Seismic Vulnerability Assessment

Kinder Morgan

Eugene Terminal

1765 Prairie Road

Eugene, OR 97402

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Norwest Engineering, Inc.
4110 NE 122nd Avenue, Suite 207
Portland, OR 97230
(503) 254-0110

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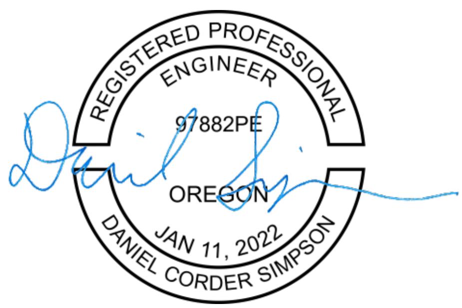
Date: 05/29/2024

Printed Name: Michael J. Smith, PE

Discipline: Structural & Civil Engineering

Licensing Agency: State of Oregon



Expires: 06/30/2024

Printed Name: Daniel Simpson, PE

Discipline: Geotechnical Engineering

Licensing Agency: State of Oregon

ERRATA SHEET FOR NORWEST ENGINEERING SEISMIC VULNERABILITY ASSESSMENT

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SEISMIC VULNERABILITY ASSESSMENT

SECTION 1: Seismic Vulnerability Assessment

1.1 Facility Overview

The Eugene Terminal receives and distributes products including gasoline, ultra-low sulfur diesel with 5% Biodiesel, and ethanol. Products are received via the SFPP pipeline to Eugene. Ethanol is received by truck unloading. All products are distributed by truck.

The terminal includes the capability to perform midgrade gasoline blending, ethanol rack blending, detergent additive blending, diesel red dye injection services, and diesel lubricity addition.

The Eugen Terminal Tank Farm has 42 tanks ranging from 5,000 to 60,000 barrels with a combined total storage capacity of 708,100 barrels.

1.2 Background

Per the State, a Cascadia Subduction Zone earthquake impacting the large capacity fuel handling facilities in Oregon could create widespread environmental damage, fires, endanger health and safety of surrounding communities and place impossible demands on the state's emergency response capabilities. The purpose of this act is to protect public health, life safety and environmental safety against fires and release of fuel products from large fuel storage facilities.

Oregon Laws 2022 Chapter 99 addresses the Oregon Resilience Plan written by the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) issued February 2013 and the Oregon Fuel Action Plan written by the Oregon Department of Energy (ODOE) issued October 2017. The two plans bring the recovery of basic infrastructure from a Cascadia earthquake event into sharp relief: The projected recovery for inland areas is expected to require up to 3 months. The projected recovery for coastal areas is expected to exceed 3 to 6 months.

Continued operation of existing fuel unloading and distribution terminals in Oregon will be essential in the recovery effort. Liquid fuels (gasoline, diesel, and jet fuel) will be a critical part of the recovery process ranging from fueling emergency and public safety vehicles to construction equipment required for restoration of transportation and utilities. Liquid fuels will need to be sourced from outside of the Cascadia impact areas. but there needs to be functioning local distribution terminals (with unloading and loading capabilities) to receive and distribute that fuel.

1.3 Oregon Laws 2022 Chapter 99

The 2022 Oregon legislature adopted Senate Bill 1567 enacted as Chapter 99 of Oregon Laws 2022. The law authorizes the Oregon Department of Environmental Quality (ODEQ) to adopt requirements for Seismic Vulnerability Assessments (SVA) and the Risk Mitigation Implementation Plans (RMIP) for large capacity bulk fuels terminals in Columbia, Lane, and Multnomah counties.

Oregon Department of Environmental Quality (ODEQ) requires a Seismic Vulnerability Assessment (SVA) be submitted to the ODEQ by June 1, 2024. Within 180 days following ODEQ acceptance of the SVA, a facility-wide Seismic Risk Mitigation Implementation Plan must be submitted to the ODEQ.

The law applies to owners and operators of bulk fuel terminals or industrial facilities in Oregon with at least 2-million-gallon oil or liquid fuel products storage capacity.

1.4 The Oregon Resilience Plan

A Cascadia earthquake and tsunami will affect both Oregon and Washington. A particular vulnerability is Oregon's liquid fuel supply. Oregon depends primarily on liquid fuels transported into the state by pipeline and barges from Washington state refineries. Both states share common challenges, among them the interstate bridges and the Columbia River navigation channel as well as the regional power grid and liquid fuel supply. Once here, fuels are stored temporarily at Oregon's critical energy infrastructure hub, a six-mile stretch of the lower Willamette River where industrial facilities occupy liquefiable riverside soils. Disrupting the transportation, storage, and distribution of liquid fuels would rapidly disrupt most, if not all, sectors of the economy critical to emergency response and economic recovery.

1.5 Oregon Fuel Action Plan

As a result of a Cascadia earthquake Oregon can expect to lose most of the normal incoming supply of fuel. The Oregon Department of Geology and Mineral Industries (DOGAMI) 2013 Seismic Study found that the region's refineries and petroleum distribution terminals are expected to sustain moderate to significant damage. Existing facilities will have tank farm failures, marine dock failures, pipeline system breaks, hazardous material spills, fires, and structural damages onsite. Restoring the region's petroleum infrastructure will likely take months if not longer. In addition, the Olympic Pipeline that transports most of the gasoline, diesel, and jet fuel used in Oregon from refineries in Washington state is projected to be disabled for an extended period.

It is estimated that the existing petroleum terminals currently average a one-week fuel inventory at normal rates of consumption. So even if the terminals remain capable of distribution, they must also be capable of unloading product via barge and/or ship deliveries and/or tanker truck and/or rail car deliveries.

SECTION 2: Tank Seismic Stability Rules

2.1 Summary of the Rules

The owners and operators of bulk fuel terminals or industrial facilities with at least 2-million-gallon liquid fuel products storage capacity located in Columbia, Multnomah and Lane counties must provide a facility wide Seismic Vulnerability Assessment to ODEQ. The Oregon Department of Environmental Quality (ODEQ) Chapter 340 Division 300 Fuel Tank Seismic Stability provides the process criteria for the SVA.

2.2 Seismic Vulnerability Assessment (SVA)

The owners and operators of bulk fuel terminals or industrial facilities must:

(A) Prepare and submit to Oregon Department of Environmental Quality (DEQ) a facility-wide Seismic Vulnerability Assessment (SVA) by June 1, 2024.

(B) Be conducted and verified by an Assessment Team of qualified professionals.

(C) Evaluate the existing site structures and facilities potential to maintain safe operating conditions, or safe shutdown procedures, to protect public health, life safety and environmental safety against releases of oils or liquid fuel products, including information about operational procedures during disasters.

(D) Describe each facility component including fuel stored or handled, maximum and minimum storage volume, type of construction, age, inspection records, (if applicable), routine maintenance performed and when, and current normal operation.

(E) Summarize currently implemented spill prevention and mitigation measures and their ability to achieve the performance objective defined in 340-300-0002;

(F) Develop the Design Level Earthquake for the site in accordance with ASCE 7.

2.3 SVA Implementation

The SVA shall use the Codes and Standards as defined by OAR 340-300-0002(4) and the Design Level Earthquake determined using ASCE 7 to evaluate the potential for a spill greater than the Maximum Allowable Uncontained Spill during or after the Design Level Earthquake of all components including:

(A) Existing buildings, structures, and ancillary components.

(B) Tanks, pipes, and piping systems.

(C) Spill containment measures and structures.

(D) Transloading facilities, including wharves, berths, piers, moorings and retaining structures; railcar unloading racks, and pipeline connections.

(E) Truck Loading racks.

(F) Control equipment; and

(G) Any other structures related to or supporting facilities part of the bulk fuel terminal.

(H) Evaluate soil's vulnerability to liquefaction, lateral spreading, and seismic-induced settlement.

(I) Evaluate the safety of operating conditions, safe shutdown procedures, and potential spills.

(J) Evaluate the availability and integrity of automated fire suppression systems and sufficient supplies of firewater and firefighting foam and other emergency response equipment located in seismically resilient locations that will be accessible after an earthquake or secondary effects to mitigate the risk of fire and explosions following an earthquake.

(K) Evaluate the integrity of fire control measures such as firewalls surrounding the facility to limit fire spreading into surrounding communities; and

(L) Evaluate the availability of day and night onsite personnel trained in emergency response and able to respond in the event of an earthquake.

(M) Facility owner or operator must submit subsequent Seismic Vulnerability Assessment updates to DEQ.

2.4 Pipeline Regulations

Where in conflict with Oregon law Chapter 99, the federal Pipeline Safety Improvement Act of 2002, 49 U.S.C. 60101 et seq. prevails.

Interstate petroleum and natural gas pipelines are not subject to Oregon regulations as they are subject to regulation by the United States Federal Energy Regulatory Commission (FERC).

Intrastate pipelines are regulated by the U.S. Department of Transportation (US DOT). The US DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) may delegate some authority to state agencies, usually the Public Utilities Commission (PUC).

2.5 Seismic Risk Mitigation Implementation Plan (SRMIP)

A seismic risk mitigation implementation plan must, at a minimum, identify actions, with timelines, to protect public health, life safety and environmental safety within the facility, in areas adjacent to the facility, and in other areas that may be affected because of damages to the facility. The Oregon Department of Environmental Quality (ODEQ) Chapter 340 Division 300 Fuel Tank Seismic Stability provides the process criteria for the SRMIP.

The SRMIP, as a risk-based assessment, must include consideration of the likelihood of a magnitude 9.0 Cascadia Subduction Zone earthquake or other seismic event that exceeds the impact of the Cascadia event, the potential consequences of that event and the resources needed to respond to that event.

Following acceptance of the SVA by the DEQ, the owners and operators of the regulated facilities shall prepare and submit to DEQ the facility-wide Seismic Risk Mitigation Implementation Plan (SRMIP) within 180 days which is designed to:

(A) Mitigate earthquake-induced damage to reduce the potential of fuel spills and fires.

(B) Address potential of facility to safely shut down during or immediately after a damaging earthquake, if needed, to minimize spills (as required by the performance objective defined in 340-300-0002). Performance criteria must conform with the building codes in effect on September 1, 2023 as defined by OAR and may be based on the probabilistic or deterministic analysis or on an alternative analysis proposed by facility owner for DEQ's approval.

(C) Provide risk mitigation measures implementation plans and timeline; and

(D) Provide periodic reports of the ongoing implementation of mitigation measures.

(E) Implement the risk minimization measures described in Risk Mitigation Implementation Plans when approved by DEQ within the approved timeline.

(F) Prepare and submit to DEQ post-implementation reports documenting completion of mitigation work and addressing residual risks.

(G) The Risk Mitigation Implementation Plan must outline interim mitigation actions that will be completed within 1, 3, & 5 years based on feasibility and order of importance.

(H) All mitigation measures approved by DEQ must be completed within 10 years after the DEQ approves the Risk Mitigation Implementation Plan.

(I) Annual Risk Mitigation Implementation Plan implementation status reports must be submitted by June 1st of each year, or on a schedule approved by DEQ in the Risk Mitigation Implementation Plan.

SECTION 3: Basis for Rules Development

The Environmental Quality Commission, in consultation with the State Department of Geology and Mineral Industries, shall adopt by rule a seismic risk mitigation implementation program for bulk oils or liquid fuels terminals that is based on risk. To the extent feasible and appropriate, the program adopted under this section shall be consistent and coordinated with the program established under ORS 468B.345 to 468B.415. Rules adopted under this section shall include, but not be limited to:

2 (a) Rules for the required content of seismic risk mitigation implementation plans and rules for approval by the Department of Environmental Quality of seismic risk mitigation implementation plans.

2 (b) Provisions for training, response exercises, external peer reviews, inspections, and tests to verify the ability of the facility to sustain safe conditions and respond to uncontrolled releases of hazardous materials from the bulk oils or liquid fuels terminal due to an earthquake.

2 (c) Requirements to minimize harmful impacts to local communities and natural resources due to uncontrolled releases of hazardous materials from the bulk oils or liquid fuels terminal due to an earthquake and its associated direct and indirect impacts, including fires and flooding.

2 (d) Requirements for the inspection of bulk storage tanks at bulk oils or liquid fuels terminals.

2 (e) Design and construction standards for new bulk storage tanks constructed at bulk oils or liquid fuels terminals.

2 (f) Design and construction standards for seismic mitigation of existing bulk storage tanks, piping and related structures constructed at bulk oils or liquid fuels terminals.

2 (g) Provisions requiring the proper installation of seismically certified generators to power critical operations, or at a minimum, the installation of electrical hookups for emergency generators.

2 (h) Provisions for the review of seismic vulnerability assessments required under section 2 of this 2022 Act and seismic risk mitigation implementation plans required under subsection (1) of this section by state agencies with expertise in earthquake hazards, risk mitigation or emergency preparedness or management.

2 (i) Provisions requiring the owner or operator of a bulk oils or liquid fuels terminal to submit seismic vulnerability mitigation implementation plan updates to the department:

(A) According to a schedule established by the commission.

(B) Upon the retrofit or reconstruction of all or a part of a bulk oils or liquid fuels terminal; and

(C) Based on new scientific or technical findings, but no more frequently than once every three years.

2 (j) Provisions establishing a fee calculated to cover the costs to the department of reviewing seismic risk mitigation implementation plans submitted under this section and seismic risk assessments submitted under section 2 of this 2022 Act, less any federal funds received by the department for those purposes. Fees received by the department under this paragraph shall be deposited in the Seismic Risk Mitigation Fund established under section 6 of this 2022 Act.

2 (k) Provisions establishing grants or other financial assistance to owners or operators of bulk oils or liquid fuels terminals for improvements to existing infrastructure, provided that federal funds are made available to the department for that purpose.

SECTION 4: Assessment Methods and Approach

4.1 Summary of Evaluation Methods

4.1.1 Geotechnical

Sage's geotechnical evaluation included:

- An assessment of site conditions, including the geotechnical properties of subsurface soil and groundwater.
- A seismic hazard evaluation. Strong ground motion hazards were defined in accordance with the response spectrum in the American Society of Civil Engineers' (ASCE) *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (2017). Soil liquefaction and potential liquefaction effects were evaluated in accordance with guidelines established by the National Academies of Sciences, Engineering, and Medicine (2021).
- A geotechnical evaluation in which the results of the site-condition assessment and seismic hazard evaluation were combined to estimate the effects that earthquakes could have on site soils and foundations.

Much of the site was constructed prior to the codification of contemporary seismic design standards; as such, even moderate lateral spreading could result in an exceedance of the performance threshold specified in Oregon Administrative Rule (OAR) 340-300. To account for this, Sage established an idealized site condition or geotechnical profile that could be used to assess seismic hazards (mainly, liquefaction-induced settlement and bearing capacity loss).

4.1.2 Structural

Norwest conducted an on-site and visual-only walkdown. The walkdown is the critical first step in evaluation methodology. In the walkdown, a team of licensed professional engineers systematically reviewed the facility with focus on the terminal systems including tanks, piping support, loading racks, containment structures, building structures, and other equipment identified as in-service and potentially impactful to the transportation of bulk oil or liquid fuels.

4.1.3 Safety/Mechanical/Fire

The safety assessment was limited to review of available documentation, drawings, reports, and procedures provided by Kinder Morgan. Many of the documents have been developed in accordance with Federal regulations. The information was reviewed and analyzed by a licensed professional engineer. Judgements and conclusions were drawn relative to the facility's safety of operating conditions, fire suppression systems, emergency response, and spill containment.

4.2 Facility Areas to be Evaluated

See Figure B-1 in Appendix B for reference.

4.2.1 Area 1 (North Yard)

Area 1 comprises the north tank farm and two truck transfer racks. The tank farm contains several small to medium sized above-ground tanks, with secondary containment provided by earthen berms. Small ancillary equipment is located within the tank farm area and outside adjacent to the truck racks.

4.2.2 Area 2 (South Yard)

Area 2 comprises the south tank farm, the area between the two tank farms, and the remaining three truck transfer racks. The tank farm contains several tanks of various sizes, with a secondary containment similar in construction to Area 1. The space between the tank farms is where the administrative building is located, pipeline appurtenances, and ancillary process equipment. An out of service railcar loading rack is located in this area.

SECTION 5: Vulnerability Assessments

5.1 Summary of Evaluation Methods

5.1.1 Geotechnical Assessment (Site Wide)

5.1.1.1 Site Conditions Assessment

5.1.1.1.1 Description of surface conditions, topography, shoreline topography.

Regional topography is depicted on Figure G-1. Site topography is shown on Figure G-2. Readily available light detection and ranging data (DNR, accessed February 19, 2024) was used to evaluate the topography of the site and the surrounding area.

The site is situated in southern Willamette Valley, approximately 3 miles southeast of the confluence of the Willamette River and McKenzie River. As shown on Figures G-1 and Figure G-2, the site is practically flat and not near significant topographic features. Local topographic relief includes minor grading for secondary containment and isolated railway/highway embankments.

The site is surfaced with sod, soil, asphalt, and concrete. Tanks, mechanical equipment, buildings, and parking/drive aisles are present throughout the site.

5.1.1.1.2 Description of regional and site geology including soil stress history, deposition environment, and bedrock and soil units.

Geologic information for the site and the surrounding area was obtained from the Preliminary Geologic Map of the Eugene East and Eugene West Quadrangles, Lane County, Oregon (Madin and Murray 2006). Near-surface deposits at the site are mapped as fan-delta alluvium (quaternary aged), a broad fan of sand and gravel deposited by the Willamette and McKenzie rivers in the head of the Willamette Valley. The alluvium is likely normally consolidated to slightly overconsolidated. It is underlain by older Quaternary (Pliocene to Pleistocene) alluvium consisting of silty pebble and cobble gravel and weak conglomerate deposited by the early Willamette River. Quaternary sediments at the site extend more than 200 ft below ground surface (bgs; Madin and Murray 2006).

5.1.1.1.3 Description of field explorations and laboratory testing.

On March 18 and 19, 2024, Sage monitored the advancement of two sonic borings (B-1 and B-2). Additional details are provided in Appendix G-1. Sage also reviewed reports of previous site investigations completed by others (Branch Engineering 2019 and PSI 2023); copies of the reports are included in Appendix G-3. The approximate locations of the recent and historical explorations are shown on Figure G-2.

Borings were advanced through 9- to 9.5-ft-deep, vacuum-excavated boreholes in accordance with Kinder Morgan's safety requirements.

Sage's laboratory testing program included moisture content determinations and sieve analyses. Test results and a description of the laboratory testing program are included in Appendix G-2.

5.1.1.1.4 Description of site subsurface conditions, including soil and rock units encountered, extents and properties of those units, and groundwater conditions.

Site subsurface conditions were characterized in accordance with the following engineering stratigraphic units (ESUs):

ESU 1: Fill/medium dense alluvium. ESU 1 consists of alluvium overlain by a thin veneer of fill. The upper alluvium consists of clayey or silty sand that transitions with depth to a loose to medium dense mixture of cobbles, gravel, and sand with silt. The top portion of ESU 1 appears to be coarse-grained dominant in some areas of the site, and fine-grained dominant in other areas of the site. ESU 1 extends to an average depth of 20 ft bgs.

ESU 2: Very dense alluvium. ESU 2 consists of a very dense mixture of cobbles, gravel, sand, and silt. ESU 2 extends to the maximum depth explored (51.5 ft bgs).

During Sage's March 2024 investigation, groundwater was encountered at approximately 15.7 ft bgs in boring B-1 and at 3.8 ft bgs in boring B-2. Groundwater was encountered at approximately 10 ft bgs during Professional Service Industries, Inc.'s November 2023 site investigation and at 12 ft bgs during Branch Engineering, Inc.'s August 2019 investigation. Well reports indicate that no groundwater was encountered in Hart Crowser's April 1997 investigation, which included maximum exploration depths of 8 ft bgs (OWRDa, accessed March 26, 2024). The groundwater hydrograph for area well LANE0056763 (OWRDb, accessed March 26, 2024) shows typical groundwater depths of 6 to 10 ft bgs.

Based on the groundwater data reviewed, a design groundwater depth of 8 ft bgs was selected.

5.1.1.1.5 Description of methods, analyses, assumptions, and judgments.

Analyses for the geotechnical portion of the seismic vulnerability assessment (SVA) were completed in general accordance with current standards of practice and with methods described in peer-reviewed literature. The individual methods, analyses, assumptions, and judgments are described in the following sections.

During Sage's subsurface investigation, a 140-pound automatic trip hammer, falling approximately 30 inches, was used to drive unlined standard penetration test (SPT) and Modified California split-spoon samplers into undisturbed site soil. The Modified California sampler was used to retrieve oversized material and investigate inflated SPT blow counts, where large particles could obstruct the sampler. The Modified California sampler blow counts were converted to an equivalent SPT blow count using the method outlined by Fang (1991). In Sage's opinion, the SPT blow counts, and Modified California blow counts converted to equivalent SPT blow counts, are a reasonable representation of in situ soil conditions.

5.1.1.2 Seismic Hazard Evaluation

The following were used to support Sage's seismic hazard evaluation (see Appendix G-4):

- Modified California sampler blow count conversion (G-4-1).
- Seismic site class determination (G-4-2).
- Seismic design parameters for the site (G-4-3).
- The U.S. Geological Survey (USGS) seismic hazard disaggregation for the site (G-4-4).
- Liquefaction and residual strength calculations (G-4-5).
- Seismic bearing capacity calculations (G-4-6).

5.1.1.2.1 Description of seismic hazards at the site, including seismic evaluation criteria (expected ground shaking), liquefaction, settlement, surface effects, loss of strength, lateral spread, and slope stability as appropriate.

Sage used the USGS' 2014 National Seismic Hazard Model (v4.2.0) to review the peak ground acceleration (PGA) seismic hazard disaggregation for the site with a seismic site class of D (Petersen et al. 2014). Based on this review, more than 80 percent of the seismic hazard at the site stems from an interface rupture along the Cascadia subduction zone. The remaining seismic hazard stems from other finite fault sources, random crustal events, or random deep intra-slab events. The mean moment magnitude from the PGA disaggregation, reproduced in Table G-1, was selected for liquefaction and lateral spreading analyses.

Table G-1. Seismic Parameters for Liquefaction and Lateral Spreading Analyses

Parameter	Value
Moment magnitude (M_W)	8.71
Peak ground acceleration (PGA_M)	0.441 g

g = force of gravity

Seismic evaluation criteria (expected ground shaking) were determined in accordance with *ASCE 7,* per OAR 340-300-0002(4)(a):

- The blow counts measured in borings B-1 and B-2 were used to determine the seismic site class. Sage assumed 50 blow counts for the unexplored soil layer between 51.5 ft bgs and 100 ft bgs.
- Based on the SPT blow counts, the site classifies as a seismic Site Class D; however, the presence of liquefiable soils results in modification to a seismic Site Class F. Per *ASCE 7-16* and the 2022 *Oregon Structural Specialty Code* (hereafter, *2022 OSSC*): For structures with a fundamental period of vibration of 0.5 seconds or less, a design response spectrum corresponding to the non-liquefied site class may be used where the presence of liquefiable soils would otherwise result in a Site Class F. For structures with a longer fundamental period of vibration, a site response analysis is required to determine the design response spectrum. The minimum response spectrum allowed at this site, following a seismic site response analysis, is 80 percent of the Site Class D response spectrum. Because this is a screening-level study, potentially vulnerable structures should be assessed using the Site Class D response spectrum, even if they have a fundamental period of vibration longer than 0.5 seconds. Additional analysis (e.g., a site response analysis) may be required if components per OAR 340-300-003 (1) (f) do not exceed the performance objective per OAR 340-300-0002 (18) for the Site Class D response spectrum and the components have a fundamental period of vibration longer than 0.5 seconds.
- The parameters in Table G-2 can be used to determine the Site Class D response spectrum. Structural analyses completed with this response spectrum are subject to the requirements in the notes following Table 11.4-2 in *ASCE 7-16,* Supplement 3 and to the corresponding limitations on the use of site coefficient F_V.

Table G-2. Seismic Response Spectrum Parameters

S_s	F_a	S_1	F_v
0.743	1.206	0.42	1.880

F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

Soil liquefaction hazards, including liquefaction-induced settlement and soil strength loss, are present at the site.

5.1.1.2.2 Liquefaction/lateral spreading

Subsurface data from borings B-1 and B-2 were used to complete the following liquefaction analyses:

- **Liquefaction susceptibility** (i.e., whether the soil will behave like sand or like clay during dynamic loading) was determined by observation of soil type. All saturated soils are coarse-grain dominant and, therefore, susceptible to liquefaction if triggered.
- **Liquefaction triggering potential** (i.e., whether the earthquake cyclic stress ratio would exceed the cyclic resistance ratio of soil) was calculated in accordance with the procedure established by Boulanger and Idriss (2014). Liquefaction-triggering calculations are included in Appendix G-4.
- **Liquefaction/seismic strength loss:** Liquefied soil residual shear strength was computed using the procedure established by Idriss and Boulanger (2008), with void redistribution assumed to be negligible due to the low fines content and coarseness of the soils. An automatic trip hammer was used to drive the SPT and Modified California samplers and an assumed efficiency of 80 percent was used to compute N_{60}. Calculations are provided in Appendix G-4.
- **Lateral spreading potential** was ruled out by observing surface grades. Aside from a couple of feet of minor topographic relief, the site is flat and not near any free face.

5.1.1.2.3 Seismic settlement

Seismic settlement is the result of liquefied soil reconsolidation or ejection to the ground surface (liquefaction-induced settlement), dry sand consolidation, or reductions in seismic bearing capacity. Liquefaction-induced settlement was calculated in accordance with Boulanger and Idriss (2008); calculations are provided in Appendix G-4. Settlement caused by dry sand consolidation was not included in the calculations, as there is little, if any, dry sand at the site.

Liquefaction-induced settlement and seismic bearing capacities are discussed in Section 5.1.1.3.

5.1.1.2.4 Slope stability

The site is flat, and slope instability is not considered a seismic hazard.

5.1.1.2.5 Miscellany, Such as Surface Effects

No significant seismic hazards, other than those discussed herein, are anticipated to be present at the site.

5.1.1.3 Geotechnical Evaluation

Section 5.1.1.2 describes the methodology Sage used to evaluate seismic hazards at the site. Based on the results of its evaluation, Sage has identified the following potential hazards:

- During, or immediately after, a seismic event, an approximately 8-ft-thick, non-liquefied crustal layer will form at the site; the crust will consist of medium dense, clayey/silty sand; stiff, sandy clay/slit; or medium-dense, sandy, poorly graded gravel. It will be underlain by an average 15-ft-thick layer of medium dense, coarse-grained soils with zones that exhibit cyclic liquefaction. Some zones of free-draining, highly permeable gravel may not liquefy; however, Sage's evaluation is based on the assumption that all triggered soil layers (i.e., where CSR>CRR) will liquefy.
- Liquefaction is anticipated to cause moderate settlement and bearing capacity loss.
- A significant percentage of the seismic hazard stems from large-magnitude sources, and seismic analysis should combine internal loading and liquefied soil conditions (WSDOT 2024).

5.1.1.3.1 Seismic design parameters

Seismic design parameters are provided in Section 5.1.1.2.

5.1.1.3.2 Estimated vertical settlement

Sage estimates that 3 to 6 inches of liquefaction-induced total settlement could occur following a seismic event; as much as 3 inches of liquefaction-induced differential settlement could occur over 50-ft spans.

5.1.1.3.3 Lateral ground deformations

The site and the surrounding areas are flat, and significant seismic lateral ground movement is not anticipated.

5.1.1.3.4 Foundation design parameters

5.1.1.3.4.1 Shallow Foundations

In addition to the settlement described in Section 3.1.1.3.2, liquefaction may affect the bearing capacity of shallow foundations wider than 4 ft. Bearing capacity with liquefied soil conditions was estimated using the limit-equilibrium method of slices, implemented with Slide2 software (Rocscience). In this calculation, the zone of soil anticipated to liquefy was assigned a residual shear strength computed as the average residual shear strength of all liquefiable soil layers. The average residual shear strength (su,r) is estimated to be $s_{u,r}/\sigma'_v = 0.3$.

The allowable seismic bearing capacities in Table G-3 include a safety factor of 1.5. When calculating the allowable bearing capacities, Sage assumed that the foundation would be embedded approximately 2 to 4 ft below surrounding site grades.

Table G-3. **Seismic (liquefied soil) Shallow Foundation Allowable Bearing Capacity**

Foundation Width	4 ft	8 ft	16 ft -128 ft
Allowable Seismic Bearing Capacity	2.2 ksf	1.8 ksf	1.6 ksf

ft = feet
ksf = kips per square foot

Where seismic bearing pressures are less than those listed in Table G-3, foundations will likely experience a degree of settlement equal to or less than the settlement noted in Section 5.1.1.3.2. Where seismic bearing pressures are greater than those listed in Table G-3, foundations will likely experience bearing capacity loss and settlement beyond that noted in Section 5.1.1.3.2.

5.1.1.3.4.2 Lateral Resistance of Shallow Foundations

Basal friction can be computed with an allowable friction coefficient of 0.4 using dead loads. Passive pressure can be estimated with an allowable equivalent fluid density of 480 pounds per cubic foot for soil above groundwater. This includes a safety factor of at least 1.5. When computing passive resistance, the top foot of soil should be neglected. When combining passive resistance and basal friction, the passive component should not exceed one-third of the total resistance.

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5.1.2 Structural Assessment

As Identified in Section 5.1.1, this site is subject to liquefaction. Tanks and piping are flexible structures and seismic performance under liquefaction settlement and seismic settlement are much better, well-conceived and maintained tanks and piping have performed well in past earthquakes. The seismic performance expectations outlined below have been formed based on the perceived structural response to the ground shaking hazard on Site Class D soils. [Some items identified as low risk in a design seismic event may be subject to additional lateral displacement, settlement, or residual stresses in a liquefaction or lateral spreading event.]

5.1.2.1 Seismic Performance Expectations

5.1.2.1.1 Area 1 (North Yard)

5.1.2.1.1a Tank Farm

Eighteen operational storage tanks are provided at Area 1 of the facility with various construction dates. The storage tanks vary in size, but most are typically 60 to 100-feet in diameter and 50-feet in height. The operational tanks appear to be well engineered (per API 650), conceived and maintained. The foundations of the tanks vary with more modern installation utilizing ground improvements or piles and some older tanks on mat gravel foundations. The tanks are also self- anchored. Self-Anchored Tanks are very common and perform well during seismic events. At many of the tanks, placards were provided which give a repair or alteration date in accordance with API 653. API 653, Tank Inspection, Repair, Alteration, and Reconstruction is a standard developed and published by the American Petroleum Institute (API) and covers the inspection, repair, alteration, and reconstruction of steel aboveground storage tanks used in the petroleum and chemical industries. All active tanks are required to undergo an API 653 inspection based on certain parameters. This inspection ensures the tank floors and shells have not deteriorated as well as ensuring the tank has not experienced differential settlement. Given the nature of the inspection requirements we can be sure the tanks are plumb and have not been corroded. All the tanks are regulated by the Department of Transportation and Kinder Morgan is in compliance with all inspection requirements. Based on our analysis we believe there is a low risk of tank overturning during the design seismic event but there is a concern with tank rupturing due to non-compliance with API 650 Appendix E.

5.1.2.1.1b Truck Loading Racks

Two truck loading racks are provided at Area 1 of the facility. The truck loading racks are constructed of structural steel frames which are cantilevered to provide a canopy structure. The structure supports a canopy roof, multiple piping systems, and various mechanical and electrical equipment. Additionally, a structural steel platform level appears to have been added after construction at approximately mid-height of the building columns. The lateral resisting system of the truck loading racks appear to be moment frames in each direction. Based on the weight supported and lateral resisting system, we believe the truck loading racks are at risk in a design level seismic event.

5.1.2.1.1c Pipe Supports

Piping at Area 1 of the facility is typically buried underground. As such, pipe supports are not typically provided. Because of this we believe the piping is of low seismic risk.

5.1.2.1.1d Containment Structure

Containment at Area 1 consists of containment walls at the west end of the tank yard, and a gravel berm structure at the remainder of the yard. The containment walls consist of concrete masonry unit. The walls generally appear to be in good condition. No information has been provided regarding the foundation of the containment walls. Based on our observations, the containment walls appear to be of adequate height and construction to resist static surcharge loading in the event of a tank spill. However, based on the age of construction we believe it is unlikely the containment walls were designed for dynamic effects in the event of a spill in a seismic scenario. We believe the gravel berm is of low seismic risk.

5.1.2.1.1e Ancillary Equipment

Various ancillary equipment is provided in Area 1, including additive tanks, pumps, and electrical equipment. Most of the ancillary equipment appeared to be properly anchored and located on a foundation. We believe the anchored and founded equipment is of low risk in a design level seismic event. A few exceptions are highlighted below:

Several horizontally oriented cylindrical additive tanks, including tanks labeled A-4, A-5, A-9, and A-10 were placed on a skid which was not observed to be anchored. We believe these tanks may be subject to sliding or overturning in a design level seismic event.

5.1.2.1.1f Canopies and Building Structures

Contained in Area 1 are a few small canopies and building structures including a guard shack, a bulk container storage tank canopy, and the auxiliary office and storage buildings on the west side of the terminal access road. Limited information is available on the buildings beyond what is visually available.

The canopy structures and guard shack are light framed structures and appear to be modern construction. The buildings appear to have a low seismic mass, appear to be well conceived and are of minimal risk regarding spill prevention.

The auxiliary office building is a light framed structure of unknown construction date. The building is being used for light storage of non-petroleum materials and is of minimal risk regarding spill prevention.

The storage building is a metal building structure which was reportedly built within the past five years. The building is being used for light storage of non-petroleum materials and is of minimal risk regarding spill prevention.

5.1.2.1.2 Area 2 (South Yard)

5.1.2.1.2a Tank Farm

Sixteen operational storage tanks are provided at Area 2 of the facility with various construction dates. The storage tanks vary in size, but most are typically 60 to 100-feet in diameter and 50-feet in height. The operational tanks appear to be well engineered (per API 650), conceived and maintained. The foundations of the tanks vary with more modern installation utilizing ground improvements or piles and some older tanks on mat gravel foundations. The tanks are also self- anchored. Self-Anchored Tanks are very common and perform well during seismic events. At many of the tanks, placards were provided which give a repair or alteration date in accordance with API 653. API 653, Tank Inspection, Repair, Alteration, and Reconstruction is a standard developed and published by the American Petroleum Institute (API) and covers the inspection, repair, alteration, and reconstruction of steel aboveground storage tanks used in the petroleum and chemical industries. All active tanks are required to undergo an API 653 inspection based on certain parameters. This inspection ensures the tank floors and shells have not deteriorated as well as ensuring the tank has not experienced differential settlement. Given the nature of the inspection requirements we can be sure the tanks are plumb and have not been corroded. All the tanks are regulated by the Department of Transportation and Kinder Morgan is in compliance with all inspection requirements. Based on our analysis we believe there is a low risk of tank overturning during the design seismic event but there is a concern with tank rupturing due to non-compliance with API 650 Appendix E.

5.1.2.1.2b Truck Loading Racks

Three truck loading racks are provided at Area 2 of the facility. The truck loading racks are constructed of structural steel frames which are cantilevered to provide a canopy structure. The structure supports a canopy roof, multiple piping systems, and various mechanical and electrical equipment. Additionally, a structural steel platform level appears to have been added after construction at approximately mid-height of the building columns. The lateral resisting system of the truck loading racks appear to be moment frames in each direction. Based on the weight supported and lateral resisting system, we believe the truck loading racks are at risk in a design level seismic event.

5.1.2.1.2c Pipe Supports

Piping at Area 2 of the facility is typically buried underground with a few exceptions. As such, pipe supports are not typically provided. We believe the underground piping is of low seismic risk in a design seismic event.

Pipe supports are provided at a few locations at Area 2. Piping is typically located 3-feet above grade or less with anchorage and a foundation provided. The pipe supports appear to be well conceived, and of low seismic risk given the height of the supports.

5.1.2.1.2d Containment Structure

Containment at Area 2 consists of containment walls at the west and south ends of the tank yard, and a gravel berm structure at the remainder of the yard. The containment walls consist of concrete masonry units. The walls generally appear to be in good condition. No information has been provided regarding the foundation of the containment walls. Based on our observations, the containment walls appear to be of adequate height and are constructed to resist static surcharge loading in the event of a tank spill. However, based on the age of construction we believe it is unlikely the containment wall was designed for lateral movement in a seismic scenario. Further analysis or retrofitting may be warranted to ensure their efficacy under seismic stress, thereby fortifying the overall resilience of the tank farm infrastructure. We believe the gravel berm is of low seismic risk.

A holding basin is provided for storing non-potable water at the east end of Area 2. The holding basin is constructed of cast-in-place concrete and appears to be in fair condition. Due to the materials stored, the basin is of minimal risk regarding spill prevention.

5.1.2.1.2e Tank Car Loading Rack

A tank car loading rack is provided at the east end of Area 2 adjacent to the train tracks. The platform is constructed of structural steel braced frames and supports isolated piping and mechanical equipment. The structure has a low seismic mass, the system is out of service, and is of minimal risk regarding spill prevention.

5.1.2.1.2f Ancillary Equipment

Various ancillary equipment is provided in Area 2, including tanks, pumps, and other equipment. Most of the ancillary equipment appeared to be properly anchored and located on a foundation. We believe the anchored and founded equipment is of low seismic risk.

A vertically oriented cylindrical tank indicated as A-1 Arco Additive is provided at the south end of Area 2. The tank was placed directly on the concrete slab with no anchorage observed. We believe this item may be subject to sliding or overturning in a design level seismic event.

Two horizontally oriented cylindrical additive tanks, labeled A-2 and A-3 is placed on a skid which was not observed to be anchored. We believe these tanks may be subject to sliding or overturning in a design level seismic event.

The vapor combustion unit (VCU) consists of a relatively tall and slender stack with associated skid mounted mechanical piping and equipment serving it. The unit was constructed in the last five years, was engineered and permitted, and is likely of low risk for instigating a spill in a design level seismic event.

A water treatment system and vapor recovery unit (VRU) are located between the tank farms. These two systems are out of service and unlikely to be involved in a spill during a design level seismic event.

5.1.2.1.2g Canopies and Building Structures

Contained in Area 2 are several buildings including the office building, water treatment building, foam building, and several light storage buildings and personnel shacks.

The office building is of masonry construction with an unknown construction date. The building appears to be well maintained and conceived and is of minimal risk regarding spill prevention.

The water treatment building, foam building, storage buildings, and personnel shacks are of light framed construction with an unknown construction date. The buildings appear to be well conceived and are of minimal risk regarding spill prevention.

5.1.3 Safety Assessment

5.1.3.1 Description of fire control system

5.1.3.1.1 General system description

The Kinder Morgan Eugene terminal has six fixed (hard-piped) light water/foam systems dedicated to fire suppression at the storage tanks. In support of the fixed light water systems, the terminal has six 275-gallon storage totes of 3/6% FP-AR-AFFF type of fire suppressing foam. Lastly, the terminal has its own fire hydrant system supplying large volumes of water at adequate pressure.

The fire protection system is fed by two separate city water supply mains. The Prairie Road main is a 20” line in which the lateral enters the facility on the east, north of the main entrance. The other is a 12” main south of the site that runs east-west along the gravel fire road. The lateral from this main enters the site from the south dirt field, east of the existing tank EG-40. The fire water lines create a loop around the facility, feeding the facility hydrants. The hydrants are located throughout the terminal at safe distances at safe distances from storage tanks to maintain operability during a potential fire.

The facility’s fire control system as described above is capable of mitigating risk of fire and explosions following an earthquake, as long as the system remains undamaged. With multiple laterals from separate city water mains, the water supply is also sufficient.

5.1.3.1.2 Vulnerability of the feed and the onsite U/G lines to liq/lat spreading damage

During a seismic event, underground pipes are at risk of being damaged including the fire protection water lines that serve the facility. This applies to both water mains, which could be affected anywhere along its length upstream of this property, and the onsite lines connecting the fire hydrants. Liquefaction-induced lateral spreading may create stress on the underground pipes, potentially causing damage. If a pipe in the system breaks, the network would lose pressure and no longer be effective. Therefore, the water feed is vulnerable in a design seismic event.

5.1.3.2 Description of spill containment systems equipment, procedures

5.1.3.2.1 Assembled from SPCC plan

Kinder Morgan maintains a Spill Prevention, Control, and Countermeasure (SPCC) Plan for the Eugene facility, in accordance with 40 CFR 112. It describes personnel, training and spill prevention procedures; inspections and records; facility drainage; bulk storage containers and operational equipment; transfer operations, pumping and in-plant processes; truck loading/unloading; and security.

The facility has a secondary containment system for bulk oil and oil product storage containers to prevent oil from reaching navigable waters. All bulk storage tank installations are constructed so that a secondary means of containment is provided for the entire contents of the largest single container plus sufficient freeboard to allow for precipitation.

In the North Tank Farm, the north, east and south walls are asphalt-coated earth while the west wall is concrete filled block. The tank farm has a gravel and earth floor. Additive tanks (except EG-A4) within this tank farm have secondary containment consisting of concrete filled block walls and concrete floors.

The Terminal Manifold area is bounded north and south by the North and South Tank Farm berms and on the east and west by asphalt berms. The manifold area contains an equalizer/saturator tank ST-01 for the vapor combustion unit. The manifold area has a gravel and earth floor.

In the South Tank Farm, the north and east walls are asphalt-coated earth while the west wall is concrete filled block. The south and east walls surrounding Tanks EG-40, EG-41 and EG-42 are concrete filled blocks up to the point where the east wall joins the asphalt coated earth wall that form the remainder of the south wall of the tank farm. Additionally, Additive Tanks EG-A11 and EG-A12 have secondary containment consisting of concrete walls and floors.

Additive Tanks EG-A2 and EG-A3 located outside the tank farms have secondary containment consisting of epoxy coated concrete walls and floors. The red dye totes EG-BK50 A& B are equipped with individual metal pan containment.

Based on the soil data available for this Facility, containment areas are sufficiently impervious to contain a discharge from an aboveground facility with line-of-sight inspection capability (tanks, containers, piping, etc.) until clean up occurs.

In addition to the containment system, the facility has a strong tank integrity program which significantly increases the chances of detecting corrosion or anomalies in the tank shell before it becomes compromised. Discharges would be detected during daily visual inspections and while conducting normal operations. In the event of a discharge, recovery would commence expeditiously by using contracted vacuum trucks and excavation equipment.

The facility's spill prevention and secondary containment measures described above are adequate if an earthquake were to rupture the single largest tank in each containment area. In an extreme event where multiple tanks are ruptured simultaneously, the spill volume would exceed the containment capacity. However, it is not standard practice to design for this event and would require excessive infrastructure and space.

5.1.3.2.1.1 Mechanical-specific items

Containers are constructed of a material that is compatible with the oil and oil products stored and the conditions of storage (including pressure and temperature). Redundant high-level alarms automatically shut down pipeline transfer operations. Alarm condition is verified by the Operator prior to resuming transfer. Bulk storage container bottoms and associated buried appurtenances are cathodically protected.

The outside of all bulk storage containers and their associated supports and foundations are inspected during formal facility monthly inspections for signs of discharges or accumulation of oil inside secondary containment areas. Field-erected aboveground bulk containers are integrity tested on a regular schedule and when material repairs are made using API Standard 653 (Tanks 30,000 gallons and larger). Small shop-built containers, and those less than 30,000 gallons, may alternatively follow STI-SP001 testing standards set forth in STI-SP001.

All aboveground valves and pipes/pipelines are regularly examined during operating personnel rounds and formally monthly. During these examinations, operating personnel assess the general condition and necessity for corrective actions of items such as flange joints, valve glands and bodies, pipe supports, metal surfaces, expansion joints, catch pans, valve locks and other appurtenances. Periodic pressure testing may be warranted for piping in areas where facility drainage is such that a failure might lead to a spill event. Liquid level sensing devices on tanks are tested monthly to ensure proper operation.

The facility's buried piping installations are provided with corrosion protection. Buried piping installations are wrapped and coated to reduce corrosion. When a section of buried line is exposed for any reason, it is examined for deterioration. If corrosion damage is found, additional examination and corrective action will be taken as indicated by the magnitude of damage.

The mechanical-specific measures described above play a significant role to improve site safety and mitigate risk of damage during a seismic event.

5.1.3.3 Description of onsite emergency equipment, ops safety measures, personnel policies, and procedures

Kinder Morgan has placed fire extinguishers (including CO2, stored pressure, and dry chemical units) throughout the facility. Instructions for their use are printed on a label attached to the fire extinguisher. All are checked monthly and inspected annually.

The facility maintains notification and response procedures to be implemented immediately after discovering a discharge incident and securing the source. Oil-handling personnel must undergo minimum initial training including operation and maintenance of equipment, discharge procedure protocols, applicable oil spill prevention laws, rules, and regulation, general facility operations and the contents of the SPCC. Facility personnel maintain a high level of training and awareness on the Facility’s Integrated Contingency Plan and can implement this contingency plan in the event of an emergency.

Kinder Morgan maintains a Fire Prevention and Protection Plan for the Eugene Terminal. The purpose of the plan is to provide employees with a minimum standard for fire protection and prevention and incorporates Kinder Morgan’s policy on fire prevention, training and maintenance. The plan complies with the OSHA Fire Prevention Standard, Title 29 CFR 1910.39 and Cal-OSHA Title 8 Sec. 3221

The facility also maintains an evacuation plan in the event of an emergency. The diagram includes a primary emergency response command center, primary and secondary evacuation assembly areas, main exits, gates, and stairs/ladders.

With many procedures and policies in place, the Eugene terminal is adequately prepared to respond to any emergency, including an earthquake.

SECTION 6: APPENDICIES

6.1 Appendix A: Geotechnical Exhibits

Appendix A-1 Boring Logs

Appendix A-2 Laboratory Data

Appendix A-3 Historical Data

Appendix A-4 Calculations

Figure A-1 Vicinity Map

Figure A-2 Site Plan

GEOTECHNICAL BORINGS

On March 18 and 19, 2024, Western States Soil Conservation, Inc., subcontracted by Sage Geotechnical, LLC, advanced and sampled two sonic borings using a track-mounted Geoprobe 8150LS drill rig. In accordance with Kinder Morgan's safety requirements, vacuum excavation was used to clear the upper 9 to 9.5 feet (ft) of the borings.

Sage personnel coordinated and monitored the explorations, collected representative soil and rock samples, and maintained detailed logs of the subsurface soil and groundwater conditions observed. Each representative soil type was described using the soil classification system shown on Figure G-1-1, in general accordance with ASTM International standard D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).*

Disturbed soil samples were collected from the borings at 5-ft intervals using a 1.5-inch-inside-diameter standard penetration test split-spoon sampler or a 2.375-inch-inside-diameter Modified California sampler. A 140-pound automatic hammer, falling approximately 30 inches, was used to drive the sampler 18 inches (or a portion thereof) into the undisturbed soil. The number of blows required to drive the sampler the final 12 inches (or a portion thereof) of soil penetration is noted on the boring logs.

Where recoverable, continuous disturbed soil samples were obtained between the split-spoon samples using the sonic core barrel.

Upon completion of drilling and sampling, the boreholes were decommissioned in general accordance with the Oregon Administrative Rules.

Summary boring logs are presented on Figures G-1-2 and G-1-3. The stratigraphic contacts shown on the logs represent the approximate boundaries between soil and rock types; actual transitions may be more gradual. The soil conditions depicted are for the specific locations indicated and may not be representative of conditions at other locations.

Project: **Kinder Morgan Eugene Terminal SVA**	Key to Log of Boring
Project Location: **Eugene, Oregon**	**Sheet 1 of 1**
Project Number: **012006**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance, blows/ft	Material Type	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9

COLUMN DESCRIPTIONS

1 Elevation (feet): Elevation (MSL, feet).
2 Depth (feet): Depth in feet below the ground surface.
3 Sample Type: Type of soil sample collected at the depth interval shown.
4 Sample Number: Sample identification number.
5 Sampling Resistance, blows/ft: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
6 Material Type: Type of material encountered.
7 Graphic Log: Graphic depiction of the subsurface material encountered.
8 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
9 REMARKS AND OTHER TESTS: Comments and observations regarding drilling or sampling made by driller or field personnel.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity
COMP: Compaction test
CONS: One-dimensional consolidation test
LL: Liquid Limit, percent
PI: Plasticity Index, percent
SA: Sieve analysis (percent passing No. 200 Sieve)
UC: Unconfined compressive strength test, Qu, in ksf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

Silty GRAVEL (GM)
Poorly graded GRAVEL (GP)
Poorly graded GRAVEL with Silt (GP-GM)
Well graded GRAVEL (GW)
Well graded GRAVEL with Silt (GW-GM)
Silty SAND (SM)
Poorly graded SAND with Silt (SP-SM)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler
Bulk Sample
3-inch-OD California w/ brass rings
CME Sampler
Drill-stem core barrel
3.25" OD split spoon (Dames & Moore) w/o liners
Grab Sample
2.5-inch-OD Modified California w/ brass liners
Pitcher Sample
2-inch-OD unlined split spoon (SPT)
Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting, AW)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
? Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Figure G-1-1

Project: **Kinder Morgan Eugene Terminal SVA**	# Log of Boring B-1
Project Location: **Eugene, Oregon**	**Sheet 1 of 2**
Project Number: **012006**	

Date(s) Drilled **3/18/2024**	Logged By **LGL**	Checked By **DCS**
Drilling Method **Sonic**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **51.5 feet bgs**
Drill Rig Type **Geoprobe 8150LS**	Drilling Contractor **Western States Soil Conservation. Inc.**	Approximate Surface Elevation **Not Measured**
Groundwater Level and Date Measured **15.72**	Sampling Method(s) **Bulk, California, SPT**	Hammer Data **140# 30" drop auto hammer**
Borehole Backfill **Bentonite**	Location **44.094958, -123.157136**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance, blows/ft	Material Type	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0				SM		6 inches of crushed GRAVEL (dense, moist) **(FILL)**	
					GW-GM		Brown, sandy, fine to coarse GRAVEL with silt (medium dense, moist) **(FAN DEPOSITS)**	
	5						Grades to with cobbles	
			S-1				Vacuum truck excavation to 9 ft bgs	
	10		S-2	2 13 24 **(37)**				GS w = 12.3%
			S-3					
					SP-SM		Brownish-gray, fine to coarse SAND with gravel and silt (medium dense, moist)	
	15		S-4	7/13/13 **(26)**			15.72 ft bgs ∇	GS w = 20.9%
			S-5					
					GW		Brown, sandy, fine to coarse GRAVEL (medium dense, wet)	
			S-6					GS w = 5.7%
					SM		Brown, silty, gravelly, fine to coarse SAND (medium dense, wet)	
	20		S-7	5/15/21 **(36)**				-200 = 34.2% w = 20.5%
					GP-GM		Brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet)	
			S-8					
	25		S-9	18/33/41 **(74)**				
			S-10		GM		Dark brown, silty, sandy, fine to coarse GRAVEL (very dense, wet)	
	30							

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Figure G-1-2

Project: **Kinder Morgan Eugene Terminal SVA**	Log of Boring B-1
Project Location: **Eugene, Oregon**	**Sheet 2 of 2**
Project Number: **012006**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance, blows/ft	Material Type	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	30		S-11	25/80/77 **(157)**	GM		Dark brown, silty, sandy, fine to coarse GRAVEL (very dense, wet)	
					GP-GM		Dark brown, sandy, fine to coarse GRAVEL with silt (very dense, wet)	
			S-12					
	35		S-13	11/34/84 **(118)**				
					SM		Dark brown, silty, fine to coarse SAND (very dense, wet)	
					GM		Brown, silty, sandy, fine to coarse GRAVEL (very dense, wet)	
			S-14					
	40		S-15	9/18/36 **(54)**				
			S-16					
	45		S-17	28/90/57 **(147)**				
	50		S-18	20/29/26 **(54)**				
							Total depth = 51.5 ft bgs	
	55							
	60							
	65							

Figure G-1-2

Project: **Kinder Morgan Eugene Terminal SVA**	# Log of Boring B-2
Project Location: **Eugene, Oregon**	**Sheet 1 of 2**
Project Number: **012006**	

Date(s) Drilled **3/19/2024**	Logged By **LGL**	Checked By **DCS**
Drilling Method **Sonic**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **51.5 feet bgs**
Drill Rig Type **Geoprobe 8150LS**	Drilling Contractor **Western States**	Approximate Surface Elevation **Not Measured**
Groundwater Level and Date Measured **3.80**	Sampling Method(s) **Bulk, California, SPT**	Hammer Data **140# 30" drop auto hammer**
Borehole Backfill **Bentonite**	Location **44.093591, -123.155629**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance, blows/ft	Material Type	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0				SM		6 inches of crushed GRAVEL (dense, moist) **(FILL)**	
					GW		Brown, sandy, fine to coarse GRAVEL (medium dense, moist) **(FAN DEPOSITS)**	
							3.80 ft bgs ▽	
	5						Grades to wet	
	10		S-1	11 12 15 **(27)**			Vacuum truck excavation to 9.5 ft bgs	
			S-2					-200 = 1.8% w = 14.6%
			S-3					
	15		S-4	4/8/12 **(20)**			Grades to loose	GS w = 11.1%
					GP-GM		Brown, sandy, fine to coarse GRAVEL with silt (loose, wet)	
			S-5					GS w = 11.4%
	20		S-6	5/6/4 **(10)**				
					GP		Dark brown, sandy, fine to coarse GRAVEL (medium dense, wet)	
			S-7					
	25		S-8	17/17/14 **(30)**				-200 = 2.7% w = 13.0%
					GP-GM		Dark brown, sandy, fine to coarse GRAVEL with silt (medium dense, wet)	
			S-9					-200 = 9.4% w = 12.9%
	30							

Project: **Kinder Morgan Eugene Terminal SVA**	Log of Boring B-2
Project Location: **Eugene, Oregon**	**Sheet 2 of 2**
Project Number: **012006**	

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance, blows/ft	Material Type	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	30		S-10	11/38/27 **(65)**	SM		Brown, silty, gravelly, fine to coarse SAND (very dense, wet)	
			S-11					
	35		S-12	31/47/31 **(78)**			Grades to dense	
					GP-GM		Brown, sandy, fine to coarse GRAVEL with silt (dense, wet)	
			S-13					
	40		S-14	19/44 50/5" **(94/11")**			Grades to very dense	
			S-15					
	45		S-17	48/56/56 **(112)**	GM		Brown, silty, sandy, fine to coarse GRAVEL (dense, moist)	
	50		S-17	10/30/31 **(61)**			Grades to very dense	
							Total depth = 51.5 ft bgs	
	55							
	60							
	65							

C:\Users\DanielSimpson\Sage Geotechnical LLC\Sage Geotechnical - Documents\Projects\012 Norwest\006 Kinder Morgan SVA\T Analysis_Eugene\012006 boring logs.bg4[master 0 lab).tpl]

Figure G-1-3

LABORATORY TESTING

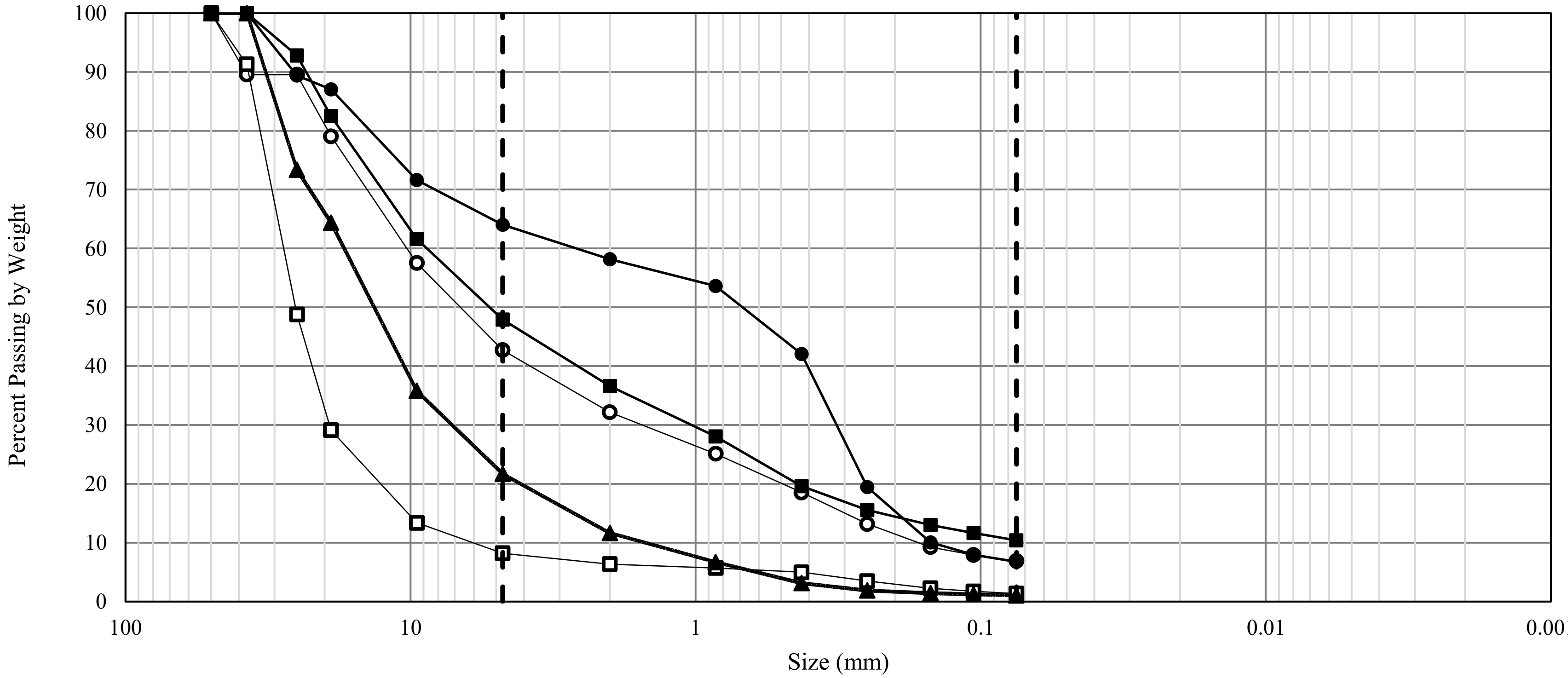
Soil samples collected from borings B-1 and B-2 were transported to Sage Geotechnical's laboratory for further examination and testing. Field log descriptions were checked against the samples and updated, where appropriate, in accordance with ASTM International (ASTM) standard D2487, *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*.

Moisture Content Determination

Natural moisture content determinations were performed on select soil samples in accordance with ASTM standard test method D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. The natural moisture content is shown as "W = xx" (i.e., percentage of dry weight) in the "Remarks and Other Tests" column on the boring logs in Appendix G-1.

Grain Size Analysis

Grain size analyses were performed on select soil samples in accordance with ASTM standard test method D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*. Samples selected for grain size analysis are designated with a "GS" in the "Remarks and Other Tests" column on the boring logs in Appendix G-1. The results of the grain size analyses are presented on Figure G-2-1.



	Depth	w	D90	D60	D30	D10	Cu	Cc	% G	% S	% F	USCS
	(ft)	(%)	(mm)	(mm)	(mm)	(mm)	-	-	(%)	(%)	(%)	-
B-1 S-2	10.0	12.3%	37.96	10.29	1.54	0.17	62.057	1.388	57.3	35.8	6.9	GW-GM
B-1 S-4	15.0	20.9%	25.60	2.63	0.32	0.15	17.523	0.261	36.0	57.3	6.7	SP-SM
B-1 S-6	18.0	5.7%	37.04	27.82	19.24	6.06	4.594	2.197	91.8	6.8	1.3	GW
B-2 S-4	15.0	11.1%	32.20	17.09	7.15	1.51	11.339	1.984	78.3	20.6	1.0	GW
B-2 S-5	18.0	11.4%	23.21	8.76	1.03	-	-	-	52.1	37.5	10.4	GP-GM

w = as-received moisture content
% G = percent gravel and larger
% S = percent sand
% F = percent fines
USCS = Unified Soil Classification System group symbol
To be well-graded: 1 < Cc < 3, Cu > 4 for GW, Cu > 6 for SW

SAGE GEOTECHNICAL

Grain Size Analysis Results
ASTM D6913/D7928

Kinder Morgan Eugene Terminal SVA

Eugene, Oregon | Figure G-2-1

Appendix G-3
Historical Data

GEOTECHNICAL ENGINEERING REPORT

KM Terminal Proposed Tank
1765 Prairie Road
Eugene, Oregon 97402
PSI Project No. 07041531

PREPARED FOR:

Energy Transfer
525 Fritztown Road
Sinking Springs, PA 19608

December 22, 2023

BY:

PROFESSIONAL SERVICE INDUSTRIES, INC.
6032 N. Cutter Circle, Suite 480
Portland, OR 97217
Phone: (503) 289–1778

Professional Services Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR, 97217
Office – (503) 289-1778

December 22, 2023

Energy Transfer
525 Fritztown Road
Sinking Springs, PA 19608

Attn: Mr. Andrew Strine, PMP
Project Manager
Andrew.Strine@energytransfer.com

Re: **Geotechnical Engineering Report**
KM Terminal Proposed Tank
1765 Prairie Road
Eugene, Oregon 97402
PSI Project No. 07041531

Professional Service Industries, Inc. (PSI), an Intertek company, is pleased to submit this geotechnical engineering report for the referenced project. This report includes the results from the field exploration and laboratory testing along with recommendations for use in preparation of the appropriate design and construction documents for this project.

PSI appreciates the opportunity to provide this geotechnical engineering report and looks forward to continuing participation during the design and construction phases of this project. PSI also has great interest in providing materials testing and inspection services during the construction of this project and will be glad to meet with you to further discuss how we can be of assistance as the project advances.

If there are questions pertaining to this report, or if PSI may be of further service, please contact us at your convenience.

Respectfully submitted,
Professional Services Industries, Inc.

REGISTERED PROFESSIONAL ENGINEER
103412PE
OREGON
JULY 11, 2023
TYLER KRISTOFOR BERNIUS
EXPIRES: 12/31/25
12/22/2023

Md Monsurul Huda
Staff Geotechnical Engineer
mdmonsurul.huda@intertek.com

Tyler K. Bernius, PE
Senior Engineer
tyler.bernius@intertek.com

Britton W. Gentry, PE, GE
Chief Engineer
britton.gentry@intertek.com

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1.0 PROJECT INFORMATION

1.1 PROJECT AUTHORIZATION

Professional Service Industries, Inc. (PSI), an Intertek company, has completed a field exploration and geotechnical evaluation for the Kinder Morgan Terminal Proposed Tank project. Mr. Andrew Strine, representing Energy Transfer, authorized PSI's services on November 6, 2023, by signing PSI Proposal No. 0704-372454.

1.2 PROJECT DESCRIPTION

Based on the information provided by Andy Strine of Energy Transfer in an email dated April 28, 2022, the proposed construction will consist of the installation of a horizontal pressure vessel, or tank, to hold a butane product. The tank is anticipated to be supported on two (2) pier foundations, but other foundations may be looked at depending on feasibility and room. Energy Transfer is unsure of which size vessel will be required at this time. The vessel will be either 60,000 gallons or 90,000 gallons. See below for loading information:

TABLE 1.1: ANTICIPATED TANK WEIGHTS

	APPROXIMATE WEIGHTS		
Vessel Size	**Weight – Empty**	**Weight – Full Butane**	**Weight – Full Water**
60,000 Gal	135,000 lb	400,000 lb	627,000 lb
90,000 Gal	155,000 lb	560,000 lb	906,000 lb

The geotechnical recommendations presented in this report are based on the available project information, structure locations, and the subsurface materials encountered during the field investigation. Should any of the above information or design basis made by PSI be inconsistent with the planned construction, it is requested that you contact us immediately to allow us to make any necessary modifications to this report. PSI will not be held responsible for changes to the project if not provided the opportunity to review the information and provide modifications to our recommendations.

2.0 SITE AND SUBSURFACE CONDITIONS

2.1 SITE DESCRIPTION

Currently the site consists of an approximate 1.75-acre parcel located northeast of the intersection of Prairie Road and Maxwell Road at the address referenced above. Based on an aerial view, the site consists of an open lot covered in rock or compacted soil.

2.2 SITE GEOLOGY

The near surface geology is mapped as Pleistocene and Holocene age Older Alluvium (Qoal). This alluvium consists predominately of sand, silt, and clay deposited by flooding of the Willamette and McKenzie Rivers. The alluvium can reach from a few meters to tens of meters thick.

2.3 TOPOGRAPHY

Based on available topographic mapping and Google Earth, the site appears to be generally flat with an elevation of approximately 390 feet above mean sea level.

2.4 FAULTING

According to USGS Quaternary Faults and Folds database, there is no active fault within 30 miles of the proposed site.

2.5 FIELD EXPLORATION AND LABORATORY TESTING PROGRAM

To evaluate soil conditions at the subject site, PSI advanced two geotechnical borings. The first five (5) feet of the borings were advanced using hand auger and then drilled with a track-mounted drill rig (Beretta T-26), using a hollow stem auger method. Both borings were advanced in the general area of the proposed structure to a depth of approximately 31½ feet below the ground surface (bgs). Locations of the soil borings, as well as the proposed improvements, are shown on Figure 2.

Sampling procedures were performed in general accordance with applicable ASTM methods (ASTM D1586, ASTM D1587, and/or ASTM D3550). Complete field exploration methodologies are presented in Appendix A. Samples were identified in the field, placed in sealed containers, and transported to the laboratory for further classification and testing. At the completion of drilling, the soil borings were backfilled with bentonite to match the ground surface.

The boring locations were selected by PSI personnel and located in the field using a recreational-grade GPS system. However, elevations of the ground surface at the boring locations were not provided and should be surveyed by others prior to construction. The references to elevations of various subsurface strata are based on depths below existing grade at the time of drilling. The approximate boring locations are depicted on the Boring Location Plan provided in the Figures.

PSI supplemented the field exploration with a laboratory testing program to determine additional engineering characteristics of the subsurface soils encountered. The laboratory testing program was conducted in general accordance with applicable ASTM Test Methods, and is included in Appendix A. Portions of samples not altered or consumed by laboratory testing will be discarded 30 days from the date shown on this report.

2.6 Subsurface Conditions

The results of the field and laboratory testing have been used to generalize a subsurface profile at the project site. The following subsurface descriptions provide a highlighted generalization of the major subsurface stratification features and material characteristics.

Table 2.1: Generalized Soil Profile

Stratum	Top (ft)	Bottom (ft)	Description
1	0	2½	Fill: LEAN CLAY with varying amounts of SAND and GRAVEL, moist.
2	2½	8½ to 13	LEAN CLAY with SAND to SANDY CLAY with SILT, moist, loose to medium dense. Varying amount of sand and fines content.
3	8½ to 13	31.5	SANDY GRAVEL with SILT (GP-GM), very moist to wet, medium dense to very dense.

The boring logs included in Appendix A should be reviewed for specific information at individual boring locations. The boring logs include soil descriptions, stratifications, locations of the samples, and field and laboratory test data. The descriptions provided on the logs only represent the conditions at that actual boring location; the stratifications represent the approximate boundaries between subsurface materials. The actual transitions between strata may be more gradual and less distinct. Variations will occur and should be expected across the site.

2.7 Groundwater Information

Water level measurements were performed during drilling and after completion of drilling. Specific information concerning groundwater is noted on each boring log presented in the Appendix of this report. Ground water was encountered between 10 to 12 feet bgs.

The groundwater levels presented in this report were measured at the time of PSI field activities. The contractor should determine the actual groundwater levels at the site before construction activities as groundwater depth can vary depending on time of year and amount of rainfall.

2.8 Seismic Design Parameters

We understand that the project is governed by the International Building Code (IBC), 2021 edition. The 2021 State Building Code takes effect on October 20, 2023, and all jurisdictions are required to enforce this code as the minimum standard. As part of this code, the design of structures must consider dynamic forces resulting from seismic events. These forces are dependent upon the magnitude of the earthquake event as well as the properties of the soil that underlie the site.

As part of the procedure to evaluate seismic forces, the code requires the evaluation of the Seismic Site Class, which categorizes the site based upon the characteristics of the subsurface profile within the upper 100 feet of the ground surface. Our borings extended to a depth of 31½ feet bgs, but to define the Site Class for this project, we have interpreted the results of soil test borings drilled within the project site and estimated appropriate soil properties below the base of the borings to a depth of 100 feet as permitted by the code. The estimated soil properties were based upon the soils encountered at the site, data available in published geologic reports, and our experience with subsurface conditions in the general site area.

Based upon our evaluation, the subsurface conditions at the site are consistent with the characteristics of a **Site Class "D"** as defined in Chapter 20.3.3 of the ASCE 7-16. The associated probabilistic ground acceleration values and site coefficients for the general site area were obtained from the USGS geohazards web page (https://seismicmaps.org/) using the **ASCE 7-16** option and are presented in the table below.

TABLE 2.2: SEISMIC DESIGN PARAMETERS

Period (sec)	Mapped MCE Spectral Response Acceleration (g)		Site Coefficients		Adjusted MCE_R Spectral Response Acceleration (g)		Design Spectral Response Acceleration (g)	
0.2	S_s	0.741	F_a	1.207	S_{Ms}	0.895	S_{Ds}	0.597
1.0	S_1	0.419	F_v	1.881	S_{M1}	0.789	S_{D1}	0.526

2% Probability of Exceedance in 50 years for Latitude, Longitude: 44.0919°, -123.1556°
MCE_R = Maximum Considered Earthquake
* See 11.4.7 in ASCE 7-16

The Site Coefficients referring to ASCE 7-16 Section 11.4.7 require the structural engineer to apply appropriate calculations as needed. Design of structures should comply with the requirements of the governing justification's building codes and standard practices of the Structural Engineering Association of Oregon.

In accordance with ASCE 7-16, Chapter 11, for a site with S_1>0.2, the Fa value is governed by Section 11.4.8. Section 11.4.8 requires a ground motion hazard analysis be performed for structures on all sites having S_1>0.2. Section 11.4.8 includes an exception where ground motion hazard analyses is not required for structures on Site Class D sites with S_1 greater than or equal to 0.2, provided the value of the seismic response coefficient C_s is determined by Eq. (12.8-2) of ASCE 7-16 for values of $T \leq 1.5T$ and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for $T_L \geq T > 1.5T$ or Eq. (12.8-4) for $T > T_L$. This report assumes that this exception can be applied to this project.

3.0 GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

3.1 GEOTECHNICAL DISCUSSION

The primary geotechnical consideration at this site for drilled pier construction is relatively shallow ground water (approximately 10 feet below existing ground surface) encountered at both the boring locations (B1, and B2) and risk of caving soils. Drilled Pier capacity is calculated without including the top 2 feet of the existing subsurface. If shallow foundations are used there is approximately 2-3 feet of undocumented fill on the site that should be removed replaced with structural fill. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

The following geotechnical design recommendations have been developed based on the previously described project characteristics and subsurface conditions encountered. The proposed construction should be performed in accordance with these recommendations and the applicable building code, and local governmental standards which have jurisdiction over this project. If there are changes in the project criteria, PSI should be retained to determine if modifications in the recommendations will be required. The findings of such a review would be presented in a supplemental report. Once final design plans and specifications are available, a general review by PSI is recommended to confirm that the conditions anticipated in preparing this geotechnical report are consistent with the earthwork and foundation recommendations contained within the construction documents.

3.2 SITE PREPARATION (IF NEEDED)

The proposed area of the proposed tank should be stripped and grubbed of any construction debris, trash, vegetation, organic laden materials, and existing gravel bed in conflict with the proposed construction a minimum of 5 feet outside the structural limits. Depressions or low areas resulting from stripping and grubbing should be backfilled with approved soil and compacted in accordance with the recommendations presented in this report.

During and following stripping and excavation, the contractor must use care to protect the subgrade from disturbance by construction traffic. The use of trackhoes equipped with smooth-edged buckets in lieu of scrapers for excavation tends to minimize the potential of subgrade disturbance. Also, the contractor should plan the earthwork operations such that heavy construction traffic is not permitted on the exposed fine-grained subgrade. Placement of structural fill concurrently with excavation is appropriate for this purpose. Exposed soils should be periodically evaluated by a geotechnical engineer during earthwork to detect any loose, soft, or disturbed areas that will require over excavation and replacement with structural fill.

3.3 EARTHWORK

3.3.1 PROOF ROLLING

Following site preparation and over-excavation, the newly exposed subgrades in site improvement areas intended for structures must be approved by the geotechnical engineer prior to fill placement. These exposed subgrades should be proof rolled with a loaded tandem axle dump truck or similar piece of rubber-tired equipment (20 tons or greater) in the presence of the geotechnical engineer's representative. The purpose of the proof rolling is to detect the existence of marginal or loose near-surface materials or unsuitable soils that may require undercutting. Areas which deflect, rut or pump excessively during proof rolling, and which cannot de densified in-place, should be undercut to suitable soils and backfilled and/or as directed by the geotechnical engineer. Proof rolling should not be performed on saturated, frozen or during wet weather conditions.

3.3.2 Structural Fill

3.3.2.1 General

All fill within the proposed construction areas should be placed as compacted structural fill. All structural fill materials should be compacted per table below. Coarse granular fill should be compacted until well keyed. No brush, roots, construction debris, or other deleterious material should be placed within the structural fills. The earthwork contractor's compactive effort should be evaluated on the basis of field observations, and lift thicknesses should be adjusted accordingly to meet compaction requirements. Additional information regarding specific types of fill is provided below

Table 3.1: Compaction Criteria and Testing Frequency

Material Type	Density Test Method	Minimum Compaction (%)	Moisture Content Range (ref. to optimum moisture content)		Testing Frequency (min. 3 per lift)
			Minimum	Maximum	
Engineered Fill (coarse-grained/ Base Rock)	ASTM D 1557	95	-3%	+3%	1 per 2,500 sf

3.3.2.2 Granular Fill

Imported granular fill materials should consist of sand, gravel, or fragmental rock with a maximum size on the order of 4 inches and with not more than about 5% passing the No. 200 sieve (washed analysis). Material satisfying these requirements can usually be placed during periods of wet weather. The first lift of granular fill placed over a fine-grained subgrade should be about 18 in. thick and subsequent lifts about 12 inches thick when using medium- to heavy-weight vibratory rollers. Granular structural fill should be limited to a maximum size of about 1 ½ inches when compacted with hand-operated equipment. We also recommend that lift thicknesses be limited to less than 8 inches when using hand-operated vibratory plate compactors.

3.3.3 Excavations

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better ensure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

We are providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or other parties' compliance with local, state, and federal safety or other regulations.

3.3.4 SLOPES

Any permanent cut or fill slopes should not exceed 4 Horizontal to 1 Vertical (4H:1V). Excavations extending below a 1H:1V plane extending down from any adjacent footings should be shored for safety. All excavations should be inspected by a representative of the geotechnical engineer during construction to allow any modifications to be made due to variation in the soil types. All work should be performed in accordance with Department of Labor Occupational Safety and Health Administration (OSHA) guidelines as described in the previous section.

3.3.5 UTILITIES

Utility trenches may be backfilled with imported soil above the pipe zone. Trench backfill should be moisture conditioned to within 0 to 4 percent above the optimum moisture content, compacted in 6- to 8-inch lifts to a minimum of 90 percent of the maximum dry density as determined by the modified Proctor (ASTM D1557). In pavement areas, the top 12-inches of soil subgrade should reach a minimum of 95 percent of this Proctor. If rocks larger than 3-inches in maximum size are encountered, they should be removed from the backfill material prior to placement in the utility trenches. Pipe zone backfill requirements should be in conformance with the requirements of the local agencies having jurisdiction but should consist of clean granular sand material having a sand equivalent equal to or above 30. Jetting or flooding of utility backfill is not recommended. If smaller compaction equipment such as jumping jacks or plate compactors are used, thinner lifts will be required to achieve compaction. Where utilities cross building perimeters, concrete or concrete slurry should be used for backfilling around the utility to prevent moisture from migrating along the utility trench and entering the building envelope.

3.4 FOUNDATIONS

According to the initial estimate of the client, the structural loads of the proposed development are anticipated to be supported on deep foundations constructed in accordance with the following design criteria. PSI has included shallow foundation recommendations if a different route is taken or for ancillary equipment in the vicinity.

3.4.1 SHALLOW FOUNDATIONS

Shallow foundations should be found a minimum of 24 inches of Structural Fill. They can be designed for a maximum net allowable soil bearing pressure of 2,500 pounds per square foot (psf) and a modulus of subgrade reaction (k) of 150 pounds per cubic inch (pci) if foundations are bearing on 2 feet of structural fill that is properly moisture conditioned and compacted. Minimum widths of 24 inches for column footings and 18 inches for continuous footings should be used in foundation design to reduce the possibility of a local bearing capacity failure. The above recommended allowable soil bearing pressure may be increased by one third (⅓) for short term wind and/or seismic loads.

If unsuitable soils are encountered at footing excavation bottoms, the unsuitable material should be over excavated to suitable subgrade material and replaced with granular structural fill. The total width of the over excavation area beneath the design footing elevation should increase by 1 foot for each foot of over-excavation. The over excavated areas should be backfilled with Engineered Fill or ABC and compacted in accordance with the Fill Materials section of this report. Alternatively, upon approval by the geotechnical engineer, the foundation bearing surface could be lowered to the suitable subgrade material or backfilled with lean concrete.

Based on the assumed loads and the recommended site preparation, we estimate that post-construction total settlement will be less than 1 inch. Differential settlement is estimated to be less than ½ inch over a 40-foot span. These magnitudes of estimated settlements are assumed to be within tolerable limits but should be confirmed by the project architect and structural engineer.

We recommend the use of a smooth-edged excavator to make the footing excavations. The foundation excavations should be observed by a representative of PSI prior to steel or concrete placement to assess that the foundation materials can support the design loads and are consistent with the materials and recommendations discussed in this report.

The base frictional resistance and the passive soil resistance will counteract the horizontal loads on shallow foundations. Footings cast against natural competent soil or compacted soil may be designed using a frictional coefficient between the concrete and soil of 0.35. An ultimate equivalent fluid pressure of 300 pounds per cubic foot (pcf) may be used to compute the ultimate passive resistance. Passive resistance within the upper 2 feet of soil should be neglected if the footings are placed using form boards. If the footings are cast against competent natural soils or properly compacted fill soils and the soils above the footings are paved or consist of concrete floor slabs, the passive resistance within the upper 2 feet can be taken into account. The passive resistance of any un-compacted fill material or loose natural soils should be neglected. It is recommended that the overturning moments on the foundations be resisted by the weight of the foundation system. A minimum factor of safety of 2 should be used for sliding resistance.

The uplift resistance of a shallow foundation formed in an open excavation will be limited to the weight of the foundation concrete and the soil above it and any sustained dead load. The ultimate uplift resistance may be based on unit weights of 110 pounds per cubic foot (pcf) for soil and 150 pcf for concrete. This value should then be reduced by an appropriate factor of safety to arrive at the allowable uplift load. If there is a chance of submergence, the buoyant unit weights should be used.

After opening, footing excavations should be observed, and concrete should be placed as quickly as possible to avoid exposure of the excavations to wetting and drying and freezing soils in the winter. Surface run-off water should be drained away from the excavations and not be allowed to pond within 20 feet of the open excavation during or after construction. When possible, the foundation concrete should be placed during the same day the foundation excavation is made. If it is required that footing excavations be left open for more than one day, they should be protected to reduce moisture loss or gain.

PSI should be consulted during the design of the foundation pad to verify that the appropriate parameters are utilized. PSI should provide periodic observation during construction of the foundation pad to verify that the design parameters and the soil materials used during construction correspond.

3.4.2 DEEP FOUNDATIONS

3.4.3 DRILLED PIER RECOMMENDATIONS

Drilled shafts are planned for the support of the tank. The axial load carrying capacity of a drilled shaft can be computed using the static method of analysis. According to this method, axial capacity, Q, at a given penetration is taken as the sum of the skin friction on the side of the shaft, Q_{sf}, and the end bearing at the shaft tip, Q_{eb}, so that:

$$Q = Q_{sf} + Q_{eb} = f \cdot A_{sf} + q \cdot A_{eb}$$

where A_{sf} and A_{eb} represent, respectively, the embedded surface area and the end area of the shaft; f and q_{eb} represent, respectively, the unit skin friction and the unit end bearing.

The total allowable axial capacity in compression will be the summation of the allowable frictional capacity and the allowable end bearing capacity. The total allowable axial capacity in tension will be the allowable frictional capacity alone neglecting end bearing component, plus the weight of the pier.

3.4.3.1 STRAIGHT SHAFT DRILLED PIERS

PSI recommends that the proposed tank be supported on deep straight shaft drilled piers to minimize the potential for undesirable settlement and to reduce potential foundation movements as the structure support will be based below the seasonal active zone. The following tables outline the requirements for drilled shaft design and construction considerations for support of these structures.

TABLE 3.2: PARAMETERS FOR AXIAL DESIGN

Material	Depth, feet	Allowable Skin Friction, f, psf (F.S. = 2)	Allowable End Bearing, q, psf (F.S. = 3)
Clayey Sand (Undocumented Fill)	0 to 2	—	—
Clayey Sand (Undocumented Fill)	2 to 5	250	—
Silty Sand	5 to 10	620	—
Sandy Gravel	10 to 20	1600	48000
Sandy Gravel	20 to 30	1900	60000

Notes: Detailed Settlement Analysis is outside project scope

The minimum embedment depth was selected to locate the pier base below the depth of seasonal moisture change and within a specified desired stratum. Actual pier depths may need to be deeper depending upon the actual compressive loads on the pier.

Where pier groups may be required, the spacing should be a minimum of three times the selected diameter center-to-center. Drilled shaft elements with center-to-center spacing less than 10 feet should not be installed within 24 hours following placement of adjacent elements.

An isolated single drilled shaft having a diameter of less than 84 inches when designed as discussed, is not anticipated to settle greater than approximately ½ inch. A detailed group settlement analysis was not performed, as the actual configurations are not known at this time. If a group settlement analysis is desired, PSI should be contacted to perform such a settlement analysis. As stated previously PSI has not been provided loading information. The settlement estimate is based on the capacity of a single drilled shaft pier supporting approximately 500 kips. The settlement should be considered an estimate and a more refined analysis should be made based on actual loading conditions.

3.4.3.2 GENERAL PIER CONSTRUCTION RECOMMENDATIONS

The performance of the foundation system is highly dependent on the quality of the installation. PSI recommends the installation procedure in accordance with FHWA-NHI-10-016, May 2010.

PSI recommends that the drilling contractor review the field exploration logs of this report before starting excavations for the drilled piers. The contractor shall realize that groundwater may be encountered and that drilled pier sidewalls are susceptible to sloughing even if groundwater is not encountered. If temporary casing is used during concrete placement, keep a concrete head of at least 2 feet above the bottom of the casing as it is being removed. Permanent casing may be used if approved by structural engineer. A representative of the Geotechnical Engineer should be on site to observe and document the entire drilling and installation of the deep foundation system, if used.

When the drilling processes are completed for the pier, the reinforcing steel and the concrete should be placed immediately after the final cleanout pass is conducted on the base. The tremie method of concrete placement should be adopted when placing concrete below the groundwater table (if present at design pier depth) to prevent segregation of the concrete materials. If concrete is placed by the free-fall method into a dry excavation, it should be placed to avoid contact with the excavation sidewalls to prevent segregation and be limited to a drop of less than 20 feet. If groundwater is encountered, then contractor may need to use the "slurry method" (even with temporary casing) in order to keep the hole stable for the entire depth of the shaft.

Concrete placed in the pier excavations should have a slump in the range of 7 to 9 inches to reduce the potential for the formation of voids as the temporary pier casing is extracted. The concrete mix should be designed to attain the required 28-day design strength when placed at this slump. PSI should be retained to observe and document the drilled pier construction and to evaluate whether the subsurface and pier bearing conditions are as anticipated in this report. The contractor should submit their procedures for drilled pier installation to the Geotechnical Engineer for approval prior to the start of the drilled pier construction.

3.5 DRAINAGE CONSIDERATIONS

Site grading should be carefully planned to promote positive drainage away from structures and to divert surface water away from or into stormwater systems. Water should not be allowed to collect near the structures either during or after construction.

Pavement surfaces and open space areas should be sloped such that surface water runoff is collected and routed to suitable discharge points. We also recommend that ground surfaces adjacent to buildings be sloped to facilitate positive drainage away from the buildings.

A positive slope gradient of 2 percent down and away from the building perimeter should be applied to the finished subgrade (inclusive of topsoil). This slope should extend no less than 5 feet away from the outside building perimeter, with drainage swales provided to remove runoff from around the structure. Any utility trench that enters the perimeter of a structures should be excavated with a slight slope down and away from the perimeter of the structure.

3.5.1 MOISTURE SENSITIVE SOILS / WEATHER RELATED CONCERNS

The soils encountered at this site are expected to be sensitive to disturbances caused by construction traffic and changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils which become wet may be slow to dry and thus potentially making difficult for drilled pier equipment and cranes to easily access the site.

If grading occurs in a period of increased rainfall, unstable subgrade conditions may be present. These conditions may require stabilizing the subgrade with admixtures, such as cement kiln dust or a coarse aggregate. Isolated areas may be stabilized using a separation fabric with one foot compacted aggregate base over the geogrid. Additional recommendations can be provided, as required, during construction.

3.5.2 Design Measures to Reduce Changes in Soil Moisture

Final grading should be designed to provide positive drainage away from the structure. Soil areas within 10-feet of the structure should slope at a minimum of 5 percent away from the building, if possible.

Landscaped or planted areas should not be placed within 10 feet of the footings of the proposed structures. Where concrete flat work such as sidewalks are placed next to the structure, concrete should be placed adjacent to the foundation to prevent a planter strip that would trap surface water between the foundation and the sidewalk. For vegetation planted near the buildings, plants that require very little moisture should be used.

3.6 Plan Review and Construction Observation

After final plans and specifications are complete, PSI should review the final design and specifications so that the earthwork and foundation recommendations are properly interpreted and implemented. It is considered imperative that the Geotechnical Engineer and/or their representative be present during earthwork operations and foundation installations to observe the field conditions with respect to the design documents and specifications. PSI will not be responsible for changes in the project design or project information it was not provided, or interpretations and field quality control observations made by others. PSI would be pleased to provide these services for this project.

4.0 GEOTECHNICAL RISK AND REPORT LIMITATIONS

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed structure will perform as planned. The engineering recommendations presented in the preceding sections constitute PSI's professional estimate of those measures that are necessary for the proposed structure to perform according to the proposed design based on the information generated and referenced during this evaluation, and PSI's experience in working with these conditions.

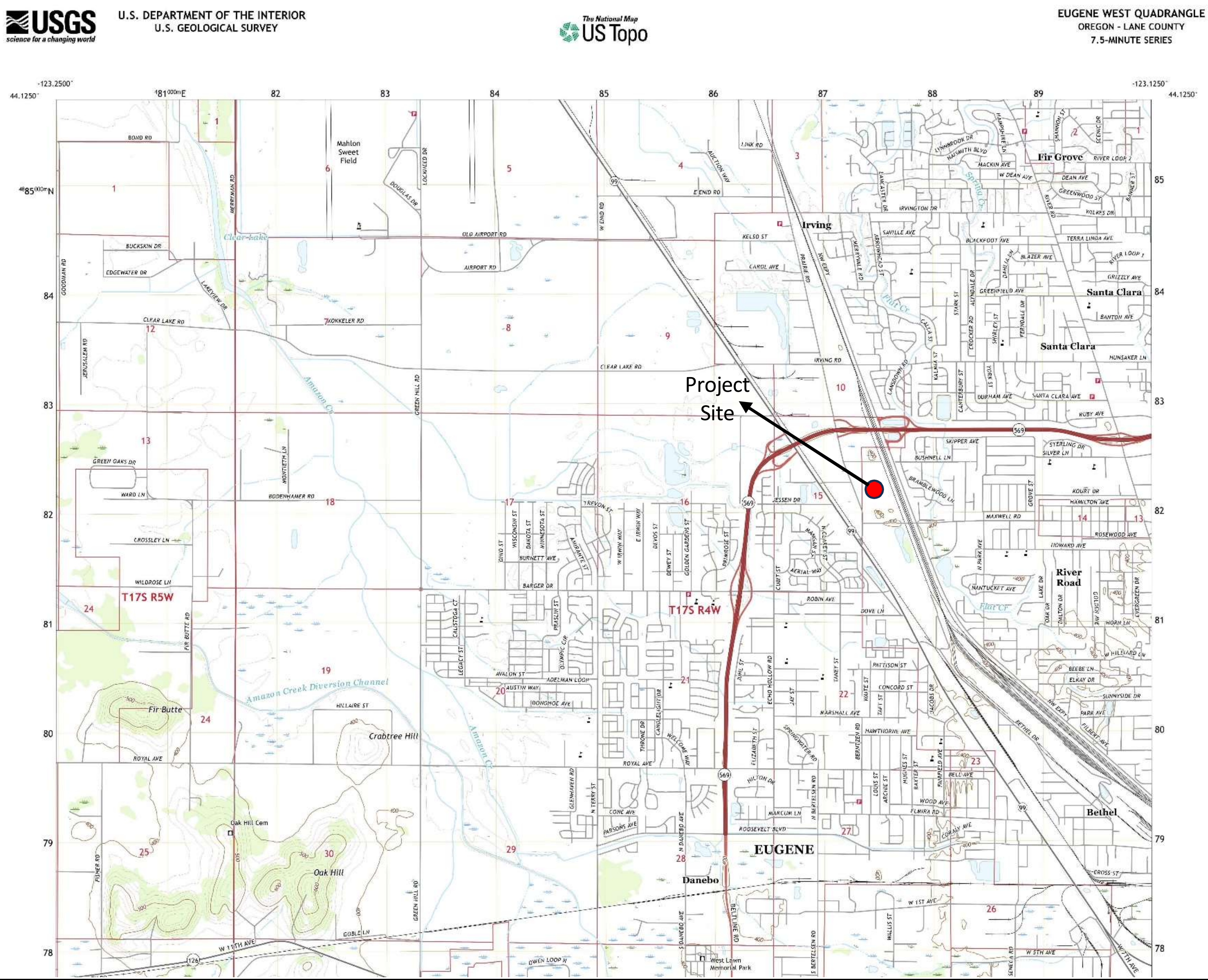
Services performed by PSI for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this area. No warranty, expressed or implied, is made.

The recommendations submitted are based on the available subsurface information obtained by PSI, and information provided by the client, client's representative and client's design consultants. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation and/or other recommendations are required. If PSI is not retained to perform these functions, PSI cannot be responsible for the impact of those conditions on the performance of the project.

The Geotechnical Engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations.

This report has been prepared for the exclusive use of Client and their design consultants, for the aforementioned project parameters.

FIGURES



Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97217
Phone: (503) 289–1778

Site Vicinity Map

PSI Project No. 07041531

KM Terminal Proposed Tank

1765 Prairie Road
Eugene, OR 97402

Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97217
Phone: (503) 289–1778

BORING LOCATION PLAN

PSI Project No. 07041531

KM Terminal Proposed Tank

1765 Prairie Road
Eugene, OR 97402

APPENDIX A

Field Exploration & Laboratory Testing Program

FIELD EXPLORATION PROGRAM

PSI explored subsurface conditions on November 28, 2023. The field exploration consisted of advancing two hollow stem borings in the footprint of the proposed tank.

Approximate exploration locations are shown on Figure 2, Boring Location Map. PSI notified the Oregon Utility Notification Center to indicate the approximate location of underground utilities in the vicinity of the proposed exploration locations prior to commencing field activities.

A representative from PSI's office observed the drilling and prepared borings logs of the conditions encountered. During field activities, the encountered subsurface conditions were observed, logged, and visually classified (in general accordance with ASTM D2488/D2487). Field notes were maintained to summarize soil types and descriptions, water levels, changes in subsurface conditions, and drilling conditions.

It should be noted that the subsurface conditions presented on the boring logs are representative of the conditions at the specific locations drilled. Variations may occur and should be expected across the site. The soil morphology represents the approximate boundary between subsurface materials and the transitions may be gradual and indistinct.

Boring Location Selection and Staking

The boring plan was proposed by PSI in the Excavation plan and approved by Energy Transfer and Kinder Morgan through the excavation plan on November 21, 2023 prior to drilling. The approved boring plan was superimposed onto Google Earth™ Imagery and the latitude and longitude were recorded. The approximate elevation of the boring locations were recorded with a recreational grade hand-held GPS. The location of the borings in the field were established by hand-held GPS using the coordinates from Google Earth™. The latitude, longitude and elevation are noted on each boring log with the perceived accuracy unknown. If accurate locations and elevations are needed, PSI recommends the client/owner have boring locations and elevations determined by survey methods.

Hollow Stem Borings

The two Hollow Stem borings were advanced using a Beretta T-26 track-mounted drill rig owned and operated by PLI Systems, Inc. located out of Hillsboro Oregon. Soil samples were recovered at selected depths during drilling using a Split Spoon Sampler driven by a 140-lb weight free falling 30 inches. A standard split spoon sampler with an outside diameter of 2.0 inches and inside diameter of 1.42 inches was used in general conformance with the ASTM D3350 Test Method. The number of blows required to drive the sampler 12 inches is designated as the penetration resistance (N-value, blows per foot) and provides an indication of the consistency of cohesive soils and the relative density of granular materials.

Field Classification

Soil samples were initially classified visually in the field. Consistency, color, relative moisture, degree of plasticity, and other distinguishing characteristics of the soil samples were noted. The terminology used in the soil classifications and other modifiers are depicted in the General Notes and Soil Classification Chart.

BORING B01

DATE STARTED:	11/28/23	**DRILL COMPANY:**	PLI Systems, Inc.
DATE COMPLETED:	11/28/23	**DRILLER:** Armando	**LOGGED BY:** MMH
COMPLETION DEPTH	31.5 ft	**DRILL RIG:**	Beretta T26
BENCHMARK:	N/A	**DRILLING METHOD:**	Hollow Stem Auger
ELEVATION:	378 ft	**SAMPLING METHOD:**	SS
LATITUDE:	44.0922°	**HAMMER TYPE:**	Automatic
LONGITUDE:	-123.1557°	**EFFICIENCY**	80%
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	TKB
REMARKS:			

Water

▽ While Drilling	12	feet
▼ Upon Completion	10	feet
Delay	N/A	

BORING LOCATION:
See Figure 2

Elevation (feet)	Depth, (feet)	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
378	0		1		**FILL (LEAN CLAY with SAND and GRAVEL)**: brown, moist, top 2 to 3 inches of gravel surface, subrounded to rounded gravel.	FILL		20	LL = 35 PL = 22 Fines=48.9%
			2		**CLAYEY SAND**: reddish brown, moist, loose to medium dense.			20	
375	5	SS	3	18		SC	2-3-4 N=7	26	Fines=47.5%
370		SS	4	14	**SANDY GRAVEL with SILT**: brown to gray, moist to wet, medium dense to very dense, subrounded to subangular.		2-6-7 N=13	14	
	10	SS	5	11			9-10-12 N=22	13	Fines=9.8%
365	15	SS	6	8			6-11-16 N=27	13	Fines=7.4%
360	20	SS	7	8		GP	26-50/5	14	
355	25	SS	8	12			9-20-50 N=70	11	Fines=9.8%
350	30	SS	9	7	-- Heaving at 30 feet.		20-15-43 N=58	13	
					-- Drilling Terminated at 31.5 feet depth				

STANDARD PENETRATION TEST DATA
N in blows/ft ◎
× Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✳ Qp
0 2.0 4.0

Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97219
Telephone: (503) 289-1778

PROJECT NO.: 07041531
PROJECT: Kinder Morgan Terminal
LOCATION: 1765 Prairie Road
Eugene
Oregon 97402

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B02

DATE STARTED:	11/28/23	**DRILL COMPANY:**	PLI Systems, Inc.
DATE COMPLETED:	11/28/23	**DRILLER:** Armando	**LOGGED BY:** MMH
COMPLETION DEPTH	31.5 ft	**DRILL RIG:**	Beretta T26
BENCHMARK:	N/A	**DRILLING METHOD:**	Hollow Stem Auger
ELEVATION:	378 ft	**SAMPLING METHOD:**	SS
LATITUDE:	44.0919°	**HAMMER TYPE:**	Automatic
LONGITUDE:	-123.1557°	**EFFICIENCY**	80%
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	TKB
REMARKS:			

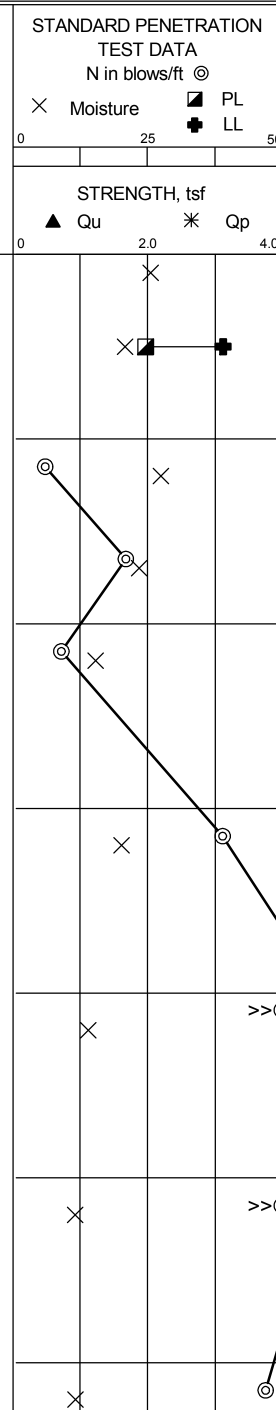
Water

∇	While Drilling	13 feet
▼	Upon Completion	10 feet
∇	Delay	N/A

BORING LOCATION:
See Figure 2

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
378	0	1		**FILL (LEAN CLAY with varying amounts of SAND and GRAVEL)**: brown, moist, top 2 to 3 inches of gravel surface, subrounded to rounded gravel.	FILL		26	
375		2		**Sandy LEAN CLAY**: reddish brown, moist, medium stiff, some gravel.	CL		21	LL = 39 PL = 25 Fines=68.5%
	5	3	12			3-3-3 N=6	28	
370		4	14	**SAND with SILT**: gray, moist, medium dense to loose. No gravel.	SP-SM	3-4-17 N=21	23	Fines=18.7%
	10	5	15	-- trace silt		3-4-5 N=9	15	Fines=10.1%
365				**SANDY GRAVEL with SILT**: gray, wet, dense to very dense, subrounded to subangular.	GP			
	15	6	4			19-19-20 N=39	20	
360	20	7	11			30-50/5	14	
355	25	8	18			24-27-30 N=57	12	
350	30	9	18	-- Heaving at 30 feet.		5-16-31 N=47	12	Fines=7.5%
				-- Drilling Terminated at 31.5 feet depth.				

STANDARD PENETRATION TEST DATA



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PROJECT NO.:	07041531
PROJECT:	Kinder Morgan Terminal
LOCATION:	1765 Prairie Road Eugene Oregon 97402

The stratification lines represent approximate boundaries. The transition may be gradual.

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

- SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
- HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
- M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
- R.C.: Diamond Bit Core Sampler
- H.A.: Hand Auger
- P.A.: Power Auger - Handheld motorized auger

- SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
- ST: Shelby Tube - 3" O.D., except where noted.
- RC: Rock Core
- TC: Texas Cone
- BS: Bulk Sample
- PM: Pressuremeter
- CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

- N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
- N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
- Q_u: Unconfined compressive strength, TSF
- Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
- w%: Moisture/water content, %
- LL: Liquid Limit, %
- PL: Plastic Limit, %
- PI: Plasticity Index = (LL-PL),%
- DD: Dry unit weight, pcf
- ▼, ▽, ▼: Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LABORATORY TESTING PROGRAM AND PROCEDURES

Soil samples obtained during the field explorations were examined in our laboratory. The physical characteristics of the samples were noted, and the field classifications were modified, where necessary. Representative samples were selected during the course of the examination for further testing.

- **Moisture Content**

Natural moisture content determinations were made on selected soil samples in general accordance with ASTM D2216. The natural moisture content is defined as the ratio of the weight of water to the dry weight of soil, expressed as a percentage. Results are shown on the exploration logs.

- **Visual-Manual Classification**

The soil samples were classified in general accordance with guidelines presented in ASTM D2487. Certain terminology incorporating current local engineering practice, as provided in the Soil Classification Chart, is included with, or in lieu of, ASTM terminology. The term which best described the major portion of the sample was used in determining the soil type (i.e., gravel, sand, silt or clay). Results are shown on the exploration logs.

- **Sieve Analysis**

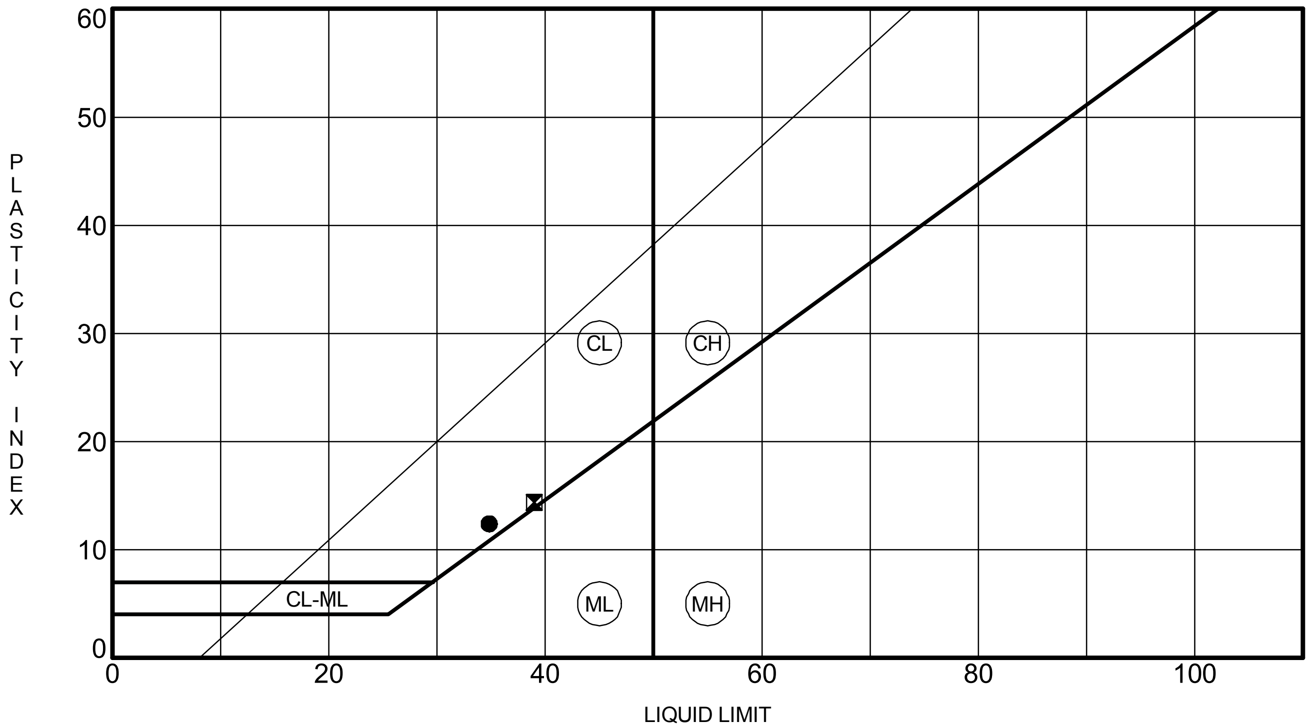
The determination of the amount of material finer than the U.S. Standard No. 200 (75-µm) sieve was made on selected soil sample in general accordance with ASTM D1140. In general, the sample was dried in an oven and then washed with water over the No. 200 sieve. The mass retained on the No. 200 sieve was dried in an oven, and the dry weight recorded. Results from this test procedure assist in determining the fraction, by weight, of coarse-grained and fine-grained soils in the sample. Results are shown on the exploration logs.
The determination of the gradation curve of the coarse-grained material was made on selected soil samples in general accordance with ASTM D6913. In general, the oven dried mass retained on the No. 200 sieve is passed over progressively smaller sieve openings, by agitating the sieves by hand or by a mechanical apparatus. The mass retained on each sieve is recorded as a fraction of the total sample, including the percent passing the No. 200 sieve. Results are shown on the Grain Size Analyses below.

- **Atterberg Limits**

The Atterberg Limits are defined by the liquid limit (LL) and plastic limit (PL) states of a given soil. These tests are performed in general accordance with ASTM D4318. These limits are used to determine the moisture content limits where the soil characteristics change from behaving more like a fluid on the liquid limit end to where the soil behaves more like individual soil particles on the plastic limit end. The plasticity index (PI) is the difference between the liquid limit and the plastic limit. The plasticity index is used in conjunction with the liquid limit to assess if the material will behave like a silt or clay.

- **Fines Content**

Fines content testing is performed in general accordance with guidelines presented in ASTM D1140, Standard Test Methods for Determining the Amount of Material Finer than 75-μm (No. 200) Sieve in Soils by Washing. The fines content is the fraction of soil that passes the U.S. Standard Number 200 Sieve. This sieve differentiates fines (silt and clay) from fine sand. Soil material that remains on the 200 sieve is sand. Material that passes the sieve is fines. The test is used to refine soil type



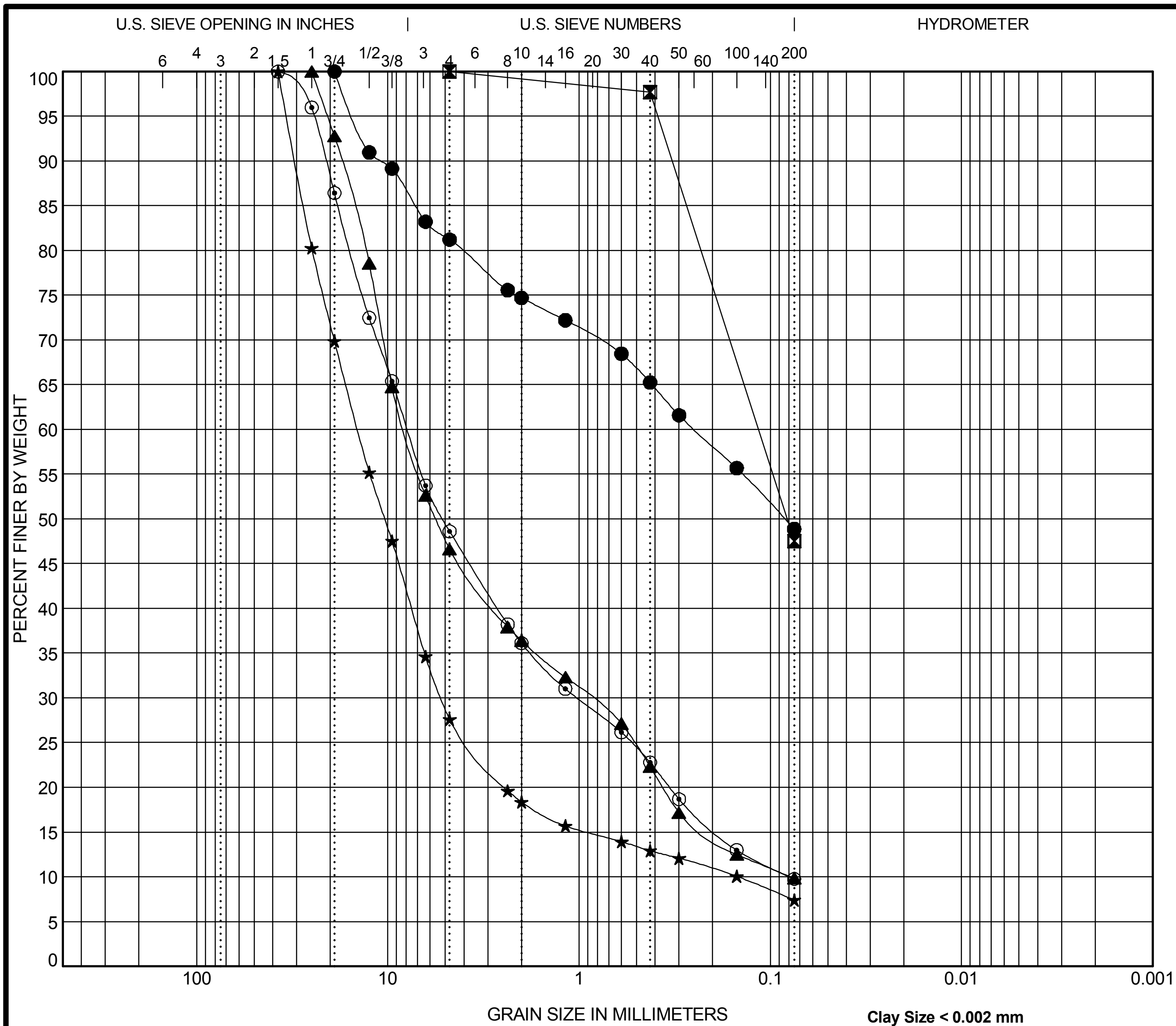
	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B01**	**0.5**	**35**	**22**	**13**	**48.9**	Lean Clay
⊠	**B02**	**2.5**	**39**	**25**	**14**	**68.5**	Lean Clay

intertek psi

Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97219
Telephone: (503) 289-1778
Fax: (503) 289-1918

ATTERBERG LIMIT RESULTS

PSI Job No.: 07041531
Project: Kinder Morgan Terminal
Location: 1765 Prairie Road
Eugene



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● B01	0.5		35	22	13		
⊠ B01	5.0						
▲ B01	10.0					1.21	103.74
★ B01	15.0					12.97	96.84
⊙ B01	25.0					1.69	99.78

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B01	0.5	19	0.249			18.8	32.3	48.9	
⊠ B01	5.0	4.75	0.115			0.0	52.5	47.5	
▲ B01	10.0	25	8.115	0.875	0.078	53.4	36.8	9.8	
★ B01	15.0	37.5	14.337	5.247	0.148	72.4	20.2	7.4	
⊙ B01	25.0	37.5	7.889	1.026	0.079	51.4	38.8	9.8	

Professional Service Industries, Inc.
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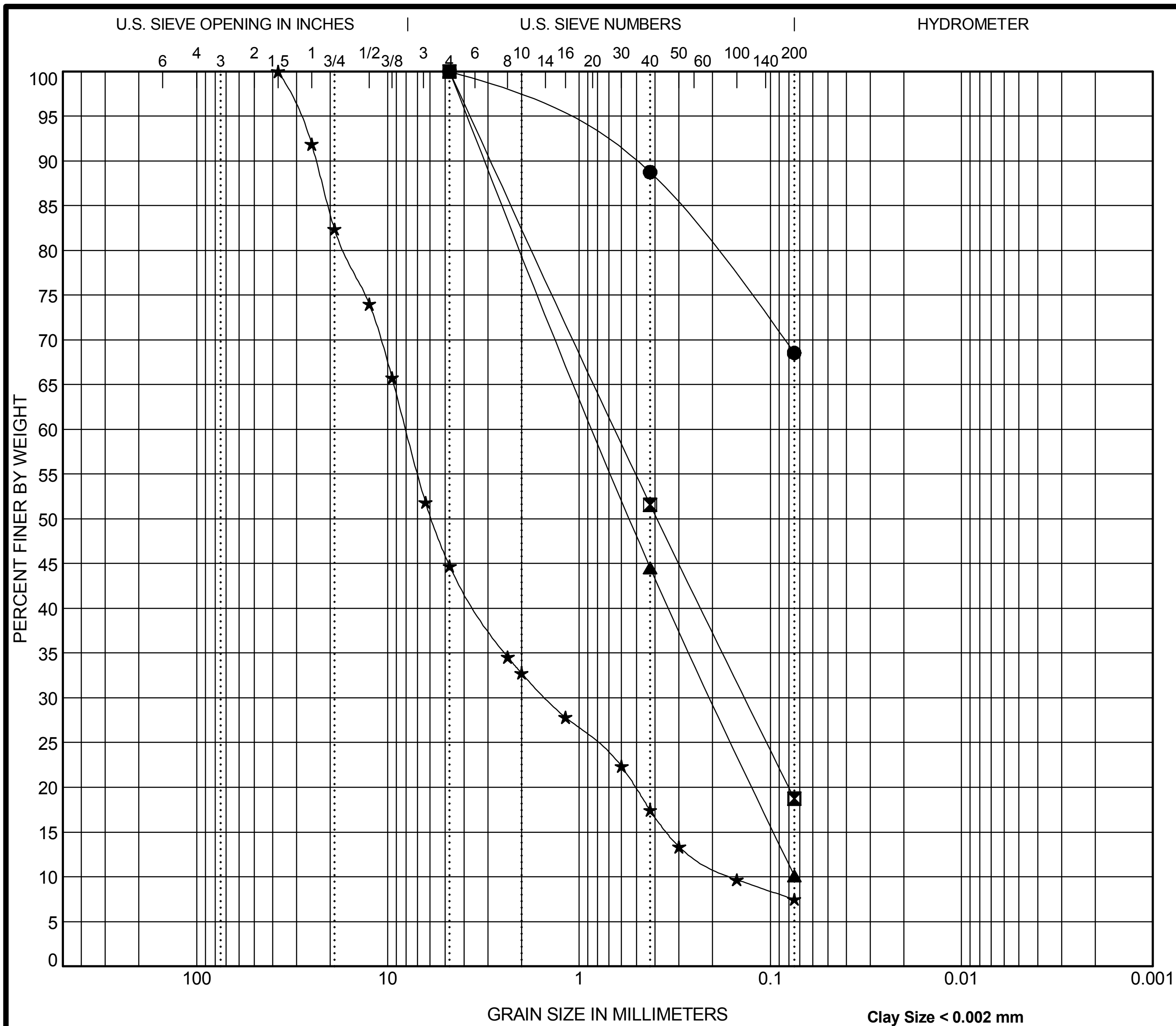
GRAIN SIZE DISTRIBUTION

Project: Kinder Morgan Terminal
PSI Job No.: 07041531
Location: 1765 Prairie Road
Eugene



Clay Size < 0.002 mm

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B02**	**2.5**		**39**	**25**	**14**		
⧗	**B02**	**7.5**						
▲	**B02**	**10.0**					**0.67**	**11.16**
★	**B02**	**30.0**					**1.73**	**50.32**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B02**	**2.5**	**4.75**				**0.0**	**31.5**	**68.5**	
⧗	**B02**	**7.5**	**4.75**	**0.646**	**0.136**		**0.0**	**81.3**	**18.7**	
▲	**B02**	**10.0**	**4.75**	**0.833**	**0.204**		**0.0**	**89.9**	**10.1**	
★	**B02**	**30.0**	**37.5**	**8.041**	**1.49**	**0.16**	**55.3**	**37.2**	**7.5**	

intertek psi

Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97219
Telephone: (503) 289-1778
Fax: (503) 289-1918

GRAIN SIZE DISTRIBUTION

Project: Kinder Morgan Terminal
PSI Job No.: 07041531
Location: 1765 Prairie Road
Eugene

Branch Engineering inc
Since 1977
civil · transportation
structural · geotechnical
SURVEYING

August 30, 2019

Mr. Pat Carroll
Norwest Engineering Inc.
4110 NW 122nd Avenue, Suite 207
Portland, Oregon 97230

RE: **GEOTECHNICAL FOUNDATION INVESTIGATION**
KINDER MORGAN EUGENE TERMINAL – VCU FOUNDATION
1765 PRAIRIE ROAD EUGENE, OREGON
BRANCH ENGINEERING INC. PROJECT NO. 19-346

Pursuant to your request, Branch Engineering Inc. (BEI) performed a geotechnical engineering investigation at the subject site referenced above for the proposed construction of a new Vapor Combustion Unit (VCU) foundation and tower enclosure.

This report is intended to present field investigation findings and site research to assess the feasibility of the proposed site development from a geotechnical engineering perspective and provide pertinent geotechnical recommendations for design and construction.

The accompanying report presents the results of our site research, field exploration and testing, data analyses, and our conclusions and recommended geotechnical design parameters for the project. Based on the results of our study, no geotechnical/geologic hazards were identified at the site and the site is suitable for the planned development, provided that the recommendations of this report are implemented in the design and construction of the project.

Sincerely,

Branch Engineering Inc.

REGISTERED PROFESSIONAL ENGINEER
#16,170
OREGON
SEPT 15, 1992
RONALD J. DERRICK
EXPIRES: 12/31/2019

Ronald J. Derrick, P.E., G.E.
Principal Geotechnical Engineer

EUGENE-SPRINGFIELD ALBANY-SALEM-CORVALLIS

310 5th Street, Springfield, OR 97477 | p: 541.746.0637 | www.branchengineering.com

TABLE OF CONTENTS

1.0 INTRODUCTION

The subject site is located at latitude 44.093585° north and longitude 123.155638° west within the Kinder Morgan Eugene Terminal at 1765 Prairie Road in Eugene, Oregon. The site consists of an area of the terminal complex, along the eastern boundary of the property where a new foundation to support a Vapor Combustion Unit and tower enclosure is proposed.

This report presents the results and findings of Branch Engineering, Inc. (BEI) field observations, testing, and research for the subject site. Our investigation included the evaluation of the subsurface conditions at the site to provide geotechnical recommendations for the design and construction of the foundation.

1.1 Project and Site Description

Our understanding of the project is that a new foundation slab will be constructed near the location of our subsurface investigation to support a new Vapor Combustion Unit and tower enclosure. The foundation loads are expected to be approximately 30-kips and uplift from wind loads is expected to contribute to foundation loads as well. BEI is not aware of any additional proposed site improvements at this time.

The site topography is relatively flat with the ground surface covered with gravel. Spill containment berms, or dikes are present to the south and north of the proposed work area, surrounding fuel tanks. The site is bordered to the east by Union Pacific railroad tracks and is surrounded by Kinder Morgan facilities to the north, west, and south. Industrial properties and land use are present in the area of the site accessed by Prairie Road.

1.2 Scope of Work

Our scope of work included a site visit and subsurface investigation on August 12, 2019 following required safety training for all personnel visiting the site. Prior to any subsurface work the work area was cleared for any existing utilities by ground penetrating radar operated by GPR Data. Two exploratory hand auger borings were advanced to approximately 4-feet below ground surface (BGS) before switching to a truck mounted GeoProbe to advance the holes to a maximum depth of 20-feet BGS. Static water levels were measured in one of the borings before the holes were filled with bentonite chips and abandoned.

The soil was visually classified in accordance with the American Society of Testing and Materials (ASTM) Method D-2488, representative soil samples were collected for laboratory in-situ moisture content, and Free Swell (IS 2720) testing. A Dynamic Cone Penetrometer (DCP) equipped with Vane Shear tip was used to evaluate the consistency of the site soil. The DCP testing consists of a graduated steel rod driven into the soil by dropping a 35-lb slide hammer a vertical distance of 18-inches and recording blow counts. Torque readings using the Vane Shear tip were recorded to measure soil shear strength.

Field log summaries of the site exploratory borings, including field test results are presented in Appendix A. Also included in Appendix A are copies of nearby well logs from the Oregon Department of Water Resources on-line database, and the soil survey mapping of the site.

1.3 Site Information Resources

The following site investigation activities were performed and literature resources were reviewed for pertinent site information:

- Review of the United States Department of the Interior Geological Survey (USGS) 2014 Eugene West Quadrangle Map.
- Two exploratory borings were advanced on site at the approximate locations shown on Figure-1.
- Review of the Lane County area Web Soil Survey, United States Department of Agricultural (USDA) Natural Resources Conservation Service (NRCS), see Appendix A.
- Review of the USGS Geologic Map of Oregon, (USGS 1991, Walker & MacLeod) and Oregon Department of Geologic and Mineral Resources (DOGAMI) open file report O-10-03, Geologic Map of the Southern Willamette Valley, 2010.
- Review of Oregon Department of Water Resources Well Logs from nearby locations, see Appendix A.
- Review of DOGAMI online hazard viewer for the subject site vicinity.

2.0 SITE SUBSURFACE CONDITIONS

The analyses, conclusions and recommendations contained in this report are based on site conditions as they presently exist and assume the exploratory borings, presented in Appendix A, are representative of the subsurface conditions throughout the site. If, during construction, subsurface conditions differ from those encountered in the exploratory borings; BEI requests that we be informed to review the site conditions and adjust our recommendations, if necessary.

2.1 Site Soils

The NRCS Web Soil Survey maps one soil unit present in the area of the proposed work, Malabon silty clay loam which is described as well drained alluvial silty clay. The soil description is consistent with our field observations.

In the exploratory borings, hand tools were used to remove gravel fill placed over the site soil and the upper fine grain soil until underlying rounded gravel deposits were encountered. Approximately 12-inches to 16-inches of crushed rock fill was observed overlying moist, brown silty clay. Trace fine grain sand content was observed in the silty clay which increased with depth.

At a depth of 48-inches in B-1 and 50-inches in B-2 sandy, rounded gravel alluvial deposits were encountered and the hand auger was met with refusal. The GeoProbe was used to advance the borings to 20-feet BGS in B-1 and 15-feet BGS in B-2. In both borings sandy rounded gravel was observed throughout the portion of the boring underneath the fine grain alluvial soil.

2.2 Soil Shrink/Swell Potential

Representative samples of the subsurface site materials were collected and tested for In-Situ Moisture Content and Free Swell (IS 2720) potential by air drying a pulverized sample and rehydrating in a graduated column. Free Swell test results showed 40% to 45% shrink/swell potential from samples of the silty clay overlying the alluvial gravel deposits. These results are considered to be moderate. In-Situ moisture content of the site soil ranged from 32.3% to 33.0%.

2.3 Ground Water

Groundwater was encountered in both borings with depth, and static water levels were measured at 12-feet BGS in boring B-1. Well logs, obtained from the Oregon Water Resources Department Well Report Query, from previous work on the site were reviewed and static water levels were reported between 3-feet and 8-feet BGS. Perched lenses of water may be present above the gravel deposits and may be responsible for the reported shallow groundwater measurements in the well logs. A pond, which is likely a former borrow pit is present approximately 0.5-miles south southwest of the site and water levels can be observed varying seasonally.

We expect that ground water levels (from the regional water table or perched lenses) will fluctuate with the seasons and should be expected to be highest during the late winter and spring months when rainstorms are more intense and frequent, and soils are near saturation. The presence of ground water is not expected to impact the proposed development, groundwater may be encountered in excavations but impacts can be mitigated by implementing dewatering measures during construction.

3.0 GEOLOGIC SETTING

The following sections described the regional and local site geology. Our field findings are consistent with the geologic mapping of the site area by the Oregon Department of Geology and Mineral Industries.

3.1 Regional Geology

The subject site lies within the southern portion of the Willamette Valley, east of the Coast Range and west of the Cascade Mountains Provinces. In Oregon, the Willamette Valley is an elongate basin which narrows at either end before pinching out. The basin is approximately 130 miles long and 40 miles wide. The valley is drained by the Willamette River and drops from an elevation of approximately 400 feet at Eugene to near sea level at the northern end of the basin where the Willamette River drains into the Columbia River Basin.

The Willamette River Valley in the area of the subject site is believed to be underlain by undifferentiated sedimentary rock, tuffs and basalt from the Miocene and Oligocene epochs (approximately 15 to 35 million years ago).

Deposits of silt and clay from fluvial and lacustrine environments covered the bedrock to various depths during the presence of low energy streams and lakes in the mid-Willamette Valley. Subsequent compression forces and uplifting of the Cascade and Coast Range Mountains depressed the Willamette River Valley.

The rapid uplift of the Cascade and Coast Range mountains steepened stream gradients causing increased erosion of the mountains and resulting deposition of thick gravel layers incised within the fluvial and lacustrine deposits.

Approximately 13,500 years ago the Willamette Valley was cyclically flooded by catastrophic breaks in the ice dams of Lake Missoula. These flood events filled the valley to an elevation of 350 to 400-feet above sea level before retreating, causing sequences of upward fining deposits of silt and clay that may or may not still be present in areas depending on erosion by subsequent creek and river actions. (Orr and Orr, 2012)

3.2 Site Geology

The O-10-03 Digital Geologic Map of the Southern Willamette Valley (Open-File Report DOGAMI, 2010) maps the site geologic unit as Terrace and Fan Deposits (Quaternary) which is described as deeply dissected unconsolidated to semi-consolidated deposits of gravel, sand, silt, and clay that form upper alluvial terraces along the rivers and streams that drain the Cascades. The mapped geologic description of the site geology is consistent with our observations of alluvial fine grain soil overlying gravel deposits.

3.3 Site Stability and Geologic Hazards

Per Section 1803.5.11 of the 2014 Oregon Structural Specialty code potential geologic and seismic hazards were evaluated as part of this geotechnical investigation:

1. Slope Instability: The site is relative flat with no slopes present on, above, or below the site that could impact the site due to slope instability or landslide activity.
2. Liquefaction: No loose, or saturated sands soil that could produce liquefaction during seismic events was encountered in the exploratory borings.
3. Total and Differential Settlement: Provided the recommendations in this report are implemented in the design and construction of the proposed development the total and differential settlement is not expected to exceed 1/2” and 1/4” respectively.
4. Surface Displacement due to faulting or seismically induced lateral spreading or lateral flow: The nearest mapped quaternary faults are approximately 4-miles southwest of the site and 15-miles east of the site. No slopes consisting of material susceptible to seismically induced lateral spread are present in the area of the proposed construction. The risk of surface displacement due to faulting or seismically induced lateral spreading or lateral flow is low.

3.4 Seismic Site Classification

Based on the soil properties encountered in our site pits and on-site well log information, Site Class C Very Dense Soil and Soft Rock (Table 20.1-1 ASCE 7) is recommended for design of site structures provided the recommendations contained in this report are implemented in the design and construction of the project.

4.0 CONCLUSIONS

Based on our field observations, subsurface explorations, and data analyses, we conclude that the site is geologic and geotechnically suitable for the proposed development provided that the recommendations of this report are incorporated into the design and construction of the project. Our investigation did not reveal any specific site features or subsurface conditions that would impede the proposed design and construction of the project.

5.0 RECOMMENDATIONS

The following sections present site-specific recommendations for site preparation, drainage, foundations, utility excavations, and slab design. General material and construction specifications for the items discussed herein are provided in Appendix B.

The subsurface conditions observed in our site investigation are consistent; however, the test pits only represent a very small portion of the site. Should soft or unsuitable soils extend to a depth greater than that described herein, or areas of distinct soil variation be discovered, this office shall be notified to perform site observation and additional excavation may be required.

5.1 Site Preparation and Foundation Subgrade Requirements

The following recommendations are for earthwork in the building foundation areas, roadways, and parking areas. Earthwork shall be performed in general accordance with the standard of practice as described in Appendix J of the 2014 Oregon Structural Specialty Code and as specified in this report.

All areas intended to directly or laterally support structures or roadways shall be stripped of vegetation, organic soil, unsuitable fill, and/or other deleterious material. These strippings shall be removed from the site or reserved for use in landscaping or non-structural areas. The subgrade soils are moisture sensitive and will soften with prolonged exposure to moisture. Recommended subgrade preparation is as follows:

Foundation Subgrade Preparation
In both exploratory borings sandy rounded gravel deposits were encountered less than 4.5-feet BGS. During our field exploration work ground penetrating radar and on-site utility locates only showed one electrical line present in the work area. Due to the potential of consolidation under loads of the silty clay material overlying the rounded gravels we recommend that in areas intended to support the proposed foundation slab the fine grain silty clay is removed to expose the gravel deposits. Compacted aggregate with a minimum thickness of 12-inches shall be placed on the rounded gravel subgrade material. Additional compacted aggregate may be placed if required to raise the elevation of the compacted aggregate to the bottom of footing design elevation. Placement of the compacted aggregate shall extend outward from the outer edges of foundation footings a horizontal distance equivalent to the height of the compacted aggregate.

A site visit by the geotechnical engineer or designated representative during excavation to the rounded gravel subgrade material is recommended prior to the placement of compacted aggregate to confirm the suitability of the subgrade soil.

5.2 Engineered Fill Recommendations

All engineered fill placed on the site shall consist of homogenous material and shall meet the following recommendations. It is our understanding that fill may be placed on portions of the site which may result in a significant quantity of material imported to the site.

- Fill placement areas shall be stripped of organic material and soft soil, and subgrade approved by the Geotechnical Engineer prior to the placement of fill materials. Sloped areas shall be benched with horizontal areas cut level prior to fill placement.

- Prior to placement, fill material shall be approved by the Geotechnical Engineer. Acceptable fill shall be free of organics or other deleterious materials. The clay soil present on the site is not acceptable for use as engineered fill.

- The fill shall be moisture conditioned within 2% +/- of optimum moisture content and compacted in lifts with loose lift thickness not exceeding 8- inches with appropriate equipment for the fill material.

- Periodic visits to the site to verify lift thickness, source material, and compaction efforts shall be conducted by the Geotechnical Engineer or designated representative and documented.

- The recommended compaction level for engineered fill is 95% of ASHTO T-180/ASTM 1557-D (modified Proctor) unless otherwise specified. Compaction shall be measured by testing with nuclear densometer ASTM D-6938, or D-1556 sand cone method. If compaction testing by nuclear densometer is not possible due to the nature of the approved fill material, proof rolling with a fully loaded 10 CY dump truck observed by the Geotechnical Engineer or designated representative shall be conducted.

5.3 Soil Bearing Capacity and Settlement

Following subgrade preparation as described above and the placement of a minimum of 12-inches of compacted aggregate on the gravel deposits an allowable bearing capacity of 3,000 psf may be used. The bearing capacity may be increased by 1/3 for short term loads such as wind and seismic.

Estimated total and differential settlement for foundations bearing compacted aggregate on the gravel deposits is not expected to exceed 1/2" and 1/4" respectively. The removal of the fine grain soil overlying the gravel is recommended due to the potential for settlement in excess of the amounts described above, due to the potential of eccentric loading. The seismic site classification also reflects the removal of the fine grain soil with the proposed foundation loads transferred to the underlying gravel deposits.

5.4 Lateral Earth Pressures and Friction Coefficient

Lateral earth pressures and friction coefficients are given below and assume no hydrostatic pressure or surcharge loads are present. Any wall foundations should bear on a leveling course of compacted aggregate 12-inches in thickness placed on the rounded gravel deposits with areas behind wall backfilled with free draining angular rock.

Table-1 Lateral Earth Pressures

Material	Passive Earth Pressure (Kp)	Active Earth Pressure (Ka)	At-Rest Earth Pressure (Ko)
Rounded Gravel Deposits	390 pcf	30 pcf	50 pcf
Silty Clay Soil	245 pcf	45 pcf	65 pcf

A coefficient of friction of 0.45 may be used for concrete poured on a minimum of 12-inches of compacted aggregate.

5.5 Drainage

Design and construction of a site drainage system is not expected to be required for the proposed construction due to the relatively flat topography surrounding the site and the pervious site surface of crushed rock which does not produce a large amount of surface runoff. However, we do recommend that the ground surface near the perimeter of the proposed foundation slab be graded to slope away from the foundation and water not be allowed to pond adjacent to new foundations.

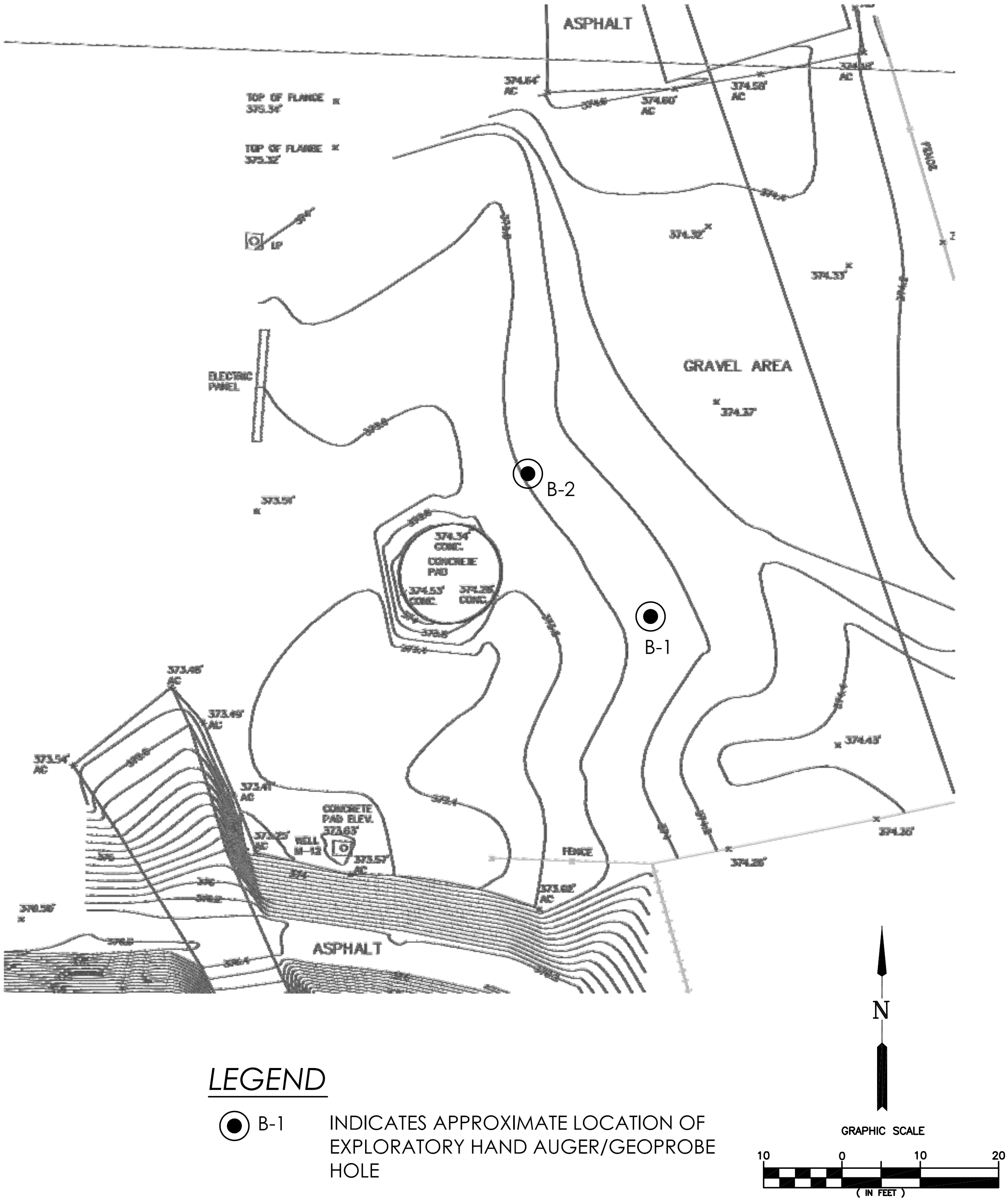
5.6 Wet Weather/Dry Weather Construction Practices

The site material is moisture sensitive and will soften with exposure to precipitation. BEI recommends that foundation subgrade preparation and general site earthwork be performed during the dry season, generally May through October if possible. Construction during the wet season may require special drainage considerations, such as covering of excavations, or pumping to mitigate standing water in footing excavations, and/or over-excavation of soft soils. The site soil should not be left exposed to prolonged precipitation.

6.0 REPORT LIMITATIONS

This report has presented BEI's site observations and research, subsurface explorations, geotechnical engineering analyses, and recommendations for the proposed site development. The conclusions in this report are based on the conditions described in this report and are intended for the exclusive use of Kinder Morgan and their representatives for use in design and construction of the development described herein. The analysis and recommendations may not be suitable for other structures or purposes.

Services performed by the geotechnical engineer for this project have been conducted with the level of care and skill exercised by other current geotechnical professionals in this area. No warranty is herein expressed or implied. The conclusions in this report are based on the site conditions as they currently exist and it is assumed that the limited site locations that were physically investigated generally represent the subsurface conditions at the site. Should site development or site conditions change, or if a substantial amount of time goes by between our site investigation and site development, we reserve the right to review this report for its applicability. If you have any questions regarding the contents of this report please contact our office.



LEGEND

B-1 INDICATES APPROXIMATE LOCATION OF EXPLORATORY HAND AUGER/GEOPROBE HOLE

SCALE: 1:20 (8.5"x11")

SITE MAP - KINDER MORGAN EUGENE TERMINAL VCU — FIGURE-1

1765 PRAIRIE ROAD, EUGENE, OREGON — 8-12-2019

PROJECT NO. 19-346

APPENDIX A

Boring Log Summaries, Well Logs, and NRCS Soil Survey

Borehole ID: B-1

Sheet 1 of 1

Client: Norwest Engineering		**Project Name:** Kinder Morgan Eugene Terminal - VCU	
Project Number: 19-346		**Project Location:** 1765 Prairie Road	
Date Started: Aug 12 2019	**Completed:** Aug 12 2019	**Logged By:** MWR	**Checked By:** RJD
Drilling Contractor: BB&A		**Latitude:** **Longitude:**	**Elevation:** 374.00
Drilling Method: Hand Auger		**Ground Water Levels**	
Equipment: Hand Auger			
Hammer Type:		After drilling	12.00 on Aug 12 2019
Notes:			

Depth	Graphic	Material Description	Sample	Recovery % RQD	Blow Counts (N Value)	Pocket Pen. (tsf)	SPT N-Value PL MC LL Fines Content (10 20 30 40 50 60 70 80 90)
0–1		Fill: 1.5" minus and 0.75" minus compacted aggregate, dry, silty (GW)					
1–2.5		Medium Stiff, moist, brown Silty Clay					
2.5–4		Moist, light brown, Silty Clay with trace fine grain sand content at 36"					
4–12		Moist, Sandy Gravel, brown and gray with occasional red, purple clastic volcanic rocks					
12–20		Wet, Sandy Gravel, brown and gray with occasional red, purple clastic volcanic rocks					
20–30							

Borehole ID: B-2

Branch ENGINEERING INC. Since 1977 — civil · transportation · structural · geotechnical · SURVEYING

Client: Norwest Engineering		**Project Name:** Kinder Morgan Eugene Terminal - VCU	
Project Number: 19-346		**Project Location:** 1765 Prairie Road	
Date Started: Aug 12 2019	**Completed:** Aug 12 2019	**Logged By:** MWR	**Checked By:** RJD
Drilling Contractor: BB&A		**Latitude:** **Longitude:**	**Elevation:** 374.00
Drilling Method: Hand Auger		**Ground Water Levels**	
Equipment: Hand Auger			
Hammer Type:			
Notes:			

Depth	Graphic	Material Description	Sample	Recovery % RQD	Blow Counts (N Value)	Pocket Pen. (tsf)	SPT N-Value PL MC LL Fines Content (10 20 30 40 50 60 70 80 90)
0–1.3		Fill: 1.5" minus and 0.75" minus compacted aggregate, dry, silty (GW)					
1.3–1.7		Medium Stiff, moist, brown Silty Clay					
1.7–4.2		Moist, light brown, Silty Clay with trace fine grain sand content at 34"					
4.2–15		Moist, Sandy Gravel, brown and gray with occasional red, purple clastic volcanic rocks, wet at approximateyl 10'					
15–30							

DYNAMIC VANE SHEAR LOG

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PROJECT NUMBER: 19-346
DATE STARTED: 08-12-2019
DATE COMPLETED: 08-12-2019

HOLE #: VS-1
CREW: MWR
PROJECT: Kinder Morgan VCU
ADDRESS: 1765 Prarie Road
LOCATION: Eugene, Oregon

SURFACE ELEVATION: 374'
WATER ON COMPLETION: No
HAMMER WEIGHT: 35 lbs.
CONE AREA: 10 sq. cm

DEPTH	BLOWS PER 10 cm	RESISTANCE Kg/cm²	GRAPH OF CONE RESISTANCE 0 50 100 150	N'	COHESIVE SOIL CONSISTENCY	TORQUE ft.-lbs.	SHEAR psf
-							
-							
- 1 ft							
-							
-							
- 2 ft	5	17.6	•••••	5	MEDIUM STIFF		
-	10	35.3	••••••••••	10	STIFF		
-	13	45.8	•••••••••••••	13	STIFF	30	3300
- 3 ft	11	38.8	•••••••••••	11	STIFF		
- 1 m							
-							
- 4 ft							
-							
-							
- 5 ft							
-							
-							
- 6 ft							
-							
- 2 m							
- 7 ft							
-							
-							
- 8 ft							
-							
-							
- 9 ft							
-							
-							
- 3 m 10 ft							
-							
-							
-							
- 11 ft							
-							
-							
- 12 ft							
-							
-							
- 4 m 13 ft							

C:\temp\WCV_XL97.XLS

DYNAMIC VANE SHEAR LOG

Branch ENGINEERING inc
Since 1977
civil · transportation
structural · geotechnical
SURVEYING

PROJECT NUMBER: 19-346
DATE STARTED: 08-12-2019
DATE COMPLETED: 08-12-2019

HOLE #: VS-2
CREW: MWR
PROJECT: Kinder Morgan VCU
ADDRESS: 1765 Prairie Road
LOCATION: Eugene, Oregon

SURFACE ELEVATION: 374'
WATER ON COMPLETION: No
HAMMER WEIGHT: 35 lbs.
CONE AREA: 10 sq. cm

DEPTH	BLOWS PER 10 cm	RESISTANCE Kg/cm²	GRAPH OF CONE RESISTANCE 0 50 100 150	N'	COHESIVE SOIL CONSISTENCY	TORQUE ft.-lbs.	SHEAR psf
-		0.0					
-							
- 1 ft							
-							
-							
- 2 ft							
-	6	21.2	••••••	6	MEDIUM STIFF		
-	11	38.8	•••••••••••	11	STIFF	35	3850
- 3 ft	16	56.4	••••••••••••••••	16	VERY STIFF		
- 1 m	13	45.8	•••••••••••••	13	STIFF	34	3740
-							
- 4 ft							
-							
-							
- 5 ft							
-							
-							
- 6 ft							
-							
- 2 m							
- 7 ft							
-							
-							
- 8 ft							
-							
-							
- 9 ft							
-							
-							
- 3 m 10 ft							
-							
-							
-							
- 11 ft							
-							
-							
- 12 ft							
-							
-							
- 4 m 13 ft							

STATE OF OREGON
GEOTECHNICAL HOLE REPORT
(as required by OAR 690-240-035)

Lane 54832

RECEIVED
JUN 22 1998
WATER RESOURCES DEPT.
SALEM, OREGON

(1) OWNER/PROJECT: Hole Number 4
Name Attn: Sid Carr / Sante Fe. PP Eugene Terminal
Address 1765 Prairie Rd.
City Eugene State OR Zip 97402

(2) TYPE OF WORK
☑ New ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) CONSTRUCTION:
☑ Rotary Air ☐ Hand Auger ☐ Hollow Stem Auger
☐ Rotary Mud ☐ Cable Tool ☐ Push Probe ☐ Other

(4) TYPE OF HOLE:
☐ Uncased Temporary ☐ Cased Permanent
☐ Uncased Permanent ☐ Slope Stability ☑ Other

(5) USE OF HOLE: Cathodic Anode Hole

(6) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Hole 50' ft.

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds
13"	0	50'	Loresco	50'	8'	21 bags
			Bentonite Chips	8'	2'	3 bags

Backfill placed from 50' ft. to 8 ft. Material Loresco
Filter Pack placed from ____ ft. to ____ ft. Size of pack ____

(7) CASING/SCREEN:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Screen:					☐	☐	☐	☐
					☐	☐	☐	☐

Slot size ____

(8) WELL TEST:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian
Permeability ____ Yield ____ GPM ____
Conductivity ____ PH ____
Temperature of water ____ °F/C Depth artesian flow found ____ ft.
Was water analysis done? ☐ Yes ☐ No
By whom? ____
Depth of strata analyzed. From ____ ft. to ____ ft.
Remarks: ____

(9) LOCATION OF HOLE by legal description:
County Lane Latitude 44° Longitude 123°
Township 17 S N or (S) Range 4 W E or (W. WM.)
Section 15 SW 1/4 NW 1/4
Tax Lot 4000 ~~Lot~~ ____ Block ____ ~~Subdivision~~ 0
Street Address of Well (or nearest address)
1765 Prairie Rd. Eugene 97402
Map with location indentified must be attached

(10) STATIC WATER LEVEL:
3' ft. below land surface. Date 6/4/98
Artesian pressure ____ lb. per square inch. Date ____

(11) SUBSURFACE LOG:
Ground Elevation ____

Material Description	From	To	SWL
Sandy Gravels	0'	19'	3'
Sand Stone	19'	38'	3'
Cobbles, gravels + Sand	38'	50'	3'

Date Started 6/4/98 Date Completed 6/4/98

(12) ABANDONMENT LOG:

Material Description	From	To	Sacks or Pounds

Date started ____ Date Completed ____

Professional Certification
(to be signed by a licensed water supply or monitoring well constructor, or registered geologist or civil engineer).

I accept responsibility for the construction, alteration, or abandonment work performed during the construction dates reported above. All work performed during this time is in compliance with Oregon's geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License or Registration Number 10045
Signed [signature] Date 6/4/98
Affiliation CASCADE DRILLING, INC-ORE

THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

0R8090

STATE OF OREGON
~~MONI~~TORING WELL REPORT
(as required by ORS 537.765 & OAR 690-240-095)

LANE
50668

RECEIVED
APR 24 1996
WATER RESOURCES DEPT.
SALEM, OREGON

Start Card # 81605

(1) OWNER/PROJECT: WELL NO. MW-11

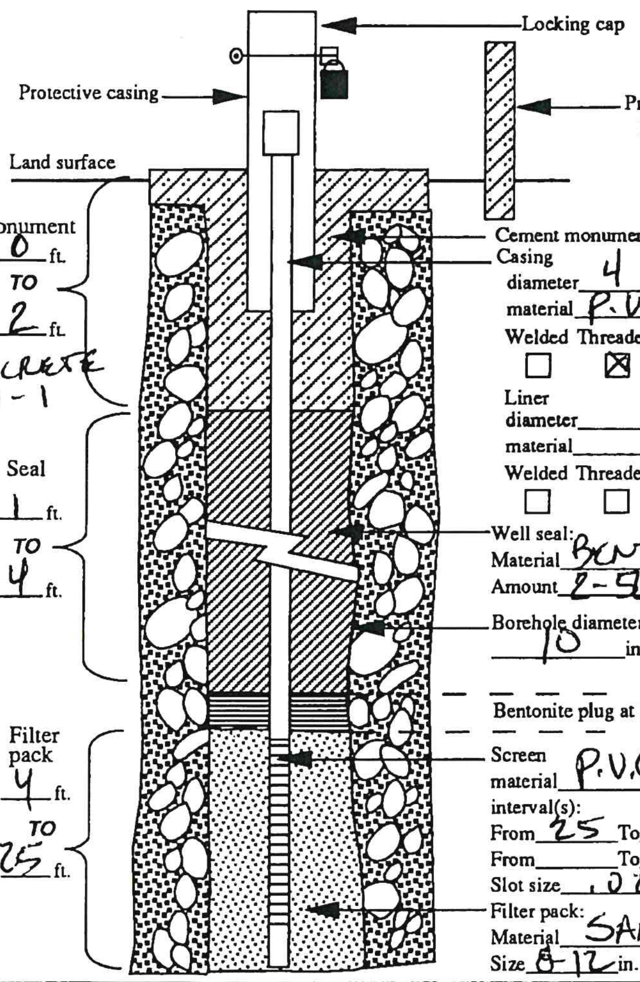
Name SANTA FE PACIFIC PIPELINE
Address 888 S. FIGUERO ST.
City L.A. State CA. Zip 90017

(2) TYPE OF WORK:
☐ New construction ☒ Repair ☐ Recondition
☐ Conversion ☐ Deepening ☐ Abandonment

(3) DRILLING METHOD
☐ Rotary Air ☐ Rotary Mud ☐ Cable
☒ Hollow Stem Auger ☐ Other

(4) BORE HOLE CONSTRUCTION

Special Standards Yes ☒ No ☐ Depth of completed well 25 ft.



Monument 0 ft. TO 2 ft.
CONCRETE 0-1
Cement monument
Casing diameter 4 in.
material P.V.C.
Welded ☐ Threaded ☒ Glued ☐
Liner diameter ____ in.
material ____
Welded ☐ Threaded ☐ Glued ☐
Seal 1 ft. TO 4 ft.
Well seal: Material BENTONITE CHIPS
Amount 2-50# BAGS
Borehole diameter 10 in.
Bentonite plug at least 2 ft. thick
Filter pack 4 ft. TO 25 ft.
Screen material P.V.C.
interval(s): From 25 To 5
From ____ To ____
Slot size .02 in.
Filter pack: Material SAND
Size 8-12 in.

(5) WELL TEST:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Permeability ____ Yield ____ GPM
Conductivity ____ PH ____
Temperature of water 53 °F/C Depth artesian flow found ____ ft.
Was water analysis done? ☒ Yes ☐ No
By whom? HART CROWSER
Depth of strata to be analyzed. From ____ ft. to ____ ft.
Remarks: ____

Name of supervising Geologist/Engineer DOANNE

(6) LOCATION OF WELL By legal description

Well Location County LANE
Township 17 (N or S) Range 4 (E or W) Section 15
1. SW 1/4 of NE 1/4 of above section.
2. Street address of well location 1765 PRAIRIE RD. EUGENE OR 97401
3. Tax lot number of well location 4000
4. ATTACH MAP WITH LOCATION IDENTIFIED.

(7) STATIC WATER LEVEL:
6 Ft. below land surface. Date 4-5-96
Artesian Pressure ____ lb/sq. in. Date ____

(8) WATER BEARING ZONES:
Depth at which water was first found 6

From	To	Est. Flow Rate	SWL

(9) WELL LOG: Ground elevation ____

Material	From	To	SWL
BENTONITE	0	4	
SAND	4	25	
THE WELL WAS ORIGINALLY INSTALLED WITH AIR ROTARY USING 10" CASING. IT BECAME DAMAGED. I PULLED THE WELL, REDRILLED THE HOLE, THEN REINSTALLED IN THE SAME HOLE.			

Date started 4-5-96 Completed 4-5-96

(unbonded) Monitor Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to the best knowledge and belief.
Signed David Abernathy MWC Number 10025 Date 4-5-96

(bonded) Monitor Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.
Signed [signature] MWC Number 10011 Date 4/19/96

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

STATE OF OREGON

GEOTECHNICAL HOLE REPORT

(as required by OAR 690-240-035)

LANE 52313

Received date 5/2/1997

(1) OWNER/PROJECT

Hole No. 9

Co.Job No. 172

Name PACIFIC PIPELIN SANTA FE
SANTA FE PACIFIC PIPELINE

Street 1100 TOWN AND COUNTRY RD

City ORANGE State CA Zip 92868

(2) TYPE OF WORK

☒ New ☐ Alter (Recondition) ☐ Alter (Repair)
☐ Deepening ☐ Abandonment

(3) CONSTRUCTION

☐ Rotary Air ☐ Hand Auger ☐ Hollow Stem Auger
☐ Rotary Mud ☐ Cable Tool ☒ Push Probe Other

(4) TYPE OF HOLE

☒ Uncased Temporary ☐ Cased Permanent
☐ Uncased Permanent ☐ Slope Stabilit Other

(5) USE OF HOLE

(6) BORE HOLE CONSTRUCTION

Special Standards ☐ Depth of completed well 12 ft.

HOLE

Diameter	From	To
1.50	0	12

SEAL

From	To	Material	Amount	Seal Grout Weight	Units
0	12	BE	5		P

Backfill placed from ft. TO ft. Material

Filter pack placed from ft. TO ft. Size in.

(7) CASING/SCREEN

Screen ☐

(8) WELL TEST

Permeability Yield GPM

Conductivity PH

Temperature of water 52 °F/C Depth artesian flow found ft.

Was water analysis done? ☒

By Whom? HART CROWSER

Depth of strata to be analyzed. From ft. to ft.

Remarks

Name of supervising Geologist/Engineer

(9) LOCATION OF HOLE By legal description

County Lane Latitude Longitude

Township 17.00 S Range 4.00 W

Section 15 SW 1/4 NE 1/4

Tax lot Lot Block Subdivision

Legal desc:

Street Address of Well (or nearest address)
1765 PRAIRIE RD, EUGENE

MAP with location indentified must be attached

(10) STATIC WATER LEVEL

8.2 Ft. below land surface. Date 4/17/1997

Artesian Pressure lb/sq. in. Date

(11) SUBSURFACE LOG

Ground Elevation ft.

Material	From	To	SWL
SANDY GRAVEL	0	12	

Date started 4/17/1997 Completed 4/17/1997

(12) ABANDONMENT LOG

Date started Completed

Professional Certification

(to be signed by a licensed water supply or monitoring well constructor, or registered geologist or civil engineer).

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License or Registration Number 10347

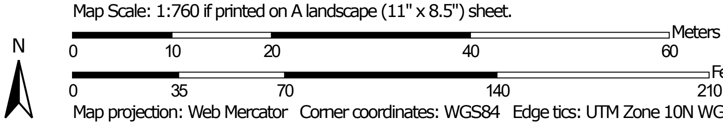
Signed By THOMAS WILSON Date

Affiliation GEO-TECH EXPLORATIONS

THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

Soil Map—Lane County Area, Oregon

Map Scale: 1:760 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lane County Area, Oregon
Survey Area Data: Version 15, Sep 18, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 23, 2015—Feb 12, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
75	Malabon silty clay loam	1.9	78.3%
2226A	Awbrig-Urban land complex, 0 to 2 percent slopes	0.5	21.7%
Totals for Area of Interest		**2.5**	**100.0%**

Lane County Area, Oregon

75—Malabon silty clay loam

Map Unit Setting

National map unit symbol: 238s
Elevation: 300 to 650 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Malabon and similar soils: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Malabon

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty and clayey alluvium

Typical profile

H1 - 0 to 12 inches: silty clay loam
H2 - 12 to 42 inches: silty clay
H3 - 42 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 11.4 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: C
Forage suitability group: Well drained < 15% Slopes (G002XY002OR)

Hydric soil rating: No

Data Source Information

Soil Survey Area: Lane County Area, Oregon
Survey Area Data: Version 15, Sep 18, 2018

APPENDIX B:

Recommended Earthwork Specifications

GEOTECHNICAL SPECIFICATIONS

General Earthwork

1. All areas where structural fills, fill slopes, structures, or roadways are to be constructed shall be stripped of organic topsoil and cleared of surface and subsurface deleterious material, including but limited to vegetation, roots, or other organic material, undocumented fill, construction debris, soft or unsuitable soils as directed by the Geotechnical Engineer of Record. These materials shall be removed from the site or stockpiled in a designated location for reuse in landscape areas if suitable for that purpose. Existing utilities and structures that are not to be used as part of the project design or by neighboring facilities, shall be removed or properly abandoned, and the associated debris removed from the site.
2. Upon completion of site stripping and clearing, the exposed soil and/or rock shall be observed by the Geotechnical Engineer of Record or a designated representative to assess the subgrade condition for the intended overlying use. Pits, depressions, or holes created by the removal of root wads, utilities, structures, or deleterious material shall be properly cleared of loose material, benched and backfilled with fill material approved by the Geotechnical Engineer of Record compacted to the project specifications.
3. In structural fill areas, the subgrade soil shall be scarified to a depth of 4-inches, if soil fill is used, moisture conditioned to within 2% of the materials optimum moisture for compaction, and blended with the first lift of fill material. The fill placement and compaction equipment shall be appropriate for fill material type, required degree of blending, and uncompacted lift thickness. Assuming proper equipment selection, the total uncompacted thickness of the scarified subgrade and first fill lift shall not exceed 8-inches, subsequent lifts of uncompacted fill shall not exceed 8-inches unless otherwise approved by the Geotechnical Engineer of Record. The uncompacted lift thickness shall be assessed based on the type of compaction equipment used and the results of initial compaction testing. Fine-grain soil fill is generally most effectively compacted using a kneading style compactor, such as a sheeps-foot roller, where as granular materials are more effectively compacted using a smooth, vibratory roller or impact style compactor.
4. All structural soil fill shall be well blended, moisture conditioned to within 2% of the material's optimum moisture content for compaction and compacted to at least 90% of the material's maximum dry density as determined by ASTM Method D-1557, or an equivalent method. Soil fill shall not contain more than 10% rock material and no solid material over 3-inches in diameter unless approved by the Geotechnical Engineer of Record. Rocks shall be evenly distributed throughout each lift of fill that they are contained within and shall not be clumped together in such a way that voids can occur.
5. All structural granular fill shall be well blended, moisture conditioned at or up to 3% above of the material's optimum moisture content for compaction and compacted to at least 95% of the material's maximum dry density as determined by ASTM Method D-1557 or an equivalent method. The granular fill shall not contain solid particles over 2-inches in diameter unless special density testing methods or proof-rolling is approved by the Geotechnical Engineer of Record. Granular fill is generally considered to be a crushed aggregate with a fracture surface of at least 70% and a maximum size not exceeding 1.5-inches in diameter, well-graded with less than 10%, by weight, passing the No. 200 Sieve.
6. Structural fill shall be field tested for compliance with project specifications for every 2-feet in vertical rise or 500 cy placed, whichever is less. In-place field density testing shall be performed by a competent individual, trained in the testing and placement of soil and aggregate fill placement, using either ASTM Method D-1556/4959/4944 (Sand Cone), D-6938 (Nuclear Densometer), or D-2937/4959/4944 (Drive Cylinder). Should the fill materials not be suitable for testing by the above methods, then observation of placement, compaction and proof-rolling with a loaded 10 cy dump-truck, or equivalent ground pressure equipment, by a trained individual may be used to assess and document the compliance with structural fill specifications.

Utility Excavations

1. Utility excavations are to be excavated to the design depth for bedding and placement and shall not be over-excavated. Trench widths shall only be of sufficient width to allow placement and proper construction of the utility and backfill of the trench.
2. Backfilling of a utility trench will be dependent on its location, use, depth, and utility line material type. Trenches that are required to meet structural fill specifications, such as those under or near buildings, or within pavement areas, shall have granular material strategically compacted to at least the spring-line of the utility conduit to mitigate pipeline movement and deformation. The initial lift thickness of backfill overlying the pipeline will be dependent on the pipeline material, type of backfill, and the compaction equipment, so as not to cause deflection or deformation of the pipeline. Trench backfill shall conform to the General Earthwork specifications for placement, compaction, and testing of structural fill.

Geotextiles

1. All geotextiles shall be resistant to ultraviolet degradation, and to biological and chemical environments normally found in soils. Geotextiles shall be stored so that they are not in direct sunlight or exposed to chemical products. The use of a geotextile shall be specified and shall meet the following specification for each use.

Subgrade/Aggregate Separation

Woven or nonwoven fabric conforming to the following physical properties:

• Minimum grab tensile strength	ASTM Method D-4632	180 lb
• Minimum puncture strength (CBR)	ASTM Method D-6241	371 lb
• Elongation	ASTM Method D-4632	15%
• Maximum apparent opening size	ASTM Method D-4751	No. 40
• Minimum permittivity	ASTM Method D-4491	0.05 s^{-1}

Drainage Filtration

Woven fabric conforming to the following physical properties:

• Minimum grab tensile strength	ASTM Method D-4632	110 lb
• Minimum puncture strength (CBR)	ASTM Method D-6241	220 lb
• Elongation	ASTM Method D-4632	50%
• Maximum apparent opening size	ASTM Method D-4751	No. 40
• Minimum permittivity	ASTM Method D-4491	0.5 s^{-1}

Geogrid Base Reinforcement

Extruded biaxially or triaxially oriented polypropylene conforming to the following physical properties:

• Peak tensile strength	ASTM Method D-6637	925 lb/ft
• Tensile strength at 2% strain	ASTM Method D-6637	300 lb/ft
• Tensile strength at 5% strain	ASTM Method D-6637	600 lb/ft
• Flexural Rigidity	ASTM Method D-1388	250,000 mg-cm
• Effective Opening Size	ASTM Method D-4751	1.5x rock size

G-4-1
California Sampler Blow Count Conversion

Kinder Morgan Eugene Terminal SVA

California to SPT Blow Count Conversion

	A	B	C	D	E
1			SPT	CalMod	
2	Sampler OD, in		2	3	
3	Sampler ID, in		1.375	2.375	
4	Hammer Weight, lbf		140	140	
5	Hammer fall, in		30	30	
6	Sampler Hammer Energy (ft^2/lb)		8.93E-06	2.2E-05	=(D2^3-D3^3)/(144*D4*D5)
7	SPT/Calmod Ratio		1	0.40	=C6/D6
8					
9	B-1				
10	Depth	Field N	Sampler Type	Multiplier	SPT N-Value
11	10	37	CalMod	0.40	15
12	15	26	SPT	1.00	26
13	20	36	CalMod	0.40	14
14	25	74	SPT	1.00	74
15	30	157	CalMod	0.40	62
16	35	118	CalMod	0.40	47
17	40	54	SPT	1.00	54
18	45	147	CalMod	0.40	58
19	50	54	SPT	1.00	54
20					
21	B-2				
22	Depth	Field N	Sampler Type	Multiplier	SPT N-Value
23	10	27	SPT	1.00	27
24	15	20	CalMod	0.40	8
25	20	10	SPT	1.00	10
26	25	30	CalMod	0.40	12
27	30	65	SPT	1.00	65
28	35	78	CalMod	0.40	31
29	40	100	SPT	1.00	100
30	45	112	CalMod	0.40	44
31	50	61	SPT	1.00	61

G-4-2
Site Class Calculation

Site Class Calculation
Kinder Morgan Eugene Terminal SVA

	A	B	C	D	E
1	**B-1**				
2	**Blow Count Depth (ft)**	**Field SPT N-Value**	**Layer Thickness, di (ft)**	**di/N**	**Notes**
3	**10**	**15**	**10**	0.666667	Measured, required to Vac top 10'
4	15	26	5	0.192308	Measured
5	20	14	5	0.357143	Measured
6	25	74	5	0.067568	Measured
7	30	62	5	0.080645	Measured
8	35	47	5	0.106383	Measured
9	40	54	5	0.092593	Measured
10	45	58	5	0.086207	Measured
11	50	54	5	0.092593	Measured
12	100	50	50	1	Extrapolated
13					
14			=SUM(D3:D12)	2.742105	**Sum**
15				**N_bar**	
16			=100/D14	36.46833	**Site Class D**
17					
18					
19	**B-2**				
20	**Blow Count Depth (ft)**	**Field SPT N-Value**	**Layer Thickness, di (ft)**	**di/N**	**Notes**
21	**10**	**27**	**10**	0.37037	Measured, required to Vac top 10'
22	15	8	5	0.625	Measured
23	20	10	5	0.5	Measured
24	25	12	5	0.416667	Measured
25	30	65	5	0.076923	Measured
26	35	31	5	0.16129	Measured
27	40	100	5	0.05	Measured
28	45	44	5	0.113636	Measured
29	50	61	5	0.081967	Measured
30	100	50	50	1	Extrapolated
31					
32			=SUM(D21:D30)	3.395854	**Sum**
33				**N_bar**	
34			=100/D32	29.44767	**Site Class D**

G-4-3
Building Code Seismic Design Parameters

This is a beta release of the new ATC Hazards by Location website. Please contact us with feedback.

The ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

ATC Hazards by Location

Search Information

Address:	1765 Prairie Rd, Eugene, OR 97402, USA
Coordinates:	44.0924618, -123.1582652
Elevation:	390 ft
Timestamp:	2024-03-20T17:23:25.915Z
Hazard Type:	Seismic
Reference Document:	ASCE7-16
Risk Category:	III
Site Class:	D

Basic Parameters

Name	Value	Description
S_S	0.743	MCE_R ground motion (period=0.2s)
S_1	0.42	MCE_R ground motion (period=1.0s)
S_{MS}	0.896	Site-modified spectral acceleration value
S_{M1}	* null	Site-modified spectral acceleration value
S_{DS}	0.597	Numeric seismic design value at 0.2s SA
S_{D1}	* null	Numeric seismic design value at 1.0s SA

* See Section 11.4.8

Additional Information

Name	Value	Description
SDC	* null	Seismic design category
F_a	1.206	Site amplification factor at 0.2s
F_v	* null	Site amplification factor at 1.0s
CR_S	0.872	Coefficient of risk (0.2s)
CR_1	0.86	Coefficient of risk (1.0s)
PGA	0.354	MCE_G peak ground acceleration
F_{PGA}	1.246	Site amplification factor at PGA
PGA_M	0.441	Site modified peak ground acceleration
T_L	16	Long-period transition period (s)
SsRT	0.743	Probabilistic risk-targeted ground motion (0.2s)
SsUH	0.852	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
SsD	1.5	Factored deterministic acceleration value (0.2s)
S1RT	0.42	Probabilistic risk-targeted ground motion (1.0s)
S1UH	0.489	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
S1D	0.696	Factored deterministic acceleration value (1.0s)
PGAd	0.581	Factored deterministic acceleration value (PGA)

* See Section 11.4.8

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Please note that the ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

Disclaimer

Hazard loads are provided by the U.S. Geological Survey Seismic Design Web Services.

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TABLE 1613.2.3(2) VALUES OF SITE COEFFICIENT F_V[a]

SITE CLASS	MAPPED RISK TARGETED MAXIMUM CONSIDERED EARTHQUAKE (MCE_R) SPECTRAL RESPONSE ACCELERATION PARAMETER AT 1-SECOND PERIOD					
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2[c]	2.0[c]	1.9[c]	1.8[c]	1.7[c]
E	4.2	3.3[c]	2.8[c]	2.4[c]	2.2[c]	2.0[c]
F	Note b	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.
b. Values shall be determined in accordance with Section 11.4.8 of ASCE 7.
c. See requirements for site-specific ground motions in Section 11.4.8 of ASCE 7.

S1 = 0.42g
Fv =
1.9-0.1*(0.02/0.1)
Fv = 1.880

G-4-4
Seismic Hazard (PGA) Disaggregation

```
*** Deaggregation of Seismic Hazard at One Period of Spectral Acceleration ***
*** Data from Dynamic: Conterminous U.S. 2014 (update) (unknown) ****
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: Total
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 100 %
  Residual: 0 %
  Trace: 0.65 %
Mean (over all sources):
  m: 8.71
  r: 71.61 km
  ε□: 0.82 σ
Mode (largest m-r bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.2 σ
  Contribution: 18.51 %
Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.09 σ
  Contribution: 14.14 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
270 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
270 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
270 8.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
250 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
250 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
250 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
250 8.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

													0.000	0.000	0.000
62	250	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63	250	8.5	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
64	250	8.7	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
65	250	8.9	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
66	230	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
67	230	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68	230	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
69	230	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	230	8.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71	230	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
72	230	8.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
73	210	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
74	210	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75	210	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
76	210	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
77	210	8.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
78	210	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
79	210	8.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
80	210	8.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
81	190	7.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
82	190	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
83	190	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
84	190	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
85	190	7.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
86	190	8.1	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003
87	190	8.3	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
88	190	8.5	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
89	190	8.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
90	170	6.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
91	170	7.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
92	170	7.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
93	170	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
94	170	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
95	170	7.9	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001

96	170	8.1	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000
97	170	8.3	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001
98	170	8.5	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000
99	170	8.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000
100	150	6.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
101	150	6.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
102	150	7.1	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.010
103	150	7.3	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000
104	150	7.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000
105	150	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
106	150	7.9	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.000
107	150	8.1	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.002
108	150	8.3	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.008	0.001
109	150	8.5	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.007	0.000
110	150	8.7	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.000
111	130	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
112	130	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
113	130	6.9	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.012
114	130	7.1	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.038	0.006
115	130	7.3	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.005	0.001
116	130	7.5	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.001	0.000
117	130	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
118	130	7.9	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.012	0.012	0.002
119	130	8.1	0.141	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.101	0.039	0.001
120	130	8.3	0.096	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.065	0.030	0.000
121	130	8.5	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.006	0.000
122	130	8.7	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000
123	110	6.5	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
124	110	6.7	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.015
125	110	6.9	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.051	0.008
126	110	7.1	0.135	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.065	0.062	0.009
127	110	7.3	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.017	0.004	0.000
128	110	7.5	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008	0.001	0.000
129	110	7.7	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.000	0.000
130	110	7.9	0.169	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003			

	0.121	0.043	0.002									
131	110	8.1	0.606	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.503	0.095	0.007									
132	110	8.3	1.343	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1.223	0.088	0.033									
133	110	8.5	1.995	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.680
	1.243	0.050	0.022									
134	110	8.7	8.372	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.362
	2.557	0.367	0.086									
135	110	8.9	5.422	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.987
	0.000	0.436	0.000									
136	110	9.1	10.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.824
	1.089	0.148	0.000									
137	90	6.5	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.020	0.010									
138	90	6.7	0.114	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.015	0.087	0.012									
139	90	6.9	0.235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.147	0.080	0.009									
140	90	7.1	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.107
	0.285	0.054	0.001									
141	90	7.3	0.065	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.045
	0.018	0.001	0.000									
142	90	7.5	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.031
	0.004	0.000	0.000									
143	90	7.7	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.005	0.003
	0.000	0.000	0.000									
144	90	7.9	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.012
	0.016	0.002	0.000									
145	90	8.1	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020
	0.016	0.003	0.000									
146	90	8.3	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016
	0.004	0.001	0.000									
147	90	8.5	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032
	0.004	0.001	0.000									
148	90	8.7	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004
	0.001	0.000	0.000									
149	70	6.5	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.062	0.059	0.004									
150	70	6.7	0.421	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042
	0.296	0.079	0.004									
151	70	6.9	0.719	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.342
	0.351	0.027	0.000									
152	70	7.1	1.146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.153	0.859
	0.134	0.000	0.000									
153	70	7.3	0.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.097	0.055
	0.002	0.000	0.001									
154	70	7.5	0.097	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.077	0.006
	0.000	0.000	0.001									
155	70	7.7	0.019	0.000	0.000	0.000	0.000	0.000	0.002	0.009	0.007	0.000
	0.000	0.000	0.000									
156	70	7.9	0.106	0.000	0.000	0.000	0.000	0.001	0.009	0.006	0.004	0.071
	0.015	0.001	0.000									
157	70	8.1	0.157	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.131
	0.013	0.000	0.000									
158	70	8.3	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.039
	0.004	0.000	0.000									
159	70	8.5	1.707	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.421	1.144
	0.142	0.000	0.000									
160	70	8.7	1.076	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.836	0.241
	0.000	0.000	0.000									
161	50	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
162	50	6.5	0.289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.135
	0.150	0.004	0.000									
163	50	6.7	0.820	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.663
	0.117	0.000	0.001									
164	50	6.9	1.251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.618	0.618
	0.012	0.000	0.003									

165	50	7.1	1.770	0.000	0.000	0.000	0.000	0.000	0.000	0.219	1.425	0.119	0.000	0.002	0.005
166	50	7.3	0.227	0.000	0.000	0.000	0.000	0.000	0.006	0.127	0.081	0.000	0.000	0.008	0.005
167	50	7.5	0.136	0.000	0.000	0.000	0.000	0.000	0.031	0.090	0.004	0.000	0.000	0.008	0.002
168	50	7.7	0.024	0.000	0.000	0.000	0.000	0.003	0.009	0.009	0.000	0.000	0.001	0.001	0.000
169	50	7.9	0.424	0.000	0.000	0.000	0.001	0.009	0.002	0.006	0.158	0.247	0.000	0.000	0.000
170	50	8.1	1.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.574	0.435	0.000	0.000	0.000
171	50	8.3	0.607	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.438	0.169	0.000	0.000	0.000
172	50	8.5	3.735	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.728	0.008	0.000	0.000	0.000
173	50	8.7	3.671	0.000	0.000	0.000	0.000	0.000	0.000	0.265	3.406	0.000	0.000	0.000	0.000
174	50	8.9	14.793	0.000	0.000	0.000	0.000	0.000	0.000	6.348	8.445	0.000	0.000	0.000	0.000
175	50	9.1	15.566	0.000	0.000	0.000	0.000	0.000	0.000	11.431	4.135	0.000	0.000	0.000	0.000
176	50	9.3	18.509	0.000	0.000	0.000	0.000	0.000	0.000	14.143	4.366	0.000	0.000	0.000	0.000
177	30	5.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
178	30	5.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
179	30	5.5	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
180	30	5.7	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004
181	30	5.9	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004
182	30	6.1	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.004
183	30	6.3	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.012	0.005
184	30	6.5	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.011	0.004
185	30	6.7	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.011	0.004
186	30	6.9	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.012	0.015	0.003
187	30	7.1	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.019	0.016	0.001
188	30	7.3	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.030	0.013	0.001
189	30	7.5	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.020	0.004	0.000
190	30	7.7	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000
191	30	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
192	10	5.1	0.108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.020	0.026	0.006
193	10	5.3	0.118	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.063	0.010	0.033	0.003
194	10	5.5	0.128	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.036	0.032	0.020	0.002
195	10	5.7	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.030	0.037	0.011	0.001
196	10	5.9	0.093	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.034	0.014	0.034	0.007	0.000
197	10	6.1	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.028	0.050	0.026	0.005	0.000
198	10	6.3	0.123	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.033	0.049	0.021	0.003	0.000
199	10	6.5	0.116	0.000	0.000	0.000	0.000	0.000	0.001	0.021	0.041	0.033			

```
0.018   0.002   0.000
10  6.7 0.102   0.000   0.000   0.000   0.000   0.000   0.002   0.018   0.038   0.029
0.014   0.001   0.000
10  6.9 0.089   0.000   0.000   0.000   0.000   0.000   0.003   0.013   0.035   0.029
0.007   0.000   0.000
10  7.1 0.077   0.000   0.000   0.000   0.000   0.000   0.004   0.013   0.029   0.026
0.005   0.000   0.000
10  7.3 0.063   0.000   0.000   0.000   0.000   0.000   0.003   0.013   0.023   0.021
0.002   0.000   0.000
10  7.5 0.028   0.000   0.000   0.000   0.000   0.000   0.001   0.007   0.011   0.008
0.001   0.000   0.000
10  7.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000
0.000   0.000   0.000
10  7.9 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 46.3
  Distance (km): 56.689974
  Magnitude: 9.0967361
  Epsilon (mean values): 0.37930855
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 46.3
  Distance (km): 56.689974
  Magnitude: 9.0967361
  Epsilon (mean values): 0.37930855
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
sub0_ch_mid.in:
  Percent Contributed: 17.98
  Distance (km): 104.7607
  Magnitude: 8.9210701
  Epsilon (mean values): 1.2890059
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 17.98
  Distance (km): 104.7607
  Magnitude: 8.9210701
  Epsilon (mean values): 1.2890059
  Azimuth: 257.03562
  Latitude: 43.86274
  Longitude: -124.49237
sub0_ch_top.in:
  Percent Contributed: 4.49
  Distance (km): 117.0827
  Magnitude: 8.8238245
  Epsilon (mean values): 1.4912003
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 4.49
  Distance (km): 117.0827
  Magnitude: 8.8238245
  Epsilon (mean values): 1.4912003
  Azimuth: 258.07157
  Latitude: 43.85837
  Longitude: -124.62968
sub2_ch_bot.in:
  Percent Contributed: 4.39
  Distance (km): 56.294667
  Magnitude: 8.7263979
  Epsilon (mean values): 0.62717503
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 4.39
  Distance (km): 56.294667
  Magnitude: 8.7263979
  Epsilon (mean values): 0.62717503
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
coastalOR_deep.in:
```

```
    Percent Contributed: 3.78
    Distance (km): 61.136319
    Magnitude: 6.943333
    Epsilon (mean values): 1.2716704
  coastalOR_deep.in:
    Percent Contributed: 3.67
    Distance (km): 63.863986
    Magnitude: 6.9381328
    Epsilon (mean values): 1.2563925
  sub3_ch_bot.in:
    Percent Contributed: 2.62
    Distance (km): 71.601596
    Magnitude: 8.5785697
    Epsilon (mean values): 1.0347295
  Cascadia Megathrust - Goldfinger Case D Characteristic:
    Percent Contributed: 2.62
    Distance (km): 71.601596
    Magnitude: 8.5785697
    Epsilon (mean values): 1.0347295
    Azimuth: 229.04629
    Latitude: 43.7
    Longitude: -123.78006
  sub1_GRb0_bot.in:
    Percent Contributed: 2.58
    Distance (km): 58.101151
    Magnitude: 8.442658
    Epsilon (mean values): 0.8408893
  Cascadia floater over southern zone - Goldfinger Case B:
    Percent Contributed: 2.58
    Distance (km): 58.101151
    Magnitude: 8.442658
    Epsilon (mean values): 0.8408893
    Azimuth: 244.46631
    Latitude: 43.88167
    Longitude: -123.76421
  sub1_ch_bot.in:
    Percent Contributed: 2.15
    Distance (km): 56.327816
    Magnitude: 8.8542815
    Epsilon (mean values): 0.54227074
  Cascadia Megathrust - Goldfinger Case B Characteristic:
    Percent Contributed: 2.15
    Distance (km): 56.327816
    Magnitude: 8.8542815
    Epsilon (mean values): 0.54227074
    Azimuth: 244.46631
    Latitude: 43.88167
    Longitude: -123.76421
  sub1_GRb1_bot.in:
    Percent Contributed: 2.07
    Distance (km): 58.983179
    Magnitude: 8.3301188
    Epsilon (mean values): 0.9261585
  Cascadia floater over southern zone - Goldfinger Case B:
    Percent Contributed: 2.07
    Distance (km): 58.983179
    Magnitude: 8.3301188
    Epsilon (mean values): 0.9261585
    Azimuth: 244.46631
    Latitude: 43.88167
    Longitude: -123.76421
  sub2_ch_mid.in:
    Percent Contributed: 1.19
    Distance (km): 104.54395
    Magnitude: 8.4714849
    Epsilon (mean values): 1.5659064
  Cascadia Megathrust - Goldfinger Case C Characteristic:
    Percent Contributed: 1.19
    Distance (km): 104.54395
```

```
  Magnitude: 8.4714849
  Epsilon (mean values): 1.5659064
  Azimuth: 257.03562
  Latitude: 43.86274
  Longitude: -124.49237
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Abrahamson, Silva & Kamai (2014)
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 0.45 %
  Residual: 0 %
  Trace: 0.04 %
Mean (over all sources):
  m: 6.21
  r: 14.53 km
  ε□: 1.5 σ
Mode (largest m-r bin):
  m: 5.1
  r: 9.31 km
  ε□: 1.69 σ
  Contribution: 0.05 %
Mode (largest m-r-ε□ bin):
  m: 5.1
  r: 6.53 km
  ε□: 1.36 σ
  Contribution: 0.03 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
110 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

392	70	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
393	70	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
394	70	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
395	70	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
396	50	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
397	50	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
398	50	6.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
399	50	6.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
400	50	7.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
401	50	7.3	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002
402	50	7.5	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001
403	50	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
404	50	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
405	30	5.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
406	30	5.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
407	30	5.5	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
408	30	5.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
409	30	5.9	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
410	30	6.1	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001
411	30	6.3	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.002
412	30	6.5	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.002
413	30	6.7	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.001
414	30	6.9	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.001
415	30	7.1	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.005	0.000
416	30	7.3	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.004	0.000
417	30	7.5	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.001	0.000
418	30	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
419	30	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
420	10	5.1	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.001	0.016	0.002
421	10	5.3	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.004	0.012	0.000
422	10	5.5	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.008	0.007	0.000
423	10	5.7	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.010	0.004	0.000
424	10	5.9	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.005	0.009	0.002	0.000
425	10	6.1	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.011	0.008	0.001	0.000
426	10	6.3	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.014			

```
0.007   0.000   0.000
10  6.5 0.029   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.009   0.011
0.006   0.000   0.000
10  6.7 0.025   0.000   0.000   0.000   0.000   0.000   0.000   0.005   0.009   0.007
0.004   0.000   0.000
10  6.9 0.021   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.007   0.008
0.003   0.000   0.000
10  7.1 0.018   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.007   0.007
0.001   0.000   0.000
10  7.3 0.015   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.006   0.006
0.000   0.000   0.000
10  7.5 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.003
0.000   0.000   0.000
10  7.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
10  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Boore, Stewart, Seyhan & Atkinson (2014)
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^-1
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr^-1
Totals:
  Binned: 0.59 %
  Residual: 0 %
  Trace: 0.07 %
Mean (over all sources):
  m: 6.24
  r: 14.1 km
  ε□: 1.23 σ
Mode (largest m-r bin):
  m: 5.5
  r: 9.35 km
  ε□: 1.13 σ
  Contribution: 0.06 %
Mode (largest m-r-ε□ bin):
  m: 5.5
  r: 6.73 km
  ε□: 0.71 σ
  Contribution: 0.04 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
```

487	Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
488	90	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
489	90	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
490	70	7.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
491	70	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
492	70	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
493	70	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
494	70	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
495	50	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
496	50	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
497	50	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
498	50	6.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
499	50	7.1	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
500	50	7.3	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002
501	50	7.5	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001
502	50	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
503	50	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
504	30	5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
505	30	5.5	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
506	30	5.7	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
507	30	5.9	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001
508	30	6.1	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.001
509	30	6.3	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.002
510	30	6.5	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.004	0.002
511	30	6.7	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.005	0.001
512	30	6.9	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.006	0.000
513	30	7.1	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.008	0.005	0.000
514	30	7.3	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.012	0.003	0.000
515	30	7.5	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.007	0.001	0.000
516	30	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
517	30	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
518	10	5.1	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.005	0.003	0.002
519	10	5.3	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.023	0.002	0.009	0.001
520	10	5.5	0.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.000	0.019	0.004	0.000

```
10  5.7 0.052   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.030   0.002   0.016   0.003   0.000
10  5.9 0.041   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.018   0.003   0.014   0.001   0.000
10  6.1 0.051   0.000   0.000   0.000   0.000   0.000   0.000   0.020   0.003   0.020   0.008   0.001   0.000
10  6.3 0.044   0.000   0.000   0.000   0.000   0.000   0.000   0.015   0.011   0.013   0.005   0.000   0.000
10  6.5 0.038   0.000   0.000   0.000   0.000   0.000   0.000   0.011   0.016   0.007   0.005   0.000   0.000
10  6.7 0.033   0.000   0.000   0.000   0.000   0.000   0.000   0.008   0.013   0.009   0.003   0.000   0.000
10  6.9 0.027   0.000   0.000   0.000   0.000   0.000   0.000   0.005   0.013   0.008   0.001   0.000   0.000
10  7.1 0.023   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.011   0.008   0.000   0.000   0.000
10  7.3 0.019   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.008   0.006   0.000   0.000   0.000
10  7.5 0.008   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.004   0.002   0.000   0.000   0.000
10  7.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
10  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Campbell & Bozorgnia (2014)
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 0.13 %
  Residual: 0 %
  Trace: 0.04 %
Mean (over all sources):
  m: 6.5
  r: 11.2 km
  ε□: 1.57 σ
Mode (largest m-r bin):
  m: 6.5
  r: 9.64 km
  ε□: 1.29 σ
  Contribution: 0.02 %
Mode (largest m-r-ε□ bin):
  m: 6.51
  r: 8.99 km
  ε□: 1.27 σ
  Contribution: 0.01 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
```

578 ε5: [-0.5 .. 0.0)
579 ε6: [0.0 .. 0.5)
580 ε7: [0.5 .. 1.0)
581 ε8: [1.0 .. 1.5)
582 ε9: [1.5 .. 2.0)
583 ε10: [2.0 .. 2.5)
584 ε11: [2.5 .. +∞]
585 Closest Distance, rRup (km) Magnitude (Mw) ALL_ε ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0) ε=[0,0.5) ε=[0.5,1) ε=[1,1.5) ε=[1.5,2) ε=[2,2.5) ε=[2.5,∞)
586 70 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
587 50 7.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
588 50 7.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
589 50 7.5 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
590 50 7.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
591 50 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
592 30 5.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
593 30 6.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
594 30 6.3 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
595 30 6.5 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001
596 30 6.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001
597 30 6.9 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001
598 30 7.1 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001
599 30 7.3 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.001
600 30 7.5 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.000
601 30 7.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
602 30 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
603 10 5.1 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.000
604 10 5.3 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.000
605 10 5.5 0.005 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.001 0.001
606 10 5.7 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.000 0.001
607 10 5.9 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.003 0.002 0.000
608 10 6.1 0.013 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.005 0.002 0.000
609 10 6.3 0.015 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.007 0.005 0.002 0.000
610 10 6.5 0.017 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.005 0.007 0.003 0.002 0.000
611 10 6.7 0.015 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.007 0.003 0.001 0.000
612 10 6.9 0.012 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.006 0.003 0.000 0.000
613 10 7.1 0.010 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.004 0.003 0.000 0.000
614 10 7.3 0.007 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.003 0.002 0.000 0.000
615 10 7.5 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001

```
0.001   0.000   0.000
10  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
10  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Chiou & Youngs (2014)
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 0.42 %
  Residual: 0 %
  Trace: 0.06 %
Mean (over all sources):
  m: 6.37
  r: 13.24 km
  ε□: 1.27 σ
Mode (largest m-r bin):
  m: 6.1
  r: 9.92 km
  ε□: 1.17 σ
  Contribution: 0.03 %
Mode (largest m-r-ε□ bin):
  m: 5.5
  r: 6.71 km
  ε□: 1.23 σ
  Contribution: 0.02 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5)
ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)
ε=[2,2.5)   ε=[2.5,∞)
110 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
70  7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

													0.000	0.000	0.000
676	70	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
677	70	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
678	70	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
679	50	6.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
680	50	6.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
681	50	7.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
682	50	7.3	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
683	50	7.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
684	50	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
685	50	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
686	30	5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
687	30	5.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
688	30	5.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
689	30	5.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
690	30	6.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
691	30	6.3	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
692	30	6.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001
693	30	6.7	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.001
694	30	6.9	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.001
695	30	7.1	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.004	0.000
696	30	7.3	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.009	0.003	0.000
697	30	7.5	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.006	0.001	0.000
698	30	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
699	30	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
700	10	5.1	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.014	0.006	0.001
701	10	5.3	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.003	0.008	0.001
702	10	5.5	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.002	0.008	0.001
703	10	5.7	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.014	0.007	0.004	0.000
704	10	5.9	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.004	0.008	0.002	0.000
705	10	6.1	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.014	0.005	0.001	0.000
706	10	6.3	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.010	0.014	0.005	0.001	0.000
707	10	6.5	0.032	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.011	0.008	0.004	0.001	0.000
708	10	6.7	0.030	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.012	0.006	0.004	0.000	0.000
709	10	6.9	0.028	0.000	0.000	0.000	0.000	0.000	0.003	0.004	0.012	0.007	0.001	0.000	0.000

710 10 7.1 0.026 0.000 0.000 0.000 0.000 0.000 0.004 0.005 0.009 0.007 0.001 0.000 0.000
711 10 7.3 0.022 0.000 0.000 0.000 0.000 0.000 0.003 0.007 0.007 0.005 0.000 0.000 0.000
712 10 7.5 0.010 0.000 0.000 0.000 0.000 0.000 0.001 0.004 0.003 0.002 0.000 0.000 0.000
713 10 7.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
714 10 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
715 Principal Sources (faults, subduction, random seismicity having > 3% contribution
716 PSHA Deaggregation. %contributions.
717 site: Test
718 longitude: 123.158°W
719 latitude: 44.092°E
720 imt: Peak Ground Acceleration
721 vs30 = 259 m/s (Site class D)
722 return period: 2475 yrs.
723 #This deaggregation corresponds to: GMM: Atkinson & Macias (2009) : Interface
724 Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
725 Deaggregation targets:
726 Return period: 2475 yrs
727 Exceedance rate: 0.0004040404 yr^{-1}
728 PGA ground motion: 0.53308997 g
729 Recovered targets:
730 Return period: 2415.6964 yrs
731 Exceedance rate: 0.00041395931 yr^{-1}
732 Totals:
733 Binned: 23.4 %
734 Residual: 0 %
735 Trace: 0.05 %
736 Mean (over all sources):
737 m: 9.01
738 r: 61.76 km
739 ε□: 0.55 σ
740 Mode (largest m-r bin):
741 m: 9.34
742 r: 56.69 km
743 ε□: 0.03 σ
744 Contribution: 7.44 %
745 Mode (largest m-r-ε□ bin):
746 m: 9.34
747 r: 56.69 km
748 ε□: 0.03 σ
749 Contribution: 7.44 %
750 Discretization:
751 r: min = 0.0, max = 1000.0, Δ = 20.0 km
752 m: min = 4.4, max = 9.4, Δ = 0.2
753 ε: min = -3.0, max = 3.0, Δ = 0.5 σ
754 Epsilon keys:
755 ε0: [-∞ .. -2.5)
756 ε1: [-2.5 .. -2.0)
757 ε2: [-2.0 .. -1.5)
758 ε3: [-1.5 .. -1.0)
759 ε4: [-1.0 .. -0.5)
760 ε5: [-0.5 .. 0.0)
761 ε6: [0.0 .. 0.5)
762 ε7: [0.5 .. 1.0)
763 ε8: [1.0 .. 1.5)
764 ε9: [1.5 .. 2.0)
765 ε10: [2.0 .. 2.5)
766 ε11: [2.5 .. +∞]
767 Closest Distance, rRup (km) Magnitude (Mw) ALL_ε ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0) ε=[0,0.5) ε=[0.5,1) ε=[1,1.5) ε=[1.5,2) ε=[2,2.5) ε=[2.5,∞)
768 130 8.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
769 130 8.5 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

```
130 8.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
110 7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
110 8.1 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007
110 8.3 0.033   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.033
110 8.5 0.072   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.050   0.022
110 8.7 0.453   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.367   0.086
110 8.9 0.436   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.436   0.000
110 9.1 1.237   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.089   0.148   0.000
90  7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.000
90  8.1 0.003   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.000
90  8.3 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000
90  8.5 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.001   0.000
90  8.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.000   0.000
70  7.9 0.017   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007   0.009   0.001   0.000
70  8.1 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.018   0.013   0.000   0.000
70  8.3 0.012   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.008   0.004   0.000   0.000
70  8.5 0.321   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.179   0.142   0.000   0.000
70  8.7 0.241   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.239   0.000   0.000   0.000
50  7.9 0.112   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.112   0.000   0.000   0.000
50  8.1 0.277   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.277   0.000   0.000   0.000
50  8.3 0.169   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.169   0.000   0.000   0.000
50  8.5 1.093   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.085   0.008   0.000   0.000   0.000
50  8.7 1.132   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.132   0.000   0.000   0.000   0.000
50  8.9 4.850   0.000   0.000   0.000   0.000   0.000   0.000   0.581   4.269   0.000   0.000   0.000   0.000
50  9.1 5.451   0.000   0.000   0.000   0.000   0.000   0.000   5.451   0.000   0.000   0.000   0.000   0.000
50  9.3 7.440   0.000   0.000   0.000   0.000   0.000   0.000   7.440   0.000   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 16.85
  Distance (km): 56.689974
  Magnitude: 9.1151466
  Epsilon (mean values): 0.28985067
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 16.85
  Distance (km): 56.689974
  Magnitude: 9.1151466
  Epsilon (mean values): 0.28985067
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
sub0_ch_mid.in:
  Percent Contributed: 1.82
  Distance (km): 104.7607
```

```
  Magnitude: 8.9791549
  Epsilon (mean values): 1.8819149
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 1.82
  Distance (km): 104.7607
  Magnitude: 8.9791549
  Epsilon (mean values): 1.8819149
  Azimuth: 257.03562
  Latitude: 43.86274
  Longitude: -124.49237
sub2_ch_bot.in:
  Percent Contributed: 1.38
  Distance (km): 56.294667
  Magnitude: 8.736035
  Epsilon (mean values): 0.67035951
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 1.38
  Distance (km): 56.294667
  Magnitude: 8.736035
  Epsilon (mean values): 0.67035951
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: BC Hydro (2012) : Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 29.91 %
  Residual: 0 %
  Trace: 0.08 %
Mean (over all sources):
  m: 8.85
  r: 79.71 km
  ε□: 1 σ
Mode (largest m-r bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.56 σ
  Contribution: 4.37 %
Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.56 σ
  Contribution: 4.37 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
```

882 ε7: [0.5 .. 1.0)
883 ε8: [1.0 .. 1.5)
884 ε9: [1.5 .. 2.0)
885 ε10: [2.0 .. 2.5)
886 ε11: [2.5 .. +∞]
887 Closest Distance, rRup (km) Magnitude (Mw) ALL_ε ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0) ε=[0,0.5) ε=[0.5,1) ε=[1,1.5) ε=[1.5,2) ε=[2,2.5) ε=[2.5,∞)
888 270 8.5 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
889 250 8.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
890 250 8.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
891 250 8.5 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004
892 250 8.7 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.006
893 250 8.9 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004
894 230 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
895 230 8.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
896 230 8.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
897 230 8.5 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
898 210 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
899 210 8.1 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
900 210 8.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
901 210 8.5 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.000
902 210 8.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
903 190 7.9 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
904 190 8.1 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.003
905 190 8.3 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.000
906 190 8.5 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.000
907 190 8.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.000
908 170 7.9 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.001
909 170 8.1 0.008 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.008 0.000
910 170 8.3 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.000
911 170 8.5 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.000
912 170 8.7 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001 0.000
913 150 7.9 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.000
914 150 8.1 0.013 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.013 0.000
915 150 8.3 0.007 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.006 0.000
916 150 8.5 0.010 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.004 0.000
917 150 8.7 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.000 0.000
918 130 7.9 0.020 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

```
0.011   0.010   0.000
130 8.1 0.107   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.101   0.006   0.000
130 8.3 0.065   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.065   0.000   0.000
130 8.5 0.032   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.032   0.000   0.000
130 8.7 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.004   0.000   0.000
110 7.9 0.121   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.121   0.000   0.000
110 8.1 0.408   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.408   0.000   0.000
110 8.3 0.811   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.811   0.000   0.000
110 8.5 1.081   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.519
0.561   0.000   0.000
110 8.7 4.023   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.668
1.355   0.000   0.000
110 8.9 2.342   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.342
0.000   0.000   0.000
110 9.1 3.798   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   3.798
0.000   0.000   0.000
90  7.9 0.018   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.011
0.007   0.000   0.000
90  8.1 0.022   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.019
0.004   0.000   0.000
90  8.3 0.011   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.011
0.000   0.000   0.000
90  8.5 0.018   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.018
0.000   0.000   0.000
90  8.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
0.000   0.000   0.000
70  7.9 0.042   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.042
0.000   0.000   0.000
70  8.1 0.070   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.012   0.057
0.000   0.000   0.000
70  8.3 0.024   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.008   0.016
0.000   0.000   0.000
70  8.5 0.674   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.033   0.641
0.000   0.000   0.000
70  8.7 0.367   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.366   0.001
0.000   0.000   0.000
50  7.9 0.166   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.158   0.008
0.000   0.000   0.000
50  8.1 0.385   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.385   0.000
0.000   0.000   0.000
50  8.3 0.217   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.217   0.000
0.000   0.000   0.000
50  8.5 1.209   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.209   0.000
0.000   0.000   0.000
50  8.7 1.109   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.109   0.000
0.000   0.000   0.000
50  8.9 4.176   0.000   0.000   0.000   0.000   0.000   0.000   0.000   4.176   0.000
0.000   0.000   0.000
50  9.1 4.135   0.000   0.000   0.000   0.000   0.000   0.000   0.000   4.135   0.000
0.000   0.000   0.000
50  9.3 4.366   0.000   0.000   0.000   0.000   0.000   0.000   0.000   4.366   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 11.98
  Distance (km): 56.689974
  Magnitude: 9.0807597
  Epsilon (mean values): 0.63413343
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 11.98
  Distance (km): 56.689974
  Magnitude: 9.0807597
```

  Epsilon (mean values): 0.63413343
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
sub0_ch_mid.in:
  Percent Contributed: 7.39
  Distance (km): 104.7607
  Magnitude: 8.9020883
  Epsilon (mean values): 1.2869097
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 7.39
  Distance (km): 104.7607
  Magnitude: 8.9020883
  Epsilon (mean values): 1.2869097
  Azimuth: 257.03562
  Latitude: 43.86274
  Longitude: -124.49237
sub0_ch_top.in:
  Percent Contributed: 2.12
  Distance (km): 117.0827
  Magnitude: 8.8065546
  Epsilon (mean values): 1.4633593
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 2.12
  Distance (km): 117.0827
  Magnitude: 8.8065546
  Epsilon (mean values): 1.4633593
  Azimuth: 258.07157
  Latitude: 43.85837
  Longitude: -124.62968
sub2_ch_bot.in:
  Percent Contributed: 1.31
  Distance (km): 56.294667
  Magnitude: 8.7160683
  Epsilon (mean values): 0.73186016
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 1.31
  Distance (km): 56.294667
  Magnitude: 8.7160683
  Epsilon (mean values): 0.73186016
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: BC Hydro (2012) : Slab
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr^{-1}
Totals:
  Binned: 5.08 %
  Residual: 0 %
  Trace: 0.11 %
Mean (over all sources):
  m: 6.97
  r: 66.97 km
  ε□: 1.28 σ
Mode (largest m-r bin):
  m: 7.1

```
    r: 51.99 km
    ε□: 0.75 σ
    Contribution: 0.86 %
  Mode (largest m-r-ε□ bin):
    m: 7.1
    r: 51.87 km
    ε□: 0.74 σ
    Contribution: 0.8 %
  Discretization:
    r: min = 0.0, max = 1000.0, Δ = 20.0 km
    m: min = 4.4, max = 9.4, Δ = 0.2
    ε: min = -3.0, max = 3.0, Δ = 0.5 σ
  Epsilon keys:
    ε0: [-∞ .. -2.5)
    ε1: [-2.5 .. -2.0)
    ε2: [-2.0 .. -1.5)
    ε3: [-1.5 .. -1.0)
    ε4: [-1.0 .. -0.5)
    ε5: [-0.5 .. 0.0)
    ε6: [0.0 .. 0.5)
    ε7: [0.5 .. 1.0)
    ε8: [1.0 .. 1.5)
    ε9: [1.5 .. 2.0)
    ε10: [2.0 .. 2.5)
    ε11: [2.5 .. +∞]
  Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
  270 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  270 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  250 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  250 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  250 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  230 7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  230 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  230 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  230 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  210 7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  210 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  210 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  210 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  190 7.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  190 7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  190 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  190 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  190 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  170 6.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
  170 7.1 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
  170 7.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

0.000 0.000 0.001
1074 170 7.5 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.001 0.000
1075 170 7.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1076 170 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1077 150 6.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1078 150 6.9 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.001
1079 150 7.1 0.013 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.003 0.010
1080 150 7.3 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.003 0.000
1081 150 7.5 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.001 0.002 0.000
1082 150 7.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1083 150 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1084 130 6.5 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1085 130 6.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.001
1086 130 6.9 0.014 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.002 0.012
1087 130 7.1 0.044 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.001 0.038 0.006
1088 130 7.3 0.009 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.004 0.005 0.000
1089 130 7.5 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.006 0.000 0.000
1090 130 7.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.001 0.000 0.000
1091 130 7.9 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1092 110 6.5 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.002
1093 110 6.7 0.020 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.005 0.015
1094 110 6.9 0.058 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.001 0.051 0.006
1095 110 7.1 0.119 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.065 0.054 0.000
1096 110 7.3 0.018 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002
0.016 0.000 0.000
1097 110 7.5 0.013 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.008
0.005 0.000 0.000
1098 110 7.7 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002
0.000 0.000 0.000
1099 110 7.9 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002
0.000 0.000 0.000
1100 90 6.5 0.028 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.020 0.008
1101 90 6.7 0.101 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.015 0.083 0.003
1102 90 6.9 0.190 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.143 0.046 0.000
1103 90 7.1 0.328 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.105
0.224 0.000 0.000
1104 90 7.3 0.043 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.038
0.004 0.000 0.000
1105 90 7.5 0.026 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.005 0.020
0.000 0.000 0.000
1106 90 7.7 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.002
0.000 0.000 0.000
1107 90 7.9 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.001
0.000 0.000 0.000

```
70  6.5 0.094   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.059   0.035   0.000
70  6.7 0.298   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.042   0.234   0.023   0.000
70  6.9 0.471   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.288   0.183   0.000   0.000
70  7.1 0.682   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.111   0.557   0.015   0.000   0.000
70  7.3 0.083   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.057   0.027   0.000   0.000   0.000
70  7.5 0.048   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.048   0.000   0.000   0.000   0.000
70  7.7 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.005   0.000   0.000   0.000   0.000
70  7.9 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.004   0.000   0.000   0.000   0.000
50  6.5 0.174   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.103   0.070   0.000   0.000
50  6.7 0.466   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.022   0.418   0.026   0.000   0.000
50  6.9 0.659   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.357   0.302   0.000   0.000   0.000
50  7.1 0.861   0.000   0.000   0.000   0.000   0.000   0.000   0.022   0.796   0.044   0.000   0.000   0.000
50  7.3 0.097   0.000   0.000   0.000   0.000   0.000   0.000   0.043   0.055   0.000   0.000   0.000   0.000
50  7.5 0.055   0.000   0.000   0.000   0.000   0.000   0.000   0.051   0.004   0.000   0.000   0.000   0.000
50  7.7 0.008   0.000   0.000   0.000   0.000   0.000   0.000   0.008   0.000   0.000   0.000   0.000   0.000
50  7.9 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.006   0.000   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
coastalOR_deep.in:
  Percent Contributed: 2.29
  Distance (km): 64.450641
  Magnitude: 6.9346278
  Epsilon (mean values): 1.3217558
coastalOR_deep.in:
  Percent Contributed: 2.19
  Distance (km): 66.429354
  Magnitude: 6.9277228
  Epsilon (mean values): 1.2803482
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Zhao et al. (2006) : Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 36.59 %
  Residual: 0 %
  Trace: 0.08 %
Mean (over all sources):
  m: 8.92
  r: 75.61 km
  ε□: 0.72 σ
Mode (largest m-r bin):
  m: 9.34
```

```
  r: 56.69 km
  ε□: 0.15 σ
  Contribution: 6.7 %
Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.15 σ
  Contribution: 6.7 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
210 8.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
210 8.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
190 8.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
190 8.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
190 8.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
170 8.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
170 8.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
170 8.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.000
170 8.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.000
150 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
150 8.1 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
150 8.3 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001
150 8.5 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.000
150 8.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.000
130 7.9 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.002
130 8.1 0.034   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.033   0.001
130 8.3 0.030   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.030   0.000
130 8.5 0.019   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.013   0.006   0.000
130 8.7 0.003   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.000   0.000
110 7.9 0.043   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.043   0.000
110 8.1 0.190   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

```
        0.095   0.095   0.000
        110 8.3 0.500   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
        0.412   0.088   0.000
        110 8.5 0.842   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.161
        0.681   0.000   0.000
        110 8.7 3.896   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.694
        1.202   0.000   0.000
        110 8.9 2.644   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.644
        0.000   0.000   0.000
        110 9.1 5.026   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   5.026
        0.000   0.000   0.000
        90  7.9 0.009   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
        0.009   0.001   0.000
        90  8.1 0.014   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
        0.012   0.000   0.000
        90  8.3 0.008   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.005
        0.003   0.000   0.000
        90  8.5 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.015
        0.002   0.000   0.000
        90  8.7 0.003   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.002
        0.000   0.000   0.000
        70  7.9 0.028   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.022
        0.006   0.000   0.000
        70  8.1 0.056   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.056
        0.000   0.000   0.000
        70  8.3 0.023   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007   0.015
        0.000   0.000   0.000
        70  8.5 0.711   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.387   0.324
        0.000   0.000   0.000
        70  8.7 0.469   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.469   0.000
        0.000   0.000   0.000
        50  7.9 0.128   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.128
        0.000   0.000   0.000
        50  8.1 0.346   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.189   0.158
        0.000   0.000   0.000
        50  8.3 0.221   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.221   0.000
        0.000   0.000   0.000
        50  8.5 1.433   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.433   0.000
        0.000   0.000   0.000
        50  8.7 1.430   0.000   0.000   0.000   0.000   0.000   0.000   0.265   1.165   0.000
        0.000   0.000   0.000
        50  8.9 5.767   0.000   0.000   0.000   0.000   0.000   0.000   5.767   0.000   0.000
        0.000   0.000   0.000
        50  9.1 5.980   0.000   0.000   0.000   0.000   0.000   0.000   5.980   0.000   0.000
        0.000   0.000   0.000
        50  9.3 6.703   0.000   0.000   0.000   0.000   0.000   0.000   6.703   0.000   0.000
        0.000   0.000   0.000
        Principal Sources (faults, subduction, random seismicity having > 3% contribution
        sub0_ch_bot.in:
          Percent Contributed: 17.46
          Distance (km): 56.689974
          Magnitude: 9.0899319
          Epsilon (mean values): 0.29076123
        Cascadia Megathrust - whole CSZ Characteristic:
          Percent Contributed: 17.46
          Distance (km): 56.689974
          Magnitude: 9.0899319
          Epsilon (mean values): 0.29076123
          Azimuth: 244.46631
          Latitude: 43.88167
          Longitude: -123.76421
        sub0_ch_mid.in:
          Percent Contributed: 8.78
          Distance (km): 104.7607
          Magnitude: 8.9250416
          Epsilon (mean values): 1.1681575
        Cascadia Megathrust - whole CSZ Characteristic:
          Percent Contributed: 8.78
          Distance (km): 104.7607
```

```
  Magnitude: 8.9250416
  Epsilon (mean values): 1.1681575
  Azimuth: 257.03562
  Latitude: 43.86274
  Longitude: -124.49237
sub0_ch_top.in:
  Percent Contributed: 2.14
  Distance (km): 117.0827
  Magnitude: 8.8334657
  Epsilon (mean values): 1.4342274
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 2.14
  Distance (km): 117.0827
  Magnitude: 8.8334657
  Epsilon (mean values): 1.4342274
  Azimuth: 258.07157
  Latitude: 43.85837
  Longitude: -124.62968
sub2_ch_bot.in:
  Percent Contributed: 1.7
  Distance (km): 56.294667
  Magnitude: 8.7265008
  Epsilon (mean values): 0.51151981
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 1.7
  Distance (km): 56.294667
  Magnitude: 8.7265008
  Epsilon (mean values): 0.51151981
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
sub3_ch_bot.in:
  Percent Contributed: 1.11
  Distance (km): 71.601596
  Magnitude: 8.5817746
  Epsilon (mean values): 0.90948935
Cascadia Megathrust - Goldfinger Case D Characteristic:
  Percent Contributed: 1.11
  Distance (km): 71.601596
  Magnitude: 8.5817746
  Epsilon (mean values): 0.90948935
  Azimuth: 229.04629
  Latitude: 43.7
  Longitude: -123.78006
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Zhao et al. (2006) : Slab
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^-1
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr^-1
Totals:
  Binned: 3.44 %
  Residual: 0 %
  Trace: 0.07 %
Mean (over all sources):
  m: 7.01
  r: 59.19 km
  ε□: 1.14 σ
Mode (largest m-r bin):
```

m: 7.1
r: 51.55 km
ε□: 0.69 σ
Contribution: 0.9 %
Mode (largest m-r-ε□ bin):
m: 7.1
r: 52.5 km
ε□: 0.73 σ
Contribution: 0.63 %
Discretization:
r: min = 0.0, max = 1000.0, Δ = 20.0 km
m: min = 4.4, max = 9.4, Δ = 0.2
ε: min = −3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
ε0: [−∞ .. −2.5)
ε1: [−2.5 .. −2.0)
ε2: [−2.0 .. −1.5)
ε3: [−1.5 .. −1.0)
ε4: [−1.0 .. −0.5)
ε5: [−0.5 .. 0.0)
ε6: [0.0 .. 0.5)
ε7: [0.5 .. 1.0)
ε8: [1.0 .. 1.5)
ε9: [1.5 .. 2.0)
ε10: [2.0 .. 2.5)
ε11: [2.5 .. +∞]

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(−∞,−2.5)	ε=[−2.5,−2)	ε=[−2,−1.5)	ε=[−1.5,−1)	ε=[−1,−0.5)	ε=[−0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
230	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
210	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
190	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
190	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
170	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
170	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
170	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
150	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
150	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
150	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
150	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
130	7.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
130	7.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
130	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
130	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
130	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110	6.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110	6.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
110	7.1	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.009
110	7.3	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.000

```
110 7.5 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.001   0.000
110 7.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000   0.000
110 7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000   0.000   0.000
90  6.5 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
90  6.7 0.013   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.009
90  6.9 0.046   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.033   0.009
90  7.1 0.119   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.062   0.054   0.001
90  7.3 0.022   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007   0.013   0.001   0.000
90  7.5 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.011   0.004   0.000   0.000
90  7.7 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.001   0.000   0.000   0.000
90  7.9 0.005   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.002   0.000   0.000   0.000   0.000
70  6.5 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.024   0.004
70  6.7 0.123   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.063   0.056   0.004
70  6.9 0.248   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.054   0.168   0.027   0.000
70  7.1 0.463   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.042   0.302   0.119   0.000   0.000
70  7.3 0.070   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.040   0.028   0.002   0.000   0.000
70  7.5 0.048   0.000   0.000   0.000   0.000   0.000   0.000   0.011   0.030   0.006   0.000   0.000   0.000
70  7.7 0.011   0.000   0.000   0.000   0.000   0.000   0.002   0.007   0.002   0.000   0.000   0.000   0.000
70  7.9 0.013   0.000   0.000   0.000   0.000   0.001   0.009   0.003   0.000   0.000   0.000   0.000   0.000
50  6.5 0.115   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.032   0.080   0.004   0.000
50  6.7 0.353   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.017   0.245   0.091   0.000   0.000
50  6.9 0.589   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.261   0.316   0.012   0.000   0.000
50  7.1 0.903   0.000   0.000   0.000   0.000   0.000   0.000   0.197   0.630   0.075   0.000   0.000   0.000
50  7.3 0.117   0.000   0.000   0.000   0.000   0.000   0.006   0.085   0.026   0.000   0.000   0.000   0.000
50  7.5 0.071   0.000   0.000   0.000   0.000   0.000   0.031   0.040   0.000   0.000   0.000   0.000   0.000
50  7.7 0.013   0.000   0.000   0.000   0.000   0.003   0.009   0.001   0.000   0.000   0.000   0.000   0.000
50  7.9 0.012   0.000   0.000   0.000   0.001   0.009   0.002   0.000   0.000   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
coastalOR_deep.in:
  Percent Contributed: 1.5
  Distance (km): 56.062975
  Magnitude: 6.9566584
  Epsilon (mean values): 1.1950031
coastalOR_deep.in:
  Percent Contributed: 1.48
  Distance (km): 60.067565
  Magnitude: 6.9535384
  Epsilon (mean values): 1.220941
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
```

imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Grid
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr^{-1}
Totals:
  Binned: 1.59 %
  Residual: 0 %
  Trace: 0.06 %
Mean (over all sources):
  m: 6.29
  r: 13.76 km
  ε□: 1.34 σ
Mode (largest m-r bin):
  m: 6.1
  r: 9.97 km
  ε□: 1.13 σ
  Contribution: 0.13 %
Mode (largest m-r-ε□ bin):
  m: 5.29
  r: 6.63 km
  ε□: 1.25 σ
  Contribution: 0.06 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
110	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	7.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	7.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
70	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
70	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

													0.000	0.000	0.000
1469	50	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1470	50	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1471	50	6.9	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
1472	50	7.1	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005
1473	50	7.3	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.005
1474	50	7.5	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.002
1475	50	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
1476	50	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1477	30	5.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1478	30	5.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1479	30	5.5	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
1480	30	5.7	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004
1481	30	5.9	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004
1482	30	6.1	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.004
1483	30	6.3	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.012	0.005
1484	30	6.5	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.011	0.004
1485	30	6.7	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.011	0.004
1486	30	6.9	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.012	0.015	0.003
1487	30	7.1	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.019	0.016	0.001
1488	30	7.3	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.030	0.013	0.001
1489	30	7.5	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.009	0.020	0.004	0.000
1490	30	7.7	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000
1491	30	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
1492	10	5.1	0.108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.020	0.026	0.006
1493	10	5.3	0.118	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.063	0.010	0.033	0.003
1494	10	5.5	0.128	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.036	0.032	0.020	0.002
1495	10	5.7	0.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.030	0.037	0.011	0.001
1496	10	5.9	0.093	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.034	0.014	0.034	0.007	0.000
1497	10	6.1	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.028	0.050	0.026	0.005	0.000
1498	10	6.3	0.123	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.033	0.049	0.021	0.003	0.000
1499	10	6.5	0.116	0.000	0.000	0.000	0.000	0.000	0.001	0.021	0.041	0.033	0.018	0.002	0.000
1500	10	6.7	0.102	0.000	0.000	0.000	0.000	0.000	0.002	0.018	0.038	0.029	0.014	0.001	0.000
1501	10	6.9	0.089	0.000	0.000	0.000	0.000	0.000	0.003	0.013	0.035	0.029	0.007	0.000	0.000
1502	10	7.1	0.077	0.000	0.000	0.000	0.000	0.000	0.004	0.013	0.029	0.026	0.005	0.000	0.000

10 7.3 0.063 0.000 0.000 0.000 0.000 0.000 0.003 0.013 0.023 0.021 0.002 0.000 0.000
10 7.5 0.028 0.000 0.000 0.000 0.000 0.000 0.001 0.007 0.011 0.008 0.001 0.000 0.000
10 7.7 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001 0.000 0.000 0.000 0.000
10 7.9 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Slab
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr^{-1}
Totals:
  Binned: 8.52 %
  Residual: 0 %
  Trace: 0.12 %
Mean (over all sources):
  m: 6.99
  r: 63.82 km
  ε□: 1.22 σ
Mode (largest m-r bin):
  m: 7.1
  r: 51.77 km
  ε□: 0.72 σ
  Contribution: 1.76 %
Mode (largest m-r-ε□ bin):
  m: 7.1
  r: 52.15 km
  ε□: 0.73 σ
  Contribution: 1.43 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw) ALL_ε ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0) ε=[0,0.5) ε=[0.5,1) ε=[1,1.5) ε=[1.5,2) ε=[2,2.5) ε=[2.5,∞)
270 7.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
270 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
250 7.5 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

1563	250	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1564	250	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1565	230	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1566	230	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1567	230	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1568	230	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1569	210	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1570	210	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1571	210	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1572	210	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1573	190	7.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1574	190	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1575	190	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1576	190	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1577	190	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1578	170	6.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1579	170	7.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
1580	170	7.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1581	170	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
1582	170	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1583	170	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1584	150	6.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1585	150	6.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1586	150	7.1	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.010
1587	150	7.3	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000
1588	150	7.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000
1589	150	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1590	150	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
1591	130	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1592	130	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1593	130	6.9	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.012
1594	130	7.1	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.038	0.006
1595	130	7.3	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.005	0.001
1596	130	7.5	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.001	0.000
1597	130	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

0.001 0.000 0.000
1598 130 7.9 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.001 0.000 0.000
1599 110 6.5 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002
1600 110 6.7 0.020 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.005 0.015
1601 110 6.9 0.060 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.051 0.008
1602 110 7.1 0.135 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.065 0.062 0.009
1603 110 7.3 0.023 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002 0.017 0.004 0.000
1604 110 7.5 0.017 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.008 0.008 0.001 0.000
1605 110 7.7 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.001 0.000 0.000
1606 110 7.9 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.003 0.000 0.000 0.000
1607 90 6.5 0.030 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.020 0.010
1608 90 6.7 0.114 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.015 0.087 0.012
1609 90 6.9 0.235 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.147 0.080 0.009
1610 90 7.1 0.447 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.107 0.285 0.054 0.001
1611 90 7.3 0.065 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.045 0.018 0.001 0.000
1612 90 7.5 0.042 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.031 0.004 0.000 0.000
1613 90 7.7 0.008 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.005 0.003 0.000 0.000 0.000
1614 90 7.9 0.008 0.000 0.000 0.000 0.000 0.000 0.000 0.003 0.005 0.001 0.000 0.000 0.000
1615 70 6.5 0.125 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.062 0.059 0.004
1616 70 6.7 0.421 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.042 0.296 0.079 0.004
1617 70 6.9 0.719 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.342 0.351 0.027 0.000
1618 70 7.1 1.146 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.153 0.859 0.134 0.000 0.000
1619 70 7.3 0.154 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.097 0.055 0.002 0.000 0.000
1620 70 7.5 0.096 0.000 0.000 0.000 0.000 0.000 0.000 0.012 0.077 0.006 0.000 0.000 0.000
1621 70 7.7 0.018 0.000 0.000 0.000 0.000 0.000 0.002 0.009 0.007 0.000 0.000 0.000 0.000
1622 70 7.9 0.019 0.000 0.000 0.000 0.000 0.001 0.009 0.006 0.004 0.000 0.000 0.000 0.000
1623 50 6.5 0.289 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.135 0.150 0.004 0.000
1624 50 6.7 0.819 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.039 0.663 0.117 0.000 0.000
1625 50 6.9 1.248 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.618 0.618 0.012 0.000 0.000
1626 50 7.1 1.764 0.000 0.000 0.000 0.000 0.000 0.000 0.219 1.425 0.119 0.000 0.000 0.000
1627 50 7.3 0.214 0.000 0.000 0.000 0.000 0.000 0.006 0.127 0.081 0.000 0.000 0.000 0.000
1628 50 7.5 0.126 0.000 0.000 0.000 0.000 0.000 0.031 0.090 0.004 0.000 0.000 0.000 0.000
1629 50 7.7 0.022 0.000 0.000 0.000 0.000 0.003 0.009 0.009 0.000 0.000 0.000 0.000 0.000
1630 50 7.9 0.018 0.000 0.000 0.000 0.001 0.009 0.002 0.006 0.000 0.000 0.000 0.000 0.000
1631 Principal Sources (faults, subduction, random seismicity having > 3% contribution
1632 coastalOR_deep.in:

```
  Percent Contributed: 3.78
  Distance (km): 61.136319
  Magnitude: 6.943333
  Epsilon (mean values): 1.2716704
coastalOR_deep.in:
  Percent Contributed: 3.67
  Distance (km): 63.863986
  Magnitude: 6.9381328
  Epsilon (mean values): 1.2563925
PSHA Deaggregation. %contributions.
site: Test
longitude: 123.158°W
latitude: 44.092°E
imt: Peak Ground Acceleration
vs30 = 259 m/s (Site class D)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.53308997 g
Recovered targets:
  Return period: 2415.6964 yrs
  Exceedance rate: 0.00041395931 yr⁻¹
Totals:
  Binned: 89.9 %
  Residual: 0 %
  Trace: 0.16 %
Mean (over all sources):
  m: 8.92
  r: 73.37 km
  ε□: 0.77 σ
Mode (largest m-r bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.2 σ
  Contribution: 18.51 %
Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 56.69 km
  ε□: 0.09 σ
  Contribution: 14.14 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
270 8.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
250 8.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
250 8.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

1697	250	8.5	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004									
1698	250	8.7	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.006									
1699	250	8.9	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.004									
1700	230	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
1701	230	8.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
1702	230	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
1703	230	8.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.001									
1704	210	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
1705	210	8.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.001									
1706	210	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
1707	210	8.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.001	0.000									
1708	210	8.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000									
1709	190	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.001									
1710	190	8.1	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.001	0.003									
1711	190	8.3	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.001	0.000									
1712	190	8.5	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.002	0.000									
1713	190	8.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.001	0.000									
1714	170	7.9	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.003	0.001									
1715	170	8.1	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.008	0.000									
1716	170	8.3	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.004	0.001									
1717	170	8.5	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.004	0.000									
1718	170	8.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.001	0.002	0.000									
1719	150	7.9	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.006	0.000									
1720	150	8.1	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.013	0.002									
1721	150	8.3	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.001	0.008	0.001									
1722	150	8.5	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.006	0.007	0.000									
1723	150	8.7	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.003	0.001	0.000									
1724	130	7.9	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.011	0.012	0.002									
1725	130	8.1	0.141	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.101	0.039	0.001									
1726	130	8.3	0.096	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.065	0.030	0.000									
1727	130	8.5	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.044	0.006	0.000									
1728	130	8.7	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.007	0.000	0.000									
1729	110	7.9	0.165	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.121	0.043	0.002									
1730	110	8.1	0.606	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.503	0.095	0.007									
1731	110	8.3	1.343	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
1.223   0.088   0.033
110 8.5 1.995   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.680
1.243   0.050   0.022
110 8.7 8.372   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   5.362
2.557   0.367   0.086
110 8.9 5.422   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   4.987
0.000   0.436   0.000
110 9.1 10.061  0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   8.824
1.089   0.148   0.000
90  7.9 0.029   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.011
0.016   0.002   0.000
90  8.1 0.040   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.020
0.016   0.003   0.000
90  8.3 0.021   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.016
0.004   0.001   0.000
90  8.5 0.038   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.032
0.004   0.001   0.000
90  8.7 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.004
0.001   0.000   0.000
70  7.9 0.087   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.071
0.015   0.001   0.000
70  8.1 0.157   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.012   0.131
0.013   0.000   0.000
70  8.3 0.058   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.016   0.039
0.004   0.000   0.000
70  8.5 1.707   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.421   1.144
0.142   0.000   0.000
70  8.7 1.076   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.836   0.241
0.000   0.000   0.000
50  7.9 0.406   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.158   0.247
0.000   0.000   0.000
50  8.1 1.009   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.574   0.435
0.000   0.000   0.000
50  8.3 0.607   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.438   0.169
0.000   0.000   0.000
50  8.5 3.735   0.000   0.000   0.000   0.000   0.000   0.000   0.000   3.728   0.008
0.000   0.000   0.000
50  8.7 3.671   0.000   0.000   0.000   0.000   0.000   0.000   0.265   3.406   0.000
0.000   0.000   0.000
50  8.9 14.793  0.000   0.000   0.000   0.000   0.000   0.000   6.348   8.445   0.000
0.000   0.000   0.000
50  9.1 15.566  0.000   0.000   0.000   0.000   0.000   0.000   11.431  4.135   0.000
0.000   0.000   0.000
50  9.3 18.509  0.000   0.000   0.000   0.000   0.000   0.000   14.143  4.366   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 46.3
  Distance (km): 56.689974
  Magnitude: 9.0967361
  Epsilon (mean values): 0.37930855
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 46.3
  Distance (km): 56.689974
  Magnitude: 9.0967361
  Epsilon (mean values): 0.37930855
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
sub0_ch_mid.in:
  Percent Contributed: 17.98
  Distance (km): 104.7607
  Magnitude: 8.9210701
  Epsilon (mean values): 1.2890059
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 17.98
  Distance (km): 104.7607
  Magnitude: 8.9210701
  Epsilon (mean values): 1.2890059
```

```
    Azimuth: 257.03562
    Latitude: 43.86274
    Longitude: -124.49237
  sub0_ch_top.in:
    Percent Contributed: 4.49
    Distance (km): 117.0827
    Magnitude: 8.8238245
    Epsilon (mean values): 1.4912003
  Cascadia Megathrust - whole CSZ Characteristic:
    Percent Contributed: 4.49
    Distance (km): 117.0827
    Magnitude: 8.8238245
    Epsilon (mean values): 1.4912003
    Azimuth: 258.07157
    Latitude: 43.85837
    Longitude: -124.62968
  sub2_ch_bot.in:
    Percent Contributed: 4.39
    Distance (km): 56.294667
    Magnitude: 8.7263979
    Epsilon (mean values): 0.62717503
  Cascadia Megathrust - Goldfinger Case C Characteristic:
    Percent Contributed: 4.39
    Distance (km): 56.294667
    Magnitude: 8.7263979
    Epsilon (mean values): 0.62717503
    Azimuth: 244.46631
    Latitude: 43.88167
    Longitude: -123.76421
  sub3_ch_bot.in:
    Percent Contributed: 2.62
    Distance (km): 71.601596
    Magnitude: 8.5785697
    Epsilon (mean values): 1.0347295
  Cascadia Megathrust - Goldfinger Case D Characteristic:
    Percent Contributed: 2.62
    Distance (km): 71.601596
    Magnitude: 8.5785697
    Epsilon (mean values): 1.0347295
    Azimuth: 229.04629
    Latitude: 43.7
    Longitude: -123.78006
  sub1_GRb0_bot.in:
    Percent Contributed: 2.58
    Distance (km): 58.101151
    Magnitude: 8.442658
    Epsilon (mean values): 0.8408893
  Cascadia floater over southern zone - Goldfinger Case B:
    Percent Contributed: 2.58
    Distance (km): 58.101151
    Magnitude: 8.442658
    Epsilon (mean values): 0.8408893
    Azimuth: 244.46631
    Latitude: 43.88167
    Longitude: -123.76421
  sub1_ch_bot.in:
    Percent Contributed: 2.15
    Distance (km): 56.327816
    Magnitude: 8.8542815
    Epsilon (mean values): 0.54227074
  Cascadia Megathrust - Goldfinger Case B Characteristic:
    Percent Contributed: 2.15
    Distance (km): 56.327816
    Magnitude: 8.8542815
    Epsilon (mean values): 0.54227074
    Azimuth: 244.46631
    Latitude: 43.88167
    Longitude: -123.76421
  sub1_GRb1_bot.in:
```

```
  Percent Contributed: 2.07
  Distance (km): 58.983179
  Magnitude: 8.3301188
  Epsilon (mean values): 0.9261585
Cascadia floater over southern zone - Goldfinger Case B:
  Percent Contributed: 2.07
  Distance (km): 58.983179
  Magnitude: 8.3301188
  Epsilon (mean values): 0.9261585
  Azimuth: 244.46631
  Latitude: 43.88167
  Longitude: -123.76421
sub2_ch_mid.in:
  Percent Contributed: 1.19
  Distance (km): 104.54395
  Magnitude: 8.4714849
  Epsilon (mean values): 1.5659064
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 1.19
  Distance (km): 104.54395
  Magnitude: 8.4714849
  Epsilon (mean values): 1.5659064
  Azimuth: 257.03562
  Latitude: 43.86274
  Longitude: -124.49237
```

G-4-5
Liquefaction and Residual Strength Calculations

					Liquefaction Analysis								Residual Shear Strength Analysis								
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$cs-Sr			Residual Shear Strength ratio, Sr / sig_v'					
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	10.0	15	GP-GM	7	24	25	0.39	0.52	1.7	3.4	3.0		24.8					0.25	0.40		
	15.0	26	SP-SM	6	42	40	2.00	2.00	0.4	1.5	1.0		39.7								
	20.0	14	SM	34	21	21	0.57	0.46	0.4	1.5	1.0		22.7					0.21	0.40		
	25.0	74	GP-GM	10	100	98	2.00	2.00	0.0	0.0	0.0		99.3								
	30.0	62	GM	20	83	83	2.00	2.00	0.0	0.0	0.0		83.8								
	35.0	47	GP-GM	10	59	60	2.00	2.00	0.0	0.0	0.0		61.4								
	40.0	54	GM	20	63	67	2.00	1.92	0.0	0.0	0.0		68.0								
	45.0	58	GM	20	64	70	2.00	1.85	0.0	0.0	0.0		70.8								
	50.0	54	GM	20	56	63	2.00	1.79	0.0	0.0	0.0		64.3								

Seismic Parameters	
Max Acceleration (g) :	0.49
Earthquake Magnitude:	8.71

Liquefaction and Residual Shear Strength Analysis Results, B-1

Kinder Morgan Eugene Terminal SVA
Eugene, Oregon

Figure G-4-1

					Liquefaction Analysis								Residual Shear Strength Analysis								
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$cs-Sr			Residual Shear Strength ratio, Sr / sig_v'					
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	10.0	27	GP-GM	2	42	40	2.00	2.00	3.3	5.8	5.0		40.4								
	15.0	8	GM	1	13	14	0.18	0.28	3.3	5.8	5.0		13.8					0.12	0.17		
	20.0	10	GP-GM	11	15	15	0.22	0.29	2.0	3.7	3.2		16.2					0.14	0.30		
	25.0	12	GP	3	17	17	0.22	0.28	1.0	1.8	1.6		16.8					0.14	0.35		
	30.0	65	SP-SM	9	88	87	2.00	2.00	0.0	0.0	0.0		87.4								
	35.0	31	SP-SM	10	39	40	2.00	1.99	0.0	0.0	0.0		41.0								
	40.0	100	GP-GM	10	89	94	2.00	1.91	0.0	0.0	0.0		94.8								
	45.0	44	GM	20	49	53	2.00	1.84	0.0	0.0	0.0		54.3								
	50.0	61	GM	20	64	72	2.00	1.78	0.0	0.0	0.0		72.9								

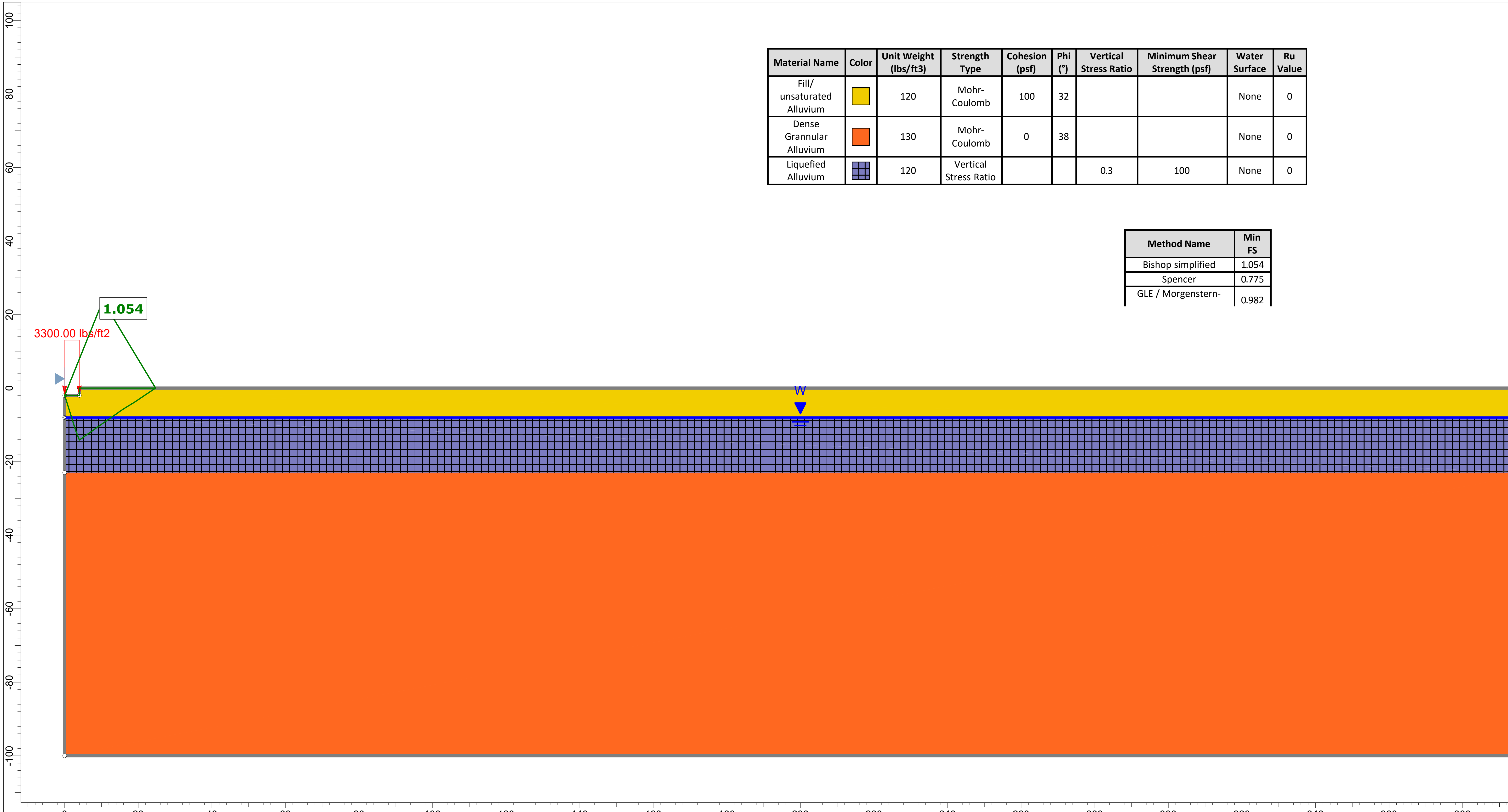
Seismic Parameters	
Max Acceleration (g) :	0.49
Earthquake Magnitude:	8.71

Liquefaction and Residual Shear Strength Analysis Results, B-1

Kinder Morgan Eugene Terminal SVA
Eugene, Oregon

Figure X.

G-4-6
Seismic Bearing Capacity Calculations



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill/ unsaturated Alluvium		120	Mohr-Coulomb	100	32			None	0
Dense Grannular Alluvium		130	Mohr-Coulomb	0	38			None	0
Liquefied Alluvium		120	Vertical Stress Ratio			0.3	100	None	0

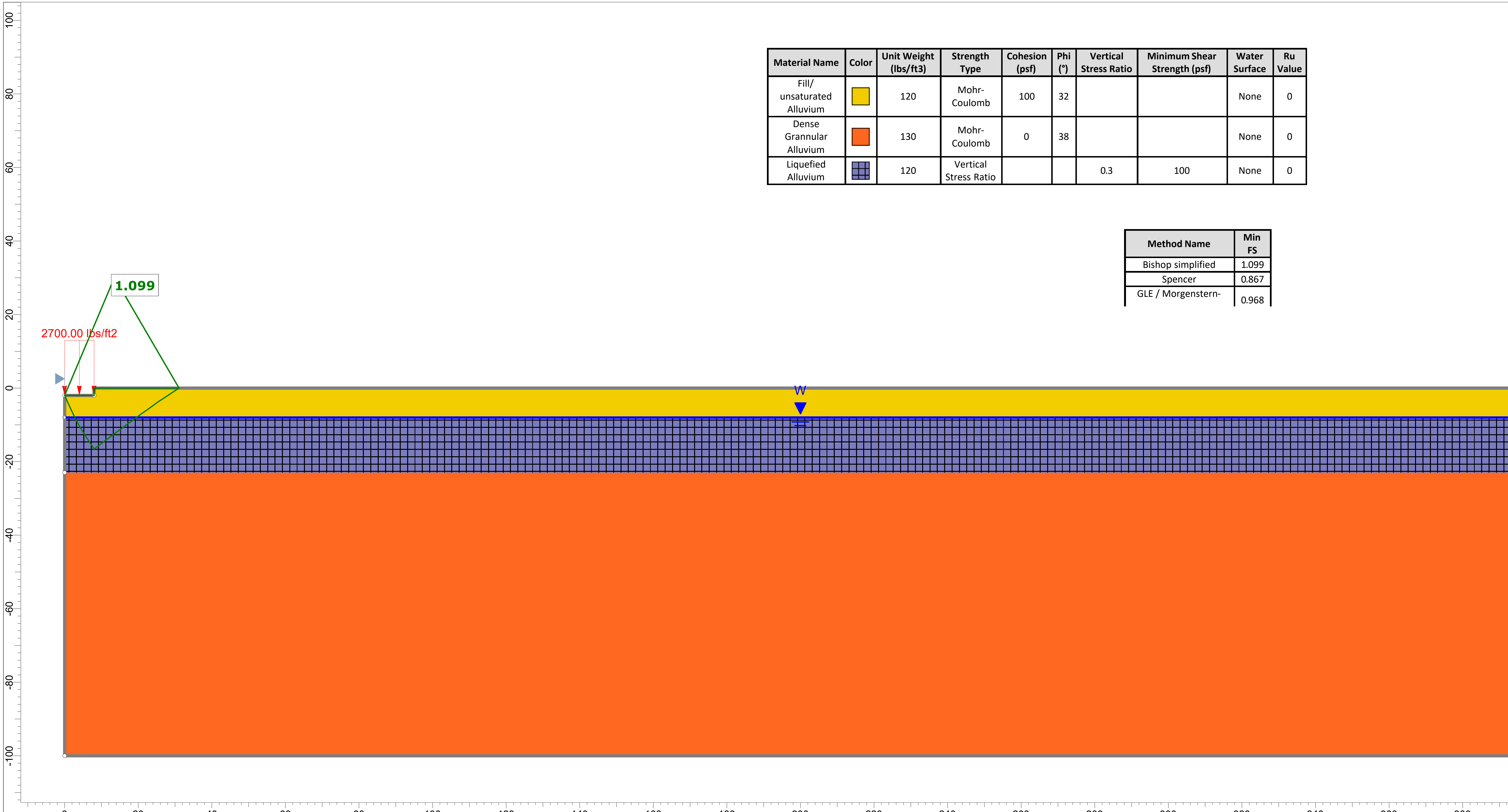
Method Name	Min FS
Bishop simplified	1.054
Spencer	0.775
GLE / Morgenstern-	0.982

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program

Group	4ft wide	*Scenario*	Master Scenario
Drawn By		*Checked By*	
Date	3/25/2024, 10:09:55 AM	*File Name*	KM Eugene Bearing Cap.slmd



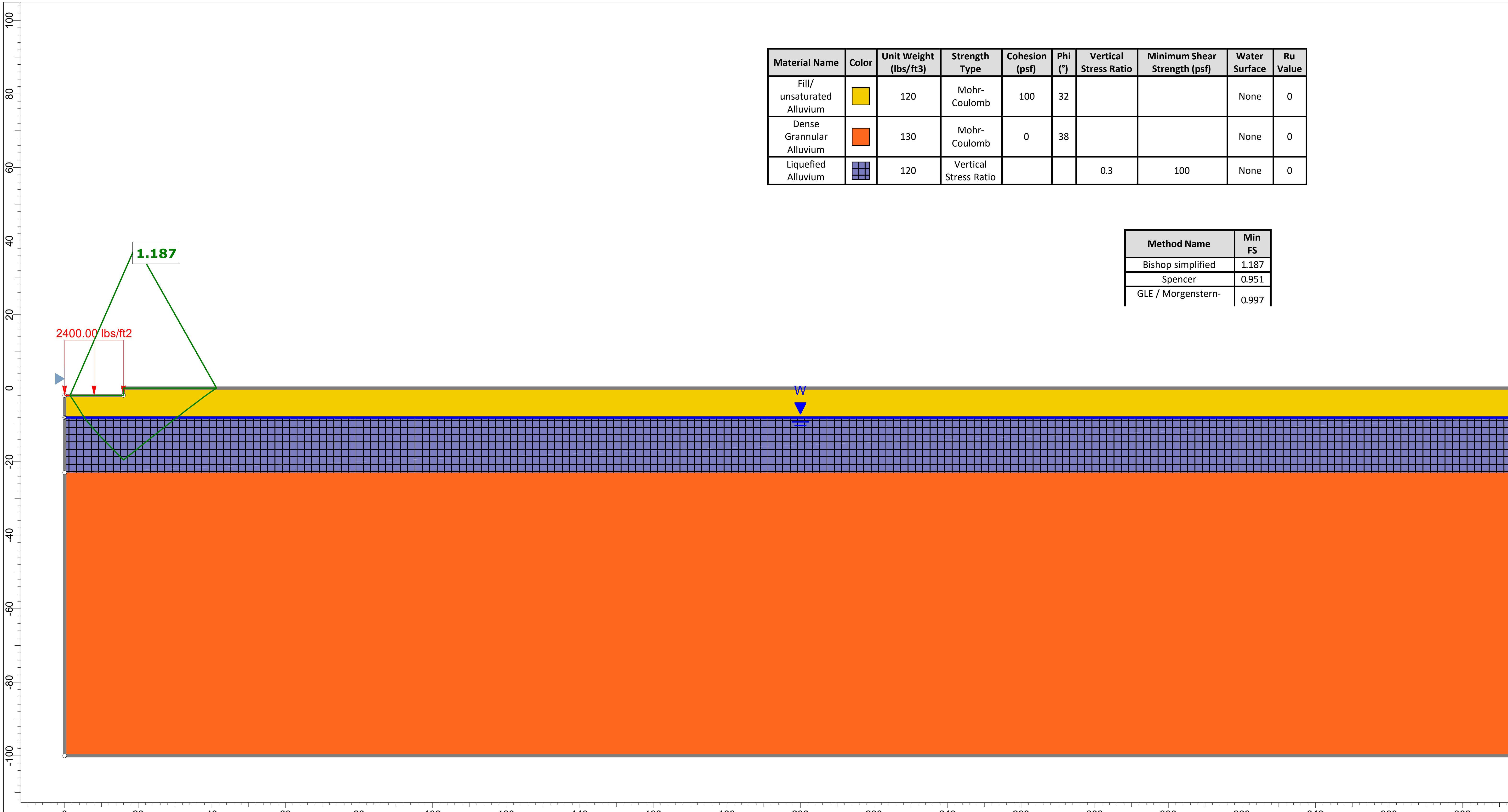
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill/ unsaturated Alluvium		120	Mohr-Coulomb	100	32			None	0
Dense Grannular Alluvium		130	Mohr-Coulomb	0	38			None	0
Liquefied Alluvium		120	Vertical Stress Ratio			0.3	100	None	0

Method Name	Min FS
Bishop simplified	1.099
Spencer	0.867
GLE / Morgenstern-	0.968

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program
Group	8ft wide
Scenario	Master Scenario
Drawn By	
Checked By	
Date	3/25/2024, 10:09:55 AM
File Name	KM Eugene Bearing Cap.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill/ unsaturated Alluvium		120	Mohr-Coulomb	100	32			None	0
Dense Grannular Alluvium		130	Mohr-Coulomb	0	38			None	0
Liquefied Alluvium		120	Vertical Stress Ratio			0.3	100	None	0

Method Name	Min FS
Bishop simplified	1.187
Spencer	0.951
GLE / Morgenstern-	0.997

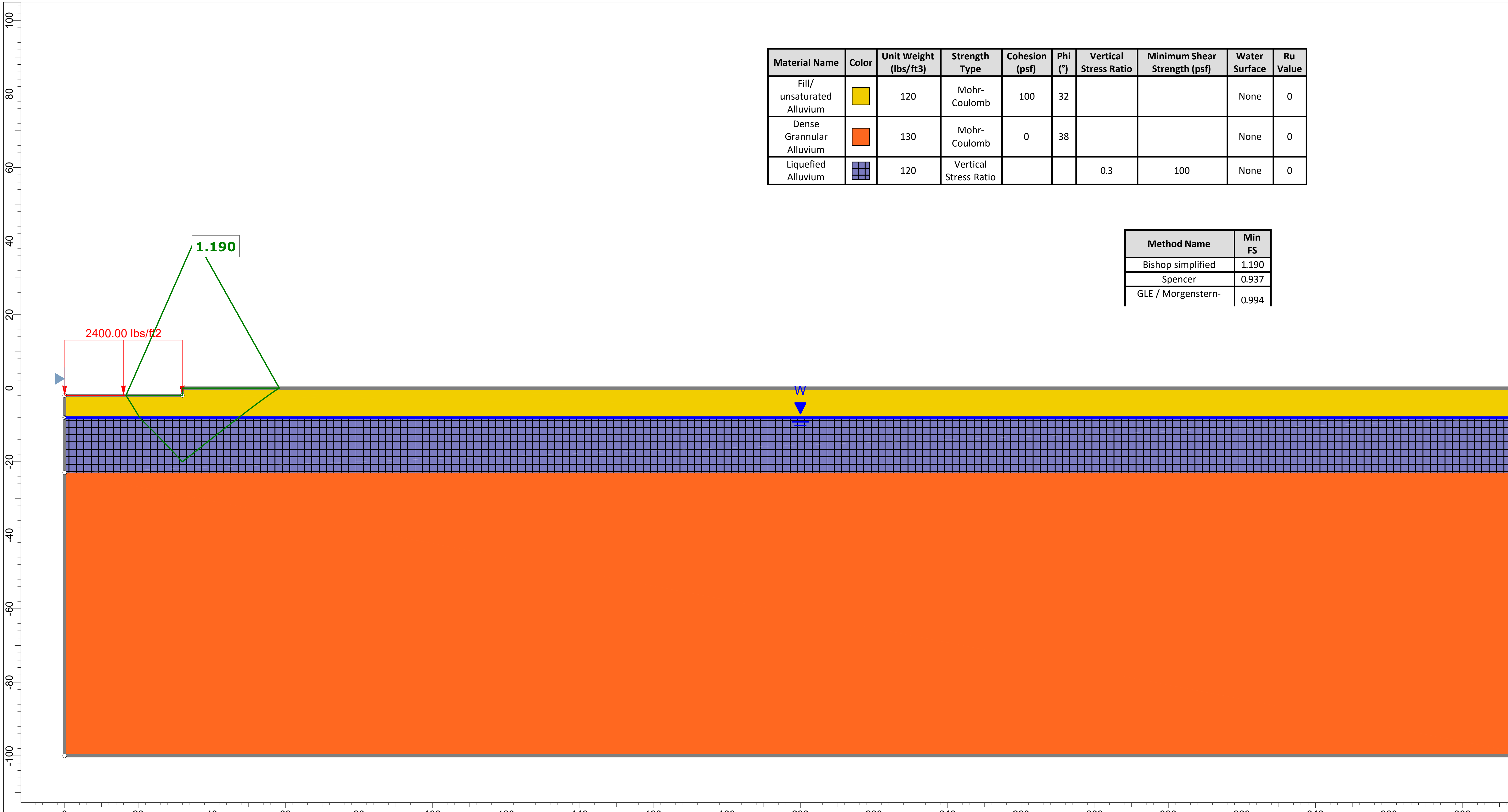
SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program
Group	16ft wide
Scenario	Master Scenario
Drawn By	
Checked By	
Date	3/25/2024, 10:09:55 AM
File Name	KM Eugene Bearing Cap.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill/ unsaturated Alluvium		120	Mohr-Coulomb	100	32			None	0
Dense Grannular Alluvium		130	Mohr-Coulomb	0	38			None	0
Liquefied Alluvium		120	Vertical Stress Ratio			0.3	100	None	0

Method Name	Min FS
Bishop simplified	1.190
Spencer	0.937
GLE / Morgenstern-	0.994

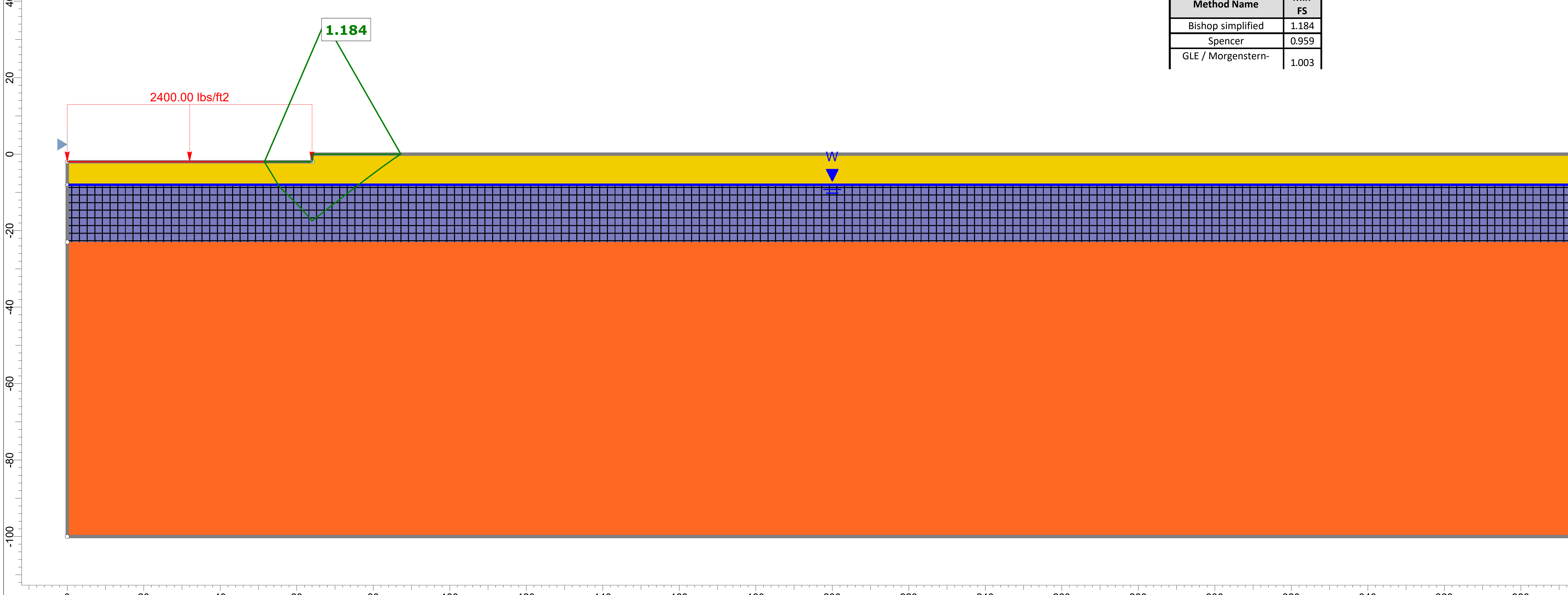


SAGE GEOTECHNICAL	*Project* Slide2 - An Interactive Slope Stability Program
Group 32ft wide	*Scenario* Master Scenario
Drawn By	*Checked By*
Date 3/25/2024, 10:09:55 AM	*File Name* KM Eugene Bearing Cap.slmd

SLIDEINTERPRET 9.028

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill/ unsaturated Alluvium		120	Mohr-Coulomb	100	32			None	0
Dense Grannular Alluvium		130	Mohr-Coulomb	0	38			None	0
Liquefied Alluvium		120	Vertical Stress Ratio			0.3	100	None	0

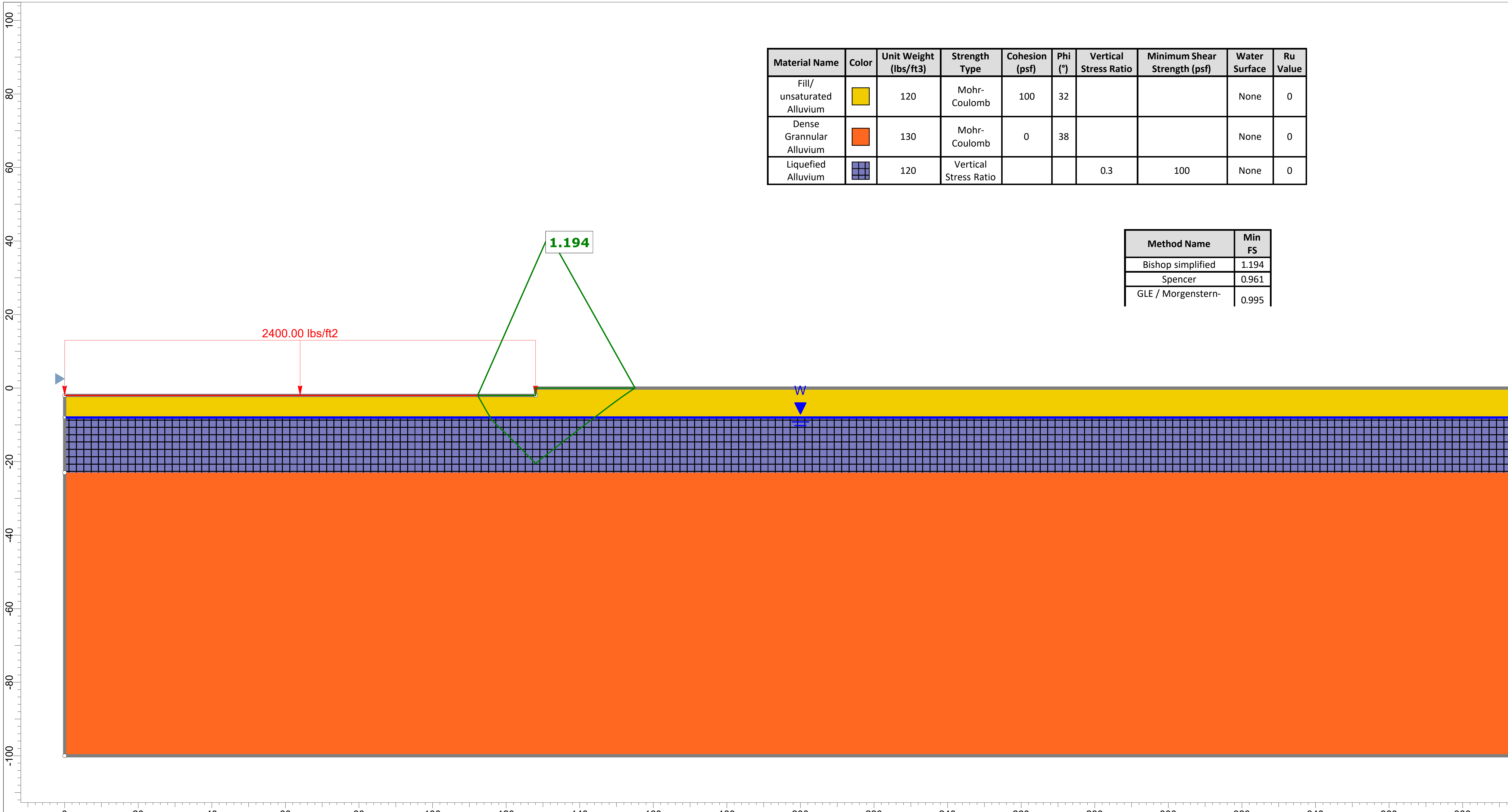
Method Name	Min FS
Bishop simplified	1.184
Spencer	0.959
GLE / Morgenstern-	1.003



SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program		
Group	64ft wide	Scenario	Master Scenario
Drawn By		Checked By	
Date	3/25/2024, 10:09:55 AM	File Name	KM Eugene Bearing Cap.slmd



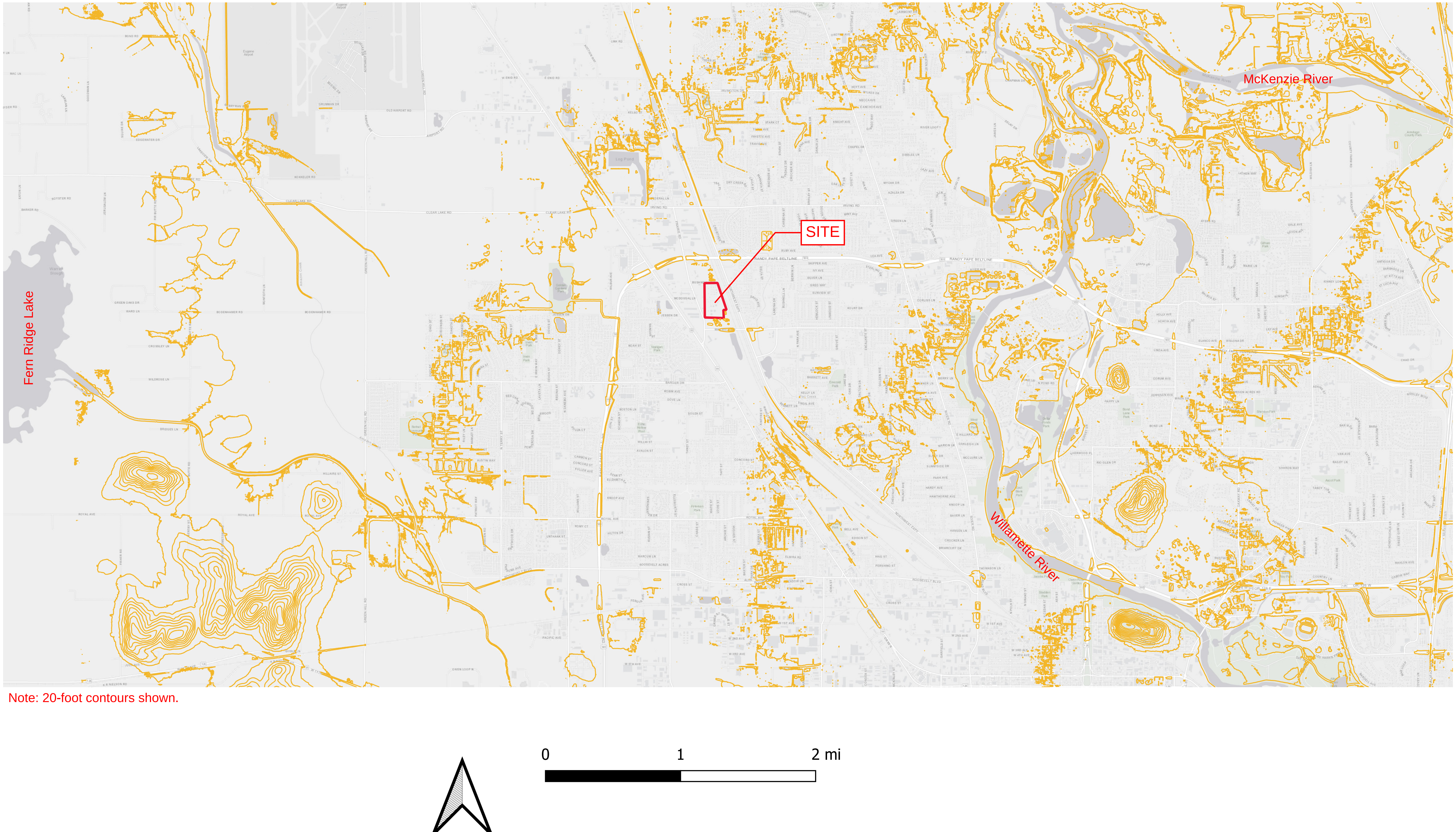
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill/ unsaturated Alluvium		120	Mohr-Coulomb	100	32			None	0
Dense Grannular Alluvium		130	Mohr-Coulomb	0	38			None	0
Liquefied Alluvium		120	Vertical Stress Ratio			0.3	100	None	0

Method Name	Min FS
Bishop simplified	1.194
Spencer	0.961
GLE / Morgenstern-	0.995

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program
Group	128ft wide
Scenario	Master Scenario
Drawn By	
Checked By	
Date	3/25/2024, 10:09:55 AM
File Name	KM Eugene Bearing Cap.slmd



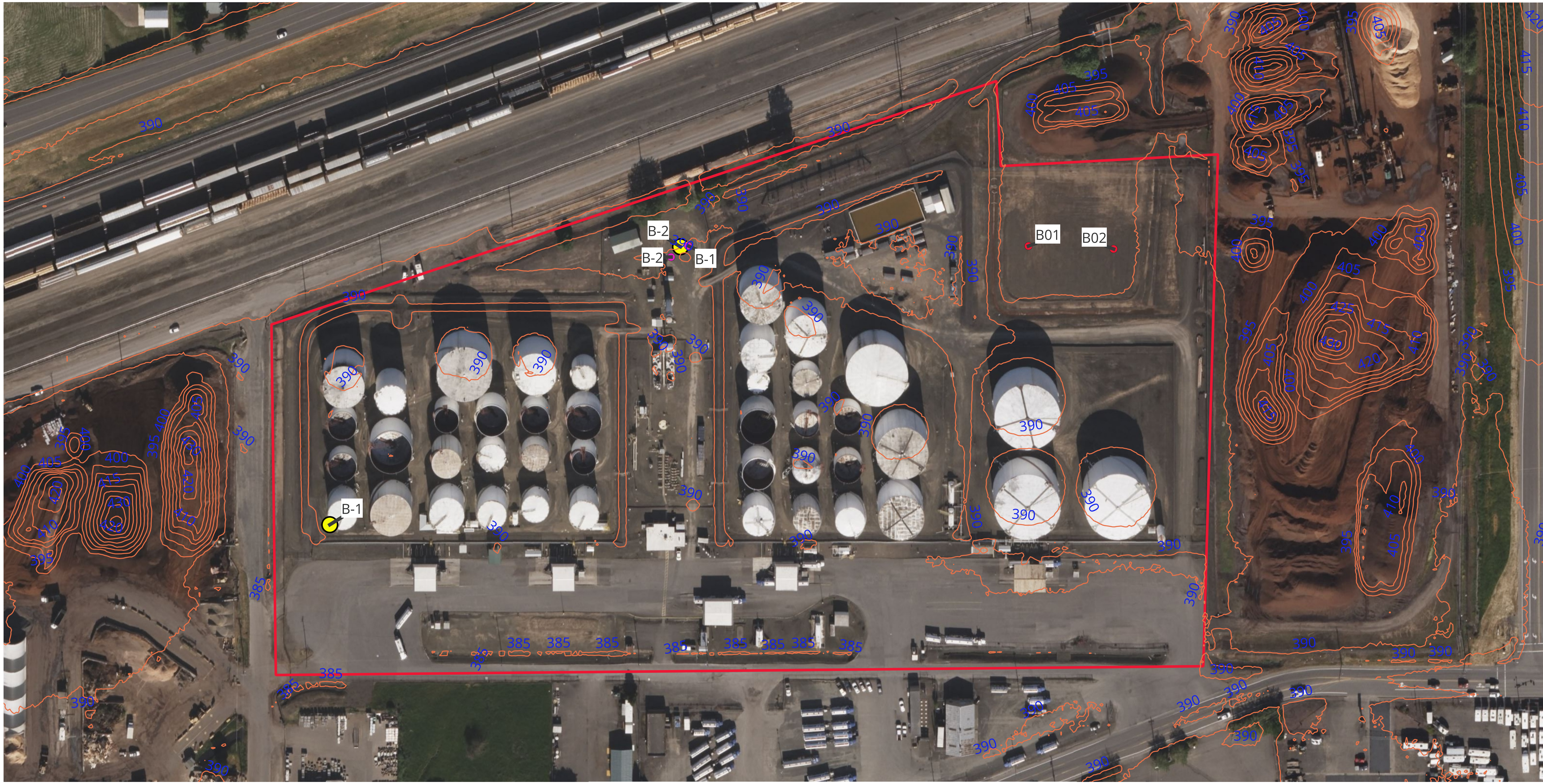
Vicinity Map

Kinder Morgan Eugene Terminal SVA

Eugene, Oregon

Figure G-1

SAGE GEOTECHNICAL



0 100 200 ft

Contours (5-ft intervals)

PSI (2023) Boring Location and Designation

Branch Engineering (2019) Boring Location and Designation

Sage (2024) Boring Location and Designation

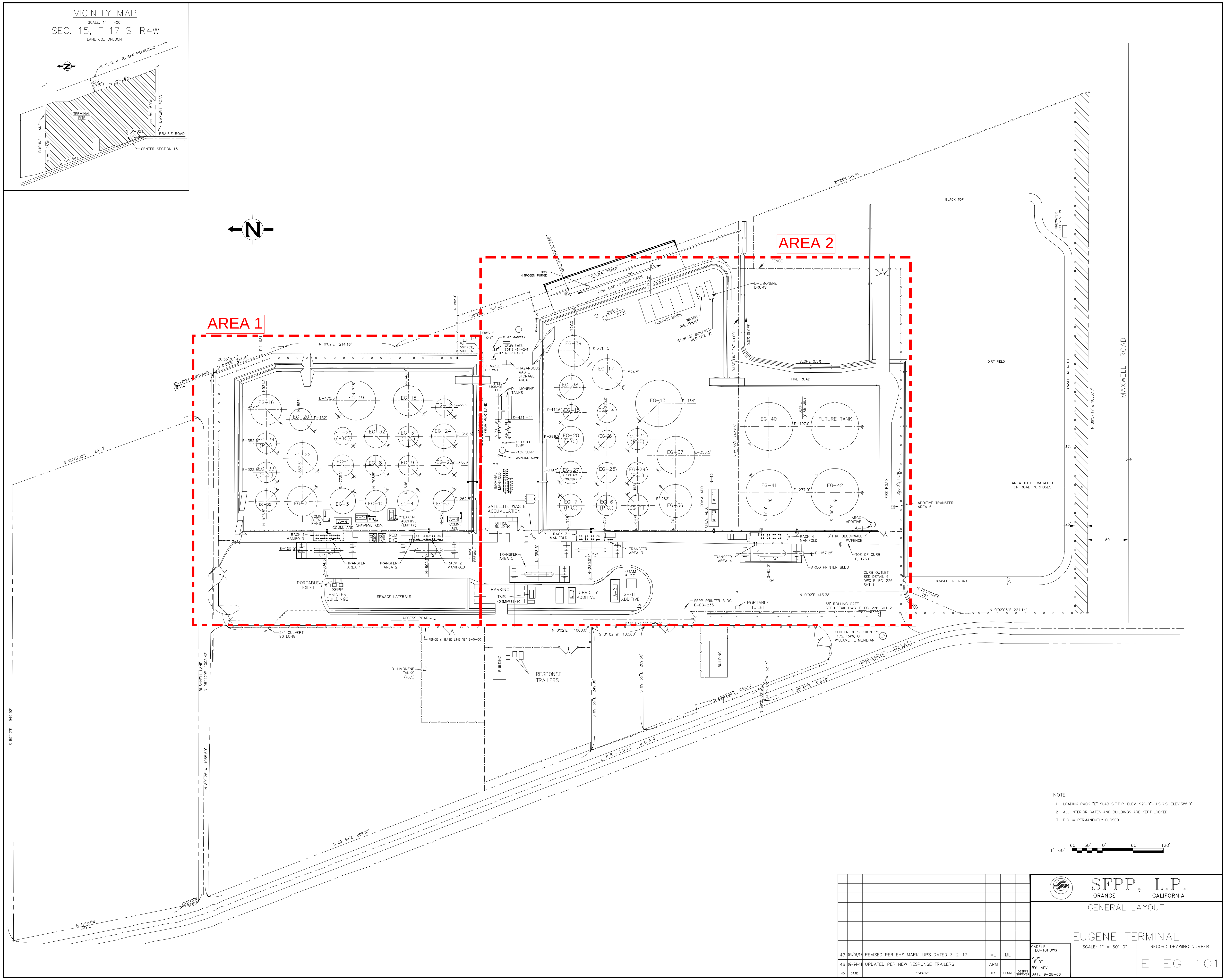
Approximate Site Boundary

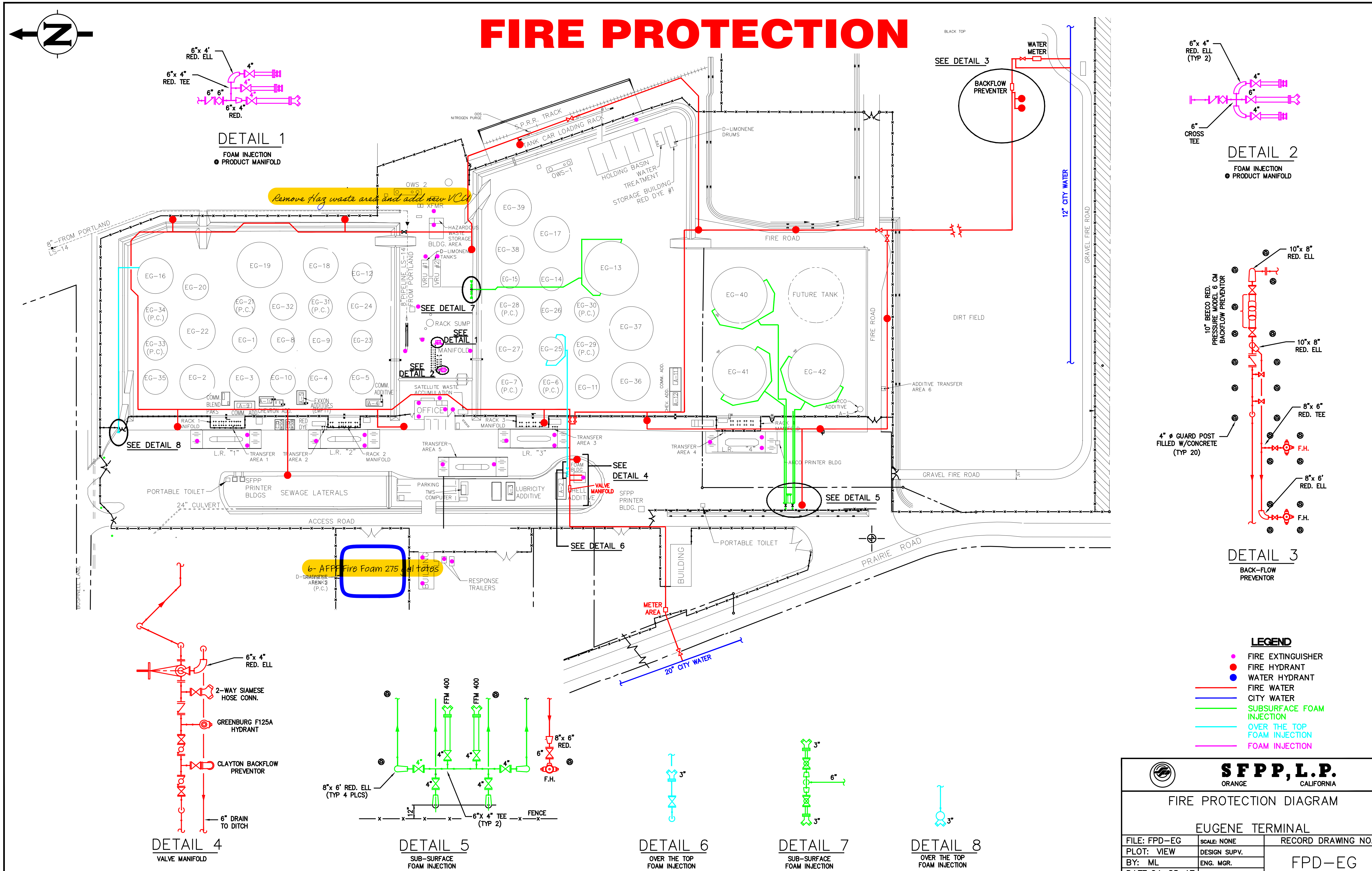
Bing Maps Satellite Imagery

SAGE GEOTECHNICAL

Site Plan	
Kinder Morgan Eugene Terminal SVA	
Eugene, Oregon	Figure G-2

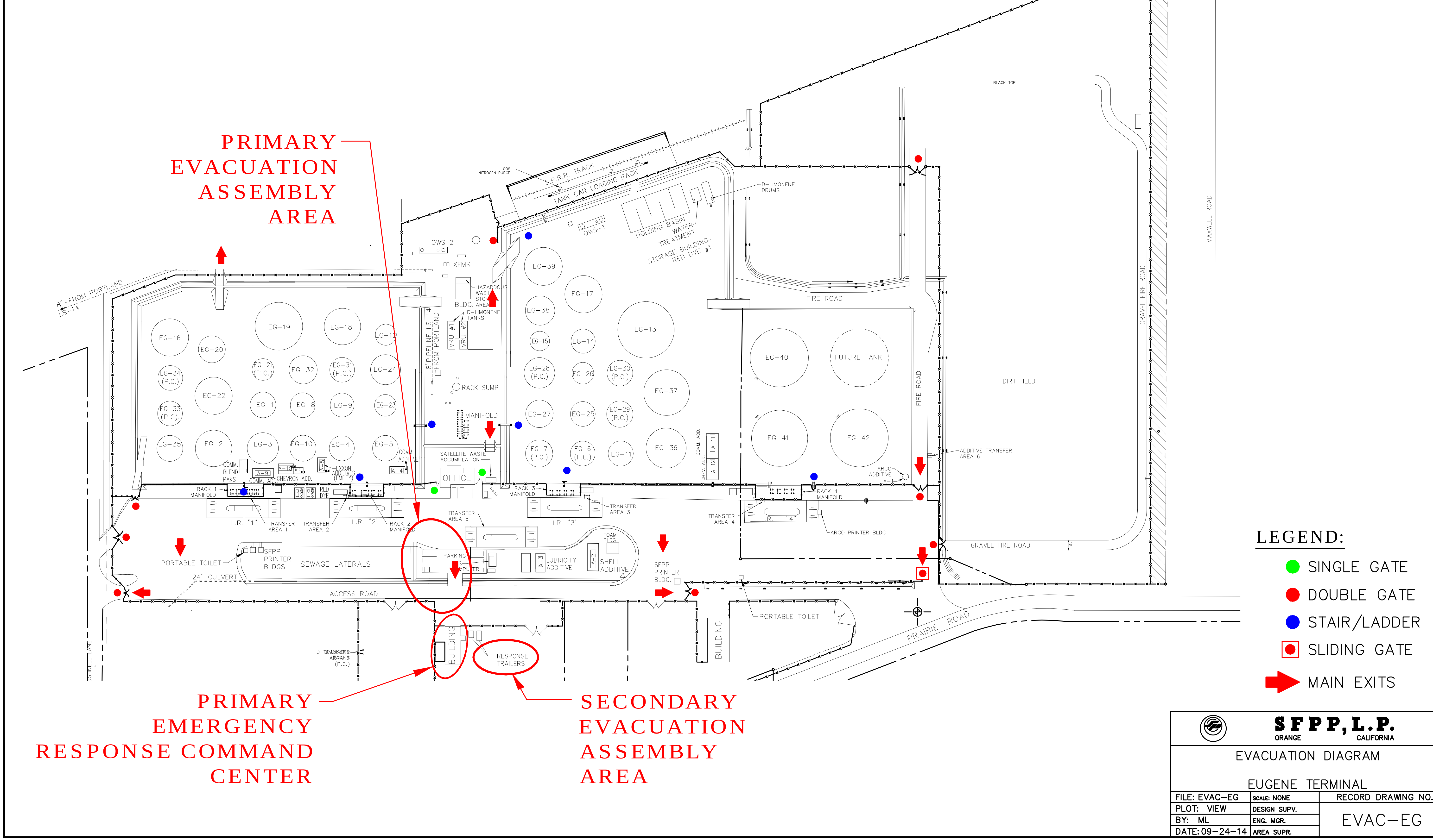
6.2 Appendix B: Site Plans


VICINITY MAP
SCALE: 1" = 400'
SEC. 15, T 17 S-R4W
LANE CO., OREGON
TERMINAL SITE
S. P. R. R. TO SAN FRANCISCO
BUSHNELL LANE
MAXWELL ROAD
PRAIRIE ROAD
CENTER SECTION 15
AREA 1
AREA 2
N
BLACK TOP
DIRT FIELD
MAXWELL ROAD
PRAIRIE ROAD
BUSHNELL LANE
S.P.R.R. TRACK
TANK CAR LOADING RACK
HOLDING BASIN
WATER TREATMENT
STORAGE BUILDING RED DYE #1
D-LIMONENE DRUMS
FENCE
FIRE ROAD
GRAVEL FIRE ROAD
FUTURE TANK
EG-1
EG-2
EG-3
EG-4
EG-5
EG-6 (P.C.)
EG-7 (P.C.)
EG-8
EG-9
EG-10
EG-11
EG-12
EG-13
EG-14
EG-15
EG-16
EG-17
EG-18
EG-19
EG-20
EG-21 (P.C.)
EG-22
EG-23
EG-24
EG-25
EG-26
EG-27 (CONTACT WATER)
EG-28 (P.C.)
EG-29 (P.C.)
EG-30 (P.C.)
EG-31 (P.C.)
EG-32
EG-33 (P.C.)
EG-34 (P.C.)
EG-35
EG-36
EG-37
EG-38
EG-39
EG-40
EG-41
EG-42
HAZARDOUS WASTE STORAGE AREA
D-LIMONENE TANKS
STEEL STORAGE BLDG.
SATELLITE WASTE ACCUMULATION
OFFICE BUILDING
RACK 1 MANIFOLD
RACK 2 MANIFOLD
RACK 3 MANIFOLD
RACK 4 MANIFOLD
TRANSFER AREA 1
TRANSFER AREA 2
TRANSFER AREA 3
TRANSFER AREA 4
TRANSFER AREA 5
ADDITIVE TRANSFER AREA 6
ARCO PRINTER BLDG
ARCO ADDITIVE
CHEVRON ADD.
EXXON ADDITIVE (EMPTY)
RED DYE
COMM. BLEND PAKS
PORTABLE TOILET
SFPP PRINTER BUILDINGS
SEWAGE LATERALS
PARKING
TMS COMPUTER
LUBRICITY ADDITIVE
SHELL ADDITIVE
FOAM BLDG
SFPP PRINTER BLDG. E-EG-233
ACCESS ROAD
24" CULVERT 90' LONG
D-LIMONENE TANKS (P.C.)
RESPONSE TRAILERS
BUILDING
55' ROLLING GATE SEE DETAIL DWG. E-EG-226 SHT 2
CENTER OF SECTION 15, T17S, R4W, OF WILLAMETTE MERIDIAN
AREA TO BE VACATED FOR ROAD PURPOSES
NOTE
1. LOADING RACK "E" SLAB S.F.P.P. ELEV. 92'-0"+U.S.G.S. ELEV.385.0'
2. ALL INTERIOR GATES AND BUILDINGS ARE KEPT LOCKED.
3. P.C. = PERMANENTLY CLOSED
1"=60'
47 03/06/17 REVISED PER EHS MARK-UPS DATED 3-2-17 ML ML
46 09-24-14 UPDATED PER NEW RESPONSE TRAILERS ARM
NO. DATE REVISIONS BY CHECKED DESIGN SUPRVSR
SFPP, L.P.
ORANGE CALIFORNIA
GENERAL LAYOUT
EUGENE TERMINAL
CADFILE: EG-101.DWG
SCALE: 1" = 60'-0"
RECORD DRAWING NUMBER
BY: VFV
DATE: 9-28-06
E-EG-101



FIRE PROTECTION
Z
DETAIL 1
FOAM INJECTION @ PRODUCT MANIFOLD
6"x 4' RED. ELL
6"x 4" RED. TEE
6"x 4" RED.
DETAIL 2
FOAM INJECTION @ PRODUCT MANIFOLD
6"x 4" RED. ELL (TYP 2)
6" CROSS TEE
DETAIL 3
BACK-FLOW PREVENTOR
10"x 8" RED. ELL
10" BEECO RED. PRESSURE MODEL 6 CM BACKFLOW PREVENTOR
8"x 6" RED. TEE
8"x 6' RED. ELL
4" ø GUARD POST FILLED W/CONCRETE (TYP 20)
F.H.
DETAIL 4
VALVE MANIFOLD
6"x 4" RED. ELL
2-WAY SIAMESE HOSE CONN.
GREENBURG F125A HYDRANT
CLAYTON BACKFLOW PREVENTOR
6" DRAIN TO DITCH
DETAIL 5
SUB-SURFACE FOAM INJECTION
FFM 400
8"x 6' RED. ELL (TYP 4 PLCS)
6"x 4" TEE (TYP 2)
FENCE
8"x 6" RED.
F.H.
DETAIL 6
OVER THE TOP FOAM INJECTION
DETAIL 7
SUB-SURFACE FOAM INJECTION
DETAIL 8
OVER THE TOP FOAM INJECTION
SEE DETAIL 3
WATER METER
BACKFLOW PREVENTER
12" CITY WATER
20" CITY WATER
METER AREA
Remove Haz waste area and add new VCU
6- AFFF Fire Foam 275 gal totes
S.P.R.R. TRACK
TANK CAR LOADING RACK
HOLDING BASIN
WATER TREATMENT
STORAGE BUILDING RED DYE #1
D-LIMONENE DRUMS
FIRE ROAD
GRAVEL FIRE ROAD
DIRT FIELD
FUTURE TANK
PRAIRIE ROAD
ACCESS ROAD
SEWAGE LATERALS
PORTABLE TOILET
24" CULVERT
8"-FROM PORTLAND LS-14
HAZARDOUS WASTE STORAGE BLDG. AREA
SEE DETAIL 7
SEE DETAIL 1
SEE DETAIL 2
SEE DETAIL 4
SEE DETAIL 5
SEE DETAIL 6
SEE DETAIL 8
OFFICE
RESPONSE TRAILERS
BUILDING
SFPP PRINTER BLDG.
LUBRICITY ADDITIVE
VALVE MANIFOLD
EG-16 EG-20 EG-19 EG-18 EG-12 EG-34 (P.C.) EG-21 (P.C.) EG-32 EG-31 (P.C.) EG-24 EG-22 EG-33 (P.C.) EG-1 EG-8 EG-9 EG-23 EG-35 EG-2 EG-3 EG-10 EG-4 EG-5
EG-39 EG-17 EG-38 EG-15 EG-14 EG-13 EG-28 (P.C.) EG-26 EG-30 (P.C.) EG-37 EG-27 EG-25 EG-29 (P.C.) EG-7 (P.C.) EG-6 (P.C.) EG-11 EG-36
EG-40 EG-41 EG-42
LEGEND
FIRE EXTINGUISHER
FIRE HYDRANT
WATER HYDRANT
FIRE WATER
CITY WATER
SUBSURFACE FOAM INJECTION
OVER THE TOP FOAM INJECTION
FOAM INJECTION
SFPP, L.P.
ORANGE CALIFORNIA
FIRE PROTECTION DIAGRAM
EUGENE TERMINAL
FILE: FPD-EG
PLOT: VIEW
BY: ML
DATE: 04-25-17
SCALE: NONE
DESIGN SUPV.
ENG. MGR.
AREA SUPR.
RECORD DRAWING NO.
FPD-EG

EVACUATION PLAN



6.3 Appendix C: Photographs

Picture 1. Typical view of tank farm.

Picture 2. View of typical truck loading rack.

Picture 3. View of typical truck loading rack framing.

Picture 4. Typical view of buried piping.

Picture 5. Typical view of containment wall.

Picture 6. Typical view of gravel berm containment.

Picture 7. Typical view of unanchored additive tank.

Picture 8. Typical canopy structure.

Picture 9. View of office building.

Picture 10. Tank car loading rack at South Yard.

Picture 11. Unanchored vertical additive tank at South Yard.

Picture 12. Unanchored electrical transformer at South Yard.