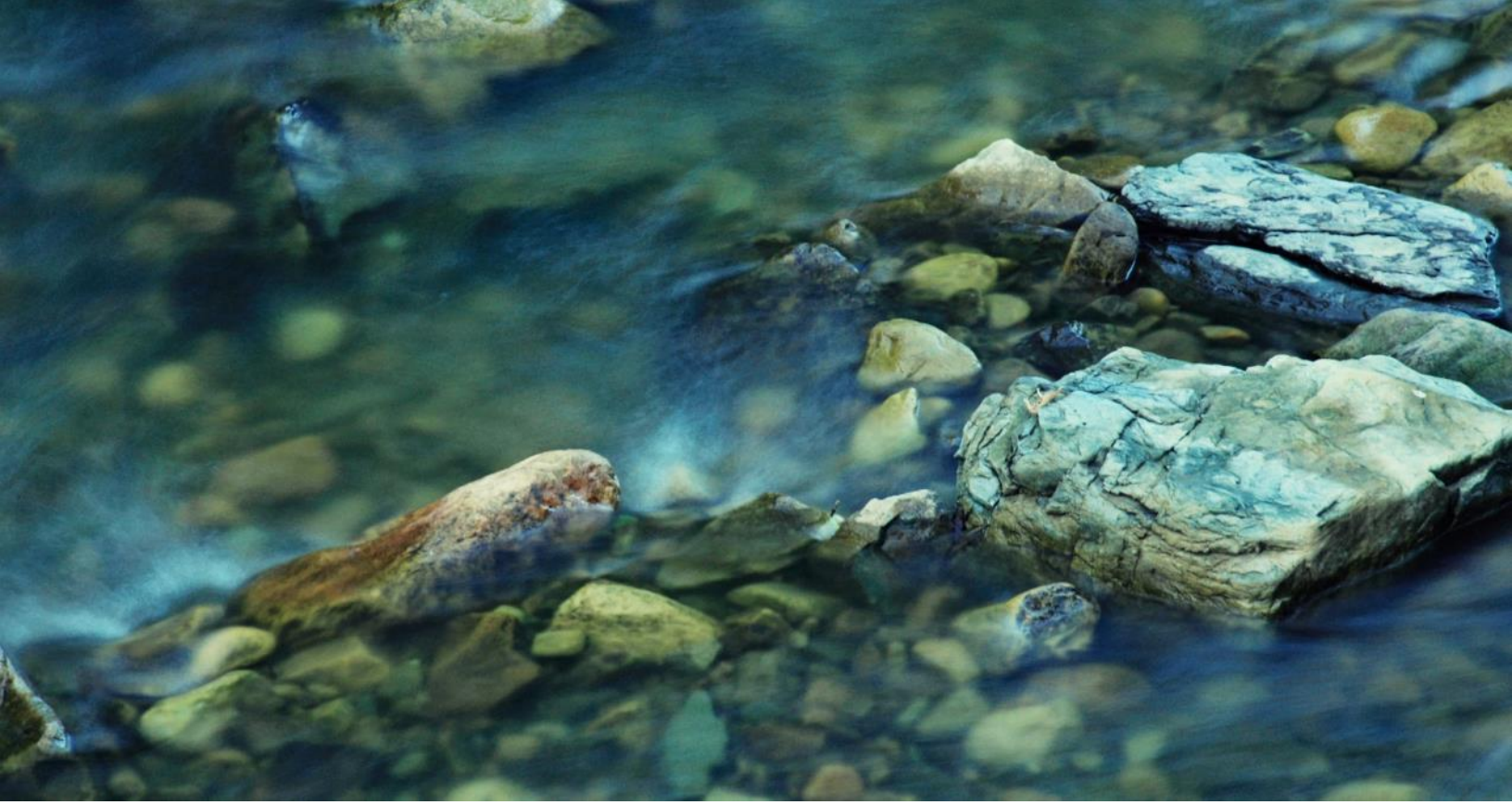

October 2020
Parcel 86 Shoreline Repair Project

ANCHOR QEA

Conceptual Design Options Evaluation

Prepared for Port of Tacoma

October 2020
Parcel 86 Shoreline Repair Project

Conceptual Design Options Evaluation

Prepared for
Port of Tacoma
One Sitcum Plaza
Tacoma, Washington 98421

Prepared by
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Project Number: 200092-01.05
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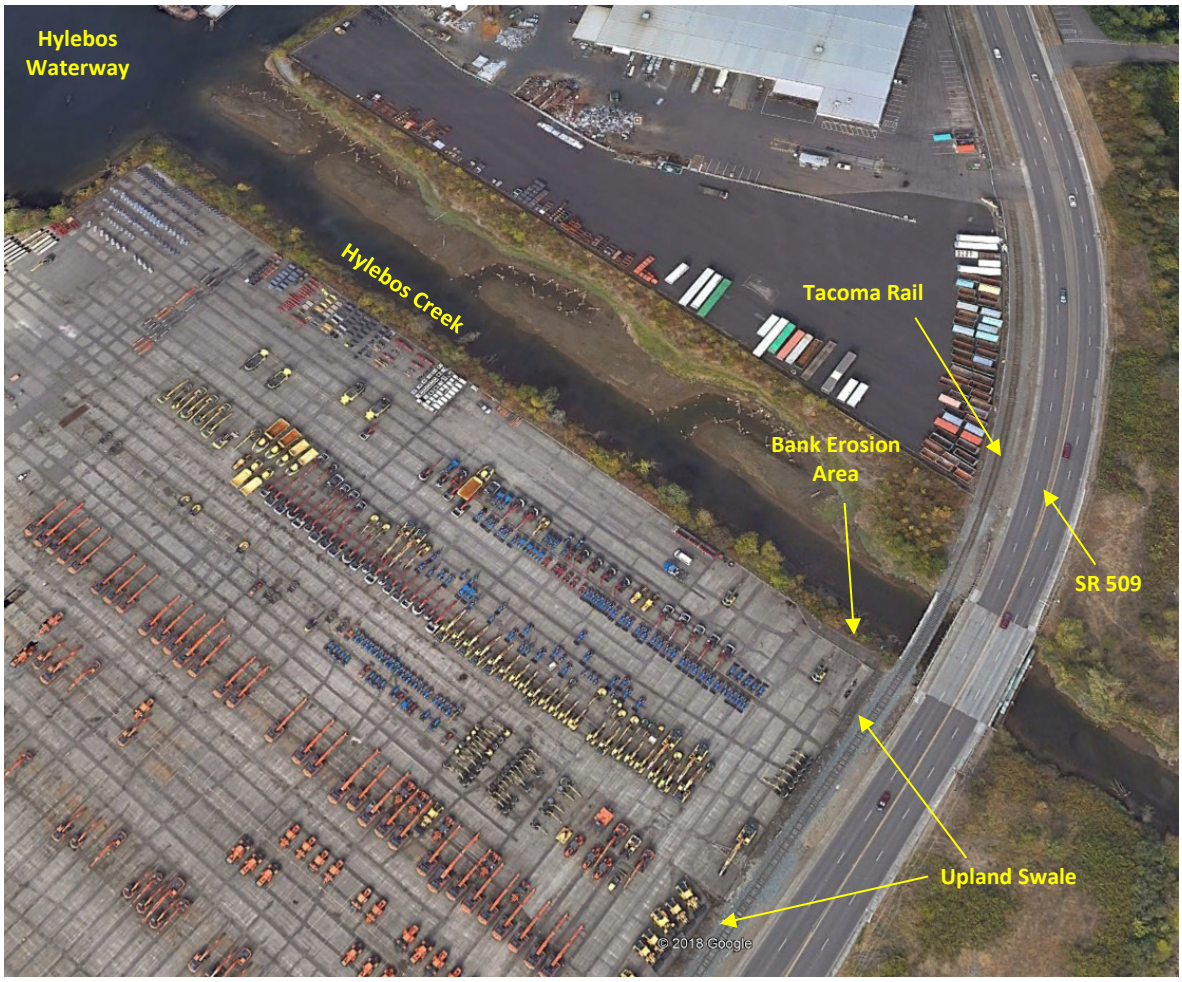
ABBREVIATIONS

ASTM	ASTM International
BGS	below ground surface
MLLW	mean lower low water
OHW	ordinary high water
pcf	pounds per cubic foot
Port	Port of Tacoma
psf	pounds per square foot
SPT	Standard Penetration Tests

1 Introduction

Erosion of the shoreline bank in the southeast corner of Port of Tacoma (Port) Parcel 86, located at 3701 Taylor Way, was previously identified by the Port. This erosion has progressed landward and has exposed a manhole that is part of the Parcel 86 stormwater management system. It also threatens the integrity of the environmental cap constructed on the property. The Port contracted with Anchor QEA, LLC, to investigate the cause of the erosion and develop potential options for restoring the eroded bank. An overview of the site is provided in Figure 1.

Figure 1
Overview of Parcel 86



Parcel 86 is a cleanup site, regulated by the Washington State Department of Ecology (Ecology). The former owner and operator, Louisiana Pacific, placed Asarco slag and road ballast across the site to stabilize the ground for operation of heavy log-yard machinery. The remedy was implemented in

1993 and consists of a low-permeability asphalt cap and stormwater drainage system. The Enforcement Order (DE92TC-S312) and Restrictive Covenant prohibits disturbance of the cap and exposure to contaminated soil and slag under the cap. The area of erosion is within clean backfill. Ecology has been notified of the erosion.

Anchor QEA previously conducted a site visit in June 2019 to perform a visual inspection of the bank erosion and potential seep location. From the site visit, it was concluded that gravel material observed on the slope was most likely crushed bedding rock placed around the stormwater vault exposed in the upper portions of the eroded bank. It was not apparent if the bank erosion occurred due to a leak from the adjacent stormwater vaults, a groundwater seep channeled along the bedding gravel for the vault, high creek flows, or some combination of causes. There was no flow or seep visible at the time of the site visit.

Following the site visit, Anchor QEA reviewed existing site information and performed a site investigation to identify sources of the seep and cause(s) of bank erosion at the site. Potential options to address erosion issues were explored and a subsequent geotechnical investigation was performed to address data gaps that had been identified and to inform the development of conceptual design alternatives. This report summarizes previous assessments as well as the geotechnical investigation performed at the project site. This report also presents a new conceptual design option for protecting the Parcel 86 environmental cap and compares this alternative to those previously considered.

2 Previous Work and Data Gaps

Anchor QEA performed a bank erosion assessment in 2019 to assess the causes of on-site erosion. Visual observations performed in June 2019 indicated the vault of an adjacent manhole, MH7, had been exposed, and bedding gravel had been expelled down the bank. Based on these visual observations, it appeared that flow seeping through the top of the bank was the direct cause of erosion; however, the cause of the seep was unknown.

A stormwater system is located inland of the bank as well as three adjacent manholes, MH7, MH8, and MH9. Based on a review of the tidal datums for the Hylebos Creek, it was determined that one possible cause for the erosion was the draining of water retained within the gravel bedding during high tide. An additional investigation was performed in November 2019 to determine if the stormwater system, specifically MH7, MH8, and MH9 vaults were leaking and causing erosion. Following hydrostatic testing, although minor leakage from each vault occurred, it was determined that the flow rates of these leaks alone were not significant enough to have cause erosion of this severity.

The initial assessment concluded that there were multiple sources of inflow and drainage[1] that were causing erosion along the Parcel 86 shoreline, and any permeable erosion control measures (e.g., riprap slope protection) would need to handle significant drainage of water through the slope. Several preliminary options were considered to deal with erosion along the bank, including revegetation of the eroded slope (soft shore stabilization), hard armoring with rock or concrete matting, or a combination of the two. The preliminary recommendation at the time was to construct a rock slope within the footprint of observed erosion; however, this alternative was not optimal as it would require filling below the Ordinary High Water (OHW) mark. Filling the area with rock below the OHW mark would trigger more extensive permitting requirements and mitigation for the change in habitat substrate type.

In the Spring 2020, the Port requested that Anchor QEA evaluate a range of options to protect the Parcel 86 environmental cap and related stormwater infrastructure. Initial options included a retaining structure that could potentially be installed above the OHW mark and concepts that would be more habitat friendly for areas below the OHW mark. Anchor QEA considered a range of retaining structures such as king-pile, mechanically stabilized earth and sheet pile wall configurations. During the preliminary evaluation of retaining wall options, the need for supplemental bank reinforcement waterward of the wall was considered (e.g., riprap, Envirolok). After a site inspection, Anchor QEA

[1] Prior to a more detailed evaluation of the groundwater elevations in relation to the construction of the stormwater system (briefly summarized in Section 4.2), it was assumed that bank erosion was caused by a combination of overland flow, seepage through the stormwater system manholes, discharge of groundwater at low tide, and tidal exchange into the permeable bank soils.

determined that supplemental reinforcement would not be necessary to protect the environmental cap and stormwater system.

In order to develop a conceptual design of a retaining structure, several data gaps needed to be filled. These included elevation surveys of the eroded bank, utility information, and geotechnical characterization of the subsurface soils near the existing bank. Subsequent sections of this report include a summary of the activities performed to close these data gaps.

3 Data Gaps Investigation

3.1 Elevation and Infrastructure Surveys

A topographical survey of the project area, including the bank of the Hylebos Waterway down to the creek centerline, was performed by Sitts & Hill Engineers, Inc., on June 23, 2020. The survey also included the four on-site groundwater monitoring wells and documentation of the stormwater system adjacent to the bank erosion area. The results of the stormwater system and topographic survey are shown in Figure 2. The coordinates for the groundwater monitoring wells are summarized in Table 1.

Table 1
Groundwater Monitoring Well Coordinates

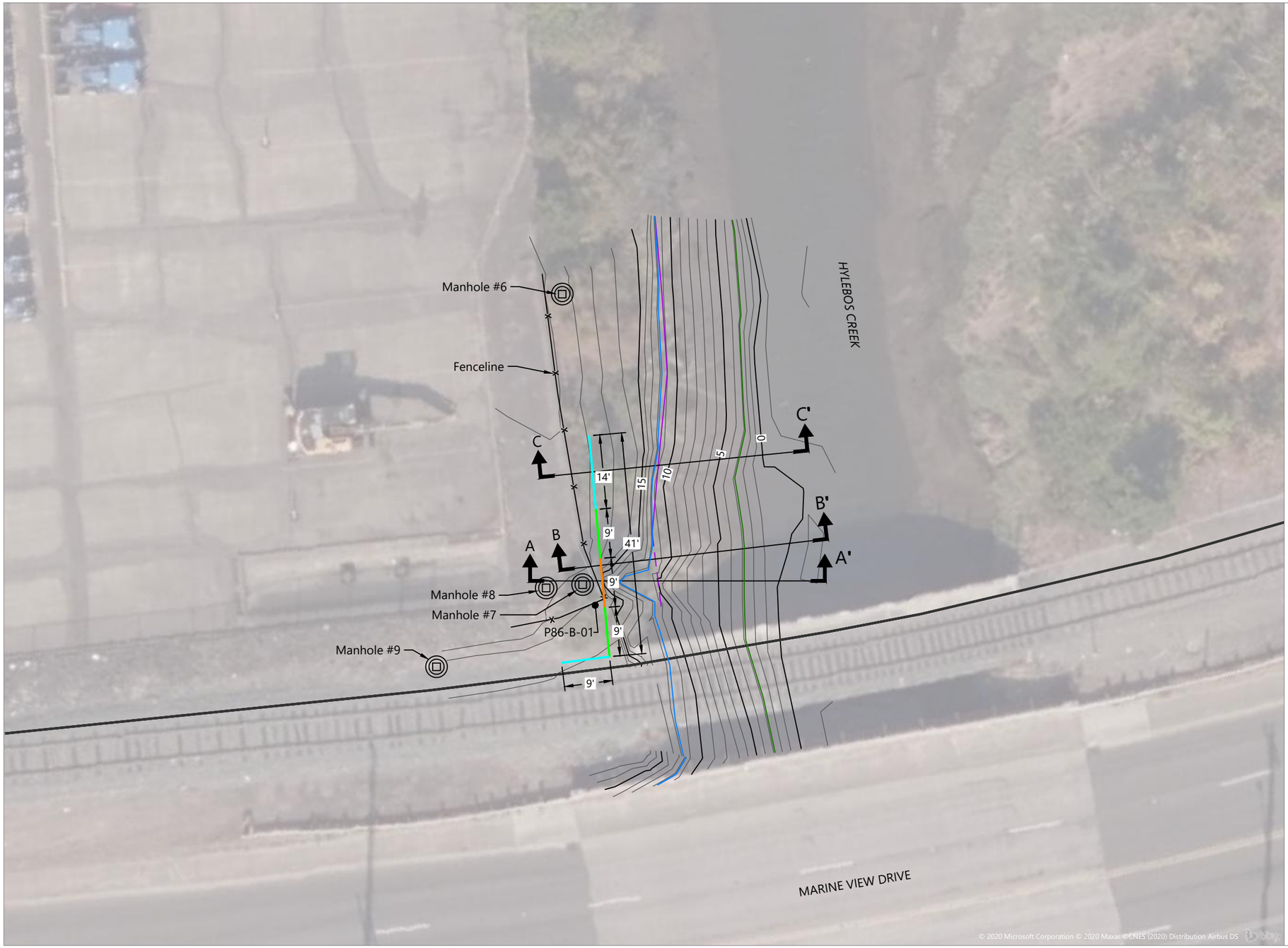
Well ID	Northing/ Easting[1]	Ground Elevation[2] (feet MLLW)	Rim Elevation[2] (feet MLLW)	Elevation of North Edge of 2-inch PVC Pipe (feet MLLW)
MW1	707651.455/ 1178329.942	22.450	22.400	21.739
MW2	708183.038/ 1178.348.780	20.981	20.946	20.563
MW4	708119.588/ 1178691.495	19.680	19.654	19.357
MW5	707948.138/ 1178887.849	19.259	19.240	18.929

Note:
1. Washington State Plane Coordinate System, South Zone, NAD 83/2011 (per Port of Tacoma survey control map – 2016)
2. Measured on north side.

3.2 Subsurface Investigation

Subsurface geotechnical conditions adjacent to the eroding Hylebos Creek bank were investigated by Anchor QEA on July 28, 2020. The exploration and testing involved the following:

- Drill one Hallow Stem Auger boring to a final depth of 81.5 feet below ground surface (BGS).
- Perform Standard Penetration Tests (SPT) and record blow counts at 5-foot intervals throughout boring.
- Visually classify soils within each exploration.
- Collect representative soil samples and submit for geotechnical laboratory testing.



LEGEND:

- Cross Section Location and Designation
- P86-B-01 ● Existing Geotechnical Boring Location
- Proposed Steel Wall Location (40' deep sheet section)
- Proposed Steel Wall Location (25' deep sheet section)
- Proposed Steel Wall Location (15' deep sheet section)
- 5 Existing Contours (1' & 5' Intervals)
- Ordinary High Water (OHW, See Note 1)
- Mean Higher-High Water (MHHW), +11.78'
- Mean Low Water (MLW), +2.84'

0 20
Feet

SOURCE: Aerial ©2020 Microsoft Corporation ©2020 DigitalGlobe ©CNES (2020) Distribution Airbus DS. Survey by Sitts & Hill, dated June 2020.
HORIZONTAL DATUM: Washington State Plane South Zone, North American Datum of 1983/2011 (NAD83/2011), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTES:

1. Location of OHW mark shown along Section A-A' was approximated based on observations along adjacent non-eroded shoreline areas.
2. 40' deep sheet pile section may consist of a box pile configuration (i.e., two rows of sheet piles welded together to increase structural stiffness). Other sections will consist of a single sheet.

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Filepath: K:\Projects\0092-Port of Tacoma\Parcel 86 Shoreline Repair Project\0092-RP-001 (Section).dwg Figure 2

ANCHOR QEA

Figure 2
Project Layout

Conceptual Design Options Evaluation
Parcel 86 Shoreline Repair Project - Port of Tacoma

Subsurface drilling was performed by Boretec, Inc., using a lightweight, limited access RCT 60 Track Drill rig. SPTs were performed at 5-foot depth intervals. SPT blow counts were collected using a 140-pound auto hammer dropped from a height of 30 inches to drive a 2-inch outside diameter split spoon sampler into the subsurface. The standard penetration resistance (N-value) was recorded for each sample interval and was calculated as the total number of blows needed for the sampler to penetrate the final 12 inches of an 18-inch sampling interval.

The location and depth of exploration was selected by Anchor QEA based upon the proposed project limits, site access, and design needs. The boring location is depicted in Figure 2. This boring was used to develop a subsurface profile of the soil layers within the alignment of a potential retaining structure. Representative soil samples were obtained from split spoon samples at each interval of collection and submitted to Materials Testing and Consulting, Inc., for the following analyses:

- Moisture content (ASTM International [ASTM] D2216)
- Organic content (ASTM D2974)
- Atterberg limits (ASTM D4318)
- Particle size (ASTM D6913)
- Particle size with hydrometer (ASTM D7928)
- Specific gravity (ASTM D854)

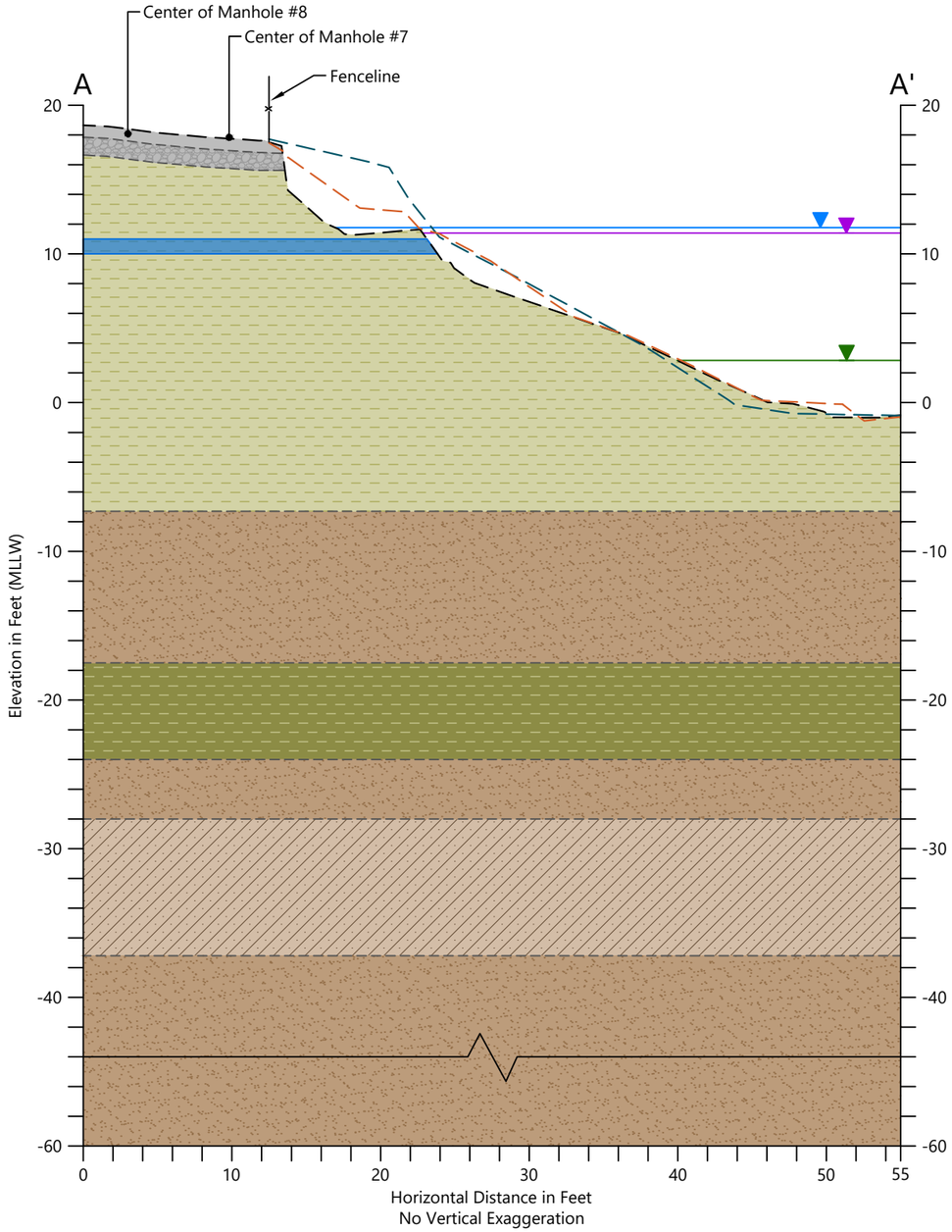
The soil boring log is provided in Attachment A. A summary of laboratory results from geotechnical testing are provided in Attachment B.

3.3 Subsurface Soil Profile

The following is a description of the subsurface lithology encountered at the location of the geotechnical boring. The key characteristics of the major soil units encountered during the investigation are generally described from the ground surface downward. Table 2 and Figure 3 provide summaries of the layers encountered.

Asphalt Surface. The surface of the property is graded and paved with asphalt. This is the main component of the Parcel 86 environmental cap.

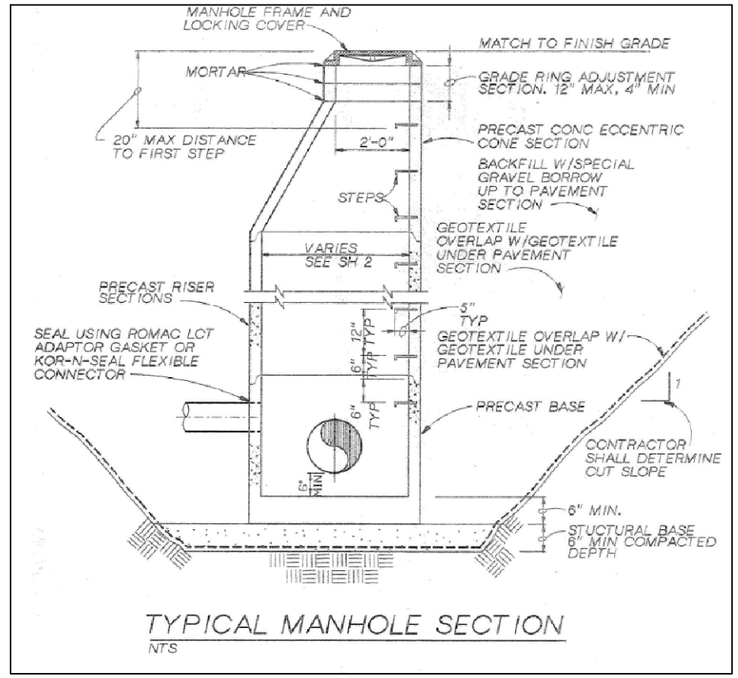
Gravel Base. The asphalt is underlain by a subbase layer consisting of gravel up to 2 inches in diameter. The gravel also underlies the foundations of the manholes and other components of the stormwater system. Adjacent to the bank of the Hylebos Waterway, this material extends approximately to elevation 10.1 feet MLLW at MH7 and is exposed along the creek bank (refer to typical detail in Figure 3).



LEGEND:

- Cross Section A-A' Existing Ground Surface
- Cross Section B-B' Existing Ground Surface
- Cross Section C-C' Existing Ground Surface
- Geologic Contact
- Asphalt
- Coarse Gravel Base
- Silt (ML)
- Silt (MH)
- Poorly-Graded Sand with Silt (SP-SM)
- Silty Sand (SM)
- Zone of Groundwater Elevation Fluctuation
- Ordinary High Water (OHW, See Note 1)
- Mean Higher-High Water (MHHW), +11.78'
- Mean Low Water (MLW), +2.84'

SOURCE: Survey by Sitts & Hill, dated June 2020.
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTE:
1. Location of OHW mark shown in Section A-A' was approximated based on observations along adjacent non-eroded shoreline areas.



SOURCE: Typical manhole section from Drawing No. 6 dated July 23, 1993 from Plan Set, "Louisiana-Pacific Corporation Tacoma Log Sort Yard RCC Cap, Tacoma, WA" by CH2M Hill, Project No. SEA35052.C0.
NOTE: Top of structural base material below Manhole #7 is estimated at elevation 10.31' MLLW.

Publish Date: 2020/10/23 1:40 PM | User: tgriga
Filepath: K:\Projects\0092-Port of Tacoma\Parcel 86 Shoreline Repair Project\0092-RP-001 (Section).dwg Figure 3

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Figure 3
Generalized Subsurface Soil Profile
Conceptual Design Options Evaluation
Parcel 86 Shoreline Repair Project - Port of Tacoma

Silt (ML). A 23-foot layer of silt was encountered immediately below the gravel base layer. The silt was soft, predominantly olive gray, and ranged in moisture from moist to wet with a range in moisture content of 32% to 46.5%. The average N-value in this silt was 3. Atterberg limit testing confirmed that the silt in this layer was of low plasticity. The bank of the Hylebos Creek is predominantly composed of this material.

Poorly Graded Sand with Silt (SP-SM). Poorly graded sand with silt was encountered below the primary silt layer. This sand ranged from loose to dense, moist to wet, and was grayish brown to black. The moisture content of this unit ranged from 21.6% to 51.1%. Within this unit of sand with silt were layers of silt and silty sand of thickness of 35.3 feet to 41.6 feet BGS and 45.6 feet to 55.3 feet BGS, respectively.

Table 2 summarizes the subsurface geologic profile observed in the boring and associated modeling parameters used to develop a conceptual retaining wall configuration. Modeling parameters were established using geotechnical laboratory test results, as well as standard empirical correlations of measured SPT-N values to soil engineering design properties. Selection of the design properties was based on experience with similar materials on other projects and consistent with geotechnical engineering design guidance.

Table 2
Subsurface Soil Profile and Preliminary Soil Engineering Properties

Subsurface Unit	Depth below Ground Surface (feet)	Total Unit Weight (ɣ) (pcf)	Effective Cohesion (c′) (psf)	Friction Angle (φ′) (degrees)
Asphalt	0–0.8	—	—	—
Gravel Base	0.8–2	—	—	—
Layer 1: Silt (ML)	2–25	100	500	18
Layer 2: Poorly Graded Sand with Silt (SP-SM)	25–35.3	115	0	32
Layer 3: Silt (MH)	35.3–41.8	95	500	16
Layer 4: Poorly Graded Sand with Silt (SP-SM)	41.8–45.6	110	0	30
Layer 5: Silty Sand (SM)	45.6–55.3	110	200	19
Layer 6: Poorly Graded Sand with Silt (SP-SM)	55.3–80.1	125	0	32

3.4 Groundwater

The groundwater elevation summary presented in the previous evaluation, Figure 7 in *Parcel 86 Bank Erosion Assessment* (Anchor QEA 2019), did not accurately capture the zone of groundwater fluctuation due to uncertainty in the appropriate elevation datum conversion. The four groundwater

monitoring wells were surveyed at time of the topographic survey allowing for accurate documentation of the typical groundwater elevations adjacent to the creek bank (Figure 3). The estimated zone of groundwater fluctuation shown in geologic cross-section in Figure 3 is based on seasonal water level observations made during the long-term monitoring events required by the Ecology cleanup (under Enforcement Order No. DE 92TC-S312) for the Former Louisiana Pacific/ Pony Lumber (Pony) Facility. This monitoring occurred periodically between 2007 and 2019. After review of these data, we have made the following conclusions about groundwater at the site: 1) the horizontal gradient towards the creek are relatively flat, and 2) there is a slight downward gradient from the upper silt into the underlying sand layer.

The survey also documented the stormwater manholes and confirmed that the gravel bedding below the manholes sits within the zone of groundwater fluctuation at approximately 10.3 feet MLLW. This elevation is consistent with observations of groundwater seeps that emanate from the bank adjacent to MH7. To better understand the groundwater levels upgradient MH7, we recommend that piezometers be installed and monitored for several tidal cycles during the upcoming high precipitation weather season.

4 Sheet Pile Wall Conceptual Design and Considerations

Multiple types of retaining structures, including mechanically stabilized earth, sheet pile, and soldier pile walls, were considered in the initial concept development. However, because of the limited landside access to the slope and installation costs, only a single option (a sheet pile wall) was advanced further. This section presents the results of the preliminary modeling used to develop the conceptual wall configuration and considerations related to the ability of a sheet pile wall to serve as a viable long-term solution to the bank erosion issue.

4.1 Conceptual Design

Following the subsurface field investigation and receipt of laboratory testing results, a conceptual sheet pile wall design was developed for the site. Multiple sheet pile wall sections were modeled using SupportIT, a design software package used to model earth pressures acting on cantilever sheet pile walls. The model utilizes subsurface soil properties combined with sheet pile wall structural strength data to determine design criteria such as minimum embedment depth requirements and anticipated bending moments. Anchor QEA consulted a steel supplier, NucorSkyline, to determine available and appropriate steel sheet pile sections for use at the site based on existing site conditions and long-term maintenance expectations. Because several segments of the wall would be exposed to saline water, the evaluations focused on available sections composed of ASTM A690 steel, which is an alloy that develops an oxidized layer that protects against erosion without supplemental coating or active corrosion protection anode systems.

Based on a review of the topographical survey, location of stormwater infrastructure, and extents of bank erosion, a preliminary alignment for the wall was determined (Figure 2). The topography of the existing slope varies significantly along the alignment; therefore, three cross sections were modeled. Table 3 provides a summary of each section of the bank that was modeled and the approximate embedment depths and horizontal extents of sheet pile wall that would be required to protect the Parcel 86 environmental cap.

Embedment elevations for each section were determined by modeling each section using NZ19 ASTM A690 Grade 50 Hot Rolled Sheet Pile. NZ19 sheet pile section was selected due to its availability and ability to be rolled using ASTM A690 steel. The data for the sheet section was provided by NucorSkyline and incorporated into the model as well as the subsurface soil profile determined by the geotechnical investigation and lab results. Embedment depths were calculated based on conservative estimates that allow contingencies for future erosion of the creek bank waterside of the wall. We have also performed the initial embedment depth calculation assuming that the full pressure of 11 feet of water (i.e., the difference between higher groundwater levels and low tide conditions) will act as a driving force on the wall. Figure 4 shows the preliminary model output of the most critical section of the wall, i.e. the area with the most significant erosion adjacent to MH7.

Table 3
Summary of Preliminary Sheet Pile Lengths along the Conceptual Wall Alignment

Evaluated Section	Approximate Length of Segment along Alignment	Preliminary Sheet Depth (bgs)	Notes about Slope Condition at Cross-Section
Section A-A′	10 feet	35–40 feet	Shoreline is not stable and significant erosion has occurred. Multiple groundwater seeps are observed and gravel base layer around and below the stormwater system provides continuous flow path. Erosion will continue until remedy is constructed.
Section B-B′	10 feet	20–25 feet	Adjacent to main bank erosion area. Shoreline appears relatively stable and is vegetated on the upper slope, but potential future erosion may be expected as the adjacent erosion area expands.
Section C-C′ and Segment Perpendicular to Creek Bank	25 feet	10–20 feet	West of observed bank erosion. Shoreline is stable and vegetated. Some groundwater seeps are observed, but they are more diffuse and erosion is naturally prevented by existing vegetation.

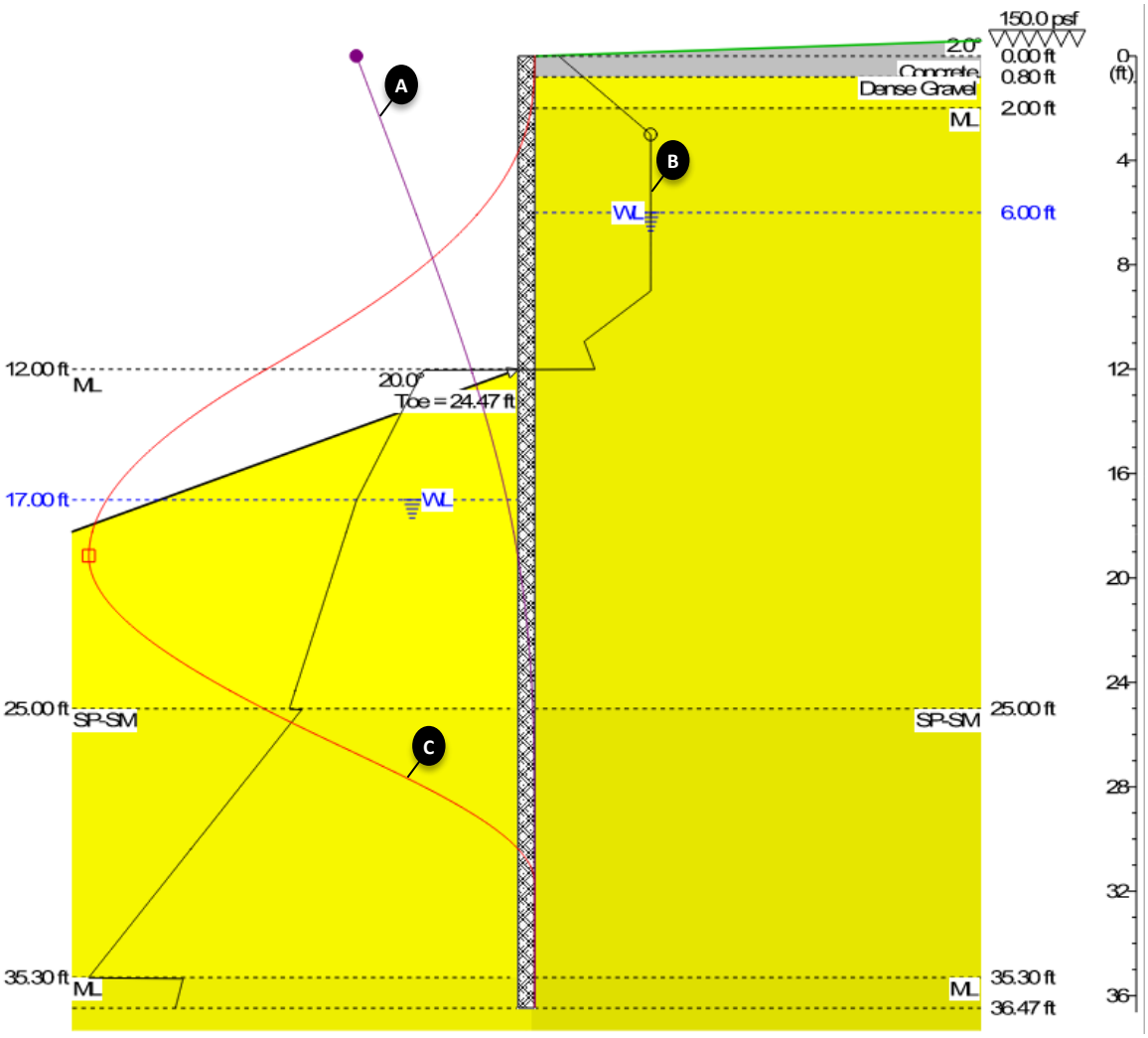
Embedment elevations for each section were determined by modeling each section using NZ19 ASTM A690 Grade 50 Hot Rolled Sheet Pile. NZ19 sheet pile section was selected due to its availability and ability to be rolled using ASTM A690 steel. The data for the sheet section was provided by NucorSkyline and incorporated into the model as well as the subsurface soil profile determined by the geotechnical investigation and lab results. Embedment depths were calculated based on conservative estimates that allow contingencies for future erosion of the creek bank waterside of the wall. We have also performed the initial embedment depth calculation assuming that the full pressure of 11 feet of water (i.e., the difference between higher groundwater levels and low tide conditions) will act as a driving force on the wall. Figure 4 shows the preliminary model output of the most critical section of the wall, i.e. the area with the most significant erosion adjacent to MH7.

The maximum deflection[2] along each cross section was estimated using the model. For Sections B-B′ and C-C′, the expected deflection was less than 1 inch; however, for Section A-A′ the initial maximum wall deflection was estimated at approximately 15 inches for a standard wall configuration. To mediate this, we worked with NucorSkyline to evaluate options. Traditional options such as tie backs were not considered feasible as they would require construction at the location of the stormwater treatment vault. The selected solution includes a box pile wall, which is simply two sheet piles welded together back to back. The installation of a box pile configuration along Section A-A′ is expected to reduce the deflection from 15 inches to an acceptable tolerance of 1 to 2 inches. Additional

[2] Deflection is generally defined as the horizontal displacement of the top of a cantilever sheet pile wall that will occur over time. Though not to scale, this is depicted on Figure 4.

structural solutions (e.g., the use of a thicker gauge sheet pile section) to mitigate the deflection along Section A-A' will be evaluated during intermediate design to confirm there are no other cost-effective options that maybe used in lieu of a box pile configuration.

Figure 4
Conceptual Design Section for Sheet Pile Wall at Section A-A'



Notes:
1. The graphic depicts the conceptual design section for a box configuration sheet pile wall segment that would be installed along Section A-A' to a depth of approximately 35 to 40 feet bgs. The section was modeled using SupportIT retaining wall design software developed by GTSoft Limited.
2. The three lines (labeled A, B, and C) represent the following model output (not to scale):
   A. The shape deflection (horizontal displacement of the sheet pile) that will occur over time.
   B. The active/driving (the right) and passive/resisting (the left) earth pressures that are exerted on the wall.
   C. The bending moment diagram.

4.2 Additional Considerations

In addition to protecting the Parcel 86 environmental cap and preventing the bank erosion from progressing, the selected solution must also not produce new areas of erosion and not cause failure of the creek bank during construction. This section addresses these concerns.

4.2.1 Potential to Cause New Areas of Erosion

Based on multiple field events to inspect the bank conditions and the recent elevation survey, we believe the primary cause of the erosion adjacent to MH7 is an unknown event[3] that caused the loss of vegetation and fine grained, low-permeability soil/sediment from the upper bank. After this material was eroded, the gravel base beneath and surrounding the stormwater system was exposed resulting in a high-permeability pathway for site groundwater to preferentially discharge to the creek. This pathway also provided a conduit for tidal waters to infiltrate the bank and erode the gravel base material. These conclusions are based on our evaluation of the long-term groundwater monitoring data that was collected as part of the Pony Facility cleanup requirements.

Based on our assessment of the bank slope (Figure 3), we do not believe that hydrodynamic forces that act on the bank during tidal exchange are a significant source of the observed erosion. The topography of the slopes west of the main erosion area (i.e., represented by Section A-A') is fairly consistent below the mean higher high water elevation and continues westward along the creek. This indicates that the creek bank is stable outside of the influence of the concentrated groundwater seep.

The installation of a sheet pile wall would prevent groundwater seepage in the areas where the gravel base is exposed on the bank. For stability, we have assumed that the wall would extend from a location as close as feasible to the railroad bridge westward to a location where the bank is well vegetated and stable (i.e., approximately at Section C-C'). Beginning the wall at the bridge will allow for the restoration of the lost upper bank vegetation and infiltration of intermittent overland flow that may currently spill into the creek from the existing swale. Groundwater that would have discharged directly to the creek would now be captured behind the wall and would flow west. Compared to the full length of the Parcel 86 shoreline, the sheet pile wall would represent a very small area and similarly a small volume of the groundwater that discharges along the bank. Therefore, it is not expected that installation of the wall would increase the erosion potential along downstream areas of the bank.

4.2.2 Potential to Cause Bank Failures During Construction

Sheet pile walls are commonly installed using vibratory and impact hammer methods. Vibratory pile driving is effective for quick installation in comparison to impact driving as the vibrations cause a

[3] It is likely that the cause of the initial loss of vegetation along the bank between the railroad and MH7 was the construction of the railroad bridge improvements and related activities. However, because there is limited documentation prior to, during and after this work, we can not conclusively state this was the initial cause.

liquefaction effect immediately adjacent to the piling, which temporarily reduces localized soil strength. In some cases, such as in dense soils or stiff silts and clays, this method could potentially cause failure of adjacent slopes. Depending on the subsurface soil conditions, the different methods and applied energy levels are used. The upper 25 feet of soils at the site consist of soft silt. With the exception of approximately 10 feet of wall alignment, it is expected that the sheet piles will terminate in this layer. Based on our experience at other sites, it is likely that very little driving force (i.e., hammer energy) will be required to install the sheet piles into this layer thus significantly reducing the potential for installation to cause bank failure. For the 10-foot segment of wall with preliminary embedment depths of 35 to 40 feet BGS, the deeper soils consist of medium dense sand and soft silt. Increased hammer energy would likely be required to drive the piles deeper; however, this could be accomplished using an impact hammer which have a lower potential to cause a strength reduction in adjacent soils. Given the potential for surficial bank soils to fail, we plan to specify the use of an impact hammer for this project.

4.2.3 Sheet Pile Installation

We have assumed that sheet piles would be installed from an on-land position. Landside access to the location of the proposed wall is limited by the railroad and the infrastructure associated with the stormwater management system. Based on our preliminary outreach to local pile installation contractors, we believe that American Crane models 9299 or 9310 will be suitable to support pile installation for this project. These cranes have the reach and load capacity to facilitate pile installation while the crane is positioned landward of the stormwater treatment vault.

5 Alternatives Comparison and Recommendation

To assist the Port in selection of a final solution to progress with final design and permitting, we have prepared a comparison matrix of the key factors to consider (Table 4). Given the desire to complete the work as soon as possible, we recommend that the Port move forward with the sheet pile wall solution. We believe this solution will provide the best long-term solution to protect the Parcel 86 environmental cap and preserve the natural state of the lower portion of the creek bank.

Table 4
Comparison of Parcel 86 Environmental Cap and Bank Protection Alternatives

Evaluation Metric	Armoring of Full Slope Extents	Retaining Wall at Upper Slope
Construction Cost[1]	$170,000 to $230,000 (includes mitigation)	$150,000 to $200,000
Permitting	Work will occur below the OWH mark and require Federal permits and reviews. Mitigation is an expected requirement.	Work will occur above the OWH mark; therefore, a streamlined permitting process is expected. Requirements for mitigation or enhancement of the existing creek bank are not expected.
Constructability	Extensive excavation of existing slope is required prior to rock filling to maintain existing bank elevations. Construction would likely need to occur from the waterside.	Upland site access is limited by loading restrictions over the existing stormwater system, but can be addressed through the use of high-capacity, long-reach crane equipment.
Potential to Affect Downstream Bank Stability	Groundwater seeps would be allowed to freely flow through the permeable layers of the erosion protection, so no additional landside driven erosion would be expected. It is possible that end-effect erosion on adjacent non-armored areas could occur from waterside hydrodynamic forces, but this would be evaluated during detailed design.	Future groundwater seeps would be eliminated by the impermeable wall. Groundwater behind the wall will flow towards the west and discharge in stable areas of the vegetated bank. Because the wall is short compared to the length of the property shoreline, no significant change in seep rate is expected. Erosion from the waterside is not expected, but would be considered in the detailed design.
Time to Implementation	Permits may require up to 12 months to obtain. Work would also be required to occur between July 15 and February 14. Therefore, it is expected that construction would not commence prior to late 2021.	Permit timeframes would be significantly less than the other alternative and in-water work windows would not apply. It is possible that construction could commence in early 2021.

Notes:
1. Costs are planning level and based on conceptual designs. They are provided only for the purpose of comparing the cost of the two proposed solutions. Costs could be higher or lower based on resolution of access issues.

6 References

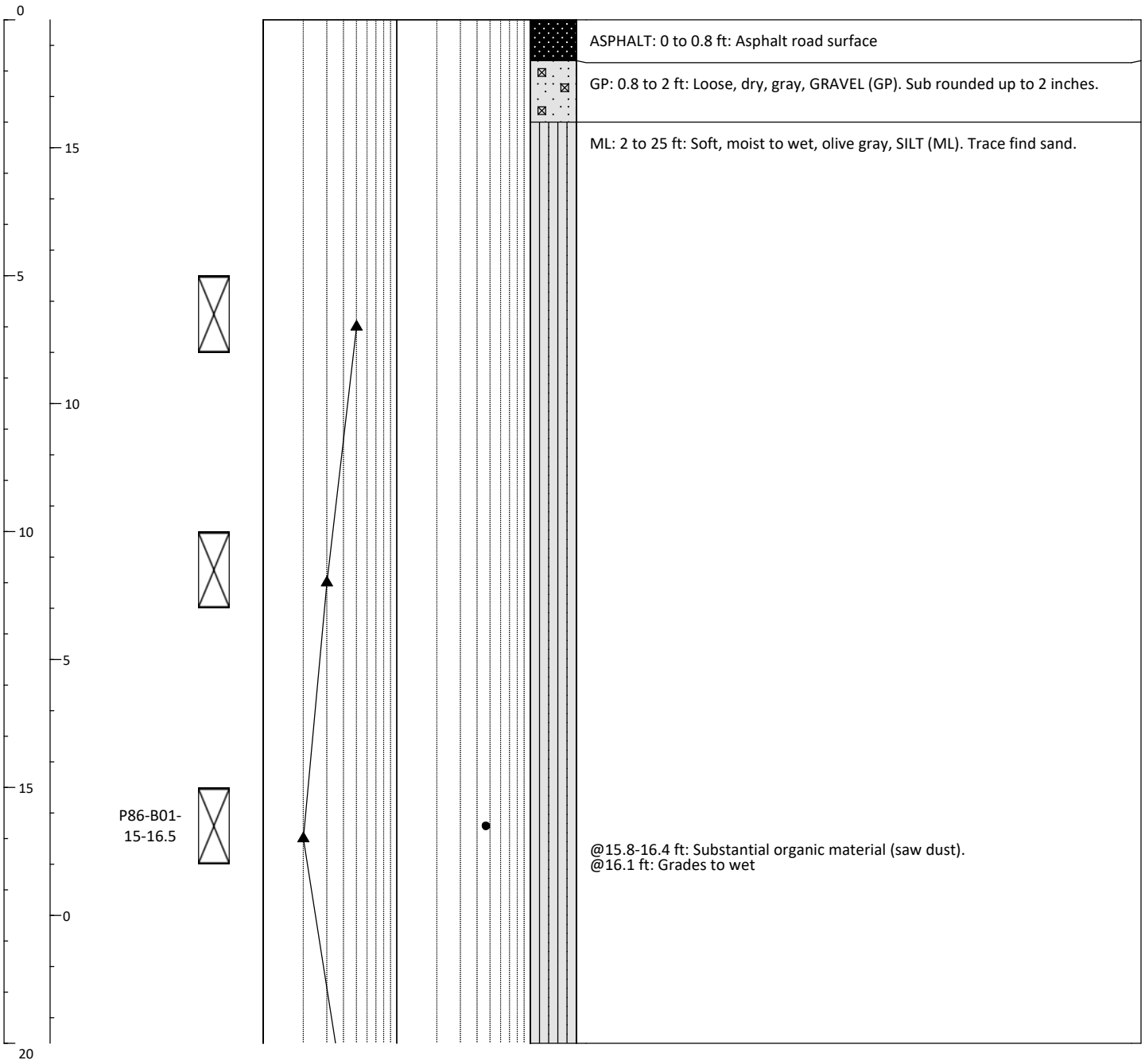
Anchor QEA, 2019. *Parcel 86 Bank Erosion Assessment.* Prepared for Port of Tacoma. December 2019.

Attachment A
Boring Log P86-B-01

Soil Boring Log

P86-B-01

Project: Parcel 86 Shoreline Repair Project	Location: Tacoma, Washington	Collection Date: 7/28/2020
Project #: 200092-01.05	N/LAT: N/A E/LONG: N/A	Total Depth (ft): 81.5
Client: Port of Tacoma	Observed GW (bgs): N/A	Hammer: 140-lb Auto Hammer
Method: Hollow Stem Auger	Elevation (ft): 17.5 ft MLLW	Hammer Efficiency: Unknown
Contractor: Holocene	Sampler(s): 1.375 ID x 1.5 OD Split Spoon	Logged By: Sam Giannakos



Soil Description

Samples and descriptions are in recovered depths.
Classification scheme: USCS

ASPHALT: 0 to 0.8 ft: Asphalt road surface

GP: 0.8 to 2 ft: Loose, dry, gray, GRAVEL (GP). Sub rounded up to 2 inches.

ML: 2 to 25 ft: Soft, moist to wet, olive gray, SILT (ML). Trace find sand.

@15.8-16.4 ft: Substantial organic material (saw dust).
@16.1 ft: Grades to wet

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206-287-3347

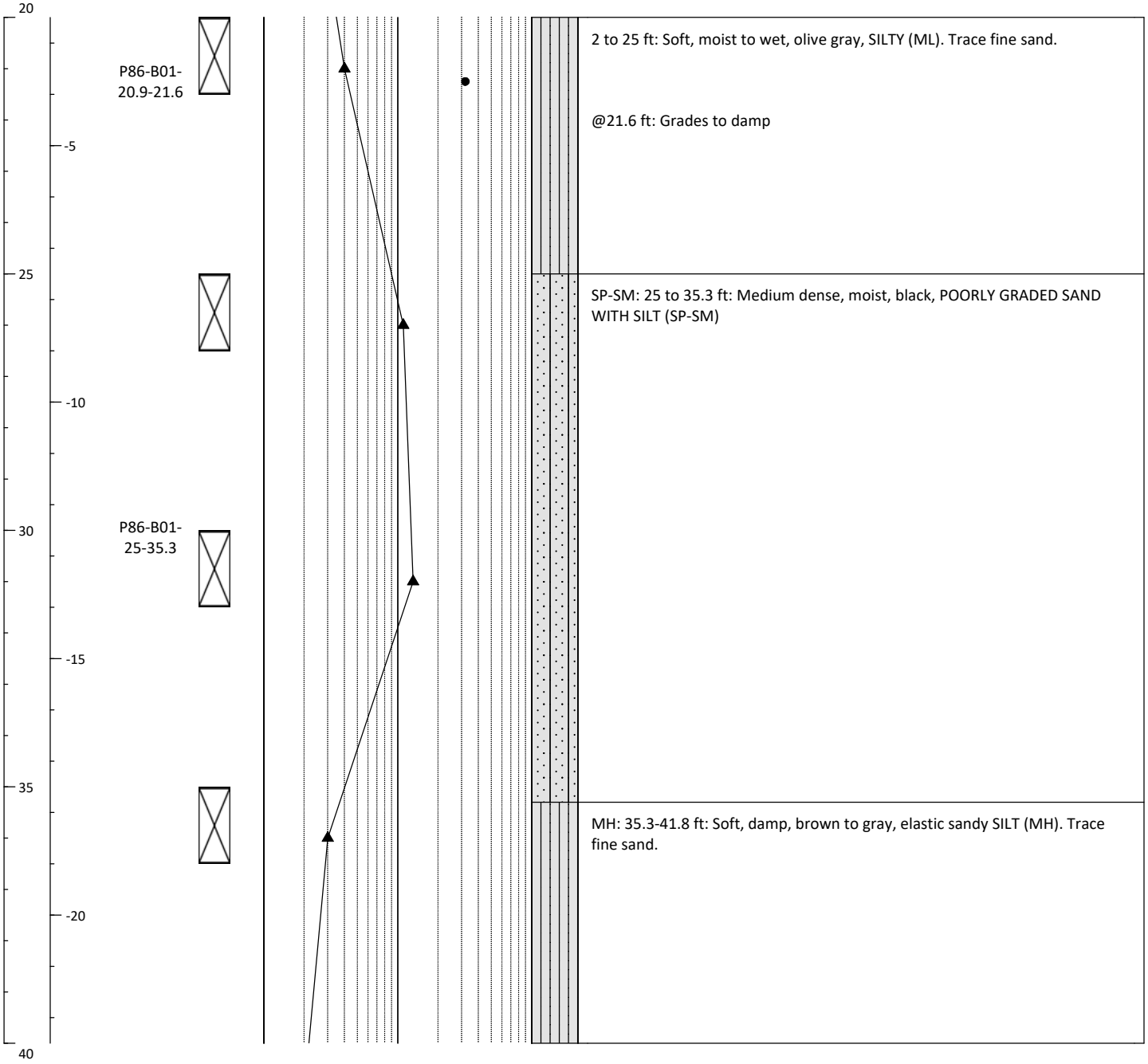
△ SPT N-Value
● Moisture Content (%)

Notes:

Soil Boring Log

P86-B-01

Project: Parcel 86 Shoreline Repair Project	Location: Tacoma, Washington	Collection Date: 7/28/2020
Project #: 200092-01.05	N/LAT: N/A E/LONG: N/A	Total Depth (ft): 81.5
Client: Port of Tacoma	Observed GW (bgs): N/A	Hammer: 140-lb Auto Hammer
Method: Hollow Stem Auger	Elevation (ft): 17.5 ft MLLW	Hammer Efficiency: Unknown
Contractor: Holocene	Sampler(s): 1.375 ID x 1.5 OD Split Spoon	Logged By: Sam Giannakos



Soil Description

Samples and descriptions are in recovered depths.
Classification scheme: USCS

2 to 25 ft: Soft, moist to wet, olive gray, SILTY (ML). Trace fine sand.

@21.6 ft: Grades to damp

SP-SM: 25 to 35.3 ft: Medium dense, moist, black, POORLY GRADED SAND WITH SILT (SP-SM)

MH: 35.3-41.8 ft: Soft, damp, brown to gray, elastic sandy SILT (MH). Trace fine sand.

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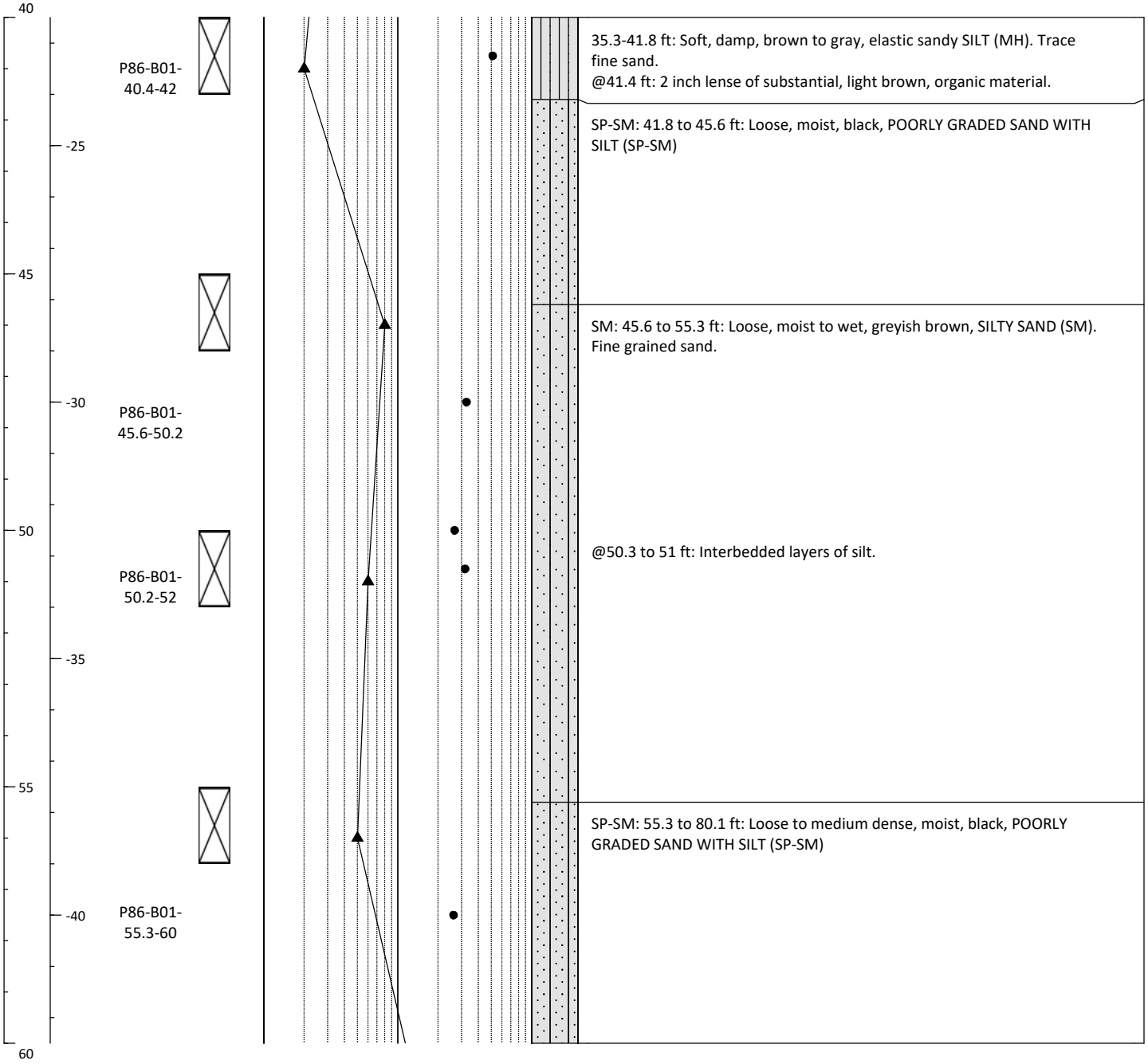
△ SPT N-Value
● Moisture Content (%)

Notes:

Soil Boring Log

P86-B-01

Project: Parcel 86 Shoreline Repair Project	Location: Tacoma, Washington	Collection Date: 7/28/2020
Project #: 200092-01.05	N/LAT: N/A E/LONG: N/A	Total Depth (ft): 81.5
Client: Port of Tacoma	Observed GW (bgs): N/A	Hammer: 140-lb Auto Hammer
Method: Hollow Stem Auger	Elevation (ft): 17.5 ft MLLW	Hammer Efficiency: Unknown
Contractor: Holocene	Sampler(s): 1.375 ID x 1.5 OD Split Spoon	Logged By: Sam Giannakos



Soil Description

Samples and descriptions are in recovered depths.
Classification scheme: USCS

35.3-41.8 ft: Soft, damp, brown to gray, elastic sandy SILT (MH). Trace fine sand.
@41.4 ft: 2 inch lense of substantial, light brown, organic material.

SP-SM: 41.8 to 45.6 ft: Loose, moist, black, POORLY GRADED SAND WITH SILT (SP-SM)

SM: 45.6 to 55.3 ft: Loose, moist to wet, greyish brown, SILTY SAND (SM). Fine grained sand.

@50.3 to 51 ft: Interbedded layers of silt.

SP-SM: 55.3 to 80.1 ft: Loose to medium dense, moist, black, POORLY GRADED SAND WITH SILT (SP-SM)

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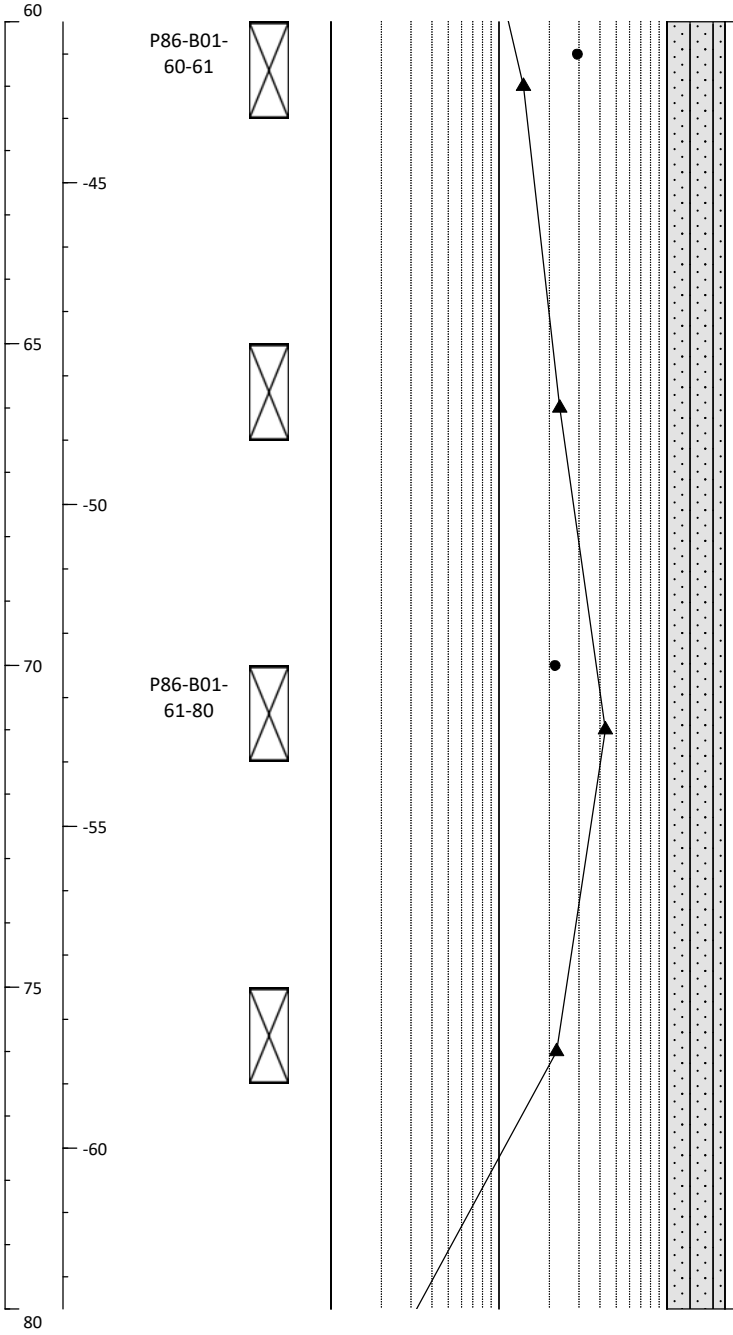
△ SPT N-Value
● Moisture Content (%)

Notes:

Soil Boring Log

P86-B-01

Project: Parcel 86 Shoreline Repair Project	Location: Tacoma, Washington	Collection Date: 7/28/2020
Project #: 200092-01.05	N/LAT: N/A E/LONG: N/A	Total Depth (ft): 81.5
Client: Port of Tacoma	Observed GW (bgs): N/A	Hammer: 140-lb Auto Hammer
Method: Hollow Stem Auger	Elevation (ft): 17.5 ft MLLW	Hammer Efficiency: Unknown
Contractor: Holocene	Sampler(s): 1.375 ID x 1.5 OD Split Spoon	Logged By: Sam Giannakos



Soil Description

Samples and descriptions are in recovered depths.
Classification scheme: USCS

55.3 to 80.1 ft: Loose to medium dense, moist, black, POORLY GRADED SAND WITH SILT (SP-SM) @60 ft: Lense of silt.

@61.5 ft: Grades to medium dense.

@71 ft: Grades to dense.

@76 ft: Grades to medium dense.

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△ SPT N-Value
● Moisture Content (%)

Notes:

Soil Boring Log

P86-B-01

Project: Parcel 86 Shoreline Repair Project	Location: Tacoma, Washington	Collection Date: 7/28/2020
Project #: 200092-01.05	N/LAT: N/A E/LONG: N/A	Total Depth (ft): 81.5
Client: Port of Tacoma	Observed GW (bgs): N/A	Hammer: 140-lb Auto Hammer
Method: Hollow Stem Auger	Elevation (ft): 17.5 ft MLLW	Hammer Efficiency: Unknown
Contractor: Holocene	Sampler(s): 1.375 ID x 1.5 OD Split Spoon	Logged By: Sam Giannakos

Depth (ft)	Elevation (ft MLLW)	Samples	Values Less than 1	Uncorrected Standard Penetration Resistance (blows per foot) and Moisture Content (%) 1 2 5 10 20 50 100	Lithology	Soil Description
80		P86-B01-80.1-82				ML: @80.1 ft: Grades to very soft, damp, grey, SILT (ML)
	-65					
85						
	-70					
90						
	-75					
95						
	-80					
100						

Soil Description

Samples and descriptions are in recovered depths.
Classification scheme: USCS

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△ SPT N-Value
● Moisture Content (%)

Notes:

Attachment B
Geotechnical Lab Report

Materials Testing & Consulting, Inc.

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Client:	Anchor QEA, LLC	**Date:**	August 10, 2020
Address:	1201 3rd Ave, Suite 2600	**Project:**	Parcel 86 Shoreline Repair
	Seattle, WA 98101	**Project #:**	20S051-02
Attn:	Nik Bacher	**Sample #:**	Multiple

As requested MTC, Inc. has performed the following test(s) on the sample referenced above. The testing was performed in accordance with current applicable AASHTO or ASTM standards as indicated below. The results obtained in our laboratory were as follows below or on the attached pages:

	Test(s) Performed:	Test Results		Test(s) Performed:	Test Results
X	Sieve Analysis	See Attached		Sulfate Soundness	
	Proctor			Bulk Density & Voids	
	Sand Equivalent			WSDOT Degradation	
	Direct Shear	See Attached		CEC	
X	Moisture Content			Organic Content	
	Specific Gravity, Coarse		X	Specific Gravity, Soils	See Attached
	Specific Gravity, Fine				
X	Hydrometer Analysis	See Attached			
X	Atterberg Limits	See Attached			
	Hydraulic Conductivity				
	Consolidation				

If you have any questions concerning the test results, the procedures used, or if we can be of any further assistance please call on us at the number below.

Respectfully Submitted,

Beth Goble
Senior Laboratory Technician

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: Parcel 86 Shoreline Repair
Project #: 20S051-02
Date Received: July 30, 2020
Date Tested: July 30, 2020

Client: Anchor, QEA, LLC
Sampled by: Others
Tested by: B. Goble

Moisture Content - ASTM D2216

Sample #	Location	Tare	Wet + Tare	Dry + Tare	Wgt. Of Moisture	Wgt. Of Soil	% Moisture
S20-0432	P86-B01-15-16.5	10.0	83.2	59.9	23.2	49.9	46.5%
S20-0433	P86-B01-20.9-21.6	10.6	139.5	108.3	31.2	97.7	32.0%
S20-0434	P86-B01-25-35.3	10.5	252.3	201.5	50.8	191.0	26.6%
S20-0435	P86-B01-40.4-42	10.3	82.8	58.3	24.5	48.0	51.1%
S20-0436	P86-B01-45.6-50.2	10.2	131.4	101.7	29.8	91.4	32.6%
S20-0437	P86-B01-50.2-52	10.1	68.4	54.3	14.1	44.2	31.8%
S20-0438	P86-B01-55.3-60	9.9	228.1	182.9	45.2	173.0	26.1%
S20-0439	P86-B01-60-61	10.8	72.2	58.3	13.9	47.5	29.3%
S20-0440	P86-B01-61-80	10.2	194.6	161.8	32.8	151.6	21.6%
S20-0441	P86-B01-80.1-82	10.4	231.8	168.2	63.6	157.8	40.3%

Reviewed by: EGabriel Goble

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Sieve Report

Project: Parcel 86 Shoreline Repair
Project #: 20S051-02
Client: Anchor QEA, LLC
Source: P86-B01-25-35.3
Sample#: S20-0434

Date Received: 30-Jul-20
Sampled By: Others
Date Tested: 6-Aug-20
Tested By: B. Goble

ASTM D-2487 Unified Soils Classification System
SP-SM, Poorly graded Sand with Silt
Sample Color:
Brown

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

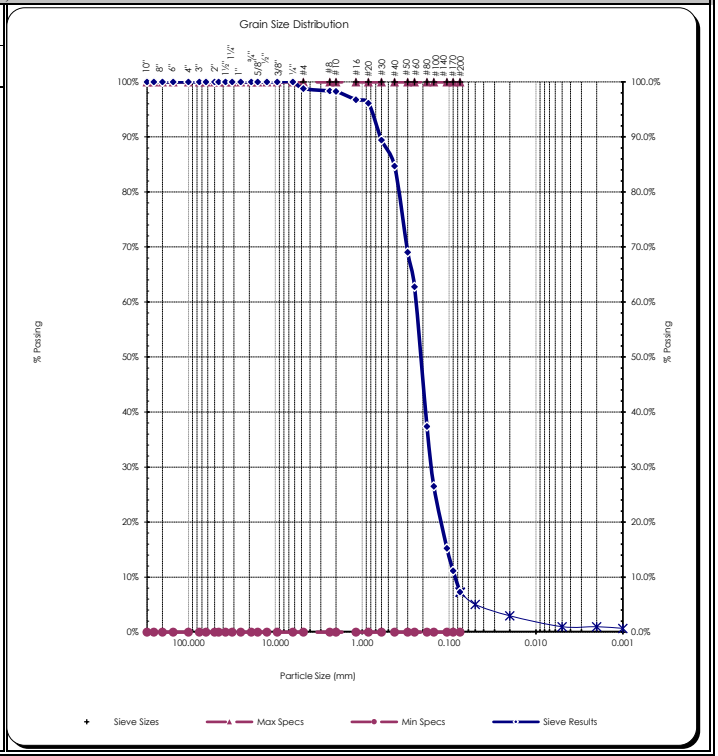
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ =	0.051	mm	% Gravel =	1.2%	Coeff. of Curvature, C_C = 1.23
$D_{(10)}$ =	0.086	mm	% Sand =	91.5%	Coeff. of Uniformity, C_U = 2.83
$D_{(15)}$ =	0.105	mm	% Silt & Clay =	7.3%	Fineness Modulus = 1.21
$D_{(30)}$ =	0.160	mm	Liquid Limit =	n/a	Plastic Limit = n/a
$D_{(50)}$ =	0.215	mm	Plasticity Index =	n/a	Moisture %, as sampled = 26.6%
$D_{(60)}$ =	0.242	mm	Sand Equivalent =	n/a	Req'd Sand Equivalent =
$D_{(90)}$ =	0.622	mm	Fracture %, 1 Face =	n/a	Req'd Fracture %, 1 Face =
Dust Ratio =	5/58		Fracture %, 2+ Faces =	n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50		100%	100.0%	0.0%
3/8"	9.50		100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		98%	100.0%	0.0%
#10	2.00	98%	98%	100.0%	0.0%
#16	1.18		97%	100.0%	0.0%
#20	0.850	96%	96%	100.0%	0.0%
#30	0.600		89%	100.0%	0.0%
#40	0.425	85%	85%	100.0%	0.0%
#50	0.300		69%	100.0%	0.0%
#60	0.250	63%	63%	100.0%	0.0%
#80	0.180		37%	100.0%	0.0%
#100	0.150	27%	27%	100.0%	0.0%
#140	0.106		15%	100.0%	0.0%
#170	0.090		11%	100.0%	0.0%
#200	0.075	7.3%	7.3%	100.0%	0.0%



Comments: _____

Reviewed by: EJ Goble

Materials Testing & Consulting, Inc.

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Hydrometer Report

Project:	Parcel 86 Shoreline Repair	**Date Received:**	30-Jul-20
Project #:	20S051-02	**Sampled By:**	Others
Client :	Anchor QEA, LLC	**Date Tested:**	6-Aug-20
Source:	P86-B01-25-35.3	**Tested By:**	B. Goble
Sample#:	S20-0434		

ASTM D 2487 Soils Classification
SP-SM, Poorly graded Sand with Silt
Sample Color
Brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	115.72	grams
Hydroscopic Moist.:	16.50%	
Adj. Sample Wgt :	99.33	grams

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	4	4.0%	0.0381 mm
5	3	3.0%	0.0243 mm
15	3	3.0%	0.0140 mm
30	2	2.0%	0.0100 mm
60	1	1.0%	0.0071 mm
250	1	1.0%	0.0035 mm
1440	1	1.0%	0.0014 mm

% Gravel:	1.2%	**Liquid Limit:**	n/a
% Sand:	91.5%	**Plastic Limit:**	n/a
% Silt:	6.3%	**Plasticity Index:**	n/a
% Clay:	1.0%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	99%	4.750 mm
#10	98%	2.000 mm
#20	96%	0.850 mm
#40	85%	0.425 mm
#100	27%	0.150 mm
#200	7.3%	0.075 mm
Silts	7.2%	0.074 mm
	5.0%	0.050 mm
	3.0%	0.020 mm
Clays	1.0%	0.005 mm
	1.0%	0.002 mm
Colloids	0.7%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification

Comments: _____

Reviewed by: EJ Goble

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Sieve Report

Project: Parcel 86 Shoreline Repair
Project #: 20S051-02
Client: Anchor QEA, LLC
Source: P86-B01-50.2-52
Sample#: S20-0437

Date Received: 30-Jul-20
Sampled By: Others
Date Tested: 6-Aug-20
Tested By: B. Goble

ASTM D-2487 Unified Soils Classification System
N/A
Sample Color:
Brown

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

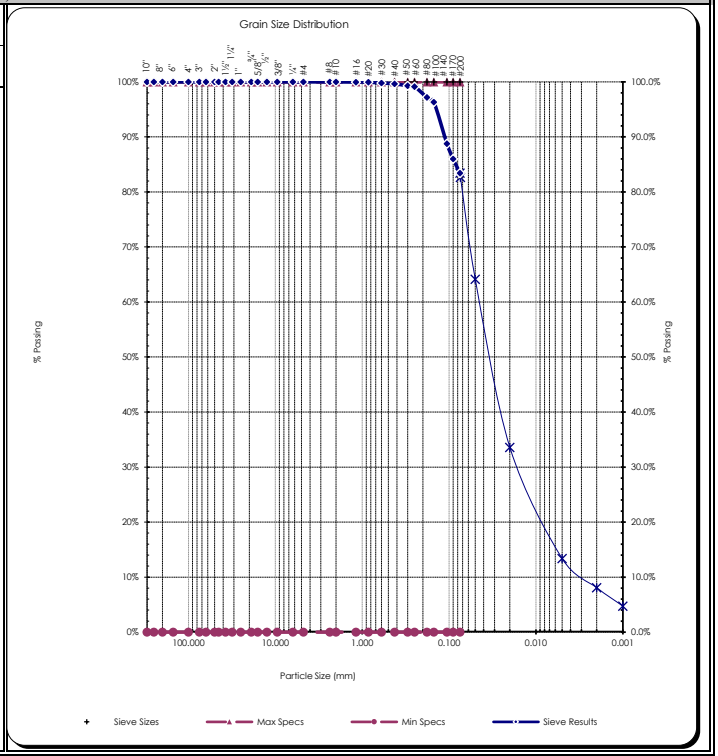
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ =	0.004	mm	% Gravel =	0.0%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ =	0.009	mm	% Sand =	16.6%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ =	0.013	mm	% Silt & Clay =	83.4%	Fineness Modulus = 0.05
$D_{(30)}$ =	0.027	mm	Liquid Limit =	n/a	Plastic Limit = n/a
$D_{(50)}$ =	0.045	mm	Plasticity Index =	n/a	Moisture %, as sampled = 31.8%
$D_{(60)}$ =	0.054	mm	Sand Equivalent =	n/a	Req'd Sand Equivalent =
$D_{(90)}$ =	0.113	mm	Fracture %, 1 Face =	n/a	Req'd Fracture %, 1 Face =
Dust Ratio =	77/92		Fracture %, 2+ Faces =	n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50		100%	100.0%	0.0%
3/8"	9.50		100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		100%	100.0%	0.0%
#10	2.00	100%	100%	100.0%	0.0%
#16	1.18		100%	100.0%	0.0%
#20	0.850	100%	100%	100.0%	0.0%
#30	0.600		100%	100.0%	0.0%
#40	0.425	100%	100%	100.0%	0.0%
#50	0.300		99%	100.0%	0.0%
#60	0.250	99%	99%	100.0%	0.0%
#80	0.180		97%	100.0%	0.0%
#100	0.150	96%	96%	100.0%	0.0%
#140	0.106		89%	100.0%	0.0%
#170	0.090		86%	100.0%	0.0%
#200	0.075	83.4%	83.4%	100.0%	0.0%



Comments: _____

Reviewed by: _____

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Hydrometer Report

Project:	Parcel 86 Shoreline Repair	**Date Received:**	30-Jul-20
Project #:	20S051-02	**Sampled By:**	Others
Client :	Anchor QEA, LLC	**Date Tested:**	6-Aug-20
Source:	P86-B01-50.2-52	**Tested By:**	B. Goble
Sample#:	S20-0437		

ASTM D 2487 Soils Classification
N/A
Sample Color
Brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	55.53	grams
Hydroscopic Moist.:	25.30%	
Adj. Sample Wgt :	44.32	grams

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	23	51.9%	0.0341 mm
5	16	36.1%	0.0226 mm
15	12	27.1%	0.0133 mm
30	11	24.8%	0.0095 mm
60	7	15.8%	0.0069 mm
250	5	11.3%	0.0034 mm
1440	3	6.8%	0.0014 mm

% Gravel:	0.0%	**Liquid Limit:**	n/a
% Sand:	16.6%	**Plastic Limit:**	n/a
% Silt:	70.1%	**Plasticity Index:**	n/a
% Clay:	13.4%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	100%	2.000 mm
#20	100%	0.850 mm
#40	100%	0.425 mm
#100	96%	0.150 mm
#200	83.4%	0.075 mm
Silts	82.6%	0.074 mm
	64.1%	0.050 mm
	33.6%	0.020 mm
Clays	13.4%	0.005 mm
	8.1%	0.002 mm
Colloids	4.7%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification

Comments: _____

Reviewed by: EJ Gabe Goble

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Sieve Report

Project: Parcel 86 Shoreline Repair
Project #: 20S051-02
Client: Anchor QEA, LLC
Source: P86-B01-61-80
Sample#: S20-0440

Date Received: 30-Jul-20
Sampled By: Others
Date Tested: 6-Aug-20
Tested By: B. Goble

ASTM D-2487 Unified Soils Classification System
SP-SM, Poorly graded Sand with Silt
Sample Color:
Brown

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

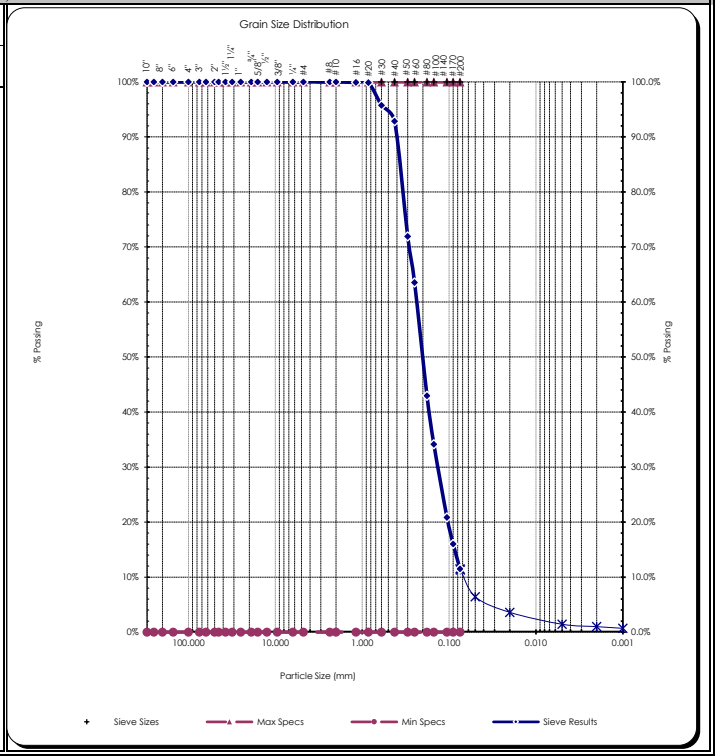
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ =	0.033	mm	% Gravel =	0.0%	Coeff. of Curvature, C_C = 1.20
$D_{(10)}$ =	0.065	mm	% Sand =	88.5%	Coeff. of Uniformity, C_U = 3.65
$D_{(15)}$ =	0.087	mm	% Silt & Clay =	11.5%	Fineness Modulus = 0.98
$D_{(30)}$ =	0.136	mm	Liquid Limit =	n/a	Plastic Limit = n/a
$D_{(50)}$ =	0.204	mm	Plasticity Index =	n/a	Moisture %, as sampled = 21.6%
$D_{(60)}$ =	0.238	mm	Sand Equivalent =	n/a	Req'd Sand Equivalent =
$D_{(90)}$ =	0.408	mm	Fracture %, 1 Face =	n/a	Req'd Fracture %, 1 Face =
Dust Ratio =	1/8		Fracture %, 2+ Faces =	n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50		100%	100.0%	0.0%
3/8"	9.50		100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		100%	100.0%	0.0%
#10	2.00	100%	100%	100.0%	0.0%
#16	1.18		100%	100.0%	0.0%
#20	0.850	100%	100%	100.0%	0.0%
#30	0.600		96%	100.0%	0.0%
#40	0.425	93%	93%	100.0%	0.0%
#50	0.300		72%	100.0%	0.0%
#60	0.250	64%	64%	100.0%	0.0%
#80	0.180		43%	100.0%	0.0%
#100	0.150	34%	34%	100.0%	0.0%
#140	0.106		21%	100.0%	0.0%
#170	0.090		16%	100.0%	0.0%
#200	0.075	11.5%	11.5%	100.0%	0.0%



Comments: _____

Reviewed by: EJohn Goble

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Hydrometer Report

Project:	Parcel 86 Shoreline Repair	**Date Received:**	30-Jul-20
Project #:	20S051-02	**Sampled By:**	Others
Client :	Anchor QEA, LLC	**Date Tested:**	6-Aug-20
Source:	P86-B01-61-80	**Tested By:**	B. Goble
Sample#:	S20-0440		

ASTM D 2487 Soils Classification
SP-SM, Poorly graded Sand with Silt
Sample Color
Brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	115.28	grams
Hydroscopic Moist.:	15.30%	
Adj. Sample Wgt :	99.98	grams

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	4	4.0%	0.0381 mm
5	4	4.0%	0.0241 mm
15	3	3.0%	0.0140 mm
30	3	3.0%	0.0099 mm
60	2	2.0%	0.0070 mm
250	1	1.0%	0.0035 mm
1440	1	1.0%	0.0014 mm

% Gravel:	0.0%	**Liquid Limit:**	n/a
% Sand:	88.5%	**Plastic Limit:**	n/a
% Silt:	10.1%	**Plasticity Index:**	n/a
% Clay:	1.4%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	100%	2.000 mm
#20	100%	0.850 mm
#40	93%	0.425 mm
#100	34%	0.150 mm
#200	11.5%	0.075 mm
Silts	11.3%	0.074 mm
	6.4%	0.050 mm
	3.6%	0.020 mm
Clays	1.4%	0.005 mm
	1.0%	0.002 mm
Colloids	0.7%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification

Comments: _____

Reviewed by: EJ Goble

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ASTM D4318 - Liquid Limit, Plastic Limit and Plasticity Index of Soils

Project:	Parcel 86 Shoreline Repair	**Date Received:**	30-Jul-20
Project #:	20S051-02	**Sampled By:**	Others
Client:	Anchor QEA, LLC	**Date Tested:**	6-Aug-20
Source:	P86-B01-20.9-21.6	**Tested By:**	B. Goble
Sample #:	S20-0433		

Unified Soils Classification System, ASTM D-2487
No Data Provided
Sample Color
Brown

Liquid Limit Determination

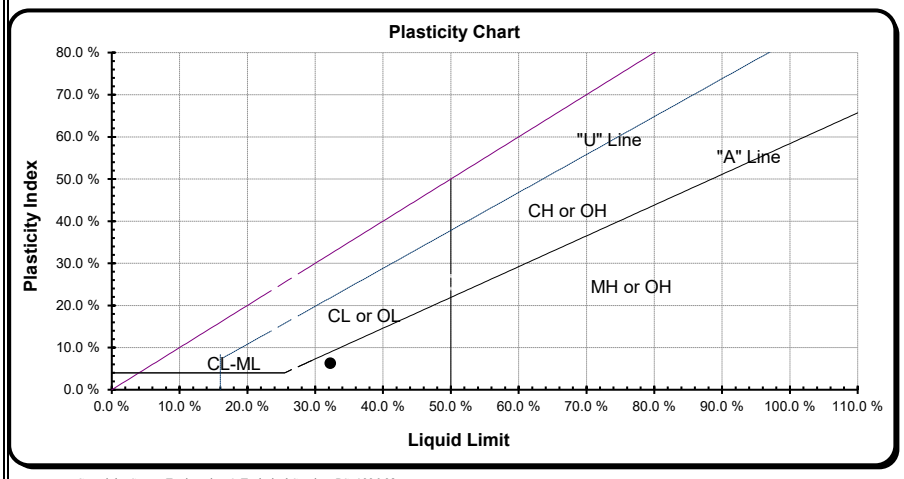
	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	11.12	12.71	12.62			
Weight of Dry Soils + Pan:	8.82	10.02	9.89			
Weight of Pan:	1.56	1.56	1.58			
Weight of Dry Soils:	7.26	8.46	8.31			
Weight of Moisture:	2.30	2.69	2.73			
% Moisture:	31.7 %	31.8 %	32.9 %			
Number of Blows:	31	26	21			

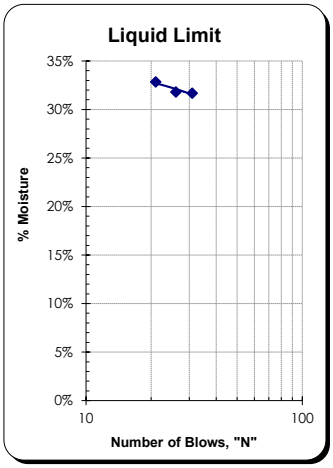
Liquid Limit @ 25 Blows: 32.2 %
Plastic Limit: 25.9 %
Plasticity Index, I_P: 6.3 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	9.56	8.28				
Weight of Dry Soils + Pan:	7.91	6.90				
Weight of Pan:	1.57	1.56				
Weight of Dry Soils:	6.34	5.34				
Weight of Moisture:	1.65	1.38				
% Moisture:	26.0 %	25.8 %				

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04





Comments: _____

Reviewed by: _____

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ASTM D4318 - Liquid Limit, Plastic Limit and Plasticity Index of Soils

Project:	Parcel 86 Shoreline Repair	**Date Received:**	30-Jul-20
Project #:	20S051-02	**Sampled By:**	Others
Client:	Anchor QEA, LLC	**Date Tested:**	6-Aug-20
Source:	P86-B01-40.4-42	**Tested By:**	B. Goble
Sample #:	S20-0435		

Unified Soils Classification System, ASTM D-2487
No Data Provided
Sample Color
Brown

Liquid Limit Determination

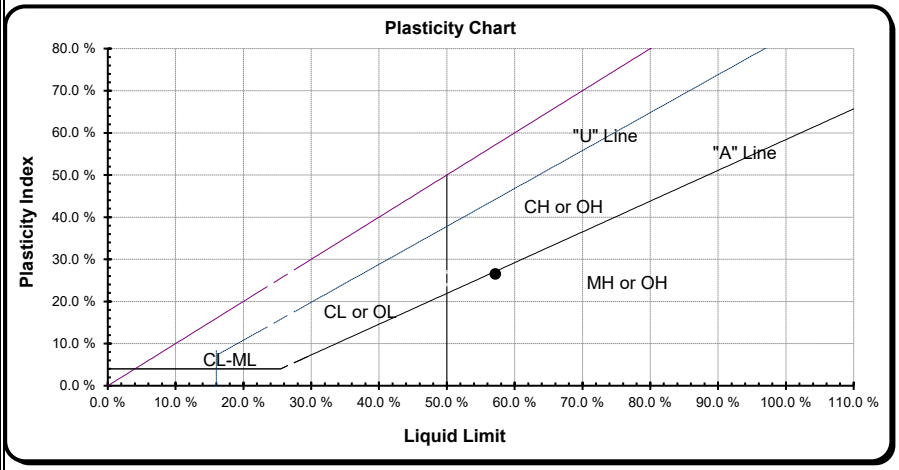
	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	9.56	9.68	9.42			
Weight of Dry Soils + Pan:	6.69	6.75	6.55			
Weight of Pan:	1.56	1.57	1.57			
Weight of Dry Soils:	5.13	5.18	4.98			
Weight of Moisture:	2.87	2.93	2.87			
% Moisture:	56.0 %	56.6 %	57.6 %			
Number of Blows:	33	27	23			

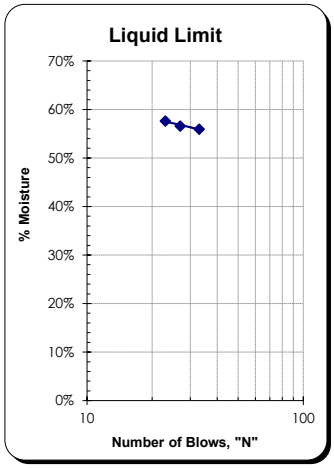
Liquid Limit @ 25 Blows: 57.1 %
Plastic Limit: 30.6 %
Plasticity Index, I_P: 26.5 %

Plastic Limit Determination

	#1	#2	#3	#4	#5	#6
Weight of Wet Soils + Pan:	9.97	10.95				
Weight of Dry Soils + Pan:	8.00	8.75				
Weight of Pan:	1.56	1.57				
Weight of Dry Soils:	6.44	7.18				
Weight of Moisture:	1.97	2.20				
% Moisture:	30.6 %	30.6 %				

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04





Comments: _____

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Project: Parcel 86 Shoreline Repair
Project #: 20S051-02
Date Received: April 3, 2019
Date Tested: May 9, 2019

Client: Anchor QEA, LLC
Sampled by: Others
Tested by: B. Goble

Specific Gravity - ASTM D854

Sample #	Source	Specific Gravity
S20-0432	P86-B01-15-16.5	2.63
S20-0436	P86-B01-45.6-50.2	2.67
S20-0439	P86-B01-60-61	2.67

Reviewed by: EGabriel Goble

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