

APPENDIX E
LIQUEFACTION EVALUATION

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GENERAL

Analyses were conducted to evaluate the potential for liquefaction of the Piñon Ridge overburden soils under the design seismic loading conditions. Data for the analyses were obtained from Standard Penetration Tests (SPT) conducted as part of the Phase 2 geotechnical exploration program (both split spoon and modified California barrel samplers were used). Detailed liquefaction analyses are presented in this appendix, and the following discussion summarizes these analyses.

SEISMIC DESIGN CRITERIA

The seismic review conducted by Kleinfelder (2008) established the seismic risk at the site. The Maximum Considered Earthquake (MCE) is a moment magnitude **M** 4.8 earthquake occurring at a distance of 15.5 kilometers (km) from the site, with an associated peak ground acceleration (PGA) of 0.16g. The Design Earthquake has a PGA of 0.11g, equal to two-thirds of the PGA for the MCE.

LIQUEFACTION POTENTIAL USING SPT DATA

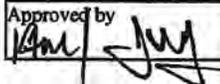
The liquefaction potential of the overburden soils were evaluated using the results of Standard Penetration Tests (SPTs). Though the water table is well below the zone of interest, this liquefaction analysis conservatively evaluates the liquefaction potential of the overburden soil assuming the phreatic surface is at the ground surface.

The results from the SPT liquefaction evaluation presented in this appendix show that the overburden soils at the Piñon Ridge Project site are not susceptible to liquefaction for either the design earthquake or the MCE. The minimum factor of safety against liquefaction under the design earthquake and MCE events were evaluated to be 4.3 and 2.9, respectively, in drill hole GA-BH-36 at a depth of 10 feet where the unadjusted blow count was 9. Therefore, the liquefaction analyses indicate that liquefaction of the overburden soils is not predicted for any earthquake event that may be expected at the site, up to the MCE, even in the event of saturation.

APPENDIX E-1
LIQUEFACTION ANALYSES



Subject Piñon Ridge
Liquefaction Assessment
Using SPT Data

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OBJECTIVE:

Evaluate the potential for liquefaction of the overburden soils at the Piñon Ridge site using the results of SPT tests.

GIVEN:

- Results of SPT tests (using both split spoon and modified California barrel samplers) conducted during hollow stem auger drilling of borings GA-BH-01 through GA-BH-48 to depths of up to 100 feet. Drillholes were advanced to bedrock using 8-inch O.D., 4.25-inch I.D. hollow stem auger.

SITE SEISMICITY:

- The Maximum Considered Earthquake (MCE) has a peak ground acceleration of 0.161g with a return period of 2475 years based on a M 4.8 earthquake located 15.5 km from the project site (Kleinfelder, 2008).
- The Design Earthquake (DE) (taken as 2/3 of the MCE) has a peak ground acceleration of 0.107g (Kleinfelder, 2008).

ASSUMPTIONS:

- The average overburden soil density is 107 pounds per cubic foot (pcf);
- The water surface is well below the deepest overburden soils (phreatic surface below bedrock contact);
- Though no subsurface water was identified during the field investigation, these analyses evaluate the liquefaction potential of the overburden soil conservatively assuming the phreatic surface at the ground surface.

METHODOLOGY:

The selected method to assess liquefaction potential of foundation materials is based on the Simplified Method using correlations to blow counts from Standard Penetration Tests (SPTs) as set forth in Youd et al (2001) and discussed in NRC (1985). It is important to note that the Simplified Method cannot directly address the effects of variable void ratio, variability in percent fines, or the plasticity of the fines on liquefaction. Guo and Prakash (1999) presented a summary of laboratory test data that showed liquefaction of silt and silty clay soils is highly dependent on clay content, plasticity of the fines, and void ratio. The data presented indicated that for soils at a constant void ratio, increasing the percent fines decreases resistance to liquefaction, which is counter to traditional approaches. The data also showed that increasing the plasticity index to above 20 significantly increased resistance to liquefaction. Similar findings are presented in Polito and Martin (2001).

The Simplified Method requires estimating the Cyclic Stress Ratio (CSR) and Cyclic Resistance Ratio (CRR) of the soil. The CRR can be estimated using information from SPT tests, corrected to account for various effects. To use the Simplified Method, the SPT N value is normalized to an overburden pressure of approximately 100 kiloPascals (kPa) and a hammer energy ratio of 60 percent. The equation to normalize the blow count is:

$$(N_1)_{60} = N_m \cdot C_n \cdot C_E \cdot C_B \cdot C_R \cdot C_S$$

where:



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- $(N_1)_{60}$ = the SPT blow count normalized to an overburden pressure of 100 kiloPascal (kPa) (2116.8 pounds per square foot (psf)) and a hammer energy ratio of 60 percent;
- N_m = the measured blow count;
- C_n = the overburden correction factor;
- C_E = the energy ratio correction factor;
- C_B = the borehole diameter correction factor;
- C_R = the rod length correction factor; and
- C_s = the sampling method factor.

The correction factors are summarized as follows:

Factor	Equipment Variable	Term	Correction
Overburden Pressure	-	C_n	$(2116.8 \text{pcf} / \sigma')^{0.5}$
Overburden Pressure	-	C_n	$C_n = 1.7$
Energy Ratio	Safety Hammer	C_E	0.7 to 1.2
Borehole Diameter	200 mm	C_B	1.15
Rod Length	< 10 ft	C_R	0.75
Rod Length	10-13 ft	C_R	0.80
Rod Length	13-20 ft	C_R	0.85
Rod Length	20-30 ft	C_R	0.95
Rod Length	> 30 ft	C_R	1.0
Sampling Method	Standard sampler	C_s	1.0
Sampling Method	Sampler without liners	C_s	1.1 to 1.3

Notes: (1) Assumed energy ratio correction factor (C_E) of 0.95; (2) Assumed borehole diameter correction factor (C_B) of 1.15; and (3) Assumed $C_s = 1.0$ when using modified California barrel and $C_s = 1.2$ when using split spoon sampler.

The $(N_1)_{60}$ may also be corrected for the percent of fines using the relationship:

$$(N_1)_{60cs} = \alpha + \beta(N_1)_{60}$$

where α and β are coefficients based on the following relationships:

$$\alpha = 0 \text{ for } FC \leq 5\%$$

$$\alpha = \exp[1.76 - (190 / FC^2)] \text{ for } 5\% < FC < 35\%$$

$$\alpha = 5 \text{ for } FC \geq 35\%$$



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$$\beta = 0 \text{ for } FC \leq 5\%$$

$$\beta = \exp\left[0.99 + \left(\frac{FC^{1.5}}{1000}\right)\right] \text{ for } 5\% < FC < 35\%$$

$$\beta = 1.2 \text{ for } FC \geq 35\%$$

It is important to note that the fines correction, although widely used, is considered as a rough approximation only. The fines content of the tailings at the test depths was obtained from the results of laboratory test data. Where data was unavailable, a fines content of 39 percent was assumed based on average laboratory testing results of overburden soils.

Once the corrected value for $(N_1)_{60cs}$ is found, the CRR is calculated as:

$$CRR_{7.5} = \frac{1}{34 - (N_1)_{60cs}} + \frac{(N_1)_{60cs}}{135} + \frac{50}{[10 \cdot (N_1)_{60cs} + 45]^2} - \frac{1}{200}$$

for $(N_1)_{60cs}$ values less than 30. Where $(N_1)_{60cs} \geq 30$, clean granular soils are too dense to liquefy and are classed as non-liquefiable (Youd, et al., 2001).

Note that the value calculated is the CRR normalized to a 7.5 magnitude earthquake, hence the $CRR_{7.5}$ notation. When evaluating the liquefaction potential of soil, the $CRR_{7.5}$ must be corrected to the magnitude earthquake of interest. The correction for earthquake magnitude is discussed later.

The CSR is independent of soil properties and may be approximated using the equation:

$$CSR = 0.65 \left(\frac{a_{max}}{g}\right) \left(\frac{\sigma_v}{\sigma'_v}\right) r_d$$

where:

a_{max} = the maximum ground acceleration.

σ_v = the total vertical stress;

σ'_v = the effective vertical stress; and

r_d = a stress reduction coefficient.

Based on the earthquake hazard assessment conducted by Kleinfelder (2008), the Piñon Ridge site has a Design Earthquake (DE) ground acceleration of 0.11 g, therefore a_{max} divided by g is equal to 0.11.

The stress reduction coefficient, r_d , can be approximated as (per Youd et al., 2001):

$$r_d = \frac{(1.000 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5})}{(1.000 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^2)}$$

where z = depth beneath the ground surface in meters.



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Liquefaction potential for a soil unit is evaluated by dividing $CRR_{7.5}$ by CSR and then correcting to the magnitude earthquake of interest, as:

$$FS = \frac{CRR_{7.5}}{CSR} \cdot MSF$$

If FS is less than 1.0, liquefaction is likely. If FS is greater than 1.0, liquefaction is unlikely. Field experience has shown that the Simplified Method is somewhat conservative; so many designers consider FS values close to unity as an indication of no liquefaction. The Magnitude Scaling Factor (MSF) derived by Seed, and published in Youd et al. (2001), may be calculated as follows:

$$MSF = 10^{2.24} / M_w^{2.56}$$

where M_w is the earthquake magnitude. For the Piñon Mill site, a magnitude 4.8 earthquake was evaluated, which corresponds to the Design Earthquake (DE). This magnitude earthquake was selected based on the results of the site-specific seismicity study (Kleinfelder, 2008).

RESULTS:

To assess liquefaction potential of the overburden soils at the Piñon Ridge site, the logs from multiple representative geotechnical borings and laboratory test data from split spoon samplers and modified California barrel samplers were used. The boring logs include the SPT blow counts and soil lithologic descriptions with depth.

Spreadsheets were developed for each of the proposed areas (evaporation ponds, tailings cells, and ore pads) to assess the liquefaction potential assuming saturated conditions, which is considered very conservative as the phreatic surface is well below the overburden soils and the lining of each facility should prevent the underlying soil from becoming saturated. Spreadsheets showing the liquefaction analysis and results for the three proposed areas are attached.

The results from the SPT liquefaction evaluation presented above show that the overburden soils on the Piñon Mill site are not susceptible to liquefaction for the design earthquake. The lowest factor of safety against liquefaction was calculated to be 4.3, assuming saturated conditions in GA-BH-36 at a depth of 10 feet, where the unadjusted blow count was 9.



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**PIÑON RIDGE LIQUEFACTION ANALYSIS
EVAPORATION POND AREA
ASSUMED SHALLOW PNEATIC SURFACE
(DESIGN EARTHQUAKE EVENT)**

Earthquake Moment Magnitude, $M_w = 4.8$
 Earthquake Radius (km) = 15.5
 Maximum horizontal ground acceleration = 0.11
 Unit weight (pcf) = 107
 Depth to water (ft) = 0

44.6

Hoile No. GA-BH-	Depth (feet/BS)	Depth (m)	Sampler Type ¹	Soil Type	σ_v (psf)	σ'_v (psf)	N_{60} (blows/ft)	C_H	C_c	C_R	C_n	C_u	$(N_{1,60})_{cs}$ (blows/ft)	Fines Content ² (%)	α	β	$(N_{1,60})_{cs}$ (blows/ft)	r_d	CSR	(CRR) _s	MSF	FS _{s,c} ³	Liquefaction Potential
01	2.00	0.61	MCB	S	214	89	24	1.70	0.95	1.15	0.75	1	33.4	39	5.000	1.200	45.1	0.997	0.171	No Liquefaction	3.13	10.0	No Liquefaction
01	9.00	2.74	MCB	S	963	401	42	1.70	0.95	1.15	0.75	1	58.5	34.4	4.950	1.192	74.7	0.981	0.168	No Liquefaction	3.13	10.0	No Liquefaction
01	14.00	4.27	MCB	S	1498	624	50	1.70	0.95	1.15	0.85	1	78.9	39	5.000	1.200	99.7	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
01	19.00	5.79	MCB	S	2033	847	50	1.58	0.95	1.15	0.85	1	71.4	39	5.000	1.200	93.1	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
01	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.95	1	73.0	39	5.000	1.200	92.6	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
02	3.00	0.91	MCB	S	321	134	50	1.70	0.95	1.15	0.75	1	69.6	39	5.000	1.200	88.6	0.995	0.171	No Liquefaction	3.13	10.0	No Liquefaction
02	9.00	2.74	MCB	S	963	401	50	1.70	0.95	1.15	0.75	1	69.6	39	5.000	1.200	88.6	0.995	0.171	No Liquefaction	3.13	10.0	No Liquefaction
02	14.00	4.27	MCB	S	1498	624	50	1.70	0.95	1.15	0.85	1	73.4	39	5.000	1.200	99.7	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
02	19.00	5.79	MCB	S	2033	847	50	1.58	0.95	1.15	0.85	1	73.4	39	5.000	1.200	99.7	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
02	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.95	1	66.4	39	5.000	1.200	84.7	0.935	0.169	No Liquefaction	3.13	10.0	No Liquefaction
02	29.00	8.84	MCB	S	3103	1293	50	1.28	0.95	1.15	0.95	1	63.6	39	5.000	1.200	81.3	0.889	0.153	No Liquefaction	3.13	10.0	No Liquefaction
02	35.00	10.67	MCB	S	3745	1561	50	1.16	0.95	1.15	0.95	1	60.3	39	5.000	1.200	77.3	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
03	1.50	0.46	MCB	S	4173	1739	50	1.10	0.95	1.15	0.75	1	48.3	39	5.000	1.200	63.5	0.998	0.171	No Liquefaction	3.13	10.0	No Liquefaction
03	4.00	1.22	MCB	S	161	67	35	1.70	0.95	1.15	0.75	1	60.3	39	5.000	1.200	82.1	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
03	9.00	2.74	MCB	S	963	401	50	1.70	0.95	1.15	0.75	1	58.5	39	5.000	1.200	75.2	0.993	0.170	No Liquefaction	3.13	10.0	No Liquefaction
03	14.00	4.27	MCB	S	1498	624	42	1.70	0.95	1.15	0.85	1	66.4	39	5.000	1.200	84.6	0.981	0.168	No Liquefaction	3.13	10.0	No Liquefaction
03	19.00	5.79	MCB	S	2033	847	50	1.58	0.95	1.15	0.85	1	66.4	39	5.000	1.200	84.6	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
03	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.95	1	73.4	39	5.000	1.200	99.7	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
03	29.00	8.84	MCB	S	3103	1293	50	1.28	0.95	1.15	0.95	1	66.4	39	5.000	1.200	84.6	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
03	34.00	10.37	MCB	S	3638	1516	50	1.18	0.95	1.15	0.95	1	64.4	39	5.000	1.200	82.1	0.897	0.154	No Liquefaction	3.13	10.0	No Liquefaction
03	39.00	11.89	MCB	S	4173	1739	50	1.10	0.95	1.15	0.95	1	60.3	39	5.000	1.200	77.3	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
03	44.00	13.41	MCB	S	4708	1962	50	1.04	0.95	1.15	0.95	1	53.4	39	5.000	1.200	69.5	0.763	0.131	No Liquefaction	3.13	10.0	No Liquefaction
15	3.00	0.91	MCB	S	321	134	17	1.70	0.95	1.15	0.75	1	23.7	39	5.000	1.200	33.4	0.995	0.171	No Liquefaction	3.13	10.0	No Liquefaction
15	9.00	2.74	MCB	S	963	401	32	1.70	0.95	1.15	0.75	1	21.7	39	5.000	1.200	33.4	0.995	0.171	No Liquefaction	3.13	10.0	No Liquefaction
15	14.00	4.27	MCB	S	1498	624	41	1.70	0.95	1.15	0.75	1	23.7	39	5.000	1.200	33.4	0.995	0.171	No Liquefaction	3.13	10.0	No Liquefaction
15	18.00	5.49	MCB	S	1926	803	41	1.62	0.95	1.15	0.85	1	48.3	39	5.000	1.200	58.5	0.981	0.168	No Liquefaction	3.13	10.0	No Liquefaction
15	22.00	6.71	MCB	S	2454	1026	50	1.41	0.95	1.15	0.95	1	48.3	39	5.000	1.200	58.5	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
15	26.00	7.93	MCB	S	2982	1249	50	1.28	0.95	1.15	0.95	1	61.8	39	5.000	1.200	79.2	0.962	0.165	No Liquefaction	3.13	10.0	No Liquefaction
15	30.00	9.15	MCB	S	3510	1472	50	1.28	0.95	1.15	0.95	1	73.0	39	5.000	1.200	92.6	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
15	34.00	10.37	MCB	S	4038	1695	50	1.18	0.95	1.15	0.95	1	66.4	39	5.000	1.200	84.7	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
15	38.00	11.59	MCB	S	4566	1918	50	1.10	0.95	1.15	0.95	1	60.3	39	5.000	1.200	77.3	0.897	0.154	No Liquefaction	3.13	10.0	No Liquefaction
15	42.00	12.81	MCB	S	5094	2141	50	1.04	0.95	1.15	0.95	1	53.4	39	5.000	1.200	69.5	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
15	46.00	14.03	MCB	S	5622	2364	50	0.98	0.95	1.15	0.95	1	43.1	39	5.000	1.200	56.7	0.813	0.140	No Liquefaction	3.13	10.0	No Liquefaction
15	50.00	15.25	MCB	S	6150	2587	50	0.94	0.95	1.15	0.95	1	53.1	39	5.000	1.200	69.5	0.763	0.131	No Liquefaction	3.13	10.0	No Liquefaction
15	54.00	16.47	MCB	S	6678	2810	50	0.90	0.95	1.15	0.95	1	51.2	39	5.000	1.200	66.5	0.713	0.122	No Liquefaction	3.13	10.0	No Liquefaction
15	58.00	17.69	MCB	S	7206	3033	50	0.86	0.95	1.15	0.95	1	49.0	39	5.000	1.200	63.8	0.667	0.114	No Liquefaction	3.13	10.0	No Liquefaction
15	62.00	18.91	MCB	S	7734	3256	50	0.82	0.95	1.15	0.95	1	47.0	39	5.000	1.200	61.4	0.629	0.108	No Liquefaction	3.13	10.0	No Liquefaction
15	66.00	20.13	MCB	S	8262	3479	50	0.78	0.95	1.15	0.95	1	45.3	39	5.000	1.200	59.4	0.597	0.102	No Liquefaction	3.13	10.0	No Liquefaction
16	4.00	1.22	MCB	S	428	177	30	1.70	0.95	1.15	0.75	1	69.6	39	5.000	1.200	99.7	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
16	9.00	2.74	MCB	S	963	401	35	1.70	0.95	1.15	0.75	1	69.6	39	5.000	1.200	99.7	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
16	14.00	4.27	MCB	S	1498	624	50	1.58	0.95	1.15	0.85	1	73.0	39	5.000	1.200	99.7	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
16	19.00	5.79	MCB	S	2033	847	42	1.58	0.95	1.15	0.85	1	61.6	39	5.000	1.200	84.7	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
16	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.95	1	66.4	39	5.000	1.200	92.4	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
16	29.00	8.84	MCB	S	3103	1293	50	1.28	0.95	1.15	0.95	1	64.5	40.3	5.000	1.200	82.4	0.897	0.154	No Liquefaction	3.13	10.0	No Liquefaction
16	34.00	10.37	MCB	S	3638	1516	50	1.18	0.95	1.15	0.95	1	60.3	39	5.000	1.200	77.3	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
16	39.00	11.89	MCB	S	4173	1739	50	1.10	0.95	1.15	0.95	1	56.7	39	5.000	1.200	73.1	0.813	0.140	No Liquefaction	3.13	10.0	No Liquefaction
16	44.00	13.41	MCB	S	4708	1962	50	0.98	0.95	1.15	0.95	1	53.8	39	5.000	1.200	69.5	0.763	0.131	No Liquefaction	3.13	10.0	No Liquefaction
16	49.00	14.94	MCB	S	5243	2185	50	0.94	0.95	1.15	0.95	1	51.2	39	5.000	1.200	66.5	0.713	0.122	No Liquefaction	3.13	10.0	No Liquefaction
16	54.00	16.46	MCB	S	5778	2408	50	0.90	0.95	1.15	0.95	1	49.0	39	5.000	1.200	63.8	0.667	0.114	No Liquefaction	3.13	10.0	No Liquefaction
16	59.00	17.99	MCB	S	6313	2631	50	0.86	0.95	1.15	0.95	1	51.2	39	5.000	1.200	61.4	0.629	0.108	No Liquefaction	3.13	10.0	No Liquefaction
16	64.00	19.51	MCB	S	6848	2854	50	0.82	0.95	1.15	0.95	1	49.0	39	5.000	1.200	59.4	0.597	0.102	No Liquefaction	3.13	10.0	No Liquefaction
16	69.00	21.04	MCB	S	7383	3077	50	0.83	0.95	1.15	0.95	1	47.0	39	5.000	1.200	57.4	0.567	0.100	No Liquefaction	3.13	10.0	No Liquefaction
17	1.00	0.30	MCB	S	107	45	50	1.70	0.95	1.15	0.75	1	45.3	35.9	5.000	1.200	59.4	0.997	0.171	No Liquefaction	3.13	10.0	No Liquefaction
17	5.00	1.52	MCB	S	535	223	50	1.70	0.95	1.15	0.75	1	69.6	39	5.000	1.200	88.6	0.990	0.168	No Liquefaction	3.13	10.0	No Liquefaction
17	10.00	3.05	MCB	S	1070	446	37	1.70	0.95	1.15	0.8	1	55.0	39	5.000	1.200	71.0	0.979	0.168	No Liquefaction	3.13	10.0	No Liquefaction
17	15.00	4.57	MCB	S	1659	691	50	1.70	0.95	1.15	0.85	1	78.9	39	5.000	1.200	99.7	0.967	0.166	No Liquefaction	3.13	10.0	No Liquefaction
17	20.00	6.10	MCB	S	2140	892	50																

**PIÑON RIDGE LIQUEFACTION ANALYSIS
TAILINGS CELL AREA
ASSUMED SHALLOW PNEATIC SURFACE
(DESIGN EARTHQUAKE EVENT)**

Earthquake Moment Magnitude, $M_w = 4.8$
 Earthquake Radius (km) = 15.5
 Maximum horizontal ground acceleration = 0.17
 Unit weight (pcf) = 107
 Depth to water (ft) = 0
 44.6

Hole No. GA-BT-	Depth (feet/Bft)	Depth (m)	Sampler Type	Soil Type	σ'_v (psf)	σ'_v (kPa)	N_{60} (blows/ft)	C_u	C_k	C_r	C_s	C_b	C_a	Fines Content (%)	α	β	β (blows/ft)	t_d	CSR	(CRRI) _s	MSF	FS_{L-10}	Liquefaction Potential
18	2.00	0.61	MCH	S	314	89	18	0.73	1.15	0.95	1.15	0.73	1.15	39	5.000	1.200	35.1	0.997	0.171	No Liquefaction	3.13	10.9	No Liquefaction
18	3.00	0.91	MCH	S	323	95	16	0.70	1.15	0.95	1.15	0.70	1.15	39	5.000	1.200	31.7	0.997	0.170	No Liquefaction	3.13	10.9	No Liquefaction
18	4.00	1.22	MCH	S	333	102	14	0.68	1.15	0.95	1.15	0.68	1.15	39	5.000	1.200	28.3	0.997	0.168	No Liquefaction	3.13	10.9	No Liquefaction
18	5.00	1.52	MCH	S	346	110	12	0.65	1.15	0.95	1.15	0.65	1.15	39	5.000	1.200	25.6	0.997	0.166	No Liquefaction	3.13	10.9	No Liquefaction
18	6.00	1.83	MCH	S	360	119	10	0.62	1.15	0.95	1.15	0.62	1.15	39	5.000	1.200	23.2	0.997	0.164	No Liquefaction	3.13	10.9	No Liquefaction
18	7.00	2.13	MCH	S	374	128	9	0.60	1.15	0.95	1.15	0.60	1.15	39	5.000	1.200	21.0	0.997	0.162	No Liquefaction	3.13	10.9	No Liquefaction
18	8.00	2.44	MCH	S	389	137	8	0.58	1.15	0.95	1.15	0.58	1.15	39	5.000	1.200	19.0	0.997	0.160	No Liquefaction	3.13	10.9	No Liquefaction
18	9.00	2.74	MCH	S	405	146	7	0.56	1.15	0.95	1.15	0.56	1.15	39	5.000	1.200	17.2	0.997	0.158	No Liquefaction	3.13	10.9	No Liquefaction
18	10.00	3.05	MCH	S	421	155	6	0.54	1.15	0.95	1.15	0.54	1.15	39	5.000	1.200	15.6	0.997	0.156	No Liquefaction	3.13	10.9	No Liquefaction
21	2.00	0.61	MCH	S	314	89	18	0.73	1.15	0.95	1.15	0.73	1.15	39	5.000	1.200	35.1	0.997	0.171	No Liquefaction	3.13	10.9	No Liquefaction
21	3.00	0.91	MCH	S	323	95	16	0.70	1.15	0.95	1.15	0.70	1.15	39	5.000	1.200	31.7	0.997	0.170	No Liquefaction	3.13	10.9	No Liquefaction
21	4.00	1.22	MCH	S	333	102	14	0.68	1.15	0.95	1.15	0.68	1.15	39	5.000	1.200	28.3	0.997	0.168	No Liquefaction	3.13	10.9	No Liquefaction
21	5.00	1.52	MCH	S	346	110	12	0.65	1.15	0.95	1.15	0.65	1.15	39	5.000	1.200	25.6	0.997	0.166	No Liquefaction	3.13	10.9	No Liquefaction
21	6.00	1.83	MCH	S	360	119	10	0.62	1.15	0.95	1.15	0.62	1.15	39	5.000	1.200	23.2	0.997	0.164	No Liquefaction	3.13	10.9	No Liquefaction
21	7.00	2.13	MCH	S	374	128	9	0.60	1.15	0.95	1.15	0.60	1.15	39	5.000	1.200	21.0	0.997	0.162	No Liquefaction	3.13	10.9	No Liquefaction
21	8.00	2.44	MCH	S	389	137	8	0.58	1.15	0.95	1.15	0.58	1.15	39	5.000	1.200	19.0	0.997	0.160	No Liquefaction	3.13	10.9	No Liquefaction
21	9.00	2.74	MCH	S	405	146	7	0.56	1.15	0.95	1.15	0.56	1.15	39	5.000	1.200	17.2	0.997	0.158	No Liquefaction	3.13	10.9	No Liquefaction
21	10.00	3.05	MCH	S	421	155	6	0.54	1.15	0.95	1.15	0.54	1.15	39	5.000	1.200	15.6	0.997	0.156	No Liquefaction	3.13	10.9	No Liquefaction
27	5.00	1.52	SS	S	415	123	50	1.05	1.15	0.95	1.15	1.05	1.15	31	4.770	1.161	74.3	0.969	0.162	No Liquefaction	3.13	10.9	No Liquefaction
27	6.00	1.83	MCH	S	446	130	38	1.00	1.15	0.95	1.15	1.00	1.15	39	5.000	1.200	66.8	0.942	0.158	No Liquefaction	3.13	10.9	No Liquefaction
27	7.00	2.13	MCH	S	480	139	28	0.95	1.15	0.95	1.15	0.95	1.15	39	5.000	1.200	61.3	0.921	0.153	No Liquefaction	3.13	10.9	No Liquefaction
27	8.00	2.44	MCH	S	515	148	20	0.90	1.15	0.95	1.15	0.90	1.15	39	5.000	1.200	56.2	0.899	0.146	No Liquefaction	3.13	10.9	No Liquefaction
27	9.00	2.74	MCH	S	550	157	14	0.85	1.15	0.95	1.15	0.85	1.15	39	5.000	1.200	51.6	0.876	0.138	No Liquefaction	3.13	10.9	No Liquefaction
27	10.00	3.05	MCH	S	585	166	10	0.80	1.15	0.95	1.15	0.80	1.15	39	5.000	1.200	47.1	0.853	0.130	No Liquefaction	3.13	10.9	No Liquefaction
35	10.00	3.05	MCH	S	575	163	14	0.78	1.15	0.95	1.15	0.78	1.15	39	5.000	1.200	52.3	0.842	0.129	No Liquefaction	3.13	10.9	No Liquefaction
35	15.00	4.57	MCH	S	669	194	8	0.70	1.15	0.95	1.15	0.70	1.15	39	5.000	1.200	48.1	0.829	0.127	No Liquefaction	3.13	10.9	No Liquefaction
35	20.00	6.10	MCH	S	763	224	4	0.60	1.15	0.95	1.15	0.60	1.15	39	5.000	1.200	44.3	0.816	0.126	No Liquefaction	3.13	10.9	No Liquefaction
35	25.00	7.62	MCH	S	857	254	3	0.55	1.15	0.95	1.15	0.55	1.15	39	5.000	1.200	40.6	0.803	0.125	No Liquefaction	3.13	10.9	No Liquefaction
35	30.00	9.15	MCH	S	951	284	2	0.50	1.15	0.95	1.15	0.50	1.15	39	5.000	1.200	36.9	0.790	0.124	No Liquefaction	3.13	10.9	No Liquefaction
35	35.00	10.67	MCH	S	1045	314	2	0.45	1.15	0.95	1.15	0.45	1.15	39	5.000	1.200	33.2	0.777	0.123	No Liquefaction	3.13	10.9	No Liquefaction
35	40.00	12.20	MCH	S	1139	344	2	0.40	1.15	0.95	1.15	0.40	1.15	39	5.000	1.200	29.5	0.764	0.122	No Liquefaction	3.13	10.9	No Liquefaction
35	45.00	13.72	SS	S	1233	374	2	0.35	1.15	0.95	1.15	0.35	1.15	39	5.000	1.200	25.8	0.751	0.121	No Liquefaction	3.13	10.9	No Liquefaction
35	50.00	15.24	SS	S	1327	404	2	0.30	1.15	0.95	1.15	0.30	1.15	39	5.000	1.200	22.1	0.738	0.120	No Liquefaction	3.13	10.9	No Liquefaction
35	55.00	16.76	SS	S	1421	434	2	0.25	1.15	0.95	1.15	0.25	1.15	39	5.000	1.200	18.4	0.725	0.119	No Liquefaction	3.13	10.9	No Liquefaction
35	60.00	18.29	SS	S	1515	464	2	0.20	1.15	0.95	1.15	0.20	1.15	39	5.000	1.200	14.7	0.712	0.118	No Liquefaction	3.13	10.9	No Liquefaction
35	65.00	19.81	SS	S	1609	494	2	0.15	1.15	0.95	1.15	0.15	1.15	39	5.000	1.200	11.0	0.699	0.117	No Liquefaction	3.13	10.9	No Liquefaction
35	70.00	21.34	SS	S	1703	524	2	0.10	1.15	0.95	1.15	0.10	1.15	39	5.000	1.200	7.3	0.686	0.116	No Liquefaction	3.13	10.9	No Liquefaction
35	75.00	22.87	MCH	S	1797	554	2	0.05	1.15	0.95	1.15	0.05	1.15	39	5.000	1.200	3.6	0.673	0.115	No Liquefaction	3.13	10.9	No Liquefaction
35	80.00	24.39	MCH	S	1891	584	2	0.00	1.15	0.95	1.15	0.00	1.15	39	5.000	1.200	0.0	0.660	0.114	No Liquefaction	3.13	10.9	No Liquefaction
35	85.00	25.91	MCH	S	1985	614	2	0.00	1.15	0.95	1.15	0.00	1.15	39	5.000	1.200	0.0	0.647	0.113	No Liquefaction	3.13	10.9	No Liquefaction
35	90.00	27.44	MCH	S	2079	644	2	0.00	1.15	0.95	1.15	0.00	1.15	39	5.000	1.200	0.0	0.634	0.112	No Liquefaction	3.13	10.9	No Liquefaction
35	95.00	28.96	MCH	S	2173	674	2	0.00	1.15	0.95	1.15	0.00	1.15	39	5.000	1.200	0.0	0.621	0.111	No Liquefaction	3.13	10.9	No Liquefaction
35	100.00	30.49	MCH	S	2267	704	2	0.00	1.15	0.95	1.15	0.00	1.15	39	5.000	1.200	0.0	0.608	0.110	No Liquefaction	3.13	10.9	No Liquefaction
21	5.00	1.52	MCH	S	314	89	18	0.73	1.15	0.95	1.15	0.73	1.15	39	5.000	1.200	35.1	0.997	0.171	No Liquefaction	3.13	10.9	No Liquefaction
21	10.00	3.05	MCH	S	323	95	16	0.70	1.15	0.95	1.15	0.70	1.15	39	5.000	1.200	31.7	0.997	0.170	No Liquefaction	3.13	10.9	No Liquefaction
21	15.00	4.57	MCH	S	333	102	14	0.68	1.15	0.95	1.15	0.68	1.15	39	5.000	1.200	28.3	0.997	0.168	No Liquefaction	3.13	10.9	No Liquefaction
21	20.00	6.10	MCH	S	346	110	12	0.65	1.15	0.95	1.15	0.65	1.15	39	5.000	1.200	25.6	0.997	0.166	No Liquefaction	3.13	10.9	No Liquefaction
21	25.00	7.62	MCH	S	360	119	10	0.62	1.15	0.95	1.15	0.62	1.15	39	5.000	1.200	23.2	0.997	0.164	No Liquefaction	3.13	10.9	No Liquefaction
21	30.00	9.15	MCH	S	374	128	9	0.60	1.15	0.95	1.15	0.60	1.15	39	5.000	1.200	21.0	0.997	0.162	No Liquefaction	3.13	10.9	No Liquefaction
21	35.00	10.67	MCH	S	389	137	8	0.58	1.15	0.95	1.15	0.58	1.15	39	5.000	1.200	19.0	0.997	0.160	No Liquefaction	3.13	10.9	No Liquefaction
21	40.00	12.20	MCH	S	405	146	7	0.56	1.15	0.95	1.15	0.56	1.15	39	5.000	1.200	17.2	0.997	0.158	No Liquefaction	3.13	10.9	No Liquefaction
21	45.00	13.72	SS	S	421	155	6	0.54	1.15	0.95	1.15	0.54	1.15	39	5.000	1.200	15.6	0.997	0.156	No Liquefaction	3.13	10.9	No Liquefaction
27	5.00	1.52	SS	S	415	123	50	1.05	1.15	0.95	1.15	1.05	1.15	31	4.770	1.161	74.3	0.969	0.162	No Liquefaction	3.13	10.9	No Liquefaction
27	6.00	1.83	MCH	S	446	130	38	1.00	1.15	0.95	1.15	1.00	1.15	39	5.000	1.200	66.8	0.942	0.158	No Liquefaction	3.13	10.9	No Liquefaction
27	7.00	2.13	MCH	S	480	139	28	0.95	1.15	0.95	1.15	0.95	1.15	39	5.000	1.200	61.3	0.921	0.153	No Liquefaction	3.13	10.9	No Liquefaction
27	8.00	2.44	MCH	S	515	148	20	0.90	1.15	0.95	1.15	0.90	1.15	39	5.000	1.200	56.2	0.899	0.146	No Liquefaction	3.13	10.9	No Liquefaction
27	9.00	2.74	MCH	S	550	157	14	0.85	1.15	0.95	1.15	0.85	1.15	39	5.000	1.200	51.6	0.876	0.138	No L			

**PIÑON RIDGE LIQUEFACTION ANALYSIS
ORE PAD AREA
ASSUMED SHALLOW PHREATIC SURFACE
(DESIGN EARTHQUAKE EVENT)**

Earthquake Moment Magnitude, $M_w = 4.8$
 Earthquake Radius (km) = 15.5
 Maximum horizontal ground acceleration = 0.11
 Unit weight (pcf) = 107
 Depth to water (ft) = 0

44.6

Hole No. GA-BH-	Depth (feet Dgs)	Depth (m)	Sampler Type ¹	Soil Type	σ_v (psf)	σ_v' (psf)	N_{60} (blows/ft)	C_u	C_R	C_B	C_N	C_a	$N_{1/60}$ (blows/ft)	Fines Content ² (%)	α	β	($N_{1/60}$) _{cs} (blows/ft)	T_e	CSR	(CSR) _{7.5}	MSF	$FB_{1/3}$	Liquefaction Potential
44	4.00	1.22	MCB	S	428	178	11	1	0.75	1.15	1.15	1	15.3	39	5.000	1.200	23.4	0.993	0.170	0.263	3.13	4.8	No Liquefaction
44	9.00	2.74	MCB	S	963	401	15	1	0.95	1.15	1.15	1	20.9	39	5.000	1.200	30.1	0.981	0.168	No Liquefaction	3.13	10.0	No Liquefaction
44	14.00	4.27	MCB	S	1498	624	18	1	0.95	1.15	1.15	1	28.4	39	5.000	1.200	39.1	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
44	19.00	5.79	MCB	S	2033	847	21	1	0.95	1.15	1.15	1	30.8	39	5.000	1.200	42.0	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
44	24.00	7.32	MCB	S	2568	1070	25	1	0.95	1.15	1.15	1	33.2	39	5.000	1.200	49.6	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
44	29.00	8.84	MCB	S	3103	1293	30	1	0.95	1.15	1.15	1	35.6	39	5.000	1.200	57.2	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
44	34.00	10.37	MCB	S	3638	1516	35	1	0.95	1.15	1.15	1	38.0	39	5.000	1.200	64.8	0.897	0.154	No Liquefaction	3.13	10.0	No Liquefaction
45	2.00	0.61	MCB	S	214	89	23	1	0.75	1.15	1.15	1	32.0	39	5.000	1.200	43.4	0.997	0.171	No Liquefaction	3.13	10.0	No Liquefaction
45	9.00	2.74	MCB	S	963	401	17	1	0.95	1.15	1.15	1	23.7	39	5.000	1.200	33.4	0.981	0.168	No Liquefaction	3.13	10.0	No Liquefaction
45	14.00	4.27	MCB	S	1498	624	18	1	0.95	1.15	1.15	1	28.4	39	5.000	1.200	39.1	0.971	0.167	No Liquefaction	3.13	10.0	No Liquefaction
45	19.00	5.79	MCB	S	2033	847	21	1	0.95	1.15	1.15	1	30.8	39	5.000	1.200	42.0	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
45	24.00	7.32	MCB	S	2568	1070	25	1	0.95	1.15	1.15	1	33.2	39	5.000	1.200	49.6	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
45	29.00	8.84	MCB	S	3103	1293	30	1	0.95	1.15	1.15	1	35.6	39	5.000	1.200	57.2	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
45	34.00	10.37	MCB	S	3638	1516	35	1	0.95	1.15	1.15	1	38.0	39	5.000	1.200	64.8	0.897	0.154	No Liquefaction	3.13	10.0	No Liquefaction
45	39.00	11.89	MCB	S	4173	1739	40	1	0.95	1.15	1.15	1	40.4	39	5.000	1.200	72.4	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
45	44.00	13.41	MCB	S	4708	1962	45	1	0.95	1.15	1.15	1	42.8	39	5.000	1.200	84.8	0.823	0.131	No Liquefaction	3.13	10.0	No Liquefaction
46	3.00	0.91	MCB	S	321	134	18	1	0.75	1.15	1.15	1	53.8	39	5.000	1.200	77.3	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
46	9.00	2.74	MCB	S	963	401	17	1	0.95	1.15	1.15	1	25.1	39	5.000	1.200	35.1	0.995	0.171	No Liquefaction	3.13	10.0	No Liquefaction
46	14.00	4.27	MCB	S	1498	624	18	1	0.95	1.15	1.15	1	23.7	39	5.000	1.200	33.4	0.981	0.168	No Liquefaction	3.13	10.0	No Liquefaction
46	19.00	5.79	MCB	S	2033	847	19	1	0.95	1.15	1.15	1	27.9	39	5.000	1.200	38.5	0.959	0.165	No Liquefaction	3.13	10.0	No Liquefaction
46	24.00	7.32	MCB	S	2568	1070	23	1	0.95	1.15	1.15	1	30.9	39	5.000	1.200	43.6	0.945	0.162	No Liquefaction	3.13	10.0	No Liquefaction
46	29.00	8.84	MCB	S	3103	1293	28	1	0.95	1.15	1.15	1	33.3	39	5.000	1.200	49.0	0.925	0.159	No Liquefaction	3.13	10.0	No Liquefaction
46	34.00	10.37	MCB	S	3638	1516	33	1	0.95	1.15	1.15	1	35.7	39	5.000	1.200	56.4	0.897	0.154	No Liquefaction	3.13	10.0	No Liquefaction
46	39.00	11.89	MCB	S	4173	1739	38	1	0.95	1.15	1.15	1	38.1	39	5.000	1.200	63.8	0.860	0.147	No Liquefaction	3.13	10.0	No Liquefaction
46	44.00	13.41	MCB	S	4708	1962	43	1	0.95	1.15	1.15	1	40.5	39	5.000	1.200	71.2	0.823	0.131	No Liquefaction	3.13	10.0	No Liquefaction
46	49.00	14.94	MCB	S	5243	2185	48	1	0.95	1.15	1.15	1	42.9	39	5.000	1.200	83.6	0.786	0.124	No Liquefaction	3.13	10.0	No Liquefaction
47	5.00	1.52	MCB	S	535	223	12	1	0.75	1.15	1.15	1	16.7	39	5.000	1.200	25.1	0.990	0.170	No Liquefaction	3.13	10.0	No Liquefaction
47	10.00	3.05	MCB	S	1070	446	12	1	0.95	1.15	1.15	1	17.8	39	5.000	1.200	26.2	0.979	0.168	No Liquefaction	3.13	10.0	No Liquefaction
47	15.00	4.57	MCB	S	1605	669	13	1	0.95	1.15	1.15	1	18.9	39	5.000	1.200	27.3	0.969	0.166	No Liquefaction	3.13	10.0	No Liquefaction
47	20.00	6.10	MCB	S	2140	892	14	1	0.95	1.15	1.15	1	20.0	39	5.000	1.200	28.4	0.957	0.164	No Liquefaction	3.13	10.0	No Liquefaction
47	25.00	7.62	MCB	S	2675	1115	15	1	0.95	1.15	1.15	1	21.1	39	5.000	1.200	29.5	0.942	0.162	No Liquefaction	3.13	10.0	No Liquefaction
47	30.00	9.15	MCB	S	3210	1338	16	1	0.95	1.15	1.15	1	22.2	39	5.000	1.200	30.6	0.927	0.158	No Liquefaction	3.13	10.0	No Liquefaction
47	35.00	10.67	SS	S	3745	1561	17	1	0.95	1.15	1.15	1	23.3	39	5.000	1.200	31.7	0.912	0.154	No Liquefaction	3.13	10.0	No Liquefaction
47	40.00	12.20	SS	S	4280	1784	18	1	0.95	1.15	1.15	1	24.4	39	5.000	1.200	32.8	0.897	0.150	No Liquefaction	3.13	10.0	No Liquefaction
48	2.00	0.61	MCB	S	214	89	13	1	0.75	1.15	1.15	1	18.1	39	5.000	1.200	26.7	0.997	0.171	No Liquefaction	3.13	10.0	No Liquefaction
48	5.00	1.52	MCB	S	535	223	13	1	0.95	1.15	1.15	1	19.2	39	5.000	1.200	27.8	0.979	0.168	No Liquefaction	3.13	10.0	No Liquefaction
48	10.00	3.05	MCB	S	1070	446	13	1	0.95	1.15	1.15	1	20.3	39	5.000	1.200	28.9	0.969	0.166	No Liquefaction	3.13	10.0	No Liquefaction
48	15.00	4.57	MCB	S	1605	669	14	1	0.95	1.15	1.15	1	21.4	39	5.000	1.200	30.0	0.957	0.164	No Liquefaction	3.13	10.0	No Liquefaction
48	20.00	6.10	MCB	S	2140	892	15	1	0.95	1.15	1.15	1	22.5	39	5.000	1.200	31.1	0.942	0.162	No Liquefaction	3.13	10.0	No Liquefaction
48	25.00	7.62	MCB	S	2675	1115	16	1	0.95	1.15	1.15	1	23.6	39	5.000	1.200	32.2	0.927	0.158	No Liquefaction	3.13	10.0	No Liquefaction
48	30.00	9.15	MCB	S	3210	1338	17	1	0.95	1.15	1.15	1	24.7	39	5.000	1.200	33.3	0.912	0.154	No Liquefaction	3.13	10.0	No Liquefaction
48	35.00	10.67	MCB	S	3745	1561	18	1	0.95	1.15	1.15	1	25.8	39	5.000	1.200	34.4	0.897	0.150	No Liquefaction	3.13	10.0	No Liquefaction
48	40.00	12.20	MCB	S	4280	1784	19	1	0.95	1.15	1.15	1	26.9	39	5.000	1.200	35.5	0.882	0.146	No Liquefaction	3.13	10.0	No Liquefaction
48	45.00	13.72	MCB	S	4815	2007	20	1	0.95	1.15	1.15	1	28.0	39	5.000	1.200	36.6	0.867	0.142	No Liquefaction	3.13	10.0	No Liquefaction
48	50.00	15.24	MCB	S	5350	2230	21	1	0.95	1.15	1.15	1	29.1	39	5.000	1.200	37.7	0.852	0.138	No Liquefaction	3.13	10.0	No Liquefaction

Notes:

- SS = split spoon (no liner) and MCB = modified California barrel (with liner).
- Assumed values are highlighted.
- Where soil was deemed non-liquefiable, a FS of 10 was assumed to allow plotting of the data.

**PIÑON RIDGE LIQUEFACTION ANALYSIS
EVAPORATION POND AREA
ASSUMED SHALLOW PHREATIC SURFACE
(MCE EARTHQUAKE EVENT)**

Earthquake Moment Magnitude, $M_w = 4.8$
 Earthquake Radius (km) = 15.5
 Maximum horizontal ground acceleration = 0.16
 Unit weight (pcf) = 107
 Depth to water (ft) = 0

44.6

Hole No. GA-BH-	Depth (feet base)	Depth (m)	Sampler Type ¹	Soil Type	σ_v (psf)	σ_v' (psf)	$N_{1,60}$ (blows/ft)	C_u	C_c	C_s	C_n	C_1	C_2	Fines Content ² (%)	α	β	$(N_{1,60})_{cs}$ (blows/ft)	r_d	CSR	(CRR) _s	MSF	FS _{msf}	Liquefaction Potential
01	2.00	0.61	MCB	S	214	89	24	1.70	0.95	1.15	0.75	1	1	33.4	3.9	5.000	45.1	0.997	0.249	No Liquefaction	3.13	10.0	No Liquefaction
01	14.00	4.27	MCB	S	963	401	42	1.70	0.95	1.15	0.75	1	1	58.5	34.4	4.930	74.7	0.981	0.245	No Liquefaction	3.13	10.0	No Liquefaction
01	19.00	5.79	MCB	S	1498	624	50	1.70	0.95	1.15	0.85	1	1	78.9	39	5.000	99.7	0.971	0.242	No Liquefaction	3.13	10.0	No Liquefaction
01	24.00	7.32	MCB	S	2033	847	50	1.58	0.95	1.15	0.85	1	1	73.0	39	5.000	92.6	0.959	0.239	No Liquefaction	3.13	10.0	No Liquefaction
02	3.00	0.91	MCB	S	2568	1070	50	1.41	0.95	1.15	0.75	1	1	69.6	39	5.000	86.6	0.945	0.236	No Liquefaction	3.13	10.0	No Liquefaction
02	9.00	2.74	MCB	S	321	134	50	1.70	0.95	1.15	0.75	1	1	58.9	39	5.000	88.6	0.945	0.248	No Liquefaction	3.13	10.0	No Liquefaction
02	14.00	4.27	MCB	S	1498	624	50	1.70	0.95	1.15	0.85	1	1	78.9	39	5.000	99.7	0.971	0.242	No Liquefaction	3.13	10.0	No Liquefaction
02	19.00	5.79	MCB	S	2033	847	50	1.58	0.95	1.15	0.85	1	1	73.0	39	5.000	92.6	0.945	0.236	No Liquefaction	3.13	10.0	No Liquefaction
02	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.95	1	1	66.4	39	5.000	84.7	0.925	0.231	No Liquefaction	3.13	10.0	No Liquefaction
02	29.00	8.84	MCB	S	3103	1293	50	1.16	0.95	1.15	1	1	1	63.6	39	5.000	81.3	0.891	0.222	No Liquefaction	3.13	10.0	No Liquefaction
02	35.00	10.67	MCB	S	3745	1561	50	1.10	0.95	1.15	1	1	1	60.3	39	5.000	77.3	0.860	0.214	No Liquefaction	3.13	10.0	No Liquefaction
03	1.50	0.46	MCB	S	161	67	35	1.70	0.95	1.15	0.75	1	1	48.8	39	5.000	73.0	0.891	0.248	No Liquefaction	3.13	10.0	No Liquefaction
03	4.00	1.22	MCB	S	428	178	42	1.70	0.95	1.15	0.75	1	1	58.5	39	5.000	75.2	0.981	0.248	No Liquefaction	3.13	10.0	No Liquefaction
03	9.00	2.74	MCB	S	963	401	50	1.70	0.95	1.15	0.75	1	1	69.6	39	5.000	84.6	0.945	0.248	No Liquefaction	3.13	10.0	No Liquefaction
03	14.00	4.27	MCB	S	1498	624	42	1.70	0.95	1.15	0.85	1	1	66.3	39	5.000	84.6	0.945	0.248	No Liquefaction	3.13	10.0	No Liquefaction
03	19.00	5.79	MCB	S	2033	847	50	1.58	0.95	1.15	0.85	1	1	73.4	39	5.000	92.6	0.945	0.239	No Liquefaction	3.13	10.0	No Liquefaction
03	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.85	1	1	66.4	39	5.000	84.6	0.945	0.239	No Liquefaction	3.13	10.0	No Liquefaction
03	29.00	8.84	MCB	S	3103	1293	50	1.28	0.95	1.15	0.85	1	1	66.4	39	5.000	84.6	0.945	0.239	No Liquefaction	3.13	10.0	No Liquefaction
03	34.00	10.37	MCB	S	3638	1516	50	1.18	0.95	1.15	0.85	1	1	64.3	39	5.000	82.6	0.925	0.231	No Liquefaction	3.13	10.0	No Liquefaction
03	39.00	11.89	MCB	S	4173	1739	50	1.10	0.95	1.15	1	1	1	60.3	39	5.000	77.3	0.860	0.214	No Liquefaction	3.13	10.0	No Liquefaction
03	44.00	13.41	MCB	S	4708	1962	50	1.04	0.95	1.15	1	1	1	57.7	39	5.000	73.0	0.813	0.203	No Liquefaction	3.13	10.0	No Liquefaction
03	49.00	14.94	MCB	S	5245	2185	50	0.98	0.95	1.15	0.75	1	1	53.8	39	5.000	69.5	0.763	0.190	No Liquefaction	3.13	10.0	No Liquefaction
15	3.00	0.91	MCB	S	321	134	37	1.70	0.95	1.15	0.85	1	1	44.6	39	5.000	65.8	0.860	0.214	No Liquefaction	3.13	6.3	No Liquefaction
15	9.00	2.74	MCB	S	963	401	42	1.70	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	14.00	4.27	MCB	S	1498	624	31	1.70	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	19.00	5.79	MCB	S	1926	803	41	1.62	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	29.00	8.84	MCB	S	3103	1293	50	1.28	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	34.00	10.37	MCB	S	3638	1516	16	1.18	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	39.00	11.89	MCB	S	4173	1739	16	1.10	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	44.00	13.41	MCB	S	4708	1962	38	1.04	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	49.00	14.94	MCB	S	5245	2185	50	0.98	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	54.00	16.46	MCB	S	5778	2408	50	0.94	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	59.00	17.99	MCB	S	6313	2631	50	0.90	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	64.00	19.51	MCB	S	6848	2854	50	0.86	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
15	69.00	21.04	MCB	S	7383	3077	50	0.85	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	4.00	1.22	MCB	S	428	178	50	1.70	0.95	1.15	0.75	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	9.00	2.74	MCB	S	963	401	35	1.70	0.95	1.15	0.75	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	14.00	4.27	MCB	S	1498	624	50	1.70	0.95	1.15	0.75	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	19.00	5.79	MCB	S	2033	847	42	1.58	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	29.00	8.84	MCB	S	3103	1293	50	1.28	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	34.00	10.37	MCB	S	3638	1516	16	1.18	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	39.00	11.89	MCB	S	4173	1739	16	1.10	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	44.00	13.41	MCB	S	4708	1962	38	1.04	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	49.00	14.94	MCB	S	5245	2185	50	0.98	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	54.00	16.46	MCB	S	5778	2408	50	0.94	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	59.00	17.99	MCB	S	6313	2631	50	0.90	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	64.00	19.51	MCB	S	6848	2854	50	0.86	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
16	69.00	21.04	MCB	S	7383	3077	50	0.85	0.95	1.15	1	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	1.00	0.30	MCB	S	107	45	50	1.70	0.95	1.15	0.75	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	5.00	1.52	MCB	S	335	223	50	1.70	0.95	1.15	0.75	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	10.00	3.05	MCB	S	1070	446	37	1.70	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	15.00	4.57	MCB	S	1659	691	50	1.70	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	20.00	6.10	MCB	S	2149	892	50	1.54	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	24.00	7.32	MCB	S	2568	1070	50	1.41	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	30.00	9.30	MCB	S	3264	1360	50	1.25	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991	0.248	No Liquefaction	3.13	10.0	No Liquefaction
17	35.00	10.82	MCB	S	3799	1583	50	1.16	0.95	1.15	0.85	1	1	48.8	39	5.000	58.5	0.991					

**PIÑON RIDGE LIQUEFACTION ANALYSIS
ORE PAD AREA
ASSUMED SHALLOW PHREATIC SURFACE
(MCE EARTHQUAKE EVENT)**

Earthquake Moment Magnitude, $M_w = 4.8$
 Earthquake Radius (km) = 15.5
 Maximum horizontal ground acceleration = 0.16
 Unit weight (pcf) = 107
 Depth to water (ft) = 0

44.6

Hole No. GA-BH-	Depth (feet bgs)	Depth (m)	Sampler Type ¹	Soil Type	σ'_v (psf)	σ'_v (psf)	N_{F50} (blows/ft)	C_H	C_E	C_0	C_{R1}	C_s	$(N_1)_{60}$ (blows/ft)	Fines Content ² (%)	α	β	$(M_1)_{60}$ (blows/ft)	T_v	CSR	(CRR) _{7.5}	MSF	$FS_{bu,c}$ ³	Liquefaction Potential
44	4.00	1.22	MCB	s	428	178	11	1.70	0.95	1.15	0.75	1	15.3	39	5.000	1.200	23.4	0.993	0.248	0.263	3.13	3.3	No Liquefaction
44	9.00	2.74	MCB	s	963	401	15	1.70	0.95	1.15	0.75	1	20.9	39	5.000	1.200	30.1	0.981	0.245	No Liquefaction	3.13	10.0	No Liquefaction
44	14.00	4.27	MCB	s	1498	624	18	1.70	0.95	1.15	0.85	1	28.4	39	5.000	1.200	39.1	0.971	0.242	No Liquefaction	3.13	10.0	No Liquefaction
44	19.00	5.79	MCB	s	2033	847	21	1.58	0.95	1.15	0.85	1	30.8	39	5.000	1.200	42.0	0.959	0.239	No Liquefaction	3.13	10.0	No Liquefaction
44	24.00	7.32	MCB	s	2568	1070	50	1.41	0.95	1.15	0.95	1	73.0	39	5.000	1.200	92.6	0.945	0.236	No Liquefaction	3.13	10.0	No Liquefaction
44	29.00	8.84	MCB	s	3103	1293	50	1.28	0.95	1.15	0.95	1	66.4	39	5.000	1.200	84.7	0.925	0.231	No Liquefaction	3.13	10.0	No Liquefaction
44	34.00	10.37	MCB	s	3638	1516	50	1.18	0.95	1.15	1	64.5	39	5.000	1.200	82.4	0.897	0.224	No Liquefaction	3.13	10.0	No Liquefaction	
45	2.00	0.61	MCB	s	214	89	23	1.70	0.95	1.15	0.75	1	32.0	39	5.000	1.200	43.4	0.997	0.249	No Liquefaction	3.13	10.0	No Liquefaction
45	9.00	2.74	MCB	s	963	401	17	1.70	0.95	1.15	0.75	1	23.7	39	5.000	1.200	33.4	0.981	0.245	No Liquefaction	3.13	10.0	No Liquefaction
45	14.00	4.27	MCB	s	1498	624	18	1.70	0.95	1.15	0.85	1	28.4	39	5.000	1.200	39.1	0.971	0.242	No Liquefaction	3.13	10.0	No Liquefaction
45	19.00	5.79	MCB	s	2033	847	50	1.58	0.95	1.15	0.85	1	73.4	39	5.000	1.200	92.6	0.959	0.239	No Liquefaction	3.13	10.0	No Liquefaction
45	24.00	7.32	MCB	s	2568	1070	50	1.41	0.95	1.15	0.95	1	73.0	39	5.000	1.200	92.6	0.945	0.236	No Liquefaction	3.13	10.0	No Liquefaction
45	29.00	8.84	MCB	s	3103	1293	50	1.28	0.95	1.15	0.95	1	66.4	39	5.000	1.200	84.7	0.925	0.231	No Liquefaction	3.13	10.0	No Liquefaction
45	34.00	10.37	MCB	s	3638	1516	50	1.18	0.95	1.15	1	64.5	39	5.000	1.200	82.4	0.897	0.224	No Liquefaction	3.13	10.0	No Liquefaction	
45	39.00	11.89	MCB	s	4173	1739	50	1.10	0.95	1.15	1	60.3	39	5.000	1.200	77.3	0.860	0.214	No Liquefaction	3.13	10.0	No Liquefaction	
45	44.00	13.41	MCB	s	4708	1982	50	1.04	0.95	1.15	1	56.7	39	5.000	1.200	69.5	0.763	0.190	No Liquefaction	3.13	10.0	No Liquefaction	
46	3.00	0.91	MCB	s	321	134	18	1.70	0.95	1.15	0.75	1	25.1	39	5.000	1.200	35.1	0.995	0.248	No Liquefaction	3.13	10.0	No Liquefaction
46	9.00	2.74	MCB	s	963	401	17	1.70	0.95	1.15	0.75	1	23.7	39	5.000	1.200	33.4	0.981	0.245	No Liquefaction	3.13	10.0	No Liquefaction
46	14.00	4.27	MCB	s	1498	624	50	1.70	0.95	1.15	0.85	1	78.9	39	5.000	1.200	99.7	0.959	0.239	No Liquefaction	3.13	10.0	No Liquefaction
46	19.00	5.79	MCB	s	2033	847	19	1.58	0.95	1.15	0.85	1	71.0	39	5.000	1.200	92.6	0.945	0.236	No Liquefaction	3.13	10.0	No Liquefaction
46	24.00	7.32	MCB	s	2568	1070	50	1.41	0.95	1.15	0.95	1	66.4	39	5.000	1.200	84.7	0.925	0.231	No Liquefaction	3.13	10.0	No Liquefaction
46	29.00	8.84	MCB	s	3103	1293	50	1.28	0.95	1.15	0.95	1	64.5	39	5.000	1.200	82.4	0.897	0.224	No Liquefaction	3.13	10.0	No Liquefaction
46	34.00	10.37	MCB	s	3638	1516	50	1.18	0.95	1.15	1	60.3	39	5.000	1.200	77.3	0.860	0.214	No Liquefaction	3.13	10.0	No Liquefaction	
46	39.00	11.89	MCB	s	4173	1739	50	1.10	0.95	1.15	1	56.7	39	5.000	1.200	69.5	0.763	0.190	No Liquefaction	3.13	10.0	No Liquefaction	
46	44.00	13.41	MCB	s	4708	1982	50	1.04	0.95	1.15	1	53.8	39	5.000	1.200	65.5	0.663	0.158	No Liquefaction	3.13	10.0	No Liquefaction	
47	5.00	1.52	MCB	s	535	223	12	1.70	0.95	1.15	0.75	1	16.7	39	5.000	1.200	25.1	0.990	0.247	No Liquefaction	3.13	3.7	No Liquefaction
47	10.00	3.05	MCB	s	1070	446	32	1.70	0.95	1.15	0.8	1	16.7	39	5.000	1.200	25.1	0.990	0.247	No Liquefaction	3.13	3.7	No Liquefaction
47	15.00	4.57	MCB	s	1605	669	40	1.70	0.95	1.15	0.85	1	63.1	39	5.000	1.200	80.8	0.969	0.242	No Liquefaction	3.13	10.0	No Liquefaction
47	20.00	6.10	MCB	s	2140	892	21	1.54	0.95	1.15	0.95	1	33.6	15	2.498	1.048	37.7	0.957	0.239	No Liquefaction	3.13	10.0	No Liquefaction
47	25.00	7.62	MCB	s	2675	1115	50	1.38	0.95	1.15	0.95	1	71.5	24.5	4.235	1.111	83.7	0.942	0.235	No Liquefaction	3.13	10.0	No Liquefaction
47	30.00	9.15	MCB	s	3210	1338	50	1.26	0.95	1.15	0.95	1	65.3	39	5.000	1.200	83.3	0.921	0.230	No Liquefaction	3.13	10.0	No Liquefaction
47	35.00	10.67	SS	s	3745	1561	50	1.16	0.95	1.15	1	61.4	39	5.000	1.200	80.8	0.891	0.222	No Liquefaction	3.13	10.0	No Liquefaction	
47	40.00	12.20	SS	s	4280	1784	50	1.09	0.95	1.15	1	57.9	39	5.000	1.200	77.3	0.860	0.214	No Liquefaction	3.13	10.0	No Liquefaction	
48	2.00	0.61	MCB	s	214	89	20	1.70	0.95	1.15	0.75	1	18.1	39	5.000	1.200	26.7	0.997	0.249	No Liquefaction	3.13	4.2	No Liquefaction
48	5.00	1.52	MCB	s	535	223	20	1.70	0.95	1.15	0.75	1	18.1	39	5.000	1.200	26.7	0.997	0.249	No Liquefaction	3.13	4.2	No Liquefaction
48	10.00	3.05	MCB	s	1070	446	13	1.70	0.95	1.15	0.8	1	19.3	39	5.000	1.200	28.2	0.979	0.244	No Liquefaction	3.13	4.8	No Liquefaction
48	15.00	4.57	MCB	s	1605	669	20	1.70	0.95	1.15	0.85	1	31.6	39	5.000	1.200	42.9	0.969	0.242	No Liquefaction	3.13	10.0	No Liquefaction
48	20.00	6.10	MCB	s	2140	892	48	1.54	0.95	1.15	0.95	1	76.7	39	5.000	1.200	97.1	0.957	0.239	No Liquefaction	3.13	10.0	No Liquefaction
48	25.00	7.62	MCB	s	2675	1115	50	1.38	0.95	1.15	0.95	1	71.5	39	5.000	1.200	92.6	0.942	0.235	No Liquefaction	3.13	10.0	No Liquefaction
48	30.00	9.15	MCB	s	3210	1338	50	1.26	0.95	1.15	0.95	1	65.3	39	5.000	1.200	83.3	0.921	0.230	No Liquefaction	3.13	10.0	No Liquefaction
48	35.00	10.67	MCB	s	3745	1561	39	1.16	0.95	1.15	1	49.6	39	5.000	1.200	64.5	0.891	0.222	No Liquefaction	3.13	10.0	No Liquefaction	
48	40.00	12.20	MCB	s	4280	1784	50	1.09	0.95	1.15	1	46.5	39	5.000	1.200	61.4	0.851	0.212	No Liquefaction	3.13	10.0	No Liquefaction	
48	45.00	13.72	MCB	s	4815	2007	50	1.03	0.95	1.15	1	43.3	39	5.000	1.200	58.4	0.804	0.200	No Liquefaction	3.13	10.0	No Liquefaction	
48	50.00	15.24	MCB	s	5350	2230	36	0.97	0.95	1.15	1	38.3	18.4	3.316	1.069	44.3	0.753	0.188	No Liquefaction	3.13	10.0	No Liquefaction	

Notes:

- SS = split spoon (no liner) and MCB = modified California barrel (with liner).
- Assumed values are highlighted.
- Where soil was deemed non-liquefiable, a FS of 10 was assumed to allow plotting of the data.