project. This approach is particularly well suited to the less-aggressive alignment. In this case, the trail could be placed next to the road. Also, since this would all occur well above the ordinary high water mark, the state and federal permit effort is likely to be minimal. Costs may be large if they necessitate other transportation changes. However, an elevated trail along Water Street could impact the character of those structures waterward of Water Street, which would be counter to Eggleston et al. (2021) and would require engagement of the community and potentially local artists.

Efficacy: 5, Cost: 1, Access: 3, Environmental Impact: 1

Breakwaters: Since the city's primary issues on its southern shoreline relate to wave energy, it may be possible to delay damage to historic structures from sea level rise by suppressing wave energy using a breakwater. The effectiveness of breakwaters can be seen in the analysis of Blue Coast Engineering (2024), where the lowest total water levels are within the confines of the marina (Table 1), which is protected by a breakwater. Breakwaters are typically employed to reduce erosion and provide still water for marine operations, but they can also be used to reduce storm damage. Breakwaters, particularly when designed in combination with beach nourishment, can produce new nearshore and offshore habitats for

aquatic species that have been lost to past development and human modification (e.g., eelgrass, rockfish), though the nearshore geomorphic and habitat composition changes associated with them would need to be investigated in more detail.

Efficacy: 1, Cost: 1, Access: 3, Environmental Impact: 4

Retreat Strategy

Moving Buildings: Much of the area being assessed will eventually require permanent flood protection. Since flooding will continue to get worse over time, retreat represents a reasonable, if sometimes uncomfortable, alternative. While many of the buildings are constructed in such a way as to make it difficult if not impossible to move them, many of the smaller timber structures on the edges of the Historic District are easily movable. Moving structures is often much cheaper than the construction (and maintenance) of permanent protective structures. Or moving buildings could facilitate the retention or construction of other protective structures, such that they could be removed and used for mitigation purposes. However, moving buildings in the Historic District could damage the historical character of this area, which means this strategy may not be feasible.

Efficacy: 5, Cost: 1, Access: 5, Environmental Impact: 5

The cumulative impacts of these plans are expected to be discrete, since only the southern shoreline of the city is expected to be protected in this way. Protection of small residential properties that are not historically significant, typical of most of the rest of the city, is a fundamentally different problem. Also, the City's SMP specifically regulates areas by shoreline designation and changes are not being proposed to other areas. For the green alternatives, which are more feasible in the less intensely developed areas, the existing SMP should be sufficient to permit development while protecting nearshore resources.

These methods could also be employed in tandem and in a phased manner. For instance, a breakwater could be constructed to reduce wave heights, with other temporary measures installed for those predictable extreme high-water events. Currently, most of structures along the southern shoreline along the City's Waterwalk are not at significant risk to wholesale inundation (i.e., the still water flood levels are well below their finished floors). While inundation risk increases monotonically (consistently and continuously) with time, it is possible that wholesale inundation of most buildings in the Historic District will not occur prior to 2050. However, they are currently at risk from storm-wave damage. Therefore, combining a breakwater with a plan for temporary structures could provide a relatively reliable and ecologically low-impact solution to increase the longevity of the historic structures and the viability of the activities within them without compromising the accessibility of the city's shoreline. This also points to a potentially phased approach to adaptation, where earlier measures allow the City time to reconfigure its low-lying areas for much greater sea level rise at the end of the century, where more intensive measures may be necessary.

Recommended Code Revisions

Port Waterwalk

Confluence Environmental (2024) provided a detailed assessment of the environmental impacts and mitigation opportunities associated with the Port's Waterwalk project. Although some portions of the Waterwalk will be exempt from federal permits because they are located well above the existing ordinary high water mark (again, the 8.9 feet NAVD 88 will be required, not 8.7 feet NAVD 88 as currently planned), there are numerous actions and locations that will likely trigger federal permits. These actions will likely trigger the need for mitigation, which will be administered by state and federal agencies. Table 7 in Confluence Environmental's report (2024) provides a calculation of mitigation credits, which suggests that the available onsite mitigation will be sufficient to permit the project. Despite the calculation, it is unclear whether these mitigation credit totals will be accepted by the state and federal agencies, particularly since mitigation is not always located where the impacts would occur.

In terms of the City's SMP code, in the Larry Scott Trail section, the proposed action is largely in line with the existing SMP. In the Boat Haven boatyard, it is less clear, particularly for those areas where there will be impacts below the ordinary high water mark. The City's current code for Boat Haven allows for bulkheads and revetments, as a conditional use (Port Townsend Municipal Code, Table 5.12-1). Walls, particularly those above the ordinary high water mark, are not mentioned. The City should consider revising the table to include walls outside the ordinary high water mark, since in highly developed places like Boat Haven, the additional impact from their construction is minimal. This characterization would further encourage the Port to develop designs and construction activities to avoid intertidal areas, where the greatest ecological impacts would occur. For the Flats District, there is a greater diversity of shoreline protection. Some of these measures already meet requirements set forth in the SMP. These soft-shore techniques are typically implemented in lower-density development areas (KPFF 2024). In the Flats District, the City could consider allowing flexibility for flood protection structures above the ordinary high water mark, since they will only be implemented in those areas already intensely developed.

Future Resiliency Actions

The City's Waterwalk and associated protective structures may be much more challenging to permit than the Port's, depending on the alignment selected because of the constrained nature of shoreline, particularly in the Historic District. The more protective alignment likely would require work below the ordinary high water mark in many locations. These impacts would trigger federal permits, which would require significant mitigation. The identification of mitigation opportunities is beyond the scope of this memorandum. There are likely mitigation possibilities available, but without an extensive evaluation, it is unclear whether they would be sufficient to permit the alignment.

The less-aggressive alignment should be much more feasible from a planning perspective. For instance, this alignment might be able to avoid federal permits altogether, since it lies well outside of the ordinary high water mark and is in an entirely developed area. As such, the only environmental permit that may be required would be a shoreline permit. The SMP should be revised for the Historic District, as described above for the Boat Haven District, to accommodate walls in upland areas, which should facilitate adaptive projects that do not impact vulnerable habitats. The obvious drawback of the less-aggressive alignment is that it leaves some properties vulnerable to inundation. The City may also consider adding breakwaters as a conditional use with specific criteria and/or prescriptive standards.

To facilitate a decision about SMP revisions, the City should consider a further, more sophisticated evaluation of the city assets at risk. This might include extending the Blue Coast Engineering (2024) model or developing a new model of the Historic District and Point Hudson. The analysis performed by Blue Coast Engineering (2024) was suitable for the small area around Boat Haven, but it might not be appropriate for the Historic District, particularly in the vicinity of Point Hudson where tides, currents, and swell complicate an estimate of total water level.

Further, the City should consider incentivizing retreat actions, particularly for those structures on the waterward side of any protective structure and any assets that are highly sensitive to coastal flooding. Sensitive assets are assets that would be damaged or degraded from being exposed to salt water and/or assets that, if they were exposed, could result in environmental damage or degradation or loss of human life. These highly sensitive assets with high (hazard) exposure are the most vulnerable structures, and mitigating flood impacts via relocation or redesign should be a priority. The finished floors of these structures are likely to be below flood water surface elevations in 2100. Currently, relocation of structures would require a Shoreline Substantial Development Permit. The City should consider easing permit requirements relocation of any structure in this zone, since by removal of development, it will necessarily meet the environmental intent of the SMP and help achieve no net loss of ecological function.

The City (and the Port) may also consider a mechanism to re-evaluate sea level rise planning as science evolves and future sea level rises are realized (or not). This may include new provisions for new development or redevelopment that go beyond current requirements, which only factor in expected sea level rise in typical planning horizons (i.e., 30 years or less).

Along these lines, the City should also consider revision of its Non-Conforming Structures section (Chapter 11). All the overwater structures along Water Street are non-conforming. Currently the code states that if the structures are damaged to greater than one-half of the replacement cost, they must be made conforming. This would likely necessitate their removal in most cases. Since without action all the overwater structures—many of which are historic and therefore sought to be retained as a part of Port Townsend's historic character—are likely to be damaged to this extent beyond 2050, consider allowing non-conforming structures to persist if they are raised above some threshold (e.g., assuming 5 feet per the City's sea level rise analysis [Port Townsend 2022]). Also consider adding specific sections to Chapter 11 to address floor raising to encourage action prior to damage. Raising of structures, which might include replacement of pollutant-generating piles with more benign steel or concrete piers, could easily benefit nearshore habitat and water quality as well.

A checklist for precise actions to be taken will be provided following public and agency input.

Summary

The document summarizes a range of measures that could be taken throughout the city's southern shoreline to protect the area from future sea level rise. However, not all measures are feasible in this diverse area. Table 2 summarizes the general characteristics of the shoreline designations and the feasible measures that could be taken to solicit stakeholder input. Based on this input, the SMP will be revised to accommodate those measures identified by the stakeholders.

Table 2. Summary of Shoreline Designations and Applicable Adaptive Measures.

Shoreline Designation	Relative Elevation	Type of Buildings	Existing Building Setbacks from OHWM[a]	Habitat	Potential Adaptation Strategies (private: parcel specific)	Public Investment Adaptation Strategies
Larry Scott Trail	Low	N/A	N/A	Moderate	Green	BRIC, RCO (ALEA, SRFB)
Boat Haven	Low	New, wood, metal	75 to 100	Minimal	Permanent structures, temporary	BRIC, private
Flats District	Variable	Variable	0 to 50 (variable)	Low to Moderate	Permanent structures, building elevations, temporary, retreat	BRIC, private
Historic District	High	Masonry historic, large	<10	Minimal	Permanent structures, building elevations, temporary	BRIC, private
Point Hudson	Medium	Historic, wood, small	10 to 100 (variable)	High	Green, building elevations, temporary	BRIC, ALEA, RCO (ALEA, SRFB), private

[a] OHWM must be delineated by a qualified professional, but along marine shorelines it is close to, but typically slightly higher than MHHW.

References

Blue Coast Engineering. 2024. Sea Level Rise and Waterwalk: FEMA BRIC Grant Support Draft Report. Appendix B. March 22.

Brucal, A., and J. Lynham. 2021. Coastal Armoring and Sinking Property Values: The Case of Seawalls in California. Environmental Economics and Policy Studies 23:55–77.

Confluence Environmental. 2024. Sea Level Rise and Waterwalk: FEMA BRIC Grant Support Draft Report, Appendix D. March.

Eggleston, J., J. Parker, and J. Wellock. 2021. The Secretary of the Interior's Standards for Rehabilitation & Guidelines on Flood Adaptation for Rehabilitating Historic Buildings. U.S. Department of the Interior, National Park Service, Technical Preservation Services, Washington, DC.

Herrera. 2020. Advisement on Impacts of Sea Level Rise on City of Port Orchard Shoreline. Prepared for City of Port Orchard. October 2.

KPFF. 2024. Sea Level Rise and Waterwalk: FEMA BRIC Grant Support Draft Report. March 29.

Local 20/20. 2024. King Tide – Dec 14, 2024, website. <https://l2020.org/king-tide-dec-14-2024/>.

Miller, I.M., H. Morgan, G. Mauger, T. Newton, R. Weldon, D. Schmidt, M. Welch, and E. Grossman. 2018. Projected Sea Level Rise for Washington State – A 2018 Assessment. A collaboration of Washington Sea Grant, University of Washington Climate Impacts Group, University of Oregon, University of Washington, and U.S. Geological Survey. Prepared for the Washington Coastal Resilience Project.

NOAA. 2022. NOAA Digital Coast mapper. <https://coast.noaa.gov/digitalcoast/tools/slr.html>.

NOAA. 2024. Probabilistic Extra-Tropical Storm Surge website. <https://slosh.nws.noaa.gov/petss/index.php>.

Port Townsend, City of. 1990. Port Townsend Urban Waterfront Plan. <https://weblink.cityofpt.us/weblink/0/edoc/202066/Urban%20Waterfront%20Plan%20Preferred%20Alternative%201990.pdf>.

Port Townsend, City of. 2007, last amended 2018. Shoreline Master Program. <https://cityofpt.us/planning-community-development/page/planning>.

Port Townsend, City of. 2022. The City of Port Townsend Sea Level Rise and Coastal Flooding Risk Assessment. Prepared by the City of Port Townsend and Cascadia Consulting Group. October.