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Subsurface Exploration, Geologic Hazard, and Preliminary Geotechnical Engineering Report

WESTERN BOAT YARD EXPANSION

Port of Port Townsend, Washington

Prepared For:

REID MIDDLETON, INC.

Project No. 20240066E001
May 23, 2024

Associated Earth Sciences, Inc.

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Kirkland | Mount Vernon | Tacoma

May 23, 2024
Project No. 20240066E001

Reid Middleton, Inc.
728 134th Street SW, Suite 200
Everett, Washington 98204

Attention: Shannon Kinsella, P.E., PMP

Subject: Subsurface Exploration, Geologic Hazard,
and Preliminary Geotechnical Engineering Report
Western Boat Yard Expansion
Port of Port Townsend, Washington

Dear Shannon Kinsella:

We are pleased to present our preliminary geotechnical engineering report for the proposed Western Boat Yard Expansion project at the Port of Port Townsend, Washington. This report summarizes the results of our subsurface exploration, geologic hazard, and geotechnical engineering studies, and offers preliminary design recommendations based on our present understanding of the project. Once project plans are fully developed, we should review the plans and confirm or update the recommendations in this report.

We have enjoyed working with you on this study and are confident that the recommendations presented in this report will aid in the successful completion of your project. If you should have any questions or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

G. Bradford Drew, P.E.
Associate Engineer

BD/ld – 20240066E001-002

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Port of Port Townsend, Washington

Prepared for:
Reid Middleton, Inc.
728 134th Street SW, Suite 200
Everett, Washington 98204

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I. PROJECT AND SITE CONDITIONS

1.0 INTRODUCTION

This report presents the results of Associated Earth Sciences, Inc.'s (AESI's) subsurface exploration, geologic hazard, and geotechnical engineering study for the proposed Western Boat Yard Expansion project at the Port of Port Townsend (Port), Washington. Our understanding of the project is based on our correspondence with Reid Middleton, Inc., and our review of a conceptual plan set (Sheets C1.0 through C1.3), dated April 15, 2024.

The site location is shown on the "Vicinity Map," Figure 1. The approximate locations of the explorations completed for this study are shown on the "Existing Site and Exploration Plan," Figure 2, and the "Proposed Improvements and Exploration Locations," Figure 3. The regional geologic mapping of the project site and vicinity is shown on Figure 4. Copies of the exploration logs are included in Appendix A, laboratory test results are included in Appendix B, and the liquefaction analysis results are included in Appendix C.

1.1 Purpose and Scope

The purpose of this study was to provide subsurface data to be used in the design and development of the subject project. Our study included reviewing available geologic literature, completing five exploration borings across the proposed boat yard expansion area, and performing geologic studies to assess the type, thickness, distribution, and physical properties of the subsurface sediments and groundwater conditions. Geotechnical engineering studies were completed to assess geologic hazards at the site and to formulate geotechnical recommendations for site preparation, earthwork and site grading, temporary cut slopes, structural fill, and gravel lot surfacing. This report summarizes our fieldwork and offers preliminary recommendations based on our present understanding of the project. We recommend that we be allowed to review the recommendations presented in this report and revise them, if needed, when the project design has been finalized.

1.2 Authorization

Authorization to proceed with this study was granted to AESI by Reid Middleton, Inc. via email on April 12, 2024. Our study was accomplished in general accordance with our scope of work and cost proposal dated April 12, 2024. This report has been prepared for the exclusive use of Reid Middleton, Inc. and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering and engineering geology practices in effect in this area at the time our report was prepared. No other warranty, express or implied, is made.

2.0 PROJECT AND SITE DESCRIPTION

The project site is located along the western extent of the Port's existing boat yard in Port Townsend, Washington, as shown on the "Vicinity Map," Figure 1. The project area is bordered to the east by the existing boat yard and marina, to the south by Port Townsend Bay, and to the northwest by a steep slope that ascends to West Sims Way. The existing boat yard provides both covered and outdoor workspace for vessels of varying sizes. Vessels are transferred from the water to the workspace by mobile boat lifts with lifting capacities ranging from 75 to 300 tons. The proposed project area is located southwest of the existing boat yard and primarily consists of densely vegetated land with the Port's maintenance shop, gravel parking, and covered storage area located at the southwest corner of the site.

The project area is relatively flat to gently sloping towards Port Townsend Bay with an overall vertical relief of less than 5 feet. The central portion of the project area is undeveloped and densely vegetated with tall grasses, shrubs, blackberry bushes, deciduous trees, evergreen trees, and other ground cover. This area is relatively flat but small drainage ditches, swales, and berms have created a slightly undulating surface throughout the site. An existing 18-inch culvert is located at the northern extent of the project area that outfalls collected stormwater to a treatment swale.

A steep slope borders the project boundary to the northwest. This slope ascends to West Sims Way and has an overall height of about 20 feet at the eastern extent (adjacent to the existing boat yard) and ranges up to approximately 80 feet in height at the western extent of the project area. Slope inclinations range from approximately 60 to 85 percent. Existing site features and Light Detection and Ranging (LIDAR)-based topographic contours are shown on Figure 2.

We understand the Port is planning to expand the existing boat yard to the southwest and the expanded area may cover roughly 6 acres. Existing ground surface elevations within the proposed expansion area generally range from 8 to 10 feet with isolated topographic lows and highs near elevation 7 feet and 12 feet, respectively. The conceptual grading plan indicates that proposed site grades will generally be raised by 2 to 4 feet across most of the project area and fills up to 7 feet in height will be required in isolated low-lying areas. The project also includes new stormwater treatment swales, potentially relocating the Larry Scott Memorial Trail to follow the northern project boundary, and the installation/replacement of water and sewer lines. The project may also relocate the Port's maintenance shop, but current plans indicate the shop is to remain in its existing location. The proposed site features are shown on Figure 3.

3.0 SITE AND SUBSURFACE EXPLORATION

Our field explorations for this study were completed on April 15, 2024, and included advancing five exploration borings (EB-1 through EB-5) to define the general soil and shallow groundwater conditions below the area of proposed improvements. The exploration locations are shown on the "Existing Site and Exploration Plan," Figure 2, and the "Proposed Improvements and Exploration Locations," Figure 3. The locations of our field explorations were approximated by measurements from known site features. The various types of materials, as well as the depths where characteristics of the materials changed, are indicated on the exploration logs presented in Appendix A. The depths indicated on the logs where conditions changed may represent gradational variations between material types in the field.

The conclusions and recommendations presented in this report are based, in part, on our site reconnaissance and the exploration borings completed for this study. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, interpolation of subsurface conditions between field explorations is necessary. It should be noted that subsurface conditions differing from those depicted on the logs may be present at the site due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of variations between the field explorations may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

3.1 Exploration Borings

The exploration borings were completed by Advance Drill Technologies, Inc., an independent driller working under subcontract to AESI, by advancing a 6-inch outside-diameter, hollow-stem auger with a track-mounted drill rig. During the drilling process, samples were generally obtained at 2½- to 5-foot-depth intervals. As the borehole advanced below the water table, the driller added water within the hollow-stem auger to help maintain borehole stability. After drilling, each borehole was backfilled with bentonite grout in combination with bentonite chips and the surface was patched with native material.

Disturbed but representative samples were obtained by using the Standard Penetration Test (SPT) procedure in accordance with *ASTM International* (ASTM) D-1586. This test and sampling method consists of driving a standard 2-inch, outside-diameter, split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded, and the number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance ("N") or blow count. If a total of 50 is recorded within one 6-inch interval, the blow count is recorded as the number of blows for the corresponding number of inches of penetration. The resistance, or

N-value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils; these values are plotted on the attached exploration boring logs.

The borings were continuously observed and logged by a geologist from our firm. The samples obtained from the split-barrel sampler were classified in the field and representative portions placed in watertight containers. The samples were then transported to our laboratory for further visual classification and laboratory testing. The exploration logs presented in Appendix A are based on the N-values, field observations, and drilling action.

4.0 SUBSURFACE CONDITIONS

Subsurface conditions at the project site were inferred from the field explorations accomplished for this study, our visual reconnaissance of the site, and review of selected geologic literature. Detailed descriptions of the materials encountered in the explorations are provided on the exploration logs in Appendix A and the regional geologic mapping of the project site and vicinity is shown on Figure 4. Our explorations generally encountered a layer of existing fill overlying natural beach (Holocene) sediments and pre-Fraser undifferentiated sediments at depth. The following section presents more detailed subsurface information organized from the shallowest (youngest) to the deepest (oldest) sediment types.

4.1 Stratigraphy

Sod/Topsoil

A surficial layer of sod and organic topsoil was encountered directly below the ground surface in EB-1, EB-3, and EB-4. The thickness of the organic topsoil horizon ranged from approximately 2 to 4 inches. Organic topsoil can be expected in the undeveloped areas onsite and this horizon may be thicker at unexplored areas. The topsoil is not suitable for use as structural fill and should be removed prior to construction in these areas.

Crushed Rock Aggregate (Gravel Lot Surfacing)

In explorations EB-2 and EB-5, we encountered crushed rock aggregate that serves as the gravel surfacing for vehicle parking and vessel storage. The crushed rock layer was approximately 4 inches thick in EB-2 and 6 inches thick in EB-5.

Fill

Directly below the sod and topsoil in EB-1, EB-3, and EB-4, and directly below the gravel lot surfacing in EB-2 and EB-5, we encountered existing fill soils (those not naturally deposited). The existing fill soils were variable in density and composition and extended to depths of about

3 to 9.5 feet below existing site grades. The existing fill was generally in a loose to medium dense condition and the moisture content typically increased with depth from slightly moist to wet near the water table. The existing fill ranged from brown sand with some silt and gravel with scattered organics, to dark brown and black, silty sand with scattered to abundant organic debris (roots, rootlets, wood fragments, and fine organics), to gray gravel with some sand and trace silt. Within EB-4, we observed a strong septic odor from samples obtained at depths of about 5 to 9 feet.

Holocene Beach Deposits

Directly below the fill at all exploration locations, we encountered loose to medium dense sand with trace to some silt and variable amounts of shell fragments. We interpret these sediments to be representative of Holocene beach deposits. These sediments were deposited in an intertidal environment during the Holocene epoch. The sediments extended to depths of 19 feet, 18 feet, and 15 feet within EB-1, EB-3, and EB-4, respectively, and beyond the maximum depth explored within EB-2 and EB-5 (approximately 21.5 feet). It should be noted that a few of the N-values indicated a dense condition within this unit; however, we infer that the blow counts were overstated due to an elevated gravel content. For geotechnical considerations, the Holocene beach deposits are in a medium dense condition.

Pre-Fraser Undifferentiated

Directly below the Holocene beach deposits, explorations EB-1, EB-3, and EB-4 encountered a deposit of dense to very dense, moist to wet, light gray to gray, sand and silty sand with trace to some gravel and occasional thin interbeds of sandy silt. These sediments were also observed to contain abundant quantities of fine mica flakes (i.e., micaceous). We interpret these sediments to be representative of pre-Fraser undifferentiated deposits. These sediments were deposited prior to the most recent glaciation of the project region, known as the Fraser Glaciation, and were subsequently overridden by several thousand feet of glacial ice. Where encountered, these sediments extended beyond the maximum depth of our explorations (21 to 21.5 feet). It should be noted that although the sample obtained at 20 feet within EB-1 contained mica, the blow counts appeared overstated due to soil heave, so we have queried this sample as possible pre-Fraser undifferentiated or possible beach deposits on the exploration log in Appendix A.

4.2 Geologic Mapping

Review of the regional geologic map of the project area (*Geologic Map of the Port Townsend South and part of the Port Townsend North 7.5-Minute Quadrangles, Jefferson County, Washington*, Washington Division of Geology and Earth Resources, Geologic Map GM-57, by H.W. Schasse and S.L. Slaughter [2005]), indicates that the site is underlain by a combination of "modified land" (Qml) and fill (Qf) with Vashon advance outwash and Vashon lodgement till mapped along the slope that ascends to West Sims Way and in the upland area to the north. The regional geologic mapping of the project site and vicinity is shown on Figure 4. The term "modified land" refers to soil, sediment, or other geologic material that was locally reworked by excavation and/or redistribution to modify topography. The term "fill" refers to any material that was placed to elevate and reshape the land surface and includes engineered and non-engineered fills. Our interpretation of the sediments encountered in our explorations is in agreement with the regional geologic map in that we encountered fill soils overlying native beach deposits at all locations explored.

4.3 Soil Mapping

Review of regional soils mapping (*Soil Survey of Jefferson County Area, Washington*, U.S. Department of Agriculture [USDA], Soils Conservation Service [SCS] now referred to as Natural Resources Conservation Service [NRCS]) on the NRCS *Web Soil Survey* indicates that the subject site is predominately underlain by cut and fill land, with "rough broken land" mapped along the northwest project boundary, Clallam gravelly sandy loam mapped along the northeast property boundary, and coastal beach deposits mapped to the southeast. The "rough broken land" typically consists of marine bluffs which have steep slopes greater than 50 percent. Tidal action and storms have undermined the toe of the bluffs causing land to slide from above. The Clallam gravelly sandy loam mapped along the northeastern project boundary and in the uplands to the north are soils typically derived from glacial till.

Our interpretation of the near-surface sediments encountered in our explorations is generally consistent with the regional soils mapping in that we encountered fill soils overlying native beach deposits at all locations explored. No explorations were completed along the slope or upland area to the north; however, we observed coastal bluffs to the west of the site that appeared consistent with the "rough broken land" soil unit description.

4.4 Hydrology

Groundwater was encountered at depth in all explorations completed for this study. Within EB-1 through EB-5, groundwater depths at the time of drilling ranged from approximately 5.2 to 5.8 feet below existing grade. The approximate depths to groundwater at the time of drilling are depicted on the subsurface exploration logs in Appendix A and summarized in Table 1 below. The groundwater observed at these boring locations is interpreted to be representative of an unconfined water table aquifer underlying the site, is tidally influenced, and closely correlates to the elevation of water in Port Townsend Bay.

Table 1
Summary of Observed Groundwater Levels at Time of Drilling

Exploration Boring No.	Depth to Groundwater(1) (feet)	Water-Bearing Unit(s)
EB-1	5.6 ATD(2)	Beach Deposits
EB-2	5.8 ATD	Beach Deposits
EB-3	5.6 ATD	Fill/Beach Deposits
EB-4	5.3 ATD	Fill/Beach Deposits
EB-5	5.2 ATD	Fill/Beach Deposits

(1) Groundwater depths correspond to depth below the existing ground surface.
(2) ATD = At Time of Drilling (April 15, 2024). The tide was in at all locations at the time of drilling.

The explorations for this study were conducted in mid-April when regional groundwater levels are typically elevated but not at seasonal high levels. Groundwater at this site is tidally influenced. We observed that the tide was in at the time of drilling for all explorations.

Perched groundwater may be encountered at other locations onsite where vertical infiltration of surface water is impeded by lower-permeability strata such as layers of silty fill that may be present above the beach deposits. Due to the variable nature of the existing fill at the subject site, seepages may be discontinuous and occur at random intervals. The occurrence and level of perched groundwater seepage below the site can be expected to increase in the wetter winter months.

It should be noted that the duration and quantity of groundwater seepage will largely depend on the soil grain-size distribution, topography, seasonal precipitation, on- and off-site land usage, tidal fluctuations, and other factors.

4.5 Laboratory Testing

Grain-Size Analysis

AESI performed three grain-size analyses (sieves) on representative samples of existing fill and beach deposits collected from explorations EB-3, EB-4, and EB-5 to support soil classification in the field and for use in our liquefaction analysis. The grain-size analyses test results are included in Appendix B and are presented below in Table 2 with soil descriptions based on the ASTM D-2487 Unified Soil Classification System (USCS).

Table 2
Summary of Grain-Size Analyses

Exploration Boring No.	Sample Depth (feet)	Geologic Unit	USCS Soil Description	Fines Content (%)
EB-3	2.5-4	Fill	Gravelly SAND, some silt (SP-SM)	7.5
EB-4	0-1.5	Fill	Gravelly SAND, some silt (SP-SM)	7.3
EB-5	0-1.5	Fill	Very gravelly SAND, some silt (SW-SM)	10.8

USCS = Unified Soil Classification System
Fines Content % = percent of total weight passing the U.S. No. 200 Sieve

Organic Matter Content

AESI also conducted an organic matter content determination on a sample of existing fill collected from EB-3 at a depth interval of 2.5 to 4 feet (split sample from EB-3 in Table 1 above) in accordance with ASTM D-2974. The soil sample had an organic matter content of 20.4 percent.

II. GEOLOGIC HAZARDS AND MITIGATIONS

The following discussion of potential geologic hazards is based on the geologic conditions as observed and discussed herein.

5.0 LANDSLIDE HAZARDS AND RECOMMENDED MITIGATION

A steep slope borders the project site to the northwest that ascends to West Sims Way. This slope has an overall height of about 20 feet at the eastern extent (adjacent to the existing boat yard) and ranges up to approximately 80 feet in height at the western extent of the project area. Slope inclinations range from approximately 60 to 85 percent. Existing site features and LIDAR-based topographic contours are shown on Figure 2. As shown on the "Regional Geology and LIDAR-Based Shaded Relief," Figure 4, this slope is mapped as Vashon lodgement till at higher elevations overlying Vashon advance outwash at lower elevations. These geologic units were exposed along the coastal bluffs to the west of the project area.

5.1 Limited Visual Slope Reconnaissance

AESI completed a limited visual slope reconnaissance on April 15, 2024. The slope generally has a thick cover of blackberry brambles along with scattered evergreen and deciduous trees. AESI was able to access a narrow segment of the slope located to the northwest of exploration EB-3 that was relatively clear of thick vegetation. At this location, the total slope height was estimated at 50 feet. We attempted a few hand augers at the toe, mid-slope, and near the crest of the slope and encountered up to 6 feet of loose to medium dense sand with some silt and gravel, interpreted to be either weathered material or colluvium that blankets the slope face. The hand augers could not be extended beyond a depth of 4 to 6 feet due to gravel obstructions and/or increasing soil resistance; therefore, no samples of native material could be retrieved to confirm the presence of Vashon advance outwash or Vashon lodgement till at depth.

We could not see any obvious signs of instability due to the thick cover of brambles; however, we reviewed the 2019 Olympics South LIDAR-based shaded relief map of the slope, as provided on the Washington State Department of Natural Resources (WADNR), Division of Geology and Earth Resources, LIDAR portal. LIDAR imagery is a remote sensing technology that can be used to generate a detailed expression of the ground surface topography, even in densely vegetated areas. For this reason, LIDAR-based topographic imagery can be helpful in distinguishing surface features (such as old landslide features) that may otherwise not be easily recognizable. The LIDAR-based shaded relief map of the project site and vicinity along with topographic contours are shown on Figure 4.

The LIDAR imagery does not reveal any indications of recent catastrophic landsliding activity at the project site; however, the map does indicate the presence of shallow scarps and hummocky topography scattered across the slope face. There appears to be two separate scarp features located directly north of the maintenance shop area and near the western extent of the project boundary. The remaining areas within the limits of the proposed boat yard expansion are relatively flat to gently sloping toward the bay and the risk for landsliding in these areas is low, in our opinion.

It should be noted that a detailed slope stability analysis was beyond the scope of work for this study, and the potential for deep-seated slope failures has not been evaluated. Additional borings advanced from the top of slope would be required to evaluate the potential for deep-seated landslide hazards affecting the site and proposed improvements.

5.2 Catchment Berm

We recommend that the project include the construction of a catchment berm or barrier along the toe of the slope to mitigate potential shallow debris flows and shallow slides from impacting the expanded boat yard and stored vessels. We have not completed a detailed analysis of slope stability including the possible size of debris flow or shallow slide events. We are available to provide a more detailed slope analysis depending on site planning and layout. For preliminary planning, we recommend that a catchment berm should have a minimum height of 4 feet and side slopes of 2H:1V (Horizontal:Vertical) or flatter on either side of the berm's crest. The berm should be offset from the slope toe such that the berm's side slopes can provide catchment to potential debris flows and shallow slides. We understand that the Larry Scott Memorial Trail may be relocated to follow the northern project boundary along the toe of the slope. The relocated trail could be supported on the catchment berm.

5.3 Stormwater Treatment Swales

We understand that two stormwater treatment swales are currently proposed along the northern project boundary, near the toe of the steep slope. The swales should be lined with quarry spalls and rock check dams to mitigate soil erosion that could potentially undermine the toe and result in unstable slope conditions.

6.0 SEISMIC HAZARDS AND RECOMMENDED MITIGATION

The following discussion is a general assessment of seismic hazards that is intended to be useful to the project design team in terms of understanding seismic issues, and to the structural engineer for design.

All of Western Washington is at risk of strong seismic events resulting from movement of the tectonic plates associated with the Cascadia Subduction Zone (CSZ), where the offshore Juan de Fuca plate subducts beneath the continental North American plate. The site lies within a zone of strong potential shaking from subduction zone earthquakes associated with the CSZ. The CSZ can produce earthquakes up to magnitude 9.0, and the recurrence interval is estimated to be on the order of 500 years. Geologists infer the most recent subduction zone earthquake occurred in 1700 (Goldfinger et al., 2012[1]). Three main types of earthquakes are typically associated with subduction zone environments: crustal, intraplate, and interplate earthquakes. Seismic records in the Puget Sound region document a distinct zone of shallow crustal seismicity (e.g., the Seattle Fault Zone). These shallow fault zones may include surficial expressions of previous seismic events, such as fault scarps, displaced shorelines, and shallow bedrock exposures. The shallow fault zones typically extend from the surface to depths ranging from 16 to 19 miles. A deeper zone of seismicity is associated with the subducting Juan de Fuca plate. Subduction zone seismic events produce intraplate earthquakes at depths ranging from 25 to 45 miles beneath the Puget Lowland including the 1949, 7.2-magnitude event; the 1965, 6.5-magnitude event; and the 2001, 6.8-magnitude event) and interplate earthquakes at shallow depths near the Washington coast including the 1700 earthquake, which had a magnitude of approximately 9.0. The 1949 earthquake appears to have been the largest in this region during recorded history and was centered in the Olympia area. Evaluation of earthquake return rates indicates that an earthquake of the magnitude between 5.5 and 6.0 is likely within a given 20-year period.

Generally, there are four types of potential geologic hazards associated with large seismic events: 1) surficial ground rupture, 2) seismically induced landslides or lateral spreading, 3) liquefaction, and 4) ground motion. The potential for each of these hazards to adversely impact the proposed project is discussed below.

6.1 Surficial Ground Rupture

The site falls approximately 2.5 miles southwest of the suspected traces of the southeastward extension of the Southern Whidbey Island Fault Zone (SWIFZ). A recent study by the U.S. Geological Survey (USGS) (Sherrod et al., 2005[2]) indicates that "strong" evidence of prehistoric earthquake activity has been observed along two fault strands thought to be part of the southeastward extension of the SWIFZ located about 2.5 miles northeast of the site. The study suggests as many as nine earthquake events along the SWIFZ may have occurred within the last 16,400 years. Understanding of this fault system is somewhat limited with studies still ongoing.

[1] Goldfinger, C., Nelson, C.H., Morey, A.E., Johnson, J.E., Patton, J.R., Karabanov, E., Gutierrez-Pastor, J., Eriksson, A.T., Gracia, E., Dunhill, G., Enkin, R.J., Dallimore, A., and Vallier, T., 2012, *Turbidite Event History—Methods and Implications for Holocene Paleoseismicity of the Cascadia Subduction Zone*: U.S. Geological Survey Professional Paper 1661–F, 170.

[2] Sherrod et al., 2005, *Holocene Fault Scarps and Shallow Magnetic Anomalies Along the Southern Whidbey Island Fault Zone near Woodinville, Washington*, Open-File Report 2005-1136, March 2005.

The recurrence interval of movement along this fault system is still unknown, although it is hypothesized to be in excess of one thousand years. Due to the observed distance to suspected fault traces, and the suspected long recurrence interval, the potential for surficial ground rupture along the SWIFZ is considered to be low during the expected life of the proposed improvements, in our opinion.

6.2 Liquefaction and Lateral Spreading

Liquefaction is a process through which unconsolidated soil loses strength as a result of vibrations, such as those which occur during a seismic event. During normal conditions, the weight of the soil is supported by both grain-to-grain contacts and by the fluid pressure within the pore spaces of the soil below the water table. Extreme vibratory shaking can disrupt the grain-to-grain contact, increase the pore pressure, and result in a temporary decrease in soil shear strength. The soil is said to be liquefied when nearly all of the weight of the soil is supported by pore pressure alone. Liquefaction can result in deformation of the sediment and settlement of overlying structures. Areas most susceptible to liquefaction include those areas underlain by very soft to stiff, non-cohesive silt and very loose to medium dense, non-silty to silty sands with low relative densities, accompanied by a shallow water table.

To evaluate the extent of liquefaction risk and estimated settlement potential during a design-level seismic event, we performed a liquefaction hazard analysis utilizing data obtained from our exploration borings. Our liquefaction analysis was completed with the aid of LiquefyPro computer software Version 5.9a (2015) by CivilTech Corporation. This program accepts input for SPT data, groundwater levels, soil unit weight, and the depth and grain-size distribution of the sediments of concern to calculate seismically induced settlement. The following parameters were used during the analysis:

- Soil unit weights were estimated based on density of soil samples retrieved from representative geologic units during drilling.

- Silt contents were inferred from a combination of visual and laboratory classification of soil samples obtained from the SPT borings.

- The groundwater level was assumed to be 5 feet below the existing ground surface during earthquake shaking.

- We used the Tokimatsu M-Correction method in the LiquefyPro computer software to obtain the liquefaction-induced settlement values.

- A design event is considered a magnitude 7.0 earthquake with a peak horizontal ground acceleration of 0.63g as determined from the American Society of Civil Engineers (ASCE) Hazard Tool website at https://ascehazardtool.org.

The results of the liquefaction analysis indicate that the saturated beach deposits are susceptible to liquefaction and are predicted to experience up to 3 inches of liquefaction-induced settlement during a design-level seismic event. The design seismic event is based on an exceedance probability of 2 percent over a period of 50 years, which equates to a return period of approximately 2,475 years. The results of our liquefaction analysis are provided in Appendix C.

It should be noted that the entire profile of the beach deposits is expected to be susceptible to liquefaction. The beach deposits extended beyond the maximum depth of our explorations (21.5 feet below existing grade) within EB-2 and EB-5; therefore, the magnitude of predicted settlement may be higher than our current analysis indicates.

Conclusions

Based on our liquefaction analysis, there is a risk of damage to the proposed improvements by liquefaction due to the presence of loose to medium dense beach sediments accompanied by a shallow groundwater table. We did not complete a detailed lateral spreading analysis for this study; however, based on our experience with similar subsurface conditions and topographic setting, we anticipate that the site is also susceptible to lateral spreading and flow failure during an extreme earthquake event, and that the ground displacement could be on the order of tens of feet toward the bay.

Due to the scale of the site and the magnitude of the hazard, the Port may choose to repair and replace damages to the boat yard expansion improvements by liquefaction and lateral spreading, rather than mitigate the hazard. We recommend the design team discuss the above seismic hazards with the Port to determine if seismic mitigation measures are desired for any of the infrastructure elements associated with the boat yard expansion. If the project chooses to relocate the Port's maintenance shop, the relocated building could be supported on small-diameter pipe piles to mitigate the effects of liquefaction-induced settlement. We are available to provide location-specific design parameters for pipe piles if the Port chooses to relocate the maintenance shop and the new location is known.

6.3 Ground Motion/Seismic Site Class

Should the project include seismic retrofits to the Port's maintenance shop or construct a new building, structural design should follow the *International Building Code* (IBC) standards. We assume that structural design would follow the 2021 IBC and the ASCE 7-16 - *Minimum Design Loads for Buildings and Other Structures*. Based on the results of our explorations, we recommend that the project be designed in accordance with Site Class "D" as defined in Table 20.3-1 of ASCE 7-16. Note that Site Class "D" only applies to structures with building periods less than 0.5 seconds. Future buildings at the site that have building periods greater than 0.5 seconds will need to follow Site Class "F" requirements due to liquefaction potential and a site response analysis would be required.

7.0 EROSION HAZARDS AND RECOMMENDED MITIGATION

Based on our explorations, the near-surface sediments across the site consist of existing fill overlying beach deposits. The existing fill sediments underlying the site contain significant quantities of silt and fine sand. These sediments will be susceptible to erosion and off-site sediment transport when exposed during construction. Therefore, the project should follow best management practices (BMPs) to mitigate erosion hazards and potential for off-site sediment transport.

The Washington State Department of Ecology (Ecology) Construction Stormwater General Permit (also known as the National Pollutant Discharge Elimination System [NPDES] permit) requires weekly Temporary Erosion and Sedimentation Control (TESC) inspections and turbidity monitoring of site runoff for all sites that are 1 or more acres in size that discharge stormwater to surface waters of the state. The TESC inspections and turbidity monitoring of runoff must be completed by a Certified Erosion and Sediment Control Lead (CESCL) for the duration of the construction. Requirements for inspections, sampling, and reporting can be found in the Construction Stormwater General Permit online at ecology.wa.gov.

In order to meet the current Ecology requirements, a properly developed, constructed, and maintained erosion control plan consistent with local standards and best management erosion control practices will be required for this project. It is often necessary to make adjustments and provide additional measures to the TESC plan in order to improve its effectiveness. Ultimately, the success of the TESC plan depends on a proactive approach to project planning and contractor implementation and maintenance.

To mitigate and reduce the erosion hazard and potential for off-site sediment transport, we recommend the following:

- Construction activity should be scheduled or phased as much as possible to avoid earthwork activity during the wet season.

- The winter performance of a site is dependent on a well-conceived plan for control of site erosion and stormwater runoff. The site plan should include ground-cover measures and staging areas. The contractor should be prepared to implement and maintain the required measures to reduce the amount of exposed ground.

- TESC elements and perimeter flow control should be established prior to the start of grading. This should include, but is not limited to, silt fencing, swales with check dams, rocked construction entrance, etc.

- During the wetter months of the year, or when significant storm events are predicted during the summer months, the work area should be stabilized so that if showers occur, it can receive the rainfall without excessive erosion or sediment transport. The required measures for an area to be "buttoned-up" will depend on the time of year and the duration that the area will be left unworked. During the winter months, areas that are to be left unworked for more than 2 days should be mulched or covered with plastic. During the summer months, stabilization will usually consist of seal-rolling the subgrade. Such measures will aid in the contractor's ability to get back into a work area after a storm event. The stabilization process also includes establishing temporary stormwater conveyance channels through work areas to route runoff to the approved treatment/discharge facilities.

- Surface runoff and discharge should be controlled during and following development. Uncontrolled discharge may promote erosion and sediment transport.

- Soils that are to be reused around the site should be stored in such a manner as to reduce erosion from the stockpile. Protective measures may include, but are not limited to, covering stockpiles with plastic sheeting, or the use of silt fences around stockpile perimeters.

It is our opinion that with the proper implementation of the TESC plans and by field-adjusting appropriate erosion mitigation (BMPs) throughout construction, the potential adverse impacts from erosion hazards on the project may be mitigated.

III. PRELIMINARY DESIGN RECOMMENDATIONS

8.0 INTRODUCTION

Our explorations indicate that, from a geotechnical engineering standpoint, the proposed project is feasible provided the recommendations contained herein are properly followed. The site is generally underlain by existing fill overlying beach deposits and pre-Fraser undifferentiated deposits at depth, and groundwater is shallow. Based on explorations and analyses completed to date, we have identified the following geotechnical considerations that will impact design and construction of the project:

- The existing fill was encountered to depths ranging from about 3 and 9.5 feet below existing grade and was variable in density and composition, ranging from loose to medium dense, slightly moist to wet, brown sand with some silt and gravel with scattered organics, to dark brown and black, silty sand with scattered to abundant organic debris (roots, rootlets, wood fragments, and fine organics), to gray gravel with some sand and trace silt. Portions of the existing fill that contain significant quantities of organics will require overexcavation/replacement, and some areas may be difficult to recompact to a firm and unyielding condition when exposed after clearing and grubbing.

- Groundwater was encountered at depths ranging from about 5.2 to 5.8 feet below existing grade at the time of drilling. The explorations for this study were conducted in mid-April when regional groundwater levels are typically elevated but not at seasonal high levels, and groundwater at this site is tidally influenced. Significant dewatering efforts may be required to control groundwater flow into excavations for underground utilities.

The following sections provide our preliminary recommendations for site preparation, earthwork and site grading, temporary cut slopes, structural fill, and gravel lot surfacing. We recommend that we be allowed to review the recommendations presented in this report and revise them, if needed, when the project design has been finalized.

9.0 SITE PREPARATION

Site preparation for the expanded boat yard area should include removal of all vegetation, topsoil, and any other deleterious materials within areas to receive structural fill or new gravel surfacing. Any depressions below planned final grades resulting from clearing and grubbing activities should be backfilled with structural fill, as discussed under the "Structural Fill" section of this report.

9.1 Site Drainage and Surface Water Control

The site should be graded to prevent water from ponding in construction areas and/or flowing into excavations. Accumulated water must be removed from subgrades and work areas immediately prior to performing further work in the area. Equipment access may be limited, and the amount of soil rendered unfit for use as structural fill may be greatly increased if drainage efforts are not accomplished in a timely sequence. Finished grades should always promote free and positive drainage away from planned improvements.

It should be noted that we observed up to 6 inches of standing water within the low-lying vegetated areas during our initial site reconnaissance on April 3, 2024, after the site received substantial rainfall on the previous day(s). No surface water was observed at the time of our exploration on April 15, 2024 after the site had several days of dry weather. During initial site preparation and prior to the start of mass grading, the contractor should establish temporary stormwater conveyance channels through the site to route runoff away from low-lying areas and areas to receive structural fill.

9.2 Site Disturbance

The existing fill and native sediments contain a moderate to high percentage of fine-grained material. These sediments are considered to be highly moisture-sensitive and subject to disturbance when wet. The contractor must use care during site preparation and excavation operations so that the underlying soils are not softened. If disturbance occurs, the softened soils should be removed, and the area brought to grade with structural fill.

9.3 Wet Weather Considerations

The on-site soils containing silt contents greater than 5 percent are considered to be highly moisture-sensitive. If construction takes place in, during, or immediately following the wetter periods of the year, we anticipate the on-site soils will become unsuitable for structural fill applications. For construction immediately following wet periods, significant, but unavoidable effort will be needed to scarify, aerate, and dry site soils to reduce moisture content prior to compaction in structural fill applications. Care should be taken to seal all earthwork areas during mass grading at the end of each workday by grading all surfaces to drain and sealing them with a smooth-drum roller. Stockpiled soils that will be reused in structural fill applications should be covered whenever rain is possible.

Construction during extended wet weather periods could create the need to overexcavate exposed soils if they become disturbed and cannot be recompacted due to elevated moisture content and/or weather conditions. Even during dry weather periods, soft/wet soils may be encountered in some portions of the site that will require overexcavation. If overexcavation is necessary, it should be confirmed through continuous observation and testing by AESI. Soils that have become unstable may require remedial measures in the form of one or more of the following:

1. Drying and recompaction. Selective drying may be accomplished by scarifying or windrowing surficial material during extended periods of dry and warm weather.

2. Removal of affected soils to expose a suitable bearing subgrade and replacement with compacted structural fill.

3. Mechanical stabilization with a coarse crushed aggregate such as ballast or quarry spalls compacted into the subgrade, possibly in conjunction with a geotextile.

Consideration should be given to protecting access and staging areas with an appropriate section of crushed rock. The crushed rock should be underlain by engineering stabilization fabric (such as Mirafi 500X or approved equivalent) to reduce the potential of fine-grained materials pumping up through the rock during wet weather and turning the area to mud. The fabric will also aid in supporting construction equipment, thus reducing the amount of crushed rock required. We recommend that at least 10 inches of rock be placed over the fabric. Crushed rock used for access and staging areas should be of at least 2-inch size.

9.4 Overexcavation Considerations

Within our explorations, the near-surface existing fill soils generally consisted of granular sediments (sand with variable silt and gravel content) and appear to be suitable for support of structural fills with proper preparation; however, explorations EB-3 and EB-4 encountered scattered to abundant quantities of organic material (roots, rootlets, wood debris, and fine organics) directly below the ground surface to depths of 2 to 4 feet below existing grade that may require overexcavation prior to placement of structural fill. It is not possible to estimate overexcavation quantities based on a set of widely spaced borings, and pockets of excessively organic material can be expected in unexplored areas. If a firmer assessment of overexcavation quantities is desired for the project, we are available to assist with completing additional explorations consisting of an array of shallow test pits with an excavator.

9.5 Potential for Contaminated Soils

During our field exploration, we encountered soils within EB-4 that contained a strong septic odor from a depth of about 5 to 9 feet below existing grade. The source of the odor could not be identified in the field. We recommend that this area be further explored/assessed prior to construction.

9.6 Temporary Cut Slopes

In our opinion, stable construction slopes should be the responsibility of the contractor and should be determined during construction based on the local conditions encountered at that time. For planning purposes, we anticipate that temporary, unsupported cut slopes in areas of existing fill or loose to medium dense beach deposits can be made at a maximum inclination of 1.5H:1V. Flatter slope inclinations on the order of 3H:1V may be required where perched groundwater seepage is present. Temporary vertical cuts up to 4 feet in height may not be feasible in loose to medium dense sandy material and unsupported excavations below the groundwater table should not be attempted. As is typical with earthwork operations, some sloughing and raveling may occur, and cut slopes may have to be adjusted in the field based on the presence of surface water or perched seepage zones. In addition, WISHA/OSHA regulations should be followed at all times.

9.7 Utility Trenches and Dewatering Considerations

The depth to groundwater at the time of drilling in mid-April ranged from about 5 to 6 feet below existing grade, and is tidally influenced. Significant dewatering efforts may be required to control groundwater flow into excavations for utility trenches deeper than about 4 feet. The contractor should be prepared to utilize trench boxes with appropriate dewatering systems in place as needed for trench excavations that extend below the groundwater table. Where relatively shallow excavations on the order of 4 feet or less are required and take place in the drier months of the year, we anticipate that surface and groundwater seepage could be managed during construction with conventional ditches and sumps.

10.0 STRUCTURAL FILL

Placement of structural fill will be necessary to establish desired grades across the site and to backfill utility trenches. Based on the referenced conceptual plans, we understand that site grades will generally be raised by 2 to 4 feet across most of the project area, and that fills up to 7 feet in height will be required in isolated low-lying areas. All references to structural fill in this report refer to subgrade preparation, fill type, and placement and compaction of materials as discussed in this section. If a percentage of compaction is specified under another section of this report, the value given in that section should be used.

10.1 Subgrade Compaction

After overexcavation/stripping has been performed to the satisfaction of the geotechnical engineer/engineering geologist, the exposed ground should be recompacted to a firm and unyielding condition and proof-rolled using a fully-loaded dump truck. Soft or yielding areas observed during proof-rolling should be overexcavated as necessary to provide a suitable subgrade and backfilled with structural fill. Proof-rolling should only be attempted if soil moisture contents are at or near optimum moisture content. Proof-rolling of wet subgrades could result in further degradation.

If the subgrade contains too much moisture, suitable recompaction may be difficult or impossible to attain and should probably not be attempted. In lieu of recompaction, the area to receive fill should be blanketed with washed rock or quarry spalls to act as a capillary break between the new fill and the wet subgrade. Where the exposed ground remains soft and further overexcavation is impractical, placement of an engineering stabilization fabric may be necessary to prevent contamination of the free-draining layer by silt migration from below. After the exposed ground is approved, or a free-draining rock course is laid, structural fill may be placed to attain desired grades.

10.2 Structural Fill Compaction

Structural fill is defined as non-organic soil, acceptable to the geotechnical engineer, placed in maximum 8-inch loose lifts, with each lift being compacted to at least 95 percent of the modified Proctor maximum dry density using ASTM D-1557 as the standard. Utility trench backfill should be placed and compacted in accordance with applicable municipal codes and standards. The top of the compacted fill should extend horizontally a minimum distance of 3 feet beyond parking/storage areas before sloping down at an angle no steeper than 2H:1V. Fill slopes should either be overbuilt and trimmed back to final grade or surface-compacted to the specified density.

10.3 Reuse of On-Site Soils as Structural Fill

The existing fill and native beach deposits consisting primarily of sand and silty sand are suitable for reuse in structural fill applications if such reuse is specifically allowed by project plans and specifications, if excessively organic and any other deleterious materials are removed, and if moisture content is adjusted to allow compaction to the specified level and to a firm and unyielding condition. Soils in which the amount of fine-grained material (smaller than the No. 200 sieve) is greater than approximately 5 percent (measured on the minus No. 4 sieve size) should be considered moisture-sensitive. Most of the near-surface fill soils contained significant silt fractions and are considered highly moisture-sensitive. These moisture-sensitive soils are classified as “sand, some silt” (SP-SM or SW-SM), “gravel, some silt” (GP-GM), and “silty sand” (SM) and on our boring logs in Appendix A. These soils may be difficult to reuse as structural fill during wet weather conditions.

Additionally, construction equipment traversing the site when the silty native sediments are very moist or wet can cause considerable disturbance. During the wetter portion of the year, typically from October to April, we recommend assuming that the on-site soils will not be suitable for reuse in structural fill applications. An alternative would include using only a select import material consisting of a clean, free-draining gravel and/or sand. Free-draining fill consists of non-organic soil with the amount of fine-grained material limited to 5 percent by weight when measured on the minus No. 4 sieve fraction.

10.4 Imported Structural Fill

We recommend that imported structural fill used to raise site grades consist of a well-graded granular material with less than 5 percent fines, such as Washington State Department of Transportation (WSDOT) 9-03.14(1) Gravel Borrow (except that the material passing the No. 200 sieve should be less than 5 percent) or similar.

10.5 Structural Fill Testing

The contractor should note that any proposed fill soils must be evaluated by AESI prior to their use as structural fill. This would require that we have a large enough sample of material to meet ASTM requirements for minimum sample size based on the maximum soils particle size, at least 3 business days in advance to perform a Proctor test and determine its field compaction standard.

A representative from our firm should observe the stripped subgrade and be present during placement of structural fill to observe the work and perform a representative number of in-place density tests. In this way, the adequacy of the earthwork may be evaluated as filling progresses and any problem areas may be corrected at that time. It is important to understand that taking random compaction tests on a part-time basis will not assure uniformity or acceptable performance of a fill. As such, we are available to aid the owner in developing a suitable monitoring and testing frequency.

11.0 GRAVEL LOT SURFACING

The conceptual plans indicate that the southwest corner of the boat yard expansion area will support the 75-ton mobile boat lift, and the remaining expansion area will support the 300-ton mobile lift. Based on a set of historical plans prepared by Reid Middleton, Inc., titled "Port of Port Townsend Enhanced Haulout and Stormwater Facilities," dated August 1996, we understand that the gravel section for existing boat yard areas that support the 75-ton mobile lift was originally designed to consist of 6 inches of Crushed Surfacing Top Course (CSTC) overlying 8 inches of Crushed Surfacing Base Course (CSBC). Gravel sections that support the 300-ton lift were originally designed to consist of 8 inches of CSTC overlying 12 inches of CSBC overlying 12 inches of subbase.

Recent borings completed by AESI for the neighboring Boat Haven Marina Stormwater Improvements project indicate that the thickness of the existing gravel section within the southern drive lane of the boat yard (8th Street) may range from approximately 8 to 14 inches. During our site reconnaissance, we observed that this drive lane section appeared to be performing well under transient loading of the 300-ton lift.

Based on the information above, it is our opinion that the original gravel sections specified in the referenced 1996 plans will be suitable for the expanded boat yard area provided the gravel section is placed on properly compacted structural fill and a firm and unyielding subgrade surface.

12.0 PROJECT DESIGN AND CONSTRUCTION MONITORING

We recommend that we be allowed to review the final project plans when they are completed and to revise the recommendations presented in this report, where appropriate. We are also available to provide geotechnical engineering and monitoring services during construction. The integrity of earthwork, structural fills, and foundation systems depends on proper site preparation and construction procedures. In addition, engineering decisions may have to be made in the field in the event that variations in subsurface conditions become apparent.

We have enjoyed working with you on this study and are confident these recommendations will aid in the successful completion of your project. If you should have any questions or require further assistance, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

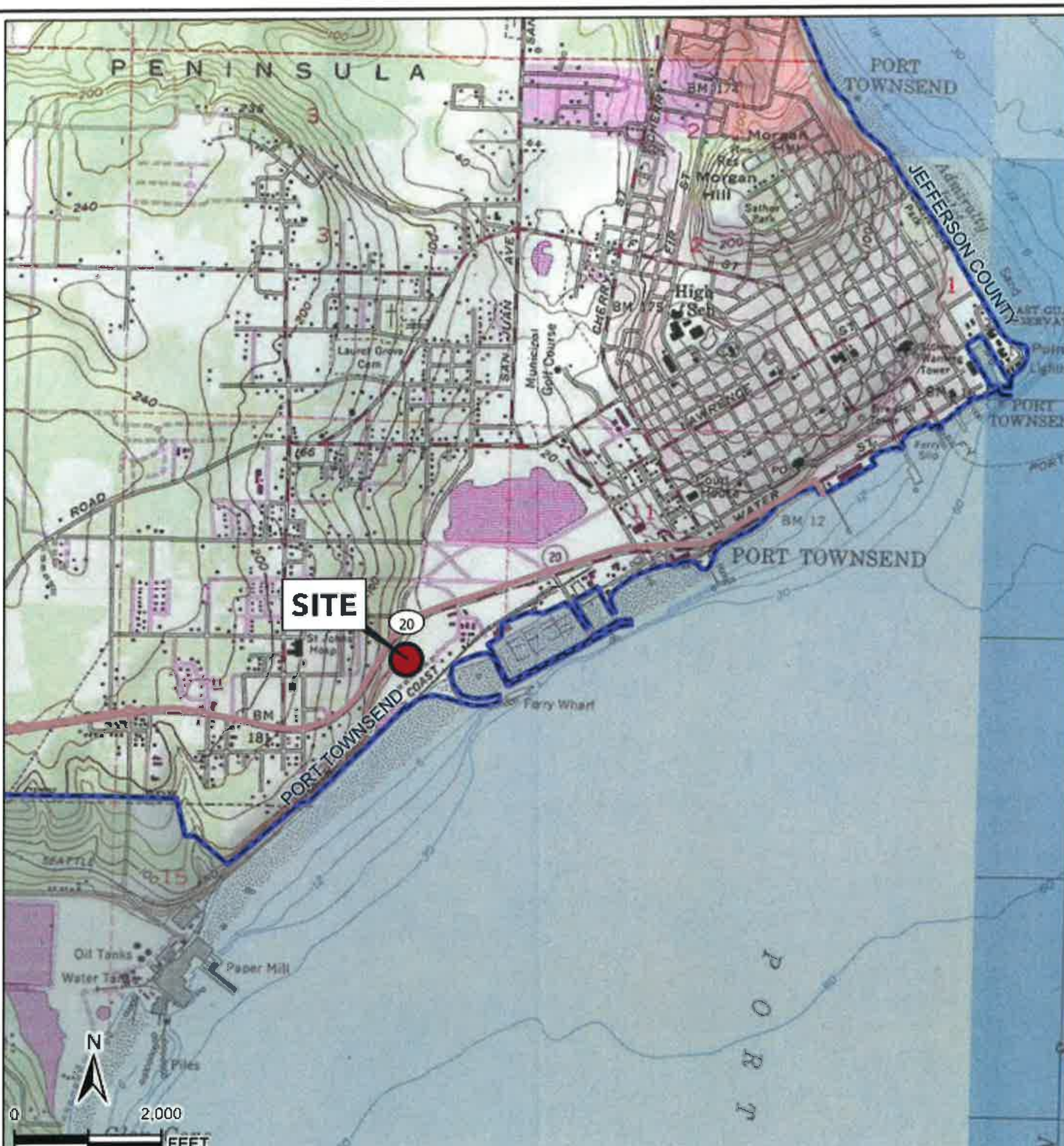
Brendan C. Young, L.G.
Senior Staff Geologist

G. BRADFORD DREW
STATE OF WASHINGTON
57948
REGISTERED
PROFESSIONAL ENGINEER
5/23/24

Kurt D. Merriman, P.E.
Senior Principal Engineer

G. Bradford Drew, P.E.
Associate Engineer

LIST OF ATTACHMENTS



COUNTY LOCALE

ESRI, USGS, NATIONAL GEOGRAPHIC, DELORME, NATURALVUE, I-CUBED, GEBCO; ARCGIS ONLINE BASEMAP. WADOT STATE ROUTES 24K (12/20). JEFFERSON CO.: PARCELS (4/24), ROADS (4/24).

NOTE: LOCATION AND DISTANCES SHOWN ARE APPROXIMATE. BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

LOCATION

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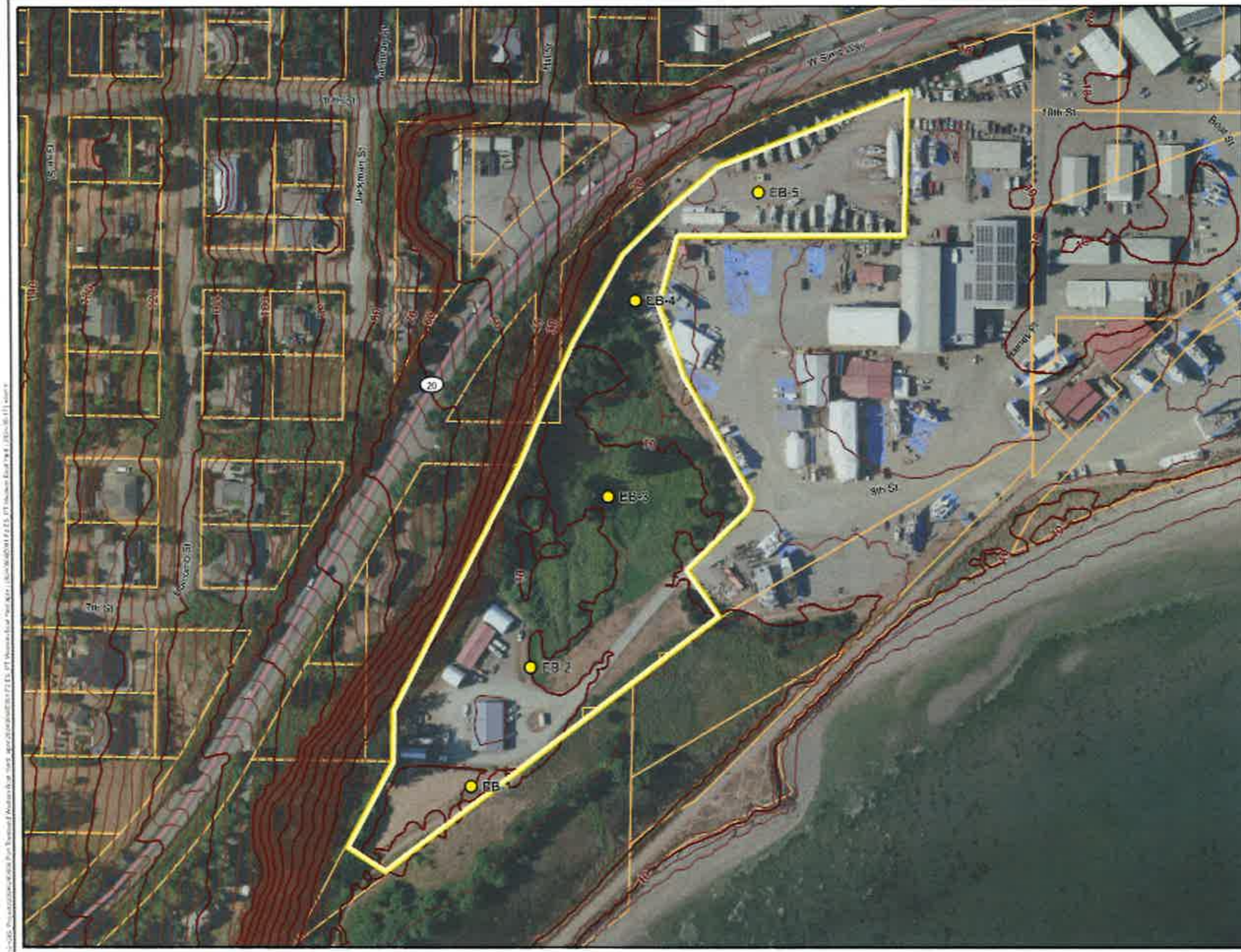
VICINITY MAP

PORT OF PORT TOWNSEND WESTERN BOAT YARD EXPANSION
PORT TOWNSEND, WASHINGTON

PROJECT NO.	DATE	FIGURE
20240066E001	5/24	1



LEGEND

- SITE
- EXPLORATION BORING
- CONTOUR 10 FT
- CONTOUR 2 FT
- PARCEL

N

0 150

FEET

DATA SOURCES/REFERENCES:
JEFFERSON COUNTY: ROADS (4/24), PARCELS (4/24). EAGLEVIEW TECHNOLOGIES, INC.: AERIAL IMAGERY (2021). WADOT STATE ROUTES 24K (12/20). WA DNR: OLYMPICS_SOUTH_OPSW_2019 ACQUIRED BETWEEN SEPT 2017 AND APRIL 2019, CELL SIZE 3'. CONTOURS DERIVED FROM LIDAR.

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION. LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

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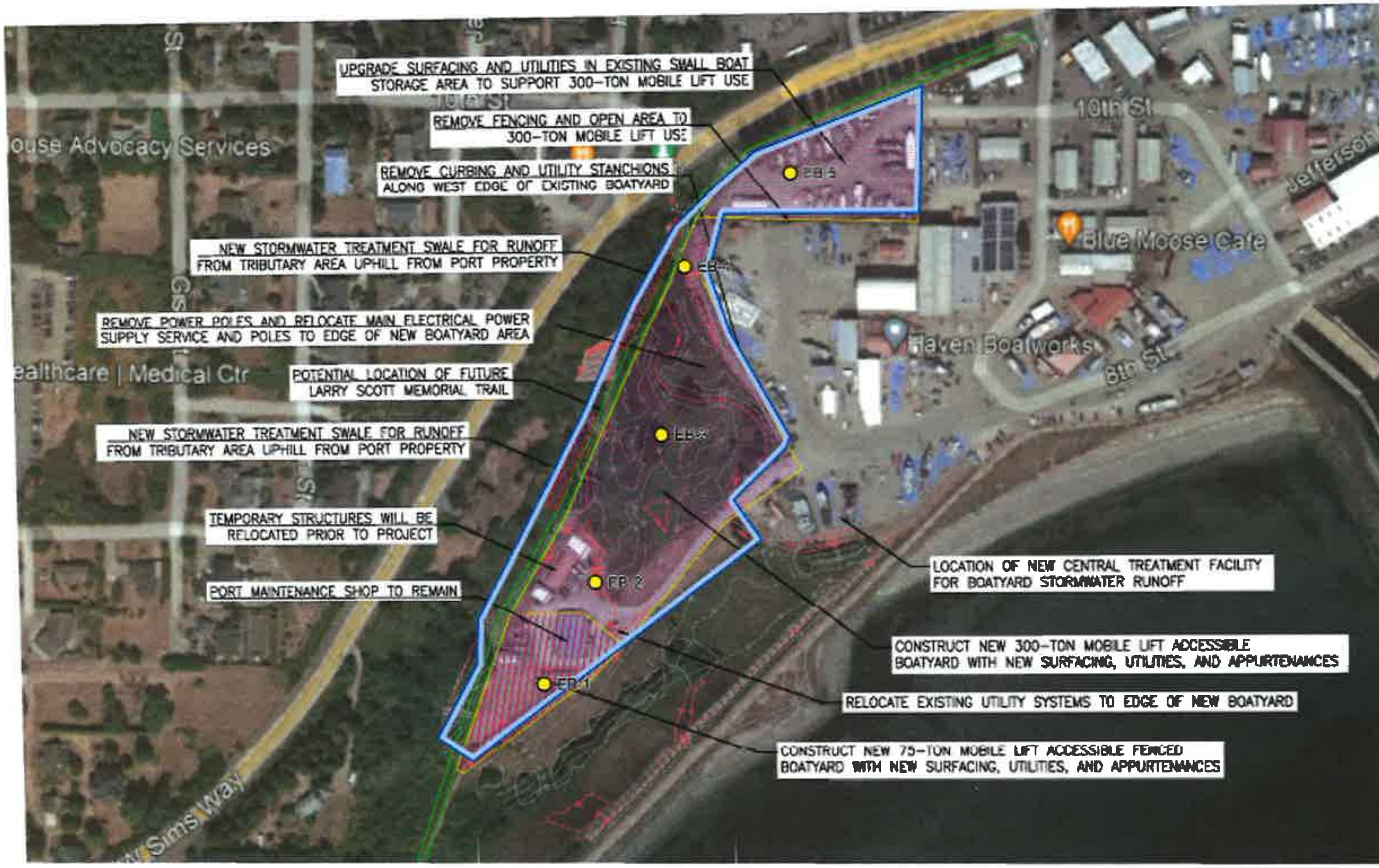
EXISTING SITE AND EXPLORATION PLAN

PORT OF PORT TOWNSEND WESTERN BOAT YARD EXPANSION
PORT TOWNSEND, WASHINGTON

PROJECT NO	DATE	FIGURE
20240066E001	5/24	2



LEGEND
SITE
EXPLORATION BORING

N
0 200
FEET

DATA SOURCES/REFERENCES
REID MIDDLETON, PORT OF PORT TOWNSEND BOATYARD EXPANSION, SITE PLAN, SHEET C1.0, 4/15/2024.

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION. LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

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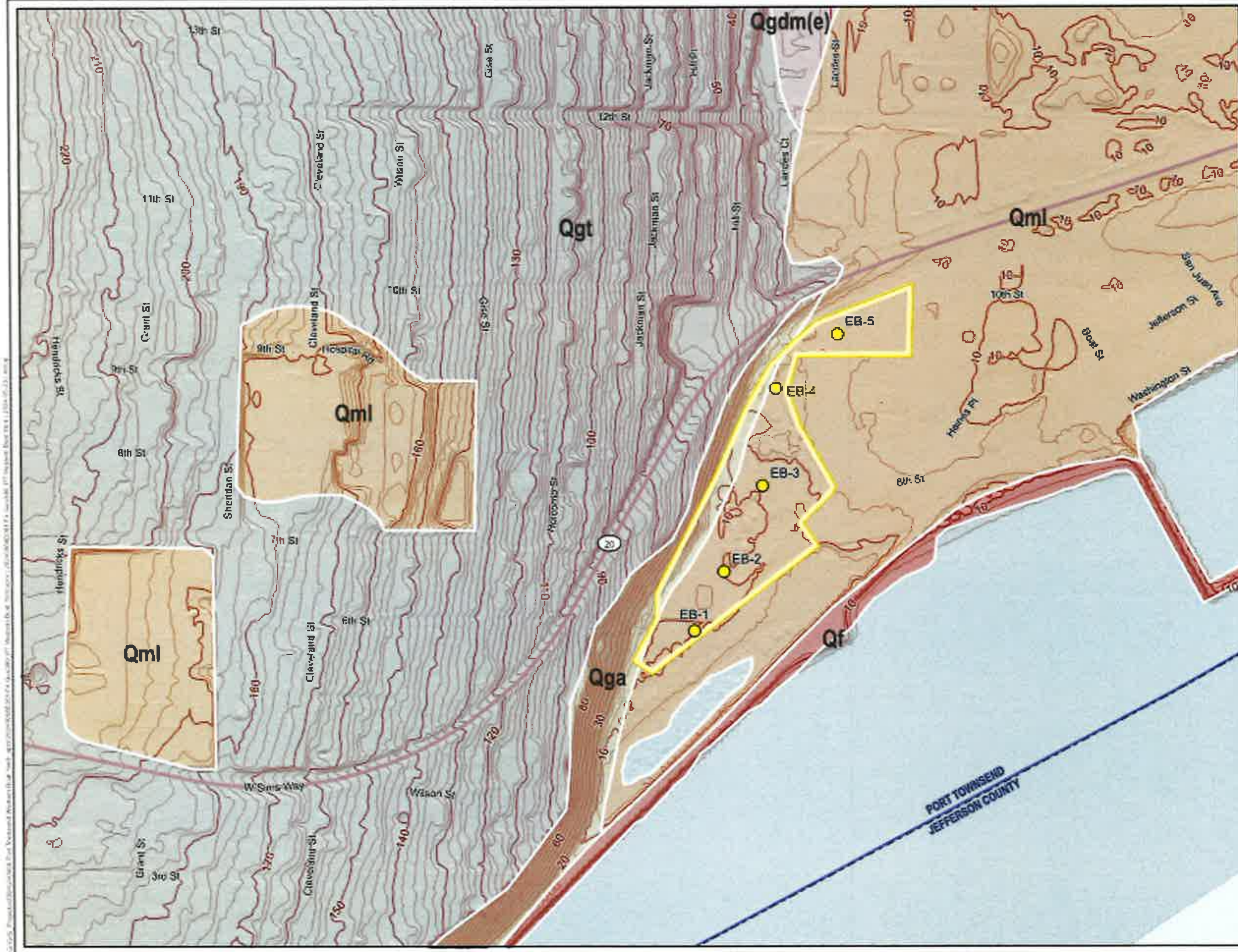
PROPOSED IMPROVEMENTS AND EXPLORATION LOCATIONS

PORT OF PORT TOWNSEND WESTERN BOAT YARD EXPANSION
PORT TOWNSEND, WASHINGTON

PROJECT NO.	DATE	FIGURE
20240066E001	5/24	3



LEGEND

- SITE
- EXPLORATION BORING
- CONTOUR 10 FT
- CONTOUR 2 FT
- CITY BOUNDARY

GEOLOGIC UNIT

- **Qf**: FILL
- **Qml**: MODIFIED LAND
- **Qgdm(e)**: EVERSON GLACIOMARINE DRIFT
- **Qgt**: VASHON LODGEMENT TILL
- **Qga**: VASHON ADVANCE OUTWASH
- WATER

N

0 300

FEET

DATA SOURCES/REFERENCES:
JEFFERSON COUNTY: ROADS (4/24), CITIES (4/24). EAGLEVIEW TECHNOLOGIES, INC.: AERIAL IMAGERY (2021). WSDOT STATE ROUTES 24K (12/20). WA DNR: SURFACE GEOLOGY (3/23), OLYMPICS_SOUTH_OPSW_2019 ACQUIRED BETWEEN SEPT 2017 AND APRIL 2019, CELL SIZE 3'. CONTOURS DERIVED FROM LIDAR.

BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION. LOCATION AND DISTANCES SHOWN ARE APPROXIMATE.

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REGIONAL GEOLOGY AND LIDAR-BASED SHADED RELIEF

FORT OF PORT TOWNSEND WESTERN BOAT YARD EXPANSION
PORT TOWNSEND, WASHINGTON

PROJECT NO	DATE	FIGURE
20240066E001	5/24	4

APPENDIX A

Exploration Logs

				Symbol	Description
Coarse-Grained Soils - More than 50%(1) Retained on No. 200 Sieve	Gravels - More than 50%(1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines(2)		GW	Well-graded gravel and gravel with sand, little to no fines
				GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥12% Fines(2)		GM	Silty gravel and silty gravel with sand
				GC	Clayey gravel and clayey gravel with sand
	Sands - 50%(1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines(2)		SW	Well-graded sand and sand with gravel, little to no fines
				SP	Poorly-graded sand and sand with gravel, little to no fines
		≥12% Fines(2)		SM	Silty sand and silty sand with gravel
				SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50%(1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50			ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
				CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
				OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More			MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
				CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
				OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils				PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT(3) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT(3) blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

- G = Grain Size
- M = Moisture Content
- A = Atterberg Limits
- C = Chemical
- DD = Dry Density
- K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

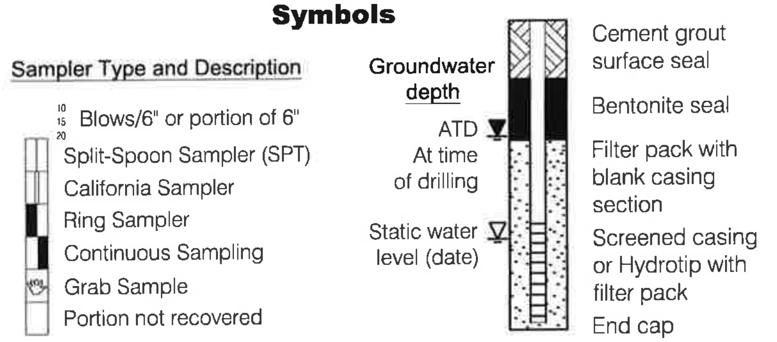
(4) Estimated Percentage

Component	Percentage by Weight
Trace	<5
Some	5 to <12
Modifier (silty, sandy, gravelly)	12 to <30
Very *modifier* (silty, sandy, gravelly)	30 to <50

Moisture Content

- Dry - Absence of moisture, dusty, dry to the touch
- Slightly Moist - Perceptible moisture
- Moist - Damp but no visible water
- Very Moist - Water visible but not free draining
- Wet - Visible free water, usually from below water table

Symbols



Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

(1) Percentage by dry weight
(2) Combined USCS symbols used for fines between 5% and 12%
(3) (SPT) Standard Penetration Test (ASTM D-1586)
(4) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

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EXPLORATION LOG KEY

FIGURE: A1

Blocks\ dwg \ log_key 2022.dwg LAYOUT: Layout 5 - 2022 Logdraft

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Exploration Boring EB-1

Port of Port Townsend Western Boat Yard Expansion — Sheet: 1 of 1

Port Townsend, WA	Start Date: 4/15/24	Logged By: BCY
20240066E001	Ending Date: 4/15/24	Approved By: JHS

Driller/Equipment: ADT / D-50 Hollow Stem Auger
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
Groundwater Depth ATD (ft): 5.6

Total Depth (ft): 21.5
Ground Surface Elevation (ft): ≈10
Datum: NAVD 88
Groundwater Depth Post Drilling (ft) (Date): ()

Depth (ft)	Sample	Description	Water Level	Blows/6"	Blows/Foot
0		**Sod/Topsoil - 3 inches**			
		Fill			
3	1	Upper 6 inches: Slightly moist, brown, fine SAND, some silt, trace gravel; scattered organics (rootlets) (SP-SM).		6 4 7	11
		Holocene Beach Deposits			
		Lower 12 inches: Moist, gray, fine to medium SAND, some gravel, trace silt; occasional shell fragments (SP).			
	2	Wet, gray, fine SAND, some gravel, trace to some silt; heavily organic, silty, sand in tip at 5 feet (SP-SM).	▼	6 5 7	12
6	3	Wet, gray, fine SAND, trace silt, trace gravel (SP).		5 4 5	9
9	4	As above; no gravel. Driller adding water.		3 4 5	9
12					
15	5	Wet, gray, fine SAND, trace gravel, trace silt; occasional medium sand (SP).		7 6 4	10
18		**Holocene Beach Deposits (?) / Pre-Fraser Undifferentiated (?)**			
21	6	Wet, gray, fine SAND, trace silt; massive; blow count overstated; sampler overfilled; micaceous (SP).		13 21 29	50

Groundwater encountered at 5.6 feet ATD. Soil heaving from 15 to 20 feet. Tide was in.

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Exploration Boring EB-2

Port of Port Townsend Western Boat Yard Expansion — Sheet: 1 of 1

Port Townsend, WA	Start Date: 4/15/24	Logged By: BCY
20240066E001	Ending Date: 4/15/24	Approved By: JHS

Driller/Equipment: ADT / D-50 Hollow Stem Auger
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
Groundwater Depth ATD (ft): 5.8

Total Depth (ft): 21.5
Ground Surface Elevation (ft): ≈10
Datum: NAVD 88
Groundwater Depth Post Drilling (ft) (Date): ()

Depth (ft)	Sample Type	Sample	% Recovery	Graphic Symbol	Description	Water Level	Blows/6"	Blows/Foot	Other Tests
0					**Gravel Surfacing - 4 inches**				
					Fill				
3		1			Slightly moist, brown, gravelly, SAND, trace silt (SP). Transitioning to black fine sand for bottom 6 inches.		5 4 5	9	
					Holocene Beach Deposits				
		2			Wet, gray, gravelly, fine to medium SAND, some silt; massive (SP-SM).	▼	4 8 9	17	
6					Driller notes gravelly drill action from 6 to 7.5 feet.				
		3			Wet, gray, fine to medium SAND, some gravel, trace to some silt; auger bouncing on gravel; blow counts overstated (SP-SM).		17 20 20	40	
9		4			Wet, gray, predominately fine SAND, some gravel, trace to some silt; massive (SP-SM). Driller adding water.		9 11 15	26	
12									
15		5			Wet, gray, fine SAND, trace silt; massive (SP).		5 6 9	15	
18					Driller notes gravel chatter increasing.				
21		6			Wet, gray, fine SAND, some gravel, trace silt; blow counts may be overstated due to gravel or heave (SP).		13 20 21	41	
					Groundwater encountered at 5.8 feet ATD. Tide was in.				

associated earth sciences incorporated

Exploration Boring EB-3

Port of Port Townsend Western Boat Yard Expansion — Sheet: 1 of 1

Port Townsend, WA	Start Date: 4/15/24	Logged By: BCY
20240066E001	Ending Date: 4/15/24	Approved By: JHS

Driler/Equipment: ADT / D-50 Hollow Stem Auger
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
Groundwater Depth ATD (ft): 5.6

Total Depth (ft): 21
Ground Surface Elevation (ft): ≈9
Datum: NAVD 88
Groundwater Depth Post Drilling (ft) (Date): ()

Depth (ft)	Sample	Description	Water Level	Blows/6"	Blows/Foot
0	1	**Sod/Topsoil - 4 inches**			
		Fill			
		Slightly moist, black, organic, fine SAND, some gravel, some silt; abundant organics (SP-SM).		2 3 3	6
3	2	Very moist, black to dark gray, gravelly, SAND, some silt; abundant rootlets and wood debris; organic content of soil =20% (SP-SM).		3 4 6	10
6	3	Wet, gray, GRAVEL, some fine to medium sand, trace silt; occasional inclusions of dark brown to black, silty, fine sand, abundant organics; broken gravel in split spoon (GP-GM).	▼	11 12 12	24
	4	As above; poor recovery; pushing on large gravel.		11 15 21	36
9		**Holocene Beach Deposits**			
	5	Wet, gray, fine to medium SAND, some gravel, trace silt; rare shell fragments (SP). Driller adding water.		9 10 11	21
12					
15	6	Wet, gray, fine to medium SAND, trace silt; scattered shell fragments (SP).		9 10 12	22
18		Heavy gravel chatter.			
		Pre-Fraser Undifferentiated			
	7	Moist, light gray, silty, fine SAND, trace to some gravel; micaceous; unsorted (SM).		21 50/6"	50/6"
21		Groundwater encountered at 5.6 feet ATD. Tide was in.			

Columns also include: Sample Type, % Recovery, Graphic Symbol, Other Tests. Blows/Foot scale: 10, 20, 30, 40, 50+.

5/23/2024
20240066E001

associated earth sciences incorporated

Exploration Boring EB-4

Port of Port Townsend Western Boat Yard Expansion — Sheet: 1 of 1

Port Townsend, WA	Start Date: 4/15/24	Logged By: BCY
20240066E001	Ending Date: 4/15/24	Approved By: JHS

Driller/Equipment: ADT / D-50 Hollow Stem Auger
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
Groundwater Depth ATD (ft): 5.3
Total Depth (ft): 21
Ground Surface Elevation (ft): ≈9
Datum: NAVD 88
Groundwater Depth Post Drilling (ft) (Date): ()

Depth (ft)	Sample	Description	Water Level	Blows/6"	Blows/Foot
0	1	**Sod/Topsoil - 2 inches** **Fill** Slightly moist, brown, gravelly, SAND, some silt; scattered organics (rootlets/ fine organics) (SP-SM).		3 9 14	23
	2	Upper 12 inches: As above, slightly moist. Lower 6 inches: Slightly moist, gray, fine SAND (SP).		6 8 10	18
3					
	3	Very moist to wet, tan to gray, fine SAND, trace silt; brown, silty, fine sand observed in tip of spoon with scattered organics (rootlets); strong septic odor (SP).	▼	3 2 3	5
6					
	4	Wet, dark brown, silty, SAND, some gravel; abundant organics; becoming dark gray, sandy, gravel, trace silt; scattered organics; strong septic odor (SM).		3 5 7	12
9					
	5	**Holocene Beach Deposits** Driller adding water. Wet, gray, fine to medium SAND, some gravel, trace silt; scattered shell fragments; scattered organics (grass/reeds) (SP).		7 8 11	19
12					
15	6	**Pre-Fraser Undifferentiated** Very moist, gray, silty, fine SAND, some gravel; occasional interbed (less than 2 inches thick) of gray, fine sandy, silt; unsorted (SM).		5 29 38	67
18					
	7	Wet, gray, very silty, fine SAND; rare gravel; micaceous; massive (SM).		9 50/6"	50/6"
21		Groundwater encountered at 5.3 feet ATD. Tide was in.			

5/23/2024
20240066E001

associated earth sciences incorporated

Exploration Boring EB-5

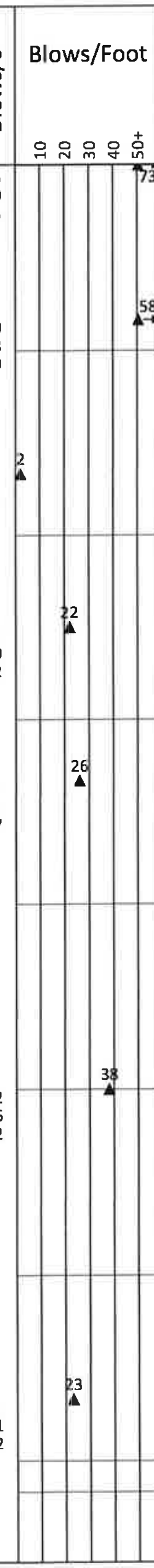
Port of Port Townsend Western Boat Yard Expansion — Sheet: 1 of 1

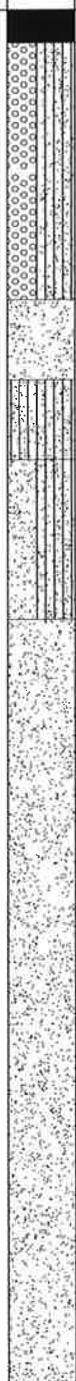
Port Townsend, WA	Start Date: 4/15/24	Logged By: BCY
20240066E001	Ending Date: 4/15/24	Approved By: JHS

Driller/Equipment: ADT / D-50 Hollow Stem Auger
Hammer Weight/Drop: 140#/30"
Hole Diameter (in): 6
▼ Groundwater Depth ATD (ft): 5.2

Total Depth (ft): 21.5
Ground Surface Elevation (ft): ≈10
Datum: NAVD 88
▽ Groundwater Depth Post Drilling (ft) (Date): ()

Depth (ft)	Sample	Description	Water Level	Blows/6"	Blows/Foot
0	1	**Gravel Surfacing - 6 inches**		25 40 33	73
		Fill Dry to slightly moist, brown, very gravelly, fine to coarse SAND, some silt; broken gravel in tip of spoon; blow counts overstated (SW-SM).			
3	2	Dry to slightly moist, brown to tan, very gravelly, SAND, some silt; broken gravel in spoon; blow counts may be overstated (SW-SM).		40 38 20	58
	3	Upper 9 inches: Wet, gray, fine SAND, trace silt (SP).	▼	1 1 1	2
6		Lower 9 inches: Black organic soil with layer (1.5 inches thick) of brown, silty, fine SAND, some gravel (SM).			
	4	Water added. Wet, brownish gray, gravelly, fine SAND, some silt; increase in gravel with depth; broken gravel in spoon, blow counts overstated (SP-SM).		9 10 12	22
9	5	**Holocene Beach Deposits** Wet, gray, fine SAND, some gravel, trace silt; scattered to abundant shells (SP). Driller adding water.		5 9 17	26
12					
15	6	Poor recovery, trace amounts of sand in sampler.		12 16 22	38
18					
21	7	Wet, gray, fine SAND, some gravel, trace silt; scattered to abundant shells (SP).		9 11 12	23



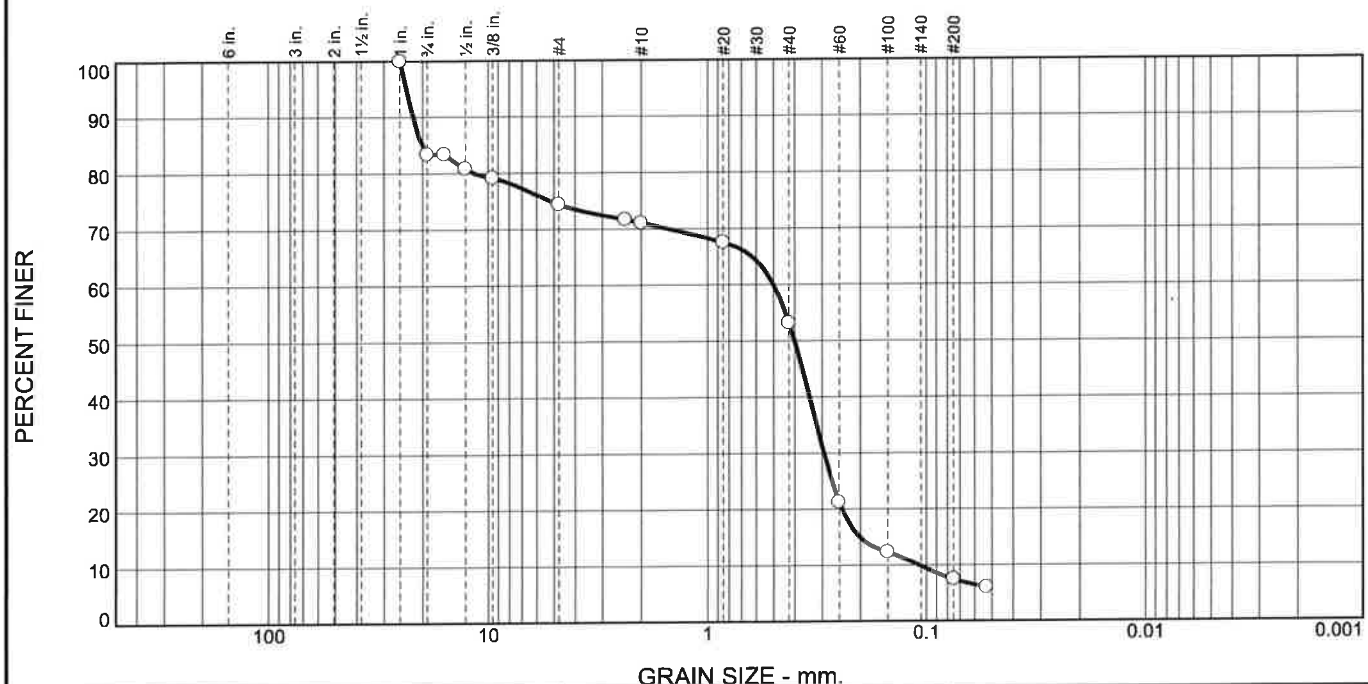


Groundwater encountered at 5.2 feet ATD.
Tide was in.

APPENDIX B

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	16.6	9.0	3.4	17.8	45.7	7.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	83.4		
5/8"	83.4		
1/2"	80.8		
3/8"	79.2		
#4	74.4		
#8	71.7		
#10	71.0		
#20	67.5		
#40	53.2		
#60	21.2		
#100	12.4		
#200	7.5		
#270	6.1		

* (no specification provided)

Material Description

gravelly SAND some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 22.1419 D_{85}= 20.1334 D_{60}= 0.5017
D_{50}= 0.4011 D_{30}= 0.2941 D_{15}= 0.2017
D_{10}= 0.1077 C_u= 4.66 C_c= 1.60

Remarks

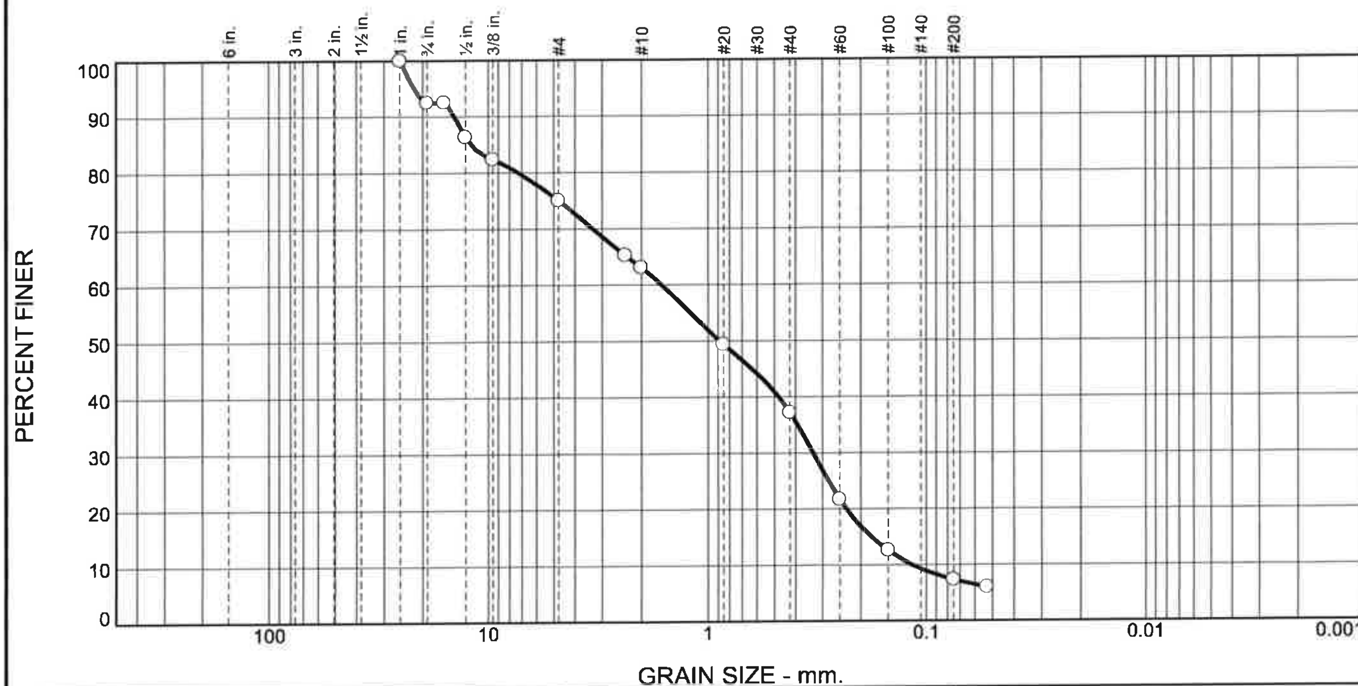
Date Received: 5-7-2024 **Date Tested:** 5-10-2024
Tested By: FEW
Checked By: BCY/BD
Title:

Location: Onsite
Sample Number: EB-3 **Depth:** 2.5-4'
Date Sampled: 4-15-2024

associated earth sciences incorporated

Client: Reid Middleton
Project: Port of Port Townsend Western Boat Yard Expansion
Project No: 20240066 E001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	7.5	17.5	12.0	25.8	29.9	7.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	92.5		
5/8"	92.5		
1/2"	86.3		
3/8"	82.3		
#4	75.0		
#8	65.2		
#10	63.0		
#20	49.4		
#40	37.2		
#60	21.7		
#100	12.5		
#200	7.3		
#270	6.0		

* (no specification provided)

Material Description

gravelly SAND some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 14.2780 D_{85}= 12.0324 D_{60}= 1.6287
D_{50}= 0.8859 D_{30}= 0.3314 D_{15}= 0.1796
D_{10}= 0.1164 C_u= 13.99 C_c= 0.58

Remarks

Date Received: 5-7-2024 **Date Tested:** 5-10-2024

Tested By: FEW

Checked By: BCY/BD

Title:

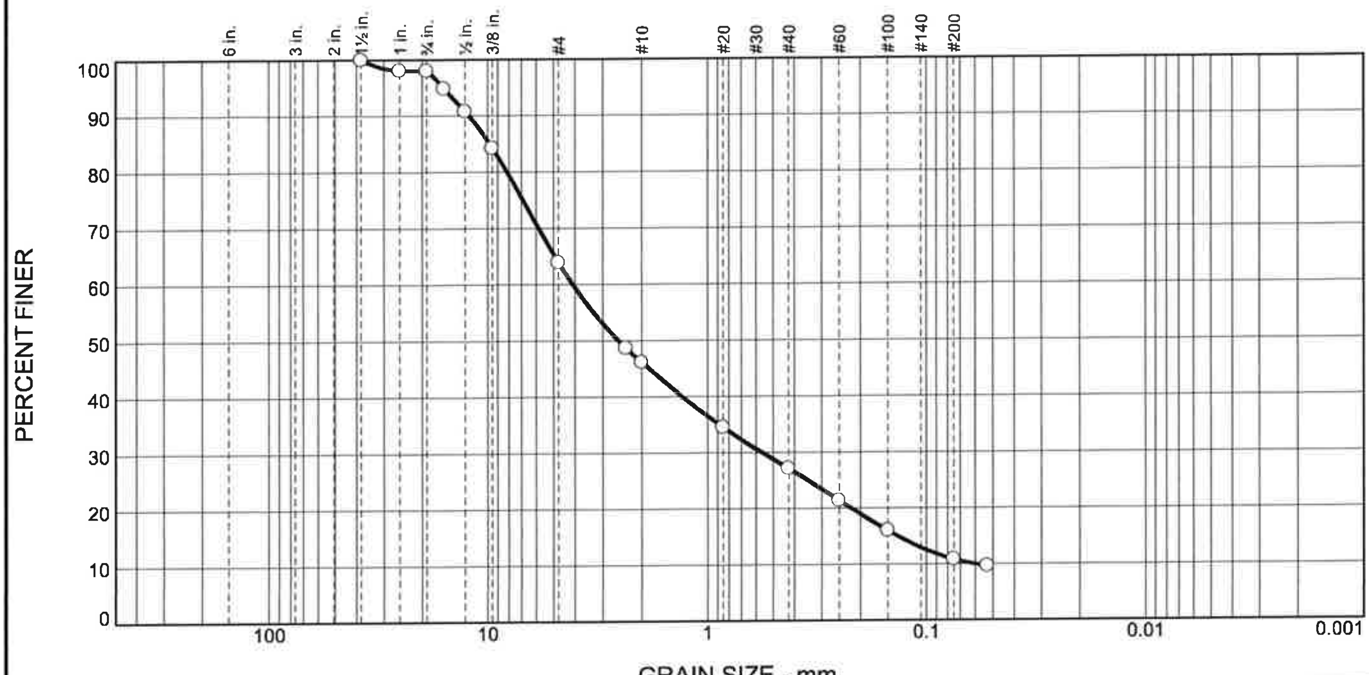
Location: Onsite
Sample Number: EB-4 **Depth:** 0-1.5'
Date Sampled: 4-15-2024

associated earth sciences incorporated

Client: Reid Middleton
Project: Port of Port Townsend Western Boat Yard Expansion

Project No: 20240066 E001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.0	34.1	17.8	19.0	16.3	10.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100.0		
1"	98.0		
3/4"	98.0		
5/8"	94.8		
1/2"	90.8		
3/8"	84.2		
#4	63.9		
#8	48.7		
#10	46.1		
#20	34.5		
#40	27.1		
#60	21.4		
#100	16.0		
#200	10.8		
#270	9.6		

* (no specification provided)

Material Description

very gravelly SAND some silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=**

Classification

USCS (D 2487)= SW-SM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 12.2126 D_{85}= 9.8103 D_{60}= 4.1034
D_{50}= 2.5552 D_{30}= 0.5615 D_{15}= 0.1349
D_{10}= 0.0599 C_u= 68.48 C_c= 1.28

Remarks

Date Received: 5-7-2024 **Date Tested:** 5-10-2024

Tested By: FEW

Checked By: BCY/BD

Title:

Location: Onsite
Sample Number: EB-5 **Depth:** 0'-1.5'
Date Sampled: 4-15-2024

associated earth sciences incorporated

Client: Reid Middleton
Project: Port of Port Townsend Western Boat Yard Expansion

Project No: 20240066 E001 **Figure**

associated earth sciences incorporated

Moisture, Ash, and Organic Matter of Peat and Other Organic Soils - ASTM 2974

Date Sampled	Project	Project No.		Soil Description
4/15/2024	Port of Port Townsend Western Boat Yard Expansion	20240066 E001		Black to dark gray, gravelly SAND, some silt (SP-SM)
Tested By	**Location**	**EB/EP No.**	**Depth**	
FEW		EB-3	2.5-4'	

Moisture Content

Sample ID	**EB-3 @ 2.5-4'**
Wet Weight + Pan	**745.7**
Dry Weight + Pan	**674.7**
Weight of Pan	**357.9**
Weight of Moisture	**71.0**
Dry Weight of Soil	**316.8**
% Moisture	**22.4**

Organic Matter and Ash Content

Dry Soil Before Burn + Pan	**745.7**
Dry Soil After Burn + Pan	**666.5**
Weight of Pan	**357.9**
Wt. Loss Due to Ignition	**79.2**
Actual Wt. Of Soil After Burn	**308.5**
% Organics	**20.4**

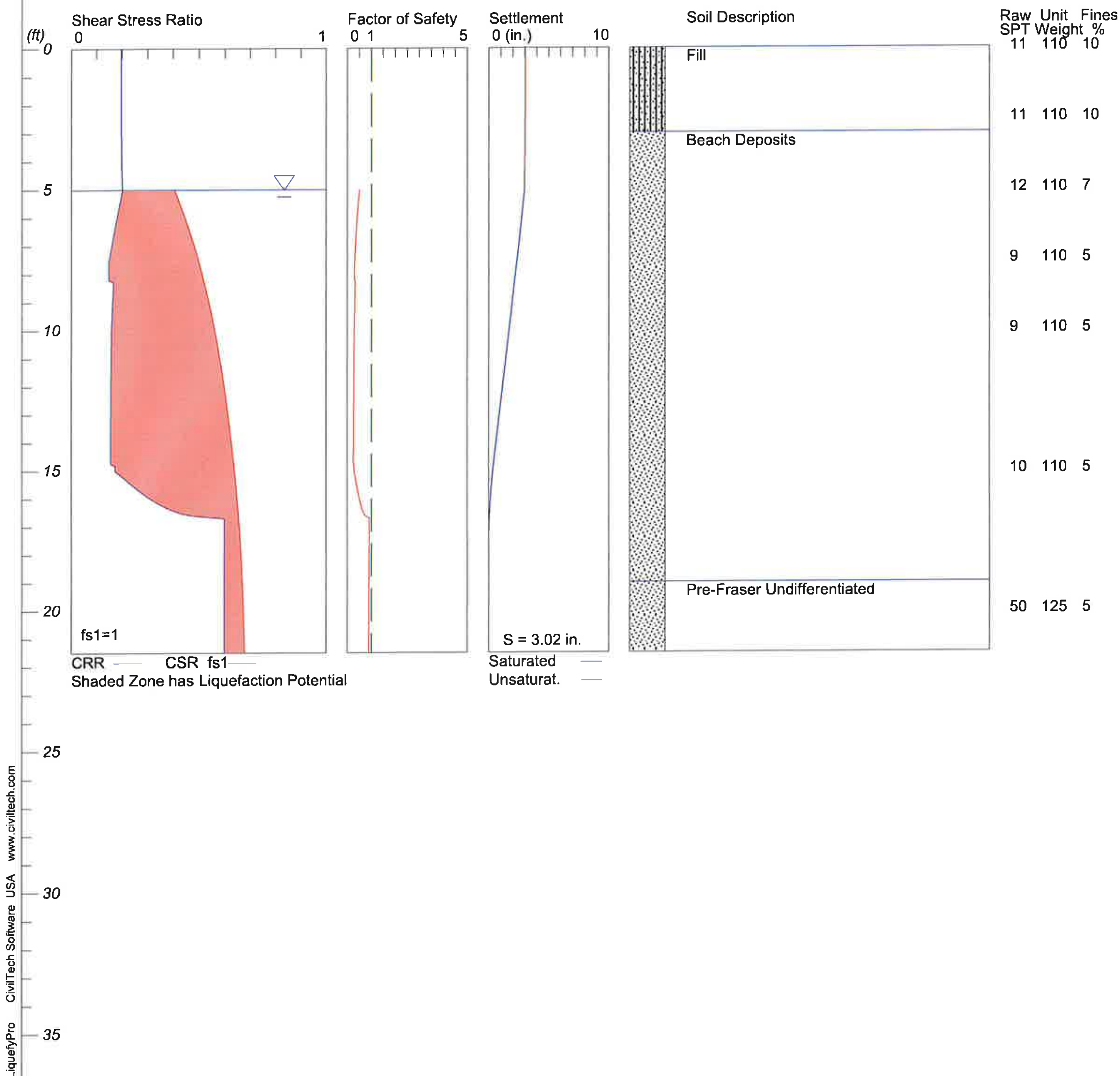
APPENDIX C

Liquefaction Analysis Results

LIQUEFACTION ANALYSIS

Port of Port Townsend Western Boat Yard Expansion

Hole No.=EB-1 ***Water Depth=5 ft*** ***Surface Elev.=10*** ***Magnitude=7.0***
Acceleration=0.63g

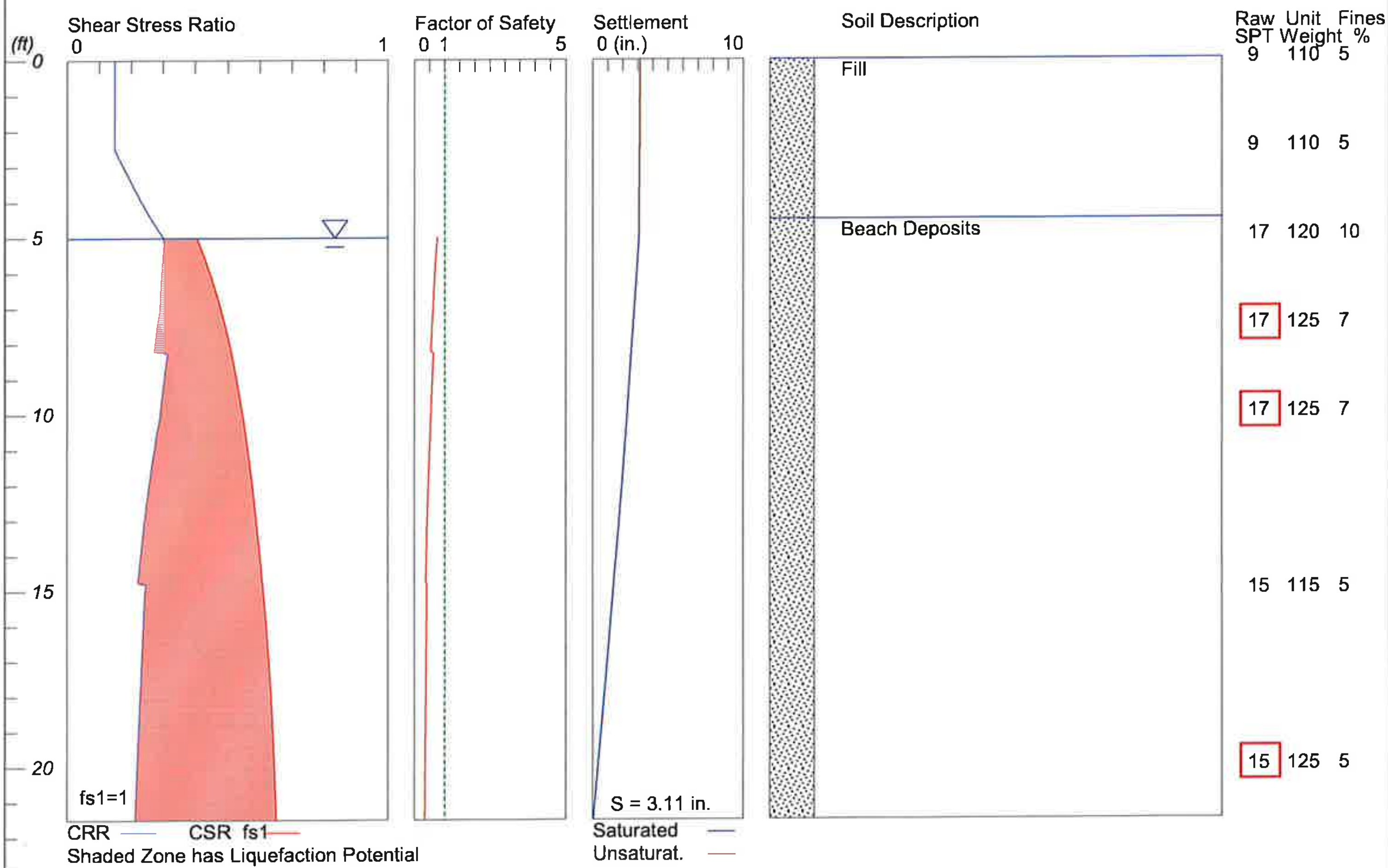


LIQUEFACTION ANALYSIS

Port of Port Townsend Western Boat Yard Expansion

Hole No.=EB-2 Water Depth=5 ft Surface Elev.=10

Magnitude=7.0
Acceleration=0.63g



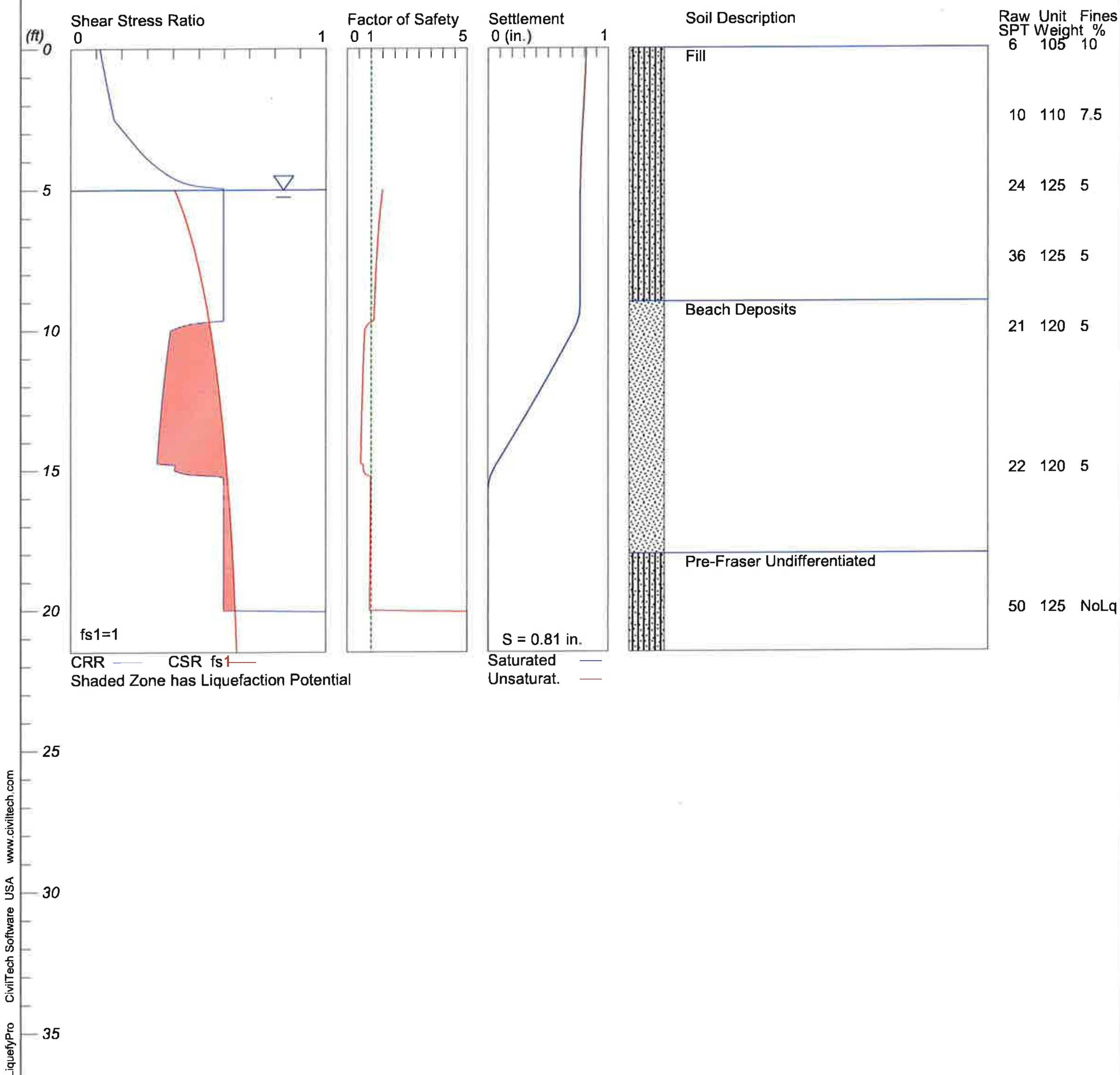
Note: SPT N-values outlined in red were adjusted to account for overstated blow counts due to soil heave or elevated gravel content.

LIQUEFACTION ANALYSIS

Port of Port Townsend Western Boat Yard Expansion

Hole No.=EB-3   Water Depth=5 ft   Surface Elev.=9

Magnitude=7.0
Acceleration=0.63g

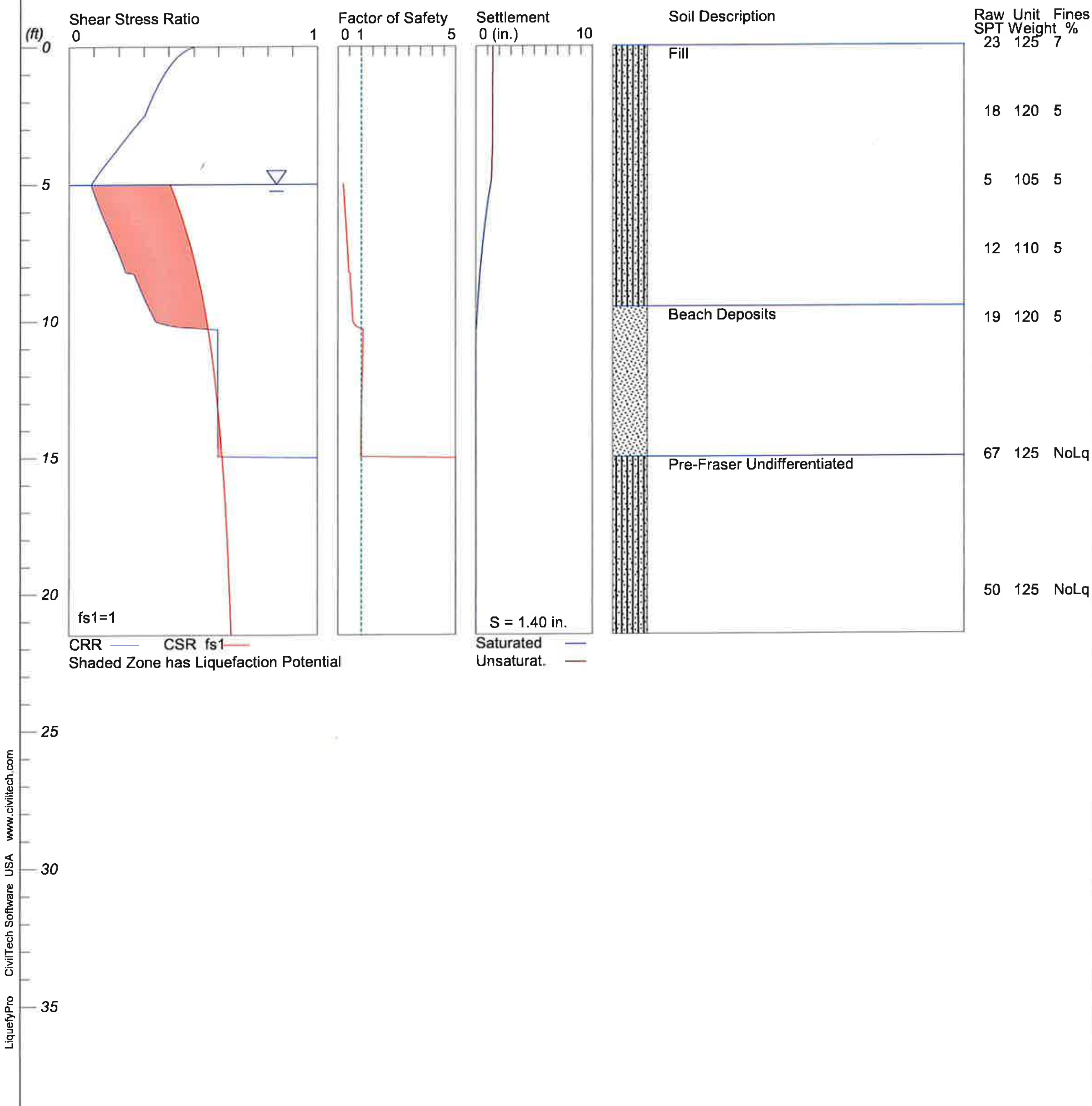


LIQUEFACTION ANALYSIS

Port of Port Townsend Western Boat Yard Expansion

Hole No.=EB-4 Water Depth=5 ft Surface Elev.=9

Magnitude=7.0
Acceleration=0.63g

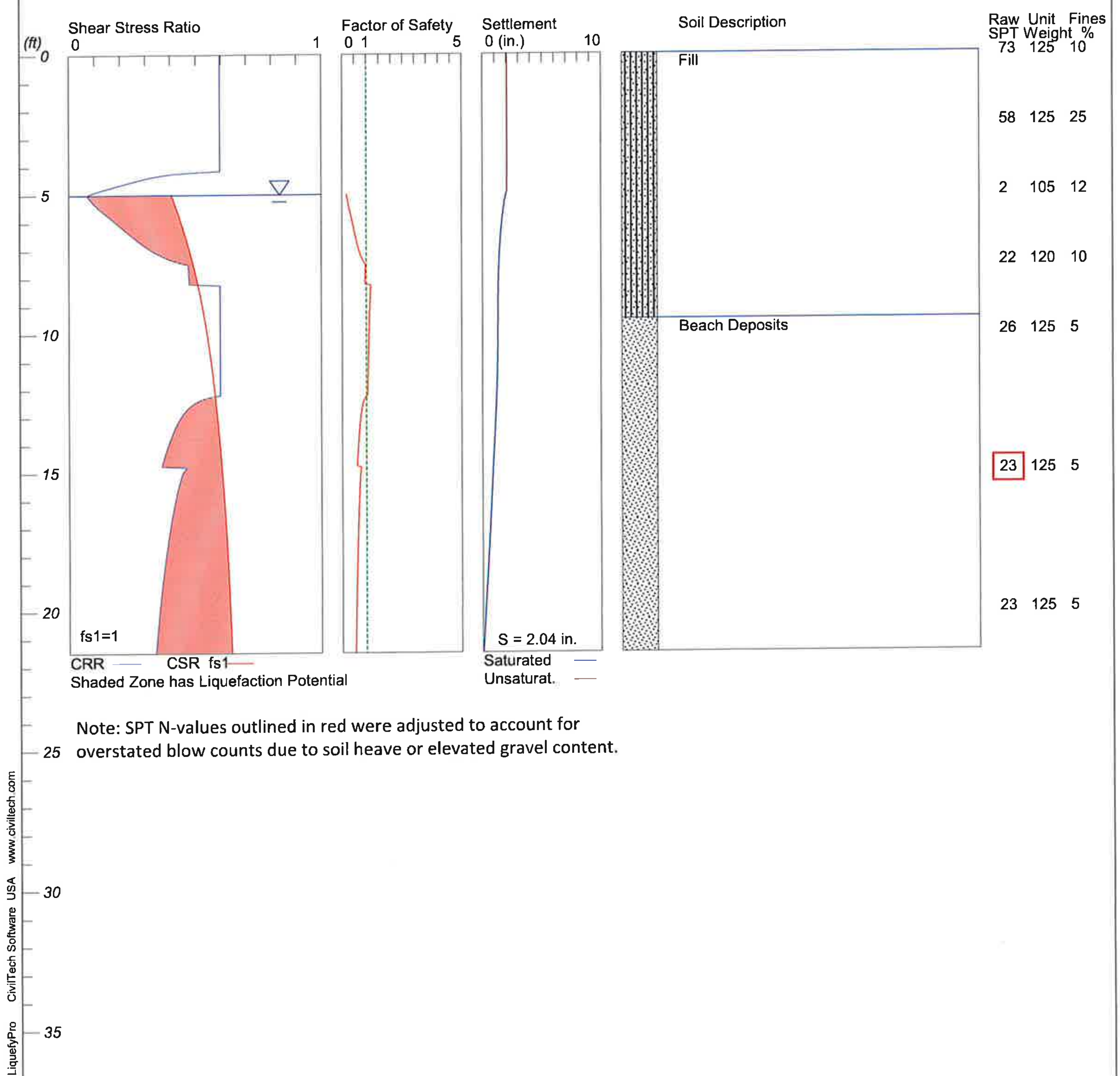


LIQUEFACTION ANALYSIS

Port of Port Townsend Western Boat Yard Expansion

Hole No.=EB-5   Water Depth=5 ft   Surface Elev.=10

Magnitude=7.0
Acceleration=0.63g



Note: SPT N-values outlined in red were adjusted to account for overstated blow counts due to soil heave or elevated gravel content.

CivilTech Corporation

Plate A-1