LOWMAN BEACH PARK

Feasibility Study Report

Prepared for
Seattle Parks & Recreation Department

December 7, 2017

Photograph by Dept. of Ecology on 7/29/2016

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EXECUTIVE SUMMARY

The remaining 1950s-era concrete seawall at Lowman Beach Park has begun to fail and requires removal and/or replacement. Environmental Science Associates (ESA) has prepared this feasibility study for the Seattle Parks and Recreation Department (SPR) to investigate site conditions, develop alternative design concepts for the seawall and shoreline, and evaluate the relative advantages and disadvantages of each alternative suitable for selection of a preferred concept.

Site Background

Lowman Beach Park is located on Puget Sound in the Morgan Junction neighborhood in West Seattle and just to the north of Lincoln Park. The approximately 1.5-acre park is bordered to the north and south by private residential properties and to the east by Beach Drive. Park amenities includes a swing set, tennis court, gravel paths, a bench, lawn area and water access to Puget Sound. The approximately 300 feet of park shoreline is characterized by a 140-foot long concrete seawall at its north end, with the remainder of the shoreline composed of a gravel beach and vegetated backshore that was created in 1995 by removal of a 1930s-era seawall.

Major initial improvements to the park were completed by 1936 and included a comfort station (demolished in late 1980s), tennis court (remains), and stone-and-mortar seawall that extended along the entire shoreline. The north end of the original seawall failed and was replaced in 1951 with the existing concrete seawall; the southern end was removed in 1995 and replaced with a gravel beach and retaining wall that extends landward (return wall). The park currently supports a range of active and passive recreation activities including tennis, beach exploring, sunset watching, picnicking, walking, swimming, windsurfing, nature viewing, stand up paddle boarding, and kayaking among others.

Need for Seawall Replacement or Removal

Initial damage to the remaining 1950s-era segmented concrete seawall was noted in early 2015 near the location of an 18-inch Seattle Public Utilities outfall that had separated from the seawall. Subsequent slumping and movement of the seawall has continued to the present time and much of the remaining concrete seawall at Lowman Beach Park has begun to actively fail. Observations of the seawall's condition indicate loss of bearing material (erosion) beneath the seawall foundation that has contributed to tipping, cracking, and differential settlement of seawall segments. The existing seawall segments are subject to ongoing erosion and loss of passive resistance in front of the wall which may result in further failure. Remaining seawall segments do not have adequate retaining capacity, especially under seismic loading. Essentially, much of the seawall has reached the end of its useful life and needs to be removed or replaced.

Methodology & Key Findings

Technical studies were conducted and revealed a number of key considerations related to historical and archeological resources, ecology, coastal processes (geomorphology, erosion/accretion, sediment transport, shoreline evolution), geotechnical conditions, and structural design. Key findings are summarized below.

The original tennis court constructed by the WPA in 1936 remains onsite and in use. The court's position relative to the shoreline constrains the distance that the shoreline and new structures can be moved landward. If the tennis court is determined Historic Register-eligible, it is likely there would be constraints on altering the tennis court and its setting, or more likely that mitigation would be required for doing so. Otherwise, no significant archaeological resources were identified while digging test pits behind the seawall. Archaeological resources beneath the tennis court are unknown and should be investigated if the selected alternative includes court removal or alteration.

Natural ecological processes are currently lacking at Lowman Beach Park, providing opportunity for restorative actions. The existing mixed sand/gravel beach at the south end of the park supports both benthic organisms and recreational uses but is primarily composed of small to medium pebbles that are generally too large to provide suitable spawning gravel for forage fish that are prey for salmon. Opportunities to enhance the nearshore ecosystem function could be realized by seawall removal and replacement with intertidal beach and native marine riparian plantings.

Review of historical photos, survey, and numerical modeling reveals that shoreline processes at the park are complex and vary both spatially and through time. In general, properties to the north of the park and the northern half of the park itself appear to have experienced both long-term and short-term trends of erosion. From the limited data available, it appears that recent erosion rates (1994 to present) have been higher than historic rates (prior to 1994) at the north end of the park and at the property immediate north of the park. The year 1994 is the point at which relatively complete survey data become available. The data therefore generally support the observations and concern about erosion noted by property owners to the north of the park after the 1995 gravel beach creation. However, the data also suggest background erosion was occurring prior to 1994. Sufficiently detailed data were not available to draw further conclusions on historic versus recent erosion outside the immediate vicinity of the park.

Properties to the south of the park and the south end of the park itself appear to have experienced lower rates of historic erosion and have actually accreted (added) sediment from 1994 to present. The reversal from erosion to accretion can be largely attributed to the seawall removal and beach restoration completed in 1995 that restored natural beach processes and allowed the beaches to reach equilibrium with wave and tidal forces by accreting, rather than eroding. It is likely that some fraction of the sediment deposited at the south end of the park would have otherwise been distributed more broadly along the shoreline if the beach restoration had not occurred in 1995.

Due to the lack of both historical survey data and estimates of erosion trends outside of the park, estimating the actual effect of the beach restoration on properties to the north of the park requires substantial speculation.

The potential risk that any additional restored beach might also aggrade, as was experienced after 1995, and exacerbate adjacent erosion/accretion processes could be mitigated by 1) placing sacrificial beach nourishment material at the toe of the seawall at its north end during construction and 2) constructing the restored beach profile as far seaward as possible such that an erosion response is elicited after initial construction, rather than accretion as occurred after 1995. Constructing the beach in this manner and allowing it to erode would therefore contribute new beach sediments to the shoreline that could be transport to adjacent shorelines by waves and currents. The extents of the beach construction geometry would require more detailed analysis and design, including consideration of permitting and cost implications for the overbuilt beach.

Conceptual Alternatives

Informed by technical studies, three conceptual design alternatives were developed to remove and replace the existing seawall with various combinations of structures and beaches. The alternatives encompass the full range of options from preserving existing park upland landscape and uses, to transformation of the park to a primarily beach-oriented shoreline park. As a result, the alternatives differ with respect to impacts to cultural resources, improvements to ecology, change to coastal processes, construction cost, potential impacts, and future recreational use of the park as described below.

The *No Action Alternative* would almost certainly result in partial seawall failure, emergency response, and partial park closure within the next few years. This alternative is not preferred and does not provide benefits compared to other alternatives.

Alternative 1 would expand intertidal beach areas, while maintaining the tennis court with a seat wall. This alternative is advantageous because it preserves the primary existing recreation activities at the park, while increasing access to Puget Sound, improving ecological processes, and promoting resiliency to rising sea levels. Some slight improvement to coastal processes (sediment supply) could be realized at neighboring properties by allowing the restored beach to erode to its equilibrium position, thus supplying sediment to the littoral system. Grant funding sources could likely be sought and obtained to offset some of costs for this alternative. The beach would be designed to erode to an equilibrium condition and would require adjacent property owner agreement to allow beach compatible materials to be placed on their property to achieve the most beneficial outcome.

Alternative 2 would essentially revert the shoreline to a more natural state by setting the shoreline landward into the existing uplands and allowing for more adaptive capacity in the facing of rising sea levels. This alternative is advantageous because ecological processes would be substantially improved and beach access opportunities maximized. Excess excavated beach-compatible materials could be used as advanced beach nourishment for the park and to supply adjacent properties experiencing beach erosion. This alternative would necessitate removal of the WPA-era tennis court, likely require some mitigating signage, and would impact existing park uses. Grant funding sources could likely be sought and obtained to offset most of costs for this alternative. The beach would be designed to erode to an equilibrium condition and would require adjacent property owner agreement to allow beach compatible materials to be placed on their property to achieve the most beneficial outcome.

Alternative 3 would keep the park in its current state, but provide a more robust and reliable seawall replacing the existing failing wall. This alternative preserves the most upland areas behind the seawall, but also does little to address or improve access to the water, ecological function, coastal processes (e.g. erosion), and future sea level rise. Grant funding sources are not widely available for shoreline structure replacement when more restorative alternatives are feasible.

Conceptual construction costs estimates were developed for each alternative. Costs are expected to be very similar amongst the alternatives (with the exception of the *No Action Alternative* that was not estimated) and therefore do not provide substantial differentiation for selecting a preferred alternative.

Next Steps

The existing condition of the seawall requires some immediate actions, while the conceptual alternatives for removal and replacement are considered.

- Disconnect and divert the existing SPU outfall. Reconnection might further scour the seabed and exacerbate ongoing erosion, wall undermining, and accelerate wall movement.
- Coordinate with the property owner to the north to shore-up the cracked concrete block wall at the north property boundary.
- Isolate the existing seawall from public access, both above and below the seawall. As the wet season continues and soils become saturated wall failure is more likely and creates a potential life-safety risk for the public in the vicinity.
- Continue monitoring movement and condition of the seawall top and undermining at the toe. Be prepared to notify regulatory agencies of potential failure and need to implement emergency action. Conduct twice-yearly survey of beach topography in conjunction with ongoing wall monitoring.

Selection of the preferred alternative would benefit from:

- Evaluation of the relative merits of the alternatives and tradeoffs associated with each alternative

- Engagement with the public and adjacent property owners, in order to inform them of the technical findings and to inform selection of the preferred alternative concept for more detailed design development

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CHAPTER 1
Introduction

1.1 Study Purpose

The remaining concrete seawall at Lowman Beach Park has begun to fail and requires removal and/or replacement. Environmental Science Associates (ESA) has prepared this feasibility study for the Seattle Parks and Recreation Department (SPR) to investigate site conditions, develop alternative design concepts for the seawall and shoreline, and evaluate the relative advantages and disadvantages of each alternative suitable for selection of a preferred concept. Chapter 1 of this report summarizes the scope of this study, opportunities, and constraints considered in the analysis. Chapter 2 summarizes the results of technical studies that informed the conceptual design development. Chapter 3 provides descriptions of the three identified alternatives and the No Action Alternative, and Chapter 4 evaluates the advantages and disadvantages of each conceptual alternative. Chapter 5 summarizes the analysis and provides recommendations for next steps. Supplemental technical materials and details are provided in the attached Appendices.

1.2 Scope of Work

This Feasibility Study Report was developed in accordance with ESA's scope of work authorized by SPR in January 2017. ESA's scope of work specifically focuses on evaluating the removal and replacement of the existing seawall and excludes other park planning and programming elements not directly related. Conceptual alternatives developed and described herein are provided for planning purposes and require additional analysis, permitting, and design in a future phase of work.

1.3 Project Setting

Lowman Beach Park is located on Puget Sound in the Morgan Junction neighborhood in West Seattle (see Figure 1) and just to the north of Lincoln Park. The approximately 1.5-acre park is bordered to the north and south by private residential properties and to the east by Beach Drive. The recently constructed King County Murray CSO Control Facility is located east of the park and also includes facilities located beneath portions of the southern part of the park and adjacent street. Multiple outfalls are present in the offshore areas at both the north and south ends of the park, including an 18-inch Seattle Public Utilities stormwater outfall that penetrates the existing seawall above the existing beach. The approximately 300 feet long park shoreline is characterized by a low beach and a failing 140 feet long concrete seawall at the north, with the remainder composed of a gravel beach and vegetated backshore.

ESA understands that initial seawall damage was noted in early 2015 near the location of an18-inch Seattle Public Utilities outfall had separated from the wall. Subsequent slumping and movement of the wall nearest the outfall occurred in late 2015 has continued to the present time. SPU and SPR have been monitoring the wall periodically and including quarterly surveys in 2017. Wall movement continues to occur and a remedy is required.

1.4 Current Park Use

Park amenities includes a swing set, tennis court, gravel paths, a bench, lawn area (formerly used for construction of the adjacent King County Murray CSO Control Facility.) and water access to Puget Sound. According to a public survey conducted by the SPR in 2016, the park currently supports a range of active and passive recreation activities including tennis, beach exploring, sunset watching, picnicking, walking, swimming, windsurfing, nature viewing, stand up paddle boarding, and kayaking among others. The park provides views of the Olympia Mountains to the west, Lincoln Park to the south, and Alki Point to the north. Annual park events include viewing the Christmas Ships each December. Beach closures have occasionally occurred due to poor water quality following combined sewer overflow events (Lane 1980; Seattle Time 1959). which are presumed to improve in future given the recent completion of the adjacent sewer control facility.

SOURCE: King County Parcel Viewer 2017

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Figure 1

Site Map

CHAPTER 2
Technical Studies

ESA conducted a range of technical studies investigating historic and existing site conditions to inform the development of conceptual design alternatives. The following sections summarize the methodology and outcome of these studies. More detail can be found in the Appendices as referenced in this section.

2.1 History and Archaeology

2.1.1 Cultural Setting

Today's Lowman Beach Park is located within the ceded lands of the *Dkhw'Duw'Absh* (Duwamish) people. The Duwamish were signatories of the 1855 Point Elliott Treaty with the United States. Today's Duwamish people are enrolled in the Duwamish, Suquamish and Muckleshoot Tribes. Oral history and archaeological evidence demonstrates Native American people have lived in this region of the Puget Sound for thousands of years.

In 1851, non-Native settlement of Puget Sound began with the arrival of the Denny Party at Alki Point. At this time numerous Duwamish villages were located on the shores of Puget Sound and the riverbanks of the Duwamish. Duwamish people and non-Native settlers lived in close proximity during this time. Following the Treaty Wars of the mid-1850s, Native people were forcibly removed from their traditional lands to reservations established by the United States government. Some Duwamish people stayed in West Seattle but their homes were subject to arson as development by non-Native people increased (Thrush 2007:84-85).

During the 1920s ethnographer T.T. Waterman interviewed Native people to record place names within the Puget Sound region. This work identified eight locations along the shoreline between Duwamish Head and Brace Point alone (Hilbert et al. 2001; Thrush 2007; Waterman 1922). These include places with religious associations, outlets of streams, a prairie, an inundated area where cranberries and cattails were gathered, and a fishing location. In addition, several places within 0.25 mile are associated with oral tradition myths.

Among these locations is at Lowman Beach Park, where as Pelly Creek formerly joined the Puget Sound. This outlet is known in Lushootseed as *gʷal* or "capsized/to capsize", which is thought to be related to the conditions off shore and potential for canoes overturning (Hilbert et al. 2001:68; Thrush 2007:232; Waterman 1922:189). Having a name associated to this location suggests Lowman Beach Park is an area that has significance to the Duwamish people.

2.1.2 Previous Cultural Resources Investigations

Only four cultural resources surveys have been conducted within one mile of the project area (Dellert 2014; Kiers 2006; Nelson et al. 2011; Schultz et al. 2013). Three were carried out at Lowman Beach Park, however these survey areas excluded the tennis courts and seawall.

There are two known archaeological sites within one mile of Lowman Beach Park. The first is archaeological site 45-KI-1190, which is 140 feet east of the park. This site was dated to circa 1900-1920s and contained charcoal, square nails, ceramic tile, and glass bottles (Dellert 2014; Raff-Tierney 2014). The second is a burial site approximately 1.0 mile south near the Fauntleroy Ferry Dock (45-KI-1028).

Despite the lack of recorded archaeological sites, the project location is classified as Very High Risk for containing intact archaeological resources, according to the Washington State Department of Archaeology and Historic Preservation's Statewide Predictive Model (DAHP 2010). Further, it is located within the ceded lands of the Duwamish people and at the outlet of a small freshwater stream with associated Lushootseed name. Archaeological sites are commonly found along the beaches of Elliott Bay and, in particular, at the outlets of streams (DAHP 2017).

2.1.3 Lowman Beach Park

Today's Lowman Beach Park was originally established as Lincoln Beach Park. Located within the 1904 Lincoln Beach plat, it is sited on lands reserved for a park (Figure 2). The Lincoln Beach subdivision was platted by the Yesler Logging Company, who logged the area prior to platting (USGS 1897).

The park was established in December of 1909. The area was remote during the first decade of the 20th century but by 1912 a modest number of beachside single-family residences had been built to the north of the park and on the hill to the southeast (Figure 3). In April of 1925, the name was changed from Lincoln Beach Park to Lowman Beach Park to avoid confusion with the newly developed Lincoln Park, located just south at Point Williams. The park's new namesake was J.D. Lowman, who was an employee the Yesler Logging Company.

In 1927, a 30 feet by 14 feet comfort station (restroom building) was designed by L. Glenn Hall, landscape architect (Seattle Department of Parks 1927a). It was located above the beach at the park's center point and has since been removed (Figures 4 - 7). Additionally, an angled swing set was once located near the tennis courts (Figure 6 & 7).

In 1936 the SPR built a stone and mortar seawall (Figures 6 & 7) using federal grant funds from the Works Progress Administration (WPA). That same year the tennis courts were also constructed as a WPA-funded project. Between 1935 and 1939, Seattle undertook many infrastructure improvement projects using funding made available by the WPA. Projects were carried out across the SPR and local laborers were hired whenever possible (Phelps 1976:182-185). Other WPA projects in West Seattle were seeding the Highland Park playground, earthwork at the Duwamish Head Park (now Hamilton Viewpoint Park), and constructing the West Seattle

Golf Course (Eals 1987:200). The WPA was a national program created during the Great Depression to provide employment opportunities across the nation. Many of the projects completed by the WPA have been recognized as historically significant due to their association with this national program and its role in addressing the unemployment crisis of the 1930s. The tennis court has not previously been evaluated regarding eligibility for listing on national, state, or local historic registers.

The 1936 seawall originally extended across the entire shoreline of the park and featured a pair of steps connected to a platform at the seawall's center point (Seattle Department of Parks 1936). In 1950 the north portion of the original seawall began to fail, and in 1951 the portion of the seawall north of the steps was replaced and the portion to the south of the steps was reinforced with a concrete support along its base (Seattle Department of Parks 1951). In 1973, a combined sewer overflow outfall was constructed in the Park, necessitating closure of the tennis courts for several months (Seattle Times 1973). In 1994, the south portion of the 1936 seawall failed, and in 1995 a portion of the remaining seawall was replaced with a new concrete return wall and gravel beach restoration (Pascoe & Talley, Inc. 1995). It appears that the original seawall steps were also removed at this time. A portion of the 1951 construction is still extant, however, and a subject of this feasibility study. The seawall has not previously been evaluated regarding eligibility for listing on national, state, or local historic registers.

Since at least 1952, Lowman Beach Park has been a scheduled stop for the annual Christmas Ship program (Seattle Times 1952).

2.1.4 Geotechnical-Archaeological Field Investigation

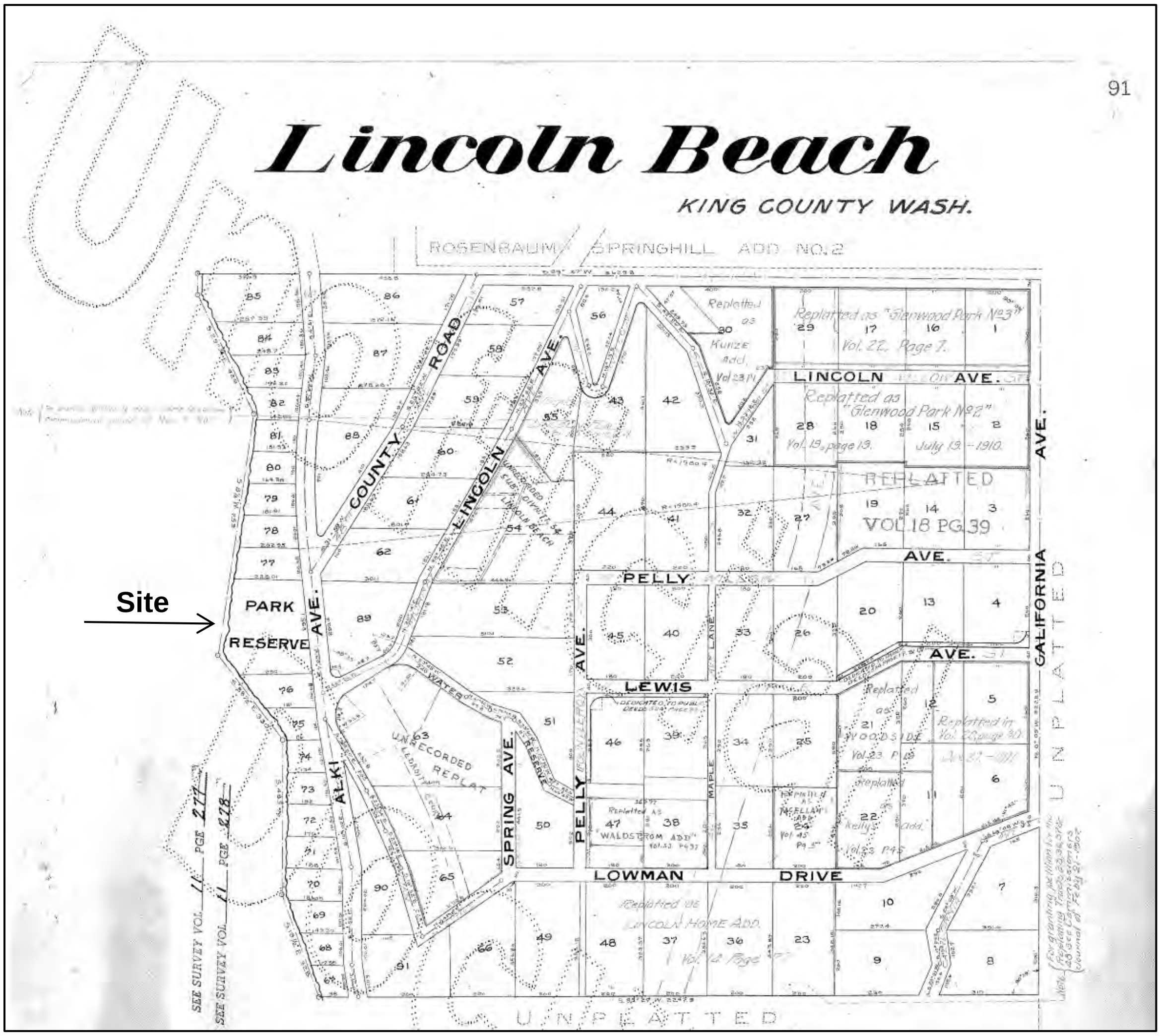
On May 3, 2017, ESA and Robinson Noble conducted archaeological and geotechnical and field investigations consisting of three mechanical test pits between the seawall and the tennis court (see Appendix C for figures depicting the test pits). Chris Lockwood, ESA Senior Archaeologist and Geoarchaeologist, observed the test pits and stratigraphy, examined spoils piles, and recorded historic and recent debris. No precontact artifacts or features were encountered.

Test Pit A, the northernmost test pit, contained well graded gravel with sand (fill) overlying gravelly sand (fill) overlying very stiff clay (likely Pleistocene-aged Lawton clay). Given the proximity of the test pit to two existing storm pipes, the fill is interpreted to have been placed during pipe installation. The fill contained an approximately 6-foot long length of dock or anchor chain and several fragments of lumber.

Test Pit B, the center pit, contained well graded gravel with sand (fill) overlying interbedded gravel with sand (uplifted beach) overlying very stiff clay (likely Pleistocene-aged Lawton clay). The top of the uplifted beach deposit contained a partially intact topsoil, marking the original "pre-fill" ground surface. The extreme west end of the test pit contained abundant, highly-corroded, ferrous cable, possibly the remains of kind of structural tieback, as well as concrete fragments. Test Pit B also contained trace amounts of highly-fragmented, clear, green, and brown bottle glass.

Test Pit C, the southernmost pit, contained well graded gravel (fill) overlying interbedded gravel with sand (uplifted beach) overlying very stiff clay (likely Pleistocene-aged Lawton clay). Similar to Test Pit B, the top of the uplifted beach deposit in Test Pit C contained a partially intact topsoil. The extreme west end of Test Pit C contained a moderate amount of highly-corroded, ferrous cable, as well as concrete fragments. Test Pit C also contained trace amounts of highly-fragmented, clear, green, and brown bottle glass.

Given the historic construction sequence near this portion of the seawall, with original construction in 1936, wall replacement in 1951, and placement and maintenance of storm pipes and other utilities, it is to be expected that some demolition debris remains on site within fill deposits. After more than a century of public recreational use, it is expected that additional fragments of beverage bottles, jars, cans, and other personal items have accumulated across the parcel through occasional, opportunistic disposal of these items. While such artifacts would reflect decades of public use of the park, it would be difficult if not impossible to establish a chronological date for many of the objects. Further, even if dates can be established, it is highly unlikely that specific items could be attributed to specific visitors or even to broad groups of visitors, and thus appear unlikely to contribute important historical information.



SOURCE: Wright (1904)

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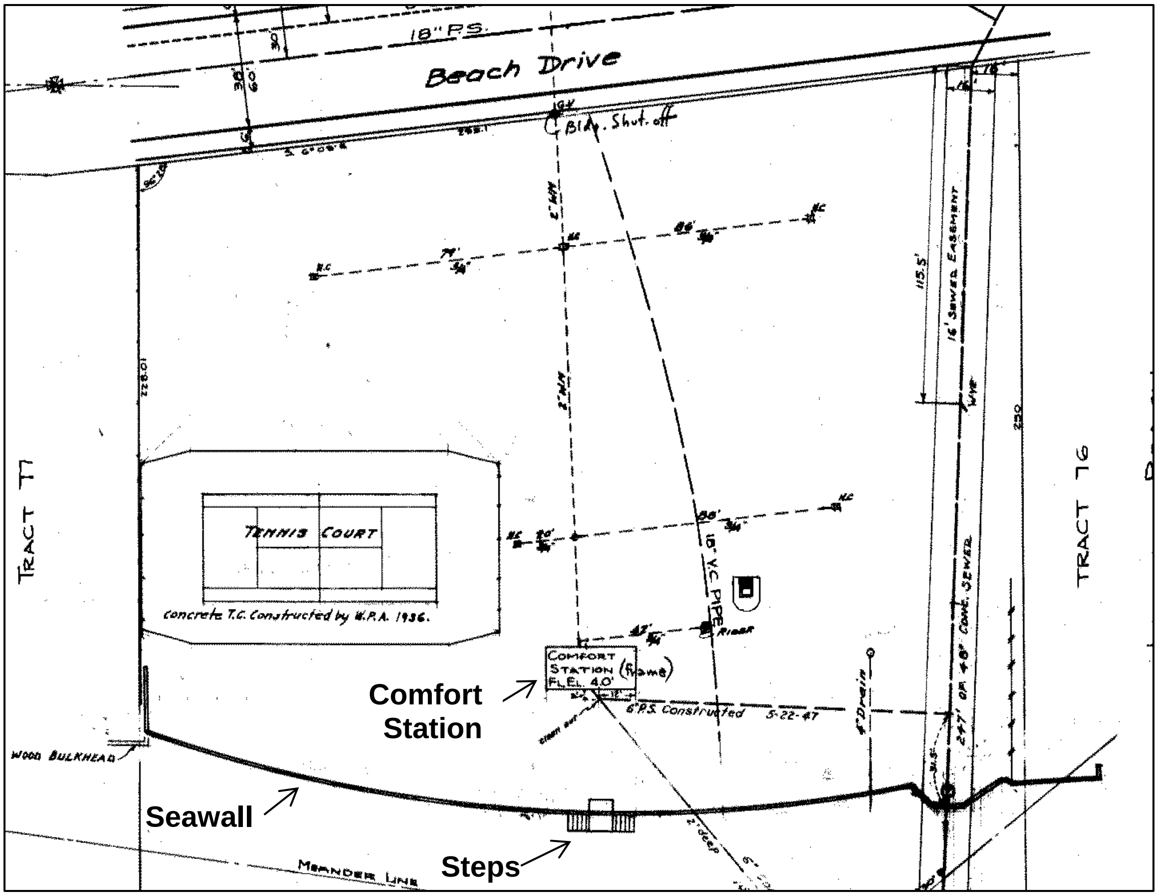
Figure 2

Plat of the Lincoln Beach neighborhood showing land reserved for park

SOURCE: Baist Map Company (1912)

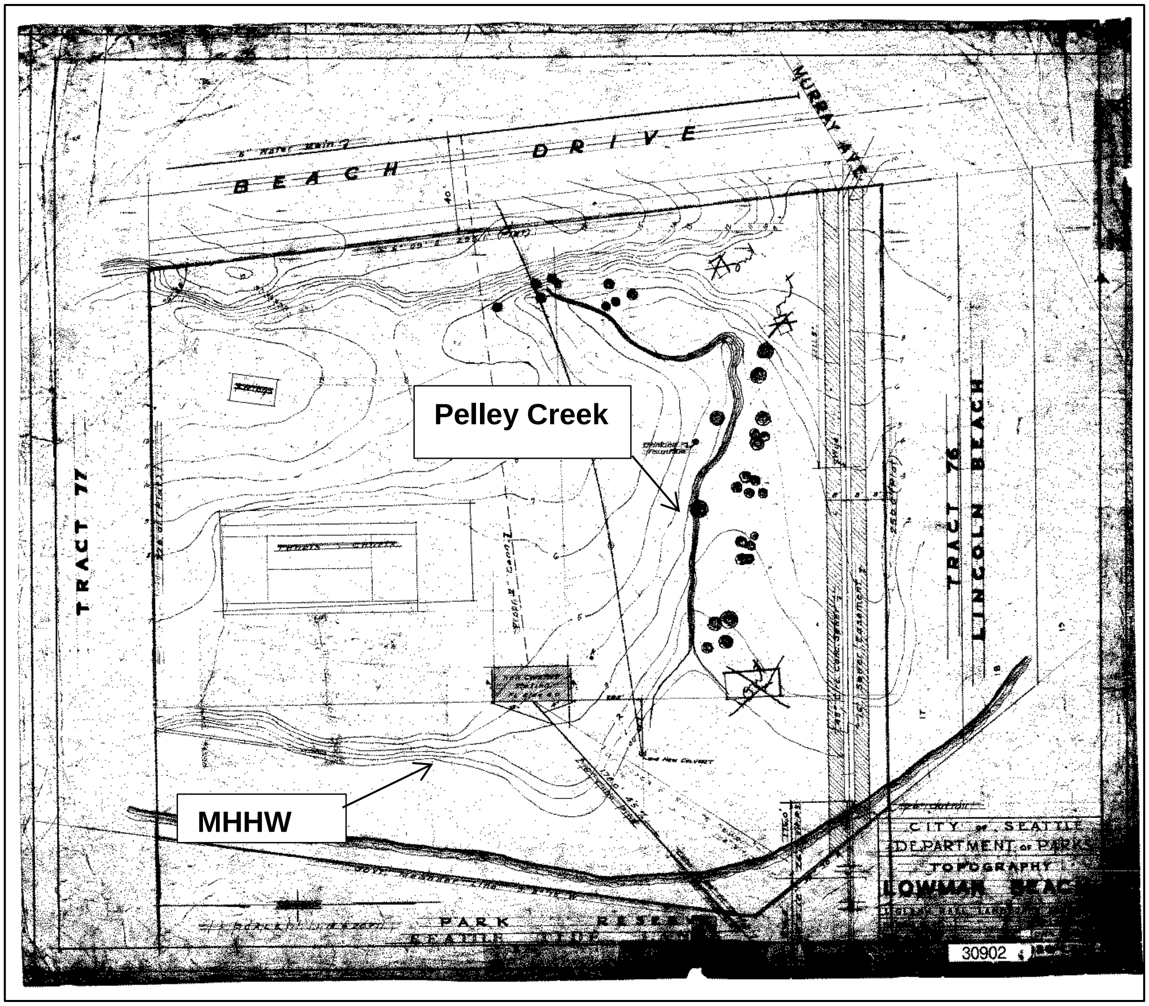
Lowman Beach Park Feasibility Study. D160292.00
Figure 3
Lowman Beach Park in 1912



SOURCE: Seattle Department of Parks (1956)

Lowman Beach Park Feasibility Study. D160292.00

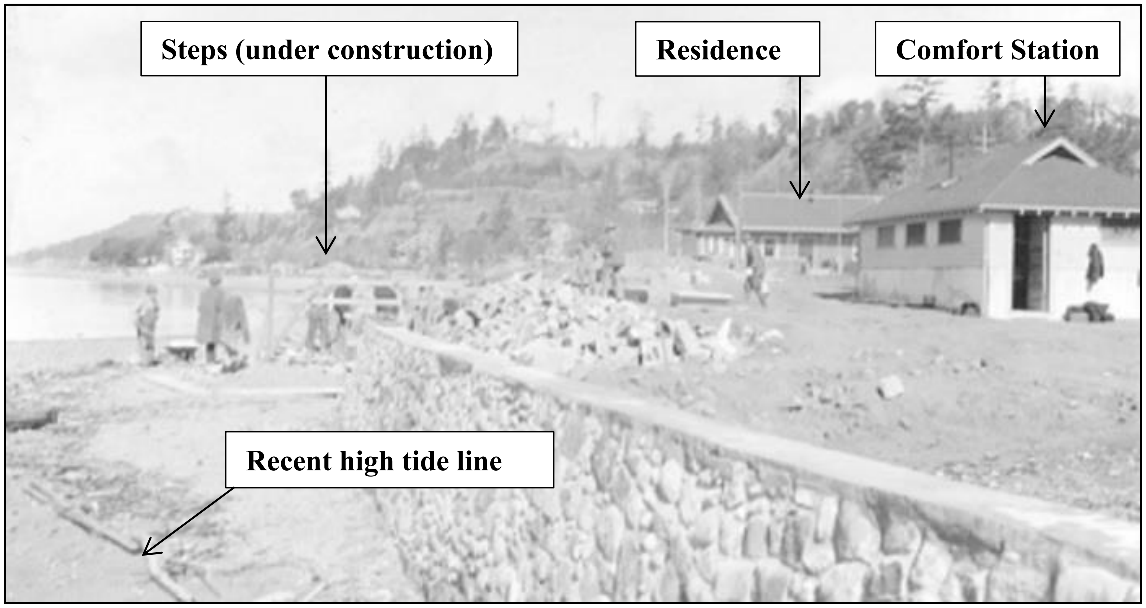
Figure 4
Detail of Lowman Beach Park amenities from as-built drawing circa 1956



SOURCE: Seattle Department of Parks (1927b)

Lowman Beach Park Feasibility Study. D160292.00

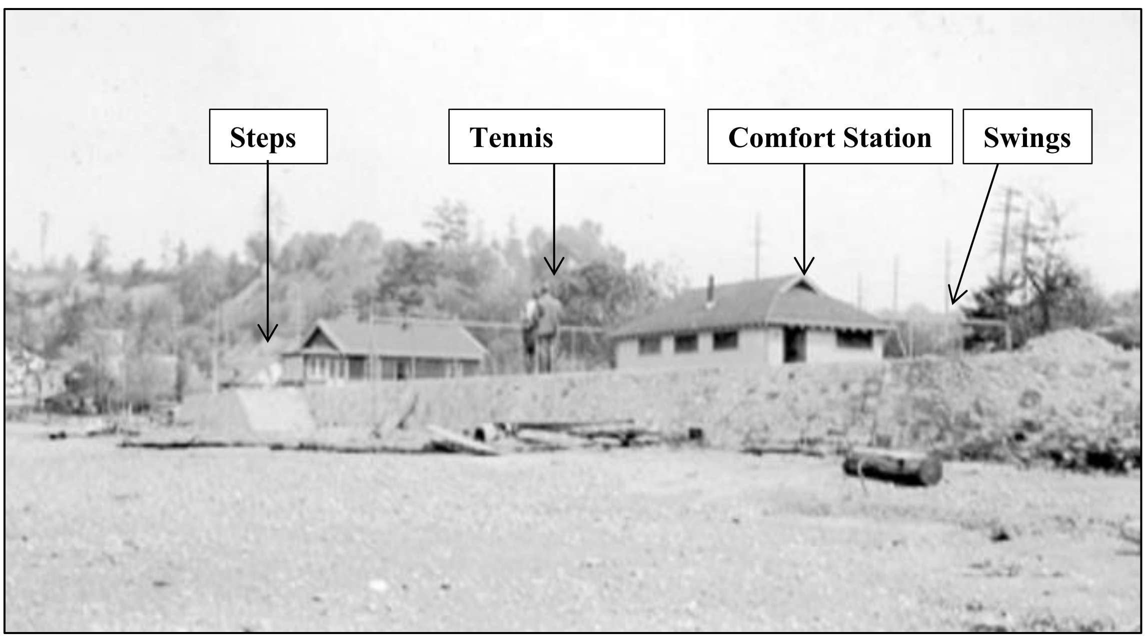
Figure 5
Topography of Lowman Beach Park in the1920s



SOURCE: Seattle Municipal Archives, Don Sherwood Parks History Collection, Item Number 29783

Lowman Beach Park Feasibility Study. D160292.00

Figure 6
Seawall and Comfort Station Under Construction in 1936



SOURCE: Seattle Municipal Archives, Don Sherwood Parks History Collection, Item Number 29784

Lowman Beach Park Feasibility Study. D160292.00

Figure 7
Seawall and Comfort Station Near Completion in 1936

2.2 Ecology

The nearshore ecosystem is the interface between land and sea where nutrients, detritus, and organisms from marine and terrestrial ecosystems occur through natural ecological processes such as movements of sediment, recruitment of large woody debris and beach wrack, tidal hydrodynamics, and freshwater inputs (Fresh et al. 2011). Development along the Puget Sound has had detrimental effects to these natural processes overall, but primarily in areas of shoreline armoring. Shoreline armoring disrupts the connectivity of nearshore ecosystem and imposes both landward and seaward impacts. For example, one ecological consequence in the presence of shoreline armoring is a lack of wood and beach wrack (non-woody vegetation). These materials support a wide array of invertebrate assemblages that are important to the diets of juvenile salmon and provide foraging opportunities for shorebirds and riparian birds such as song sparrow (Heerhartz 2013). Additional ecological consequences of shoreline armoring include impeding sediment transport (see subsequent section) which supports beach maintenance and forage fish habitat, exacerbation of beach erosion which damages habitat, and elimination of vegetation which shades the upper beach zone and provides organic inputs.

These natural ecological processes are currently lacking at Lowman Beach Park, providing opportunity for restorative actions. The seawall at the north end of the park provides an abrupt halt to nearshore ecological processes including sediment deposition from Puget Sound and upland sources, the establishment of marine riparian and backshore vegetation, and wood recruitment. The lack of these process may compound erosion in the vicinity of the project site, and further degrades available habitat. Some wood recruitment and vegetation establishment is present in the southern portions of the project site where the seawall was removed under a previous restoration program. However, habitat and ecological processes in this area may be further improved by more substantial planting riparian vegetation. Anthropogenic intrusion further prevents ecological processes from fully establishing.

Currently, native coastal vegetation is minimal except for a small area (< 1,000 square feet) of dune grass (Leymus sp.) interspersed with gumweed (Grindelia integrifolia) to the south. Below the ordinary high water mark (OHWM) several small patches of fleshy jaumea (Jaumea carnoa) are interspersed within the beached wood debris (driftwood). Other vegetation present occurs further away from the shore includes a few ornamental trees, native shrubs, and mowed grass, which provide little shade or habitat value. Shade is necessary to maintain cooler temperatures required by juvenile salmonids, spawning forage fish, and other aquatic organism. Areas of compacted soils, unable to support vegetation, are present in user-defined trails providing beach and seawall access. No wetlands were observed on site.

The beach is primarily composed of small to medium pebbles that are generally too large to provide suitable spawning gravel for forage fish like sand lance or surf smelt. This uniform sediment also lacks habitat complexity (i.e. large rocks or boulders) that can provide refuge for migrating juvenile salmon. No eelgrass or kelp is mapped by the Washington State Department of Natural Resources' (WDNR) Nearshore Habitat Eelgrass Monitoring Program (WDNR 2017). No forage fish spawning is mapped to occur at the site by the Washington State Department of

Fish and Wildlife's (WDFW) Forage Fish Spawning Map. However, suitable habitat for sand smelt spawning occurs approximately 0.25 mile to the south near Lincoln Park (WDFW 2017a). The WDFW Priority Habitat and Species (PHS) Program maps the presence of geoduck approximately 0.1 mile offshore (WDFW 2017b).

2.3 Coastal Processes

This section discusses coastal geomorphic processes at the project site and adjacent areas, including available data, water levels, wind, waves, sediment transport, and shoreline trends. This section summarizes site activities and establishes a physical processes baseline to evaluate the potential effects of proposed design alternatives. Table 1 summarizes the primary sources of data and information used in the study to quantify site evolution and change to the present time.

TABLE 1
PRIMARY HISTORICAL MAPS, PHOTOGRAPHS, AND ELEVATION DATA EMPLOYED

Year	Data Format / *Activity*	Source & Description
1877	Topographic Map (T-Sheet)	Contours by US Coast Survey indicate creek mouth
1894	Topographic Map	USGS quad with 50 feet contours
1904	Plat Map	Shows "Park Reserve" at project site
1912	Real Estate Map	Baist Real Estate Map notes "Park" at site
1927	Design Drawings	Tennis court and bathhouse, date approximate
1927	Topographic Map	City survey of site prior to park, date approximate
1931-56	Sewer Plan Drawing	Sewer, tennis court, and comfort station as-built
1934	Bathymetry	Soundings and depth contours offshore of site
1936-7	Aerial Photograph	Black and white photo from King County roads
1942	Aerial Photograph	US Army Corps of Engineers
1949	Topographic Map	USGS quad with 50 feet contours
1951	Seawall Repair Drawings	Erosion noted behind wall and at toe of wall
1952	Murphy Residence Seawall Drawings	Elevations at park boundary and north provided
1968	Topographic Map	USGS quad with 50 feet contours
1968	Aerial Photograph	USGS low resolution
1977	Oblique aerial photograph	Dept. of Ecology color photo
1977	Aerial Photograph	Color high resolution at mid tide
1983	Topographic Map	USGS 10 feet contours and shoreline from 1977-78
1990	Aerial Photograph	B&W High resolution at low tide
1990	Oblique aerial photograph	Medium resolution from Dept. of Ecology
1991	Aerial Photograph	Medium resolution at mid tide
1993	Satellite Based Topography	Does not cover water areas
1993	Aerial Photograph	High resolution showing sand fronting seawalls

1994	Topographic Map	Design drawings for beach restoration
1994	Ground level photo	Bernhard residence beach and seawall
2000	Oblique aerial photograph	High resolution from Dept. of Ecology
2000	LiDAR Survey Data	Puget lowlands survey from PSLC
2002	Aerial Photograph	USDA
2008	NOAA Bathymetry	Multi-beam survey of Puget Sound
2003	LiDAR Survey Blue/Green	Survey of limited tidelands from US Army Corps
2006	Oblique aerial photograph	High resolution from Dept. of Ecology
2009	Aerial Photograph	USGS
2014	Aerial Photograph	USGS
2015	Aerial Photograph	NAIP
2016	LiDAR Survey Data	Survey at low-tide from King County
2016	Oblique aerial photograph	High resolution from Dept. of Ecology
Feb 2017	City Topographic Survey	Laser scanner and traditional survey, 1-foot contours

2.3.1 Geomorphic Setting

Review of topographic maps (T-Sheets) from 1877 indicate that project site historically formed the mouth of Pelly Creek and its associated deltaic shoal, beaches, and vegetation along the shoreline. Historical photographs and maps from the 1920s imply a relatively low bank shoreline to either side of the creek mouth but no data were discovered that depict the pre-development condition of the shoreline and tidelands in great detail.

The project shoreline exists as part of the littoral cell[1] KI-5-1 (Johannessen et al. 2005), partially depicted in Figure 8. This cell is characterized by a high percentage of modified (e.g. armored) shorelines. Previous studies describe net longshore drift from south to north (Johannessen et al. 2005) in this drift cell, though detailed evaluations of drift at the project site scale are not available from prior analyses. Typical for beach processes in Puget Sound, sand and gravel is transported primarily by waves and wave-driven currents (Finlayson 2006), and less so by other factors. Historically, the Pelly Creek delta would have composed an accretion shoreform, evidence of which remains today in the shallow deltaic shoreform offshore of the park that can be seen in historic and recent bathymetry and photographs. Low lying feeder bluffs may have fed the beaches to the north of the site, historically.

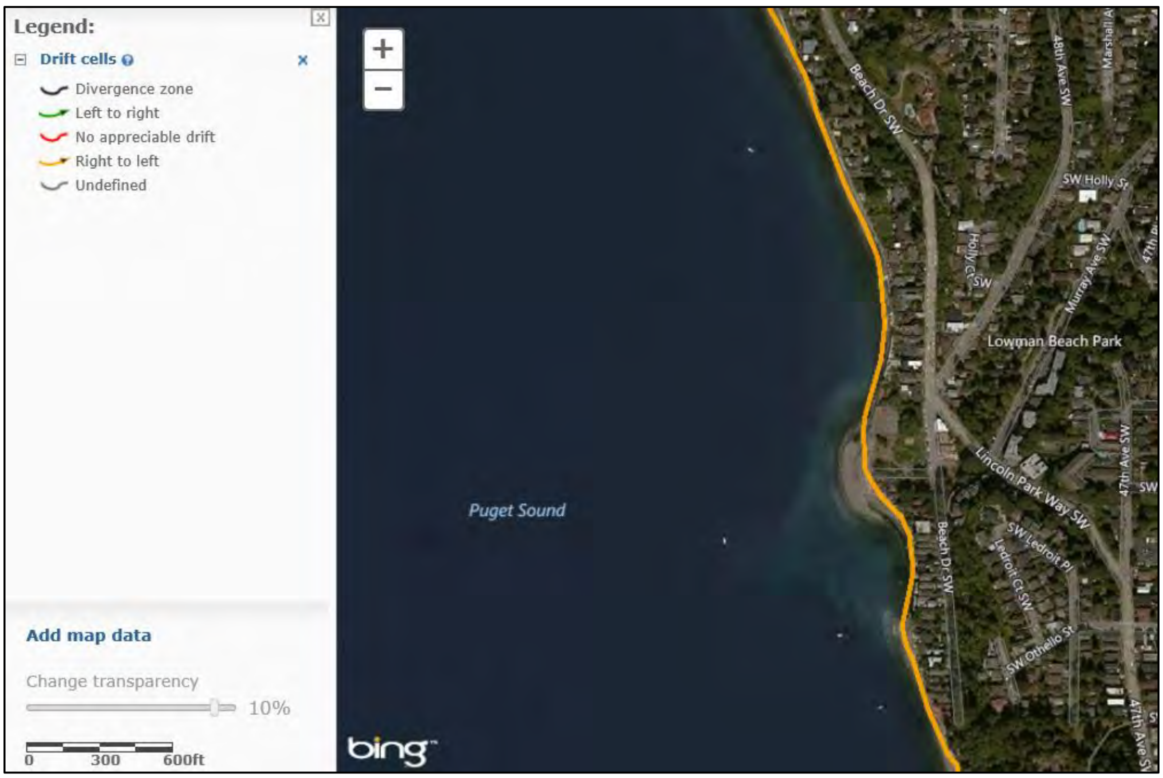
Existing Shoreline Condition

Beaches fronting the park are composed primarily of gravel and pebbles at the surface. Some minor surface sand lenses are present here and there on the beach face but appear to be transient features. Dynamic lobes of sediment forming to the north and south indicating seasonal response to waves from both the north and south directions. Beaches immediately to the north are lower

1 A reach of shoreline that contains a complete cycle of sedimentation including sources, transport paths, and sinks.

and coarser, with cobbles and grey clay exposed near the north end of the park. North of the park the presence of smaller grain size materials (sand, shell hash) is only present in the lee of stairs and landings that project out onto the beach. Approximately 700 feet north or the park, beach planform and profile becomes more natural and gradually transition to higher elevation and less coarse sediment. Bulkheads in this zone are lower and encroach relatively little onto the active beach compared to structures immediately north of the park.

To the south of the park, beaches are backed by bulkheads but are also more sheltered from southerly waves by Point Williams. These beaches are composed of a higher percentage of sand and smaller gravel, becoming sandier south and east of the park before transitioning to a bulkhead-backed low beach. This low beach joins the beaches at the north end of Lincoln Park which are composed of sandy gravel and have a relatively natural beach profile, despite a riprap-armored in the upper backshore near the trail.



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SOURCE: WA Department of Ecology, Coastal Atlas

Figure 8
Partial depiction of drift cell KI-5-1, with drift from south to north

Historic and Present Sediment Supply

Historically, eroding shoreline bluffs in the south of the drift cell supplied sediment to the drift cell, thus maintaining and replenishing beaches. Bluff erosion is estimated to account for 90 percent of sediment supply to Puget Sound Beaches similar to the project site. Sediment at the site would also have been historically supplied by Pelly Creek and other small drainages within the drift cell. Creeks do not presently discharge directly into Puget Sound or convey sediment in a natural manner. Bulkheads, seawalls, and watershed modifications have essentially cut off new natural sediment supply to the beaches within the drift cell, and at Lowman Beach Park since about 1930. Thus the littoral cell is essentially maintained by those sediments present on existing beaches or materials placed artificially. Estimates of sediment supply quantities and transport rates are not available from previous studies.

General Effects of Shoreline Armoring

Numerous studies demonstrate the observed effects of shoreline armoring with bulkheads and seawalls on physical beach processes (MacDonald et al. 1994, USGS 2009, NRC 2009, Johannessen et al. 2014). Effects generally include the following:

- Direct loss of beach area by placement of structures
- Downdrift impacts due to sediment impoundment and disruption of transport
- Substrate coarsening due to higher wave action and sediment supply
- Beach profile lowering and narrowing due to passive (e.g. background) erosion

All of the above have been observed at Lowman Beach Park and adjacent properties, particularly to the north of the park. MacDonald et al (1994) conclude that the location of the seawall relative to the ordinary high water mark (e.g. typical action of waves) is a primary factor determining the relative effect on physical processes. Structures located further seaward, where wave action is stronger and more frequent, cause greater disruption to physical processes. Bulkheads and seawalls interfere with natural wave dissipation and run-up, obstruct natural erosion and deposition of gravel and sand by preventing backshore development through berm formation, and restrict the dynamic movement of the mixed sand-gravel beach profile that changes with wave and tidal conditions. Structures located landward of the typical action of waves, however, typically have little to no effect on physical processes.

Experience at other Seawalls in West Seattle

As evidenced by the body of scientific research, experience at the project site, and adjacent areas in West Seattle, erosion tends to occur in the presence shoreline structures that interfere both with sediment supply and sediment transport. At nearby Lincoln Park to the south, degradation of the beach in front of the historic seawall (built circa 1936) resulted in seawall undermining by the 1950s, frequent spot repairs and underpinning, and eventually a large scale beach nourishment project was completed by the U.S. Army Corps of Engineers in 1988 by placing sediment offshore of the seawall. Periodic beach nourishment (1994, 2002, 2010) has been required to supplement the lack of natural sediment supply and maintain the unnatural position of the shoreline at Point Williams resulting from historic structures. There remains some debate whether the seawall at Lincoln Park exacerbated the erosion, or whether the seawall was undermined by natural background erosion. In either case, seawalls located on shores that naturally erode (which are most shores in Puget Sound) are subject to eventual scour and undermining. Note that shorelines at Lincoln Park located north of Point Williams have required relatively little maintenance and repair, owing to less exposure to waves from the south and position and orientation of the structures that are in relative equilibrium with wave conditions and shoreline planform.

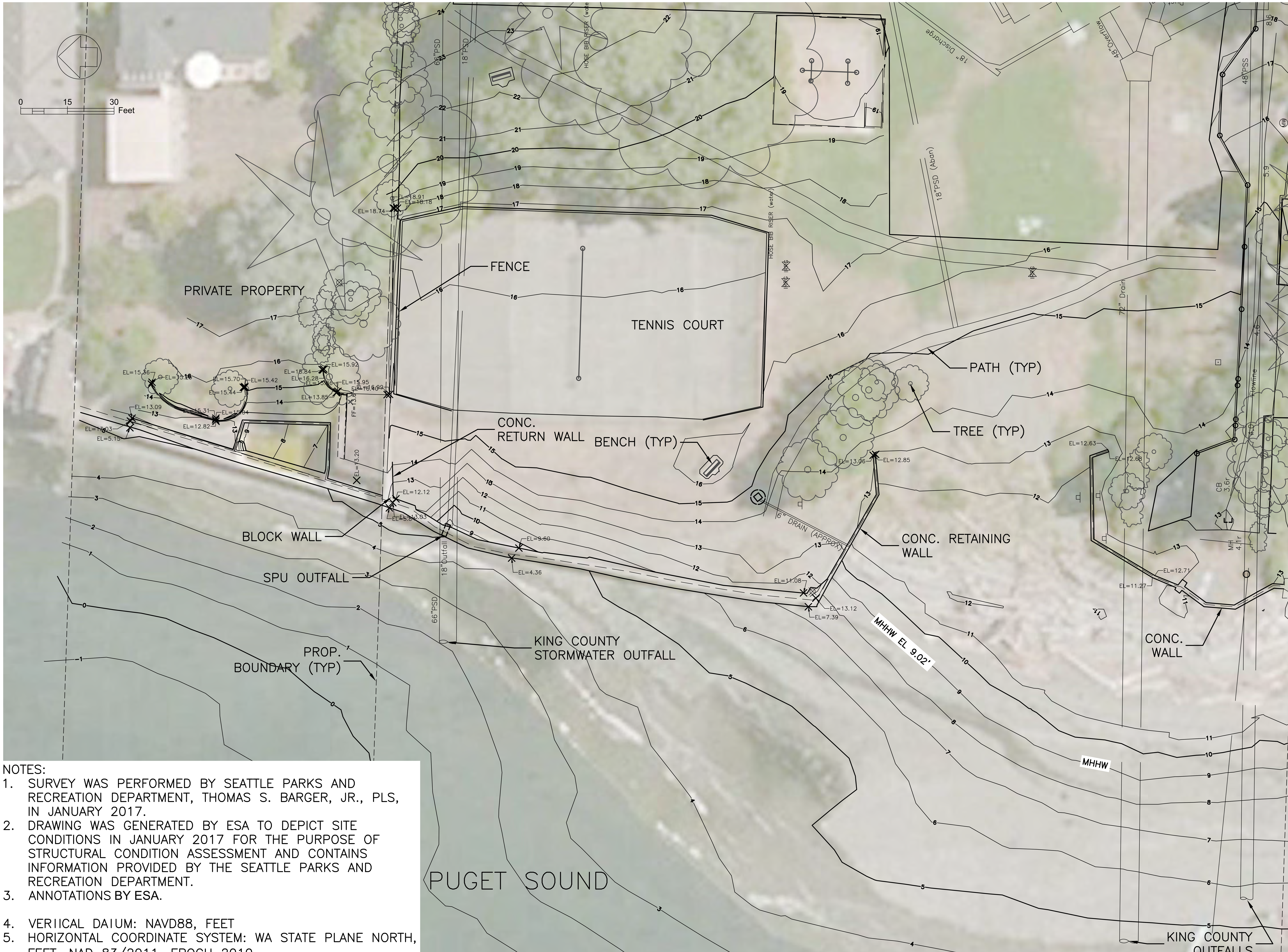
At Emma Schmitz Park, approximately 1.5 miles to the north, undermining and overall deterioration of the 90-year old seawall will soon lead to replacement with a soldier-pile type seawall. Studies by the US Army Corps of Engineers (USACE) attribute a previous failure in 1998 to a combination of sediment scour since original construction in 1927 and gradual degradation of the structure due to its age (USACE 2014). The remaining portion of intact seawall would be subject to similar failure that occurred in 1998 and will be replaced in the next few years to protect significant sewer infrastructure behind the wall.

2.3.2 Topography and Bathymetry

ESA relied upon existing public data and survey performed by the SPR in 2017 to characterize existing site elevations. The survey was limited to the park and immediately adjacent properties. Survey extended offshore to the -2.0 feet NAVD88 elevation contour (approximately Mean Lower Low Water). Figure 9 provides the existing site basemap developed from SPR provided data. Other sources of topographic information are summarized in Table 1. Note that aerial LiDAR survey data were available for years 2000, 2003, and 2016 but the coverage were very sparse north of the park and not deemed suitable for use in those areas. LiDAR data have a vertical accuracy of about ±0.5 feet and therefore are not nearly as accurate as traditional surveys performed by SPR.

2.3.3 Sediment Size & Distribution

ESA observed widely variable sediment size distributions alongshore and offshore of the project site. Sediments generally coarsen from south to north, with sandy gravel at the south end of the park transitioning to larger gravel and cobble at the north end of the park. Coarse surface gravels compose the lower foreshore and offshore areas out to MLLW. Beaches north of the park are characterized by large gravel and cobble at the surface, and in some cases underlain by grey clay. Some pockets of sand and smaller gravel are present north of the park in the lee of concrete steps and ramps that protrude out from seawalls. Beaches south of the park generally consist of smaller surface gravel and higher percentage of sand. Figure 10 depicts typical surface sediment size from north (left) to south (right) in the park vicinity. In surface sediments dominated by gravel, sand mixed with gravel, silt, and shell can typically be found just below the surface.



NOTES:

1. SURVEY WAS PERFORMED BY SEATTLE PARKS AND RECREATION DEPARTMENT, THOMAS S. BARGER, JR., PLS, IN JANUARY 2017.
2. DRAWING WAS GENERATED BY ESA TO DEPICT SITE CONDITIONS IN JANUARY 2017 FOR THE PURPOSE OF STRUCTURAL CONDITION ASSESSMENT AND CONTAINS INFORMATION PROVIDED BY THE SEATTLE PARKS AND RECREATION DEPARTMENT.
3. ANNOTATIONS BY ESA.
4. VERTICAL DATUM: NAVD88, FEET
5. HORIZONTAL COORDINATE SYSTEM: WA STATE PLANE NORTH, FEET, NAD 83/2011 EPOCH 2010

VERIFY SCALE 0 1"

BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REVISIONS			
NO.	DESCRIPTION	BY	DATE
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5			

PREPARED BY: ESA, 5309 Shilshole Ave. NW, Seattle, WA 98107, P: (206) 789-9658, F: (206) 789-9684

PREPARED FOR: SEATTLE PARKS AND RECREATION

SHEET TITLE: EXISTING BASEMAP

PROJECT: LOWMAN BEACH PARK FEASIBILITY STUDY

APPROVED	
DESIGNED	J. DARNELL
DRAWN	E. BARTOLOMEO
INCHARGE	J. DARNELL License XXXX
SCALE	AS SHOWN
ESA JOB #	XXXX
PROJECT #	D160292.00
DATE	APRIL 1, 2017
SHEET	FIGURE 9

A. Private seawall toe cobble north of park

B. Gravel upper foreshore at wing-wall

C. Gravel backshore at south end of park

D. Exposed clay & cobble at north end of park

E. Small gravel foreshore and wrack

F. Gravel foreshore in central beach

G. Quarry spalls at north park boundary

H. Cobble/gravel lower foreshore at park

I. Sandy beach 165 feet southeast of park

SOURCE: ESA 2017

Figure 10
Sediment Size & Distribution

2.3.4 Water Levels

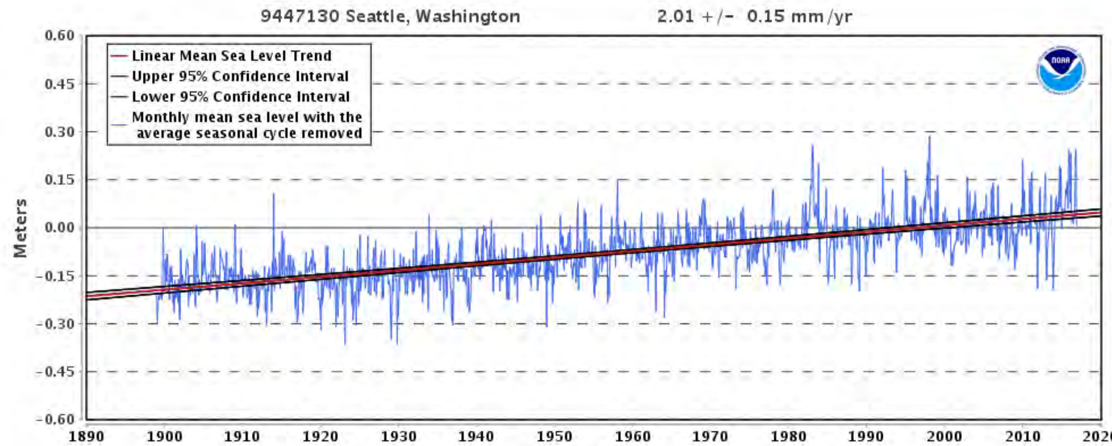
The Seattle tide gage (NOAA Station 9447130) located in Elliott Bay provides representative tide level data for the project site. The gage is tied into the SPR's NAVD88 datum and has established tidal datum relationships provided in Table 2. The greater diurnal tide range at this location is 11.36 feet. Extreme tides rise approximately three feet above MHHW.

TABLE 2
TIDAL DATUMS IN SEATTLE, WA (STA. 9447130, EPOCH 1983-2001)

Tidal Datum		Elevation, feet NAVD88
Highest Observed (1/27/1983)[1]	HOT	12.14 (4:36 AM)
Highest Astronomical Tide (1/12/1997)	HAT	10.92 (3:36 PM)
Mean Higher High Water	MHHW	9.02
Mean High Water	MHW	8.15
Mean Tide Level	MTL	4.32
Mean Sea Level	MSL	4.3
Diurnal Tide Level	DTL	3.34
Mean Low Water	MLW	0.49
North American Vertical Datum	NAVD	0.00
Mean Lower Low Water	MLLW	-2.34
Lowest Astronomical Tide (6/22/1986)	LAT	-6.64 (6:36 PM)
Lowest Observed (1/4/1916)[1]	LOT	-7.38 (0:00 AM)

1. The highest and lowest observed tide data is based on the recorded 6 min measurements.

Linear mean sea-level trends at the Seattle tide station tide gauge have been calculated by NOAA between 1899 to 2016. The trend shows an increase in relative sea-level of approximately 2.01 ± 0.15 mm/year which is equivalent to a relative increase of 0.66 feet over 100 years. The available tidal data at Seattle were used to develop a tide time series that was corrected (normalized) for historic sea-level rise. To estimate present day flood risk, the trend in historic water level data was removed according to this absolute sea-level rise rate (Figure 11). Water levels in the past were increased by the historic sea-level rise rate multiplied by the number of years before the present. Raising the historic elevations and detrending the data removes the effects of lower historic sea levels and thus provides an unbiased way to compare the effects of individual extreme water level events at present sea levels and into the future.



SOURCE: NOAA 2017

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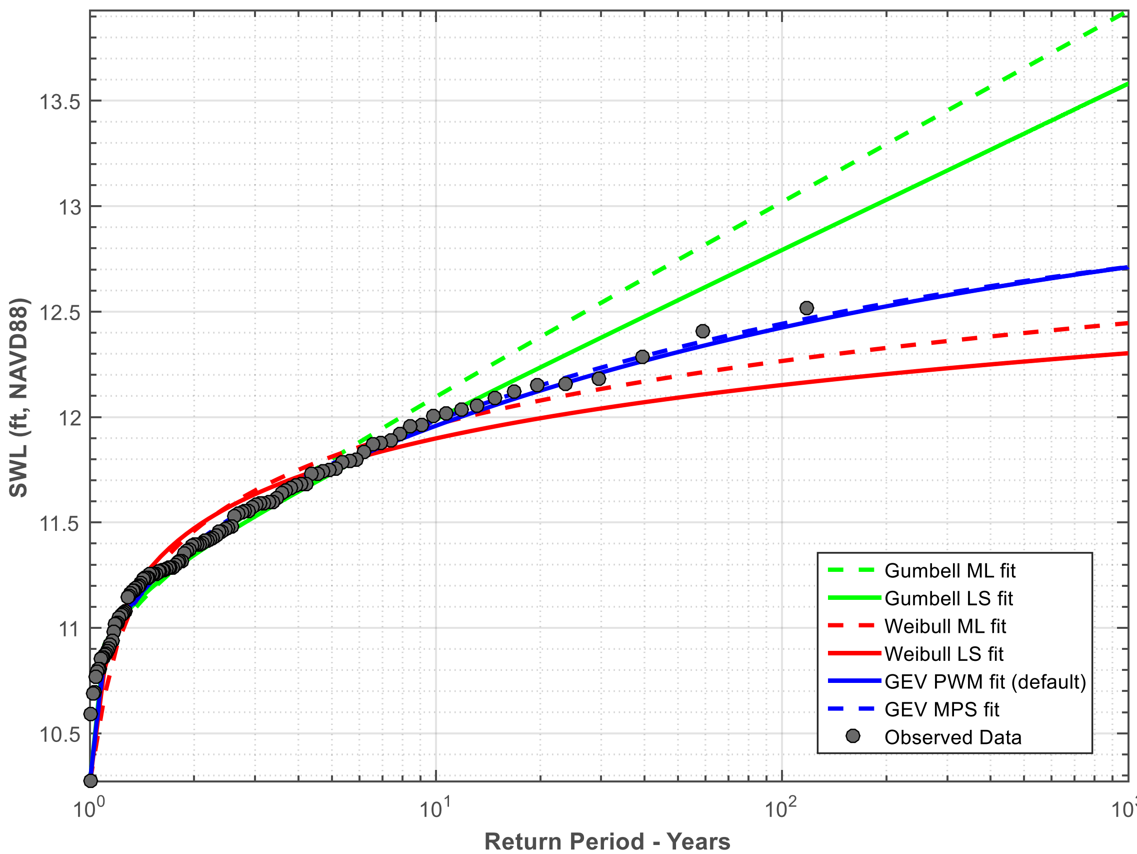
Figure 11
Monthly Mean Sea Trend from 1899 to 2016 at Seattle, WA

An extreme value analysis of 118 years of the recorded water levels from 1899 to 2016 was conducted based on the detrended tide data at the Seattle tide station. From the detrended time series, the maximum still water level elevation from each year was obtained and fit to a Gumbel, Weibull and the General Extreme Value Distribution (GEV) as shown graphically in Figure 12. Several distributions are examined in order to find the best distribution for the data set. For this case the GEV distribution provides the best fit to the majority of the extreme events. Table 3 summarizes the extreme SWLs obtained from the GEV distribution based on the detrended tide data.



SOURCE: WA Department of Ecology, Coastal Atlas

Lowman Beach Park Feasibility Study. D160292.00

Figure 12
Detrended still water level extreme value analysis for Seattle, WA

TABLE 3
EXTREME STILL WATER LEVEL VALUES FOR PRESENT DAY SEA LEVELS

Return Period (years)	**Elevation, feet NAVD88**
1	10.3
2	11.4
5	11.8
10	12.0
20	12.1
50	12.3
100	12.4

Future Sea Level Rise

Future sea level rise rates are inherently uncertain. However, the National Research Council's (NRC 2012) report on *Sea-Level Rise for the Coasts of California, Oregon, and Washington* serves as a starting place to consider sea level rise values for planning and conceptual design purposes (Table 4). Projected future sea-level rise by 2100 (roughly 80-year planning horizon) ranges from approximately 4 inches to 4 feet. For the purpose of this analysis and comparison of alternatives, the mid-range projection is considered. This represents a roughly three-fold increase in sea levels rise rates compared to the long term historic linear rates measured in Seattle. The effects of sea-level rise over a defined planning horizon will need to be considered further in detailed design and permitting phase of the project.

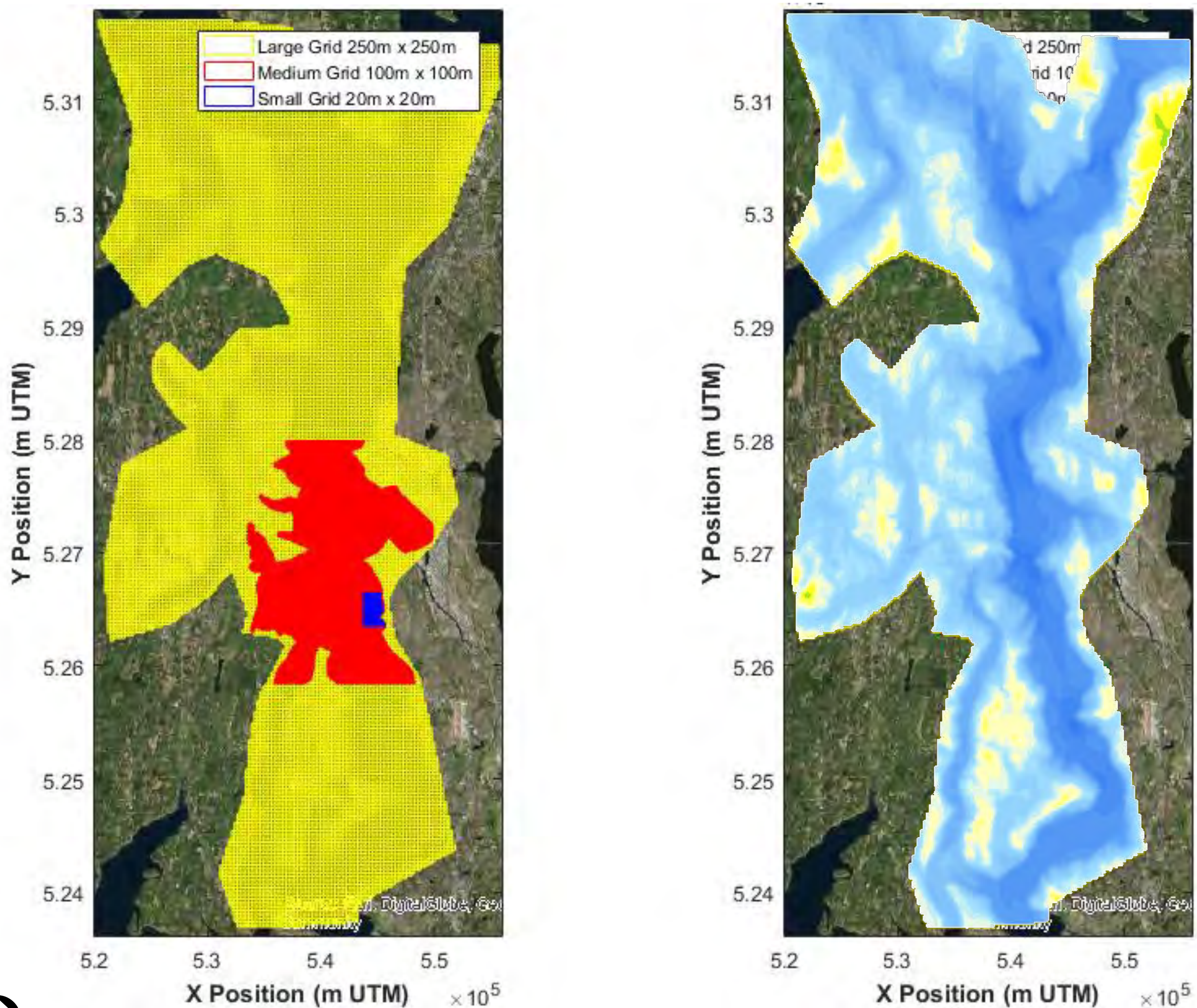
TABLE 4
POTENTIAL SEA LEVEL RISE SCENARIOS BY NRC(2012)* FOR SEATTLE IN INCHES

	2030	2050	2100
*Low end of range	-1.5	-1.0	3.9
Historic Linear Trend	1.0	2.6	6.6
*Mid-Range Projection	2.6	6.5	24.3
*High end of range	8.9	18.8	56.3

Mid-range Projection = A1B scenario, Low = B1 scenario, High = A1FI scenario

2.3.5 Waves

Wind waves are the primary driver of sediment transport on Puget Sound beaches, however wave measurements are not available at the project site. Therefore, ESA employed numerical methods to simulate wave conditions in the vicinity of Lowman Beach Park. To model wind-waves at the site, ESA applied the industry-standard SWAN model (Deltares 2011). Modeling was accomplished by developing three scaled grids of Puget Sound (Figure 13) and the project area. The largest SWAN grid accounts for wave growth and propagation throughout Puget Sound, while the smaller grids simulate the localized effects of bathymetric variation and wave sheltering. Example modeling results for winds from the north and south cases are provided in Figure 14.

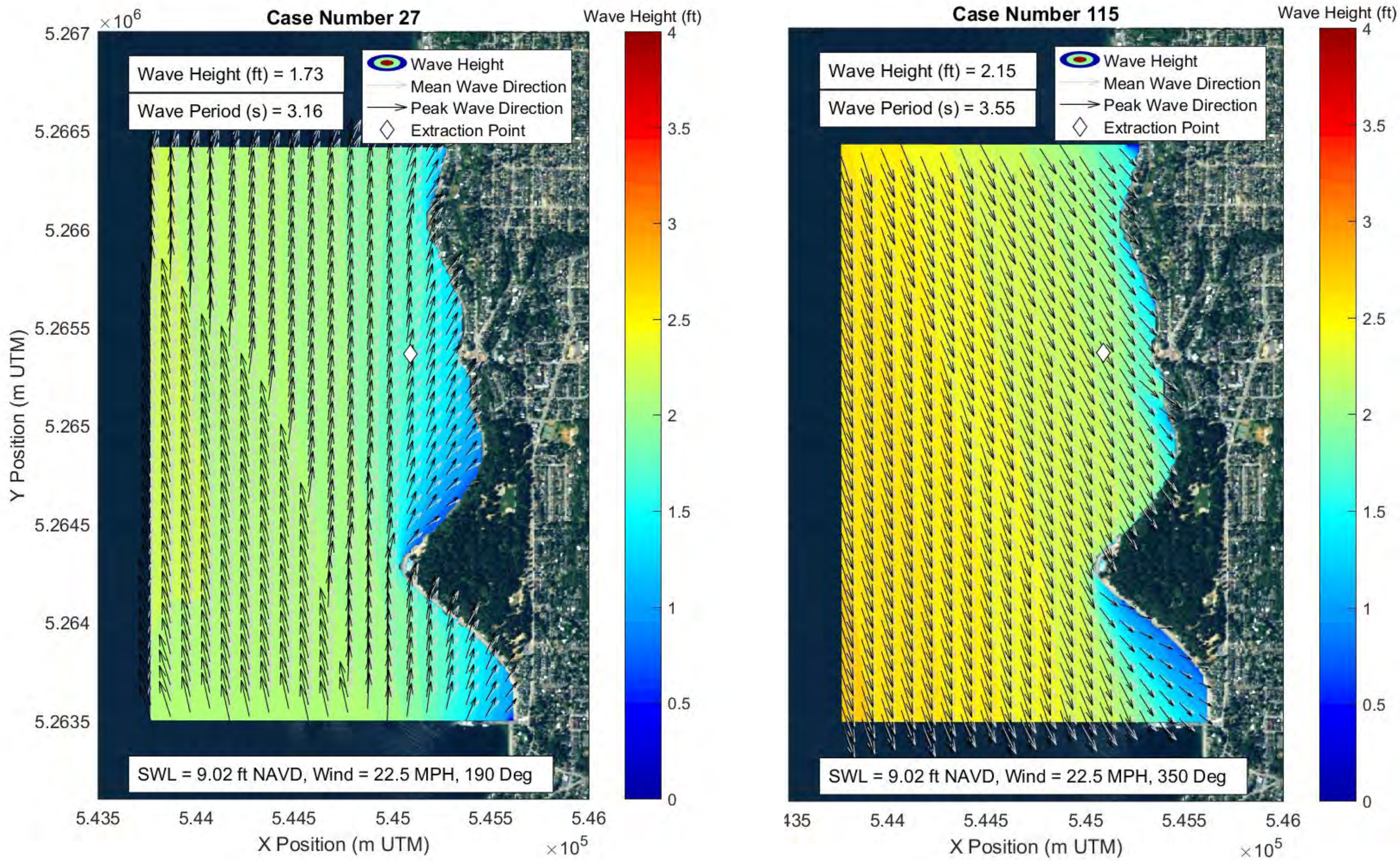


NOT TO SCALE

SOURCE: ESA 2017

Lowman Beach Park Feasibility Study. D160292.00

Figure 13
SWAN Wave Model Grids Coverage (left) and Bathymetry (right)



(A) Waves from South

(B) Waves from North

N NOT TO SCALE

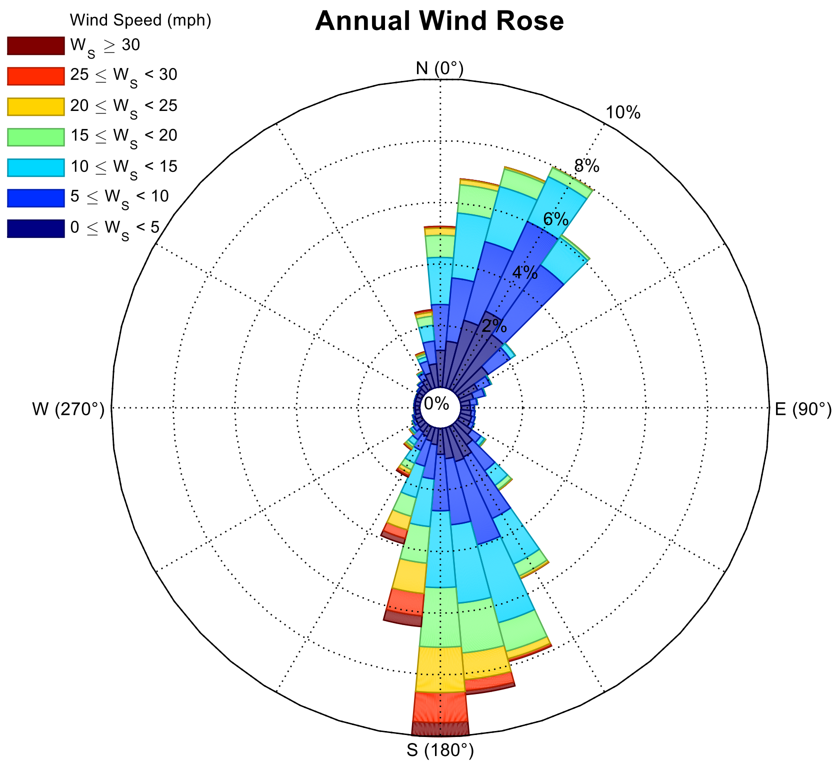
SOURCE: ESA 2017

Lowman Beach Park Feasibility Study. D160292.00

Figure 14

Example Wave Model Results for Winds from South (left) and North (right)

Winds measured at West Point (WPOW1) in Seattle, WA, from 1984 to 2016 were analyzed and applied as input to model the full range of wind speeds and wind fetch directions generating waves in central Puget Sound. Figure 15 presents the wind rose at West Point, illustrating the dominant wind (and waves) from and north and south directions. Wave model results were extracted offshore of Lowman Beach Park for the full range of wind speed and directions (more than 100 cases). These cases were then compiled to generate a 30-year simulated wave time series offshore of Lowman Beach Park (Figure 16). The accuracy of the model was verified by comparison with limited wave measurements offshore of West Point in Puget Sound in 1993 and 1994.



SOURCE: NDBC source data.

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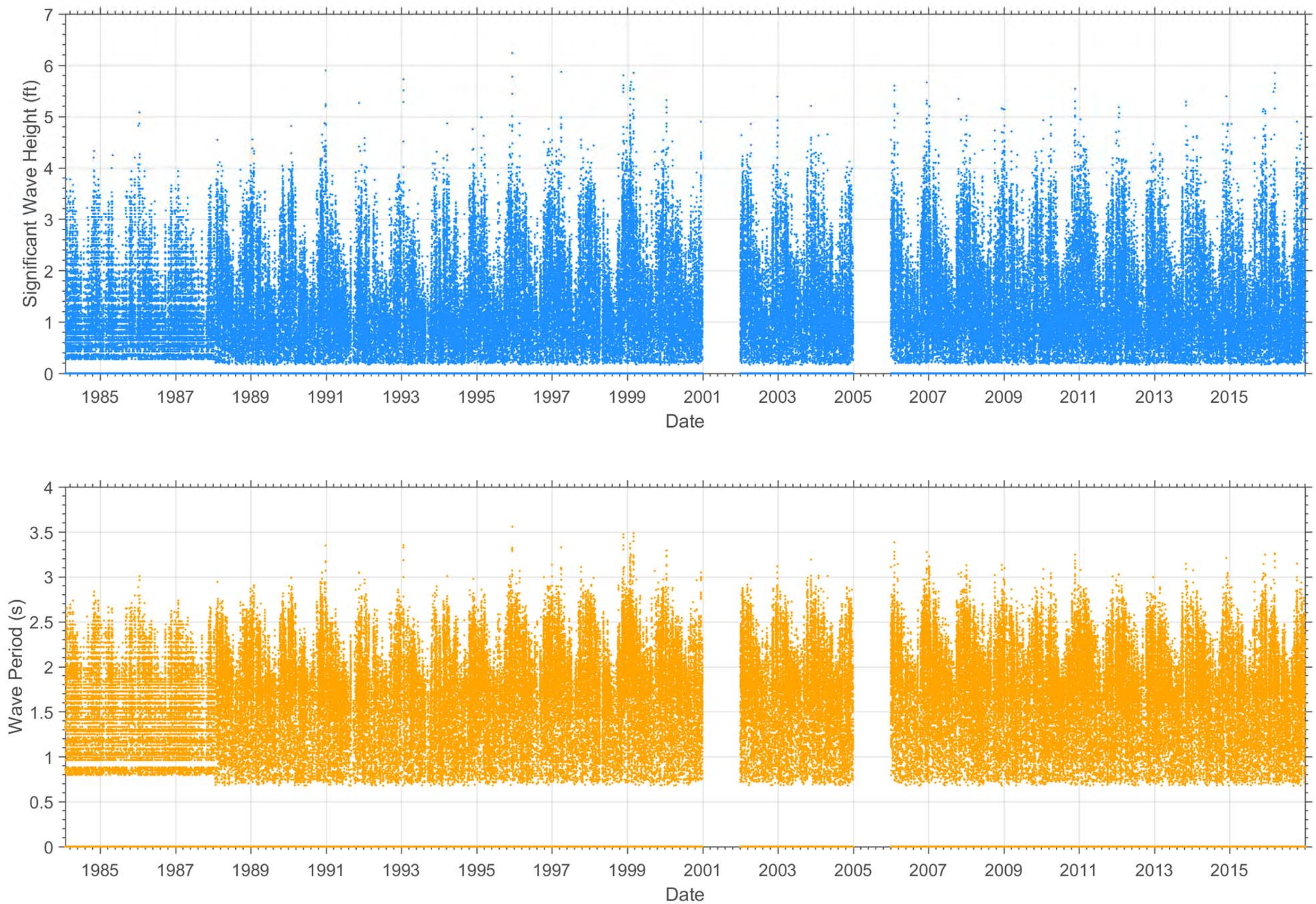
Figure 15
Wind rose at West Point (WPOW1) in Seattle, WA

Vessel wakes generated by passing commercial ships and passenger ferries have the potential to cause beach erosion and sediment transport as vessels transit Puget Sound. In terms of sediment transport, commercial ship wakes transiting north-south through Puget Sound presumably create energy as equal amounts of north-south direction sediment transport. Thus the net effect of these wakes on longshore sediment transport and beach formation is probably negligible compared to that of wind waves. Ferry wakes resulting the Vashon-Southworth route are likely only to reach the site upon the return trip to Fauntleroy Terminal; therefore, these wake effects may tend to cause net transport of sediment to the north.



SOURCE: ESA 2017
Note that meteorological equipment changed in 1988.

Figure 16
Simulated Wave Height and Period
Time Series Offshore of Park

2.3.6 Shoreline Evolution & Trends

Erosion at Loman Beach Park is evident from review of the available topographic data and photographs dating back to the late 1920s. Figure 17 & 18 provides photographic comparisons of the shorelines from 1936 to present time, for reference. While historic data are sparse, the information available supports the concept that erosion has been occurring at Lowman Beach Park (and presumably adjacent areas) since the seawall improvements were originally completed in 1936. Table 5 provides a summary of data and interpretation of beach elevation changes and Figure 19 presents the rates of change in a visual manner within the park vicinity. Beach restoration at the south end of the park was completed in 1995 and design surveys from 1994 are a primary source for computing historic and recent rates of erosion. Historic erosion rates (prior to 1994) are estimated to average about -0.025 feet/year whereas after 1994, rates averaged -0.078 feet/year. Therefore, it appears that average erosion rates are higher during the recent period, when compared to rates before 1994. For reference, Figure 20 provides the visual estimate of beach elevation change at the Bernhard residence (400 feet north of the park) referenced in Table 5.

TABLE 5
BEACH ELEVATION CHANGE SUMMARY

Year	Interpretation
1877- 1920s	No fine scale topographic data are available. It is assumed that natural beaches were largely intact and relatively few bulkheads or seawalls were present during this period.
1920s	Late 1920s era park topography (no bathymetry) indicate a creek mouth and beach apex approximately 125 feet from park south property boundary. No data are available below MHHW and adjacent properties are not included. At the original 1936 seawall steps, pre-development elevation was about EL. 9.3 feet. Grades were lower than EL. 9.3 feet along the remainder of the seawall alignment before construction but precise elevations are not known.
1936	Original seawall was constructed seaward of MHHW as evidenced by ground photos, aerial photos, and later as-built drawings. Beach was wider in front of the park than properties within about 300 feet north of the park. Bulkheads and seawalls within about 300 feet of the north park boundary appear to have been constructed at an unnatural angle to the topographic contours and further seaward than properties further to the north. The private bulkhead immediately south of park jutted out into the water at high tide. No elevation data are available at this time.
1951	City Drawings indicate that the original north seawall has washed out and eroded a large area between the tennis court and seawall. Beach grade 85 feet south of north park property line is approximately 4.25 feet below top of the new seawall, or about EL. 8.25 feet. New seawall footing is constructed roughly 1.75 feet deeper than the previous footing. Wall heights of 8ft, 5ft, and 3 feet are called for, indicating gradually rising beach grades from north to south along the park shoreline.
1952	Murphy residence (immediately north of park) seawall drawings indicate beach EL. 7.95 feet at the north park boundary (consistent with SPR 1951 drawings) and lower beach elevations at Murphy north property boundary of EL. 6.1 feet. Lower beach elevations to the north of the park are consistent with historical aerial photos showing narrower beaches north of the park.
1977	Sewer profile drawing at north end of seawall, near existing 18-inch SPU outfall, indicates beach EL. 7.9 feet. Concrete piles placed as a groyne are present in aerial photos at property to the south of the park, but having little apparent effect. Concrete piles apparently remain buried in the existing beach.
1987	South service road outfall drawings show beach grade at about EL. 9.0 feet at end of service road bulkhead, near an abandoned outfall.
1994	Topographic survey shows the beach at the north property boundary at EL. 6.9 feet. At distance of 85 feet distance south of north boundary, beach EL. 6.5 feet, and south property boundary beach at EL.

	9.9 feet. Higher beach grades (about 3 feet) at the south end of park are apparent before wall removal. Bernhard residence beach elevation photograph is available circa this year (see Figure 20).
2000	LiDAR data flown at mid-high tide obscures beach elevations along structure toes, except at the south boundary where elevations were in the range of 10.0 to 10.5 feet.
2003	LiDAR survey flown using water-surface penetrating technology does not provide adequate survey density north of the park. At south property boundary, EL. 10.0 to 10.5 feet.
2016	King County LiDAR indicate an accreting beach from 2003 to 2016 within the south portion of the park and on private properties to the south of the park. Elevations increased by approximately 6 feet to south of the park and beach increased elevation and extents. Data are inconclusive north of the park due to tide conditions in 2000 survey and sparse coverage in 2003 but trends of beach erosion from 1994 to present are suspected per residents comments, site observations, and photographs.
2017	City survey indicates murphy residence north property boundary of EL. 5.0 feet. At the north park property boundary, grades are approximately EL. 5.34 feet on top of spalls but actual beach grade about 1 foot lower, 85 feet south of north park boundary EL. 5.4 feet, south property boundary EL. 11.3 feet. Bernhard residence beach elevation dropped by approximately 13 inches from 1994 to 2017 based on photo comparisons.

Early park topographic mapping indicates that the original seawall was constructed seaward of MHHW and exposed to wave action at high tide. By the early 1950s the north portion of the seawall, where beach grades were lowest, failed and was replaced. At the same time, underpinning/repairs to the original seawall at the south end were made. Erosion continued from the 1950s to the 1990s, with beach grades dropping by about 1.25 feet, on average, along the seawall toe.

From 1994 to 2017 the beach grades at the north end of park lowered by almost 3 feet. At the middle point of the existing seawall, beaches grade lowered by about 1.5 feet. In the restored beach area, accretion (rising elevations) has occurred near the existing return wall and restored beach to the south of the seawall. Beaches immediately to the north of the park have continued to experience erosion from 1994 to 2017. Based on limited data, beach elevations at the toe of seawalls north of the park are estimated to have lowered by 1.0 to 2.5 feet during this period, with the most pronounced erosion occurring immediately north of the park and diminishing further to the north. Beaches to the north of the park have also lost the veneer of sand that was present near the toe of bulkheads in historical photos from 1993 and ground-level photos from 1994. Areas of grey clay are exposed at the surface, making fine sediment and small gravel deposition unlikely. Approximate beach elevation derived from LiDAR survey data near structure toes north of the park is depicted in Figure 21.

From 1994 to 2017, properties the south of the park have experienced accretion of more than 6 vertical feet in some areas, where the beach has built out seaward and elevated. Comparison of LiDAR surveys from 2003 to 2016 confirm accretion on beaches fronting the park and properties to the south; net increase in beach sediment volume in the park vicinity is approximately 1,150 cubic yards (CY) during this period. Figure 22 depicts the location and magnitude of beach elevation change and net volumetric change from 2003 to 2016 where red indicates accretion, and blue erosion. Approximately 60 percent of the accreted beach sediment has deposited south of the park. The source of the accreted sediments has not been definitively determined but likely includes a combination of sediment supplied from beaches located to the south at Lincoln Park, offshore sediments redistributed landward onto the beach, and sediments from north of the park.

N NOT TO SCALE

SOURCE: King County Roads 1936, USGS 1977.

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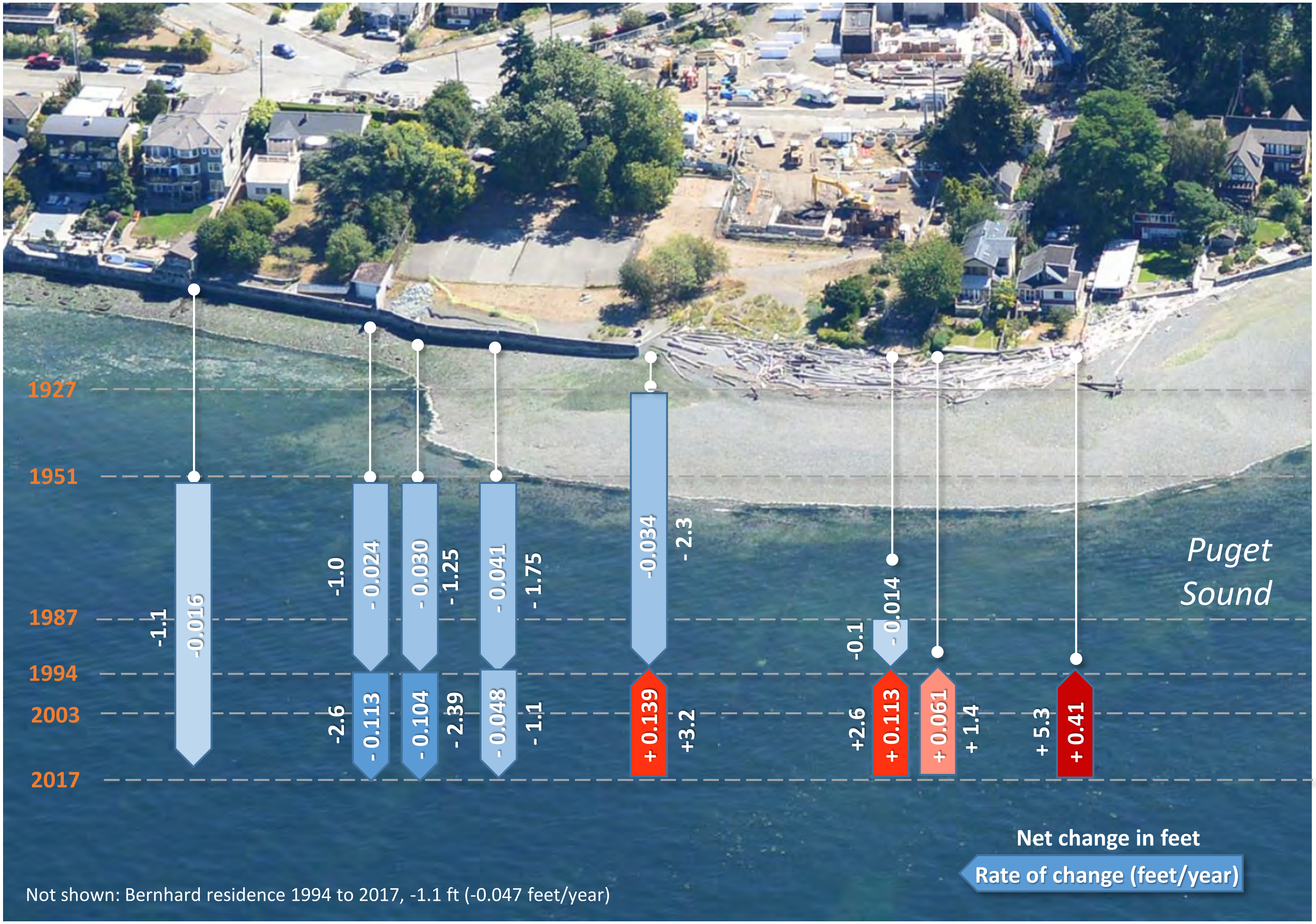
Figure 17
Comparison of Aerial Photographs
from 1936 and 1977

NOT TO SCALE

SOURCE: USGS 1990, NOAA 2014.

Figure 18
Comparison of Aerial Photographs from 1990 and 2014



N NOT TO SCALE

SOURCE: ESA 2017

Notes: 1. Positive values (red) indicate accretion, negative values (blue) indicate erosion
2. Beach restoration occurred in 1995.

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Figure 19

Beach Elevation Change Summary

NOT TO SCALE

SOURCE: ESA 2017 (photo to left). J. Bernhard 1994 (photo to right).

Lowman Beach Park Feasibility Study. D160292.00

Figure 20
Comparison of Ground Photos of Beach Level at 6751 Beach Dr. SW

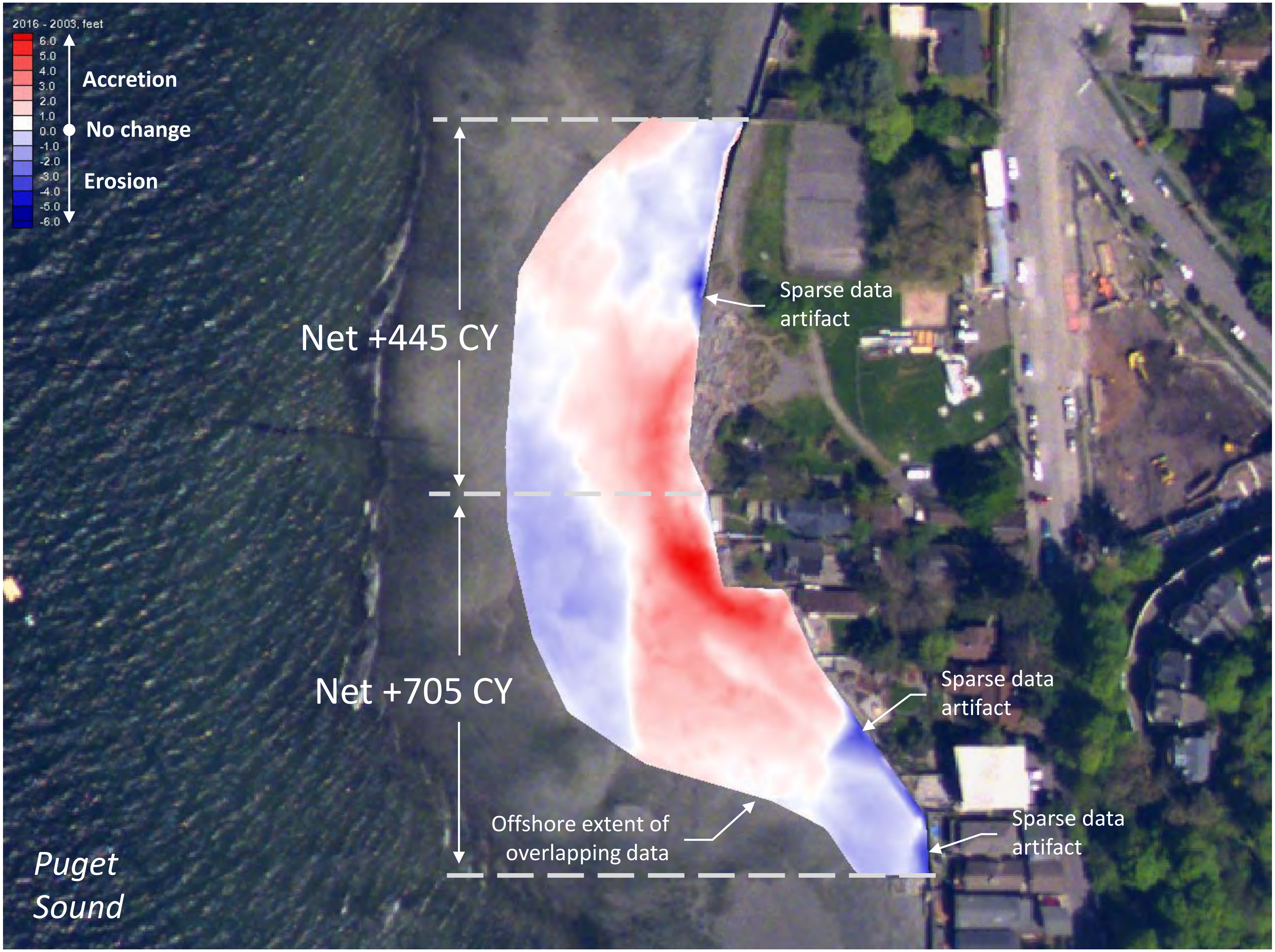
NOT TO SCALE

SOURCE: Photo by Dept. of Ecology 2016. Elevation data adapted from King County LiDAR 2016.

Lowman Beach Park Feasibility Study. D160292.00

Figure 21

Beach Elevation Near Structure Toe from 2016 King County LiDAR



N NOT TO SCALE

SOURCE: USACE 2003 LiDAR, King County 2016 LiDAR
Notes: LiDAR accuracy ±0.5 ft; surface difference accuracy ±1.0 ft.

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Figure 22
Elevation change from 2003 to 2016

Potential Sediment Transport Estimates

Like other areas in Puget Sound, wind-generated waves are the driving force for sediment transport (Finlayson 2006) along beaches in the vicinity of Lowman Beach Park. Previous studies suggest that net littoral drift (e.g. net sediment transport) at the project site and on adjacent beaches is generally from south-to-north. Rates of transport vary with available supply, beach geometry, wave conditions, and sediment composition, among other factors. To estimate sediment transport rates and directions at Lowman Beach Park, ESA applied a rage of standard empirical methods (Van Wellen 2000, Kamphius 1991, Van Rijn 2014) suitable for mixed sand/gravel beaches and simulated potential sediment transport in the vicinity of the park using the 30-year wave time series described in the previous sub-section. By simulating sediment transport over this long period, overall trends in potential sediment transport rate and direction can be deduced. Figure 23 depicts the results of the sediment transport simulations and provides the average annual direction and magnitude of sediment transport for four methods at the four locations in the park vicinity. Note that potential estimated rates vary amongst the methods, as indicated in the figure, by as much as fifty percent. The potential sediment transport estimates indicate a convergence of sediment from north and south at the park. This convergence is generally consistent with the accretion that has occurred at the park, and erosion north of the park. The transport rates from the north likely overestimate actual rates under current conditions, due to the lack of transportable sand and gravel present on the beaches. Transport rates from the south, when summed, generally agree with net accretion volumes computed from 2003 to 2016.

Expected Future Trends Without Park Improvements

Based upon review of site survey and recent aerial photography, the beach planform at the south end of the park is expected to continue to migrate seaward until the beach berm reaches the corner where the 1990s-era return wall meets the 1950s-era remaining seawall. Beach sediments are already beginning to spill northward of the return wall, indicating that the beach planform may be reaching equilibrium with the return wall and will not build out much further.

To the south of the park, the data suggest continuing trends of accretion as beach sediments deposit on the sheltered and naturally sloped beaches southeast of the park. Backshore elevations have reached equilibrium with wave forces immediately south of the park and are not expected to rise more than 0.5 feet or so in these areas. However, the width of the backshore may slightly increase and fluctuate with tide and wave conditions. Trends of erosion are expected to continue immediately north of the park and in front of the existing seawall due to altered cross shore and longshore sediment transport processes and the degraded state of the beach.

Expected Future Trends Considering Park Improvements

Improvements to the park (e.g. shoreline restoration, or seawall replacement) would have little effect on the southern part of the park and shorelines that have grown steadily following the 1995 beach restoration. Were a portion of the seawall removed and beach restored, the potential risk that additional restored beach aggradation could exacerbate adjacent erosion/accretion processes could be mitigated by 1) placing sacrificial beach nourishment material at the toe of the seawall at its north end during construction and 2) constructing the restored beach profile as far seaward as possible such that an erosion response is elicited after initial construction, rather than accretion as occurred after 1995. Because much of the soil landward of the seawall appears to be beach-compatible, this approach would maximize the sediment made available for redistribution to the littoral system (and adjacent properties) while minimizing costs to haul and dispose of suitable beach sediments that could be used as beach nourishment. It is expected that this approach would help to mitigate ongoing erosion at properties immediately to the north of the park, but would not eliminate background erosion. If a replacement seawall were constructed along the existing seawall alignment, then recent erosion trends would continue for the foreseeable future, as sediment slowly spreads northward from the previous beach restoration area.

NOT TO SCALE

SOURCE: ESA 2017
Notes:
1. Rate is the average of years 1984-2016, using average of four different computational methods.
2. Range indicates the excursion of the four methods from the average.

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Figure 23
Potential Average Net Annual Longshore Sediment Transport

2.4 Geotechnical Investigation

Robinson Noble performed a site geotechnical investigation by reviewing of existing site information, excavating and logging three test pits landward of the existing seawall in May 2017, performing laboratory tests on soil samples from the test pits, and preparing a technical memorandum summarizing their findings and conceptual design recommendations for the three project alternatives (see Appendix C). Key findings from the geotechnical investigation include the following:

- All test pits encountered primarily gravel and sand, including native outwash and beach deposits.
- Native gravel soils were underlain by stiff to hard clay about 7 feet below grade at the landward side of the seawall (EL. 4.0 feet NAVD88). Stiff clay was also observed on the seaward side of the seawall roughly 0.5 to 1.0 feet below grade. The grey color clay is relatively impervious to groundwater.
- Various fill and buried topsoil layers were observed within the trenches, including some brick and concrete debris. Fill assumed to have been placed during installation of two stormwater outfalls may require improvement or replacement with structural fill.
- New structure footings should be founded on hard native clay soils, and soil improvements may be required in unconsolidated soils to deal with settlement potential. Structures should be protected against scour and erosion at their base.
- Existing seawall segments are subject to ongoing erosion and loss of passive resistance which may result in further failure. Remaining walls do not have adequate retaining capacity, especially under seismic loading.
- Additional geotechnical investigation is warranted in the next phase, dependent upon the type of structures selected for more detailed design.

2.5 Structural Engineering Assessment

Reid Middleton provided structural engineering support by first conducting a condition assessment for the existing seawall (see Appendix A) and then by evaluating structural design concepts to replace the existing seawall as part of the alternatives design development (see Appendix B). In collaboration with ESA, and Robinson Noble, replacement seawall design alternatives considered included a soldier pile wall, seat wall, and retaining wall.

Key findings from the structural condition assessment include:

- Loss of bearing material (erosion) beneath the seawall foundation has contributed to tipping, cracking, and differential settlement of seawall segments.

- The seawall is actively failing and complete collapse may be imminent. Annual inspections are recommended until replacement, and public access above and below the failing seawall segments should be limited.
- It is likely cost-prohibitive to repair segments of the seawall that have tipped and cracked substantially. These have reached the end of their useful life. SPR should be ready to implement a plan to deal with more extensive collapse, should it occur.
- Limited portions of the existing seawall may be incorporated into a replacement project, but would require toe protection and would have a service life less than other new seawall elements.

Seawall replacement design concepts are summarized as part of the alternatives analysis in Sections 3 & 4. Refer to Appendix B for more detailed information.

CHAPTER 3
Development of Alternatives

ESA, in coordination with the SPR, developed a range conceptual alternatives to remove and/or replace the existing seawall. The conceptual alternatives described in this chapter were developed in consideration of the site opportunities and constraints summarized below. A description of the conceptual alternatives is provided in this section, and more detailed comparison of the alternatives presented in Chapter 4. Alternative conceptual schematics are provided in Appendix E. For Alternatives 1 & 2 these depict a conservative eroded condition of the beach profile necessary for determining retaining structure extents and maximum area of impact; actual profile immediately after construction could be further seaward and with steeper slopes.

3.1 Opportunities and Constraints

- Existing Tennis Court. The original tennis court constructed by the WPA in 1936 remains onsite and in use. The court's position relative to the shoreline constrains the distance that the shoreline and new structures can be moved landward. The court has not previously been evaluated regarding its eligibility for listing on national, state, or local historic registers. However, if the tennis court is determined Register-eligible, it is likely there would be constraints on altering the tennis court and its setting, or more likely that mitigation would be required for doing so.

- Existing Seawall. A portion of the 1951 seawall is still extant, but would be mostly removed or replaced due to its age and susceptibility to failure. The seawall has not previously been evaluated regarding its eligibility for listing on national, state, or local historic registers. It is unlikely that the seawall would be determined Register-eligible.

- Viewshed. The park provides views of the Olympic Mountains to the west, Alki Point to the north, and Point Williams to the south. It is desirable that these views remain intact for future park visitors.

- Gathering Space. Uplands behind the seawall provide gather space for picnicking and water viewing, including the December Christmas ships. Preservation of some upland space along the shoreline would allow existing park uses to continue.

- Cultural Resources. No significant archaeological resources were identified while digging test pits behind the seawall. This provides the opportunity to restore site grades and excavate with low probability of encountering artifacts between the tennis court and existing seawall. The presence or absence of buried archaeological resources beneath the tennis court is unknown and should be investigated if the court is to be removed.

- Adjacent Private Property. Adjacent private properties include both tidelands and uplands. Structures along the shore are vulnerable to both overtopping (flooding) and undermining (erosion) by waves and tides. The position and condition of the adjacent private structures to the north constrains the ability of the design to retreat landward due to the potential to exacerbate ongoing erosion. Properties to the south are less likely to experience adverse effects from changes to the existing seawall.

- Stormwater & CSO Utilities. Stormwater currently discharges through seawall via the 18-inch disconnected SPU outfall. A second larger 66-inch outfall (King County) is located on a similar alignment but buried below the existing seawall footing. The buried outfall constrains the replacement the seawall foundation design where it overlaps the utility easement. It is assumed that the SPU outfall would be removed and flows rerouted as part of seawall replacement activities but the King County outfall would remain.

- Other Utilities. Irrigation systems between the tennis court and seawall would be modified/removed under most alternatives and a catch basin removed/replaced.

- Trees & Vegetation. No significant trees or rare plants are present in the vicinity of the existing seawall and beach. There remains opportunity to revegetate the site uplands upon modification of seawall and cluster plantings to provide some shading and nutrient exchange with the adjacent beach.

- Nearshore Habitat. The existing mixed sand/gravel beach supports benthic organisms and recreational uses. Impacts to the existing beaches and backshore would be minimized and overall extents of beach can be increased where possible.

- Creek Daylighting. The concept of rerouting stormwater and groundwater base flows into a natural channel that flows through the south end of the park was explored but not carried forward into design. Daylighting the creek without providing upstream habitat would provide minimal ecological function, may interfere conflict with existing infrastructure, could introduce potential water quality issues in the park, and may not be sustainable given the accreting beach and sediment transport regime.

- Shore Accessibility and Beach Recreation. Pedestrian access to Puget Sound from the Park currently requires navigating steep drop-offs at the seawall and street end, or maneuvering through and over driftwood along the backshore beach area. Water and beach access can be improved with grading, minor path improvements etc. Overall area of beach can also be increased to improve beach recreation.

3.2 Alternatives

3.2.1 No Action Alternative

Under this alternative continued erosion is expected seaward of and behind the existing seawall, resulting in continued toe undermining, settlement and further deterioration of individual seawall segments. Failure of the most vulnerable wall segments, which appears imminent, would require emergency action and after-the-fact permitting to stabilize the adjacent uplands and protect the remaining structures in the vicinity from further damage due to exacerbated erosion landward of the wall. Emergency actions may include placing riprap, rock, super-sacks or other materials to shore up existing segments and close gaps.

3.2.2 Alternative 1

Alternative 1 would remove approximately 130 linear feet of existing seawall and replace it with 64 linear feet of new seawall, setback the shoreline to create a beach, and maintain the position of the existing tennis court by constructing a 69-foot long concrete seat wall. Existing views would be preserved by providing a small viewing area at the north end of the park along a small section of seawall. New gravel paths would be installed to reach the seat wall, viewing areas, and beach zone.

Because Alternative 1 does not remove the tennis court, it appears unlikely to intersect significant archaeological resources. Excavation of fill sediments outside of the tennis court footprint may contain mixtures of construction and demolition debris associated with historic and recent use of the parcel, but such remains are unlikely to be considered significant. The alternative abuts the tennis court with a path and concrete seat wall, which (if the court is determined to be Register-eligible) could be considered to be an Adverse Effect to the court's historic setting; Section 106 Consulting Parties would then need to consult regarding how best to avoid, minimize, or mitigate for adverse effects.

3.2.3 Alternative 2

Alternative 2 would remove 130 linear feet of existing seawall, install 64 linear feet of new seawall and 61 linear feet of retaining wall in an east/west direction, remove the tennis court and replace it partially with a backshore beach, lawn, and marine riparian plantings. Existing views would be preserved by providing a small viewing area at the north end of the park along a small section of new seawall. New paths would be installed to reach the seat wall, viewing area, and beach.

If the tennis court is determined Register-eligible, its removal would be considered an Adverse Effect under Section 106. Section 106 Consulting Parties would have to consult regarding how best to avoid, minimize, or mitigate for adverse effects. By removing the tennis court, Alternative 2 also has the greatest risk for inadvertently exposing buried archaeological remains, since the presence/absence of such remains beneath the tennis court has not been assessed. It is possible that removal of the tennis court could trigger a requirement for archaeological monitoring during construction. Discovery of archaeological remains beneath the court could result in a stop-work while Section 106 Consulting Parties determine how best to avoid, minimize impacts, or mitigate adverse effects to the archaeological resource.

3.2.4 Alternative 3

Alternative 3 would replace 130 feet of the seawall within its existing footprint with a new seawall meeting modern design standards. No additional nearshore habitat or backshore will be created under Alternative 3. This alternative also includes improving and extending the current path to follow the back of the seawall, as well as the planting of a few marine riparian trees landward of the proposed path.

Because Alternative 3 does not remove or impact the tennis court, it appears unlikely to intersect significant archaeological resources. Excavation of fill sediments outside of the tennis court footprint may contain mixtures of construction and demolition debris associated with historic and recent use of the parcel, but such remains are unlikely to be considered significant. Alternative 3 maintains greater distance between the tennis court and improved path than does Alternative 1, and, therefore, would avoid having an Adverse Effect on historic properties.

CHAPTER 4
Evaluation of Alternatives

This section compares and contrasts the various alternatives with respect to key criteria, opportunities, and constraints.

4.1 Cultural & Historical Resources

- Under any alternatives, the tennis court and seawall should be recorded as historic properties due to their age (greater than 50 years) and evaluated regarding their Register-eligibility during project permitting.
- Alternative 1 would have a low likelihood for intersecting buried archaeological remains. However, the proximity of the new path and new seat wall to the tennis court could result in a finding of Adverse Effect if the tennis court is determined Register-eligible.
- Alternative 2 would have the highest risk for exposing unrecorded archaeological remains beneath the tennis court, and would also result in an Adverse Effect if the tennis court is determined Register-eligible and then removed.
- Alternative 3 has approximately the same low likelihood risk as Alternative 1 for intersecting buried archaeological remains. Alternative 3 would likely avoid having an Adverse Effect to the historic setting of the tennis court, if the court is determined Register-eligible.

4.2 Coastal Process

The alternatives would cause a range of responses to ongoing coastal processes in a littoral cell lacking natural sediment supply and geometrically constrained by existing infrastructure and private property.

- No-action Alternative would allow existing coastal processes to continue and likely result in the undermining and failure of the existing seawall. Initially, gravel and sand materials would be released to the beach and distributed along the adjacent shorelines by waves. Erosion along private beaches to the north would continue in the near-term and beach aggradation to the south would continue southward though at a slightly lower rate than observed in past 20 years as the beaches reach equilibrium.
- Alternative 1 would place beach compatible sediment at slopes and grades promoting natural beach cross-shore processes, but the seat wall would interfere with complete backshore function. Modeling and observations of nearby beaches suggests that portions of the seat wall might be buried by deposited sediments particularly in the sheltered pocket near the return wall. Longshore sediment transport to the north would be limited

by the return wall that would retain the created beach area. It is likely that the created beach would experience a similar planform response to the previous beach restoration, including accumulation of sediment until equilibrium is reached and the beach profile projects out seaward beyond the return wall. The potential risk of beach aggradation exacerbating adjacent erosion/accretion processes could be mitigated by 1) placing sacrificial beach nourishment material at the toe of the seawall at its north end during construction and 2) constructing the beach profile as far seaward as possible such that an erosion response is elicited after initial construction. As the overbuilt constructed beach erodes and reaches equilibrium, the eroded beach sediments would be available for transport to adjacent shorelines. The extents of the beach construction geometry would require more detailed analysis and design, including consideration of permitting and cost implications for the overbuilt beach.

- Alternative 2 would place beach compatible sediment at slopes and grades promoting natural beach cross-shore processes and full backshore function. Longshore sediment transport to the north would be limited by the return wall that would retain the created beach area. It is likely that the created beach would experience a similar planform response to the previous beach restoration, including accumulation of sediment until equilibrium is reached and the beach profile projects out seaward beyond the return wall. The potential risk of beach aggradation exacerbating adjacent erosion/accretion processes could be mitigated by 1) placing sacrificial beach nourishment material at the toe of the seawall at its north end during construction and 2) constructing the beach profile as far seaward as possible such that an erosion response is elicited after initial construction. As the overbuilt constructed beach erodes and reaches equilibrium, the eroded beach sediments would be available for transport to adjacent shorelines. The extents of the overbuilt beach construction geometry would require more detailed analysis and design, including consideration of permitting and cost implications for the overbuilt beach. Potential cost savings could be realized by minimizing excavation and haul of material landward of the existing seawall
- Alternative 3 would promote the continuation of existing coastal processes including the continued erosion of beaches fronting the replacement seawall and along properties to the north. Beach aggradation to the south would continue southward though at a slightly lower rate than observed in past 20 years as the beaches reach equilibrium. It would be possible to couple this alternative with placing a two or three-foot-thick layer of sacrificial beach nourishment along the toe of the replacement wall to provide a temporary sediment source for beaches at the park and to the north.

4.3 Resiliency to Sea Level Rise

The project site has already experience roughly 4 inches of sea level rise in the last 50 years and conceptual alternatives would be subject to accelerated sea level rise. While the rate of future sea level rise is inherently uncertain due to the many physical and anthropogenic factors, a range from mean of 2 feet of rise to high of 4.6 feet by 2100 should be planned for based on the projections by NRC (2012). Regardless of the rate of sea level rise, the net effect will be to cause 1) Deeper water at the face of seawall and bulkheads 2) Increased wave energy reaching seawalls and bulkheads due to increased water depth and 3) Continued and likely accelerated landward retreat of the shoreline and beach profile in erosion prone areas. The response of each alternative to rising sea levels and its ability to adapt without losing its primary function is termed "resiliency". Alternatives that allow for landward retreat of the shoreline are more resilient to sea level rise in the long term, and generally more resilient to coastal storms in the short term.

- No Action Alternative would likely result in seawall failure well before ongoing sea level rise would have the opportunity to measurably effect processes including wave overtopping, flooding during high tides, etc. Storm events and background erosion is of greater concern under this alternative.
- Alternative 1 would create a beach with partial backshore that is capable to respond to adapt to rising sea level in the near-term. As sea level rises and tides more frequency impinge on the seat wall, the shoreline's ability to retreat will be prevented. This would result in a coarser beach, more frequent wave overtopping, and likely reduced overall beach area compared to the conceptual design plans within about 25 years.
- Alternative 2 would be relatively resilient to sea level rise and provides adaptive capacity for the shorelines to naturally retreat without significant increased impacts to upland infrastructure. This alternative is the most ideal from a sea level rise adaptation.
- Alternative 3 would experience increased wave overtopping along the seawall at high tide and more frequent erosion of the path and uplands landward of the seawall as sea levels rise. If ground elevations behind the seawall were to remain at existing levels (roughly +12 feet NAVD88), these areas currently only inundated by a 20-year water level would become inundated annually under sea level rise scenarios of two feet. This alternative should include elevating the seawall crest by at least 1.5 feet above existing elevations.

4.4 Nearshore Habitat

- In Alternative 1, a moderate increase in nearshore habitat is anticipated. The installation of the seat wall would occur approximately 10 to 15 feet landward of the current seawall and would be positioned to create approximately 3,000 square feet (SF) of additional nearshore habitat below Elevation 11.0 feet NAVD88, primarily at its southern end. An additional 585 SF of new backshore (between Elevation 11.0 feet and 12.0 feet NAVD) will also be created. This would provide a wider beach habitat and intertidal zone than currently present and therefore, likely support more wood recruitment and beach wrack accumulation. Beach nourishment would also occur in a limited area that would provide some smaller materials, such as sands and gravels, to the current pebble-dominated sediment composition. These additional sands and gravels may provide feeding and refuge habitat for juvenile salmon, and habitat for forage fish species. Additional shrub plantings near the southern overlook are proposed under this alternative which would provide ecological benefits including sediment control, minor water quality improvement, and nutrient inputs (Gianou 2014). However, a net increase in the transfer of organic material and invertebrates from the marine riparian area to the beach is not anticipated, due to the removal of several trees to make way for the improved path. The improvements to the path will however impede the establishment of user-defined trails and ensure the success of native plantings.

- Alternative 2 This alternative provides the largest increase (approximately 6,070 SF) in nearshore habitat. An additional 1,055 SF of backshore will also be created. With the majority of the seawall removed, the beach will be designed to mimic a natural backshore and over time, natural ecological processes are anticipated to return to the beach. Beach nourishment would also occur over the majority of the site and due to the lower wave energy produced by this alternative would be able to support smaller material (sand and small gravel) than other alternatives. As natural processes recover, natural sediment input and beach maintenance is also expected to occur, which would likely abate erosion. As with Alternative 1, the additional sands and gravels may provide feeding and refuge habitat for juvenile salmon, and would occur over a much larger area under Alternative 2.

  Because Alternative 2 would increase the amount of fine material and natural sands across a larger area, it also provides the possibility for additional spawning habitat for surf smelt, and overtime may provide a connection with the current spawning habitat at Lincoln Park to the south. Wood recruitment and wrack accumulation would likely increase over much of the site and support larger invertebrate assemblages which would result in an increase in shore birds. In addition, Alternative 2 proposes the planting clusters of several marine riparian trees and shrubs that would provide shade to the restored shoreline and result in ecological benefits similar to Alternative 1 (i.e. sediment control, water quality improvement, and nutrient inputs). Due to a net increase in vegetation, a net increase in the terrestrial input of organic material and invertebrates is also anticipated. The recruitment and establishment of additional nearshore vegetation is also likely under this alternative which would further support the connectivity between the upland and nearshore ecosystems. Overall, Alternative 2 would provide the greatest ecological functional lift of the three alternatives. This alternative will result in a gradual transition from the nearshore habitat to a vegetated upland habitat which will restore ecological functions, restore habitat connections, and allow the beach to develop more naturally.

- For Alternative 3, increasing the number of trees within the marine riparian zone will provide shade to the shoreline and an increase the available habitat for riparian bird species such as song sparrow. Benefits such as minor water quality improvements and nutrient inputs would also occur, however these benefits would not reach the marine zone due to the replacement seawall. The improvement and delineation of a path to the seawall will likely allow some vegetation, primarily groundcover, to return to this area. Some additional organic material export from these trees to the beach can also be anticipated. However, due to the lack of additional beach habitat and the associated lack of additional wood recruitment, a net increase in the transfer of organic material and invertebrates from the marine riparian area to the beach is anticipated to be low or unlikely. No modification to the existing sediment or possibilities for an increase in sediment deposition would occur and therefore, habitat improvements for salmon, forage fish, or any additional nearshore benthic species will not occur. Wave energy against the sea wall will remain unchanged and further contribute to ongoing erosion and degradation of the lower intertidal beach in the future.

4.5 Permitting Requirements

Because the project demolition and construction requires in-water work for all alternatives, a number of federal, state, and local permits will be required before construction can begin. A federal Clean Water Act Section 404 and Section 401 permit will be required for all three alternatives.

Alternative 1 would likely require an Individual Section 404 Permit. The Corps of Engineers (Corps) is the agency that grants Section 404 Permits. An Individual Permit is a type of Corps permit that is issued for a specific activity, after a public notice and comment period. The Corps considers comments submitted in response to the proposed work described in the public notice, before issuing the individual permit. In contrast, the Nationwide Permit process was developed for smaller project types or those that provide benefits without the more stringent requirements of an Individual Permit.

Alternative 2 may qualify for Nationwide Permit (NWP) 27 – *Aquatic Habitat Restoration, Establishment, and Enhancement Activities*. According to the NWP Regional Conditions, “activities involving *new* bank stabilization” in tidal waters in WRIA 8 cannot be authorized by a NWP. If the Corps considers the modification of the northern section of the seawall under Alternative 2 to be *new* bank stabilization, Alternative 2 would likely require an Individual 404 permit. Alternative 3 may also qualify for NWP, specifically NWP 3 for Maintenance, if the new wall is built within its existing footprint.

Under all three alternatives, the Corps may require compensatory mitigation to offset losses of waters of the U.S. and ensure that the net adverse effects on the aquatic environment are minimal. However, Alternatives 1 and 2 may be considered to be a self-mitigating project as the long-term benefits to the environment are anticipated to outweigh the temporary impacts during construction. Discussions with the Corps regarding the applicability of nationwide permits and required mitigation, are recommended before project designs are submitted with permit applications.

Granting a Section 404 Permit also requires a Section 401 Water Quality Certificate, which is a federal program delegated to the Washington Department of Ecology in this state. Under Alternative 3, water quality certification would be pre-approved as part of the Corps’ Nationwide 3 Permit for Maintenance if the project is designed to occur within its original footprint. Alternatives 1 and 2 would require an individual certification or Letter of Verification from Ecology.

Both of these federal permits can be applied for using the Joint Aquatic Resources Permit Application (JARPA) form. In addition, additional state and local permits will also be required for all three alternatives. A Hydraulic Project Approval (HPA) permit is required from WDFW for actions in and around waterbodies. The City of Seattle's jurisdiction under the Shoreline Management Program (SMP) includes Puget Sound, thus, a local shoreline permit from the City of Seattle is required. The HPA and the SMP permit also use the JARPA form – thus all agencies shall receive the same information regarding the project methods and anticipated impacts. See the attached Lowman Beach Park Draft Permit Matrix (Appendix F) for additional permits that may be required under the three alternatives.

4.6 Recreation

Project alternatives would result in changes to recreational opportunities and use at the park.

- No Action Alternative would result in an unsafe condition persisting along the shoreline as seawall segments degrade and potentially fail without warning. Recommended isolation of the seawall with fencing and signage would reduce recreation use of the upland and beach adjacent to the wall. Wall failure would necessitate closing a large portion of the park for public safety and during repairs.
- Alternative 1 would reduce the amount of upland lawn by exchanging it for intertidal beach, minor native plantings, and a concrete seat wall. The seat wall would provide new seating and water viewing opportunities, along with improved beach access along its entire length. The adjacency of the seat wall and path to the tennis court might cause some minor impact to play on the court and loss of tennis balls down onto the beach. Key viewsheds to the south, west, and north would be maintained.
- Alternative 2 would remove the tennis court and exchange it for intertidal beach and upland lawn area with plantings. Key viewsheds would be maintained but the overall layout of the park would become more beach oriented with lawn activities and other amenities located further landward from the beach in the southeast corner of the park.
- Alternative 3 would essentially maintain existing recreational uses of the site, with some minor improvements along the seawall. The new seawall would facilitate safer use of the beach and uplands along the wall compared to existing conditions.

4.7 Constructability

Each alternative would be constructed using proven materials and standard equipment for land-based construction of shoreline facilities. Some slight differences in demolition, temporary shoring, and work area isolation would exist amongst the alternatives due to sequencing of demolition and installation of new features.

- No Action Alternative would have no construction unless emergency conditions arose. Emergency actions might include clearing failed segments of the concrete seawall, filling gaps in the wall with riprap, and reinforcing remaining seawall segment toe with rock and riprap to minimize overturning and further undermining.
- Alternative 1 would require methods and techniques to isolate the work areas from the influence of the tide and to temporarily stabilize the seat wall excavation to prevent undermining of the tennis court. Most of the excavation and grading would be

accomplished "in-the-dry" landward of the existing seawall, taking advantage of low tides to place beach materials seaward of the existing wall. Existing beach-compatible materials landward of the seawall would be reused, to the extent possible, to construct the restored beach in an overbuilt fashion to minimize hauling and disposal cost of excavated sand/gravel. Temporary stabilization of the existing seawall may be required during construction of landward elements. Temporary dams to isolate seawater from the work area may be required to satisfy regulatory requirements. Dewatering of the work area is anticipated due to the permeable nature of the upland soils and tides influence groundwater elevations. Excessive vibration during pile installation may damage the adjacent unreinforced block wall at the park boundary. Care will need to be taken to avoid impacting the buried King County Metro sewer pipe.

- Alternative 2 would utilize standard earthwork equipment to demolish the existing seawall and place and grade the beach materials. Isolation of the new seawall segment at the north end of the park would be provided by combination of temporary dam and earthen berms. Dewatering of the work area is anticipated due to the permeable nature of the upland soils and tides influence groundwater elevations. Excessive vibration during pile installation may damage the adjacent unreinforced block wall at the park boundary. Care will need to be taken to avoid impacting the buried King County Metro sewer pipe.
- Alternative 3 would revolve around the sequencing of existing seawall demolition and its replacement with the new soldier pile wall roughly along the same alignment as the existing wall. Constructability would be increased if the wall could be constructed seaward or landward of the existing wall alignment. Excessive vibration during pile installation may damage the adjacent unreinforced block wall at the park boundary. Care will need to be taken to avoid impacting the buried King County Metro sewer pipe.

4.8 Maintenance

The conceptual alternatives provide solutions for different maintenance time frames and spatial scales. Estimates of maintenance require further refinement through more detailed analysis and design of the preferred alternative.

- No Action Alternative would not include planned maintenance. However, this alternative would likely require an emergency action (unknown cost) within the next few years.
- Alternative 1 would require typical trail maintenance, minimal vegetation trimming, and floating wood debris clearing where the new trail meets the upper beach and on the seat wall. Frequent beach nourishment is not anticipated as the overbuilt beach will erode to equilibrium conditions and sediment supply appears ample from the south.
- Alternative 2 would require typical trail maintenance, minimal vegetation trimming, and floating wood debris clearing where the trail meets the upper beach. Frequent beach nourishment is not anticipated as the overbuilt beach will erode to equilibrium conditions and sediment supply appears ample from the south.

- Alternative 3 would require typical trail maintenance, minimal vegetation trimming, and periodic placement of beach material at the toe of the seawall. Graffiti removal may also be required on the new seawall structure.

4.9 Construction Cost

For planning purposes, conceptual level construction costs were developed for Alternatives 1 through 3; costs were not developed for the No Action Alternative. The project quantities are based on the conceptual level design effort including typical sections and project element dimensions developed in the AutoCAD software package. Estimates exclude local sales tax and the cost of relocating and diverting the SPU outfall and minor park amenities. Unit prices reflect recent engineering experience of the project team. A 40 percent contingency is included to account for project uncertainties such as final design refinements, permitting conditions, fuel prices, material availability, and bidding climate. Estimates are subject to refinement and revision as the preferred alternative is selected and detailed design is developed in future stages.

Table 6 in the subsequent section summarizes costs for each alternative and more detailed cost and quantity summary can be found in the Appendix D. Construction cost amongst the alternatives is expected to be similar

CHAPTER 5
Summary and Recommendations

Informed by technical studies, three conceptual design alternatives were developed to remove and replace the existing seawall with various combinations of structures and beaches. The alternatives encompass the full range of options from preserving existing park upland landscape and uses, to transformation of the park to a primarily beach-oriented shoreline park. As a result, the alternatives differ with respect to impacts to cultural resources, improvements to ecology, change to coastal processes, construction cost, potential impacts, and future recreational use of the park. Table 6 summarizes each alternative relative to key criteria. A brief narrative summary for each is also provided below.

The *No Action Alternative* would almost certainly result in partial seawall failure, emergency response, and partial park closure within the next few years. This alternative is not preferred and does not provide benefits compared to other alternatives.

Alternative 1 would expand intertidal beach areas, while maintaining the tennis court with a seat wall. This alternative is advantageous because it preserves the primary existing recreation activities at the park, while increasing access to Puget Sound, improving ecological processes, and promoting resiliency to rising sea levels. Some slight improvement to coastal processes (sediment supply) could be realized at neighboring properties by allowing the restored beach to erode to its equilibrium position, thus supplying sediment to the littoral system. Grant funding sources could likely be sought and obtained to offset some of costs for this alternative. The beach would be designed to erode to an equilibrium condition and would require adjacent property owner agreement to allow beach compatible materials to be placed on their property to achieve the most beneficial outcome.

Alternative 2 would essentially revert the shoreline to a more natural state by setting the shoreline landward into the existing uplands and allowing for more adaptive capacity in the facing of rising sea levels. This alternative is advantageous because ecological processes would be substantially improved and beach access opportunities maximized. Excess excavated beach-compatible materials could be used as advanced beach nourishment for the park and to supply adjacent properties experiencing beach erosion. This alternative would necessitate removal of the WPA-era tennis court, likely require some mitigation signage, and would impact existing park uses. Grant funding sources could likely be sought and obtained to offset most of costs for this alternative. The beach would be designed to erode to an equilibrium condition and would require adjacent property owner agreement to allow beach compatible materials to be placed on their property to achieve the most beneficial outcome.

Alternative 3 would keep the park in its current state, but provide a more robust and reliable seawall replacing the existing failing wall. This alternative preserves the most upland areas behind the seawall, but also does little to address or improve access to the water, ecological function, coastal processes (e.g. erosion), and future sea level rise. Grant funding sources are not widely available for shoreline structure replacement when more restorative alternatives are feasible.

TABLE 6
ALTERNATIVES ANALYSIS TABLE

Criteria	No Action[1]	Alt. 1 Beach & Seat Wall	Alt. 2 Beach	Alt. 3 Replacement Seawall
Improved Coastal Processes	N/A	Medium	Medium/High	Low
Cultural Resource Impacts	Low	Low/Medium	Medium	Low
Resiliency to Sea Level Rise	N/A	Medium	High	Low
Potential Ecosystem Benefits	N/A	Medium	High	Low
View shed Preservation	N/A	Medium	Medium	High
Permitting Challenges	Medium	Low	Low	Medium
Maintenance	High	Medium	Low	Medium
Water Access	Low	Medium	High	Low
Upland Recreation	High	Medium	Low	High
Constructability	N/A	Medium	High	Medium
Construction Cost	N/A[1]	$ 1,023,928	$ 936,492	$ 901,399

1. Ongoing erosion will likely necessitate emergency shoreline protection and erosion control; cost is not determined.

The existing condition of the seawall requires some immediate actions, while the conceptual alternatives for removal and replacement are considered. Recommendations include the following:

- Disconnect and divert the existing SPU outfall. Reconnection might further scour the seabed and exacerbate ongoing erosion, wall undermining, and accelerate wall movement.

- Coordinate with the property owner to the north to shore-up the cracked concrete block wall at the north property boundary.

- Isolate the existing seawall from public access, both above and below the seawall. As the wet season continues and soils become saturated wall failure is more likely and creates a potential life-safety risk for the public in the vicinity.

- Continue monitoring movement and condition of the seawall top and undermining at the toe. Be prepared to notify regulatory agencies of potential failure and need to implement emergency action. Conduct twice-yearly survey of beach topography in conjunction with ongoing wall monitoring.

Selection of the preferred alternative concept would benefit from:

- Evaluation of the relative merits of the alternatives and tradeoffs associated with each alternative

- Engagement with the public and adjacent property owners, in order to inform them of the technical findings and to inform selection of the preferred alternative concept for more detailed design development

CHAPTER 6
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APPENDIX A
Seawall Condition Assessment

City of Seattle Parks & Recreation Department

LOWMAN BEACH PARK SEAWALL CONDITION ASSESSMENT

Seattle, Washington

Nov 30, 2017

ESA # D160292.00

PREPARED FOR

PREPARED BY

City of Seattle
Lowman Beach Park Seawall Condition Assessment

November 2017

The engineering material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a registered professional engineer is affixed below.

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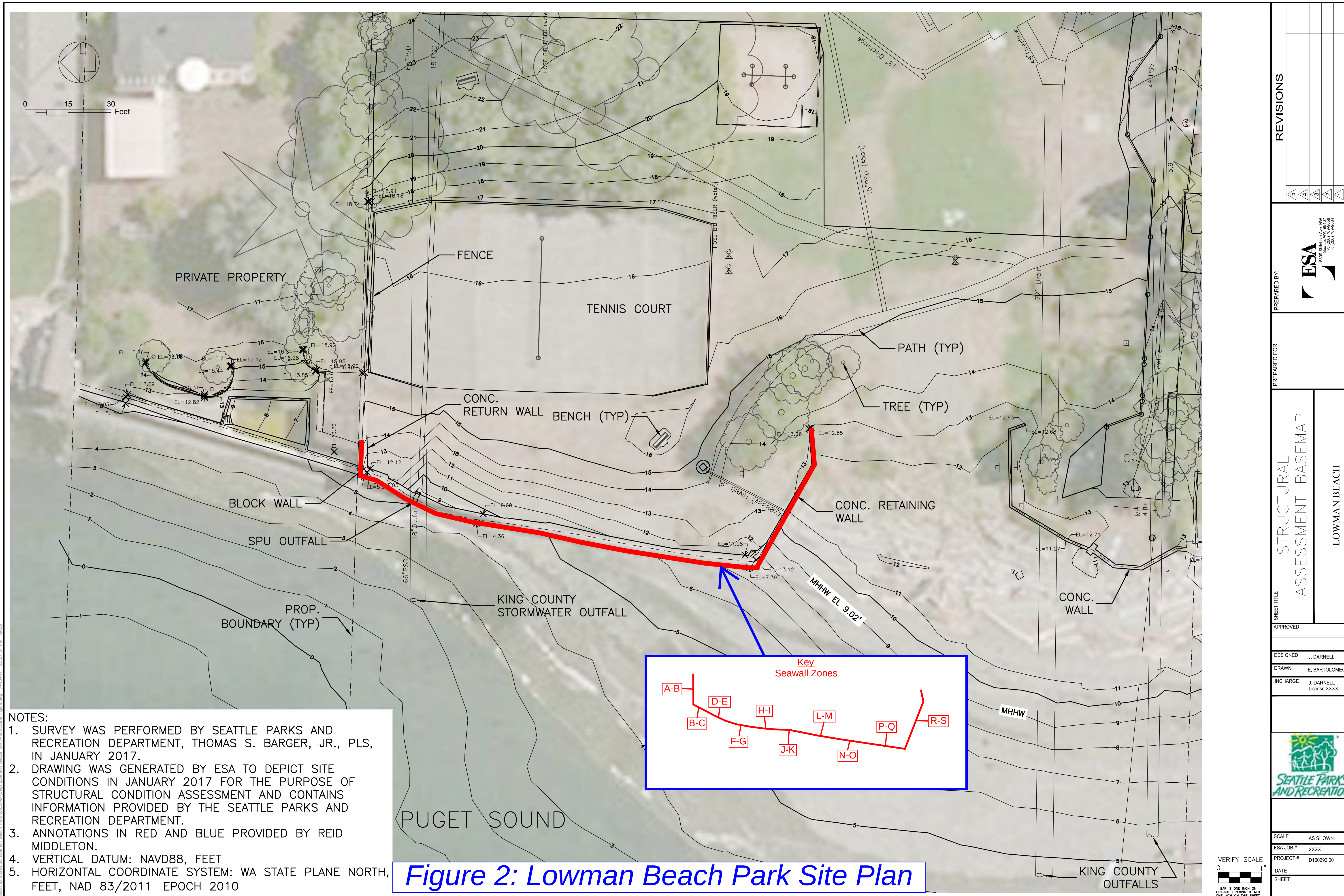
1 - INTRODUCTION

Lowman Beach Park is located within the city of Seattle, Washington, and is operated by the City of Seattle Parks and Recreation Department (Seattle Parks & Rec). The park consists of a seawall, a beach, and an uplands area containing a tennis court. The seawall had a notable failure near its northern end (see Figure 1), and Reid Middleton was asked to perform a condition assessment of the entire length of seawall.

The history of the seawall was investigated, a site visit performed, and the condition of the seawall documented by zone, as shown in Figure 2.

Figure 1. Failed Seawall (Photo taken on 10/18/2016).



NOTES:
1. SURVEY WAS PERFORMED BY SEATTLE PARKS AND RECREATION DEPARTMENT, THOMAS S. BARGER, JR., PLS, IN JANUARY 2017.
2. DRAWING WAS GENERATED BY ESA TO DEPICT SITE CONDITIONS IN JANUARY 2017 FOR THE PURPOSE OF STRUCTURAL CONDITION ASSESSMENT AND CONTAINS INFORMATION PROVIDED BY THE SEATTLE PARKS AND RECREATION DEPARTMENT.
3. ANNOTATIONS IN RED AND BLUE PROVIDED BY REID MIDDLETON.
4. VERTICAL DATUM: NAVD88, FEET
5. HORIZONTAL COORDINATE SYSTEM: WA STATE PLANE NORTH, FEET, NAD 83/2011 EPOCH 2010

Figure 2: Lowman Beach Park Site Plan

Background

The original seawall was constructed in the 1930's and is no longer present onsite. The northern portion failed and was replaced in the 1950's, at which point the southern portion was reinforced with concrete toe protection. In 1994 the southern portion of the seawall failed, and subsequently was converted from a seawall to a beach in 1995. During the 1995 project, wing walls were added to the remaining northern half of the seawall and the existing seawall to the south of the park. The drawings representing the current composition of the Seawall from Zones A-B through P-Q are dated 1951 (see Figure 3). The original construction is a cantilevered seawall without a footing for stability or toe protection to prevent erosion. The seawall was constructed using cast-in-place concrete by casting segments of seawall in place, with minimal to no connection between adjacent segments.

A portion of the park was reconfigured in 1995, which replaced a portion of the seawall that was constructed around 1951. The drawings representing the current composition of the Seawall at Zone R-S are dated 1995, showing the new section of cantilevered seawall with a footing for stability (see Figure 4). The toe of the new section of seawall was cast as one piece and installed well below grade.

Late in 2015 the remaining seawall failed; a portion of the seawall shifted position, tilting out towards the water. Based on comparison of photographs taken in 2015 and site visits on 10/18/2016 and 05/31/2017, the condition of the seawall appears to have continued to worsen since the 2015 failure. Based on review of historical records, over the past roughly 70 years the beach elevation has decreased approximately two to three feet in front of the northern portion of the seawall.

In summary, the history of the seawall is as follows:

- 1930's: Original seawall constructed
- 1950: Northern half of the seawall fails
- 1951: Northern half of the wall is replaced and concrete toe protection installed in front of the southern half.
- 1994: South half of the wall fails
- 1995: South half of the wall is removed and replaced with a beach, wing walls are added to the remaining north half of the seawall in the park and the existing seawall to the south of the park
- 2015: North half of the seawall fails

Structures of this type would typically be anticipated to have a thirty to fifty year design life. In the case of the Lowman Beach Seawall, the wall has aged beyond its anticipated service life. Drawings from 1951 show a few feet of beach material above the toe of the seawall which is now exposed, causing undermining at some locations. This undermining caused a loss of global stability and partial collapse. The portions of the seawall constructed around 1951 are beyond their anticipated service life, and if re-used as part of a seawall replacement project, they may have a service life less than the other new project elements.

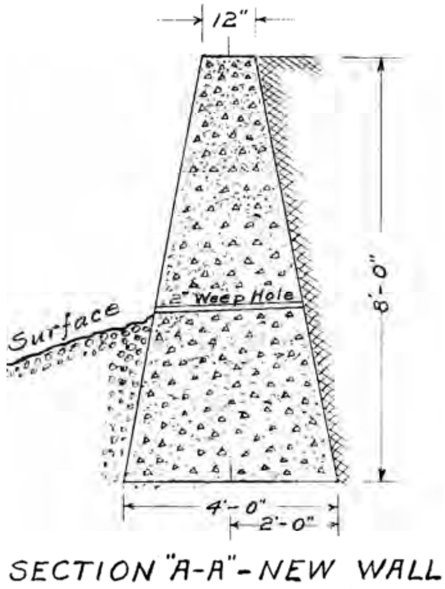


Figure 3. 1951 Seawall Design, Zones A-B through P-Q.

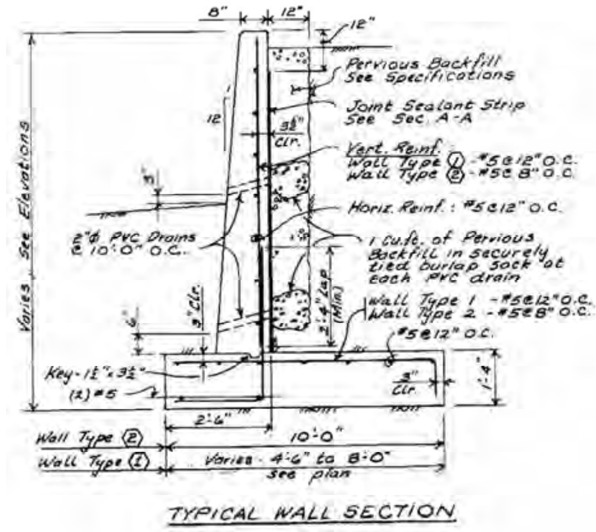


Figure 4. 1995 Seawall Design, Zone R-S.

2 - CONDITION ASSESSMENT

The conditions of the seawall were assessed by Reid Middleton during two site visits; one on October 18, 2016 and one on May 31, 2017. Results of the assessment are provided below, and photographs are provided in Appendix A.

Assessment Criteria, Procedures, and Results

Visible structural components of the landing float were inspected, and results of the site observation are summarized in Table 1. Reid Middleton conducted a visual inspection of the overall system, including cast-in-place concrete seawall segments and the toe protection. Inspections were performed in accordance with the methods described in *ASCE Manuals and Reports on Engineering Practice No. 130 (MOP 130); Waterfront Facilities Inspection and Assessment.*

The general condition of each of the elements and specific damage conditions observed are shown in Appendix A and discussed below. The condition rating criteria follow:

Good	No visible damage or only minor damage is noted. No repairs are required.
Satisfactory	Limited minor to moderate deterioration was observed. No repairs are required.
Fair	Primary elements are sound, but minor to moderate defects or deterioration are observed. Repairs are recommended, but the priority of the recommended repairs is low.
Poor	Advanced deterioration is observed on widespread portions of the structure. Repairs may need to be carried out with moderate urgency.
Serious	Advanced deterioration or breakage may have affected the primary structural components significantly. Local failures are possible, and repairs should be carried out on a high-priority basis.
Critical	Extremely advanced deterioration or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and repairs should be carried out on a high priority basis.

Table 1. Condition Assessment Results.

ITEM	PHOTO	RATING	EXISTING CONDITION
North Retaining Wall Origin: Unknown, likely 1950's	5, 6	Fair	Structural: Not much visible, no damage notes. CMU privacy wall on top of retaining wall in serious condition. Length unknown, wall terminates underground Toe: N/A Rotation & Settlement: N/A
Zone A-B Length = 5' Origin: 1950's	5, 6, 7, 8	Fair	Structural: Some spalling[1] at mudline where intersects Zone B-C. Toe: Exposed, material loss beginning, not protected. Rotation & Settlement: Minimal, has return portion perpendicular to shoreline that adds stability.
Zone B-C (8') Zone D-E (15') Zone F-G (8') Zone H-I (22') Zone J-K (15') Origin: 1950's	10 - 24	Critical	Structural: Cracking and spalling[1]. Original seawall segments have broken full-height into smaller segments. Toe: Exposed, material loss below wall, not protected. Rotation & Settlement: Segments appear to have rotated outwards and translated away from shore. Multiple segments broken full-height due to differential settlement.
Zone L-M Length = 16' Origin: 1950's	24, 25	Critical	Structural: Cracking and spalling[1]. Toe: Exposed, material loss below wall, not protected. Rotation & Settlement: Less than adjacent panels, but appears that some has occurred.
Zone N-O Length = 29' Origin: 1950's	25, 26	Serious	Structural: Cracking and spalling[1]. Toe: Exposed, material loss below wall beginning, not protected. Rotation & Settlement: Appears to have slight rotation outwards and slight translation away from shore.
Zone P-Q Length = 28' Origin: 1950's	26, 27, 28, 29	Serious	Structural: Cracking and spalling[1]. Multiple full-height cracks. Toe: Evidence of material loss below wall, not protected. Rotation & Settlement: Evidence of settlement observed, full-height cracking pattern.
Zone R-S Length = 50'± Origin: 1995	29, 31	Good	Structural: No visible damage. Toe: Buried, does not appear to be exposed. Rotation & Settlement: None visible.

[1]Cracking and spalling occurred where adjacent portions of seawall bear due to differential settlement and rotation.

Material Loss, Differential Settlement, & Tipping

Zones B-C through P-Q of the seawall appear to have been constructed without adequate toe protection, and the toe has been exposed as the shoreline eroded over time. Evidence of soil loss under the toe were noted where the underneath side of the seawall can be visually observed from the waterward side. Cracking/spalling has occurred due to differential settlement between adjacent seawall segments, and rotation occurred due to loss of underlying bearing soil. The entirety of Zones B-C through P-Q are susceptible to failure due to loss of underlying bearing soil, and will continue to fail as bearing soil loss increases in extent and severity.

Photographs were taken during two site visits several months apart. During the second site visit erosion and associated damages were observed to have increased. Continued erosion and the associated settlement-related movements (vertical settlement and tipping) are anticipated to continue, and it is not clear how close the facility is to a global overturning failure.

Storm Outfall

An existing storm outfall connection was disconnected within Zone D-E due to translation and rotation of the seawall. It is anticipated that soil will continue to be washed out from behind and below the existing seawall at the location of the disconnected storm outfall, accelerating the already occurring failure of the seawall.

Adjacent Facilities (Retaining Wall, Seawall to the North)

To the north of the Lowman Beach seawall is a private residence. There is a seawall protecting this private residence roughly in-line with the existing Lowman Beach Park seawall. This private seawall appears to be concrete construction, similar to the other walls in the vicinity and presumably subject to similar failure mechanisms as the Lowman Beach seawall.

The northern portion of the Lowman Beach park is separated from the adjacent private residence by a concrete retaining wall running approximately east-west (referred to as the North Retaining Wall in Table 1). Design drawings and date of installation for the north retaining wall were not available to Reid Middleton at the time this report was written. It appears to be concrete construction, possibly matching the vintage of the seawall built around 1951.

Uncertainties/Unknowns

Some uncertainties and unknowns remain, and are listed below:

1. Depth of embedment of the concrete north retaining wall running approximately east-west along the northern boundary of the park.
2. Detailing of seawall protecting the private property to the north of the park.
3. Remaining life before complete collapse of seawall that is actively failing.
4. Exact extents of loss of bearing soil underneath the seawall, as it tends to settle as material is lost.

On-going Maintenance Recommendations

Periodic inspections should be performed in accordance with the ASCE MOP 130-2015 (Waterfront Facilities Inspection and Assessment), which recommends a routine inspection in approximately one year given the advanced deterioration and localized failures observed.

We understand that Seattle Parks & Rec routinely surveys the seawall top at crack and joint locations. This data should be analyzed on a routine basis to evaluate the extent of movement, as further collapse may be precluded by a warning of additional or accelerated movement. Indications of further collapse would indicate an elevated risk to park users and may warrant more extensive use restrictions both behind and in front of the seawall. If additional or accelerated movement is observed, it is recommended that Seattle Parks & Rec increase the frequency of monitoring, and be ready to implement a plan to deal with more extensive collapse, should it occur.

Risk of Continued Operations

The existing seawall is actively failing, and is at a high risk of collapse. The probability of failure increases the longer the system goes without repairs. The ultimate collapse may be slow and progressive, or could occur rapidly. Seattle Parks & Rec should take measures to protect the public in case of collapse, and have a plan in place to deal with a collapse should it occur.

New Construction - Considerations

During review of the site conditions and original construction drawings, a number of considerations associated with the seawall replacement project were identified, as follows:

1. Rubble used for fill behind approximately Zone B-C through Zone H-I during original construction in the 1950's could be a pile driving obstruction.
2. The depth of the existing north retaining wall running east-west along the north portion of the park that delineates the adjacent property is unknown. Depending on the nature of upland regrading, the stresses on the wall may be increased, or the wall may be undermined. It is recommended that these risks be avoided if possible by avoiding disturbance and locating the original design drawings if possible.
3. Adjacent bulkheads on private properties to the North of the park may be currently undermined and unstable, and may be damaged by vibrations during pile driving.
4. Zone A-B (1950's era) of the existing seawall could likely be reused, though it should be secured to the concrete retaining wall running shoreward and the toe protected from further erosion.
5. Zones B-C through P-Q (1950's era) of the existing seawall are failing due to loss of bearing material and the resulting differential settlement along the wall alignment.
6. Zones B-C through L-M (1950's era) are failing due to loss of stability and substantial tipping that resulted from loss of bearing soil from underneath the existing wall.
7. Structural damage due to differential settlement may be repairable for incorporation into the replacement project. It is likely cost-prohibitive to repair segments of the seawall that

have tipped and cracked substantially due to a loss of stability and subsequent settlement, causing them to reach the end of their useful design life.

3 - CONCLUSION

The seawall is actively failing, and the complete collapse may be imminent. It is recommended that annual inspections be performed until replacement. A select few portions of the existing seawall may be incorporated into the replacement project, but the majority of the seawall has exceeded its useful life and needs to be replaced. For public safety, it is recommended that the City limit access above and below the failing seawall.

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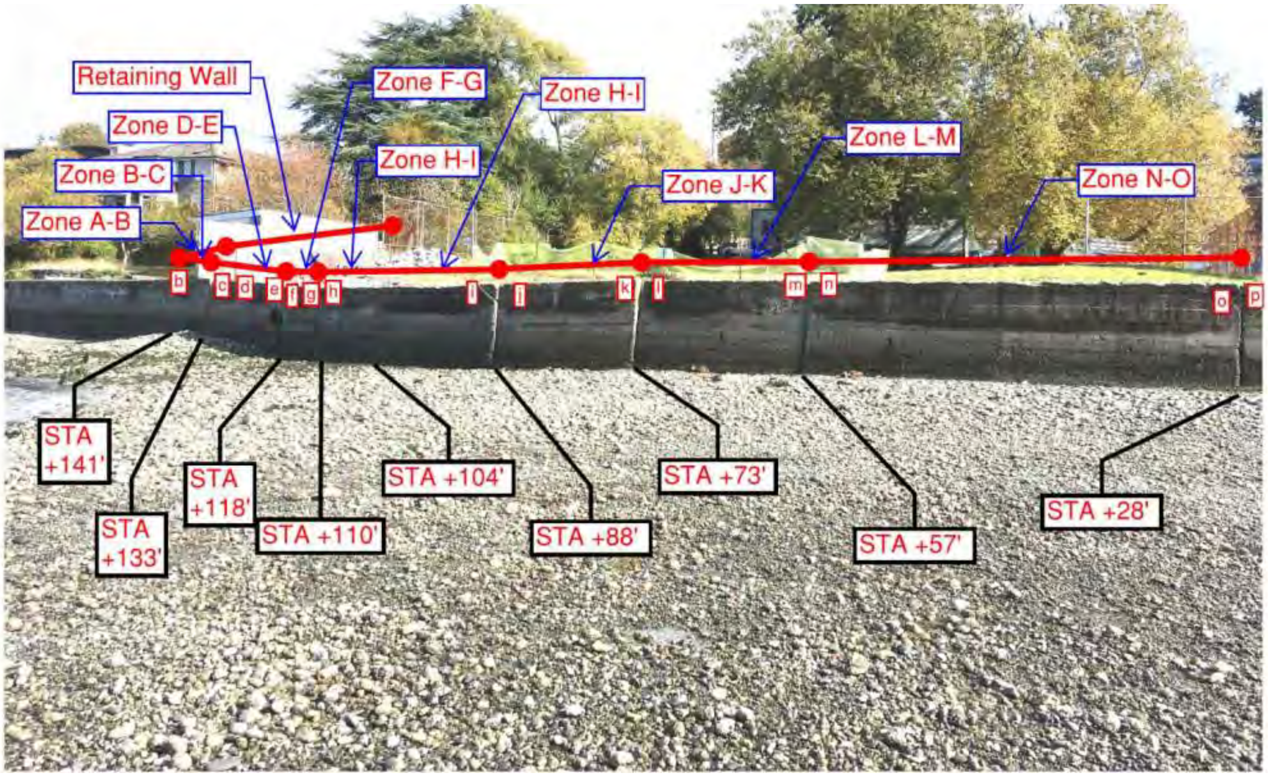

Photo 1. North Portion of Seawall.
Source: Reid Middleton Site Visit 10/18/2016
Note: Dimensions roughly field measured – for assessment purposes only.

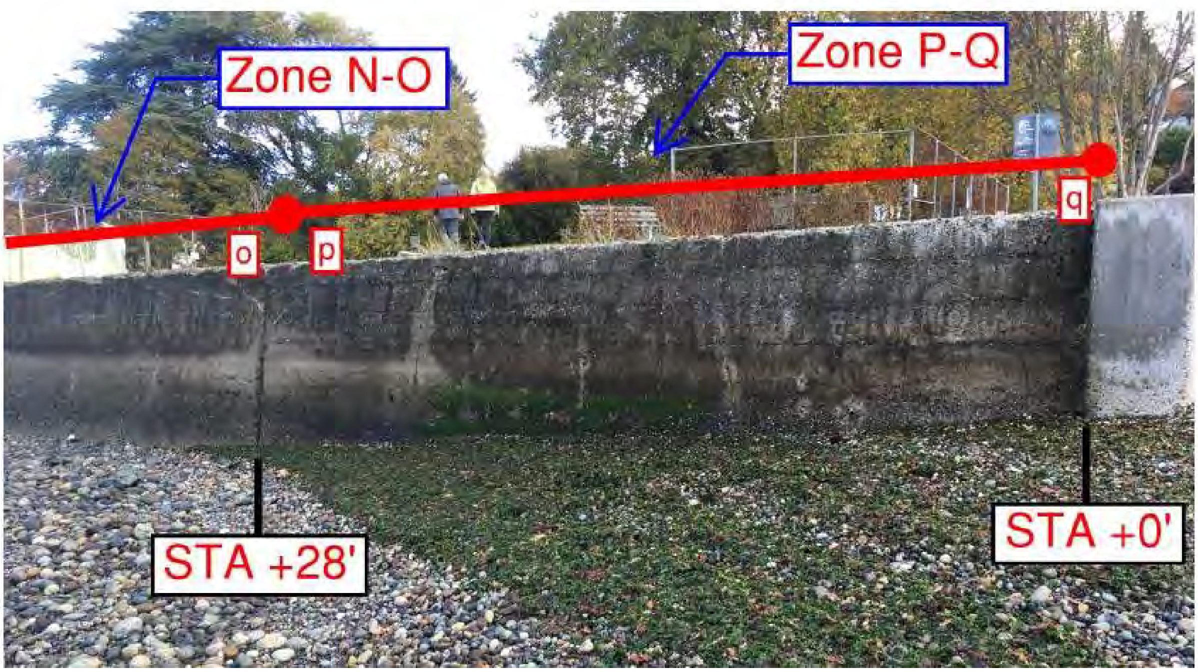

Photo 2. South Portion of Seawall.
Source: Reid Middleton Site Visit 10/18/2016
Note: Dimensions roughly field measured – for assessment purposes only.

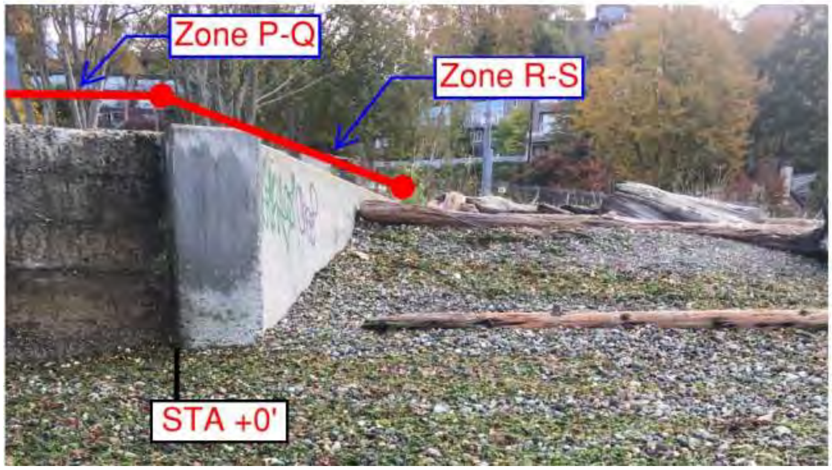

Photo 3. Southern Seawall Return.
Source: Reid Middleton Site Visit 10/18/2016

Photo 4. Adjacent Property to the North.
Source: Reid Middleton Site Visit 10/18/2016

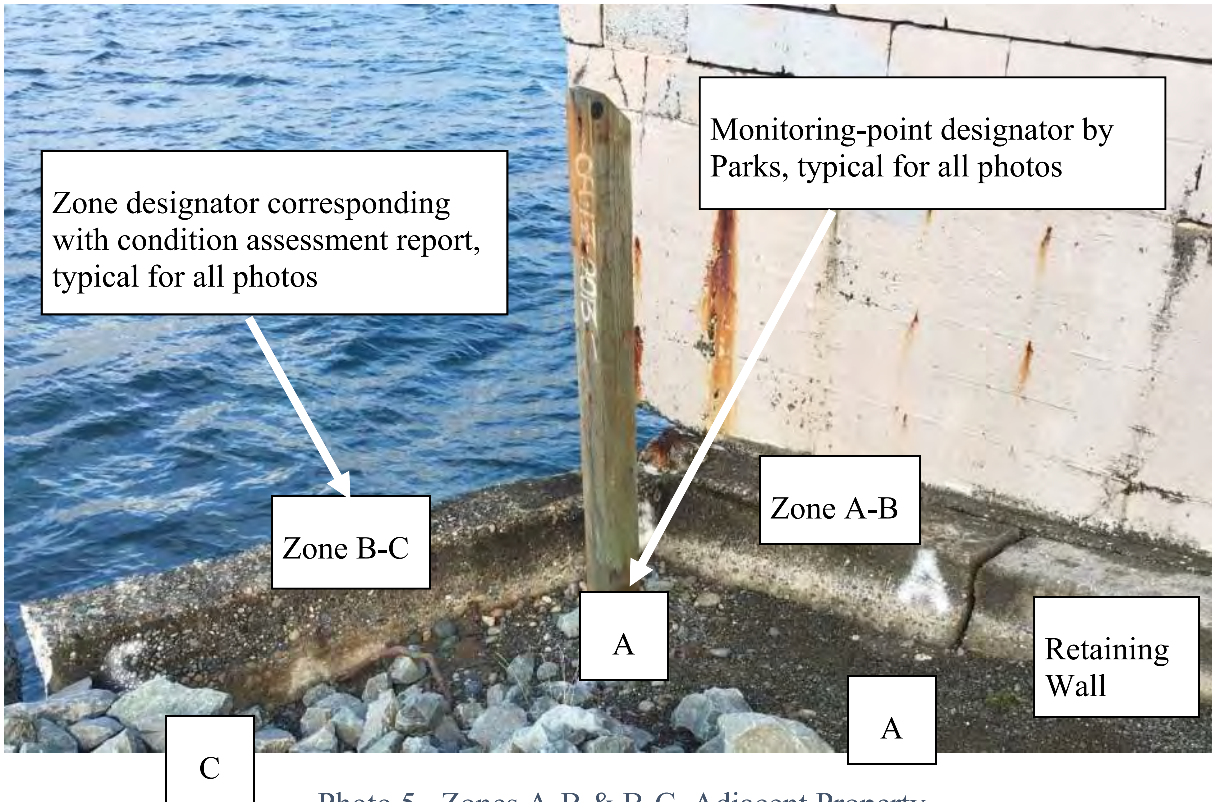

Photo 5. Zones A-B & B-C, Adjacent Property.
Source: Reid Middleton Site Visit 10/18/2016

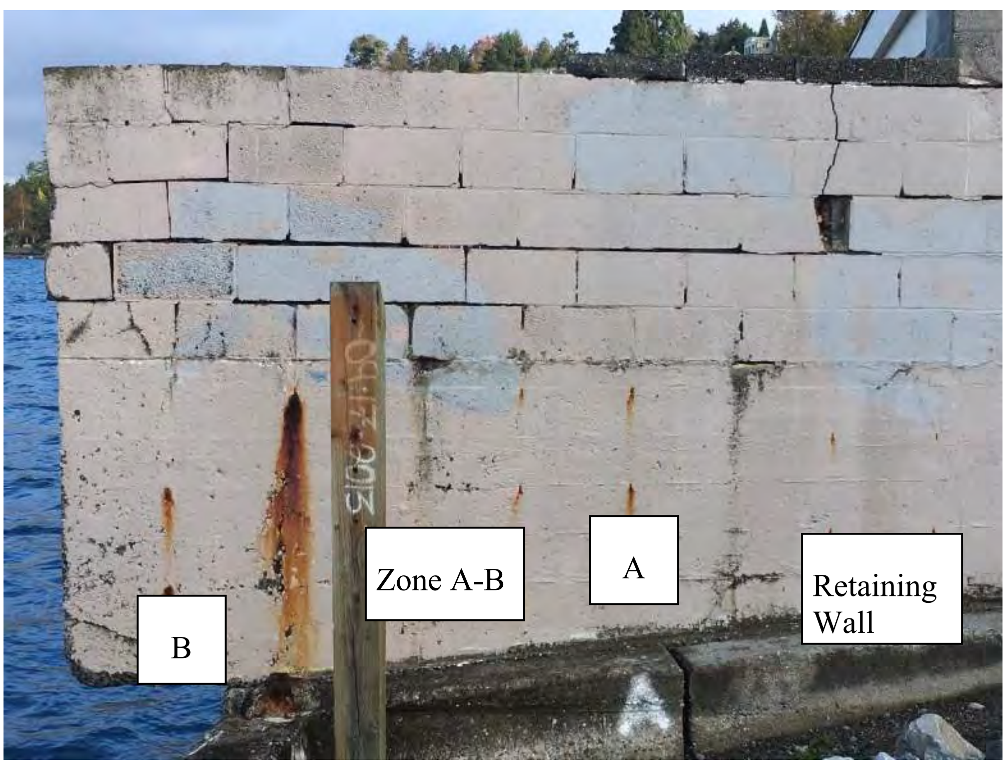

Photo 6. Zone A-B, Adjacent Property.
Source: Reid Middleton Site Visit 10/18/2016

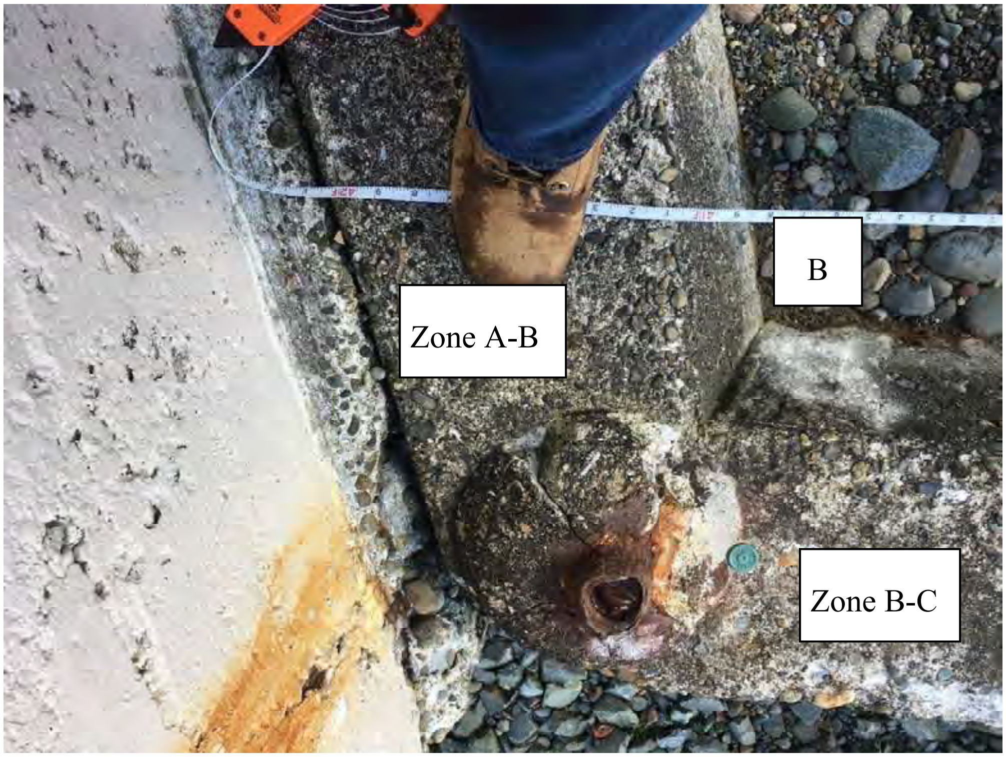

Photo 7. Zones A-B & B-C.
Source: Reid Middleton Site Visit 10/18/2016

Photo 8. Zone B-C, Adjacent Property.
Source: Reid Middleton Site Visit 10/18/2016

Photo 9. Private Seawall to the North.
Source: Reid Middleton Site Visit 10/18/2016

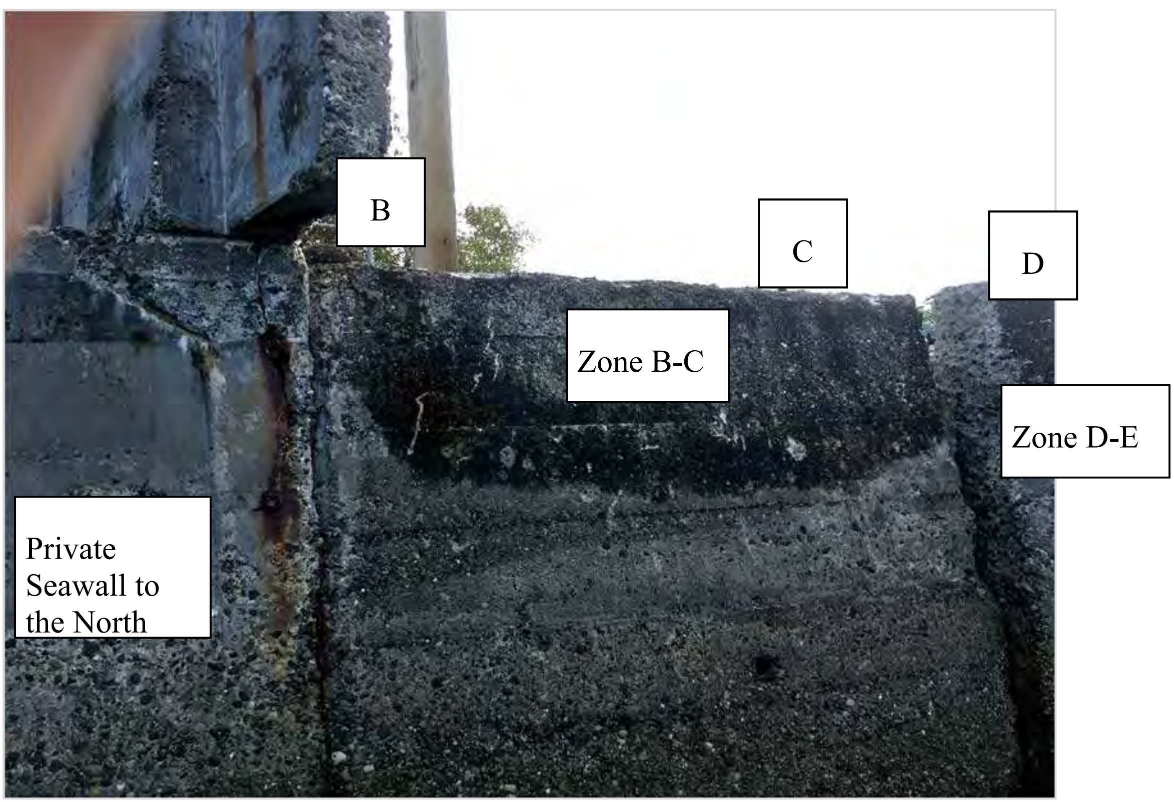

Photo 10. Zones B-C & C-D.
Source: Reid Middleton Site Visit 10/18/2016

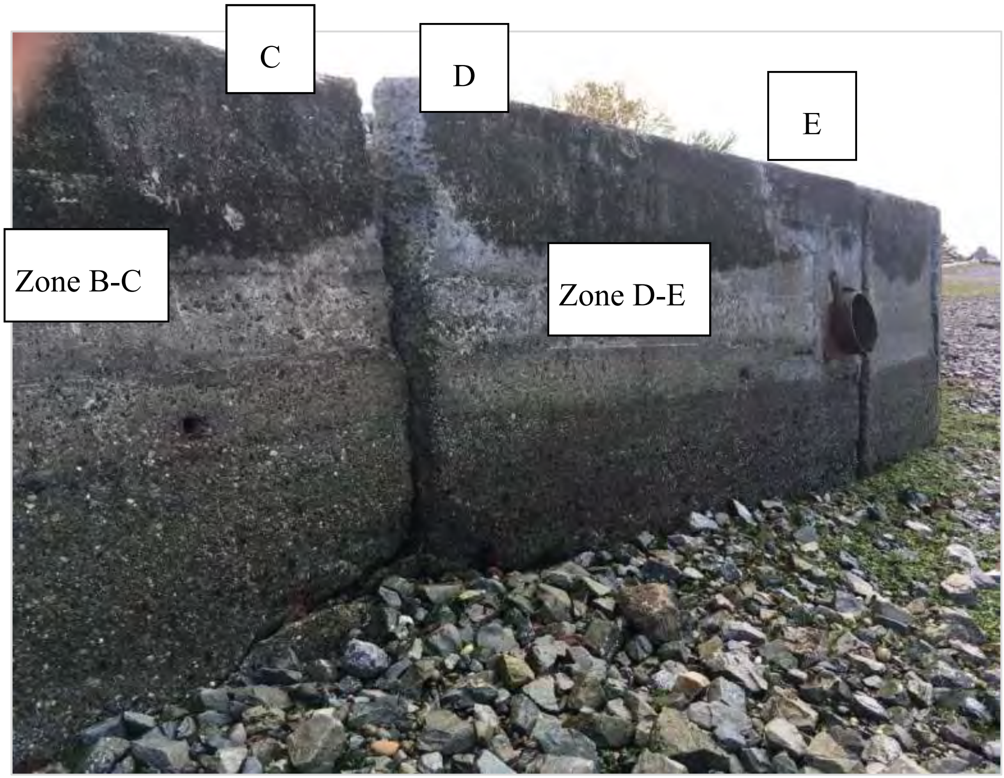

Photo 11. Zones B-C & D-E, Outfall.
Source: Reid Middleton Site Visit 10/18/2016

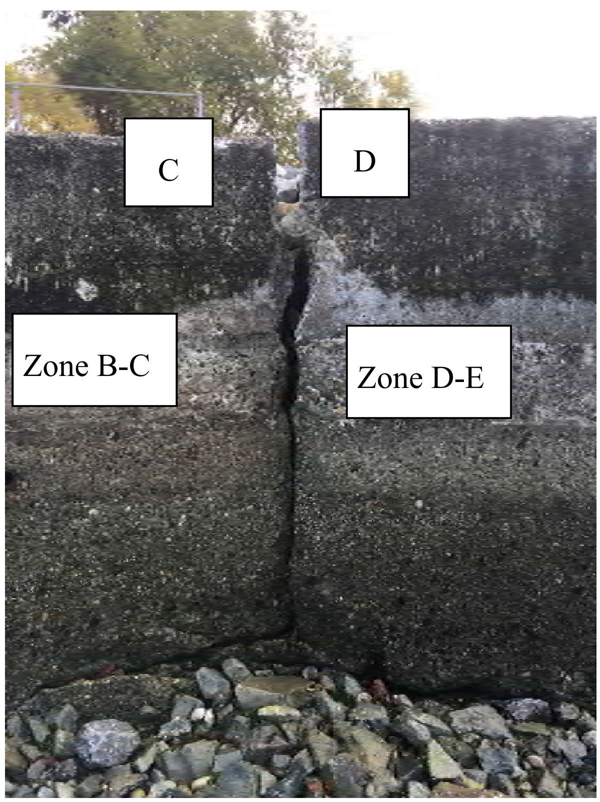

Photo 12. Zones B-C & D-E.
Source: Reid Middleton Site Visit 10/18/2016

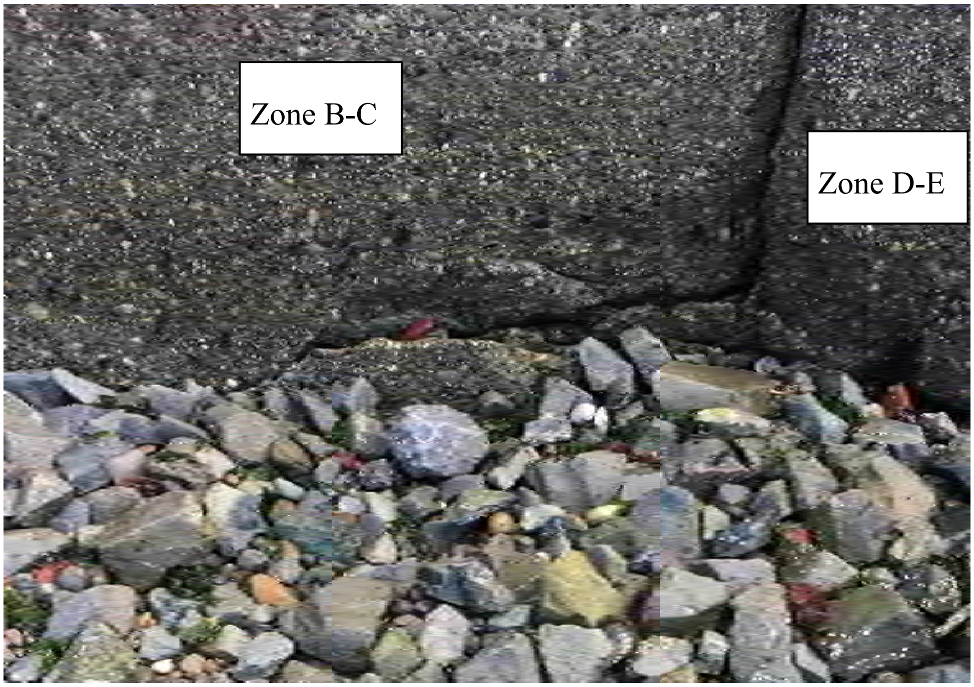

Photo 13. Zones B-C & D-E, Beach Material.
Source: Reid Middleton Site Visit 10/18/2016

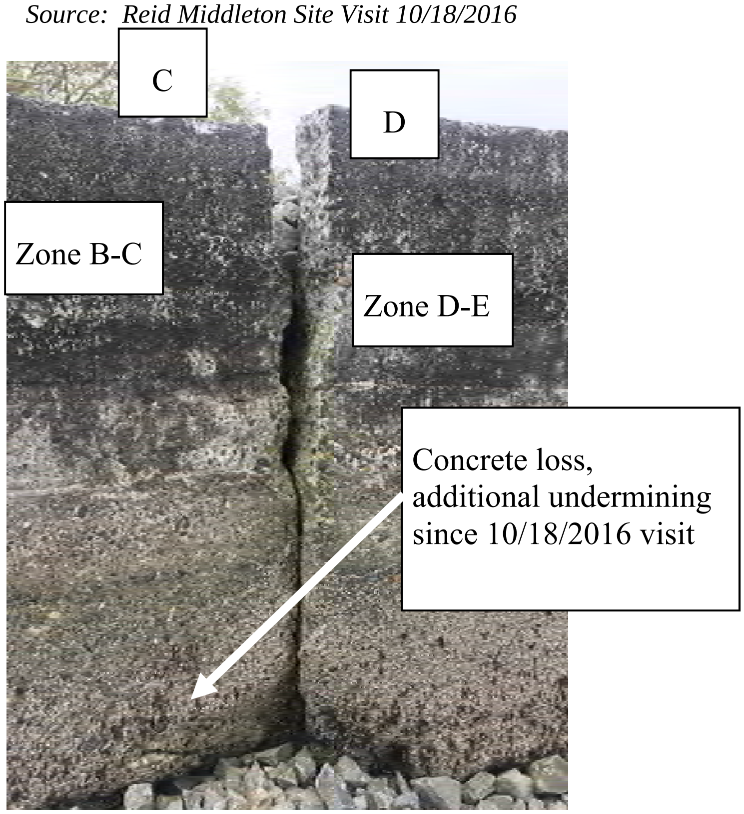

Photo 14. Zones B-C & D-E.
Source: Reid Middleton Site Visit 5/31/2017

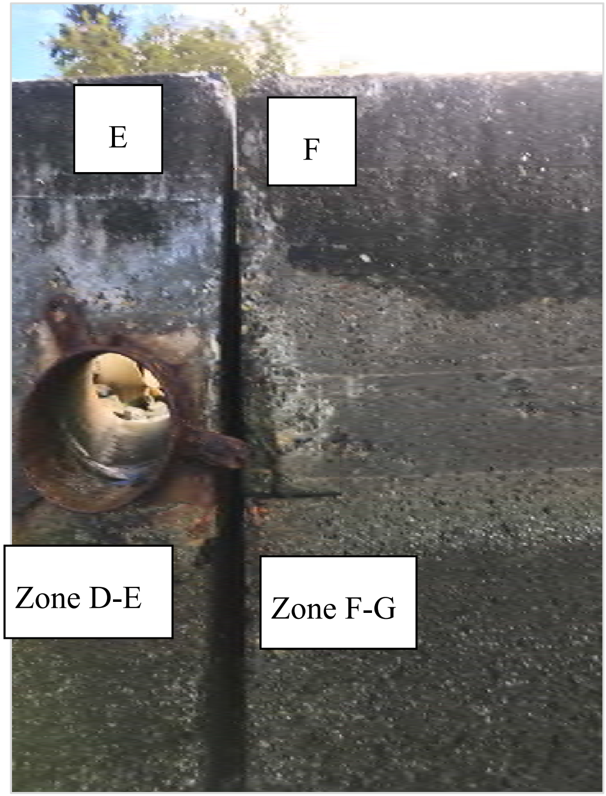

Photo 15. Zones D-E & F-G.
Source: Reid Middleton Site Visit 10/18/2016

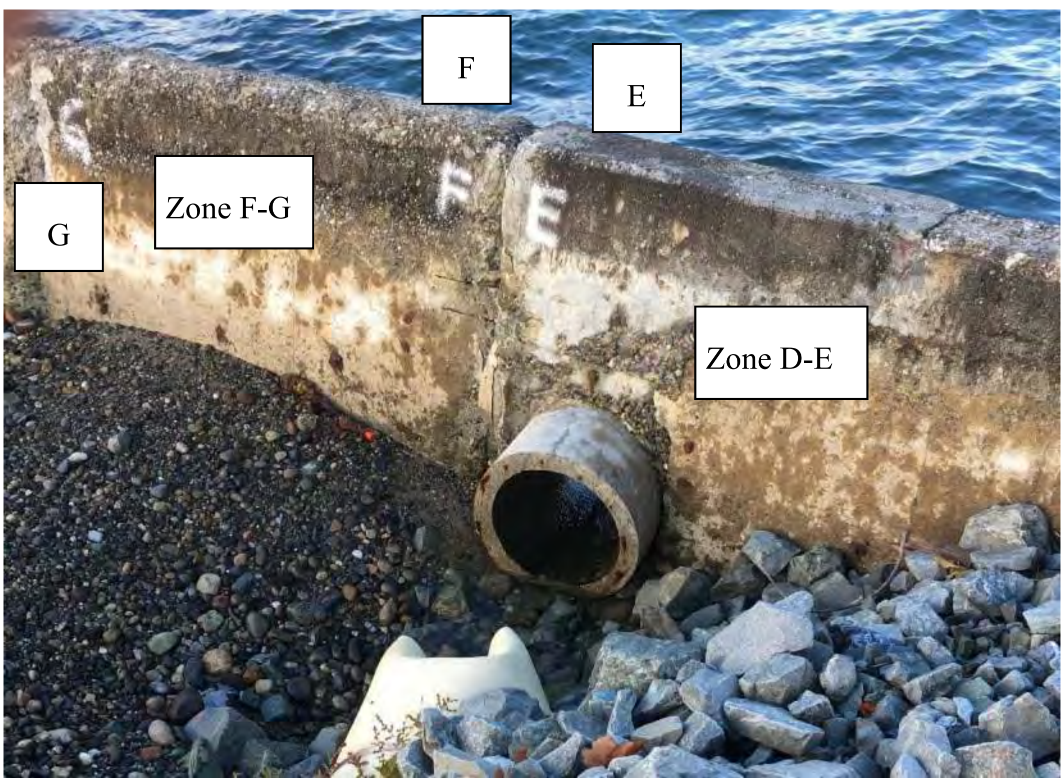

Photo 16. Zones D-E & F-G, Broken Outfall.
Source: Reid Middleton Site Visit 10/18/2016

Photo 17. Southern View from Zone B-C.
Source: Reid Middleton Site Visit 10/18/2016

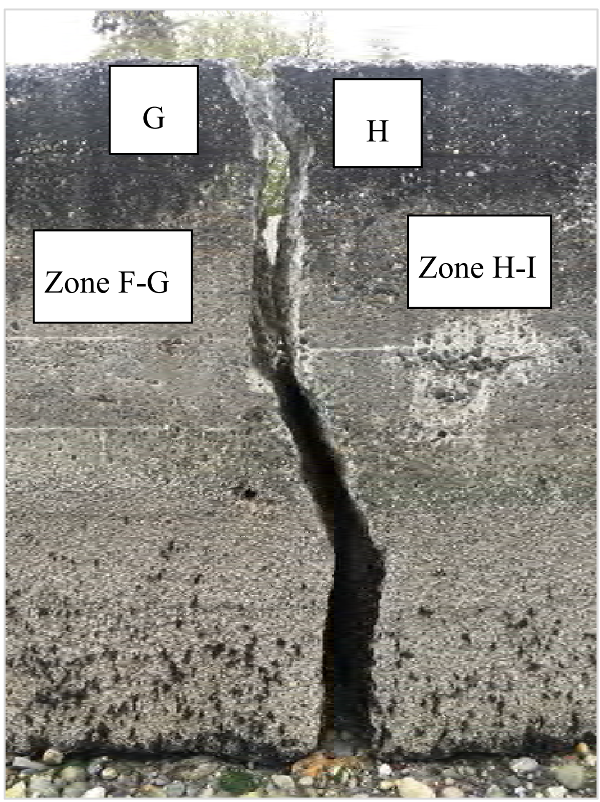

Photo 18. Zones F-G & H-I.
Source: Reid Middleton Site Visit 05/31/2017

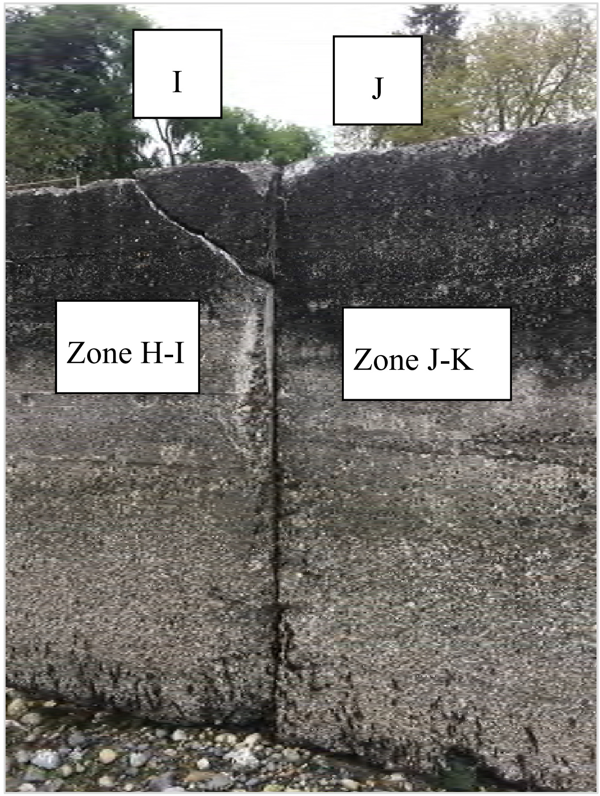

Photo 19. Zones H-I & J-K.
Source: Reid Middleton Site Visit 5/31/2017

Photo 20. Beach Material at Zone J-K.
Source: Reid Middleton Site Visit 10/18/2016

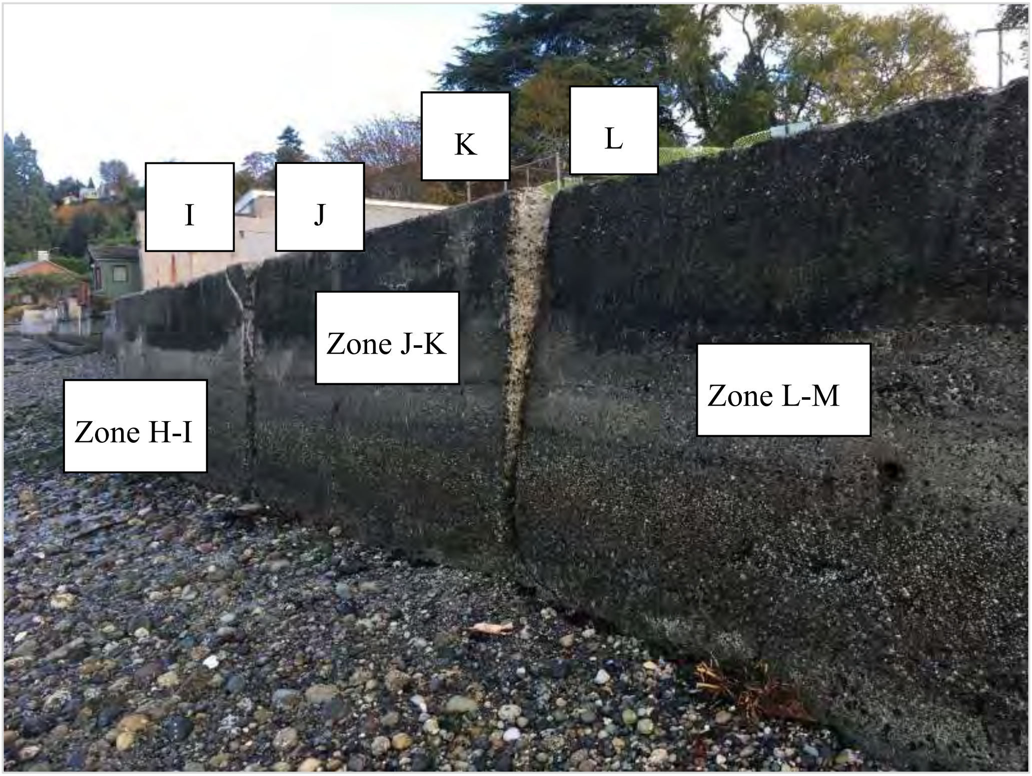

Photo 21. Zones I-J, J-K, & L-M.
Source: Reid Middleton Site Visit 10/18/2016

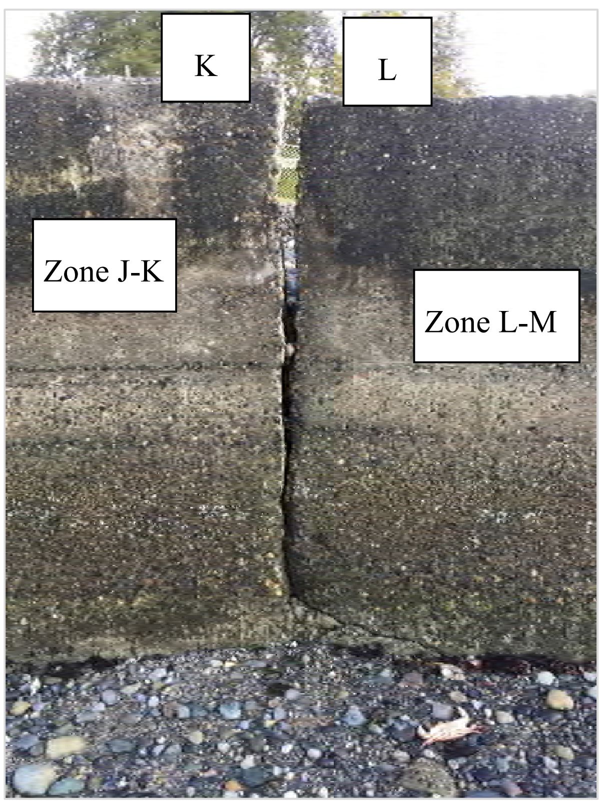

Photo 22. Zone J-K & L-M.
Source: Reid Middleton Site Visit 10/18/2016

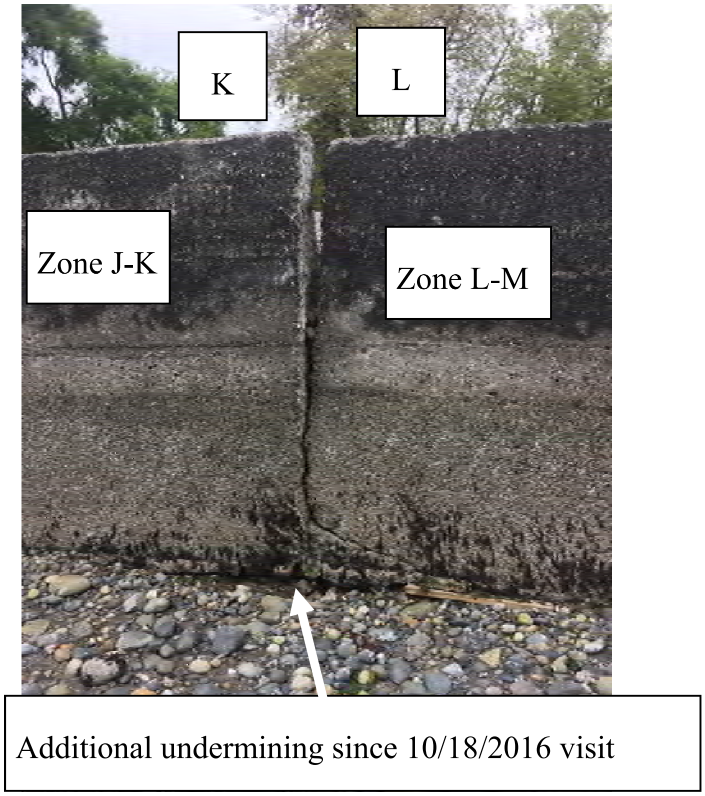

Photo 23. Zone J-K & L-M.
Source: Reid Middleton Site Visit 5/31/2017

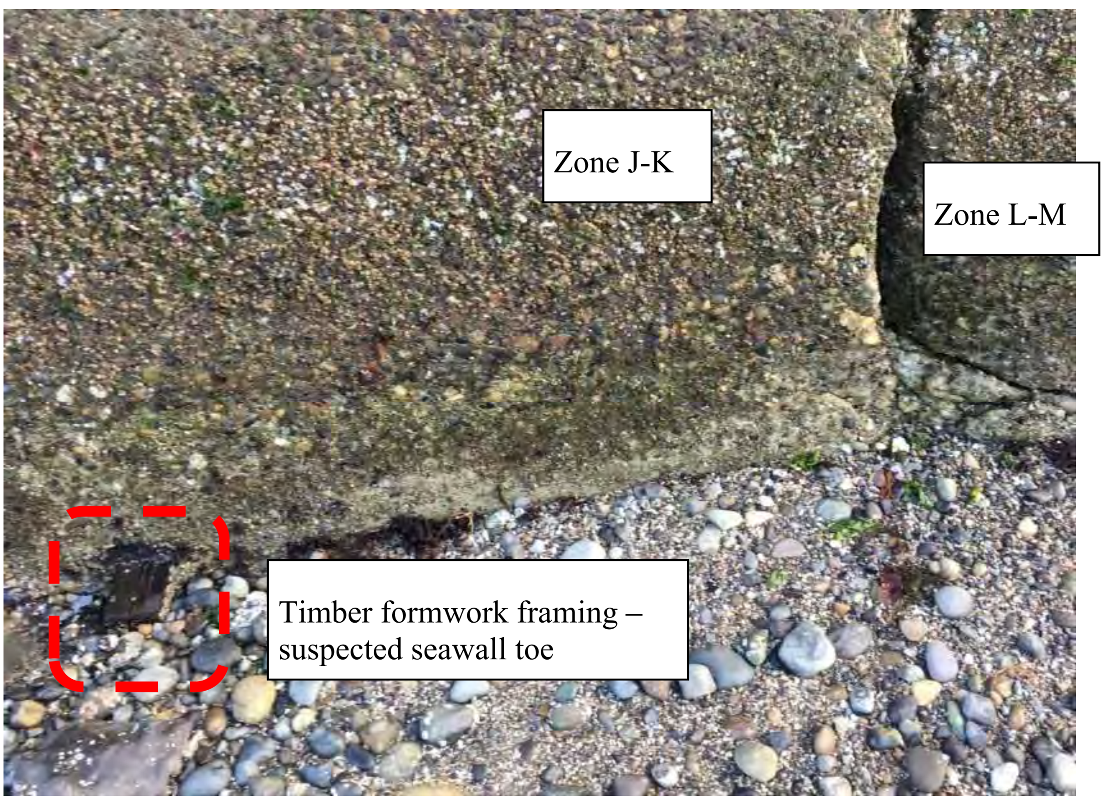

Photo 24. Zone J-K & L-M.
Source: Reid Middleton Site Visit 10/18/2016

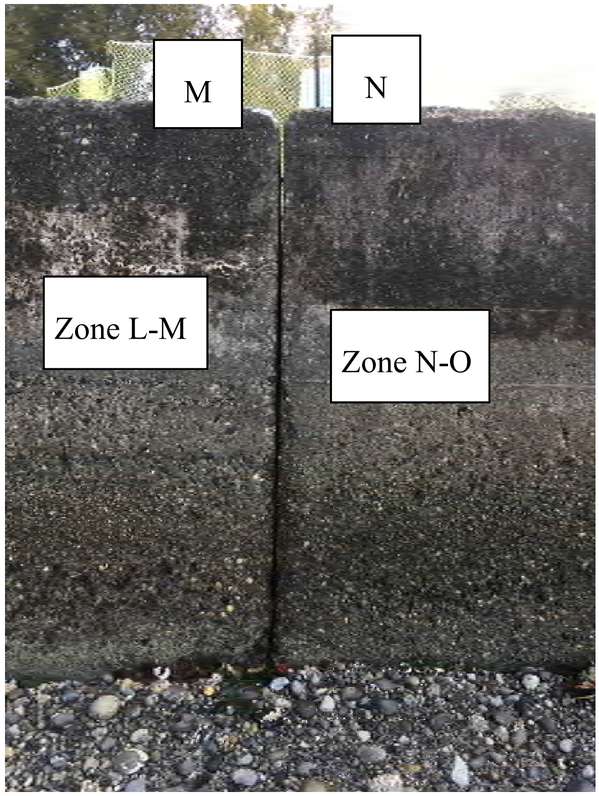

Photo 25. Zones L-M & N-O.
Source: Reid Middleton Site Visit 10/18/2016

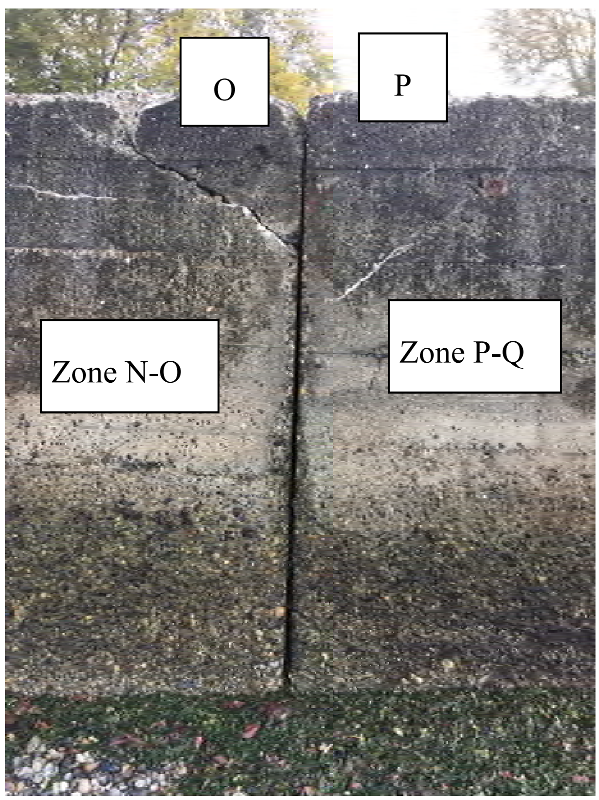

Photo 26. Zones N-O & P-Q.
Source: Reid Middleton Site Visit 10/18/2016

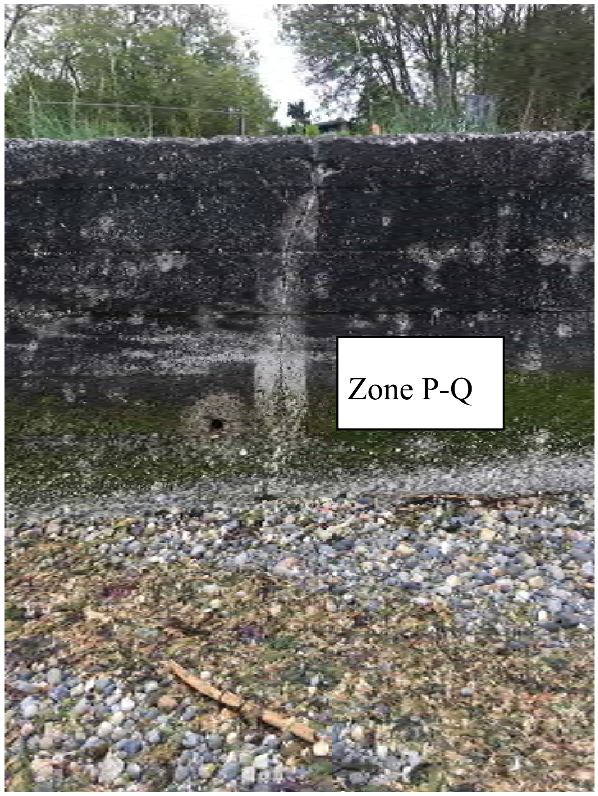

Photo 27. Zone P-Q.
Source: Reid Middleton Site Visit 5/31/2017

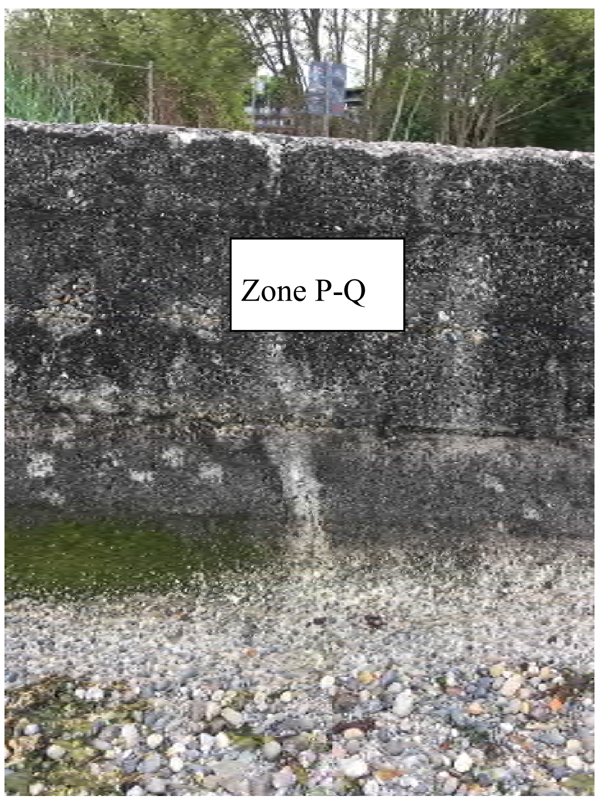

Photo 28. Zone P-Q.
Source: Reid Middleton Site Visit 10/18/2016

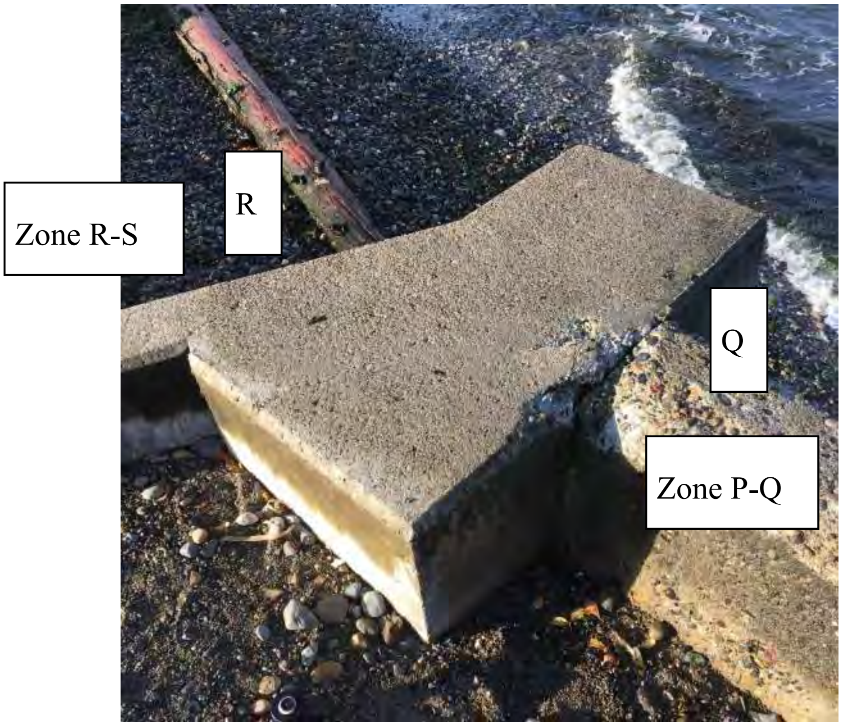

Photo 29. Zones P-Q & R-S.
Source: Reid Middleton Site Visit 10/18/2016

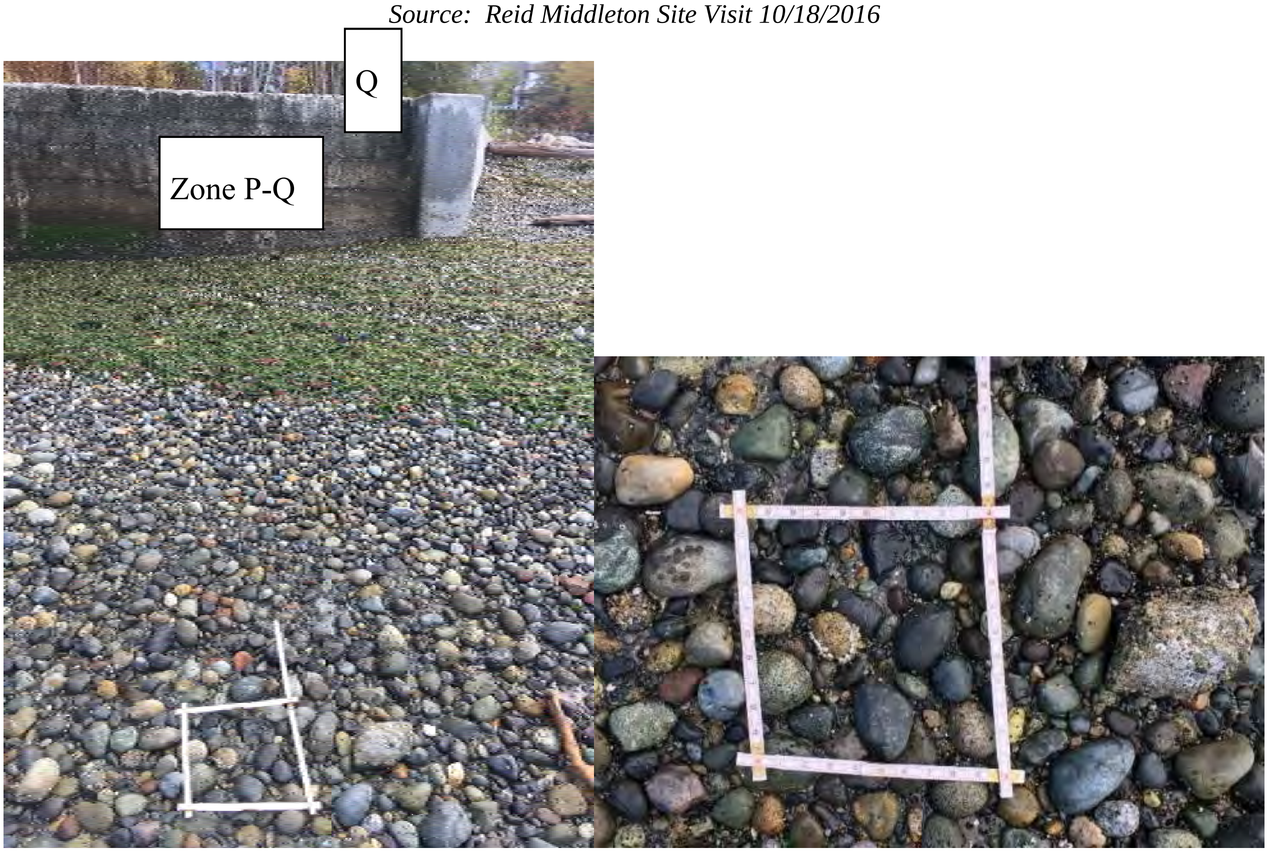

Photo 30. Zone P-Q, Lower Beach Material.
Source: Reid Middleton Site Visit 10/18/2016

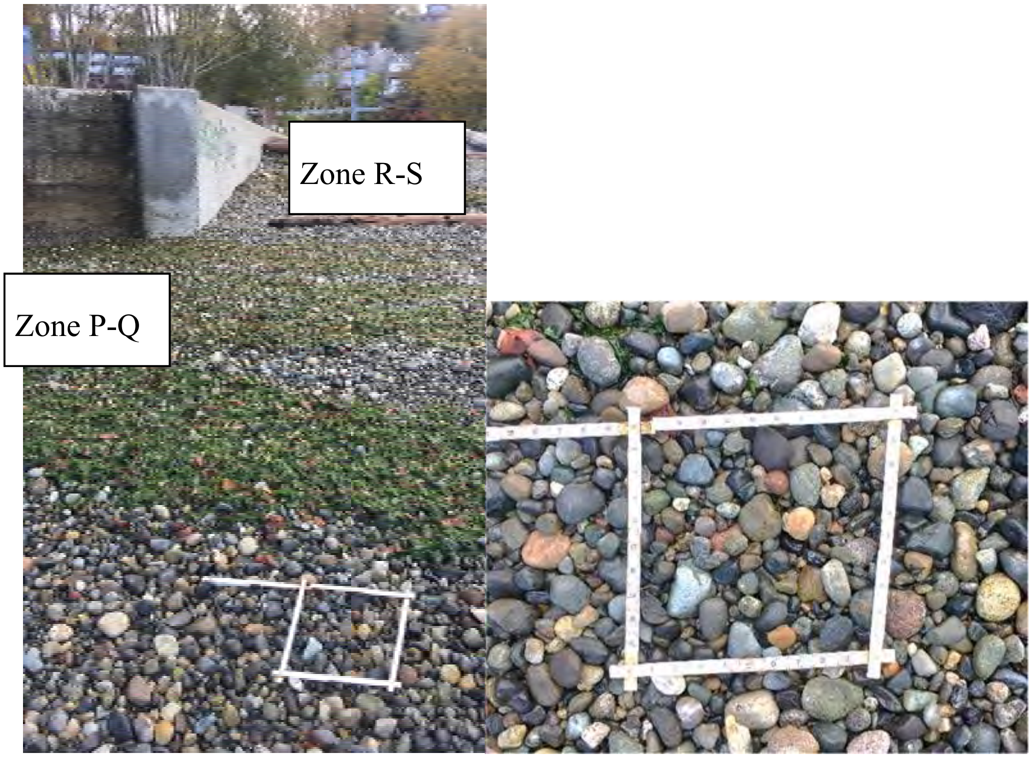

Photo 31. Zones P-Q & R-S, Upper Beach Material.
Source: Reid Middleton Site Visit 10/18/2016

Photo 32. View to the South from Zone R-S.
Source: Reid Middleton Site Visit 10/18/2016

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APPENDIX B

Structural Engineering Report

City of Seattle Parks & Recreation Department

LOWMAN BEACH PARK FEASIBILITY STUDY REPORT STRUCTURAL CONSIDERATIONS

Seattle, Washington

Nov. 30, 2017
ESA # D160292.00

PREPARED FOR

ESA

SEATTLE PARKS AND RECREATION

PREPARED BY

Reid Middleton

City of Seattle
Lowman Beach Park
Feasibility Study Report - Structural Considerations

November 2017

The engineering material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a registered professional engineer is affixed below.

11/30/2017

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Project Engineer

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1 - INTRODUCTION

Lowman Beach Park is located within the city of Seattle, Washington, and is operated by the City of Seattle Parks and Recreation Department (Parks). The park consists of a seawall, a beach, and upland features, including a tennis court. The existing seawall has failed near its northern end, and Reid Middleton, Inc., was asked to provide a condition assessment of the entire length of seawall and a feasibility study report that explores three site development alternatives. This report compares the three seawall replacement alternatives from a structural engineering perspective. The condition assessment was provided in a separate report dated August 2017.

Reid Middleton's scope is limited to the seawall replacement project within the Lowman Beach Park site. The information presented in this feasibility study report is not intended to be extrapolated outside the park to other properties in the vicinity.

2 - DESIGN ELEMENTS

Three conceptual design alternatives were developed by ESA in collaboration with Reid Middleton. These alternatives are shown in ESA's corresponding feasibility study report. The potential structural design elements that were considered for inclusion in the alternatives are described below.

Design Element – Soldier Pile Seawall

A soldier pile seawall consists of driven steel piling that support precast concrete panels. The piling are typically installed by placing in an augured hole and securing in place with grout or concrete or by use of a pile driving hammer. Installation in an augured hole using grout or concrete would have environmental implications due to the possibility of grout or concrete entering the water and may complicate the permitting process.

Installation of the precast concrete panels requires access to the bottom of the panels, which will likely require temporary shoring or a coffer dam, depending on the site geometry and location of the soldier pile seawall. A soldier pile seawall is suited for applications with relatively straight alignments but would be difficult to detail and install for irregular alignments. Note that the temporary shoring or coffer dam would need to be designed and installed with consideration for adjacent properties and large stormwater outfall that extends waterward of the existing seawall.

A new soldier pile seawall would need to be protected against undermining with precast concrete panels that extend adequately below the beach elevation.

Design and installation of a soldier pile seawall would need to be carefully coordinated to avoid damage to a large stormwater outfall that extends waterward of the existing seawall.

To design a soldier pile seawall, design properties of the site soils need to be determined by a geotechnical engineer. These properties are typically determined from geotechnical borings or test pits. The soil borings can be used by the geotechnical engineer to determine pile driving conditions, and the likelihood of premature refusal or driving obstructions. This concept is depicted in Figure 1, Section A.

Note that a new soldier pile wall would likely need to be in the same alignment as the existing soldier pile wall to maintain continuity with a privately owned seawall to the north of the project site. Two options have been considered for transitioning from the new seawall to the existing adjacent structures. The first option consists of leaving a short end portion of the existing seawall (Zone A-B, see condition assessment report by Reid Middleton dated August 2017), attaching the new seawall to this existing seawall segment, and reinforcing the connection between the existing portion of the seawall and an existing retaining wall running perpendicular with the shoreline along the north park boundary. The second option consists of removing the northern portion of the existing seawall, and attaching the new seawall directly to the retaining wall running perpendicular to the shoreline along the north park boundary.

Design Element – Seat Wall

A seat wall is a concrete stair-like structure sized to provide users with geometry and surfaces suitable for sitting. It is typically constructed of cast-in-place concrete. The seat wall will need to be protected from tidal inundation while it is being formed and cast. Protection from tidal inundation is typically provided by use of either temporary shoring or a coffer dam accompanied by dewatering. When a seat wall is installed well behind an existing bulkhead or seawall, it is sometimes possible to leave the existing bulkhead or seawall in-place during installation to eliminate the need for temporary shoring or a coffer dam.

Depending on site conditions and the final configuration, piling support for the seat wall may be required to prevent long-term settlement, provide stability during a seismic event, or protect the large stormwater outfall that extends waterward of the existing seawall.

To avoid future undermining due to toe scour, the seat wall toe would need to be located well below the proposed beach elevation. Additionally, the toe would need to be protected by armor rock and geotextile fabric underneath the proposed beach elevation to further protect against undermining.

Design and installation of a seat wall would need to be carefully coordinated to avoid damage to the large stormwater outfall that extends waterward of the existing seawall. This concept is depicted at a conceptual level in Figure 1, Section B.

Design Element – Cantilevered Retaining Wall

The retaining wall would be made of concrete and consist of a cantilevered vertical stem portion and a horizontal footing. Retaining walls such as this are typically made of cast-in-place concrete, though precast concrete alternatives could be evaluated later as part of the design process.

The retaining wall may need to be installed with the use of temporary shoring or a coffer dam and dewatering equipment. Note that the temporary shoring or coffer dam would need to be designed and installed with consideration for adjacent properties and large stormwater outfall that extends waterward of the existing seawall.

To avoid future undermining due to toe scour, the retaining wall toe would be located well below the proposed beach elevation. Additionally, the toe would need to be protected by armor rock and geotextile fabric underneath the proposed beach elevation to further protect against undermining. This concept is depicted at a conceptual level in Figure 1, Section C.

Design Element – Repair of Existing Seawall

The existing seawall consists of approximately 13 independent segments of cast-in-place concrete gravity wall. These segments have experienced varying levels of undermining, which has caused movement consisting of settlement, rotation, and tipping. This movement has caused structural damage and a reduction in overall stability. Repairing the existing seawall would consist of realigning and repairing the existing seawall segments, securing them together, providing additional overturning resistance in the form of a tie-back system as needed, and adding scour protection for the undermined toe. These repairs would be extensive, and if performed, would only marginally extend the useful life of the seawall.

Over time, concrete structures exposed to marine environments deteriorate due to corrosion of embedded metals (embeds, rebar) and deterioration of the concrete due to commonly occurring environmental factors such as sulfates, freeze-thaw cycles, and abrasion and erosion. Repairing the existing seawall would not reset these time-dependent deterioration mechanisms. Therefore, there is an upper limit to the remaining useful life of a repaired seawall. Concrete structures in marine environments are typically anticipated to have around a 30-year to 50-year service life. The majority of the seawall was installed in 1951, so it is more than 65 years old and well past its anticipated service life. Accordingly, repairing the seawall is not a long-term or financially suitable project approach.

In some cases, a repair could only marginally increase the seawall's ability to withstand previously problematic failure mechanisms, such as undermining of the toe. A repair that provided an adequate safety factor in accordance with modern engineering standards would be very extensive, and would likely have more maintenance and a shorter service life than a new replacement seawall.

It is likely feasible to perform some short-term repairs that may slow seawall movement, increasing the likelihood that the replacement project could occur prior to complete collapse of the seawall. These short-term repairs would likely not restore lost stability, leaving the seawall suceptable to failure during a seismic event.

3 - DESIGN ALTERNATIVES

Three seawall replacement alternatives were created by ESA and provided to the public as part of a public outreach process. Detailed site plans showing these alternatives are provided in ESA's feasibility study report.

Alternative 1

Starting at the north end of the park, Alternative 1 consists of short portion of a new soldier pile seawall approximately in the same alignment as the existing seawall, a portion of soldier pile seawall aligned approximately perpendicular with the shoreline that transitions into a seat wall aligned roughly parallel with the existing seawall.

The cost estimate for the structural elements of this alternative includes the following primary work elements:

- Mobilization and demobilization
- Temporary erosion and sediment control
- Removal of existing seawall & retaining wall
- Temporary shoring and coffer dam
- New seawall consisting of steel HP piles, concrete panels, and associated excavation/fill
- New cast-in-place concrete seat wall with armor rock toe protection and associated excavation/fill

Alternative 2

Starting at the north end of the park, Alternative 2 consists of short portion of a new soldier pile seawall approximately in the same alignment as the existing seawall, a portion of soldier pile seawall aligned approximately perpendicular with the shoreline that transitions into a cantilevered retaining wall that follows an alignment curved towards the south.

The cost estimate for the structural elements of this alternative includes the following primary work elements:

- Mobilization and demobilization
- Temporary erosion and sediment control
- Removal of existing seawall & retaining wall
- Temporary shoring and coffer dam
- New seawall consisting of steel HP piles, concrete panels, and associated excavation/fill
- New cast-in-place concrete cantilevered retaining wall with armor rock toe protection, and associated excavation/fill

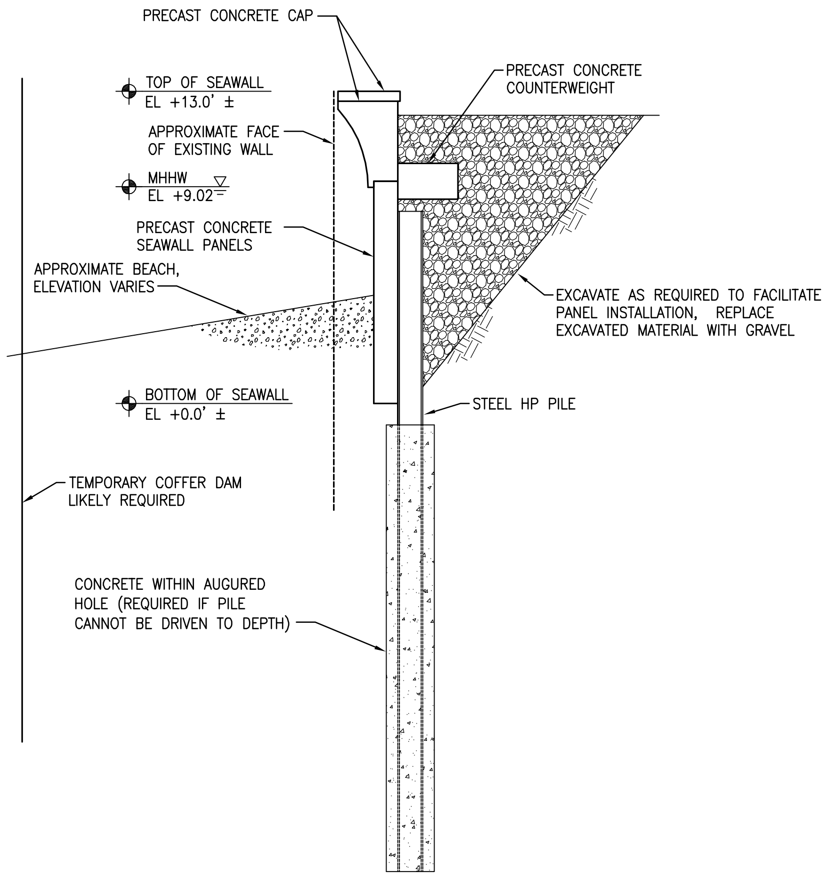
Alternative 3

Alternative 3 consists of a new soldier pile seawall in approximately the same alignment as the existing seawall.

The cost estimate for the structural elements of this alternative includes the following:

- Mobilization and demobilization
- Temporary erosion and sediment control
- Removal of existing seawall
- Temporary shoring and coffer dam
- New seawall consisting of steel HP piles, concrete panels, and associated excavation/fill

Figure 1 provided below contains detailed drawings of the design elements, and Table 1 provided below contains an alternative evaluation.



A – SECTION –TYP SOLDIER PILE SEAWALL
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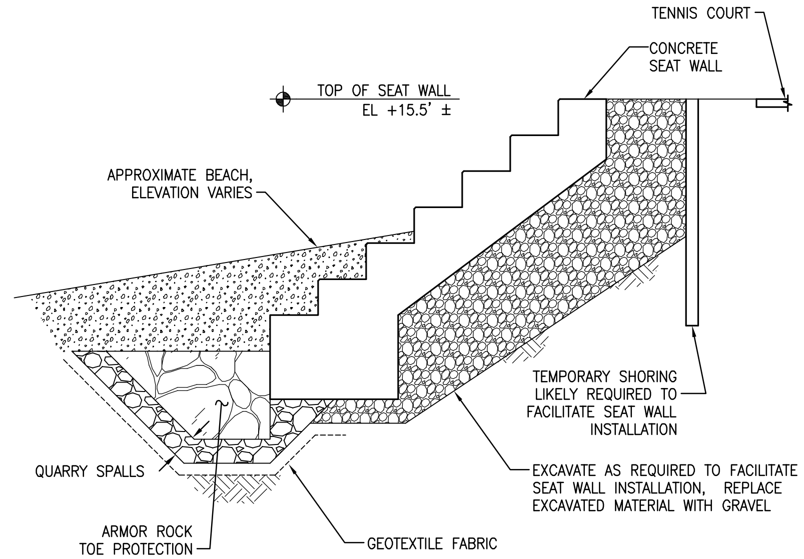
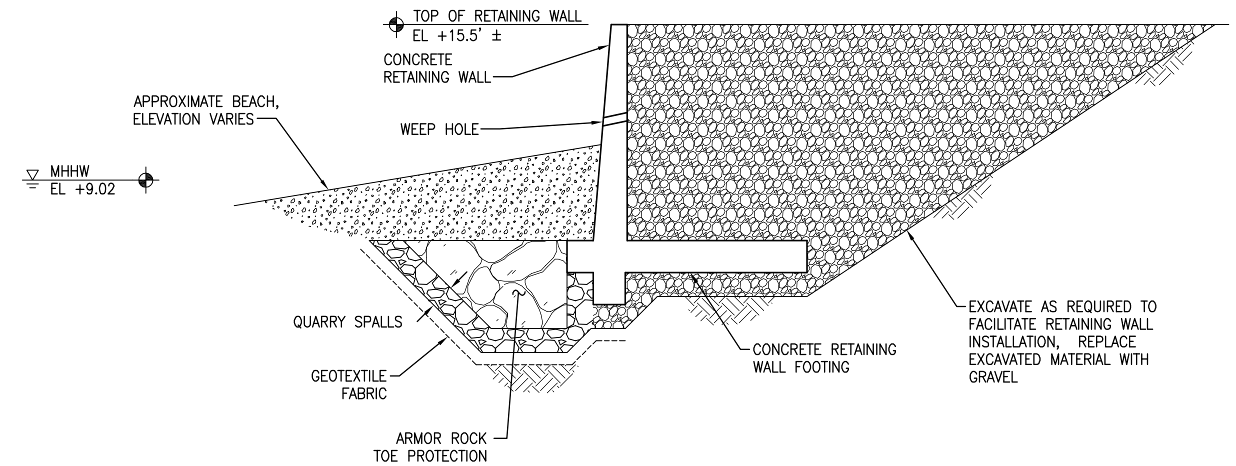
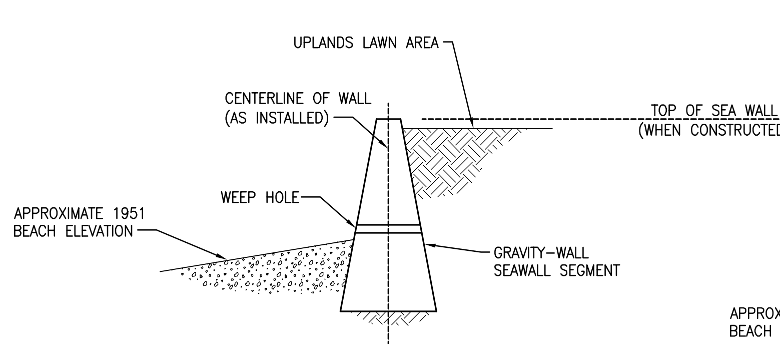


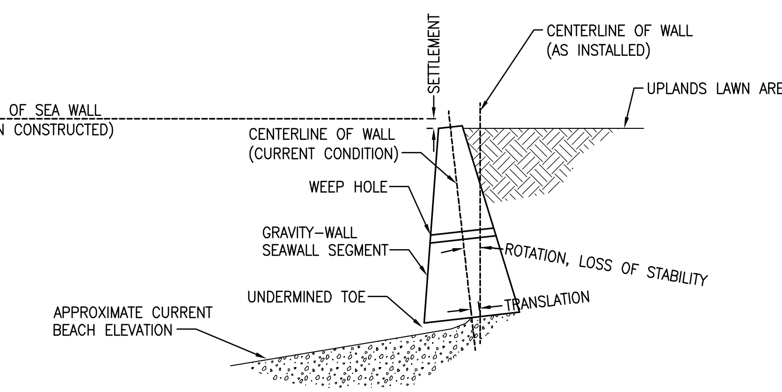
B – SECTION – SEAT WALL
SCALE: 1/4"=1'-0"



C – SECTION – RETAINING WALL
SCALE: 1/4"=1'-0"



B – SECTION – 1951 SEAWALL CONDITION
SCALE: 1/4"=1'-0"



B – SECTION – CURRENT SEAWALL CONDITION
SCALE: 1/4"=1'-0"

NOTES

1. VERTICAL DATUM: ELEVATIONS SHOWN ARE REFERENCED TO THE NAVD 88 DATUM.

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TYPICAL SECTIONS

FIGURE 1

CITY OF SEATTLE - LOWMAN BEACH PARK FEASIBILITY STUDY

Table 1. Alternative Comparison.

Alternative	Partial Cost[1]	Durability	Constructability	Structures Located on Adjacent Properties: Impacts of Construction	Environmental Permitting	Additional Data Needed In Future Phases
Alternative 1 Replace with Pocket Beach, Seat Wall Contains: Soldier pile seawall & seat wall	$800k to $900k	Moderately High. Switching to a pocket beach has the potential for future beach nourishment needs. The structures could be designed with consideration for environmental factors, including the potential for future beach-level fluctuations.	Coffer dam, temporary shoring required. Temporary shoring may be required to protect the tennis court during the excavation if it is to remain. Coffer dam below MHHW likely required to remove existing seawall, construct new seawall to prevent existing backfill material from being washed away, and would simplify seat wall installation.	Impacts to adjacent properties possible due to pile driving vibrations. Measures would need to be taken to avoid damaging stormwater outfall. Steel piling to be driven nearby to adjacent property to the north. Existing adjacent retaining wall and seawall structures may be affected. Documenting pre-construction conditions and monitoring during construction can to some degree mitigate this risk, along with careful consideration for detailing during the design phase. Large existing King County stormwater outfall (approximately 72" diameter) runs underneath the proposed seawall alignment and extends waterward of the proposed seawall alignment. Design and installation of a soldier pile seawall would need to be carefully coordinated to avoid damage to the large existing storm outfall that extends waterward of the existing seawall. Target tip elevations for driven piling would be below stormwater outfall pipe.	New portion of seawall could be built along existing seawall alignment and maintain connection point with existing structure to the north by using a coffer dam below MHHW. Likely BMPs include using fully cured pre-cast concrete panels with texture to provide habitat for marine organism. Additionally, there will likely be restrictions regarding the use of cast-in-place concrete or grout below MHHW, and restrictions about uncured concrete coming in contact with tidal waters.	Geotechnical borings and report to facilitate design of soldier piling. As-built location and depth of King County stormwater outfall. Information about sensitivity of King County stormwater outfall to pile driving operations, susceptibility to damage.
Alternative 2 Replace with Pocket Beach, Modified Seawall Contains: Soldier pile seawall, retaining wall	$650k to $750k	Moderately High. Switching to a pocket beach has the potential for future beach nourishment needs. The structures could be designed with consideration for environmental factors, including the potential for future beach-level fluctuations.	Coffer dam, temporary shoring required. Alternative 1 discussion about coffer dams additionally applies to this alternative. Coffer dam would likely simplify retaining wall installation.	Impacts to adjacent properties possible due to pile driving vibrations. Measures would need to be taken to avoid damaging stormwater outfall. Same as Alternative 1.	Same as Alternative 1. Likely BMPs include using fully cured pre-cast concrete panels with texture to provide habitat for marine organism. Additionally, there will likely be restrictions regarding the use of cast-in-place concrete or grout below MHHW, and restrictions about uncured concrete coming in contact with tidal waters.	Same as Alternative 1.
Alternative 3 Rebuild Seawall Contains: Soldier pile seawall	$750k to $850k	High. The structures could be designed with consideration for environmental factors, including the potential for future beach-level fluctuations.	Coffer dam required. Alternative 1 discussion about coffer dams additionally applies to this alternative.	Impacts to adjacent properties possible due to pile driving vibrations. Measures would need to be taken to avoid damaging stormwater outfall. Same as Alternative 1, but as a longer portion of seawall would be installed than in Alternative 1, there would be more pile driving and correspondingly more ground vibrations that may affect adjacent existing structures.	Alternative 1 discussion about coffer dams additionally applies to this alternative. Likely BMPs include using fully cured pre-cast concrete panels with texture to provide habitat for marine organism.	Same as Alternative 1.

[1]For notes on probable cost, see the detailed Opinion of Probable Costs provided in Appendix A. Costs shown do not include uplands features; these were determined and provided separately by ESA.

ehw\24wf\2017\004 lowman beach\reports\engineering report\lowman beach park feasibility study report_jap.docx\jap

APPENDIX A: OPINION OF PROBABLE CONSTRUCTION COSTS

ReidMiddleton

OPINION OF PROBABLE CONSTRUCTION COSTS

728 134th Street SW, Suite 200
Everett, WA 98204

City of Seattle
Lowman Beach Park
Seawall Replacement - Soldier Pile Seawall Unit Cost w/o Piles

PROJECT INFORMATION

Project title:	Lowman Beach Park
Project location:	Seattle, WA
Project description:	Seawall Replacement
Job number:	242017.004
Client:	ESA
Estimator:	JAP
Project manager:	JAP
Q/A checker:	WWA
File name/path:	H:\24Wf\2017\004 Lowman Beach\Cost & Quant
Date:	November 29, 2017
Notes:	1. Final Engineering Design, Bidding, Management, Construction Administration, and other soft costs not included 2. Unit prices below include the General Contractor's overhead and profit. 3. Unit cost for LF of seawall from this spreadsheet used within the alternative costs

Item No.	Description	Unit	Quantity	Unit Price	Subtotal	Total Cost
1.0	**MOBILIZATION / DEMOBILIZATION**					
1.01	N/A		0	$0	$0	
	MOBILIZATION / DEMOBILIZATION SUBTOTAL					**$0**
2.0	**DEMOLITION**					
2.01	Remove and dispose of existing seawall	LF	0	$0	$0	
2.02	Remove and dispose of existing concrete retaining wall	LF	0	$0	$0	
2.03	Install temporary coffer dam	LF	0	$0	$0	
	DEMOLITION SUBTOTAL					**$0**
3.00	**NEW SEAWALL INSTALLATION**					
3.01	Supply & Install precast concrete seawall panels	CY	0.74	$1,000	$740	
3.02	NOTE: Piles included separately	EA	1	$0	$0	
3.03	Excavation, Grading, & Fill	CY	3.6	$45	$162	
	NEW SEAWALL INSTALLATION SUBTOTAL					**$902**
	SUBTOTAL					**$902**

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OPINION OF PROBABLE CONSTRUCTION COSTS

728 134th Street SW, Suite 200
Everett, WA 98204

City of Seattle
Lowman Beach Park
Seawall Replacement - Retaining Wall Unit Cost

PROJECT INFORMATION

Project title:	Lowman Beach Park
Project location:	Seattle, WA
Project description:	Seawall Replacement
Job number:	242017.004
Client:	ESA
Estimator:	JAP
Project manager:	JAP
Q/A checker:	WWA
File name/path:	H:\24Wf\2017\004 Lowman Beach\Cost & Quant
Date:	November 29, 2017
Notes:	1. Final Engineering Design, Bidding, Management, Construction Administration, and other soft costs not included 2. Unit prices below include the General Contractor's overhead and profit. 3. Unit cost for LF of seawall from this spreadsheet used within the alternative costs

Item No.	Description	Unit	Quantity	Unit Price	Subtotal	Total Cost
1.0	**MOBILIZATION / DEMOBILIZATION**					
1.01	N/A		0	$0	$0	
	MOBILIZATION / DEMOBILIZATION SUBTOTAL					**$0**
2.0	**DEMOLITION**					
2.01	Remove and dispose of existing seawall	LF	0	$0	$0	
2.02	Remove and dispose of existing concrete retaining wall	LF	0	$0	$0	
2.03	Install temporary coffer dam	LF	0	$0	$0	
	DEMOLITION SUBTOTAL					**$0**
3.00	**NEW RETAINING WALL INSTALLATION**					
3.01	Supply & Install concrete retaining wall	CY	0.90	$1,000	$900	
3.02	Supply & Install armor rock toe protection	CY	0.7	$65	$46	
3.03	Supply & Install quarry spall toe protection	CY	0.5	$65	$33	
3.04	Supply & Install geotextile fabric	SY	0.5	$5	$3	
3.03	Excavation, Grading, & Fill	CY	6.5	$45	$293	
	NEW RETAINING WALL INSTALLATION SUBTOTAL					**$1,273**
	SUBTOTAL					**$1,273**

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Everett, WA 98204

OPINION OF PROBABLE CONSTRUCTION COSTS

City of Seattle
Lowman Beach Park
Seawall Replacement - Seat Wall Unit Cost w/o Piles

PROJECT INFORMATION

Project title:	Lowman Beach Park
Project location:	Seattle, WA
Project description:	Seawall Replacement
Job number:	242017.004
Client:	ESA
Estimator:	JAP
Project manager:	JAP
Q/A checker:	WWA
File name/path:	H:\24Wf\2017\004 Lowman Beach\Cost & Quant
Date:	November 29, 2017
Notes:	1. Final Engineering Design, Bidding, Management, Construction Administration, and other soft costs not included 2. Unit prices below include the General Contractor's overhead and profit. 3. Costs included for the seawall assuming piles will not be grouted. If they were to be grouted, pile steel savings would likely offset grouting costs 4. Unit cost for LF of seawall from this spreadsheet used within the alternative costs

Item No.	Description	Unit	Quantity	Unit Price	Subtotal	Total Cost
1.0	**MOBILIZATION / DEMOBILIZATION**					
1.01	N/A		0	$0	$0	
	MOBILIZATION / DEMOBILIZATION SUBTOTAL					**$0**
2.0	**DEMOLITION**					
2.01	Remove and dispose of existing seawall	LF	0	$0	$0	
2.02	Remove and dispose of existing concrete retaining wall	LF	0	$0	$0	
2.03	Install Temporary Shoring	LF	0	$0	$0	
	DEMOLITION SUBTOTAL					**$0**
3.00	**NEW SEAT WALL INSTALLATION**					
3.01	Supply & Install concrete seat wall	CY	2.00	$1,000	$2,000	
3.02	Supply & Install armor rock toe protection	CY	0.7	$65	$46	
3.03	Supply & Install quarry spall toe protection	CY	0.5	$65	$33	
3.04	Supply & Install geotextile fabric	SY	0.5	$5	$3	
3.03	Excavation, Grading, & Fill	CY	2.6	$45	$117	
	NEW SEAT WALL INSTALLATION SUBTOTAL					**$2,198**
	SUBTOTAL					**$2,198**

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728 134th Street SW, Suite 200
Everett, WA 98204

OPINION OF PROBABLE CONSTRUCTION COSTS

City of Seattle
Lowman Beach Park
Seawall Replacement - Alternative 1

PROJECT INFORMATION

Project title:	Lowman Beach Park
Project location:	Seattle, WA
Project description:	Seawall Replacement
Job number:	242017.004
Client:	ESA
Estimator:	JAP
Project manager:	JAP
Q/A checker:	WWA
File name/path:	H:\24Wf\2017\004 Lowman Beach\Cost & Quant
Date:	November 29, 2017

Notes:

1. Final Engineering Design, Bidding, Management, Construction Administration, and other soft costs not included

2. Unit prices below include the General Contractor's overhead and profit.

3. Costs included for the seawall assuming piles will not be grouted. If they were to be grouted, pile steel savings would likely offset grouting costs

Item No.	Description	Unit	Quantity	Unit Price	Subtotal	Total Cost
1.0	**MOBILIZATION / DEMOBILIZATION**					
1.01	Mobilization and demobilization	LS	1	$70,000	$70,000	
1.02	Temporary Erosion and Sediment Control	LS	1	$10,000	$10,000	
	MOBILIZATION / DEMOBILIZATION SUBTOTAL					**$80,000**
2.0	**DEMOLITION & TEMPORARY STRUCTURES**					
2.01	Remove and dispose of existing seawall	LF	130	$150	$19,500	
2.02	Remove and dispose of existing concrete retaining wall	LF	50	$100	$5,000	
2.03	Install temporary shoring for seat wall installation	LF	70	$200	$14,000	
2.04	Install temporary coffer dam	LF	278	$420	$116,760	
	DEMOLITION & TEMPORARY STRUCTURES SUBTOTAL					**$155,260**
3.00	**NEW SEAWALL**					
3.01	Supply new HP18x135 x 60' long	EA	12	$9,000	$108,000	
3.02	Install new steel piles	EA	12	$4,000	$48,000	
3.03	New sea wall - concrete, excavation & fill	LF	64	$902	$57,728	
	NEW SEAWALL SUBTOTAL					**$213,728**
3.00	**NEW SEAT WALL**					
3.01	Supply & install new seat wall	LF	69	$2,198	$151,628	
	NEW SEAT WALL SUBTOTAL					**$151,628**
	SUBTOTAL					**$600,616**
	DESIGN REFINEMENT CONTINGENCY @ 20%					**$120,100**
	CONSTRUCTION CONTINGENCY @ 20%					**$120,100**
	SALES TAX (not included)					**$0**
	ALT 1 OPINION OF PROBABLE CONSTRUCTION COST				**(Rounded)**	**$841,000**

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728 134th Street SW, Suite 200

Everett, WA 98204

OPINION OF PROBABLE CONSTRUCTION COSTS

City of Seattle
Lowman Beach Park
Seawall Replacement - Alternative 2

PROJECT INFORMATION

Project title:	Lowman Beach Park
Project location:	Seattle, WA
Project description:	Seawall Replacement
Job number:	242017.004
Client:	ESA
Estimator:	JAP
Project manager:	JAP
Q/A checker:	WWA
File name/path:	H:\24Wf\2017\004 Lowman Beach\Cost & Quant
Date:	November 29, 2017
Notes:	1. Final Engineering Design, Bidding, Management, Construction Administration, and other soft costs not included 2. Unit prices below include the General Contractor's overhead and profit. 3. Costs included for the seawall assuming piles will not be grouted. If they were to be grouted, pile steel savings would likely offset grouting costs

Item No.	Description	Unit	Quantity	Unit Price	Subtotal	Total Cost
1.0	**MOBILIZATION / DEMOBILIZATION**					
1.01	Mobilization and demobilization	LS	1	$60,000	$60,000	
1.02	Temporary Erosion and Sediment Control	LS	1	$10,000	$10,000	
	MOBILIZATION / DEMOBILIZATION SUBTOTAL					**$70,000**
2.0	**DEMOLITION & TEMPORARY STRUCTURES**					
2.01	Remove and dispose of existing seawall	LF	130	$150	$19,500	
2.02	Remove and dispose of existing concrete retaining wall	LF	50	$100	$5,000	
2.04	Install temporary coffer dam	LF	278	$420	$116,760	
	DEMOLITION & TEMPORARY STRUCTURES SUBTOTAL					**$141,260**
3.00	**NEW SEAWALL**					
3.01	Supply new HP18x135 x 60' long	EA	12	$9,000	$108,000	
3.02	Install new steel piles	EA	12	$4,000	$48,000	
3.03	New sea wall - concrete, excavation & fill	LF	64	$902	$57,728	
	NEW SEAWALL SUBTOTAL					**$213,728**
3.00	**NEW RETAINING WALL**					
3.01	Supply & install new retaining wall	LF	61	$1,273	$77,653	
	NEW RETAINING WALL SUBTOTAL					**$77,653**
	SUBTOTAL					**$502,641**
	DESIGN REFINEMENT CONTINGENCY @ 20%					**$100,500**
	CONSTRUCTION CONTINGENCY @ 20%					**$100,500**
	SALES TAX (not included)					**$0**
	ALT 2 OPINION OF PROBABLE CONSTRUCTION COST			**(Rounded)**		**$704,000**

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728 134th Street SW, Suite 200
Everett, WA 98204

OPINION OF PROBABLE CONSTRUCTION COSTS

City of Seattle
Lowman Beach Park
Seawall Replacement - Alternative 3

PROJECT INFORMATION	
Project title:	Lowman Beach Park
Project location:	Seattle, WA
Project description:	Seawall Replacement
Job number:	242017.004
Client:	ESA
Estimator:	JAP
Project manager:	JAP
Q/A checker:	WWA
File name/path:	H:\24Wf\2017\004 Lowman Beach\Cost & Quant
Date:	November 29, 2017
Notes:	1. Final Engineering Design, Bidding, Management, Construction Administration, and other soft costs not included 2. Unit prices below include the General Contractor's overhead and profit. 3. Costs included for the seawall assuming piles will not be grouted. If they were to be grouted, pile steel savings would likely offset grouting cost

Item No.	Description	Unit	Quantity	Unit Price	Subtotal	Total Cost
1.0	**MOBILIZATION / DEMOBILIZATION**					
1.01	Mobilization and demobilization	LS	1	$55,000	$55,000	
1.02	Temporary Erosion and Sediment Control	LS	1	$10,000	$10,000	
	MOBILIZATION / DEMOBILIZATION SUBTOTAL					**$65,000**
2.0	**DEMOLITION & TEMPORARY STRUCTURES**					
2.01	Remove and dispose of existing seawall	LF	130	$150	$19,500	
2.03	Install temporary coffer dam	LF	278	$420	$116,760	
	DEMOLITION & TEMPORARY STRUCTURES SUBTOTAL					**$136,260**
3.00	**NEW SEA WALL**					
3.01	Supply new HP18x135 x 60' long	EA	19	$9,000	$171,000	
3.02	Install new steel piles	EA	19	$4,000	$76,000	
3.03	New sea wall - concrete, excavation & fill	LF	130	$902	$117,260	
	NEW SEA WALL SUBTOTAL					**$364,260**
	SUBTOTAL					**$565,520**
	DESIGN REFINEMENT CONTINGENCY @ 20%					**$113,100**
	CONSTRUCTION CONTINGENCY @ 20%					**$113,100**
	SALES TAX (not included)					**$0**
	ALT 3 OPINION OF PROBABLE CONSTRUCTION COST			**(Rounded)**		**$792,000**

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(425) 741-3800
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File No. 242017.004

APPENDIX C

Geotechnical Report

See PDF Attachment.

APPENDIX D
Conceptual Quantities and Costs

Lowman Beach Park Feasibility Study - Alternative 1
Conceptual Level Construction Cost Estimate
Date: 12/01/2017

By: E. Bartelomeo
Checked: J. Darnell

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	EXTENSION
SITE PREPARATION					
1	MOBILIZATION	1	LS	$ 80,000.00	$ 80,000
2	TEMPORARY EROSION AND SEDIMENT CONTROL	1	LS	$ 15,000.00	$ 15,000
3	TREE REMOVAL	4	EA	$ 750.00	$ 3,000
4	GRUBBING	7000	SF	$ 0.35	$ 2,450
DEMOLITION & TEMPORARY STRUCTURES					
5	REMOVE AND DISPOSE OF EXISTING SEAWALL	130	LF	$ 150.00	$ 19,500
6	REMOVE AND DISPOSE OF EXISTING RETAINING WALL	50	LF	$ 100.00	$ 5,000
7	TEMPORARY SHORING	70	LF	$ 200.00	$ 14,000
8	TEMPORARY COFFER DAM	278	LF	$ 420.00	$ 116,760
SEAWALL					
9	SUPPLY AND INSTALL STEEL SOLDIER PILES	12	EA	$ 13,000.00	$ 156,000
10	CONCRETE PANEL SUPPLY, INSTALLATION AND STRUCTURAL EX./FILL	64	LF	$ 902.00	$ 57,728
SEAT WALL					
11	SUPPLY AND INSTALL SEAT WALL	69	LF	$ 2,198.00	$ 151,662
12	ROCK/COBBLE TOE PROTECTION	69	LF	$ 155.00	$ 10,695
EARTHWORK					
13	EXCAVATION AND STOCKPILE	770	CY	$ 15.00	$ 11,550
14	HAUL AND DISPOSE EXCESS AND UNSUITABLE MATERIAL	140	CY	$ 15.00	$ 2,100
14	BEACH SEDIMENT BACKFILL, PLACEMENT & GRADING	630	CY	$ 10.00	$ 6,300
15	IMPORT AND PLACE FISH MIX GRAVEL	20	CY	$ 120.00	$ 2,400
SITE RESTORATION					
16	TREES	3	EA	$ 350.00	$ 1,050
17	SHRUBS	80	EA	$ 12.00	$ 960
18	GRAVEL PATH, 5 FT WIDE	200	LF	$ 50.00	$ 10,000
19	SEEDING	580	SY	$ 2.00	$ 1,160
	DIRECT ITEM SUBTOTAL				$ 667,315
	CONTINGENCY	40%			$ 266,926
	CONSTRUCTION TOTAL				**$ 934,241**

NOTES:
1. Does not include permitting, engineering design, management, or other soft costs.
2. Earthwork assumes onsite reuse of most excavated materails as backfill, or reuse as beach nourishment.
3. Miscellaneous park amenities are not included.

Lowman Beach Park Feasibility Study - Alternative 2
Conceptual Level Construction Cost Estimate
Date: 12/01/2017

By: E. Bartelomeo
Checked: J. Darnell

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	EXTENSION
SITE PREPARATION					
1	MOBILIZATION	1	LS	$ 65,000.00	$ 65,000
2	TEMPORARY EROSION AND SEDIMENT CONTROL	1	LS	$ 15,000.00	$ 15,000
3	TREE REMOVAL	6	EA	$ 750.00	$ 4,500
4	GRUBBING	7000	SF	$ 0.35	$ 2,450
DEMOLITION & TEMPORARY STRUCTURES					
5	REMOVE AND DISPOSE OF EXISTING SEAWALL	130	LF	$ 150.00	$ 19,500
6	REMOVE AND DISPOSE OF EXISTING RETAINING WALL	50	LF	$ 100.00	$ 5,000
7	REMOVE AND DISPOSE OF TENNIS COURT	1	LS	$ 17,000.00	$ 17,000
8	TEMPORARY COFFER DAM	278	LF	$ 420.00	$ 116,760
SEAWALL					
9	SUPPLY AND INSTALL STEEL SOLDIER PILES	12	EA	$ 13,000.00	$ 156,000
10	CONCRETE PANEL SUPPLY, INSTALLATION AND STRUCTURAL EX./FILL	64	LF	$ 902.00	$ 57,728
REATAINING WALL					
11	SUPPLY AND INSTALL CONCRETE RETAINING WALL	61	LF	$ 1,273.00	$ 77,653
EARTHWORK					
12	EXCAVATION AND STOCKPILE	2,330	CY	$ 15.00	$ 34,950
13	HAUL AND DISPOSE EXCESS AND UNSUITABLE MATERIAL	1,000	CY	$ 15.00	$ 15,000
14	BEACH SEDIMENT PLACEMENT AND GRADING	1,330	CY	$ 10.00	$ 13,300
15	IMPORT AND PLACE FISH MIX GRAVEL	30	CY	$ 120.00	$ 3,600
SITE RESTORATION					
16	TREES	5	EA	$ 350.00	$ 1,750
17	SHRUBS	100	EA	$ 12.00	$ 1,200
18	GRAVEL PATH, 5 FT WIDE	60	LF	$ 50.00	$ 3,000
19	SEEDING	470	SY	$ 2.00	$ 940
	DIRECT ITEM SUBTOTAL				$ 610,331
	CONTINGENCY	40%			$ 244,132.40
	CONSTRUCTION TOTAL				**$ 854,463**

NOTES:
1. Does not include permitting, engineering design, management, or other soft costs.
2. Earthwork assumes onsite reuse of up to half of excavated materails as advanced beach nourishment.
3. Miscellaneous park amenities are not included.

Lowman Beach Park Feasibility Study - Alternative 3
Conceptual Level Construction Cost Estimate
Date: 12/01/2017

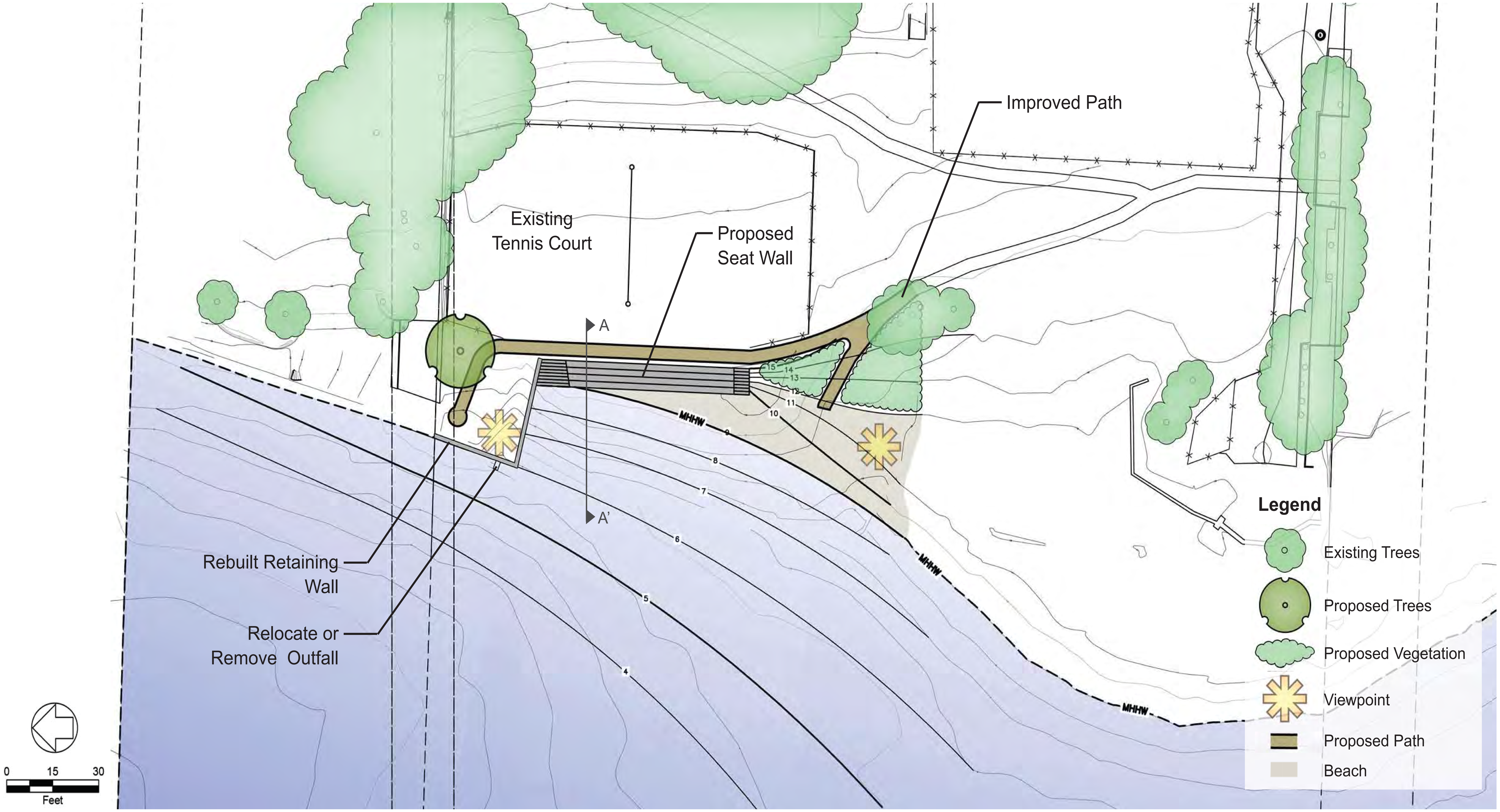
By: E. Bartelomeo
Checked: J. Darnell

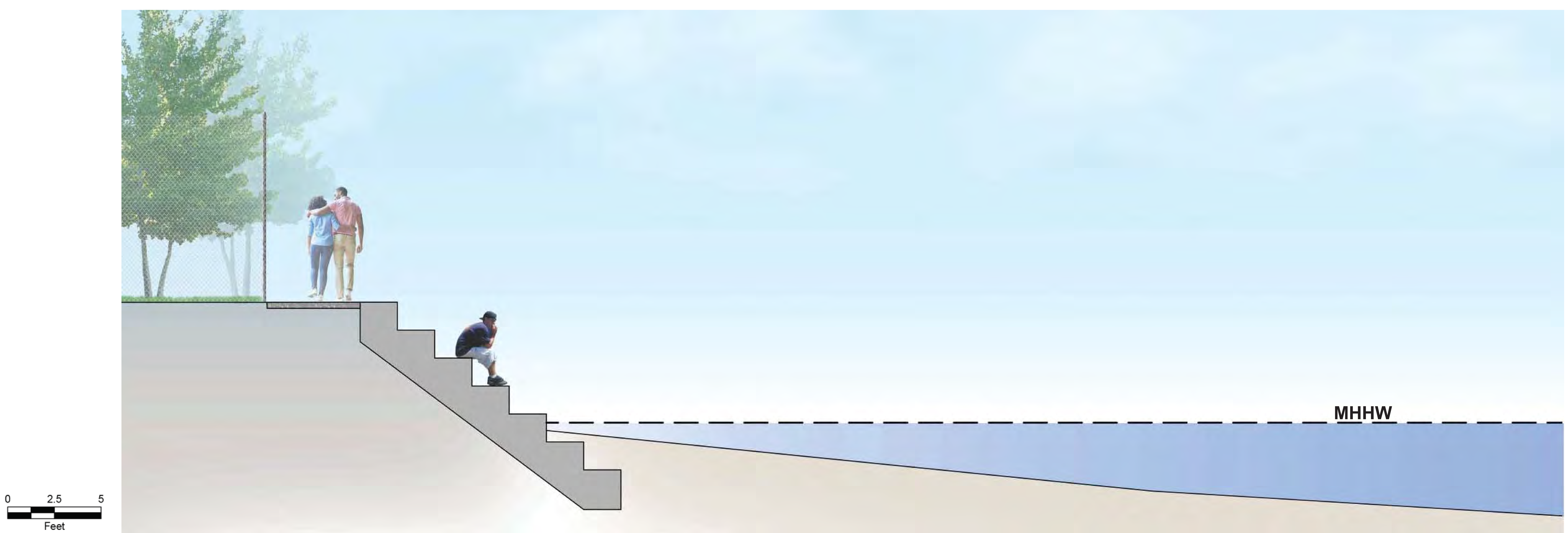
ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	EXTENSION
SITE PREPARATION					
1	MOBILIZATION	1	LS	$ 60,000.00	$ 60,000
2	TEMPORARY EROSION AND SEDIMENT CONTROL	1	LS	$ 15,000.00	$ 15,000
3	GRUBBING	1000	SF	$ 0.35	$ 350
DEMOLITION & TEMPORARY STRUCTURES					
4	REMOVE AND DISPOSE OF EXISTING SEAWALL	130	LF	$ 150.00	$ 19,500
5	TEMPORARY COFFER DAM	278	LF	$ 420.00	$ 116,760
SEA WALL					
6	SUPPLY AND INSTALL STEEL SOLDIER PILES	19	EA	$ 13,000.00	$ 247,000
7	CONCRETE PANEL SUPPLY, INSTALLATION AND STRUCTURAL EX./FILL	130	LF	$ 902.00	$ 117,260
EARTHWORK					
8	MISC GRADING AND FILL	50	CY	$ 50.00	$ 2,500
RESTORATION					
9	TREES	3	EA	$ 350.00	$ 1,050
10	SHRUBS	40	EA	$ 12.00	$ 480
11	GRAVEL PATH, 5 FT WIDE	140	LF	$ 50.00	$ 7,000
12	SEEDING	280	SY	$ 2.00	$ 560
	DIRECT ITEM SUBTOTAL				$ 587,460
	CONTINGENCY	40%			$ 234,984
	CONSTRUCTION TOTAL				**$ 822,444**

NOTES:
1. Does not include permitting, engineering design, management, or other soft costs.
2. Miscellaneous park amenities are not included.

APPENDIX E

Conceptual Schematic Drawings

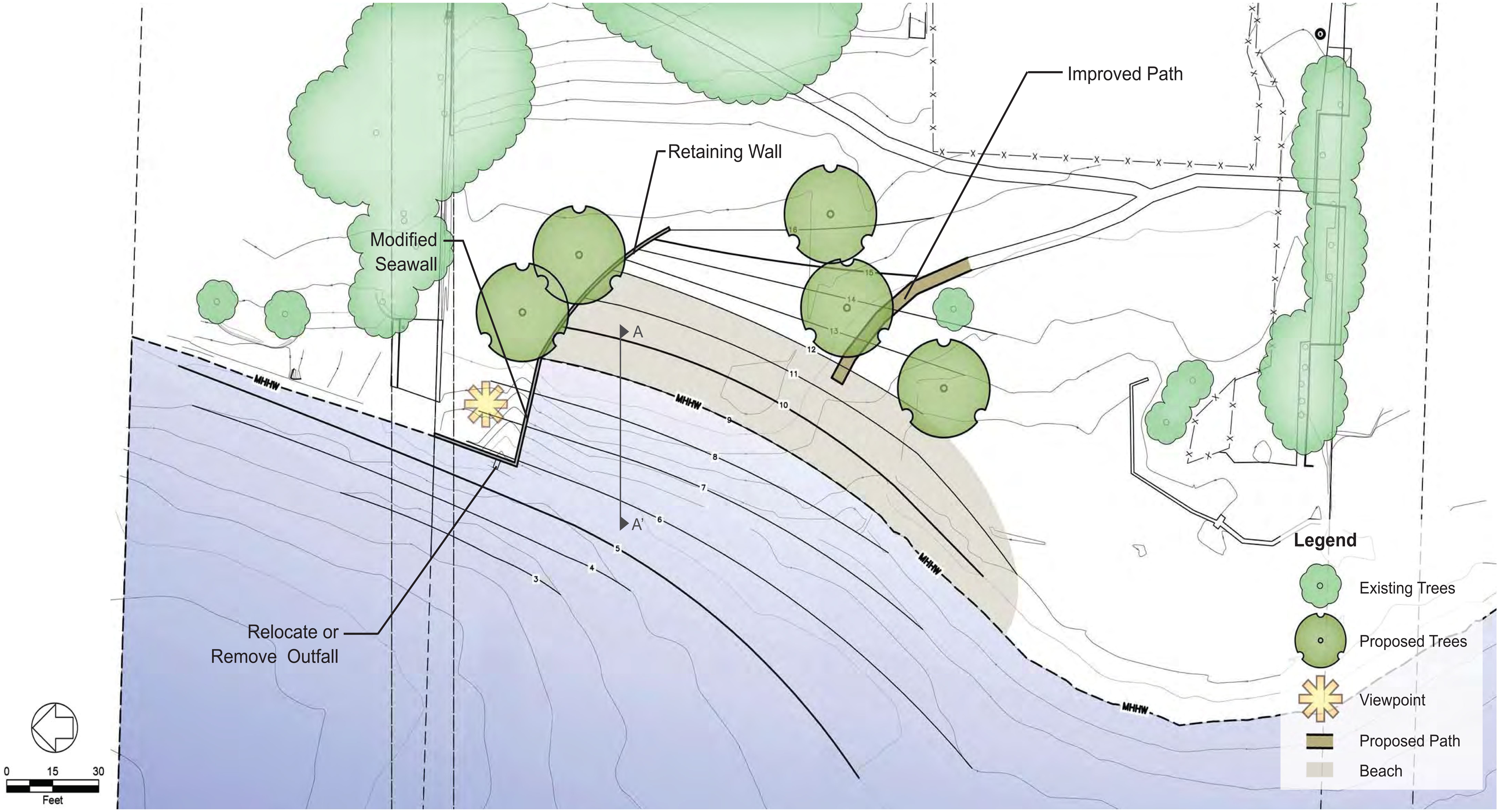




Seattle Parks & Recreation

ESA

DRAFT Lowman
Beach Alternative 1
Replace with Seat Wall



Seattle Parks & Recreation

ESA

DRAFT Lowman Beach Alternative 2
Modify Seawall

Seattle Parks & Recreation

ESA

DRAFT Lowman Beach Alternative 3

Rebuild Seawall

APPENDIX F
Conceptual Permit Matrix

Conceptual Permit Matrix

Potential Permits/Approvals	Regulated Activity	Alternative 1	Alternative 2	Alternative 3	Comments
US Army Corps of Engineers (Corps), Seattle District Section 404 *Triggered by placement of fill within waters of the U.S. (wetlands and streams)*	Required if construction discharges dredged or fill material into waters of the U.S.	✓ Individual Permit Likely	✓ Nationwide or Individual Permit (uncertain at this time)	✓ Nationwide Permit Likely	Alternatives 1 would likely require an Individual 404 permit. Alternative 2 may qualify for Nationwide Permit (NWP) 27 – Aquatic Habitat Restoration, Establishment, and Enhancement Activities. According to Regional Conditions of NWP 27 "activities involving *new* bank stabilization in tidal waters in WRIA 8 cannot be authorized by a NWP. If the Corps considers this new bank stabilization, Alternative 1 would likely require an Individual 404 permit. Alternative 3 would likely qualify for NWP 3 – *Maintenance*, if the project is designed to occur within its original footprint. An Individual 404 permit requires additional documentation (e.g., Alternatives Analysis) and extended review time.
NOAA Fisheries, National Marine Fisheries Service (NMFS) Endangered Species Act – Section 7 consultation *Triggered by Section 404 Corps Permit (above)*	Required if project has federal nexus (e.g. federally issued permits)) or involves activity that may have an impact on ESA-listed species or designated critical habitat.	✓	✓	✓	Because the majority of the work will occur below the ordinary high water mark (OHWM) and the project location is designated as critical habitat by NMFS, a Biological Assessment (BA) would be required for Section 7 consultation.
Washington Department of Archaeology and Historic Preservation (DAHP) and Potentially Affected Tribes National Historic Preservation Act – Section 106 consultation *Triggered by Section 404 Corps Permit*	Necessary if project has federal nexus and potential for ground disturbance or effects on historic properties. Corps consultation with DAHP and potentially affected tribes is required.	✓ Mitigation may be required	✓ Mitigation may be required	✓	The onsite tennis court may be considered eligible for inclusion in the National Register and a monitoring plan may be implemented during construction. The Corps is responsible for initiating consultation once it has determined there is an undertaking within its Permit Area.
Washington Department of Ecology (Ecology) Section 401 Water Quality Certification *Triggered by Section 404 Corps permit*	Triggered by a federal permit or license to conduct any activity that might result in a discharge of dredge or fill material into waters of the US.	✓ Individual Permit	✓ Individual Permit	✓ Pre-approved through Nationwide Permit 3 (Maintenance)	Alternative 1 would likely require an Individual 401 because it would likely require an Individual 404 permit. Alternative 2 would likely require an Individual 401 permit because the project involves fill in tidal waters. Under Alternative 3, water quality certification would be pre-approved as part of the Corps Nationwide Permit 3 (Maintenance) if the project is designed to occur within its original footprint.

POTENTIAL PERMITS/APPROVALS	REGULATED ACTIVITY	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	COMMENTS
Washington Department of Ecology (Ecology) Coastal Zone Management Consistency Certification *Triggered by project location*	Activities and development located within Washington's coastal counties which involve federal activities, federal licenses or permits, and federal assistance programs (e.g., funding) require a written Coastal Zone Management (CZM) Consistency Determination by Ecology.	✓	✓	✓	
Washington Department of Fish and Wildlife (WDFW) Hydraulic Project Approval (HPA) *Required for projects that affect waters of the State including streams (e.g., bridges, culverts, dredging, outfall structures, debris removal).*	Required if project involves work that uses, diverts, obstructs, or changes the natural flow or bed of state waters.	✓	✓	✓	Apply online using the Aquatic Protection Permitting System (APPS). SEPA process must be completed prior to APPS submittal.
City of Seattle State Environmental Policy Act (SEPA) Threshold Determination *Required for City projects.*	Any proposal that requires a state or local agency decision to license, fund, or undertake a project can trigger environmental review under SEPA (see WAC 197-11-704 for a complete definition of agency action). SEPA requires all governmental agencies to consider the environmental impacts before project approval.	✓	✓	✓	The City will issue SEPA Checklist and decision. It is expected the project will meet the standards for a Determination of Non-Significance (DNS).
City of Seattle State Shoreline Management Act Shoreline Substantial Development Permit (SSDP). Based on location and fair market value of project.	Any proposal that is within 200 feet of a Shoreline of the State (Puget Sound) and whose value exceeds $6,416.	✓	✓	✓	Must also be noted in Section 10b of the JARPA form. A copy of the form must be provided with the application. The SEPA checklist must be submitted at the same time as the SSDP application.

POTENTIAL PERMITS/APPROVALS	REGULATED ACTIVITY	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	COMMENTS
City of Seattle Critical Areas Review *Triggered by projects located in a critical area (wetlands, fish and wildlife habitat conservation areas, and associated buffers)*	Required if construction or other project activities will cause disturbance within environmentally critical areas.	✓	✓	✓	The Critical Areas Reports will need to include the potential impacts of the proposed project and associated mitigation measures as required by the City's critical areas regulations. The City maps three environmentally critical areas occurring on the project site: flood prone, liquefaction zone, and riparian corridor.
City of Seattle Grading Permit	Required if the project involves any land disturbing activity within 100 feet of the ordinary high watermark (OHWM) or within a critical area (shoreline) buffer.	✓	✓	✓	Grading work will primarily occur within 100 feet of OHMW.
City of Seattle Tree and Vegetation Removal Permit *Required for removal of trees from a critical area or buffer*	Required for removal of trees from a critical area or its associated buffer and must be specifically approved as part of a critical area approval.	✓	✓	✓	A restoration plan, called an environmentally critical area (ECA) revegetation approval, will be needed to plant native vegetation and to remove non-native or invasive plants in the ECA.