SEISMIC RISK ASSESSMENT

Zenith Portland Terminal—Remaining Structures
5501 NW Front Avenue
Portland, Oregon

For
Zenith Energy Management LLC
May 30, 2024

Project: Zenith-4-01

NV5

May 30, 2024

Zenith Energy Management LLC
5501 NW Front Avenue
Portland, OR 97210

Attention: Carlos Munguia

Seismic Risk Assessment
Zenith Portland Terminal—Remaining Structures
5501 NW Front Avenue
Portland, Oregon
Project: Zenith-4-01

NV5 is pleased to submit this report that documents our seismic risk assessment for existing tanks and structures at the Zenith Portland Terminal in Portland, Oregon. Our services were conducted in accordance with our revised proposal dated September 25, 2023.

We appreciate the opportunity to be of continued service to you. Please contact us if you have questions regarding this report.

Sincerely,

NV5

Scott V. Mills, P.E., G.E.
Principal Engineer

cc: Mark Colvin, Zenith Energy Management LLC

TAP:SVM:sn
Attachments
One copy submitted
Document ID: Zenith-4-01-053024-geor.docx

EXECUTIVE SUMMARY

This report presents the results our seismic risk assessment of the Zenith bulk fuel terminal located at 5501 NW Front Avenue in Portland, Oregon, within the Oregon Critical Energy Infrastructure Hub. The study was conducted using the provisions in the 2019 SOSSC and API 650 Annex E “Seismic Design for Storage Tanks.” Both of these documents refer to the ASCE 7-16 Standard. The seismic events used in this risk assessment and structural review include “The Big One,” a magnitude 9.0 earthquake that could occur on the CSZ where the Juan de Fuca Plate is being subducted beneath the North American Plate. It also considered all other regional and local events included in the USGS fault database that could affect the facility.

As a result of our seismic study of all regional and local seismic events, NV5 determined the following:

- The largest amount of liquefaction-induced settlement is computed to be between 4 and 9 inches under design levels of ground shaking. Differential settlement of one-half the total predicted settlement (approximately 2 to 4.5 inches) and is expected over a distance of 50 feet. This is of low risk to large-diameter storage tank and similar large structures.
- Lateral spreading is not considered a site hazard.
- Structural analyses for Tanks 63, 105, 127, and 130; a building; and the containment walls are provided in the previous reports, which are included in presented in Appendix B.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BGS	below ground surface
CPT	cone penetration test
CRBG	Columbia River Basalt Group
CSZ	Cascadia subduction zone
fps	feet per second
g	gravitational acceleration (32.2 feet/second^2)
H:V	horizontal to vertical
km	kilometers
Ma	million years ago
MCE	maximum considered earthquake
MCE_R	risk-targeted maximum considered earthquake
mm	millimeter
PGA_M	maximum considered earthquake geometric mean peak ground acceleration adjusted for site effects
SOSSC	State of Oregon Structural Specialty Code
SPT	standard penetration test
USGS	U.S. Geological Survey
Vs_{30}	shear wave velocity for the upper 100 feet (30 meters)

1.0 INTRODUCTION

The Zenith Portland Terminal is a 31.3-acre bulk fuel terminal located at 5501 NW Front Avenue in Portland, Oregon. The terminal is occupied by numerous storage tanks and buildings. NV5 has previously performed studies for Tanks 63, 105, 127, and 130; a building; and the containment walls in reports dated May 29, 2020, and July 14, 2022. Figure 1 shows the site location relative to existing physical features. Figure 2 shows the location of our explorations in relation to the tanks and the on-site structures.

Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents. All elevations included in this report are relative to City of Portland datum.

2.0 SCOPE OF SERVICES

NV5 conducted a seismic geotechnical analysis for use in assessing the structures. Our specific scope of services is presented as follows:

- Reviewed readily available, published geologic data and our in-house files for existing information on subsurface conditions in the site vicinity and our previous explorations at nearby surrounding sites.
- Explored subsurface conditions by conducting six additional CPTs within the Zenith Portland Terminal to depths between 52.2 and 76.6 feet BGS at the locations shown on Figure 2.
- Assessed the following seismic hazards:
    - Surface fault rupture
    - Liquefaction and lateral spreading
    - Ground shaking and ground motion amplification
- Provided a site response spectrum for use in computing seismic forces on the structures and tanks in accordance with the 2019 SOSSC and ASCE 7-16.
- Prepared this report documenting our findings.

3.0 SITE DESCRIPTION

3.1 GEOLOGIC CONDITIONS

The Portland-Vancouver metropolitan area is situated within the Puget-Willamette Trough physiographic province, a north-south structural basin lying between the Coast Ranges to the west and the Cascade Range to the east. The Zenith Portland Terminal is in the extreme western part of the Portland Basin physiographic province. The Portland Basin, a major component of the Willamette Trough, is a subsided lowland formed through northeast-directed compression due to large-scale plate movement and subduction and right-lateral extension along a series of faults reaching from central Oregon, across the Cascades, and into the lower Willamette Valley (for general discussion, see Burns, 1998; Orr and Orr, 1999).

The site is northeast of the Tualatin Mountains, an uplifted block of Columbia River Basalt on the southwestern edge of the Portland Basin. The soil underlying the site is primarily recent alluvial deposits of the Willamette River and dredged fill material placed early in the 20th century. The fill generally consists of dredged sand from the Columbia and Willamette rivers.

3.2 SURFACE CONDITIONS

The Zenith Portland Terminal is in Portland's Northwest Industrial Area. The 31.3-acre bulk fuel terminal is bound by NW Doane Avenue to the northwest, NW Front Avenue to the northeast, railroad track to the southwest, and NW St. Helens Road farther to the southwest. Figure 2 shows the site location relative to existing physical features. Industrial buildings are southeast of the terminal. The terminal is occupied by numerous aboveground storage tanks and buildings. The site is essentially flat.

3.3 SUBSURFACE CONDITIONS

Our knowledge of site subsurface conditions is based on six additional CPTs (CPT-3 through CPT-8) and previous on-site explorations at the approximate locations shown on Figure 2. The CPT logs are presented in Appendix A. Our previous reports, which include the prior explorations, are presented in Appendix B. The site generally consists of fill underlain by alluvium. The following sections provide a detailed description of the subsurface conditions.

3.3.1 Fill

Fill was encountered to depths between approximately 4 and 27 feet BGS in CPT-3 through CPT-8. The fill generally consists of silty/clayey sand or sandy silt/clay. SPTs and CPT results show that the silty/clayey sand vary in relative density between loose and medium dense and the sandy silt/clay is generally medium stiff.

3.3.2 Alluvium

Alluvium that consists of silt and clay with interbeds of sand underlies the fill to depths between 52.2 and 76.6 feet BGS in CPT-3 through CPT-8. Tip and shaft resistance shows that the alluvium varies between very soft and stiff.

3.3.3 Basalt Bedrock

Bedrock was encountered underlying the alluvium in all explorations to the maximum depths explored. From geotechnical explorations conducted for this study and from previous geotechnical investigations, bedrock is encountered at depths between 52.2 and 76.6 feet BGS.

3.3.4 Groundwater

Groundwater was measured at depths between 5 and 14 feet BGS using a pore pressure dissipation test. Prior explorations at the terminal encountered groundwater at a depth of 15 feet BGS. This is consistent with our experience in the site vicinity and our pore pressure dissipation test results.

4.0 SEISMIC HAZARDS

We conducted a seismic hazard assessment for use in evaluation of the on-site tanks and structures. The provisions of the 2019 SOSSC were used to assess the tanks and other on-site structures. The 2019 SOSSC refers to ASCE 7-16 for seismic design. Seismic design of petroleum tanks is typically conducted using Annex E of the API 650 Standard. The 12th edition of API 650 was current at the time of this report. API 650 also refers to the ASCE 7-16 Standard for seismic design.

4.1 SEISMIC SOURCES

4.1.1 Earthquake Source Zones

Three scenario earthquakes were considered for this study consistent with the local seismic setting. Two of the possible earthquake sources are associated with the CSZ, and the third event is a shallow, local crustal earthquake that could occur in the North American Plate. The three earthquake scenarios are discussed below.

4.1.2 Regional Events

The CSZ is the region where the Juan de Fuca Plate is being subducted beneath the North American Plate. This subduction is occurring in the coastal region between Vancouver Island and northern California. Evidence has accumulated suggesting that this subduction zone has generated eight great earthquakes in the last 4,000 years, with the most recent event occurring approximately 300 years ago (Weaver and Shedlock, 1991). The fault trace is mapped approximately 50 to 120 km off the Oregon Coast. Two types of subduction zone earthquakes are possible and considered in this study:

1. An interface event earthquake on the seismogenic part of the interface between the Juan de Fuca Plate and the North American Plate on the CSZ. This source is reportedly capable of generating an earthquake with a moment magnitude of 9.0.
2. A deep intraplate earthquake on the seismogenic part of the subducting Juan de Fuca Plate. These events typically occur at depths between 30 and 60 km. This source can generate an earthquake with a moment magnitude of up to 7.5.

Although a deep intraplate event can generate an earthquake with a magnitude of 7.5, ground shaking intensity will be controlled by an event on the Portland Hill fault even though it is only capable of generating a 6.8 to 7.0 magnitude earthquake. This is because of its proximity to the site and depth BGS. Shaking duration for CSZ interface is expected to be the longest. This study is based on USGS's probabilistic maps and considers all of these sources: crustal events, the CSZ deep intraplate event, and the CSZ interface event.

4.1.3 Local Events

A significant earthquake could occur on a local fault near the site within the design life of the facility. Such an event would cause ground shaking at the site that could be more intense than the CSZ events, although the duration would be shorter. Figure 3 shows the locations of mapped Quaternary faults within a 30-km radius of the terminal. Figure 4 shows the interpreted locations of recent seismic events (USGS, 2019). The three closest mapped faults to the site are the Portland Hills fault, East Bank fault, and Oatfield fault. A discussion of these faults is provided below. Table 1 lists the fault length and distance to the site.

Table 1. Closest Mapped Crustal Faults

Source	Closest Mapped Distance[1] (km)	Mapped Length[1] (km)
Portland Hills fault	< 0.5	49
East Bank fault	1.1	29
Oatfield fault	2.4	24

1. Reported by USGS (2019)

4.1.3.1 Portland Hills Fault

The northwest-striking Portland Hills fault forms the prominent linear northeastern margin of the Tualatin Mountains (Portland Hills) and the southwestern margin of the Portland Basin; this basin may be a right-lateral, pull-apart basin in the forearc of the CSZ or a piggyback synclinal basin formed between antiformal uplifts of the Portland fold belt. The fault is part of the Portland Hills-Clackamas River structural zone, which controlled the deposition of Miocene CRBG lavas in the region. The crest of the Portland Hills is defined by the northwest-striking Portland Hills anticline. The sense of displacement on the Portland Hills fault is poorly known and controversial. The fault was originally mapped as a down-to-the-northeast normal fault. The fault has also been mapped as part of a regional-scale zone of right-lateral, oblique-slip faults and as a steep escarpment caused by asymmetrical folding above a southwest-dipping blind thrust. Reverse displacement with a right-lateral, strike-slip component may be most consistent with the tectonic setting, mapped geologic relations, aeromagnetic data, and microseismicity in the area. Fault scarps on surficial Quaternary deposits have not been described along the fault trace, but some geomorphic (steep, linear escarpment, triangular facets, over-steepened, and knick-pointed tributaries) and geophysical (aeromagnetic, seismic reflection, and ground penetrating radar) evidence suggest Quaternary displacement (Personius, 2017). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

4.1.3.2 East Bank Fault

The northwest-striking East Bank fault lies in the Portland Basin, which may be a right-lateral, pull-apart basin in the forearc of the CSZ; the fault lies a few km east of and is parallel to the Portland Hills fault, which forms the southwestern margin of the basin. The East Bank fault has been mapped as a high-angle, normal fault with a down-to-the-southwest displacement direction; however, down-to-the-northeast reverse displacement with a right-lateral, strike-slip component is consistent with tectonic setting, mapped geologic relations, aeromagnetic data, and microseismicity in the area. Fault scarps on surficial Quaternary deposits have not been described along the fault trace, and the fault is mapped as buried by latest Pleistocene Missoula flood deposits. However, recently acquired shallow seismic-reflection suggest probable down-to-the-northeast offset of unconformities, paleochannels, and sediments associated with flood deposits at several locations across the East Bank fault (Personius, 2002a). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

4.1.3.3 Oatfield Fault

The northwest-striking Oatfield fault forms northeast-facing escarpments in volcanic rocks of the Miocene CRBG in the Tualatin Mountains and northern Willamette Valley. The fault may be part of the Portland Hills-Clackamas River structural zone. The Oatfield fault is primarily mapped as a very high-angle, reverse fault with apparent down-to-the-southwest displacement, but a few-km-long reach of the fault with down-to-the-northeast displacement is mapped in the vicinity of the Willamette River. This apparent change in displacement direction along strike may reflect a discontinuity in the fault trace or could reflect the right-lateral, strike-slip displacement that characterizes other parts of the Portland Hills-Clackamas River structural zone. The fault has also been modeled as a 70-degree, east-dipping reverse fault. Reverse displacement with a right-lateral, strike-slip component is consistent with the tectonic setting, mapped geologic relations, and microseismicity in the area. Fault scarps on surficial deposits have not been described, but exposures in a light rail tunnel showing offset of approximately 1 Ma Boring Lava across the fault indicate Quaternary displacement (Personius, 2002b). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

5.0 SITE RESPONSE ANALYSIS

Local soil conditions influence the characteristics of earthquake ground shaking and these effects must be considered when estimating ground shaking levels for seismic design. These effects are quantified by conducting a site response analysis, which involves the propagation of earthquake motions from the base rock through the overlying soil layers to the ground surface. We determined a base rock spectrum using the USGS Unified Hazard Tool. We scaled ground motions to match the base rock spectrum. We constructed a soil column based on the subsurface conditions encountered in the CPTs and propagated the ground motions to the ground surface using the DEEPSOIL application.

To evaluate the overall site, we have divided the site into four sectors as shown on Figure 2. We have performed site response analyses for our two previous assessments. Those site response analyses can be used for structures within sectors 1 and 4. Multiple soil columns were considered for sectors 2 and 3, as the depth to bedrock varied in each CPT.

5.1 RISK-TARGETED BEDROCK SPECTRUM

We obtained a probabilistic target bedrock spectrum to which ground motions can be scaled before running a site response analysis through the overlying soil column. We determined the spectral accelerations for the outcropping bedrock response spectrum for periods ranging from 0 to 5 seconds from the USGS Unified Hazard Tool using the Dynamic: Conterminous U.S. 2014 model (v4.2.0). We determined the spectral accelerations for periods ranging from 0 to 5 seconds for a return period of 2 percent in 50 years. The response spectrum is consistent with a shear wave velocity equal to 760 meters per second in the upper 30 meters of the soil profile.

The maximum direction was adopted as the ground motion intensity parameter for use in lieu of explicit consideration of directional effects. The maximum horizontal response may be estimated by factoring the average response period by period-dependent factors. The commentary to ASCE 7-16 recommends a factor of 1.1 at periods less than 0.2 second, 1.3 at a period of 1 second, and 1.5 at 5 seconds and greater. We used linear interpolation to compute factors at periods greater than 0.2 second.

The risk-targeted bedrock spectrum, MCE_R, was computed using Method 1 outlined in ASCE 7-16 Section 21.2.1.1 to achieve a 1-percent probability of collapse in a 50-year period. A risk coefficient of C_{RS} = 0.891 was applied to the spectrum at periods of 0.2 second or less and a risk coefficient of C_{R1} = 0.871 was applied to the spectrum at periods greater than 1 second. Linear interpolation was used to compute risk coefficients between periods of 0.2 and 1.0 second. Figures 5 and 6 shows the target bedrock spectrum for sectors 2 and 3, respectively. The target bedrock spectrum is consistent across the site. As such, Table 2 provides a summary of values used to compute the MCE_R target bedrock response spectrum throughout the site.

Table 2. Risk-Targeted Bedrock Spectrum

Period (seconds)	MCE Target Bedrock Spectral Acceleration (g)	Maximum Direction Factor	C_R	MCE_R Target Bedrock Spectral Acceleration (g)
0.0	0.432	1.10	0.891	0.423
0.1	0.923	1.10	0.891	0.905
0.2	0.955	1.10	0.891	0.936
0.3	0.785	1.13	0.890	0.786
0.5	0.564	1.18	0.888	0.588
1.0	0.190	1.55	0.871	0.257
2.0	0.124	1.40	0.871	0.152
3.0	0.092	1.45	0.871	0.116
4.0	0.069	1.50	0.871	0.090
5.0	0.432	1.10	0.891	0.423

5.2 BASE GROUND MOTIONS

Six recorded base ground motions were selected to represent the local seismic setting. We considered faulting mechanism, magnitude, and distance to recording station. Ground motions at the site are controlled by a crustal event and the CSZ interface event. We selected two acceleration time histories to represent the crustal seismic sources and four acceleration time histories to represent the CSZ seismic sources as input for the seismic response analysis. Table 3 lists the ground motions selected for this study.

Table 3. Selected Ground Motions

Ground Motion/Recording Station	Magnitude	Distance (km)	Component
Crustal Records			
Imperial Valley 1979 / Delta	6.53	22.0	262
Kobe 1995 / Abeno	6.9	24.9	000
CSZ Records			
Tohoku 2011 / Tsukuba City Hall	9.0	106.9	004
Arequipa 2001 / MOQ	8.4	60.0	000
Maule 2010 / Santiago Puente Alto	8.8	75.0	NS
Maule 2010 / Colegio Las Americas	8.8	81.9	NS

5.3 SITE CONDITION MODELING

We determined acceleration response spectra for the postulated scenarios discussed above by performing a site-specific seismic response analysis. A nonlinear seismic site response analysis was conducted. The site response analysis was performed using the DEEPSOIL Version 7.0 application.

The input soil models used in our analysis are based on the findings of our subsurface exploration program and experience in the site vicinity. Since the depth to bedrock varied between the CPTs, we conducted a response analysis using multiple soil profiles within sectors 2 and 3 with varying depths to bedrock. Tables 4 and 5 provide a summary of the soil models used in our analysis. The acceleration response spectra produced by our equivalent linear seismic response analysis is shown on Figures 5 and 6 for sectors 2 and 3, respectively.

Table 4. Input Soil Column Sector 2

Depth Interval (feet BGS)	Subsurface Unit	Shear Wave Velocity (fps)	Modulus Reduction Curve	Damping Curve
0[1] to 25	Fill	420 – 582	Seed and Idriss, 1970 (Mean)	MRDF with Darendeli Reduction Factor
25 to 45	Alluvium	643 – 650	Vucetic & Dobry, 1991 PI: 33	MRDF with Darendeli Reduction Factor
45 to 73	Alluvium	698 – 1,018	Vucetic & Dobry, 1991 PI: 0	MRDF with Darendeli Reduction Factor
>73	Bedrock	2,400	Not applicable	Not applicable

1. Output at ground surface

Table 5. Input Soil Column Sector 3

Depth Interval (feet BGS)	Subsurface Unit	Shear Wave Velocity (fps)	Modulus Reduction Curve	Damping Curve
0[1] to 5	Fill	424	Seed and Idriss, 1970 (Mean)	MRDF with Darendeli Reduction Factor
5 to 20	Alluvium	424 – 353	Vucetic & Dobry, 1991 PI: 33	MRDF with Darendeli Reduction Factor
20 to 53	Alluvium	588 – 758	Vucetic & Dobry, 1991 PI: 0	MRDF with Darendeli Reduction Factor
>76	Bedrock	2,400	Not applicable	Not applicable

1. Output at ground surface

Profiles with bedrock located at varying depths were considered but did not produce results significantly different from the chosen soil column. We used the most conservative results from the varying soil columns for each sector.

5.4 DETERMINISTIC MCE$_R$ RESPONSE SPECTRUM

Since the largest spectral response acceleration of the probabilistic study is less than 1.2 F_a, a deterministic response spectrum is not required. Therefore, the site-specific MCE$_R$ response is the probabilistic MCE$_R$ response spectrum.

5.5 DESIGN RESPONSE SPECTRUM

ASCE 7-16 Section 21.3 states that the site-specific MCE$_R$ response spectrum is reduced to two-thirds of the acceleration at any period. However, the lower bound for design ground motions is 80 percent of the generalized response spectrum as outlined in ASCE 7-16 Section 11.4.5.

5.6 DESIGN ACCELERATION PARAMETERS

To develop the final design response spectrum, the parameter S_{DS} is taken from the site-specific response spectrum at a period of 0.2 second but should not be smaller than 90 percent of the peak spectral acceleration taken at any period larger than 0.2 second. The parameter S_{D1} is taken as the maximum value of the product, T and SA, for periods from 1 second to 2 seconds for sites with Vs_{30} of greater 1,200 fps and for periods from 1 second to 5 seconds for sites with Vs_{30} smaller than 1,200 fps. Figures 7 and 8 show the design response spectrum for sectors 2 and 3, respectively.

6.0 GEOLOGIC HAZARDS

In addition to ground shaking, site-specific geologic conditions can influence the potential for earthquake damage. Deep deposits of loose or soft alluvium can amplify ground motions, resulting in increased seismic loads on structures. Other geologic hazards are related to soil failure and permanent ground deformation. Permanent ground deformation could result from liquefaction, lateral spreading, landsliding, and fault rupture. The following sections provide additional discussion regarding potential seismic hazards that could affect the facility.

6.1 FAULT SURFACE RUPTURE

Faults are not mapped beneath the property by the USGS Seismic Mapping Project. Consequently, it is our opinion that the probability of surface fault rupture beneath the site is low.

6.2 LIQUEFACTION

Liquefaction is caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. In general, loose, saturated sand soil with low silt and clay content is the most susceptible to liquefaction. Silty soil with low plasticity is moderately susceptible to liquefaction under relatively higher levels of ground shaking.

We performed liquefaction analysis using the information from explorations and the results of laboratory testing. Triggering was completed in accordance with Boulanger and Idriss (2014). Evaluation was completed for the CSZ interface event using Mw = 9.0 and PGA = 0.25 g and for the crustal fault event using Mw = 7.0 and PGA = 0.55 g. The more conservative result was obtained using the CSZ interface fault event, which was used for our analysis.

We anticipate 4 to 9 inches of liquefaction-induced settlement at the ground surface throughout the site. A differential settlement of one-half of these values can be assumed over a distance of 50 feet.

6.3 LATERAL SPREADING

The closest structure considered in this study is approximately 750 feet from the west bank of the Willamette River. In our opinion, the risk of lateral spreading should be considered low under design levels of ground shaking.

6.4 GROUND MOTION AMPLIFICATION

Soil capable of significantly amplifying ground motions beyond the levels determined by our site-specific seismic response analysis was not encountered during our subsurface investigation program. We conclude the level of amplification determined by our response analysis is appropriate and the facility can be designed using the levels of ground shaking prescribed by the building codes.

7.0 LIMITATIONS

We have prepared this report for use by Zenith Energy Management. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Soil explorations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in this report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

NV5

Tyler A. Pierce, P.E.
Associate Engineer

Scott V. Mills, P.E., G.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
91210PE
OREGON
July 12, 2016
TYLER PIERCE
EXPIRES: 12/31/24

REFERENCES

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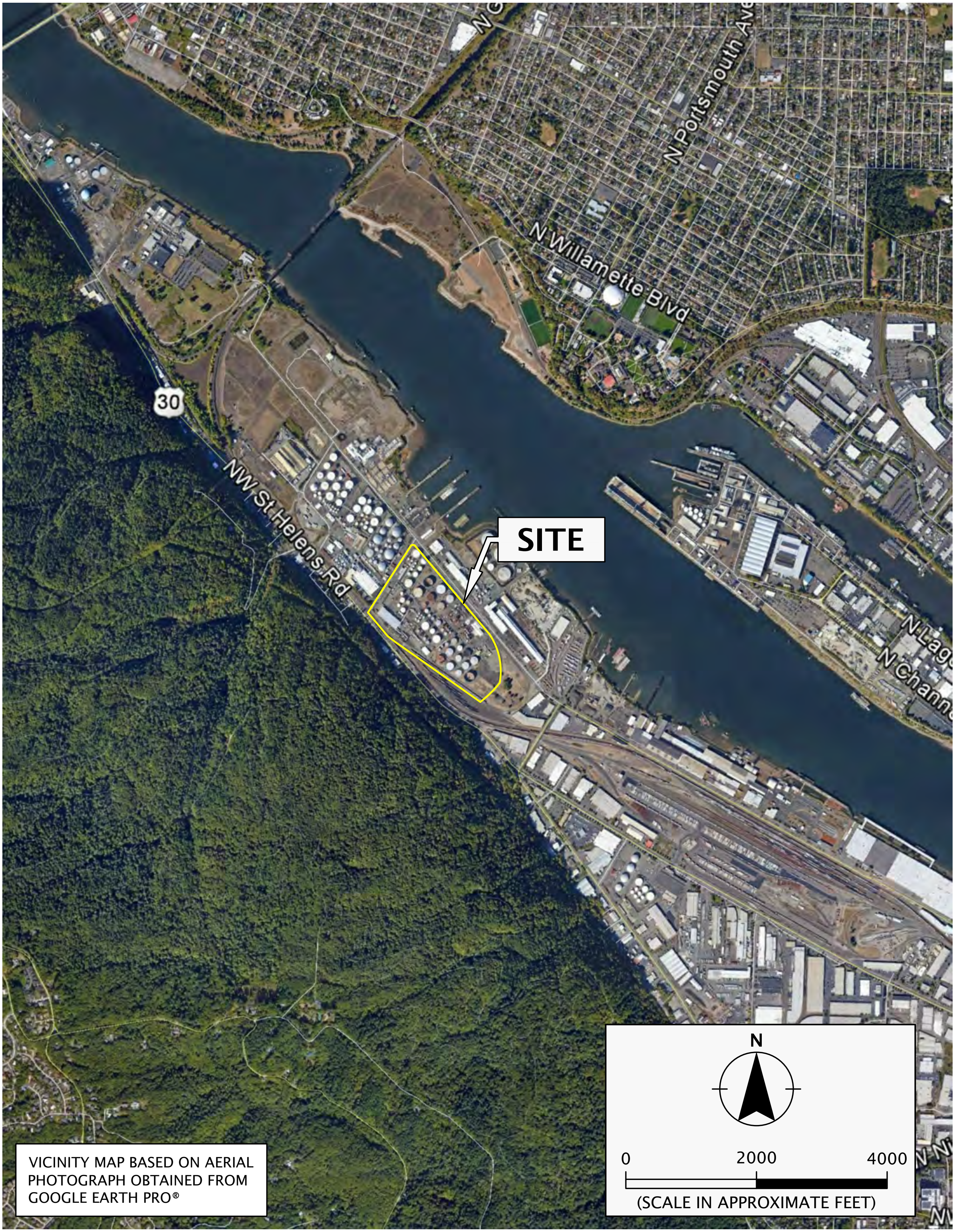
FIGURES



VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

NV5	ZENITH-4-01	**VICINITY MAP**
	MAY 2024	ZENITH TERMINAL - REMAINING STRUCTURES PORTLAND, OR
		FIGURE 1

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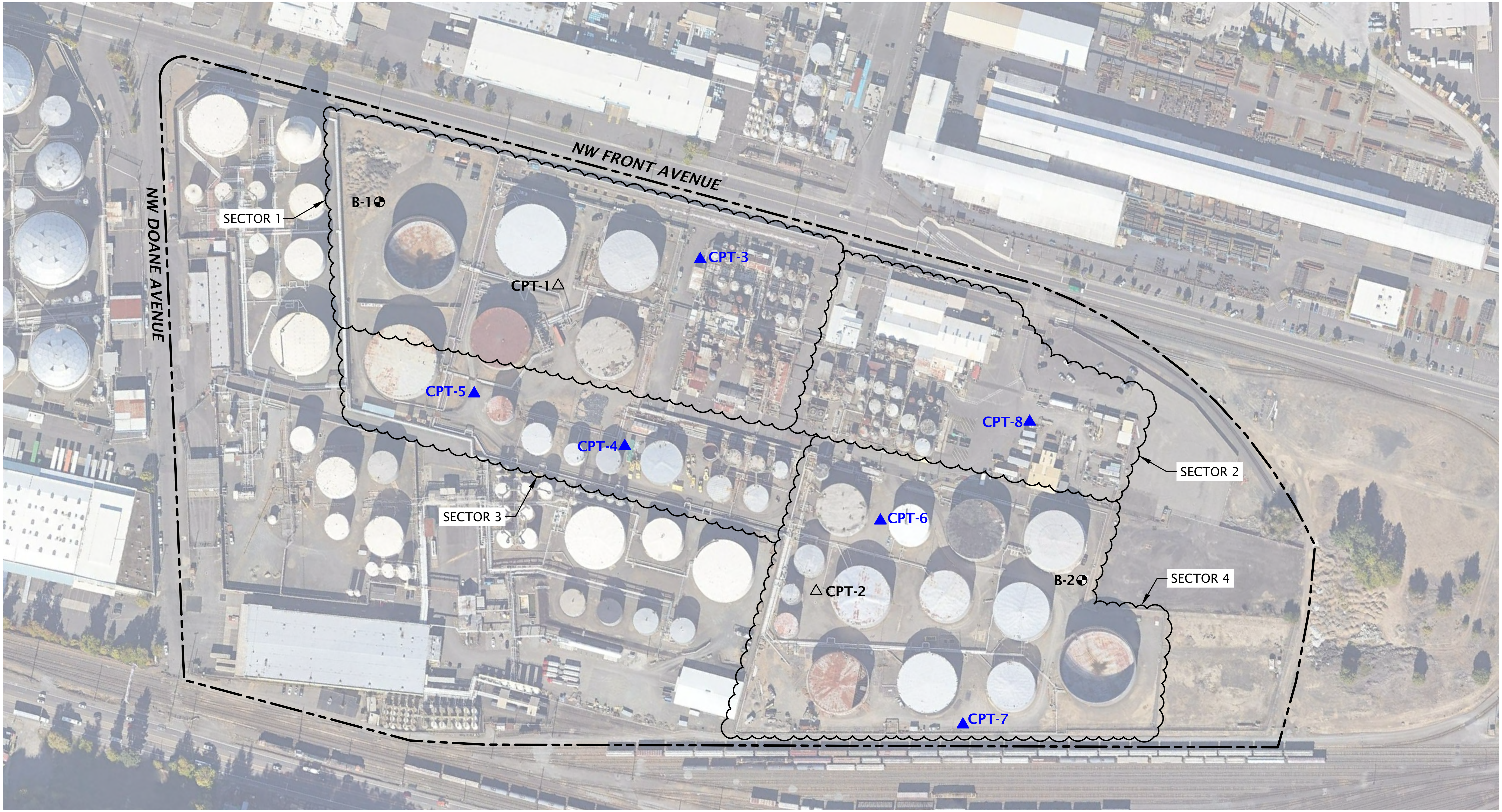
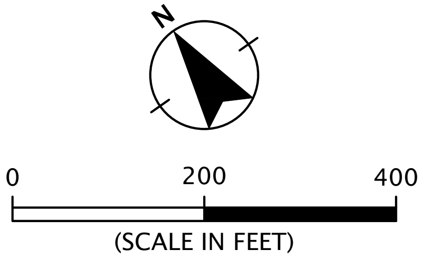


LEGEND:

— · — · —	APPROXIMATE SITE BOUNDARY
︵︵︵︵	SECTOR BOUNDARY
CPT-3▲	CPT
CPT-1△	CPT (NV5 2022)
B-1◒	BORING (GEODESIGN 2020)



SITE PLAN BASED ON AERIAL PHOTOGRAPH DATED
JULY 20, 2018, OBTAINED FROM GOOGLE EARTH PRO

NV5

ZENITH-4-01

MAY 2024

SITE PLAN

ZENITH TERMINAL – REMAINING STRUCTURES
PORTLAND, OR

FIGURE 2

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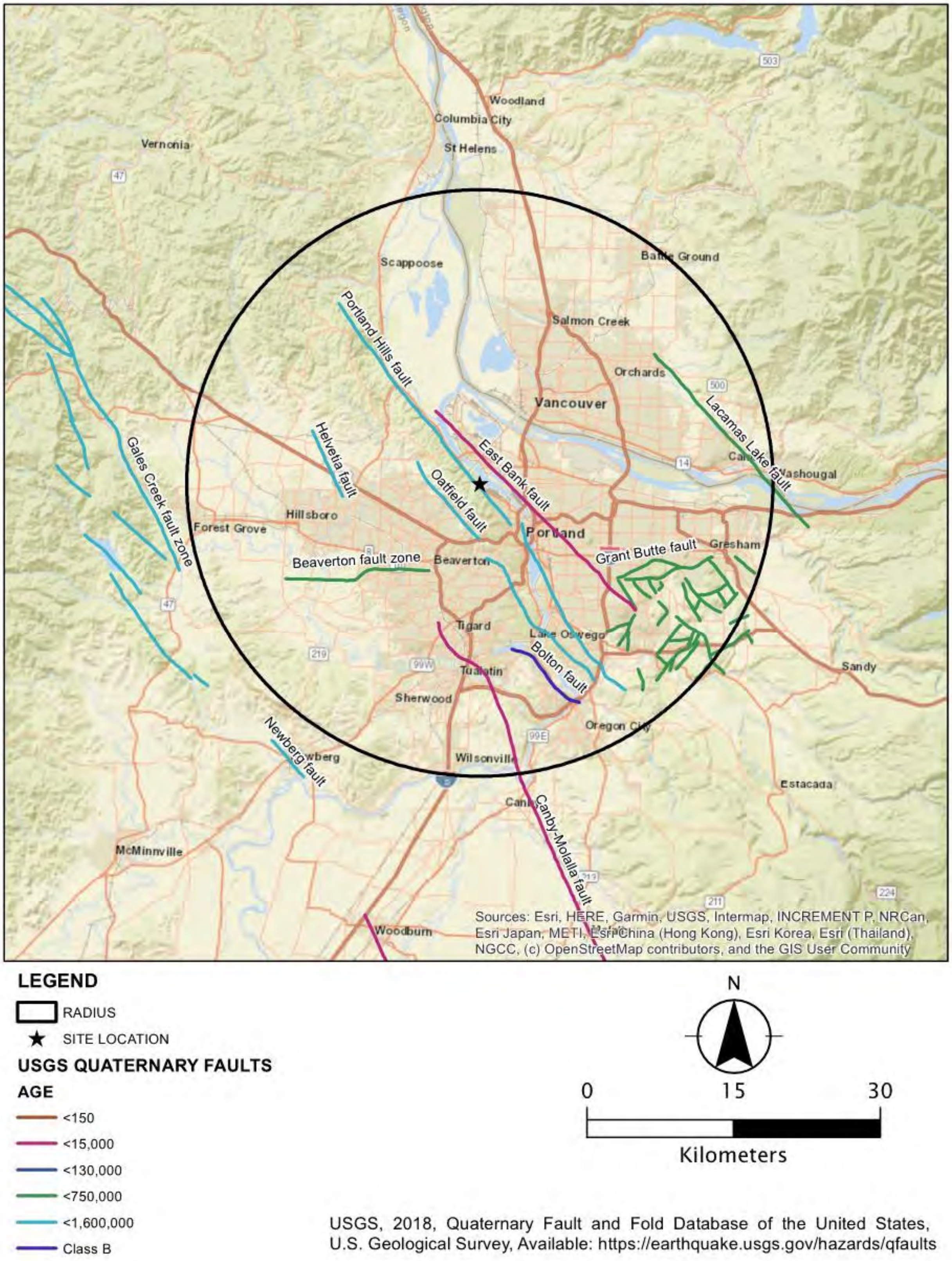

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

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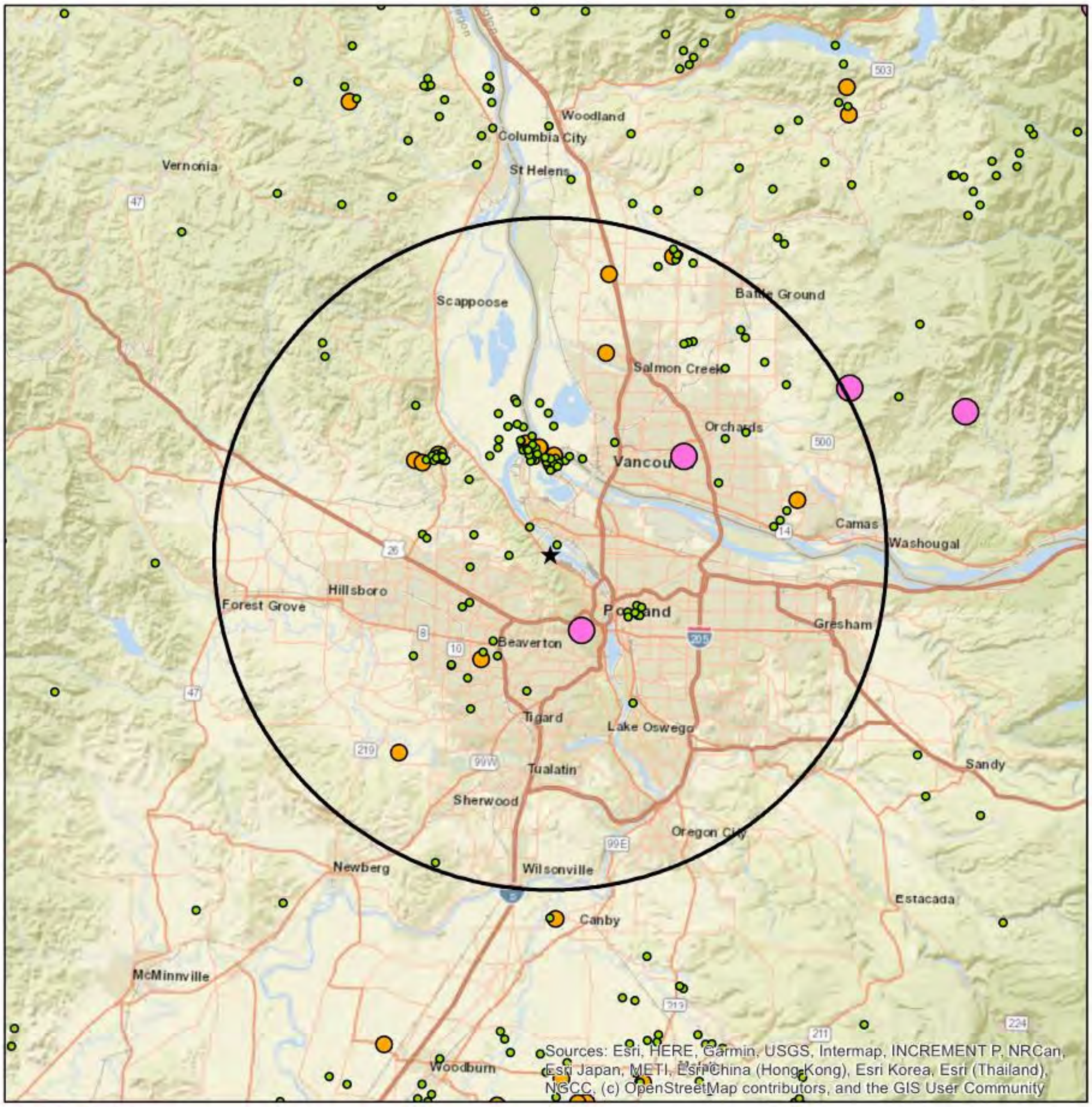
NV5	ZENITH-4-01	**QUATERNARY FAULT MAP**
	MAY 2024	ZENITH TERMINAL—REMAINING STRUCTURES PORTLAND, OR
		FIGURE 3



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

▭ RADIUS

★ SITE LOCATION

INSTRUMENTAL EARTHQUAKE MAGNITUDE

● 2.0 - 3.0

● 3.0 - 4.0

● 4.0 - 6.0

● > 6.0

N

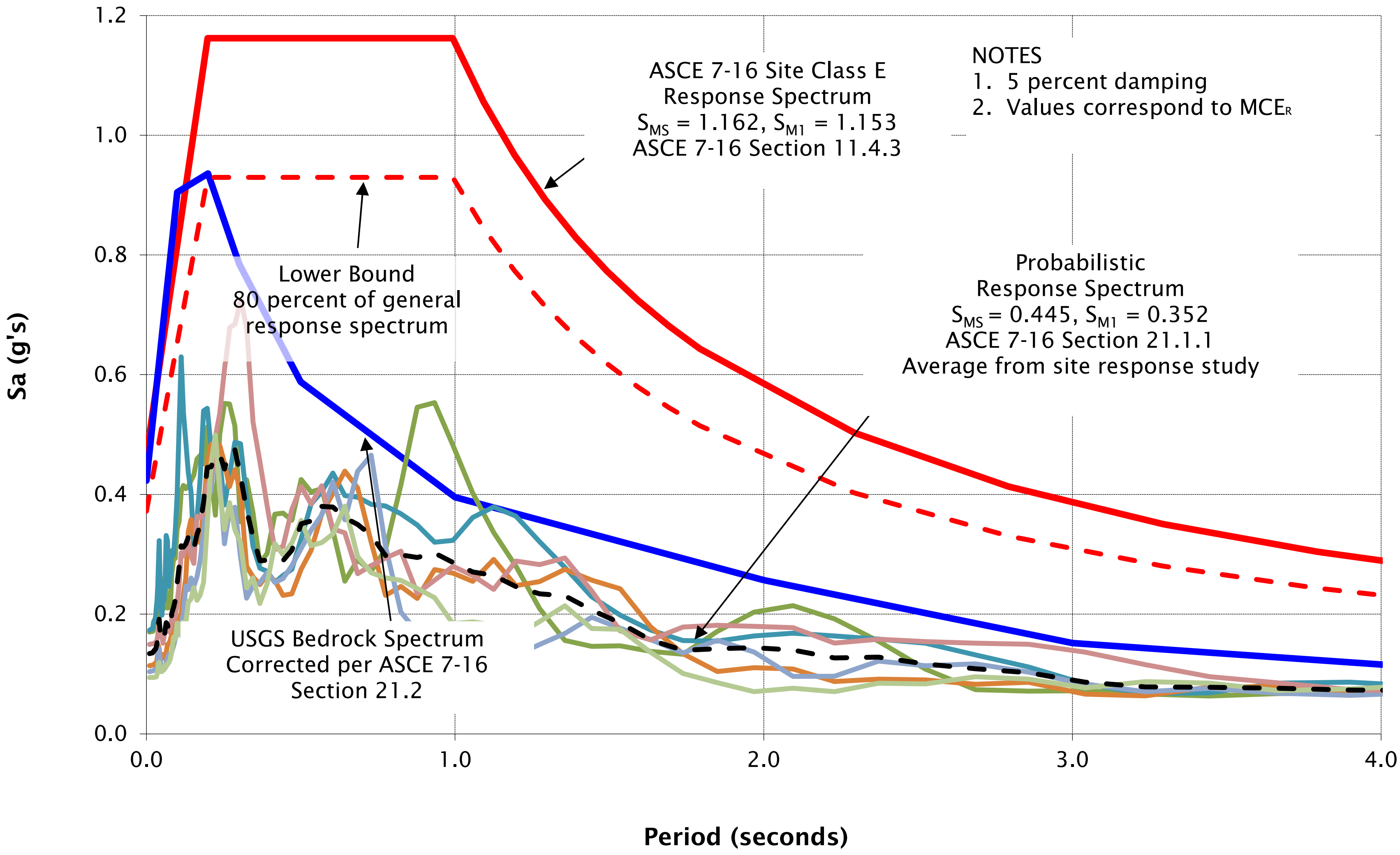
0 15 30

Kilometers

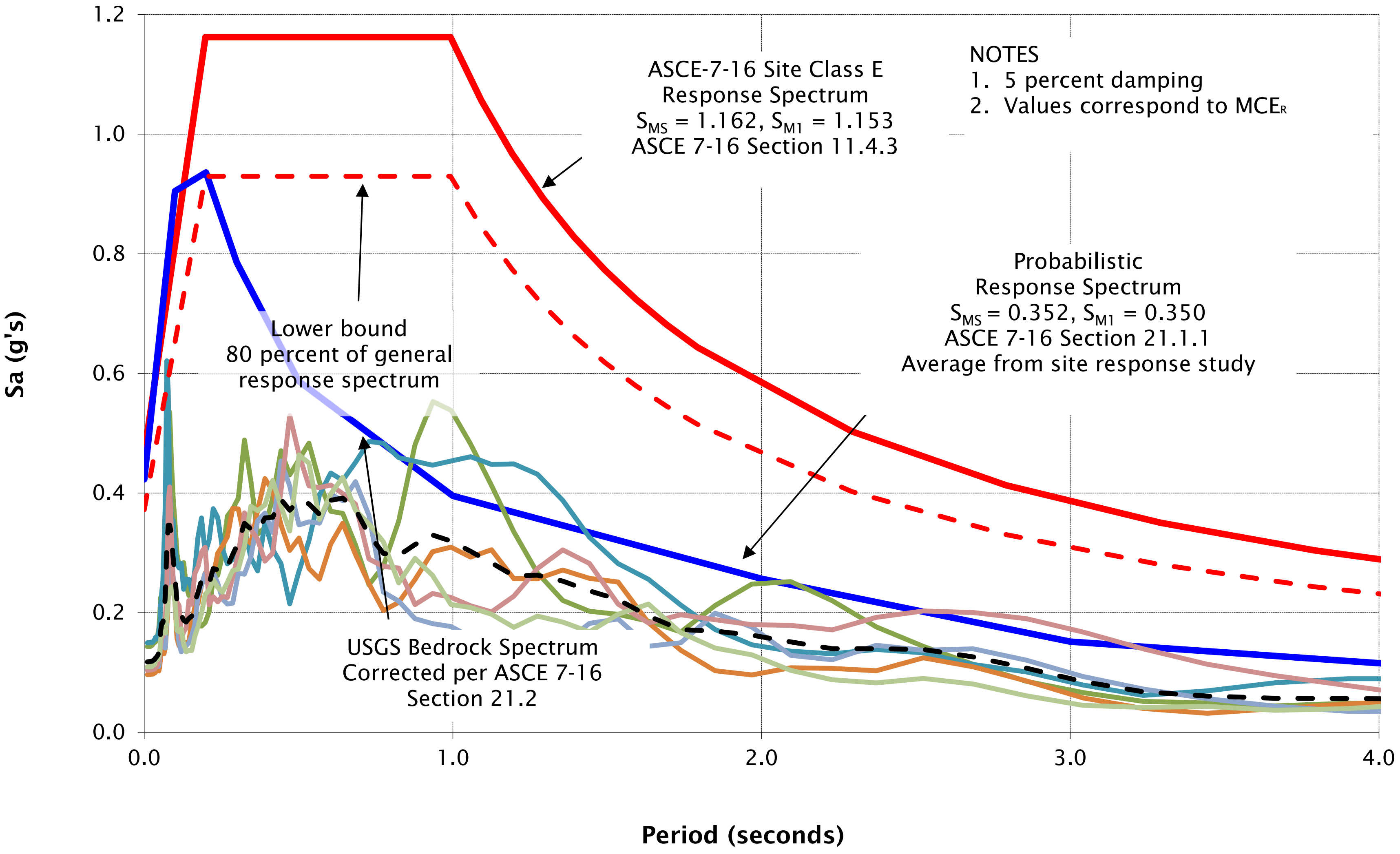
USGS, 2019, Earthquake Hazards Program, US Earthquake Information by State, U.S. Geological Survey, Available: http://earthquake.usgs.gov/earthquakes/search

NV5	ZENITH-4-01	**HISTORICAL SEISMICITY MAP**	
	MAY 2024	ZENITH TERMINAL—REMAINING STRUCTURES PORTLAND, OR	**FIGURE 4**

Zenith-3-01-F3_4.docx Print Date: 5/16/24



NV5	ZENITH-4-01	**SITE RESPONSE SPECTRA—SECTOR 2**	
	MAY 2024	ZENITH TERMINAL—REMAINING STRUCTURES PORTLAND, OR	**FIGURE 5**



ASCE-7-16 Site Class E
Response Spectrum
S_{MS} = 1.162, S_{M1} = 1.153
ASCE 7-16 Section 11.4.3

NOTES
1. 5 percent damping
2. Values correspond to MCE_R

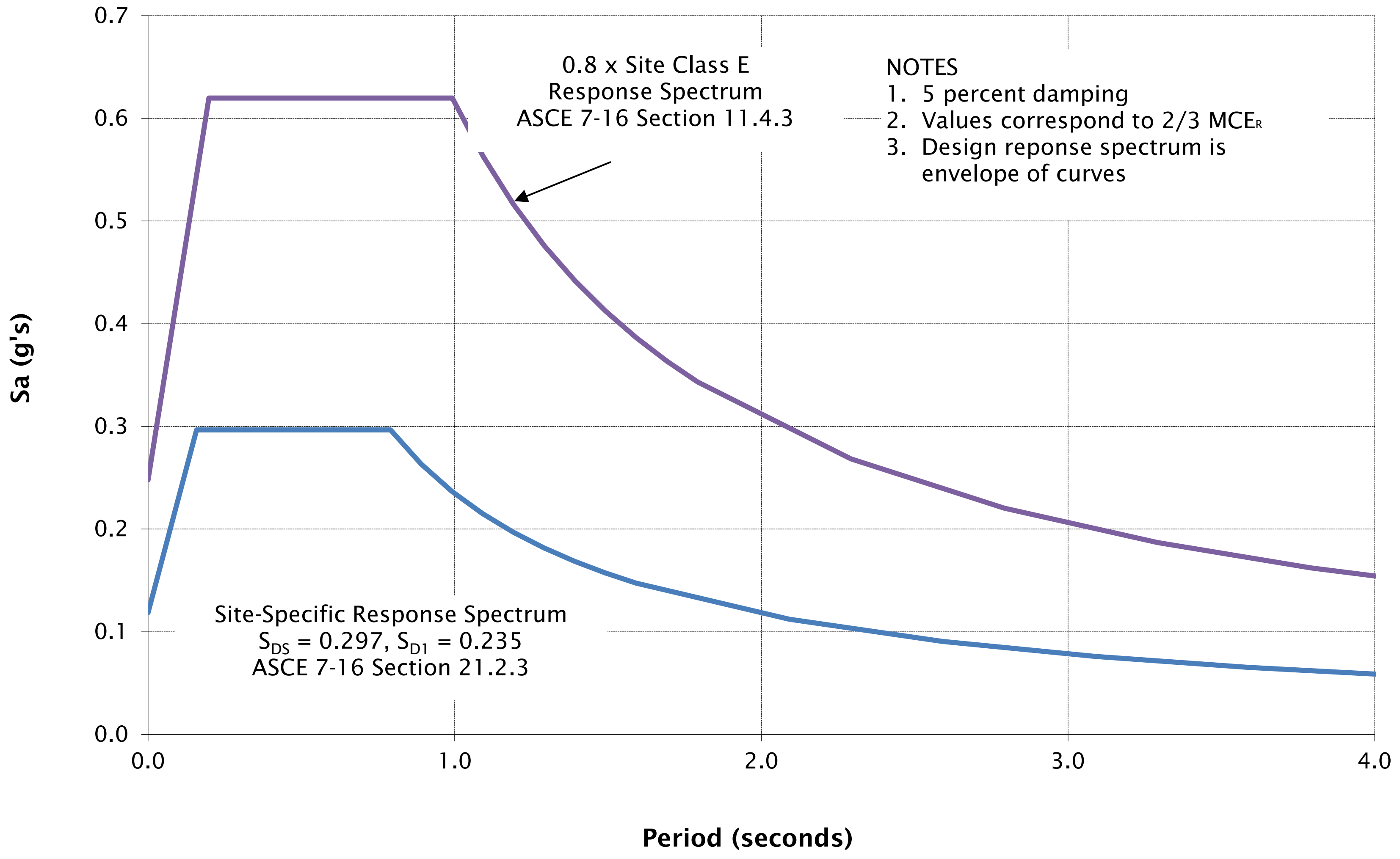
Lower bound
80 percent of general
response spectrum

Probabilistic
Response Spectrum
S_{MS} = 0.352, S_{M1} = 0.350
ASCE 7-16 Section 21.1.1
Average from site response study

USGS Bedrock Spectrum
Corrected per ASCE 7-16
Section 21.2

NV5	ZENITH-4-01	**SITE RESPONSE SPECTRA—SECTOR 3**
	MAY 2024	ZENITH TERMINAL—REMAINING STRUCTURES PORTLAND, OR

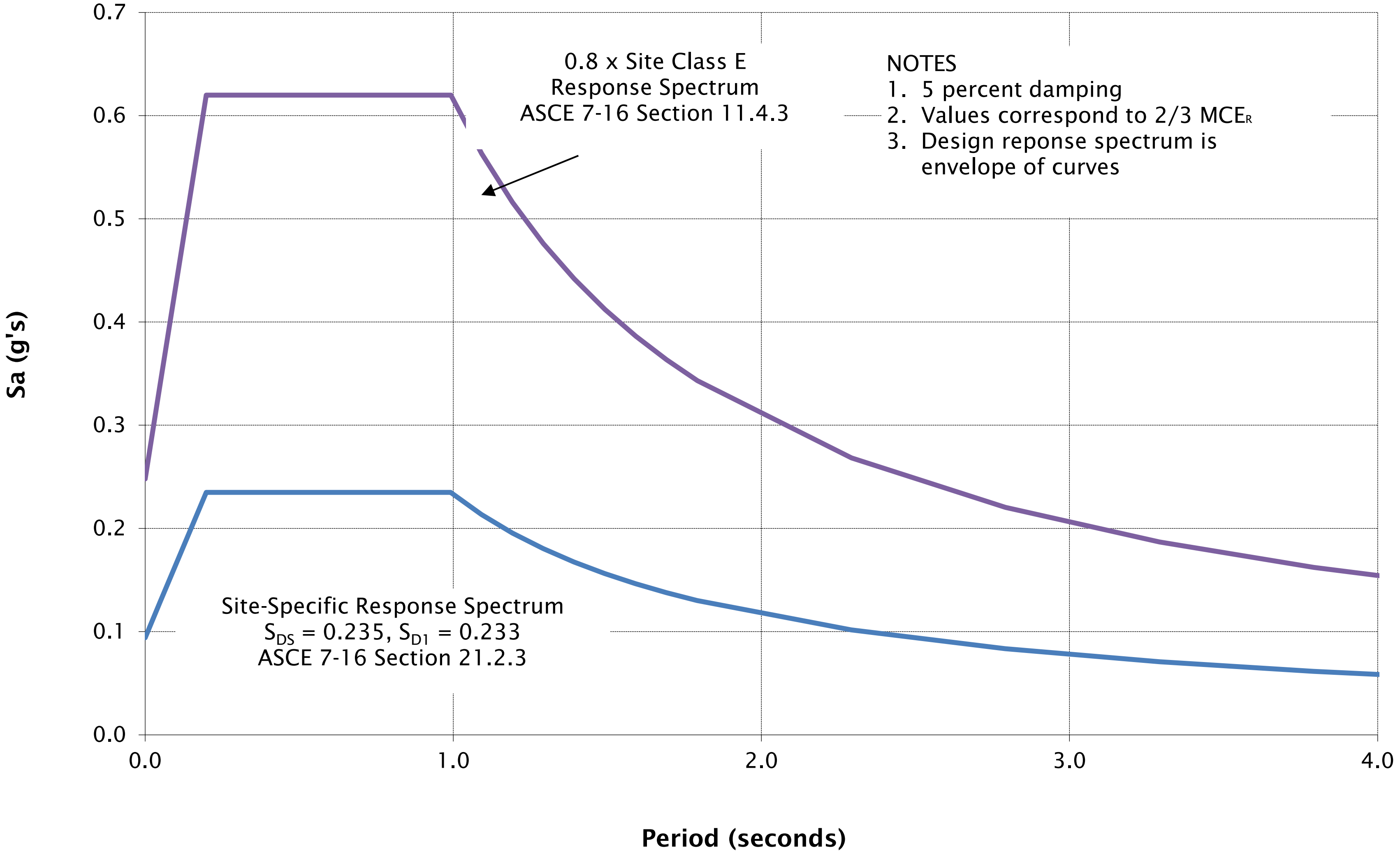
FIGURE 6



NOTES
1. 5 percent damping
2. Values correspond to 2/3 MCE_R
3. Design reponse spectrum is envelope of curves

NV5	ZENITH-4-01	**DESIGN RESPONSE SPECTRUM—SECTOR 2**
	MAY 2024	ZENITH TERMINAL—REMAINING STRUCTURES PORTLAND, OR

FIGURE 7



0.8 x Site Class E
Response Spectrum
ASCE 7-16 Section 11.4.3

NOTES
1. 5 percent damping
2. Values correspond to 2/3 MCE_R
3. Design reponse spectrum is envelope of curves

Site-Specific Response Spectrum
S_{DS} = 0.235, S_{D1} = 0.233
ASCE 7-16 Section 21.2.3

N|V|5

ZENITH-4-01

MAY 2024

DESIGN RESPONSE SPECTRUM—SECTOR 3

ZENITH TERMINAL—REMAINING STRUCTURES
PORTLAND, OR

FIGURE 8

APPENDIX A

APPENDIX A

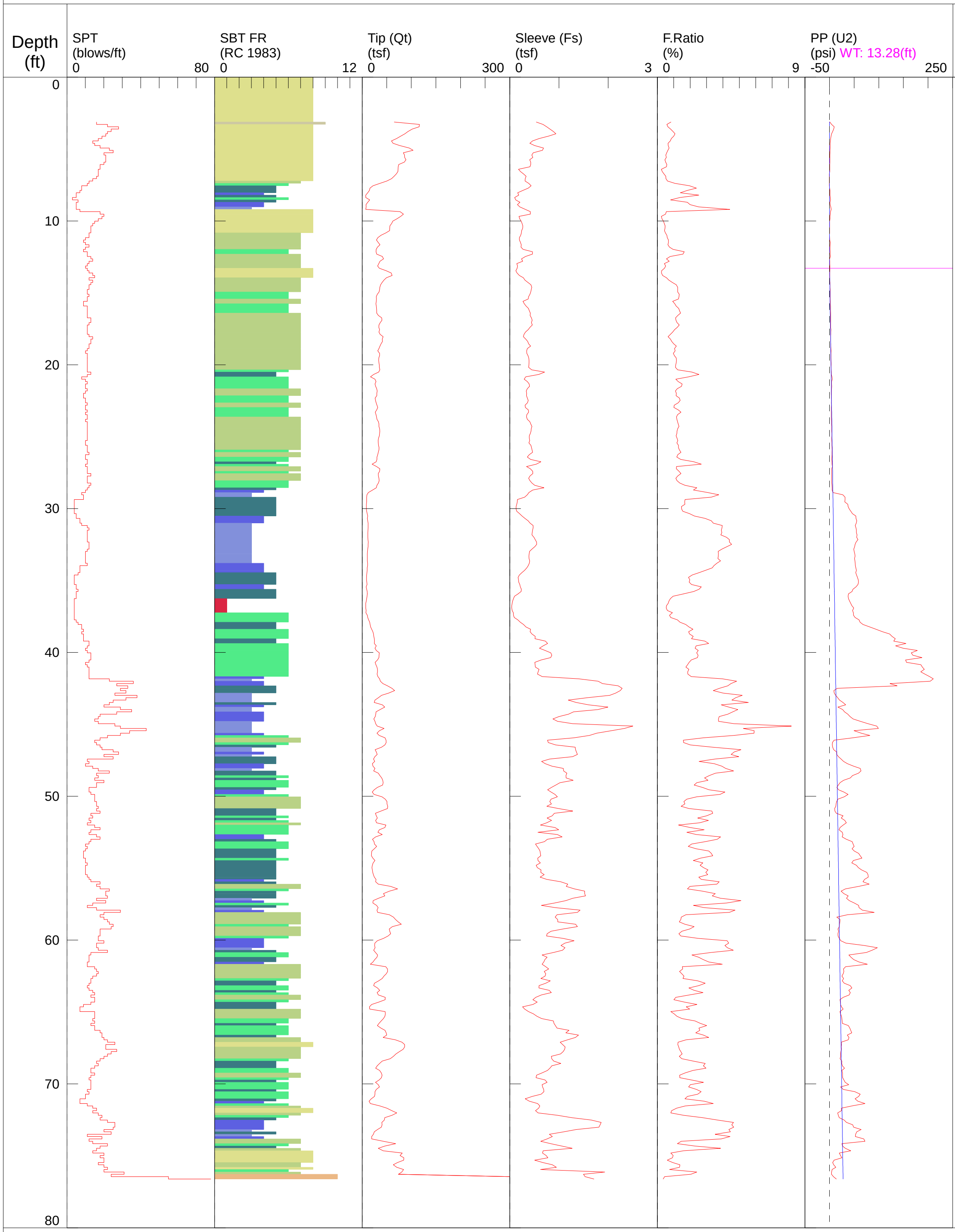
CONE PENETRATION TESTING

The CPTs (CPT-3 through CPT-8) were performed in general accordance with ASTM D5778 by Oregon Geotechnical Explorations, Inc. of Keizer, Oregon, between February 5 and 8, 2024, at the approximate locations shown on Figure 2. The CPTs were advanced to refusal at depths between 52.2 and 76.6 feet BGS. The results of the CPTs performed for this project are presented in this appendix.

The CPT is an in-situ test that provides assistance in characterizing subsurface stratigraphy. The test includes advancing a 35.6-mm-diameter cone equipped with a load cell, friction sleeve, strain gauges, porous stone, and geophone through the soil profile. The cone is advanced at a rate of approximately 2 centimeters per second. Tip resistance, sleeve friction, and pore pressure are typically recorded at 0.1-meter intervals. At select depths, the CPT advancement can be suspended and pore water dissipation rates measured. The shear wave velocity of the subsurface soil was also measured at 2-meter intervals.

NV5 / CPT-3 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 9:46:08 AM
TOTAL DEPTH: 76.608 ft



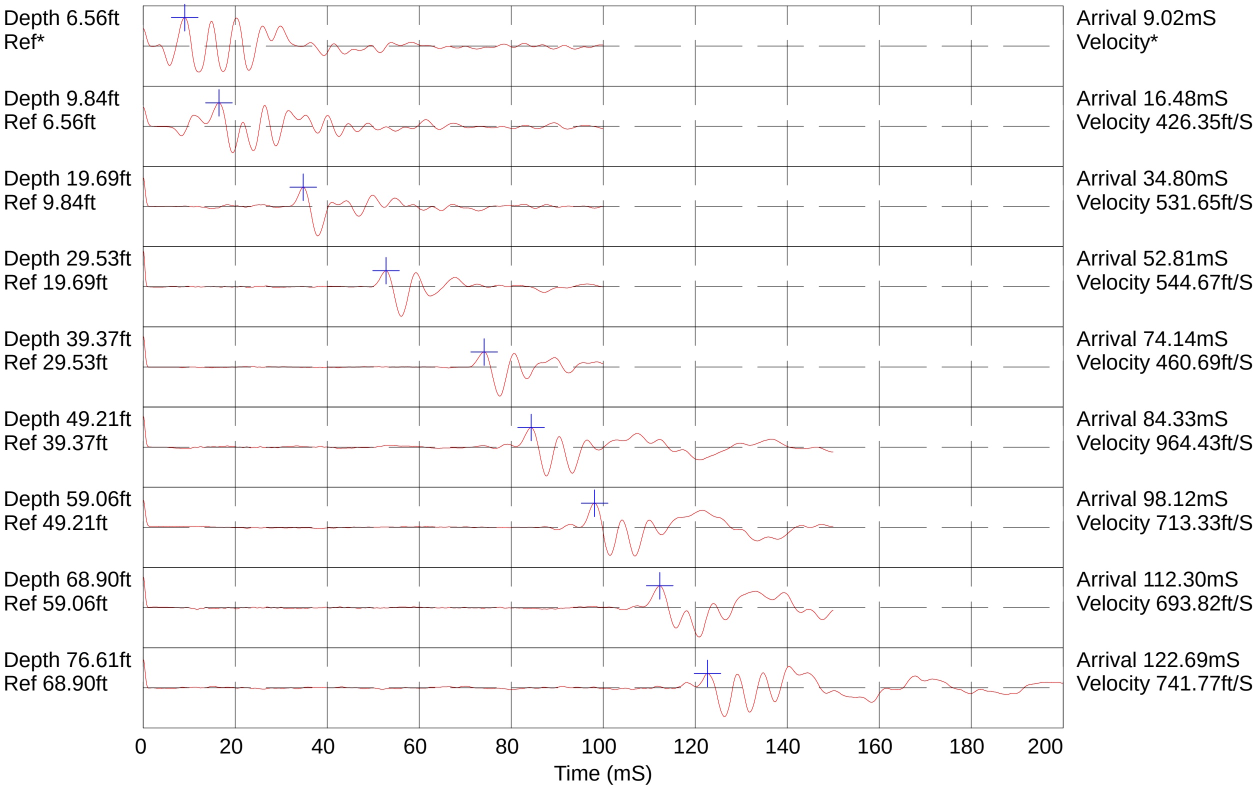
REMARKS

`Predrill to 3 feet`

🟥 1 sensitive fine grained
🟪 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟦 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

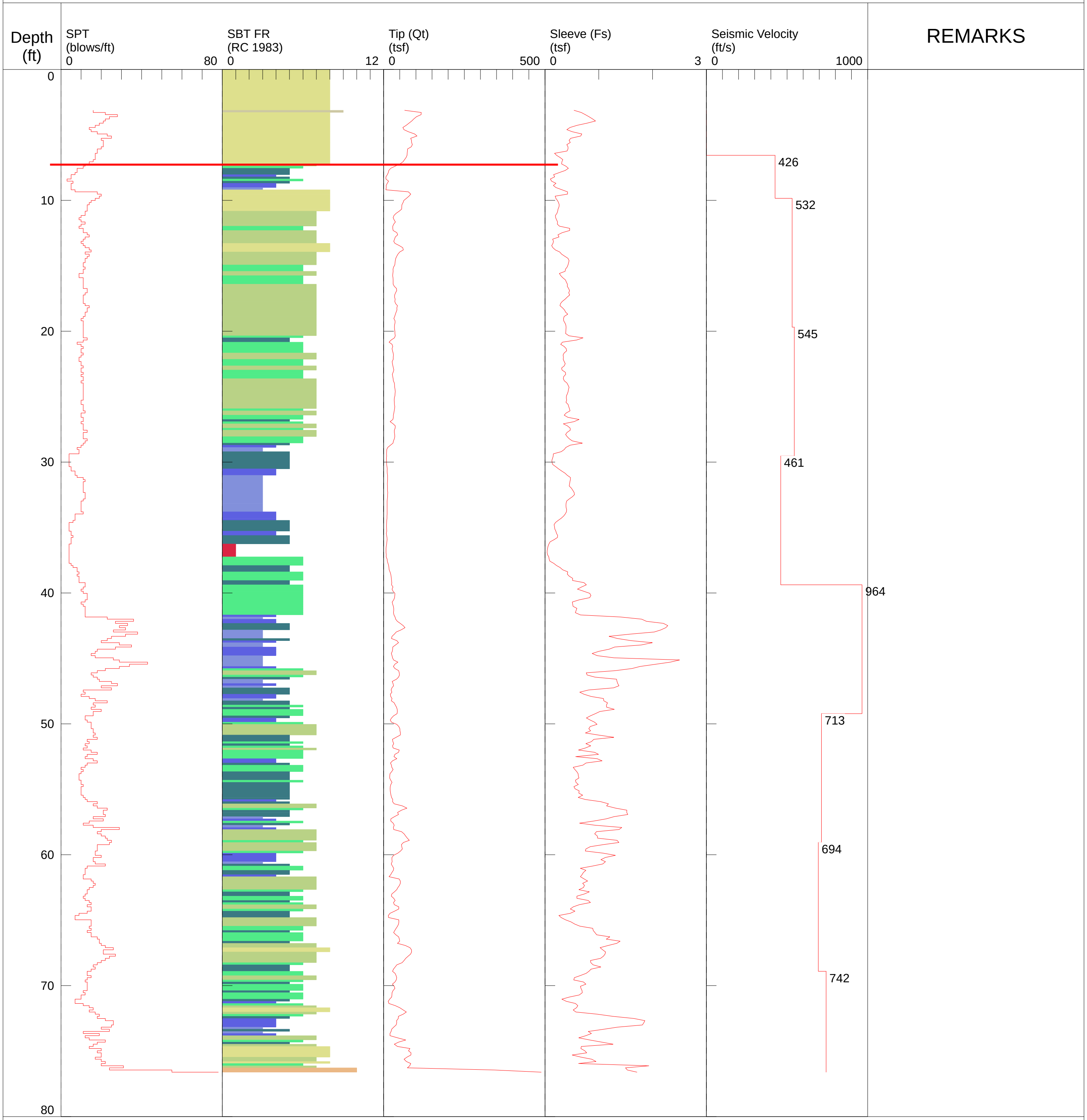
COMMENT: NV5 / CPT-3 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 2.03
* = Not Determined

NV5 / CPT-3 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 9:46:08 AM
TOTAL DEPTH: 76.608 ft

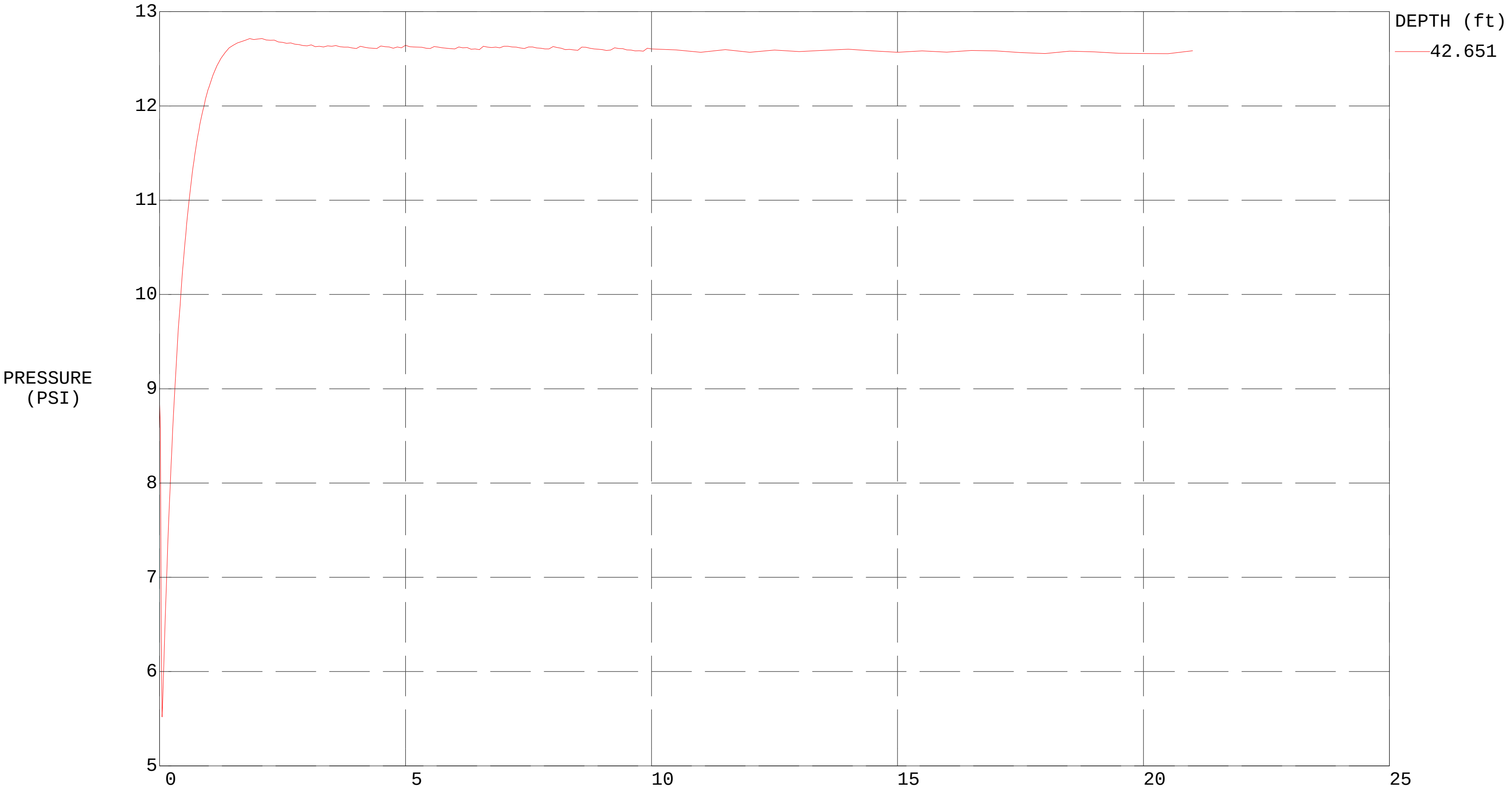


🟥 1 sensitive fine grained
🟥 2 organic material
🟪 3 clay
🟦 4 silty clay to clay
🟦 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-3 / 5501 NW Front Ave Portland

CONE ID: DDG1661
TEST DATE: 2/5/2024 9:46:08 AM



MAXIMUM PRESSURE = 12.714 (PSI)
HYDROSTATIC PRESSURE = 12.727 (PSI), WATER TABLE: 13.28 ft

NV5 / CPT-3 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 9:46:08 AM
TOTAL DEPTH: 76.608 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
3.117	65.23	0.5393	0.827	0.495	16	8	sand to silty sand
3.281	116.35	0.6735	0.579	4.075	22	9	sand
3.445	115.99	0.7496	0.646	9.448	28	8	sand to silty sand
3.609	101.88	0.8164	0.801	8.209	24	8	sand to silty sand
3.773	93.25	0.8860	0.950	6.170	22	8	sand to silty sand
3.937	86.80	0.9382	1.081	4.084	21	8	sand to silty sand
4.101	78.43	0.7834	0.999	2.834	19	8	sand to silty sand
4.265	69.91	0.5968	0.854	2.281	17	8	sand to silty sand
4.429	59.51	0.4648	0.781	1.552	14	8	sand to silty sand
4.593	62.79	0.4066	0.648	1.181	15	8	sand to silty sand
4.757	76.23	0.5016	0.658	1.100	18	8	sand to silty sand
4.921	95.92	0.6850	0.714	1.114	23	8	sand to silty sand
5.085	103.36	0.6649	0.643	1.012	25	8	sand to silty sand
5.249	83.68	0.4782	0.571	0.890	20	8	sand to silty sand
5.413	86.11	0.4463	0.518	0.531	21	8	sand to silty sand
5.577	86.51	0.4701	0.543	0.552	21	8	sand to silty sand
5.741	88.81	0.4052	0.456	0.438	21	8	sand to silty sand
5.906	85.61	0.4276	0.499	0.414	20	8	sand to silty sand
6.070	74.18	0.4276	0.576	0.282	18	8	sand to silty sand
6.234	73.37	0.4091	0.558	0.225	18	8	sand to silty sand
6.398	72.79	0.1767	0.243	0.198	17	8	sand to silty sand
6.562	72.59	0.2164	0.298	0.160	17	8	sand to silty sand
6.726	69.54	0.2791	0.401	-0.564	17	8	sand to silty sand
6.890	64.87	0.3320	0.512	-0.447	16	8	sand to silty sand
7.054	59.91	0.3120	0.521	-0.452	14	8	sand to silty sand
7.218	50.11	0.3094	0.617	-0.495	12	8	sand to silty sand
7.382	35.97	0.3874	1.077	-0.598	11	7	silty sand to sandy silt
7.546	22.17	0.4344	1.959	-0.600	8	6	sandy silt to clayey silt
7.710	15.79	0.3755	2.377	-0.067	8	5	clayey silt to silty clay
7.874	14.68	0.2682	1.827	0.813	7	5	clayey silt to silty clay
8.038	11.38	0.1597	1.403	0.693	5	5	clayey silt to silty clay
8.202	7.18	0.1810	2.519	0.873	5	4	silty clay to clay
8.366	7.18	0.0987	1.374	1.411	3	5	clayey silt to silty clay
8.530	15.09	0.1217	0.807	1.755	6	6	sandy silt to clayey silt
8.694	11.25	0.2052	1.824	0.890	5	5	clayey silt to silty clay
8.858	7.72	0.1536	1.990	1.255	5	4	silty clay to clay
9.022	8.09	0.2033	2.512	2.427	5	4	silty clay to clay
9.186	7.16	0.3162	4.415	3.197	7	3	clay
9.350	76.75	0.4188	0.546	1.894	18	8	sand to silty sand
9.514	83.95	0.4188	0.499	1.442	20	8	sand to silty sand
9.678	78.51	0.1885	0.240	0.897	19	8	sand to silty sand
9.843	70.85	0.2017	0.285	0.655	17	8	sand to silty sand
10.007	62.29	0.2307	0.370	0.148	15	8	sand to silty sand
10.171	60.08	0.2503	0.417	0.079	14	8	sand to silty sand
10.335	56.30	0.2650	0.471	0.067	13	8	sand to silty sand
10.499	56.00	0.2608	0.466	-0.010	13	8	sand to silty sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
10.663	55.87	0.2422	0.433	-0.019	13	8	sand to silty sand
10.827	48.33	0.2358	0.488	-0.026	12	8	sand to silty sand
10.991	38.38	0.2207	0.575	-0.088	12	7	silty sand to sandy silt
11.155	32.00	0.1933	0.604	0.026	10	7	silty sand to sandy silt
11.319	29.15	0.1970	0.676	0.225	9	7	silty sand to sandy silt
11.483	32.30	0.2166	0.670	1.480	10	7	silty sand to sandy silt
11.647	36.20	0.2330	0.644	1.047	12	7	silty sand to sandy silt
11.811	31.00	0.2286	0.737	0.777	10	7	silty sand to sandy silt
11.975	28.31	0.2701	0.954	0.947	9	7	silty sand to sandy silt
12.139	28.10	0.4592	1.634	1.083	11	6	sandy silt to clayey silt
12.303	29.53	0.4599	1.557	1.126	11	6	sandy silt to clayey silt
12.467	41.08	0.3202	0.779	1.662	13	7	silty sand to sandy silt
12.631	43.50	0.2392	0.550	0.100	14	7	silty sand to sandy silt
12.795	36.08	0.2605	0.722	0.285	12	7	silty sand to sandy silt
12.959	33.70	0.1417	0.421	0.292	11	7	silty sand to sandy silt
13.123	31.34	0.1581	0.505	0.521	10	7	silty sand to sandy silt
13.287	34.75	0.1488	0.428	0.490	11	7	silty sand to sandy silt
13.451	48.78	0.1229	0.252	0.483	12	8	sand to silty sand
13.615	58.92	0.1464	0.248	0.342	14	8	sand to silty sand
13.780	60.67	0.1934	0.319	0.189	15	8	sand to silty sand
13.944	49.48	0.2743	0.554	0.120	12	8	sand to silty sand
14.108	44.20	0.3087	0.699	0.306	14	7	silty sand to sandy silt
14.272	40.44	0.3699	0.915	0.808	13	7	silty sand to sandy silt
14.436	37.42	0.4289	1.146	1.038	12	7	silty sand to sandy silt
14.600	36.04	0.4474	1.241	1.028	12	7	silty sand to sandy silt
14.764	35.47	0.4387	1.237	1.081	11	7	silty sand to sandy silt
14.928	34.46	0.4277	1.241	1.143	11	7	silty sand to sandy silt
15.092	30.85	0.4113	1.333	1.138	12	6	sandy silt to clayey silt
15.256	28.91	0.3810	1.318	1.122	11	6	sandy silt to clayey silt
15.420	29.07	0.3748	1.289	1.215	11	6	sandy silt to clayey silt
15.584	28.64	0.2670	0.932	1.339	9	7	silty sand to sandy silt
15.748	27.90	0.2946	1.056	1.320	9	7	silty sand to sandy silt
15.912	28.93	0.3296	1.139	1.746	11	6	sandy silt to clayey silt
16.076	29.25	0.3807	1.301	1.784	11	6	sandy silt to clayey silt
16.240	29.45	0.3958	1.344	1.808	11	6	sandy silt to clayey silt
16.404	29.41	0.4166	1.416	1.956	11	6	sandy silt to clayey silt
16.568	33.17	0.4140	1.248	2.066	11	7	silty sand to sandy silt
16.732	39.86	0.4399	1.104	2.047	13	7	silty sand to sandy silt
16.896	40.20	0.4559	1.134	2.011	13	7	silty sand to sandy silt
17.060	36.67	0.4405	1.201	1.975	12	7	silty sand to sandy silt
17.224	34.26	0.4576	1.336	2.107	11	7	silty sand to sandy silt
17.388	33.77	0.4106	1.216	1.966	11	7	silty sand to sandy silt
17.552	35.52	0.3743	1.054	2.638	11	7	silty sand to sandy silt
17.717	34.29	0.3196	0.932	2.520	11	7	silty sand to sandy silt
17.881	36.50	0.2894	0.793	2.487	12	7	silty sand to sandy silt
18.045	42.70	0.2767	0.648	2.300	14	7	silty sand to sandy silt
18.209	40.97	0.3235	0.790	2.253	13	7	silty sand to sandy silt
18.373	41.25	0.3633	0.881	2.336	13	7	silty sand to sandy silt
18.537	38.44	0.3840	0.999	2.439	12	7	silty sand to sandy silt
18.701	36.28	0.4218	1.163	2.485	12	7	silty sand to sandy silt
18.865	33.99	0.3561	1.047	2.731	11	7	silty sand to sandy silt
19.029	31.72	0.3440	1.085	2.920	10	7	silty sand to sandy silt
19.193	35.49	0.3459	0.975	2.755	11	7	silty sand to sandy silt
19.357	35.32	0.3680	1.042	2.654	11	7	silty sand to sandy silt
19.521	33.83	0.3874	1.145	2.642	11	7	silty sand to sandy silt
19.685	33.47	0.3901	1.165	2.690	11	7	silty sand to sandy silt
19.849	33.93	0.3898	1.149	3.075	11	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
20.013	34.95	0.3879	1.110	3.058	11	7	silty sand to sandy silt
20.177	34.86	0.3840	1.102	2.984	11	7	silty sand to sandy silt
20.341	35.88	0.4444	1.239	3.099	11	7	silty sand to sandy silt
20.505	33.61	0.7077	2.106	3.293	13	6	sandy silt to clayey silt
20.669	23.31	0.5901	2.531	3.503	11	5	clayey silt to silty clay
20.833	16.90	0.3229	1.911	4.704	8	5	clayey silt to silty clay
20.997	25.99	0.2921	1.124	5.455	10	6	sandy silt to clayey silt
21.161	28.12	0.3558	1.265	4.156	11	6	sandy silt to clayey silt
21.325	26.13	0.3942	1.508	4.103	10	6	sandy silt to clayey silt
21.490	27.32	0.4012	1.469	4.216	10	6	sandy silt to clayey silt
21.654	29.44	0.3564	1.211	4.010	11	6	sandy silt to clayey silt
21.818	30.50	0.3342	1.096	3.871	10	7	silty sand to sandy silt
21.982	29.64	0.3427	1.156	3.678	9	7	silty sand to sandy silt
22.146	29.72	0.3389	1.141	3.800	9	7	silty sand to sandy silt
22.310	26.45	0.3552	1.343	3.788	10	6	sandy silt to clayey silt
22.474	27.01	0.3754	1.390	3.965	10	6	sandy silt to clayey silt
22.638	28.39	0.3591	1.265	3.833	11	6	sandy silt to clayey silt
22.802	30.22	0.3098	1.025	3.750	10	7	silty sand to sandy silt
22.966	31.65	0.3172	1.002	3.551	10	7	silty sand to sandy silt
23.130	29.57	0.3777	1.278	3.568	11	6	sandy silt to clayey silt
23.294	26.65	0.3846	1.443	3.640	10	6	sandy silt to clayey silt
23.458	28.23	0.3455	1.224	3.678	11	6	sandy silt to clayey silt
23.622	29.19	0.3397	1.164	3.606	11	6	sandy silt to clayey silt
23.786	30.18	0.3578	1.186	3.709	10	7	silty sand to sandy silt
23.950	33.15	0.4076	1.230	3.955	11	7	silty sand to sandy silt
24.114	33.85	0.4277	1.264	4.168	11	7	silty sand to sandy silt
24.278	34.20	0.4482	1.311	4.331	11	7	silty sand to sandy silt
24.442	35.37	0.4379	1.238	4.366	11	7	silty sand to sandy silt
24.606	35.96	0.4304	1.197	4.300	11	7	silty sand to sandy silt
24.770	35.24	0.4177	1.185	4.493	11	7	silty sand to sandy silt
24.934	34.87	0.3977	1.140	4.407	11	7	silty sand to sandy silt
25.098	33.29	0.3967	1.192	4.311	11	7	silty sand to sandy silt
25.262	32.49	0.4046	1.245	4.343	10	7	silty sand to sandy silt
25.427	32.76	0.3896	1.189	4.443	10	7	silty sand to sandy silt
25.591	33.35	0.4297	1.289	4.476	11	7	silty sand to sandy silt
25.755	34.37	0.4416	1.285	5.026	11	7	silty sand to sandy silt
25.919	33.89	0.4537	1.339	5.127	11	7	silty sand to sandy silt
26.083	32.50	0.4654	1.432	5.046	12	6	sandy silt to clayey silt
26.247	31.69	0.3944	1.244	5.050	10	7	silty sand to sandy silt
26.411	30.07	0.3552	1.181	4.603	10	7	silty sand to sandy silt
26.575	29.95	0.4246	1.418	4.328	11	6	sandy silt to clayey silt
26.739	28.39	0.6322	2.227	4.656	11	6	sandy silt to clayey silt
26.903	20.18	0.5389	2.671	4.799	10	5	clayey silt to silty clay
27.067	29.23	0.3402	1.164	5.710	11	6	sandy silt to clayey silt
27.231	36.00	0.4173	1.159	4.295	11	7	silty sand to sandy silt
27.395	35.56	0.4680	1.316	4.237	11	7	silty sand to sandy silt
27.559	32.80	0.4697	1.432	4.242	13	6	sandy silt to clayey silt
27.723	33.13	0.4087	1.234	4.352	11	7	silty sand to sandy silt
27.887	34.02	0.3830	1.126	4.199	11	7	silty sand to sandy silt
28.051	34.55	0.4111	1.190	4.309	11	7	silty sand to sandy silt
28.215	32.97	0.4516	1.369	4.364	13	6	sandy silt to clayey silt
28.379	30.25	0.5063	1.674	4.723	12	6	sandy silt to clayey silt
28.543	28.87	0.6951	2.407	5.110	11	6	sandy silt to clayey silt
28.707	21.25	0.4680	2.203	5.280	10	5	clayey silt to silty clay
28.871	12.62	0.3879	3.072	6.825	8	4	silty clay to clay
29.035	9.53	0.3568	3.743	26.878	9	3	clay
29.199	9.17	0.3012	3.285	31.283	9	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
29.364	9.12	0.1537	1.686	31.297	4	5	clayey silt to silty clay
29.528	9.19	0.1529	1.664	30.857	4	5	clayey silt to silty clay
29.692	8.43	0.1415	1.679	36.828	4	5	clayey silt to silty clay
29.856	8.76	0.1286	1.468	37.596	4	5	clayey silt to silty clay
30.020	8.76	0.1295	1.478	40.092	4	5	clayey silt to silty clay
30.184	9.20	0.1426	1.550	43.091	4	5	clayey silt to silty clay
30.348	10.21	0.1995	1.954	46.384	5	5	clayey silt to silty clay
30.512	11.09	0.2506	2.259	53.390	5	5	clayey silt to silty clay
30.676	10.61	0.3084	2.906	53.658	7	4	silty clay to clay
30.840	11.31	0.3724	3.293	55.270	7	4	silty clay to clay
31.004	12.16	0.4135	3.401	54.153	8	4	silty clay to clay
31.168	11.96	0.4726	3.951	52.087	11	3	clay
31.332	12.01	0.4728	3.937	53.632	12	3	clay
31.496	11.87	0.4634	3.903	54.540	11	3	clay
31.660	11.58	0.4557	3.935	54.225	11	3	clay
31.824	11.65	0.4506	3.867	55.805	11	3	clay
31.988	11.65	0.4898	4.206	54.964	11	3	clay
32.152	11.76	0.5165	4.391	57.561	11	3	clay
32.316	12.34	0.5418	4.390	53.914	12	3	clay
32.480	12.13	0.5484	4.521	51.774	12	3	clay
32.644	12.01	0.5093	4.240	51.056	12	3	clay
32.808	11.45	0.4504	3.934	49.019	11	3	clay
32.972	10.82	0.4012	3.707	49.861	10	3	clay
33.136	10.56	0.3923	3.716	51.159	10	3	clay
33.301	10.50	0.3897	3.712	51.793	10	3	clay
33.465	10.60	0.3911	3.689	50.686	10	3	clay
33.629	10.52	0.4045	3.845	51.336	10	3	clay
33.793	10.99	0.3985	3.628	52.147	11	3	clay
33.957	10.89	0.3759	3.453	52.403	7	4	silty clay to clay
34.121	10.36	0.3466	3.346	53.357	7	4	silty clay to clay
34.285	10.20	0.2990	2.930	54.230	7	4	silty clay to clay
34.449	9.66	0.2460	2.546	53.163	6	4	silty clay to clay
34.613	9.22	0.1950	2.116	54.792	4	5	clayey silt to silty clay
34.777	8.89	0.1685	1.895	56.499	4	5	clayey silt to silty clay
34.941	8.94	0.1766	1.976	58.075	4	5	clayey silt to silty clay
35.105	9.38	0.1817	1.936	58.809	4	5	clayey silt to silty clay
35.269	9.73	0.2030	2.086	57.635	5	5	clayey silt to silty clay
35.433	7.98	0.2136	2.677	53.684	5	4	silty clay to clay
35.597	9.20	0.2336	2.539	47.453	6	4	silty clay to clay
35.761	10.38	0.2300	2.215	45.669	5	5	clayey silt to silty clay
35.925	10.44	0.1673	1.602	38.354	5	5	clayey silt to silty clay
36.089	10.02	0.0958	0.956	37.672	5	5	clayey silt to silty clay
36.253	9.22	0.0727	0.788	38.516	4	5	clayey silt to silty clay
36.417	8.17	0.0577	0.706	40.496	4	1	sensitive fine grained
36.581	7.41	0.0487	0.658	43.002	4	1	sensitive fine grained
36.745	7.36	0.0408	0.554	45.375	4	1	sensitive fine grained
36.909	7.35	0.0395	0.537	48.861	4	1	sensitive fine grained
37.073	7.99	0.0486	0.608	46.747	4	1	sensitive fine grained
37.238	7.69	0.0704	0.915	48.302	4	1	sensitive fine grained
37.402	10.44	0.0770	0.738	48.514	4	6	sandy silt to clayey silt
37.566	11.33	0.0917	0.809	51.692	4	6	sandy silt to clayey silt
37.730	13.27	0.1621	1.222	59.593	5	6	sandy silt to clayey silt
37.894	15.49	0.2138	1.381	61.851	6	6	sandy silt to clayey silt
38.058	16.10	0.2784	1.730	68.054	8	5	clayey silt to silty clay
38.222	17.09	0.3296	1.928	81.739	8	5	clayey silt to silty clay
38.386	19.51	0.4232	2.169	94.095	9	5	clayey silt to silty clay
38.550	21.65	0.4125	1.906	107.378	8	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
38.714	23.06	0.4510	1.956	122.025	9	6	sandy silt to clayey silt
38.878	23.61	0.5154	2.183	126.819	9	6	sandy silt to clayey silt
39.042	24.60	0.5110	2.078	133.718	9	6	sandy silt to clayey silt
39.206	24.99	0.7230	2.893	130.282	12	5	clayey silt to silty clay
39.370	24.58	0.7684	3.126	155.218	12	5	clayey silt to silty clay
39.534	28.81	0.6795	2.359	134.094	11	6	sandy silt to clayey silt
39.698	26.20	0.6030	2.302	149.295	10	6	sandy silt to clayey silt
39.862	28.71	0.7166	2.496	178.404	11	6	sandy silt to clayey silt
40.026	34.81	0.8322	2.391	165.948	13	6	sandy silt to clayey silt
40.190	34.42	0.8547	2.483	169.160	13	6	sandy silt to clayey silt
40.354	33.93	0.8303	2.447	187.599	13	6	sandy silt to clayey silt
40.518	30.96	0.6380	2.061	154.434	12	6	sandy silt to clayey silt
40.682	26.28	0.5083	1.935	156.297	10	6	sandy silt to clayey silt
40.846	27.90	0.5138	1.842	185.528	11	6	sandy silt to clayey silt
41.011	30.03	0.5210	1.735	188.486	12	6	sandy silt to clayey silt
41.175	31.03	0.5936	1.913	192.381	12	6	sandy silt to clayey silt
41.339	31.15	0.5761	1.850	185.234	12	6	sandy silt to clayey silt
41.503	30.32	0.5638	1.859	193.570	12	6	sandy silt to clayey silt
41.667	31.93	0.6593	2.065	203.207	12	6	sandy silt to clayey silt
41.831	35.34	1.4033	3.971	210.670	23	4	silty clay to clay
41.995	37.15	1.7958	4.833	204.369	36	3	clay
42.159	42.05	1.8848	4.482	122.888	27	4	silty clay to clay
42.323	51.28	2.2023	4.295	137.178	33	4	silty clay to clay
42.487	60.46	2.2834	3.777	15.352	29	5	clayey silt to silty clay
42.651	65.98	2.2455	3.403	8.585	32	5	clayey silt to silty clay
42.815	53.75	2.1505	4.001	9.481	26	5	clayey silt to silty clay
42.979	39.24	2.0298	5.173	12.265	38	3	clay
43.143	33.02	1.5771	4.776	16.246	32	3	clay
43.307	26.21	1.1907	4.543	20.094	25	3	clay
43.471	24.26	1.3461	5.549	27.098	23	3	clay
43.635	41.09	1.6003	3.895	32.701	20	5	clayey silt to silty clay
43.799	45.88	1.9953	4.349	16.684	29	4	silty clay to clay
43.963	36.48	1.7903	4.908	26.703	35	3	clay
44.127	28.22	1.2969	4.596	30.329	27	3	clay
44.291	27.78	1.1932	4.296	36.926	18	4	silty clay to clay
44.455	26.55	1.0007	3.769	41.496	17	4	silty clay to clay
44.619	23.57	0.8768	3.720	47.639	15	4	silty clay to clay
44.783	26.07	0.9704	3.723	62.601	17	4	silty clay to clay
44.948	27.43	1.2822	4.674	78.075	26	3	clay
45.112	30.61	2.4993	8.166	95.642	29	3	clay
45.276	44.44	2.3297	5.243	99.222	43	3	clay
45.440	35.06	2.0667	5.896	49.634	34	3	clay
45.604	30.00	1.7678	5.893	64.268	29	3	clay
45.768	34.67	1.6199	4.673	81.725	22	4	silty clay to clay
45.932	46.56	1.3038	2.800	47.221	18	6	sandy silt to clayey silt
46.096	48.48	0.7669	1.582	9.154	15	7	silty sand to sandy silt
46.260	48.94	0.7817	1.597	5.730	16	7	silty sand to sandy silt
46.424	46.24	0.9309	2.013	5.380	18	6	sandy silt to clayey silt
46.588	39.61	1.3286	3.354	6.129	19	5	clayey silt to silty clay
46.752	26.26	1.3377	5.093	8.271	25	3	clay
46.916	28.88	1.3533	4.686	14.228	28	3	clay
47.080	30.60	1.3748	4.493	14.563	20	4	silty clay to clay
47.244	25.72	1.2758	4.961	17.817	25	3	clay
47.408	23.10	0.8092	3.504	23.298	11	5	clayey silt to silty clay
47.572	25.37	0.6451	2.543	28.344	12	5	clayey silt to silty clay
47.736	20.83	0.7212	3.462	36.128	10	5	clayey silt to silty clay
47.900	21.80	0.8573	3.933	48.809	14	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
48.064	26.11	1.0873	4.165	62.075	17	4	silty clay to clay
48.228	23.52	1.0925	4.645	63.666	23	3	clay
48.392	32.72	1.1606	3.547	58.704	16	5	clayey silt to silty clay
48.556	36.06	1.1423	3.168	46.711	17	5	clayey silt to silty clay
48.720	39.86	1.1447	2.872	42.036	15	6	sandy silt to clayey silt
48.885	41.73	1.2891	3.089	28.454	20	5	clayey silt to silty clay
49.049	42.58	1.0215	2.399	21.249	16	6	sandy silt to clayey silt
49.213	41.65	0.9359	2.247	17.588	16	6	sandy silt to clayey silt
49.377	30.75	0.8457	2.751	14.783	12	6	sandy silt to clayey silt
49.541	24.40	0.7690	3.152	18.446	12	5	clayey silt to silty clay
49.705	20.35	0.8381	4.117	29.131	13	4	silty clay to clay
49.869	24.14	0.9214	3.817	37.601	15	4	silty clay to clay
50.033	40.26	0.9683	2.405	29.841	15	6	sandy silt to clayey silt
50.197	46.96	0.8403	1.789	16.780	15	7	silty sand to sandy silt
50.361	50.38	0.8138	1.615	14.161	16	7	silty sand to sandy silt
50.525	50.44	0.8476	1.681	13.166	16	7	silty sand to sandy silt
50.689	52.11	0.7528	1.444	12.497	17	7	silty sand to sandy silt
50.853	51.45	0.9898	1.924	10.187	16	7	silty sand to sandy silt
51.017	38.50	1.2780	3.319	10.668	18	5	clayey silt to silty clay
51.181	26.91	0.9079	3.374	13.664	13	5	clayey silt to silty clay
51.345	28.69	0.8628	3.008	27.220	14	5	clayey silt to silty clay
51.509	30.90	0.7592	2.457	23.585	12	6	sandy silt to clayey silt
51.673	27.25	0.8481	3.112	30.769	13	5	clayey silt to silty clay
51.837	29.16	0.7515	2.577	34.088	11	6	sandy silt to clayey silt
52.001	48.23	0.6226	1.291	27.753	15	7	silty sand to sandy silt
52.165	45.99	0.9205	2.001	21.223	18	6	sandy silt to clayey silt
52.329	34.78	0.9941	2.858	19.051	13	6	sandy silt to clayey silt
52.493	31.98	0.5720	1.788	25.723	12	6	sandy silt to clayey silt
52.657	40.81	0.9671	2.370	26.962	16	6	sandy silt to clayey silt
52.822	27.57	1.0624	3.854	25.560	18	4	silty clay to clay
52.986	20.95	0.7637	3.645	34.061	13	4	silty clay to clay
53.150	24.11	0.7029	2.915	45.745	12	5	clayey silt to silty clay
53.314	25.01	0.5225	2.089	47.790	10	6	sandy silt to clayey silt
53.478	29.48	0.5549	1.882	49.930	11	6	sandy silt to clayey silt
53.642	24.88	0.5893	2.369	45.501	10	6	sandy silt to clayey silt
53.806	19.61	0.6154	3.138	50.164	9	5	clayey silt to silty clay
53.970	18.90	0.6201	3.281	59.081	9	5	clayey silt to silty clay
54.134	18.69	0.6307	3.375	62.169	9	5	clayey silt to silty clay
54.298	21.58	0.5664	2.625	65.713	10	5	clayey silt to silty clay
54.462	26.19	0.5746	2.194	48.244	10	6	sandy silt to clayey silt
54.626	22.37	0.6204	2.773	45.248	11	5	clayey silt to silty clay
54.790	20.57	0.5364	2.607	54.416	10	5	clayey silt to silty clay
54.954	19.92	0.5604	2.813	58.319	10	5	clayey silt to silty clay
55.118	20.56	0.6346	3.086	64.923	10	5	clayey silt to silty clay
55.282	21.34	0.6294	2.949	75.488	10	5	clayey silt to silty clay
55.446	22.80	0.6991	3.066	78.071	11	5	clayey silt to silty clay
55.610	24.53	0.6176	2.518	78.484	12	5	clayey silt to silty clay
55.774	28.09	0.7504	2.671	71.019	13	5	clayey silt to silty clay
55.938	27.46	1.0340	3.766	67.946	18	4	silty clay to clay
56.102	32.55	1.1800	3.625	80.405	16	5	clayey silt to silty clay
56.266	57.75	1.1449	1.983	59.278	18	7	silty sand to sandy silt
56.430	71.87	1.3126	1.826	32.146	23	7	silty sand to sandy silt
56.594	55.51	1.5216	2.741	23.301	21	6	sandy silt to clayey silt
56.759	43.17	1.5206	3.523	28.796	21	5	clayey silt to silty clay
56.923	46.04	1.5390	3.343	37.868	22	5	clayey silt to silty clay
57.087	33.35	1.2816	3.842	34.236	16	5	clayey silt to silty clay
57.251	22.35	1.1390	5.096	40.013	21	3	clay

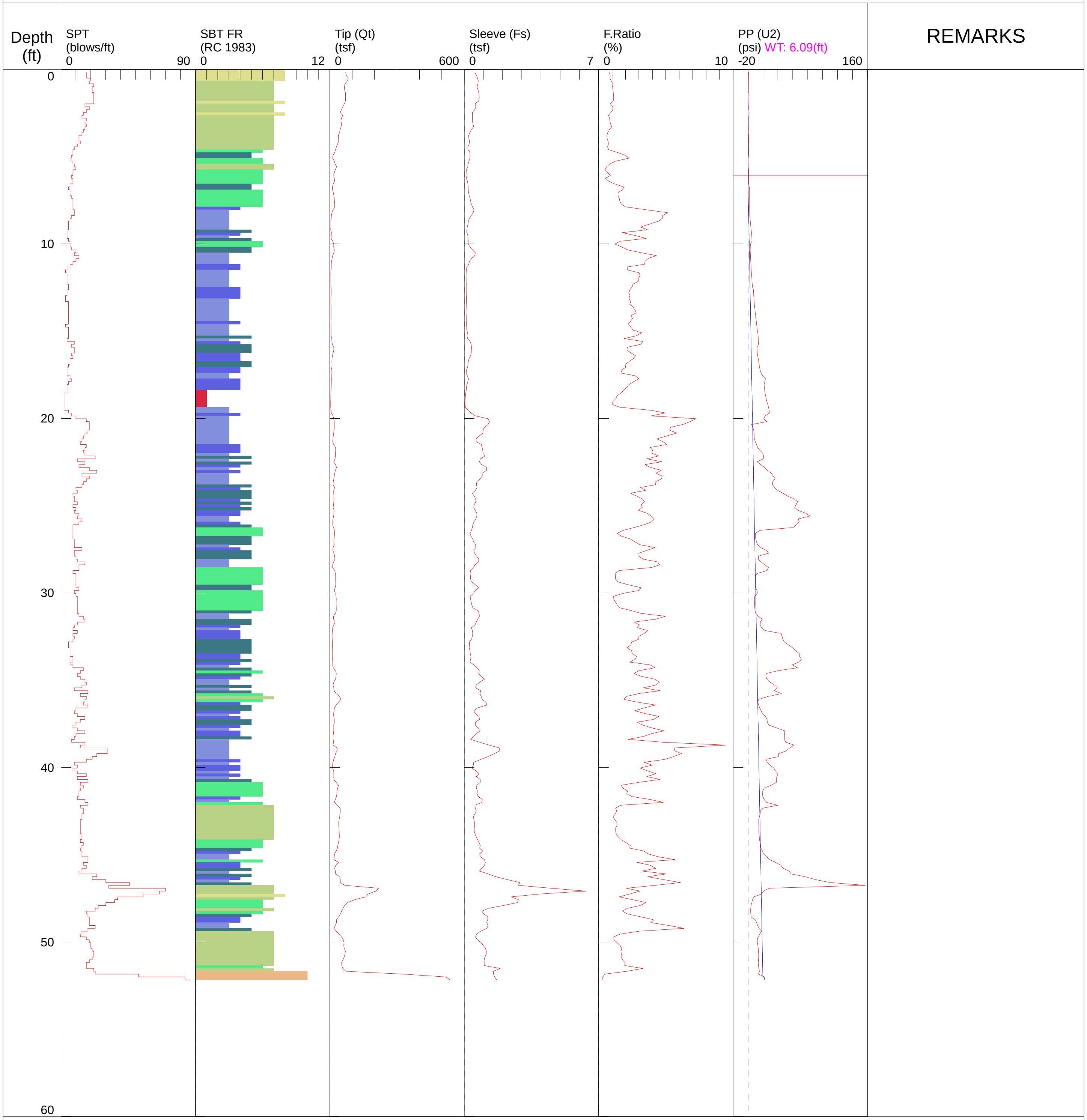
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
57.415	21.63	0.9124	4.219	50.016	14	4	silty clay to clay
57.579	29.23	0.6435	2.202	58.938	11	6	sandy silt to clayey silt
57.743	32.46	0.9234	2.844	59.844	16	5	clayey silt to silty clay
57.907	30.12	1.4269	4.738	66.418	29	3	clay
58.071	31.37	1.3765	4.388	90.823	20	4	silty clay to clay
58.235	55.11	0.9573	1.737	36.187	18	7	silty sand to sandy silt
58.399	63.37	0.9229	1.456	14.553	20	7	silty sand to sandy silt
58.563	67.98	0.9723	1.430	21.227	22	7	silty sand to sandy silt
58.727	73.29	0.9768	1.333	20.859	23	7	silty sand to sandy silt
58.891	79.74	1.3379	1.678	20.070	25	7	silty sand to sandy silt
59.055	61.51	1.3747	2.235	19.927	24	6	sandy silt to clayey silt
59.219	54.87	1.0808	1.970	16.885	18	7	silty sand to sandy silt
59.383	56.15	0.8408	1.497	18.136	18	7	silty sand to sandy silt
59.547	57.94	0.7591	1.310	16.978	18	7	silty sand to sandy silt
59.711	52.46	0.7487	1.427	17.339	17	7	silty sand to sandy silt
59.875	43.59	1.0804	2.478	19.623	17	6	sandy silt to clayey silt
60.039	30.78	1.3093	4.254	22.920	20	4	silty clay to clay
60.203	25.78	1.1216	4.351	33.071	16	4	silty clay to clay
60.367	25.28	1.0404	4.115	70.292	16	4	silty clay to clay
60.532	26.31	1.1237	4.270	96.959	17	4	silty clay to clay
60.696	23.16	1.0720	4.629	86.203	22	3	clay
60.860	27.11	0.8882	3.277	74.821	13	5	clayey silt to silty clay
61.024	31.18	0.6562	2.105	39.155	12	6	sandy silt to clayey silt
61.188	30.23	0.7602	2.514	43.292	12	6	sandy silt to clayey silt
61.352	25.49	0.7122	2.794	49.009	12	5	clayey silt to silty clay
61.516	21.99	0.6893	3.135	59.906	11	5	clayey silt to silty clay
61.680	16.62	0.6565	3.951	76.617	11	4	silty clay to clay
61.844	48.09	0.7295	1.517	32.533	15	7	silty sand to sandy silt
62.008	51.38	0.7911	1.540	28.110	16	7	silty sand to sandy silt
62.172	51.90	0.7000	1.349	29.004	17	7	silty sand to sandy silt
62.336	49.13	0.7324	1.491	27.655	16	7	silty sand to sandy silt
62.500	44.14	0.7161	1.622	24.843	14	7	silty sand to sandy silt
62.664	40.70	0.6317	1.552	28.349	13	7	silty sand to sandy silt
62.828	33.45	0.8221	2.458	25.635	13	6	sandy silt to clayey silt
62.992	25.10	0.7322	2.917	29.812	12	5	clayey silt to silty clay
63.156	23.44	0.5942	2.534	41.838	11	5	clayey silt to silty clay
63.320	30.94	0.5924	1.915	45.394	12	6	sandy silt to clayey silt
63.484	35.75	0.8014	2.242	38.899	14	6	sandy silt to clayey silt
63.648	30.39	0.8447	2.779	41.948	15	5	clayey silt to silty clay
63.812	32.97	0.6402	1.942	39.741	13	6	sandy silt to clayey silt
63.976	46.83	0.5264	1.124	27.748	15	7	silty sand to sandy silt
64.140	46.76	0.4699	1.005	21.050	15	7	silty sand to sandy silt
64.304	33.76	0.5569	1.650	22.332	13	6	sandy silt to clayey silt
64.469	19.47	0.4703	2.416	22.148	9	5	clayey silt to silty clay
64.633	14.70	0.2592	1.763	24.142	7	5	clayey silt to silty clay
64.797	15.23	0.3005	1.973	27.842	7	5	clayey silt to silty clay
64.961	46.73	0.3807	0.815	21.103	15	7	silty sand to sandy silt
65.125	47.22	0.4810	1.019	22.227	15	7	silty sand to sandy silt
65.289	46.16	0.5539	1.200	24.121	15	7	silty sand to sandy silt
65.453	43.11	0.6479	1.503	24.802	14	7	silty sand to sandy silt
65.617	38.63	0.8874	2.297	25.541	15	6	sandy silt to clayey silt
65.781	34.32	0.8972	2.614	25.737	13	6	sandy silt to clayey silt
65.945	30.83	0.9274	3.008	37.902	15	5	clayey silt to silty clay
66.109	37.99	0.9613	2.530	41.013	15	6	sandy silt to clayey silt
66.273	46.55	1.2035	2.586	42.859	18	6	sandy silt to clayey silt
66.437	48.73	1.1400	2.339	45.205	19	6	sandy silt to clayey silt
66.601	49.77	1.3967	2.806	36.034	19	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
66.765	42.76	1.3342	3.120	39.337	20	5	clayey silt to silty clay
66.929	67.41	1.1734	1.741	37.897	22	7	silty sand to sandy silt
67.093	81.19	1.0232	1.260	23.681	26	7	silty sand to sandy silt
67.257	86.14	1.0738	1.247	24.250	21	8	sand to silty sand
67.421	86.48	1.1251	1.301	23.760	21	8	sand to silty sand
67.585	83.07	1.1143	1.342	24.075	27	7	silty sand to sandy silt
67.749	75.97	1.0867	1.431	22.918	24	7	silty sand to sandy silt
67.913	68.62	1.0329	1.505	22.277	22	7	silty sand to sandy silt
68.077	63.39	0.8440	1.332	22.555	20	7	silty sand to sandy silt
68.241	57.18	0.8518	1.490	21.254	18	7	silty sand to sandy silt
68.406	40.95	0.8929	2.181	24.922	16	6	sandy silt to clayey silt
68.570	35.55	1.0373	2.918	24.707	17	5	clayey silt to silty clay
68.734	30.53	0.8553	2.802	25.883	15	5	clayey silt to silty clay
68.898	27.46	0.8151	2.968	30.496	13	5	clayey silt to silty clay
69.062	35.22	0.7653	2.173	24.943	13	6	sandy silt to clayey silt
69.226	38.76	0.6539	1.687	26.376	15	6	sandy silt to clayey silt
69.390	40.36	0.5460	1.353	26.070	13	7	silty sand to sandy silt
69.554	39.07	0.5335	1.366	26.570	12	7	silty sand to sandy silt
69.718	34.63	0.7152	2.065	28.765	13	6	sandy silt to clayey silt
69.882	27.05	0.7600	2.810	31.854	13	5	clayey silt to silty clay
70.046	32.67	0.6578	2.013	38.964	13	6	sandy silt to clayey silt
70.210	35.13	0.6674	1.900	22.040	13	6	sandy silt to clayey silt
70.374	28.87	0.6878	2.383	28.016	11	6	sandy silt to clayey silt
70.538	26.05	0.6948	2.668	51.243	12	5	clayey silt to silty clay
70.702	25.90	0.6377	2.462	62.152	10	6	sandy silt to clayey silt
70.866	24.94	0.4563	1.830	58.957	10	6	sandy silt to clayey silt
71.030	18.59	0.3126	1.681	51.604	7	6	sandy silt to clayey silt
71.194	13.90	0.3964	2.852	57.491	7	5	clayey silt to silty clay
71.358	16.59	0.5657	3.410	71.994	11	4	silty clay to clay
71.522	35.94	0.6109	1.700	45.456	14	6	sandy silt to clayey silt
71.686	49.98	0.5871	1.175	23.846	16	7	silty sand to sandy silt
71.850	60.37	0.5226	0.866	24.166	14	8	sand to silty sand
72.014	70.46	0.5760	0.817	16.275	17	8	sand to silty sand
72.178	60.63	0.9693	1.599	17.705	19	7	silty sand to sandy silt
72.343	45.73	1.2593	2.754	19.534	18	6	sandy silt to clayey silt
72.507	45.21	1.6566	3.664	29.501	22	5	clayey silt to silty clay
72.671	40.08	1.8576	4.635	34.217	26	4	silty clay to clay
72.835	40.54	1.8366	4.531	46.924	26	4	silty clay to clay
72.999	38.86	1.8106	4.660	48.725	25	4	silty clay to clay
73.163	30.95	1.3487	4.358	64.232	20	4	silty clay to clay
73.327	24.75	1.1008	4.447	55.236	24	3	clay
73.491	22.85	0.8046	3.521	52.661	11	5	clayey silt to silty clay
73.655	19.49	0.8637	4.431	52.395	19	3	clay
73.819	19.47	0.7585	3.896	69.591	12	4	silty clay to clay
73.983	43.22	0.6298	1.457	71.918	14	7	silty sand to sandy silt
74.147	68.13	0.8318	1.221	24.850	22	7	silty sand to sandy silt
74.311	46.28	1.0574	2.285	26.139	18	6	sandy silt to clayey silt
74.475	32.92	1.2657	3.845	31.962	16	5	clayey silt to silty clay
74.639	42.70	0.6758	1.583	43.012	14	7	silty sand to sandy silt
74.803	81.50	0.6659	0.817	19.518	20	8	sand to silty sand
74.967	76.83	0.7402	0.963	22.275	18	8	sand to silty sand
75.131	84.75	0.7758	0.915	25.077	20	8	sand to silty sand
75.295	84.33	0.5065	0.601	9.228	20	8	sand to silty sand
75.459	71.88	0.6709	0.933	6.196	17	8	sand to silty sand
75.623	63.30	0.8676	1.371	8.408	20	7	silty sand to sandy silt
75.787	70.46	0.9478	1.345	12.561	22	7	silty sand to sandy silt
75.951	84.19	0.6235	0.741	5.278	20	8	sand to silty sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
76.115	80.52	1.9301	2.397	4.010	31	6	sandy silt to clayey silt
76.280	73.64	1.4985	2.035	3.915	24	7	silty sand to sandy silt
76.444	343.83	1.5304	0.445	7.753	55	10	gravelly sand to sand
76.608	488.30	1.7104	0.350	13.750	78	10	gravelly sand to sand

NV5 / CPT-4 / 5501 NW Front Ave Portland

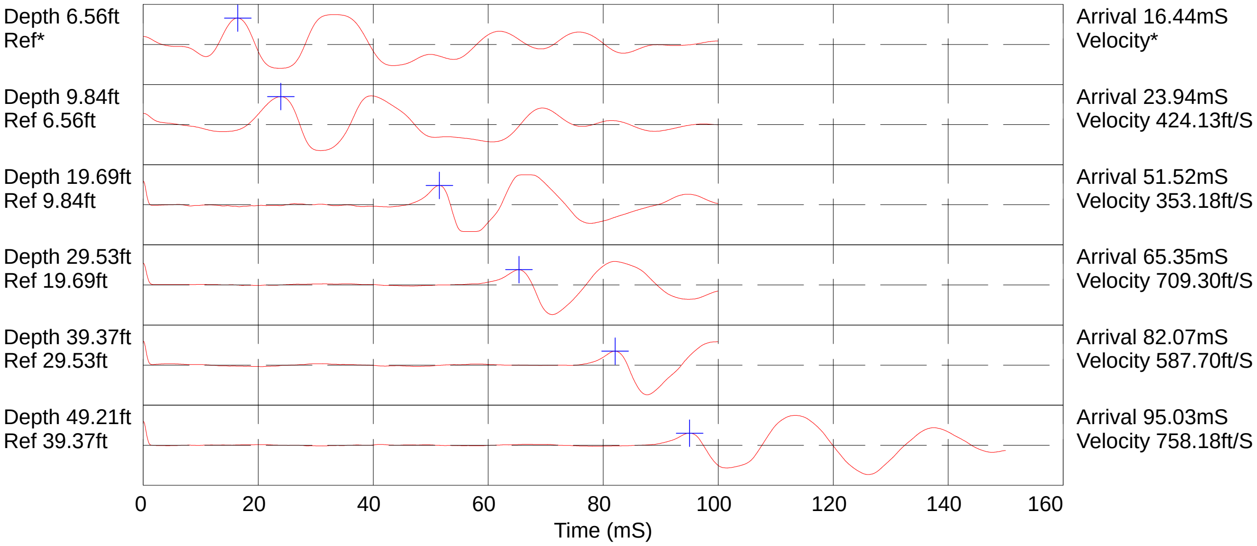
OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 11:38:35 AM
TOTAL DEPTH: 52.165 ft



🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟩 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-4 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 2.03
* = Not Determined

NV5 / CPT-4 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
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TEST DATE: 2/5/2024 11:38:35 AM
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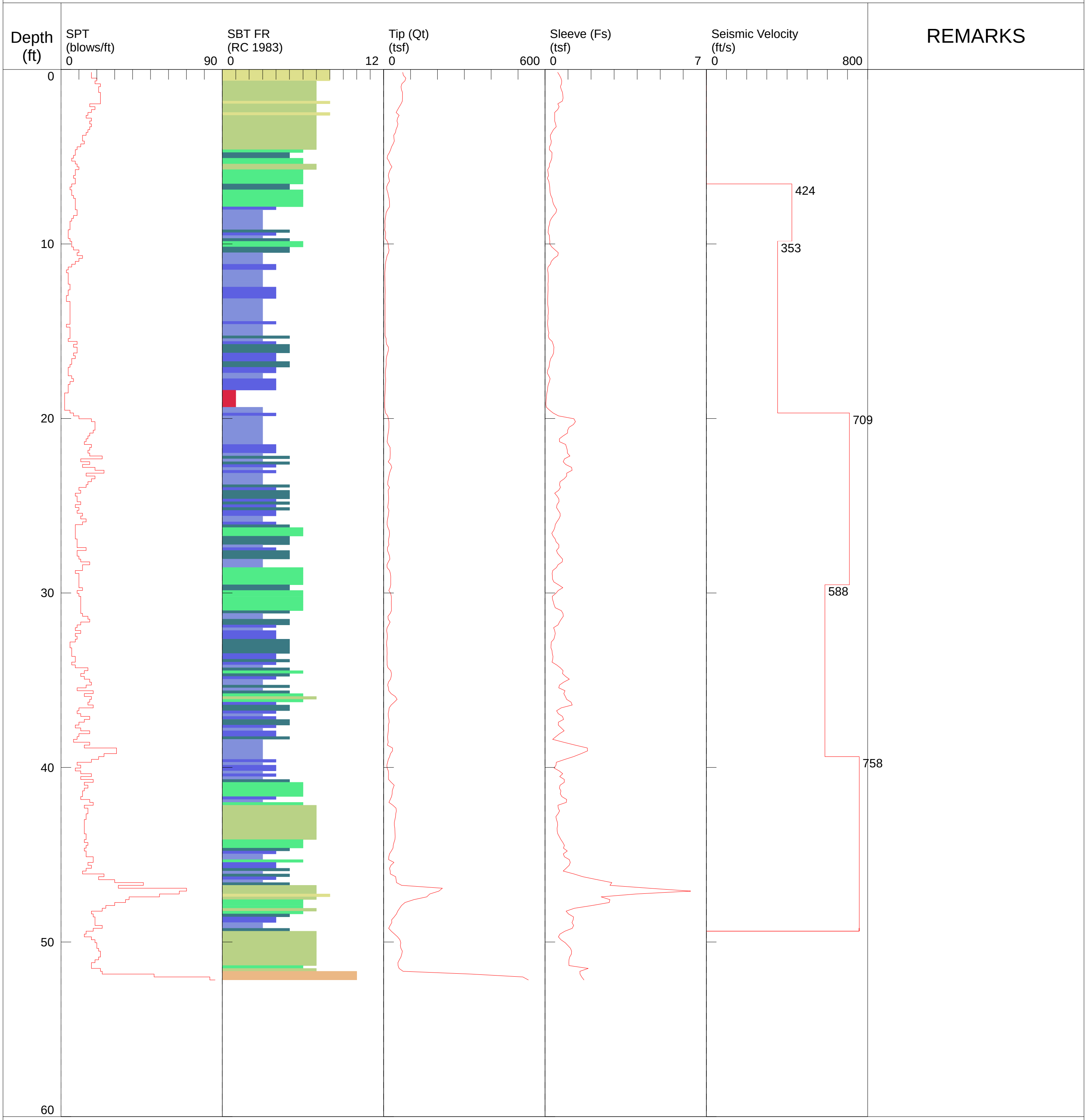

1 sensitive fine grained
2 organic material
3 clay

4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt

7 silty sand to sandy silt
8 sand to silty sand
9 sand

10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-4 / 5501 NW Front Ave Portland

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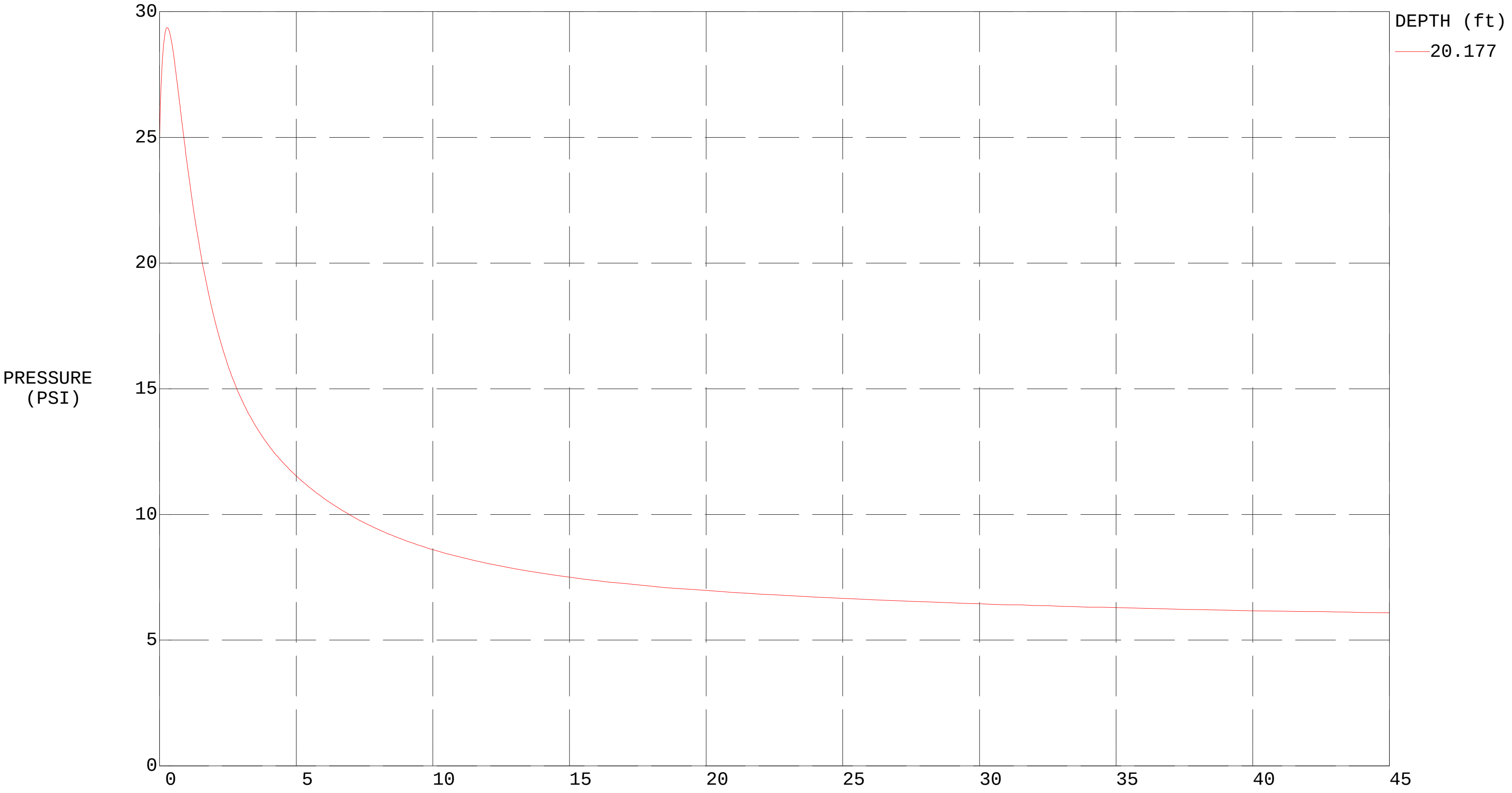


MAXIMUM PRESSURE = 29.364 (PSI)
HYDROSTATIC PRESSURE = 6.107 (PSI), WATER TABLE: 6.09 ft

NV5 / CPT-4 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 11:38:35 AM
TOTAL DEPTH: 52.165 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.164	71.00	0.5480	0.772	0.916	17	8	sand to silty sand
0.328	72.98	0.6293	0.862	1.062	17	8	sand to silty sand
0.492	82.63	0.6909	0.836	1.071	20	8	sand to silty sand
0.656	78.74	0.7273	0.924	1.064	19	8	sand to silty sand
0.820	67.92	0.7166	1.055	1.047	22	7	silty sand to sandy silt
0.984	64.92	0.6685	1.030	1.012	21	7	silty sand to sandy silt
1.148	65.76	0.7023	1.068	0.997	21	7	silty sand to sandy silt
1.312	69.86	0.7615	1.090	1.105	22	7	silty sand to sandy silt
1.476	70.05	0.7731	1.104	1.442	22	7	silty sand to sandy silt
1.640	70.04	0.7819	1.116	1.210	22	7	silty sand to sandy silt
1.804	69.49	0.7530	1.084	1.150	22	7	silty sand to sandy silt
1.969	64.82	0.5567	0.859	1.148	16	8	sand to silty sand
2.133	58.26	0.6143	1.055	1.090	19	7	silty sand to sandy silt
2.297	52.26	0.5510	1.055	1.083	17	7	silty sand to sandy silt
2.461	46.44	0.4193	0.903	1.447	15	7	silty sand to sandy silt
2.625	57.84	0.4218	0.729	1.136	14	8	sand to silty sand
2.789	51.74	0.4213	0.814	1.064	17	7	silty sand to sandy silt
2.953	49.54	0.4181	0.844	1.035	16	7	silty sand to sandy silt
3.117	52.69	0.4616	0.876	1.000	17	7	silty sand to sandy silt
3.281	50.36	0.4861	0.965	1.052	16	7	silty sand to sandy silt
3.445	45.70	0.3676	0.804	1.000	15	7	silty sand to sandy silt
3.609	43.83	0.2982	0.680	0.990	14	7	silty sand to sandy silt
3.773	37.76	0.2305	0.610	0.949	12	7	silty sand to sandy silt
3.937	38.29	0.2406	0.628	0.916	12	7	silty sand to sandy silt
4.101	39.66	0.2740	0.691	0.923	13	7	silty sand to sandy silt
4.265	35.01	0.2549	0.728	0.918	11	7	silty sand to sandy silt
4.429	29.55	0.1935	0.655	0.911	9	7	silty sand to sandy silt
4.593	25.70	0.1911	0.743	0.918	8	7	silty sand to sandy silt
4.757	21.22	0.3023	1.425	0.892	8	6	sandy silt to clayey silt
4.921	14.96	0.2994	2.001	0.909	7	5	clayey silt to silty clay
5.085	13.13	0.2957	2.252	1.241	6	5	clayey silt to silty clay
5.249	19.84	0.2523	1.272	1.308	8	6	sandy silt to clayey silt
5.413	24.05	0.1957	0.814	1.155	9	6	sandy silt to clayey silt
5.577	30.65	0.1833	0.598	1.172	10	7	silty sand to sandy silt
5.741	24.67	0.1155	0.468	0.952	8	7	silty sand to sandy silt
5.906	20.23	0.1361	0.673	0.823	8	6	sandy silt to clayey silt
6.070	17.52	0.1520	0.868	0.866	7	6	sandy silt to clayey silt
6.234	19.71	0.1004	0.509	0.868	8	6	sandy silt to clayey silt
6.398	22.05	0.1640	0.744	0.813	8	6	sandy silt to clayey silt
6.562	15.74	0.1874	1.191	0.815	6	6	sandy silt to clayey silt
6.726	11.02	0.2046	1.856	1.576	5	5	clayey silt to silty clay
6.890	11.91	0.2124	1.784	1.973	6	5	clayey silt to silty clay
7.054	15.57	0.2232	1.434	2.052	6	6	sandy silt to clayey silt
7.218	17.67	0.2535	1.435	2.045	7	6	sandy silt to clayey silt
7.382	20.00	0.3072	1.536	2.076	8	6	sandy silt to clayey silt
7.546	21.11	0.3316	1.570	2.114	8	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
7.710	21.81	0.3690	1.692	2.121	8	6	sandy silt to clayey silt
7.874	21.86	0.4343	1.987	2.167	8	6	sandy silt to clayey silt
8.038	14.47	0.5082	3.512	2.322	9	4	silty clay to clay
8.202	9.15	0.4691	5.125	2.229	9	3	clay
8.366	7.72	0.3682	4.767	2.523	7	3	clay
8.530	5.87	0.2777	4.734	2.657	6	3	clay
8.694	4.86	0.2171	4.468	3.003	5	3	clay
8.858	5.13	0.1934	3.773	3.427	5	3	clay
9.022	5.09	0.1588	3.117	3.668	5	3	clay
9.186	4.00	0.1453	3.633	3.926	4	3	clay
9.350	7.50	0.1310	1.748	4.988	4	5	clayey silt to silty clay
9.514	6.92	0.1898	2.742	5.026	4	4	silty clay to clay
9.678	5.54	0.1954	3.529	5.225	5	3	clay
9.843	13.37	0.2135	1.597	5.380	6	5	clayey silt to silty clay
10.007	16.91	0.2054	1.215	3.310	6	6	sandy silt to clayey silt
10.171	17.30	0.2962	1.712	3.104	7	6	sandy silt to clayey silt
10.335	20.09	0.4380	2.180	2.870	10	5	clayey silt to silty clay
10.499	18.19	0.5759	3.167	2.999	9	5	clayey silt to silty clay
10.663	12.90	0.5542	4.296	3.152	12	3	clay
10.827	10.37	0.3848	3.711	3.415	10	3	clay
10.991	7.99	0.2752	3.444	3.599	8	3	clay
11.155	6.72	0.2299	3.418	3.891	6	3	clay
11.319	6.30	0.1337	2.121	4.084	4	4	silty clay to clay
11.483	5.29	0.1129	2.131	4.271	3	4	silty clay to clay
11.647	4.50	0.1354	3.010	4.622	4	3	clay
11.811	4.48	0.1383	3.085	4.964	4	3	clay
11.975	4.70	0.1377	2.931	5.146	4	3	clay
12.139	4.66	0.1375	2.953	5.359	4	3	clay
12.303	4.89	0.1248	2.554	5.646	5	3	clay
12.467	5.28	0.1312	2.483	5.954	5	3	clay
12.631	5.60	0.1292	2.308	7.231	4	4	silty clay to clay
12.795	5.63	0.1261	2.240	7.418	4	4	silty clay to clay
12.959	5.25	0.1221	2.327	7.666	3	4	silty clay to clay
13.123	5.12	0.1151	2.250	7.891	3	4	silty clay to clay
13.287	4.89	0.1164	2.382	8.157	5	3	clay
13.451	5.10	0.1182	2.316	8.532	5	3	clay
13.615	5.15	0.1322	2.565	8.888	5	3	clay
13.780	5.23	0.1417	2.711	9.369	5	3	clay
13.944	5.20	0.1453	2.792	9.771	5	3	clay
14.108	5.35	0.1278	2.388	10.216	5	3	clay
14.272	5.23	0.1319	2.520	10.615	5	3	clay
14.436	4.97	0.1177	2.370	11.139	5	3	clay
14.600	5.19	0.1129	2.175	11.552	3	4	silty clay to clay
14.764	5.18	0.1246	2.405	11.942	5	3	clay
14.928	5.39	0.1373	2.545	12.487	5	3	clay
15.092	5.26	0.1681	3.196	13.071	5	3	clay
15.256	5.19	0.1451	2.795	13.563	5	3	clay
15.420	9.28	0.1758	1.895	13.817	4	5	clayey silt to silty clay
15.584	9.33	0.3070	3.289	13.673	9	3	clay
15.748	11.27	0.3523	3.126	14.044	7	4	silty clay to clay
15.912	18.05	0.3847	2.132	12.167	9	5	clayey silt to silty clay
16.076	17.95	0.3777	2.104	12.210	9	5	clayey silt to silty clay
16.240	15.41	0.3717	2.412	12.439	7	5	clayey silt to silty clay
16.404	11.96	0.3276	2.739	12.810	8	4	silty clay to clay
16.568	9.66	0.2491	2.579	13.683	6	4	silty clay to clay
16.732	9.31	0.2117	2.274	14.343	6	4	silty clay to clay
16.896	9.77	0.1926	1.972	14.926	5	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.060	8.74	0.1754	2.007	15.421	4	5	clayey silt to silty clay
17.224	6.92	0.1189	1.717	16.256	4	4	silty clay to clay
17.388	5.81	0.0966	1.662	17.432	4	4	silty clay to clay
17.552	6.04	0.1635	2.708	19.489	6	3	clay
17.717	7.43	0.2216	2.981	23.480	7	3	clay
17.881	7.32	0.1915	2.616	22.430	5	4	silty clay to clay
18.045	6.31	0.1434	2.271	21.553	4	4	silty clay to clay
18.209	5.63	0.1169	2.078	21.792	4	4	silty clay to clay
18.373	5.52	0.1028	1.863	22.399	4	4	silty clay to clay
18.537	5.07	0.0846	1.669	22.861	2	1	sensitive fine grained
18.701	4.64	0.0631	1.359	23.576	2	1	sensitive fine grained
18.865	4.28	0.0545	1.274	24.382	2	1	sensitive fine grained
19.029	4.17	0.0438	1.053	25.233	2	1	sensitive fine grained
19.193	3.87	0.0399	1.032	26.538	2	1	sensitive fine grained
19.357	3.86	0.0608	1.574	27.402	2	1	sensitive fine grained
19.521	5.16	0.1991	3.856	28.275	5	3	clay
19.685	7.06	0.3502	4.959	28.681	7	3	clay
19.849	14.93	0.5853	3.919	22.770	10	4	silty clay to clay
20.013	17.26	1.2503	7.242	21.194	17	3	clay
20.177	19.42	1.3205	6.799	24.893	19	3	clay
20.341	19.73	1.2336	6.253	4.861	19	3	clay
20.505	19.43	1.0412	5.357	6.471	19	3	clay
20.669	18.57	0.9800	5.278	7.561	18	3	clay
20.833	16.84	0.9756	5.794	8.102	16	3	clay
20.997	15.44	0.7831	5.072	8.293	15	3	clay
21.161	14.31	0.6201	4.331	8.427	14	3	clay
21.325	13.11	0.6273	4.786	9.625	13	3	clay
21.490	17.60	0.8954	5.089	11.380	17	3	clay
21.654	24.36	0.9317	3.825	13.159	16	4	silty clay to clay
21.818	24.08	0.9660	4.012	15.766	15	4	silty clay to clay
21.982	24.68	0.9735	3.944	19.475	16	4	silty clay to clay
22.146	24.37	1.0829	4.443	21.012	23	3	clay
22.310	23.57	0.8464	3.592	20.527	11	5	clayey silt to silty clay
22.474	16.80	0.7908	4.706	12.368	16	3	clay
22.638	26.06	0.9007	3.457	17.043	12	5	clayey silt to silty clay
22.802	30.12	1.1547	3.834	21.969	19	4	silty clay to clay
22.966	25.23	1.1743	4.653	25.931	24	3	clay
23.130	21.98	0.9369	4.263	30.967	14	4	silty clay to clay
23.294	19.85	0.9378	4.725	33.827	19	3	clay
23.458	17.73	0.8305	4.686	36.462	17	3	clay
23.622	15.47	0.6574	4.250	32.914	15	3	clay
23.786	14.86	0.6292	4.234	32.961	14	3	clay
23.950	21.51	0.6670	3.102	35.248	10	5	clayey silt to silty clay
24.114	16.82	0.5899	3.506	39.827	11	4	silty clay to clay
24.278	17.56	0.4173	2.376	46.539	8	5	clayey silt to silty clay
24.442	18.37	0.5191	2.826	53.067	9	5	clayey silt to silty clay
24.606	18.58	0.6028	3.244	61.721	9	5	clayey silt to silty clay
24.770	17.74	0.6065	3.418	66.392	11	4	silty clay to clay
24.934	16.44	0.5203	3.165	64.237	8	5	clayey silt to silty clay
25.098	15.37	0.4976	3.237	62.554	10	4	silty clay to clay
25.262	19.31	0.5737	2.970	67.049	9	5	clayey silt to silty clay
25.427	18.15	0.6543	3.605	77.444	12	4	silty clay to clay
25.591	16.86	0.6580	3.903	82.978	11	4	silty clay to clay
25.755	14.55	0.6038	4.151	67.255	14	3	clay
25.919	13.05	0.5129	3.930	68.589	12	3	clay
26.083	13.15	0.4445	3.379	65.308	8	4	silty clay to clay
26.247	16.05	0.4242	2.643	60.459	8	5	clayey silt to silty clay

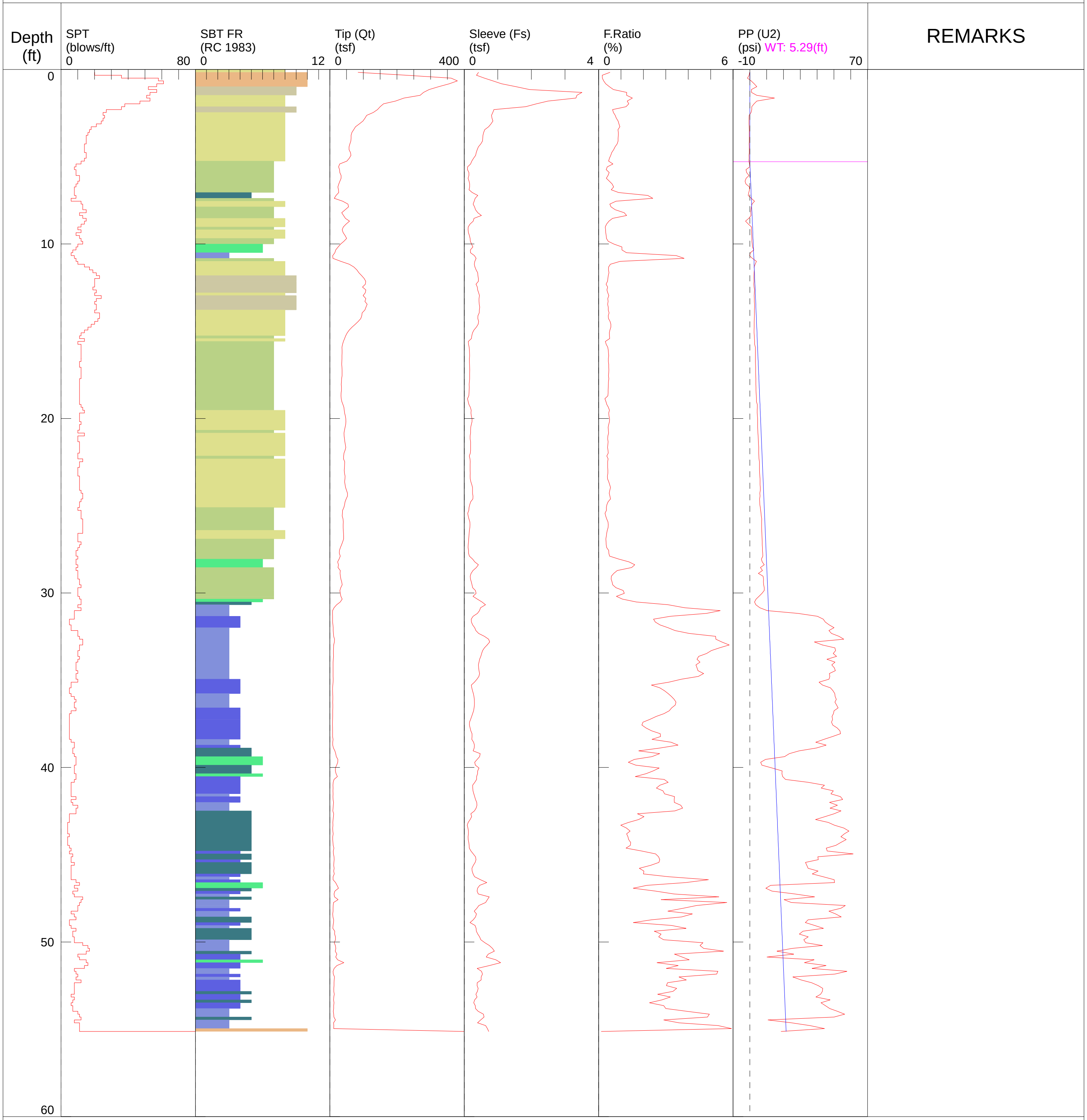
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
26.411	20.63	0.3796	1.840	16.222	8	6	sandy silt to clayey silt
26.575	21.54	0.2942	1.366	9.835	8	6	sandy silt to clayey silt
26.739	20.66	0.3529	1.708	9.799	8	6	sandy silt to clayey silt
26.903	18.76	0.4406	2.349	10.538	9	5	clayey silt to silty clay
27.067	17.89	0.4837	2.704	11.249	9	5	clayey silt to silty clay
27.231	19.53	0.5994	3.069	12.853	9	5	clayey silt to silty clay
27.395	14.28	0.5978	4.187	17.265	14	3	clay
27.559	13.98	0.4964	3.551	25.223	9	4	silty clay to clay
27.723	18.15	0.5439	2.996	27.572	9	5	clayey silt to silty clay
27.887	21.49	0.6449	3.002	13.917	10	5	clayey silt to silty clay
28.051	23.20	0.7630	3.289	13.836	11	5	clayey silt to silty clay
28.215	17.04	0.7480	4.389	17.452	16	3	clay
28.379	12.45	0.5651	4.537	22.595	12	3	clay
28.543	12.59	0.4941	3.923	27.390	12	3	clay
28.707	21.52	0.3325	1.545	25.328	8	6	sandy silt to clayey silt
28.871	25.12	0.3089	1.230	12.655	10	6	sandy silt to clayey silt
29.035	25.88	0.3208	1.240	9.692	10	6	sandy silt to clayey silt
29.199	25.97	0.3257	1.254	9.603	10	6	sandy silt to clayey silt
29.364	26.40	0.3822	1.448	9.620	10	6	sandy silt to clayey silt
29.528	26.55	0.5865	2.209	9.630	10	6	sandy silt to clayey silt
29.692	24.34	0.7714	3.169	9.740	12	5	clayey silt to silty clay
29.856	19.09	0.5730	3.002	11.980	9	5	clayey silt to silty clay
30.020	25.76	0.4727	1.835	12.435	10	6	sandy silt to clayey silt
30.184	28.27	0.3122	1.104	9.061	11	6	sandy silt to clayey silt
30.348	28.85	0.3251	1.127	8.589	11	6	sandy silt to clayey silt
30.512	28.72	0.3590	1.250	8.853	11	6	sandy silt to clayey silt
30.676	28.76	0.3929	1.366	8.958	11	6	sandy silt to clayey silt
30.840	28.96	0.4493	1.551	9.118	11	6	sandy silt to clayey silt
31.004	29.06	0.7067	2.432	9.371	11	6	sandy silt to clayey silt
31.168	24.70	0.7782	3.151	10.400	12	5	clayey silt to silty clay
31.332	15.99	0.7946	4.970	13.621	15	3	clay
31.496	16.61	0.7060	4.252	19.197	16	3	clay
31.660	23.64	0.6273	2.654	16.624	11	5	clayey silt to silty clay
31.824	18.52	0.5630	3.040	16.232	9	5	clayey silt to silty clay
31.988	13.09	0.3742	2.858	18.011	8	4	silty clay to clay
32.152	11.34	0.4158	3.667	22.837	11	3	clay
32.316	13.01	0.4421	3.398	44.306	8	4	silty clay to clay
32.480	13.95	0.4174	2.992	45.520	9	4	silty clay to clay
32.644	12.77	0.3805	2.980	46.635	8	4	silty clay to clay
32.808	11.10	0.2733	2.463	48.596	5	5	clayey silt to silty clay
32.972	11.07	0.2650	2.393	54.323	5	5	clayey silt to silty clay
33.136	12.23	0.2563	2.096	59.885	6	5	clayey silt to silty clay
33.301	12.32	0.3032	2.460	63.422	6	5	clayey silt to silty clay
33.465	12.65	0.3145	2.486	68.687	6	5	clayey silt to silty clay
33.629	12.36	0.3478	2.815	68.910	8	4	silty clay to clay
33.793	12.26	0.3344	2.727	71.480	8	4	silty clay to clay
33.957	13.15	0.3033	2.306	67.482	6	5	clayey silt to silty clay
34.121	13.16	0.5036	3.825	59.361	8	4	silty clay to clay
34.285	15.84	0.6642	4.193	65.858	15	3	clay
34.449	26.21	0.7851	2.995	40.429	13	5	clayey silt to silty clay
34.613	29.01	0.7578	2.612	24.365	11	6	sandy silt to clayey silt
34.777	28.02	0.8946	3.192	23.800	13	5	clayey silt to silty clay
34.941	25.19	1.0564	4.194	25.324	16	4	silty clay to clay
35.105	17.87	0.8089	4.525	29.640	17	3	clay
35.269	14.76	0.6249	4.234	35.575	14	3	clay
35.433	17.80	0.5934	3.333	39.483	9	5	clayey silt to silty clay
35.597	19.14	0.8693	4.541	35.405	18	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
35.761	27.54	0.8173	2.967	44.739	13	5	clayey silt to silty clay
35.925	43.28	0.8816	2.037	26.773	17	6	sandy silt to clayey silt
36.089	49.77	0.9386	1.886	14.620	16	7	silty sand to sandy silt
36.253	39.29	1.1273	2.869	12.925	15	6	sandy silt to clayey silt
36.417	27.91	1.1824	4.236	14.283	18	4	silty clay to clay
36.581	20.62	0.6988	3.389	15.452	10	5	clayey silt to silty clay
36.745	18.80	0.5025	2.673	17.377	9	5	clayey silt to silty clay
36.909	16.57	0.5792	3.495	19.147	11	4	silty clay to clay
37.073	16.94	0.7597	4.484	23.222	16	3	clay
37.238	19.76	0.8048	4.074	25.606	13	4	silty clay to clay
37.402	20.34	0.5827	2.864	25.857	10	5	clayey silt to silty clay
37.566	17.54	0.5729	3.265	27.978	8	5	clayey silt to silty clay
37.730	17.73	0.7030	3.966	38.356	11	4	silty clay to clay
37.894	17.05	0.8299	4.866	49.282	16	3	clay
38.058	16.17	0.6354	3.928	49.084	10	4	silty clay to clay
38.222	14.55	0.4798	3.298	48.823	9	4	silty clay to clay
38.386	15.15	0.3317	2.190	48.577	7	5	clayey silt to silty clay
38.550	16.78	0.8023	4.781	50.542	16	3	clay
38.714	13.84	1.3035	9.421	61.611	13	3	clay
38.878	32.67	1.8366	5.621	55.676	31	3	clay
39.042	32.63	1.8455	5.655	51.346	31	3	clay
39.206	25.43	1.5703	6.175	41.073	24	3	clay
39.370	22.26	1.2356	5.550	40.633	21	3	clay
39.534	17.53	0.8644	4.932	23.683	17	3	clay
39.698	14.54	0.4896	3.367	26.060	9	4	silty clay to clay
39.862	12.00	0.4794	3.994	29.401	11	3	clay
40.026	12.89	0.3962	3.074	34.705	8	4	silty clay to clay
40.190	16.96	0.6182	3.644	36.709	11	4	silty clay to clay
40.354	18.07	0.7692	4.258	40.181	17	3	clay
40.518	17.79	0.6367	3.580	38.650	11	4	silty clay to clay
40.682	18.42	0.8397	4.558	37.957	18	3	clay
40.846	27.98	0.8398	3.002	38.000	13	5	clayey silt to silty clay
41.011	38.90	0.6573	1.690	31.256	15	6	sandy silt to clayey silt
41.175	34.91	0.6229	1.784	21.720	13	6	sandy silt to clayey silt
41.339	32.04	0.6886	2.149	19.709	12	6	sandy silt to clayey silt
41.503	31.82	0.6655	2.092	19.534	12	6	sandy silt to clayey silt
41.667	29.56	0.7356	2.489	19.611	11	6	sandy silt to clayey silt
41.831	24.46	0.9398	3.843	21.486	16	4	silty clay to clay
41.995	19.29	0.9265	4.803	24.977	18	3	clay
42.159	34.42	0.5584	1.622	39.686	13	6	sandy silt to clayey silt
42.323	45.64	0.5755	1.261	20.156	15	7	silty sand to sandy silt
42.487	47.23	0.6318	1.338	16.615	15	7	silty sand to sandy silt
42.651	45.15	0.5635	1.248	16.371	14	7	silty sand to sandy silt
42.815	43.80	0.4740	1.082	15.247	14	7	silty sand to sandy silt
42.979	41.81	0.4980	1.191	14.362	13	7	silty sand to sandy silt
43.143	39.83	0.5372	1.349	14.338	13	7	silty sand to sandy silt
43.307	39.86	0.5450	1.367	14.618	13	7	silty sand to sandy silt
43.471	41.47	0.5217	1.258	14.714	13	7	silty sand to sandy silt
43.635	42.12	0.5287	1.255	14.537	13	7	silty sand to sandy silt
43.799	42.48	0.5561	1.309	14.659	14	7	silty sand to sandy silt
43.963	42.96	0.6194	1.442	15.084	14	7	silty sand to sandy silt
44.127	41.56	0.6919	1.665	15.445	13	7	silty sand to sandy silt
44.291	38.41	0.7749	2.018	16.191	15	6	sandy silt to clayey silt
44.455	35.91	0.8416	2.344	16.744	14	6	sandy silt to clayey silt
44.619	34.57	0.7996	2.313	17.270	13	6	sandy silt to clayey silt
44.783	28.71	0.9620	3.350	19.221	14	5	clayey silt to silty clay
44.948	21.64	0.7960	3.678	20.560	14	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.112	18.99	0.8422	4.435	25.003	18	3	clay
45.276	18.63	1.0541	5.658	28.987	18	3	clay
45.440	38.46	1.1002	2.860	37.194	15	6	sandy silt to clayey silt
45.604	27.35	1.0525	3.848	44.387	17	4	silty clay to clay
45.768	21.53	0.9141	4.245	46.711	14	4	silty clay to clay
45.932	24.47	0.7900	3.229	54.863	12	5	clayey silt to silty clay
46.096	24.98	1.2538	5.020	57.750	24	3	clay
46.260	44.79	1.6361	3.652	76.375	21	5	clayey silt to silty clay
46.424	46.66	2.2692	4.863	90.967	30	4	silty clay to clay
46.588	47.71	2.9009	6.081	110.468	46	3	clay
46.752	67.10	2.8197	4.202	157.002	32	5	clayey silt to silty clay
46.916	218.28	4.5158	2.069	28.485	70	7	silty sand to sandy silt
47.080	205.45	6.3182	3.075	20.943	66	7	silty sand to sandy silt
47.244	171.18	3.9516	2.308	18.023	55	7	silty sand to sandy silt
47.408	160.51	2.4369	1.518	7.879	38	8	sand to silty sand
47.572	112.25	2.8197	2.512	5.945	36	7	silty sand to sandy silt
47.736	79.42	2.7845	3.506	5.148	30	6	sandy silt to clayey silt
47.900	66.10	2.0403	3.086	3.967	25	6	sandy silt to clayey silt
48.064	59.03	1.2713	2.154	3.534	23	6	sandy silt to clayey silt
48.228	51.94	0.9179	1.767	3.422	17	7	silty sand to sandy silt
48.392	47.66	1.0151	2.130	3.675	18	6	sandy silt to clayey silt
48.556	38.94	1.2391	3.182	4.192	19	5	clayey silt to silty clay
48.720	29.70	1.2204	4.109	9.838	19	4	silty clay to clay
48.885	30.12	1.1695	3.883	11.301	19	4	silty clay to clay
49.049	23.95	1.2437	5.193	12.798	23	3	clay
49.213	18.60	1.1805	6.346	14.828	18	3	clay
49.377	28.55	0.8623	3.020	18.140	14	5	clayey silt to silty clay
49.541	40.48	0.6484	1.602	15.797	13	7	silty sand to sandy silt
49.705	51.84	0.5823	1.123	13.317	17	7	silty sand to sandy silt
49.869	60.45	0.6886	1.139	12.499	19	7	silty sand to sandy silt
50.033	63.54	0.8751	1.377	12.530	20	7	silty sand to sandy silt
50.197	62.16	0.9941	1.599	13.198	20	7	silty sand to sandy silt
50.361	64.31	1.1074	1.722	13.791	21	7	silty sand to sandy silt
50.525	69.66	1.1563	1.660	13.879	22	7	silty sand to sandy silt
50.689	67.55	1.1402	1.688	14.156	22	7	silty sand to sandy silt
50.853	64.33	1.0720	1.666	14.142	21	7	silty sand to sandy silt
51.017	58.44	1.0358	1.772	13.884	19	7	silty sand to sandy silt
51.181	52.71	1.0352	1.964	13.621	17	7	silty sand to sandy silt
51.345	53.55	1.0364	1.935	13.953	17	7	silty sand to sandy silt
51.509	57.15	1.8709	3.274	14.737	22	6	sandy silt to clayey silt
51.673	72.36	1.5124	2.090	15.436	23	7	silty sand to sandy silt
51.837	324.85	1.5200	0.468	14.042	52	10	gravelly sand to sand
52.001	517.93	1.5904	0.307	21.887	83	10	gravelly sand to sand
52.165	538.14	1.6905	0.314	22.088	86	10	gravelly sand to sand

NV5 / CPT-5 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/6/2024 11:52:19 AM
TOTAL DEPTH: 55.118 ft



🟥 1 sensitive fine grained
🟪 2 organic material
🟦 3 clay

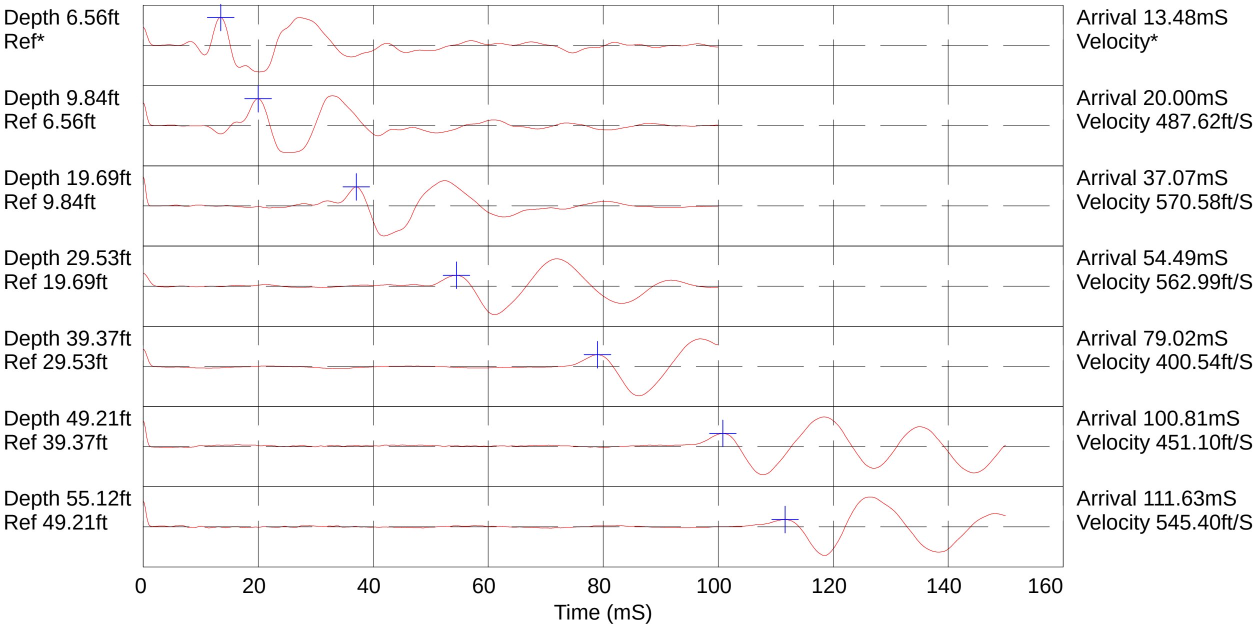
🟦 4 silty clay to clay
🟩 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt

🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand

🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

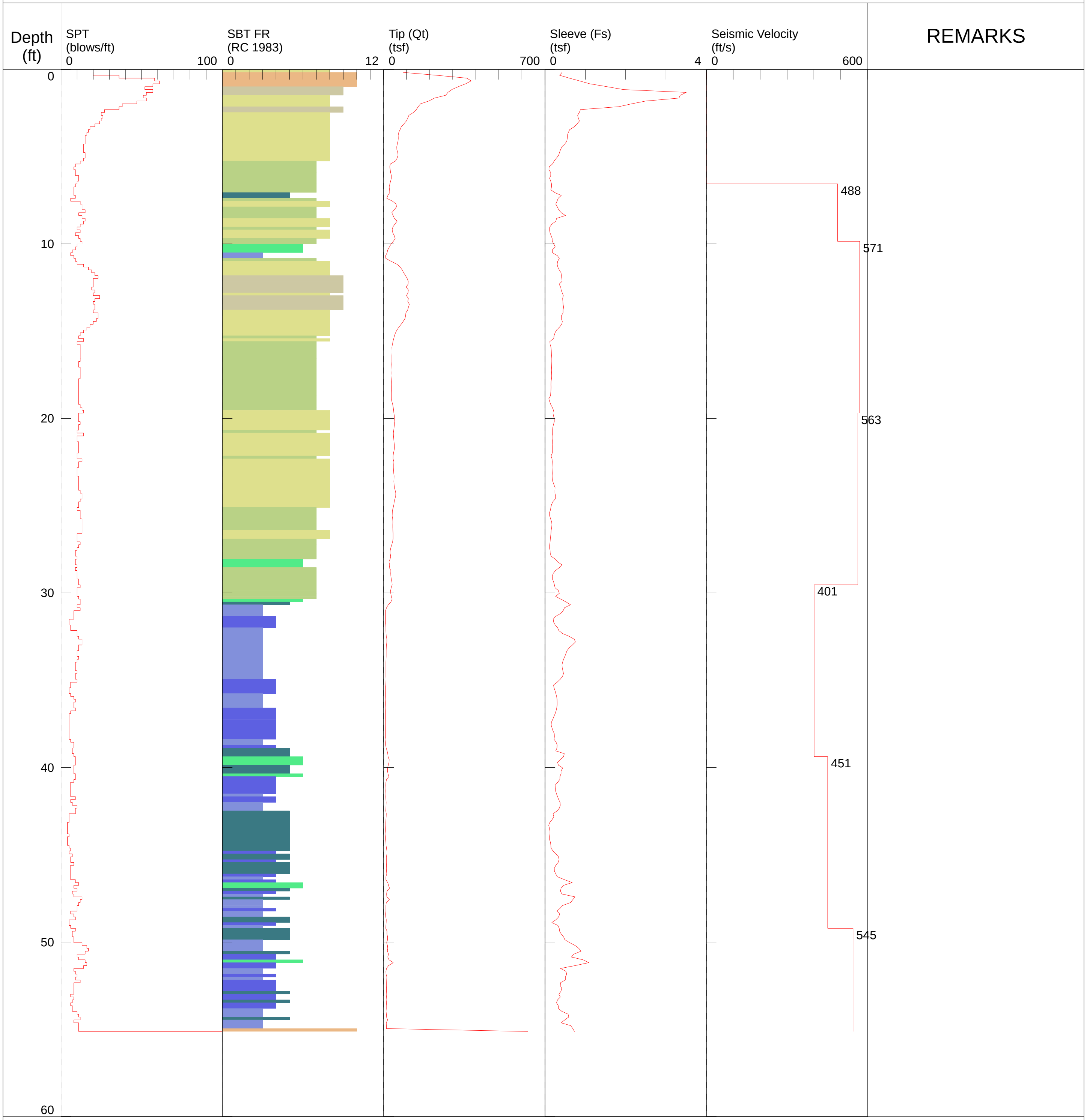
COMMENT: NV5 / CPT-5 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 2.03
* = Not Determined

NV5 / CPT-5 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/6/2024 11:52:19 AM
TOTAL DEPTH: 55.118 ft

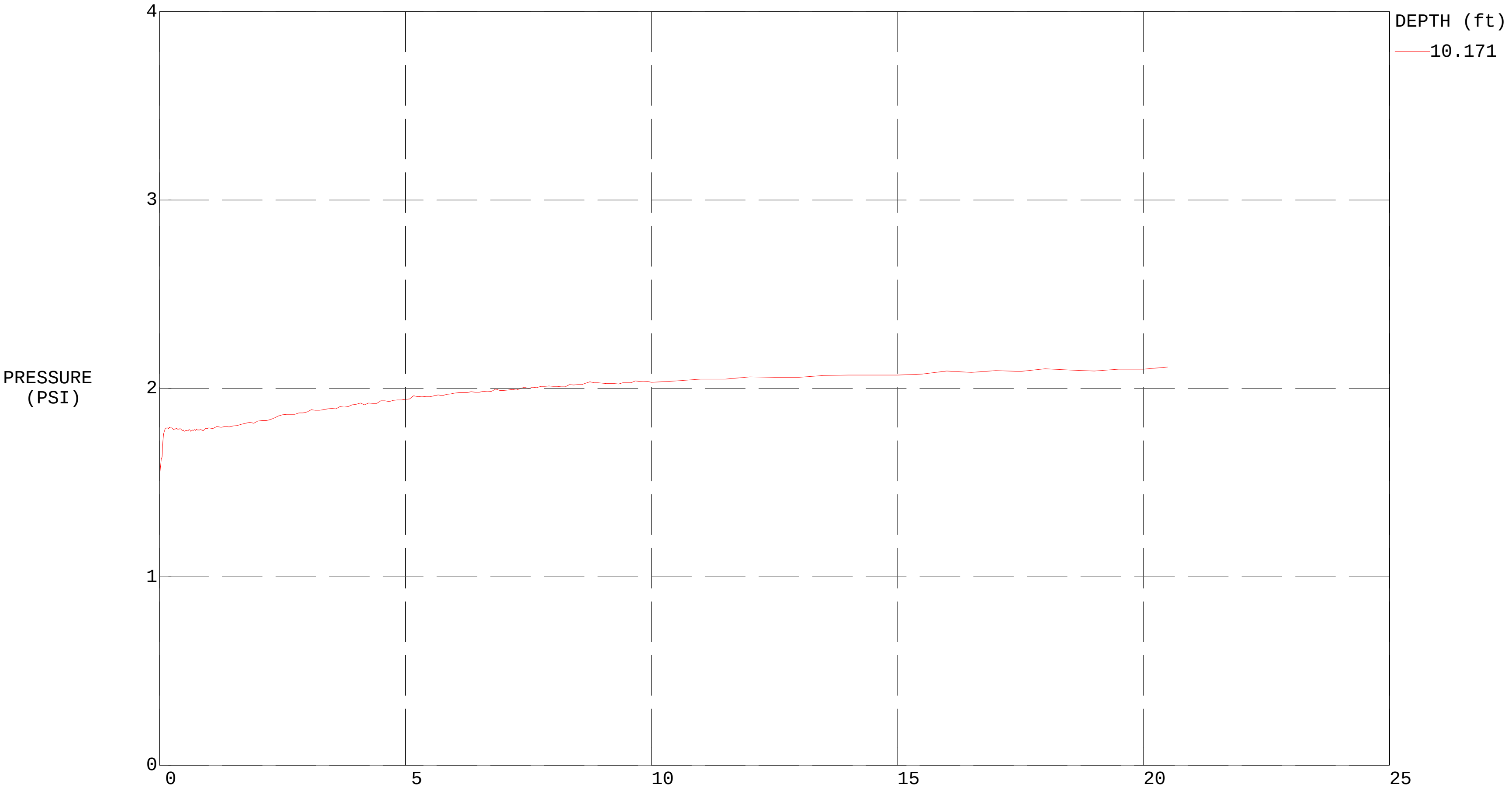


- 🟥 1 sensitive fine grained
- 🟥 2 organic material
- 🟦 3 clay
- 🟦 4 silty clay to clay
- 🟦 5 clayey silt to silty clay
- 🟩 6 sandy silt to clayey silt
- 🟩 7 silty sand to sandy silt
- 🟨 8 sand to silty sand
- 🟫 9 sand
- 🟧 10 gravelly sand to sand
- ⬜ 11 very stiff fine grained (*)
- ⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-5 / 5501 NW Front Ave Portland

CONE ID: DDG1661
TEST DATE: 2/6/2024 11:52:19 AM



MAXIMUM PRESSURE = 2.114 (PSI) TIME: (MINUTES)
HYDROSTATIC PRESSURE = 2.116 (PSI), WATER TABLE: 5.29 ft

NV5 / CPT-5 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/6/2024 11:52:19 AM
TOTAL DEPTH: 55.118 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.164	83.94	0.4246	0.506	-0.172	20	8	sand to silty sand
0.328	228.11	0.3625	0.159	-0.442	36	10	gravelly sand to sand
0.492	361.05	0.6019	0.167	-1.459	58	10	gravelly sand to sand
0.656	379.61	0.8559	0.225	0.753	61	10	gravelly sand to sand
0.820	355.58	1.1098	0.312	2.571	57	10	gravelly sand to sand
0.984	323.95	1.5369	0.474	4.091	52	10	gravelly sand to sand
1.148	295.82	1.9410	0.656	0.885	57	9	sand
1.312	278.86	3.5017	1.256	0.957	53	9	sand
1.476	268.71	3.3497	1.247	4.060	51	9	sand
1.640	220.53	3.3225	1.507	14.666	53	8	sand to silty sand
1.804	195.59	2.4937	1.275	4.099	47	8	sand to silty sand
1.969	159.61	2.1488	1.346	2.461	38	8	sand to silty sand
2.133	149.86	1.8251	1.218	1.126	36	8	sand to silty sand
2.297	141.64	0.8806	0.622	1.157	27	9	sand
2.461	129.37	0.8487	0.656	0.698	25	9	sand
2.625	109.62	0.8089	0.738	-0.481	26	8	sand to silty sand
2.789	104.82	0.8263	0.788	-0.502	25	8	sand to silty sand
2.953	98.70	0.8545	0.866	-0.517	24	8	sand to silty sand
3.117	87.78	0.7972	0.908	-0.536	21	8	sand to silty sand
3.281	76.42	0.7238	0.947	-0.440	18	8	sand to silty sand
3.445	71.09	0.6120	0.861	-0.407	17	8	sand to silty sand
3.609	65.70	0.5772	0.879	-0.430	16	8	sand to silty sand
3.773	63.05	0.5557	0.881	-0.378	15	8	sand to silty sand
3.937	63.40	0.5499	0.867	-0.378	15	8	sand to silty sand
4.101	62.45	0.5411	0.867	-0.378	15	8	sand to silty sand
4.265	59.64	0.4933	0.827	-0.471	14	8	sand to silty sand
4.429	57.08	0.4192	0.734	-0.414	14	8	sand to silty sand
4.593	57.18	0.3842	0.672	-0.390	14	8	sand to silty sand
4.757	61.36	0.3589	0.585	-0.430	15	8	sand to silty sand
4.921	62.75	0.3383	0.539	-0.514	15	8	sand to silty sand
5.085	58.05	0.2806	0.483	-0.493	14	8	sand to silty sand
5.249	50.80	0.2257	0.444	-0.564	12	8	sand to silty sand
5.413	29.21	0.1865	0.638	-0.256	9	7	silty sand to sandy silt
5.577	26.35	0.1010	0.383	-0.103	8	7	silty sand to sandy silt
5.741	28.81	0.0962	0.334	-2.327	9	7	silty sand to sandy silt
5.906	29.75	0.1402	0.471	-1.954	9	7	silty sand to sandy silt
6.070	33.61	0.1403	0.417	-0.526	11	7	silty sand to sandy silt
6.234	33.57	0.1139	0.339	-2.255	11	7	silty sand to sandy silt
6.398	30.00	0.1416	0.472	-2.846	10	7	silty sand to sandy silt
6.562	26.76	0.1606	0.600	-2.382	9	7	silty sand to sandy silt
6.726	24.09	0.1616	0.671	-0.273	8	7	silty sand to sandy silt
6.890	25.64	0.1441	0.562	-0.258	8	7	silty sand to sandy silt
7.054	26.59	0.2374	0.893	-0.658	8	7	silty sand to sandy silt
7.218	18.33	0.4013	2.190	-1.016	9	5	clayey silt to silty clay
7.382	13.46	0.3251	2.416	0.863	6	5	clayey silt to silty clay
7.546	38.34	0.2980	0.777	2.762	12	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
7.710	53.93	0.2665	0.494	1.270	13	8	sand to silty sand
7.874	55.64	0.3060	0.550	0.880	13	8	sand to silty sand
8.038	45.94	0.3377	0.735	0.660	15	7	silty sand to sandy silt
8.202	35.34	0.4024	1.139	0.564	11	7	silty sand to sandy silt
8.366	40.88	0.5088	1.245	0.727	13	7	silty sand to sandy silt
8.530	46.34	0.2886	0.623	-0.646	15	7	silty sand to sandy silt
8.694	58.64	0.2694	0.459	-2.585	14	8	sand to silty sand
8.858	48.23	0.1710	0.355	-0.873	12	8	sand to silty sand
9.022	39.81	0.1175	0.295	0.933	10	8	sand to silty sand
9.186	36.82	0.1139	0.309	0.913	12	7	silty sand to sandy silt
9.350	39.50	0.1243	0.315	1.028	9	8	sand to silty sand
9.514	45.40	0.1512	0.333	1.110	11	8	sand to silty sand
9.678	50.05	0.1752	0.350	1.169	12	8	sand to silty sand
9.843	42.07	0.1813	0.431	1.215	13	7	silty sand to sandy silt
10.007	32.23	0.2184	0.677	1.452	10	7	silty sand to sandy silt
10.171	24.65	0.2558	1.038	1.530	9	6	sandy silt to clayey silt
10.335	17.47	0.1807	1.035	2.341	7	6	sandy silt to clayey silt
10.499	14.89	0.1852	1.244	0.368	6	6	sandy silt to clayey silt
10.663	8.79	0.3043	3.463	-0.246	8	3	clay
10.827	9.29	0.3544	3.813	1.526	9	3	clay
10.991	32.67	0.3116	0.954	3.898	10	7	silty sand to sandy silt
11.155	57.74	0.3015	0.522	3.106	14	8	sand to silty sand
11.319	71.60	0.3174	0.443	2.573	17	8	sand to silty sand
11.483	80.43	0.3529	0.439	2.604	19	8	sand to silty sand
11.647	86.65	0.3979	0.459	2.422	21	8	sand to silty sand
11.811	94.76	0.4076	0.430	2.384	23	8	sand to silty sand
11.975	102.07	0.4192	0.411	2.413	20	9	sand
12.139	106.97	0.4233	0.396	2.525	20	9	sand
12.303	105.81	0.3498	0.331	2.322	20	9	sand
12.467	97.23	0.3892	0.400	2.444	19	9	sand
12.631	107.12	0.3992	0.373	2.769	21	9	sand
12.795	105.57	0.4280	0.405	2.647	20	9	sand
12.959	98.91	0.4529	0.458	2.575	24	8	sand to silty sand
13.123	107.09	0.4367	0.408	2.623	21	9	sand
13.287	104.67	0.4410	0.421	2.628	20	9	sand
13.451	111.05	0.4478	0.403	2.724	21	9	sand
13.615	107.57	0.4623	0.430	2.726	21	9	sand
13.780	104.19	0.4487	0.431	2.676	20	9	sand
13.944	96.29	0.4458	0.463	2.700	23	8	sand to silty sand
14.108	94.91	0.4067	0.428	2.671	23	8	sand to silty sand
14.272	92.45	0.4034	0.436	2.647	22	8	sand to silty sand
14.436	84.53	0.4301	0.509	2.561	20	8	sand to silty sand
14.600	76.00	0.4153	0.546	2.575	18	8	sand to silty sand
14.764	66.03	0.3591	0.544	2.571	16	8	sand to silty sand
14.928	57.71	0.2890	0.501	2.525	14	8	sand to silty sand
15.092	51.84	0.2470	0.476	2.516	12	8	sand to silty sand
15.256	46.93	0.2264	0.483	2.630	11	8	sand to silty sand
15.420	43.96	0.2155	0.490	2.700	14	7	silty sand to sandy silt
15.584	40.42	0.1215	0.301	2.807	10	8	sand to silty sand
15.748	37.94	0.1273	0.336	2.862	12	7	silty sand to sandy silt
15.912	36.08	0.1459	0.405	3.283	12	7	silty sand to sandy silt
16.076	36.30	0.1563	0.431	3.274	12	7	silty sand to sandy silt
16.240	36.31	0.1588	0.437	3.262	12	7	silty sand to sandy silt
16.404	36.12	0.1609	0.445	3.264	12	7	silty sand to sandy silt
16.568	36.13	0.1563	0.433	3.274	12	7	silty sand to sandy silt
16.732	35.86	0.1557	0.434	3.295	11	7	silty sand to sandy silt
16.896	35.38	0.1593	0.450	3.321	11	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.060	36.11	0.1612	0.446	3.374	12	7	silty sand to sandy silt
17.224	36.28	0.1647	0.454	3.374	12	7	silty sand to sandy silt
17.388	36.25	0.1623	0.448	3.420	12	7	silty sand to sandy silt
17.552	36.47	0.1600	0.439	3.448	12	7	silty sand to sandy silt
17.717	35.05	0.1601	0.457	3.496	11	7	silty sand to sandy silt
17.881	34.90	0.1522	0.436	3.530	11	7	silty sand to sandy silt
18.045	33.95	0.1468	0.432	3.551	11	7	silty sand to sandy silt
18.209	34.73	0.1482	0.427	3.654	11	7	silty sand to sandy silt
18.373	34.52	0.1471	0.426	3.671	11	7	silty sand to sandy silt
18.537	33.58	0.1423	0.424	3.716	11	7	silty sand to sandy silt
18.701	33.27	0.1373	0.413	3.790	11	7	silty sand to sandy silt
18.865	33.92	0.0942	0.278	3.852	11	7	silty sand to sandy silt
19.029	35.64	0.1169	0.328	3.926	11	7	silty sand to sandy silt
19.193	39.01	0.1409	0.361	4.398	12	7	silty sand to sandy silt
19.357	41.70	0.1815	0.435	4.398	13	7	silty sand to sandy silt
19.521	42.90	0.2073	0.483	4.369	14	7	silty sand to sandy silt
19.685	44.10	0.1985	0.450	4.352	11	8	sand to silty sand
19.849	46.11	0.2121	0.460	4.503	11	8	sand to silty sand
20.013	47.61	0.2311	0.485	4.584	11	8	sand to silty sand
20.177	48.06	0.2318	0.482	4.596	12	8	sand to silty sand
20.341	47.03	0.2115	0.450	4.625	11	8	sand to silty sand
20.505	45.29	0.1923	0.425	4.632	11	8	sand to silty sand
20.669	43.56	0.1888	0.434	4.706	10	8	sand to silty sand
20.833	42.34	0.1872	0.442	4.785	14	7	silty sand to sandy silt
20.997	42.48	0.1752	0.412	4.897	10	8	sand to silty sand
21.161	43.58	0.1758	0.403	4.957	10	8	sand to silty sand
21.325	44.56	0.1862	0.418	5.043	11	8	sand to silty sand
21.490	46.15	0.1904	0.413	5.158	11	8	sand to silty sand
21.654	47.58	0.1884	0.396	5.230	11	8	sand to silty sand
21.818	45.35	0.1879	0.414	5.258	11	8	sand to silty sand
21.982	42.42	0.1820	0.429	5.273	10	8	sand to silty sand
22.146	40.99	0.1490	0.364	5.352	10	8	sand to silty sand
22.310	40.78	0.1738	0.426	5.407	13	7	silty sand to sandy silt
22.474	44.32	0.1775	0.401	5.672	11	8	sand to silty sand
22.638	44.05	0.1770	0.402	5.643	11	8	sand to silty sand
22.802	43.61	0.1748	0.401	5.684	10	8	sand to silty sand
22.966	42.80	0.1750	0.409	5.706	10	8	sand to silty sand
23.130	43.57	0.1793	0.412	5.801	10	8	sand to silty sand
23.294	45.29	0.1768	0.390	5.916	11	8	sand to silty sand
23.458	44.84	0.1776	0.396	6.028	11	8	sand to silty sand
23.622	44.18	0.1968	0.445	6.036	11	8	sand to silty sand
23.786	45.18	0.2219	0.491	6.052	11	8	sand to silty sand
23.950	46.82	0.2484	0.531	6.191	11	8	sand to silty sand
24.114	49.72	0.2463	0.495	6.181	12	8	sand to silty sand
24.278	52.69	0.2468	0.468	5.883	13	8	sand to silty sand
24.442	52.30	0.2629	0.503	6.088	13	8	sand to silty sand
24.606	48.44	0.2547	0.526	5.808	12	8	sand to silty sand
24.770	45.66	0.1925	0.422	5.851	11	8	sand to silty sand
24.934	44.15	0.1625	0.368	5.887	11	8	sand to silty sand
25.098	41.67	0.1436	0.345	6.222	10	8	sand to silty sand
25.262	37.88	0.1327	0.350	6.445	12	7	silty sand to sandy silt
25.427	37.39	0.1054	0.282	6.629	12	7	silty sand to sandy silt
25.591	36.90	0.1177	0.319	6.767	12	7	silty sand to sandy silt
25.755	39.19	0.1395	0.356	7.038	13	7	silty sand to sandy silt
25.919	39.85	0.1659	0.416	6.987	13	7	silty sand to sandy silt
26.083	39.64	0.1705	0.430	6.963	13	7	silty sand to sandy silt
26.247	39.48	0.1656	0.419	6.966	13	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
26.411	40.09	0.1533	0.382	7.045	13	7	silty sand to sandy silt
26.575	40.71	0.1458	0.358	7.133	10	8	sand to silty sand
26.739	41.21	0.1393	0.338	7.222	10	8	sand to silty sand
26.903	41.08	0.1315	0.320	7.277	10	8	sand to silty sand
27.067	38.48	0.1275	0.331	7.339	12	7	silty sand to sandy silt
27.231	35.01	0.1170	0.334	7.348	11	7	silty sand to sandy silt
27.395	31.46	0.1126	0.358	7.437	10	7	silty sand to sandy silt
27.559	28.52	0.1272	0.446	7.516	9	7	silty sand to sandy silt
27.723	28.26	0.1282	0.454	7.628	9	7	silty sand to sandy silt
27.887	31.00	0.1511	0.488	7.700	10	7	silty sand to sandy silt
28.051	27.78	0.2513	0.905	6.841	9	7	silty sand to sandy silt
28.215	23.08	0.3130	1.356	7.310	9	6	sandy silt to clayey silt
28.379	25.96	0.4191	1.614	8.589	10	6	sandy silt to clayey silt
28.543	24.42	0.3602	1.475	6.270	9	6	sandy silt to clayey silt
28.707	31.32	0.2598	0.829	7.528	10	7	silty sand to sandy silt
28.871	30.29	0.2037	0.673	5.086	10	7	silty sand to sandy silt
29.035	31.43	0.1784	0.567	7.884	10	7	silty sand to sandy silt
29.199	33.14	0.1856	0.560	8.138	11	7	silty sand to sandy silt
29.364	35.43	0.2124	0.600	8.049	11	7	silty sand to sandy silt
29.528	37.03	0.2321	0.627	8.142	12	7	silty sand to sandy silt
29.692	32.42	0.2487	0.767	8.542	10	7	silty sand to sandy silt
29.856	30.11	0.3292	1.093	8.520	10	7	silty sand to sandy silt
30.020	31.04	0.3552	1.144	7.193	10	7	silty sand to sandy silt
30.184	33.14	0.2620	0.791	5.411	11	7	silty sand to sandy silt
30.348	36.93	0.3908	1.058	3.711	12	7	silty sand to sandy silt
30.512	31.23	0.5266	1.686	2.736	12	6	sandy silt to clayey silt
30.676	20.41	0.6328	3.100	3.604	10	5	clayey silt to silty clay
30.840	12.62	0.4841	3.837	5.916	12	3	clay
31.004	8.31	0.4513	5.428	10.335	8	3	clay
31.168	8.17	0.3932	4.813	28.571	8	3	clay
31.332	8.31	0.2662	3.204	40.138	8	3	clay
31.496	8.34	0.2042	2.448	43.660	5	4	silty clay to clay
31.660	8.44	0.2135	2.528	44.844	5	4	silty clay to clay
31.824	9.18	0.2514	2.738	47.235	6	4	silty clay to clay
31.988	10.06	0.3110	3.092	50.114	6	4	silty clay to clay
32.152	10.15	0.3460	3.408	47.015	10	3	clay
32.316	10.60	0.4282	4.039	48.560	10	3	clay
32.480	11.49	0.5994	5.218	53.048	11	3	clay
32.644	13.87	0.7256	5.233	55.901	13	3	clay
32.808	13.74	0.7551	5.494	38.452	13	3	clay
32.972	11.69	0.6811	5.826	43.112	11	3	clay
33.136	11.11	0.5993	5.392	50.592	11	3	clay
33.301	10.84	0.5447	5.026	51.008	10	3	clay
33.465	10.75	0.5184	4.821	49.576	10	3	clay
33.629	10.99	0.4902	4.461	51.590	11	3	clay
33.793	10.48	0.4596	4.386	45.891	10	3	clay
33.957	9.67	0.4371	4.520	50.612	9	3	clay
34.121	9.70	0.4213	4.344	48.706	9	3	clay
34.285	9.74	0.4276	4.388	50.234	9	3	clay
34.449	9.95	0.4409	4.433	50.894	10	3	clay
34.613	9.81	0.4594	4.682	47.321	9	3	clay
34.777	9.75	0.4340	4.450	47.622	9	3	clay
34.941	10.25	0.3790	3.698	47.053	10	3	clay
35.105	9.70	0.3032	3.126	41.168	6	4	silty clay to clay
35.269	8.96	0.2113	2.358	43.177	6	4	silty clay to clay
35.433	8.26	0.2250	2.725	47.984	5	4	silty clay to clay
35.597	8.43	0.2477	2.937	49.440	5	4	silty clay to clay

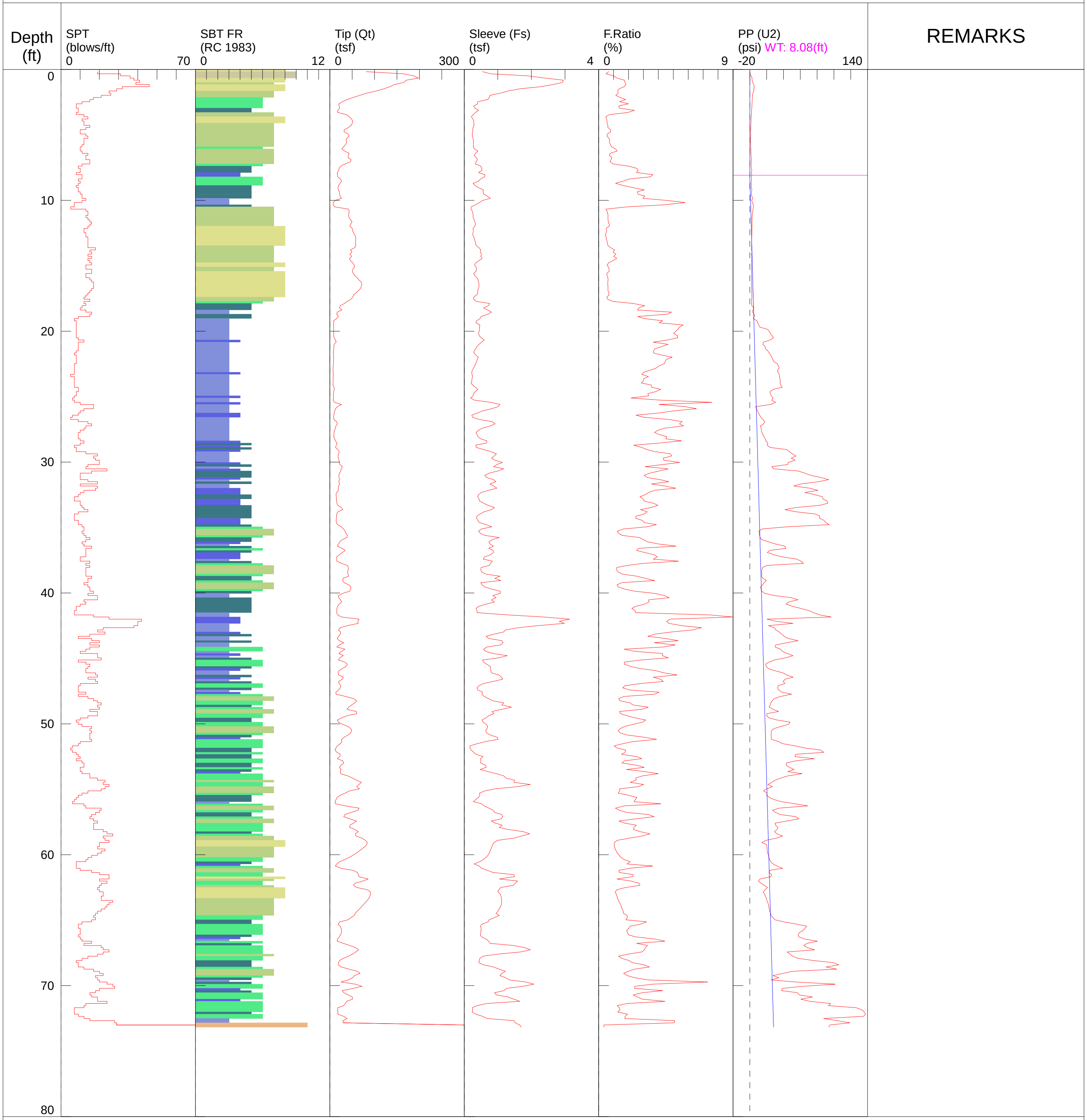
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
35.761	8.74	0.2710	3.101	50.499	6	4	silty clay to clay
35.925	8.87	0.2884	3.250	50.719	8	3	clay
36.089	8.90	0.3000	3.369	51.403	9	3	clay
36.253	8.78	0.3035	3.455	50.602	8	3	clay
36.417	8.85	0.3025	3.417	51.611	8	3	clay
36.581	8.95	0.2911	3.255	52.467	9	3	clay
36.745	8.75	0.2756	3.149	50.097	6	4	silty clay to clay
36.909	8.60	0.2504	2.912	49.770	5	4	silty clay to clay
37.073	8.58	0.2210	2.575	48.849	5	4	silty clay to clay
37.238	8.40	0.1919	2.284	49.222	5	4	silty clay to clay
37.402	8.02	0.1586	1.977	48.639	5	4	silty clay to clay
37.566	8.01	0.1547	1.932	49.337	5	4	silty clay to clay
37.730	8.25	0.1744	2.115	51.924	5	4	silty clay to clay
37.894	8.36	0.1974	2.362	53.546	5	4	silty clay to clay
38.058	8.40	0.2309	2.749	53.990	5	4	silty clay to clay
38.222	8.42	0.2325	2.761	49.086	5	4	silty clay to clay
38.386	9.39	0.2234	2.378	44.098	6	4	silty clay to clay
38.550	8.55	0.2763	3.230	39.229	8	3	clay
38.714	8.56	0.3032	3.544	45.403	8	3	clay
38.878	10.72	0.2946	2.749	39.693	7	4	silty clay to clay
39.042	14.90	0.2663	1.788	29.262	7	5	clayey silt to silty clay
39.206	17.46	0.4752	2.721	23.475	8	5	clayey silt to silty clay
39.370	19.31	0.4599	2.382	20.596	9	5	clayey silt to silty clay
39.534	24.09	0.3840	1.594	9.352	9	6	sandy silt to clayey silt
39.698	23.40	0.3096	1.323	6.442	9	6	sandy silt to clayey silt
39.862	20.13	0.3325	1.651	7.150	8	6	sandy silt to clayey silt
40.026	16.37	0.4421	2.701	13.286	8	5	clayey silt to silty clay
40.190	16.39	0.3981	2.429	19.202	8	5	clayey silt to silty clay
40.354	18.75	0.3967	2.116	19.087	9	5	clayey silt to silty clay
40.518	22.51	0.3686	1.637	19.501	9	6	sandy silt to clayey silt
40.682	12.51	0.3662	2.927	21.242	8	4	silty clay to clay
40.846	10.14	0.3150	3.107	34.757	6	4	silty clay to clay
41.011	9.21	0.2517	2.734	44.392	6	4	silty clay to clay
41.175	9.81	0.2527	2.577	42.397	6	4	silty clay to clay
41.339	9.16	0.2631	2.872	49.610	6	4	silty clay to clay
41.503	9.73	0.2864	2.943	48.256	6	4	silty clay to clay
41.667	9.15	0.3098	3.385	53.871	9	3	clay
41.831	9.97	0.3363	3.372	55.246	6	4	silty clay to clay
41.995	11.05	0.3731	3.377	47.379	7	4	silty clay to clay
42.159	10.36	0.3797	3.665	52.087	10	3	clay
42.323	9.45	0.3538	3.743	47.723	9	3	clay
42.487	8.91	0.3035	3.405	54.206	9	3	clay
42.651	11.36	0.1975	1.739	50.081	5	5	clayey silt to silty clay
42.815	10.82	0.2190	2.024	44.693	5	5	clayey silt to silty clay
42.979	9.90	0.1762	1.781	39.057	5	5	clayey silt to silty clay
43.143	9.02	0.1203	1.334	46.666	4	5	clayey silt to silty clay
43.307	9.12	0.0900	0.987	50.282	4	5	clayey silt to silty clay
43.471	8.76	0.1088	1.241	55.937	4	5	clayey silt to silty clay
43.635	8.83	0.1238	1.403	58.907	4	5	clayey silt to silty clay
43.799	10.01	0.1249	1.248	56.245	5	5	clayey silt to silty clay
43.963	8.74	0.1145	1.310	54.148	4	5	clayey silt to silty clay
44.127	8.61	0.1154	1.340	57.336	4	5	clayey silt to silty clay
44.291	9.36	0.1338	1.429	54.096	4	5	clayey silt to silty clay
44.455	10.23	0.1445	1.413	51.150	5	5	clayey silt to silty clay
44.619	12.23	0.1492	1.220	45.437	6	5	clayey silt to silty clay
44.783	10.41	0.1994	1.915	45.980	5	5	clayey silt to silty clay
44.948	10.58	0.2683	2.536	61.427	7	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.112	12.55	0.3354	2.671	40.458	6	5	clayey silt to silty clay
45.276	12.78	0.3486	2.728	40.685	6	5	clayey silt to silty clay
45.440	12.12	0.3259	2.690	33.071	8	4	silty clay to clay
45.604	11.68	0.2716	2.324	33.868	6	5	clayey silt to silty clay
45.768	12.66	0.2300	1.817	34.597	6	5	clayey silt to silty clay
45.932	11.62	0.2344	2.017	40.551	6	5	clayey silt to silty clay
46.096	13.25	0.2648	1.999	37.146	6	5	clayey silt to silty clay
46.260	9.85	0.3056	3.102	43.483	6	4	silty clay to clay
46.424	9.86	0.4833	4.902	50.188	9	3	clay
46.588	17.35	0.6738	3.883	50.418	11	4	silty clay to clay
46.752	21.39	0.4602	2.151	12.365	8	6	sandy silt to clayey silt
46.916	25.80	0.3973	1.540	9.450	10	6	sandy silt to clayey silt
47.080	15.05	0.3824	2.540	13.121	7	5	clayey silt to silty clay
47.244	12.41	0.4173	3.363	26.852	8	4	silty clay to clay
47.408	13.88	0.7447	5.367	38.488	13	3	clay
47.572	24.77	0.6903	2.787	20.383	12	5	clayey silt to silty clay
47.736	11.13	0.6362	5.716	24.640	11	3	clay
47.900	9.98	0.4360	4.369	56.786	10	3	clay
48.064	9.93	0.3739	3.766	54.165	10	3	clay
48.228	9.57	0.2952	3.086	47.008	6	4	silty clay to clay
48.392	8.73	0.3648	4.180	50.987	8	3	clay
48.556	9.09	0.3366	3.703	54.378	9	3	clay
48.720	11.33	0.2673	2.359	34.688	5	5	clayey silt to silty clay
48.885	10.91	0.1690	1.550	32.983	5	5	clayey silt to silty clay
49.049	9.86	0.3208	3.253	38.461	6	4	silty clay to clay
49.213	9.06	0.3534	3.900	43.739	9	3	clay
49.377	14.54	0.3611	2.483	31.594	7	5	clayey silt to silty clay
49.541	14.42	0.4018	2.787	29.418	7	5	clayey silt to silty clay
49.705	17.11	0.4584	2.680	34.736	8	5	clayey silt to silty clay
49.869	16.95	0.4918	2.901	32.026	8	5	clayey silt to silty clay
50.033	13.19	0.6142	4.658	33.158	13	3	clay
50.197	16.53	0.7479	4.525	43.108	16	3	clay
50.361	17.91	0.8389	4.685	25.204	17	3	clay
50.525	16.07	0.8952	5.571	16.167	15	3	clay
50.689	21.12	0.7151	3.386	26.070	10	5	clayey silt to silty clay
50.853	17.52	0.6532	3.728	10.199	11	4	silty clay to clay
51.017	23.34	0.9422	4.037	38.241	15	4	silty clay to clay
51.181	41.60	1.0835	2.605	32.402	16	6	sandy silt to clayey silt
51.345	21.15	0.7515	3.553	45.344	14	4	silty clay to clay
51.509	12.70	0.3835	3.021	37.010	8	4	silty clay to clay
51.673	9.68	0.5149	5.322	57.745	9	3	clay
51.837	10.29	0.5419	5.267	50.588	10	3	clay
52.001	14.05	0.5039	3.587	25.572	9	4	silty clay to clay
52.165	12.85	0.5028	3.915	30.522	12	3	clay
52.329	12.52	0.3854	3.079	36.713	8	4	silty clay to clay
52.493	12.58	0.3804	3.024	40.628	8	4	silty clay to clay
52.657	11.91	0.4151	3.485	43.397	8	4	silty clay to clay
52.822	11.86	0.3938	3.320	43.156	8	4	silty clay to clay
52.986	13.11	0.3458	2.637	42.070	6	5	clayey silt to silty clay
53.150	11.88	0.3803	3.200	39.260	8	4	silty clay to clay
53.314	10.97	0.3096	2.822	47.711	7	4	silty clay to clay
53.478	12.54	0.2840	2.266	42.299	6	5	clayey silt to silty clay
53.642	11.29	0.3279	2.905	44.923	7	4	silty clay to clay
53.806	11.23	0.3360	2.992	47.563	7	4	silty clay to clay
53.970	10.55	0.4153	3.936	52.058	10	3	clay
54.134	11.57	0.5720	4.942	56.341	11	3	clay
54.298	12.11	0.5884	4.857	50.083	12	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
54.462	16.80	0.4881	2.905	10.763	8	5	clayey silt to silty clay
54.626	11.08	0.3971	3.585	24.807	11	3	clay
54.790	11.90	0.6344	5.332	35.774	11	3	clay
54.954	11.64	0.6902	5.927	44.361	11	3	clay
55.118	624.41	0.7302	0.117	18.576	100	10	gravelly sand to sand

NV5 / CPT-6 / 5501 NW Front Ave Portland

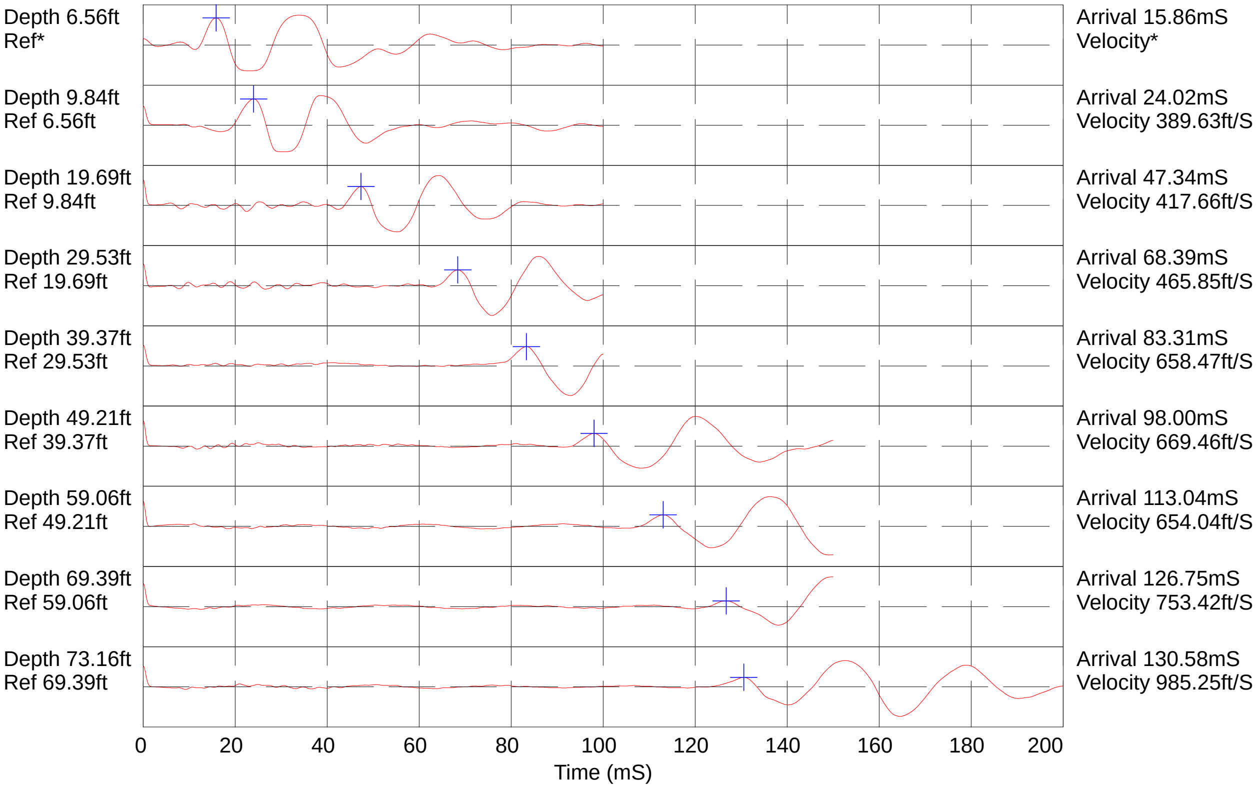
OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 1:19:30 PM
TOTAL DEPTH: 73.163 ft



🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟩 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-6 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 2.03
* = Not Determined

NV5 / CPT-6 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 1:19:30 PM
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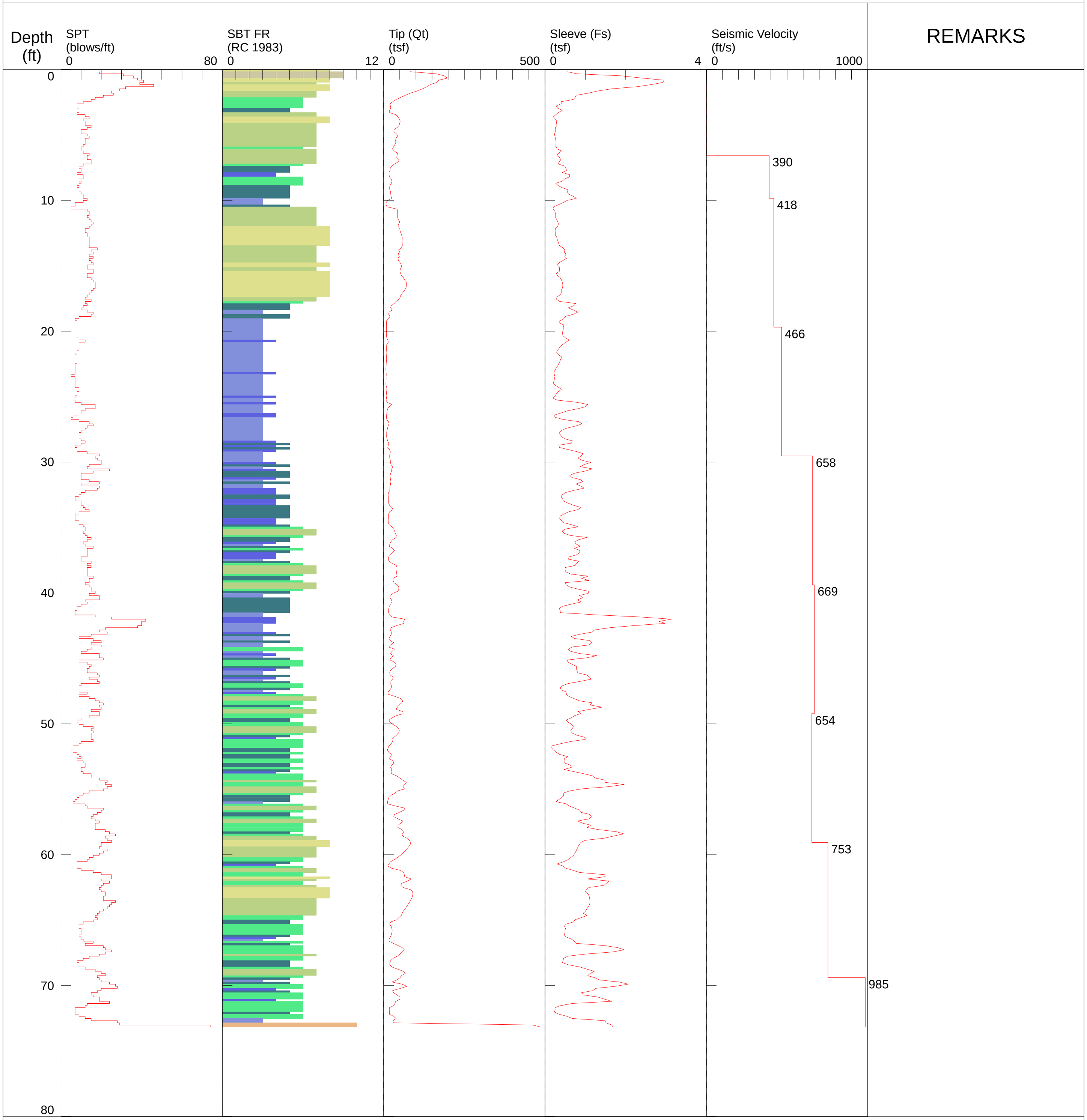

🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟦 5 clayey silt to silty clay
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⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-6 / 5501 NW Front Ave Portland

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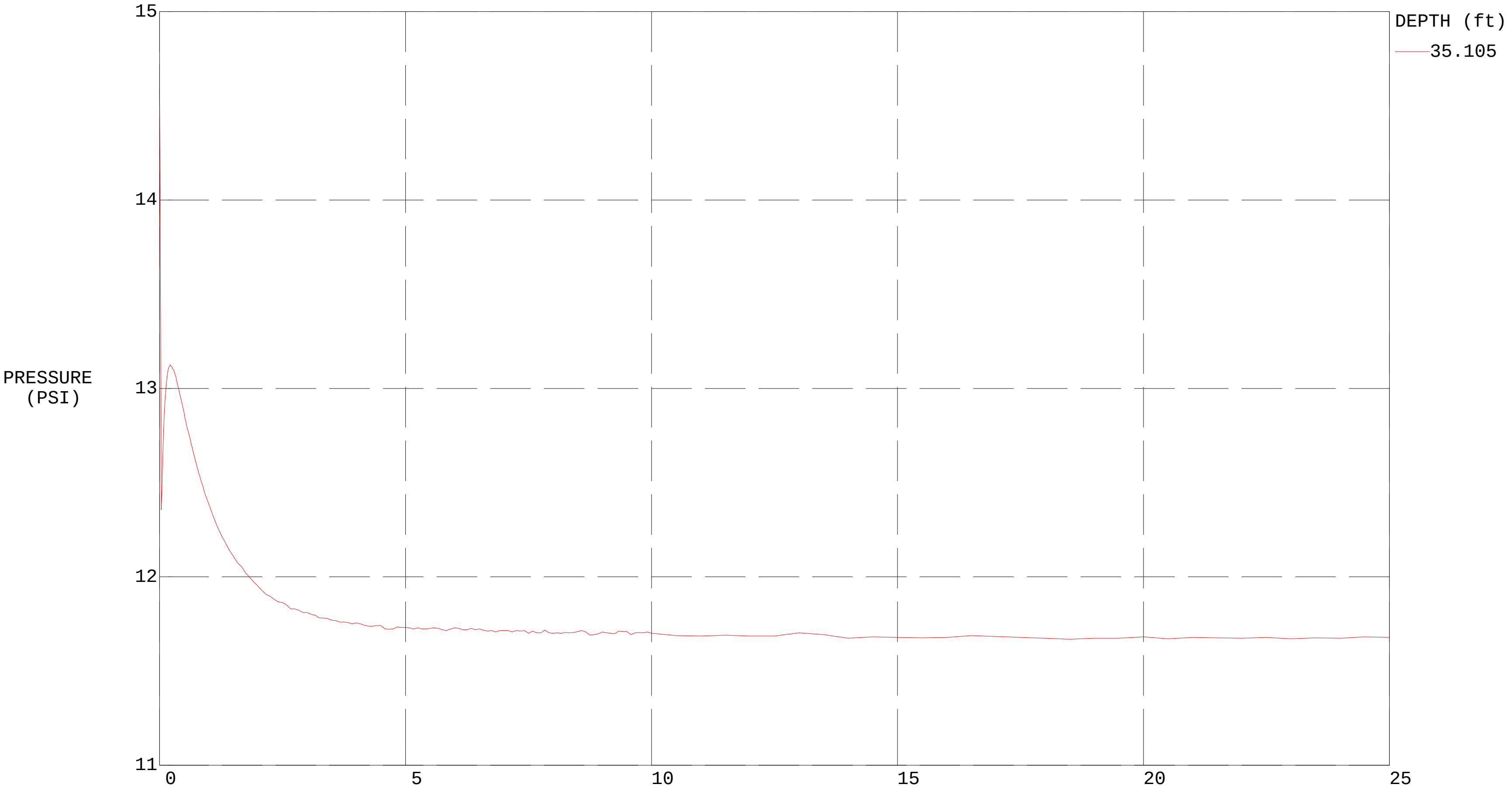


MAXIMUM PRESSURE = 14.582 (PSI)
HYDROSTATIC PRESSURE = 11.714 (PSI), WATER TABLE: 8.08 ft

NV5 / CPT-6 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/5/2024 1:19:30 PM
TOTAL DEPTH: 73.163 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.164	80.93	0.5401	0.667	-0.112	19	8	sand to silty sand
0.328	163.12	0.7962	0.488	0.012	31	9	sand
0.492	187.59	1.8881	1.006	1.425	36	9	sand
0.656	197.71	2.4187	1.223	2.659	38	9	sand
0.820	170.89	2.9477	1.725	2.540	41	8	sand to silty sand
0.984	164.84	2.9214	1.772	3.632	39	8	sand to silty sand
1.148	144.53	2.6474	1.832	4.309	46	7	silty sand to sandy silt
1.312	134.00	2.2869	1.707	5.361	32	8	sand to silty sand
1.476	120.55	1.6538	1.372	4.658	29	8	sand to silty sand
1.640	103.47	1.3083	1.264	4.541	25	8	sand to silty sand
1.804	82.35	1.0758	1.306	3.642	26	7	silty sand to sandy silt
1.969	67.17	0.7690	1.145	3.070	21	7	silty sand to sandy silt
2.133	52.31	0.7455	1.425	2.881	17	7	silty sand to sandy silt
2.297	38.81	0.7021	1.809	2.709	15	6	sandy silt to clayey silt
2.461	28.37	0.4017	1.416	2.609	11	6	sandy silt to clayey silt
2.625	20.00	0.3984	1.992	2.542	8	6	sandy silt to clayey silt
2.789	20.72	0.2783	1.343	2.456	8	6	sandy silt to clayey silt
2.953	22.29	0.3133	1.406	2.339	9	6	sandy silt to clayey silt
3.117	17.89	0.4267	2.385	1.743	9	5	clayey silt to silty clay
3.281	17.19	0.3354	1.952	1.863	8	5	clayey silt to silty clay
3.445	37.00	0.2672	0.722	2.159	12	7	silty sand to sandy silt
3.609	43.74	0.2112	0.483	1.342	14	7	silty sand to sandy silt
3.773	47.92	0.2554	0.533	1.342	11	8	sand to silty sand
3.937	51.16	0.2871	0.561	1.339	12	8	sand to silty sand
4.101	50.00	0.2825	0.565	1.234	12	8	sand to silty sand
4.265	47.76	0.2960	0.620	1.119	15	7	silty sand to sandy silt
4.429	41.83	0.2586	0.618	1.110	13	7	silty sand to sandy silt
4.593	32.06	0.2537	0.791	0.973	10	7	silty sand to sandy silt
4.757	31.69	0.2564	0.809	0.873	10	7	silty sand to sandy silt
4.921	40.11	0.2369	0.591	0.940	13	7	silty sand to sandy silt
5.085	43.14	0.2423	0.562	0.937	14	7	silty sand to sandy silt
5.249	38.28	0.2618	0.684	0.911	12	7	silty sand to sandy silt
5.413	36.50	0.2716	0.744	0.770	12	7	silty sand to sandy silt
5.577	37.67	0.2728	0.724	0.803	12	7	silty sand to sandy silt
5.741	34.74	0.2730	0.786	0.933	11	7	silty sand to sandy silt
5.906	30.85	0.2677	0.868	0.842	10	7	silty sand to sandy silt
6.070	26.87	0.3049	1.135	1.200	10	6	sandy silt to clayey silt
6.234	33.02	0.4087	1.238	1.150	11	7	silty sand to sandy silt
6.398	43.21	0.3370	0.780	1.428	14	7	silty sand to sandy silt
6.562	41.36	0.2939	0.711	1.196	13	7	silty sand to sandy silt
6.726	40.77	0.3600	0.883	1.655	13	7	silty sand to sandy silt
6.890	47.49	0.3948	0.831	1.717	15	7	silty sand to sandy silt
7.054	46.20	0.3532	0.765	1.664	15	7	silty sand to sandy silt
7.218	33.66	0.3277	0.974	1.526	11	7	silty sand to sandy silt
7.382	24.39	0.4879	2.000	1.468	9	6	sandy silt to clayey silt
7.546	20.49	0.5214	2.544	1.550	10	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
7.710	20.05	0.5306	2.647	2.446	10	5	clayey silt to silty clay
7.874	16.85	0.4269	2.534	1.597	8	5	clayey silt to silty clay
8.038	16.87	0.6126	3.631	2.286	11	4	silty clay to clay
8.202	17.60	0.6104	3.468	1.710	11	4	silty clay to clay
8.366	23.75	0.4856	2.045	1.982	9	6	sandy silt to clayey silt
8.530	26.08	0.4259	1.633	1.674	10	6	sandy silt to clayey silt
8.694	23.44	0.2656	1.133	1.547	9	6	sandy silt to clayey silt
8.858	19.77	0.3225	1.631	1.679	8	6	sandy silt to clayey silt
9.022	18.32	0.4145	2.263	1.746	9	5	clayey silt to silty clay
9.186	18.78	0.5730	3.052	2.379	9	5	clayey silt to silty clay
9.350	21.49	0.5558	2.586	1.935	10	5	clayey silt to silty clay
9.514	22.08	0.5837	2.644	1.901	11	5	clayey silt to silty clay
9.678	22.52	0.6953	3.088	2.236	11	5	clayey silt to silty clay
9.843	26.18	0.7742	2.957	3.408	13	5	clayey silt to silty clay
10.007	11.82	0.5461	4.619	2.207	11	3	clay
10.171	7.83	0.4526	5.779	3.070	7	3	clay
10.335	7.54	0.3331	4.419	3.941	7	3	clay
10.499	10.97	0.2093	1.909	4.199	5	5	clayey silt to silty clay
10.663	41.48	0.1993	0.480	3.730	13	7	silty sand to sandy silt
10.827	43.27	0.2440	0.564	3.372	14	7	silty sand to sandy silt
10.991	42.46	0.2569	0.605	3.101	14	7	silty sand to sandy silt
11.155	42.24	0.2650	0.627	2.805	13	7	silty sand to sandy silt
11.319	42.77	0.2650	0.619	2.623	14	7	silty sand to sandy silt
11.483	46.69	0.2938	0.629	2.563	15	7	silty sand to sandy silt
11.647	49.53	0.3199	0.646	2.568	16	7	silty sand to sandy silt
11.811	46.37	0.3331	0.718	2.501	15	7	silty sand to sandy silt
11.975	44.34	0.3118	0.703	2.473	14	7	silty sand to sandy silt
12.139	50.05	0.2592	0.518	2.518	12	8	sand to silty sand
12.303	50.43	0.2706	0.537	2.446	12	8	sand to silty sand
12.467	53.16	0.2664	0.501	2.406	13	8	sand to silty sand
12.631	55.50	0.2496	0.450	2.219	13	8	sand to silty sand
12.795	57.68	0.2876	0.499	2.222	14	8	sand to silty sand
12.959	57.84	0.3019	0.522	2.202	14	8	sand to silty sand
13.123	57.37	0.3236	0.564	2.186	14	8	sand to silty sand
13.287	57.61	0.3377	0.586	2.155	14	8	sand to silty sand
13.451	57.92	0.3606	0.623	2.150	14	8	sand to silty sand
13.615	55.63	0.4413	0.793	2.150	18	7	silty sand to sandy silt
13.780	46.00	0.4953	1.077	2.006	15	7	silty sand to sandy silt
13.944	49.45	0.4746	0.960	2.537	16	7	silty sand to sandy silt
14.108	44.60	0.5178	1.161	2.171	14	7	silty sand to sandy silt
14.272	48.66	0.4886	1.004	2.269	16	7	silty sand to sandy silt
14.436	44.08	0.5345	1.213	2.245	14	7	silty sand to sandy silt
14.600	45.97	0.4422	0.962	2.147	15	7	silty sand to sandy silt
14.764	50.85	0.3479	0.684	2.267	16	7	silty sand to sandy silt
14.928	54.47	0.3078	0.565	2.140	13	8	sand to silty sand
15.092	54.91	0.3554	0.647	2.114	13	8	sand to silty sand
15.256	51.61	0.3605	0.699	2.023	16	7	silty sand to sandy silt
15.420	50.20	0.3547	0.706	1.966	16	7	silty sand to sandy silt
15.584	52.50	0.2814	0.536	1.958	13	8	sand to silty sand
15.748	55.60	0.3150	0.567	1.992	13	8	sand to silty sand
15.912	61.27	0.3764	0.614	2.021	15	8	sand to silty sand
16.076	65.09	0.4100	0.630	2.061	16	8	sand to silty sand
16.240	69.98	0.4262	0.609	2.145	17	8	sand to silty sand
16.404	71.49	0.4380	0.613	2.188	17	8	sand to silty sand
16.568	70.38	0.4385	0.623	2.210	17	8	sand to silty sand
16.732	68.28	0.4258	0.624	2.222	16	8	sand to silty sand
16.896	63.91	0.3987	0.624	2.238	15	8	sand to silty sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.060	58.61	0.4010	0.684	2.260	14	8	sand to silty sand
17.224	53.25	0.3717	0.698	2.284	13	8	sand to silty sand
17.388	51.09	0.2760	0.540	2.398	12	8	sand to silty sand
17.552	47.02	0.2793	0.594	2.018	15	7	silty sand to sandy silt
17.717	38.48	0.3657	0.950	2.092	12	7	silty sand to sandy silt
17.881	32.66	0.7620	2.333	2.195	13	6	sandy silt to clayey silt
18.045	23.21	0.7176	3.092	2.241	11	5	clayey silt to silty clay
18.209	21.34	0.5763	2.700	4.802	10	5	clayey silt to silty clay
18.373	26.78	0.6965	2.601	3.695	13	5	clayey silt to silty clay
18.537	16.63	0.8098	4.869	3.262	16	3	clay
18.701	15.39	0.7100	4.613	5.158	15	3	clay
18.865	19.17	0.5026	2.622	5.313	9	5	clayey silt to silty clay
19.029	15.44	0.4682	3.033	3.967	7	5	clayey silt to silty clay
19.193	8.70	0.3721	4.278	8.300	8	3	clay
19.357	8.53	0.3463	4.060	9.245	8	3	clay
19.521	8.28	0.4689	5.663	10.526	8	3	clay
19.685	8.39	0.4537	5.408	11.820	8	3	clay
19.849	8.56	0.4544	5.307	20.924	8	3	clay
20.013	8.52	0.4388	5.149	23.076	8	3	clay
20.177	8.58	0.4303	5.013	24.642	8	3	clay
20.341	8.49	0.4481	5.278	26.407	8	3	clay
20.505	9.56	0.5055	5.289	28.160	9	3	clay
20.669	12.96	0.5966	4.604	24.035	12	3	clay
20.833	14.23	0.5206	3.658	16.201	9	4	silty clay to clay
20.997	9.52	0.4419	4.642	15.417	9	3	clay
21.161	8.95	0.3792	4.238	18.076	9	3	clay
21.325	9.12	0.3451	3.785	18.537	9	3	clay
21.490	8.11	0.2985	3.679	21.220	8	3	clay
21.654	7.80	0.2867	3.675	23.050	7	3	clay
21.818	8.16	0.3443	4.217	24.819	8	3	clay
21.982	8.55	0.4210	4.921	26.003	8	3	clay
22.146	8.57	0.3892	4.540	27.277	8	3	clay
22.310	8.24	0.3673	4.455	28.212	8	3	clay
22.474	7.74	0.3408	4.405	32.498	7	3	clay
22.638	7.74	0.3137	4.052	33.992	7	3	clay
22.802	7.28	0.2808	3.860	34.765	7	3	clay
22.966	7.08	0.2479	3.502	32.976	7	3	clay
23.130	7.33	0.2207	3.010	33.397	7	3	clay
23.294	8.01	0.2317	2.892	34.834	5	4	silty clay to clay
23.458	7.43	0.2468	3.323	35.102	7	3	clay
23.622	7.74	0.2337	3.018	35.530	7	3	clay
23.786	7.48	0.2241	2.998	36.218	7	3	clay
23.950	7.12	0.2034	2.857	35.879	7	3	clay
24.114	6.96	0.2458	3.534	36.721	7	3	clay
24.278	9.38	0.3351	3.573	38.643	9	3	clay
24.442	9.80	0.4072	4.154	27.978	9	3	clay
24.606	8.64	0.3299	3.818	23.992	8	3	clay
24.770	8.35	0.2750	3.292	24.252	8	3	clay
24.934	7.82	0.2622	3.352	25.508	7	3	clay
25.098	8.72	0.1882	2.159	27.521	6	4	silty clay to clay
25.262	7.36	0.3048	4.144	26.034	7	3	clay
25.427	10.42	0.7888	7.568	30.518	10	3	clay
25.591	26.03	1.0592	4.069	24.941	17	4	silty clay to clay
25.755	17.29	1.0062	5.820	6.851	17	3	clay
25.919	12.57	0.8219	6.537	7.765	12	3	clay
26.083	10.89	0.5496	5.046	8.939	10	3	clay
26.247	9.86	0.3950	4.005	10.266	9	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
26.411	9.04	0.2261	2.502	11.703	6	4	silty clay to clay
26.575	8.30	0.2521	3.038	13.169	5	4	silty clay to clay
26.739	9.48	0.4481	4.727	15.773	9	3	clay
26.903	14.92	0.8343	5.590	17.523	14	3	clay
27.067	16.98	0.9186	5.410	16.612	16	3	clay
27.231	13.71	0.7783	5.676	12.468	13	3	clay
27.395	12.23	0.5421	4.433	13.374	12	3	clay
27.559	10.74	0.4275	3.982	13.764	10	3	clay
27.723	9.33	0.3489	3.740	14.252	9	3	clay
27.887	9.32	0.3780	4.055	15.541	9	3	clay
28.051	9.01	0.4112	4.561	16.694	9	3	clay
28.215	10.86	0.4878	4.491	18.418	10	3	clay
28.379	12.24	0.6765	5.527	18.910	12	3	clay
28.543	16.42	0.6578	4.007	21.419	10	4	silty clay to clay
28.707	14.63	0.3428	2.344	20.527	7	5	clayey silt to silty clay
28.871	12.48	0.3596	2.882	23.865	8	4	silty clay to clay
29.035	17.67	0.5680	3.214	43.579	8	5	clayey silt to silty clay
29.199	20.92	0.7885	3.769	47.233	13	4	silty clay to clay
29.364	19.92	0.9553	4.796	50.329	19	3	clay
29.528	18.25	0.8918	4.886	54.947	17	3	clay
29.692	18.91	0.8175	4.322	49.275	18	3	clay
29.856	20.88	0.9099	4.358	53.880	20	3	clay
30.020	21.00	1.1372	5.415	45.561	20	3	clay
30.184	22.60	0.9726	4.304	45.150	14	4	silty clay to clay
30.348	28.08	0.8725	3.107	26.089	13	5	clayey silt to silty clay
30.512	25.21	1.1725	4.652	28.552	24	3	clay
30.676	24.77	1.0045	4.055	57.321	16	4	silty clay to clay
30.840	21.58	0.7386	3.422	65.526	10	5	clayey silt to silty clay
31.004	20.04	0.6107	3.047	72.509	10	5	clayey silt to silty clay
31.168	20.52	0.6649	3.239	84.632	10	5	clayey silt to silty clay
31.332	21.35	0.8795	4.120	93.762	14	4	silty clay to clay
31.496	19.97	0.9395	4.706	81.803	19	3	clay
31.660	21.68	0.7686	3.545	60.406	10	5	clayey silt to silty clay
31.824	19.96	0.8806	4.412	52.374	19	3	clay
31.988	18.83	0.9684	5.144	71.196	18	3	clay
32.152	19.21	0.7219	3.758	80.914	12	4	silty clay to clay
32.316	15.35	0.5133	3.344	65.454	10	4	silty clay to clay
32.480	13.74	0.4291	3.124	77.368	9	4	silty clay to clay
32.644	14.48	0.3998	2.761	86.132	7	5	clayey silt to silty clay
32.808	14.66	0.4369	2.979	87.217	7	5	clayey silt to silty clay
32.972	15.00	0.4570	3.046	91.797	10	4	silty clay to clay
33.136	15.78	0.5799	3.676	92.758	10	4	silty clay to clay
33.301	17.93	0.7098	3.959	82.927	11	4	silty clay to clay
33.465	25.56	0.8973	3.510	54.997	12	5	clayey silt to silty clay
33.629	28.85	0.8106	2.810	41.682	14	5	clayey silt to silty clay
33.793	18.14	0.5887	3.246	55.234	9	5	clayey silt to silty clay
33.957	15.45	0.4720	3.055	77.834	7	5	clayey silt to silty clay
34.121	15.07	0.3808	2.528	83.250	7	5	clayey silt to silty clay
34.285	14.64	0.3622	2.475	82.978	7	5	clayey silt to silty clay
34.449	13.98	0.4081	2.919	88.136	9	4	silty clay to clay
34.613	14.67	0.4447	3.031	90.479	9	4	silty clay to clay
34.777	16.93	0.6546	3.867	94.221	11	4	silty clay to clay
34.941	25.44	0.8196	3.221	43.892	12	5	clayey silt to silty clay
35.105	30.56	0.5084	1.663	14.443	12	6	sandy silt to clayey silt
35.269	34.01	0.4250	1.250	10.718	11	7	silty sand to sandy silt
35.433	36.13	0.4797	1.328	11.206	12	7	silty sand to sandy silt
35.597	39.44	0.6256	1.586	11.519	13	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
35.761	38.14	1.0439	2.737	12.291	15	6	sandy silt to clayey silt
35.925	27.82	0.8330	2.994	14.073	13	5	clayey silt to silty clay
36.089	22.39	0.7343	3.279	22.301	11	5	clayey silt to silty clay
36.253	19.10	0.7687	4.024	30.388	12	4	silty clay to clay
36.417	16.79	0.8705	5.184	41.568	16	3	clay
36.581	27.31	0.7285	2.667	42.818	13	5	clayey silt to silty clay
36.745	33.90	0.8620	2.543	23.413	13	6	sandy silt to clayey silt
36.909	28.05	0.8659	3.087	20.694	13	5	clayey silt to silty clay
37.073	20.95	0.7820	3.732	29.009	13	4	silty clay to clay
37.238	15.38	0.6039	3.927	38.263	10	4	silty clay to clay
37.402	15.48	0.5673	3.665	55.655	10	4	silty clay to clay
37.566	15.66	0.8397	5.360	60.896	15	3	clay
37.730	26.13	0.7835	2.999	63.809	13	5	clayey silt to silty clay
37.894	39.37	0.7448	1.892	19.915	15	6	sandy silt to clayey silt
38.058	41.24	0.5014	1.216	15.189	13	7	silty sand to sandy silt
38.222	41.41	0.4957	1.197	14.329	13	7	silty sand to sandy silt
38.386	39.87	0.5152	1.292	14.132	13	7	silty sand to sandy silt
38.550	40.43	0.6416	1.587	14.300	13	7	silty sand to sandy silt
38.714	41.89	1.0672	2.547	14.011	16	6	sandy silt to clayey silt
38.878	29.20	0.9107	3.119	15.500	14	5	clayey silt to silty clay
39.042	29.05	1.0873	3.743	19.506	14	5	clayey silt to silty clay
39.206	32.00	0.4933	1.541	17.055	12	6	sandy silt to clayey silt
39.370	42.63	0.5237	1.228	14.931	14	7	silty sand to sandy silt
39.534	46.91	0.6150	1.311	12.671	15	7	silty sand to sandy silt
39.698	46.80	0.8156	1.743	13.310	15	7	silty sand to sandy silt
39.862	44.76	1.0726	2.396	14.106	17	6	sandy silt to clayey silt
40.026	28.73	1.0749	3.741	17.655	14	5	clayey silt to silty clay
40.190	19.49	0.8544	4.384	28.624	19	3	clay
40.354	19.99	0.9444	4.724	49.069	19	3	clay
40.518	24.22	0.8101	3.344	57.374	12	5	clayey silt to silty clay
40.682	26.52	0.8953	3.376	45.905	13	5	clayey silt to silty clay
40.846	21.23	0.6529	3.075	43.034	10	5	clayey silt to silty clay
41.011	17.49	0.4343	2.483	50.891	8	5	clayey silt to silty clay
41.175	15.84	0.3527	2.227	60.294	8	5	clayey silt to silty clay
41.339	15.57	0.3774	2.424	70.481	7	5	clayey silt to silty clay
41.503	15.43	0.3811	2.470	75.907	7	5	clayey silt to silty clay
41.667	17.57	1.3120	7.467	83.473	17	3	clay
41.831	26.40	2.3655	8.960	96.797	25	3	clay
41.995	65.39	3.1330	4.791	20.345	42	4	silty clay to clay
42.159	62.07	2.8287	4.557	31.524	40	4	silty clay to clay
42.323	63.35	2.9753	4.697	51.367	40	4	silty clay to clay
42.487	39.43	2.1944	5.565	22.036	38	3	clay
42.651	23.47	1.6146	6.878	29.236	22	3	clay
42.815	19.48	1.2233	6.280	30.915	19	3	clay
42.979	24.09	1.1728	4.868	34.968	23	3	clay
43.143	23.46	0.8806	3.754	38.076	15	4	silty clay to clay
43.307	19.60	0.6479	3.305	40.779	9	5	clayey silt to silty clay
43.471	16.34	0.7308	4.471	45.492	16	3	clay
43.635	20.97	1.1173	5.328	57.283	20	3	clay
43.799	30.96	1.1585	3.741	43.981	15	5	clayey silt to silty clay
43.963	21.28	1.0884	5.116	30.797	20	3	clay
44.127	15.55	0.6730	4.327	29.881	15	3	clay
44.291	33.63	0.5740	1.707	36.503	13	6	sandy silt to clayey silt
44.455	26.51	0.6356	2.398	38.557	10	6	sandy silt to clayey silt
44.619	20.00	0.8572	4.285	44.672	19	3	clay
44.783	30.03	1.2816	4.267	51.250	19	4	silty clay to clay
44.948	22.15	1.0338	4.667	42.732	21	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.112	19.30	0.5483	2.842	29.355	9	5	clayey silt to silty clay
45.276	33.50	0.5739	1.713	22.567	13	6	sandy silt to clayey silt
45.440	38.99	0.6679	1.713	18.714	15	6	sandy silt to clayey silt
45.604	36.14	0.7789	2.155	19.487	14	6	sandy silt to clayey silt
45.768	27.97	0.7738	2.766	21.974	13	5	clayey silt to silty clay
45.932	20.72	0.7929	3.826	29.585	13	4	silty clay to clay
46.096	18.57	0.8112	4.367	39.387	18	3	clay
46.260	19.73	1.0338	5.240	43.679	19	3	clay
46.424	30.12	1.1043	3.666	51.341	14	5	clayey silt to silty clay
46.588	27.63	1.1451	4.144	41.795	18	4	silty clay to clay
46.752	19.87	0.8610	4.334	39.559	19	3	clay
46.916	20.48	0.5723	2.794	41.680	10	5	clayey silt to silty clay
47.080	24.74	0.4350	1.758	33.760	9	6	sandy silt to clayey silt
47.244	23.56	0.3782	1.605	33.146	9	6	sandy silt to clayey silt
47.408	19.32	0.4025	2.083	34.224	9	5	clayey silt to silty clay
47.572	13.48	0.5451	4.044	37.847	13	3	clay
47.736	13.89	0.5209	3.750	49.605	9	4	silty clay to clay
47.900	35.34	0.5985	1.693	36.646	14	6	sandy silt to clayey silt
48.064	52.93	0.7140	1.349	29.078	17	7	silty sand to sandy silt
48.228	59.83	0.8515	1.423	26.534	19	7	silty sand to sandy silt
48.392	55.84	1.1721	2.099	24.795	21	6	sandy silt to clayey silt
48.556	48.47	1.1159	2.302	24.035	19	6	sandy silt to clayey silt
48.720	42.47	1.4092	3.318	23.143	20	5	clayey silt to silty clay
48.885	38.27	1.1127	2.908	27.497	15	6	sandy silt to clayey silt
49.049	59.21	0.8251	1.393	34.093	19	7	silty sand to sandy silt
49.213	60.22	0.8792	1.460	20.225	19	7	silty sand to sandy silt
49.377	37.77	0.7262	1.923	20.094	14	6	sandy silt to clayey silt
49.541	26.00	0.6440	2.477	22.806	10	6	sandy silt to clayey silt
49.705	16.80	0.5287	3.147	32.364	8	5	clayey silt to silty clay
49.869	19.25	0.5655	2.938	47.914	9	5	clayey silt to silty clay
50.033	28.34	0.6559	2.314	46.011	11	6	sandy silt to clayey silt
50.197	40.58	0.7004	1.726	36.680	16	6	sandy silt to clayey silt
50.361	46.91	0.6764	1.442	28.533	15	7	silty sand to sandy silt
50.525	48.74	0.6340	1.301	25.673	16	7	silty sand to sandy silt
50.689	46.20	0.6707	1.452	25.419	15	7	silty sand to sandy silt
50.853	40.45	0.7733	1.912	25.321	15	6	sandy silt to clayey silt
51.017	31.96	0.9855	3.083	25.484	15	5	clayey silt to silty clay
51.181	25.84	1.0031	3.882	25.618	16	4	silty clay to clay
51.345	27.10	0.6215	2.294	34.322	10	6	sandy silt to clayey silt
51.509	23.91	0.3892	1.628	38.983	9	6	sandy silt to clayey silt
51.673	16.66	0.1733	1.040	53.338	6	6	sandy silt to clayey silt
51.837	13.58	0.1658	1.221	65.404	5	6	sandy silt to clayey silt
52.001	11.53	0.2083	1.807	83.927	6	5	clayey silt to silty clay
52.165	15.94	0.2798	1.756	88.107	8	5	clayey silt to silty clay
52.329	23.55	0.3609	1.533	54.528	9	6	sandy silt to clayey silt
52.493	21.86	0.5599	2.561	53.739	10	5	clayey silt to silty clay
52.657	16.80	0.4848	2.886	76.275	8	5	clayey silt to silty clay
52.822	28.72	0.4967	1.730	54.638	11	6	sandy silt to clayey silt
52.986	31.18	0.4855	1.557	43.428	12	6	sandy silt to clayey silt
53.150	25.13	0.6307	2.510	43.273	12	5	clayey silt to silty clay
53.314	21.45	0.6544	3.051	46.860	10	5	clayey silt to silty clay
53.478	25.23	0.4722	1.871	52.580	10	6	sandy silt to clayey silt
53.642	23.10	0.7155	3.098	45.205	11	5	clayey silt to silty clay
53.806	24.07	0.9576	3.978	61.910	15	4	silty clay to clay
53.970	40.06	1.1775	2.940	45.387	15	6	sandy silt to clayey silt
54.134	50.08	1.2409	2.478	36.976	19	6	sandy silt to clayey silt
54.298	59.49	1.4932	2.510	30.178	23	6	sandy silt to clayey silt

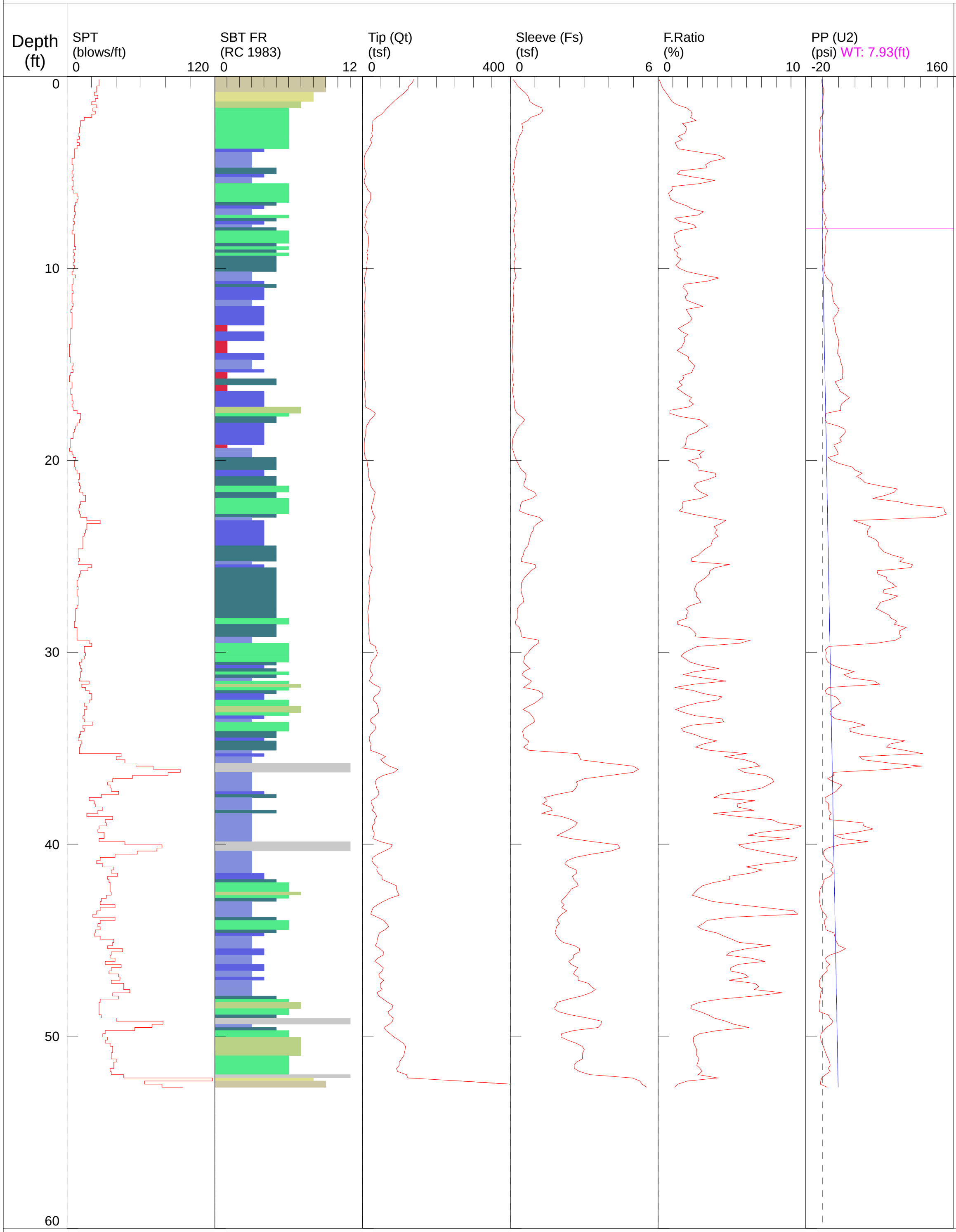
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
54.462	70.06	1.4815	2.115	26.120	22	7	silty sand to sandy silt
54.626	65.21	1.9629	3.010	21.314	25	6	sandy silt to clayey silt
54.790	59.88	1.5801	2.639	26.780	23	6	sandy silt to clayey silt
54.954	66.42	0.9241	1.391	19.972	21	7	silty sand to sandy silt
55.118	43.93	0.6175	1.405	16.352	14	7	silty sand to sandy silt
55.282	34.50	0.4514	1.308	20.541	11	7	silty sand to sandy silt
55.446	23.58	0.4682	1.986	20.044	9	6	sandy silt to clayey silt
55.610	16.41	0.4188	2.552	23.071	8	5	clayey silt to silty clay
55.774	13.91	0.3423	2.461	28.590	7	5	clayey silt to silty clay
55.938	11.70	0.2755	2.356	37.404	6	5	clayey silt to silty clay
56.102	12.54	0.5224	4.167	54.222	12	3	clay
56.266	34.64	0.5919	1.709	68.761	13	6	sandy silt to clayey silt
56.430	65.52	0.7362	1.124	34.521	21	7	silty sand to sandy silt
56.594	62.86	0.8601	1.368	26.943	20	7	silty sand to sandy silt
56.759	47.63	0.9013	1.892	30.625	18	6	sandy silt to clayey silt
56.923	33.64	1.1155	3.316	35.989	16	5	clayey silt to silty clay
57.087	30.95	1.1465	3.705	54.538	15	5	clayey silt to silty clay
57.251	43.95	1.1001	2.503	58.213	17	6	sandy silt to clayey silt
57.415	59.14	0.8078	1.366	44.153	19	7	silty sand to sandy silt
57.579	53.02	0.9302	1.754	29.917	17	7	silty sand to sandy silt
57.743	44.68	1.1303	2.530	30.479	17	6	sandy silt to clayey silt
57.907	44.27	1.0430	2.356	33.521	17	6	sandy silt to clayey silt
58.071	56.27	1.3121	2.332	32.038	22	6	sandy silt to clayey silt
58.235	63.34	1.7653	2.787	29.186	24	6	sandy silt to clayey silt
58.399	56.86	1.9490	3.428	32.323	27	5	clayey silt to silty clay
58.563	58.53	1.7072	2.917	38.770	22	6	sandy silt to clayey silt
58.727	71.56	1.4708	2.056	31.352	23	7	silty sand to sandy silt
58.891	79.46	0.9946	1.252	19.178	25	7	silty sand to sandy silt
59.055	83.86	0.8889	1.060	14.336	20	8	sand to silty sand
59.219	82.15	0.8452	1.029	19.907	20	8	sand to silty sand
59.383	77.92	0.8219	1.055	20.278	19	8	sand to silty sand
59.547	71.64	0.7942	1.109	20.520	23	7	silty sand to sandy silt
59.711	65.64	0.7684	1.171	20.642	21	7	silty sand to sandy silt
59.875	59.17	0.7421	1.254	21.113	19	7	silty sand to sandy silt
60.039	51.43	0.7060	1.373	22.029	16	7	silty sand to sandy silt
60.203	42.71	0.6413	1.502	22.677	14	7	silty sand to sandy silt
60.367	33.06	0.5659	1.712	23.432	13	6	sandy silt to clayey silt
60.532	21.84	0.4605	2.108	25.080	8	6	sandy silt to clayey silt
60.696	15.74	0.2988	1.898	27.696	8	5	clayey silt to silty clay
60.860	12.38	0.4461	3.603	32.325	8	4	silty clay to clay
61.024	24.96	0.5163	2.068	38.818	10	6	sandy silt to clayey silt
61.188	51.48	0.6948	1.350	23.901	16	7	silty sand to sandy silt
61.352	61.97	0.8558	1.381	22.837	20	7	silty sand to sandy silt
61.516	63.98	1.4835	2.319	25.878	25	6	sandy silt to clayey silt
61.680	65.17	1.4914	2.289	24.982	25	6	sandy silt to clayey silt
61.844	85.62	1.0463	1.222	12.069	20	8	sand to silty sand
62.008	73.83	1.5877	2.150	10.194	24	7	silty sand to sandy silt
62.172	55.94	1.5198	2.717	13.322	21	6	sandy silt to clayey silt
62.336	52.96	1.4637	2.764	17.189	20	6	sandy silt to clayey silt
62.500	60.28	1.0860	1.802	21.005	19	7	silty sand to sandy silt
62.664	83.44	1.0293	1.234	18.069	20	8	sand to silty sand
62.828	90.07	0.9979	1.108	15.957	22	8	sand to silty sand
62.992	90.93	1.0683	1.175	17.370	22	8	sand to silty sand
63.156	89.63	1.0940	1.221	18.547	21	8	sand to silty sand
63.320	87.11	1.1079	1.272	19.601	21	8	sand to silty sand
63.484	83.52	1.1109	1.330	20.276	27	7	silty sand to sandy silt
63.648	79.37	1.1136	1.403	21.266	25	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
63.812	75.05	1.1051	1.472	22.060	24	7	silty sand to sandy silt
63.976	70.54	1.0750	1.524	22.559	23	7	silty sand to sandy silt
64.140	66.01	1.0358	1.569	23.138	21	7	silty sand to sandy silt
64.304	60.86	1.0040	1.650	23.679	19	7	silty sand to sandy silt
64.469	57.04	0.9458	1.658	24.647	18	7	silty sand to sandy silt
64.633	54.52	1.0427	1.912	25.283	17	7	silty sand to sandy silt
64.797	47.08	0.9043	1.921	27.045	18	6	sandy silt to clayey silt
64.961	40.49	0.7390	1.825	29.750	16	6	sandy silt to clayey silt
65.125	22.25	0.7120	3.199	40.272	11	5	clayey silt to silty clay
65.289	18.48	0.5214	2.821	55.511	9	5	clayey silt to silty clay
65.453	22.81	0.4818	2.112	67.511	9	6	sandy silt to clayey silt
65.617	25.14	0.5073	2.018	65.495	10	6	sandy silt to clayey silt
65.781	26.35	0.4968	1.886	63.264	10	6	sandy silt to clayey silt
65.945	25.83	0.4986	1.931	58.986	10	6	sandy silt to clayey silt
66.109	23.83	0.4748	1.992	57.489	9	6	sandy silt to clayey silt
66.273	21.05	0.5188	2.464	58.288	10	5	clayey silt to silty clay
66.437	17.19	0.6546	3.807	65.603	11	4	silty clay to clay
66.601	16.33	0.7249	4.438	80.395	16	3	clay
66.765	30.18	0.7676	2.543	68.068	12	6	sandy silt to clayey silt
66.929	44.79	1.4640	3.268	64.139	21	5	clayey silt to silty clay
67.093	57.60	1.8056	3.135	68.228	22	6	sandy silt to clayey silt
67.257	64.33	1.9686	3.060	77.114	25	6	sandy silt to clayey silt
67.421	57.83	1.6701	2.888	44.179	22	6	sandy silt to clayey silt
67.585	50.15	0.9892	1.972	47.804	19	6	sandy silt to clayey silt
67.749	42.46	0.5642	1.329	50.769	14	7	silty sand to sandy silt
67.913	29.70	0.4642	1.563	57.436	11	6	sandy silt to clayey silt
68.077	22.06	0.4469	2.026	75.438	8	6	sandy silt to clayey silt
68.241	19.16	0.4317	2.253	99.470	9	5	clayey silt to silty clay
68.406	18.97	0.5785	3.050	105.798	9	5	clayey silt to silty clay
68.570	25.57	0.8672	3.391	90.721	12	5	clayey silt to silty clay
68.734	43.11	1.0381	2.408	103.215	17	6	sandy silt to clayey silt
68.898	61.50	1.2204	1.985	50.583	20	7	silty sand to sandy silt
69.062	67.44	1.1251	1.668	39.726	22	7	silty sand to sandy silt
69.226	54.98	1.0604	1.929	27.428	18	7	silty sand to sandy silt
69.390	50.90	1.2277	2.412	34.394	19	6	sandy silt to clayey silt
69.554	40.75	1.3533	3.321	25.238	20	5	clayey silt to silty clay
69.718	25.21	1.8389	7.293	54.545	24	3	clay
69.882	56.80	2.0629	3.632	101.304	27	5	clayey silt to silty clay
70.046	71.95	1.7415	2.420	63.163	28	6	sandy silt to clayey silt
70.210	52.38	1.2612	2.408	38.543	20	6	sandy silt to clayey silt
70.374	27.62	1.1834	4.285	37.684	18	4	silty clay to clay
70.538	31.04	0.9059	2.919	56.343	15	5	clayey silt to silty clay
70.702	41.31	0.9558	2.314	59.019	16	6	sandy silt to clayey silt
70.866	50.43	1.3053	2.588	74.517	19	6	sandy silt to clayey silt
71.030	50.65	1.4785	2.919	60.832	19	6	sandy silt to clayey silt
71.194	37.24	1.6525	4.437	71.179	24	4	silty clay to clay
71.358	34.89	0.6709	1.923	96.209	13	6	sandy silt to clayey silt
71.522	30.73	0.3811	1.240	93.523	12	6	sandy silt to clayey silt
71.686	17.82	0.2455	1.378	126.262	7	6	sandy silt to clayey silt
71.850	17.51	0.2495	1.425	133.850	7	6	sandy silt to clayey silt
72.014	18.18	0.2318	1.275	136.069	7	6	sandy silt to clayey silt
72.178	17.76	0.3443	1.938	137.726	9	5	clayey silt to silty clay
72.343	30.98	0.5477	1.768	135.251	12	6	sandy silt to clayey silt
72.507	38.73	0.6781	1.751	87.837	15	6	sandy silt to clayey silt
72.671	29.25	1.4875	5.086	103.741	28	3	clay
72.835	29.93	1.5146	5.061	118.758	29	3	clay
72.999	461.48	1.6504	0.358	95.364	74	10	gravelly sand to sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
73.163	488.06	1.6905	0.346	94.009	78	10	gravelly sand to sand

NV5 / CPT-7 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/6/2024 9:50:45 AM
TOTAL DEPTH: 52.657 ft

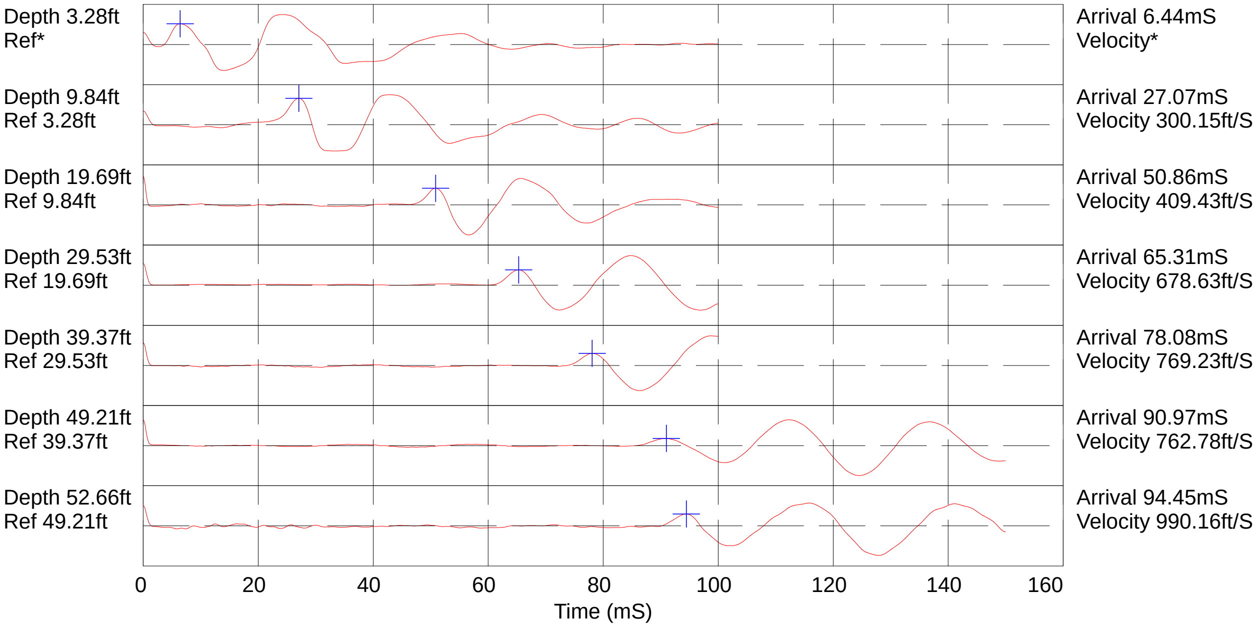


REMARKS

🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟩 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

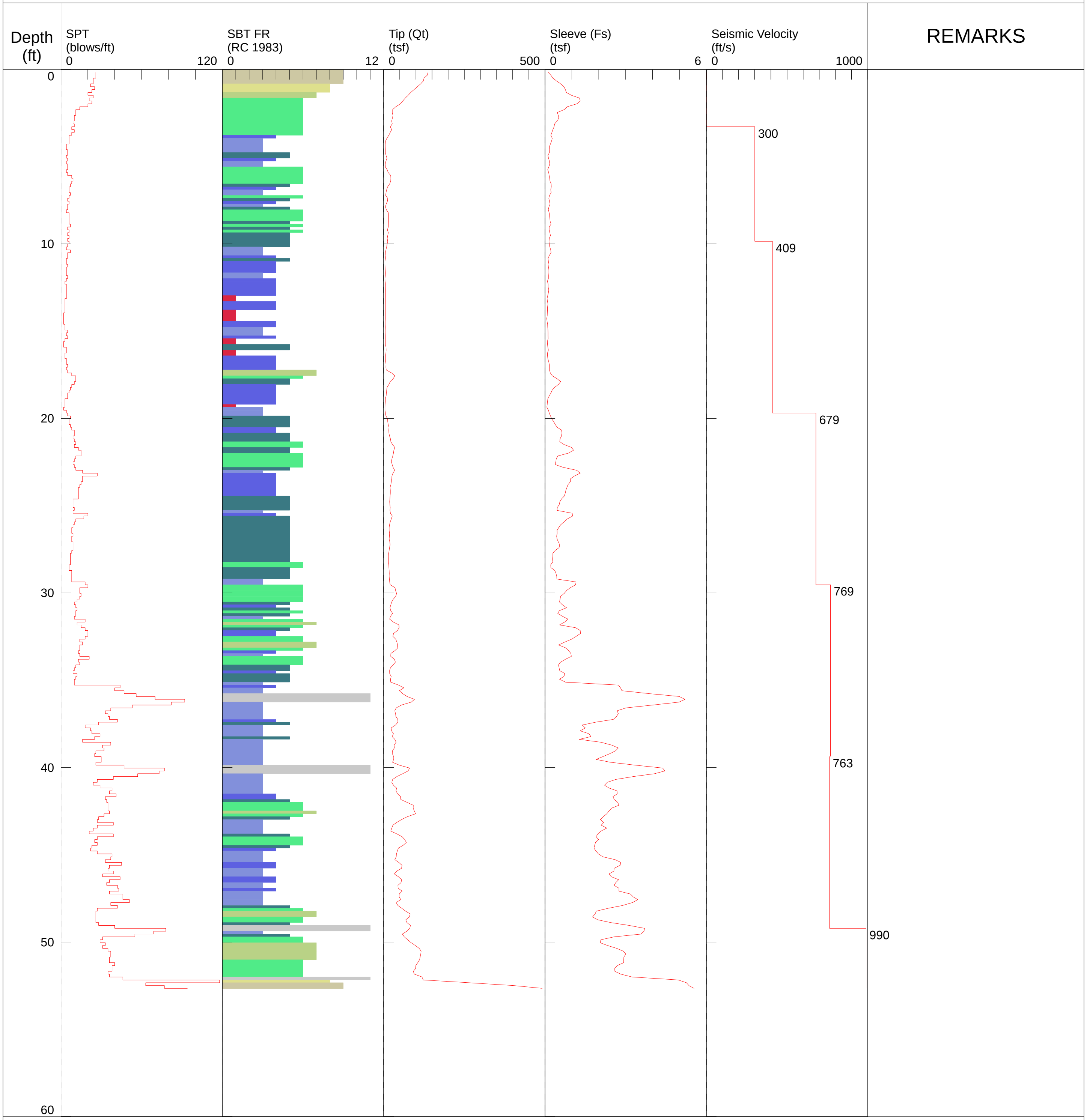
COMMENT: NV5 / CPT-7 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 2.03
* = Not Determined

NV5 / CPT-7 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/6/2024 9:50:45 AM
TOTAL DEPTH: 52.657 ft



- 🟥 1 sensitive fine grained
- 🟥 2 organic material
- 🟦 3 clay
- 🟦 4 silty clay to clay
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- 🟩 6 sandy silt to clayey silt
- 🟩 7 silty sand to sandy silt
- 🟨 8 sand to silty sand
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- 🟧 10 gravelly sand to sand
- ⬜ 11 very stiff fine grained (*)
- ⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-7 / 5501 NW Front Ave Portland

CONE ID: DDG1661
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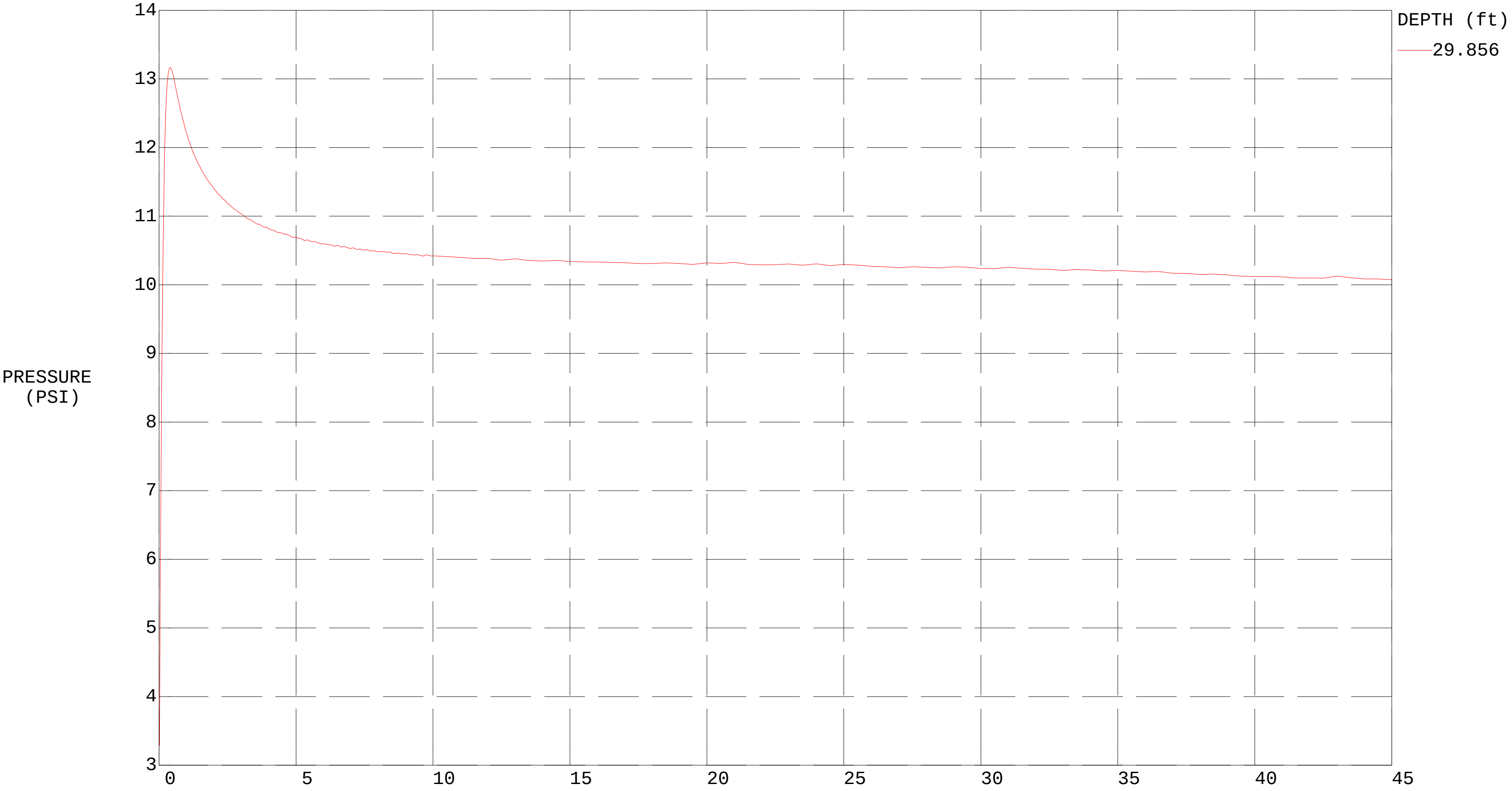
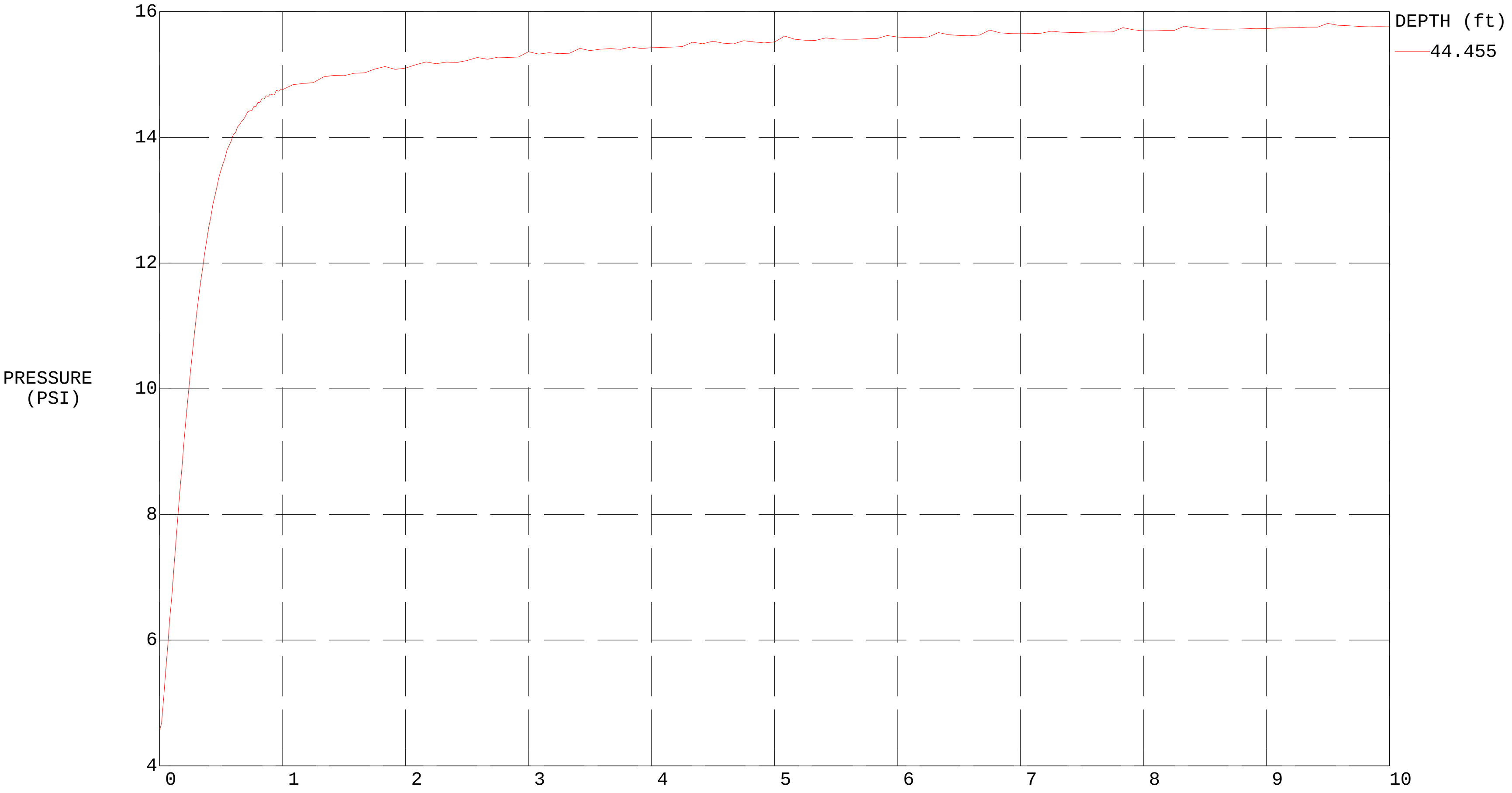


MAXIMUM PRESSURE = 13.164 (PSI)
TIME: (MINUTES)
HYDROSTATIC PRESSURE = 9.504 (PSI), WATER TABLE: 7.93 ft

COMMENT: NV5 / CPT-7 / 5501 NW Front Ave Portland

CONE ID: DDG1661
TEST DATE: 2/6/2024 9:50:45 AM



MAXIMUM PRESSURE = 15.813 (PSI)

HYDROSTATIC PRESSURE = 15.831 (PSI), WATER TABLE: 7.93 ft

NV5 / CPT-7 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1661
TEST DATE: 2/6/2024 9:50:45 AM
TOTAL DEPTH: 52.657 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.164	137.86	0.1175	0.085	-0.550	26	9	sand
0.328	134.86	0.2203	0.163	-0.404	26	9	sand
0.492	124.96	0.2954	0.236	0.318	24	9	sand
0.656	123.26	0.4262	0.346	1.597	24	9	sand
0.820	114.67	0.5769	0.503	1.554	22	9	sand
0.984	104.74	0.7020	0.670	1.145	25	8	sand to silty sand
1.148	94.16	0.7568	0.804	0.672	23	8	sand to silty sand
1.312	84.20	0.7932	0.942	0.540	20	8	sand to silty sand
1.476	75.63	0.9871	1.305	0.387	24	7	silty sand to sandy silt
1.640	66.95	1.2842	1.918	0.430	21	7	silty sand to sandy silt
1.804	59.12	1.3105	2.217	1.310	23	6	sandy silt to clayey silt
1.969	51.45	1.1842	2.302	1.188	20	6	sandy silt to clayey silt
2.133	37.80	0.8315	2.200	-2.009	14	6	sandy silt to clayey silt
2.297	27.88	0.7135	2.560	-1.846	11	6	sandy silt to clayey silt
2.461	27.79	0.4586	1.650	-1.585	11	6	sandy silt to clayey silt
2.625	26.14	0.4942	1.890	-1.619	10	6	sandy silt to clayey silt
2.789	26.96	0.5157	1.913	-3.092	10	6	sandy silt to clayey silt
2.953	24.75	0.4501	1.819	-3.063	9	6	sandy silt to clayey silt
3.117	26.67	0.3621	1.358	-3.123	10	6	sandy silt to clayey silt
3.281	20.62	0.3386	1.642	-3.372	8	6	sandy silt to clayey silt
3.445	24.94	0.2900	1.163	-2.807	10	6	sandy silt to clayey silt
3.609	20.57	0.2553	1.241	-3.023	8	6	sandy silt to clayey silt
3.773	15.69	0.2156	1.375	-3.097	6	6	sandy silt to clayey silt
3.937	9.88	0.2714	2.746	-3.013	6	4	silty clay to clay
4.101	5.90	0.2414	4.094	-2.530	6	3	clay
4.265	4.53	0.2043	4.509	-1.624	4	3	clay
4.429	4.59	0.1638	3.567	-0.041	4	3	clay
4.593	4.91	0.1578	3.215	0.868	5	3	clay
4.757	4.89	0.1623	3.317	1.487	5	3	clay
4.921	7.35	0.1082	1.473	2.233	4	5	clayey silt to silty clay
5.085	10.31	0.1320	1.281	2.226	5	5	clayey silt to silty clay
5.249	6.74	0.1646	2.443	1.155	4	4	silty clay to clay
5.413	4.78	0.1828	3.826	1.282	5	3	clay
5.577	4.94	0.1405	2.845	3.018	5	3	clay
5.741	10.70	0.0989	0.924	4.443	4	6	sandy silt to clayey silt
5.906	13.81	0.1324	0.958	3.463	5	6	sandy silt to clayey silt
6.070	21.73	0.1529	0.704	0.655	8	6	sandy silt to clayey silt
6.234	22.45	0.1756	0.782	0.684	9	6	sandy silt to clayey silt
6.398	21.93	0.1851	0.844	0.677	8	6	sandy silt to clayey silt
6.562	18.48	0.2296	1.243	0.753	7	6	sandy silt to clayey silt
6.726	12.23	0.2330	1.905	0.885	6	5	clayey silt to silty clay
6.890	9.26	0.2119	2.288	1.050	6	4	silty clay to clay
7.054	7.52	0.2308	3.068	1.686	7	3	clay
7.218	6.14	0.1675	2.728	3.922	6	3	clay
7.382	12.54	0.1402	1.118	4.811	5	6	sandy silt to clayey silt
7.546	11.66	0.1678	1.438	3.085	6	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
7.710	7.89	0.1882	2.386	2.929	5	4	silty clay to clay
7.874	5.68	0.1465	2.577	3.936	5	3	clay
8.038	8.34	0.1236	1.482	6.813	4	5	clayey silt to silty clay
8.202	14.40	0.1544	1.072	4.871	6	6	sandy silt to clayey silt
8.366	15.58	0.1726	1.108	3.671	6	6	sandy silt to clayey silt
8.530	15.42	0.1796	1.165	3.544	6	6	sandy silt to clayey silt
8.694	15.41	0.1906	1.237	3.441	6	6	sandy silt to clayey silt
8.858	14.84	0.2246	1.513	3.525	7	5	clayey silt to silty clay
9.022	14.12	0.1508	1.069	3.644	5	6	sandy silt to clayey silt
9.186	11.53	0.1523	1.321	3.778	6	5	clayey silt to silty clay
9.350	14.24	0.1789	1.256	2.334	5	6	sandy silt to clayey silt
9.514	12.84	0.1998	1.556	2.516	6	5	clayey silt to silty clay
9.678	11.22	0.1554	1.385	2.618	5	5	clayey silt to silty clay
9.843	12.35	0.1478	1.197	2.793	6	5	clayey silt to silty clay
10.007	10.88	0.1594	1.466	1.839	5	5	clayey silt to silty clay
10.171	9.16	0.1790	1.954	2.372	4	5	clayey silt to silty clay
10.335	7.07	0.2126	3.007	3.549	7	3	clay
10.499	5.46	0.2250	4.121	5.543	5	3	clay
10.663	4.72	0.1578	3.344	9.053	5	3	clay
10.827	6.30	0.1119	1.777	12.636	4	4	silty clay to clay
10.991	7.46	0.1248	1.672	11.559	4	5	clayey silt to silty clay
11.155	7.53	0.1439	1.911	11.624	5	4	silty clay to clay
11.319	6.91	0.1390	2.014	11.887	4	4	silty clay to clay
11.483	6.45	0.1189	1.843	12.628	4	4	silty clay to clay
11.647	6.27	0.1190	1.899	13.272	4	4	silty clay to clay
11.811	5.09	0.1251	2.455	14.525	5	3	clay
11.975	4.18	0.1270	3.037	17.966	4	3	clay
12.139	4.42	0.0841	1.900	20.448	3	4	silty clay to clay
12.303	5.83	0.1178	2.023	18.729	4	4	silty clay to clay
12.467	5.56	0.1202	2.164	16.072	4	4	silty clay to clay
12.631	6.07	0.1398	2.301	12.903	4	4	silty clay to clay
12.795	5.88	0.1247	2.122	14.283	4	4	silty clay to clay
12.959	5.75	0.1011	1.758	15.445	4	4	silty clay to clay
13.123	5.63	0.0775	1.376	15.976	3	1	sensitive fine grained
13.287	5.67	0.0913	1.608	15.981	3	1	sensitive fine grained
13.451	5.38	0.1085	2.015	17.394	3	4	silty clay to clay
13.615	5.06	0.0886	1.750	19.001	3	4	silty clay to clay
13.780	4.88	0.0883	1.810	20.053	3	4	silty clay to clay
13.944	5.05	0.0857	1.698	19.943	2	1	sensitive fine grained
14.108	5.13	0.0812	1.583	19.487	2	1	sensitive fine grained
14.272	4.98	0.0640	1.284	18.896	2	1	sensitive fine grained
14.436	4.69	0.0778	1.657	18.482	2	1	sensitive fine grained
14.600	4.67	0.0956	2.048	20.984	3	4	silty clay to clay
14.764	4.82	0.1000	2.077	22.127	3	4	silty clay to clay
14.928	4.72	0.1080	2.286	22.755	5	3	clay
15.092	4.56	0.1137	2.493	24.159	4	3	clay
15.256	4.91	0.1156	2.357	24.805	5	3	clay
15.420	5.22	0.1194	2.285	24.872	3	4	silty clay to clay
15.584	5.19	0.0867	1.670	24.162	2	1	sensitive fine grained
15.748	5.04	0.0878	1.741	24.764	2	1	sensitive fine grained
15.912	7.55	0.1057	1.399	15.350	4	5	clayey silt to silty clay
16.076	7.77	0.1281	1.648	18.064	4	5	clayey silt to silty clay
16.240	7.09	0.0911	1.284	20.402	3	1	sensitive fine grained
16.404	5.88	0.0919	1.561	21.447	3	1	sensitive fine grained
16.568	5.60	0.1051	1.877	27.954	4	4	silty clay to clay
16.732	6.10	0.1378	2.259	33.196	4	4	silty clay to clay
16.896	7.47	0.1571	2.102	27.837	5	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.060	7.02	0.1681	2.394	23.349	4	4	silty clay to clay
17.224	8.09	0.1673	2.068	22.205	5	4	silty clay to clay
17.388	24.70	0.1989	0.805	22.459	8	7	silty sand to sandy silt
17.552	34.58	0.2726	0.788	4.357	11	7	silty sand to sandy silt
17.717	29.71	0.4446	1.496	3.587	11	6	sandy silt to clayey silt
17.881	20.54	0.5807	2.827	3.436	10	5	clayey silt to silty clay
18.045	16.19	0.5022	3.103	5.751	8	5	clayey silt to silty clay
18.209	10.71	0.3607	3.367	19.601	7	4	silty clay to clay
18.373	9.28	0.2635	2.840	27.557	6	4	silty clay to clay
18.537	8.51	0.2211	2.599	27.964	5	4	silty clay to clay
18.701	7.81	0.1585	2.030	24.575	5	4	silty clay to clay
18.865	5.42	0.1037	1.911	21.345	3	4	silty clay to clay
19.029	4.99	0.0939	1.884	23.119	3	4	silty clay to clay
19.193	4.34	0.0804	1.852	14.073	3	4	silty clay to clay
19.357	4.17	0.0692	1.661	15.979	2	1	sensitive fine grained
19.521	4.12	0.1265	3.068	18.367	4	3	clay
19.685	5.67	0.1583	2.792	19.554	5	3	clay
19.849	6.85	0.2001	2.920	7.468	7	3	clay
20.013	12.16	0.2497	2.053	11.851	6	5	clayey silt to silty clay
20.177	12.66	0.3222	2.544	21.739	6	5	clayey silt to silty clay
20.341	13.95	0.3782	2.712	36.312	7	5	clayey silt to silty clay
20.505	16.85	0.4538	2.694	39.746	8	5	clayey silt to silty clay
20.669	15.95	0.6196	3.885	48.744	10	4	silty clay to clay
20.833	16.10	0.6324	3.928	41.943	10	4	silty clay to clay
20.997	18.29	0.6160	3.368	48.256	9	5	clayey silt to silty clay
21.161	21.18	0.5571	2.631	52.056	10	5	clayey silt to silty clay
21.325	22.44	0.5470	2.437	70.607	11	5	clayey silt to silty clay
21.490	27.24	0.7027	2.580	91.469	10	6	sandy silt to clayey silt
21.654	34.34	0.9883	2.878	87.798	13	6	sandy silt to clayey silt
21.818	31.58	1.0607	3.359	77.059	15	5	clayey silt to silty clay
21.982	30.30	0.8747	2.886	61.475	15	5	clayey silt to silty clay
22.146	28.23	0.4759	1.685	91.206	11	6	sandy silt to clayey silt
22.310	25.47	0.4155	1.632	109.782	10	6	sandy silt to clayey silt
22.474	24.12	0.4007	1.661	147.903	9	6	sandy silt to clayey silt
22.638	26.22	0.3717	1.418	148.736	10	6	sandy silt to clayey silt
22.802	29.56	0.6813	2.305	151.268	11	6	sandy silt to clayey silt
22.966	34.00	1.1750	3.455	137.884	16	5	clayey silt to silty clay
23.130	28.69	1.3120	4.573	38.268	27	3	clay
23.294	25.79	1.0920	4.234	48.995	16	4	silty clay to clay
23.458	25.09	0.9502	3.788	58.718	16	4	silty clay to clay
23.622	23.60	0.9436	3.999	55.564	15	4	silty clay to clay
23.786	22.29	0.8547	3.834	54.715	14	4	silty clay to clay
23.950	20.03	0.8141	4.065	55.999	13	4	silty clay to clay
24.114	20.82	0.7759	3.726	64.708	13	4	silty clay to clay
24.278	20.69	0.7515	3.633	68.508	13	4	silty clay to clay
24.442	19.96	0.7140	3.577	68.089	13	4	silty clay to clay
24.606	19.25	0.6134	3.187	71.748	9	5	clayey silt to silty clay
24.770	18.69	0.5515	2.951	75.206	9	5	clayey silt to silty clay
24.934	19.37	0.5277	2.724	85.240	9	5	clayey silt to silty clay
25.098	20.52	0.4577	2.231	98.990	10	5	clayey silt to silty clay
25.262	19.62	0.4469	2.278	94.489	9	5	clayey silt to silty clay
25.427	20.96	1.0131	4.832	109.930	20	3	clay
25.591	26.55	1.0260	3.865	108.110	17	4	silty clay to clay
25.755	23.80	0.8325	3.498	66.896	11	5	clayey silt to silty clay
25.919	20.47	0.7086	3.462	67.492	10	5	clayey silt to silty clay
26.083	18.07	0.5865	3.246	78.441	9	5	clayey silt to silty clay
26.247	17.17	0.5089	2.965	78.680	8	5	clayey silt to silty clay

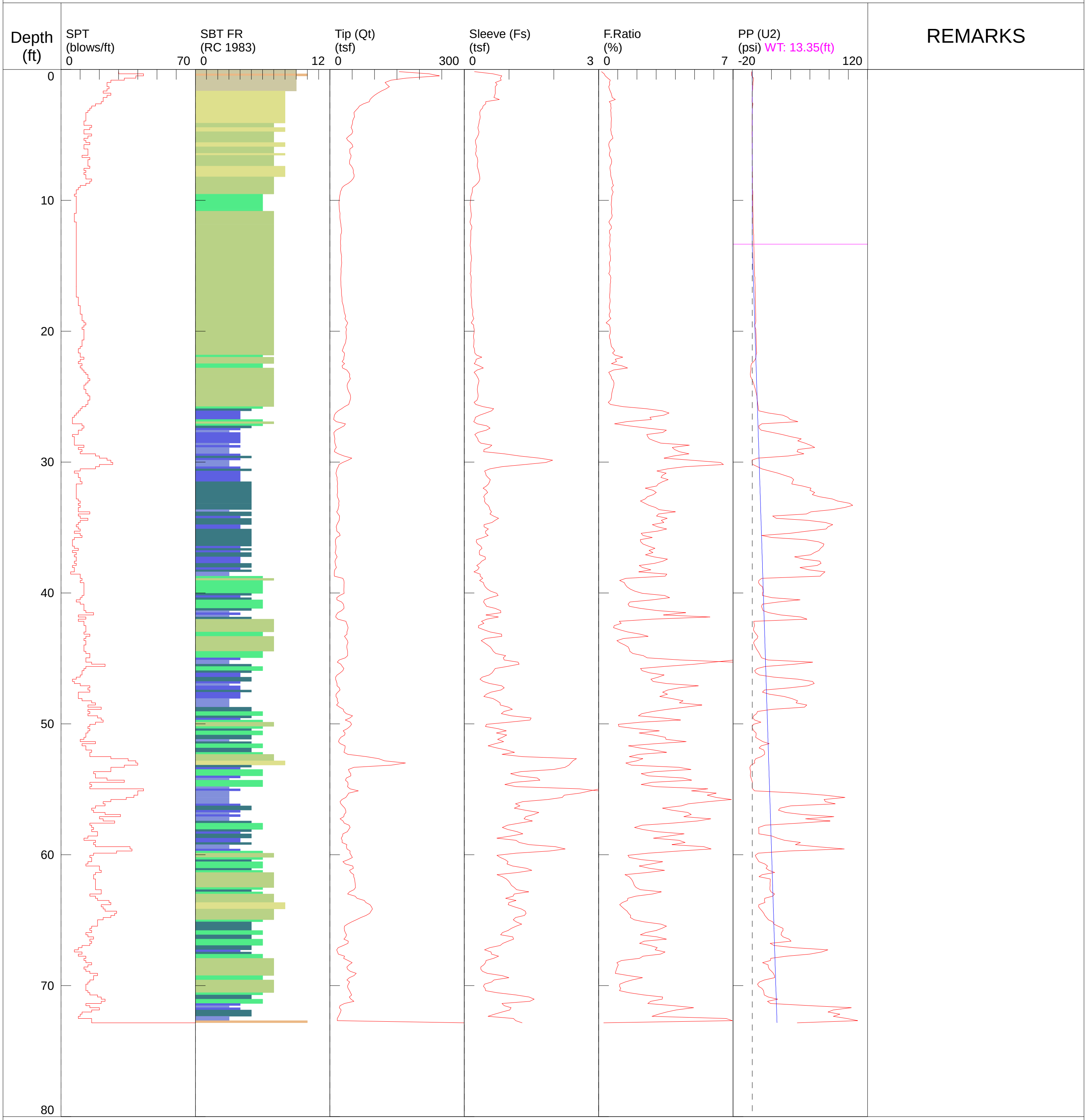
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
26.411	16.98	0.4480	2.638	85.015	8	5	clayey silt to silty clay
26.575	18.00	0.4529	2.516	90.321	9	5	clayey silt to silty clay
26.739	17.74	0.4334	2.443	75.077	8	5	clayey silt to silty clay
26.903	17.18	0.4496	2.618	73.953	8	5	clayey silt to silty clay
27.067	18.99	0.4907	2.584	92.174	9	5	clayey silt to silty clay
27.231	19.74	0.5464	2.768	83.437	9	5	clayey silt to silty clay
27.395	18.21	0.5252	2.885	70.603	9	5	clayey silt to silty clay
27.559	17.08	0.3741	2.190	68.773	8	5	clayey silt to silty clay
27.723	15.49	0.2910	1.879	65.806	7	5	clayey silt to silty clay
27.887	14.12	0.2893	2.049	73.312	7	5	clayey silt to silty clay
28.051	14.83	0.2836	1.912	81.172	7	5	clayey silt to silty clay
28.215	14.85	0.2913	1.961	83.556	7	5	clayey silt to silty clay
28.379	15.89	0.2115	1.331	90.795	6	6	sandy silt to clayey silt
28.543	16.52	0.2172	1.315	87.815	6	6	sandy silt to clayey silt
28.707	16.96	0.3639	2.146	102.096	8	5	clayey silt to silty clay
28.871	17.23	0.4104	2.382	94.109	8	5	clayey silt to silty clay
29.035	17.02	0.4363	2.563	94.212	8	5	clayey silt to silty clay
29.199	17.73	0.4407	2.486	96.099	8	5	clayey silt to silty clay
29.364	18.47	1.1530	6.243	89.439	18	3	clay
29.528	20.48	1.1334	5.534	64.928	20	3	clay
29.692	35.27	0.9371	2.657	8.085	14	6	sandy silt to clayey silt
29.856	36.66	0.8083	2.205	3.714	14	6	sandy silt to clayey silt
30.020	40.01	0.7185	1.796	4.795	15	6	sandy silt to clayey silt
30.184	37.42	0.5835	1.559	4.273	14	6	sandy silt to clayey silt
30.348	30.17	0.5615	1.861	4.673	12	6	sandy silt to clayey silt
30.512	24.87	0.5379	2.163	7.301	10	6	sandy silt to clayey silt
30.676	22.31	0.6452	2.892	12.970	11	5	clayey silt to silty clay
30.840	19.54	0.7996	4.093	23.774	12	4	silty clay to clay
31.004	21.93	0.5395	2.460	38.992	11	5	clayey silt to silty clay
31.168	27.98	0.4726	1.689	26.232	11	6	sandy silt to clayey silt
31.332	21.22	0.6447	3.038	34.305	10	5	clayey silt to silty clay
31.496	18.74	0.8608	4.593	63.398	18	3	clay
31.660	30.13	0.7298	2.422	70.029	12	6	sandy silt to clayey silt
31.824	47.28	0.5364	1.134	8.298	15	7	silty sand to sandy silt
31.988	47.99	1.1304	2.355	3.647	18	6	sandy silt to clayey silt
32.152	42.67	1.3085	3.067	4.866	20	5	clayey silt to silty clay
32.316	30.60	1.3215	4.318	16.364	20	4	silty clay to clay
32.480	28.65	1.1603	4.050	19.943	18	4	silty clay to clay
32.644	37.64	0.9908	2.632	22.263	14	6	sandy silt to clayey silt
32.808	40.83	0.7427	1.819	16.057	16	6	sandy silt to clayey silt
32.972	43.19	0.5078	1.176	11.045	14	7	silty sand to sandy silt
33.136	43.76	0.7677	1.754	9.252	14	7	silty sand to sandy silt
33.301	34.96	0.8771	2.509	10.739	13	6	sandy silt to clayey silt
33.465	22.22	0.9601	4.320	16.069	14	4	silty clay to clay
33.629	22.04	0.9775	4.434	37.299	21	3	clay
33.793	33.35	0.7590	2.276	51.865	13	6	sandy silt to clayey silt
33.957	36.42	0.5761	1.582	33.473	14	6	sandy silt to clayey silt
34.121	29.19	0.5016	1.719	33.997	11	6	sandy silt to clayey silt
34.285	21.09	0.5238	2.484	48.646	10	5	clayey silt to silty clay
34.449	18.15	0.5479	3.019	74.125	9	5	clayey silt to silty clay
34.613	18.65	0.7379	3.957	101.092	12	4	silty clay to clay
34.777	23.17	0.7040	3.039	81.851	11	5	clayey silt to silty clay
34.941	21.15	0.5368	2.538	78.283	10	5	clayey silt to silty clay
35.105	21.82	0.7653	3.508	101.099	10	5	clayey silt to silty clay
35.269	45.81	2.7325	5.964	122.049	44	3	clay
35.433	62.30	2.8056	4.503	45.121	40	4	silty clay to clay
35.597	48.74	2.8613	5.871	49.923	47	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
35.761	58.59	3.8589	6.587	81.141	56	3	clay
35.925	72.63	4.9899	6.870	120.884	70	11	very stiff fine grained (*)
36.089	95.58	5.2058	5.447	82.373	92	11	very stiff fine grained (*)
36.253	85.54	4.9841	5.827	13.444	82	11	very stiff fine grained (*)
36.417	55.25	4.0215	7.279	13.857	53	3	clay
36.581	38.99	3.0106	7.721	6.605	37	3	clay
36.745	34.29	2.6842	7.827	13.922	33	3	clay
36.909	36.73	2.7230	7.414	23.820	35	3	clay
37.073	37.87	2.6567	7.016	20.271	36	3	clay
37.238	43.70	2.5384	5.809	16.933	42	3	clay
37.402	44.17	1.8854	4.269	10.373	28	4	silty clay to clay
37.566	36.60	1.3807	3.773	3.606	18	5	clayey silt to silty clay
37.730	22.88	1.4960	6.538	3.520	22	3	clay
37.894	24.42	1.3051	5.345	7.934	23	3	clay
38.058	30.32	1.6329	5.386	7.690	29	3	clay
38.222	26.42	1.7072	6.462	8.126	25	3	clay
38.386	34.30	1.2763	3.721	10.778	16	5	clayey silt to silty clay
38.550	38.54	2.0732	5.380	8.401	37	3	clay
38.714	32.31	2.4841	7.688	9.104	31	3	clay
38.878	33.31	2.7265	8.186	49.476	32	3	clay
39.042	26.91	2.6189	9.730	50.222	26	3	clay
39.206	26.62	2.4155	9.075	61.843	25	3	clay
39.370	30.93	2.1531	6.962	40.669	30	3	clay
39.534	31.20	1.8998	6.090	14.931	30	3	clay
39.698	27.45	2.4345	8.868	24.673	26	3	clay
39.862	48.80	3.3579	6.881	55.330	47	3	clay
40.026	80.44	4.3719	5.435	21.247	77	11	very stiff fine grained (*)
40.190	75.90	4.4551	5.869	6.631	73	11	very stiff fine grained (*)
40.354	59.10	4.0782	6.900	1.798	57	11	very stiff fine grained (*)
40.518	41.00	3.2871	8.017	1.377	39	3	clay
40.682	28.06	2.6330	9.384	3.367	27	3	clay
40.846	25.09	2.3162	9.232	5.548	24	3	clay
41.011	30.36	2.2098	7.280	11.913	29	3	clay
41.175	40.06	2.3855	5.955	12.894	38	3	clay
41.339	38.01	2.6767	7.041	10.321	36	3	clay
41.503	42.97	2.6888	6.257	13.195	41	3	clay
41.667	52.29	2.5223	4.824	9.701	33	4	silty clay to clay
41.831	53.15	2.5773	4.849	2.114	34	4	silty clay to clay
41.995	72.72	2.7055	3.720	1.648	35	5	clayey silt to silty clay
42.159	91.75	2.7515	2.999	-0.177	35	6	sandy silt to clayey silt
42.323	91.38	2.4742	2.707	-2.626	35	6	sandy silt to clayey silt
42.487	94.84	2.3836	2.513	-3.312	36	6	sandy silt to clayey silt
42.651	99.03	2.2958	2.318	-3.333	32	7	silty sand to sandy silt
42.815	73.42	2.1698	2.955	-3.723	28	6	sandy silt to clayey silt
42.979	55.65	2.0557	3.694	-3.384	27	5	clayey silt to silty clay
43.143	40.36	2.1865	5.417	-2.568	39	3	clay
43.307	28.64	2.0873	7.288	-1.483	27	3	clay
43.471	25.01	2.2975	9.187	-0.005	24	3	clay
43.635	22.06	2.0858	9.457	3.453	21	3	clay
43.799	40.31	1.9657	4.876	5.969	39	3	clay
43.963	57.10	1.8990	3.326	2.449	27	5	clayey silt to silty clay
44.127	65.45	1.9947	3.048	2.750	25	6	sandy silt to clayey silt
44.291	70.29	1.8772	2.671	3.869	27	6	sandy silt to clayey silt
44.455	60.23	1.8475	3.068	4.579	23	6	sandy silt to clayey silt
44.619	45.70	1.8185	3.980	14.214	22	5	clayey silt to silty clay
44.783	42.60	1.8940	4.446	15.099	27	4	silty clay to clay
44.948	39.65	1.9823	4.999	15.802	38	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.112	39.05	2.1453	5.494	17.614	37	3	clay
45.276	34.35	2.6057	7.586	19.965	33	3	clay
45.440	46.96	2.8203	6.006	28.351	45	3	clay
45.604	56.65	2.7913	4.927	20.972	36	4	silty clay to clay
45.768	55.60	2.5666	4.617	9.053	35	4	silty clay to clay
45.932	40.80	2.5603	6.275	3.850	39	3	clay
46.096	32.89	2.3766	7.225	4.838	31	3	clay
46.260	45.44	2.4647	5.424	9.271	44	3	clay
46.424	55.69	2.7405	4.921	5.354	36	4	silty clay to clay
46.588	53.96	2.6331	4.880	6.095	34	4	silty clay to clay
46.752	44.03	2.5660	5.827	2.346	42	3	clay
46.916	44.98	2.7561	6.127	-1.067	43	3	clay
47.080	57.08	2.7507	4.819	-3.278	36	4	silty clay to clay
47.244	48.42	3.1728	6.553	-3.577	46	3	clay
47.408	48.03	3.2778	6.825	-3.056	46	3	clay
47.572	52.98	3.4528	6.518	-0.079	51	3	clay
47.736	38.75	3.2582	8.409	-1.942	37	3	clay
47.900	44.33	2.8786	6.493	-2.107	42	3	clay
48.064	55.99	2.3535	4.203	-2.716	27	5	clayey silt to silty clay
48.228	67.81	1.9070	2.812	-3.393	26	6	sandy silt to clayey silt
48.392	82.06	1.8664	2.274	-3.730	26	7	silty sand to sandy silt
48.556	79.91	1.7670	2.211	-3.618	26	7	silty sand to sandy silt
48.720	68.58	1.9608	2.859	-3.085	26	6	sandy silt to clayey silt
48.885	72.10	2.4415	3.386	7.119	28	6	sandy silt to clayey silt
49.049	82.90	3.1338	3.780	9.453	40	5	clayey silt to silty clay
49.213	80.94	3.6996	4.571	12.786	78	11	very stiff fine grained (*)
49.377	71.67	3.6801	5.135	10.861	69	11	very stiff fine grained (*)
49.541	57.88	3.5662	6.161	4.598	55	3	clay
49.705	63.86	2.5675	4.020	1.994	31	5	clayey silt to silty clay
49.869	74.44	2.0771	2.790	-1.554	29	6	sandy silt to clayey silt
50.033	85.22	2.0518	2.408	-2.095	33	6	sandy silt to clayey silt
50.197	97.93	2.3226	2.372	-1.779	31	7	silty sand to sandy silt
50.361	110.24	2.6687	2.421	-0.399	35	7	silty sand to sandy silt
50.525	116.13	2.9107	2.506	1.184	37	7	silty sand to sandy silt
50.689	115.12	3.0060	2.611	2.803	37	7	silty sand to sandy silt
50.853	113.37	2.9347	2.589	4.173	36	7	silty sand to sandy silt
51.017	111.25	2.9264	2.631	5.476	36	7	silty sand to sandy silt
51.181	105.43	2.9242	2.774	7.248	40	6	sandy silt to clayey silt
51.345	99.55	2.6857	2.698	8.912	38	6	sandy silt to clayey silt
51.509	99.37	2.5954	2.612	9.623	38	6	sandy silt to clayey silt
51.673	91.66	2.5980	2.834	7.281	35	6	sandy silt to clayey silt
51.837	94.84	2.8098	2.963	9.701	36	6	sandy silt to clayey silt
52.001	118.82	3.2307	2.719	3.981	46	6	sandy silt to clayey silt
52.165	122.78	4.9532	4.034	-0.729	118	11	very stiff fine grained (*)
52.329	264.21	5.2582	1.990	-1.844	63	8	sand to silty sand
52.493	404.13	5.3514	1.324	-2.401	77	9	sand
52.657	491.31	5.5414	1.128	5.921	94	9	sand

NV5 / CPT-8 / 5501 NW Front Ave Portland

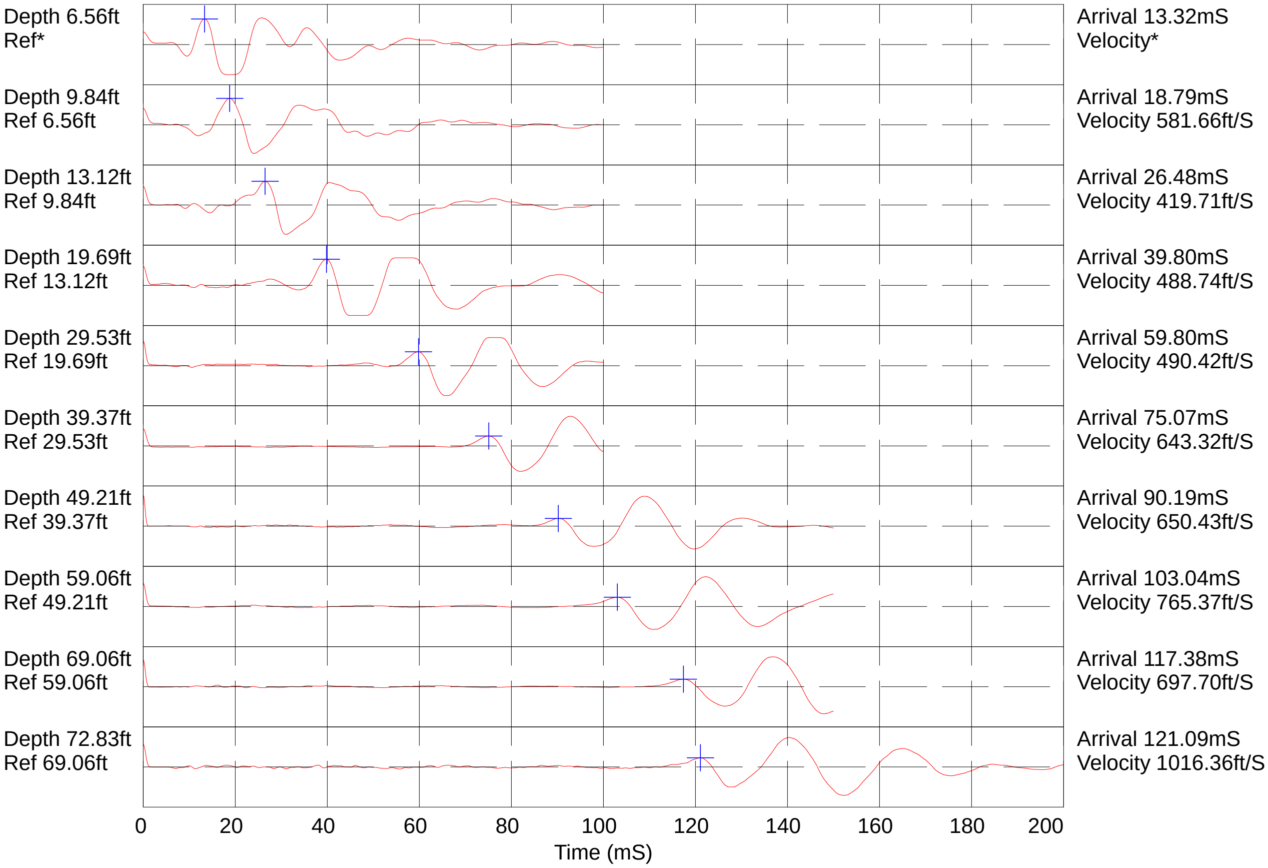
OPERATOR: OGE BAK
CONE ID: DDG1296
TEST DATE: 2/8/2024 1:33:51 PM
TOTAL DEPTH: 72.835 ft



■ 1 sensitive fine grained
■ 2 organic material
■ 3 clay
■ 4 silty clay to clay
■ 5 clayey silt to silty clay
■ 6 sandy silt to clayey silt
■ 7 silty sand to sandy silt
■ 8 sand to silty sand
■ 9 sand
■ 10 gravelly sand to sand
■ 11 very stiff fine grained (*)
■ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

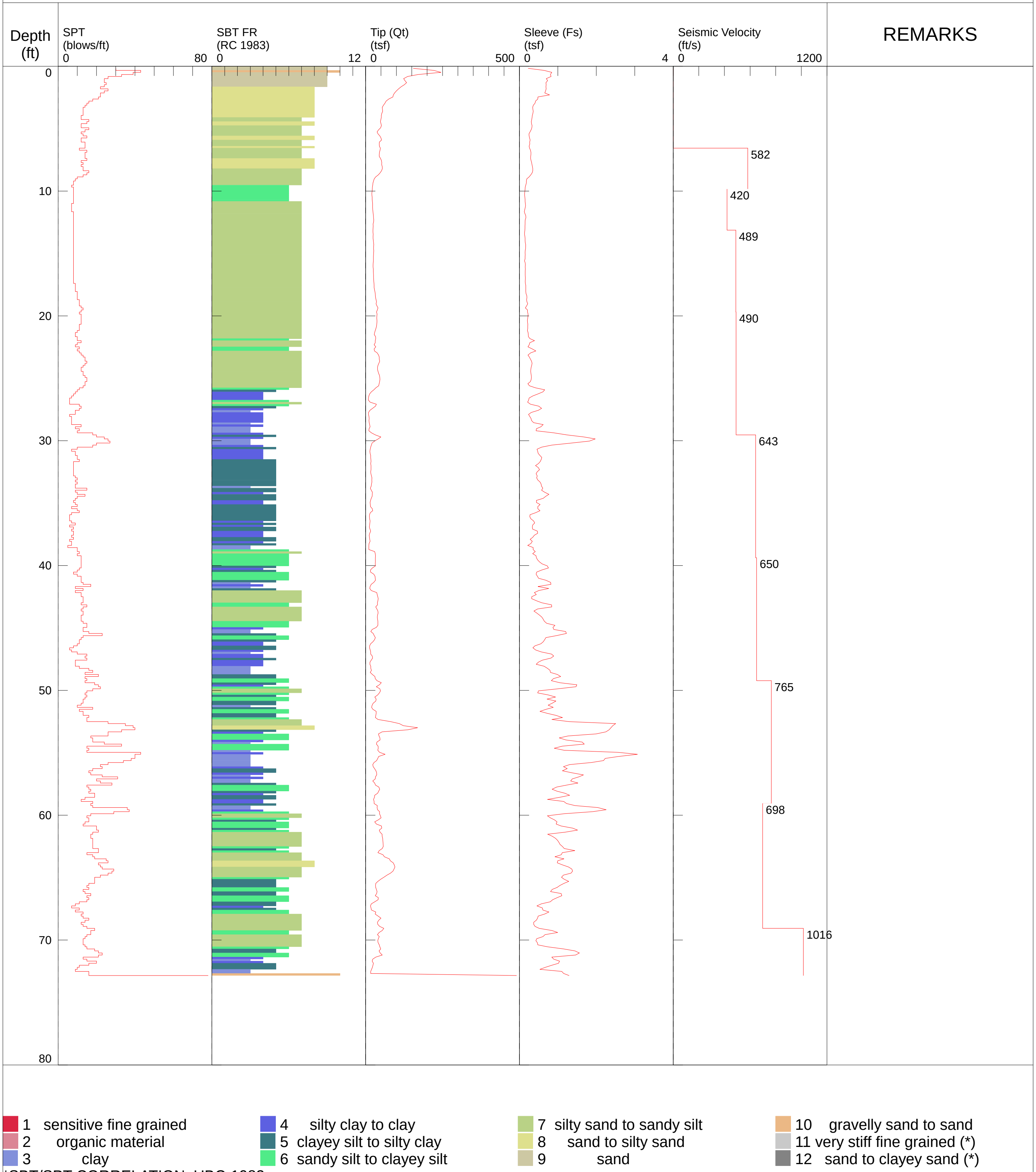
COMMENT: NV5 / CPT-8 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 2.03
* = Not Determined

NV5 / CPT-8 / 5501 NW Front Ave Portland

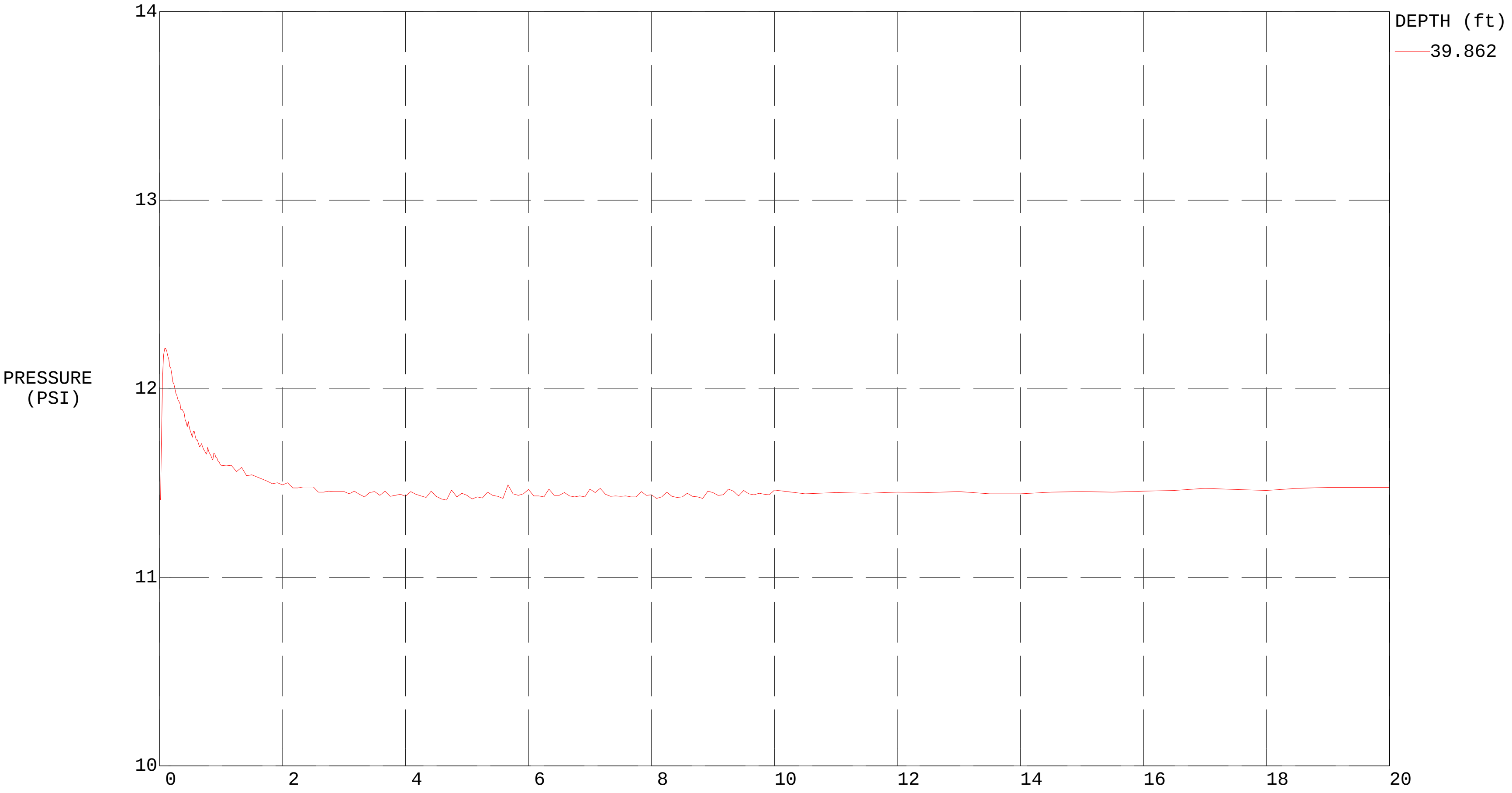
OPERATOR: OGE BAK
CONE ID: DDG1296
TEST DATE: 2/8/2024 1:33:51 PM
TOTAL DEPTH: 72.835 ft



*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-8 / 5501 NW Front Ave Portland

CONE ID: DDG1296
TEST DATE: 2/8/2024 1:33:51 PM



MAXIMUM PRESSURE = 12.214 (PSI)
HYDROSTATIC PRESSURE = 11.492 (PSI), WATER TABLE: 13.35 ft

NV5 / CPT-8 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1296
TEST DATE: 2/8/2024 1:33:51 PM
TOTAL DEPTH: 72.835 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.164	154.76	0.2287	0.148	-0.458	30	9	sand
0.328	221.92	0.6414	0.289	-0.852	43	9	sand
0.492	244.32	0.8408	0.344	-0.548	39	10	gravelly sand to sand
0.656	170.51	0.8045	0.472	1.400	33	9	sand
0.820	136.62	0.8244	0.603	1.210	26	9	sand
0.984	123.40	0.6966	0.565	0.746	24	9	sand
1.148	127.38	0.7346	0.577	0.724	24	9	sand
1.312	132.92	0.6896	0.519	0.419	25	9	sand
1.476	125.49	0.6955	0.554	0.388	24	9	sand
1.640	115.32	0.6910	0.599	0.201	22	9	sand
1.804	107.07	0.6946	0.649	-0.115	26	8	sand to silty sand
1.969	99.92	0.6811	0.682	-0.081	24	8	sand to silty sand
2.133	93.97	0.6607	0.703	-0.092	22	8	sand to silty sand
2.297	89.87	0.7811	0.869	-0.201	22	8	sand to silty sand
2.461	88.29	0.4813	0.545	-0.338	21	8	sand to silty sand
2.625	75.12	0.4795	0.638	0.788	18	8	sand to silty sand
2.789	66.43	0.4203	0.633	0.277	16	8	sand to silty sand
2.953	62.68	0.4065	0.648	0.207	15	8	sand to silty sand
3.117	58.01	0.3628	0.625	0.106	14	8	sand to silty sand
3.281	53.88	0.3457	0.642	0.006	13	8	sand to silty sand
3.445	54.45	0.3488	0.641	-0.218	13	8	sand to silty sand
3.609	55.14	0.3577	0.649	-0.196	13	8	sand to silty sand
3.773	52.49	0.3497	0.666	-0.221	13	8	sand to silty sand
3.937	51.02	0.3361	0.659	-0.240	12	8	sand to silty sand
4.101	50.80	0.3294	0.648	-0.221	12	8	sand to silty sand
4.265	49.32	0.3198	0.648	-0.246	16	7	silty sand to sandy silt
4.429	47.62	0.3069	0.644	-0.263	15	7	silty sand to sandy silt
4.593	49.79	0.3118	0.626	-0.212	12	8	sand to silty sand
4.757	51.12	0.3305	0.647	-0.260	12	8	sand to silty sand
4.921	48.62	0.3224	0.663	-0.254	16	7	silty sand to sandy silt
5.085	42.62	0.3040	0.713	-0.187	14	7	silty sand to sandy silt
5.249	37.32	0.2755	0.738	-0.240	12	7	silty sand to sandy silt
5.413	39.91	0.2487	0.623	-0.215	13	7	silty sand to sandy silt
5.577	46.04	0.2516	0.546	-0.170	15	7	silty sand to sandy silt
5.741	49.98	0.2627	0.526	-0.064	12	8	sand to silty sand
5.906	51.37	0.2776	0.540	-0.106	12	8	sand to silty sand
6.070	44.78	0.2645	0.591	-0.078	14	7	silty sand to sandy silt
6.234	44.48	0.2680	0.602	-0.011	14	7	silty sand to sandy silt
6.398	44.71	0.2516	0.563	0.008	14	7	silty sand to sandy silt
6.562	47.65	0.2624	0.551	0.047	11	8	sand to silty sand
6.726	46.90	0.2880	0.614	0.092	15	7	silty sand to sandy silt
6.890	44.96	0.2999	0.667	0.115	14	7	silty sand to sandy silt
7.054	44.09	0.3005	0.682	0.117	14	7	silty sand to sandy silt
7.218	44.27	0.2919	0.659	0.145	14	7	silty sand to sandy silt
7.382	48.27	0.2897	0.600	0.156	15	7	silty sand to sandy silt
7.546	51.22	0.3020	0.590	0.198	12	8	sand to silty sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
7.710	52.41	0.3170	0.605	0.237	13	8	sand to silty sand
7.874	52.20	0.3259	0.624	0.243	12	8	sand to silty sand
8.038	53.97	0.3374	0.625	0.249	13	8	sand to silty sand
8.202	54.33	0.3469	0.639	0.279	13	8	sand to silty sand
8.366	51.40	0.3478	0.677	0.254	16	7	silty sand to sandy silt
8.530	47.13	0.3329	0.706	0.221	15	7	silty sand to sandy silt
8.694	41.29	0.2964	0.718	0.221	13	7	silty sand to sandy silt
8.858	32.52	0.2511	0.772	0.201	10	7	silty sand to sandy silt
9.022	27.79	0.1902	0.685	0.176	9	7	silty sand to sandy silt
9.186	25.62	0.1781	0.695	0.193	8	7	silty sand to sandy silt
9.350	23.70	0.1785	0.753	0.615	8	7	silty sand to sandy silt
9.514	22.94	0.1647	0.718	0.584	7	7	silty sand to sandy silt
9.678	21.95	0.1491	0.679	0.545	8	6	sandy silt to clayey silt
9.843	21.47	0.1452	0.676	0.506	8	6	sandy silt to clayey silt
10.007	21.00	0.1413	0.673	0.609	8	6	sandy silt to clayey silt
10.171	20.25	0.1340	0.661	0.598	8	6	sandy silt to clayey silt
10.335	20.57	0.1332	0.648	0.606	8	6	sandy silt to clayey silt
10.499	20.96	0.1411	0.673	0.645	8	6	sandy silt to clayey silt
10.663	21.21	0.1457	0.687	0.701	8	6	sandy silt to clayey silt
10.827	21.76	0.1467	0.674	0.740	8	6	sandy silt to clayey silt
10.991	22.79	0.1535	0.674	0.785	7	7	silty sand to sandy silt
11.155	22.54	0.1581	0.702	0.833	7	7	silty sand to sandy silt
11.319	22.57	0.1526	0.676	0.880	7	7	silty sand to sandy silt
11.483	23.09	0.1379	0.597	0.886	7	7	silty sand to sandy silt
11.647	23.86	0.1274	0.534	0.872	8	7	silty sand to sandy silt
11.811	24.49	0.1440	0.588	0.883	8	7	silty sand to sandy silt
11.975	25.12	0.1665	0.663	0.989	8	7	silty sand to sandy silt
12.139	25.73	0.1697	0.660	1.042	8	7	silty sand to sandy silt
12.303	26.34	0.1480	0.562	1.115	8	7	silty sand to sandy silt
12.467	26.18	0.1472	0.562	1.190	8	7	silty sand to sandy silt
12.631	24.25	0.1471	0.607	1.506	8	7	silty sand to sandy silt
12.795	24.43	0.1444	0.591	1.484	8	7	silty sand to sandy silt
12.959	24.31	0.1443	0.594	1.500	8	7	silty sand to sandy silt
13.123	24.01	0.1422	0.592	1.528	8	7	silty sand to sandy silt
13.287	23.88	0.1355	0.567	1.598	8	7	silty sand to sandy silt
13.451	24.39	0.1324	0.543	1.626	8	7	silty sand to sandy silt
13.615	24.08	0.1403	0.583	1.657	8	7	silty sand to sandy silt
13.780	24.23	0.1463	0.604	1.696	8	7	silty sand to sandy silt
13.944	24.75	0.1473	0.595	1.735	8	7	silty sand to sandy silt
14.108	25.46	0.1505	0.591	1.788	8	7	silty sand to sandy silt
14.272	26.30	0.1610	0.612	1.844	8	7	silty sand to sandy silt
14.436	26.11	0.1621	0.621	1.911	8	7	silty sand to sandy silt
14.600	25.88	0.1579	0.610	1.919	8	7	silty sand to sandy silt
14.764	26.50	0.1479	0.558	1.989	8	7	silty sand to sandy silt
14.928	26.05	0.1467	0.563	2.026	8	7	silty sand to sandy silt
15.092	25.47	0.1483	0.582	2.070	8	7	silty sand to sandy silt
15.256	25.05	0.1463	0.584	2.154	8	7	silty sand to sandy silt
15.420	25.21	0.1465	0.581	2.213	8	7	silty sand to sandy silt
15.584	25.04	0.1324	0.529	2.271	8	7	silty sand to sandy silt
15.748	24.57	0.1488	0.606	2.327	8	7	silty sand to sandy silt
15.912	24.31	0.1550	0.638	2.780	8	7	silty sand to sandy silt
16.076	24.33	0.1511	0.621	2.755	8	7	silty sand to sandy silt
16.240	24.70	0.1546	0.626	2.769	8	7	silty sand to sandy silt
16.404	24.90	0.1492	0.599	2.819	8	7	silty sand to sandy silt
16.568	25.00	0.1500	0.600	2.883	8	7	silty sand to sandy silt
16.732	25.46	0.1518	0.596	2.936	8	7	silty sand to sandy silt
16.896	25.89	0.1543	0.596	2.967	8	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.060	26.06	0.1527	0.586	3.006	8	7	silty sand to sandy silt
17.224	26.29	0.1502	0.571	3.070	8	7	silty sand to sandy silt
17.388	26.94	0.1532	0.569	3.126	9	7	silty sand to sandy silt
17.552	27.45	0.1629	0.594	3.168	9	7	silty sand to sandy silt
17.717	27.43	0.1648	0.601	3.221	9	7	silty sand to sandy silt
17.881	28.51	0.1646	0.577	3.280	9	7	silty sand to sandy silt
18.045	30.24	0.1667	0.551	3.341	10	7	silty sand to sandy silt
18.209	31.11	0.1711	0.550	3.367	10	7	silty sand to sandy silt
18.373	31.76	0.1907	0.600	3.409	10	7	silty sand to sandy silt
18.537	32.26	0.1931	0.599	3.481	10	7	silty sand to sandy silt
18.701	33.80	0.1858	0.550	3.523	11	7	silty sand to sandy silt
18.865	35.36	0.1962	0.555	3.596	11	7	silty sand to sandy silt
19.029	33.77	0.2152	0.637	3.545	11	7	silty sand to sandy silt
19.193	36.84	0.1864	0.506	3.819	12	7	silty sand to sandy silt
19.357	39.88	0.1531	0.384	3.434	13	7	silty sand to sandy silt
19.521	37.77	0.2093	0.554	2.663	12	7	silty sand to sandy silt
19.685	35.47	0.2115	0.596	2.805	11	7	silty sand to sandy silt
19.849	37.26	0.2233	0.599	3.816	12	7	silty sand to sandy silt
20.013	36.16	0.2208	0.611	3.783	12	7	silty sand to sandy silt
20.177	36.08	0.2157	0.598	3.853	12	7	silty sand to sandy silt
20.341	36.68	0.2048	0.558	3.945	12	7	silty sand to sandy silt
20.505	37.02	0.2102	0.568	3.942	12	7	silty sand to sandy silt
20.669	35.88	0.2188	0.610	4.054	11	7	silty sand to sandy silt
20.833	35.29	0.2170	0.615	4.138	11	7	silty sand to sandy silt
20.997	33.44	0.2150	0.643	4.194	11	7	silty sand to sandy silt
21.161	31.06	0.2055	0.661	4.266	10	7	silty sand to sandy silt
21.325	29.56	0.2249	0.761	4.333	9	7	silty sand to sandy silt
21.490	27.79	0.2318	0.834	4.428	9	7	silty sand to sandy silt
21.654	32.32	0.2338	0.723	4.579	10	7	silty sand to sandy silt
21.818	32.58	0.2724	0.836	3.825	10	7	silty sand to sandy silt
21.982	31.27	0.3920	1.253	3.816	12	6	sandy silt to clayey silt
22.146	30.97	0.2668	0.861	3.043	10	7	silty sand to sandy silt
22.310	27.56	0.2567	0.932	1.492	9	7	silty sand to sandy silt
22.474	33.13	0.2217	0.669	-0.866	11	7	silty sand to sandy silt
22.638	27.30	0.3322	1.217	-1.453	10	6	sandy silt to clayey silt
22.802	28.39	0.4271	1.504	-1.489	11	6	sandy silt to clayey silt
22.966	37.66	0.2908	0.772	-1.484	12	7	silty sand to sandy silt
23.130	41.80	0.2200	0.526	-1.911	13	7	silty sand to sandy silt
23.294	44.35	0.2585	0.583	-2.118	14	7	silty sand to sandy silt
23.458	44.06	0.2882	0.654	-1.749	14	7	silty sand to sandy silt
23.622	45.73	0.3122	0.683	-0.749	15	7	silty sand to sandy silt
23.786	43.12	0.3310	0.768	0.332	14	7	silty sand to sandy silt
23.950	40.16	0.3204	0.798	1.140	13	7	silty sand to sandy silt
24.114	38.59	0.3056	0.792	1.875	12	7	silty sand to sandy silt
24.278	38.81	0.2965	0.764	2.601	12	7	silty sand to sandy silt
24.442	40.14	0.2929	0.730	3.199	13	7	silty sand to sandy silt
24.606	42.26	0.2972	0.703	3.733	13	7	silty sand to sandy silt
24.770	44.84	0.3069	0.684	4.210	14	7	silty sand to sandy silt
24.934	46.34	0.3107	0.670	4.688	15	7	silty sand to sandy silt
25.098	46.43	0.3041	0.655	4.979	15	7	silty sand to sandy silt
25.262	45.32	0.2830	0.624	5.225	14	7	silty sand to sandy silt
25.427	43.77	0.2181	0.498	5.479	14	7	silty sand to sandy silt
25.591	42.22	0.2593	0.614	5.705	13	7	silty sand to sandy silt
25.755	33.14	0.4178	1.261	6.068	11	7	silty sand to sandy silt
25.919	26.67	0.6571	2.464	6.121	10	6	sandy silt to clayey silt
26.083	18.46	0.6128	3.320	6.859	9	5	clayey silt to silty clay
26.247	13.18	0.4828	3.663	16.881	8	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
26.411	10.21	0.3464	3.393	31.747	7	4	silty clay to clay
26.575	9.41	0.2512	2.671	37.013	6	4	silty clay to clay
26.739	8.67	0.2384	2.748	39.514	6	4	silty clay to clay
26.903	14.61	0.2124	1.453	47.540	6	6	sandy silt to clayey silt
27.067	34.92	0.2876	0.824	9.885	11	7	silty sand to sandy silt
27.231	31.92	0.5023	1.574	6.834	12	6	sandy silt to clayey silt
27.395	22.57	0.5753	2.549	7.094	11	5	clayey silt to silty clay
27.559	13.97	0.4930	3.529	9.167	9	4	silty clay to clay
27.723	9.20	0.3069	3.334	20.870	9	3	clay
27.887	9.41	0.2360	2.509	30.948	6	4	silty clay to clay
28.051	10.54	0.2697	2.559	40.170	7	4	silty clay to clay
28.215	11.45	0.3023	2.640	50.999	7	4	silty clay to clay
28.379	10.81	0.3138	2.903	47.334	7	4	silty clay to clay
28.543	11.39	0.3678	3.230	55.084	7	4	silty clay to clay
28.707	13.05	0.6168	4.728	60.364	12	3	clay
28.871	14.61	0.5595	3.829	65.077	9	4	silty clay to clay
29.035	11.20	0.4424	3.949	47.680	11	3	clay
29.199	10.30	0.4330	4.202	46.644	10	3	clay
29.364	19.05	0.8951	4.700	53.804	18	3	clay
29.528	31.66	1.2337	3.897	37.399	20	4	silty clay to clay
29.692	49.19	1.6775	3.410	5.454	24	5	clayey silt to silty clay
29.856	40.94	1.9719	4.816	-0.285	26	4	silty clay to clay
30.020	28.71	1.8222	6.348	-0.316	27	3	clay
30.184	20.87	1.3552	6.493	0.626	20	3	clay
30.348	18.72	0.8442	4.509	5.280	18	3	clay
30.512	15.99	0.5749	3.596	9.815	10	4	silty clay to clay
30.676	15.02	0.4556	3.034	18.051	7	5	clayey silt to silty clay
30.840	13.53	0.4751	3.511	26.651	9	4	silty clay to clay
31.004	14.67	0.4868	3.320	33.451	9	4	silty clay to clay
31.168	16.38	0.5313	3.244	40.626	10	4	silty clay to clay
31.332	16.08	0.5818	3.619	43.104	10	4	silty clay to clay
31.496	16.97	0.5654	3.331	41.964	11	4	silty clay to clay
31.660	17.43	0.5408	3.102	41.131	8	5	clayey silt to silty clay
31.824	16.46	0.4966	3.016	52.287	8	5	clayey silt to silty clay
31.988	17.26	0.4203	2.435	61.130	8	5	clayey silt to silty clay
32.152	17.28	0.4912	2.843	60.054	8	5	clayey silt to silty clay
32.316	17.39	0.5220	3.002	65.077	8	5	clayey silt to silty clay
32.480	16.28	0.4628	2.843	62.599	8	5	clayey silt to silty clay
32.644	17.00	0.4323	2.542	69.796	8	5	clayey silt to silty clay
32.808	19.02	0.4604	2.421	83.383	9	5	clayey silt to silty clay
32.972	20.59	0.4480	2.176	88.722	10	5	clayey silt to silty clay
33.136	19.83	0.4770	2.406	101.364	9	5	clayey silt to silty clay
33.301	20.37	0.5343	2.623	104.586	10	5	clayey silt to silty clay
33.465	19.04	0.5627	2.954	96.193	9	5	clayey silt to silty clay
33.629	18.28	0.5743	3.141	83.316	9	5	clayey silt to silty clay
33.793	15.22	0.6081	3.996	61.085	15	3	clay
33.957	18.43	0.5750	3.119	56.442	9	5	clayey silt to silty clay
34.121	21.70	0.6531	3.010	21.214	10	5	clayey silt to silty clay
34.285	21.46	0.7662	3.570	24.960	14	4	silty clay to clay
34.449	21.07	0.6879	3.265	57.920	10	5	clayey silt to silty clay
34.613	18.22	0.6183	3.395	76.272	9	5	clayey silt to silty clay
34.777	15.81	0.4422	2.796	83.729	8	5	clayey silt to silty clay
34.941	14.36	0.4413	3.074	78.943	9	4	silty clay to clay
35.105	15.25	0.5393	3.537	76.946	10	4	silty clay to clay
35.269	15.54	0.4768	3.067	57.196	7	5	clayey silt to silty clay
35.433	21.55	0.4758	2.207	39.360	10	5	clayey silt to silty clay
35.597	23.05	0.5338	2.316	9.834	11	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
35.761	15.19	0.4244	2.793	20.191	7	5	clayey silt to silty clay
35.925	12.67	0.2749	2.170	55.388	6	5	clayey silt to silty clay
36.089	12.22	0.2681	2.193	69.129	6	5	clayey silt to silty clay
36.253	12.94	0.2985	2.307	74.660	6	5	clayey silt to silty clay
36.417	14.18	0.3676	2.593	73.786	7	5	clayey silt to silty clay
36.581	13.57	0.3974	2.930	71.154	9	4	silty clay to clay
36.745	13.09	0.3441	2.629	69.394	6	5	clayey silt to silty clay
36.909	11.84	0.3342	2.823	64.742	8	4	silty clay to clay
37.073	14.02	0.3421	2.440	60.739	7	5	clayey silt to silty clay
37.238	16.23	0.4670	2.878	44.090	8	5	clayey silt to silty clay
37.402	13.25	0.4742	3.580	53.662	8	4	silty clay to clay
37.566	11.63	0.3899	3.352	70.288	7	4	silty clay to clay
37.730	11.97	0.3485	2.913	71.598	8	4	silty clay to clay
37.894	13.20	0.2785	2.109	67.519	6	5	clayey silt to silty clay
38.058	14.63	0.3342	2.284	49.661	7	5	clayey silt to silty clay
38.222	11.01	0.2997	2.722	58.741	7	4	silty clay to clay
38.386	10.39	0.2170	2.090	75.831	5	5	clayey silt to silty clay
38.550	10.09	0.3583	3.550	72.738	10	3	clay
38.714	10.23	0.3543	3.464	70.824	10	3	clay
38.878	29.08	0.4124	1.418	9.823	11	6	sandy silt to clayey silt
39.042	31.16	0.3418	1.097	6.792	10	7	silty sand to sandy silt
39.206	32.03	0.4283	1.337	6.521	12	6	sandy silt to clayey silt
39.370	31.75	0.4426	1.394	7.932	12	6	sandy silt to clayey silt
39.534	31.73	0.4708	1.484	10.714	12	6	sandy silt to clayey silt
39.698	31.61	0.5209	1.648	10.916	12	6	sandy silt to clayey silt
39.862	31.23	0.5891	1.887	11.421	12	6	sandy silt to clayey silt
40.026	31.87	0.7254	2.276	10.664	12	6	sandy silt to clayey silt
40.190	22.00	0.7554	3.433	10.689	11	5	clayey silt to silty clay
40.354	15.65	0.5781	3.695	20.376	10	4	silty clay to clay
40.518	15.93	0.4480	2.812	49.728	8	5	clayey silt to silty clay
40.682	26.40	0.4308	1.631	27.257	10	6	sandy silt to clayey silt
40.846	30.40	0.4666	1.535	10.645	12	6	sandy silt to clayey silt
41.011	31.18	0.4991	1.601	9.555	12	6	sandy silt to clayey silt
41.175	31.83	0.6879	2.161	10.335	12	6	sandy silt to clayey silt
41.339	26.37	0.8106	3.074	11.153	13	5	clayey silt to silty clay
41.503	18.04	0.8182	4.536	17.263	17	3	clay
41.667	14.34	0.4842	3.376	29.660	9	4	silty clay to clay
41.831	13.19	0.7649	5.798	50.642	13	3	clay
41.995	18.09	0.5039	2.785	56.958	9	5	clayey silt to silty clay
42.159	36.04	0.3863	1.072	1.498	12	7	silty sand to sandy silt
42.323	37.48	0.4394	1.172	1.769	12	7	silty sand to sandy silt
42.487	39.33	0.3198	0.813	2.333	13	7	silty sand to sandy silt
42.651	40.90	0.3180	0.778	1.604	13	7	silty sand to sandy silt
42.815	39.73	0.4499	1.132	1.282	13	7	silty sand to sandy silt
42.979	38.12	0.5811	1.525	2.439	12	7	silty sand to sandy silt
43.143	38.53	0.8341	2.165	4.121	15	6	sandy silt to clayey silt
43.307	32.65	0.8402	2.573	5.903	13	6	sandy silt to clayey silt
43.471	36.25	0.4705	1.298	5.166	12	7	silty sand to sandy silt
43.635	39.64	0.3768	0.950	2.400	13	7	silty sand to sandy silt
43.799	40.39	0.4461	1.105	1.422	13	7	silty sand to sandy silt
43.963	38.50	0.5212	1.354	2.182	12	7	silty sand to sandy silt
44.127	37.80	0.5810	1.537	3.347	12	7	silty sand to sandy silt
44.291	38.71	0.6177	1.596	4.546	12	7	silty sand to sandy silt
44.455	39.85	0.6474	1.625	5.948	13	7	silty sand to sandy silt
44.619	39.68	0.7070	1.782	7.286	15	6	sandy silt to clayey silt
44.783	39.70	0.9237	2.327	8.412	15	6	sandy silt to clayey silt
44.948	34.54	0.8719	2.525	9.742	13	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.112	20.99	0.8932	4.256	16.355	13	4	silty clay to clay
45.276	16.79	1.2005	7.150	62.915	16	3	clay
45.440	24.38	1.2231	5.017	44.386	23	3	clay
45.604	28.01	0.9592	3.424	13.545	13	5	clayey silt to silty clay
45.768	31.55	0.6895	2.185	5.258	12	6	sandy silt to clayey silt
45.932	29.00	0.6564	2.263	2.453	11	6	sandy silt to clayey silt
46.096	23.46	0.6210	2.647	3.531	11	5	clayey silt to silty clay
46.260	16.39	0.5584	3.406	7.549	10	4	silty clay to clay
46.424	12.99	0.4029	3.103	22.644	8	4	silty clay to clay
46.588	12.87	0.3498	2.719	47.440	6	5	clayey silt to silty clay
46.752	14.84	0.4211	2.838	62.820	7	5	clayey silt to silty clay
46.916	16.10	0.5676	3.526	64.491	10	4	silty clay to clay
47.080	16.09	0.8354	5.193	57.808	15	3	clay
47.244	21.27	0.8916	4.193	38.854	14	4	silty clay to clay
47.408	22.74	0.8193	3.602	12.843	15	4	silty clay to clay
47.572	17.90	0.5960	3.330	10.544	9	5	clayey silt to silty clay
47.736	13.86	0.4964	3.581	17.808	9	4	silty clay to clay
47.900	13.70	0.4366	3.186	33.180	9	4	silty clay to clay
48.064	16.83	0.6415	3.812	41.089	11	4	silty clay to clay
48.228	16.64	0.7313	4.394	47.110	16	3	clay
48.392	18.93	0.7966	4.209	45.680	18	3	clay
48.556	14.95	0.8042	5.379	56.757	14	3	clay
48.720	21.86	0.9866	4.513	54.341	21	3	clay
48.885	30.06	1.0747	3.575	20.538	14	5	clayey silt to silty clay
49.049	31.46	0.8866	2.818	5.428	15	5	clayey silt to silty clay
49.213	36.85	0.8298	2.252	4.493	14	6	sandy silt to clayey silt
49.377	50.73	1.0502	2.070	1.511	19	6	sandy silt to clayey silt
49.541	44.58	1.4928	3.349	0.520	21	5	clayey silt to silty clay
49.705	34.53	1.4721	4.263	2.389	22	4	silty clay to clay
49.869	45.80	1.0072	2.199	8.988	18	6	sandy silt to clayey silt
50.033	48.54	0.4953	1.020	1.277	15	7	silty sand to sandy silt
50.197	44.66	0.4737	1.061	-0.224	14	7	silty sand to sandy silt
50.361	38.97	0.7511	1.927	0.374	15	6	sandy silt to clayey silt
50.525	29.68	0.9376	3.159	1.534	14	5	clayey silt to silty clay
50.689	34.00	0.7168	2.108	3.942	13	6	sandy silt to clayey silt
50.853	33.23	0.9482	2.854	3.967	13	6	sandy silt to clayey silt
51.017	24.57	0.8525	3.470	3.425	12	5	clayey silt to silty clay
51.181	21.19	0.7433	3.509	6.904	10	5	clayey silt to silty clay
51.345	19.31	0.8796	4.556	10.932	18	3	clay
51.509	23.35	0.6943	2.974	17.629	11	5	clayey silt to silty clay
51.673	34.22	0.5336	1.559	9.410	13	6	sandy silt to clayey silt
51.837	33.99	0.7317	2.153	7.102	13	6	sandy silt to clayey silt
52.001	32.95	0.9487	2.879	11.966	16	5	clayey silt to silty clay
52.165	31.64	1.1182	3.534	12.843	15	5	clayey silt to silty clay
52.329	40.15	0.8443	2.103	12.737	15	6	sandy silt to clayey silt
52.493	81.28	1.2979	1.597	9.385	26	7	silty sand to sandy silt
52.657	109.08	2.5046	2.296	3.805	35	7	silty sand to sandy silt
52.822	122.22	2.4268	1.986	2.207	39	7	silty sand to sandy silt
52.986	168.83	2.3806	1.410	2.612	40	8	sand to silty sand
53.150	137.03	2.3336	1.703	-1.333	33	8	sand to silty sand
53.314	53.77	2.2493	4.183	-2.635	26	5	clayey silt to silty clay
53.478	41.50	1.9965	4.811	-2.252	26	4	silty clay to clay
53.642	43.31	1.2633	2.917	-1.584	17	6	sandy silt to clayey silt
53.806	46.66	1.0363	2.221	-2.014	18	6	sandy silt to clayey silt
53.970	46.96	1.2107	2.578	-2.084	18	6	sandy silt to clayey silt
54.134	37.05	1.6291	4.397	-1.369	24	4	silty clay to clay
54.298	34.88	1.6882	4.840	-0.520	33	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
54.462	40.26	1.1153	2.770	0.257	15	6	sandy silt to clayey silt
54.626	40.88	0.9054	2.215	-0.198	16	6	sandy silt to clayey silt
54.790	39.29	1.1612	2.955	-0.229	15	6	sandy silt to clayey silt
54.954	45.15	2.5664	5.684	0.293	43	3	clay
55.118	63.38	3.0662	4.838	2.467	40	4	silty clay to clay
55.282	42.16	2.5809	6.122	48.862	40	3	clay
55.446	39.48	2.2317	5.652	75.630	38	3	clay
55.610	35.70	2.1861	6.123	96.570	34	3	clay
55.774	27.02	1.8679	6.912	74.750	26	3	clay
55.938	22.88	1.3053	5.704	76.261	22	3	clay
56.102	24.53	1.1444	4.665	86.411	23	3	clay
56.266	28.86	1.2441	4.310	39.905	18	4	silty clay to clay
56.430	33.58	1.1164	3.325	29.039	16	5	clayey silt to silty clay
56.594	35.61	1.3571	3.811	27.184	17	5	clayey silt to silty clay
56.759	35.88	1.6643	4.639	34.744	23	4	silty clay to clay
56.923	32.10	1.5471	4.820	52.259	31	3	clay
57.087	30.95	1.3735	4.438	84.959	20	4	silty clay to clay
57.251	22.85	1.3337	5.837	55.447	22	3	clay
57.415	29.52	1.5193	5.146	81.053	28	3	clay
57.579	32.06	1.2277	3.830	48.474	15	5	clayey silt to silty clay
57.743	42.80	0.9676	2.261	13.422	16	6	sandy silt to clayey silt
57.907	45.45	0.8494	1.869	6.599	17	6	sandy silt to clayey silt
58.071	42.29	0.9753	2.306	6.809	16	6	sandy silt to clayey silt
58.235	39.07	1.1803	3.021	6.946	19	5	clayey silt to silty clay
58.399	29.35	1.3060	4.449	6.943	19	4	silty clay to clay
58.563	28.45	1.0397	3.655	20.370	14	5	clayey silt to silty clay
58.727	25.51	0.7292	2.858	26.092	12	5	clayey silt to silty clay
58.891	27.62	1.1547	4.181	33.565	18	4	silty clay to clay
59.055	27.21	1.2257	4.504	50.206	17	4	silty clay to clay
59.219	37.89	1.4469	3.818	45.034	18	5	clayey silt to silty clay
59.383	37.14	2.0351	5.479	67.137	36	3	clay
59.547	38.49	2.2544	5.858	95.790	37	3	clay
59.711	45.41	1.9047	4.195	37.533	29	4	silty clay to clay
59.875	45.00	1.1630	2.585	6.292	17	6	sandy silt to clayey silt
60.039	47.88	0.7275	1.519	3.151	15	7	silty sand to sandy silt
60.203	50.37	0.8058	1.600	4.127	16	7	silty sand to sandy silt
60.367	41.02	0.9132	2.226	5.610	16	6	sandy silt to clayey silt
60.532	29.33	0.9785	3.337	6.996	14	5	clayey silt to silty clay
60.696	34.83	0.9539	2.739	13.167	13	6	sandy silt to clayey silt
60.860	51.20	1.0820	2.113	15.827	20	6	sandy silt to clayey silt
61.024	52.43	1.3866	2.645	14.397	20	6	sandy silt to clayey silt
61.188	44.02	1.5104	3.431	17.369	21	5	clayey silt to silty clay
61.352	46.87	1.1933	2.546	23.407	18	6	sandy silt to clayey silt
61.516	53.49	0.7337	1.372	10.376	17	7	silty sand to sandy silt
61.680	53.31	0.8484	1.591	6.948	17	7	silty sand to sandy silt
61.844	55.25	0.9397	1.701	18.766	18	7	silty sand to sandy silt
62.008	55.95	0.9895	1.769	18.758	18	7	silty sand to sandy silt
62.172	56.45	1.0270	1.819	18.456	18	7	silty sand to sandy silt
62.336	56.76	1.0544	1.858	18.599	18	7	silty sand to sandy silt
62.500	57.31	1.1173	1.949	18.322	18	7	silty sand to sandy silt
62.664	53.88	1.1674	2.167	18.395	21	6	sandy silt to clayey silt
62.828	44.08	1.4380	3.262	19.510	21	5	clayey silt to silty clay
62.992	39.75	1.1150	2.805	23.251	15	6	sandy silt to clayey silt
63.156	56.24	1.0903	1.939	21.127	18	7	silty sand to sandy silt
63.320	61.06	0.9250	1.515	12.910	19	7	silty sand to sandy silt
63.484	77.03	1.1552	1.500	12.614	25	7	silty sand to sandy silt
63.648	80.44	0.9952	1.237	13.293	26	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
63.812	89.53	0.9815	1.096	6.817	21	8	sand to silty sand
63.976	92.95	1.1219	1.207	6.535	22	8	sand to silty sand
64.140	95.14	1.2751	1.340	8.390	23	8	sand to silty sand
64.304	92.08	1.3625	1.480	10.376	29	7	silty sand to sandy silt
64.469	88.92	1.3809	1.553	11.983	28	7	silty sand to sandy silt
64.633	80.58	1.3423	1.666	13.084	26	7	silty sand to sandy silt
64.797	69.43	1.1449	1.649	14.844	22	7	silty sand to sandy silt
64.961	59.00	1.0939	1.854	16.825	19	7	silty sand to sandy silt
65.125	49.10	1.1621	2.367	21.353	19	6	sandy silt to clayey silt
65.289	39.56	1.2829	3.243	22.454	19	5	clayey silt to silty clay
65.453	32.78	1.1584	3.534	26.950	16	5	clayey silt to silty clay
65.617	32.06	1.0553	3.292	32.001	15	5	clayey silt to silty clay
65.781	32.68	0.9785	2.994	31.987	16	5	clayey silt to silty clay
65.945	34.72	0.8547	2.462	30.344	13	6	sandy silt to clayey silt
66.109	37.31	0.8098	2.170	30.009	14	6	sandy silt to clayey silt
66.273	35.64	1.0839	3.041	32.157	17	5	clayey silt to silty clay
66.437	31.20	1.1017	3.531	38.293	15	5	clayey silt to silty clay
66.601	41.32	0.9801	2.372	40.310	16	6	sandy silt to clayey silt
66.765	40.45	0.8627	2.133	18.590	15	6	sandy silt to clayey silt
66.929	29.84	0.8011	2.684	22.767	11	6	sandy silt to clayey silt
67.093	18.71	0.5710	3.051	43.255	9	5	clayey silt to silty clay
67.257	15.44	0.4540	2.940	78.734	7	5	clayey silt to silty clay
67.421	17.28	0.5967	3.453	72.297	11	4	silty clay to clay
67.585	18.89	0.6088	3.222	59.685	9	5	clayey silt to silty clay
67.749	33.11	0.7661	2.314	35.566	13	6	sandy silt to clayey silt
67.913	30.74	0.6542	2.128	19.163	12	6	sandy silt to clayey silt
68.077	40.68	0.4860	1.195	18.928	13	7	silty sand to sandy silt
68.241	49.74	0.4727	0.950	10.790	16	7	silty sand to sandy silt
68.406	42.86	0.4381	1.022	16.498	14	7	silty sand to sandy silt
68.570	38.13	0.3700	0.970	16.668	12	7	silty sand to sandy silt
68.734	39.47	0.3688	0.934	17.755	13	7	silty sand to sandy silt
68.898	45.55	0.4066	0.893	20.172	15	7	silty sand to sandy silt
69.062	59.01	0.5134	0.870	21.999	19	7	silty sand to sandy silt
69.226	53.88	0.8462	1.571	23.049	17	7	silty sand to sandy silt
69.390	43.68	0.9960	2.280	23.304	17	6	sandy silt to clayey silt
69.554	38.13	0.6660	1.747	12.746	15	6	sandy silt to clayey silt
69.718	44.12	0.6100	1.382	7.468	14	7	silty sand to sandy silt
69.882	41.23	0.4527	1.098	5.415	13	7	silty sand to sandy silt
70.046	39.54	0.4280	1.083	6.538	13	7	silty sand to sandy silt
70.210	40.65	0.4660	1.146	9.907	13	7	silty sand to sandy silt
70.374	44.02	0.4790	1.088	11.726	14	7	silty sand to sandy silt
70.538	46.17	0.7262	1.573	12.114	15	7	silty sand to sandy silt
70.702	48.94	1.1543	2.359	12.528	19	6	sandy silt to clayey silt
70.866	43.42	1.4468	3.332	16.601	21	5	clayey silt to silty clay
71.030	47.06	1.5587	3.312	26.363	23	5	clayey silt to silty clay
71.194	53.90	1.4627	2.714	15.830	21	6	sandy silt to clayey silt
71.358	32.88	0.8417	2.560	19.102	13	6	sandy silt to clayey silt
71.522	22.87	0.8920	3.901	59.688	15	4	silty clay to clay
71.686	21.12	1.0445	4.946	103.113	20	3	clay
71.850	25.20	1.0162	4.032	84.288	16	4	silty clay to clay
72.014	23.83	0.8435	3.539	78.904	11	5	clayey silt to silty clay
72.178	21.71	0.6774	3.121	91.136	10	5	clayey silt to silty clay
72.343	19.12	0.5317	2.780	84.322	9	5	clayey silt to silty clay
72.507	16.58	1.1001	6.634	98.484	16	3	clay
72.671	16.53	1.1503	6.959	109.827	16	3	clay
72.835	490.54	1.2903	0.263	46.691	78	10	gravelly sand to sand

APPENDIX B

APPENDIX B

PREVIOUS REPORTS

SEISMIC RISK ASSESSMENT

Zenith Portland Terminal
5501 NW Front Avenue
Portland, Oregon

For
Zenith Energy Management LLC
May 29, 2020

GeoDesign Project: Zenith-1-01

GEODESIGN INC
AN NV5 COMPANY

May 29, 2020

Zenith Energy Management LLC
5501 NW Front Avenue
Portland, OR 97210

Attention: Dana Love

Seismic Risk Assessment
Zenith Portland Terminal
5501 NW Front Avenue
Portland, Oregon
GeoDesign Project: Zenith-1-01

We are pleased to submit this report that documents our seismic risk assessment of Tank 105, Tank 130, and the warehouse building located at the Zenith Portland Terminal in Portland, Oregon. Our services were conducted on accordance with our September 9, 2019 proposal.

We appreciate the opportunity to be of continued service to you. Please contact us if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

Brett A. Shipton, P.E., G.E.
Principal Engineer

BAS:kt
Attachments
One copy submitted (via email only)
Document ID: Zenith-1-01-052920-geor-rev.docx

9450 SW Commerce Circle, Suite 300 I Wilsonville, OR 97070 I 503.968.8787   www.geodesigninc.com

EXECUTIVE SUMMARY

This report presents the results of seismic vulnerability study of Tank 105, Tank 130, and the warehouse building at the Zenith bulk fuel terminal located at 5501 NW Front Avenue in Portland, Oregon. The study included a geotechnical investigation and structural assessment of the building and tanks. The study was conducted using the provisions in the 2019 SOSSC and API 650 Annex E. Both of these documents refer to the ASCE 7-16 Standard.

The structural evaluation of the warehouse building was conducted by KPFF Consulting Engineers and a structural evaluation of Tanks 105 and 130 was conducted by PEMY Consulting, LLC. A summary of the findings is presented below.

- Liquefaction-induced settlement is computed to be approximately 6 inches under design levels of ground shaking. A differential settlement of one-half the total predicted settlement is expected over a distance of 50 feet.
- Lateral spreading is not considered a site hazard.
- The existing shallow foundation system of Tanks 105 and 130 are adequate. Deep foundations that consist of piling is not required to meet the requirements of the 2019 SOSSC, API 650 Annex E, and the ASCE 7-16 Standard.
- A cursory study of the warehouse building was conducted. It is expected that the building will not collapse and life safety will be protected under design levels of ground shaking.

TABLE OF CONTENTS **PAGE NO.**

TABLE OF CONTENTS **PAGE NO.**

APPENDICES

ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BGS	below ground surface
CRBG	Columbia River Basalt Group
CSZ	Cascadia subduction zone
g	gravitational acceleration (32.2 feet/second^2)
km	kilometers
MCE	maximum considered earthquake
MCE_R	risk-targeted maximum considered earthquake
mm	millimeter
SOSSC	State of Oregon Structural Specialty Code
SPT	standard penetration test
USGS	U.S. Geological Survey
Vs_{30}	shear wave velocity for the upper 100 feet (30 meters)

1.0 INTRODUCTION

The Zenith Portland Terminal is a 31.3-acre bulk fuel terminal located at 5501 NW Front Avenue in Portland Oregon. The terminal is occupied by numerous storage tanks and buildings. This study focuses on Tank 105, Tank 130, and the warehouse building. Figure 1 shows the site location relative to existing physical features. Figure 2 shows the location of Tank 105, Tank 130, and the warehouse building in the terminal.

Tank 105 is a 48-foot-tall, 144-foot-diameter, floating roof storage tank with a capacity of approximately 124,990 bbls, or 5,249,580 gallons, originally constructed in 1975. Tank 130 is a 40-foot-tall, 130-foot-diameter, fixed-roof storage tank with a capacity of approximately 70,921 bbls, or 2,978,682 gallons, which was originally constructed in 1967. The warehouse building is a single-story, 4,380-square-foot, metal-framed structure. As-built plans were not available at the time of this report.

This report documents GeoDesign's geotechnical seismic analysis for use in assessing the structures. A structural evaluation of the warehouse building was conducted by KPFF Consulting Engineers (KPFF) and a structural evaluation of Tanks 105 and 130 was conducted by PEMY Consulting, LLC (PEMY). Those studies are presented in the appendices of this report.

Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents. All elevations included in this report are relative to City of Portland datum.

2.0 SCOPE OF SERVICES

GeoDesign conducted a seismic geotechnical analysis for use in assessing the structures. Structural evaluations of the warehouse building and the tanks were conducted KPFF and PEMY, respectively. The scope of services completed by GeoDesign is presented as follows:

- Reviewed readily available, published geologic data and our in-house files for existing information on subsurface conditions in the site vicinity and our previous explorations at nearby surrounding sites.
- Explored subsurface conditions by drilling two borings at the locations shown on Figure 2. The borings were drilled to depths of 50 and 80 feet BGS.
- Collected soil samples for laboratory testing and maintained a detailed log of subsurface conditions encountered in each exploration.
- Conducted the following geotechnical laboratory tests:
  - Ten moisture content determinations in general accordance with ASTM D2216
  - Five particle-size analyses in general accordance with ASTM D1140
  - Five Atterberg limits tests in general accordance with ASTM D4318
- Assessed the following seismic hazards:
  - Surface fault rupture
  - Liquefaction and lateral spreading
  - Ground shaking and ground motion amplification

- Provided a site response spectrum for use in computing seismic forces on the tanks and warehouse building in accordance with the 2019 SOSSC and ASCE 7-16.
- Prepared this report that documents our findings. The findings of KPFF and PEMY are presented in the appendices of this report.

3.0 SITE DESCRIPTION

3.1 GEOLOGIC CONDITIONS

The Portland-Vancouver metropolitan area is situated within the Puget-Willamette Trough physiographic province, a north-south structural basin lying between the Coast Ranges to the west and the Cascade Range to the east. The Zenith Portland Terminal is located in the extreme western part of the Portland Basin physiographic province. The Portland Basin, a major component of the Willamette Trough, is a subsided lowland formed through northeast-directed compression due to large-scale plate movement and subduction and right-lateral extension along a series of faults reaching from central Oregon, across the Cascades, and into the lower Willamette Valley (for general discussion see Burns, 1998; Orr and Orr, 1999).

The site is located northeast of the Tualatin Mountains, an uplifted block of Columbia River Basalt on the southwestern edge of the Portland Basin. The soil underlying the site is primarily recent alluvial deposits of the Willamette River and dredged fill material placed early in the twentieth century. The fill generally consists of dredged sand from the Columbia and Willamette rivers.

3.2 SURFACE CONDITIONS

The Zenith Portland Zenith Terminal is in Portland's Northwest Industrial area. The 31.3-acre bulk fuel terminal is bound by NW Doane Avenue to the northwest, NW Front Avenue to the northwest, railroad track to the southwest and NE St. Helens Road further to the southwest. Figure 2 shows the site location relative to existing physical features. Industrial buildings are located southeast of the terminal. The terminal is occupied by numerous aboveground storage tanks and buildings. The site is essentially flat.

3.3 SUBSURFACE CONDITIONS

Our knowledge of site subsurface conditions is based on two borings (B-1 and B-2) at the approximate locations shown on Figure 2. Our subsurface exploration and laboratory testing programs, the exploration logs, and results of laboratory testing are summarized in Appendix A. The site is generally fill underlain by alluvium. The following sections provide a detailed description of the subsurface conditions.

3.3.1 Fill

Fill was encountered to depths of 22 and 23 feet BGS in borings B-1 and B-2, respectively. The fill generally consists of sand with varying proportions of silt. The upper 5.5 feet of fill in boring B-2 consists of clay. SPTs show that the sand varies in relative density between loose and medium dense and the clay is very soft.

3.3.2 Alluvium

Alluvium that consists silt and clay underlies the fill to depths of 74 and 49 feet BGS in borings B-1 and B-2, respectively. SPTs show that the alluvium is very soft to very stiff. Laboratory tests show that the plasticity of the alluvium varies between highly plastic and non-plastic.

3.3.3 Basalt Bedrock

Bedrock was encountered underlying the alluvium in both borings to the maximum depths explored in each boring.

3.3.4 Groundwater

Groundwater was not measured in the borings as they were drilled using drilling mud. Prior explorations at the terminal encountered groundwater at a depth of 15 feet BGS. This is consistent with our experience in the site vicinity.

4.0 SEISMIC HAZARDS

We conducted a seismic hazard assessment for use in evaluation of Tank 105, Tank 130, and the warehouse building. The provisions of the 2019 SOSSC were used to assess the warehouse building and tanks. The 2019 SOSSC refers to ASCE 7-16 for seismic design. Seismic design of petroleum tanks is typically conducted using Annex E of the API 650 Standard. The 12th edition of API 650 was current at the time of this report. API 650 also refers to the ASCE 7 Standard for seismic design.

4.1 SEISMIC SOURCES

4.1.1 Earthquake Source Zones

Three scenario earthquakes were considered for this study consistent with the local seismic setting. Two of the possible earthquake sources are associated with the CSZ, and the third event is a shallow, local crustal earthquake that could occur in the North American Plate. The three earthquake scenarios are discussed below.

4.1.2 Regional Events

The CSZ is the region where the Juan de Fuca Plate is being subducted beneath the North American Plate. This subduction is occurring in the coastal region between Vancouver Island and northern California. Evidence has accumulated suggesting that this subduction zone has generated eight great earthquakes in the last 4,000 years, with the most recent event occurring approximately 300 years ago (Weaver and Shedlock, 1991). The fault trace is mapped approximately 50 to 120 km off the Oregon Coast. Two types of subduction zone earthquakes are possible and considered in this study:

1. An interface event earthquake on the seismogenic part of the interface between the Juan de Fuca Plate and the North American Plate on the CSZ. This source is reportedly capable of generating an earthquake with a moment magnitude of 9.0.
2. A deep intraplate earthquake on the seismogenic part of the subducting Juan de Fuca Plate. These events typically occur at depths of between 30 and 60 km. This source can generate an earthquake with a moment magnitude of up to 7.5.

4.1.3 Local Events

A significant earthquake could occur on a local fault near the site within the design life of the facility. Such an event would cause ground shaking at the site that could be more intense than the CSZ events, though the duration would be shorter. Figure 3 shows the locations of mapped Quaternary faults within a 30-km radius of the terminal. Figure 4 shows the interpreted locations of seismic events that occurred between 1833 and 1993 (USGS 2019). The three closest mapped faults to the site are the Portland Hills fault, East Bank fault, and Oatfield fault. A discussion of these faults is provided below. Table 1 lists the fault length and distance to the site.

4.1.3.1 Portland Hills Fault

The northwest-striking Portland Hills fault forms the prominent linear northeastern margin of the Tualatin Mountains (Portland Hills) and the southwestern margin of the Portland Basin; this basin may be a right-lateral, pull-apart basin in the forearc of the CSZ or a piggyback synclinal basin formed between antiformal uplifts of the Portland fold belt. The fault is part of the Portland Hills-Clackamas River structural zone, which controlled the deposition of Miocene CRBG lavas in the region. The crest of the Portland Hills is defined by the northwest-striking Portland Hills anticline. Sense of displacement on the Portland Hills fault is poorly known and controversial. The fault was originally mapped as a down-to-the-northeast normal fault. The fault has also been mapped as part of a regional-scale zone of right-lateral, oblique-slip faults and as a steep escarpment caused by asymmetrical folding above a southwest-dipping blind thrust. Reverse displacement with a right-lateral, strike-slip component may be most consistent with the tectonic setting, mapped geologic relations, aeromagnetic data, and microseismicity in the area. Fault scarps on surficial Quaternary deposits have not been described along the fault trace, but some geomorphic (steep, linear escarpment, triangular facets, over-steepened, and knick-pointed tributaries) and geophysical (aeromagnetic, seismic reflection, and ground penetrating radar) evidence suggest Quaternary displacement (Personius, 2017). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

4.1.3.2 East Bank Fault

The northwest-striking East Bank fault lies in the Portland Basin, which may be a right-lateral, pull-apart basin in the forearc of the CSZ; the fault lies a few kilometers east of and is parallel to the Portland Hills fault, which forms the southwestern margin of the basin. The East Bank fault has been mapped as a high-angle, normal fault with a down-to-the-southwest displacement direction, but down-to-the-northeast reverse displacement with a right-lateral, strike-slip component is consistent with tectonic setting, mapped geologic relations, aeromagnetic data, and microseismicity in the area. Fault scarps on surficial Quaternary deposits have not been described along the fault trace, and the fault is mapped as buried by latest Pleistocene Missoula flood deposits, but recently acquired shallow seismic-reflection suggest probable down-to-the-northeast offset of unconformities, paleochannels, and sediments associated with flood deposits at several locations across the East Bank fault (Personius, 2002). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

4.1.3.3 Oatfield Fault

The northwest-striking Oatfield fault forms northeast-facing escarpments in volcanic rocks of the Miocene CRBG in the Tualatin Mountains and northern Willamette Valley. The fault may be part of the Portland Hills-Clackamas River structural zone. The Oatfield fault is primarily mapped as a very high-angle, reverse fault with apparent down-to-the-southwest displacement, but a few kilometer-long reach of the fault with down-to-the-northeast displacement is mapped in the vicinity of the Willamette River. This apparent change in displacement direction along strike may reflect a discontinuity in the fault trace or could reflect the right-lateral, strike-slip displacement that characterizes other parts of the Portland Hills-Clackamas River structural zone. The fault has also been modeled as a 70-degree, east-dipping reverse fault. Reverse displacement with a right-lateral, strike-slip component is consistent with the tectonic setting, mapped geologic relations, and microseismicity in the area. Fault scarps on surficial deposits have not been described, but exposures in a light rail tunnel showing offset of approximately 1 M_a Boring Lava across the fault indicate Quaternary displacement (Personius, 2002). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

Table 1. Closest Mapped Crustal Faults

Source	**Closest Mapped Distance[1] (km)**	**Mapped Length[1] (km)**
Portland Hills fault	< 0.5	49
East Bank fault	1.1	29
Oatfield fault	2.4	24

1. Reported by USGS (USGS, 2018)

5.0 SITE RESPONSE ANALYSIS

Local soil conditions influence the characteristics of earthquake ground shaking and these effects must be considered when estimating ground shaking levels for seismic design. These effects are quantified by conducting a site response analysis, which involves the propagation of earthquake motions from the base rock through the overlying soil layers to the ground surface. We determined a base rock spectrum using the USGS Unified Hazard Tool. We scaled ground motions to match the base rock spectrum. We constructed a soil column based on the subsurface conditions encountered in the borings and propagated the ground motions to the ground surface using the DEEPSOIL application. Two soil columns were considered as the depth to bedrock varied in each boring. The depth to bedrock is 74 and 49 feet BGS in borings B-1 and B-2, respectively. We discuss this process in more detail and present the results of our analysis below.

5.1 RISK-TARGETED BEDROCK SPECTRUM

We obtained a probabilistic target bedrock spectrum to which ground motions can be scaled to prior to running a site response analysis through the overlying soil column. We determined the spectral accelerations for the outcropping bedrock response spectrum for periods ranging from 0 to 5 seconds from the USGS Unified Hazard Tool using the Dynamic: Conterminous U.S. 2014 model (v4.2.0). We determined the spectral accelerations for periods ranging from 0 to 5 seconds for a return period of 2 percent in 50 years. The response spectrum is consistent with a shear wave velocity equal to 760 meters per second in the upper 30 meters of the soil profile.

The maximum direction was adopted as the ground motion intensity parameter for use in lieu of explicit consideration of directional effects. The maximum horizontal response may reasonably be estimated by factoring the average response period by period-dependent factors. The commentary to ASCE 7-16 recommends a factor of 1.1 at periods less than 0.2 second, 1.3 at a period of 1 second, and 1.5 at 5 seconds and greater. We used linear interpolation to compute factors at periods greater than 0.2 second.

The risk-targeted bedrock spectrum, MCE_R, target bedrock spectrum was computed using Method 1 outlined in ASCE 7-16 Section 21.2.1.1 to achieve a 1 percent probability of collapse in a 50-year period. A risk coefficient of C_{RS} = 0.891 was applied to the spectrum at periods of 0.2 second or less and a risk coefficient of C_{R1} = 0.871 was applied to the spectrum at periods greater than 1 second. Linear interpolation was used to compute risk coefficients between periods of 0.2 and 1.0 second. Figure 5 shows the target bedrock spectrum. Table 2 provides a summary of values used to compute the MCE_R target bedrock response spectrum.

Table 2. Risk-Targeted Bedrock Spectrum

Period (seconds)	MCE Target Bedrock Spectral Acceleration (g)	Maximum Direction Factor	C_R	MCE_R Target Bedrock Spectral Acceleration (g)
0.0	0.432	1.10	0.891	0.423
0.1	0.923	1.10	0.891	0.905
0.2	0.955	1.10	0.891	0.936
0.3	0.785	1.13	0.890	0.786
0.5	0.564	1.18	0.888	0.588
0.8	0.345	1.30	0.882	0.395
1.0	0.190	1.55	0.871	0.257
2.0	0.124	1.40	0.871	0.152
3.0	0.092	1.45	0.871	0.116
4.0	0.069	1.50	0.871	0.090
5.0	0.432	1.10	0.891	0.423

5.2 BASE GROUND MOTIONS

Six recorded base ground motions were selected to represent the local seismic setting. We considered faulting mechanism, magnitude, and distance to recording station. Ground motions at the site are controlled by a crustal event and the CSZ interface event. We selected two acceleration time histories to represent the crustal seismic sources and four acceleration time histories to represent the CSZ seismic sources as input for the seismic response analysis. Table 3 lists the ground motions selected for this study.

Table 3. Selected Ground Motions

Ground Motion/Recording Station	Magnitude	Distance (km)	Component
Crustal Records			
Imperial Valley 1979 / Delta	6.53	22.0	262
Kobe 1995 / Abeno	6.9	24.9	000
CSZ Records			
Tohoku 2011 / Tsukuba City Hall	9.0	106.9	004
Arequipa 2001 / MOQ	8.4	60.0	000
Maule 2010 / Santiago Puente Alto	8.8	75.0	NS
Maule 2010 / Colegio Las Americas	8.8	81.9	NS

5.3 SITE CONDITION MODELING

We determined acceleration response spectra for the postulated scenarios discussed above by performing a site-specific seismic response analysis. A non-linear seismic site response analysis was conducted. The site response analysis was performed using the DEEPSOIL Version 7.0 application.

The input soil models used in our analysis are based on the findings of our subsurface exploration program and experience in the site vicinity. Since the depth to bedrock varied between the two borings, we conducted a response analysis using two soil profiles. Table 4 provides a summary of the soil models used in our analysis. The acceleration response spectra produced by our equivalent linear seismic response analysis is presented on Figure 5.

Table 4. Input Soil Column

Depth Interval (feet)	Subsurface Unit	Shear Wave Velocity (feet per second)	Modulus Reduction Curve	Damping Curve
0[1] to 20	Fill	530 to 837	Seed and Idriss, 1970 (Mean)	MRDF with Darendeli Reduction Factor
20 to 40	Alluvium	436 to 571	Vucetic & Dobry, 1991 PI: 33	MRDF with Darendeli Reduction Factor
40 to 75	Alluvium	604	Vucetic & Dobry, 1991 PI: 0	MRDF with Darendeli Reduction Factor
>75	Bedrock	2,400	Not applicable	Not applicable

1. Output at ground surface

A shallower soil profile, with bedrock located at a depth of 49 feet BGS, was also considered but does not produce results significantly different from those with bedrock located at a depth of 75 feet BGS.

5.4 DETERMINISTIC MCE_R RESPONSE SPECTRUM

Since the largest spectral response acceleration of the probabilistic study is less than 1.2 F_a, a deterministic response spectrum is not required. Therefore, the site-specific MCE_R response is the probabilistic MCE_R response spectrum.

5.5 DESIGN RESPONSE SPECTRUM

ASCE 7-16 Section 21.3 states that the site-specific MCE_R response spectrum is reduced to two-thirds of the acceleration at any period. However, the lower bound for design ground motions is 80 percent of the generalized response spectrum as outlined in ASCE 7-16 Section 11.4.5.

5.6 DESIGN ACCELERATION PARAMETERS

To develop the final design response spectrum, the parameter S_{DS} is taken from the site-specific response spectrum at a period of 0.2 second but should not be smaller than 90 percent of the peak spectral acceleration taken at any period larger than 0.2 second. The parameter S_{D1} is taken as the maximum value of the product, T and SA, for periods from 1 second to 2 seconds for sites with Vs_{30} of greater 1,200 feet per second and for periods from 1 second to 5 seconds for sites with Vs_{30} smaller than 1,200 feet per second. Figure 6 shows the design response spectrum.

6.0 GEOLOGIC HAZARDS

In addition to ground shaking, site-specific geologic conditions can influence the potential for earthquake damage. Deep deposits of loose or soft alluvium can amplify ground motions, resulting in increased seismic loads on structures. Other geologic hazards are related to soil failure and permanent ground deformation. Permanent ground deformation could result from liquefaction, lateral spreading, landsliding, and fault rupture. The following sections provide additional discussion regarding potential seismic hazards that could affect the planned facility.

6.1 FAULT SURFACE RUPTURE

Faults are not mapped beneath the property by the USGS Seismic Mapping Project. Consequently, it is our opinion that the probability of surface fault rupture beneath the site is low.

6.2 LIQUEFACTION

Liquefaction is caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. In general, loose, saturated sand soil with low silt and clay content is the most susceptible to liquefaction. Silty soil with low plasticity is moderately susceptible to liquefaction under relatively higher levels of ground shaking. We anticipate 6 inches of liquefaction-induced settlement at the ground surface. A differential settlement of half of this value can be assumed over a distance of 50 feet.

6.3 LATERAL SPREADING

The closest structure considered in this study is located approximately 800 feet from the west bank of the Willamette River. In our opinion, the risk of lateral spreading should be considered low under design levels of ground shaking.

6.4 GROUND MOTION AMPLIFICATION

Soil capable of significantly amplifying ground motions beyond the levels determined by our site-specific seismic response analysis was not encountered during our subsurface investigation program. We conclude the level of amplification determined by our response analysis is appropriate and the facility can be designed using the levels of ground shaking prescribed by the building codes.

7.0 STRUCTURAL ASSESSMENT

A structural assessment of the warehouse building was conducted by KPFF. The findings of that study are presented in Appendix B. A structural assessment of Tanks 105 and 130 was conducted by PEMY. The findings of that study are presented in Appendix C.

8.0 CONCLUSIONS

Based on the results of this study, the existing shallow foundation systems of Tanks 105 and Tanks 130 are adequate. In our opinion, a deep foundation system that consists of piling is not required to meet the requirements of the 2019 SOSSC and ASCE 7-16 Standard.

Only a cursory study of the warehouse building was conducted. However, based on that study it is expected that the building will not collapse and life safety will be protected under current design levels of ground shaking.

9.0 LIMITATIONS

We have prepared this report for use by Zenith Energy Management. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Soil explorations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in this report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

◆ ◆ ◆

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc.

Brett A. Shipton, P.E., G.E.
Principal Engineer

REGISTERED PROFESSIONAL
ENGINEER
56207
OREGON
July 11, 2000
BRETT A. SHIPTON
EXPIRES: 6/30/20

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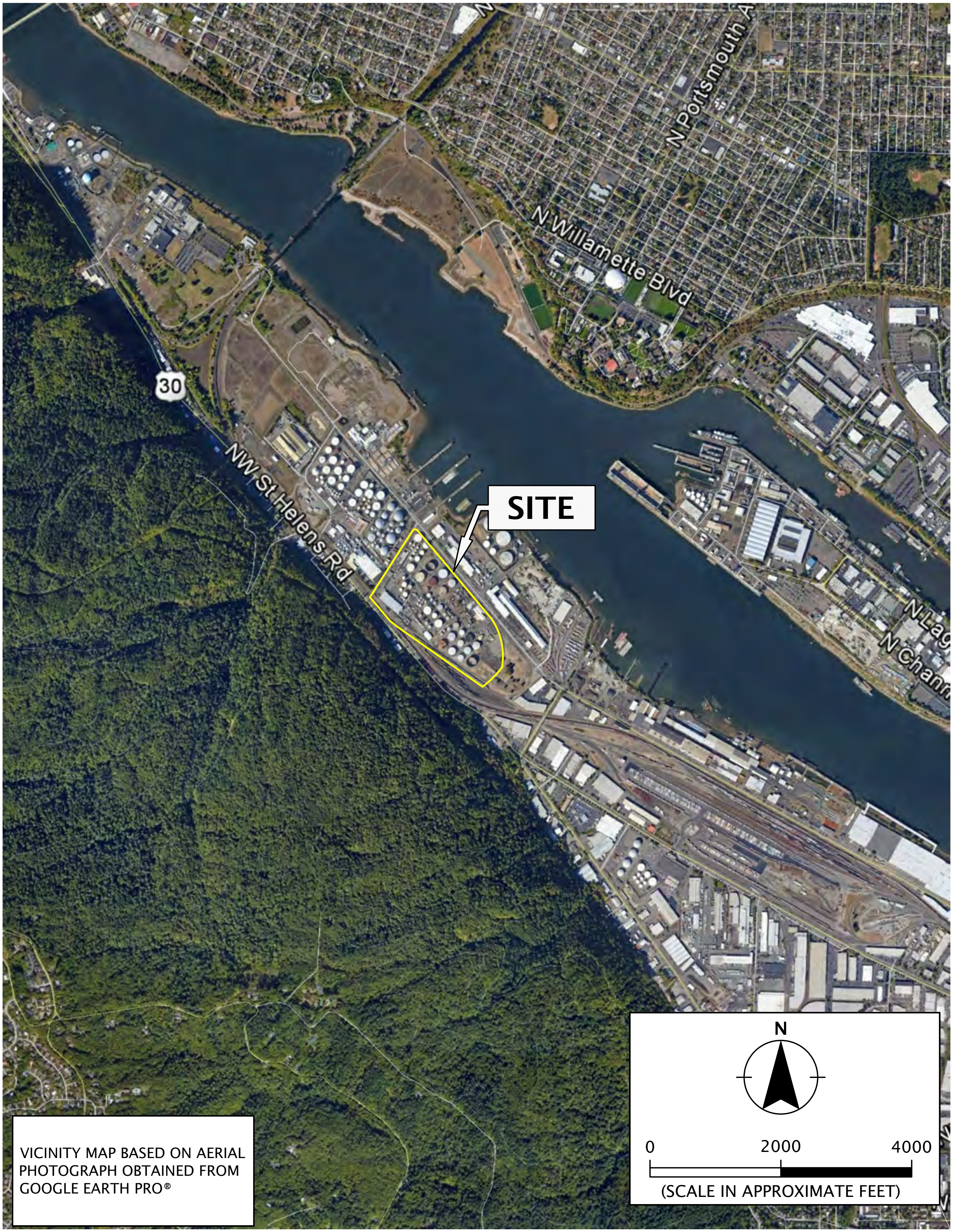
FIGURES



VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

GEODESIGN INC AN NV5 COMPANY	ZENITH-1-01	**VICINITY MAP**	
	MAY 2020	ZENITH PORTLAND TERMINAL PORTLAND, OR	**FIGURE 1**

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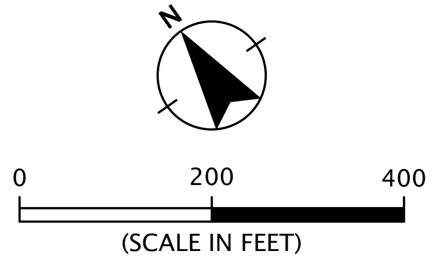
File Name: J:\S-Z\Zenith\Zenith-1\Zenith-1-01\Figures\CAD\Zenith-1-01-VM01.dwg | Layout: FIGURE 1

LEGEND:

B-1●	BORING
— - - —	APPROXIMATE SITE BOUNDARY

SITE PLAN BASED ON AERIAL PHOTOGRAPH
OBTAINED FROM GOOGLE EARTH PRO®,
DECEMBER 30, 2019



SITE PLAN

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE 2

ZENITH-1-01

MAY 2020

GEODESIGN™
AN NV5 COMPANY

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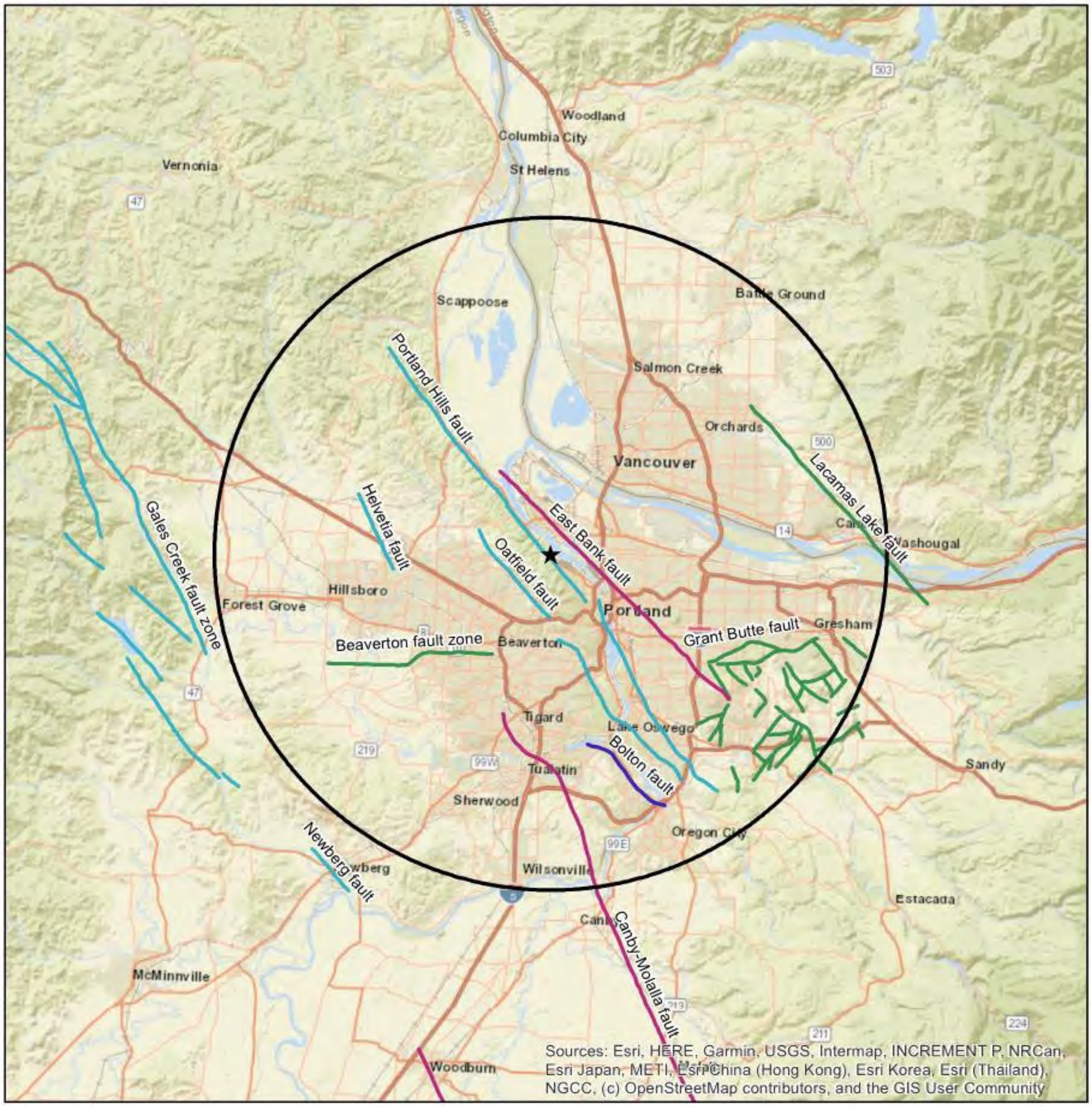


Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

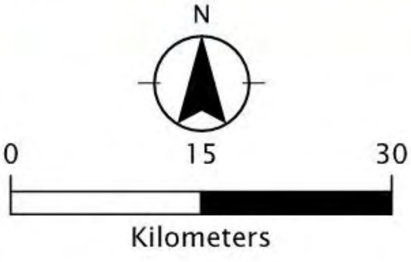
▭ RADIUS

★ SITE LOCATION

USGS QUATERNARY FAULTS

AGE

- <150
- <15,000
- <130,000
- <750,000
- <1,600,000
- Class B



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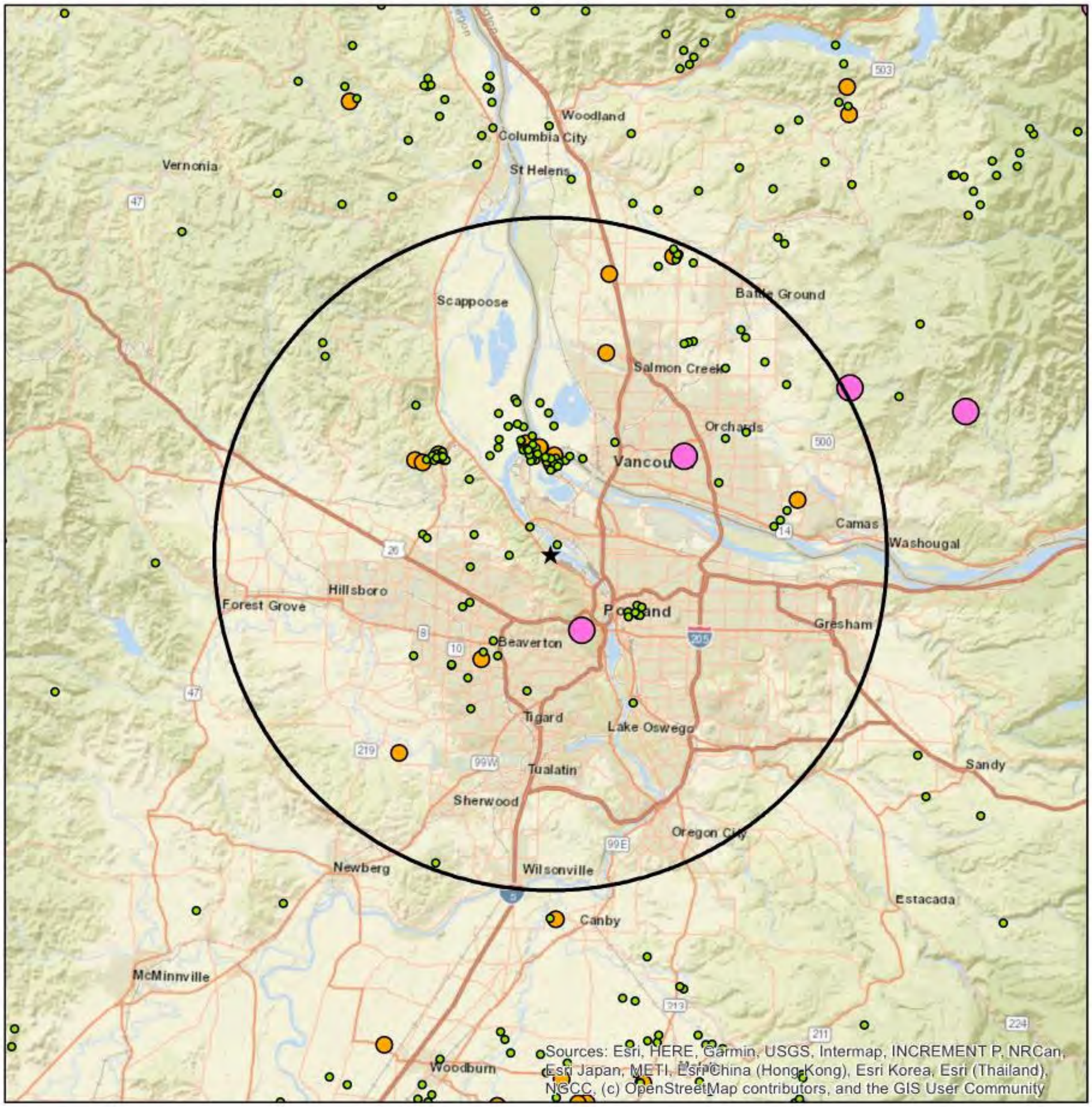
ZENITH-1-01

MAY 2020

QUATERNARY FAULT MAP

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE 3



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

LEGEND

▭ RADIUS

★ SITE LOCATION

INSTRUMENTAL EARTHQUAKE MAGNITUDE

- ● 2.0 - 3.0
- ● 3.0 - 4.0
- ● 4.0 - 6.0
- ● > 6.0

N

0 15 30

Kilometers

USGS, 2019, Earthquake Hazards Program, US Earthquake Information by State, U.S. Geological Survey, Available: http://earthquake.usgs.gov/earthquakes/search

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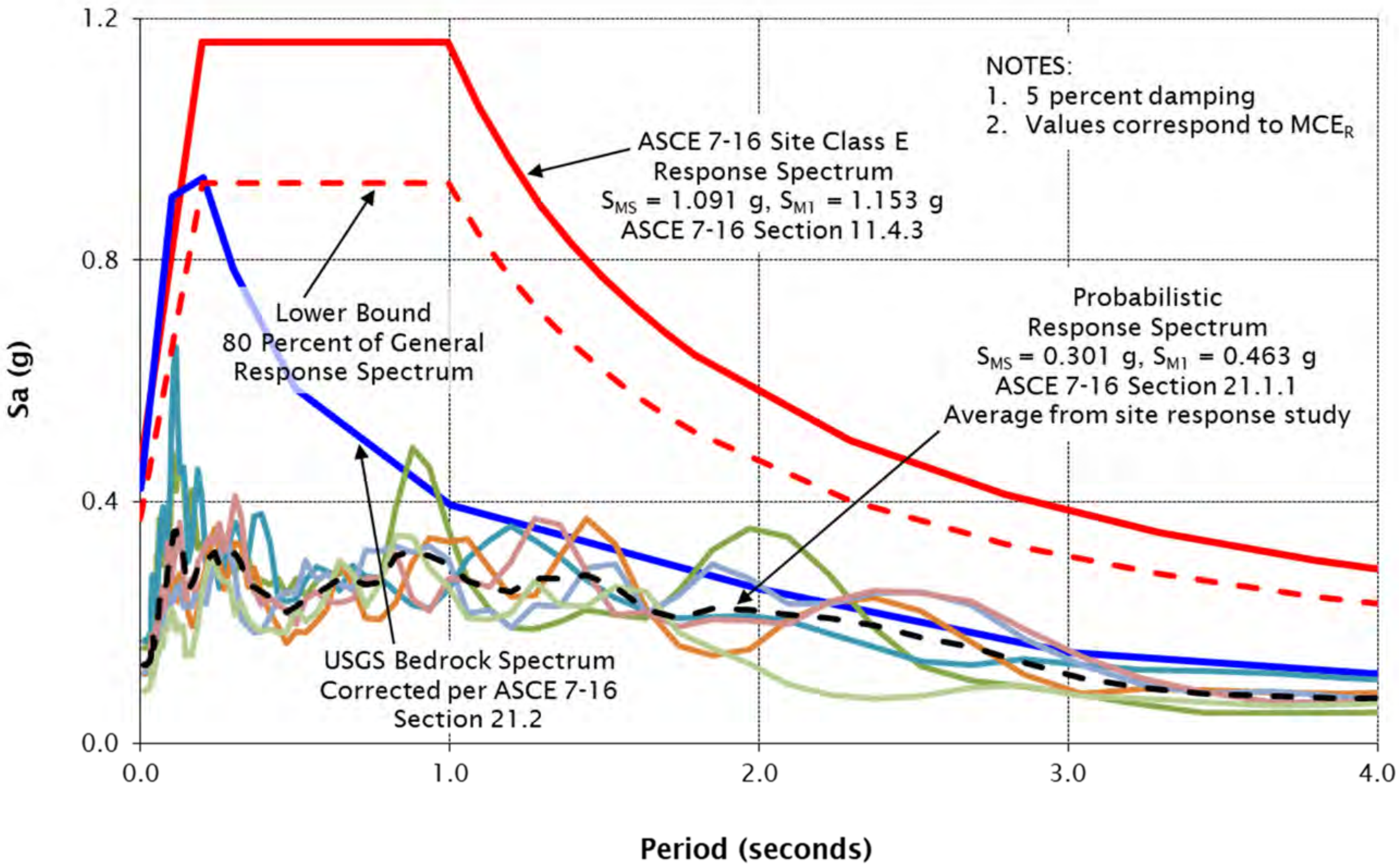
ZENITH-1-01

HISTORICAL SEISMICITY MAP

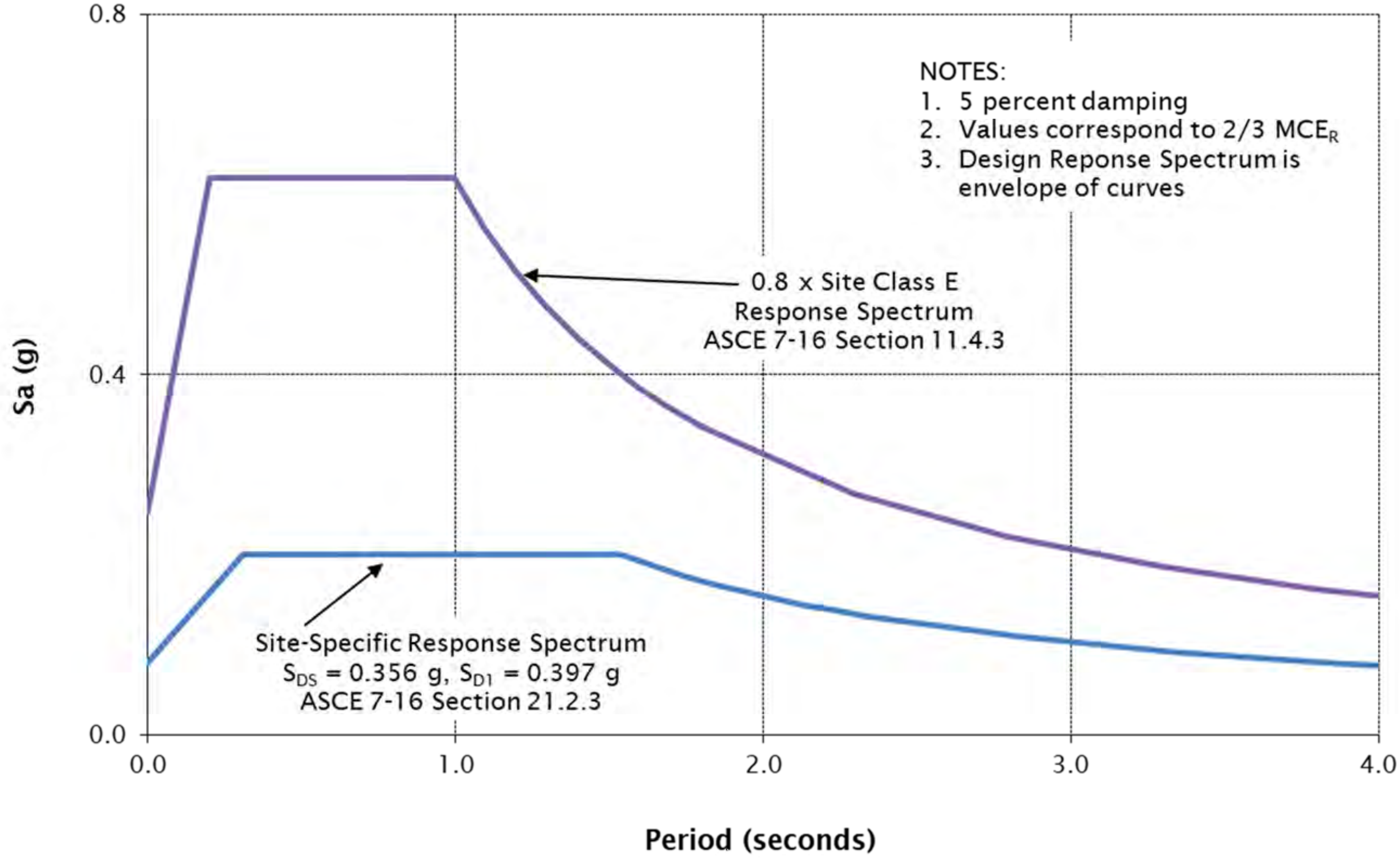
MAY 2020

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE 4



GEODESIGN INC AN NV5 COMPANY	ZENITH-1-01	**SITE RESPONSE SPECTRA**	
	MAY 2020	ZENITH PORTLAND TERMINAL PORTLAND, OR	**FIGURE 5**



GEODESIGN INC AN NV5 COMPANY	ZENITH-1-01	**DESIGN RESPONSE SPECTRUM**
	MAY 2020	ZENITH PORTLAND TERMINAL PORTLAND, OR

FIGURE 6

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

GENERAL

We explored subsurface conditions at the site by drilling two borings (B-1 and B-2) to depths of 50 and 80 feet BGS. Figure 2 shows the approximate exploration locations. The borings were drilled on November 26 and 27, 2019 using mud rotary drilling methods. Drilling services were provided by Western States Soil Conservation, Inc. of Hubbard, Oregon. The exploration logs are presented in this appendix.

The exploration locations were located in the field pacing from survey existing site features. This information should be considered accurate only to the degree implied by the methods used.

SOIL SAMPLING

A member of our geotechnical staff observed the explorations. We collected representative samples of the various soil encountered in the explorations for geotechnical laboratory testing. Sampling methods and intervals are shown on the exploration logs.

Soil samples were collected by conducting SPTs in general conformance with ASTM D1586. The sampler was driven with a 140-pound automatic trip hammer free-falling 30 inches. The number of blows required to drive the sampler 1 foot, or as otherwise indicated, into the soil is shown adjacent to the sample symbols on the exploration logs. Disturbed samples were collected from the split barrel for subsequent classification and index testing.

The calibration factor for the SPT hammer used by Western States Soil Conservation, Inc. was 82.2 percent. The results of the calibration testing are presented at the end of this appendix.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the “Exploration Key” (Table A-1) and “Soil Classification System” (Table A-2), which are presented in this appendix. The exploration logs indicate the depths at which the soils or their characteristics change, although the change actually could be gradual. If the change occurred between sample locations, the depth was interpreted. Classifications are shown on the exploration logs.

LABORATORY TESTING

CLASSIFICATION

The soil samples were classified in the laboratory to confirm field classifications. The laboratory classifications are shown on the exploration logs if those classifications differed from the field classifications.

MOISTURE CONTENT

We tested the natural moisture content of select soil samples in general accordance with ASTM D2216. The natural moisture content is a ratio of the weight of the water to soil in a test sample and is expressed as a percentage. The test results are presented in this appendix.

ATTERBERG LIMITS

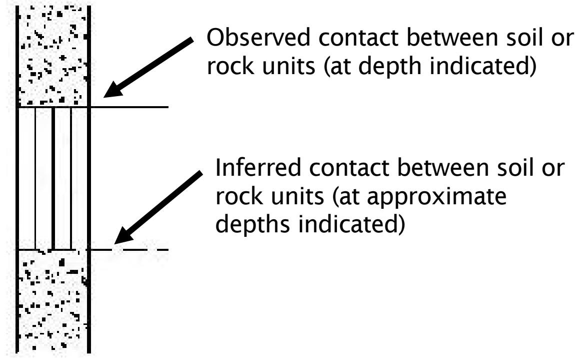
The plastic limit and liquid limit (Atterberg limits) of select soil samples were determined in accordance with ASTM D4318. The Atterberg limits and the plasticity index were completed to aid in the classification of the soil. The test results are presented in this appendix.

PARTICLE-SIZE ANALYSES

Particle-size analysis was conducted on select soil samples. Testing included percent fines determinations in general accordance with ASTM D 1140. The test results are presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
▯	Location of sample collected in general accordance with ASTM D1586 using Standard Penetration Test with recovery
◧	Location of sample collected using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D1587 with recovery
▤	Location of sample collected using Dames & Moore sampler and 300-pound hammer or pushed with recovery
▤	Location of sample collected using Dames & Moore sampler and 140-pound hammer or pushed with recovery
◪	Location of sample collected using 3-inch-O.D. California split-spoon sampler and 140-pound hammer with recovery
⊠	Location of grab sample
▮	Rock coring interval
▽	Water level during drilling
▼	Water level taken on date shown

Graphic Log of Soil and Rock Types



GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Non-Plastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

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EXPLORATION KEY

TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOIL

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 – 11	0 – 4
Loose	4 – 10	11 – 26	4 – 10
Medium Dense	10 – 30	26 – 74	10 – 30
Dense	30 – 50	74 – 120	30 – 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 – 4	3 – 6	2 – 5	0.25 – 0.50
Medium Stiff	4 – 8	6 – 12	5 – 9	0.50 – 1.0
Stiff	8 – 15	12 – 25	9 – 19	1.0 – 2.0
Very Stiff	15 – 30	25 – 65	19 – 31	2.0 – 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.					
Percent	Silt and Clay In:		Percent	Sand and Gravel In:	
	Fine-Grained Soil	Coarse-Grained Soil		Fine-Grained Soil	Coarse-Grained Soil
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

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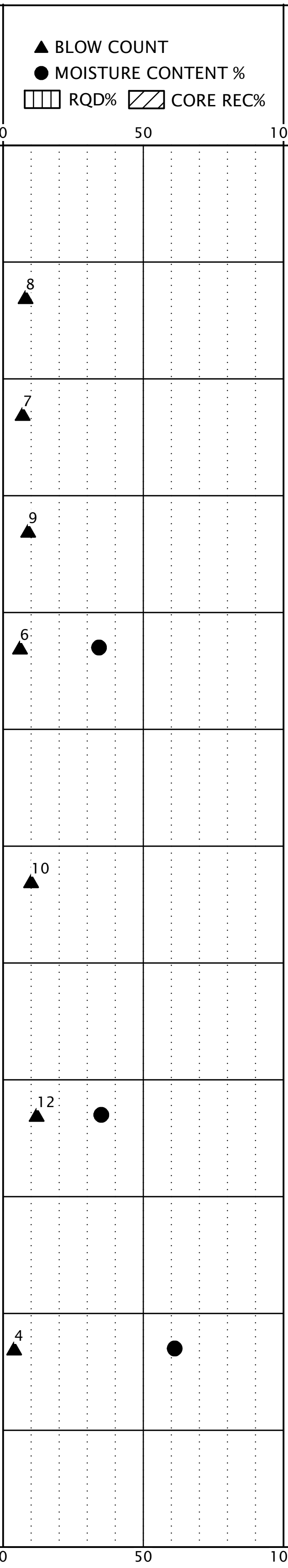
SOIL CLASSIFICATION SYSTEM

TABLE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Loose, brown, silty SAND (SM); moist, sand is fine to medium - **FILL**.				
2.5				8	
5.0				7	
7.5	gray at 8.5 feet			9	
10.0			P200	6	P200 = 27%
12.5					
15.0	medium dense at 15.0 feet			10	
17.5	Medium dense, brown SAND with silt (SP-SM); wet - **FILL**.	17.0			
20.0			P200	12	P200 = 10%
22.5	Soft to medium stiff, dark gray SILT (MH); wet, silt has high plasticity.	22.0			
25.0			ATT	4	LL = 70% PL = 37%
27.5					
30.0					



DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Pierce
COMPLETED: 11/26/19

BORING METHOD: mud rotary (see document text)
BORING BIT DIAMETER: 4 1/4 inches

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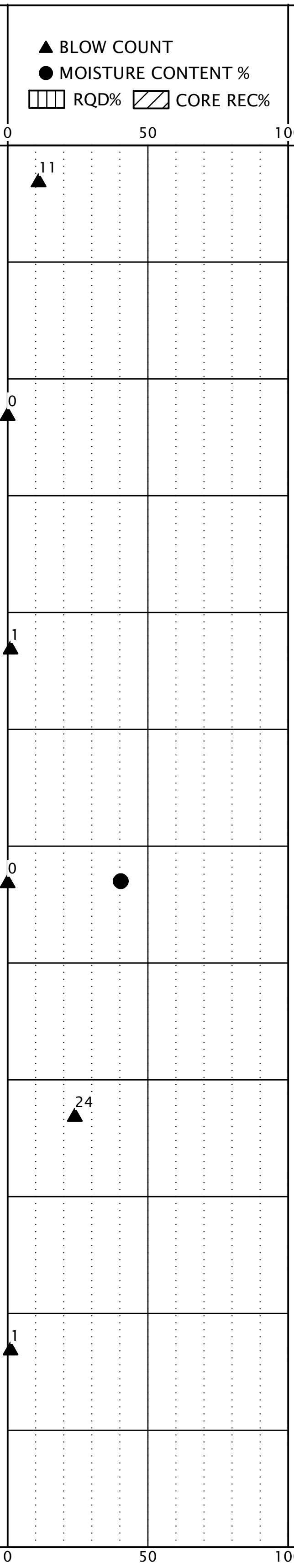
ZENITH-1-01

MAY 2020

BORING B-1

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-1



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	▲ BLOW COUNT	INSTALLATION AND COMMENTS
30.0	stiff, light gray with orange-brown mottles at 30.0 feet			11	
32.5					
35.0	very soft, light brown at 35.0 feet			0	
37.5					
40.0				1	
42.5					
	Very soft, light brown with orange mottled SILT (ML); wet.	44.0			
45.0			ATT	0	LL = NP PL = NP
47.5					
50.0	very stiff, dark gray to gray at 50.0 feet			24	
52.5					
55.0	very soft at 55.0 feet			1	
57.5					
60.0					

DRILLED BY: Western States Soil Conservation, Inc.   LOGGED BY: T. Pierce   COMPLETED: 11/26/19

BORING METHOD: mud rotary (see document text)   BORING BIT DIAMETER: 4 1/4 inches

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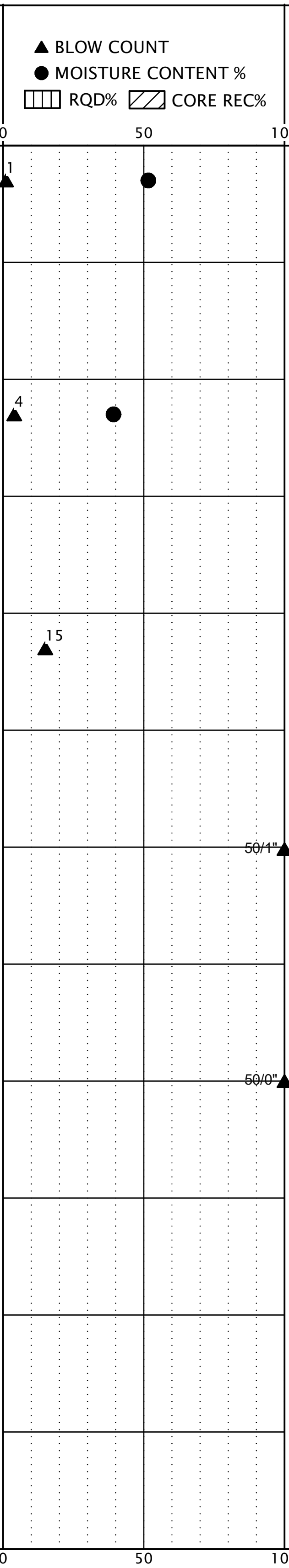
MAY 2020

BORING B-1
(continued)

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-1

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
60.0	(continued from previous page)		ATT	1	LL = NP PL = NP
65.0			P200	4	P200 = 59%
68.0	Stiff to very stiff, dark gray SILT (MH), minor sand; wet, sand is fine.	68.0			
70.0				15	
74.0	Medium hard, black BASALT.	74.0			
75.0				50/1"	
80.0	Exploration completed at a depth of 80.0 feet. Hammer efficiency factor is 82.2 percent.	80.0		50/0"	Surface elevation was not measured at the time of exploration.



DEPTH FEET: 60.0, 62.5, 65.0, 67.5, 70.0, 72.5, 75.0, 77.5, 80.0, 82.5, 85.0, 87.5, 90.0

DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Pierce
COMPLETED: 11/26/19

BORING METHOD: mud rotary (see document text)
BORING BIT DIAMETER: 4 1/4 inches

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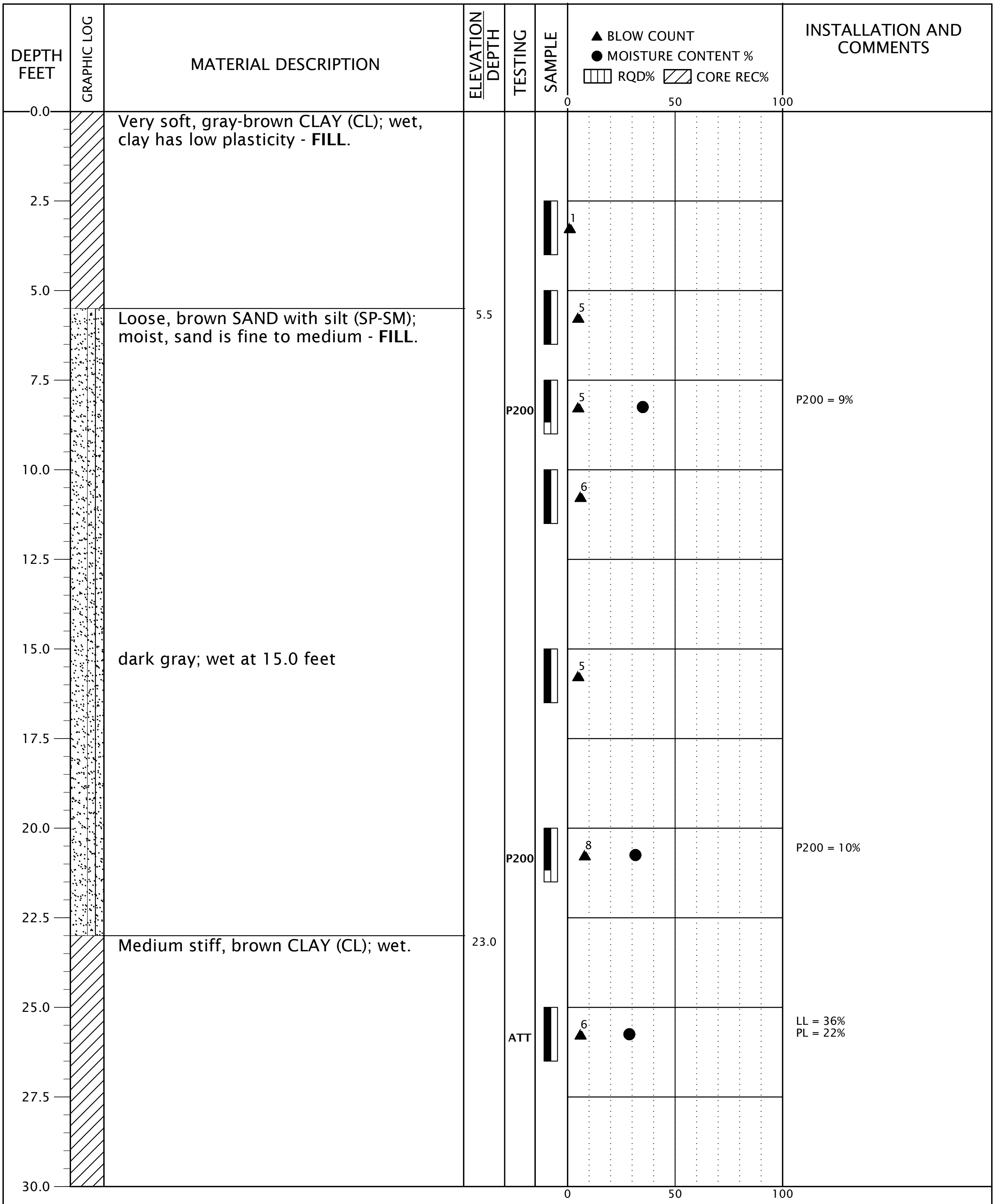
ZENITH-1-01

MAY 2020

BORING B-1
(continued)

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-1



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	▲ BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Very soft, gray-brown CLAY (CL); wet, clay has low plasticity - **FILL**.				
2.5				1	
5.0				5	
	Loose, brown SAND with silt (SP-SM); moist, sand is fine to medium - **FILL**.	5.5			
7.5			P200	5 ●	P200 = 9%
10.0				6	
12.5					
15.0	dark gray; wet at 15.0 feet			5	
17.5					
20.0			P200	8 ●	P200 = 10%
22.5					
	Medium stiff, brown CLAY (CL); wet.	23.0			
25.0			ATT	6 ●	LL = 36% PL = 22%
27.5					
30.0					

DRILLED BY: Western States Soil Conservation, Inc.

LOGGED BY: T. Pierce

COMPLETED: 11/27/19

BORING METHOD: mud rotary (see document text)

BORING BIT DIAMETER: 4 1/4 inches

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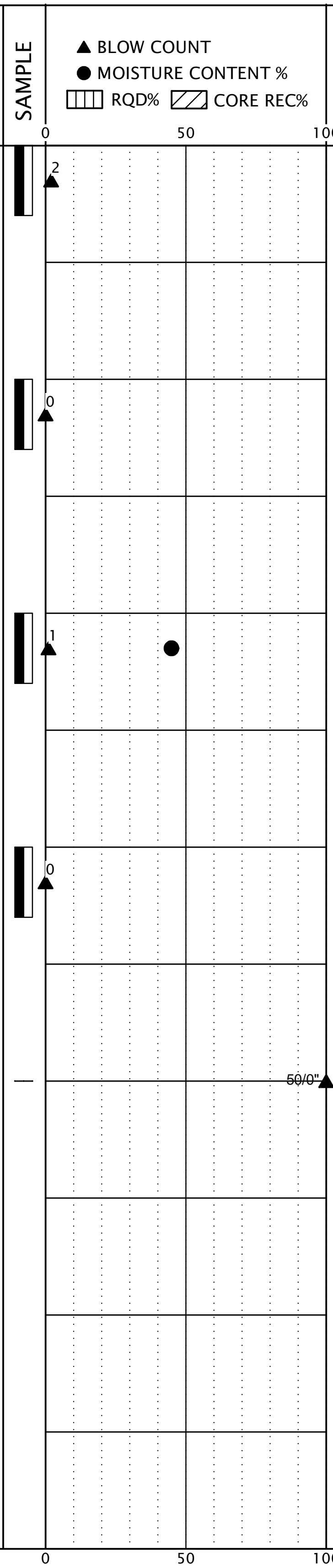
BORING B-2

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	INSTALLATION AND COMMENTS
30.0	soft at 30.0 feet			
35.0	very soft at 35.0 feet			
39.5	Very soft, brown with orange mottled SILT (ML); wet.	39.5	ATT	LL = NP PL = NP
45.0	gray at 45.0 feet			
49.0	Medium hard, black BASALT.	49.0		
50.0	Exploration completed at a depth of 50.0 feet. Hammer efficiency factor is 82.2 percent.	50.0		Surface elevation was not measured at the time of exploration.



DRILLED BY: Western States Soil Conservation, Inc.

LOGGED BY: T. Pierce

COMPLETED: 11/27/19

BORING METHOD: mud rotary (see document text)

BORING BIT DIAMETER: 4 1/4 inches

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ZENITH-1-01

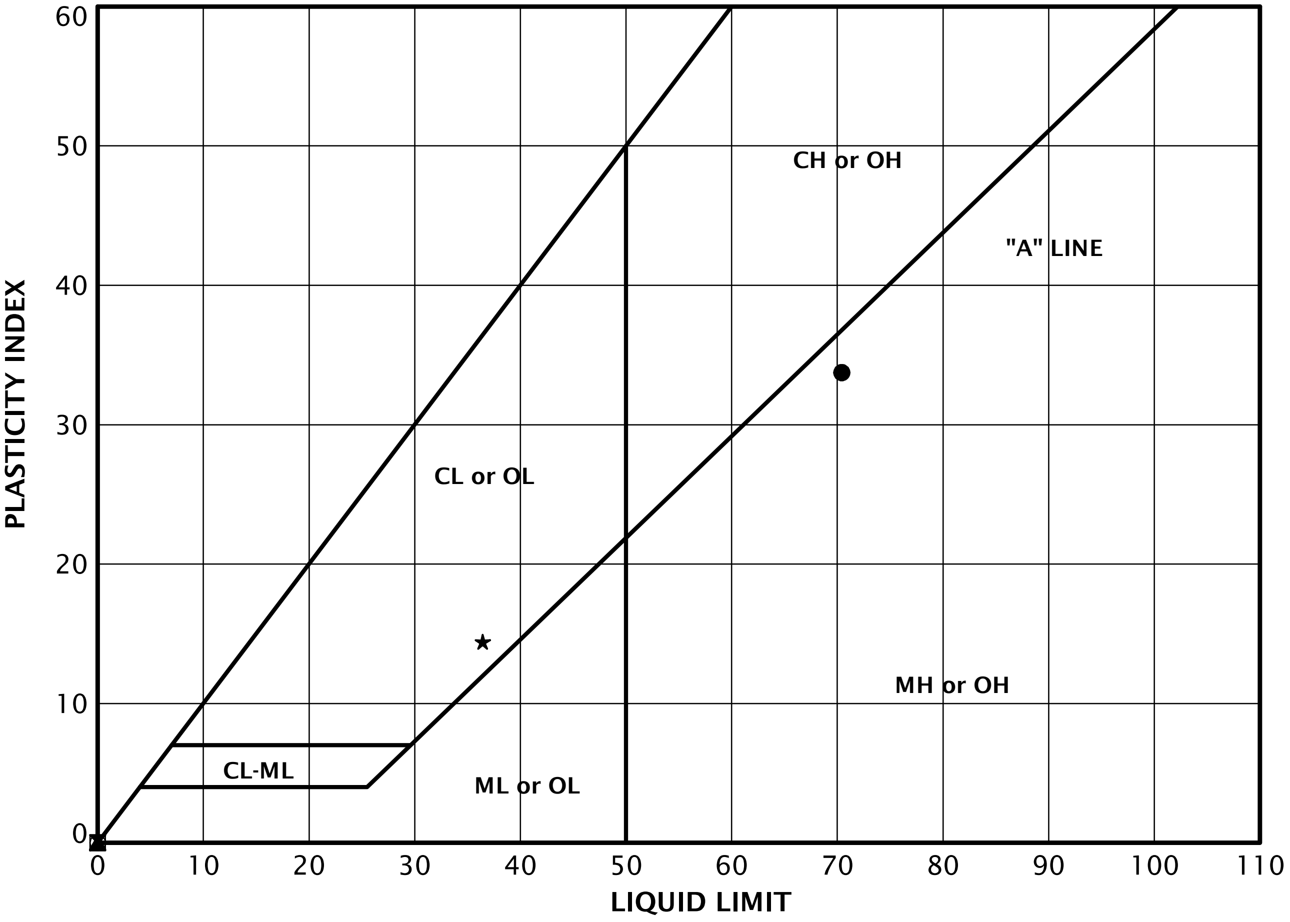
MAY 2020

BORING B-2
(continued)

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-2

BORING LOG - GDI-NV5 - 1 PER PAGE ZENITH-1-01-B1_2.GPJ GDI_NV5.GDT PRINT DATE: 5/29/20:KM:KT



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-1	25.0	61	70	37	33
⧗	B-1	45.0	40	NP	NP	NP
▲	B-1	60.0	52	NP	NP	NP
★	B-2	25.0	29	36	22	14
⊙	B-2	40.0	45	NP	NP	NP

ATTERBERG_LIMITS 7 ZENITH-1-01-B1_2.GPJ GEODESIGN.GDT PRINT DATE: 5/29/20:KT

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ZENITH-1-01

MAY 2020

ATTERBERG LIMITS TEST RESULTS

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-3

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	10.0		34				27			
B-1	20.0		35				10			
B-1	25.0		61					70	37	33
B-1	45.0		40					NP	NP	NP
B-1	60.0		52					NP	NP	NP
B-1	65.0		39				59			
B-2	7.5		35				9			
B-2	20.0		32				10			
B-2	25.0		29					36	22	14
B-2	40.0		45					NP	NP	NP

LAB SUMMARY - GDI-NV5 ZENITH-1-01-B1_2.GPJ GDI_NV5.GDT PRINT DATE: 5/29/20:KT

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ZENITH-1-01

MAY 2020

SUMMARY OF LABORATORY DATA

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-4

Summary of SPT Test Results

Project: WSSC-8-04, Test Date: 12/27/2018

EMX: Maximum Energy

ETR: Energy Transfer Ratio - Rated

Start Depth ft	Final Depth ft	**N Value**	**N60 Value**	Average EMX ft-lb	Average ETR %
25.00	26.50	**0**	**0**	0.00	0.0
30.00	31.50	**31**	**42**	267.77	76.5
35.00	36.50	**34**	**46**	305.69	87.3
40.00	41.50	**0**	**0**	0.00	0.0
			Overall Average Values:	287.61	82.2
			Standard Deviation:	32.43	9.3
			Overall Maximum Value:	387.60	110.7
			Overall Minimum Value:	234.46	67.0

APPENDIX B

February 3, 2020

Mr. Brett Shipton
GeoDesign, Inc.
9450 SW Commerce Circle, Suite 300
Wilsonville, OR 97070

Re: Zenith Energy Warehouse Building—Assessment

Dear Brett:

We are pleased to submit this letter summarizing our findings of the structural observation performed at the Zenith Energy Warehouse Building in Portland, Oregon. The purpose of this work was to assess the seismic performance of the building structure by means of a limited visual review.

The warehouse building is a single-story loading dock building that serves as a part storage and fabrication shop for Zenith Energy. The overall building consists of two main single-story steel warehouses (north and south structures) with two auxiliary warehouse structures on the east side. The overall warehouse building is approximately 20,000 SF. As-built drawings were not available during the time of this assessment and the date of construction is unknown but it could possibly date to the 1960's.

The warehouses and auxiliary structures are similar construction. They consist of metal roof decking on steel joists. These joists are supported on gable frames made of wide flange steel beams and columns. The floor is a concrete slab-on-grade. This slab is elevated about 3 feet above exterior grade and enclosed by a concrete perimeter wall. The building envelope is enclosed with metal siding. The north warehouse contains a steel framed mezzanine for storage and a standalone CMU structure that houses fire suppression equipment. The auxiliary structures butt up against the warehouse structures but are separated by CMU walls. The walls serve as bearing walls for small portions of the roof in the axillary structures.

The roof diaphragms of the warehouses and auxiliary structures are laterally braced by the steel roof decking. The diaphragms are also braced with steel rod cross braces in one bay of framing. The structures' wall elements are braced by two lines of steel rod cross braces in one bay of framing in the north-south direction. The gable frames act as moment frames that provide multiple lines of resistance in the east-west direction. These frames and cross braces appear to be in good condition and they appear to provide sufficient redundancy for the overall building to resist seismic forces. Additional lines of resistance do not appear to be needed.

The steel framed mezzanine in the north warehouse appears to be independently braced with wood sheathed walls in each direction. The CMU fire control structure also appears to be independently braced by CMU walls in each direction.

Mechanical connections are used throughout the warehouse and auxiliary structures. The roof is screwed to the joists, the joists are bolted to the support frames, and the columns are bolted to the foundations. This connectivity appears to provide a proper load path for seismic loads to transfer to the foundation.

Each warehouse and auxiliary structure appears to be vertically and laterally independent but they butt up against each other at many locations. The lack of separation and difference in height makes adjacent structures susceptible to pounding during a seismic event which could cause structural damage. This pounding could be mitigated by tying the structures together throughout the line of contact.

It is understood that this warehouse building sits on a high risk liquefaction site. Although this tends to be problematic for typical building construction where column spacing may be 30 feet on center, structural damage due to differential settlement may not be as severe in the warehouse building given the gable frame columns are 50 feet on center. Furthermore, the lightweight and flexible nature of the structure may make it less susceptible to damage if soils liquefy.

In summary, the warehouse building appears to offer a moderate-to-good level of seismic strength as determined from the limited visual review. A more detailed analysis could be conducted (e.g. detailed field measurements and radar scanning) to better determine seismic strength of components and overall seismic resiliency.

If you have any questions, please don't hesitate to call me.

Sincerely,

Rich Poirier, PE

RP/bd\2020-02-03_Zenith Energy Warehouse Building Assessment_10022000052

APPENDIX C

PEMY Consulting, LLC.

SEISMIC ANALYSIS OF TANKS 130 AND 105 AT ZENITH PORTLAND TERMINAL

Prepared for Zenith Energy Management LLC

ABSTRACT

The seismic analysis in this report shows that Tanks 130 and 105 are suitable for service to any liquid design height chosen by the operator. The tanks are self-anchored and should not slide under the design seismic loading. The report is based on the Geodesign ground motion criteria and identifies key assumptions used in the analysis following the rules of ASCE 7-16 and API 650 12th edition.

Thang Hoang
Andy Wong
PEMyers
ATYearwood

Report
March 02, 2020

Table of Contents

Introduction

Tank 130 and Tank 105 are located at Zenith Portland terminal in Portland, Oregon. Tank 105 is a 48 ft high, 144 ft diameter, floating roof storage tank originally constructed in 1975. Meanwhile, Tank 130 is a 40 ft high, 130 ft diameter, fixed-roof storage tank, which was originally constructed in 1967.

A site-specific seismic geotechnical analysis was performed by GeoDesign, which provided spectral response acceleration parameters for use in accessing the ground surface accelerations to which the tank will be subjected. This PEMY Consulting report is intended to be an Appendix in the GeoDesign report.

This report documents structural evaluation following the rules of ASCE 7-16 and the 12th edition of API 650 Annex E in which anchorage ratio, compressive and tensile stresses, sliding force, were computed to estimate the maximum safe fill height to maintain liquid containment and integrity of the tanks during the scenario earthquake. In addition, an alternate method called the Manos method was used as an additional check to ensure that both methods provide the same result for the suitability of these tanks in the design earthquake.

The computations were performed by a seismic program developed by PEMY Consulting, LLC. This program processed the basic design information of each tank and the design spectral acceleration parameters as inputs while returning the maximum safe fill height after evaluating the shell structures with different criteria in API 650 Annex E and the Manos method.

Overall, the analysis results show that Tank 130 and Tank 105 are safe under the design spectral acceleration parameters with the tanks completely filled with liquid up to the shell height with a liquid of specific gravity of 1.0 (i.e. specific gravity of water). The maximum operating height is established by the tank owner/operator and involves consideration of overfill levels, sloshing wave heights and other limitations.

Tank Basic Design Information

The basic design information of the tanks was provided by the Terminal. The information for each tank is listed below.

Tank 130

Table 1. Tank 130 basic design information

Tank diameter	130.00 ft
Tank height	40.00 ft
Maximum product specific gravity	SG = 1
Cone roof slope	1:16
Location	Latitude: 45^o 33' 34'' N Longitude: 122^o 44' 10'' W
Course thickness	Course 1: 0.75'' Course 2: 0.562''

	Course 3: 0.5’’ Course 4: 0.375’’ Course 5: 0.25’’
Course height	Course 1: 8’ Course 2: 8’ Course 3: 8’ Course 4: 8’ Course 5: 8’
Seismic Use Group	SUG I
Anchorage information	Self-anchorage No annular ring. Assume annular ring thickness of 0.25’’ (there is an allowance in Annex E to use part of the tank bottom in calculating uplift resistance)
Effective impulsive weight of product	W_1/W_T = 35%
Operating height	38.33 ft

Tank 105

Table 2. Tank 105 basic design information

Tank diameter	144.00 ft
Tank height	48.00 ft
Maximum product specific gravity	SG = 1
Floating roof	
Location	Latitude: N/A Longitude: N/A Assume to have same location as Tank 130
Course thickness	Course 1: 0.968’’ Course 2: 0.817’’ Course 3: 0.684’’ Course 4: 0.521’’ Course 5: 0.334’’
Course height	Course 1: 7.91’ Course 2: 9.5’ Course 3: 9.5’ Course 4: 9.5’ Course 5: 9.59’ NOTE: Total of given course heights is 46 ft while tank height is 48 ft. Assume 48-foot height in analysis.
Seismic Use Group	SUG I
Anchorage information	Self-anchorage Annular ring thickness: 0.375’’
Effective impulsive weight of product	W_1/W_T = 37.5%
Operating height	N/A. Assume 48 ft.

Seismic Response Spectrum

Since the Zenith Terminal is on soil classified in ASCE7-16 as a site class F site, a site-specific analysis is required to evaluate the spectral acceleration parameters. The site-specific analysis was performed by GeoDesign. The results are summarized in Figure 1.

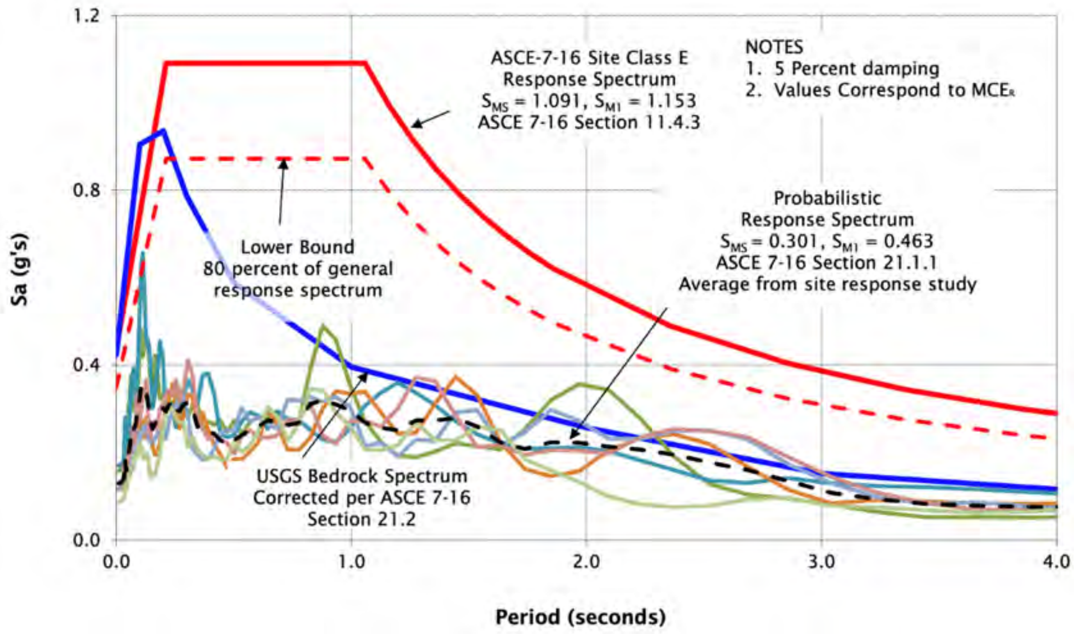


Figure 1. Response spectra for Zenith Portland terminal

Per ASCE 7-16, the site-specific response spectrum will be calculated from the envelope of the site-specific spectra and 80% of the mapped Site Class E spectrum. Since the site-specific response spectrum (dashed black line) is well below 80% of the mapped response spectrum of site class E, the response spectrum used will be based on 80% of the general response spectrum (the response spectrum is given with a solid red line – the 80% spectrum with the dashed red line). Therefore, to construct the design response spectrum, we used the values of the 80% mapped MCE_R, 5% damped, spectral response acceleration parameters, which are: $S_{MS} = 80\% * 1.091 = 0.873$, and $S_{M1} = 80\% * 1.153 = 0.922$. As a result, the design, 5% damped, spectral response acceleration parameters are: $S_{DS} = \frac{2}{3} S_{MS} = 0.582$, and $S_{D1} = \frac{2}{3} S_{M1} = 0.615$

The response spectral curves are reproduced in Figure 2 – the design response spectrum is constructed by ASCE 7-16, section 11.4.6.

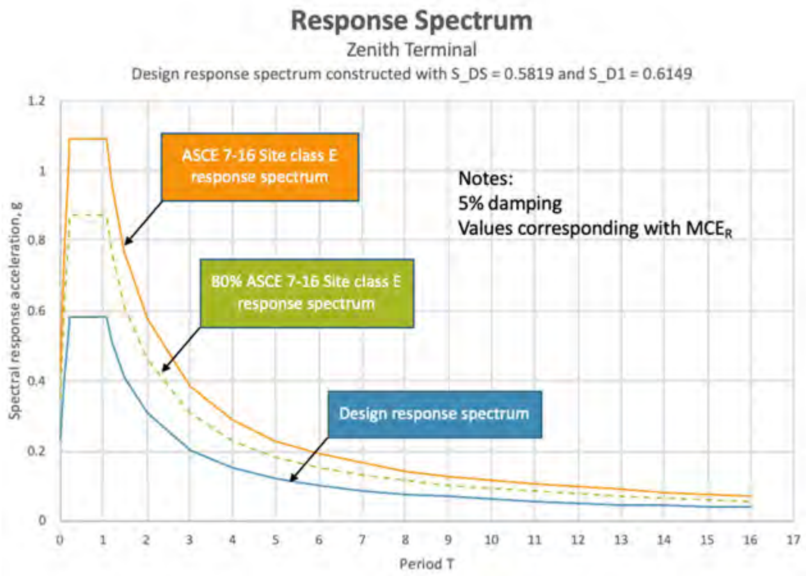


Figure 2. Spectral curves created from GeoDesign's results

Other seismic properties are listed in Table 3. The convective and impulsive design response spectral acceleration parameters, A_c and A_i, are calculated per API 650 Annex E as functions of S_{ac}^* and S_{ai}^*, which are determined from the design response spectrum, respectively. We have included a vertical acceleration ground motion component in the analysis. Additionally, we used the USGS online tool to determine the long period transition period, which is T_L = 16 seconds.

Table 3. Spectral response acceleration parameters and seismic properties

S_{DS}	0.582 g
S_{D1}	0.615 g
A_i	0.166 g
A_c	0.06 g
Vertical acceleration A_v	0.27 g
Long period T_L	16 sec
Site class	F

Seismic Analysis

Excessive seismic accelerations could potentially induce excessive overturning moments, compressive stresses in the shell, and hoop forces which could be damaging to the tanks and in a worst-case scenario result in loss of contents. The goal of this analysis is to calculate the maximum safe fill height of each tank for which the tank will not fail by buckling (i.e. "elephant's foot"), sliding, hoop stress, overturning moment, sloshing waves damaging roof structures. In addition, an informal visual inspection on the piping systems and supports was done at the terminal to foresee failure due to breaking piping. See recommendations later.

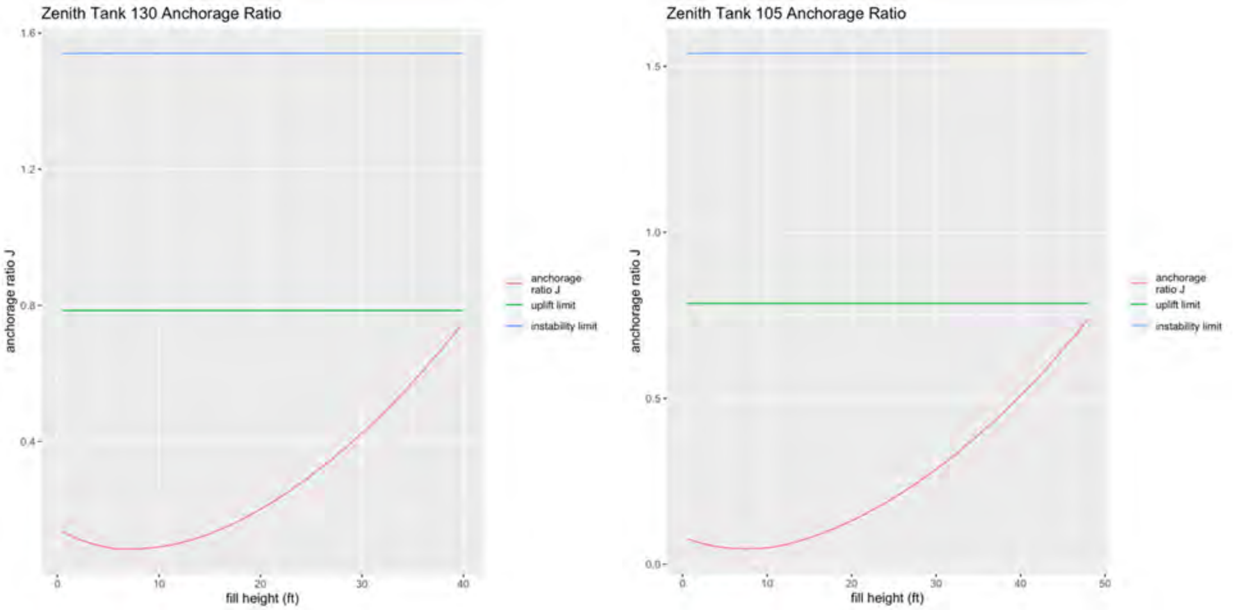
The following sections are based upon the analyses of the anchorage ratio, shell compression, shell hoop (tensile) stresses, sliding forces, and breaking piping. A second check on API 650 was conducted using an independent method called the Manos method. The analysis looks at these loading conditions at each fill height throughout the range of the tank shell. The sloshing wave height is also computed and considered to assist Zenith in setting a maximum operating level.

Anchorage Ratio

Earthquake ground shaking causes overturning moments on the tank. As the two tanks are self-anchored, the resistance to overturning is provided by the weight of the tank shell and weight of roof supported by the shell. Additional overturning resistance is provided by the weight of a portion of the tank liquid contents.

The overturning resistance is dependent on the part of the width of a bottom annulus uplifted by the overturning moment. The overturning resisting force of the annulus that lifts off the foundation is a function of annular plate thickness. In our analysis, we used an annular ring thickness for Tank 130 of 0.25'' whereas for Tank 105 the annular plate thickness was 0.375''.

According to API 650 Annex E, tank stability under an overturning moment is governed by the anchorage ratio, which is the ratio of the seismic overturning moment to the resisting moment. The program calculates this anchorage ratio with fill heights ranging from the bottom to the top of the tank shell and then comparing it to the critical values in API 650 (Figure 3).

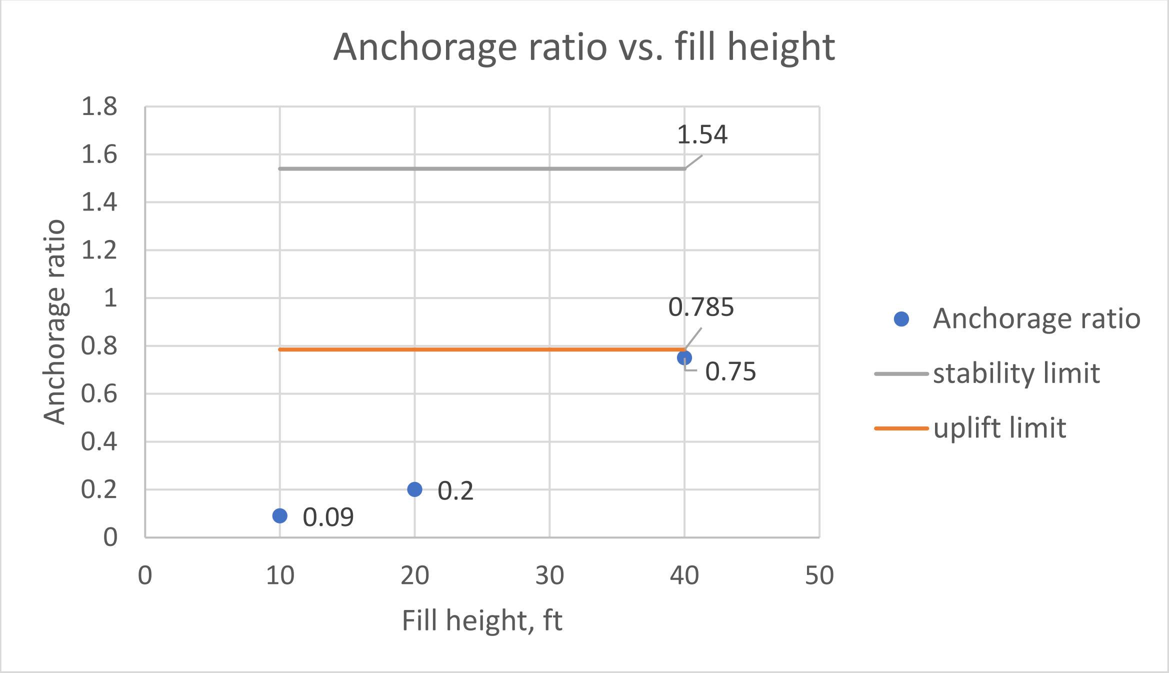


a. Tank 130 b. Tank 105

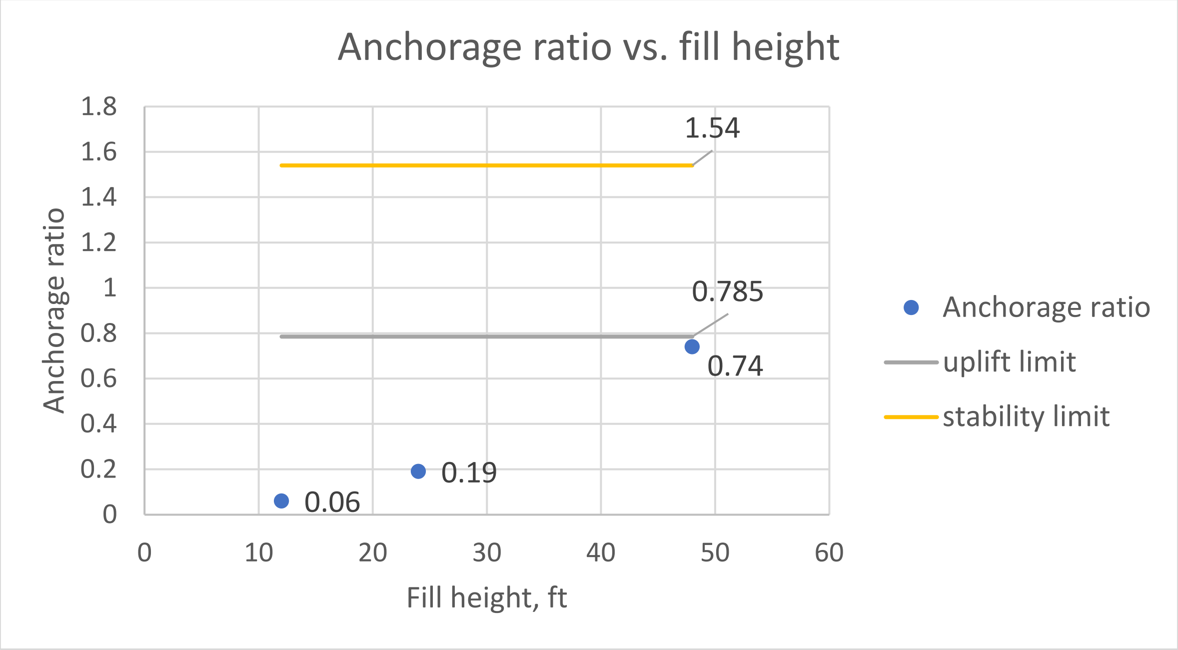
Figure 3. Anchorage ratio vs. fill height

There are two key thresholds of anchorage ratio defined in API 650 Annex E. One is shown as the green line (anchorage ratio = 0.785) above which the tank is uplifting but still stable for the design load providing the shell compression requirements are satisfied. The other one is shown as blue line (anchorage ratio = 1.54) above which tank is unstable and cannot be self-anchored for the design load. When an unanchored tank approaches the anchorage ratio of 1.54, the development of shell buckling also known as "elephant's foot" is likely.

In addition, Figure 4 examines the anchorage ratios of the two tanks at fill heights 25%, 50%, and 100% of maximum shell heights.



a. Tank 130, fill heights at 10 ft, 20 ft, and 40 ft



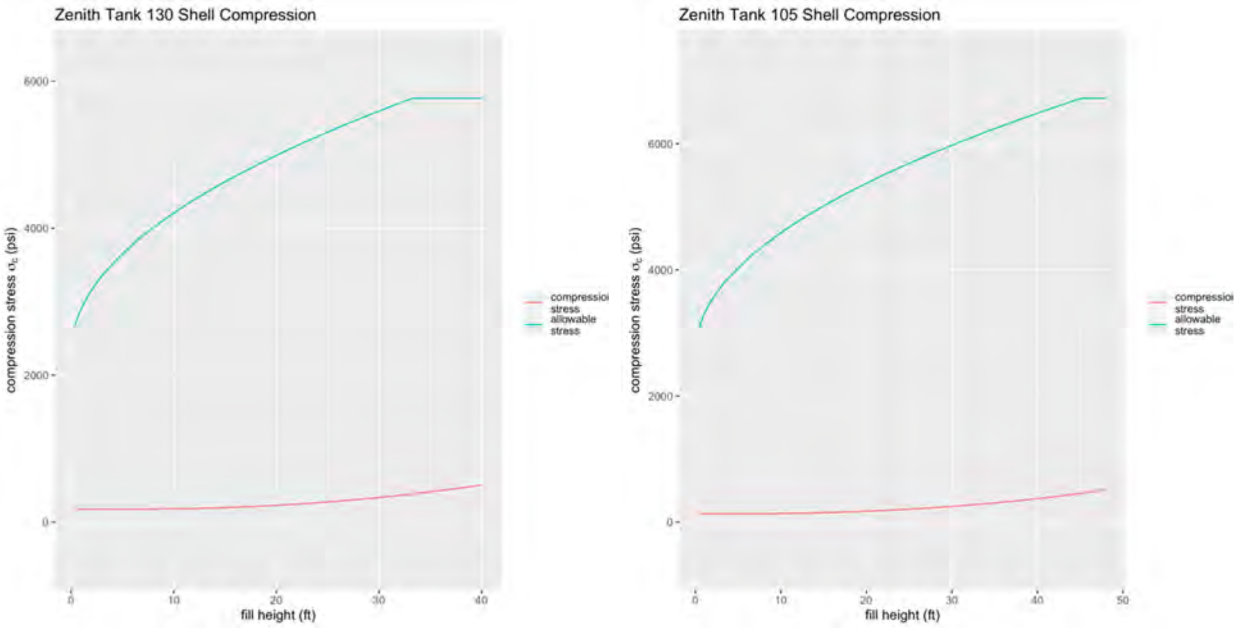
b. Tank 105, fill heights at 12 ft, 24 ft, and 48 ft

Figure 4. Anchorage ratio vs. fill height at 25%, 50%, and 100% fill heights.

According to the plots, both Tank 130 and Tank 105 have anchorage ratios below the uplift limit line for all fill heights, meaning they are both stable with fill height up to the maximum shell height.

Compressive stress

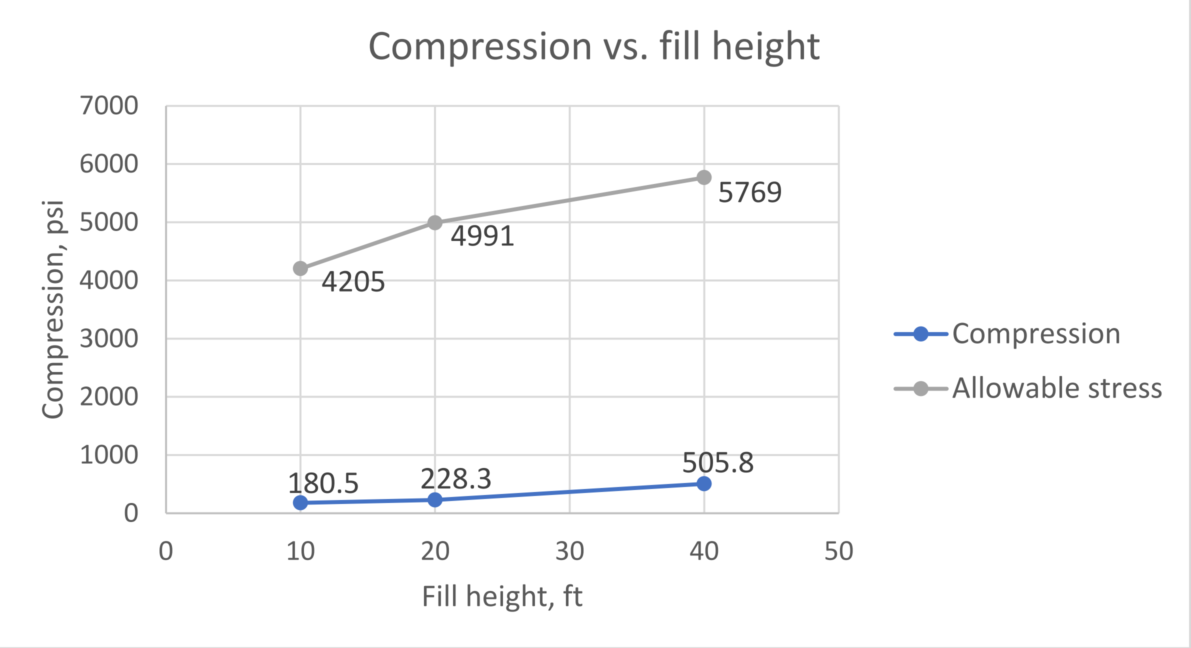
High compressive stresses can occur from seismic overturning moment. One side of the tank will uplift while the opposite side will go into compression. The maximum compressive stress occurs near the bottom of the first course of the shell.



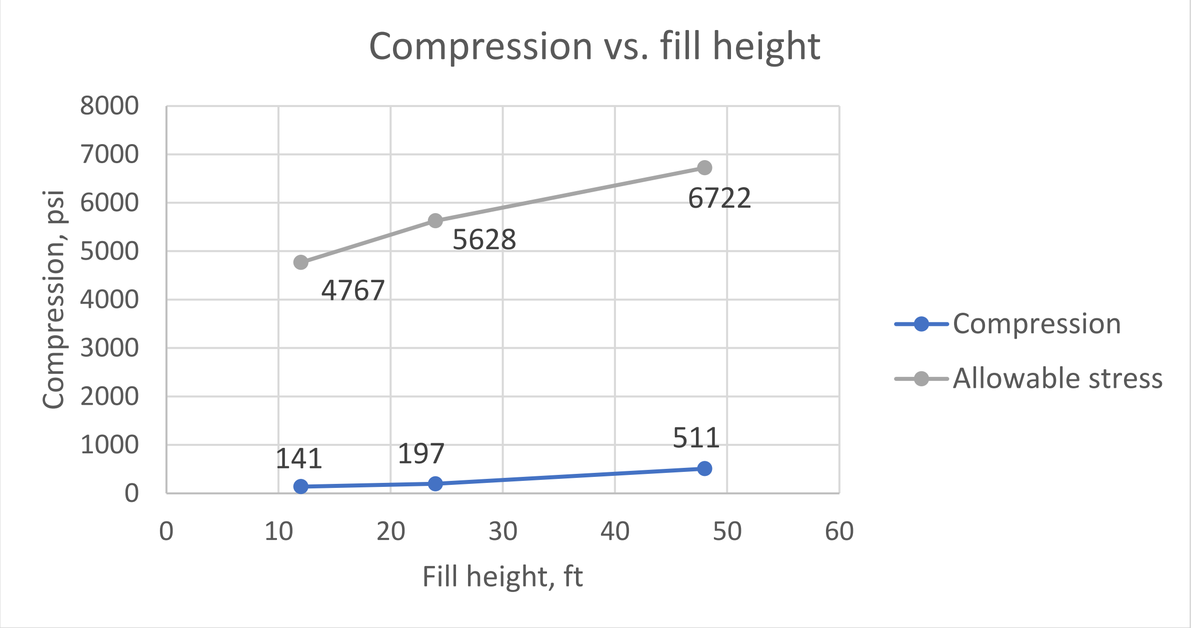
a. Tank 130 b. Tank 105

Figure 5. Compressive stress vs. fill height

The shell compression plots above (Figure 5) gives the seismically induced compressive stresses (the red line) in the shell. When the compression stress is above the allowable stress (the blue line), it is likely for the shell to buckle when undergoing the design seismic accelerations. The fill height at which the shell buckles only if the red line equals or exceeds the blue line. The compression is also examined specifically for the fill heights at 25%, 50%, and 100% of maximum fill height (Figure 6).



a. Tank 130, fill heights at 10 ft, 20 ft, and 40 ft



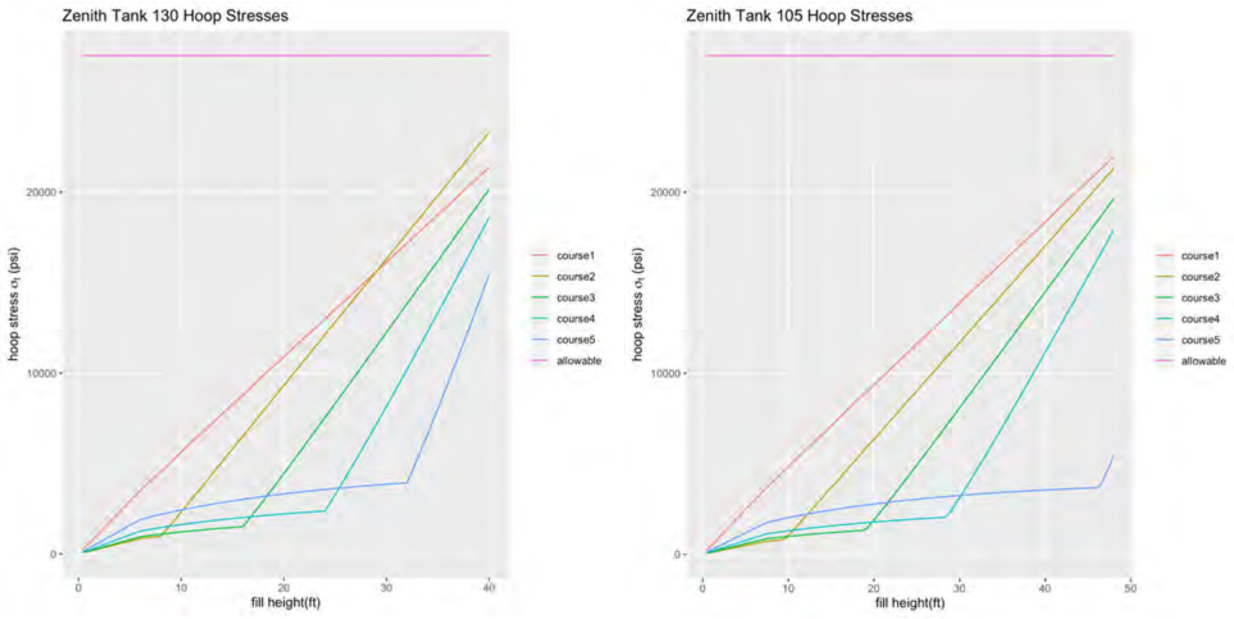
b. Tank 105, fill heights at 12 ft, 24 ft, and 48 ft

Figure 6. Compressive stress vs. fill heights at 25%, 50%, and 100%.

From Figure 5 and 6, it is clear that the risk of excessive compression stresses is nonexistent at any fill height.

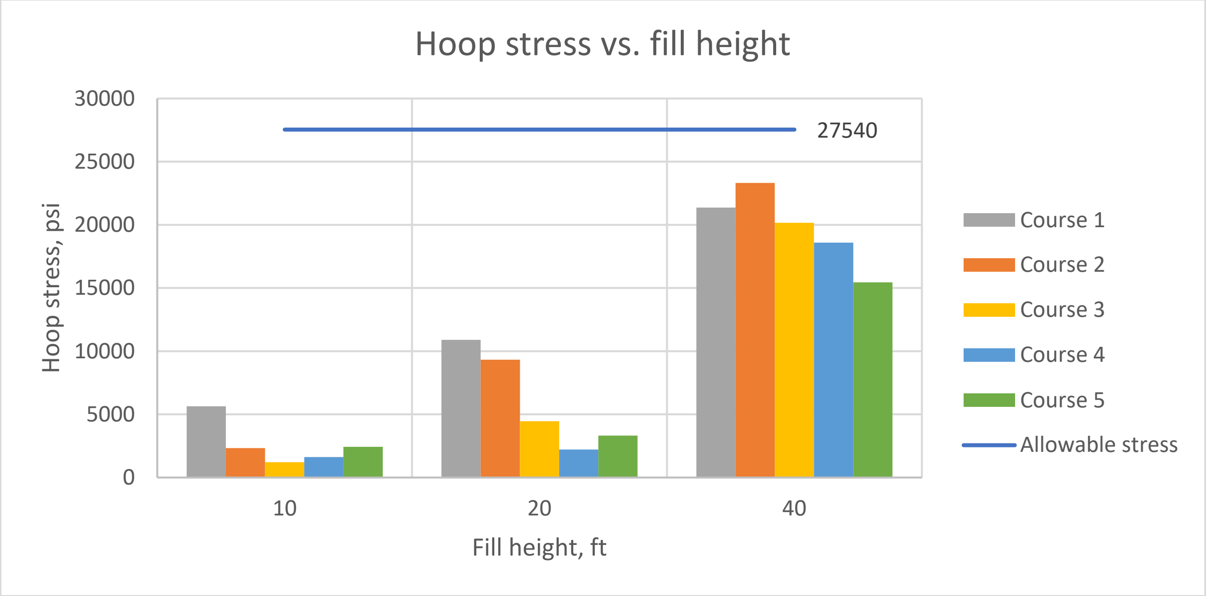
Hoop stress

Horizontal and vertical ground shaking also cause tensile stresses in the shell. When the tank undergoes seismic accelerations, the lower portion of the stored liquid in the tank moves in unison with the shell. This is called the impulsive component. The upper portion of the liquid moves independently from the tank shell and produces sloshing waves. This is called the convective component. Both the impulsive and convective components of the liquid create forces in the shell that result in tensile stresses. The PEMY program calculates tensile hoop stresses in each course corresponding to all of the possible fill heights (see Figure 7). This includes the stresses caused by the combination of lateral and vertical ground motion. The tensile stress in each course is compared with the maximum allowable hoop tension membrane stress (27450 psi) calculated per the API 650 Annex E standard, shown by the horizontal pink line.

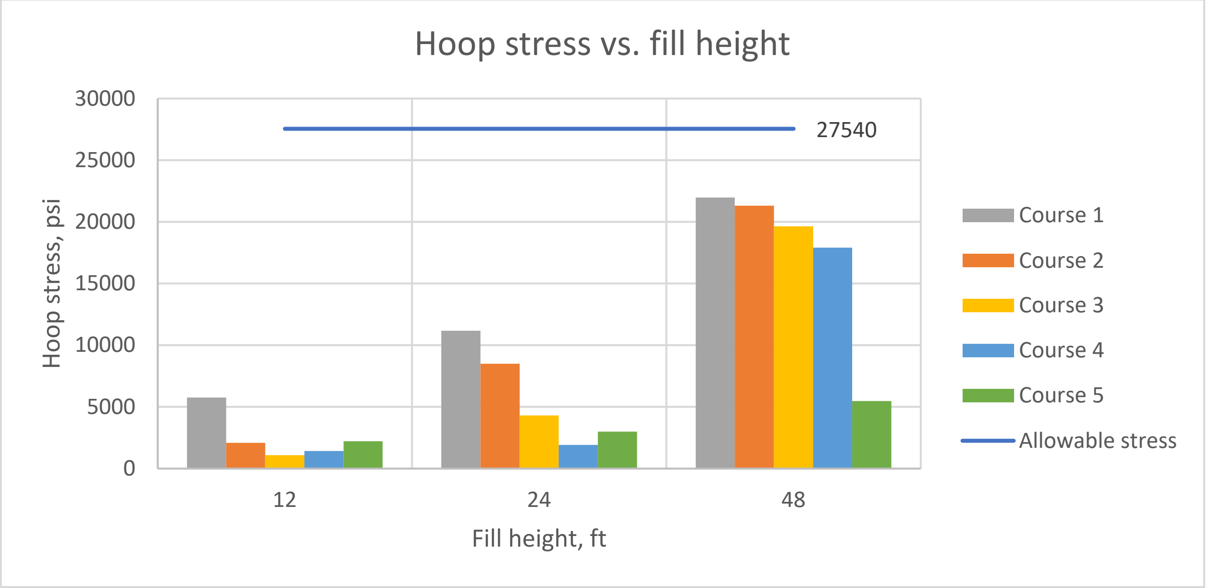


a. Tank 130 b. Tank 105

Figure 7. Tensile/Hoop stress vs. fill height



a. Tank 130, fill heights at 10 ft, 20 ft, and 40 ft



b. Tank 105, fill heights at 12 ft, 24 ft, and 48 ft

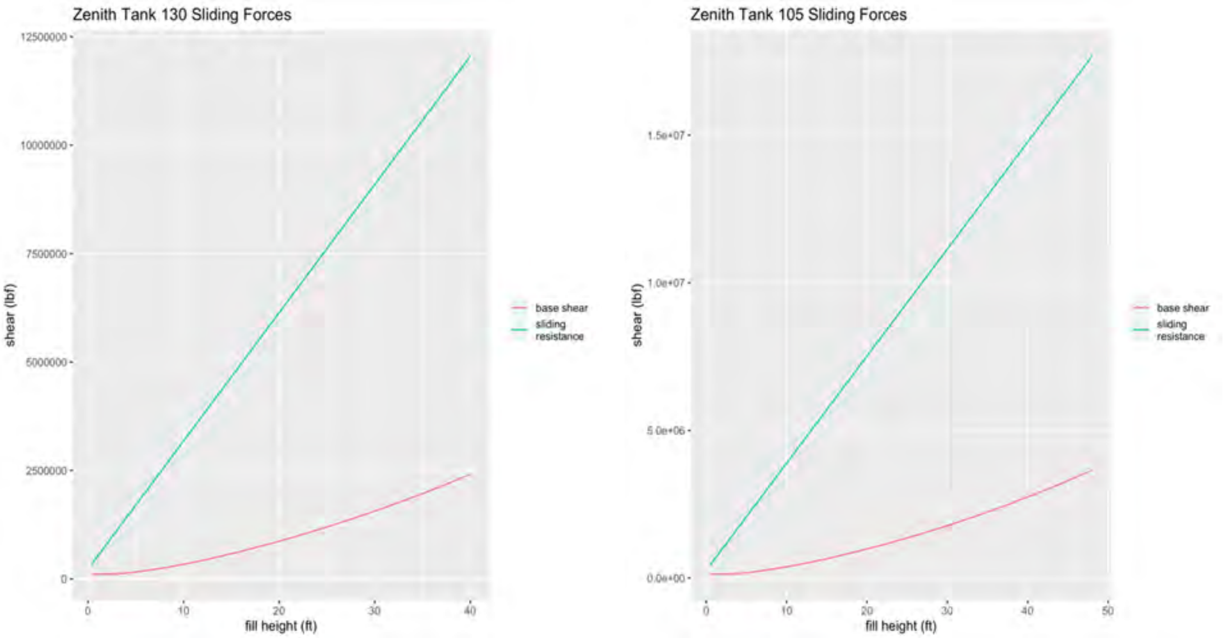
Figure 8. Tensile/Hoop stress vs. fill height at 25%, 50%, and 100%

Additionally, hoop stresses in each course are examined for specific fill heights at 25%, 50%, and 100%. The result is illustrated in Figure 8 to confirm the stresses being well below allowable hoop stress (27540 psi) at the specified fill heights.

Based on the plots, all stresses are within acceptable limits. Compressive stresses due to overturning are well below the allowable levels. Tensile hoop stresses caused by horizontal and vertical acceleration are also below the allowable levels.

Sliding force

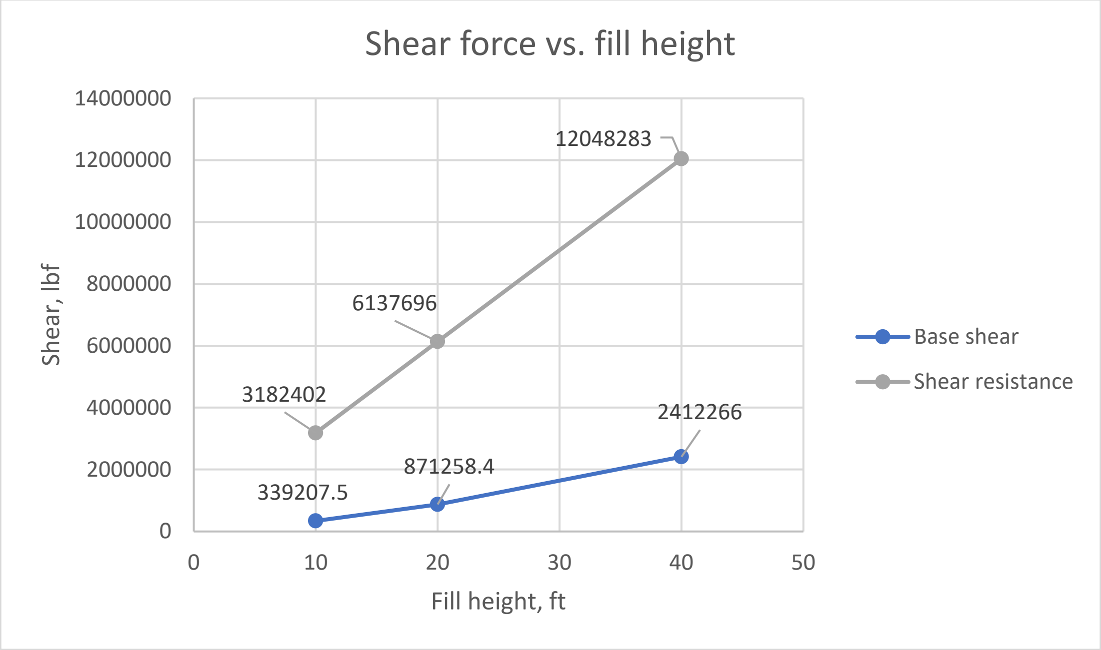
The sliding force plots (Figure 9) give the base shear (the red line) and the sliding resistance due to friction (the blue line). If the base shear is greater than the sliding resistance, it is likely the tank will slide non-negligibly with the design seismic accelerations. However, the calculations show both Tank 130 and Tank 105 would not experience a base shear force greater than their sliding resistances; therefore, they are not expected to slide with any fill height.



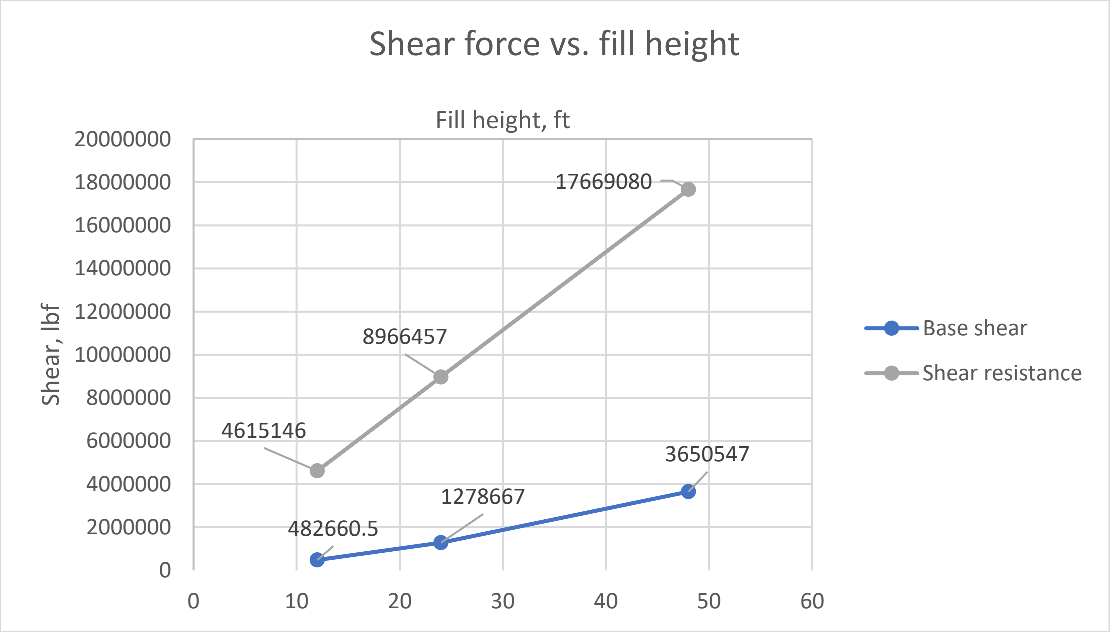
a. Tank 130 b. Tank 105

Figure 9. Sliding force vs. fill height

To have a more detailed examination of sliding force, Figure 10 shows the sliding forces of each tank at fill heights of 25%, 50%, and 100%. Again, the shear forces are well below the shear resistance, confirming that the tanks will not slide under the design earthquake.



a. Tank 130, fill heights at 10 ft, 20 ft, and 40 ft

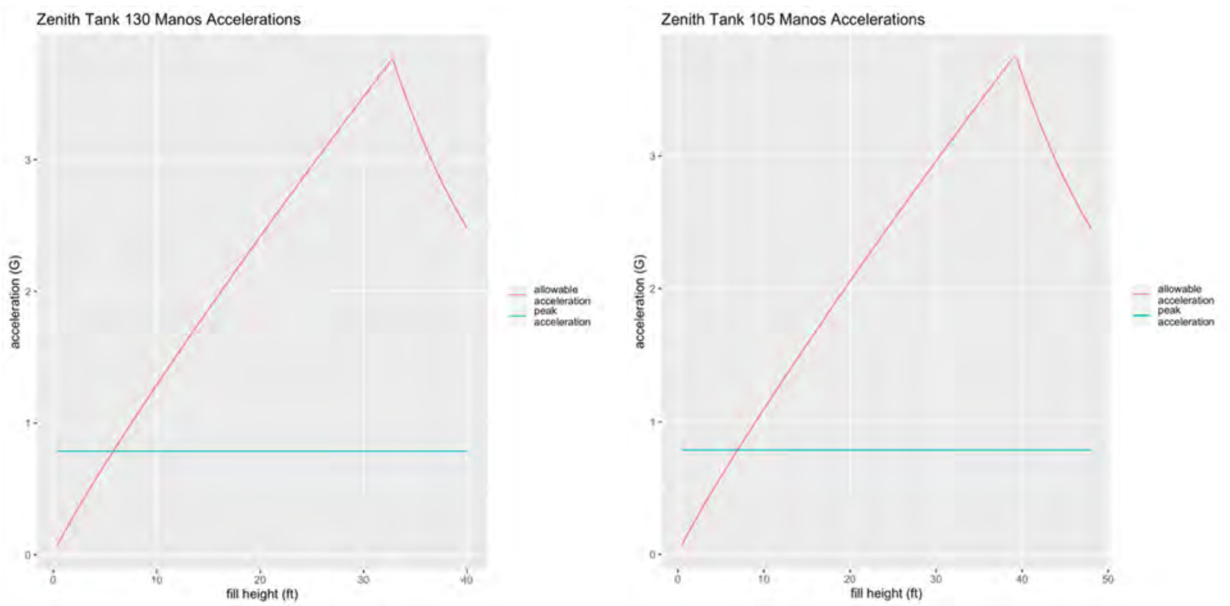


b. Tank 105, fill heights at 12 ft, 24 ft, and 48 ft

Figure 10. Sliding force vs. fill height at 25%, 50% and 100%

Manos method

The Manos seismic risk methodology is concerned with tank overturning and shell buckling, just like the anchorage ratio method of API 650. However, instead of calculating the overturning directly, the Manos method calculates the acceleration required to cause this shell failure and the acceleration experienced by the tank with given tank and site properties. The plots in Figure 11 show the amount of acceleration required to cause the tanks to fail (in red) and the peak seismic acceleration experienced by the tanks (in green). The acceptable fill heights are those where the peak acceleration is below the allowable acceleration.



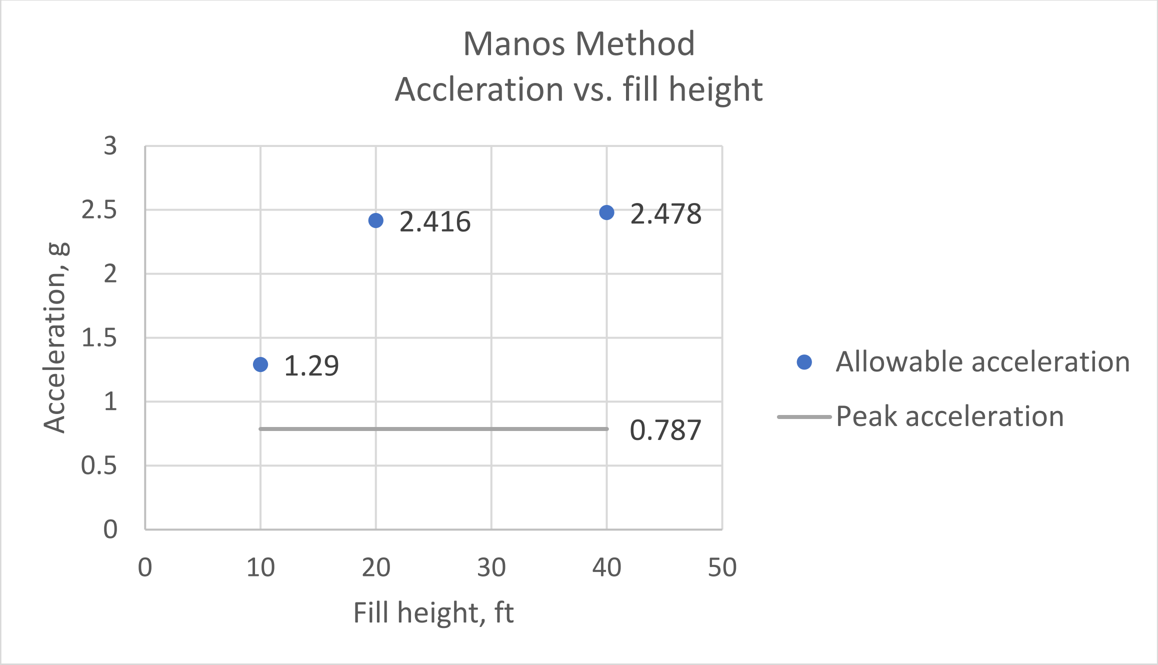
a. Tank 130

b. Tank 105

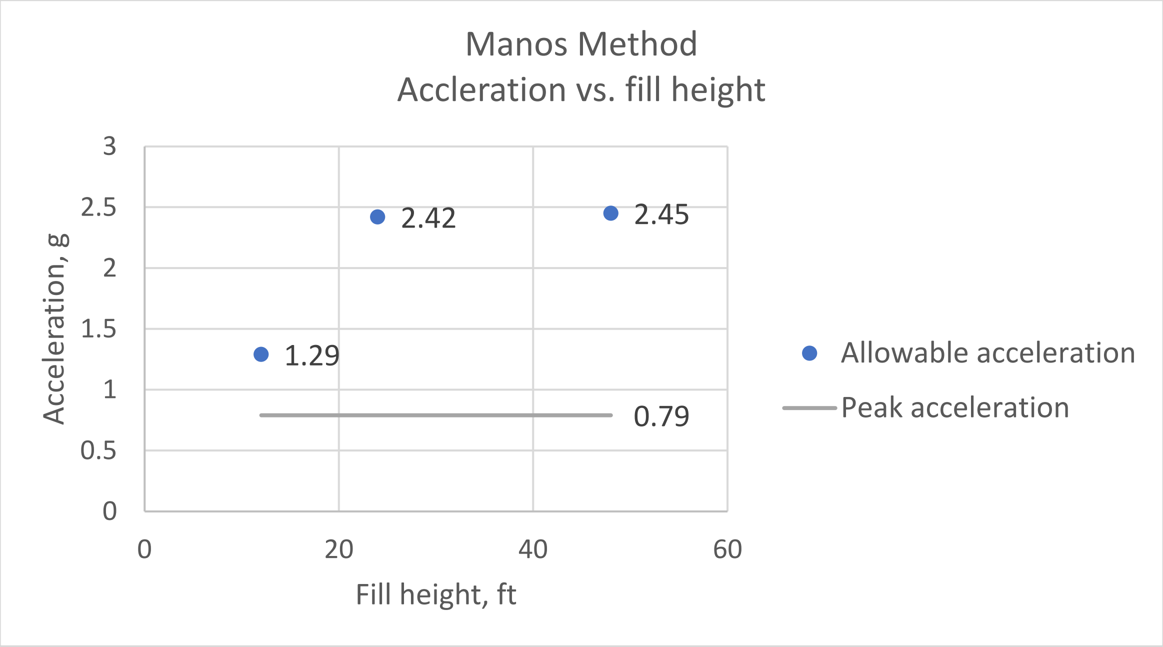
Figure 11. Manos method—acceleration vs. fill height

Both tanks meet the Manos criteria for all shell heights. Even though the acceleration line crosses the allowable acceleration values at low fill heights, it should be obvious that it is safe to operate the tanks at these low fill height ranges.

Also, the fill heights at 25%, 50%, and 100% are examined in Figure 12 to show the allowable accelerations (blue dots) at those specific fill heights being above the peak acceleration (grey line) that the tanks experience.



a. Tank 130, fill heights at 10 ft, 20 ft, and 40 ft.



b. Tank 105, fill heights at 12 ft, 24 ft, and 48 ft.

Figure 12. Manos method—acceleration vs. fill height at 25%, 50%, and 100%

Freeboard calculation

Because both tanks have a calculated maximum safe fill height equal to their maximum shell heights, it is necessary to consider sloshing wave height exceeding the top shell, resulting in loss of tank content or damage to the roof structure. The tank seismic calculations assume that sloshing waves will not impact the tank fixed roof. The calculations depend on the presence of a safe amount of freeboard height and will not be valid if the operational height exceeds the recommended freeboard.

API 650 Annex E provides equations to estimate the height of sloshing wave above the product design height and recommended minimum freeboard for different cases of SUG and design spectral acceleration parameters. With SUG I and the design spectral acceleration parameters (S_{DS} and S_{D1}) given in the sections above, the results of sloshing wave height and recommended freeboard are summarized in Table 4.

Table 4. Sloshing wave height and recommended freeboard per API 650 Annex E

	Tank 130	Tank 105
Sloshing wave height	3.77 ft	3.9 ft
Recommended freeboard	2.64 ft	2.73 ft

In order to accommodate sloshing waves without spillage or the waves impacting the fixed roofs, the maximum liquid level shall be 37.36 ft for Tank 130 and 45.27 ft for Tank 105.

As provided from the terminal, Tank 130’s maximum liquid fill height is 35’-6’’ while its shell height is 40’. Meanwhile, Tank 105’s maximum liquid fill height is 43’-4’’ while its shell height is 48’. Therefore, with these maximum operating liquid levels, both tanks will meet the requirement of freeboard recommended by API 650 Annex E.

Piping Inspection

In addition to the seismic analysis, we have looked at the piping systems at the terminal to evaluate the risk of breaking piping. During an earthquake, soil liquefaction can occur and cause the tanks to settle. The photos taken from the terminal show that some piping systems attached to the two tanks have supports adjacent to the nozzles. This can cause damage to the piping or tank nozzles when the tanks settle about 1ft during liquefaction. Details of the photos are shown in Figure 13 and 14.

(a) (b) (c)

Figure 13. Tank 130 (black tank) and the attached piping system.

(a) The piping system attached to Tank 130 with supports under the pipes.
(b) A side view of the piping system of Tank 130.
(c) A closer view of Tank 130 with attached piping and support.

Figure 14. Tank 105 and the attached piping system.

Conclusions

The seismic analyses of the two tanks are based on the rules of the ASCE 7-16 standards, which is used by the 2019 Oregon Structural Specialty Code and API 650 Annex E. The Oregon Structural Specialty Code is the building code that was recently adopted by the State of Oregon and the City of Portland. Therefore, it is certain that the analysis in this report is in compliance with the governing design codes of the City of Portland and the State of Oregon.

These analyses indicate that both Tank 130 and Tank 105 are well within safe limits for general structural stability under the scenario earthquake with the tanks completely filled with a liquid less than or equal to the specific gravity of water. The two tanks are stable against overturning moment and sliding force resulting from the design ground motion. Compressive and tensile stresses in both tanks are acceptable under the seismic loads.

In addition, it is recommended to set overfill levels for both tanks based on the lower of API 2350 4th edition and sloshing wave height calculated in the report. Although the two tanks' structures would be stable under the scenario earthquake, filling up the tanks without setting freeboards would result in the case of sloshing waves exceeding the top shell, damaging the roof structures and losing the tank content.

References

1. The American Petroleum Institute Standard 650, Welded Tanks for Oil Storage. Twelfth Edition © 2013 American Petroleum Institute.
   Addendum 1, September 2014
   Addendum 2, January 2016
   Errata 1, July 2013
   Errata 2, December 2014
2. The American Society of Civil Engineers Standard, Minimum Design Loads and Associated Criteria for Buildings and Other Structures. 7-16 Edition © 2017 American Society of Civil Engineers.
3. Manos, George C., "Earthquake Tank-Wall Stability of Unanchored Tanks", American Society of Civil Engineers, Journal of Structural Engineering, Vol. 112, No. 8, August 1986.

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SEISMIC RISK ASSESSMENT

Zenith Portland Terminal – Tanks 63 and 127
5501 NW Front Avenue
Portland, Oregon

For
Zenith Energy Management LLC
July 14, 2022

Project: Zenith-3-01

July 14, 2022

Zenith Energy Management LLC
5501 NW Front Avenue
Portland, OR 97210

Attention: Dana Love

Seismic Risk Assessment
Zenith Portland Terminal – Tanks 63 and 127
5501 NW Front Avenue
Portland, Oregon
Project: Zenith-3-01

NV5 is pleased to submit this report that documents our seismic risk assessment of Tank 63, Tank 127, and the containment dike walls located at the Zenith Portland Terminal in Portland, Oregon. Our services were conducted on accordance with our proposal dated October 11, 2021.

We appreciate the opportunity to be of continued service to you. Please contact us if you have questions regarding this report.

Sincerely,

NV5

Brett A. Shipton, P.E., G.E.
Principal Engineer

cc: Dirk Kramer, Zenith Energy Management LLC (via email only)

TAP:BAS:kt
Attachments
One copy submitted (via email only)
Document ID: Zenith-3-01-071422-geor.docx

EXECUTIVE SUMMARY

This report presents the results our seismic risk assessment of Tank 63, Tank 127, and the containment walls at the Zenith bulk fuel terminal located at 5501 NW Front Avenue in Portland, Oregon, within the Oregon Critical Energy Infrastructure (CEI) Hub. The study included a geotechnical investigation of the site and structural assessment of the walls and tanks. The study was conducted using the provisions in the 2019 SOSSC and API 650 Annex E “Seismic Design for Storage Tanks.” Both of these documents refer to the ASCE 7-16 Standard. The seismic events used in this risk assessment and structural review include “The Big One,” a magnitude 9.0 earthquake that could occur on the CSZ where the Juan de Fuca Plate is being subducted beneath the North American Plate. It also considered all other regional and local events, included in USGS’s fault database that could affect the facility.

The structural evaluation of the concrete containment walls was conducted by KPFF Consulting Engineers and a structural evaluation of Tanks 63 and 127 was conducted by PEMY Consulting, LLC. A summary of the findings is presented below.

- Tank 63 and Tank 127 are within safe limits for structural integrity when evaluated to local and regional seismic events including those earthquake sources associated with the CSZ.
- Tank 63 and Tank 127 being built to a code predating the introduction of Annex E “Seismic Design for Storage Tanks” are found to perform well when compared to updated design codes and computer modeling.
- Liquefaction-induced settlement is computed to be approximately 8 inches under design levels of ground shaking. Differential settlement of one-half the total predicted settlement (approximately 4 inches) and is expected over a distance of 50 feet. This is of low risk to large-diameter storage tank and similar large structures.
- Lateral spreading is not considered a site hazard.
- The earthen dike walls meet the recommended factors of safety under static, seismic, and post-seismic conditions.
- The concrete containment walls are expected to perform well during shaking and following shaking, while supporting liquids. Cantilever concrete walls will adequately contain liquid to within 1 foot to 1.5 feet from the top of the walls and the gravity walls will adequately contain liquids to the top of the walls.
- Differential settlement across the site could cause vertical cracking along the concrete containment walls, but will not cause overall wall failure. Slow seepage of product may occur through the cracks.
- The existing shallow foundation system of Tanks 63 and 127 appears to be adequate under seismic conditions, although some liquefaction-induced settlement is expected. Deep foundations that consist of piling are not required to meet the requirements of the 2019 SOSSC, API 650 Annex E, and the ASCE 7-16 Standard.
- Both tanks are suitable for service, with exception of the freeboard height for Tank 127 for sloshing waves, which is a minimal reduction from a fill height of 38.5 to 37.09 feet. Please refer to the PEMY report presented in Appendix E for a detailed description.

TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDICES (continued)

ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BGS	below ground surface
CPT	cone penetration test
CRBG	Columbia River Basalt Group
CSZ	Cascadia subduction zone
fps	feet per second
g	gravitational acceleration (32.2 feet/second^2)
H:V	horizontal to vertical
km	kilometers
MCE	maximum considered earthquake
MCE_R	risk-targeted maximum considered earthquake
mm	millimeter
PGA_M	maximum considered earthquake geometric mean peak ground acceleration adjusted for site effects
SOSSC	State of Oregon Structural Specialty Code
SPT	standard penetration test
USGS	U.S. Geological Survey
Vs_{30}	shear wave velocity for the upper 100 feet (30 meters)

1.0 INTRODUCTION

The Zenith Portland Terminal is a 31.3-acre bulk fuel terminal located at 5501 NW Front Avenue in Portland Oregon. The terminal is occupied by numerous storage tanks and buildings. This study focuses on Tank 63, Tank 127, and the containment walls. Figure 1 shows the site location relative to existing physical features. Figure 2 shows the location of Tank 63, Tank 127, and the containment walls.

The containment walls consist of either cantilever concrete retaining walls or earthen embankments. The earthen dike walls are generally 3 to 4 feet tall with slopes inclined between 2H:1V and 4H:1V. The concrete walls are up to 6.5 feet tall, and the earthen embankments are up to 4 feet tall.

Tank 63 is a 45-foot-tall, 144-foot-diameter, floating roof storage tank with a capacity of approximately 132,371 bbls, or 5,559,582 gallons, originally constructed in 1941. Tank 127 is a 40-foot-tall, 60-foot-diameter, fixed-roof storage tank with a capacity of approximately 20,000 bbls, or 840,000 gallons, which was originally constructed in 1965.

This report documents NV5's geotechnical seismic analysis for use in assessing the structures. A structural evaluation of the concrete containment walls was conducted by KPFF Consulting Engineers (KPFF), the earthen containment walls were evaluated by NV5, and a structural evaluation of Tanks 63 and 127 was conducted by PEMY Consulting, LLC (PEMY). Those studies are presented in the appendices of this report.

Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents. All elevations included in this report are relative to City of Portland datum.

2.0 SCOPE OF SERVICES

NV5 conducted a seismic geotechnical analysis for use in assessing the structures. Structural evaluations of the containment dike walls and the tanks were conducted KPFF and PEMY, respectively. The scope of services completed by NV5 is presented as follows:

- Reviewed readily available, published geologic data and our in-house files for existing information on subsurface conditions in the site vicinity and our previous explorations at nearby surrounding sites.
- Explored subsurface conditions by conducting two CPTs near the proposed tanks to depths between 53.2 and 76.3 feet BGS at the locations shown on Figure 2.
- Assessed the following seismic hazards:
  - Surface fault rupture
  - Liquefaction and lateral spreading
  - Ground shaking and ground motion amplification
- Provided a site response spectrum for use in computing seismic forces on the tanks and containment dike walls in accordance with the 2019 SOSSC and ASCE 7-16.
- Prepared this report that documents our findings. The findings of KPFF and PEMY are presented in the appendices of this report.

3.0 SITE DESCRIPTION

3.1 GEOLOGIC CONDITIONS

The Portland-Vancouver metropolitan area is situated within the Puget-Willamette Trough physiographic province, a north-south structural basin lying between the Coast Ranges to the west and the Cascade Range to the east. The Zenith Portland Terminal is located in the extreme western part of the Portland Basin physiographic province. The Portland Basin, a major component of the Willamette Trough, is a subsided lowland formed through northeast-directed compression due to large-scale plate movement and subduction and right-lateral extension along a series of faults reaching from central Oregon, across the Cascades, and into the lower Willamette Valley (for general discussion see Burns, 1998; Orr and Orr, 1999).

The site is located northeast of the Tualatin Mountains, an uplifted block of Columbia River Basalt on the southwestern edge of the Portland Basin. The soil underlying the site is primarily recent alluvial deposits of the Willamette River and dredged fill material placed early in the twentieth century. The fill generally consists of dredged sand from the Columbia and Willamette rivers.

3.2 SURFACE CONDITIONS

The Zenith Portland Zenith Terminal is in Portland's Northwest Industrial area. The 31.3-acre bulk fuel terminal is bound by NW Doane Avenue to the northwest, NW Front Avenue to the northwest, railroad track to the southwest, and NE St. Helens Road further to the southwest. Figure 2 shows the site location relative to existing physical features. Industrial buildings are located southeast of the terminal. The terminal is occupied by numerous aboveground storage tanks and buildings. The site is essentially flat.

3.3 SUBSURFACE CONDITIONS

Our knowledge of site subsurface conditions is based on two CPTs (CPT-1 and CPT-2) and previous on-site explorations at the approximate locations shown on Figure 2. The CPT logs are presented in Appendix A. The exploration logs and results of laboratory testing from our previous explorations are presented in Appendix B. The site generally consists of fill underlain by alluvium. The following sections provide a detailed description of the subsurface conditions.

3.3.1 Fill

Fill was encountered to depths of approximately 13 and 27 feet BGS in CPT-1 and CPT-2, respectively. The fill generally consists of silty/clayey sand or sandy silt/clay. SPTs and CPT results show that the silty/clayey sand varies in relative density between loose and medium dense and the sandy silt/clay is generally medium stiff.

3.3.2 Alluvium

Alluvium that consists of silt and clay with interbeds of sand underlies the fill to depths of 53.2 and 76.3 feet BGS in CPT-1 and CPT-2, respectively. Tip and shaft resistance shows that the alluvium varies between very soft and stiff.

3.3.3 Basalt Bedrock

Bedrock was encountered underlying the alluvium in all explorations to the maximum depths explored. From geotechnical explorations conducted for this study and from previous geotechnical investigations, bedrock is encountered between 69 and 78.5 feet.

3.3.4 Groundwater

Groundwater was measured at approximately 17 feet BGS using a pore pressure dissipation test. Prior explorations at the terminal encountered groundwater at a depth of 15 feet BGS. This is consistent with our experience in the site vicinity and our pore pressure dissipation test results.

4.0 SEISMIC HAZARDS

We conducted a seismic hazard assessment for use in evaluation of Tank 63, Tank 127, and the containment dike walls. The provisions of the 2019 SOSSC were used to assess the tanks and walls. The 2019 SOSSC refers to ASCE 7-16 for seismic design. Seismic design of petroleum tanks is typically conducted using Annex E of the API 650 Standard. The 12th edition of API 650 was current at the time of this report. API 650 also refers to the ASCE 7-16 Standard for seismic design.

4.1 SEISMIC SOURCES

4.1.1 Earthquake Source Zones

Three scenario earthquakes were considered for this study consistent with the local seismic setting. Two of the possible earthquake sources are associated with the CSZ, and the third event is a shallow, local crustal earthquake that could occur in the North American Plate. The three earthquake scenarios are discussed below.

4.1.2 Regional Events

The CSZ is the region where the Juan de Fuca Plate is being subducted beneath the North American Plate. This subduction is occurring in the coastal region between Vancouver Island and northern California. Evidence has accumulated suggesting that this subduction zone has generated eight great earthquakes in the last 4,000 years, with the most recent event occurring approximately 300 years ago (Weaver and Shedlock, 1991). The fault trace is mapped approximately 50 to 120 km off the Oregon Coast. Two types of subduction zone earthquakes are possible and considered in this study:

1. An interface event earthquake on the seismogenic part of the interface between the Juan de Fuca Plate and the North American Plate on the CSZ. This source is reportedly capable of generating an earthquake with a moment magnitude of 9.0.
2. A deep intraplate earthquake on the seismogenic part of the subducting Juan de Fuca Plate. These events typically occur at depths of between 30 and 60 km. This source can generate an earthquake with a moment magnitude of up to 7.5.

Although a deep intraplate event can generate an earthquake with a magnitude of 7.5, ground shaking intensity will be controlled by an event on the Portland Hill fault even though it is only capable of generating a 6.8 to 7.0 magnitude earthquake. This is because of its proximity to the site and depth below ground surface. Shaking duration for CSZ interface is expected to be the longest. This study is based on USGS's probabilistic maps and considers all of these sources: crustal events, the CSZ deep intraplate event, and the CSZ interface event.

4.1.3 Local Events

A significant earthquake could occur on a local fault near the site within the design life of the facility. Such an event would cause ground shaking at the site that could be more intense than the CSZ events, although the duration would be shorter. Figure 3 shows the locations of mapped Quaternary faults within a 30-km radius of the terminal. Figure 4 shows the interpreted locations of recent seismic events (USGS, 2019). The three closest mapped faults to the site are the Portland Hills fault, East Bank fault, and Oatfield fault. A discussion of these faults is provided below. Table 1 lists the fault length and distance to the site.

Table 1. Closest Mapped Crustal Faults

Source	Closest Mapped Distance[1] (km)	Mapped Length[1] (km)
Portland Hills fault	< 0.5	49
East Bank fault	1.1	29
Oatfield fault	2.4	24

1. Reported by USGS (USGS, 2019)

4.1.3.1 Portland Hills Fault

The northwest-striking Portland Hills fault forms the prominent linear northeastern margin of the Tualatin Mountains (Portland Hills) and the southwestern margin of the Portland Basin; this basin may be a right-lateral, pull-apart basin in the forearc of the CSZ or a piggyback synclinal basin formed between antiformal uplifts of the Portland fold belt. The fault is part of the Portland Hills-Clackamas River structural zone, which controlled the deposition of Miocene CRBG lavas in the region. The crest of the Portland Hills is defined by the northwest-striking Portland Hills anticline. Sense of displacement on the Portland Hills fault is poorly known and controversial. The fault was originally mapped as a down-to-the-northeast normal fault. The fault has also been mapped as part of a regional-scale zone of right-lateral, oblique-slip faults and as a steep escarpment caused by asymmetrical folding above a southwest-dipping blind thrust. Reverse displacement with a right-lateral, strike-slip component may be most consistent with the tectonic setting, mapped geologic relations, aeromagnetic data, and microseismicity in the area. Fault scarps on surficial Quaternary deposits have not been described along the fault trace, but some geomorphic (steep, linear escarpment, triangular facets, over-steepened, and knick-pointed tributaries) and geophysical (aeromagnetic, seismic reflection, and ground penetrating radar) evidence suggest Quaternary displacement (Personius, 2017). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

4.1.3.2 East Bank Fault

The northwest-striking East Bank fault lies in the Portland Basin, which may be a right-lateral, pull-apart basin in the forearc of the CSZ; the fault lies a few kilometers east of and is parallel to the Portland Hills fault, which forms the southwestern margin of the basin. The East Bank fault has been mapped as a high-angle, normal fault with a down-to-the-southwest displacement direction, but down-to-the-northeast reverse displacement with a right-lateral, strike-slip component is consistent with tectonic setting, mapped geologic relations, aeromagnetic data, and microseismicity in the area. Fault scarps on surficial Quaternary deposits have not been described along the fault trace, and the fault is mapped as buried by latest Pleistocene Missoula flood deposits, but recently acquired shallow seismic-reflection suggest probable down-to-the-northeast offset of unconformities, paleochannels, and sediments associated with flood deposits at several locations across the East Bank fault (Personius, 2002). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

4.1.3.3 Oatfield Fault

The northwest-striking Oatfield fault forms northeast-facing escarpments in volcanic rocks of the Miocene CRBG in the Tualatin Mountains and northern Willamette Valley. The fault may be part of the Portland Hills-Clackamas River structural zone. The Oatfield fault is primarily mapped as a very high-angle, reverse fault with apparent down-to-the-southwest displacement, but a few kilometer-long reach of the fault with down-to-the-northeast displacement is mapped in the vicinity of the Willamette River. This apparent change in displacement direction along strike may reflect a discontinuity in the fault trace or could reflect the right-lateral, strike-slip displacement that characterizes other parts of the Portland Hills-Clackamas River structural zone. The fault has also been modeled as a 70-degree, east-dipping reverse fault. Reverse displacement with a right-lateral, strike-slip component is consistent with the tectonic setting, mapped geologic relations, and microseismicity in the area. Fault scarps on surficial deposits have not been described, but exposures in a light rail tunnel showing offset of approximately 1 Ma Boring Lava across the fault indicate Quaternary displacement (Personius, 2002). USGS reports that this fault has a slip rate of less than 0.2 mm per year.

5.0 SITE RESPONSE ANALYSIS

Local soil conditions influence the characteristics of earthquake ground shaking and these effects must be considered when estimating ground shaking levels for seismic design. These effects are quantified by conducting a site response analysis, which involves the propagation of earthquake motions from the base rock through the overlying soil layers to the ground surface. We determined a base rock spectrum using the USGS Unified Hazard Tool. We scaled ground motions to match the base rock spectrum. We constructed a soil column based on the subsurface conditions encountered in the CPTs and propagated the ground motions to the ground surface using the DEEPSOIL application. Two soil columns were considered as the depth to bedrock varied in each CPT. The depth to bedrock is 53 and 76 feet BGS in CPT-1 and CPT-2, respectively. We discuss this process in more detail and present the results of our analysis below.

5.1 RISK-TARGETED BEDROCK SPECTRUM

We obtained a probabilistic target bedrock spectrum to which ground motions can be scaled to prior to running a site response analysis through the overlying soil column. We determined the spectral accelerations for the outcropping bedrock response spectrum for periods ranging from 0 to 5 seconds from the USGS Unified Hazard Tool using the Dynamic: Conterminous U.S. 2014 model (v4.2.0). We determined the spectral accelerations for periods ranging from 0 to

5 seconds for a return period of 2 percent in 50 years. The response spectrum is consistent with a shear wave velocity equal to 760 meters per second in the upper 30 meters of the soil profile.

The maximum direction was adopted as the ground motion intensity parameter for use in lieu of explicit consideration of directional effects. The maximum horizontal response may be estimated by factoring the average response period by period-dependent factors. The commentary to ASCE 7-16 recommends a factor of 1.1 at periods less than 0.2 second, 1.3 at a period of 1 second, and 1.5 at 5 seconds and greater. We used linear interpolation to compute factors at periods greater than 0.2 second.

The risk-targeted bedrock spectrum, MCE_R, target bedrock spectrum was computed using Method 1 outlined in ASCE 7-16 Section 21.2.1.1 to achieve a 1 percent probability of collapse in a 50-year period. A risk coefficient of C_{RS} = 0.891 was applied to the spectrum at periods of 0.2 second or less and a risk coefficient of C_{R1} = 0.871 was applied to the spectrum at periods greater than 1 second. Linear interpolation was used to compute risk coefficients between periods of 0.2 and 1.0 second. Figure 5 shows the target bedrock spectrum. Table 2 provides a summary of values used to compute the MCE_R target bedrock response spectrum.

Table 2. Risk-Targeted Bedrock Spectrum

Period (seconds)	MCE Target Bedrock Spectral Acceleration (g)	Maximum Direction Factor	C_R	MCE_R Target Bedrock Spectral Acceleration (g)
0.0	0.432	1.10	0.891	0.423
0.1	0.923	1.10	0.891	0.905
0.2	0.955	1.10	0.891	0.936
0.3	0.785	1.13	0.890	0.786
0.5	0.564	1.18	0.888	0.588
0.8	0.345	1.30	0.882	0.395
1.0	0.190	1.55	0.871	0.257
2.0	0.124	1.40	0.871	0.152
3.0	0.092	1.45	0.871	0.116
4.0	0.069	1.50	0.871	0.090
5.0	0.432	1.10	0.891	0.423

5.2 BASE GROUND MOTIONS

Six recorded base ground motions were selected to represent the local seismic setting. We considered faulting mechanism, magnitude, and distance to recording station. Ground motions at the site are controlled by a crustal event and the CSZ interface event. We selected two acceleration time histories to represent the crustal seismic sources and four acceleration time histories to represent the CSZ seismic sources as input for the seismic response analysis. Table 3 lists the ground motions selected for this study.

Table 3. Selected Ground Motions

Ground Motion/Recording Station	Magnitude	Distance (km)	Component
Crustal Records			
Imperial Valley 1979/Delta	6.53	22.0	262
Kobe 1995/Abeno	6.9	24.9	000
CSZ Records			
Tohoku 2011/Tsukuba City Hall	9.0	106.9	004
Arequipa 2001/MOQ	8.4	60.0	000
Maule 2010/Santiago Puente Alto	8.8	75.0	NS
Maule 2010/Colegio Las Americas	8.8	81.9	NS

5.3 SITE CONDITION MODELING

We determined acceleration response spectra for the postulated scenarios discussed above by performing a site-specific seismic response analysis. A nonlinear seismic site response analysis was conducted. The site response analysis was performed using the DEEPSOIL Version 7.0 application.

The input soil models used in our analysis are based on the findings of our subsurface exploration program and experience in the site vicinity. Since the depth to bedrock varied between the two CPTs, we conducted a response analysis using two soil profiles. Table 4 provides a summary of the soil models used in our analysis. The acceleration response spectra produced by our equivalent linear seismic response analysis is presented on Figure 5.

Table 4. Input Soil Column

Depth Interval (feet BGS)	Subsurface Unit	Shear Wave Velocity (fps)	Modulus Reduction Curve	Damping Curve
0[1] to 20	Fill	482 to 494	Seed and Idriss, 1970 (Mean)	MRDF with Darendeli Reduction Factor
20 to 40	Alluvium	525 to 549	Vucetic & Dobry, 1991 PI: 33	MRDF with Darendeli Reduction Factor
40 to 75	Alluvium	549 to 776	Vucetic & Dobry, 1991 PI: 0	MRDF with Darendeli Reduction Factor
>76	Bedrock	2,400	Not applicable	Not applicable

1. Output at ground surface

A shallower soil profile, with bedrock located at a depth of 53 feet BGS, was also considered but does not produce results significantly different from those with bedrock located at a depth of 76 feet BGS.

5.4 DETERMINISTIC MCE$_R$ RESPONSE SPECTRUM

Since the largest spectral response acceleration of the probabilistic study is less than 1.2 F_a, a deterministic response spectrum is not required. Therefore, the site-specific MCE$_R$ response is the probabilistic MCE$_R$ response spectrum.

5.5 DESIGN RESPONSE SPECTRUM

ASCE 7-16 Section 21.3 states that the site-specific MCER response spectrum is reduced to two-thirds of the acceleration at any period. However, the lower bound for design ground motions is 80 percent of the generalized response spectrum as outlined in ASCE 7-16 Section 11.4.5.

5.6 DESIGN ACCELERATION PARAMETERS

To develop the final design response spectrum, the parameter S_{DS} is taken from the site-specific response spectrum at a period of 0.2 second but should not be smaller than 90 percent of the peak spectral acceleration taken at any period larger than 0.2 second. The parameter S_{D1} is taken as the maximum value of the product, T and SA, for periods from 1 second to 2 seconds for sites with Vs_{30} of greater 1,200 fps and for periods from 1 second to 5 seconds for sites with Vs_{30} smaller than 1,200 fps. Figure 6 shows the design response spectrum.

6.0 GEOLOGIC HAZARDS

In addition to ground shaking, site-specific geologic conditions can influence the potential for earthquake damage. Deep deposits of loose or soft alluvium can amplify ground motions, resulting in increased seismic loads on structures. Other geologic hazards are related to soil failure and permanent ground deformation. Permanent ground deformation could result from liquefaction, lateral spreading, landsliding, and fault rupture. The following sections provide additional discussion regarding potential seismic hazards that could affect the planned facility.

6.1 FAULT SURFACE RUPTURE

Faults are not mapped beneath the property by the USGS Seismic Mapping Project. Consequently, it is our opinion that the probability of surface fault rupture beneath the site is low.

6.2 LIQUEFACTION

Liquefaction is caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. In general, loose, saturated sand soil with low silt and clay content is the most susceptible to liquefaction. Silty soil with low plasticity is moderately susceptible to liquefaction under relatively higher levels of ground shaking. We anticipate 6 to 8 inches of liquefaction-induced settlement at the ground surface near Tank 127 and up to 1 inch of settlement near Tank 63. A differential settlement of one-half of these values can be assumed over a distance of 50 feet.

6.3 LATERAL SPREADING

The closest structure considered in this study is located approximately 800 feet from the west bank of the Willamette River. In our opinion, the risk of lateral spreading should be considered low under design levels of ground shaking.

6.4 GROUND MOTION AMPLIFICATION

Soil capable of significantly amplifying ground motions beyond the levels determined by our site-specific seismic response analysis was not encountered during our subsurface investigation program. We conclude the level of amplification determined by our response analysis is appropriate and the facility can be designed using the levels of ground shaking prescribed by the building codes.

7.0 STRUCTURAL ASSESSMENT

Our assessment of the earthen containment dike walls is provided below, and the result of our analysis is presented in Appendix C. A structural assessment of the concrete containment dike walls was conducted by KPFF and the findings of that study are presented in Appendix D. A structural assessment of Tanks 63 and 127 was conducted by PEMY and the findings of that study are presented in Appendix E.

7.1 EARTHEN CONTAINMENT DIKE WALLS

Earthen dike walls are used as containment walls on portions of the eastern half of the site. During our site visits, we did not observe any evidence of previous failures or cracking.

Stability analysis was completed to determine if existing dike walls meets required factors of safety for static and seismic conditions. Standard of care generally dictates that minimum factors of safety for static and seismic conditions be 1.5 and 1.13, respectively. In addition, analysis was performed assuming a post-seismic condition where the dike walls are fully loaded by the liquids stored in the tanks.

Analysis was completed using SLOPE/W by Geo-Slope International, Ltd. SLOPE/W performs two-dimensional limiting equilibrium analysis to compute slope stability. The factor of safety against slope failure is simplistically defined as the ratio of the forces resisting slope movement (e.g., soil strength, soil mass, etc.) to the forces driving slope movement (e.g., soil weight, water pressure). The program predicts the location and geometry of "critical failures planes." Critical failure planes are the zones with the lowest factors of safety. A factor of safety less than 1.0 infers that the model is not in equilibrium and slope movement is likely to occur.

7.1.1 Geometry and Soil Parameters

The geometry was based on our site walk conducted on December 10, 2021. Based on our observations, the earthen dike walls are between 2 and 4 feet high and the slopes are between 4H:1V and 2H:1V steep on both sides of the walls. The earthen walls are constructed with 1½-inch-minus gravel.

Soil parameters for the earthen embankment are based on experience with similar materials and the parameters for the subgrade soil are based on the results of the nearby CPTs and borings.

A seismic coefficient of 0.155 g (one-third of PGA_M = 0.466 g) was used for the seismic condition under seismic conditions. For the post-seismic fully loaded condition, we assumed the walls will support oil up to the top of the earthen walls. Based on previous analysis, we use a specific gravity of 1 for the fluid being retained by the dike walls.

Soil parameters, loading, and results of the analysis are presented in Appendix C.

7.1.2 Slope Stability Analysis Results

Analysis indicates factors of safety for the static and seismic conditions are above the minimum factors of safety for static, seismic, and post-seismic fully loaded conditions of 1.5, 1.13, and 1.5, respectively. If the wall remains fully loaded for an extended period of time and the contained fluid infiltrates into the dike wall and it saturates the dike walls, shallow failures may be expected. The potential failures will likely be less than 1 foot deep and may occur on the downhill side of the dike wall.

8.0 CONCLUSIONS

Earthen embankment containment walls should remain stable during the static, seismic, and post-seismic conditions. If the spilled liquids are allowed to infiltrate into the embankments shallow slope failures should be expected. The results of our stability analysis are presented in Appendix C.

Concrete containment walls will perform well for both the shaking and post-shaking cases. Failures were not predicted for the shaking case. For the post-shaking case, the cantilever walls are expected to withstand liquid pressures at heights 1 foot to 1.5 feet below the top of the wall. The gravity walls are expected to withstand static liquid lateral pressures equal to their exposed heights. KPFF’s report is presented in Appendix D.

Tanks 63 and 127 are adequate, with exception of the freeboard height when the liquid in the tank is sloshing during the seismic event. In our opinion, a deep foundation system that consists of piling is not required to meet the requirements of the 2019 SOSSC and ASCE 7-16 Standard. PEMY’s report is presented in Appendix E.

9.0 LIMITATIONS

We have prepared this report for use by Zenith Energy Management. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Soil explorations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in this report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

◆ ◆ ◆

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

NV5

Tyler A. Pierce, P.E.
Senior Project Engineer

Brett A. Shipton, P.E., G.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
56207
OREGON
July 11, 2000
BRETT A. SHIPTON
EXPIRES: 6/30/24

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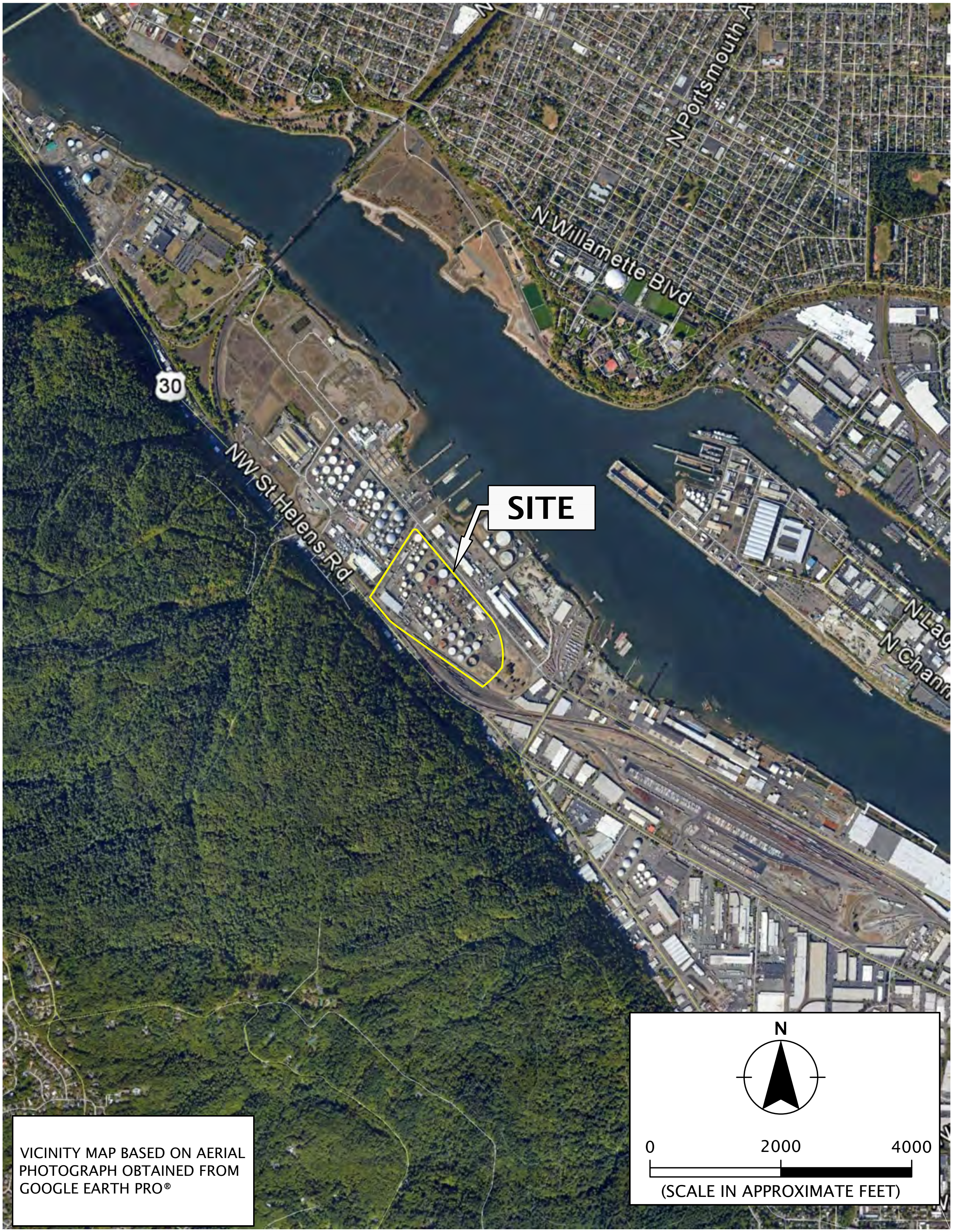
FIGURES

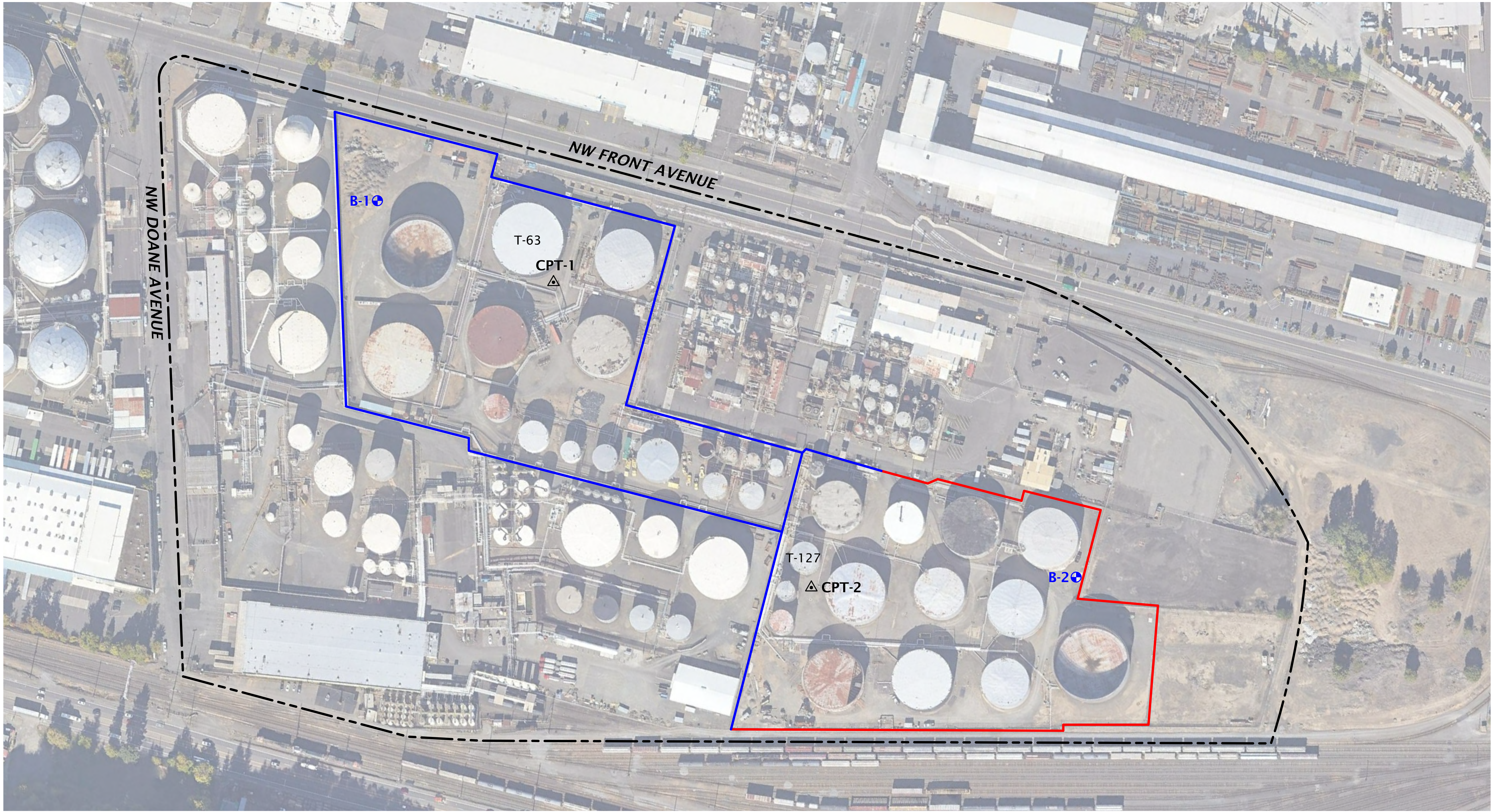


VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

Printed By: aday | Print Date: 7/14/2022 8:59:27 AM
File Name: J:\S-Z\Zenith\Zenith-3\zenith-3-01\Figures\CAD\Zenith-3-01-VM01.dwg | Layout: FIGURE 1

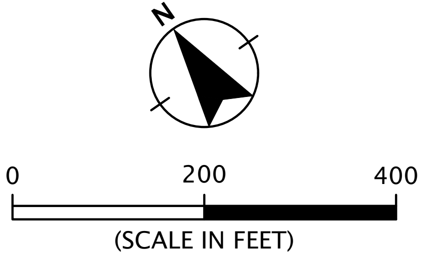
NV5

NV5	ZENITH-3-01	**VICINITY MAP**	
	JULY 2022	ZENITH PORTLAND TERMINAL – TANKS 63 & 127 PORTLAND, OR	**FIGURE 1**



LEGEND:

CPT-1 ◬	CONE PENETRATION TEST
B-1 ⊕	BORING (GEODESIGN, 2020)
— · —	APPROXIMATE SITE BOUNDARY
🟥	EARTHEN CONTAINMENT DIKE WALL
🟦	CONCRETE CONTAINMENT DIKE WALL



SITE PLAN BASED ON AERIAL PHOTOGRAPH
OBTAINED FROM GOOGLE EARTH PRO®,
DECEMBER 30, 2019

FIGURE 2

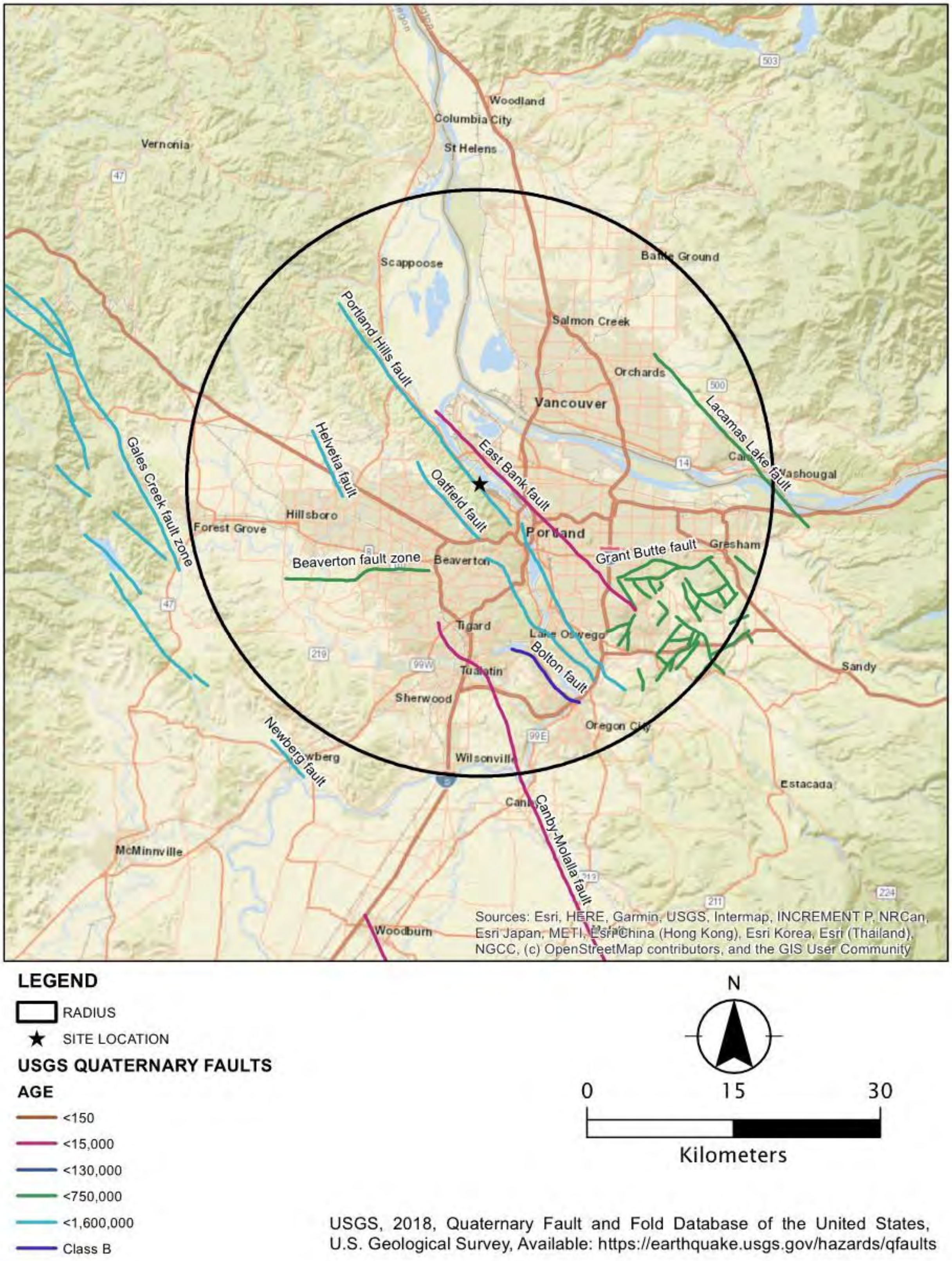
SITE PLAN

ZENITH PORTLAND TERMINAL – TANKS 63 & 127
PORTLAND, OR

ZENITH-3-01

JULY 2022

NV5



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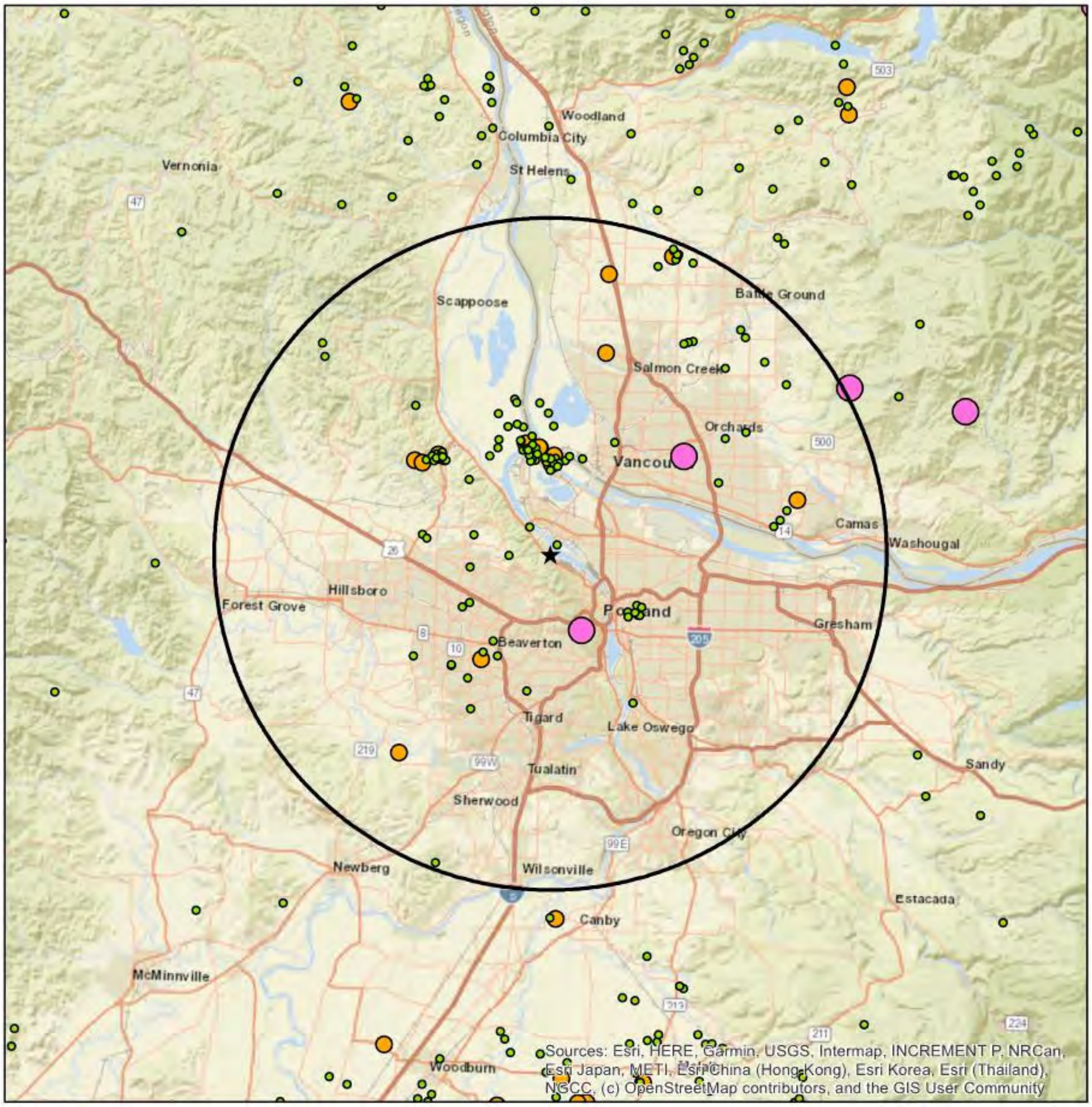
ZENITH-3-01	**QUATERNARY FAULT MAP**	
JULY 2022	ZENITH PORTLAND TERMINAL – TANKS 63 & 127 PORTLAND, OR	**FIGURE 3**



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

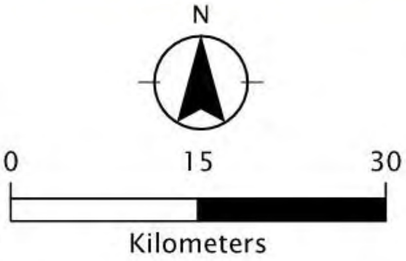
LEGEND

▭ RADIUS

★ SITE LOCATION

INSTRUMENTAL EARTHQUAKE MAGNITUDE

- ● 2.0 - 3.0
- ● 3.0 - 4.0
- ● 4.0 - 6.0
- ● > 6.0



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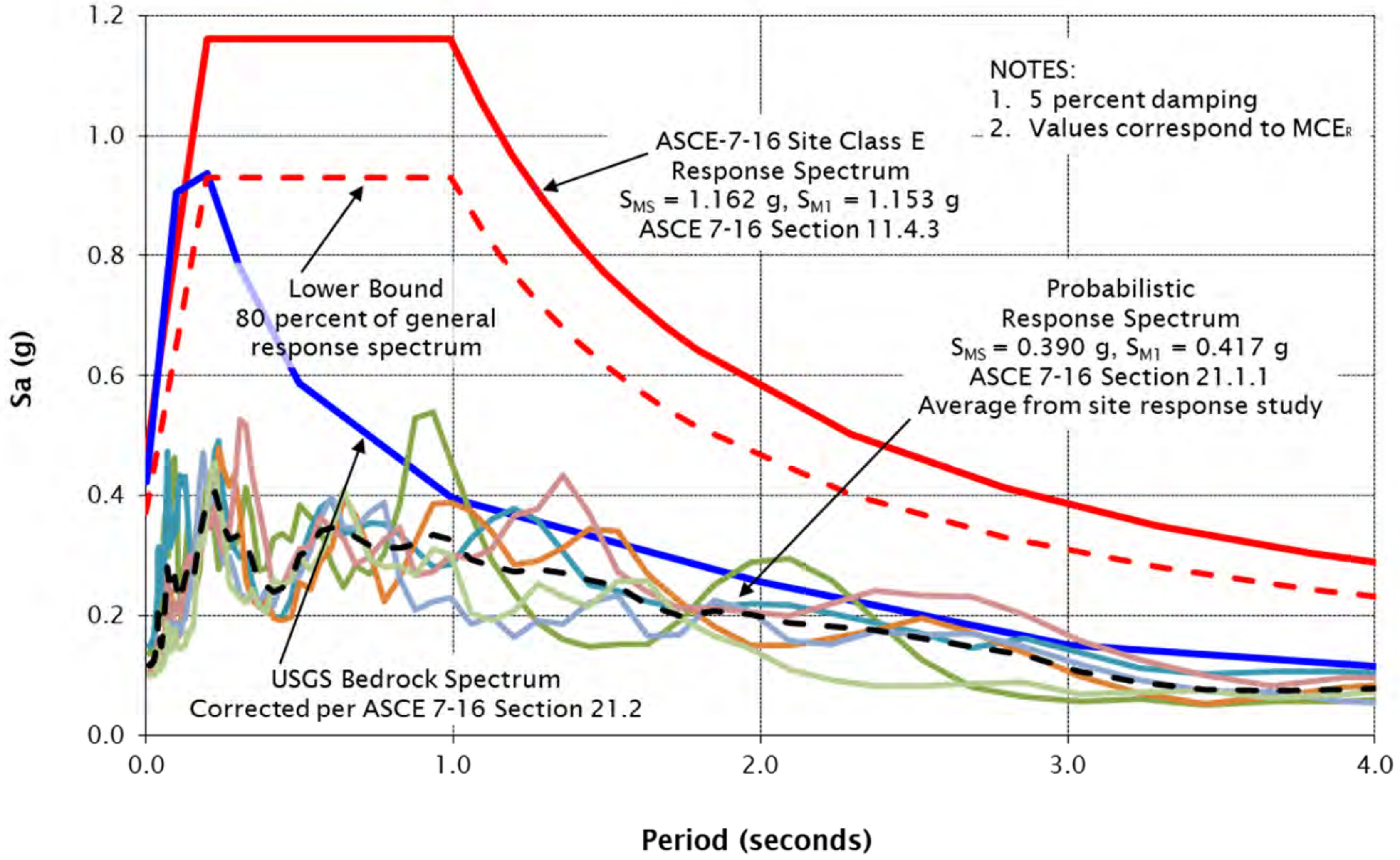
ZENITH-3-01

JULY 2022

HISTORICAL SEISMICITY MAP

ZENITH PORTLAND TERMINAL – TANKS 63 & 127
PORTLAND, OR

FIGURE 4



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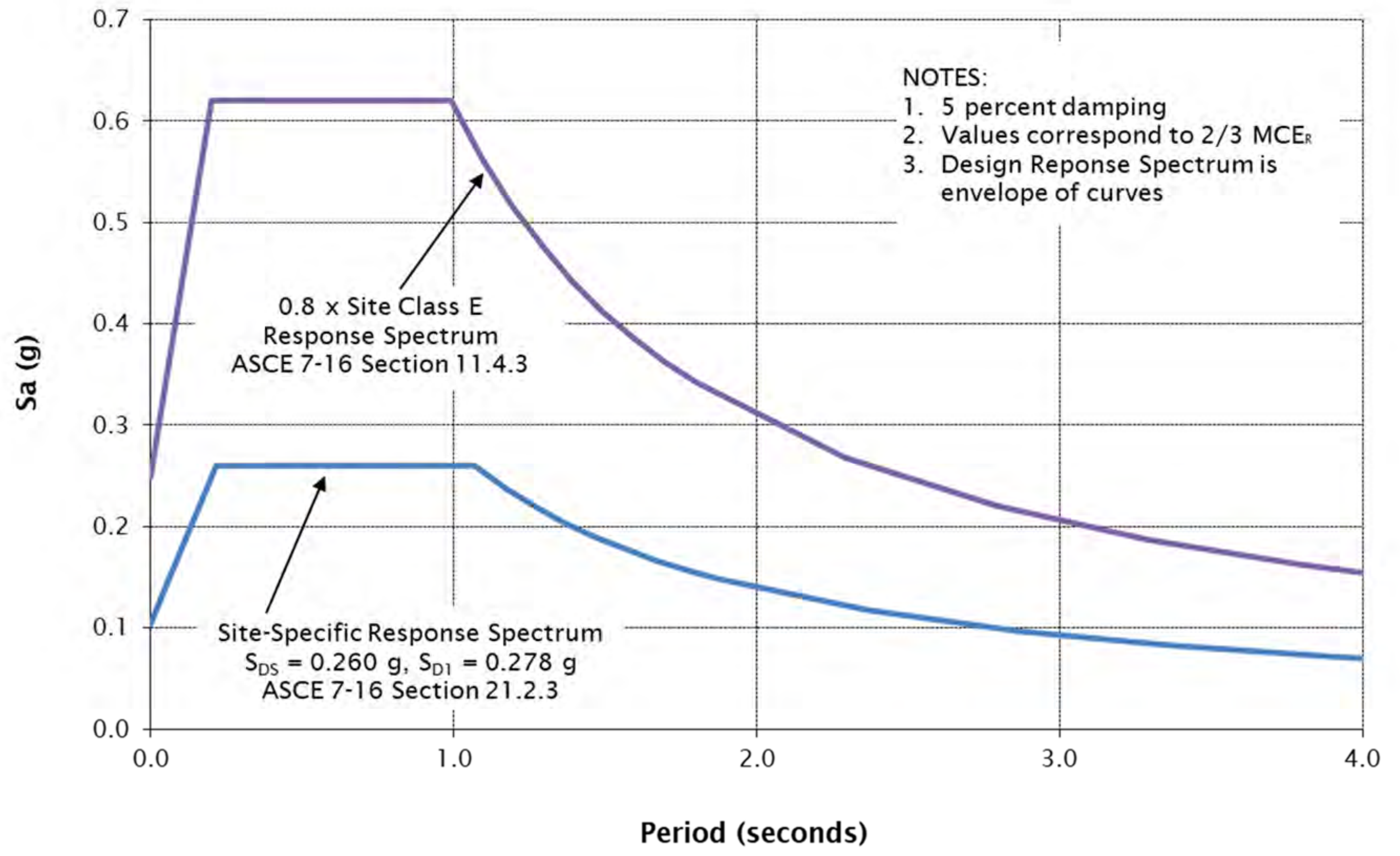
ZENITH-3-01

JULY 2022

SITE RESPONSE SPECTRA

ZENITH PORTLAND TERMINAL – TANKS 63 & 127
PORTLAND, OR

FIGURE 5



NOTES:
1. 5 percent damping
2. Values correspond to 2/3 MCE_R
3. Design Reponse Spectrum is envelope of curves

NV5	ZENITH-3-01	**DESIGN RESPONSE SPECTRUM**
	JULY 2022	ZENITH PORTLAND TERMINAL – TANKS 63 & 127 PORTLAND, OR
		FIGURE 6

APPENDIX A

APPENDIX A

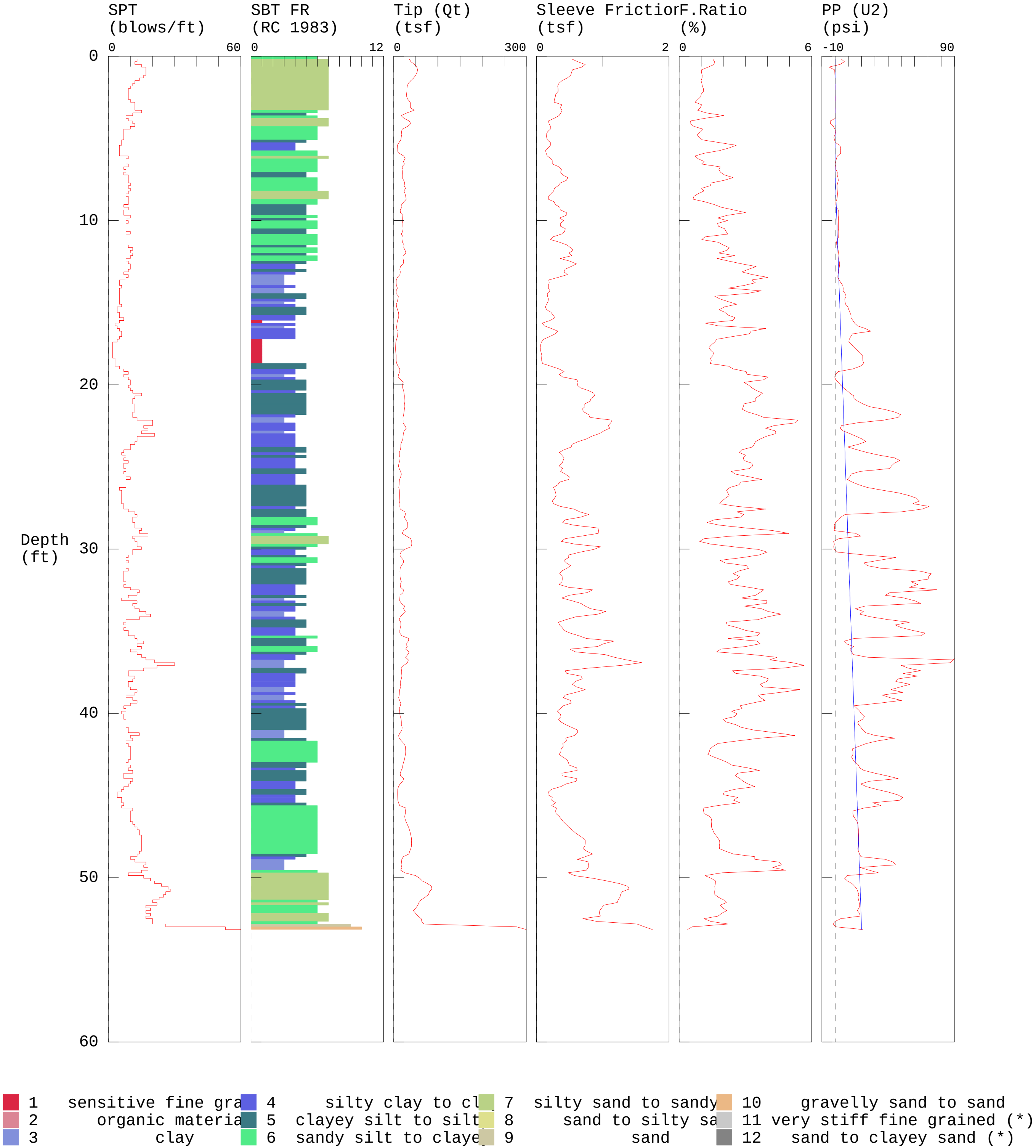
CONE PENETRATION TESTING

The CPTs (CPT-1 and CPT-2) were performed in general accordance with ASTM D5778 by Oregon Geotechnical Explorations, Inc. of Keizer, Oregon on November 23, 2021, at the approximate locations shown on Figure 2. The CPTs were advanced to refusal at depths between from 53.2 to 76.3 feet BGS. The results of the CPTs performed for this project are presented in this appendix.

The CPT is an in-situ test that provides assistance in characterizing subsurface stratigraphy. The test includes advancing a 35.6-millimeter-diameter cone equipped with a load cell, friction sleeve, strain gauges, porous stone, and geophone through the soil profile. The cone is advanced at a rate of approximately 2 centimeters per second. Tip resistance, sleeve friction, and pore pressure are typically recorded at 0.1-meter intervals. At select depths, the CPT advancement can be suspended and pore water dissipation rates measured. Shear wave velocity of the subsurface soil was also measured at 2-meter intervals.

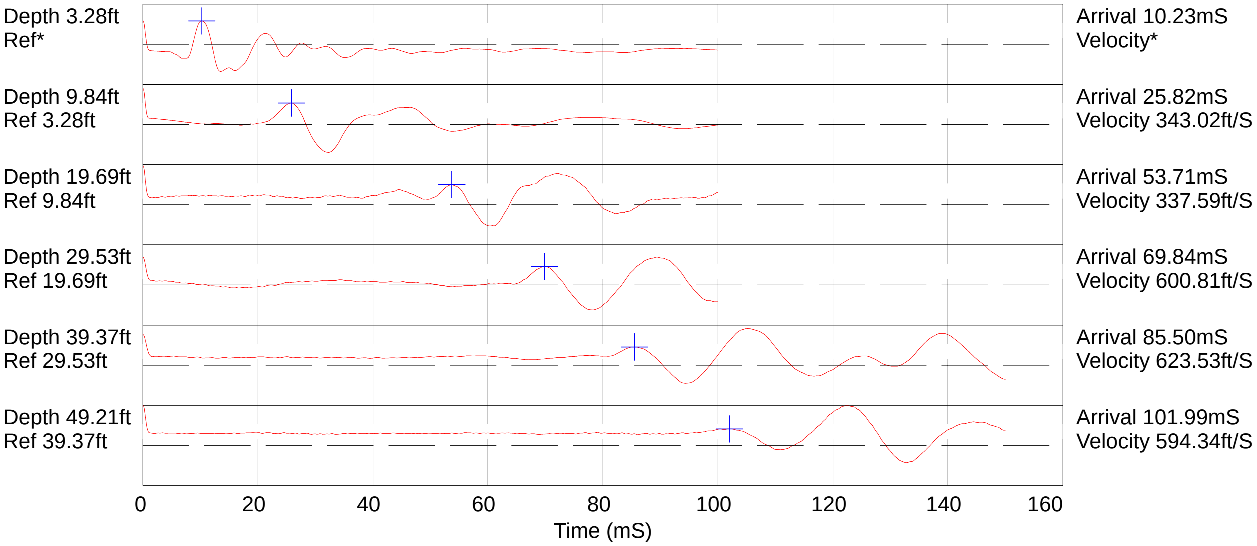
NV5 / CPT-1 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1586
HOLE NUMBER: CPT-1
TEST DATE: 11/23/2021 10:38:40 AM
TOTAL DEPTH: 53.150 ft



*SBT/SPT CORRELATION: UBC-1983

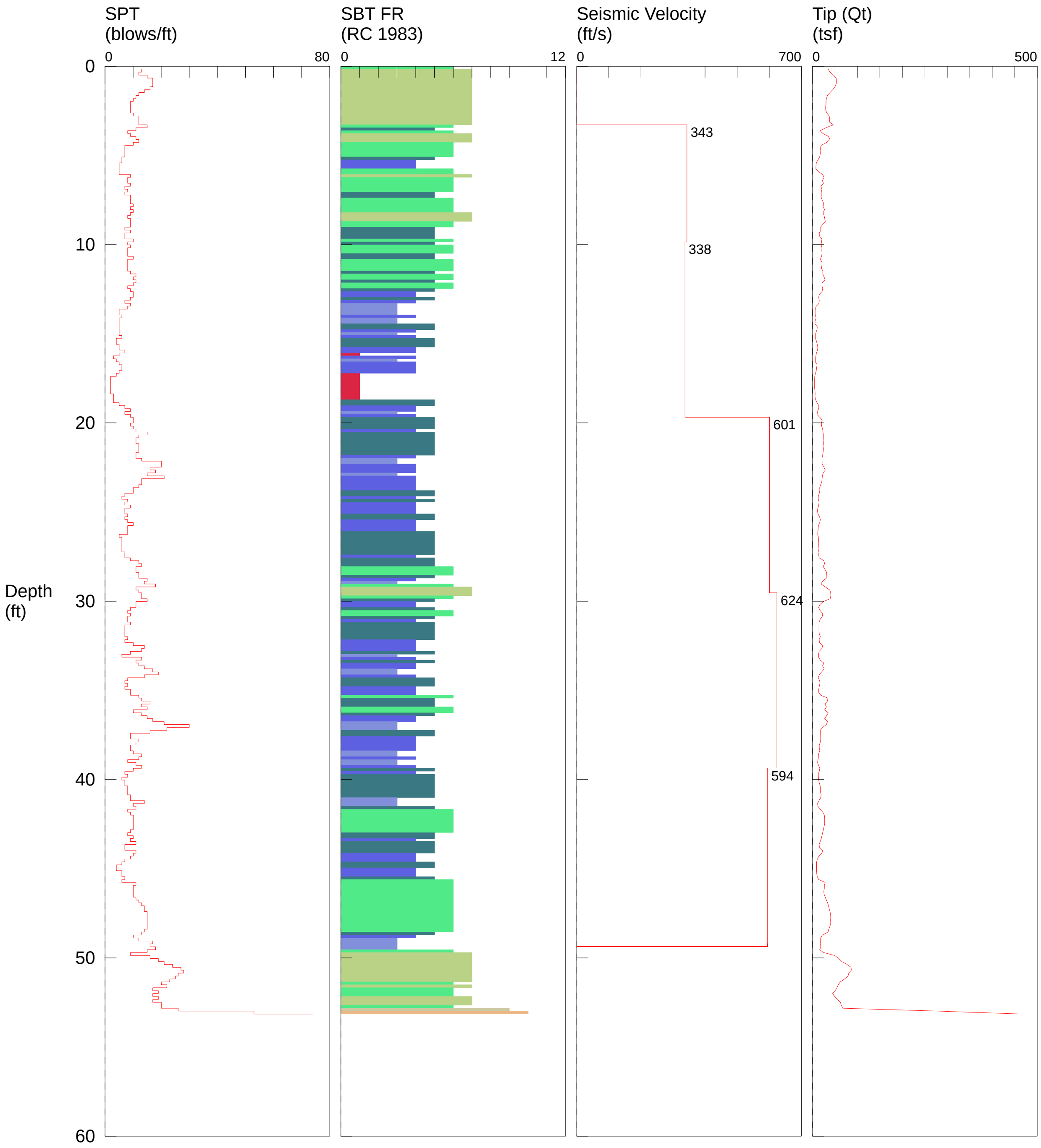
COMMENT: NV5 / CPT-1 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 4.27
* = Not Determined

NV5 / CPT-1 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1586
HOLE NUMBER: CPT-1
TEST DATE: 11/23/2021 10:38:40 AM
TOTAL DEPTH: 53.150 ft

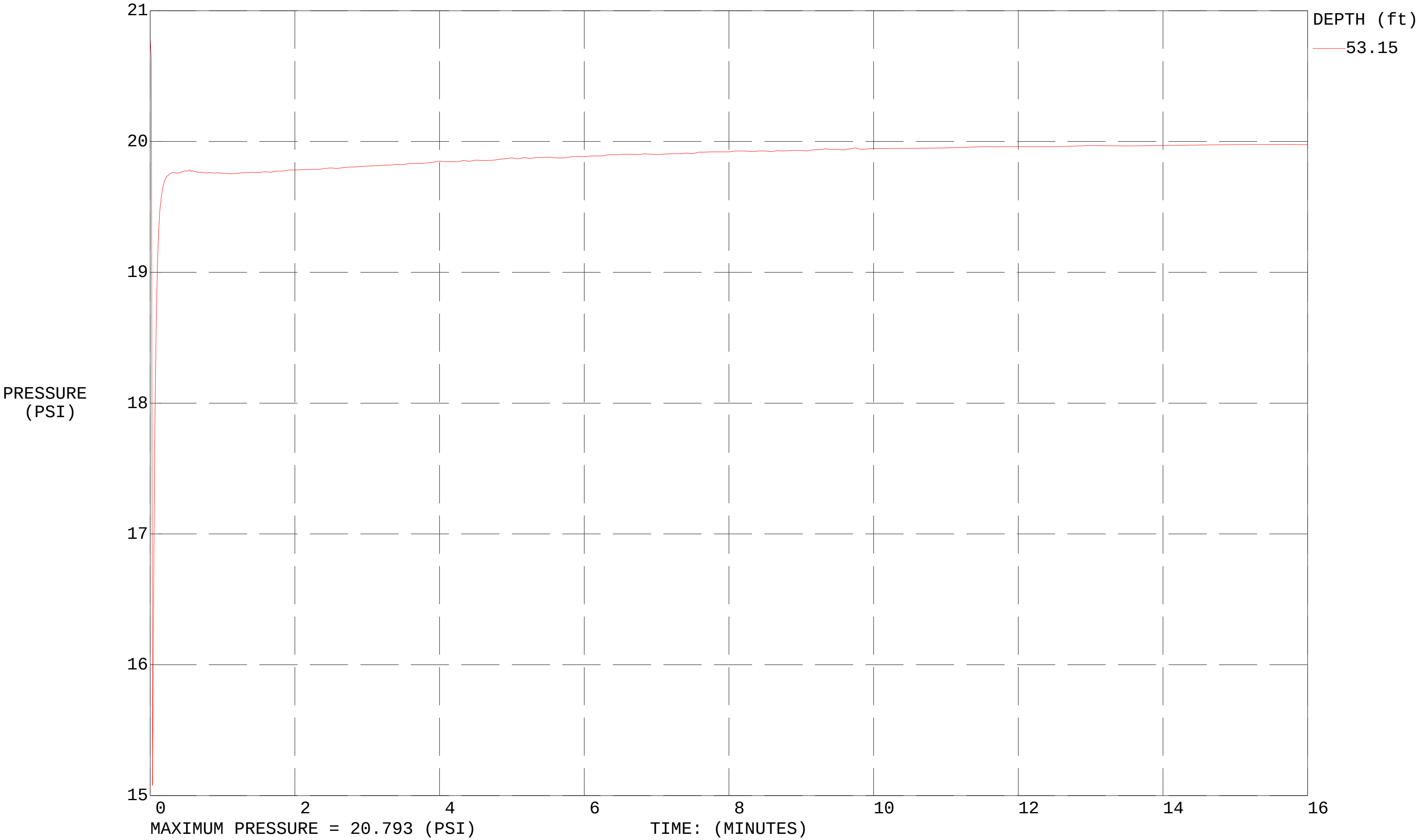


🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟩 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: NV5 / CPT-1 / 5501 NW Front Ave Portland

TEST DATE: 11/23/2021 10:38:40 AM



MAXIMUM PRESSURE = 20.793 (PSI)

HYDROSTATIC PRESSURE = 19.992 (PSI), WATER TABLE: 7.02 ft

NV5 / CPT-1 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1586
HOLE NUMBER: CPT-1
TEST DATE: 11/23/2021 10:38:40 AM
TOTAL DEPTH: 53.150 ft

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.164	35.02	0.5331	1.523	4.598	13	6	sandy silt to clayey silt
0.328	38.80	0.6209	1.600	7.056	12	7	silty sand to sandy silt
0.492	46.63	0.7349	1.576	3.538	15	7	silty sand to sandy silt
0.656	52.02	0.6848	1.316	-4.609	17	7	silty sand to sandy silt
0.820	53.95	0.5433	1.007	-0.320	17	7	silty sand to sandy silt
0.984	52.59	0.5288	1.006	-0.245	17	7	silty sand to sandy silt
1.148	49.76	0.5169	1.039	-0.152	16	7	silty sand to sandy silt
1.312	44.99	0.4667	1.037	-0.111	14	7	silty sand to sandy silt
1.476	38.86	0.3858	0.993	-0.120	12	7	silty sand to sandy silt
1.640	33.24	0.3406	1.025	-0.107	11	7	silty sand to sandy silt
1.804	30.54	0.3188	1.044	-0.066	10	7	silty sand to sandy silt
1.969	29.62	0.3249	1.097	-0.032	9	7	silty sand to sandy silt
2.133	29.60	0.3262	1.102	-0.011	9	7	silty sand to sandy silt
2.297	29.02	0.2915	1.004	0.002	9	7	silty sand to sandy silt
2.461	29.23	0.2837	0.971	0.027	9	7	silty sand to sandy silt
2.625	31.95	0.2704	0.846	0.050	10	7	silty sand to sandy silt
2.789	37.00	0.2675	0.723	0.052	12	7	silty sand to sandy silt
2.953	38.03	0.3847	1.012	0.050	12	7	silty sand to sandy silt
3.117	37.30	0.3583	0.961	0.068	12	7	silty sand to sandy silt
3.281	46.22	0.3868	0.837	-0.064	15	7	silty sand to sandy silt
3.445	29.77	0.3667	1.232	0.005	11	6	sandy silt to clayey silt
3.609	16.66	0.3383	2.031	0.118	8	5	clayey silt to silty clay
3.773	22.96	0.2658	1.158	0.186	9	6	sandy silt to clayey silt
3.937	35.07	0.1793	0.511	-3.742	11	7	silty sand to sandy silt
4.101	38.72	0.1901	0.491	-3.615	12	7	silty sand to sandy silt
4.265	31.66	0.2116	0.668	-1.382	10	7	silty sand to sandy silt
4.429	19.33	0.2090	1.081	-0.118	7	6	sandy silt to clayey silt
4.593	17.30	0.1687	0.975	0.513	7	6	sandy silt to clayey silt
4.757	18.17	0.1473	0.811	-0.007	7	6	sandy silt to clayey silt
4.921	17.07	0.1519	0.890	-0.933	7	6	sandy silt to clayey silt
5.085	15.78	0.1660	1.052	-0.502	6	6	sandy silt to clayey silt
5.249	11.66	0.2114	1.814	0.195	6	5	clayey silt to silty clay
5.413	8.20	0.2116	2.581	3.529	5	4	silty clay to clay
5.577	7.81	0.1764	2.258	4.221	5	4	silty clay to clay
5.741	7.55	0.1371	1.816	4.026	5	4	silty clay to clay
5.906	12.94	0.1450	1.120	4.233	5	6	sandy silt to clayey silt
6.070	22.55	0.1622	0.719	1.741	9	6	sandy silt to clayey silt
6.234	25.72	0.2204	0.857	0.853	8	7	silty sand to sandy silt
6.398	21.69	0.2453	1.131	0.495	8	6	sandy silt to clayey silt
6.562	24.17	0.2445	1.012	0.125	9	6	sandy silt to clayey silt
6.726	18.36	0.3410	1.858	0.508	7	6	sandy silt to clayey silt
6.890	21.02	0.3780	1.799	0.570	8	6	sandy silt to clayey silt
7.054	19.45	0.3637	1.870	1.693	7	6	sandy silt to clayey silt
7.218	19.19	0.3939	2.053	1.559	9	5	clayey silt to silty clay

Depth	Tip (Qt)	Sleeve Friction (Fs)	F.Ratio	PP (U2)	SPT		Soil Behavior Type
ft	(tsf)	(tsf)	(%)	(psi)	(blows/ft)	Zone	UBC-1983
7.382	19.38	0.4729	2.439	2.122	9	5	clayey silt to silty clay
7.546	22.24	0.4530	2.036	2.356	9	6	sandy silt to clayey silt
7.710	24.97	0.3621	1.450	1.872	10	6	sandy silt to clayey silt
7.874	23.27	0.3284	1.411	1.359	9	6	sandy silt to clayey silt
8.038	26.71	0.2708	1.014	1.473	10	6	sandy silt to clayey silt
8.202	23.08	0.2585	1.120	1.627	9	6	sandy silt to clayey silt
8.366	25.61	0.2169	0.847	1.836	8	7	silty sand to sandy silt
8.530	26.81	0.1790	0.667	1.627	9	7	silty sand to sandy silt
8.694	28.34	0.1773	0.626	1.280	9	7	silty sand to sandy silt
8.858	22.96	0.2641	1.150	0.470	9	6	sandy silt to clayey silt
9.022	18.03	0.2859	1.586	0.542	7	6	sandy silt to clayey silt
9.186	18.48	0.3522	1.906	0.803	9	5	clayey silt to silty clay
9.350	14.59	0.3600	2.468	2.322	7	5	clayey silt to silty clay
9.514	15.12	0.4532	2.997	2.299	7	5	clayey silt to silty clay
9.678	20.64	0.4487	2.174	2.240	10	5	clayey silt to silty clay
9.843	20.00	0.3492	1.746	2.531	8	6	sandy silt to clayey silt
10.007	18.86	0.4119	2.184	2.403	9	5	clayey silt to silty clay
10.171	20.72	0.3607	1.741	2.376	8	6	sandy silt to clayey silt
10.335	20.48	0.3623	1.770	2.365	8	6	sandy silt to clayey silt
10.499	21.24	0.4360	2.053	2.410	8	6	sandy silt to clayey silt
10.663	20.03	0.4247	2.120	2.617	10	5	clayey silt to silty clay
10.827	17.12	0.3756	2.193	2.644	8	5	clayey silt to silty clay
10.991	21.21	0.2482	1.171	2.608	8	6	sandy silt to clayey silt
11.155	20.99	0.2139	1.019	1.593	8	6	sandy silt to clayey silt
11.319	19.76	0.3501	1.772	1.051	8	6	sandy silt to clayey silt
11.483	23.03	0.4592	1.994	1.176	9	6	sandy silt to clayey silt
11.647	22.64	0.5124	2.263	1.922	11	5	clayey silt to silty clay
11.811	25.58	0.5544	2.167	2.247	10	6	sandy silt to clayey silt
11.975	27.60	0.4925	1.784	2.512	11	6	sandy silt to clayey silt
12.139	21.12	0.5325	2.521	2.937	10	5	clayey silt to silty clay
12.303	20.91	0.3568	1.707	2.708	8	6	sandy silt to clayey silt
12.467	22.37	0.4990	2.230	3.028	9	6	sandy silt to clayey silt
12.631	21.31	0.6035	2.833	3.411	10	5	clayey silt to silty clay
12.795	14.94	0.5208	3.486	3.182	10	4	silty clay to clay
12.959	13.67	0.4303	3.149	2.769	9	4	silty clay to clay
13.123	14.67	0.4160	2.836	2.501	7	5	clayey silt to silty clay
13.287	14.09	0.4658	3.307	2.149	9	4	silty clay to clay
13.451	8.11	0.3260	4.018	2.038	8	3	clay
13.615	5.64	0.1849	3.279	2.944	5	3	clay
13.780	5.57	0.1920	3.450	4.326	5	3	clay
13.944	6.05	0.1792	2.964	5.742	6	3	clay
14.108	8.02	0.1789	2.230	6.128	5	4	silty clay to clay
14.272	5.50	0.2042	3.712	5.921	5	3	clay
14.436	5.28	0.1629	3.085	7.419	5	3	clay
14.600	10.44	0.1677	1.607	8.270	5	5	clayey silt to silty clay
14.764	9.77	0.1796	1.838	7.276	5	5	clayey silt to silty clay
14.928	7.83	0.1727	2.206	7.328	5	4	silty clay to clay
15.092	5.92	0.1539	2.602	7.968	6	3	clay
15.256	6.54	0.1339	2.047	9.521	4	4	silty clay to clay
15.420	8.49	0.1535	1.809	10.338	4	5	clayey silt to silty clay
15.584	10.51	0.2176	2.071	11.132	5	5	clayey silt to silty clay
15.748	11.35	0.2512	2.213	11.956	5	5	clayey silt to silty clay
15.912	10.96	0.2775	2.532	11.965	7	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
16.076	8.47	0.2056	2.428	13.299	5	4	silty clay to clay
16.240	7.27	0.0856	1.177	14.700	3	1	sensitive fine grained
16.404	6.74	0.1195	1.772	16.831	4	4	silty clay to clay
16.568	5.73	0.2247	3.920	22.772	5	3	clay
16.732	9.92	0.3233	3.259	26.907	6	4	silty clay to clay
16.896	8.91	0.2828	3.174	13.095	6	4	silty clay to clay
17.060	8.19	0.1974	2.409	11.817	5	4	silty clay to clay
17.224	6.50	0.1106	1.701	10.742	4	4	silty clay to clay
17.388	4.68	0.0754	1.610	10.299	2	1	sensitive fine grained
17.552	4.26	0.0628	1.472	12.539	2	1	sensitive fine grained
17.717	4.22	0.0569	1.349	14.418	2	1	sensitive fine grained
17.881	4.21	0.0598	1.418	16.493	2	1	sensitive fine grained
18.045	4.54	0.0702	1.549	18.778	2	1	sensitive fine grained
18.209	5.19	0.0792	1.527	20.780	2	1	sensitive fine grained
18.373	5.39	0.0764	1.418	20.802	3	1	sensitive fine grained
18.537	5.36	0.0778	1.453	20.929	3	1	sensitive fine grained
18.701	6.76	0.0941	1.392	21.758	3	1	sensitive fine grained
18.865	9.73	0.2174	2.235	18.928	5	5	clayey silt to silty clay
19.029	13.90	0.3386	2.437	13.413	7	5	clayey silt to silty clay
19.193	13.73	0.4170	3.038	2.381	9	4	silty clay to clay
19.357	11.15	0.3420	3.067	0.468	7	4	silty clay to clay
19.521	9.84	0.3958	4.024	-0.409	9	3	clay
19.685	15.97	0.6109	3.824	0.461	10	4	silty clay to clay
19.849	21.42	0.6277	2.930	2.483	10	5	clayey silt to silty clay
20.013	19.62	0.6173	3.146	4.131	9	5	clayey silt to silty clay
20.177	20.12	0.6619	3.289	6.296	10	5	clayey silt to silty clay
20.341	22.35	0.7810	3.495	8.894	11	5	clayey silt to silty clay
20.505	22.98	0.8672	3.774	11.195	15	4	silty clay to clay
20.669	24.27	0.8758	3.609	14.055	12	5	clayey silt to silty clay
20.833	23.93	0.8225	3.437	14.123	11	5	clayey silt to silty clay
20.997	23.47	0.8101	3.451	17.214	11	5	clayey silt to silty clay
21.161	24.79	0.7281	2.937	21.013	12	5	clayey silt to silty clay
21.325	25.14	0.7306	2.906	26.117	12	5	clayey silt to silty clay
21.490	24.10	0.6872	2.851	36.873	12	5	clayey silt to silty clay
21.654	23.12	0.7215	3.121	45.238	11	5	clayey silt to silty clay
21.818	22.40	0.7879	3.517	49.516	11	5	clayey silt to silty clay
21.982	20.95	0.8053	3.844	47.437	13	4	silty clay to clay
22.146	21.19	1.1396	5.379	36.632	20	3	clay
22.310	21.27	1.1192	5.262	16.740	20	3	clay
22.474	25.08	1.0826	4.317	4.864	16	4	silty clay to clay
22.638	28.28	1.1063	3.912	3.713	18	4	silty clay to clay
22.802	23.39	1.0165	4.347	5.944	15	4	silty clay to clay
22.966	21.69	0.9503	4.382	11.037	21	3	clay
23.130	21.07	0.8327	3.952	15.678	13	4	silty clay to clay
23.294	20.48	0.7504	3.663	20.453	13	4	silty clay to clay
23.458	18.22	0.6294	3.454	23.051	12	4	silty clay to clay
23.622	15.76	0.5354	3.397	17.296	10	4	silty clay to clay
23.786	15.85	0.5261	3.319	9.473	10	4	silty clay to clay
23.950	14.64	0.4151	2.835	16.645	7	5	clayey silt to silty clay
24.114	12.64	0.3431	2.714	24.054	6	5	clayey silt to silty clay
24.278	12.73	0.3819	2.999	33.157	8	4	silty clay to clay
24.442	14.36	0.4168	2.902	44.725	7	5	clayey silt to silty clay
24.606	13.68	0.4015	2.935	48.865	9	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
24.770	11.71	0.3855	3.291	44.612	7	4	silty clay to clay
24.934	10.33	0.3438	3.327	42.508	7	4	silty clay to clay
25.098	12.34	0.3922	3.179	41.058	8	4	silty clay to clay
25.262	15.39	0.3637	2.363	18.907	7	5	clayey silt to silty clay
25.427	17.14	0.4349	2.537	12.137	8	5	clayey silt to silty clay
25.591	15.62	0.4940	3.162	10.998	10	4	silty clay to clay
25.755	13.04	0.4870	3.736	9.096	8	4	silty clay to clay
25.919	12.49	0.3492	2.797	12.982	8	4	silty clay to clay
26.083	11.86	0.3205	2.702	17.888	8	4	silty clay to clay
26.247	11.25	0.2582	2.296	24.268	5	5	clayey silt to silty clay
26.411	12.96	0.2782	2.146	36.056	6	5	clayey silt to silty clay
26.575	13.19	0.2899	2.198	47.759	6	5	clayey silt to silty clay
26.739	13.07	0.2962	2.266	56.002	6	5	clayey silt to silty clay
26.903	12.97	0.2712	2.091	61.426	6	5	clayey silt to silty clay
27.067	12.33	0.2396	1.943	63.542	6	5	clayey silt to silty clay
27.231	14.13	0.2586	1.831	58.635	7	5	clayey silt to silty clay
27.395	13.72	0.3601	2.625	70.961	7	5	clayey silt to silty clay
27.559	14.43	0.5658	3.922	65.677	9	4	silty clay to clay
27.723	24.94	0.6503	2.608	50.304	12	5	clayey silt to silty clay
27.887	27.01	0.7882	2.918	7.567	13	5	clayey silt to silty clay
28.051	23.81	0.6672	2.802	4.171	11	5	clayey silt to silty clay
28.215	27.42	0.4336	1.581	2.605	11	6	sandy silt to clayey silt
28.379	31.10	0.3935	1.266	0.157	12	6	sandy silt to clayey silt
28.543	30.76	0.5641	1.834	-0.624	12	6	sandy silt to clayey silt
28.707	30.53	0.9267	3.035	-0.318	15	5	clayey silt to silty clay
28.871	22.21	0.9390	4.228	-0.833	14	4	silty clay to clay
29.035	18.78	0.9324	4.966	15.426	18	3	clay
29.199	28.37	0.6823	2.406	19.279	11	6	sandy silt to clayey silt
29.364	38.24	0.4276	1.118	2.667	12	7	silty sand to sandy silt
29.528	40.48	0.3736	0.923	-1.185	13	7	silty sand to sandy silt
29.692	40.69	0.5796	1.424	-0.601	13	7	silty sand to sandy silt
29.856	39.16	0.9647	2.464	-1.132	15	6	sandy silt to clayey silt
30.020	24.01	0.8626	3.593	-0.676	11	5	clayey silt to silty clay
30.184	16.48	0.6564	3.983	1.963	11	4	silty clay to clay
30.348	13.47	0.4881	3.623	21.987	9	4	silty clay to clay
30.512	16.82	0.4840	2.878	45.833	8	5	clayey silt to silty clay
30.676	22.26	0.4121	1.851	33.035	9	6	sandy silt to clayey silt
30.840	21.60	0.4488	2.078	21.726	8	6	sandy silt to clayey silt
31.004	17.00	0.5182	3.047	24.411	8	5	clayey silt to silty clay
31.168	14.49	0.4553	3.143	35.055	9	4	silty clay to clay
31.332	14.14	0.3803	2.689	63.853	7	5	clayey silt to silty clay
31.496	14.29	0.3497	2.448	72.529	7	5	clayey silt to silty clay
31.660	14.20	0.3880	2.732	70.582	7	5	clayey silt to silty clay
31.824	14.97	0.3896	2.602	70.116	7	5	clayey silt to silty clay
31.988	17.27	0.3840	2.223	57.321	8	5	clayey silt to silty clay
32.152	14.55	0.3393	2.332	62.298	7	5	clayey silt to silty clay
32.316	15.34	0.4843	3.158	56.118	10	4	silty clay to clay
32.480	22.15	0.8468	3.822	76.891	14	4	silty clay to clay
32.644	20.97	0.7634	3.640	41.210	13	4	silty clay to clay
32.808	14.36	0.4979	3.467	37.833	9	4	silty clay to clay
32.972	13.56	0.3826	2.822	52.060	6	5	clayey silt to silty clay
33.136	13.37	0.5324	3.982	59.960	13	3	clay
33.301	17.01	0.6704	3.942	64.570	11	4	silty clay to clay

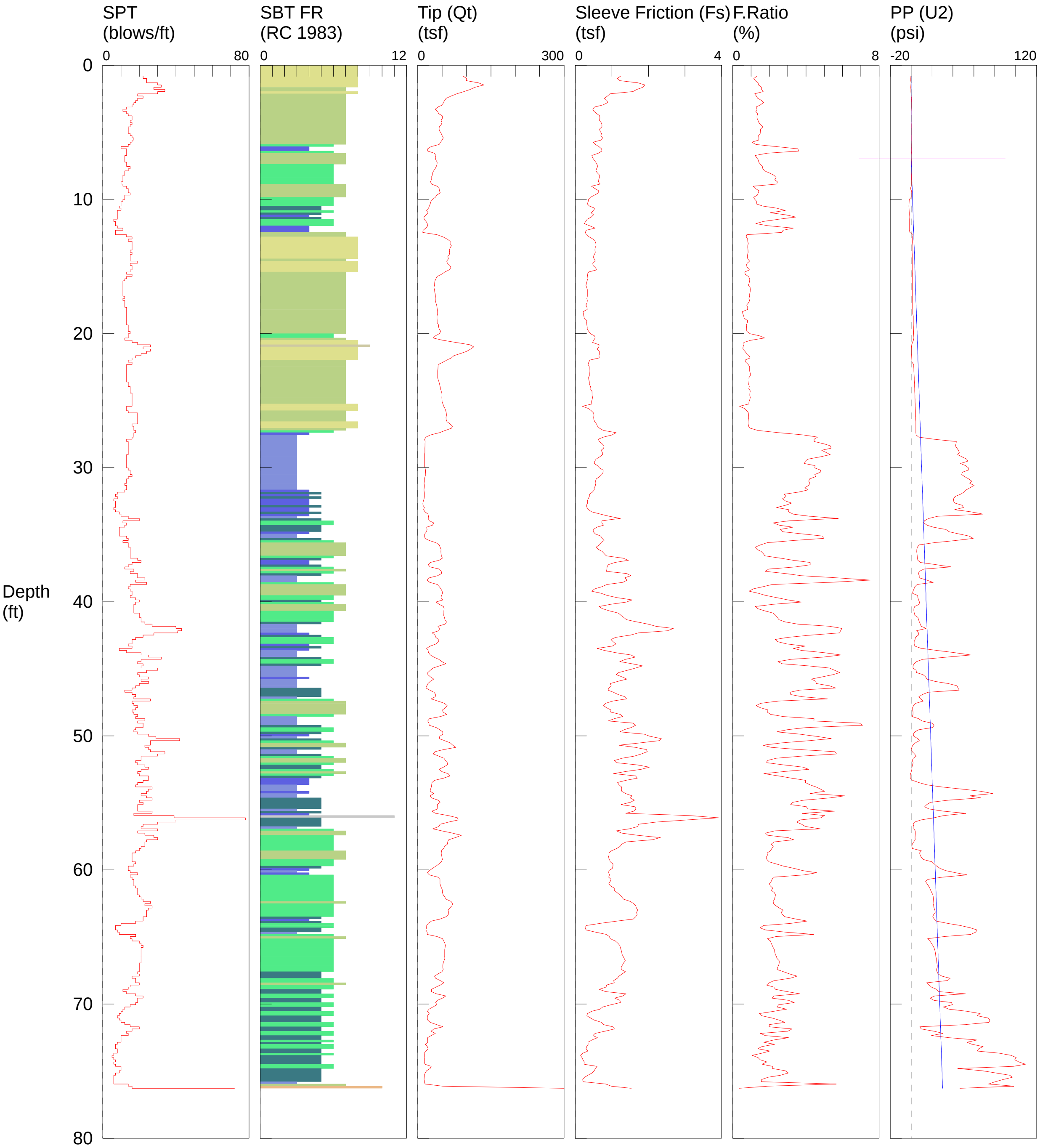
Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
33.465	24.89	0.7364	2.959	22.486	12	5	clayey silt to silty clay
33.629	21.95	0.8190	3.731	15.317	14	4	silty clay to clay
33.793	25.96	1.0446	4.023	21.349	17	4	silty clay to clay
33.957	20.18	0.9294	4.605	18.585	19	3	clay
34.121	14.83	0.5928	3.997	26.773	14	3	clay
34.285	12.53	0.4458	3.558	39.989	8	4	silty clay to clay
34.449	15.62	0.3329	2.131	56.059	7	5	clayey silt to silty clay
34.613	16.11	0.3502	2.173	45.345	8	5	clayey silt to silty clay
34.777	14.80	0.3874	2.617	49.818	7	5	clayey silt to silty clay
34.941	13.78	0.4139	3.003	58.299	9	4	silty clay to clay
35.105	13.78	0.5056	3.670	67.797	9	4	silty clay to clay
35.269	18.12	0.6389	3.527	65.040	12	4	silty clay to clay
35.433	33.83	0.7504	2.218	14.498	13	6	sandy silt to clayey silt
35.597	33.17	1.1696	3.526	7.017	16	5	clayey silt to silty clay
35.761	27.62	1.0117	3.663	8.295	13	5	clayey silt to silty clay
35.925	30.60	0.9247	3.022	13.960	15	5	clayey silt to silty clay
36.089	27.03	0.5058	1.871	11.139	10	6	sandy silt to clayey silt
36.253	34.93	0.5907	1.691	12.591	13	6	sandy silt to clayey silt
36.417	31.44	1.0313	3.281	13.606	15	5	clayey silt to silty clay
36.581	26.66	1.1798	4.426	24.788	17	4	silty clay to clay
36.745	33.14	1.3568	4.095	93.193	21	4	silty clay to clay
36.909	30.95	1.5872	5.127	86.899	30	3	clay
37.073	22.72	1.2843	5.653	49.895	22	3	clay
37.238	16.90	0.7963	4.712	54.952	16	3	clay
37.402	17.87	0.4300	2.407	64.524	9	5	clayey silt to silty clay
37.566	17.82	0.4567	2.563	51.488	9	5	clayey silt to silty clay
37.730	18.32	0.6728	3.673	62.044	12	4	silty clay to clay
37.894	17.14	0.6921	4.038	47.759	11	4	silty clay to clay
38.058	14.76	0.5847	3.961	45.740	9	4	silty clay to clay
38.222	14.76	0.5398	3.656	56.563	9	4	silty clay to clay
38.386	15.94	0.6054	3.797	49.044	10	4	silty clay to clay
38.550	13.45	0.7342	5.460	42.038	13	3	clay
38.714	12.94	0.5955	4.602	51.121	12	3	clay
38.878	12.14	0.4356	3.590	35.545	8	4	silty clay to clay
39.042	10.97	0.4031	3.676	41.459	11	3	clay
39.206	13.15	0.5121	3.894	50.131	13	3	clay
39.370	15.92	0.5233	3.286	32.937	10	4	silty clay to clay
39.534	14.75	0.4063	2.755	14.323	7	5	clayey silt to silty clay
39.698	12.63	0.3598	2.850	16.552	8	4	silty clay to clay
39.862	13.27	0.3149	2.373	18.424	6	5	clayey silt to silty clay
40.026	13.71	0.3605	2.629	19.951	7	5	clayey silt to silty clay
40.190	14.81	0.3698	2.498	22.026	7	5	clayey silt to silty clay
40.354	16.85	0.3323	1.972	20.689	8	5	clayey silt to silty clay
40.518	17.29	0.3689	2.134	17.014	8	5	clayey silt to silty clay
40.682	17.26	0.4416	2.559	17.711	8	5	clayey silt to silty clay
40.846	18.82	0.5285	2.808	19.456	9	5	clayey silt to silty clay
41.011	18.32	0.6190	3.380	20.904	9	5	clayey silt to silty clay
41.175	14.21	0.6202	4.365	23.165	14	3	clay
41.339	10.93	0.5732	5.247	30.266	10	3	clay
41.503	11.91	0.4400	3.696	44.934	11	3	clay
41.667	17.18	0.4535	2.640	32.020	8	5	clayey silt to silty clay
41.831	22.70	0.3976	1.752	23.657	9	6	sandy silt to clayey silt
41.995	26.28	0.4049	1.541	17.988	10	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
42.159	26.56	0.3709	1.396	12.827	10	6	sandy silt to clayey silt
42.323	26.89	0.3678	1.368	13.490	10	6	sandy silt to clayey silt
42.487	26.55	0.3436	1.294	13.451	10	6	sandy silt to clayey silt
42.651	25.27	0.3948	1.562	12.423	10	6	sandy silt to clayey silt
42.815	24.26	0.4591	1.892	13.490	9	6	sandy silt to clayey silt
42.979	22.17	0.4813	2.171	15.376	8	6	sandy silt to clayey silt
43.143	20.75	0.4926	2.374	17.546	10	5	clayey silt to silty clay
43.307	19.56	0.6067	3.102	18.447	9	5	clayey silt to silty clay
43.471	16.91	0.6137	3.629	21.653	11	4	silty clay to clay
43.635	14.52	0.3832	2.639	30.116	7	5	clayey silt to silty clay
43.799	15.24	0.3878	2.545	38.963	7	5	clayey silt to silty clay
43.963	22.27	0.6119	2.748	47.589	11	5	clayey silt to silty clay
44.127	20.64	0.5983	2.899	25.754	10	5	clayey silt to silty clay
44.291	14.33	0.4471	3.121	19.275	9	4	silty clay to clay
44.455	10.64	0.3647	3.427	23.517	7	4	silty clay to clay
44.619	9.00	0.2252	2.502	31.088	6	4	silty clay to clay
44.783	8.78	0.1794	2.043	39.927	4	5	clayey silt to silty clay
44.948	8.64	0.1712	1.983	46.879	4	5	clayey silt to silty clay
45.112	8.98	0.2381	2.652	50.953	6	4	silty clay to clay
45.276	9.28	0.2286	2.464	49.078	6	4	silty clay to clay
45.440	10.54	0.2895	2.747	28.312	7	4	silty clay to clay
45.604	13.28	0.2302	1.734	34.621	6	5	clayey silt to silty clay
45.768	27.86	0.3024	1.085	21.522	11	6	sandy silt to clayey silt
45.932	26.10	0.2887	1.106	13.465	10	6	sandy silt to clayey silt
46.096	26.14	0.2964	1.134	13.299	10	6	sandy silt to clayey silt
46.260	24.96	0.3423	1.372	13.853	10	6	sandy silt to clayey silt
46.424	25.56	0.3728	1.458	15.306	10	6	sandy silt to clayey silt
46.588	27.87	0.4039	1.449	16.515	11	6	sandy silt to clayey silt
46.752	30.63	0.4465	1.458	17.076	12	6	sandy silt to clayey silt
46.916	33.32	0.4867	1.461	17.382	13	6	sandy silt to clayey silt
47.080	35.34	0.5346	1.513	17.518	14	6	sandy silt to clayey silt
47.244	36.93	0.5806	1.572	17.527	14	6	sandy silt to clayey silt
47.408	38.52	0.6361	1.651	17.668	15	6	sandy silt to clayey silt
47.572	39.98	0.6970	1.743	17.709	15	6	sandy silt to clayey silt
47.736	40.32	0.7364	1.827	17.650	15	6	sandy silt to clayey silt
47.900	39.99	0.7341	1.836	17.636	15	6	sandy silt to clayey silt
48.064	40.30	0.7297	1.811	17.645	15	6	sandy silt to clayey silt
48.228	38.50	0.7028	1.825	17.133	15	6	sandy silt to clayey silt
48.392	36.03	0.7608	2.111	17.589	14	6	sandy silt to clayey silt
48.556	34.48	0.8472	2.457	18.342	13	6	sandy silt to clayey silt
48.720	21.58	0.7380	3.419	19.377	10	5	clayey silt to silty clay
48.885	18.07	0.6180	3.421	37.951	12	4	silty clay to clay
49.049	17.57	0.7937	4.518	43.799	17	3	clay
49.213	16.85	0.7804	4.631	45.519	16	3	clay
49.377	18.43	0.7804	4.234	18.630	18	3	clay
49.541	15.60	0.7520	4.822	25.761	15	3	clay
49.705	24.55	0.4768	1.942	32.576	9	6	sandy silt to clayey silt
49.869	49.22	0.5737	1.166	9.033	16	7	silty sand to sandy silt
50.033	58.62	0.8502	1.450	7.085	19	7	silty sand to sandy silt
50.197	64.56	1.0643	1.649	9.246	21	7	silty sand to sandy silt
50.361	76.55	1.2539	1.638	12.780	24	7	silty sand to sandy silt
50.525	85.59	1.3801	1.612	14.754	27	7	silty sand to sandy silt
50.689	86.27	1.3971	1.619	16.347	28	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
50.853	80.66	1.2939	1.604	17.133	26	7	silty sand to sandy silt
51.017	78.68	1.2675	1.611	17.852	25	7	silty sand to sandy silt
51.181	71.02	1.2585	1.772	17.248	23	7	silty sand to sandy silt
51.345	61.55	1.2336	2.004	17.689	20	7	silty sand to sandy silt
51.509	57.04	1.2190	2.137	18.120	22	6	sandy silt to clayey silt
51.673	54.37	1.0094	1.857	18.490	17	7	silty sand to sandy silt
51.837	50.06	0.9857	1.969	18.022	19	6	sandy silt to clayey silt
52.001	44.31	0.9535	2.152	16.731	17	6	sandy silt to clayey silt
52.165	49.16	0.9464	1.925	18.376	19	6	sandy silt to clayey silt
52.329	54.81	0.9643	1.759	18.830	17	7	silty sand to sandy silt
52.493	62.10	0.6981	1.124	4.287	20	7	silty sand to sandy silt
52.657	63.61	0.9162	1.440	-0.102	20	7	silty sand to sandy silt
52.822	68.33	1.5166	2.219	-1.684	26	6	sandy silt to clayey silt
52.986	278.02	1.6305	0.586	0.576	53	9	sand
53.150	464.75	1.7505	0.377	20.809	74	10	gravelly sand to sand

NV5 / CPT-2 / 5501 NW Front Ave Portland

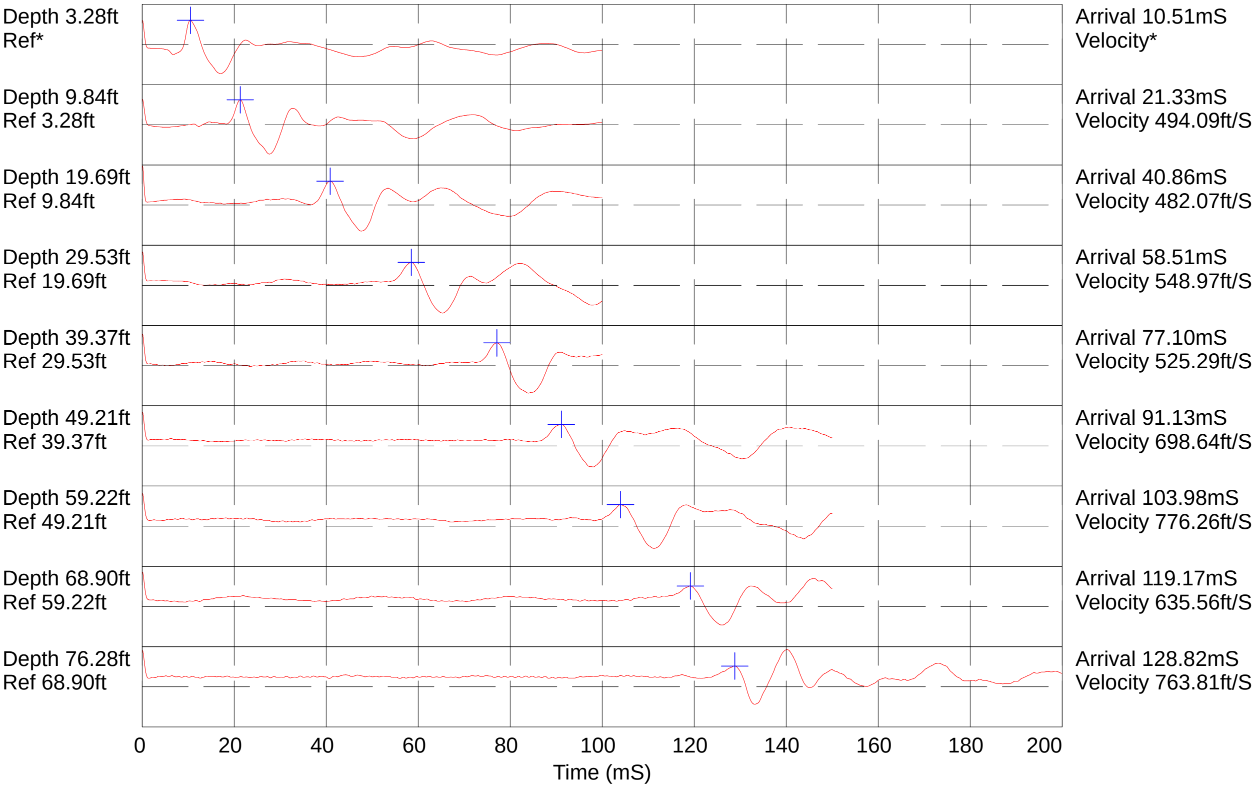
OPERATOR: OGE BAK
CONE ID: DDG1586
HOLE NUMBER: CPT-2
TEST DATE: 11/23/2021 12:00:53 PM
TOTAL DEPTH: 76.280 ft



🟥 1 sensitive fine grained
🟥 2 organic material
🟦 3 clay
🟦 4 silty clay to clay
🟦 5 clayey silt to silty clay
🟩 6 sandy silt to clayey silt
🟩 7 silty sand to sandy silt
🟨 8 sand to silty sand
🟫 9 sand
🟧 10 gravelly sand to sand
⬜ 11 very stiff fine grained (*)
⬛ 12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

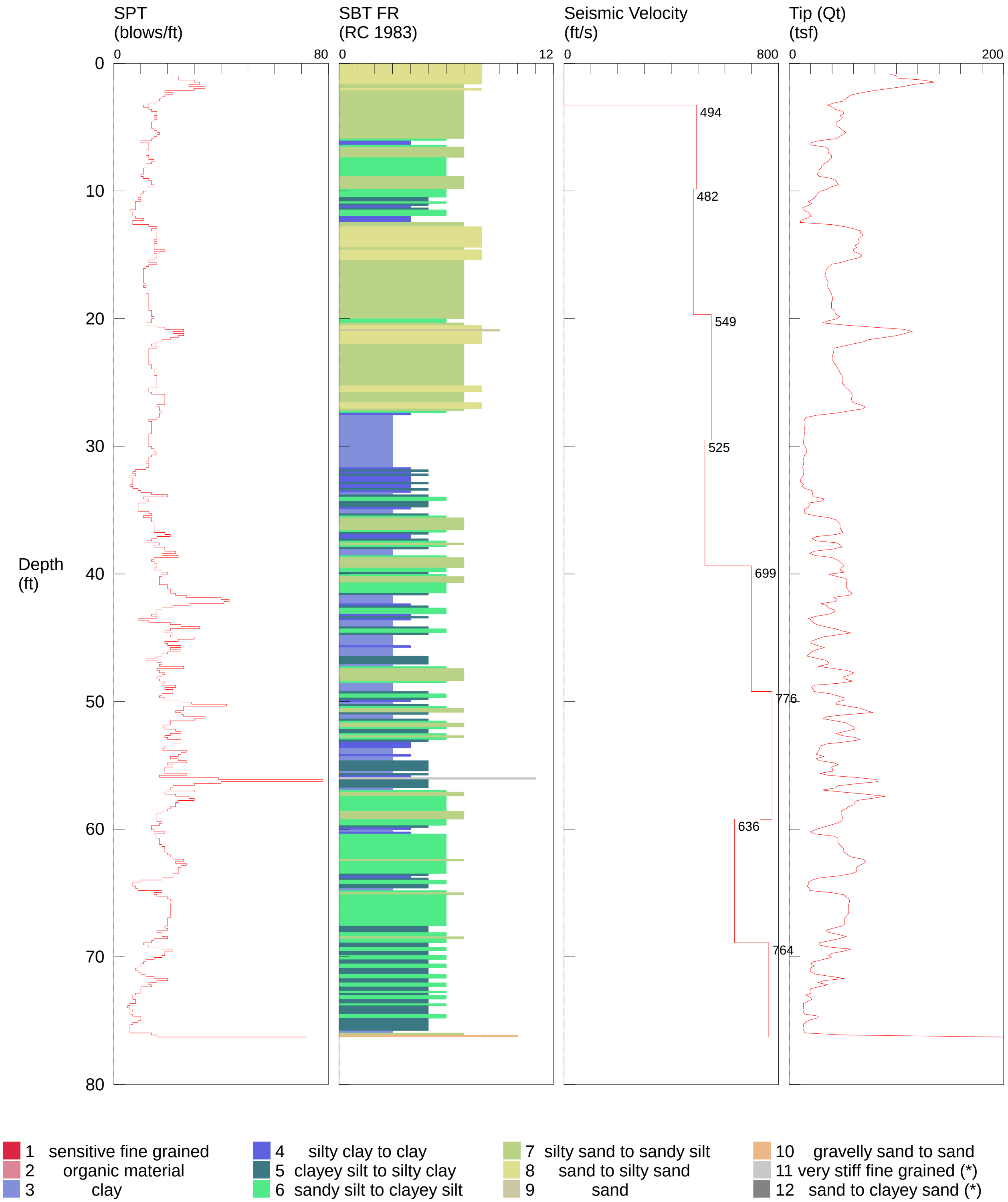
COMMENT: NV5 / CPT-2 / 5501 NW Front Ave Portland



Hammer to Rod String Distance (ft): 4.27
* = Not Determined

NV5 / CPT-2 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1586
HOLE NUMBER: CPT-2
TEST DATE: 11/23/2021 12:00:53 PM
TOTAL DEPTH: 76.280 ft



*SBT/SPT CORRELATION: UBC-1983

NV5 / CPT-2 / 5501 NW Front Ave Portland

OPERATOR: OGE BAK
CONE ID: DDG1586
HOLE NUMBER: CPT-2
TEST DATE: 11/23/2021 12:00:53 PM
TOTAL DEPTH: 76.280 ft

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
0.820	93.09	1.2348	1.326	-0.322	22	8	sand to silty sand
0.984	99.96	1.1480	1.148	-0.436	24	8	sand to silty sand
1.148	99.53	1.2187	1.224	-0.458	24	8	sand to silty sand
1.312	124.08	1.7122	1.380	-0.272	30	8	sand to silty sand
1.476	135.55	1.9018	1.403	-0.315	32	8	sand to silty sand
1.640	117.53	1.8509	1.575	-0.422	28	8	sand to silty sand
1.804	107.06	1.6792	1.569	-0.386	34	7	silty sand to sandy silt
1.969	94.71	1.5763	1.664	-0.338	30	7	silty sand to sandy silt
2.133	79.54	0.9461	1.190	-0.245	19	8	sand to silty sand
2.297	68.67	0.8792	1.280	-0.177	22	7	silty sand to sandy silt
2.461	58.11	0.7932	1.365	0.254	19	7	silty sand to sandy silt
2.625	55.19	0.8658	1.569	0.191	18	7	silty sand to sandy silt
2.789	52.54	0.8843	1.683	0.166	17	7	silty sand to sandy silt
2.953	50.62	0.7620	1.505	0.136	16	7	silty sand to sandy silt
3.117	41.42	0.5253	1.268	0.143	13	7	silty sand to sandy silt
3.281	35.68	0.4749	1.331	0.120	11	7	silty sand to sandy silt
3.445	40.73	0.5130	1.259	-0.011	13	7	silty sand to sandy silt
3.609	42.77	0.5844	1.366	0.000	14	7	silty sand to sandy silt
3.773	50.09	0.6646	1.327	-0.020	16	7	silty sand to sandy silt
3.937	50.72	0.6732	1.327	-0.014	16	7	silty sand to sandy silt
4.101	47.70	0.6558	1.375	0.007	15	7	silty sand to sandy silt
4.265	49.53	0.7063	1.426	0.009	16	7	silty sand to sandy silt
4.429	48.15	0.7257	1.507	0.025	15	7	silty sand to sandy silt
4.593	43.94	0.7274	1.655	0.064	14	7	silty sand to sandy silt
4.757	43.46	0.6590	1.516	0.086	14	7	silty sand to sandy silt
4.921	45.10	0.6812	1.511	0.084	14	7	silty sand to sandy silt
5.085	47.81	0.7157	1.497	0.086	15	7	silty sand to sandy silt
5.249	49.90	0.7009	1.404	0.082	16	7	silty sand to sandy silt
5.413	52.50	0.7462	1.421	0.084	17	7	silty sand to sandy silt
5.577	50.04	0.7090	1.417	0.095	16	7	silty sand to sandy silt
5.741	47.01	0.4910	1.044	0.113	15	7	silty sand to sandy silt
5.906	43.79	0.5534	1.264	0.138	14	7	silty sand to sandy silt
6.070	27.17	0.6487	2.387	0.225	10	6	sandy silt to clayey silt
6.234	20.17	0.7168	3.554	0.261	13	4	silty clay to clay
6.398	20.17	0.7270	3.605	0.247	13	4	silty clay to clay
6.562	33.72	0.6286	1.864	0.172	13	6	sandy silt to clayey silt
6.726	36.98	0.4521	1.223	0.107	12	7	silty sand to sandy silt
6.890	36.18	0.4696	1.298	0.118	12	7	silty sand to sandy silt
7.054	36.79	0.5104	1.387	0.145	12	7	silty sand to sandy silt
7.218	39.55	0.5592	1.414	0.150	13	7	silty sand to sandy silt
7.382	39.36	0.5932	1.507	0.161	13	7	silty sand to sandy silt
7.546	37.90	0.6148	1.622	0.175	15	6	sandy silt to clayey silt
7.710	35.49	0.5812	1.638	0.191	14	6	sandy silt to clayey silt
7.874	32.37	0.5610	1.733	0.186	12	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
8.038	30.28	0.6076	2.007	0.202	12	6	sandy silt to clayey silt
8.202	29.74	0.6656	2.238	0.229	11	6	sandy silt to clayey silt
8.366	27.69	0.6554	2.367	0.229	11	6	sandy silt to clayey silt
8.530	27.89	0.6396	2.293	0.220	11	6	sandy silt to clayey silt
8.694	25.91	0.6317	2.438	0.216	10	6	sandy silt to clayey silt
8.858	28.11	0.6767	2.407	0.204	11	6	sandy silt to clayey silt
9.022	39.61	0.4394	1.109	0.118	13	7	silty sand to sandy silt
9.186	43.82	0.5378	1.227	-0.942	14	7	silty sand to sandy silt
9.350	44.44	0.6363	1.432	0.143	14	7	silty sand to sandy silt
9.514	46.10	0.6394	1.387	0.111	15	7	silty sand to sandy silt
9.678	39.12	0.5257	1.344	0.075	12	7	silty sand to sandy silt
9.843	36.21	0.4128	1.140	0.032	12	7	silty sand to sandy silt
10.007	29.95	0.3604	1.203	-1.893	11	6	sandy silt to clayey silt
10.171	26.67	0.3519	1.319	-1.972	10	6	sandy silt to clayey silt
10.335	25.55	0.3255	1.274	-2.131	10	6	sandy silt to clayey silt
10.499	23.76	0.3863	1.626	-2.249	9	6	sandy silt to clayey silt
10.663	21.89	0.5247	2.397	-2.179	10	5	clayey silt to silty clay
10.827	17.70	0.5069	2.863	-2.031	8	5	clayey silt to silty clay
10.991	21.17	0.4307	2.035	-1.838	8	6	sandy silt to clayey silt
11.155	17.34	0.5001	2.884	-1.884	8	5	clayey silt to silty clay
11.319	12.64	0.4350	3.441	-1.972	8	4	silty clay to clay
11.483	12.95	0.3260	2.518	-1.881	6	5	clayey silt to silty clay
11.647	17.03	0.2824	1.659	-1.856	7	6	sandy silt to clayey silt
11.811	19.58	0.2465	1.259	-1.881	7	6	sandy silt to clayey silt
11.975	20.24	0.3972	1.963	-1.904	8	6	sandy silt to clayey silt
12.139	16.46	0.5432	3.301	-1.906	11	4	silty clay to clay
12.303	10.87	0.2989	2.751	-1.868	7	4	silty clay to clay
12.467	10.19	0.2728	2.677	-1.239	7	4	silty clay to clay
12.631	39.36	0.3001	0.762	1.936	13	7	silty sand to sandy silt
12.795	51.51	0.3778	0.733	1.312	16	7	silty sand to sandy silt
12.959	59.99	0.4826	0.804	1.103	14	8	sand to silty sand
13.123	66.51	0.5411	0.813	0.990	16	8	sand to silty sand
13.287	66.18	0.5623	0.850	0.908	16	8	sand to silty sand
13.451	68.79	0.5632	0.819	0.876	16	8	sand to silty sand
13.615	66.41	0.5419	0.816	0.867	16	8	sand to silty sand
13.780	64.64	0.5372	0.831	0.874	15	8	sand to silty sand
13.944	65.45	0.5466	0.835	0.878	16	8	sand to silty sand
14.108	64.74	0.5259	0.812	0.903	15	8	sand to silty sand
14.272	61.51	0.4884	0.794	0.926	15	8	sand to silty sand
14.436	62.92	0.5132	0.816	0.924	15	8	sand to silty sand
14.600	59.46	0.5465	0.919	0.937	19	7	silty sand to sandy silt
14.764	60.81	0.4768	0.784	0.946	15	8	sand to silty sand
14.928	65.64	0.4849	0.739	0.958	16	8	sand to silty sand
15.092	67.87	0.5499	0.810	0.958	16	8	sand to silty sand
15.256	64.29	0.5852	0.910	0.976	15	8	sand to silty sand
15.420	55.47	0.3612	0.651	0.985	13	8	sand to silty sand
15.584	48.83	0.3290	0.674	0.990	16	7	silty sand to sandy silt
15.748	39.53	0.3363	0.851	1.237	13	7	silty sand to sandy silt
15.912	37.09	0.3441	0.928	1.219	12	7	silty sand to sandy silt
16.076	35.15	0.3218	0.915	1.207	11	7	silty sand to sandy silt
16.240	34.31	0.3073	0.896	1.203	11	7	silty sand to sandy silt
16.404	34.03	0.2872	0.844	1.196	11	7	silty sand to sandy silt
16.568	33.19	0.3126	0.942	1.189	11	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
16.732	34.13	0.3271	0.958	1.191	11	7	silty sand to sandy silt
16.896	34.85	0.3283	0.942	1.223	11	7	silty sand to sandy silt
17.060	35.69	0.3274	0.917	1.248	11	7	silty sand to sandy silt
17.224	36.24	0.3326	0.918	1.262	12	7	silty sand to sandy silt
17.388	35.76	0.3146	0.880	1.285	11	7	silty sand to sandy silt
17.552	36.13	0.3303	0.914	1.310	12	7	silty sand to sandy silt
17.717	37.26	0.3183	0.854	1.325	12	7	silty sand to sandy silt
17.881	38.36	0.2887	0.753	1.369	12	7	silty sand to sandy silt
18.045	39.24	0.3177	0.810	1.396	13	7	silty sand to sandy silt
18.209	39.92	0.3244	0.813	1.425	13	7	silty sand to sandy silt
18.373	40.49	0.2122	0.524	1.477	13	7	silty sand to sandy silt
18.537	40.55	0.2207	0.544	1.514	13	7	silty sand to sandy silt
18.701	39.39	0.2345	0.595	2.033	13	7	silty sand to sandy silt
18.865	39.45	0.2449	0.621	2.036	13	7	silty sand to sandy silt
19.029	39.46	0.3152	0.799	2.033	13	7	silty sand to sandy silt
19.193	39.51	0.3120	0.790	2.040	13	7	silty sand to sandy silt
19.357	42.64	0.3153	0.739	2.061	14	7	silty sand to sandy silt
19.521	42.80	0.3241	0.757	2.065	14	7	silty sand to sandy silt
19.685	43.85	0.3247	0.740	2.074	14	7	silty sand to sandy silt
19.849	47.08	0.3651	0.775	2.220	15	7	silty sand to sandy silt
20.013	44.23	0.4150	0.938	2.265	14	7	silty sand to sandy silt
20.177	35.67	0.5285	1.482	2.304	14	6	sandy silt to clayey silt
20.341	31.20	0.5418	1.737	2.410	12	6	sandy silt to clayey silt
20.505	51.35	0.5027	0.979	2.115	16	7	silty sand to sandy silt
20.669	77.95	0.4701	0.603	1.219	19	8	sand to silty sand
20.833	106.70	0.6506	0.610	0.404	26	8	sand to silty sand
20.997	114.77	0.6426	0.560	0.204	22	9	sand
21.161	108.26	0.5993	0.554	0.231	26	8	sand to silty sand
21.325	100.25	0.6552	0.654	0.184	24	8	sand to silty sand
21.490	87.97	0.6632	0.754	0.197	21	8	sand to silty sand
21.654	74.19	0.6486	0.874	0.304	18	8	sand to silty sand
21.818	68.90	0.6520	0.946	0.429	16	8	sand to silty sand
21.982	59.60	0.3986	0.669	0.579	14	8	sand to silty sand
22.146	51.46	0.3658	0.711	0.738	16	7	silty sand to sandy silt
22.310	41.85	0.3506	0.838	2.288	13	7	silty sand to sandy silt
22.474	41.61	0.3814	0.917	2.378	13	7	silty sand to sandy silt
22.638	41.39	0.3798	0.918	2.449	13	7	silty sand to sandy silt
22.802	40.73	0.3760	0.923	2.537	13	7	silty sand to sandy silt
22.966	40.64	0.3880	0.955	2.628	13	7	silty sand to sandy silt
23.130	40.75	0.3876	0.951	2.726	13	7	silty sand to sandy silt
23.294	40.72	0.3598	0.884	2.821	13	7	silty sand to sandy silt
23.458	41.77	0.3705	0.887	2.894	13	7	silty sand to sandy silt
23.622	43.39	0.3842	0.885	2.989	14	7	silty sand to sandy silt
23.786	44.55	0.3861	0.867	3.082	14	7	silty sand to sandy silt
23.950	45.71	0.4133	0.904	3.161	15	7	silty sand to sandy silt
24.114	46.57	0.4059	0.872	3.245	15	7	silty sand to sandy silt
24.278	47.83	0.4535	0.948	3.316	15	7	silty sand to sandy silt
24.442	49.22	0.4601	0.935	3.393	16	7	silty sand to sandy silt
24.606	49.44	0.4584	0.927	3.466	16	7	silty sand to sandy silt
24.770	49.29	0.4719	0.957	3.520	16	7	silty sand to sandy silt
24.934	49.52	0.4582	0.925	3.602	16	7	silty sand to sandy silt
25.098	49.98	0.4427	0.886	3.670	16	7	silty sand to sandy silt
25.262	51.53	0.4527	0.879	3.742	16	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
25.427	53.23	0.1923	0.361	3.835	13	8	sand to silty sand
25.591	55.66	0.3599	0.647	3.899	13	8	sand to silty sand
25.755	57.39	0.4366	0.761	4.201	14	8	sand to silty sand
25.919	58.51	0.4984	0.852	4.180	19	7	silty sand to sandy silt
26.083	58.84	0.5098	0.866	4.203	19	7	silty sand to sandy silt
26.247	58.06	0.5004	0.862	4.258	19	7	silty sand to sandy silt
26.411	58.28	0.5075	0.871	4.308	19	7	silty sand to sandy silt
26.575	59.72	0.5271	0.883	4.342	19	7	silty sand to sandy silt
26.739	65.70	0.5773	0.879	4.396	16	8	sand to silty sand
26.903	71.00	0.6080	0.856	4.405	17	8	sand to silty sand
27.067	69.29	0.6608	0.954	4.339	17	8	sand to silty sand
27.231	55.80	0.7716	1.383	4.353	18	7	silty sand to sandy silt
27.395	44.71	1.1159	2.496	4.448	17	6	sandy silt to clayey silt
27.559	26.05	1.0043	3.856	4.664	17	4	silty clay to clay
27.723	16.69	0.7734	4.633	7.165	16	3	clay
27.887	14.01	0.6224	4.441	21.826	13	3	clay
28.051	14.88	0.6605	4.440	43.268	14	3	clay
28.215	14.69	0.7287	4.960	42.860	14	3	clay
28.379	14.69	0.7843	5.337	42.224	14	3	clay
28.543	14.41	0.7756	5.382	43.643	14	3	clay
28.707	14.56	0.7065	4.851	45.159	14	3	clay
28.871	14.57	0.7430	5.099	46.010	14	3	clay
29.035	14.06	0.7481	5.323	44.344	13	3	clay
29.199	13.95	0.6651	4.768	48.683	13	3	clay
29.364	13.75	0.5634	4.096	53.127	13	3	clay
29.528	13.44	0.5326	3.964	53.960	13	3	clay
29.692	13.24	0.5186	3.916	47.133	13	3	clay
29.856	13.47	0.6064	4.503	52.165	13	3	clay
30.020	14.74	0.6606	4.480	54.779	14	3	clay
30.184	15.85	0.7605	4.798	54.661	15	3	clay
30.348	15.91	0.7611	4.784	48.867	15	3	clay
30.512	16.20	0.7250	4.477	48.148	16	3	clay
30.676	14.64	0.6632	4.530	51.180	14	3	clay
30.840	13.65	0.5734	4.201	54.883	13	3	clay
31.004	13.31	0.5521	4.147	57.900	13	3	clay
31.168	12.91	0.5440	4.213	55.943	12	3	clay
31.332	13.45	0.5569	4.139	60.215	13	3	clay
31.496	13.10	0.5148	3.930	56.254	13	3	clay
31.660	12.59	0.5188	4.121	52.584	12	3	clay
31.824	13.05	0.4671	3.579	50.379	8	4	silty clay to clay
31.988	13.88	0.3899	2.808	47.238	7	5	clayey silt to silty clay
32.152	13.24	0.3861	2.916	42.020	8	4	silty clay to clay
32.316	12.97	0.3515	2.710	40.565	6	5	clayey silt to silty clay
32.480	11.52	0.3316	2.879	40.295	7	4	silty clay to clay
32.644	10.46	0.3362	3.213	41.811	7	4	silty clay to clay
32.808	10.54	0.3047	2.892	48.561	7	4	silty clay to clay
32.972	13.38	0.3197	2.389	50.052	6	5	clayey silt to silty clay
33.136	11.67	0.3575	3.063	41.466	7	4	silty clay to clay
33.301	14.62	0.4466	3.054	57.341	9	4	silty clay to clay
33.465	20.84	0.6873	3.297	68.648	10	5	clayey silt to silty clay
33.629	22.10	0.9303	4.209	25.346	14	4	silty clay to clay
33.793	21.36	1.2310	5.764	16.665	20	3	clay
33.957	23.33	0.7281	3.122	12.648	11	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
34.121	32.77	0.7235	2.207	11.890	13	6	sandy silt to clayey silt
34.285	30.43	0.7718	2.537	15.065	12	6	sandy silt to clayey silt
34.449	18.10	0.5932	3.277	21.231	9	5	clayey silt to silty clay
34.613	18.85	0.4872	2.585	33.162	9	5	clayey silt to silty clay
34.777	17.89	0.4899	2.738	36.246	9	5	clayey silt to silty clay
34.941	14.37	0.5472	3.809	45.681	9	4	silty clay to clay
35.105	14.09	0.6924	4.915	55.376	13	3	clay
35.269	14.84	0.7355	4.958	59.375	14	3	clay
35.433	23.69	0.7845	3.311	42.610	11	5	clayey silt to silty clay
35.597	37.11	0.7013	1.890	22.128	14	6	sandy silt to clayey silt
35.761	43.60	0.6624	1.519	7.798	14	7	silty sand to sandy silt
35.925	45.86	0.5666	1.235	5.905	15	7	silty sand to sandy silt
36.089	47.58	0.6318	1.328	5.365	15	7	silty sand to sandy silt
36.253	47.34	0.7357	1.554	5.238	15	7	silty sand to sandy silt
36.417	47.54	0.7928	1.668	5.472	15	7	silty sand to sandy silt
36.581	48.51	0.8499	1.752	5.769	15	7	silty sand to sandy silt
36.745	50.28	1.3080	2.601	5.828	19	6	sandy silt to clayey silt
36.909	43.59	1.4464	3.318	6.448	21	5	clayey silt to silty clay
37.073	25.54	1.0798	4.227	8.794	16	4	silty clay to clay
37.238	21.32	0.9032	4.236	24.372	14	4	silty clay to clay
37.402	25.26	0.8674	3.433	38.028	12	5	clayey silt to silty clay
37.566	44.06	0.8644	1.962	12.169	17	6	sandy silt to clayey silt
37.730	47.97	0.8490	1.770	7.598	15	7	silty sand to sandy silt
37.894	49.05	1.4060	2.867	6.829	19	6	sandy silt to clayey silt
38.058	40.69	1.5183	3.732	7.576	19	5	clayey silt to silty clay
38.222	23.77	1.3525	5.690	7.644	23	3	clay
38.386	18.88	1.4203	7.523	14.920	18	3	clay
38.550	24.55	1.2963	5.279	21.032	24	3	clay
38.714	39.78	0.8676	2.181	5.712	15	6	sandy silt to clayey silt
38.878	44.20	0.7280	1.647	3.513	14	7	silty sand to sandy silt
39.042	47.30	0.5319	1.125	2.646	15	7	silty sand to sandy silt
39.206	49.87	0.4439	0.890	1.734	16	7	silty sand to sandy silt
39.370	51.02	0.7100	1.392	1.178	16	7	silty sand to sandy silt
39.534	48.50	0.8718	1.798	6.100	15	7	silty sand to sandy silt
39.698	47.61	1.1593	2.435	6.330	18	6	sandy silt to clayey silt
39.862	51.61	1.5557	3.014	6.942	20	6	sandy silt to clayey silt
40.026	37.23	1.3942	3.745	7.927	18	5	clayey silt to silty clay
40.190	44.07	0.9597	2.178	7.537	17	6	sandy silt to clayey silt
40.354	52.69	0.6503	1.234	3.266	17	7	silty sand to sandy silt
40.518	54.10	0.7381	1.364	2.544	17	7	silty sand to sandy silt
40.682	53.34	0.9431	1.768	2.471	17	7	silty sand to sandy silt
40.846	53.44	1.1768	2.202	2.919	20	6	sandy silt to clayey silt
41.011	53.25	1.2494	2.346	3.477	20	6	sandy silt to clayey silt
41.175	54.43	1.3262	2.436	6.352	21	6	sandy silt to clayey silt
41.339	55.62	1.4028	2.522	6.958	21	6	sandy silt to clayey silt
41.503	58.84	1.6912	2.874	7.791	23	6	sandy silt to clayey silt
41.667	55.83	1.9935	3.571	8.651	27	5	clayey silt to silty clay
41.831	41.50	2.2019	5.306	9.666	40	3	clay
41.995	44.87	2.6772	5.966	14.271	43	3	clay
42.159	42.93	2.5248	5.881	4.966	41	3	clay
42.323	29.51	1.7233	5.840	6.954	28	3	clay
42.487	35.18	1.5128	4.300	6.870	22	4	silty clay to clay
42.651	36.70	1.1063	3.015	3.990	18	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
42.815	42.08	0.9730	2.312	3.631	16	6	sandy silt to clayey silt
42.979	42.33	1.0351	2.445	2.810	16	6	sandy silt to clayey silt
43.143	37.59	1.1091	2.950	2.798	14	6	sandy silt to clayey silt
43.307	25.59	1.0130	3.958	3.384	16	4	silty clay to clay
43.471	17.96	0.5942	3.308	9.498	9	5	clayey silt to silty clay
43.635	21.09	0.7924	3.757	24.329	13	4	silty clay to clay
43.799	22.09	1.1062	5.007	41.720	21	3	clay
43.963	25.73	1.5200	5.908	56.969	25	3	clay
44.127	33.19	1.6390	4.938	33.947	32	3	clay
44.291	43.00	1.3803	3.210	11.189	21	5	clayey silt to silty clay
44.455	49.32	1.2153	2.464	5.075	19	6	sandy silt to clayey silt
44.619	57.52	1.5487	2.692	2.767	22	6	sandy silt to clayey silt
44.783	44.45	1.8419	4.144	1.661	21	5	clayey silt to silty clay
44.948	31.20	1.6472	5.279	1.654	30	3	clay
45.112	25.49	1.4198	5.570	4.732	24	3	clay
45.276	20.14	1.1787	5.854	5.009	19	3	clay
45.440	20.40	1.1174	5.478	11.245	20	3	clay
45.604	26.32	1.2813	4.869	13.837	25	3	clay
45.768	32.77	1.4073	4.294	14.904	21	4	silty clay to clay
45.932	25.62	1.1636	4.541	22.582	25	3	clay
46.096	21.04	0.9584	4.556	35.232	20	3	clay
46.260	18.64	0.9805	5.260	43.731	18	3	clay
46.424	16.35	0.9181	5.615	44.734	16	3	clay
46.588	24.41	0.8912	3.651	45.967	12	5	clayey silt to silty clay
46.752	33.39	1.0426	3.122	16.079	16	5	clayey silt to silty clay
46.916	36.89	1.1704	3.173	10.630	18	5	clayey silt to silty clay
47.080	35.87	1.3592	3.789	7.219	17	5	clayey silt to silty clay
47.244	27.16	1.4025	5.163	8.962	26	3	clay
47.408	40.86	1.0237	2.505	11.481	16	6	sandy silt to clayey silt
47.572	54.44	0.8277	1.520	4.219	17	7	silty sand to sandy silt
47.736	60.32	0.7691	1.275	2.208	19	7	silty sand to sandy silt
47.900	56.91	0.8485	1.491	1.305	18	7	silty sand to sandy silt
48.064	50.53	0.9746	1.929	1.337	16	7	silty sand to sandy silt
48.228	51.70	0.9669	1.870	1.718	17	7	silty sand to sandy silt
48.392	59.37	1.2259	2.065	1.657	19	7	silty sand to sandy silt
48.556	47.03	1.2919	2.747	0.853	18	6	sandy silt to clayey silt
48.720	23.95	1.0634	4.441	7.049	23	3	clay
48.885	20.32	0.9006	4.431	10.433	19	3	clay
49.049	22.77	1.5776	6.927	19.672	22	3	clay
49.213	23.27	1.6513	7.095	21.767	22	3	clay
49.377	38.01	1.5239	4.009	20.378	18	5	clayey silt to silty clay
49.541	44.94	1.3343	2.969	7.299	17	6	sandy silt to clayey silt
49.705	50.74	1.2242	2.413	3.382	19	6	sandy silt to clayey silt
49.869	51.47	1.8833	3.659	2.061	25	5	clayey silt to silty clay
50.033	44.84	2.0409	4.551	2.485	29	4	silty clay to clay
50.197	43.67	2.3523	5.386	6.423	42	3	clay
50.361	54.81	2.2979	4.192	7.766	26	5	clayey silt to silty clay
50.525	66.82	1.7655	2.642	3.940	26	6	sandy silt to clayey silt
50.689	71.76	1.1918	1.661	1.384	23	7	silty sand to sandy silt
50.853	77.95	1.6335	2.096	0.583	25	7	silty sand to sandy silt
51.017	53.81	1.9408	3.607	-0.068	26	5	clayey silt to silty clay
51.181	35.23	1.9673	5.584	0.899	34	3	clay
51.345	31.84	1.8079	5.678	3.089	30	3	clay

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
51.509	42.92	1.6130	3.758	4.843	21	5	clayey silt to silty clay
51.673	53.85	1.2765	2.370	1.961	21	6	sandy silt to clayey silt
51.837	56.77	1.0653	1.876	0.974	18	7	silty sand to sandy silt
52.001	60.59	1.1244	1.856	1.868	19	7	silty sand to sandy silt
52.165	60.84	1.6862	2.771	1.232	23	6	sandy silt to clayey silt
52.329	52.61	2.0223	3.844	0.740	25	5	clayey silt to silty clay
52.493	43.55	1.8036	4.141	0.490	21	5	clayey silt to silty clay
52.657	49.17	1.3615	2.769	0.113	19	6	sandy silt to clayey silt
52.822	61.78	1.0504	1.700	-0.563	20	7	silty sand to sandy silt
52.986	66.12	1.6485	2.493	-1.037	25	6	sandy silt to clayey silt
53.150	52.62	1.6949	3.221	-0.901	25	5	clayey silt to silty clay
53.314	34.59	1.3780	3.984	1.325	22	4	silty clay to clay
53.478	29.12	1.1532	3.961	7.153	19	4	silty clay to clay
53.642	28.27	1.1920	4.217	14.625	18	4	silty clay to clay
53.806	27.82	1.2649	4.547	29.081	27	3	clay
53.970	26.30	1.2616	4.797	48.649	25	3	clay
54.134	25.30	1.2681	5.013	66.431	24	3	clay
54.298	32.64	1.3749	4.212	77.860	21	4	silty clay to clay
54.462	25.37	1.5486	6.103	56.118	24	3	clay
54.626	28.01	1.4944	5.336	66.195	27	3	clay
54.790	41.64	1.6184	3.887	36.062	20	5	clayey silt to silty clay
54.954	45.75	1.5028	3.285	18.392	22	5	clayey silt to silty clay
55.118	39.50	1.2497	3.164	14.915	19	5	clayey silt to silty clay
55.282	40.44	1.6292	4.029	12.714	19	5	clayey silt to silty clay
55.446	40.61	1.6595	4.087	16.781	19	5	clayey silt to silty clay
55.610	28.69	1.5945	5.558	30.922	27	3	clay
55.774	36.26	1.3774	3.799	52.203	17	5	clayey silt to silty clay
55.938	61.78	3.0951	5.010	31.335	39	4	silty clay to clay
56.102	81.30	3.9112	4.811	21.667	78	11	very stiff fine grained (*)
56.266	82.87	3.0486	3.679	9.330	40	5	clayey silt to silty clay
56.430	63.10	2.2078	3.499	3.189	30	5	clayey silt to silty clay
56.594	45.85	1.7241	3.760	1.807	22	5	clayey silt to silty clay
56.759	43.10	1.7112	3.971	2.485	21	5	clayey silt to silty clay
56.923	30.84	1.4742	4.780	2.526	30	3	clay
57.087	48.95	1.1218	2.292	3.756	19	6	sandy silt to clayey silt
57.251	71.37	1.2737	1.785	3.924	23	7	silty sand to sandy silt
57.415	89.25	1.7002	1.905	3.788	28	7	silty sand to sandy silt
57.579	77.26	2.3264	3.011	3.606	30	6	sandy silt to clayey silt
57.743	63.40	2.1079	3.325	3.749	24	6	sandy silt to clayey silt
57.907	61.25	1.3882	2.266	2.342	23	6	sandy silt to clayey silt
58.071	60.44	1.2663	2.095	0.946	23	6	sandy silt to clayey silt
58.235	55.31	1.2239	2.213	0.481	21	6	sandy silt to clayey silt
58.399	52.99	1.1308	2.134	1.019	20	6	sandy silt to clayey silt
58.563	48.24	0.9952	2.063	9.702	18	6	sandy silt to clayey silt
58.727	49.24	0.9202	1.869	7.946	16	7	silty sand to sandy silt
58.891	48.83	0.9245	1.893	8.576	16	7	silty sand to sandy silt
59.055	49.49	0.9022	1.823	9.786	16	7	silty sand to sandy silt
59.219	50.37	0.9386	1.864	11.754	16	7	silty sand to sandy silt
59.383	48.28	0.9585	1.985	19.808	18	6	sandy silt to clayey silt
59.547	43.80	1.0294	2.350	21.976	17	6	sandy silt to clayey silt
59.711	37.06	1.0281	2.774	24.472	14	6	sandy silt to clayey silt
59.875	30.02	1.0088	3.360	27.552	14	5	clayey silt to silty clay
60.039	23.99	0.9158	3.817	32.704	15	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
60.203	19.87	0.9096	4.579	42.442	19	3	clay
60.367	23.81	0.9325	3.917	53.508	15	4	silty clay to clay
60.532	41.13	0.9118	2.217	29.880	16	6	sandy silt to clayey silt
60.696	45.53	0.9778	2.148	16.073	17	6	sandy silt to clayey silt
60.860	45.39	0.9506	2.094	13.710	17	6	sandy silt to clayey silt
61.024	45.58	0.9128	2.002	15.063	17	6	sandy silt to clayey silt
61.188	46.98	0.9623	2.048	16.490	18	6	sandy silt to clayey silt
61.352	48.71	1.0629	2.182	17.718	19	6	sandy silt to clayey silt
61.516	50.51	1.0649	2.108	18.683	19	6	sandy silt to clayey silt
61.680	50.47	1.1415	2.262	19.599	19	6	sandy silt to clayey silt
61.844	52.01	1.2155	2.337	20.689	20	6	sandy silt to clayey silt
62.008	55.01	1.2688	2.306	20.984	21	6	sandy silt to clayey silt
62.172	57.87	1.3157	2.274	21.202	22	6	sandy silt to clayey silt
62.336	68.10	1.4997	2.202	21.000	26	6	sandy silt to clayey silt
62.500	71.61	1.5956	2.228	20.929	23	7	silty sand to sandy silt
62.664	70.01	1.6489	2.355	21.447	27	6	sandy silt to clayey silt
62.828	65.46	1.6682	2.548	21.853	25	6	sandy silt to clayey silt
62.992	62.18	1.7078	2.747	22.586	24	6	sandy silt to clayey silt
63.156	63.25	1.6761	2.650	22.933	24	6	sandy silt to clayey silt
63.320	62.56	1.6921	2.705	21.467	24	6	sandy silt to clayey silt
63.484	57.96	1.6508	2.848	20.594	22	6	sandy silt to clayey silt
63.648	45.83	1.5854	3.460	22.039	22	5	clayey silt to silty clay
63.812	28.15	1.1435	4.063	23.946	18	4	silty clay to clay
63.976	21.35	0.6784	3.178	34.676	10	5	clayey silt to silty clay
64.140	18.08	0.3042	1.683	47.092	7	6	sandy silt to clayey silt
64.304	17.84	0.2650	1.485	56.708	7	6	sandy silt to clayey silt
64.469	16.50	0.2960	1.794	63.029	8	5	clayey silt to silty clay
64.633	19.22	0.5502	2.863	61.588	9	5	clayey silt to silty clay
64.797	19.15	0.8462	4.419	56.965	18	3	clay
64.961	39.52	0.9301	2.353	31.403	15	6	sandy silt to clayey silt
65.125	50.58	0.9555	1.889	15.605	16	7	silty sand to sandy silt
65.289	53.06	1.0951	2.064	17.761	20	6	sandy silt to clayey silt
65.453	55.49	1.1612	2.093	19.148	21	6	sandy silt to clayey silt
65.617	56.47	1.2148	2.151	20.605	22	6	sandy silt to clayey silt
65.781	55.95	1.2337	2.205	21.651	21	6	sandy silt to clayey silt
65.945	55.10	1.2492	2.267	22.359	21	6	sandy silt to clayey silt
66.109	55.29	1.2671	2.292	22.995	21	6	sandy silt to clayey silt
66.273	55.22	1.2765	2.312	23.242	21	6	sandy silt to clayey silt
66.437	55.03	1.3056	2.372	23.512	21	6	sandy silt to clayey silt
66.601	55.43	1.3385	2.415	24.002	21	6	sandy silt to clayey silt
66.765	53.85	1.3684	2.541	24.320	21	6	sandy silt to clayey silt
66.929	51.99	1.3203	2.539	24.533	20	6	sandy silt to clayey silt
67.093	51.33	1.2889	2.511	24.824	20	6	sandy silt to clayey silt
67.257	51.35	1.2558	2.445	24.899	20	6	sandy silt to clayey silt
67.421	51.96	1.2564	2.418	24.166	20	6	sandy silt to clayey silt
67.585	49.36	1.3699	2.775	24.633	19	6	sandy silt to clayey silt
67.749	40.99	1.2759	3.112	25.586	20	5	clayey silt to silty clay
67.913	34.07	1.1975	3.515	29.376	16	5	clayey silt to silty clay
68.077	36.62	1.1461	3.130	37.265	18	5	clayey silt to silty clay
68.241	46.23	1.0457	2.262	34.742	18	6	sandy silt to clayey silt
68.406	53.29	1.0640	1.997	14.668	20	6	sandy silt to clayey silt
68.570	46.27	0.8547	1.847	17.151	15	7	silty sand to sandy silt
68.734	37.56	0.8395	2.235	19.159	14	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve Friction (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
68.898	28.13	0.6570	2.335	24.234	11	6	sandy silt to clayey silt
69.062	27.96	0.8310	2.972	26.365	13	5	clayey silt to silty clay
69.226	37.90	1.3851	3.655	51.720	18	5	clayey silt to silty clay
69.390	57.47	1.2972	2.257	22.457	22	6	sandy silt to clayey silt
69.554	50.55	1.0765	2.130	18.117	19	6	sandy silt to clayey silt
69.718	39.92	1.2217	3.061	21.765	19	5	clayey silt to silty clay
69.882	36.65	1.2311	3.359	38.368	18	5	clayey silt to silty clay
70.046	39.17	0.9817	2.506	39.426	15	6	sandy silt to clayey silt
70.210	31.06	0.7488	2.411	30.861	12	6	sandy silt to clayey silt
70.374	23.06	0.6761	2.932	35.904	11	5	clayey silt to silty clay
70.538	19.89	0.4464	2.244	53.338	10	5	clayey silt to silty clay
70.702	23.20	0.3357	1.447	66.029	9	6	sandy silt to clayey silt
70.866	19.96	0.3162	1.584	63.249	8	6	sandy silt to clayey silt
71.030	19.48	0.4184	2.147	73.664	9	5	clayey silt to silty clay
71.194	20.28	0.5108	2.519	75.241	10	5	clayey silt to silty clay
71.358	25.20	0.7168	2.844	74.340	12	5	clayey silt to silty clay
71.522	38.84	0.7748	1.995	51.393	15	6	sandy silt to clayey silt
71.686	51.48	1.0246	1.990	8.143	20	6	sandy silt to clayey silt
71.850	33.06	1.0717	3.242	9.593	16	5	clayey silt to silty clay
72.014	26.89	0.8087	3.008	21.923	13	5	clayey silt to silty clay
72.178	36.21	0.5437	1.502	30.514	14	6	sandy silt to clayey silt
72.343	27.35	0.4812	1.760	19.432	10	6	sandy silt to clayey silt
72.507	19.91	0.6065	3.046	36.287	10	5	clayey silt to silty clay
72.671	20.30	0.4542	2.238	62.906	10	5	clayey silt to silty clay
72.835	20.35	0.3430	1.686	53.483	8	6	sandy silt to clayey silt
72.999	15.45	0.3538	2.291	58.133	7	5	clayey silt to silty clay
73.163	19.44	0.3086	1.587	68.943	7	6	sandy silt to clayey silt
73.327	21.22	0.2908	1.371	64.563	8	6	sandy silt to clayey silt
73.491	16.95	0.3438	2.028	63.113	8	5	clayey silt to silty clay
73.655	13.11	0.2092	1.595	84.181	6	5	clayey silt to silty clay
73.819	13.35	0.1407	1.054	95.555	5	6	sandy silt to clayey silt
73.983	13.07	0.1804	1.380	100.551	6	5	clayey silt to silty clay
74.147	13.96	0.2092	1.498	98.944	7	5	clayey silt to silty clay
74.311	13.22	0.2458	1.860	103.045	6	5	clayey silt to silty clay
74.475	14.77	0.2352	1.592	109.245	7	5	clayey silt to silty clay
74.639	27.34	0.5939	2.172	97.670	10	6	sandy silt to clayey silt
74.803	25.33	0.5471	2.160	44.553	10	6	sandy silt to clayey silt
74.967	18.21	0.5210	2.861	67.388	9	5	clayey silt to silty clay
75.131	15.19	0.4616	3.039	80.992	7	5	clayey silt to silty clay
75.295	13.26	0.3448	2.601	94.341	6	5	clayey silt to silty clay
75.459	13.07	0.2511	1.922	96.663	6	5	clayey silt to silty clay
75.623	12.87	0.2019	1.568	87.830	6	5	clayey silt to silty clay
75.787	13.56	0.2113	1.558	80.529	6	5	clayey silt to silty clay
75.951	14.72	0.8329	5.659	74.018	14	3	clay
76.115	51.19	0.9803	1.915	98.254	16	7	silty sand to sandy silt
76.280	450.32	1.5304	0.340	46.602	72	10	gravelly sand to sand

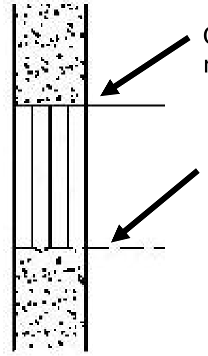
APPENDIX B

APPENDIX B

PREVIOUS EXPLORATIONS

SYMBOL	SAMPLING DESCRIPTION
◨	Location of sample collected in general accordance with ASTM D1586 using Standard Penetration Test with recovery
◧	Location of sample collected using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D1587 with recovery
▥	Location of sample collected using Dames & Moore sampler and 300-pound hammer or pushed with recovery
▤	Location of sample collected using Dames & Moore sampler and 140-pound hammer or pushed with recovery
◩	Location of sample collected using 3-inch-O.D. California split-spoon sampler and 140-pound hammer with recovery
⊠	Location of grab sample
▮	Rock coring interval
▽	Water level during drilling
▼	Water level taken on date shown

Graphic Log of Soil and Rock Types



Observed contact between soil or rock units (at depth indicated)

Inferred contact between soil or rock units (at approximate depths indicated)

GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Non-Plastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

GEODESIGN INC AN NV5 COMPANY	EXPLORATION KEY	TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOIL

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 – 11	0 – 4
Loose	4 – 10	11 – 26	4 – 10
Medium Dense	10 – 30	26 – 74	10 – 30
Dense	30 – 50	74 – 120	30 – 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 – 4	3 – 6	2 – 5	0.25 – 0.50
Medium Stiff	4 – 8	6 – 12	5 – 9	0.50 – 1.0
Stiff	8 – 15	12 – 25	9 – 19	1.0 – 2.0
Very Stiff	15 – 30	25 – 65	19 – 31	2.0 – 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.

Percent	Silt and Clay In:		Percent	Sand and Gravel In:	
	Fine-Grained Soil	Coarse-Grained Soil		Fine-Grained Soil	Coarse-Grained Soil
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

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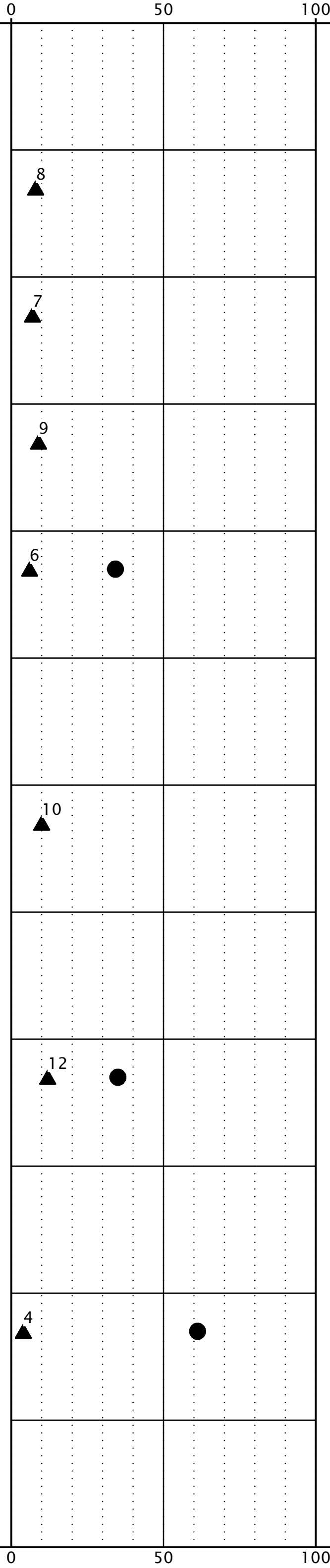
SOIL CLASSIFICATION SYSTEM

TABLE A-2

▲ BLOW COUNT
● MOISTURE CONTENT %
▥ RQD% ▨ CORE REC%

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT	INSTALLATION AND COMMENTS
0.0		Loose, brown, silty SAND (SM); moist, sand is fine to medium - **FILL**.					
2.5						8	
5.0						7	
7.5		gray at 8.5 feet				9	
10.0				P200		6	P200 = 27%
12.5							
15.0		medium dense at 15.0 feet				10	
17.5		Medium dense, brown SAND with silt (SP-SM); wet - **FILL**.	17.0				
20.0				P200		12	P200 = 10%
22.5		Soft to medium stiff, dark gray SILT (MH); wet, silt has high plasticity.	22.0				
25.0				ATT		4	LL = 70% PL = 37%
27.5							
30.0							



DRILLED BY: Western States Soil Conservation, Inc.

LOGGED BY: T. Pierce

COMPLETED: 11/26/19

BORING METHOD: mud rotary (see document text)

BORING BIT DIAMETER: 4 1/4 inches

GEODESIGN INC
AN NV5 COMPANY

ZENITH-1-01

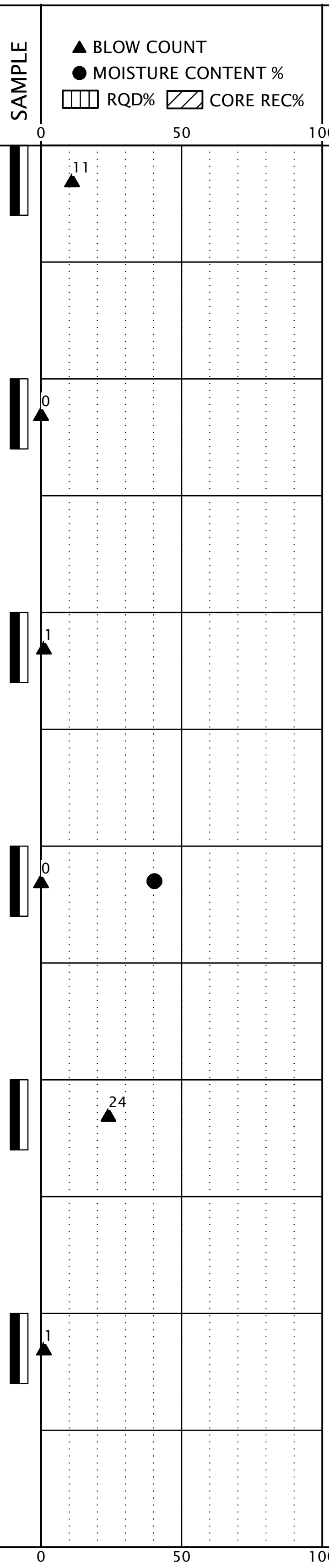
MAY 2020

BORING B-1

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-1

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT	INSTALLATION AND COMMENTS
30.0		stiff, light gray with orange-brown mottles at 30.0 feet				11	
35.0		very soft, light brown at 35.0 feet				0	
40.0						1	
44.0		Very soft, light brown with orange mottled SILT (ML); wet.	44.0				
45.0				ATT		0	LL = NP PL = NP
50.0		very stiff, dark gray to gray at 50.0 feet				24	
55.0		very soft at 55.0 feet				1	



DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: T. Pierce COMPLETED: 11/26/19

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 1/4 inches

GEODESIGN INC
AN NV5 COMPANY

ZENITH-1-01

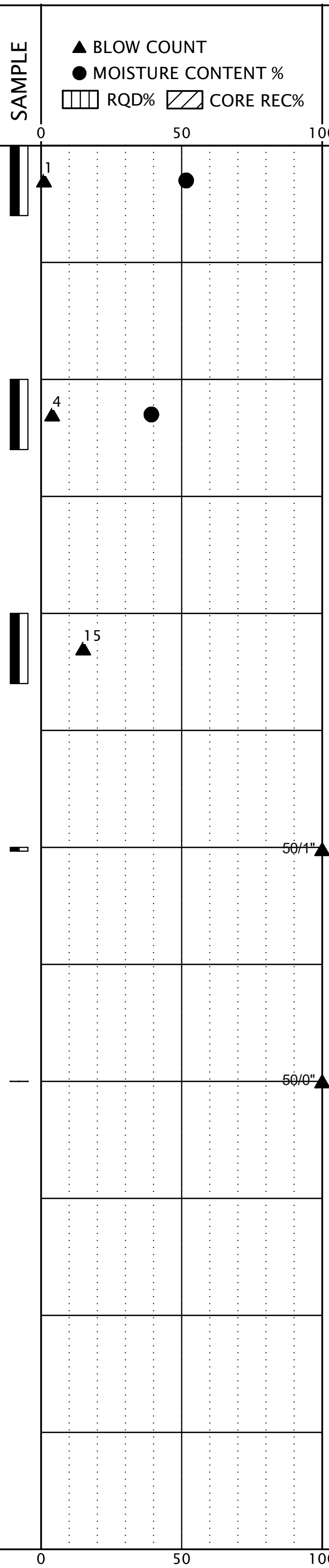
MAY 2020

BORING B-1
(continued)

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-1

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	INSTALLATION AND COMMENTS
60.0	(continued from previous page)		ATT	LL = NP PL = NP
65.0			P200	P200 = 59%
67.5	Stiff to very stiff, dark gray SILT (MH), minor sand; wet, sand is fine.	68.0		
72.5	Medium hard, black BASALT.	74.0		
80.0	Exploration completed at a depth of 80.0 feet. Hammer efficiency factor is 82.2 percent.	80.0		Surface elevation was not measured at the time of exploration.



DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Pierce
COMPLETED: 11/26/19

BORING METHOD: mud rotary (see document text)
BORING BIT DIAMETER: 4 1/4 inches

GEODESIGN INC
AN NV5 COMPANY

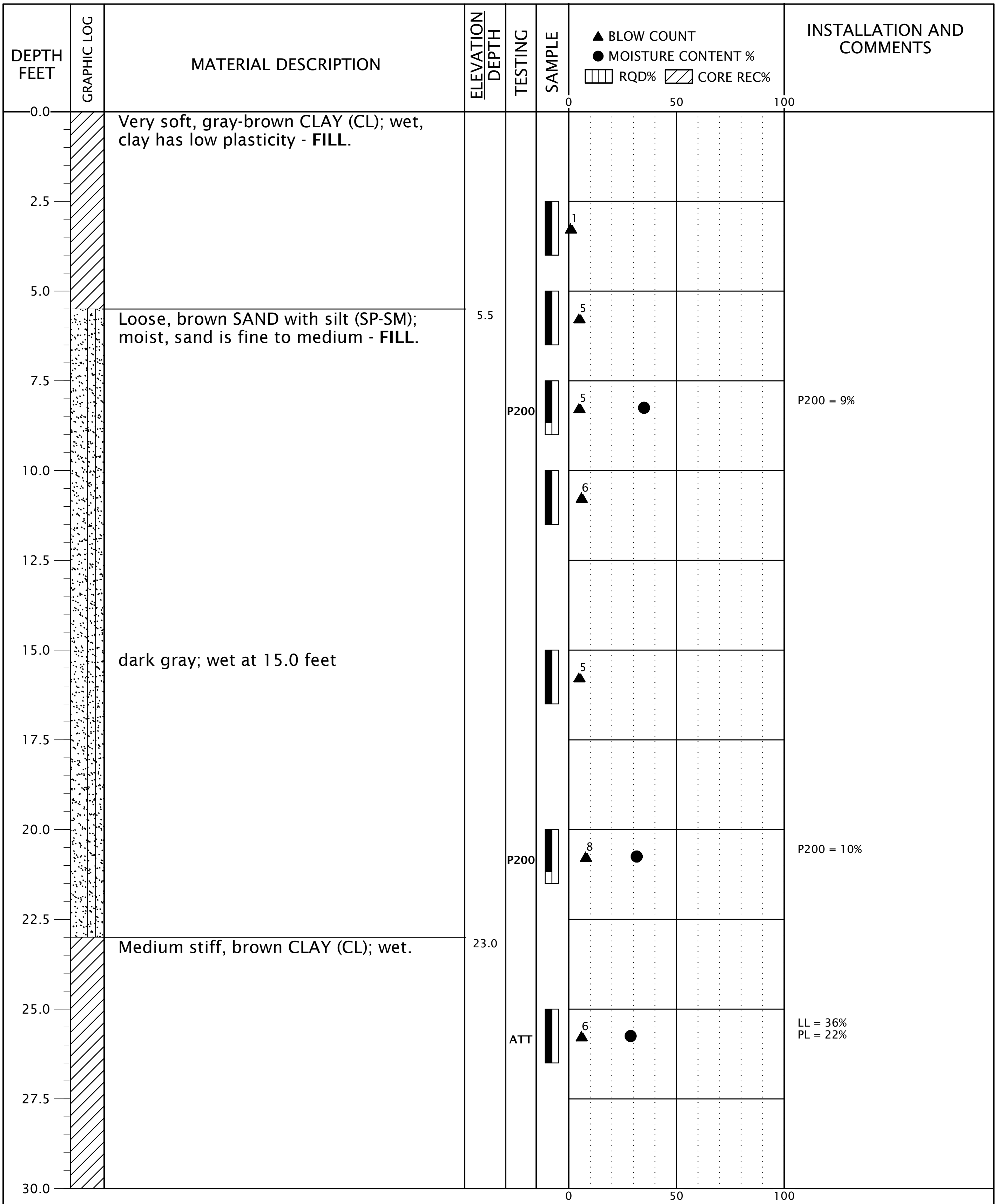
ZENITH-1-01

MAY 2020

BORING B-1
(continued)

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-1



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Very soft, gray-brown CLAY (CL); wet, clay has low plasticity - **FILL**.				
2.5				1	
5.0				5	
	Loose, brown SAND with silt (SP-SM); moist, sand is fine to medium - **FILL**.	5.5			
7.5			P200	5	P200 = 9%
10.0				6	
12.5					
15.0	dark gray; wet at 15.0 feet			5	
17.5					
20.0			P200	8	P200 = 10%
22.5					
	Medium stiff, brown CLAY (CL); wet.	23.0			
25.0			ATT	6	LL = 36% PL = 22%
27.5					
30.0					

DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: T. Pierce
COMPLETED: 11/27/19

BORING METHOD: mud rotary (see document text)
BORING BIT DIAMETER: 4 1/4 inches

GEODESIGN INC
AN NV5 COMPANY

ZENITH-1-01

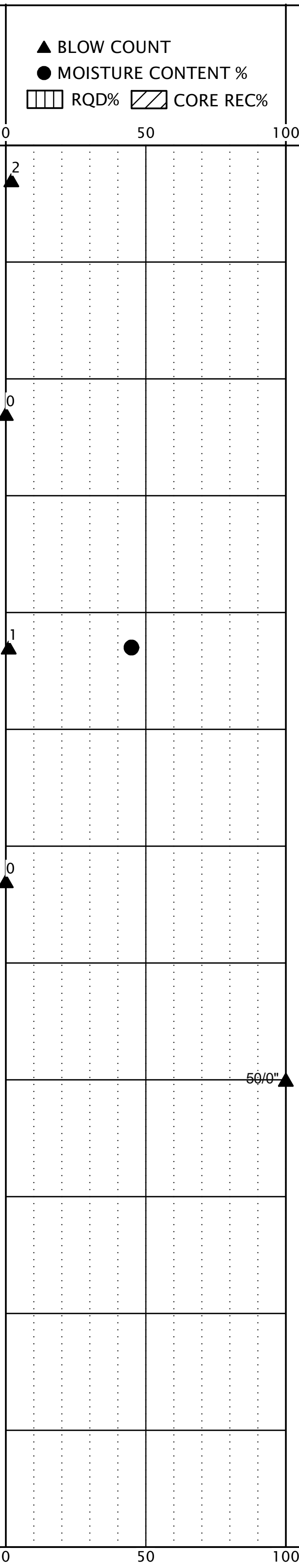
MAY 2020

BORING B-2

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	BLOW COUNT	INSTALLATION AND COMMENTS
30.0	soft at 30.0 feet			2	
35.0	very soft at 35.0 feet			0	
	Very soft, brown with orange mottled SILT (ML); wet.	39.5			
40.0			ATT	1	LL = NP PL = NP
45.0	gray at 45.0 feet			0	
	Medium hard, black BASALT.	49.0			
50.0	Exploration completed at a depth of 50.0 feet. Hammer efficiency factor is 82.2 percent.	50.0		50/0"	Surface elevation was not measured at the time of exploration.



DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: T. Pierce COMPLETED: 11/27/19

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 1/4 inches

GEODESIGN INC
AN NV5 COMPANY

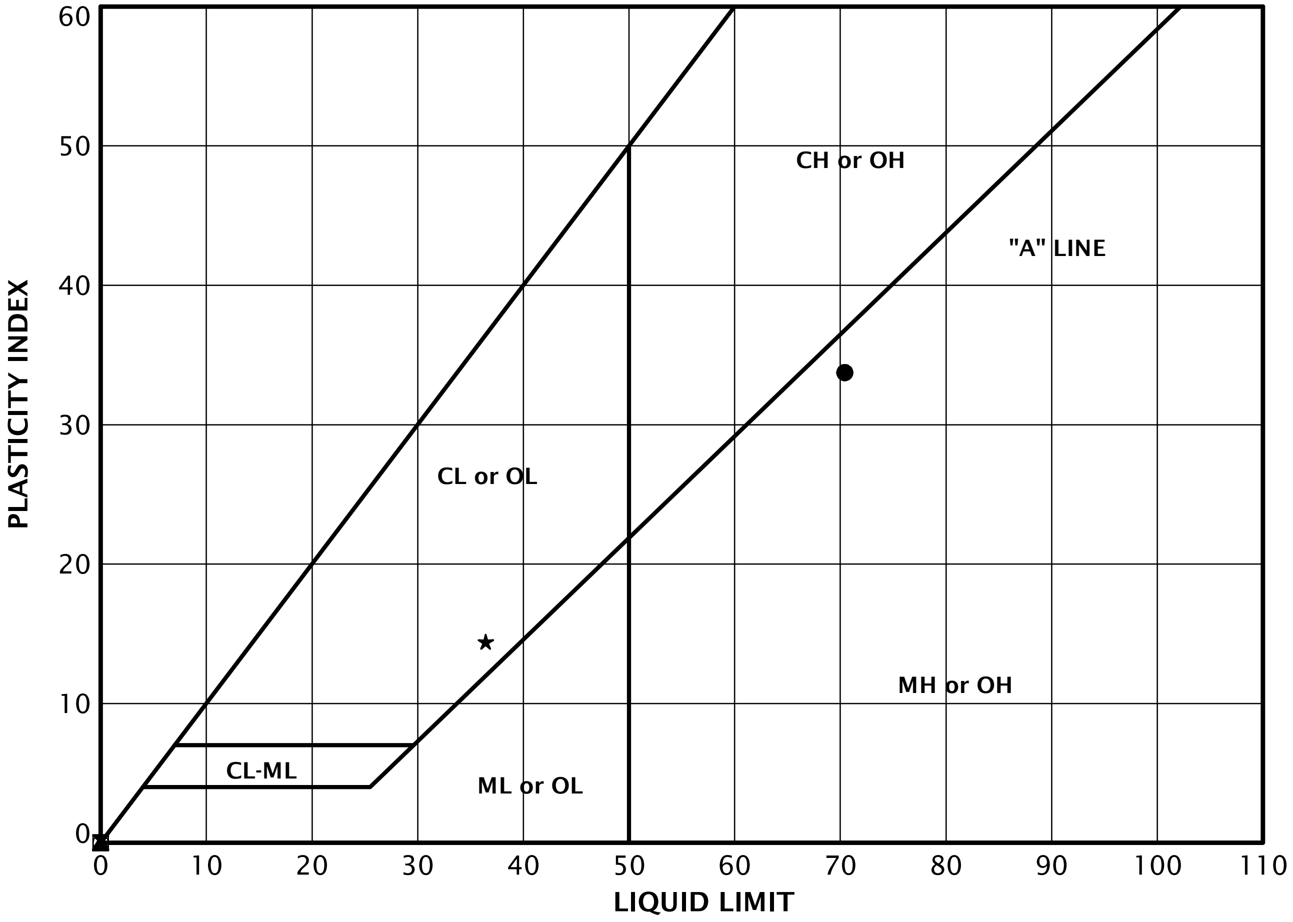
ZENITH-1-01

MAY 2020

BORING B-2
(continued)

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-2



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-1	25.0	61	70	37	33
⧗	B-1	45.0	40	NP	NP	NP
▲	B-1	60.0	52	NP	NP	NP
★	B-2	25.0	29	36	22	14
⊙	B-2	40.0	45	NP	NP	NP

GEODESIGN INC
AN NV5 COMPANY

ZENITH-1-01

MAY 2020

ATTERBERG LIMITS TEST RESULTS

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-3

ATTERBERG_LIMITS 7 ZENITH-1-01-B1_2.GPJ GEODESIGN.GDT PRINT DATE: 5/29/20:KT

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	10.0		34				27			
B-1	20.0		35				10			
B-1	25.0		61					70	37	33
B-1	45.0		40					NP	NP	NP
B-1	60.0		52					NP	NP	NP
B-1	65.0		39				59			
B-2	7.5		35				9			
B-2	20.0		32				10			
B-2	25.0		29					36	22	14
B-2	40.0		45					NP	NP	NP

GEODESIGN INC
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ZENITH-1-01

MAY 2020

SUMMARY OF LABORATORY DATA

ZENITH PORTLAND TERMINAL
PORTLAND, OR

FIGURE A-4

Summary of SPT Test Results

Project: WSSC-8-04, Test Date: 12/27/2018

EMX: Maximum Energy

ETR: Energy Transfer Ratio - Rated

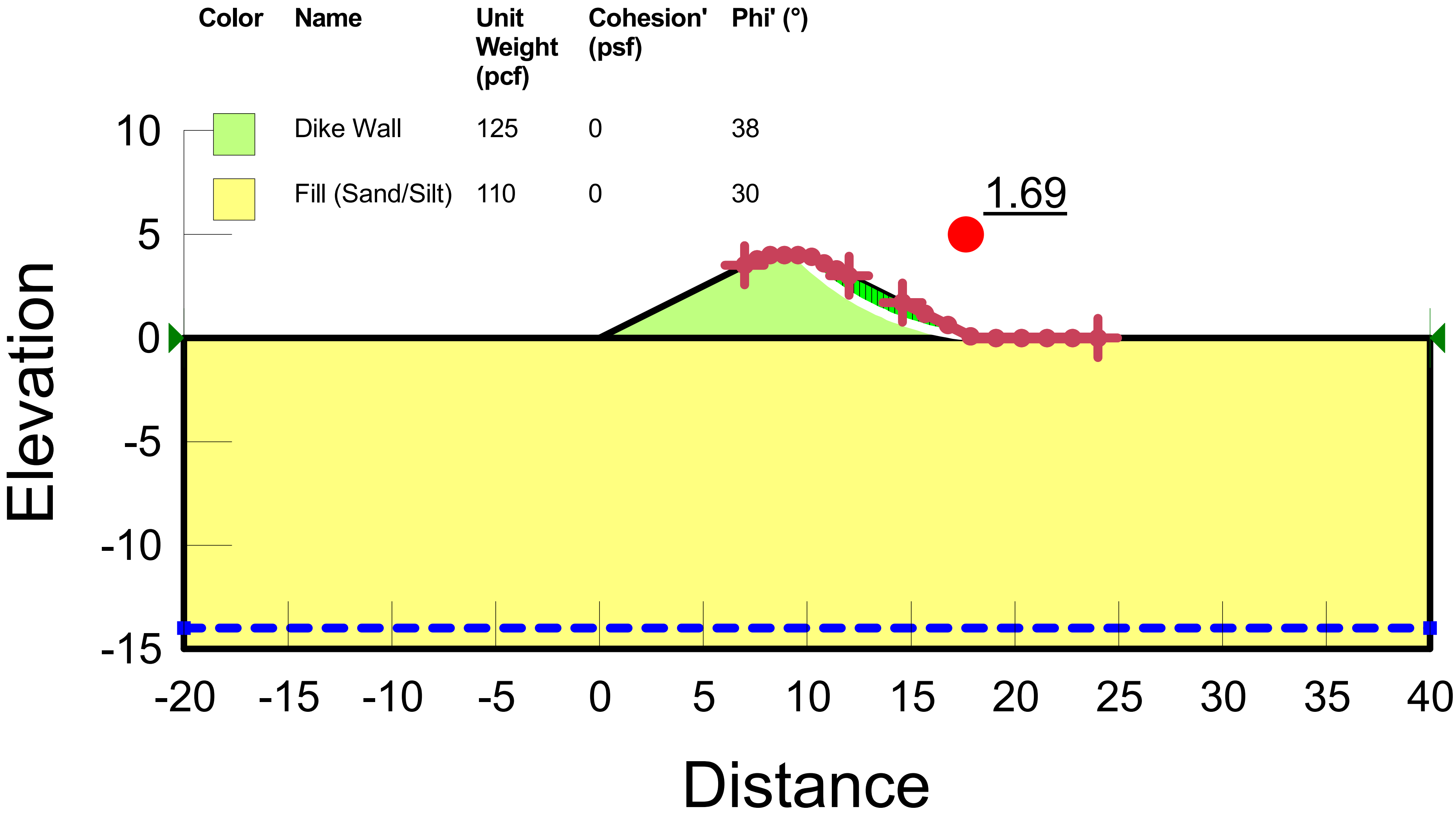
Start Depth ft	Final Depth ft	**N Value**	**N60 Value**	Average EMX ft-lb	Average ETR %
25.00	26.50	**0**	**0**	0.00	0.0
30.00	31.50	**31**	**42**	267.77	76.5
35.00	36.50	**34**	**46**	305.69	87.3
40.00	41.50	**0**	**0**	0.00	0.0
			Overall Average Values:	287.61	82.2
			Standard Deviation:	32.43	9.3
			Overall Maximum Value:	387.60	110.7
			Overall Minimum Value:	234.46	67.0

APPENDIX C

APPENDIX C

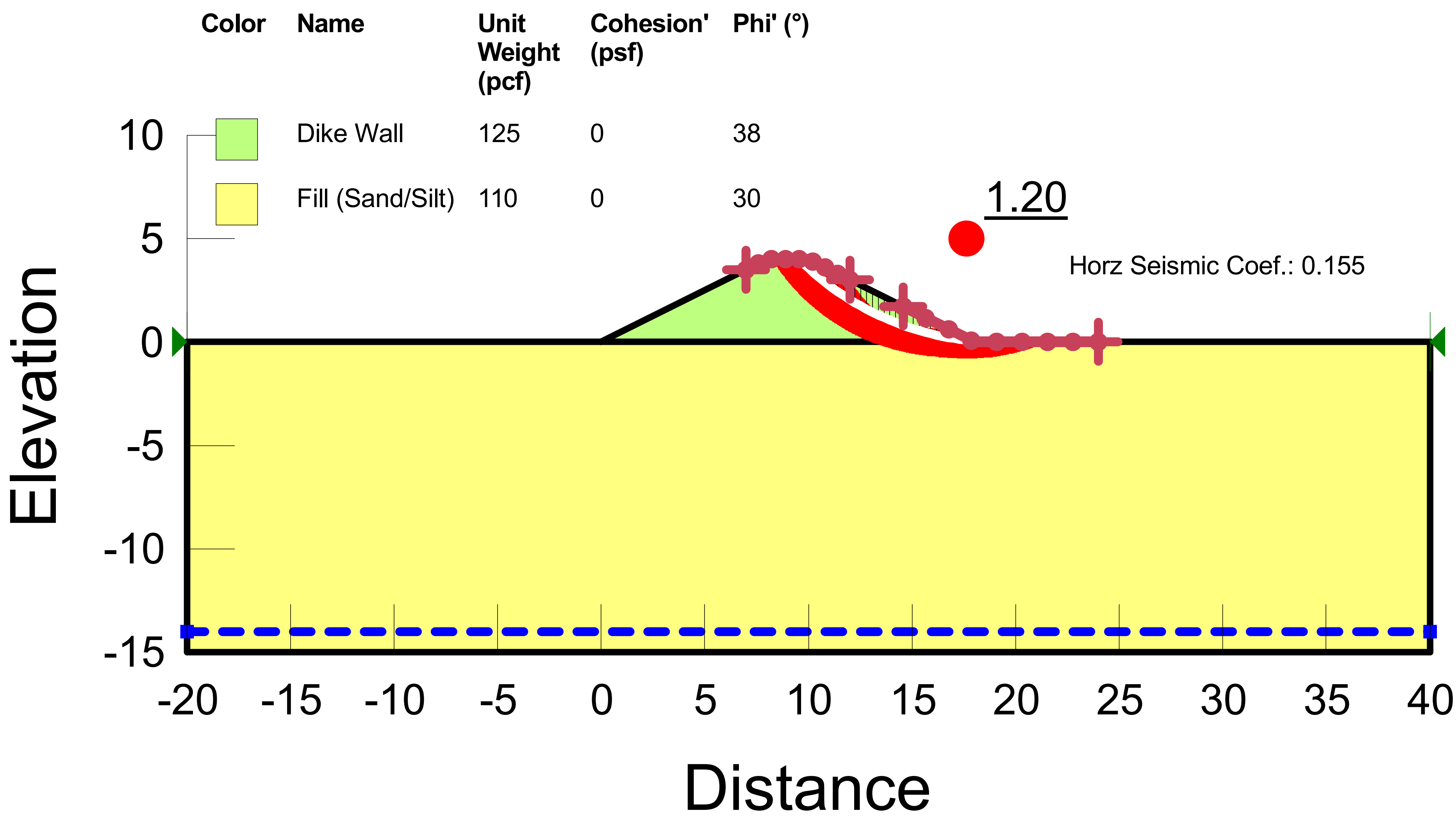
EARTHEN DIKE STABILITY RESULTS

Zenith-3-01 - Earthen Dike Wall - Static



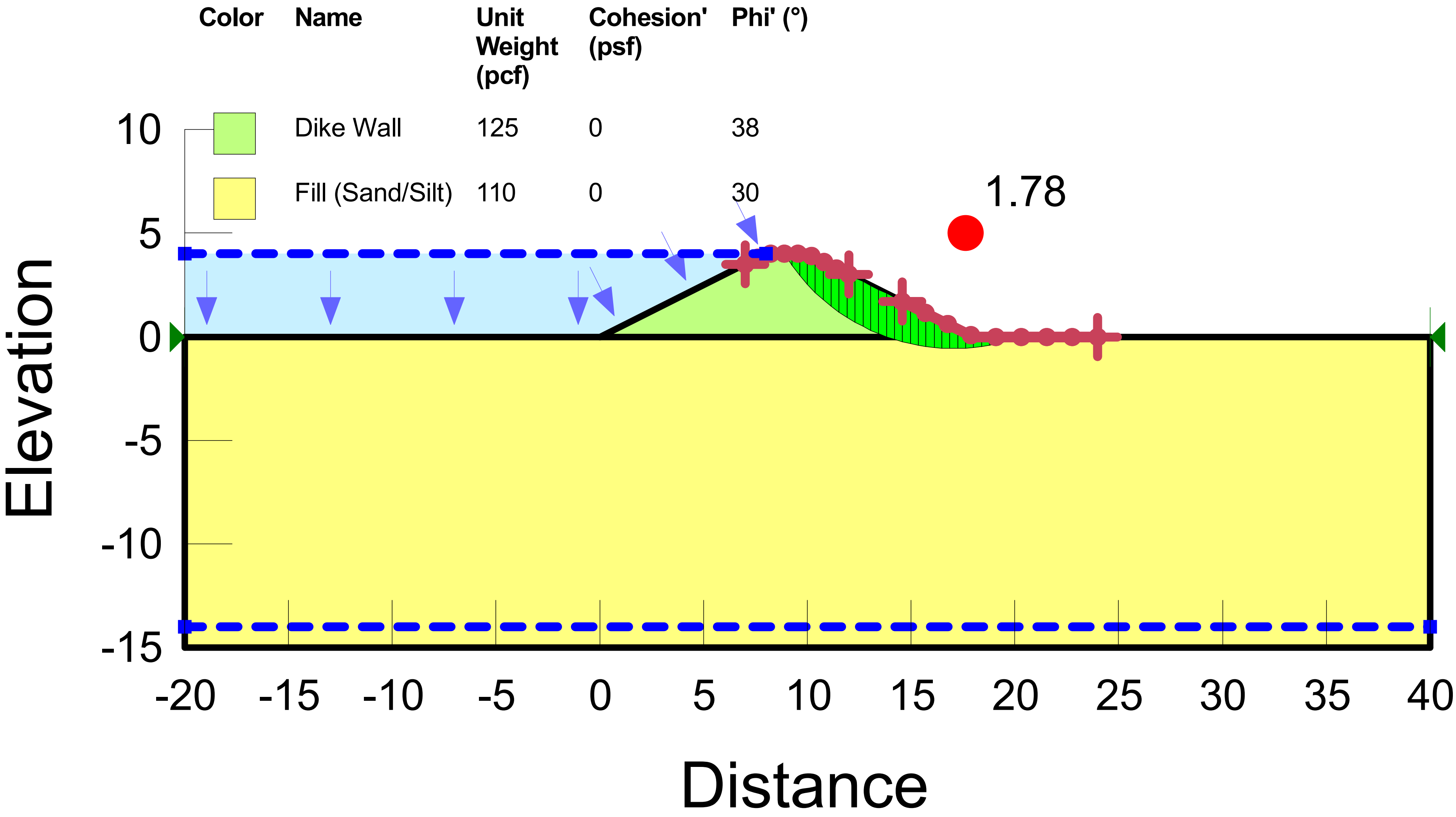
Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟩	Dike Wall	125	0	38
🟨	Fill (Sand/Silt)	110	0	30

Zenith-3-01 - Earthen Dike Wall - Seismic



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟩	Dike Wall	125	0	38
🟨	Fill (Sand/Silt)	110	0	30

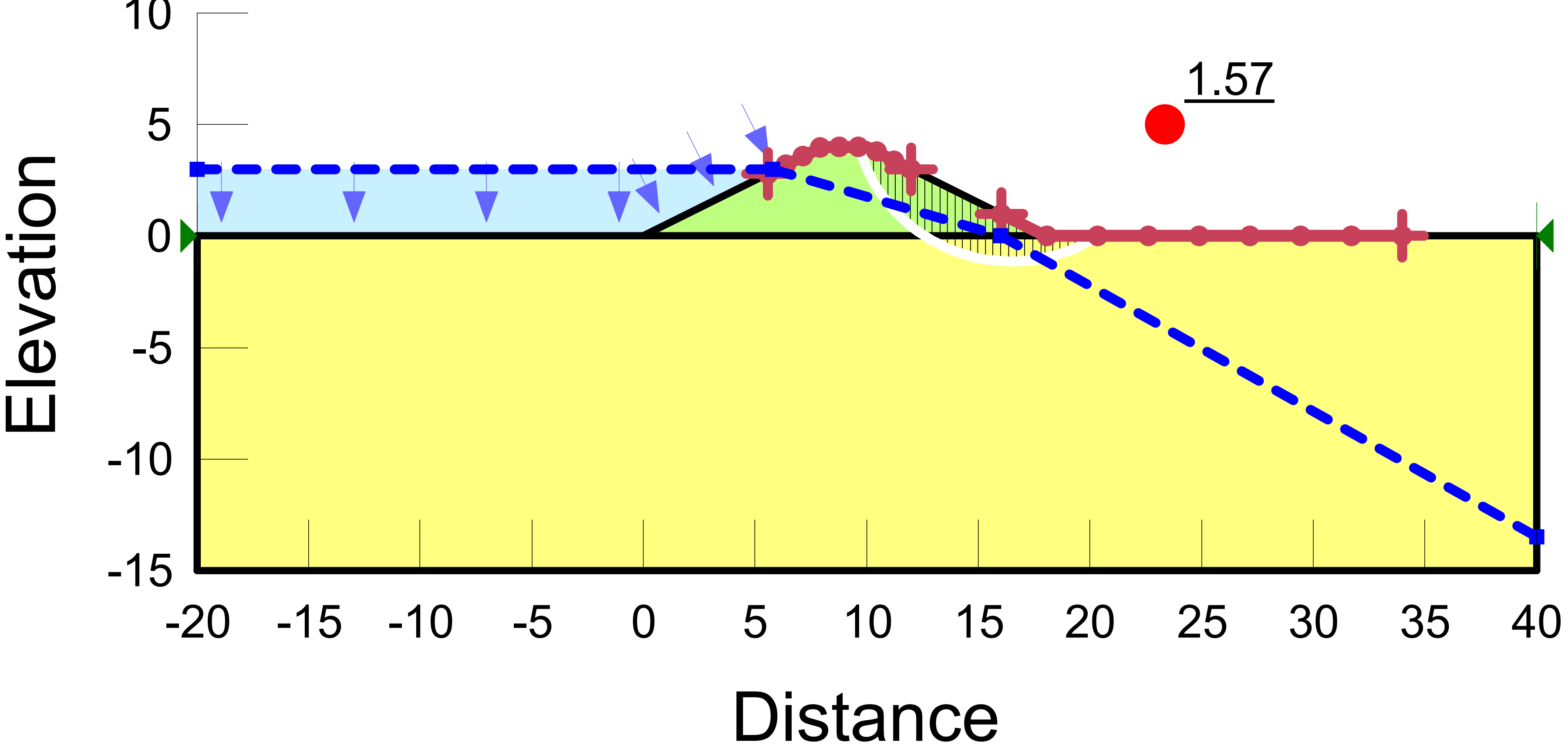
Zenith-3-01 - Earthen Dike Wall - Post Seismic



Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟩	Dike Wall	125	0	38
🟨	Fill (Sand/Silt)	110	0	30

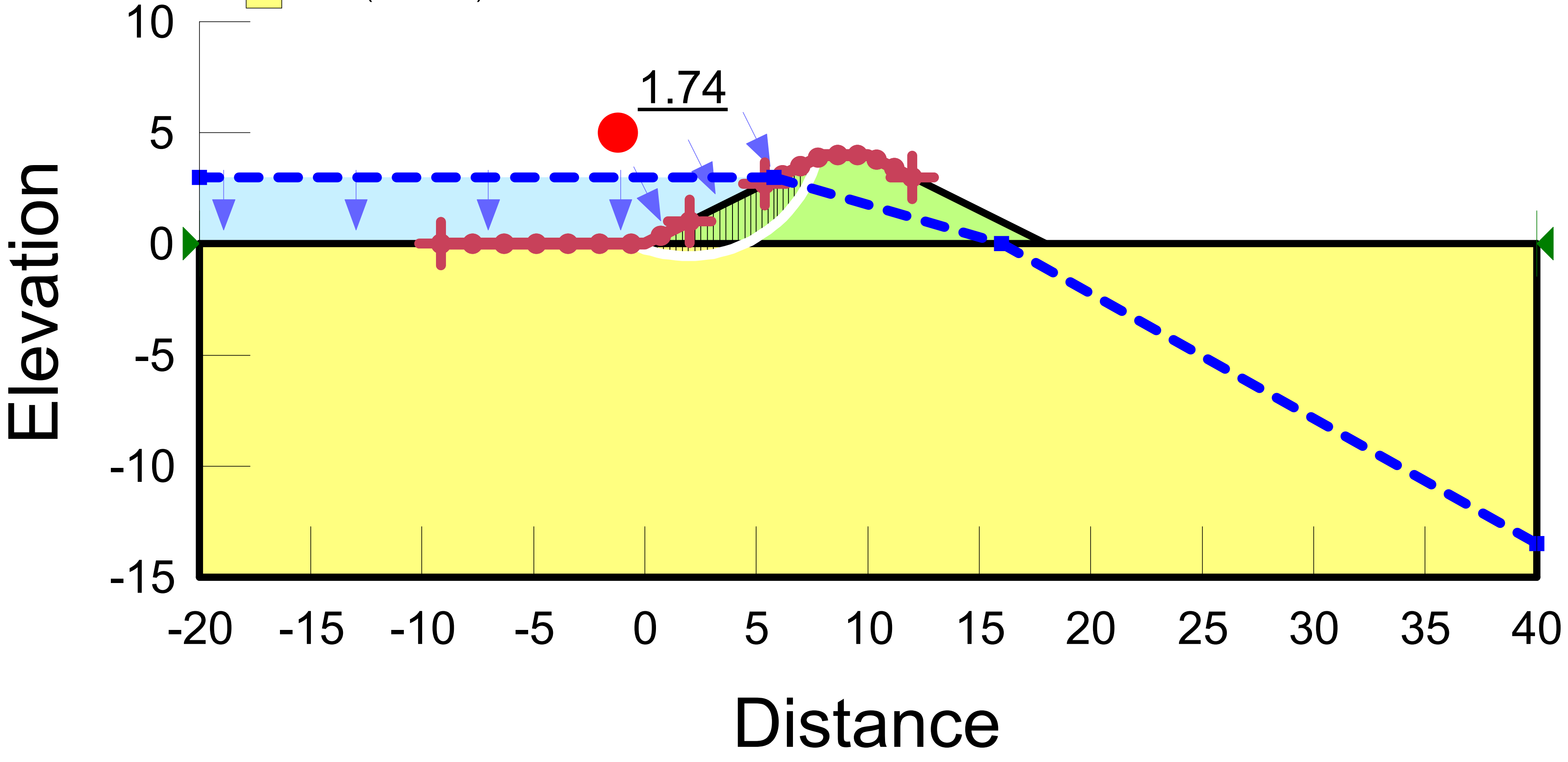
Zenith-3-01 - Earthen Dike Wall - Post Seismic - Undrained

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Dike Wall	125	0	38
🟨	Fill (Sand/Silt)	110	0	30



Zenith-3-01 - Earthen Dike Wall - Post Seismic - Undrained

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Dike Wall	125	0	38
🟨	Fill (Sand/Silt)	110	0	30



APPENDIX D

APPENDIX D

STRUCTURAL ASSESSMENT OF CONTAINMENT WALLS

KPFF performed an analytical study to determine the seismic shaking performance and post-shaking performance of four different concrete wall types.

ZENITH ENERGY CONTAINMENT WALLS

STRUCTURAL ASSESSMENT OF CONTAINMENT WALLS

MAY 19, 2022

SUBMITTED TO

BRETT SHIPTON
NV5

SUBMITTED BY

KPFF CONSULTING ENGINEERS
111 SW 5TH AVENUE, SUITE 2600
PORTLAND, OR 97204

STRUCTURAL
REGISTERED PROFESSIONAL
ENGINEER
76643PE
OREGON
MAY 10, 2005
NATHAN A. INGRAFFEA
EXPIRES: 6-30-23

ZENITH ENERGY CONTAINMENT WALLS

TABLE OF CONTENTS

DESCRIPTION PAGE NO.

ZENITH ENERGY CONTAINMENT WALLS

STRUCTURAL ASSESSMENT OF CONTAINMENT WALLS

EXECUTIVE SUMMARY

The Zenith Energy is a bulk fuel storage terminal located in Portland, OR. The facility is surrounded by walls designed to contain spillage from its on-site storage tanks. An analytical study was undertaken to determine the seismic shaking performance and post-shaking performance of four different concrete wall types: 6.5-foot cantilever wall, 6.0-foot cantilever wall, 6.5-foot gravity wall, and a 3.0-foot gravity wall. All four wall types were found to be able to withstand a code level seismic load for the seismic shaking load case. For the post-shaking load case where the walls were laterally loaded with static liquid pressures, the two gravity walls were found to resist a liquid load height equal to their individual heights. The two cantilever walls were found to withstand liquid loads 1 to 1.5 feet below the top of wall. However, per the terminal's Spill Prevention, Control, and Countermeasure (SPCC plan) the tank farm with the referenced cantilever walls has 3 feet 4 inches of excess freeboard from top of wall available.

INTRODUCTION

Zenith Energy is a bulk fuel storage and transfer terminal located in Portland, OR. The entire facility sits on a flat 39-acre site and contains a few single-story buildings, large storage tanks, and various refinery equipment. The facility was constructed in 1947 as an asphalt refinery. Zenith took over the site in 2017 after its predecessor began using the site to refine crude oil. Today, Zenith uses the facility to store and transfer various liquid fuels including crude oil, gasoline, diesel, and biodiesel.

This report details the results of a structural assessment of the outdoor containment walls that surround the perimeter of the facility. It is our understanding that the existing fuel storage tanks could leak or fail during a seismic event. Therefore, an analytical study was undertaken to assess the effect of a containment wall subjected to lateral liquid pressure imposed by escaped fuel.

EXISTING CONDITIONS

The outdoor containment walls consist of various wall types that vary from 3 to 9.3 feet in height. The wall types include concrete cantilever walls, concrete gravity walls, earth berms, and CMU walls. An assessment of the earth berms is not included in the scope of this report. A site map identifying wall types is provided in the Appendix.

The southern and eastern side of the site consists of a mix of 3-foot concrete gravity walls and 3-foot earth berms. The 3-foot concrete gravity wall was constructed in 1966 (Photo 1) and there is approximately 1100 LF on site.

The northern and western walls consist of a mix of concrete gravity walls and concrete cantilever walls. The gravity walls are 6.5 feet in height (Photo 2). The concrete cantilever walls occur at three different heights: 6 feet, 6.5 feet and 9.3 feet in height. The 6.5-foot cantilever wall was constructed in 1945 (Photo 3) and there is approximately 1200 LF of wall on site. The 6-foot cantilever wall was constructed in 1975 (Photo 4) and there is approximately 350 LF of wall on site. The 9.3-foot cantilever wall on the west side of the facility serves as the containment wall between Zenith and another industrial facility (Photo 5). It is believed that this wall is owned and maintained by the neighboring facility and so this wall was not included in the scope of this study.

On the north side, there is approximately 400 LF of 6-foot-tall CMU wall. No as-built drawings were available for this wall and so its assessment was excluded from this study. However, it is assumed that the CMU wall would perform similarly to the 6-foot concrete based on its assumed period of construction and its currently good condition.

No major structural issues were observed for any containment wall. There was one small area of concrete deterioration at the base of one of the 6.5-foot cantilever wall segments (Photo 6). There were also numerous locations where concrete cracks and spawls had been repaired with epoxy sealant over the years. In general, the vast majority of the walls appeared to be in very good condition. Walls appeared plumb and had no open cracks or other exposed rebar. Note that this condition assessment was limited to visually exposed portions of the wall only. Concealed portions, such as the footing, could not be observed.

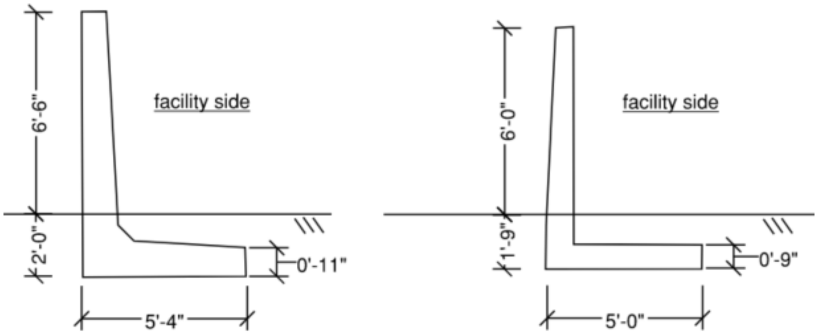
ANALYSIS

The Zenith Energy facility is located in a high seismic region and the ground soil is susceptible to liquefaction according to geologic exploration performed by NV5 in 2021. Therefore, the potential for leaks in pipes and tanks becomes a concern during a seismic event. The likelihood of spillage of these systems is outside the scope of this study. However, it is helpful to understand the containment ability of the existing containment walls if a large spill event were to occur.

This analytical study was broken into two load cases. The first load case considered a code level seismic load on the wall as defined by the 2019 Oregon Structural Specialty Code (OSSC). This load case considered a "during shaking" condition where the lateral liquid pressure has not reached the wall, yet the wall is subjected to a lateral loading from its own seismic mass. This lateral load on the wall was developed using the seismic provisions of ASCE7-16 Chapter 15 as referenced in the OSSC. NV5 provided the soil parameters of 35pcf active and 270pcf passive pressure for this during shaking condition.

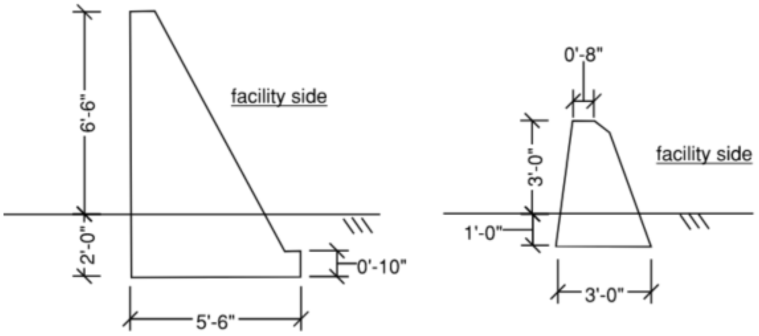
The second load case considered a “post-shaking” condition where the wall is no longer subjected to inertial seismic loads and is instead subjected to a lateral pressure loading from spilled fuel. A static lateral pressure equal to the weight of the heaviest fuel (specific gravity of 1.1) was applied to the wall. Buoyant soil parameters were used with an active pressure of 15pcf and a passive pressure of 180pcf.

A 2-D analytical model was used to assess a typical cross-section of each wall type. Wall geometry was determined from as-built drawings. Four wall types were assessed as shown in Figure 1. Loading diagrams for each load case can be found in the Appendix.



A. 6.5ft Cantilever Wall

B. 6.0ft Cantilever Wall



C. 6.5ft Gravity Wall

D. 3.0ft Gravity Wall

Figure 1. Wall Sections

Containment wall sliding, overturning, and soil bearing analytical checks were performed to assess wall stability. The sliding stability check assessed the wall’s ability to resist translational movement. Sliding resistance is provided by the frictional force between the soil and wall structure. The overturning stability check assessed the wall’s ability to resist rotational movement from lateral pressure. The OSSC defines minimum safety factors for sliding and overturning stability. Soiling bearing from the wall footing was checked by comparing soil bearing pressure to an allowable soil bearing pressure provided by NV5.

The containment walls were also checked for strength resistance in the concrete. For the concrete cantilever walls, the stem and footing were checked for adequate flexural and shear strength as defined in the OSSC using the as-built rebar detailing. The concrete gravity walls were not subjected to the same flexural and shear loads. Their strength is achieved through stability.

RESULTS

The containment walls performed well under the assessed "during shaking" and "post-shaking" loading conditions. In the "during shaking" load condition where the walls were subjected to inertial seismic loading only, overturning and sliding stability were adequate. The concrete structure also provided sufficient resistance to the seismic loading.

The containment walls provided different levels of performance for the "post-shaking" load case where the walls were subjected to lateral liquid loads shown in Figure 2. A summary of the findings is provided in Table 1. Note that the cantilever walls could not retain a liquid fuel height equal to their exposed height. Sliding stability failures are predicted to occur when fuel height equals the wall exposed height. Therefore, a maximum fluid height was calculated for each cantilever wall based on allowable limits for stability established by the OSSC. These maximum fluid heights are provided in Table 1. The 6.5-foot gravity wall could resist at a fluid height just below its exposed height, yet it should be considered satisfactory for full liquid height. The 3-foot gravity wall was able to resist a fuel height equal to its exposed height.

An analytical assessment of the walls' ability to prevent leakage of retained fuel for prolonged periods was outside the scope of this study. However, it is noted that the wall footings do not appear to contain fabric liners so fuel seepage into the ground might be expected after a spill event. Although no visible open cracks were observed in the walls, it is unlikely that the walls will prevent fuel leakage from occurring over time. It's expected that any potential leak would outflow relatively slowly. Coupled with mitigation/recovery efforts, the site and surrounding areas will likely be protected from harm.

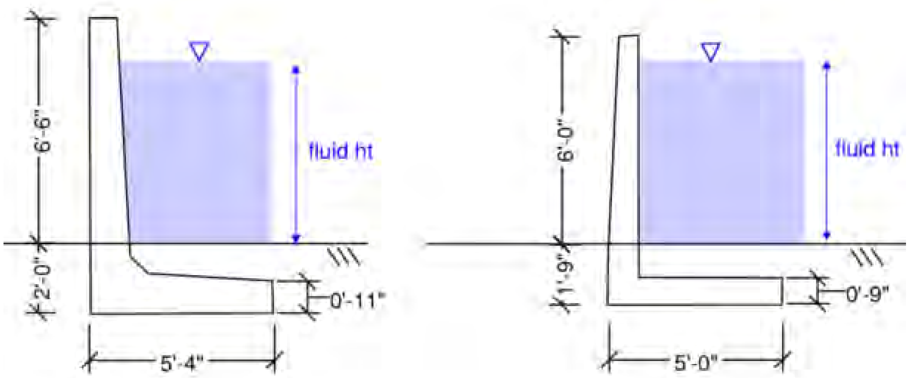
Soil analysis by NV5 indicates that the site is susceptible to liquefaction induced settlement. Settlement is anticipated to be up to 8 inches with a differential settlement of up to 4 inches over 50 feet. This settlement could cause in-plane rotations along the length of the walls which could cause vertically oriented flexural cracking at regular intervals. The cracks could be the source of additional fuel leakage; however, in-plane rotation and related cracking is not expected to cause wall instability.

NV5 has determined that lateral spread is not considered a hazard for the site. Therefore, lateral spreading was not considered when assessing wall performance.

SUMMARY

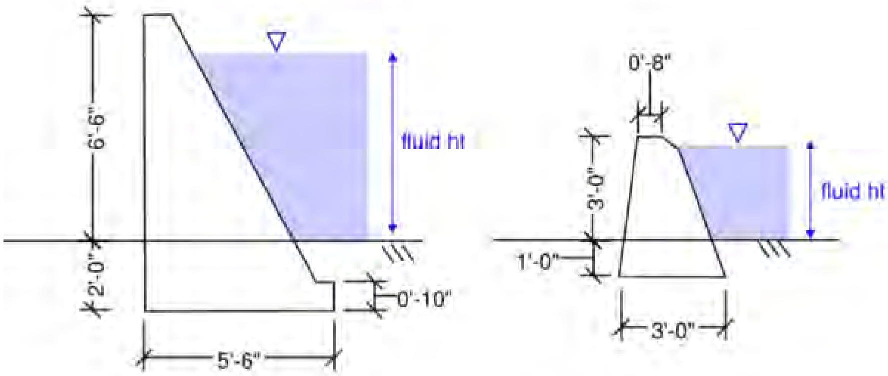
Each of the four containment wall types performed reasonably well for both the “during shaking” and “post-shaking” analytical load cases. No failures are predicted for the “during shaking” load case. For the “post-shaking” load case, the cantilever walls can withstand static liquid pressures at heights 1 to 1.5 feet below the top of wall, but as mentioned earlier, the cantilever walls have freeboard of 3 feet 4 inches from the top. The gravity walls can withstand static liquid lateral pressures equal to their exposed height.

It should be noted that not all wall types could be loaded to their maximum exposed height simultaneously because the Zenith facility is on a flat lot and overall site spillage could not exceed 3 feet of height which is equal to the height of the shortest wall. Therefore, containment capacity for the entire site is considered to be 3 feet maximum. However, the theoretical maximum liquid height for each wall type is helpful to understand as a basis of performance.



A. 6.5ft Cantilever Wall

B. 6.0ft Cantilever Wall



C. 6.5ft Gravity Wall

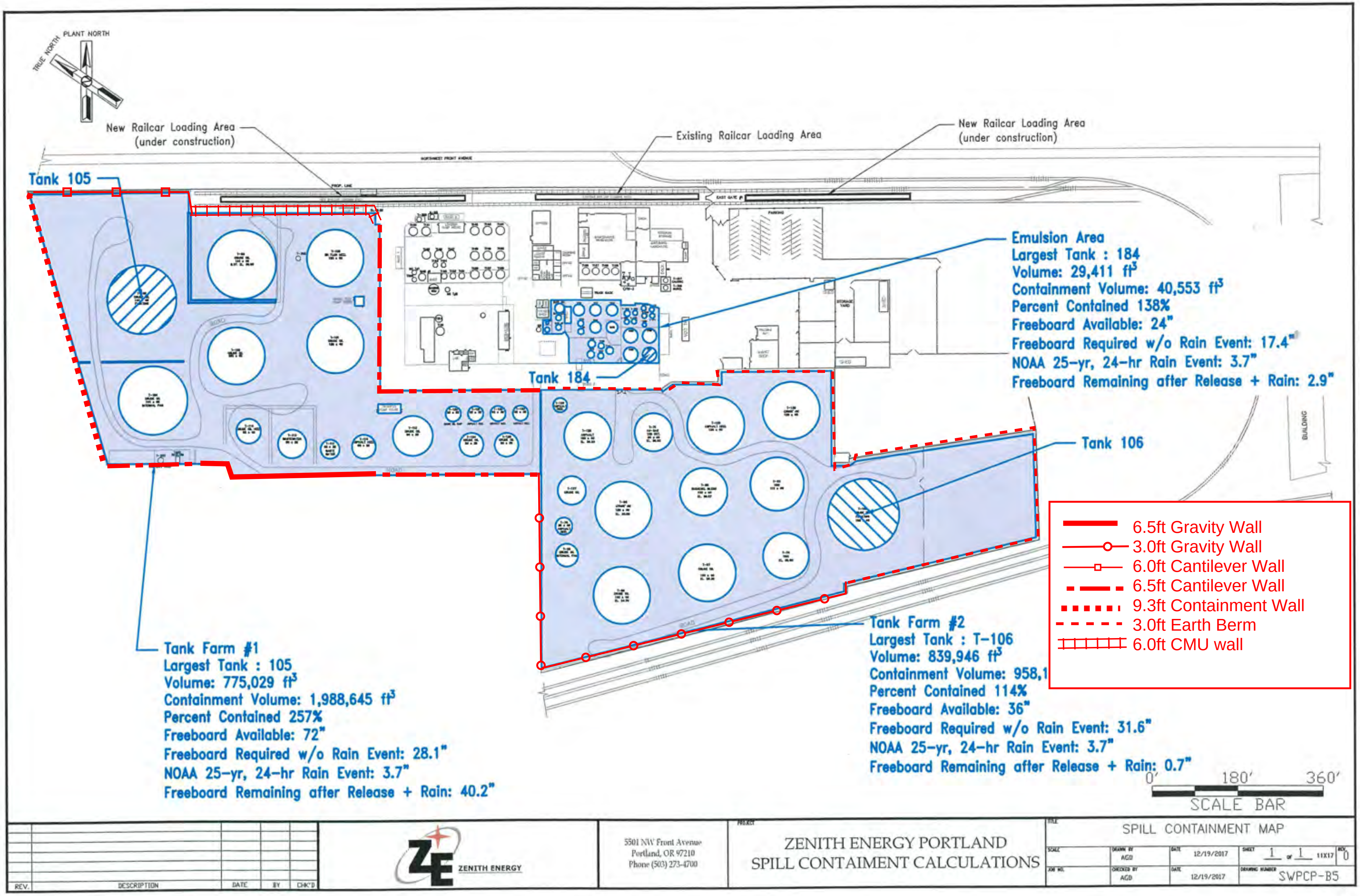
D. 3.0ft Gravity Wall

Figure 2. Load Case 2 on Wall Sections

Table 1. Wall Performance by Load Case

Wall Type	**During Shaking Load Case**	**Post-Shaking Load Case**	
		max fluid ht	failure mechanism
6.5ft Cantilever	wall okay	5.5 ft	Sliding
6.0ft Cantilever	wall okay	4.7 ft	Sliding
6.5ft Gravity	wall okay	6.3 ft (~6.5ft ok)	Sliding
3.0ft Gravity	wall okay	3.0 ft	N/A

APPENDIX A



PLANT NORTH
TRUE NORTH
New Railcar Loading Area (under construction)
Existing Railcar Loading Area
New Railcar Loading Area (under construction)
Tank 105
Emulsion Area
Largest Tank : 184
Volume: 29,411 ft³
Containment Volume: 40,553 ft³
Percent Contained 138%
Freeboard Available: 24"
Freeboard Required w/o Rain Event: 17.4"
NOAA 25-yr, 24-hr Rain Event: 3.7"
Freeboard Remaining after Release + Rain: 2.9"
Tank 184
Tank 106
6.5ft Gravity Wall
3.0ft Gravity Wall
6.0ft Cantilever Wall
6.5ft Cantilever Wall
9.3ft Containment Wall
3.0ft Earth Berm
6.0ft CMU wall
Tank Farm #1
Largest Tank : 105
Volume: 775,029 ft³
Containment Volume: 1,988,645 ft³
Percent Contained 257%
Freeboard Available: 72"
Freeboard Required w/o Rain Event: 28.1"
NOAA 25-yr, 24-hr Rain Event: 3.7"
Freeboard Remaining after Release + Rain: 40.2"
Tank Farm #2
Largest Tank : T-106
Volume: 839,946 ft³
Containment Volume: 958,1
Percent Contained 114%
Freeboard Available: 36"
Freeboard Required w/o Rain Event: 31.6"
NOAA 25-yr, 24-hr Rain Event: 3.7"
Freeboard Remaining after Release + Rain: 0.7"
0'
180'
360'
SCALE BAR
BUILDING
REV.
DESCRIPTION
DATE
BY
CHK'D
ZENITH ENERGY
5501 NW Front Avenue
Portland, OR 97210
Phone (503) 273-4700
PROJECT
ZENITH ENERGY PORTLAND
SPILL CONTAIMENT CALCULATIONS
TITLE
SPILL CONTAINMENT MAP
SCALE
DRAWN BY AGD
DATE 12/19/2017
SHEET 1 of 1 11X17
REV. 0
JOB NO.
CHECKED BY AGD
DATE 12/19/2017
DRAWING NUMBER SWPCP-B5

APPENDIX B

SITE PHOTOS

Photo 1 - 3.0-foot Concrete Gravity Wall

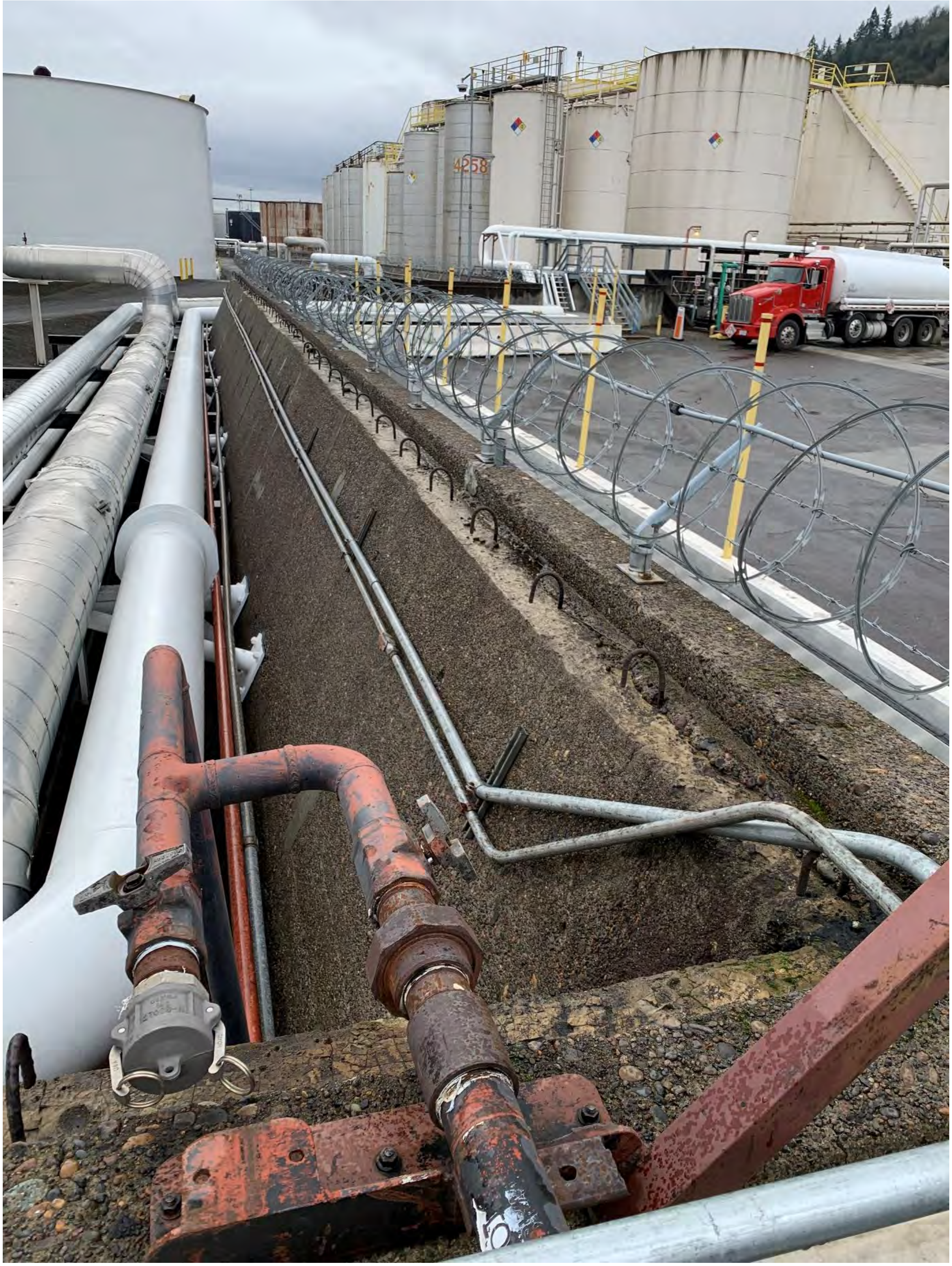


Photo 2 - 8.5-foot Concrete Gravity Wall

Photo 3 - 6.5-foot Concrete Cantilever Wall

Photo 4 - 6.0-foot Concrete Cantilever Wall

Photo 5 - 9.3-foot Concrete Containment Wall

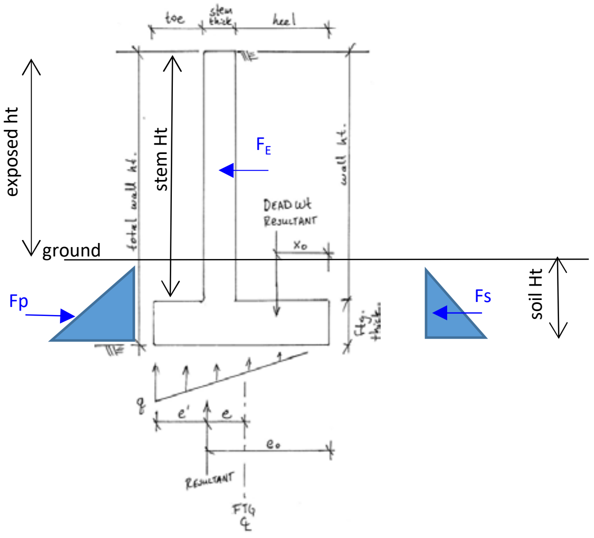
Photo 6 – Concrete Degradation at 6.5-foot Concrete Cantilever Wall

Appendix C

	Project: Zenith Energy Containment Walls	By: RP	Sheet No.
	Location: Portland, OR	Date: 02/21/22	
	Client: NV5	Revised:	Job No.
	Subject: 6ft Cantilever Wall - Eq Load Case	Date:	22100845

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
0	pcf	fluid, Horiz	spec grav= 1
0	pcf	fluid, vert	spec grav= 1
35	pcf	soil pressure	
270	pcf	Passive pressure	
2.5	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

93	in	Tot Wall Ht	7.75	ft
72	in	exposed ht	6.00	ft
0	in	fluid ht	0.00	ft
84	in	stem ht	7.00	ft
7.5	in	Avg Stem	0.63	ft
0.0	in	Toe Length	0.00	ft
52.5	in	Heal Length	4.38	ft
60.0	in	Ftg length	5.00	ft
9	in	Ftg Thick	0.75	ft
0.35		Coeff. Friction at Soil Interface		
21	in	passive ht	1.75	ft
21	in	soil ht	1.75	ft

Loads

0	lbs	Wt fluid
656	lbs	Wt stem
563	lbs	Wt ftg
0	lbs	fluid Lateral Force, F_H
54	lbs	soil Force, F_s
413	lbs	Soil Passive Force, F_p
604	lbs	Earthquake Lateral Force, F_E =Cs*W
1219	lbs	W, Dead Load (wall total + fluid+superimposed)

Seis loading per ASCE7-16 Ch 15.4

C_s=	0.496	S_{DS}/(R/Ie)
$C_{s,max}$=	7.568	S_{D1}/(0.065sec*R/Ie)
$C_{s,min}$=	0.03	min(0.03;0.044S_{DS}*I_p)
R=	1.25	Table 15.4-2
I_e=	1.0	
S_{MS}=	1.162	
S_{M1}=	1.153	
S_{DS}=	0.620	2/3*S_{MS}*0.8 lower bound factor
S_{D1}=	0.615	2/3*S_{M1}*0.8 lower bound factor

COMBO: D+H+L

Sliding Force	54	lbs
Mo	31	lb ft
Result location	outside middle third	
ResistMoment	1612	lb ft
Toe Bear, q_{toe}	543	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	51.6	>1.5, OK
Sliding F.O.S.	15.7	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	477	lbs
Mo	1,040	lb ft
Result location	outside middle third	
ResistMoment	1612	lb ft
Toe Bear, q_{toe}	1217	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	1.55	>1.1, OK
Sliding F.O.S.	1.76	>1.1, OK

COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	371	lbs
Mo	780	lb ft
Result location	outside middle third	
ResistMoment	1612	lb ft
Toe Bear, q_{toe}	922	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.07	>1.1, OK
Sliding F.O.S.	2.27	>1.1, OK

COMBO: 1.2D+1.6H+1.6L

Mo	50	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	628	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	-181	lb-ft
Top Vu heel	-505	lb
Stem Mu	9	lb-ft
StemVu	28	lb

COMBO: 1.2D+1.6H+0.5L+E

Mo	1,536	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	1816	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	1113	lb-ft
Top Vu heel	44	lb
Stem Mu	1042	lb-ft
Stem Vu	632	lb

kpff	Project: Zenith Energy Containment Walls	By: RP	Sheet No.
	Location: Portland, OR	Date: 02/21/22	
	Client: NV5	Revised:	Job No.
	Subject: 6ft Cantilever Wall - Eq Load Case	Date:	22100845

Reinforcing Design

f'c	2,500	psi	per As-Built
fy	33,000	psi	assumed

Stem Wall Reinforcing

Mu max=	1042	lb-ft		b=	12	in
Mu max=	12.5	kip-in		d=	5.19	in
Vu =	0.6	kip		β_1	0.85	
bar=	#5			a=	0.397	in
As	0.31	in^2		c=	0.467	in
s=	12	in		es=	0.030	
As, prov=	0.31	in^2		ϕ=	0.9	
clearance=	2	in				
ϕ Mn=	45.4	kip-in				
DCR =	**0.28**	**<1.0, OK**	Mu/max / ϕ Mn			
ϕ Vn=	4.7	kip				
DCR =	**0.14**	**<1.0, OK**	Vu / ϕ Vn			

Top Footing Reinforcing

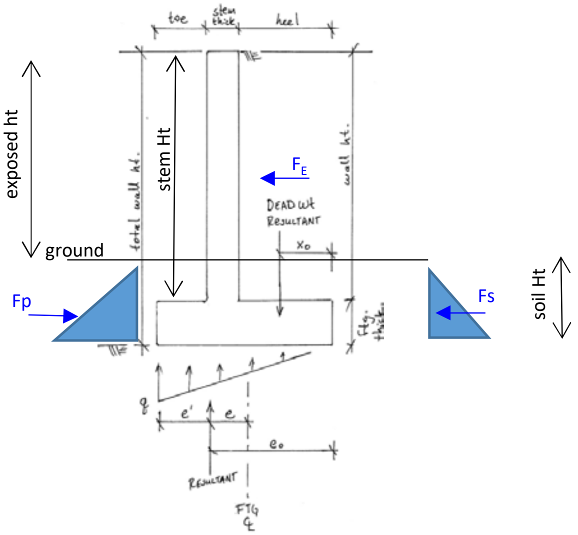
Mu max=	1113	lb-ft		b=	12	in
Mu max=	13.4	kip-in		d=	6.69	in
Vu =	0.04	kip		β_1	0.85	
bar=	#5			a=	0.397	in
As	0.31	in^2		c=	0.467	in
s=	12	in		es=	0.040	
As, prov=	0.31	in^2		ϕ=	0.9	
clearance=	2	in				
ϕ Mn=	59	kip-in				
DCR =	**0.23**	**<1.0, OK**				
ϕ Vn=	6.0	kip				
DCR =	**0.01**	**<1.0, OK**	Vu / ϕ Vn			

Bot Footing Reinforcing - (not applicable)

Project: Zenith Energy Containment Walls	By: RP	Sheet No.	
Location: Portland, OR	Date: 02/21/22		
Client: NV5	Revised:	Job No.	
Subject: 6.5ft Cantilever Wall - Eq Load Case	Date:	22100845	

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
0	pcf	fluid, Horiz	spec grav= 1
0	pcf	fluid, vert	spec grav= 1
35	pcf	soil pressure	
270	pcf	Passive pressure	
2.88	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

104	in	Tot Wall Ht	8.69	ft
80	in	exposed ht	6.69	ft
0	in	fluid ht	0.00	ft
90.625	in	stem ht	7.55	ft
11.75	in	Avg Stem	0.98	ft
0.0	in	Toe Length	0.00	ft
52.25	in	Heal Length	4.35	ft
64.0	in	Ftg length	5.33	ft
13.6	in	Avg Ftg Thk	1.13	ft
0.35		Coeff. Frictior Coeff. Frictior Coeff. Friction at Soil Interface		
24	in	passive ht	2.00	ft
24	in	soil ht	2.00	ft

Loads

0	lbs	Wt fluid
1109	lbs	Wt stem
907	lbs	Wt ftg
0	lbs	fluid Lateral Force, F_H
70	lbs	soil Force, F_s
540	lbs	Soil Passive Force, F_p
1000	lbs	Earthquake Lateral Force, F_E
2016	lbs	Dead Load (wall total + fluid+superimposed)

Seis loading per ASCE7-16 Ch 15.4

C_s=	0.496	S_{DS}/(R/Ie)
$C_{s,max}$=	7.568	S_{D1}/(0.065sec*R/Ie)
$C_{s,min}$=	0.03	min(0.03;0.044S_{DS}*I_p)
R=	1.25	Table 15.4-2
I_e=	1.0	
S_{MS}=	1.162	
S_{M1}=	1.153	
S_{DS}=	0.620	2/3*S_{MS}*0.8 lower bound factor
S_{D1}=	0.615	2/3*S_{M1}*0.8 lower bound factor

COMBO: D+H+L

Sliding Force	70	lbs
Mo	47	lb ft
Result location	outside middle third	
ResistMoment	2963	lb ft
Toe Bear, q_{toe}	827	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	63.5	>1.5, OK
Sliding F.O.S.	17.8	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	770	lbs
Mo	2,017	lb ft
Result location	outside middle third	
ResistMoment	2963	lb ft
Toe Bear, q_{toe}	2076	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	1.47	>1.1, OK
Sliding F.O.S.	1.62	>1.1, OK

COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	595	lbs
Mo	1,513	lb ft
Result location	outside middle third	
ResistMoment	2963	lb ft
Toe Bear, q_{toe}	1497	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	1.96	>1.1, OK
Sliding F.O.S.	2.09	>1.1, OK

COMBO: 1.2D+1.6H+1.6L

Mo	75	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	962	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	-184	lb-ft
Top Vu heel	-680	lb
Stem Mu	6	lb-ft
StemVu	21	lb

COMBO: 1.2D+1.6H+0.5L+E

Mo	2,957	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	3322	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	1893	lb-ft
Top Vu heel	629	lb
Stem Mu	1755	lb-ft
Stem Vu	1021	lb

kpff	Project: Zenith Energy Containment Walls	By: RP	Sheet No.
	Location: Portland, OR	Date: 02/21/22	
	Client: NV5	Revised:	Job No.
	Subject: 6.5ft Cantilever Wall - Eq Load Case	Date:	22100845

Reinforcing Design

f'c	2,500	psi	assumed
fy	33,000	psi	assumed

Stem Wall Reinforcing

Mu max=	1755	lb-ft		b=	12	in
Mu max=	21.1	kip-in		d=	9.00	in
Vu =	1.0	kip		β_1	0.85	
bar=	#4			a=	0.677	in
As	0.20	in^2		c=	0.797	in
s=	4.5	in		es=	0.031	
As, prov=	0.52	in^2		ϕ=	0.9	
clearance=	2.5	in				
ϕ Mn=	134.6	kip-in				
DCR =	**0.16**	**<1.0, OK**				
ϕ Vn=	8.1	kip				
DCR =	**0.13**	**<1.0, OK**	Vu / ϕ Vn			

Top Footing Reinforcing

Mu max=	1893	lb-ft		b=	12	in
Mu max=	22.7	kip-in		d=	10.73	in
Vu =	0.6	kip		β_1	0.85	
bar=	#6			a=	1.016	in
As	0.44	in^2		c=	1.195	in
s=	6.75	in		es=	0.024	
As, prov=	0.79	in^2		ϕ=	0.9	
clearance=	2.5	in				
ϕ Mn=	134.0	kip-in				
DCR =	**0.17**	**<1.0, OK**				
ϕ Vn=	9.7	kip				
DCR =	**0.07**	**<1.0, OK**	Vu / ϕ Vn			

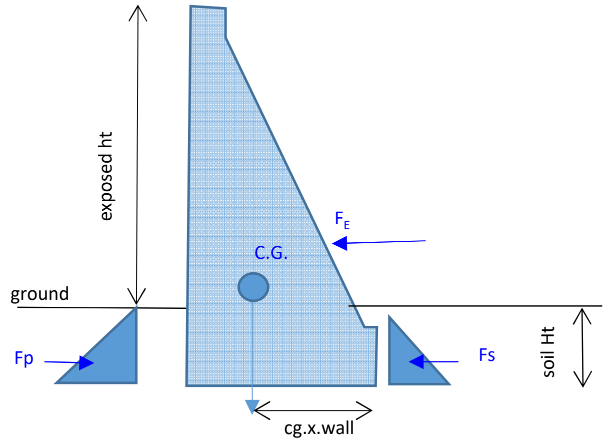
Bot Footing Reinforcing - (not applicable)

kpff

Project:	Zenith Energy Containment Walls	By:	RP	Sheet No.
Location:	Portland, OR	Date:	02/21/22	
Client:	NV5	Revised:		Job No.
Subject:	6.5ft Gravity Wall - Eq Load Case	Date:		22100845

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
0	pcf	fluid, Horiz	spec grav= 1
0	pcf	fluid, vert	spec grav= 1
35	pcf	soil pressure	
270	pcf	Passive pressure	
3.34	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

102	in	Tot Wall Ht	8.50	ft
78	in	exposed ht	6.50	ft
0	in	fluid ht	0.00	ft
15	in	Stem Thick	1.25	ft
66.0	in	Ftg length	5.50	ft
0.35		Coeff. Friction at Soil Interface		
24	in	passive ht	2.00	ft
24	in	soil ht	2.00	ft
25	deg	θ, angle of back wall, from vert		

Loads

0	lbs	Wt fluid	cg.x.fluid =	22	in
4366	lbs	Wt wall	cg.x.wall =	41	in
0	lbs	fluid Force, F_F	F_x=	0	lbs
			F_y=	0	lbs
70	lbs	soil Force, F_s			
540	lbs	Soil Passive Force, F_p			
2164	lbs	Earthquake Lateral Force, F_E			
4366	lbs	Dead Load (wall total + fluid+superimposed)			

Seis loading per ASCE7-16 Ch 15.4

C_s=	0.496	S_{DS}/(R/Ie)
$C_{s,max}$=	7.568	S_{D1}/(0.065sec*R/Ie)
$C_{s,min}$=	0.03	min(0.03;0.044S_{DS}*I_p)
R=	1.25	Table 15.4-2
I_e=	1.0	
S_{MS}=	1.162	
S_{M1}=	1.153	
S_{DS}=	0.620	2/3*S_{MS}*0.8
S_{D1}=	0.615	2/3*S_{M1}*0.8

COMBO: D+H+L

Sliding Force	70	lbs
Mo	47	lb ft
Result location	within middle third	
ResistMoment	9095	lb ft
Toe Bear, q_{toe}	1309	psf, OK
Heal Bear, q_{heal}	279	psf, OK
OT F.O.S.	194.9	>1.5, OK
Sliding F.O.S.	29.5	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	1,585	lbs
Mo	5,110	lb ft
Result location	within middle third	
ResistMoment	9095	lb ft
Toe Bear, q_{toe}	2924	psf, OK
Heal Bear, q_{heal}	-726	psf, OK
OT F.O.S.	1.78	>1.1, OK
Sliding F.O.S.	1.30	>1.1, OK

COMBO: D+H+0.75(0.7E) +0.75L

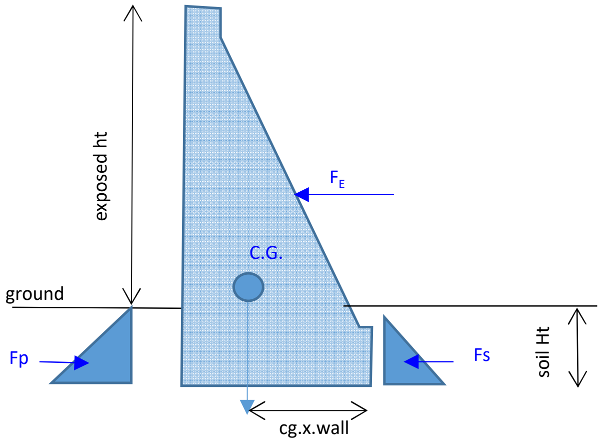
Sliding Force	1,136	lbs
Mo	3,844	lb ft
Result location	within middle third	
ResistMoment	9095	lb ft
Toe Bear, q_{toe}	2264	psf, OK
Heal Bear, q_{heal}	-475	psf, OK
OT F.O.S.	2.37	>1.1, OK
Sliding F.O.S.	1.82	>1.1, OK

kpff

Project: Zenith Energy Containment Walls	By: RP	Sheet No.	
Location: Portland, OR	Date: 02/21/22		
Client: NV5	Revised:	Job No.	
Subject: 3ft Gravity Wall - Eq Load Case	Date:	22100845	

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
0	pcf	fluid, Horiz	spec grav= 1.1
0	pcf	fluid, vert	spec grav= 1.1
35	pcf	soil pressure	
270	pcf	Passive pressure	
1.66	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

48	in	Tot Wall Ht	4.00	ft
36	in	exposed ht	3.00	ft
0	in	fluid ht	0.00	ft
8	in	Stem Thick	0.67	ft
36.0	in	Ftg length	3.00	ft
0.35		Coeff. Friction at Soil Interface		
12	in	passive ht	1.00	ft
12	in	soil ht	1.00	ft
25	deg	θ, angle of back wall, from vert		

Loads

0	lbs	Wt fluid	cg.x.fluid =	6	in
1195	lbs	Wt wall	cg.x.wall =	17	in
0	lbs	fluid Force, F_F	F_x=	0	lbs
			F_y=	0	lbs
18	lbs	soil Force, F_s			
135	lbs	Soil Passive Force, F_p			
592	lbs	Earthquake Lateral Force, F_E			
1195	lbs	Dead Load (wall total + fluid+superimposed)			

Seis loading per ASCE7-16 Ch 15.4

C_s=	0.496	S_{DS}/(R/Ie)
$C_{s,max}$=	7.568	S_{D1}/(0.065sec*R/Ie)
$C_{s,min}$=	0.03	min(0.03;0.044S_{DS}*I_p)
R=	1.25	Table 15.4-2
I_e=	1.0	
S_{MS}=	1.162	
S_{M1}=	1.153	
S_{DS}=	0.620	2/3*S_{MS}*0.8
S_{D1}=	0.615	2/3*S_{M1}*0.8

COMBO: D+H+L

Sliding Force	18	lbs
Mo	6	lb ft
Result location	within middle third	
ResistMoment	1892	lb ft
Toe Bear, q_{toe}	491	psf, OK
Heal Bear, q_{heal}	306	psf, OK
OT F.O.S.	324.3	>1.5, OK
Sliding F.O.S.	31.6	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	432	lbs
Mo	693	lb ft
Result location	within middle third	
ResistMoment	1892	lb ft
Toe Bear, q_{toe}	764	psf, OK
Heal Bear, q_{heal}	32	psf, OK
OT F.O.S.	2.73	>1.1, OK
Sliding F.O.S.	1.28	>1.1, OK

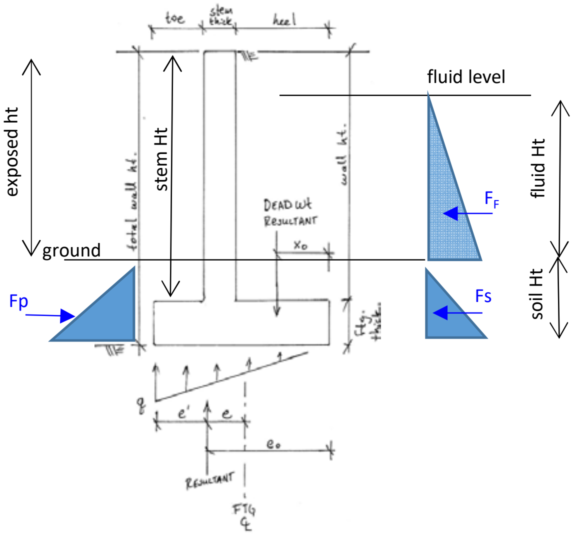
COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	311	lbs
Mo	522	lb ft
Result location	within middle third	
ResistMoment	1892	lb ft
Toe Bear, q_{toe}	650	psf, OK
Heal Bear, q_{heal}	147	psf, OK
OT F.O.S.	3.63	>1.1, OK
Sliding F.O.S.	1.78	>1.1, OK

kpff	Project: Zenith Energy Containment Walls	By: RP	Sheet No.
	Location: Portland, OR	Date: 02/21/22	
	Client: NV5	Revised:	Job No.
	Subject: 6ft Cantilever Wall - Fuel Load Case	Date:	22100845

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
68.2	pcf	fluid, Horiz	spec grav= 1.1
68.2	pcf	fluid, vert	spec grav= 1.1
15	pcf	soil pressure	
180	pcf	Passive pressure	
0	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

93	in	Tot Wall Ht	7.75	ft
72	in	exposed ht	6.00	ft
56	in	fluid ht	4.67	ft
84	in	stem ht	7.00	ft
7.5	in	Avg Stem	0.63	ft
0.0	in	Toe Length	0.00	ft
52.5	in	Heal Length	4.38	ft
60.0	in	Ftg length	5.00	ft
9	in	Ftg Thick	0.75	ft
0.35		Coeff. Friction at Soil Interface		
21	in	passive ht	1.75	ft
21	in	soil ht	1.75	ft

Loads

1392	lbs	Wt fluid
656	lbs	Wt stem
563	lbs	Wt ftg
743	lbs	fluid Lateral Force, F_F
23	lbs	soil Force, F_s
276	lbs	Soil Passive Force, F_p
0	lbs	Earthquake Lateral Force, F_E
2611	lbs	Dead Load (wall total + fluid+superimposed)

COMBO: D+H+L

Sliding Force	766	lbs
Mo	2,468	lb ft
Result location	outside middle third	
ResistMoment	5530	lb ft
Toe Bear, q_{toe}	1411	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.24	>1.5, OK
Sliding F.O.S.	1.55	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	766	lbs
Mo	2,455	lb ft
Result location	outside middle third	
ResistMoment	5530	lb ft
Toe Bear, q_{toe}	1405	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.25	>1.1, OK
Sliding F.O.S.	1.55	>1.1, OK

COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	766	lbs
Mo	2,455	lb ft
Result location	outside middle third	
ResistMoment	5530	lb ft
Toe Bear, q_{toe}	1405	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.25	>1.1, OK
Sliding F.O.S.	1.55	>1.1, OK

COMBO: 1.2D+1.6H+1.6L

Mo	3,949	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	2224	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	3561	lb-ft
Top Vu heel	365	lb
Stem Mu	3040	lb-ft
StemVu	1200	lb

COMBO: 1.2D+1.6H+0.5L+E

Mo	3,949	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	2224	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	3561	lb-ft
Top Vu heel	365	lb
Stem Mu	3040	lb-ft
Stem Vu	1200	lb

kpff

Project: Zenith Energy Containment Walls	By: RP	Sheet No.
Location: Portland, OR	Date: 02/21/22	W3
Client: NV5	Revised:	Job No.
Subject: 6ft Cantilever Wall - Fuel Load Case	Date:	22100845

Reinforcing Design

f'c	2,500	psi	per As-Built
fy	33,000	psi	Gr 33 Structural assumed

Stem Wall Reinforcing

Mu max=	3040	lb-ft		b=	12	in
Mu max=	36.5	kip-in		d=	5.19	in
Vu =	1.2	kip		β_1	0.85	
bar=	#5			a=	0.397	in
As	0.31	in^2		c=	0.467	in
s=	12	in		es=	0.030	
As, prov=	0.31	in^2		ϕ=	0.9	
clearance=	2	in				
ϕ Mn=	45.4	kip-in				
DCR =	**0.80**	**<1.0, OK**				
ϕ Vn=	4.7	kip				
DCR =	**0.26**	**<1.0, OK**	Vu / ϕ Vn			

Top Footing Reinforcing

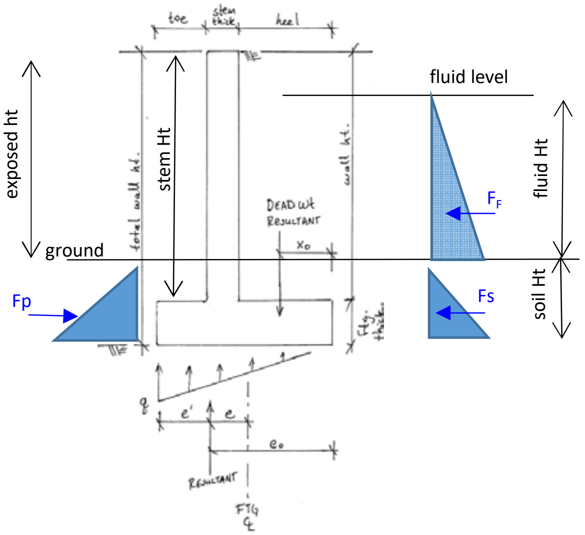
Mu max=	3561	lb-ft		b=	12	in
Mu max=	42.7	kip-in		d=	6.69	in
Vu =	0.4	kip		β_1	0.85	
bar=	#5			a=	0.397	in
As	0.31	in^2		c=	0.467	in
s=	12	in		es=	0.040	
As, prov=	0.31	in^2		ϕ=	0.9	
clearance=	2	in				
ϕ Mn=	59	kip-in				
DCR =	**0.72**	**<1.0, OK**				
ϕ Vn=	6.0	kip				
DCR =	**0.06**	**<1.0, OK**	Vu / ϕ Vn			

Bot Footing Reinforcing - (not applicable)

Project: Zenith Energy Containment Walls	By: RP	Sheet No.
Location: Portland, OR	Date: 02/21/22	
Client: NV5	Revised:	Job No.
Subject: 6.5ft Cantilever Wall-Fuel Load Case	Date:	22100845

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
68.2	pcf	fluid, Horiz	spec grav= 1.1
68.2	pcf	fluid, vert	spec grav= 1.1
15	pcf	soil pressure	
180	pcf	Passive pressure	
0	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

104	in	Tot Wall Ht	8.69	ft
80	in	exposed ht	6.69	ft
66	in	fluid ht	5.50	ft
90.625	in	stem ht	7.55	ft
11.75	in	Avg Stem	0.98	ft
0.0	in	Toe Length	0.00	ft
52.25	in	Heal Length	4.35	ft
64.0	in	Ftg length	5.33	ft
13.6	in	Avg Ftg Thk	1.13	ft
0.35		Coeff. Friction at Soil Interface		
24	in	passive ht	2.00	ft
24	in	soil ht	2.00	ft

Loads

1633	lbs	Wt fluid
1109	lbs	Wt stem
907	lbs	Wt ftg
1032	lbs	fluid Lateral Force, F_F
30	lbs	soil Force, F_s
360	lbs	Soil Passive Force, F_p
0	lbs	Earthquake Lateral Force, F_E
3649	lbs	Dead Load (wall total + fluid+superimposed)

COMBO: D+H+L

Sliding Force	1,062	lbs
Mo	3,974	lb ft
Result location	outside middle third	
ResistMoment	8119	lb ft
Toe Bear, q_{toe}	2025	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.04	>1.5, OK
Sliding F.O.S.	1.54	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	1,062	lbs
Mo	3,954	lb ft
Result location	outside middle third	
ResistMoment	8119	lb ft
Toe Bear, q_{toe}	2016	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.05	>1.1, OK
Sliding F.O.S.	1.54	>1.1, OK

COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	1,062	lbs
Mo	3,954	lb ft
Result location	outside middle third	
ResistMoment	8119	lb ft
Toe Bear, q_{toe}	2016	psf, OK
Heal Bear, q_{heal}	0	psf, OK
OT F.O.S.	2.05	>1.1, OK
Sliding F.O.S.	1.54	>1.1, OK

COMBO: 1.2D+1.6H+1.6L

Mo	6,359	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	3393	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	5301	lb-ft
Top Vu heel	1163	lb
Stem Mu	4459	lb-ft
StemVu	1659	lb

COMBO: 1.2D+1.6H+0.5L+E

Mo	6,359	lb ft
ResultLocation	outside middle third	
Toe Bear, q_{toe}	3393	psf
Heal Bear, q_{heal}	0	psf
Bot Mu toe	0	lb-ft
Top Mu heel	5301	lb-ft
Top Vu heel	1163	lb
Stem Mu	4459	lb-ft
Stem Vu	1659	lb

kpff

Project: Zenith Energy Containment Walls	By: RP	Sheet No.
Location: Portland, OR	Date: 02/21/22	
Client: NV5	Revised:	Job No.
Subject: 6.5ft Cantilever Wall-Fuel Load Case	Date:	22100845

Reinforcing Design

f'c	2,500	psi	assumed
fy	33,000	psi	assumed

Stem Wall Reinforcing

Mu max=	4459	lb-ft		b=	12	in
Mu max=	53.5	kip-in		d=	9.00	in
Vu =	1.7	kip		β_1	0.85	
bar=	#4			a=	0.677	in
As	0.20	in^2		c=	0.797	in
s=	4.5	in		es=	0.031	
As, prov=	0.52	in^2		ϕ=	0.9	
clearance=	2.5	in				
ϕ Mn=	134.6	kip-in				
DCR =	**0.40**	**<1.0, OK**				
ϕ Vn=	8.1	kip				
DCR =	**0.20**	**<1.0, OK**	Vu / ϕ Vn			

Top Footing Reinforcing

Mu max=	5301	lb-ft		b=	12	in
Mu max=	63.6	kip-in		d=	10.73	in
Vu =	1.2	kip		β_1	0.85	
bar=	#6			a=	1.016	in
As	0.44	in^2		c=	1.195	in
s=	6.75	in		es=	0.024	
As, prov=	0.79	in^2		ϕ=	0.9	
clearance=	2.5	in				
ϕ Mn=	134.0	kip-in				
DCR =	**0.47**	**<1.0, OK**				
ϕ Vn=	9.7	kip				
DCR =	**0.12**	**<1.0, OK**	Vu / ϕ Vn			

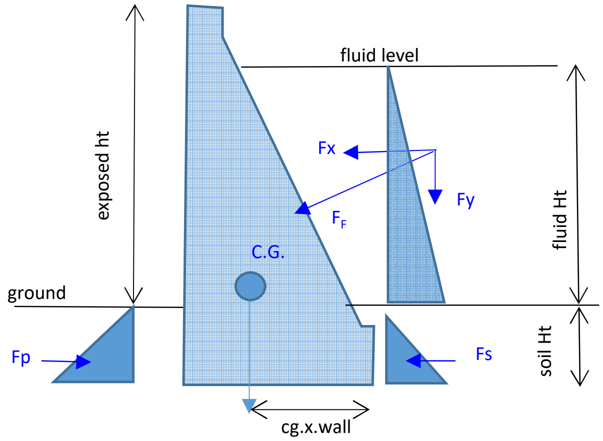
Bot Footing Reinforcing - (not applicable)

kpff

Project: Zenith Energy Containment Walls	By: RP	Sheet No.	
Location: Portland, OR	Date: 02/21/22		
Client: NV5	Revised:	Job No.	
Subject: 6.5ft Gravity Wall - Fuel Load Case	Date:	22100845	

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
68.2	pcf	fluid, Horiz	spec grav= 1.1
68.2	pcf	fluid, vert	spec grav= 1.1
15	pcf	soil pressure	
180	pcf	Passive pressure	
0	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

102	in	Tot Wall Ht	8.50	ft
78	in	exposed ht	6.50	ft
76	in	fluid ht	6.33	ft
15	in	Stem Thick	1.25	ft
66.0	in	Ftg length	5.50	ft
0.35		Coeff. Friction at Soil Interface		
24	in	passive ht	2.00	ft
24	in	soil ht	2.00	ft
25	deg	θ, angle of back wall, from vert		

Loads

673	lbs	Wt fluid	cg.x.fluid =	22	in
4366	lbs	Wt wall	cg.x.wall =	41	in
1509	lbs	fluid Force, F_F	F_x=	1368	lbs
			F_y=	638	lbs
30	lbs	soil Force, F_s			
360	lbs	Soil Passive Force, F_p			
0	lbs	Earthquake Lateral Force, F_E			
5039	lbs	Dead Load (wall total + fluid+superimposed)			

COMBO: D+H+L

Sliding Force	1,398 lbs
Mo	5,643 lb ft
Result location	outside middle third
ResistMoment	13901 lb ft
Toe Bear, q_{toe}	2528 psf, NG
Heal Bear, q_{heal}	0 psf, OK
OT F.O.S.	2.46 >1.5, OK
Sliding F.O.S.	1.52 >1.5, OK

COMBO: D+H+0.7E

Sliding Force	1,398 lbs
Mo	5,643 lb ft
Result location	outside middle third
ResistMoment	13901 lb ft
Toe Bear, q_{toe}	2528 psf, OK
Heal Bear, q_{heal}	0 psf, OK
OT F.O.S.	2.46 >1.1, OK
Sliding F.O.S.	1.52 >1.1, OK

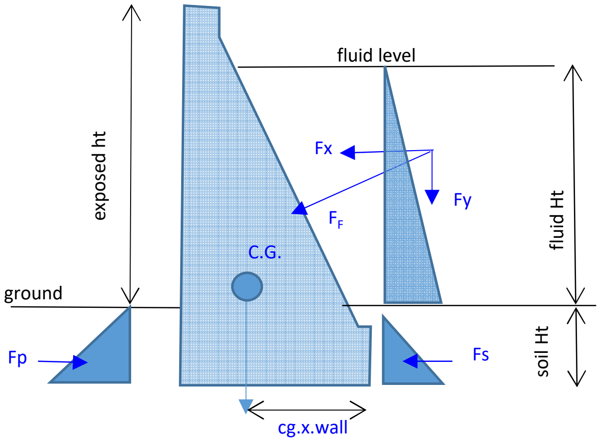
COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	1,368 lbs
Mo	5,643 lb ft
Result location	outside middle third
ResistMoment	13901 lb ft
Toe Bear, q_{toe}	2528 psf, OK
Heal Bear, q_{heal}	0 psf, OK
OT F.O.S.	2.46 >1.1, OK
Sliding F.O.S.	1.55 >1.1, OK

Project:	Zenith Energy Containment Walls	By: RP	Sheet No.
Location:	Portland, OR	Date: 02/21/22	
Client:	NV5	Revised:	Job No.
Subject:	3ft Gravity Wall - Fuel Load Case	Date:	22100845

Soil Properties

0	lbs	superimposed Dead Load on Wall	
0	lbs	superimposed Live Load on Wall	
68.2	pcf	fluid, Horiz	spec grav= 1.1
68.2	pcf	fluid, vert	spec grav= 1.1
15	pcf	soil pressure	
180	pcf	Passive pressure	
0	ft	Location of EQ resultant	
No		Restrained at Base?	
2500	psf	Allowable Bearing	
3750	psf	Allowable Bearing w/ Seis	
1.5		Min OT F.O.S.	
1.5		Min Sliding F.O.S.	
1.1		Min OT F.O.S. for Seis	
1.1		Min Sliding F.O.S. for Seis	



Wall Geometry

48	in	Tot Wall Ht	4.00	ft
36	in	exposed ht	3.00	ft
36	in	fluid ht	3.00	ft
8	in	Stem Thick	0.67	ft
36.0	in	Ftg length	3.00	ft
0.35		Coeff. Friction at Soil Interface		
12	in	passive ht	1.00	ft
12	in	soil ht	1.00	ft
25	deg	θ, angle of back wall, from vert		

Loads

76	lbs	Wt fluid	cg.x.fluid =	6	in
1195	lbs	Wt wall	cg.x.wall =	17	in
339	lbs	fluid Force, F_F	F_x=	307	lbs
			F_y=	143	lbs
8	lbs	soil Force, F_s			
90	lbs	Soil Passive Force, F_p			
0	lbs	Earthquake Lateral Force, F_E			
1271	lbs	Dead Load (wall total + fluid+superimposed)			

COMBO: D+H+L

Sliding Force	314	lbs
Mo	616	lb ft
Result location	within middle third	
ResistMoment	2440	lb ft
Toe Bear, q_{toe}	650	psf, OK
Heal Bear, q_{heal}	293	psf, OK
OT F.O.S.	3.96	>1.5, OK
Sliding F.O.S.	1.70	>1.5, OK

COMBO: D+H+0.7E

Sliding Force	314	lbs
Mo	616	lb ft
Result location	within middle third	
ResistMoment	2440	lb ft
Toe Bear, q_{toe}	650	psf, OK
Heal Bear, q_{heal}	293	psf, OK
OT F.O.S.	3.96	>1.1, OK
Sliding F.O.S.	1.70	>1.1, OK

COMBO: D+H+0.75(0.7E) +0.75L

Sliding Force	307	lbs
Mo	616	lb ft
Result location	within middle third	
ResistMoment	2440	lb ft
Toe Bear, q_{toe}	650	psf, OK
Heal Bear, q_{heal}	293	psf, OK
OT F.O.S.	3.96	>1.1, OK
Sliding F.O.S.	1.74	>1.1, OK

APPENDIX E

APPENDIX E

STRUCTURAL ASSESSMENT OF TANKS 63 AND 127

PEMY performed the following tasks:

- Provided a detailed API 650 Annex E seismic analysis for Tanks 63 and 127.
- Reviewed relevant API, International Building Code, and other methodologies for computing seismic loads.
- Conducted a site visit to observe the condition of the tanks.
- Developed the computational methodologies for the applicable codes and performed analyses.
- Developed the conditions and criteria for compliance and provided flow-charted logic for what could and what does not apply. Provided informal scenario analysis involving the tanks and connected components and provided potential recommendation for mitigation.

PEMY Consulting, LLC.

SEISMIC ANALYSIS OF TANKS 63 AND 127 AT ZENITH PORTLAND TERMINAL

Prepared for GeoDesign, Inc. and Zenith Energy Management LLC

ABSTRACT

The seismic analysis in this report shows that Tank 63 and 127 are suitable for service to the current liquid design height chosen by the operator. The tanks are self-anchored and will not slide or overturn under the design seismic loading. The report is based on the Geodesign ground motion criteria and identifies key assumptions used in the analysis following the rules of ASCE 7-16, API 650 12th edition, and the 2019 Oregon Structural Specialty Code (OSSC).

PE Myers
Andy Wong
AT Yearwood
Draft Report
March 20, 2022

Table of Contents

Introduction

Tank 63 and Tank 127 are located at Zenith Portland terminal in Portland, Oregon. Tank 63 is a 45.5 ft high, 144 ft diameter, internal floating roof storage tank originally constructed in 1944. Meanwhile, Tank 127 is a 40.31 ft high, 60 ft diameter, fixed-roof storage tank which was originally constructed in 1937.

A site-specific seismic geotechnical analysis was performed by GeoDesign, which provided spectral response acceleration parameters for use in accessing the ground surface accelerations to which the tank will be subjected. This PEMY Consulting report is intended to be an Appendix in the GeoDesign report.

In accordance with the 2019 Oregon Structural Specialty Code, this report documents structural evaluation following the rules of ASCE 7-16 and the 12th edition of API 650 Annex E in which anchorage ratio, compressive and tensile stresses, and sliding force were computed to estimate the maximum safe fill height to maintain liquid containment and integrity of the tanks during the design and code compliant scenario earthquake. In addition, an alternate method called the Manos method was used as an additional check to ensure that both methods provide the same result for the suitability of these tanks in the design earthquake.

The analyses and computations were supplemented by a seismic program developed by PEMY Consulting, LLC. This program processed the basic design information of each tank and the design spectral acceleration parameters as inputs while returning the maximum safe fill height after evaluating the shell structures with different criteria in API 650 Annex E and the Manos method.

Overall, the analyses results show that Tank 63 and 127 are safe and fit-for-purpose under the design spectral acceleration parameters with the tanks filled to their current safe operating height with a liquid of specific gravity of 1.0 (i.e., the specific gravity of water). The maximum operating height is established by the tank owner/operator and involves consideration of overfill levels, sloshing wave heights and other limitations.

Tank Basic Design Information

The basic design information of the tanks was provided by the Terminal. The information for each tank is listed below.

Tank 63

Table 1. Tank 63 basic design information

Tank diameter	144.00 ft
Tank height	45.50 ft
Maximum product specific gravity	SG = 1
Roof type	Fixed roof: steel cone Internal floating roof
Location	Latitude: 45° 33’ 34’’ N Longitude: 122° 44’ 10’’ W
Measured course thickness	Course 1: 0.878’’ Course 2: 0.769’’ Course 3: 0.658’’ Course 4: 0.560’’ Course 5: 0.462’’ Course 6: 0.409 Course 7: 0.307 Course 8: 0.248
Course heights	Course 1: 63” Course 2: 65” Course 3: 71” Course 4: 69” Course 5: 69” Course 6: 69” Course 7: 70” Course 8: 70”
Seismic Use Group	SUG I
Anchorage information	Self-anchored Annular ring: unknown Assume annular ring thickness of 0.25’’ (Annex E permits credit for a part of the tank bottom in calculating uplift resistance)
Effective impulsive weight of product	W_1/W_T = 70%
Maximum operating height	39.25 ft

Tank 127

Table 2. Tank 127 basic design information

Tank diameter	60.00 ft
Tank height	40.31 ft
Maximum product specific gravity	SG = 1
Roof type	Fixed roof: steel cone
Location	Latitude: N/A Longitude: N/A Assume to have same location as Tank 63

Measured course thickness	Course 1: 0.439'' Course 2: 0.379'' Course 3: 0.304'' Course 4: 0.245'' Course 5: 0.243'' Course 6: 0.251" Course 7: 0.252"
Course height	Course 1: 5.33' Course 2: 5.83' Course 3: 5.83' Course 4: 5.83' Course 5: 5.83' Course 6: 5.83' Course 7: 5.83'
Seismic Use Group	SUG I
Anchorage information	Self-anchored Annular ring: unknown Assume annular ring thickness of 0.25'' (Annex E permits credit for a part of the tank bottom in calculating uplift resistance)
Effective impulsive weight of product	W_1/W_T = 37.5%
Maximum operating height	38.5 ft

Seismic Response Spectrum

Since the Zenith Terminal is on soil classified in ASCE7-16 as a site class F site, a site-specific analysis is required to evaluate the spectral acceleration parameters. The site-specific analysis was performed by GeoDesign. The results are summarized in Figure 1.

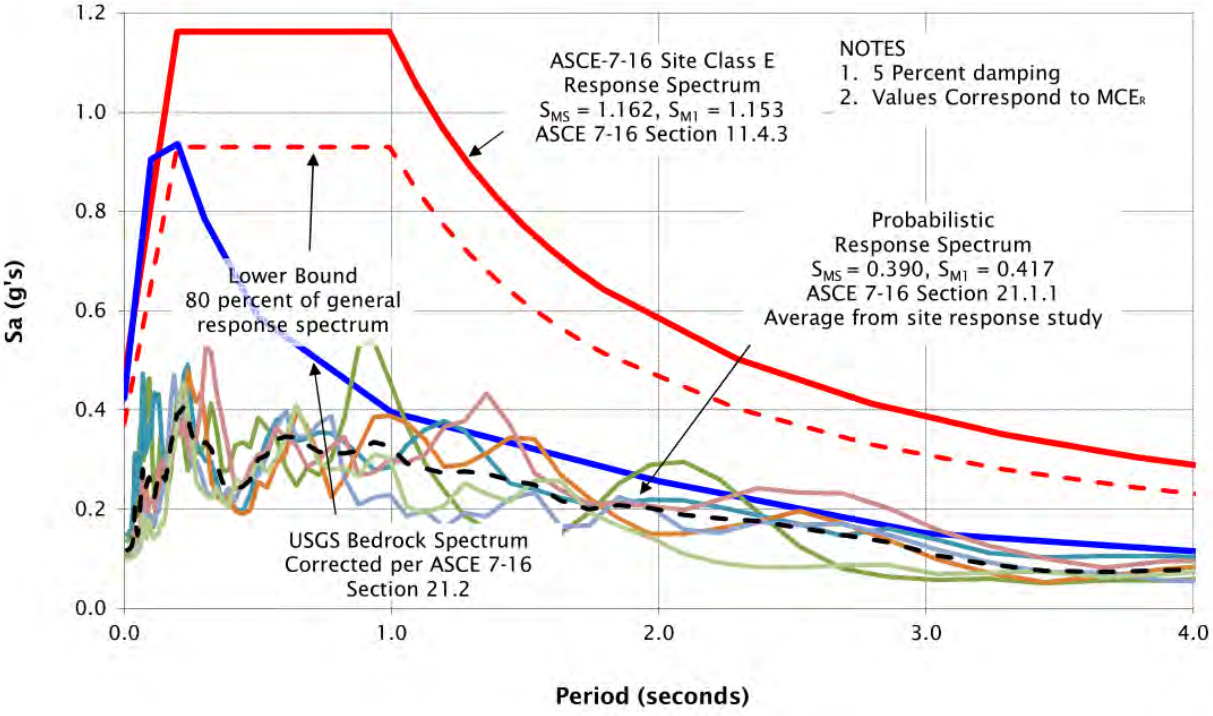


Figure 1. Response spectra for Zenith Portland terminal

Per ASCE 7-16, the site-specific response spectrum will be calculated from the envelope of the site-specific spectra and 80% of the mapped Site Class E spectrum. Since the site-specific response spectrum (dashed black line) is well below 80% of the mapped response spectrum of site class E, the response spectrum used will be based on 80% of the general response spectrum (the response spectrum is given with a solid red line – the 80% spectrum with the dashed red line). Therefore, to construct the design response spectrum, we used the values of the 80% mapped MCE_R, 5% damped, spectral response acceleration parameters, which are: $S_{MS} = 80\% * 1.162 = 0.930$, and $S_{M1} = 80\% * 1.153 = 0.922$. As a result, the design, 5% damped, spectral response acceleration parameters are: $S_{DS} = \frac{2}{3} S_{MS} = 0.620$, and $S_{D1} = \frac{2}{3} S_{M1} = 0.615$

The response spectral curves are reproduced in Figure 2 – the design response spectrum is constructed by ASCE 7-16, section 11.4.6.

phil@pemyconsulting.com

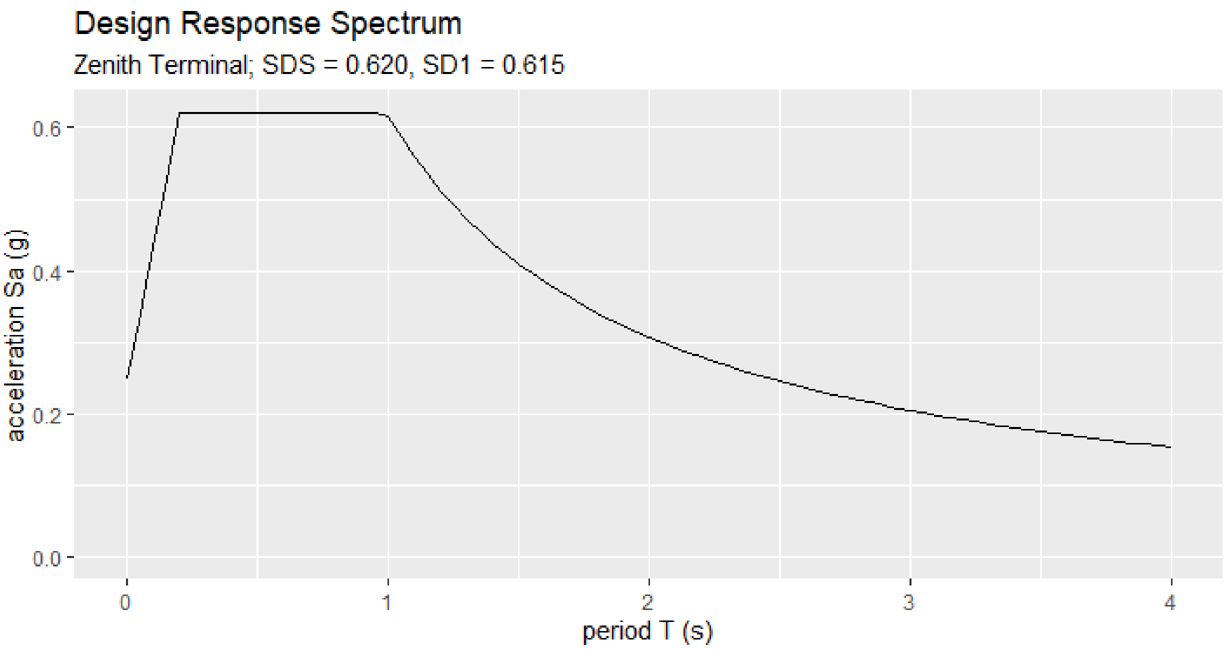


Figure 2. Spectral curves created from GeoDesign's results

Other seismic properties are listed in Table 3. The convective and impulsive design response spectral acceleration parameters, A_c and A_i, are calculated per API 650 Annex E as functions of S_{ac}^* and S_{ai}^*, which are determined from the design response spectrum, respectively. We have included a vertical acceleration ground motion component in the analysis. Although vertical acceleration is optional under the API 650 Annex E rules, we have conservatively added it to consider the worst possible case. Additionally, we used the USGS online tool to determine the long period transition period, which is T_L = 16 seconds.

Table 3. Spectral response acceleration parameters and seismic properties

S_{DS}	0.620 g
S_{D1}	0.615 g
A_i	0.177 g
A_c	0.046 g
Vertical acceleration A_v	0.291 g
Long period T_L	16 sec
Site class	F

Seismic Analysis

Excessive seismic accelerations could potentially induce excessive overturning moments, compressive stresses in the shell, and hoop forces which could be damaging to the tanks and in a worst-case scenario result in loss of contents. The goal of this analysis is to calculate the maximum safe fill height of each tank for which the tank will not fail by buckling (i.e., "elephant's foot"), sliding, hoop stress, overturning moment, sloshing waves damaging roof structures. In addition, an informal visual inspection on the piping systems and supports was done at the terminal to foresee failure due to breaking piping. See recommendations later.

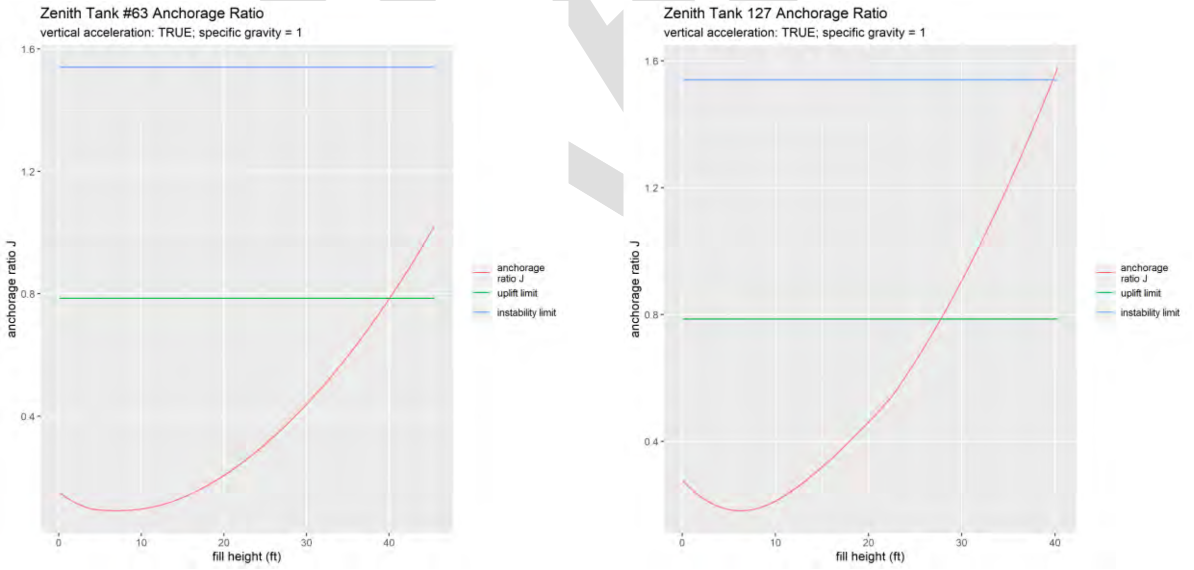
The following sections are based upon the analyses of the anchorage ratio, shell compression, shell hoop (tensile) stresses, sliding forces, and breaking piping. A second check on API 650 was conducted using an independent method called the Manos method. The analysis looks at these loading conditions at each fill height throughout the range of the tank shell. The sloshing wave height is also computed and considered to assist Zenith in setting a maximum operating level.

Anchorage Ratio

Earthquake ground shaking causes overturning moments on the tank. As the two tanks are self-anchored, the resistance to overturning is provided by the weight of the tank shell and weight of roof supported by the shell. Additional overturning resistance is provided by the weight of a portion of the tank liquid contents.

The overturning resistance is dependent on the part of the width of a bottom annulus uplifted by the overturning moment. The overturning resisting force of the annulus that lifts off the foundation is a function of annular plate thickness. With no annular plate thickness provided, we used a portion of the tank bottom to resist overturning, as described in API 650 Annex E. In our analysis, we used an annular ring thickness of 0.25’’ for Tank 63 and 127.

According to API 650 Annex E, tank stability under an overturning moment is governed by the anchorage ratio, which is the ratio of the seismic overturning moment to the resisting moment. The program calculates this anchorage ratio with fill heights ranging from the bottom to the top of the tank shell and then comparing it to the critical values in API 650 (Figure 3).



a. Tank 63

b. Tank 127

Figure 3. Anchorage ratio vs. fill height

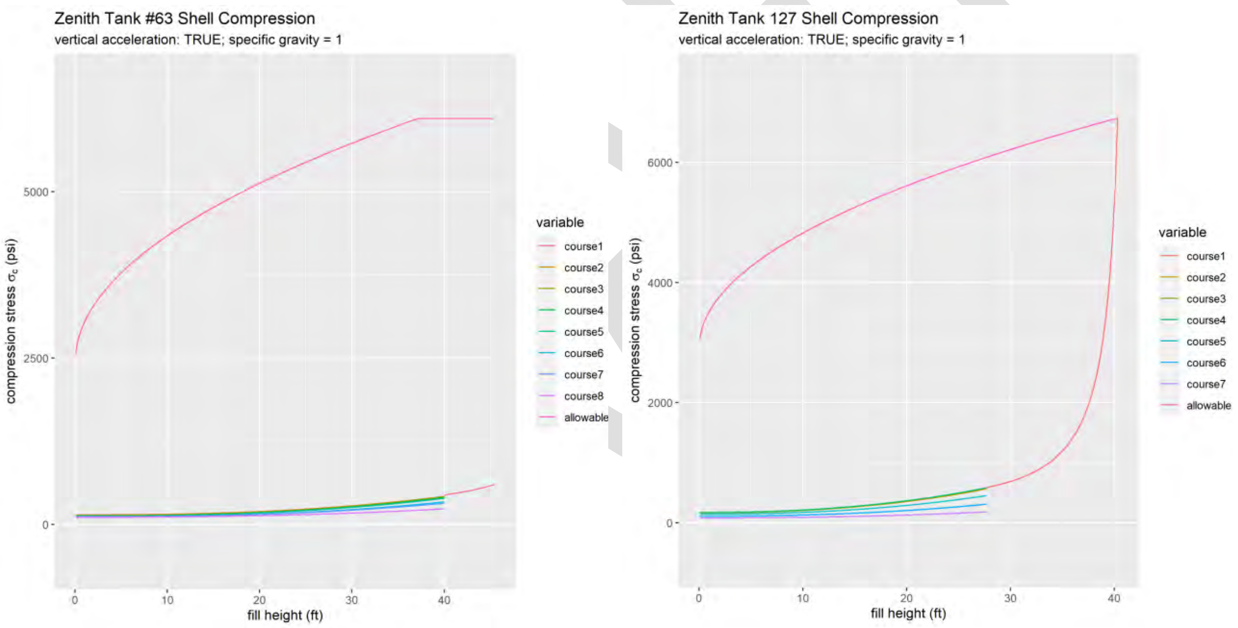
There are two key thresholds of anchorage ratio defined in API 650 Annex E. One is shown as the green line (anchorage ratio = 0.785) above which the tank is uplifting but still stable for the design load providing the shell compression requirements are satisfied. The other one is shown as blue line (anchorage ratio = 1.54) above which tank is unstable and cannot be self-anchored for the design load. When an unanchored tank exceeds the anchorage ratio of 1.54, the development of shell buckling also known as “elephant’s foot” is likely.

According to the plots, Tank 63 has an anchorage ratio below the instability limit line for all fill heights, meaning it is stable with fill height up to the maximum shell height. At fill heights greater than 40.04 ft, however, uplift is expected that may damage piping and other appurtenances.

Tank 127 has an anchorage ratio above the instability limit for heights greater than 39.74 ft. Fill heights greater than 27.69 ft are expected to have some uplift that may damage piping and other appurtenances.

Compressive stress

High compressive stresses can occur from the seismic overturning moment. One side of the tank will uplift while the opposite side will go into compression. The maximum compressive stress occurs near the bottom of the first course of the shell.



a. Tank 63 b. Tank 127

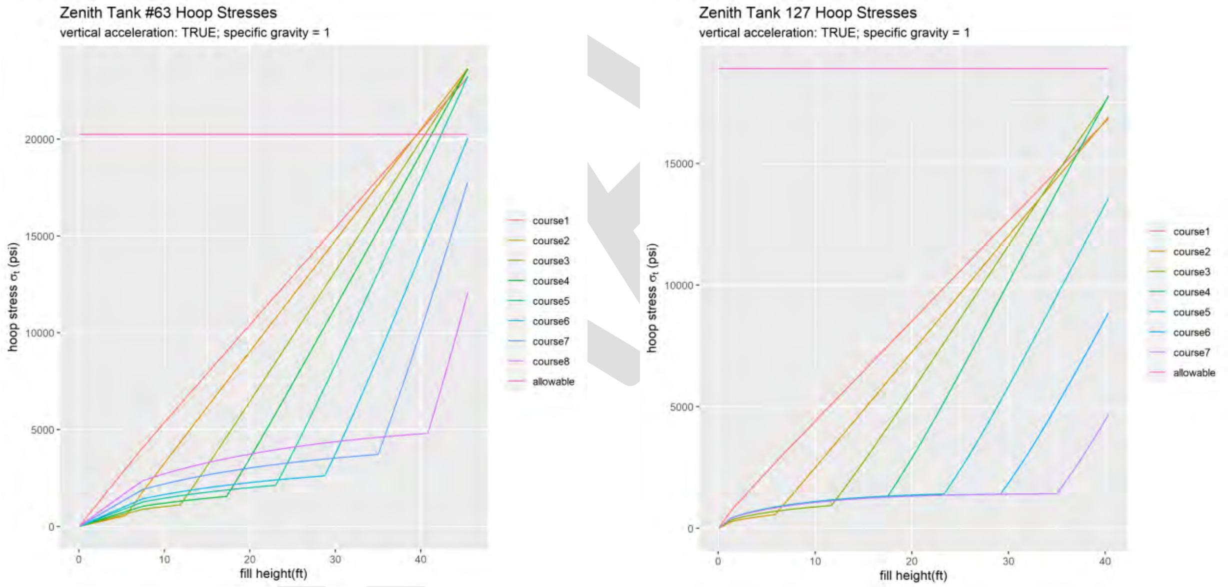
Figure 4. Compressive stress vs. fill height

The shell compression plots above (Figure 4) gives the seismically induced compressive stresses (see the colored lines for each course) in the shell. Compression stresses are only calculated for courses after the first for certain fill heights. When the compression stress is above the allowable stress (the magenta line), it is likely for the shell to buckle when undergoing the design seismic accelerations.

From Figure 4, it is clear that the risk of excessive compression stresses is nonexistent at any fill height for Tank 63. However, for Tank 127, the tank fails of excessive compression stresses at fill heights greater than 40.26 ft. This is expected as the tank exceeds the instability limit at fill heights greater than 39.74 ft.

Hoop stress

Horizontal and vertical ground shaking also cause tensile stresses in the shell. When the tank undergoes seismic accelerations, the lower portion of the stored liquid in the tank moves in unison with the shell. This is called the impulsive component. The upper portion of the liquid moves independently from the tank shell and produces sloshing waves. This is called the convective component. Both the impulsive and convective components of the liquid create forces in the shell that result in tensile stresses. The PEMY program calculates tensile hoop stresses in each course corresponding to all of the possible fill heights (see Figure 5). This includes the stresses caused by the combination of lateral and vertical ground motion. The tensile stress in each course is compared with the maximum allowable hoop tension membrane stress calculated per the API 650 Annex E standard. This is 90% of the yield stress of 30,000 psi for unknown shell material, times the joint efficiency of the shell. Tank 63 has a joint efficiency of 0.75, so its maximum allowable hoop tension membrane stress is 20,250 psi; for Tank 127, with a joint efficiency of 0.7, it is 18,900 psi. The maximum allowable hoop tension membrane stress is shown by the horizontal pink line.



a. Tank 63 c. Tank 127

Figure 5. Tensile/Hoop stress vs. fill height

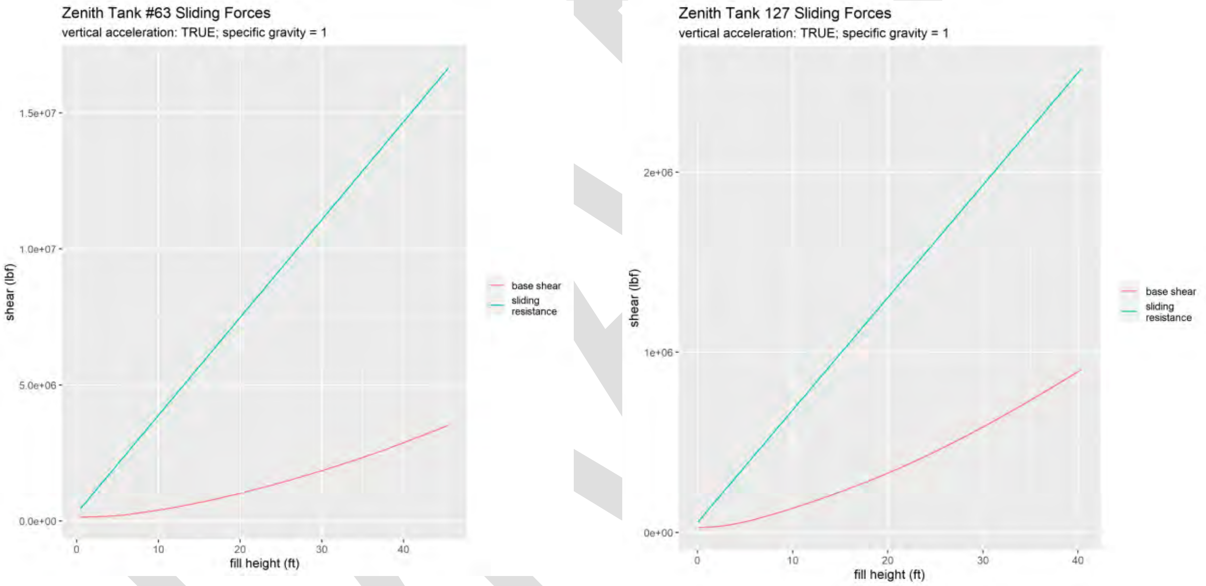
From Figure 5, Tank 63 has hoop stresses that exceed the allowable stress. For Tank 63, this hoop stress limit is reached at 39.53 ft. In comparison, Tank 127 does not have hoop stresses that exceed the allowable stress at any fill height.

Based on the plots so far, the maximum safe fill height for Tank 63 is 39.53 ft out of a maximum shell height of 45.5 ft. This is due to its exceedance of the allowable hoop stress at fill heights greater than those specified. So far, the maximum safe fill height for Tank 127 is 39.74 ft out of a maximum shell height of 40.3 ft. This is due to its exceedance of the anchorage ratio instability limit.

As provided from the terminal, Tank 63's maximum liquid fill height is 39.25 ft and Tank 127's maximum liquid fill height is 38.5 ft. As Tank 63 and Tank 127's maximum fill heights are less than or equal to the maximum safe fill heights calculated above, both tanks meet the anchorage ratio, shell compression, and hoop force criteria in API 650 Annex E.

Sliding force

The sliding force plots (Figure 6) give the base shear (the red line) and the sliding resistance due to friction (the blue line). If the base shear is greater than the sliding resistance, it is likely the tank will slide non-negligibly with the design seismic accelerations. However, the calculations show both Tank 63 and Tank 127 would not experience a base shear force greater than their sliding resistances; therefore, they are not expected to slide with any fill height.

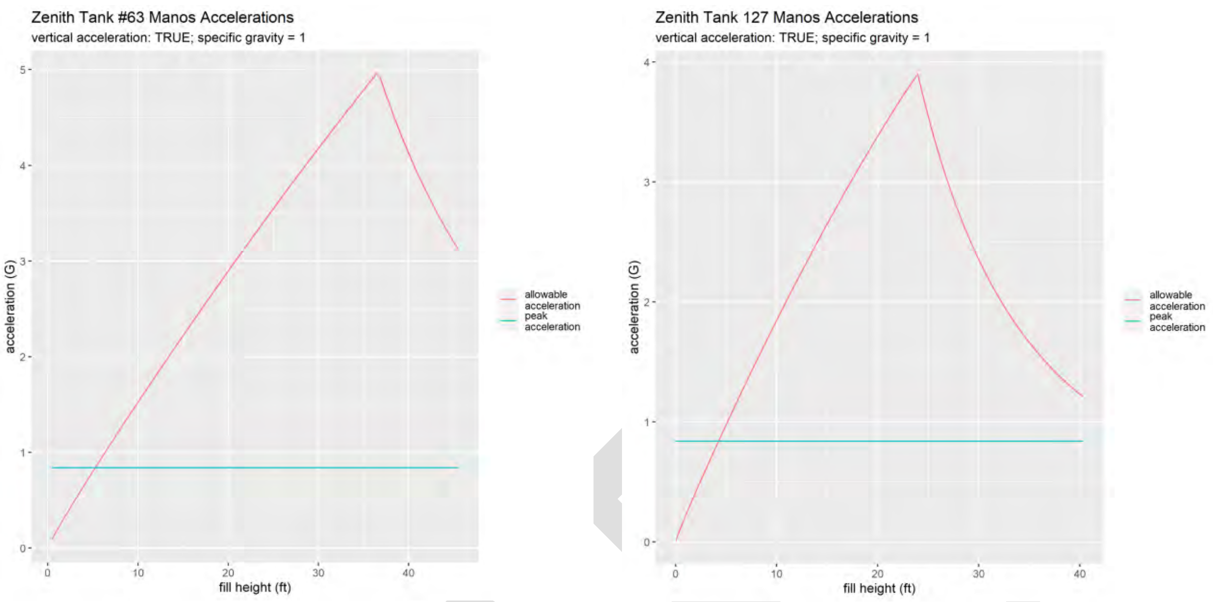


a. Tank 63 b. Tank 127

Figure 6. Sliding force vs. fill height

Manos method

The Manos seismic risk methodology is concerned with tank overturning and shell buckling, just like the anchorage ratio method of API 650. However, instead of calculating the overturning directly, the Manos method calculates the acceleration required to cause this shell failure and the acceleration experienced by the tank with given tank and site properties. The plots in Figure 7 show the amount of acceleration required to cause the tanks to fail (in red) and the peak seismic acceleration experienced by the tanks (in green). The acceptable fill heights are those where the peak acceleration is below the allowable acceleration.



a. Tank 63 b. Tank 127

Figure 7. Manos method—acceleration vs. fill height

Both tanks meet the Manos criteria for all shell heights. Even though the acceleration line crosses the allowable acceleration values at low fill heights, it should be obvious that it is safe to operate the tanks at these low fill height ranges.

Freeboard calculation

Because both tanks have a calculated maximum safe fill height close to their maximum shell heights, it is necessary to consider sloshing wave height exceeding the top shell, resulting in loss of tank content or damage to the roof structure. The tank seismic calculations assume that sloshing waves will not impact the tank fixed roof. The calculations depend on the presence of a safe amount of freeboard height and will not be valid if the operational height exceeds the recommended freeboard.

API 650 Annex E provides equations to estimate the height of sloshing wave above the product design height and recommended minimum freeboard for different cases of SUG and design spectral acceleration parameters. With SUG I and the design spectral acceleration parameters (S_{DS} and S_{D1}) given in the sections above, the results of sloshing wave height and recommended freeboard are summarized in Table 4.

Table 4. Sloshing wave height and recommended freeboard per API 650 Annex E

	Tank 63	Tank 127
Sloshing wave height	3.81 ft	4.60 ft

Recommended freeboard	2.67 ft	3.22 ft

In order to accommodate sloshing waves without spillage or the waves impacting the fixed roofs, the maximum liquid level shall be no greater than 42.83 ft for Tank 63 and 37.09 ft for Tank 127.

As provided from the terminal, Tank 63's maximum liquid fill height is 39.25 ft while its shell height is 45.5 ft. Meanwhile, Tank 127's current maximum liquid fill height is 38.5 ft while its shell height is 40.31 ft. Therefore, with the current maximum operating liquid levels, only Tank 63 meets the freeboard recommendation set by API 650 Annex E. Tanks that are filled to above this level risk damage to the roof and spillage caused by sloshing waves.

Summary of Analysis

Below, in Table 5, is a summary of the maximum fill heights calculated from the seismic analysis. The maximum fill for the recommended freeboard and the current maximum operating height are provided for comparison.

Table 5. Summary of Fill Height Recommendations

	Tank 63	Tank 127
Shell Height	45.5 ft	40.31 ft
Anchorage ratio	-	*39.74 ft*
Compressive stress	-	*40.26 ft*
Hoop stress	*39.53 ft*	-
Sliding Forces	-	-
Manos Method	-	-
Maximum allowable	39.53 ft	39.74 ft
Recommendation for freeboard	42.83 ft	37.09 ft
Current max operating height	39.25 ft	38.5 ft
Final recommended max fill	**39.25 ft**	**38.5 ft** **37.09 ft (freeboard)**

Piping Inspection

In addition to the seismic analysis, we performed a visual inspection of Tank 63 and 127, with a focus on their piping systems. We were primarily concerned with the possibility of piping breaking due to differential settlement. During an earthquake, soil liquefaction can occur and cause the tanks to settle. GeoDesign's seismic analysis estimates liquefaction-induced settlement up to 8 inches, which translates to a differential settlement of 4 inches over 50 feet. This settlement can cause damage to inflexible piping and other appurtenances.

Tank 63

PEMY identified two major points of interest regarding Tank 63: firstly, its nozzles and piping supports; secondly, its floating roof.

Tank 63's nozzles and piping supports are listed below, and their position about the circumference of the tank is shown in Figure 8.

- Nozzle 1: 16" diameter, 15' to a T joint. The branch connection has an elbow down and enters the soil.
- Nozzle 2: 16" diameter, 7.5' to a T joint. The branch connection is 9.5' to a pipe support.
- Nozzle 3: 16" diameter, 10' to a T joint and pipe support.
- Nozzle 4: 12" diameter, 6' to pipe support.

These pipes may not be flexible enough for the estimated liquefaction-induced settlement, which may lead to breaking piping. An advanced piping analysis could be conducted to quantify the risks due to this settlement. The piping could be redesigned to add more flexibility.

Tank 63 has an internal pan floating roof, and this type of roof is known to have poor seismic performance compared to other steel floating roof types. This design lacks rigidity. In addition, this design lacks watertight compartments, so it can take on product from sloshing waves during an earthquake and lose buoyancy. To reduce the risk of the floating roof sinking due to these risk factors, modifications to the existing roof or the use of an alternative design may be considered. Sinking of a floating roof does not typically result in loss of liquid containment.

Figure 8. Tank 63 nozzles and piping supports.

Tank 127

As Tank 127's nozzles and piping will be replaced and redesigned in the future, we are not concerned with risks to the existing piping due to liquefaction-induced settlement. As long as the new nozzle piping is designed with sufficient flexibility for the expected seismic movements, the risk of breaking piping should be minimized.

Figure 9 identifies several old non-code tank features, meaning the details clearly do not comply with current API 650 and API 653 Standards. To the left of the manway, there is an area with corner welds of inadequate size. In addition, the manway repad itself does not meet API 653 weld spacing requirements. This repad has a thin flange and is lower in elevation than preferred. To the right of the manway, an existing tombstone repad was slotted through and left in place. A closer view of this is shown in Figure 10. These features are at greater risk of failure during a seismic event, which could cause high stress and yielding deformations at the lower shell. We recommend that these non-code features are removed and replaced with flush inserts and a new manway built to current requirements of API 650.

Both Tanks

Notably, both Tank 63 and 127 have column supported roofs. At the time of the original tank construction, these roof columns would have been designed for vertical loadings and there is some possibility the columns may fail during an earthquake due to horizontal shaking and liquid sloshing. Buckling failure of the roof structure does not typically result in loss of liquid containment.

Figure 9. Tank 127 non-code features.

Figure 10. Closeup of Tank 127 non-code tombstone repad.

Conclusions

The seismic analyses of the two tanks are based on the rules of the ASCE 7-16 standards, which is used by the 2019 Oregon Structural Specialty Code, and API 650 Annex E. The Oregon Structural Specialty Code is the building code that was recently adopted by the State of Oregon and the City of Portland. Therefore, it is certain that the analysis in this report is in compliance with the governing design codes of the City of Portland and the State of Oregon.

These analyses indicate that Tank 63 and Tank 127 are within safe limits for general structural stability under the scenario earthquake with the tank filled to liquids of specific gravity up to that of water. The tank is stable against overturning moment and sliding force resulting from the design ground motion. Compressive and tensile stresses in the tank are acceptable under the seismic loads.

In addition, it is recommended to set overfill levels for both tanks based on the lower of API 2350 4th edition and the sloshing wave height calculated in the report. Although the two tanks' structures would be stable under the scenario earthquake, filling up the tanks without setting freeboards would result in the case of sloshing waves exceeding the top shell, damaging the roof structures and losing some of the tank contents. This is of particular concern for Tank 127 if its maximum operating fill height is not reduced to 37.09 ft.

Table 6. Summary of recommendations in this report

	Tank 63	Tank 127
Final recommended max fill	39.25 ft	38.5 ft 37.09 ft (freeboard)
Assess and increase piping flexibility as needed	12" and 16" piping (or advanced analysis) Conduct structural analysis of tank-to-piping flexibility for uplift and liquefaction settlement	Design new nozzles and piping for seismic and liquefaction settlement Conduct structural analysis of tank-to-piping flexibility for uplift and liquefaction settlement
Shell repair/modification		Replace non-code features with new shell insert plate, manway

References

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3. Manos, George C., “Earthquake Tank-Wall Stability of Unanchored Tanks”, American Society of Civil Engineers, Journal of Structural Engineering, Vol. 112, No. 8, August 1986.

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