Draft

LOWMAN BEACH PARK SHORELINE RESTORATION

Draft 90% Design Report

Prepared for
Seattle Parks & Recreation Department

February 2020

ESA

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LOWMAN BEACH PARK SHORELINE RESTORATION

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1.0 Introduction

Environmental Science Associates (ESA) has prepared this basis of design report for the City of Seattle Parks and Recreation Department (SPR). The Lowman Beach Park Shoreline Restoration Project will enhance the park and the shoreline in a naturally sustainable way that meets multiple objectives: Improve ADA access in the park, substantially improve the ecological process, increase nearshore habitat and allow more adaptive capacity in the face of rising sea levels.

The Basis of Design Report is intended to document the rationale for project design decisions and details the engineering design criteria and characteristics of the habitat restoration elements proposed for the site. Major project design elements include:

1. Removing the existing seawall along the Puget Sound Shoreline that is failing and the accompanying retaining wall.
2. Constructing a new seawall near the northern boundary of the park.
3. Removing the tennis court and restoring the backshore beach with native materials, grading and planting while maintaining access and recreation.
4. Daylighting Pelly Creek through the park.
5. Constructing ADA-accessible paths and landscaping in the upland portion of the park.

The report also briefly summarizes the existing conditions of the site and the key findings from a range of technical studies that was conducted prior to this design. The technical studies revealed a number of key considerations related to historical and archeological resources, ecology, coastal process (geomorphology, erosion/accretion, sediment transport, shoreline evolution), geotechnical conditions, structure conditions, existing utilities and creek, coastal, structural and landscape design.

The technical studies and supplemental information reference on this report are included as appendices.

2.0 Site Characterization

Lowman Beach Park is located on Puget Sound in the Morgan Junction neighborhood in West Seattle and just to the north of Lincoln Park (**Figure 2-1**). The approximately 1.5-acre park is bordered to the north and south by private residential properties and the east by Beach Drive. 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. The seawall portion is failing such that it is close to toppling over and there has been erosion landward of it. The gravel beach and vegetated backshore portion of the park were created in the 1995 restoration project that removed a 1930s-era seawall. 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 paddleboarding, and kayaking among others.

Technical studies were conducted by ESA, Reid Middleton and Robinson Noble between 2017 to 2018 to characterize the existing site conditions, evaluate different alternatives, and inform the design of the project. The following sections summarize the methodology, key findings, and outcome of these studies. The studies can be found in the appendices as referenced in this section.

2.1 History and Archaeology

This section summarizes ESA findings on the History and Archeology of the site. The reader is referred to Appendix A and B for detailed information on this subject.

2.1.1 History

Today's Lowman Beach Park is located within the ceded lands of the *Dkhw'Duw'Absh* (Duwamish) people. Oral history and archaeological evidence demonstrate that Native American people have lived in this region of the Puget Sound for thousands of years.

Among these locations is Lowman Beach Park, where 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 offshore and potential for canoes overturning (Hilbert et al. 2001:68; Thrush 2007:232; Waterman 1922:189). Having a name associated with this location suggests that Lowman Beach Park is an area that has significance to the Duwamish people.

Lowman Beach Park was originally established as Lincoln Beach Park. 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. In April of 1925, the name was changed from Lincoln Beach Park to Lowman Beach Park.

SOURCE: ESRI 2016; ESA, 2018

Figure 2-1
Project Location and Vicinity Map

ESA

In 1936 the SPR built a stone and mortar seawall using federal grant funds from the Works Progress Administration (WPA). That same year the tennis courts were also constructed as a WPA-funded project. 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 1936 seawall originally extended across the entire shoreline of the park (Seattle Department of Parks 1956). 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. The portion to the south of the steps was reinforced with concrete support along its base (Seattle Department of Parks 1951). In 1994, the southern 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).

The remaining 1950s-era concrete seawall begun to fail in early 2015 and Parks start looking at possible alternatives for the removal and replacement of the seawall.

2.1.2 Archaeology

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 Dr. Chris Lockwood, ESA Senior Archaeologist, and Geoarchaeologist observed the test pits and stratigraphy, examined spoils piles and recorded historical and recent debris. No pre-contact artifacts or features were encountered.

2.2 Ecology

This section summarizes ESA findings on the present ecology at the site. The reader is referred to Appendix A for detailed information on these findings.

Development along the Puget Sound has had detrimental effects on the natural processes overall, but primarily in areas of shoreline armoring. Shoreline armoring disrupts the connectivity of the nearshore ecosystem and imposes both landward and seaward impacts. 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).

The existing mixed sand/gravel beach at the south end of the park supports benthic organisms. Some wood recruitment and vegetation establishment are present in the southern portions of the project site where the seawall was removed under a previous restoration program. However natural ecological processes are currently lacking at Lowman Beach Park, providing an opportunity for restorative actions.

Forage fish spawning has not been documented at the park. Surf smelt spawning has been documented approximately 0.25 miles to the south in Lincoln Park.

2.3 Pipe Infrastructure

Pelly Creek currently flows through Lowman Beach Park in a 400-foot long, 18” diameter concrete pipe, which was installed in 1973 (Metropolitan Engineers, 1973). The pipe starts on the eastern side of Beach Drive SW and carries the creek underneath the road and the park before outfalling through the seawall to Puget Sound. Seawall deterioration has broken the pipe just above the outfall and evidence of overflow and erosion is visible in this area.

Slightly to the north of the Pelly Creek pipe and at greater depth is a 66-inch municipal storm sewer outfall that extends several hundred feet offshore. Maintaining appropriate depths of cover over this pipe and protecting it from damage during construction, the erosive creek flows, and wave action were all considerations in design.

Several other large outfall pipes cross under the southern portion of the park, including pipes associated with the City of Seattle’s newly constructed combined sewer overflow (CSO) facility, but these are outside of the limits of grading and will not be affected by this project.

2.4 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. A detailed analysis of the coastal process at Lowman Beach is shown in Appendix A.

Review of historical photos, surveys, 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.

Properties to the south of the park and the south end of the park itself appear to have experienced lower rates of historical erosion and have accreted (added) sediment from 1994 to the 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.

2.4.1 Existing Shoreline Condition

Historical photographs and maps from the 1920s imply a relatively low bank shoreline to either side of the creek mouth, but no detailed data were discovered that depict the pre-development condition of the shoreline and tidelands in detail.

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 small gravel is transported primarily by waves and wave-driven currents (Finlayson 2006), and less so by other factors.

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 and coarser, with cobbles and grey silt exposed near the north end of the park. Beaches gradually transition to higher elevation and less coarse sediment north 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.

2.4.2 Historical 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. Sediment at the site would also have been historically supplied by Pelly Creek and other small drainages within the drift cell. 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. Estimates of sediment supply quantities and transport rates are not available from previous studies.

Periodic placement of material at Lincoln Park might be a source of new material at Lowman beach, however, an estimate of the contribution from those placements are difficult due to the complexity of the coastal processes south of the site and it will require a multi-year study and a level of effort outside of the scope of this project. Although some material from the Lincoln Beach nourishment is expected to reach Lowman eventually, the contribution is considered small, thus the littoral cell is primarily maintained by those sediments present on the beach or materials placed artificially at the site.

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 to the MLLW. Beaches north of the park are characterized by large gravel and cobble at the surface, and in some cases underlain by a layer of grey clay.

2.4.3 General Effects of Shoreline Armoring

Numerous studies demonstrate the observed effects of shoreline armoring with bulkheads/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 the 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 a greater disruption to physical processes. Structures placed or located landward of the typical action of waves have little to no effect on physical processes. Early park topographic mapping indicates that the original seawall was constructed seaward of MHHW and exposed to wave action at high tide.

Bulkheads and seawalls typically 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 conditions. 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. Seawalls located on shores that naturally erode (which are most shores in Puget Sound) are subject to eventual scour and undermining.

2.4.4 Water Levels

The Seattle tide gauge (NOAA Station 9447130) located in Elliott Bay provides representative tide level data for the project site. The gauge is tied into the City's NAVD88 datum and has established tidal datum relationships provided in **Table 2-1**. The greater diurnal tide range at this location is 11.36 feet. Extreme tides rise approximately three feet above MHHW.

TABLE 2-1
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)

NOTES:

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

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 the General Extreme Value Distribution. The results are summarized in **Table 2-2**.

TABLE 2-2
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

2.4.5 Future Sea Level Rise

The initial sea level rise rates considered for this study were based on the National Research Council's (NRC 2012) report on *Sea-Level Rise for the Coasts of California, Oregon, and Washington.* However, in 2018, a new report prepared for the Washington Coastal Resilience Project (WCRP, 2018) presented new values of sea level rise rates in the Washington coastline by areas. These values were updated and used on the 60% design. The sea level rise rates for the site area are presented in **Table 2-3.** Based on these results the sea level rise consider on the design was an increase of 0.5 ft by 2030, 1 ft by 2050, and 2 ft by 2100 (roughly 80-year planning horizon).

TABLE 2-3
PROJECTED ABSOLUTE SEA LEVEL CHANGE[1] AT LOWMAN BEACH AREA (WCRP, 2018) IN FEET.

Year	Greenhouse Gas Scenario[2]	Central Estimate (50%)	Likely Range (83-17%)
2030	Low	0.4	0.3-0.5
	High	0.4	0.3-0.5
2050	Low	0.8	0.6-1.0
	High	0.8	0.6-1.1
2100	Low	1.9	1.3-2.5
	High	2.3	1.7-3.1

1. All projections are given relative to the average sea level for 1991-2019.
2. Two different greenhouse gas scenarios (RCP 4.5 ["Low"] and RCP 8.5 ["High"], Van Vuuren *et al.,* 2011)

2.4.6 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.

Winds measured at West Point (WPOW1) 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. The accuracy of the model was verified by comparison with limited wave measurements offshore of West Point in Puget Sound in 1993 and 1994. An extreme analysis of the 33 years of the resulting wave hindcast record produced by ESA was conducted. The maximum wave height from each year was obtained and fit to the General Extreme Value distribution. The results are summarized in **Table 2-4**.

TABLE 2-4
EXTREME WAVE HEIGHT (FT)

Return Period (years)	Ho
1	3.9
2	5.2
5	5.7
10	5.9
20	6.1
50	6.3
100	6.4

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.

2.4.7 Shoreline Evolution and Trends

Figure 2-2 presents the rates of change in a visual manner within the park vicinity. 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 compared to rates before 1994. **Figure 2-3** depicts the results of the longshore sediment transport simulations done from wave and water level conditions from 1984 to 2016. It provides the average annual direction and magnitude of sediment transport for four methods at the four locations in the park vicinity. 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. **Figure 2-3** shows the estimate transport rates after the beach is restored. The results show a small transport rate to the north of the site although actual transport rates and directions may change year by year. Based on these results and the performance of the beach design shown in Appendix G is expected that the beach will largely remain on place with lower rates of erosion to the north.

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.

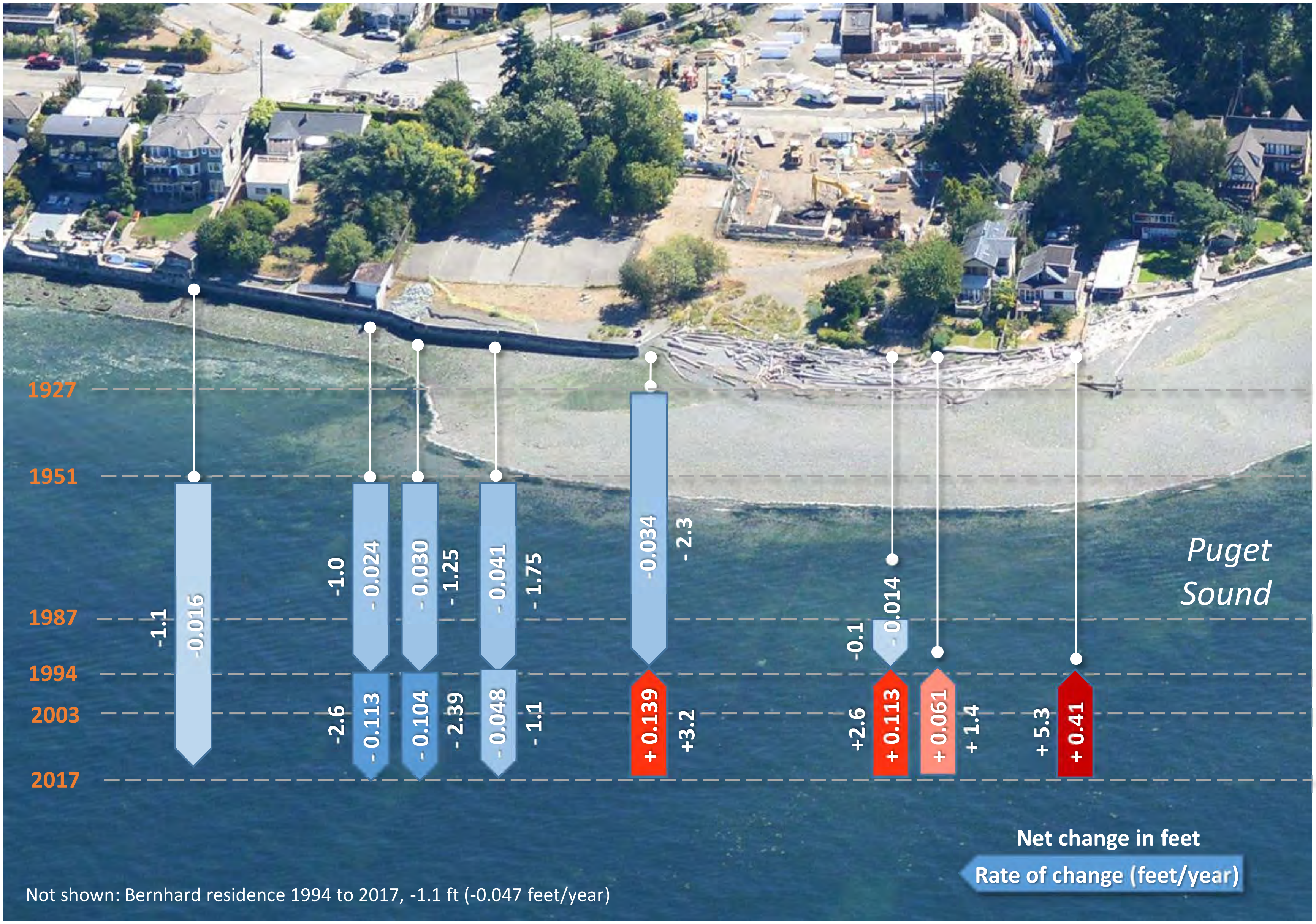
2.5 Geotechnical Investigation

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.

The 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 the 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 the adequate retaining capacity, especially under seismic loading.

The reader is referred to Appendix C for detailed information on the geotechnical report and these findings.



NOT TO SCALE

SOURCE: ESA 2017

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

Lowman Beach Park Feasibility Study. D160292.00

Figure 2-2

Beach Elevation Change Summary

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.

Lowman Beach Park Feasibility Study. D160292.00

Figure 23
Potential Average Net Annual Longshore Sediment Transport

2.6 Seawall Conditions Assessment

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 have continued to the present time, and much of the remaining concrete seawall at Lowman Beach Park has begun to actively fail. 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.

Reid Middleton conducted a condition assessment for the existing seawall. The reader is referred to Appendix D for detailed information on the present seawall conditions.

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. The city should be ready to implement a plan to deal with more extensive collapse, should it occur.

3.0 Pelly Creek Daylighting Design Approach

Pelly Creek is a small coastal stream which enters Puget Sound via a piped outfall in Lowman Beach Park. An 1895 topographic map of West Seattle shows an approximately ¾ mile long creek with one small tributary flowing into Puget Sound in this location. Historical maps of the park from the 1927 (**Figure 3-1**) show a sinuous creek channel emerging from a culvert under Beach Drive SW and flowing through the southern portion of the park. We could not confirm when the creek was initially piped, but the current pipe system was installed in 1973.

This section summarizes ESA's design process and findings for the Pelly Creek portion of the design. The reader is referred to Appendix E for more information on methodology and alternatives considered.

When designing the daylighted portion of the pipe, ESA considered:

- Physical constraints of the site
- Hydrology and high flow recurrence intervals
- Water velocity and scour potential
- Sediment and debris load
- Public safety
- Appropriateness of the design for the setting

The location where the pipe ends and the daylighted creek begins was largely determined by the physical constraints of the site. Where the pipe first enters park property near Beach Drive SW, it is 10 feet below the ground surface. In order to daylight the creek on the slope above the beach, it was necessary to modify a section of the existing pipe system to reduce the overall pipe slope and have the new end of the pipe surface in the park to form the upstream end of the daylighted creek section. The pipe modifications also adjust the alignment to the south, away from the northern boundary of the property and the buried 66" stormwater outfall to where the creek can be a more central feature of the park. Another site constraint was the presence of several large trees on the slope above the proposed creek opening. Preserving these trees was important to SPR, so special consideration was given to limiting work in their root zones. These factors significantly constrained where the pipe opening could be situated.

Pelly Creek is ungauged, so peak flows and recurrence intervals were estimated based on watershed area and land use. More information on the modeling process is included in Appendix E. Several different methods were compared, and a design flow of 6 cfs was selected, representing the 100-year recurrence interval. Because the final reach of the pipe is still relatively steep, an energy dissipation pool will be installed at the pipe opening to slow flows and reduce stream power before the creek enters the restored channel. The footprint and depth of this structure has been minimized to for the safety of the public and to maximize the available restoration area. More information on this structure can be found on the design plans and in Appendix E.

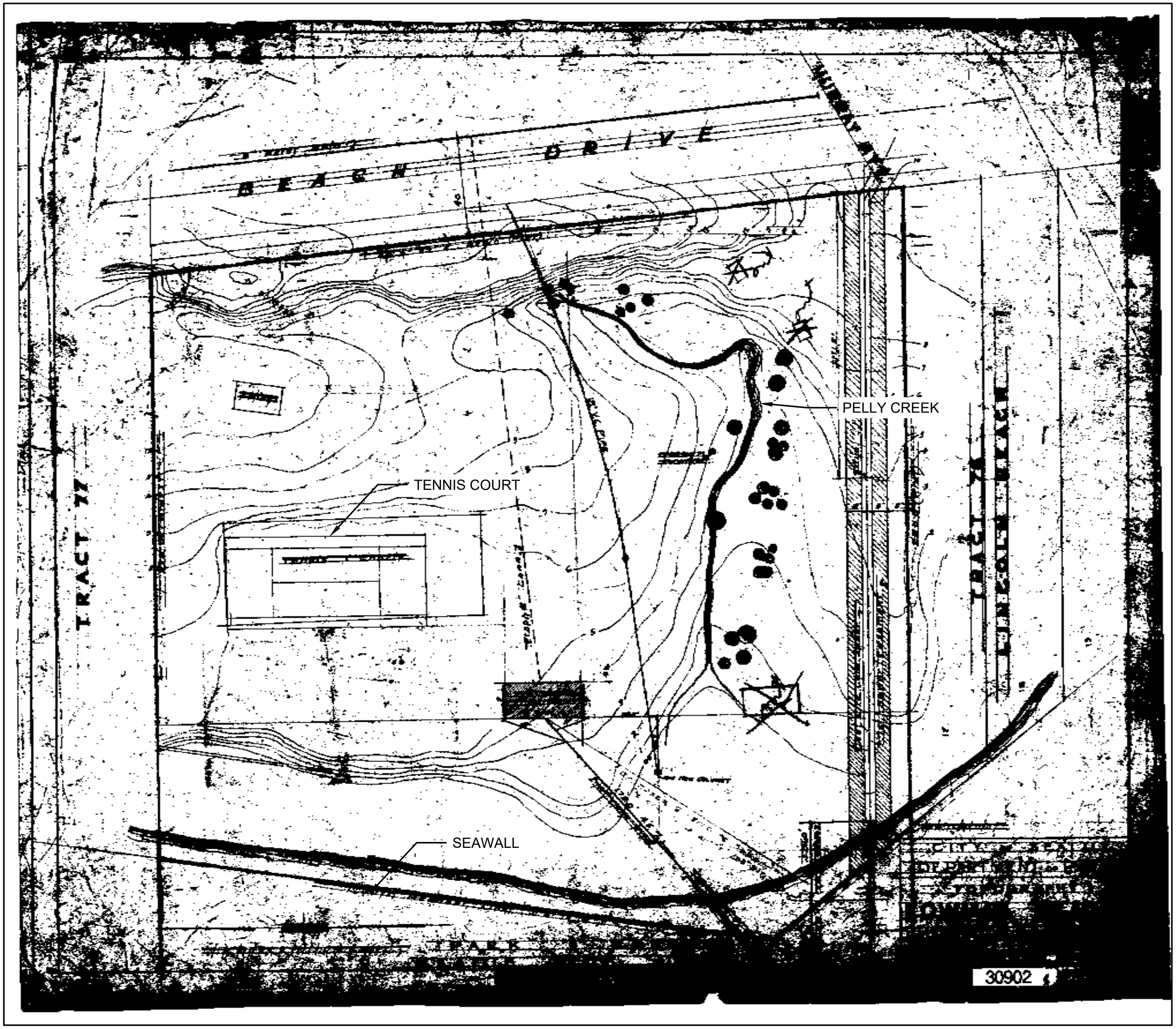


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Figure 3-1
Lowman Beach Park
1927 Map

The channel form was selected to be appropriate to the slope of the reach and to reference the sinuous stream form observed on the historical maps. The slope of the upland daylighted reach (before the creek reaches the beach) is 6.5%, fixed by the elevation of the pipe opening and the elevation of the back beach. Based on hydraulics, a bankfull width of 5 feet and a channel depth of 1 foot was selected to carry the design flow with 5 inches of freeboard. The bed of the channel will be slightly sloped towards the thalweg to provide a low flow path. Across the back beach, the channel will have the same dimensions but a 0.2% slope. No channel will be graded into the shore face. The creek will make its own channel in this zone. Minimal sediment or debris is expected due to the length of the pipe system and the presence of several manholes.

When selecting the appropriate substrate, the design team balanced our desire for a dynamic channel with a self-defined low-flow path with the need for the creek to remain in a relatively stable alignment through the upland reach in the park. To achieve this, two layers of cobble will be employed. Upper six inches is a 4" streambed cobble mix (D_{50} of 1.5 inches). Portions of this mix should become mobile at the 2- to 5-year flow event, allowing the stream to shape its own channel. Below that is eight inches of an 8" streambed cobble mix (D_{50} of 3 inches), which will remain stable in the design flow event. Once the creek reaches the back beach, it will flow directly over the beach material with no constructed bed. Additional fines will be washed into the beach sediments in the immediate vicinity to keep streamflows on the surface through the back-beach reach. We assume that the channel will interact dynamically with the beach sediments over time to come to a natural alignment that provides for habitat values while being a feature of interest within the park.

4.0 Shoreline Restoration Design Approach

ESA completed a beach restoration design that comprises the restoration of the back beach at the site with native materials, grading, and planting. The design was developed by applying coastal geomorphology and investigated with process-based morpho-dynamic models and applied geomorphology using reference sites and regional guidance documents.

The design conforms with the variation between the expected natural morphology along the shore, and the constraints formed by the park facilities and neighbored structures to the north. The primary parameters taking into consideration were the prevailing coastal processes, wave exposure, tide climate, sediment grain size, and associated beach geometry (specifically, slope, berm elevation, and beach width). ESA evaluated the geometry and the beach profiles located south of the site and other reference sites on the Puget Sound. The resulting beach profile is a modification of a natural profile adapted to the constraints of the park.

The proposed beach nourishment would be approximately 200 ft wide and contemplates placing approximately 2,000 CY of native material back into the littoral system. **Figure 4-1** shows a plan view of the proposed beach grading. The beach profile has been designed to be constructed/restored as far seaward as possible such that an erosion response is elicited after initial construction rather than accretion as occurred after 1995. The beach profile after construction is shown in **Figure 4-2** (top). The width of the backshores varies from a 25-30 ft, and it goes from El 12.5 ft to El 12.0 ft. The beach foreshore goes from El. 12.0 to El 6.0 ft in a slope of 8:1. At El. 6.0 ft a lower bench of 20 ft width would be constructed. The purpose of the bench is to add material to the littoral system to move alongshore or cross-shore and allow the design to have a buffer of the material before it reaches a natural state. From the bench, the new beach profile will match the existing grade in slopes that vary from 3:1 on the north to 12:1 on the south. The proposed beach material would be a mixture of gravel, gravelly sand, and sand. The backshore would be composed of uniform coarse gravel, the foreshore would be composed of a mix of gravel and coarse sand, and the toe of the beach will be composed of a mixture of coarse sand gravel and cobble. **Figure 4-3** shows an example of the proposed material for each of the beach sections. See Appendix H for detail information on the sieve analysis, the recommended beach material and the material placement on the new nourish beach

ESA used a process-based morphodynamic model for gravel beaches call XBeach-G (McCall et al., 2015) to evaluate the performance and evolution of the new design grade. **Figure 4-2** (bottom) shows a graphic representation of the results of the model after a 10-year storm was model at a typical range of water levels at the site. The resulted beach profile mimics existing natural beach profiles found south of the site and other places in Puget Sound (Johannessen, *et al*, 2014). The backshore of the beach is expected to evolve into a vegetated beach with wood debris from storm events. A storm berm is expected to form after several high tide storms. The foreshore of the beach is expected to have small changes with slopes close to the design slope and ranging from 7:1 to 10:1 depending on future wave conditions. The lower bench will provide additional storm mitigation and beach material to be transited along the shore. Based on the previous coastal study done by ESA (See Appendix A), we expect that some of the material on the lower bench would gradually move north of the site.

The lower beach will flatten during high tide storms and push upwards to the foreshore during low tide storm events. The reader is referred to Appendix G to see the results of the performance of the beach nourishment design and the seawall-beach process with the processed-based morphodynamic model XBeach-G.

Constructing the beach in this manner and allowing it to evolve and reach an equilibrium condition would contribute beach sediment to the shoreline that could be transported to adjacent shorelines by waves and currents. The design 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.

4.1 Seawall Design Considerations

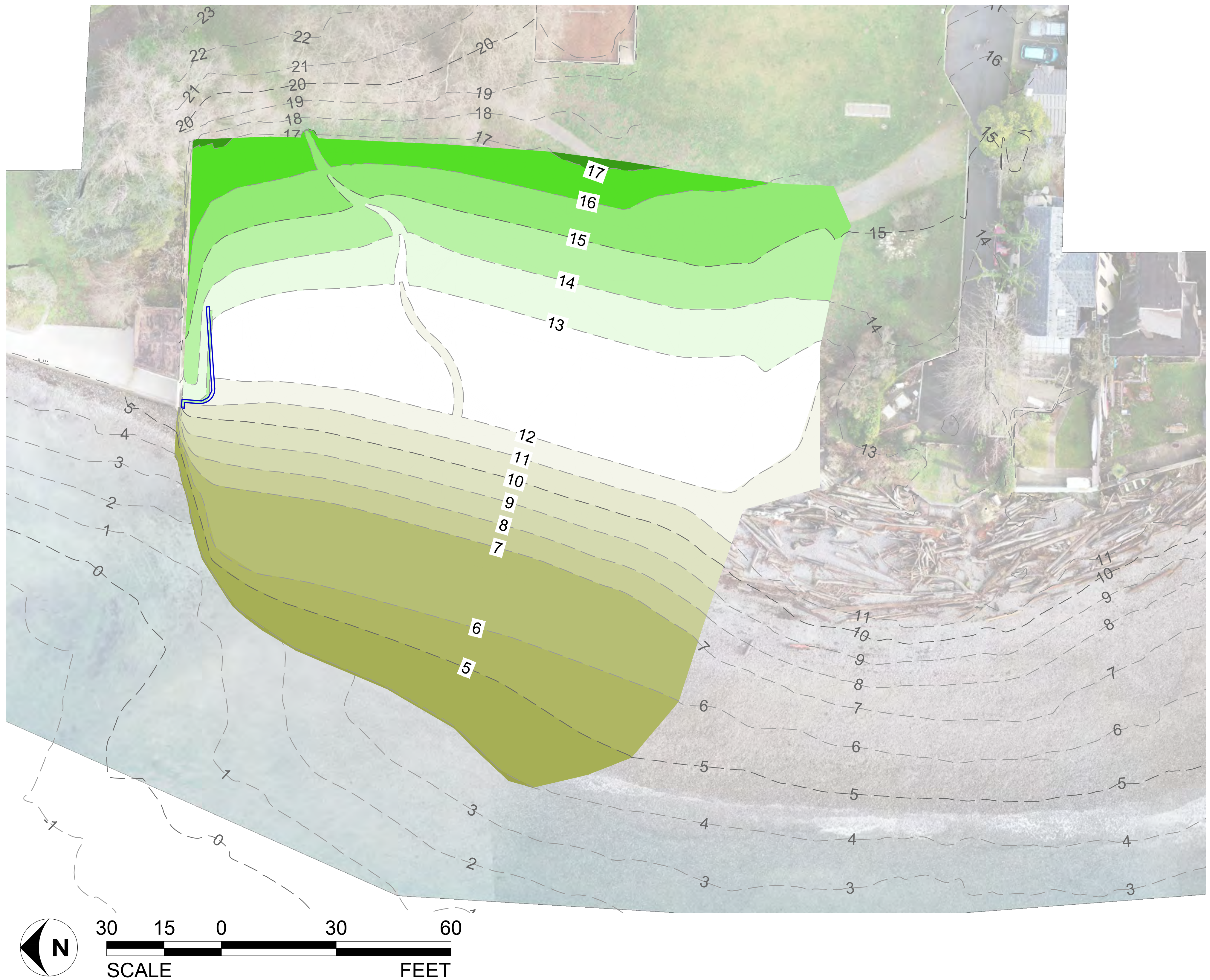
This section highlights the design parameters for the proposed seawall other than the structural design. The reader is referred to Appendix F for information on the structural design of the seawall. When designing the seawall at Lowman Beach, ESA's team considered the scour depth, wave reflection, beach erosion, seawall effects on the shoreline, and wave overtopping.

The geometry, location, and footprint of the seawall was designed to reduce the potential for adverse effects of the seawall on the shoreline and the beach while maintaining the integrity of the neighbor's seawall and property north of the park. **Figure 4-4** shows the footprint of the proposed seawall and the existing seawall. The new seawall is smaller and located farther inland than the existing seawall, which will result in less wave reflection than caused by the existing seawall. The seawall is placed at a minimum buffer distance of 6 ft from the existing 66-in RCP outfall pipe, to avoid any damage to the existing outfall. Inspection of the outfall will be done before and after construction.

Beach material would be put on the front of the seawall at El. 10.0 ft and up (**Figure 4-5**). In essence, placing the seawall landward of the typical action of the waves and reducing the effect of the seawall on the coastal process and the beach. Some degree of beach erosion is expected during extreme events below the shore side of the seawall. 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.

The height of the seawall was estimated at 14.5 ft (See **Figure 4-5**) by taking into account the 100-year extreme water level plus sea level rise by 2050 for the mid and high range projections. This elevation of 14.5 feet will provide freeboard that diminishes as sea levels rise. Wave runup overtopping of the wall may occur infrequently.

DWG: \\sfo-file01\PROJECTS\SEA\16xxxx\D160292.00 Lowman Beach Park\08_CAD\Dwgs\WORKING\SnowH\PermittingFigs.dwg USER: Pablo Quiroga PLOT DATE: 2/24/2020 5:04:26 PM

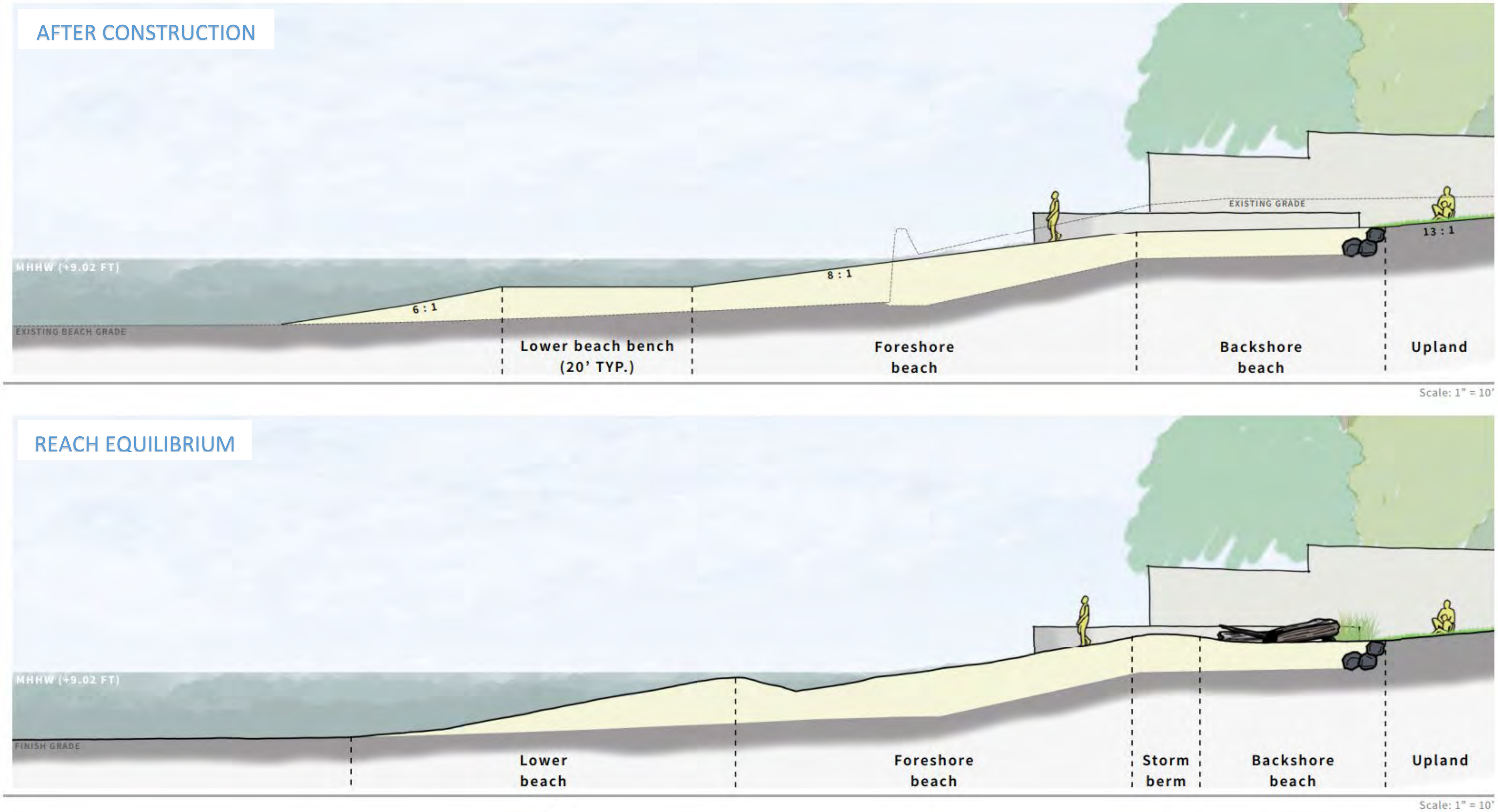


MIN EL	MAX EL	COLOR
0.0	1.0	
1.0	2.0	
2.0	3.0	
3.0	4.0	
4.0	5.0	
5.0	6.0	
6.0	7.0	
7.0	8.0	
8.0	9.0	
9.0	10.0	
10.0	11.0	
11.0	12.0	
12.0	13.0	
13.0	14.0	
14.0	15.0	
15.0	16.0	
16.0	17.0	
17.0	18.0	
18.0	19.0	

Lowman Beach Park - Shoreline Restoration

Figure 4-1
Beach Nourishment
Plan View

ESA



SOURCE: ESA, 2019

Lowman Beach Park Shoreline Restoration.D160292.02

Figure 4-2
Beach Design
Cross Section

Beach Toe - Cobble and Gravel

Foreshore - Mix Gravel and Coarse Sand

Backshore – Coarse Gravel

SOURCE: ESA, 2019

Lowman Beach Park Shoreline Restoration.D160292.02

Figure 4-3
Beach Nourishment Material Photos

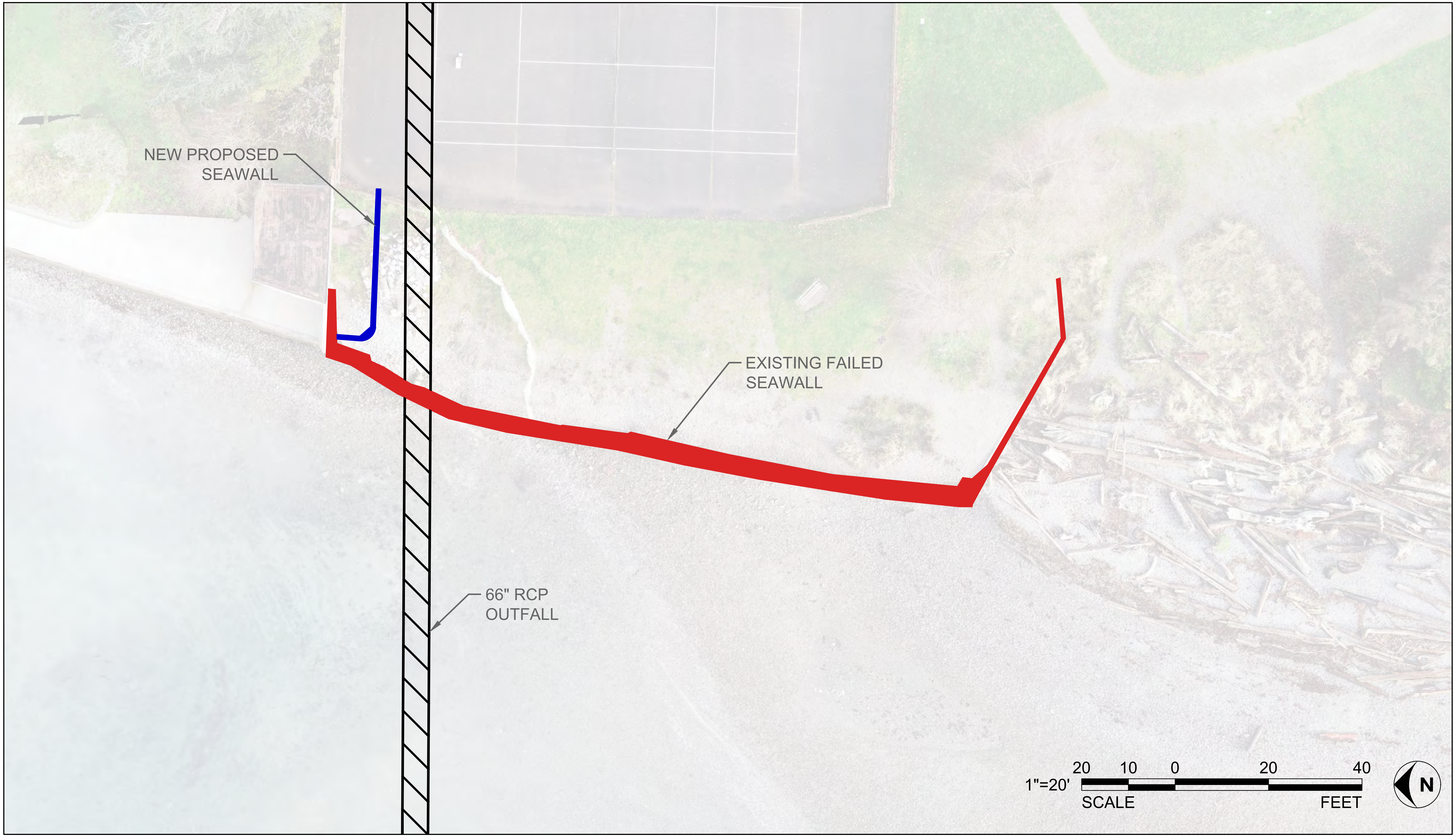
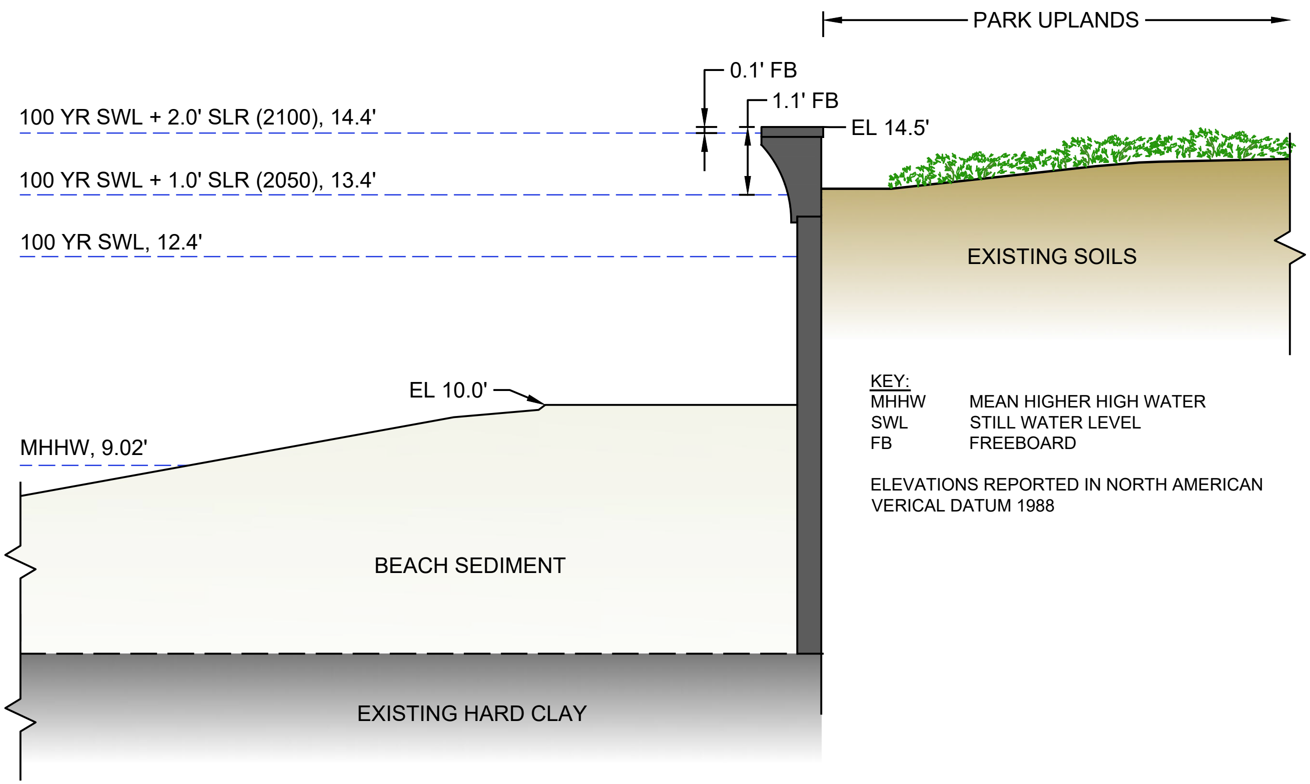


Figure 4-4
Seawall Geometry
Plan View

ESA



Lowman Beach Park - Shoreline Restoration

Figure 4-5
Seawall Design
Cross Section

ESA

5.0 Landscape Design Approach

The goal behind the landscape design was to maximize coastal revegetation while maintaining some of the services of Lowman as a public Park. The design includes 3,000 sf of restore coastal vegetation. It is expected that the back of the new beach will naturally vegetate with time, increasing the footprint of coastal vegetation on the restored shoreline.

We have considered and researched deciduous and coniferous tree alternatives to Pacific madrones (*Arbutus menziesii*) and shore pines (*Pinus contorta* var. *contorta*) respectively. It is our conclusion, based on best arboricultural practices and extensive regional planting experience, that shore pines and Pacific madrones are the best and most appropriate choices for this site, both aesthetically and functionally. Below are alternatives we considered and can discuss further.

Deciduous alternatives to Pacific madrone:

1. *Crataegus douglasii* / black hawthorn – mature height of 20-30 ft., nicest flower of our options.
2. *Frangula purshiana* / cascara (formerly known as *Rhamnus purshiana*) – mature height of 15-30 ft., broad leaf makes for nice foliage.
3. *Populus tremuloides* / quaking aspen – mature height of 65-80 ft., lovely white bark and trembling leaves.
4. *Acer Macrophyllum* / big-leaf maple – mature height of 60-100 ft., beautiful large leaves and tree habit.
5. *Alnus rubra* / red alder – mature height of 68-80 ft., very common tree throughout the Pacific Northwest.

Coniferous alternatives to shore pine:

1. *Tsuga heterophylla* / western hemlock – mature height of 70-200 ft., usually requires shelter from wind.
2. *Picea sitchensis* / sitka spruce – mature height of 80-160 ft., long lived, likes wet conditions.
3. *Thuja plicata* / western red cedar – mature height of 70-120 ft., widespread species, long-lived.
4. *Abies grandis* / grand fir – mature height of 80-200 ft., very fast growing.
5. *Pinus monitcola* / western white pine – mature height of 80-130 ft., becomes columnar with age.

6.0 Summary and Recommendations

The Lowman beach shoreline restoration project would remove approximately 200 linear feet of the remaining existing seawall and retaining/returning wall, install 40 linear feet of a new seawall to protect the properties north of the park. Remove the tennis court and replace it partially with a backshore beach, lawn, and marine riparian plantings. Daylighting Pelly Creek through the park and construct ADA-accessible paths and landscaping in the upland portion of the park.

6.1 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 a low probability of encountering artifacts between the tennis court and existing seawall. Although 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 during the removal of the tennis court, and a discovery plan must be put on place.

It is possible that the 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.

6.2 Daylighting of Pelly Creek

The daylighting of the Pelly Creek will provide freshwater input to the system while also providing a feature of interest within the park. We assume that the channel will interact dynamically with the beach and will naturally align over time.

The reroute and opening of the Pelly Creek will be done with caution to protect existing trees and utilities. A water diversion plan must be implemented during construction.

6.3 Shoreline Restoration

This project will substantially improve the natural coastal process at the site while also improving the beach access opportunities at the park. The existing seawall will be removed and replaced by a smaller seawall in order to transition from the neighboring seawall, to remain. The new, smaller seawall will have less interaction with waves and result in less wave reflection. All of this will reduce the effects of a hard structure on the natural coastal process while maintaining the existing protection of the property north of the park.

The project will introduce new beach sediment material to the littoral system. The new beach material will be similar to the existing material and placed at slopes and grades that will promote natural beach cross-shore processes and backshore ecological function. It is expected that the placement of new material to the littoral system will help to mitigate ongoing erosion at properties immediately to the north of the park. However, the project is not expected to stop the erosion trend to the north, which is the result of larger impacts distant from the site.

Improvements to the park (e.g., shoreline restoration, seawall replacement) are expected to have little effect on the southern part of the park where the shore has grown steadily since 1995.

We recommend placement of beach material immediately north of the project site (farther north than shown in the 60%-complete drawings and this report) to achieve the best outcome. Placing sediment farther north will allow a more gradual slope to the north, and result in a geometry closer to the expected equilibrium. This would require the approval of the property owner to allow beach materials to be placed on their property.

6.4 Coastal Resilience

This project would essentially revert the shoreline to a more natural state by restoring a natural morphology (geometry and sediments) with the capacity to adapt to waves and water levels, including higher sea levels. The project site has already experience roughly 4 inches of sea level rise in the last 50 years and we expect that sea-level rise will accelerate. The restored beach will adapt to higher sea levels by aggrading vertically and migrating landward, while dissipating incident waves and limiting wave attack on landward features.

6.5 Nearshore Habitat

Habitat and ecological process in this area will be further improved by the daylighting of Pelly Creek, restoring a creek channel and delivering freshwater across the shore. Also, the marine riparian habitat will be expanded by way of the site grading and planting. The old seawall will be removed and replaced with intertidal and supratidal beach, expected to support fish and birds.

The existing mixed sand/gravel beach supports benthic organisms and recreational uses. Impacts on the existing beaches and backshore will be limited, and overall extents of the beach will be increased.

The project will provide 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 evolve more naturally.

Major ecological benefits and potential benefits of the project include:

- Approximately 16,445 SF in nearshore habitat and additional 6,915 SF of backshore will 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.
- The additional sands and gravels may provide feeding and refuge habitat for juvenile salmon.
- The project 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. 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 shorebirds.
- The planting clusters of several marine riparian trees and shrubs will provide shade to the restored shoreline and result in ecological benefits. Due to a net increase in vegetation, a net

increase in the terrestrial input of organic material and invertebrates is anticipated. The recruitment and establishment of additional nearshore vegetation is expected, and will support the connectivity between the upland and nearshore ecosystems.

6.6 Recreation and Accessibility

The project will remove the tennis court and exchange it for intertidal beach and upland lawn area with plantings. Key viewsheds from the Olympic Mountains to the West, Alki Point to the north and Point Williams to the south will remain intact, 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. Upland space will be preserved, allowing the existing uses to continue.

ADA-accessible paths to the beach will be constructed. A “landing pad” south of the beach will enhance shore access.

6.7 Constructability

The project consists of conducting work both above and below the Mean Higher High Water Mark (MHHW). The project will be constructed by standard earthwork and site equipment to demolish the existing retaining wall and seawall and to build the new design backshore at the site and daylight Pelly Creek. Water management including deqatering of excavation Dewatering of the work areas are anticipated due to the permeable nature of the upland soils and tidal influence to groundwater elevations.

The new seawall will be constructed behind the existing seawall to prevent damage to an adjacent retaining wall and building. Excessive vibration during pile installation could damage the adjacent unreinforced block wall at the park boundary, and hence pile installation will require monitoring and adjustments to avoid damages. Care will also be needed to avoid impacting the buried King County Metro sewer pipe.

6.8 Maintenance

The project will 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. Small transport rates to the north and erosion near the new seawall are expected. We recommend anticipating placing approximately 150-250 cy/year of beach material every 8 to 10 years. Monitoring post-construction is recommended to evaluate project performance to inform future nourishment projects and to identify any remedial actions that may be desired.

6.9 Construction Cost

Table 6-1 details unit costs, quantities, and total costs by bid item. Item numbers and specification sections are listed on the left side of the table. The proposed project is estimated to cost $834,000.00(rounded), and it meets the available construction budget. A bidding option ($8,900.00) is included on the cost estimate to account for the possibility that none of the excavated material would be suitable to be placed on the beach grading. In that case, all the excavated material would be off-hauled, and all the beach grading material will be imported.

Lowman Beach Park - 90% CD

Construction Cost Estimate

Date: 1/24/2020

By: P. Quiroga, A. Greenberg, E. Bartolomeo

Checked: B. Battalio, T. Johnson, H. White

ITEM NO.	ITEM DESCRIPTION	QTY	UNIT	UNIT PRICE	EXTENSION
SITE PREPARATION					**$ 103,650**
1	MOBILIZATION	1	LS	$ 100,000.00	$ 100,000
2	CLEARING AND GRUBBING	7000	SF	$ 0.35	$ 2,450
3	TREE REMOVAL	6	EA	$ 200.00	$ 1,200
EROSION CONTROL					**$ 37,060**
4	EROSION/WATER POLLUTION CONTROL	1	EST	$ 5,000.00	$ 5,000
5	ESC LEAD	35	DAY	$ 130.00	$ 4,550
6	HIGH VISIBILITY FENCE	400	LF	$ 4.00	$ 1,600
7	FILTER FENCE	310	LF	$ 6.00	$ 1,860
8	TREE AND VEGETATION PROTECTION	480	LF	$ 5.00	$ 2,400
9	COMPOST SOCK	465	LF	$ 10.00	$ 4,650
10	STABILIZED CONSTRUCTION ENTRANCE	100	SY	$ 50.00	$ 5,000
11	TEMPORARY STREAM DIVERSION	1	LS	$ 12,000.00	$ 12,000
DEMOLITION & TEMPORARY STRUCTURES					**$ 84,000**
12	REMOVE AND DISPOSE OF EXISTING SEAWALL	145	LF	$ 320.00	$ 46,400
13	REMOVE AND DISPOSE OF EXISTING RETAINING WALL	55	LF	$ 320.00	$ 17,600
14	REMOVE AND DISPOSE OF TENNIS COURT	1	LS	$ 20,000.00	$ 20,000
WALL					**$ 216,250**
15	SUPPLY NEW W14 X 132 X 45' LONG	8	EA	$ 7,500.00	$ 60,000
16	TEMPORARY CASING (INSTALLATION)	8	EA	$ 2,000.00	$ 16,000
17	TEMPORARY CASING (REMOVAL)	8	EA	$ 2,000.00	$ 16,000
18	DESIGN AND FABRICATE PILE TEMPLATE	1	LS	$ 5,000.00	$ 5,000
19	INSTALL NEW PILE (AUGERED HOLE METHOD)	8	EA	$ 4,000.00	$ 32,000
20	SUPPLY LAGGING PANELS AND CAP	525	SF	$ 90.00	$ 47,250
21	INSTALL LAGGING PANELS AND CAP	1	LS	$ 20,000.00	$ 20,000
22	TEMPORARY SHORING OF ADJACENT RETAINING WALL	1	LS	$ 5,000.00	$ 5,000
23	EXCAVATION, GEOTEXTILE, FILL	1	LS	$ 10,000.00	$ 10,000
24	VIDEO OF OUTFALL PIPE BEFORE AND AFTER	1	LS	$ 5,000.00	$ 5,000
EARTHWORK AND BEACH NOURISHMENT					**$ 158,100**
25	EXCAVATION AND STOCKPILE	2,000	CY	$ 15.00	$ 30,000
26	HAUL AND DISPOSE EXCESS AND UNSUITABLE MATERIAL	1,800	CY	$ 20.00	$ 36,000
27	TEMPORARY ISOLATION BERM	1	LS	$ 10,000.00	$ 10,000
28	SELECTED BEACH MATERIAL (REUSE) PLACEMENT AND GRADING	200	CY	$ 20.00	$ 4,000
29	IMPORT AND PLACE BEACH MATERIAL TYPE 1	700	CY	$ 40.00	$ 28,000
30	IMPORT AND PLACE BEACH MATERIAL TYPE 2	750	CY	$ 40.00	$ 30,000
31	IMPORT AND PLACE BEACH MATERIAL TYPE 3	350	CY	$ 40.00	$ 14,000
32	BURIED TOE PROTECTION - ONE MAN STREAMBED BOULDER	50	TN	$ 70.00	$ 3,500
33	BURIED TOE PROTECTION - 8" STREAMBED COBBLE	40	TN	$ 65.00	$ 2,600
PELLY CREEK PIPE REROUTE					**$ 35,200**
34	PELLY CREEK PIPE REROUTE, NEW 18" RCP STORM DRAIN PIPE	90	LF	$ 180.00	$ 16,200
35	48" MAINTENANCE HOLE	2	EA	$ 6,000.00	$ 12,000
36	ABANDON EXISTING PIPE (STA 0+31 TO STA 1+20)	1	LS	$ 4,000.00	$ 4,000
37	DEMOLISH EXISTING PIPE (STA 1+20 TO STA 2+25)	1	LS	$ 3,000.00	$ 3,000
PELLY CREEK STREAM RESTORATION					**$ 10,160**
38	HAUL AND DISPOSE EXCESS AND UNSUITABLE MATERIAL	35	CY	$ 20.00	$ 700
39	STREAMBED COBBLE MIX	60	TN	$ 65.00	$ 3,900
40	ROCK FOR EROSION CONTROL AND SCOUR PROTECTION CLASS A	20	TN	$ 200.00	$ 4,000
41	LANDSCAPE ROCK	5	TN	$ 225.00	$ 1,125
42	GEOTEXTILE FOR SEPARATION	80	SY	$ 5.00	$ 400
43	NATIVE MATERIAL	5	CY	$ 7.00	$ 35
SITE RESTORATION					**$ 50,025**
44	GRAVEL PAVING - 1/4" MINUS	7	TN	$ 75.00	$ 525
45	GRAVEL PAVING - 5/8" MINUS	13	TN	$ 55.00	$ 715
46	SALVAGE AND REINSTALL (2) BENCHES	1	LS	$ 1,000.00	$ 1,000
47	SALVAGE AND REINSTALL (2) SIGNS	1	LS	$ 1,000.00	$ 1,000
48	CONCRETE PAVING - LANDING PAD	301	SF	$ 25.00	$ 7,525
49	CRUSHED ROCK BASE COURSE	4	TN	$ 55.00	$ 220
50	MINERAL SOIL TRAIL - COMPACTION	8	CY	$ 25.00	$ 200
51	IRRIGATION ALLOWANCE	1	LS	$ 25,000.00	$ 25,000
52	FINE COMPOST	112	CY	$ 40.00	$ 4,480
53	ARBORIST WOOD CHIP MULCH	20	CY	$ 30.00	$ 600
54	HAND SEEDING	1,505	SY	$ 3.00	$ 4,515
55	PSIPE TREES - 6'-8' HT.	7	EA	$ 300.00	$ 2,100
56	PSIPE LIVESTAKES - 1" DIAMETER	40	EA	$ 5.00	$ 200
57	PSIPE - 10" PLUGS	389	EA	$ 5.00	$ 1,945
	DIRECT ITEM SUBTOTAL				$ 694,445
	CONTINGENCY	20%			$ 138,900
	SALES TAX (not included, 10.1%)				$ -
	CONSTRUCTION TOTAL (Rounded)				**$ 834,000**
	BIDDING OPTION A (No Reusable Material)				**$ 842,900**

NOTES:

1. Does not include permitting, engineering design, management, or other soft costs.
2. Unit Prices include the General Contractor's overhead and profit
3. Bidding Option A. Assumes that none of the excavated material is suitable for the beach grading. All excavated material will be hauled and all the beach grading material will be imported.

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