

Appendix E1 Geotechnical Investigation Report

Appendices

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PRELIMINARY GEOTECHNICAL INVESTIGATION

PROPOSED MULTI-FAMILY RESIDENTIAL DEVELOPMENT HAWTHORNE BOULEVARD AND VIA VALMONTE TORRANCE, CALIFORNIA



GEOCON
WEST, INC.

GEOTECHNICAL
ENVIRONMENTAL
MATERIALS

PREPARED FOR

**REYLENN PROPERTIES, LLC
SOLANA BEACH, CALIFORNIA**

PROJECT NO. A9201-06-01E

JUNE 30, 2017



Project No. A9201-06-01E

June 30, 2017

Mr. Derek Empey
Reylen Properties, LLC
444 South Cedros Avenue
Solana Beach, California 92705

Subject: PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED MULTI-FAMILY RESIDENTIAL DEVELOPMENT
HAWTHORNE BOULEVARD AND VIA VALMONTE
TORRANCE, CALIFORNIA

Dear Mr. Empey:

In accordance with the terms and conditions of our Professional Services Agreement dated January 28, 2015 and subsequent proposal dated January 27, 2017, we have performed a Preliminary Geotechnical Investigation for the proposed residential development at the subject property located south and west of Via Valmonte and Hawthorne Boulevard in the City of Torrance, California. The accompanying report presents the findings of our study, and our conclusions and recommendations pertaining to the geotechnical aspects of proposed design and construction. Based on the results of our investigation, it is our opinion that the site can be developed as proposed, provided the recommendations of this report are followed and implemented during design and construction.

Due to the preliminary nature of the project at this time, the recommendations presented herein should also be considered preliminary. Additional analyses may be required in order to provide comprehensive geotechnical recommendations for design and construction.

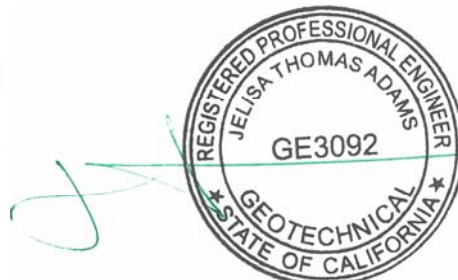
If you have any questions regarding this report, or if we may be of further service, please contact the undersigned.

Very truly yours,

GEOCON WEST, INC.



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PRELIMINARY GEOTECHNICAL INVESTIGATION

1. PURPOSE AND SCOPE

This report presents the results of our preliminary geotechnical investigation for the proposed residential development at the vacant property located south of Via Valmonte and west of Hawthorne Boulevard in the city of Torrance, California (see Vicinity Map, Figure 1). The purpose of the investigation was to evaluate subsurface soil and geologic conditions underlying the site and, based on conditions encountered, to provide conclusions and recommendations pertaining to the geotechnical aspects of design and construction.

Due to the preliminary nature of the project at this time, the recommendations presented herein should also be considered preliminary. Additional analyses may be required in order to provide comprehensive geotechnical recommendations for design and construction.

The scope of this investigation included a literature review, site reconnaissance, field exploration, laboratory testing, engineering analysis, and the preparation of this report. We have also performed a fault rupture hazard investigation at the site. The results of the fault rupture hazard investigation are presented in a separate report dated January 21, 2016 (Geocon, 2016).

Field exploration was initially performed between July 14, 2015 and July 24, 2015, and included drilling seventeen large-diameter bucket auger borings utilizing a truck mounted LM-60 Lo-Drill and a truck-mounted E-Z Bore bucket auger drilling machine. The large-diameter borings were advanced to approximate depths between 11 feet and 111½ feet below the existing ground surface. Four of the large-diameter borings were downhole logged by a Certified Engineering Geologist (CEG). In addition, six 4-inch diameter borings were excavated utilizing manual augers and digging equipment to depths between 7 and 23½ feet beneath the existing ground surface.

Supplemental field exploration was performed between May 1, 2017 and May 4, 2017 and included drilling nine 8-inch diameter borings using a truck-mounted hollow-stem auger drilling machine. The borings were excavated to approximate depths between 60½ and 120½ feet below the existing ground surface. In addition, three 8-inch diameter borings were excavated to depths between 15 and 25 feet for the purposes of percolation testing.

The approximate locations of the exploratory borings are depicted on the Geologic Map (see Figure 2A). A detailed discussion of the field investigation, including boring logs, is presented in Appendix A.

Laboratory tests were performed on selected soil samples obtained during the investigation to determine pertinent physical and chemical soil properties. Appendix B presents a summary of the laboratory test results.

The recommendations presented herein are based on analysis of the data obtained during the investigation and our experience with similar soil and geologic conditions. References reviewed to prepare this report are provided in the *List of References* section.

If project details vary significantly from those described above, Geocon should be contacted to determine the necessity for review and possible revision of this report.

2. SITE AND PROJECT DESCRIPTION

The property is an approximately 23.35-acre irregular-shaped parcel and is currently vacant. The project area to be developed is approximately 5.72 acres and is bounded by Via Valmonte on the north and west, Hawthorne Boulevard on the east, and a 200- to 250-foot-high, north-facing, former quarry slope on the south (referred to herein as Slope 3). The lower 120 to 180 vertical feet of Slope 3 has been graded to a generally uniform inclination ranging from approximately 48 to 50 degrees (with localized areas inclined at approximately 60 degrees) and exposes Miocene age sedimentary bedrock of the Monterey Formation. The upper elevations of the slope have undergone little to no grading and are inclined at gradients of less than 2:1 (horizontal to vertical). The elevation at the base of the north-facing slope ranges from approximately 200 to 220 feet above Mean Sea Level (MSL) in the western portion of the site and ranges from approximately 240 to 245 feet MSL in the eastern portion of the site with a maximum elevation of approximately 460 feet MSL at the crest.

The site topography, north of the former quarry slope (Slope 3), has also been altered by previous diatomite and diatomaceous soil mining activities. As a result, the existing site topography generally slopes toward the center of the site which is a topographic low. The area of the topographic low was previously mined to approximately Elevation 110 feet MSL and later backfilled to create two level pads, the lower pad at approximately Elevation 190 to Elevation 220 feet MSL and the upper pad at approximately Elevation 235 feet MSL to Elevation 245 feet MSL. Between approximately 2 and 80 feet of artificial fill is present at the site. Existing slopes bounding the proposed development on the northwest (Slope 1) and east-northeast (Slope 2) are considered graded slopes (from past mining operations). Slope 1 ranges from approximately 40 to 80 feet in height and is inclined at gradients ranging from 1¼:1 to 1½:1 (horizontal to vertical). Slope 2 is approximately 50 feet in height and is inclined at gradients ranging from 2:1 to 1½:1 (horizontal to vertical).

Information regarding the proposed project was provided by the client. It is our understanding that that the planned multi-family residential development will consist of three multi-family residential buildings a six-story parking structure, and community areas. The multi-family residential buildings will consist of four-stories of residential units over one level of podium parking. The proposed finished floor elevations range from 190.75 to 193.5 feet MSL. The proposed site development is shown on the Site Plan (see Figure 2B).

Based on the proposed site elevations, excavations on the order of 50 feet and fills less than 5 feet will be required to achieve the desired elevations for the proposed development.

Based on the preliminary nature of the design at this time, wall and column loads were not available. It is anticipated that column loads for the proposed residential structures will be up to 400 kips, and wall loads will be up to 4 kips per linear foot. It is anticipated that the column loads for the proposed parking structure will be up to 900 kips, and wall loads will be up to 8 kips per linear foot.

Due to the preliminary nature of the project at this time, the recommendations presented herein should also be considered preliminary. As the project proceeds, additional analyses may be required in order to provide comprehensive geotechnical recommendations for design and construction. Any changes in the design, location or elevation of any structure, as outlined in this report, should be reviewed by this office.

3. PRIOR INVESTIGATIONS

We previously performed a preliminary geotechnical evaluation for the site that consisted of a literature review, including review of published geologic maps and reports, historic topographic maps, available local groundwater level data, and recent nearby fault investigations. The results of the preliminary geotechnical evaluation were presented in a separate report dated November 11, 2014.

Also, a previous geotechnical investigation was performed at the site by Pacific Soils, Inc. and field explorations were performed at the site between February 8, 2005 and September 21, 2005. The results of the investigation were presented in a report dated June 4, 2008. We were provided with a copy of the field exploration logs for review. However, we were not provided a full copy of the prior Pacific Soils report.

Based on our review of the Pacific Soils report, four bucket auger borings and nine test pits were performed as part of their geotechnical investigation at the site. The bucket auger borings (B-101, B-102, B-201 and B-202) were advanced to depths up to approximately 111 feet below the existing ground surface and the test pits (EP-1 to EP-9) were advanced to a maximum depth of 17 feet beneath the existing ground surface. Pacific Soils also utilized boring data from a previous geotechnical investigation at the site by Western Laboratories (1996). The locations of the Pacific Soils (2008) explorations and Western Laboratories (1996) are shown on Figure 2A. Copies of these exploration logs are provided as Appendix C. Boring B-102 and test pits EP-5 through EP-9 do not provide geologic information pertinent to our investigation and therefore are not shown on Figure 2A.

Other documents we reviewed include the following:

- *Butcher Hill Topographic Survey*, Bolten Engineering Corporation, undated, Scale: 1" = 50'.
- *Topographic Map for Butcher Construction Company, 1976*, Scale: 1" = 40'
- *Geotechnical Boring Logs, Plates A-1 through A-8, Pacific Soils*, dated June 2008, W.O. 102568.

- *Western Laboratories Testing Results, Plates E-1 through E-7*, dated June 2008, W.O. 102568.
- *Western Laboratories Boring and Test Pit Logs, Plates D1 through D-13*, dated June 2008, W.O. 102568.
- *Western Laboratories, 1996, Addendum No. 2, Preliminary Geotechnical Engineering Report, Butcher Hill Residential Development, West of Hawthorne Boulevard, Between Via Valmonte and Rolling Hills Road, Torrance, California*, dated April 23, 1996, W.O. 93-1605.
- *Draft Environmental Impact Report, Butcher Mountain, Tentative Tract No. 51753, EAS94-0008, ZON94-0002, State Clearinghouse No. 95041055*, prepared for the City of Torrance Planning Department, Prepared by Envicom Corporation, dated August 11, 1995.
- *Final Draft Environmental Impact Report 76-11 for D. Butcher, Tentative Tract 33120*, Prepared by Environmental Division, Planning Department, City of Torrance, Dated July 1977.
- *Action Engineering Consultants, 1976, Proposed Residential Development, Southwest Corner of Hawthorne Boulevard and Via Valmonte Avenue in the City of Torrance, California*, Prepared for Butcher Construction Company, 2371 Torrance Boulevard, Torrance, California, Work Order 4H2-507-01, dated July 27, 1976.
- *John D. Merrill, CPG, 1976, Engineering Geology Report, Tentative Tract, Hawthorne Boulevard and Via Valmonte Street, Torrance, California*, for Action Engineering Consultants, Project 63487, dated August 4, 1976.
- *Environmental Impact Evaluation of Proposed Tract 26507 in the City of Torrance, Prepared for Mr. Philip Nicholson-Trustee*, Prepared by LANDCO, Land Consultants and Civil Engineers, dated April 18, 1972.
- *Site Plan and Parking Plan*, Withee Malcolm Architects, undated.

A complete list of the documents reviewed as part of this study is presented in the *List of References* section of this report.

4. GEOLOGIC SETTING

The site is located on the northern flank of the Palos Verdes Hills, the westernmost onshore uplift of the Peninsular Ranges geomorphic province. The sedimentary rock in the Palos Verdes Hills are folded and faulted into a dome-like structure with the north and south limbs dipping downward away from the central portion of the hills. The sedimentary rocks along the north side of the hills dip to the north at inclinations of approximately 17 to 86 degrees. The major geologic structure in the area is the northwest-trending Palos Verdes Fault Zone, a zone of right-lateral strike-slip and oblique-slip faults. The Palos Verdes Fault Zone is generally located along the northern edge of the Palos Verdes Hills between San Pedro Bay on the southeast and Santa Monica Bay on the northwest. The northeastern strand of the fault zone is the boundary between the uplifted Palos Verdes Hills to the south and the Los Angeles Basin to the north.

5. SOIL AND GEOLOGIC CONDITIONS

Based on our field investigation and published geologic maps of the area, the geologic materials exposed at the site include artificial fill, overburden soil, Pleistocene age marine sand, San Pedro Sand and Lomita Marl, and Miocene age sedimentary bedrock of the Monterey Formation. Detailed stratigraphic profiles are provided on the boring logs in Appendix A.

5.1 Artificial Fill (af)

Artificial fill was encountered in our field explorations to depths between 2 and 74 feet below existing ground surface. On the lower pad, the fill is shallowest near the base of the adjacent slopes and increases in thickness towards the central area of the site. On the slopes bounding the proposed development on the northwest (Slope 1) and east-northeast (Slope 2), the fill is approximately 2 to 5½ feet thick. The artificial fill generally consists of light to dark brown and yellowish brown sand, silty sand, and clayey sand, with lesser amounts of gravelly sand, sandy silt and clay. As observed in the large-diameter borings, the fill contains localized lifts of concentrated concrete, brick, and rock fragments (up to 22 inches in longest dimension) with localized pockets of debris such as wire, PVC pipe, plastic and metal debris. The artificial fill is characterized as slightly moist and loose to medium dense. The fill is the result of backfilling the previous mining pit, a process that has been on-going since the 1960s. Deeper fill may exist between excavations and in other portions of the site that were not directly explored.

5.2 Overburden Soil

Overburden soil was encountered within the upper 5 feet in boring B1, located at the top of the north-facing slope (Slope 3). The overburden soil was derived from in-situ weathering of the underlying sedimentary bedrock and consists primarily of light gray sandy silt with varied amounts of gravel and roots. The soils are primarily dry and soft and are underlain by the sedimentary bedrock of the Monterey Formation.

5.3 Marine Sand (Qm)

Late Pleistocene age marine sand was encountered below the fill soils in hand augers HA1 through HA3 and borings B16 and B21 (on Slope 2) to a maximum depth of 15 feet. The marine sand generally consists of light brown to brown and reddish brown, fine to medium-grained sand, silty sand and sandy silt with lenses of coarse-grained sand and rounded gravel. As observed in our trenches, excavated for our concurrent fault investigation at the site, the marine sand is generally massive to horizontally bedded. The marine sand is characterized as dry to slightly moist and loose to dense or firm to hard. Although weakly developed bedding is locally observed in this formation, this material is considered predominantly massive.

5.4 San Pedro Sand (Qsp)

The late Pleistocene age San Pedro Sand (Dibblee, 1999) underlies the fill on Slope 1, the marine sand on Slope 2, and the proposed building areas on the existing graded pads. The San Pedro Sand ranges from light gray to yellowish brown (where oxidized), fine- to coarse-grained sand that is generally massive to well-bedded, moderately cemented to friable (uncemented) with local gravel-rich beds and some rounded cobbles. As observed in our trenches, excavated for our concurrent fault investigation at the site, the San Pedro Sand is generally massive but locally exhibits crudely stratified sand beds that dip to the north between 20 and 65 degrees. The sand is characterized as slightly moist and medium dense to very dense. Although bedding is locally observed in this formation, this material is considered predominantly massive.

5.5 Lomita Marl (Qlm)

The mid-Pleistocene age Lomita Marl underlies the San Pedro Sand (Dibblee, 1999) and is locally exposed on the north-facing slope (Slope 3) along the southern project boundary. The Lomita Marl was not encountered in our explorations at the site. However, as observed in very limited exposures on Slope 3, the Lomita Marl is generally fossiliferous, calcareous, fine-grained sandstone and siltstone that is massive to poorly bedded and dips to the northeast at inclinations of 50 degrees or steeper (Woodring et al., 1946). The very limited exposures of the Lomita Marl are included in the Monterey Formation units shown on Figure 2A.

5.6 Monterey Formation Bedrock (Tm)

Sedimentary bedrock of the Valmonte Diatomite member of the Miocene age Monterey Formation was encountered in borings B1 and B2 and is exposed on the north-facing slope (Slope 3) along the southern site boundary. As encountered in the borings, the Valmonte Diatomite consists of interbedded white diatomaceous siltstone and sandstone and brown to yellow brown clayey siltstone with localized siliceous and cherty beds. As exposed on Slope 3, the bedrock is predominantly diatomaceous siltstone and sandstone with localized lenses of well-cemented siliceous siltstone, fossiliferous sandstone, and cherty sandstone. The bedrock is thinly bedded with well-developed bedding and ranges from very soft (diatomaceous siltstone and sandstone beds) to medium hard (cherty and siliceous beds). The diatomaceous-rich portion of this formation is reported to be highly porous with low permeability, highly expansive, has poor slope stability, and is not suitable for fill material (City of Torrance, 2009).

Based on published geologic maps, previous geotechnical reports for the site, and downhole logging of large-diameter borings B1 and B2 at the site, the Monterey Formation bedrock dips to the northeast and northwest at inclinations of approximately 17 to 86 degrees. The bedding exposed on the slope face generally dips 50 to 80 degrees to the north.

6. GROUNDWATER

Based on a review of the Seismic Hazard Zone Report for the Torrance 7.5 Minute Quadrangle, Los Angeles County, California (California Division of Mines and Geology [CDMG], 1998), there is no reported data for the historically highest groundwater level in the immediate area.

The Los Angeles County Department of Public Works (LACDPW) has maintained various wells in the vicinity of the subject site over the past 70 years. The closest groundwater monitoring well to the site is Well No. 769 located approximately 1.4 miles to the northeast (LACDPW, 2017a). Data for this well is available for the monitoring period between 1946 and 1991. The monitoring data indicates that the depth to groundwater has fluctuated between the high and low measurements of 82.7 feet below the existing ground surface in October 2008 to 164.4 feet below the existing ground surface in April, 1971, respectively (LACDPW, 2017a). The most recent groundwater level measurement for Well No. 240A was measured in October, 2008 at a depth of 82.7 feet below the existing ground surface (LACDPW, 2017a).

Groundwater was not encountered in our borings drilled to a maximum depth of 120.5 feet beneath the existing ground surface within the proposed building area and 111.5 feet beneath the existing ground surface at the top of Slope 3. Based on the lack of groundwater encountered in the previous explorations as well as the historic groundwater levels in nearby monitoring wells, groundwater is not anticipated to adversely impact the proposed development. However, it is not uncommon for groundwater levels to vary seasonally or for groundwater seepage conditions to develop where none previously existed, especially in impermeable fine-grained soils which are heavily irrigated or after seasonal rainfall. In addition, recent requirements for stormwater infiltration could result in shallower seepage conditions in the immediate site vicinity. Proper surface drainage of irrigation and precipitation will be critical for future performance of the project. Recommendations for drainage are provided in the *Surface Drainage* section of this report (see Section 8.23).

7. GEOLOGIC HAZARDS

7.1 Surface Fault Rupture

7.1.1 General

The numerous faults in Southern California include active, potentially active, and inactive faults. The criteria for these major groups are based on criteria developed by the California Geological Survey (CGS, formerly known as California Division of Mines and Geology [CDMG]) for the Alquist-Priolo Earthquake Fault Zone Program (Bryant and Hart, 2007). By definition, an active fault is one that has had surface displacement within Holocene time (about the last 11,000 years). A potentially active fault has demonstrated surface displacement during Quaternary time (approximately the last 1.6 million years), but has had no known Holocene movement. Faults that have not moved in the last 1.6 million years are considered inactive.

The site is not within a currently established Alquist-Priolo Earthquake Fault Zone for surface fault rupture hazards (CGS, 2017; CDMG, 1986). However, the site is located within a City of Torrance Fault Hazard Management Zone (City of Torrance, 2009). As previously discussed, we have performed a fault rupture hazard investigation for the proposed development in accordance with the requirements of the City of Torrance. The results of this investigation are presented under separate cover (Geocon, 2016).

7.1.2 Palos Verdes Fault

The results of our fault rupture hazard investigation (Geocon, 2016) indicate the active Palos Verdes Fault is located offsite, approximately 350 feet to the north. Active faults are not present at the site and the potential for surface fault rupture to occur at the site is considered very low. However, the site is located within a zone of minor shearing that is considered a consequence of either folding of the northeastern flank of the Palos Verdes Hills or a result of minor movement during periods of strong ground shaking or liquefaction prior to uplift of this portion of the peninsula. All the features observed are minor and considered Middle Pleistocene age.

Since the former mining operation has significantly altered the original ground surface at the site and the majority of the upper portion of the San Pedro Sand has been removed and replaced with up to 80 feet of fill soils, there is some uncertainty as to the potential for differential movement along these minor shears during a future earthquake. Therefore, we conclude there is a minor risk that a future earthquake may generate minor secondary slip along these features.

It is our opinion that a structural setback from these features is not warranted. However, mitigation measures are necessary to eliminate the potential for differential settlement that may adversely affect the proposed structures. These mitigation measures are presented in the Conclusions and Recommendations section of this report.

7.1.3 Other Nearby Faults

Other nearby active faults include the Cabrillo Fault and the Newport-Inglewood Fault Zone approximately 1.9 miles south and 7.5 miles northeast of the site, respectively. The active San Andreas Fault Zone is located approximately 52 miles northeast of the site (Ziony and Jones, 1989). The faults in the Los Angeles area and the general site vicinity are shown in Figure 4, Regional Fault Map.

The Compton Thrust underlies the site and the majority of the city of Torrance at depths greater than several kilometers (City of Torrance, 2009). Also, several buried thrust faults, commonly referred to as blind thrusts, underlie the Los Angeles Basin at depth. These faults are not exposed at the ground surface and are typically identified at depths greater than 3.0 kilometers. The October 1, 1987 M_w 5.9 Whittier Narrows earthquake and the January 17, 1994 M_w 6.7 Northridge earthquake were a result of movement on the Puente Hills Blind Thrust and the Northridge Thrust, respectively. These thrust faults and others in the Los Angeles area are not exposed at the surface and do not present a potential

surface fault rupture hazard at the site; however, these deep thrust faults are considered active features capable of generating future earthquakes that could result in moderate to significant ground shaking at the site.

7.2 Seismicity

As with all of Southern California, the site has experienced historic earthquakes from various regional faults. The seismicity of the region surrounding the site was formulated based on research of an electronic database of earthquake data. The epicenters of recorded earthquakes with magnitudes equal to or greater than 5.0 in the site vicinity are depicted on Figure 5, Regional Seismicity Map. A partial list of moderate to major magnitude earthquakes that have occurred in the Southern California area within the last 100 years is included in the following table.

LIST OF HISTORIC EARTHQUAKES

Earthquake (Oldest to Youngest)	Date of Earthquake	Magnitude	Distance to Epicenter (Miles)	Direction to Epicenter
San Jacinto-Hemet area	April 21, 1918	6.8	78	E
Near Redlands	July 23, 1923	6.3	90	E
Long Beach	March 10, 1933	6.4	25	SE
Tehachapi	July 21, 1952	7.5	91	NW
San Fernando	February 9, 1971	6.6	42	N
Whittier Narrows	October 1, 1987	5.9	24	NE
Sierra Madre	June 28, 1991	5.8	38	NE
Landers	June 28, 1992	7.3	113	ENE
Big Bear	June 28, 1992	6.4	92	ENE
Northridge	January 17, 1994	6.7	31	NW

The site could be subjected to strong ground shaking in the event of an earthquake. However, this hazard is common in Southern California and the effects of ground shaking can be mitigated if the proposed structures are designed and constructed in conformance with current building codes and engineering practices.

7.3 Seismic Design Criteria

The following table summarizes site-specific design criteria obtained from the 2016 California Building Code (CBC; Based on the 2016 International Building Code [IBC] and ASCE 7-10), Chapter 16 Structural Design, Section 1613 Earthquake Loads. The data was calculated using the computer program *U.S. Seismic Design Maps*, provided by the USGS. The short spectral response uses a period of 0.2 second. The values presented below are for the risk-targeted maximum considered earthquake (MCE_R).

2016 CBC SEISMIC DESIGN PARAMETERS

Parameter	Value	2016 CBC Reference
Site Class	D	Table 1613.3.2
MCE _R Ground Motion Spectral Response Acceleration – Class B (short), S _S	1.730g	Figure 1613.3.1(1)
MCE _R Ground Motion Spectral Response Acceleration – Class B (1 sec), S ₁	0.673g	Figure 1613.3.1(2)
Site Coefficient, F _A	1.0	Table 1613.3.3(1)
Site Coefficient, F _V	1.5	Table 1613.3.3(2)
Site Class Modified MCE _R Spectral Response Acceleration (short), S _{MS}	1.730g	Section 1613.3.3 (Eqn 16-37)
Site Class Modified MCE _R Spectral Response Acceleration – (1 sec), S _{M1}	1.010g	Section 1613.3.3 (Eqn 16-38)
5% Damped Design Spectral Response Acceleration (short), S _{DS}	1.153g	Section 1613.3.4 (Eqn 16-39)
5% Damped Design Spectral Response Acceleration (1 sec), S _{D1}	0.673g	Section 1613.3.4 (Eqn 16-40)

The table below presents the mapped maximum considered geometric mean (MCE_G) seismic design parameters for projects located in Seismic Design Categories of D through F in accordance with ASCE 7-10.

ASCE 7-10 PEAK GROUND ACCELERATION

Parameter	Value	ASCE 7-10 Reference
Mapped MCE _G Peak Ground Acceleration, PGA	0.720g	Figure 22-7
Site Coefficient, F _{PGA}	1.0	Table 11.8-1
Site Class Modified MCE _G Peak Ground Acceleration, PGAM	0.720g	Section 11.8.3 (Eqn 11.8-1)

The Maximum Considered Earthquake Ground Motion (MCE) is the level of ground motion that has a 2 percent chance of exceedance in 50 years, with a statistical return period of 2,475 years. According to the 2016 California Building Code and ASCE 7-10, the MCE is to be utilized for the evaluation of liquefaction, lateral spreading, seismic settlements, and it is our understanding that the intent of the Building code is to maintain “Life Safety” during a MCE event. The Design Earthquake Ground Motion (DE) is the level of ground motion that has a 10 percent chance of exceedance in 50 years, with a statistical return period of 475 years.

Deaggregation of the MCE peak ground acceleration was performed using the USGS 2008 Probabilistic Seismic Hazard Analysis (PSHA) Interactive Deaggregation online tool. The result of the deaggregation analysis indicates that the predominant earthquake contributing to the MCE peak ground acceleration is characterized as a 6.90 magnitude event occurring at a hypocentral distance of 4.9 kilometers from the site.

Deaggregation was also performed for the Design Earthquake (DE) peak ground acceleration, and the result of the analysis indicates that the predominant earthquake contributing to the DE peak ground acceleration is characterized as a 6.66 magnitude occurring at a hypocentral distance of 17.4 kilometers from the site.

Conformance to the criteria in the above tables for seismic design does not constitute any kind of guarantee or assurance that significant structural damage or ground failure will not occur if a large earthquake occurs. The primary goal of seismic design is to protect life, not to avoid all damage, since such design may be economically prohibitive.

7.4 Liquefaction Potential

Liquefaction is a phenomenon in which loose, saturated, relatively cohesionless soil deposits lose shear strength during strong ground motions. Primary factors controlling liquefaction include intensity and duration of ground motion, gradation characteristics of the subsurface soils, in-situ stress conditions, and the depth to groundwater. Liquefaction is typified by a loss of shear strength in the liquefied layers due to rapid increases in pore water pressure generated by earthquake accelerations.

The current standard of practice, as outlined in the “Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California” and “Special Publication 117A, Guidelines for Evaluating and Mitigating Seismic Hazards in California” requires liquefaction analysis to a depth of 50 feet below the lowest portion of the proposed structure. Liquefaction typically occurs in areas where the soils below the water table are composed of poorly consolidated, fine to medium-grained, primarily sandy soil. In addition to the requisite soil conditions, the ground acceleration and duration of the earthquake must also be of a sufficient level to induce liquefaction.

A review of the State of California Seismic Hazard Zone Map for the Torrance Quadrangle (CDMG, 1999) indicates that the site is not located in an area designated as “liquefiable”. In addition, according to the Safety Element of the City of Torrance General Plan (2009), the site is not located within an area identified as having a potential for liquefaction. Historic high groundwater levels in monitoring wells in the south Torrance area indicate groundwater levels have been below a depth of 80 feet for the last 70 years. Also, groundwater was not encountered in our borings drilled within the building area to a maximum depth of 120½ feet beneath the existing ground surface. Based on these considerations, it is our opinion that the potential for liquefaction and associated ground deformations beneath the site is very low.

7.5 Seismically Induced Settlement

Dynamic compaction of dry and loose sands may occur during a major earthquake. Typically, settlements occur in thick beds of such soils. The seismically-induced settlement calculations were performed in accordance with the American Society of Civil Engineers, Technical Engineering and Design Guides as adapted from the US Army Corps of Engineers, No. 9.

Calculation of the potential for seismically-included settlement of dry sands was performed for borings B16 through B19, and B21 through B24. Only the portions of the borings below the proposed site elevations were analyzed, which corresponds to soil profiles ranging from approximately 50 to 62 feet in depth below proposed grades.

The calculations provided herein indicate that the upper 50 to 60 feet of site soils below the proposed elevations would be prone to less than 0.2 inches of total settlement as a result of the Design Earthquake peak ground acceleration ($\frac{2}{3}PGA_M$). Differential settlement at the ground surface is anticipated to be less than $\frac{1}{4}$ inch over a distance of 20 feet. Calculation of the anticipated seismically induced settlements is provided as Appendix D.

It is our understanding that the intent of the Building Code is to maintain “Life Safety” during Maximum Considered Earthquake level events. Therefore, additional analysis was performed to evaluate the potential for liquefaction during a MCE event. The structural engineer should evaluate the proposed structure for the anticipated MCE liquefaction induced settlements and verify that anticipated deformations would not cause the foundation system to lose the ability to support the gravity loads and/or cause collapse of the structure.

The calculations provided herein indicate that the upper 50 to 60 feet of site soils below the proposed elevations would be prone to less than 0.66 inches of total settlement as a result of the Maximum Considered Earthquake peak ground acceleration (PGA_M). Differential settlement at the ground surface is anticipated to be less than $\frac{1}{3}$ inch over a distance of 20 feet. Calculation of the anticipated seismically induced settlements is provided as Appendix D.

7.6 Slope Stability

There are no known deep-seated landslides near the site, nor is the site in the path of any known or potential landslides. However, a steep north-facing slope (Slope 3) exists along the southern site boundary. This slope exposes well-bedded diatomaceous siltstone and sandstone of the Valmonte Member of the Monterey Formation and locally some massive to weakly bedded calcareous-rich sandstone and siltstone of Pleistocene age Lomita Marl. A review of the State of California Seismic Hazard Zone Map for the Torrance Quadrangle (CDMG, 1999) indicates this slope may have a potential for earthquake-induced landslides.

Slopes 1 and 2 range in height from 40 to 80 feet and are inclined at gradients ranging from 1¼:1 to 2:1 (horizontal to vertical). These slopes are underlain by San Pedro Sand and marine sand that are generally homogeneous formations and not considered bedded for the purposes of slope stability evaluation.

Slope 3 ranges from 200 to 250 feet in height. This former quarry slope has been generally graded to a uniform inclination ranging from 48 to 50 degrees (locally up to 60 degrees) and exposes Miocene age sedimentary bedrock of the Monterey Formation. Based on geologic mapping of surface exposures and downhole logging of large-diameter borings at the site, the Monterey Formation bedrock is highly fractured and generally dips in a consistent manner to the north. As shown on Figure 2A (Geologic Map) and Figure 3A (see geologic sections A, B, F, and G), the bedding exposed on the slope face generally dips 50 to 68 degrees to the north. This bedding orientation is favorable with respect to global stability, generally being inclined at angles steeper than the slope inclination or exhibiting a “dip slope” condition. Both these conditions are highly stable with respect to global stability. Furthermore, considering the well-developed bedding of the Monterey Formation, slope stability analysis consisting of planar analyses and wedge-failure analyses are considered appropriate for slope stability evaluation. Also, the bedrock exposed in Slope 3 is soft, highly fractured, and highly weathered. This condition has resulted in areas of continued sloughing and localized rockfalls and some overhanging areas. Areas of debris accumulation (slough) have been designated on the Geologic Map (Figure 2A).

General Slope Stability Approach

In accordance with the current standard of practice, as outlined in the “Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in California” and “Special Publication 117A, Guidelines for Evaluating and Mitigating Seismic Hazards in California”, slopes should demonstrate the following conditions when analyzed for stability:

- Global Static Stability - minimum factor of safety of 1.5
- Global Pseudo-Static Stability - minimum factor of safety of 1.0 at screening criteria
- Surficial Stability - minimum factor of safety of 1.5

Shear strength parameters were determined from laboratory direct shear tests on samples obtained during our field investigation. In addition, we reviewed the laboratory test results from Pacific Soils and Western Laboratories. Based on our review of the prior direct shear testing performed by Pacific Soils, we excluded the shear strength results from Pacific Soils boring B-101 at a depth of 50 and 95 feet. The data points for these two samples showed significant scatter and it is our opinion that a mohr-coulumb failure envelope cannot be confidently established for these tests.

The stability analyses presented herein were performed by selecting average strength parameters for each of the geologic units. The values used in the slope stability analyses are summarized in the table below.

SUMMARY OF SOIL PROPERTIES USED FOR SLOPE STABILITY ANALYSES

Material	Density (pcf)	Friction Angle (degrees)	Cohesion (psf)	Remarks
Engineered Fill	125	30	180	Saturated, Peak
Artificial Fill (af)	112	33	125	Saturated, Peak
Marine sand (Qm)	120	33	240	Saturated, Peak
San Pedro Sand (Qsp)	125	39	375	Saturated, Peak
Monterey Formation Bedrock (Tm)	75	35	200	Field Moisture, Residual

The Monterey Formation bedrock generally consists of siltstone, diatomaceous siltstone and sandstone, and clayey siltstone which are considered relatively impermeable materials and are non-waterbearing. No groundwater or water seepage was observed within the Monterey Formation bedrock during the current or prior explorations. Furthermore, it is our understanding that the sloped portion of the site will be dedicated as open space with no appreciable source of water that could inundate the hillside. Based on these considerations, it is our opinion that the use of field moisture shear strengths is appropriate given the lack of potential for the slope to become saturated.

Due to the relatively light load associated with existing and proposed structures located adjacent to the slopes, the structure loads are considered negligible with no appreciable impact to the slope stability analyses and, therefore, were not incorporated into the analyses.

Pseudo-Static Approach

In accordance with the “Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Evaluating and Mitigating Landslide Hazards in California (2002)” and the “Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117A (2008)”, seismic slope performance may be evaluated by first applying a screening analysis based on the seismic coefficient (k_{eq}). The seismic coefficient (k_{eq}) is based on the maximum horizontal acceleration (MHA_r) and f_{eq} , a factor related to the seismicity of the site. Graphs to estimate the value of f_{eq} based on slope displacement, earthquake magnitude, rupture distance, and MHA_r are available in SP117A.

As recommended by SP117, seismic slope stability analysis shall be evaluated based on a maximum displacement of 5 centimeters where potential failure planes intersect stiff improvements (such as structures) and for ground motions corresponding to the Design Earthquake hazard level. The MHAr corresponding to the Design Earthquake hazard level was taken as two-thirds of the $PGAM$. A value of 0.48g was used as MHAr in the analysis. As discussed in Section 7.3, the earthquake characterizing the DE peak ground acceleration is a 6.66 magnitude occurring at a hypocentral distance of 17.4 kilometers from the site.

Based on these input values, the seismic coefficient (keq) was evaluated as 0.24g and was used in the pseudo-static slope stability analysis. If the pseudo-static stability analysis results in a factor of safety of greater than 1.0, the slope passes the screening criteria and analysis of slope deformations is not required. If the resulting factor of safety is less than one, analyses to determine the estimated displacements are required.

Slope 1

Slope 1, located adjacent to Via Valmonte, ranges from approximately 40 to 80 feet in height, and is inclined at gradients ranging from 1¼:1 to 1½:1 (horizontal to vertical). This slope is prone to surficial instability as evidenced by four surficial failures observed during geologic mapping of the slope. The surficial failures range from 1 to 2 feet in thickness and are shown on Figure 2A.

Slope 1 was analyzed for gross static, pseudo-static, and surficial stability at Cross-Sections C-C' and D-D'. Slope stability analyses were performed using the two-dimensional computer program *GeoStudio2007 Slope/W* by Geo-Slope International Ltd.

Slope 1 at Cross-Section C-C'

Slope 1 at Cross-Section C-C' was analyzed using entry and exit with circular failure surfaces and using the GLE method.

Analysis of Slope 1 at Cross-Section C-C' indicates a factor of safety of 1.59 for gross stability under static conditions. This exceeds the minimum required factor of safety of 1.5 and therefore the slope is considered stable with respect to gross stability under static conditions. The slope geometry, geologic structure, and calculated factor of safety are presented on Figures E1 and E2. The critical failure surface is shown on computer generated output.

Analysis of Slope 1 at Cross-Section C-C' indicates a factor of safety of 1.09 for gross stability when subject to the seismic coefficient acceleration (keq). The factor of safety exceeds the minimum required factor of safety of 1.0. Therefore, the slope passes the screening criteria, is considered stable under pseudo-static loading, and analysis of slope deformations is not required. The slope geometry, geologic structure, and calculated factor of safety for are presented on Figures E3 and E4. The critical failure surface is shown on computer generated output.

Surficial slope stability calculations were performed for the artificial fill exposed on the slope face. The calculated factor of safety for surficial slope stability is approximately 1.0, which is less than the required minimum factor of safety of 1.5. The results of the surficial slope stability analysis indicate Slope 1 could be prone to surficial instability. It is our understanding this slope will not be graded as part of the currently proposed project and it is planned to leave this slope in its current configuration. Furthermore, two retaining walls are proposed to be constructed along Slope 1 (see Site Plan, Figure 2B). Based on this consideration, mitigation of the potential for surficial instability of Slope 1 to impact the proposed development can be achieved by incorporating a slough wall at the top of proposed retaining walls to prevent surficial failures from accumulating on-site.

The surficial stability calculations are presented on Figures E5. Recommendations for the proposed slough wall and other mitigation measures for surficial instability of Slope 1 are presented in Section 8.15 of this report.

Slope 1 at Cross-Section D-D'

Slope 1 at Cross-Section D-D' was analyzed using entry and exit with circular failure surfaces and using the GLE method.

Analysis of Slope 1 at Cross-Section D-D' indicates a factor of safety of 1.97 for gross stability under static conditions. This exceeds the minimum required factor of safety of 1.5 and therefore the slope is considered stable with respect to gross stability under static conditions. The slope geometry, geologic structure, and calculated factor of safety are presented on Figure E6. The critical failure surface is shown on computer generated output.

Analysis of Slope 1 at Cross-Section D-D' indicates a factor of safety of 1.33 for gross stability when subject to the seismic coefficient acceleration (k_{eq}). The factor of safety exceeds the minimum required factor of safety of 1.0. Therefore, the slope passes the screening criteria, is considered stable under pseudo-static loading, and analysis of slope deformations is not required. The slope geometry, geologic structure, and calculated factor of safety for are presented on Figure E7. The critical failure surface is shown on computer generated output.

Surficial slope stability calculations were performed for the artificial fill exposed on the slope face. The calculated factor of safety for surficial slope stability is approximately 1.04, which is less than the required minimum factor of safety of 1.5. As previously discussed, this slope will not be graded as part of the currently proposed project. Section D-D crosses the north maintenance bench access ramp, between two proposed retaining walls. Slough from surficial failures may accumulate along the access ramp and against the north wall of Building A.

The surficial stability calculations are presented on Figure E8. Recommendations for mitigation measures for surficial instability of Slope 1 are presented in Section 8.15 of this report.

Slope 2

As a part of the proposed site development, Slope 2 will be removed for construction of the proposed Buildings B and C. Therefore, stability analyses of Slope 2 are not necessary.

Slope 3

Slope stability analyses of Slope 3 were performed for planar and wedge failures by a third-party consultant, GeoStabilization International (Geostabilization, 2016). Copies of the report and updated letter prepared by GeoStabilization International are included herein as Appendix F. Based on the findings of their study, Slope 3 is considered stable under gross static and pseudo-static conditions. However, as previously indicated, there is a potential for surficial instability consisting of sloughing and/or rockfall. Localized areas of surficial sloughing were observed during our geologic mapping of Slope 3 as evidenced by slough accumulation at the toe of the slope (see Geologic Map, Figure 2A).

Geologic data was provided to Geostabilization International for rockfall simulation modeling. Data provided include slope heights, slope inclinations, exposed lithology, bedding thickness, spacing of joints/fractures, rockfall sources, characterization of rock blocks (size, shape and roughness) in areas of slough accumulation, orientation of geologic structure (bedding, joint and fractures), joint/fracture spacing, rock strength, and other characteristics necessary for modeling.

The results of the rockfall simulation modeling performed by GeoStabilization indicate that mitigation of surficial slope instability, in the form of sloughing and/or rockfall, should be incorporated into the site design. The rockfall measures are discussed in the *Rockfall Catchment and Slough Protection* section of this report (Section 8.15).

7.7 Earthquake-Induced Flooding

Earthquake-induced flooding is inundation caused by failure of dams or other water-retaining structures due to earthquakes. Based on a review of the Safety Element for the City of Torrance (2009), the site is not located within a potential inundation area for an earthquake-induced dam failure. The probability of earthquake-induced flooding is considered very low.

7.8 Tsunamis, Seiches, and Flooding

The site is not located within a coastal area. Therefore, tsunamis, seismic sea waves, are not considered a significant hazard at the site.

Seiches are large waves generated in enclosed bodies of water in response to ground shaking. No major water-retaining structures are located immediately up gradient from the project site. Flooding from a seismically-induced seiche is considered unlikely.

The site is not within a flood hazard zone as indicated by the Torrance General Plan (2009) and the County of Los Angeles (2017).

7.9 Oil Fields & Methane Potential

Based on a review of the California Division of Oil, Gas and Geothermal Resources (DOGGR) Well Finder website (DOGGR, 2017), the site is not located within the limits of a known oil field and oil wells are not located in the site's immediate vicinity. However, due to the voluntary nature of record reporting by the oil well drilling companies, wells may be improperly located or not shown on the location map and undocumented wells could be encountered during construction. Any wells encountered will need to be properly abandoned in accordance with the current requirements of the DOGGR.

Since the site is not located within the boundaries of a known oil field, the potential for the presence of methane or other volatile gases at the site is considered low. However, should it be determined that a methane study is required for the proposed development it is recommended that a qualified methane consultant be retained to perform the study and provide mitigation measures as necessary.

7.10 Subsidence

Subsidence occurs when a large portion of land is displaced vertically, usually due to the withdrawal of groundwater, oil, or natural gas. Soils that are particularly subject to subsidence include those with high silt or clay content. The site is not located within an area of known ground subsidence. No large-scale extraction of groundwater, gas, oil, or geothermal energy is occurring or planned at the site or in the general site vicinity. There appears to be little or no potential for ground subsidence due to withdrawal of fluids or gases at the site.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 General

- 8.1.1 It is our opinion that neither soil nor geologic conditions were encountered during this investigation that would preclude the construction of the proposed development provided the recommendations presented herein are followed and implemented during design and construction. This report should be considered preliminary and the geotechnical design parameters presented herein should be reviewed and updated if the design, location or elevation of any structure changes.
- 8.1.2 Between 2½ and 74 feet of existing artificial fill was encountered during the site investigation. The fill is the result of backfilling the previous mining pit, and deeper fill may exist between excavations and in other portions of the site that were not directly explored. Excavations for the proposed structures are anticipated to remove some, but not all, of the existing artificial fill. Based on our site exploration and laboratory testing, it is our opinion that the upper portions of the existing artificial fill are not suitable for direct support of proposed structures. Additional information on the depths of unsuitable artificial fill is provided below. The existing fill and site soils are suitable for re-use as engineered fill provided the recommendations in the *Grading* section of this report are followed (see Section 8.4).
- 8.1.3 The upper artificial fill contains localized lifts of concentrated concrete, brick, and rock fragments (up to 22 inches in longest dimension) with localized pockets of debris such as wire, PVC pipe, plastic and metal debris. If encountered, the debris trash should be exported from the site and should not be mixed with the fill soils. Generation of trash and oversized material (greater than 8 inches) should be anticipated. Oversized materials should be managed in accordance with the recommendations provided in the *Grading* section of this report (see Section 8.4).
- 8.1.4 As discussed in Section 7.1, minor shears considered secondary features associated with regional folding or past ground shaking were observed within the San Pedro Sand at the site. These secondary features are not considered active faults. However, it is recommended that special recommendations be implemented in order to mitigate the effects of small displacements that may occur along some of these secondary features as a result of an earthquake originating along the nearby Palos Verdes Fault. It is recommended that the proposed structures be supported on a blanket of engineered fill reinforced with geosynthetic materials. The reinforced engineered fill blanket will provide a ductile sublayer that can accommodate earthquake-induced ground displacement and minimize the displacements transferred to the structures. It is also recommended that the structures be decoupled from the reinforced engineered fill blanket through the placement of a of a double layer of polyolefin sheets sandwiched between layers of clean sand, placed immediately below the mat foundation. For preliminary design purposes, a

4-foot-thick layer of engineered fill with geogrid reinforcement placed at 1-foot vertical intervals may be assumed. Once the project proceeds to a more finalized state and a project structural engineer is available to provide input, additional analyses can be performed to confirm the required thickness of and number of geosynthetic layers in the reinforced engineered fill blanket.

- 8.1.5 The finished floor elevation for Building A is 193.5 feet MSL. It is anticipated that both artificial fill and San Pedro Sand will be exposed at the pad subgrade (see Geologic Sections D-D' and F-F', Figures 3A and 3B). For Building A, it is recommended that the existing artificial fill to an elevation of approximately 177 feet MSL be excavated and properly compacted for support of the reinforced engineered fill blanket and proposed foundation. The excavation should extend laterally a minimum distance of 10 feet beyond the building footprint areas, including building appurtenances, or a distance equal to the depth of fill below the foundation, whichever is greater. Where competent San Pedro Sand is encountered above an elevation of 177 feet MSL, it is considered suitable and will not require excavation to an elevation of 177 feet MSL. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities. Recommendations for earthwork are provided in the *Grading* section of this report (see Section 8.4).
- 8.1.6 The finished floor elevation for Building B is 190.5 feet MSL. It is anticipated that artificial fill, marine sand, and San Pedro Sand will be exposed at the pad subgrade (see Geologic Sections A-A', B-B', and H-H', Figure 3A). For Building B, it is recommended that the existing artificial fill to an elevation of approximately 173 feet MSL be excavated and properly compacted for support of the reinforced engineered fill blanket and proposed foundation. The excavation should extend laterally a minimum distance of 10 feet beyond the building footprint areas, including building appurtenances, or a distance equal to the depth of fill below the foundation, whichever is greater. Where competent marine sand or San Pedro Sand is exposed at the excavation bottom, it is considered suitable and does not require excavation to an elevation of 173 feet MSL. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities. Recommendations for earthwork are provided in the *Grading* section of this report (see Section 8.4).
- 8.1.7 The finished floor elevation for Building C is 191.67 feet MSL. It is anticipated that San Pedro Sand will be exposed at the pad subgrade (see Geologic Sections E-E' and G-G', Figures 3A 3B). The San Pedro Sand is considered suitable for direct support of the reinforced engineered fill blanket and proposed foundation system.

- 8.1.8 The finished floor elevation for the parking structure varies between 190.75 and 193.9 feet MSL. It is anticipated that both artificial fill and San Pedro Sand will be exposed at the pad subgrade (see Geologic Sections A-A' and B-B', Figure 3A). For the parking structure, it is recommended that the existing artificial fill to an elevation of approximately 187 feet MSL be excavated and properly compacted for support of the reinforced engineered fill blanket and proposed foundation. The excavation should extend laterally a minimum distance of 5 feet beyond the building footprint areas, including building appurtenances, or a distance equal to the depth of fill below the foundation, whichever is greater. Where competent San Pedro Sand is exposed at the excavation bottom, it is considered suitable and does not require excavation to an elevation of 187 feet MSL. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities. Recommendations for earthwork are provided in the *Grading* section of this report (see Section 8.4).
- 8.1.9 Subsequent to the recommended grading, proposed structures may be supported on reinforced concrete mat foundations underlain by at least 4 feet of geogrid reinforced engineered fill, in turn underlain by both newly placed engineered fill and San Pedro Sand. It is the intent of the Geotechnical Engineer to allow foundations and the reinforced engineered fill blanket to derive support in both engineered fill and San Pedro Sand, if project conditions warrant such an occurrence. Recommendations for the design of a mat foundation system are provided in Section 8.8.
- 8.1.10 Retaining walls of up to 50 feet in height are anticipated as a part of the proposed project. Recommendations for the design of retaining walls are provided in Section 8.14.
- 8.1.11 Due to the nature of the proposed design and intent for retaining walls which are tucked into an existing slope, waterproofing of subterranean walls and slabs is suggested. Particular care should be taken in the design and installation of waterproofing to avoid moisture problems, or actual water seepage into the structure through any normal shrinkage cracks which may develop in the concrete walls, floor slab, foundations and/or construction joints. The design and inspection of the waterproofing is not the responsibility of the geotechnical engineer. A waterproofing consultant should be retained in order to recommend a product or method, which would provide protection to subterranean walls, floor slabs and foundations.
- 8.1.12 Excavations of up to 50 feet in vertical height are anticipated for construction of the proposed structures, including retaining walls and grading activities. Due to the depth of the excavation and the proximity to the property lines and slopes, grading activities and retaining wall construction will require sloping and/or shoring in order to provide a stable excavation. Recommendations for temporary excavations are provided in Section 8.20.

- 8.1.13 Proposed fill slopes should be properly benched and keyed into competent native soil prior to the placement of engineered fill. Proposed cut slopes should be excavated into competent native soils or constructed with a stability fill. All slope and backcut excavations must be observed and approved in writing by the Geotechnical Engineer prior to placement of additional engineered fill. Recommendations for slope construction are provided in Section 8.5
- 8.1.14 Foundations for small outlying structures, such as block walls up to 6 feet high, planter walls or trash enclosures, which will not be tied to proposed structures, may be supported on conventional foundations bearing on a minimum of 12 inches of newly placed engineered fill which extends laterally at least 12 inches beyond the foundation area. If excavation and compaction cannot be performed, such as adjacent to property lines, alternative recommendations will be required. Due to the preliminary nature of the project at this time, if required, alternative recommendations will be provided under separate cover as the project proceeds.
- 8.1.15 Where new paving is to be placed, it is recommended that all existing fill and unsuitable native soils be excavated and properly compacted for paving support. As a minimum, the upper 12 inches of soil should be scarified and properly compacted for paving support. Paving recommendations are provided in *Preliminary Pavement Recommendations* section of this report (see Section 8.13).
- 8.1.16 Based on the results of percolation testing performed at the site, a stormwater infiltration system is considered feasible for this project. Recommendations for infiltration are provided in the *Stormwater Infiltration* section of this report (see Section 8.22).
- 8.1.17 Once the design and foundation loading configuration for the proposed structure proceeds to a more finalized plan, the recommendations within this report should be reviewed and revised, if necessary. Based on the final foundation loading configurations, the potential for settlement should be re-evaluated by this office.
- 8.1.18 Any changes in the design, location or elevation of improvements, as outlined in this report, should be reviewed by this office. Geocon should be contacted to determine the necessity for review and possible revision of this report.

8.2 Soil and Excavation Characteristics

- 8.2.1 The in-situ soil and bedrock can be excavated with moderate effort using conventional excavation equipment. Minor caving should be anticipated in unshored vertical excavations, especially where loose or granular fills are encountered. The bedrock is moderately to highly weathered and should be rippable with conventional equipment; however, concretions or well cemented layers may be encountered in the bedrock which could make excavation or drilling conditions difficult. Coring or jack-hammering may be required if concretions are

encountered, and the contractor should be prepared for these conditions. All sloping cuts that expose bedrock must be inspected by a certified engineering geologist to verify the presence of out of slope bedding and to determine if there is a stability risk.

- 8.2.2 It is the responsibility of the contractor to ensure that all excavations and trenches are properly shored and maintained in accordance with applicable OSHA rules and regulations to maintain safety and maintain the stability of existing adjacent improvements.
- 8.2.3 All onsite excavations must be conducted in such a manner that potential surcharges from existing structures, construction equipment, and vehicle loads are resisted. The surcharge area may be defined by a 1:1 projection down and away from the bottom of an existing foundation or vehicle load. Penetrations below this 1:1 projection will require special excavation measures such as sloping or shoring. Excavation recommendations are provided in the *Temporary Excavations* section of this report (see Section 8.20).
- 8.2.4 The upper few feet of soils encountered during the investigation are considered to have a “low” (EI=33) expansive potential and are classified as “expansive” based on the 2016 California Building Code (CBC) Section 1803.5.3. Recommendations presented herein assume that the building foundations and slabs will derive support in these materials.
- 8.2.5 It is recommended that after finish pad grades have been achieved, laboratory testing of the subgrade soil at each building pad and flatwork areas should be performed to reevaluate expansive potential. If laboratory test results indicate the presence of “highly expansive” soils at the subgrade, additional recommendations may be required.

8.3 Minimum Resistivity, pH and Water-Soluble Sulfate

- 8.3.1 Potential of Hydrogen (pH) and resistivity testing as well as chloride content testing were previously performed on representative samples of soil to generally evaluate the corrosion potential to surface utilities. The tests were performed in accordance with California Test Method Nos. 643 and 422 and indicate that the soils are considered corrosive with respect to corrosion of buried ferrous metals on site. The results are presented in Appendix B (Figure B27) and should be considered for design of underground structures.
- 8.3.2 Laboratory tests were performed on representative samples of soil near the anticipated subterranean levels to measure the percentage of water-soluble sulfate content. Results from the laboratory water-soluble sulfate tests are presented in Appendix B (Figure B27) and indicate that the on-site materials possess “negligible” sulfate exposure to concrete structures as defined by 2016 CBC Section 1904.3 and ACI 318-11 Sections 4.2 and 4.3.

- 8.3.3 It is recommended that after finish pad grades have been achieved, laboratory testing of the subgrade soil be performed to reevaluate the corrosivity characteristics.
- 8.3.4 Geocon West, Inc. does not practice in the field of corrosion engineering and mitigation. If corrosion sensitive improvements are planned, it is recommended that a corrosion engineer be retained to evaluate corrosion test results and incorporate the necessary precautions to avoid premature corrosion of buried metal pipes and concrete structures in direct contact with the soils.

8.4 Grading

- 8.4.1 Earthwork should be observed, and compacted fill tested by representatives of Geocon West, Inc.
- 8.4.2 A preconstruction conference should be held at the site prior to the beginning of grading operations with the owner, contractor, civil engineer, building official, and geotechnical engineer in attendance. Special soil handling requirements can be discussed at that time.
- 8.4.3 It shall be the sole responsibility of the contractor to provide adequate equipment and methods to accomplish the work in accordance with applicable grading codes or agency ordinances, the recommendations presented herein, and the approved grading plans.
- 8.4.4 The existing artificial fill, native soils, and bedrock encountered during exploration are suitable for re-use as an engineered fill, provided any encountered deleterious debris is removed. Pockets of trash and debris may be encountered within the deeper artificial fill. If encountered, the trash and debris should be exported from the site and should not be mixed with the fill soils. Generation of oversized material (greater than 8 inches) should be anticipated. Rocks larger than 8 inches but less than 4 feet in maximum dimension may be incorporated into the engineered fill. Placement of oversized material (larger than 8 inches) shall be limited to the area measured at least 15 feet horizontally from the nearest slope face and 10 feet below finish grade or 3 feet below the deepest utility, whichever is deeper. It is recommended that where non-building areas are available, placement of oversized material should be performed in these areas.
- 8.4.5 If bedrock is to be utilized as an engineered fill, it may be blocky and may have to be crushed and moisture conditioned prior to utilization.
- 8.4.6 All materials utilized as engineered fill should be well-blended to create a uniform fill material prior to placement and compaction within each building pad area or slope construction. Soils must be placed uniformly and at equal thickness at the direction of the Geotechnical Engineer (a representative of Geocon West, Inc.).

- 8.4.7 Grading should commence with the removal of all existing vegetation and existing improvements from the area to be graded. All existing underground improvements planned for removal should be completely excavated and the resulting depressions properly backfilled in accordance with the procedures described herein. Deleterious debris such as wood and root structures should be exported from the site and should not be mixed with the fill soils. Asphalt and concrete should not be mixed with the fill soils unless approved by the Geotechnical Engineer. All existing underground improvements planned for removal should be completely excavated and the resulting depressions properly backfilled in accordance with the procedures described herein.
- 8.4.8 During grading operations, the Geotechnical Engineer (a representative of Geocon) should be onsite to observe that soil and geologic conditions do not differ significantly from those expected. If conditions are found to be variable, modification to the grading recommendations described herein should be implemented based on onsite observations. This may include deeper excavations to remove artificial fill or unsuitable soils, or reducing excavations where competent soil is encountered at shallower depths than anticipated.
- 8.4.9 It is recommended that the proposed structures be supported on a blanket of engineered fill reinforced with geosynthetic materials. The reinforced engineered fill blanket will provide a ductile sublayer that can accommodate earthquake-induced ground displacement and minimize the transfer of the displacements to the structures. It is also recommended that the structures be decoupled from the reinforced engineered fill blanket through the placement of a double layer of polyolefin sheets sandwiched between layers of clean sand, placed immediately below the mat foundation. For preliminary design purposes, a 4-foot-thick layer of engineered fill with geogrid reinforcement placed at 1 foot vertical intervals may be assumed. Once the project proceeds to a more finalized state and a project structural engineer is available to provide input, additional analyses can be performed to confirm the required thickness of and number of geosynthetic layers in the reinforced engineered fill blanket.
- 8.4.10 Subsequent to the excavation and compaction of the existing artificial fill as described below, the initial layer of geosynthetic reinforcement should be placed at the bottom of the 4-foot thick reinforced engineered fill blanket. A 1-foot lift of soil should be placed and compacted, and an additional layer of geosynthetic reinforcement placed. Adjacent strips of geosynthetic reinforcement should overlap in accordance with the manufactures' requirements. This procedure should be continued until four layers of geosynthetic reinforcement and 4 feet of engineered fill have been placed. The double layer of polyolefin sheets sandwiched between layers of clean sand should be placed immediately above the reinforced engineered fill blanket and immediately below the mat foundation. The geosynthetic reinforcement should extend laterally a minimum distance of 5 feet beyond the building footprint areas.

- 8.4.11 For Building A, it is recommended that the existing artificial fill to an elevation of approximately 177 feet MSL be excavated and properly compacted for support of the reinforced engineered fill blanket and proposed foundation. Deeper excavations should be conducted as necessary to remove pockets of debris or low quality artificial fill, if encountered, at the direction of the Geotechnical Engineer (a representative of Geocon). The excavation should extend laterally a minimum distance of 10 feet beyond the building footprint areas, including building appurtenances, or a distance equal to the total depth of fill below the foundation, whichever is greater. Where competent San Pedro Sand is exposed at the excavation bottom, it is considered suitable and does not require excavation to an elevation of 177 feet MSL. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities.
- 8.4.12 For Building B, it is recommended that the existing artificial fill to an elevation of approximately 173 feet MSL be excavated and properly compacted for support of the reinforced engineered fill blanket and proposed foundation. Deeper excavations should be conducted as necessary to remove pockets of debris or low quality artificial fill, if encountered, at the direction of the Geotechnical Engineer (a representative of Geocon). The excavation should extend laterally a minimum distance of 10 feet beyond the building footprint areas, including building appurtenances, or a distance equal to the total depth of fill below the foundation, whichever is greater. Where competent marine sand or San Pedro Sand is exposed at the excavation bottom, it is considered suitable and does not require excavation to an elevation of 173 feet MSL. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities.
- 8.4.13 It is anticipated that San Pedro Sand will be exposed throughout the pad subgrade of Building C, and the San Pedro Sand is considered suitable for direct support of the reinforced engineered fill blanket and proposed foundation.
- 8.4.14 For the parking structure, it is recommended that the existing artificial fill to an elevation of approximately 187 feet MSL be excavated and properly compacted for support of the reinforced engineered fill blanket and proposed foundation. Deeper excavations should be conducted as necessary to remove pockets of debris or low quality artificial fill, if encountered, at the direction of the Geotechnical Engineer (a representative of Geocon). The excavation should extend laterally a minimum distance of 5 feet beyond the building footprint areas, including building appurtenances, or a distance equal to the total depth of fill below the foundation, whichever is greater. Lateral overexcavation will not be feasible adjacent to Slope 3. Where competent San Pedro Sand is exposed at the excavation bottom, it is considered suitable and does not require excavation to an elevation of 187 feet MSL. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities.

- 8.4.15 All excavations must be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon), prior to placing fill, gravel, or construction materials. If determined to be excessively soft, additional removals or stabilization of the excavation bottom may be required in order to provide a firm working surface upon which engineered fill can be placed and heavy equipment can operate. If required, recommendations for stabilization measures can be provided under separate cover.
- 8.4.16 All fill and backfill soils should be placed in horizontal loose layers approximately 6 to 8 inches thick, moisture conditioned to optimum moisture content, and properly compacted to a minimum 90 percent of the maximum dry density in accordance with ASTM D 1557 (latest edition).
- 8.4.17 Although not anticipated for this project, all imported fill shall be observed, tested, and approved by Geocon West, Inc. prior to bringing soil to the site. Rocks larger than 8 inches in diameter shall not be used in the fill. If necessary, import soils used as structural fill should have an expansion index less than 20 and corrosivity properties that are equally or less detrimental to that of the existing onsite soils (see Figure B27).
- 8.4.18 Where the slope of the existing ground or temporary backcut is steeper than 6:1 (horizontal:vertical), or as recommended by the onsite representative of Geocon, it is recommended that the ground be cut or benched to create horizontal planes so that fill can be placed and compacted on horizontal surfaces. An illustration of the recommended benching is provided as Figure 6.
- 8.4.19 Where new paving is to be placed, it is recommended that all existing fill and unsuitable native soils be excavated and properly compacted for paving support. As a minimum, the upper 12 inches of soil should be scarified and compacted to at least 95 percent relative compaction where placing and compacting granular soils, and 92 percent relative compaction where placing and compacting fine-grained soils for paving support. Paving recommendations are provided in *Preliminary Pavement Recommendations* section of this report (see Section 8.13).
- 8.4.20 It is recommended that flexible utility connections be utilized for all rigid utilities to minimize or prevent damage to utilities from minor differential movements. Utility trenches should be properly backfilled in accordance with the requirements of the Green Book (latest edition). The pipe should be bedded with clean sands (Sand Equivalent greater than 30) to a depth of at least one foot over the pipe, and the bedding material must be inspected and approved in writing by the Geotechnical Engineer (a representative of Geocon). The use of gravel is not acceptable unless used in conjunction with filter fabric to prevent the gravel from having direct contact with soil. The remainder of the trench backfill may be derived from onsite soil or approved import soil, compacted as necessary, until the required compaction is obtained.

The use of minimum 2-sack slurry is also acceptable as backfill. Prior to placing any bedding materials or pipes, the excavation bottom must be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon).

- 8.4.21 All trench and foundation excavation bottoms must be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon), prior to placing bedding material, fill, steel, gravel or concrete.

8.5 Slope Construction

- 8.5.1 Fill slopes comprised of on-site materials should be constructed at a gradient of 2:1 or flatter. Fill slopes should be overbuilt by at least 3 feet measured perpendicular to the slope face and trimmed back to the tight fill core. This procedure is considered preferable to track-walking of slopes, as described in the following paragraph.
- 8.5.2 As an alternative, fill slope faces may be compacted by backrolling with a loaded sheepsfoot roller at vertical intervals not to exceed 4 feet, and should be track-walked at the completion of each slope such that the fill is compacted to a dry density of at least 90 percent of the laboratory maximum dry density and near or slightly above optimum moisture content to the face of the finished sloped.
- 8.5.3 Where the slope ratio of the existing ground or temporary backcut is steeper than 6:1 (horizontal:vertical), preparation for the construction of proposed slopes should include removal of all vegetation and unsuitable soils. Prior to the placement of engineered fill, the existing grade should be benched and keyed into competent native soil (see Figure 6). All backcut excavations must be observed and approved in writing by the Geotechnical Engineer prior to placement of engineered fill.
- 8.5.4 Cut slope excavations, including buttresses and shear keys, must be observed by the Geotechnical Engineer (a representative of Geocon) during grading operations to check that soil and geologic conditions do not differ significantly from those expected. Cut slopes which are excavated into soft or unsuitable soil or bedrock may require stabilization. Typically stabilization measures consist of drains and/or buttress fills. Stabilization design and details are depicted on Figure 7.
- 8.5.5 During the construction of buttresses, there is a risk that the temporary backcut slopes will become unstable. This risk can be reduced by grading the buttress fill in short segments and/or flattening the inclination of the temporary slope.

8.5.6 All graded slopes should be planted, drained, and property maintained to reduce erosion. It is recommended that finished slopes be planted as soon after completion of grading as possible. Planting on the slope stabilizes the surface and reduces the potential for erosion. It is further suggested that a jute or mesh product be placed on the slope face prior to planting; however, the planting of the slope should be performed at the direction of a qualified landscaping consultant.

8.6 Shrinkage

8.6.1 Shrinkage results when a volume of material removed at one density is compacted to a higher density. A shrinkage factor of between 10 and 20 percent should be anticipated when excavating and compacting the existing earth materials on the site to an average relative compaction of 92 percent.

8.6.2 Removal of existing underground structures or pockets of debris which are not considered suitable for reuse as engineered fill may increase the need for import soils.

8.6.3 If import soils will be utilized in the building pad or for slope construction, the soils must be placed uniformly and at equal thickness at the direction of the Geotechnical Engineer (a representative of Geocon West, Inc.). Soils can be borrowed from non-building and later replaced with imported soils.

8.7 Foundation Setback

8.7.1 The Building Code requires that foundations be sufficiently setback from an ascending or descending slope. The required setback from a descending slope with a steeper than 3:1 and gentler than 1:1 is $\frac{1}{3}$ the height of the descending slope with a minimum of 5 feet and a maximum of forty feet measured horizontally from the exterior face of the foundation to the slope face. Where the slope is steeper than 1:1, the slope setback shall be measured from an imaginary line projected at 45 degrees from the toe of the slope upwards. In lieu of relocating a structure to achieve the setback at the ground surface, foundations may be deepened as necessary to achieve the required setback.

8.7.2 The required setback from an ascending slope steeper than 3:1 and gentler than 1:1 is $\frac{1}{2}$ the height of the ascending slope with a maximum of 15 feet measured horizontally from the structure to the toe of the slope. Where the slope is steeper than 1:1, the slope setback shall be measured from an imaginary line projected at 45 degrees from the top of the slope.

8.7.3 Based on the latest set of development plans, the Building Code setbacks will be satisfied for Buildings A, B, and C. It is our understanding that the City of Torrance may consider alternate slope setback criteria for the parking structure based on the findings of the slope stability and rockfall hazard analysis presented in this geotechnical report.

8.8 Mat Foundation Design

- 8.8.1 Subsequent to the recommended grading, it is recommended that a reinforced concrete mat foundation be utilized for support of the proposed structures. The reinforced concrete mat foundation may derive support in the reinforced engineered fill blanket.
- 8.8.2 It is anticipated that the mat foundations impart an average pressure of approximately 2,500 pounds per square foot (psf) with locally higher pressures of up to 5,000 psf. The recommended maximum allowable bearing value is 5,000 psf. The allowable bearing pressure may be increased by up to one-third for transient loads due to wind or seismic forces.
- 8.8.3 It is recommended that a modulus of subgrade reaction of 150 pounds per cubic inch (pci) be utilized for the design of the mat foundation bearing in newly placed engineered fill. This value is a unit value for use with a one-foot square footing. The modulus should be reduced in accordance with the typical reduction factors when used with larger foundations.
- 8.8.4 The thickness of and reinforcement for the mat foundation should be designed by the project structural engineer.
- 8.8.5 It is recommended that the structures be decoupled from the reinforced engineered fill blanket through the placement of a of a double layer of polyolefin sheets sandwiched between layers of clean sand, placed immediately below the mat foundation. Based on the intent of the polyolefin sheets, frictional resistance should not be assumed between the mat foundation and the subgrade soils.
- 8.8.6 Foundation excavations should be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon West, Inc.), prior to the placement of reinforcing steel and concrete to verify that the exposed soil conditions are consistent with those anticipated. If unanticipated soil conditions are encountered, foundation modifications may be required.
- 8.8.7 This office should be provided a copy of the final construction plans so that the recommendations presented herein could be properly reviewed and revised if necessary.

8.9 Foundation Settlement

- 8.9.1 The enclosed seismically-induced settlement analyses indicate that the site soils could be susceptible to approximately 0.2 inches of total settlement as a result of the Design Earthquake peak ground acceleration ($\frac{2}{3}PGA_M$). The seismically induced differential settlement at the foundation level is anticipated to be less than $\frac{1}{4}$ inch over a distance of 20 feet. These settlements are in addition to the static settlements indicated below and must be considered in the structural design.

- 8.9.2 The maximum expected total static settlement for Building A supported on a reinforced mat foundation system with the maximum allowable bearing value of 5,000 psf and deriving support in the recommended bearing materials is estimated to be less than 1.4 inches. A majority of the settlement of the foundation system is expected to occur on initial application of loading; however, minor additional settlements are expected within the first twelve months. Differential static settlement between the center and corner of the mat is anticipated to be less than 1 inch.
- 8.9.3 The maximum expected total static settlement for Building B supported on a reinforced mat foundation system with the maximum allowable bearing value of 5,000 psf and deriving support in the recommended bearing materials is estimated to be less than 1.6 inches. A majority of the settlement of the foundation system is expected to occur on initial application of loading; however, minor additional settlements are expected within the first twelve months. Differential static settlement between the center and corner of the mat is anticipated to be less than 1¼ inches.
- 8.9.4 The maximum expected total settlement for Building C supported on a reinforced mat foundation system with the maximum allowable bearing value of 5,000 psf and deriving support in the recommended bearing materials is estimated to be less than 0.6 inches. A majority of the settlement of the foundation system is expected to occur on initial application of loading; however, minor additional settlements are expected within the first twelve months. Differential static settlement between the center and corner of the mat is anticipated to be less than ½ inch.
- 8.9.5 The maximum expected total settlement for the parking structure supported on a reinforced mat foundation system with the maximum allowable bearing value of 5,000 psf and deriving support in the recommended bearing materials is estimated to be less than 1.9 inches. A majority of the settlement of the foundation system is expected to occur on initial application of loading; however, minor additional settlements are expected within the first twelve months. Differential static settlement between the center and corner of the mat is anticipated to be less than 1.9 inches.
- 8.9.6 The anticipated settlement indicated in the above paragraphs include consideration of the removal of overburden, the recommended grading, and the anticipated differential thickness of engineered and artificial fill.
- 8.9.7 It is recommended that flexible utility connections be utilized for all rigid utilities to minimize or prevent damage to utilities from minor differential movements.

8.9.8 Once the design and foundation loading configurations for the proposed structures proceeds to a more finalized plan, the estimated settlements presented in this report should be reviewed and revised, if necessary. If the final foundation loading configurations are greater than the assumed loading conditions the potential for settlement should be reevaluated by this office.

8.10 Miscellaneous Foundations

8.10.1 Foundations for small outlying structures, such as block walls less than 6 feet in height, planter walls or trash enclosures, which will not be tied-in to the proposed structures, may be supported on conventional foundations bearing on a minimum of 12 inches of newly placed engineered fill. If excavation and compaction cannot be performed, such as adjacent to property lines, alternative foundation recommendations will be required. Alternative recommendations will be provided under separate cover as the project proceeds.

8.10.2 Miscellaneous foundations may be designed for a bearing value of 1,500 psf, and should be a minimum of 12 inches in width, 18 inches in depth below the lowest adjacent grade and 12 inches into the recommended bearing material. The allowable bearing pressure may be increased by up to one-third for transient loads due to wind or seismic forces.

8.10.3 Foundation excavations should be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon West, Inc.), prior to the placement of reinforcing steel and concrete to verify that the excavations and exposed soil conditions are consistent with those anticipated.

8.11 Lateral Design

8.11.1 Resistance to lateral loading may be provided by friction acting at the base of retaining wall and miscellaneous foundations, slabs and by passive earth pressure. An allowable coefficient of friction of 0.35 may be used with the dead load forces in newly placed engineering fill, undisturbed marine sand, and San Pedro Sands; an allowable coefficient of friction of 0.4 may be used with the dead load forces in bedrock.

8.11.2 Passive earth pressure for the sides of foundations and slabs poured against newly placed engineering fill, undisturbed marine sand, and San Pedro Sands may be computed as an equivalent fluid having a density of 250 pounds per cubic foot (pcf) with a maximum earth pressure of 2,500 psf. Passive earth pressure for the sides of foundations and slabs poured against bedrock may be computed as an equivalent fluid having a density of 600 pcf with a maximum earth pressure of 6,000 pcf. When combining passive and friction for lateral resistance, the passive component should be reduced by one-third. A one-third increase in the passive value may be used for wind or seismic loads.

8.11.3 Where lateral over-excavation cannot be performed, and existing artificial fill is present along the sides of foundations, passive pressure should not be used. This condition may occur along portions of the south perimeter of the parking structure.

8.12 Exterior Concrete Slabs-on-Grade

8.12.1 Exterior concrete slabs-on-grade at the ground surface subject to vehicle loading should be designed in accordance with the recommendations in the *Preliminary Pavement Recommendations* section of this report (Section 8.13).

8.12.2 Exterior slabs, not subject to traffic loads, should be at least 4 inches thick and reinforced with No. 3 steel reinforcing bars placed 18 inches on center in both horizontal directions, positioned near the slab midpoint. Prior to construction of slabs, the upper 12 inches of subgrade should be moistened to two percent above optimum moisture content and properly compacted to at least 95 percent relative compaction, as determined by ASTM Test Method D 1557 (latest edition). Crack control joints should be spaced at intervals not greater than 10 feet and should be constructed using saw-cuts or other methods as soon as practical following concrete placement. Crack control joints should extend a minimum depth of one-fourth the slab thickness. The project structural engineer should design construction joints as necessary.

8.12.3 The moisture content of the slab subgrade should be maintained and sprinkled as necessary to maintain a moist condition as would be expected in any concrete placement.

8.12.4 The recommendations of this report are intended to reduce the potential for cracking of slabs due to settlement. However, even with the incorporation of the recommendations presented herein, foundations, stucco walls, and slabs-on-grade may exhibit some cracking due to minor soil movement and/or concrete shrinkage. The occurrence of concrete shrinkage cracks is independent of the supporting soil characteristics. Their occurrence may be reduced and/or controlled by limiting the slump of the concrete, proper concrete placement and curing, and by the placement of crack control joints at periodic intervals, in particular, where re-entrant slab corners occur.

8.13 Preliminary Pavement Recommendations

8.13.1 Where new paving is to be placed, it is recommended that all existing fill and soft soils be excavated and properly compacted for paving support. The client should be aware that excavation and compaction of all existing artificial fill and soft soils in the area of new paving is not required; however, paving constructed over existing uncertified fill or unsuitable soils may experience increased settlement and/or cracking, and may therefore have a shorter design life and increased maintenance costs. As a minimum, the upper 12 inches of paving subgrade should be scarified, moisture conditioned to two percent above optimum moisture content, and

properly compacted to at least 95 percent relative compaction, as determined by ASTM Test Method D 1557 (latest edition).

8.13.2 The following pavement sections are based on an assumed R-Value of 20. Once site grading activities are complete an R-Value should be obtained by laboratory testing to confirm the properties of the soils serving as paving subgrade, prior to placing pavement.

8.13.3 The Traffic Indices listed below are estimates. Geocon does not practice in the field of traffic engineering. The actual Traffic Index for each area should be determined by the project civil engineer. If pavement sections for Traffic Indices other than those listed below are required, Geocon should be contacted to provide additional recommendations. Pavement thicknesses were determined following procedures outlined in the *California Highway Design Manual* (Caltrans). It is anticipated that the majority of traffic will consist of automobile and large truck traffic.

PRELIMINARY PAVEMENT DESIGN SECTIONS

Location	Estimated Traffic Index (TI)	Asphalt Concrete (inches)	Class 2 Aggregate Base (inches)
Automobile Parking and Driveways	4.0	3.0	4.0
Trash Truck & Fire Lanes	7.0	4.0	12.0

8.13.4 Asphalt concrete should conform to Section 203-6 of the “*Standard Specifications for Public Works Construction*” (Green Book). Class 2 aggregate base materials should conform to Section 26-1.02A of the “*Standard Specifications of the State of California, Department of Transportation*” (Caltrans). The use of Crushed Miscellaneous Base (CMB) in lieu of Class 2 aggregate base is acceptable. Crushed Miscellaneous Base should conform to Section 200-2.4 of the “*Standard Specifications for Public Works Construction*” (Green Book).

8.13.5 Unless specifically designed and evaluated by the project structural engineer, where exterior concrete paving will be utilized for support of vehicles, it is recommended that the concrete be a minimum of 6 inches of concrete reinforced with No. 3 steel reinforcing bars placed 18 inches on center in both horizontal directions. Concrete paving supporting vehicular traffic should be underlain by a minimum of 4 inches of aggregate base and a properly compacted subgrade. The subgrade and base material should be compacted to 95 percent relative compaction, as determined by ASTM Test Method D 1557 (latest edition).

8.13.6 The performance of pavements is highly dependent upon providing positive surface drainage away from the edge of pavements. Ponding of water on or adjacent to the pavement will likely result in saturation of the subgrade materials and subsequent cracking, subsidence and pavement distress. If planters are planned adjacent to paving, it is recommended that the perimeter curb be extended at least 12 inches below the bottom of the aggregate base to minimize the introduction of water beneath the paving.

8.14 Retaining Walls Design

8.14.1 The recommendations presented below are generally applicable to the design of rigid concrete or masonry retaining walls having a maximum height of 50 feet. In the event that walls higher than 50 feet are planned, Geocon should be contacted for additional recommendations.

8.14.2 Retaining wall foundations may be designed in accordance with the recommendations provided in the *Mat Foundation Design* section of this report (see Section 8.8).

8.14.3 Retaining walls should be designed utilizing the equivalent fluid pressures indicated in the following tables. Walls not restrained at the top (cantilevered) may utilize the active pressure. Restrained walls are those that are not allowed to rotate more than 0.001H (where H equals the height of the retaining portion of the wall in feet) at the top of the wall. Where walls are restrained from movement at the top the at-rest pressure should be considered.

RETAINING WALL WITH LEVEL BACKFILL SURFACE

HEIGHT OF WALL (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT- REST PRESSURE)
Up to 15	40	60
Up to 30	49	70
Up to 50	54	75

RETAINING WALL WITH SURCHARGE FROM 2:1 SLOPE

HEIGHT OF WALL (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Up to 15	70	95
Up to 30	90	105
Up to 50	100	110

- 8.14.4 The wall pressures provided above assume that the retaining wall will be properly drained preventing the buildup of hydrostatic pressure. If retaining wall drainage is not implemented, the equivalent fluid pressure to be used in design of undrained walls is 90 pcf. The value includes hydrostatic pressures plus buoyant lateral earth pressures.
- 8.14.5 Where freeboard for sloughing and impact will be incorporated into the design of walls along Slope 1, it is recommended that the freeboard be a minimum height of 24 inches and be designed for a pressure of 125 pcf. Rockfall hazard mitigation should be implemented at the top of walls proposed along Slope 3, and recommendations for rockfall hazard mitigation are provided in Section 8.15.
- 8.14.6 Additional active pressure should be added for a surcharge condition due to slopes, vehicular traffic or adjacent structures and should be designed for each condition.
- 8.14.7 In addition to the recommended earth pressure, the upper ten feet of the retaining wall adjacent to the street or driveway areas should be designed to resist a uniform lateral pressure of 100 psf, acting as a result of an assumed 300 psf surcharge behind the shoring due to normal street traffic. If the traffic is kept back at least 10 feet from the shoring, the traffic surcharge may be neglected.
- 8.14.8 Seismic lateral forces should be incorporated into the design as necessary, and recommendations for seismic lateral forces are presented in Section 8.16.

8.15 Rockfall Catchment and Slough Protection (Slopes 1 and 3)

- 8.15.1 As discussed in the Slope Stability section of this report (Section 7.6), Slope 1 could be prone to surficial instability. Mitigation of the potential for surficial instability of Slope 1 to impact the proposed development can be achieved by incorporating a slough wall at the top of retaining walls to prevent surficial failures from accumulating on-site. The wall should be a minimum of 24 inches in height and designed for impact utilizing a triangular distribution of pressure of 125 pcf. In addition, it is suggested that the face of Slope 1 be treated with a chemical binder applied to the exposed granular soils to improve surficial stability.
- 8.15.2 Based on the configuration of the Slope 3 and the observed accumulation of slough at the toe of this slope, as well as the results of the rock mechanics and rockfall analysis performed by GeoStabilization International (see Appendix F), there is a potential for sloughing and rockfall from Slope 3 to occur periodically as a result of future weathering, rainfall, and seismic activity. It is our understanding that a rockfall containment barrier consisting of a 7-foot-high wall will be constructed at the tops of the proposed retaining walls at the base of Slope 3 to mitigate rockfall hazards. In addition, between the two walls, the rear wall of the parking structure will serve as the rockfall containment barrier. Based on the analysis performed by GeoStabilization International (see Appendix F), a rockfall containment barrier which will retain all potential

rockfall is depicted on Figure 8. Where a rockfall containment barrier is incorporated into the retaining wall design, the analyses performed by GeoStabilization International indicate that the barrier should be designed to absorb a kinetic energy of 40 kilojoules.

- 8.15.3 The area upslope of slough walls and the rockfall containment barriers will require periodic evaluations and maintenance; accumulations of debris shall be removed on a periodic basis and after severe storms. It is recommended that the developer of the site create and enforce a written maintenance plan.

8.16 Dynamic (Seismic) Lateral Forces

- 8.16.1 The structural engineer should determine the seismic design category for the project in accordance with Section 1613 of the CBC. If the project possesses a seismic design category of D, E, or F, proposed retaining walls in excess of 6 feet in height should be designed with seismic lateral pressure (Section 1803.5.12 of the 2016 CBC).
- 8.16.2 A seismic load of 20 pcf should be used for design of walls that support more than 6 feet of backfill in accordance with Section 1803.5.12 of the 2016 CBC. The seismic load is applied as an equivalent fluid pressure along the height of the wall and the calculated loads result in a maximum load exerted at the base of the wall and zero at the top of the wall. This seismic load should be applied in addition to the active earth pressure. The earth pressure is based on half of two thirds of PGA_M calculated from ASCE 7-10 Section 11.8.3.

8.17 Retaining Wall Drainage

- 8.17.1 Retaining walls should be provided with a drainage system. At the base of the drain system, a subdrain covered with a minimum of 12 inches of gravel should be installed, and a compacted fill blanket or other seal placed at the surface (see Figure 9). The clean bottom and subdrain pipe, behind a retaining wall, should be observed by the Geotechnical Engineer (a representative of Geocon), prior to placement of gravel or compacting backfill.
- 8.17.2 As an alternative, a plastic drainage composite such as Miradrain or equivalent may be installed in continuous, 4-foot-wide columns along the entire back face of the wall, at 8 feet on center. The top of these drainage composite columns should terminate approximately 18 inches below the ground surface, where either hardscape or a minimum of 18 inches of relatively cohesive material should be placed as a cap (see Figure 10).
- 8.17.3 Subdrainage pipes at the base of the retaining wall drainage system should outlet to an acceptable location via controlled drainage structures. Drainage should not be allowed to flow uncontrolled over descending slopes.

8.17.4 Moisture affecting below grade walls is one of the most common post-construction complaints. Poorly applied or omitted waterproofing can lead to efflorescence or standing water. Particular care should be taken in the design and installation of waterproofing to avoid moisture problems, or actual water seepage into the structure through any normal shrinkage cracks which may develop in the concrete walls, floor slab, foundations and/or construction joints. The design and inspection of the waterproofing is not the responsibility of the geotechnical engineer. A waterproofing consultant should be retained in order to recommend a product or method, which would provide protection to subterranean walls, floor slabs and foundations.

8.18 Soil Nail Wall Design

8.18.1 Soil nail walls consist of installing closely spaced steel bars (nails) into a slope or excavation in a top-down construction sequence. Following installation of a horizontal row of nails, drains, waterproofing, and wall reinforcing steel are placed and shotcrete applied to create a final wall.

8.18.2 Soil nail walls should not be considered a permanent design to support the seismic lateral loads and soil pressures on a building wall. Therefore, the proposed building should be designed to support the expected lateral loads.

8.18.3 The wall should be designed by an engineer familiar with the design of soil nail walls.

8.18.4 In general, ground conditions are moderately suited to soil nail wall construction techniques. However, localized gravel, cobble, and oversized material could be encountered in the existing materials that could be difficult to drill. Additionally, relatively clean sands may be encountered within the existing soil that may result in some raveling of the unsupported excavation.

8.18.5 A wall drain system should be incorporated into the design of the soil nail wall. Corrosion protection should be provided for the nails if the wall will be a permanent structure.

8.18.6 Testing of the soil nails should be performed in accordance with the guidelines of the Federal Highway Administration or similar guidelines. At least two verification tests should be performed to confirm design assumptions for each soil/rock type encountered. Verification tests nails should be sacrificial and should not be used to support the proposed wall. The bond length should be adjusted to allow for pullout testing of the verification nails to evaluate the ultimate bond stress. A minimum of 5 percent of the production nails should also be proof tested and a minimum of 4 sacrificial nails should be tested at the discretion of Geocon West, Inc. Consideration should be given to testing sacrificial nails with an adjusted bond length rather than testing production nails. Geocon West, Inc. should observe the nail installation and document the nail testing.

8.18.7 The soil strength parameters listed in the table below can be used in design of the soil nails. The bond stress is dependent on drilling method, diameter, and construction method. Therefore, the designer should evaluate the bond stress based on the existing soil conditions and the construction method.

SOIL STRENGTH PARAMETERS FOR SOIL NAIL WALLS

Description	Unit Weight (Pounds Per Cubic Foot)	Friction Angle (Degrees)	Cohesion (Pounds Per Cubic Foot)
Artificial Fill	112	33	125
San Pedro Sand (Qsp)	125	39	375

8.19 Elevator Pit Design

8.19.1 Based on the potential for secondary fault displacements, it is the intent of the geotechnical grading and foundation recommendations to decouple the proposed structures from the ground in order to minimize the earthquake-induced ground displacement transferred to the structures. In order to minimize the potential for ground displacement transferred to the structures as a result of the elevator pits, it is recommended that a cold-joint be used where the pits connect to the mat foundation.

8.19.2 The elevator pit slab and retaining wall should be designed by the project structural engineer. As a minimum the slab-on-grade for the elevator pit bottom should be at least 4 inches thick and reinforced with No. 4 steel reinforcing bars placed 16 inches on center in both horizontal directions, positioned near the slab midpoint. Elevator pit walls may be designed in accordance with the recommendations in the Mat Foundation Design and Retaining Wall Design sections of this report (see Sections 8.8 and 8.14).

8.19.3 Additional active pressure should be added for a surcharge condition due to sloping ground, vehicular traffic, or adjacent foundations and should be designed for each condition as the project progresses.

8.19.4 If retaining wall drainage is to be provided, the drainage system should be designed in accordance with the Retaining Wall Drainage section of this report (see Section 8.17).

8.19.5 It is suggested that the exterior walls and slab be waterproofed to prevent excessive moisture inside of the elevator pit. Waterproofing design and installation is not the responsibility of the geotechnical engineer.

8.20 Temporary Excavations

- 8.20.1 Excavations of up to 50 feet in vertical height are anticipated for construction of the proposed structures, including retaining walls and grading activities. The excavations are expected to expose artificial fill, marine sand, San Pedro Sands, and bedrock, which are suitable for vertical excavations. Due to the adverse bedding and jointing configuration of bedrock, excavations into bedrock should be sloped or shored in order to provide a stable excavation. All cut slopes should be observed by the Project Geologist (a representative of Geocon West, Inc.) during excavation. Where adverse bedding is encountered the bedrock may be trimmed along the angle of bedding.
- 8.20.2 Vertical excavations greater than 5 feet will require sloping, shoring, or other special excavation measures in order to provide a stable excavation. Where sufficient space is available, temporary unsurcharged embankments up to 15 feet high could be sloped back at a uniform 1:1 slope gradient or flatter. Slopes higher than 15 feet may be sloped back at a uniform 2:1 slope gradient or flatter. A uniform slope does not have a vertical portion. Where space is limited, shoring measures will be required and recommendations for shoring are provided in the following section.
- 8.20.3 Where sloped embankments are utilized, the top of the slope should be barricaded to prevent vehicles and storage loads at the top of the slope within a horizontal distance equal to the height of the slope. If the temporary construction embankments are to be maintained during the rainy season, berms are suggested along the tops of the slopes where necessary to prevent runoff water from entering the excavation and eroding the slope faces. Geocon personnel should inspect the soils exposed in the cut slopes during excavation so that modifications of the slopes can be made if variations in the soil conditions occur. All excavations should be stabilized within 30 days of initial excavation.

8.21 Shoring – Soldier Pile Design and Installation

- 8.21.1 The following information on the design and installation of shoring is preliminary. Review of the final shoring plans and specifications should be made by this office prior to bidding or negotiating with a shoring contractor.
- 8.21.2 Installation of shoring on a sloping ground surface requires careful consideration of excavation sequencing. Prior to installation of shoring, grading to create a relatively flat pad for equipment access may be required. Excavation of unsupported vertical cuts into a sloping ground surface would remove support from the ascending portion of the slope and create a potentially unstable condition. Unsupported vertical excavation into a slope is not permitted. Equipment access can be created by placement of additional fill to build up a temporary equipment pad against the existing slope.

- 8.21.3 One method of shoring would consist of steel soldier piles, placed in drilled holes and backfilled with concrete. Where maximum excavation heights are less than 12 feet the soldier piles are typically designed as cantilevers. Where excavations exceed 12 feet or are surcharged, soldier piles may require lateral bracing utilizing drilled tie-back anchors or raker braces to maintain an economical steel beam size and prevent excessive deflection. The size of the steel beam, the need for lateral bracing, and the acceptable shoring deflection should be determined by the project shoring engineer.
- 8.21.4 The design embedment of the shoring pile toes must be maintained during excavation activities. The toes of the perimeter shoring piles should be deepened to take into account any required excavations necessary for grading activities, foundations, and/or adjacent drainage systems.
- 8.21.5 The proposed soldier piles may also be designed as permanent piles. The required pile depth, dimension, spacing should be determined and designed by the project structural and shoring engineers. All piles utilized for shoring can also be incorporated into a permanent retaining wall system (shotcrete wall) and should be designed in accordance with the earth pressure provided in the *Retaining Walls* section of this report (see Section 8.14).
- 8.21.6 Drilled cast-in-place soldier piles should be placed no closer than three diameters on center. The minimum diameter of the piles is 18 inches. Structural concrete should be used for the soldier piles below the excavation; lean-mix concrete may be employed above that level. As an alternative, lean-mix concrete may be used throughout the pile where the reinforcing consists of a wideflange section. The slurry must be of sufficient strength to impart the lateral bearing pressure developed by the wideflange section to the soil. For design purposes, an allowable passive value for the soils below the bottom plane of excavation may be assumed to be 250 psf per foot. The allowable capacity may be doubled for isolated piles spaced more than twice the diameter. To develop the full lateral value, provisions should be implemented to assure firm contact between the soldier piles and the undisturbed soils.
- 8.21.7 Casing may be required if caving is experienced in the drilled excavation and the contractor should be prepared to use casing and should have it readily available at the commencement of drilling activities. If casing is used, extreme care should be employed so that the pile is not pulled apart as the casing is withdrawn. At no time should the distance between the surface of the concrete and the bottom of the casing be less than 5 feet. Continuous observation of the drilling and pouring of the piles by the Geotechnical Engineer (a representative of Geocon West, Inc.), is required.
- 8.21.8 The contractor should be aware that some difficult drilling conditions could be encountered in the bedrock which could require coring and jack-hammering. The contractor should be prepared for these conditions prior to commencement of drilling activities.

- 8.21.9 Groundwater was not encountered during site exploration; however, seasonal conditions may result in groundwater seepage encountered during shoring installation. The contractor should be prepared for groundwater during pile installation should the need arise. Piles placed below the water level require the use of a tremie to place the concrete into the bottom of the hole. A tremie should consist of a rigid, water-tight tube having a diameter of not less than 6 inches with a hopper at the top. The tube should be equipped with a device that will close the discharge end and prevent water from entering the tube while it is being charged with concrete. The tremie should be supported so as to permit free movement of the discharge end over the entire top surface of the work and to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end should be closed at the start of the work to prevent water entering the tube and should be entirely sealed at all times, except when the concrete is being placed. The tremie tube should be kept full of concrete. The flow should be continuous until the work is completed and the resulting concrete seal should be monolithic and homogeneous. The tip of the tremie tube should always be kept about 5 feet below the surface of the concrete and definite steps and safeguards should be taken to insure that the tip of the tremie tube is never raised above the surface of the concrete.
- 8.21.10 A special concrete mix should be used for concrete to be placed below water. The design should provide for concrete with an unconfined compressive strength psi of 1,000 pounds per square inch (psi) over the initial job specification. An admixture that reduces the problem of segregation of paste/aggregates and dilution of paste should be included. The slump should be commensurate to any research report for the admixture, provided that it should also be the minimum for a reasonable consistency for placing when water is present.
- 8.21.11 The frictional resistance between the soldier piles and retained soil may be used to resist the vertical component of the anchor load. The coefficient of friction may be taken as 0.35 based on uniform contact between the steel beam and retained earth. The portion of soldier piles below the plane of excavation may also be employed to resist the downward loads. The downward capacity may be determined using a frictional resistance of 400 psf.
- 8.21.12 Due to the nature of the site soils, it is expected that continuous lagging between soldier piles will be required. However, it is recommended that the exposed soils be observed by the Geotechnical Engineer (a representative of Geocon West, Inc.), to verify the presence of any cohesive soils and the areas where lagging may be omitted.
- 8.21.13 The time between lagging excavation and lagging placement should be as short as possible. Soldier piles should be designed for the full-anticipated pressures. Due to arching in the soils, the pressure on the lagging will be less. It is recommended that the lagging be designed for the full design pressure but be limited to a maximum of 400 psf.

8.21.14 For the design of shoring, it is recommended that an equivalent fluid pressure based on the following table, be utilized for design. A trapezoidal distribution of lateral earth pressure may be used where shoring will be restrained at the top by bracing or tie backs. The recommended active and trapezoidal pressure are provided in the following table A diagram depicting the trapezoidal pressure distribution of lateral earth pressure is provided below the table.

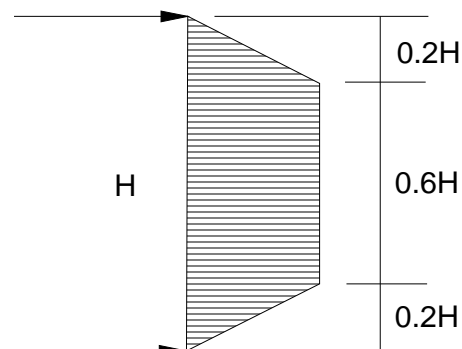
SHORING WITH LEVEL BACKFILL SURFACE

HEIGHT OF CANTILEVERED SHORING (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE Trapezoidal (Where H is the height of the shoring in feet)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Up to 15	30	28H	60
Up to 30	40	34H	70
Up to 50	45	38H	75

SHORING WITH SURCHARGE FROM 2:1 SLOPE

HEIGHT OF CANTILEVERED SHORING (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE Trapezoidal (Where H is the height of the shoring in feet)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Up to 15	48	45H	95
Up to 30	68	54H	105
Up to 50	80	59H	110

Trapezoidal Distribution of Pressure



- 8.21.15 It is very important to note that active pressures can only be achieved when movement in the soil (earth wall) occurs. If movement in the soil is not acceptable, such as adjacent to an existing structure, an at-rest pressure should be considered for design purposes.
- 8.21.16 Where a combination of sloped embankment and shoring is utilized, the pressure will be greater and must be determined for each combination. Additional active pressure should be added for a surcharge condition due to sloping ground, vehicular traffic, or adjacent structures and must be determined for each combination.
- 8.21.17 In addition to the recommended earth pressure, the upper 10 feet of the shoring adjacent to the street should be designed to resist a uniform lateral pressure of 100 psf, acting as a result of an assumed 300 psf surcharge behind the shoring due to normal street traffic. If the traffic is kept back at least ten feet from the shoring, the traffic surcharge may be neglected.
- 8.21.18 It is difficult to accurately predict the amount of deflection of a shored embankment. It should be realized that some deflection will occur. It is recommended that the deflection be minimized to prevent damage to existing structures and adjacent improvements. Where public right-of-ways are present or adjacent offsite structures do not surcharge the shoring excavation, the shoring deflection should be limited to less than 1 inch at the top of the shored embankment. Where offsite structures are within the shoring surcharge area it is recommended that the beam deflection be limited to less than ½ inch at the elevation of the adjacent offsite foundation, and no deflection at all if deflections will damage existing structures. The allowable deflection will be assessed and designed by the project shoring engineer.
- 8.21.19 Because of the depth of the excavation, some means of monitoring the performance of the shoring system is suggested. The monitoring should consist of periodic surveying of the lateral and vertical locations of the tops of all soldier piles and the lateral movement along the entire lengths of selected soldier piles.
- 8.21.20 Due to the depth of the depth of the excavation and proximity to adjacent structures, it is suggested that prior to excavation the existing improvements be inspected to document the present condition. For documentation purposes, photographs should be taken of preconstruction distress conditions and level surveys of adjacent grade and pavement should be considered. During excavation activities, the adjacent structures and pavement should be periodically inspected for signs of distress. In the even that distress or settlement is noted, an investigation should be performed and corrective measures taken so that continued or worsened distress or settlement is mitigated. Documentation and monitoring of the offsite structures and improvements is not the responsibility of the geotechnical engineer.

8.22 Stormwater Infiltration

8.22.1 During the 2017 site exploration, borings P1, P2, and P3 were utilized to perform percolation testing. The borings were advanced to the depths listed in the table below. Boring logs were not prepared for the percolation test borings; however, the soil conditions were observed to be similar to those from adjacent borings. Slotted casing was placed in the borings, and the annular space between the casing and excavation was filled with gravel. The borings were then filled with water to pre-saturate the soils. On May 5, 2017, the casings were refilled with water and percolation test readings were performed after repeated flooding of the cased excavations. Based on the test results, the average infiltration rates (adjusted percolation rate), for the earth materials encountered, are provided in the following table. The Reduction Factor (Rf), to convert the field-measured percolation rate to an infiltration rate, is also shown in the table below. This value has been calculated in accordance with the Boring Percolation Test Procedure in the County of Los Angeles Department of Public Works *GMED Guidelines for Design, Investigation, and Reporting Low Impact Development Stormwater Infiltration* (December 2014). Calculation of the percolation rate, reduction factor, and infiltration rate are provided as Figures 11 through 13.

Boring	Infiltration Depth (ft)	Measured Percolation Rate (in / hour)	Reduction Factor (Rf)	Design Infiltration Rate (in / hour)
P1	12-15	487.34	5.2	93.7
P2	20-25	26.2	15.32	1.7
P3	21-25	160.1	6.8	23.5

8.22.2 Based on the number of tests performed and consistency of the results and soils throughout the site, it is suggested that a CFv correction factor of 3.0 be used in the infiltration system design. Additional testing may be considered to lower the suggested CFv factor. In addition, provided proper maintenance is performed to minimize long-term siltation and plugging, a CFs correction factor of 1.0 may be used. Additional correction factors may be required and should be applied by the engineer in responsible charge of the design of the stormwater infiltration system and based on applicable guidelines.

8.22.3 The results of the percolation testing indicate that the soils at depths in the above table are conducive to infiltration. It is our opinion that the soil zone encountered at the depth and location as listed in the table above are suitable for infiltration of stormwater. It should be noted that the water absorbed into the ground very quickly and it is likely that that a volume-controlled infiltration system may be required to prevent percolation from occurring too quickly. It is recommended that the project civil engineer design the infiltration system in such a way as to limit the speed at which water is released into the ground from the retention chamber.

- 8.22.4 It is our further opinion that infiltration of stormwater and will not induce excessive hydro-consolidation, will not create a perched groundwater condition, will not affect soil structure interaction of existing or proposed foundations due to expansive soils, will not saturate soils supported by existing or proposed retaining walls, and will not increase the potential for liquefaction. Resulting settlements are anticipated to be less than $\frac{1}{4}$ inch, if any.
- 8.22.5 The infiltration system must be located such that the closest distance between an adjacent foundation is at least 10 feet in all directions from the zone of saturation. The zone of saturation may be assumed to project downward from the discharge of the infiltration facility at a gradient of 1:1. Additional property line or foundation setbacks may be required by the governing jurisdiction and should be incorporated into the stormwater infiltration system design as necessary.
- 8.22.6 Where the 10-foot horizontal setback cannot be maintained between the infiltration system and an adjacent footing, and the infiltration system penetrates below the foundation influence line, the proposed stormwater infiltration system must be designed to resist the surcharge from the adjacent foundation. The foundation surcharge line may be assumed to project down away from the bottom of the foundation at a 1:1 gradient. The stormwater infiltration system must still be sufficiently deep to maintain the 10-foot vertical offset between the bottom of the footing and the zone of saturation.
- 8.22.7 Subsequent to the placement of the infiltration system, it is acceptable to backfill the resulting void space between the excavation sidewalls and the infiltration system with minimum two-sack slurry provided the slurry is not placed in the infiltration zone. It is recommended that pea gravel be utilized adjacent to the infiltration zone so communication of water to the soil is not hindered.
- 8.22.8 The stormwater infiltration design drawings should be reviewed and approved by the Geotechnical Engineer. The installation of the stormwater infiltration system should be observed and approved by the Geotechnical Engineer (a representative of Geocon).

8.23 Surface Drainage

- 8.23.1 Proper surface drainage is critical to the future performance of the project. Uncontrolled infiltration of irrigation excess and storm runoff into the soils can adversely affect the performance of the planned improvements. Saturation of a soil can cause it to lose internal shear strength and increase its compressibility, resulting in a change in the original designed engineering properties. Proper drainage should be maintained at all times.

- 8.23.2 All site drainage should be collected and controlled in non-erosive drainage devices. Drainage should not be allowed to pond anywhere on the site, and especially not against any foundation or retaining wall. The site should be graded and maintained such that surface drainage is directed away from structures in accordance with 2016 CBC 1804.4 or other applicable standards. In addition, drainage should not be allowed to flow uncontrolled over any descending slope. Discharge from downspouts, roof drains and scuppers are not recommended onto unprotected soils within 5 feet of the building perimeter. Planters which are located adjacent to foundations should be sealed to prevent moisture intrusion into the soils providing foundation support. Landscape irrigation is not recommended within 5 feet of the building perimeter footings except when enclosed in protected planters.
- 8.23.3 Positive site drainage should be provided away from structures, pavement, and the tops of slopes to swales or other controlled drainage structures. The building pad and pavement areas should be fine graded such that water is not allowed to pond.
- 8.23.4 Landscaping planters immediately adjacent to paved areas are not recommended due to the potential for surface or irrigation water to infiltrate the pavement's subgrade and base course. Either a subdrain, which collects excess irrigation water and transmits it to drainage structures, or an impervious above-grade planter boxes should be used. In addition, where landscaping is planned adjacent to the pavement, it is recommended that consideration be given to providing a cutoff wall along the edge of the pavement that extends at least 12 inches below the base material.

8.24 Plan Review

- 8.24.1 Grading, foundation plans, and shoring should be reviewed by the Geotechnical Engineer (a representative of Geocon West, Inc.), prior to finalization to verify that the plans have been prepared in substantial conformance with the recommendations of this report and to provide additional analyses or recommendations.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. The recommendations of this report pertain only to the site investigated and are based upon the assumption that the soil conditions do not deviate from those disclosed in the investigation. If any variations or undesirable conditions are encountered during construction, or if the proposed construction will differ from that anticipated herein, Geocon West, Inc. should be notified so that supplemental recommendations can be given. The evaluation or identification of the potential presence of hazardous or corrosive materials was not part of the scope of services provided by Geocon West, Inc.
2. This report is issued with the understanding that it is the responsibility of the owner, or of his representative, to ensure that the information and recommendations contained herein are brought to the attention of the architect and engineer for the project and incorporated into the plans, and the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations in the field.
3. The findings of this report are valid as of the date of this report. However, changes in the conditions of a property can occur with the passage of time, whether they are due to natural processes or the works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of three years.
4. The firm that performed the geotechnical investigation for the project should be retained to provide testing and observation services during construction to provide continuity of geotechnical interpretation and to check that the recommendations presented for geotechnical aspects of site development are incorporated during site grading, construction of improvements, and excavation of foundations. If another geotechnical firm is selected to perform the testing and observation services during construction operations, that firm should prepare a letter indicating their intent to assume the responsibilities of project geotechnical engineer of record. A copy of the letter should be provided to the regulatory agency for their records. In addition, that firm should provide revised recommendations concerning the geotechnical aspects of the proposed development, or a written acknowledgement of their concurrence with the recommendations presented in our report. They should also perform additional analyses deemed necessary to assume the role of Geotechnical Engineer of Record.

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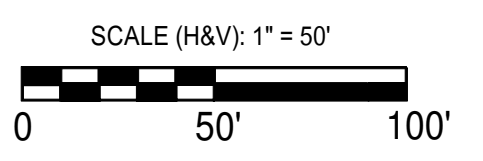
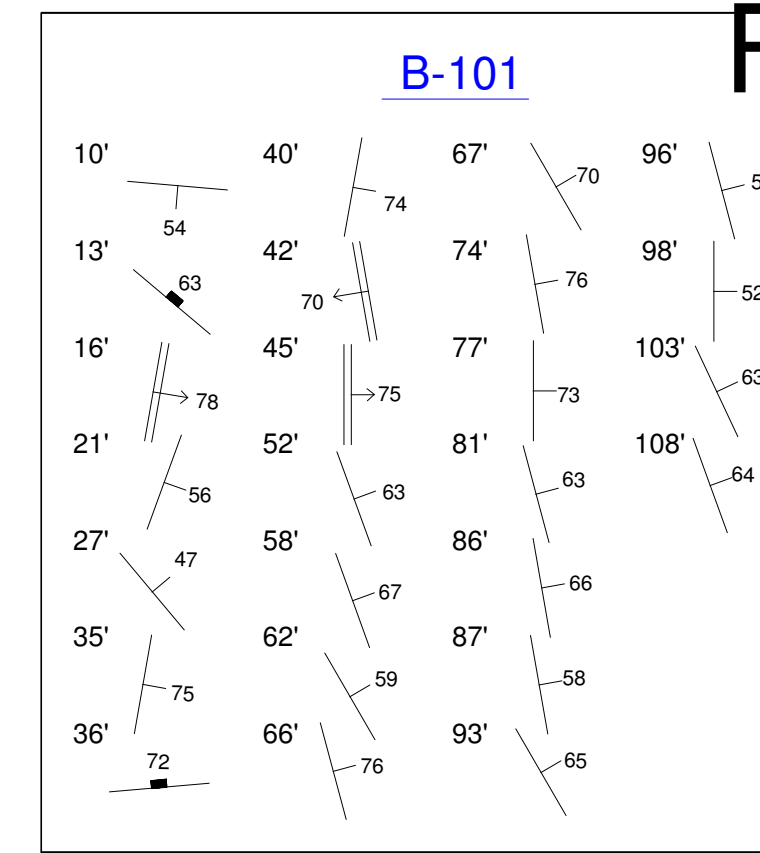
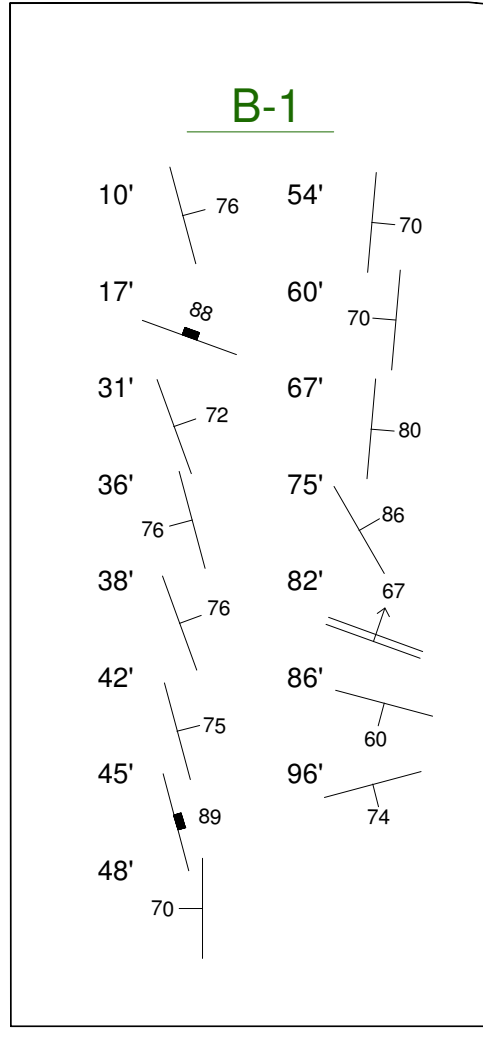
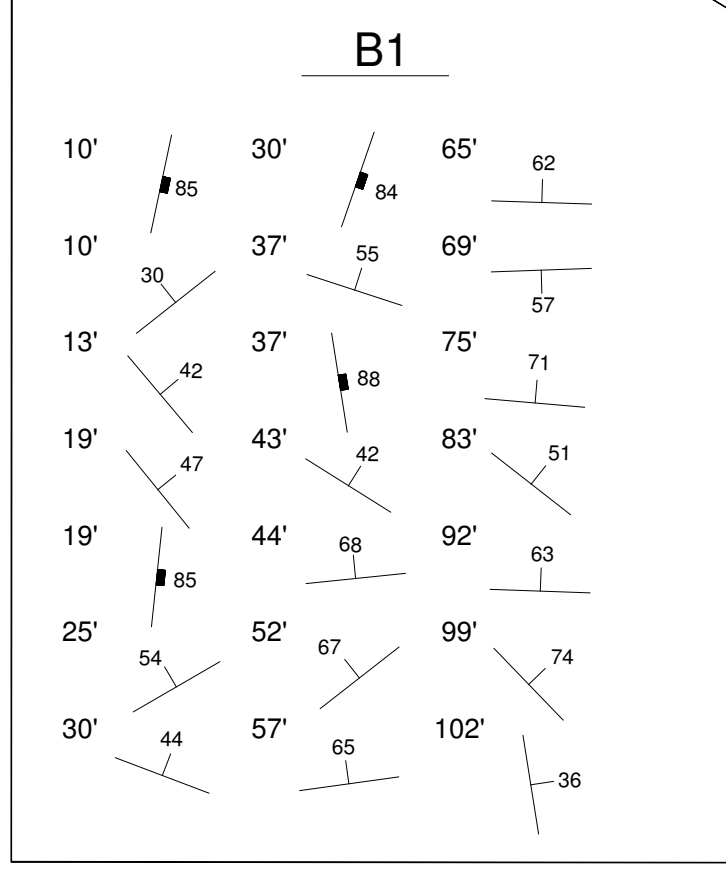
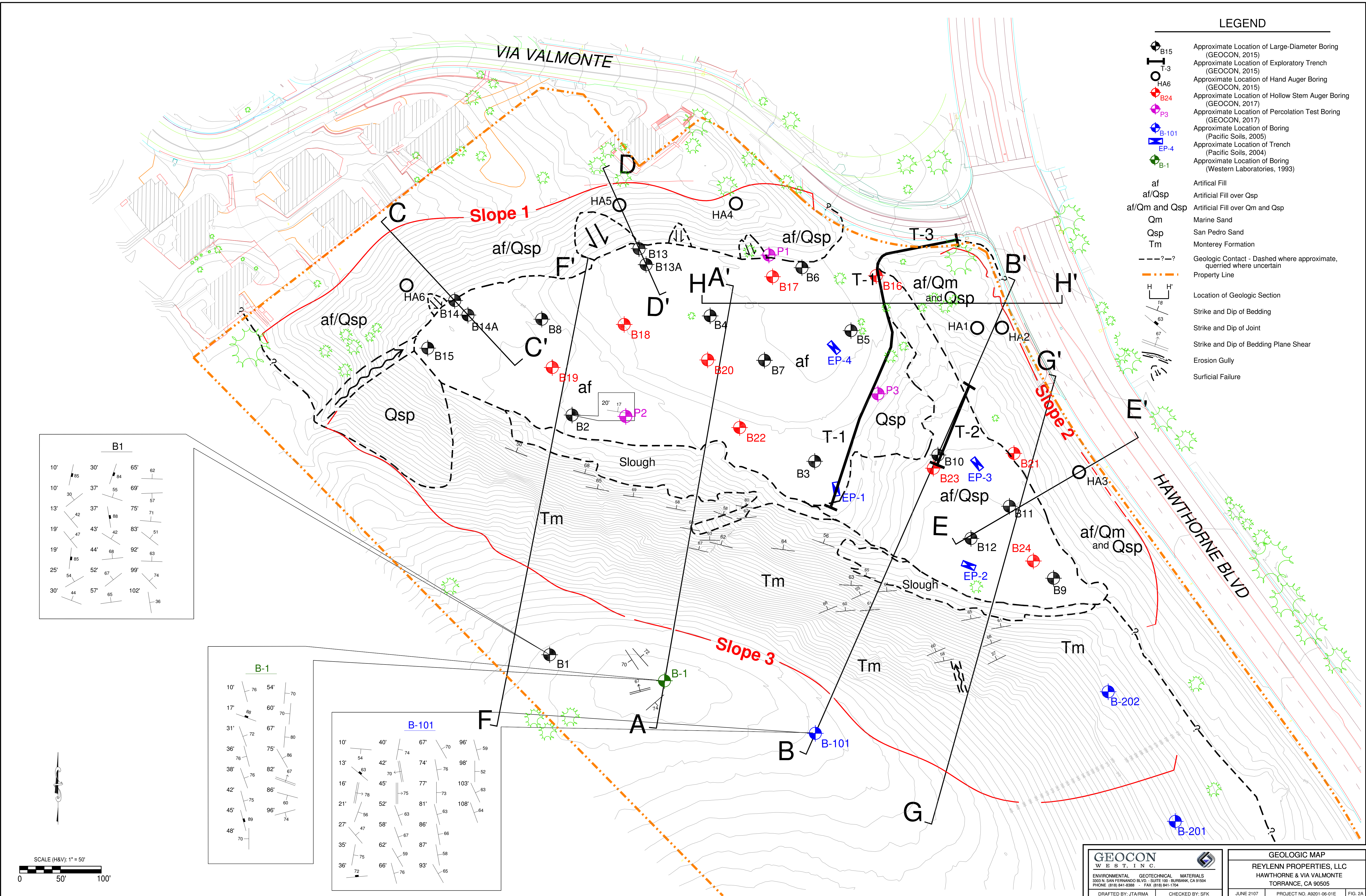
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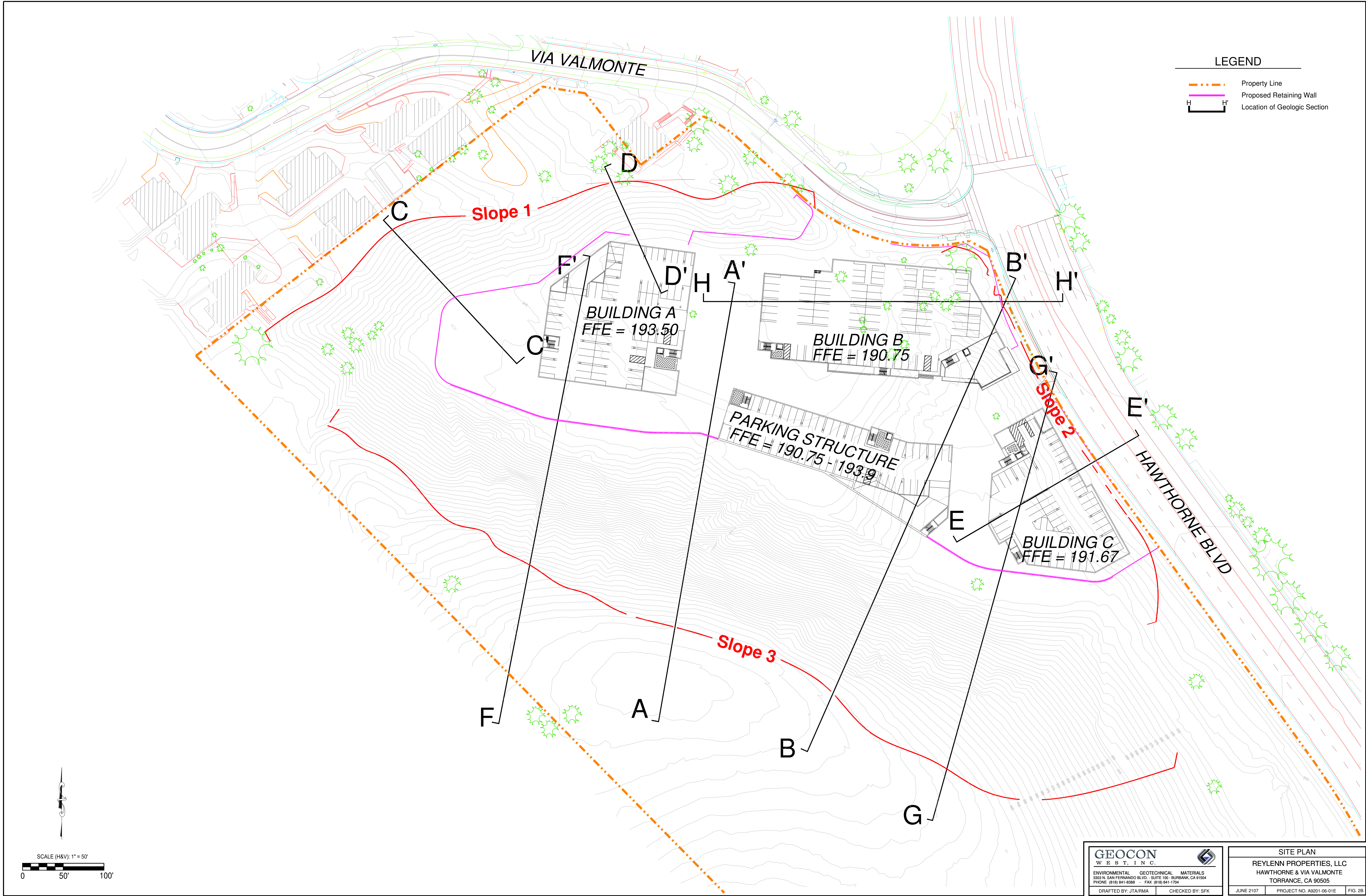
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LEGEND

- B15 Approximate Location of Large-Diameter Boring (GEOCON, 2015)
- T-3 Approximate Location of Exploratory Trench (GEOCON, 2015)
- HA6 Approximate Location of Hand Auger Boring (GEOCON, 2015)
- B24 Approximate Location of Hollow Stem Auger Boring (GEOCON, 2017)
- P3 Approximate Location of Percolation Test Boring (GEOCON, 2017)
- B-101 Approximate Location of Boring (Pacific Soils, 2005)
- EP-4 Approximate Location of Trench (Pacific Soils, 2004)
- B-1 Approximate Location of Boring (Western Laboratories, 1993)
- af Artificial Fill
- af/Qsp Artificial Fill over Qsp
- af/Qm and Qsp Artificial Fill over Qm and Qsp
- Qm Marine Sand
- Qsp San Pedro Sand
- Tm Monterey Formation
- - - - -? - ? Geologic Contact - Dashed where approximate, queried where uncertain
- - - - - Property Line
- Location of Geologic Section
- Strike and Dip of Bedding
- Strike and Dip of Joint
- Strike and Dip of Bedding Plane Shear
- Erosion Gully
- Surficial Failure



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	REYLENN PROPERTIES, LLC HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
	DRAFTED BY: JTA/RMA	CHECKED BY: SFK	JUNE 2107
	PROJECT NO. A9201-06-01E		FIG. 2A

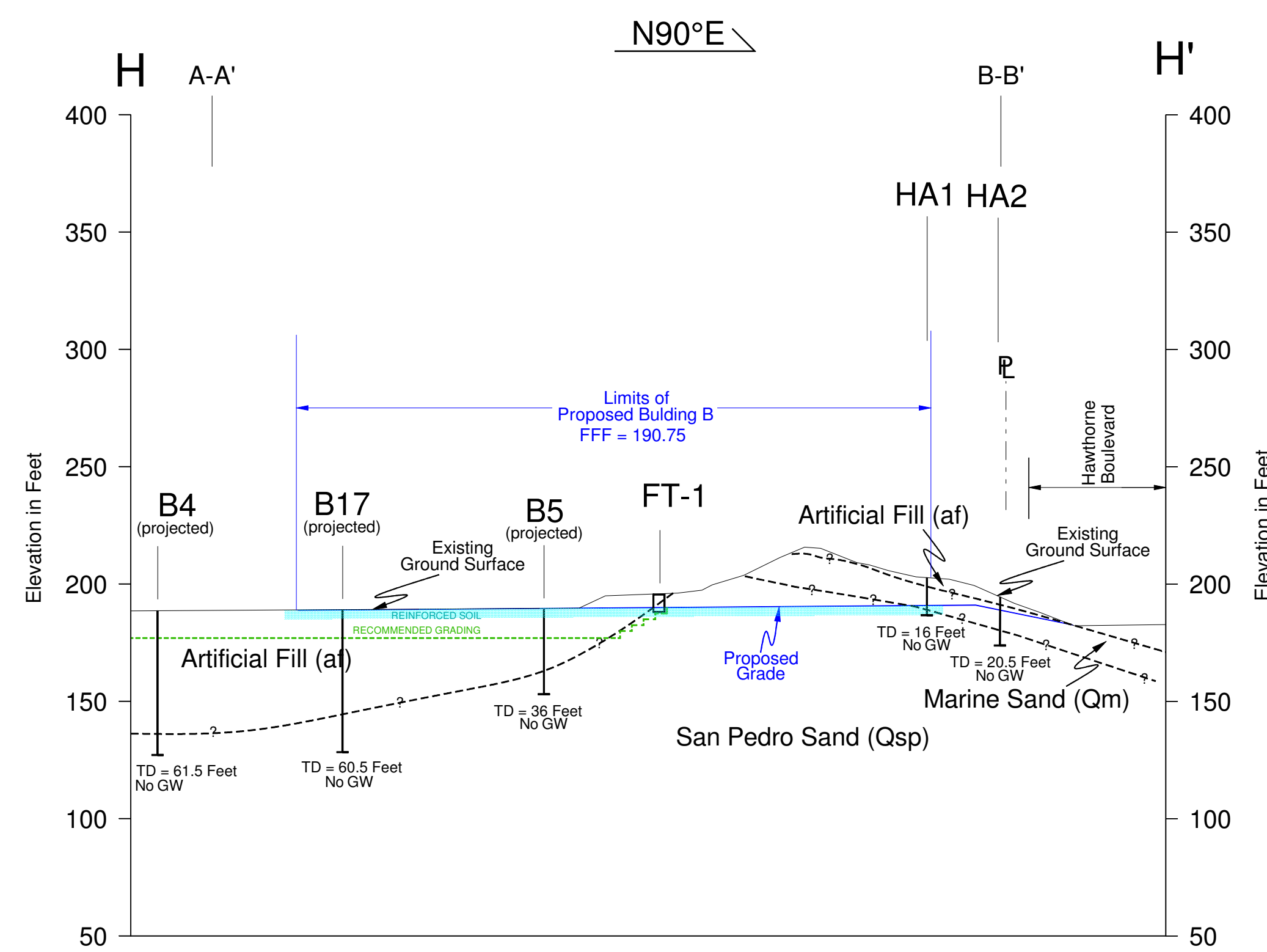
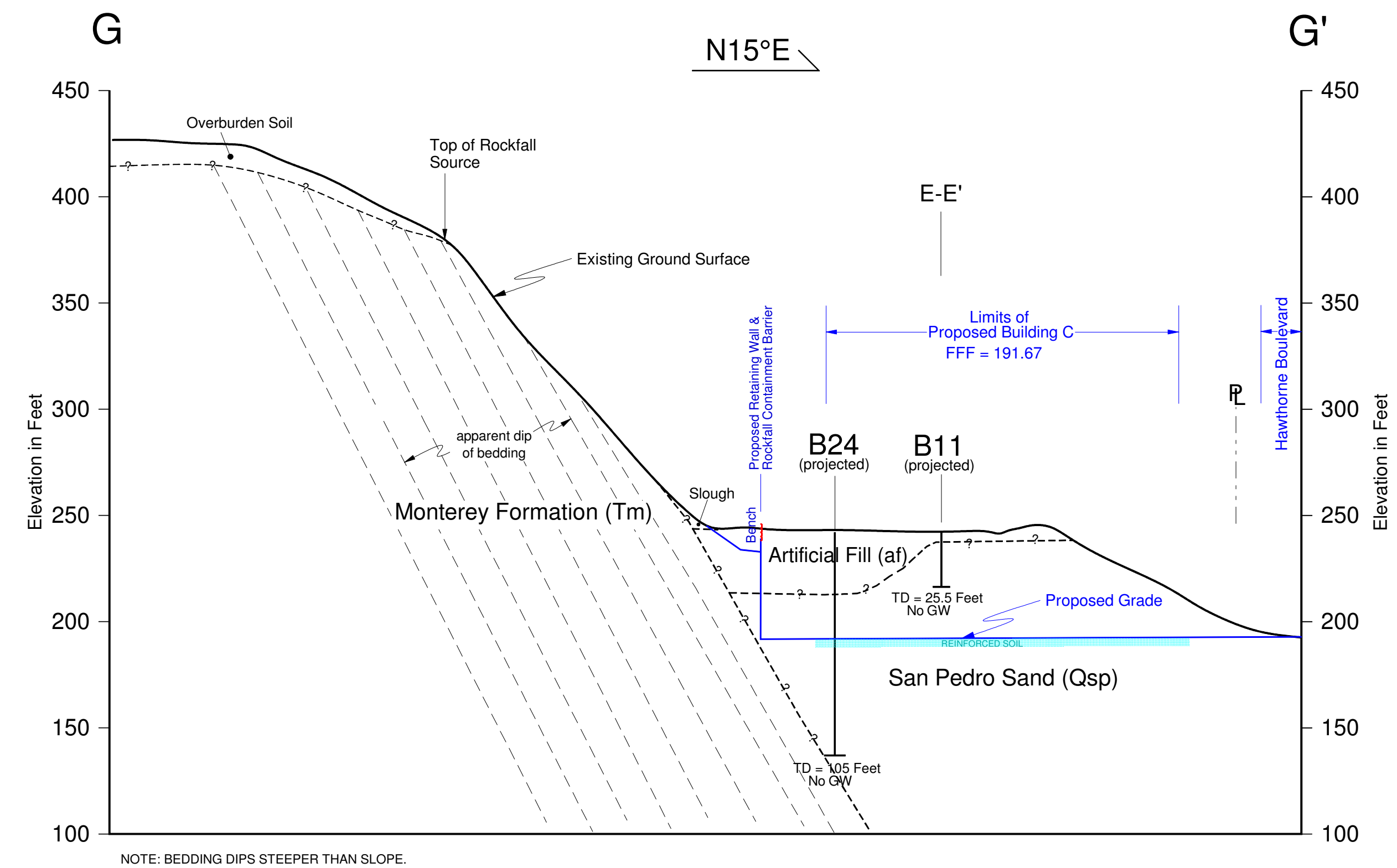
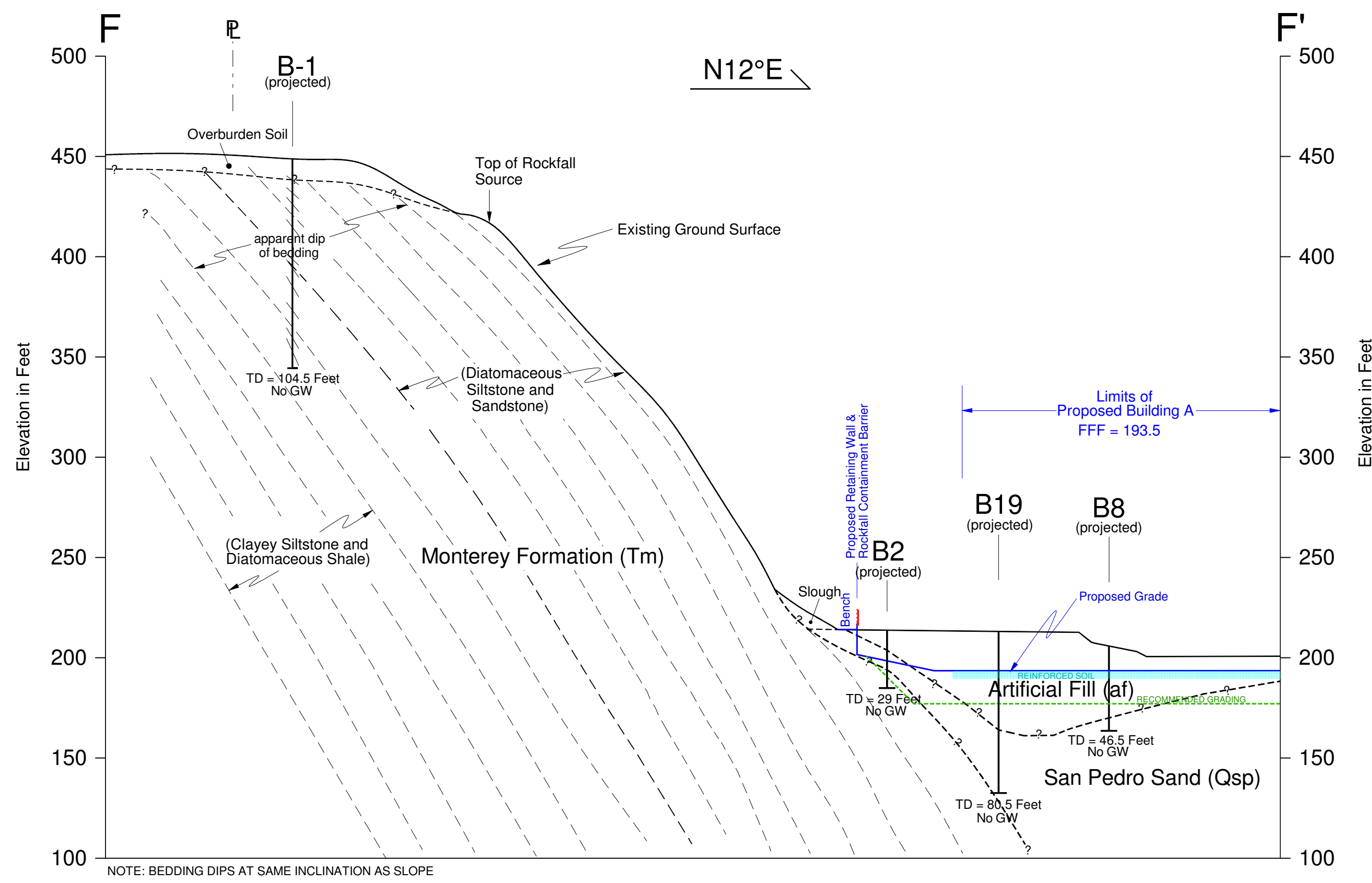
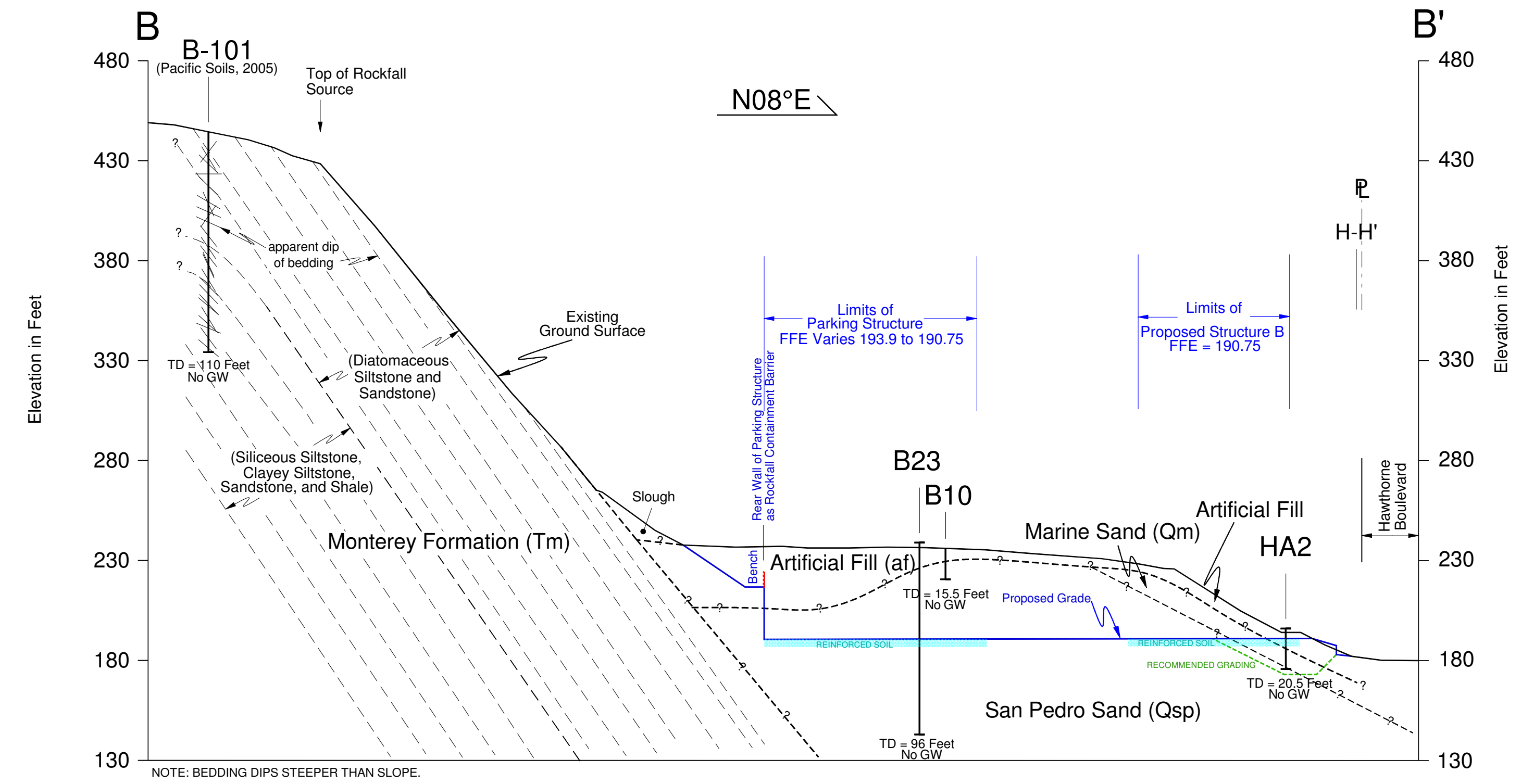
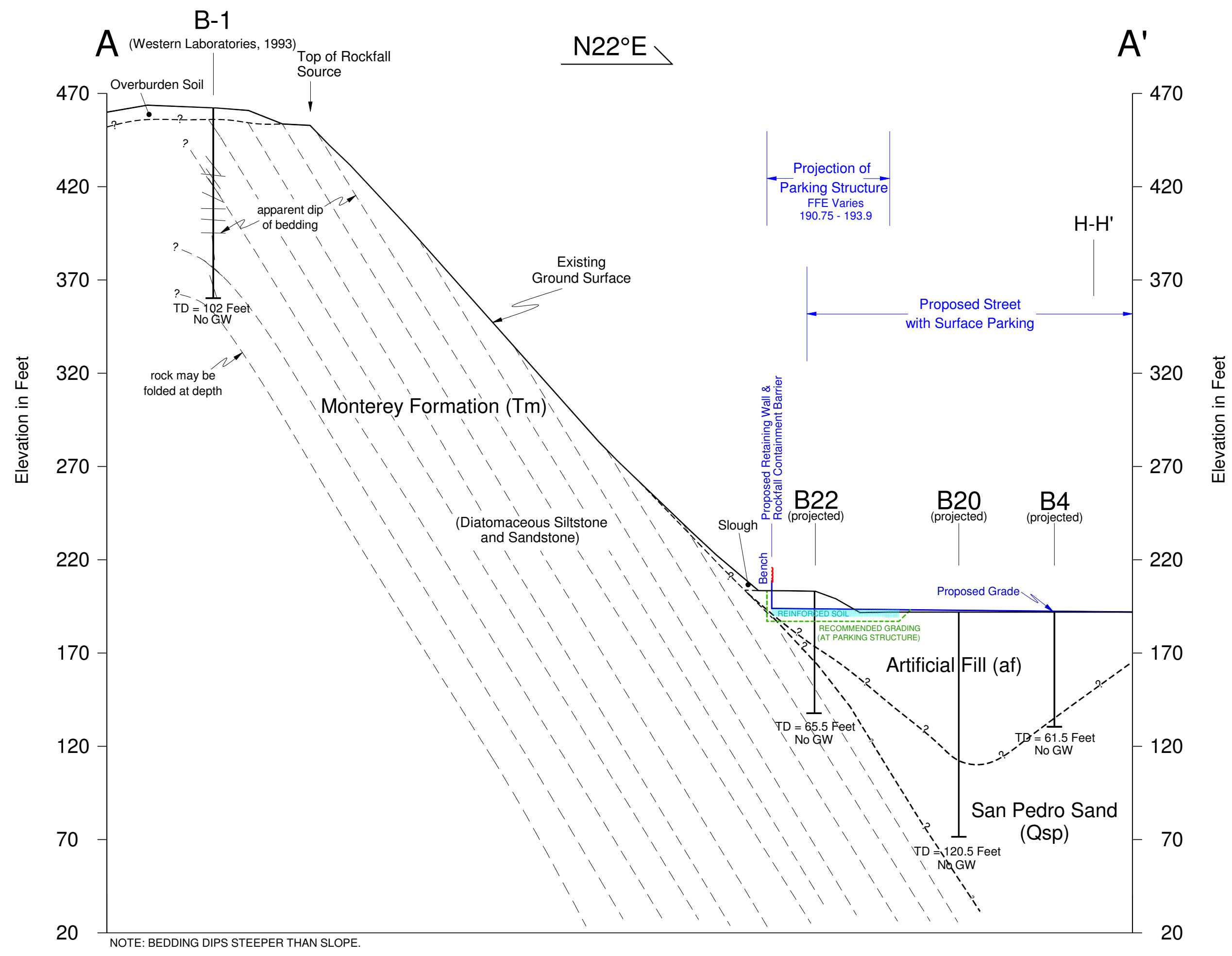


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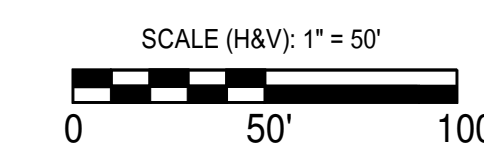
	Property Line
	Proposed Retaining Wall
	Location of Geologic Section



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	<p>JUNE 2107</p>	<p>PROJECT NO. A9201-06-01E</p>
	<p>FIG. 2B</p>	

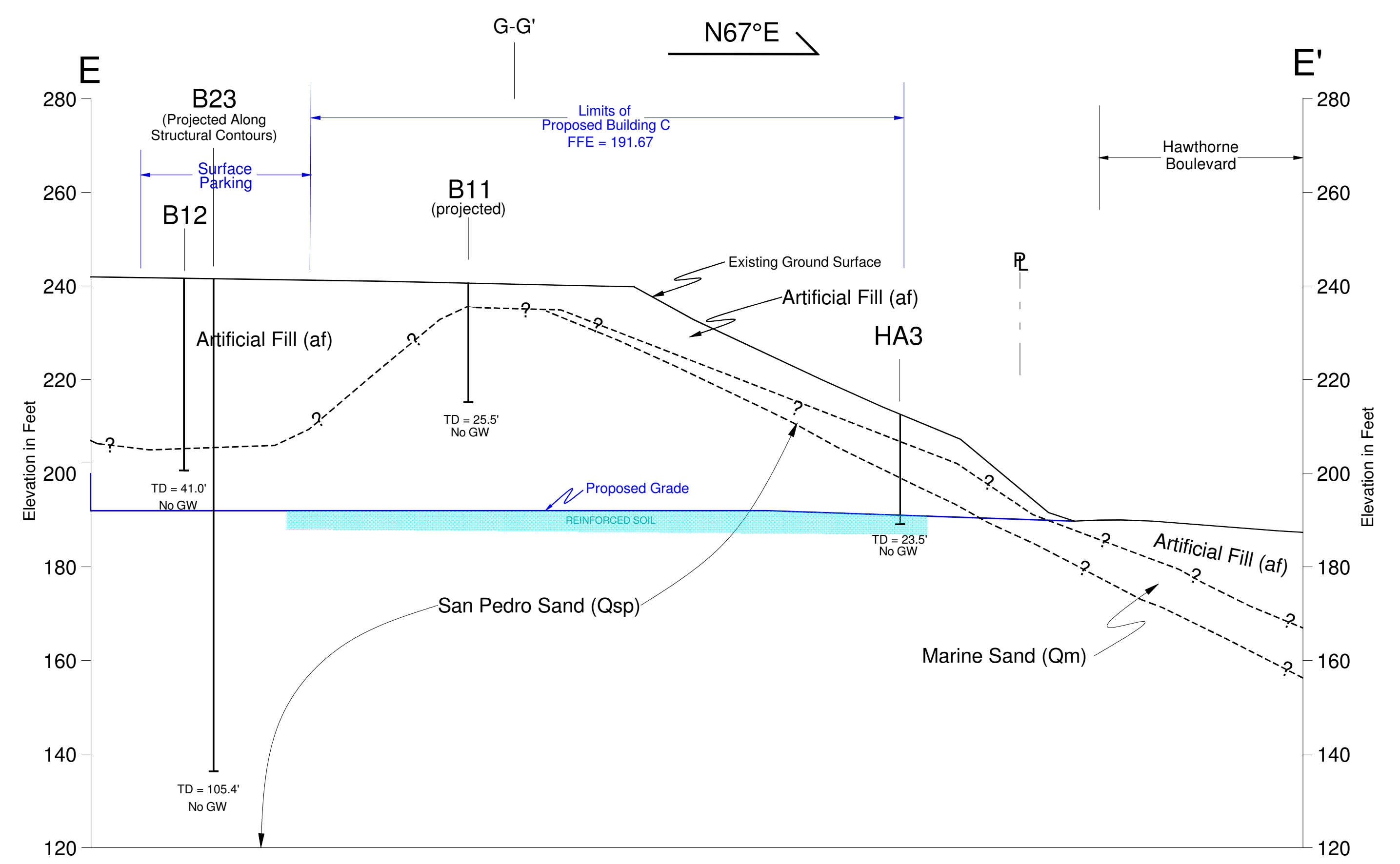
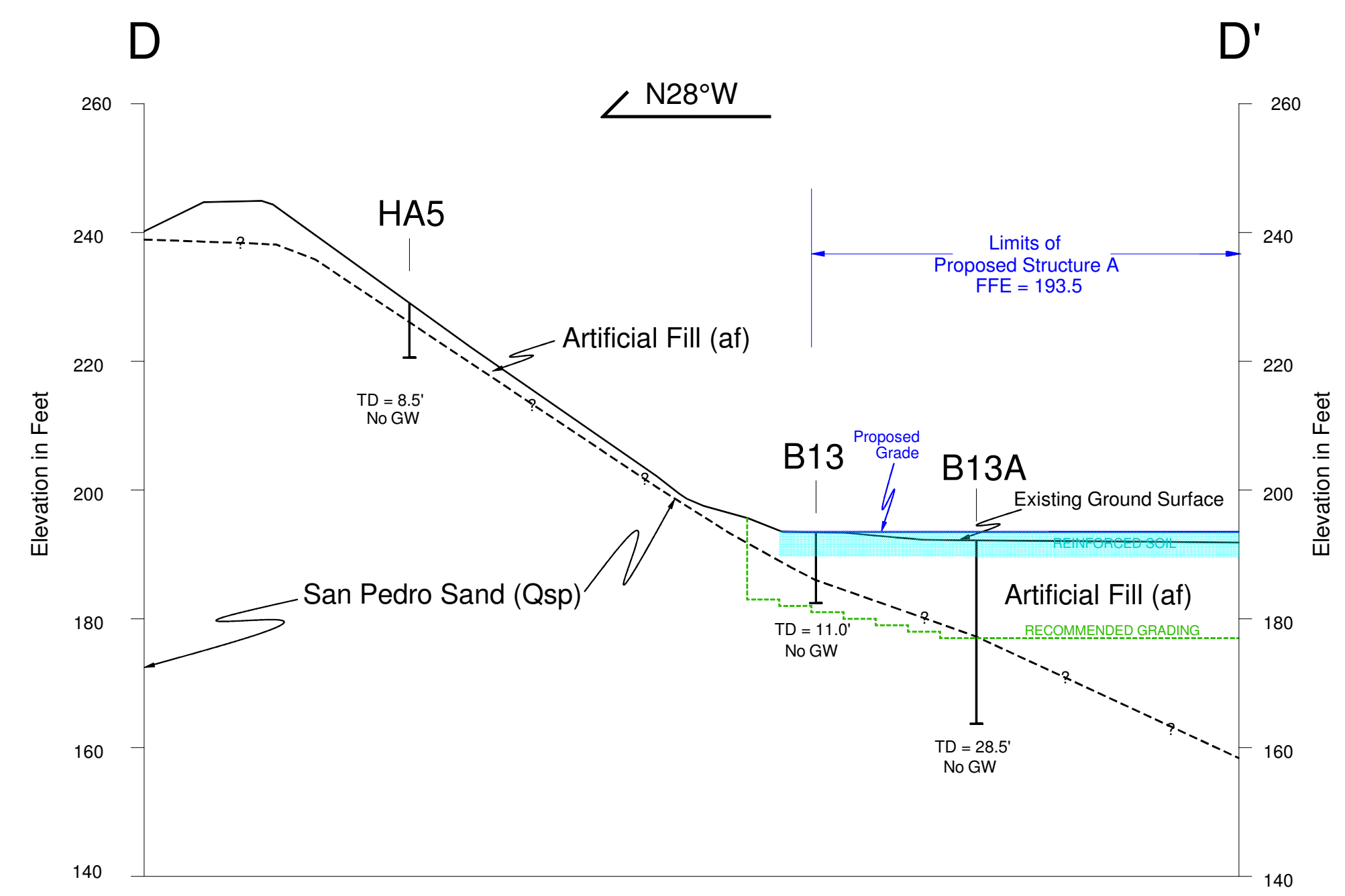
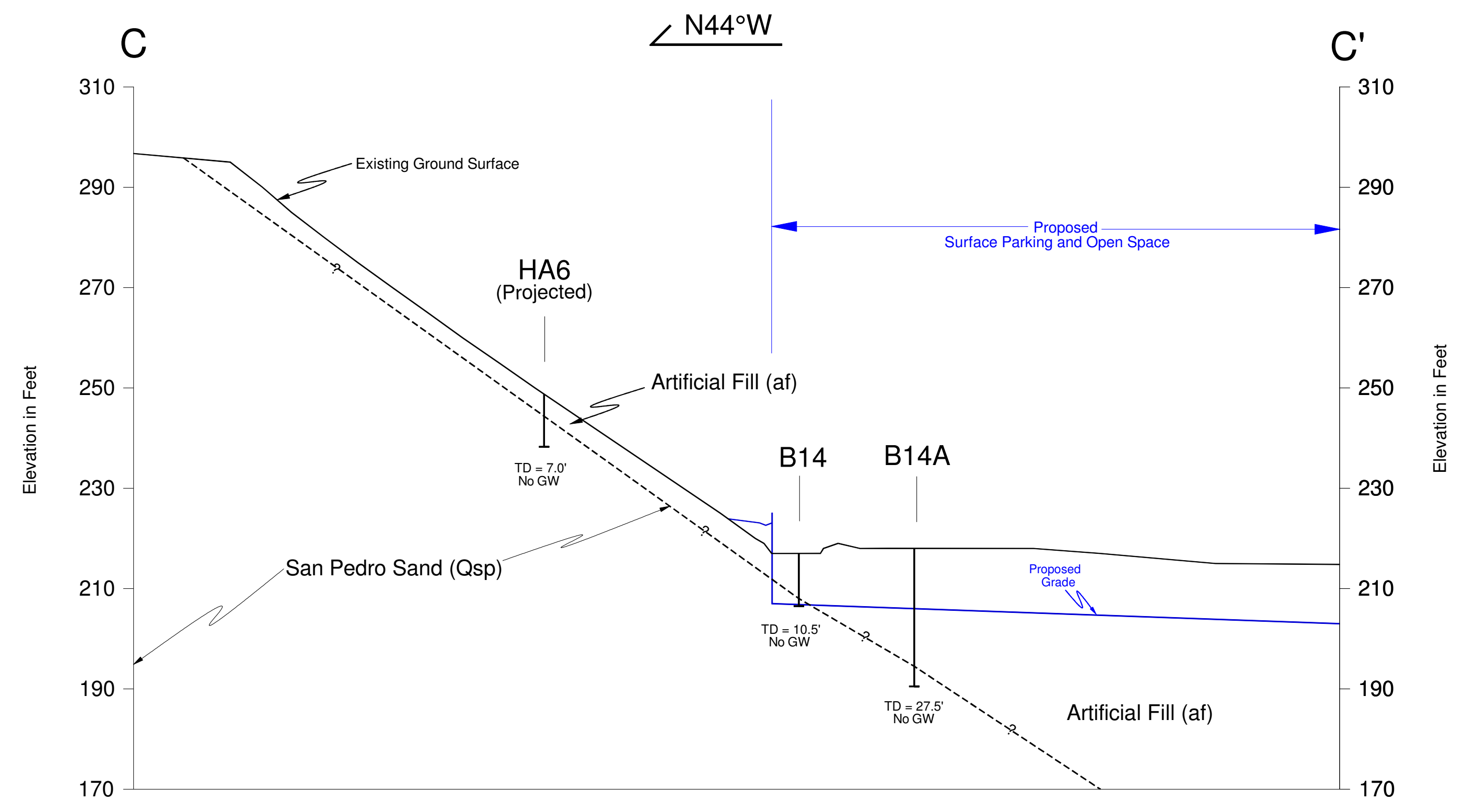


NOTES:
 1. THE SECTIONS ARE BASED ON GEOLOGIC CONDITIONS AT BORING LOCATIONS AND AT SURFACE EXPOSURES MAPPED DURING THE INVESTIGATION. THE GEOLOGIC CONDITIONS BETWEEN SUCH LOCATIONS HAVE BEEN INTERPOLATED. LOCALIZED VARIATIONS COULD OCCUR. THE SECTIONS ARE INTENDED FOR DESCRIPTIVE PURPOSES ONLY.
 2. SEE FIGURE 2A FOR LOCATION OF SECTIONS.

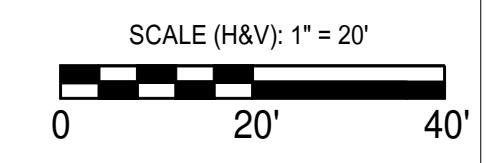


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GEOLOGIC SECTION
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 TORRANCE, CA 90505
 JUNE 2017 PROJECT NO. A9201-06-01E FIG. 3A



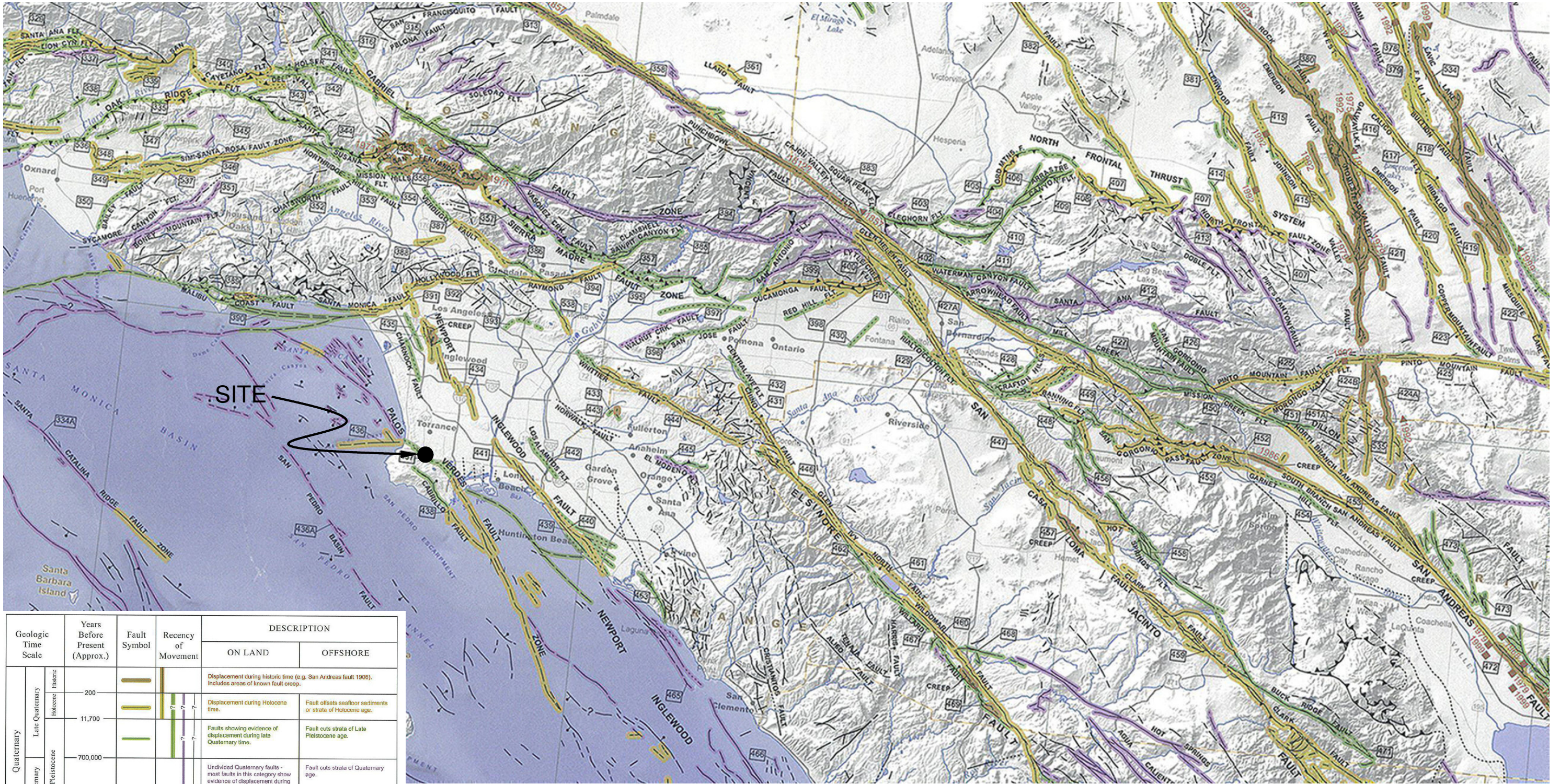
NOTES:
 1. THE SECTIONS ARE BASED ON GEOLOGIC CONDITIONS AT BORING LOCATIONS AND AT SURFACE EXPOSURES MAPPED DURING THE INVESTIGATION. THE GEOLOGIC CONDITIONS BETWEEN SUCH LOCATIONS HAVE BEEN INTERPOLATED. LOCALIZED VARIATIONS COULD OCCUR. THE SECTIONS ARE INTENDED FOR DESCRIPTIVE PURPOSES ONLY.
 2. SEE FIGURE 2A FOR LOCATION OF SECTIONS.



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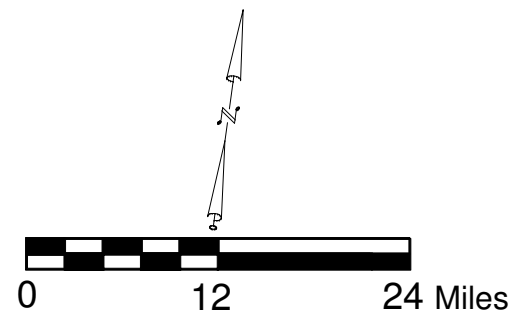
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Reference: Jennings, C.W. and Bryant, W. A., 2010, Fault Activity Map of California, California Geological Survey Geologic Data Map No. 6.



Geologic Time Scale	Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION	
				ON LAND	OFFSHORE
Quaternary	Historic			Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
	Holocene			Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.
Quaternary	Late Quaternary			Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.
	Pleistocene			Undivided Quaternary faults - most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.
Pre-Quaternary	1,600,000+			Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive.	Fault cuts strata of Pliocene or older age.
	4.5 billion (Age of Earth)				

* Quaternary now recognized as extending to 2.6 Ma (Walker and Geissman, 2009). Quaternary faults in this map were established using the previous 1.6 Ma criterion.



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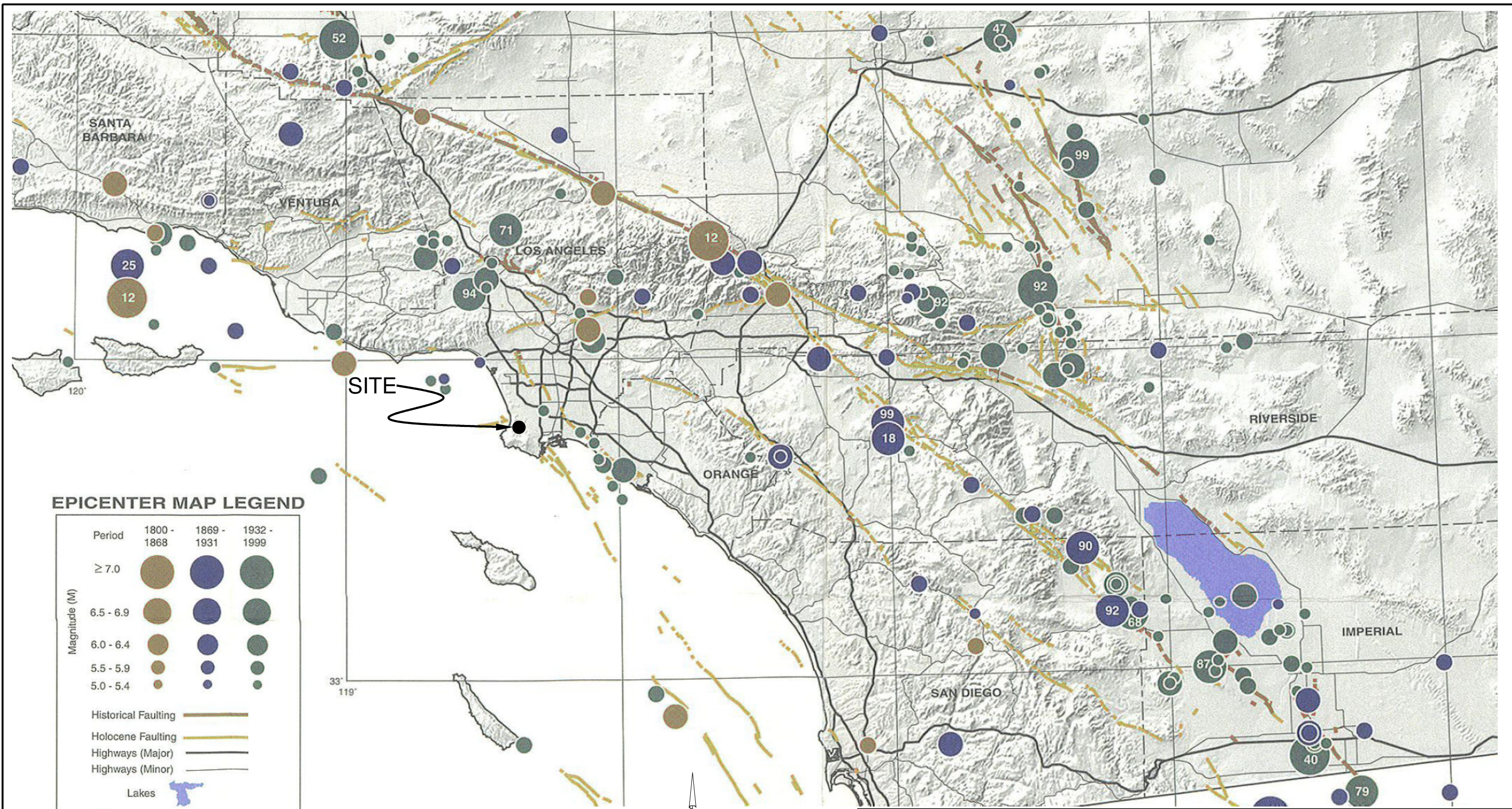
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REGIONAL FAULT MAP

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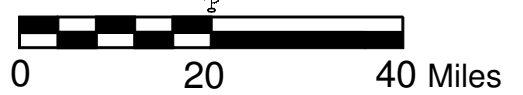
JUNE 2017 PROJECT NO. A9201-06-01E FIG. 4



EPICENTER MAP LEGEND

Period	1800 - 1868	1869 - 1931	1932 - 1999
Magnitude (M)			
≥ 7.0			
6.5 - 6.9			
6.0 - 6.4			
5.5 - 5.9			
5.0 - 5.4			
Historical Faulting			
Holocene Faulting			
Highways (Major)			
Highways (Minor)			
Lakes			
	Last two digits of M ≥ 6.5 earthquake year		

Reference: Topozada, T., Branum, D., Petersen, M., Hallstrom, C., Cramer, C., and Reichle, M., 2000, Epicenters and Areas Damaged by M≥5 California Earthquakes, 1800 - 1999, California Geological Survey, Map Sheet 49.



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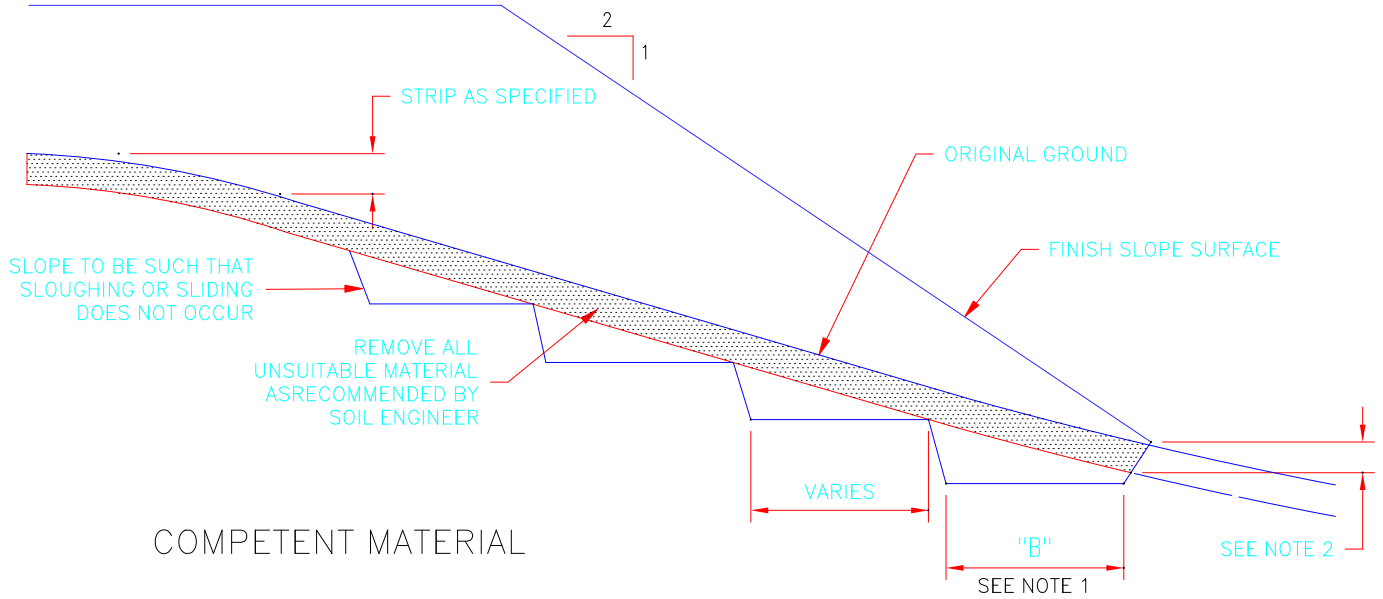
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REGIONAL SEISMICITY MAP

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JUNE 2017 PROJECT NO. A9201-06-01E FIG.5



- DETAIL NOTES:
- (1) Key width "B" should be a minimum of 10 feet wide, or sufficiently wide to permit complete coverage with the compaction equipment used. The base of the key should be graded horizontal, or inclined slightly into the natural slope.
 - (2) The outside of the bottom key should be below the topsoil or unsuitable surficial material and at least 2 feet into competent material.
Where hard rock is exposed in the bottom of the key, the depth and configuration of the key may be modified as approved by the Geotechnical Engineer.

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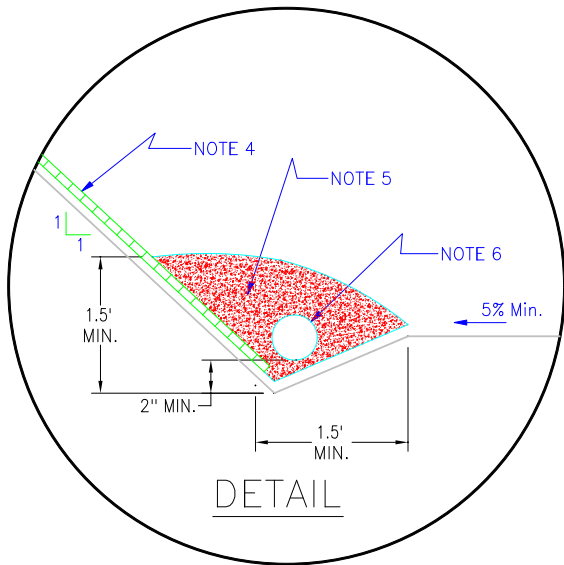
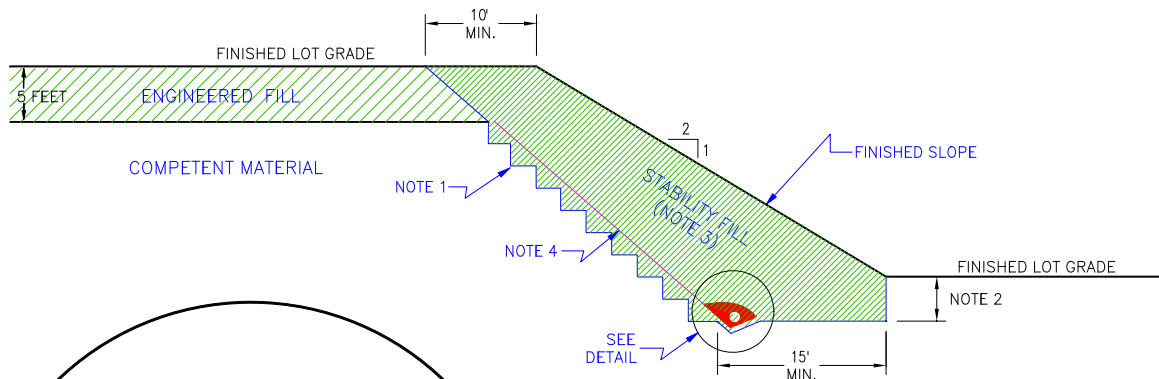
BENCHED EXCAVATION DETAIL

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TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. 6



NOTES

- 1 EXCAVATE BENCHED BACKCUT AT 1:1 INCLINATION
- 2 BASE OF BUTTRESS TO BE 3 FEET BELOW PAD GRADE, OR A MAXIMUM OF 15 FEET BELOW PAD GRADE SLOPING A MINIMUM 5% INTO SLOPE
- 3 BUTTRESS FILL TO BE COMPOSED OF PROPERLY COMPACTED ENGINEERED FILL
- 4 WHERE SEEPAGE IS ENCOUNTERED IN BACKCUT OR SLOPE HEIGHT EXCEEDS 15 FEET, CHIMNEY DRAINS ARE RECOMMENDED, CHIMNEY DRAINS TO BE APPROVED, PREFABRICATED DRAINS ARE CHIMNEY DRAIN PANELS (MIRIDRAIN 5000 OR EQUIVALENT) SPACED APPROXIMATELY 20 FEET CENTER TO CENTER AND 4 FEET WIDE
- 5 FILTER MATERIAL TO BE 1- INCH, OPEN- GRADED CRUSHED ROCK ENCLOSED IN APPROVED FILTER FABRIC
- 6 COLLECTOR PIPE TO BE 4- INCH MINIMUM DIAMETER, PERFORATED, THICK- WALLED PVC SCHEDULE 40 OR EQUIVALENT, AND SLOPED TO DRAIN AT 1 PERCENT MINIMUM TO APPROVED OUTLET

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STABILITY / BUTTRESS FILL DETAIL

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TORRANCE, CA 90505

JUNE 2107

PROJECT NO. A9201-06-01E

FIG. 7

SLOPE 3

MAINTENANCE BENCH

9.5'

7'

ROCKFALL
CONTAINMENT BARRIER

PROPOSED
RETAINING WALL

NO SCALE

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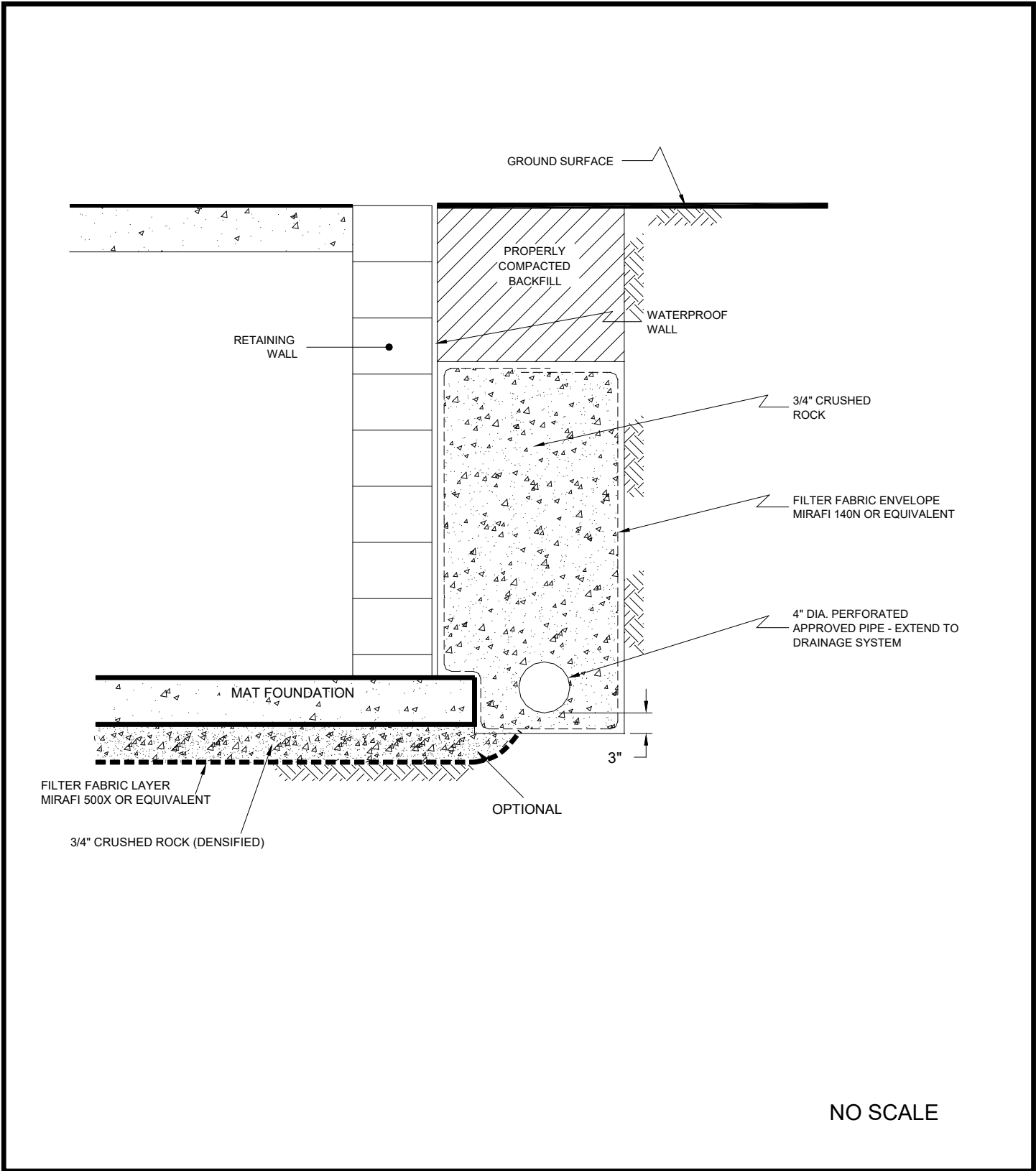
ROCKFALL CONTAINMENT BARRIER

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CALIFORNIA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. 8



NO SCALE

GEOCON
WEST, INC.



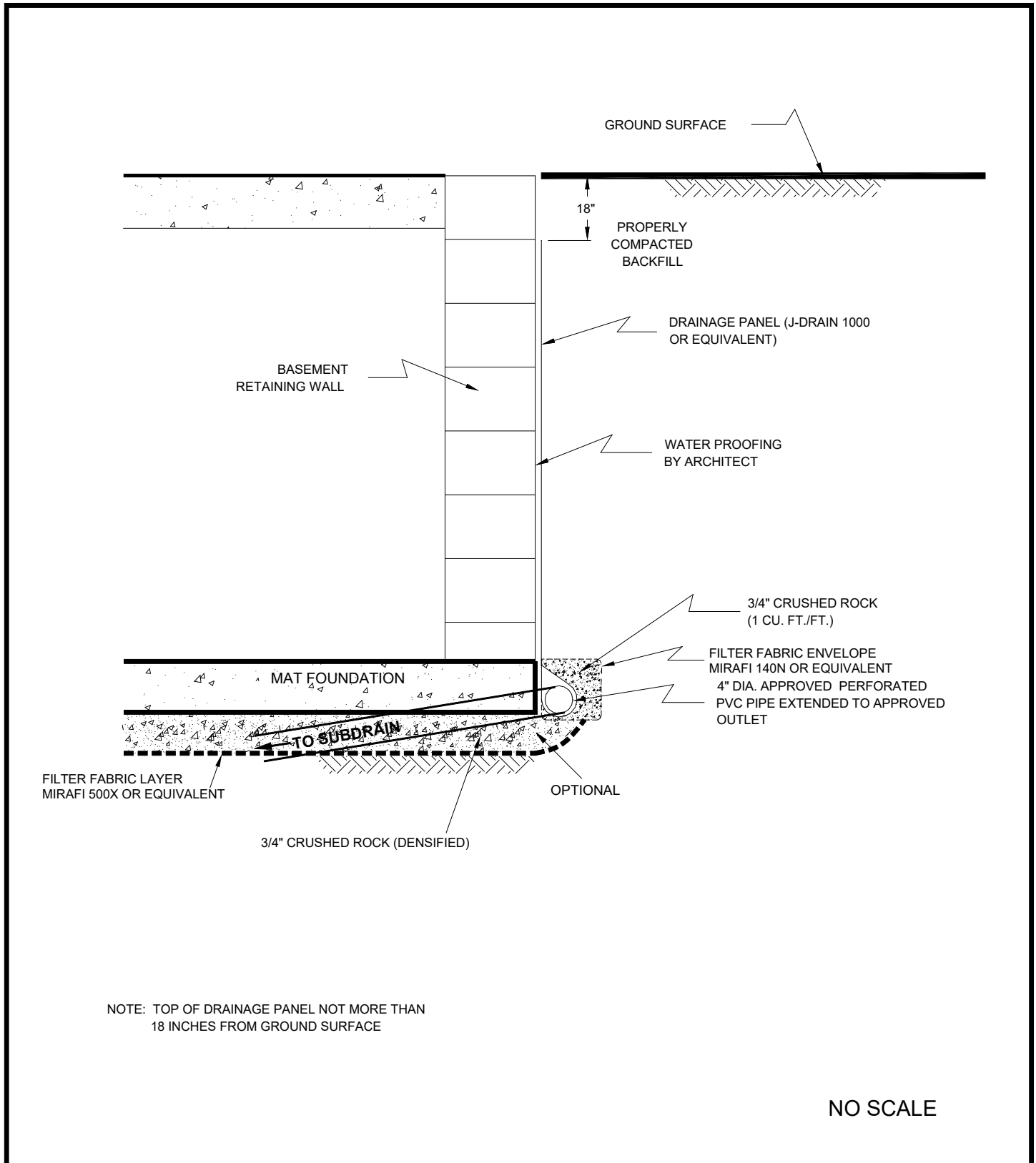
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RETAINING WALL DRAIN DETAIL

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HAWTHORNE & VIA VALMONTE
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JUNE 2017	PROJECT NO. A9201-06-01E	FIG. 9
-----------	--------------------------	--------



NOTE: TOP OF DRAINAGE PANEL NOT MORE THAN 18 INCHES FROM GROUND SURFACE

NO SCALE

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RETAINING WALL DRAIN DETAIL

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TORRANCE, CA 90505

JUNE 2017 PROJECT NO. A9201-06-01E FIG. 10

PERCOLATION TEST RESULTS

Boring P1 (Tank A)

Project No: **A9201-06-01E**
 Project Name: **Torrance**
 Testing Date: **5/5/2017**
 Tested By: **JO**

Boring Diameter, DIA: **8** inches
 Boring Depth: **15** feet
 Boring Depth: **180** inches

Reading Number	Adjusted Initial Water Depth (ft)	Adjusted Final Water Depth (ft)	Water Drop (ft)	Water Drop (in)	ΔT (min)	Percolation Rate (in/hour)
1	13.00	14.70	1.70	20.4	2	597.07
2	12.00	14.70	2.70	32.4	5	377.60
3						

Average: 12.50 14.70

Preadjusted Perc Rate* **487.34**

* Based only on Stabilized Readings

Initial Water Depth, d₁ = 30 inches
 Final Water Depth, d₂ = 3.6 inches
 Water Level Drop, Δd = 26.4 inches
 Boring Diameter, DIA = 8 inches

$$R_f = \left(\frac{2d_1 - \Delta d}{DIA} \right) + 1$$

Reduction Factor, R_f = **5.2**

Infiltration Rate = **93.7** inches/hour

FIGURE 11

PERCOLATION TEST RESULTS

Boring P2 (Tank B)

Project No: A9201-06-01E	Boring Diameter, DIA: 8 inches
Project Name: Torrance	Boring Depth: 25 feet
Testing Date: 5/5/2017	Boring Depth: 300 inches
Tested By: RA	

Reading Number	Adjusted Initial Water Depth (ft)	Adjusted Final Water Depth (ft)	Water Drop (ft)	Water Drop (in)	ΔT (min)	Percolation Rate (in/hour)
1	20.00	20.94	0.94	11.3	30	22.56
2	19.05	20.28	1.23	14.8	30	29.52
3	20.00	21.10	1.10	13.2	30	26.40

Average:	19.68	20.77		Preadjusted Perc Rate*	26.16
----------	-------	-------	--	------------------------	--------------

* Based only on Stabilized Readings

Initial Water Depth, d ₁ =	63.8	inches
Final Water Depth, d ₂ =	50.72	inches
Water Level Drop, Δd =	13.08	inches
Boring Diameter, DIA =	8	inches

$$R_f = \left(\frac{2d_1 - \Delta d}{DIA} \right) + 1$$

Reduction Factor, R_f = **15.315**

Infiltration Rate = 1.7 inches/hour

FIGURE 12

PERCOLATION TEST RESULTS

Boring P3 (Tank C)

Project No: A9201-06-01E	Boring Diameter, DIA: 8 inches
Project Name: Torrance	Boring Depth: 25 feet
Testing Date: 5/5/2017	Boring Depth: 300 inches
Tested By: RA	

Reading Number	Adjusted Initial Water Depth (ft)	Adjusted Final Water Depth (ft)	Water Drop (ft)	Water Drop (in)	ΔT (min)	Percolation Rate (in/hour)
1	21.20	23.95	2.75	33.0	10	198.00
2	21.90	24.20	2.30	27.6	10	165.60
3	22.75	24.37	1.62	19.4	10	116.64

Average:	21.95	24.17		Preadjusted Perc Rate*	160.08
----------	-------	-------	--	------------------------	---------------

* Based only on Stabilized Readings

Initial Water Depth, d ₁ =	36.6	inches
Final Water Depth, d ₂ =	9.92	inches
Water Level Drop, Δd =	26.68	inches
Boring Diameter, DIA =	8	inches

$$R_f = \left(\frac{2d_1 - \Delta d}{DIA} \right) + 1$$

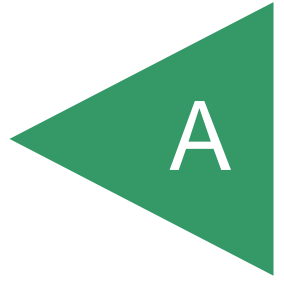
Reduction Factor, R_f = **6.815**

Infiltration Rate = **23.5** inches/hour

FIGURE 13

APPENDIX

A



APPENDIX A

FIELD INVESTIGATION

Field exploration was initially performed between July 14, 2015 and July 24, 2015 and included drilling seventeen large-diameter bucket auger borings utilizing a truck mounted LM-60 Lo-Drill and a truck-mounted E-Z Bore bucket auger drilling machine. The large-diameter borings were advanced to approximate depths between 11 feet and 111½ feet below the existing ground surface. Four of the large-diameter borings were downhole logged by a Certified Engineering Geologist (CEG). In addition, six 4-inch diameter borings were excavated utilizing manual augers and digging equipment to depths between 7 and 23½ feet beneath the existing ground surface.

Supplemental field exploration was performed between May 1, 2017 and May 4, 2017, and included drilling nine 8-inch diameter borings using a truck-mounted hollow-stem auger drilling machine. The borings were excavated to approximate depths between 60½ and 120½ feet below the existing ground surface. In addition, three 8-inch diameter borings were excavated to depths between 15 and 25 feet for the purposes of percolation testing.

Representative and relatively undisturbed samples were obtained in the borings by driving a 3-inch, O.D., California Modified Sampler into the “undisturbed” soil mass. The California Modified Sampler was equipped with 1-inch high by 2₃/₈-inch diameter brass sampler rings to facilitate soil removal and testing. Bulk samples were also obtained. Standard penetration tests were performed in borings B16 through B19 and B21 through B24.

The soil conditions encountered in the borings were visually examined, classified and logged in general accordance with the Unified Soil Classification System (USCS). The logs depict the soil and geologic conditions encountered and the depth at which samples were obtained. Logs of the borings are presented on Figures A1 through A32. Boring logs were not prepared for the percolation test borings. The location of the borings are shown on Figure 2A.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 1		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>452'</u>	DATE COMPLETED <u>7/14/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					OVERBURDEN SOIL (Qs) Sandy Silt, very soft, dry, light gray, fine- to medium-grained, some coarse-grained, abundant rootlets, abundant calcium carbonate, gravel to 2".				
2	B1@2.5'						2		
4									
6	B1@5.5'				- contact varies from 4.0-6.0', dips to north		4		
8	B1@7.5'				MONTEREY FORMATION (TM) Siltstone, very soft (H1), dry, yellowish brown, some fine-grained sandstone beds, thinly bedded to laminated, intensely fractured, intensely weathered, abundant gopher holes in upper 8 feet. - 7.5' soft (H2), pale yellowish brown, diatomaceous-rich		2		
10					- 10.0' Fracture: N12E, 85SE Bedding: N52E, 30NW - 10.5' becoming more diatomaceous-rich, highly weathered		4		
12									
14					- 13.0' some siliceous siltstone interbeds, very soft (H1) to soft (H2), thinly bedded, highly fractured Bedding: N40W, 42NE				
16	B1@15.5'				- 15.0' diatomaceous-rich, soft (H2), white, moderately to intensely fractured, moderately weathered		6		
18					- 18.0' pale yellowish brown, intensely weathered, thinly bedded				
20					- 19.0' some clayey siltstone interbeds Bedding: N39W, 47NE Fracture: N6E, 85SE				
22	B1@21'				- 21.0' soft (H2), highly weathered, diatomaceous content decreasing, laminated		6		
24									
26	B1@26'				Siltstone, siliceous, medium hard (H3), white, thinly bedded, moderately cemented, moderately to intensely fractured, some fractures open to 1/4". Bedding: N60E, 54NW.		1	51.2	36.5
28					- 28.0' pale yellowish brown				

Figure A1,
Log of Boring 1, Page 1 of 4

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 1		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>452'</u>	DATE COMPLETED <u>7/14/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30	B1@31'				- 30.0' soft (H2), increase in diatomaceous siltstone interbeds Bedding: N69W, 44NE Fracture: N19E, 84SE		5		
32					Clayey Siltstone, soft (H2), thinly bedded, moderately weathered.				
34									
36	B1@36'				Siltstone, diatomaceous, white, laminated, slightly weathered.		4		
38					- 37.0' Bedding: N72W, 55NE Fracture: N9W, 88NE				
40					Clayey Siltstone, light brown, thinly bedded, moderately weathered, trace diatomaceous siltstone interbeds.				
42	B1@41'						4		
44					- 43.0' predominantly clayey siltstone, clay coatings on bedding, slightly polished, no striations Bedding: N58W, 42NE				
46	B1@46'				- 44.0' Bedding: N84E, 68NW - 45.0' very pale brown, laminated, slightly weathered, moderately to intensely fractured		6		
48									
50									
52	B1@51'				- 51.0' becomes diatomaceous-rich - 52.0' Bedding: N52E, 67NW - 52.5' very soft (H1)		18	41.8	47.0
54									
56	B1@56'						15		
58					- 57.0' Bedding: N82E, 65NW - 58.0' highly weathered, clay-coated surfaces common, pale brown				

**Figure A1,
Log of Boring 1, Page 2 of 4**

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 1		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>452'</u>	DATE COMPLETED <u>7/14/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
60	B1@61'				- 60.5' laminated to thinly bedded, pale yellowish brown		16		
62					- 63.0' clay-coated bedding and fracture surfaces, highly weathered, highly fractured				
64					- 65.0' some fine-grained sandstone interbeds, yellowish brown				
66	B1@66'				Bedding: N88W, 62NE		15		
68					- 69.0' Bedding: N88E, 57SE				
70									
72	B1@71'						18		
74						- 73.5' very fine- to fine-grained sandstone interbeds, yellowish brown, thinly bedded, moderately weathered			
76	B1@76'					- 75.0' Bedding: N85W, 71NE			
78						- 76.0' laminated, slightly weathered		35	
80					- 78.0' some diatomaceous-rich siltstone beds, clay films along bedding				
82	B1@81'					25	54.7	50.2	
84					- 83.0' some very fine-grained sandstone interbeds, trace oxidation staining				
86	B1@86'				Bedding: N52W, 51NE				
88					- 84.0' moderately weathered				
					- 87.0' moderately fractured, yellowish brown		20		

Figure A1,
Log of Boring 1, Page 3 of 4

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 1		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>452'</u>	DATE COMPLETED <u>7/14/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
90	B1@91'				- 90.0' diatomaceous-rich siltstone interbeds		20		
92					- 92.0' Bedding: N88W, 63NE				
94					Interbedded Clayey Siltstone and Diatomaceous Siltstone, soft (H2), brown to light brown, thinly bedded, moderately weathered.				
96	B1@96'						21		
98						- 99.0' Bedding: N44W, 74NE			
100						- 100.5' olive brown, some clay films along bedding			
102	B1@101'					- 102.0' Bedding: N9W, 36NE		13	
104						- 102.5' yellowish brown, slightly weathered, slightly fractured, trace very fine-grained sand			
106	B1@106'					- 104.0' brown, highly weathered			
108						- 106.0' no recovery			
110						- 108.5' moderately fractured, slightly weathered			
	B1@111'				Siltstone, diatomaceous, massive, soft (H2), some clayey siltstone interbeds, trace oxidation staining.	15	45.2	54.1	
					Total depth of boring: 111.5 feet Overburden to 5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs				

**Figure A1,
Log of Boring 1, Page 4 of 4**

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 2		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>210'</u>	DATE COMPLETED <u>7/16/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0	BULK 0-2.5'				ARTIFICIAL FILL (af) Sandy Silt, soft, dry, gray, some diatomaceous siltstone fragments.				
2					Silty Sand, well-graded, medium dense, slightly moist, brown, some brick and concrete fragments.				
4	B2@3.5'				- 3.5' poorly graded, yellowish brown, fine- to medium-grained, some coarse-grained, some brick fragments (to 3"), rock fragments (to 6")		5		
6	BULK 5-7.5 B2@6'				- 6.0' some slate fragments (to 1"), some cobbles (to 4")		4	103.8	13.1
8	B2@8.5'				SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, pale light brown, fine- to medium-grained, some silt, friable, massive, trace rounded cobbles, subrounded (to 3"), contract with fill flat.		P	96.3	8.0
10					- 10.0' caving				
12	B2@11'				- 11.0' light brown, trace coarse-grained sand		P	105.1	3.2
14	B2@13.5'			SP	- 14.0' yellowish brown		2	106.4	2.8
16	B2@16'				- 14.5' caving (approximately 8" into sidewall)		4	104.0	4.5
18					- 15.0' increase in coarse-grained sand, some rounded gravel (to 2")				
20	B2@18.5'						2	-	-
22	B2@21'				MONTEREY FORMATION (Tm) Interbedded Clayey Siltstone and diatomaceous Siltstone, very soft (H1), brown, thinly bedded, intensely fractured.		2		
24	B2@23.5'				Claystone, very soft (H1), brown, thinly bedded to laminated, slightly weathered, intensely fractured.		3	108.2	5.4
26	B2@26'				- 26.0' some polished surfaces randomly oriented, no striations, laminated		5		
28									

Figure A2,
Log of Boring 2, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.








DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 2 ELEV. (MSL.) <u>210'</u> DATE COMPLETED <u>7/16/15</u> EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
30	B2@31'				MATERIAL DESCRIPTION - 31.0' some diatomaceous siltstone interbeds Total depth of boring: 31.5 feet Fill to 8 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs	4		

Figure A2,
Log of Boring 2, Page 2 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS  ... SAMPLING UNSUCCESSFUL  ... DISTURBED OR BAG SAMPLE	 ... STANDARD PENETRATION TEST  ... CHUNK SAMPLE	 ... DRIVE SAMPLE (UNDISTURBED)  ... WATER TABLE OR SEEPAGE
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NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 3		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>201'</u>	DATE COMPLETED <u>7/16/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silty Sand, well-graded, medium dense, slightly moist, brown, fine- to medium-grained, some subangular cobbles (to 6"), some brick debris.				
2					- 2.5' some clay, some concrete fragments (to 8")				
4	B3@3.5'						4		
6	B3@6'				- 6.0' poorly graded, rock fragments (to over 12"), fine- to medium-grained, some coarse-grained		7	125.1	6.0
8					- 7.0' no rock fragments				
10	B3@8.5'				- 9.0' trace coarse-grained sand		4	117.0	9.5
12	B3@11'				- 10.0' some cobbles (to 4")		3	111.8	6.2
14	B3@13.5'				SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, fine- to medium-grained, trace coarse-grained, friable.		3		
16	B3@16'				- 16.0' increase in coarse-grained sand		3	108.6	7.5
18	B3@18.5'						3	114.7	5.9
20				SP					
22	B3@21'				- 21.0' yellowish brown, fine- to medium-grained, some coarse-grained		2	101.3	4.5
24	B3@23.5'				- 22.0' some subrounded gravel (to 1.5")		1		
26	B3@26'						7		
28					- 28.0' weakly bedded, some oxidation staining along bedding				
					Total depth of boring: 28 feet Fill to 13.5 feet.				

Figure A3,
Log of Boring 3, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 4		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>192'</u>	DATE COMPLETED <u>7/16/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0	BULK 0-5'				ARTIFICIAL FILL (af) Gravelly Sand, well-graded, medium dense, slightly moist, light brown, rock debris (to 8.5"), asphalt debris, some claystone fragments, friable.				
2									
4									
6	B4@6'						6	-	-
8									
10	BULK 10-15								
12	B4@11'				Silty Sand, poorly graded, medium dense, slightly moist, very fine- to fine-grained. - 13.0' some rock fragments (to 7") - 14.0' some claystone fragments (to 9")		4	88.0	20.4
14									
16	B4@16'				Sand with Silt, poorly graded, medium dense, slightly moist, dark brown, fine- to medium-grained, some coarse-grained, some clay, rock fragments (to 6"). - 17.5' wood fragments (to 4") - 19.0' rock fragments (to 3")		6	84.6	16.0
18									
20					Clayey Sand, poorly graded, medium dense, slightly moist, fine- to medium-grained, some coarse-grained, some gravel (to 4"). - 22.0' large rock fragments (to 8") - 23.5' plastic tarp debris (to 3")				
22	B4@21'						4	104.4	14.9
24									
26	B4@26'				Silty Sand, poorly graded, medium dense, slightly moist, yellowish brown, fine- to medium-grained, some clay, some gravel (to 2"), friable.				
28	BULK 27-30'				Sand, poorly graded, medium dense, slightly moist, light gray, very fine- to medium-grained, friable.		7	107.3	10.8

Figure A4,
Log of Boring 4, Page 1 of 3

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 4		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>192'</u>	DATE COMPLETED <u>7/16/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30					- 29.5' some gravel (to 3")				
32	B4@31'				- 31.5' some subrounded coarse-grained sand	3	114.1	3.7	
34					- 33.0' some angular rock fragments (to 4")				
36	B4@36'				- 37.0' some cobbles (to 4")	6	111.6	3.5	
40	BULK 40-45'								
42	B4@41'				- 41.5' rounded gravel (to 1"), increase in coarse-grained sand, decrease in gravel content	7	99.6	4.2	
44					- 44.0' trace subrounded cobbles (to 4")				
46					- 45.0' some subrounded gravel (to 2")				
48					- 46.0' no recovery				
50									
52	B4@51'				SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, pale brown, fine- to medium-grained, trace coarse-grained, weakly developed bedding, friable.	8	91.4	5.4	
54				SP	- 52.5' subrounded cobbles (to 3.5"), increase in coarse-grained sand				
56	B4@56'				- 56.0' medium-grained	7	96.1	3.8	
58					- 56.5' light gray, some coarse-grained sand, trace subangular cobbles, friable - 57.5' some coarse-grained sand				

Figure A4,
Log of Boring 4, Page 2 of 3

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

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DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 4		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>192'</u>	DATE COMPLETED <u>7/16/15</u>				
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>					
					MATERIAL DESCRIPTION					
60	B4@61'			SP SW	<p>Sand, well-graded, dense, slightly moist, light gray, subrounded to rounded coarse gravel, massive, friable.</p> <p>Total depth of boring: 61.5 feet Fill to 50.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.</p> <p>*Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs</p>		11	101.3	1.4	

Figure A4,
Log of Boring 4, Page 3 of 3

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
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DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 5		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>190'</u>	DATE COMPLETED <u>7/17/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silty Sand, well-graded, medium dense, dry, light brown, large rock fragments (to 6"), some claystone and siltstone fragments (to 12").				
2									
4	B5@3'	■			- 3.5' sand with silt lens, well-graded, dry, yellowish brown, medium-grained, some coarse-grained, some gravel (to 2") - 4.5' large rock fragments (to 18"), some clay fragments mixed with sand		5	102.0	18.6
6	B5@6'	■			Clayey Sand, well-graded, medium dense, dark gray, some rock fragments (to 2"), organic odor. - 7.0' rock fragments (to 9")		3	93.7	28.9
8	B5@8'	■					3		
10					- 10.5' increase in gravel content, large rock fragments (to 6")				
12	B5@11'	■			- 12.0' rock fragments (to 12")		3	93.4	23.3
14					- 13.5' plastic PVC pipe - 14.5' large rock fragments (to 15")				
16	B5@16'	■			Silty Sand, well-graded, loose to medium dense, dark yellowish brown, some clay.		2	107.7	18.6
18					Sand, poorly graded, slightly moist, yellowish brown, fine- to medium-grained, some gravel (to 3"), friable.				
20									
22	B5@21'	■			- 21.0' some subrounded gravel (to 3/4") - 22.5' some subrounded cobbles (to 7")		2	97.0	5.2
24									
26	B5@26'	■			SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, yellowish brown, fine- to medium-grained, trace coarse-grained, massive, rounded gravel (to 2"), friable.		4		
28				SP					

Figure A5,
Log of Boring 5, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	□ ... SAMPLING UNSUCCESSFUL	□ ... STANDARD PENETRATION TEST	■ ... DRIVE SAMPLE (UNDISTURBED)
	⊗ ... DISTURBED OR BAG SAMPLE	■ ... CHUNK SAMPLE	▼ ... WATER TABLE OR SEEPAGE

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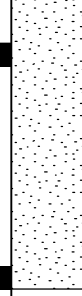







DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 5		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>190'</u>	DATE COMPLETED <u>7/17/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30	B5@31'			SP	- 31.0' some rounded coarse gravel		4	111.3	9.9
32									
34									
36	B5@36'						7		
					Total depth of boring: 36.5 feet Fill to 26 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs				

Figure A5,
Log of Boring 5, Page 2 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

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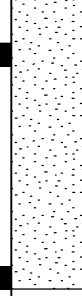
DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 6		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>189'</u>	DATE COMPLETED <u>7/16/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silty Sand, well-graded, medium dense, dry, light yellowish brown, large rock fragments (to 8").				
2					Clayey Sand, well-graded, loose to medium dense, slightly moist, dark brown, fine- to medium-grained, some coarse-grained, large rock fragments (to 5"), some brick fragments.				
4									
6	B6@6'				Silty Sand, poorly graded, loose to medium dense, slightly moist, yellowish brown, very fine- to medium-grained, trace clay. - 7.5' large pockets of clay and rock debris - 9.0' some coarse-grained sand		2	111.3	9.9
8									
10									
12	B6@11'				- 12.0' yellowish brown, very fine- to fine-grained, friable		3	--	--
14									
16	B6@16'				- 16.0' trace coarse-grained sand		3	91.6	9.4
18					- 18.0' large rounded cobbles (to 6") - 19.0' trace rounded gravel (to 1.5"), some claystone fragments				
20									
22	BULK 20-25' B6@21'				SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, yellowish brown, very fine- to fine-grained, trace coarse-grained, weakly bedded, friable. - 21.5' increase in coarse-grained sand content, oxidation staining in bedding plane		3	88.9	4.4
24				SP					
26	B6@26'				- 25.0' dense, trace rounded coarse-grained sand, micaceous, friable		9		
28									

Figure A6,
Log of Boring 6, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 6		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>189'</u>	DATE COMPLETED <u>7/16/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30	B6@31'			SP	- 31.5' some cobbles (to 2"), large chunk of claystone (1"), thinly bedded, slightly to moderately weathered, moderately fractured		7	98.8	5.0
32									
34									
36	B6@36'				- 35.5' trace medium-grained sand, slightly oxidized		10	93.8	3.5
					Total depth of boring: 36.5 feet Fill to 20 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs				

**Figure A6,
Log of Boring 6, Page 2 of 2**

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 7		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>191'</u>	DATE COMPLETED <u>7/20/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sandy Silt, very soft, slightly moist, light brown, fine- to medium-grained, some coarse-grained, some fine gravel and rock debris (to 5"), some diatomaceous siltstone fragments (to 7").				
2	B7@3'	█			Silty Sand, well-graded, medium dense, slightly moist, some fine gravel and rock fragments (to 3"). - 4.0' some claystone and siltstone fragments (to 12")		4	108.6	19.0
6	B7@6'	█			Sand, well-graded, medium dense, slightly moist, some silt, highly oxidized, yellowish brown, friable. Clay, firm, slightly moist, rock fragments (to 6"), organic odor.		4	103.4	11.6
8	B7@8'	█					3	120.8	8.8
12	B7@11'	█			Clayey Sand with Silt, medium dense, slightly moist, grayish brown, medium-grained, some coarse-grained. - 13.0' some metal wire debris		4	97.1	22.9
14					Clay, firm, slightly moist, some silt, rock fragments (to 3.5"), organic odor. - 14.0' some slate fragments (to 8"), wood debris (to 10"), metal scrap (to 5"), paper				
16	B7@16'	█			Clayey Sand with Silt, medium dense, slightly moist, medium-grained, some coarse-grained, grayish brown, metal debris (to 9"). - 18.0' rock fragments (to 11")		4	112.6	12.2
22	B7@21'	█			Sand, poorly graded, medium dense, slightly moist, grayish brown, medium-grained, some coarse-grained, some fine gravel and rock debris (to 5"), friable. - 21.5' some gravel (to 3"), rounded to subrounded, some claystone fragments (to 6")		3	122.0	12.9
26	B7@26'	█		SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense to dense, slightly moist, yellowish brown, fine- to medium-grained, some coarse-grained, massive, friable.		6		
28									

**Figure A7,
Log of Boring 7, Page 1 of 2**

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	□	... SAMPLING UNSUCCESSFUL	□	... STANDARD PENETRATION TEST	█	... DRIVE SAMPLE (UNDISTURBED)
	⊗	... DISTURBED OR BAG SAMPLE	■	... CHUNK SAMPLE	▼	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 7		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>191'</u>	DATE COMPLETED <u>7/20/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30	B7@31'			SP	- 31.0' increase in coarse-grained sand - 32.5' subrounded cobble (to 5")		5		
32									
34									
36	B7@36'				- 38.0' trace subrounded cobbles (to 4")		4		
38									
40	B7@41'			SW	Sand, well-graded, medium dense, slightly moist, yellowish brown, some silt, friable, rounded to subrounded coarse-grained, friable.		4		
42									
44									
46	B7@46'			SP	Sand, poorly graded, slightly moist, yellowish brown, coarse-grained, some medium-grained, massive, friable.		4		
					Total depth of boring: 46.5 feet Fill to 25 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				
					*Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs				

Figure A7,
Log of Boring 7, Page 2 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 8		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>213'</u>	DATE COMPLETED <u>7/20/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0	BULK 0-5'				ARTIFICIAL FILL (af) Sandy Silt, soft, dry, light grayish brown, some diatomaceous siltstone fragments, brick fragments (to 3").				
2									
4	B8@3'				- 5.0' some gravel (to 3")	2	110.5	4.3	
6									
8	B8@6'					3	87.3	23.0	
10									
12	B8@8'				Silty Sand, poorly graded, medium dense, slightly moist, yellowish brown, fine- to medium-grained, trace coarse-grained, friable.	3	108.1	2.9	
14					- 9.5' some rock fragments (to 3")				
16					Clay, firm, slightly moist, dark brown, some coarse-grained sand, rock fragments (to 5"), organic odor.				
18	B8@11'					4	118.5	12.1	
20					Sand with Clay, poorly graded, medium dense, grayish brown, fine- to medium-grained, some rock fragments (to 3").				
22					- 17.5' rock fragments (to 5")				
24	B8@16'				- 19.0' rock fragments (to 6"), increase in clay content	3	112.6	14.0	
26					- 21.5' rock fragments (to 1.5")				
28	B8@21'				- 22.5' some plastic piping	5	115.0	9.4	
30					- 23.5' rock fragments (to 5"), organic odor				
32	B8@26'				Silty Sand, poorly graded, slightly moist, yellowish brown, fine- to medium-grained, trace coarse-grained, friable.				
34					- 27.5' some very soft claystone fragments (to 8")				

Figure A8,
Log of Boring 8, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 8		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>213'</u>	DATE COMPLETED <u>7/20/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30	B8@31'						2		
32									
34						- 34.0' very soft claystone fragments (to 7")			
36	B8@36'					SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, light yellowish brown, very fine- to fine-grained, trace silt, friable.	3		
38									
40	BULK 40-45'			SP		- 41.0' trace coarse-grained sand	5		
42	B8@41'								
44									
46	B8@46'					- 45.0' increase in coarse-grained sand content, subrounded, trace rounded gravel (to 1.5")	6		
					Total depth of boring: 46.5 feet Fill to 36 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				
					*Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-25 feet, 4,900 lbs, 25-50 feet, 3,400 lbs, 50-75 feet, 2,200 lbs, 70-100 feet, 1,200 lbs				

Figure A8,
Log of Boring 8, Page 2 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 9		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>243'</u>	DATE COMPLETED <u>7/23/15</u>				
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>					
MATERIAL DESCRIPTION										
0	BULK 0-5'				ARTIFICIAL FILL (af) Silt with Sand, soft to stiff, slightly moist, pale grayish brown, fine- to medium-grained, friable.					
2	B9@2'						7			
4						- 4.0' some paper fragments				
6	B9@5'						10			
8	B9@7'					Sandy Silt with Clay, firm, slightly moist, grayish brown, medium- to coarse-grained, some diatomaceous siltstone fragments (to 2").				
10	B9@10'					- 8.5' rock fragments (to 5")				
12						- 10.5' some rock fragments (to 1")		66.4	38.6	
14						- 11.5' rock fragments (to 3")				
16	B9@15'									
18						- 15.5' reworked diatomaceous siltstone, very soft (H1), laminated, intensely fractured, slightly weathered		82.6	20.2	
20	B9@20'					SAN PEDRO SAND (Qsp)	21	128.5	2.7	
22	BULK 21-23'			SP		Sand, poorly graded, dense, slightly moist, light grayish brown, medium- to coarse-grained, massive, friable.				
						Total depth of boring: 23 feet Fill to 20 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				
						*Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs				

Figure A9,
Log of Boring 9, Page 1 of 1

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 10		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>236'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0									
2	B10@2'				ARTIFICIAL FILL (af) Sandy Silt, firm to stiff, slightly moist, light gray, fine- to medium-grained, some gravel (to 2").		8		
4	B10@5'				SAN PEDRO SAND (Qsps) Sand, poorly graded, dense, yellowish brown, fine- to medium-grained, some coarse-grained, friable.		10		
6	B10@7'				- 5.5' light gray to white		13		
8				SP	- 7.5' increase in coarse-grained sand				
10					- 9.0' trace rounded gravel (to 1")				
12									
14					- 14.0' medium- to coarse-grained sand				
15	B10@15'						15		
					Total depth of boring: 15.5 feet Fill to 3 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs				

Figure A10,
Log of Boring 10, Page 1 of 1

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 11			PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>240'</u>	DATE COMPLETED <u>7/23/15</u>	EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>			
MATERIAL DESCRIPTION										
0					ARTIFICIAL FILL (af) Silt with Sand, firm, slightly moist, pale grayish brown, fine- to medium-grained, friable.					
2	B11@2'				Sand with Silt, poorly graded, medium dense, slightly moist, dark brown, medium-grained, some coarse-grained, friable.			10		
4					- 4.0' rock fragments (to 2")					
6	B11@5'				SAN PEDRO SAND (Qsps) Sand, poorly graded, dense, slightly moist, light gray to white, medium- to coarse-grained, some fine-grained, friable.			12	89.1	26.7
8	B11@7'							13		
10	B11@10'				- 9.0' coarse-grained sand			16		
14					- 13.5' trace fine-grained sand					
16	B11@15'			SP				20		
20	B11@20'				- 20.5' coarse-grained sand, friable			18		
24	B11@25'							20		
					Total depth of boring: 25.5 feet Fill to 5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760					

**Figure A11,
Log of Boring 11, Page 1 of 2**

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS					
	... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 11		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>240'</u>	DATE COMPLETED <u>7/23/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
					MATERIAL DESCRIPTION				
					lbs, 45-60 feet, 490 lbs				

**Figure A11,
Log of Boring 11, Page 2 of 2**

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/> ... SAMPLING UNSUCCESSFUL	<input type="checkbox"/> ... STANDARD PENETRATION TEST	<input type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input checked="" type="checkbox"/> ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 12		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>242'</u>	DATE COMPLETED <u>7/23/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silt with Sand, stiff, slightly moist, pale grayish brown, fine- to medium-grained, friable.				
2	B12@2'	■			- 3.0' some glass and brick fragments (to 2")		10		
4					Silty Clay with Sand, stiff, slightly moist, brown, medium- to coarse-grained, some rock fragments (to 1"), organic odor.				
6	B12@5'	■			- 6.0' angular rock fragments (to 5")		13		
8	B12@7'	■			- 7.5' decrease in clay content, increase in silt content		14	89.7	22.3
10	B12@10'	■			- 10.0' subangular rock fragments (to 2")		15	93.1	25.9
12					- 11.5' rock fragments (to 3")				
14									
16	B12@15'	■			Sand, poorly graded, dense, slightly moist, yellowish brown, fine- to medium-grained, trace silt, friable.		21		
18									
20	B12@20'	■			- 21.0' subangular rock fragments (to 5")		23		
22									
24									
26	B12@25'	■			Sandy Clay, stiff, slightly moist, dark brown, medium- to coarse-grained, angular rock fragments (to 1").		25		
28					- 27.0' angular rock fragments (to 4")				
					- 29.0' decrease in sand content, increase in clay content				

Figure A12,
Log of Boring 12, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 12		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>242'</u>	DATE COMPLETED <u>7/23/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
30	B12@30'						26	104.4	11.5
32									
34						- 33.5' subrounded cobbles (to 11")			
36	B12@36'						28		
38				SP		SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, light gray, medium- to coarse-grained.			
40	B12@40'					- 40.5' heavy caving	27		
					Total depth of boring: 41 feet Fill to 36 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs				

Figure A12,
Log of Boring 12, Page 2 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input checked="" type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.


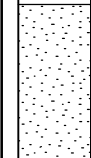






DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 13		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>193'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0	B13@5'						11		
2									
4									
6									
8				SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, dark yellowish brown, very fine- to fine-grained, friable. - 8.5' trace subrounded cobbles (to 5")				
10									
					Total depth of boring: 11 feet Fill to 7.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs				

Figure A13,
Log of Boring 13, Page 1 of 1

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
 IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 13A		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>192'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silty Sand, medium dense, well-graded, slightly moist, rock fragments (to 6").				
2					- 2.0' rock fragments (to 11")				
4					Sandy Clay, firm, slightly moist, brown, fine- to medium-grained, some coarse-grained, some siltstone fragments (to 1").		9	100.8	11.0
6	B13A@5'				- 8.5' rock fragments (to 11") - 9.0' increase in sand content				
8					Clayey Sand, poorly graded, medium dense to dense, slightly moist, olive brown, very fine- to fine-grained, some subrounded cobbles (to 5"), organic odor.		16	125.2	10.6
10	B13A@10'				Sand, well-graded, dark yellowish brown, coarse-grained, trace rounded gravel (to 1"). - 13.0' rock fragments (to 6")				
12					SAN PEDRO SAND (Qsp) Silty Sand, poorly graded, slightly moist, light grayish brown, very fine- to fine-grained, friable. - 16.0' trace subrounded cobbles (to 3")		12	94.0	7.8
14	B13A@15'			SP					
16					Total depth of boring: 18.5 feet Fill to 15 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				
18	B13A@18'				*Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs		13	88.4	4.4

Figure A14,
Log of Boring 13A, Page 1 of 1

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.











DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 14		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>217'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0	BULK 0-5'								
2									
4	B14@5'						8	110.5	12.8
6									
8									
10	B14@10'						13		
12				SM					
14	B15@15'							88.6	2.4
					Total depth of boring: 15.5 feet Fill to 9 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs				

Figure A15,
Log of Boring 14, Page 1 of 1

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 14A		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>218'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sand, poorly graded, medium dense, slightly moist, pale brown, very fine- to fine-grained, some claystone fragments (to 5"), friable.				
2					Sand, well-graded, slightly moist, yellowish brown, some rock fragments (to 5").				
4									
6									
8					Sandy Clay, firm, slightly moist, olive brown, fine- to medium-grained, organic odor.				
10	B14A@10				- 10.0' some rock fragments (to 4")		8	121.5	11.9
12									
14									
16	B14A@15				- 15.5' trace subrounded cobbles (to 3")		12		
18									
20	B14A@20				Silty Sand, poorly graded, medium dense, slightly moist, dark yellowish brown, fine- to medium-grained, trace clay, trace cobbles (to 3").		17	120.3	9.5
22					- 21.5' rock fragments (to 5")				
24					SAN PEDRO SAND (Qsp) Silty Sand, poorly graded, medium dense to dense, pale brown, very fine- to fine-grained, friable, micaceous.				
26	BULK 25-26' B14A@25 B14A@27			SM			16	98.4	3.4
					Total depth of boring: 27.5 feet Fill to 23.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.		18	92.5	2.8

Figure A16,
Log of Boring 14A, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input checked="" type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 14A ELEV. (MSL.) <u>218'</u> DATE COMPLETED <u>7/24/15</u> EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
MATERIAL DESCRIPTION								
<p>*Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs</p>								

**Figure A16,
Log of Boring 14A, Page 2 of 2**

A9201-06-01E BORING LOGS 1 TO 15.GPJ







SAMPLE SYMBOLS <input type="checkbox"/> ... SAMPLING UNSUCCESSFUL <input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input type="checkbox"/> ... STANDARD PENETRATION TEST <input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input checked="" type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED) <input checked="" type="checkbox"/> ... WATER TABLE OR SEEPAGE
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NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
 IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 15		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>217'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sand, well-graded, loose to medium dense, pale brown, some silt, some rock fragments (to 5").				
2									
4					- 4.0' trace subrounded cobbles (to 2")				
6	B15@5'				- 6.0' rock fragments (to 11")		11		
8	B15@7.5'				- 8.5' tree branch		19		
10	B15@10'				- 10.0' trace subrounded cobbles (to 3")		19		
12	BULK 10-15'				- 12.0' subrounded gravel (to 1")				
14					- 13.0' subrounded cobbles (to 3")				
16	B15@15'						20		
18									
20	BULK 19-19.5'				- 19.0' decrease in cobbles				
22	B15@20'				SAN PEDRO SAND (Qsp) Sandy Silt to Silty Sand, dense, slightly moist, pale brown, fine- to medium-grained, trace coarse-grained, friable.		22		
24					- 23.5' subrounded gravel (to 2")				
26	B15@25'			ML/SM	- 24.0' increase in coarse-grained sand		22		
28					- 26.5' trace subrounded cobbles (to 3")				

Figure A17,
Log of Boring 15, Page 1 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING 15		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>217'</u>	DATE COMPLETED <u>7/24/15</u>			
					EQUIPMENT <u>BUCKET AUGER</u> BY: <u>RA</u>				
					MATERIAL DESCRIPTION				
30					- 30.0 to 32.5' cobble-rich zone				
32									
34				ML/SM	- 33.0' sand with gravel, yellowish brown, very fine- to fine-grained				
36	BULK 35-37'								
38	B15@37'				Sand with Silt, poorly graded, dense, slightly moist, yellowish brown, very fine- to fine-grained, some coarse-grained, some gravel (to 1").		21		
40				SP-SM	- 40.0' trace clay, cobble-rich zone (to 1")				
	B15@41'						22		
					Total depth of boring: 41.5 feet Fill to 20 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for Kelly Bar falling 12 inches. Kelly Bar weights: 0-15 feet, 1,770 lbs, 15-30 feet, 1,200 lbs, 30-45 feet, 760 lbs, 45-60 feet, 490 lbs				

Figure A17,
Log of Boring 15, Page 2 of 2

A9201-06-01E BORING LOGS 1 TO 15.GPJ



SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

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DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B16		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>202</u>	DATE COMPLETED <u>5/1/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sandy Silt, firm, dry, light brown, fine-grained.				
2					MARINE SAND (Qm) Sandy Silt, stiff, dry, light brown, fine-grained.				
4	B16@3.5'					- firm	35	120.5	8.2
6	B16@5'					- firm	9	--	8.5
8						- hard, light yellowish brown			
10	B16@8.5'					- hard, light yellowish brown	59	117.1	3.7
12	B16@10'					- firm	14	--	2.3
14				ML		- hard			
16	B16@13.5'					- hard	71	115.3	1.7
18	B16@15'					- hard	60	--	3.9
20	B16@18.5'					- hard	50 (5")	102.7	5.7
22	B16@20'					- hard	31	--	4.3
24	B16@23'					- hard	50 (6")	112.1	2.5
26	B16@25'					Silty Sand, dense, dry, light brown, fine-grained.	39	--	2.4
28	B16@27.9'			SM		- hard	50 (5")	103.1	5.9

Figure A18,
Log of Boring B16, Page 1 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B16		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>202</u>	DATE COMPLETED <u>5/1/2017</u>				
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>			
MATERIAL DESCRIPTION										
30	B16@30'			SM			35	--	6.3	
32	BULK 30-35'									
34	B16@33'			SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, dry, light yellowish brown, fine- to medium-grained.		50 (5")	106.0	3.1	
36	B16@35'					- medium- to coarse-grained, trace gravel (to 2.5")		46	--	3.4
38	B16@38'					- very dense, fine-grained		50 (6")	128.3	1.6
40	B16@40'					- some oxidation		57	--	5.4
42	B16@42.8'					- highly oxidized		50 (4")	94.6	3.6
44	B16@45'					- slightly moist, fine- to medium-grained		67	--	4.0
46	B16@47.8'					- fine-grained		50 (4")	94.8	8.5
48	B16@50'					- oxidized		62	--	4.9
50	B16@52.5'							50 (6")	--	--
52	B16@55'							81	--	3.6
54	B16@57.7'					50 (3")	106.2	5.7		

Figure A18,
Log of Boring B16, Page 2 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.


DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B16 ELEV. (MSL.) <u>202</u> DATE COMPLETED <u>5/1/2017</u> EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>	PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
60	B16@60'			SP	MATERIAL DESCRIPTION	58	--	--
<p>Total depth of boring: 61.5 feet Fill to 2 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.</p> <p>*Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.</p>								

Figure A18,
Log of Boring B16, Page 3 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/> ... SAMPLING UNSUCCESSFUL <input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input type="checkbox"/> ... STANDARD PENETRATION TEST <input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input checked="" type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED) <input checked="" type="checkbox"/> ... WATER TABLE OR SEEPAGE
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NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B17		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>189</u>	DATE COMPLETED <u>5/1/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sandy Silt, stiff, slightly moist, dark brown, fine- to medium-grained, trace coarse-grained.				
2									
4	B17@3.5'				- firm		33	102.6	23.5
6	B17@5'						13	--	15.5
8	B17@7.5'				Silty Sand, dense, slightly moist, dark brown, fine- to medium-grained.		50 (6")	--	9.0
10	B17@9.5'				Sandy Silt, firm, slightly moist, dark brown, fine- to medium-grained, trace brick fragments.		21	--	17.5
12					- trace clay				
14	B17@12.5'				- stiff		39	100.7	16.2
16	B17@15'				- firm		15	--	13.3
18	B17@17.5'				Silty Sand, medium dense, dark brown, fine- to medium-grained, trace coarse-grained, trace fine gravel.		33	124.4	10.8
20	B17@20'						26	--	11.2
22	B17@22.5'						47	124.4	11.6
24					Sandy Silt, stiff, slightly moist, dark brown, trace gravel (to 1").				
26	B17@25'						22	--	26.7
28	B17@27.5'				Sand, poorly graded, very dense, slightly moist, brown, fine- to medium-grained, trace silt, friable.		50 (5")	101.1	4.9

Figure A19,
Log of Boring B17, Page 1 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B17		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>189</u>	DATE COMPLETED <u>5/1/2017</u>				
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>					
MATERIAL DESCRIPTION										
30	B17@30'				- dense		35	--	13.7	
32	B17@32.5'				- medium dense		38	110.11	7.11	
34										
36	B17@35'						10	--	5.5	
38	B17@37.5'					- loose		17	104.7	6.3
40	B17@40'						7	--	5.4	
42										
44	B17@42.5'					- medium dense		20	103.6	6.6
46	B17@45'					- loose		10	--	14.3
48	B17@47.5'					SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, brown, coarse-grained.		50 (6")	106.1	6.4
50	B17@50'				- medium dense, oxidation mottling		27	--	7.7	
52	B17@52.5'			SP			32	106.8	8.5	
54										
56	B17@55'						12	--	6.7	
58	B17@57.5'					- dense, light brown, fine- to medium-grained, some coarse-grained, friable		50 (6")	116.8	2.7

Figure A19,
Log of Boring B17, Page 2 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS					
	... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B17 ELEV. (MSL.) <u>189</u> DATE COMPLETED <u>5/1/2017</u> EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>	PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
60	B17@60'				MATERIAL DESCRIPTION Sandstone, coarse-grained, laminated, medium hard, intensely fractured. Total depth of boring: 60.5 feet Fill to 46 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.	53	--	1.5

Figure A19,
Log of Boring B17, Page 3 of 3

A9201-06-1E BORING LOGS 16-24.GPJ







SAMPLE SYMBOLS <input type="checkbox"/> ... SAMPLING UNSUCCESSFUL <input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input type="checkbox"/> ... STANDARD PENETRATION TEST <input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input checked="" type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED) <input checked="" type="checkbox"/> ... WATER TABLE OR SEEPAGE
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NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B18		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>197</u>	DATE COMPLETED <u>5/3/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silty Sand, medium dense, slightly moist, dark brown, fine- to medium-grained.				
2	B18@2.5'						14	--	28.7
4					- trace fine gravel (to 1")				
6	B18@5'				- loose		30	89.4	27.4
8	B18@7.5'				- glass debris		9	--	33.9
10	B18@10'				- medium dense, increase in silt content		32	92.3	26.7
12					Sand, poorly graded, medium dense, slightly moist, dark brown, fine-grained.				
14	B18@12.5'				- some clayey silt chunks, trace gravel (to 1")		21	--	12.1
16	B18@15'						48	110.7	2.6
18	B18@17.5'						16	--	6.4
20	B18@20'				- loose, brown		12	105.0	5.5
22					- dense				
24	B18@22.5'				- medium dense, some chunks of clayey silt		38	--	19.0
26	B18@25'						33	96.8	17.9
28	B18@27.5'			SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, light brown, medium- to coarse-grained, some cementation, locally friable. - coarse-grained		36	--	1.8

Figure A20,
Log of Boring B18, Page 1 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.


DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B18		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)		
					ELEV. (MSL.) <u>197</u>	DATE COMPLETED <u>5/3/2017</u>					
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>						
MATERIAL DESCRIPTION											
30	B18@30'			SP	- very dense, decrease in coarse-grained sand		50 (6")	118.4	2.7		
32	B18@32.5'							67	--	1.7	
34	B18@35'							50 (4")	113.8	1.5	
36	B18@37.5'							63	--	1.4	
38	B18@40'							50 (6")	107.9	1.4	
40	B18@42.5'							50 (6")	--	1.6	
42	B18@45'							50 (6")	109.9	1.9	
44	B18@47.5'							50 (4")	--	--	
46	B18@50'							50 (5")	98.8	1.5	
48	B18@52.5'							50 (3")	--	1.7	
50	B18@55'							50 (5")	101.0	1.9	
52	B18@57.5'							50 (6")	--	1.9	
54											
56											
58											

Figure A20,
Log of Boring B18, Page 2 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS		
	... SAMPLING UNSUCCESSFUL	
	... DISTURBED OR BAG SAMPLE	
	... STANDARD PENETRATION TEST	
	... CHUNK SAMPLE	
	... WATER TABLE OR SEEPAGE	

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B18 ELEV. (MSL.) <u>197</u> DATE COMPLETED <u>5/3/2017</u> EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>	PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
60	B18@60'			SP	MATERIAL DESCRIPTION Total depth of boring: 60.5 feet Fill to 27 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.	50 (6")	108.6	2.0

**Figure A20,
Log of Boring B18, Page 3 of 3**

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS <input type="checkbox"/> ... SAMPLING UNSUCCESSFUL <input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input type="checkbox"/> ... STANDARD PENETRATION TEST <input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input checked="" type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED) <input checked="" type="checkbox"/> ... WATER TABLE OR SEEPAGE
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NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B19		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>212</u>	DATE COMPLETED <u>5/2/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>RMA</u>		
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silt, firm, slightly moist, trace fine-grained sand.				
2	B19@2.5'				Silty Sand, loose, slightly moist, yellowish brown, fine- to medium-grained.		14	--	11.7
4					Silt, hard, slightly moist, dark brown, fine-grained.				
6	B19@5'				Silty Sand, dense, slightly moist, yellowish brown, fine- to medium-grained.		50 (6")	118.8	12.9
8	B19@7.5'				Sand, poorly graded, dense, slightly moist, light brown, fine-grained.		33	--	--
10	B19@10'						67	116.6	11.4
12									
14	B19@12.5'						32	--	9.8
16	B19@15'						50 (5")	122.5	9.4
18	B19@17.5'				- medium dense		24	--	14.6
20	B19@20'				- dense		50 (5")	109.6	15.1
22									
24	B19@22.5'				- wood debris		15	--	16.8
26	B19@25'				- medium dense		48	111.4	12.9
28	B19@27.5'				Sand, poorly graded, loose to medium dense, slightly moist, fine-grained, friable.		10	--	8.7

Figure A21,
Log of Boring B19, Page 1 of 3

A9201-06-1E BORING LOGS 16-24.GPJ







SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B19		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>212</u>	DATE COMPLETED <u>5/2/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>RMA</u>				
MATERIAL DESCRIPTION									
30	B19@30'				- medium dense		26	95.5	4.0
32	B19@32.5'						23	--	6.1
34	B19@35'				Clayey Silt, stiff, slightly moist, brown, trace fine-grained sand.		38	--	4.3
36	B19@37.5'				Sand, poorly graded, medium dense, slightly moist, light brown, fine-grained, friable.		22	--	2.0
38	B19@40'				Silty Sand, very dense, slightly moist, light brown, fine- to medium-grained, trace coarse-grained.		50 (4")	101.1	11.5
40	B19@42.5'				- chunks of clay in sand matrix		39	--	8.5
42	B19@45'						75	81.0	39.3
44	B19@47.5'				Sand, poorly graded, medium dense, slightly moist, light brown, fine-grained, friable.		26	--	4.5
46	B19@50'				Clayey Silt, stiff, slightly moist, brown, trace fine-grained sand.				
48	B19@50'				SAN PEDRO SAND (Qsp) Sand, poorly graded, very dense, slightly moist, light brown, fine-grained, friable.		50 (5")	--	4.5
50	B19@52.5'				- dense, some clay interbeds		32	--	3.4
52	B19@55'			SP	- dense, fine- to medium-grained, trace coarse-grained		50 (6")	82.8	33.8
54	B19@57.5'				- very dense, increase in coarse-grained sand		51	--	2.1

Figure A21,
Log of Boring B19, Page 2 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B19		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>212</u>	DATE COMPLETED <u>5/2/2017</u>				
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>RMA</u>			
MATERIAL DESCRIPTION										
60	B19@60'				- dense		68	113.2	4.9	
62	B19@62.5'				- very dense		55	--	22.1	
64	B19@65'				- trace fine-grained sand		50 (6")	108.7	4.0	
66	B19@67.5'			SP	- dense		40	--	28.8	
70	B19@70'				- very dense		50 (5")	99.4	6.3	
72	B19@72.5'						55	--	7.5	
74	B19@75'						50 (5")	110.5	4.8	
76	B19@77.5'					Sand, poorly graded, laminated, very dense, slightly moist, light brown.		55	--	5.2
78	B19@80'			SP				50 (4")	80.9	38.0
80	B19@80'					Total depth of boring: 80.5 feet Fill to 49 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.				

Figure A21,
Log of Boring B19, Page 3 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS					
	... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B20		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>192</u>	DATE COMPLETED <u>5/1/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sandy Silt, stiff, wet, dark brown, fine- to medium-grained, some coarse-grained.				
2									
4									
6	B20@5'						30	106.7	17.8
8					Sand with Silt, poorly graded, medium dense, slightly moist, dark brown, fine-grained, trace gravel (to 3").				
10	B20@10'				- dense		50 (5")	116.3	12.1
12									
14					- increase in silt content, some coarse-grained				
16	B20@15'						78	125.1	11.9
18									
20	B20@20'				- very dense, some plastic debris		50 (5")	--	10.4
22									
24					- medium dense, trace gravel (to 1")				
26	B20@25'						39	99.8	22.7
28					Sand, poorly graded, medium dense, slightly moist, brown, fine-grained, trace medium-grained, trace silt and fine gravel.				

Figure A22,
Log of Boring B20, Page 1 of 5

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B20		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>192</u>	DATE COMPLETED <u>5/1/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>				
MATERIAL DESCRIPTION									
30	B20@30'						27	118.0	9.1
32									
34									
36	B20@35'				- decrease in silt content		23	111.7	7.8
38									
40	B20@40'				- increase in medium- to coarse-grained		21	115.0	2.9
42									
44									
46	B20@45'				Sand, poorly graded, medium dense, slightly moist to moist, brown, fine- to medium-grained, some coarse-grained, trace silt, oxidized, friable.		26	119.4	7.9
48									
50	B20@50'				- fine- to medium-grained, trace gravel (to 1")		50 (6")	124.8	8.6
52									
54					- yellowish brown, some oxidation mottling				
56	B20@55'						27	97.8	4.2
58					- some coarse-grained				

Figure A22,
Log of Boring B20, Page 2 of 5

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/> ... SAMPLING UNSUCCESSFUL	<input type="checkbox"/> ... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input type="checkbox"/> ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B20		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>192</u>	DATE COMPLETED <u>5/1/2017</u>				
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>			
MATERIAL DESCRIPTION										
60	B20@60'				- very dense		50 (4")	113.1	3.3	
62										
64						- oxidized				
66	B20@65'					- friable		50 (5")	106.3	3.3
68										
70	B20@70'				- some clayey sand chunks		50 (3")	107.9	1.0	
72										
74	B20@75'					SAN PEDRO SAND (Qsp) Sand, poorly graded, very dense, slightly moist, light brown, medium-grained, friable.		50 (5")	--	--
76										
78										
80	B20@80'	SP			- oxidation mottling		50 (5")	104.5	2.3	
82										
84										
86	B20@85'							50 (4")	110.4	1.2
88										

Figure A22,
Log of Boring B20, Page 3 of 5

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B20		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>192</u>	DATE COMPLETED <u>5/1/2017</u>				
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>					
MATERIAL DESCRIPTION										
90	B20@90'			SP	- highly oxidized bed		50 (4")	--	--	
92										
94										
96	B20@95'					- light brown, unoxidized		50 (5")	110.4	2.0
98										
100	B20@100'							50 (6")	107.1	2.4
102										
104										
106	B20@105'							50 (2.5")	102.7	2.0
108										
110	B20@111'					50 (3")	--	--		
112	B20@115'					50 (4")	--	0.6		
114					- some coarse-grained, trace fine gravel (to 1")					
116										
118					- fine-grained, friable					

Figure A22,
Log of Boring B20, Page 4 of 5

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.


DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B20 ELEV. (MSL.) <u>192</u> DATE COMPLETED <u>5/1/2017</u> EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>	PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
120	B20@120			SP	MATERIAL DESCRIPTION Total depth of boring: 120.5 feet Fill to 74 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.	50 (5")	--	1.0

Figure A22,
Log of Boring B20, Page 5 of 5

A9201-06-1E BORING LOGS 16-24.GPJ




SAMPLE SYMBOLS <input type="checkbox"/> ... SAMPLING UNSUCCESSFUL <input checked="" type="checkbox"/> ... DISTURBED OR BAG SAMPLE	<input type="checkbox"/> ... STANDARD PENETRATION TEST <input checked="" type="checkbox"/> ... CHUNK SAMPLE	<input checked="" type="checkbox"/> ... DRIVE SAMPLE (UNDISTURBED) <input checked="" type="checkbox"/> ... WATER TABLE OR SEEPAGE
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NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B21		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>236</u>	DATE COMPLETED <u>5/3/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
0					MARINE SAND (Qm) Organic layer, silt organic				
2	B21@2.5'				Sandy Silt, firm, slightly moist, brown, fine-grained, trace medium- to coarse-grained.		11	--	31.3
4									
6	B21@6'				- grades to silty sand, medium dense, slightly moist, brown, fine- to medium-grained		20	--	30.1
8	B21@7.5'				SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, brown, fine- to medium-grained, trace coarse-grained, trace silt.		13	--	3.1
10									
12	B21@11'				- yellowish brown		26	107.4	5.0
14	B21@12.5'						26	--	4.1
16	B21@16'						32	111.0	3.9
18	B21@17.5'			SP	- increase in coarse-grained		25	--	2.5
20									
22	B21@21'						57	106.6	3.1
24	B21@22.5'				- very dense, fine- to medium-grained		61	--	5.3
26	B21@26'				- medium dense		24	111.2	4.8
28	B21@27.5'				- dense, trace coarse-grained		41	--	3.0

Figure A23,
Log of Boring B21, Page 1 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B21		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>236</u>	DATE COMPLETED <u>5/3/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
30	B21@31'			SP	- light yellowish brown, fine- to coarse-grained	54	113.7	4.1	
32	B21@32.5'		41		--	12.1			
34									
36	B21@36'		80		113.7	4.3			
38	B21@37.5'		- very dense		60	--	2.5		
40									
42	B21@40.5'		- dense		50 (6")	--	2.5		
44	B21@42.5'		- very dense		38	--	3.7		
46	B21@45' BULK 45-50'		- slightly oxidized		50 (5")	108.2	3.0		
48	B21@47.5'				51	--	4.8		
50									
52	B21@50.5'		50 (4")	108.5	4.4				
54	B21@52.5'		66	--	3.7				
56	B21@55.5'		50 (4")	115.3	5.3				
58	B21@57.5'		78	--	6.8				

Figure A23,
Log of Boring B21, Page 2 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B21		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)		
					ELEV. (MSL.) <u>236</u>	DATE COMPLETED <u>5/3/2017</u>					
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>				
MATERIAL DESCRIPTION											
60	B21@60.5'			SP			50 (4")	109.9	4.3		
62	B21@62.5'							50 (6")	--	3.6	
64											
66	B21@65'							50 (5")	114.6	3.8	
68	B21@67.5'							- increase oxidation	50 (6")	--	4.3
70	B21@70'								50 (2")	109.9	3.8
72											
74	B21@72.5'								50 (6")	--	3.2
76	B21@75.5'								50 (3")	111.0	3.1
78	B21@77.5'								50 (4")	--	3.1
80											
82	B21@80.5'								50 (3")	107.6	3.4
84	B21@82.5'							- highly oxidized	50 (4")	--	2.3
86	B21@85'					50 (6")	106.6	2.9			
88	B21@87'					50 (5")	--	3.3			

Figure A23,
Log of Boring B21, Page 3 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B21		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>236</u>	DATE COMPLETED <u>5/3/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
90	B21@90'			SP	- trace coarse-grained		50 (6")	106.8	3.6
92	B21@92.5'		50 (5")				--	3.5	
94	B21@95'		50 (6")				108.4	3.7	
96	B21@97.5'		50 (6")				--	3.1	
98	B21@100'		50 (6")				111.1	3.5	
100	B21@102.5'		50 (6")				--	3.6	
102	B21@105'		50 (5")				110.9	3.8	
104	B21@107.5'		50 (5")				--	2.7	
106	B21@110'		50 (5")				109.1	3.0	
<p>Total depth of boring: 110.5 feet Fill to 7.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. Surface restored.</p> <p>*Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.</p>									

Figure A23,
Log of Boring B21, Page 4 of 4

A9201-06-1E BORING LOGS 16-24.GPJ







SAMPLE SYMBOLS					
	... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B22		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>203</u>	DATE COMPLETED <u>5/3/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Silty Sand, medium dense, slightly moist, dark brown with red mottles, fine- to medium-grained.				
2	B22@2.5'						13	--	37.9
4					- decrease in silt content				
6	B22@5'						22	121.2	13.0
8	B22@7.5'				Sand with Silt, poorly graded, medium dense, slightly moist, dark brown, fine-grained.		14	--	11.0
10	B22@10'				- trace coarse-grained		24	114.9	15.7
12	B22@12.5'				Sand, poorly graded, medium dense, slightly moist, light brown, fine- to medium-grained, friable.		17	--	10.1
14	B22@15'						29	120.9	8.4
16									
18	B22@17.5'				- trace silt		21	--	5.3
20	B22@20'						27	117.0	8.3
22	B22@22.5'				- loose, light brown, fine- to medium-grained		9	--	4.0
24	B22@25'				Sand with Silt, poorly graded, medium dense, slightly moist, light brown, fine- to medium-grained.		21	--	3.7
26									
28	B22@27.5'			SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, yellowish brown, fine- to medium-grained, some coarse-grained.		38	--	2.2

Figure A24,
Log of Boring B22, Page 1 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B22		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>203</u>	DATE COMPLETED <u>5/3/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>				
MATERIAL DESCRIPTION									
30	B22@30'			SP	- medium-grained, moderately cemented, locally friable	50 (6")	118.0	2.8	
32	B22@32.5'		- very dense		50 (5")	--	2.1		
34	B22@35'		- trace coarse-grained, trace silt		50 (3')	119.1	1.1		
38	B22@37.5'		- medium- to coarse-grained		62	--	2.5		
40	B22@40'		- dense		50 (6")	115.1	3.1		
42	B22@42.5'		- very dense		50 (6")	--	1.7		
44	B22@45'		- fine- to medium-grained, trace coarse-grained		50 (6")	--	1.8		
48	B22@47.5'		- light brown, fine-grained, trace coarse-grained		50 (6")	--	3.7		
50	B22@50'		- fine- to medium-grained		50 (6")	105.4	3.6		
52	B22@52.5'		- trace coarse-grained		50 (4")	--	4.0		
54	B22@55'		- fine- to medium-grained, trace coarse-grained		50 (5")	100.4	3.4		
58	B22@57.5'				50 (5")	--	3.0		

Figure A24,
Log of Boring B22, Page 2 of 3

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.




DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B22 ELEV. (MSL.) <u>203</u> DATE COMPLETED <u>5/3/2017</u> EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>	PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
MATERIAL DESCRIPTION								
60	B22@60'			SP		50 (4")	79.3	3.5
62	B22@62.5'				- increase in medium-grained	50 (3")	--	3.2
64	B22@65'				- medium-grained	50 (5")	91.5	4.0
					Total depth of boring: 65.5 feet. Fill to 27 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.			

Figure A24,
Log of Boring B22, Page 3 of 3

A9201-06-1E BORING LOGS 16-24.GPJ







SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B23		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>239</u>	DATE COMPLETED <u>5/4/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sandy Silt, firm, slightly moist, brown, fine-grained.				
2									
4	B23@3'						13	--	16.4
6	B23@6'				- stiff, increase in sand content, fine-grained		29	88.5	30.1
8	B23@8'				- trace fine gravel		19	--	20.8
10									
12	B23@11'			SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, brown, fine- to medium-grained, some coarse-grained.		57	101.1	23.7
14	B23@13'			ML	Sandy Silt, firm, slightly moist, brown, fine grained.		19	--	23.3
16	B23@16'				Sand, poorly graded, medium dense, slightly moist, brown, fine- to medium-grained, some coarse-grained.		53	88.5	16.3
18	B23@17.5'				- dense, medium-grained, yellowish brown		45	--	0.3
20									
22	B23@21'			SP	- very dense		50 (5")	107.5	2.5
24	B23@23'				- dense		39	--	1.5
26	B23@26'				- oxidized		86	112.4	2.7
28	B23@28'						42	--	1.6

Figure A25,
Log of Boring B23, Page 1 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B23		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>239</u>	DATE COMPLETED <u>5/4/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
30	B23@30.5'			SP	- light yellowish brown, fine- to medium-grained	50 (6")	106.3	2.0	
32			- very dense, medium-grained		53	--	1.7		
34	B23@33'								
36	B23@35.5'						50 (6")	106.2	3.1
38	B23@38'					- oxidized	45	--	2.6
40									
42	B23@40.5'						50 (5")	105.2	3.0
44	B23@43'					- fine- to coarse-grained	53	--	0.5
46	BULK 45-50'					- gravel bed (2" thick), gravel rounded (to 0.5")	50 (4")	110.2	2.1
48	B23@45.5'								
50	B23@48'				82	--	1.9		
52	B23@50.5'				50 (5")	99.8	1.9		
54	B23@53'				59	--	1.4		
56	B23@55'				50(6")	113.4	2.2		
58	B23@58'				54	--	1.6		

Figure A25,
Log of Boring B23, Page 2 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B23		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)		
					ELEV. (MSL.) <u>239</u>	DATE COMPLETED <u>5/4/2017</u>					
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>						
MATERIAL DESCRIPTION											
60	B23@60'			SP	- fine- to medium-grained		50(6")	110.5	1.9		
62											
64	B23@63'								67	--	9.1
66	B23@65.3'								50(3")	107.5	2.6
68	B23@68'								50(6")	--	1.4
70	B23@70'								50(6")	104.7	1.6
72											
74	B23@73'								81	--	1.0
76	B23@75.5'								50(3")	101.4	1.8
78	B23@78'							- fine- to coarse-grained			
80	B23@80'					50(6")	109.6	1.9			
82											
84	B23@83'					50(6")	--	1.6			
86	B23@85'				- oxidized, some fine gravel (to 0.5")						
88	B23@88'					50(6")	--	1.6			

Figure A25,
Log of Boring B23, Page 3 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B23		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>239</u>	DATE COMPLETED <u>5/4/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
90	B23@90'			SP			50(6")	104.9	1.7
92	B23@92.5'		50 (5")				--	1.4	
94	B23@95'		50 (2")				--	--	
					- no recovery Total depth of boring: 95.5 feet Fill to 11 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. Surface restored. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.				

Figure A25,
Log of Boring B23, Page 4 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS					
	... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B24		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>242</u>	DATE COMPLETED <u>5/4/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u> BY: <u>MDS</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sandy Silt, stiff, dry, light brown, fine- to medium-grained, trace coarse-grained.				
2									
4	B24@2.5'						26	--	30.8
6	B24@6'				- hard, trace clay		44	63.7	38.7
8	B24@8'				- stiff		20	--	26.7
10									
12	B24@11'				- hard		47	62.9	35.6
14	B24@13'				- stiff		17	--	25.4
16	B24@16'				- hard		45	68.4	30.0
18	B24@18'				- stiff, brown		24	--	25.8
20									
22	B24@21'				- hard		47	91.1	21.7
24	B24@23'						30	--	22.8
26	B24@26'						42	104.1	15.9
28	B24@28'				- stiff		20	--	22.7

Figure A26,
Log of Boring B24, Page 1 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	<input type="checkbox"/>	... SAMPLING UNSUCCESSFUL	<input type="checkbox"/>	... STANDARD PENETRATION TEST	<input checked="" type="checkbox"/>	... DRIVE SAMPLE (UNDISTURBED)
	<input checked="" type="checkbox"/>	... DISTURBED OR BAG SAMPLE	<input checked="" type="checkbox"/>	... CHUNK SAMPLE	<input type="checkbox"/>	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B24		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>242</u>	DATE COMPLETED <u>5/4/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
30	B24@31'				- hard		50	--	18.1
32	B24@33'				SAN PEDRO SAND (Qsp) Sand, poorly graded, dense, slightly moist, yellowish brown, fine- to coarse-grained.		32	--	6.6
34									
36	B24@36'				- very dense		50 (5")	109.0	6.5
38	B24@38'				- oxidized		51	--	1.2
40									
40.5	B24@40.5'				- dense		50 (6")	111.2	1.8
42									
44	B24@43'						50	--	2.6
46	B24@45.5'			SP	- increase in coarse-grained		50 (6")	114.5	5.1
48	B24@48'				- very dense		51	--	1.6
50	B24@50'						50 (6")	112.5	2.3
52	BULK 50-55'								
54	B24@53'						51	--	1.4
56	B24@55'						50 (6")	107.4	1.9
58	B24@58'						53	--	2.0

Figure A26,
Log of Boring B24, Page 2 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B24		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	
					ELEV. (MSL.) <u>242</u>	DATE COMPLETED <u>5/4/2017</u>				
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>			
MATERIAL DESCRIPTION										
60	B24@60.5'			SP	- some silt		50 (4")	109.7	1.9	
62	B24@63'						78	--	4.1	
64	B24@65'						50 (6")	106.1	3.1	
66	B24@68'						50 (3")	--	1.3	
68	B24@70'						50 (5")	111.0	2.1	
70	B24@73'						- very light brown, fine-grained, no silt	52	--	12.8
72	B24@75'							50 (6")	96.4	12.1
74	B24@78'						- some silt	82	--	9.8
76	B24@80'						- medium-grained	50 (5")	103.6	50.6
78	B24@82.5'							50 (6")	--	2.9
80	B24@85'	50 (5")	94.4	1.4						
82	B24@88'	50 (5")	--	0.8						

Figure A26,
Log of Boring B24, Page 3 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B24		PENETRATION RESISTANCE (BLOWS/FT*)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>242</u>	DATE COMPLETED <u>5/4/2017</u>			
					EQUIPMENT <u>HOLLOW STEM AUGER</u>		BY: <u>MDS</u>		
MATERIAL DESCRIPTION									
90	B24@90'					- fine- to medium-grained, trace shell fragments	50 (6")	96.7	1.4
92	B24@92.5'			SP		- slightly oxidized	50 (4")	--	2.8
94									
96	B24@95'					Silty Sand, very dense, slightly moist, yellowish brown, fine-grained.	50 (6")	102.2	15.4
98	B24@97.5'						75	--	13.1
100	B24@100'			SM			50 (6")	106.2	14.7
102	B24@102.5'						50 (6")	--	15.5
104									
105	B24@105'						50 (5")	100.3	14.9
					Total depth of boring: 105.5 feet Fill to 32 feet. Backfilled with soil cuttings and tamped. Surface restored. *Penetration resistance for 140-pound hammer falling 30 inches by auto-hammer.				

Figure A26,
Log of Boring B24, Page 4 of 4

A9201-06-1E BORING LOGS 16-24.GPJ

SAMPLE SYMBOLS		
	... SAMPLING UNSUCCESSFUL	
	... DISTURBED OR BAG SAMPLE	
	... STANDARD PENETRATION TEST	
	... CHUNK SAMPLE	
		... DRIVE SAMPLE (UNDISTURBED)
		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	HAND AUGER 1		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>203'</u>	DATE COMPLETED <u>7/22/15</u>			
					EQUIPMENT <u>HAND AUGER</u> BY: <u>RP</u>				
MATERIAL DESCRIPTION									
0	BULK 0-3'				ARTIFICIAL FILL (af) Silty Sand, loose to medium dense, dry, brown, fine- to coarse-grained, trace rootlets.				
2					Sandy Silt, firm slightly moist, brown to olive brown, fine-grained, some coarse-grained.				
4	HA1@3'				MARINE SAND (Qm) Silty Sand, loose, slightly moist, brown to reddish brown, fine-grained, some coarse-grained, trace rootlets.				
6				SM					
8	HA1@7.5'								
10	HA1@10'								
12									
14	HA1@13.5'			SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, pale brown to brown, fine-grained, trace medium-grained, trace silt.				
16	HA1@15.5'				Total depth of boring: 16 feet Fill to 2.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				

Figure A27,
Log of HAND AUGER 1, Page 1 of 1

A9201-06-01E HAND AUGER LOGS.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.













DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	HAND AUGER 2		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>196'</u>	DATE COMPLETED <u>7/22/15</u>			
					EQUIPMENT <u>HAND AUGER</u> BY: <u>RP</u>				
MATERIAL DESCRIPTION									
0	BULK 0-3'					ARTIFICIAL FILL (af) Silty Sand, loose, slightly moist, dark brown, fine- to coarse-grained, some rounded gravel (to 1/2"), trace rootlets. - 1.5' mottled brown and reddish brown, slightly porous, trace rootlets			
2	HA2@2'							93.4	10.9
4	HA2@3.5'					MARINE SAND (Qm) Silty Sand, medium dense, slightly moist, reddish brown, fine-grained, trace coarse-grained, some silt. - 8.5' decrease in silt content			
6				SM					
8									
10	HA2@10'								
12									
14									
16	HA2@15'					SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, pale brown, fine-grained, some medium-grained.			
18				SP					
20	HA2@20'								
					Total depth of boring: 20.5 feet Fill to 3 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				

Figure A28,
Log of HAND AUGER 2, Page 1 of 1

A9201-06-01E HAND AUGER LOGS.GPJ







SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	HAND AUGER 3		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>208'</u>	DATE COMPLETED <u>7/22/15</u>			
					EQUIPMENT <u>HAND AUGER</u> BY: <u>RP</u>				
MATERIAL DESCRIPTION									
0						ARTIFICIAL FILL (af) Silty Sand, loose to medium dense, slightly moist, brown, fine- to coarse-grained, trace rootlets. - 2.0' mottled pale brown and reddish brown, trace silt, sand is sub-rounded			
2	HA3@2.5'								
6	HA3@6'				MARINE SAND (Qm) Silty Sand, reddish brown, slightly moist, medium dense, fine- to coarse-grained. - 9.5' decrease in silt content, trace rootlets				
8									
10	HA3@10'			SM					
16	HA3@15'				SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, pale brown to yellowish brown, fine- to coarse-grained, trace fine rounded gravel (to 3/4"). - 23.5' slightly porous, grading to mostly fine-grained				
18									
20	HA3@20'			SP					
24	HA3@23.5'								
					Total depth of boring: 23.5 feet Fill to 5.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				

Figure A29,
Log of HAND AUGER 3, Page 1 of 1

A9201-06-01E HAND AUGER LOGS.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.









DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	HAND AUGER 4		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>232'</u>	DATE COMPLETED <u>7/23/15</u>			
					EQUIPMENT <u>HAND AUGER</u> BY: <u>RP</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sand, poorly graded, loose, dry to slightly moist, pale brown to yellowish brown, fine-grained, large amount of siltstone fragments (to 4.5"), thinly bedded, highly weathered, massive, friable, some roots (to 2").				
2									
4					SAN PEDRO SAND (Qsp) Sand, poorly graded, loose, slightly moist, pale brown to yellowish brown, fine-grained, some cemented fragments. - 6.5' some sandstone fragments				
6	HA4@5'			SP					
8	HA4@7.5'				- 8.5' refusal Total depth of boring: 8.5 feet Fill to 5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				

Figure A30,
Log of HAND AUGER 4, Page 1 of 1

A9201-06-01E HAND AUGER LOGS.GPJ

SAMPLE SYMBOLS	 ... SAMPLING UNSUCCESSFUL	 ... STANDARD PENETRATION TEST	 ... DRIVE SAMPLE (UNDISTURBED)
	 ... DISTURBED OR BAG SAMPLE	 ... CHUNK SAMPLE	 ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED.
 IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.


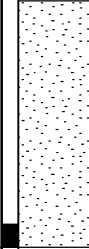







DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	HAND AUGER 5		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>227'</u>	DATE COMPLETED <u>7/23/15</u>			
					EQUIPMENT <u>HAND AUGER</u> BY: <u>RP</u>				
MATERIAL DESCRIPTION									
0									
2	HA5@2'				ARTIFICIAL FILL (af) Sand, poorly graded, very loose, dry, white to pale brown, fine- to coarse-grained, some cobbles, heavy amount of trash (from 1.5-2' below slope face).				
4				SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, very loose, dry, white to pale brown, fine- to coarse-grained, some rounded cobbles, caving sands.				
6									
8	HA5@8'				- 7.5' trace medium-grained sand, slightly oxidized - 8.5' caving sands Total depth of boring: 8.5 feet Fill to 3 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				

Figure A31,
Log of HAND AUGER 5, Page 1 of 1

A9201-06-01E HAND AUGER LOGS.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.









DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	HAND AUGER 6		PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					ELEV. (MSL.) <u>253'</u>	DATE COMPLETED <u>7/23/15</u>			
					EQUIPMENT <u>HAND AUGER</u> BY: <u>RP</u>				
MATERIAL DESCRIPTION									
0					ARTIFICIAL FILL (af) Sand, poorly graded, loose, dry, pale brown, fine-grained, some coarse-grained, some rootlets, trash debris (to 1.5'), cobbles and boulders (to 2').				
2									
4	HA6@3'			SP	SAN PEDRO SAND (Qsp) Sand, poorly graded, medium dense, slightly moist, pale brown to yellowish brown, fine-grained.				
6	HA6@6'								
					Total depth of boring: 7 feet Fill to 2.5 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.				

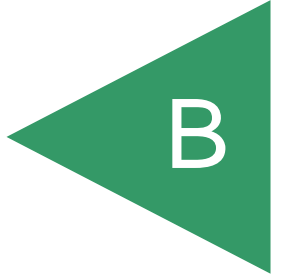
Figure A32,
Log of HAND AUGER 6, Page 1 of 1

A9201-06-01E HAND AUGER LOGS.GPJ

SAMPLE SYMBOLS		... SAMPLING UNSUCCESSFUL		... STANDARD PENETRATION TEST		... DRIVE SAMPLE (UNDISTURBED)
		... DISTURBED OR BAG SAMPLE		... CHUNK SAMPLE		... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

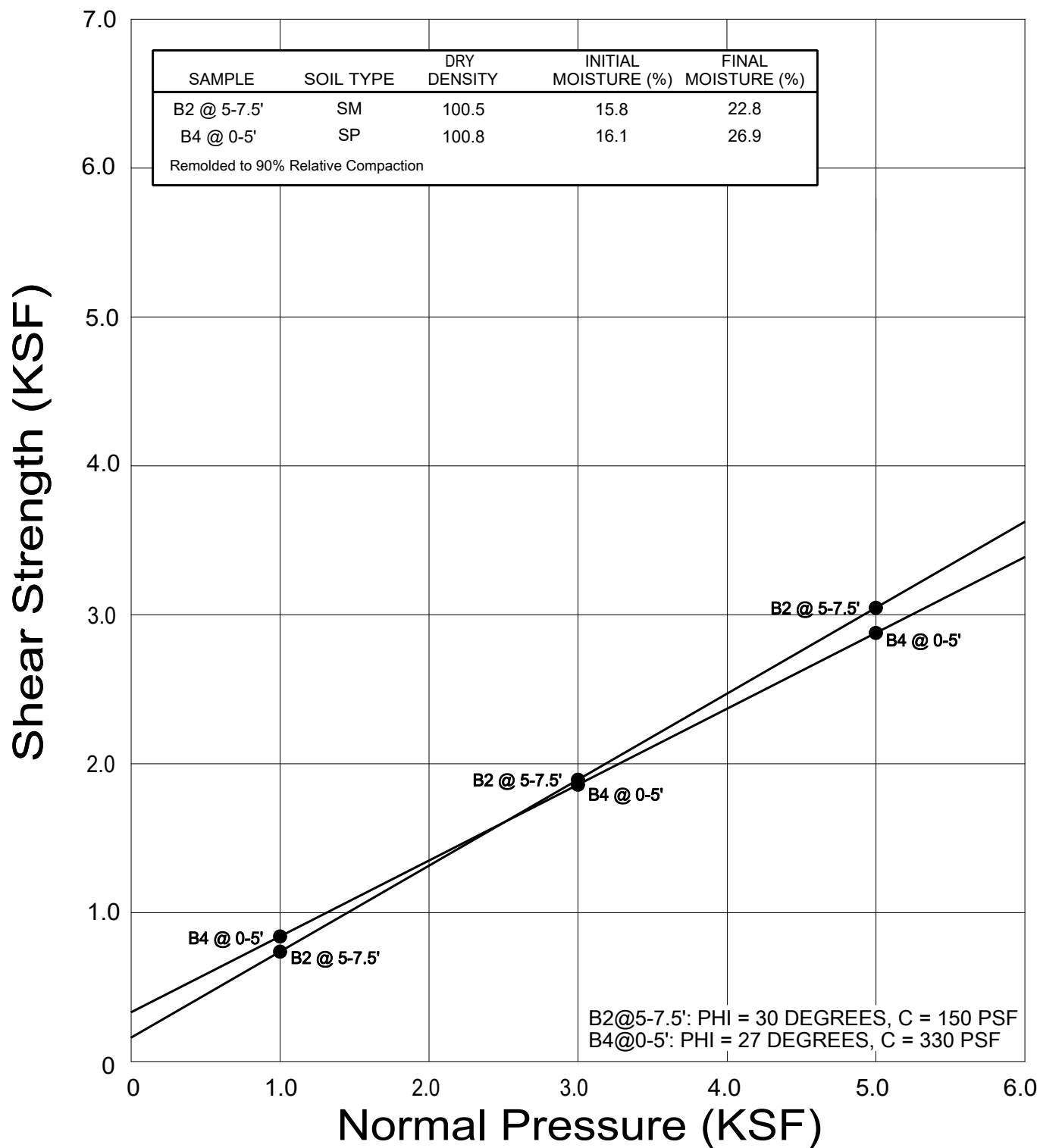
APPENDIX



APPENDIX B

LABORATORY TESTING

Laboratory tests were performed in accordance with generally accepted test methods of the “American Society for Testing and Materials (ASTM)”, or other suggested procedures. Selected samples were tested for direct shear strength, consolidation and expansion characteristics, grain size distribution, corrosivity, in-place dry density and moisture content. The results of the laboratory tests are summarized in Figures B1 through B27. The in-place dry density and moisture content of the samples tested are presented on the boring logs, Appendix A.



● Direct Shear, Saturated

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Drafted by: JTA

Checked by: NDB

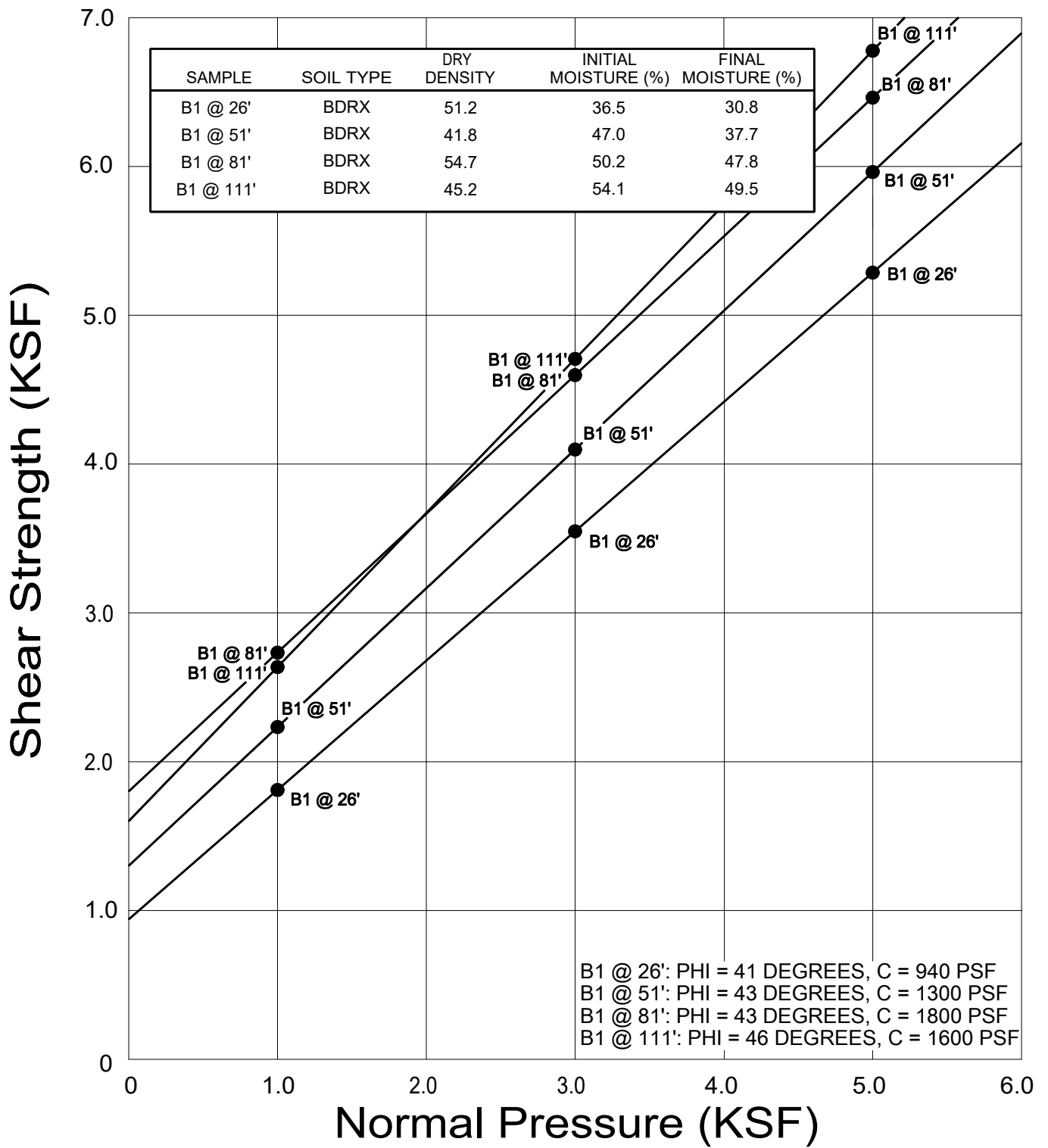
DIRECT SHEAR TEST RESULTS

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
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JUNE 2017

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FIG. B1



● Direct Shear, Field Moisture

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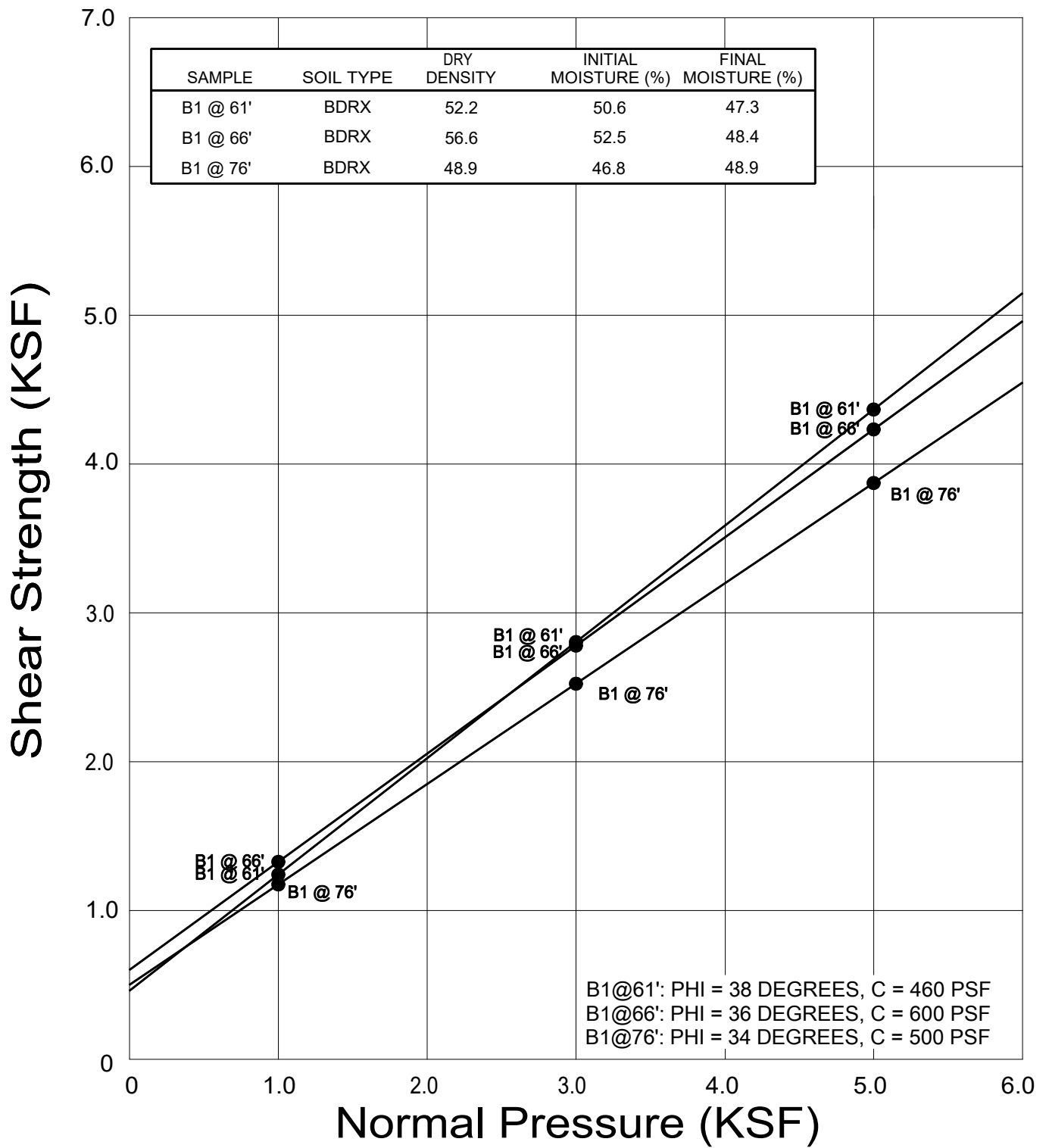
DIRECT SHEAR TEST RESULTS

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FIG. B2



● Direct Shear, Field Moisture, Residual

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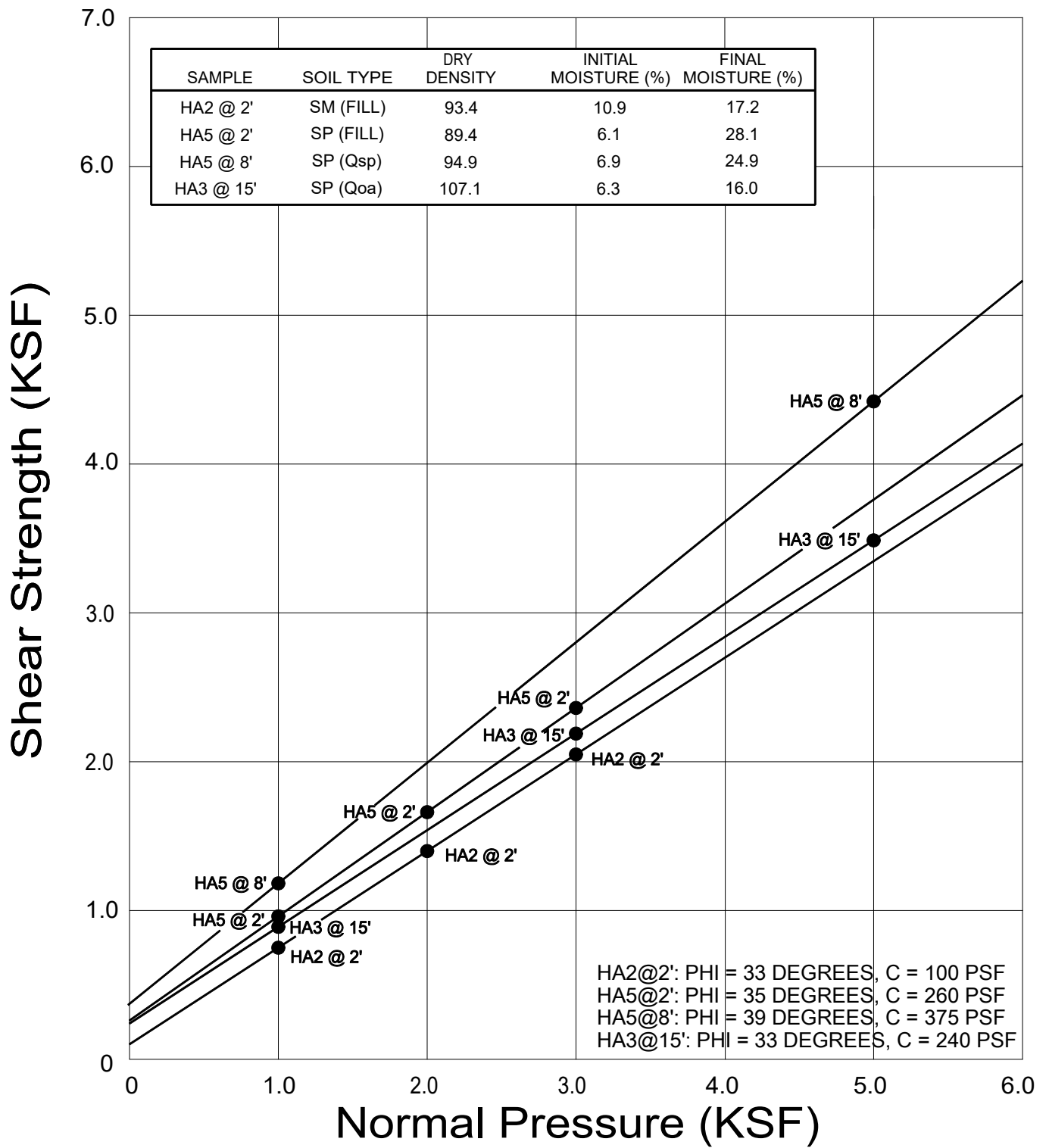
DIRECT SHEAR TEST RESULTS

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FIG. B3



● Direct Shear, Saturated

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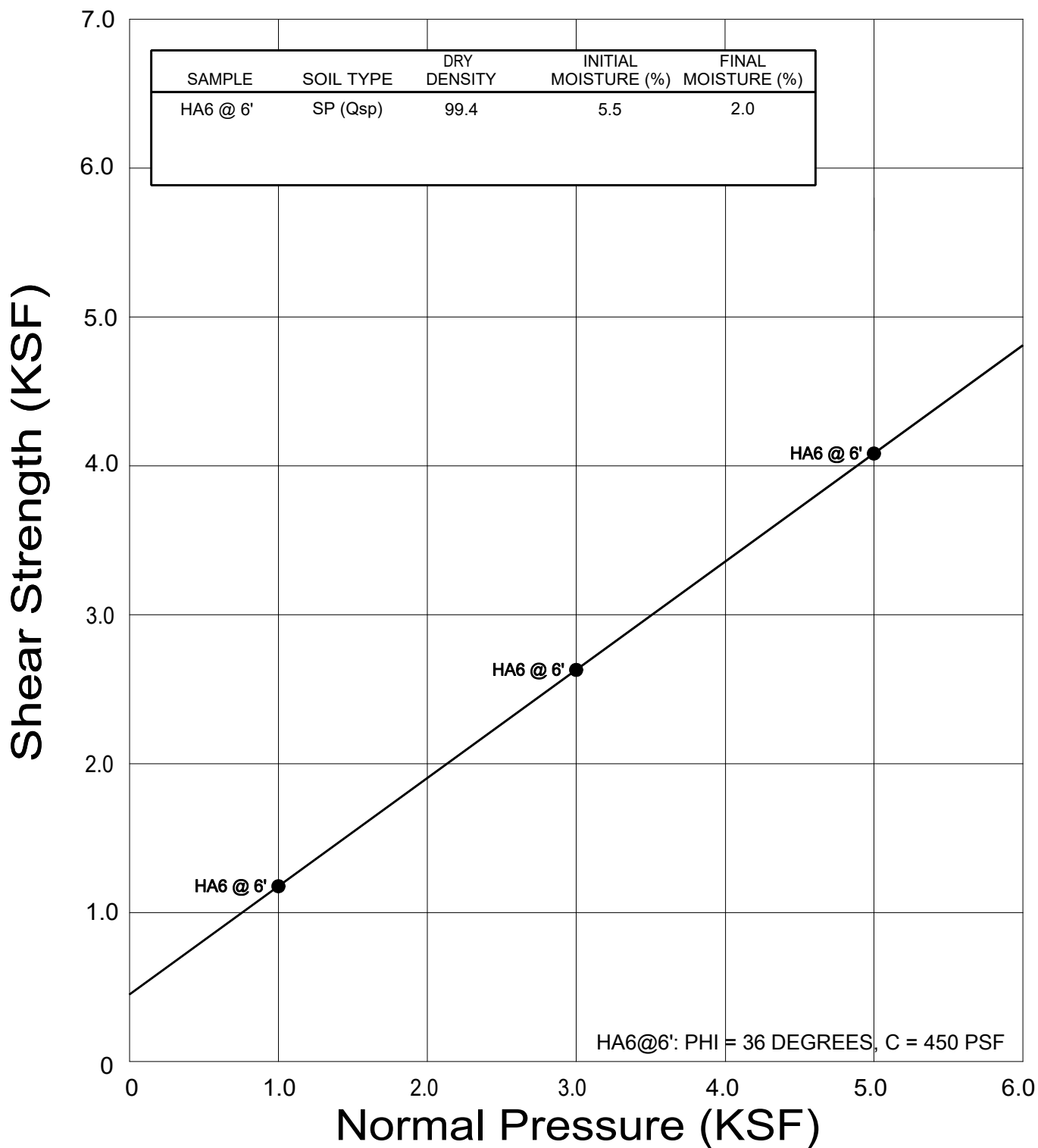
DIRECT SHEAR TEST RESULTS

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FIG. B4



● Direct Shear, Field Moisture

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DIRECT SHEAR TEST RESULTS

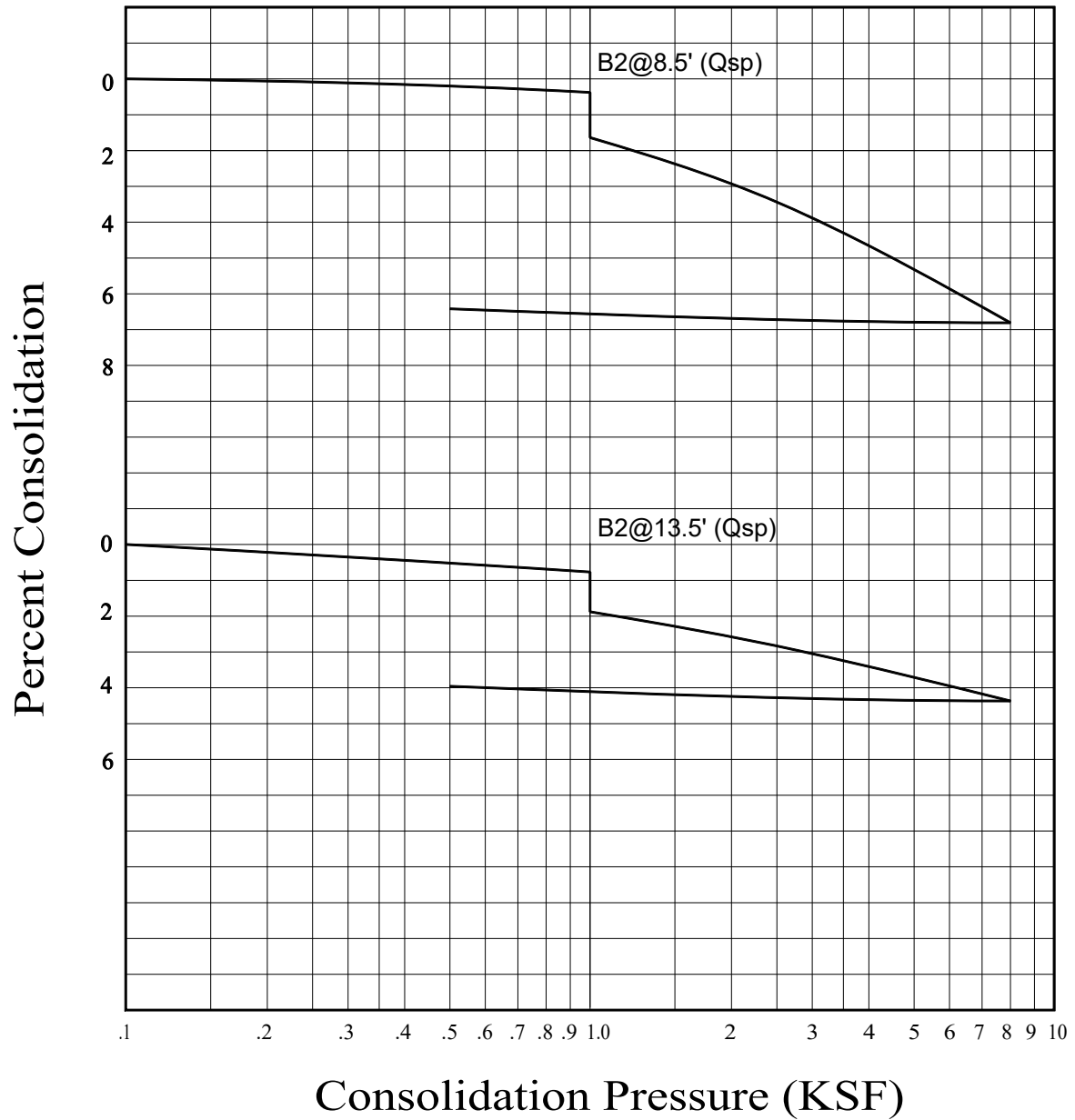
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FIG. B5

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

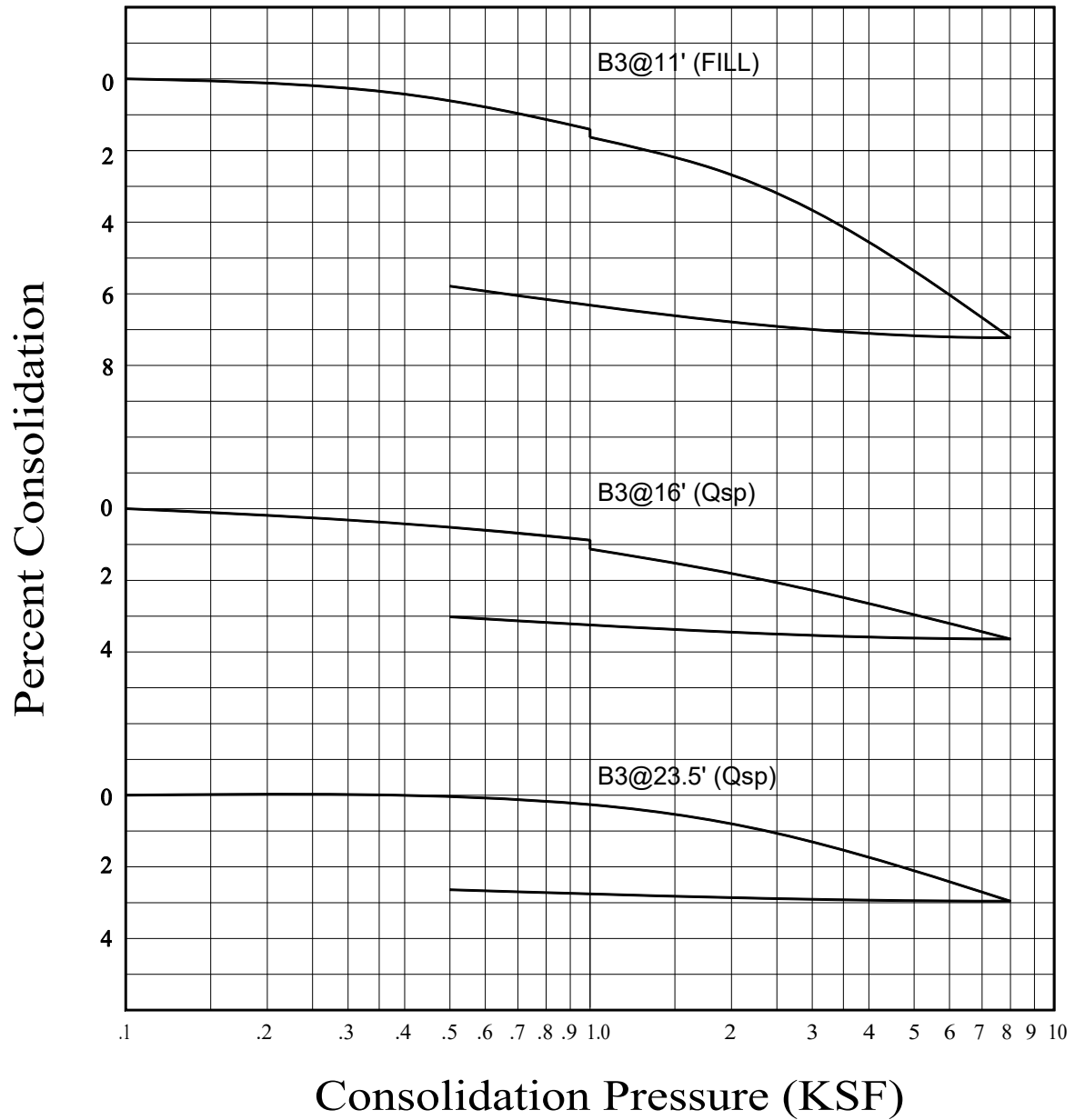
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FIG. B6

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

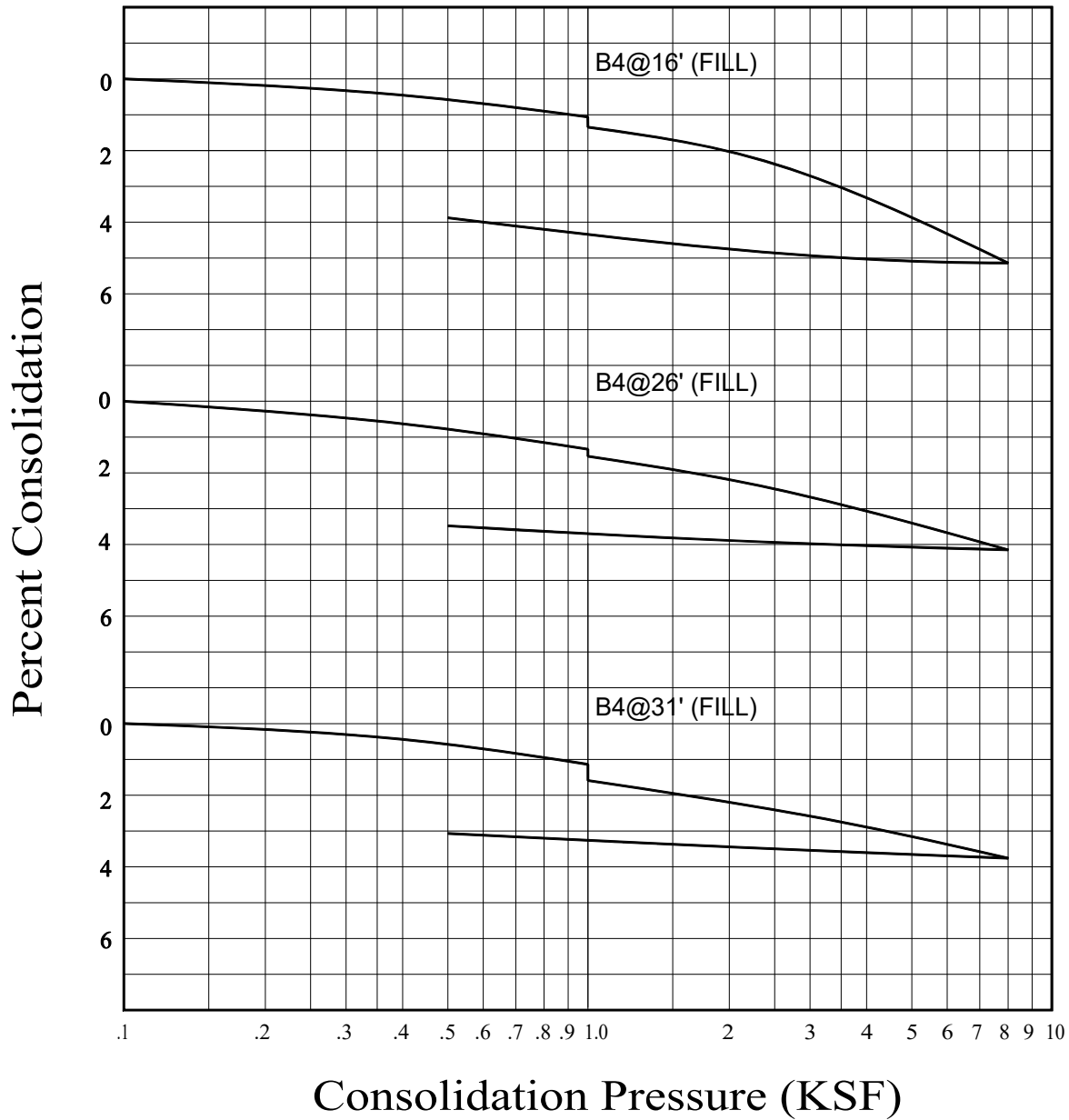
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FIG. B7

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

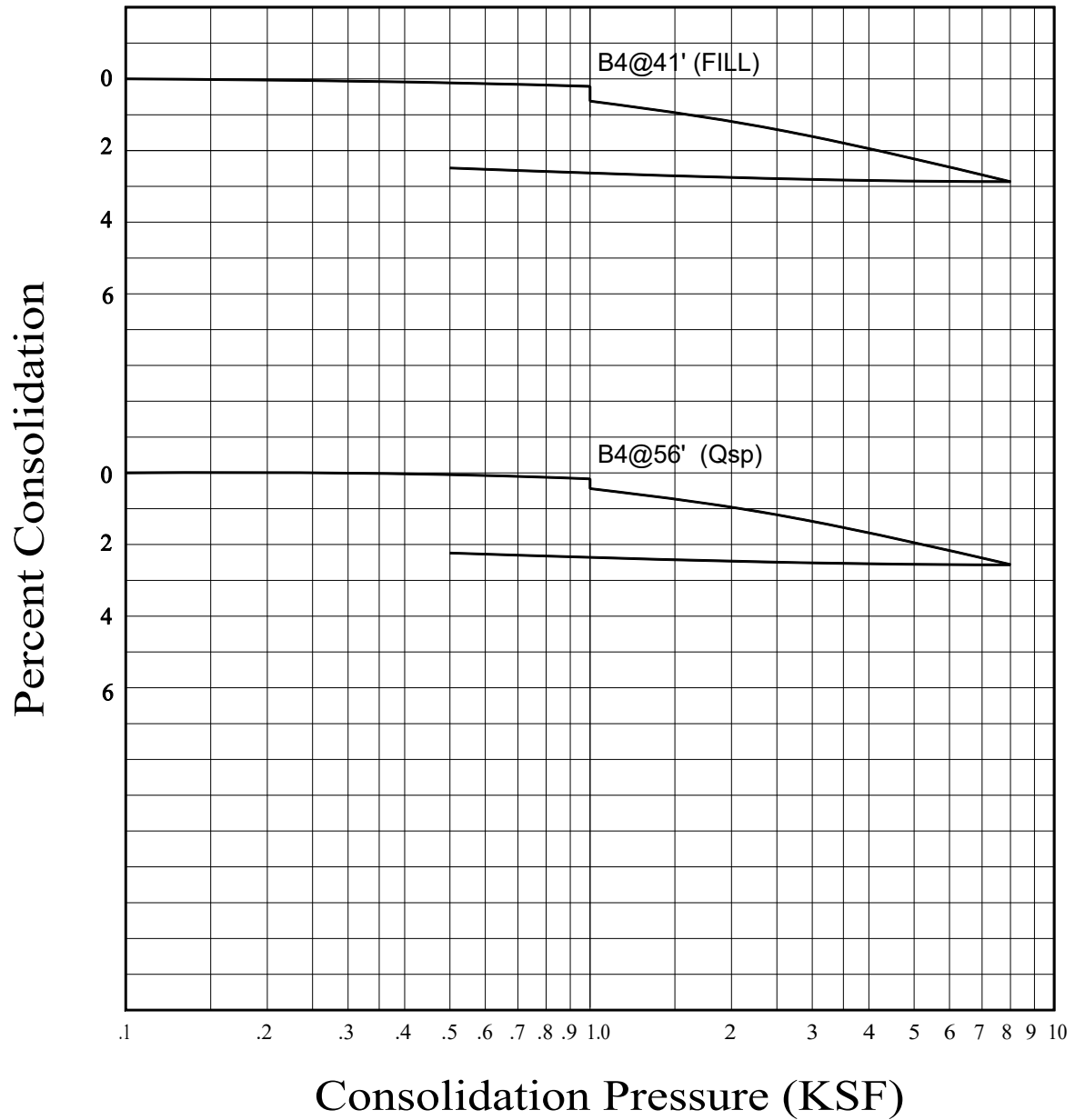
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FIG. B8

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

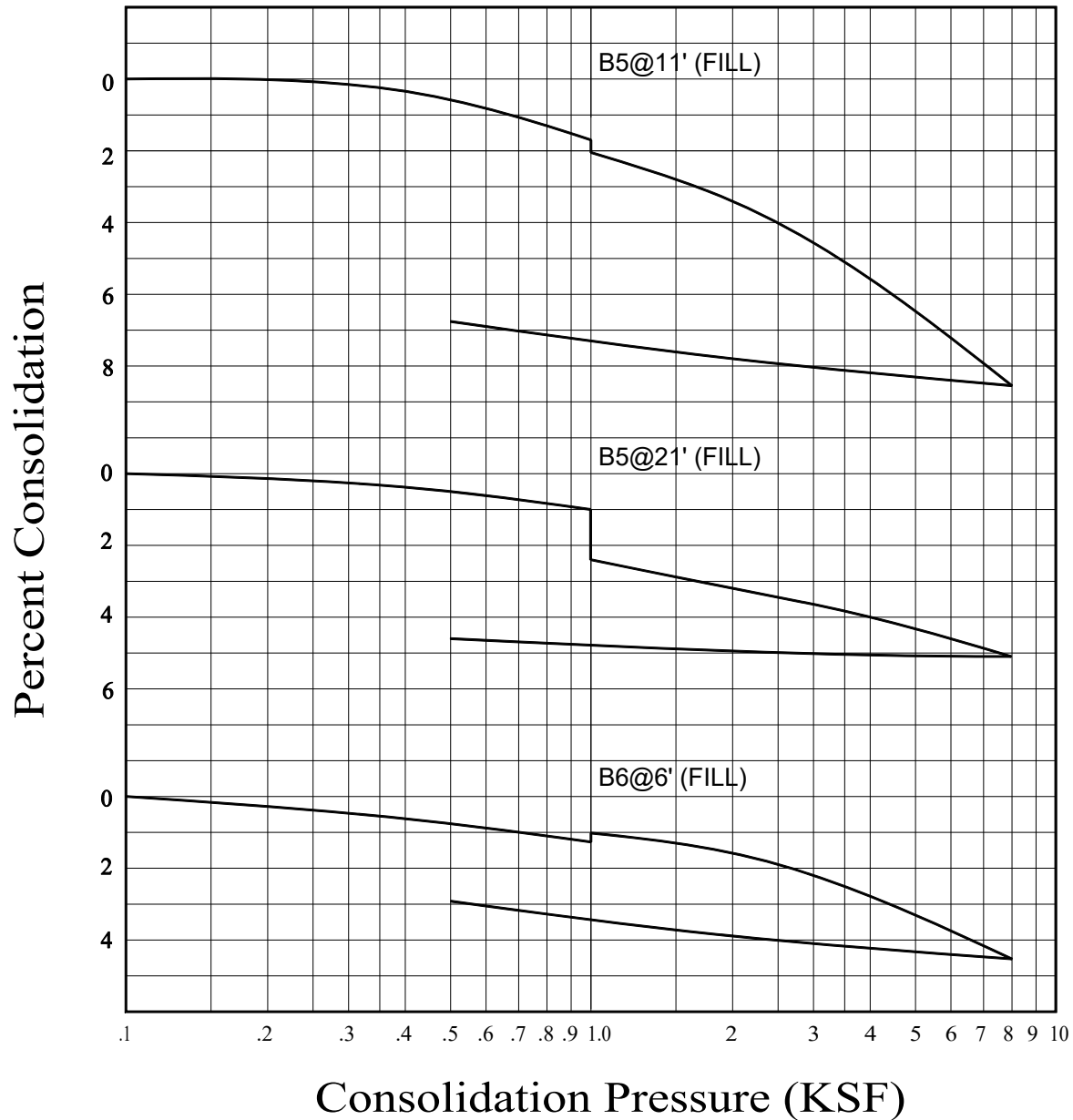
REYLENN PROPERTIES, LLC
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FIG. B9

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

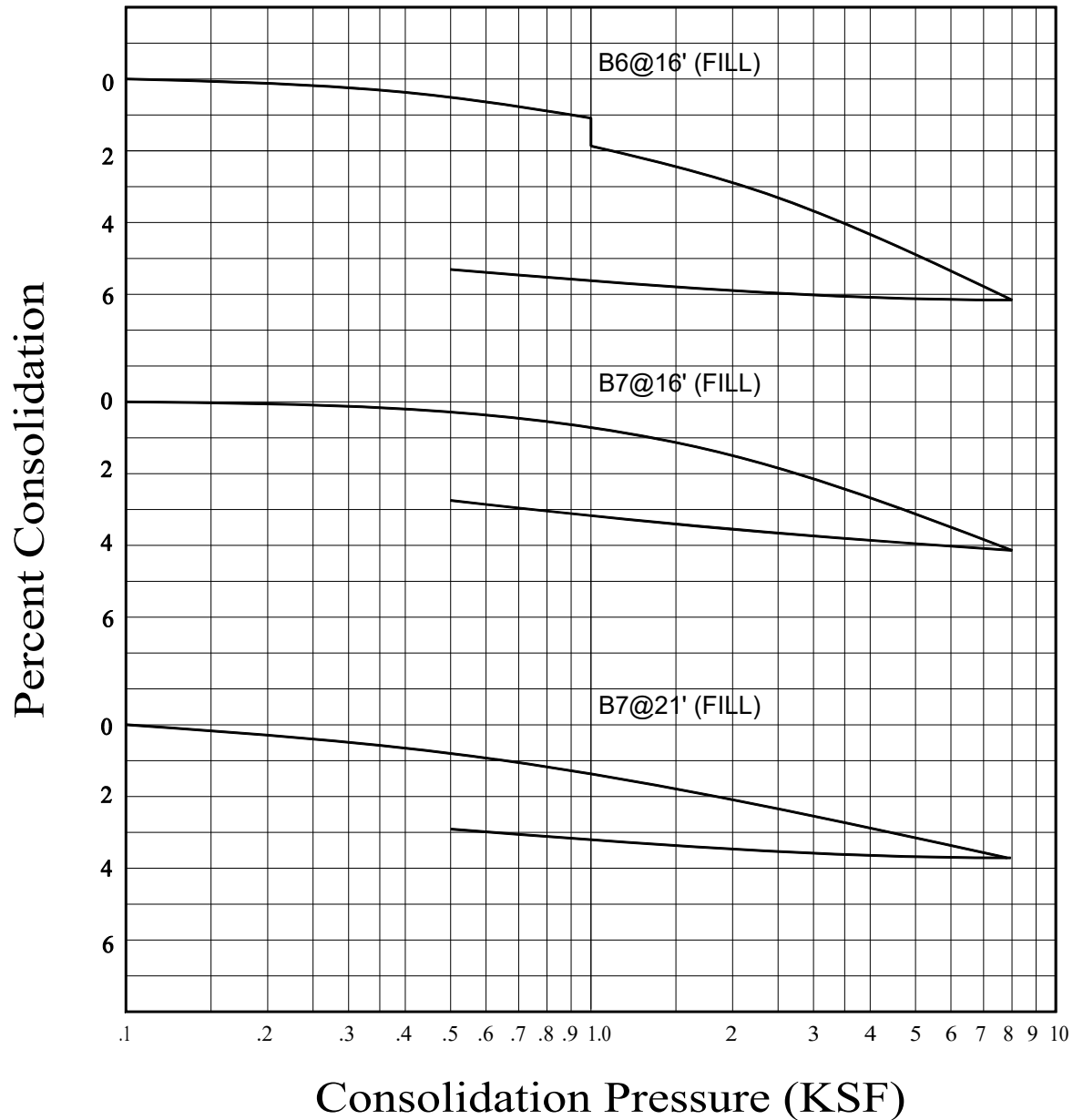
REYLENN PROPERTIES, LLC
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FIG. B10

WATER ADDED AT 1 KSF



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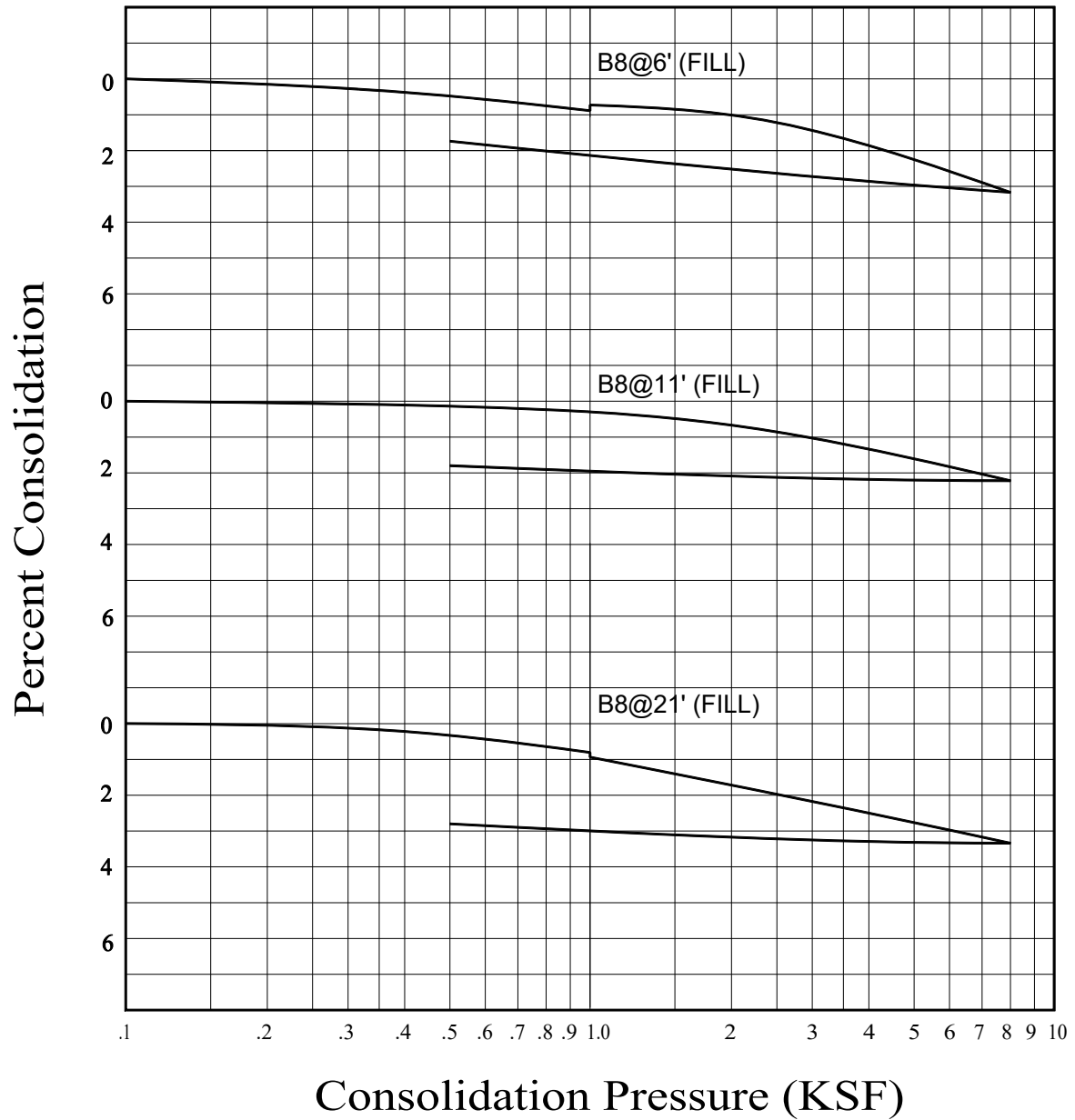
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FIG. B11

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

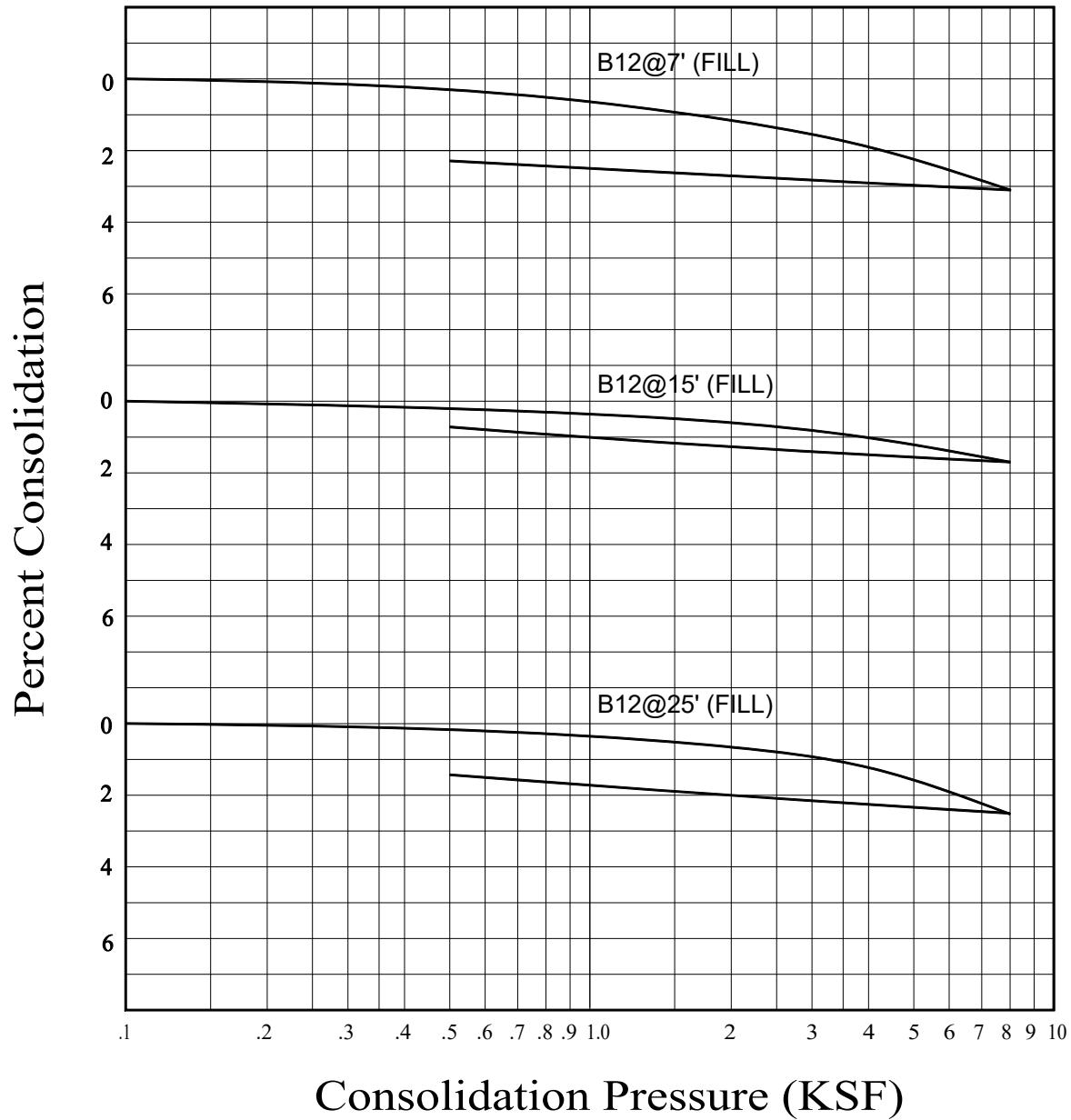
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FIG. B12

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

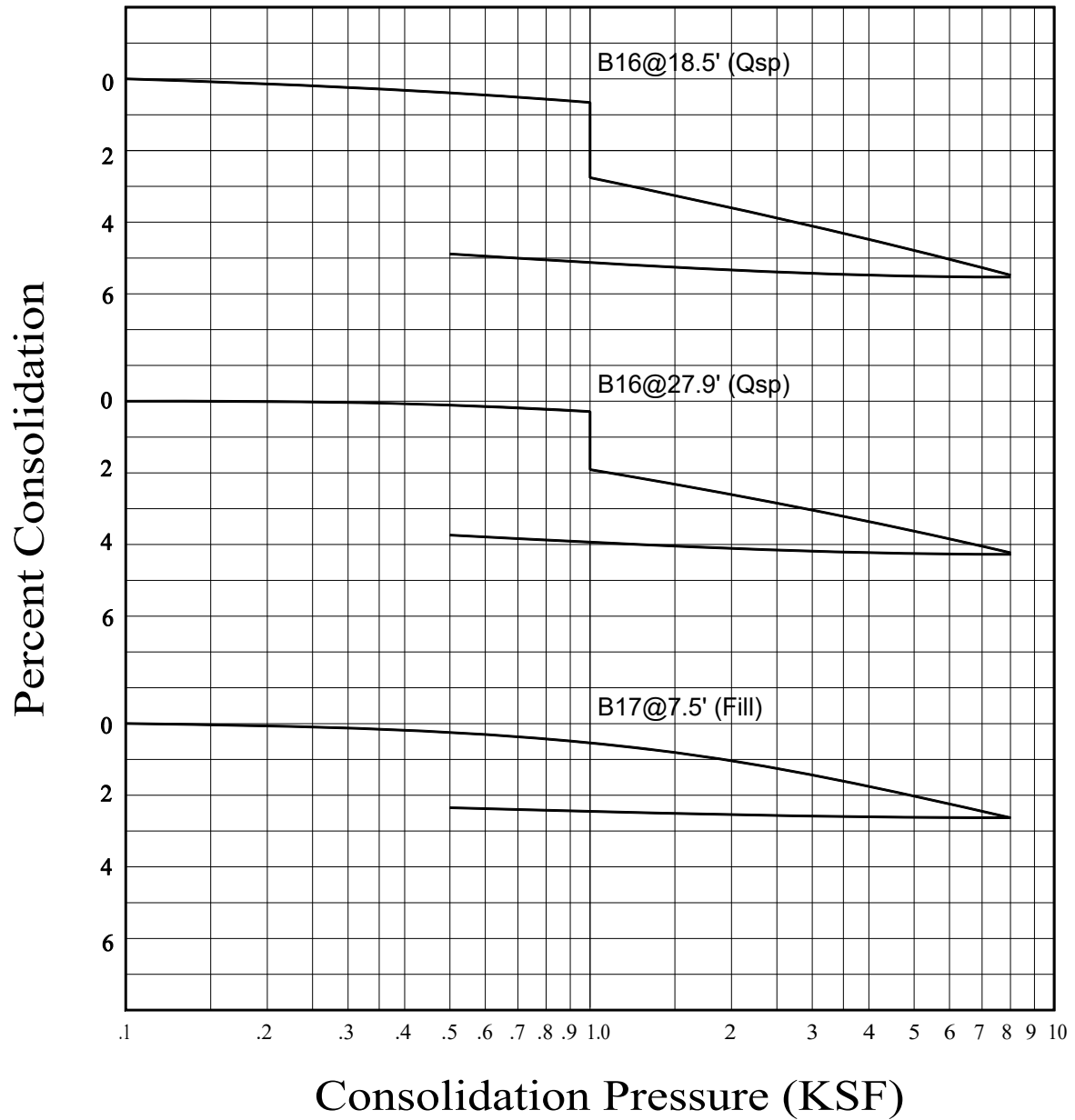
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JUNE 2017

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FIG. B13

WATER ADDED AT 1 KSF



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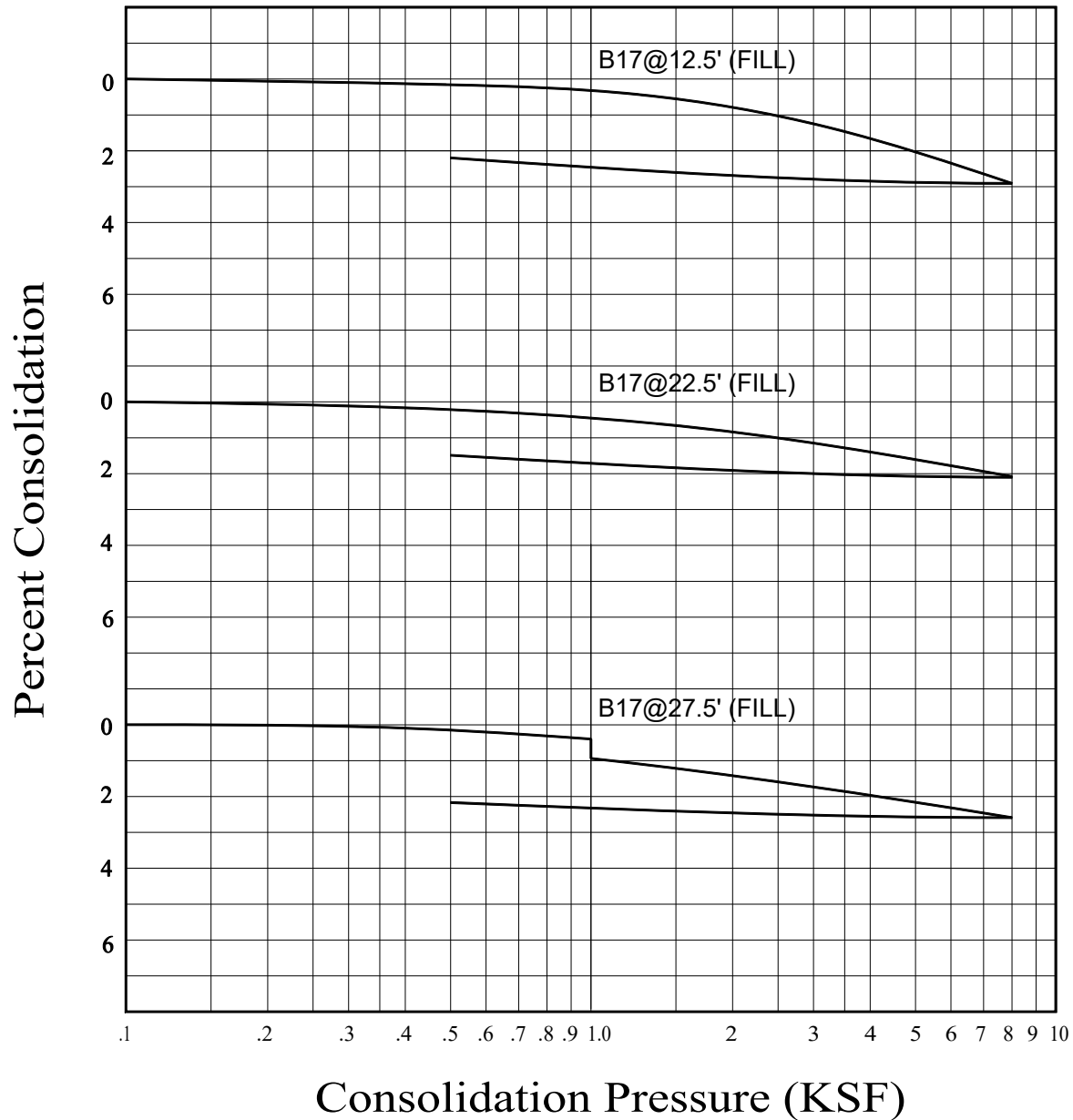
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FIG. B14

WATER ADDED AT 1 KSF



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CONSOLIDATION TEST RESULTS

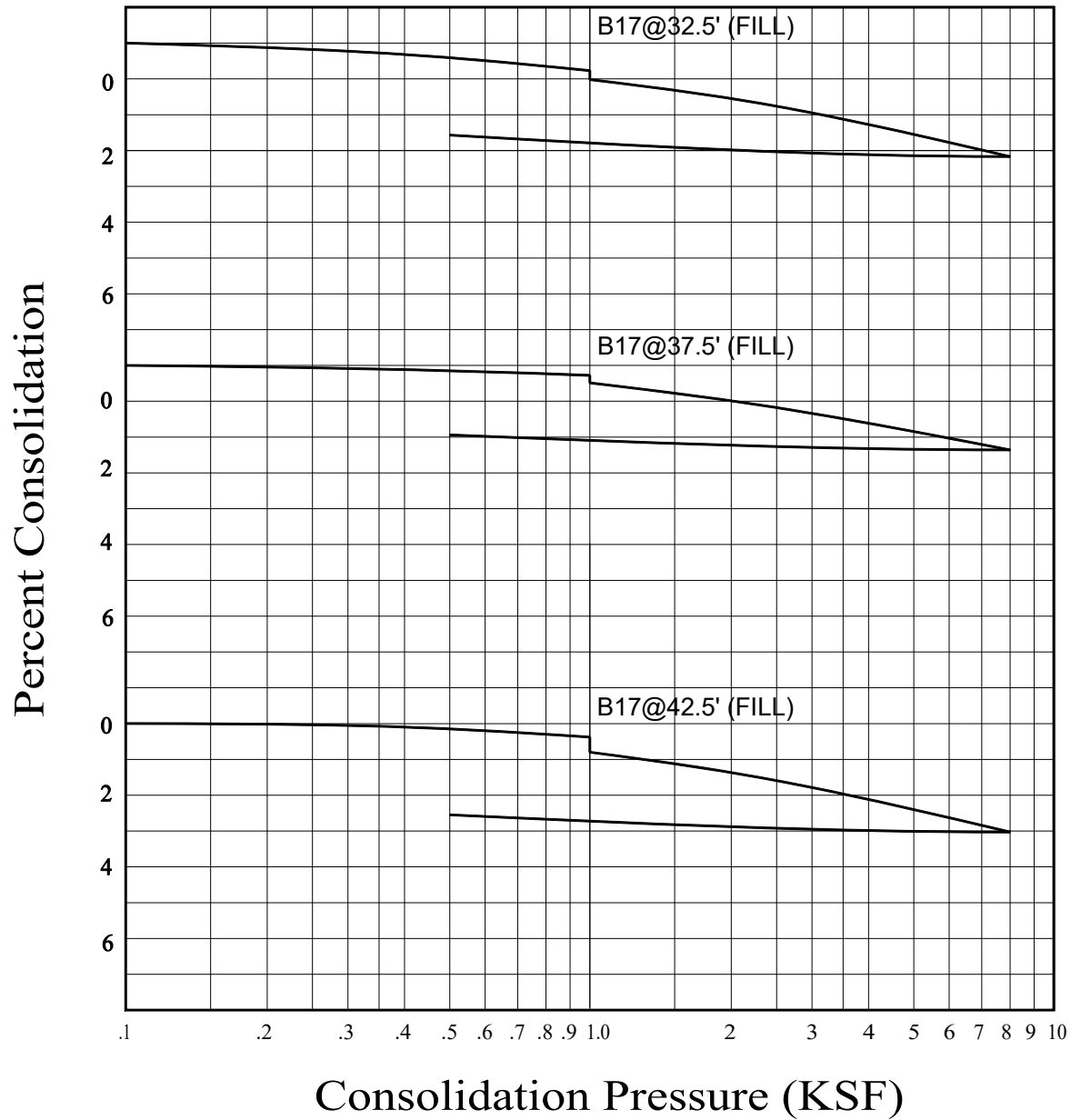
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FIG. B15

WATER ADDED AT 1 KSF



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ENVIRONMENTAL GEOTECHNICAL MATERIALS
3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504
PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JTA

Checked by: NDB

CONSOLIDATION TEST RESULTS

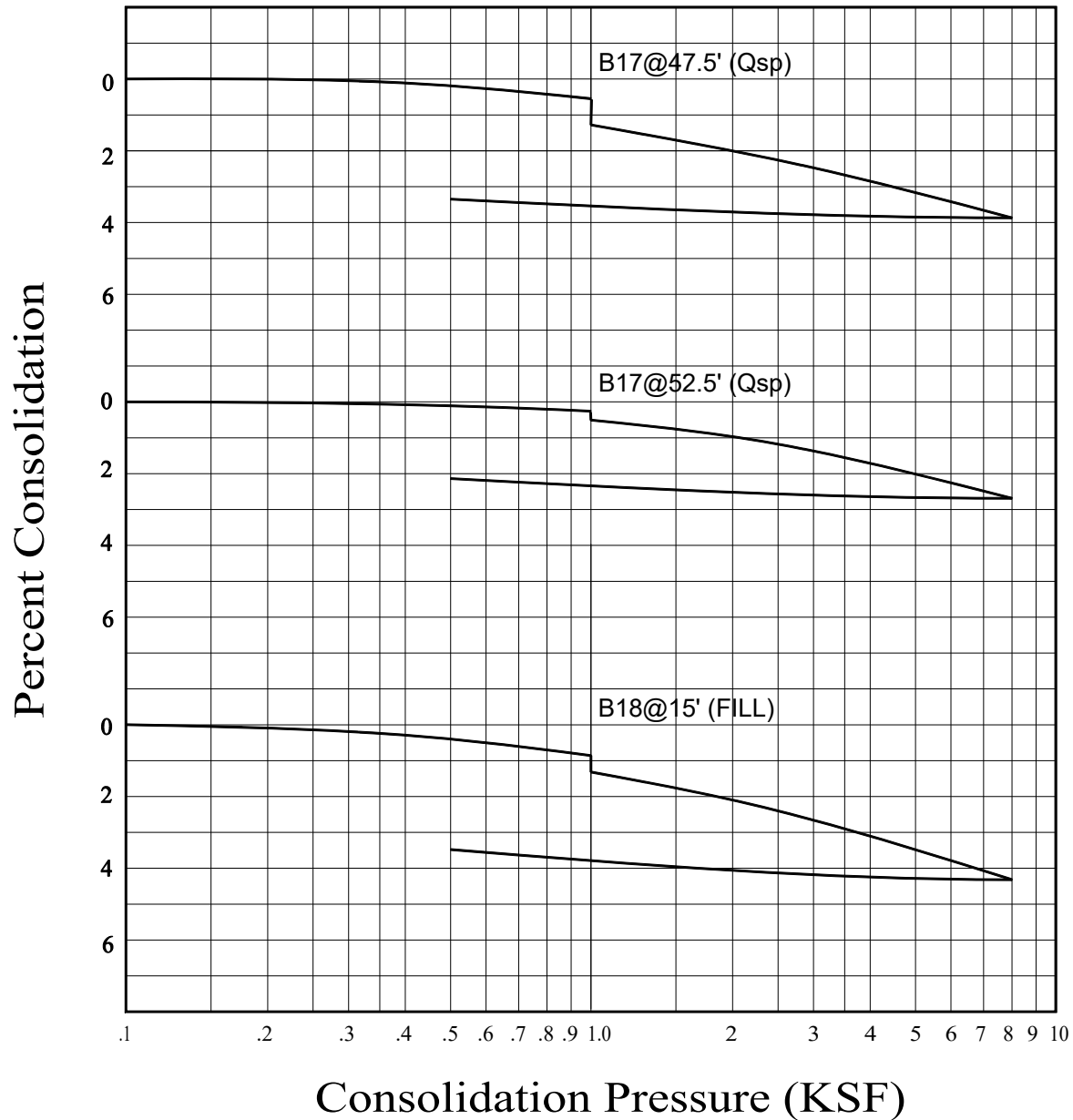
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B16

WATER ADDED AT 1 KSF



GEOCON
WEST, INC.



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CONSOLIDATION TEST RESULTS

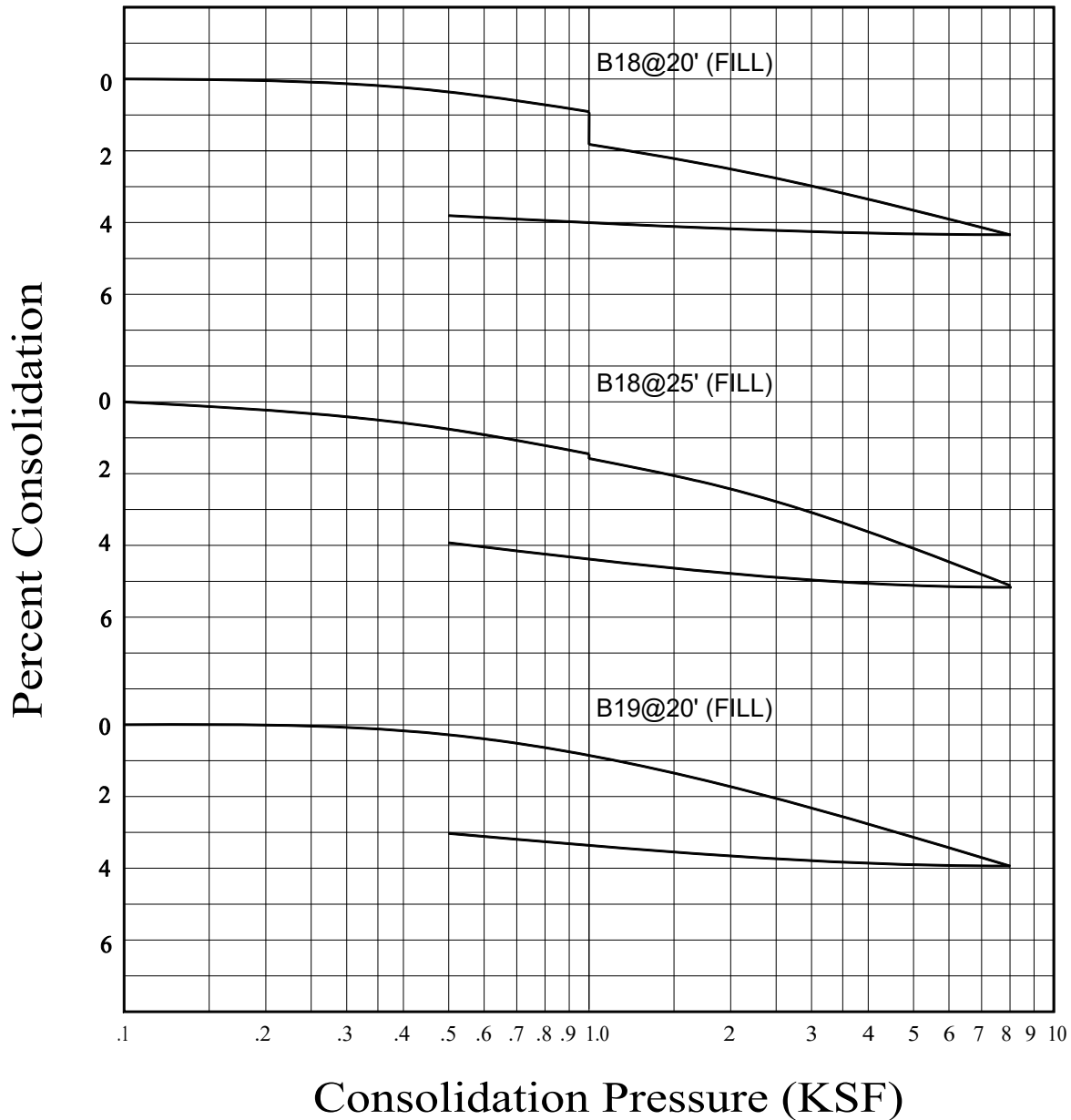
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

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FIG. B17

WATER ADDED AT 1 KSF



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Drafted by: JTA

Checked by: NDB

CONSOLIDATION TEST RESULTS

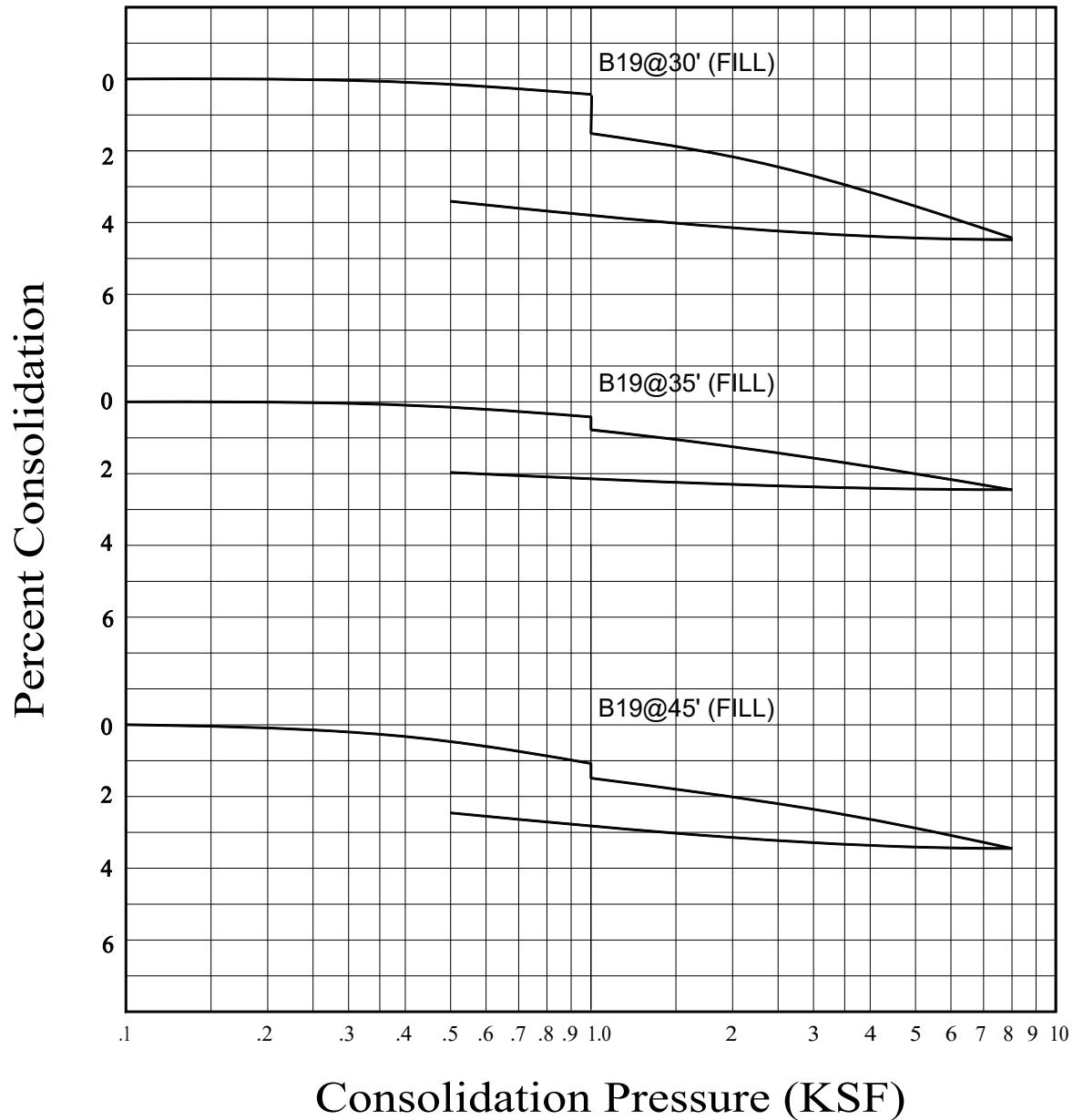
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

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PROJECT NO. A9201-06-01E

FIG. B18

WATER ADDED AT 1 KSF



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Drafted by: JTA

Checked by: NDB

CONSOLIDATION TEST RESULTS

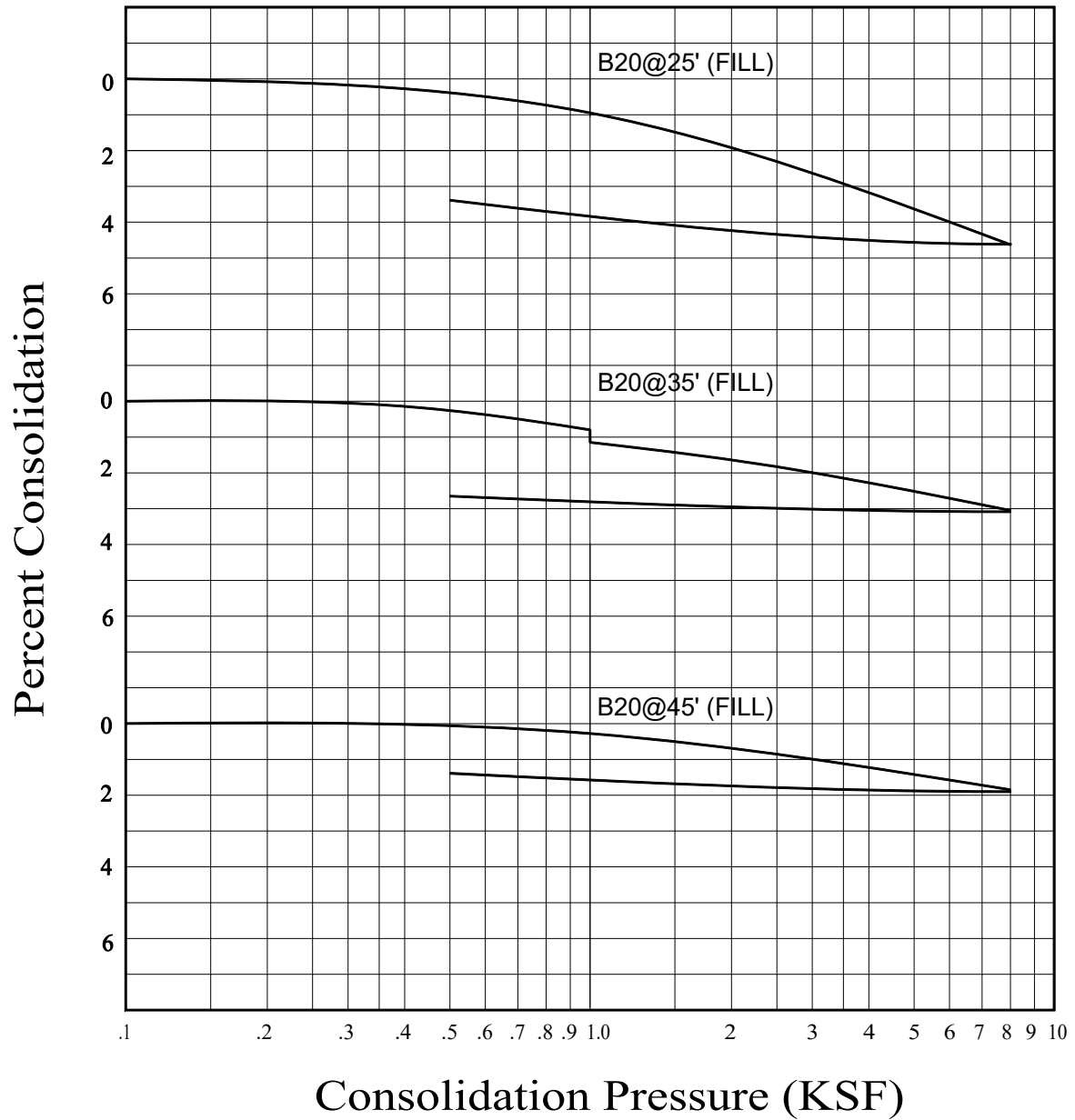
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B19

WATER ADDED AT 1 KSF



GEOCON
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PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JTA

Checked by: NDB

CONSOLIDATION TEST RESULTS

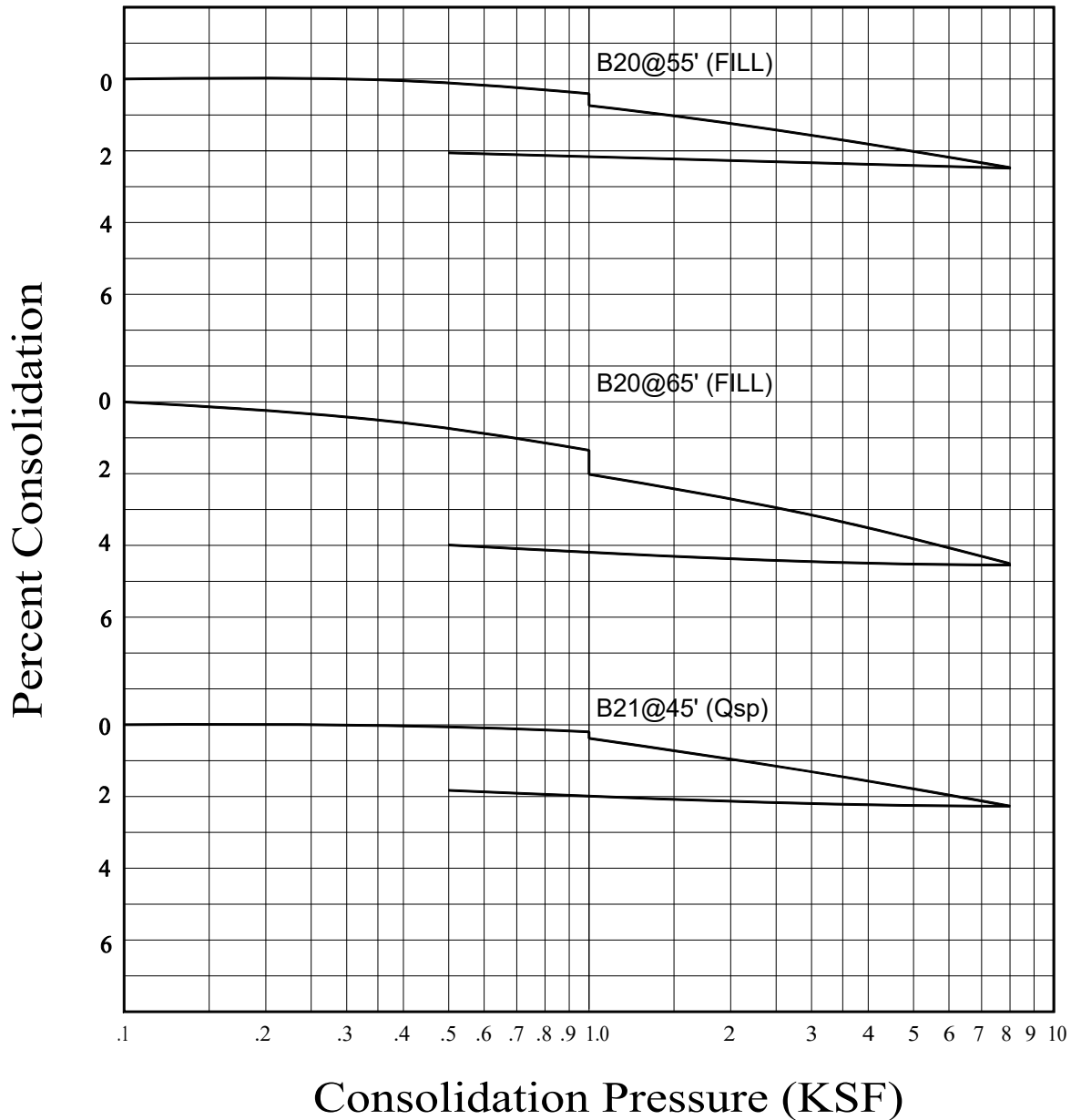
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B20

WATER ADDED AT 1 KSF



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PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JTA

Checked by: NDB

CONSOLIDATION TEST RESULTS

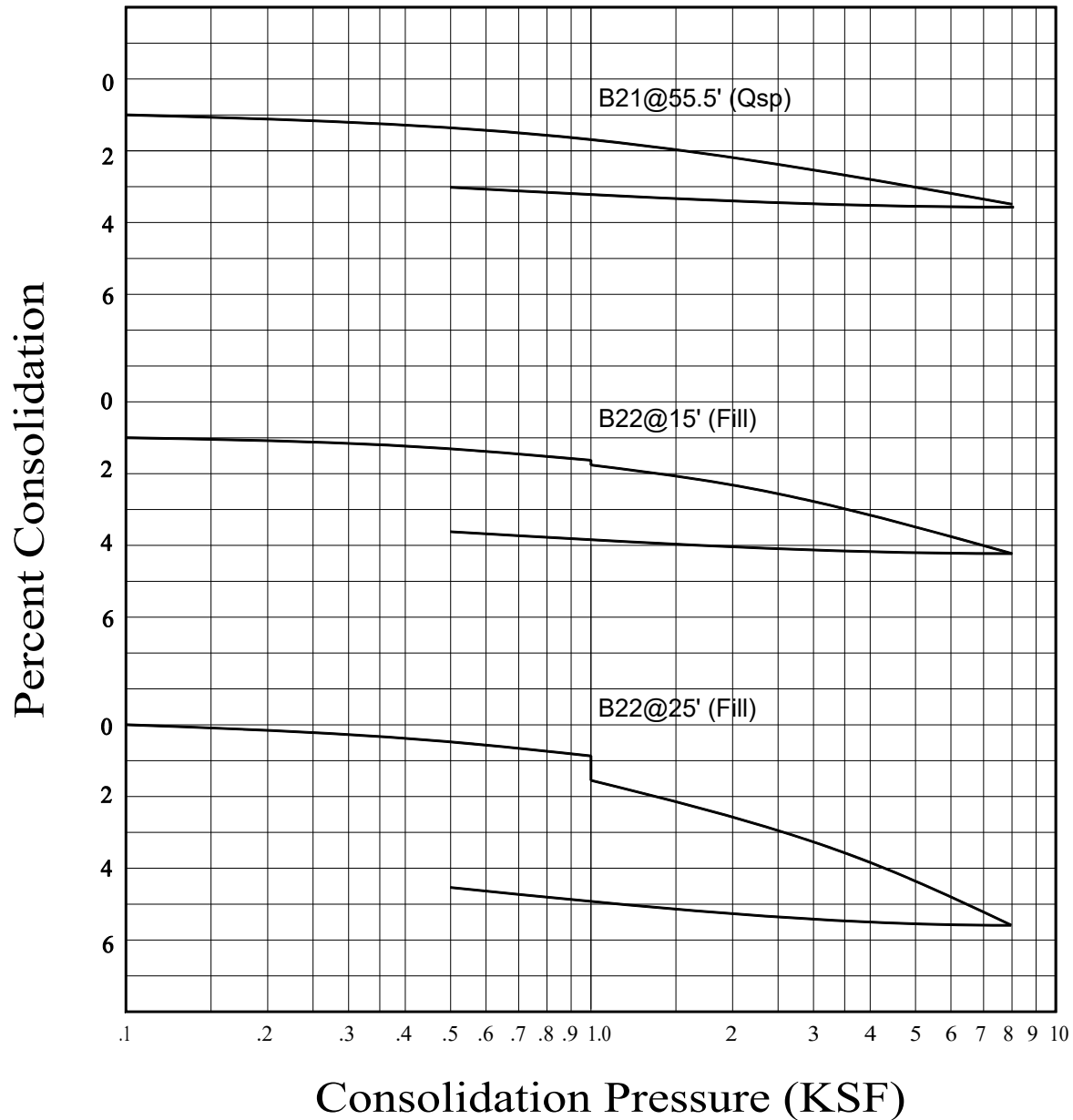
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B21

WATER ADDED AT 1 KSF



GEOCON
WEST, INC.



ENVIRONMENTAL GEOTECHNICAL MATERIALS
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PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JTA

Checked by: NDB

CONSOLIDATION TEST RESULTS

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B22

SAMPLE	PERCENT PASSING NO. 200 SIEVE
B16 @ 5'	25.2
B16 @ 15'	23.6
B16 @ 25'	17.0
B16 @ 35'	13.4
B16 @ 45'	6.7
B16 @ 55'	7.9
B17 @ 5'	35.1
B17 @ 7.5'	20.6
B17 @ 9.5'	51.4
B17 @ 15'	24.3
B17 @ 20'	22.3
B17 @ 25'	54.1
B17 @ 30'	26.0
B17 @ 40'	8.7
B17 @ 50'	21.5
B18 @ 7.5'	47.4
B18 @ 12.5'	27.3
B18 @ 17.5'	14.0
B18 @ 22.5'	34.3
B18 @ 27.5'	3.4
B18 @ 32.5'	4.2
B18 @ 42.5'	52.2
B18 @ 52.5'	5.5
B19 @ 12.5'	20.5
B19 @ 17.5'	28.7
B19 @ 22.5'	23.9
B19 @ 27.5'	44.0
B19 @ 32.5'	15.7
B19 @ 35'	15.7
B19 @ 37.5'	7.5
B19 @ 42.5'	22.2

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WEST, INC.



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PHONE (818) 841-8388 - FAX (818) 841-1704

DRAFTED BY: JTA

CHECKED BY: NDB

GRAIN SIZE ANALYSIS

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B23

SAMPLE	PERCENT PASSING NO. 200 SIEVE
B19 @ 47.5'	10.5
B19 @ 52.5'	12.5
B19 @ 57.5'	11.1
B19 @ 67.5'	88.8
B19 @ 77.5'	14.2
B21 @ 6'	49.2
B21 @ 12.5'	3.8
B21 @ 17.5'	2.9
B21 @ 27.5'	2.8
B21 @ 37.5'	4.7
B21 @ 47.5'	3.0
B21 @ 57.5'	5.2
B21 @ 67.5'	2.9
B21 @ 77.5'	2.4
B21 @ 87'	3.2
B21 @ 97.5'	3.3
B21 @ 107.5'	4.9
B22 @ 7.5'	20.8
B22 @ 12.5'	16.2
B22 @ 22.5'	7.2
B22 @ 25'	15.8
B22 @ 27.5'	3.8
B22 @ 37.5'	5.6
B22 @ 47.5'	6.7
B22 @ 57.5'	8.8
B23 @ 8'	49.9
B23 @ 13'	64.7
B23 @ 17.5'	2.6
B23 @ 28'	4.3
B23 @ 38'	3.6
B23 @ 48'	4.1

GEOCON
WEST, INC.



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PHONE (818) 841-8388 - FAX (818) 841-1704

DRAFTED BY: JTA

CHECKED BY: NDB

GRAIN SIZE ANALYSIS

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B24

SAMPLE	PERCENT PASSING NO. 200 SIEVE
B23 @ 58'	3.5
B23 @ 68'	2.7
B23 @ 78'	3.5
B23 @ 88'	2.9
B24 @ 8'	56.9
B24 @ 23'	57.9
B24 @ 33'	17.1
B24 @ 43'	6.2
B24 @ 53'	5.9
B24 @ 63'	7.3
B24 @ 73'	32.0
B24 @ 82.5'	7.9
B24 @ 92.5'	10.3
B24 @ 102.5'	54.5

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ENVIRONMENTAL GEOTECHNICAL MATERIALS
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PHONE (818) 841-8388 - FAX (818) 841-1704

DRAFTED BY: JTA

CHECKED BY: NDB

GRAIN SIZE ANALYSIS

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B25

**SUMMARY OF LABORATORY EXPANSION INDEX TEST RESULTS
ASTM D 4829-11**

Sample No.	Moisture Content (%)		Dry Density (pcf)	Expansion Index	*UBC Classification	**CBC Classification
	Before	After				
B2 @ 5-7.5'	12.3	24.1	101.8	33	Low	Expansive

* Reference: 1997 Uniform Building Code, Table 18-I-B.

** Reference: 2013 California Building Code, Section 1803.5.3

**SUMMARY OF LABORATORY MAXIMUM DENSITY AND
AND OPTIMUM MOISTURE CONTENT TEST RESULTS
ASTM D 1557-12**

Sample No.	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture (%)
B2 @ 5-7.5'	Brown Silty Sand	112.5	14.5
B4 @ 0-5'	Light Brown Gravelly Sand	112.0	15.5
B4 @ 10-15'	Brown Silty Sand	121.2	12.1
B4 @ 23-30'	Light Gray Sand	120.0	11.0
B4 @ 45-50'	Light Gray Sand	116.0	11.0

ORGANIC CONTENT

Sample No.	Organic Content (%)
B4@0-5'	2.8
B5@6'	4.4
B7@8'	3.9
B7@16'	3.3
B9@10'	3.0
B12@5'	2.0

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PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JTA

Checked by: NDB

LABORATORY TEST RESULTS

REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B26

**SUMMARY OF LABORATORY POTENTIAL OF
HYDROGEN (pH) AND RESISTIVITY TEST RESULTS
CALIFORNIA TEST NO. 643**

Sample No.	pH	Resistivity (ohm centimeters)
B4 @ 10-15'	7.93	650 (Severely Corrosive)
B8 @ 40-45'	8.4	2200 (Moderately Corrosive)

**SUMMARY OF LABORATORY CHLORIDE CONTENT TEST RESULTS
EPA NO. 325.3**

Sample No.	Chloride Ion Content (%)
B4 @ 10-15'	0.043
B8 @ 40-45'	0.006

**SUMMARY OF LABORATORY WATER SOLUBLE SULFATE TEST RESULTS
CALIFORNIA TEST NO. 417**

Sample No.	Water Soluble Sulfate (% SO ₄)	Sulfate Exposure*
B4 @ 10-15'	0.097	Negligible
B8 @ 40-45'	0.000	Negligible

* Reference: 2013 California Building Code, Section 1904.3 and ACI 318-11 Section 4.3.

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ENVIRONMENTAL GEOTECHNICAL MATERIALS
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PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JTA

Checked by: NDB

CORROSIVITY TEST RESULTS

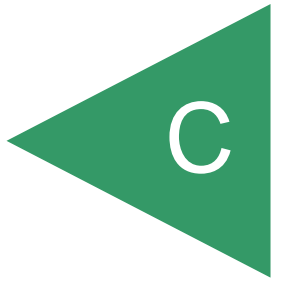
REYLENN PROPERTIES, LLC
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

JUNE 2017

PROJECT NO. A9201-06-01E

FIG. B27

APPENDIX



APPENDIX C
PRIOR EXPLORATION LOGS

GEOTECHNICAL BORING LOG

SHEET 1 OF 3

PROJECT NO. 102568
 DATE STARTED 2/9/05
 DATE FINISHED 2/10/05
 DRILLER J & N Drilling
 TYPE OF DRILL RIG 30" Bucket Auger

PROJECT NAME Butcher Hill
 GROUND ELEV. 444
 GW DEPTH (FT) _____
 DRIVE WT. See Note
 DROP 12 inches

BORING DESIG. B-101
 LOGGED BY CRN
 NOTE 0-24' 3548#; 24-47' 2577#; 47-73' 1648#; 73-90' 810#; 90-110' 1660

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SAT. URATION (%)	OTHER TESTS
440						MONTEREY FORMATION (Tm) Silty Sandstone; very fine- to fine-grained, yellowish brown, dry to moist, moderately hard, abundant rootlets top 1± foot.				
5						Diatomaceous Siltstone; pale yellowish brown to yellowish gray, dry, moderately hard to hard, abundant shells (clam, turritella), some rounded to subrounded pebbles, cobbles and boulders (up to 1± ft.) of vesicular basalt, vague bedding - slightly laminated, generally massive.				
10					B: N85W, 54SW		60.9	37.5	47	
15		R/B	8 P/R 4"		J: N50W, 63NE	Diatomaceous Claystone; very pale grayish orange, dry, moderately hard to hard, well bedded - laminated.				
20					F: N10E, 78SE	Fault: 1± ft. crush zone, highly jumbled fragments of Siltstone and Claystone, abundant white carbonate, soft.				
25		R/B	2 P/R 5"		B: N20E, 56SE		60.6	38.2		
30					B: N40W, 47NE	Silicified Shale lens; 3± inches thick, grayish orange, dry, very hard, slightly fractured/jointed.				
35		R	2			Diatomaceous Claystone; grayish orange, dry, moderately hard, well bedded - laminated.	99.8	56.1	136	
40					B: N10E, 75SE J: N85E, 72NW	Silicified Shale lens, 1-1/2± ft. thick, highly jointed/fractured	6.3	106.3	30	
45		R	8 for 10" P/R 4"			Diatomaceous Siltstone; grayish orange, dry, moderately hard, poorly bedded - slightly laminated, generally massive.				
405										

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

▼ GROUNDWATER LEVEL
 ► WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



**PACIFIC SOILS
 ENGINEERING, INC.**
 PLATE A-1

GEOTECHNICAL BORING LOG

PROJECT NO. 102568
 DATE STARTED 2/9/05
 DATE FINISHED 2/10/05
 DRILLER J & N Drilling
 TYPE OF DRILL RIG 30" Bucket Auger

PROJECT NAME Butcher Hill
 GROUND ELEV. 444
 GW DEPTH (FT) _____
 DRIVE WT. See Note
 DROP 12 inches

BORING DESIG. B-101
 LOGGED BY CRN
 NOTE 0-24' 3548#; 24-47'
2577#; 47-73' 1646#;
73-90' 810#; 90-110' 1660

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SATURATION (%)	OTHER TESTS
400		R/B	3		B: (Hanging Wall) N10E, 74SE F: N10W, 70SW B: (Footwall) N-S, 68E	Normal Fault: 6 to 8± inch crush zone, offsets Claystone 2± inches, soft.	53.1	39.2	44	
45		R	2		F: N10W Vertical to 75NE	Fault: 8 to 10± inch crush zone/gouge, black staining along fault plane, undulatory.	7.0	95.3	25	
395		R/B	6			Diatomaceous Claystone; grayish orange, dry, moderately hard, poorly to well bedded - laminated, some subrounded pebbles of well cemented Siltstone.	37.5	60.0	57	
390					B: N20W, 63NE	Silicified Shale layer; 6 to 8± inches thick, very hard, highly jointed/fractured.				
55		R	4				44.6	39.1	37	
385					B: N20W, 67NE					
60		R/B	6				43.7	46.8	46	
					B: N30W, 59NE					
380										
65		R	7				40.8	42.6	38	
					B: N15W, 76NE B: N30W, 70NE	Silicified Shale layer; 4 to 6± inches thick, very hard, highly fractured/jointed.				
375										
70		R/B	7				45.2	41.4	40	
					B: N10W, 76NE	Silicified Shale layer; 1± foot thick, very hard, moderately fractured/jointed.				
370										
75		R	30 for 6" P/R 2"				3.6	91.2	12	
					B: N-S, 73E					
365										

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.

GEOTECHNICAL BORING LOG

PROJECT NO. 102568
 DATE STARTED 2/9/05
 DATE FINISHED 2/10/05
 DRILLER J & N Drilling
 TYPE OF DRILL RIG 30" Bucket Auger

PROJECT NAME Butcher Hill
 GROUND ELEV. 444
 GW DEPTH (FT) _____
 DRIVE WT. See Note
 DROP 12 inches

BORING DESIG. B-101
 LOGGED BY CBN
 NOTE 0-24' 3548#; 24-47'
2577#; 47-73' 1648#;
73-90' 810#; 90-110' 1860

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SATURATION (%)	OTHER TESTS
85	360	R/B 35 for 10" P/R 5"			B: N15W, 63NE	Silicified Shale layer; 1± foot thick, very hard, moderately fractured/jointed.	35.0	52.6	43	
85		R 31 for 6" P/R 5"			B: N10W, 66NE B: N10W, 58NE	Interbedded Claystone with Diatoms; grayish orange, dry, moderately hard, distinct bedding, 1+ foot thick. Basalt layer; 6± inches thick, dark gray to black, very hard, moderately fractured, baked lower contact 2 to 3± inches thick.	39.9	52.2	49	
90	355	R 40 for 6" P/R 4"				Added 20-foot stem.	34.0	45.3	34	
95	350	R/B 25			B: N30W, 65NE B: N15W, 59NE	Sandy Claystone with Diatoms; very fine- to fine-grained, light yellowish orange, dry, moderately hard, poorly to well bedded - laminated to massive.	39.7	54.2	51	
100	345	R 28			B: N-S, 52NE	Diatomaceous Claystone; grayish orange, dry, moderately hard, poorly to well bedded - laminated to massive, some subrounded pebbles of well cemented Siltstone.	38.5	40.1	33	
105	340	R/B 30 for 7" P/R 5"			B: N25W, 63NE		22.7	66.4	40	
110	335	R 30 for 6" P/R 4"			B: N20W, 64NE		36.2	39.4	30	
Total Depth 111 feet. No water, No caving. Hole backfilled with cuttings and tamped.										
*P/R 4 = Partial ring sample recovery and number of rings recovered.										

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.

GEOTECHNICAL BORING LOG

SHEET 1 OF 1

PROJECT NO. 102568
 DATE STARTED 4/4/05
 DATE FINISHED 4/5/05
 DRILLER D & D Construction
 TYPE OF DRILL RIG 24" Bucket

PROJECT NAME Butcher Hill
 GROUND ELEV. 349
 GW DEPTH (FT) _____
 DRIVE WT. _____
 DROP _____

BORING DESIG. B-102
 LOGGED BY CRN
 NOTE Track Mounted

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SATURATION (%)	OTHER TESTS
						SOIL: Sandy Silt to Silty Sand; very fine- to fine-grained, dark yellowish brown, slightly moist, loose, abundant rootlets.				
5	345					MONTEREY FORMATION (Tm) Conglomerate; matrix of Sandy Claystone to Clayey Sandstone, very fine- to fine-grained, olive gray, slightly moist, soft/loose, weathered.				
10	340				B: N20E 23SE	Silicified shale concretion, pale gray, laminated, very hard, up to 1-1/2 foot with some shell fragments, generally massive, some vague alignment of concretion pebbles and cobbles.				
15	335	B			AB: B50E 26SE	Cobbles and boulders throughout, refusal.				
						Total Depth 15 feet, Refusal. No water. Hole backfilled with cuttings and tamped.				

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.

PLATE A-4

GEOTECHNICAL BORING LOG

PROJECT NO. 102568
 DATE STARTED 9/21/05
 DATE FINISHED 9/21/05
 DRILLER Hillside Repair & Drilling, Inc.
 TYPE OF DRILL RIG 24" Crawler Rig

PROJECT NAME Butcher Hill
 GROUND ELEV. 285
 GW DEPTH (FT) _____
 DRIVE WT. _____
 DROP _____

BORING DESIG. B-201
 LOGGED BY CRN
 NOTE _____

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SAT. URATION (%)	OTHER TESTS
285						MONTEREY FORMATION (Tm) Diatomaceous Siltstone; white to light brownish tan, slightly moist, firm, laminated.				
5	280	B			B: N10E, 44SE					
10	275				B: N30W, 35SW					
15	270				B: N30W, 48SW					
20	265				B: N35W, 45SW					
25	260	B								
30	255				B: N35W, 45SW	1/2 inch thick concretion layer, brown to dark brown, dry, very hard.				
35	250				B: N20W, 42SW					
345					B: N25W, 34SW					

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.
 PLATE A-5

GEOTECHNICAL BORING LOG

PROJECT NO. 102568
 DATE STARTED 9/21/05
 DATE FINISHED 9/21/05
 DRILLER Hillside Repair & Drilling, Inc.
 TYPE OF DRILL RIG 24" Crawler Rig

PROJECT NAME Butcher Hill
 GROUND ELEV. 285
 GW DEPTH (FT) _____
 DRIVE WT. _____
 DROP _____

BORING DESIG. B-201
 LOGGED BY CRN
 NOTE _____

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SATURATION (%)	OTHER TESTS
45	240	B			B: N35W, 42SW J: N40W, 50NE B: N50W, 55SW F: N60W, 34SW B: N10W, 44SW B: N25W, 36SW B: N25W, 32SW	Fault 1/4 inch thick clay gouge, olive gray, slightly moist, firm, flowers into upper strata approx. 6-8 inches.				
55	230	B				Total Depth 57 feet. No water, No caving. Backfilled with cuttings and tamped.				

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.
 PLATE A-6

GEOTECHNICAL BORING LOG

PROJECT NO. 102568
 DATE STARTED 9/21/05
 DATE FINISHED 9/22/05
 DRILLER Hillside Repair & Drilling, Inc.
 TYPE OF DRILL RIG 24" Crawler Rig

PROJECT NAME Butcher Hill
 GROUND ELEV. 275
 GW DEPTH (FT) _____
 DRIVE WT. _____
 DROP _____

BORING DESIG. B-202
 LOGGED BY CRN
 NOTE _____

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SAT. URATION (%)	OTHER TESTS
275						MONTEREY FORMATION (Tm) Diatomaceous Siltstone; white to light brown tan, slightly moist, firm, highly fractured siliceous siltstone in upper 12 feet, becomes laminated, punky siltstone below.				
5	270	B								
10	265				B: N40W, 65NE J: N20E, 47SE N80E, 37SE	Abundant white carbonate along joints.				
15	260				J: N10E, 80NW N50W, 57NE N60W, 61NE	Highly jointed.				
20	255	B								
25	250				B: N60W, 80SW	Abundant joints.				
30	245				B: N65W, 87NE					
35	240	B			B: N50W, 55SW	Moderate belling from 35 to 37 feet. Highly jointed, abundant white carbonate.				
235										

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.

GEOTECHNICAL BORING LOG

PROJECT NO. 102568
 DATE STARTED 9/21/05
 DATE FINISHED 9/22/05
 DRILLER Hillside Repair & Drilling, Inc.
 TYPE OF DRILL RIG 24" Crawler Rig

PROJECT NAME Butcher Hill
 GROUND ELEV. 275
 GW DEPTH (FT) _____
 DRIVE WT. _____
 DROP _____

BORING DESIG. B-202
 LOGGED BY CRN
 NOTE _____

DEPTH (feet)	ELEV.	SAMPLE TYPE	BLOWS/FT	LITHOLOGY	ATTITUDES	GEOTECHNICAL DESCRIPTION	MOISTURE CONT. (%)	DRY (pcf) DENSITY	SAT. URATION (%)	OTHER TESTS
235					B: N30W, 48SW	Some white carbonates.				
45	230				B: N50W, 57SW					
50	225				B: N20W, 36SW					
55	220	B			B: N20W, 63SW					
Total Depth 57 feet. Severe caving in upper 12 feet on 9/21/05. Cased hole on 9/22/05 and logged to 57 feet. Bottom of boring at 57 feet. No water, minor belling at 35 to 37 feet. Boring backfilled with cuttings and tamped.										

SAMPLE TYPES:
 RING (DRIVE) SAMPLE
 SPT (SPLIT SPOON) SAMPLE
 BULK SAMPLE TUBE SAMPLE

GROUNDWATER LEVEL
 WATER SEEP CONTACT
 BEDDING FAULT
 JOINTING SHEAR



PACIFIC SOILS ENGINEERING, INC.
 PLATE A-8

TABLE II
LOG OF EXPLORATORY PITS

Log No.	Depth (ft.)	Description	Logged: 12/17/04 Equip: JD455E Trackhoe Logged By: DO
EP-1	0 to 7	<u>FILL (af)</u> : Sand, tan brown, slightly moist, loose.	
	@ 5	Trash	
	7 to 15	<u>SAN PEDRO SAND (Qsp)</u> : Sand, tan brown, slightly moist, loose to medium dense.	
		Total Depth 15 feet. No groundwater was encountered. No caving observed. Hole backfilled and wheel-rolled in-place. Bulk sample at 5 feet.	
EP-2	0 to 9	<u>COLLUVIUM (Qcol)</u> : Diatomaceous Silt, light brown, dry, soft, angular clasts to 12 inches in size, caving.	
	@ 9	Vegetation	
	9 to 10	<u>SAN PEDRO SAND (Qsp)</u> : Sand, tan brown, slightly moist, loose to medium dense.	
		Total Depth 10 feet. No groundwater was encountered. Caving observed throughout. Hole backfilled and wheel-rolled in-place. Bulk sample at 6 feet.	

TABLE II
LOG OF EXPLORATORY PITS

Log No.	Depth (ft.)	Description	Logged: 12/17/04 Equip: JD455E Trackhoe Logged By: DO
EP-3	0 to 4	<u>FILL (af)</u> : Silty Sand, dark brown, slightly moist, medium dense, fine-grained.	
	4 to 9	<u>SAN PEDRO SAND (Qsp)</u> : Sand, tan brown, slightly moist, loose to medium dense, caving.	
Total Depth 9 feet. No groundwater was encountered. Caving from 4 to 9 feet. Hole backfilled and wheel-rolled in-place.			
EP-4	0 to 5	<u>FILL (af)</u> : Sand, tan brown, slightly moist, loose, fine-grained, vegetation at 5 feet.	
	5 to 11	<u>ALLUVIUM (Qal)</u> : Sand, tan brown, slightly moist, loose, fine-grained, caving.	
Total Depth 11 feet. No groundwater was encountered. Caving from 5 to 11 feet. Hole backfilled and wheel-rolled in-place.			
EP-5	0 to 10	<u>ALLUVIUM (Qal)</u> : Sand, light brown, dry, loose, fine-grained, horizontal stratification, roots.	
	10 to 16	<u>SAN PEDRO SAND (Qsp)</u> : Sand, tan brown, slightly moist, loose, fine-grained.	
Total Depth 16 feet. No groundwater was encountered. Caving throughout. Hole backfilled and wheel-rolled in-place.			

GEOLOGIC LOG - TEST BORING

Project No.: 1299 Date: 8-23-93 Boring No.: 1
 Equipment: Bucketauger Boring Dimensions: Dia 2' D 101'
 Elevation: 460-plan

Depth, ft.	Description	Unit
0-1	Mod firm damp brn cl silt	Colluvium
1-101	Firm damp gray & tan diatomaceous siltstone lt gr at 39-47' brn at 47-49' <u>Strata</u> 10'-N15W76N 31- N20W72N 36- N15W76S 38- N20W76N 42- N15W75N 48- NS70W 54- N5E70S 60- N5E70N 67- N5E80S 75- N30W86N '86- N75W60S 96- N75E74S <u>Fault</u> 82'-N70W67N <u>Joints</u> 17'-N70W88N 45'-N15W89N	Valmonte Mem.

No Seepage

BORING 1

W.O.93-1605
Page 1 of 5

Client: MR. DAN E. BUTCHER
Project: BUTCHER HILL DEVELOPMENT Date: 8-23-93

Depth ft.	Sample	Lab Test	Blows/ft.	BORING LOG	Dry Unit Weight Lbs/Cu. Ft.	Moisture content PGT/Dry WT.	Notes	
0				24" Dia. Bucket Rig w/3350 Lb. Kelly				
	B	EX		0.0-34.0' NATURAL GROUND-Diatomaceous SILTSTONE(WH-WM)-Lt. Brown/White, highly to moderately weathered, dry to moist				
5	R		6		58.3	60.2	56	
10	R		4		66.4	58.1		
15	R	DS	2		60.6	49.2		
20	R		4		60.9	41.8		
25	R		4		48.5	63.5		
30	R				2045 Lb. Kelly	48.5	71.4	

Continued on following page

BORING 1
(Continued)

W.O 93-1605
Page 2 of 6

Client: MR. DAN E. BUTCHER
Project: BUTCHER HILL DEVELOPMENT Date: 8-23-93

BORING LOG					Dry Unit Weight	Lbs/Cu Ft.	Moisture content	PCT/Dry WT.	Notes
Depth Ft.	Sample	Lab Test	Blows/ft.						
				24" Dia. Bucket Rig w/2045 Lb. Kelly					
35	R	DS	7	34.0-39.0'	Diatomaceous SILTSTONE(WM) Lt. Brown/White, moderately weathered moist	40.5	65.7		
40	R		7	39.0-48.0'	Diatomaceous SILTSTONE(WM)- White, moderately weathered, moist	40.1	85.5		
45	R		5			49.4	56.0		
50	R		6			43.7	69.8		
55	R	DS	15			42.3	57.5		
60	R		14		1200 Lb. Kelly	50.2	51.8		
65	R		13			54.3	50.5		

Continued on following page

BORING 1
(Continued)

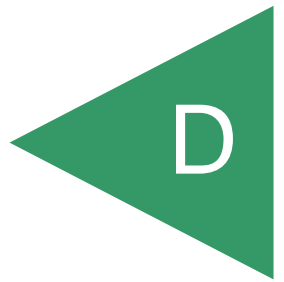
W.C 93-1605
Page 3 of 6

Client: MR. DAN E. BUTCHER
Project: BUTCHER HILL DEVELOPMENT

Date: 8-25-93

BORING LOG						Dry Unit Weight	Moisture content	Notes
Depth ft.	Sample	Lab Test	Blows/ft.			Lbs/Cu.Ft.	PCT/Dry WT.	
				24" Dia. Bucket Rig w/1200 Lb. Kelly				
				68.0-100' Diatomaceous SILTSTONE(WM)- White, moderately weathered, moist				
70	R		20/ 6"			60.3	39.2	
75	R		35/ 11"			59.4	34.1	
80	R	DS	30			84.1	38.8	
85	R		34			63.2	40.3	
90	R		22		2200 Lb. Kelly	45.5	53.7	
95	R		25			51.8	57.7	
100	R		31		Borings Halted & Backfilled No Groundwater Encountered	65.5	37.3	

APPENDIX



APPENDIX D
SEISMICALLY INDUCED SETTLEMENT CALCULATIONS



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA_M (g):	0.720
2/3 PGA_M (g):	0.480
Calculated Mag. Wtg. Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len. Corr. (CR) (0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4													
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq. Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe. Fac.	
1.0	115.0	0	9.0	1.0	1		73	2.000	23.3	115.0	0.259	0.998	0.231	--	
2.0	115.0	0	9.0	2.0	1	25	71	2.000	28.0	115.0	0.349	0.993	0.230	--	
3.0	115.0	0	9.0	3.0	1	25	69	2.000	28.0	115.0	0.349	0.989	0.229	--	
4.0	115.0	0	9.0	4.0	1	25	67	2.000	28.0	115.0	0.349	0.984	0.228	--	
5.0	115.0	0	9.0	5.0	1	25	66	2.000	28.0	115.0	0.349	0.979	0.227	--	
6.0	115.0	0	9.0	6.0	1	25	64	1.817	25.9	115.0	0.301	0.975	0.226	--	
7.0	115.0	0	9.0	7.0	1	25	63	1.671	24.2	115.0	0.272	0.970	0.225	--	
8.0	115.0	0	9.0	8.0	1	25	62	1.556	22.8	115.0	0.253	0.966	0.223	--	
9.0	115.0	0	9.0	9.0	1	25	60	1.462	21.7	115.0	0.239	0.961	0.222	--	
10.0	115.0	0	14.0	10.0	1	25	74	1.382	29.8	115.0	0.445	0.957	0.221	--	
11.0	115.0	0	14.0	10.0	1	25	74	1.315	28.5	115.0	0.367	0.952	0.220	--	
12.0	115.0	0	14.0	10.0	1	25	74	1.257	27.5	115.0	0.335	0.947	0.219	--	
13.0	115.0	0	14.0	10.0	1	25	74	1.205	26.5	115.0	0.314	0.943	0.218	--	
14.0	115.0	0	14.0	10.0	1	25	74	1.160	25.7	115.0	0.298	0.938	0.217	--	
15.0	115.0	0	71.0	15.0	1	24	153	1.119	114.9	115.0	Inf.	0.934	0.216	--	
16.0	115.0	0	71.0	15.0	1	24	153	1.082	111.3	115.0	Inf.	0.929	0.215	--	
17.0	115.0	0	71.0	15.0	1	24	153	1.049	108.0	115.0	Inf.	0.925	0.214	--	
18.0	115.0	0	71.0	15.0	1	24	153	1.019	105.0	115.0	Inf.	0.920	0.213	--	
19.0	115.0	0	71.0	15.0	1	24	153	0.991	102.2	115.0	Inf.	0.915	0.212	--	
20.0	115.0	0	31.0	20.0	1	24	94	0.965	50.5	115.0	Inf.	0.911	0.211	--	
21.0	115.0	0	31.0	20.0	1	24	94	0.941	49.4	115.0	Inf.	0.906	0.210	--	
22.0	115.0	0	31.0	20.0	1	24	94	0.919	48.3	115.0	Inf.	0.902	0.209	--	
23.0	115.0	0	31.0	20.0	1	24	94	0.898	47.3	115.0	Inf.	0.897	0.208	--	
24.0	115.0	0	31.0	20.0	1	24	94	0.879	46.4	115.0	Inf.	0.893	0.207	--	
25.0	115.0	0	31.0	20.0	1	24	94	0.861	45.5	115.0	Inf.	0.888	0.206	--	
26.0	115.0	0	39.0	24.0	1	17	100	0.844	56.4	115.0	Inf.	0.883	0.204	--	
27.0	115.0	0	39.0	24.0	1	17	100	0.828	55.4	115.0	Inf.	0.879	0.203	--	
28.0	115.0	0	39.0	24.0	1	17	100	0.813	54.4	115.0	Inf.	0.874	0.202	--	
29.0	115.0	0	39.0	24.0	1	17	100	0.798	53.5	115.0	Inf.	0.870	0.201	--	
30.0	115.0	0	35.0	30.0	1	17	89	0.785	50.2	115.0	Inf.	0.865	0.200	--	
31.0	115.0	0	35.0	30.0	1	17	89	0.772	49.4	115.0	Inf.	0.861	0.199	--	
32.0	115.0	0	35.0	30.0	1	17	89	0.759	48.6	115.0	Inf.	0.856	0.198	--	
33.0	115.0	0	35.0	30.0	1	17	89	0.747	47.9	115.0	Inf.	0.851	0.197	--	
34.0	115.0	0	46.0	35.0	1	13	97	0.736	60.4	115.0	Inf.	0.847	0.196	--	
35.0	115.0	0	46.0	35.0	1	13	97	0.725	59.5	115.0	Inf.	0.842	0.195	--	
36.0	115.0	0	46.0	35.0	1	13	97	0.715	58.7	115.0	Inf.	0.838	0.194	--	
37.0	115.0	0	46.0	35.0	1	13	97	0.705	57.9	115.0	Inf.	0.833	0.193	--	
38.0	115.0	0	46.0	35.0	1	13	97	0.696	57.2	115.0	Inf.	0.829	0.192	--	
39.0	115.0	0	46.0	35.0	1	13	97	0.687	56.5	115.0	Inf.	0.824	0.191	--	
40.0	115.0	0	57.0	40.0	1	7	103	0.678	67.1	115.0	Inf.	0.819	0.190	--	
41.0	115.0	0	57.0	40.0	1	7	103	0.670	66.2	115.0	Inf.	0.815	0.189	--	
42.0	115.0	0	57.0	40.0	1	7	103	0.661	65.4	115.0	Inf.	0.810	0.188	--	
43.0	115.0	0	57.0	40.0	1	7	103	0.654	64.7	115.0	Inf.	0.806	0.186	--	
44.0	115.0	0	57.0	40.0	1	7	103	0.646	63.9	115.0	Inf.	0.801	0.185	--	
45.0	115.0	0	67.0	45.0	1	7	107	0.639	74.2	115.0	Inf.	0.797	0.184	--	
46.0	115.0	0	67.0	45.0	1	7	107	0.632	73.4	115.0	Inf.	0.792	0.183	--	
47.0	115.0	0	67.0	45.0	1	7	107	0.625	72.6	115.0	Inf.	0.787	0.182	--	
48.0	115.0	0	67.0	45.0	1	7	107	0.618	71.9	115.0	Inf.	0.783	0.181	--	
49.0	115.0	0	67.0	45.0	1	7	107	0.612	71.1	115.0	Inf.	0.778	0.180	--	
50.0	115.0	0	62.0	50.0	1	7	99	0.606	65.2	115.0	Inf.	0.774	0.179	--	
51.0	115.0	0	62.0	50.0	1	7	99	0.600	64.5	115.0	Inf.	0.769	0.178	--	
52.0	115.0	0	62.0	50.0	1	7	99	0.594	63.9	115.0	Inf.	0.765	0.177	--	
53.0	115.0	0	62.0	50.0	1	7	99	0.588	63.3	115.0	Inf.	0.760	0.176	--	
54.0	115.0	0	62.0	50.0	1	7	99	0.583	62.7	115.0	Inf.	0.755	0.175	--	
55.0	115.0	0	81.0	55.0	1	8	109	0.577	81.3	115.0	Inf.	0.751	0.174	--	
56.0	115.0	0	81.0	55.0	1	8	109	0.572	80.6	115.0	Inf.	0.746	0.173	--	
57.0	115.0	0	81.0	55.0	1	8	109	0.567	79.9	115.0	Inf.	0.742	0.172	--	
58.0	115.0	0	81.0	55.0	1	8	109	0.562	79.2	115.0	Inf.	0.737	0.171	--	
59.0	115.0	0	81.0	55.0	1	8	109	0.557	78.5	115.0	Inf.	0.733	0.170	--	
60.0	115.0	0	58.0	60.0	1	8	89	0.552	55.9	115.0	Inf.	0.728	0.168	--	
61.0	115.0	0	58.0	60.0	1	8	89	0.548	55.5	115.0	Inf.	0.723	0.167	--	

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS DESIGN EARTHQUAKE

DE EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration (g):	0.480

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress (Tav) (tsf)	Field SPT (N)	Correction Factor (C _{er})	Relative Density (Dr) (%)	Correction Factor (C _{cn})	Corrected (N1) ₆₀	rd Factor	Maximum Shear Mod. (G _{max}) (tsf)	veff *(G _{eff}) (G _{max})	veff Shear Strain	veff *100%	Volumetric Strain M7.5 (E15) (%)	Number of Strain Cycles (N _c)	Corrected Vol. Strains (E _c)	Estimated Settlement (S) (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.009	9	1.25	72.7	2.0	23.3	1.0	177.162	5.02E-05	1.00E-04	0.010	8.33E-03	8.3559	6.40E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.027	9	1.25	70.7	2.0	28.0	1.0	326.298	8.01E-05	1.90E-04	0.019	1.27E-02	8.3559	9.75E-03	
3.0	1.0	2.5	115.0	0.14	0.10	0.045	9	1.25	68.9	2.0	28.0	1.0	421.249	1.01E-04	3.00E-03	0.300	2.00E-01	8.3559	1.54E-01	
4.0	1.0	3.5	115.0	0.20	0.13	0.063	9	1.25	67.3	2.0	28.0	1.0	498.429	1.18E-04	8.10E-04	0.081	5.41E-02	8.3559	4.16E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.081	9	1.25	65.7	2.0	28.0	1.0	565.165	1.31E-04	8.10E-04	0.081	5.41E-02	8.3559	4.16E-02	
6.0	1.0	5.5	115.0	0.32	0.21	0.098	9	1.25	64.3	1.8	25.9	1.0	608.537	1.46E-04	4.50E-04	0.045	3.30E-02	8.3559	2.54E-02	CUT
7.0	1.0	6.5	115.0	0.37	0.25	0.116	9	1.25	62.9	1.7	24.2	1.0	646.771	1.59E-04	4.50E-04	0.045	3.58E-02	8.3559	2.75E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.134	9	1.25	61.6	1.6	22.8	1.0	681.624	1.71E-04	4.50E-04	0.045	3.84E-02	8.3559	2.95E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.151	9	1.25	60.4	1.5	21.7	1.0	713.808	1.82E-04	4.50E-04	0.045	4.07E-02	8.3559	3.13E-02	
10.0	1.0	9.5	115.0	0.55	0.37	0.169	14	1.25	74.0	1.4	29.8	1.0	837.951	1.70E-04	4.50E-04	0.045	2.79E-02	8.3559	2.15E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.186	14	1.25	74.0	1.3	28.5	1.0	868.719	1.78E-04	4.50E-04	0.045	2.94E-02	8.3559	2.26E-02	
12.0	1.0	11.5	115.0	0.66	0.44	0.204	14	1.25	74.0	1.3	27.5	0.9	897.754	1.85E-04	4.50E-04	0.045	3.07E-02	8.3559	2.36E-02	0.01
13.0	1.0	12.5	115.0	0.72	0.48	0.221	14	1.25	74.0	1.2	26.5	0.9	925.298	1.92E-04	4.50E-04	0.045	3.20E-02	8.3559	2.46E-02	0.01
14.0	1.0	13.5	115.0	0.78	0.52	0.238	14	1.25	74.0	1.2	25.7	0.9	951.542	1.98E-04	3.70E-04	0.037	2.74E-02	8.3559	2.10E-02	0.01
15.0	1.0	14.5	115.0	0.83	0.56	0.255	71	1.25	152.9	1.1	114.9	0.9	1624.074	1.22E-04	3.70E-04	0.037	4.54E-03	8.3559	3.49E-03	0.00
16.0	1.0	15.5	115.0	0.89	0.60	0.272	71	1.25	152.9	1.1	111.3	0.9	1661.291	1.26E-04	3.70E-04	0.037	4.72E-03	8.3559	3.63E-03	0.00
17.0	1.0	16.5	115.0	0.95	0.64	0.288	71	1.25	152.9	1.0	108.0	0.9	1696.976	1.29E-04	3.70E-04	0.037	4.89E-03	8.3559	3.76E-03	0.00
18.0	1.0	17.5	115.0	1.01	0.67	0.305	71	1.25	152.9	1.0	105.0	0.9	1731.280	1.31E-04	3.70E-04	0.037	5.06E-03	8.3559	3.89E-03	0.00
19.0	1.0	18.5	115.0	1.06	0.71	0.321	71	1.25	152.9	1.0	102.2	0.9	1764.333	1.34E-04	3.70E-04	0.037	5.23E-03	8.3559	4.02E-03	0.00
20.0	1.0	19.5	115.0	1.12	0.75	0.337	31	1.25	94.0	1.0	50.5	0.9	1432.247	1.71E-04	3.70E-04	0.037	1.22E-02	8.3559	9.35E-03	0.00
21.0	1.0	20.5	115.0	1.18	0.79	0.353	31	1.25	94.0	0.9	49.4	0.9	1457.378	1.74E-04	3.70E-04	0.037	1.25E-02	8.3559	9.61E-03	0.00
22.0	1.0	21.5	115.0	1.24	0.83	0.369	31	1.25	94.0	0.9	48.3	0.9	1481.744	1.76E-04	3.70E-04	0.037	1.28E-02	8.3559	9.87E-03	0.00
23.0	1.0	22.5	115.0	1.29	0.87	0.384	31	1.25	94.0	0.9	47.3	0.9	1505.405	1.79E-04	3.70E-04	0.037	1.32E-02	8.3559	1.01E-02	0.00
24.0	1.0	23.5	115.0	1.35	0.91	0.400	31	1.25	94.0	0.9	46.4	0.9	1528.410	1.81E-04	3.70E-04	0.037	1.35E-02	8.3559	1.04E-02	0.00
25.0	1.0	24.5	115.0	1.41	0.94	0.415	31	1.25	94.0	0.9	45.5	0.9	1550.806	1.83E-04	3.70E-04	0.037	1.38E-02	8.3559	1.06E-02	0.00
26.0	1.0	25.5	115.0	1.47	0.98	0.430	39	1.25	100.1	0.8	56.4	0.9	1699.383	1.71E-04	3.70E-04	0.037	1.07E-02	8.3559	8.19E-03	0.00
27.0	1.0	26.5	115.0	1.52	1.02	0.444	39	1.25	100.1	0.8	55.4	0.9	1721.865	1.73E-04	3.00E-04	0.030	8.83E-03	8.3559	6.79E-03	0.00
28.0	1.0	27.5	115.0	1.58	1.06	0.459	39	1.25	100.1	0.8	54.4	0.9	1743.806	1.74E-04	3.00E-04	0.030	9.02E-03	8.3559	6.93E-03	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.473	39	1.25	100.1	0.8	53.5	0.9	1765.327	1.75E-04	3.00E-04	0.030	9.21E-03	8.3559	7.07E-03	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.487	35	1.25	88.6	0.8	50.2	0.9	1757.485	1.80E-04	3.00E-04	0.030	9.95E-03	8.3559	7.65E-03	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.501	35	1.25	88.6	0.8	49.4	0.9	1777.679	1.81E-04	3.00E-04	0.030	1.01E-02	8.3559	7.79E-03	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.514	35	1.25	88.6	0.8	48.6	0.9	1797.451	1.82E-04	3.00E-04	0.030	1.03E-02	8.3559	7.94E-03	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.528	35	1.25	88.6	0.7	47.9	0.9	1816.822	1.83E-04	3.00E-04	0.030	1.05E-02	8.3559	8.08E-03	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.541	46	1.25	96.5	0.7	60.4	0.8	1992.166	1.69E-04	3.00E-04	0.030	7.97E-03	8.3559	6.12E-03	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.553	46	1.25	96.5	0.7	59.5	0.8	2012.117	1.70E-04	3.00E-04	0.030	8.10E-03	8.3559	6.23E-03	0.00
36.0	1.0	35.5	115.0	2.04	1.37	0.566	46	1.25	96.5	0.7	58.7	0.8	2031.694	1.71E-04	3.00E-04	0.030	8.24E-03	8.3559	6.33E-03	0.00
37.0	1.0	36.5	115.0	2.10	1.41	0.578	46	1.25	96.5	0.7	57.9	0.8	2050.914	1.71E-04	3.00E-04	0.030	8.37E-03	8.3559	6.44E-03	0.00
38.0	1.0	37.5	115.0	2.16	1.44	0.590	46	1.25	96.5	0.7	57.2	0.8	2069.793	1.72E-04	3.00E-04	0.030	8.51E-03	8.3559	6.54E-03	0.00
39.0	1.0	38.5	115.0	2.21	1.48	0.602	46	1.25	96.5	0.7	56.5	0.8	2088.346	1.73E-04	3.00E-04	0.030	8.64E-03	8.3559	6.64E-03	0.00
40.0	1.0	39.5	115.0	2.27	1.52	0.613	57	1.25	102.6	0.7	67.1	0.8	2240.252	1.63E-04	3.00E-04	0.030	7.02E-03	8.3559	5.40E-03	0.00
41.0	1.0	40.5	115.0	2.33	1.56	0.624	57	1.25	102.6	0.7	66.2	0.8	2259.056	1.63E-04	3.00E-04	0.030	7.13E-03	8.3559	5.48E-03	0.00
42.0	1.0	41.5	115.0	2.39	1.60	0.635	57	1.25	102.6	0.7	65.4	0.8	2277.553	1.63E-04	3.00E-04	0.030	7.23E-03	8.3559	5.56E-03	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.646	57	1.25	102.6	0.7	64.7	0.8	2295.578	1.64E-04	3.00E-04	0.030	7.34E-03	8.3559	5.64E-03	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.657	57	1.25	102.6	0.6	63.9	0.8	2313.679	1.64E-04	3.00E-04	0.030	7.44E-03	8.3559	5.72E-03	0.00
45.0	1.0	44.5	115.0	2.56	1.71	0.667	67	1.25	106.6	0.6	74.2	0.8	2459.620	1.56E-04	3.00E-04	0.030	6.22E-03	8.3559	4.78E-03	0.00
46.0	1.0	45.5	115.0	2.62	1.75	0.677	67	1.25	106.6	0.6	73.4	0.8	2477.957	1.56E-04	3.00E-04	0.030	6.30E-03	8.3559	4.84E-03	0.00
47.0	1.0	46.5	115.0	2.67	1.79	0.686	67	1.25	106.6	0.6	72.6	0.8	2496.028	1.56E-04	3.00E-04	0.030	6.38E-03	8.3559	4.91E-03	0.00
48.0	1.0	47.5	115.0	2.73	1.83	0.696	67	1.25	106.6	0.6	71.9	0.8	2513.843	1.56E-04	3.00E-04	0.030	6.47E-03	8.3559	4.97E-03	0.00
49.0	1.0	48.5	115.0	2.79	1.87	0.705	67	1.25	106.6	0.6	71.1	0.8	2531.411	1.56E-04	3.00E-04	0.030	6.55E-03	8.3559	5.03E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	0.714	62	1.25	98.7	0.6	65.2	0.8	2484.068	1.60E-04	3.00E-04	0.030	7.27E-03	8.3559	5.59E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	0.722	62	1.25	98.7	0.6	64.5	0.8	2500.735	1.60E-04	3.00E-04	0.030	7.36E-03	8.3559	5.65E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	62	1.25	98.7	0.6	63.9	0.8	2517.185	1.60E-04	3.00E-04	0.030	7.44E-03	8.3559	5.72E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	62	1.25	98.7	0.6	63.3	0.8	2533.423	1.60E-04	3.00E-04	0.030	7.53E-03	8.3559	5.79E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	62	1.25	98.7	0.6	62.7	0.8	2549.458	1.60E-04	3.00E-04	0.030	7.61E-03	8.3559	5.85E-03	0.00
55.0	1.0	54.5	115.0	3.1																



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA_M (g):	0.720
2/3 PGA_M (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4													
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.	
1.0	115.0	0	13.0	1.0	1		87	2.000	33.6	115.0	Infin.	0.998	0.231	--	
2.0	115.0	0	13.0	2.0	1	35	85	2.000	40.6	115.0	Infin.	0.993	0.230	--	
3.0	115.0	0	13.0	3.0	1	35	83	2.000	40.6	115.0	Infin.	0.989	0.229	--	
4.0	115.0	0	13.0	4.0	1	35	81	2.000	40.6	115.0	Infin.	0.984	0.228	--	
5.0	115.0	0	13.0	5.0	1	35	79	2.000	40.6	115.0	Infin.	0.979	0.227	--	
6.0	115.0	0	13.0	6.0	1	35	77	1.817	37.6	115.0	Infin.	0.975	0.226	--	
7.0	115.0	0	21.0	7.0	1	21	96	1.671	49.0	115.0	Infin.	0.970	0.225	--	
8.0	115.0	0	21.0	8.0	1	21	94	1.556	45.9	115.0	Infin.	0.966	0.223	--	
9.0	115.0	0	21.0	9.0	1	21	92	1.462	43.3	115.0	Infin.	0.961	0.222	--	
10.0	115.0	0	21.0	10.0	1	51	91	1.382	44.6	115.0	Infin.	0.957	0.221	--	
11.0	115.0	0	21.0	10.0	1	51	91	1.315	42.7	115.0	Infin.	0.952	0.220	--	
12.0	115.0	0	21.0	10.0	1	51	91	1.257	41.1	115.0	Infin.	0.947	0.219	--	
13.0	115.0	0	21.0	10.0	1	51	91	1.205	39.7	115.0	Infin.	0.943	0.218	--	
14.0	115.0	0	21.0	10.0	1	51	91	1.160	38.5	115.0	Infin.	0.938	0.217	--	
15.0	115.0	0	15.0	15.0	1	51	70	1.119	30.4	115.0	Infin.	0.934	0.216	--	
16.0	115.0	0	15.0	15.0	1	51	70	1.082	29.6	115.0	0.426	0.929	0.215	--	
17.0	115.0	0	15.0	15.0	1	51	70	1.049	28.9	115.0	0.381	0.925	0.214	--	
18.0	115.0	0	26.0	20.0	1	24	86	1.019	45.4	115.0	Infin.	0.920	0.213	--	
19.0	115.0	0	26.0	20.0	1	24	86	0.991	44.3	115.0	Infin.	0.915	0.212	--	
20.0	115.0	0	26.0	20.0	1	24	86	0.965	43.2	115.0	Infin.	0.911	0.211	--	
21.0	115.0	0	26.0	20.0	1	22	86	0.941	41.8	115.0	Infin.	0.906	0.210	--	
22.0	115.0	0	26.0	20.0	1	22	86	0.919	40.9	115.0	Infin.	0.902	0.209	--	
23.0	115.0	0	26.0	20.0	1	22	86	0.898	40.1	115.0	Infin.	0.897	0.208	--	
24.0	115.0	0	26.0	20.0	1	22	86	0.879	39.3	115.0	Infin.	0.893	0.207	--	
25.0	115.0	0	22.0	25.0	1	54	74	0.861	38.2	115.0	Infin.	0.888	0.206	--	
26.0	115.0	0	22.0	25.0	1	54	74	0.844	37.6	115.0	Infin.	0.883	0.204	--	
27.0	115.0	0	22.0	25.0	1	54	74	0.828	37.0	115.0	Infin.	0.879	0.203	--	
28.0	115.0	0	35.0	30.0	1	3	89	0.813	49.1	115.0	Infin.	0.874	0.202	--	
29.0	115.0	0	35.0	30.0	1	3	89	0.798	48.2	115.0	Infin.	0.870	0.201	--	
30.0	115.0	0	35.0	30.0	1	3	89	0.785	47.4	115.0	Infin.	0.865	0.200	--	
31.0	115.0	0	35.0	30.0	1	3	89	0.772	46.6	115.0	Infin.	0.861	0.199	--	
32.0	115.0	0	35.0	30.0	1	3	89	0.759	45.8	115.0	Infin.	0.856	0.198	--	
33.0	115.0	0	35.0	30.0	1	3	89	0.747	45.1	115.0	Infin.	0.851	0.197	--	
34.0	115.0	0	35.0	30.0	1	3	89	0.736	44.4	115.0	Infin.	0.847	0.196	--	
35.0	115.0	0	10.0	35.0	1	9	45	0.725	13.4	115.0	0.132	0.842	0.195	--	
36.0	115.0	0	10.0	35.0	1	9	45	0.715	13.2	115.0	0.130	0.838	0.194	--	
37.0	115.0	0	10.0	35.0	1	9	45	0.705	13.0	115.0	0.128	0.833	0.193	--	
38.0	115.0	0	10.0	35.0	1	9	45	0.696	12.9	115.0	0.127	0.829	0.192	--	
39.0	115.0	0	10.0	35.0	1	9	45	0.687	12.7	115.0	0.125	0.824	0.191	--	
40.0	115.0	0	7.0	40.0	1	9	36	0.678	9.0	115.0	0.088	0.819	0.190	--	
41.0	115.0	0	7.0	40.0	1	9	36	0.670	8.9	115.0	0.087	0.815	0.189	--	
42.0	115.0	0	50.0	42.5	1	9	94	0.661	57.9	115.0	Infin.	0.810	0.188	--	
43.0	115.0	0	50.0	42.5	1	9	94	0.654	57.2	115.0	Infin.	0.806	0.186	--	
44.0	115.0	0	50.0	42.5	1	9	94	0.646	56.6	115.0	Infin.	0.801	0.185	--	
45.0	115.0	0	50.0	42.5	1	9	94	0.639	56.0	115.0	Infin.	0.797	0.184	--	
46.0	115.0	0	50.0	42.5	1	9	94	0.632	55.3	115.0	Infin.	0.792	0.183	--	
47.0	115.0	0	50.0	47.5	1	22	90	0.625	57.7	115.0	Infin.	0.787	0.182	--	
48.0	115.0	0	50.0	47.5	1	22	90	0.618	57.2	115.0	Infin.	0.783	0.181	--	
49.0	115.0	0	50.0	47.5	1	22	90	0.612	56.8	115.0	Infin.	0.778	0.180	--	
50.0	115.0	0	50.0	47.5	1	22	90	0.606	56.1	115.0	Infin.	0.774	0.179	--	
51.0	115.0	0	50.0	47.5	1	22	90	0.600	55.6	115.0	Infin.	0.769	0.178	--	
52.0	115.0	0	50.0	52.5	1	22	87	0.594	55.1	115.0	Infin.	0.765	0.177	--	
53.0	115.0	0	50.0	52.5	1	22	87	0.588	54.6	115.0	Infin.	0.760	0.176	--	
54.0	115.0	0	50.0	52.5	1	22	87	0.583	54.1	115.0	Infin.	0.755	0.175	--	
55.0	115.0	0	50.0	52.5	1	22	87	0.577	53.6	115.0	Infin.	0.751	0.174	--	
56.0	115.0	0	50.0	52.5	1	22	87	0.572	53.2	115.0	Infin.	0.746	0.173	--	
57.0	115.0	0	50.0	57.5	1	9	84	0.567	49.8	115.0	Infin.	0.742	0.172	--	
58.0	115.0	0	50.0	57.5	1	9	84	0.562	49.3	115.0	Infin.	0.737	0.171	--	
59.0	115.0	0	50.0	57.5	1	9	84	0.557	48.9	115.0	Infin.	0.733	0.170	--	
60.0	115.0	0	50.0	57.5	1	9	84	0.552	48.5	115.0	Infin.	0.728	0.168	--	



Client : Solana - Torrance
 File No. : A9201-06-01E
 Boring : 17

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS DESIGN EARTHQUAKE

DE EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration (g):	0.480

Fig 4.1

Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress [T _{av}] (tsf)	Field SPT [N]	Correction Factor [C _{er}]	Relative Density [D _r] (%)	Correction Factor [C _n]	Corrected [N]60	rd Factor	Maximum Shear Mod. [G _{max}] (tsf)	[y _{eff}] ¹ [G _{eff}] [G _{max}]	Shear Strain [y _{eff}] ¹ 100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [N _c]	Corrected Vol. Strains [E _c]	Estimated Settlement [S] (inches)	
1.0	1.0	0.5	115.0	0.03	0.02	0.009	13	1.25	87.4	2.0	33.6	1.0	200.265	4.44E-05	6.00E-05	0.006	3.22E-03	8.3559	2.47E-03	0.00
2.0	1.0	1.5	115.0	0.09	0.06	0.027	13	1.25	85.0	2.0	40.6	1.0	369.431	7.07E-05	1.40E-04	0.014	5.98E-03	8.3559	4.60E-03	0.00
3.0	1.0	2.5	115.0	0.14	0.10	0.045	13	1.25	82.9	2.0	40.6	1.0	476.934	8.96E-05	1.60E-04	0.016	6.83E-03	8.3559	5.25E-03	0.00
4.0	1.0	3.5	115.0	0.20	0.13	0.063	13	1.25	80.9	2.0	40.6	1.0	564.315	1.04E-04	1.70E-04	0.017	7.26E-03	8.3559	5.58E-03	0.00
5.0	1.0	4.5	115.0	0.26	0.17	0.081	13	1.25	79.0	2.0	40.6	1.0	639.873	1.16E-04	1.70E-04	0.017	7.26E-03	8.3559	5.58E-03	0.00
6.0	1.0	5.5	115.0	0.32	0.21	0.098	13	1.25	77.2	1.8	37.6	1.0	689.068	1.29E-04	1.50E-04	0.015	7.04E-03	8.3559	5.41E-03	0.00
7.0	1.0	6.5	115.0	0.37	0.25	0.116	21	1.25	96.1	1.7	49.0	1.0	818.795	1.26E-04	1.50E-04	0.015	5.11E-03	8.3559	3.93E-03	0.00
8.0	1.0	7.5	115.0	0.43	0.29	0.134	21	1.25	94.1	1.6	45.9	1.0	860.371	1.35E-04	1.50E-04	0.015	5.53E-03	8.3559	4.25E-03	0.00
9.0	1.0	8.5	115.0	0.49	0.33	0.151	21	1.25	92.3	1.5	43.3	1.0	898.554	1.44E-04	1.50E-04	0.015	5.93E-03	8.3559	4.56E-03	0.00
10.0	1.0	9.5	115.0	0.55	0.37	0.169	21	1.25	90.6	1.4	44.6	1.0	958.713	1.48E-04	1.50E-04	0.015	5.74E-03	8.3559	4.41E-03	0.00
11.0	1.0	10.5	115.0	0.60	0.40	0.186	21	1.25	90.6	1.3	42.7	1.0	993.893	1.55E-04	1.50E-04	0.015	6.03E-03	8.3559	4.64E-03	0.00
12.0	1.0	11.5	115.0	0.66	0.44	0.204	21	1.25	90.6	1.3	41.1	0.9	1027.090	1.62E-04	1.50E-04	0.015	6.31E-03	8.3559	4.85E-03	0.00
13.0	1.0	12.5	115.0	0.72	0.48	0.221	21	1.25	90.6	1.2	39.7	0.9	1058.581	1.67E-04	1.50E-04	0.015	6.58E-03	8.3559	5.06E-03	0.00
14.0	1.0	13.5	115.0	0.78	0.52	0.238	21	1.25	90.6	1.2	38.5	0.9	1088.585	1.73E-04	1.60E-04	0.016	7.29E-03	8.3559	5.60E-03	0.00
15.0	1.0	14.5	115.0	0.83	0.56	0.255	15	1.25	70.3	1.1	30.4	0.9	1042.146	1.90E-04	1.60E-04	0.016	9.70E-03	8.3559	7.45E-03	0.00
16.0	1.0	15.5	115.0	0.89	0.60	0.272	15	1.25	70.3	1.1	29.6	0.9	1068.343	1.95E-04	1.60E-04	0.016	1.00E-02	8.3559	7.69E-03	0.00
17.0	1.0	16.5	115.0	0.95	0.64	0.288	15	1.25	70.3	1.0	28.9	0.9	1093.566	2.00E-04	1.60E-04	0.016	1.03E-02	8.3559	7.91E-03	0.00
18.0	1.0	17.5	115.0	1.01	0.67	0.305	26	1.25	86.1	1.0	45.4	0.9	1309.221	1.74E-04	1.60E-04	0.016	5.98E-03	8.3559	4.60E-03	0.00
19.0	1.0	18.5	115.0	1.06	0.71	0.321	26	1.25	86.1	1.0	44.3	0.9	1334.940	1.77E-04	1.60E-04	0.016	6.17E-03	8.3559	4.74E-03	0.00
20.0	1.0	19.5	115.0	1.12	0.75	0.337	26	1.25	86.1	1.0	43.2	0.9	1359.800	1.80E-04	1.60E-04	0.016	6.34E-03	8.3559	4.88E-03	0.00
21.0	1.0	20.5	115.0	1.18	0.79	0.353	26	1.25	86.1	0.9	41.8	0.9	1378.762	1.84E-04	1.60E-04	0.016	6.60E-03	8.3559	5.08E-03	0.00
22.0	1.0	21.5	115.0	1.24	0.83	0.369	26	1.25	86.1	0.9	40.9	0.9	1401.911	1.86E-04	1.60E-04	0.016	6.78E-03	8.3559	5.21E-03	0.00
23.0	1.0	22.5	115.0	1.29	0.87	0.384	26	1.25	86.1	0.9	40.1	0.9	1424.393	1.89E-04	1.60E-04	0.016	6.94E-03	8.3559	5.34E-03	0.00
24.0	1.0	23.5	115.0	1.35	0.91	0.400	26	1.25	86.1	0.9	39.3	0.9	1446.255	1.91E-04	1.60E-04	0.016	7.11E-03	8.3559	5.46E-03	0.00
25.0	1.0	24.5	115.0	1.41	0.94	0.415	22	1.25	74.3	0.9	38.2	0.9	1462.693	1.94E-04	1.60E-04	0.016	7.36E-03	8.3559	5.65E-03	0.00
26.0	1.0	25.5	115.0	1.47	0.98	0.430	22	1.25	74.3	0.8	37.6	0.9	1484.155	1.96E-04	1.60E-04	0.016	7.50E-03	8.3559	5.77E-03	0.00
27.0	1.0	26.5	115.0	1.52	1.02	0.444	22	1.25	74.3	0.8	37.0	0.9	1505.118	1.97E-04	1.30E-04	0.013	6.21E-03	8.3559	4.77E-03	0.00
28.0	1.0	27.5	115.0	1.58	1.06	0.459	35	1.25	88.6	0.8	49.1	0.9	1684.280	1.80E-04	1.30E-04	0.013	4.43E-03	8.3559	3.40E-03	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.473	35	1.25	88.6	0.8	48.2	0.9	1704.453	1.82E-04	1.30E-04	0.013	4.53E-03	8.3559	3.48E-03	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.487	35	1.25	88.6	0.8	47.4	0.9	1724.159	1.83E-04	1.30E-04	0.013	4.62E-03	8.3559	3.55E-03	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.501	35	1.25	88.6	0.8	46.6	0.9	1743.425	1.84E-04	1.30E-04	0.013	4.71E-03	8.3559	3.62E-03	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.514	35	1.25	88.6	0.8	45.8	0.9	1762.274	1.86E-04	1.30E-04	0.013	4.81E-03	8.3559	3.69E-03	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.528	35	1.25	88.6	0.7	45.1	0.9	1780.729	1.87E-04	1.30E-04	0.013	4.90E-03	8.3559	3.76E-03	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.541	35	1.25	88.6	0.7	44.4	0.8	1798.809	1.88E-04	1.30E-04	0.013	4.99E-03	8.3559	3.83E-03	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.553	10	1.25	45.0	0.7	13.4	0.8	1223.333	2.80E-04	3.00E-04	0.030	4.86E-02	8.3559	3.74E-02	0.01
36.0	1.0	35.5	115.0	2.04	1.37	0.566	10	1.25	45.0	0.7	13.2	0.8	1235.423	2.81E-04	3.00E-04	0.030	4.94E-02	8.3559	3.80E-02	0.01
37.0	1.0	36.5	115.0	2.10	1.41	0.578	10	1.25	45.0	0.7	13.0	0.8	1247.296	2.82E-04	3.00E-04	0.030	5.02E-02	8.3559	3.86E-02	0.01
38.0	1.0	37.5	115.0	2.16	1.44	0.590	10	1.25	45.0	0.7	12.9	0.8	1258.962	2.83E-04	3.00E-04	0.030	5.09E-02	8.3559	3.91E-02	0.01
39.0	1.0	38.5	115.0	2.21	1.48	0.602	10	1.25	45.0	0.7	12.7	0.8	1270.431	2.84E-04	3.00E-04	0.030	5.17E-02	8.3559	3.97E-02	0.01
40.0	1.0	39.5	115.0	2.27	1.52	0.613	7	1.25	36.0	0.7	9.0	0.8	1149.105	3.17E-04	5.20E-04	0.052	1.35E-01	8.3559	1.03E-01	0.02
41.0	1.0	40.5	115.0	2.33	1.56	0.624	7	1.25	36.0	0.7	8.9	0.8	1159.184	3.18E-04	5.20E-04	0.052	1.37E-01	8.3559	1.05E-01	0.03
42.0	1.0	41.5	115.0	2.39	1.60	0.635	50	1.25	93.7	0.7	57.9	0.8	2186.726	1.70E-04	1.30E-04	0.013	3.63E-03	8.3559	2.79E-03	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.646	50	1.25	93.7	0.7	57.2	0.8	2204.282	1.70E-04	1.30E-04	0.013	3.68E-03	8.3559	2.83E-03	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.657	50	1.25	93.7	0.6	56.6	0.8	2221.567	1.71E-04	1.30E-04	0.013	3.73E-03	8.3559	2.87E-03	0.00
45.0	1.0	44.5	115.0	2.56	1.71	0.667	50	1.25	93.7	0.6	56.0	0.8	2238.592	1.71E-04	1.30E-04	0.013	3.78E-03	8.3559	2.91E-03	0.00
46.0	1.0	45.5	115.0	2.62	1.75	0.677	50	1.25	93.7	0.6	55.3	0.8	2255.366	1.71E-04	1.30E-04	0.013	3.83E-03	8.3559	2.95E-03	0.00
47.0	1.0	46.5	115.0	2.67	1.79	0.686	50	1.25	90.0	0.6	57.7	0.8	2312.474	1.68E-04	1.30E-04	0.013	3.64E-03	8.3559	2.80E-03	0.00
48.0	1.0	47.5	115.0	2.73	1.83	0.696	50	1.25	90.0	0.6	57.2	0.8	2329.487	1.68E-04	1.30E-04	0.013	3.69E-03	8.3559	2.83E-03	0.00
49.0	1.0	48.5	115.0	2.79	1.87	0.705	50	1.25	90.0	0.6	56.6	0.8	2346.272	1.68E-04	1.30E-04	0.013	3.73E-03	8.3559	2.87E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	0.714	50	1.25	90.0	0.6	56.1	0.8	2362.837	1.68E-04	1.30E-04	0.013	3.77E-03	8.3559	2.90E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	0.722	50	1.25	90.0	0.6	55.6	0.8	2379.190	1.68E-04	1.30E-04	0.013	3.81E-03	8.3559	2.93E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	50	1.25	86.7	0.6	55.1	0.8	2395.336	1.68E-04	1.30E-04	0.013	3.86E-03	8.3559	2.96E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	50	1.25	86.7	0.6	54.6	0.8	2411.283	1.68E-04	1.30E-04	0.013	3.90E-03	8.3559	3.00E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	50	1.25	86.7	0.6	54.1	0.8	2427.038	1.68E-04	1.30E-04	0.013	3.94E-03</			



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA _M (g):	0.720
2/3 PGA _M (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):														
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.
1.0	115.0	0	14.0	1.0	1		91	2.000	36.2	115.0	Inf.	0.998	0.231	--
2.0	115.0	0	14.0	2.0	1	47	88	2.000	43.2	115.0	Inf.	0.993	0.230	--
3.0	115.0	0	14.0	3.0	1	47	86	2.000	43.2	115.0	Inf.	0.989	0.229	--
4.0	115.0	0	14.0	4.0	1	47	84	2.000	43.2	115.0	Inf.	0.984	0.228	--
5.0	115.0	0	14.0	5.0	1	47	82	2.000	43.2	115.0	Inf.	0.979	0.227	--
6.0	115.0	0	14.0	6.0	1	47	80	1.817	39.9	115.0	Inf.	0.975	0.226	--
7.0	115.0	0	9.0	7.0	1	47	63	1.671	26.5	115.0	0.312	0.970	0.225	--
8.0	115.0	0	9.0	8.0	1	47	62	1.556	25.1	115.0	0.287	0.966	0.223	--
9.0	115.0	0	9.0	9.0	1	47	60	1.462	24.0	115.0	0.270	0.961	0.222	--
10.0	115.0	0	9.0	10.0	1	47	59	1.382	23.1	115.0	0.257	0.957	0.221	--
11.0	115.0	0	9.0	10.0	1	47	59	1.315	22.3	115.0	0.246	0.952	0.220	--
12.0	115.0	0	9.0	10.0	1	47	59	1.257	21.6	115.0	0.237	0.947	0.219	--
13.0	115.0	0	21.0	12.5	1	27	86	1.205	37.9	115.0	Inf.	0.943	0.218	--
14.0	115.0	0	21.0	12.5	1	27	86	1.160	36.7	115.0	Inf.	0.938	0.217	--
15.0	115.0	0	21.0	12.5	1	27	86	1.119	35.6	115.0	Inf.	0.934	0.216	--
16.0	115.0	0	21.0	12.5	1	27	86	1.082	34.6	115.0	Inf.	0.929	0.215	--
17.0	115.0	0	16.0	17.5	1	14	69	1.049	26.9	115.0	0.322	0.925	0.214	--
18.0	115.0	0	16.0	17.5	1	14	69	1.019	26.2	115.0	0.307	0.920	0.213	--
19.0	115.0	0	16.0	17.5	1	14	69	0.991	25.5	115.0	0.295	0.915	0.212	--
20.0	115.0	0	38.0	22.5	1	14	100	0.965	60.8	115.0	Inf.	0.911	0.211	--
21.0	115.0	0	38.0	22.5	1	14	100	0.941	59.3	115.0	Inf.	0.906	0.210	--
22.0	115.0	0	38.0	22.5	1	14	100	0.919	58.0	115.0	Inf.	0.902	0.209	--
23.0	115.0	0	38.0	22.5	1	14	100	0.898	56.7	115.0	Inf.	0.897	0.208	--
24.0	115.0	0	38.0	22.5	1	14	100	0.879	55.5	115.0	Inf.	0.893	0.207	--
25.0	115.0	0	38.0	22.5	1	14	100	0.861	54.4	115.0	Inf.	0.888	0.206	--
26.0	115.0	0	38.0	22.5	1	14	100	0.844	53.4	115.0	Inf.	0.883	0.204	--
27.0	115.0	0	38.0	22.5	1	14	100	0.828	52.4	115.0	Inf.	0.879	0.203	--
28.0	115.0	0	36.0	37.5	1	3	83	0.813	50.5	115.0	Inf.	0.874	0.202	--
29.0	115.0	0	36.0	37.5	1	3	83	0.798	49.6	115.0	Inf.	0.870	0.201	--
30.0	115.0	0	36.0	37.5	1	3	83	0.785	48.7	115.0	Inf.	0.865	0.200	--
31.0	115.0	0	36.0	37.5	1	3	83	0.772	47.9	115.0	Inf.	0.861	0.199	--
32.0	115.0	0	67.0	32.5	1	4	119	0.759	87.7	115.0	Inf.	0.856	0.198	--
33.0	115.0	0	67.0	32.5	1	4	119	0.747	86.4	115.0	Inf.	0.851	0.197	--
34.0	115.0	0	67.0	32.5	1	4	119	0.736	85.1	115.0	Inf.	0.847	0.196	--
35.0	115.0	0	67.0	32.5	1	4	119	0.725	83.8	115.0	Inf.	0.842	0.195	--
36.0	115.0	0	67.0	32.5	1	4	119	0.715	82.7	115.0	Inf.	0.838	0.194	--
37.0	115.0	0	63.0	37.5	1	4	110	0.705	76.6	115.0	Inf.	0.833	0.193	--
38.0	115.0	0	63.0	37.5	1	4	110	0.696	75.6	115.0	Inf.	0.829	0.192	--
39.0	115.0	0	63.0	37.5	1	4	110	0.687	74.6	115.0	Inf.	0.824	0.191	--
40.0	115.0	0	63.0	37.5	1	4	110	0.678	73.7	115.0	Inf.	0.819	0.190	--
41.0	115.0	0	63.0	37.5	1	4	110	0.670	72.8	115.0	Inf.	0.815	0.189	--
42.0	115.0	0	100.0	42.5	1	4	132	0.661	114.1	115.0	Inf.	0.810	0.188	--
43.0	115.0	0	100.0	42.5	1	4	132	0.654	112.7	115.0	Inf.	0.806	0.186	--
44.0	115.0	0	100.0	42.5	1	4	132	0.646	111.4	115.0	Inf.	0.801	0.185	--
45.0	115.0	0	100.0	42.5	1	4	132	0.639	110.2	115.0	Inf.	0.797	0.184	--
46.0	115.0	0	100.0	42.5	1	4	132	0.632	109.0	115.0	Inf.	0.792	0.183	--
47.0	115.0	0	100.0	47.5	1	6	127	0.625	107.9	115.0	Inf.	0.787	0.182	--
48.0	115.0	0	100.0	47.5	1	6	127	0.618	106.8	115.0	Inf.	0.783	0.181	--
49.0	115.0	0	100.0	47.5	1	6	127	0.612	105.7	115.0	Inf.	0.778	0.180	--
50.0	115.0	0	100.0	47.5	1	6	127	0.606	104.6	115.0	Inf.	0.774	0.179	--
51.0	115.0	0	100.0	47.5	1	6	127	0.600	103.5	115.0	Inf.	0.769	0.178	--
52.0	115.0	0	100.0	52.5	1	6	123	0.594	102.5	115.0	Inf.	0.765	0.177	--
53.0	115.0	0	100.0	52.5	1	6	123	0.588	101.6	115.0	Inf.	0.760	0.176	--
54.0	115.0	0	100.0	52.5	1	6	123	0.583	100.6	115.0	Inf.	0.755	0.175	--
55.0	115.0	0	100.0	52.5	1	6	123	0.577	99.7	115.0	Inf.	0.751	0.174	--
56.0	115.0	0	100.0	52.5	1	6	123	0.572	98.8	115.0	Inf.	0.746	0.173	--
57.0	115.0	0	100.0	57.5	1	6	118	0.567	97.9	115.0	Inf.	0.742	0.172	--
58.0	115.0	0	100.0	57.5	1	6	118	0.562	97.0	115.0	Inf.	0.737	0.171	--
59.0	115.0	0	100.0	57.5	1	6	118	0.557	96.2	115.0	Inf.	0.733	0.170	--
60.0	115.0	0	100.0	57.5	1	6	118	0.552	95.4	115.0	Inf.	0.728	0.168	--

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS DESIGN EARTHQUAKE

DE EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration (g):	0.480

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress [T _{av}]	Field SPT [N]	Correction Factor [C _{er}]	Relative Density [D _r] (%)	Correction Factor [C _n]	Corrected [N] ₁₆₀	rd Factor	Maximum Shear Mod. [G _{max}] (tsf)	[y _{eff}] ¹ [G _{eff}] [G _{max}]	y _{eff} Shear Strain	[y _{eff}] ¹ *100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [N _c]	Corrected Vol. Strains [E _c]	Estimated Settlement [S] (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.009	14	1.25	90.7	2.0	36.2	1.0	205.274	4.33E-05	7.80E-05	0.008	3.82E-03	8.3559	2.94E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.027	14	1.25	88.2	2.0	43.2	1.0	377.111	6.93E-05	1.40E-04	0.014	5.55E-03	8.3559	4.27E-03	CUT
3.0	1.0	2.5	115.0	0.14	0.10	0.045	14	1.25	86.0	2.0	43.2	1.0	486.849	8.77E-05	1.90E-04	0.019	7.54E-03	8.3559	5.79E-03	
4.0	1.0	3.5	115.0	0.20	0.13	0.063	14	1.25	83.9	2.0	43.2	1.0	576.047	1.02E-04	8.10E-04	0.081	3.21E-02	8.3559	2.47E-02	0.01
5.0	1.0	4.5	115.0	0.26	0.17	0.081	14	1.25	82.0	2.0	43.2	1.0	653.176	1.13E-04	8.10E-04	0.081	3.21E-02	8.3559	2.47E-02	0.01
6.0	1.0	5.5	115.0	0.32	0.21	0.098	14	1.25	80.2	1.8	39.9	1.0	703.153	1.26E-04	4.50E-04	0.045	1.96E-02	8.3559	1.51E-02	0.00
7.0	1.0	6.5	115.0	0.37	0.25	0.116	9	1.25	62.9	1.7	26.5	1.0	666.553	1.54E-04	4.50E-04	0.045	3.22E-02	8.3559	2.47E-02	0.01
8.0	1.0	7.5	115.0	0.43	0.29	0.134	9	1.25	61.6	1.6	25.1	1.0	703.661	1.66E-04	4.50E-04	0.045	3.42E-02	8.3559	2.63E-02	0.01
9.0	1.0	8.5	115.0	0.49	0.33	0.151	9	1.25	60.4	1.5	24.0	1.0	738.015	1.76E-04	4.50E-04	0.045	3.61E-02	8.3559	2.78E-02	0.01
10.0	1.0	9.5	115.0	0.55	0.37	0.169	9	1.25	59.3	1.4	23.1	1.0	770.122	1.85E-04	4.50E-04	0.045	3.79E-02	8.3559	2.91E-02	0.01
11.0	1.0	10.5	115.0	0.60	0.40	0.186	9	1.25	59.3	1.3	22.3	1.0	800.354	1.93E-04	4.50E-04	0.045	3.95E-02	8.3559	3.03E-02	0.01
12.0	1.0	11.5	115.0	0.66	0.44	0.204	9	1.25	59.3	1.3	21.6	0.9	828.992	2.00E-04	1.00E-03	0.100	9.10E-02	8.3559	7.00E-02	0.02
13.0	1.0	12.5	115.0	0.72	0.48	0.221	21	1.25	85.9	1.2	37.9	0.9	1042.383	1.70E-04	4.50E-04	0.045	2.09E-02	8.3559	1.60E-02	0.00
14.0	1.0	13.5	115.0	0.78	0.52	0.238	21	1.25	85.9	1.2	36.7	0.9	1071.384	1.76E-04	3.70E-04	0.037	1.79E-02	8.3559	1.37E-02	0.00
15.0	1.0	14.5	115.0	0.83	0.56	0.255	21	1.25	85.9	1.1	35.6	0.9	1099.093	1.81E-04	3.70E-04	0.037	1.85E-02	8.3559	1.42E-02	0.00
16.0	1.0	15.5	115.0	0.89	0.60	0.272	21	1.25	85.9	1.1	34.6	0.9	1125.653	1.85E-04	3.70E-04	0.037	1.92E-02	8.3559	1.47E-02	0.00
17.0	1.0	16.5	115.0	0.95	0.64	0.288	16	1.25	69.4	1.0	26.9	0.9	1067.422	2.04E-04	7.10E-04	0.071	4.98E-02	8.3559	3.83E-02	0.01
18.0	1.0	17.5	115.0	1.01	0.67	0.305	16	1.25	69.4	1.0	26.2	0.9	1089.410	2.09E-04	7.10E-04	0.071	5.15E-02	8.3559	3.96E-02	0.01
19.0	1.0	18.5	115.0	1.06	0.71	0.321	16	1.25	69.4	1.0	25.5	0.9	1110.614	2.13E-04	7.10E-04	0.071	5.31E-02	8.3559	4.08E-02	0.01
20.0	1.0	19.5	115.0	1.12	0.75	0.337	38	1.25	100.0	1.0	60.8	0.9	1523.256	1.61E-04	3.70E-04	0.037	9.75E-03	8.3559	7.49E-03	0.00
21.0	1.0	20.5	115.0	1.18	0.79	0.353	38	1.25	100.0	0.9	59.3	0.9	1549.313	1.64E-04	3.70E-04	0.037	1.00E-02	8.3559	7.71E-03	0.00
22.0	1.0	21.5	115.0	1.24	0.83	0.369	38	1.25	100.0	0.9	58.0	0.9	1574.554	1.66E-04	3.70E-04	0.037	1.03E-02	8.3559	7.93E-03	0.00
23.0	1.0	22.5	115.0	1.29	0.87	0.384	38	1.25	100.0	0.9	56.7	0.9	1599.040	1.68E-04	3.70E-04	0.037	1.06E-02	8.3559	8.14E-03	0.00
24.0	1.0	23.5	115.0	1.35	0.91	0.400	38	1.25	100.0	0.9	55.5	0.9	1622.827	1.70E-04	3.70E-04	0.037	1.09E-02	8.3559	8.35E-03	0.00
25.0	1.0	24.5	115.0	1.41	0.94	0.415	38	1.25	100.0	0.9	54.4	0.9	1645.963	1.72E-04	3.70E-04	0.037	1.11E-02	8.3559	8.55E-03	0.00
26.0	1.0	25.5	115.0	1.47	0.98	0.430	38	1.25	100.0	0.8	53.4	0.9	1668.493	1.74E-04	3.70E-04	0.037	1.14E-02	8.3559	8.75E-03	0.00
27.0	1.0	26.5	115.0	1.52	1.02	0.444	38	1.25	100.0	0.8	52.4	0.9	1690.454	1.76E-04	3.00E-04	0.030	9.44E-03	8.3559	7.25E-03	0.00
28.0	1.0	27.5	115.0	1.58	1.06	0.459	36	1.25	83.0	0.8	50.5	0.9	1700.170	1.79E-04	3.00E-04	0.030	9.88E-03	8.3559	7.59E-03	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.473	36	1.25	83.0	0.8	49.6	0.9	1720.533	1.80E-04	3.00E-04	0.030	1.01E-02	8.3559	7.76E-03	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.487	36	1.25	83.0	0.8	48.7	0.9	1740.426	1.81E-04	3.00E-04	0.030	1.03E-02	8.3559	7.92E-03	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.501	36	1.25	83.0	0.8	47.9	0.9	1759.873	1.83E-04	3.00E-04	0.030	1.05E-02	8.3559	8.08E-03	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.514	67	1.25	118.8	0.8	87.7	0.9	2188.143	1.49E-04	3.00E-04	0.030	5.09E-03	8.3559	3.91E-03	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.528	67	1.25	118.8	0.7	86.4	0.9	2211.058	1.50E-04	3.00E-04	0.030	5.18E-03	8.3559	3.98E-03	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.541	67	1.25	118.8	0.7	85.1	0.8	2233.506	1.51E-04	3.00E-04	0.030	5.28E-03	8.3559	4.06E-03	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.553	67	1.25	118.8	0.7	83.8	0.8	2255.513	1.52E-04	3.00E-04	0.030	5.37E-03	8.3559	4.13E-03	0.00
36.0	1.0	35.5	115.0	2.04	1.37	0.566	67	1.25	118.8	0.7	82.7	0.8	2277.098	1.52E-04	3.00E-04	0.030	5.47E-03	8.3559	4.20E-03	0.00
37.0	1.0	36.5	115.0	2.10	1.41	0.578	63	1.25	109.8	0.7	76.6	0.8	2251.603	1.56E-04	3.00E-04	0.030	5.98E-03	8.3559	4.60E-03	0.00
38.0	1.0	37.5	115.0	2.16	1.44	0.590	63	1.25	109.8	0.7	75.6	0.8	2271.980	1.57E-04	3.00E-04	0.030	6.08E-03	8.3559	4.67E-03	0.00
39.0	1.0	38.5	115.0	2.21	1.48	0.602	63	1.25	109.8	0.7	74.6	0.8	2291.999	1.57E-04	3.00E-04	0.030	6.18E-03	8.3559	4.75E-03	0.00
40.0	1.0	39.5	115.0	2.27	1.52	0.613	63	1.25	109.8	0.7	73.7	0.8	2311.674	1.58E-04	3.00E-04	0.030	6.27E-03	8.3559	4.82E-03	0.00
41.0	1.0	40.5	115.0	2.33	1.56	0.624	63	1.25	109.8	0.7	72.8	0.8	2331.019	1.58E-04	3.00E-04	0.030	6.37E-03	8.3559	4.89E-03	0.00
42.0	1.0	41.5	115.0	2.39	1.60	0.635	100	1.25	132.4	0.7	114.1	0.8	2741.343	1.36E-04	3.00E-04	0.030	3.71E-03	8.3559	2.85E-03	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.646	100	1.25	132.4	0.7	112.7	0.8	2763.187	1.36E-04	3.00E-04	0.030	3.77E-03	8.3559	2.89E-03	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.657	100	1.25	132.4	0.6	111.4	0.8	2784.691	1.36E-04	3.00E-04	0.030	3.82E-03	8.3559	2.93E-03	0.00
45.0	1.0	44.5	115.0	2.56	1.71	0.667	100	1.25	132.4	0.6	110.2	0.8	2805.869	1.36E-04	3.00E-04	0.030	3.87E-03	8.3559	2.97E-03	0.00
46.0	1.0	45.5	115.0	2.62	1.75	0.677	100	1.25	132.4	0.6	109.0	0.8	2826.731	1.36E-04	3.00E-04	0.030	3.92E-03	8.3559	3.01E-03	0.00
47.0	1.0	46.5	115.0	2.67	1.79	0.686	100	1.25	127.2	0.6	107.9	0.8	2848.316	1.37E-04	3.00E-04	0.030	3.97E-03	8.3559	3.05E-03	0.00
48.0	1.0	47.5	115.0	2.73	1.83	0.696	100	1.25	127.2	0.6	106.8	0.8	2868.601	1.37E-04	3.00E-04	0.030	4.02E-03	8.3559	3.09E-03	0.00
49.0	1.0	48.5	115.0	2.79	1.87	0.705	100	1.25	127.2	0.6	105.7	0.8	2888.603	1.37E-04	3.00E-04	0.030	4.07E-03	8.3559	3.13E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	0.714	100	1.25	127.2	0.6	104.6	0.8	2908.332	1.37E-04	3.00E-04	0.030	4.12E-03	8.3559	3.17E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	0.722	100	1.25	127.2	0.6	103.5	0.8	2927.797	1.37E-04	3.00E-04	0.030	4.17E-03	8.3559	3.21E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	100	1.25	122.6	0.6	102.5	0.8	2947.007	1.37E-04	3.00E-04	0.030	4.22E-03	8.3559	3.24E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	100	1.25	122.6	0.6	101.6	0.8	2965.970	1.37E-04	3.00E-04	0.030	4.27E-03	8.3559	3.28E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	100	1.25	122.6	0.6	100.6	0.8	2984.695	1.37E-04</						



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA_M (g):	0.720
2/3 PGA_M (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N_{60} :	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4													
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.	
1.0	115.0	0	10.0	1.0	1		77	2.000	25.9	115.0	0.301	0.998	0.231	--	
2.0	115.0	0	10.0	2.0	1		75	2.000	25.9	115.0	0.301	0.993	0.230	--	
3.0	115.0	0	10.0	3.0	1		73	2.000	25.9	115.0	0.301	0.989	0.229	--	
4.0	115.0	0	10.0	4.0	1		71	2.000	25.9	115.0	0.301	0.984	0.228	--	
5.0	115.0	0	10.0	5.0	1		69	2.000	25.9	115.0	0.301	0.979	0.227	--	
6.0	115.0	0	10.0	6.0	1		68	1.817	23.5	115.0	0.262	0.975	0.226	--	
7.0	115.0	0	10.0	7.0	1		66	1.671	21.6	115.0	0.237	0.970	0.225	--	
8.0	115.0	0	33.0	8.0	1	6	118	1.556	66.5	115.0	Inf.	0.966	0.223	--	
9.0	115.0	0	33.0	9.0	1	6	116	1.462	62.5	115.0	Inf.	0.961	0.222	--	
10.0	115.0	0	33.0	10.0	1	6	114	1.382	59.1	115.0	Inf.	0.957	0.221	--	
11.0	115.0	0	33.0	10.0	1	6	114	1.315	56.3	115.0	Inf.	0.952	0.220	--	
12.0	115.0	0	32.0	12.5	1	21	106	1.257	55.6	115.0	Inf.	0.947	0.219	--	
13.0	115.0	0	32.0	12.5	1	21	106	1.205	53.5	115.0	Inf.	0.943	0.218	--	
14.0	115.0	0	32.0	12.5	1	21	106	1.160	51.6	115.0	Inf.	0.938	0.217	--	
15.0	115.0	0	24.0	17.5	1	29	85	1.119	45.2	115.0	Inf.	0.934	0.216	--	
16.0	115.0	0	24.0	17.5	1	29	85	1.082	43.9	115.0	Inf.	0.929	0.215	--	
17.0	115.0	0	24.0	17.5	1	29	85	1.049	42.7	115.0	Inf.	0.925	0.214	--	
18.0	115.0	0	24.0	17.5	1	29	85	1.019	41.6	115.0	Inf.	0.920	0.213	--	
19.0	115.0	0	15.0	22.5	1	24	63	0.991	28.2	115.0	0.345	0.915	0.212	--	
20.0	115.0	0	15.0	22.5	1	24	63	0.965	27.6	115.0	0.328	0.911	0.211	--	
21.0	115.0	0	15.0	22.5	1	24	63	0.941	27.0	115.0	0.315	0.906	0.210	--	
22.0	115.0	0	15.0	22.5	1	24	63	0.919	26.5	115.0	0.304	0.902	0.209	--	
23.0	115.0	0	15.0	22.5	1	24	63	0.898	26.0	115.0	0.294	0.897	0.208	--	
24.0	115.0	0	15.0	22.5	1	24	63	0.879	25.5	115.0	0.286	0.893	0.207	--	
25.0	115.0	0	15.0	22.5	1	24	63	0.861	25.1	115.0	0.279	0.888	0.206	--	
26.0	115.0	0	15.0	22.5	1	24	63	0.844	24.7	115.0	0.272	0.883	0.204	--	
27.0	115.0	0	15.0	22.5	1	24	63	0.828	24.3	115.0	0.266	0.879	0.203	--	
28.0	115.0	0	10.0	27.5	1	16	48	0.813	16.2	115.0	0.166	0.874	0.202	--	
29.0	115.0	0	10.0	27.5	1	16	48	0.798	16.0	115.0	0.164	0.870	0.201	--	
30.0	115.0	0	10.0	27.5	1	16	48	0.785	15.7	115.0	0.162	0.865	0.200	--	
31.0	115.0	0	10.0	27.5	1	16	48	0.772	15.5	115.0	0.159	0.861	0.199	--	
32.0	115.0	0	23.0	32.5	1	16	70	0.759	32.6	115.0	Inf.	0.856	0.198	--	
33.0	115.0	0	23.0	32.5	1	16	70	0.747	32.2	115.0	Inf.	0.851	0.197	--	
34.0	115.0	0	23.0	32.5	1	16	70	0.736	31.7	115.0	Inf.	0.847	0.196	--	
35.0	115.0	0	21.0	35.0	1	16	65	0.725	28.8	115.0	0.339	0.842	0.195	--	
36.0	115.0	0	21.0	35.0	1	16	65	0.715	28.4	115.0	0.327	0.838	0.194	--	
37.0	115.0	0	21.0	35.0	1	16	65	0.705	28.0	115.0	0.317	0.833	0.193	--	
38.0	115.0	0	22.0	37.5	1	8	65	0.696	27.0	115.0	0.287	0.829	0.192	--	
39.0	115.0	0	22.0	37.5	1	8	65	0.687	26.6	115.0	0.280	0.824	0.191	--	
40.0	115.0	0	39.0	42.5	1	22	83	0.678	49.6	115.0	Inf.	0.819	0.190	--	
41.0	115.0	0	39.0	42.5	1	22	83	0.670	49.1	115.0	Inf.	0.815	0.189	--	
42.0	115.0	0	39.0	42.5	1	22	83	0.661	48.5	115.0	Inf.	0.810	0.188	--	
43.0	115.0	0	39.0	42.5	1	22	83	0.654	48.0	115.0	Inf.	0.806	0.186	--	
44.0	115.0	0	39.0	42.5	1	22	83	0.646	47.5	115.0	Inf.	0.801	0.185	--	
45.0	115.0	0	26.0	47.5	1	22	65	0.639	32.7	115.0	Inf.	0.797	0.184	--	
46.0	115.0	0	26.0	47.5	1	22	65	0.632	32.3	115.0	Inf.	0.792	0.183	--	
47.0	115.0	0	26.0	47.5	1	11	65	0.625	29.3	115.0	0.338	0.787	0.182	--	
48.0	115.0	0	26.0	47.5	1	11	65	0.618	29.0	115.0	0.324	0.783	0.181	--	
49.0	115.0	0	26.0	47.5	1	11	65	0.612	28.7	115.0	0.313	0.778	0.180	--	
50.0	115.0	0	32.0	52.5	1	13	69	0.606	35.2	115.0	Inf.	0.774	0.179	--	
51.0	115.0	0	32.0	52.5	1	13	69	0.600	34.8	115.0	Inf.	0.769	0.178	--	
52.0	115.0	0	32.0	52.5	1	13	69	0.594	34.5	115.0	Inf.	0.765	0.177	--	
53.0	115.0	0	32.0	52.5	1	13	69	0.588	34.2	115.0	Inf.	0.760	0.176	--	
54.0	115.0	0	51.0	57.5	1	11	85	0.583	52.7	115.0	Inf.	0.755	0.175	--	
55.0	115.0	0	51.0	57.5	1	11	85	0.577	52.2	115.0	Inf.	0.751	0.174	--	
56.0	115.0	0	51.0	57.5	1	11	85	0.572	51.7	115.0	Inf.	0.746	0.173	--	
57.0	115.0	0	51.0	57.5	1	11	85	0.567	51.3	115.0	Inf.	0.742	0.172	--	
58.0	115.0	0	51.0	57.5	1	11	85	0.562	50.9	115.0	Inf.	0.737	0.171	--	
59.0	115.0	0	51.0	57.5	1	11	85	0.557	50.4	115.0	Inf.	0.733	0.170	--	
60.0	115.0	0	51.0	57.5	1	11	85	0.552	50.0	115.0	Inf.	0.728	0.168	--	
61.0	115.0	0	55.0	62.5	1	11	85	0.548	53.4	115.0	Inf.	0.723	0.167	--	
62.0	115.0	0	55.0	62.5	1	11	85	0.543	53.0	115.0	Inf.	0.719	0.166	--	
63.0	115.0	0	55.0	62.5	1	11	85	0.539	52.6	115.0	Inf.	0.714	0.165	--	
64.0	115.0	0	55.0	62.5	1	11	85	0.535	52.2	115.0	Inf.	0.710	0.164	--	
65.0	115.0	0	55.0	62.5	1	11	85	0.531	51.8	115.0	Inf.	0.705	0.163	--	
66.0	115.0	0	40.0	67.5	1	11	70	0.526	37.8	115.0	Inf.	0.701	0.162	--	
67.0	115.0	0	40.0	67.5	1	11	70	0.523	37.5	115.0	Inf.	0.696	0.161	--	
68.0	115.0	0	40.0	67.5	1	11	70	0.519	37.2	115.0	Inf.	0.691	0.160	--	
69.0	115.0	0	40.0	67.5	1	11	70	0.515	36.9	115.0	Inf.	0.687	0.159	--	
70.0	115.0	0	40.0	67.5	1	11	70	0.511	36.7	115.0	Inf.	0.682	0.158	--	
71.0	115.0	0	55.0	72.5	1	11	80	0.507	49.6	115.0	Inf.	0.678	0.157	--	
72.0	115.0	0	55.0	72.5	1	11	80	0.504	49.2	115.0	Inf.	0.673	0.156	--	
73.0	115.0	0	55.0	72.5	1	11	80	0.500	48.9	115.0	Inf.	0.669	0.155	--	
74.0	115.0	0	55.0	72.5	1	11	80	0.497	48.6	115.0	Inf.	0.664	0.154	--	
75.0	115.0	0	55.0	72.5	1	11	80	0.494	48.3	115.0	Inf.	0.659	0.153	--	
76.0	115.0	0	55.0	77.5	1	14	78	0.490	48.7	115.0	Inf.	0.655	0.152	--	
77.0	115.0	0	55.0	77.5	1	14	78	0.487	48.4	115.0	Inf.	0.650	0.150	--	
78.0	115.0	0	55.0	77.5	1	14	78	0.484	48.1	115.0	Inf.	0.646	0.149	--	
79.0	115.0	0	55.0	77.5	1	14	78	0.481	47.8	115.0	Inf.	0.641	0.148	--	
80.0	115.0	0	55.0	77.5	1	14	78	0.478	47.5	115.0	Inf.	0.637	0.147	--	



TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9
EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS
DESIGN EARTHQUAKE

DE EARTHQUAKE INFORMATION:	
Earthquake Magnitude	6.66
Peak Horiz. Acceleration (g)	0.48(3)

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress (TsV)	Field SPT (N)	Correction Factor [Cor]	Relative Density [Dr] (%)	Correction Factor [Cor]	Corrected [N]160	rd	Maximum Shear Mod. [Gmax] (tsf)	[veff]*[Geff] [Gmax]	veff Shear Strain	[veff]*100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [Nc]	Corrected Vol. Strains [Ec]	Estimated Settlement [S] (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.009	10	1.25	76.6	2.0	25.9	1.0	183.495	4.84E-05	6.00E-05	0.006	4.40E-03	8.3559	3.39E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.027	10	1.25	74.6	2.0	25.9	1.0	317.822	8.22E-05	1.60E-04	0.016	1.17E-02	8.3559	9.03E-03	
3.0	1.0	2.5	115.0	0.14	0.10	0.045	10	1.25	72.7	2.0	25.9	1.0	410.307	1.04E-04	2.30E-04	0.023	1.69E-02	8.3559	1.30E-02	
4.0	1.0	3.5	115.0	0.20	0.13	0.063	10	1.25	70.9	2.0	25.9	1.0	485.482	1.21E-04	1.70E-04	0.017	1.25E-02	8.3559	9.59E-03	
5.0	1.0	4.5	115.0	0.26	0.17	0.081	10	1.25	69.3	2.0	25.9	1.0	550.485	1.34E-04	1.70E-04	0.017	1.25E-02	8.3559	9.59E-03	
6.0	1.0	5.5	115.0	0.32	0.21	0.098	10	1.25	67.7	1.8	23.5	1.0	589.416	1.50E-04	1.50E-04	0.015	1.24E-02	8.3559	9.50E-03	
7.0	1.0	6.5	115.0	0.37	0.25	0.116	10	1.25	66.3	1.7	21.6	1.0	623.169	1.65E-04	1.50E-04	0.015	1.37E-02	8.3559	1.05E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.134	33	1.25	118.0	1.6	66.5	0.9	873.674	1.92E-04	1.50E-04	0.015	1.20E-03	8.3559	2.72E-03	
9.0	1.0	8.5	115.0	0.49	0.33	0.151	33	1.25	115.7	1.5	62.5	1.0	1015.194	1.28E-04	1.50E-04	0.015	3.82E-03	8.3559	2.94E-03	
10.0	1.0	9.5	115.0	0.55	0.37	0.169	33	1.25	113.5	1.4	59.1	1.0	1053.577	1.35E-04	1.50E-04	0.015	4.08E-03	8.3559	3.14E-03	
11.0	1.0	10.5	115.0	0.60	0.40	0.186	33	1.25	113.5	1.3	56.3	1.0	1089.355	1.42E-04	1.50E-04	0.015	4.34E-03	8.3559	3.33E-03	
12.0	1.0	11.5	115.0	0.66	0.44	0.204	32	1.25	106.1	1.3	55.6	0.9	1135.832	1.46E-04	1.50E-04	0.015	4.39E-03	8.3559	3.38E-03	
13.0	1.0	12.5	115.0	0.72	0.48	0.221	32	1.25	106.1	1.2	53.5	0.9	1168.920	1.52E-04	1.50E-04	0.015	4.60E-03	8.3559	3.54E-03	
14.0	1.0	13.5	115.0	0.78	0.52	0.238	32	1.25	106.1	1.2	51.6	0.9	1200.354	1.57E-04	1.60E-04	0.016	5.13E-03	8.3559	3.94E-03	
15.0	1.0	14.5	115.0	0.83	0.56	0.255	24	1.25	85.0	1.1	45.2	0.9	1189.749	1.67E-04	1.60E-04	0.016	6.02E-03	8.3559	4.63E-03	
16.0	1.0	15.5	115.0	0.89	0.60	0.272	24	1.25	85.0	1.1	43.9	0.9	1218.176	1.71E-04	1.60E-04	0.016	6.24E-03	8.3559	4.79E-03	
17.0	1.0	16.5	115.0	0.95	0.64	0.288	24	1.25	85.0	1.0	42.7	0.9	1245.486	1.75E-04	1.60E-04	0.016	6.44E-03	8.3559	4.95E-03	
18.0	1.0	17.5	115.0	1.01	0.67	0.305	24	1.25	85.0	1.0	41.6	0.9	1271.792	1.79E-04	1.60E-04	0.016	6.64E-03	8.3559	5.11E-03	
19.0	1.0	18.5	115.0	1.06	0.71	0.321	15	1.25	62.9	1.0	28.2	0.9	1148.486	2.06E-04	3.70E-04	0.037	2.45E-02	8.3559	1.88E-02	0.00
20.0	1.0	19.5	115.0	1.12	0.75	0.337	15	1.25	62.9	1.0	27.6	0.9	1170.441	2.09E-04	3.70E-04	0.037	2.52E-02	8.3559	1.93E-02	0.00
21.0	1.0	20.5	115.0	1.18	0.79	0.353	15	1.25	62.9	0.9	27.0	0.9	1191.720	2.13E-04	3.70E-04	0.037	2.58E-02	8.3559	1.98E-02	0.00
22.0	1.0	21.5	115.0	1.24	0.83	0.369	15	1.25	62.9	0.9	26.5	0.9	1212.378	2.16E-04	3.70E-04	0.037	2.64E-02	8.3559	2.03E-02	0.00
23.0	1.0	22.5	115.0	1.29	0.87	0.384	15	1.25	62.9	0.9	26.0	0.9	1232.460	2.18E-04	3.70E-04	0.037	2.70E-02	8.3559	2.08E-02	0.00
24.0	1.0	23.5	115.0	1.35	0.91	0.400	15	1.25	62.9	0.9	25.5	0.9	1252.008	2.21E-04	3.70E-04	0.037	2.76E-02	8.3559	2.12E-02	0.01
25.0	1.0	24.5	115.0	1.41	0.94	0.415	15	1.25	62.9	0.9	25.1	0.9	1271.060	2.23E-04	3.70E-04	0.037	2.82E-02	8.3559	2.17E-02	0.01
26.0	1.0	25.5	115.0	1.47	0.98	0.430	15	1.25	62.9	0.8	24.7	0.9	1289.647	2.25E-04	3.70E-04	0.037	2.88E-02	8.3559	2.21E-02	0.01
27.0	1.0	26.5	115.0	1.52	1.02	0.444	15	1.25	62.9	0.8	24.3	0.9	1307.799	2.27E-04	3.00E-04	0.030	2.98E-02	8.3559	1.83E-02	0.00
28.0	1.0	27.5	115.0	1.58	1.06	0.459	10	1.25	48.4	0.8	16.2	0.9	1164.656	2.61E-04	3.00E-04	0.030	3.89E-02	8.3559	1.61E-02	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.473	10	1.25	48.4	0.8	16.0	0.9	1179.694	2.63E-04	3.00E-04	0.030	3.95E-02	8.3559	3.02E-02	0.01
30.0	1.0	29.5	115.0	1.70	1.14	0.487	10	1.25	48.4	0.8	15.7	0.9	1194.414	2.64E-04	3.00E-04	0.030	4.00E-02	8.3559	3.07E-02	0.01
31.0	1.0	30.5	115.0	1.75	1.18	0.501	10	1.25	48.4	0.8	15.5	0.9	1208.832	2.66E-04	3.00E-04	0.030	4.06E-02	8.3559	3.12E-02	0.01
32.0	1.0	31.5	115.0	1.81	1.21	0.514	23	1.25	69.6	0.8	32.6	0.9	1573.335	2.08E-04	3.00E-04	0.030	1.67E-02	8.3559	1.28E-02	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.528	23	1.25	69.6	0.7	32.2	0.9	1590.449	2.09E-04	3.00E-04	0.030	1.70E-02	8.3559	1.30E-02	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.541	23	1.25	69.6	0.7	31.7	0.8	1607.231	2.10E-04	3.00E-04	0.030	1.73E-02	8.3559	1.33E-02	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.553	21	1.25	65.2	0.7	28.8	0.8	1579.182	2.17E-04	3.00E-04	0.030	1.94E-02	8.3559	1.49E-02	0.00
36.0	1.0	35.5	115.0	2.04	1.37	0.566	21	1.25	65.2	0.7	28.4	0.8	1594.988	2.18E-04	3.00E-04	0.030	1.97E-02	8.3559	1.51E-02	0.00
37.0	1.0	36.5	115.0	2.10	1.41	0.578	21	1.25	65.2	0.7	28.0	0.8	1610.455	2.19E-04	3.00E-04	0.030	2.00E-02	8.3559	1.54E-02	0.00
38.0	1.0	37.5	115.0	2.16	1.44	0.590	22	1.25	64.9	0.7	27.0	0.8	1611.617	2.21E-04	3.00E-04	0.030	2.09E-02	8.3559	1.61E-02	0.00
39.0	1.0	38.5	115.0	2.21	1.48	0.602	22	1.25	64.9	0.7	26.6	0.8	1625.972	2.22E-04	3.00E-04	0.030	2.13E-02	8.3559	1.63E-02	0.00
40.0	1.0	39.5	115.0	2.27	1.52	0.613	39	1.25	82.7	0.7	49.6	0.8	2026.327	1.80E-04	1.30E-04	0.013	4.37E-03	8.3559	3.36E-03	0.00
41.0	1.0	40.5	115.0	2.33	1.56	0.624	39	1.25	82.7	0.7	49.1	0.8	2043.977	1.80E-04	1.30E-04	0.013	4.43E-03	8.3559	3.40E-03	0.00
42.0	1.0	41.5	115.0	2.39	1.60	0.635	39	1.25	82.7	0.7	48.5	0.8	2061.353	1.80E-04	1.30E-04	0.013	4.49E-03	8.3559	3.45E-03	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.646	39	1.25	82.7	0.7	48.0	0.8	2078.465	1.81E-04	1.30E-04	0.013	4.55E-03	8.3559	3.50E-03	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.657	39	1.25	82.7	0.6	47.5	0.8	2095.323	1.81E-04	1.30E-04	0.013	4.61E-03	8.3559	3.54E-03	0.00
45.0	1.0	44.5	115.0	2.56	1.71	0.667	26	1.25	64.9	0.6	32.7	0.8	1870.846	2.04E-04	3.00E-04	0.030	1.67E-02	8.3559	1.28E-02	0.00
46.0	1.0	45.5	115.0	2.62	1.75	0.677	26	1.25	64.9	0.6	32.3	0.8	1885.619	2.05E-04	3.00E-04	0.030	1.68E-02	8.3559	1.29E-02	0.00
47.0	1.0	46.5	115.0	2.67	1.79	0.686	26	1.25	64.9	0.6	29.3	0.8	1844.610	2.11E-04	3.00E-04	0.030	1.90E-02	8.3559	1.46E-02	0.00
48.0	1.0	47.5	115.0	2.73	1.83	0.696	26	1.25	64.9	0.6	29.0	0.8	1858.029	2.11E-04	3.00E-04	0.030	1.92E-02	8.3559	1.48E-02	0.00
49.0	1.0	48.5	115.0	2.79	1.87	0.705	26	1.25	64.9	0.6	28.7	0.8	1871.266	2.11E-04	3.00E-04	0.030	1.94E-02	8.3559	1.49E-02	0.00
50.0	1.0	49.5	115.0	2.85	1.91	0.714	32	1.25	69.4	0.6	35.2	0.8	2022.640	1.97E-04	1.30E-04	0.013	6.60E-03	8.3559	5.07E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	0.722	32	1.25	69.4	0.6	34.8	0.8	2036.509	1.97E-04	1.30E-04	0.013	6.68E-03	8.3559	5.13E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	32	1.25	69.4	0.6	34.5	0.8	2050.202	1.96E-04	1.30E-04	0.013	6.75E-03	8.3559	5.19E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	32	1.25	69.4	0.6	34.2	0.8	2063.723	1.96E-04	1.30E-04	0.013	6.83E-03	8.3559	5.25E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	51	1.25	84.6	0.6	52.7	0.8	2405.586	1.69E-04	1.30E-04	0.013	4.07E-03	8.3559	3.13E-03	0.00
55.0	1.0	54.5	115.0	3.13	2.10	0.754	51	1.25	84.6	0.6	52.2	0.8	2420.685	1.69E-04	1.30E-04	0.013	4.			



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA_M (g):	0.720
$2/3 PG_{AV}$ (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):														
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq. Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe Fact.
1.0	115.0	0	11.0	1.0	1		80	2.000	28.5	115.0	0.364	0.998	0.231	--
2.0	115.0	0	11.0	2.0	1	49	78	2.000	35.5	115.0	Infin.	0.993	0.230	--
3.0	115.0	0	11.0	3.0	1	49	76	2.000	35.5	115.0	Infin.	0.989	0.229	--
4.0	115.0	0	11.0	4.0	1	49	74	2.000	35.5	115.0	Infin.	0.984	0.228	--
5.0	115.0	0	11.0	5.0	1	49	73	2.000	35.5	115.0	Infin.	0.979	0.227	--
6.0	115.0	0	13.0	6.0	1	49	77	1.817	37.5	115.0	Infin.	0.975	0.226	--
7.0	115.0	0	13.0	7.0	1	49	75	1.671	39.0	115.0	Infin.	0.970	0.225	--
8.0	115.0	0	13.0	8.0	1	49	74	1.556	33.2	115.0	Infin.	0.966	0.223	--
9.0	115.0	0	13.0	9.0	1	4	73	1.462	24.6	115.0	Infin.	0.279	0.961	0.222
10.0	115.0	0	13.0	10.0	1	4	71	1.382	23.3	115.0	Infin.	0.259	0.957	0.221
11.0	115.0	0	13.0	10.0	1	4	71	1.315	22.1	115.0	Infin.	0.244	0.952	0.220
12.0	115.0	0	13.0	10.0	1	4	71	1.257	21.1	115.0	Infin.	0.231	0.947	0.219
13.0	115.0	0	26.0	12.5	1	4	96	1.205	40.5	115.0	Infin.	0.943	0.218	--
14.0	115.0	0	26.0	12.5	1	4	96	1.160	39.0	115.0	Infin.	0.938	0.217	--
15.0	115.0	0	26.0	12.5	1	4	96	1.119	37.6	115.0	Infin.	0.934	0.216	--
16.0	115.0	0	26.0	12.5	1	4	96	1.082	36.4	115.0	Infin.	0.929	0.215	--
17.0	115.0	0	26.0	12.5	1	4	96	1.049	35.3	115.0	Infin.	0.925	0.214	--
18.0	115.0	0	25.0	17.5	1	3	87	1.019	37.6	115.0	Infin.	0.920	0.213	--
19.0	115.0	0	25.0	17.5	1	3	87	0.991	36.5	115.0	Infin.	0.915	0.212	--
20.0	115.0	0	25.0	17.5	1	3	87	0.965	35.6	115.0	Infin.	0.911	0.211	--
21.0	115.0	0	26.0	17.5	1	3	87	0.941	34.7	115.0	Infin.	0.906	0.210	--
22.0	115.0	0	25.0	17.5	1	3	87	0.919	33.9	115.0	Infin.	0.902	0.209	--
23.0	115.0	0	24.0	22.5	1	3	80	0.898	34.5	115.0	Infin.	0.897	0.208	--
24.0	115.0	0	24.0	22.5	1	3	80	0.879	33.8	115.0	Infin.	0.893	0.207	--
25.0	115.0	0	24.0	22.5	1	3	80	0.861	33.1	115.0	Infin.	0.888	0.206	--
26.0	115.0	0	24.0	22.5	1	3	80	0.844	32.4	115.0	Infin.	0.883	0.204	--
27.0	115.0	0	24.0	22.5	1	3	80	0.828	31.8	115.0	Infin.	0.879	0.203	--
28.0	115.0	0	31.0	27.5	1	3	85	0.813	42.5	115.0	Infin.	0.874	0.202	--
29.0	115.0	0	31.0	27.5	1	3	85	0.798	41.8	115.0	Infin.	0.870	0.201	--
30.0	115.0	0	31.0	27.5	1	3	85	0.785	41.1	115.0	Infin.	0.865	0.200	--
31.0	115.0	0	31.0	27.5	1	3	85	0.772	40.4	115.0	Infin.	0.861	0.199	--
32.0	115.0	0	31.0	27.5	1	3	85	0.759	39.8	115.0	Infin.	0.856	0.198	--
33.0	115.0	0	41.0	32.5	1	3	93	0.747	52.9	115.0	Infin.	0.851	0.197	--
34.0	115.0	0	41.0	32.5	1	3	93	0.736	52.1	115.0	Infin.	0.847	0.196	--
35.0	115.0	0	41.0	32.5	1	3	93	0.725	51.3	115.0	Infin.	0.842	0.195	--
36.0	115.0	0	41.0	32.5	1	3	93	0.715	50.6	115.0	Infin.	0.838	0.194	--
37.0	115.0	0	41.0	32.5	1	3	93	0.705	49.9	115.0	Infin.	0.833	0.193	--
38.0	115.0	0	60.0	37.5	1	5	107	0.696	72.0	115.0	Infin.	0.829	0.192	--
39.0	115.0	0	60.0	37.5	1	5	107	0.687	71.1	115.0	Infin.	0.824	0.191	--
40.0	115.0	0	60.0	37.5	1	5	107	0.678	70.2	115.0	Infin.	0.819	0.190	--
41.0	115.0	0	60.0	37.5	1	5	107	0.670	69.3	115.0	Infin.	0.815	0.189	--
42.0	115.0	0	60.0	37.5	1	5	107	0.661	68.5	115.0	Infin.	0.810	0.188	--
43.0	115.0	0	38.0	42.5	1	5	82	0.654	42.5	115.0	Infin.	0.806	0.186	--
44.0	115.0	0	38.0	42.5	1	5	82	0.646	42.3	115.0	Infin.	0.801	0.185	--
45.0	115.0	0	38.0	42.5	1	5	82	0.639	41.9	115.0	Infin.	0.797	0.184	--
46.0	115.0	0	38.0	42.5	1	5	82	0.632	41.4	115.0	Infin.	0.792	0.183	--
47.0	115.0	0	38.0	42.5	1	5	82	0.625	41.0	115.0	Infin.	0.787	0.182	--
48.0	115.0	0	51.0	47.5	1	3	91	0.618	54.4	115.0	Infin.	0.783	0.181	--
49.0	115.0	0	51.0	47.5	1	3	91	0.612	53.8	115.0	Infin.	0.778	0.180	--
50.0	115.0	0	51.0	47.5	1	3	91	0.606	53.2	115.0	Infin.	0.774	0.179	--
51.0	115.0	0	51.0	47.5	1	3	91	0.600	52.8	115.0	Infin.	0.769	0.178	--
52.0	115.0	0	51.0	47.5	1	3	91	0.594	52.2	115.0	Infin.	0.765	0.177	--
53.0	115.0	0	66.0	52.5	1	3	100	0.588	67.0	115.0	Infin.	0.760	0.176	--
54.0	115.0	0	66.0	52.5	1	3	100	0.583	66.3	115.0	Infin.	0.755	0.175	--
55.0	115.0	0	66.0	52.5	1	3	100	0.577	65.7	115.0	Infin.	0.751	0.174	--
56.0	115.0	0	66.0	52.5	1	3	100	0.572	65.1	115.0	Infin.	0.746	0.173	--
57.0	115.0	0	66.0	52.5	1	3	100	0.567	64.5	115.0	Infin.	0.742	0.172	--
58.0	115.0	0	78.0	57.5	1	5	105	0.562	75.7	115.0	Infin.	0.737	0.171	--
59.0	115.0	0	78.0	57.5	1	5	105	0.557	75.0	115.0	Infin.	0.733	0.170	--
60.0	115.0	0	78.0	57.5	1	5	105	0.552	74.4	115.0	Infin.	0.728	0.168	--
61.0	115.0	0	78.0	57.5	1	5	105	0.548	73.8	115.0	Infin.	0.723	0.167	--
62.0	115.0	0	78.0	57.5	1	5	105	0.543	73.2	115.0	Infin.	0.719	0.166	--
63.0	115.0	0	100.0	62.5	1	5	115	0.539	93.0	115.0	Infin.	0.714	0.165	--
64.0	115.0	0	100.0	62.5	1	5	115	0.534	92.3	115.0	Infin.	0.710	0.164	--
65.0	115.0	0	100.0	62.5	1	5	115	0.531	91.6	115.0	Infin.	0.705	0.163	--
66.0	115.0	0	100.0	62.5	1	5	115	0.526	90.9	115.0	Infin.	0.701	0.162	--
67.0	115.0	0	100.0	62.5	1	5	115	0.523	90.2	115.0	Infin.	0.696	0.161	--
68.0	115.0	0	100.0	67.5	1	3	111	0.519	89.5	115.0	Infin.	0.691	0.160	--
69.0	115.0	0	100.0	67.5	1	3	111	0.515	88.8	115.0	Infin.	0.687	0.159	--
70.0	115.0	0	100.0	67.5	1	3	111	0.511	88.2	115.0	Infin.	0.682	0.158	--
71.0	115.0	0	100.0	67.5	1	3	111	0.507	87.5	115.0	Infin.	0.678	0.157	--
72.0	115.0	0	100.0	67.5	1	3	111	0.504	86.9	115.0	Infin.	0.673	0.156	--
73.0	115.0	0	100.0	72.5	1	3	108	0.500	86.3	115.0	Infin.	0.669	0.155	--
74.0	115.0	0	100.0	72.5	1	3	108	0.497	85.7	115.0	Infin.	0.664	0.154	--
75.0	115.0	0	100.0	72.5	1	3	108	0.494	85.2	115.0	Infin.	0.659	0.153	--
76.0	115.0	0	100.0	72.5	1	3	108	0.490	84.6	115.0	Infin.	0.655	0.152	--
77.0	115.0	0	100.0	72.5	1	3	108	0.487	84.0	115.0	Infin.	0.650	0.150	--
78.0	115.0	0	100.0	77.5	1	2	105	0.484	83.5	115.0	Infin.	0.646	0.149	--
79.0	115.0	0	100.0	77.5	1	2	105	0.481	83.0	115.0	Infin.	0.641	0.148	--
80.0	115.0	0	100.0	77.5	1	2	105	0.478	82.4	115.0	Infin.	0.637	0.147	--
81.0	115.0	0	100.0	77.5	1	2	105	0.475	81.9	115.0	Infin.	0.632	0.146	--
82.0	115.0	0	100.0	77.5	1	2	105	0.472	81.4	115.0	Infin.	0.627	0.145	--
83.0	115.0	0	100.0	82.5	1	2	103	0.469	80.9	115.0	Infin.	0.625	0.145	--
84.0	115.0	0	100.0	82.5	1	2	103	0.466	80.4	115.0	Infin.	0.625	0.145	--
85.0	115.0	0	100.0	82.5	1	2	103	0.464	80.0	115.0	Infin.	0.625	0.145	--
86.0	115.0	0	100.0	82.5	1	2	103	0.461	79.5	115.0	Infin.	0.625	0.145	--
87.0	115.0	0	100.0	82.5	1	2	103	0.458	79.0	115.0	Infin.	0.625	0.145	--
88.0	115.0	0	100.0	87.5	1	3	100							



**TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9
EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS
DESIGN EARTHQUAKE**

DE EARTHQUAKE INFORMATION	
Earthquake Magnitude	6.85
Peak Horiz. Acceleration (g)	0.453

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (psf)	Mean Effective Pressure (psf)	Average Shear Stress (Tav) (psf)	Field SPT (N)	Correction (C) (N)	Relative Density (Dr) (%)	Correction (C) (%)	Corrected N100	rd Factor	Maximum Shear Stress (Gmax) (tsf)	Volume Change Factor (Vc) (%)	ycff Shear Strain (%)	Volume Change Factor (Vc) (%)	Number of Strain Cycles (Nc)	Corrected Settlement (Ecl) (inches)	Estimated Settlement (ES) (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.009	11	1.25	80.4	2.0	26.5	1.0	189.418	4.99E-05	7.80E-05	0.008	5.11E-03	8.3559	3.93E-03
2.0	1.0	1.5	115.0	0.09	0.06	0.027	11	1.25	78.2	2.0	35.5	1.0	193.032	7.40E-05	1.60E-04	0.016	6.05E-03	8.3559	1.16E-03
3.0	1.0	2.5	115.0	0.14	0.10	0.045	11	1.25	76.2	2.0	35.5	1.0	455.763	9.37E-05	2.30E-04	0.023	1.16E-02	8.3559	6.89E-03
4.0	1.0	3.5	115.0	0.20	0.13	0.063	11	1.25	74.4	2.0	35.5	1.0	639.296	1.09E-04	8.10E-04	0.081	4.07E-02	8.3559	3.13E-02
4.5	1.0	4.5	115.0	0.28	0.17	0.081	11	1.25	72.7	2.0	35.5	1.0	811.470	1.21E-04	8.10E-04	0.081	4.07E-02	8.3559	3.13E-02
6.0	1.0	5.5	115.0	0.32	0.21	0.098	13	1.25	77.2	1.8	37.6	1.0	698.068	1.29E-04	4.50E-04	0.045	2.11E-02	8.3559	1.62E-02
7.0	1.0	6.5	115.0	0.37	0.25	0.116	13	1.25	75.6	1.7	35.1	1.0	732.449	1.40E-04	4.50E-04	0.045	2.29E-02	8.3559	1.76E-02
8.0	1.0	7.5	115.0	0.43	0.29	0.134	13	1.25	74.1	1.6	33.2	1.0	772.002	1.51E-04	4.50E-04	0.045	2.45E-02	8.3559	1.88E-02
9.0	1.0	8.5	115.0	0.49	0.33	0.151	13	1.25	72.6	1.5	24.6	1.0	743.741	1.74E-04	4.50E-04	0.045	4.51E-02	8.3559	2.70E-02
10.0	1.0	9.5	115.0	0.55	0.37	0.169	13	1.25	71.3	1.4	23.3	1.0	771.833	1.84E-04	4.50E-04	0.045	3.76E-02	8.3559	2.89E-02
11.0	1.0	10.5	115.0	0.60	0.40	0.186	13	1.25	71.3	1.3	22.1	1.0	798.017	1.93E-04	4.50E-04	0.045	3.99E-02	8.3559	3.07E-02
12.0	1.0	11.5	115.0	0.66	0.44	0.204	13	1.25	71.3	1.3	21.1	0.9	822.596	2.02E-04	1.90E-03	0.100	9.36E-02	8.3559	7.19E-02
13.0	1.0	12.5	115.0	0.72	0.48	0.221	26	1.25	95.6	1.2	40.5	0.9	1065.603	1.66E-04	4.50E-04	0.045	1.93E-02	8.3559	1.48E-02
14.0	1.0	13.5	115.0	0.78	0.52	0.238	26	1.25	95.6	1.2	39.0	0.9	1093.294	1.72E-04	3.70E-04	0.037	1.66E-02	8.3559	1.28E-02
15.0	1.0	14.5	115.0	0.84	0.56	0.255	26	1.25	95.6	1.1	37.4	0.9	1119.644	1.77E-04	3.70E-04	0.037	1.73E-02	8.3559	1.33E-02
16.0	1.0	15.5	115.0	0.89	0.60	0.272	26	1.25	95.6	1.1	36.4	0.9	1144.817	1.82E-04	3.70E-04	0.037	1.80E-02	8.3559	1.39E-02
17.0	1.0	16.5	115.0	0.95	0.64	0.288	26	1.25	95.6	1.0	35.3	0.9	1168.928	1.87E-04	3.70E-04	0.037	1.87E-02	8.3559	1.44E-02
18.0	1.0	17.5	115.0	1.01	0.67	0.305	25	1.25	86.8	1.0	37.6	0.9	1229.361	1.85E-04	3.70E-04	0.037	1.74E-02	8.3559	1.33E-02
19.0	1.0	18.5	115.0	1.06	0.71	0.321	25	1.25	86.8	1.0	36.5	0.9	1252.345	1.89E-04	3.70E-04	0.037	1.79E-02	8.3559	1.36E-02
20.0	1.0	19.5	115.0	1.12	0.75	0.337	25	1.25	86.8	1.0	35.6	0.9	1274.515	1.92E-04	3.70E-04	0.037	1.85E-02	8.3559	1.42E-02
21.0	1.0	20.5	115.0	1.18	0.79	0.353	25	1.25	86.8	0.9	34.7	0.9	1295.940	1.96E-04	3.70E-04	0.037	1.91E-02	8.3559	1.47E-02
22.0	1.0	21.5	115.0	1.24	0.83	0.369	25	1.25	86.8	0.9	33.9	0.9	1316.678	1.99E-04	3.70E-04	0.037	1.96E-02	8.3559	1.51E-02
23.0	1.0	22.5	115.0	1.29	0.87	0.384	24	1.25	79.5	0.9	34.5	0.9	1354.797	1.99E-04	3.70E-04	0.037	1.92E-02	8.3559	1.48E-02
24.0	1.0	23.5	115.0	1.35	0.91	0.400	24	1.25	79.5	0.9	33.8	0.9	1374.578	2.01E-04	7.10E-04	0.071	3.79E-02	8.3559	2.91E-02
25.0	1.0	24.5	115.0	1.41	0.95	0.415	24	1.25	79.5	0.8	33.1	0.9	1393.905	2.04E-04	7.10E-04	0.071	3.86E-02	8.3559	2.96E-02
26.0	1.0	25.5	115.0	1.47	0.98	0.430	24	1.25	79.5	0.8	32.4	0.9	1412.516	2.06E-04	7.10E-04	0.071	3.95E-02	8.3559	3.05E-02
27.0	1.0	26.5	115.0	1.52	1.02	0.444	24	1.25	79.5	0.8	31.8	0.9	1430.744	2.08E-04	5.20E-04	0.052	2.98E-02	8.3559	2.29E-02
28.0	1.0	27.5	115.0	1.58	1.06	0.459	24	1.25	85.2	0.8	42.5	0.9	1606.159	1.89E-04	3.00E-04	0.030	1.21E-02	8.3559	9.32E-03
29.0	1.0	28.5	115.0	1.64	1.10	0.473	24	1.25	85.2	0.8	41.8	0.9	1625.402	1.91E-04	3.00E-04	0.030	1.24E-02	8.3559	9.59E-03
30.0	1.0	29.5	115.0	1.70	1.14	0.487	31	1.25	85.2	0.8	41.1	0.9	1644.168	1.92E-04	3.00E-04	0.030	1.26E-02	8.3559	9.72E-03
31.0	1.0	30.5	115.0	1.75	1.18	0.501	31	1.25	85.2	0.8	40.4	0.9	1662.561	1.93E-04	3.00E-04	0.030	1.29E-02	8.3559	9.92E-03
32.0	1.0	31.5	115.0	1.81	1.21	0.514	31	1.25	85.2	0.8	39.8	0.9	1680.536	1.94E-04	3.00E-04	0.030	1.32E-02	8.3559	1.01E-02
33.0	1.0	32.5	115.0	1.87	1.25	0.528	41	1.25	92.9	0.7	52.9	0.9	1877.168	1.77E-04	3.00E-04	0.030	9.35E-03	8.3559	7.18E-03
34.0	1.0	33.5	115.0	1.93	1.29	0.541	41	1.25	92.9	0.7	52.1	0.8	1896.228	1.78E-04	3.00E-04	0.030	9.52E-03	8.3559	7.31E-03
35.0	1.0	34.5	115.0	1.98	1.33	0.553	41	1.25	92.9	0.7	51.3	0.9	1914.370	1.79E-04	3.00E-04	0.030	9.69E-03	8.3559	7.44E-03
36.0	1.0	35.5	115.0	2.04	1.37	0.566	41	1.25	92.9	0.7	50.6	0.8	1933.235	1.80E-04	3.00E-04	0.030	9.85E-03	8.3559	7.57E-03
37.0	1.0	36.5	115.0	2.10	1.41	0.578	41	1.25	92.9	0.7	49.9	0.8	1951.220	1.80E-04	3.00E-04	0.030	1.00E-02	8.3559	7.70E-03
38.0	1.0	37.5	115.0	2.16	1.44	0.590	60	1.25	107.2	0.7	72.0	0.8	2235.329	1.59E-04	3.00E-04	0.030	6.45E-03	8.3559	4.96E-03
39.0	1.0	38.5	115.0	2.21	1.48	0.602	60	1.25	107.2	0.7	71.1	0.8	2255.025	1.60E-04	3.00E-04	0.030	6.62E-03	8.3559	5.10E-03
40.0	1.0	39.5	115.0	2.27	1.52	0.613	60	1.25	107.2	0.7	70.2	0.8	2274.382	1.60E-04	3.00E-04	0.030	6.65E-03	8.3559	5.11E-03
41.0	1.0	40.5	115.0	2.33	1.56	0.624	60	1.25	107.2	0.7	69.3	0.8	2293.416	1.61E-04	3.00E-04	0.030	6.75E-03	8.3559	5.19E-03
42.0	1.0	41.5	115.0	2.39	1.60	0.635	60	1.25	107.2	0.7	68.5	0.8	2312.185	1.61E-04	3.00E-04	0.030	6.79E-03	8.3559	5.27E-03
43.0	1.0	42.5	115.0	2.44	1.64	0.646	38	1.25	81.6	0.7	42.8	0.8	2001.426	1.88E-04	3.00E-04	0.030	1.20E-02	8.3559	9.24E-03
44.0	1.0	43.5	115.0	2.50	1.68	0.657	38	1.25	81.6	0.6	42.3	0.8	2016.996	1.88E-04	3.00E-04	0.030	1.22E-02	8.3559	9.37E-03
45.0	1.0	44.5	115.0	2.56	1.71	0.667	38	1.25	81.6	0.6	41.6	0.8	2032.320	1.89E-04	3.00E-04	0.030	1.24E-02	8.3559	9.50E-03
46.0	1.0	45.5	115.0	2.62	1.75	0.677	38	1.25	81.6	0.6	41.4	0.8	2047.445	1.89E-04	3.00E-04	0.030	1.25E-02	8.3559	9.63E-03
47.0	1.0	46.5	115.0	2.67	1.79	0.686	38	1.25	81.6	0.6	41.0	0.8	2062.336	1.89E-04	3.00E-04	0.030	1.27E-02	8.3559	9.75E-03
48.0	1.0	47.5	115.0	2.73	1.83	0.696	51	1.25	90.6	0.6	54.4	0.8	2291.054	1.71E-04	3.00E-04	0.030	9.03E-03	8.3559	6.94E-03
49.0	1.0	48.5	115.0	2.79	1.87	0.705	51	1.25	90.6	0.6	53.8	0.8	2307.038	1.71E-04	3.00E-04	0.030	9.14E-03	8.3559	7.07E-03
50.0	1.0	49.5	115.0	2.85	1.91	0.714	51	1.25	90.6	0.6	53.3	0.8	2322.768	1.71E-04	3.00E-04	0.030	9.26E-03	8.3559	7.11E-03
51.0	1.0	50.5	115.0	2.90	1.95	0.722	51	1.25	90.6	0.6	52.8	0.8	2338.305	1.71E-04	3.00E-04	0.030	9.37E-03	8.3559	7.20E-03
52.0	1.0	51.5	115.0	2.96	1.98	0.731	51	1.25	90.6	0.6	52.2	0.8	2353.639	1.71E-04	3.00E-04	0.030	9.47E-03	8.3559	7.26E-03
53.0	1.0	52.5	115.0	3.02	2.02	0.739	66	1.25	99.6	0.6	67.0	0.8	2591.359	1.57E-04	3.00E-04	0.030	7.04E-03	8.3559	5.41E-03
54.0	1.0	53.5	115.0	3.08	2.06	0.747	66	1.25	99.6	0.6	66.3	0.8	2607.646	1.57E-04	3.00E-04	0.030	7.12E-03	8.3559	5.47E-03
55.0	1.0	54.5	115.0	3.13	2.10	0.754	66	1.25	99.6	0.6	65.7	0.8	2623.730	1.57E-04	3.00E-04	0.030	7.20E-03	8.3559	5.53E-03
56.0	1.0	55.5	115.0	3.19	2.14	0.762	66	1.25	99.6	0.6	65.1	0.7	2639.620	1.57E-04	3.00E-04	0.030	7.28E-03	8.3559	5.59E-03
57.0	1.0	56.5	115.0	3.25	2.18	0.769	66	1.25	99.6	0.6	64.5	0.7	2645.319	1.57E-04	3.00E-04	0.030	7.35E-03	8.3	



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA _M (g):	0.720
2/3 PGA _M (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4															
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.			
1.0	115.0	0	13.0	1.0	1		87	2.000	33.6	115.0	Inf.	0.998	0.231	--			
2.0	115.0	0	13.0	2.0	1	21	85	2.000	37.3	115.0	Inf.	0.993	0.230	--			
3.0	115.0	0	13.0	3.0	1	21	83	2.000	37.3	115.0	Inf.	0.989	0.229	--			
4.0	115.0	0	13.0	4.0	1	21	81	2.000	37.3	115.0	Inf.	0.984	0.228	--			
5.0	115.0	0	13.0	5.0	1	21	79	2.000	37.3	115.0	Inf.	0.979	0.227	--			
6.0	115.0	0	13.0	6.0	1	21	77	1.817	34.2	115.0	Inf.	0.975	0.226	--			
7.0	115.0	0	13.0	7.0	1	21	76	1.671	31.8	115.0	Inf.	0.970	0.225	--			
8.0	115.0	0	14.0	8.0	1	21	77	1.556	31.9	115.0	Inf.	0.966	0.223	--			
9.0	115.0	0	14.0	9.0	1	21	75	1.462	30.2	115.0	Inf.	0.961	0.222	--			
10.0	115.0	0	14.0	10.0	1	21	74	1.382	28.7	115.0	0.374	0.957	0.221	--			
11.0	115.0	0	14.0	10.0	1	21	74	1.315	27.5	115.0	0.336	0.952	0.220	--			
12.0	115.0	0	14.0	10.0	1	21	74	1.257	26.4	115.0	0.312	0.947	0.219	--			
13.0	115.0	0	17.0	12.5	1	16	77	1.205	29.1	115.0	0.392	0.943	0.218	--			
14.0	115.0	0	17.0	12.5	1	16	77	1.160	28.1	115.0	0.353	0.938	0.217	--			
15.0	115.0	0	17.0	12.5	1	16	77	1.119	27.2	115.0	0.329	0.934	0.216	--			
16.0	115.0	0	17.0	12.5	1	16	77	1.082	26.4	115.0	0.312	0.929	0.215	--			
17.0	115.0	0	17.0	12.5	1	16	77	1.049	25.7	115.0	0.297	0.925	0.214	--			
18.0	115.0	0	21.0	17.5	1	16	80	1.019	34.2	115.0	Inf.	0.920	0.213	--			
19.0	115.0	0	21.0	17.5	1	16	80	0.991	33.3	115.0	Inf.	0.915	0.212	--			
20.0	115.0	0	21.0	17.5	1	16	80	0.965	32.5	115.0	Inf.	0.911	0.211	--			
21.0	115.0	0	21.0	17.5	1	16	80	0.941	31.8	115.0	Inf.	0.906	0.210	--			
22.0	115.0	0	21.0	17.5	1	16	80	0.919	31.1	115.0	Inf.	0.902	0.209	--			
23.0	115.0	0	9.0	22.5	1	7	49	0.898	13.5	115.0	0.143	0.897	0.208	--			
24.0	115.0	0	9.0	22.5	1	7	49	0.879	13.2	115.0	0.140	0.893	0.207	--			
25.0	115.0	0	9.0	22.5	1	7	49	0.861	12.9	115.0	0.137	0.888	0.206	--			
26.0	115.0	0	9.0	22.5	1	16	49	0.844	14.7	115.0	0.156	0.883	0.204	--			
27.0	115.0	0	9.0	22.5	1	16	49	0.828	14.4	115.0	0.153	0.879	0.203	--			
28.0	115.0	0	38.0	27.5	1	4	94	0.813	52.1	115.0	Inf.	0.874	0.202	--			
29.0	115.0	0	38.0	27.5	1	4	94	0.798	51.2	115.0	Inf.	0.870	0.201	--			
30.0	115.0	0	38.0	27.5	1	4	94	0.785	50.4	115.0	Inf.	0.865	0.200	--			
31.0	115.0	0	38.0	27.5	1	4	94	0.772	49.5	115.0	Inf.	0.861	0.199	--			
32.0	115.0	0	100.0	32.5	1	4	145	0.759	131.0	115.0	Inf.	0.856	0.198	--			
33.0	115.0	0	100.0	32.5	1	4	145	0.747	128.9	115.0	Inf.	0.851	0.197	--			
34.0	115.0	0	100.0	32.5	1	4	145	0.736	127.0	115.0	Inf.	0.847	0.196	--			
35.0	115.0	0	100.0	32.5	1	4	145	0.725	125.1	115.0	Inf.	0.842	0.195	--			
36.0	115.0	0	100.0	32.5	1	4	145	0.715	123.4	115.0	Inf.	0.838	0.194	--			
37.0	115.0	0	100.0	37.5	1	6	138	0.705	121.8	115.0	Inf.	0.833	0.193	--			
38.0	115.0	0	100.0	37.5	1	6	138	0.696	120.2	115.0	Inf.	0.829	0.192	--			
39.0	115.0	0	100.0	37.5	1	6	138	0.687	118.6	115.0	Inf.	0.824	0.191	--			
40.0	115.0	0	100.0	37.5	1	6	138	0.678	117.1	115.0	Inf.	0.819	0.190	--			
41.0	115.0	0	100.0	37.5	1	6	138	0.670	115.6	115.0	Inf.	0.815	0.189	--			
42.0	115.0	0	100.0	42.5	1	6	132	0.661	114.2	115.0	Inf.	0.810	0.188	--			
43.0	115.0	0	100.0	42.5	1	6	132	0.654	112.9	115.0	Inf.	0.806	0.186	--			
44.0	115.0	0	100.0	42.5	1	6	132	0.646	111.6	115.0	Inf.	0.801	0.185	--			
45.0	115.0	0	100.0	42.5	1	6	132	0.639	110.3	115.0	Inf.	0.797	0.184	--			
46.0	115.0	0	100.0	42.5	1	6	132	0.632	109.1	115.0	Inf.	0.792	0.183	--			
47.0	115.0	0	100.0	47.5	1	7	127	0.625	108.2	115.0	Inf.	0.787	0.182	--			
48.0	115.0	0	100.0	47.5	1	7	127	0.618	107.0	115.0	Inf.	0.783	0.181	--			
49.0	115.0	0	100.0	47.5	1	7	127	0.612	105.9	115.0	Inf.	0.778	0.180	--			
50.0	115.0	0	100.0	47.5	1	7	127	0.606	104.9	115.0	Inf.	0.774	0.179	--			
51.0	115.0	0	100.0	47.5	1	7	127	0.600	103.8	115.0	Inf.	0.769	0.178	--			
52.0	115.0	0	100.0	52.5	1	7	123	0.594	102.8	115.0	Inf.	0.765	0.177	--			
53.0	115.0	0	100.0	52.5	1	7	123	0.588	101.8	115.0	Inf.	0.760	0.176	--			
54.0	115.0	0	100.0	52.5	1	7	123	0.583	100.9	115.0	Inf.	0.755	0.175	--			
55.0	115.0	0	100.0	52.5	1	7	123	0.577	100.0	115.0	Inf.	0.751	0.174	--			
56.0	115.0	0	100.0	52.5	1	7	123	0.572	99.1	115.0	Inf.	0.746	0.173	--			
57.0	115.0	0	100.0	57.5	1	9	118	0.567	98.7	115.0	Inf.	0.742	0.172	--			
58.0	115.0	0	100.0	57.5	1	9	118	0.562	97.8	115.0	Inf.	0.737	0.171	--			
59.0	115.0	0	100.0	57.5	1	9	118	0.557	97.0	115.0	Inf.	0.733	0.170	--			
60.0	115.0	0	100.0	57.5	1	9	118	0.552	96.2	115.0	Inf.	0.728	0.168	--			
61.0	115.0	0	100.0	57.5	1	9	118	0.548	95.4	115.0	Inf.	0.723	0.167	--			
62.0	115.0	0	100.0	57.5	1	9	118	0.543	94.6	115.0	Inf.	0.719	0.166	--			
63.0	115.0	0	100.0	57.5	1	9	118	0.539	93.9	115.0	Inf.	0.714	0.165	--			
64.0	115.0	0	100.0	57.5	1	9	118	0.535	93.1	115.0	Inf.	0.710	0.164	--			
65.0	115.0	0	100.0	57.5	1	9	118	0.531	92.4	115.0	Inf.	0.705	0.163	--			

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 6 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS DESIGN EARTHQUAKE

DE EARTHQUAKE INFORMATION:

Earthquake Magnitude	6.66
Peak Horiz. Acceleration (g)	0.480

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress [Tav] (tsf)	Field SPT [N]	Correction Factor [Ccr]	Relative Density [Dr] (%)	Correction Factor [Cn]	Corrected [N]160	rd Factor	Maximum Shear Mod. [Gmax] (tsf)	[veff]*[Geff] [Gmax]	shear Strain [veff]*100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [Nc]	Corrected Vol. Strains [Ecl]	Estimated Settlement [S] (inches)	
1.0	1.0	0.5	115.0	0.03	0.02	0.009	13	1.25	87.4	2.0	33.6	1.0	200.265	4.44E-05	7.80E-05	0.008	4.18E-03	8.3559	3.21E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.027	13	1.25	85.0	2.0	37.3	1.0	359.105	7.28E-05	1.60E-04	0.016	7.57E-03	8.3559	5.82E-03	
3.0	1.0	2.5	115.0	0.14	0.10	0.045	13	1.25	82.9	2.0	37.3	1.0	463.602	9.21E-05	2.30E-04	0.023	1.09E-02	8.3559	8.36E-03	
4.0	1.0	3.5	115.0	0.20	0.13	0.063	13	1.25	80.9	2.0	37.3	1.0	548.542	1.07E-04	8.10E-04	0.081	3.83E-02	8.3559	2.94E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.081	13	1.25	79.0	2.0	37.3	1.0	621.988	1.19E-04	8.10E-04	0.081	3.83E-02	8.3559	2.94E-02	
6.0	1.0	5.5	115.0	0.32	0.21	0.098	13	1.25	77.2	1.8	34.2	1.0	668.178	1.33E-04	4.50E-04	0.045	2.36E-02	8.3559	1.81E-02	CUT
7.0	1.0	6.5	115.0	0.37	0.25	0.116	13	1.25	75.6	1.7	31.8	1.0	708.642	1.45E-04	4.50E-04	0.045	2.58E-02	8.3559	1.98E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.134	14	1.25	76.9	1.6	31.9	1.0	761.778	1.53E-04	4.50E-04	0.045	2.57E-02	8.3559	1.98E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.151	14	1.25	75.4	1.5	30.2	1.0	796.206	1.63E-04	4.50E-04	0.045	2.75E-02	8.3559	2.11E-02	
10.0	1.0	9.5	115.0	0.55	0.37	0.169	14	1.25	74.0	1.4	28.7	1.0	828.200	1.72E-04	4.50E-04	0.045	2.91E-02	8.3559	2.24E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.186	14	1.25	74.0	1.3	27.5	1.0	858.172	1.80E-04	4.50E-04	0.045	3.07E-02	8.3559	2.36E-02	0.01
12.0	1.0	11.5	115.0	0.66	0.44	0.204	14	1.25	74.0	1.3	26.4	0.9	886.429	1.87E-04	4.50E-04	0.045	3.22E-02	8.3559	2.47E-02	0.01
13.0	1.0	12.5	115.0	0.72	0.48	0.221	17	1.25	77.3	1.2	29.1	0.9	954.332	1.86E-04	4.50E-04	0.045	2.87E-02	8.3559	2.20E-02	0.01
14.0	1.0	13.5	115.0	0.78	0.52	0.238	17	1.25	77.3	1.2	28.1	0.9	980.278	1.92E-04	3.70E-04	0.037	2.46E-02	8.3559	1.89E-02	0.00
15.0	1.0	14.5	115.0	0.83	0.56	0.255	17	1.25	77.3	1.1	27.2	0.9	1005.038	1.98E-04	3.70E-04	0.037	2.56E-02	8.3559	1.96E-02	0.00
16.0	1.0	15.5	115.0	0.89	0.60	0.272	17	1.25	77.3	1.1	26.4	0.9	1028.745	2.03E-04	7.10E-04	0.071	5.08E-02	8.3559	3.91E-02	0.01
17.0	1.0	16.5	115.0	0.95	0.64	0.288	17	1.25	77.3	1.0	25.7	0.9	1051.508	2.08E-04	7.10E-04	0.071	5.26E-02	8.3559	4.04E-02	0.01
18.0	1.0	17.5	115.0	1.01	0.67	0.305	21	1.25	79.5	1.0	34.2	0.9	1191.116	1.91E-04	3.70E-04	0.037	1.94E-02	8.3559	1.49E-02	0.00
19.0	1.0	18.5	115.0	1.06	0.71	0.321	21	1.25	79.5	1.0	33.3	0.9	1214.255	1.95E-04	3.70E-04	0.037	2.01E-02	8.3559	1.54E-02	0.00
20.0	1.0	19.5	115.0	1.12	0.75	0.337	21	1.25	79.5	1.0	32.5	0.9	1236.612	1.98E-04	3.70E-04	0.037	2.06E-02	8.3559	1.59E-02	0.00
21.0	1.0	20.5	115.0	1.18	0.79	0.353	21	1.25	79.5	0.9	31.8	0.9	1258.252	2.01E-04	7.10E-04	0.071	4.07E-02	8.3559	3.13E-02	0.01
22.0	1.0	21.5	115.0	1.24	0.83	0.369	21	1.25	79.5	0.9	31.1	0.9	1279.231	2.04E-04	7.10E-04	0.071	4.18E-02	8.3559	3.21E-02	0.01
23.0	1.0	22.5	115.0	1.29	0.87	0.384	9	1.25	48.7	0.9	13.5	0.9	989.732	2.72E-04	7.10E-04	0.071	1.14E-01	8.3559	8.78E-02	0.02
24.0	1.0	23.5	115.0	1.35	0.91	0.400	9	1.25	48.7	0.9	13.2	0.9	1004.463	2.75E-04	7.10E-04	0.071	1.17E-01	8.3559	9.01E-02	0.02
25.0	1.0	24.5	115.0	1.41	0.94	0.415	9	1.25	48.7	0.9	12.9	0.9	1018.792	2.78E-04	7.10E-04	0.071	1.20E-01	8.3559	9.23E-02	0.02
26.0	1.0	25.5	115.0	1.47	0.98	0.430	9	1.25	48.7	0.8	14.7	0.9	1084.634	2.68E-04	7.10E-04	0.071	1.03E-01	8.3559	7.91E-02	0.02
27.0	1.0	26.5	115.0	1.52	1.02	0.444	9	1.25	48.7	0.8	14.4	0.9	1099.851	2.70E-04	5.20E-04	0.052	7.69E-02	8.3559	5.91E-02	0.01
28.0	1.0	27.5	115.0	1.58	1.06	0.459	38	1.25	94.3	0.8	52.1	0.9	1718.947	1.77E-04	3.00E-04	0.030	9.50E-03	8.3559	7.30E-03	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.473	38	1.25	94.3	0.8	51.2	0.9	1739.535	1.78E-04	3.00E-04	0.030	9.70E-03	8.3559	7.46E-03	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.487	38	1.25	94.3	0.8	50.4	0.9	1759.647	1.79E-04	3.00E-04	0.030	9.91E-03	8.3559	7.61E-03	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.501	38	1.25	94.3	0.8	49.5	0.9	1779.309	1.81E-04	3.00E-04	0.030	1.01E-02	8.3559	7.77E-03	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.514	100	1.25	145.1	0.8	131.0	0.9	2500.638	1.31E-04	3.00E-04	0.030	3.15E-03	8.3559	2.42E-03	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.528	100	1.25	145.1	0.7	128.9	0.9	2526.825	1.31E-04	3.00E-04	0.030	3.21E-03	8.3559	2.46E-03	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.541	100	1.25	145.1	0.7	127.0	0.8	2552.479	1.32E-04	3.00E-04	0.030	3.26E-03	8.3559	2.51E-03	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.553	100	1.25	145.1	0.7	125.1	0.8	2577.629	1.33E-04	3.00E-04	0.030	3.32E-03	8.3559	2.55E-03	0.00
36.0	1.0	35.5	115.0	2.04	1.37	0.566	100	1.25	145.1	0.7	123.4	0.8	2602.296	1.33E-04	3.00E-04	0.030	3.38E-03	8.3559	2.60E-03	0.00
37.0	1.0	36.5	115.0	2.10	1.41	0.578	100	1.25	138.4	0.7	121.8	0.8	2627.512	1.34E-04	3.00E-04	0.030	3.43E-03	8.3559	2.64E-03	0.00
38.0	1.0	37.5	115.0	2.16	1.44	0.590	100	1.25	138.4	0.7	120.2	0.8	2651.306	1.34E-04	3.00E-04	0.030	3.49E-03	8.3559	2.68E-03	0.00
39.0	1.0	38.5	115.0	2.21	1.48	0.602	100	1.25	138.4	0.7	118.6	0.8	2674.680	1.35E-04	3.00E-04	0.030	3.54E-03	8.3559	2.72E-03	0.00
40.0	1.0	39.5	115.0	2.27	1.52	0.613	100	1.25	138.4	0.7	117.1	0.8	2697.654	1.35E-04	3.00E-04	0.030	3.60E-03	8.3559	2.77E-03	0.00
41.0	1.0	40.5	115.0	2.33	1.56	0.624	100	1.25	138.4	0.7	115.6	0.8	2720.243	1.35E-04	3.00E-04	0.030	3.65E-03	8.3559	2.81E-03	0.00
42.0	1.0	41.5	115.0	2.39	1.60	0.635	100	1.25	132.4	0.7	114.2	0.8	2742.464	1.36E-04	3.00E-04	0.030	3.71E-03	8.3559	2.85E-03	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.646	100	1.25	132.4	0.7	112.9	0.8	2764.330	1.36E-04	3.00E-04	0.030	3.76E-03	8.3559	2.89E-03	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.657	100	1.25	132.4	0.6	111.6	0.8	2785.857	1.36E-04	3.00E-04	0.030	3.81E-03	8.3559	2.93E-03	0.00
45.0	1.0	44.5	115.0	2.56	1.71	0.667	100	1.25	132.4	0.6	110.3	0.8	2807.056	1.36E-04	3.00E-04	0.030	3.86E-03	8.3559	2.97E-03	0.00
46.0	1.0	45.5	115.0	2.62	1.75	0.677	100	1.25	132.4	0.6	109.1	0.8	2827.941	1.36E-04	3.00E-04	0.030	3.92E-03	8.3559	3.01E-03	0.00
47.0	1.0	46.5	115.0	2.67	1.79	0.686	100	1.25	127.2	0.6	108.2	0.8	2850.778	1.36E-04	3.00E-04	0.030	3.96E-03	8.3559	3.04E-03	0.00
48.0	1.0	47.5	115.0	2.73	1.83	0.696	100	1.25	127.2	0.6	107.0	0.8	2871.106	1.36E-04	3.00E-04	0.030	4.01E-03	8.3559	3.08E-03	0.00
49.0	1.0	48.5	115.0	2.79	1.87	0.705	100	1.25	127.2	0.6	105.9	0.8	2891.152	1.37E-04	3.00E-04	0.030	4.06E-03	8.3559	3.12E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	0.714	100	1.25	127.2	0.6	104.9	0.8	2910.925	1.37E-04	3.00E-04	0.030	4.11E-03	8.3559	3.16E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	0.722	100	1.25	127.2	0.6	103.8	0.8	2930.434	1.37E-04	3.00E-04	0.030	4.16E-03	8.3559	3.19E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	100	1.25	122.6	0.6	102.8	0.8	2949.687	1.37E-04	3.00E-04	0.030	4.21E-03	8.3559	3.23E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	100	1.25	122.6	0.6	101.8	0.8	2968.694	1.36E-04	3.00E-04	0.030	4.25E-03	8.3559	3.27E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	100	1.25	122.6	0.6	100.9	0.8	2987.461	1.36E-04	3.00E-04	0.030	4.30E-03	8.3559	3.31E-03	0.00
55.0	1.0	54.5	115.0																	



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEE (1996) METHOD

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA_M (g):	0.720
2/3 PGA_M (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N_{60} :	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf): 62.4

Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.
1.0	115.0	0	13.0	1.0	1		87	2.000	33.6	115.0	Inf.	0.998	0.231	--
2.0	115.0	0	13.0	2.0	1	50	85	2.000	40.6	115.0	Inf.	0.993	0.230	--
3.0	115.0	0	13.0	3.0	1	50	83	2.000	40.6	115.0	Inf.	0.989	0.229	--
4.0	115.0	0	13.0	4.0	1	50	81	2.000	40.6	115.0	Inf.	0.984	0.228	--
5.0	115.0	0	13.0	5.0	1	50	79	2.000	40.6	115.0	Inf.	0.979	0.227	--
6.0	115.0	0	13.0	6.0	1	50	77	1.817	37.6	115.0	Inf.	0.975	0.226	--
7.0	115.0	0	13.0	7.0	1	50	75	1.871	35.1	115.0	Inf.	0.970	0.225	--
8.0	115.0	0	19.0	8.0	1	50	90	1.556	45.2	115.0	Inf.	0.966	0.223	--
9.0	115.0	0	19.0	9.0	1	50	88	1.462	42.9	115.0	Inf.	0.961	0.222	--
10.0	115.0	0	19.0	10.0	1	50	86	1.382	41.0	115.0	Inf.	0.957	0.221	--
11.0	115.0	0	19.0	10.0	1	50	86	1.315	39.3	115.0	Inf.	0.952	0.220	--
12.0	115.0	0	19.0	12.5	1	3	82	1.257	30.9	115.0	Inf.	0.947	0.219	--
13.0	115.0	0	19.0	12.5	1	3	82	1.205	29.6	115.0	Inf.	0.943	0.218	--
14.0	115.0	0	19.0	12.5	1	65	82	1.160	35.5	115.0	Inf.	0.938	0.217	--
15.0	115.0	0	19.0	12.5	1	65	82	1.119	34.5	115.0	Inf.	0.934	0.216	--
16.0	115.0	0	45.0	17.5	1	3	116	1.082	71.9	115.0	Inf.	0.929	0.215	--
17.0	115.0	0	45.0	17.5	1	3	116	1.049	69.7	115.0	Inf.	0.925	0.214	--
18.0	115.0	0	45.0	17.5	1	3	116	1.019	67.6	115.0	Inf.	0.920	0.213	--
19.0	115.0	0	45.0	17.5	1	3	116	0.991	65.8	115.0	Inf.	0.915	0.212	--
20.0	115.0	0	45.0	17.5	1	3	116	0.965	64.1	115.0	Inf.	0.911	0.211	--
21.0	115.0	0	45.0	17.5	1	3	116	0.941	62.5	115.0	Inf.	0.906	0.210	--
22.0	115.0	0	45.0	17.5	1	3	116	0.919	61.0	115.0	Inf.	0.902	0.209	--
23.0	115.0	0	44.0	22.5	1	3	108	0.898	63.2	115.0	Inf.	0.897	0.208	--
24.0	115.0	0	44.0	22.5	1	3	108	0.879	61.9	115.0	Inf.	0.893	0.207	--
25.0	115.0	0	44.0	22.5	1	3	108	0.861	60.6	115.0	Inf.	0.888	0.206	--
26.0	115.0	0	44.0	22.5	1	3	108	0.844	59.4	115.0	Inf.	0.883	0.204	--
27.0	115.0	0	44.0	22.5	1	3	108	0.828	58.3	115.0	Inf.	0.879	0.203	--
28.0	115.0	0	42.0	27.5	1	4	99	0.813	57.6	115.0	Inf.	0.874	0.202	--
29.0	115.0	0	42.0	27.5	1	4	99	0.798	56.6	115.0	Inf.	0.870	0.201	--
30.0	115.0	0	42.0	27.5	1	4	99	0.785	55.7	115.0	Inf.	0.865	0.200	--
31.0	115.0	0	42.0	27.5	1	4	99	0.772	54.7	115.0	Inf.	0.861	0.199	--
32.0	115.0	0	42.0	27.5	1	4	99	0.759	53.9	115.0	Inf.	0.856	0.198	--
33.0	115.0	0	53.0	32.5	1	4	106	0.747	68.3	115.0	Inf.	0.851	0.197	--
34.0	115.0	0	53.0	32.5	1	4	106	0.736	67.3	115.0	Inf.	0.847	0.196	--
35.0	115.0	0	53.0	32.5	1	4	106	0.725	66.3	115.0	Inf.	0.842	0.195	--
36.0	115.0	0	53.0	32.5	1	4	106	0.715	65.4	115.0	Inf.	0.838	0.194	--
37.0	115.0	0	53.0	32.5	1	4	106	0.705	64.5	115.0	Inf.	0.833	0.193	--
38.0	115.0	0	45.0	37.5	1	4	93	0.696	54.0	115.0	Inf.	0.829	0.192	--
39.0	115.0	0	45.0	37.5	1	4	93	0.687	53.3	115.0	Inf.	0.824	0.191	--
40.0	115.0	0	45.0	37.5	1	4	93	0.678	52.6	115.0	Inf.	0.819	0.190	--
41.0	115.0	0	45.0	37.5	1	4	93	0.670	52.0	115.0	Inf.	0.815	0.189	--
42.0	115.0	0	45.0	37.5	1	4	93	0.661	51.3	115.0	Inf.	0.810	0.188	--
43.0	115.0	0	53.0	42.5	1	4	96	0.654	59.8	115.0	Inf.	0.806	0.186	--
44.0	115.0	0	53.0	42.5	1	4	96	0.646	59.1	115.0	Inf.	0.801	0.185	--
45.0	115.0	0	53.0	42.5	1	4	96	0.639	58.4	115.0	Inf.	0.797	0.184	--
46.0	115.0	0	53.0	42.5	1	4	96	0.632	57.8	115.0	Inf.	0.792	0.183	--
47.0	115.0	0	53.0	42.5	1	4	96	0.625	57.1	115.0	Inf.	0.787	0.182	--
48.0	115.0	0	82.0	47.5	1	4	115	0.618	87.5	115.0	Inf.	0.783	0.181	--
49.0	115.0	0	82.0	47.5	1	4	115	0.612	86.5	115.0	Inf.	0.778	0.180	--
50.0	115.0	0	82.0	47.5	1	4	115	0.606	85.7	115.0	Inf.	0.774	0.179	--
51.0	115.0	0	82.0	47.5	1	4	115	0.600	84.8	115.0	Inf.	0.769	0.178	--
52.0	115.0	0	82.0	47.5	1	4	115	0.594	84.0	115.0	Inf.	0.765	0.177	--
53.0	115.0	0	59.0	52.5	1	4	94	0.588	59.9	115.0	Inf.	0.760	0.176	--
54.0	115.0	0	59.0	52.5	1	4	94	0.583	59.3	115.0	Inf.	0.755	0.175	--
55.0	115.0	0	59.0	52.5	1	4	94	0.577	58.7	115.0	Inf.	0.751	0.174	--
56.0	115.0	0	59.0	52.5	1	4	94	0.572	58.2	115.0	Inf.	0.746	0.173	--
57.0	115.0	0	59.0	52.5	1	4	94	0.567	57.7	115.0	Inf.	0.742	0.172	--
58.0	115.0	0	54.0	57.5	1	4	87	0.562	52.3	115.0	Inf.	0.737	0.171	--
59.0	115.0	0	54.0	57.5	1	4	87	0.557	51.9	115.0	Inf.	0.733	0.170	--
60.0	115.0	0	54.0	57.5	1	4	87	0.552	51.5	115.0	Inf.	0.728	0.168	--
61.0	115.0	0	54.0	57.5	1	4	87	0.548	51.0	115.0	Inf.	0.723	0.167	--
62.0	115.0	0	54.0	57.5	1	4	87	0.543	50.6	115.0	Inf.	0.719	0.166	--
63.0	115.0	0	67.0	62.5	1	4	94	0.539	62.3	115.0	Inf.	0.714	0.165	--
64.0	115.0	0	67.0	62.5	1	4	94	0.535	61.8	115.0	Inf.	0.710	0.164	--
65.0	115.0	0	67.0	62.5	1	4	94	0.531	61.3	115.0	Inf.	0.705	0.163	--
66.0	115.0	0	67.0	62.5	1	4	94	0.526	60.8	115.0	Inf.	0.701	0.162	--
67.0	115.0	0	67.0	62.5	1	4	94	0.523	60.4	115.0	Inf.	0.696	0.161	--
68.0	115.0	0	100.0	67.5	1	3	111	0.519	89.5	115.0	Inf.	0.691	0.160	--
69.0	115.0	0	100.0	67.5	1	3	111	0.515	88.8	115.0	Inf.	0.687	0.159	--
70.0	115.0	0	100.0	67.5	1	3	111	0.511	88.2	115.0	Inf.	0.682	0.158	--
71.0	115.0	0	100.0	67.5	1	3	111	0.507	87.5	115.0	Inf.	0.678	0.157	--
72.0	115.0	0	100.0	67.5	1	3	111	0.504	86.9	115.0	Inf.	0.673	0.156	--
73.0	115.0	0	100.0	72.5	1	3	108	0.500	86.3	115.0	Inf.	0.669	0.155	--
74.0	115.0	0	100.0	72.5	1	3	108	0.497	85.7	115.0	Inf.	0.664	0.154	--
75.0	115.0	0	100.0	72.5	1	3	108	0.494	85.2	115.0	Inf.	0.659	0.153	--
76.0	115.0	0	100.0	72.5	1	3	108	0.490	84.6	115.0	Inf.	0.655	0.152	--
77.0	115.0	0	100.0	72.5	1	3	108	0.487	84.0	115.0	Inf.	0.650	0.150	--
78.0	115.0	0	100.0	77.5	1	4	105	0.484	83.5	115.0	Inf.	0.646	0.149	--
79.0	115.0	0	100.0	77.5	1	4	105	0.481	83.0	115.0	Inf.	0.641	0.148	--
80.0	115.0	0	100.0	77.5	1	4	105	0.478	82.4	115.0	Inf.	0.637	0.147	--
81.0	115.0	0	100.0	77.5	1	4	105	0.475	81.9	115.0	Inf.	0.632	0.146	--
82.0	115.0	0	100.0	77.5	1	4	105	0.472	81.4	115.0	Inf.	0.627	0.145	--
83.0	115.0	0	100.0	82.5	1	4	103	0.469	90.9	115.0	Inf.	0.625	0.145	--
84.0	115.0	0	100.0	82.5	1	4	103	0.466	90.4	115.0	Inf.	0.625	0.145	--
85.0	115.0	0	100.0	82.5	1	4	103	0.464	90.0	115.0	Inf.	0.625	0.145	--
86.0	115.0	0	100.0	82.5	1	4	103	0.461	89.5	115.0	Inf.	0.625	0.145	--
87.0	115.0	0	100.0	82.5	1	4	103	0.458	89.0	115.0	Inf.	0.625	0.145	--
88.0	115.0	0	100.0	87.5	1									



TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9
EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS
DESIGN EARTHQUAKE

DE EARTHQUAKE INFORMATION:

Earthquake Magnitude	6.65
Peak Horiz. Acceleration (g)	0.483

Fig 1.4 Fig 2.4

Fig 4.4

Depth of Base of Struts (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (psf)	Mean Effective Pressure at Mid-point (psf)	Average Cyclic Shear Stress (Tavg)	Field Factor	Correction Factor (Cf)	Relative Density (%)	Correction Factor (Cf)	Corrected Density (pcf)	rd Factor	Maximum Shear Modulus (G)	gamma (Cent)	gamma (Strain)	gamma (100%)	Volumetric Strain (%)	Number of Strain Cycles	Corrected Vol. Strains	Estimated Settlement (S) (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.009	13	1.25	87.4	2.0	33.6	1.0	200.265	4.44E-05	7.80E-05	0.008	4.18E-03	8.3559	3.21E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.027	13	1.25	85.0	2.0	40.6	1.0	369.431	7.07E-05	1.60E-04	0.016	6.83E-03	8.3559	5.25E-03	
3.0	1.0	2.5	115.0	0.14	0.10	0.045	13	1.25	82.9	2.0	40.6	1.0	476.934	8.96E-05	1.90E-04	0.019	8.11E-03	8.3559	6.24E-03	
4.0	1.0	3.5	115.0	0.20	0.13	0.063	13	1.25	80.9	2.0	40.6	1.0	564.315	1.04E-04	8.10E-04	0.081	3.46E-02	8.3559	2.66E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.081	13	1.25	79.0	2.0	40.6	1.0	639.873	1.16E-04	8.10E-04	0.081	3.46E-02	8.3559	2.66E-02	
6.0	1.0	5.5	115.0	0.32	0.21	0.098	13	1.25	77.2	1.8	37.6	1.0	689.068	1.29E-04	4.50E-04	0.045	2.11E-02	8.3559	1.62E-02	
7.0	1.0	6.5	115.0	0.37	0.25	0.116	13	1.25	75.6	1.7	35.1	1.0	732.449	1.40E-04	4.50E-04	0.045	2.29E-02	8.3559	1.76E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.134	19	1.25	89.6	1.6	45.2	1.0	856.191	1.36E-04	4.50E-04	0.045	1.89E-02	8.3559	1.30E-02	
9.0	1.0	8.5	115.0	0.48	0.33	0.151	19	1.25	87.8	1.5	42.9	1.0	896.631	1.45E-04	4.50E-04	0.045	1.80E-02	8.3559	1.38E-02	
10.0	1.0	9.5	115.0	0.55	0.37	0.169	19	1.25	86.2	1.4	41.0	1.0	932.340	1.53E-04	4.50E-04	0.045	1.90E-02	8.3559	1.46E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.186	19	1.25	86.2	1.3	39.3	1.0	966.777	1.60E-04	4.50E-04	0.045	2.00E-02	8.3559	1.54E-02	
12.0	1.0	11.5	115.0	0.64	0.44	0.204	19	1.25	84.4	1.2	37.6	1.0	1001.114	1.67E-04	4.50E-04	0.045	2.07E-02	8.3559	1.62E-02	
13.0	1.0	12.5	115.0	0.72	0.48	0.221	19	1.25	81.7	1.2	29.6	0.9	959.818	1.85E-04	4.50E-04	0.045	2.81E-02	8.3559	2.16E-02	
14.0	1.0	13.5	115.0	0.78	0.52	0.238	19	1.25	81.7	1.2	35.5	0.9	1059.541	1.78E-04	3.70E-04	0.037	1.86E-02	8.3559	1.43E-02	
15.0	1.0	14.5	115.0	0.83	0.56	0.255	19	1.25	81.7	1.1	34.5	0.9	1087.669	1.83E-04	3.70E-04	0.037	1.92E-02	8.3559	1.48E-02	
16.0	1.0	15.5	115.0	0.89	0.60	0.272	45	1.25	116.4	1.1	71.9	0.9	1436.156	1.45E-04	3.70E-04	0.037	7.97E-03	8.3559	6.13E-03	
17.0	1.0	16.5	115.0	0.95	0.64	0.288	45	1.25	116.4	1.0	69.7	0.9	1466.400	1.49E-04	3.70E-04	0.037	8.29E-03	8.3559	6.36E-03	
18.0	1.0	17.5	115.0	1.01	0.67	0.305	45	1.25	116.4	1.0	67.6	0.9	1495.445	1.52E-04	3.70E-04	0.037	8.57E-03	8.3559	6.58E-03	
19.0	1.0	18.5	115.0	1.06	0.71	0.321	45	1.25	116.4	1.0	65.8	0.9	1523.404	1.55E-04	3.70E-04	0.037	8.86E-03	8.3559	6.81E-03	
20.0	1.0	19.5	115.0	1.12	0.75	0.337	45	1.25	116.4	1.0	64.1	0.9	1550.372	1.58E-04	3.70E-04	0.037	9.15E-03	8.3559	7.03E-03	
21.0	1.0	20.5	115.0	1.18	0.79	0.353	45	1.25	116.4	0.9	62.5	0.9	1576.434	1.61E-04	3.70E-04	0.037	9.43E-03	8.3559	7.25E-03	
22.0	1.0	21.5	115.0	1.24	0.83	0.369	45	1.25	116.4	0.9	61.0	0.9	1601.661	1.63E-04	3.70E-04	0.037	9.70E-03	8.3559	7.46E-03	
23.0	1.0	22.5	115.0	1.29	0.87	0.384	44	1.25	107.7	0.9	63.2	0.9	1658.140	1.62E-04	3.70E-04	0.037	9.29E-03	8.3559	7.14E-03	
24.0	1.0	23.5	115.0	1.35	0.91	0.400	44	1.25	107.7	0.9	61.9	0.9	1682.350	1.64E-04	3.70E-04	0.037	9.54E-03	8.3559	7.35E-03	
25.0	1.0	24.5	115.0	1.41	0.94	0.415	44	1.25	107.7	0.9	60.4	0.9	1705.983	1.65E-04	3.70E-04	0.037	9.78E-03	8.3559	7.52E-03	
26.0	1.0	25.5	115.0	1.47	0.98	0.430	44	1.25	107.7	0.8	59.4	0.9	1728.783	1.68E-04	3.70E-04	0.037	1.00E-02	8.3559	7.70E-03	
27.0	1.0	26.5	115.0	1.52	1.02	0.444	44	1.25	107.7	0.8	58.3	0.9	1751.093	1.70E-04	3.00E-04	0.030	8.31E-03	8.3559	6.93E-03	
28.0	1.0	27.5	115.0	1.58	1.06	0.459	42	1.25	99.1	0.8	57.6	0.9	1772.260	1.71E-04	3.00E-04	0.030	8.42E-03	8.3559	6.47E-03	
29.0	1.0	28.5	115.0	1.64	1.10	0.473	42	1.25	99.1	0.8	56.4	0.9	1792.643	1.72E-04	3.00E-04	0.030	8.51E-03	8.3559	6.81E-03	
30.0	1.0	29.5	115.0	1.70	1.14	0.487	42	1.25	99.1	0.8	55.7	0.9	1819.341	1.74E-04	3.00E-04	0.030	8.79E-03	8.3559	6.75E-03	
31.0	1.0	30.5	115.0	1.75	1.18	0.501	42	1.25	99.1	0.8	54.7	0.9	1839.670	1.75E-04	3.00E-04	0.030	8.96E-03	8.3559	6.89E-03	
32.0	1.0	31.5	115.0	1.81	1.21	0.514	42	1.25	99.1	0.8	53.9	0.9	1859.560	1.76E-04	3.00E-04	0.030	9.14E-03	8.3559	7.02E-03	
33.0	1.0	32.5	115.0	1.87	1.25	0.528	53	1.25	105.6	0.7	62.5	0.9	2056.255	1.69E-04	3.00E-04	0.030	3.89E-03	8.3559	3.28E-03	
34.0	1.0	33.5	115.0	1.93	1.29	0.541	53	1.25	105.6	0.7	61.3	0.8	2065.638	1.63E-04	3.00E-04	0.030	6.99E-03	8.3559	5.37E-03	
35.0	1.0	34.5	115.0	1.98	1.33	0.553	53	1.25	105.6	0.7	60.3	0.8	2085.990	1.64E-04	3.00E-04	0.030	7.12E-03	8.3559	5.47E-03	
36.0	1.0	35.5	115.0	2.04	1.37	0.566	53	1.25	105.6	0.7	59.4	0.8	2105.953	1.65E-04	3.00E-04	0.030	7.24E-03	8.3559	5.56E-03	
37.0	1.0	36.5	115.0	2.10	1.41	0.578	53	1.25	105.6	0.7	58.6	0.8	2125.541	1.65E-04	3.00E-04	0.030	7.36E-03	8.3559	5.65E-03	
38.0	1.0	37.5	115.0	2.16	1.44	0.590	45	1.25	92.8	0.7	54.0	0.8	2030.931	1.75E-04	3.00E-04	0.030	9.11E-03	8.3559	7.00E-03	
39.0	1.0	38.5	115.0	2.21	1.48	0.602	45	1.25	92.8	0.7	53.3	0.8	2048.826	1.76E-04	3.00E-04	0.030	9.25E-03	8.3559	7.11E-03	
40.0	1.0	39.5	115.0	2.27	1.52	0.613	45	1.25	92.8	0.7	52.6	0.8	2066.413	1.76E-04	3.00E-04	0.030	9.39E-03	8.3559	7.22E-03	
41.0	1.0	40.5	115.0	2.33	1.56	0.624	45	1.25	92.8	0.7	52.0	0.8	2083.706	1.77E-04	3.00E-04	0.030	9.54E-03	8.3559	7.33E-03	
42.0	1.0	41.5	115.0	2.39	1.60	0.635	45	1.25	92.8	0.7	51.3	0.8	2100.717	1.77E-04	3.00E-04	0.030	9.68E-03	8.3559	7.44E-03	
43.0	1.0	42.5	115.0	2.44	1.64	0.646	53	1.25	96.4	0.7	59.8	0.8	2236.152	1.68E-04	3.00E-04	0.030	8.07E-03	8.3559	6.20E-03	
44.0	1.0	43.5	115.0	2.50	1.68	0.657	53	1.25	96.4	0.6	59.1	0.8	2253.560	1.68E-04	3.00E-04	0.030	8.18E-03	8.3559	6.29E-03	
45.0	1.0	44.5	115.0	2.56	1.71	0.667	53	1.25	96.4	0.6	58.4	0.8	2270.898	1.68E-04	3.00E-04	0.030	8.29E-03	8.3559	6.37E-03	
46.0	1.0	45.5	115.0	2.62	1.75	0.677	53	1.25	96.4	0.6	57.8	0.8	2287.581	1.69E-04	3.00E-04	0.030	8.39E-03	8.3559	6.46E-03	
47.0	1.0	46.5	115.0	2.67	1.79	0.686	53	1.25	96.4	0.6	57.1	0.8	2304.218	1.69E-04	3.00E-04	0.030	8.51E-03	8.3559	6.54E-03	
48.0	1.0	47.5	115.0	2.73	1.83	0.696	82	1.25	115.2	0.6	87.5	0.8	2684.004	1.46E-04	3.00E-04	0.030	5.11E-03	8.3559	3.93E-03	
49.0	1.0	48.5	115.0	2.79	1.87	0.705	82	1.25	115.2	0.6	86.5	0.8	2702.708	1.46E-04	3.00E-04	0.030	5.17E-03	8.3559	3.97E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	0.714	82	1.25	115.2	0.6	85.7	0.8	2721.157	1.46E-04	3.00E-04	0.030	5.23E-03	8.3559	4.01E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	0.722	82	1.25	115.2	0.6	84.8	0.8	2739.360	1.46E-04	3.00E-04	0.030	5.30E-03	8.3559	4.07E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	82	1.25	115.2	0.6	84.0	0.8	2757.323	1.46E-04	3.00E-04	0.030	5.36E-03	8.3559	4.12E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	59	1.25	94.2	0.6	59.0	0.8	2486.668	1.63E-04	3.00E-04	0.030	8.05E-03	8.3559	6.19E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	59	1.25	94.2	0.6	58.2	0.7	2504.967	1.63E-04	3.00E-04	0.030	8.14E-03	8.3559	6.26E-03	0.00
55.0	1.0	54.5	115.0	3.13	2.10	0.754	59	1.25	94.2	0.6	58.7	0.8	2517.852	1.63E-04	3.00E-04	0.030	8.23E-03	8.3559	6.33E-03	0.00
56.0	1.0	55.5	115.0	3.19	2.14	0.762	59	1.25	94.2	0.6	58.2	0.7	2533.158	1.63E-04	3.00E-04					



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL DESIGN EARTHQUAKE

NCEER (1996) METHOD

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.66
Peak Horiz. Acceleration PGA_M (g):	0.720
$2/3$ PGA_M (g):	0.480
Calculated Mag.Wtg.Factor:	0.741
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4													
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (pcf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact	
1.0	115.0	0	26.0	1.0	1		124	2.000	67.3	115.0	Infin.	0.998	0.231	--	
2.0	115.0	0	26.0	2.0	1		57	120	2.000	74.3	115.0	Infin.	0.993	0.230	--
3.0	115.0	0	26.0	3.0	1		57	117	2.000	74.3	115.0	Infin.	0.989	0.229	--
4.0	115.0	0	26.0	4.0	1		57	114	2.000	74.3	115.0	Infin.	0.984	0.228	--
5.0	115.0	0	26.0	5.0	1		57	112	2.000	74.3	115.0	Infin.	0.979	0.227	--
6.0	115.0	0	26.0	6.0	1		57	109	1.817	68.1	115.0	Infin.	0.975	0.226	--
7.0	115.0	0	26.0	7.0	1		57	107	1.671	63.2	115.0	Infin.	0.970	0.225	--
8.0	115.0	0	26.0	8.0	1		57	92	1.556	47.3	115.0	Infin.	0.966	0.223	--
9.0	115.0	0	20.0	9.0	1		57	90	1.462	44.8	115.0	Infin.	0.961	0.222	--
10.0	115.0	0	20.0	10.0	1		57	88	1.382	42.8	115.0	Infin.	0.957	0.221	--
11.0	115.0	0	20.0	10.0	1		57	88	1.315	41.0	115.0	Infin.	0.952	0.220	--
12.0	115.0	0	20.0	10.0	1		57	88	1.267	39.5	115.0	Infin.	0.947	0.219	--
13.0	115.0	0	17.0	12.5	1		57	77	1.205	33.5	115.0	Infin.	0.943	0.218	--
14.0	115.0	0	17.0	12.5	1		57	77	1.160	32.5	115.0	Infin.	0.938	0.217	--
15.0	115.0	0	17.0	12.5	1		57	77	1.119	31.6	115.0	Infin.	0.934	0.216	--
16.0	115.0	0	17.0	12.5	1		57	77	1.082	30.8	115.0	Infin.	0.929	0.215	--
17.0	115.0	0	17.0	12.5	1		57	77	1.049	30.1	115.0	Infin.	0.925	0.214	--
18.0	115.0	0	24.0	17.5	1		57	85	1.019	43.1	115.0	Infin.	0.920	0.213	--
19.0	115.0	0	24.0	17.5	1		57	85	0.991	42.1	115.0	Infin.	0.915	0.212	--
20.0	115.0	0	24.0	17.5	1		57	85	0.965	41.2	115.0	Infin.	0.911	0.211	--
21.0	115.0	0	24.0	17.5	1		57	85	0.941	40.3	115.0	Infin.	0.906	0.210	--
22.0	115.0	0	24.0	17.5	1		57	85	0.919	39.5	115.0	Infin.	0.902	0.209	--
23.0	115.0	0	30.0	22.5	1		58	89	0.898	50.1	115.0	Infin.	0.897	0.208	--
24.0	115.0	0	30.0	22.5	1		58	89	0.879	49.2	115.0	Infin.	0.893	0.207	--
25.0	115.0	0	30.0	22.5	1		58	89	0.861	48.3	115.0	Infin.	0.888	0.206	--
26.0	115.0	0	30.0	22.5	1		58	89	0.844	47.5	115.0	Infin.	0.883	0.204	--
27.0	115.0	0	30.0	22.5	1		58	89	0.828	46.7	115.0	Infin.	0.879	0.203	--
28.0	115.0	0	20.0	27.5	1		58	68	0.813	34.5	115.0	Infin.	0.874	0.202	--
29.0	115.0	0	20.0	27.5	1		58	68	0.798	34.0	115.0	Infin.	0.870	0.201	--
30.0	115.0	0	20.0	27.5	1		58	68	0.785	33.5	115.0	Infin.	0.865	0.200	--
31.0	115.0	0	20.0	27.5	1		58	68	0.772	33.1	115.0	Infin.	0.861	0.199	--
32.0	115.0	0	20.0	27.5	1		58	68	0.759	32.6	115.0	Infin.	0.856	0.198	--
33.0	115.0	0	32.0	32.5	1		6	82	0.747	41.5	115.0	Infin.	0.851	0.197	--
34.0	115.0	0	32.0	32.5	1		6	82	0.736	40.9	115.0	Infin.	0.847	0.196	--
35.0	115.0	0	32.0	32.5	1		6	82	0.725	40.3	115.0	Infin.	0.842	0.195	--
36.0	115.0	0	32.0	32.5	1		6	82	0.715	39.8	115.0	Infin.	0.838	0.194	--
37.0	115.0	0	32.0	32.5	1		6	82	0.705	39.2	115.0	Infin.	0.833	0.193	--
38.0	115.0	0	51.0	37.5	1		6	99	0.696	61.5	115.0	Infin.	0.829	0.192	--
39.0	115.0	0	51.0	37.5	1		6	99	0.687	60.7	115.0	Infin.	0.824	0.191	--
40.0	115.0	0	51.0	37.5	1		6	99	0.678	59.9	115.0	Infin.	0.819	0.190	--
41.0	115.0	0	51.0	37.5	1		6	99	0.670	59.2	115.0	Infin.	0.815	0.189	--
42.0	115.0	0	51.0	37.5	1		6	99	0.661	58.5	115.0	Infin.	0.810	0.188	--
43.0	115.0	0	50.0	42.5	1		6	94	0.654	56.7	115.0	Infin.	0.806	0.186	--
44.0	115.0	0	50.0	42.5	1		6	94	0.646	56.0	115.0	Infin.	0.801	0.185	--
45.0	115.0	0	50.0	42.5	1		6	94	0.638	55.2	115.0	Infin.	0.797	0.184	--
46.0	115.0	0	50.0	42.5	1		6	94	0.632	54.8	115.0	Infin.	0.792	0.183	--
47.0	115.0	0	50.0	42.5	1		6	94	0.625	54.2	115.0	Infin.	0.787	0.182	--
48.0	115.0	0	51.0	47.5	1		6	91	0.618	54.7	115.0	Infin.	0.783	0.181	--
49.0	115.0	0	51.0	47.5	1		6	91	0.612	54.1	115.0	Infin.	0.778	0.180	--
50.0	115.0	0	51.0	47.5	1		6	91	0.606	53.6	115.0	Infin.	0.774	0.179	--
51.0	115.0	0	51.0	47.5	1		6	91	0.600	53.0	115.0	Infin.	0.769	0.178	--
52.0	115.0	0	51.0	47.5	1		6	91	0.594	52.5	115.0	Infin.	0.765	0.177	--
53.0	115.0	0	51.0	52.5	1		6	88	0.588	51.9	115.0	Infin.	0.760	0.176	--
54.0	115.0	0	51.0	52.5	1		6	88	0.583	51.5	115.0	Infin.	0.755	0.175	--
55.0	115.0	0	51.0	52.5	1		6	88	0.577	51.0	115.0	Infin.	0.751	0.174	--
56.0	115.0	0	51.0	52.5	1		6	88	0.572	50.5	115.0	Infin.	0.746	0.173	--
57.0	115.0	0	51.0	52.5	1		6	88	0.567	50.1	115.0	Infin.	0.742	0.172	--
58.0	115.0	0	53.0	57.5	1		6	86	0.562	51.6	115.0	Infin.	0.737	0.171	--
59.0	115.0	0	53.0	57.5	1		6	86	0.557	51.1	115.0	Infin.	0.733	0.170	--
60.0	115.0	0	53.0	57.5	1		6	86	0.552	50.7	115.0	Infin.	0.728	0.168	--
61.0	115.0	0	53.0	57.5	1		6	86	0.548	50.3	115.0	Infin.	0.723	0.167	--
62.0	115.0	0	53.0	57.5	1		6	86	0.541	49.9	115.0	Infin.	0.719	0.166	--
63.0	115.0	0	78.0	62.5	1		7	101	0.539	73.1	115.0	Infin.	0.714	0.165	--
64.0	115.0	0	78.0	62.5	1		7	101	0.535	72.5	115.0	Infin.	0.710	0.164	--
65.0	115.0	0	78.0	62.5	1		7	101	0.531	71.9	115.0	Infin.	0.705	0.163	--
66.0	115.0	0	78.0	62.5	1		7	101	0.526	71.4	115.0	Infin.	0.701	0.162	--
67.0	115.0	0	78.0	62.5	1		7	101	0.523	70.8	115.0	Infin.	0.696	0.161	--
68.0	115.0	0	90.0	67.5	1		7	106	0.519	81.1	115.0	Infin.	0.691	0.160	--
69.0	115.0	0	90.0	67.5	1		7	106	0.515	80.5	115.0	Infin.	0.687	0.159	--
70.0	115.0	0	90.0	67.5	1		7	106	0.511	79.9	115.0	Infin.	0.682	0.158	--
71.0	115.0	0	90.0	67.5	1		7	106	0.507	79.3	115.0	Infin.	0.678	0.157	--
72.0	115.0	0	52.0	72.5	1		7	78	0.504	45.7	115.0	Infin.	0.673	0.156	--
73.0	115.0	0	52.0	72.5	1		7	78	0.500	45.4	115.0	Infin.	0.669	0.155	--
74.0	115.0	0	52.0	72.5	1		7	78	0.497	45.1	115.0	Infin.	0.664	0.154	--
75.0	115.0	0	52.0	72.5	1		7	78	0.494	44.8	115.0	Infin.	0.659	0.153	--
76.0	115.0	0	52.0	72.5	1		7	78	0.490	44.5	115.0	Infin.	0.655	0.152	--
77.0	115.0	0	52.0	72.5	1		7	78	0.487	44.2	115.0	Infin.	0.650	0.150	--
78.0	115.0	0	82.0	77.5	1		7	95	0.484	69.0	115.0	Infin.	0.646	0.149	--
79.0	115.0	0	82.0	77.5	1		7	95	0.481	68.6	115.0	Infin.	0.641	0.148	--
80.0	115.0	0	82.0	77.5	1		7	95	0.478	68.1	115.0	Infin.	0.637	0.147	--
81.0	115.0	0	82.0	77.5	1		7	95	0.475	67.7	115.0	Infin.	0.632	0.146	--
82.0	115.0	0	82.0	77.5	1		7	95	0.472	67.3	115.0	Infin.	0.627	0.145	--
83.0	115.0	0	100.0	82.5	1		8	103	0.469	81.6	115.0	Infin.	0.625	0.145	--
84.0	115.0	0	100.0	82.5	1		8	103	0.466	81.1	115.0	Infin.	0.625	0.145	--
85.0	115.0	0	100.0	82.5	1		8	103	0.464	80.6	115.0	Infin.	0.625	0.145	--
86.0	115.0</														



TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS DESIGN EARTHQUAKE

DESIGN EARTHQUAKE INFORMATION	
Earthquake Magnitude	5.65
Peak Horiz. Acceleration (g)	0.483

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress (tsf)	Field SPT (blows/ft)	Correction Factor (C _{er})	Relative Density (%)	Correction Factor (C _{cr})	Corrected N ₆₀ (blows)	rd Factor	Maximum Shear Mod. (Gmax) (tsf)	y _{eff} (1/G _{max})	y _{eff} Shear Strain (%)	Volumetric Strain M _f 5 (E/15) (%)	Number of Strain Cycles (N _c)	Corrected Vol. Strains (E _c)	Estimated Settlement (S) (inches)	
																				26
2.0	1.0	1.5	115.0	0.09	0.06	0.027	26	1.25	123.6	2.0	74.3	1.0	451.686	5.79E-06	1.00E-04	0.010	2.07E-03	8.3559	1.59E-03	
3.0	1.0	2.5	115.0	0.14	0.10	0.045	26	1.25	117.2	2.0	74.3	1.0	583.127	7.32E-05	1.60E-04	0.016	3.31E-03	8.3559	2.55E-03	
4.0	1.0	3.5	115.0	0.20	0.13	0.063	26	1.25	114.3	2.0	74.3	1.0	689.965	8.50E-05	1.60E-04	0.016	3.31E-03	8.3559	2.55E-03	
5.0	1.0	4.5	115.0	0.26	0.17	0.081	26	1.25	111.7	2.0	74.3	1.0	782.347	9.49E-05	1.70E-04	0.017	3.52E-03	8.3559	2.71E-03	
6.0	1.0	5.5	115.0	0.32	0.21	0.098	26	1.25	109.2	1.8	66.1	1.0	860.379	1.06E-04	4.50E-04	0.045	1.02E-02	8.3559	7.95E-03	
7.0	1.0	6.5	115.0	0.37	0.25	0.116	26	1.25	106.9	1.7	63.2	1.0	891.083	1.15E-04	4.50E-04	0.045	1.13E-02	8.3559	8.69E-03	
8.0	1.0	7.5	115.0	0.43	0.29	0.134	20	1.25	91.9	1.6	47.3	1.0	868.704	1.34E-04	4.50E-04	0.045	1.60E-02	8.3559	1.23E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.151	20	1.25	90.1	1.5	44.8	1.0	908.593	1.43E-04	4.50E-04	0.045	1.71E-02	8.3559	1.31E-02	
10.0	1.0	9.5	115.0	0.56	0.37	0.169	20	1.25	88.4	1.4	42.8	1.0	945.710	1.55E-04	4.50E-04	0.045	1.81E-02	8.3559	1.39E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.186	20	1.25	88.4	1.3	41.0	1.0	980.522	1.57E-04	4.50E-04	0.045	1.90E-02	8.3559	1.46E-02	
12.0	1.0	11.5	115.0	0.66	0.44	0.204	20	1.25	88.4	1.3	39.5	0.9	1013.379	1.64E-04	4.50E-04	0.045	1.98E-02	8.3559	1.53E-02	
13.0	1.0	12.5	115.0	0.72	0.48	0.221	17	1.25	77.3	1.2	33.5	0.9	1000.028	1.77E-04	4.50E-04	0.045	2.42E-02	8.3559	1.86E-02	
14.0	1.0	13.5	115.0	0.78	0.52	0.238	17	1.25	77.3	1.2	31.8	0.9	1028.810	1.84E-04	4.70E-04	0.047	2.07E-02	8.3559	1.59E-02	
15.0	1.0	14.5	115.0	0.83	0.56	0.255	17	1.25	77.3	1.1	31.6	0.9	1056.354	1.88E-04	3.70E-04	0.037	2.14E-02	8.3559	1.64E-02	
16.0	1.0	15.5	115.0	0.89	0.60	0.272	17	1.25	77.3	1.1	30.8	0.9	1082.797	1.93E-04	3.70E-04	0.037	2.20E-02	8.3559	1.69E-02	
17.0	1.0	16.5	115.0	0.95	0.64	0.288	17	1.25	77.3	1.0	30.1	0.9	1108.252	1.97E-04	3.70E-04	0.037	2.27E-02	8.3559	1.74E-02	
18.0	1.0	17.5	115.0	1.01	0.67	0.305	24	1.25	85.0	1.0	43.1	0.9	1286.897	1.77E-04	3.70E-04	0.037	1.47E-02	8.3559	1.13E-02	
19.0	1.0	18.5	115.0	1.06	0.71	0.321	24	1.25	85.0	1.0	42.1	0.9	1312.648	1.80E-04	3.70E-04	0.037	1.52E-02	8.3559	1.16E-02	
20.0	1.0	19.5	115.0	1.12	0.75	0.337	24	1.25	85.0	1.0	41.2	0.9	1337.858	1.83E-04	3.70E-04	0.037	1.56E-02	8.3559	1.20E-02	
21.0	1.0	20.5	115.0	1.18	0.79	0.353	24	1.25	85.0	0.9	40.3	0.9	1362.296	1.86E-04	3.70E-04	0.037	1.59E-02	8.3559	1.23E-02	
22.0	1.0	21.5	115.0	1.24	0.83	0.369	24	1.25	85.0	0.9	39.5	0.9	1386.024	1.89E-04	3.70E-04	0.037	1.63E-02	8.3559	1.25E-02	
23.0	1.0	22.5	115.0	1.29	0.87	0.384	30	1.25	88.9	0.9	50.1	0.9	1534.451	1.75E-04	3.70E-04	0.037	1.23E-02	8.3559	9.44E-03	
24.0	1.0	23.5	115.0	1.35	0.91	0.400	30	1.25	88.9	0.9	49.2	0.9	1558.446	1.77E-04	3.70E-04	0.037	1.26E-02	8.3559	9.66E-03	
25.0	1.0	24.5	115.0	1.41	0.94	0.415	30	1.25	88.9	0.8	48.3	0.9	1582.441	1.79E-04	3.70E-04	0.037	1.29E-02	8.3559	9.88E-03	
26.0	1.0	25.5	115.0	1.47	0.98	0.430	30	1.25	88.9	0.8	47.5	0.9	1606.419	1.81E-04	3.70E-04	0.037	1.31E-02	8.3559	1.01E-02	CUT
27.0	1.0	26.5	115.0	1.52	1.02	0.444	30	1.25	88.9	0.8	46.7	0.9	1626.875	1.83E-04	3.00E-04	0.030	1.08E-02	8.3559	8.33E-03	
28.0	1.0	27.5	115.0	1.58	1.06	0.459	20	1.25	68.4	0.8	34.4	0.9	1497.028	2.03E-04	5.20E-04	0.052	2.71E-02	8.3559	2.08E-02	
29.0	1.0	28.5	115.0	1.64	1.10	0.473	20	1.25	68.4	0.8	33.6	0.9	1516.954	2.04E-04	5.20E-04	0.052	2.75E-02	8.3559	2.12E-02	
30.0	1.0	29.5	115.0	1.70	1.14	0.487	20	1.25	68.4	0.8	33.5	0.9	1536.173	2.06E-04	5.20E-04	0.052	2.80E-02	8.3559	2.15E-02	
31.0	1.0	30.5	115.0	1.75	1.18	0.501	20	1.25	68.4	0.8	33.1	0.9	1555.155	2.07E-04	5.20E-04	0.052	2.84E-02	8.3559	2.19E-02	
32.0	1.0	31.5	115.0	1.81	1.21	0.514	20	1.25	68.4	0.8	32.6	0.9	1573.770	2.08E-04	5.20E-04	0.052	2.89E-02	8.3559	2.22E-02	
33.0	1.0	32.5	115.0	1.87	1.25	0.528	32	1.25	92.5	0.87	42.1	0.9	1732.225	1.92E-04	3.00E-04	0.030	1.19E-02	8.3559	9.98E-03	
34.0	1.0	33.5	115.0	1.93	1.29	0.541	32	1.25	92.5	0.87	40.9	0.8	1749.872	1.93E-04	3.00E-04	0.030	1.27E-02	8.3559	9.77E-03	
35.0	1.0	34.5	115.0	1.98	1.33	0.553	32	1.25	92.5	0.87	40.3	0.8	1767.173	1.94E-04	3.00E-04	0.030	1.29E-02	8.3559	9.94E-03	
36.0	1.0	35.5	115.0	2.04	1.37	0.566	32	1.25	92.5	0.87	39.8	0.8	1784.144	1.95E-04	3.00E-04	0.030	1.32E-02	8.3559	1.01E-02	
37.0	1.0	36.5	115.0	2.10	1.41	0.578	32	1.25	92.5	0.87	39.2	0.8	1801.215	1.96E-04	3.00E-04	0.030	1.34E-02	8.3559	1.03E-02	
38.0	1.0	37.5	115.0	2.16	1.44	0.590	51	1.25	98.8	0.7	61.5	0.8	2120.680	1.68E-04	3.00E-04	0.030	7.79E-03	8.3559	5.99E-03	
39.0	1.0	38.5	115.0	2.21	1.48	0.602	51	1.25	98.8	0.7	60.7	0.8	2139.408	1.68E-04	3.00E-04	0.030	7.92E-03	8.3559	6.08E-03	
40.0	1.0	39.5	115.0	2.27	1.52	0.613	51	1.25	98.8	0.7	59.9	0.8	2157.816	1.69E-04	3.00E-04	0.030	8.04E-03	8.3559	6.18E-03	
41.0	1.0	40.5	115.0	2.32	1.56	0.624	51	1.25	98.8	0.7	59.2	0.8	2175.917	1.69E-04	3.00E-04	0.030	8.16E-03	8.3559	6.27E-03	
42.0	1.0	41.5	115.0	2.39	1.60	0.635	51	1.25	98.8	0.7	58.5	0.8	2193.722	1.70E-04	3.00E-04	0.030	8.28E-03	8.3559	6.36E-03	
43.0	1.0	42.5	115.0	2.44	1.64	0.646	50	1.25	93.7	0.7	56.7	0.8	2196.788	1.71E-04	3.00E-04	0.030	8.60E-03	8.3559	6.61E-03	
44.0	1.0	43.5	115.0	2.50	1.68	0.657	50	1.25	93.7	0.7	56.0	0.8	2215.057	1.71E-04	3.00E-04	0.030	8.72E-03	8.3559	6.70E-03	
45.0	1.0	44.5	115.0	2.56	1.71	0.667	50	1.25	93.7	0.6	55.4	0.8	2230.786	1.71E-04	3.00E-04	0.030	8.84E-03	8.3559	6.79E-03	
46.0	1.0	45.5	115.0	2.62	1.75	0.678	50	1.25	93.7	0.6	54.8	0.8	2247.415	1.72E-04	3.00E-04	0.030	8.96E-03	8.3559	6.88E-03	
47.0	1.0	46.5	115.0	2.67	1.79	0.688	50	1.25	93.7	0.6	54.2	0.8	2263.802	1.72E-04	3.00E-04	0.030	9.07E-03	8.3559	6.97E-03	
48.0	1.0	47.5	115.0	2.73	1.83	0.698	51	1.25	90.9	0.6	54.3	0.8	2280.978	1.71E-04	3.00E-04	0.030	9.39E-03	8.3559	7.29E-03	
49.0	1.0	48.5	115.0	2.79	1.87	0.705	51	1.25	90.9	0.6	54.1	0.8	2311.013	1.71E-04	3.00E-04	0.030	9.09E-03	8.3559	6.98E-03	
50.0	1.0	49.5	115.0	2.85	1.91	0.714	51	1.25	90.9	0.6	53.6	0.8	2326.829	1.71E-04	3.00E-04	0.030	9.20E-03	8.3559	7.07E-03	
51.0	1.0	50.5	115.0	2.90	1.95	0.722	51	1.25	90.9	0.6	53.0	0.8	2342.435	1.71E-04	3.00E-04	0.030	9.31E-03	8.3559	7.15E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	0.731	51	1.25	90.9	0.6	52.5	0.8	2357.831	1.71E-04	3.00E-04	0.030	9.42E-03	8.3559	7.24E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	0.739	51	1.25	87.6	0.6	51.9	0.8	2371.976	1.71E-04	3.00E-04	0.030	9.54E-03	8.3559	7.33E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	0.747	51	1.25	87.6	0.6	51.5	0.8	2386.972	1.71E-04	3.00E-04	0.030	9.65E-03	8.3559	7.42E-03	0.00
55.0	1.0	54.5	115.0	3.13	2.10	0.754	51	1.25	87.6	0.6	51.0	0.8	2401.782	1.71E-04	3.00E-04	0.030	9.76E-03	8.3559	7.50E-03	0.00
56.0	1.0	55.5	115.0	3.19	2.14	0.762	51	1.25</												



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

NCEER (1996) METHOD

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA_M (g):	0.720
Calculated Mag.Wtg.Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf): 62.4

Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.
1.0	115.0	0	9.0	1.0	1	25	73	2.000	28.0	115.0	0.349	0.998	0.379	--
2.0	115.0	0	9.0	2.0	1	25	71	2.000	28.0	115.0	0.349	0.993	0.377	--
3.0	115.0	0	9.0	3.0	1	25	69	2.000	28.0	115.0	0.349	0.989	0.376	--
4.0	115.0	0	9.0	4.0	1	25	67	2.000	28.0	115.0	0.349	0.984	0.374	--
5.0	115.0	0	9.0	5.0	1	25	66	2.000	28.0	115.0	0.349	0.979	0.372	--
6.0	115.0	0	9.0	6.0	1	25	64	1.817	25.9	115.0	0.301	0.975	0.370	--
7.0	115.0	0	9.0	7.0	1	25	63	1.671	24.2	115.0	0.272	0.970	0.369	--
8.0	115.0	0	9.0	8.0	1	25	62	1.556	22.8	115.0	0.253	0.966	0.367	--
9.0	115.0	0	9.0	9.0	1	25	60	1.462	21.7	115.0	0.239	0.961	0.365	--
10.0	115.0	0	14.0	10.0	1	25	74	1.382	29.8	115.0	0.445	0.957	0.363	--
11.0	115.0	0	14.0	10.0	1	25	74	1.315	28.5	115.0	0.367	0.952	0.362	--
12.0	115.0	0	14.0	10.0	1	25	74	1.257	27.5	115.0	0.335	0.947	0.360	--
13.0	115.0	0	14.0	10.0	1	25	74	1.205	26.5	115.0	0.314	0.943	0.358	--
14.0	115.0	0	14.0	10.0	1	25	74	1.160	25.7	115.0	0.298	0.938	0.356	--
15.0	115.0	0	71.0	15.0	1	24	153	1.119	114.9	115.0	Inf.	0.934	0.355	--
16.0	115.0	0	71.0	15.0	1	24	153	1.082	111.3	115.0	Inf.	0.929	0.353	--
17.0	115.0	0	71.0	15.0	1	24	153	1.049	108.0	115.0	Inf.	0.925	0.351	--
18.0	115.0	0	71.0	15.0	1	24	153	1.019	105.0	115.0	Inf.	0.920	0.349	--
19.0	115.0	0	71.0	15.0	1	24	153	0.991	102.2	115.0	Inf.	0.915	0.348	--
20.0	115.0	0	31.0	20.0	1	24	94	0.965	50.5	115.0	Inf.	0.911	0.346	--
21.0	115.0	0	31.0	20.0	1	24	94	0.941	49.4	115.0	Inf.	0.906	0.344	--
22.0	115.0	0	31.0	20.0	1	24	94	0.919	48.3	115.0	Inf.	0.902	0.343	--
23.0	115.0	0	31.0	20.0	1	24	94	0.898	47.3	115.0	Inf.	0.897	0.341	--
24.0	115.0	0	31.0	20.0	1	24	94	0.879	46.4	115.0	Inf.	0.893	0.339	--
25.0	115.0	0	31.0	20.0	1	24	94	0.861	45.5	115.0	Inf.	0.888	0.337	--
26.0	115.0	0	39.0	24.0	1	17	100	0.844	56.4	115.0	Inf.	0.883	0.336	--
27.0	115.0	0	39.0	24.0	1	17	100	0.828	55.4	115.0	Inf.	0.879	0.334	--
28.0	115.0	0	39.0	24.0	1	17	100	0.813	54.4	115.0	Inf.	0.874	0.332	--
29.0	115.0	0	39.0	24.0	1	17	100	0.798	53.5	115.0	Inf.	0.870	0.330	--
30.0	115.0	0	35.0	30.0	1	17	89	0.785	50.2	115.0	Inf.	0.865	0.329	--
31.0	115.0	0	35.0	30.0	1	17	89	0.772	49.4	115.0	Inf.	0.861	0.327	--
32.0	115.0	0	35.0	30.0	1	17	89	0.759	48.6	115.0	Inf.	0.856	0.325	--
33.0	115.0	0	35.0	30.0	1	17	89	0.747	47.9	115.0	Inf.	0.851	0.323	--
34.0	115.0	0	46.0	35.0	1	13	97	0.736	60.4	115.0	Inf.	0.847	0.322	--
35.0	115.0	0	46.0	35.0	1	13	97	0.725	59.5	115.0	Inf.	0.842	0.320	--
36.0	115.0	0	46.0	35.0	1	13	97	0.715	58.7	115.0	Inf.	0.838	0.318	--
37.0	115.0	0	46.0	35.0	1	13	97	0.705	57.9	115.0	Inf.	0.833	0.316	--
38.0	115.0	0	46.0	35.0	1	13	97	0.696	57.2	115.0	Inf.	0.829	0.315	--
39.0	115.0	0	46.0	35.0	1	13	97	0.687	56.5	115.0	Inf.	0.824	0.313	--
40.0	115.0	0	57.0	40.0	1	7	103	0.678	67.1	115.0	Inf.	0.819	0.311	--
41.0	115.0	0	57.0	40.0	1	7	103	0.670	66.2	115.0	Inf.	0.815	0.310	--
42.0	115.0	0	57.0	40.0	1	7	103	0.661	65.4	115.0	Inf.	0.810	0.308	--
43.0	115.0	0	57.0	40.0	1	7	103	0.654	64.7	115.0	Inf.	0.806	0.306	--
44.0	115.0	0	57.0	40.0	1	7	103	0.646	63.9	115.0	Inf.	0.801	0.304	--
45.0	115.0	0	67.0	45.0	1	7	107	0.639	74.2	115.0	Inf.	0.797	0.303	--
46.0	115.0	0	67.0	45.0	1	7	107	0.632	73.4	115.0	Inf.	0.792	0.301	--
47.0	115.0	0	67.0	45.0	1	7	107	0.625	72.6	115.0	Inf.	0.787	0.299	--
48.0	115.0	0	67.0	45.0	1	7	107	0.618	71.9	115.0	Inf.	0.783	0.297	--
49.0	115.0	0	67.0	45.0	1	7	107	0.612	71.1	115.0	Inf.	0.778	0.296	--
50.0	115.0	0	62.0	50.0	1	7	99	0.606	65.2	115.0	Inf.	0.774	0.294	--
51.0	115.0	0	62.0	50.0	1	7	99	0.600	64.5	115.0	Inf.	0.769	0.292	--
52.0	115.0	0	62.0	50.0	1	7	99	0.594	63.9	115.0	Inf.	0.765	0.290	--
53.0	115.0	0	62.0	50.0	1	7	99	0.588	63.3	115.0	Inf.	0.760	0.289	--
54.0	115.0	0	62.0	50.0	1	7	99	0.583	62.7	115.0	Inf.	0.755	0.287	--
55.0	115.0	0	81.0	55.0	1	8	109	0.577	81.3	115.0	Inf.	0.751	0.285	--
56.0	115.0	0	81.0	55.0	1	8	109	0.572	80.6	115.0	Inf.	0.746	0.283	--
57.0	115.0	0	81.0	55.0	1	8	109	0.567	79.9	115.0	Inf.	0.742	0.282	--
58.0	115.0	0	81.0	55.0	1	8	109	0.562	79.2	115.0	Inf.	0.737	0.280	--
59.0	115.0	0	81.0	55.0	1	8	109	0.557	78.5	115.0	Inf.	0.733	0.278	--
60.0	115.0	0	58.0	60.0	1	8	89	0.552	55.9	115.0	Inf.	0.728	0.277	--
61.0	115.0	0	58.0	60.0	1	8	89	0.548	55.5	115.0	Inf.	0.723	0.275	--

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration (g):	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress (Tav) (tsf)	Field SPT (N)	Correction Factor (C _{er})	Relative Density (Dr) (%)	Correction Factor (C _{cn})	Corrected (N1) ₆₀	rd Factor	Maximum Shear Mod. (G _{max}) (tsf)	veff *(Geff) (G _{max})	yeff Shear Strain	veff *100%	Volumetric Strain M7.5 (E15) (%)	Number of Strain Cycles (N _c)	Corrected Vol. Strains (E _c)	Estimated Settlement (S) (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	9	1.25	72.7	2.0	28.0	1.0	188.388	7.07E-05	1.60E-04	0.016	1.07E-02	10.0787	8.93E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.040	9	1.25	70.7	2.0	28.0	1.0	326.298	1.20E-04	3.00E-03	0.300	2.00E-01	10.0787	1.68E-01	
3.0	1.0	2.5	115.0	0.14	0.10	0.067	9	1.25	68.9	2.0	28.0	1.0	421.249	1.52E-04	3.00E-03	0.300	2.00E-01	10.0787	1.68E-01	
4.0	1.0	3.5	115.0	0.20	0.13	0.094	9	1.25	67.3	2.0	28.0	1.0	498.429	1.76E-04	8.10E-04	0.081	5.41E-02	10.0787	4.52E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.121	9	1.25	65.7	2.0	28.0	1.0	565.165	1.96E-04	8.10E-04	0.081	5.41E-02	10.0787	4.52E-02	
6.0	1.0	5.5	115.0	0.32	0.21	0.148	9	1.25	64.3	1.8	25.9	1.0	608.537	2.19E-04	1.00E-03	0.100	7.34E-02	10.0787	6.14E-02	CUT
7.0	1.0	6.5	115.0	0.37	0.25	0.174	9	1.25	62.9	1.7	24.2	1.0	646.771	2.38E-04	1.00E-03	0.100	7.97E-02	10.0787	6.66E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.201	9	1.25	61.6	1.6	22.8	1.0	681.624	2.56E-04	1.00E-03	0.100	8.53E-02	10.0787	7.13E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.227	9	1.25	60.4	1.5	21.7	1.0	713.808	2.72E-04	1.00E-03	0.100	9.05E-02	10.0787	7.57E-02	
10.0	1.0	9.5	115.0	0.55	0.37	0.253	14	1.25	74.0	1.4	29.8	1.0	837.951	2.54E-04	1.00E-03	0.100	6.21E-02	10.0787	5.19E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.279	14	1.25	74.0	1.3	28.5	1.0	868.719	2.66E-04	1.00E-03	0.100	6.53E-02	10.0787	5.46E-02	
12.0	1.0	11.5	115.0	0.66	0.44	0.305	14	1.25	74.0	1.3	27.5	0.9	897.754	2.77E-04	1.00E-03	0.100	6.83E-02	10.0787	5.71E-02	0.01
13.0	1.0	12.5	115.0	0.72	0.48	0.331	14	1.25	74.0	1.2	26.5	0.9	925.298	2.87E-04	1.00E-03	0.100	7.12E-02	10.0787	5.95E-02	0.01
14.0	1.0	13.5	115.0	0.78	0.52	0.357	14	1.25	74.0	1.2	25.7	0.9	951.542	2.96E-04	7.10E-04	0.071	5.25E-02	10.0787	4.39E-02	0.01
15.0	1.0	14.5	115.0	0.83	0.56	0.382	71	1.25	152.9	1.1	114.9	0.9	1624.074	1.83E-04	3.70E-04	0.037	4.54E-03	10.0787	3.80E-03	0.00
16.0	1.0	15.5	115.0	0.89	0.60	0.407	71	1.25	152.9	1.1	111.3	0.9	1661.291	1.88E-04	3.70E-04	0.037	4.72E-03	10.0787	3.95E-03	0.00
17.0	1.0	16.5	115.0	0.95	0.64	0.432	71	1.25	152.9	1.0	108.0	0.9	1696.976	1.93E-04	3.70E-04	0.037	4.89E-03	10.0787	4.09E-03	0.00
18.0	1.0	17.5	115.0	1.01	0.67	0.457	71	1.25	152.9	1.0	105.0	0.9	1731.280	1.97E-04	3.70E-04	0.037	5.06E-03	10.0787	4.23E-03	0.00
19.0	1.0	18.5	115.0	1.06	0.71	0.481	71	1.25	152.9	1.0	102.2	0.9	1764.333	2.01E-04	7.10E-04	0.071	1.00E-02	10.0787	8.38E-03	0.00
20.0	1.0	19.5	115.0	1.12	0.75	0.506	31	1.25	94.0	1.0	50.5	0.9	1432.247	2.57E-04	7.10E-04	0.071	2.34E-02	10.0787	1.95E-02	0.00
21.0	1.0	20.5	115.0	1.18	0.79	0.529	31	1.25	94.0	0.9	49.4	0.9	1457.378	2.61E-04	7.10E-04	0.071	2.40E-02	10.0787	2.01E-02	0.00
22.0	1.0	21.5	115.0	1.24	0.83	0.553	31	1.25	94.0	0.9	48.3	0.9	1481.744	2.65E-04	7.10E-04	0.071	2.46E-02	10.0787	2.06E-02	0.00
23.0	1.0	22.5	115.0	1.29	0.87	0.576	31	1.25	94.0	0.9	47.3	0.9	1505.405	2.68E-04	7.10E-04	0.071	2.53E-02	10.0787	2.11E-02	0.01
24.0	1.0	23.5	115.0	1.35	0.91	0.599	31	1.25	94.0	0.9	46.4	0.9	1528.410	2.71E-04	7.10E-04	0.071	2.59E-02	10.0787	2.16E-02	0.01
25.0	1.0	24.5	115.0	1.41	0.94	0.622	31	1.25	94.0	0.9	45.5	0.9	1550.806	2.74E-04	7.10E-04	0.071	2.65E-02	10.0787	2.21E-02	0.01
26.0	1.0	25.5	115.0	1.47	0.98	0.644	39	1.25	100.1	0.8	56.4	0.9	1699.383	2.56E-04	7.10E-04	0.071	2.04E-02	10.0787	1.71E-02	0.00
27.0	1.0	26.5	115.0	1.52	1.02	0.666	39	1.25	100.1	0.8	55.4	0.9	1721.865	2.59E-04	5.20E-04	0.052	1.53E-02	10.0787	1.28E-02	0.00
28.0	1.0	27.5	115.0	1.58	1.06	0.688	39	1.25	100.1	0.8	54.4	0.9	1743.806	2.61E-04	5.20E-04	0.052	1.56E-02	10.0787	1.31E-02	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.709	39	1.25	100.1	0.8	53.5	0.9	1765.327	2.63E-04	5.20E-04	0.052	1.60E-02	10.0787	1.33E-02	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.730	35	1.25	88.6	0.8	50.2	0.9	1757.485	2.69E-04	5.20E-04	0.052	1.72E-02	10.0787	1.44E-02	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.751	35	1.25	88.6	0.8	49.4	0.9	1777.679	2.71E-04	5.20E-04	0.052	1.76E-02	10.0787	1.47E-02	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.771	35	1.25	88.6	0.8	48.6	0.9	1797.451	2.73E-04	5.20E-04	0.052	1.79E-02	10.0787	1.50E-02	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.791	35	1.25	88.6	0.7	47.9	0.9	1816.822	2.74E-04	5.20E-04	0.052	1.82E-02	10.0787	1.52E-02	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.811	46	1.25	96.5	0.7	60.4	0.8	1992.166	2.54E-04	5.20E-04	0.052	1.38E-02	10.0787	1.15E-02	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.830	46	1.25	96.5	0.7	59.5	0.8	2012.117	2.55E-04	5.20E-04	0.052	1.40E-02	10.0787	1.17E-02	0.00
36.0	1.0	35.5	115.0	2.04	1.37	0.848	46	1.25	96.5	0.7	58.7	0.8	2031.694	2.56E-04	5.20E-04	0.052	1.43E-02	10.0787	1.19E-02	0.00
37.0	1.0	36.5	115.0	2.10	1.41	0.867	46	1.25	96.5	0.7	57.9	0.8	2050.914	2.57E-04	5.20E-04	0.052	1.45E-02	10.0787	1.21E-02	0.00
38.0	1.0	37.5	115.0	2.16	1.44	0.885	46	1.25	96.5	0.7	57.2	0.8	2069.793	2.58E-04	5.20E-04	0.052	1.47E-02	10.0787	1.23E-02	0.00
39.0	1.0	38.5	115.0	2.21	1.48	0.902	46	1.25	96.5	0.7	56.5	0.8	2088.346	2.59E-04	5.20E-04	0.052	1.50E-02	10.0787	1.25E-02	0.00
40.0	1.0	39.5	115.0	2.27	1.52	0.919	57	1.25	102.6	0.7	67.1	0.8	2240.252	2.44E-04	5.20E-04	0.052	1.22E-02	10.0787	1.02E-02	0.00
41.0	1.0	40.5	115.0	2.33	1.56	0.936	57	1.25	102.6	0.7	66.2	0.8	2259.506	2.44E-04	5.20E-04	0.052	1.24E-02	10.0787	1.03E-02	0.00
42.0	1.0	41.5	115.0	2.39	1.60	0.953	57	1.25	102.6	0.7	65.4	0.8	2277.553	2.45E-04	5.20E-04	0.052	1.25E-02	10.0787	1.05E-02	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.969	57	1.25	102.6	0.7	64.7	0.8	2295.578	2.45E-04	5.20E-04	0.052	1.27E-02	10.0787	1.06E-02	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.984	57	1.25	102.6	0.6	63.9	0.8	2313.679	2.46E-04	5.20E-04	0.052	1.29E-02	10.0787	1.08E-02	0.00
45.0	1.0	44.5	115.0	2.56	1.71	1.000	67	1.25	106.6	0.6	74.2	0.8	2459.620	2.33E-04	5.20E-04	0.052	1.08E-02	10.0787	9.01E-03	0.00
46.0	1.0	45.5	115.0	2.62	1.75	1.014	67	1.25	106.6	0.6	73.4	0.8	2477.957	2.33E-04	5.20E-04	0.052	1.09E-02	10.0787	9.13E-03	0.00
47.0	1.0	46.5	115.0	2.67	1.79	1.029	67	1.25	106.6	0.6	72.6	0.8	2496.028	2.34E-04	5.20E-04	0.052	1.11E-02	10.0787	9.25E-03	0.00
48.0	1.0	47.5	115.0	2.73	1.83	1.043	67	1.25	106.6	0.6	71.9	0.8	2513.843	2.34E-04	5.20E-04	0.052	1.12E-02	10.0787	9.37E-03	0.00
49.0	1.0	48.5	115.0	2.79	1.87	1.057	67	1.25	106.6	0.6	71.1	0.8	2531.411	2.34E-04	5.20E-04	0.052	1.13E-02	10.0787	9.49E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	1.070	62	1.25	98.7	0.6	65.2	0.8	2484.068	2.40E-04	5.20E-04	0.052	1.26E-02	10.0787	1.05E-02	0.00
51.0	1.0	50.5	115.0	2.90	1.95	1.083	62	1.25	98.7	0.6	64.5	0.8	2500.735	2.40E-04	5.20E-04	0.052	1.28E-02	10.0787	1.07E-02	0.00
52.0	1.0	51.5	115.0	2.96	1.98	1.095	62	1.25	98.7	0.6	63.9	0.8	2517.185	2.40E-04	5.20E-04	0.052	1.29E-02	10.0787	1.08E-02	0.00
53.0	1.0	52.5	115.0	3.02	2.02	1.108	62	1.25	98.7	0.6	63.3	0.8	2533.423	2.40E-04	5.20E-04	0.052	1.31E-02	10.0787	1.09E-02	0.00
54.0	1.0	53.5	115.0	3.08	2.06	1.119	62	1.25	98.7	0.6	62.7	0.8	2549.458	2.40E-04	5.20E-04	0.052	1.32E-02	10.0787		



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

NCEER (1996) METHOD

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA_M (g):	0.720
Calculated Mag.Wtg.Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf): 62.4

Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.
1.0	115.0	0	13.0	1.0	1	35	87	2.000	40.6	115.0	Inf.	0.998	0.379	--
2.0	115.0	0	13.0	2.0	1	35	85	2.000	40.6	115.0	Inf.	0.993	0.377	--
3.0	115.0	0	13.0	3.0	1	35	83	2.000	40.6	115.0	Inf.	0.989	0.376	--
4.0	115.0	0	13.0	4.0	1	35	81	2.000	40.6	115.0	Inf.	0.984	0.374	--
5.0	115.0	0	13.0	5.0	1	35	79	2.000	40.6	115.0	Inf.	0.979	0.372	--
6.0	115.0	0	13.0	6.0	1	35	77	1.817	37.6	115.0	Inf.	0.975	0.370	--
7.0	115.0	0	21.0	7.0	1	21	96	1.671	49.0	115.0	Inf.	0.970	0.369	--
8.0	115.0	0	21.0	8.0	1	21	94	1.556	45.9	115.0	Inf.	0.966	0.367	--
9.0	115.0	0	21.0	9.0	1	21	92	1.462	43.3	115.0	Inf.	0.961	0.365	--
10.0	115.0	0	21.0	10.0	1	51	91	1.382	44.6	115.0	Inf.	0.957	0.363	--
11.0	115.0	0	21.0	10.0	1	51	91	1.315	42.7	115.0	Inf.	0.952	0.362	--
12.0	115.0	0	21.0	10.0	1	51	91	1.257	41.1	115.0	Inf.	0.947	0.360	--
13.0	115.0	0	21.0	10.0	1	51	91	1.205	39.7	115.0	Inf.	0.943	0.358	--
14.0	115.0	0	21.0	10.0	1	51	91	1.160	38.5	115.0	Inf.	0.938	0.356	--
15.0	115.0	0	15.0	15.0	1	51	70	1.119	30.4	115.0	Inf.	0.934	0.355	--
16.0	115.0	0	15.0	15.0	1	51	70	1.082	29.6	115.0	0.426	0.929	0.353	--
17.0	115.0	0	15.0	15.0	1	51	70	1.049	28.9	115.0	0.381	0.925	0.351	--
18.0	115.0	0	26.0	20.0	1	24	86	1.019	45.4	115.0	Inf.	0.920	0.349	--
19.0	115.0	0	26.0	20.0	1	24	86	0.991	44.3	115.0	Inf.	0.915	0.348	--
20.0	115.0	0	26.0	20.0	1	24	86	0.965	43.2	115.0	Inf.	0.911	0.346	--
21.0	115.0	0	26.0	20.0	1	22	86	0.941	41.8	115.0	Inf.	0.906	0.344	--
22.0	115.0	0	26.0	20.0	1	22	86	0.919	40.9	115.0	Inf.	0.902	0.343	--
23.0	115.0	0	26.0	20.0	1	22	86	0.898	40.1	115.0	Inf.	0.897	0.341	--
24.0	115.0	0	26.0	20.0	1	22	86	0.879	39.3	115.0	Inf.	0.893	0.339	--
25.0	115.0	0	22.0	25.0	1	54	74	0.861	38.2	115.0	Inf.	0.888	0.337	--
26.0	115.0	0	22.0	25.0	1	54	74	0.844	37.6	115.0	Inf.	0.883	0.336	--
27.0	115.0	0	22.0	25.0	1	54	74	0.828	37.0	115.0	Inf.	0.879	0.334	--
28.0	115.0	0	35.0	30.0	1	3	89	0.813	49.1	115.0	Inf.	0.874	0.332	--
29.0	115.0	0	35.0	30.0	1	3	89	0.798	48.2	115.0	Inf.	0.870	0.330	--
30.0	115.0	0	35.0	30.0	1	3	89	0.785	47.4	115.0	Inf.	0.865	0.329	--
31.0	115.0	0	35.0	30.0	1	3	89	0.772	46.6	115.0	Inf.	0.861	0.327	--
32.0	115.0	0	35.0	30.0	1	3	89	0.759	45.8	115.0	Inf.	0.856	0.325	--
33.0	115.0	0	35.0	30.0	1	3	89	0.747	45.1	115.0	Inf.	0.851	0.323	--
34.0	115.0	0	35.0	30.0	1	3	89	0.736	44.4	115.0	Inf.	0.847	0.322	--
35.0	115.0	0	10.0	35.0	1	9	45	0.725	13.4	115.0	0.132	0.842	0.320	--
36.0	115.0	0	10.0	35.0	1	9	45	0.715	13.2	115.0	0.130	0.838	0.318	--
37.0	115.0	0	10.0	35.0	1	9	45	0.705	13.0	115.0	0.128	0.833	0.316	--
38.0	115.0	0	10.0	35.0	1	9	45	0.696	12.9	115.0	0.127	0.829	0.315	--
39.0	115.0	0	10.0	35.0	1	9	45	0.687	12.7	115.0	0.125	0.824	0.313	--
40.0	115.0	0	7.0	40.0	1	9	36	0.678	9.0	115.0	0.088	0.819	0.311	--
41.0	115.0	0	7.0	40.0	1	9	36	0.670	8.9	115.0	0.087	0.815	0.310	--
42.0	115.0	0	50.0	42.5	1	9	94	0.661	57.9	115.0	Inf.	0.810	0.308	--
43.0	115.0	0	50.0	42.5	1	9	94	0.654	57.2	115.0	Inf.	0.806	0.306	--
44.0	115.0	0	50.0	42.5	1	9	94	0.646	56.6	115.0	Inf.	0.801	0.304	--
45.0	115.0	0	50.0	42.5	1	9	94	0.639	56.0	115.0	Inf.	0.797	0.303	--
46.0	115.0	0	50.0	42.5	1	9	94	0.632	55.3	115.0	Inf.	0.792	0.301	--
47.0	115.0	0	50.0	47.5	1	22	90	0.625	57.7	115.0	Inf.	0.787	0.299	--
48.0	115.0	0	50.0	47.5	1	22	90	0.618	57.2	115.0	Inf.	0.783	0.297	--
49.0	115.0	0	50.0	47.5	1	22	90	0.612	56.6	115.0	Inf.	0.778	0.296	--
50.0	115.0	0	50.0	47.5	1	22	90	0.606	56.1	115.0	Inf.	0.774	0.294	--
51.0	115.0	0	50.0	47.5	1	22	90	0.600	55.6	115.0	Inf.	0.769	0.292	--
52.0	115.0	0	50.0	52.5	1	22	87	0.594	55.1	115.0	Inf.	0.765	0.290	--
53.0	115.0	0	50.0	52.5	1	22	87	0.588	54.6	115.0	Inf.	0.760	0.289	--
54.0	115.0	0	50.0	52.5	1	22	87	0.583	54.1	115.0	Inf.	0.755	0.287	--
55.0	115.0	0	50.0	52.5	1	22	87	0.577	53.6	115.0	Inf.	0.751	0.285	--
56.0	115.0	0	50.0	52.5	1	22	87	0.572	53.2	115.0	Inf.	0.746	0.283	--
57.0	115.0	0	50.0	57.5	1	9	84	0.567	49.8	115.0	Inf.	0.742	0.282	--
58.0	115.0	0	50.0	57.5	1	9	84	0.562	49.3	115.0	Inf.	0.737	0.280	--
59.0	115.0	0	50.0	57.5	1	9	84	0.557	48.9	115.0	Inf.	0.733	0.278	--
60.0	115.0	0	50.0	57.5	1	9	84	0.552	48.5	115.0	Inf.	0.728	0.277	--

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration (g):	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress [Tav]	Field SPT [N]	Correction Factor [Ccr]	Relative Density [Dr] (%)	Correction Factor [Cn]	Corrected [N]60	rd Factor	Maximum Shear Mod. [Gmax] (tsf)	$\gamma_{eff}^{*1}[\text{Geff}]$ [Gmax]	yeff Shear Strain	$\gamma_{eff}^{*100\%}$	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [Nc]	Corrected Vol. Strains [Ec]	Estimated Settlement [S] (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	13	1.25	87.4	2.0	40.6	1.0	213.291	6.25E-05	1.40E-04	0.014	5.98E-03	10.0787	5.00E-03	0.00
2.0	1.0	1.5	115.0	0.09	0.06	0.040	13	1.25	85.0	2.0	40.6	1.0	369.431	1.06E-04	3.00E-03	0.300	1.28E-01	10.0787	1.07E-01	0.03
3.0	1.0	2.5	115.0	0.14	0.10	0.067	13	1.25	82.9	2.0	40.6	1.0	476.934	1.34E-04	3.00E-03	0.300	1.28E-01	10.0787	1.07E-01	0.03
4.0	1.0	3.5	115.0	0.20	0.13	0.094	13	1.25	80.9	2.0	40.6	1.0	564.315	1.56E-04	8.10E-04	0.081	3.46E-02	10.0787	2.89E-02	0.01
5.0	1.0	4.5	115.0	0.26	0.17	0.121	13	1.25	79.0	2.0	40.6	1.0	639.873	1.73E-04	8.10E-04	0.081	3.46E-02	10.0787	2.89E-02	0.01
6.0	1.0	5.5	115.0	0.32	0.21	0.148	13	1.25	77.2	1.8	37.6	1.0	689.068	1.93E-04	4.50E-04	0.045	2.11E-02	10.0787	1.77E-02	0.00
7.0	1.0	6.5	115.0	0.37	0.25	0.174	21	1.25	96.1	1.7	49.0	1.0	818.795	1.88E-04	4.50E-04	0.045	1.53E-02	10.0787	1.28E-02	0.00
8.0	1.0	7.5	115.0	0.43	0.29	0.201	21	1.25	94.1	1.6	45.9	1.0	860.371	2.03E-04	1.00E-03	0.100	3.69E-02	10.0787	3.08E-02	0.01
9.0	1.0	8.5	115.0	0.49	0.33	0.227	21	1.25	92.3	1.5	43.3	1.0	898.554	2.16E-04	1.00E-03	0.100	3.95E-02	10.0787	3.30E-02	0.01
10.0	1.0	9.5	115.0	0.55	0.37	0.253	21	1.25	90.6	1.4	44.6	1.0	958.713	2.22E-04	1.00E-03	0.100	3.82E-02	10.0787	3.20E-02	0.01
11.0	1.0	10.5	115.0	0.60	0.40	0.279	21	1.25	90.6	1.3	42.7	1.0	993.893	2.33E-04	1.00E-03	0.100	4.02E-02	10.0787	3.36E-02	0.01
12.0	1.0	11.5	115.0	0.66	0.44	0.305	21	1.25	90.6	1.3	41.1	0.9	1027.090	2.42E-04	1.00E-03	0.100	4.21E-02	10.0787	3.52E-02	0.01
13.0	1.0	12.5	115.0	0.72	0.48	0.331	21	1.25	90.6	1.2	39.7	0.9	1058.581	2.51E-04	1.00E-03	0.100	4.39E-02	10.0787	3.67E-02	0.01
14.0	1.0	13.5	115.0	0.78	0.52	0.357	21	1.25	90.6	1.2	38.5	0.9	1088.585	2.59E-04	7.10E-04	0.071	3.23E-02	10.0787	2.70E-02	0.01
15.0	1.0	14.5	115.0	0.83	0.56	0.382	15	1.25	70.3	1.1	30.4	0.9	1042.146	2.86E-04	7.10E-04	0.071	4.30E-02	10.0787	3.60E-02	0.01
16.0	1.0	15.5	115.0	0.89	0.60	0.407	15	1.25	70.3	1.1	29.6	0.9	1068.343	2.93E-04	7.10E-04	0.071	4.44E-02	10.0787	3.71E-02	0.01
17.0	1.0	16.5	115.0	0.95	0.64	0.432	15	1.25	70.3	1.0	28.9	0.9	1093.566	2.99E-04	7.10E-04	0.071	4.57E-02	10.0787	3.82E-02	0.01
18.0	1.0	17.5	115.0	1.01	0.67	0.457	26	1.25	86.1	1.0	45.4	0.9	1309.221	2.61E-04	7.10E-04	0.071	2.66E-02	10.0787	2.22E-02	0.01
19.0	1.0	18.5	115.0	1.06	0.71	0.481	26	1.25	86.1	1.0	44.3	0.9	1334.940	2.66E-04	7.10E-04	0.071	2.74E-02	10.0787	2.29E-02	0.01
20.0	1.0	19.5	115.0	1.12	0.75	0.506	26	1.25	86.1	1.0	43.2	0.9	1359.800	2.70E-04	7.10E-04	0.071	2.82E-02	10.0787	2.35E-02	0.01
21.0	1.0	20.5	115.0	1.18	0.79	0.529	26	1.25	86.1	0.9	41.8	0.9	1378.762	2.76E-04	7.10E-04	0.071	2.93E-02	10.0787	2.45E-02	0.01
22.0	1.0	21.5	115.0	1.24	0.83	0.553	26	1.25	86.1	0.9	40.9	0.9	1401.911	2.80E-04	7.10E-04	0.071	3.01E-02	10.0787	2.51E-02	0.01
23.0	1.0	22.5	115.0	1.29	0.87	0.576	26	1.25	86.1	0.9	40.1	0.9	1424.393	2.83E-04	7.10E-04	0.071	3.08E-02	10.0787	2.58E-02	0.01
24.0	1.0	23.5	115.0	1.35	0.91	0.599	26	1.25	86.1	0.9	39.3	0.9	1446.255	2.87E-04	7.10E-04	0.071	3.15E-02	10.0787	2.64E-02	0.01
25.0	1.0	24.5	115.0	1.41	0.94	0.622	22	1.25	74.3	0.9	38.2	0.9	1462.693	2.91E-04	7.10E-04	0.071	3.27E-02	10.0787	2.73E-02	0.01
26.0	1.0	25.5	115.0	1.47	0.98	0.644	22	1.25	74.3	0.8	37.6	0.9	1484.155	2.94E-04	7.10E-04	0.071	3.33E-02	10.0787	2.78E-02	0.01
27.0	1.0	26.5	115.0	1.52	1.02	0.666	22	1.25	74.3	0.8	37.0	0.9	1505.118	2.96E-04	5.20E-04	0.052	2.48E-02	10.0787	2.08E-02	0.00
28.0	1.0	27.5	115.0	1.58	1.06	0.688	35	1.25	88.6	0.8	49.1	0.9	1684.280	2.70E-04	5.20E-04	0.052	1.77E-02	10.0787	1.48E-02	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.709	35	1.25	88.6	0.8	48.2	0.9	1704.453	2.73E-04	5.20E-04	0.052	1.81E-02	10.0787	1.51E-02	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.730	35	1.25	88.6	0.8	47.4	0.9	1724.159	2.75E-04	5.20E-04	0.052	1.85E-02	10.0787	1.55E-02	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.751	35	1.25	88.6	0.8	46.6	0.9	1743.425	2.76E-04	5.20E-04	0.052	1.89E-02	10.0787	1.58E-02	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.771	35	1.25	88.6	0.8	45.8	0.9	1762.274	2.78E-04	5.20E-04	0.052	1.92E-02	10.0787	1.61E-02	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.791	35	1.25	88.6	0.7	45.1	0.9	1780.729	2.80E-04	5.20E-04	0.052	1.96E-02	10.0787	1.64E-02	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.811	35	1.25	88.6	0.7	44.4	0.8	1798.809	2.81E-04	5.20E-04	0.052	1.99E-02	10.0787	1.67E-02	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.830	10	1.25	45.0	0.7	13.4	0.8	1223.333	4.20E-04	1.30E-03	0.130	2.11E-01	10.0787	1.76E-01	0.04
36.0	1.0	35.5	115.0	2.04	1.37	0.848	10	1.25	45.0	0.7	13.2	0.8	1235.423	4.21E-04	1.30E-03	0.130	2.14E-01	10.0787	1.79E-01	0.04
37.0	1.0	36.5	115.0	2.10	1.41	0.867	10	1.25	45.0	0.7	13.0	0.8	1247.296	4.23E-04	1.30E-03	0.130	2.17E-01	10.0787	1.82E-01	0.04
38.0	1.0	37.5	115.0	2.16	1.44	0.885	10	1.25	45.0	0.7	12.9	0.8	1258.962	4.24E-04	1.30E-03	0.130	2.21E-01	10.0787	1.85E-01	0.04
39.0	1.0	38.5	115.0	2.21	1.48	0.902	10	1.25	45.0	0.7	12.7	0.8	1270.431	4.25E-04	1.30E-03	0.130	2.24E-01	10.0787	1.87E-01	0.04
40.0	1.0	39.5	115.0	2.27	1.52	0.919	7	1.25	36.0	0.7	9.0	0.8	1149.105	4.75E-04	1.30E-03	0.130	3.37E-01	10.0787	2.82E-01	0.07
41.0	1.0	40.5	115.0	2.33	1.56	0.936	7	1.25	36.0	0.7	8.9	0.8	1159.184	4.76E-04	1.30E-03	0.130	3.41E-01	10.0787	2.85E-01	0.07
42.0	1.0	41.5	115.0	2.39	1.60	0.953	50	1.25	93.7	0.7	57.9	0.8	2186.726	2.55E-04	5.20E-04	0.052	1.45E-02	10.0787	1.21E-02	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.969	50	1.25	93.7	0.7	57.2	0.8	2204.282	2.56E-04	5.20E-04	0.052	1.47E-02	10.0787	1.23E-02	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.984	50	1.25	93.7	0.6	56.6	0.8	2221.567	2.56E-04	5.20E-04	0.052	1.49E-02	10.0787	1.25E-02	0.00
45.0	1.0	44.5	115.0	2.56	1.71	1.000	50	1.25	93.7	0.6	56.0	0.8	2238.592	2.56E-04	5.20E-04	0.052	1.51E-02	10.0787	1.27E-02	0.00
46.0	1.0	45.5	115.0	2.62	1.75	1.014	50	1.25	93.7	0.6	55.3	0.8	2255.366	2.56E-04	5.20E-04	0.052	1.53E-02	10.0787	1.28E-02	0.00
47.0	1.0	46.5	115.0	2.67	1.79	1.029	50	1.25	90.0	0.6	57.7	0.8	2312.474	2.52E-04	5.20E-04	0.052	1.46E-02	10.0787	1.22E-02	0.00
48.0	1.0	47.5	115.0	2.73	1.83	1.043	50	1.25	90.0	0.6	57.2	0.8	2329.487	2.52E-04	5.20E-04	0.052	1.47E-02	10.0787	1.23E-02	0.00
49.0	1.0	48.5	115.0	2.79	1.87	1.057	50	1.25	90.0	0.6	56.6	0.8	2346.272	2.52E-04	5.20E-04	0.052	1.49E-02	10.0787	1.25E-02	0.00
50.0	1.0	49.5	115.0	2.85	1.91	1.070	50	1.25	90.0	0.6	56.1	0.8	2362.837	2.52E-04	5.20E-04	0.052	1.51E-02	10.0787	1.26E-02	0.00
51.0	1.0	50.5	115.0	2.90	1.95	1.083	50	1.25	90.0	0.6	55.6	0.8	2379.190	2.52E-04	5.20E-04	0.052	1.53E-02	10.0787	1.28E-02	0.00
52.0	1.0	51.5	115.0	2.96	1.98	1.095	50	1.25	86.7	0.6	55.1	0.8	2395.336	2.52E-04	5.20E-04	0.052	1.54E-02	10.0787	1.29E-02	0.00
53.0	1.0	52.5	115.0	3.02	2.02	1.108	50	1.25	86.7	0.6	54.6	0.8	2411.283	2.52E-04	5.20E-04	0.052	1.56E-02	10.0787	1.30E-02	0.00
54.0	1.0	53.5	115.0	3.08	2.06	1.119	50	1.25	86.7	0.6	54.1	0.8	2427.038	2.52E-04	5.20E-04	0.052	1.			



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

NCEER (1996) METHOD

By Thomas F. Blake (1994-1996)

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA_M (g):	0.720
Calculated Mag.Wtg.Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf): 62.4

Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.
1.0	115.0	0	14.0	1.0	1	47	91	2.000	43.2	115.0	Inf.	0.998	0.379	--
2.0	115.0	0	14.0	2.0	1	47	88	2.000	43.2	115.0	Inf.	0.993	0.377	--
3.0	115.0	0	14.0	3.0	1	47	86	2.000	43.2	115.0	Inf.	0.989	0.376	--
4.0	115.0	0	14.0	4.0	1	47	84	2.000	43.2	115.0	Inf.	0.984	0.374	--
5.0	115.0	0	14.0	5.0	1	47	82	2.000	43.2	115.0	Inf.	0.979	0.372	--
6.0	115.0	0	14.0	6.0	1	47	80	1.817	39.9	115.0	Inf.	0.975	0.370	--
7.0	115.0	0	9.0	7.0	1	47	63	1.671	26.5	115.0	0.312	0.970	0.369	--
8.0	115.0	0	9.0	8.0	1	47	62	1.556	25.1	115.0	0.287	0.966	0.367	--
9.0	115.0	0	9.0	9.0	1	47	60	1.462	24.0	115.0	0.270	0.961	0.365	--
10.0	115.0	0	9.0	10.0	1	47	59	1.382	23.1	115.0	0.257	0.957	0.363	--
11.0	115.0	0	9.0	10.0	1	47	59	1.315	22.3	115.0	0.246	0.952	0.362	--
12.0	115.0	0	9.0	10.0	1	47	59	1.257	21.6	115.0	0.237	0.947	0.360	--
13.0	115.0	0	21.0	12.5	1	27	86	1.205	37.9	115.0	Inf.	0.943	0.358	--
14.0	115.0	0	21.0	12.5	1	27	86	1.160	36.7	115.0	Inf.	0.938	0.356	--
15.0	115.0	0	21.0	12.5	1	27	86	1.119	35.6	115.0	Inf.	0.934	0.355	--
16.0	115.0	0	21.0	12.5	1	27	86	1.082	34.6	115.0	Inf.	0.929	0.353	--
17.0	115.0	0	16.0	17.5	1	14	69	1.049	26.9	115.0	0.322	0.925	0.351	--
18.0	115.0	0	16.0	17.5	1	14	69	1.019	26.2	115.0	0.307	0.920	0.349	--
19.0	115.0	0	16.0	17.5	1	14	69	0.991	25.5	115.0	0.295	0.915	0.348	--
20.0	115.0	0	38.0	22.5	1	14	100	0.965	60.8	115.0	Inf.	0.911	0.346	--
21.0	115.0	0	38.0	22.5	1	14	100	0.941	59.3	115.0	Inf.	0.906	0.344	--
22.0	115.0	0	38.0	22.5	1	14	100	0.919	58.0	115.0	Inf.	0.902	0.343	--
23.0	115.0	0	38.0	22.5	1	14	100	0.898	56.7	115.0	Inf.	0.897	0.341	--
24.0	115.0	0	38.0	22.5	1	14	100	0.879	55.5	115.0	Inf.	0.893	0.339	--
25.0	115.0	0	38.0	22.5	1	14	100	0.861	54.4	115.0	Inf.	0.888	0.337	--
26.0	115.0	0	38.0	22.5	1	14	100	0.844	53.4	115.0	Inf.	0.883	0.336	--
27.0	115.0	0	38.0	22.5	1	14	100	0.828	52.4	115.0	Inf.	0.879	0.334	--
28.0	115.0	0	36.0	37.5	1	3	83	0.813	50.5	115.0	Inf.	0.874	0.332	--
29.0	115.0	0	36.0	37.5	1	3	83	0.798	49.6	115.0	Inf.	0.870	0.330	--
30.0	115.0	0	36.0	37.5	1	3	83	0.785	48.7	115.0	Inf.	0.865	0.329	--
31.0	115.0	0	36.0	37.5	1	3	83	0.772	47.9	115.0	Inf.	0.861	0.327	--
32.0	115.0	0	67.0	32.5	1	4	119	0.759	87.7	115.0	Inf.	0.856	0.325	--
33.0	115.0	0	67.0	32.5	1	4	119	0.747	86.4	115.0	Inf.	0.851	0.323	--
34.0	115.0	0	67.0	32.5	1	4	119	0.736	85.1	115.0	Inf.	0.847	0.322	--
35.0	115.0	0	67.0	32.5	1	4	119	0.725	83.8	115.0	Inf.	0.842	0.320	--
36.0	115.0	0	67.0	32.5	1	4	119	0.715	82.7	115.0	Inf.	0.838	0.318	--
37.0	115.0	0	63.0	37.5	1	4	110	0.705	76.6	115.0	Inf.	0.833	0.316	--
38.0	115.0	0	63.0	37.5	1	4	110	0.696	75.6	115.0	Inf.	0.829	0.315	--
39.0	115.0	0	63.0	37.5	1	4	110	0.687	74.6	115.0	Inf.	0.824	0.313	--
40.0	115.0	0	63.0	37.5	1	4	110	0.678	73.7	115.0	Inf.	0.819	0.311	--
41.0	115.0	0	63.0	37.5	1	4	110	0.670	72.8	115.0	Inf.	0.815	0.310	--
42.0	115.0	0	100.0	42.5	1	4	132	0.661	114.1	115.0	Inf.	0.810	0.308	--
43.0	115.0	0	100.0	42.5	1	4	132	0.654	112.7	115.0	Inf.	0.806	0.306	--
44.0	115.0	0	100.0	42.5	1	4	132	0.646	111.4	115.0	Inf.	0.801	0.304	--
45.0	115.0	0	100.0	42.5	1	4	132	0.639	110.2	115.0	Inf.	0.797	0.303	--
46.0	115.0	0	100.0	42.5	1	4	132	0.632	109.0	115.0	Inf.	0.792	0.301	--
47.0	115.0	0	100.0	47.5	1	6	127	0.625	107.9	115.0	Inf.	0.787	0.299	--
48.0	115.0	0	100.0	47.5	1	6	127	0.618	106.8	115.0	Inf.	0.783	0.297	--
49.0	115.0	0	100.0	47.5	1	6	127	0.612	105.7	115.0	Inf.	0.778	0.296	--
50.0	115.0	0	100.0	47.5	1	6	127	0.606	104.6	115.0	Inf.	0.774	0.294	--
51.0	115.0	0	100.0	47.5	1	6	127	0.600	103.5	115.0	Inf.	0.769	0.292	--
52.0	115.0	0	100.0	52.5	1	6	123	0.594	102.5	115.0	Inf.	0.765	0.290	--
53.0	115.0	0	100.0	52.5	1	6	123	0.588	101.6	115.0	Inf.	0.760	0.289	--
54.0	115.0	0	100.0	52.5	1	6	123	0.583	100.6	115.0	Inf.	0.755	0.287	--
55.0	115.0	0	100.0	52.5	1	6	123	0.577	99.7	115.0	Inf.	0.751	0.285	--
56.0	115.0	0	100.0	52.5	1	6	123	0.572	98.8	115.0	Inf.	0.746	0.283	--
57.0	115.0	0	100.0	57.5	1	6	118	0.567	97.9	115.0	Inf.	0.742	0.282	--
58.0	115.0	0	100.0	57.5	1	6	118	0.562	97.0	115.0	Inf.	0.737	0.280	--
59.0	115.0	0	100.0	57.5	1	6	118	0.557	96.2	115.0	Inf.	0.733	0.278	--
60.0	115.0	0	100.0	57.5	1	6	118	0.552	95.4	115.0	Inf.	0.728	0.277	--

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration (g):	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress [Tav] (tsf)	Field SPT [N]	Correction Factor [Ccr]	Relative Density [Dr] (%)	Correction Factor [Cn]	Corrected [N]60	rd Factor	Maximum Shear Mod. [Gmax] (tsf)	[yeff] ¹ [Geff] [Gmax]	yeff Shear Strain	[yeff] ¹ 100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [Nc]	Corrected Vol. Strains [Ec]	Estimated Settlement [S] (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	14	1.25	90.7	2.0	43.2	1.0	217.725	6.12E-05	1.40E-04	0.014	5.55E-03	10.0787	4.64E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.040	14	1.25	88.2	2.0	43.2	1.0	377.111	1.04E-04	3.00E-03	0.300	1.19E-01	10.0787	9.95E-02	CUT
3.0	1.0	2.5	115.0	0.14	0.10	0.067	14	1.25	86.0	2.0	43.2	1.0	486.849	1.32E-04	3.00E-03	0.300	1.19E-01	10.0787	9.95E-02	
4.0	1.0	3.5	115.0	0.20	0.13	0.094	14	1.25	83.9	2.0	43.2	1.0	576.047	1.53E-04	8.10E-04	0.081	3.21E-02	10.0787	2.69E-02	0.006
5.0	1.0	4.5	115.0	0.26	0.17	0.121	14	1.25	82.0	2.0	43.2	1.0	653.176	1.70E-04	8.10E-04	0.081	3.21E-02	10.0787	2.69E-02	0.006
6.0	1.0	5.5	115.0	0.32	0.21	0.148	14	1.25	80.2	1.8	39.9	1.0	703.153	1.89E-04	4.50E-04	0.045	1.96E-02	10.0787	1.64E-02	0.004
7.0	1.0	6.5	115.0	0.37	0.25	0.174	9	1.25	62.9	1.7	26.5	1.0	666.551	2.31E-04	1.00E-03	0.100	7.15E-02	10.0787	5.98E-02	0.014
8.0	1.0	7.5	115.0	0.43	0.29	0.201	9	1.25	61.6	1.6	25.1	1.0	703.663	2.48E-04	1.00E-03	0.100	7.61E-02	10.0787	6.36E-02	0.015
9.0	1.0	8.5	115.0	0.49	0.33	0.227	9	1.25	60.4	1.5	24.0	1.0	738.015	2.63E-04	1.00E-03	0.100	8.03E-02	10.0787	6.71E-02	0.016
10.0	1.0	9.5	115.0	0.55	0.37	0.253	9	1.25	59.3	1.4	23.1	1.0	770.122	2.77E-04	1.00E-03	0.100	8.41E-02	10.0787	7.03E-02	0.017
11.0	1.0	10.5	115.0	0.60	0.40	0.279	9	1.25	59.3	1.3	22.3	1.0	800.354	2.89E-04	1.00E-03	0.100	8.77E-02	10.0787	7.33E-02	0.018
12.0	1.0	11.5	115.0	0.66	0.44	0.305	9	1.25	59.3	1.3	21.6	0.9	828.992	3.00E-04	2.70E-03	0.270	2.46E-01	10.0787	2.05E-01	0.049
13.0	1.0	12.5	115.0	0.72	0.48	0.331	21	1.25	85.9	1.2	37.9	0.9	1042.383	2.55E-04	1.00E-03	0.100	4.64E-02	10.0787	3.88E-02	0.009
14.0	1.0	13.5	115.0	0.78	0.52	0.357	21	1.25	85.9	1.2	36.7	0.9	1071.384	2.63E-04	7.10E-04	0.071	3.43E-02	10.0787	2.86E-02	0.007
15.0	1.0	14.5	115.0	0.83	0.56	0.382	21	1.25	85.9	1.1	35.6	0.9	1099.093	2.71E-04	7.10E-04	0.071	3.55E-02	10.0787	2.97E-02	0.007
16.0	1.0	15.5	115.0	0.89	0.60	0.407	21	1.25	85.9	1.1	34.6	0.9	1125.653	2.78E-04	7.10E-04	0.071	3.68E-02	10.0787	3.07E-02	0.007
17.0	1.0	16.5	115.0	0.95	0.64	0.432	16	1.25	69.4	1.0	26.9	0.9	1067.422	3.06E-04	1.20E-03	0.120	8.42E-02	10.0787	7.04E-02	0.017
18.0	1.0	17.5	115.0	1.01	0.67	0.457	16	1.25	69.4	1.0	26.2	0.9	1089.410	3.13E-04	1.20E-03	0.120	8.70E-02	10.0787	7.27E-02	0.017
19.0	1.0	18.5	115.0	1.06	0.71	0.481	16	1.25	69.4	1.0	25.5	0.9	1110.614	3.19E-04	1.20E-03	0.120	8.97E-02	10.0787	7.50E-02	0.018
20.0	1.0	19.5	115.0	1.12	0.75	0.506	38	1.25	100.0	1.0	60.8	0.9	1523.256	2.41E-04	7.10E-04	0.071	1.87E-02	10.0787	1.56E-02	0.004
21.0	1.0	20.5	115.0	1.18	0.79	0.529	38	1.25	100.0	0.9	59.3	0.9	1549.313	2.45E-04	7.10E-04	0.071	1.93E-02	10.0787	1.61E-02	0.004
22.0	1.0	21.5	115.0	1.24	0.83	0.553	38	1.25	100.0	0.9	58.0	0.9	1574.554	2.49E-04	7.10E-04	0.071	1.98E-02	10.0787	1.66E-02	0.004
23.0	1.0	22.5	115.0	1.29	0.87	0.576	38	1.25	100.0	0.9	56.7	0.9	1599.040	2.52E-04	7.10E-04	0.071	2.03E-02	10.0787	1.70E-02	0.004
24.0	1.0	23.5	115.0	1.35	0.91	0.599	38	1.25	100.0	0.9	55.5	0.9	1622.827	2.55E-04	7.10E-04	0.071	2.08E-02	10.0787	1.74E-02	0.004
25.0	1.0	24.5	115.0	1.41	0.94	0.622	38	1.25	100.0	0.9	54.4	0.9	1645.963	2.58E-04	7.10E-04	0.071	2.13E-02	10.0787	1.78E-02	0.004
26.0	1.0	25.5	115.0	1.47	0.98	0.644	38	1.25	100.0	0.8	53.4	0.9	1668.493	2.61E-04	7.10E-04	0.071	2.18E-02	10.0787	1.83E-02	0.004
27.0	1.0	26.5	115.0	1.52	1.02	0.666	38	1.25	100.0	0.8	52.4	0.9	1690.454	2.64E-04	5.20E-04	0.052	1.64E-02	10.0787	1.37E-02	0.003
28.0	1.0	27.5	115.0	1.58	1.06	0.688	36	1.25	83.0	0.8	50.5	0.9	1700.170	2.68E-04	5.20E-04	0.052	1.71E-02	10.0787	1.43E-02	0.003
29.0	1.0	28.5	115.0	1.64	1.10	0.709	36	1.25	83.0	0.8	49.6	0.9	1720.533	2.70E-04	5.20E-04	0.052	1.75E-02	10.0787	1.46E-02	0.004
30.0	1.0	29.5	115.0	1.70	1.14	0.730	36	1.25	83.0	0.8	48.7	0.9	1740.426	2.72E-04	5.20E-04	0.052	1.79E-02	10.0787	1.49E-02	0.004
31.0	1.0	30.5	115.0	1.75	1.18	0.751	36	1.25	83.0	0.8	47.9	0.9	1759.873	2.74E-04	5.20E-04	0.052	1.82E-02	10.0787	1.52E-02	0.004
32.0	1.0	31.5	115.0	1.81	1.21	0.771	67	1.25	118.8	0.8	87.7	0.9	2188.143	2.24E-04	5.20E-04	0.052	8.82E-03	10.0787	7.37E-03	0.002
33.0	1.0	32.5	115.0	1.87	1.25	0.791	67	1.25	118.8	0.7	86.4	0.9	2211.058	2.25E-04	5.20E-04	0.052	8.98E-03	10.0787	7.51E-03	0.002
34.0	1.0	33.5	115.0	1.93	1.29	0.811	67	1.25	118.8	0.7	85.1	0.8	2233.506	2.26E-04	5.20E-04	0.052	9.15E-03	10.0787	7.65E-03	0.002
35.0	1.0	34.5	115.0	1.98	1.33	0.830	67	1.25	118.8	0.7	83.8	0.8	2255.513	2.28E-04	5.20E-04	0.052	9.31E-03	10.0787	7.79E-03	0.002
36.0	1.0	35.5	115.0	2.04	1.37	0.848	67	1.25	118.8	0.7	82.7	0.8	2277.098	2.28E-04	5.20E-04	0.052	9.47E-03	10.0787	7.92E-03	0.002
37.0	1.0	36.5	115.0	2.10	1.41	0.867	63	1.25	109.8	0.7	76.6	0.8	2251.603	2.34E-04	5.20E-04	0.052	1.04E-02	10.0787	8.67E-03	0.002
38.0	1.0	37.5	115.0	2.16	1.44	0.885	63	1.25	109.8	0.7	75.6	0.8	2271.980	2.35E-04	5.20E-04	0.052	1.05E-02	10.0787	8.81E-03	0.002
39.0	1.0	38.5	115.0	2.21	1.48	0.902	63	1.25	109.8	0.7	74.6	0.8	2291.999	2.36E-04	5.20E-04	0.052	1.07E-02	10.0787	8.95E-03	0.002
40.0	1.0	39.5	115.0	2.27	1.52	0.919	63	1.25	109.8	0.7	73.7	0.8	2311.674	2.36E-04	5.20E-04	0.052	1.09E-02	10.0787	9.09E-03	0.002
41.0	1.0	40.5	115.0	2.33	1.56	0.936	63	1.25	109.8	0.7	72.8	0.8	2331.019	2.37E-04	5.20E-04	0.052	1.10E-02	10.0787	9.23E-03	0.002
42.0	1.0	41.5	115.0	2.39	1.60	0.953	100	1.25	132.4	0.7	114.1	0.8	2741.343	2.03E-04	5.20E-04	0.052	6.43E-03	10.0787	5.38E-03	0.001
43.0	1.0	42.5	115.0	2.44	1.64	0.969	100	1.25	132.4	0.7	112.7	0.8	2763.187	2.04E-04	5.20E-04	0.052	6.53E-03	10.0787	5.46E-03	0.001
44.0	1.0	43.5	115.0	2.50	1.68	0.984	100	1.25	132.4	0.6	111.4	0.8	2784.691	2.04E-04	5.20E-04	0.052	6.62E-03	10.0787	5.53E-03	0.001
45.0	1.0	44.5	115.0	2.56	1.71	1.000	100	1.25	132.4	0.6	110.2	0.8	2805.869	2.04E-04	5.20E-04	0.052	6.71E-03	10.0787	5.61E-03	0.001
46.0	1.0	45.5	115.0	2.62	1.75	1.014	100	1.25	132.4	0.6	109.0	0.8	2826.731	2.05E-04	5.20E-04	0.052	6.80E-03	10.0787	5.69E-03	0.001
47.0	1.0	46.5	115.0	2.67	1.79	1.029	100	1.25	127.2	0.6	107.9	0.8	2848.316	2.05E-04	5.20E-04	0.052	6.88E-03	10.0787	5.75E-03	0.001
48.0	1.0	47.5	115.0	2.73	1.83	1.043	100	1.25	127.2	0.6	106.8	0.8	2868.601	2.05E-04	5.20E-04	0.052	6.97E-03	10.0787	5.83E-03	0.001
49.0	1.0	48.5	115.0	2.79	1.87	1.057	100	1.25	127.2	0.6	105.7	0.8	2888.603	2.05E-04	5.20E-04	0.052	7.06E-03	10.0787	5.90E-03	0.001
50.0	1.0	49.5	115.0	2.85	1.91	1.070	100	1.25	127.2	0.6	104.6	0.8	2908.332	2.05E-04	5.20E-04	0.052	7.14E-03	10.0787	5.97E-03	0.001
51.0	1.0	50.5	115.0	2.90	1.95	1.083	100	1.25	127.2	0.6	103.5	0.8	2927.797	2.05E-04	5.20E-04	0.052	7.23E-03	10.0787	6.04E-03	0.001
52.0	1.0	51.5	115.0	2.96	1.98	1.095	100	1.25	122.6	0.6	102.5	0.8	2947.007	2.05E-04	5.20E-04	0.052	7.31E-03	10.0787	6.12E-03	0.001
53.0	1.0	52.5	115.0	3.02	2.02	1.108	100	1.25	122.6	0.6	101.6	0.8	2965.970	2.05E-04	5.20E-04	0.052	7.40E-03	10.0787	6.19E-03	0.001
54.0	1.0	53.5	115.0	3.08	2.06	1.119	100	1.25	12											



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

**NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:**

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA_M (g):	0.720
Calculated Mag.Wtg.Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

**By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:**

Energy Correction (CE) for N_{60} :	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):															
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.	
1.0	115.0	0	10.0	1.0	1		77	2.000	25.9	115.0	0.301	0.998	0.379	--	
2.0	115.0	0	10.0	2.0	1		75	2.000	25.9	115.0	0.301	0.993	0.377	--	
3.0	115.0	0	10.0	3.0	1		73	2.000	25.9	115.0	0.301	0.989	0.376	--	
4.0	115.0	0	10.0	4.0	1		71	2.000	25.9	115.0	0.301	0.984	0.374	--	
5.0	115.0	0	10.0	5.0	1		69	2.000	25.9	115.0	0.301	0.979	0.372	--	
6.0	115.0	0	10.0	6.0	1		68	1.817	23.5	115.0	0.262	0.975	0.370	--	
7.0	115.0	0	10.0	7.0	1		66	1.671	21.6	115.0	0.237	0.970	0.369	--	
8.0	115.0	0	33.0	8.0	1	6	118	1.556	66.5	115.0	Inf.	0.966	0.367	--	
9.0	115.0	0	33.0	9.0	1	6	116	1.462	62.5	115.0	Inf.	0.961	0.365	--	
10.0	115.0	0	33.0	10.0	1	6	114	1.382	59.1	115.0	Inf.	0.957	0.363	--	
11.0	115.0	0	33.0	10.0	1	6	114	1.315	56.3	115.0	Inf.	0.952	0.362	--	
12.0	115.0	0	32.0	12.5	1	21	106	1.257	55.6	115.0	Inf.	0.947	0.360	--	
13.0	115.0	0	32.0	12.5	1	21	106	1.205	53.5	115.0	Inf.	0.943	0.358	--	
14.0	115.0	0	32.0	12.5	1	21	106	1.160	51.6	115.0	Inf.	0.938	0.356	--	
15.0	115.0	0	24.0	17.5	1	29	85	1.119	45.2	115.0	Inf.	0.934	0.355	--	
16.0	115.0	0	24.0	17.5	1	29	85	1.082	43.9	115.0	Inf.	0.929	0.353	--	
17.0	115.0	0	24.0	17.5	1	29	85	1.049	42.7	115.0	Inf.	0.925	0.351	--	
18.0	115.0	0	24.0	17.5	1	29	85	1.019	41.6	115.0	Inf.	0.920	0.349	--	
19.0	115.0	0	15.0	22.5	1	24	63	0.991	28.2	115.0	0.345	0.915	0.348	--	
20.0	115.0	0	15.0	22.5	1	24	63	0.965	27.6	115.0	0.328	0.911	0.346	--	
21.0	115.0	0	15.0	22.5	1	24	63	0.941	27.0	115.0	0.315	0.906	0.344	--	
22.0	115.0	0	15.0	22.5	1	24	63	0.919	26.5	115.0	0.304	0.902	0.343	--	
23.0	115.0	0	15.0	22.5	1	24	63	0.898	26.0	115.0	0.294	0.897	0.341	--	
24.0	115.0	0	15.0	22.5	1	24	63	0.879	25.5	115.0	0.286	0.893	0.339	--	
25.0	115.0	0	15.0	22.5	1	24	63	0.861	25.1	115.0	0.279	0.888	0.337	--	
26.0	115.0	0	15.0	22.5	1	24	63	0.844	24.7	115.0	0.272	0.883	0.336	--	
27.0	115.0	0	15.0	22.5	1	24	63	0.828	24.3	115.0	0.266	0.879	0.334	--	
28.0	115.0	0	10.0	27.5	1	16	48	0.813	16.2	115.0	0.166	0.874	0.332	--	
29.0	115.0	0	10.0	27.5	1	16	48	0.798	16.0	115.0	0.164	0.870	0.330	--	
30.0	115.0	0	10.0	27.5	1	16	48	0.785	15.7	115.0	0.162	0.865	0.329	--	
31.0	115.0	0	10.0	27.5	1	16	48	0.772	15.5	115.0	0.159	0.861	0.327	--	
32.0	115.0	0	23.0	32.5	1	16	70	0.759	32.6	115.0	Inf.	0.856	0.325	--	
33.0	115.0	0	23.0	32.5	1	16	70	0.747	32.2	115.0	Inf.	0.851	0.323	--	
34.0	115.0	0	23.0	32.5	1	16	70	0.736	31.7	115.0	Inf.	0.847	0.322	--	
35.0	115.0	0	21.0	35.0	1	16	65	0.725	28.8	115.0	0.339	0.842	0.320	--	
36.0	115.0	0	21.0	35.0	1	16	65	0.715	28.4	115.0	0.327	0.838	0.318	--	
37.0	115.0	0	21.0	35.0	1	16	65	0.705	28.0	115.0	0.317	0.833	0.316	--	
38.0	115.0	0	22.0	37.5	1	8	65	0.696	27.0	115.0	0.287	0.829	0.315	--	
39.0	115.0	0	22.0	37.5	1	8	65	0.687	26.6	115.0	0.280	0.824	0.313	--	
40.0	115.0	0	39.0	42.5	1	22	83	0.678	49.6	115.0	Inf.	0.819	0.311	--	
41.0	115.0	0	39.0	42.5	1	22	83	0.670	49.1	115.0	Inf.	0.815	0.310	--	
42.0	115.0	0	39.0	42.5	1	22	83	0.661	48.5	115.0	Inf.	0.810	0.308	--	
43.0	115.0	0	39.0	42.5	1	22	83	0.654	48.0	115.0	Inf.	0.806	0.306	--	
44.0	115.0	0	39.0	42.5	1	22	83	0.646	47.5	115.0	Inf.	0.801	0.304	--	
45.0	115.0	0	26.0	47.5	1	22	65	0.639	32.7	115.0	Inf.	0.797	0.303	--	
46.0	115.0	0	26.0	47.5	1	22	65	0.632	32.3	115.0	Inf.	0.792	0.301	--	
47.0	115.0	0	26.0	47.5	1	11	65	0.625	29.3	115.0	0.338	0.787	0.299	--	
48.0	115.0	0	26.0	47.5	1	11	65	0.618	29.0	115.0	0.324	0.783	0.297	--	
49.0	115.0	0	26.0	47.5	1	11	65	0.612	28.7	115.0	0.313	0.778	0.296	--	
50.0	115.0	0	32.0	52.5	1	13	69	0.606	35.2	115.0	Inf.	0.774	0.294	--	
51.0	115.0	0	32.0	52.5	1	13	69	0.600	34.8	115.0	Inf.	0.769	0.292	--	
52.0	115.0	0	32.0	52.5	1	13	69	0.594	34.5	115.0	Inf.	0.765	0.290	--	
53.0	115.0	0	32.0	52.5	1	13	69	0.588	34.2	115.0	Inf.	0.760	0.289	--	
54.0	115.0	0	51.0	57.5	1	11	85	0.583	52.7	115.0	Inf.	0.755	0.287	--	
55.0	115.0	0	51.0	57.5	1	11	85	0.577	52.2	115.0	Inf.	0.751	0.285	--	
56.0	115.0	0	51.0	57.5	1	11	85	0.572	51.7	115.0	Inf.	0.746	0.283	--	
57.0	115.0	0	51.0	57.5	1	11	85	0.567	51.3	115.0	Inf.	0.742	0.282	--	
58.0	115.0	0	51.0	57.5	1	11	85	0.562	50.9	115.0	Inf.	0.737	0.280	--	
59.0	115.0	0	51.0	57.5	1	11	85	0.557	50.4	115.0	Inf.	0.733	0.278	--	
60.0	115.0	0	51.0	57.5	1	11	85	0.552	50.0	115.0	Inf.	0.728	0.277	--	
61.0	115.0	0	55.0	62.5	1	11	85	0.548	53.4	115.0	Inf.	0.723	0.275	--	
62.0	115.0	0	55.0	62.5	1	11	85	0.543	53.0	115.0	Inf.	0.719	0.273	--	
63.0	115.0	0	55.0	62.5	1	11	85	0.539	52.6	115.0	Inf.	0.714	0.271	--	
64.0	115.0	0	55.0	62.5	1	11	85	0.535	52.2	115.0	Inf.	0.710	0.270	--	
65.0	115.0	0	55.0	62.5	1	11	85	0.531	51.8	115.0	Inf.	0.705	0.268	--	
66.0	115.0	0	40.0	67.5	1	11	70	0.526	37.8	115.0	Inf.	0.701	0.266	--	
67.0	115.0	0	40.0	67.5	1	11	70	0.523	37.5	115.0	Inf.	0.696	0.264	--	
68.0	115.0	0	40.0	67.5	1	11	70	0.519	37.2	115.0	Inf.	0.691	0.263	--	
69.0	115.0	0	40.0	67.5	1	11	70	0.515	36.9	115.0	Inf.	0.687	0.261	--	
70.0	115.0	0	40.0	67.5	1	11	70	0.511	36.7	115.0	Inf.	0.682	0.259	--	
71.0	115.0	0	55.0	72.5	1	11	80	0.507	49.6	115.0	Inf.	0.678	0.257	--	
72.0	115.0	0	55.0	72.5	1	11	80	0.504	49.2	115.0	Inf.	0.673	0.256	--	
73.0	115.0	0	55.0	72.5	1	11	80	0.500	48.9	115.0	Inf.	0.669	0.254	--	
74.0	115.0	0	55.0	72.5	1	11	80	0.497	48.6	115.0	Inf.	0.664	0.252	--	
75.0	115.0	0	55.0	72.5	1	11	80	0.494	48.3	115.0	Inf.	0.659	0.250	--	
76.0	115.0	0	55.0	77.5	1	14	78	0.490	48.7	115.0	Inf.	0.655	0.249	--	
77.0	115.0	0	55.0	77.5	1	14	78	0.487	48.4	115.0	Inf.	0.650	0.247	--	
78.0	115.0	0	55.0	77.5	1	14	78	0.484	48.1	115.0	Inf.	0.646	0.245	--	
79.0	115.0	0	55.0	77.5	1	14	78	0.481	47.8	115.0	Inf.	0.641	0.244	--	
80.0	115.0	0	55.0	77.5	1	14	78	0.478	47.5	115.0	Inf.	0.637	0.242	--	



TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9
EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS
MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION:	
Earthquake Magnitude	6.90
Peak Horiz. Acceleration (g)	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress (Tav) (tsf)	Field SPT (N)	Correction Factor [Cor]	Relative Density [Dr] (%)	Correction Factor [Cor]	Corrected [N]60	rd	Maximum Shear Mod. [Gmax] (tsf)	[veff]/[Geff] [Gmax]	veff Shear Strain	[veff]*100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [Nc]	Corrected Vol. Strains [E1]	Estimated Settlement [S] (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	10	1.25	76.6	2.0	25.9	1.0	183.495	7.26E-05	1.60E-04	0.016	1.17E-02	10.0787	9.82E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.040	10	1.25	74.6	2.0	25.9	1.0	317.822	1.23E-04	3.00E-03	0.300	2.20E-01	10.0787	1.84E-01	
3.0	1.0	2.5	115.0	0.14	0.10	0.067	10	1.25	72.7	2.0	25.9	1.0	410.307	1.56E-04	3.00E-03	0.300	2.20E-01	10.0787	1.84E-01	
4.0	1.0	3.5	115.0	0.20	0.13	0.094	10	1.25	70.9	2.0	25.9	1.0	485.482	1.81E-04	8.10E-04	0.081	5.95E-02	10.0787	4.97E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.121	10	1.25	69.3	2.0	25.9	1.0	550.485	2.01E-04	5.00E-03	0.500	3.67E-01	10.0787	3.07E-01	
6.0	1.0	5.5	115.0	0.32	0.21	0.148	10	1.25	67.7	1.8	23.5	1.0	589.416	2.26E-04	1.00E-03	0.100	8.24E-02	10.0787	6.89E-02	
7.0	1.0	6.5	115.0	0.37	0.25	0.174	10	1.25	66.3	1.7	21.6	1.0	623.169	2.47E-04	1.00E-03	0.100	9.11E-02	10.0787	7.61E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.201	33	1.25	118.0	1.6	66.5	0.9	873.674	1.79E-04	4.50E-04	0.045	1.79E-02	10.0787	8.71E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.227	33	1.25	115.7	1.5	62.5	1.0	1015.194	1.91E-04	4.50E-04	0.045	1.15E-02	10.0787	9.58E-03	
10.0	1.0	9.5	115.0	0.55	0.37	0.253	33	1.25	113.5	1.4	59.1	1.0	1053.577	2.02E-04	1.00E-03	0.100	2.72E-02	10.0787	2.28E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.279	33	1.25	113.5	1.3	56.3	1.0	1089.355	2.12E-04	1.00E-03	0.100	2.89E-02	10.0787	2.42E-02	
12.0	1.0	11.5	115.0	0.66	0.44	0.305	32	1.25	106.1	1.3	55.6	0.9	1135.832	2.19E-04	1.00E-03	0.100	2.93E-02	10.0787	2.45E-02	
13.0	1.0	12.5	115.0	0.72	0.48	0.331	32	1.25	106.1	1.2	53.5	0.9	1168.920	2.27E-04	1.00E-03	0.100	3.07E-02	10.0787	2.57E-02	
14.0	1.0	13.5	115.0	0.78	0.52	0.357	32	1.25	106.1	1.2	51.6	0.9	1200.354	2.35E-04	7.10E-04	0.071	2.28E-02	10.0787	1.90E-02	
15.0	1.0	14.5	115.0	0.83	0.56	0.382	24	1.25	85.0	1.1	45.2	0.9	1189.749	2.50E-04	7.10E-04	0.071	2.67E-02	10.0787	2.23E-02	
16.0	1.0	15.5	115.0	0.89	0.60	0.407	24	1.25	85.0	1.1	43.9	0.9	1218.176	2.57E-04	7.10E-04	0.071	2.77E-02	10.0787	2.31E-02	
17.0	1.0	16.5	115.0	0.95	0.64	0.432	24	1.25	85.0	1.0	42.7	0.9	1245.486	2.63E-04	7.10E-04	0.071	2.86E-02	10.0787	2.39E-02	
18.0	1.0	17.5	115.0	1.01	0.67	0.457	24	1.25	85.0	1.0	41.6	0.9	1271.792	2.68E-04	7.10E-04	0.071	2.95E-02	10.0787	2.46E-02	
19.0	1.0	18.5	115.0	1.06	0.71	0.481	15	1.25	62.9	1.0	28.2	0.9	1148.486	3.09E-04	1.20E-03	0.120	7.95E-02	10.0787	6.65E-02	0.016
20.0	1.0	19.5	115.0	1.12	0.75	0.506	15	1.25	62.9	1.0	27.6	0.9	1170.441	3.14E-04	1.20E-03	0.120	8.16E-02	10.0787	6.83E-02	0.016
21.0	1.0	20.5	115.0	1.18	0.79	0.529	15	1.25	62.9	0.9	27.0	0.9	1191.720	3.19E-04	1.20E-03	0.120	8.37E-02	10.0787	7.00E-02	0.017
22.0	1.0	21.5	115.0	1.24	0.83	0.553	15	1.25	62.9	0.9	26.5	0.9	1212.378	3.23E-04	1.20E-03	0.120	8.57E-02	10.0787	7.17E-02	0.017
23.0	1.0	22.5	115.0	1.29	0.87	0.576	15	1.25	62.9	0.9	26.0	0.9	1232.460	3.27E-04	1.20E-03	0.120	8.77E-02	10.0787	7.33E-02	0.018
24.0	1.0	23.5	115.0	1.35	0.91	0.599	15	1.25	62.9	0.9	25.5	0.9	1252.008	3.31E-04	1.20E-03	0.120	8.96E-02	10.0787	7.49E-02	0.018
25.0	1.0	24.5	115.0	1.41	0.94	0.622	15	1.25	62.9	0.9	25.1	0.9	1271.060	3.35E-04	1.20E-03	0.120	9.15E-02	10.0787	7.65E-02	0.018
26.0	1.0	25.5	115.0	1.47	0.98	0.644	15	1.25	62.9	0.8	24.7	0.9	1289.647	3.38E-04	1.20E-03	0.120	9.33E-02	10.0787	7.80E-02	0.019
27.0	1.0	26.5	115.0	1.52	1.02	0.666	15	1.25	62.9	0.8	24.3	0.9	1307.799	3.41E-04	8.10E-04	0.081	6.42E-02	10.0787	5.37E-02	0.013
28.0	1.0	27.5	115.0	1.58	1.06	0.688	10	1.25	48.4	0.8	16.2	0.9	1164.656	3.91E-04	8.10E-04	0.081	1.04E-01	10.0787	8.71E-02	0.011
29.0	1.0	28.5	115.0	1.64	1.10	0.709	10	1.25	48.4	0.8	16.0	0.9	1179.694	3.94E-04	8.10E-04	0.081	1.05E-01	10.0787	8.87E-02	0.021
30.0	1.0	29.5	115.0	1.70	1.14	0.730	10	1.25	48.4	0.8	15.7	0.9	1194.414	3.96E-04	8.10E-04	0.081	1.08E-01	10.0787	9.02E-02	0.022
31.0	1.0	30.5	115.0	1.75	1.18	0.751	10	1.25	48.4	0.8	15.5	0.9	1208.832	3.99E-04	8.10E-04	0.081	1.10E-01	10.0787	9.18E-02	0.022
32.0	1.0	31.5	115.0	1.81	1.21	0.771	23	1.25	69.6	0.8	32.6	0.9	1573.335	3.12E-04	8.10E-04	0.081	4.50E-02	10.0787	3.77E-02	0.009
33.0	1.0	32.5	115.0	1.87	1.25	0.791	23	1.25	69.6	0.7	32.2	0.9	1590.449	3.13E-04	8.10E-04	0.081	4.58E-02	10.0787	3.83E-02	0.009
34.0	1.0	33.5	115.0	1.93	1.29	0.811	23	1.25	69.6	0.7	31.7	0.8	1607.231	3.15E-04	8.10E-04	0.081	4.66E-02	10.0787	3.90E-02	0.009
35.0	1.0	34.5	115.0	1.98	1.33	0.830	21	1.25	65.2	0.7	28.8	0.8	1579.182	3.25E-04	8.10E-04	0.081	5.23E-02	10.0787	4.38E-02	0.011
36.0	1.0	35.5	115.0	2.04	1.37	0.848	21	1.25	65.2	0.7	28.4	0.8	1594.988	3.26E-04	8.10E-04	0.081	5.32E-02	10.0787	4.45E-02	0.011
37.0	1.0	36.5	115.0	2.10	1.41	0.867	21	1.25	65.2	0.7	28.0	0.8	1610.455	3.27E-04	8.10E-04	0.081	5.40E-02	10.0787	4.51E-02	0.011
38.0	1.0	37.5	115.0	2.16	1.44	0.885	22	1.25	64.9	0.7	27.0	0.8	1611.617	3.31E-04	8.10E-04	0.081	5.45E-02	10.0787	4.56E-02	0.011
39.0	1.0	38.5	115.0	2.21	1.48	0.902	22	1.25	64.9	0.7	26.6	0.8	1625.972	3.32E-04	8.10E-04	0.081	5.74E-02	10.0787	4.80E-02	0.012
40.0	1.0	39.5	115.0	2.27	1.52	0.919	39	1.25	82.7	0.7	49.6	0.8	2026.327	2.70E-04	5.20E-04	0.052	1.75E-02	10.0787	1.46E-02	0.004
41.0	1.0	40.5	115.0	2.33	1.56	0.936	39	1.25	82.7	0.7	49.1	0.8	2043.977	2.70E-04	5.20E-04	0.052	1.77E-02	10.0787	1.48E-02	0.004
42.0	1.0	41.5	115.0	2.39	1.60	0.953	39	1.25	82.7	0.7	48.5	0.8	2061.353	2.71E-04	5.20E-04	0.052	1.80E-02	10.0787	1.50E-02	0.004
43.0	1.0	42.5	115.0	2.44	1.64	0.969	39	1.25	82.7	0.7	48.0	0.8	2078.465	2.71E-04	5.20E-04	0.052	1.82E-02	10.0787	1.52E-02	0.004
44.0	1.0	43.5	115.0	2.50	1.68	0.984	39	1.25	82.7	0.6	47.5	0.8	2095.323	2.71E-04	5.20E-04	0.052	1.84E-02	10.0787	1.54E-02	0.004
45.0	1.0	44.5	115.0	2.56	1.71	1.000	26	1.25	64.9	0.6	32.7	0.8	1870.846	3.07E-04	8.10E-04	0.081	4.50E-02	10.0787	3.76E-02	0.009
46.0	1.0	45.5	115.0	2.62	1.75	1.014	26	1.25	64.9	0.6	32.3	0.8	1885.619	3.07E-04	8.10E-04	0.081	4.55E-02	10.0787	3.80E-02	0.009
47.0	1.0	46.5	115.0	2.67	1.79	1.029	26	1.25	64.9	0.6	29.3	0.8	1844.610	3.16E-04	8.10E-04	0.081	5.12E-02	10.0787	4.28E-02	0.010
48.0	1.0	47.5	115.0	2.73	1.83	1.043	26	1.25	64.9	0.6	29.0	0.8	1858.029	3.16E-04	8.10E-04	0.081	5.19E-02	10.0787	4.33E-02	0.010
49.0	1.0	48.5	115.0	2.79	1.87	1.057	26	1.25	64.9	0.6	28.7	0.8	1871.266	3.16E-04	8.10E-04	0.081	5.25E-02	10.0787	4.39E-02	0.011
50.0	1.0	49.5	115.0	2.85	1.91	1.070	32	1.25	69.4	0.6	35.2	0.8	2022.640	2.95E-04	5.20E-04	0.052	2.64E-02	10.0787	2.21E-02	0.005
51.0	1.0	50.5	115.0	2.90	1.95	1.083	32	1.25	69.4	0.6	34.8	0.8	2036.509	2.95E-04	5.20E-04	0.052	2.67E-02	10.0787	2.23E-02	0.005
52.0	1.0	51.5	115.0	2.96	1.98	1.095	32	1.25	69.4	0.6	34.5	0.8	2050.202	2.95E-04	5.20E-04	0.052	2.70E-02	10.0787	2.26E-02	0.005
53.0	1.0	52.5	115.0	3.02	2.02	1.108	32	1.25	69.4	0.6	34.2	0.8	2063.723	2.94E-04	5.20E-04	0.052	2.73E-02	10.0787	2.28E-02	0.005
54.0	1.0	53.5	115.0	3.08	2.06	1.119	51	1.25	84.6	0.6	52.7	0.8	2405.586	2.54E-04	5.20E-04	0.052	1.63E-02	10.0787	1.36E-02	0.003
55.0	1.0	54.5	115.0	3.13	2.10	1.131	51</													



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

NCEER (1996) METHOD

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA_M (g):	0.720
Calculated Mag.Wtg.Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

By Thomas F. Blake (1994-1996)

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4															
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	<200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe Fact.			
1.0	115.0	0	11.0	1.0	1	49	80	2.000	35.5	115.0	Infin.	0.998	0.379	--			
2.0	115.0	0	11.0	2.0	1	49	78	2.000	35.5	115.0	Infin.	0.993	0.377	--			
3.0	115.0	0	11.0	3.0	1	49	76	2.000	35.5	115.0	Infin.	0.989	0.376	--			
4.0	115.0	0	11.0	4.0	1	49	74	2.000	35.5	115.0	Infin.	0.984	0.374	--			
5.0	115.0	0	11.0	5.0	1	49	73	2.000	35.5	115.0	Infin.	0.979	0.372	--			
6.0	115.0	0	13.0	6.0	1	49	77	1.815	34.7	115.0	Infin.	0.975	0.370	--			
7.0	115.0	0	13.0	7.0	1	49	76	1.671	35.1	115.0	Infin.	0.970	0.369	--			
8.0	115.0	0	13.0	8.0	1	49	74	1.556	33.2	115.0	Infin.	0.966	0.367	--			
9.0	115.0	0	13.0	9.0	1	4	73	1.462	24.6	115.0	0.279	0.961	0.365	--			
10.0	115.0	0	13.0	10.0	1	4	71	1.382	23.3	115.0	0.259	0.957	0.363	--			
11.0	115.0	0	13.0	10.0	1	4	71	1.315	22.1	115.0	0.244	0.952	0.362	--			
12.0	115.0	0	13.0	10.0	1	4	71	1.257	21.1	115.0	0.231	0.947	0.360	--			
13.0	115.0	0	26.0	12.5	1	4	98	1.205	40.5	115.0	Infin.	0.943	0.358	--			
14.0	115.0	0	26.0	12.5	1	4	96	1.160	39.0	115.0	Infin.	0.938	0.356	--			
15.0	115.0	0	26.0	12.5	1	4	96	1.119	37.6	115.0	Infin.	0.934	0.355	--			
16.0	115.0	0	26.0	12.5	1	4	96	1.082	36.4	115.0	Infin.	0.929	0.353	--			
17.0	115.0	0	26.0	12.5	1	4	96	1.049	35.3	115.0	Infin.	0.925	0.351	--			
18.0	115.0	0	25.0	17.5	1	3	87	1.019	37.6	115.0	Infin.	0.920	0.349	--			
19.0	115.0	0	25.0	17.5	1	3	87	0.991	36.5	115.0	Infin.	0.915	0.348	--			
20.0	115.0	0	25.0	17.5	1	3	87	0.965	35.6	115.0	Infin.	0.910	0.346	--			
21.0	115.0	0	25.0	17.5	1	3	87	0.941	34.7	115.0	Infin.	0.906	0.344	--			
22.0	115.0	0	25.0	17.5	1	3	87	0.919	33.9	115.0	Infin.	0.902	0.343	--			
23.0	115.0	0	24.0	22.5	1	3	80	0.898	34.5	115.0	Infin.	0.897	0.341	--			
24.0	115.0	0	24.0	22.5	1	3	80	0.879	33.8	115.0	Infin.	0.893	0.339	--			
25.0	115.0	0	24.0	22.5	1	3	80	0.861	33.1	115.0	Infin.	0.888	0.337	--			
26.0	115.0	0	24.0	22.5	1	3	80	0.844	32.4	115.0	Infin.	0.883	0.336	--			
27.0	115.0	0	24.0	22.5	1	3	80	0.828	31.8	115.0	Infin.	0.879	0.334	--			
28.0	115.0	0	31.0	27.5	1	3	85	0.815	43.5	115.0	Infin.	0.874	0.332	--			
29.0	115.0	0	31.0	27.5	1	3	85	0.798	41.8	115.0	Infin.	0.870	0.330	--			
30.0	115.0	0	31.0	27.5	1	3	85	0.785	41.1	115.0	Infin.	0.865	0.329	--			
31.0	115.0	0	31.0	27.5	1	3	85	0.772	40.4	115.0	Infin.	0.861	0.327	--			
32.0	115.0	0	31.0	27.5	1	3	85	0.759	39.8	115.0	Infin.	0.856	0.325	--			
33.0	115.0	0	41.0	32.5	1	3	93	0.747	52.9	115.0	Infin.	0.851	0.323	--			
34.0	115.0	0	41.0	32.5	1	3	93	0.736	52.1	115.0	Infin.	0.847	0.322	--			
35.0	115.0	0	41.0	32.5	1	3	93	0.725	51.3	115.0	Infin.	0.843	0.320	--			
36.0	115.0	0	41.0	32.5	1	3	93	0.715	50.6	115.0	Infin.	0.838	0.318	--			
37.0	115.0	0	41.0	32.5	1	3	93	0.705	49.9	115.0	Infin.	0.833	0.316	--			
38.0	115.0	0	60.0	37.5	1	5	107	0.696	72.0	115.0	Infin.	0.829	0.315	--			
39.0	115.0	0	60.0	37.5	1	5	107	0.687	71.1	115.0	Infin.	0.824	0.313	--			
40.0	115.0	0	60.0	37.5	1	5	107	0.678	70.2	115.0	Infin.	0.819	0.311	--			
41.0	115.0	0	60.0	37.5	1	5	107	0.670	69.3	115.0	Infin.	0.815	0.310	--			
42.0	115.0	0	60.0	37.5	1	5	107	0.661	68.5	115.0	Infin.	0.810	0.308	--			
43.0	115.0	0	38.0	42.5	1	5	82	0.654	42.8	115.0	Infin.	0.806	0.306	--			
44.0	115.0	0	38.0	42.5	1	5	82	0.646	42.3	115.0	Infin.	0.801	0.304	--			
45.0	115.0	0	38.0	42.5	1	5	82	0.639	41.9	115.0	Infin.	0.797	0.303	--			
46.0	115.0	0	38.0	42.5	1	5	82	0.632	41.4	115.0	Infin.	0.792	0.301	--			
47.0	115.0	0	38.0	42.5	1	5	82	0.625	41.0	115.0	Infin.	0.787	0.299	--			
48.0	115.0	0	51.0	47.5	1	3	91	0.618	54.4	115.0	Infin.	0.783	0.297	--			
49.0	115.0	0	51.0	47.5	1	3	91	0.612	53.9	115.0	Infin.	0.778	0.296	--			
50.0	115.0	0	51.0	47.5	1	3	91	0.606	53.3	115.0	Infin.	0.774	0.294	--			
51.0	115.0	0	51.0	47.5	1	3	91	0.600	52.8	115.0	Infin.	0.769	0.292	--			
52.0	115.0	0	51.0	47.5	1	3	91	0.594	52.2	115.0	Infin.	0.765	0.290	--			
53.0	115.0	0	66.0	52.5	1	3	100	0.588	67.0	115.0	Infin.	0.760	0.289	--			
54.0	115.0	0	66.0	52.5	1	3	100	0.583	66.3	115.0	Infin.	0.755	0.287	--			
55.0	115.0	0	66.0	52.5	1	3	100	0.577	65.7	115.0	Infin.	0.751	0.286	--			
56.0	115.0	0	66.0	52.5	1	3	100	0.572	65.1	115.0	Infin.	0.746	0.283	--			
57.0	115.0	0	66.0	52.5	1	3	100	0.567	64.5	115.0	Infin.	0.742	0.282	--			
58.0	115.0	0	78.0	57.5	1	5	105	0.562	75.7	115.0	Infin.	0.737	0.280	--			
59.0	115.0	0	78.0	57.5	1	5	105	0.557	75.0	115.0	Infin.	0.733	0.278	--			
60.0	115.0	0	78.0	57.5	1	5	105	0.552	74.4	115.0	Infin.	0.728	0.277	--			
61.0	115.0	0	78.0	57.5	1	5	105	0.548	73.8	115.0	Infin.	0.723	0.275	--			
62.0	115.0	0	78.0	57.5	1	5	105	0.543	73.2	115.0	Infin.	0.719	0.273	--			
63.0	115.0	0	100.0	62.5	1	5	115	0.539	93.0	115.0	Infin.	0.714	0.271	--			
64.0	115.0	0	100.0	62.5	1	5	115	0.535	92.3	115.0	Infin.	0.710	0.270	--			
65.0	115.0	0	100.0	62.5	1	5	115	0.531	91.6	115.0	Infin.	0.705	0.268	--			
66.0	115.0	0	100.0	62.5	1	5	115	0.526	90.9	115.0	Infin.	0.701	0.266	--			
67.0	115.0	0	100.0	62.5	1	5	115	0.523	90.2	115.0	Infin.	0.696	0.264	--			
68.0	115.0	0	100.0	67.5	1	3	111	0.519	89.5	115.0	Infin.	0.691	0.263	--			
69.0	115.0	0	100.0	67.5	1	3	111	0.515	88.8	115.0	Infin.	0.687	0.261	--			
70.0	115.0	0	100.0	67.5	1	3	111	0.511	88.2	115.0	Infin.	0.682	0.259	--			
71.0	115.0	0	100.0	67.5	1	3	111	0.507	87.5	115.0	Infin.	0.678	0.257	--			
72.0	115.0	0	100.0	67.5	1	3	111	0.504	86.9	115.0	Infin.	0.673	0.256	--			
73.0	115.0	0	100.0	72.5	1	3	108	0.500	86.3	115.0	Infin.	0.669	0.254	--			
74.0	115.0	0	100.0	72.5	1	3	108	0.497	85.7	115.0	Infin.	0.664	0.252	--			
75.0	115.0	0	100.0	72.5	1	3	108	0.494	85.2	115.0	Infin.	0.659	0.250	--			
76.0	115.0	0	100.0	72.5	1	3	108	0.490	84.6	115.0	Infin.	0.655	0.249	--			
77.0	115.0	0	100.0	72.5	1	3	108	0.487	84.0	115.0	Infin.	0.650	0.247	--			
78.0	115.0	0	100.0	77.5	1	2	105	0.484	83.5	115.0	Infin.	0.646	0.245	--			
79.0	115.0	0	100.0	77.5	1	2	105	0.481	83.0	115.0	Infin.	0.641	0.244	--			
80.0	115.0	0	100.0	77.5	1	2	105	0.478	82.4	115.0	Infin.	0.637	0.242	--			
81.0	115.0	0	100.0	77.5	1	2	105	0.475	81.9	115.0	Infin.	0.632	0.240	--			
82.0	115.0	0	100.0	77.5	1	2	105	0.472	81.4	115.0	Infin.	0.627	0.238	--			
83.0	115.0	0	100.0	82.5	1	2	103	0.469	80.9	115.0	Infin.	0.625	0.237	--			
84.0	115.0	0	100.0	82.5	1	2	103	0.466	80.4	115.0	Infin.	0.625	0.237	--			
85.0	115.0	0	100.0	82.5	1	2	103	0.462	80.0	115.0	Infin.	0.625	0.237	--			
86.0	115.0	0	100.0	82.5	1	2	103	0.461	79.5	115.0	Infin.	0.625	0.237	--			
87.0	115.0	0	100.0	82.5	1	2	103	0.458	79.0	115.0	Infin.	0.625	0.237	--			
88.0	115.0	0	100.0	87.5	1	3	100	0.456	78.6	115.0	Infin.	0.625	0.237	--			
89.0	115.0	0	100.0	87													



TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION	
Earthquake Magnitude	6.80
Peak Horiz. Acceleration (g)	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (psf)	Mean Effective Pressure (psf)	Average Shear Stress (Tavg)	Field Correction (C ₁)	Relative Density (%)	Correction Factor (C ₂)	Corrected N ₆₀ (blows)	rd Factor	Maximum Shear Stress (τ _{max}) (ksf)	γ _{eff} (ksf)	Volume Change Factor (V _v) (%)	Number of Strains (N _c)	Corrected Volume Strain (ε _v) (%)	Estimated Settlement (S _t) (inches)		
1.0	1.0	0.5	115.0	0.03	0.02	0.013	11	72.5	80.4	2.0	35.5	1.0	203.823	5.54E-05	1.40E-04	0.014	7.04E-03	10.0787	5.89E-03
2.0	1.0	1.5	115.0	0.09	0.06	0.040	11	72.5	78.2	2.0	35.5	1.0	353.032	1.11E-04	3.00E-03	0.300	1.51E-01	10.0787	1.26E-01
3.0	1.0	2.5	115.0	0.14	0.10	0.067	11	72.5	77.0	2.0	35.5	1.0	455.773	1.40E-04	3.00E-03	0.300	1.51E-01	10.0787	1.26E-01
4.0	1.0	3.5	115.0	0.20	0.13	0.094	11	72.5	74.4	2.0	35.5	1.0	539.296	1.83E-04	8.10E-04	0.081	4.07E-02	10.0787	3.41E-02
4.5	1.0	4.5	115.0	0.28	0.17	0.121	11	72.5	72.7	2.0	35.5	1.0	611.470	1.81E-04	8.10E-04	0.081	4.07E-02	10.0787	3.41E-02
6.0	1.0	5.5	115.0	0.32	0.148	0.113	13	72.5	77.2	1.8	37.6	1.0	698.968	1.93E-04	4.50E-04	0.045	1.11E-02	10.0787	7.7E-02
7.0	1.0	6.5	115.0	0.37	0.25	0.174	13	72.5	75.6	1.7	35.1	1.0	732.449	2.11E-04	1.00E-03	0.100	5.09E-02	10.0787	4.26E-02
8.0	1.0	7.5	115.0	0.43	0.29	0.201	13	72.5	74.1	1.6	33.2	1.0	772.002	2.29E-04	1.00E-03	0.100	4.95E-02	10.0787	4.58E-02
9.0	1.0	8.5	115.0	0.49	0.33	0.227	13	72.5	72.6	1.5	24.6	1.0	743.741	2.61E-04	1.00E-03	0.100	8.85E-02	10.0787	6.53E-02
10.0	1.0	9.5	115.0	0.55	0.37	0.253	13	72.5	71.3	1.4	23.3	1.0	771.833	2.76E-04	1.00E-03	0.100	8.35E-02	10.0787	6.98E-02
11.0	1.0	10.5	115.0	0.60	0.40	0.279	13	72.5	71.3	1.3	22.1	1.0	798.017	2.90E-04	1.00E-03	0.100	8.66E-02	10.0787	7.41E-02
12.0	1.0	11.5	115.0	0.66	0.44	0.305	13	72.5	71.3	1.3	21.1	0.9	822.586	3.03E-04	2.70E-03	0.270	2.53E-01	10.0787	2.11E-01
13.0	1.0	12.5	115.0	0.72	0.48	0.331	26	125	95.6	1.2	40.5	0.9	1065.603	2.49E-04	1.00E-03	0.100	4.28E-02	10.0787	3.58E-02
14.0	1.0	13.5	115.0	0.78	0.52	0.357	26	125	95.6	1.2	39.0	0.9	1093.294	2.58E-04	1.00E-03	0.100	3.18E-02	10.0787	2.66E-02
15.0	1.0	14.5	115.0	0.80	0.56	0.382	26	125	95.6	1.1	37.4	0.9	1119.826	2.95E-04	1.00E-03	0.071	3.32E-02	10.0787	2.78E-02
16.0	1.0	15.5	115.0	0.89	0.60	0.407	26	125	95.6	1.1	36.4	0.9	1144.817	2.73E-04	7.10E-04	0.071	3.46E-02	10.0787	2.89E-02
17.0	1.0	16.5	115.0	0.95	0.64	0.432	26	125	95.6	1.0	35.3	0.9	1188.928	2.80E-04	7.10E-04	0.071	3.59E-02	10.0787	3.00E-02
18.0	1.0	17.5	115.0	1.01	0.67	0.457	25	125	86.8	1.0	37.6	0.9	1229.361	2.77E-04	7.10E-04	0.071	3.33E-02	10.0787	2.79E-02
19.0	1.0	18.5	115.0	1.08	0.71	0.481	25	125	86.8	1.0	36.5	0.9	1252.345	2.96E-04	7.10E-04	0.071	3.44E-02	10.0787	2.89E-02
20.0	1.0	19.5	115.0	1.12	0.75	0.506	25	125	86.8	1.0	35.6	0.9	1274.515	2.88E-04	7.10E-04	0.071	3.55E-02	10.0787	2.97E-02
21.0	1.0	20.5	115.0	1.18	0.79	0.529	25	125	86.8	0.9	34.7	0.9	1295.940	2.93E-04	7.10E-04	0.071	3.66E-02	10.0787	3.06E-02
22.0	1.0	21.5	115.0	1.24	0.83	0.553	25	125	86.8	0.9	33.9	0.9	1316.678	2.98E-04	7.10E-04	0.071	3.77E-02	10.0787	3.15E-02
23.0	1.0	22.5	115.0	1.29	0.87	0.576	24	125	79.5	0.9	34.5	0.9	1354.797	2.98E-04	7.10E-04	0.071	3.69E-02	10.0787	3.09E-02
24.0	1.0	23.5	115.0	1.35	0.91	0.599	24	125	79.5	0.9	33.8	0.9	1374.578	3.02E-04	1.20E-03	0.120	6.40E-02	10.0787	5.35E-02
25.0	1.0	24.5	115.0	1.41	0.95	0.622	24	125	79.5	0.8	33.1	0.9	1393.805	3.05E-04	1.20E-03	0.120	1.49E-02	10.0787	1.49E-02
26.0	1.0	25.5	115.0	1.47	0.98	0.644	24	125	79.5	0.8	32.4	0.9	1412.516	3.08E-04	1.20E-03	0.120	1.72E-02	10.0787	5.62E-02
27.0	1.0	26.5	115.0	1.52	1.02	0.666	24	125	79.5	0.8	31.8	0.9	1430.744	3.11E-04	8.10E-04	0.081	4.64E-02	10.0787	3.88E-02
28.0	1.0	27.5	115.0	1.58	1.06	0.688	31	125	85.2	0.8	42.5	0.9	1606.159	2.83E-04	5.20E-04	0.052	2.10E-02	10.0787	1.76E-02
29.0	1.0	28.5	115.0	1.64	1.09	0.709	31	125	85.2	0.8	41.8	0.9	1625.042	2.86E-04	5.20E-04	0.052	2.40E-02	10.0787	1.98E-02
30.0	1.0	29.5	115.0	1.70	1.14	0.730	31	125	85.2	0.8	41.1	0.9	1644.188	2.88E-04	5.20E-04	0.052	2.19E-02	10.0787	1.83E-02
31.0	1.0	30.5	115.0	1.75	1.18	0.751	31	125	85.2	0.8	40.4	0.9	1662.561	2.90E-04	5.20E-04	0.052	2.24E-02	10.0787	1.87E-02
32.0	1.0	31.5	115.0	1.81	1.21	0.771	31	125	85.2	0.8	39.8	0.9	1680.934	2.92E-04	5.20E-04	0.052	1.91E-02	10.0787	1.91E-02
33.0	1.0	32.5	115.0	1.87	1.25	0.791	41	125	92.9	0.7	52.9	0.9	1877.168	2.65E-04	5.20E-04	0.052	1.62E-02	10.0787	1.35E-02
34.0	1.0	33.5	115.0	1.93	1.29	0.811	41	125	92.9	0.7	52.1	0.8	1896.228	2.67E-04	5.20E-04	0.052	1.65E-02	10.0787	1.38E-02
35.0	1.0	34.5	115.0	1.98	1.33	0.830	41	125	92.9	0.7	51.3	0.8	1915.374	2.69E-04	5.20E-04	0.052	1.68E-02	10.0787	1.40E-02
36.0	1.0	35.5	115.0	2.04	1.37	0.848	41	125	92.9	0.7	50.6	0.8	1933.235	2.69E-04	5.20E-04	0.052	1.71E-02	10.0787	1.43E-02
37.0	1.0	36.5	115.0	2.10	1.41	0.867	41	125	92.9	0.7	49.9	0.8	1951.220	2.70E-04	5.20E-04	0.052	1.74E-02	10.0787	1.45E-02
38.0	1.0	37.5	115.0	2.16	1.44	0.885	60	125	107.2	0.7	72.0	0.8	2235.329	2.39E-04	5.20E-04	0.052	1.12E-02	10.0787	9.35E-03
39.0	1.0	38.5	115.0	2.21	1.48	0.902	60	125	107.2	0.7	71.1	0.8	2253.022	2.40E-04	5.20E-04	0.052	1.15E-02	10.0787	9.46E-03
40.0	1.0	39.5	115.0	2.27	1.52	0.919	60	125	107.2	0.7	70.2	0.8	2274.382	2.40E-04	5.20E-04	0.052	1.15E-02	10.0787	9.64E-03
41.0	1.0	40.5	115.0	2.33	1.56	0.936	60	125	107.2	0.7	69.3	0.8	2293.416	2.41E-04	5.20E-04	0.052	1.17E-02	10.0787	9.79E-03
42.0	1.0	41.5	115.0	2.39	1.60	0.953	60	125	107.2	0.7	68.5	0.8	2312.182	2.41E-04	5.20E-04	0.052	1.16E-02	10.0787	9.79E-03
43.0	1.0	42.5	115.0	2.44	1.64	0.969	38	125	81.6	0.7	42.8	0.8	2001.420	2.81E-04	5.20E-04	0.052	2.08E-02	10.0787	1.74E-02
44.0	1.0	43.5	115.0	2.50	1.68	0.984	38	125	81.6	0.6	42.3	0.8	2016.998	2.82E-04	5.20E-04	0.052	2.11E-02	10.0787	1.77E-02
45.0	1.0	44.5	115.0	2.56	1.71	1.000	38	125	81.6	0.6	41.6	0.8	2032.616	2.83E-04	5.20E-04	0.052	2.14E-02	10.0787	1.79E-02
46.0	1.0	45.5	115.0	2.62	1.75	1.014	38	125	81.6	0.6	41.4	0.8	2047.445	2.83E-04	5.20E-04	0.052	2.17E-02	10.0787	1.82E-02
47.0	1.0	46.5	115.0	2.67	1.79	1.029	38	125	81.6	0.6	41.0	0.8	2062.336	2.83E-04	5.20E-04	0.052	2.20E-02	10.0787	1.84E-02
48.0	1.0	47.5	115.0	2.73	1.83	1.043	51	125	90.6	0.6	54.4	0.8	2291.054	2.59E-04	5.20E-04	0.052	1.57E-02	10.0787	1.31E-02
49.0	1.0	48.5	115.0	2.81	1.87	1.057	51	125	90.6	0.6	53.8	0.8	2307.020	2.61E-04	5.20E-04	0.052	1.59E-02	10.0787	1.33E-02
50.0	1.0	49.5	115.0	2.85	1.91	1.070	51	125	90.6	0.6	53.3	0.8	2322.768	2.57E-04	5.20E-04	0.052	1.60E-02	10.0787	1.34E-02
51.0	1.0	50.5	115.0	2.90	1.95	1.083	51	125	90.6	0.6	52.8	0.8	2338.305	2.57E-04	5.20E-04	0.052	1.62E-02	10.0787	1.36E-02
52.0	1.0	51.5	115.0	2.96	1.98	1.096	51	125	90.6	0.6	52.2	0.8	2353.639	2.58E-04	5.20E-04	0.052	1.64E-02	10.0787	1.37E-02
53.0	1.0	52.5	115.0	3.02	2.02	1.108	66	125	99.6	0.6	67.0	0.8	2591.359	2.35E-04	5.20E-04	0.052	1.22E-02	10.0787	1.02E-02
54.0	1.0	53.5	115.0	3.08	2.06	1.119	66	125	99.6	0.6	66.3	0.8	2597.648	2.35E-04	5.20E-04	0.052	1.23E-02	10.0787	1.03E-02
55.0	1.0	54.5	115.0	3.13	2.10	1.131	66	125	99.6	0.6	65.7	0.8	2613.730	2.35E-04	5.20E-04	0.052	1.24E-02	10.0787	1.04E-02
56.0	1.0	55.5	115.0	3.19	2.14	1.142	66	125	99.6	0.6	65.1	0.7	2629.620	2.35E-04	5.20E-04	0.052	1.26E-02	10.0787	1.05E-02
57.0	1.0	56.5	115.0	3.25	2.18	1.153	66	125	99.6	0.6	64.5	0.7	2645.319	2.35E-04	5.20E-04	0.052	1.27E-02	10.0787	1.



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

NCEER (1996) METHOD

By Thomas F. Blake (1994-1996)

EARTHQUAKE INFORMATION:

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA _M (g):	0.720
Calculated Mag.Wtg.Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

ENERGY & ROD CORRECTIONS:

Energy Correction (CE) for N60:	1.25
Rod Len.Corr.(CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf): 62.4

Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq.Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe.Fact.
1.0	115.0	0	13.0	1.0	1	21	87	2.000	37.3	115.0	Inf.	0.998	0.379	--
2.0	115.0	0	13.0	2.0	1	21	85	2.000	37.3	115.0	Inf.	0.993	0.377	--
3.0	115.0	0	13.0	3.0	1	21	83	2.000	37.3	115.0	Inf.	0.989	0.376	--
4.0	115.0	0	13.0	4.0	1	21	81	2.000	37.3	115.0	Inf.	0.984	0.374	--
5.0	115.0	0	13.0	5.0	1	21	79	2.000	37.3	115.0	Inf.	0.979	0.372	--
6.0	115.0	0	13.0	6.0	1	21	77	1.817	34.2	115.0	Inf.	0.975	0.370	--
7.0	115.0	0	13.0	7.0	1	21	76	1.671	31.8	115.0	Inf.	0.970	0.369	--
8.0	115.0	0	14.0	8.0	1	21	77	1.556	31.9	115.0	Inf.	0.966	0.367	--
9.0	115.0	0	14.0	9.0	1	21	75	1.462	30.2	115.0	Inf.	0.961	0.365	--
10.0	115.0	0	14.0	10.0	1	21	74	1.382	28.7	115.0	0.374	0.957	0.363	--
11.0	115.0	0	14.0	10.0	1	21	74	1.315	27.5	115.0	0.336	0.952	0.362	--
12.0	115.0	0	14.0	10.0	1	21	74	1.257	26.4	115.0	0.312	0.947	0.360	--
13.0	115.0	0	17.0	12.5	1	16	77	1.205	29.1	115.0	0.392	0.943	0.358	--
14.0	115.0	0	17.0	12.5	1	16	77	1.160	28.1	115.0	0.353	0.938	0.356	--
15.0	115.0	0	17.0	12.5	1	16	77	1.119	27.2	115.0	0.329	0.934	0.355	--
16.0	115.0	0	17.0	12.5	1	16	77	1.082	26.4	115.0	0.312	0.929	0.353	--
17.0	115.0	0	17.0	12.5	1	16	77	1.049	25.7	115.0	0.297	0.925	0.351	--
18.0	115.0	0	21.0	17.5	1	16	80	1.019	34.2	115.0	Inf.	0.920	0.349	--
19.0	115.0	0	21.0	17.5	1	16	80	0.991	33.3	115.0	Inf.	0.915	0.348	--
20.0	115.0	0	21.0	17.5	1	16	80	0.965	32.5	115.0	Inf.	0.911	0.346	--
21.0	115.0	0	21.0	17.5	1	16	80	0.941	31.8	115.0	Inf.	0.906	0.344	--
22.0	115.0	0	21.0	17.5	1	16	80	0.919	31.1	115.0	Inf.	0.902	0.343	--
23.0	115.0	0	9.0	22.5	1	7	49	0.898	13.5	115.0	0.143	0.897	0.341	--
24.0	115.0	0	9.0	22.5	1	7	49	0.879	13.2	115.0	0.140	0.893	0.339	--
25.0	115.0	0	9.0	22.5	1	7	49	0.861	12.9	115.0	0.137	0.888	0.337	--
26.0	115.0	0	9.0	22.5	1	16	49	0.844	14.7	115.0	0.156	0.883	0.336	--
27.0	115.0	0	9.0	22.5	1	16	49	0.828	14.4	115.0	0.153	0.879	0.334	--
28.0	115.0	0	38.0	27.5	1	4	94	0.813	52.1	115.0	Inf.	0.874	0.332	--
29.0	115.0	0	38.0	27.5	1	4	94	0.798	51.2	115.0	Inf.	0.870	0.330	--
30.0	115.0	0	38.0	27.5	1	4	94	0.785	50.4	115.0	Inf.	0.865	0.329	--
31.0	115.0	0	38.0	27.5	1	4	94	0.772	49.5	115.0	Inf.	0.861	0.327	--
32.0	115.0	0	100.0	32.5	1	4	145	0.759	131.0	115.0	Inf.	0.856	0.325	--
33.0	115.0	0	100.0	32.5	1	4	145	0.747	128.9	115.0	Inf.	0.851	0.323	--
34.0	115.0	0	100.0	32.5	1	4	145	0.736	127.0	115.0	Inf.	0.847	0.322	--
35.0	115.0	0	100.0	32.5	1	4	145	0.725	125.1	115.0	Inf.	0.842	0.320	--
36.0	115.0	0	100.0	32.5	1	4	145	0.715	123.4	115.0	Inf.	0.838	0.318	--
37.0	115.0	0	100.0	37.5	1	6	138	0.705	121.8	115.0	Inf.	0.833	0.316	--
38.0	115.0	0	100.0	37.5	1	6	138	0.696	120.2	115.0	Inf.	0.829	0.315	--
39.0	115.0	0	100.0	37.5	1	6	138	0.687	118.6	115.0	Inf.	0.824	0.313	--
40.0	115.0	0	100.0	37.5	1	6	138	0.678	117.1	115.0	Inf.	0.819	0.311	--
41.0	115.0	0	100.0	37.5	1	6	138	0.670	115.6	115.0	Inf.	0.815	0.310	--
42.0	115.0	0	100.0	42.5	1	6	132	0.661	114.2	115.0	Inf.	0.810	0.308	--
43.0	115.0	0	100.0	42.5	1	6	132	0.654	112.9	115.0	Inf.	0.806	0.306	--
44.0	115.0	0	100.0	42.5	1	6	132	0.646	111.6	115.0	Inf.	0.801	0.304	--
45.0	115.0	0	100.0	42.5	1	6	132	0.639	110.3	115.0	Inf.	0.797	0.303	--
46.0	115.0	0	100.0	42.5	1	6	132	0.632	109.1	115.0	Inf.	0.792	0.301	--
47.0	115.0	0	100.0	47.5	1	7	127	0.625	108.2	115.0	Inf.	0.787	0.299	--
48.0	115.0	0	100.0	47.5	1	7	127	0.618	107.0	115.0	Inf.	0.783	0.297	--
49.0	115.0	0	100.0	47.5	1	7	127	0.612	105.9	115.0	Inf.	0.778	0.296	--
50.0	115.0	0	100.0	47.5	1	7	127	0.606	104.9	115.0	Inf.	0.774	0.294	--
51.0	115.0	0	100.0	47.5	1	7	127	0.600	103.8	115.0	Inf.	0.769	0.292	--
52.0	115.0	0	100.0	52.5	1	7	123	0.594	102.8	115.0	Inf.	0.765	0.290	--
53.0	115.0	0	100.0	52.5	1	7	123	0.588	101.8	115.0	Inf.	0.760	0.289	--
54.0	115.0	0	100.0	52.5	1	7	123	0.583	100.9	115.0	Inf.	0.755	0.287	--
55.0	115.0	0	100.0	52.5	1	7	123	0.577	100.0	115.0	Inf.	0.751	0.285	--
56.0	115.0	0	100.0	52.5	1	7	123	0.572	99.1	115.0	Inf.	0.746	0.283	--
57.0	115.0	0	100.0	57.5	1	9	118	0.567	98.7	115.0	Inf.	0.742	0.282	--
58.0	115.0	0	100.0	57.5	1	9	118	0.562	97.8	115.0	Inf.	0.737	0.280	--
59.0	115.0	0	100.0	57.5	1	9	118	0.557	97.0	115.0	Inf.	0.733	0.278	--
60.0	115.0	0	100.0	57.5	1	9	118	0.552	96.2	115.0	Inf.	0.728	0.277	--
61.0	115.0	0	100.0	57.5	1	9	118	0.548	95.4	115.0	Inf.	0.723	0.275	--
62.0	115.0	0	100.0	57.5	1	9	118	0.543	94.6	115.0	Inf.	0.719	0.273	--
63.0	115.0	0	100.0	57.5	1	9	118	0.539	93.9	115.0	Inf.	0.714	0.271	--
64.0	115.0	0	100.0	57.5	1	9	118	0.535	93.1	115.0	Inf.	0.710	0.270	--
65.0	115.0	0	100.0	57.5	1	9	118	0.531	92.4	115.0	Inf.	0.705	0.268	--

TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 6 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION:

Earthquake Magnitude	6.90
Peak Horiz. Acceleration (g)	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress [Tav] (tsf)	Field SPT [N]	Correction Factor [Ccr]	Relative Density [Dr] (%)	Correction Factor [Cn]	Corrected N160	rd Factor	Maximum Shear Mod. [Gmax] (tsf)	[veff][Geff] [Gmax]	sheff Shear Strain	[veff]*100%	Volumetric Strain M7.5 [E15] (%)	Number of Strain Cycles [Nc]	Corrected Vol. Strains [Ecl]	Estimated Settlement [S] (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	13	1.25	87.4	2.0	37.3	1.0	207.329	6.43E-05	1.40E-04	0.014	6.62E-03	10.0787	5.54E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.040	13	1.25	85.0	2.0	37.3	1.0	359.105	1.09E-04	3.00E-03	0.300	1.42E-01	10.0787	1.19E-01	
3.0	1.0	2.5	115.0	0.14	0.10	0.067	13	1.25	82.9	2.0	37.3	1.0	463.602	1.38E-04	3.00E-03	0.300	1.42E-01	10.0787	1.19E-01	
4.0	1.0	3.5	115.0	0.20	0.13	0.094	13	1.25	80.9	2.0	37.3	1.0	548.542	1.60E-04	8.10E-04	0.081	3.83E-02	10.0787	3.20E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.121	13	1.25	79.0	2.0	37.3	1.0	621.988	1.78E-04	8.10E-04	0.081	3.83E-02	10.0787	3.20E-02	
6.0	1.0	5.5	115.0	0.32	0.21	0.148	13	1.25	77.2	1.8	34.2	1.0	668.178	1.99E-04	4.50E-04	0.045	2.36E-02	10.0787	1.97E-02	
7.0	1.0	6.5	115.0	0.37	0.25	0.174	13	1.25	75.6	1.7	31.8	1.0	708.642	2.18E-04	1.00E-03	0.100	5.73E-02	10.0787	4.79E-02	
8.0	1.0	7.5	115.0	0.43	0.29	0.201	14	1.25	76.9	1.6	31.9	1.0	761.778	2.29E-04	1.00E-03	0.100	5.72E-02	10.0787	4.78E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.227	14	1.25	75.4	1.5	30.2	1.0	796.206	2.44E-04	1.00E-03	0.100	6.11E-02	10.0787	5.11E-02	
10.0	1.0	9.5	115.0	0.55	0.37	0.253	14	1.25	74.0	1.4	28.7	1.0	828.200	2.57E-04	1.00E-03	0.100	6.48E-02	10.0787	5.41E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.279	14	1.25	74.0	1.3	27.5	1.0	858.172	2.70E-04	1.00E-03	0.100	6.82E-02	10.0787	5.70E-02	0.01
12.0	1.0	11.5	115.0	0.66	0.44	0.305	14	1.25	74.0	1.3	26.4	0.9	886.429	2.81E-04	1.00E-03	0.100	7.15E-02	10.0787	5.98E-02	0.01
13.0	1.0	12.5	115.0	0.72	0.48	0.331	17	1.25	77.3	1.2	29.1	0.9	954.332	2.78E-04	1.00E-03	0.100	6.37E-02	10.0787	5.33E-02	0.01
14.0	1.0	13.5	115.0	0.78	0.52	0.357	17	1.25	77.3	1.2	28.1	0.9	980.278	2.88E-04	7.10E-04	0.071	4.72E-02	10.0787	3.94E-02	0.01
15.0	1.0	14.5	115.0	0.83	0.56	0.382	17	1.25	77.3	1.1	27.2	0.9	1005.038	2.96E-04	7.10E-04	0.071	4.90E-02	10.0787	4.10E-02	0.01
16.0	1.0	15.5	115.0	0.89	0.60	0.407	17	1.25	77.3	1.1	26.4	0.9	1028.745	3.04E-04	1.20E-03	0.120	8.59E-02	10.0787	7.19E-02	0.02
17.0	1.0	16.5	115.0	0.95	0.64	0.432	17	1.25	77.3	1.0	25.7	0.9	1051.508	3.11E-04	1.20E-03	0.120	8.89E-02	10.0787	7.43E-02	0.02
18.0	1.0	17.5	115.0	1.01	0.67	0.457	21	1.25	79.5	1.0	34.2	0.9	1191.116	2.86E-04	7.10E-04	0.071	3.73E-02	10.0787	3.12E-02	0.01
19.0	1.0	18.5	115.0	1.06	0.71	0.481	21	1.25	79.5	1.0	33.3	0.9	1214.255	2.92E-04	7.10E-04	0.071	3.85E-02	10.0787	3.22E-02	0.01
20.0	1.0	19.5	115.0	1.12	0.75	0.506	21	1.25	79.5	1.0	32.5	0.9	1236.612	2.97E-04	7.10E-04	0.071	3.96E-02	10.0787	3.31E-02	0.01
21.0	1.0	20.5	115.0	1.18	0.79	0.529	21	1.25	79.5	0.9	31.8	0.9	1258.252	3.02E-04	1.20E-03	0.120	6.88E-02	10.0787	5.76E-02	0.01
22.0	1.0	21.5	115.0	1.24	0.83	0.553	21	1.25	79.5	0.9	31.1	0.9	1279.231	3.06E-04	1.20E-03	0.120	7.07E-02	10.0787	5.91E-02	0.01
23.0	1.0	22.5	115.0	1.29	0.87	0.576	9	1.25	48.7	0.9	13.5	0.9	989.732	4.08E-04	2.20E-03	0.220	3.54E-01	10.0787	2.96E-01	0.07
24.0	1.0	23.5	115.0	1.35	0.91	0.599	9	1.25	48.7	0.9	13.2	0.9	1004.463	4.13E-04	2.20E-03	0.220	3.63E-01	10.0787	3.04E-01	0.07
25.0	1.0	24.5	115.0	1.41	0.94	0.622	9	1.25	48.7	0.9	12.9	0.9	1018.792	4.17E-04	2.20E-03	0.220	3.72E-01	10.0787	3.11E-01	0.07
26.0	1.0	25.5	115.0	1.47	0.98	0.644	9	1.25	48.7	0.8	14.7	0.9	1084.634	4.02E-04	2.20E-03	0.220	3.19E-01	10.0787	2.67E-01	0.06
27.0	1.0	26.5	115.0	1.52	1.02	0.666	9	1.25	48.7	0.8	14.4	0.9	1099.851	4.05E-04	1.30E-03	0.130	1.92E-01	10.0787	1.61E-01	0.04
28.0	1.0	27.5	115.0	1.58	1.06	0.688	38	1.25	94.3	0.8	52.1	0.9	1718.947	2.65E-04	5.20E-04	0.052	1.65E-02	10.0787	1.38E-02	0.00
29.0	1.0	28.5	115.0	1.64	1.10	0.709	38	1.25	94.3	0.8	51.2	0.9	1739.535	2.67E-04	5.20E-04	0.052	1.68E-02	10.0787	1.41E-02	0.00
30.0	1.0	29.5	115.0	1.70	1.14	0.730	38	1.25	94.3	0.8	50.4	0.9	1759.647	2.69E-04	5.20E-04	0.052	1.72E-02	10.0787	1.44E-02	0.00
31.0	1.0	30.5	115.0	1.75	1.18	0.751	38	1.25	94.3	0.8	49.5	0.9	1779.309	2.71E-04	5.20E-04	0.052	1.75E-02	10.0787	1.46E-02	0.00
32.0	1.0	31.5	115.0	1.81	1.21	0.771	100	1.25	145.1	0.8	131.0	0.9	2500.638	1.96E-04	3.00E-04	0.030	3.15E-03	10.0787	2.63E-03	0.00
33.0	1.0	32.5	115.0	1.87	1.25	0.791	100	1.25	145.1	0.7	128.9	0.9	2526.825	1.97E-04	3.00E-04	0.030	3.21E-03	10.0787	2.68E-03	0.00
34.0	1.0	33.5	115.0	1.93	1.29	0.811	100	1.25	145.1	0.7	127.0	0.8	2552.479	1.98E-04	3.00E-04	0.030	3.26E-03	10.0787	2.73E-03	0.00
35.0	1.0	34.5	115.0	1.98	1.33	0.830	100	1.25	145.1	0.7	125.1	0.8	2577.629	1.99E-04	3.00E-04	0.030	3.32E-03	10.0787	2.78E-03	0.00
36.0	1.0	35.5	115.0	2.04	1.37	0.848	100	1.25	145.1	0.7	123.4	0.8	2602.296	2.00E-04	3.00E-04	0.030	3.38E-03	10.0787	2.83E-03	0.00
37.0	1.0	36.5	115.0	2.10	1.41	0.867	100	1.25	138.4	0.7	121.8	0.8	2627.512	2.01E-04	5.20E-04	0.052	5.95E-03	10.0787	4.97E-03	0.00
38.0	1.0	37.5	115.0	2.16	1.44	0.885	100	1.25	138.4	0.7	120.2	0.8	2651.306	2.01E-04	5.20E-04	0.052	6.05E-03	10.0787	5.06E-03	0.00
39.0	1.0	38.5	115.0	2.21	1.48	0.902	100	1.25	138.4	0.7	118.6	0.8	2674.680	2.02E-04	5.20E-04	0.052	6.14E-03	10.0787	5.14E-03	0.00
40.0	1.0	39.5	115.0	2.27	1.52	0.919	100	1.25	138.4	0.7	117.1	0.8	2697.654	2.02E-04	5.20E-04	0.052	6.24E-03	10.0787	5.22E-03	0.00
41.0	1.0	40.5	115.0	2.33	1.56	0.936	100	1.25	138.4	0.7	115.6	0.8	2720.243	2.03E-04	5.20E-04	0.052	6.33E-03	10.0787	5.29E-03	0.00
42.0	1.0	41.5	115.0	2.39	1.60	0.953	100	1.25	132.4	0.7	114.2	0.8	2742.464	2.03E-04	5.20E-04	0.052	6.42E-03	10.0787	5.37E-03	0.00
43.0	1.0	42.5	115.0	2.44	1.64	0.969	100	1.25	132.4	0.7	112.9	0.8	2764.330	2.04E-04	5.20E-04	0.052	6.52E-03	10.0787	5.45E-03	0.00
44.0	1.0	43.5	115.0	2.50	1.68	0.984	100	1.25	132.4	0.6	111.6	0.8	2785.857	2.04E-04	5.20E-04	0.052	6.61E-03	10.0787	5.53E-03	0.00
45.0	1.0	44.5	115.0	2.56	1.71	1.000	100	1.25	132.4	0.6	110.3	0.8	2807.056	2.04E-04	5.20E-04	0.052	6.70E-03	10.0787	5.60E-03	0.00
46.0	1.0	45.5	115.0	2.62	1.75	1.014	100	1.25	132.4	0.6	109.1	0.8	2827.941	2.05E-04	5.20E-04	0.052	6.79E-03	10.0787	5.68E-03	0.00
47.0	1.0	46.5	115.0	2.67	1.79	1.029	100	1.25	127.2	0.6	108.2	0.8	2850.778	2.05E-04	5.20E-04	0.052	6.86E-03	10.0787	5.73E-03	0.00
48.0	1.0	47.5	115.0	2.73	1.83	1.043	100	1.25	127.2	0.6	107.0	0.8	2871.106	2.05E-04	5.20E-04	0.052	6.95E-03	10.0787	5.81E-03	0.00
49.0	1.0	48.5	115.0	2.79	1.87	1.057	100	1.25	127.2	0.6	105.9	0.8	2891.152	2.05E-04	5.20E-04	0.052	7.03E-03	10.0787	5.88E-03	0.00
50.0	1.0	49.5	115.0	2.85	1.91	1.070	100	1.25	127.2	0.6	104.9	0.8	2910.925	2.05E-04	5.20E-04	0.052	7.12E-03	10.0787	5.95E-03	0.00
51.0	1.0	50.5	115.0	2.90	1.95	1.083	100	1.25	127.2	0.6	103.8	0.8	2930.434	2.05E-04	5.20E-04	0.052	7.21E-03	10.0787	6.02E-03	0.00
52.0	1.0	51.5	115.0	2.96	1.98	1.095	100	1.25	122.6	0.6	102.8	0.8	2949.687	2.05E-04	5.20E-04	0.052	7.29E-03	10.0787	6.10E-03	0.00
53.0	1.0	52.5	115.0	3.02	2.02	1.108	100	1.25	122.6	0.6	101.8	0.8	2968.694	2.05E-04	5.20E-04	0.052	7.37E-03	10.0787	6.17E-03	0.00
54.0	1.0	53.5	115.0	3.08	2.06	1.119	100	1.25	122.6	0.6	100.9	0.8	2987.461	2.05E-04	5.20E-04	0.052	7.46E-03	10.0787	6.	



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

**NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:**

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA _w (g):	0.720
Calculated Mag. Wtg. Factor:	0.812
Historic High Groundwater:	120.0
Groundwater Depth During Exploration:	120.0

**By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:**

Energy Correction (CE) for N60:	1.25
Rod Len. Corr. (CR)(0-no or 1-yes):	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use Ksigma (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):		62.4												
Depth to Base (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq. Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1) ₆₀	Eff. Unit Wt. (pcf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe Fact.
1.0	115.0	0	13.0	1.0	1	50	87	2,000	40.6	115.0	Inf.	0.998	0.379	--
2.0	115.0	0	13.0	2.0	1	50	85	2,000	40.6	115.0	Inf.	0.993	0.377	--
3.0	115.0	0	13.0	3.0	1	50	83	2,000	40.6	115.0	Inf.	0.989	0.376	--
4.0	115.0	0	13.0	4.0	1	50	81	2,000	40.6	115.0	Inf.	0.984	0.374	--
5.0	115.0	0	13.0	5.0	1	50	79	2,000	40.6	115.0	Inf.	0.979	0.372	--
6.0	115.0	0	13.0	6.0	1	50	77	1,817	37.6	115.0	Inf.	0.975	0.370	--
7.0	115.0	0	13.0	7.0	1	50	76	1,671	35.1	115.0	Inf.	0.970	0.369	--
8.0	115.0	0	19.0	8.0	1	50	90	1,556	45.2	115.0	Inf.	0.966	0.367	--
9.0	115.0	0	19.0	9.0	1	50	88	1,462	42.9	115.0	Inf.	0.961	0.365	--
10.0	115.0	0	19.0	10.0	1	50	86	1,382	41.0	115.0	Inf.	0.957	0.363	--
11.0	115.0	0	19.0	10.0	1	50	86	1,315	39.3	115.0	Inf.	0.952	0.362	--
12.0	115.0	0	19.0	12.5	1	3	82	1,257	30.9	115.0	Inf.	0.947	0.360	--
13.0	115.0	0	19.0	12.5	1	3	82	1,205	29.6	115.0	0.430	0.943	0.358	--
14.0	115.0	0	19.0	12.5	1	65	82	1,160	35.5	115.0	Inf.	0.938	0.356	--
15.0	115.0	0	19.0	12.5	1	65	82	1,119	34.5	115.0	Inf.	0.934	0.355	--
16.0	115.0	0	45.0	17.5	1	3	116	1,082	71.9	115.0	Inf.	0.929	0.353	--
17.0	115.0	0	45.0	17.5	1	3	116	1,049	69.7	115.0	Inf.	0.925	0.351	--
18.0	115.0	0	45.0	17.5	1	3	116	1,019	67.6	115.0	Inf.	0.920	0.349	--
19.0	115.0	0	45.0	17.5	1	3	116	0,991	65.8	115.0	Inf.	0.915	0.348	--
20.0	115.0	0	45.0	17.5	1	3	116	0,965	64.1	115.0	Inf.	0.911	0.346	--
21.0	115.0	0	45.0	17.5	1	3	116	0,941	62.5	115.0	Inf.	0.906	0.344	--
22.0	115.0	0	45.0	17.5	1	3	116	0,919	61.0	115.0	Inf.	0.902	0.343	--
23.0	115.0	0	44.0	22.5	1	3	108	0,898	63.2	115.0	Inf.	0.897	0.341	--
24.0	115.0	0	44.0	22.5	1	3	108	0,879	61.9	115.0	Inf.	0.893	0.339	--
25.0	115.0	0	44.0	22.5	1	3	108	0,861	60.6	115.0	Inf.	0.888	0.337	--
26.0	115.0	0	44.0	22.5	1	3	108	0,844	59.4	115.0	Inf.	0.883	0.336	--
27.0	115.0	0	44.0	22.5	1	3	108	0,828	58.3	115.0	Inf.	0.879	0.334	--
28.0	115.0	0	42.0	27.5	1	4	99	0,813	57.6	115.0	Inf.	0.874	0.332	--
29.0	115.0	0	42.0	27.5	1	4	99	0,798	56.6	115.0	Inf.	0.870	0.330	--
30.0	115.0	0	42.0	27.5	1	4	99	0,785	55.7	115.0	Inf.	0.865	0.328	--
31.0	115.0	0	42.0	27.5	1	4	99	0,772	54.7	115.0	Inf.	0.861	0.327	--
32.0	115.0	0	42.0	27.5	1	4	99	0,759	53.9	115.0	Inf.	0.856	0.325	--
33.0	115.0	0	53.0	32.5	1	4	106	0,747	68.3	115.0	Inf.	0.851	0.323	--
34.0	115.0	0	53.0	32.5	1	4	106	0,736	67.3	115.0	Inf.	0.847	0.322	--
35.0	115.0	0	53.0	32.5	1	4	106	0,725	66.3	115.0	Inf.	0.842	0.320	--
36.0	115.0	0	53.0	32.5	1	4	106	0,715	65.4	115.0	Inf.	0.838	0.318	--
37.0	115.0	0	53.0	32.5	1	4	106	0,705	64.5	115.0	Inf.	0.833	0.316	--
38.0	115.0	0	45.0	37.5	1	4	93	0,696	54.0	115.0	Inf.	0.829	0.315	--
39.0	115.0	0	45.0	37.5	1	4	93	0,687	53.3	115.0	Inf.	0.824	0.313	--
40.0	115.0	0	45.0	37.5	1	4	93	0,678	52.6	115.0	Inf.	0.819	0.311	--
41.0	115.0	0	45.0	37.5	1	4	93	0,670	52.0	115.0	Inf.	0.815	0.310	--
42.0	115.0	0	45.0	37.5	1	4	93	0,661	51.3	115.0	Inf.	0.810	0.308	--
43.0	115.0	0	53.0	42.5	1	4	96	0,654	59.8	115.0	Inf.	0.806	0.306	--
44.0	115.0	0	53.0	42.5	1	4	96	0,646	59.1	115.0	Inf.	0.801	0.304	--
45.0	115.0	0	53.0	42.5	1	4	96	0,639	58.4	115.0	Inf.	0.797	0.303	--
46.0	115.0	0	53.0	42.5	1	4	96	0,632	57.8	115.0	Inf.	0.792	0.301	--
47.0	115.0	0	53.0	42.5	1	4	96	0,625	57.1	115.0	Inf.	0.787	0.299	--
48.0	115.0	0	82.0	47.5	1	4	115	0,618	87.5	115.0	Inf.	0.783	0.297	--
49.0	115.0	0	82.0	47.5	1	4	115	0,612	86.5	115.0	Inf.	0.778	0.296	--
50.0	115.0	0	82.0	47.5	1	4	115	0,606	85.7	115.0	Inf.	0.774	0.294	--
51.0	115.0	0	82.0	47.5	1	4	115	0,600	84.8	115.0	Inf.	0.769	0.292	--
52.0	115.0	0	82.0	47.5	1	4	115	0,594	84.0	115.0	Inf.	0.765	0.290	--
53.0	115.0	0	59.0	52.5	1	4	94	0,588	59.9	115.0	Inf.	0.760	0.289	--
54.0	115.0	0	59.0	52.5	1	4	94	0,583	59.3	115.0	Inf.	0.755	0.287	--
55.0	115.0	0	59.0	52.5	1	4	94	0,577	58.7	115.0	Inf.	0.751	0.285	--
56.0	115.0	0	59.0	52.5	1	4	94	0,572	58.2	115.0	Inf.	0.746	0.283	--
57.0	115.0	0	59.0	52.5	1	4	94	0,567	57.7	115.0	Inf.	0.742	0.282	--
58.0	115.0	0	54.0	57.5	1	4	87	0,562	52.3	115.0	Inf.	0.737	0.280	--
59.0	115.0	0	54.0	57.5	1	4	87	0,557	51.9	115.0	Inf.	0.733	0.278	--
60.0	115.0	0	54.0	57.5	1	4	87	0,552	51.5	115.0	Inf.	0.728	0.277	--
61.0	115.0	0	54.0	57.5	1	4	87	0,548	51.0	115.0	Inf.	0.723	0.275	--
62.0	115.0	0	54.0	57.5	1	4	87	0,543	50.6	115.0	Inf.	0.719	0.273	--
63.0	115.0	0	67.0	62.5	1	4	94	0,539	62.3	115.0	Inf.	0.714	0.271	--
64.0	115.0	0	67.0	62.5	1	4	94	0,535	61.8	115.0	Inf.	0.710	0.270	--
65.0	115.0	0	67.0	62.5	1	4	94	0,531	61.3	115.0	Inf.	0.705	0.268	--
66.0	115.0	0	67.0	62.5	1	4	94	0,526	60.8	115.0	Inf.	0.701	0.266	--
67.0	115.0	0	67.0	62.5	1	4	94	0,523	60.4	115.0	Inf.	0.696	0.264	--
68.0	115.0	0	100.0	67.5	1	3	111	0,519	89.5	115.0	Inf.	0.691	0.263	--
69.0	115.0	0	100.0	67.5	1	3	111	0,515	88.8	115.0	Inf.	0.687	0.261	--
70.0	115.0	0	100.0	67.5	1	3	111	0,511	88.2	115.0	Inf.	0.682	0.259	--
71.0	115.0	0	100.0	67.5	1	3	111	0,507	87.5	115.0	Inf.	0.678	0.257	--
72.0	115.0	0	100.0	67.5	1	3	111	0,504	86.9	115.0	Inf.	0.673	0.256	--
73.0	115.0	0	100.0	72.5	1	3	108	0,500	86.3	115.0	Inf.	0.669	0.254	--
74.0	115.0	0	100.0	72.5	1	3	108	0,497	85.7	115.0	Inf.	0.664	0.252	--
75.0	115.0	0	100.0	72.5	1	3	108	0,494	85.2	115.0	Inf.	0.659	0.250	--
76.0	115.0	0	100.0	72.5	1	3	108	0,490	84.6	115.0	Inf.	0.655	0.249	--
77.0	115.0	0	100.0	72.5	1	3	108	0,487	84.0	115.0	Inf.	0.650	0.247	--
78.0	115.0	0	100.0	77.5	1	4	105	0,484	83.5	115.0	Inf.	0.646	0.245	--
79.0	115.0	0	100.0	77.5	1	4	105	0,481	83.0	115.0	Inf.	0.641	0.244	--
80.0	115.0	0	100.0	77.5	1	4	105	0,478	82.4	115.0	Inf.	0.637	0.242	--
81.0	115.0	0	100.0	77.5	1	4	105	0,475	81.9	115.0	Inf.	0.632	0.240	--
82.0	115.0	0	100.0	77.5	1	4	105	0,472	81.4	115.0	Inf.	0.627	0.238	--
83.0	115.0	0	100.0	82.5	1	4	103	0,469	80.9	115.0	Inf.	0.625	0.237	--
84.0	115.0	0	100.0	82.5	1	4	103	0,466	80.4	115.0	Inf.	0.625	0.237	--
85.0	115.0	0	100.0	82.5	1	4	103	0,464	80.0	115.0	Inf.	0.625	0.237	--
86.0	115.0	0	100.0	82.5	1	4	103	0,461	79.5	115.0	Inf.	0.625	0.237	--
87.0	115.0	0	100.0	82.5	1	4	103	0,458	79.0	115.0	Inf.	0.625	0.237	--
88.0	115.0	0	100.0	87.5	1	3	100	0,456	78.6	115.0	Inf.	0.625	0.237	--
89.0	115.0	0	100.0	87.5	1	3								



**TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9
 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS
 MAXIMUM CONSIDERED EARTHQUAKE**

MCE EARTHQUAKE INFORMATION:	
Earthquake Magnitude	6.30
Peak Horiz. Acceleration (g)	0.720

Fig 4.1 Fig 4.2

Fig 4.4

Depth of Base of Struts (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (tsf)	Mean Effective Pressure at Mid-point (tsf)	Average Cyclic Shear Stress (tsf)	Field Factor	Correction Factor	Relative Density (%)	Correction Factor	Corrected r_d Factor	rd Factor	Maximum Shear Mod. (GPa)	γ_{eff} (in)	γ_{eff} (%)	Volumetric Strain M.T.5 (%)	Number of Strain Cycles	Corrected Vol. Strains	Estimated Settlement (S) (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	13	1.25	87.4	2.0	40.6	1.0	213.291	6.25E-05	1.40E-04	0.014	5.98E-03	10.0787	5.00E-03
2.0	1.0	1.5	115.0	0.09	0.06	0.040	13	1.25	85.0	2.0	40.6	1.0	369.431	1.06E-04	3.00E-03	0.300	1.28E-01	10.0787	1.07E-01
3.0	1.0	2.5	115.0	0.14	0.10	0.067	13	1.25	82.9	2.0	40.6	1.0	476.934	1.34E-04	3.00E-03	0.300	1.28E-01	10.0787	1.07E-01
4.0	1.0	3.5	115.0	0.20	0.13	0.094	13	1.25	80.9	2.0	40.6	1.0	564.315	1.56E-04	8.10E-04	0.081	3.46E-02	10.0787	2.89E-02
5.0	1.0	4.5	115.0	0.26	0.17	0.121	13	1.25	79.0	2.0	40.6	1.0	639.873	1.73E-04	8.10E-04	0.081	3.46E-02	10.0787	2.89E-02
6.0	1.0	5.5	115.0	0.32	0.21	0.148	13	1.25	77.2	1.8	37.6	1.0	689.068	1.93E-04	4.50E-04	0.045	2.11E-02	10.0787	1.77E-02
7.0	1.0	6.5	115.0	0.37	0.25	0.174	13	1.25	75.6	1.7	35.1	1.0	732.449	2.11E-04	1.00E-03	0.100	5.09E-02	10.0787	4.26E-02
8.0	1.0	7.5	115.0	0.43	0.29	0.201	19	1.25	89.6	1.6	45.2	1.0	856.191	2.04E-04	1.00E-03	0.100	3.75E-02	10.0787	3.14E-02
9.0	1.0	8.5	115.0	0.48	0.33	0.227	19	1.25	87.8	1.5	42.9	1.0	896.631	2.17E-04	1.00E-03	0.100	4.00E-02	10.0787	3.34E-02
10.0	1.0	9.5	115.0	0.55	0.37	0.253	19	1.25	86.2	1.4	41.0	1.0	932.340	2.29E-04	1.00E-03	0.100	4.23E-02	10.0787	3.54E-02
11.0	1.0	10.5	115.0	0.60	0.40	0.279	19	1.25	86.2	1.3	39.3	1.0	966.777	2.39E-04	1.00E-03	0.100	4.44E-02	10.0787	3.71E-02
12.0	1.0	11.5	115.0	0.66	0.44	0.305	19	1.25	84.4	1.2	37.6	1.0	1003.055	2.49E-04	1.00E-03	0.100	4.64E-02	10.0787	3.86E-02
13.0	1.0	12.5	115.0	0.72	0.48	0.331	19	1.25	81.7	1.2	29.6	0.9	959.818	2.77E-04	1.00E-03	0.100	6.24E-02	10.0787	5.22E-02
14.0	1.0	13.5	115.0	0.78	0.52	0.357	19	1.25	81.7	1.2	35.5	0.9	1059.541	2.66E-04	7.10E-04	0.071	3.57E-02	10.0787	2.98E-02
15.0	1.0	14.5	115.0	0.83	0.56	0.382	19	1.25	81.7	1.1	34.5	0.9	1087.669	2.74E-04	7.10E-04	0.071	3.69E-02	10.0787	3.09E-02
16.0	1.0	15.5	115.0	0.89	0.60	0.407	45	1.25	116.4	1.1	71.9	0.9	1436.156	2.18E-04	7.10E-04	0.071	1.53E-02	10.0787	1.28E-02
17.0	1.0	16.5	115.0	0.95	0.64	0.432	45	1.25	116.4	1.0	69.7	0.9	1466.400	2.23E-04	7.10E-04	0.071	1.59E-02	10.0787	1.33E-02
18.0	1.0	17.5	115.0	1.01	0.67	0.457	45	1.25	116.4	1.0	67.6	0.9	1495.445	2.28E-04	7.10E-04	0.071	1.65E-02	10.0787	1.38E-02
19.0	1.0	18.5	115.0	1.06	0.71	0.481	45	1.25	116.4	1.0	65.8	0.9	1523.404	2.33E-04	7.10E-04	0.071	1.70E-02	10.0787	1.42E-02
20.0	1.0	19.5	115.0	1.12	0.75	0.506	45	1.25	116.4	1.0	64.1	0.9	1550.372	2.37E-04	7.10E-04	0.071	1.76E-02	10.0787	1.47E-02
21.0	1.0	20.5	115.0	1.18	0.79	0.529	45	1.25	116.4	0.9	62.5	0.9	1576.434	2.41E-04	7.10E-04	0.071	1.81E-02	10.0787	1.51E-02
22.0	1.0	21.5	115.0	1.24	0.83	0.553	45	1.25	116.4	0.9	61.0	0.9	1601.661	2.45E-04	7.10E-04	0.071	1.86E-02	10.0787	1.56E-02
23.0	1.0	22.5	115.0	1.29	0.87	0.576	44	1.25	107.7	0.9	63.2	0.9	1658.140	2.43E-04	7.10E-04	0.071	1.78E-02	10.0787	1.49E-02
24.0	1.0	23.5	115.0	1.35	0.91	0.599	44	1.25	107.7	0.9	61.9	0.9	1682.350	2.46E-04	7.10E-04	0.071	1.83E-02	10.0787	1.53E-02
25.0	1.0	24.5	115.0	1.41	0.94	0.622	44	1.25	107.7	0.9	60.7	0.9	1705.933	2.49E-04	7.10E-04	0.071	1.88E-02	10.0787	1.57E-02
26.0	1.0	25.5	115.0	1.47	0.98	0.644	44	1.25	107.7	0.8	59.4	0.9	1728.783	2.52E-04	7.10E-04	0.071	1.92E-02	10.0787	1.61E-02
27.0	1.0	26.5	115.0	1.52	1.02	0.666	44	1.25	107.7	0.8	58.3	0.9	1751.093	2.54E-04	5.20E-04	0.052	1.44E-02	10.0787	1.20E-02
28.0	1.0	27.5	115.0	1.58	1.06	0.688	42	1.25	99.1	0.8	57.6	0.9	1772.260	2.56E-04	5.20E-04	0.052	1.48E-02	10.0787	1.22E-02
29.0	1.0	28.5	115.0	1.64	1.10	0.710	42	1.25	99.1	0.8	56.5	0.9	1792.647	2.58E-04	5.20E-04	0.052	1.52E-02	10.0787	1.25E-02
30.0	1.0	29.5	115.0	1.70	1.14	0.730	42	1.25	99.1	0.8	55.7	0.9	1819.341	2.60E-04	5.20E-04	0.052	1.52E-02	10.0787	1.27E-02
31.0	1.0	30.5	115.0	1.75	1.18	0.751	42	1.25	99.1	0.8	54.7	0.9	1839.670	2.62E-04	5.20E-04	0.052	1.55E-02	10.0787	1.30E-02
32.0	1.0	31.5	115.0	1.81	1.21	0.771	42	1.25	99.1	0.8	53.9	0.9	1859.960	2.64E-04	5.20E-04	0.052	1.58E-02	10.0787	1.32E-02
33.0	1.0	32.5	115.0	1.87	1.25	0.791	53	1.25	105.6	0.7	52.5	0.9	1879.215	2.65E-04	5.20E-04	0.052	1.60E-02	10.0787	1.35E-02
34.0	1.0	33.5	115.0	1.93	1.29	0.811	53	1.25	105.6	0.7	67.3	0.8	2065.638	2.45E-04	5.20E-04	0.052	1.21E-02	10.0787	1.01E-02
35.0	1.0	34.5	115.0	1.98	1.33	0.830	53	1.25	105.6	0.7	66.3	0.8	2085.990	2.46E-04	5.20E-04	0.052	1.23E-02	10.0787	1.03E-02
36.0	1.0	35.5	115.0	2.04	1.37	0.848	53	1.25	105.6	0.7	65.4	0.8	2105.953	2.47E-04	5.20E-04	0.052	1.26E-02	10.0787	1.05E-02
37.0	1.0	36.5	115.0	2.10	1.41	0.867	53	1.25	105.6	0.7	64.5	0.8	2125.916	2.48E-04	5.20E-04	0.052	1.28E-02	10.0787	1.07E-02
38.0	1.0	37.5	115.0	2.16	1.44	0.885	45	1.25	92.8	0.7	54.0	0.8	2030.931	2.63E-04	5.20E-04	0.052	1.58E-02	10.0787	1.32E-02
39.0	1.0	38.5	115.0	2.21	1.48	0.902	45	1.25	92.8	0.7	53.3	0.8	2048.826	2.64E-04	5.20E-04	0.052	1.60E-02	10.0787	1.34E-02
40.0	1.0	39.5	115.0	2.27	1.52	0.919	45	1.25	92.8	0.7	52.6	0.8	2066.413	2.64E-04	5.20E-04	0.052	1.63E-02	10.0787	1.36E-02
41.0	1.0	40.5	115.0	2.33	1.56	0.936	45	1.25	92.8	0.7	52.0	0.8	2083.706	2.65E-04	5.20E-04	0.052	1.65E-02	10.0787	1.38E-02
42.0	1.0	41.5	115.0	2.39	1.60	0.953	45	1.25	92.8	0.7	51.3	0.8	2100.717	2.65E-04	5.20E-04	0.052	1.68E-02	10.0787	1.40E-02
43.0	1.0	42.5	115.0	2.44	1.64	0.969	53	1.25	106.4	0.7	59.8	0.8	2236.157	2.62E-04	5.20E-04	0.052	1.40E-02	10.0787	1.17E-02
44.0	1.0	43.5	115.0	2.50	1.68	0.984	53	1.25	106.4	0.6	59.1	0.8	2253.560	2.62E-04	5.20E-04	0.052	1.42E-02	10.0787	1.19E-02
45.0	1.0	44.5	115.0	2.56	1.71	1.000	53	1.25	106.4	0.6	58.4	0.8	2270.998	2.63E-04	5.20E-04	0.052	1.44E-02	10.0787	1.20E-02
46.0	1.0	45.5	115.0	2.62	1.75	1.014	53	1.25	106.4	0.6	57.6	0.8	2287.581	2.63E-04	5.20E-04	0.052	1.46E-02	10.0787	1.22E-02
47.0	1.0	46.5	115.0	2.67	1.79	1.029	53	1.25	106.4	0.6	57.1	0.8	2304.218	2.63E-04	5.20E-04	0.052	1.48E-02	10.0787	1.23E-02
48.0	1.0	47.5	115.0	2.73	1.83	1.043	82	1.25	115.2	0.6	87.5	0.8	2684.004	2.19E-04	5.20E-04	0.052	8.85E-03	10.0787	7.40E-03
49.0	1.0	48.5	115.0	2.79	1.87	1.057	82	1.25	115.2	0.6	86.5	0.8	2702.708	2.19E-04	5.20E-04	0.052	8.99E-03	10.0787	7.50E-03
50.0	1.0	49.5	115.0	2.85	1.91	1.070	82	1.25	115.2	0.6	85.7	0.8	2721.157	2.19E-04	5.20E-04	0.052	9.13E-03	10.0787	7.60E-03
51.0	1.0	50.5	115.0	2.90	1.95	1.083	82	1.25	115.2	0.6	84.8	0.8	2739.360	2.19E-04	5.20E-04	0.052	9.18E-03	10.0787	7.68E-03
52.0	1.0	51.5	115.0	2.96	1.98	1.095	82	1.25	115.2	0.6	84.0	0.8	2757.323	2.19E-04	5.20E-04	0.052	9.29E-03	10.0787	7.77E-03
53.0	1.0	52.5	115.0	3.02	2.02	1.108	59	1.25	94.2	0.6	59.0	0.8	2486.668	2.44E-04	5.20E-04	0.052	1.40E-02	10.0787	1.17E-02
54.0	1.0	53.5	115.0	3.08	2.06	1.119	59	1.25	94.2	0.6	58.2	0.7	2503.974	2.44E-04	5.20E-04	0.052	1.42E-02	10.0787	1.18E-02
55.0	1.0	54.5	115.0	3.13	2.10	1.131	59	1.25	94.2	0.6	58.7	0.8	2517.852	2.44E-04	5.20E-04	0.052	1.43E-02	10.0787	1.19E-02
56.0	1.0	55.5	115.0	3.19	2.14	1.142	59	1.25	94.2	0.6	58.2	0.7	2533.158	2.44E-04	5.20E-04	0.052	1.44E-02	10.0787	1.21E-02
57.0	1.0	56.5	115.0	3.25	2.18	1.153	59	1.25	94.2	0.6	57.7	0.7							



EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL MAXIMUM CONSIDERED EARTHQUAKE

**NCEER (1996) METHOD
 EARTHQUAKE INFORMATION:**

Earthquake Magnitude:	6.90
Peak Horiz. Acceleration PGA_M (g):	0.720
Calculated Mag. Wtg Factor:	0.812
Historic High Groundwater:	120.0
ck b	120.0

**By Thomas F. Blake (1994-1996)
 ENERGY & ROD CORRECTIONS:**

Energy Correction (CE) for N60:	1.25
Rod Len. Corr. (CR) _{0-no or 1-yes} :	1.0
Bore Dia. Corr. (CB):	1.15
Sampler Corr. (CS):	1.20
Use K_{sigma} (0 or 1):	1.0

LIQUEFACTION CALCULATIONS:

Unit Wt. Water (pcf):														
Depth to Depth (ft)	Total Unit Wt. (pcf)	Water (0 or 1)	FIELD SPT (N)	Depth of SPT (ft)	Liq Sus. (0 or 1)	-200 (%)	Est. Dr (%)	CN Factor	Corrected (N1)60	Eff. Unit Wt. (psf)	Resist. CRR	rd Factor	Induced CSR	Liquefac. Safe Fact.
1.0	115.0	0	26.0	1.0	1	57	124	2.000	74.3	115.0	Inf.	0.998	0.379	--
2.0	115.0	0	26.0	2.0	1	57	120	2.000	74.3	115.0	Inf.	0.993	0.377	--
3.0	115.0	0	26.0	3.0	1	57	117	2.000	74.3	115.0	Inf.	0.989	0.376	--
4.0	115.0	0	26.0	4.0	1	57	114	2.000	74.3	115.0	Inf.	0.984	0.374	--
5.0	115.0	0	26.0	5.0	1	57	112	2.000	74.3	115.0	Inf.	0.979	0.372	--
6.0	115.0	0	26.0	6.0	1	57	109	1.817	68.1	115.0	Inf.	0.975	0.370	--
7.0	115.0	0	26.0	7.0	1	57	107	1.671	63.2	115.0	Inf.	0.970	0.369	--
8.0	115.0	0	20.0	8.0	1	57	92	1.556	47.3	115.0	Inf.	0.966	0.367	--
9.0	115.0	0	20.0	9.0	1	57	90	1.462	44.8	115.0	Inf.	0.961	0.365	--
10.0	115.0	0	20.0	10.0	1	57	88	1.382	42.8	115.0	Inf.	0.957	0.363	--
11.0	115.0	0	20.0	10.0	1	57	88	1.315	41.0	115.0	Inf.	0.952	0.362	--
12.0	115.0	0	20.0	10.0	1	57	88	1.257	39.5	115.0	Inf.	0.947	0.360	--
13.0	115.0	0	17.0	12.5	1	57	77	1.205	33.5	115.0	Inf.	0.943	0.358	--
14.0	115.0	0	17.0	12.5	1	57	77	1.160	32.5	115.0	Inf.	0.938	0.356	--
15.0	115.0	0	17.0	12.5	1	57	77	1.119	31.6	115.0	Inf.	0.934	0.355	--
16.0	115.0	0	17.0	12.5	1	57	77	1.082	30.8	115.0	Inf.	0.929	0.353	--
17.0	115.0	0	17.0	12.5	1	57	77	1.049	30.1	115.0	Inf.	0.925	0.351	--
18.0	115.0	0	24.0	17.5	1	57	85	1.019	43.1	115.0	Inf.	0.920	0.349	--
19.0	115.0	0	24.0	17.5	1	57	85	0.991	42.1	115.0	Inf.	0.915	0.348	--
20.0	115.0	0	24.0	17.5	1	57	85	0.965	41.2	115.0	Inf.	0.911	0.346	--
21.0	115.0	0	24.0	17.5	1	57	85	0.941	40.3	115.0	Inf.	0.906	0.344	--
22.0	115.0	0	24.0	17.5	1	57	85	0.919	39.5	115.0	Inf.	0.902	0.343	--
23.0	115.0	0	30.0	22.5	1	58	89	0.898	50.1	115.0	Inf.	0.897	0.341	--
24.0	115.0	0	30.0	22.5	1	58	89	0.879	49.2	115.0	Inf.	0.893	0.339	--
25.0	115.0	0	30.0	22.5	1	58	89	0.861	48.3	115.0	Inf.	0.888	0.337	--
26.0	115.0	0	30.0	22.5	1	58	89	0.844	47.5	115.0	Inf.	0.883	0.336	--
27.0	115.0	0	30.0	22.5	1	58	89	0.828	46.7	115.0	Inf.	0.879	0.334	--
28.0	115.0	0	20.0	27.5	1	58	68	0.813	34.4	115.0	Inf.	0.874	0.332	--
29.0	115.0	0	20.0	27.5	1	58	68	0.798	34.0	115.0	Inf.	0.870	0.330	--
30.0	115.0	0	20.0	27.5	1	58	68	0.785	33.5	115.0	Inf.	0.865	0.329	--
31.0	115.0	0	20.0	27.5	1	58	68	0.772	33.1	115.0	Inf.	0.861	0.327	--
32.0	115.0	0	20.0	27.5	1	58	68	0.759	32.6	115.0	Inf.	0.856	0.325	--
33.0	115.0	0	32.0	32.5	1	6	82	0.747	41.5	115.0	Inf.	0.851	0.323	--
34.0	115.0	0	32.0	32.5	1	6	82	0.736	40.9	115.0	Inf.	0.847	0.322	--
35.0	115.0	0	32.0	32.5	1	6	82	0.725	40.3	115.0	Inf.	0.842	0.320	--
36.0	115.0	0	32.0	32.5	1	6	82	0.715	39.8	115.0	Inf.	0.838	0.318	--
37.0	115.0	0	32.0	32.5	1	6	82	0.705	39.2	115.0	Inf.	0.833	0.316	--
38.0	115.0	0	51.0	37.5	1	6	99	0.696	61.5	115.0	Inf.	0.829	0.315	--
39.0	115.0	0	51.0	37.5	1	6	99	0.687	60.7	115.0	Inf.	0.824	0.313	--
40.0	115.0	0	51.0	37.5	1	6	99	0.678	59.9	115.0	Inf.	0.819	0.311	--
41.0	115.0	0	51.0	37.5	1	6	99	0.670	59.2	115.0	Inf.	0.815	0.310	--
42.0	115.0	0	51.0	37.5	1	6	99	0.661	58.5	115.0	Inf.	0.810	0.308	--
43.0	115.0	0	50.0	42.5	1	6	94	0.654	56.7	115.0	Inf.	0.806	0.306	--
44.0	115.0	0	50.0	42.5	1	6	94	0.646	56.0	115.0	Inf.	0.801	0.304	--
45.0	115.0	0	50.0	42.5	1	6	94	0.639	55.4	115.0	Inf.	0.797	0.303	--
46.0	115.0	0	50.0	42.5	1	6	94	0.632	54.8	115.0	Inf.	0.792	0.301	--
47.0	115.0	0	50.0	42.5	1	6	94	0.625	54.2	115.0	Inf.	0.787	0.299	--
48.0	115.0	0	51.0	47.5	1	6	91	0.618	54.7	115.0	Inf.	0.783	0.297	--
49.0	115.0	0	51.0	47.5	1	6	91	0.612	54.1	115.0	Inf.	0.778	0.296	--
50.0	115.0	0	51.0	47.5	1	6	91	0.606	53.6	115.0	Inf.	0.774	0.294	--
51.0	115.0	0	51.0	47.5	1	6	91	0.600	53.0	115.0	Inf.	0.769	0.292	--
52.0	115.0	0	51.0	47.5	1	6	91	0.594	52.5	115.0	Inf.	0.765	0.290	--
53.0	115.0	0	51.0	52.5	1	6	88	0.588	51.9	115.0	Inf.	0.760	0.289	--
54.0	115.0	0	51.0	52.5	1	6	88	0.583	51.5	115.0	Inf.	0.755	0.287	--
55.0	115.0	0	51.0	52.5	1	6	88	0.577	51.0	115.0	Inf.	0.751	0.285	--
56.0	115.0	0	51.0	52.5	1	6	88	0.572	50.5	115.0	Inf.	0.746	0.283	--
57.0	115.0	0	51.0	52.5	1	6	88	0.567	50.1	115.0	Inf.	0.742	0.282	--
58.0	115.0	0	53.0	57.5	1	6	86	0.562	51.6	115.0	Inf.	0.737	0.280	--
59.0	115.0	0	53.0	57.5	1	6	86	0.557	51.1	115.0	Inf.	0.733	0.278	--
60.0	115.0	0	53.0	57.5	1	6	86	0.552	50.7	115.0	Inf.	0.728	0.277	--
61.0	115.0	0	53.0	57.5	1	6	86	0.548	50.3	115.0	Inf.	0.723	0.275	--
62.0	115.0	0	53.0	57.5	1	6	86	0.543	49.9	115.0	Inf.	0.719	0.273	--
63.0	115.0	0	78.0	62.5	1	7	101	0.539	73.1	115.0	Inf.	0.714	0.271	--
64.0	115.0	0	78.0	62.5	1	7	101	0.535	72.5	115.0	Inf.	0.710	0.270	--
65.0	115.0	0	78.0	62.5	1	7	101	0.531	71.9	115.0	Inf.	0.705	0.268	--
66.0	115.0	0	78.0	62.5	1	7	101	0.526	71.4	115.0	Inf.	0.701	0.266	--
67.0	115.0	0	78.0	62.5	1	7	101	0.523	70.8	115.0	Inf.	0.696	0.264	--
68.0	115.0	0	90.0	67.5	1	7	106	0.519	81.1	115.0	Inf.	0.691	0.263	--
69.0	115.0	0	90.0	67.5	1	7	106	0.515	80.5	115.0	Inf.	0.687	0.261	--
70.0	115.0	0	90.0	67.5	1	7	106	0.511	79.9	115.0	Inf.	0.682	0.259	--
71.0	115.0	0	90.0	67.5	1	7	106	0.507	79.3	115.0	Inf.	0.678	0.257	--
72.0	115.0	0	52.0	72.5	1	7	78	0.504	45.7	115.0	Inf.	0.673	0.256	--
73.0	115.0	0	52.0	72.5	1	7	78	0.500	45.4	115.0	Inf.	0.669	0.254	--
74.0	115.0	0	52.0	72.5	1	7	78	0.497	45.1	115.0	Inf.	0.664	0.252	--
75.0	115.0	0	52.0	72.5	1	7	78	0.494	44.8	115.0	Inf.	0.659	0.250	--
76.0	115.0	0	52.0	72.5	1	7	78	0.490	44.5	115.0	Inf.	0.655	0.249	--
77.0	115.0	0	52.0	72.5	1	7	78	0.487	44.2	115.0	Inf.	0.650	0.247	--
78.0	115.0	0	82.0	77.5	1	7	95	0.484	69.0	115.0	Inf.	0.646	0.245	--
79.0	115.0	0	82.0	77.5	1	7	95	0.481	68.6	115.0	Inf.	0.641	0.244	--
80.0	115.0	0	82.0	77.5	1	7	95	0.478	68.1	115.0	Inf.	0.637	0.242	--
81.0	115.0	0	82.0	77.5	1	7	95	0.475	67.7	115.0	Inf.	0.632	0.240	--
82.0	115.0	0	82.0	77.5	1	7	95	0.472	67.3	115.0	Inf.	0.627	0.238	--
83.0	115.0	0	100.0	82.5	1	8	103	0.469	81.6	115.0	Inf.	0.625	0.237	--
84.0	115.0	0	100.0	82.5	1	8	103	0.466	81.1	115.0	Inf.	0.625	0.237	--
85.0	115.0	0	100.0	82.5	1	8	103	0.464	80.6	115.0	Inf.	0.625	0.237	--
86.0	115.0	0	100.0	82.5	1	8	103	0.461	80.2	115.0	Inf.	0.625	0.237	--
87.0	115.0	0	100.0	82.5	1	8	103	0.458	79.7	115.0	Inf.	0.625	0.237	--
88.0	115.0	0	100.0	87.5	1	8	100	0.456	79.3	115.0	Inf.	0.625	0.237	--
89.0	115.0	0	100.0	87.5										



TECHNICAL ENGINEERING AND DESIGN GUIDES AS ADAPTED FROM THE US ARMY CORPS OF ENGINEERS, NO. 9 EVALUATION OF EARTHQUAKE-INDUCED SETTLEMENTS IN DRY SANDY SOILS MAXIMUM CONSIDERED EARTHQUAKE

MCE EARTHQUAKE INFORMATION:	
Earthquake Magnitude	6.99
Peak Horiz. Acceleration (g)	0.720

Fig 4.1 Fig 4.2

Fig 4.4

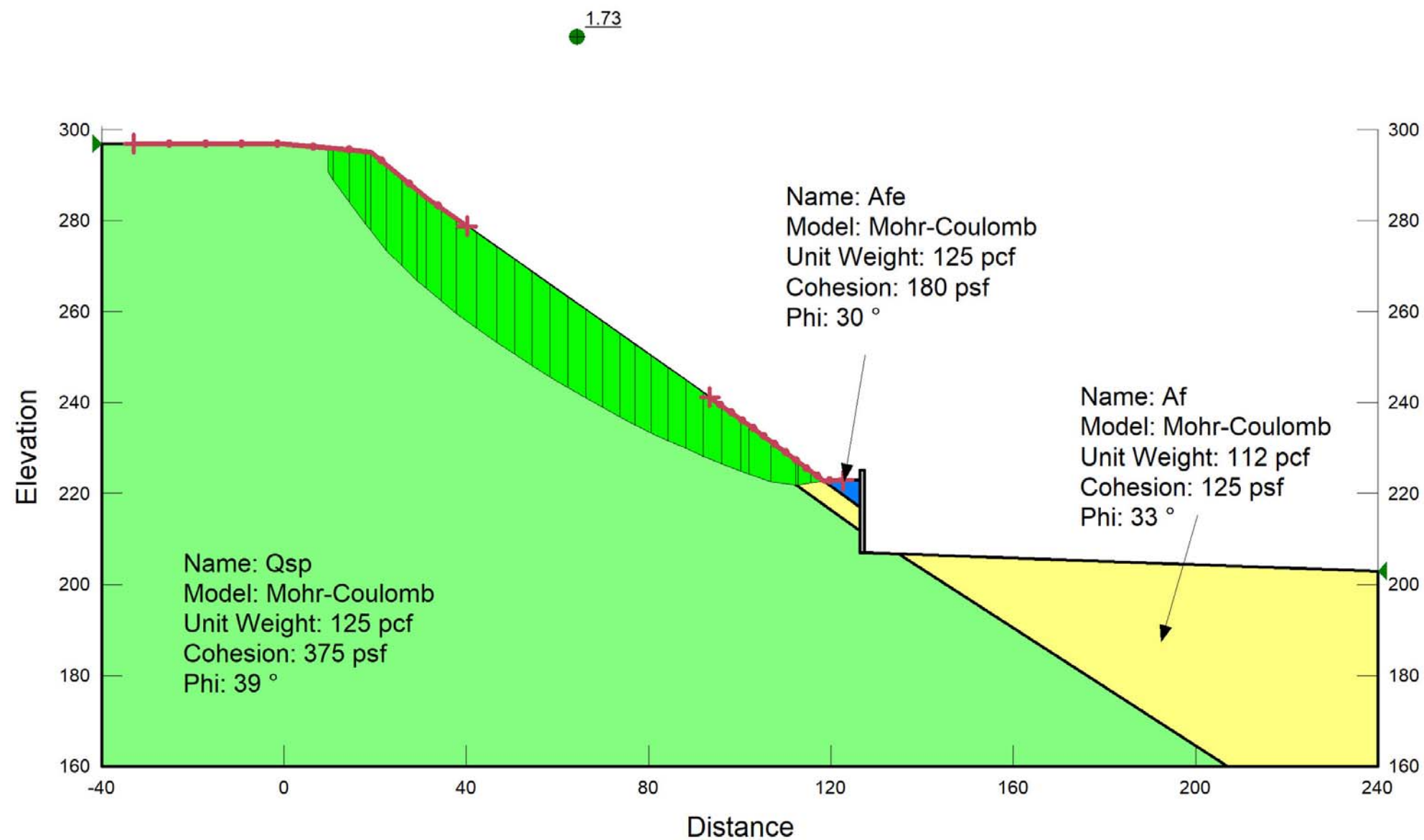
Depth of Base of Strata (ft)	Thickness of Layer (ft)	Depth of Mid-point of Layer (ft)	Soil Unit Weight (pcf)	Overburden Pressure at Mid-point (psf)	Mean Effective Pressure at Mid-point (psf)	Average Cyclic Shear Stress (tsf)	Field SPT (N)	Correction Factor (C ₁)	Relative Density (%)	Correction Factor (C ₂)	Corrected N ₁₆₀	rd Factor	Maximum Shear Mod. (Gmax) (tsf)	y _{eff} (G _{max}) (Gmax)	y _{eff} Shear Strain (%)	y _{eff} 100%	Volumetric Strain M _{5.75} (E15) (%)	Number of Strain Cycles (N _c)	Corrected Vol. Strains (E _c)	Estimated Settlement (S) (inches)
1.0	1.0	0.5	115.0	0.03	0.02	0.013	26	1.25	123.6	2.0	74.3	1.0	260.782	5.11E-05	1.00E-04	0.010	2.07E-03	10.0787	1.73E-03	
2.0	1.0	1.5	115.0	0.09	0.06	0.040	26	1.25	120.3	2.0	74.3	1.0	451.688	6.67E-05	1.90E-04	0.019	3.94E-03	10.0787	3.20E-03	
3.0	1.0	2.5	115.0	0.14	0.10	0.067	26	1.25	117.2	2.0	74.3	1.0	583.127	1.10E-04	3.00E-03	0.300	6.21E-02	10.0787	5.20E-02	
4.0	1.0	3.5	115.0	0.20	0.13	0.094	26	1.25	114.3	2.0	74.3	1.0	689.965	1.27E-04	8.10E-04	0.081	1.68E-02	10.0787	1.40E-02	
5.0	1.0	4.5	115.0	0.26	0.17	0.121	26	1.25	111.7	2.0	74.3	1.0	782.347	1.42E-04	8.10E-04	0.081	1.68E-02	10.0787	1.40E-02	
6.0	1.0	5.5	115.0	0.32	0.21	0.148	26	1.25	109.2	1.8	66.1	1.0	840.379	1.58E-04	4.50E-04	0.045	1.02E-02	10.0787	8.65E-03	
7.0	1.0	6.5	115.0	0.37	0.25	0.174	26	1.25	106.9	1.7	63.2	1.0	891.083	1.73E-04	4.50E-04	0.045	1.13E-02	10.0787	9.46E-03	
8.0	1.0	7.5	115.0	0.43	0.29	0.201	20	1.25	91.9	1.6	47.3	1.0	868.704	2.01E-04	1.00E-03	0.100	3.56E-02	10.0787	2.98E-02	
9.0	1.0	8.5	115.0	0.49	0.33	0.227	20	1.25	90.1	1.5	44.8	1.0	908.593	2.14E-04	1.00E-03	0.100	3.80E-02	10.0787	3.18E-02	
10.0	1.0	9.5	115.0	0.56	0.37	0.253	20	1.25	88.4	1.4	42.8	1.0	945.710	2.25E-04	1.00E-03	0.100	4.02E-02	10.0787	3.36E-02	
11.0	1.0	10.5	115.0	0.60	0.40	0.279	20	1.25	88.4	1.3	41.0	1.0	980.522	2.36E-04	1.00E-03	0.100	4.22E-02	10.0787	3.53E-02	
12.0	1.0	11.5	115.0	0.66	0.44	0.305	20	1.25	88.4	1.3	39.5	0.9	1013.379	2.46E-04	1.00E-03	0.100	4.42E-02	10.0787	3.69E-02	
13.0	1.0	12.5	115.0	0.72	0.48	0.331	17	1.25	77.3	1.2	33.5	0.9	1000.028	2.66E-04	1.00E-03	0.100	5.38E-02	10.0787	4.50E-02	
14.0	1.0	13.5	115.0	0.78	0.52	0.357	15	1.25	77.3	1.2	32.0	0.9	1028.810	2.74E-04	7.10E-04	0.071	5.77E-02	10.0787	3.31E-02	
15.0	1.0	14.5	115.0	0.83	0.56	0.382	17	1.25	77.3	1.1	31.6	0.9	1056.354	2.82E-04	7.10E-04	0.071	4.10E-02	10.0787	3.43E-02	
16.0	1.0	15.5	115.0	0.89	0.60	0.407	17	1.25	77.3	1.1	30.8	0.9	1082.797	2.89E-04	7.10E-04	0.071	4.23E-02	10.0787	3.54E-02	
17.0	1.0	16.5	115.0	0.96	0.64	0.432	17	1.25	77.3	1.0	30.1	0.9	1108.252	2.95E-04	7.10E-04	0.071	4.35E-02	10.0787	3.64E-02	
18.0	1.0	17.5	115.0	1.01	0.67	0.457	24	1.25	85.0	1.0	43.1	0.9	1286.897	2.86E-04	7.10E-04	0.071	2.83E-02	10.0787	2.36E-02	
19.0	1.0	18.5	115.0	1.06	0.71	0.481	24	1.25	85.0	1.0	42.1	0.9	1312.648	2.70E-04	7.10E-04	0.071	2.91E-02	10.0787	2.43E-02	
20.0	1.0	19.5	115.0	1.12	0.75	0.506	24	1.25	85.0	1.0	41.2	0.9	1337.858	2.75E-04	7.10E-04	0.071	2.98E-02	10.0787	2.50E-02	
21.0	1.0	20.5	115.0	1.18	0.79	0.529	24	1.25	85.0	0.9	40.3	0.9	1362.296	2.79E-04	7.10E-04	0.071	3.06E-02	10.0787	2.56E-02	
22.0	1.0	21.5	115.0	1.24	0.83	0.553	24	1.25	85.0	0.9	39.5	0.9	1386.024	2.83E-04	7.10E-04	0.071	3.13E-02	10.0787	2.62E-02	
23.0	1.0	22.5	115.0	1.29	0.87	0.576	30	1.25	88.9	0.9	50.1	0.9	1534.451	2.63E-04	7.10E-04	0.071	2.36E-02	10.0787	1.97E-02	
24.0	1.0	23.5	115.0	1.35	0.91	0.599	30	1.25	88.9	0.9	49.2	0.9	1558.446	2.66E-04	7.10E-04	0.071	2.41E-02	10.0787	2.02E-02	
25.0	1.0	24.5	115.0	1.41	0.94	0.622	30	1.25	88.9	0.8	48.3	0.9	1582.441	2.69E-04	7.10E-04	0.071	2.46E-02	10.0787	2.06E-02	
26.0	1.0	25.5	115.0	1.47	0.98	0.644	30	1.25	88.9	0.8	47.5	0.9	1604.619	2.72E-04	7.10E-04	0.071	2.51E-02	10.0787	2.10E-02	CUT
27.0	1.0	26.5	115.0	1.52	1.02	0.666	30	1.25	88.9	0.8	46.7	0.9	1626.875	2.74E-04	5.20E-04	0.052	1.88E-02	10.0787	1.57E-02	
28.0	1.0	27.5	115.0	1.58	1.06	0.688	20	1.25	68.4	0.8	34.4	0.9	1497.028	3.04E-04	8.10E-04	0.081	4.22E-02	10.0787	3.53E-02	
29.0	1.0	28.5	115.0	1.64	1.10	0.710	20	1.25	68.4	0.8	33.5	0.9	1519.254	3.07E-04	8.10E-04	0.081	4.29E-02	10.0787	3.58E-02	
30.0	1.0	29.5	115.0	1.70	1.14	0.730	20	1.25	68.4	0.8	33.5	0.9	1536.173	3.08E-04	8.10E-04	0.081	4.36E-02	10.0787	3.65E-02	
31.0	1.0	30.5	115.0	1.75	1.18	0.751	20	1.25	68.4	0.8	33.1	0.9	1555.155	3.10E-04	8.10E-04	0.081	4.43E-02	10.0787	3.71E-02	
32.0	1.0	31.5	115.0	1.81	1.21	0.771	20	1.25	68.4	0.8	32.6	0.9	1573.770	3.11E-04	8.10E-04	0.081	4.50E-02	10.0787	3.76E-02	
33.0	1.0	32.5	115.0	1.87	1.25	0.791	32	1.25	82.1	0.7	42.1	0.7	1732.821	2.74E-04	5.20E-04	0.052	1.81E-02	10.0787	1.81E-02	
34.0	1.0	33.5	115.0	1.93	1.29	0.811	32	1.25	82.1	0.7	40.9	0.8	1749.872	2.89E-04	5.20E-04	0.052	2.20E-02	10.0787	1.84E-02	
35.0	1.0	34.5	115.0	1.98	1.33	0.830	32	1.25	82.1	0.7	40.3	0.8	1767.173	2.90E-04	5.20E-04	0.052	2.24E-02	10.0787	1.87E-02	
36.0	1.0	35.5	115.0	2.04	1.37	0.848	32	1.25	82.1	0.7	39.8	0.8	1784.144	2.92E-04	5.20E-04	0.052	2.28E-02	10.0787	1.91E-02	
37.0	1.0	36.5	115.0	2.10	1.41	0.867	32	1.25	82.1	0.7	39.1	0.8	1801.214	2.93E-04	5.20E-04	0.052	2.32E-02	10.0787	1.94E-02	
38.0	1.0	37.5	115.0	2.16	1.44	0.885	51	1.25	98.8	0.7	61.5	0.8	2120.680	2.52E-04	5.20E-04	0.052	1.35E-02	10.0787	1.13E-02	
39.0	1.0	38.5	115.0	2.21	1.48	0.902	51	1.25	98.8	0.7	60.7	0.8	2139.408	2.52E-04	5.20E-04	0.052	1.37E-02	10.0787	1.15E-02	
40.0	1.0	39.5	115.0	2.27	1.52	0.919	51	1.25	98.8	0.7	59.9	0.8	2157.816	2.53E-04	5.20E-04	0.052	1.39E-02	10.0787	1.17E-02	
41.0	1.0	40.5	115.0	2.33	1.56	0.936	51	1.25	98.8	0.7	59.2	0.8	2175.917	2.54E-04	5.20E-04	0.052	1.41E-02	10.0787	1.18E-02	
42.0	1.0	41.5	115.0	2.39	1.60	0.953	51	1.25	98.8	0.7	58.5	0.8	2193.722	2.54E-04	5.20E-04	0.052	1.44E-02	10.0787	1.20E-02	
43.0	1.0	42.5	115.0	2.44	1.64	0.969	50	1.25	93.7	0.7	56.7	0.8	2196.788	2.56E-04	5.20E-04	0.052	1.49E-02	10.0787	1.25E-02	
44.0	1.0	43.5	115.0	2.50	1.68	0.984	50	1.25	93.7	0.6	55.8	0.8	2215.027	2.57E-04	5.20E-04	0.052	1.51E-02	10.0787	1.26E-02	
45.0	1.0	44.5	115.0	2.56	1.71	1.000	50	1.25	93.7	0.6	55.4	0.8	2230.786	2.57E-04	5.20E-04	0.052	1.53E-02	10.0787	1.28E-02	
46.0	1.0	45.5	115.0	2.62	1.75	1.014	50	1.25	93.7	0.6	54.8	0.8	2247.415	2.57E-04	5.20E-04	0.052	1.55E-02	10.0787	1.30E-02	
47.0	1.0	46.5	115.0	2.67	1.79	1.029	50	1.25	93.7	0.6	54.2	0.8	2263.802	2.58E-04	5.20E-04	0.052	1.57E-02	10.0787	1.32E-02	
48.0	1.0	47.5	115.0	2.73	1.83	1.043	48	1.25	90.9	0.6	52.9	0.7	2282.978	2.59E-04	5.20E-04	0.052	1.59E-02	10.0787	1.35E-02	
49.0	1.0	48.5	115.0	2.79	1.87	1.057	51	1.25	90.9	0.6	54.1	0.8	2311.013	2.59E-04	5.20E-04	0.052	1.58E-02	10.0787	1.32E-02	
50.0	1.0	49.5	115.0	2.85	1.91	1.070	51	1.25	90.9	0.6	53.6	0.8	2326.829	2.59E-04	5.20E-04	0.052	1.59E-02	10.0787	1.33E-02	
51.0	1.0	50.5	115.0	2.90	1.95	1.083	51	1.25	90.9	0.6	53.0	0.8	2342.435	2.59E-04	5.20E-04	0.052	1.61E-02	10.0787	1.35E-02	0.003
52.0	1.0	51.5	115.0	2.96	1.98	1.096	51	1.25	90.9	0.6	52.5	0.8	2357.837	2.59E-04	5.20E-04	0.052	1.62E-02	10.0787	1.37E-02	0.003
53.0	1.0	52.5	115.0	3.02	2.02	1.108	51	1.25	87.6	0.6	51.9	0.8	2371.976	2.59E-04	5.20E-04	0.052	1.65E-02	10.0787	1.38E-02	0.003
54.0	1.0	53.5	115.0	3.08	2.06	1.119	51	1.25	87.6	0.6	51.5	0.8	2386.972	2.59E-04	5.20E-04	0.052	1.67E-02	10.0787	1.40E-02	0.003
55.0	1.0	54.5	115.0	3.13	2.10	1.131	51	1.25	87.6	0.6	51.0	0.8								

APPENDIX

A solid green triangle pointing to the left, containing the letter 'E' in white.

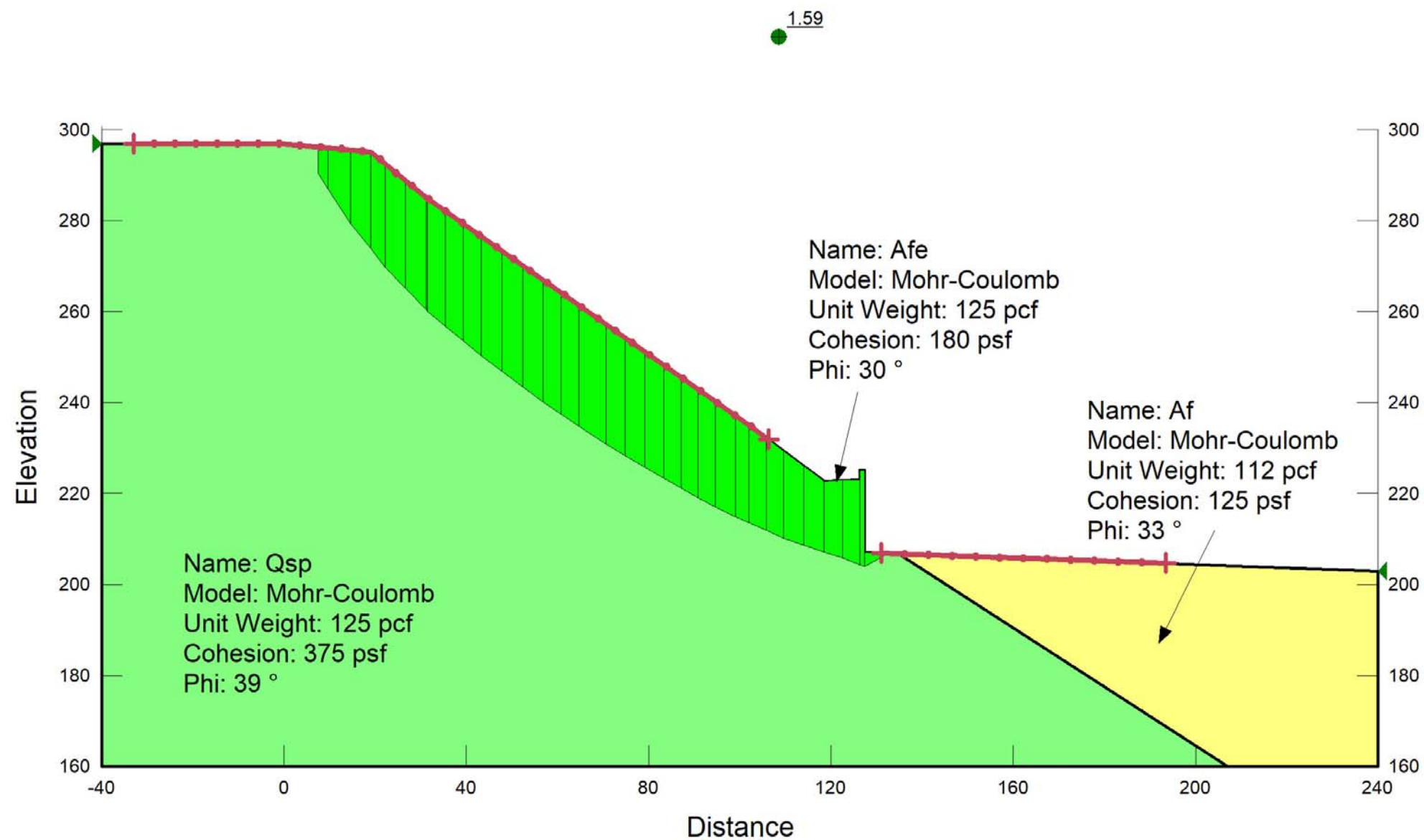
E

APPENDIX E
SLOPE STABILITY



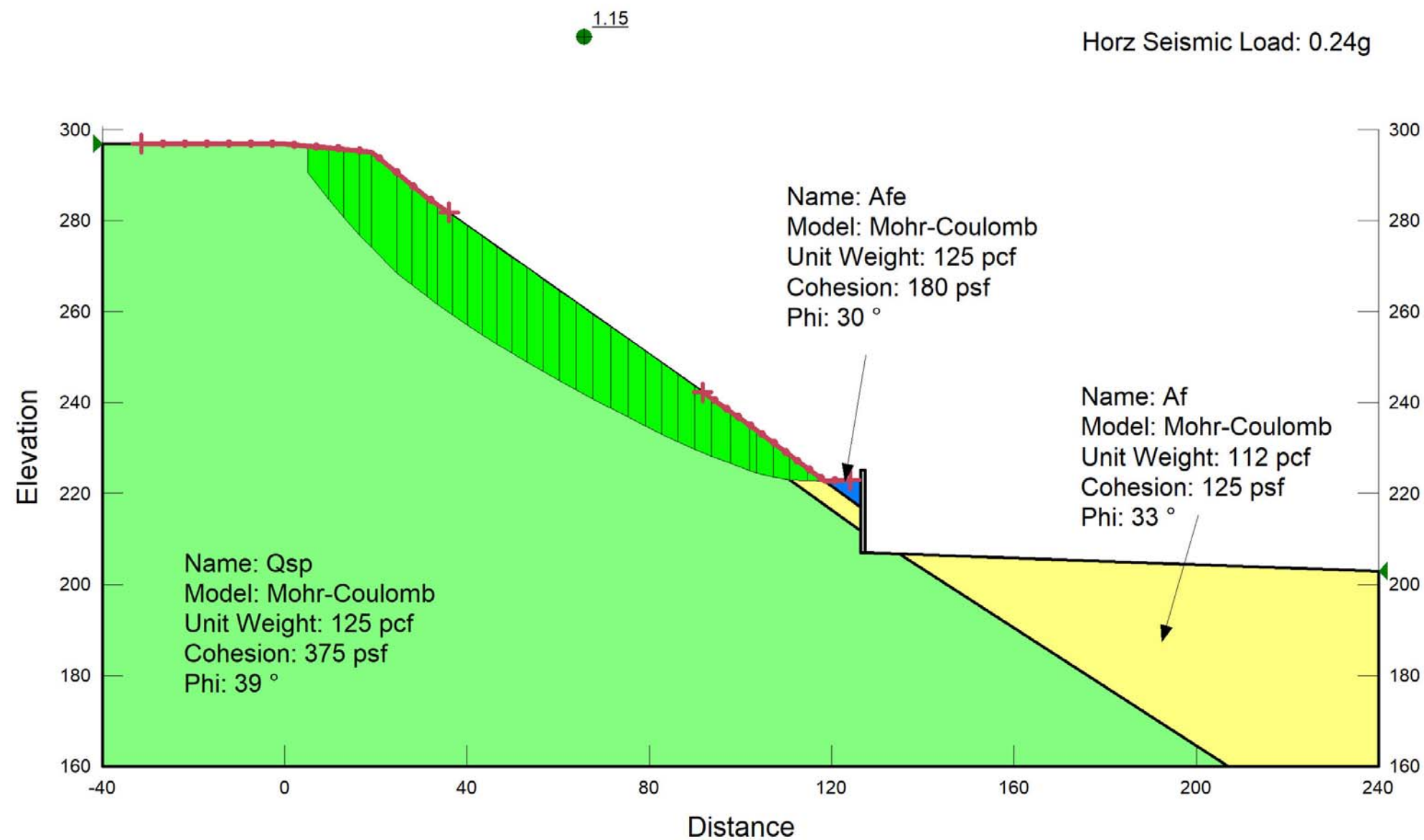
SLOPE 1
SECTION C-C'
STATIC

GEOCON WEST, INC.		
ENVIRONMENTAL GEOTECHNICAL MATERIALS 3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504 PHONE (818) 841-8388 - FAX (818) 841-1704		
JTA		9000
SLOPE STABILITY ANALYSIS		
MKS RESIDENTIAL HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
JUNE 2017	PROJECT NO. A9201-06-01E	FIG. E1



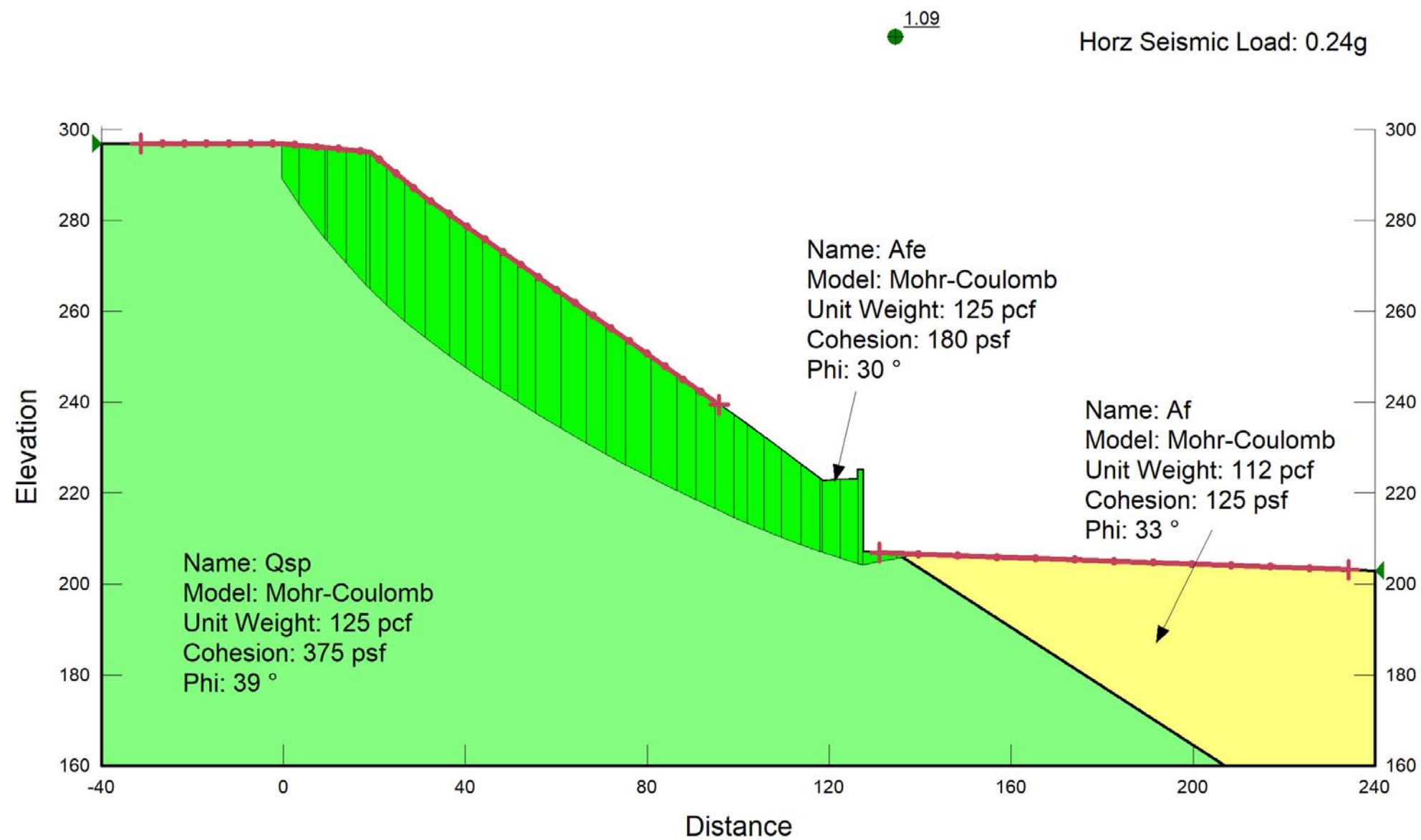
SLOPE 1
SECTION C-C'
STATIC

GEOCON WEST, INC.		
ENVIRONMENTAL GEOTECHNICAL MATERIALS 3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504 PHONE (818) 841-8388 - FAX (818) 841-1704		
JTA		9000
SLOPE STABILITY ANALYSIS		
MKS RESIDENTIAL HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
JUNE 2017	PROJECT NO. A9201-06-01E	FIG. E2



SLOPE 1
SECTION C-C'
PSUEDO-STATIC

GEOCON WEST, INC.		
ENVIRONMENTAL GEOTECHNICAL MATERIALS 3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504 PHONE (818) 841-8388 - FAX (818) 841-1704		
JTA		9000
SLOPE STABILITY ANALYSIS		
MKS RESIDENTIAL HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
JUNE 2017	PROJECT NO. A9201-06-01E	FIG. E3



SLOPE 1
SECTION C-C'
PSUEDO-STATIC

GEOCON WEST, INC.		
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JTA		9000
SLOPE STABILITY ANALYSIS		
MKS RESIDENTIAL HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
JUNE 2017	PROJECT NO. A9201-06-01E	FIG. E4

Slope 1 @ Section C-C' - Artificial Fill (af)

ASSUMED CONDITIONS:

Slope Height	H	=	Infinite
Depth of Saturation	Z	=	4 feet
Slope Inclination	2:1	(Horizontal:Vertical)	
Slope Angle	i	=	35 degrees
Unit Weight of Water	γ_w	=	62.4 pounds per cubic foot
Total Unit Weight of Soil	γ_t	=	112 pounds per cubic foot
Angle of Internal Friction	ϕ	=	33 degrees
Apparent Cohesion	C	=	125 pounds per square foot

Slope saturated to vertical depth Z below slope face.
Seepage forces parallel to slope face

ANALYSIS:

$$FS = \frac{C + (\gamma_t - \gamma_w)Z \cos^2 i \tan \phi}{\gamma_t Z \sin i \cos i} = 1.0$$

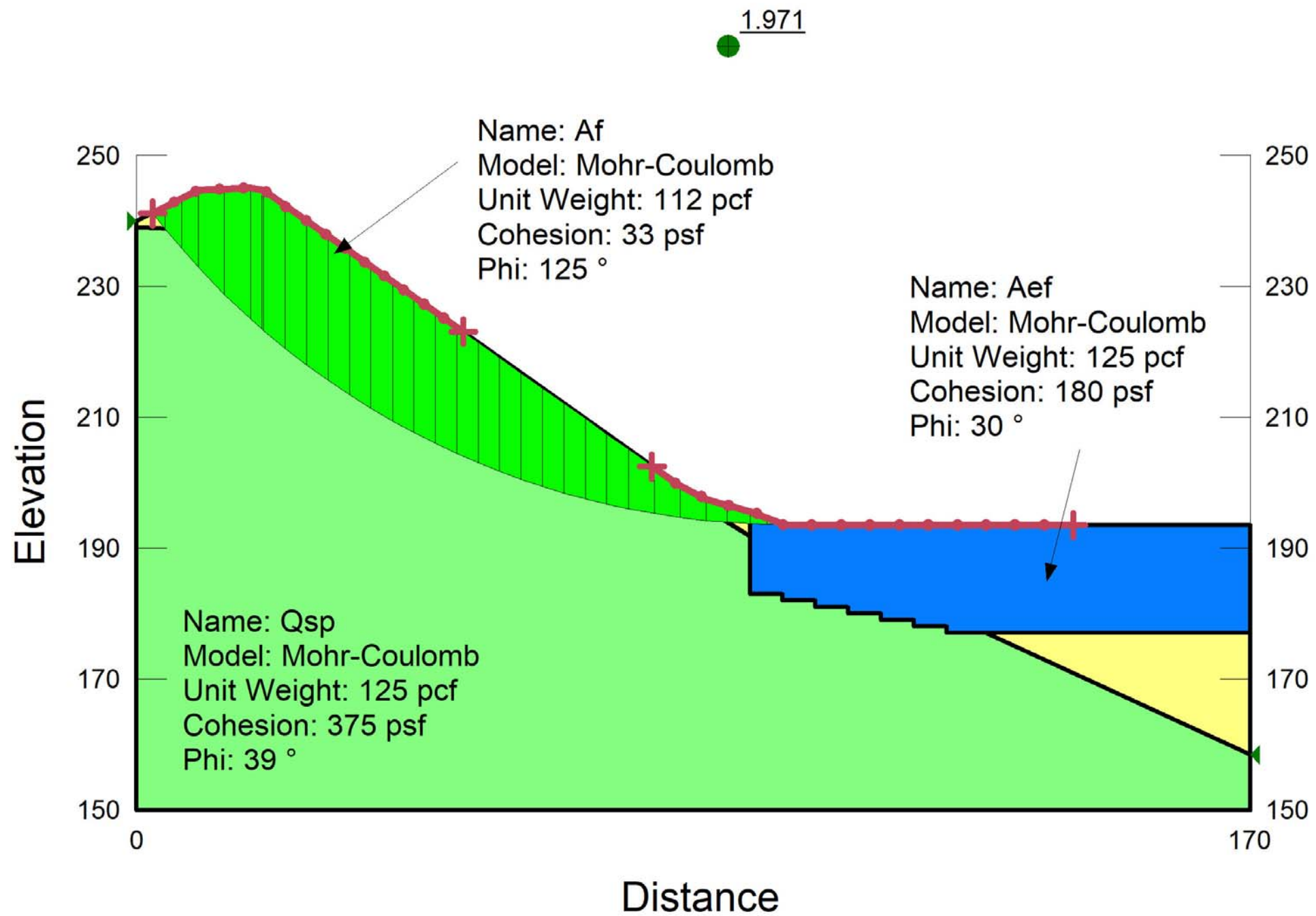
REFERENCES:

- (1) Haefeli, R. *The Stability of Slopes Acted Upon by Parallel Seepage*, Proc. Second International Conference, SMFE, Rotterdam, 1948, 1, 57-62.
- (2) Skempton, A. W., and F. A. Delory, *Stability of Natural Slopes in London Clay*, Proc. Fourth International Conference, SMFE, London, 1957, 2, 378-81.

SURFICIAL SLOPE STABILITY ANALYSIS

**MKS RESIDENTIAL
HAWTHORNE & VIA VALMONTE
TORRANCE, CALIFORNIA**

FIGURE E5



SLOPE 1
SECTION D-D'
STATIC



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JTA

9000

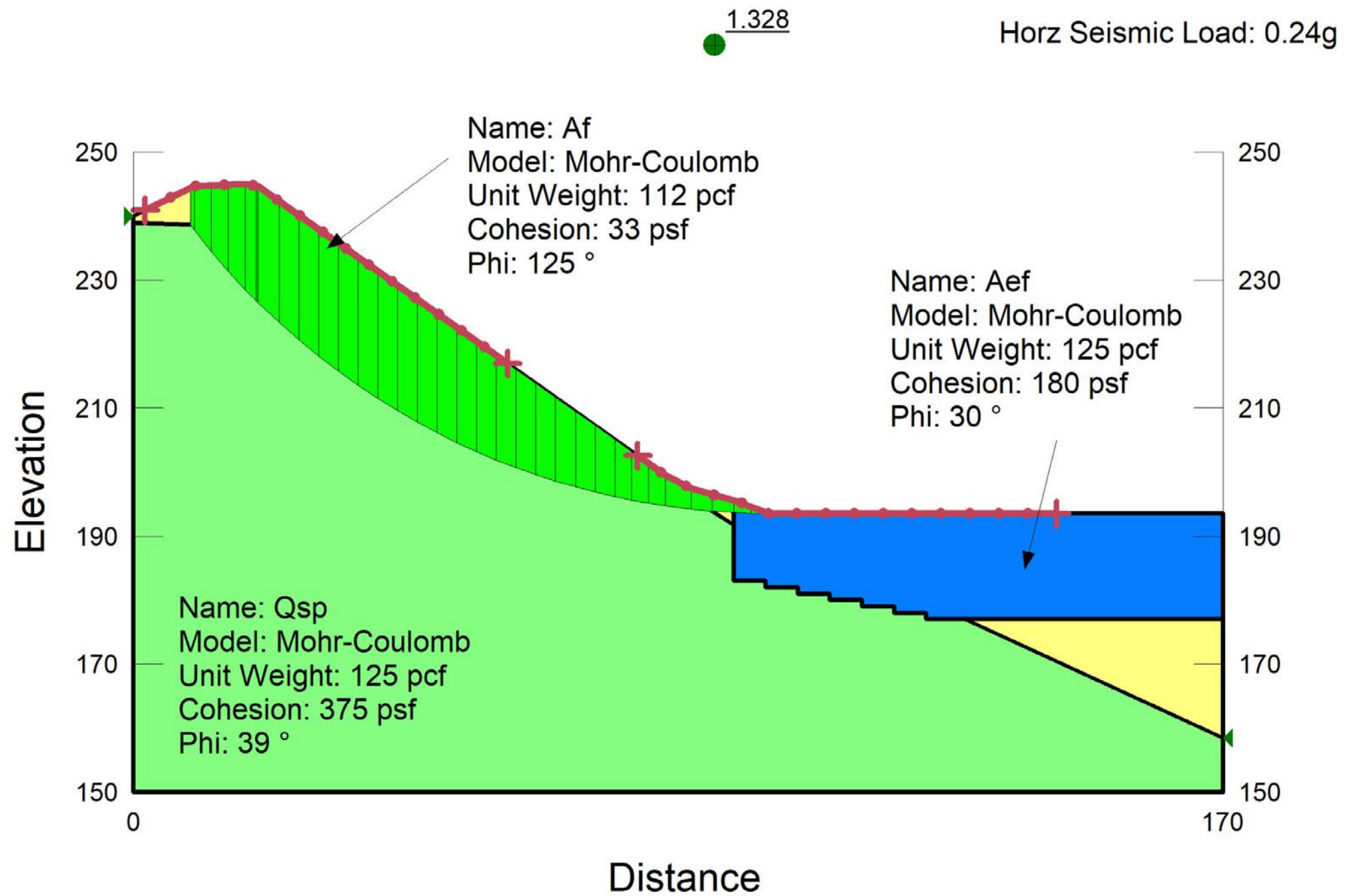
SLOPE STABILITY ANALYSIS

MKS RESIDENTIAL
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

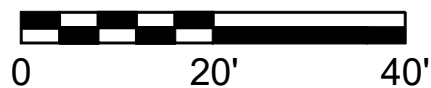
JUNE 2017

PROJECT NO. A9201-06-01E

FIG. E6



SLOPE 1
 SECTION D-D'
 PSEUDO-STATIC



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JTA		9000
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SLOPE STABILITY ANALYSIS

MKS RESIDENTIAL
 HAWTHORNE & VIA VALMONTE
 TORRANCE, CA 90505

JUNE 2017	PROJECT NO. A9201-06-01E	FIG. E7
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Slope 1 @ Section D-D' - Artificial Fill (af)

ASSUMED CONDITIONS:

Slope Height	H	=	Infinite
Depth of Saturation	Z	=	4 feet
Slope Inclination	2:1	(Horizontal:Vertical)	
Slope Angle	i	=	33.7 degrees
Unit Weight of Water	γ_w	=	62.4 pounds per cubic foot
Total Unit Weight of Soil	γ_t	=	112 pounds per cubic foot
Angle of Internal Friction	ϕ	=	33 degrees
Apparent Cohesion	C	=	125 pounds per square foot

Slope saturated to vertical depth Z below slope face.
Seepage forces parallel to slope face

ANALYSIS:

$$FS = \frac{C + (\gamma_t - \gamma_w)Z \cos^2 i \tan \phi}{\gamma_t Z \sin i \cos i} = 1.04$$

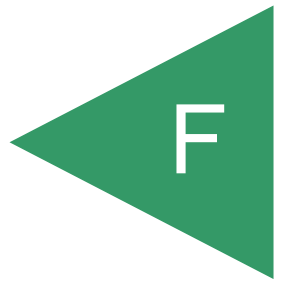
REFERENCES:

- (1) Haefeli, R. *The Stability of Slopes Acted Upon by Parallel Seepage*, Proc. Second International Conference, SMFE, Rotterdam, 1948, 1, 57-62.
- (2) Skempton, A. W., and F. A. Delory, *Stability of Natural Slopes in London Clay*, Proc. Fourth International Conference, SMFE, London, 1957, 2, 378-81.

SURFICIAL SLOPE STABILITY ANALYSIS

**MKS RESIDENTIAL
HAWTHORNE & VIA VALMONTE
TORRANCE, CALIFORNIA**

APPENDIX



APPENDIX F

ROCK MECHANICS AND ROCKFALL ANALYSIS

Rock Mechanics and Rockfall Simulation Modeling for MKS Residential Torrance, CA, prepared by GeoStabilization International, dated February 23, 2016;

Updated Rockfall Simulation Modeling for MKS Residential Torrance, CA, prepared by GeoStabilization International, dated May 6, 2017.



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February 23, 2016

Jelisa Thomas, PE
Project Engineer Geocon West, Inc.
3303 N. San Fernando Blvd. Suite 100,
Burbank, CA 91504

Subject: Rock Mechanics and Rockfall Simulation Modeling for MKS Residential Torrance, CA

Dear Jelisa,

GeoStabilization International was asked to provide rock mechanics and rockfall simulation modeling for a project for MKS Residential located in Torrance, CA. This letter presents the results of the modeling.

Information provided

Geocon West Inc. provided geological structural information, geologic cross-sections, topographic cross-sections, and field observations to conduct the analysis. The scope of the work included rock mechanics modeling based on the geologic structure data and develop factors of safety as well as recommendations for the rock slopes based on the analysis. The focus of this investigation was for slopes that dipped slightly to the east of north at a slope dip of approximately 50°.

Furthermore, there was a concern about rockfall. To analyze this information geologic data and cross-sections were provided by Geocon West Inc. and computer simulations were performed using the Colorado Rockfall Simulation program (CRSP 4.0). Assessments of the hazard are presented as well as mitigation options.

Rock Mass Stability

The slopes in the project area are controlled by its geologic structure. Geologic structure data was provided by Geocon. The first step in this analysis was to analyze the four provided data sets to ascertain if the geology was similar throughout the site or if there were different geologic domains. This was performed using the Dips computer program by Rocscience. The data that was collected from down-hole logging and geologic mapping of surface exposures show similar geologic structure throughout the four data sets. This allows the four data sets to be combined into one stereonet for analysis.

The geologic structure is shown in Figure 1. This shows a predominance of four discontinuity sets throughout the project area. These four discontinuities are provided in the Table 1 below.

For large-scale rock slopes failures they generally occur along the discontinuities in the rock mass in the form of planar, wedge, or toppling failures. Of these three failure mechanisms planar and wedge failures are the most likely, where toppling failures occur generally in specific geologic situations and present themselves generally as rockfalls.

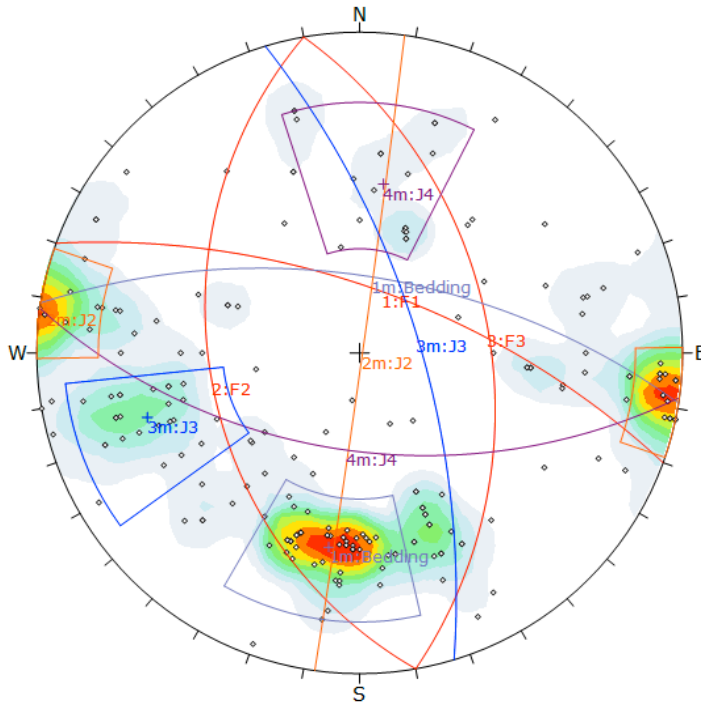


Figure 1. Combined Geologic Data used in the analysis.

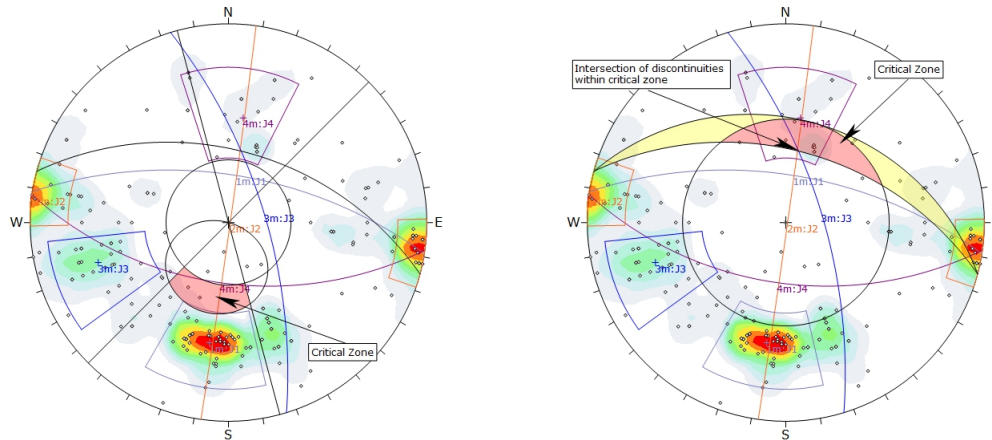
Table 1. Summary of discontinuities found in the provided data set.

Discontinuity No.	Name	Avg. Dip	Avg. Dip Direction
1	J1	63	009
2	J2	89	098
3	J3	69	073
4	J4	56	188

To analyze the data to identify the potential modes of failure a kinematic analysis was performed using the Dips computer software. Figures 2 and 3 show the planar and wedge analyses that trend in the northeast direction (015 compass heading). In Figure 2 (planar sliding analysis) there is a pink area that is identified on the lower half of the stereonet. In this pole plot this is referred to as the “critical zone”. If poles of the discontinuities occur in this zone then they have the potential of “daylighting” and should be analyzed for stability. It should be noted that the trend of the rock slope extends from compass direction 008 to 022. Planar stability uses a lateral limit of +/- 20° to define the critical zone. For this analysis to account for this variation in the slope stability the direction of the slope was assume to be in the 015 direction with an increased lateral limit to 30°.

As shown in Figure 2 the closest discontinuity set to the critical zone is Discontinuity J1. However, this joint set dips (average 63°) steeper than the angle for the slope (generally 50°) and therefore, generally locked into place. There are two individual discontinuities that fall within this zone. Since they fall outside the normal trend of a discontinuity set their prevalence and effect on global stability is generally considered less. It is also less likely that, unless these discontinuities

are identified in the field as a structure such as a fault, they will result in a large failure. In that light a stability analysis was conducted to analyze stability along these discontinuities.



Figures 2 and 3. Figure 2 (left) pole plot stereonet showing kinematic analysis for planar failures, and Figure 3 (right) pole plot stereonet showing kinematic analysis for wedge failures.

This analysis was performed using the RocPlane computer program by Rocscience and is shown in Figure 4. The shear strength for the discontinuity is assumed to have a friction angle of 35 degrees and a cohesion value of 200 psf, based on test data provided by Geocon. Analysis included dry conditions, 25% saturated, and pseudo-static loads with 25% saturated conditions. Pseudo-static loads were provided by Geocon. It should be noted that in rock slope stability using 25% of the discontinuity filled with water to model saturated conditions more appropriately models conditions with some exceptions. These exceptions include very wet environments and closed discontinuities that don't allow the flow of water (e.g. ice covered slopes). The results of the planar analysis is provided below in Table 2.

Table 2. Summary of Planar Analysis

Condition	Safety Factor
Static- Dry Conditions	2
Static- 25% Saturated Conditions	1.8
Pseudo-Static and 25% Saturated	1.3

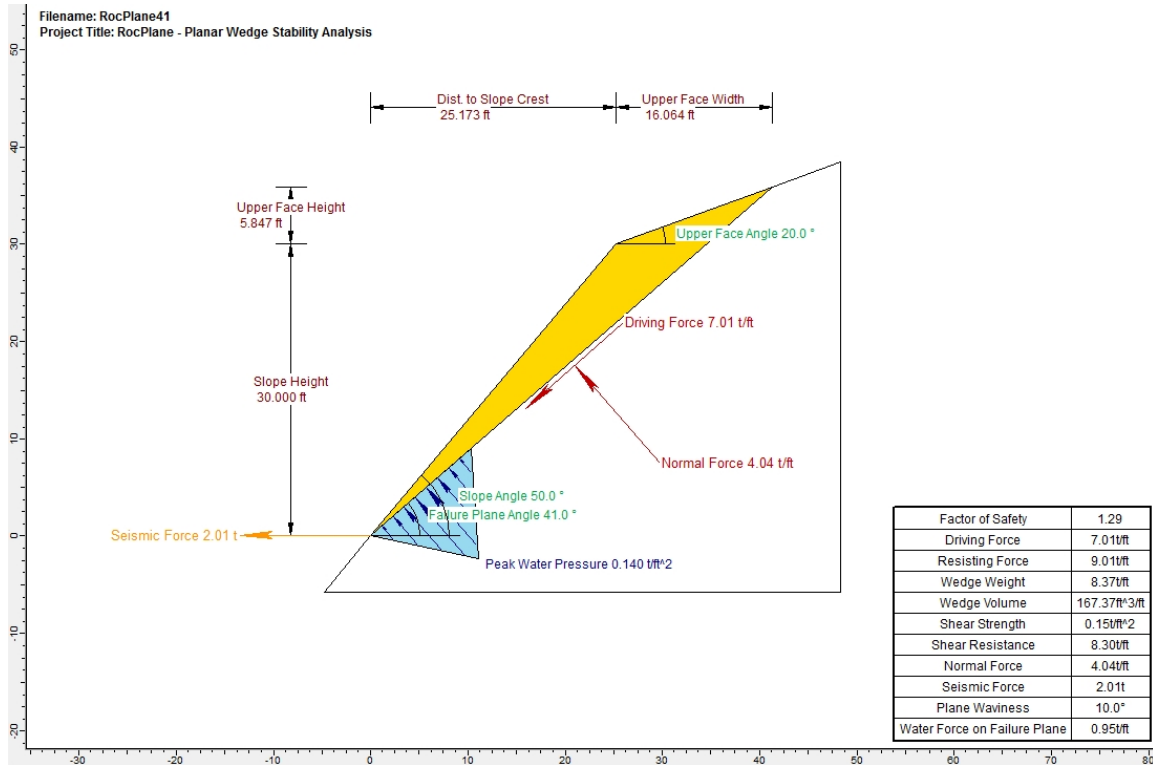


Figure 4. Pseudo-static equilibrium analysis for identified potential planar mode of failure.

Planar analysis conclusions

Based on the geologic structure data the general trend of the main discontinuity is dipping steeper than the slope face and therefore, does not “daylight from the slope”. There may be some isolated structures that dip more gently than the slope face and should be examined by a professional engineer or geologist to assess their individual stability. It is unlikely that these identified discontinuities will result in large-scale failure, but do present themselves as likely rockfalls that are discussed later in this letter.

Wedge Failure Analysis

In a similar manner to the planar failures, wedge failures (or failures along two or more discontinuities) can be identified using the stereonet. The Dips computer program was also used to perform this task. Figure 3 shows the kinematic analysis to identify wedge failures. In this stereonet one is looking for the intersection of great circles representing the discontinuity sets. If the intersection falls into the pink or yellow areas there is a kinematic potential for failure which should be examined. Looking in the north direction (015) the only intersection falling near the critical zone is the intersection of J2 and J3 which has a trend of 010 and plunge of 49 degrees. Since this was the only intersection to fall within the zone this was analyzed for stability. It should be noted however, that the average plunge is near the average slope angle that limits its ability to fail.

To analyze this potential wedge the SWedge computer program by Rocscience was utilized and is shown in Figure 5. As with the planar failure dry conditions, 25% saturated, pseudo-static with 25% saturated was analyzed. The results are provided in Table 3 below.

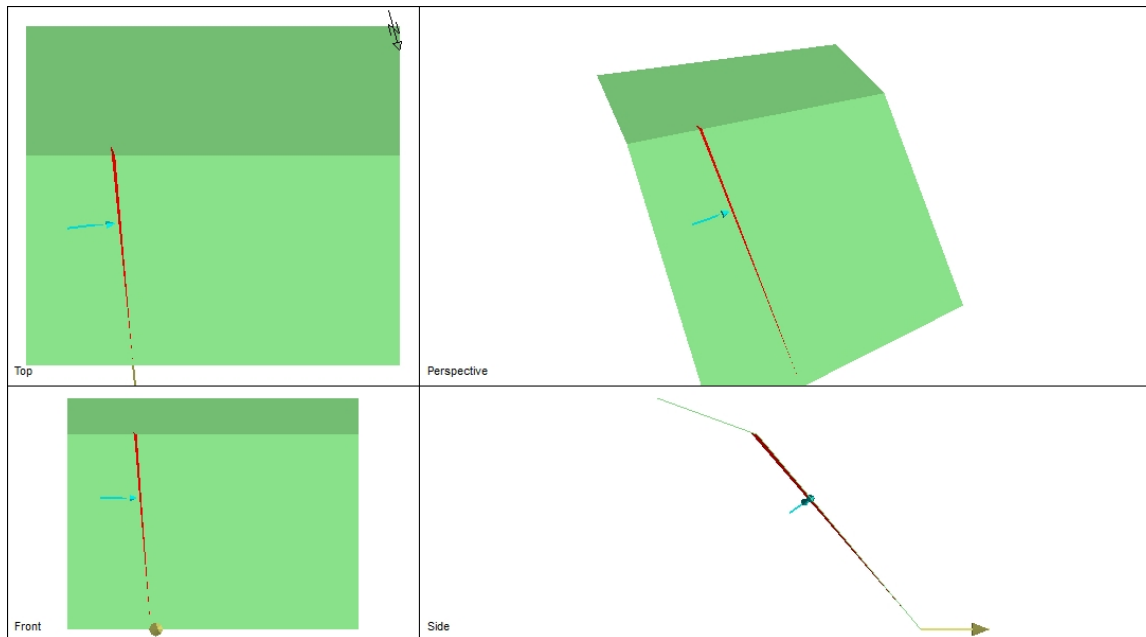


Figure 5. Wedge failure analysis identified in the stereonet. Note the limited geometry for this 200-foot tall slope.

Table 3. Summary of Wedge Analysis

Condition	Safety Factor
Static- Dry Conditions	+8
Static- 25% Saturated Conditions	8
Pseudo-Static and 25% Saturated	6

Wedge analysis conclusions

Similarly to the planar failures the potential wedge failure results in a very narrow, high angle wedge. Its geometry lends itself to smaller failures and presents itself more of a rockfall generator than a global failure.

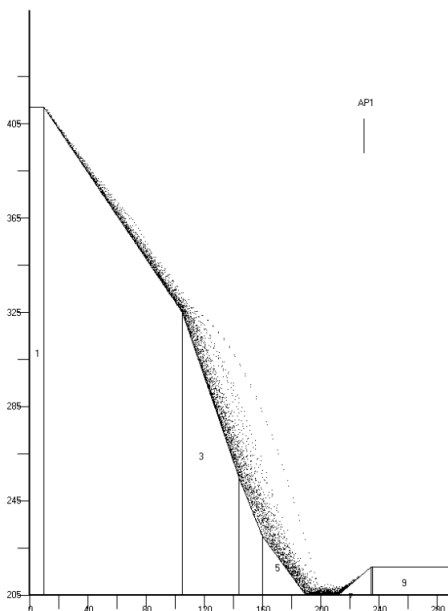
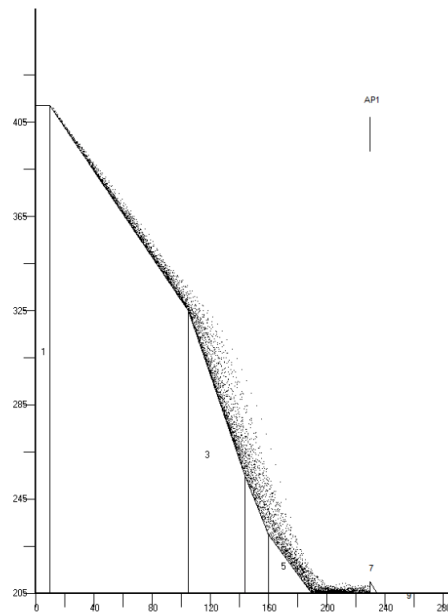
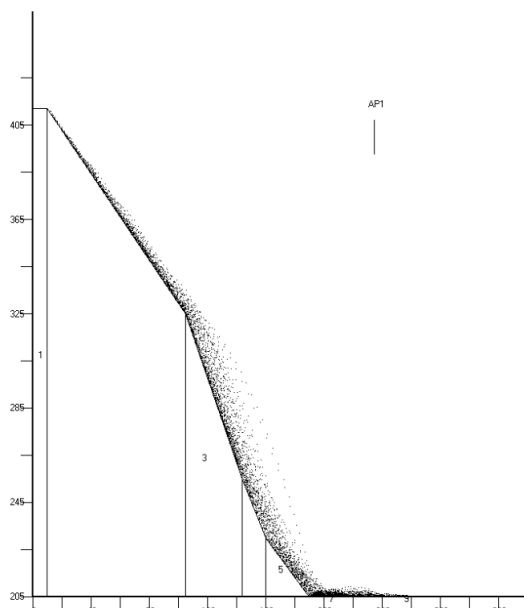
General comments

Geologic structure can change over a relatively short area. It is recommended that a professional engineer or professional geologist inspect the rock slope for larger blocks that have the potential for release since rockfall is the more likely mode of failure. If blocks are identified they can be mitigated by removal or minor amounts of reinforcement.

Rockfall simulation

A site civil plan was provided to GSI by Geocon. To conduct the rockfall simulation modeling the Colorado Rockfall Simulation Program (CRSP 4.0) was utilized. Cross-sections for the project were initially configured into the program and calibrated using the Oregon Catchment area guide (FHWA-OR-RD-02-04). This calibration was done on rockfalls generated at a height of 80-100 feet. After calibration rockfalls were generated from the full height of the slope.

For the majority of the project area structures are generally found to be at least 40 feet from the toe of the slope, an area that can be considered a rockfall catchment area. Three scenarios were modeled for rockfall simulation and include a flat catchment area, barrier placed 40 feet from the slope for a flat catchment area, and the construction of a rockfall berm. Results can be seen in Figures 6, 7, and 8.



Figures 6. Upper left figure showing results of the flat ditch rockfall simulation model.

Figure 7. Upper right figure showing results of a barrier placed 40 feet from toe of the slope.

Figure 8. Left figure showing results of berm placed 40 feet from toe of the slope.

The flat catchment area indicates the longest run out of rockfalls of all models presented (Figure 6). Based on the model rockfalls have the extreme potential of running out up to 70 feet. This is slightly greater than the expected rockfall run outs shown on the FHWA catchment guide due to the height of the slope.

Rockfall trajectories for on slopes that generally grade just steeper than a 1H: 1V grade, such as the subject slopes, the majority of rockfall trajectories are expected to be rolling with slight bouncing (Figure 9). Therefore, when a barrier is placed in the pathway of a rockfall the bounce heights are expected to be relatively low. A barrier was placed 40 feet from the toe of the slope and contained all the potential rockfalls (Figure 7). Based on the model the maximum bounce height at this location is 3 feet with kinetic energies of approximately 20 kJ. These are both relatively low values. In this case a barrier such as a jersey type barrier would suffice. This model can be seen in Figure 8.

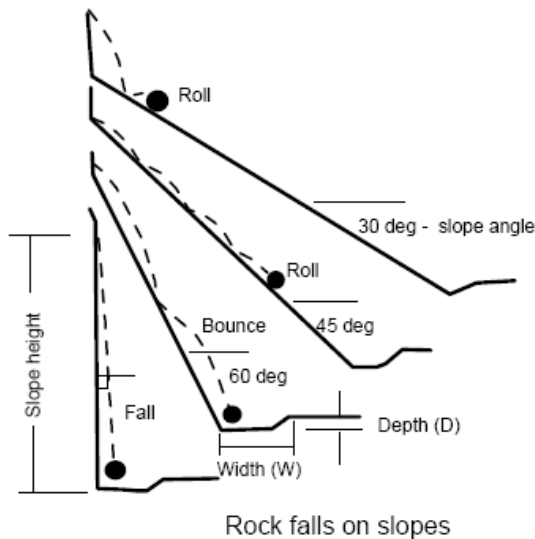
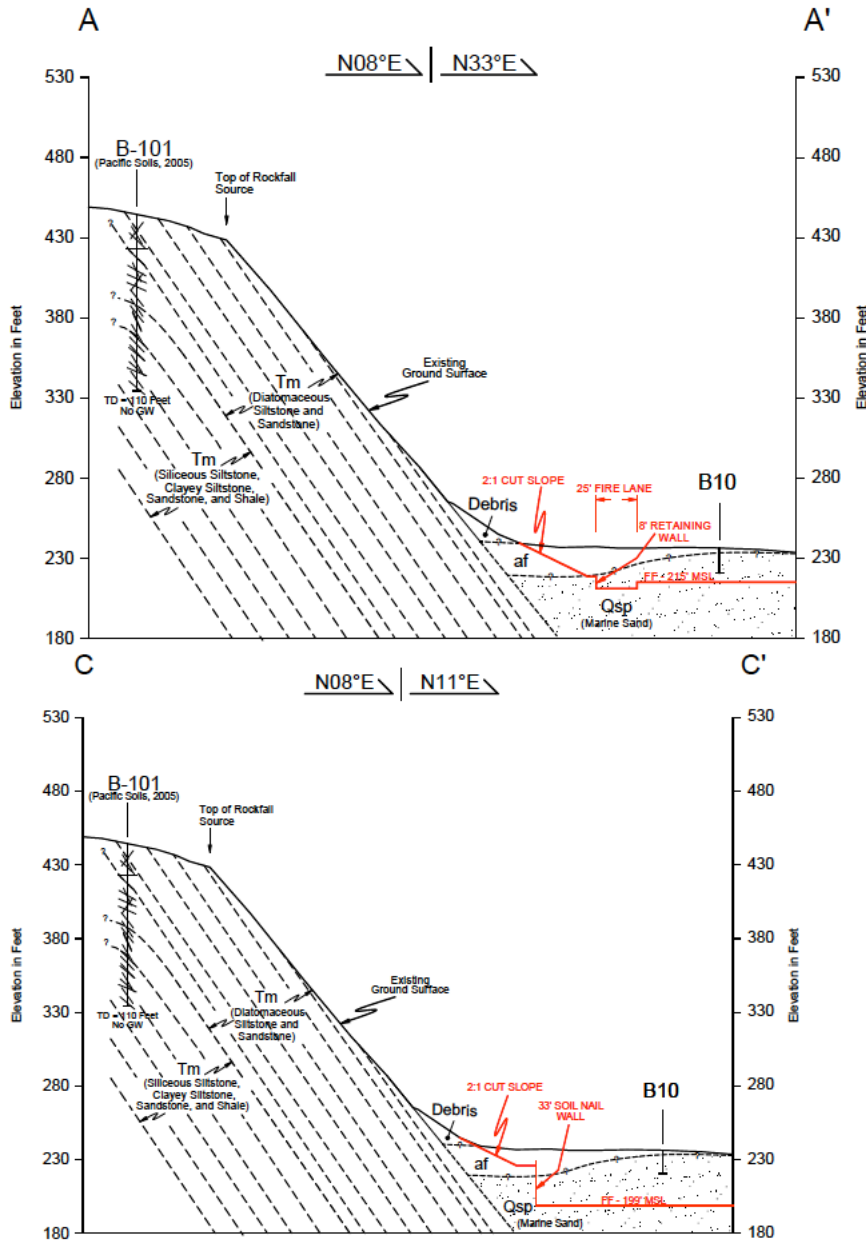


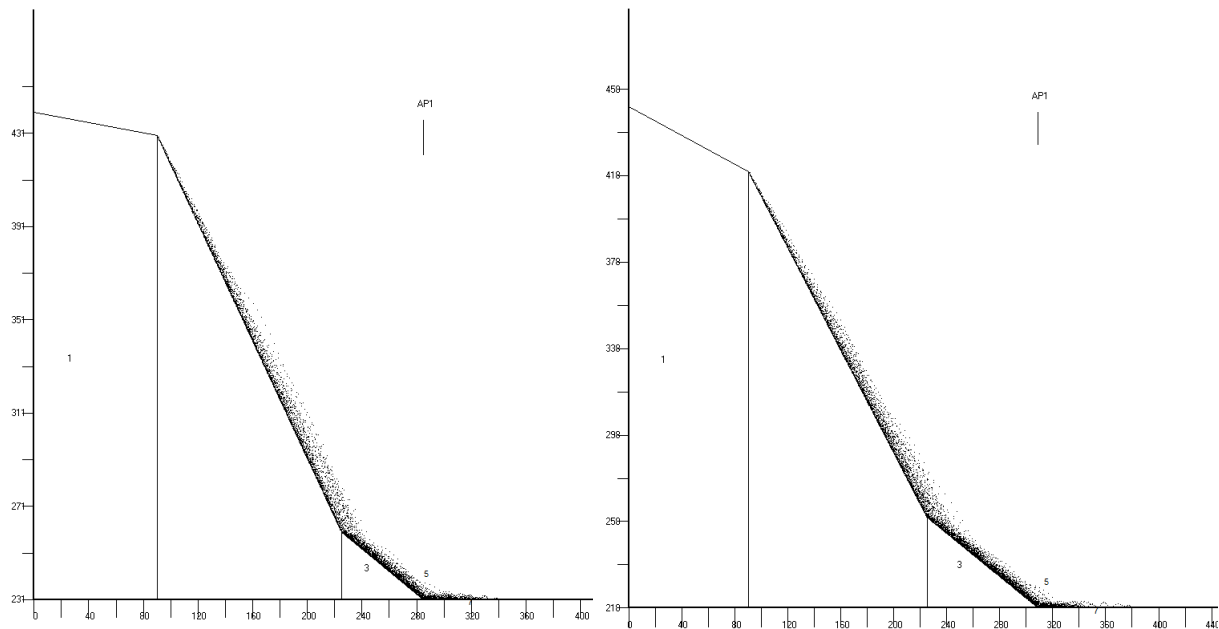
Figure 9. Illustration showing how rockfalls behave differently on different angled slopes.

To model a berm constructed at the toe of the slope a 12 foot high 2H:1V barrier was modeled with the maximum height of the catchment area located 40 feet from the toe of the slope. This model shows the berm satisfactorily contains all the rockfalls as well. This model can be seen in Figure 8.

There are two identified areas where structures are closer to the toe of the slope than for the typical areas. These two areas are identified by cross-sections named A-A' and C-C'. These two cross-sections are shown in Figures 10 and 11. The results of the analysis shows that a significant amount of horizontal roll out should be expected in the location of the proposed soil nail wall. Results are shown in Figures 12 and 13.



Figures 10 and 11. Cross-provided to develop the CRSP rockfall simulations.



Figures 12 and 13. CRSP analyses for cross-sections A-A' and C-C'.

The result of the analysis shows that down the constructed 2H: 1V slope bouncing and rolling of rocks can be expected, if generated. The bounce heights for both slopes ranged from 6-9 feet in height. It is recommended that for these areas a rockfall containment barrier be constructed to contain these rocks near the toe of the 2H: 1V slope. Options for this barrier include a rockfall barrier fence or a GCS wall barrier. A rockfall barrier fence is a flexible system that can be built at varying heights, but should be constructed at a height to contain all rockfalls. Since the energies of the rockfalls in the model indicate energies in the order of 20 kJ, many market fences can be used. The appearance of these fences is that it is a fence. Another aesthetic option would be to construct a barrier such as a stand along GCS wall. These can also be constructed at varying heights and since they have a considerably higher energy absorbing capacity would function very well. Facing of the GCS wall can also be varied for aesthetic purposes.

The performed analysis will be provided in an attached document. If you have any questions concerning this analysis feel free to contact me at marty@gsi.us or (540) 315-0270.

Sincerely,



Martin J. Woodard, PhD PG PE
 Rockfall Division Engineer
 GeoStabilization International
marty@gsi.us

Data Table for Rockfall Analysis

Data Table for Rock Fall Analysis						
Section	Exploration Number	Rock Type	Discontinuity Type	Depth (ft)	Dip Direction (asmouth)	Dip Angle (degrees)
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	10	75	76
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Joint	17	20	88
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	31	70	72
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	36	255	76
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	38	70	76
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	42	75	75
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Joint	45	75	89
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	48	270	70
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	54	95	70
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	60	275	70
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	67	95	80
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	75	60	86
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Fault	82	20	67
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	86	195	60
A	B-1 (Western Laboratories, 1993)	Diatomaceous Siltstone	Bedding	96	165	74
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	359	59
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	340	68
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	338	57
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	338	57
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	333	64
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	358	60
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	200	67
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Bedding	S	355	60
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Joint	S	331	81
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Joint	S	302	68
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Joint	S	294	78
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Joint	S	111	44
A	Area 8 (Geocon West, 2016)	Cg-Fg Sand to Sandy Silt	Joint	S	98	90
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	8	80
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	5	72
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	10	58
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	6	71
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	9	60
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	10	60
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	0	63
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	10	67
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	18	61
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	20	64
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	6	62
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	274	87
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	275	86
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	272	86
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	279	88
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	200	45
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	202	42
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	235	70
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	99	65
A	Area 9 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	275	80
A	Area 10 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	332	68
A	Area 10 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	344	63
A	Area 10 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	43	71

Data provided by Geocon for structural analysis

Data Table for Rockfall Analysis

Data Table for Rock Fall Analysis						
Section	Exploration Number	Rock Type	Discontinuity Type	Depth (ft)	Dip Direction (azimuth)	Dip Angle (degrees)
B	B-101 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	11	185	54
B	B-101 (Pacific Soils, 2005)	Diatomaceous Claystone	Joint	13	40	63
B	B-101 (Pacific Soils, 2005)	Diatomaceous Claystone	Fault	16	100	78
B	B-101 (Pacific Soils, 2005)	Diatomaceous Claystone	Bedding	21	110	56
B	B-101 (Pacific Soils, 2005)	Silicified Shale Lense	Bedding	27	50	47
B	B-101 (Pacific Soils, 2005)	Silicified Shale Lense	Bedding	35	100	75
B	B-101 (Pacific Soils, 2005)	Silicified Shale Lense	Joint	35	355	72
B	B-101 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	40	100	74
B	B-101 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	40	90	58
B	B-101 (Pacific Soils, 2005)	Diatomaceous Siltstone	Fault	40	260	70
B	B-101 (Pacific Soils, 2005)	Diatomaceous Siltstone	Fault	46	80	90-75
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	52	70	63
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	58	70	67
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	62	60	59
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	66	75	76
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	67	60	70
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	74	80	76
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	77	90	73
B	B-101 (Pacific Soils, 2005)	Silicified Shale Layer	Bedding	81	75	63
B	B-101 (Pacific Soils, 2005)	ntrbedded Claystone w. Diatomit	Bedding	86	80	66
B	B-101 (Pacific Soils, 2005)	Basalt Layer	Bedding	87	80	58
B	B-101 (Pacific Soils, 2005)	Sandy Claystone w. Diatoms	Bedding	93	60	65
B	B-101 (Pacific Soils, 2005)	Sandy Claystone w. Diatoms	Bedding	96	75	59
B	B-101 (Pacific Soils, 2005)	Diatomaceous Claystone	Bedding	98	90	52
B	B-101 (Pacific Soils, 2005)	Diatomaceous Claystone	Bedding	103	65	52
B	B-101 (Pacific Soils, 2005)	Diatomaceous Claystone	Bedding	108	70	64
B	Area 6 (Geocon West, 2016)	Fossiliferous Sandstone	Joint	S	117	85
B	Area 6 (Geocon West, 2016)	Fossiliferous Sandstone	Joint	S	70	80
B	Area 6 (Geocon West, 2016)	Fossiliferous Sandstone	Joint	S	97	89
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	180	45
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	198	74
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	186	64
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	165	76
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	275	56
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	275	55
B	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	294	84
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	68
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	50
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	55
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	4	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	2	63
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	20	64
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	18	61
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	19	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	60
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	21	64
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	160	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	80	74
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	282	90
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	274	86
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	278	87
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	80	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	282	89
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	275	89

Data Table for Rockfall Analysis

Data Table for Rock Fall Analysis						
Section	Exploration Number	Rock Type	Discontinuity Type	Depth (ft)	Dip Direction (asmouth)	Dip Angle (degrees)
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	12	50	65
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Joint	12	110	47
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Joint	12	170	37
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Joint	17	280	80
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Joint	17	40	57
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Joint	17	30	61
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	26	210	80
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	31	25	67
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	35	220	55
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	40	240	48
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	44	220	57
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	48	250	36
G	B-202 (Pacific Soils, 2005)	Diatomaceous Siltstone	Bedding	50	250	63
G	Area 3 (Geocon West, 2016)	Silty Sand	Joint	S	5	60
G	Area 6 (Geocon West, 2016)	Fossiliferous Sandstone	Joint	S	117	85
G	Area 6 (Geocon West, 2016)	Fossiliferous Sandstone	Joint	S	70	80
G	Area 6 (Geocon West, 2016)	Fossiliferous Sandstone	Joint	S	97	89
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	270	45
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	198	74
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	186	64
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	165	76
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	275	56
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	275	55
G	Area 6 (Geocon West, 2016)	Cherty Sandstone	Joint	S	336	84
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	68
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	50
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	55
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	4	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	2	63
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	20	64
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	18	61
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	19	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	338	60
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Bedding	S	21	64
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	160	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	80	74
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	282	90
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	274	86
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	278	87
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	80	62
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	282	89
B	Area 7 (Geoncon West, 2016)	Diatomaceous Sandstone	Joint	S	275	89
G	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	23	30
G	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	23	55
G	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	337	27
G	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	357	61
G	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	350	65
G	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	350	65
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	144	70
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	128	85
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	282	88
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	7	78
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	110	47
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	250	85
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	275	80
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	280	65
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	150	50
G	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	256	71

Data Table for Rockfall Analysis

Data Table for Rock Fall Analysis						
Section	Exploration Number	Rock Type	Discontinuity Type	Depth (ft)	Dip Direction (asmouth)	Dip Angle (degrees)
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Bedding	10	322	30
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Fracture	10	102	85
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Bedding	13	50	42
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Bedding	19	51	47
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Fracture	19	96	85
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Bedding	26	330	54
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Bedding	30	21	44
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Fracture	30	109	84
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Bedding	37	18	55
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone	Fracture	37	81	88
F	B-1 (Geocon West, 2015)	Clayey Siltstone	Bedding	43	32	42
F	B-1 (Geocon West, 2015)	Clayey Siltstone	Bedding	44	354	68
F	B-1 (Geocon West, 2015)	Diatomaceous-rich Clayey Siltstone	Bedding	52	322	67
F	B-1 (Geocon West, 2015)	Diatomaceous-rich Clayey Siltstone	Bedding	57	352	65
F	B-1 (Geocon West, 2015)	Clayey Siltstone w. fg SS interbeds	Bedding	65	2	62
F	B-1 (Geocon West, 2015)	Clayey Siltstone w. fg SS interbeds	Bedding	69	178	57
F	B-1 (Geocon West, 2015)	Clayey Siltstone w. fg SS interbeds	Bedding	75	5	71
F	B-1 (Geocon West, 2015)	Clayey Siltstone w. fg SS interbeds	Bedding	83	38	51
F	B-1 (Geocon West, 2015)	Diatomaceous Siltstone Interbeds	Bedding	92	2	63
F	B-1 (Geocon West, 2015)	rd Clayey Siltstone & Diatomaceous	Bedding	99	46	74
F	B-1 (Geocon West, 2015)	rd Clayey Siltstone & Diatomaceous	Bedding	102	81	36
F	B-2 (Geocon West, 2015)	Diatomaceous Sandstone	Bedding	S	9	17
F	Area 10 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	332	68
F	Area 10 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	344	63
F	Area 10 (Geocon West, 2016)	Diatomaceous Sandstone	Fracture	S	43	71
F	Area 11 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	4	61
F	Area 11 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	26	53
F	Area 11 (Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	340	74
F	Area 11 (Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	80	90
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	100	79
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	5	69
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	4	58
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	12	68
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	10	60
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	1	60
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	18	68
F	(Geocon West, 2016)	Diatomaceous Sandstone	Bedding	S	18	65
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	256	72
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	200	45
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	202	42
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	200	44
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	201	44
F	(Geocon West, 2016)	Diatomaceous Sandstone	Joint	S	279	65

Pole plot for planar analysis

Symbol	Feature
◊	Pole Vectors

Color	Density Concentrations
Light Blue	0.00 - 1.00
Light Green	1.00 - 2.00
Green	2.00 - 3.00
Yellow-Green	3.00 - 4.00
Yellow	4.00 - 5.00
Orange	5.00 - 6.00
Red-Orange	6.00 - 7.00
Red	7.00 - 8.00
Dark Red	8.00 - 9.00
Black	9.00 - 10.00

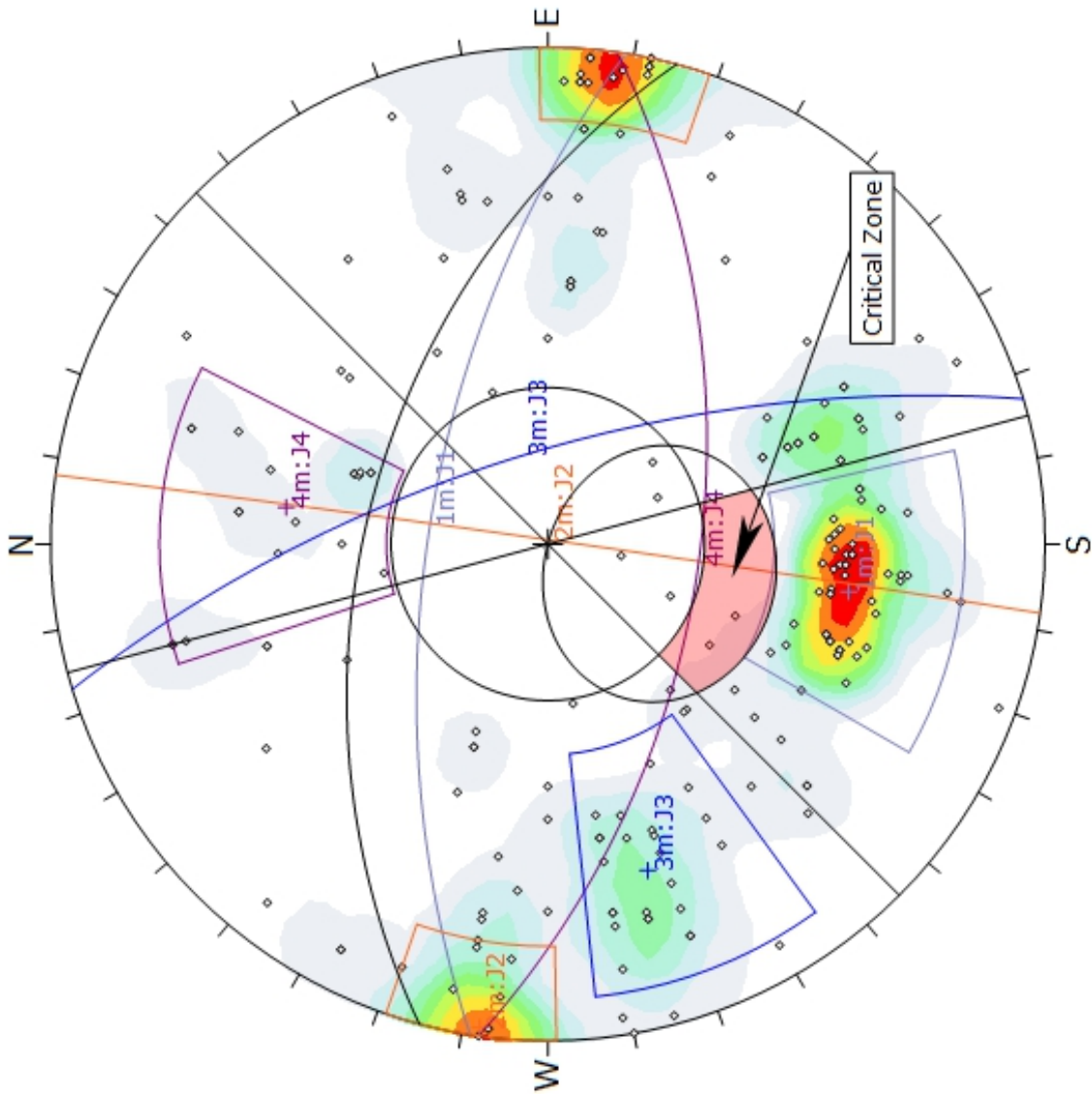
Maximum Density	9.96%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis		Planes Sliding	
Slope Dip	50		
Slope Dip Direction	15		
Friction Angle	35°		
Lateral Limits	30°		

	Critical	Total	%
Planes Sliding (All)	2	206	0.97%

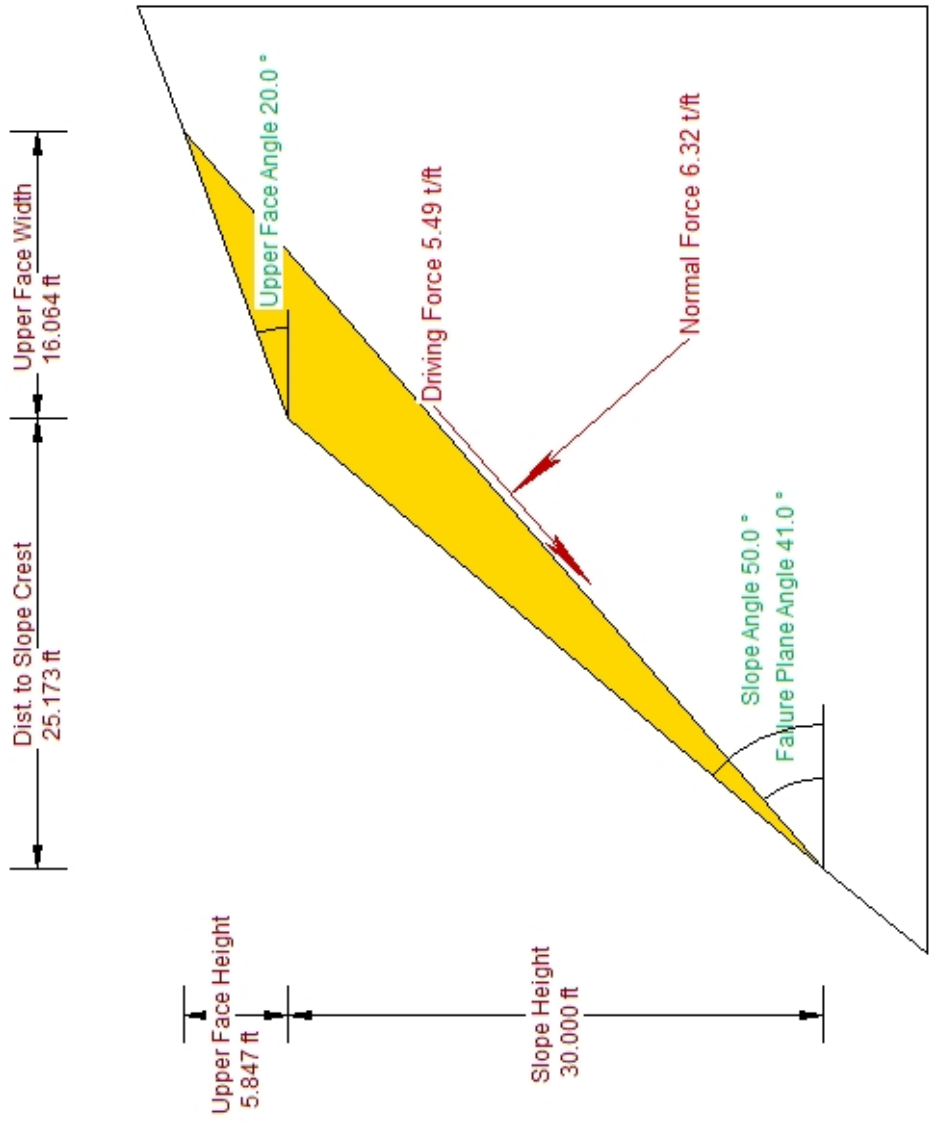
Color	Dip	Dip Direction	Label
Blue	63	9	J1
Orange	89	98	J2
Green	69	73	J3
Purple	56	188	J4

Plot Mode	Pole Vectors
Vector Count	206 (206 Entries)
Hemisphere	Lower
Projection	Equal Angle



Static planar analysis

Filename: RocPlane41
 Project Title: RocPlane - Planar Wedge Stability Analysis



Factor of Safety	2.00
Driving Force	5.49t/ft
Resisting Force	11.00t/ft
Wedge Weight	8.37t/ft
Wedge Volume	167.37ft ³ /ft
Shear Strength	0.18t/ft ²
Shear Resistance	9.89t/ft
Normal Force	6.32t/ft
Plane Waviness	10.0°



RocPlane Analysis Information

Document Name:

RocPlane1

Job Title:

RocPlane - Planar Wedge Stability Analysis with no additional forces

Analysis Results:

Analysis type = Deterministic
Normal Force = 6.31579 t/ft
Resisting Force = 11 t/ft
Driving Force = 5.49023 t/ft
Factor of Safety = 2.00355

Geometry:

Slope Height = 30 ft
Wedge Weight = 8.3685 t/ft
Wedge Volume = 167.37 ft³/ft
Rock Unit Weight = 0.05 t/ft²
Slope Angle = 50 °
Failure Plane Angle = 41 °
Upper Face Angle = 20 °
Bench Width : Not Present
Waviness = 10 °

Intersection Point (B) of slope and upper face = (25.173 , 30)
Intersection point (C) of failure plane and upper face = (41.2371 , 35.8469)
Failure plane length (Origin --> C) = 54.6397 ft
Slope length (Origin --> B) = 39.1227 ft

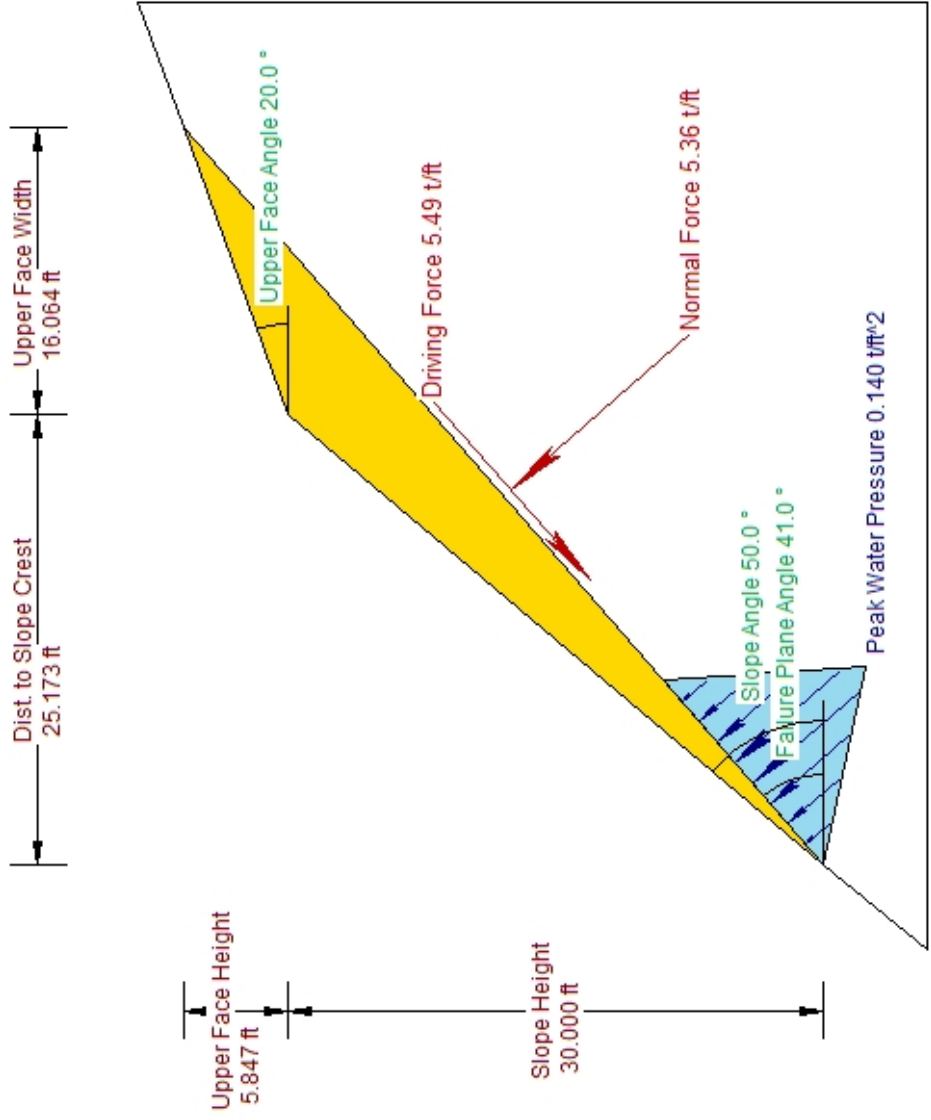
Tension Crack : Not Present

Strength:

Shear Strength Model : Mohr-Coulomb
Friction Angle = 35 °
Cohesion = 0.1 t/ft²
Shear Strength: 0.180937 t/ft²
Shear Resistance: 9.88633 t/ft

External Forces : Not Present

Filename: RocPlane41
 Project Title: RocPlane - Planar Wedge Stability Analysis



Static/Saturated

Factor of Safety	1.85
Driving Force	5.49t/ft
Resisting Force	10.16t/ft
Wedge Weight	8.37t/ft
Wedge Volume	167.37ft ³ /ft
Shear Strength	0.17t/ft ²
Shear Resistance	9.22t/ft
Normal Force	5.36t/ft
Plane Waviness	10.0 °
Water Force on Failure Plane	0.95t/ft



RocPlane Analysis Information

Document Name:

RocPlane41

Job Title:

RocPlane - Planar Wedge Stability Analysis with water pressure

Analysis Results:

Analysis type = Deterministic
Normal Force = 5.36094 t/ft
Resisting Force = 10.163 t/ft
Driving Force = 5.49023 t/ft
Factor of Safety = 1.85111

Geometry:

Slope Height = 30 ft
Wedge Weight = 8.3685 t/ft
Wedge Volume = 167.37 ft³/ft
Rock Unit Weight = 0.05 t/ft²
Slope Angle = 50 °
Failure Plane Angle = 41 °
Upper Face Angle = 20 °
Bench Width : Not Present
Waviness = 10 °

Intersection Point (B) of slope and upper face = (25.173 , 30)
Intersection point (C) of failure plane and upper face = (41.2371 , 35.8469)
Failure plane length (Origin --> C) = 54.6397 ft
Slope length (Origin --> B) = 39.1227 ft

Tension Crack : Not Present

Strength:

Shear Strength Model : Mohr-Coulomb
Friction Angle = 35 °
Cohesion = 0.1 t/ft²
Shear Strength: 0.168701 t/ft²
Shear Resistance: 9.21774 t/ft

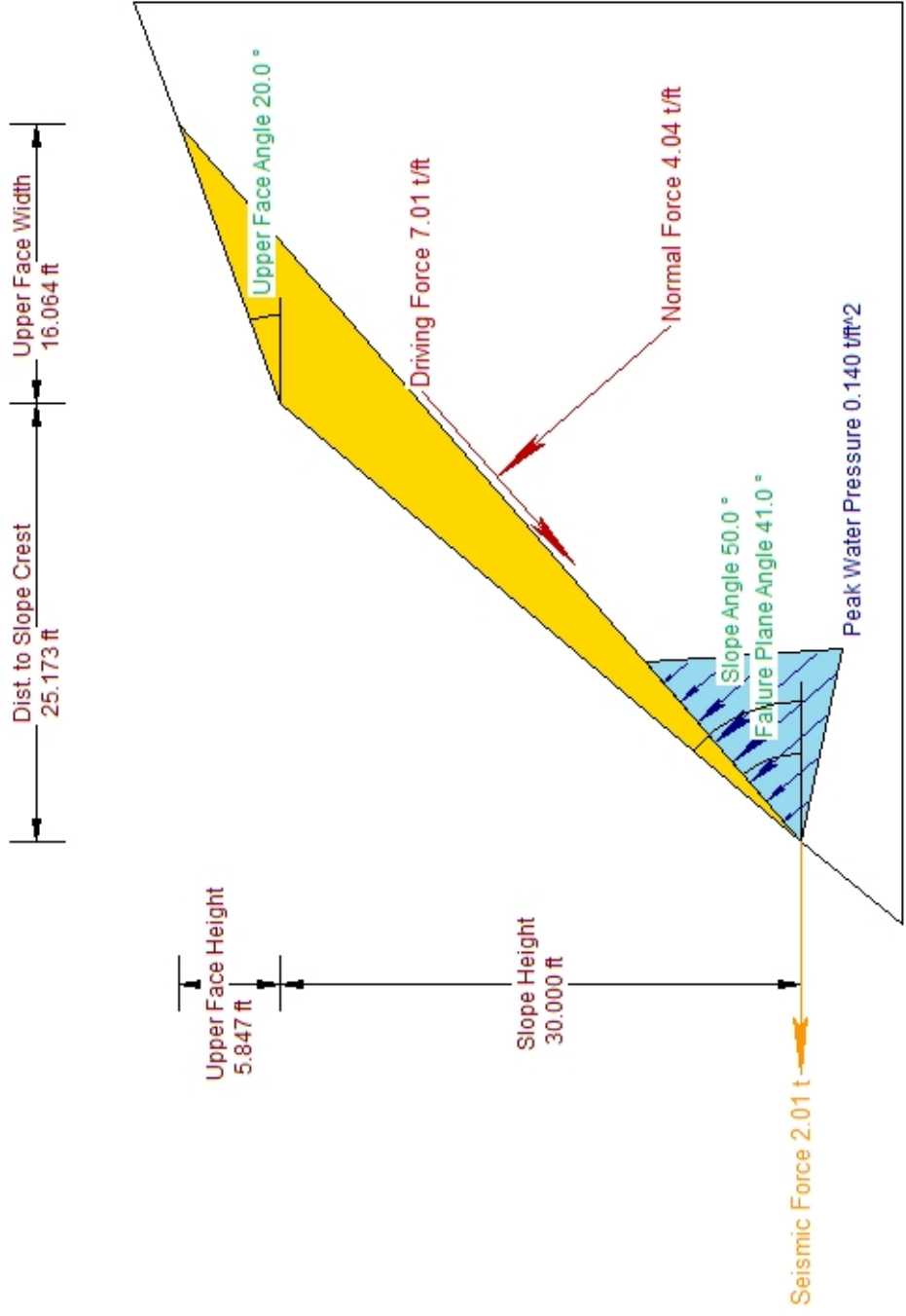
Water Pressure:

Water Unit Weight = 0.0312 t/ft²
Pressure Distribution Model : Peak Pressure - Mid Height
Percent Filled : 25 %
Water Force on Failure Plane = 0.954847 t/ft

External Forces : Not Present

Filename: RocPlane41
 Project Title: RocPlane - Planar Wedge Stability Analysis

Pseudo-Static



Factor of Safety	1.29
Driving Force	7.01 t/ft
Resisting Force	9.01 t/ft
Wedge Weight	8.37 t/ft
Wedge Volume	167.37 ft³/ft
Shear Strength	0.15 t/ft²
Shear Resistance	8.30 t/ft
Normal Force	4.04 t/ft
Seismic Force	2.01 t
Plane Waviness	10.0°
Water Force on Failure Plane	0.95 t/ft

RocPlane Analysis Information

Document Name:

RocPlane41

Job Title:

RocPlane - Planar Wedge Stability Analysis with water and seismic loads

Analysis Results:

Analysis type = Deterministic
Normal Force = 4.04329 t/ft
Resisting Force = 9.00805 t/ft
Driving Force = 7.00602 t/ft
Factor of Safety = 1.28576

Geometry:

Slope Height = 30 ft
Wedge Weight = 8.3685 t/ft
Wedge Volume = 167.37 ft³/ft
Rock Unit Weight = 0.05 t/ft²
Slope Angle = 50 °
Failure Plane Angle = 41 °
Upper Face Angle = 20 °
Bench Width : Not Present
Waviness = 10 °

Intersection Point (B) of slope and upper face = (25.173 , 30)
Intersection point (C) of failure plane and upper face = (41.2371 , 35.8469)
Failure plane length (Origin --> C) = 54.6397 ft
Slope length (Origin --> B) = 39.1227 ft

Tension Crack : Not Present

Strength:

Shear Strength Model : Mohr-Coulomb
Friction Angle = 35 °
Cohesion = 0.1 t/ft²
Shear Strength: 0.151815 t/ft²
Shear Resistance: 8.29511 t/ft

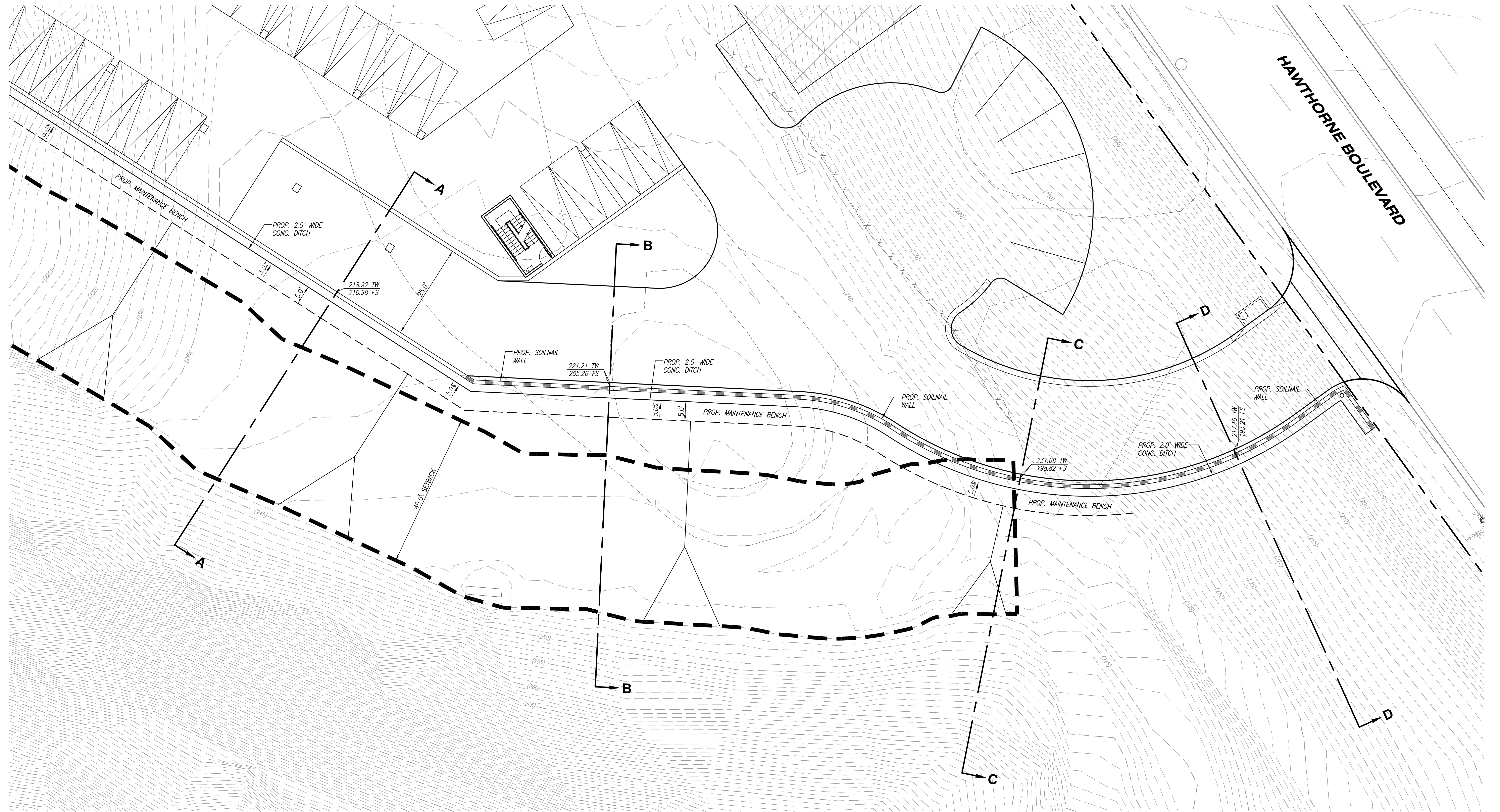
Water Pressure:

Water Unit Weight = 0.0312 t/ft²
Pressure Distribution Model : Peak Pressure - Mid Height
Percent Filled : 25 %
Water Force on Failure Plane = 0.954847 t/ft

Seismic Force:

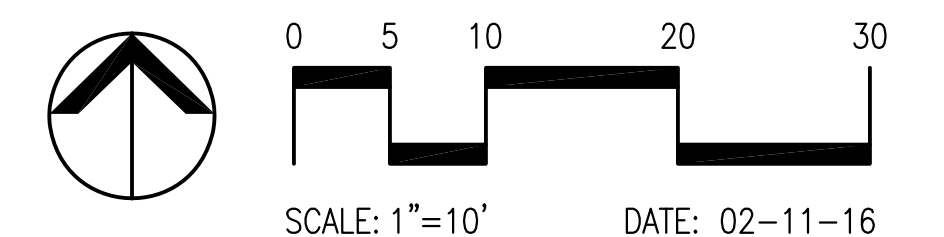
Direction : Horizontal
Seismic Coefficient : 0.24
Seismic Force : 2.00844 t/ft

External Forces : Not Present

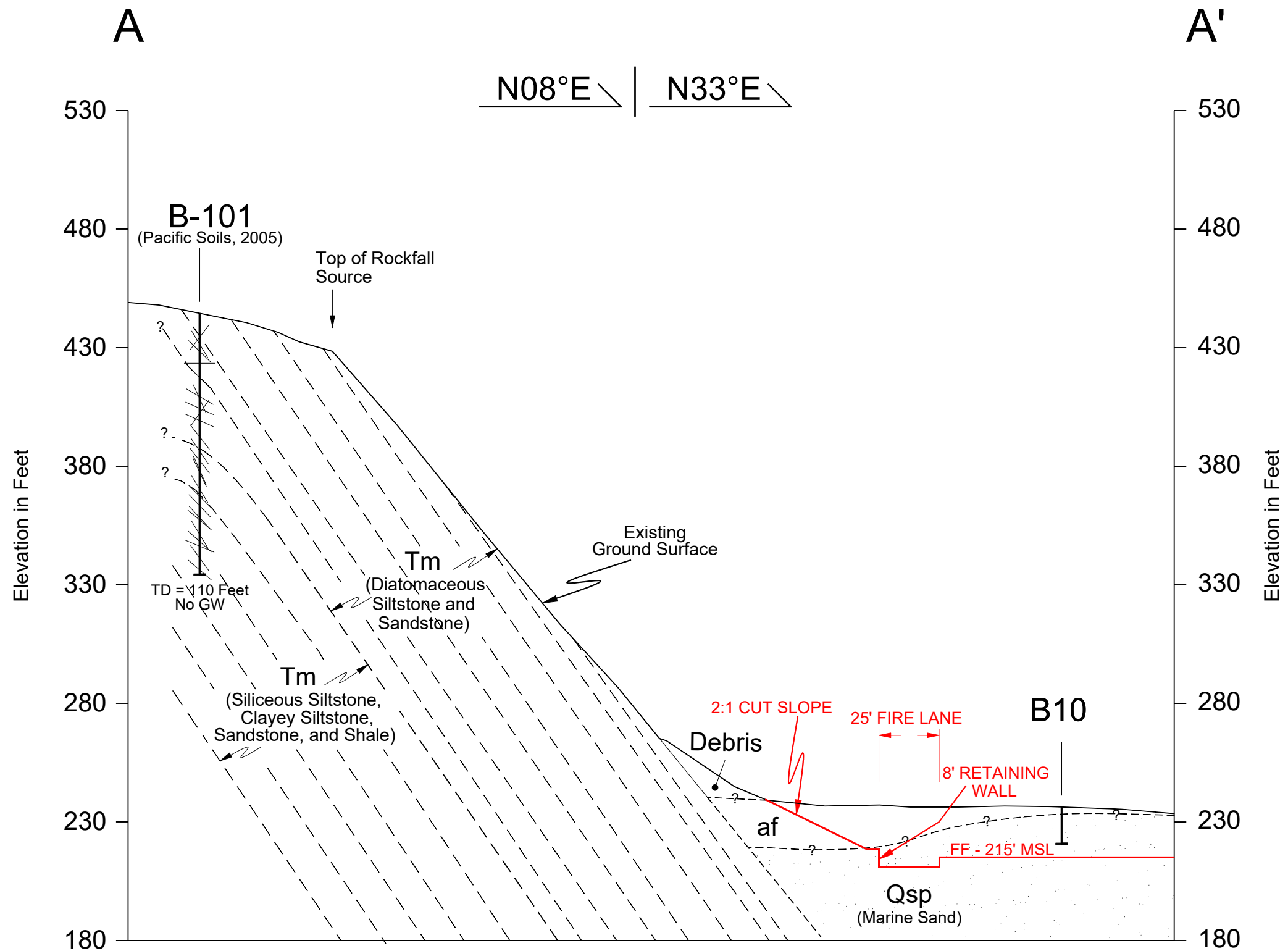


SOLANA TORRANCE
REYLENN PROPERTIES LLC

PARTIAL PRELIMINARY GRADING PLAN
TORRANCE, CALIFORNIA

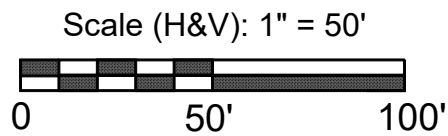


KHR ASSOCIATES
 CONSULTING ENGINEERS/SURVEYORS/PLANNERS
 20411 SW Birch Street - Suite 310
 Newport Beach, California 92660
 Tel (949) 756-6440
 Fax (949) 756-6444



NOTES:

1. THE SECTIONS ARE BASED ON GEOLOGIC CONDITIONS AT BORING LOCATIONS AND AT SURFACE EXPOSURES MAPPED DURING THE INVESTIGATION. THE GEOLOGIC CONDITIONS BETWEEN SUCH LOCATIONS HAVE BEEN INTERPOLATED. LOCALIZED VARIATIONS COULD OCCUR. THE SECTIONS ARE INTENDED FOR DESCRIPTIVE PURPOSES ONLY.
2. SEE PARTIAL PRELIMINARY GRADING PLAN (KHR ASSOCIATES) FOR APPROXIMATE LOCATION OF SECTIONS.
3. BEDDING DIPS STEEPER THAN SLOPE.



GEOCON
WEST, INC.

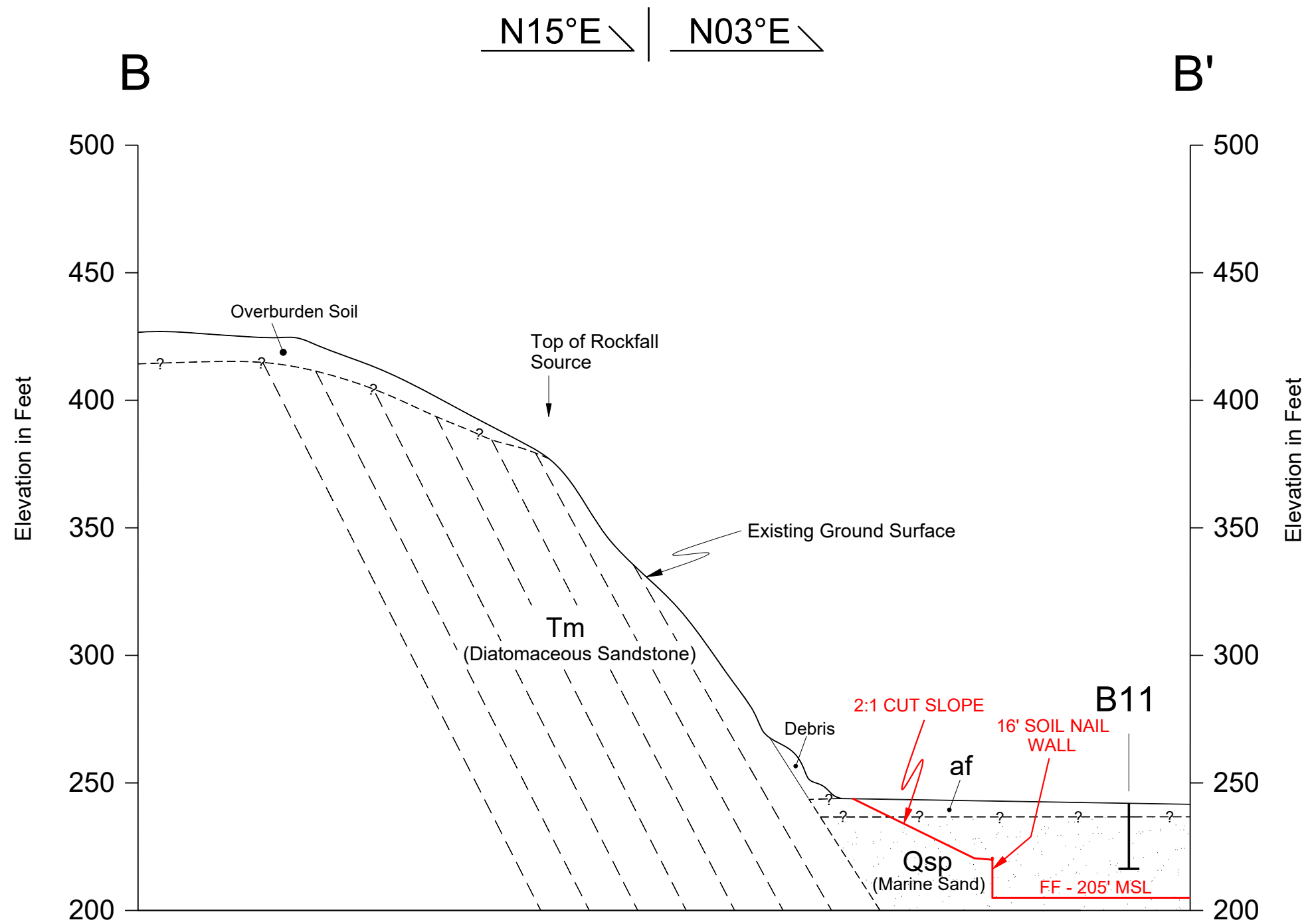
ENVIRONMENTAL GEOTECHNICAL MATERIALS
3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504
PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted By: RMA Checked By: SFK / GAK

CIVIL SECTION A-A'

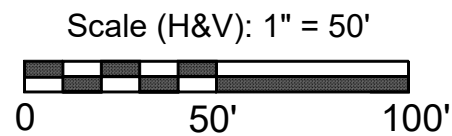
MKS RESIDENTIAL
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

FEB 2016 PROJECT NO. A9201-06-01C FIG. 1



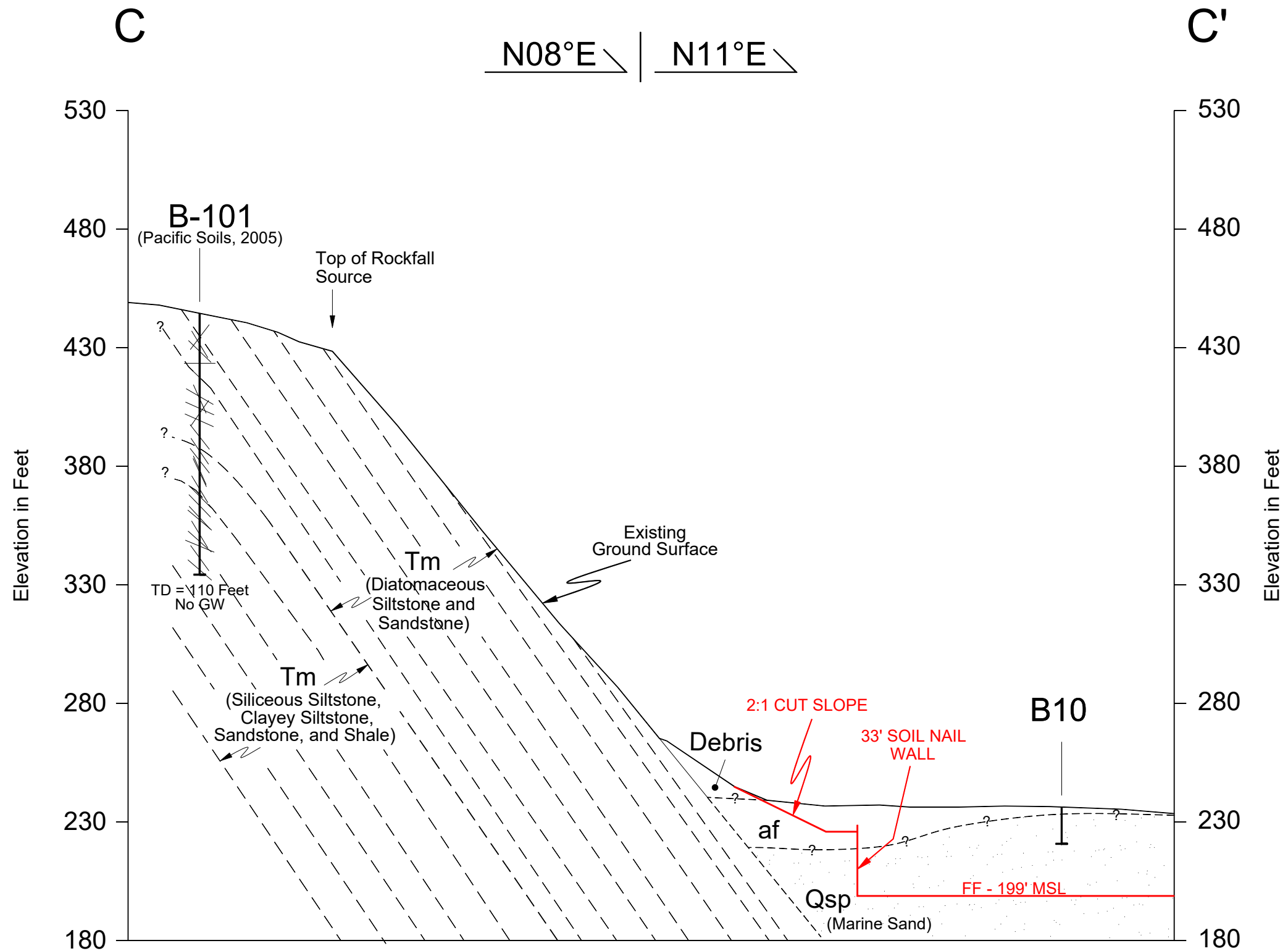
NOTES:

1. THE SECTIONS ARE BASED ON GEOLOGIC CONDITIONS AT BORING LOCATIONS AND AT SURFACE EXPOSURES MAPPED DURING THE INVESTIGATION. THE GEOLOGIC CONDITIONS BETWEEN SUCH LOCATIONS HAVE BEEN INTERPOLATED. LOCALIZED VARIATIONS COULD OCCUR. THE SECTIONS ARE INTENDED FOR DESCRIPTIVE PURPOSES ONLY.
2. SEE PARTIAL PRELIMINARY GRADING PLAN (KHR ASSOCIATES) FOR APPROXIMATE LOCATION OF SECTIONS.
3. BEDDING DIPS STEEPER THAN SLOPE.



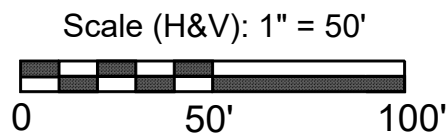
GEOCON WEST, INC.	
ENVIRONMENTAL GEOTECHNICAL MATERIALS 3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504 PHONE (818) 841-8388 - FAX (818) 841-1704	
Drafted By: RMA	Checked By: SFK / GAK

CIVIL SECTION B-B'		
MKS RESIDENTIAL HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
FEB 2016	PROJECT NO. A9201-06-01C	FIG. 2



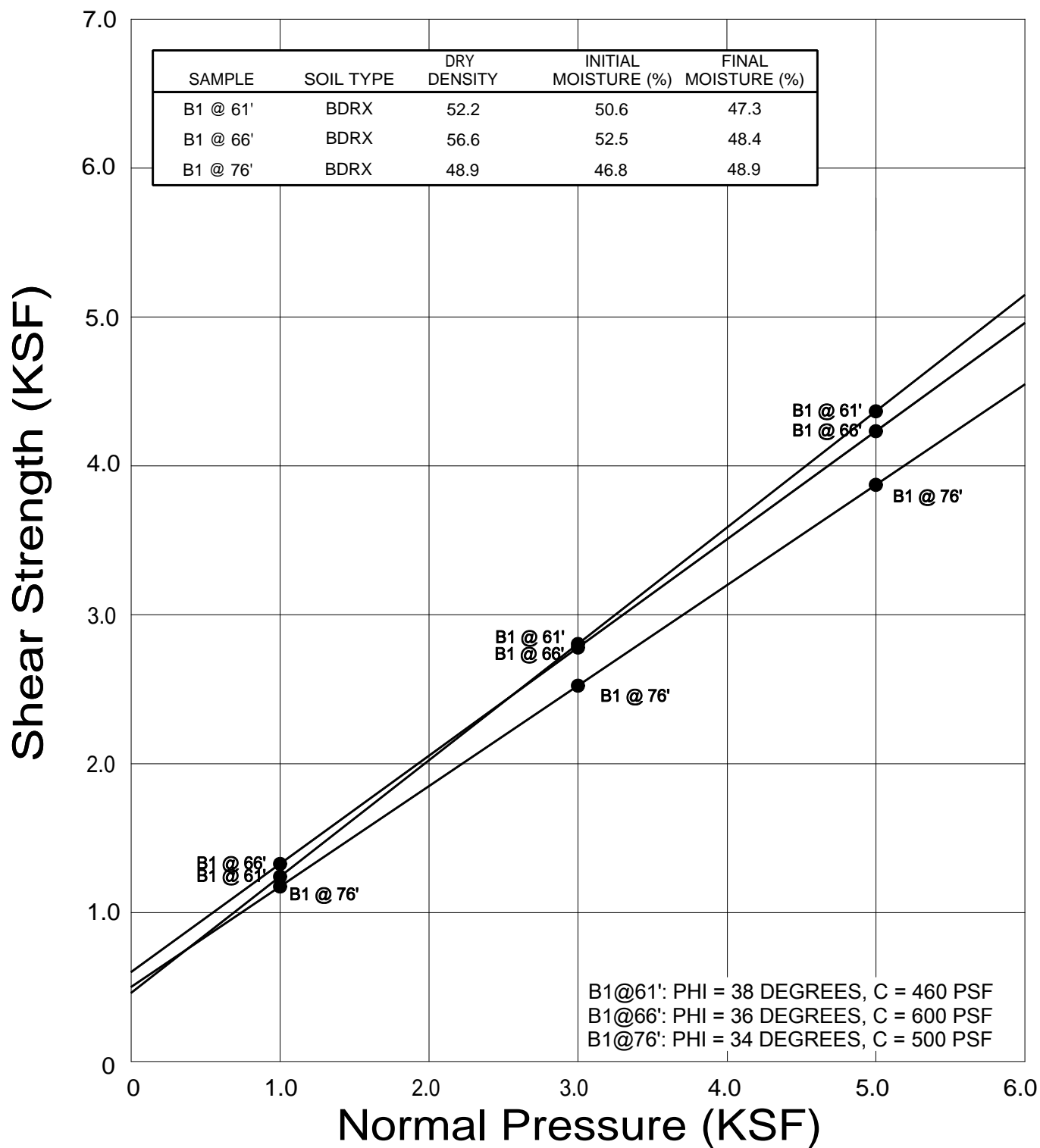
NOTES:

1. THE SECTIONS ARE BASED ON GEOLOGIC CONDITIONS AT BORING LOCATIONS AND AT SURFACE EXPOSURES MAPPED DURING THE INVESTIGATION. THE GEOLOGIC CONDITIONS BETWEEN SUCH LOCATIONS HAVE BEEN INTERPOLATED. LOCALIZED VARIATIONS COULD OCCUR. THE SECTIONS ARE INTENDED FOR DESCRIPTIVE PURPOSES ONLY.
2. SEE PARTIAL PRELIMINARY GRADING PLAN (KHR ASSOCIATES) FOR APPROXIMATE LOCATION OF SECTIONS.
3. BEDDING DIPS STEEPER THAN SLOPE.



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Drafted By: RMA	Checked By: SFK / GAK	

CIVIL SECTION C-C'		
MKS RESIDENTIAL HAWTHORNE & VIA VALMONTE TORRANCE, CA 90505		
FEB 2016	PROJECT NO. A9201-06-01C	FIG. 3



● Direct Shear, Field Moisture, Residual

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3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504
PHONE (818) 841-8388 - FAX (818) 841-1704

Drafted by: JMT

Checked by: NDB

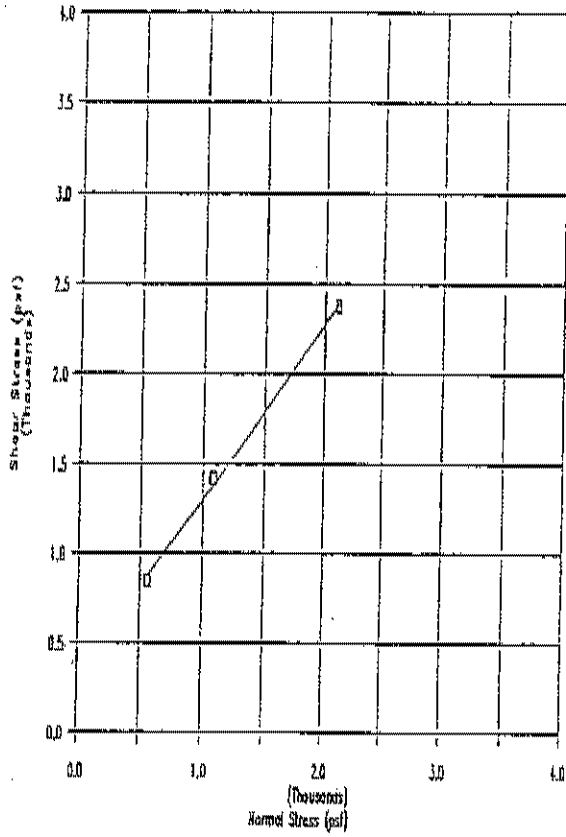
DIRECT SHEAR TEST RESULTS

MKS RESIDENTIAL
HAWTHORNE & VIA VALMONTE
TORRANCE, CA 90505

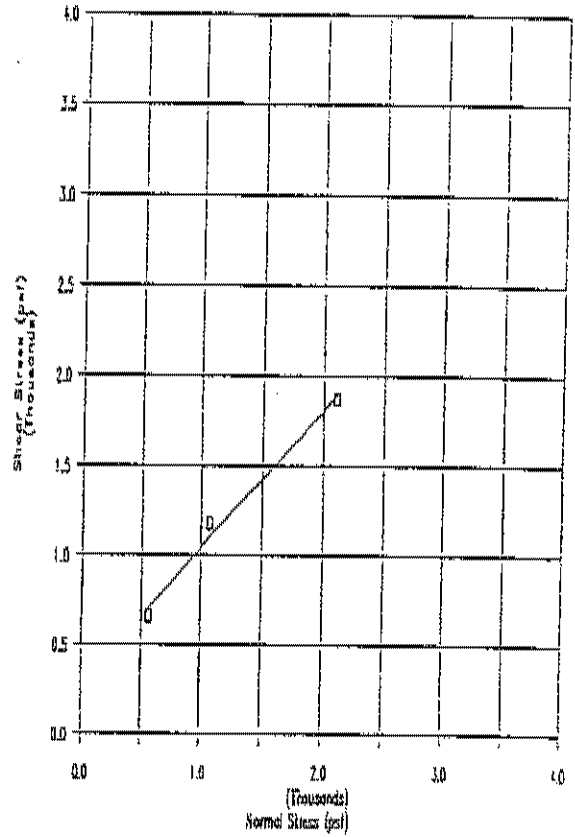
DRAFT

PROJECT NO. A9201-06-01C

FIG. B3



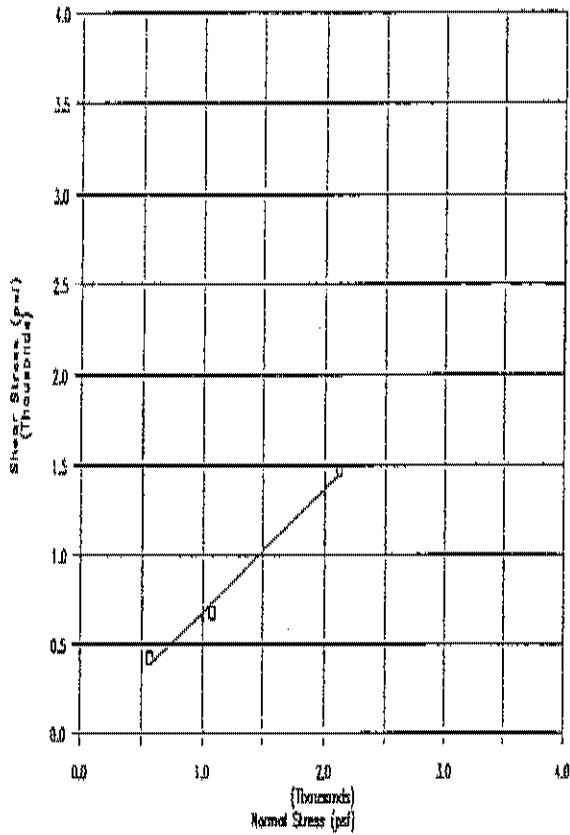
B-1 AT 15.0 FEET
 Angle of internal friction = 44 deg
 Cohesion = 320 psf
 R² = .998



* B-1 AT 15.0 FEET
 37 deg
 270 psf
 0.989
 * Residual

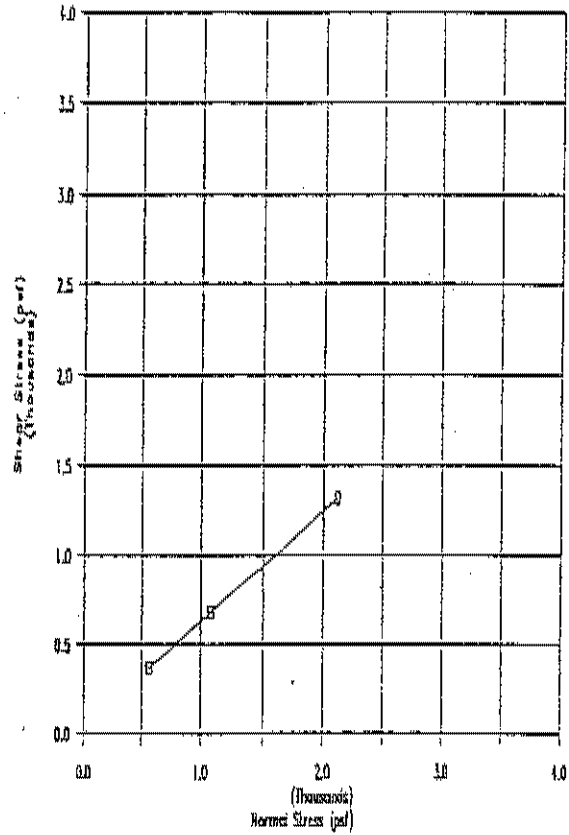
DIRECT SHEAR TEST DATA

Prepared for: MR. DAN E. BUTCHER



B-2 AT 15.0 FEET

Angle of internal friction = 34 deg
 Cohesion = 0 psf
 R² = 0.990



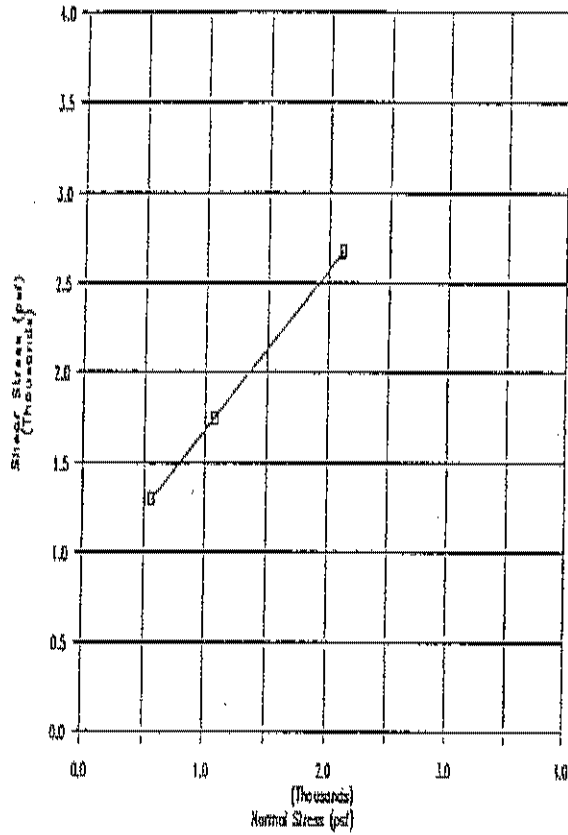
* B-2 AT 15.0 FEET

Angle of internal friction = 31 deg
 Cohesion = 20 psf
 R² = 1.0

* Residual

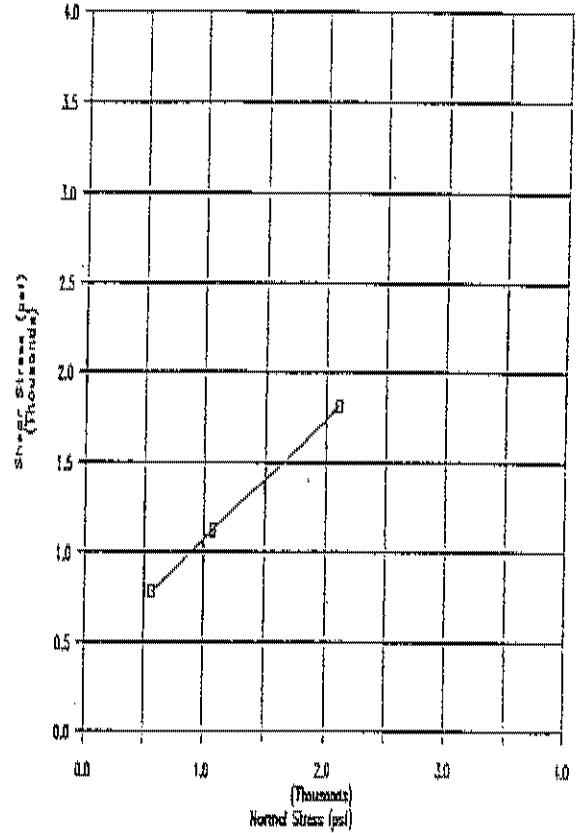
DIRECT SHEAR TEST DATA

Prepared for: MR. DAN E. BUTCHER



B-1 AT 35.0 FEET

Angle of internal friction = 42 deg
 Cohesion = 790 psf
 R² = 1.0



* B-1 AT 35.0 FEET

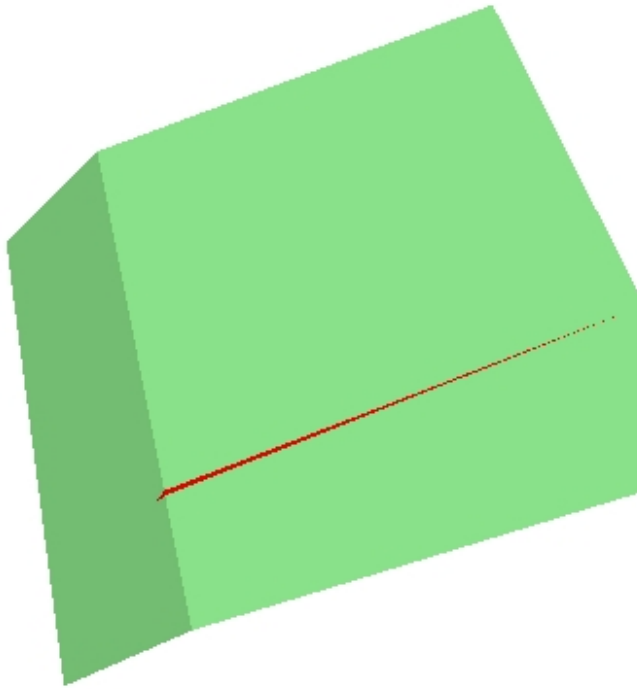
34 deg
 400 psf
 1.0

* Residual

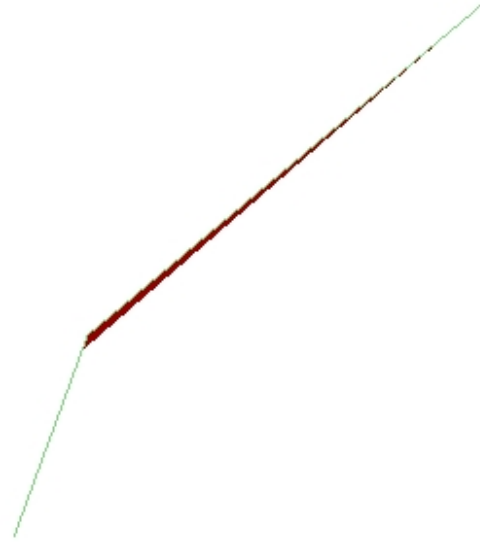
DIRECT SHEAR TEST DATA

Prepared for: MR. DAN E. BUTCHER

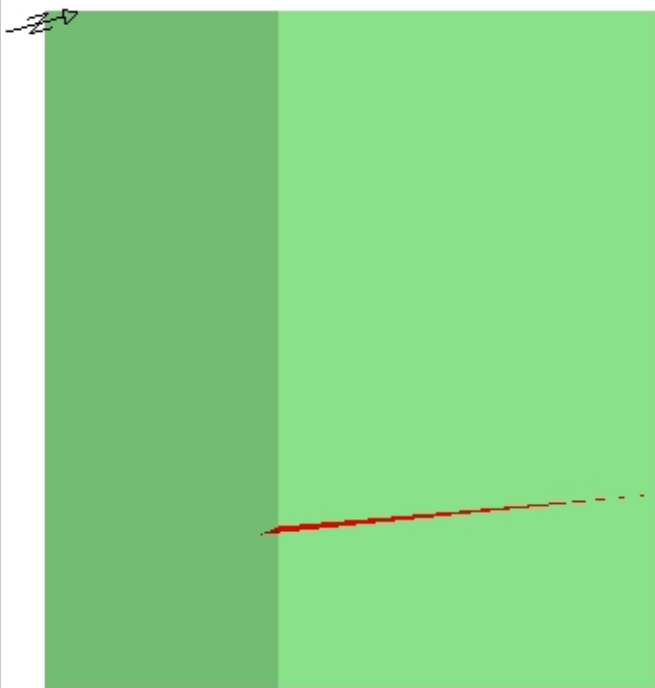
Wedge Analysis: Static



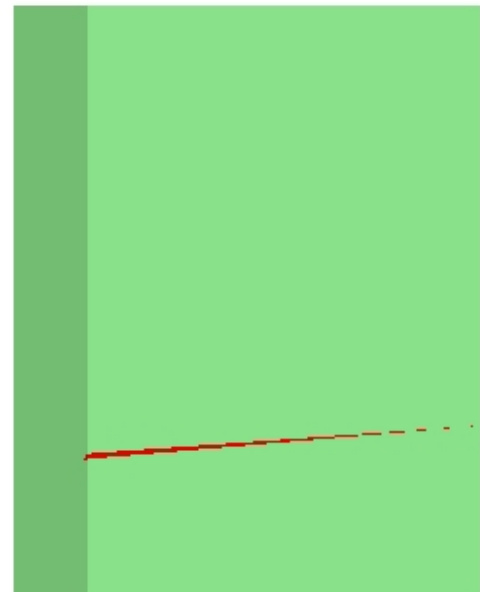
Perspective



Side



Top



Front

Swedge Analysis Information

Document Name:

- Wedge analysis with no additional forces

Project Summary:

- Job Title: SWEDGE - Surface Wedge Stability Analysis
- Date Created: 1/28/2016, 11:24:38 PM

Analysis Results:

- Analysis type: Deterministic
- Safety Factor: 8.7084
- Wedge height (on slope) [ft]: 200.00
- Bench width (on upper face) [ft]: 8.01
- Wedge volume [ft³]: 510.045
- Wedge weight [tons]: 25.502
- Wedge area (joint1) [ft²]: 560.32
- Wedge area (joint2) [ft²]: 702.34
- Wedge area (slope) [ft²]: 359.22
- Wedge area (upper face) [ft²]: 11.72

Effective Normal and Strength Properties:

	Joint 1	Joint 2
Effective Normal force [tons]	26.83	32.01
Effective Normal stress [t/ft ²]	0.05	0.05
Shear Strength [t/ft ²]	0.13	0.13
Strength due to Waviness [t/ft ²]	0.00	0.00

- Driving force [tons]: 19.23
- Resisting force [tons]: 167.46

Failure Mode:

- Sliding on intersection line (joints 1&2)

Joint Sets 1&2 line of Intersection:

Plunge [deg]	Trend [deg]	Length [ft]
48.94	9.15	269.10

Trace Lengths:

	Slope Face [ft]	Upper Face [ft]
Joint 1	261.64	8.57
Joint 2	261.47	9.28

Persistence:

- Joint 1 [ft]: 269.10
- Joint 2 [ft]: 269.10

Intersection Angles:

	Slope Face	Upper Face
Joint 1 & Joint 2	0.60	17.14
Joint 1 & Crest	86.26	96.24
Joint 2 & Crest	93.14	66.62

Dip and Dip Direction:

	Dip [deg]	Dip Direction [deg]
Joint Set 1	89.00	98.00
Joint Set 2	69.00	73.00
Slope	50.00	15.00
Upper Face	20.00	15.00

Joint Set 1 Data:

- Cohesion [t/ft^2]: 0.10
- Friction Angle [deg]: 35.00

Joint Set 2 Data:

- Cohesion [t/ft^2]: 0.10
- Friction Angle [deg]: 35.00

Slope Data:

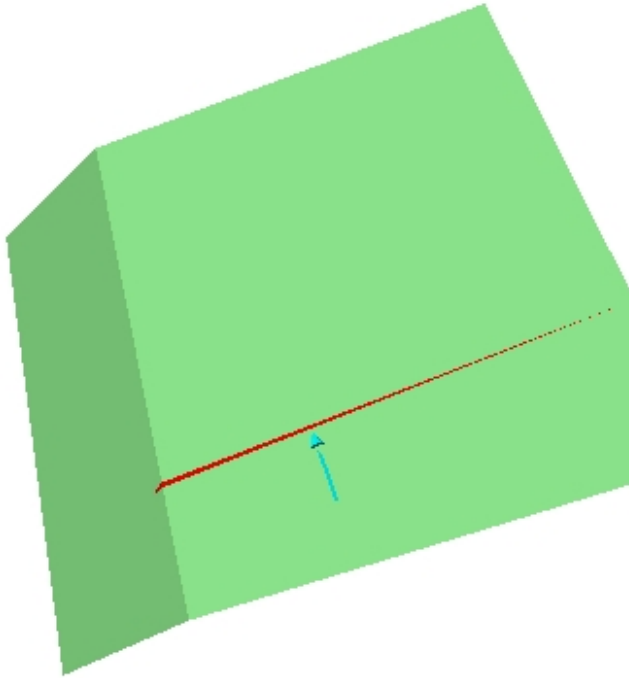
- Slope height [ft]: 200.00
- Rock unit weight [t/ft^3]: 0.05
- Water pressures in the slope: NO
- Overhanging slope face: NO
- Externally applied force: NO
- Tension crack: NO

Wedge Vertices:

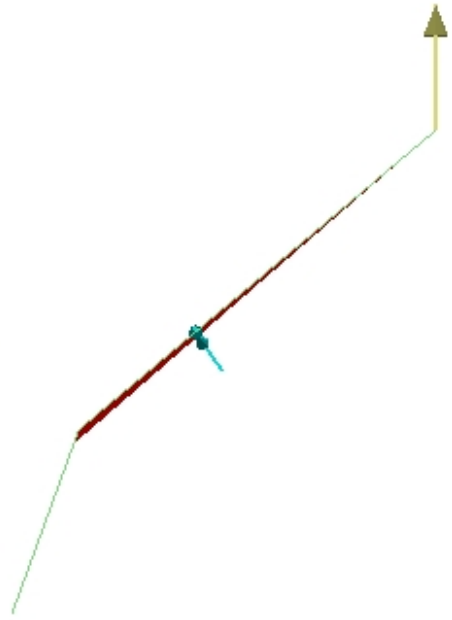
- Coordinates in Easting,Northing,Up Format
- 1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	x	y	z
124	0.000	0.000	0.000
134	-26.929	-166.524	200.000
234	-29.587	-165.812	200.000
123	-28.101	-174.498	202.914

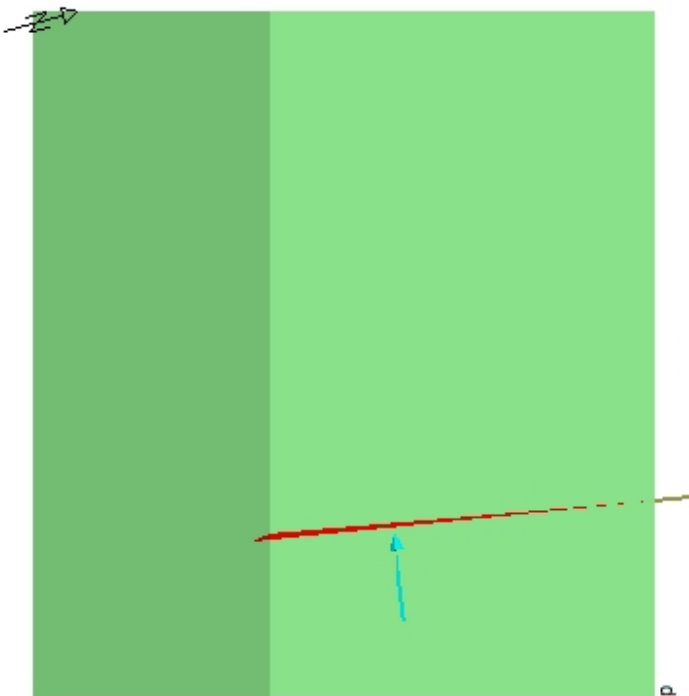
Wedge Analysis: Saturated



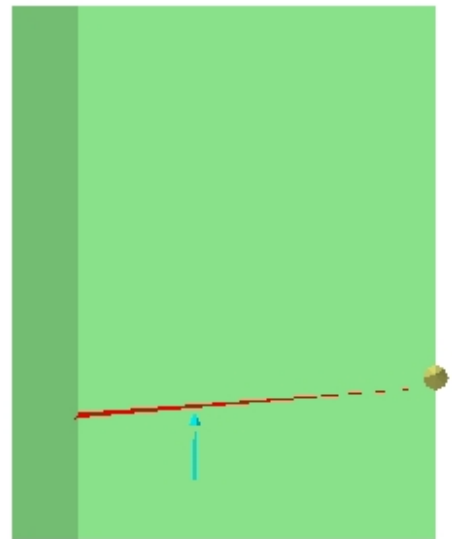
Perspective



Side



Top



Front

Swedge Analysis Information

Document Name:

- Wedge Analysis with water pressure

Project Summary:

- Job Title: SWEDGE - Surface Wedge Stability Analysis
- Date Created: 1/28/2016, 11:24:38 PM

Analysis Results:

- Analysis type: Deterministic
- Safety Factor: 7.9505
- Wedge height (on slope) [ft]: 200.00
- Bench width (on upper face) [ft]: 8.01
- Wedge volume [ft³]: 510.045
- Wedge weight [tons]: 25.502
- Wedge area (joint1) [ft²]: 560.32
- Wedge area (joint2) [ft²]: 702.34
- Wedge area (slope) [ft²]: 359.22
- Wedge area (upper face) [ft²]: 11.72

Effective Normal and Strength Properties:

	Joint 1	Joint 2
Effective Normal force [tons]	17.59	20.43
Effective Normal stress [t/ft²]	0.03	0.03
Shear Strength [t/ft²]	0.12	0.12
Strength due to Waviness [t/ft²]	0.00	0.00

- Driving force [tons]: 19.23
- Resisting force [tons]: 152.89

Water Pressures/Forces:

	Average pressure [t/ft ²]	Water force [tons]
Joint 1	N/A	9.24
Joint 2	N/A	11.58
Fissures	0.02	N/A

Failure Mode:

- Sliding on intersection line (joints 1&2)

Joint Sets 1&2 line of Intersection:

Plunge [deg]	Trend [deg]	Length [ft]
48.94	9.15	269.10

Trace Lengths:

	Slope Face [ft]	Upper Face [ft]
Joint 1	261.64	8.57
Joint 2	261.47	9.28

Persistence:

- Joint 1 [ft]: 269.10
- Joint 2 [ft]: 269.10

Intersection Angles:

	Slope Face	Upper Face
Joint 1 & Joint 2	0.60	17.14
Joint 1 & Crest	86.26	96.24
Joint 2 & Crest	93.14	66.62

Dip and Dip Direction:

	Dip [deg]	Dip Direction [deg]
Joint Set 1	89.00	98.00
Joint Set 2	69.00	73.00
Slope	50.00	15.00
Upper Face	20.00	15.00

Joint Set 1 Data:

- Cohesion [t/ft^2]: 0.10
- Friction Angle [deg]: 35.00

Joint Set 2 Data:

- Cohesion [t/ft^2]: 0.10
- Friction Angle [deg]: 35.00

Slope Data:

- Slope height [ft]: 200.00
- Rock unit weight [t/ft^3]: 0.05
- Water pressures in the slope: YES
- Overhanging slope face: NO
- Externally applied force: NO
- Tension crack: NO

Water Pressure Data:

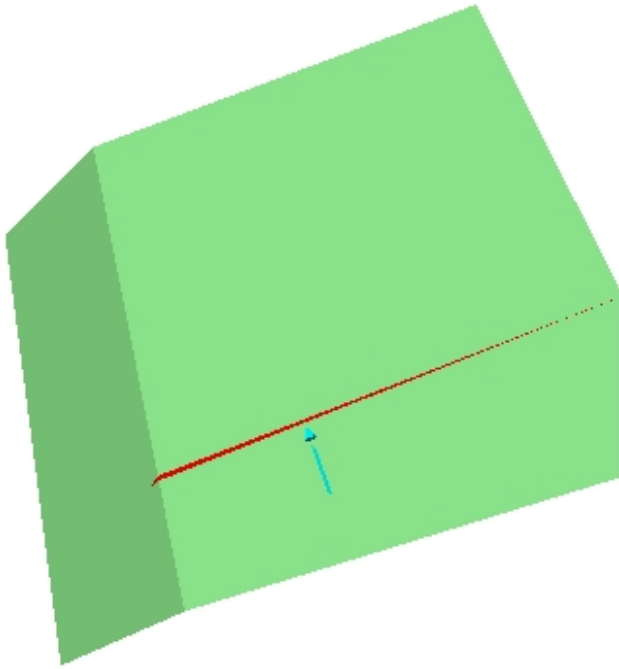
- Water unit weight [t/ft^3]: 0.031
- Pressure definition method: Percent Filled Fissures
- Percent Filled: 25.000 %

Wedge Vertices:

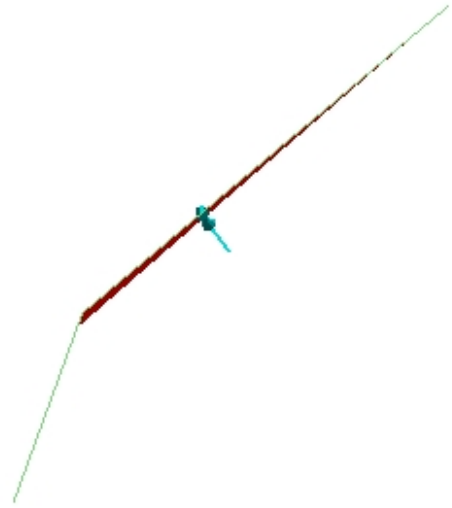
- Coordinates in Easting,Northing,Up Format
- 1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	x	y	z
124	0.000	0.000	0.000
134	-26.929	-166.524	200.000
234	-29.587	-165.812	200.000
123	-28.101	-174.498	202.914

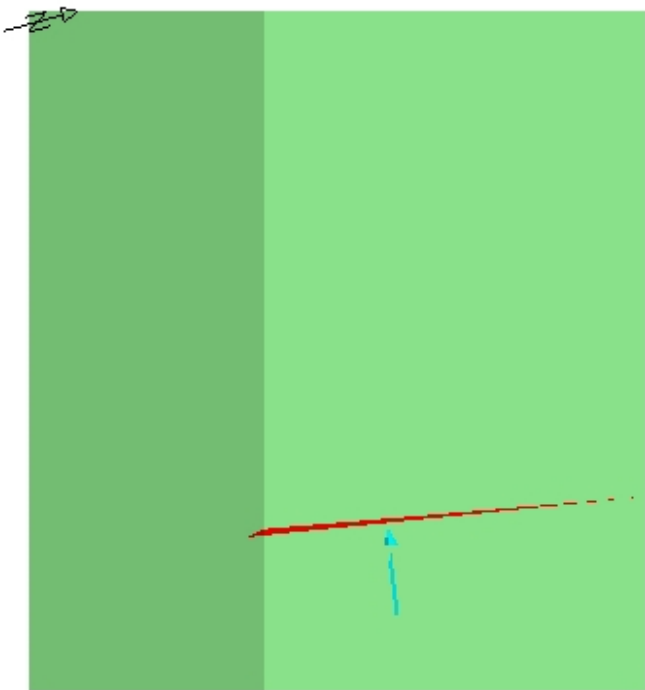
Wedge Analysis: Pseudo-static



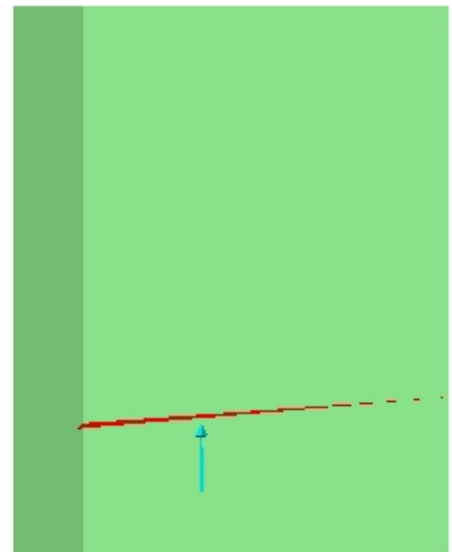
Perspective



Side



Top



Front

Swedge Analysis Information

Document Name:

- Wedge with water and pseudo-static load

Project Summary:

- Job Title: SWEDGE - Surface Wedge Stability Analysis
- Date Created: 1/28/2016, 11:24:38 PM

Analysis Results:

- Analysis type: Deterministic
- Safety Factor: 6.0875
- Wedge height (on slope) [ft]: 200.00
- Bench width (on upper face) [ft]: 8.01
- Wedge volume [ft³]: 510.045
- Wedge weight [tons]: 25.502
- Wedge area (joint1) [ft²]: 560.32
- Wedge area (joint2) [ft²]: 702.34
- Wedge area (slope) [ft²]: 359.22
- Wedge area (upper face) [ft²]: 11.72

Effective Normal and Strength Properties:

	Joint 1	Joint 2
Effective Normal force [tons]	10.20	11.61
Effective Normal stress [t/ft ²]	0.02	0.02
Shear Strength [t/ft ²]	0.11	0.11
Strength due to Waviness [t/ft ²]	0.00	0.00

- Driving force [tons]: 23.25
- Resisting force [tons]: 141.54

Water Pressures/Forces:

	Average pressure [t/ft ²]	Water force [tons]
Joint 1	N/A	9.24
Joint 2	N/A	11.58
Fissures	0.02	N/A

Seismic Force:

- Seismic force [tons]: 6.12

Failure Mode:

- Sliding on intersection line (joints 1&2)

Joint Sets 1&2 line of Intersection:

Plunge [deg]	Trend [deg]	Length [ft]
48.94	9.15	269.10

Trace Lengths:

	Slope Face [ft]	Upper Face [ft]
Joint 1	261.64	8.57
Joint 2	261.47	9.28

Persistence:

- Joint 1 [ft]: 269.10
- Joint 2 [ft]: 269.10

Intersection Angles:

	Slope Face	Upper Face
Joint 1 & Joint 2	0.60	17.14
Joint 1 & Crest	86.26	96.24
Joint 2 & Crest	93.14	66.62

Dip and Dip Direction:

	Dip [deg]	Dip Direction [deg]
Joint Set 1	89.00	98.00
Joint Set 2	69.00	73.00
Slope	50.00	15.00
Upper Face	20.00	15.00

Joint Set 1 Data:

- Cohesion [t/ft^2]: 0.10
- Friction Angle [deg]: 35.00

Joint Set 2 Data:

- Cohesion [t/ft^2]: 0.10
- Friction Angle [deg]: 35.00

Slope Data:

- Slope height [ft]: 200.00
- Rock unit weight [t/ft^3]: 0.05
- Water pressures in the slope: YES
- Overhanging slope face: NO
- Externally applied force: NO
- Tension crack: NO

Water Pressure Data:

- Water unit weight [t/ft^3]: 0.031
- Pressure definition method: Percent Filled Fissures

- Percent Filled: 25.000 %

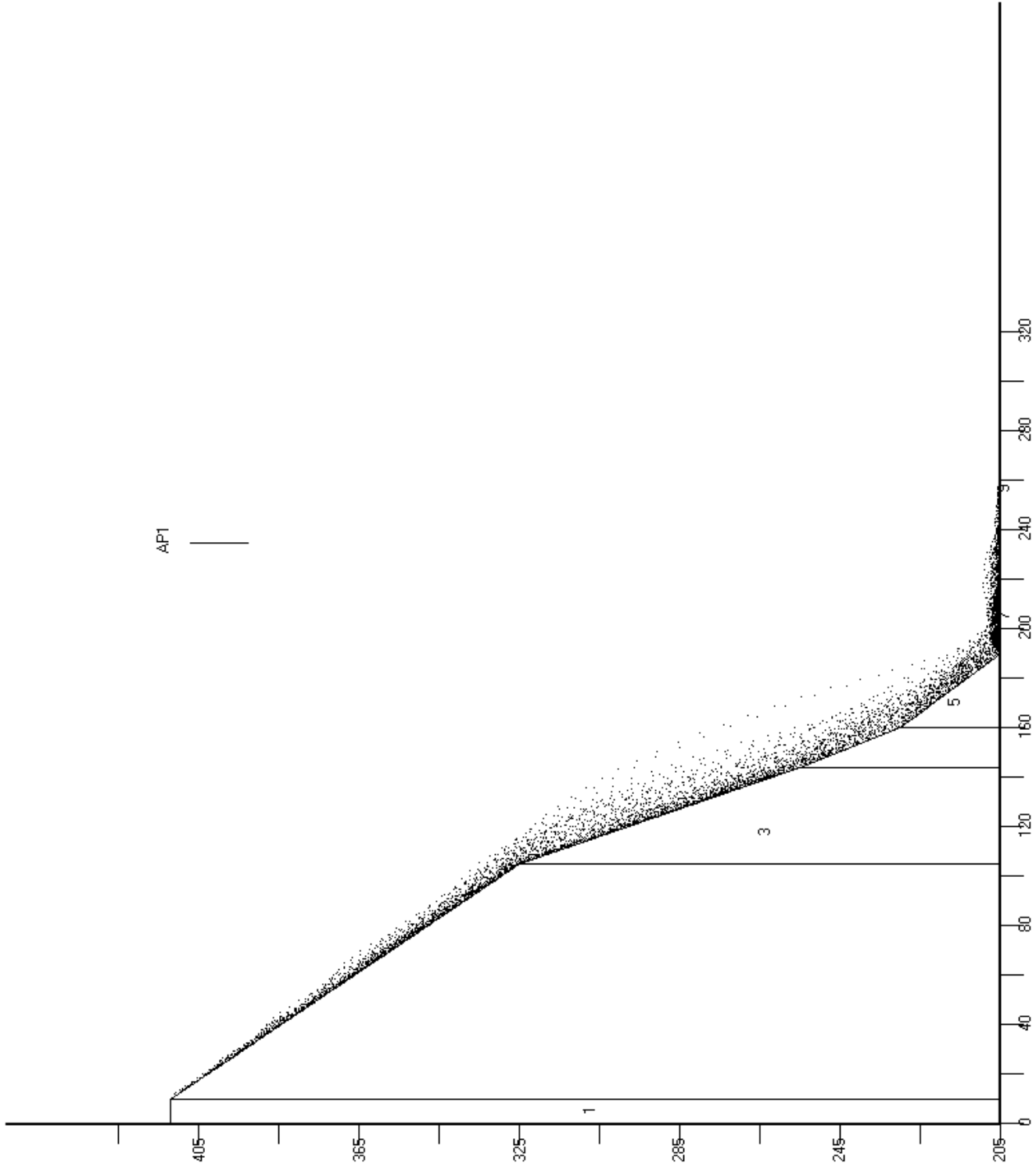
Seismic Data:

- Direction: line of intersection J1&J2 but horizontal
- Seismic coefficient: 0.240
- Trend [deg]: 9.15, Plunge [deg]: -0.00

Wedge Vertices:

- Coordinates in Easting,Northing,Up Format
- 1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	x	y	z
124	0.000	0.000	0.000
134	-26.929	-166.524	200.000
234	-29.587	-165.812	200.000
123	-28.101	-174.498	202.914



CRSP Input File -\\psf\Home\Desktop\Projects\California Rock Slope\Flat Ditch Results.doc

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point 1 X-Coordinate: 235
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 410
Initial Y-Base Starting Zone Coordinate: 265

Remarks: Calibration run

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.75	.25	0	412	10	412
2	1	.85	.3	10	412	105	325
3	1	.85	.3	105	325	144	255
4	1.25	.85	.3	144	255	160	230
5	1.25	.75	.2	160	230	190	205
6	1.25	.75	.2	190	205	200	205
7	1.25	.75	.2	200	205	210	205
8	1.25	.75	.2	210	205	235	205
9	1.25	.75	.2	235	205	310	205

CRSP Simulation Specifications: Used with
\\psf\Home\Desktop\Projects\California Rock Slope\Flat Ditch Results.doc

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 9
Rock Density: 155 lb/ft³
Rock Shape: Spherical
Diameter: 3 ft

CRSP Analysis Point 1 Data - \\psf\Home\Desktop\Projects\California Rock Slope\Flat Ditch Results.doc

Analysis Point 1: X = 235, Y = 205

Total Rocks Passing Analysis Point: 21

Cumulative Probability Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)	Bounce
50%	14.4	11582	0.12
75%	18.15	17221	5.73
90%	21.51	22293	10.78
95%	23.53	25338	13.81
98%	25.8	28755	17.21

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 25.75	Maximum: 2.06	Maximum: 32672
Average: 14.4	Average: .42	Average: 11582
Minimum: 3.96	G. Mean: .12	Std. Dev.: 8351
Std. Dev.: 5.54	Std. Dev.: 8.31	

Remarks: Calibration run

CRSP Data Collected at End of Each Cell - \\psf\Home\Desktop\Projects\California Rock Slope\Flat Ditch Results.doc

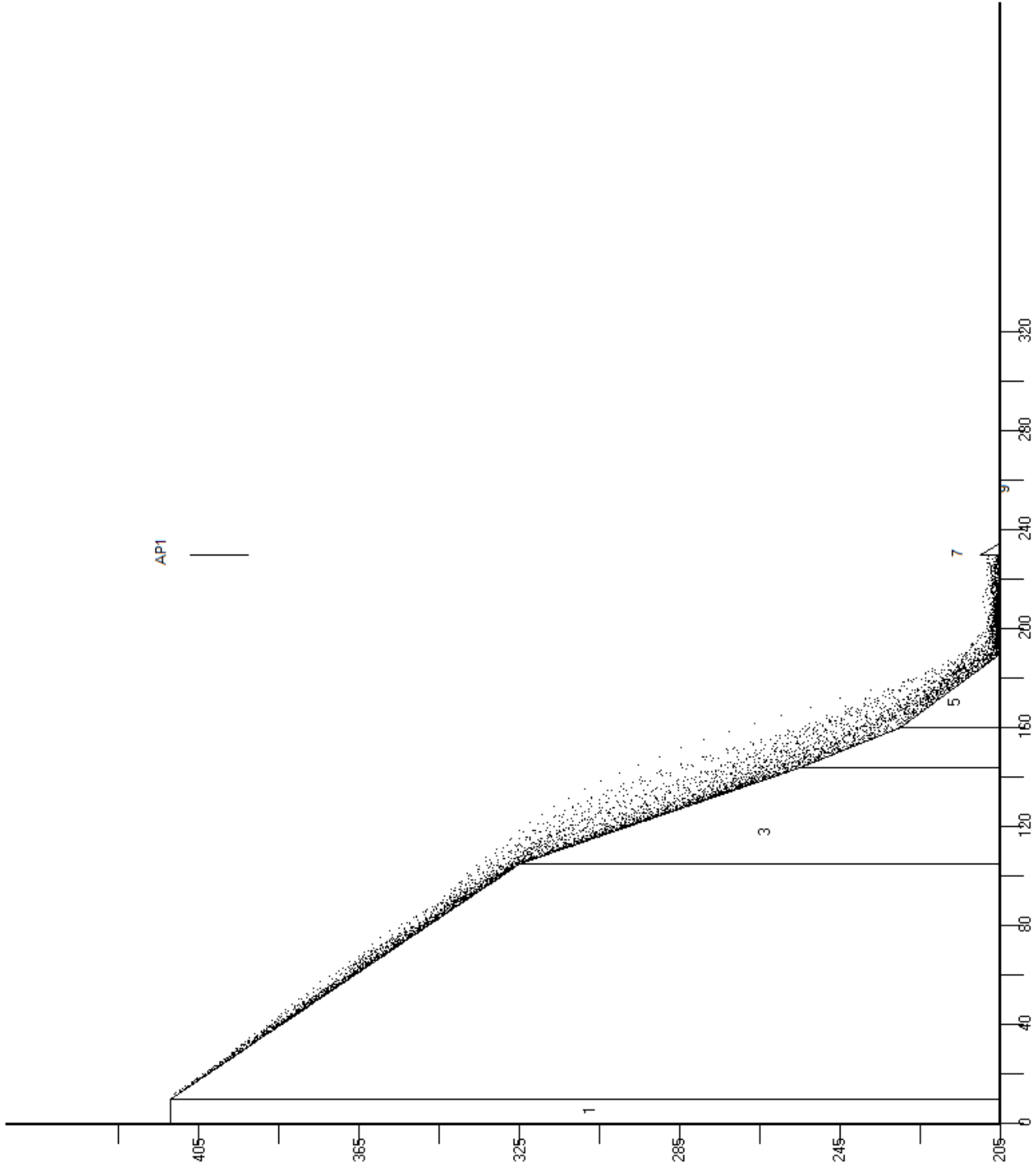
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks		past end of cell		
2	55	32	11.37	10	3
3	88	53	16.35	44	9
4	91	57	16.1	47	9
5	98	46	13.16	13	4
6	62	24	12.71	4	0
7	36	18	8.18	3	0
8	26	14	5.54	2	0
9	No rocks		past end of cell		

CRSP Rocks Stopped Data - \\psf\Home\Desktop\Projects\California Rock Slope\Flat Ditch Results.doc

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	0

30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	10
200 To 210 ft	25
210 To 220 ft	26
220 To 230 ft	12
230 To 240 ft	10
240 To 250 ft	12
250 To 260 ft	3
260 To 270 ft	2
270 To 280 ft	0
280 To 290 ft	0
290 To 300 ft	0
300 To 310 ft	0



CRSP Input File -\\psf\Home\Desktop\Projects\California Rock Slope\CRSP Torrence Barrier at 230.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point 1 X-Coordinate: 230
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 410
Initial Y-Base Starting Zone Coordinate: 265

Remarks: Berm Run

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.75	.25	0	412	10	412
2	1	.85	.3	10	412	105	325
3	1	.85	.3	105	325	144	255
4	1.25	.85	.3	144	255	160	230
5	1.25	.75	.2	160	230	190	205
6	1.25	.75	.2	190	205	230	205
7	1.25	.75	.2	230	205	230.1	210
8	1.25	.75	.2	230.1	210	235	205
9	1.25	.75	.2	235	205	310	205

CRSP Simulation Specifications: Used with
\\psf\Home\Desktop\Projects\California Rock Slope\CRSP Torrence Barrier at 230.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 9
Rock Density: 155 lb/ft³
Rock Shape: Spherical
Diameter: 3 ft

CRSP Analysis Point 1 Data - \\psf\Home\Desktop\Projects\California Rock Slope\CRSP Torrence Barrier at 230.dat

Analysis Point 1: X = 230, Y = 205

Total Rocks Passing Analysis Point: 20

Cumulative Probability Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)	Bounce
50%	14.05	11590	0.4
75%	17.92	17793	4.69
90%	21.4	23372	8.55
95%	23.49	26722	10.87
98%	25.83	30481	13.46

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 28.79	Maximum: 2.96	Maximum: 39636
Average: 14.05	Average: .89	Average: 11590
Minimum: 5.67	G. Mean: .4	Std. Dev.: 9186
Std. Dev.: 5.73	Std. Dev.: 6.35	

Remarks: Berm Run

CRSP Data Collected at End of Each Cell - \\psf\Home\Desktop\Projects\California Rock Slope\CRSP Torrence Barrier at 230.dat

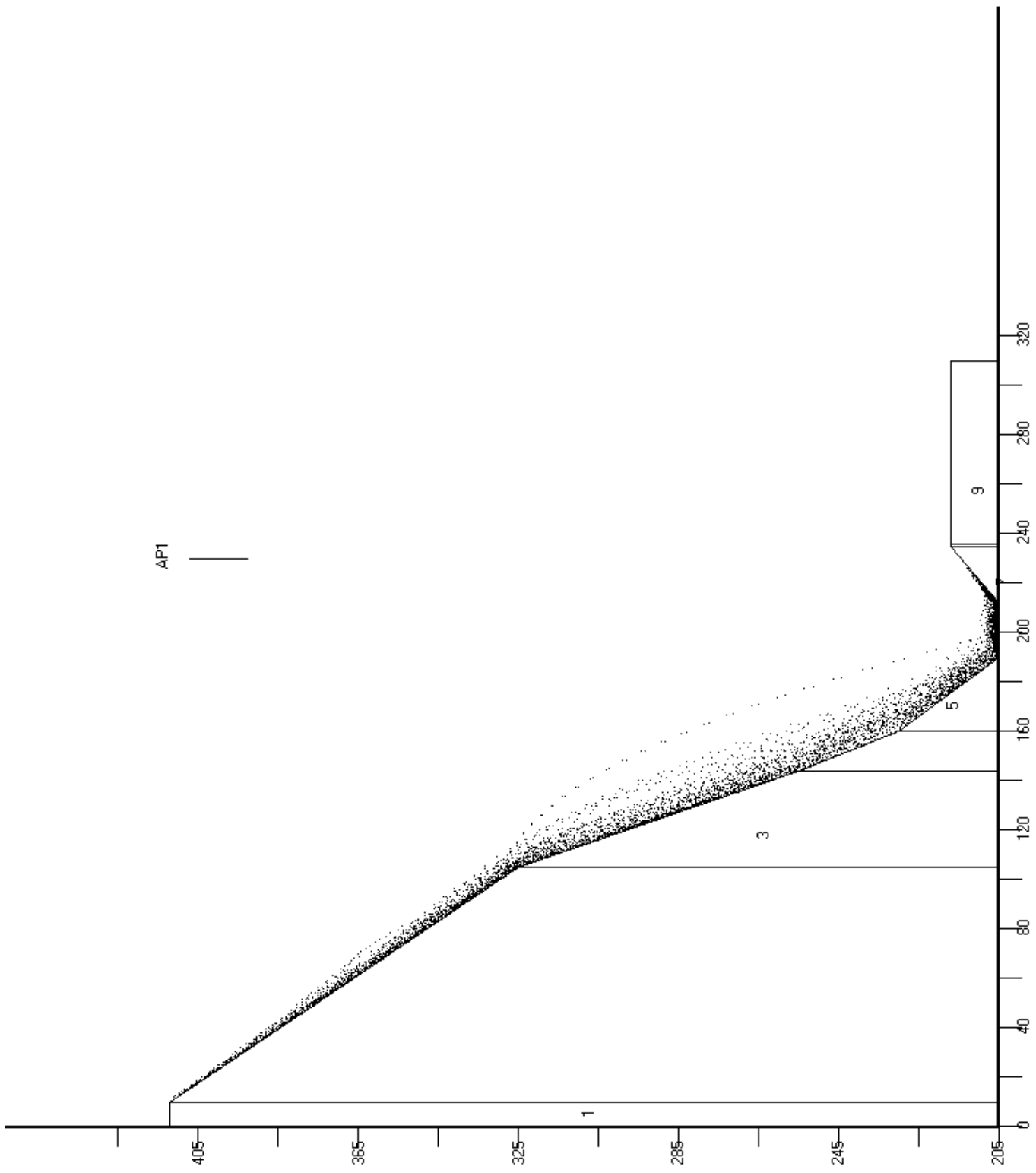
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks		past end of cell		
2	51	32	10.99	10	2
3	82	51	16.24	42	10
4	87	55	15.07	40	10
5	82	46	12.5	10	3
6	29	14	5.73	3	0
7	No rocks		past end of cell		
8	No rocks		past end of cell		
9	No rocks		past end of cell		

CRSP Rocks Stopped Data - \\psf\Home\Desktop\Projects\California Rock Slope\CRSP Torrence Barrier at 230.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0

20 To	30 ft	0
30 To	40 ft	0
40 To	50 ft	0
50 To	60 ft	0
60 To	70 ft	0
70 To	80 ft	0
80 To	90 ft	0
90 To	100 ft	0
100 To	110 ft	0
110 To	120 ft	0
120 To	130 ft	0
130 To	140 ft	0
140 To	150 ft	0
150 To	160 ft	0
160 To	170 ft	0
170 To	180 ft	0
180 To	190 ft	0
190 To	200 ft	14
200 To	210 ft	26
210 To	220 ft	29
220 To	230 ft	24
230 To	240 ft	7
240 To	250 ft	0
250 To	260 ft	0
260 To	270 ft	0
270 To	280 ft	0
280 To	290 ft	0
290 To	300 ft	0
300 To	310 ft	0



CRSP Input File -\\psf\Home\Desktop\Projects\California Rock Slope\10 foot 2 to 1 to el 215 from 205.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 9
Analysis Point 1 X-Coordinate: 230
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 410
Initial Y-Base Starting Zone Coordinate: 265

Remarks: Berm Run

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.75	.25	0	412	10	412
2	1	.85	.3	10	412	105	325
3	1	.85	.3	105	325	144	255
4	1.25	.85	.3	144	255	160	230
5	1.25	.75	.2	160	230	190	205
6	1.25	.75	.2	190	205	212	205
7	1.25	.75	.2	212	205	235	217
8	1.25	.75	.2	235	217	236	217
9	1.25	.75	.2	236	217	310	217

CRSP Simulation Specifications: Used with
\\psf\Home\Desktop\Projects\California Rock Slope\10 foot 2 to 1 to el 215 from 205.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 9
Rock Density: 155 lb/ft³
Rock Shape: Spherical
Diameter: 3 ft

CRSP Analysis Point 1 Data - \\psf\Home\Desktop\Projects\California Rock Slope\10 foot 2 to 1 to el 215 from 205.dat

Analysis Point 1: X = 230, Y = 214

NO ROCKS PAST ANALYSIS POINT 1

CRSP Data Collected at End of Each Cell - \\psf\Home\Desktop\Projects\California Rock Slope\10 foot 2 to 1 to el 215 from 205.dat

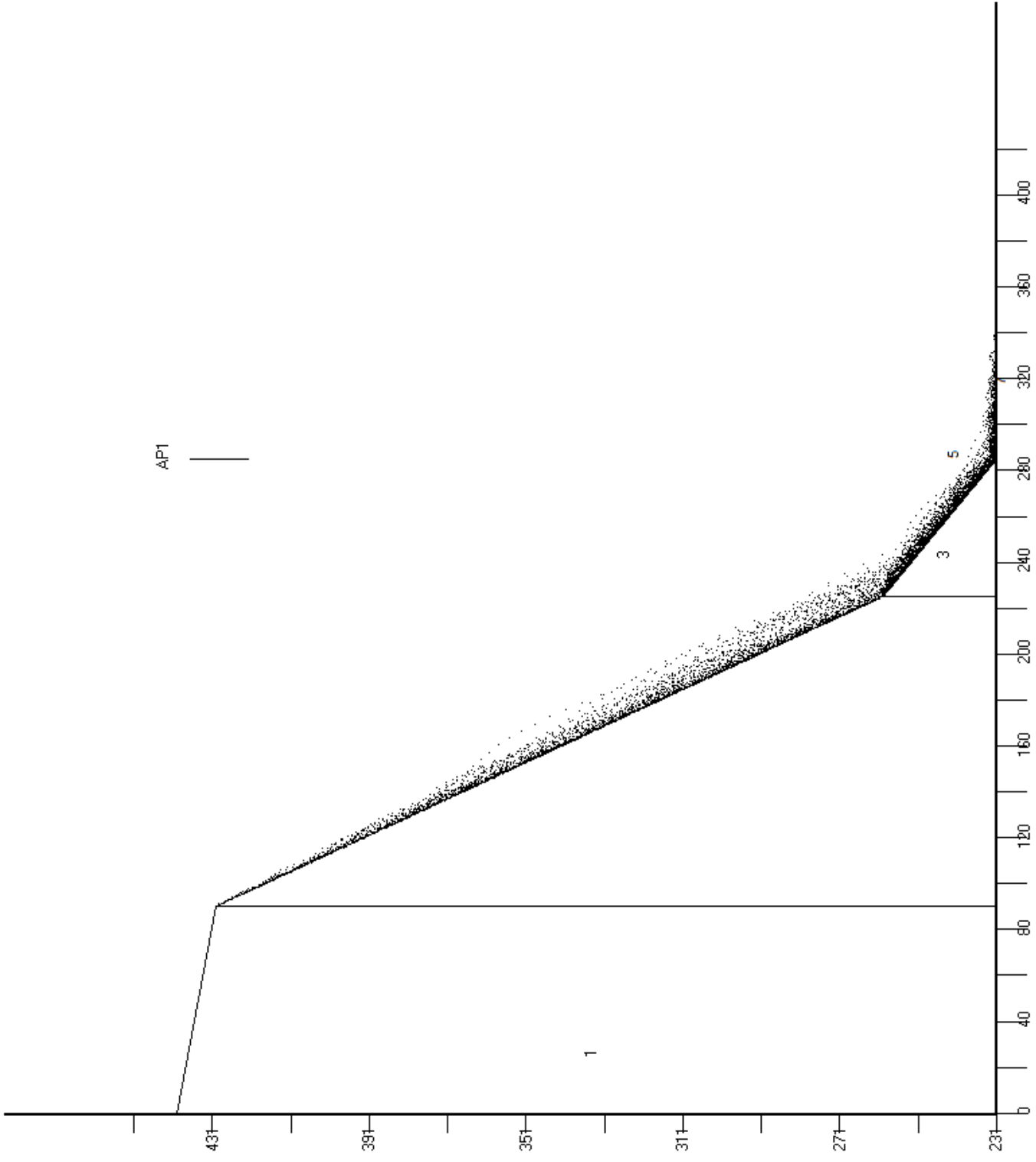
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	50	33	11.42	9	2
3	84	52	16.1	49	10
4	89	56	15.64	53	11
5	89	46	13.6	23	3
6	30	17	6.68	4	0
7	No rocks	past end of cell			
8	No rocks	past end of cell			
9	No rocks	past end of cell			

CRSP Rocks Stopped Data - \\psf\Home\Desktop\Projects\California Rock Slope\10 foot 2 to 1 to el 215 from 205.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 80 ft	0
80 To 90 ft	0
90 To 100 ft	0
100 To 110 ft	0
110 To 120 ft	0
120 To 130 ft	0
130 To 140 ft	0
140 To 150 ft	0
150 To 160 ft	0
160 To 170 ft	0
170 To 180 ft	0
180 To 190 ft	0
190 To 200 ft	8
200 To 210 ft	23

210	To	220	ft	58
220	To	230	ft	11
230	To	240	ft	0
240	To	250	ft	0
250	To	260	ft	0
260	To	270	ft	0
270	To	280	ft	0
280	To	290	ft	0
290	To	300	ft	0
300	To	310	ft	0



CRSP Input File -\\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section C to C prime.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point 1 X-Coordinate: 285
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 430
Initial Y-Base Starting Zone Coordinate: 260

Remarks: Section C-C'

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.75	.2	0	440	90	430
2	1	.8	.25	90	430	225	260
3	1.25	.75	.2	225	260	285	231
4	1.25	.7	.2	285	231	286	231
5	1.25	.7	.2	286	231	287	231
6	1.25	.7	.2	287	231	288	231
7	1.25	.7	.2	288	231	400	231

CRSP Simulation Specifications: Used with
\\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section C to C prime.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 7
Rock Density: 85 lb/ft³
Rock Shape: Spherical
Diameter: 2.5 ft

CRSP Analysis Point 1 Data - \\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section C to C prime.dat

Analysis Point 1: X = 285, Y = 231

Total Rocks Passing Analysis Point: 87

Cumulative Probability Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)	Bounce
50%	25.48	10865	0.79
75%	33.21	16401	4.37
90%	40.16	21379	7.58
95%	44.33	24368	9.51
98%	49.02	27723	11.68

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 51.75	Maximum: 7.13	Maximum: 37182
Average: 25.48	Average: 1.61	Average: 10865
Minimum: 4.17	G. Mean: .79	Std. Dev.: 8197
Std. Dev.: 11.45	Std. Dev.: 5.29	

Remarks: Section C-C'

CRSP Data Collected at End of Each Cell - \\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section C to C prime.dat

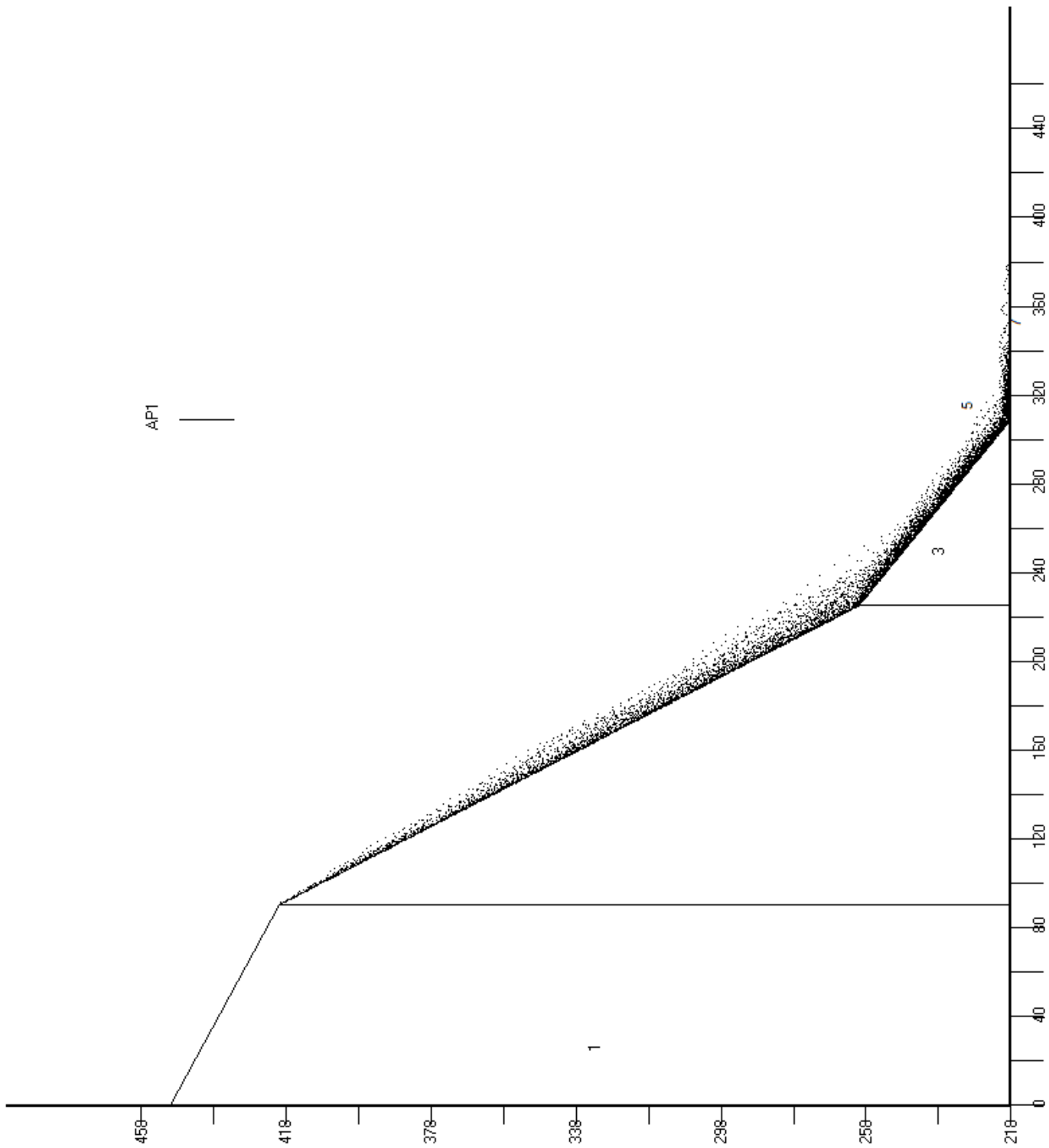
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks		past end of cell		
2	82	45	16.2	20	6
3	52	25	11.45	7	1
4	48	24	12	7	1
5	49	22	12.01	7	1
6	49	20	11.12	7	0
7	No rocks		past end of cell		

CRSP Rocks Stopped Data - \\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section C to C prime.dat

X Interval	Rocks Stopped
0 To 10 ft	1
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0

60 To	70 ft	0
70 To	80 ft	0
80 To	90 ft	0
90 To	100 ft	0
100 To	110 ft	0
110 To	120 ft	0
120 To	130 ft	0
130 To	140 ft	0
140 To	150 ft	0
150 To	160 ft	0
160 To	170 ft	0
170 To	180 ft	0
180 To	190 ft	0
190 To	200 ft	0
200 To	210 ft	0
210 To	220 ft	0
220 To	230 ft	0
230 To	240 ft	0
240 To	250 ft	2
250 To	260 ft	3
260 To	270 ft	2
270 To	280 ft	1
280 To	290 ft	24
290 To	300 ft	32
300 To	310 ft	15
310 To	320 ft	11
320 To	330 ft	5
330 To	340 ft	2
340 To	350 ft	2
350 To	360 ft	0
360 To	370 ft	0
370 To	380 ft	0
380 To	390 ft	0
390 To	400 ft	0



CRSP Input File -\\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section A to A prime.bmp

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point 1 X-Coordinate: 309
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 420
Initial Y-Base Starting Zone Coordinate: 260

Remarks: Section A-A'

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.75	.25	0	450	90	420
2	1	.80	.3	90	420	225	260
3	1	.7	.2	225	260	309	218
4	1.25	.7	.2	309	218	314	218
5	1.25	.7	.2	314	218	315	218
6	1.25	.7	.2	315	218	316	218
7	1.25	.7	.2	316	218	450	218

CRSP Simulation Specifications: Used with
\\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section A to A prime.bmp

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 7
Rock Density: 85 lb/ft³
Rock Shape: Spherical
Diameter: 2.5 ft

CRSP Analysis Point 1 Data - \\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section A to A prime.bmp

Analysis Point 1: X = 309, Y = 218

Total Rocks Passing Analysis Point: 99

Cumulative Probability Ht. (ft)	Velocity (ft/sec)	Energy (ft-lb)	Bounce
50%	26.89	11670	0.82
75%	33.59	17322	4.94
90%	39.61	22405	8.64
95%	43.23	25457	10.86
98%	47.29	28882	13.36

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 55.02	Maximum: 9.53	Maximum: 44477
Average: 26.89	Average: 1.82	Average: 11670
Minimum: 8.11	G. Mean: .82	Std. Dev.: 8370
Std. Dev.: 9.92	Std. Dev.: 6.1	

Remarks: Section A-A'

CRSP Data Collected at End of Each Cell - \\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section A to A prime.bmp

Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks		past end of cell		
2	74	45	16.34	21	5
3	55	27	9.92	10	1
4	54	20	11.64	8	0
5	55	20	11.79	7	0
6	45	20	10.69	7	0
7	No rocks		past end of cell		

CRSP Rocks Stopped Data - \\psf\Home\Desktop\Projects\California Rock Slope\Final Push\Section A to A prime.bmp

X Interval	Rocks Stopped
0 To 10 ft	1
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0

60 To	70 ft	0
70 To	80 ft	0
80 To	90 ft	0
90 To	100 ft	0
100 To	110 ft	0
110 To	120 ft	0
120 To	130 ft	0
130 To	140 ft	0
140 To	150 ft	0
150 To	160 ft	0
160 To	170 ft	0
170 To	180 ft	0
180 To	190 ft	0
190 To	200 ft	0
200 To	210 ft	0
210 To	220 ft	0
220 To	230 ft	0
230 To	240 ft	0
240 To	250 ft	0
250 To	260 ft	0
260 To	270 ft	0
270 To	280 ft	0
280 To	290 ft	0
290 To	300 ft	0
300 To	310 ft	0
310 To	320 ft	33
320 To	330 ft	31
330 To	340 ft	17
340 To	350 ft	7
350 To	360 ft	8
360 To	370 ft	1
370 To	380 ft	1
380 To	390 ft	1
390 To	400 ft	0
400 To	410 ft	0
410 To	420 ft	0
420 To	430 ft	0
430 To	440 ft	0
440 To	450 ft	0



Martin Woodard, Ph.D., P.G., P.E.

Rockfall Division Engineer
P: 855.579.0536 | F: 970.245.7737
E: marty@gsi.us | C: 540.315.0270
www.geostabilization.com

May 6, 2017

Jelisa Thomas Adams, PE GE
Project Engineer Geocon West, Inc.
3303 N. San Fernando Blvd. Suite 100,
Burbank, CA 91504

Subject: Updated Rockfall Simulation Modeling for MKS Residential Torrance, CA

Dear Jelisa,

GeoStabilization International was asked to provide rock mechanics and rockfall simulation modeling for a project for MKS Residential located in Torrance, CA. This letter presents the results of the modeling.

Information provided

For the letter report dated 23 February 2016 Geocon West Inc. provided geological structural information, geologic cross-sections, topographic cross-sections, and field observations to conduct the analysis. The scope of the work for that letter rockfall analysis based on the cross-sections and field observations (by Geocon West) and computer simulations utilizing the Colorado Rockfall Simulation program (CRSP 4.0).

Based on the review and updated civil plans we were requested to update the rockfall simulations based on new cross-sections. The computer simulations for this analysis used the RocFall computer program by Rocscience. This computer program is similar in nature to CRSP but has a more modern interface and additional tools that can be utilized.

Rockfall simulation

Cross-sections for the project were initially configured into the program and calibrated using the Oregon Catchment Area Design Guide (FHWA-OR-RD-02-04) utilizing cross-section 3+80 since the grade of this slope most closely aligned with the FHWA design charts. This calibration was done on rockfalls generated at a height of 80-100 feet. After calibration, rockfalls were generated from the full height of the slope. The slope parameters were then used on all other cross-sections.

After the simulations were running, a barrier was placed at the location identified in the cross-sections to determine bounce heights and energies required at those locations. Table 1 summarizes the findings at the locations of the barriers for each of the cross-sections analyzed.

Cross-section STA	Impact with Barrier	95% Maximum Height (Ft)	Percentile Bounce	95% Maximum Energy (Ft-lbs)	Percentile
3+80	Yes	0.2		23,703	
5+50	No	NA		NA	
7+50	Yes	4.5		29,288	
9+50	Yes	0.9		30,034	
11+25	no	NA		NA	

The models did not indicate a tremendous amount of bouncing, primarily due to the relative low angle of the slope and lack of significant surface roughness in the model. Surface roughness is a variable used in rockfall modeling to approximate undulations in the slope. Figure 1 illustrates a typical model from cross-section at STA 3+80. This does follow the general scale that is expected with slopes around this type of angle as illustrated in Figure 2.

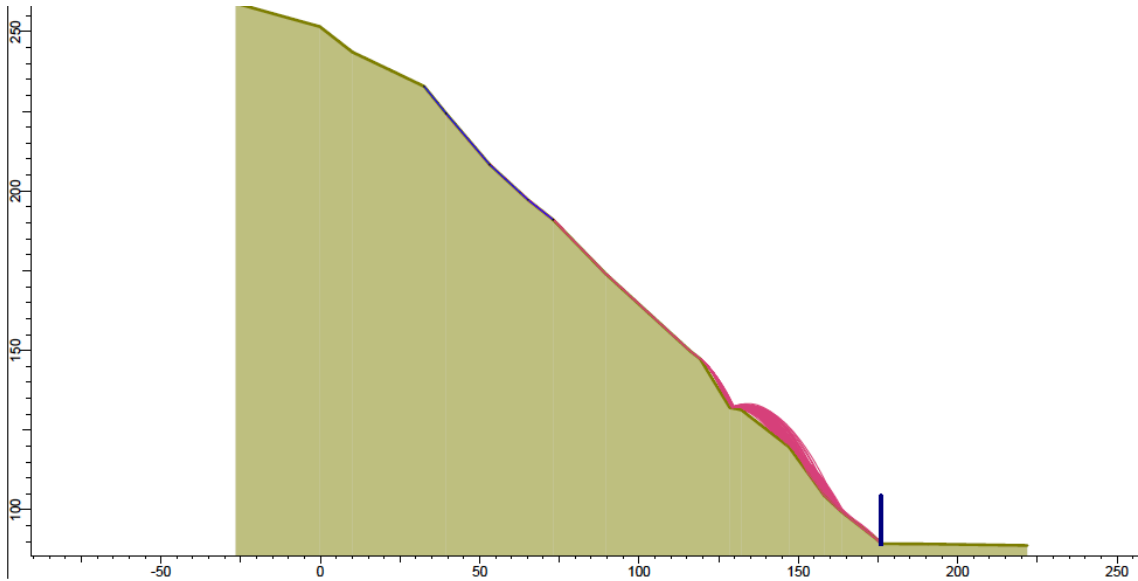


Figure 1. Rockfall simulation for cross-section at STA 3+80.

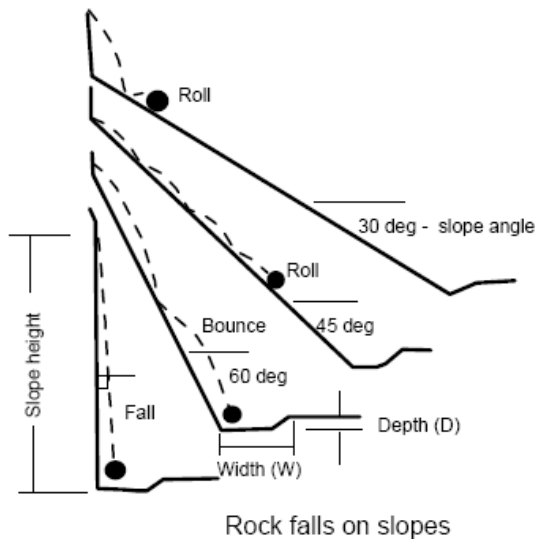


Figure 2. Typical rock trajectories based on slope angle.

Rockfall trajectories for slopes that generally grade just steeper than a 1H: 1V grade, such as the subject slopes, are expected to have rockfall trajectories that primarily roll with slight bouncing (Figure 2). Therefore, when a barrier is placed in the pathway of a rockfall the bounce heights are expected to be relatively low. A barrier was placed at the locations identified in the cross-sections. From RocFall a barrier summary report was generated where the rocks impacted the barriers. From this report we find that the 95% Percentile maximum height and energy was

roughly 1 foot and just over 30,000 ft-lbs of force (approximately 40 kJ). From personal communications with the author of CRSP (Jerry Higgins) the energies reported from these algorithms are over estimated and the mean energies should be used. For this case the maximum-recorded energy was nearly 15,000 ft-lbs or 20 kJ. This matches the same energies reported in our previous letter.

To put this amount of energy into perspective the low energy systems offered by rockfall barrier suppliers are 500 kJ systems. This is in a range where a jersey-type barrier can be used both for the bounce heights and energies found with this analysis.

I do recommend that the slope be inspected or scaled to further reduce any risk of rockfall for the structures. If, during that inspection, areas that fall outside the models observed, reduction of rockfall risk can be taken. Reduction of the risk can be accomplished by scaling out geologic structures are securing them in place with a number of different options.

The performed analysis will be provided in an attached document. If you have any questions concerning this analysis feel free to contact me at marty@gsi.us or (540) 315-0270.

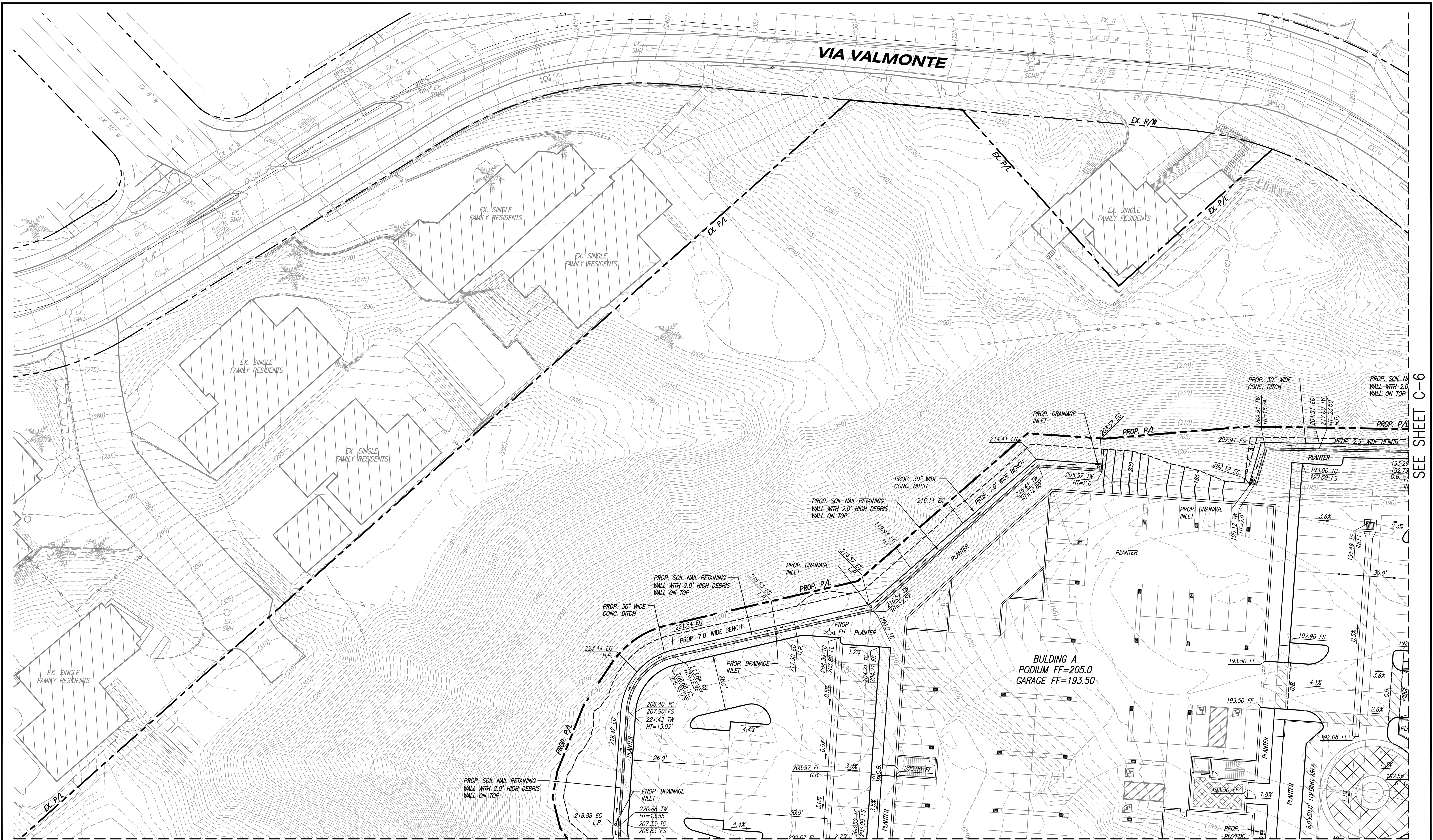
Sincerely,



Martin J. Woodard, PhD PG PE
Rockfall Division Engineer
GeoStabilization International
marty@gsi.us

Attachments

- Civil Drawings and Cross-Sections (provided by Geocon West, Inc.)
- Rockfall Simulation Models
- Simulation Reports
- Barrier Reports

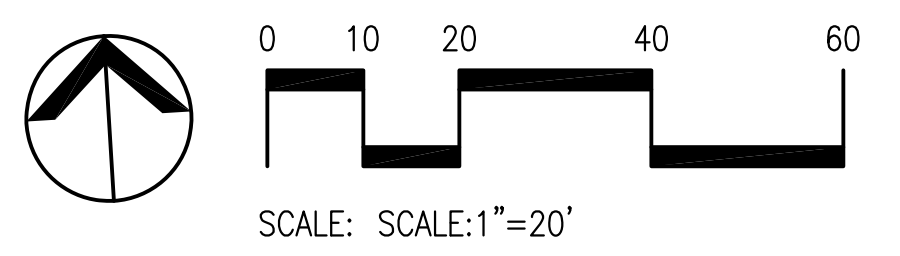


SEE SHEET C-7

SEE SHEET C-6

GRADING QUANTITY ESTIMATE:

CUT = XX,XXX C.Y.	EXPORT = XX,XXX C.Y.
FILL = XX,XXX C.Y.	MAX CUT HEIGHT = XX.XX'
NET = XX,XXX C.Y.	MAX FILL HEIGHT = XX.XX'



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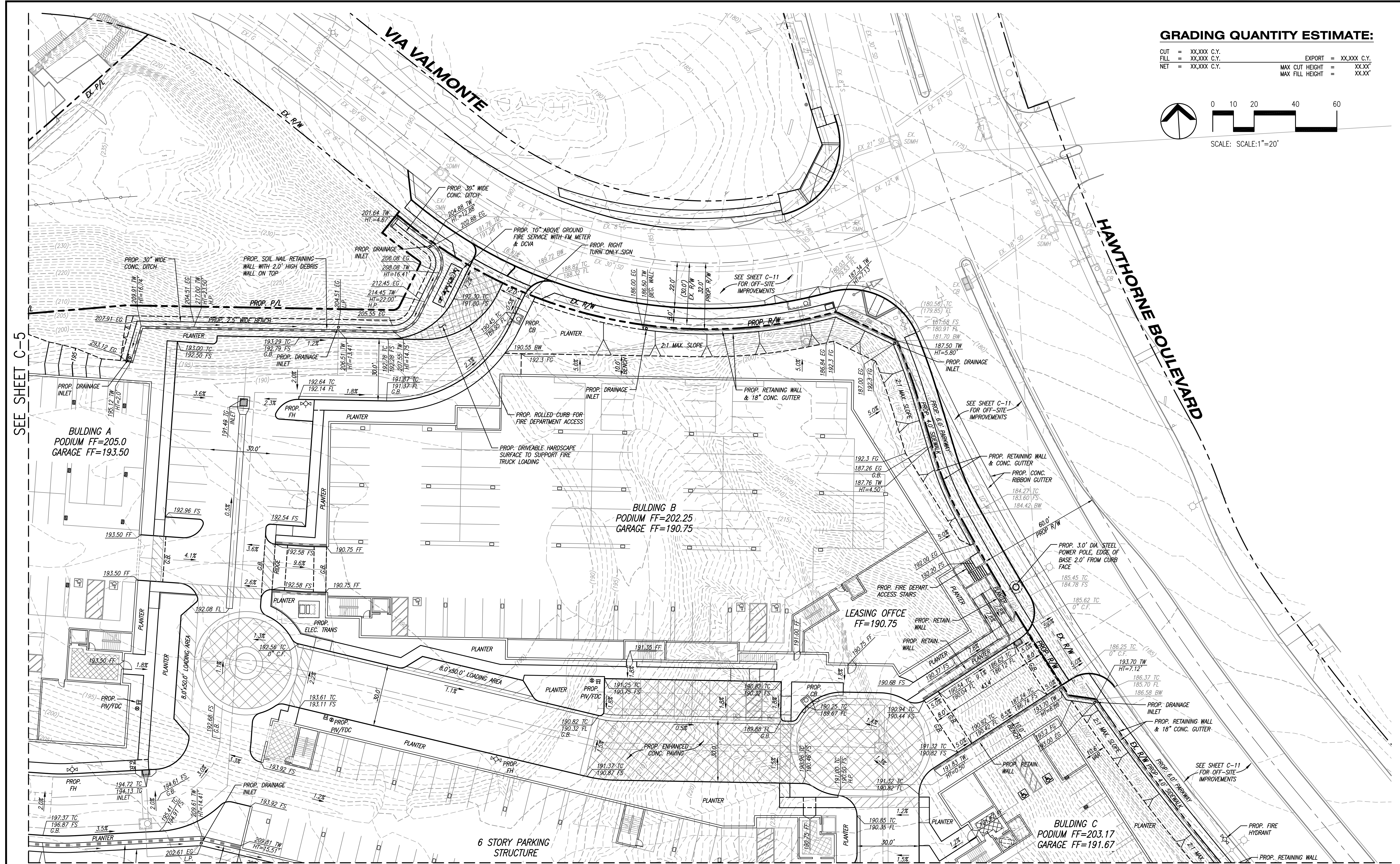
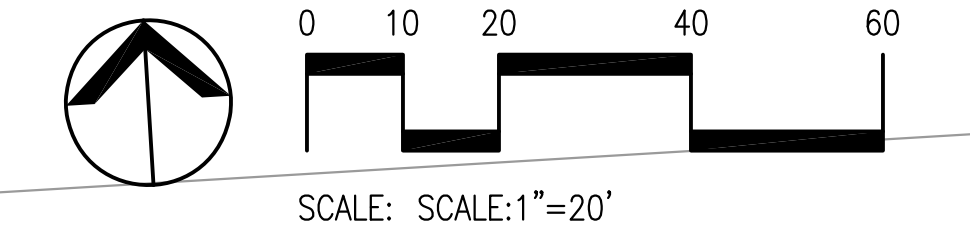
PRELIMINARY GRADING PLAN - SHEET C-5
TORRANCE, CALIFORNIA

KHR ASSOCIATES
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Newport Beach, California 92660
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Fax (949) 756-6444

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GRADING QUANTITY ESTIMATE:

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FILL = XX,XXX C.Y.	MAX CUT HEIGHT = XX.XX'
NET = XX,XXX C.Y.	MAX FILL HEIGHT = XX.XX'



SEE SHEET C-5

SEE SHEET C-8

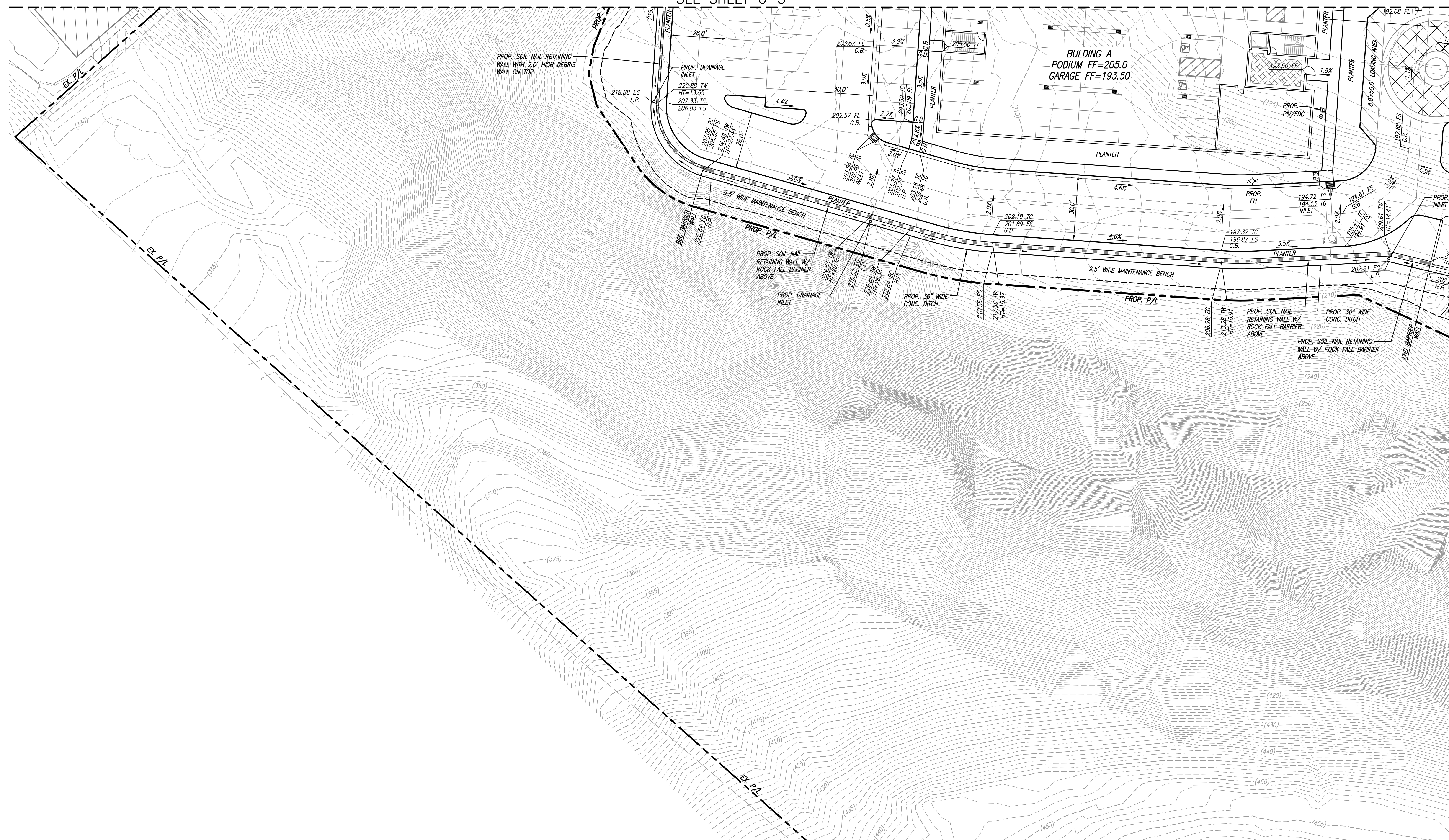
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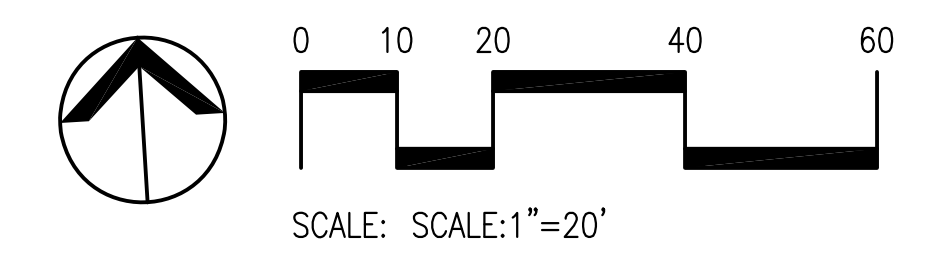
SEE SHEET C-5



SEE SHEET C-8

GRADING QUANTITY ESTIMATE:

CUT = XX.XXX C.Y.	EXPORT = XX.XXX C.Y.
FILL = XX.XXX C.Y.	MAX CUT HEIGHT = XX.XX'
NET = XX.XXX C.Y.	MAX FILL HEIGHT = XX.XX'

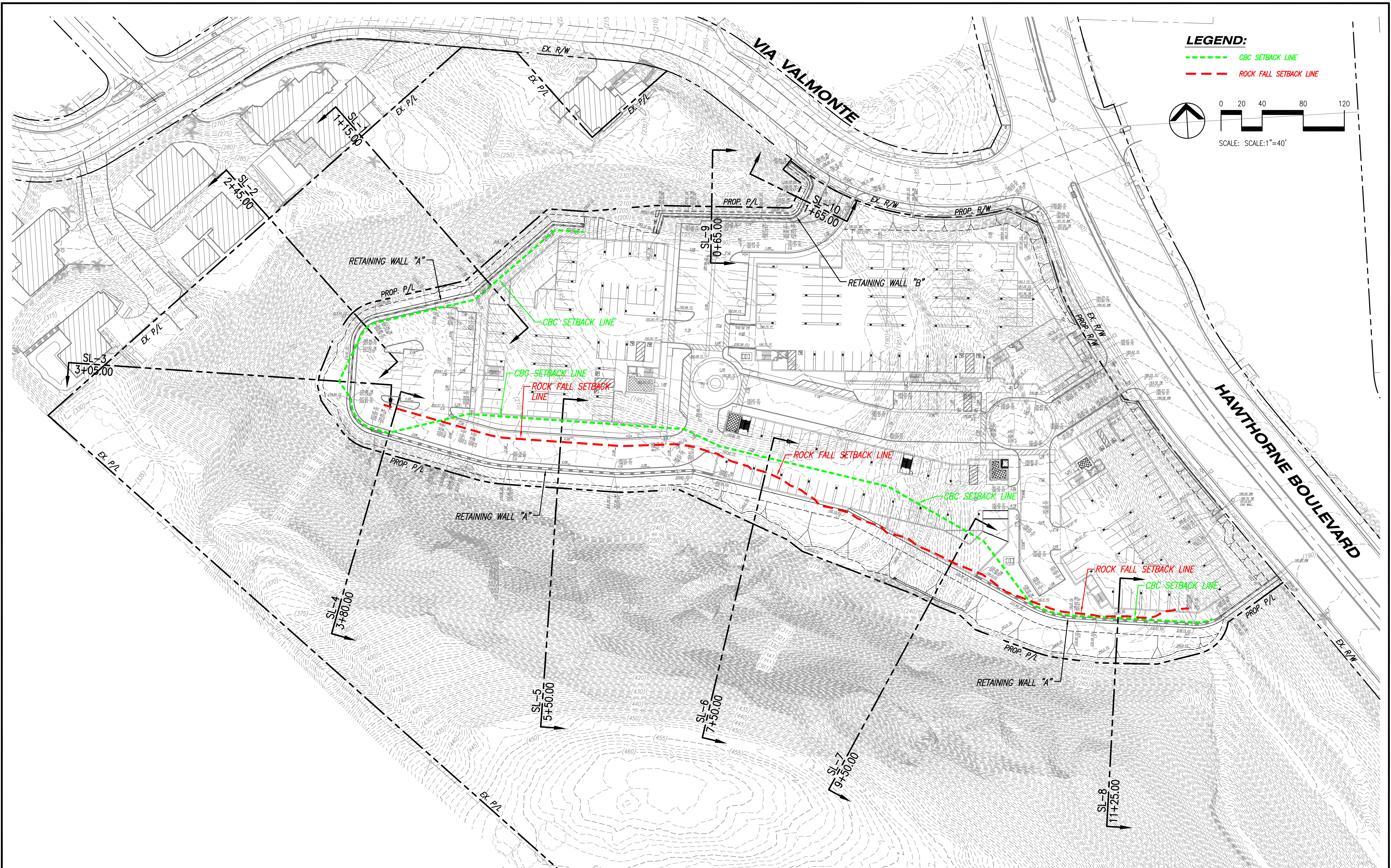


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PRELIMINARY GRADING PLAN - SHEET C-7
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LEGEND:

- CBC SETBACK LINE
- ROCK FALL SETBACK LINE

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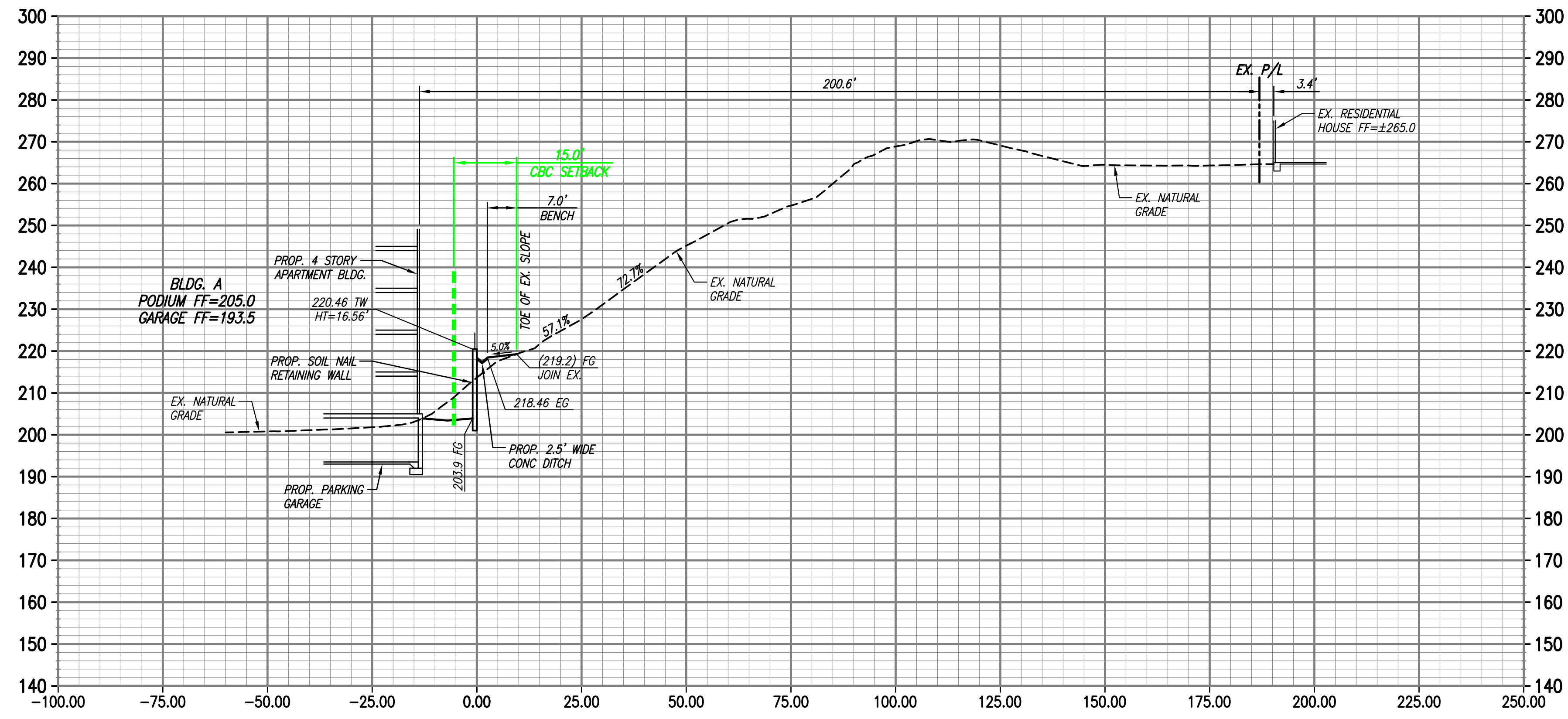
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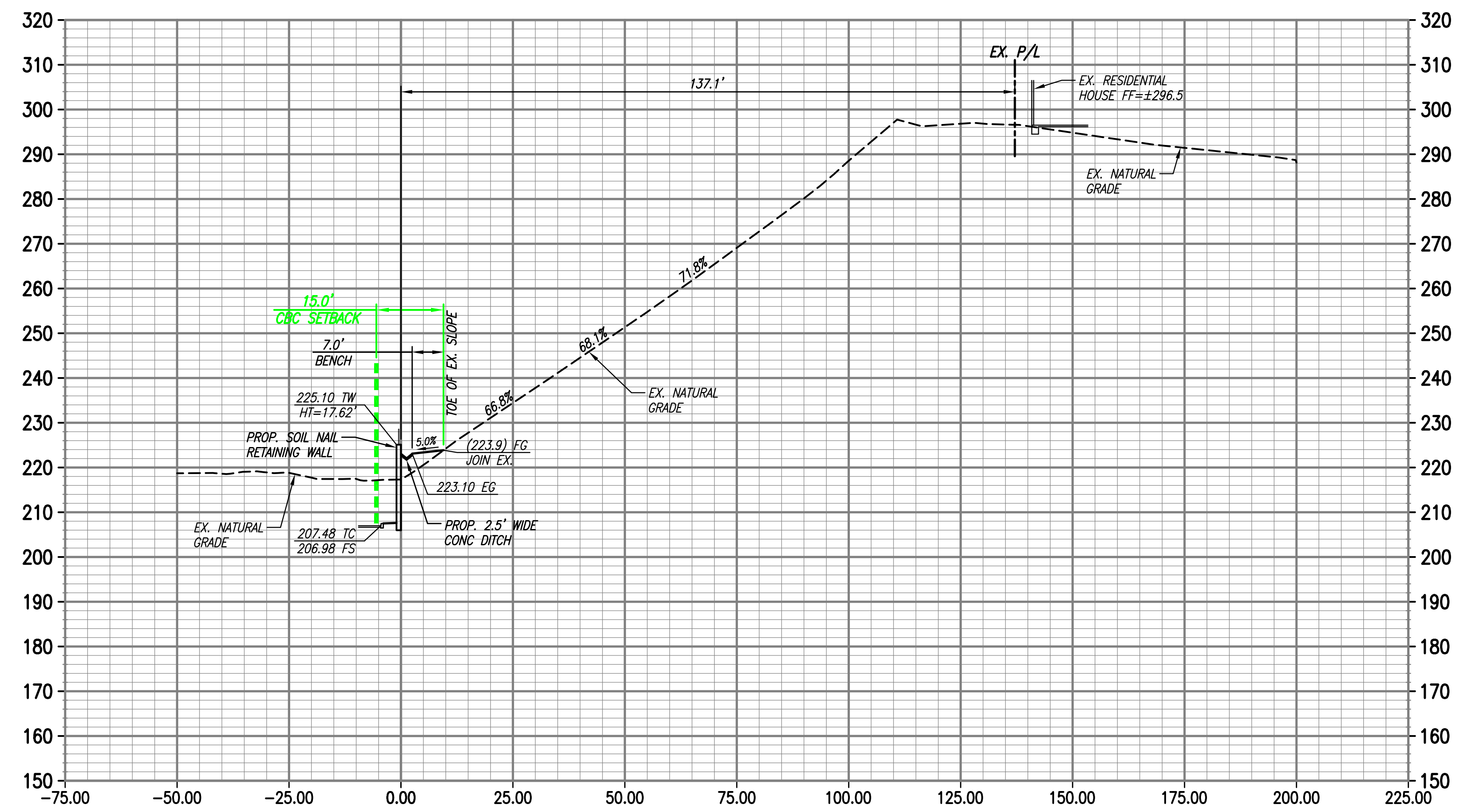
SITE SECTION PLAN VIEW - SHEET C-9
TORRANCE, CALIFORNIA

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STATION = 1+15.00



STATION = 2+45.00

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 - - - - - CBC SETBACK LINE
 - - - - - ROCK FALL SETBACK LINE

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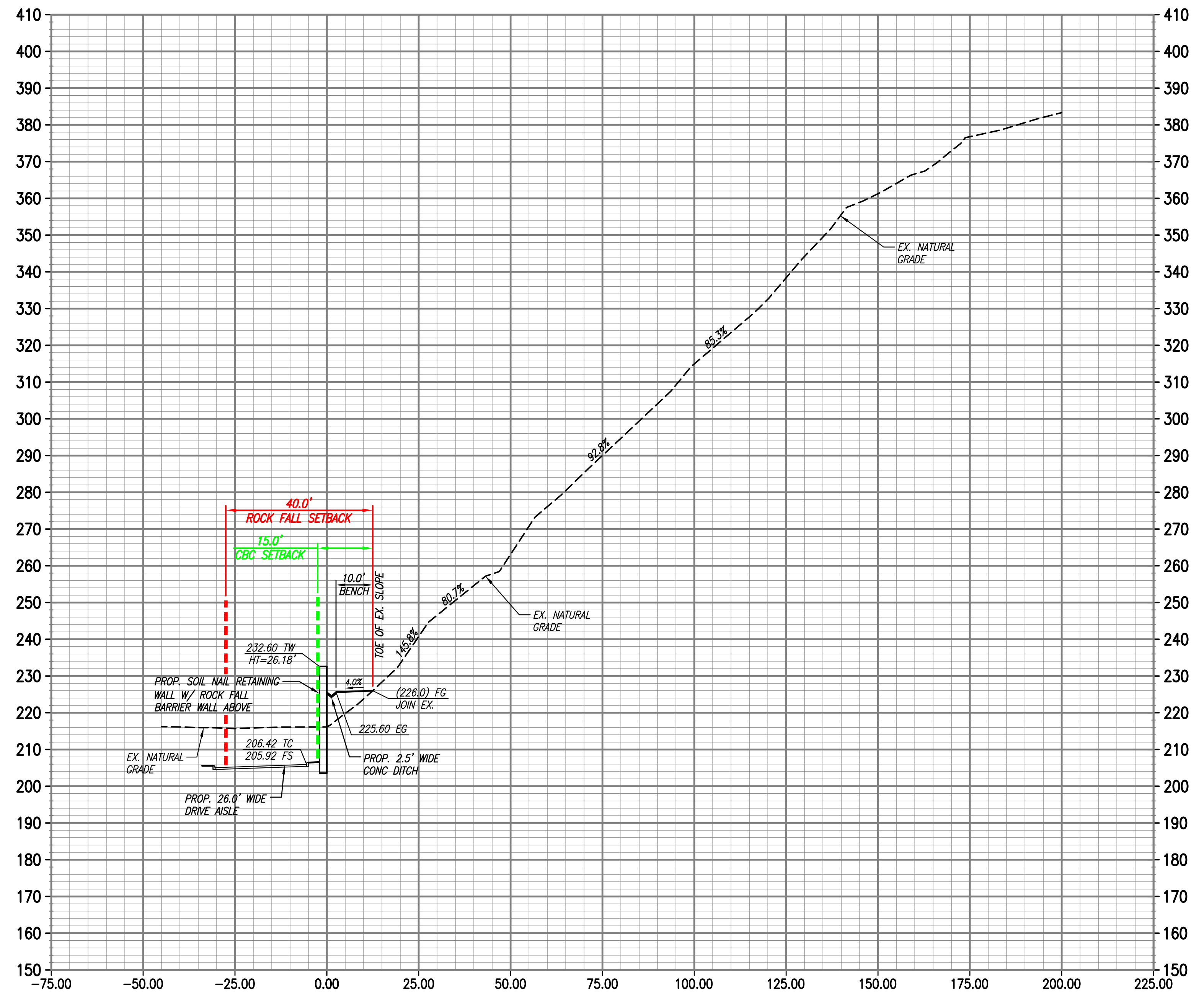
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SLOPE SECTION (RETAINING WALL "A") - STATION 1+15.00 & 2+45.00 SHEET C-10

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STATION = 3+80.00

LEGEND:

- CBC SETBACK LINE
- ROCK FALL SETBACK LINE

(SCALE: 1"=20')

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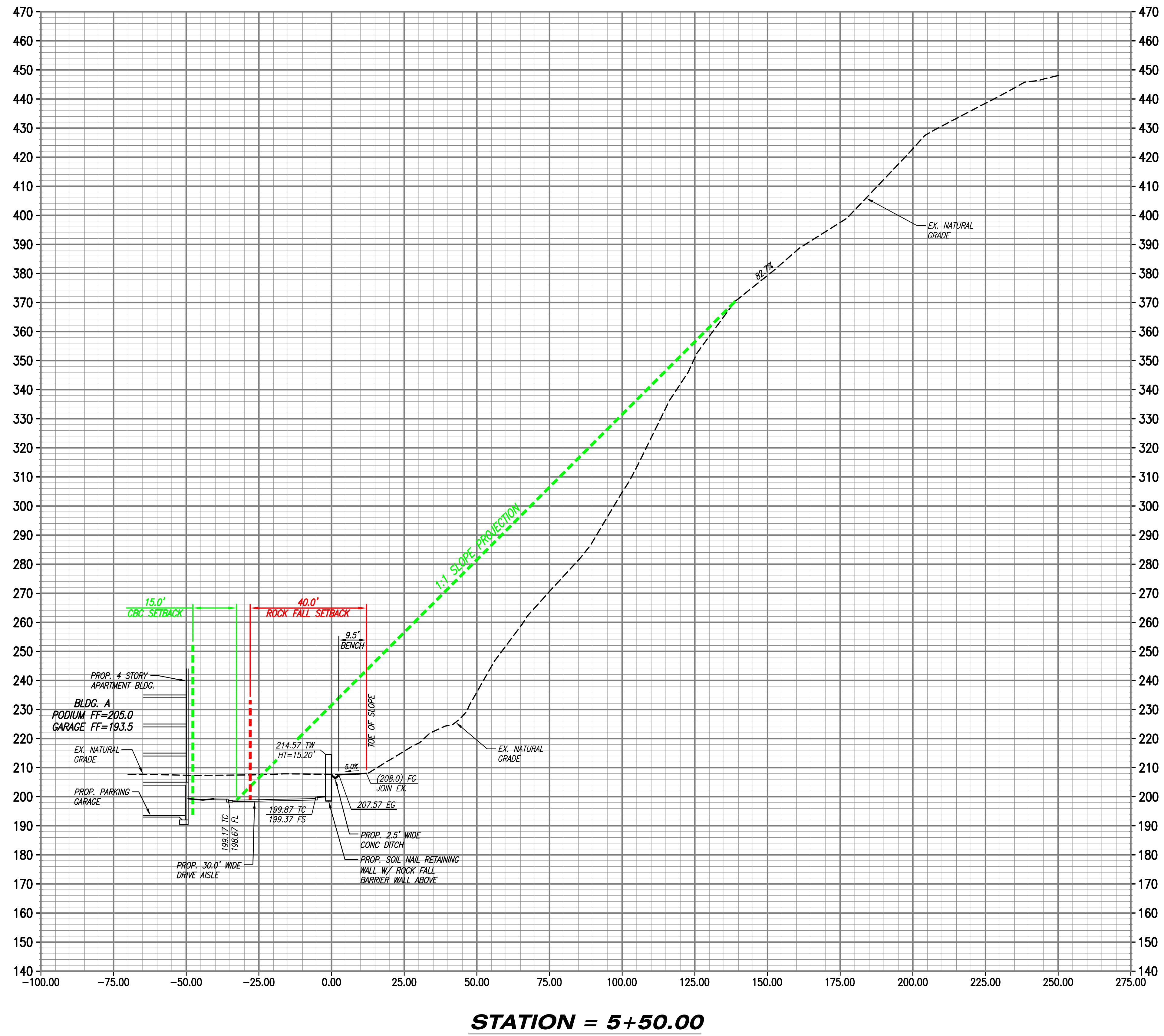
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SLOPE SECTION (RETAINING WALL "A") - STATION 3+80.00 SHEET C-12

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R:\Reylen\Reylen-Torrance\03\Pre\Drawings\03day\03-C800-BSE.dwg April 07, 2017 - 4:45pm Mike Thomas



STATION = 5+50.00

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 - - - - - CBC SETBACK LINE
 - - - - - ROCK FALL SETBACK LINE

(SCALE: 1"=20')

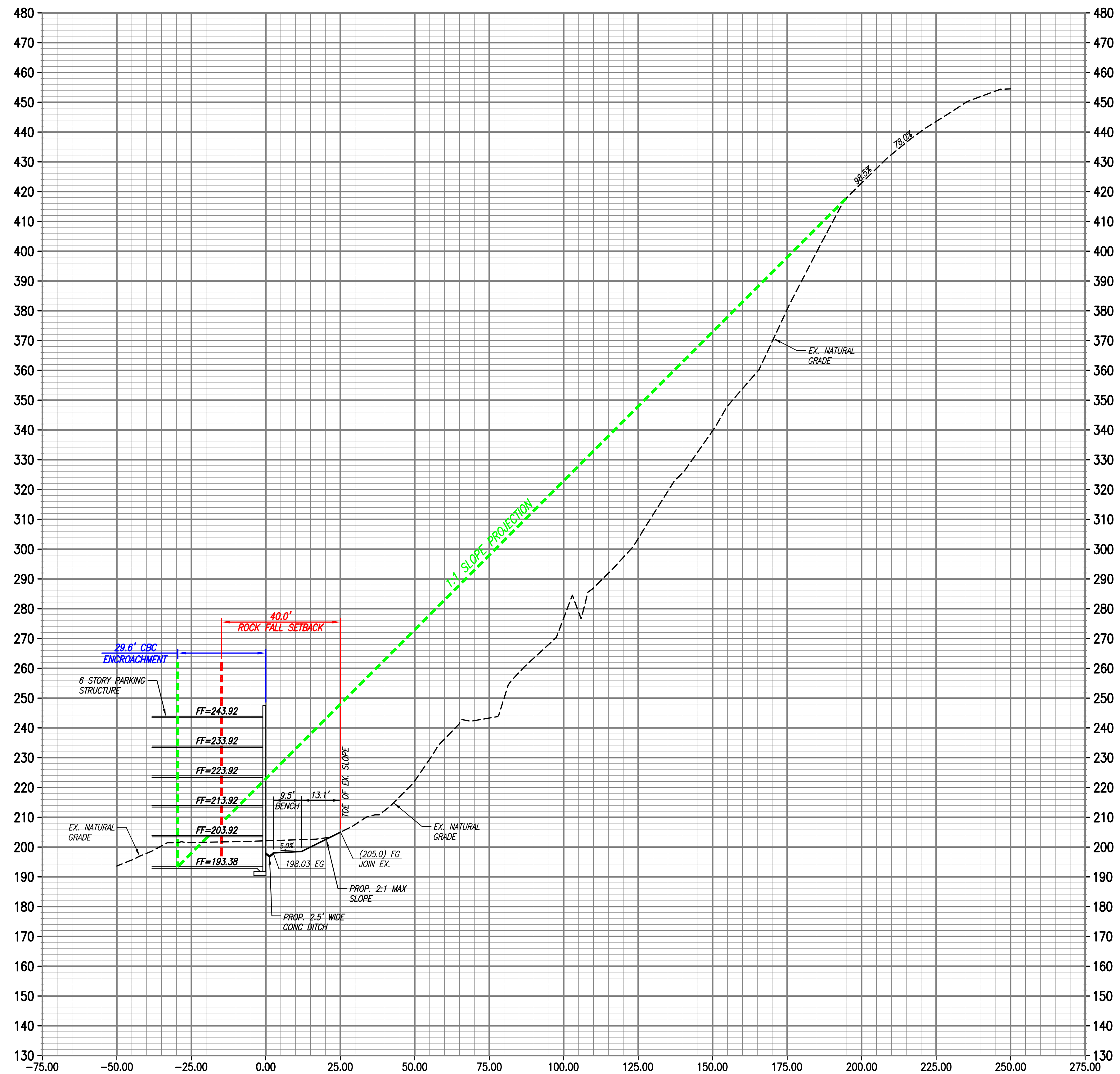
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SLOPE SECTION (RETAINING WALL "A") - STATION 5+50.00 SHEET C-13

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R:\Reylen\Reylen-Torrance\03\Pre\Reylen\03\Station 5+50.00\03-08-2017 - 4:45pm Mike Thomas



STATION = 7+50.00

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- - - - - ROCK FALL SETBACK LINE

(SCALE: 1"=20')

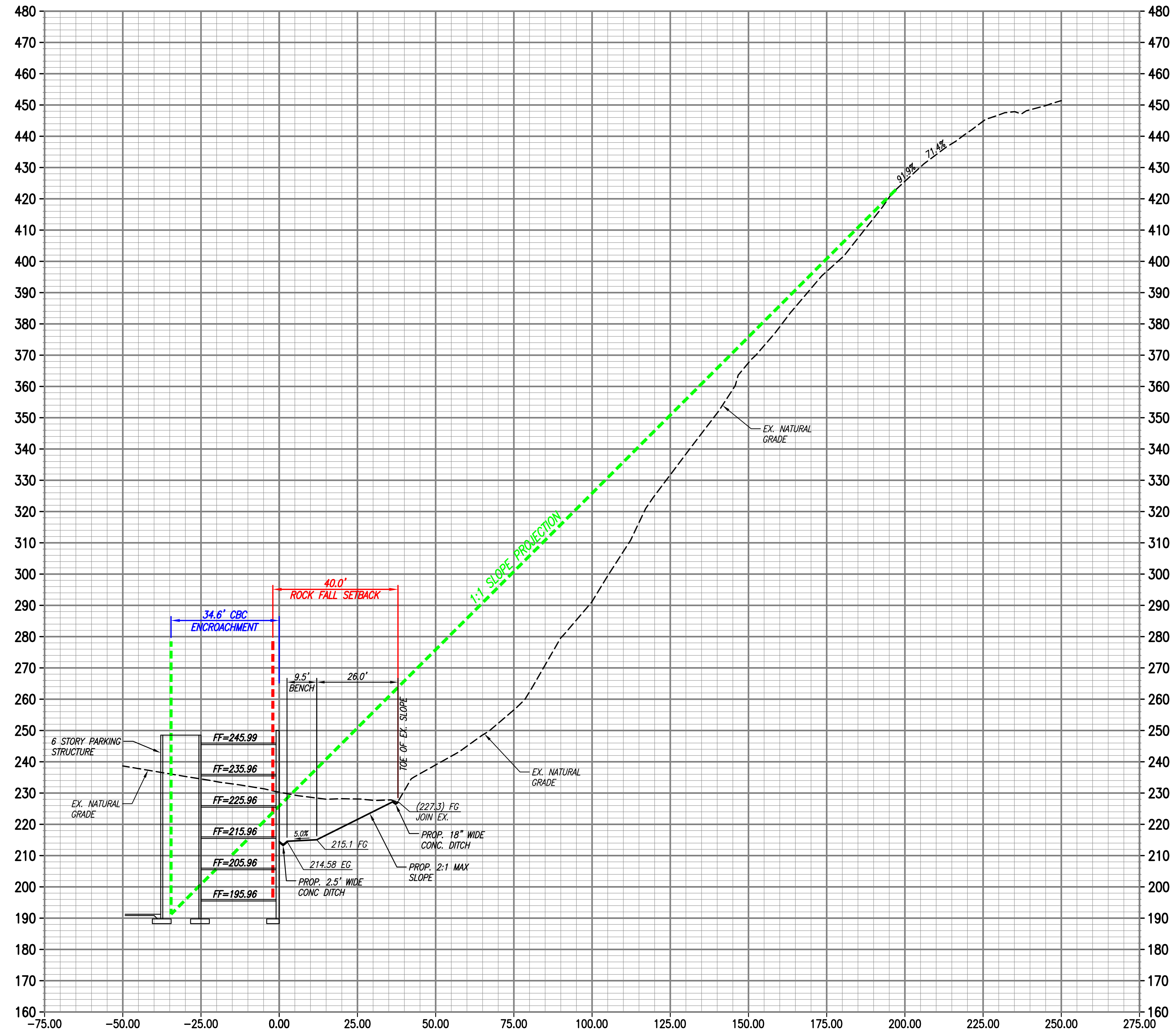
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SLOPE SECTION (RETAINING WALL "A") - STATION 7+50.00 SHEET C-14

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STATION = 9+50.00

LEGEND:

- CBC SETBACK LINE
- ROCK FALL SETBACK LINE

(SCALE: 1"=20')

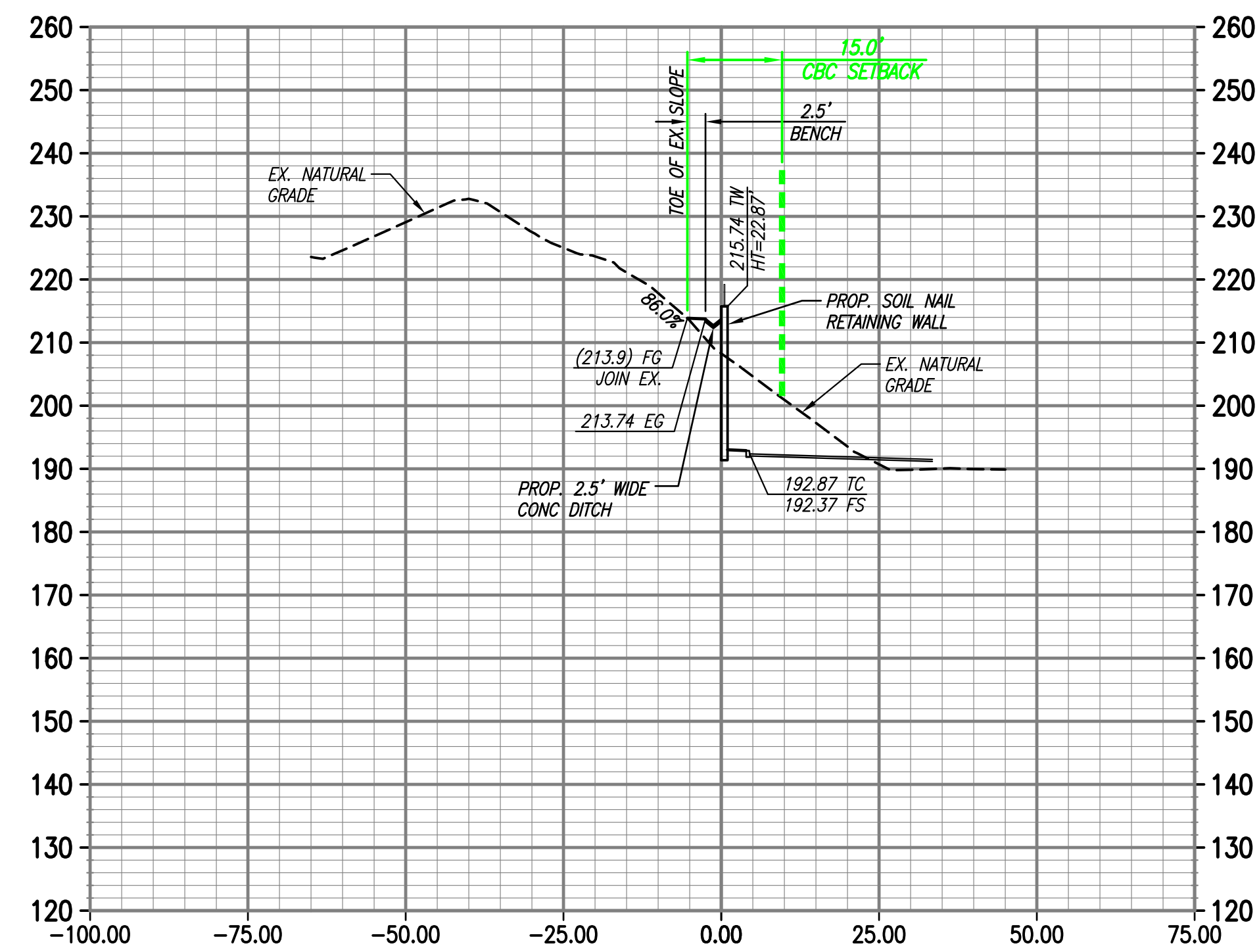
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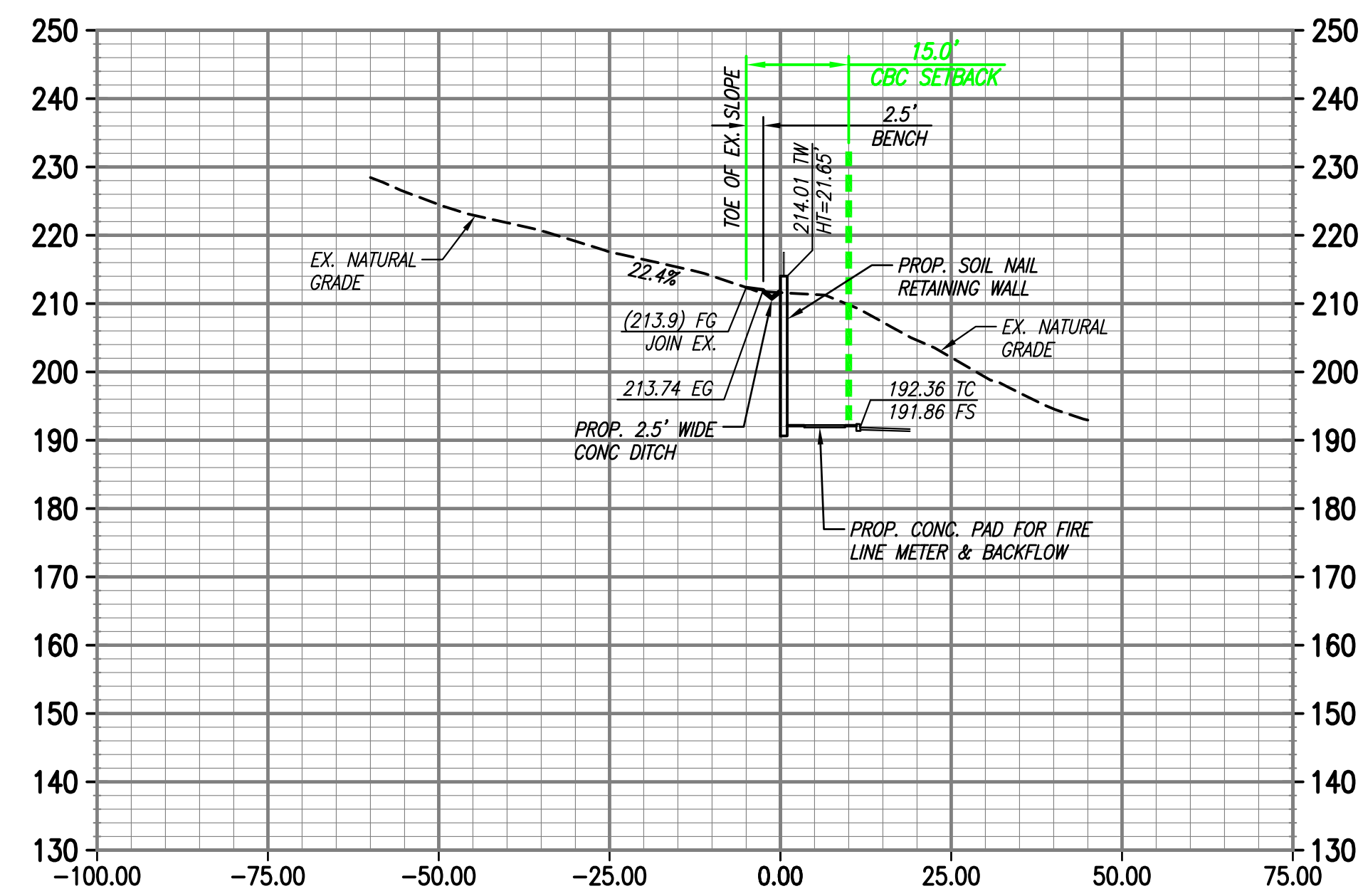
SLOPE SECTION (RETAINING WALL "A") - STATION 9+50.00 SHEET C-15

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STATION = 0+65.00



STATION = 1+65.00

LEGEND:

- CBC SETBACK LINE
- ROCK FALL SETBACK LINE

(SCALE: 1"=20')

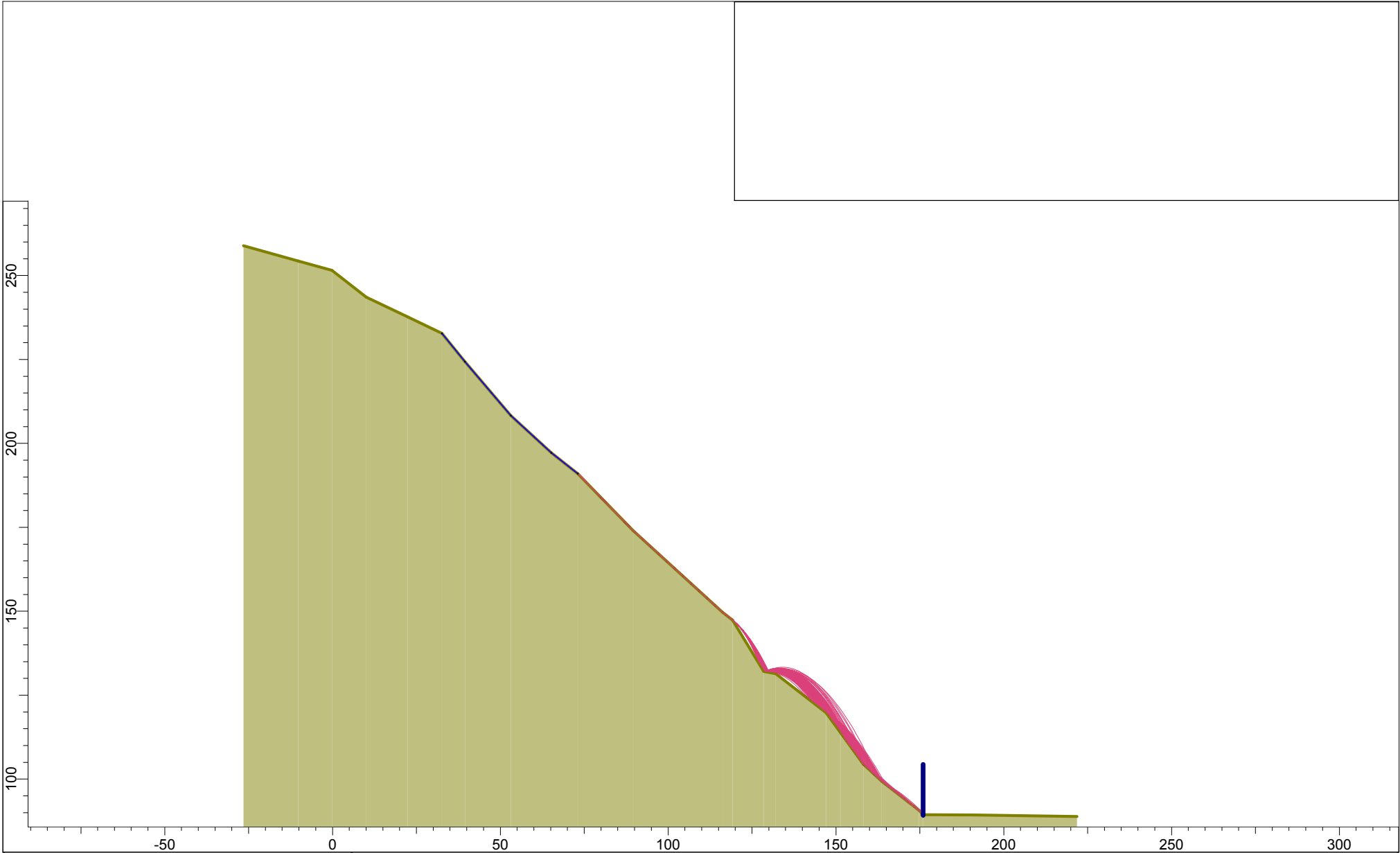
SOLANA


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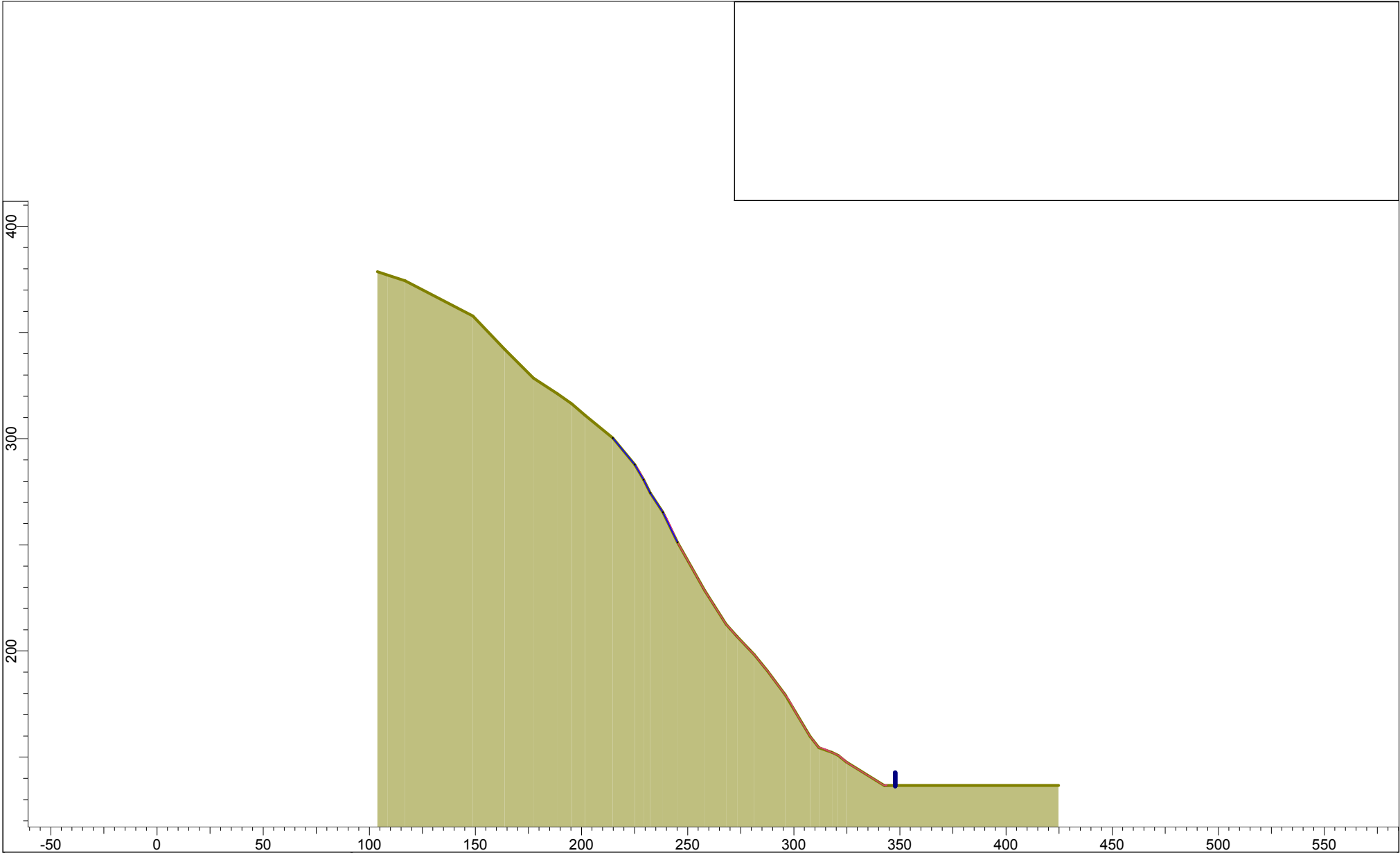
SLOPE SECTION (RETAINING WALL "B") - STATION 1+15.00 & 2+45.00 SHEET C-17

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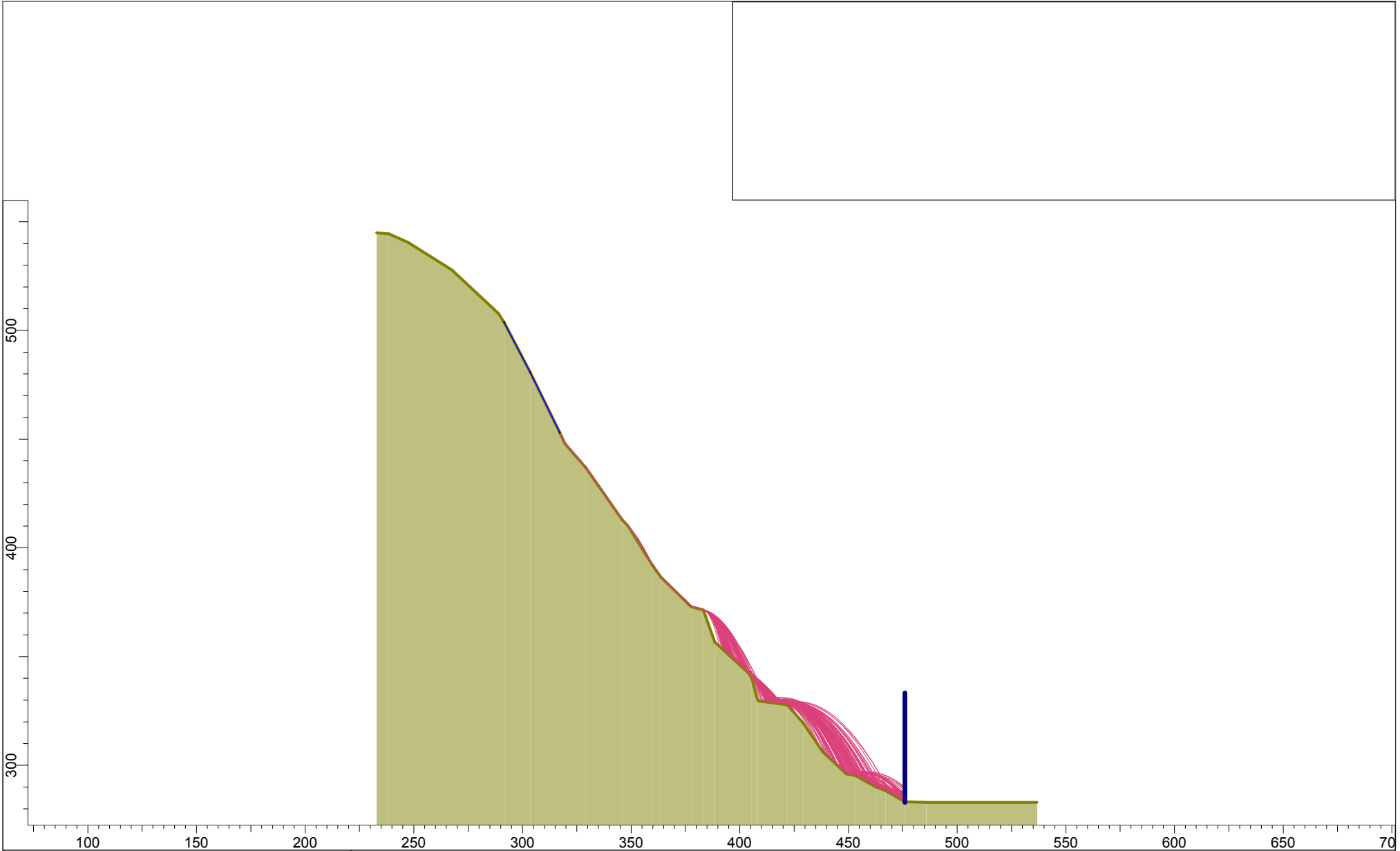



	<i>Project</i> STA 3+80 with Barrier	
	<i>Analysis Description</i>	
	<i>Drawn By</i>	<i>Company</i>
	<i>Date</i> 5/6/2017, 12:51:04 PM	<i>File Name</i> New 3+80.fal6

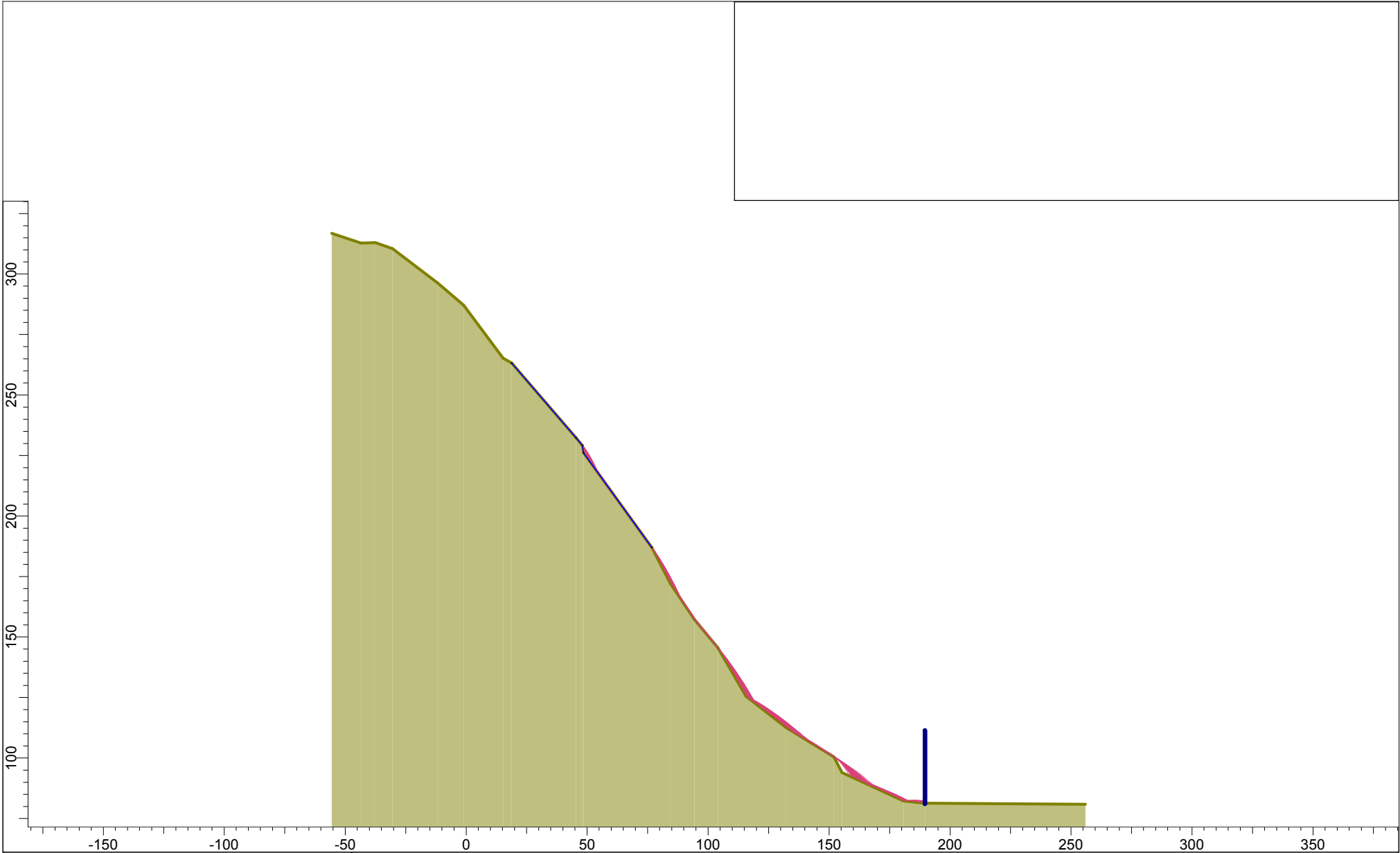



ROCFALL 6.004

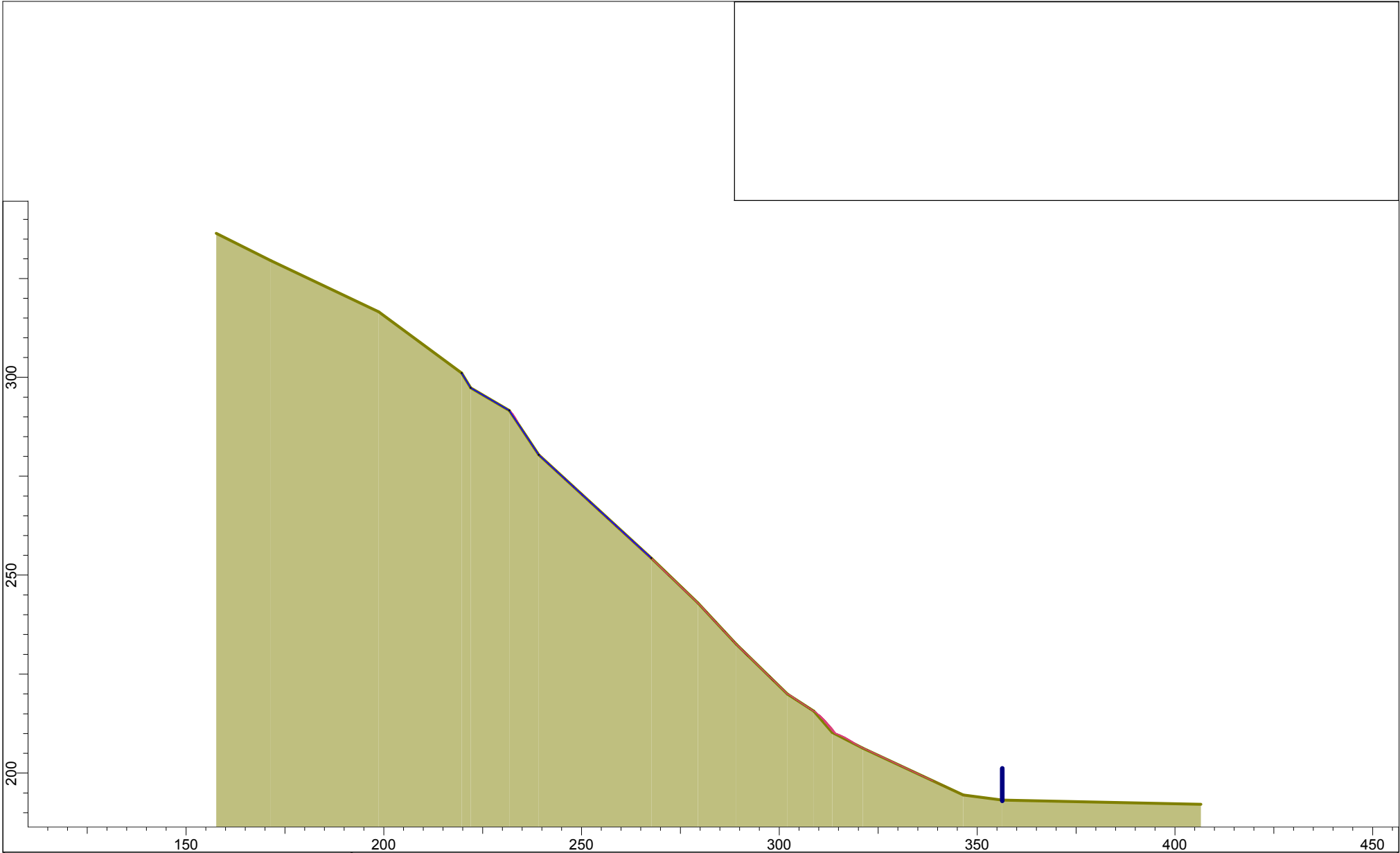
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<i>Analysis Description</i>			
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<i>Date</i>		<i>File Name</i>	
5/6/2017, 12:59:09 PM		New 5+50.fal6	




	<i>Project</i> STA 7+50 with Barrier	
	<i>Analysis Description</i>	
	<i>Drawn By</i>	<i>Company</i>
	<i>Date</i> 5/6/2017, 1:01:38 PM	<i>File Name</i> New 7+50.fal6



	<i>Project</i> STA 9+50 with Barrier	
	<i>Analysis Description</i>	
	<i>Drawn By</i>	<i>Company</i>
	<i>Date</i> 5/6/2017, 1:03:21 PM	<i>File Name</i> New 9+50.fal6



	<i>Project</i> STA 11+25 with Barrier	
	<i>Analysis Description</i>	
	<i>Drawn By</i>	<i>Company</i>
	<i>Date</i> 5/6/2017, 1:04:46 PM	<i>File Name</i> New 11+25.fal6

RocFall Analysis Information

Project Summary

File Name New 3+80

File Version 6.004

Date Created 5/6/2017, 12:51:04 PM

Project Settings

General Settings:

Engine Lump Mass
Units Imperial Foot-Pounds (ft, lb, ft-lb)
Rock Throw Mode Number of rocks controlled by seeder

Engine Conditions:

Friction Angle Use friction angle from material editor
Consider Angular Velocity Yes
Maximum time per rock 5s
Maximum steps per rock 20000
Normal velocity cutoff 0.33ft/s
Stopped velocity cutoff 0.33ft/s
Maximum timestep 0.01s
Switch Velocity -3.3e-009ft/s

Random Number Generation:

Sampling Method Monte-Carlo
Random Seed Pseudo-random seed: 12345234

Slope Geometry

Vertex	X	Y	X Std.Dev.	Y Std.Dev.
1	-26.5698	258.883		
2	-10.2431	254.314		
3	-0.178098	251.497		
4	10.0021	243.543		
5	22.4104	237.668		
6	32.5329	232.772		
7	39.3902	224.286		
8	53.1046	208.294		
9	65.1864	197.197		
10	73.0232	190.995		
11	89.5407	174.02		
12	116.171	149.706		
13	119.116	147.402		
14	128.462	132.046		
15	132.047	131.406		
16	146.996	119.783		
17	151.338	113.755		
18	158.092	104.433		
19	163.56	99.3693		
20	174.656	90.6895		
21	175.942	89.4036		
22	190.656	89.3232		
23	221.747	88.8488		

Slope Material Assignment

Material	From Vertex	To Vertex
Bedrock Outcrops 1	1	23

Material Properties

Bedrock Outcrops 1

"Bedrock Outcrops 1" Properties

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.3	Normal	0.04	0.12	0.12
Tangential Restitution	0.8	Normal	0.04	0.12	0.12
Friction Angle (°)	30	None			
Slope Roughness (°)		None			

Seeders

Seeder 1

Seeder Properties

Name Seeder 1
 Location (32.5329, 232.772), (39.3902, 224.286), (53.1046, 208.294), (65.1864, 197.197), (73.0232, 190.995)

Rocks to Throw

Number of Rocks 100 Overall
 Rock Types Group 1, Group 1 1

Initial Conditions

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (ft/s)	1	Normal	0.15	0.45	0.45
Vertical Velocity (ft/s)	0	None			
Rotational Velocity (°/s)	0	None			
Initial Rotation (°/s)	0	Uniform		0	360

Rock Types

Group 1

Properties

Name Group 1
 Color 

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (lb)	2204.6	None			
Density (lb/ft ³)	168.56	None			

Group 1 1

Properties

Name Group 1 1
 Color 

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (lb)	1200	None			
Density (lb/ft ³)	100	None			

Barriers

Barrier 1

Name Barrier 1
 Type Fence
 Model Custom
 Capacity Infinite
 Location (175.942, 89.4036) to (175.942, 104.404)
 Length (ft) 15
 Sensitivity Barrier False

Fence Models

RocFall Analysis Information

Project Summary

File Name New 5+50

File Version 6.004

Date Created 5/6/2017, 12:59:09 PM

Project Settings

General Settings:

Engine Lump Mass
Units Imperial Foot-Pounds (ft, lb, ft-lb)
Rock Throw Mode Number of rocks controlled by seeder

Engine Conditions:

Friction Angle Use friction angle from material editor
Consider Angular Velocity Yes
Maximum time per rock 5s
Maximum steps per rock 20000
Normal velocity cutoff 0.33ft/s
Stopped velocity cutoff 0.33ft/s
Maximum timestep 0.01s
Switch Velocity -3.3e-009ft/s

Random Number Generation:

Sampling Method Monte-Carlo
Random Seed Pseudo-random seed: 12345234

Slope Geometry

Vertex	X	Y	X Std.Dev.	Y Std.Dev.
1	103.758	378.628		
2	108.545	377.033		
3	116.802	374.282		
4	148.833	357.659		
5	163.69	342.026		
6	177.297	328.426		
7	188.714	321.078		
8	195.439	316.389		
9	201.539	311.074		
10	214.676	300.287		
11	224.998	287.781		
12	229.221	280.59		
13	232.349	274.337		
14	238.344	265.276		
15	245.21	251.061		
16	257.959	228.514		
17	268.072	212.492		
18	273.27	206.708		
19	281.312	198.179		
20	287.589	190.533		
21	295.827	179.455		
22	307.609	159.706		
23	311.826	154.412		
24	318.005	152.158		
25	320.849	150.785		
26	324.682	147.637		
27	342.532	136.658		
28	424.771	136.634		

Slope Material Assignment

Material	From Vertex	To Vertex
Bedrock Outcrops 1	1	28

Material Properties

Bedrock Outcrops 1

"Bedrock Outcrops 1" Properties

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.3	Normal	0.04	0.12	0.12
Tangential Restitution	0.8	Normal	0.04	0.12	0.12
Friction Angle (°)	30	None			
Slope Roughness (°)		None			

Seeders

Seeder 1

Seeder Properties

Name	Seeder 1
Location	(214.676, 300.287), (224.998, 287.781), (229.221, 280.59), (232.349, 274.337), (238.344, 265.276), (245.21, 251.061)

Rocks to Throw

Number of Rocks	100 Overall
Rock Types	Group 1 1

Initial Conditions

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (ft/s)	1	Normal	0.15	0.45	0.45
Vertical Velocity (ft/s)	0	None			
Rotational Velocity (°/s)	0	None			
Initial Rotation (°/s)	0	Uniform		0	360

Rock Types

Group 1 1

Properties

Name	Group 1 1
Color	

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (lb)	1200	None			
Density (lb/ft ³)	100	None			

Barriers

Barrier 1

Name	Barrier 1
Type	Fence
Model	Custom
Capacity	Infinite
Location	(347.763, 136.656) to (347.763, 142.656)
Length (ft)	6
Sensitivity Barrier	False

Fence Models

RocFall Analysis Information

Project Summary

File Name New 7+50
 File Version 6.004

 Date Created 5/6/2017, 1:01:38 PM

Project Settings

General Settings:

Engine Lump Mass
 Units Imperial Foot-Pounds (ft, lb, ft-lb)
 Rock Throw Mode Number of rocks controlled by seeder

Engine Conditions:

Friction Angle Use friction angle from material editor
 Consider Angular Velocity Yes
 Maximum time per rock 5s
 Maximum steps per rock 20000
 Normal velocity cutoff 0.33ft/s
 Stopped velocity cutoff 0.33ft/s
 Maximum timestep 0.01s
 Switch Velocity -3.3e-009ft/s

Random Number Generation:

Sampling Method Monte-Carlo
 Random Seed Pseudo-random seed: 12345234

Slope Geometry

Vertex	X	Y	X Std.Dev.	Y Std.Dev.
1	232.881	544.807		
2	238.459	544.386		
3	247.405	540.389		
4	267.507	527.765		
5	288.871	507.778		
6	291.502	503.78		
7	303.5	480.743		
8	317.092	453.017		
9	319.618	447.757		
10	329.195	436.816		
11	345.833	412.913		
12	348.569	409.968		
13	359.639	392.118		
14	363.638	386.543		
15	377.53	372.868		
16	383.213	371.395		
17	388.476	356.667		
18	403.641	342.664		
19	405.43	340.139		
20	407.64	332.039		
21	408.377	329.515		
22	421.858	327.714		
23	429.124	319.381		
24	438.175	306.021		
25	449.022	296.012		
26	453.238	295.16		
27	462.499	290.005		
28	466.999	288.25		
29	475.92	283.203		
30	485.851	282.866		
31	536.685	282.866		

Slope Material Assignment

Material	From Vertex	To Vertex
Bedrock Outcrops 1	1	31

Material Properties

Bedrock Outcrops 1

"Bedrock Outcrops 1" Properties					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.3	Normal	0.04	0.12	0.12
Tangential Restitution	0.8	Normal	0.04	0.12	0.12
Friction Angle (°)	30	None			
Slope Roughness (°)		None			

Seeders

Seeder 1

Seeder Properties

Name Seeder 1
 Location (291.502, 503.78), (303.5, 480.743), (317.092, 453.017)

Rocks to Throw

Number of Rocks 100 Overall
 Rock Types Group 1 1

Initial Conditions

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (ft/s)	1	None			
Vertical Velocity (ft/s)	0	None			
Rotational Velocity (°/s)	0	None			
Initial Rotation (°/s)	0	Uniform		0	360

Rock Types

Group 1 1

Properties

Name Group 1 1
 Color 

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (lb)	1200	None			
Density (lb/ft ³)	100	None			

Barriers

Barrier 1

Name Barrier 1
 Type Fence
 Model Custom
 Capacity Infinite
 Location (475.92, 283.203) to (475.92, 333.203)
 Length (ft) 50
 Sensitivity Barrier False

Fence Models

RocFall Analysis Information

Project Summary

File Name New 9+50

File Version 6.004

Date Created 5/6/2017, 1:03:21 PM

Project Settings

General Settings:

Engine Lump Mass
Units Imperial Foot-Pounds (ft, lb, ft-lb)
Rock Throw Mode Number of rocks controlled by seeder

Engine Conditions:

Friction Angle Use friction angle from material editor
Consider Angular Velocity Yes
Maximum time per rock 5s
Maximum steps per rock 20000
Normal velocity cutoff 0.33ft/s
Stopped velocity cutoff 0.33ft/s
Maximum timestep 0.01s
Switch Velocity -3.3e-009ft/s

Random Number Generation:

Sampling Method Monte-Carlo
Random Seed Pseudo-random seed: 12345234

Slope Geometry

Vertex	X	Y	X Std.Dev.	Y Std.Dev.
1	-55.578	316.766		
2	-43.4895	312.789		
3	-37.5218	312.942		
4	-30.4829	310.495		
5	-11.8146	296.271		
6	-1.10327	287.094		
7	15.2697	265.222		
8	18.7892	263.234		
9	45.4145	232.338		
10	48.0158	229.126		
11	48.4749	226.067		
12	76.7306	186.949		
13	84.4269	172.025		
14	94.2782	157.255		
15	103.976	145.562		
16	115.687	125.49		
17	132.206	112.528		
18	151.967	100.492		
19	155.363	94.0105		
20	180.836	82.2829		
21	189.636	81.357		
22	255.892	80.8764		

Slope Material Assignment

Material	From Vertex	To Vertex
Bedrock Outcrops	1	22

Material Properties

Bedrock Outcrops

"Bedrock Outcrops" Properties					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.35	Normal	0.04	0.12	0.12
Tangential Restitution	0.85	Normal	0.04	0.12	0.12
Friction Angle (°)	30	None			
Slope Roughness (°)		None			

Seeders

Seeder 1

Seeder Properties

Name Seeder 1
 Location (18.7892, 263.234), (45.4145, 232.338), (48.0158, 229.126), (48.4749, 226.067), (76.7306, 186.949)

Rocks to Throw

Number of Rocks 100 Overall
 Rock Types Group 1 1

Initial Conditions

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (ft/s)	1	None			
Vertical Velocity (ft/s)	0	None			
Rotational Velocity (°/s)	0	None			
Initial Rotation (°/s)	0	Uniform		0	360

Rock Types

Group 1 1

Properties

Name Group 1 1
 Color 

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (lb)	1200	None			
Density (lb/ft ³)	100	None			

Barriers

Barrier 1

Name Barrier 1
 Type Fence
 Model Custom
 Capacity Infinite
 Location (189.636, 81.357) to (189.636, 111.357)
 Length (ft) 30
 Sensitivity Barrier False

Fence Models

RocFall Analysis Information

Project Summary

File Name New 11+25
File Version 6.004

Date Created 5/6/2017, 1:04:46 PM

Project Settings

General Settings:

Engine Lump Mass
Units Imperial Foot-Pounds (ft, lb, ft-lb)
Rock Throw Mode Number of rocks controlled by seeder

Engine Conditions:

Friction Angle Use friction angle from material editor
Consider Angular Velocity Yes
Maximum time per rock 5s
Maximum steps per rock 20000
Normal velocity cutoff 0.33ft/s
Stopped velocity cutoff 0.33ft/s
Maximum timestep 0.01s
Switch Velocity -3.3e-009ft/s

Random Number Generation:

Sampling Method Monte-Carlo
Random Seed Pseudo-random seed: 12345234

Slope Geometry

Vertex	X	Y	X Std.Dev.	Y Std.Dev.
1	157.632	336.358		
2	171.417	329.469		
3	198.7	316.551		
4	219.665	301.05		
5	221.963	297.318		
6	231.727	291.577		
7	239.194	280.381		
8	267.627	254.259		
9	279.407	242.946		
10	289.118	232.521		
11	302.065	219.939		
12	308.719	215.625		
13	313.395	210.232		
14	321.127	206.278		
15	346.484	194.414		
16	356.374	193.156		
17	406.547	192.077		

Slope Material Assignment

Material	From Vertex	To Vertex
Bedrock Outcrops	1	17

Material Properties

Bedrock Outcrops

"Bedrock Outcrops" Properties

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.3	Normal	0.04	0.12	0.12
Tangential Restitution	0.8	Normal	0.04	0.12	0.12
Friction Angle (°)	30	None			
Slope Roughness (°)		None			

Seeders

Seeder 1

Seeder Properties

Name Seeder 1
 Location (219.665, 301.05), (221.963, 297.318), (231.727, 291.577), (239.194, 280.381), (267.627, 254.259)

Rocks to Throw

Number of Rocks 100 Overall
 Rock Types Group 1 1

Initial Conditions

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (ft/s)	1	Normal	0.15	0.45	0.45
Vertical Velocity (ft/s)	0	None			
Rotational Velocity (°/s)	0	None			
Initial Rotation (°/s)	0	Uniform		0	360

Rock Types

Group 1 1

Properties

Name Group 1 1
 Color 

	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (lb)	1200	None			
Density (lb/ft ³)	100	None			

Barriers

Barrier 1

Name Barrier 1
 Type Fence
 Model Custom
 Capacity Infinite
 Location (356.374, 193.156) to (356.374, 201.156)
 Length (ft) 8
 Sensitivity Barrier False

Fence Models

Barrier Report

Barrier Entity Properties

Barrier Name	Barrier 1
Capacity	Infinite
Height	15.00ft
Hits	100 / 100 rocks

Impact Statistics

Based on actual values for all impacted rocks.

	95% Percentile	Mean	Minimum	Maximum
Impact Along Height	0.22ft	0.19ft	0.04ft	0.83ft
Translational Velocity	27.52ft/s	22.07ft/s	16.46ft/s	40.76ft/s
Translation Energy	23703.23ft-lb	13523.05ft-lb	5052.57ft-lb	56182.47ft-lb

Barrier Design

Name	RMC 050 ICAT/2
Manufacturer	Maccaferri
Certification	ETAG 027
Rated Capacity	500.0kJ
Min Height	9.8m
Max Height	11.5m

The modeled barrier height of 15.00ft is larger than barrier standard maximum height 11.48ft. For non standard heights, please contact the producer.

Tested Values	Capacity	Elongation	Residual Height
MEL	534kJ	3.4m	60.5%
SEL	186kJ	2.70 m	74.7 %

Verification per UNI 11211:4

Based on selected percentile for height and velocity of impacted rocks and supplied parameters.

Design Parameters

Design Procedure MEL

Barrier Parameters

Capacity C 393878.4 ft-lb
0

Maximum Elongation 11.15 ft

Residual Height 60.5 %

Input Parameters

Rock Mass M 1000.00 lb

Rock Density 2700.00 lb/ft³

Rock Volume 0.370 ft³

Avg. Rock Radius R 0.446 ft

Separation Distance 0.00 ft

Free Border f_{\min} 0.00 ft

Model Output

Impact Along Height H_t 0.22 ft 95th percentile

Impact Velocity V_t 27.52 ft/s 95th percentile

Safety Coefficients

Quality of topographic survey γ_{dp} 1.00

Precision of block survey γ_{vol} 1.00

Evaluation of the unit weight of rock γ_γ 1.00

Reliability of rockfall simulation	γ_{Tr}	1.00
Impact energy	γ_R	1.00
Barrier capacity	γ_E	1.00
Barrier deformation	γ_d	1.00
Radius of block	γ_{Rb}	1.00

Design Parameters

Design Mass	M_d	1000.00 lb	$M \gamma_{vol} \gamma_\gamma$
Design Velocity	V_d	27.52 ft/s	$V_t \gamma_{tr} \gamma_{dp}$
Design Energy	E_d	11765.32 ft-lb	$(0.5 M_d V_d^2) \gamma_R$
Design Impact Along Height	H_d	1.17 ft	$H_t \gamma_{tr} \gamma_{dp} + R \gamma_{Rb} + f_{min}$
Design Barrier Deformation	D_d	11.15 ft	$D \gamma_d$
Design Barrier Height		15.00 ft	H_{total}
Design Barrier Capacity		393878.4 0 ft-lb	$E_{barrier} / \gamma_E$

Verification

Energy	11765.32 <= 393878.40	Valid
Height	1.17 <= 15.00	Valid
Elongation	11.15 > 0.00	Invalid

Residual Height

Barrier Height	9.1 ft
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Barrier Report

Barrier Entity Properties

Barrier Name	Barrier 1
Capacity	Infinite
Height	50.00ft
Hits	97 / 100 rocks

Impact Statistics

Based on actual values for all impacted rocks.

	95% Percentile	Mean	Minimum	Maximum
Impact Along Height	4.49ft	1.09ft	0.00ft	6.56ft
Translational Velocity	39.63ft/s	31.65ft/s	5.23ft/s	42.09ft/s
Translation Energy	29288.43ft-lb	19415.32ft-lb	510.73ft-lb	33033.42ft-lb

Barrier Design

Name	RMC 050 ICAT/2
Manufacturer	Maccaferri
Certification	ETAG 027
Rated Capacity	500.0kJ
Min Height	9.8m
Max Height	11.5m

The modeled barrier height of 50.00ft is larger than barrier standard maximum height 11.48ft. For non standard heights, please contact the producer.

Tested Values	Capacity	Elongation	Residual Height
MEL	534kJ	3.4m	60.5%
SEL	186kJ	2.70 m	74.7 %

Verification per UNI 11211:4

Based on selected percentile for height and velocity of impacted rocks and supplied parameters.

Design Parameters

Design Procedure MEL

Barrier Parameters

Capacity C 393878.4 ft-lb
0

Maximum Elongation 11.15 ft

Residual Height 60.5 %

Input Parameters

Rock Mass M 1000.00 lb

Rock Density 2700.00 lb/ft³

Rock Volume 0.370 ft³

Avg. Rock Radius R 0.446 ft

Separation Distance 0.00 ft

Free Border f_{\min} 0.00 ft

Model Output

Impact Along Height H_t 4.49 ft 95th percentile

Impact Velocity V_t 39.63 ft/s 95th percentile

Safety Coefficients

Quality of topographic survey γ_{dp} 1.00

Precision of block survey γ_{vol} 1.00

Evaluation of the unit weight of rock γ_γ 1.00

Reliability of rockfall simulation	γ_{Tr}	1.00
Impact energy	γ_R	1.00
Barrier capacity	γ_E	1.00
Barrier deformation	γ_d	1.00
Radius of block	γ_{Rb}	1.00

Design Parameters

Design Mass	M_d	1000.00 lb	$M \gamma_{vol} \gamma_\gamma$
Design Velocity	V_d	39.63 ft/s	$V_t \gamma_{tr} \gamma_{dp}$
Design Energy	E_d	24406.87 ft-lb	$(0.5 M_d V_d^2) \gamma_R$
Design Impact Along Height	H_d	5.43 ft	$H_t \gamma_{tr} \gamma_{dp} + R \gamma_{Rb} + f_{min}$
Design Barrier Deformation	D_d	11.15 ft	$D \gamma_d$
Design Barrier Height		50.00 ft	H_{total}
Design Barrier Capacity		393878.4 0 ft-lb	$E_{barrier} / \gamma_E$

Verification

Energy	24406.87 <= 393878.40	Valid
Height	5.43 <= 50.00	Valid
Elongation	11.15 > 0.00	Invalid

Residual Height

Barrier Height	30.3 ft
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Barrier Report

Barrier Entity Properties

Barrier Name	Barrier 1
Capacity	Infinite
Height	30.00ft
Hits	87 / 100 rocks

Impact Statistics

Based on actual values for all impacted rocks.

	95% Percentile	Mean	Minimum	Maximum
Impact Along Height	0.85ft	0.24ft	0.00ft	0.96ft
Translational Velocity	40.13ft/s	25.27ft/s	1.79ft/s	45.33ft/s
Translation Energy	30034.60ft-lb	14795.12ft-lb	59.45ft-lb	38321.38ft-lb

Barrier Design

Name	RMC 050 ICAT/2
Manufacturer	Maccaferri
Certification	ETAG 027
Rated Capacity	500.0kJ
Min Height	9.8m
Max Height	11.5m

The modeled barrier height of 30.00ft is larger than barrier standard maximum height 11.48ft. For non standard heights, please contact the producer.

Tested Values	Capacity	Elongation	Residual Height
MEL	534kJ	3.4m	60.5%
SEL	186kJ	2.70 m	74.7 %

Verification per UNI 11211:4

Based on selected percentile for height and velocity of impacted rocks and supplied parameters.

Design Parameters

Design Procedure MEL

Barrier Parameters

Capacity C 393878.4 ft-lb
0

Maximum Elongation 11.15 ft

Residual Height 60.5 %

Input Parameters

Rock Mass M 1000.00 lb

Rock Density 2700.00 lb/ft³

Rock Volume 0.370 ft³

Avg. Rock Radius R 0.446 ft

Separation Distance 0.00 ft

Free Border f_{\min} 0.00 ft

Model Output

Impact Along Height H_t 0.85 ft 95th percentile

Impact Velocity V_t 40.13 ft/s 95th percentile

Safety Coefficients

Quality of topographic survey γ_{dp} 1.00

Precision of block survey γ_{vol} 1.00

Evaluation of the unit weight of rock γ_γ 1.00

Reliability of rockfall simulation	γ_{Tr}	1.00
Impact energy	γ_R	1.00
Barrier capacity	γ_E	1.00
Barrier deformation	γ_d	1.00
Radius of block	γ_{Rb}	1.00

Design Parameters

Design Mass	M_d	1000.00 lb	$M \gamma_{vol} \gamma_\gamma$
Design Velocity	V_d	40.13 ft/s	$V_t \gamma_{tr} \gamma_{dp}$
Design Energy	E_d	25026.90 ft-lb	$(0.5 M_d V_d^2) \gamma_R$
Design Impact Along Height	H_d	1.80 ft	$H_t \gamma_{tr} \gamma_{dp} + R \gamma_{Rb} + f_{min}$
Design Barrier Deformation	D_d	11.15 ft	$D \gamma_d$
Design Barrier Height		30.00 ft	H_{total}
Design Barrier Capacity		393878.4 0 ft-lb	$E_{barrier} / \gamma_E$

Verification

Energy	25026.90 <= 393878.40	Valid
Height	1.80 <= 30.00	Valid
Elongation	11.15 > 0.00	Invalid

Residual Height

Barrier Height	18.1 ft
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