Attach 1
V2

Finding of No Significant Impact
Alki Coastal Erosion Control Project
Section 103 Coastal Storm Damage Reduction
Seattle, King County, Washington

1. Background. The Alki Coastal Erosion Control project (Alki Project) site is located in West Seattle, Washington along the shores of Puget Sound and runs parallel to Beach Drive Southwest near Alki Point. The project site is located on City of Seattle Parks and Recreation lands in a park known as Emma Schmitz Memorial Overlook. An existing seawall built in 1927 runs continuously through the project site, providing the current storm and erosion protection for public infrastructure. Coastal storm waves, storm surge, and storm-induced erosion continue to degrade the seawall and pose a significant risk to public infrastructure. Infrastructure at risk behind the degraded seawall includes a King County owned 54-inch sewer main running throughout the entire study area, Beach Drive, and a Puget Sound Energy gas line and a Seattle Public Utilities water line located beneath the centerline of Beach Drive.

The purpose of the project is to reduce the risk of damages to public utilities and infrastructure resulting from failure of the seawall due to coastal storm events, storm surge, and storm-induced erosion. There is also an opportunity to reduce the risk of potential environmental impacts that may result from collapse of the sewer main that could result in raw sewage discharging into Puget Sound.

2. Authority. The proposed Alki project is authorized by Section 103 of the 1962 Rivers and Harbors Act, as amended, which allows the U.S. Army Corps of Engineers (Corps) to study, design, and construct small coastal storm damage reduction projects in partnership with non-Federal government agencies, such as cities, counties, special authorities, or units of state government.

3. Proposed Action. The proposed project consists of the construction of a new soldier pile wall located immediately in front of the existing seawall structure.

4. Summary of Impacts and Compliance. The impacts of the proposed project are described fully in the project Detailed Project Report/Environmental Assessment (DPR/EA) dated August 2014, and summarized herein.

a. Unavoidable adverse impacts associated with this project are expected to include short term construction impacts such as noise disturbance to fish, wildlife, and residents in the vicinity of operating heavy machinery; increased emissions from heavy machinery; and disruption of local traffic in the project vicinity during construction. All work would be completed July 16 through February 15. The work window avoids sensitive migration periods for salmonids, including bull trout. Impacts to water quality during construction would be minimal. Work would be done in the dry at low tide, but slight turbidity increases could occur during the construction period when the tides rise and hit the work area. Use of best management practices such as working from the top of the bank, minimizing on-site equipment maintenance, and ensuring all equipment and materials are clean would minimize potential for contamination. A small amount (0.02 acres) of beach would be lost due to the footprint of the new wall. To offset the loss of this habitat, the project would reclaim adjacent beach habitat by removing a portion of riprap placed in a City of Seattle 1998 emergency repair. This entails aligning the seawall back to or near its pre-1998 alignment and removing the waterward riprap and fill materials. The proposed ratio would be a 1:1 replacement as this habitat reclaims the lost habitat imposed by the new seawall and could begin to function immediately post-construction.

b. The Corps is coordinating with Federal agencies to assure careful consideration of fish and wildlife resources. The Corps has determined that this project is “not likely to adversely affect” federally listed species under the Endangered Species Act. In correspondence dated 19 September 2014 and 3 December 2014, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service respectively concurred with these findings.

c. The Corps has prepared a 404(b)(1) analysis, included as an attachment to the DPR/EA (Appendix J). Receipt of a Water Quality Certification under Section 401 of the Clean Water Act for the proposed project will be completed during the design phase and prior to construction.

d. The Corps has conducted a cultural resources investigation for this project. The pertinent Tribes have been notified and have registered no concerns. The Corps has coordinated with the State Historic Preservation Officer (SHPO) under Section 106. On May 16, 2016 the SHPO concurred with the Corps’ determination that there will be no historic properties affected by the proposed undertaking.

e. Avoidance measures and reduction of impacts will take the form of on-site biological and archaeological monitoring, implementation of best management practices during construction, and scheduling to avoid potential impacts to fish and wildlife species.

5. Finding. Based on the attached environmental documentation, coordination, and analysis conducted by the Corps environmental staff, I have determined that the proposed project will not result in significant adverse environmental impacts, does not constitute a major Federal action significantly affecting the quality of the human environment and, therefore, does not require preparation of an environmental impact statement.

_______________	__________________________________
Date	John G. Buck Colonel, Corps of Engineers District Commander

ALKI COASTAL EROSION CONTROL PROJECT

SECTION 103 COASTAL STORM DAMAGE REDUCTION

SEATTLE, WA

Integrated Detailed Project Report and Environmental Assessment
May 2016

U.S. Army Corps of Engineers, Seattle District

In Partnership with:
The City of Seattle, Washington
Parks and Recreation Department

**U.S. Army Corps of Engineers
Seattle District**

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ALKI COASTAL EROSION CONTROL PROJECT
SECTION 103 COASTAL STORM DAMAGE REDUCTION
SEATTLE, WA

Integrated Detailed Project Report and Environmental Assessment

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EXECUTIVE SUMMARY

The U.S Army Corps of Engineers, Seattle District, has partnered with the City of Seattle Parks and Recreation Department to design and implement a coastal storm damage reduction project under Section 103 of the Rivers and Harbors Act of 1962, as amended. The recommended plan would provide protection that addresses damages caused by coastal storm events occurring in Puget Sound. Coastal storms and erosion continue to threaten public infrastructure located in and around the project footprint, including a 54 inch King County sewer main, a main public arterial, City park property, and other underground utilities. In 1998, the City of Seattle was prompted to take emergency action to stabilize the shoreline to the north of the proposed federal project when storm waves resulted in the failure of a similar section of existing seawall and subsequent erosion of shoreline protection that threatened utilities, roadways, and public lands. The City completed permanent emergency repairs on this adjacent site which is not included in the scope of the proposed Federal project. In the event of a failure within the project site we expect the City of Seattle to conduct emergency operations, similar to what occurred in 1998. That would only be a temporary fix and a more permanent solution would then be formulated and implemented. We expect that the permanent solution would look similar to what is being proposed in the with project condition.

The recommended plan was chosen because it has the least environmental impacts, was the least cost alternative and meets all project purposes. The recommended plan includes construction of a soldier pile wall parallel to the shoreline throughout the study area. Preliminary coordination with resource agencies and federal tribes resulted in general concurrence with the project. However, based on this coordination the slight waterward change in footprint will require reclamation of adjacent beach habitat to offset permanent impacts. A preliminary analysis of the real estate interests in the area identified all lands needed for the project to be owned by the City of Seattle.

The implementation cost of the recommended plan is estimated to be $2.29 million and will be cost-shared 65% Federal ($1,488,000) and 35% non-Federal ($801,000). The non-Federal sponsor is responsible for all lands, easements, right-of-ways, relocations, and/or disposal areas which are currently valued at $50,000 and controlled by the sponsor. Economic analysis suggests the project could prevent millions of dollars of physical and non-physical damages, with resulting benefit-cost ratio of approximately 1.74 to 1.

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1. INTRODUCTION

The United States (U.S.) Army Corps of Engineers (Corps) proposes to construct a 500 linear foot seawall to provide coastal erosion protection for public utilities, roadways, and public lands. The project will involve construction of a new seawall immediately adjacent to and seaward of an existing deteriorated wall. The proposed work would occur in the summer of 2015. In accordance with the National Environmental Policy Act (NEPA), this integrated document examines the potential impacts of the proposed coastal storm damage reduction project.

2. STUDY AUTHORITY

Section 103 of the 1962 River and Harbor Act authorizes the Corps to study, design, and construct small coastal storm damage reduction projects in partnership with non-Federal government agencies, such as cities, counties, special authorities, or units of state government. Projects are planned and designed under this authority to protect public infrastructure from damages resulting from storm driven waves and current and to provide the same complete storm damage reduction project that would be provided under specific congressional authorizations. The maximum Federal cost for planning, design, and construction of any one project is $5,000,000. Each project must be economically justified, environmentally sound, and technically feasible.

3. STUDY INFORMATION

3.1. Study Sponsorship

The study was requested by the City of Seattle Parks and Recreation Department (City). As a part of the implementation of the project, the non-Federal sponsor of the study, the City, would be obligated to contribute 35% of the design and implementation costs including all lands, easements, right-of-ways, relocations, and disposal areas (LERRD). Refer to Appendix A for the City of Seattle Letter of Intent to sponsor the project.

3.2. Study Stakeholders

The following parties represent the project stakeholders:

- U.S. Fish and Wildlife Service (USFWS)
- National Marine Fisheries Service (NMFS)
- Muckleshoot Indian Tribe
- Suquamish Tribe
- Sauk-Suiattle Indian Tribe
- Snoqualmie Indian Tribe
- Tulalip Tribes
- Yakama Nation
- Duwamish Tribe
- Washington Department of Fish and Wildlife (WDFW)

- Washington Department of Natural Resources (DNR)
- Washington Department of Ecology (WDOE)
- Washington State Department of Archaeology and Historic Preservation (DAHP)
- Members of the general public

3.3. Study Area

The study area is located in West Seattle, Washington along the shores of Puget Sound and runs parallel to Beach Drive Southwest near Alki Point (Figure 1). The study footprint encompasses approximately 500 linear feet of shoreline and is about 75 feet wide, extending from the beach area to the easterly most edge (far side) of the existing roadway. All lands within the vicinity are owned by the City of Seattle, including the beach area extending waterward of the study footprint. There is an existing seawall that runs continuously through the study area that provides the current storm and erosion protection for public infrastructure. The existing seawall structure crest is approximately 20 feet above mean lower low water (MLLW) and has degraded since its construction in 1927. The degraded condition of the existing structure is not due to a lack of regular routine maintenance as the City of Seattle performs annual inspection and maintenance on the current structure. The infrastructure at risk behind the seawall includes a King County owned 54 inch sewer main running throughout the entire study area, as well as Beach Drive itself. In addition, there is a Puget Sound Energy gas line and a Seattle Public Utilities water line located beneath the centerline of Beach Drive that are also at risk of damages or failure caused by coastal storms. The project is located two miles north of Lincoln Park, the site of a prior Section 103 project originally constructed in 1988 by the Corps and sponsored by the City of Seattle (Figure 1).

4. PURPOSE AND NEED

4.1. Overview

This Integrated Detailed Project Report and Environmental Assessment (DPR/EA) identifies the problems, objectives, and constraints of the project and documents the analysis of environmental impacts completed to date. Additionally, this report documents the process and screening developed to select the recommended plan. Storm waves in Puget Sound threaten public and private infrastructure around the Puget Sound, including West Seattle. The project area is exposed to a relatively long fetch. Fetch is the length of water over which wind can travel and it determines the size of waves produced. The project area is exposed to a fetch length of over 11 miles for winds from the south which is capable of producing wave heights greater than 7 feet during storm events. Many utilities and arterials are located near the water and often run parallel to the shoreline making them more vulnerable to impacts from storm waves and storm-induced erosion. In 1955, King County installed a 54 inch sewer main parallel to the shoreline that services over 20,000 customers with a capacity of up to 8 million gallons of flow daily; refer to Figure 2. The existing seawall runs throughout the project area and protects utility and transportation infrastructure, as well as park lands from wave damages and erosion caused by storm events. The existing seawall, built in 1927 by the Seattle Street Department, has significantly deteriorated over time as a result of storm-induced damages from Puget Sound.

Figure 1. Project Vicinity and Location Overview

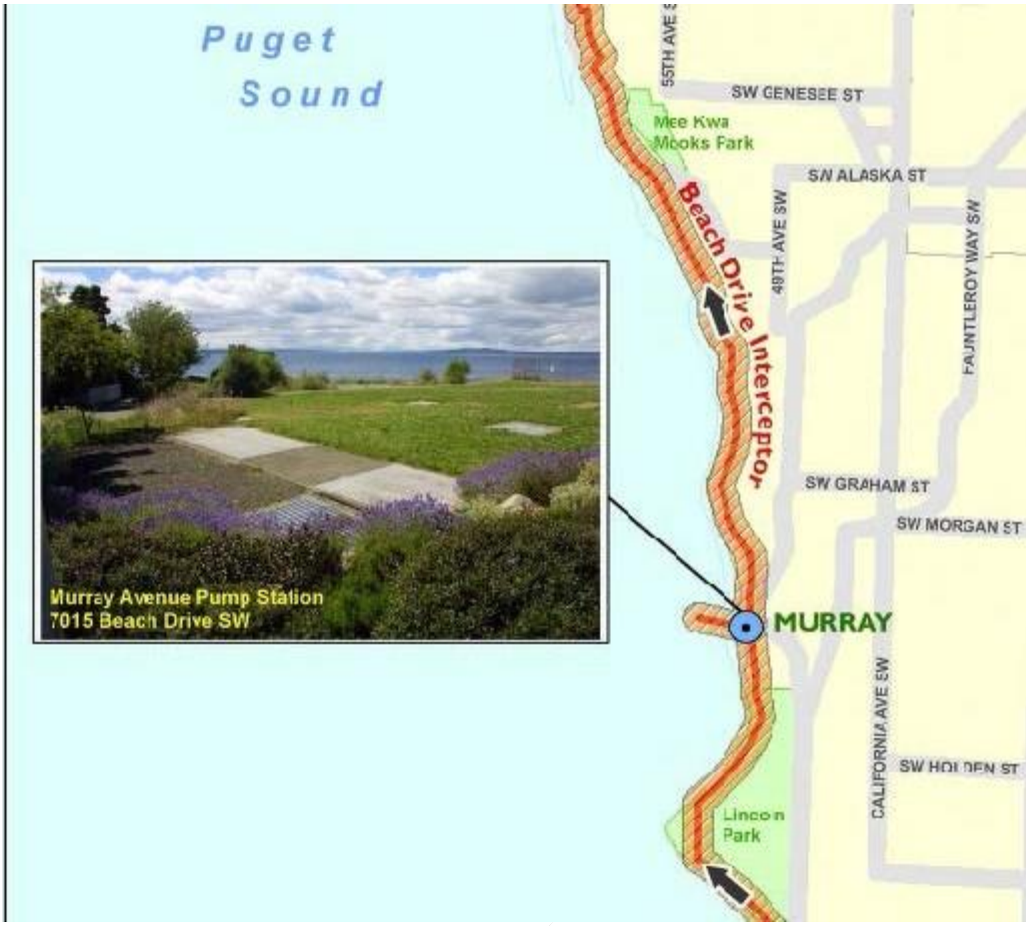

Figure 2. King County Sewer Main

4.2. Problems and Opportunities

Coastal storm waves, storm surge, and storm-induced erosion continue to degrade the seawall and pose a significant risk to public infrastructure. A series of small winter storms in 1998 caused a 500 foot section of seawall to collapse just to the north of the project site, threatening infrastructure and the marine nearshore environment with potentially millions of gallons of raw waste-water discharging directly into Puget Sound. Emergency actions were taken by the City to stabilize the shoreline and prevent major utility damages. The failed section of seawall is located immediately to the north of the Federal study area.

A failure at the 1998 repaired location (Figure 1) would result in minimal risk to both the infrastructure behind it and a potential Federal project because the local infrastructure, including the sewer main, is set back from the shoreline along the 1998 repair reach. Further, a catastrophic failure of the repair work is not anticipated to occur during the period of analysis based on the reliability of rubble mound revetments and the size of armor stone used in the emergency repair. Continued maintenance by the City is expected to be minimal and will ensure that the structure maintains its function and provides a continued level of storm protection adequate to allow the federal project to tie into the southern end. Additionally, the proposed seawall will tie into the riprap structure with sufficient overlap to prevent flanking or failure at this or other critical locations. The 1998 emergency repair work completed by the City is sufficient to provide an adequate level of storm protection to compliment proposed Federal action and is considered a permanent structure, thus no Federal action is proposed for this area.

The seawall and its components have been impacted by years of storm events and corrosion caused by salt water in Puget Sound, and further deterioration could result in failure of the structure, loss of infrastructure, contamination of the local marine environment, and erosion of public lands.

The seawall at the project site was originally constructed in 1927. The design of the original seawall included horizontal tiebacks which attached the top waler (i.e. horizontal steel trolley rails) of the seawall to concrete anchors embedded in the soil landward of the structure. These anchors were intended to provide structural support to the system, but over the years the tiebacks have detached and no longer serve their intended function. Additionally, steel trolley rails were originally embedded vertically into the concrete foundation to support the vertical concrete slabs. These rails have corroded such that the majority of the rails are now unstable. The failed vertical rails can be found along the beach during a low tide (Figure 3). Also sediment scour has occurred adjacent to the concrete footing causing further destabilization of the structure. The degraded condition of the existing seawall is not attributable to insufficient maintenance.. Annual routine maintenance has been performed by the City throughout the life of the existing structure, including inspections and minor repairs as needed. However, the seawall and its components have been impacted by years of storm events and corrosion caused by salt water in Puget Sound, and further deterioration could result in failure of the structure, loss of infrastructure, contamination of the local marine environment, and erosion of public lands.

The opportunity exists to reduce the risk of damages to public infrastructure, including the potential loss of critical utilities and transportation corridors, from coastal storm waves, storm surge, and storm-induced erosion that continue to threaten the project area. In addition, there is an opportunity to reduce the risk of potential environmental impacts that may result from collapse of the sewer main that could result in raw sewage discharging into Puget Sound.

Figure 3. Corroded steel rails and failed top waler which historically held tie back anchors. Also note scour of sediments adjacent to concrete footing.

4.3. Goals

The goal of the study is to reduce damages to public utilities and infrastructure resulting from failure of the seawall due to coastal storm events, storm surge, and storm-induced erosion.

4.4. Objectives

The study objectives within the bounds of the defined study area, evaluated over the planning period of analysis include:

- Reduce the risk of physical damages to public utilities and transportation infrastructure resulting from coastal storm events, storm surge, and storm-induced waves.
- Reduce the risk of erosion and loss of public lands due to storm damages.
- Reduce the risk of environmental impacts resulting from a sewer main failure.
- Reduce the risk of potential transportation delays and other emergency costs to residences, businesses and government entities resulting from coastal storm damages.

4.5. Constraints

The study constraints include:

- The recommended plan must not adversely affect existing infrastructure and utilities in the project area.
- The recommended plan, at a minimum, must provide an equivalent level of storm protection or greater than what is currently provided for utilities and infrastructure.
- Nearshore habitat, to the maximum extent possible, must be preserved and footprint intrusions waterward of the shoreline must be minimized to a reasonable extent.

5. EXISTING CONDITIONS

The project site is located on City of Seattle Parks and Recreation lands and provides recreation, including viewing and walking/biking paths, for local residents. The existing seawall was originally constructed by the City of Seattle in 1927 and runs parallel to Beach Drive Southwest. The seawall provides storm damage protection for public utility and transportation infrastructure located immediately behind the seawall. Further, the seawall prevents loss of public lands associated with the erosive storm and tidal forces in Puget Sound. The crest of the existing seawall is 20.3 feet above mean lower low water (MLLW) (Seattle Department of Parks and Recreation 1987). The vertical wall is comprised of 7 inch thick by 5 foot 8 inch high by 4 foot 8 inch wide (PND Engineers 2008) precast concrete slabs embedded vertically in a concrete footing that is embedded to 5.7 feet above MLLW (Seattle Department of Streets and Sewers 1922). Refer to Figure 4 below for additional information. The precast concrete slabs are held in place by vertical steel trolley rails. Horizontal tiebacks (concrete deadman and wire rope anchoring) were installed to the top waler in order to provide lateral support to the structure, but these connections have completely corroded.

Beach Drive Southwest is a main arterial that connects the west side of West Seattle to Alki Point with average daily traffic of over 5,000 vehicles. A 54 inch sewer main that services 20,000 residents and commercial businesses in the area with a capacity of up to 8 million gallons a day runs parallel to the shoreline and Beach Drive, adjacent to the existing seawall structure. The sewer main is owned and maintained by King County and is buried beneath the surface at a depth of approximately 10 feet below the roadway surface and as close as 2 feet landward from the face of the existing seawall. In addition to the sewer and roadway, there is a Puget Sound Energy gas line and a Seattle Public Utilities water line located beneath the centerline of Beach Drive Southwest. It is expected that as a result of major storm events, all utilities and infrastructure in the project area are at immediate risk of damages and loss.

In 1998, a segment of seawall to the north of the proposed federal project failed, prompting emergency actions by the City to stabilize the structure and bank; refer to Figure 5 below. This failure was stabilized by City crews with a repair consisting of a major riprap structure placed seaward of the failed seawall. The riprap extends over 50 feet into the nearshore area and provides adequate protection for infrastructure and lands from storm and tidal forces. The sewer main along this stretch of shoreline begins to move landward away from the beach; whereas, the sewer main is located much closer to the shoreline in the proposed federal project area and is considered to be at a higher risk of impacts.

Additionally, there are potentially significant environmental impacts associated with a failure of the sewer main. Puget Sound is home to a diverse ecosystem that includes several Endangered Species Act-listed species, such as bull trout, steelhead and Chinook salmon, and marbled murrelet. Sewer main failure could result in significant amounts of raw sewage discharging into Puget Sound. The nearshore area at the project location is generally wider than most nearshore areas in the general vicinity and is comprised of both sands and gravels. The study area does not include forage fish spawning, but does include patchy eel grass. The eelgrass beds and nearby kelp beds provide important food and shelter for numerous species which would be negatively impacted by failure of the sewer main. Furthermore a failure of the seawall and subsequent failure of the sewer main would likely result in emergency repairs that would have a larger footprint (such as a riprap revetment), resulting in a greater loss of beach habitat and future disturbance through repeated repairs.

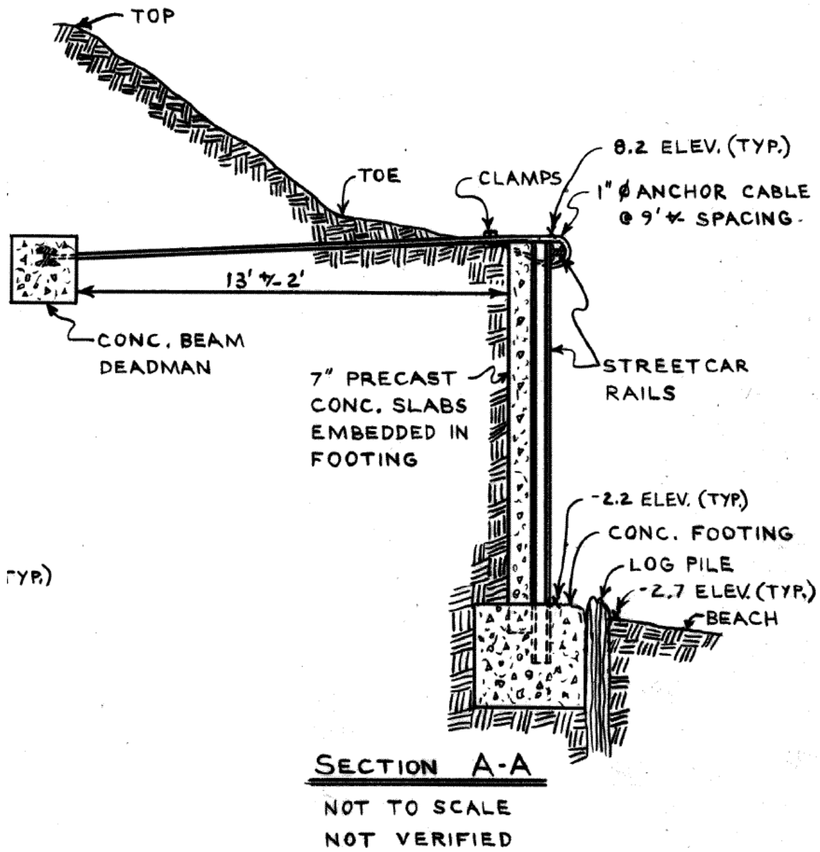

Figure 4. As-built of existing seawall. Note elevations in local datum (0 ft = -12.5 ft MLLW)

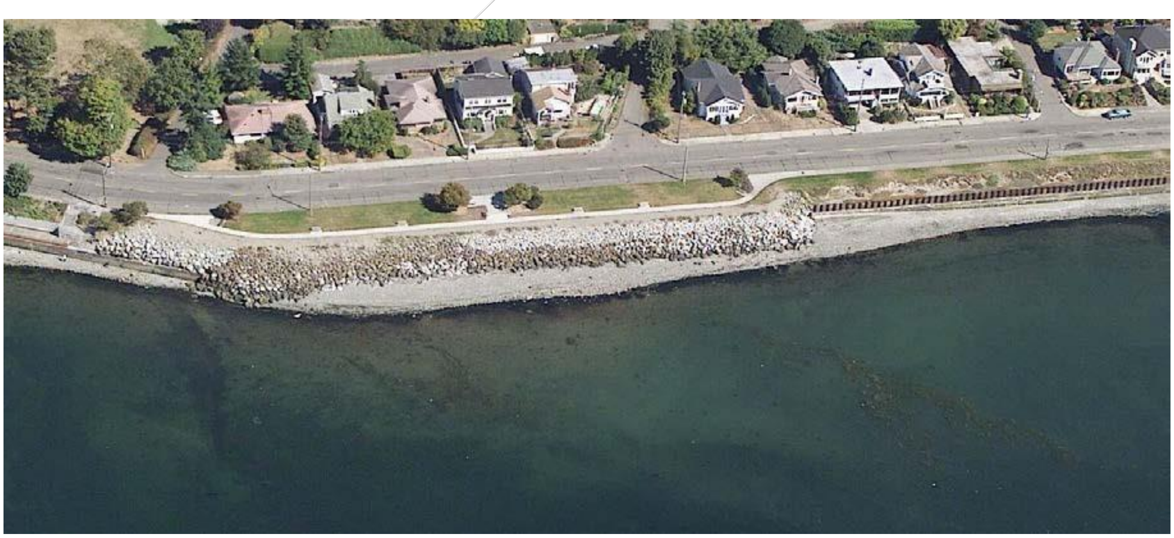

Figure 5. Extent of 1998 seawall failure.

5.1. Reliability Analysis

The integrity of the steel rail beam sections is the focus of the reliability analysis as this is the critical part of the structure which would result in the greatest consequences. Figure 6 shows the fault tree developed for the seawall. As annual wave loading exceeds the earth pressures behind the wall the highest probability of failure is during a coastal storm event. This is consistent with observations during the failure of the northern section of seawall in 1998.

The steel beam sections supporting the concrete face panels have been exposed to persistent corrosion since original construction in 1927. Over time this has reduced the cross-sectional area of the beam and thus translates to larger stresses applied in the beam. Based on lateral loading conditions (earth or wave pressures acting on the wall), the steel beam yield stress[1], and the corrosion rate of the steel, there exists a critical threshold at which the loading will exceed the allowable stress in the rail section and results in failure of the beam and wall. Assumptions of these parameters were specified and then randomly varied using a Monte Carlo simulation to develop reliability curves for the seawall. The Monte Carlo analysis is performed as described in EC 1110-2-6062 (USACE 2011a). The parameters specified in the analysis are as follows:

- Steel rail beam yield stress = 28 ksi
- Steel rail beam section modulus (assume ASCE 6040) = 18.69 in^3/ft
- Corrosion rate (thickness/year) = 0.09 mm/yr
- 1-year wave event moment at seawall footing = 6.8 kip-ft/ft (i.e. 100% chance of occurring within one year)

The results indicate that the structure is 50-percent reliable in 2023 for a 1-year event (or conversely has a 50-percent chance of failure by 2023). Refer to Figure 7 below.

[1] Yield stress: Stress at which the material will deform permanently

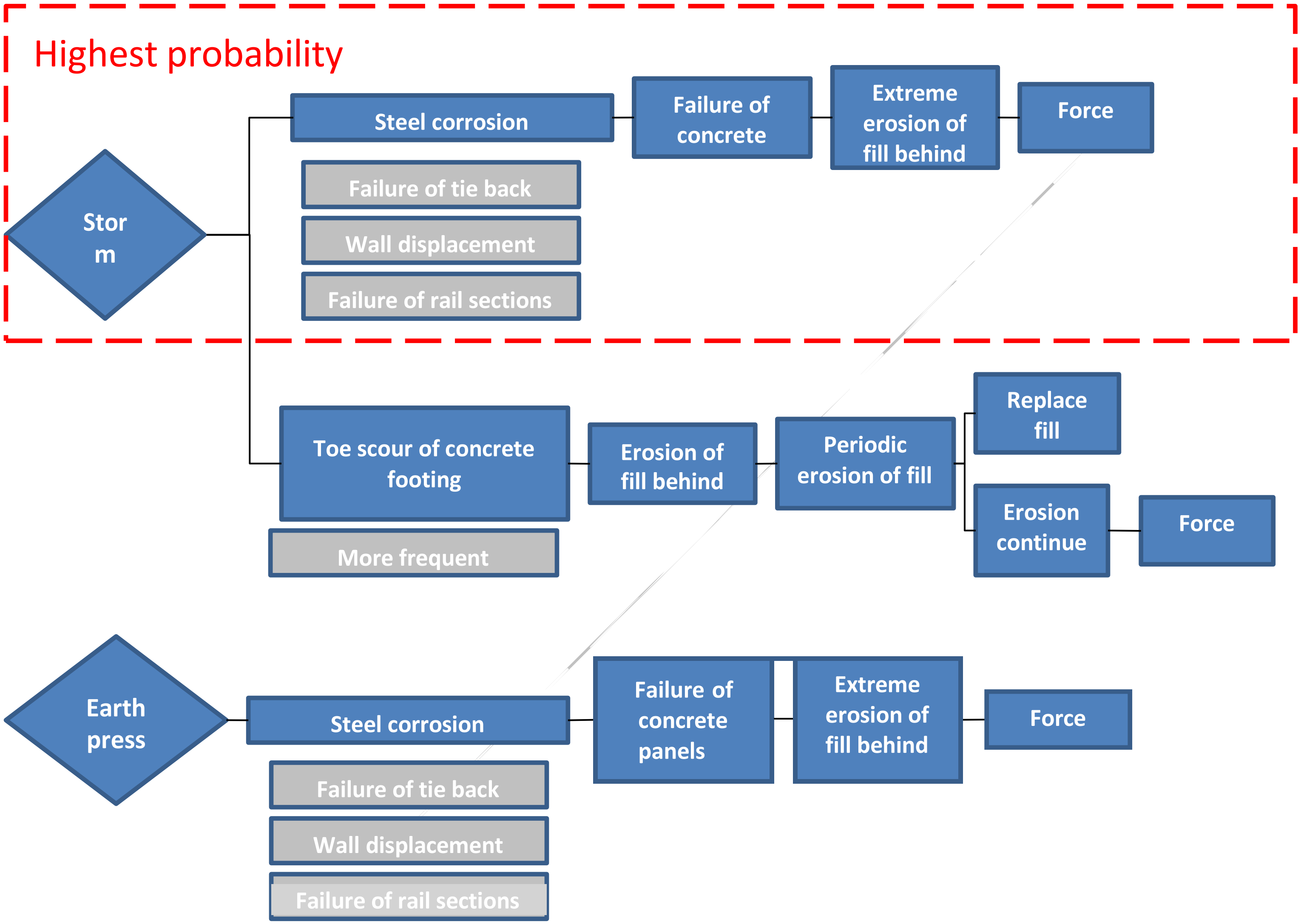

Figure 6. Fault Tree for Existing Structure.

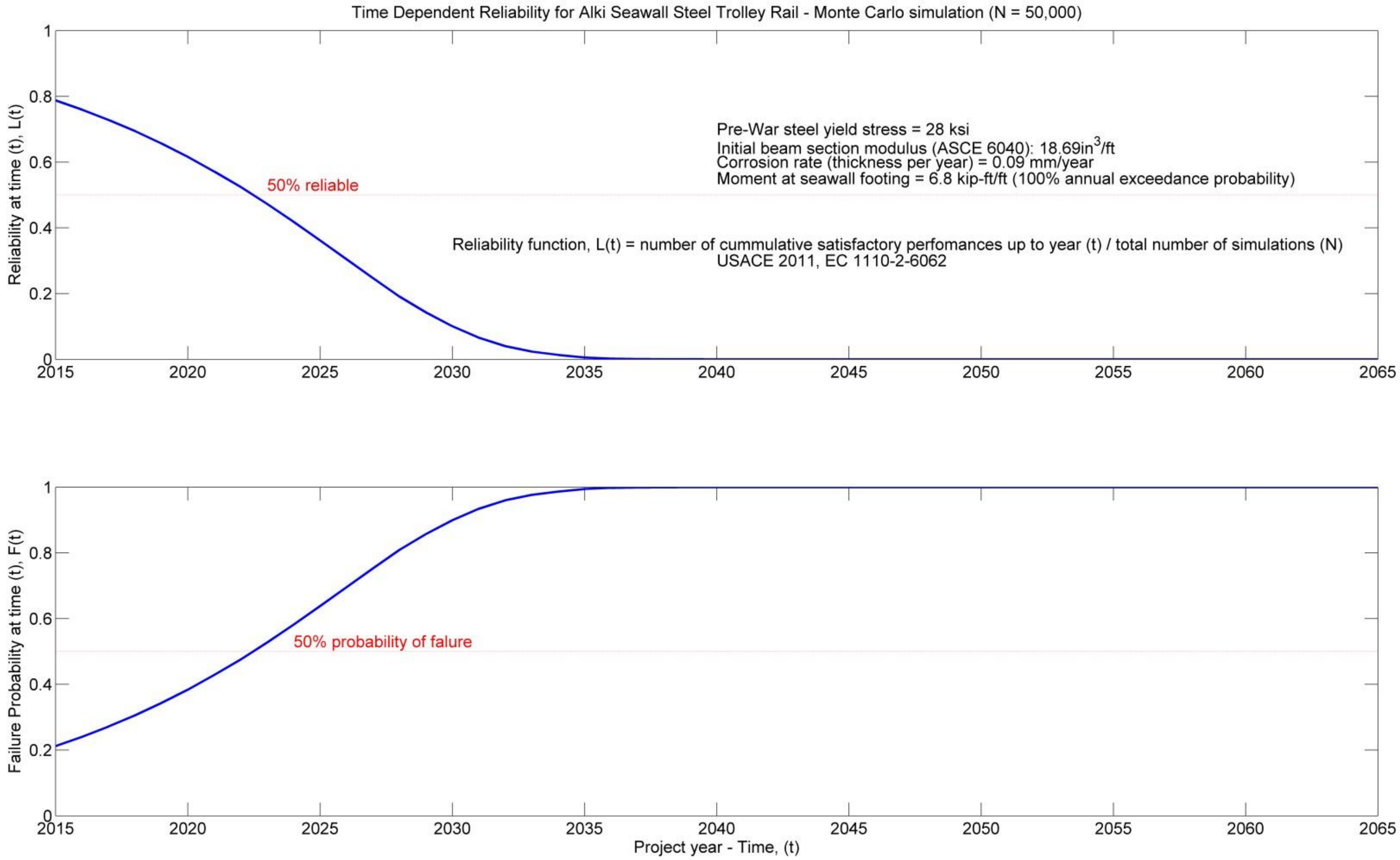

Figure 7. Computed Seawall Reliability and Failure Curves for the Annual Wave Loading Event

5.2. Coastal Engineering

The project is located in central Puget Sound which is exposed to tidal and wind generated waves. Tides in Puget Sound are mixed semidiurnal in type, indicating two daily high and low tides unequal in magnitude. The mean tidal range is 7.7 feet. The longest fetch length and strongest winds occur from the southerly directions. Winds oriented from the south produce the largest storm waves.

The seawall is fronted by a mildly sloping foreshore beach which results in depth limited conditions at the seawall. This means wave height is strictly dependent on the water depth, thus the time varying water level is a significant parameter controlling the hydraulic forcing on the seawall. Water levels during storm events are affected by tide, atmospheric pressure, and wave setup. The latter two are typically collectively termed storm surge and may result in increases in water level 2 to 3 feet above the predicted tide for durations up to 72 hours. The 2% annual exceedance probability (50-year event) water level computed at the Seattle, Washington water level station is 14.5 feet above MLLW. This water level coincident with an extreme wind event is capable of producing a wave height of 7.1 feet offshore of the seawall and resultant wave forces exceeding 3.2 kilo-pounds/foot. Given the condition of the existing seawall components, horizontal loading of this magnitude produces a high risk for catastrophic failure. Such an event would also result in significant wave overtopping of the seawall and result in further erosion of sediments behind the wall, which currently provides some lateral and overturning resistance to wave forcing. Continued loss of this material will continue to increase the fragility of the structure. Finally, progressive wave scour in front of the wall may expose the toe of the existing concrete footing. The failure in 1998 of the northern section of the seawall can be considered a strong predictor of what could occur to the southern 500 feet of seawall should no action occur. The northern section of seawall likely failed first as this section bends approximately 25 feet seaward from the southern seawall section. It is speculated near this bend point wave overtopping and erosion of sediments behind the wall was exacerbated. This may be due to increased wave heights acting on the seawall – either from wave focusing on this bend point and/or larger wave heights associated with deeper water depths in front of the wall.

The effects of sea level rise are expected to impact the crest height of any proposed Federal action. The crest elevation of the current structure is +20.3 feet MLLW; however, by increasing the crest elevation to +22 feet MLLW, the risk of overtopping is mitigated under low and intermediate sea level rise scenarios. Given the strong dependence of water level on hydraulic forcing, this project is relatively sensitive to changes in mean sea level. Thus sea level rise presents a significant risk to the future without project condition.

Refer to Appendix B for detailed coastal engineering analysis, sea level rise analysis, and supporting structural design calculations.

5.3. Geotechnical Engineering

In the feasibility phase, geotechnical investigation resources were limited to a survey of existing data. Therefore, several assumptions were made in the determination of foundation materials at the seawall location. It was considered reasonable to assume that the site conditions at the project site are similar to the geology of other nearby locations, which may have been investigated to some extent, that are within close proximity and possess similar geographic characteristics.

The project area is within the central part of the Puget Lowland. Geological history for the area was detailed as part of a 1988 Corps project at Lincoln Park ("Section 103 Lincoln Park Report" Pg. D-4) which is approximately 2.5 miles to the south along the coastline. The underlying geology is described as unconsolidated Pleistocene deposits covering a large part of the land surface within the lowland. The Vashon drift, deposited by the last glacial advance, includes carved silt and clay, extensive till, and associated outwash consisting of sand, gravel, and clay. The Vashon till is a compact, concrete like mixture of silt, sand, gravel, and clay as much as 150 feet thick but generally less than 50 feet thick. The till mantles most of the elongate hills which characterize the basin. Sea cliff development along the periphery of Puget Sound frequently exposes glacial deposits of various types, precipitating landslides in many areas.

The marine nearshore area is generally composed of marine deposits.

In 2003, Corps staff performed some preliminary boring investigations along the seawall alignment and visually identified the encountered materials to a depth of 40 to 50 feet. This information, combined with historical geotechnical data obtained by others and within close proximity to the study area alignment was compiled and used to estimate the foundation conditions. Based on this data, it is assumed that the wall is founded on predominantly stiff clayey silt with some interbedded sand layers. Boring data from all information sources support this assumption and include material descriptions to a maximum depth of 50 feet below ground surface. The material description included in the obtained boring data is also consistent with the characteristics of the Vashon drift deposits described earlier.

Refer to Appendix C for additional geotechnical information and boring logs.

5.4. Hazardous, Toxic, and Radiological Waste

A limited Phase I database search for hazardous, toxic, and radiological waste (HTRW) was conducted during the feasibility phase to identify any known pollutants or contaminants. Source data from the U.S. Environmental Protection Agency and the WDOE were searched and records do not indicate potential HTRW concerns in the project area. Additional analysis and research will be conducted as the design phase progresses, as required.

Refer to Appendix D for additional information, sources, and findings.

5.5. Future Without Project Conditions

The City of Seattle has observed storm impacts and erosion in the project area, most notably in 1998, as well as continual degradation of the existing structure over time, despite routine annual maintenance. After rebuilding the northern portion of the wall and placing riprap in 1998, the City has continued to replace voids in and around the existing seawall on at least seven occasions, including three times since 2011. The work typically includes filling voids behind and below the existing structure that have formed due to erosion resulting from storm events.

The existing structure has far exceeded its expected design life, and routine operations and maintenance (O&M) such as filling eroded sediments behind the wall will not be able to keep pace with continued corrosion of primary structural components. Based on coastal engineering analyses and estimates of future sea level change scenarios (USACE 2011b), the future without project condition scenario finds that coastal storm frequency and intensity increases throughout the period of analysis and subsequently results in a 50 percent probability of failure of the existing seawall in approximately 10 years with subsequent damage or loss of existing utilities and infrastructure. The failure mode is tied to the corrosion of tiebacks that anchor the wall (refer to Section 5.1). Failure would mostly likely be localized as opposed to wholesale wall collapse. Localized failure could lead to localized failure of the sewer force main; even localized failure of the 60+ year-old force main would impact thousands of users and contaminate Puget Sound.

If the seawall is allowed to fail the City of Seattle would place rip rap to stabilize the bank (emergency repairs), but that would only be temporary while a more permanent solution is formulated and put into place. The costs for both placement and removal of the temporary solution would make costs higher in the without project condition versus the with-project condition. It is assumed that the temporary solution would be required to be removed because Shoreline Management Act guidelines adopted in 2003 incorporate no net loss of shoreline ecological functions (WAC 173-26-186(8)) and the site has been designated as critical habitat for Chinook and bull trout since the 1998 emergency repair.

6. ALTERNATIVES ANALYSIS

6.1. Preliminary Alternatives

The City and the Corps developed and screened multiple alternatives, including the No Action alternative, as required under the National Environmental Protection Act (NEPA), as well as both structural and non-structural solutions to prevent future coastal storm damages and erosion. Additionally as per EC 1165-2-212 each alternative must consider the effect of future sea level change. Alternatives developed and screened by the Project Delivery Team (PDT) as potential solutions to coastal storm damages and future erosion are provided below followed by a brief description of each:

Alternative 1. No Action: The No Action alternative assumes that the Corps does not participate in developing solutions to reduce future storm damages. The existing seawall would remain and the infrastructure behind the seawall would continue to be vulnerable to coastal storm damage. The results of the No Action alternative reflect the future without project conditions of the project area if no action was taken by the Corps.

Alternative 2. Non-Structural Cobble Revetment: This alternative includes the placement of small cobbles in front of the existing infrastructure extending toward the water to create a sloped cobble beach (dynamic revetment) to absorb wave energy. Due to wave action this alternative would experience material transport and therefore would require periodic cobble replenishment in order to maintain the desired level of protection from coastal storms. This alternative has the largest waterward footprint, due to the need to fill from the beach to the top of the existing wall and create a gentle waterward slope of rounded rock. A conservative estimate using a 2 horizontal to 1 vertical slope would result in a footprint approximately 40 feet waterward of the existing structure.

Alternative 3. Sheet Pile Wall: This alternative consists of a new sheet pile retaining wall placed either immediately in front of or immediately behind the existing seawall. The new sheet piles would be driven to appropriate depths to provide protection from coastal storms. The sheet pile wall would tie into the ground using tiebacks, soil anchors, or other forms of support to stabilize the new seawall. Toe protection would be placed at the base of the sheet pile wall to prevent scour and undermining of the wall. The existing seawall could remain in place or be removed depending on the alignment of the final alternative.

Alternative 4. Soldier Pile Wall: This alternative consists of a soldier pile wall with concrete lagging spanning the length of the project using concrete-encased steel beams to support soldier piles spaced at several foot intervals. Small concrete lagging panels would be installed in front of the soldier piles and would be designed to withstand coastal storm events. Toe protection would be placed at the base of the soldier pile wall to prevent scour and undermining of the wall.

Alternative 5. Beach Armor / Beach Fill: This alternative consists of placing large beach armor / beach fill in front of the existing structure to provide protection from storm damages and erosion. Large armor rock would be placed from the face of the existing structure towards the water and would be sloped appropriately. This alternative is similar to the emergency repair action taken immediately to the north of the project area by the City in 1998.

Alternative 6. Retaining Wall: This alternative includes installing a concrete retaining wall reinforced with steel rebar designed to hold back soil behind the wall and withstand storm damages. The retaining wall would be supported by a large concrete footing to prevent wave overtopping of the structure and would widen the footprint of the structure when compared against other alternatives, such as the sheet pile wall and soldier pile wall. Toe protection would be placed at the base of the retaining wall to prevent scour and undermining of the wall.

6.2. Screening Criteria for Alternatives

Under Section 103, the Program Management Plan for the Continuing Authorities Program (CAP) developed by the U.S. Army Corps of Engineers' Northwestern Division provides for a formulation and evaluation of potential solutions based on the least-cost alternative (USACE 2012). Additionally, "the least cost alternative plan is considered to be justified if the total costs of the tentatively selected plan are less than the costs to relocate the threatened facilities." To reduce the number of alternatives being considered, alternatives previously discussed in this section were evaluated qualitatively by the PDT based on the following considerations:

1. Effectiveness: Evaluation of the magnitude of the benefits in addressing the specified coastal storm damage problem and opportunities.
2. Efficiency: Evaluation of the cost-effectiveness in addressing coastal storm damage problems and opportunities, including constructability, emergency repairs, and operations and maintenance.
3. Completeness: The plan must provide and account for all necessary investments needed to ensure the realization of the planned benefits: environmental risks, real estate acquisition, O&M costs, and sponsorship should be considered.
4. Acceptability: Evaluation of whether the recommended plan is acceptable to the non-federal cost-sharing partner, to state and federal resource agencies, local governments, and the general public.
5. Risk-Based Analysis: Evaluation of potential risks associated with implementation of coastal storm damage management alternatives.
    - Environmental risk / potential impacts, including intrusion and effects on habitat: Assesses the temporary and permanent environmental impacts related to implementation of the plan.
    - Required amount of fill material and rock: Assesses the environmental acceptability of the amount of fill material placed in the marine nearshore environment to reduce potential impacts to habitat.
    - Constructability / duration: Assesses constructability based on known existing conditions and the estimated construction period.

6.3. Results of Alternatives Screening

Qualitatively, the PDT and City of Seattle screened alternatives based on the above criteria. A rating scale of (-2) to (2) was used to score each alternative. An overall risk-based category was included to further screen alternatives based on assumed risk. The lowest risk, acceptable alternatives would be the ones carried forward for further evaluation and consideration in the study. In this evaluation, the No Action alternative is assumed to be the future without project condition. In the case of future without project conditions, it is expected that during the period of analysis the existing seawall structure would likely fail as a result of continued degradation related to storm events, storm surges, and storm-induced erosion and due to corrosion of the existing steel supports. A failure would prompt emergency actions to stabilize the bank and prevent damages to utilities, roadways, and erosion of public lands. This assumption is validated by the failure that occurred in 1998 as a result of a series of three small coastal storm events (3-5 year return period).

The No Action alternative was scored based on existing information and assumptions made in respect to the likelihood of storm events, storm surges, and storm-induced erosion. Each of the remaining alternatives was then scored based on comparison to the No Action alternative. In the case of a negative score, it was assumed that the condition would worsen based on the existing and future conditions (No Action alternative) and a positive score was indicative of an improvement over the existing and future conditions. The results of the screening process are provided in Appendix E and summarized below in Table 1.

Table 1. Alternative Screening Scores

Metrics Scale:

-2
-1
0 No change
1
2

	Effectiveness		Efficiency				Acceptability			Completeness	
Alternative	Maintains Intended Level of Protection for Utilities	Meets Planning Objectives and Considers Constraints	Quantity of Fill/Material Required	Overall Constructability / Duration	Assumed Construction / Emergency Repair Costs Based on Quantities / Complexity	Minimizes Operation and Maintenance Requirements	Stakeholder Acceptability	Minimizes Waterward Intrusion	Potential Environmental Impacts During Construction	Overall Completeness / External Risks (Weighted to Match Other Criteria)	**TOTAL**
Alt 1. No Action	-2	-2	-2	-2	-1	-2	-2	-2	-2	-6	**-23**
Alt 2. Non-Structural Cobble Revetment	1	1	-1	-1	1	-1	0	1	1	3	**5**
Alt 3. Sheet Pile Retaining Wall	2	2	1	0	1	2	1	-1	1	6	**15**
Alt 4. Soldier Pile Wall	2	2	1	1	2	2	1	-1	1	6	**17**
Alt 5. Beach Armor / Beach Fill	2	-1	-2	-1	2	1	-1	-2	0	6	**4**
Alt 6. Retaining Wall	2	2	1	0	2	2	1	-2	1	6	**15**

Table 1 Continued. Alternative Screening Scores

Alternative	Effectiveness	Efficiency	Acceptability	Completeness	**Final Score**	**Overall Assumed Risk Level**	Correlation to Objectives / Constraints: Reduces Risk of Physical Damages	Reduces Risk of Loss of Public Lands	Reduces Risk of Environmental Impacts	Reduces Risk of Transportation Delays	Observes Constraints
Alt 1. No Action	-4	-7	-6	-6	**-23**	**High**	--	--	--	--	-
Alt 2. Non-Structural Cobble Revetment	2	-2	**2**	3	**5**	**Low**	+	+	+	+	-
Alt 3. Sheet Pile Retaining Wall	**4**	4	**1**	**6**	**15**	**High**	++	++	++	++	+
Alt 4. Soldier Pile Wall	**4**	**6**	**1**	**6**	**17**	**Low**	++	++	++	++	+
Alt 5. Beach Armor / Beach Fill	1	0	-3	**6**	**4**	**High**	+	+	+	+	-
Alt 6. Retaining Wall	4	**5**	0	**6**	**15**	**Low**	++	++	++	++	+

6.4. Summary of Screening Results

Alternative 1. No Action: This alternative received a negative score as it did not meet the planning objectives and is unacceptable to the project sponsor. This alternative does not adequately address the risk of damages to utility and roadway infrastructure and potential erosion of public land.

The No Action alternative scored poorly in every evaluation criteria category due to the high risk of future storm damages. Given the strong dependence of water level on hydraulic forcing, this project is relatively sensitive to changes in mean sea level. Thus potential future sea level rise presents a significant risk to the no action alternative. It was assumed that annual O&M costs would increase as the site continued to degrade and an eventual failure of the existing structure would prompt emergency repairs to prevent further damage. The high risk for future damages and failure also presented an assumed high risk for potential environmental impacts related to a sewer main failure leading to a large-volume sewage release into Puget Sound. This alternative does not meet the project goal.

This alternative was not carried forward as a viable solution; however, NEPA requires that the no action alternative be evaluated in the environmental impact analysis of the project. The remaining alternatives were considered to be both complete and effective but varied in acceptability and efficiency.

Alternative 2. Cobble Revetment: This alternative received a positive score and meets several of the planning objectives.

The revetment was rated slightly lower than the structural alternatives in the effectiveness category due to potential cobble erosion from coastal storm events and surges. Additionally, routine renourishment would increase O&M requirements. This would extend the overall project duration resulting in increased costs and would require a long-term commitment to continual replenishment. The alternative was assumed to have the largest footprint requiring the placement of a large amount of fill into the nearshore environment. Due to the presence of eelgrass beds and other important aquatic habitat in this area, placement of this fill could have a large impact on aquatic habitat function and continued replenishment would require future periodic disturbance of the area. To mitigate for those environmental impacts would be costly. This alternative was, therefore, viewed as a high risk project versus other alternatives.

Because of the continual O&M expected with periodic beach nourishment and the significantly increased project footprint, this alternative was not acceptable and therefore was not carried forward.

Alternative 3. Sheet Pile Wall: This alternative received the second highest score and meets several of the planning objectives. Alternatives 3, 4, and 6, scored the highest in the screening process. These alternatives scored well in minimizing the overall footprint when compared to more intrusive alternatives such as riprap or a cobble revetment, thereby reducing environmental impacts and fill quantities. Additionally, because of the design of the project, annual O&M

requirements were assumed to be minimal. The sheet pile wall alternative, however, was viewed as a high risk because of the construction technique. Sheet piles would be driven in close proximity to the existing sewer main and the resulting vibration from pile driving could result in settlement or liquefaction of the soils, potentially damaging the sewer. Additionally, the noise associated with driving sheet piles would be a concern for nearby homeowners and fish and wildlife. Lateral support would also be required for the sheet pile alternative resulting in additional excavation and placement of tiebacks or soil anchors, adding to complexity and risk for damage to the sewer during construction. This alternative, though receiving the same relative score as others, had a lower constructability score based on a higher complexity and a higher risk to the sewer main and therefore was not carried forward for further evaluation.

Alternative 4. Soldier Pile Wall: Alternatives 4 was one of the highest scoring alternatives and was viewed as one of the lowest lower risk alternatives to implement compared to others because of the relative ease of complexity associated with construction. Additionally, the environmental impact associated with its footprint was smaller compared to other alternatives. Further, the reduced fill quantities needed during construction were assumed to minimize assumed costs and construction durations. Compared to previous alternatives, soldier piles would be installed using a different technique, such as drilling, and would minimize vibrations associations with installation. Relative to all alternatives, this alternative is estimated to have a minimum waterward intrusion based on the estimated footprint and associated construction impacts. In order to achieve no net loss of shoreline ecological functions, a best management practice (BMP) would be implemented to reclaim adjacent lost beach habitat by removing a portion of the riprap placed to the north in the 1998 emergency repair. Finally, Alternatives 4 uses common construction techniques used in coastal shoreline protection. As a result, this alternative was considered one of the most complete, effective, efficient, and acceptable alternatives and was carried forward for further consideration.

Alternative 5. Beach Armor / Beach Fill: This alternative received an overall positive score and meets some of the planning objectives. Alternative 5 rated negatively in acceptability to the sponsor and Resource Agencies, who, in an April 2013 site visit, stressed the importance of reducing fill into the nearshore area and indicated that any project similar to the 1998 emergency repair (riprap placement) would not be acceptable. Beach armor could result in a footprint increase of nearly 40 feet waterward (for a total loss of 0.4 acres of beach) and would require almost 7,000 cubic yards of material. It was assumed that extensive off-site mitigation would be required as this alternative would create a significant heavily armored structure in valuable nearshore habitat that would be unacceptable to Resource Agencies. Therefore, this alternative was not carried forward for further evaluation.

Alternative 6. Retaining Wall: Alternative 6 was also viewed as a lower risk alternative because of the relatively low environmental impact associated with a smaller footprint compared to more intrusive alternatives and the reduced fill quantities needed during construction. As in Alternative 4, the riprap removal BMP would be implemented to reclaim adjacent lost beach habitat by removing a portion of the riprap placed to the north in the 1998 emergency repair.

Additionally, Alternatives 4 and 6 are less complex in design and construction methodology and will utilize standard construction techniques. As a result, these alternatives were considered the most complete, effective, efficient, and acceptable alternatives and were carried forward for further consideration.

6.5. Final Array of Alternatives

A summary of the plans to be carried forward for further consideration is below in Table 2:

Table 2. Alternative Results

Alternative	Results
Alternative 1. No Action	Not Carried Forward
Alternative 2. Non-Structural Cobble Revetment	Not Carried Forward
Alternative 3. Sheet Pile Retaining Wall	Not Carried Forward
Alternative 4. Soldier Pile Wall	Carried Forward
Alternative 5. Beach Armor / Beach Fill	Not Carried Forward
Alternative 6. Retaining Wall	Carried Forward

Based on screening jointly conducted by the City and Corps PDT, Alternatives 4 and 6 were recommended to be carried forward for further consideration in the study because they were the highest scoring alternatives with the assumed relative lowest risk factors. While Alternative 4 scored higher than the remaining alternatives, this alternative was screened further based on constructability analysis. The location of King County's sewer main was expected to have major influence over the constructability of any alternative based on its proximity to the seawall and potential alignments of a new structure. The sewer main runs parallel to the shoreline throughout the project area and City records indicate that the western-most edge of the sewer main is at its closest location approximately 2 to 5 feet away from the back face of the existing seawall.

In comparing the final array of alternatives, while costs were not explicitly determined for each alternative, relative cost factors were used to identify the recommended plan and the National Economic Development (NED) Plan. Both alternatives evaluated further are assumed to provide the same overall net benefits to the at-risk infrastructure because they equally reduce the risk of damages to the sewer main and associated infrastructure and both maintain the intended level of storm protection. Therefore, the alternative that minimizes construction costs to the extent reasonable is assumed to be the NED plan and recommended as the preferred alternative. Both alternatives are assumed to be constructed in front of the existing structure to minimize excavation costs and risk factors during construction. Further, in evaluating the final array of alternatives, the team also considered environmental factors when comparing the alternatives to ensure that the selected plan would also be environmentally acceptable. As a result, the NED plan will consider engineering factors, relative cost factors, and environmental factors to ensure that any alternative chosen will be a successful project.

Beginning with Alterative 6, a retaining wall similar to the existing structure, this alternative would require a significant footing to prevent overtopping. Using the design of the current retaining wall as a basis, the new footing would extend a minimum of 6 feet waterward from the face of the existing structure, resulting in the permanent loss of 0.06 acres (2,700 square feet) of nearshore beach area. Construction would require excavation in front of the existing structure several feet down to install a new toe footing as well as the installation of temporary shoring of the existing structure to prevent failure during construction. While the width of the footing is much larger compared to a sheet pile or soldier pile wall, it is relatively small compared to other rock-based alternatives, such as riprap.

The assumed footprint of the toe under Alternative 6 was a minimum of 3 times the footprint of Alternative 4. In order to achieve no net loss of shoreline ecological functions, the riprap removal BMP would be implemented to reclaim adjacent lost beach habitat by removing a portion of the riprap placed to the north in the 1998 emergency repair. The square foot (SF) cost to implement the riprap removal BMP determined under Alternative 4 is estimated to be $97.00/SF for approximately 900 SF. This is based on a 2 ft wide footprint for the new structure at a length of 450 linear square feet. The existing retaining wall toe built in 1929 also incorporates tiebacks that extend 12+ feet into the bank but does not include scour protection or an adequately buried toe. Therefore, it is likely that this design would not meet current standards and would further increase the footprint, thereby increasing construction and riprap removal BMP costs. When the cost per square foot of riprap removal BMP for Alternative 4 is applied to the minimum footprint under Alternative 6 (at the same footprint as the existing toe, or a 6 foot wide base) the estimated costs add an additional 1,800 SF or an additional $175,000 to the total project costs. This minimum additional BMP cost would equate to as much as 15% of the total project cost of Alternative 4. The additional BMP costs associated with this larger footprint could increase if further structural analysis determined the base toe requirement to be larger than 6 feet.

Alternatively, in order to minimize the footprint impacts associated with Alternative 6, the existing structure could be excavated and removed. While this method could be applied to any alternative to minimize the BMP requirement, it would require significant excavation and removal of the existing structure. Further, the amount of risk to the sewer main associated with removing the existing structure would significantly increase costs due to the need to construct a temporary shoring structure between the sewer and excavation area. It is unlikely that construction in place of the existing structure would be a cost effective or safe alternative under any construction technique and was therefore not considered in the evaluation.

Alternative 4, the soldier pile wall, scored the highest in the alternative screening process. This alternative is generally easier to construct because of the use of drilled shafts to help reduce vibratory impacts and eliminating the need for additional stabilization during construction that may be required for a sheet pile wall or for excavation for a retaining wall. Further, it would be less intrusive into the Puget Sound nearshore than Alternative 6 (0.02 acres of impact vs. 0.06) if constructed immediately in front of the existing seawall. With the new seawall constructed immediately in front of the existing structure, the old seawall could be left in place and buried further reducing construction costs.

Under both alternatives construction materials are assumed to be readily available. The materials themselves are not viewed as major cost factors compared excavation requirements, and overall complexity of implementation. Operations and maintenance is assumed to be minimal under each of these alternatives.

Based on the above discussion and the relative cost factor evaluation, the NED plan is Alternative 4, a soldier pile wall. This alternative is supported by the City of Seattle and has been identified as the tentatively selected plan.

7. RECOMMENDED PLAN

Alternative 4 is the National Economic Development (NED) plan and the tentatively selected plan. Alternative 4 is the NED plan because it provides the greatest net benefits. In consideration of the effects analysis presented in chapter 8, Alternative 4 is also the recommended plan.

The recommended plan consists of a new soldier pile wall with precast concrete lagging constructed immediately in front of the existing seawall structure to a height of +22 feet MLLW; the height is two feet higher than the existing structure to account for storm wave heights and future sea-level rise (Figures 8 and 9). Columns Shafts, 24 inches in diameter, will be augured 6 foot on center to a depth of 22 feet below the existing ground upon into which steel H piles will be inserted and filled with concrete. Precast concrete face panels will then be placed vertically between columns to create the wall panels and placed to a depth below the scour level to minimize scour risks associated with long term storm events. The columns will include corrosion protection due to the potential impacts of the tidal cycle and salt water. Due to the uncertainty associated with future sea level rise scenarios, an adaptive design will be considered to allow future retrofits or modifications to the structure should worse than expected sea level change occur.

Storm waves coincident with extreme water levels can reflect off the wall and develop a standing wave pattern in front of the wall which is conducive to scour. As a result, scour at the base of the new structure is likely to occur and toe protection is required to mitigate this risk. Further, USACE Engineering Manual (EM) 1110-2-110 recommends the use of toe protection to ensure seawalls are not undermined. Therefore, a buried toe will be constructed on the seaward side of the seawall to ensure the seawall is not undermined from scour caused by standing waves. The feature also provides additional lateral support to resist earth pressures pushing the wall seaward. In order to minimize impacts, three feet of toe berm armor stone over one foot of filter rock will be buried below grade (Figure 10). The two layer filter and armor rock toe will be embedded below the existing grade and buried with a 1-12" gravel/cobble beach fill. The gravel/cobble layer will have a 5-foot top width and a 3H:1V slope, for a total width of approximately 14 feet.

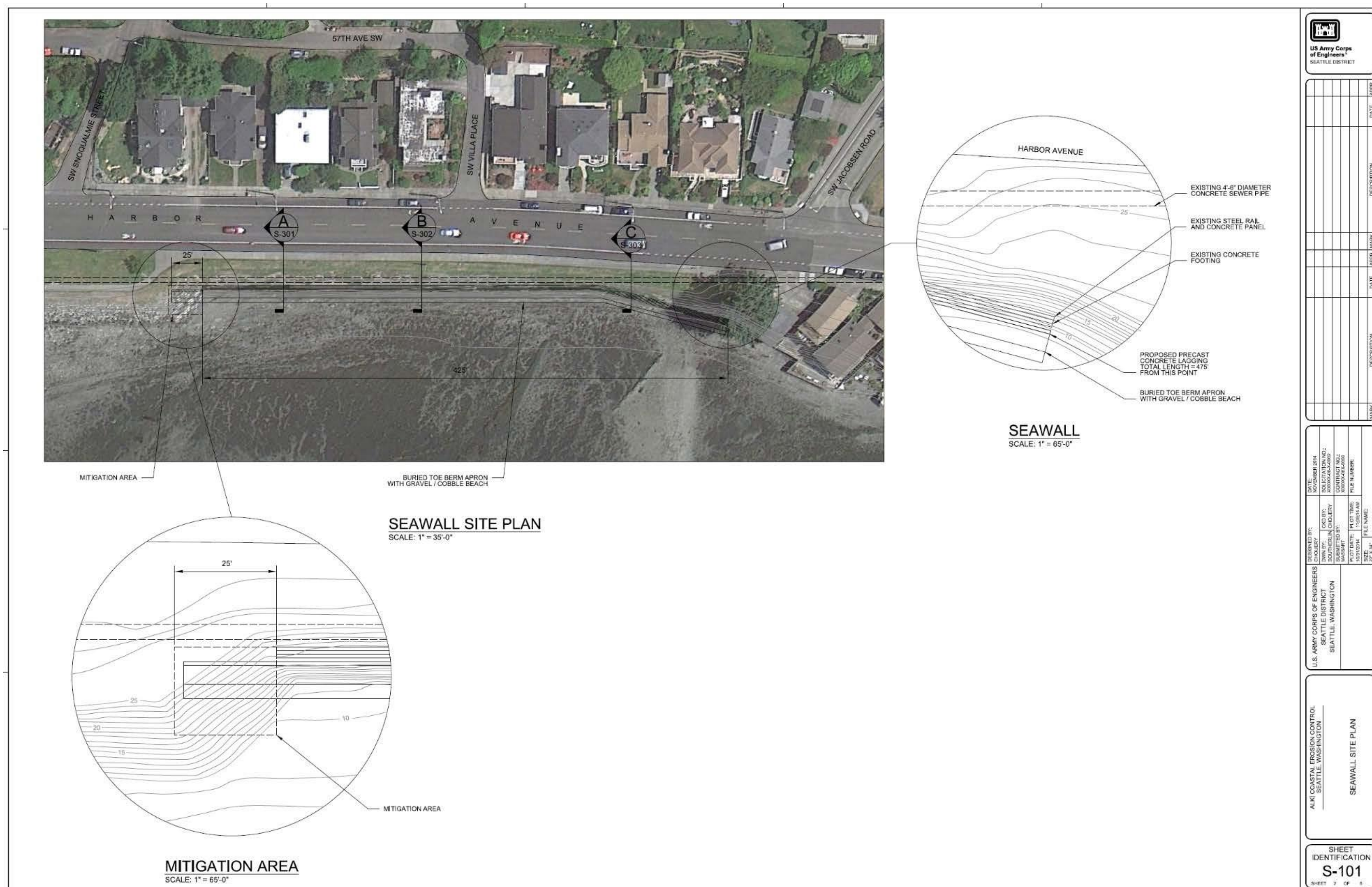

Figure 8. Site Plan

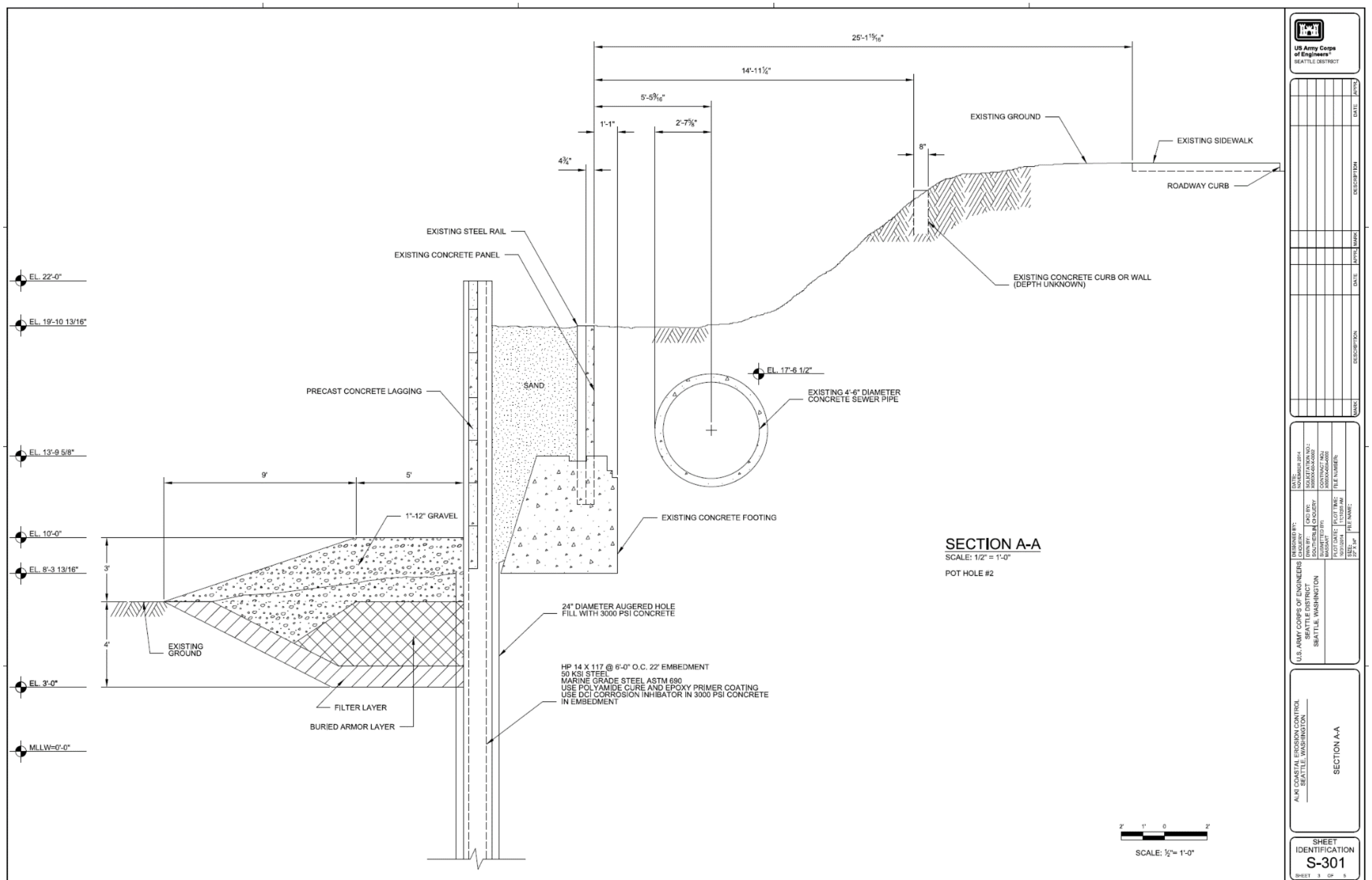

Figure 9. Section View of Soldier Pile Wall.

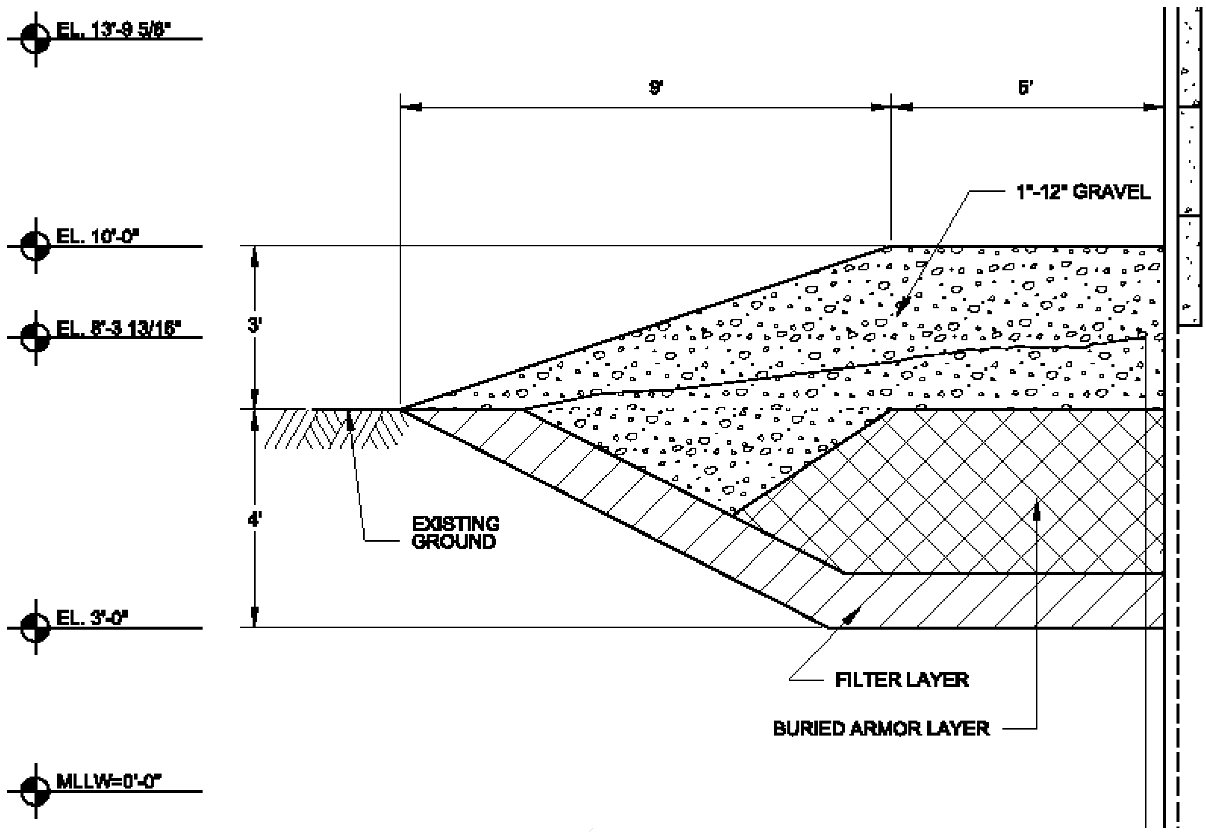

Figure 10. Scour Protection Toe

The total length of the new seawall is approximately 500 feet. The new seawall will tie into the riprap placed by the City in 1998 on the north end and an existing private seawall on the south end. The north end tie-in will entail pulling back some of the riprap and tapering the wall height down into the riprapped area, and then reworking the riprap in front of the tapered section. The south end tie-in will entail overlapping the new wall seaward of the neighboring wall, and joining the two with anchor bolts. The tie-in will be designed to ensure that most of the force applied to the joint will be borne by the new wall.

The existing seawall will be left in place and buried with backfill material to provide a stable and safe slope up to the existing sidewalk grade.

To offset the permanent loss of 0.02 acres of beach habitat required by the new seawall, a best management practice (BMP) will be implemented to reclaim adjacent lost beach habitat by removing a portion of the riprap placed to the north in the 1998 emergency repair. This will entail lengthening the amount of seawall installed in order to stabilize the shoreline back to or near its pre-1998 alignment and remove the waterward riprap and fill materials. The proposed ratio will be a 1:1 replacement as this habitat reclaims the lost habitat imposed by the new seawall and could begin to function immediately post-construction.

Refer to Appendix F for the preliminary site plan and typical cross-sections.

7.1. Preliminary Cost Estimate

A planning level cost estimate for the proposed plan was developed by the Corps' Cost Engineering Section using Micro-Computer Aided Cost Estimating System, 2nd generation (MCACES II). The cost estimate was developed using RSMeans Cost Data, MII Cost Data, user created crews and production rates with documentation to their basis, vendor quotes where applicable and quantity takeoffs wherever it's available. Assumptions were provided by the PDT based on known conditions and will be updated as design and analysis progress. The cost estimator assumed most of the work would be done by a sub-contractor so there are 2 levels of markups on the costs. The Planning, Engineering, and Design (PED) amount in the Total Project Cost Summary document (TPCS) was developed using input from the Project Manager and associated percentages applied to the overall project costs. An abbreviated cost risk analysis was performed by the PDT to determine a contingency value of 25% during the planning process to account for risk and uncertainty with the current design and known conditions.

Refer to Appendix G for a summary overview of the cost estimate and inputs.

7.2. Economic Analysis

7.2.1. Economic Profile of Study Area

The major population surrounding the project location, assumed to be the majority user of the study area, is the population of West Seattle. As such, most of the socioeconomic data is developed using demographic information for the residents of the Seattle, King County Metropolis. The resident population of King County is approximately 1.93 million with 1.5 million of those being 18 and over (Bureau 2013). The total number of businesses in King County is approximately 63,000 with the highest percent of industries being in scientific and technical services (15.3%), followed by health care (10.9%), retail trade (10.5%), and accommodation and food services (9%). The median income from 2007 through 2011 was approximately $70,600 with an estimated 2.4 persons per household. The unemployment rate in December of 2012 was approximately 6.1%; this is down by 1% from a year earlier (Washington 2013).

7.2.2. Tentatively Selected Plan Benefits

Economic benefits of the tentatively selected plan were based on the probability of damage to and failure of the existing seawall and the subsequent damages to associated facilities at the project site. Damages were separated into physical and non-physical categories. Physical categories include structural damages to buildings, streets, highways, railways, sewers, bridges, utility lines, bulkheads, seawalls, boardwalks, and other infrastructure (IWR 1991). Non-physical damages include categories such as income loss, emergency costs, temporary evacuation, temporary relocation, and transportation delays. Although many of these damages are expected to occur with the loss of the existing seawall, they were not all expected to be sufficient enough to warrant a full investigation, thus not all categories were taken as a benefit category in the investigation but may be qualified in the Economic Appendix H.

If the aforementioned physical and non-physical damages could be prevented, reduced, or otherwise avoided in the with-project versus the with-out project condition then they can be taken as a benefit of implementing the project.

7.2.3. Damages Prevented

The economic analysis was based on quantifying the physical damages to public infrastructure and non-physical damages, mostly transportation delays, which could occur as a result of coastal storm events and erosion within the project area that would cause a failure. For purposes of the analysis, the project year one, the first year a project could be in operation, was assumed to be 2015. The economic analysis is based on an economic project life of 50 years and with an interest rate of 3.375%. The existing seawall, in its current degraded state, provides a reduced level of protection to the public infrastructure than originally intended. The difference between damages in the with-project versus the with-out project condition was taken as benefits as these are considered to be damage reductions that are directly attributed to the project.

There are multiple single family residences that sit directly behind the seawall that would be affected by a failure of the existing seawall. In addition, if the seawall were to fail the road, sewer, and lands adjacent to the project would need to be repaired or replaced. Along with these physical damages, costs associated with transportation delays, emergency response, and emergency spill response and cleanup would be expected. Table 3 below provides a summary of the potential damage and the corresponding costs that could occur. Refer to Appendix H for details on the full economic analysis.

Table 3. Economic Analysis

Reduction in Physical Damages (1,000's) (FY15)	
Damage Category	Net Present Value
Roadway and Sewer	$1,686
Lost Lands (Boardwalk & Park)	$50
Reduction in Non-Physical Damages (1,000's)	
Transportation Delays	$925
Emergency Stabilization	$540
Sewage Spill Response	$120
Operations and Maintenance	$4
Total Investment Cost	$2,359
TOTAL	$5,675

Without implementation of the project, the expected annual damages (EAD) quantified is expected to be approximately $174,000. With implementation, the EAD is assumed to have been limited to no damages. Therefore the approximate EAD of at least $174,000 are considered as preventable with the project. Table 4 shows the with- and with-out EAD and the resulting expected annual damages reduced (benefits) based on the sample of infrastructure and damages. Damages beyond the 50-year recurrence interval were not estimated during the planning phase.

Table 4. Annual Project Benefits

Estimated Annual Project Benefits	
Without-Project EAD	$ 174,000.00
With-Project EAD	$ -
EAD Reduced (Annual Benefits)	**$ 174,000.00**

The total estimated project cost is approximately $2.29 million and the total economic cost used to derive the benefit to cost ratio is approximately $2.36 million. The economic cost includes interest during construction, operation and maintenance, and the value of LERRD. The estimates of these costs are annualized at the fiscal year 2015 (FY15) discount rate of 3.375% over the 50-year period of analysis at the FY14 price level. The total project costs, annualized costs, and resulting benefit to cost ratio is displayed in Table 5 below.

Table 5. Annualized Cost and Benefit-Cost Ratio

Annualized Cost and Benefit-Cost Ratio	
Total Project Costs	$ 2,289,000
Interest During Construction	$ 16,000
LERRD	$ 50,000
Total Investment Cost	$ 2,355,000
Annual Cost	
Project and Interest (50 yrs @ 3.375%)	$ 98,000
Operation and Maintenance	$ 2,000
Total Annual Cost	$ 100,000
Total Annual Benefit (EAD Reduced)	$ 174,000
Benefit-Cost Ratio	**1.74**

7.3. Operations, Maintenance, Repair, Rehabilitation, and Replacement

Expected Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs are considered to be minimal and are a 100 percent non-federal sponsor requirement. Required action could include annual inspections and replacement of soil voids on the slope landward of the project. Additionally, if changes in sea levels are accelerating quicker than intermediate risk estimates, there would be increased OMRR&R costs to the City during the period of analysis to account for modifications to the structure to ensure that the same level of storm protection is provided for the infrastructure at risk. Retrofit costs, relative to the total implementation costs, would likely be small and would be the burden of the City. Annualizing an estimated future retrofit cost over the period of performance is not expected to have a significant impact on the benefit to cost ratio and would not change the NED plan. Annual OMRR&R costs are expected to include regular inspections of the structures and labor and materials for City of Seattle crews and are estimated to be $2,000 (with project) annually over the period of analysis. The City has demonstrated capability and willingness to operate and maintain the project after construction and will be provided an O&M manual.

7.4. Real Estate Considerations

A preliminary analysis of the real property interest was conducted by the Corps' Real Estate Division (also refer to Appendix I – Real Estate Plan). The City of Seattle owns all in fee lands within the project area (0.5 acres), including the land in the immediate nearshore zone and the roadway right-of-way. City park lands or other City property is expected to be available for staging and temporary access and these sites will be identified during design. The preliminary work area analysis estimated an approximate value per square foot of park land based on the assessed tax value and that value was extrapolated to estimate the total land value for the project area. A conservative initial estimate places the City's LERRD at approximately $50,000. This value is reflected within the cost estimate developed for the planning phase. A more detailed evaluation will be completed during final design to include a real estate map, certification of real property interest, Government approved appraisal, and all rights-of-entries. Land acquisition will not be needed for this project.

7.5. Monitoring

The City of Seattle will assume operation and maintenance of the project after construction and will conduct regular inspections to ensure continued operability and safety of the structure at 100% cost to them. An Operations and Maintenance (O&M) manual will be developed during the design phase that will outline the frequency of inspection and how to operate and maintain the structure. It is expected that minimal monitoring and maintenance will be required throughout most of the intended design life of the structure. Additionally, the project will likely be included in the Seattle District's Inspection of Completed Works program and may be routinely inspected by District staff to ensure the O&M requirements are being met and the structure is being maintained.

8. AFFECTED ENVIRONMENT

8.1. Physical Characteristics and Aesthetics

The project site is located on City of Seattle Parks and Recreation lands in a park known as Emma Schmitz Memorial Overlook. Emma Schmitz Park is a linear park that is approximately 1,640 feet in length between Beach Drive and Puget Sound. The proposed project is located at the southern end of the park. The park is a grassy strip with a few trees at the top of the seawall with walking/biking paths and benches that provide recreational opportunities for local residents.

The northern section of the park also has stairs which allow visitors access to the cobble beach that runs at the toe of the seawall throughout the area. For a description of the existing seawall, see Section 4.2 Problems and Opportunities.

8.2. Soils

In the feasibility phase, geotechnical investigation resources were limited to a survey of existing data. Therefore, several assumptions were made in the determination of foundation materials at the seawall location. It was considered reasonable to assume that the site conditions at the project site are similar to the geology of other nearby locations, which may have been investigated to some extent, that are within close proximity and possess similar geographic characteristics.

The project area is within the central part of the Puget Lowland. Geological history for the area was detailed as part of a 1988 Corps project at Lincoln Park ("Section 103 Lincoln Park Report" Pg. D-4) which is approximately 2.5 miles to the south along the coastline. The underlying geology is described as unconsolidated Pleistocene deposits covering a large part of the land surface within the lowland. The Vashon drift, deposited by the last glacial advance, includes carved silt and clay, extensive till, and associated outwash consisting of sand, gravel, and clay. The Vashon till is a compact, concrete like mixture of silt, sand, gravel, and clay as much as 150 feet thick but generally less than 50 feet thick. The till mantles most of the elongate hills which characterize the basin. Sea cliff development along the periphery of Puget Sound frequently exposes glacial deposits of various types, precipitating landslides in many areas. The mariner nearshore area is generally composed of marine deposits.

In 2003, Corps staff performed preliminary boring investigations in the vicinity of the project and visually identified the encountered materials to a depth of 40 to 50 feet. This information, combined with historical geotechnical data obtained by others and within close proximity to the study area alignment was compiled and used to estimate the foundation conditions. Based on this data, it is assumed that the wall is founded on predominantly stiff clayey silt with some interbedded sand layers. Boring data from all information sources support this assumption and include material descriptions to a maximum depth of 50 feet below ground surface. The material description included in the obtained boring data is also consistent with the characteristics of the Vashon drift deposits described earlier. Refer to Appendix C for additional geotechnical information and boring logs.

8.3. Water Quality

The Puget Sound Basin contains surface- and ground-water resources of significant economic and ecological significance (USGS 1994). These provide water for a large population, recreational opportunities for residents and visitors, and an ecosystem that supports an economically important fishery. Water quality issues identified for surface waters in the Puget Sound Basin include: the degradation of aquatic habitat through destruction of riparian habitat, sediment deposition and channel scour; bacterial contamination and nutrient enrichment from sewage treatment plant discharges, failed septic systems, and agricultural runoff; and contamination by point discharges and storm runoff of metals, pesticides, and petroleum products (USGS 1994).

Index scores of marine water condition have generally declined over the past ten years, indicating an overall decrease in water quality (Puget Sound Partnership 2012). The largest driver of the decline has been the increase in nitrate levels caused by human inputs to the system. Increased nitrate levels can fuel algal blooms, leading to low dissolved oxygen. The 2012 WDOE water quality assessment indicates that marine waters in the project area are not on the 303(d) list of impaired waterbodies (WDOE 2012). Marine waters approximately 1/2 mile to the north and 1/3 mile to the south of the project area are classified as Category 5 for bacteria (WDOE 2012).

8.4. Air Quality and Noise

The Clean Air Act requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment (EPA 2012). States are required to develop a plan for any areas that cannot meet these standards, called nonattainment areas, to improve air quality. After a nonattainment area begins to consistently meet the air quality standards, it is called a maintenance area. The project area is within a maintenance area for ozone and carbon monoxide pollution (Ecology 2013). Ozone is a component of smog that is not emitted into the air but is instead formed when nitrogen oxides (NOx) and volatile organic compounds (VOCs) react with one another in the presences of sunlight. Emissions from industrial facilities, electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOCs. Carbon monoxide is an odorless, tasteless, colorless gas which is emitted primarily from any form of combustion. Emissions from motor vehicles, wood stoves, open burning, and industrial facilities are all sources of carbon monoxide pollution.

West Seattle is characterized by a mix of single family residential, low and mid-rise buildings, neighborhood commercial zones, and urban parks. Across the street from the project area are two rows of single-family residences and a 20-acre forested city park. Typical noises consist of those generated by automobiles, trucks, and other internal combustion engines as well as from boats and ships navigating Puget Sound.

8.5. Submerged Aquatic Vegetation

Eelgrass (*Zostera marina*) beds are patchy throughout the project area and running along the shoreline from Alki Point to the north and past Lincoln Park to the south. The beds are just offshore and in shallow waters all along the Puget Sound shoreline of Seattle.

Bull kelp (*Nereocystis luetkana*) is absent from the shoreline directly adjacent to the project site, but has a patchy presence immediately to the north and south of the project. A large kelp bed occurs north of Lincoln Park which is located approximately 2 miles south of the project area. While the density of the bull kelp in this area has decreased precipitously since the mid-1980's, the distribution of the kelp does not appear to have substantially changed over the same time frame (Antrim and Thom 1995). In 1996, *Laminaria* kelp was observed in many places where bull kelp was observed in previous years (EPA 1996).

8.6. Fish

Cutthroat trout (*Oncorhynchus clarki clarki*) and Chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and pink salmon (*O. gorbuscha*) feed and rear in nearshore areas in the vicinity of the project area. Juvenile salmonids feed on epibenthic invertebrates in the intertidal zone. Adult salmonids migrate along the shoreline during the late summer to early winter months. Fauntleroy Creek, about 2.8 miles south of the project area, supports a run of coho salmon that was re-introduced in 1991 as part of the Salmon in the Classroom program (Fauntleroy Watershed Council 2002). The Duwamish River, approximately 5 coastal miles from the project, supports runs of Chinook, chum, coho, pink, bull trout, and steelhead.

In addition to salmonids, marine fish such as a variety of surfperch (Embiotocidae), flatfish (Pleuronectiformes), gunnel (Pholididae), prickleback (Stichaeidae), and rockfish (*Sebastes* sp.) species occur along Puget Sound shorelines. Common species that likely utilize the project nearshore habitat include striped perch (*Embiotoca lateralis*), surf smelt (*Hypomesus pretiosus*), staghorn sculpin (*Leptocottus armatus*), English sole (*Parophrys vetulus*), copper rockfish (*Sebastes caurinus*), and cabezon (*Scorpaenichthys marmoratus*). The intertidal and shallow subtidal zones provide feeding and rearing habitat for young marine fish and offer feeding and spawning habitat for mature adult fish. As with salmonids, the benthic invertebrate resources in nearshore areas provide abundant prey for marine fish.

8.7. Birds

Shallow nearshore waters and intertidal sediments in the project area produce fish, vegetation, and invertebrate forage for a variety of waterfowl, gulls, shorebirds, and other marine birds. Bird species known to occur in the area include pigeon guillemot (*Cepphus columba*), black brant (*Branta bernicla nigricans*), common goldeneye (*Bucephala clangula*), harlequin duck (*Histrionicus histrionicus*), white-winged scoter (*Melanitta fusca*), marbled murrelet (*Brachyramphus marmoratus*), and rhinoceros auklet (*Cerorhinca monocerata*). With the exception of black brant (which prefer eelgrass and algae), these birds feed primarily on crustaceans, mollusks, and small fish.

Birds that frequent the Seattle portion of the Puget Sound shoreline must adapt to a moderately high level of disturbance. In the vicinity of the project site, the disturbance level is moderate and ranges from pedestrians (some with dogs) to regular boat traffic.

8.8. Shellfish

The intertidal area adjacent to the project provides habitat for a variety of mollusks including butter clams (*Saxidomus gigantea*), littleneck clams (*Protothaca staminea*), macoma clams (*Macoma* spp.), and common cockle (*Clinocardium nuttalli*); as well as a variety of crabs including Dungeness crabs (*Cancer magister*) and red rock crabs (*Cancer productus*). The

Washington State Department of Health advises against shellfish harvest on any beach on the eastern shore of Puget Sound between Everett and Tacoma due to pollution.

8.9. Sensitive, Threatened and Endangered Species

In accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, federally funded, constructed, permitted, or licensed projects must take into consideration impacts to federally listed and proposed threatened or endangered species. Several species protected under the Act are found in King County (Table 6).

Table 6. ESA Protected Species listed in King County

Species	Listing Status	Critical Habitat
Marbled Murrelet *Brachyramphus marmoratus*	Threatened	Designated, not in project area
Northern spotted owl *Strix occidentalis caurina*	Threatened	Designated, not in project area
Coastal/Puget Sound Bull Trout *Salvelinus confluentus*	Threatened	Designated
Puget Sound Chinook Salmon *Oncorhynchus tshawytscha*	Threatened	Designated
Puget Sound Steelhead *Oncorhynchus mykiss*	Threatened	Proposed
Bocaccio *Sebastes paucispinis*	Endangered	Proposed
Eulachon *Thaleichthys pacificus*	Threatened	Designated, not in project area
Canary rockfish *Sebastes pinniger*	Threatened	Proposed
Yelloweye rockfish *Sebastes ruberrimus*	Threatened	Proposed
Green sturgeon *Acipenser medirostris*	Threatened	Designated, not in project area
Humpback Whale *Megaptera novaeangliae*	Endangered	Not designated
Southern Resident Killer Whale *Orcinus orca*	Endangered	Designated
Leatherback Sea Turtle *Dermochelys coriacea*	Endangered	Designated, not in project area
Canada lynx *Lynx canadensis*	Threatened	Designated, not in project area
Gray wolf *Canis lupus*	Endangered	Designated, not in project area
Grizzly bear *Ursus arctos horribilis*	Threatened	Not designated
North American wolverine *Gulo gulo luteus*	Proposed	Not proposed

Many of the species listed in Table 6 would not be expected to occur at this urban project site due to a lack of habitat availability. These include Northern spotted owl, Canada lynx, gray wolf, grizzly bear, and North American wolverine.

8.9.1. Marbled Murrelet

Marbled murrelets are small seabirds that feed on fish and invertebrates usually within 2 miles of shore and nest inland in stands of mature and old-growth forest. The marbled murrelet typically forages for prey during the day and visits its nest site at dawn or dusk. Marbled murrelets spend most of their lives in the marine environment, where they forage in areas 0.3 to 2 km from shore. Prey species include herring, sand lance, anchovy, seaperch, sardines, rockfish, capelin, smelt, as well as euphasiids, mysids, and gammarid amphipods. Marbled murrelets aggregate, loaf, preen, and exhibit wing-stretching behaviors on the water.

Although marine habitat is critical to marbled murrelet survival, USFWS' primary concern with respect to declining marbled murrelet populations is loss of terrestrial nesting habitat. In the marine environment, USFWS is primarily concerned with direct mortality from gillnets and spills of oil and other pollutants (USFWS 1996). Recently the USFWS has found that noise in the marine environment, especially from pile-driving, can result in injury to marbled murrelets (USFWS 2009).

Marbled murrelets occur in Puget Sound marine habitats in relatively low numbers (Speich and Wahl 1995). The species moves about a great deal over several temporal scales: seasonally, daily, and hourly. Regional patterns of activity tend to be seasonal, and are tied to exposure to winter storm activity. There is generally a shift of birds from the Strait of Juan de Fuca and British Columbia during spring and summer to areas in the San Juan Islands and eastern bays during the fall and winter (Speich and Wahl 1995). Murrelets are often found in specific areas (e.g., Hood Canal, Rosario Strait/San Juan Islands), as foraging distribution is closely linked to tidal patterns. However, occurrences are highly variable as they move from one area to another, often in short periods of time.

8.9.2. Coastal/Puget Sound Bull Trout

The Coastal/Puget Sound bull trout Distinct Population Segment (DPS) was listed as a threatened species under the ESA in October 1999 (USFWS 1999). Bull trout populations have declined through much of the species' range; some local populations are extinct, and many other stocks are isolated and may be at risk (Rieman and McIntyre 1993). A combination of factors, including habitat degradation, expansion of exotic species, and exploitation, has contributed to the decline and fragmentation of indigenous bull trout populations. Washington's native bull trout exhibit four life histories: anadromous, adfluvial, fluvial, and resident. The least information is available on the anadromous form of bull trout, but it is assumed that they occur in a number of Puget Sound basins, possibly as far south as the Puyallup River. Bull trout movement in response to developmental and seasonal habitat requirements makes their movements difficult to predict both temporally and spatially. The following information regarding general information on bull trout distribution in Puget Sound river basins is from a WDFW summary paper (WDFW 1999). Newly emergent fry tend to rear near spawning areas, while foraging juvenile and sub-adults may migrate through river basins looking for feeding opportunities. Post-spawn adults of the non-resident life form quickly vacate spawning areas and move downstream to forage, some returning to their "home" pool for additional rearing. Anadromous sub-adults and non-spawning adults are thought to migrate from marine waters to freshwater areas to spend the winter.

Little data is available on the life history and distribution of bull trout in Puget Sound river basins (WDFW 1998). The closest river to the project area in which bull trout have been captured is the Duwamish River (USACE 2003), but it is not known if those fish were produced in the basin or strayed from other locations. Anadromous sub-adults and adults utilize estuarine and nearshore marine habitats in Puget Sound for foraging. Based on research in the Skagit Basin (Kraemer 1994), anadromous bull trout juveniles migrate to the Puget Sound estuary in April-May, then re-enter the river from August through November. Most adult fish entered the estuary in February-March, and returned to the river in May-June. Sub-adults, fish that are not sexually mature but have entered marine waters, move between the estuary and lower river throughout the year.

8.9.3. Puget Sound Chinook Salmon

Chinook salmon utilize freshwater, nearshore, and offshore environments during their lifecycles. Chinook salmon require cold, freshwater streams that contain gravel beds suitable for reproduction. Spawning occurs from November to January, with the eggs hatching the following spring. After emerging, Chinook fry seek shallow, nearshore habitat with low water velocities, and eventually move to progressively deeper, faster water as they grow. Fry will remain in streams for up to a year before they move seaward the following spring. Most Chinook return to their native streams to spawn after spending 2-4 years maturing in the open ocean.

Migrating adults on their way to spawn follow shoreline environments and may congregate around the mouth of spawning streams prior to entry. Juvenile Chinook rear exclusively in the estuarine and nearshore areas of Puget Sound. Initially, juveniles tend to follow shorelines associated with structure, but as they get larger they move into deeper water habitats. Most Chinook complete their out-migration to the Pacific Ocean in a very short time however some may remain in Puget Sound for a year or more.

The Duwamish/Green basin (approximately 5 coastal miles from the project) is the closest Chinook-bearing river to the project site. Most Puget Sound Chinook populations, including the Duwamish/Green stock, have declined in abundance since 2005 and trends since 1995 are mostly flat (Ford et. al. 2010).

Chinook life history stages that might occur near the project site include larger juveniles and adults. Since the project site is a good distance from a source of outmigrating juvenile salmonids, juvenile Chinook are likely relatively large by the time they are in the project area and, therefore, they do not rely as heavily on nearshore areas as when they enter the marine environment. However, some juvenile Chinook likely do forage in nearshore areas in the project vicinity. Adult Chinook may orient their migrations and movements with the shoreline but are not likely heavily dependent upon shoreline resources for food or refuge.

8.9.4. Puget Sound Steelhead

The Puget Sound DPS of steelhead was listed as threatened effective June 11, 2007 (NMFS 2007). Unlike salmon, steelhead can spawn more than once during their lives, returning to saltwater afterwards. According to Wydoski and Whitney (1979), Washington steelhead adults often spend two years at sea. Most spend two years in freshwater before outmigrating as smolts to the estuary and saltwater, generally from April through June and peaking in mid-April. Steelhead smolts are larger and more mobile than Chinook smolts, so they are better able to avoid some adverse circumstances.

Adult steelhead use the southern Puget Sound mainly during winter, from November through January with a peak in December (Dames and Moore 1981). In general these winter run, or ocean maturing, steelhead return as adults to the tributaries of Puget Sound from December to April. Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May (NMFS 2007). The inshore migration pattern of juvenile steelhead in Puget Sound is not well understood. It is generally thought that steelhead smolts move quickly offshore (Hartt and Dell 1986).

8.9.5. Bocaccio

Boccacio are large Pacific coast rockfish. Rockfish give birth to live larval young which are found in surface waters extending several hundred miles offshore. Larvae and juvenile rockfish remain in open ocean for several months, being passively dispersed by currents. Adults are most common between 160 and 820 feet depth, with strong associations to rocky bottoms and outcrops. Juveniles and subadults may be more common in shallower waters and are associated with reefs, kelp beds, and artificial structures such as piers. In Puget Sound, most bocaccio are found south of the Tacoma Narrows (NMFS 2013a). The primary reason for this species' decline is overfishing (NMFS 2013a).

8.9.6. Eulachon

Eulachon typically spend 3 to 5 years in saltwater before returning to freshwater to spawn from late winter through mid spring. After fertilization, the eggs sink and adhere to the river bottom, typically in areas of gravel and coarse sand. Most eulachon adults die after spawning. Eulachon eggs hatch in 20 to 40 days and the larvae are then carried downstream where they are dispersed by estuarine and ocean currents shortly after hatching. Juvenile eulachon move from shallow nearshore areas to mid-depth areas. Eulachon are infrequently found in coastal rivers and tributaries to Puget Sound (NMFS 2013b).

8.9.7. Canary Rockfish

Canary rockfish have a similar life history to bocaccio, bearing live young that disperse in surface waters. Adults are found between 160 and 820 feet depth, with strong associations to rocky bottoms and outcrops where they hover just above the bottom. Juveniles and subadults may be more common in shallower waters and are associated with reefs, kelp beds, and artificial structures such as piers. Like bocaccio, the primary reason for the decline of this species is overfishing (NMFS 2013c).

8.9.8. Yelloweye Rockfish

Yelloweye rockfish have a similar life history to bocaccio and canary rockfish. They bear live young that disperse in surface waters. Adults are found between 80 and 1560 feet depth, with strong associations to rocky bottoms and outcrops. Juveniles and subadults may be more common in shallower waters and are associated with reefs, kelp beds, and artificial structures such as piers. Yelloweye rockfish are among the longest lived of rockfishes, living up to 118 years old. Like bocaccio and canary rockfish, the primary reason for the decline of this species is overfishing (NMFS 2013d).

8.9.9. Green Sturgeon

Green sturgeon are long-lived, slow-growing fish, and are the most marine-oriented of the sturgeon species. Green sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. Adult sturgeon return to freshwater to spawn when they are about 15 years of age and more than 4 feet (1.3 m) in size. Spawning is believed to occur every 2-5 years (NMFS 2013e). Adults typically migrate into fresh water beginning in late February, and spawning occurs from March-July, with peak activity from April-June (NMFS 2013e). Green sturgeon do not spawn in Washington (NMFS 2013e). Juvenile green sturgeon spend a few years in fresh and estuarine waters before they leave for saltwater, where they disperse widely in the ocean.

8.9.10. Humpback Whale

Humpback whales are large cetaceans, reaching 52 feet in length. They are well-known for their complex and evolving vocalizations. They have very long, knobbed pectoral fins, and a small dorsal fin. They have baleen instead of teeth; the baleen is comb-like material used for filtering large amounts of water as it is forced out of their mouths in order to retain the whales' prey, which includes krill and small fish such as herring.

Although humpback whales are found in Puget Sound, they are relatively uncommon, possibly as a result of commercial whaling in the Strait of Georgia during the early 20th century (Osborne et al. 1988). In southern Puget Sound, Osborne et al. (1988) noted multiple observations of one individual in June 1986. Calambokidis and Steiger (1990) documented a large number of sightings of two juveniles in southern Puget Sound, including Commencement Bay, in June-July 1988. Humpbacks are more common in the ocean offshore of Washington and Vancouver Island. Humpbacks are not likely to be found in the vicinity of the project at the time of the proposed project work, due to their mobility and their likely desire to avoid areas of intense human activity.

8.9.11. Southern Resident Killer Whale

The orca, or killer whale, is a toothed member of the order Cetacea, which includes whales, dolphins and porpoises. The southern resident population of killer whale was listed as endangered effective February 16, 2006 (NMFS 2005). Killer whales may be found worldwide, but are more abundant in higher latitudes and in areas of higher biological productivity. Killer whales occur in groups of about 5-20 animals, though sometimes may congregate in numbers reaching over 100. Puget Sound/British Columbia killer whales are grouped into three major communities (Osborne et al. 1988). The northern resident community occurs north of the tidal boundary halfway along the east side of Vancouver Island in British Columbia. Southern resident killer whales range within about 200 miles surrounding the San Juan Islands, and do not overlap with northern residents (Osborne et al. 1988), which is supported by genetic analysis (Hoelzel et al. 1998; Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001). A transient group of killer whales travels throughout the ranges of the southern and northern residents. The transients feed primarily on marine mammals, while the resident killer whales specialize in salmon. Each of these pod communities has specialized calls and migration routes, and interbreeds only within itself.

Resident killer whales are subject to impacts due to loss of prey availability. Salmon are major components of resident killer whales' food intake, and a number of stocks of salmon have been in decline in Puget Sound. In addition, the general reduction in size of individual salmon that has been occurring over the past few decades, and changes in their body composition (energy and nutritional value) may negatively affect killer whales by requiring the whales to hunt more often for smaller prey. Killer whales are also impacted by noise and vessel operations. Sources of underwater noise pollution (vessel traffic, seismic activity, drilling, dredging, construction and sonar), especially in an industrialized area like Commencement Bay, create an ambient environment that may interfere with killer whales' echolocation capabilities as well as with their navigation and communication.

Southern Residents range throughout Puget Sound, and may occasionally migrate and/or forage as far south as Monterrey Bay, California; sightings have been documented as far north as the northern Queen Charlotte Islands in Canada (Krahn et al. 2004). The Southern Resident's customary range is thought to be primarily within Puget Sound, and through and within the Georgia and Johnstone Straits. Hunting is known to occur in waters of all depths, and killer whales have been seen to "herd" schools of fish into shallow bays to increase their feeding effectiveness. Killer whales are also known to swim with and adjacent to boats and ships transiting the Sound.

8.9.12. Leatherback Sea Turtle

The leatherback sea turtle was listed as endangered in 1970. The leatherback sea turtle is widespread in the tropical and temperate Pacific, including the U.S. and Canadian west coast from California to Alaska, and has been incidentally caught in commercial gillnets off the US west coast. There is, however, no known nesting along the U.S. west coast.

Leatherback sea turtle presence in Puget Sound has not been documented, though it may be found in the Strait of Juan de Fuca and off the Washington coast. There is no information that would indicate that the leatherback sea turtle is likely to be present in the project area. NMFS and USFWS (2007) state that sightings of this species are very rare, and there are no known breeding areas in NMFS' Northwest Region jurisdictional area, which includes Puget Sound.

8.10. Historic and Cultural Resources

The Corps has coordinated its environmental review of impacts on cultural resources for NEPA with its responsibilities to take into account effects on historic properties as required by Section 106 of the National Historic Preservation Act (NHPA). Historic properties are those cultural resources that are eligible for inclusion or listed on the National Register of Historic Places. The Corps has determined and documented the area of potential effect (APE) for both direct and indirect effects, as required at 36 C.F.R § 800.4 of the regulations implementing Section 106. The APE includes the length of the levee repair and all staging and access areas for all locations. The Washington State Historic Preservation Officer (SHPO) agreed with our determination of the APE on 25 April 2016.

The Corps has conducted a records search and literature review of the Washington Information System Architectural and Archaeological Records Database (WISAARD). The literature review and records search revealed that there are no properties listed in the National Register of Historic Places or the Washington State Historic Site Register in any of the project repair areas, and no cultural resources have been recorded within the APE. We also notified the following tribes about the project on 9 April 2013, to identify properties to which they may attach religious or cultural significance or other concerns with historic properties that may be affected: the Muckleshoot Indian Tribe, the Tulalip Tribes of the Tulalip Reservation, the Sauk-Suiattle Indian Tribe, the Snoqualmie Tribe, the Suquamish Indian Tribe and the Confederated Tribes and Bands of the Yakama Nation. The tribes did not identify any concerns with the undertaking.

On 9 April 2016, Corps archaeologists conducted a pedestrian survey of the project APE for the Alki Seawall Repair Project. All accessible areas within the APEs were visually surveyed for cultural resources, with kick scrapes performed in areas with loose ground cover. The area was highly disturbed from the construction of the seawall and previous repairs, as well as erosion due to storm action. No new cultural resources were located.

Archival research indicates that the Alki Seawall at Emma Schmitz Memorial Overlook is over 50 years old. However, the structure does not possess significant historical associations under criterion A and is a typical and undistinguished example of a seawall constructed during this period. The seawall's name association with Emma Schmitz does not connote significant associations under criterion B, as there are other historic properties that better represent her life and accomplishments as a locally prominent citizen. The seawall is a poured-in-place concrete structure reinforced with salvaged iron material, possibly remnants from streetcar rails. As a property type, the wall does not possess important physical characteristics of materials, method of construction, or style to be considered eligible under criterion C. Based on this information, the Corps is recommending that the Emma Schmitz Alki Seawall is not eligible for listing on the NRHP.

In a letter dated 16 May 2016, the State Historic Preservation Officer (SHPO) concurred with the Corps' finding of No Historic Properties Affected.

8.11. Land Use

Park visitors utilize the project area for a variety of recreational activities, see Section 7.7 for details. Aside from Emma Schmitz Memorial Park at the project site, there is another nearby park known as Me-Kwa-Mooks Park. Me-Kwa-Mooks Park is about 275 feet from the project site, up SW Jacobsen Road. The northern end of Emma Schmitz Park is directly across the street from Me Kwa Mooks. Other than public park lands, surrounding land use is primarily residential.

8.12. Recreation

Park visitors utilize the project area for a variety of recreational activities. Amenities at the site include benches, pedestrian walkway/promenade, and stairs leading down to the beach. Heaviest use occurs from late spring to fall; however, a small number of people use the park during the winter.

8.13. Transportation and Utilities

Refer to Section 5: Existing Conditions for a description of transportation infrastructure and utilities in the project area.

8.14. Hazardous, Toxic, and Radiological Waste

Refer to Section 5.4 for HTRW information.

9. EFFECTS OF THE PROPOSED ACTION

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9.1. Physical Characteristics and Aesthetics

9.1.1. No Action Alternative

Implementation of the No Action Alternative would leave the existing seawall vulnerable to further erosion and storms. This leaves the project site at a high risk for catastrophic failure. Collapse of the seawall could result in significant erosion and loss of property behind the wall and would endanger the infrastructure behind the seawall, particularly the large sewer main. An emergency response would likely be required to protect critical infrastructure. An emergency action would involve placement of riprap seaward of the project area. This would alter the physical characteristics of the site by requiring a larger footprint (approximately 40-feet wide) covering a larger area of existing beach. Riprap placed under emergency situations is also more prone to settling and loss of rock, likely requiring reworking and continuous repair throughout the project life. Thus, an emergency response under the No Action Alternative would cause a significant change to the physical characteristics and aesthetics of the site. Further, if an emergency response to a seawall failure was not undertaken the resultant loss of land and probable failure of the sewer main could cause a considerable adverse impact to the physical characteristics of the immediate area and the surrounding vicinity.

9.1.2. Soldier Pile Wall (Preferred Alternative)

The project site would continue to be maintained as a park following construction with no change to existing park amenities (sidewalks and benches). The project site would be temporarily closed to visitors during construction, though the northern sections of the park would remain open.

The existing seawall would remain in place with the new soldier pile wall placed seaward of the footing. Fill would be placed between the existing seawall and the new soldier pile wall, extending the existing park upland by 2 to 4 feet. No new park amenities would be anticipated for this filled area. Implementation of the preferred alternative would be expected to fully protect the sewer main and other infrastructure. Regular inspections would be completed throughout the project life with minimal maintenance needs. The construction of the soldier pile wall is not expected to cause a significant change to the physical characteristics of the site.

9.1.3. Retaining Wall

The Retaining Wall alternative would have the same effect on physical characteristics and aesthetics as the Soldier Pile Wall alternative.

9.2. Soils

9.2.1. No Action Alternative

As discussed above, the No Action Alternative would likely lead to an emergency action that included placement of riprap throughout the site. Existing soils for the majority of the site would be unchanged, though the land/sea interface would be modified. No significant impact to soils would occur.

9.2.2. Soldier Pile Wall (Preferred Alternative)

The Soldier Pile Wall alternative would leave the existing seawall in place and would have minimal disturbance to existing soils. Imported sandy material would be used to fill the area between the new wall and the existing seawall. This material would be clean and would be purchased from a commercial facility. Overall the changes to existing soils would be minor and this alternative would not have a significant impact on this resource.

9.2.3. Retaining Wall

The retaining wall has the greatest disturbance of soils within the project area as the removal of the seawall and shoring up of the sewer main would require extensive excavation. Much of the removed material would be preserved to use as backfill once the retaining wall was installed. Any additional material needed would be clean fill purchased from a commercial facility. Overall the disturbance would be temporary and this alternative would not have a significant impact on this resource.

9.3. Water Quality

9.3.1. No Action Alternative

The No Action Alternative maintains the vulnerability of the seawall and the sewer main. Collapse of the seawall could result in significant erosion of the shoreline, leading to increased turbidity from the suspended sediment load in the water column. Catastrophic failure of the seawall leading to a break in the sewer main could have a significant short-term impact on water quality of the Puget Sound. It is expected that a sewage release would be short-lived and that emergency actions would take place to stop the spill and stabilize the shore. A sewage release could result in high loads of fecal coliform bacteria as well as heavy metals, oil-based chemicals, pharmaceuticals, etc. being flushed into Puget Sound.

9.3.2. Soldier Pile Wall (Preferred Alternative)

The Soldier Pile Wall alternative, once constructed, would protect the sewer pipe from erosion. During construction, work would be done in the dry at low tide. When tides rise and hit the work area during the construction period, slight turbidity increases may occur. Use of best management practices such as working from the top of the bank, minimizing on-site equipment maintenance, and ensuring all equipment and materials are clean would minimize potential for contamination. A small amount (0.02 acres) of beach would be lost due to the footprint of the new wall; however, the equivalent amount of beach habitat would be reclaimed through the riprap removal BMP. Overall impacts to water quality from the soldier pile wall would be minimal.

9.3.3. Retaining Wall

The Retaining Wall alternative, once constructed, would protect the sewer pipe from erosion. However this alternative has a higher risk of disturbing the pipe during construction of the wall. Removal of the existing seawall and shoring up the pipe during construction increases the vulnerability during the work. As above, construction would be done at low tide and in the dry. The removal of the existing seawall leaves the excavated bank exposed as tides rise and hit the work area during the construction period. As a result, turbidity increases may occur and would require monitoring. Use of best management practices such as working from the top of the bank, minimizing on-site equipment maintenance, and ensuring all equipment and materials are clean would minimize potential for contamination. A small amount (0.06 acres) of beach would be lost due to the footprint of the new wall. The riprap removal BMP for this loss would be included in the final project design. Overall impacts to water quality from the retaining wall would be short-term and would be minimal.

9.4. Air Quality and Noise

9.4.1. No Action Alternative

The No Action Alternative would result in temporary effects to air quality and noise. Small repairs would require the use of heavy machinery, increasing emission and noise levels in the immediate area. The No Action Alternative could also result in the catastrophic failure of the seawall and considerable damage to the sewer main and other public infrastructure adjacent to the seawall. An emergency response would have short term effects to air quality and noise. There would be a temporary increase in emissions and noise during construction; however the effects would be minimal given the short duration of the emergency response. The pollutant production from construction equipment is expected to be de minimis and to have no effect on the existing ozone and carbon dioxide maintenance criteria. Construction noise associated with the usage of heavy machinery may disturb residents in close proximity to the site. Following construction, there would be no change in air quality or noise at the site. Overall, the impact to air quality and noise will be temporary and localized.

9.4.2. Soldier Pile Wall (Preferred Alternative)

Construction activities for the project would have short term effects to air quality and noise. Any effects would only occur during construction. Construction would occur during daylight hours, five days a week. There would be a temporary increase in emissions and noise during construction; however the effects would be minimal given the short duration of the construction. The pollutant production from construction equipment is expected to be de minimis and to have no effect on the existing ozone and carbon dioxide maintenance criteria. Construction noise associated with the usage of heavy machinery may disturb residents in close proximity to the site. Following construction, there would be no change in air quality or noise at the site.
Overall, the impact to air quality and noise will be minor.

9.4.3. Retaining Wall

The Retaining Wall alternative would have the same effects on air quality and noise as the Soldier Pile Wall alternative.

9.5. Submerged Aquatic Vegetation

9.5.1. No Action Alternative

Water clarity is the most serious water quality condition affecting eelgrass and other seagrasses (Berry et al 2003). Water clarity can be compromised by eutrophication, suspended sediment and shading due to overwater structures. Other impacts that would hamper the growth of vegetation include increased wave energy, the release of trace metals, or water temperature increases.

The No Action Alternative, with its associated higher risk of shoreline erosion and a sewage release could have short term impacts to water quality. Collapse of the wall would release suspended sediment into the water column that could potentially cover areas of submerged aquatic vegetation as it settles out. It is expected that a break in the sewer pipe would receive immediate action such that the spill would be short-lived with an emergency repair of the pipe and emergency stabilization of the shoreline. Increased nutrient loading from the sewage release could cause eutrophication, however the tidal flushing of the area coupled with the expected higher wave forces during the damaging storm event would dilute the sewage and minimize local impacts to submerged aquatic vegetation. The larger footprint of the emergency stabilization of the shoreline, likely in the form of riprap placement, would decrease the beach in the area, but would not be expected to increase local wave energy or have other impacts to diminish the site's suitability for submerged aquatic vegetation. Overall, short-term impacts to submerged aquatic vegetation could occur, but long-term effects are not expected.

9.5.2. Soldier Pile Wall (Preferred Alternative)

Construction of the wall would move the hardened shoreline slightly waterward, however no aquatic vegetation would be covered by the new footprint. Minimal change to wave energy and beach composition is expected. No long-term impact to water quality or clarity is expected. Impacts to submerged aquatic vegetation are not expected to be significant.

9.5.3. Retaining Wall

The removal of the existing seawall leaves the excavated bank exposed as tides rise through the construction period. As a result, turbidity increases may occur that could have short-term impacts to submerged aquatic vegetation. Construction of the wall would move the hardened shoreline slightly waterward; however no aquatic vegetation would be covered by the new footprint. Minimal change to wave energy and beach composition is expected. No long-term impact to water quality or clarity is expected. Impacts to submerged aquatic vegetation are not expected to be significant.

9.6. Fish

9.6.1. No Action Alternative

The No Action Alternative, with its associated higher risk of a sewage release could have short and long term impacts to habitat quality and suitability for fish. Tidal flushing of the area coupled with the higher wave forces during the damaging storm event would dilute the sewage, limiting longer term impacts to fisheries. The larger footprint of the emergency stabilization of the shoreline, likely in the form of riprap placement, would encroach on the beach, decreasing available habitat for fisheries. Construction of an emergency repair may include in water work and could potentially injure fish in the work area during construction due to rock placement. Overall, short-term impacts to fish could occur, but the long-term effect would be the loss of beach habitat due to an emergency repair.

9.6.2. Soldier Pile Wall (Preferred Alternative)

Construction of the wall would move the hardened shoreline waterward, slightly decreasing available habitat for fish, but to a much lesser extent than the No Action Alternative. Minimal change to existing habitat characteristics is expected. Construction would occur in the dry during low tides to minimize water quality impacts and thereby limit the potential for harm to fish species. Impacts to fish are not expected to be significant.

9.6.3. Retaining Wall

Construction would occur in the dry during low tides to minimize water quality impacts and thereby limit the potential for harm to fish species. During high tides, the exposed bank at the site from the removal of the existing seawall could lead to increased turbidity and short-term impacts to fish. Construction of the wall would move the hardened shoreline waterward, slightly decreasing available habitat for fish. Minimal change to existing habitat characteristics is expected. Overall impacts to fish from the retaining wall alternative are not expected to be significant.

9.7. Birds

9.7.1. No Action Alternative

The No Action Alternative, if it leads to a sewage release, could have short term impacts to habitat quality and suitability for birds that use the adjacent shoreline and shallow waters for foraging. Any emergency response to a break or to prevent a break would slightly increase activity over ambient levels. Some displacement of birds may occur. Due to the small size of the project, construction disturbance would be limited in size and duration. Birds moving from the vicinity of the project would not be displaced from locally important habitat and would likely find suitable habitat nearby. The completed project would not change habitat features important to bird life. Overall, long-term adverse impacts to birds are not anticipated as a result of the proposed work.

9.7.2. Soldier Pile Wall (Preferred Alternative)

The proposed construction would slightly increase activity over ambient levels. Some displacement of birds may occur. Due to the small size of the project, construction disturbance would be limited in size and duration. Birds moving from the vicinity of the project would not be displaced from locally important habitat. The completed project would not change habitat features important to bird life. Overall, adverse impacts to birds are not anticipated as a result of the proposed work.

9.7.3. Retaining Wall

The Retaining Wall alternative would have the same effect on birds as the Soldier Pile Wall alternative.

9.8. Shellfish

9.8.1. No Action Alternative

Sewage spills generally cause the short term closure of nearby shellfish beds for harvest, however the Washington State Department of Health advises against harvest of shellfish in this area (any beach on the eastern shore of Puget Sound between Everett and Tacoma). Implementation of the no action alternative would be expected to result in an emergency repair, such as placement of riprap, with a larger footprint and beach impact. A change in species composition within the site or larger vicinity would not be expected. Overall impacts would be short term for the reach of the shoreline.

9.8.2. Soldier Pile Wall (Preferred Alternative)

The Soldier Pile Wall alternative has the smallest footprint of the proposed repair options, thus minimizing the loss of beach habitat. The loss of 0.02 acres of beach due to soldier pile wall installation will impact the species composition in the footprint, though no change to the larger vicinity would be expected. Overall impacts would not be significant for the reach of the shoreline.

9.8.3. Retaining Wall

The Retaining Wall alternative has a larger footprint than the preferred alternative because of the requirement for a large footing at the base of the new structure. This results in a greater impact to the beach habitat including nearly 3 times as much loss of beach area. The loss of 0.06 acres of beach due to retaining wall installation will impact the species composition in the footprint, though no change to the larger vicinity would be expected. Overall impacts would not be significant for the reach of the shoreline.

9.9. Sensitive, Threatened and Endangered Species

9.9.1. No Action Alternative

Leatherback sea turtle is not known to occur in the project area and no impact to this species would occur from any of the alternatives. Humpback whales, while present in Puget Sound on rare occasions, would not be impacted by any of the alternative actions for this project as they do not use nearshore habitats.

If the no action alternative led to a large spill of raw sewage to the nearshore area, short-term impacts could occur to listed fish species in the vicinity of the spill, including the salmonids (bull trout, Chinook, and steelhead) as well as larval rockfish (bocaccio, canary rockfish, and yelloweye rockfish). Effects could include increased turbidity, decreased water clarity, increased toxins, and decreased dissolved oxygen levels. The salmonids using the area would likely be adults or larger juveniles that would be mobile enough to escape poor conditions. Effects of the spill would likely be diluted before reaching depths where it would impact adult rockfish species. Presence of eulachon in Puget Sound is so rare, that impacts to this species would be expected to be negligible. Any green sturgeon in the area would also be adults or subadults that would be highly mobile and able to escape the affected area.

Emergency shoreline stabilization could also impact any salmonids (bull trout, Chinook, and steelhead) and larval rockfish (bocaccio, canary rockfish, and yelloweye rockfish) in the project vicinity due to in-water rock placement, increased noise and activity, and potentially increased turbidity. The placement of the riprap revetment would result in the loss of approximately 0.4 acres of beach habitat that could be used by salmonids for foraging during high tides.

Marbled murrelet in the area could be disturbed by a sewage release and by construction of emergency repairs. The sewage release could temporarily reduce suitability of the vicinity for foraging. Construction activity and noise could cause murrelet to leave the area while the activity is ongoing. This species is highly mobile and would be expected to find other suitable habitat nearby.

Killer whale do not use nearshore habitats, but the use of these habitats as rearing for salmonids, their main prey species, does link them to work on shorelines. The impact to salmonids, including loss of foraging habitat, could potentially impact killer whale through a reduction in prey.

Overall impacts of the no action alternative to sensitive, threatened, and endangered species could be long-term, if emergency shoreline stabilization resulted in the permanent loss of 0.4 acres of beach habitat.

9.9.2. Soldier Pile Wall (Preferred Alternative)

Construction of the soldier pile wall could also impact any salmonids (bull trout, Chinook, and steelhead) and larval rockfish (bocaccio, canary rockfish, and yelloweye rockfish) in the project vicinity due to increased noise and activity, and potentially increased turbidity.   All work would be completed between July16 and February 15. The work window avoids sensitive migration periods for salmonids, including bull trout. Presence of eulachon in Puget Sound is so rare that impacts to this species are expected to be negligible. Any green sturgeon or salmonids in the area would be highly mobile and able to escape the construction area if noise or activity made the vicinity less desirable during construction. Similar habitat is available nearby for their use.
The placement of the soldier pile wall would result in the permanent conversion of approximately 0.02 acres of beach habitat to armored shoreline in an area that could be used by salmonids for foraging during high tides. A BMP to offset this loss in the form of riprap removal to reclaim beach habitat adjacent to the project site would be further developed and included in the final design of this project.

Similarly, construction activity and noise could cause marbled murrelet to leave the area while the activity is ongoing. This species is highly mobile and would be expected to find other suitable habitat nearby.

Killer whale do not use nearshore habitats, but the use of these habitats as rearing for salmonids, their main prey species, does link them to work on shorelines. The limited impact to salmonids would be expected to also limit potential impacts to killer whale.

Overall, with the implementation of appropriate BMPs for the permanent loss of beach habitat, impacts of the Soldier Pile Wall alternative to sensitive, threatened, and endangered species would not be significant.

9.9.3. Retaining Wall

Overall impacts from the Retaining Wall alternative to sensitive, threatened, and endangered species would be similar to the Soldier Pile Wall alternative. The retaining wall footprint would be slightly larger with the permanent conversion of 0.06 acres of beach habitat compared to 0.02 for the soldier pile wall.

9.10. Historic and Cultural Resources

9.10.1. No Action Alternative

9.10.2. The No Action Alternative would have no adverse impact on cultural resources, as there are no historic properties eligible for the National Register of Historic Places within the project APE.Soldier Pile Wall (Preferred Alternative)

9.10.3. The Preferred Alternative would have no adverse impact on cultural resources, as there are no historic properties eligible for the National Register of Historic Places within the project APE.Retaining Wall

Under the Retaining Wall Alternative the seawall would be removed. This alternative would have no adverse impact on cultural resources, as there are no historic properties eligible for the National Register of Historic Places within the project APE.

9.11. Land Use

9.11.1. No Action Alternative

The No Action Alternative could result in the catastrophic failure of the seawall and considerable damage to the sewer main and other public infrastructure adjacent to the seawall. Damage to the sewer main could cause the disruption of service to 20,000 customers in West Seattle. A permanent loss of this line is not expected as emergency repairs would occur. Emergency repairs would allow the existing residential neighborhood to continue to be serviced by the municipal sewer, though disruption of service during the repair may occur. In addition to the pipe, loss of the seawall would erode park land and would have temporary effects on the availability of the park. It is expected that emergency measures would largely restore the park to a usable state. No long term impacts to land use are expected.

9.11.2. Soldier Pile Wall (Preferred Alternative)

The Soldier Pile Wall alternative would protect the sewage main and all existing land use at the site and in the vicinity. No impacts to land use would be expected.

9.11.3. Retaining Wall

The Retaining Wall alternative would have the same effect on land use as the Soldier Pile Wall alternative.

9.12. Recreation

9.12.1. No Action Alternative

The No Action Alternative could result in the catastrophic failure of the seawall and considerable damage to the sewer main and other public infrastructure adjacent to the seawall. The 54-inch sewer has the capacity of up to 8 million gallons of flow daily. A spill of this magnitude could cause temporary closure of the site and adjacent beaches to protect visitors from contamination. Emergency repairs are expected to be undertaken in the case of this event to limit the volume of the spill. In addition to the pipe, loss of the seawall would erode park land and would have temporary effects on the availability of the park. It is expected that measures would be undertaken by the City to largely restore the park to a usable state. Impacts of the no action alternative on recreation would be temporary and would not be considered significant.

9.12.2. Soldier Pile Wall (Preferred Alternative)

The Soldier Pile Wall alternative would protect the park and existing park infrastructure. Temporary closure and detouring of sidewalks at the site would be necessary during construction but no long term change to the park status is expected. A BMP to remove a portion of the adjacent riprap would restore adjacent beach habitat. The beach is accessible to the public and would remain public lands. The conversion would be approximately 1:1 ratio of lost beach (due to the seaward encroachment) to reclaimed beach for a total of 0.02 acres. No significant impacts to recreation would be expected.

9.12.3. Retaining Wall

The Retaining Wall alternative would protect the park and existing park infrastructure. Temporary closure and detouring of sidewalks at the site will be necessary during construction but no long term change to the park status is expected. A BMP similar to the Soldier Pile Wall alternative would be needed to offset impacts to 0.06 acres beach habitat. No significant impacts to recreation would be expected.

9.13. Transportation and Utilities

9.13.1. No Action Alternative

The No Action alternative could result in the catastrophic failure of the seawall and considerable damage to the sewer main, Beach Drive, a Puget Sound Energy gas line, and a Seattle Public Utilities water line located adjacent to the seawall. Emergency repairs would allow the homes within the area to continue to be serviced by the municipal sewer and other utility lines though disruption of service would occur until the repair is complete. In addition to the pipes, loss of the seawall would erode adjacent land potentially impacting the safety and availability of the adjacent roadway. Detour routes from one side of the affected area to the other would be available via city streets at a minimum of 2.5 miles due to the lack of nearby connector streets. It is expected that measures would be undertaken by the City to restore Beach Drive to a usable state. Impacts of the no action alternative on transportation and utilities would be temporary and could be disruptive to local citizens, but would not be considered significant as they would be expected to be rectified by the City with emergency repairs.

9.13.2. Soldier Pile Wall (Preferred Alternative)

The Soldier Pile Wall alternative would protect the adjacent roadway and utility lines. Temporary closure of a single lane of Beach Drive and detouring of sidewalks at the site may be necessary during construction. Signage, flaggers and other features would be used to ensure the safety of the public and minimize traffic impacts. No long term change to the roadway or utility lines is expected. No significant impacts to transportation and utilities would be expected.

9.13.3. Retaining Wall

The Retaining Wall alternative would have the same effect on transportation as the Soldier Pile Wall alternative.

9.14. Hazardous, Toxic, and Radiological Waste

9.14.1. No Action Alternative

Records do not indicate potential HTRW concerns in the project area; therefore no significant impact is expected.

9.14.2. Soldier Pile Wall (Preferred Alternative)

Impacts would be similar to the No Action alternative.

9.14.3. Retaining Wall

Impacts would be similar to the No Action alternative.

10. CUMULATIVE EFFECTS

The NEPA defines cumulative effects as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR §1508.7).

Alterations of the South Central Puget Sound Sub-Basin shoreline, which includes the project area, are omnipresent with almost complete shoreline armoring throughout (Simenstad et. al. 2011). The WDOE Coastal Atlas indicates that the shoreline has been modified 90-100% one mile on either side of the proposed project (WDOE 2014).

The existing seawall structure was constructed in 1927. Emma Schmitz Memorial Overlook Park was donated in 1945 by Emma Schmitz "for park...and no other purpose whatsoever" (City of Seattle 1995). In 1998, the City of Seattle was prompted to take emergency action to stabilize a portion of the seawall to the north of the proposed federal project. Three small storm events caused waves that resulted in erosion of the seawall and threatened utilities, roadways, and public lands. The City completed permanent emergency repairs on this adjacent site in the form of a riprap revetment that extends 50 feet into the nearshore area. The proposed Soldier Pile Wall alternative would impact 0.02 acres of nearshore habitat compared to 0.06 acres for the Retaining Wall alternative. Habitat impacts from the proposed federal project would be addressed through removal of a portion of the adjacent riprap placed during the City's emergency repair (see Section 7 Recommended Plan).

In 1988, the Corps partnered with the City of Seattle Parks and Recreation Department at Lincoln Park, approximately 2 miles south of the Alki seawall to place armor rock along 250 feet of beach at Williams Point and complete beach nourishment. The substrate placement created a gravel beach along the Lincoln Park shoreline where erosion had previously scoured all substrate down to a hard clay layer at the toe of the seawall. Periodic renourishment of the beach is needed, with the first occurring in 1994, the second in 2002, and the third in 2010.

Future actions may include more shoreline restoration projects, similar to efforts at Lincoln Park. Other future actions may include repairs or replacement of existing infrastructure to protect property from shoreline erosion. Further development actions are unlikely, as this area is already a highly developed urban shoreline.

11. IRRETRIEVABLE AND IRREVERSIBLE COMMITMENTS OF RESOURCES

NEPA requires that the environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the preferred alternative should it be implemented." This clause refers to the use of nonrenewable resources and the effects that the use of these resources have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable period. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored because of the action (e.g., extinction of a species or the disturbance of a cultural site).

The proposed project would require an irreversible commitment of natural resources from direct consumption of fossil fuels and construction materials. There would also be an irretrievable loss of 0.02 acres of beach habitat at the project site; however, this loss will be reclaimed through the removal of riprap and recovery of equivalent beach habitat immediately adjacent to the project site. Construction will also require a one-time expenditure of both City and Federal funds that are not retrievable. The commitment of these resources is based on the concept that reduction in damages to public utilities, infrastructure, and the environment resulting from failure of the seawall due to coastal storm events, storm surge, and storm-induced erosion is anticipated to outweigh the commitment of these resources.

12. ENVIRONMENTAL COMPLIANCE

12.1. National Environmental Policy Act

Section 1500.1(c) and 1508.9(1) of the National Environmental Policy Act of 1969 (as amended) requires federal agencies to "provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact" on actions authorized, funded, or carried out by the federal government to insure such actions adequately address "environmental consequences, and take actions that protect, restore, and enhance the environment". This assessment evaluates environmental consequences from the proposed coastal erosion control project in Seattle, Washington. The draft EA was made available for public review on December 1st thru December 31th, 2014 via mailings and posting on the public Corps website. Refer to Appendix L for comments received during the public review period and Corps responses to those comments.

12.2. Endangered Species Act

In accordance with Section 7(a)(2) of the Endangered Species Act of 1973, as amended, federally funded, constructed, permitted, or licensed projects must take into consideration impacts to federally listed or proposed threatened or endangered species. The potential effects of the project and conservation measures taken to reduce those effects are addressed in more detail in a Biological Evaluation (BE). The BE was submitted to USFWS and NMFS on August 8th, 2014 for review and consultation. In correspondence dated 19 September 2014 and 3 December 2014, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service respectively concurred with the Corps' findings.

12.3. Clean Water Act Compliance

The proposed work will be evaluated pursuant to Section 404(b)(1) of the Clean Water Act in accordance with the guidelines promulgated by the Environmental Protection Agency (40 CFR 230) for evaluation of the discharge of dredged or fill material into waters of the United States. In addition, consideration has been given to the need for the work and to such water quality standards as are appropriate and applicable by law. A request for Water Quality Certification will be sent to the WDOE for consultation under Section 401 of the Clean Water Act. An individual water quality certification is expected to be needed due to the beach encroachment.

Alternatives not requiring the discharge of dredged or fill material into water of the U.S. are not available, practicable, or are more damaging to the aquatic ecosystem. The proposed discharge represents the least environmentally damaging practicable alternative and would include all appropriate and practicable measures to minimize adverse effects on the aquatic environment. The discharges and methods specified in the proposed work are in accordance with the Section 404(b)(1) guidelines (see Draft 404(b)(1) Analysis - Appendix K).

12.4. Essential Fish Habitat

In accordance with the Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act, the Corps is consulting with NMFS on any potential impacts to EFH. The Corps' determination of effects was transmitted to NMFS as a part of the BE. In a letter dated 3 December 2014, NMFS determined that the proposed action would adversely affect EFH by small increases in suspended sediments, impacts to the benthic community, and intertidal fill. The letter included conservation measures to avoid, mitigate, or offset the impact of the proposed action. The Corps provided an interim response in a letter dated 22 December, 2014 stating that implementation of the recommended conservation measures will be evaluated in the design and implementation phase. A detailed response will be sent to NMFS as design progresses in this next project phase.

12.5. Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§1361-1407) restricts harassment of marine mammals. Typical stressors from construction activities most likely to result in impacts to marine mammals that could rise to the level of harassment as defined under the MMPA include underwater detonations and vibratory pile driving. Neither of these activities are proposed for this project. Some individual animals may experience minor temporary physiological or behavioral effects in response to drilling noise, but it is not expected to result in significant (Level A or Level B) harassment of any marine mammal. There would be no permanent loss of habitat and all impacts would cease entirely at construction completion. Best management practices (e.g., working from the top of the bank, working in the dry at low tide, etc.) would further reduce the likelihood of impacts to marine mammals. Thus, the Corps has determined that it is not necessary to pursue an incidental harassment authorization under the MMPA.

12.6. Fish and Wildlife Coordination Act

In accordance with the Fish and Wildlife Coordination Act (16 USC 661 et seq.), the Corps is required to coordinate with the USFWS. The Corps met with the USFWS at the project site to solicit input on the study and how to minimize the environmental impacts of the project. USFWS has assisted in developing the best management practice incorporated into the project that will reclaim the lost beach habitat imposed by the new seawall. The USFWS has determined that a Coordination Act Report is not required for this project and the coordination is in compliance with the Act.

12.7. National Historic Preservation Act

Section 106 of the National Historic Preservation Act requires that a federally assisted or federally permitted project account for the potential effects on sites, districts, buildings, structures, or objects that are included in or eligible for inclusion in the National Register of Historic Places. In a letter dated 16 May 2016, the SHPO concurred with the Corps' finding of No Historic Properties Affected.

12.8. Clean Air Act

The proposed project was analyzed for conformity applicability pursuant to regulations implementing Section 176(c) of the Clean Air Act. The proposed activities will have temporary impacts to local air quality due to the emissions of construction vehicles, however the short duration of construction and the lack of any exceed de minimis levels of direct emissions of a criteria pollutant or its precursors long-term recurring emissions from the work is unlikely to exceed de minimis levels of direct emissions of a criteria pollutant or its precursors.

Also refer to Section 9.5 for additional information regarding impacts to air quality.

12.9. Environmental Justice

Executive Order 12898 directs federal agencies to identify and address disproportionately high and adverse human health or environmental effects of agency programs and activities on minority and low-income populations. No tribal resources would be harmed. No adverse effects to minority or low-income populations would result from the implementation of the proposed project.

12.10. Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 as amended (16 U.S.C. §1451-1464) requires Federal agencies to carry out their activities in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved State Coastal Zone Management Program. The aim of the act is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." The delegated authority for review of consistency in Washington State is WDOE. In compliance with State law, the City of Seattle has developed its own Shoreline Management Master Program under the State Shoreline Management Act. The Corps expects to be fully consistent with the enforceable polices of the City of Seattle's Shoreline Master Program. The Corps has initiated early coordination with the WDOE and will continue to coordinate with WDOE to identify the applicable state Coastal Zone Management Program (CZMP) enforceable policies for this project (see Appendix K). This early coordination will help determine what measures, if any, need to be taken so the project is consistent with the state's policies. The Corps has prepared a draft CZMA Consistency Determination during feasibility-level design phase according to the relevant city code and will submit a final consistency determination to WDOE for their review and concurrence. The final DPR/EA will include any concurrence letter the Corps receives regarding the consistency determination.

12.11. Treaties

In the mid-1850's, the United States entered into treaties with a number of Indian tribes in Washington. These treaties guaranteed the signatory tribes the right to "take fish at usual and accustomed grounds and stations . . . in common with all citizens of the territory" [U.S. v. Washington, 384 F.Supp. 312 at 332 (WDWA 1974)]. In U.S. v. Washington, 384 F.Supp. 312 at 343 - 344, the court also found that the Treaty tribes had the right to take up to 50 percent of the harvestable anadromous fish runs passing through those grounds, as needed to provide them with a moderate standard of living (Fair Share). Over the years, the courts have held that this right comprehends certain subsidiary rights, such as access to their "usual and accustomed" fishing grounds. More than de minimis impacts to access to usual and accustomed fishing area violates this treaty right [Northwest Sea Farms v. Wynn, F.Supp. 931 F.Supp. 1515 at 1522 (WDWA 1996)]. In U.S. v. Washington, 759 F.2d 1353 (9th Cir 1985) the court indicated that the obligation to prevent degradation of the fish habitat would be determined on a case-by-case basis. The Ninth Circuit has held that this right also encompasses the right to take shellfish [U.S. v. Washington, 135 F.3d 618 (9th Cir 1998)].

The project is in consultation with recognized Native American Tribes that may be impacted by the project, including usual and accustomed fishing or shellfish harvesting areas. The proposed project has been analyzed with respect to its effects on the treaty rights described above. Any tribal objections associated with the project will be resolved before the EA is finalized. We anticipate that:

1. The work will not cause the degradation of fish runs and habitat; and
2. The work will not impair the tribes' ability to meet moderate living needs.

12.12. Initial Environmental and Cultural Coordination

Preliminary Resource Agency and Tribal coordination was conducted during this phase of the study. Endangered Species Act consultation, Clean Water Act compliance, National Historic Preservation Act coordination, and NEPA documentation will be prepared during the design and implementation phase and will be completed ahead of soliciting any contract action for construction of execution of the project.

Federal, State, and local resource agencies along with Federally-recognized tribes were invited to attend a site visit during the feasibility phase. The purpose of the meeting was to solicit preliminary input on environmental and cultural topics for the tentatively selected plan. Invitees included the USFWS, NMFS, Muckleshoot Indian Tribe, Suquamish Tribe, Sauk-Suiattle Indian tribe, Snoqualmie Indian tribe, Tulalip Tribes, Yakama Nation, Duwamish Tribe (currently applying for Federal recognition), WDOE, WDFW, DNR, DAHP, and the City. Attendees to the 26 April 2013 meeting included the Corps, the City, USFWS, and WDOE.

Following the introduction to the project, questions and concerns focused on the need to move waterward and potential avoidance and minimization opportunities. Options discussed include planting the upper bank to the extent possible above the seawall or adjacent areas, removal of a portion of the northern riprap structure, and purchasing credit at a mitigation bank. Discussion also included consideration of placing wood on the beach in front of the structure or removing a potentially derelict outfall in the area. However, the concern was that removal of the pipe without replacement with some structure would cause a large change in how sediment accumulates in the area and any wood placement would require large anchors that had the potential to be quite impactful.

USFWS put forth the potential to do work outside of the typical windows recommended for fish, if work could be done during low tides and out of the water. Further discussion of the final plans will be needed to confirm this option. WDOE also stated that they felt the project would likely need an individual Water Quality Certification (as opposed to analogy to a Nationwide Permit) due to the waterward footprint change. This process can take up to one year to complete.

On April 9th, 2013 tribal coordination letters were sent out to the following Tribes informing them of the project: Tulalip Tribes of the Tulalip Reservation; Confederated Tribes and Bands of the Yakama Nation; Muckleshoot Indian Tribe; Sauk-Suiattle Indian Tribe; Snoqualmie Tribe; and Suquamish Indian Tribe. National Historic Preservation Act (NHPA) documentation will be prepared during the design and implementation phase and will include a cultural resources report and coordination with the Washington State Historic Preservation Officer and Tribes.

Refer to Appendix J for additional information regarding initial environmental and cultural coordination efforts.

13. DESIGN AND IMPLEMENTATION PHASE

13.1. Plan Implementation

Upon approval of this report, the City and Corps may initiate the design and implementation phase of the project. This phase will include completing final plans and specifications of the recommended plan, completing final environmental documentation, preparing and soliciting a construction contract, and completing construction of the project.

13.1.1. Project Partnership Agreement

A Project Partnership Agreement (PPA) must be signed by the City and Corps in order to complete design and initiate construction. The PPA will outline roles and responsibilities and will include cost sharing, LERRD, and maintenance requirements.

13.1.2. Cost Share

A detailed cost estimate for the NED has been prepared as part of the study. The sponsor has agreed to provide their share of funds through a combination of cash and work in-kind completed during the design phase, such as a site survey. Although there will be incidental shore protection benefits to the park area, the primary purpose and benefit of the project is to protect public infrastructure, and therefore, the cost share for design and implementation of the recommended plan is 65 percent Federal and 35 percent non-Federal. New recreational components for the park area are not expected to be included in this project but would be cost shared 50 percent

Federal and 50 percent non-Federal should the City request new features or upgrades within the park area and the Corps of Engineers approved construction of those features.

13.2. Final Design

During the design phase, the recommended plan will be advanced from a planning level of design to final plans and specifications ready for construction. Design will be completed in-house by the Seattle District and coordinated with the City of Seattle. District Quality Control (DQC) reviews will be scheduled and completed based on the schedule for design developed by the PDT and ahead of any external reviews to ensure that quality products have been developed. An Agency Technical Review (ATR) will be completed during the design phase and the 95 percent plans and specifications will undergo a biddability, constructability, operability, and environmental (BCOE) review conducted by the Seattle District. The ATR will be conducted by another Corps District and the team will be identified based on expertise in small scale coastal storm projects on the west coast and should include an environmental reviewer familiar with the Puget Sound region. Cost estimates will be maintained and updated as the design progresses and an Independent Government Estimate will be prepared ahead of contract bid openings.

Additional data collection and survey analyses will be conducted to confirm assumptions made during the feasibility phase, including but not limited to, topographic surveys, utility locates, and geotechnical investigations. A geotechnical investigation will be required to identify the type and distribution of foundation materials, to identify sources and characteristics of backfill materials, and to determine material parameters for use in design analyses. Specifically, the required data will be used to adequately and efficiently estimate the required pile depths, spacing, and size of the wall lagging, locate groundwater levels, estimate settlements, and identify any possible excavation problems. Testing may include but is not limited to grain size analysis, Atterberg Limit tests, determination of unit weight, moisture content, and determination of friction angle. Subsequently, the newly collected data will be used to adjust the soil properties used for the design, and to provide more accurate soil loading estimates for the structural design of the seawall. Utility locates will be essential to mapping and identifying potential risks associated with designs and construction techniques.

As part of the final design efforts, final NEPA coordination will be completed, including a final DPR/EA. Coordination through NEPA will identify the potential impacts and will help determine any mitigation required as a result of construction of the project. A project risk table will be developed and updated by the PDT as risks are identified and appropriate risk management strategies will be developed and coordinated at the appropriate levels.

13.3. Environmental Coordination

Endangered Species Act consultation with USFWS and NMFS and National Historic Preservation Act coordination with Tribes and SHPO is complete. Clean Water Act 401 certification and Coastal Zone Management Act consultation with WDOE has been initiated and will be concluded in the design phase. .

13.4. Design and Construction Schedule

The projected design and implementation schedule below is based on the assumptions and information documented within this report and is subject to change, as needed. The schedule also assumes that sufficient funding is available for the project.

Table 7. Design and Implementation Schedule

Milestone	Task Name	Projected Finish Date
CW150	Submit Federal Interest Determination Report to NWD	**21 February 2013 (A)**
CW040	Project Management Plan Approval	**28 February 2013 (A)**
CW170	Federal Interest Determination Report Approved	**04 March 2013 (A)**
CW035	Peer Review Plan Approved	**04 March 2013 (A)**
CW190	Conduct Alternative Formulation Briefing	**24 June 2013 (A)**
	Agency Technical Review of Draft Report	**August 2014 (A)**
	Public Review of Integrated Document	**31 December 2014 (A)**
CW170	NWD approval of Detailed Project Report	June 2016
CW130	Project Partnership Agreement Executed	August 2016
	Environmental Assessment/FONSI Complete	April 2017
	Plans and Specs Complete	April 2017
	Real Estate Certification	May 2017
	Construction Contract Ready to Advertise	May 2017
CC800	Construction Contract Awarded	September 2017
	Construction Begins	October 2017
CW450	Construction Physical Complete	February 2018
CW480	Notice of Project Completion	March 2018
	Project Fiscally Closed Out	July 2018

14. CONCLUSION AND RECOMMENDATION

14.1. Conclusion

This DPR/EA has identified problems and opportunities that are within the authority for Section 103 of the CAP and completed a determination of the federal interest in pursuing a project to provide protection to critical public infrastructure from coastal storm damages and preventing shoreline erosion. The NED plan meets all of the project objectives, reduces or minimizes potential adverse effects to the environment, and has the full support of the local cost-sharing partner, the City of Seattle. The NED plan will provide a long-term solution to reduce the risks associated with coastal storms in Puget Sound and will serve to protect the environment from potential impacts.

14.2. Recommendation

Based on the economic, engineering, and environmental evaluations completed as part of the study phase of the project, it has been determined that a project to protect critical public infrastructure and prevent negative environmental impacts is within the federal interest. Accordingly, the Corps of Engineers, Seattle District, recommends that the tentatively selected plan, as identified within the body of this report, be adopted and carried forward for further design and implementation pursuant to Section 103 of the Rivers and Harbors Act of 1962, as amended.

The estimated cost of the NED plan is $2.29 million. The federal proportionate share is estimated to be $1,488,000 while the non-federal proportionate share is estimated to be $801,000. Average annual net benefits are $174,000 with a total annual project cost of approximately $100,000, indicating a positive contribution to the nation's economic output by the project. Average annual benefits of the NED plan exceed the average annual cost by a ratio of 1.74 to 1.

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