Design Level Geotechnical Investigation and Geologic Hazards Study Report
Terra Linda High School
320 Nova Albion Way
San Rafael, Marin County, California

Site

August 15, 1959 Aerial Photograph (looking southwest)

SUBMITTED TO:

San Rafael City Schools
c/o Ryan Leahy, Van Pelt Construction Services
310 Nova Albion Way, Room 505
San Rafael, CA 94903
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February 16, 2018

A3GEO

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RE: Design Level Geotechnical Investigation and Geologic Hazards Study Report
Terra Linda High School
320 Nova Albion Way
San Rafael, Marin County, California

Dear Mr. Leahy,

This report presents the results of a design level geotechnical investigation and geologic hazard study by A3GEO, Inc. (A3GEO), and Lettis Consultants International, Inc., for planned improvements to Terra Linda High School (TLHS) in San Rafael, California. Our services were authorized by the San Rafael City Schools (District) under Modification #1, dated 25 September 2017, to an Independent Consultant Agreement for Professional Services originally entered on January 3, 2017. The planned improvements discussed in this report and shown on the attached figures are based on information obtained from the Proposed Site Masterplan – SD Phase (HED, 2017a).

The attached report provides information on geotechnical, geologic and seismic conditions, presents our assessment of potential site hazards and constraints, and includes design level geotechnical recommendations intended for project evaluation in a manner intended to be consistent with the State of California requirements for public school construction (CGS, 2013). This report is a design-level study, intended to be used for the design and construction of the new buildings at TLHS discussed herein, and supersedes our previous report, titled "Preliminary Geotechnical Investigation and Geologic Hazards Study Report, Terra Linda High School, 320 Nova Albion Way, San Rafael, Marin County, California", dated 16 March 2017 (A3GEO, 2017), which preliminarily assessed geotechnical conditions and geologic hazards throughout the TLHS campus.

The conclusions and recommendations presented in this report were developed in accordance with generally-accepted geotechnical principles and practices at the time that the report was prepared. Should you have questions or comments concerning our findings, the design concepts discussed, or our recommendations, please do not hesitate to call.

Sincerely,

A3GEO, Inc.

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Attachments:

- Report
- Figure 1 – Site Location Plan
- Figure 2 – Site Plan
- Figure 3 – Exploration Location Plan – Phase 2 Area of Focus
- Figure 4 – Fault Map
- Figure 5 –Predevelopment Aerial Photograph
- Figure 6 – Geologic Map
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- Appendix B – Phase 1 Cone Penetration Test Data
- Appendix C – Phase 1 Soil Boring Logs
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- Appendix E – Phase 1 Geotechnical Laboratory Test Data Sheets
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REPORT

1. INTRODUCTION

1.01 Overview

This report presents the results of a design level (Phase 2) geotechnical investigation and geologic hazards study performed by A3GEO for Terra Linda High School in San Rafael, California. Our services were authorized by the San Rafael City Schools (District) under Modification #1, dated 25 September 2017, to an Independent Consultant Agreement for Professional Services originally entered on January 3, 2017. The location of Terra Linda High School (TLHS) is shown on the Site Location Map (Figure 1), and the school address is 320 Nova Albion Way in San Rafael, California.

The 2016 SD Site Masterplan for TLHS (HED, 2017a) indicates that the current phase of the proposed project will include demolition of several existing structures and construction of several new structures, including a gymnasium, an art building, a mixed-use building containing a student commons, kitchen, black box theater, drama, and music facilities (student commons), and a small pad or unoccupied structure for an electrical switchgear (Figures 2 and 3). In March 2017, A3GEO issued a Preliminary Geotechnical Investigation and Geologic Hazards Study Report (Phase 1) (A3GEO, 2017), which addressed preliminary geotechnical, geologic and seismic conditions for the TLHS campus. This Phase 2 study supersedes the Phase 1 study and presents both geotechnical, geologic, and seismic conditions for the campus as a whole, and the results of a focused, design level evaluation for the proposed gymnasium, art building, student commons, and electrical switchgear. This study is intended to be consistent with the requirements of the State of California requirements for public school construction published by the California Geological Survey (CGS) (CGS, 2013). If, at a later date, additional structures or renovations (beyond the proposed gymnasium, art building, student commons, and electrical switchgear) are planned, an additional design level investigation may be required.

The A3GEO Phase 1 study included onsite investigations including soil borings and cone penetration tests (CPTs) to characterize general site subsurface conditions (Figure 2). This latest (Phase 2) investigation included an additional nine (9) soil borings to evaluate the subsurface conditions at or near the footprints of the proposed gymnasium, art building, student commons, and electrical switchgear (Figures 2, 3, 5). Based on email communication with the project architect (HED) in November 2017, we understand that the proposed structures have the following total square footages and geometries:

Building Name	Number of Stories	Approximate Footprint Area
Gymnasium	1 to 2	18,552 sf[1] (over 1 story)
Art Building	1	4,836 sf
Student Commons	1 to 2	30,243 sf (over 2 stories)
Electrical Switchgear	0	450 sf

At the time of this report, schematic design drawings dated 2017 were available for the proposed student commons (HED, 2017c). The proposed student commons is a one to two story, Type II-A facility with steel frame and concrete filled steel pan upper floor and roof. The seismic force resisting system will consist of both steel braced frames and steel moment frames that will span approximately 40 feet.

Based on communication with the project architect, additional information beyond what is shown on the SD Site Masterplan layout (HED, 2017a) is not available for the art building, gymnasium, or electrical switchgear, as these structures are planned for future phases. According to HED, the art building will be a light gauge frame single story structure, and the gymnasium will be a steel braced frame with long span trusses. The gymnasium may have a two-story component for offices/classrooms, although that has not been determined at this point. No information was available regarding the proposed electrical switchgear.

[1] sf = square feet

1.02 Purpose and Scope

The primary purposes of the Phase 2 study were to (1) evaluate site conditions and geologic hazards in a manner consistent with State of California requirements for public school construction (CGS, 2013); and 2) develop design-level geotechnical conclusions and recommendations for the proposed gymnasium, art building, student commons, and electrical switchgear, to supplement the campus-wide study preliminary Phase 1 study (A3GEO, 2017). The scope of our Phase 2 services consisted of:

- Reviewing existing data;
- Performing site reconnaissance;
- Performing subsurface explorations consisting of soil borings at the locations of the proposed gymnasium, student commons, art building, and electrical switchgear;
- Performing geotechnical laboratory testing;
- Characterizing geotechnical and geologic conditions; and
- Preparing this design-level report in accordance with CGS Note 48.

Our scope of services did not include an environmental assessment or investigation of the site for the presence of toxic material in the soil, groundwater, or air.

1.03 Report Organization

The remainder of this report is organized as follows:

Section 2.00 describes our methods of investigation;
Section 3.00 describes the geologic, seismic and historical setting of the site;
Section 4.00 describes site-specific geotechnical and geologic conditions;
Section 5.00 presents our assessment of site geologic hazards;
Section 6.00 discusses geotechnical considerations for the proposed improvements;
Section 7.00 presents our recommendations for the proposed improvements;
Section 8.00 outlines the limitations of our study;
Section 9.00 presents a list of selected references.

2. METHODS OF INVESTIGATION

2.01 Review of Geologic, Seismic, and Historical Information

We reviewed a variety of published and unpublished references containing information on geologic, seismic and historical conditions. Selected references are described below; a list of references used in preparing this report is presented in Section 9.00.

The geologic references that we reviewed included maps prepared by Rice, Smith and Strand (1976); Blake, Graymer and Jones (2000); and Graymer, and others (2006). There are no zoned active faults within the USGS San Rafael 7.5 minute quadrangle so there is no official Alquist-Priolo Earthquake Fault Zones Map (A-P Map) for the site area. CGS also prepares Seismic Hazard Zone maps delineating zones of required investigation for earthquake-induced landsliding and liquefaction, but no map has yet been issued for the site area.

Geologic hazard maps prepared for the local General Plan are contained in California Division of Mines and Geology (CDMG) Open-File Report 76-2 (Rice, Smith and Strand, 1976); we reviewed the Slope Stability Map from this publication as well as the more recent map of Slides and Earth Flows in USGS Open-File Report 97-745C (Wentworth and others, 1997). The latest version of the Marin General Plan references the Liquefaction Susceptibility Map in USGS Open-File Report 00-444 (Knudsen et al., 2000), which we reviewed together with the accompanying Quaternary Deposits Map. We also reviewed the more recent liquefaction susceptibility and quaternary deposit maps by Witter and others (2006).

To evaluate flood hazards, we reviewed the Tsunami Inundation Map for Emergency Planning (CGS, 2009) and online flood maps prepared by the Federal Emergency Management Agency (FEMA) (FEMA, 2016).

The earliest historic map that we reviewed showing the site area was an 1873 map of Marin County (Austin, 1873). We also obtained historic aerial photographs of the TLHS campus area from Pacific Aerial Surveys (a Quantum Spatial Company) in Novato, California. In all, Pacific Aerial Surveys provided 10 vintages of geo-referenced aerial photographs taken between 1950 and 2016. The complete set of georeferenced aerial photographs with identifying information is attached in Appendix A. The 1950 aerial photograph is also reproduced on Figure 5. A 1959 aerial photograph of the school site during construction (Bradley, 1959) is presented on the cover of this report.

2.02 Cone Penetration Tests (CPTs)

On February 22, 2017, A3GEO advanced four cone penetration test borings (CPT-1 through CPT-4) at the approximate locations shown on Figures 2 and 5. The locations of the Phase 1 CPTs were selected to provide overall site coverage for geologic, geotechnical and seismic site characterization. Gregg Drilling & Testing, Inc. (Gregg) of Martinez California performed the CPTs using truck-mounted equipment. Information on the depths of the CPTs follows (elevations[2] shown derived from the available County-provided LiDAR dataset).

Summary of CPTs

Location	Proposed Structure	Surface Elevation (feet)	CPT Depth (feet)	Bottom of CPT Elevation (feet)
CPT-1	--	80.7	24.6	56.1
CPT-2	--	76.8	21.3	55.5
CPT-3	Gymnasium	79.1	22.6	56.5
CPT-4	Gymnasium	80.6	18.2	62.4

[2] Elevations in this report are in feet and refer to North American Vertical Datum of 1988 (NAVD 88). Some historic drawings for the site reference National Geodetic Vertical Datum of 1929 (NGVD 29). To convert from NVGD 29 to NAVD 88, add 2.67 ft (NOAA, 2018).

CPTs were advanced to practical refusal under the weight of a 30-ton truck.

Gregg's plots of measured cone tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u) are presented on CPT logs attached in Appendix B. Also presented are geotechnical material descriptions interpreted based on the normalized soil behavior type (SBT_N) as prescribed by Robertson, 1990. The attached CPT logs present data and interpretations pertaining to subsurface conditions at the indicated locations at the time that the CPTs were performed; the passage of time may result in changes in the subsurface conditions. The CPT locations indicated on Figures 2, 3 and 5 were determined by measuring from existing improvements and should be considered approximate. At the conclusion of the CPT investigation, the CPT holes were backfilled with grout.

2.03 Soil Borings

A3GEO advanced five soil borings (B-1 through B-5) as part of the Phase 1 investigation, and nine soil borings (A3-17-1 through A3-17-9), during the Phase 2 investigation. During both phases, borings were advanced by Gregg using an 8-inch outer diameter hollow-stem auger drill rig.

Soil samples were obtained using a 2-inch outside diameter Standard Penetration Test (SPT) sampler without liners and a 3-inch outside diameter Modified California (MC) sampler with liners. The samplers were driven using a standard 140-pound automatic hammer with an approximate 30-inch fall. The hammer blows required to drive the sampler the final 12 inches of each 18-inch drive are presented on the boring logs. Sampler blow counts obtained using the MC sampler were adjusted to approximate SPT N-values using a factor of 0.63 to account for differences in sampler end area. Where a full 12-inch drive could not be achieved, the number of blows and corresponding amount of sampler penetration are indicated on the logs.

During drilling, an A3GEO engineer visually/manually classified the soil in general accordance with ASTM D2488 classifications, which are based on the Unified Soil Classification System (USCS). Field classifications were subsequently checked and revised, where appropriate, based on laboratory test data. The logs of the Phase 1 soil borings are attached in Appendix C preceded by: 1) a Key to Exploratory Boring Logs that describes the USCS and the symbols used on the logs; and 2) a Key to Rock Descriptions. Logs of the Phase 2 soil borings are contained in Appendix D. Groundwater depth measurements made during and after drilling are shown on the logs. Following our groundwater depth measurements, the boreholes were backfilled with grout.

The boring logs represent our interpretation of the subsurface materials at the boring locations at the time of drilling and the passage of time may result in changes in the subsurface conditions. The boring locations indicated on Figures 2, 3 and 5 were determined by measuring from existing improvements and should be considered approximate.

2.03.1 Phase 1 Soil Borings

Phase 1 soil borings were advanced on 22 February 2017 using a truck-mounted drill rig, at the approximate locations shown on Figures 2, 3 and 5. The locations of the Phase 1 soil borings were selected to provide overall site coverage for geologic, geotechnical, and seismic site characterization. Information on the depths of the borings follows (elevations shown derived from the available County-provided LiDAR dataset).

Summary of Phase 1 Soil Borings

Location	Proposed Structure	Surface Elevation (feet)	Boring Depth (feet)	Bottom of Boring Elevation (feet)
B-1	--	81.1	16.3	64.8
B-2	Student Commons	81.2	13.3	67.9
B-3	--	81.0	21.0	60.0
B-4	Gymnasium	81.1	21.0	60.1
B-5	--	91.4	20.4	71.0

Each Phase 1 soil boring was terminated in bedrock.

2.03.2 Phase 2 Soil Borings

Nine (9) Phase 2 soil borings were advanced on 22 November 2017, at the approximate locations shown on Figures 2, 3, and 5. The locations of the Phase 2 test borings were selected to provide design-level data at the locations of the proposed gymnasium, student commons, art building, and electrical switchgear. Additionally, locations were selected to meet the requirements of CGS Note 48 (CGS, 2013), which requires one boring per 5000 square feet of footprint area, and a minimum of two borings per building (borings can be shared between adjacent structures). Borings A3-17-1, A3-17-3, A3-17-5, A3-17-6, and A3-17-7 were advanced with a Mobile B61 truck-mounted hollow stem auger rig. Borings A3-17-2, A3-17-4, A3-17-8, and A3-17-9 were advanced using a Rhino M5T limited access track rig, equipped with hollow stem augers. Information on the depths of the borings follows, and elevations shown were estimated from the recent site survey base plan (Figure 3) (HED, 2017b).

Summary of Phase 2 Soil Borings

Location	Proposed Structure	Surface Elevation (feet)	Boring Depth (feet)	Bottom of Boring Elevation (feet)
A3-17-1	Gymnasium	79.5	25.3	54.2
A3-17-2	Gymnasium	80.5	21.5	59.0
A3-17-3	Art / Student Commons	81.0	15.8	65.2
A3-17-4	Student Commons	80.5	15.0	65.5
A3-17-5	Student Commons	81.0	16.0	65.0
A3-17-6	Student Commons / Switchgear	81.0	11.4	69.6
A3-17-7	Art	81.0	19.9	61.1
A3-17-8	Student Commons	81.0	13.3	67.7
A3-17-9	Gymnasium	81.0	19.3	61.7

Each of the Phase 2 test borings, with the exception of A3-17-4, terminated in bedrock. A3-17-4 was terminated at 15 ft below ground surface after the hammer winch on the drill rig broke down.

2.04 Geotechnical Laboratory Tests

Samples from both the Phase 1 and Phase 2 soil borings were examined in our laboratory to check field classifications and assign laboratory tests. Our geotechnical laboratory testing program was directed toward a quantitative and qualitative evaluation of the physical properties of the soils that underlie the site. The following geotechnical laboratory tests were performed:

- Moisture content per ASTM D-2216;
- Dry density per ASTM D-2937;
- Atterberg limits per ASTM D-4318;

- Particle size distribution per ASTM D422; and
- Unconsolidated-Undrained Triaxial Compression per ASTM D2850.

The results of the tests are presented on the boring logs in Appendix C and D at the corresponding sample depths. Laboratory data sheets for Phase 1 are attached as Appendix E, and laboratory data sheets for Phase 2 are attached as Appendix F.

2.05 Previous Geotechnical Report

We reviewed the following geotechnical/geologic report provided to us by Miller Pacific Engineering Group (MPEG):

> ***MPEG, 2003 -*** Miller Pacific Engineering Group, 2003, "Geotechnical Investigation and Geologic Hazards Evaluation, Terra Linda High School, San Rafael, California," consulting report dated October 31, 2003, MPEG Project 779.12.

The referenced report includes the logs of borings and CPTs performed at the approximate locations shown on Figures 2, 3 and 5. The logs of MPEG's borings and CPTs are attached in Appendix G. The elevation datum used to denote ground surface elevations for the MPEG borings is unknown. Boring logs state that ground surface elevations refer to "City of San Rafael Topo Map, DPW, 1998" (MPEG, 2003), however no additional information is provided. A3GEO contacted the City of San Rafael Department of Public Works to inquire about this map, but were unsuccessful in learning what datum this map likely referenced. Based on the elevation shown, we believe it is likely that the elevations shown on the MPEG, 2003 logs refer to NGVD 29.; as such we converted these values to NAVD 88 when creating the cross sections (Figures 11 and 12).

2.06 Existing School Plans

We reviewed the following set of plans obtained from the District's archives:

> ***GM&P, 1958*** - Grommé Mulvin & Priestley (GM&P), 1958, *"New High School, San Rafael High School District for the Terra Linda Area, Marin County, California,"* 48-sheet plan set dated December 16, 1958.

Selected sheets from the referenced plan set are attached in Appendix H.

2.07 Site Survey

We reviewed the recent site survey provided to us by the project architect:

> ***HED, 2017b*** – Harley Ellis Devereaux (HED), 2017b, *Site Survey, "169113_Topo-TLHS_R2000.dwg"*, field survey dated 16 May 2017, received via email on 9 October 2017.

The site survey was used to generate the base plan on Figure 3.

3. GEOLOGIC, SEISMIC, AND HISTORICAL INFORMATION

3.01 Regional Geology

The geology of the San Francisco Bay Region includes three "basement" rock complexes; the Great Valley complex, the Franciscan Complex and the Salinian complex all of which are Mesozoic in age (225 to 65 million years old). Within the region, the Mesozoic basement rocks are locally overlain by a diverse sequence of Cenozoic Era (younger than 65 million years) sedimentary and volcanic rocks. Since their deposition, the Mesozoic and Cenozoic rocks have been extensively deformed by repeated episodes of folding and faulting. Significantly, the Bay Area experienced several episodes of uplift and faulting during the late Tertiary Period (about 25 million to 2 million years ago) that produced the region's characteristic northwest-trending mountain ranges and valleys.

World-wide climate fluctuations during the Pleistocene (about 1.8 million to 11 thousand years ago) resulted in several distinct glacial periods. A lowering of sea level accompanied each glacial advance as water became stored in vast ice sheets. Melting of the ice during warm intervals caused corresponding rises in sea level. High sea levels favored rapid and widespread deposition in the bay and surrounding floodplains. Low sea levels during glacial advances steepened the gradients of streams and rivers draining to the sea thereby encouraging erosional down cutting. The most recent glacial interval ended about 15,000 years ago. Evidence suggests that during the maximum extent of this latest glaciation, sea level was 300 to 400 feet below its present elevation and the valley now occupied by San Francisco Bay drained to the Pacific Ocean more than 30 miles west of the Golden Gate. Near the beginning of the Holocene age (about 11 thousand years ago) the rising sea re-entered the Golden Gate, and sediments accumulated rapidly beneath the rising San Francisco Bay and on the surrounding floodplains. The Holocene-age surface deposits are generally less dense and weaker than Pleistocene-age soils that predate the last sea level rise.

3.02 Regional Active Faults

Within the San Francisco Bay Region, the relative motion of the Pacific and North American crustal plates is presently accommodated by a series of northwest-trending active faults that exist over a width of more than 50 miles. Approximate distances and directions from the site to Bay Area active faults follow and are also shown on Figure 4:

Approximate Distances and Directions to Bay Area Active Faults (Jennings and Bryant, 2010)

Fault System	Approximate Distance from Site	Approximate Direction from Site
San Andreas	8.5 miles	West-southwest
San Gregorio	9.0 miles	West-southwest
Hayward	10.0 miles	East-northeast
Rodgers Creek	12.5 miles	East-northeast
West Napa[3]	21.0 miles	East-northeast
Concord-Green Valley	26.5 miles	East-northeast
Calaveras	31.0 miles	Southeast
Greenville – Clayton - Marsh Creek	33.0 miles	East-southeast

[3] In 2014, a Magnitude 6.0 earthquake occurred on the West Napa fault and as a consequence the southern extent of this feature is presently being reevaluated.

Faults that are defined as active typically exhibit: 1) evidence of Holocene-age (younger than 11,000 years) displacement, 2) measurable aseismic fault creep, 3) close proximity to linear concentrations or trends of earthquake epicenters, and/or 4) prominent tectonic-related geomorphology. The major faults listed in the preceding table are near-vertical and generally exhibit right-lateral strike-slip movement (which means that the movement is predominantly horizontal and when viewed from one side of the fault, the opposite side of the fault is observed as being displaced to the right).

3.03 Regional Seismicity

Since 1836, six earthquakes of magnitude 6.5 or greater have occurred in the Bay Area (Bakun, 1999); the dates, magnitudes (M) and epicentral locations of these six large earthquakes are summarized in the table that follows.

Magnitude 6.5 or Greater Earthquakes; 1836-1998
(Bakun, 1999; Tuttle and Sykes, 1992)

Date	Magnitude	Epicenter Location
June 10, 1836	6.5	East of Monterey Bay
June 1838	6.8 – 7.2	Peninsula section of the San Andreas fault
October 8, 1865	6.5	Southwest of San Jose
October 21, 1868	6.8	Southern Hayward fault (Hayward Earthquake)
April 18, 1906	7.8	San Andreas fault (San Francisco Earthquake)
October 18, 1989	6.9	Santa Cruz Mountains (Loma Prieta Earthquake)

The Working Group on California Earthquake Probabilities (WGCEP) has developed authoritative estimates of the magnitude, location, and frequency of future earthquakes in California, which are published in Uniform California Earthquake Forecast (UCERF) reports. The most recent forecast (UCERF3) indicates the following likelihoods for one or more earthquake events of the specified magnitude occurring within the San Francisco region in the next 30 years (starting in 2014).

San Francisco Region UCERF3 Forecast
(WGCEP, 2013)

Earthquake Magnitude (greater than or equal to)	30-year Likelihood of one or more earthquake events
≥ 5.0	100%
≥ 6.0	98%
≥ 6.7	72%
≥ 7.0	51%
≥ 7.5	20%
≥ 8.0	4%

The WGCEP has also made estimates of the likelihood of earthquakes with magnitude greater than or equal to 6.7 occurring on specific faults; these probabilities are summarized in the table that follows.

San Francisco Region UCERF3 Forecast
(Aagaard et al., 2016)

Earthquake Fault	30-year Likelihood of one or more earthquake events with M≥6.7
Hayward - Rodgers Creek	33%
Calaveras	26%
San Andreas	22%
Hunting Creek, Berryessa, Green Valley, Concord, Greenville	16%
Maacama	8%
San Gregorio	6%

Compared to the previous forecast (UCERF 2; WGCEP, 2008) the likelihoods of moderate-sized earthquakes (magnitude 6.5 to 7.5) are generally lower whereas those of larger events are higher. This change reflects a better understanding of the regional fault system and the potential for multi-fault ruptures on many faults.

3.04 Local Geology

As illustrated on the cover of this report, the TLHS campus is situated on a gentle, northeast-sloping alluvial fan bounded by lower hills of Mount Tamalpais to the south and a set of northwest-trending hills to the northeast. The hills in the direct vicinity of the site are comprised of Franciscan bedrock. The hills southwest of the site are part of a continuous range extending northwest from downtown San Rafael with localized peaks at elevations above +600 feet (USGS, 2015). To the northeast of the site are smaller isolated hills the closest of which to the campus rises to above elevation +200 feet. As shown on the Site Plan (Figure 2), the nearly-level and graded alluvial fan upon which TLHS is situated is about 2,000 feet wide.

The photograph on the cover of this report and the Predevelopment Aerial Photograph on Figure 5 show the alluvial fan upon which the school is presently located was once incised by at least two creeks emanating from the hills to the southwest and a creek along the northeastern property boundary that flows both northwest and southeast in the southeast portion of the site. These creeks appear to have been altered prior to 1950 and are now buried and presumably managed by a culvert or subsurface drain. The hill directly northeast of the school (upper right-hand quadrant of the photograph on Figure 5) blocks the flow of the creeks causing the former natural creek courses to turn northwest and merge to create a northwest-trending channel in the vicinity of CPT-3, A3-17-1, B-4, and CPT-4 (Figure 5).

A recent USGS geologic map[4] (Blake, Graymer and Jones, 2000) showing the site area is presented on Figure 6. Blake, Graymer and Jones (2000) map the hills that surround the TLHS campus predominantly as Franciscan Complex Mélange described as follows:

> ***Mélange (map symbol fsr) -*** *A tectonic mixture of variably sheared shale and sandstone containing (1) hard tectonic inclusions largely of greenstone, chert, graywacke, and their metamorphosed equivalents, plus exotic high-grade metamorphic rocks and serpentinite and (2) variably resistant masses of graywacke, greenstone, and serpentinite up to several miles in longest dimension, and including minor discrete masses of limestone too small to be shown. Blocks and resistant masses have survived the extensive shearing evident in the mélange's matrix, and range in abundance from less than 1 to 50 percent or more of the rock mass. The degree of shearing in the unit ranges from gouge to unsheared rock, with resistant masses relatively unsheared and matrix sheared. Severely sheared shale is abundant in areas where blocks are abundant. Fresh, relatively unsheared rock is hard, the larger resistant masses are pervasively fractured, and blocks are commonly tough and relatively unfractured.*

[4] Geologic maps generally show materials interpreted to be present at or near the ground surface.

Sandstone is graywacke, grayish green where fresh, weathering to brown, commonly medium to coarse grained, containing abundant angular lithic grains and no detrital potassium feldspar, except rarely as much as 5 percent. Graywacke is locally veined with quartz and carbonate, and usually contains microscopic secondary pumpellyite. Topography of coherent masses resembles that of unit Kfs, whereas highly sheared matrix typically yields subdued, gently-rounded topography.

An earlier geologic map by Rice, Smith and Strand (1976) shows the TLHS campus underlain by Quaternary (less than about 2.6 million year old) alluvium and colluvium; alluvium refers to deposits that have been deposited by streams whereas colluvium refers to soils that have moved downslope by gravity. Witter et al., 2006, (Figure 7) describe the surficial geology at the site as Holocene alluvial fan deposits (Witter et al., 2006). Blake, Graymer and Jones (2000; Figure 6) map the TLHS campus predominantly as Quaternary alluvium (Figure 6). The alluvium projects to the northeast where it merges with Holocene bay mud over several thousand feet to the northeast of the site. Blake, Graymer and Jones (2000) describe the alluvium as follows:

Alluvium, Quaternary (map symbol Qal)*—Sand, gravel, silt, and clay; loose to soft and friable*

As shown on Figure 6, Blake, Graymer and Jones (2000) also map a northwest-trending inferred fault below the front (northeast) part of the campus passing near Nova Albion Way and the creek bounding the northeastern property boundary. This inferred fault is the projection of a fault mapped in the hills farther to the northwest and is not considered active.

3.05 Liquefaction Mapping

Liquefaction is a phenomenon by which certain types of soils that are below groundwater can lose strength (liquefy), compress (settle) and gain mobility (flow) in response to earthquake groundshaking. Liquefaction is considered a geologic hazard and CGS has issued official seismic hazard maps showing “zones of require investigation” for liquefaction for many parts of California; however no such maps have yet been issued for Marin County.

The U. S. Geological Survey (USGS) has published maps of liquefaction susceptibility for the central San Francisco Bay Region (Knudsen et al., 2000; Witter et al., 2006). As shown on Figures 8a and 8b, both USGS maps show all of the TLHS campus within an area of “Moderate” liquefaction susceptibility. The main differences between the two maps pertains to the region east of the site where locations of previously mapped “High” liquefaction susceptibility were reduced to “Moderate” liquefaction susceptibility following completion of more detailed Quaternary mapping. The summary description for this liquefaction susceptibility category (from Witter et al., 2006) follows.

Expect about 20 to 30 percent of future liquefaction effects to occur within geologic units assigned MODERATE susceptibility (with about 1 occurrence for every 50 square kilometers). Geologic map units within this category include latest Pleistocene to Holocene deposits from a variety of environments. Gravel quarries and percolation ponds (historical) are also assigned to this category. Together, units assigned MODERATE susceptibility cover 2,314 square kilometers of the central San Francisco Bay region. About 25 percent of historical liquefaction occurrences fall within map units assigned MODERATE susceptibility (about 0.02 occurrences per square kilometer).

The referenced liquefaction susceptibility mapping by the USGS is based on accompanying regional-level maps of Quaternary deposits coupled with groundwater depth estimates, earthquake ground motion estimates, and documented historical accounts of liquefaction occurrence. As such, the USGS susceptibility maps (Figures 8a and 8b) are not “site-specific” as no onsite data was used in their development.

3.06 Landslide Mapping

Landsliding is considered a geologic hazard and CGS has issued official seismic hazard maps showing "zones of required investigation" for earthquake-induced landsliding for many parts of California; however no such maps have yet been issued for Marin County. The landslide map on Figure 9 (Wentworth et al., 1997) shows areas of "mostly landslides" at higher elevations in the hills southeast of the TLHS campus and areas of "few landslides" extending into adjacent residential neighborhoods and onto the far western portion of the TLHS campus. The subject site is roughly mapped as being within surficial deposits lacking landslides. Generalized explanations of the mapping shown on Figure 9 follow.

> ***Mostly Landslides -*** *consists of mapped landslides, intervening areas typically narrower than 1500 feet, and narrow borders around landslides.*
>
> ***Few Landslides -*** *contains few, if any, large mapped landslides, but locally contains scattered small landslides and questionably identified larger landslides.*
>
> ***Surficial Deposits -*** *Slides and earth flows do not occur on nearly flat ground -- they require slopes that are steep and long enough to permit failure. We can thus exclude gently sloping ground from principal consideration. This boundary typically occurs at a slope of about 15 percent.*

Comparisons between Figure 9 (Landslide Hazard Map) and Figure 6 (Geologic Map) suggest that the mapped area of "few landslides" within the TLHS campus correlates to the geologic mapping of Franciscan Mélange in the same area. An earlier geologic map that includes landslides (Rice, Smith and Strand, 1976) generally shows the TLHS campus as free of landslide deposits.

3.07 Site Development History

Sheet A1A of the 1958 plans for the school (GM&P, 1958; Appendix H) includes a Partial Site Plan and Profile at A-A' that provide data on the pre-development topography and grading of the TLHS campus. This data generally shows that the natural ground surface at the site sloped gently down from southwest to northeast and that the nearly-level pad upon which the new school buildings are located was constructed prior to December 1958 by cutting and filling. The drawing titled Profile at A-A' on Sheet A1A (Appendix H) shows maximum cut and fill heights of about 9 feet and 7 feet, respectively. The photograph on the cover of this report shows that the grading to develop the TLHS campus was essentially complete in August of 1959. Appendix A includes two vertical aerial photographs taken prior to site development, the most recent of which is dated March 1, 1958.

Foundation drawings from the 1958 plans for the school (GM&P; Appendix H), generally show buildings with concrete slab-on-grade floors and spread footing foundations typically extending to depths of 3 to 3-½ feet below the top-of-slab elevation. The Foundation Note on "Sheet S-2 of Building E" indicates:

> *Soil pressure does not exceed 2,000 lbs. per sq. ft. All footings to go to hard sand and clay or to shale rock at elevations shown. If necessary to reach firm material, lower footings below elevations shown as directed by the architect. Soil Data from R. S. Harding (Oct. 24, 1958).*

It is our understanding that the referenced Soil Data from R. S. Harding have not been located.

Appendix A includes vertical aerial photographs taken in 1950, 1958, 1970, 1975, 1982, 1986, 1992, 1996, 2000 and 2015. In general, it appears that the campus was fully-developed by 1970 with the exception of a single building that appears in the most recent (2015) photograph. This building was the subject of the 2003 geotechnical investigation and geologic hazard evaluation report by MPEG; the Site Plan in MPEG's report (included in Appendix G) identifies this building as a "New Performing Arts Facility." The MPEG (2003) report includes recommendations for a shallow foundation alternative, a drilled pier foundation alternative and concrete slab-on-grade floors.

4. SITE CONDITIONS

4.01 Surface Conditions

Surface conditions in the area of the TLHS campus are illustrated on the Site Plan (Figure 2). Figure 3 also provides information on surface conditions in the vicinity of the proposed gymnasium, student commons, art building, and electrical switchgear. Topographically, the campus includes three terraces that step up from Nova Albion Way on the northeast towards Devon Drive on the southwest.

Lower Terrace - The lower terrace is near Elevation +80 feet and includes the existing TLHS buildings, adjacent parking areas and patios, and a football field surrounded by an athletic track. The proposed gymnasium, art building, student commons, and electrical switchgear will be located on the lower terrace.

Middle Terrace - The middle terrace is near Elevation + 90 feet and includes paved tennis and basketball courts.

Upper Terrace - The upper terrace extends to just above Elevation +100 feet and includes a baseball diamond and playing fields.

All three terraces are generally bounded on their upslope sides by vertical cut slopes; above the upper terrace are the rear yards of residential properties that front on Devon Drive. Inclinations of the cut slopes are on the order of 2.5H:1V (horizontal to vertical).

4.02 Site Geologic Characterization

The Site Geologic Map presented on Figure 10 shows the surficial geologic units we interpret to be present within the TLHS campus. As discussed in Section 3.07, grading to construct the campus involved cutting and filling. We used the Partial Site Plan on Sheet A1A of the 1958 plans for the school (GM&P, 1958; Appendix H) and the 1950 aerial photograph on Figure 5 to interpret the approximate lateral extent of artificial fill (map symbol AF) placed in those areas of lower topographic relief to develop level building pads. Fill was also used to bury the pre-existing creeks and swales cutting across the site. Within the campus, the +80-foot predevelopment elevation contour was used to approximate the southwestern lateral extent of the fill. The location of the artificial fill / natural alluvium and colluvium contact was them modified slightly based on observations in the test borings.

Outside of the campus, we loosely interpreted the extent of artificial fill based on our review of topographic data and historical aerial photography. The hills that surround the campus are mapped as Franciscan Mélange, generally consistent with regional geologic mapping (e.g. Figures 6 and 7). Surficial deposits outside of the areas mapped as artificial fill or mélange are mapped as Quaternary alluvium/colluvium (map symbol Qa/Qc). Based on our review of historical aerial photography and topographic maps, the site is likely covered by a thin layer of Holocene alluvium associated with fan development and is mapped within the narrow creek channels intersecting the site. The aerial distribution and lithologic characteristics of the site stratigraphy strongly suggest that Pleistocene alluvial deposits and soils underlie the Holocene alluvium and rest unconformably on the Franciscan mélange bedrock.

The Site Geologic Map presented on Figure 10 includes the location of the three interpretive cross sections developed for this study (Cross Sections A-A' through C-C', Figures 11 and 12). Cross section A-A' is oriented northeast-southwest and coincides with the historic A-A' profile shown on Sheet A1A of the 1958 school plans (GM&P; Appendix H). Cross sections B-B' and C-C' trend northwest-southeast and intersect the proposed art building / student commons, and proposed gymnasium footprints, respectively. Cross sections A-A', B-B', and C-C' are vertically exaggerated two times and include graphic representations of the subsurface geologic conditions encountered in the exploratory borings. As shown on Section A-A' (Figure 11), the top of bedrock surface drops off and fill thickness increases from the southwest to the northeast. Section B-B' indicates relatively uniform ground conditions in the areas of the proposed art building and student commons, with approximately 0 to 3 feet of artificial fill over alluvium/colluvium, over bedrock at depths ranging from approximately 9 to 15 feet. Section C-C' indicates variable fill thicknesses in the area of the proposed gymnasium, ranging from approximately 3 feet on the northwest side of the proposed footprint, to approximately 10 feet in B-4, which was drilled along the alignment of the historic creek.

4.03 Soil and Rock Conditions

The attached appendices contain subsurface data from five CPTs, 16 soil borings, and associated geotechnical laboratory tests. As noted in Section 2, CPTs provide an interpreted log of subsurface conditions with depth based on penetration resistance, whereas direct soil sampling allows for direct visual/manual examination of subsurface materials and produces samples that can be tested in the laboratory. Notably, the CPT methodology at the TLHS site cannot directly distinguish artificial fill from generally similar natural soil deposits or distinguish dense/hard natural soil from bedrock. For this reason, the discussions in this section are based primarily on borehole data, which we correlate (where appropriate), with relevant data from the CPTs.

All 15 of the 16 borings extended through Quaternary alluvium and/or colluvium and into bedrock, which was encountered at the depths/elevations indicated in the following table.

Bedrock Depths, Elevations and Descriptions

Boring	Source	Surface Elevation (feet)	Bedrock Depth (feet)	Top of Bedrock Elevation (feet)	Bedrock Description
A3-17-1	A3GEO Phase 2	79.5	23.0	56.5	Sandstone
A3-17-2	A3GEO Phase 2	80.5	18.2	62.3	Shale/Sandstone
A3-17-3	A3GEO Phase 2	81.0	12.5	68.5	Sandstone
A3-17-4	A3GEO Phase 2	80.5	NE	Below El. 65.5	NE
A3-17-5	A3GEO Phase 2	81.0	15.0	66.0	Shale/Siltstone/Sandstone
A3-17-6	A3GEO Phase 2	81.0	9.0	72.0	Sandstone
A3-17-7	A3GEO Phase 2	81.0	14.3	66.7	Shale
A3-17-8	A3GEO Phase 2	81.0	9.0	72.0	Sandstone/Shale
A3-17-9	A3GEO Phase 2	81.0	14.2	66.8	Sandstone
B-1	A3GEO Phase 1	81.1	10.0	71.1	Clayey Sandstone
B-2	A3GEO Phase 1	81.2	12.5	68.7	Shale
B-3	A3GEO Phase 1	81.0	7.0	74.0	Claystone/Shale
B-4	A3GEO Phase 1	81.1	18.5	62.6	Sandstone
B-5	A3GEO Phase 1	91.4	18.5	72.9	Shale
B-1	MPEG, 2003	82.3	18.0	62.2	Sandstone
B-2	MPEG, 2003	82.3	12.0	69.2	Sandstone

NOTES:
1. NE = Not Encountered
2. Elevations are in NAVD 88.
3. Elevations for A3GEO Phase 2 borings estimated from recent site survey data (HED, 2017b).
4. Elevations for A3GEO Phase 1 borings estimated from Lidar dataset.
5. Elevations for MPEG, 2003 borings based on elevations shown on boring logs, converted to NAVD 88.

Generalized descriptions of the materials encountered in the borings and CPTs follow.

Artificial Fill – Artificial fill and/or visibly reworked material was observed in soil borings A3-17-1 through A3-17-5, A3-17-7, A3-17-9, and B-4. The deepest amounts of fill observed (approximately 7 to 10 feet) were in borings A3-17-1, B-4, and A3-17-2 which either lie along or near the alignment of a historic creek located along the northern TLHS property boundary (Figure 5, Figure 10). It is likely that the pre-existing swales and channels intersecting the site were filled during preparation of the site for development. As shown on Section C-C', these areas of deeper fill likely underlie portions of the proposed gymnasium footprint (Figure 12).

With the exception of the former creeks and swales, fill was either observed as a thin layer (up to approximately 3.5 feet in thickness), or was absent. Based on the historic grading plan (GM&P, 1958), several of the borings where shallow fill was observed lie within a portion of the site that was supposedly either cut or experienced limited grade change during site construction in the late 1950s. The presence of fill at these locations may be related to general earthwork of the near-surface alluvial deposits during site grading, which may have disturbed the upper few feet of soil even in portions of the site identified as cuts on the historic grading plan.

Where observed, artificial fill typically consisted of medium stiff to stiff sandy clay, or medium dense to dense clayey sand, with varying amounts of gravel. Including both Phase 1 and Phase 2 samples, A3GEO performed geotechnical laboratory testing on three samples of artificial fill (B-4 at 3.5 feet, A3-17-2 at 10.5 feet, and A3-17-5 at 2.0 feet), which identified Plasticity Index (PI) values of 16, 17, and 15, respectively. Generally, these PI values would be considered indicative of soil with a low expansion potential (expansive soils are prone to shrinking/swelling with changes in moisture content). However, a surficial layer of fat clay was encountered in borehole A3-17-1 directly below the asphalt cover, suggesting expansive soils are present at or near ground surface in parts of the site.

Alluvium/Colluvium – All of the borings encountered alluvial/colluvial soils either at ground surface or below artificial fill, and directly overlying bedrock. In the area of the proposed gymnasium, the depth to alluvium/colluvium ranged from approximately 3 to 10 feet, and in the area of the proposed student commons and art building, the depth to alluvium/colluvium ranged from approximately 0.3 to 3.8 feet. The greater depth to alluvium/colluvium in the vicinity of the proposed gymnasium is likely related to the previous creek channel that existed on the northeast part of the site prior to development (Figure 5; Section C-C' on Figure 12).

The logs of borings generally show alluvial/colluvial soils consisting of lean clay and fine- to medium-grained sand that classify as either sandy lean clay (CL) or clayey sand (SC). As shown on the boring logs, adjusted sampler blow counts in the alluvium/colluvium typically range from 9 to 38 blow per foot, with pocket penetrometer uncompressive strength readings ranging from 1.0 to greater than 4.5 tsf. Blow counts and pocket penetrometer readings are representative of a deposit's degree of consolidation or stiffness, and typically increase with depth. The lower blow counts and pocket penetrometer readings observed in shallower alluvial/colluvial soils suggest the presence of a thin layer of Holocene alluvium, and the higher blow counts and pocket penetrometer values suggest the material is likely Pleistocene in age. In general, these observations are consistent with the presence of well-developed soil colors (7.5 YR) and iron-oxide development, suggesting that much of the site is underlain by late Pleistocene alluvial/colluvial deposits. The exceptions are likely where the historic creeks and swales traversed the site and deposited Holocene alluvium.

Including both Phase 1 and Phase 2 samples, A3GEO performed geotechnical laboratory testing on eight samples of alluvial/colluvial soils. Results are summarized in the table below:

Boring	Sample Depth (feet)	USCS	% Passing No. 200	PI	LL
B-2	1.0	CL	--	20	37
B-3	4.0	SC	46	21	37
B-5	4.0	CL	--	16	36
A3-17-1	12.0 - 12.5	CL/SC	45	22	40
A3-17-1	17.5 - 18.0	SC	21	10	29
A3-17-4	3.0 – 3.5	CL	53	20	37
A3-17-8	6.0 – 6.5	SC	42	21	39
A3-17-9	3.0 – 3.5	CL	--	17	33

Boring B-5 is a special case as it was drilled on the Middle Terrace at a higher elevation, far from the footprints of the proposed new gymnasium, student commons, or art building. In Boring B-5, the soils encountered below a depth of about 10 feet are essentially similar to those encountered in the other borings (adjusted blow counts from 14 to 24 blows per foot and pocket penetrometer unconfined compressive strengths greater than 4.5 tsf). However, above the 10-foot depth Boring B-5 encountered soils that were generally less compact (adjusted blow counts of 6 and 10 blows per foot and pocket penetrometer unconfined compressive strengths between 1.5 and 2.0 tsf) and included a surficial layer of sandy silt.

Franciscan Complex Bedrock – As shown in the table above, each of the soil borings, with the exception of A3-17-4, extended into bedrock materials comprised of sandstone and/or shale, which is consistent with Franciscan Complex mélange described in Section 3.04. The bedrock materials encountered in soil borings from both the Phase 1 and Phase 2 investigations (Appendices C and D) are typically described as weathered near the alluvium/bedrock contact. The adjusted sampler blow counts generally increase with depth below this contact.

4.04 Groundwater Conditions

Groundwater conditions at the site are interpreted from existing geotechnical borehole data. Previous borehole logs MPEG B-1 and MPEG B-2 (MPEG, 2003; Appendix G) note "no groundwater was observed during drilling". MPEG B-1 and MPEG B-2 were terminated in bedrock at depths of 23.5 and 16.0 feet, respectively.

Groundwater was observed in only one of the five borings drilled at the site in February 2017 as part of the Phase 1 investigation (Boring B-4), and in two of the borings drilled in November 2017 as part of the Phase 2 investigation (A3-17-1, and A3-17-7). The following groundwater conditions were observed:

Groundwater Conditions

Test Boring	Date	Ground Surface Elevation (feet)	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Top of Bedrock Elevation (feet)
B-4	2/22/2017	81.1	20.0 / 10.0	61.1 / 71.1	62.6
A3-17-1	11/22/2017	79.5	7.0	72.5	56.5
A3-17-7	11/22/2017	81.0	19.0	62.0	66.7

In Boring B-4, groundwater was encountered at 20 feet below ground surface (corresponding to Elevation +61.1 feet) immediately after drilling, and was later encountered at 10 feet below ground surface (corresponding to Elevation +71.1 feet) before the hole was backfilled with grout. A3-17-1, which is located in the vicinity of B-4, also encountered relatively shallow groundwater. Observed groundwater conditions may be related to the locations of A3-17-1 and B-4 within the historic creek (Figure 5) which runs along the northeast property boundary. In A3-17-7, groundwater was encountered approximately 5 feet below the top of bedrock. Based on the 1958 aerial photograph (Appendix A), A3-17-1 may be located within or near the alignment of a historic creek running approximately northeast across the site. Historic swales and creeks tend to focus groundwater, and these observations appear consistent with test boring data.

Other A3GEO test borings advanced during Phases 1 and 2 were observed to be free of groundwater shortly before they were backfilled with grout. We note that groundwater measurements made in open boreholes are not necessarily representative of stabilized groundwater conditions at the time that the measurements were made, which is particularly true for holes drilled in low-permeability clayey soils. It should be anticipated that groundwater levels below the site may vary in response to rainfall or other factors. Groundwater may also be present below the site at times within seepage zones or due to a locally perched condition, and along the alignments of the historic creeks.

5. GEOLOGIC HAZARD ASSESSMENT

5.01 Earthquake Ground Shaking

The San Francisco Bay Area is seismically active and it is likely that the TLHS campus will experience earthquake ground shaking within the foreseeable life of a future project. For this reason, structures at the site should be designed to resist strong ground shaking in accordance with the requirements of the California Building Code (CBC) and local design practice. The seismic design provisions of the 2016 CBC include a methodology by which sites are classified as A through F in order to quantify site-specific ground shaking effects. Based on the available data, we judge that a seismic Site Class C designation (soft rock and very dense soil profile) is appropriate for the new student commons, art building, and electrical switchgear. A seismic Site Class D (stiff soil) is appropriate for the new gymnasium. Please refer to Section 7.01 for applicable CBC seismic design parameters.

5.02 Surface Fault Rupture

Historically, earthquake fault rupture most often occurs along pre-existing active faults. The site is not located within or proximate to an Alquist-Priolo Earthquake Fault Zone and the closest known active fault (the San Andreas fault) is approximately 8.5 miles to the southwest (Section 3.02). Faults that have been mapped closer to the site, including the faults shown on Figures 5 and 10, are not considered active. In our opinion, the overall potential for surface fault rupture to affect the TLHS campus is very low.

5.03 Liquefaction

The TLHS campus is mapped by the USGS (Figures 8a and 8b) within an area of “Moderate” liquefaction susceptibility (Knudsen et al., 2000; Witter et al., 2006). Soils that are most likely to experience liquefaction are loose (adjusted blow counts less than 10), relatively clean, saturated sands and gravels. Liquefaction is only a concern where susceptible soils are submerged below groundwater at the time when an earthquake large enough to trigger liquefaction occurs. These same types of soils, when unsaturated (i.e. above groundwater), may be susceptible to seismically-induced densification. The principal effect of seismic densification is settlement.

It has long been recognized that the fines content of a soil influences the liquefaction potential of the soil. How fines influence liquefaction potential, and how soils are determined to be susceptible to liquefaction, is based primarily on the plasticity of the fines. How fines and plasticity influence liquefaction potential is a topic of ongoing research. However, there appears to be an emerging consensus that: 1) the Plasticity Index (PI) is a good indicator of liquefaction susceptibility; and 2) there exists a fines content threshold (FC_{thr}) above which a soil will behave like the fines and not the coarser matrix soil. Typically, the FC_{thr} is between about 20 and 35 percent depending on factors such as the soil’s full gradational characteristics, mineralogical composition, particle shapes, and depositional environment.

Similar soils that are medium dense (adjusted blow counts less than 30) can also experience liquefaction in some cases. Recent research has shown that cohesive soils can experience earthquake-induced strength loss that appears generally similar to liquefaction, provided that certain criteria are met. At this time, there appears to be a general consensus that cohesive soils with a plasticity index (PI) of 12 or greater can be considered highly resistant to liquefaction.

As shown on the Area Geologic Map (Figure 6), Quaternary Geologic Map (Figure 7), the Site Geologic Map (Figure 10), and the cross sections (Figures 11 and 12), Quaternary alluvium/colluvium is present either at ground surface or below artificial fill, and as discussed in Section 4.03, much of the material is interpreted to be Pleistocene in age. These deposits are typically clay-rich, moderately plastic, and moderately consolidated (medium dense to very dense and stiff to hard), reducing their susceptibility to earthquake-induced liquefaction.

Soil and groundwater conditions vary between the area of the proposed gymnasium, and the area of the proposed student commons, art building, and electrical switchgear. As such, A3GEO analyzed the liquefaction potential of soils in each of these areas separately; summaries of our analyses are presented in the sections below.

5.03.1 Liquefaction Analysis: New Gymnasium

Based on observations in Phase 1 and Phase 2 soil test borings in the vicinity of the proposed gymnasium (A3-17-1, A3-17-2, A3-17-9, and B-4), subsurface conditions generally consist of up to 10 feet of artificial fill overlying alluvium/colluvium, overlying bedrock at depths ranging from 14 to 23 feet below ground surface. Fill soils in the vicinity of the proposed gymnasium typically consist of medium stiff to stiff clay or sandy clay, with measured PI values for two samples of 16 and 17. Alluvium/colluvium typically consists of either 1) coarse-grained soils with an appreciable amount of moderately plastic fines (greater than 31%), with $N_{1,60}$ values ranging from approximately 13 to 41; and/or 2) fine-grained soils with low to moderate plasticity. As discussed in Section 4.04, groundwater was observed in borings B-4 and A3-17-1 during drilling at depths of approximately 10 and 7 feet below ground surface respectively (coincident with the top of the artificial fill). Borings A3-17-2 and A3-17-9 were dry at the time of drilling.

Due to the unsaturated nature of the soils, we conclude that the conditions necessary to trigger liquefaction in A3-17-2 and A3-17-9 are absent. B-4, where groundwater was encountered at 10 feet below ground surface, consists of lean clay with sand and sandy lean clay from ground surface to the top of bedrock (encountered at 18.5 feet). One PI analysis (of a sample at 4 feet below ground surface), indicated a PI of 16, which generally indicates non-liquefiable soils. Generally, we conclude that the soils in B-4 consist of soils with too many moderately plastic fines to be liquefiable.

A3-17-1, where groundwater was encountered at 7 feet below ground surface, encountered a layer of medium dense clayey sand from approximately 10 to 20 feet below ground surface. A3GEO performed sieve and PI analysis on two samples from this layer; the results are summarized in the following table (Appendix F):

Test Boring	Depth (feet)	Description	Adjusted N	% Gravel	% Sand	% Fines	PI	LL
A3-17-1	12.0 – 13.0	clayey SAND (SC)	17	9	46	45	22	40
A3-17-1	17.5 – 18.0	clayey SAND with gravel (SC)	15	25	54	21	10	22

Results of laboratory testing on the layer of clayey sand in A3-17-1 indicate that the upper material (represented by the sample from 12 to 13 feet) is very unlikely to liquefy based on the percentage of fines and the PI. The lower portion of the material (represented by the sample from 17.5 to 18 feet) is borderline susceptible to liquefaction based on the fines percentage and the plasticity index. Based on observations in the test borings, layers that are either susceptible or moderately susceptible to liquefaction do not appear prevalent in the vicinity of the proposed gymnasium. However, it is likely that similar, thin layers of soil moderately susceptible to liquefaction do exist elsewhere in the area, but their distribution is likely random, discontinuous, and relatively uncommon.

To supplement our visual/laboratory testing evaluations discussed above and to further evaluate the possibility of liquefaction in the area of the proposed gymnasium, we performed an analysis using data from CPT-3 and CPT-4 using commercially-available liquefaction assessment software (CLiq v. 2.2.0.32 by GeoLogismiki). Our analysis utilized two methods: 1) Youd et al., 2001, with Robertson, 2009; and 2) Idriss and Boulanger, 2008. In addition to raw data from CPTs and test borings, key inputs to the liquefaction analyses include the earthquake moment magnitude (M_W), peak ground acceleration (PGA), groundwater depth (in-situ at the time of testing and during earthquake shaking), and allowable Factor of Safety (FS). We used the following values in our analyses for the new gymnasium:

M_W = 8.05: the mean characteristic magnitude for the rupture of the San Andreas Fault (the Maximum Considered Earthquake, or MCE);

PGA = 0.50g: the geometric mean PGA (PGA_M) obtained from the USGS "Design Maps Detailed Report ASCE 7-10 Standard";

Groundwater Depth During Earthquake = 2 feet: a conservative assumption based on observing groundwater as high as 7 feet below ground surface in test boring A3-17-1;

Factor of Safety (FS) = 1.3; liquefaction was assumed to occur if the FS fell below 1.3 (in accordance with requirements of CGS Note 48 (CGS, 2013).

Although the results of our analysis did not indicate the potential for widespread liquefaction existed in the vicinity of the proposed gymnasium, the CLiq study did indicate there is a possibility of liquefaction in thin, discontinuous pockets. A further discussion of results and liquefaction related effects is provided in the sections below.

5.03.2 Liquefaction Related Effects – New Gymnasium

5.03.2.1 Settlement – New Gymnasium

We used data from CPT-3 and CPT-4 and the CLiq program to estimate the magnitude of liquefaction and cyclic-softening-induced surface settlement at each of the CPT locations. The liquefaction-induced surface settlement reports produced by the CLiq program are included in Appendix J. Settlements calculated by CLiq correspond to vertical strain (compression) within individual soil layers, which is not necessarily the same as total settlement at/near the ground surface. Accordingly, it can reasonably be assumed that liquefaction and cyclic-softening-related settlements may be less than what are shown in the following table.

Location	Total Settlement (Youd et al., 2001 / Robertson, 2009)	Total Settlement (Idriss & Boulanger, 2008)
CPT-3	0.56 inch	1.87 inch
CPT-4	0.30 inch	2.54 inch

Based on the interpreted nature of the liquefiable deposits below the proposed gymnasium, we anticipate that the relatively small seismic settlements will be associated with the portion of the footprint underlain by the historic creek that runs along the northeast boundary of the site, where groundwater was encountered during drilling. In our judgment, liquefaction-related settlement effects can be effectively mitigated in engineering design of the project; engineering evaluations and conclusions pertaining to mitigation are discussed in Section 6.04.1.

5.03.2.2 Sand Boils – New Gymnasium

Sand boils are described by the USGS as "*sand and water that come out onto the ground surface during an earthquake as a result of liquefaction at shallow depth*." Sand boils have the potential to increase the magnitude of calculated seismic settlement through ground loss. For sand boils to occur, susceptible soils must undergo a near total loss of strength and either find or create a path to the ground surface. Soils that are most susceptible to this phenomenon include clean sand (USCS classification SP), and non-plastic silts. Highly sensitive ("quick") clays can also fluidize and exhibit flow-type behavior. We interpret that the potentially liquefiable soils at the site: 1) are present in the form of relatively thin, discontinuous lenses; and 2) contain appreciable amounts of insensitive plastic fines. No "clean" potentially liquefiable SP sands or non-plastic silts were found in the borings, and the soil behavior types (SBTs) shown on the CPT logs generally indicate an absence of loose clean sand in the upper portion of the soil profile. Based on the available data, we judge there to be a generally low potential for earthquake-induced sand boils or other "ejective" phenomena to occur. Should localized sand boils occur, their effects would be reduced by the mitigation design concepts discussed in Section 6.04.1.

5.03.2.3 Reduction in Foundation Bearing Capacity – New Gymnasium

For conventional "shallow foundations" (spread footings and mats), the load that the foundation can safely support is related to the strength of the underlying bearing materials. When liquefaction occurs at shallow depths below foundations, the resultant loss of strength can reduce the bearing capacity of the supporting soil to the point at which bearing capacity failure occurs. The primary consequence of bearing capacity failure would be foundation settlement.

The data and interpretations presented in this report indicate that liquefaction can occur at relatively shallow depths below the proposed gymnasium depending on the groundwater level present at the time that the earthquake occurs. As noted in the preceding section, the soils present in the near surface contain appreciable amounts of insensitive plastic fines and will not experience near total losses of strength as the result of liquefaction. Published relationships (Kramer, 1996; Idriss and Boulanger, 2008), show that the post-liquefied "residual" strength of the soil increases with increasing blow counts (adjusted N-values) and fines content. Bearing capacity formulas generally show that the bearing capacity increases with increasing strength and also increases (independently) with increasing foundation width.

Based on the available data, we judge there to be some potential for liquefaction to occur within the influence zone of new foundations for the proposed gymnasium. We anticipate that liquefaction will be accompanied by relatively modest yet significant losses in strength and that the areas in which this occurs will be distributed throughout the site in a somewhat random and unpredictable manner. The consequences of seismic strength loss and its effect on new foundations would be reduced by the mitigation design concepts discussed in Section 6.04.1.

5.03.2.4 Lateral Spreading – New Gymnasium

Lateral spreading is a phenomenon in which blocks of non-liquefied soil move laterally on top of an underlying continuous (or near-continuous) liquefied layer. Hazards posed by lateral spreading are typically greatest where there is a nearby topographic free face towards which spreading can occur. In the area of the gymnasium, there is no significant topographic free face nearby. We judge that the overall potential for significant earthquake-induced lateral spreading to occur at the new gymnasium site is very low.

5.03.3 <u>Liquefaction Analysis: Student Commons, Art Building, and Electrical Switchgear</u>

Based on observations from the Phase 1, Phase 2, and MPEG test borings in the vicinity of the proposed student commons, art building, and electrical switchgear, subsurface conditions generally consist of 0 to 3.5 feet of artificial fill, overlying alluvium/colluvium, overlying bedrock at depths ranging from approximately 9 to 14 feet. Fill soils in the vicinity of the proposed student commons, art building, and electrical switchgear typically consist of sandy clay or clayey sand, with appreciable amounts of plastic fines (PI of 15 in one tested sample). Alluvium/colluvium typically consists of either 1) coarse-grained soils with an appreciable amount of moderately plastic fines (greater than approximately 30%), with $N_{1,60}$ values ranging from approximately 32 to 88; and/or 2) fine-grained soils with low to moderate plasticity (PI values of 20, 20, and 21 for three tested samples).

With the exception of A3-17-7, where groundwater was observed 5 feet below the top of bedrock, test borings advanced in the vicinity of the proposed student commons, art building, and electrical switchgear were dry. Based on our initial screening assessment, the conditions necessary to trigger liquefaction in the area of the proposed student commons, art building, and electrical switchgear are absent. However, as an added level of analysis, we analyzed data from MPEG CPT-1 using CLiq, with the following input parameters:

M_W = 8.05: the mean characteristic magnitude for the rupture of the San Andreas Fault (the Maximum Considered Earthquake, or MCE);

PGA = 0.50g: the geometric mean PGA (PGA_M) obtained from the USGS "Design Maps Detailed Report ASCE 7-10 Standard";

Groundwater Depth During Earthquake = 17 feet, coincident with the top of bedrock;

Factor of Safety (FS) = 1.3; liquefaction was assumed to occur if the FS fell below 1.3, in accordance with the requirements of CGS Note 48 (CGS, 2013).

Zero total liquefaction induced settlement (including cyclic softening) was calculated using CLiq. We conclude that the potential for liquefaction induced settlement, and other liquefaction-induced effects (including sand boils, reduction in foundation bearing capacity, and lateral spreading), are very low in the areas of the proposed student commons, art building, and electrical switchgear.

5.04 Landsliding

The TLHS campus is located in an area of gently-sloping ground free of mapped landslide deposits (Rice, Smith and Strand, 1976). Additionally, the soils that underlie the campus are not considered susceptible to seismic strength loss and bedrock is present below the campus at relatively shallow depths. Based on the available information, we judge that the overall potential for deep-seated landsliding within the TLHS campus to be low.

Grading of the TLHS campus has produced low (less than about 10 feet high) cut slopes that may be susceptible to shallow sliding, sloughing and/or surface erosion. Based on our review of historic aerial photography (Appendix A), it appears to us that the cut slopes within and surrounding the TLHS campus have performed relatively well since they were created almost 60 years ago (in 1958). A future failure in these cut slopes would likely be very limited in lateral extent.

We also considered the possibility that landslides occurring in the adjacent hills might in extreme circumstances extend onto the TLHS campus. In general, the residential neighborhoods that surround the site provide a buffer between the base of the hillslopes and the campus. To our knowledge the hillslopes that surround the site do not include deep deposits of materials that would likely experience dramatic reductions in strength following landslide initiation. Accordingly, we would expect deep-seated landsliding triggered by wet weather or an earthquake to have limited runout potential and judge that the existing buffer zone between the campus and the hills is likely adequate. There is also the possibility that a fast-moving debris flow landslide that emanates from the hills could extend onto the TLHS campus. This potential hazard, if it exists, would appear to be greatest within the upper and middle terraces. Based on the information currently available, we judge the overall potential for landslides from the nearby hills to extend onto the lower terrace where TLHS buildings are located to be low.

5.05 Inundation

The site is near Elevation +80 feet and is more than a mile inland from the closest tsunami zone shown on the CGS Tsunami Inundation Map (CGS, 2009). The site's location in eastern Marin County would not be directly exposed to a tsunami from the Pacific Ocean, which would necessarily enter San Francisco Bay through the Golden Gate. The valley in which Terra Linda is located drains to the northeast towards San Pablo Bay and not towards the Golden Gate. Accordingly, we judge that inundation by tsunami or seiche is not a concern.

To our knowledge, there are no significant reservoirs located upslope that could potentially pose a hazard to the TLHS campus. FEMA maps the site within an "Area of Minimal Flood Hazard (Zone X)" (FEMA, 2016). As shown on Figure 5, several historic drainages previously existed in the vicinity prior to the development of the TLHS campus. Presumably, water from nearby upslope areas currently flows below the TLHS campus and adjacent residential neighborhoods in culverts, the condition of which are unknown. Based on the information available at this time, we judge that the overall potential for the TLHS campus to be flooded by water is low provided that existing drainage facilities in the area continue to function as intended.

6. GEOTECHNICAL EVALUATIONS AND CONCLUSIONS

6.01 Feasibility

Based on the results of our preliminary investigation, we conclude that the design and construction of the proposed gymnasium, student commons, art building and electrical switchgear are feasible from a geotechnical standpoint. Our assessment of geotechnical considerations for future projects at the TLHS campus are discussed in the sections that follow.

6.02 Expansive Soils

As discussed in Section 4.03, near surface soils, including fill and natural alluvium/colluvium were generally observed to be non-expansive, however a surficial layer of fat clay was observed in at least one boring (A3-17-1), indicating that expansive soils may be present near ground surface in portions of the site. Expansive materials have the potential to damage overlying improvements unless mitigated. Alternative foundation types that are commonly used in the Bay Area to mitigate the potentially damaging effects of expansive soils on structures include: (1) shallow foundations (footings or mats) supported on a layer of compacted Non-Expansive Fill; (2) deepened spread footings supported on natural soils below the zone of significant shrink/swell behavior; and (3) deep foundations that gain support at significant depths below the zone of shrink/swell behavior. Accordingly, the foundation support options discussed in Section 6.04 are considered effective in mitigating shrink-sell effects associated with expansive soils. New pavements and slabs-on-grade would best be underlain by a layer of engineered Non-Expansive Fill to reduce the amount of movement and distress caused by expansive soils.

6.03 Undocumented Fill

As shown on the Site Geologic Map (Figure 10) and Cross Section A-A' (Figure 11) and Cross Sections B-B' & C-C' (Figure 12), a portion of the campus is underlain by artificial fill. Much of the fill shown on Figures 10 through 12 was placed during the original development of the school campus and, to our knowledge, there are no records available documenting that engineering controls were in place at the time that the site was cleared, the natural ground surface was prepared, and the fill was placed. The same is true for any localized fill that may have been placed in association with utility, sewer and storm drain installations, building foundations, underground tanks, other below-grade features, or filling of the historic creeks. Undocumented fill is considered generally unsuitable for the support of new buildings. Accordingly, the foundation support options discussed in Section 6.04 take into account the presence of undocumented fill in certain areas of the site. We judge that it is not feasible to remove all undocumented fill from beneath future pavements and slabs; in this report, we recommend that all subgrades below the Non-Expansive Fill layer supporting these types of improvements be checked to verify that they are capable of providing adequate support.

6.04 Building Foundations

As noted in Sections 6.02 and 6.03, the presence of artificial fill and surficial expansive soils are key considerations in the selection of an appropriate foundation type for the proposed gymnasium, student commons, and art building. Additionally, the potential for liquefaction-related settlement effects and reductions in bearing capacity is a primary consideration for selection of the foundation type for the proposed gymnasium. For the one- to two- story buildings planned, structural loads will be relatively light. Under static (i.e. non-earthquake) conditions, we estimate that foundations designed and constructed in accordance with the recommendations presented in this report should experience less than about ½ inch of total post-construction settlement and less than about ¼ inch of post-construction differential settlement over a horizontal distance of 30 feet.

Recommendations for proposed foundation systems for each structure are provided below.

6.04.1 Building Foundations and Slabs – Gymnasium

The footprint of the proposed gymnasium is underlain by approximately 3 to 16 feet of artificial fill, with deeper fill thicknesses corresponding to the northeast side of the structure, along the alignment of a historic creek (Figure 5). Additionally, because of the long-spans planned for this structure, the gymnasium may have relatively high column loads for a building of this size. We recommend this structure be supported on deep foundations, which would transfer load from the new gymnasium, through the artificial, undocumented fill, and down to the underlying alluvium/colluvium and bedrock. Section 7.04 contains recommendations for drilled pier foundations that gain their support in alluvium/colluvium and bedrock below the artificial fill. Uplift pressures from expansive soils also need to be considered in the design of drilled piers and grade beams. Additionally, drilled piers will need to be designed to accommodate downdrag effects from liquefaction-induced settlement.

We recommend the interior slab for the gymnasium be designed as a framed structural slab that transmits dead load of the floors and the live load on the floor through the slab to the framing and pile caps supported by the drilled piers. The structural slab should be underlain by at least 18-inches of Non-Expansive Fill. Further discussion of recommended slab design is provided in Section 7.04.2.

6.04.2 Building Foundations and Slabs - Student Commons and Art Building

The footprint of the proposed student commons and art building are underlain by a thin layer of artificial fill, underlain by alluvium/colluvium. This structure can be supported on deepened spread footings, bearing in the alluvium/colluvium below the surficial artificial fill, and below the zone of potentially significant shrink/swell behavior. Section 7.02 of this report includes recommendations for deepened spread footings.

We recommend the interior slabs of the student commons and art building be designed as soil-supported slabs-on-grade, underlain by at least 18-inches of Non-Expansive Fill. Further discussion of recommendations for slab design is provided in Section 7.03.2.

6.04.3 Building Foundations and Slabs - Electrical Switchgear

No information is available about the proposed electrical switchgear at this time, however we anticipate that this will be a concrete pad or 1 story structure with light loads. The boring nearest to the proposed electrical switchgear (A3-17-6) identified alluvium/colluvium directly below asphalt cover, however it is possible that a thin layer of fill or reworked material could be present within the proposed footprint. Additionally, it is possible that shallow expansive soils could be present within the footprint of the electrical switchgear. We recommend this structure be supported on a slab-on-grade or mat (depending on structure loads), supported on a minimum 18-inch thick layer of compacted Non-Expansive Fill. Section 7.05 of this report contains design recommendations for the foundation for the electrical switchgear.

Further, based on the preliminary footprint location for the proposed structure (Figure 3), it appears that the electrical switchgear will be notched into the existing slope between the lower and middle terraces. If so, we anticipate this structure will be surrounded by a retaining wall on three sides. Section 7.06.2 contains recommendations for unrestrained retaining walls.

6.05 Construction Considerations

We anticipate onsite soils can be excavated with conventional earth-moving equipment. It is possible that excavations could encounter obstructions that would require jackhammering, hoe-ramming or equipment capable of cutting steel to excavate. Excavations deeper than 4 feet that will be entered by workers should be shored or sloped for safety in accordance with the California Occupational Safety and Health Administration (Cal-OSHA) standards. The near-surface materials may contain debris, wood and organic-laden materials that would not be suitable for onsite re-use.

Drilled piers should be installed by a qualified drilling contractor. Zones or pockets of low-cohesion soils prone to caving may be encountered during drilling and the contractor should be prepared to utilize temporary casing, if necessary. We judge that the holes can likely be drilled using heavy auger drilling equipment; however, zones of relatively hard rock could be encountered. The contractor should be prepared to utilize suitable hard rock drilling techniques, if necessary. As noted in Section 4.04, groundwater may be encountered during drilling, particularly within the alignment of the historic creek. The contractor should note that if water accumulates in the holes, it should be removed by pumping or bailing prior to concrete placement, unless tremie methods are used. Concrete placement should start as soon as possible after the drilling and cleanout is complete. In all cases, holes for drilled piers should be concreted on the day they are drilled.

The contractor should anticipate that site excavations may need to be dewatered and that there may be environmental and regulatory aspects to the appropriate collection, storage and disposal of onsite water. The design, permitting, installation, monitoring, and abandonment of site dewatering and discharge systems are the contractor's responsibility; this includes whatever systems may be needed to handle water displaced or pumped from pier holes. The onsite soils may include materials that are wet of optimum, from an earthwork compaction standpoint. The contractor should anticipate that soils obtained from site excavations will likely include clayey materials that may need to be processed (e.g. by air drying) prior to being placed as engineered fill.

Although it is possible for excavation and/or construction to proceed during or immediately following the wet winter months, a number of geotechnical problems may occur which may increase costs and cause project delays. We advise that wet-weather issues be considered during project scheduling, noting that the contractor's responsibilities include onsite safety and construction means and methods.

7. RECOMMENDATIONS

7.01 California Building Code Seismic Parameters

Structures at the site should be designed to resist strong ground shaking in accordance with the applicable building code(s) and local design practice. This section provides mapped seismic design parameters per the CBC (Risk Category I/II/III). In accordance with ASCE 7-10 Section 20, we evaluated seismic Site Class by calculating weighted average of blow counts in borings in the areas of the proposed gymnasium, student commons, art building, and electrical switchgear. Accordingly, Site Class C (soft rock and very dense soil) is appropriate for the proposed student commons, art building, and electrical switchgear, and Site Class D (stiff soil) is appropriate for the new gymnasium. The appropriate design values are provided in the sections below, and corresponding USGS Design Maps Summary Reports and Design Maps Detailed Reports are attached in Appendix I.

7.01.1 Seismic Parameters: Student Commons, Art Building, and Electrical Switchgear

Site Class
C = Soft Rock and Very Dense Soil

Latitude and Longitude
Latitude: 37.99975°N
Longitude: 122.55454°W

Maximum Considered Earthquake Spectral Response Accelerations (for Site Class C)
(Mapped Acceleration × Site Coefficient)
S_{MS} = 1.500g (MCE spectral acceleration at short periods)
S_{M1} = 0.780g (MCE spectral acceleration at 1-second period)

Design Spectral Response Acceleration (for Site Class C)
(Maximum Considered Earthquake Spectral Acceleration × 2/3)
S_{DS} = 1.000g (design spectral acceleration at short periods)
S_{D1} = 0.520g (design spectral acceleration at 1-second period)

7.01.2 Seismic Parameters: Gymnasium

Site Class
D = Stiff Soil

Latitude and Longitude
Latitude: 38.00001°N
Longitude: 122.5534°W

Maximum Considered Earthquake Spectral Response Accelerations (for Site Class D)
(Mapped Acceleration × Site Coefficient)
S_{MS} = 1.500g (MCE spectral acceleration at short periods)
S_{M1} = 0.900g (MCE spectral acceleration at 1-second period)

Design Spectral Response Acceleration (for Site Class D)
(Maximum Considered Earthquake Spectral Acceleration × 2/3)
S_{DS} = 1.000g (design spectral acceleration at short periods)
S_{D1} = 0.600g (design spectral acceleration at 1-second period)

7.02 Demolition

Prior to demolition and site clearing, all active subsurface utilities in and immediately surrounding the site limits should be located, marked, and protected or relocated. Demolition of the existing buildings at the site should include the removal of interior slabs, retaining walls, and foundations. Plans are available for existing buildings at the site; the design team and prospective contractors should make their own independent assessments of the information shown on the existing plans.

Areas within the site limits should be cleared of concrete, asphalt concrete, aggregate base, catch basins, storm drains, sewers, utilities, and all other near-surface improvements. Any trees present should be cleared and grubbed and any soils containing vegetation and/or organic matter should be stripped. Cleared materials should be removed from the site unless they are specifically identified as suitable for reuse by the owner and A3GEO. Site strippings and grubbed materials not suitable for re-use as engineered fill should be removed from the site and stockpiled for later use as landscaped material (at the owner's discretion). The contractor should document the condition of existing improvements located outside of the site limits, and should perform any and all monitoring activities required by the owner.

Excavation will be required to remove existing below-grade improvements, undocumented fill, and to allow for the placement of Non-Expansive Fill beneath buildings, slabs, and pavements. The contractor is responsible for the design, implementation, and safety of all site excavations; this responsibility includes (but is not necessarily limited to) temporary shoring, cut slopes, and excavation dewatering.

7.03 Foundations and Slabs - Student Commons and Art Building

7.03.1 Foundations – Deepened Spread Footings – Student Commons and Art Building

We recommend that the new student commons and art building be founded on deepened spread footings, bearing a minimum of 30 inches below lowest adjacent firm finished grade, to mitigate potential damage due to surficial expansive soils. At the time of this report, finished grades are unknown. Based on observations during drilling and presuming finished grades will approximately match the current existing grades, we expect that either artificial fill or alluvium/colluvium will be present at 30 inches below finished grade, with artificial fill more likely to be present on the north side of the proposed footprints.

Deepened spread footings should bear either: 1) on alluvium/colluvium present at 30 inches below grade; or 2) on Non-Expansive Fill or flowable fill placed above the alluvium/colluvium after removal of the overlying unsuitable materials (including artificial fill). Alternatively, at locations where artificial fill is present at greater thickness than 30 inches below finished grade, spread footings could be dropped to bear directly on alluvium/colluvium.

Specific foundation design criteria are as follows:

- Deepened spread footings should be at least 16 inches wide.
- We recommend that continuous deepened spread footings enclose the entire building perimeter to mitigate the potential for moisture changes beneath the interior ground floor slab-on-grade.
- Existing topsoil, artificial fill, subsoil, and any organic materials should be removed beneath building footings and replaced with Non-Expansive Fill or flowable fill to achieve design footing bearing elevations. Where Non-Expansive Fill is used for replacement, unsuitable materials should be removed from within the entire zone of influence below the footing. The zone of influence (ZOI) is defined as the zone beneath the footing and beneath imaginary lines extending one foot laterally beyond the footing outer bottom edges and down and out on a one to one vertical (1H:1V) slope to the bearing strata.

Deepened spread footings can be evaluated using the bearing pressures in the following table (DL=Dead Loads; LL=Live Loads; Total=DL+LL+ wind or seismic).

Foundation Allowable Bearing Pressures

Load Case	Bearing Pressure (psf)	Minimum Factor of Safety
DL Allowable	3000	3.0
DL+LL Allowable	4500	2.0
Total Allowable	6000	1.5

Resistance to lateral loads can be provided by passive pressures acting on the vertical faces of below-grade structural elements and by friction along the footing bottoms. Passive resistance can be evaluated using an equivalent fluid weight of 300 pounds per cubic foot (pcf). This value can be increased by one-third for dynamic loading. A friction coefficient of 0.30 can be used to evaluate frictional resistance along the bottoms of footings. The above passive and frictional resistance values include a factor of safety of at least 1.5 and can be fully mobilized with deformations of less than ½ - and ¼ -inch, respectively.

7.03.2 Lowest Level Slab – Student Commons and Art Building

We recommend that the lowest level slabs for the student commons and art building be designed as a soil-supported slabs-on-grade, underlain by at least 18 inches of Non-Expansive Fill and aggregate base. Specifically, the upper 6 inches of this layer should consist of a moisture retarder comprised of 6 inches of compacted aggregate base, overlain by a heavy-duty impermeable membrane (Stego® wrap 15-mil or an approved equivalent), installed and taped in accordance with the manufacturer's recommendations. The aggregate base layer should be underlain by a 12-inch thick layer of Non-Expansive Fill. Slab reinforcing should be provided in accordance with the anticipated use and loading of the slab. We recommend that interior slabs-on-grade be at least 5 inches thick and be reinforced with steel bar reinforcement.

Existing fill can remain in place below the slab areas following proof-compaction of the exposed subgrade. If weak, unstable, or unsuitable materials are encountered during proof-compaction, they should be over-excavated and replaced with Non-Expansive Fill or suitable General Fill.

7.04 Foundations and Slabs - Gymnasium

7.04.1 Foundations – Drilled Piers - Gymnasium

We recommend that the new gymnasium be founded on drilled piers in bedrock. Drilled piers will allow loads to be transferred below the artificial fill, will mitigate potential damage to the new gymnasium from surficial expansive soils, will accommodate higher column loads that may be associated with the proposed long-span design, and will mitigate the effects of liquefaction related settlements and strength loss.

Foundation piers should be at least 18 inches in diameter and spaced no closer than three pier diameters, center-to-center. Drilled pier groups should be structurally tied together at their tops by grade beams; grade beams and pile caps should be underlain by at least 18 inches of Non-Expansive Fill to mitigate potential expansive soil uplift effects. Alternatively, a 6-inch minimum vertical space (void) could be provided between the ground surface and overlying structural elements.

The axial capacity of drilled piers can be evaluated using an allowable skin friction value of 600 psf in natural alluvium/colluvium and 1,800 psf in bedrock. These allowable skin friction values can be increased by one third for total compressive loads, including wind and/or seismic, but should not be increased for uplift loads. We recommend that skin friction in artificial fill be ignored in evaluating drilled pier axial capacity. We further recommend that any contribution to axial capacity from end bearing in bedrock be ignored due to difficulties associated with obtaining and/or assuring a clean bearing surface at the bottom of the pier holes. Piers will need to be designed for downdrag loads associated with liquefaction related settlement. We recommend that design downdrag loads be determined in consultation with A3GEO as design progresses, once the design team has determined final building loads and preferred drilled pier sizes.

Drilled piers should extend at least 5 feet into bedrock, regardless of load. Top of bedrock elevations in the vicinity of the proposed gymnasium ranged from approximately Elevation +56.5 to Elevation +66.8, corresponding to depths of approximately 14 to 23 feet below ground surface. This would correspond to total minimum drilled pier lengths ranging from approximately 19 to 28 feet. Piers may need to extend deeper into bedrock depending on loads.

Resistance to lateral loads can be provided by passive pressures acting on the vertical faces of grade beams and the upper portions of drilled piers. Passive resistance can be evaluated using an equivalent fluid pressure of 300 pounds per cubic foot (pcf), which can be applied over two (horizontal) pier diameters over the upper 5 feet of the pier. The preceding passive resistance values include a factor of safety of at least 1.5. We recommend that the upper foot of soil be ignored in calculating passive resistance unless the surface of the soil is confined by pavement or a concrete slab-on-grade.

7.04.2 Lowest Level Slab – Gymnasium

We recommend that the lowest-level floor for the gymnasium be designed as a framed structurally supported floor that transmits dead and live load to the framing and pile caps supported by the drilled piers.

Structurally supported floors that are cast on grade should be underlain by at least 18 inches of Non-Expansive Fill and aggregate base. Specifically, the upper 6 inches of this layer should consist of a moisture retarder comprised of 6 inches of compacted aggregate base, overlain by a heavy-duty impermeable membrane (Stego® wrap 15-mil or an approved equivalent). The aggregate base should be underlain by a 12-inch thick layer of Non-Expansive Fill. Alternatively, the Non-Expansive Fill layer is not required if there is a 6-inch minimum gap between the bottom of the proposed floor and the underlying soil.

Existing fill can remain in place below the structural slab following proof-compaction of the exposed subgrade with a large vibratory roller. If weak, unstable, or unsuitable materials are encountered during proof-compaction, they should be over-excavated and replaced with Non-Expansive Fill or suitable General Fill.

7.05 Foundations - Slab-on-Grade or Mat – Electrical Switchgear

The proposed electrical switchgear can either be founded on a slab-on-grade or mat foundation, depending on proposed structural loads and performance requirements. The slab/mat should bear on a minimum 18-inch thick layer of Non-Expansive Fill and aggregate base. Specifically, the upper 6 inches of this layer should consist of a moisture retarder comprised of 6-inches of compacted aggregate base, overlain by a heavy-duty impermeable membrane (Stego® wrap 15-mil or an approved equivalent). The aggregate base should be underlain by a 12-inch thick layer of Non-Expansive Fill. The Non-Expansive Fill should bear directly on the alluvium/colluvium. If artificial fill or other unsuitable materials are present at or below this elevation, it should be removed and replaced with either additional Non-Expansive Fill.

The slab/mat foundation can be evaluated using the bearing pressures in the following table (DL=Dead Loads; LL=Live Loads; Total=DL+LL+ wind or seismic).

Foundation Allowable Bearing Pressures

Load Case	Bearing Pressure (psf)	Minimum Factor of Safety
DL Allowable	3000	3.0
DL+LL Allowable	4500	2.0
Total Allowable	6000	1.5

Resistance to lateral loads can be provided by passive pressures acting on the vertical faces of below-grade structural elements and by friction along the footing bottoms. Passive resistance can be evaluated using an equivalent fluid weight of 300 pounds per cubic foot (pcf). This value can be increased by one-third for dynamic loading. A friction coefficient of 0.30 can be used to evaluate frictional resistance along the bottoms of footings. The above passive and frictional resistance values include a factor of safety of at least 1.5 and can be fully mobilized with deformations of less than 1/2- and 1/4-inch, respectively.

7.06 Retaining Walls

Recommended lateral pressures are provided below for design of retaining walls in the permanent condition. The following lateral pressure distributions are based on the assumption that retaining walls will be fully drained to prevent the build-up of hydrostatic pressure. Wall drainage may consist of either: (1) holes, slots or gaps in the wall that allow water to freely drain through the wall face; or (2) a wall back-drainage system that collects water from behind the wall and drains it, by gravity, to an appropriate discharge location.

Back-drainage should consist of either: (a) prefabricated drainage material (Miradrain or an approved alternative) installed in accordance with the manufacturer's recommendations, or (b) a drain rock layer at least 12 inches thick. Prefabricated drainage material should drain to a perforated plastic pipe or an approved prefabricated drainage conduit. Back-drainage should drain into a perforated plastic pipe installed (with perforations down) along the base of the walls on a 2-inch-thick bed of drain rock. Plastic pipe should be sloped to drain by gravity to a sump, relief wells or other suitable discharge and a cleanout should be provided at the pipe's upslope end. Perforated and non-perforated plastic pipe used in the drainage system should consist of 4-inch diameter Schedule 40 PVC or an approved equivalent. Drain rock should conform to Caltrans specifications for Class 2 permeable material. Alternatively, locally available, clean, ½- to ¾-inch maximum size crushed rock or gravel could be used, provided it is encapsulated in a non-woven geotextile filter fabric, such as Mirafi 140N or an approved alternative. The upper 2 feet of retaining wall backfill (above back-drainage) should be comprised of low-permeability soil to limit surface water infiltration into the retaining wall back-drainage system.

7.06.1 Restrained Walls (At-Rest)

Walls that are not free to rotate at their tops (including building walls) should be evaluated using the lateral pressure distribution for restrained walls. Design retaining walls that are restrained at the top for the following "at-rest" earth pressures:

Lateral Pressures – At-Rest Pressure Distribution

Load Condition	Lateral Pressure
Static Lateral Pressure, Level Backfill	60 pcf
Static Lateral Pressure, 3:1 Slope Behind Wall	70 pcf
Static Lateral Pressure, 2:1 Slope Behind Wall	80 pcf
Surcharge (general)	0.5 times anticipated surcharge load (uniform) – acting on the back side of the wall, applied over the full height of the wall.
Surcharge (earthquake)	See Section 7.06.3

7.06.2 Unrestrained Walls (Active)

Design retaining walls that are not restrained at the top (i.e. cantilever) for the following "active" lateral earth pressures:

Lateral Pressures – Active Pressure Distribution

Load Condition	Lateral Pressure
Static Lateral Pressure, Level Backfill	40 pcf
Static Lateral Pressure, 3:1 Slope Behind Wall	50 pcf
Static Lateral Pressure, 2:1 Slope Behind Wall	60 pcf
Surcharge (general)	0.33 times anticipated surcharge load (uniform) – acting on the back side of the wall, applied over the full height of the wall.
Surcharge (earthquake)	See Section 7.06.3

7.06.3 Seismic Lateral Earth Pressures

The applicability of seismic lateral pressure increases in conventional retaining wall design is a topic of ongoing research. The seismic lateral earth pressure increases presented in this section are conservative estimates and can be added to the lateral earth pressures presented previously, regardless of the wall restrain case (at-rest or active). Seismic lateral earth pressures and increases in lateral pressures caused be surcharge loading (e.g. vehicle surcharges) need not be applied simultaneously. A3GEO should be consulted on a case-by-case basis if it is proposed that the seismic pressure increases presented in this section not be used for design.

Seismic Lateral Pressures

Slope Behind Wall	Uniform Pressure Increase (psf)
Level	18H psf
3:1	20H psf
2:1	24H psf

7.07 Engineered Fill

Geotechnical requirements for fill materials are presented below.

General Fill - General Fill material should have an organic content of less than 3 percent by volume and should not contain environmental contaminants or rocks or lumps larger than 6 inches in greatest dimension. From a geotechnical standpoint, onsite materials can be reused as General Fill if they meet or can be processed (e.g. by sorting and/or crushing) to meet the above requirements. General Fill can be used anywhere except where Non-Expansive Fill is required.

Non-Expansive Fill - Non-Expansive Fill should conform to the requirements for General Fill, have a Plasticity Index no greater than 12, and a Liquid Limit no greater than 40. A Non-Expansive Fill layer should be required beneath concrete slabs, pavements, and in cases where uplift pressures are a concern (e.g. below grade beams that are in direct contact with the ground).

Imported Fill – Imported Fill should conform to the requirements for Non-Expansive Fill and should be evaluated by our firm and the project environmental consultant prior to its importation to the site.

Excavated onsite soils may be suitable for reuse as Non-Expansive Fill or General Fill, provided it conforms to the requirements listed above.

Preliminary geotechnical requirements for fill placement and compaction are presented below (per ASTM D-1557 Test Methods):

- General Fill that is predominantly cohesive (>15 percent passing #200 sieve) should be moisture conditioned, as necessary, to between 3 and 5 percent over optimum moisture content and compacted to at least 90 percent relative compaction.
- General Fill that is predominantly granular (<15 percent passing #200 sieve) should be moisture conditioned, as necessary, to between 2 and 4 percent over optimum moisture content and compacted to at least 95 percent relative compaction.
- Non-Expansive Fill should be moisture conditioned, as necessary, to near optimum moisture content and compacted to at least 95 percent relative compaction.

All proposed fill materials should be approved by A3GEO and the project environmental consultant prior to use.

7.08 Exterior Flatwork

We recommend exterior slabs-on-grade be supported on a minimum of 12 inches of Non-Expansive Fill. Slab reinforcing should be provided in accordance with the anticipated use and loading of the slab. We recommend that exterior slabs-on-grade be at least 4 inches thick and reinforced with steel bar reinforcement. Exterior slabs should be structurally independent from buildings. Concrete slabs that may be subject to vehicle loadings should be designed in accordance with the recommendations for rigid Portland cement concrete pavements.

Flexible asphalt concrete (AC) pavements may be used for parking areas and driveways. We developed the following recommended pavement sections for various traffic indices using the Caltrans R-value design method for flexible pavements. The pavement sections presented are based on an assumed subgrade R-value of 30 for Non-Expansive Fill.

Flexible Pavement Thickness Design for Subgrade R-Value = 30

Traffic Index	Asphalt Concrete (inches)	Caltrans Class 2 Aggregate Base (inches)	Total Thickness (inches)
4	2	6	8
5	3	6	9
6	3	9	12
7	3	12	15

For pavements, we recommend that the aggregate base be underlain by at least 12 inches of Non-Expansive Fill and that this layer extend at least 3 feet beyond the outside pavement edge unless a deepened curb or other moisture cutoff (at least 24 inches deep) is provided. The project civil engineer should choose the appropriate traffic indices for the pavement areas of the site and then use the given section for that traffic index. The upper 6 inches of subgrade beneath planned pavements should be compacted to at least 95 percent relative compaction per ASTM D-1557. Aggregate base for use in pavements should conform to Caltrans Standard Specifications for Class 2 Aggregate Base. The aggregate base used in pavement sections should be compacted to at least 95 percent relative compaction as determined by ASTM D-1557.

Rigid Portland cement concrete (PCC) pavements may also be used in driveway/loading areas. This section provides recommendations for Caltrans jointed plain concrete pavement (JPCP), which is engineered with longitudinal and transverse joints to control where cracking occurs. JPCPs do not contain steel reinforcement, other than tie bars and dowel bars. The project civil engineer should design and detail the JPCP per Caltrans specifications. We developed the following pavement thickness design using the Caltrans R-value design method for rigid pavements and an assumed traffic index. The PCC design that follows is appropriate for subgrade soils with an R-value between 10 and 40.

Portland Cement Concrete Pavement Thickness Design

Traffic Index	Portland Cement Concrete (inches)	Caltrans Class 2 Aggregate Base (inches)	Total Thickness (inches)
< 9	9	12	21

We recommend that PCC pavements be underlain by at least 12 inches of Non-Expansive Fill designed in accordance with the recommendations to this section to reduce the potential for adverse expansive soil effects.

7.09 Future Geotechnical Services

A3GEO should review the geotechnical aspects of project plans and specifications as they are being developed, to check for conformance with the intent of our geotechnical recommendations and to provide timely input, in the event that revisions are needed. We should perform a general review of the geotechnical aspects of the final plans and specifications, the results of which we should document in a formal plan review letter.

As Geotechnical Engineer of Record, if is essential that A3GEO provide geotechnical services during construction to check whether geotechnical conditions are as anticipated, provide supplemental recommendations where necessary, and document that the geotechnical aspects of the work substantially conform to the approved Contract Documents and the intent of our geotechnical recommendations. Critical aspects of construction that A3GEO should observe and/or test include: over-excavation and re-compaction beneath structures, subgrade preparation for pavements, installation of drilled piers, and placement and compaction of aggregate base for pavements.

8. LIMITATIONS

This report has been prepared for the exclusive use of the District and their consultants for specific application to the conceptual design of the TLHS improvements described herein. The opinions presented in this report were developed in accordance with generally-accepted geotechnical and engineering geologic principles and practices. No other warranty, expressed or implied, is made. In the event that any changes in the nature or design of the project are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing.

The findings of this report are valid as of the present date. However, the passing of time will likely change the conditions of the existing property due to natural processes or the works of man. In addition, due to legislation or the broadening of knowledge, changes in applicable or appropriate standards will occur. Accordingly, this report should not be relied upon after a period of three years without being reviewed by this office.

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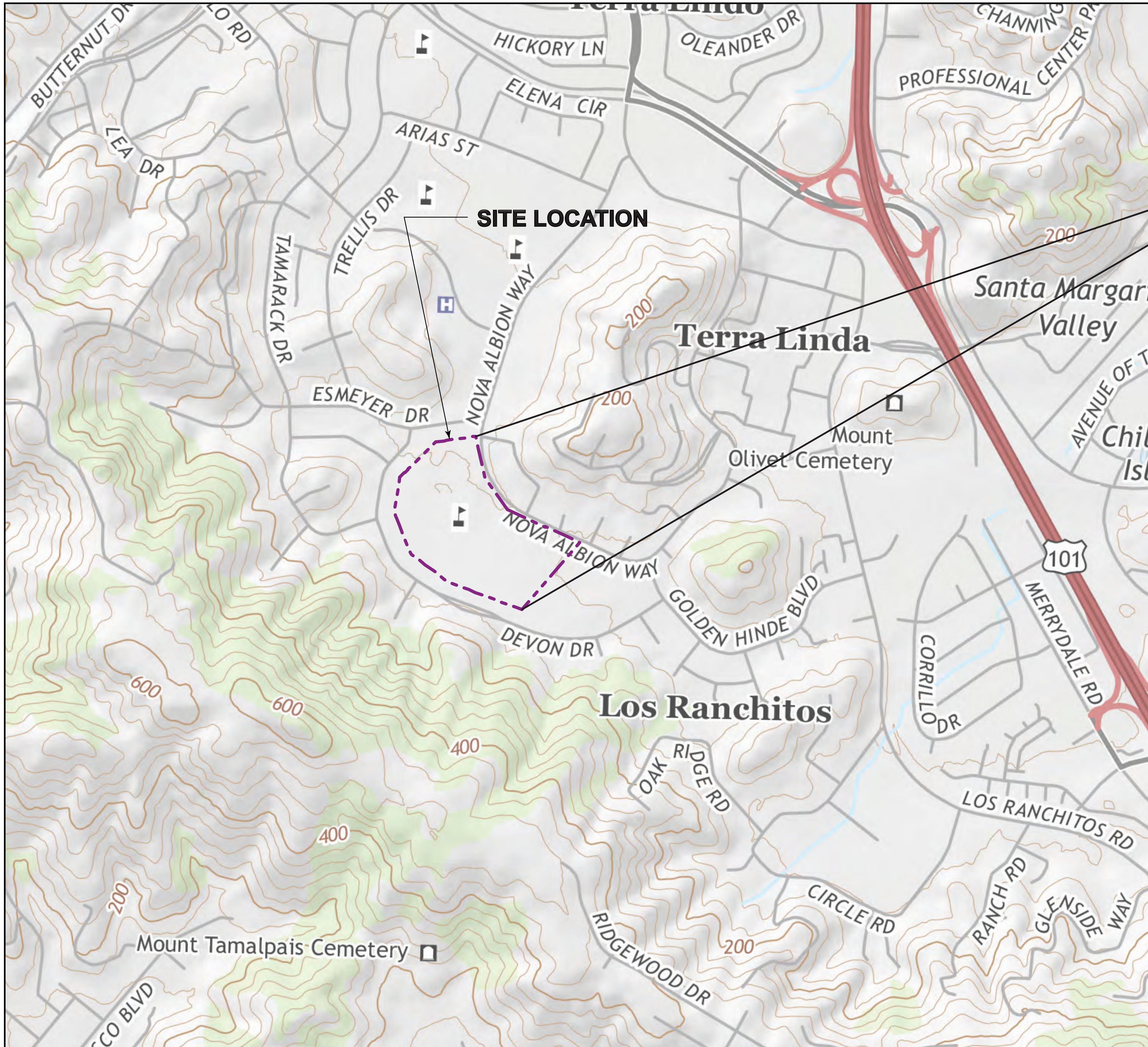
FIGURES



NOTES:

1. Base map from USGS Novato and San Rafael Quadrangles, California, 7.5-Minute Series, North American Datum of 1983 (NAD83), vertical datum NAVD88. Elevations in feet. Map dated 2015.

N

(SCALE IN FEET)

0 1,000 2,000

TERRA LINDA HIGH SCHOOL
SAN RAFAEL

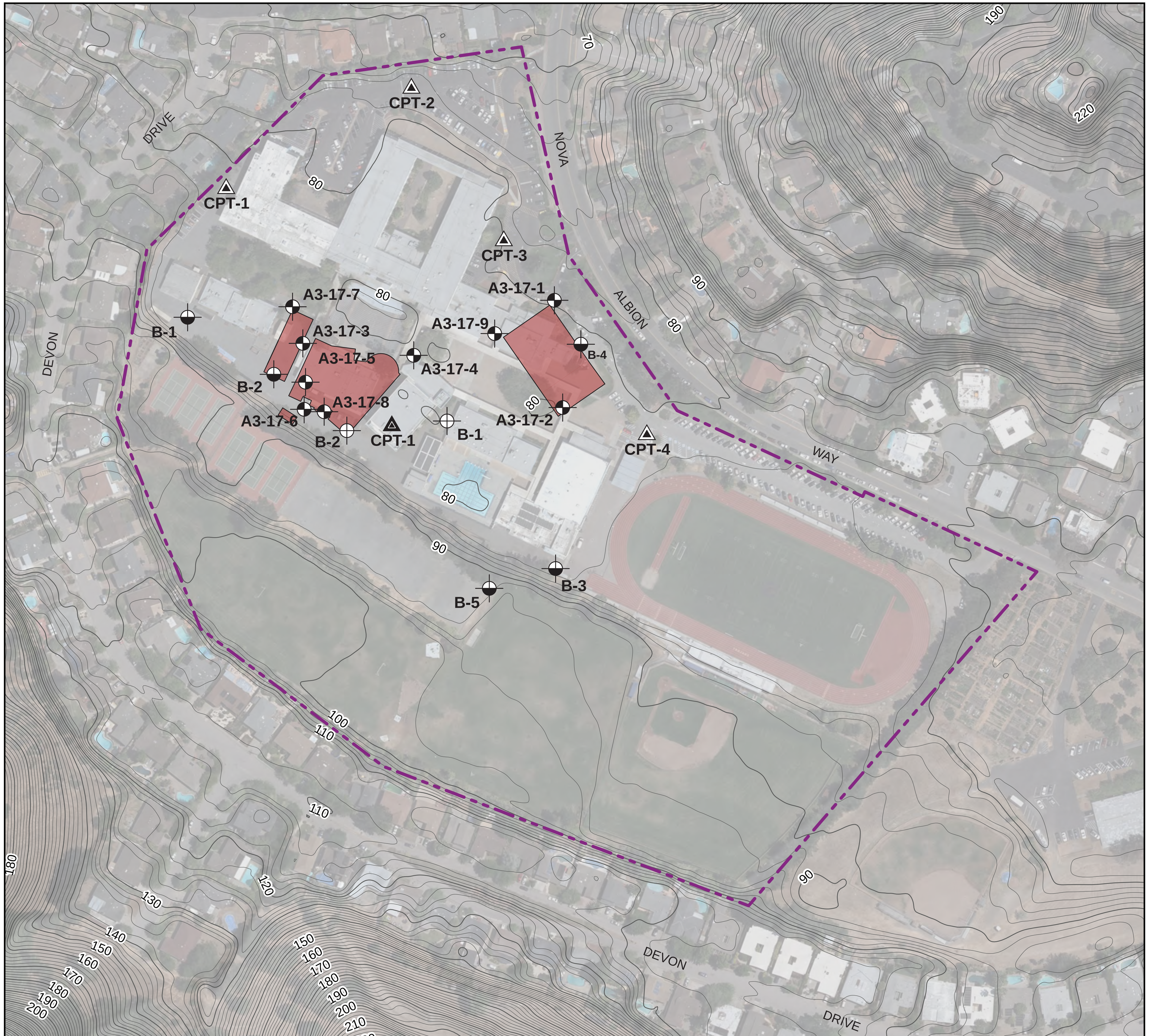
Project No. 1150-1B

SITE LOCATION MAP

A3GEO

FIGURE 1

Date: 01/26/2018



LEGEND:

PROPOSED BUILDING

A3-17-8 PHASE 2 TEST BORING (A3GEO, NOVEMBER 2017)

B-4 PHASE 1 TEST BORING (A3GEO, FEBRUARY 2017)

CPT-3 PHASE 1 CPT (A3GEO, FEBRUARY 2017)

B-2 TEST BORING (MPEG, AUGUST 2003)

CPT-1 CPT (MPEG, AUGUST 2003)

SITE BOUNDARY

100 ELEVATION CONTOURS IN FEET

NOTES:

1. Topographic contours from Marin Map, A Geographic Information System for Marin County. Data are in California State Plane coordinates, NAD83 HARN, US Survey feet.
2. Proposed building locations taken from a file titled "2016-1000 Proposed Site Masterplan - SD Phase.dwg", provided to A3GEO via email on 9 October 2017.
3. Elevations are in feet and reference North American vertical datum of 1988 (NAVD 88).

N

(SCALE IN FEET)

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TERRA LINDA HIGH SCHOOL
SAN RAFAEL

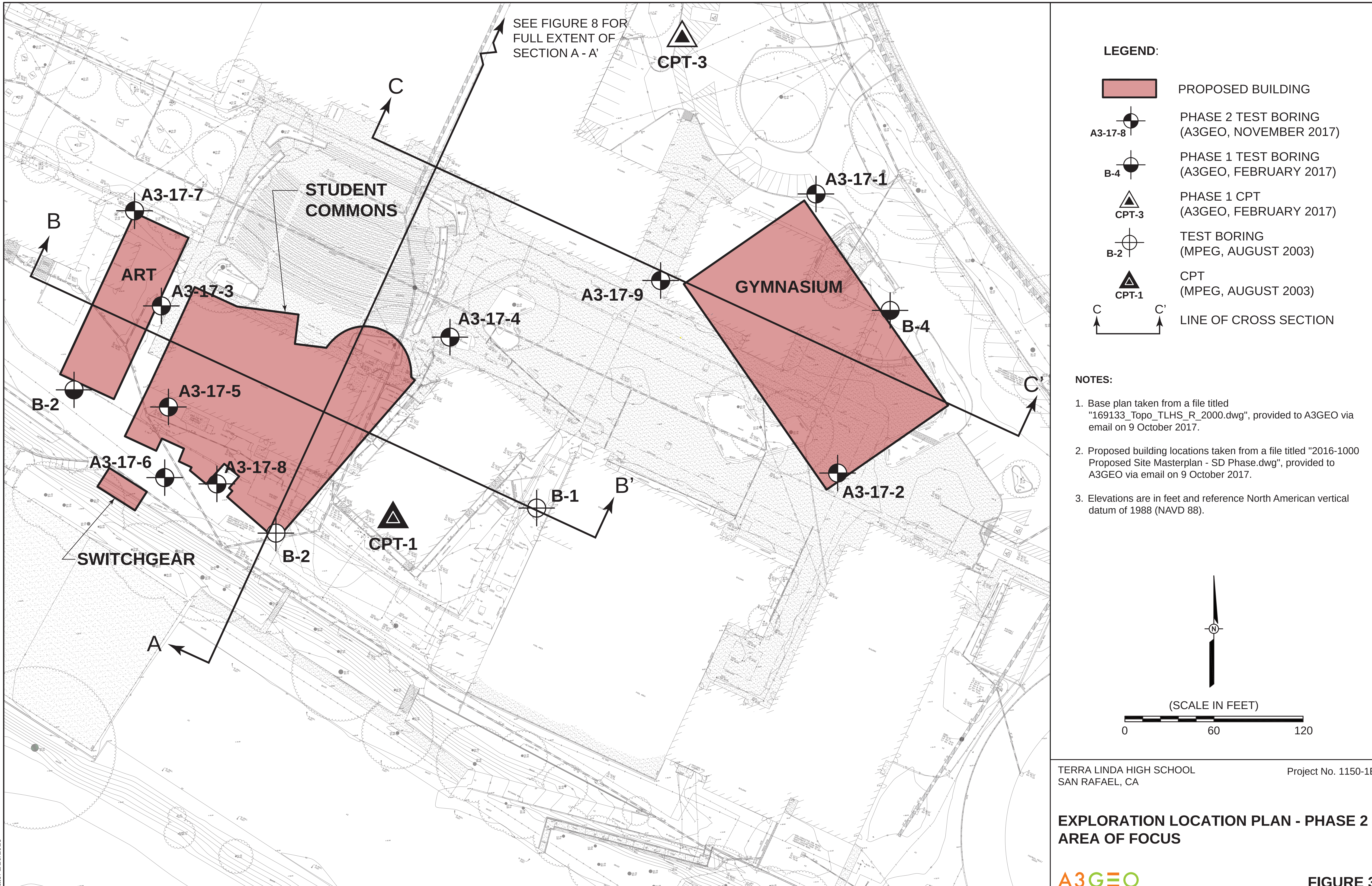
Project No. 1150-1B

SITE PLAN

A3GEO

FIGURE 2

Date: 01/26/2018



NOTES:

1. Base plan taken from a file titled "169133_Topo_TLHS_R_2000.dwg", provided to A3GEO via email on 9 October 2017.
2. Proposed building locations taken from a file titled "2016-1000 Proposed Site Masterplan - SD Phase.dwg", provided to A3GEO via email on 9 October 2017.
3. Elevations are in feet and reference North American vertical datum of 1988 (NAVD 88).

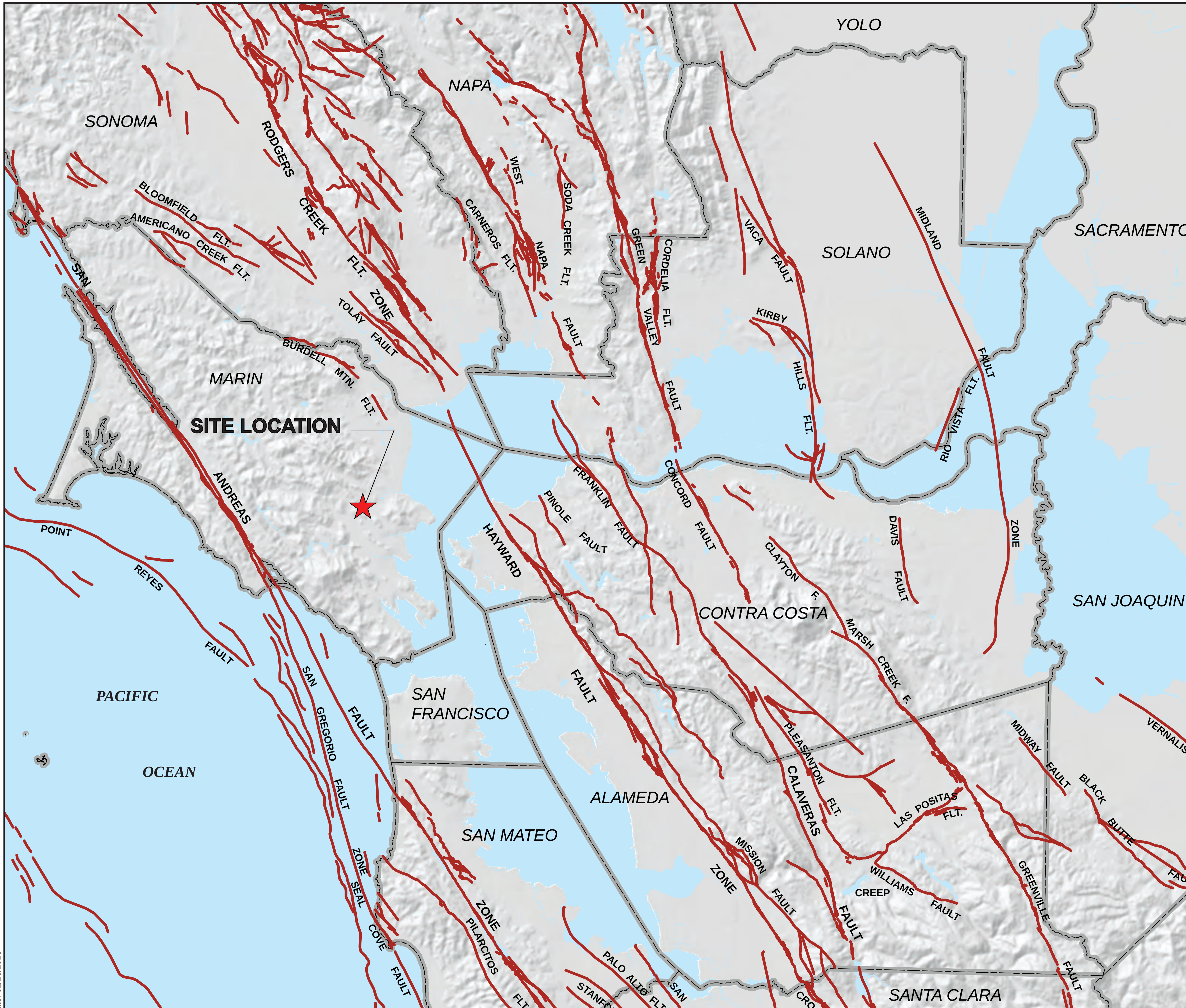
TERRA LINDA HIGH SCHOOL
SAN RAFAEL, CA

Project No. 1150-1B

EXPLORATION LOCATION PLAN - PHASE 2
AREA OF FOCUS

A3GEO

FIGURE 3



Date: 01/26/2018

LEGEND:

QUATERNARY FAULT

COUNTY BOUNDARY

NOTES:

1. Base map modified from USGS and California Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed 25 January, 2018, from USGS website: http://earthquake.usgs.gov/hazards/qfaults/

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0 8 16

TERRA LINDA HIGH SCHOOL
SAN RAFAEL

Project No. 1150-1B

QUATERNARY FAULT MAP

A3GEO

FIGURE 4

Air Photo Base: 11/8/1950

LEGEND:

PROPOSED BUILDING

A3-17-8 PHASE 2 TEST BORING (A3GEO, NOVEMBER 2017)

B-4 PHASE 1 TEST BORING (A3GEO, FEBRUARY 2017)

CPT-3 PHASE 1 CPT (A3GEO, FEBRUARY 2017)

B-2 TEST BORING (MPEG, AUGUST 2003)

CPT-1 CPT (MPEG, AUGUST 2003)

SITE BOUNDARY

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(SCALE IN FEET)

0 200 400

TERRA LINDA HIGH SCHOOL
SAN RAFAEL

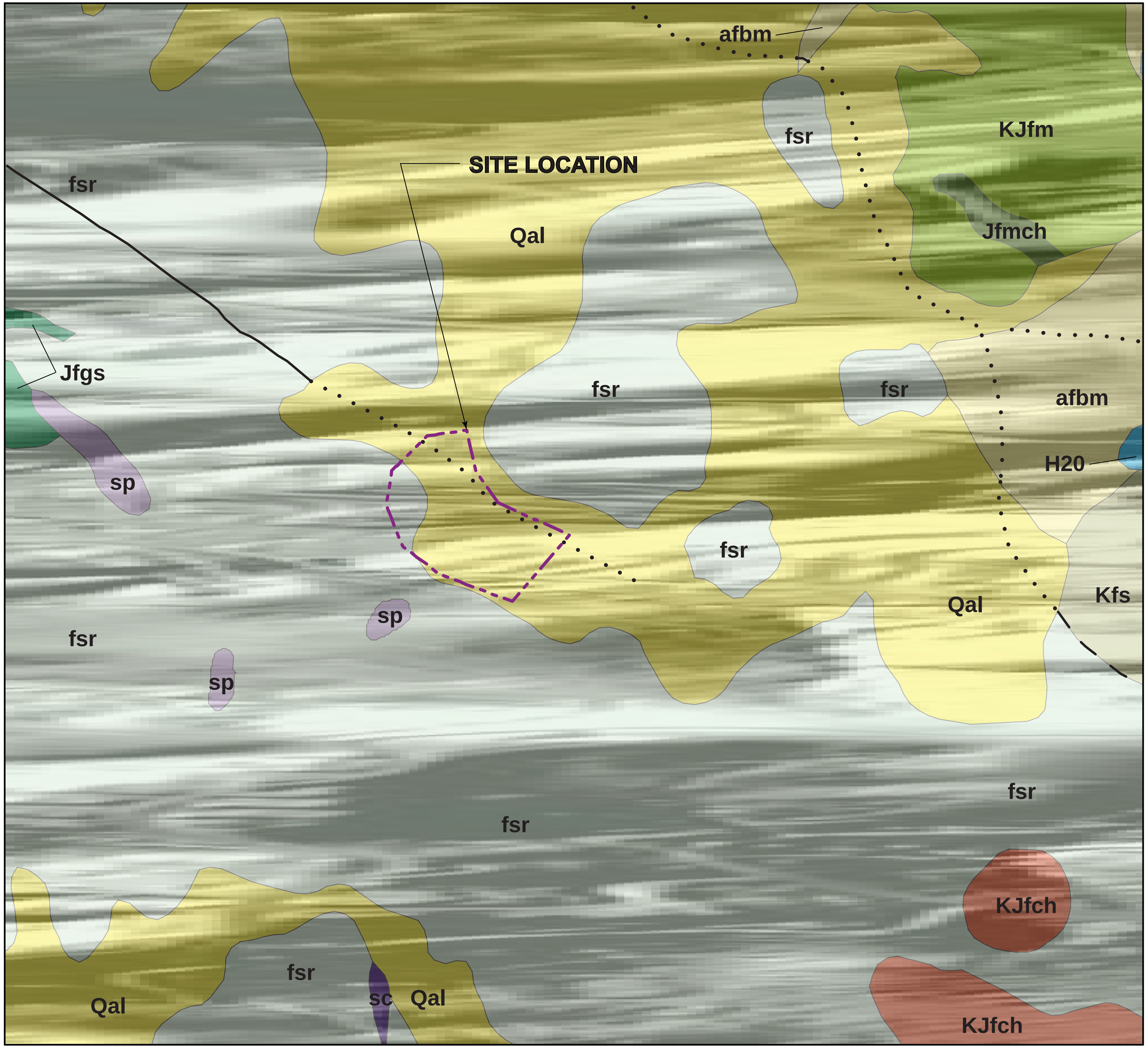
Project No. 1150-1B

PREDEVELOPMENT AERIAL PHOTOGRAPH

A3GEO

FIGURE 5

Date: 01/26/2018



LEGEND:

- afbm — QUATERNARY ARTIFICIAL FILL OVER BAY MUD
- Qal — QUATERNARY ALLUVIUM

FRANCISCAN COMPLEX

- Kfs — CRETACEOUS SANDSTONE AND SHALE
- KJfm — CRETACEOUS/JURASSIC METAMORPHIC ROCK
- KJfch — CRETACEOUS/JURASSIC CHERT
- Jfmch — JURASSIC METACHERT
- Jfgs — JURASSIC GREENSTONE
- sp — JURASSIC SERPENTINITE
- sc — JURASSIC SILICA-CARBONATE ROCK
- fsr — CRETACEOUS/JURASSIC MÉLANGE

FAULT, DASHED WHERE APPROX. LOCATED, DOTTED WHERE CONCEALED

SITE BOUNDARY

NOTES:

1. Base map modified from Blake, M.C., Graymer, R.W., and Jones, D.L., 2000, "Geologic Map and Map Database of Parts of Marin, San Francisco, Alameda, Contra Costa, and Sonoma Counties, California, " U.S. Geological Survey Miscellaneous Field Study MF 2337, Online Version 1.0.

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TERRA LINDA HIGH SCHOOL
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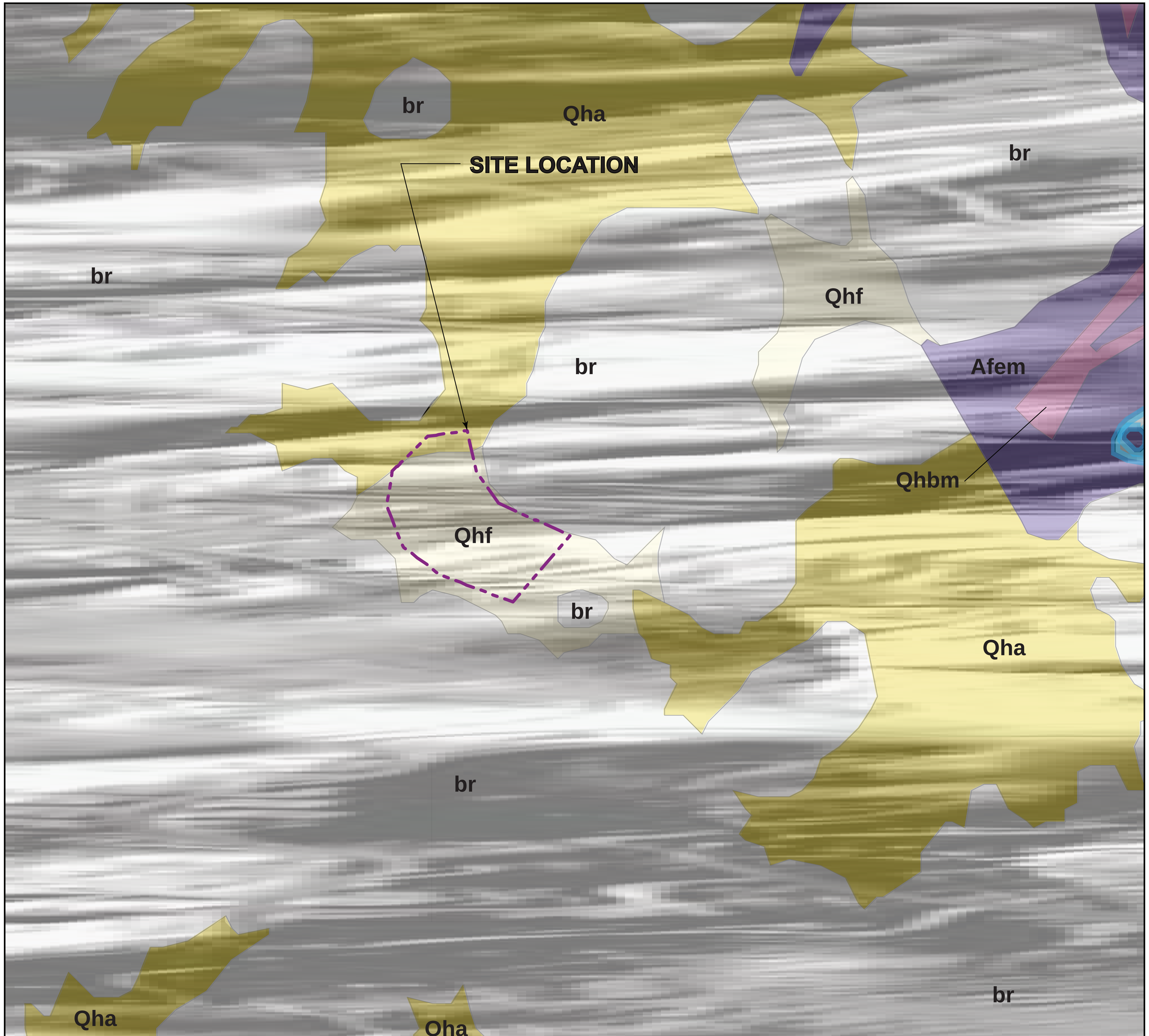
Project No. 1150-1B

GEOLOGIC MAP

A3GEO

FIGURE 6

Date: 01/26/2018



LEGEND:

Afem	HISTORICAL ARTIFICIAL FILL OVER LEVEE MUD
Qhbm	HOLOCENE SAN FRANCISCO BAY MUD
Qhf	HOLOCENE ALLUVIAL FAN DEPOSITS
Qha	HOLOCENE ALLUVIAL DEPOSITS, UNDIFFERENTIATED
br	EARLY QUATERNARY AND OLDER - OLDER DEPOSITS AND BEDROCK
- - -	SITE BOUNDARY

NOTES:

1. Base map modified from Witter et. al., 2006, "Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California," USGS Open-File Report 2006-1037.

(SCALE IN FEET)

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TERRA LINDA HIGH SCHOOL
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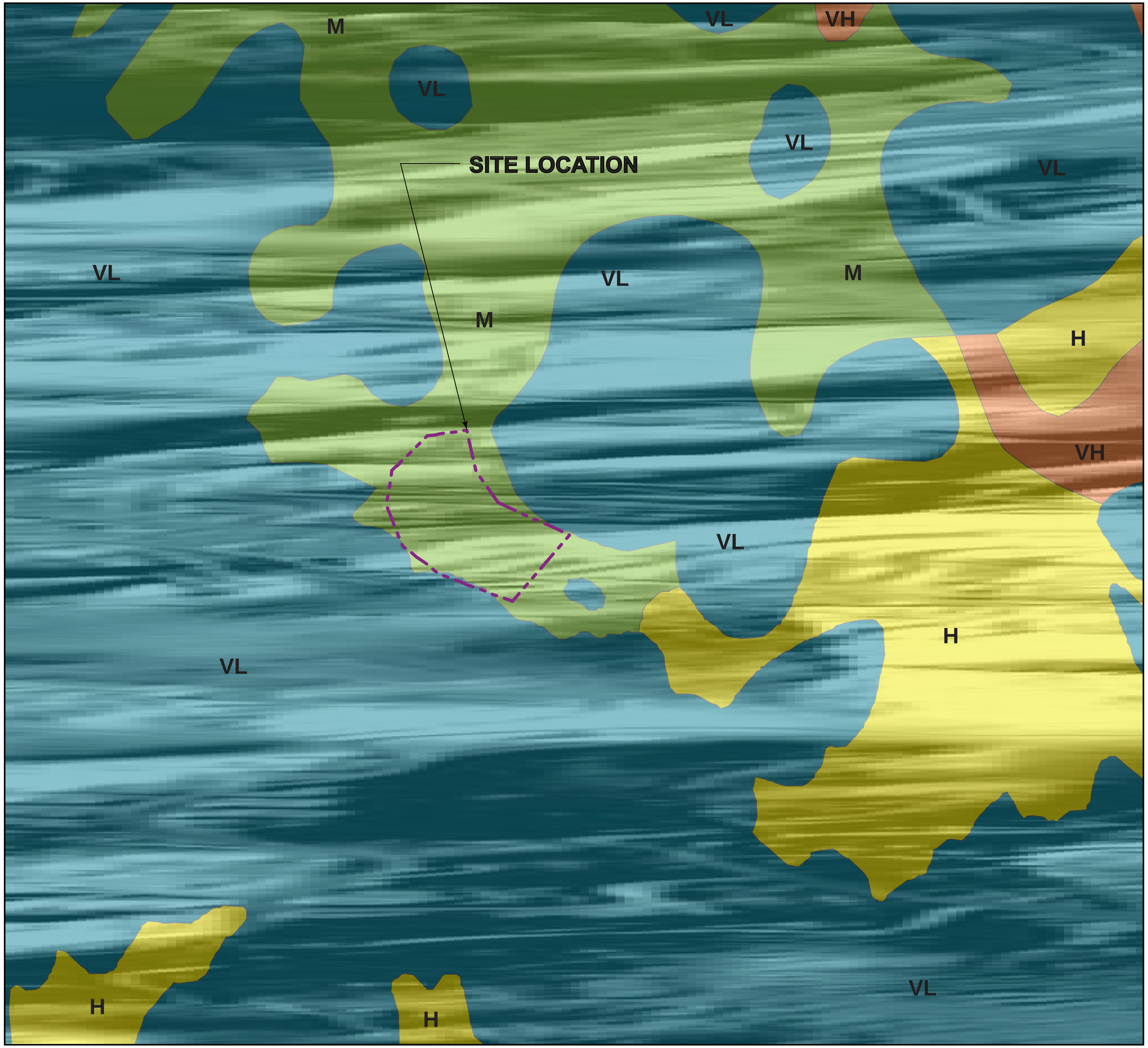
Project No. 1150-1B

QUATERNARY GEOLOGIC MAP

A3GEO

FIGURE 7

Date: 01/26/2018



LEGEND:

LIQUEFACTION POTENTIAL

VL	VERY LOW
M	MODERATE
H	HIGH
VH	VERY HIGH
	SITE BOUNDARY

NOTES:

1. Base map modified from Knudsen et. al., 2000, "Description of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region, California," U.S. Geological Survey, Part 3 of Open-File Report 00-444.

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(SCALE IN FEET)

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TERRA LINDA HIGH SCHOOL
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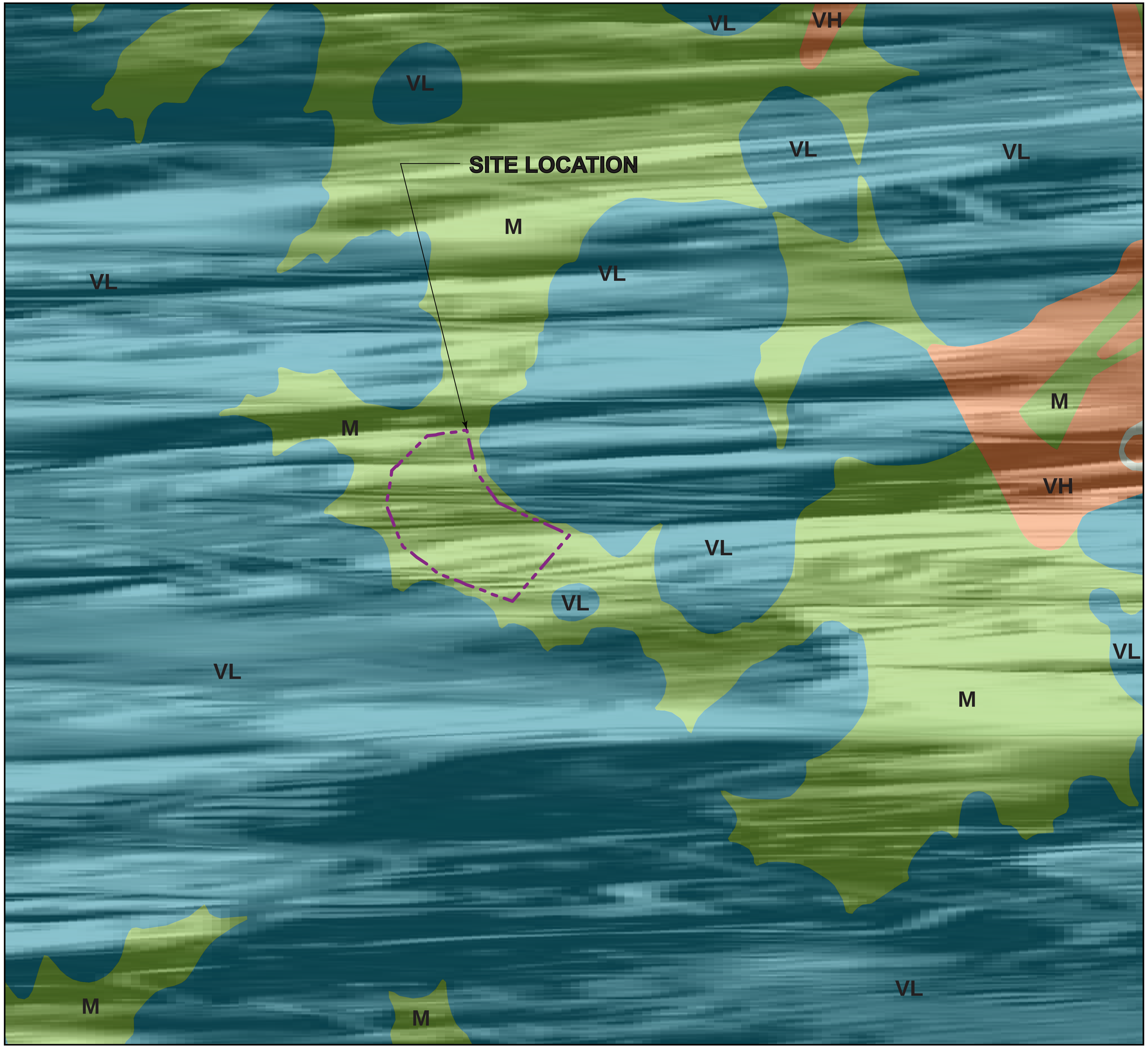
Project No. 1150-1B

LIQUEFACTION POTENTIAL MAP

A3GEO

FIGURE 8a

Date: 01/26/2018



LEGEND:

LIQUEFACTION POTENTIAL

VL	VERY LOW
M	MODERATE
VH	VERY HIGH
- - - - -	SITE BOUNDARY

NOTES:

1. Base map modified from Witter et. al., 2006, "Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California," USGS Open-File Report 2006-1037.

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(SCALE IN FEET)

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TERRA LINDA HIGH SCHOOL
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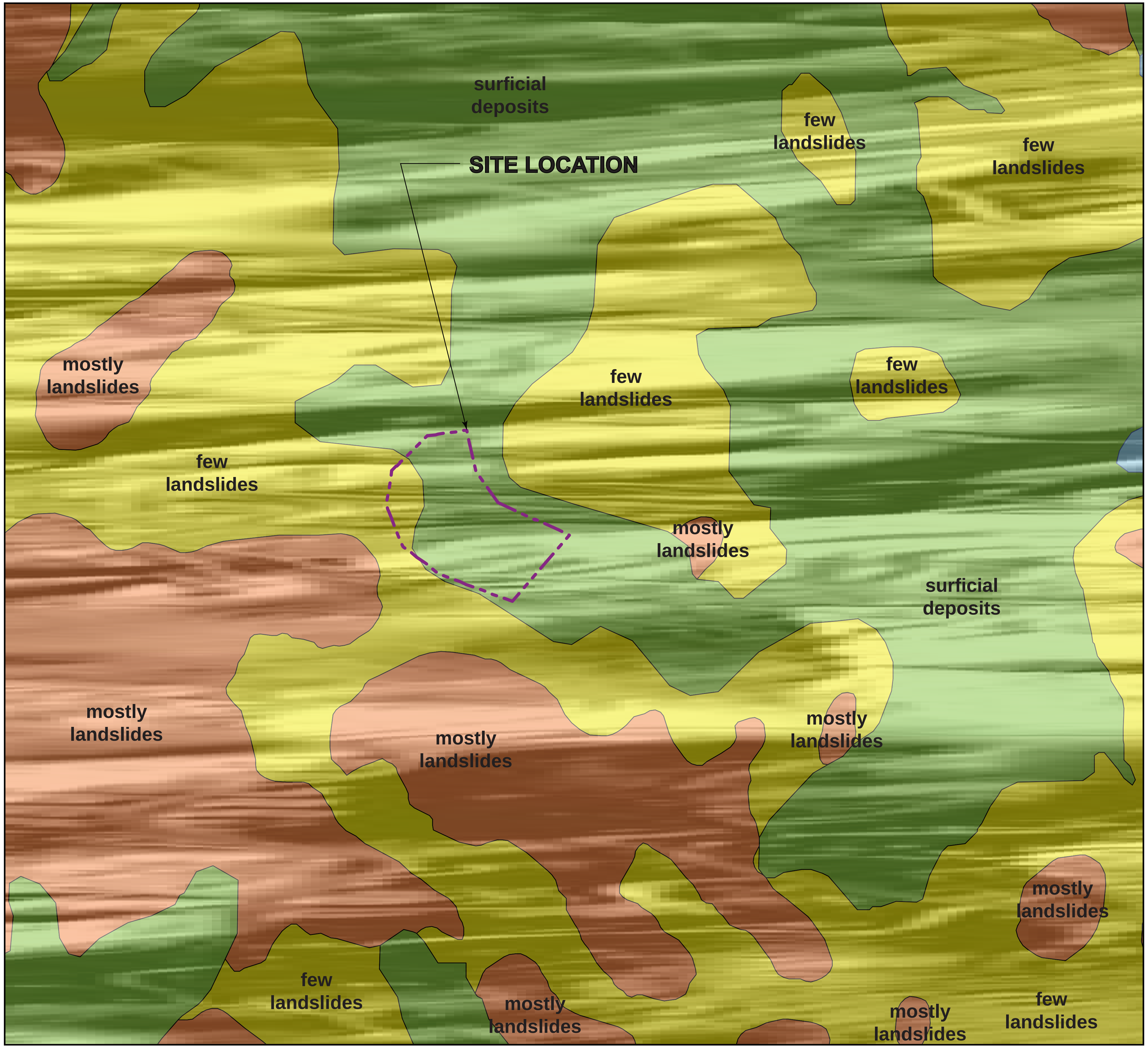
Project No. 1150-1B

LIQUEFACTION POTENTIAL MAP

A3GEO

FIGURE 8b

Date: 01/26/2018



LEGEND:

LANDSLIDE HAZARD

- SURFICIAL DEPOSITS
- FEW LANDSLIDES
- MOSTLY LANDSLIDES
- SITE BOUNDARY

NOTES:

1. Base map modified from Wentworth, et. al., 1997, "Summary Distribution of Slides and Earth Flows in the San Francisco Bay Region, California," U.S. Geological Survey Open-File Report 97-745C

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(SCALE IN FEET)

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TERRA LINDA HIGH SCHOOL
SAN RAFAEL

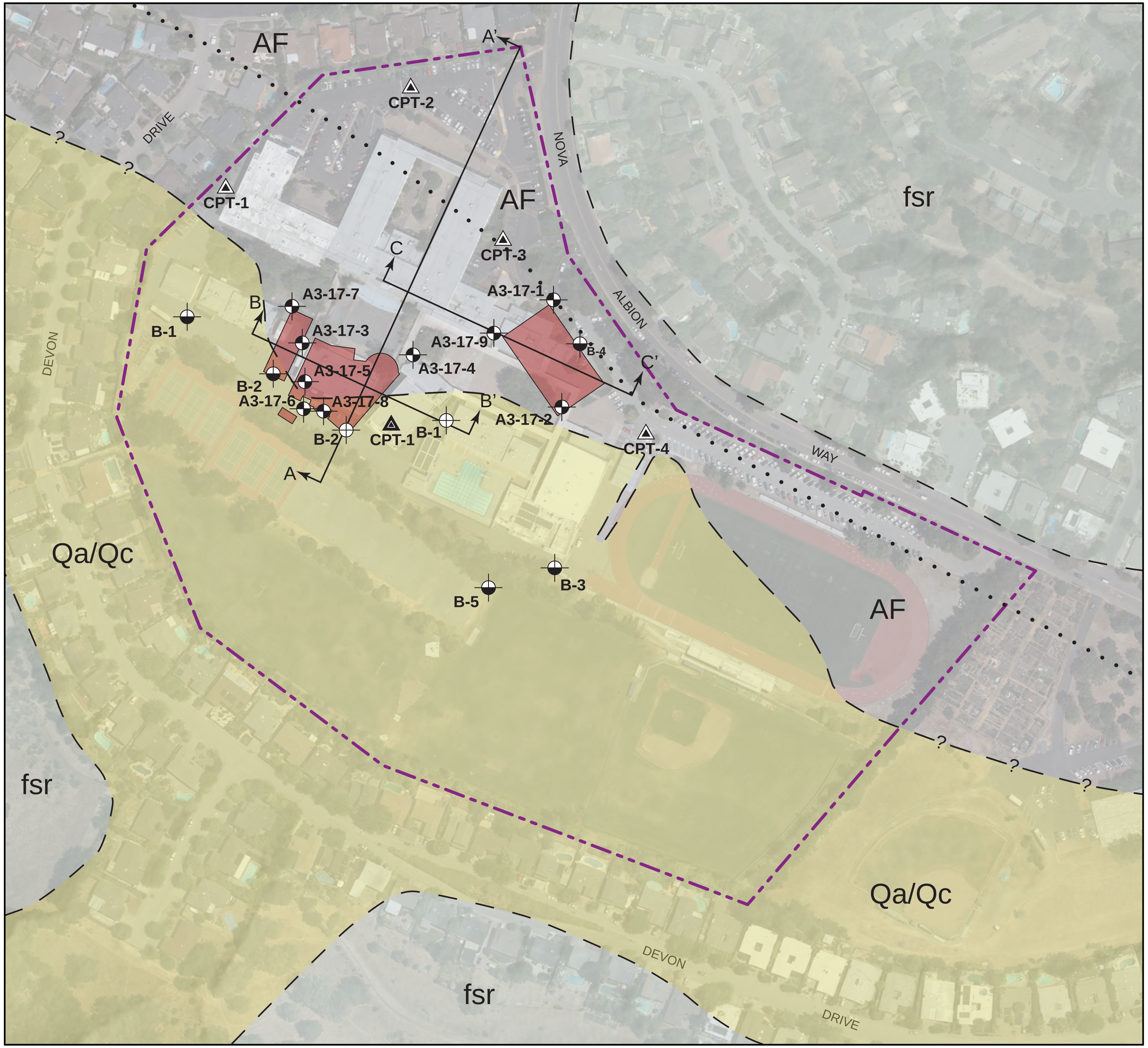
Project No. 1150-1B

LANDSLIDE HAZARD MAP

A3GEO

FIGURE 9

Date: 01/26/2018



LEGEND:

AF	ARTIFICIAL FILL
Qa/Qc	ALLUVIUM/COLLUVIUM (QUATERNARY)
fsr	CRETACEOUS/JURASSIC FRANCISCAN MÉLANGE
	GEOLOGIC CONTACT APPROXIMATELY LOCATED
	FAULT CONTACT CONCEALED
C C'	LINE OF CROSS SECTION
A3-17-8	PHASE 2 TEST BORING (A3GEO, NOVEMBER 2017)
B-4	PHASE 1 TEST BORING (A3GEO, FEBRUARY 2017)
CPT-3	PHASE 1 CPT (A3GEO, FEBRUARY 2017)
B-2	TEST BORING (MPEG, AUGUST 2003)
CPT-1	CPT (MPEG, AUGUST 2003)
	PROPOSED BUILDING
	SITE BOUNDARY

NOTES:

1. Geology from Marin Map, A Geographic Information System for Marin County. Data are in California State Plane coordinates, NAD83 HARN, US Survey feet.
2. Qaf and Qa/Qc contact based on conditions observed in test borings, and drawing A1A, dated 16 December 1958, prepared by Grommé Mulvin & Priestly Architects of San Rafael, CA for the New High School, San Rafael High School District for the Terra Linda Area, Marin County, California.
3. Fault location from USGS Miscellaneous Field Study MF-2337 for parts of Marin, San Francisco, and Contra Costa Counties, 2000.

(SCALE IN FEET)
0 200 400

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TERRA LINDA HIGH SCHOOL
SAN RAFAEL

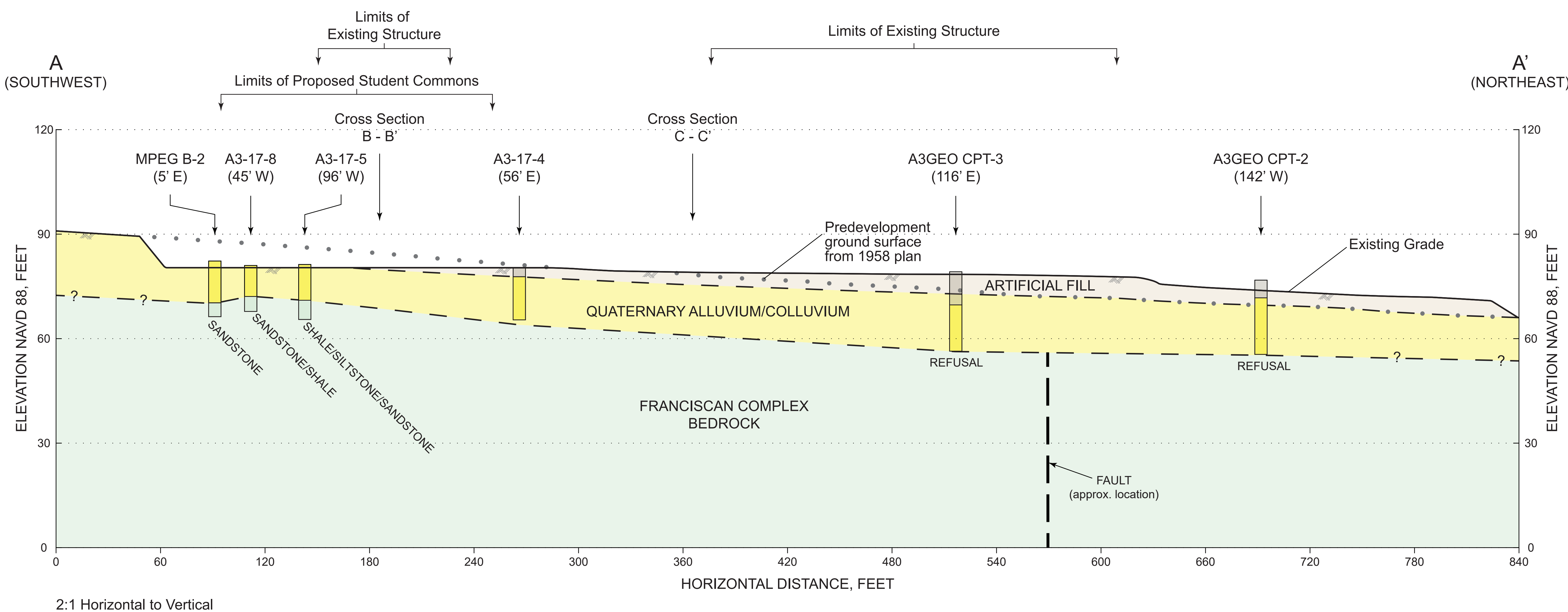
Project No. 1150-1B

SITE GEOLOGIC MAP

A3GEO

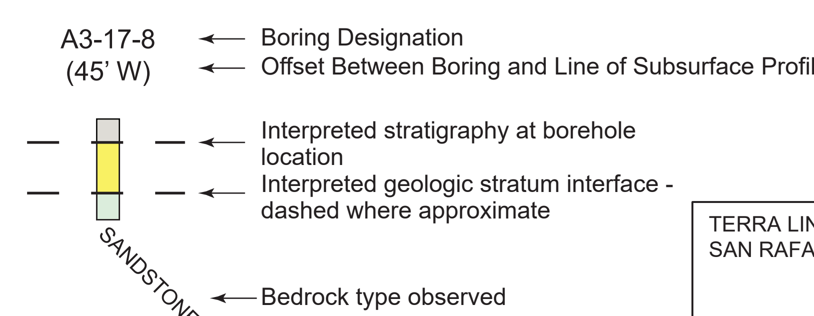
FIGURE 10

Date: 01/26/2018



NOTES:

1. Refer to Figure 8 for plan location designation and orientation of subsurface sections and as-drilled exploration locations.
2. Ground surface profiles shown were interpreted from profile A-A' on Sheet A1A of the 1958 plans for the school and are approximate.
3. Elevations for MPEG borings were assumed to be based on National Geodetic Vertical Datum of 1929 (NGVD 29). Elevations were converted to NAVD 88 by adding 2.67 feet.
4. Subsurface profile depict the general geologic conditions at the site and are based on interpretation of data encountered in explorations. Lines representing the interfaces between strata on the profile are based on interpolation between adjacent borings. Test boring sticks show the interpreted sequence of strata at each location. Actual soil conditions and interfaces between explorations may vary significantly from those indicated on profiles.
5. Refer to test boring logs for more detailed soil and rock conditions.
6. Fault location based on USGS Miscellaneous Field Study MF-2337 for Parts of Marin, San Francisco, and Contra Costa Counties, 2000.



TERRA LINDA HIGH SCHOOL
SAN RAFAEL

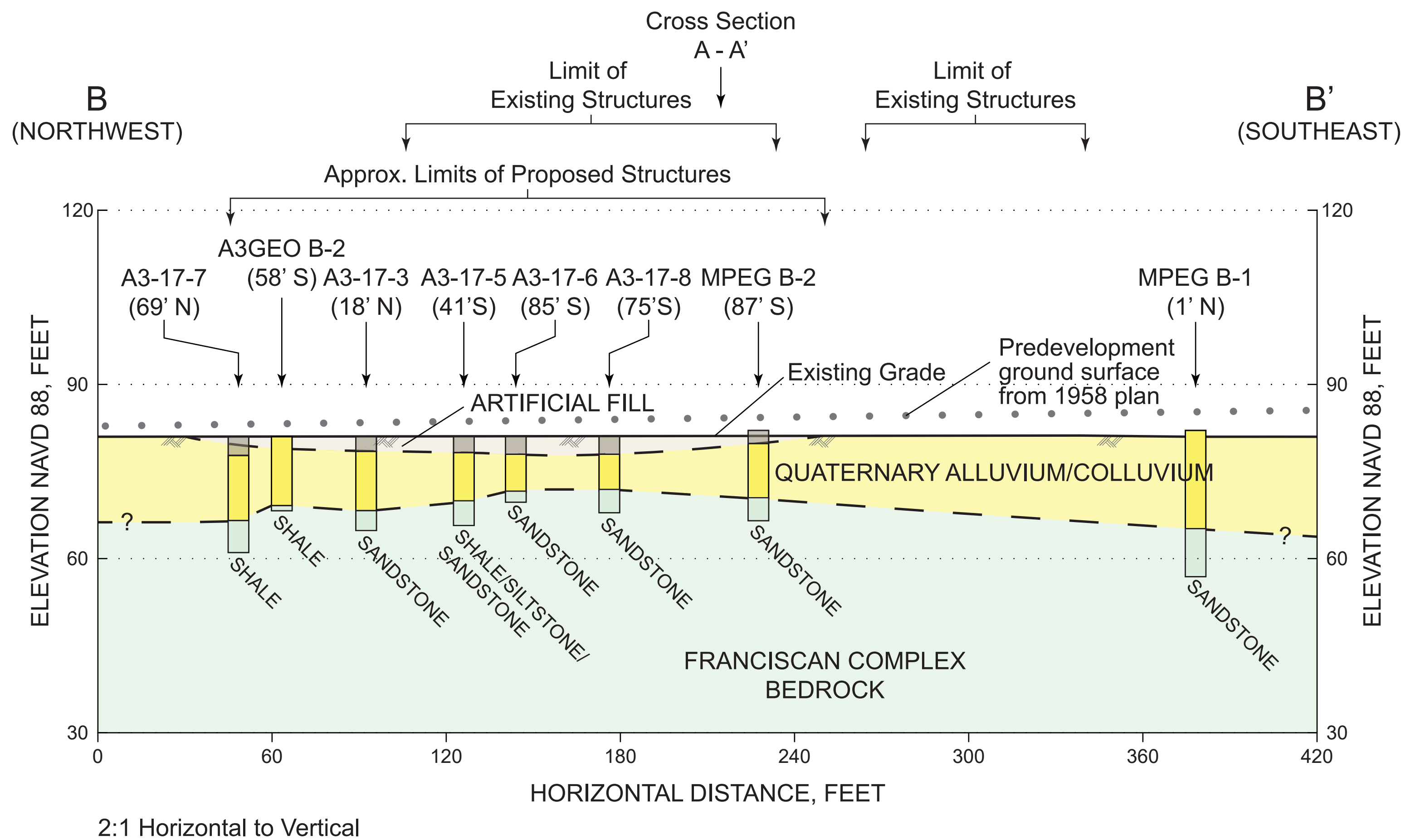
Project No. 1150-1B

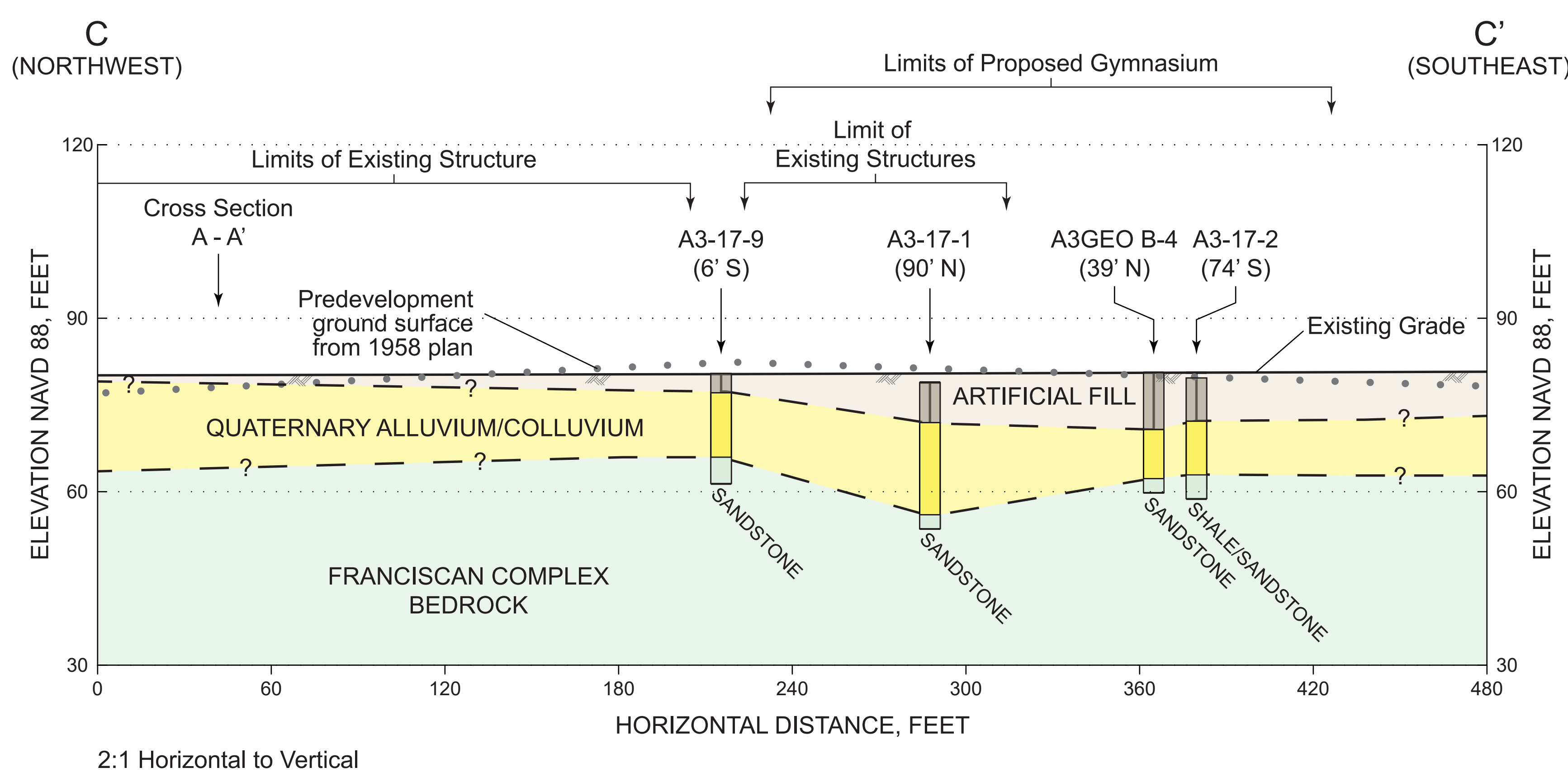
CROSS SECTION A - A'

A3GEO

FIGURE 11

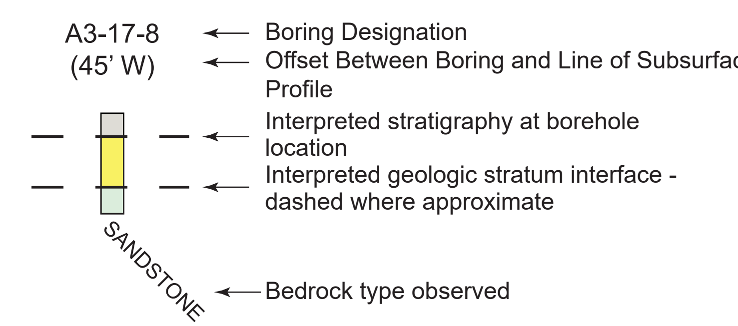
Date: 01/26/2018





NOTES:

1. Refer to Figure 8 for plan location designation and orientation of subsurface sections and as-drilled exploration locations.
2. Elevations for MPEG borings were assumed to be based on National Geodetic Vertical Datum of 1929 (NGVD 29). Elevations were converted to NAVD 88 by adding 2.67 feet.
3. Subsurface profile depict the general geologic conditions at the site and are based on interpretation of data encountered in explorations. Lines representing the interfaces between strata on the profile are based on interpolation between adjacent borings. Test boring sticks show the interpreted sequence of strata at each location. Actual soil conditions and interfaces between explorations may vary significantly from those indicated on profiles.
4. Refer to test boring logs for more detailed soil and rock conditions.



TERRA LINDA HIGH SCHOOL
SAN RAFAEL

Project No. 1150-1B

CROSS SECTIONS B - B' & C - C'

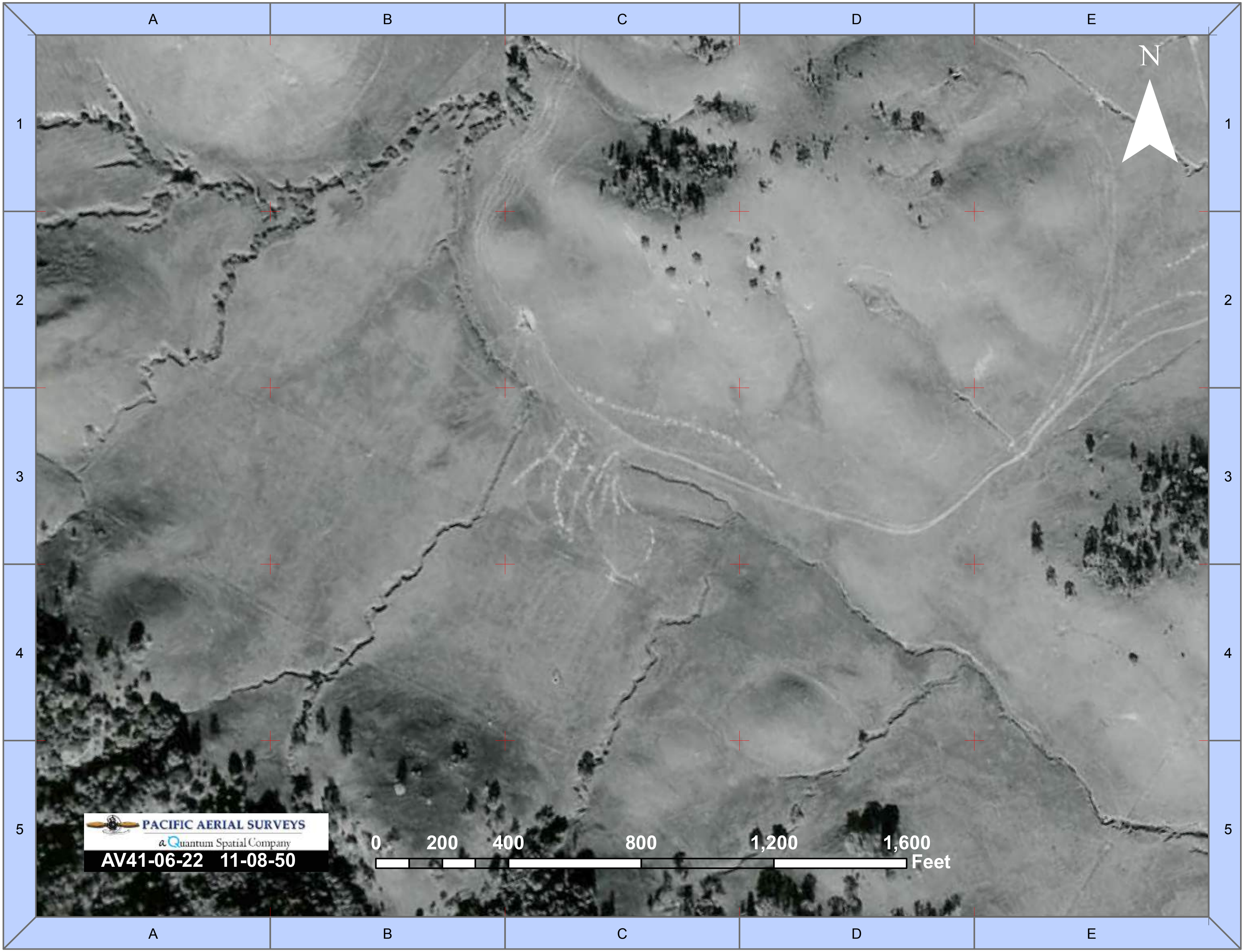
A3GEO

FIGURE 12

Date: 01/26/2018

APPENDIX A

Historic Aerial Photographs



A
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a Quantum Spatial Company
AV41-06-22 11-08-50
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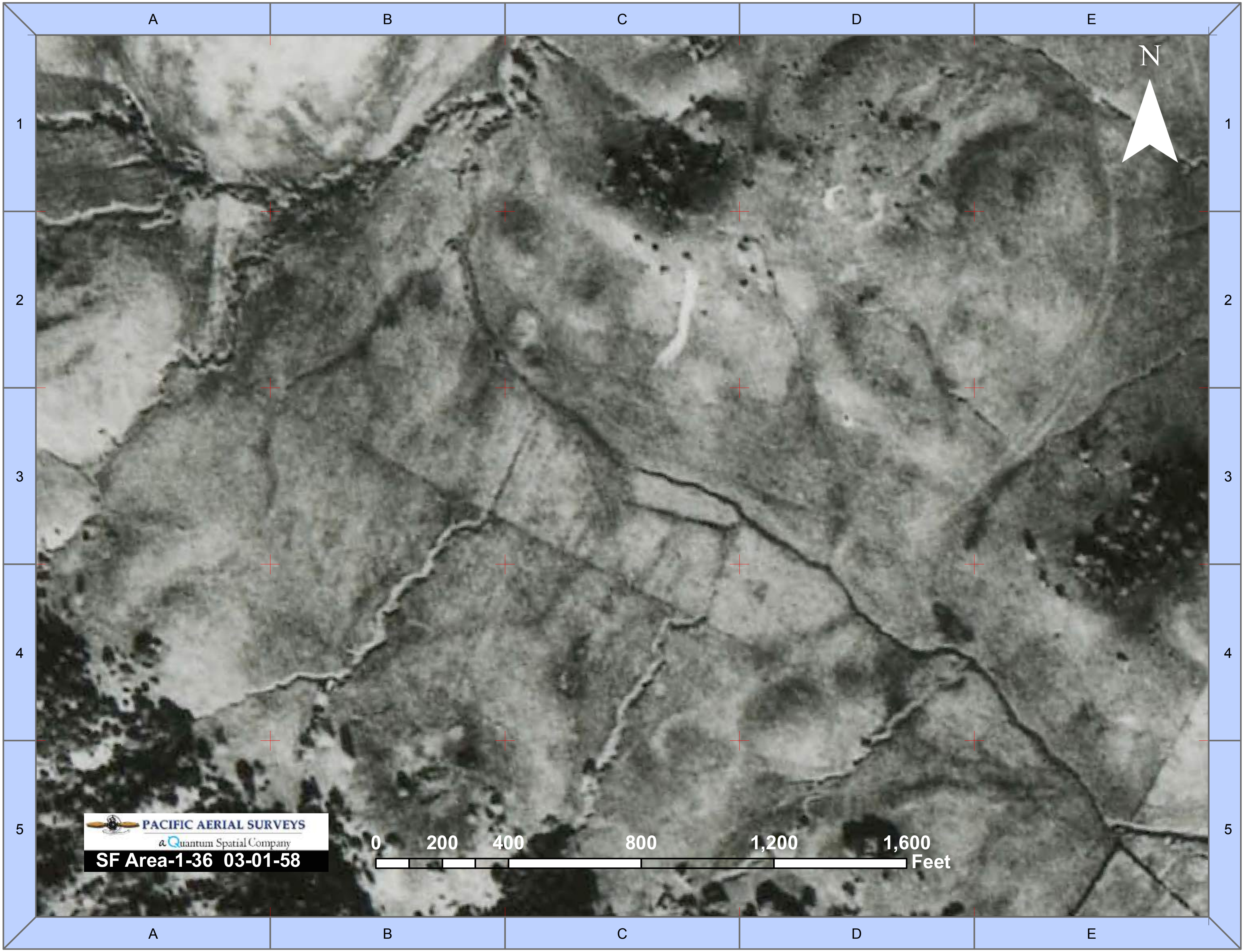
1,600
Feet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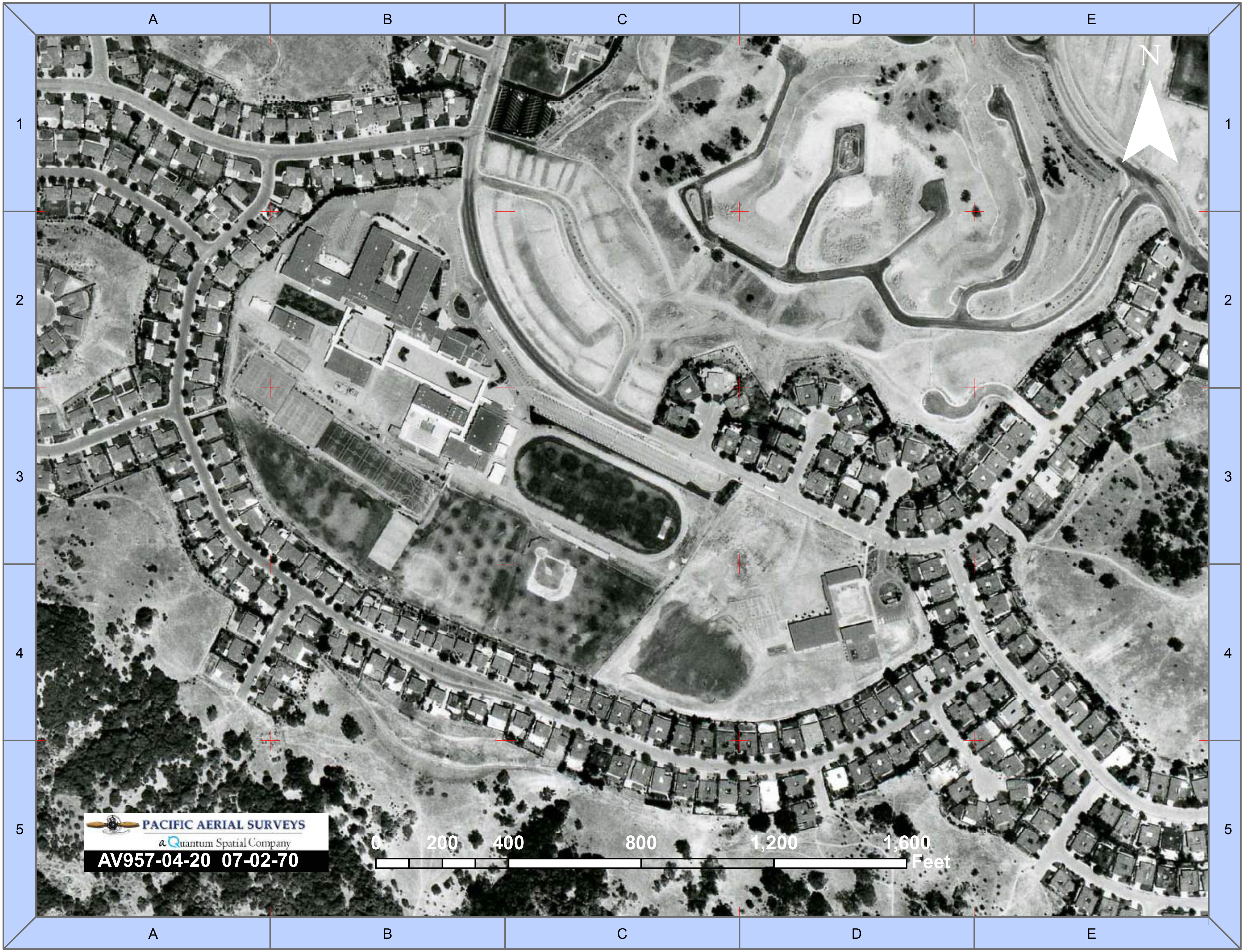
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AV957-04-20 07-02-70
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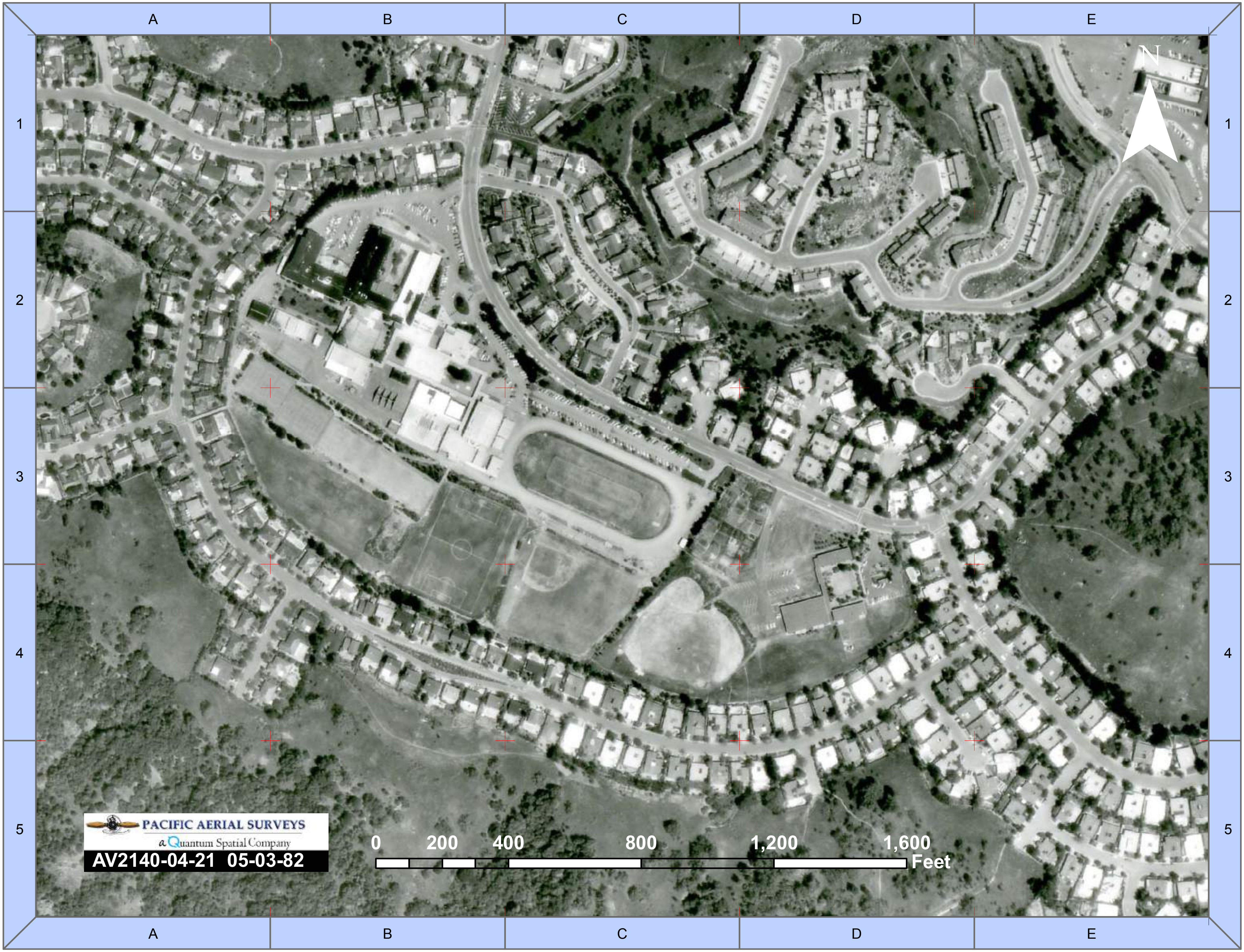
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a Quantum Spatial Company
AV2860-11-14 04-19-86
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a Quantum Spatial Company
AV4252-29-57 04-27-92
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a Quantum Spatial Company
AV5036-03-13 01-11-96
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PACIFIC AERIAL SURVEYS
a Quantum Spatial Company
AV6540-124-55 05-03-00
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PACIFIC AERIAL SURVEYS
a Quantum Spatial Company
Terra Linda HS 2015
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Feet

APPENDIX B

Phase 1 Cone Penetration Test Data

GREGG DRILLING & TESTING, INC.
GEOTECHNICAL AND ENVIRONMENTAL INVESTIGATION SERVICES

February 24, 2017

A3GEO
Attn: Wayne Magnusen

Subject: CPT Site Investigation
SRCS/Terra Linda High School
San Rafael, California
GREGG Project Number: 17-026MA

Dear Mr. Magnusen:

The following report presents the results of GREGG Drilling & Testing's Cone Penetration Test investigation for the above referenced site. The following testing services were performed:

1	Cone Penetration Tests	(CPTU)	☒
2	Pore Pressure Dissipation Tests	(PPD)	☒
3	Seismic Cone Penetration Tests	(SCPTU)	☐
4	UVOST Laser Induced Fluorescence	(UVOST)	☐
5	Groundwater Sampling	(GWS)	☐
6	Soil Sampling	(SS)	☐
7	Vapor Sampling	(VS)	☐
8	Membrane Interface Probe	(MIP)	☐
9	Vane Shear Testing	(VST)	☐
10	Dilatometer Testing	(DMT)	☐

A list of reference papers providing additional background on the specific tests conducted is provided in the bibliography following the text of the report. If you would like a copy of any of these publications or should you have any questions or comments regarding the contents of this report, please do not hesitate to contact our office at (925) 313-5800.

Sincerely,
GREGG Drilling & Testing, Inc.

Mary Walden
Operations Manager

950 Howe Rd • Martinez, California 94553 • (925) 313-5800 • FAX (925) 313-0302
www.greggdrilling.com

Cone Penetration Test Sounding Summary

-Table 1-

CPT Sounding Identification	Date	Termination Depth (feet)	Depth of Groundwater Samples (feet)	Depth of Soil Samples (feet)	Depth of Pore Pressure Dissipation Tests (feet)
CPT-01	2/22/17	25	-	-	24.6
CPT-02	2/22/17	21	-	-	-
CPT-03	2/22/17	23	-	-	-
CPT-04	2/22/17	18	-	-	17.7

Bibliography

Lunne, T., Robertson, P.K. and Powell, J.J.M., "Cone Penetration Testing in Geotechnical Practice" E & FN Spon. ISBN 0 419 23750, 1997

Roberston, P.K., "Soil Classification using the Cone Penetration Test", Canadian Geotechnical Journal, Vol. 27, 1990 pp. 151-158.

Mayne, P.W., "NHI (2002) Manual on Subsurface Investigations: Geotechnical Site Characterization", available through www.ce.gatech.edu/~geosys/Faculty/Mayne/papers/index.html, Section 5.3, pp. 107-112.

Robertson, P.K., R.G. Campanella, D. Gillespie and A. Rice, "Seismic CPT to Measure In-Situ Shear Wave Velocity", Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8, 1986 pp. 791-803.

Robertson, P.K., Sully, J., Woeller, D.J., Lunne, T., Powell, J.J.M., and Gillespie, D.J., "Guidelines for Estimating Consolidation Parameters in Soils from Piezocone Tests", Canadian Geotechnical Journal, Vol. 29, No. 4, August 1992, pp. 539-550.

Robertson, P.K., T. Lunne and J.J.M. Powell, "Geo-Environmental Application of Penetration Testing", Geotechnical Site Characterization, Robertson & Mayne (editors), 1998 Balkema, Rotterdam, ISBN 90 5410 939 4 pp 35-47.

Campanella, R.G. and I. Weemees, "Development and Use of An Electrical Resistivity Cone for Groundwater Contamination Studies", Canadian Geotechnical Journal, Vol. 27 No. 5, 1990 pp. 557-567.

DeGroot, D.J. and A.J. Lutenegger, "Reliability of Soil Gas Sampling and Characterization Techniques", International Site Characterization Conference - Atlanta, 1998.

Woeller, D.J., P.K. Robertson, T.J. Boyd and Dave Thomas, "Detection of Polyaromatic Hydrocarbon Contaminants Using the UVIF-CPT", 53rd Canadian Geotechnical Conference Montreal, QC October pp. 733-739, 2000.

Zemo, D.A., T.A. Delfino, J.D. Gallinatti, V.A. Baker and L.R. Hilpert, "Field Comparison of Analytical Results from Discrete-Depth Groundwater Samplers" BAT EnviroProbe and QED HydroPunch, Sixth national Outdoor Action Conference, Las Vegas, Nevada Proceedings, 1992, pp 299-312.

Copies of ASTM Standards are available through www.astm.org

Cone Penetration Testing Procedure (CPT)

Gregg Drilling carries out all Cone Penetration Tests (CPT) using an integrated electronic cone system, *Figure CPT*.

The cone takes measurements of tip resistance (q_c), sleeve resistance (f_s), and penetration pore water pressure (u_2). Measurements are taken at either 2.5 or 5 cm intervals during penetration to provide a nearly continuous profile. CPT data reduction and basic interpretation is performed in real time facilitating on-site decision making. The above mentioned parameters are stored electronically for further analysis and reference. All CPT soundings are performed in accordance with revised ASTM standards (D 5778-12).

The 5mm thick porous plastic filter element is located directly behind the cone tip in the u_2 location. A new saturated filter element is used on each sounding to measure both penetration pore pressures as well as measurements during a dissipation test (*PPDT*). Prior to each test, the filter element is fully saturated with oil under vacuum pressure to improve accuracy.

When the sounding is completed, the test hole is backfilled according to client specifications. If grouting is used, the procedure generally consists of pushing a hollow tremie pipe with a "knock out" plug to the termination depth of the CPT hole. Grout is then pumped under pressure as the tremie pipe is pulled from the hole. Disruption or further contamination to the site is therefore minimized.

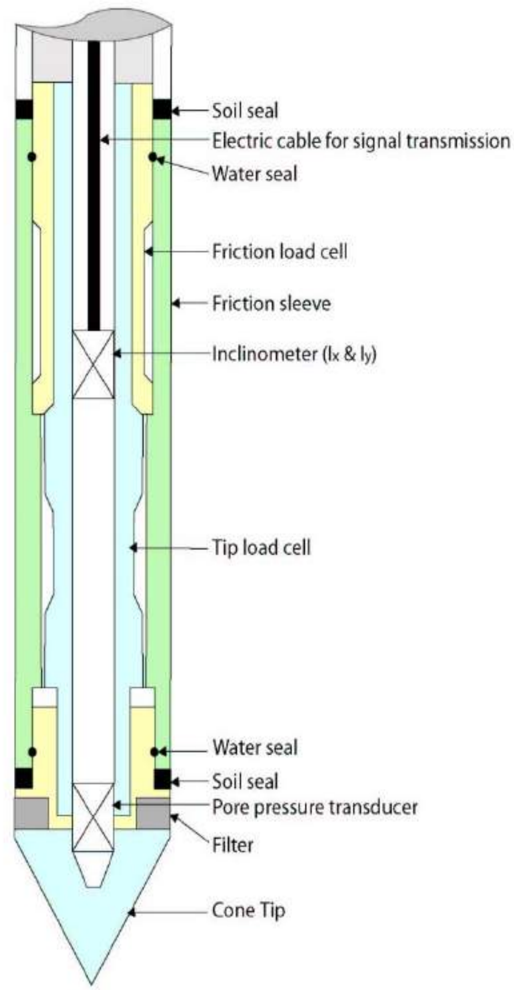


Figure CPT

Gregg 15cm^2 Standard Cone Specifications

Dimensions	
Cone base area	15 cm^2
Sleeve surface area	225 cm^2
Cone net area ratio	0.80
Specifications	
Cone load cell	
Full scale range	180 kN (20 tons)
Overload capacity	150%
Full scale tip stress	120 MPa (1,200 tsf)
Repeatability	120 kPa (1.2 tsf)
Sleeve load cell	
Full scale range	31 kN (3.5 tons)
Overload capacity	150%
Full scale sleeve stress	1,400 kPa (15 tsf)
Repeatability	1.4 kPa (0.015 tsf)
Pore pressure transducer	
Full scale range	7,000 kPa (1,000 psi)
Overload capacity	150%
Repeatability	7 kPa (1 psi)

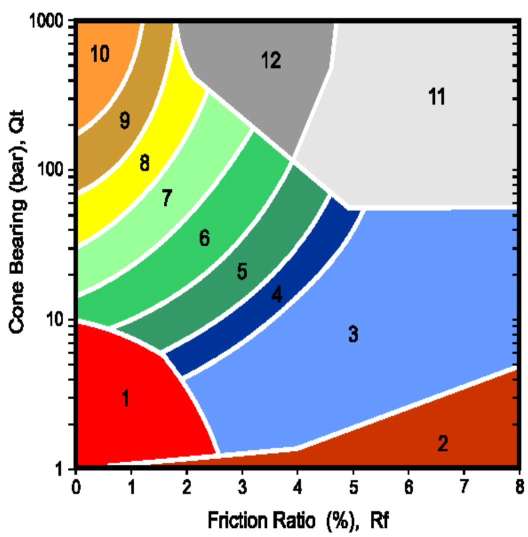
Note: The repeatability during field use will depend somewhat on ground conditions, abrasion, maintenance and zero load stability.

Cone Penetration Test Data & Interpretation

The Cone Penetration Test (CPT) data collected are presented in graphical and electronic form in the report. The plots include interpreted Soil Behavior Type (SBT) based on the charts described by Robertson (1990). Typical plots display SBT based on the non-normalized charts of Robertson et al (1986). For CPT soundings deeper than 30m, we recommend the use of the normalized charts of Robertson (1990) which can be displayed as SBTn, upon request. The report also includes spreadsheet output of computer calculations of basic interpretation in terms of SBT and SBTn and various geotechnical parameters using current published correlations based on the comprehensive review by Lunne, Robertson and Powell (1997), as well as recent updates by Professor Robertson (Guide to Cone Penetration Testing, 2015). The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg Drilling & Testing Inc. does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and does not assume any liability for use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software. Some interpretation methods require input of the groundwater level to calculate vertical effective stress. An estimate of the in-situ groundwater level has been made based on field observations and/or CPT results, but should be verified by the user.

A summary of locations and depths is available in Table 1. Note that all penetration depths referenced in the data are with respect to the existing ground surface.

Note that it is not always possible to clearly identify a soil type based solely on q_t, f_s, and u_2. In these situations, experience, judgment, and an assessment of the pore pressure dissipation data should be used to infer the correct soil behavior type.



ZONE	SBT
1	Sensitive, fine grained
2	Organic materials
3	Clay
4	Silty clay to clay
5	Clayey silt to silty clay
6	Sandy silt to clayey silt
7	Silty sand to sandy silt
8	Sand to silty sand
9	Sand
10	Gravely sand to sand
11	Very stiff fine grained*
12	Sand to clayey sand*

*over consolidated or cemented

Figure SBT (After Robertson et al., 1986) – Note: Colors may vary slightly compared to plots

GREGG

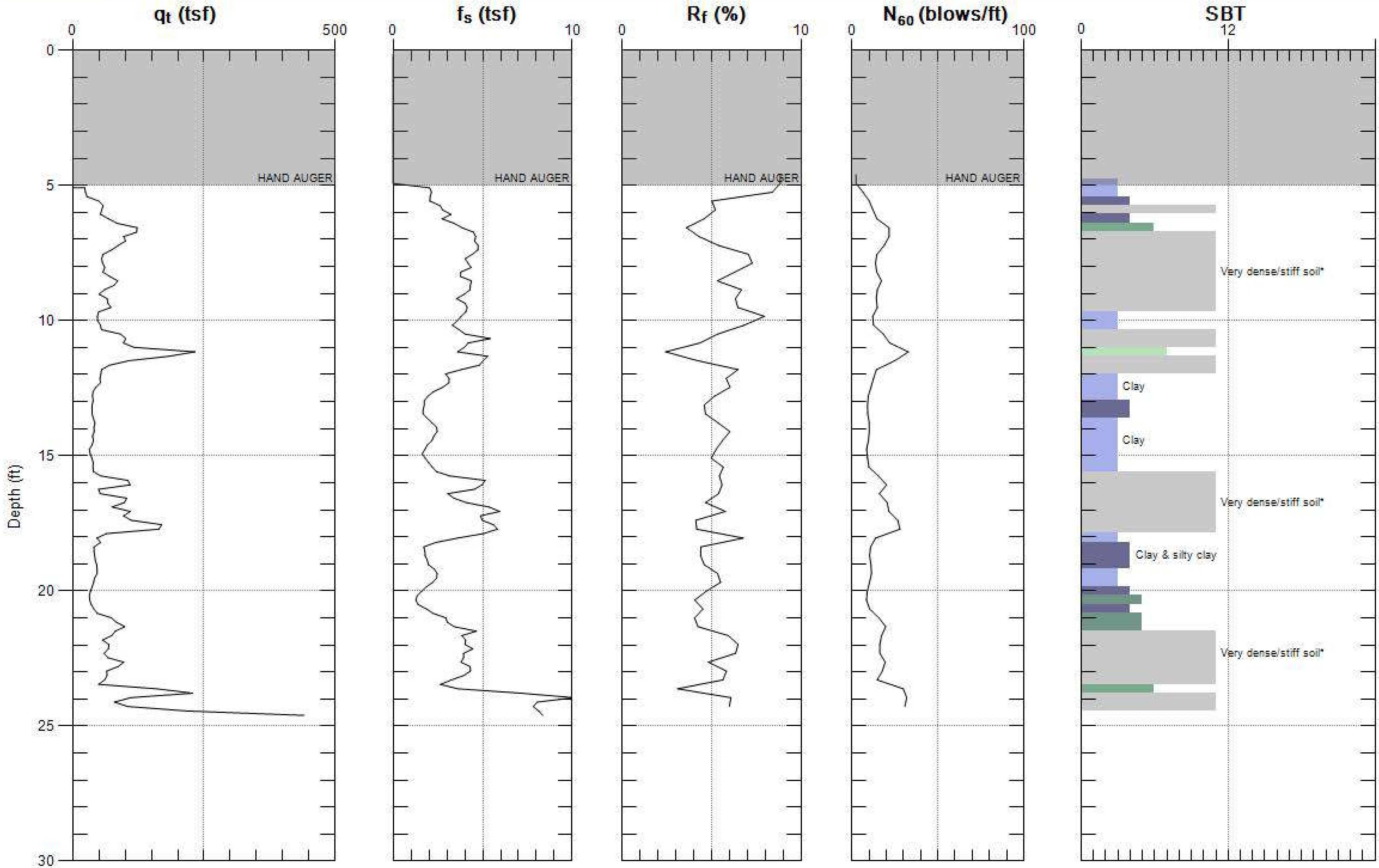
A3GEO

Site: TERRA LINDA H.S.

Sounding: CPT-1A

Engineer: J.VAN DEN BERG

Date: 2/22/17 09:24



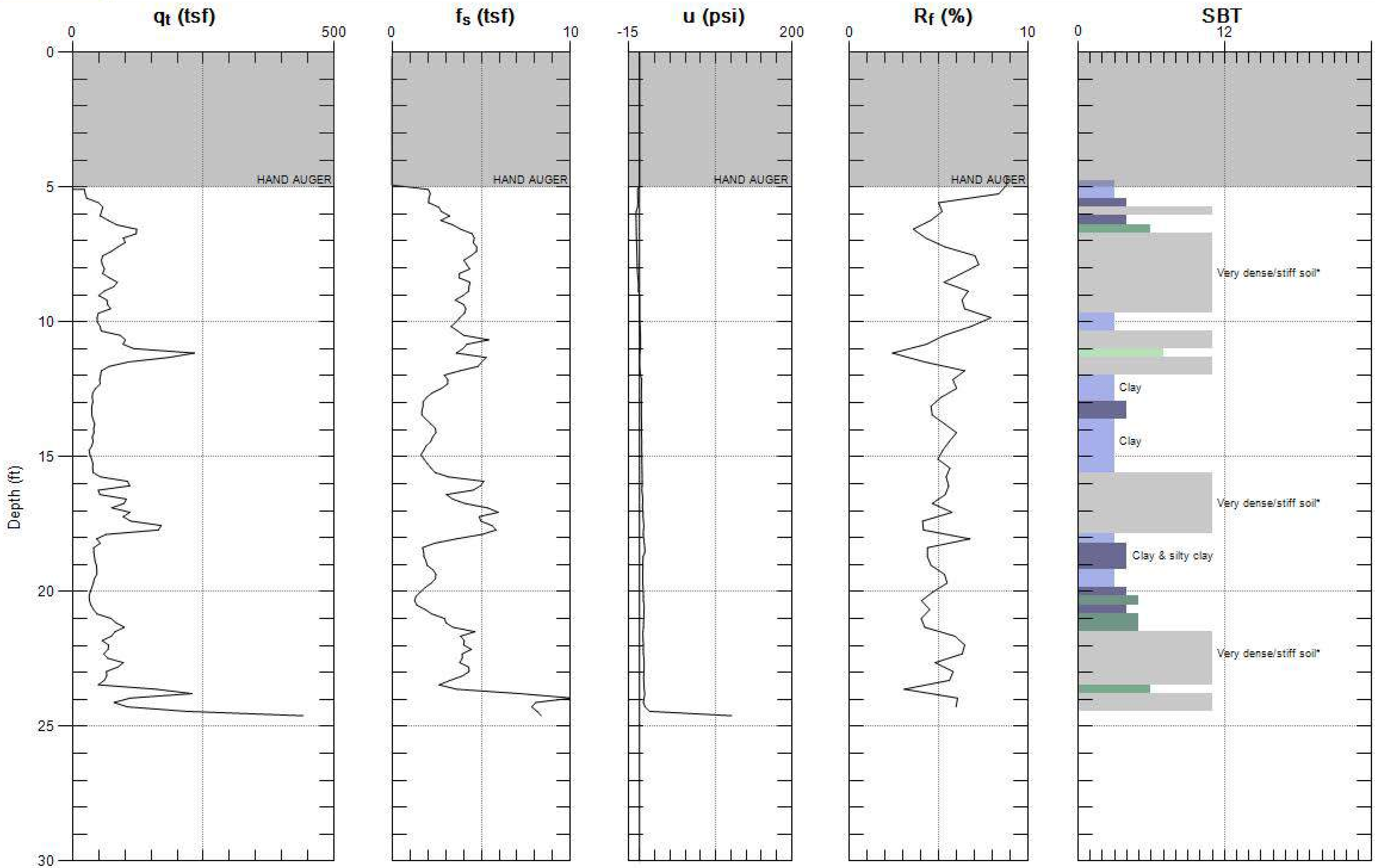
Max. Depth: 24.606 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

A3GEO

Site: TERRA LINDA H.S.
Sounding: CPT-1A

Engineer: J.VAN DEN BERG
Date: 2/22/17 09:24



Max. Depth: 24.606 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG

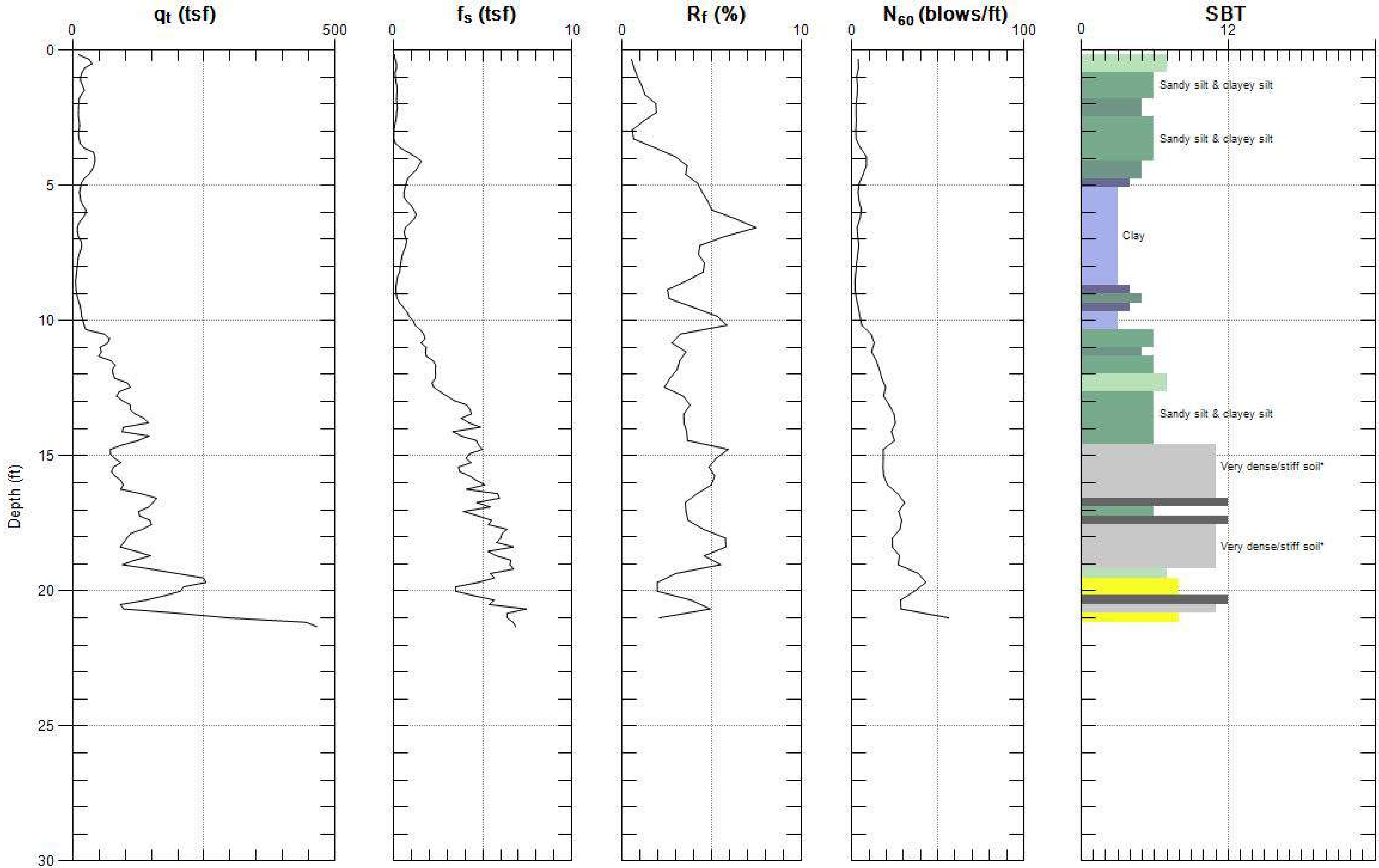
A3GEO

Site: TERRA LINDA H.S.

Sounding: CPT-02

Engineer: J.VAN DEN BERG

Date: 2/22/17 08:08



Max. Depth: 21.325 (ft)
Avg. Interval: 0.328 (ft)

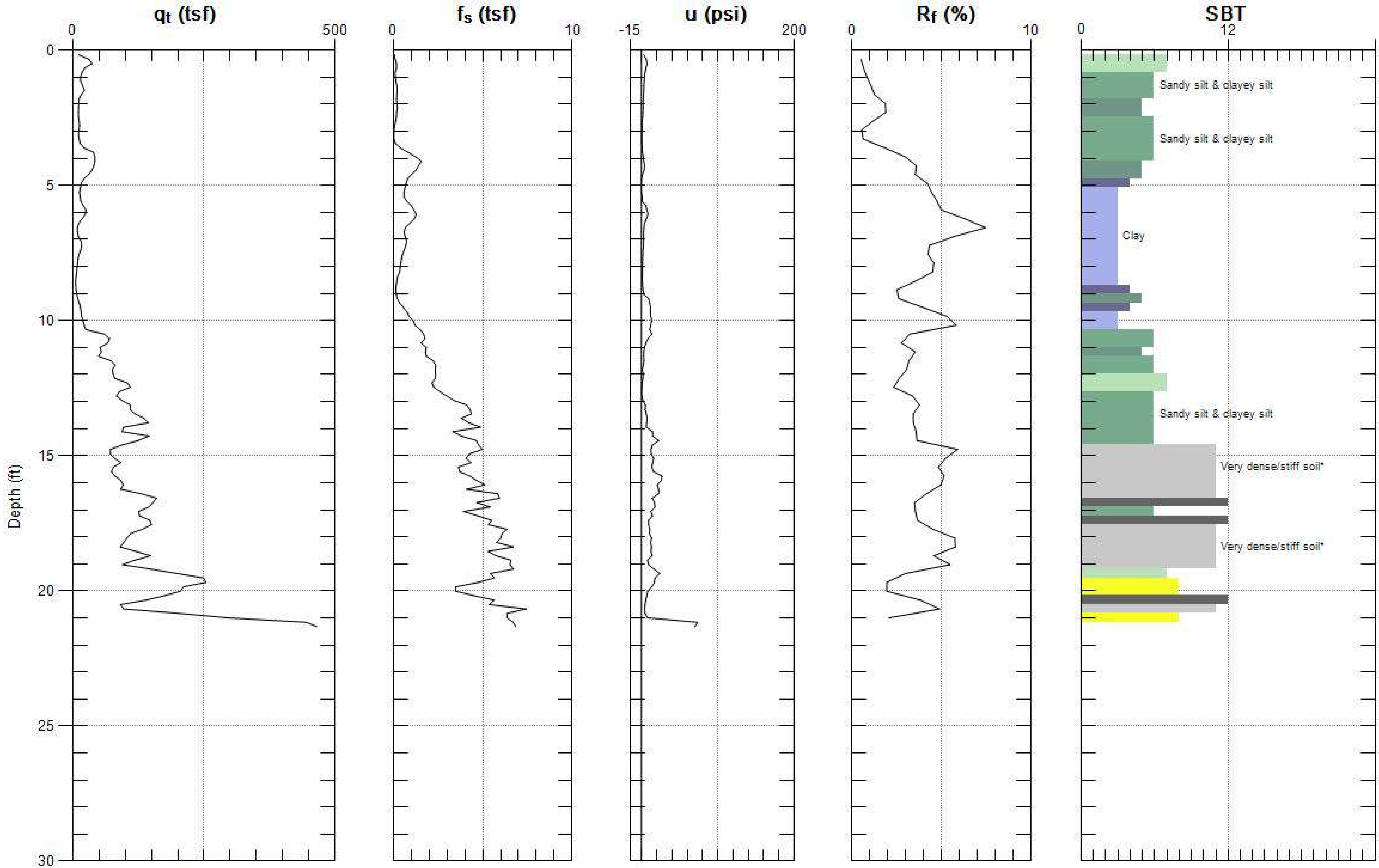
SBT: Soil Behavior Type (Robertson 1990)

GREGG

A3GEO

Site: TERRA LINDA H.S.
Sounding: CPT-02

Engineer: J.VAN DEN BERG
Date: 2/22/17 08:08



Max. Depth: 21.325 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

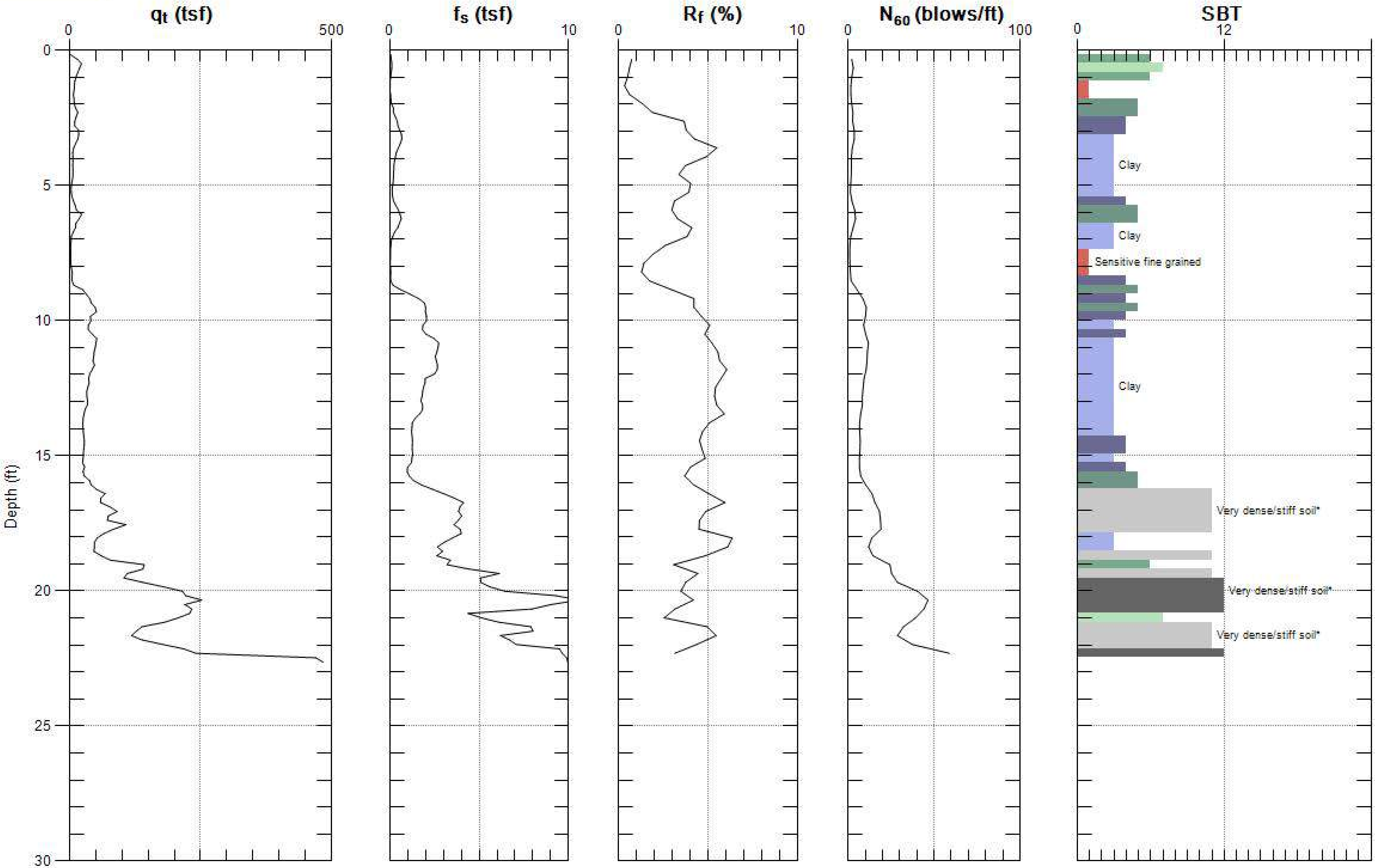
A3GEO

Site: TERRA LINDA H.S.

Sounding: CPT-03

Engineer: J.VAN DEN BERG

Date: 2/22/17 10:38



Max. Depth: 22.638 (ft)
Avg. Interval: 0.328 (ft)

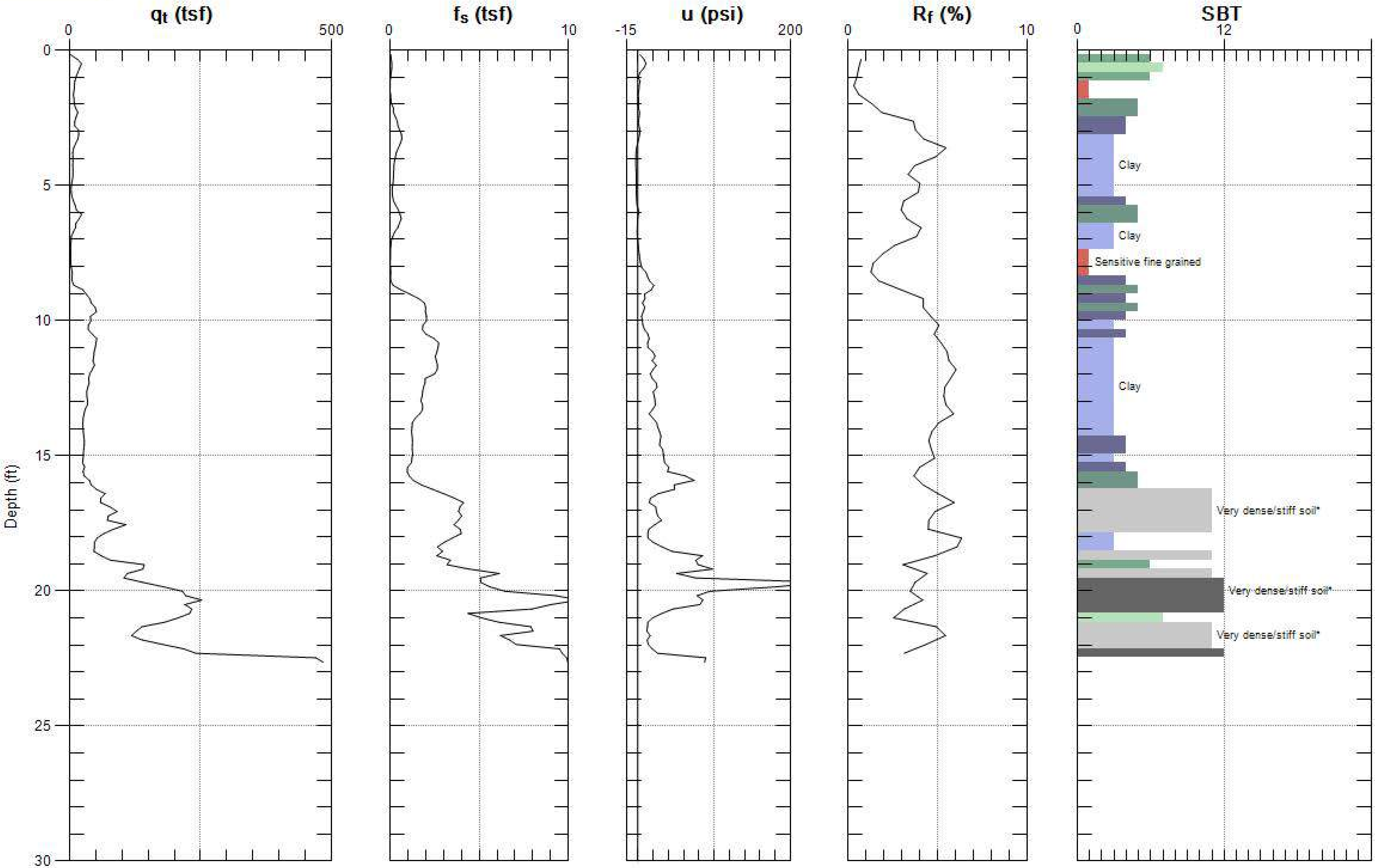
SBT: Soil Behavior Type (Robertson 1990)

GREGG

A3GEO

Site: TERRA LINDA H.S.
Sounding: CPT-03

Engineer: J.VAN DEN BERG
Date: 2/22/17 10:38



Max. Depth: 22.638 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

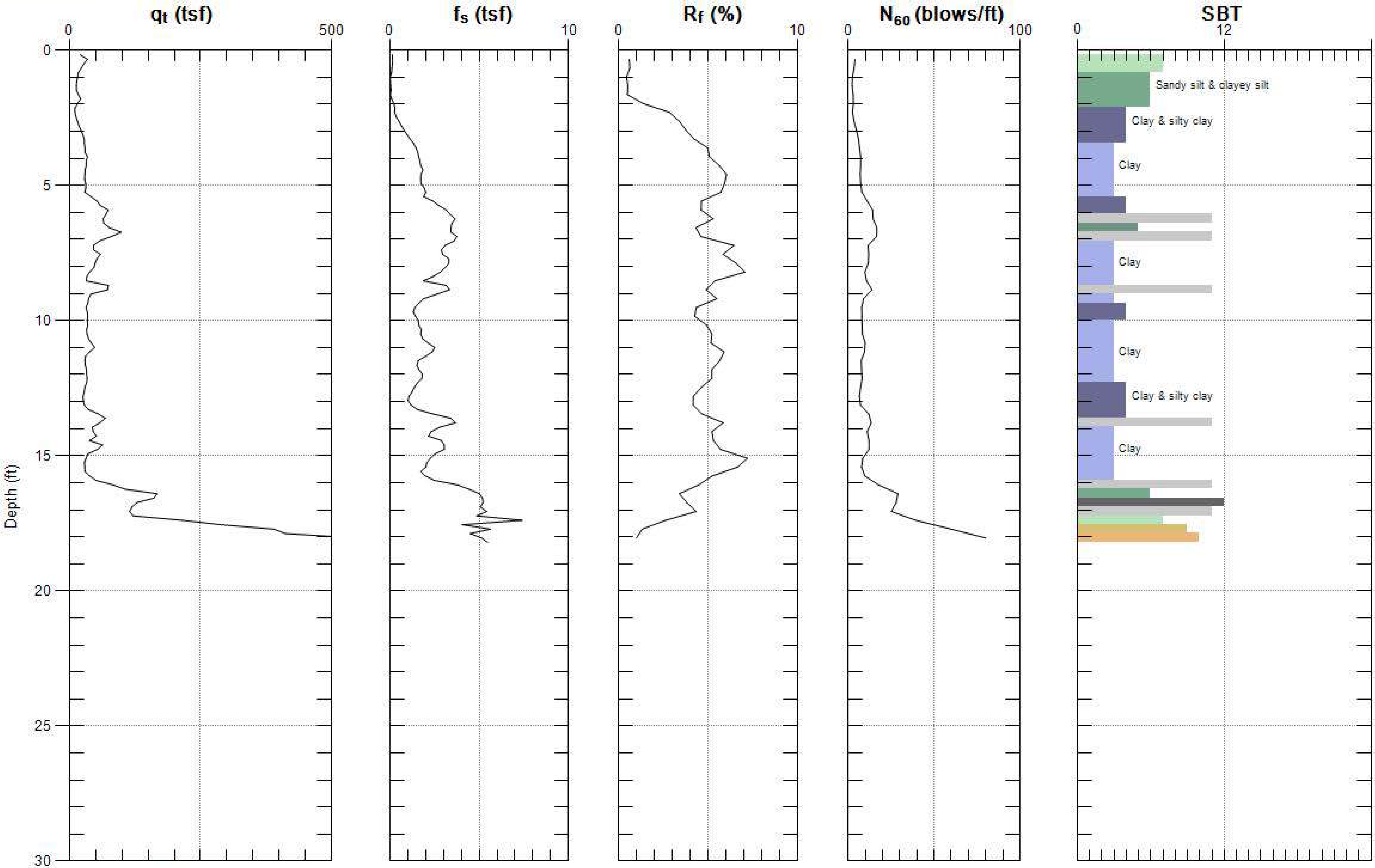
A3GEO

Site: TERRA LINDA H.S.

Sounding: CPT-04

Engineer: J.VAN DEN BERG

Date: 2/22/17 11:34



Max. Depth: 18.209 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG

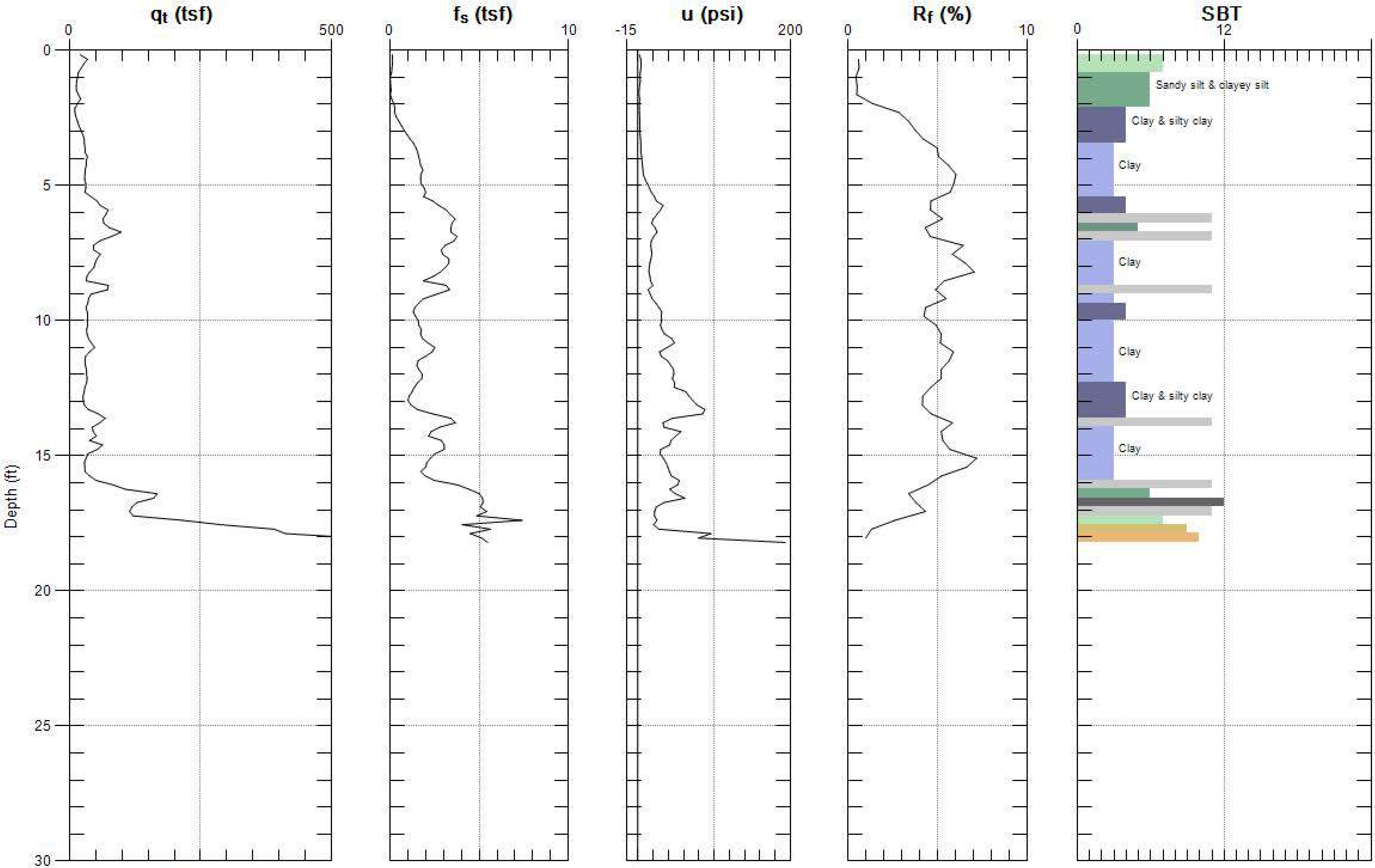
A3GEO

Site: TERRA LINDA H.S.

Sounding: CPT-04

Engineer: J.VAN DEN BERG

Date: 2/22/17 11:34



Max. Depth: 18.209 (ft)

Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

APPENDIX C

Phase 1 Soil Boring Logs

UNIFIED SOIL CLASSIFICATION CHART

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS: more than 50% retained on No. 200 sieve	COARSE GRAINED SOILS: 50% or more of coarse fraction on No. 4 sieve	CLEAN GRAVELS	GW	Well graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH SAND	GM	Silty gravels and gravel-sand-silt mixtures
			GC	Clayey gravels and gravel-sand-clay mixtures
	SANDS: more than 50% passing on No. 4 sieve	CLEAN SANDS	SW	Well graded sands and gravelly sand, little or no fines
			SP	Poorly graded sands and gravelly sand, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS: 50% or more passing No. 200 sieve	SILTS AND CLAY: Liquid Limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
			CL	Inorganic clays or low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAY: Liquid Limit 50% or greater		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic clays
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS			PT	Peat, muck, and other highly organic soils

BOUNDARY CLASSIFICATION AND GRAIN SIZES

SILT OR CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

U.S. Standard Sieve Sizes: No. 200 (0.075 mm); No. 40 (0.425 mm); No. 10 (2 mm); No. 4 (3/16"); 3/4"; 3"; 12"

SYMBOLS

Modified California (MC) Sampler (3" O.D.)	HQ ROCK CORE (RC)	101 Barrel (SS)
Standard Penetration Test: SPT (2" O.D.)	Pitcher Tube (ST)	<u>Water Levels</u> At time of drilling At end of drilling After drilling

ABBREVIATIONS

Item	Meaning
LL	Liquid Limit (%) (ASTM D 4318)
PI	Plasticity Index (%) (ASTM D 4318)
-200	Passing No. 200 (%) (ASTM D 1140)
TXCU	Laboratory consolidated undrained triaxial test of undrained shear strength (psf) (ASTM D 4767)
TXUU	Laboratory unconsolidated, undrained triaxial test of undrained shear strength (psf) (ASTM D 2850)
psf/tsf	pounds per square foot / tons per square foot
psi	pounds per square inch
OD	Outside Diameter
ID	Inside Diameter

NOTES

1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Modified California (MC) blow counts were adjusted by multiplying field blow counts by a factor of 0.63.
3. Recorded blow counts have not been adjusted for hammer energy.

A3GEO

BEDDING OF SEDIMENTARY ROCK		
SPLITTING PROPERTY	THICKNESS	STRATIFICATION
Massive	Greater than 4.0 feet	Very Thick-Bedded
Blocky	2.0 to 4.0 feet	Thick-Bedded
Slabby	0.2 to 2.0 feet	Thin-Bedded
Flaggy	0.05 to 0.2 feet	Very Thin-Bedded
Shaly or Platy	0.01 to 0.05 feet	Laminated
Papery	Less than 0.01 feet	Thinly Laminated

FRACTURING	
INTENSITY	SIZE OF PIECES IN FEET
Very Little Fractured	Greater than 4.0 feet
Occasionally Fractured	1.0 to 4.0 feet
Moderately Fractured	0.5 to 1.0 feet
Closely Fractured	0.1 to 0.5 feet
Intensely Fractured	0.05 to 0.1 feet
Crushed	Less than 0.05 feet

HARDNESS	
Soft	Reserved for plastic material alone
Low Hardness	Can be gouged deeply or carved easily by a knife blade
Moderately Hard	Can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and is readily visible after the powder has been blown away
Hard	Can be scratched by a knife blade with difficulty; scratch produces little powder and is often faintly visible
Very Hard	Cannot be scratched by a knife blade; leaves a metallic streak

STRENGTH	
Plastic	Very low strength
Friable	Crumbles easily by rubbing with fingers
Weak	An unfractured specimen of such material will crumble under light hammer blows
Moderately Strong	Specimen will withstand a few heavy hammer blows before breaking
Strong	Specimen will withstand a few heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments
Very Strong	Specimen will resist heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments

WEATHERING:	
— the physical and chemical disintegration and decomposition of rocks and minerals by natural processes such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing	
Deep	Moderate to complete mineral decomposition; extensive disintegration; deep and thorough discoloration; many fractures, all extensively coated or filled with oxides, carbonates and/or clay or silt.
Moderate	Slight change or partial decomposition of minerals; little disintegration; cementation little to unaffected. Moderate to occasionally intense discoloration. Moderately coated fractures.
Little	No megascopic decomposition of minerals; little or no effect on normal cementation. Slight and intermittent, or localized discoloration. Few stains on fracture surfaces.
Fresh	Unaffected by weathering agents. No discoloration or disintegration. Fractures usually less numerous than joints.

A3GEO, Inc.
1331 7th Street; Unit E
Berkeley, CA 94710
Telephone: 510-705-1664

BORING NUMBER B-1

CLIENT San Rafael City School District
PROJECT NAME Terra Linda High School - Preliminary Investigation
PROJECT NUMBER 1150-1A
PROJECT LOCATION San Rafael, CA
DATE STARTED 2/22/17 **COMPLETED** 2/22/17
GROUND ELEVATION 81.1 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY RES **CHECKED BY** WM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0		ASPHALTIC CONCRETE [3"]							
		AGGREGATE BASE [6"]							
		LEAN CLAY WITH SAND (CL): reddish brown, medium stiff to stiff, moderate plasticity, fine-medium sand , moist	GB						
		between 3'-4.25': some angular gravels, up to 3/4"	MC	20	>4.5	121	14	83%	32% Gravel 39% Sand -200 = 29%
5		CLAYEY SAND WITH GRAVEL (SC): olive brown, dense, well-graded sand, moist							
			MC	34	4.5 >4.5			83%	
10		CLAYEY SANDSTONE: reddish brown, friable, very deeply weathered, low hardness, fine-medium grained, moist	SPT	53				100%	
15		at 15': increased fine sand and silt content	SPT	81/10"				88%	

Bottom of borehole at 16.3 feet.
1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Ground surface elevation taken from county-provided LiDAR data (NAVD88 datum).
4. Groundwater was not encountered during drilling; hole was backfilled immediately after drilling.

A3GEO, Inc.
1331 7th Street; Unit E
Berkeley, CA 94710
Telephone: 510-705-1664

BORING NUMBER B-2

CLIENT San Rafael City School District
PROJECT NAME Terra Linda High School - Preliminary Investigation
PROJECT NUMBER 1150-1A
PROJECT LOCATION San Rafael, CA
DATE STARTED 2/22/17 **COMPLETED** 2/22/17
GROUND ELEVATION 81.2 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY RES **CHECKED BY** WM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0		ASPHALTIC CONCRETE [3"]							
		AGGREGATE BASE [6"]							
		LEAN CLAY WITH SAND (CL): reddish brown, medium stiff, moderate plasticity, fine-medium sand, moist	GB				14		LL = 37 PI = 20
		SANDY LEAN CLAY (CL): reddish brown and dark grey, very stiff, low-moderate plasticity, fine-medium sand, heavy iron staining, moist	MC	20	>4.5 4.5	111	21	94%	1% Gravel 36% Sand -200 = 63%
5									
		at 7': dark olive brown and reddish brown with grey streaks - decreasing clay content with depth	MC	23				83%	
10		CLAYEY SAND (SC): yellowish brown, dense to very dense, well-graded, primarily fine-medium sand, low plasticity fines, moist							
		at 12': very dense	MC	50/5"	3.5			100%	
		SHALE: light olive brown, friable-weak, deeply weathered, low hardness, papery bedding, dry	SPT	50/5"	>4.5			100%	

Bottom of borehole at 13.3 feet.
1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Ground surface elevation taken from county-provided LiDAR data (NAVD88 datum).
4. Groundwater was not encountered during drilling; hole was backfilled immediately after drilling.

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BORING NUMBER B-3

CLIENT San Rafael City School District
PROJECT NAME Terra Linda High School - Preliminary Investigation
PROJECT NUMBER 1150-1A
PROJECT LOCATION San Rafael, CA
DATE STARTED 2/22/17 **COMPLETED** 2/22/17
GROUND ELEVATION 81 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY RES **CHECKED BY** WM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0	ASPHALTIC CONCRETE [4"]							
	AGGREGATE BASE [3"]							
	LEAN CLAY WITH SAND (CL): olive brown and reddish brown, medium stiff, low-moderate plasticity, fine-medium sand, moist	GB						
	CLAYEY SAND (SC): olive brown, medium dense, low-moderate plasticity, fine-medium sand, some iron staining, some fine-coarse gravel, moist	MC	19		124	14	94%	LL = 37 PI = 21 14% Gravel 40% Sand -200 = 46%
5								
		MC	19	3.0			78%	
	CLAYSTONE: soft to low hardness, friable, deeply weathered, moist							
10	SHALE: dark olive brown, friable to weak, deeply weathered, low hardness, papery to platy bedding, dry	SPT	34				100%	
15		SPT	52				78%	
20		SPT	50/6"				100%	

Bottom of borehole at 21.0 feet.
1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Ground surface elevation taken from county-provided LiDAR data (NAVD88 datum).
4. Groundwater was not encountered during drilling; hole was backfilled immediately after drilling.

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BORING NUMBER B-4

CLIENT San Rafael City School District
PROJECT NAME Terra Linda High School - Preliminary Investigation
PROJECT NUMBER 1150-1A
PROJECT LOCATION San Rafael, CA
DATE STARTED 2/22/17 **COMPLETED** 2/22/17
GROUND ELEVATION 81.1 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING 20.00 ft / Elev 61.10 ft
LOGGED BY RES **CHECKED BY** WM
AT END OF DRILLING ---
NOTES
AFTER DRILLING 10.00 ft / Elev 71.10 ft

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0	ASPHALTIC CONCRETE [5"]							
	AGGREGATE BASE [6"]							
	SANDY LEAN CLAY (CL): very dark brown to black with brown sand, medium stiff, low-moderate plasticity, primarily fine-medium sand, some construction debris (nail, staple), moist [FILL]	GB						
	LEAN CLAY WITH SAND (CL): dark grey to black with light grey streaks, medium stiff, low-moderate plasticity, fine-medium sand, some gravel, up to 2", moist (FILL)	MC	7	1.0 1.25	104	22		LL = 36 PI = 16
5								
	at 6.5': stiff, dark olive brown with some iron staining	MC	9	0.75 0.75				
	at 7': some subangular gravel in shoe of sampler, up to 1"							
10								
	LEAN CLAY WITH SAND (CL): yellowish brown with dark brown streaks, stiff, some iron staining, moist	MC	18	>4.5 >4.5	111	18		
15								
	SANDY LEAN CLAY (CL): reddish brown and olive brown, some grey streaks, very stiff, primarily fine-medium sand, high sand content, moist	MC	19	4.25 >4.5				
	SANDSTONE: reddish brown and olive brown, friable-weak, deeply weathered, low hardness, crushed, dry							
20		MC	50/3"					
		SPT	50/3"					

Bottom of borehole at 21.0 feet.
1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Ground surface elevation taken from county-provided LiDAR data (NAVD88 datum).
4. See report for discussion regarding groundwater; hole backfilled shortly after drilling complete.

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BORING NUMBER B-5

CLIENT San Rafael City School District
PROJECT NAME Terra Linda High School - Preliminary Investigation
PROJECT NUMBER 1150-1A
PROJECT LOCATION San Rafael, CA
DATE STARTED 2/22/17 **COMPLETED** 2/22/17
GROUND ELEVATION 91.4 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY RES **CHECKED BY** WM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0		SANDY SILT (ML): dark brown, soft, low plasticity, fine-medium sand, moist							
			GB						
		at 3': medium stiff	MC	6	1.5 1.5	107	21		LL = 36 PI = 16
5		SANDY LEAN CLAY (CL): dark olive brown with olive brown and reddish brown spots, stiff, low-moderate plasticity, fine-medium sand, trace coarse sand, moist							
			MC	10	1.5 2.0	110	19		
		- increasing sand content with depth							
10		at 10': very stiff, increased sand content	MC	14	>4.5 >4.5 >4.5				
15		at 15': very stiff, slightly more sand	MC	24	>4.5 >4.5 >4.5				
		SHALE: dark brown, soft-weak, very deeply weathered, soft-low hardness, papery to platey bedding, crushed, some iron staining, damp							
20			SPT	50/5"					

Bottom of borehole at 20.4 feet.
1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Ground surface elevation taken from county-provided LiDAR data (NAVD88 datum).
4. Groundwater was not encountered during drilling; hole was backfilled immediately after drilling.

APPENDIX D

Phase 2 Soil Boring Logs
(This Study)

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BORING NUMBER A3-17-1

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 79.5 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
▽ **AT TIME OF DRILLING** 7.0 ft / Elev 72.5 ft
LOGGED BY DKM **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0	3" ASPHALT CONCRETE							
	6" ASPAHALT BASE							
	FAT CLAY (CH) - very dark brown, medium stiff, some fine sand, trace coarse sand, moist to wet [FILL]	GB						
		MC	7	.5				
5	FAT CLAY (CH) - similar to above, except black, brown weathered sandstone clasts present in sample [FILL]							
▽	SANDY TO GRAVELLY FAT CLAY (CH) - mottled yellowish brown and reddish brown, medium stiff, contains angular decomposed to weathered sandstone and shale clasts, moist to wet [ALLUVIUM/COLLUVIUM]	MC	9	1.0				
10	SILTY SAND (SM) - mottled yellowish brown and reddish brown, trace gravel [ALLUVIUM/COLLUVIUM]							
	CLAYEY SAND (SC) - mottled reddish brown, dark brown and yellowish brown; medium dense; medium to coarse sand; some gravel, and rock fragments [ALLUVIUM/COLLUVIUM]							
	-Lens of light gray FAT CLAY (CH) -Gradual transition to CLAYEY GRAVEL (GC) similiar to SC above	MC	17	2.0 3.0				9% Gravel 46% Sand 45% -200 PI = 22 LL = 40
15	CLAYEY SAND WITH GRAVEL (SC) - mottled reddish brown, dark brown and yellowish brown; medium dense; 15-20% angular to subrounded rock fragments [ALLUVIUM/COLLUVIUM]							
		MC	15					25% Gravel 54% Sand 21% -200 PI = 10 LL = 29
	-Decreasing gravel/rock size							
20	GRAVELLY CLAY WITH SAND (CL) - mottled reddish brown, dark brown and yellowish brown; very stiff [ALLUVIUM/COLLUVIUM]	SPT	29					
	SANDSTONE - yellowish brown, weathered, fine grained, with light grey vertical clay seams along fractures [WEATHERED BEDROCK]							
25		SPT	50/3.0"					

Bottom of borehole at 25.3 feet.
1. Split spoon refusal at 25.3'
2. Borehole was backfilled with cement grout immediately after drilling.
3. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
4. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

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BORING NUMBER A3-17-2

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 80.5 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY EA/LB **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0	3" Concrete							
	SANDY CLAY (CL) - very dark gray, stiff, some gravel, contains approximately 10% sandstone clasts, trace rootlets, organic odor, dry [FILL]							
		MC	14	>4.0 3.5				LL = 35 PI = 17
5		MC	10	2.0 1.0				
	FAT CLAY (CH) - dark yellowish brown, dry [FILL]							
	CLAYEY SAND (SC) - mottled light brown to dark brown, medium dense, contains clay seams/tongues and manganese & iron nodules [ALLUVIUM/COLLUVIUM]							
		MC	20	4.0 4.0				
10	CLAYEY SAND WITH GRAVEL (SC) - brown; dense; pockets of sandy clay with gravel; clasts of sandstone, greenstone, and shale; dry [ALLUVIUM/COLLUVIUM]	MC	33	4.0	124	15		18% Gravel 51% Sand 31% -200
15		MC	27	>4.5				
	SANDY CLAY (CL) / CLAYEY SAND (SC) - mottled olive gray and yellowish brown, very stiff, dry [ALLUVIUM/COLLUVIUM]							
	CLAYEY GRAVEL WITH SAND (GC) - gray to green, very dense, shale and sandstone with clay lined fractures [WEATHERED BEDROCK]	MC	32/5.0"					
20		SPT	50/5.0"					

Bottom of borehole at 21.5 feet.
1. Split spoon refusal at 21.5'
2. No groundwater encountered.
3. Borehole was backfilled with cement grout immediately after drilling.
4. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
5. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

BORING NUMBER A3-17-3

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 81 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY DKM **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0	2" ASPHALT CONCRETE							
	4" AGGREGATE BASE							
	SANDY CLAY (CL) - gray brown to yellowish brown, stiff, fine to medium grained sand, moist [FILL]	MC	13	4.0				
	SANDY CLAY (CL) - mottled reddish brown, yellowish brown, and dark brown; very stiff; fine to medium grained sand; moist [POSSIBLE FILL]							
5	CLAYEY SAND WITH GRAVEL (SC) - dark yellowish brown, medium dense [POSSIBLE ALLUVIUM/COLLUVIUM]	MC	16	>4.0	112	17		12% Gravel 25% Sand 63% -200
	SANDY LEAN CLAY (CL) - reddish brown to yellowish brown, very stiff, some weathered rock fragments [ALLUVIUM/COLLUVIUM]	MC	12	3.0				
	FAT CLAY WITH SILT (CH) - light gray and yellowish brown, very stiff [ALLUVIUM/COLLUVIUM]							
10	CLAYEY SAND (SC) - yellowish brown and light gray, medium dense, fine to medium grained [ALLUVIUM/COLLUVIUM]							
	CLAYEY SAND (SC) - yellowish brown and gray, high plasticity fines [WEATHERED BEDROCK]	MC	44					
15	WEATHERED SANDSTONE - yellowish brown, medium strong to weak, moderately fractured, with clay filled fractures [WEATHERED BEDROCK] -Shale fragments at 15'	SPT	50/3.0"					

Bottom of borehole at 15.8 feet.
1. Split spoon refusal at 15.8'
2. No groundwater encountered.
3. Borehole was backfilled with cement grout immediately after drilling.
4. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
5. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

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BORING NUMBER A3-17-4

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 80.5 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY EA/LB **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0		3" CONCRETE							
		SANDY LEAN CLAY (CL) - brown, hard, trace gravel, dry [FILL]							
		SANDY LEAN CLAY (CL) - olive brown, trace gravel, dry [ALLUVIUM/COLLUVIUM]	MC	38	>4.0	120	15		6% Gravel 41% Sand 53% -200 LL = 37 PI = 20 TX UU Su = 8536psf
5		-Increasing sand and gravel. Gravel consists of sandstone clasts.	MC	21	>4.0				
		SANDY CLAY WITH GRAVEL (CL-CH) - dark yellowish brown, very stiff, gravel consists of clasts of greenstone and shale [ALLUVIUM/COLLUVIUM]							
		CLAYEY SAND WITH GRAVEl (SC) - olive brown, reddish brown, yellowish brown, dark gray; dense; gravel consists of shale fragments [ALLUVIUM/COLLUVIUM]	MC	38					
10		CLAYEY GRAVEL WITH SAND AND SANDY FAT CLAY (GC-CH) - olive brown, reddish brown, yellowish brown; hard/dense; white/pale green quartzite present in sample [ALLUVIUM/COLLUVIUM]	MC	37					
15									

Bottom of borehole at 15.0 feet.
1. Exploration terminated at 15' due to hammer winch breakdown.
2. No groundwater encountered.
3. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
4. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
5. Borehole was backfilled with cement grout immediately after drilling.

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BORING NUMBER A3-17-5

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 81 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY DKM **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0		4" ASPHALT CONCRETE							
		4" AGGREGATE BASE							
		CLAYEY SAND WITH GRAVEL (SC) - reddish brown, dark brown, yellowish brown; dense; gravel includes rock fragments, moist [FILL] -Blow counts artificially high due to piece of asphalt stuck in spoon	MC	31		112	16		16% Gravel 48% Sand 36% -200 LL = 33 PI = 15
5		SANDY LEAN CLAY WITH SILT (CL) - yellowish brown, very stiff, fine to coarse sand, iron staining, greenstone fragments, moist [ALLUVIUM/COLLUVIUM]	MC	22	3.5				
		-Color change to strong brown -Angular to subrounded sandstone and greenstone clasts at 8'	MC	22					
10		Note: contact estimated SHALE - gray brown, moderately fractured, with clay filled fractures, slightly to moderatly weathered, weak to very weak, dry [BEDROCK]	MC	32/5.0"					
15		SHALE, SILTSTONE AND FINE-GRAINED SANDSTONE - gray brown, low hardness, friable, little weathering, intensely fractured [BEDROCK]	SPT	50/5.5"					

Bottom of borehole at 16.0 feet.
1. Split spoon refusal at 16'
2. No groundwater encountered.
3. Borehole was backfilled with cement grout immediately after drilling.
4. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
5. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

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BORING NUMBER A3-17-6

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 81 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY DKM **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0		4" ASPHALT CONCRETE							
		SILTY CLAY (CL) - light brown to reddish yellow, very stiff, some fine to medium grain sand, trace gravel and weathered rock fragments up to 1" diameter, pockets of light grey fat clay, moist [ALLUVIUM/COLLUVIUM]							
5			MC	17	4.0	118	14		
		CLAYEY SAND (SC) - yellowish brown, dense, fine to medium grained, cemented, with seams of light gray fat clay, moist [ALLUVIUM]	MC	55					
10		WEATHERED SANDSTONE - yellowish brown, fine to medium grained, friable to weak with discolored fractures filled with dark brown clay and silt, iron staining [WEATHERED BEDROCK]							
			SPT	50/5.0"					

Bottom of borehole at 11.4 feet.
1. Split spoon refusal at 11.4'
2. No groundwater encountered.
3. Borehole was backfilled with cement grout immediately after drilling.
4. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
5. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

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BORING NUMBER A3-17-7

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 81 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING 19.0 ft / Elev 62.0 ft
LOGGED BY DKM **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0		4" CONCRETE							
		2" AGGREGATE BASE							
		SANDY LEAN CLAY (CL) - dark gray brown, fine-medium grained sand, moist [FILL]							
		SANDY LEAN CLAY (CL) - mottled reddish brown, yellowish brown, gray, and dark grey; very stiff; fine-medium sand, some fine gravel, and rock fragments; moist [ALLUVIUM/COLLUVIUM]	MC	22	>4.5				
5									
		CLAYEY SAND WITH GRAVEL (SC) - mottled reddish brown, yellowish brown, gray, and dark grey; medium dense; fine-medium sand; moist [ALLUVIUM/COLLUVIUM]	MC	25	4.0	112	19		
		CLAYEY SAND WITH GRAVEL (SC) - reddish brown, medium dense, rock fragments present, moist [ALLUVIUM/COLLUVIUM]							
10			MC	25	3.0				
15		SHALE - gray brown, moderately hard, weak, moderately weathered, moderately fractured with clay lined fractures [WEATHERED BEDROCK]	MC	30					
	▽		SPT	50/5.0"					

Bottom of borehole at 19.9 feet.
1. Split spoon refusal at 19.9'
2. Borehole was backfilled with cement grout immediately after drilling.
3. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
4. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

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BORING NUMBER A3-17-8

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 81 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY EA/LB **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0		3" CONCRETE							
		CLAYEY SAND (SC) - brown, medium dense, some gravel, dry [ALLUVIUM/COLLUVIUM]							
			MC	20	>4.0				
5									20% Gravel 38% Sand 42% -200 LL = 39 PI = 21
		-Similar to above, but with increased gravel content and greenstone fragments up to 1" in diameter	MC	24	3.0				
		-Similar to above, except: color change to olive brown, fine to coarse sand, gravel no longer present	MC	32/5.0"	>4.0				
10		SILTY SAND (SM) - brown to strong brown, very dense, highly weathered fine sandstone with minor shale [WEATHERED BEDROCK]							
			SPT	50/3.0"					

Bottom of borehole at 13.3 feet.
1. Split spoon refusal at 13.3'
2. No groundwater encountered.
3. Borehole was backfilled with cement grout immediately after drilling.
4. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
5. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.

A3GEO, Inc.
1331 Seventh Ave, Suite E
Berkeley, CA, 94710
Telephone: 510-705-1664

BORING NUMBER A3-17-9

CLIENT San Rafael City Schools
PROJECT NAME Terra Linda High School Design Level Investigation
PROJECT NUMBER 1150-1B
PROJECT LOCATION San Rafael, CA
DATE STARTED 11/22/17 **COMPLETED** 11/22/17
GROUND ELEVATION 81 ft NAVD 88 **HOLE SIZE** 4.5
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY EA/LB **CHECKED BY** LB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	RECOVERY % (RQD)	OTHER LAB TESTS / NOTES
0		3" CONCRETE							
		SANDY CLAY (CL) - gray brown to brown, stiff, trace gravel, slight organic odor, dry [FILL]	MC	11					LL = 33 PI = 16
5		SANDY CLAY (CL) - strong brown, stiff, dry [ALLUVIUM/COLLUVIUM]							
		-Same as above except: yellowish brown, with trace gravel	MC	26	4.0 3.0				
			MC	28		110	20		2% Gravel 42% Sand 56% -200 TX UU Su = 3963psf
10		CLAYEY SAND (SC) - brown to strong brown, medium dense, contains well developed soil tongues and clay along fractures, dry [ALLUVIUM/COLLUVIUM]	MC	23	3.0				
15		CLAYEY/SILTY SAND WITH GRAVEL (SC/SM) - green gray, very dense, friable, highly weathered sandstone, dry [WEATHERED BEDROCK]	MC	32/2.0"					
		-Similar to above except: mottled olive grey with iron staining, blocky greenstone, and clay lined fractures	SPT	50/2.0"					
			SPT	50/3.0"					

Bottom of borehole at 19.3 feet.
1. Split spoon refusal at 19.3'
2. No groundwater encountered.
2. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
3. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
4. Borehole was backfilled with cement grout immediately after drilling.

APPENDIX E

Phase 1 Geotechnical Laboratory Test Data Sheets

B. HILLEBRANDT SOILS TESTING, INC.

29 Sugarloaf Terrace, Alamo, CA 94507 - Tel: (510) 409-2916 - Fax: (925) 891-9267 - Email: soiltesting@aol.com

LAB RESULTS SUMMARY FORM

Project Number: 1150-1A	**Project Name:** Terra Linda High School		**Results Due By:**
Requested By: DM	**Request Date:** 2/28/17		**Throw Samples Out On:**

					Atterberg			-200			Compaction				
Boring #	Sample Depth (feet)	Dry Density (pcf)	Moisture Content (%)	Unconfined Compressive (ksf)	Liquid Limit	Plastic Limit	Plasicity Index	Passing #4 Sieve (%)	Passing #40 sieve (%)	Passing #200 sieve (%)	Maximum Dry Density (pcf)	Optimum Moisture (%)	Pocket Penetrometer (tsf)	Torvane (tsf)	Remarks
B-1	4.0	121	14.1					68	48	29					
B-2	1.0		14.1		37	17	20								
B-2	4.0	111	20.7					99	89	63					
B-3A	4.0	124	14.4		37	16	21	86	68	46					
B-4	3.5	104	21.9		36	20	16								
B-4	10.5	111	18.1												
B-5	4.0	107	20.8		36	20	16								
B-5	6.5	110	18.8												

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MOISTURE CONTENT/DRY DENSITY

Job #: 1150-1A
Job Name: Terra Linda High School
Date: 2/28/17
Tested by: Brad Hillebrandt

Additional Tests:	FS	-200	PI, -200	PI		PI
Boring #:	B-1	B-2	B-3A	B-4	B-4	B-5
Depth:	4.0	4.0	4.0	3.5	10.5	4.0
Sample Description:	Yellowish brown clayey SAND with gravel	Dark yellowish brown and olive brown sandy CLAY	Dark yellowish brown and olive brown sandy CLAY with some gravel	Very dark gray lean CLAY with sand	Olive brown sandy CLAY	Dark brown sandy CLAY
Can #:	202	348	361	327	313	502
Wet Sample + can	1079.4	286.8	440.4	344.4	347.5	327.2
Dry Sample + can	979.2	244.2	389.4	289.3	300.2	276.7
Weight can	271.0	38.1	34.0	38.2	39.5	33.7
Weight water	100.2	42.6	51	55.1	47.3	50.5
Weight Dry Sample	708.2	206.1	355.4	251.1	260.7	243
WATER CONTENT (%)	**14.1%**	**20.7%**	**14.4%**	**21.9%**	**18.1%**	**20.8%**
Weight Sample + Liner	1221.8	1167.1	1210.5	1163.3	1127.7	1190.3
Weight Liner	249.4	254.5	211.1	274.2	262.2	274.6
Sample Length	6.0	5.8	6.0	5.95	5.6	6.0
Sample Diameter	2.39	2.39	2.39	2.39	2.39	2.39
DRY DENSITY (pcf)	**120.6**	**110.7**	**123.7**	**104.1**	**111.1**	**107.3**

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MOISTURE CONTENT/DRY DENSITY

Job #: 1150-1A
Job Name: Terra Linda High School
Date: 2/28/17
Tested by: Brad Hillebrandt

Additional Tests:						
Boring #:	B-5					
Depth:	6.5					
Sample Description:	Dark brown sandy CLAY					
Can #:	363					
Wet Sample + can	331.7					
Dry Sample + can	284.5					
Weight can	33.6					
Weight water	47.2					
Weight Dry Sample	250.9					
WATER CONTENT (%)	**18.8%**					
Weight Sample + Liner	1180.9					
Weight Liner	259.2					
Sample Length	6.0					
Sample Diameter	2.39	2.39	2.39	2.39	2.39	
DRY DENSITY (pcf)	**109.8**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	

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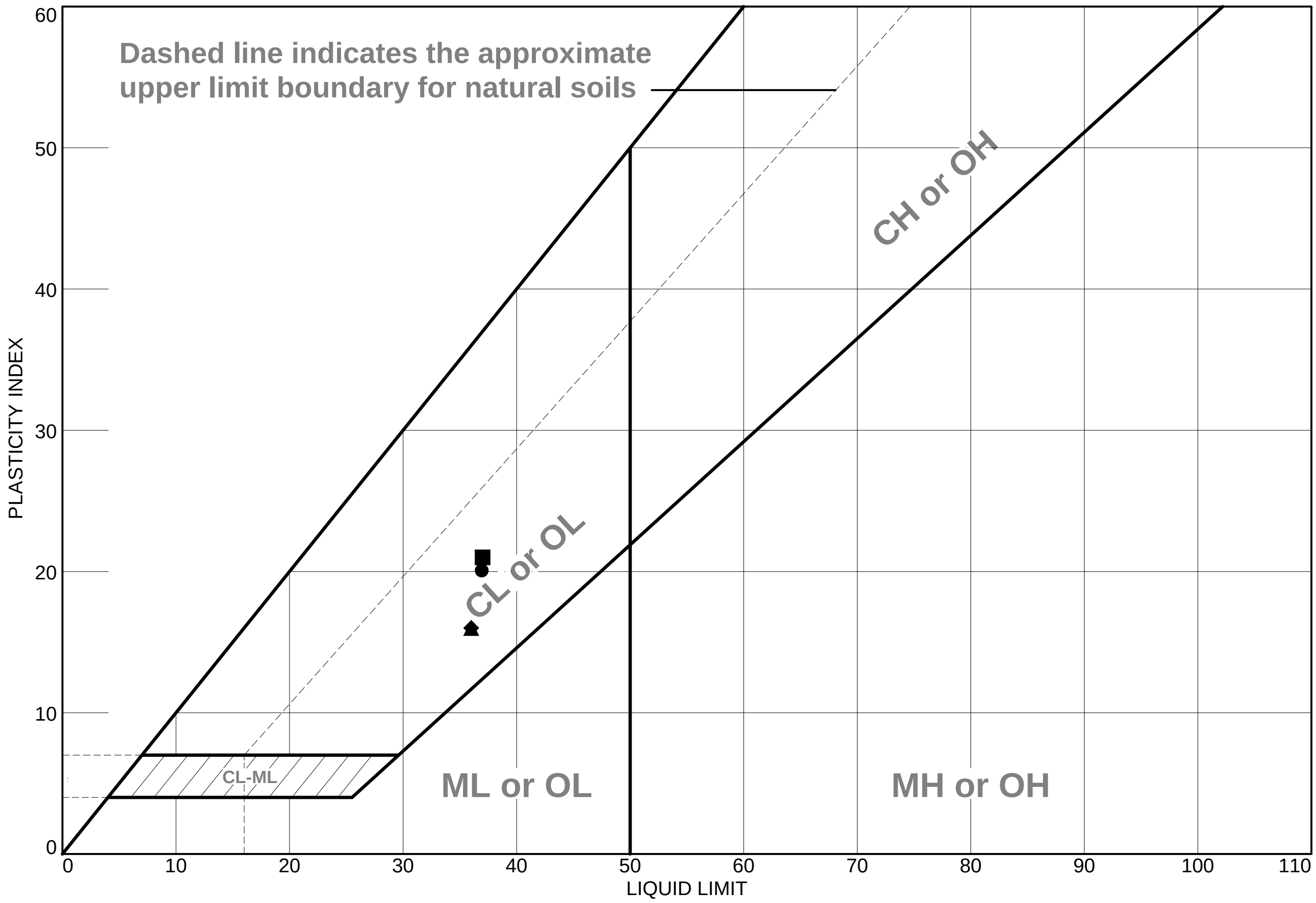
MOISTURE CONTENT WORKSHEET

Job #: 1150-1A
Job Name: Terra Linda High School
Date: 2/28/17
Tested by: B. Hillebrandt

Additional Tests:	PI								
Boring #:	B-2								
Depth:	1.0								
Sample Description:	Dark yellowish brown clayey SAND with some gravel								
Can #:	501								
Wet Sample + can	349.4								
Dry Sample + can	310.4								
Weight can	34.0								
Weight water	39								
Weight Dry Sample	276.4								
WATER CONTENT (%)	**14.1%**								

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Dark yellowish brown clayey SAND with some gravel	37	17	20			
■	Dark yellowish brown and olive brown sandy CLAY with some gravel	37	16	21	67.7	45.5	SC
▲	Very dark gray lean CLAY with sand	36	20	16			
◆	Dark brown sandy CLAY	36	20	16			

Project No. 1150-1A **Client:** A3Geo

Project: Terra Linda High School

● **Source of Sample:** B-2 **Depth:** 1.0 - 2.0'
■ **Source of Sample:** B-3A **Depth:** 4.0'
▲ **Source of Sample:** B-4 **Depth:** 3.5'
◆ **Source of Sample:** B-5 **Depth:** 4.0'

Remarks:

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+1 510-409-2816
SoilTesting@aol.com

Figure

Tested By: BH

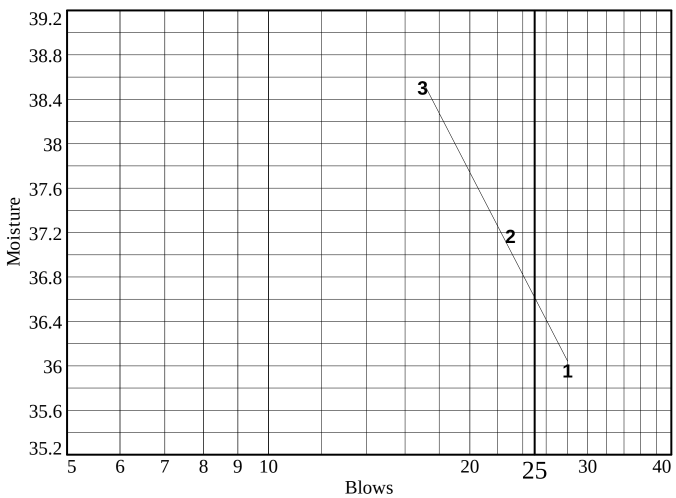
LIQUID AND PLASTIC LIMIT TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-2
Depth: 1.0 - 2.0'
Material Description: Dark yellowish brown clayey SAND with some gravel
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	30.18	30.26	27.05			
Dry+Tare	25.16	25.13	22.66			
Tare	11.20	11.33	11.26			
# Blows	28	23	17			
Moisture	36.0	37.2	38.5			



Liquid Limit= 37
Plastic Limit= 17
Plasticity Index= 20
Natural Moisture= 14.1
Liquidity Index= -0.1

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.59	17.36		
Dry+Tare	16.67	16.47		
Tare	11.12	11.31		
Moisture	16.6	17.2		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
349.4	310.4	34.0	14.1

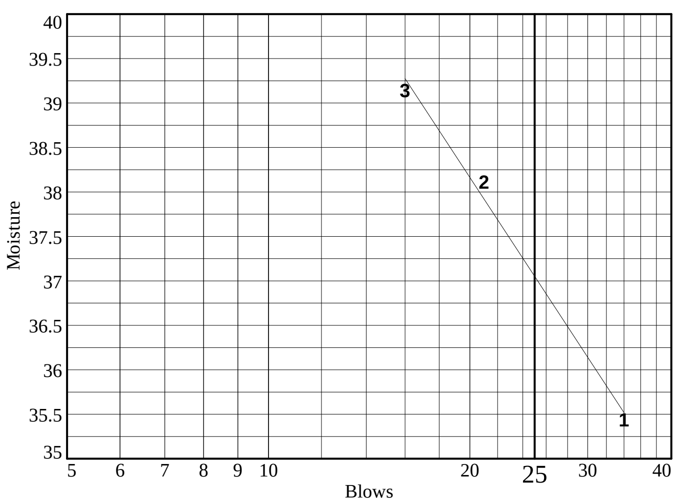
LIQUID AND PLASTIC LIMIT TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-3A
Depth: 4.0'
Material Description: Dark yellowish brown and olive brown sandy CLAY with some gravel
%<#40: 67.7 **%<#200:** 45.5 **USCS:** SC **AASHTO:** A-6(5)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	26.87	30.50	27.73			
Dry+Tare	22.79	25.19	23.04			
Tare	11.28	11.26	11.06			
# Blows	34	21	16			
Moisture	35.4	38.1	39.1			



Liquid Limit= 37
Plastic Limit= 16
Plasticity Index= 21
Natural Moisture= 14.4
Liquidity Index= -0.1

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	18.27	17.21		
Dry+Tare	17.3	16.36		
Tare	11.08	11.26		
Moisture	15.6	16.7		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
440.4	389.4	34	14.4

B. Hillebrandt Soils Testing, Inc.

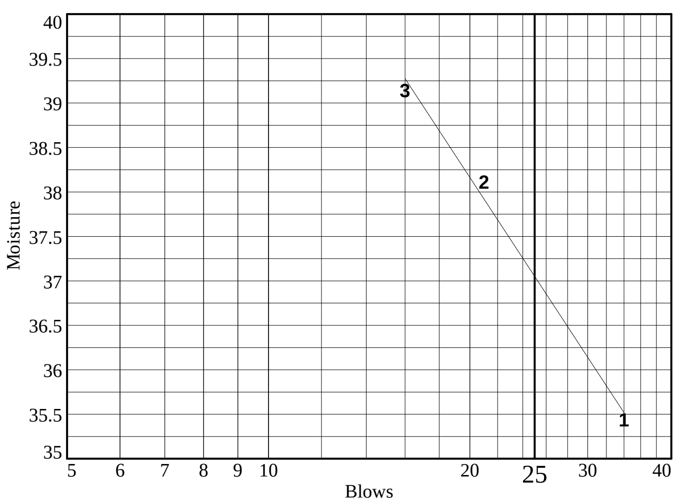
LIQUID AND PLASTIC LIMIT TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-3A
Depth: 4.0'
Material Description: Dark yellowish brown and olive brown sandy CLAY with some gravel
%<#40: 67.7 **%<#200:** 45.5 **USCS:** SC **AASHTO:** A-6(5)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	26.87	30.50	27.73			
Dry+Tare	22.79	25.19	23.04			
Tare	11.28	11.26	11.06			
# Blows	34	21	16			
Moisture	35.4	38.1	39.1			



Liquid Limit= 37
Plastic Limit= 16
Plasticity Index= 21
Natural Moisture= 14.4
Liquidity Index= -0.1

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	18.27	17.21		
Dry+Tare	17.3	16.36		
Tare	11.08	11.26		
Moisture	15.6	16.7		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
440.4	389.4	34	14.4

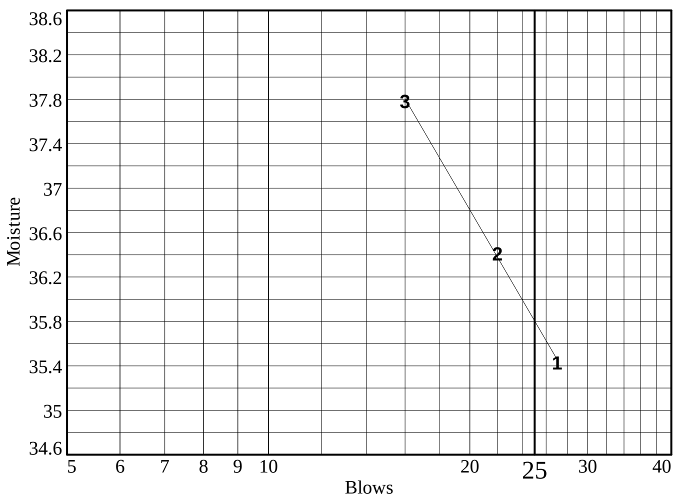
LIQUID AND PLASTIC LIMIT TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-4
Depth: 3.5'
Material Description: Very dark gray lean CLAY with sand
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	29.99	27.58	28.61			
Dry+Tare	25.10	23.17	23.86			
Tare	11.30	11.06	11.29			
# Blows	27	22	16			
Moisture	35.4	36.4	37.8			



Liquid Limit= 36
Plastic Limit= 20
Plasticity Index= 16
Natural Moisture= 21.9
Liquidity Index= 0.1

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.48	17.05		
Dry+Tare	16.43	16.06		
Tare	11.21	11.27		
Moisture	20.1	20.7		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
344.4	289.3	38.2	21.9

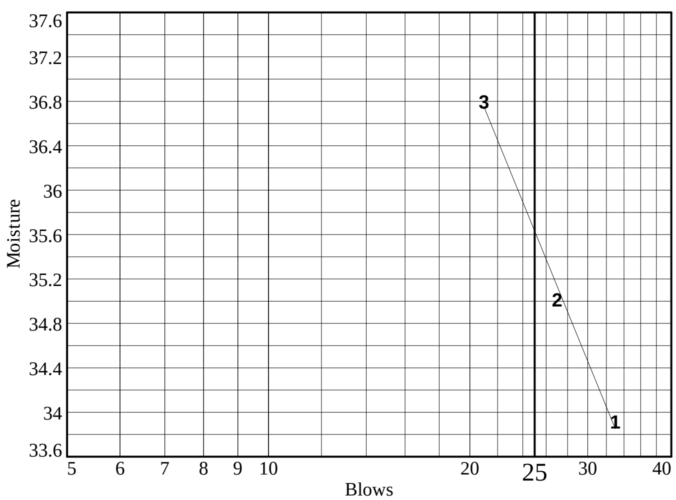
LIQUID AND PLASTIC LIMIT TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-5
Depth: 4.0'
Material Description: Dark brown sandy CLAY
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	24.05	26.27	29.78			
Dry+Tare	20.76	22.39	24.76			
Tare	11.06	11.31	11.12			
# Blows	33	27	21			
Moisture	33.9	35.0	36.8			



Liquid Limit= 36
Plastic Limit= 20
Plasticity Index= 16
Natural Moisture= 20.8
Liquidity Index= 0.1

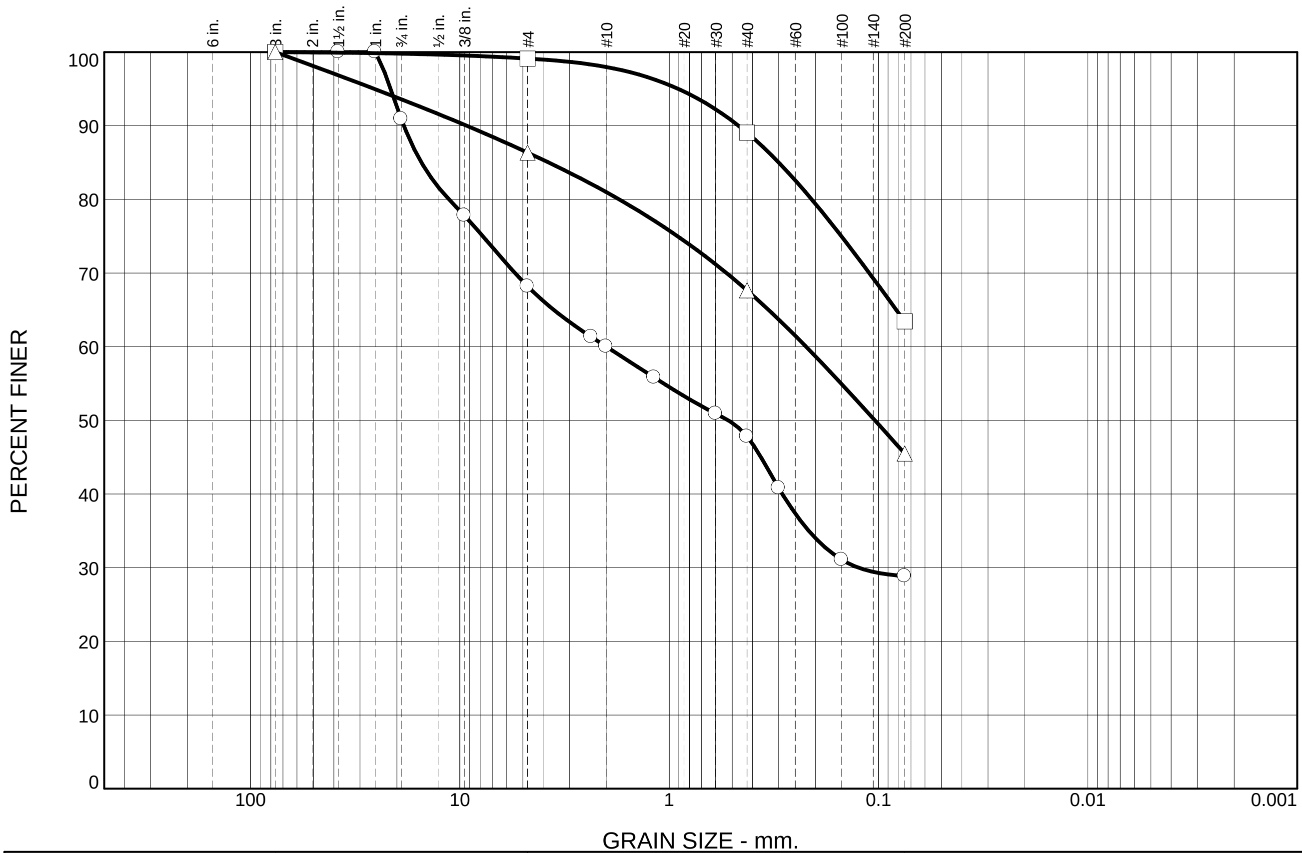
Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.27	17.79		
Dry+Tare	16.28	16.74		
Tare	11.33	11.28		
Moisture	20.0	19.2		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
327.2	276.7	33.7	20.8

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

MATERIAL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1		4.0'	Yelowish brown clayey SAND with gravel	
□	B-2		4.0'	Dark yellowish brown and olive brown sandy CLAY	
△	B-3A		4.0'	Dark yellowish brown and olive brown sandy CLAY with some gravel	SC

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Client: A3Geo
Project: Terra Linda High School

Project No.: 1150-1A **Figure**

Tested By: BH

GRAIN SIZE DISTRIBUTION TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-1
Depth: 4.0'
Material Description: Yelowish brown clayey SAND with gravel
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
979.20	271.00	0.00	3"	0.00	100.0
			1.5"	0.00	100.0
			1"	0.00	100.0
			3/4"	64.37	90.9
			3/8"	157.12	77.8
			#4	225.16	68.2
			#8	273.74	61.3
			#10	283.08	60.0
			#16	312.84	55.8
			#30	347.62	50.9
			#40	369.53	47.8
			#50	419.08	40.8
			#100	487.98	31.1
			#200	503.84	28.9

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	9.1	22.7	31.8	8.2	12.2	18.9	39.3			28.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.1246	0.2881	0.5221	1.9929	11.2655	15.2616	18.5168	21.4103

Fineness Modulus
3.23

GRAIN SIZE DISTRIBUTION TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-2
Depth: 4.0'
Material Description: Dark yellowish brown and olive brown sandy CLAY
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
244.20	38.10	0.00	3"	0.00	100.0
			#4	1.81	99.1
			#40	22.53	89.1
			#200	75.34	63.4

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.2	0.7	0.9	1.1	8.9	25.7	35.7			63.4

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
								0.2085	0.2997	0.4662	0.9050

Fineness Modulus
0.55

GRAIN SIZE DISTRIBUTION TEST DATA

3/3/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1A
Location: B-3A
Depth: 4.0'
Material Description: Dark yellowish brown and olive brown sandy CLAY with some gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
389.40	34.00	0.00	3"	0.00	100.0
			#4	48.48	86.4
			#40	114.96	67.7
			#200	193.68	45.5

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	6.4	7.2	13.6	5.4	13.3	22.2	40.9			45.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1041	0.2219	1.7339	3.7597	9.2747	25.5894

Fineness Modulus
1.84

B. Hillebrandt Soils Testing, Inc.

APPENDIX F

Phase 2 Geotechnical Laboratory Test Data Sheets
(This Study)

A3GEO

B. HILLEBRANDT SOILS TESTING, INC.

29 Sugarloaf Terrace, Alamo, CA 94507 - Tel: (510) 409-2916 - Fax: (925) 891-9267 - Email: soiltesting@aol.com

LAB RESULTS SUMMARY FORM

Project Number: 1150-1B Project Name: Terra Linda High School Results Due By:
Requested By: LB Request Date: 12/19/17 Throw Samples Out On:

					Atterberg			-200			Compaction				
Boring #	Sample Depth (feet)	Dry Density (pcf)	Moisture Content (%)	TxUU Shear Strength (psf)	Liquid Limit	Plastic Limit	Plasicity Index	Passing #4 Sieve (%)	Passing #40 sieve (%)	Passing #200 sieve (%)	Maximum Dry Density (pcf)	Optimum Moisture (%)	Pocket Penetrometer (tsf)	Torvane (tsf)	Remarks
A3-17-1	12.5							91	72	45					
A3-17-2	3.0				35	18	17								
A3-17-2	10.5	124	15.1					82	57	31					
A3-17-3	5.0	112	17.3					88	76	63					
A3-17-4	3.0	120	14.6	8536	37	17	20	94	76	53					
A3-17-5	2.0	112	16.4		33	18	15	84	57	36					
A3-17-6	4.5	118	14.3												
A3-17-7	6.5	112	18.7												
A3-17-8	6.0				39	18	21	80	62	42					
A3-17-9	3.0				33	16	17								
A3-17-9	9.0	110	20.4	3963				98	79	56					

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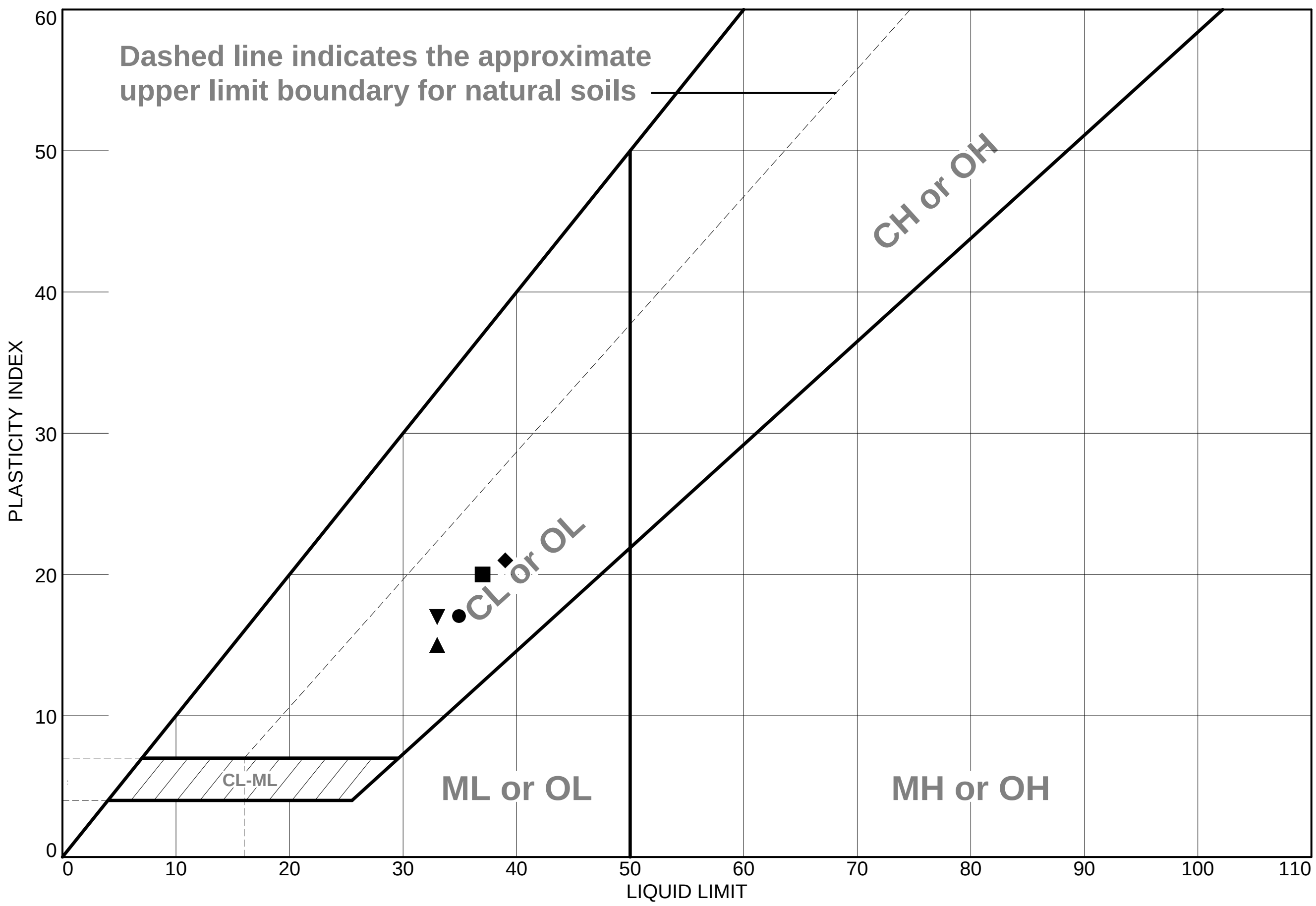
MOISTURE CONTENT/DRY DENSITY

Job #: 1150-1B
Job Name: Terra Linda High School
Date: 12/19/17
Tested by: Brad Hillebrandt

Additional Tests:	-200	-200	PI, -200			
Boring #:	A3-17-2	A3-17-3	A3-17-5	A3-17-6	A3-17-7	
Depth:	10.5	5.0	2.0	4.5	6.5	
Sample Description:	Dark yellowish brown and gray clayey SAND with gravel gravel	Dark yellowish brown and gray sandy CLAY	Yellowish brown clayey SAND with gravel	Dark yellowish brown and gray sandy CLAY with some gravel	Dark yellowish brown sandy CLAY	
Can #:	324	504	362	303	326	
Wet Sample + can	414.0	400.3	236.3	358.2	338.6	
Dry Sample + can	364.8	346.2	207.8	318.2	291.5	
Weight can	38.7	34.3	33.8	37.7	39.0	
Weight water	49.2	54.1	28.5	40	47.1	
Weight Dry Sample	326.1	311.9	174	280.5	252.5	
WATER CONTENT (%)	**15.1%**	**17.3%**	**16.4%**	**14.3%**	**18.7%**	
Weight Sample + Liner	1214.1	1113.8	1124.8	1106.9	1139.0	
Weight Liner	210.2	202.3	204.3	274.8	198.7	
Sample Length	6.0	5.9	6.0	5.25	6.0	
Sample Diameter	2.39	2.39	2.39	2.39	2.39	
DRY DENSITY (pcf)	**123.5**	**111.8**	**111.9**	**117.8**	**112.2**	

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown sandy lean CLAY with some gravel	35	18	17			CL
■	Brown sandy lean CLAY	37	17	20	75.7	52.5	CL
▲	Yellowish brown clayey SAND with gravel	33	18	15	57.2	35.8	SC
◆	Dark yellowish brown and gray clayey SAND with gravel	39	18	21	61.5	41.7	SC
▼	Dark yellowish brown sandy lean CLAY	33	16	17			CL

Project No. 1150-1B **Client:** A3Geo

Project: Terra Linda High School

●**Source of Sample:** A3-17-2 **Depth:** 3.0'
■**Source of Sample:** A3-17-4 **Depth:** 3.0'
▲**Source of Sample:** A3-17-5 **Depth:** 2.0'
◆**Source of Sample:** A3-17-8 **Depth:** 6.0'
▼**Source of Sample:** A3-17-9 **Depth:** 3.0'

Remarks:

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Figure

Tested By: BH

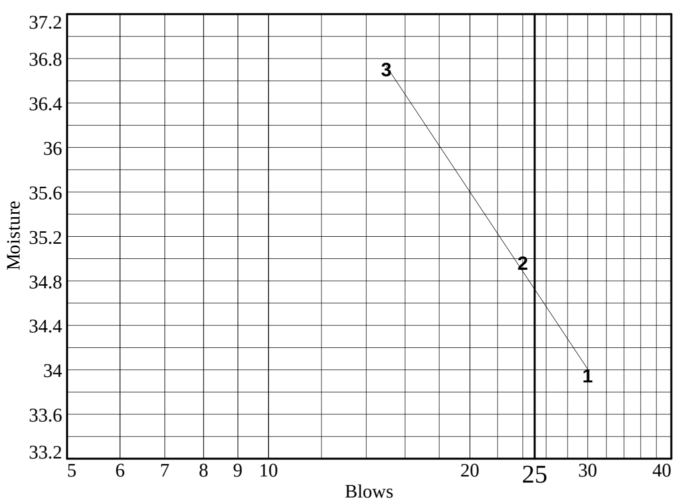
LIQUID AND PLASTIC LIMIT TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-2
Depth: 3.0'
Material Description: Brown sandy lean CLAY with some gravel
USCS: CL
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	24.08	27.28	30.80			
Dry+Tare	20.78	23.14	25.54			
Tare	11.06	11.30	11.21			
# Blows	30	24	15			
Moisture	34.0	35.0	36.7			



Liquid Limit= 35
Plastic Limit= 18
Plasticity Index= 17

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.53	17.16		
Dry+Tare	16.59	16.27		
Tare	11.12	11.31		
Moisture	17.2	17.9		

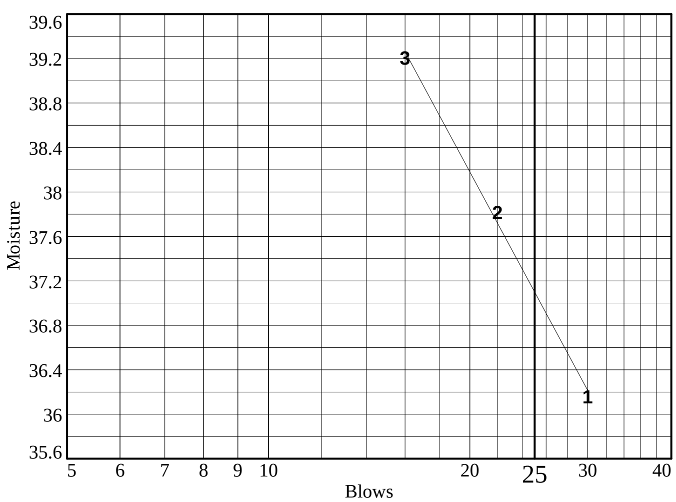
LIQUID AND PLASTIC LIMIT TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-4
Depth: 3.0'
Material Description: Brown sandy lean CLAY
%<#40: 75.7 **%<#200:** 52.5 **USCS:** CL **AASHTO:** A-6(7)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	25.83	27.85	31.65			
Dry+Tare	21.91	23.27	25.89			
Tare	11.07	11.16	11.20			
# Blows	30	22	16			
Moisture	36.2	37.8	39.2			



Liquid Limit= 37
Plastic Limit= 17
Plasticity Index= 20
Natural Moisture= 14.6
Liquidity Index= -0.1

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	17.03	17.63			
Dry+Tare	16.16	16.67			
Tare	11.27	11.05			
Moisture	17.8	17.1			

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
271.6	241.9	37.8	14.6

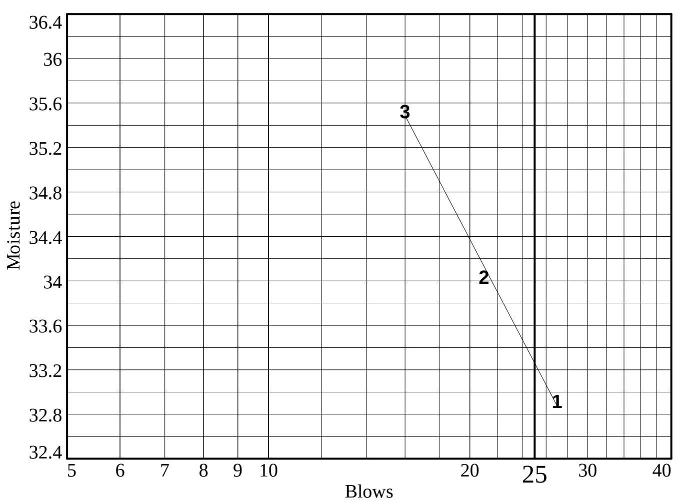
LIQUID AND PLASTIC LIMIT TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-5
Depth: 2.0'
Material Description: Yellowish brown clayey SAND with gravel
%<#40: 57.2 **%<#200:** 35.8 **USCS:** SC **AASHTO:** A-6(1)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	26.47	32.06	30.38			
Dry+Tare	22.72	26.75	25.37			
Tare	11.33	11.15	11.27			
# Blows	27	21	16			
Moisture	32.9	34.0	35.5			



Liquid Limit= 33
Plastic Limit= 18
Plasticity Index= 15
Natural Moisture= 16.4
Liquidity Index= -0.1

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	17.93	17.48			
Dry+Tare	16.91	16.51			
Tare	11.25	11.11			
Moisture	18.0	18.0			

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
236.3	207.8	33.8	16.4

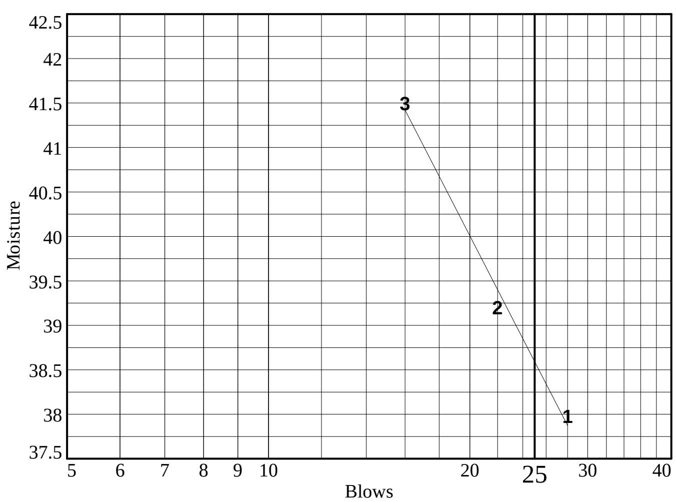
LIQUID AND PLASTIC LIMIT TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-8
Depth: 6.0'
Material Description: Dark yellowish brown and gray clayey SAND with gravel
%<#40: 61.5 **%<#200:** 41.7 **USCS:** SC **AASHTO:** A-6(4)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	25.58	27.95	29.53			
Dry+Tare	21.66	23.21	24.18			
Tare	11.34	11.12	11.29			
# Blows	28	22	16			
Moisture	38.0	39.2	41.5			



Liquid Limit= 39
Plastic Limit= 18
Plasticity Index= 21
Natural Moisture= 16.7
Liquidity Index= -0.1

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.40	18.16		
Dry+Tare	16.49	17.11		
Tare	11.29	11.33		
Moisture	17.5	18.2		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
358.6	312.8	37.8	16.7

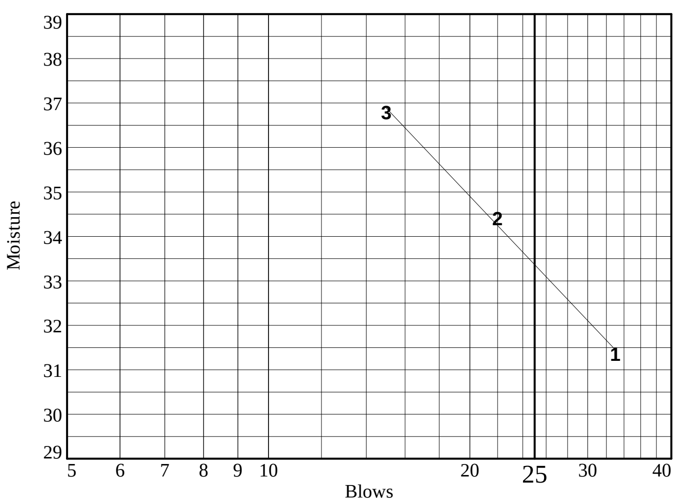
LIQUID AND PLASTIC LIMIT TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-9
Depth: 3.0'
Material Description: Dark yellowish brown sandy lean CLAY
USCS: CL
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	25.73	31.34	31.05			
Dry+Tare	22.27	26.15	25.74			
Tare	11.24	11.07	11.31			
# Blows	33	22	15			
Moisture	31.4	34.4	36.8			



Liquid Limit= 33
Plastic Limit= 16
Plasticity Index= 17
Natural Moisture= 20.4
Liquidity Index= 0.3

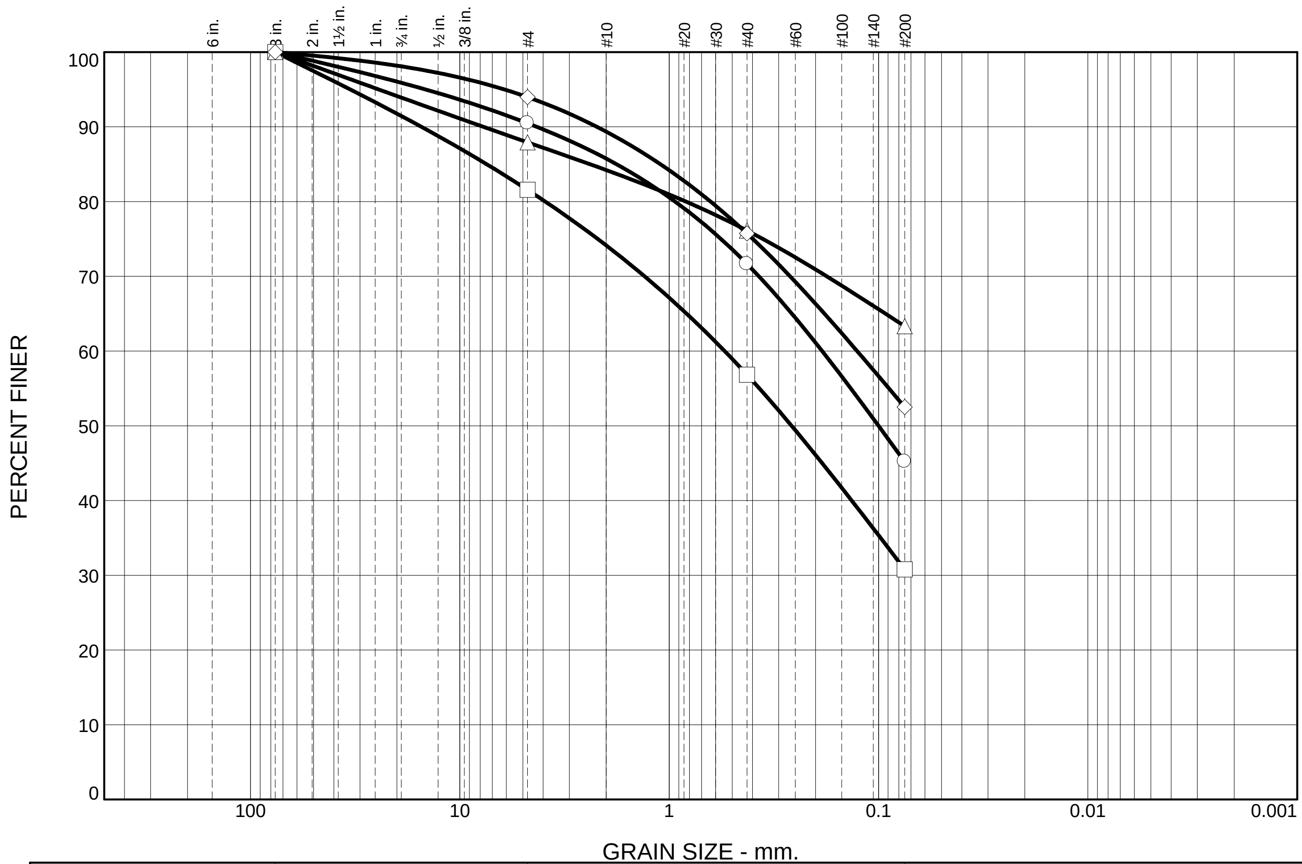
Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.12	17.25		
Dry+Tare	16.25	16.40		
Tare	11.04	11.16		
Moisture	16.7	16.2		

Natural Moisture Data

Wet+Tare	Dry+Tare	Tare	Moisture
304.49	259.29	37.67	20.4

Particle Size Distribution Report



Symbol	% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
○	0.0	4.1	5.4	4.8	14.0	26.5	45.2	
□	0.0	8.5	9.9	7.5	17.3	26.0	30.8	
△	0.0	6.1	6.0	3.7	8.1	12.8	63.3	
◇	0.0	1.9	4.1	4.6	13.7	23.2	52.5	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	A3-17-1		12.5'	Yellowish brown and gray clayey SAND	
□	A3-17-2		10.5'	Dark yellowish brown and gray clayey SAND with gravel	
△	A3-17-3		5.0'	Dark yellowish brown and gray sandy CLAY	
◇	A3-17-4		3.0'	Brown sandy lean CLAY	CL

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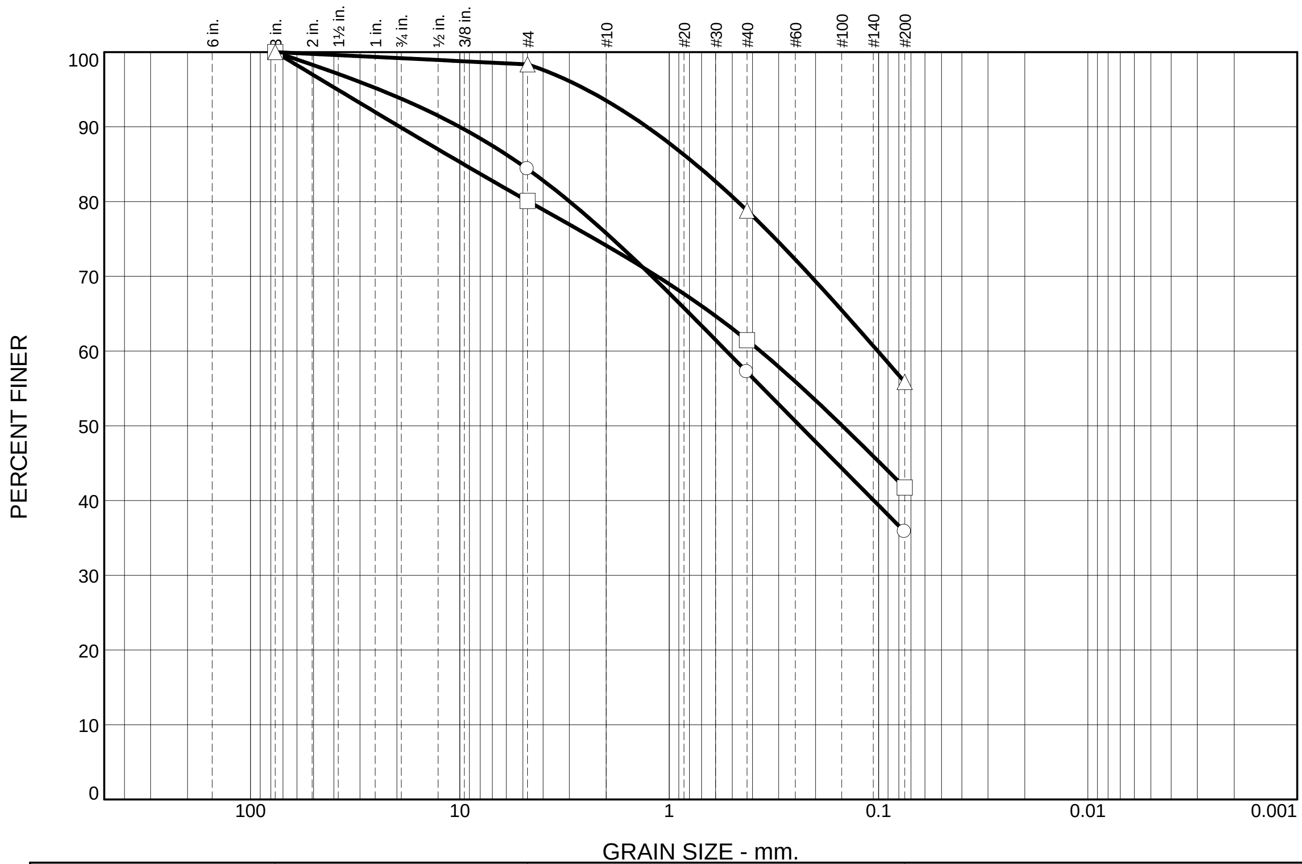
Client: A3Geo
Project: Terra Linda High School
Project No.: 1150-1B **Figure**

Tested By: BH

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	6.2	9.4	8.6	18.6	21.4	35.8	
□	0.0	10.1	9.8	6.0	12.6	19.8	41.7	
△	0.0	0.8	0.8	4.9	14.7	22.9	55.9	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	A3-17-5		2.0'	Yellowish brown clayey SAND with gravel	SC
□	A3-17-8		6.0'	Dark yellowish brown and gray clayey SAND with gravel	SC
△	A3-17-9		9.0'	Brown sandy CLAY	

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Client: A3Geo
Project: Terra Linda High School

Project No.: 1150-1B **Figure**

Tested By: BH

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-1
Depth: 12.5'
Material Description: Yellowish brown and gray clayey SAND
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
332.10	36.40	0.00	3"	0.00	100.0
			#4	28.15	90.5
			#40	83.81	71.7
			#200	162.04	45.2

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	4.1	5.4	9.5	4.8	14.0	26.5	45.3			45.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1000	0.1859	0.9375	1.7850	4.2945	14.5798

Fineness Modulus
1.54

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-2
Depth: 10.5'
Material Description: Dark yellowish brown and gray clayey SAND with gravel
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
364.80	38.70	0.00	3"	0.00	100.0
			#4	60.10	81.6
			#40	140.76	56.8
			#200	225.69	30.8

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	8.5	9.9	18.4	7.5	17.3	26.0	50.8			30.8

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
					0.1344	0.2602	0.5433	3.9085	7.4499	15.2588	33.3935

Fineness Modulus
2.45

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-3
Depth: 5.0'
Material Description: Dark yellowish brown and gray sandy CLAY
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
346.20	34.30	0.00	3"	0.00	100.0
			#4	37.65	87.9
			#40	74.46	76.1
			#200	114.38	63.3

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	6.1	6.0	12.1	3.7	8.1	12.8	24.6			63.3

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
								0.8322	2.3914	7.7153	24.4190

Fineness Modulus
1.43

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-4
Depth: 3.0'
Material Description: Brown sandy lean CLAY
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
241.90	37.80	0.00	3"	0.00	100.0
			#4	12.29	94.0
			#40	49.52	75.7
			#200	96.93	52.5

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	1.9	4.1	6.0	4.6	13.7	23.2	41.5			52.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
							0.1265	0.6344	1.1018	2.2136	6.1308

Fineness Modulus
1.23

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-5
Depth: 2.0'
Material Description: Yellowish brown clayey SAND with gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
207.80	33.80	0.00	3"	0.00	100.0
			#4	27.23	84.4
			#40	74.48	57.2
			#200	111.66	35.8

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	6.2	9.4	15.6	8.6	18.6	21.4	48.6			35.8

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
					0.1054	0.2376	0.5325	2.9886	5.1246	10.0267	24.3100

Fineness Modulus
2.29

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-8
Depth: 6.0'
Material Description: Dark yellowish brown and gray clayey SAND with gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
312.80	37.80	0.00	3"	0.00	100.0
			#4	54.76	80.1
			#40	105.99	61.5
			#200	160.22	41.7

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	10.1	9.8	19.9	6.0	12.6	19.8	38.4			41.7

D_{5}	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.1490	0.3672	4.6901	9.6011	19.3213	38.4690

Fineness Modulus
2.32

GRAIN SIZE DISTRIBUTION TEST DATA

12/28/2017

Client: A3Geo
Project: Terra Linda High School
Project Number: 1150-1B
Location: A3-17-9
Depth: 9.0'
Material Description: Brown sandy CLAY
Tested by: BH

Sieve Test Data

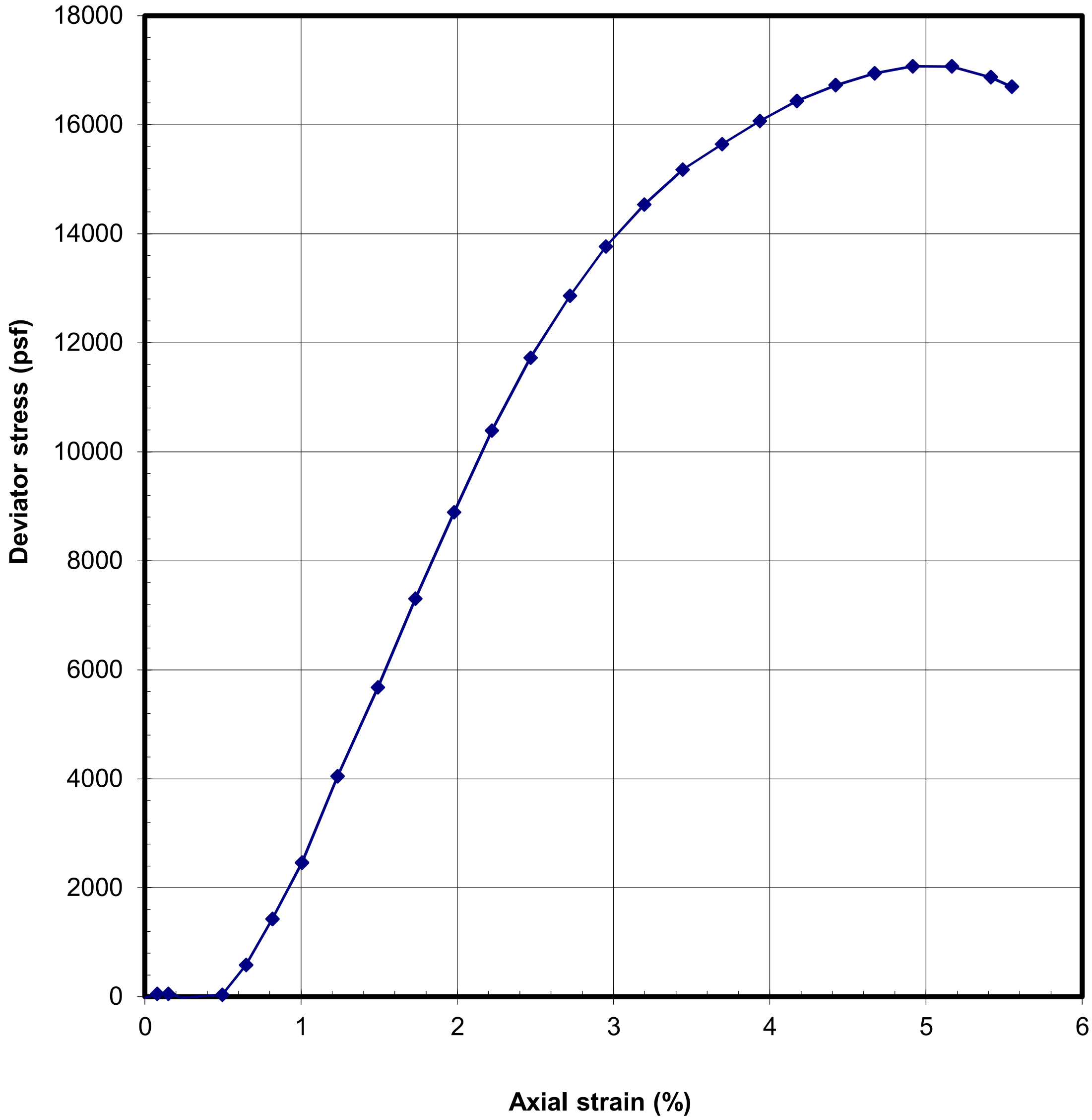
Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
259.30	37.70	0.00	3"	0.00	100.0
			#4	3.64	98.4
			#40	46.97	78.8
			#200	97.80	55.9

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.8	0.8	1.6	4.9	14.7	22.9	42.5			55.9

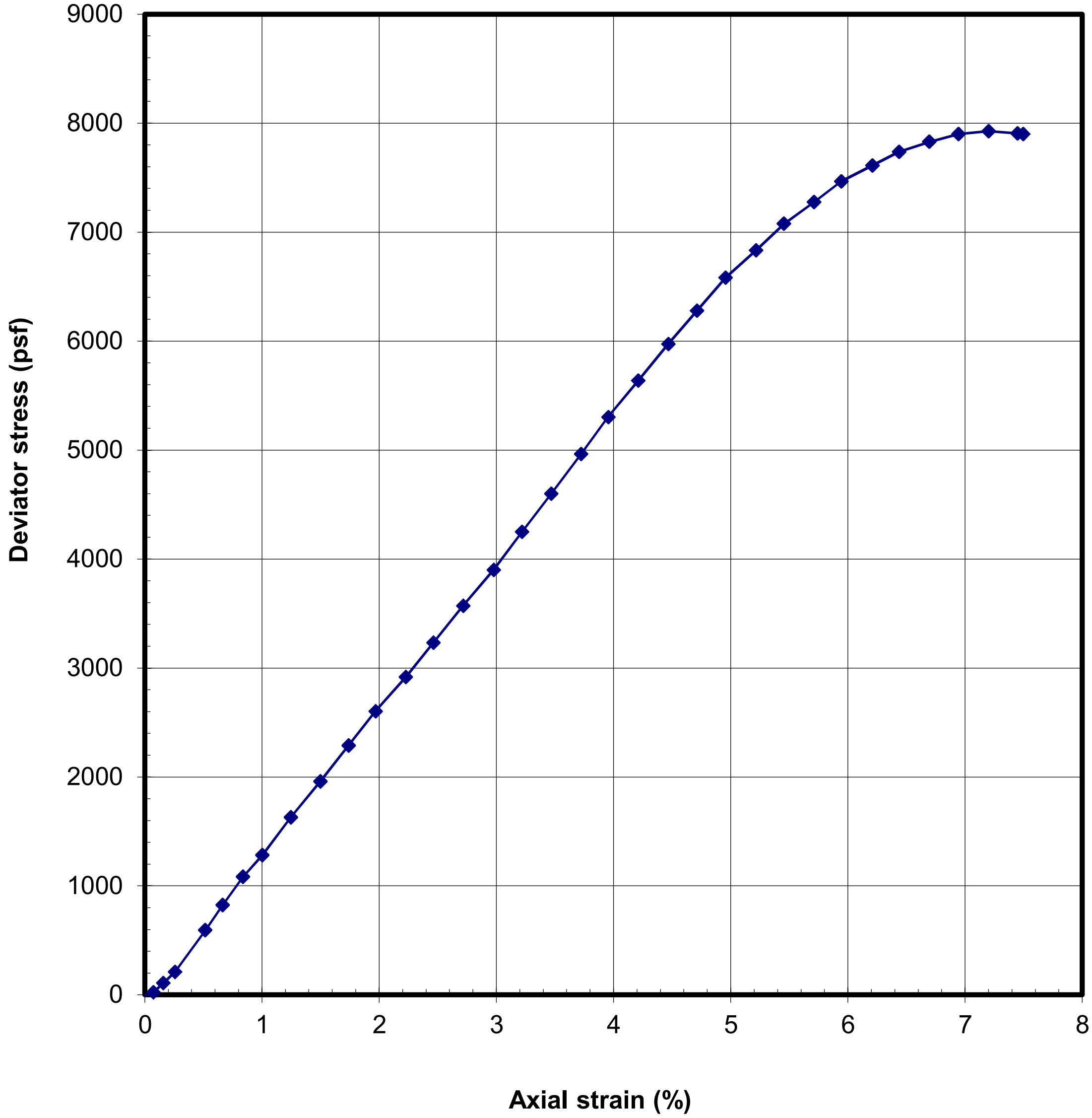
D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
							0.1008	0.4713	0.7487	1.2771	2.4948

Fineness Modulus
0.97



Sampler Type Mod Cal		Shear Strength:	8536 psf
Diameter (in): 2.39	Height (in): 5.81	Strain at Failure:	5.2%
Moisture Content:	14.6 %	Confining Pressure:	375 psf
Dry Density:	120 pcf	Strain Rate:	1%/min
Source: A3-17-4 @ 3.0 feet			
Description: Brown sandy lean CLAY (CL)			

TERRA LINDA HIGH SCHOOL	**UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST**		
B. HILLEBRANDT SOILS TESTING, INC	Date: 12/22/17	Project #: 1150-1B	Figure



Sampler Type Mod Cal		Shear Strength:	3963 psf
Diameter (in): 2.39	Height (in): 5.81	Strain at Failure:	7.2%
Moisture Content: 20.4 %		Confining Pressure:	1000 psf
Dry Density: 110 pcf		Strain Rate:	1%/min
Source: A3-17-9 @ 9.0 feet			
Description: Brown sandy lean CLAY (CL)			

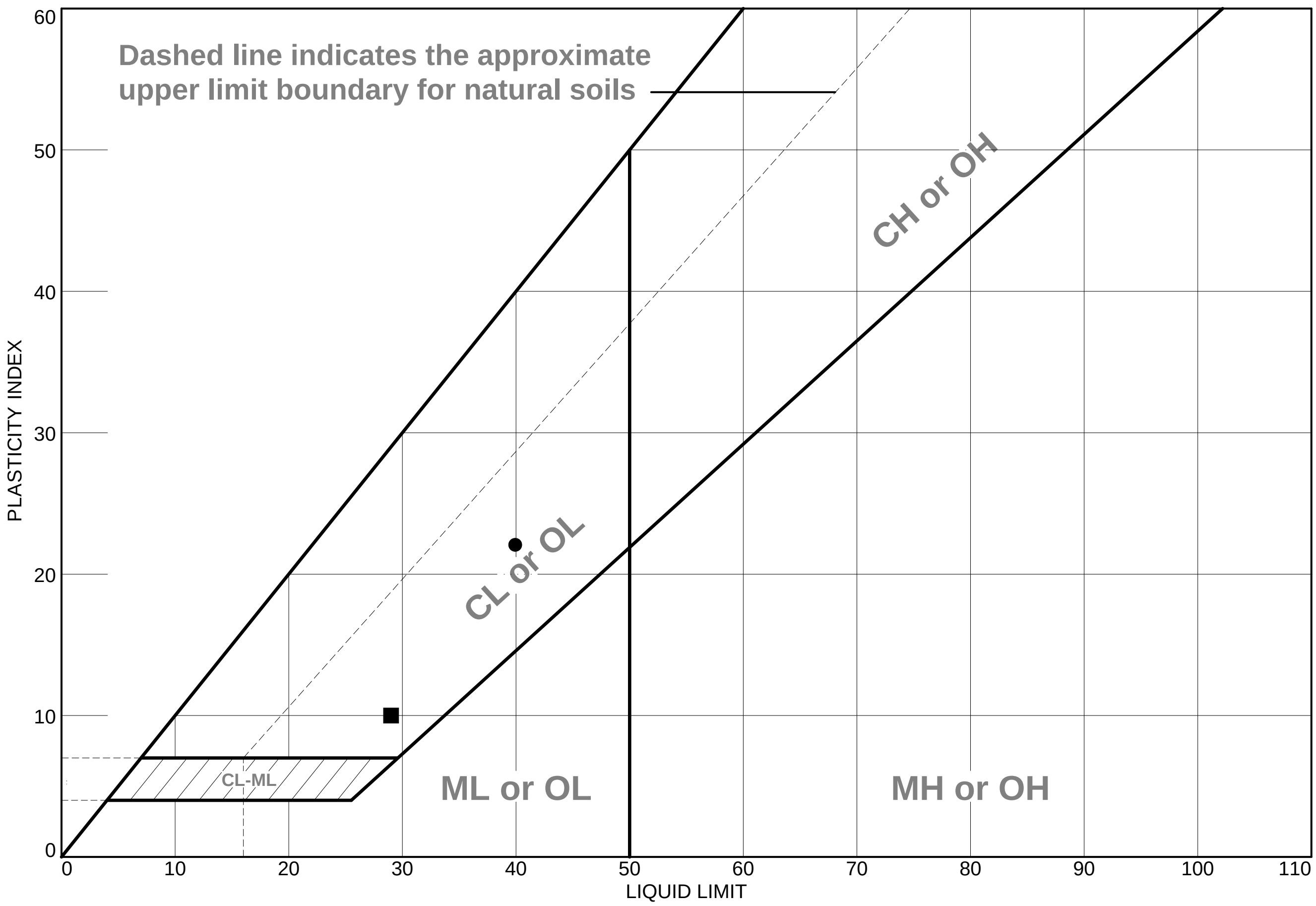
TERRA LINDA HIGH SCHOOL

UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST

B. HILLEBRANDT SOILS TESTING, INC

Date: 12/22/17 | Project #: 1150-1B | Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown sandy lean CLAY	40	18	22			CL
■	Brown clayey SAND with gravel	29	19	10	46.4	21.1	SC

Project No. 1150-1A **Client:**

Project: Terra Linda High School

●**Source of Sample:** A3-17-1 **Depth:** 12.0 - 12.5'

■**Source of Sample:** A3-17-1 **Depth:** 17.5 - 18.0'

Remarks:

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Figure

Tested By: BH

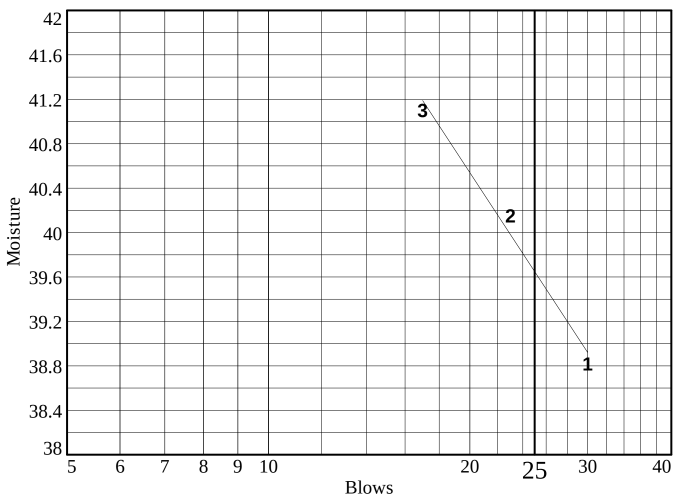
LIQUID AND PLASTIC LIMIT TEST DATA

1/27/2018

Project: Terra Linda High School
Project Number: 1150-1A
Location: A3-17-1
Depth: 12.0 - 12.5'
Material Description: Brown sandy lean CLAY
USCS: CL
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	27.16	29.04	27.66			
Dry+Tare	22.73	23.96	22.83			
Tare	11.32	11.31	11.08			
# Blows	30	23	17			
Moisture	38.8	40.2	41.1			



Liquid Limit= 40
Plastic Limit= 18
Plasticity Index= 22

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	17.37	17.79		
Dry+Tare	16.46	16.80		
Tare	11.30	11.26		
Moisture	17.6	17.9		

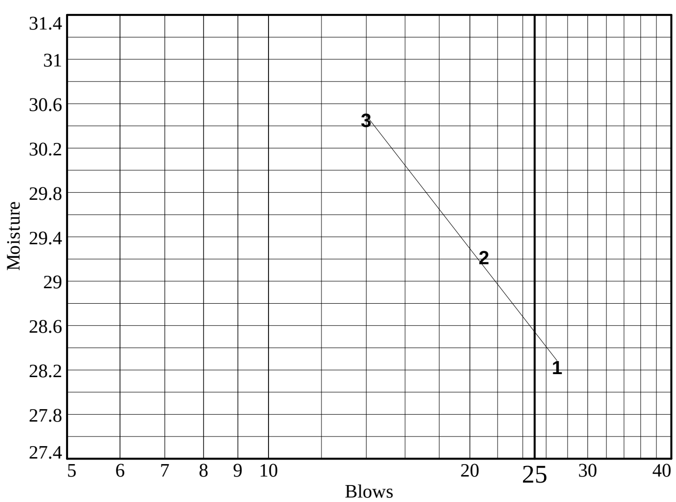
LIQUID AND PLASTIC LIMIT TEST DATA

1/27/2018

Project: Terra Linda High School
Project Number: 1150-1A
Location: A3-17-1
Depth: 17.5 - 18.0'
Material Description: Brown clayey SAND with gravel
%<#40: 46.4 **%<#200:** 21.1 **USCS:** SC **AASHTO:** A-2-4(0)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	28.91	33.23	32.81			
Dry+Tare	25.04	28.28	27.76			
Tare	11.33	11.34	11.18			
# Blows	27	21	14			
Moisture	28.2	29.2	30.5			

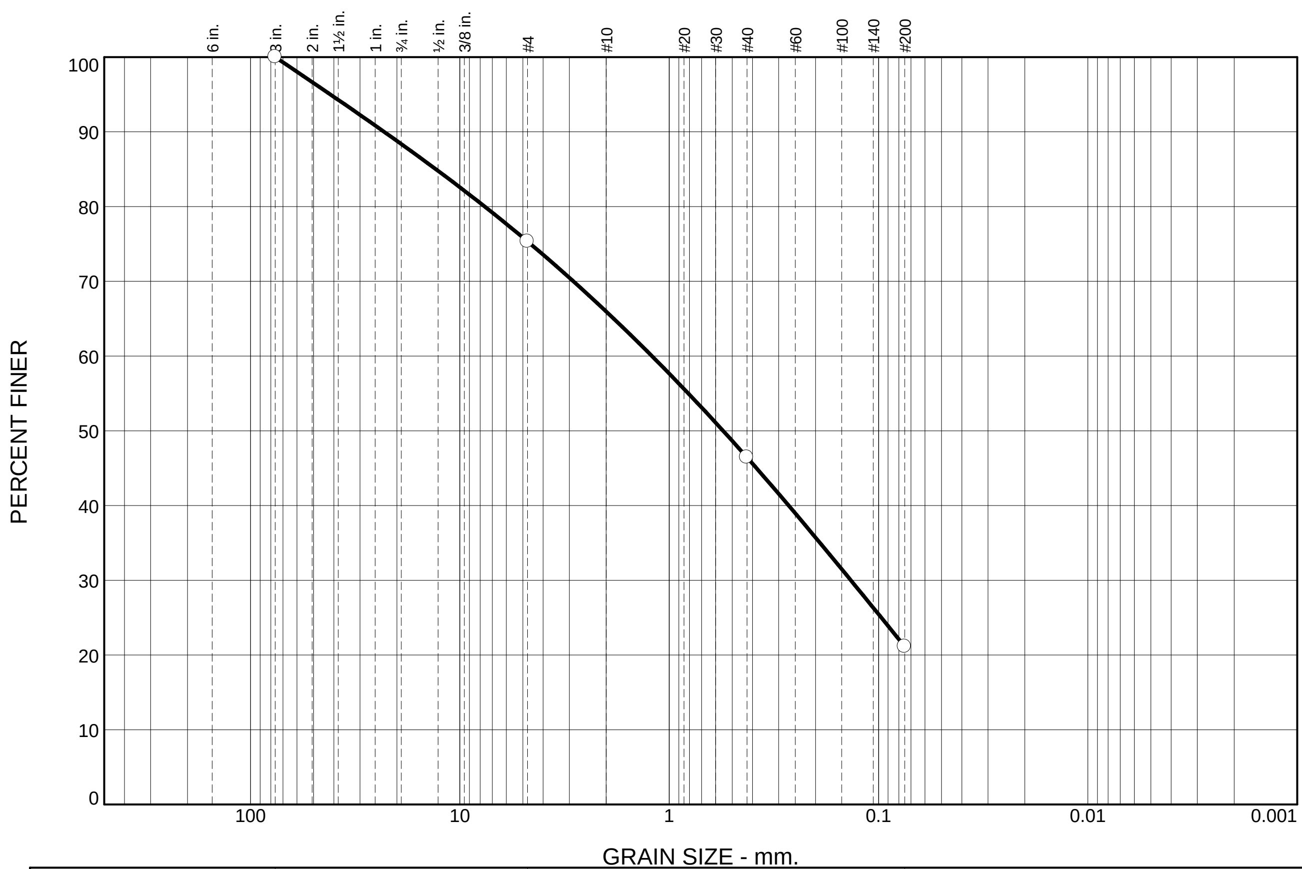


Liquid Limit= 29
Plastic Limit= 19
Plasticity Index= 10

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	19.26	18.37		
Dry+Tare	18.01	17.21		
Tare	11.38	11.30		
Moisture	18.9	19.6		

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	11.6	13.1	9.3	19.6	25.3	21.1	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	A3-17-1		17.5 - 18.0'	Brown clayey SAND with gravel	SC

B. HILLEBRANDT SOILS TESTING, INC.
+1 510-409-2816
SoilTesting@aol.com

Client:
Project: Terra Linda High School

Project No.: 1150-1A **Figure**

Tested By: BH

GRAIN SIZE DISTRIBUTION TEST DATA

1/27/2018

Project: Terra Linda High School
Project Number: 1150-1A
Location: A3-17-1
Depth: 17.5 - 18.0'
Material Description: Brown clayey SAND with gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
630.10	227.00	0.00	3"	0.00	100.0
			#4	99.41	75.3
			#40	215.89	46.4
			#200	317.87	21.1

Fractional Components

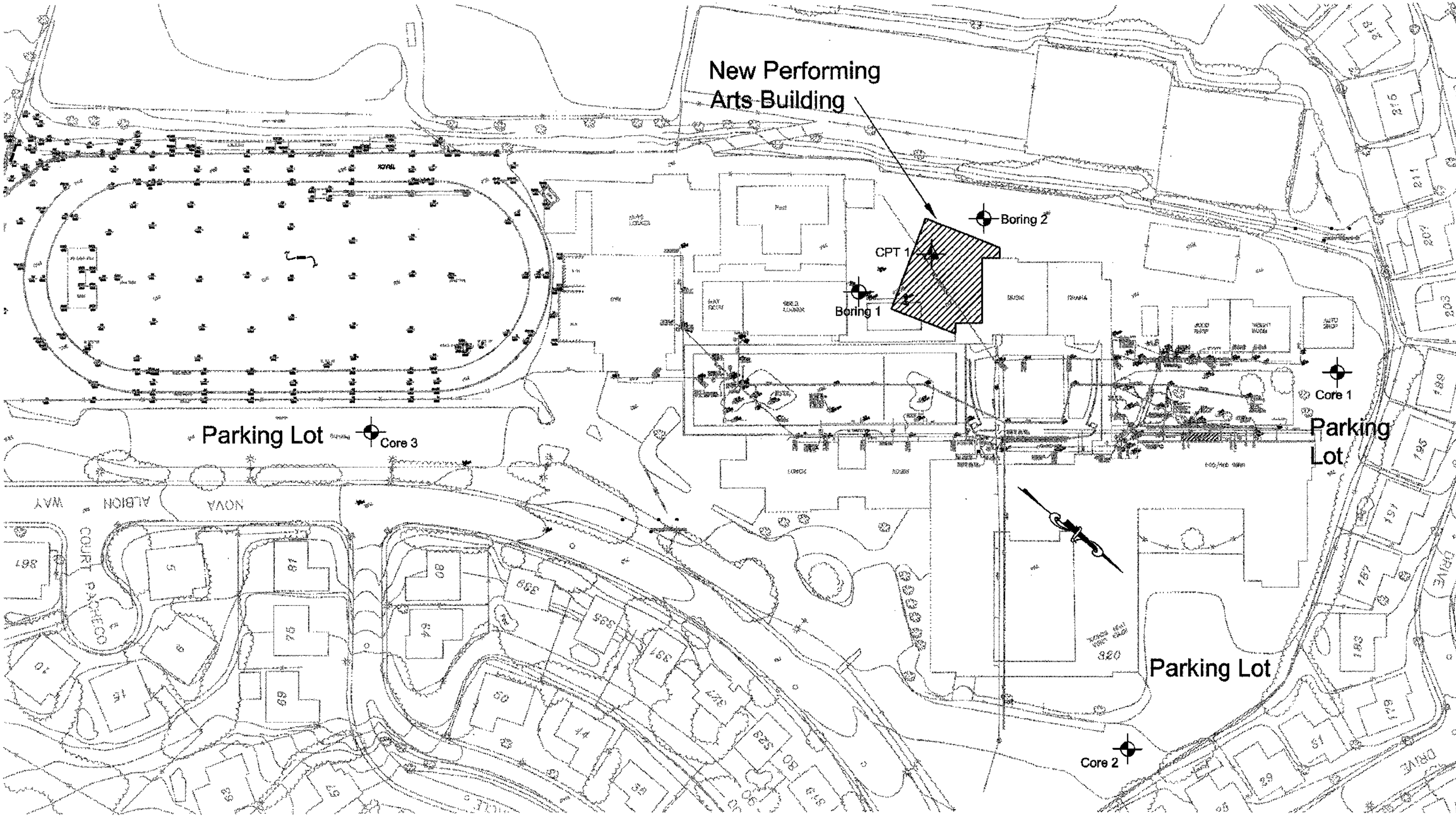
Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	11.6	13.1	24.7	9.3	19.6	25.3	54.2			21.1

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.1356	0.2686	0.5527	1.2090	7.6066	13.0207	22.9860	41.5710

Fineness Modulus
3.08

APPENDIX G

Site Plan and Data from Previous Investigation (MPEG, 2003)



Boring Or Core By MPEG, August 2003

Boring By MPEG, August 2003

SCALE

0 50 100 200 FEET

FILE: 779.12/terralindasiteplan.dwg

Miller Pacific ENGINEERING GROUP

SITE PLAN
San Rafael Schools - Terra Linda High
San Rafael, California

Project No. 779.12	Date 09/03/03	Approved By:	Figure 2

APPENDIX A

SUBSURFACE EXPLORATION AND LABORATORY TESTING

1.0 Subsurface Exploration - Borings

We explored subsurface conditions at the site by drilling 2 test borings and 3 pavement cores on August 14, 2003 at the locations shown on Figure 2. Test borings were drilled to depths between 16 and 25.5 feet using a hollow-stem auger with a diameter of 8 inches. The pavement cores were shallow and terminated in natural soils below the existing pavement section.

The soils encountered were logged and identified by our Engineer in general accordance with ASTM Standard D 2487, "Field Identification and Description of Soils (Visual-Manual Procedure)." This standard is briefly explained on Figure A-1, Soil Classification Chart and Key to Log Symbols and Figure A-2 Rock Classification Chart. The Boring Logs are presented on Figures A-3 to A-5.

We obtained "undisturbed" samples using a 3-inch diameter, split-barrel modified California sampler with 2.5 by 6-inch brass tube liners or with a 2-inch diameter, split-barrel Standard Penetration Test (SPT) sampler. The sampler was driven with a 140-pound hammer falling 30 inches. The number of blows required to drive the samplers 18 inches was recorded and is reported on the boring logs as blows per foot for the last 12 inches of driving. The samples obtained were examined in the field, sealed to prevent moisture loss, and transported to our laboratory.

2.0 Subsurface Exploration – Cone Penetration Testing

The Cone Penetration Test (CPT) is a special exploration technique that provides a continuous profile of data throughout the depth of exploration. It is particularly useful in defining stratigraphy, relative soil strength and in assessing liquefaction potential. We performed 1 CPT on August 20, 2003 at the locations shown on the Site Plan, Figure 2. The CPT equipment was mounted in a large rubber-tired van.

The CPT is a cylindrical probe, 35 mm in diameter, which is pushed into the ground at a constant rate of 2 cm/sec. The device is illustrated on Figure A-6. It is instrumented to obtain continuous measurements of cone bearing (tip resistance), sleeve friction and pore water pressure. The data is sensed by strain gages and load cells inside the instrument. Electronic signals from the instrument are continuously recorded by an on-board computer at the surface, which permits an initial evaluation of subsurface conditions during the exploration.

The recorded data is transferred to an in-office computer for reduction and analysis. The analysis of cone bearing and sleeve friction (i.e. friction ratio) indicates the soil type, the cone bearing alone indicates soil density or strength, and the pore pressure indicates the presence of clay. Variations in the data profile indicate changes in stratigraphy. This test method has been standardized and is described in detail by the ASTM Standard Test Method D3441 "Deep, Quasi-Static Cone and Friction Cone Penetration Tests of Soil." The interpretation of CPT data is illustrated on Figure A-7, and the CPT data log is presented on Figure A-8.

3.0 Laboratory Testing

We conducted laboratory tests on selected intact samples to verify field identifications and to evaluate engineering properties. The following laboratory tests were conducted in accordance with the ASTM standard test method cited:

- Laboratory Determination of Water (Moisture Content) of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D 2216;
- Density of Soil in Place by the Drive-Cylinder Method, ASTM D 2937;
- Unconfined Compressive Strength of Cohesive Soil, ASTM D 2166;
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM D 4318;
- Resistance (R)-value/expansion pressure of untreated laboratory compacted soils/aggregates, D 2844.

The moisture content, dry density, and unconfined compression test results are shown on the exploratory Boring Logs, Figures A-3 through A-5. The R-value test is summarized on Figure A-9 and the Plasticity Index Test is summarized on Figure A-10.

The exploratory boring logs, description of soils encountered and the laboratory test data reflect conditions only at the location of the boring at the time they were excavated or retrieved. Conditions may differ at other locations and may change with the passage of time due to a variety of causes including natural weathering, climate and changes in surface and subsurface drainage.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS		SYMBOL	DESCRIPTION
COARSE GRAINED SOILS over 50% sand and gravel	CLEAN GRAVEL	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
	GRAVEL with fines	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	CLEAN SAND	SW	Well-graded sands or gravely sands, little or no fines
		SP	Poorly-graded sands or gravely sands, little or no fines
	SAND with fines	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS over 50% silt and clay	SILT AND CLAY liquid limit <50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	SILT AND CLAY liquid limit >50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS		PT	Peat, muck, and other highly organic soils
ROCK			Undifferentiated as to type or composition

KEY TO BORING AND TEST PIT SYMBOLS

CLASSIFICATION TESTS

AL ATTERBERG LIMITS TEST
SA SIEVE ANALYSIS
HYD HYDROMETER ANALYSIS
P200 PERCENT PASSING NO. 200 SIEVE
P4 PERCENT PASSING NO. 4 SIEVE

STRENGTH TESTS

TV FIELD TORVANE (UNDRAINED SHEAR)
UC LABORATORY UNCONFINED COMPRESSION
TXCU CONSOLIDATED UNDRAINED TRIAXIAL
TXUU UNCONSOLIDATED UNDRAINED TRIAXIAL
UC, CU, UU = 1/2 Deviator Stress

SAMPLER TYPE

UNDISTURBED CORE SAMPLE: MODIFIED CALIFORNIA OR HYDRAULIC PISTON SAMPLE

STANDARD PENETRATION TEST SAMPLE

X DISTURBED OR BULK SAMPLE

ROCK OR CORE SAMPLE

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the location and time of exploration. Subsurface rock, soil and water conditions may differ in locations and with the passage of time. Lines defining interface between differing soil or rock description are approximate and may indicate a gradual transition.

FRACTURING AND BEDDING

Fracture Classification	Spacing	Bedding Classification
Crushed	less than 3/4 inch	Laminated
Intensely fractured	3/4 to 2-1/2 inches	Very thinly bedded
Closely fractured	2-1/2 to 8 inches	Thinly bedded
Moderately fractured	8 to 24 inches	Medium bedded
Widely fractured	2 to 6 feet	Thickly bedded
Very widely fractured	greater than 6 feet	Very thickly bedded

HARDNESS

Low	Carved or gouged with a knife
Moderate	Easily scratched with a knife, friable
Hard	Difficult to scratch, knife scratch leaves dust trace
Very hard	Rock scratches metal

STRENGTH

Friable	Crumbles by rubbing with fingers
Weak	Crumbles under light hammer blows
Moderate	Indentations <1/8 inch with moderate blow with pick end of rock hammer
Strong	Withstands few heavy hammer blows, yields large fragments
Very strong	Withstands many heavy hammer blows, yields dust, small fragments

WEATHERING

Complete	Minerals decomposed to soil, but fabric and structure preserved
High	Rock decomposition, thorough discoloration, all fractures are extensively coated with clay, oxides or carbonates
Moderate	Fracture surfaces coated with weathering minerals, moderate or localized discoloration
Slight	A few stained fractures, slight discoloration, no mineral decomposition, no affect on cementation
Fresh	Rock unaffected by weathering, no change with depth, rings under hammer impact

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the location and time of exploration. Subsurface rock, soil and water conditions may differ in other locations and with the passage of time.

FILE: Rock Class.dwg

Miller Pacific ENGINEERING GROUP

ROCK CLASSIFICATION CHART
San Rafael City Schools - Terra Linda High
San Rafael, California

A-2

Project No. 779.12 | Date 09/03/03 | Approved By: [signature]

Figure

BORING 1

EQUIPMENT: CME 75 - 8" Hollow Stem Auger
DATE: 8/14/03
ELEVATION: 79.6 feet*
*REFERENCE: City of San Rafael Topo Map used for Elevation

OTHER TEST DATA	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	DESCRIPTION
					0	0			2.5" ASPHALT CONCRETE
									2" AGGREGATE BASE
	1600	42	15.2	112.0					SILTY SANDY CLAY (CL) (COLLUVIUM) mottled orange-red to brown, dry, stiff to very stiff, low plasticity, 15% - 20% fine to medium grained sands
					1				
	1100	50	12.3	116.0		5			SILTY SANDY CLAY WITH GRAVEL (CL) light brown to brown, dry, very stiff, low plasticity, 15% - 20% fine to coarse grained sands, 5% - 10% fine to medium graded gravel to 3/4"
					2				
	1100	29	14.9	110.0	3	10			Grades brown to dark brown
					4				
						15			
					5				
		50/1"	9.9						SANDSTONE (SS) moderately weathered, light brown to brown, fine to medium grained sands
					6	20			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m³ = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

FILE: Boring Logs 779-12.dwg

Miller Pacific ENGINEERING GROUP

BORING LOG
San Rafael City Schools - Terra Linda High
San Rafael, California

A-3

Project No. 779.12 | Date 09/03/03 | Approved By: [signature]

Figure

OTHER TEST DATA	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	BORING 1 (CONTINUED)
						20			SANDSTONE (SS) moderately weathered, light brown to brown, fine to medium grained sands
					7				
									grades to slightly weathered, light gray to gray, fine to medium grained sands
		50/0"				25	☐		
									Bottom of boring at 25.3' No groundwater observed during drilling
					8				
					9				
						30			
					10				
						35			
					11				
					12				
						40			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m³ = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

FILE: Boring Logs 779-12.dwg

Miller Pacific
ENGINEERING GROUP

BORING LOG
San Rafael City Schools - Terra Linda High
San Rafael, California

A-4

Project No. 779.12 | Date 09/03/03 | Approved By: [signature] | Figure

OTHER TEST DATA	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	BORING 2
					0	0			2.5" ASPHALT CONCRETE 2" AGGREGATE BASE
	1400	34	19.9	103.0	1	5	■	▨	SILTY SANDY CLAY (CL) (COLLUVIUM) mottled orange-red to brown, dry, stiff to very stiff, low plasticity, 15% - 20% fine to medium grained sands
	2200	61	13.8	119.0	2, 3	10	■	▨	SILTY SANDY CLAY w/ GRAVEL (CL) light brown to brown, dry, very stiff, low plasticity, 15% - 20% fine to coarse grained sands, 5% - 10% fine to medium graded gravel to 3/4"
		50/5"	12.7		4	15	■	▩	SANDSTONE (SS) moderately weathered, light brown to brown, fine to medium grained sands
					5, 6	20			Bottom of boring at 16' No groundwater observed during drilling

EQUIPMENT: CME 75 - 8" Hollow Stem Continuous Flight Auger
DATE: 8/14/03
ELEVATION: 79.6 feet*
*REFERENCE: City of San Rafael Topo Map, DPW, 1998

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m³ = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

FILE: Boring Logs 779-12.dwg

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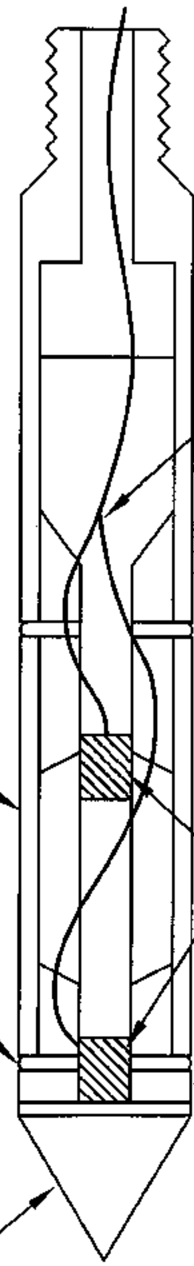
BORING LOG
San Rafael City Schools - Terra Linda High
San Rafael, California

A-5

Project No. 779.12 Date 09/03/03 Approved By: [illegible]

Figure



CONE PENETROMETER

(NO SCALE)

FILE: STD-075.779.12TL.dwt

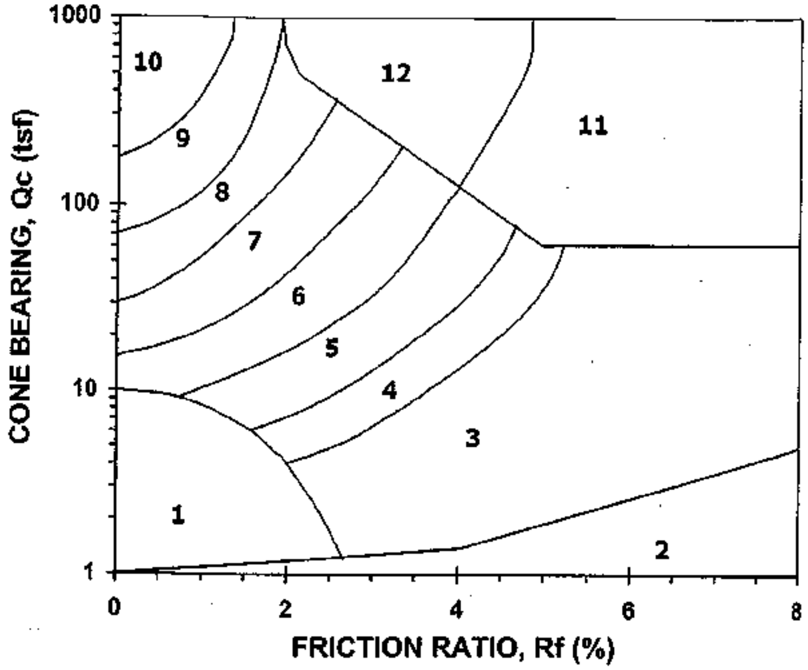
Miller Pacific ENGINEERING GROUP

CONE PENETROMETER
San Rafael City Schools - Terra Linda High
San Rafael, California

A-6

Project No. 779.12 | Date 10/29/03 | Approved By: | Figure

SIMPLIFIED SOIL BEHAVIOR TYPE CLASSIFICATION FOR STANDARD ELECTRONIC CONE PENETROMETER



ZONE	Qc/N[1]	Su Factor (Nk)[2]	SOIL BEHAVIOR TYPE[1]
1	2		Sensitive Fine Grained
2	1	for Zones 1 to 6	Organic Material
3	1	10 for Qc <= 9 tsf	CLAY
4	1.5	12 for Qc = 9 to 12 tsf	Silty CLAY to CLAY
5	2	15 for Qc > 12 tsf	Clayey SILT to Silty CLAY
6	2.5		Sandy SILT to Clayey SILT
7	3	---	Silty SAND to Sandy SILT
8	4	---	SAND to Silty SAND
9	5	---	SAND
10	6	---	Gravelly SAND to SAND
11	1	15	Very Stiff Fine Grained (*)
12	2	---	SAND to Clayey SAND (*)

(*) Overconsolidated or Cemented

Qc = Tip Bearing
Fs = Sleeve Friction
Rf = Fs/Qc*100 = Friction Ratio

References: [1]Robertson, 1986, Olsen, 1988
[2]Bonaparte & Mitchell, 1979 (young bay mud Qc <= 9)
[2]Estimated from local experience (fine grained soils Qc > 9)

Note: Testing performed in accordance with ASTM D3441

John Sarmiento & Associates
Cone Penetrometer Testing Services

FILE: STD-075 cone 779.12TL.dwt

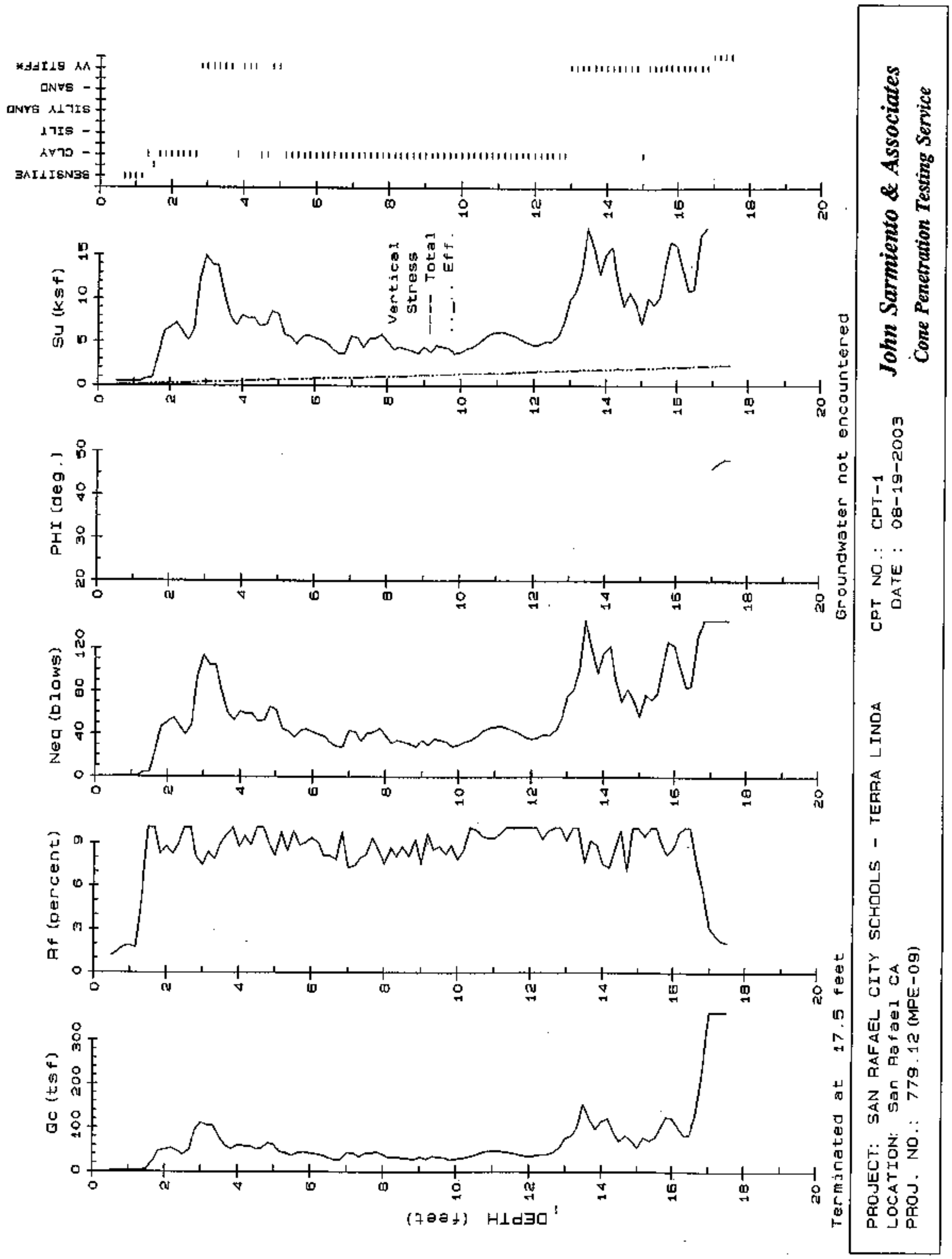
Miller Pacific ENGINEERING GROUP

CPT SOIL INTERPRETATION CHART
San Rafael City Schools - Terra Linda High
San Rafael, California

A-7

Project No. 779.12 | Date 10/29/03 | Approved By: [signature]

Figure



FILE: CPT LOGS 779.12TL.dwg

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CONE PENETRATION TEST LOG
San Rafael City Schools - Terra Linda High
San Rafael, California

A-8

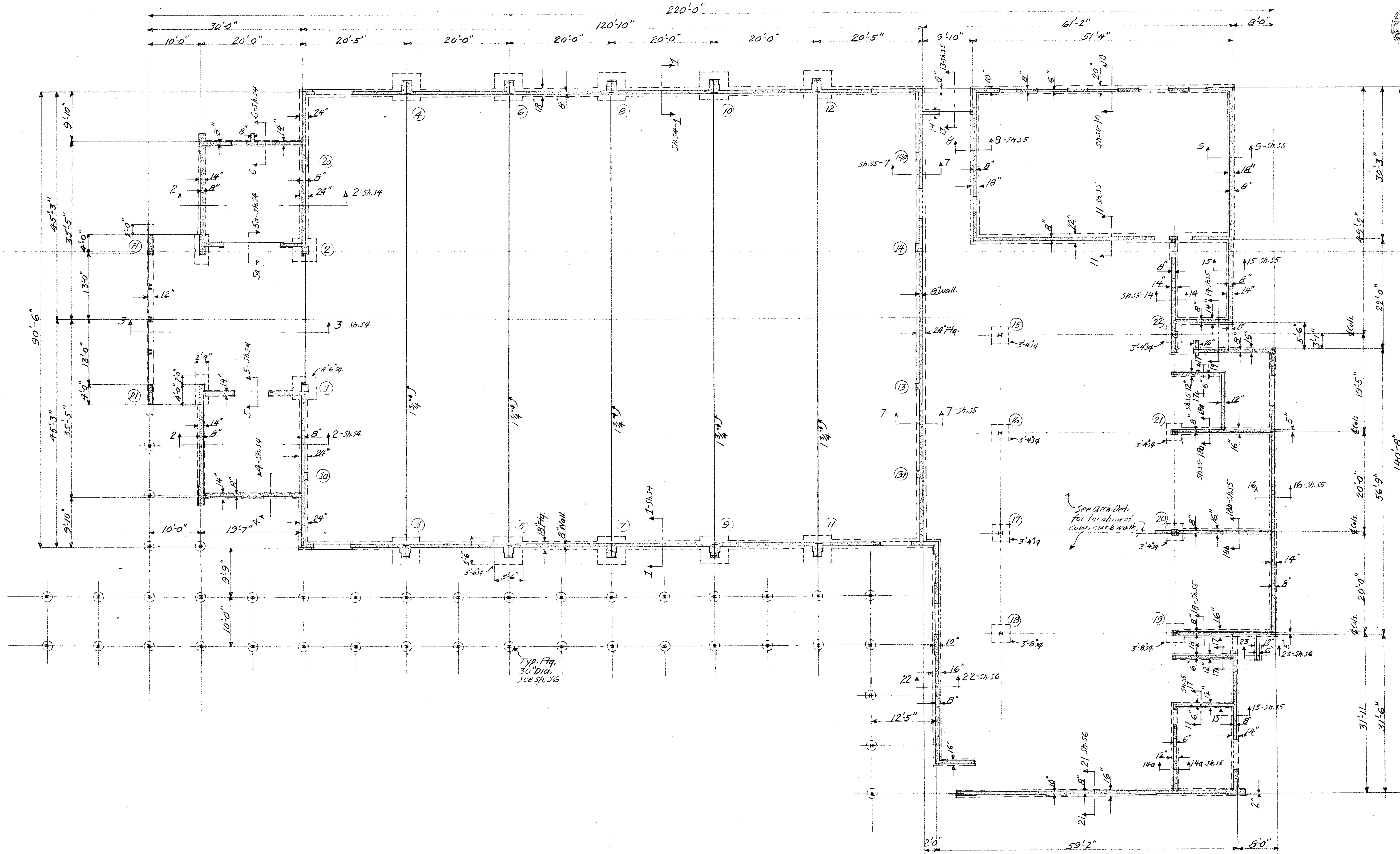
Project No. 779.12 | Date 10/29/03 | Approved By: [signature]

Figure

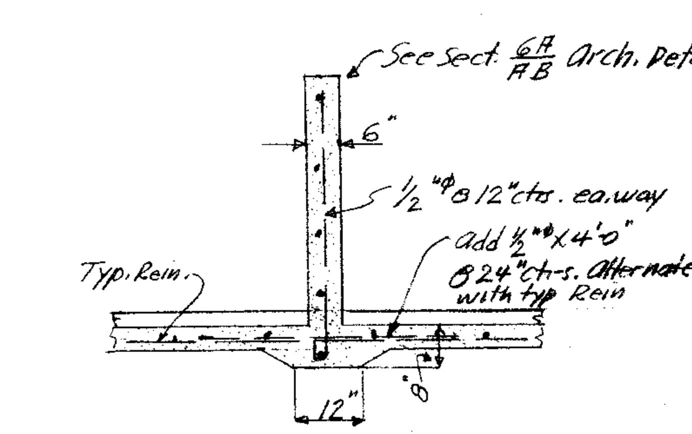
APPENDIX H

Selected Drawings from 1958 Plans for the School
(GM&P, 1958)

STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS BOARD OF EDUCATION	H. M. ENGLE CIVIL & STRUCTURAL ENGINEER 1539 4TH ST. SAN RAFAEL LICENSE NO.	GROMMÉ MULVIN & PRIESTLEY ARCHITECTS 1539 FOURTH STREET SAN RAFAEL, CAL. GL. 3-3925	NEW HIGH SCHOOL SAN RAFAEL HIGH SCHOOL DISTRICT FOR THE TERRA LINDA AREA MARIN COUNTY CALIFORNIA	JOB NO. 602-26 DATE: DEC. 16, 1958 DRAWN BY D. SCHNELL CHECKED BY J. WINNIE APPROVED DRAWING NO. A1A BLDGS. A, B, C, D, E



FLOOR AND FOUNDATION PLAN
Scale: 1/8" = 1'-0"



DETAIL LOCKER ROOM CURB WALLS
See Sect. 6A/AB

STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS	GROMMÉ, MULVIN & PRIESTLEY	NEW HIGH SCHOOL	JOB NO. 502-26	DATE: DEC. 16, 1958	DRAWING NO.
	BOARD OF EDUCATION Victor W. Jones Secy.	ARCHITECTS 1539 FOURTH STREET SAN RAFAEL, CAL. GL. 3-3925	SAN RAFAEL HIGH SCHOOL DISTRICT FOR THE TERRA LINDA AREA MARIN COUNTY CALIFORNIA	SET.	DRAWN BY H.B. CHECKED BY APPROVED	S1 BLDG. C OF SHEETS

STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS BOARD OF EDUCATION			GROMMÉ MULVIN & PRIESTLEY ARCHITECTS 1539 FOURTH STREET SAN RAFAEL, CAL. GL. 3-3925	NEW HIGH SCHOOL SAN RAFAEL HIGH SCHOOL DISTRICT. FOR THE TERRA LINDA AREA MARIN COUNTY CALIFORNIA

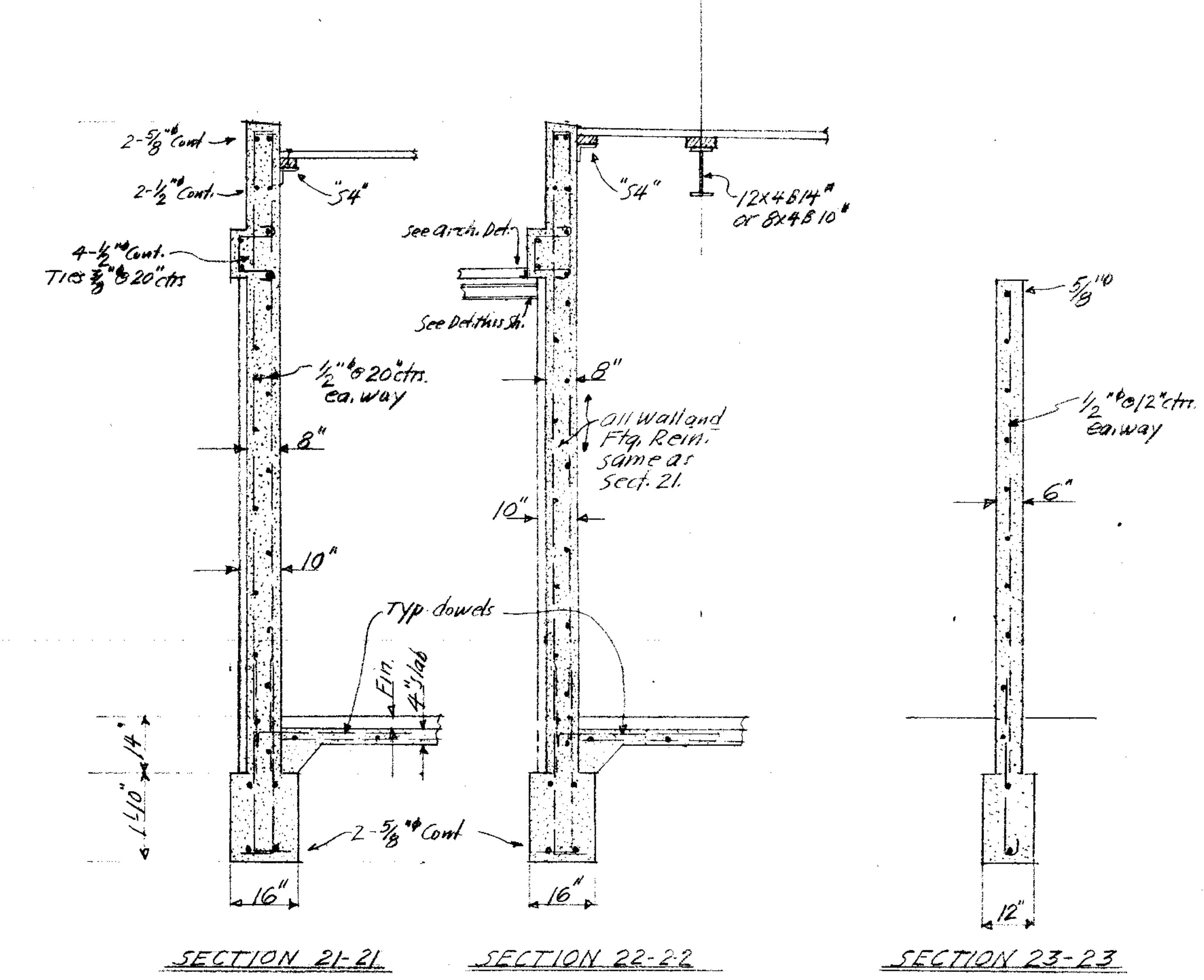
JOB NO.	DATE	DRAWN BY	CHECKED BY	DRAWING NO.
502-26	DEC. 16, 1958	H.E.		S4
SET.		APPROVED		BLDG. "C" OF SHEETS

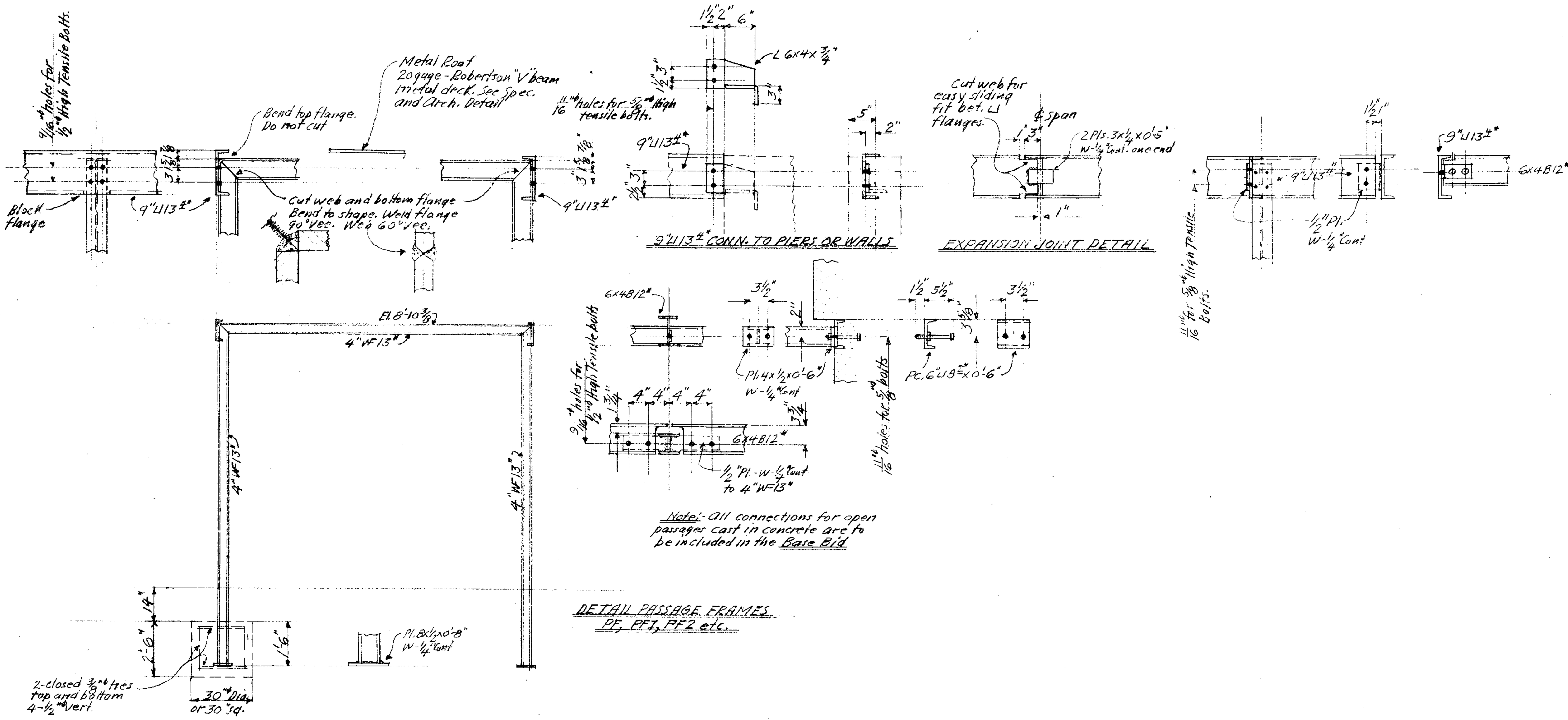
STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS. BOARD OF EDUCATION. Victor W. Jones Secy.	ROBERT R. RITTER	H. M. ENGLE

GROMMÉ, MULVIN & PRIESTLEY
ARCHITECTS
1539 FOURTH STREET
SAN RAFAEL, CAL. GL. 3-3925

NEW HIGH SCHOOL
SAN RAFAEL HIGH SCHOOL DISTRICT.
FOR THE TERRA LINDA AREA.
MARIN COUNTY CALIFORNIA.

JOB NO.	DATE: DEC-16, 1958		DRAWING NO.
502-26	DRAWN BY H.E.	CHECKED BY	S5
SET	APPROVED		BLDG. C
			OF SHEETS





STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS	GROMMÉ, MULVIN & PRIESTLEY ARCHITECTS 1539 FOURTH STREET SAN RAFAEL, CAL. GL. 3-3925	NEW HIGH SCHOOL SAN RAFAEL HIGH SCHOOL DISTRICT FOR THE TERRA LINDA AREA MARIN COUNTY CALIFORNIA	JOB NO. 502-26	DATE: DEC. 16, 1958	DRAWING NO. S6 BLDG. C
	BOARD OF EDUCATION			SET	DRAWN BY H.E. / CHECKED BY / APPROVED	OF SHEETS

STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS			
	BOARD OF EDUCATION			

GROMMÉ MULVIN & PRIESTLEY
ARCHITECTS
1539 FOURTH STREET
SAN RAFAEL, CAL. GL. 3-3925

NEW HIGH SCHOOL
SAN RAFAEL HIGH SCHOOL DISTRICT.
FOR THE TERRA LINDA AREA.
MARIN COUNTY CALIFORNIA.

JOB NO.	DATE: DEC. 16 1958		DRAWING NO.
507-2G	DRAWN BY H.E.	CHECKED BY H.E.	S-1
SET	APPROVED		BLDG. D
			OF SHEETS

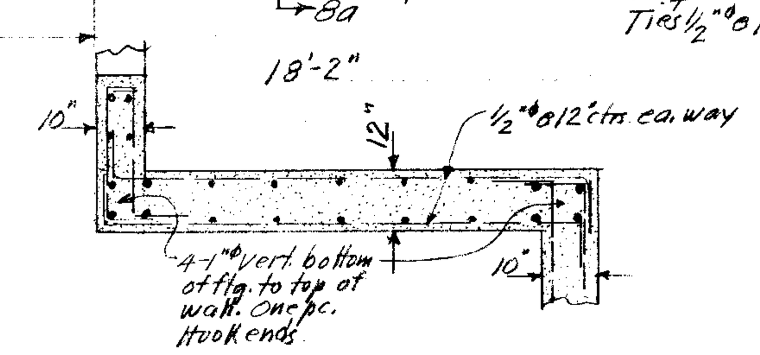
STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS BOARD OF EDUCATION	GROMMÉ MULVIN & PRIESTLEY ARCHITECTS 1539 FOURTH STREET SAN RAFAEL, CAL. GL. 3-3925	NEW HIGH SCHOOL. SAN RAFAEL HIGH SCHOOL DISTRICT. FOR THE TERRA LINDA AREA. MARIN COUNTY CALIFORNIA.	JOB NO. 502-26 SET.	DATE: DEC. 16, 1958 DRAWN BY H.E. CHECKED BY H.E. APPROVED DRAWING NO. S-1 BLDG. E. OF SHEETS

SECTION 8-8

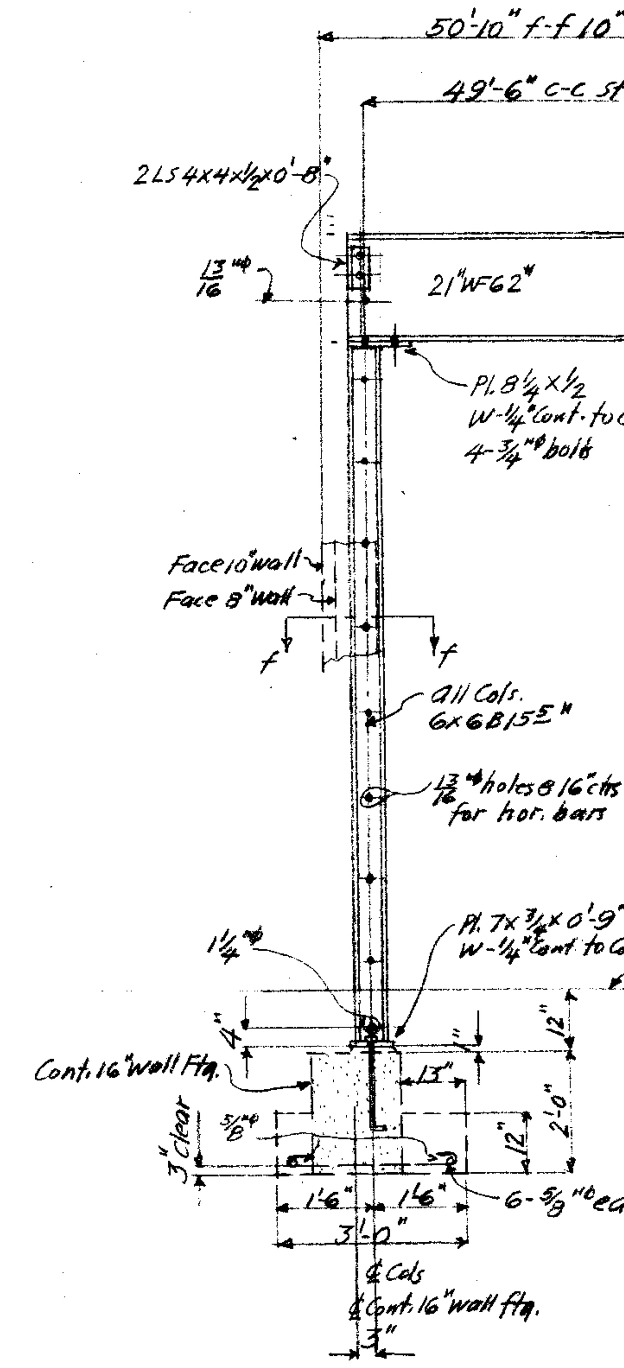
SECTION 8a-8a

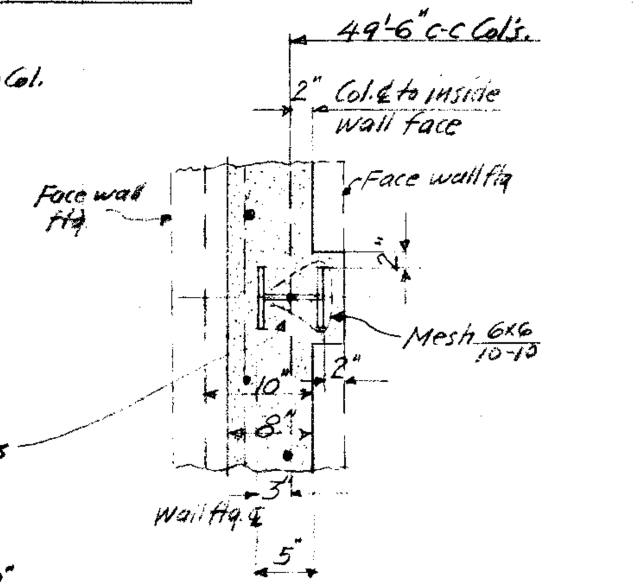
SECTION 9-9
Toilet Rm. Detail at ℄ same but opposite hand

SECTION 10-10
SECTION 10a-10a Same but opposite hand.

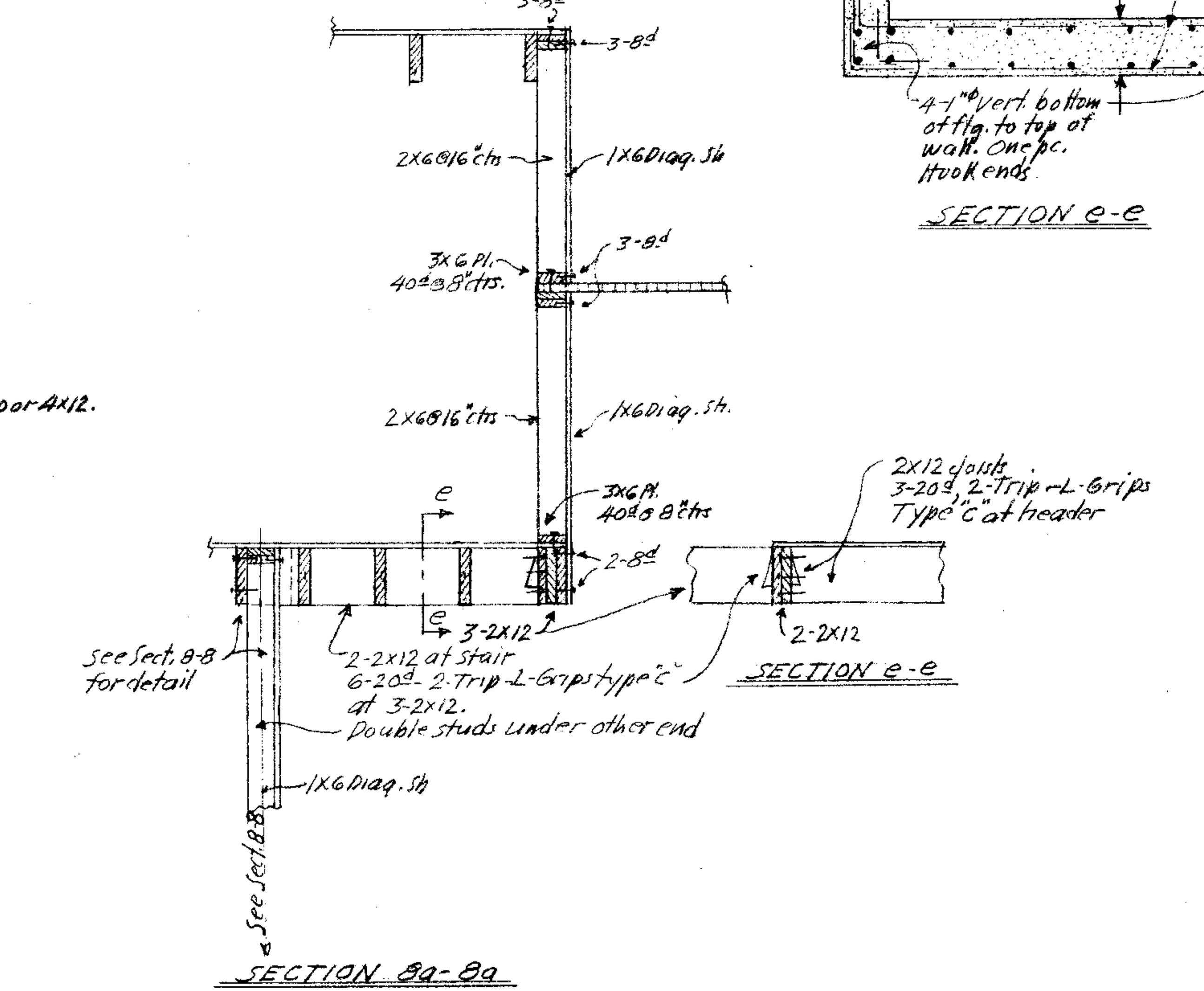


SECTION e-e





SECTION f-f

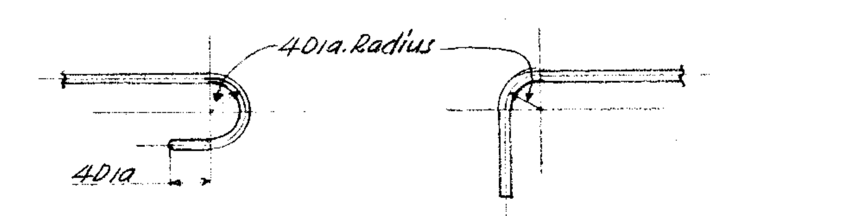


SECTION 8a-8a

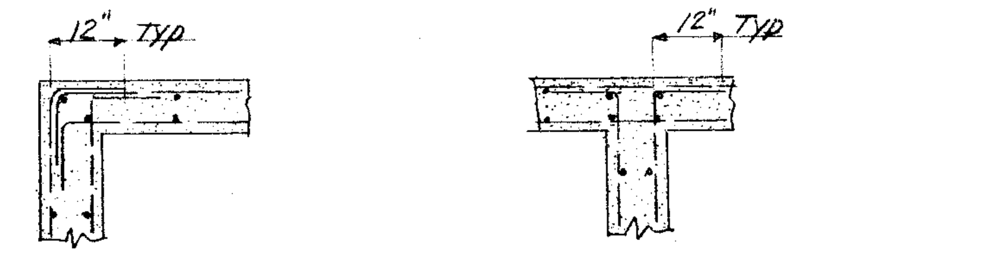
SECTION e-e

FOUNDATION NOTE:-
Soil Pressure does not exceed 2000 lbs. per sq. ft. All footings go to hard sand and clay or to shale rock at elevations shown. If necessary to reach firm material, lower footings below elevations shown as directed by the architect. Soil Data from R.S. Harding. (Oct. 24, 1958)

CONCRETE AND REINFORCING NOTE:-
All bars to be deformed-Structural Grade. Bars to lap 48 Dia. at splices except as otherwise called for.
All Structural concrete to have a minimum strength in compression of 2500 lbs. per sq. inch at 28 days.
Bars marked as continuous (Cont.) to be in as long lengths as possible. Splices to be staggered.
All beam bars to be chaired up at not over 5'-0" ctrs. All bars in slabs over 3" thick shall be chaired up with continuous metal chairs at not over 3'-6" ctrs.

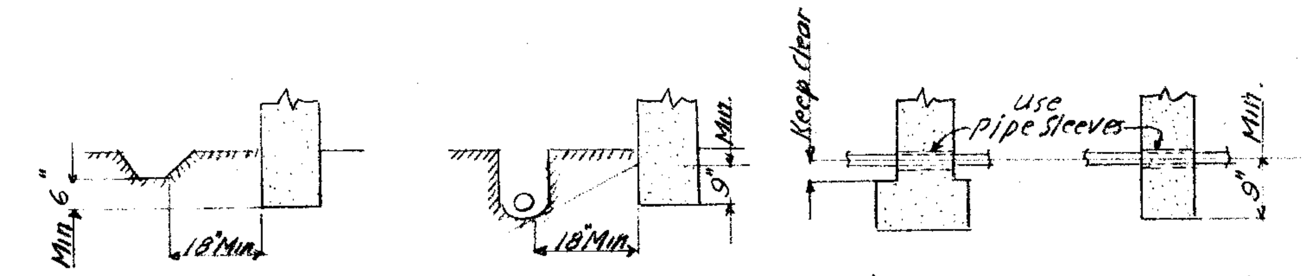


HOOK ← TYPICAL → BEND



TYPICAL CORNERS

TYPICAL INTERSECTIONS



OPEN TRENCH

FILLED TRENCH

PIPES PASSING THRU FOOTINGS

NAILING & FRAMING NOTE:
All nails to be common wire nails.
Double top plates:- 2-20d lower plate to each stud, 16d @ 18" ctrs. upper plate to lower plate. Stagger splices 4'-0" Min., 8-16d ea. side ea. cut. Lap plates at corners, with 3-16d upper to lower plate.
Multiple studs:- 16d @ 12" ctrs.- stagger for 2x6 studs or larger.
Frame stud wall corners and intersections solid.
Structural wall and roof sheathing to be laid diagonal at 45° to supports.
For 1x6 use 2-8d Min. at all bearings including blocking.
For 2x6 " 2-16d " " " " " .
Use additional nailing as called for. Cut joints on a diagonal over and parallel to a bearing. Leave at least one bearing between joints in adjoining boards. For joints on same bearing, leave at least two boards between joints on vertical diaphragms, and at least one board between joints on horizontal diaphragms. Use 3-8d at ends of all sheathing boards, Min. Structural sheathing to be continuous behind blackboards, tack boards etc.
Joists or rafters to sides of studs:- as called for on plans- 3-16d Min.
" " " at all bearings:- 2-10d toes each side.
Studs to bearings - 2-10d toes ea. side, or as called for.
Blocking between joists or rafters - 2-10d toes ea. side, ea. end, 2-10d toes ea. side to bearing. Special nailing as called for.
Cross bridging between joists:- 2-8d toes each end.
Ceiling strips:- 1x4 - 2-8d to under side of joists per bearing. Thickness one inch net. One nail slant- one straight.
For Plaster Ceilings, strips to be "Saddle" tied to sides of joists with 16ga. galvanized wire ties at 4'-0" ctrs.
Ribbons to studs - 1x4, 2-8d each bearing. 2" ribbons, nails as called for.
Built up beams:- 8" or less, 16d @ 12" ctrs. staggered. More than 8" ½" bolts at 2'-0" ctrs.
Double joists under partitions - 16d @ 12" ctrs., staggered.
Where nails tend to cause splitting, holes to be sub-drilled.

BOLT & LAG SCREW NOTE:-
Bolt holes to be bored to same diameter as nominal bolt diameter. Use Malleable Iron Washers (M.I.W.) under all heads and nuts bearing on wood. Washers to have a thickness not less than ½ bolt diameter, and an area 16 times nominal bolt area. Tighten all bolts at time of installation. Check and retighten before covering up. Check and tighten all accessable nuts before final acceptance.
Lag screws shall be screwed into place. Bore holes to same diameter and depth as shank. For threaded portion bore hole with bit not larger than diameter at root of thread.

STATE DIVISION OF ARCHITECTURE	COUNTY SUPT. OF SCHOOLS		GROMMÉ MULVIN & PRIESTLEY ARCHITECTS 1539 FOURTH STREET SAN RAFAEL, CAL. GL. 3-3925	NEW HIGH SCHOOL SAN RAFAEL HIGH SCHOOL DISTRICT. FOR THE TERRA LINDA AREA. MARIN COUNTY CALIFORNIA.	JOB NO. 502.26	DATE: DEC. 16 1958 DRAWN BY H.E. CHECKED BY H.E. APPROVED	DRAWING NO. S-2 BLDG. E. OF SHEETS
	BOARD OF EDUCATION	H. M. Engle			SET.		

APPENDIX I

USGS Ground Motion Reports

A3GEO

USGS Design Maps Summary Report

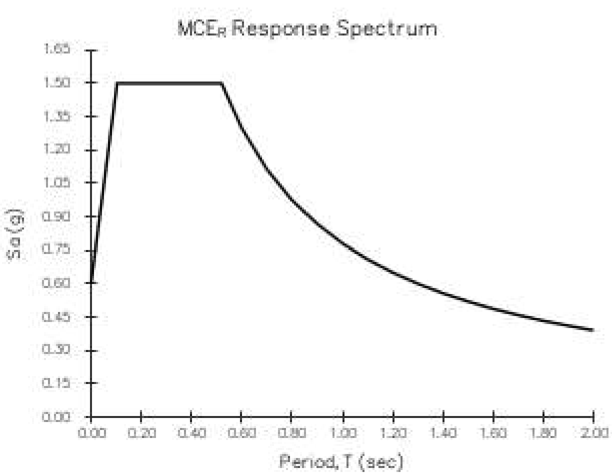
User–Specified Input

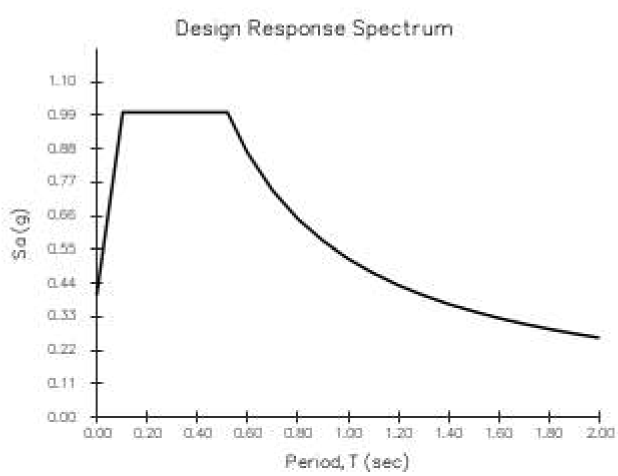
Report Title	Terra Linda High School - Student Commons/Art Building Wed January 17, 2018 18:39:06 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	37.99975°N, 122.55454°W
Site Soil Classification	Site Class C – "Very Dense Soil and Soft Rock"
Risk Category	I/II/III

USGS–Provided Output

$S_S =$ 1.500 g	$S_{MS} =$ 1.500 g	$S_{DS} =$ 1.000 g
$S_1 =$ 0.600 g	$S_{M1} =$ 0.780 g	$S_{D1} =$ 0.520 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Detailed Report

ASCE 7-10 Standard (37.99975°N, 122.55454°W)

Site Class C – "Very Dense Soil and Soft Rock", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1]	S_S = 1.500 g
From Figure 22-2 [2]	S_1 = 0.600 g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient F_a

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = C and S_S = 1.500 g, F_a = 1.000

Table 11.4–2: Site Coefficient F_v

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = C and S_1 = 0.600 g, F_v = 1.300

Equation (11.4–1): $S_{MS} = F_aS_S = 1.000 \times 1.500 = 1.500$ g

Equation (11.4–2): $S_{M1} = F_vS_1 = 1.300 \times 0.600 = 0.780$ g

Section 11.4.4 — Design Spectral Acceleration Parameters

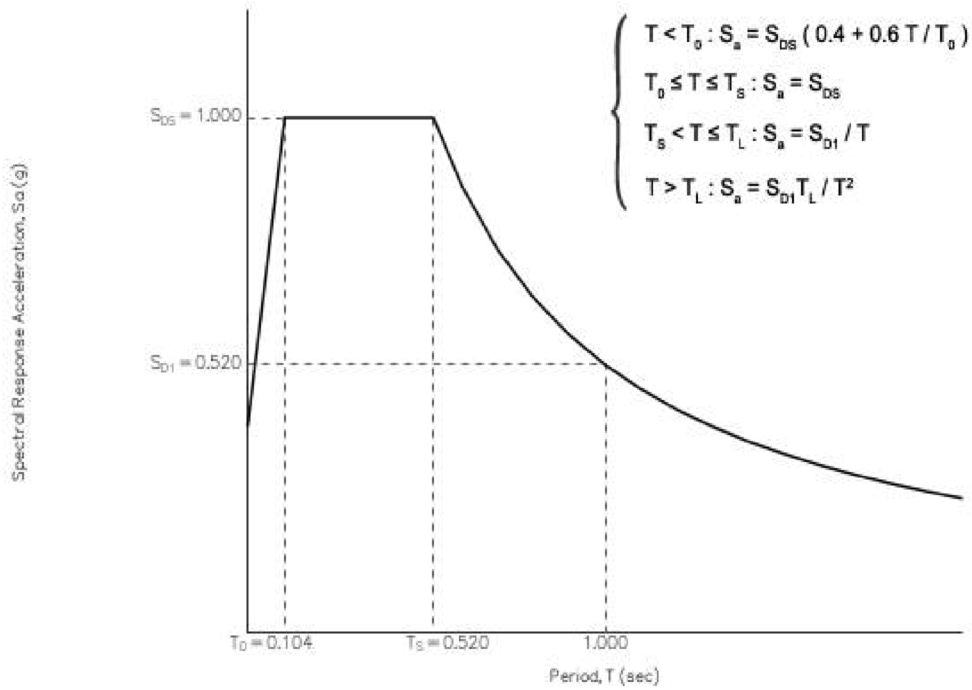
Equation (11.4–3): $S_{DS} = ⅔\ S_{MS} = ⅔ \times 1.500 = 1.000$ g

Equation (11.4–4): $S_{D1} = ⅔\ S_{M1} = ⅔ \times 0.780 = 0.520$ g

Section 11.4.5 — Design Response Spectrum

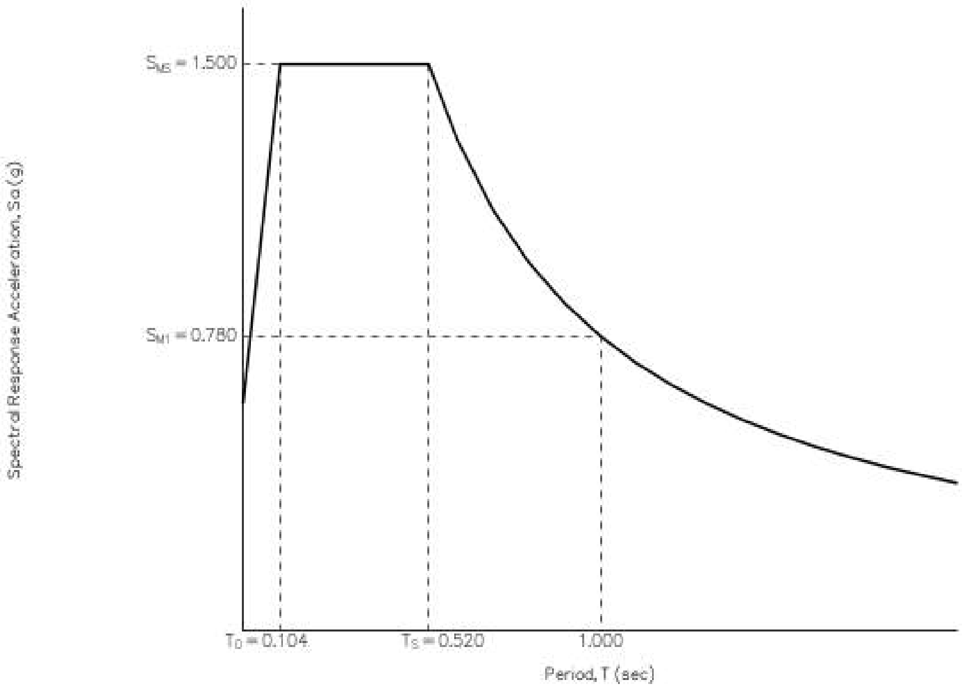
From Figure 22-12 [3] $T_L = 12$ seconds

Figure 11.4–1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.500

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.000 \times 0.500 = 0.5$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = C and PGA = 0.500 g, F_{PGA} = 1.000

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] C_{RS} = 1.070

From Figure 22-18 [6] C_{R1} = 1.024

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	**III**	**IV**
S_{DS} < 0.167g	A	A	A
0.167g ≤ S_{DS} < 0.33g	B	B	C
0.33g ≤ S_{DS} < 0.50g	C	C	D
0.50g ≤ S_{DS}	D	D	D

For Risk Category = I and S_{DS} = 1.000 g, Seismic Design Category = D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	**III**	**IV**
S_{D1} < 0.067g	A	A	A
0.067g ≤ S_{D1} < 0.133g	B	B	C
0.133g ≤ S_{D1} < 0.20g	C	C	D
0.20g ≤ S_{D1}	D	D	D

For Risk Category = I and S_{D1} = 0.520 g, Seismic Design Category = D

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = D

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

USGS Design Maps Summary Report

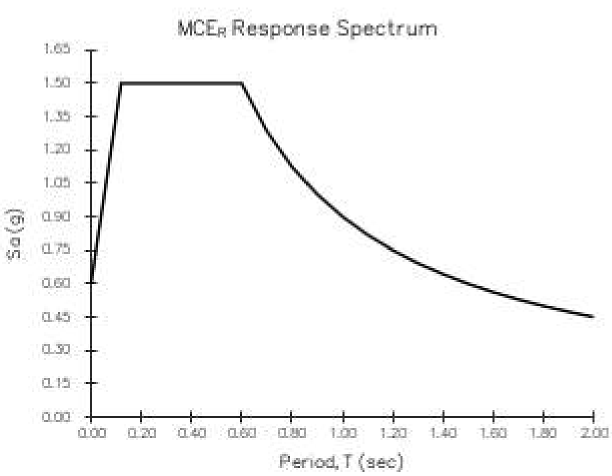
User–Specified Input

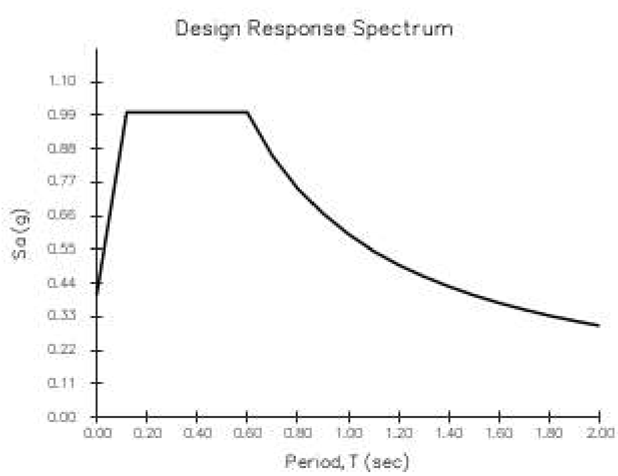
Report Title	Terra Linda High School - New Gymnasium Wed January 17, 2018 18:37:05 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	38.00001°N, 122.5534°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

S_S = 1.500 g	S_{MS} = 1.500 g	S_{DS} = 1.000 g
S_1 = 0.600 g	S_{M1} = 0.900 g	S_{D1} = 0.600 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

Design Maps Detailed Report

ASCE 7-10 Standard (38.00001°N, 122.5534°W)

Site Class D – "Stiff Soil", Risk Category I/II/III

Section 11.4.1 — Mapped Acceleration Parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

From Figure 22-1 [1]	S_S = 1.500 g
From Figure 22-2 [2]	S_1 = 0.600 g

Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 11.4.3 — Site Coefficients and Risk–Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

Table 11.4–1: Site Coefficient F_a

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_S = 1.500 g, F_a = 1.000

Table 11.4–2: Site Coefficient F_v

Site Class	Mapped MCE $_R$ Spectral Response Acceleration Parameter at 1–s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = D and S_1 = 0.600 g, F_v = 1.500

Equation (11.4–1): $S_{MS} = F_aS_S = 1.000 \times 1.500 = 1.500$ g

Equation (11.4–2): $S_{M1} = F_vS_1 = 1.500 \times 0.600 = 0.900$ g

Section 11.4.4 — Design Spectral Acceleration Parameters

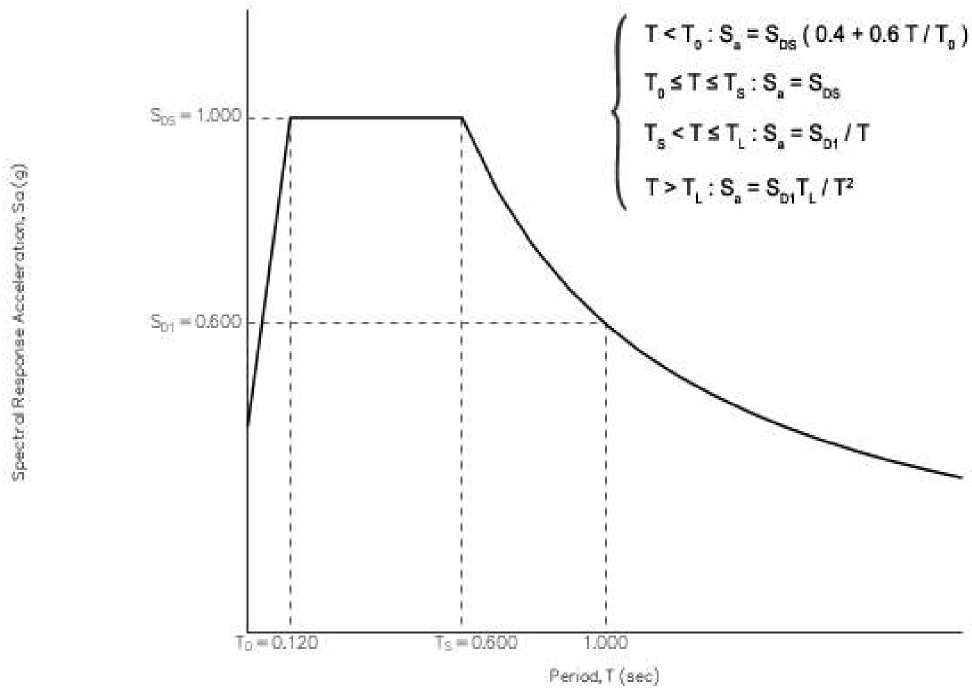
Equation (11.4–3): $S_{DS} = ⅔\, S_{MS} = ⅔ \times 1.500 = 1.000$ g

Equation (11.4–4): $S_{D1} = ⅔\, S_{M1} = ⅔ \times 0.900 = 0.600$ g

Section 11.4.5 — Design Response Spectrum

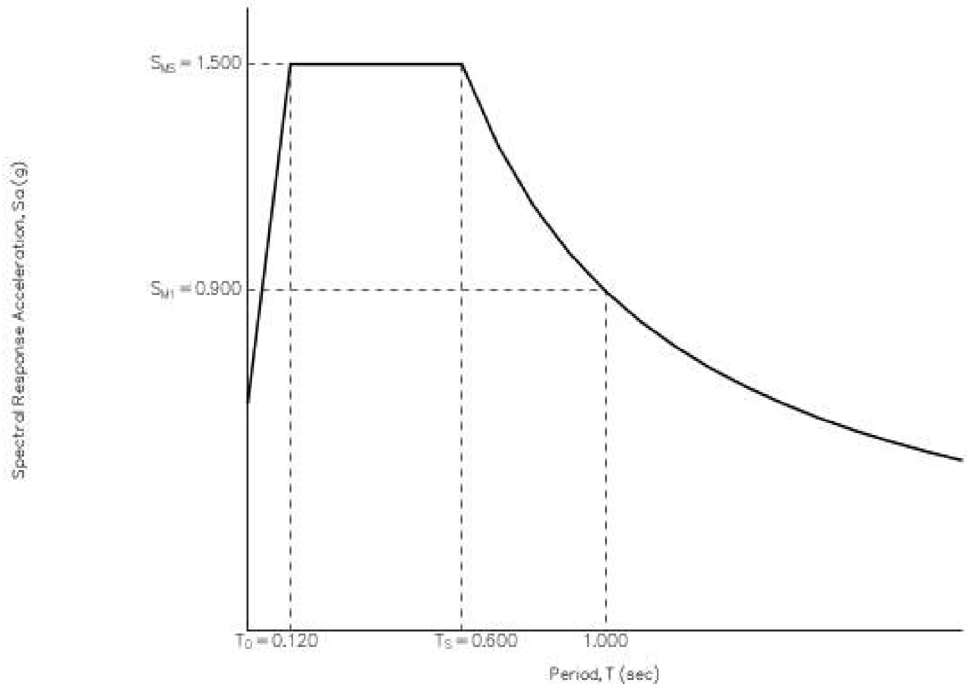
From Figure 22-12 [3] T_L = 12 seconds

Figure 11.4–1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE_R) Response Spectrum

The MCE_R Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From Figure 22-7 [4] PGA = 0.500

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.000 \times 0.500 = 0.5$ g

Table 11.8–1: Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of PGA

For Site Class = D and PGA = 0.500 g, F_{PGA} = 1.000

Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From Figure 22-17 [5] C_{RS} = 1.070

From Figure 22-18 [6] C_{R1} = 1.024

Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
S_{DS} < 0.167g	A	A	A
0.167g ≤ S_{DS} < 0.33g	B	B	C
0.33g ≤ S_{DS} < 0.50g	C	C	D
0.50g ≤ S_{DS}	D	D	D

For Risk Category = I and S_{DS} = 1.000 g, Seismic Design Category = D

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
S_{D1} < 0.067g	A	A	A
0.067g ≤ S_{D1} < 0.133g	B	B	C
0.133g ≤ S_{D1} < 0.20g	C	C	D
0.20g ≤ S_{D1}	D	D	D

For Risk Category = I and S_{D1} = 0.600 g, Seismic Design Category = D

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = D

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 22-1*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf

APPENDIX J

Liquefaction Analyses

APPENDIX J-1

Liquefaction Report for New Gymnasium – Youd et al., 2001

A3GEO

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A3GEO, Inc.
Geoconsultants
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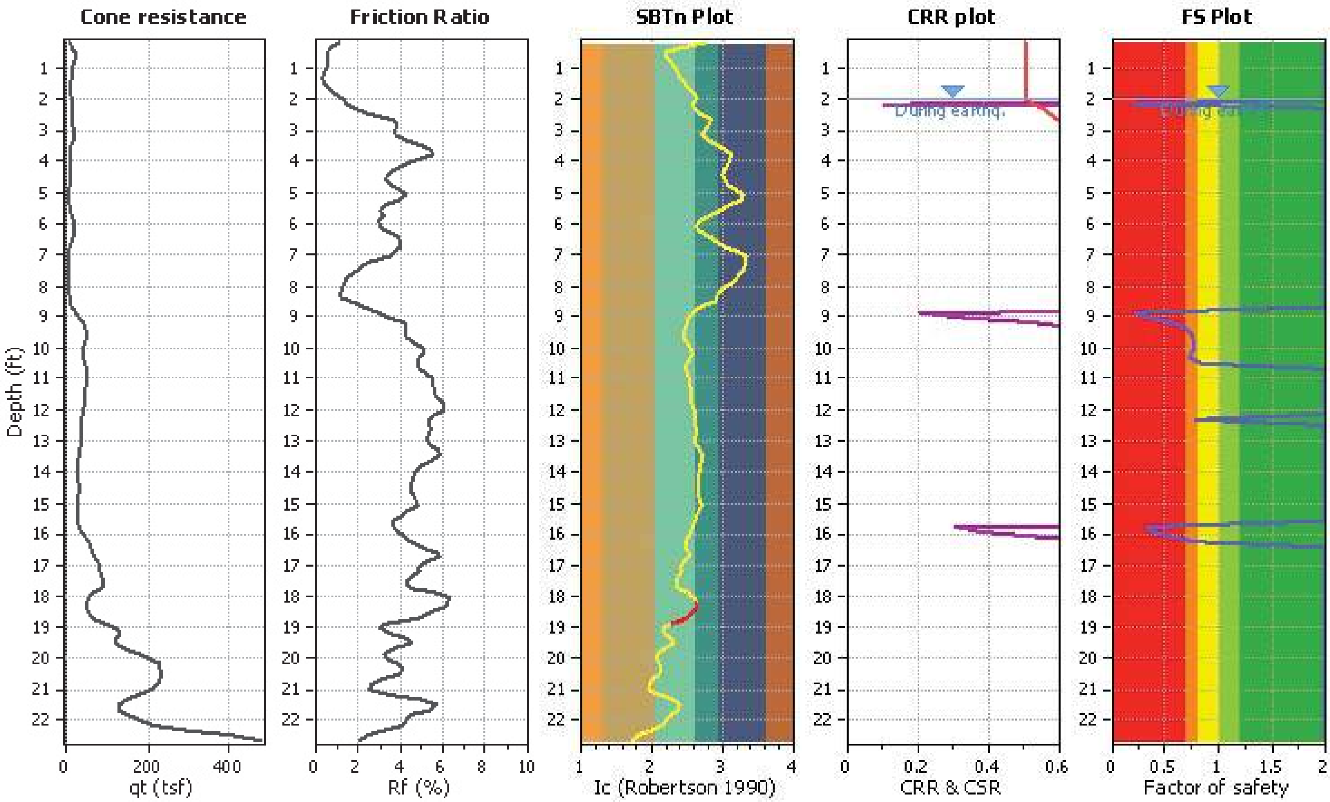
LIQUEFACTION ANALYSIS REPORT

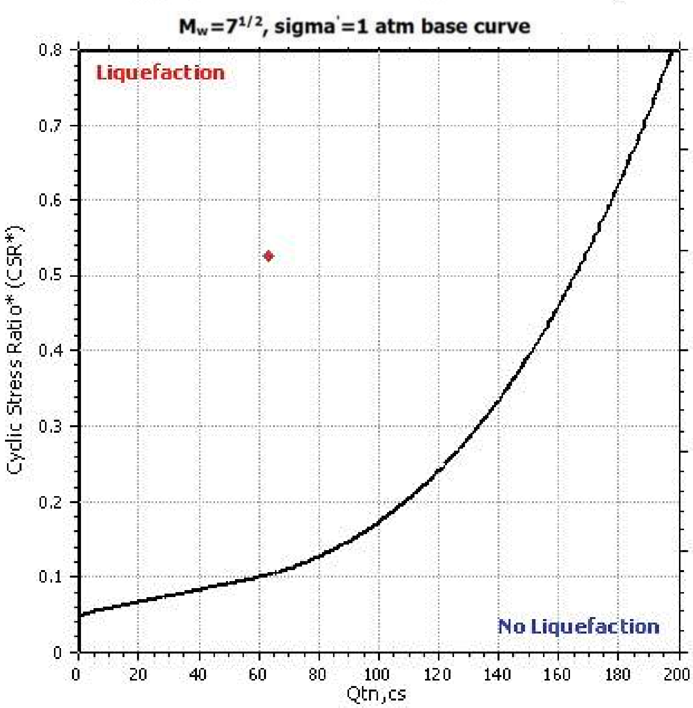
Project title : Terra Linda High School **Location : San Rafael, CA**

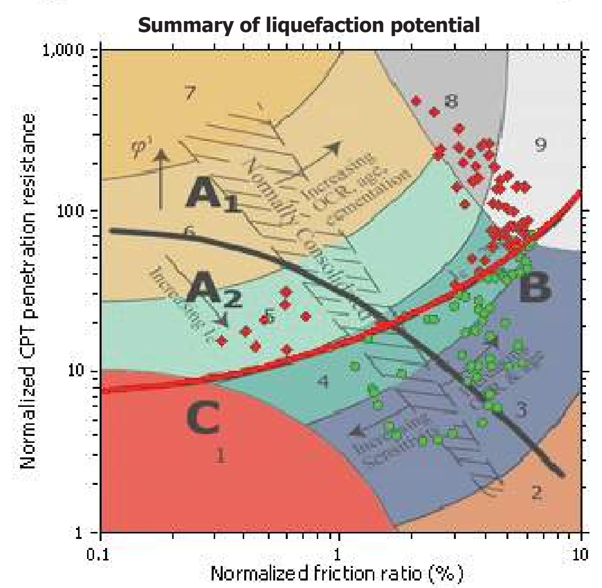
CPT file : CPT-03

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	9.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

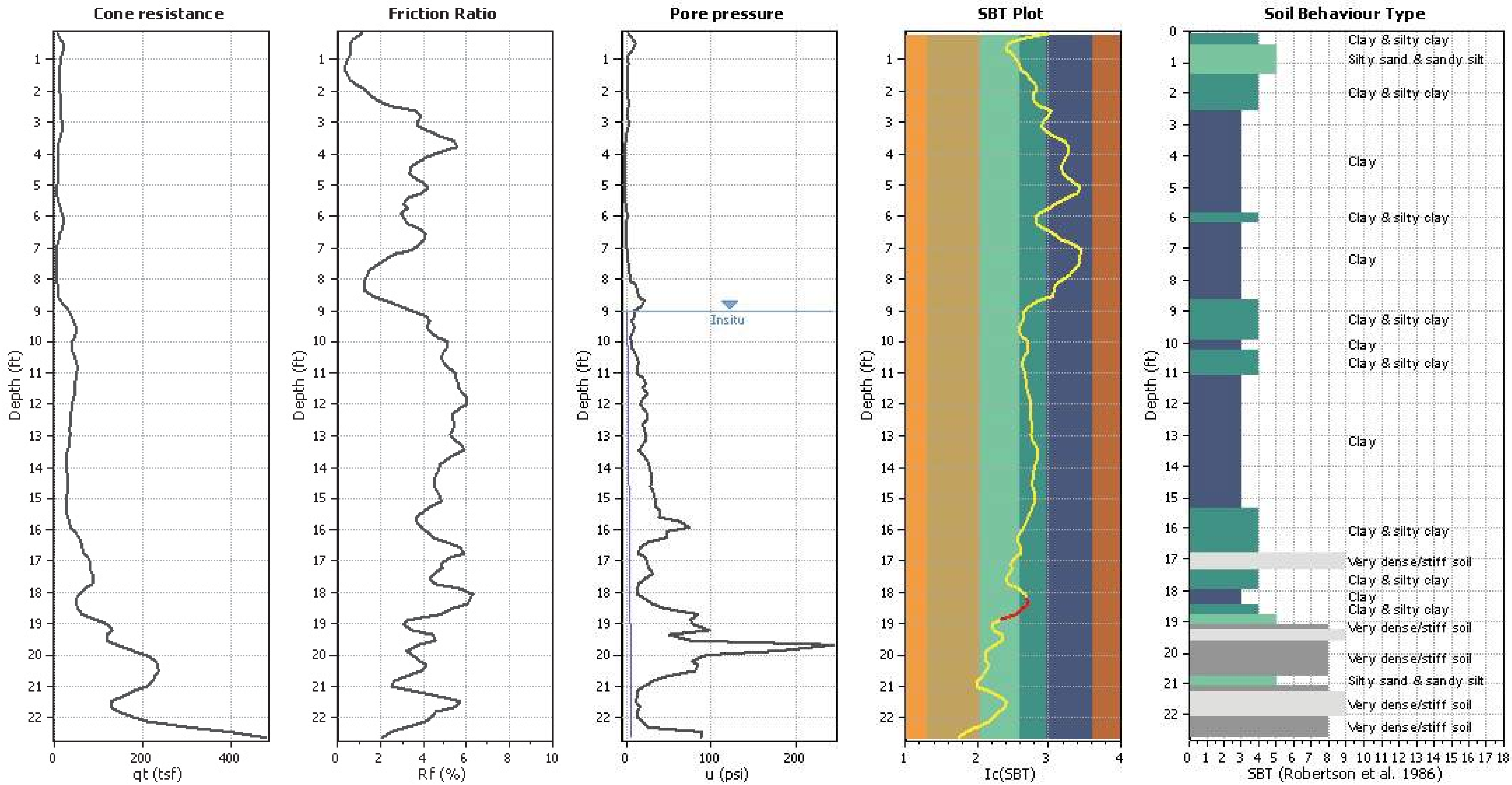






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



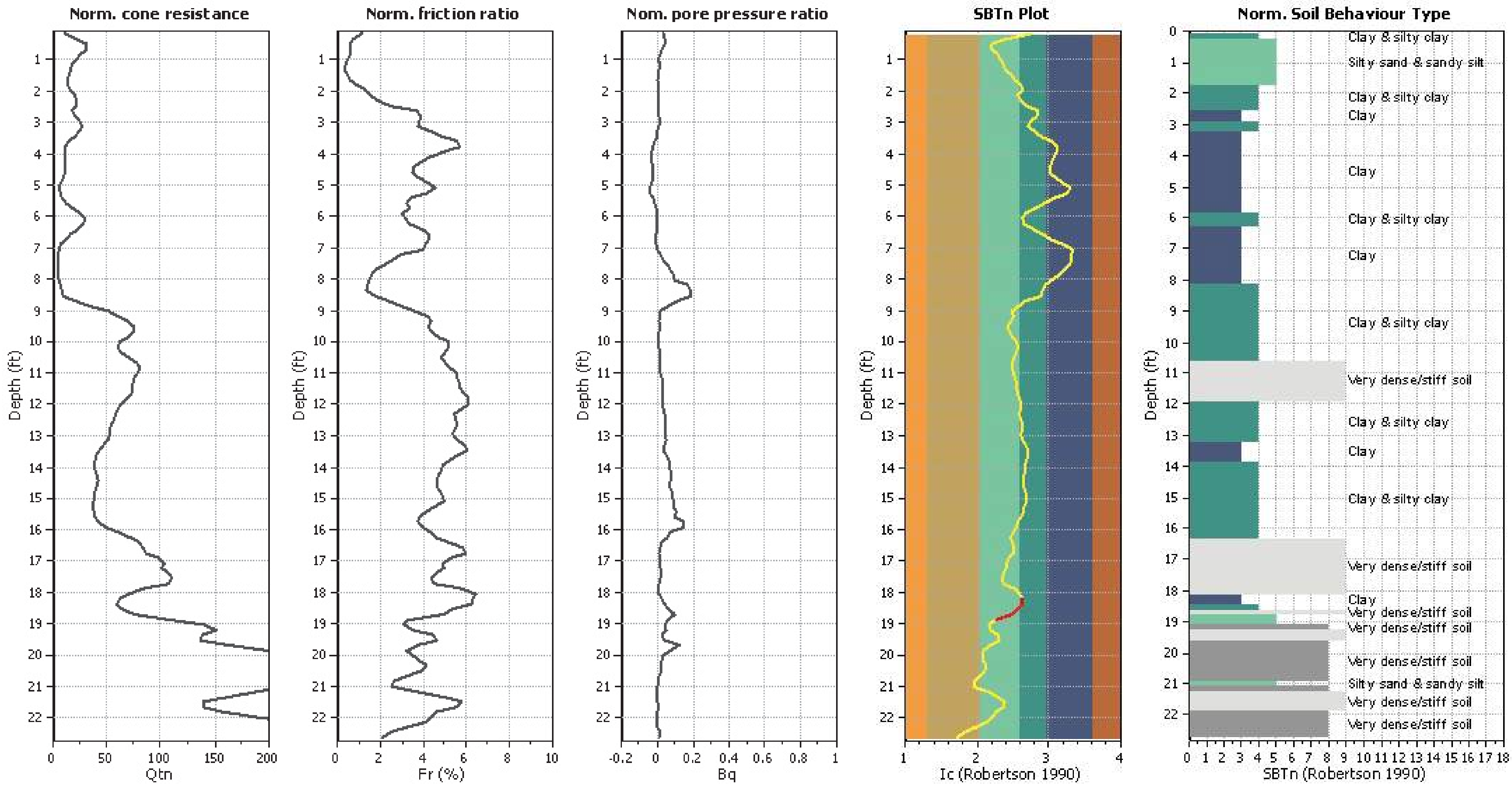
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normaliz



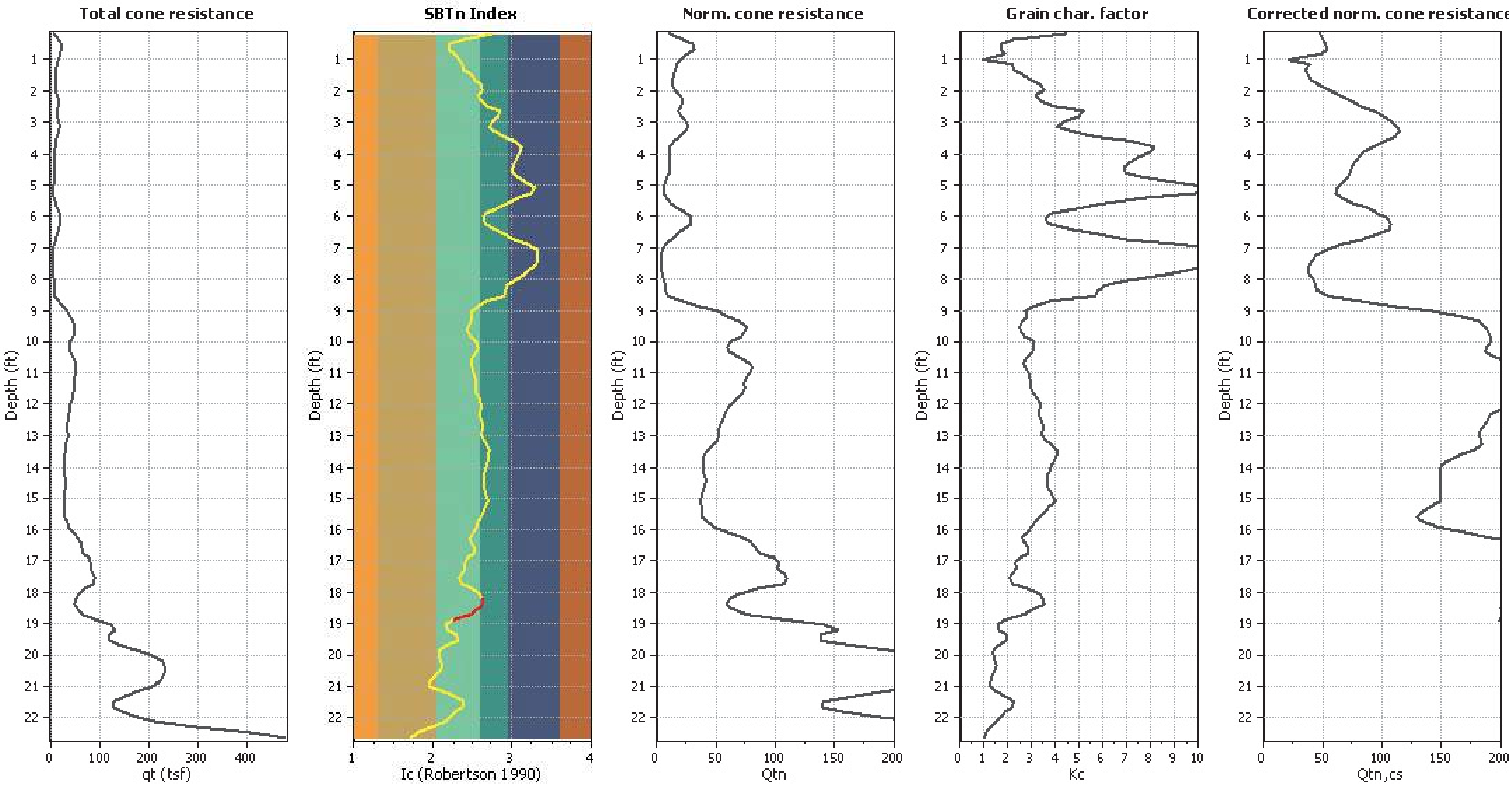
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

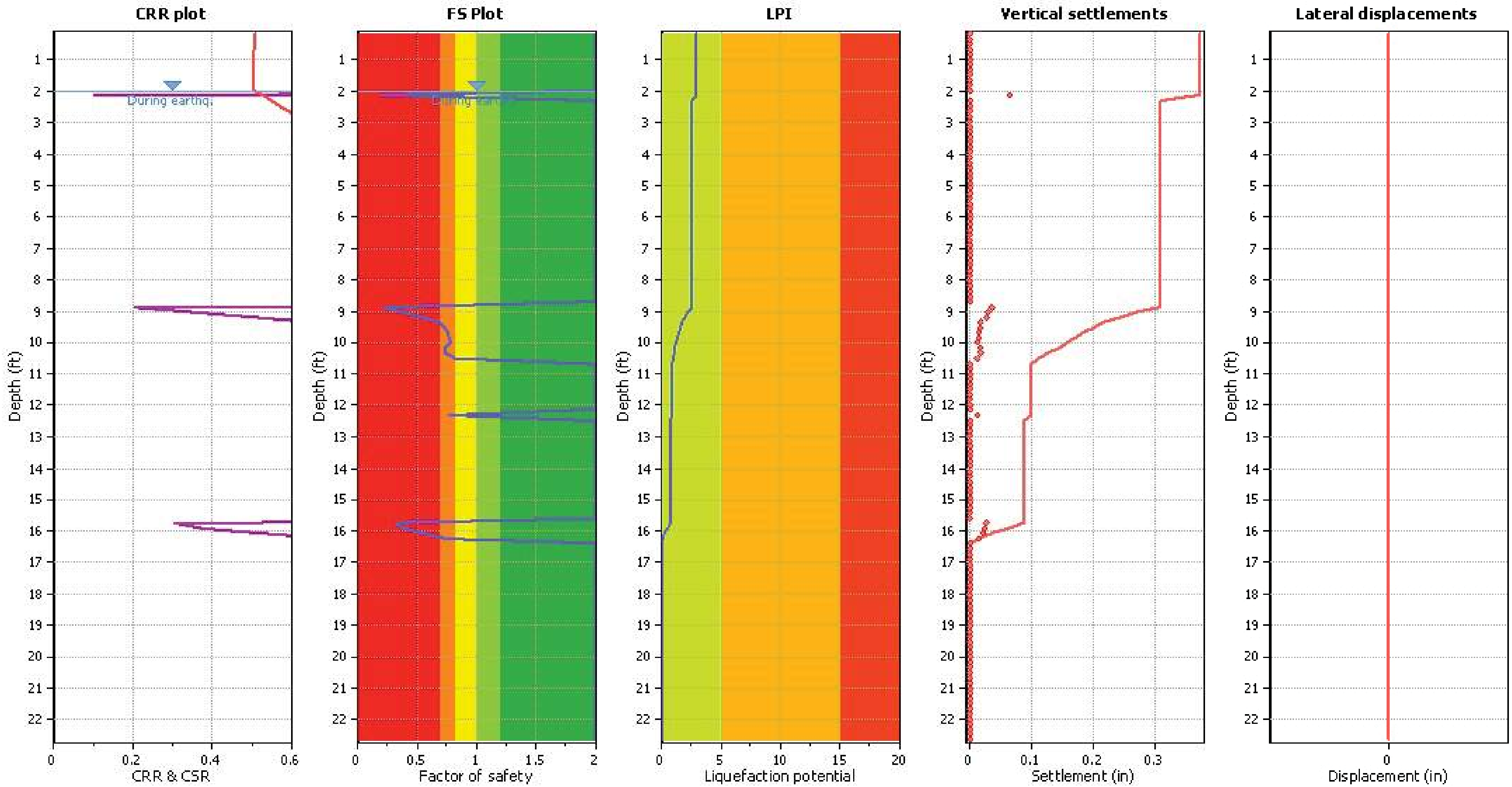
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

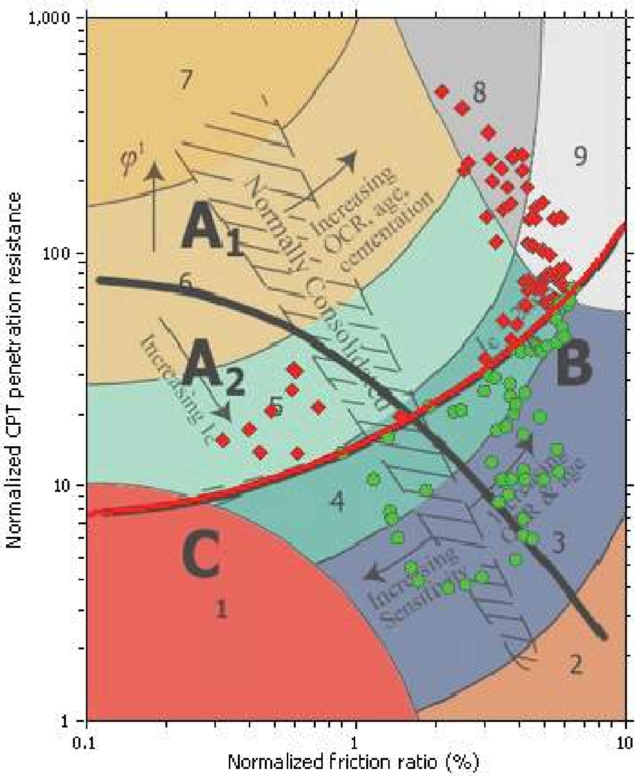
F.S. color scheme

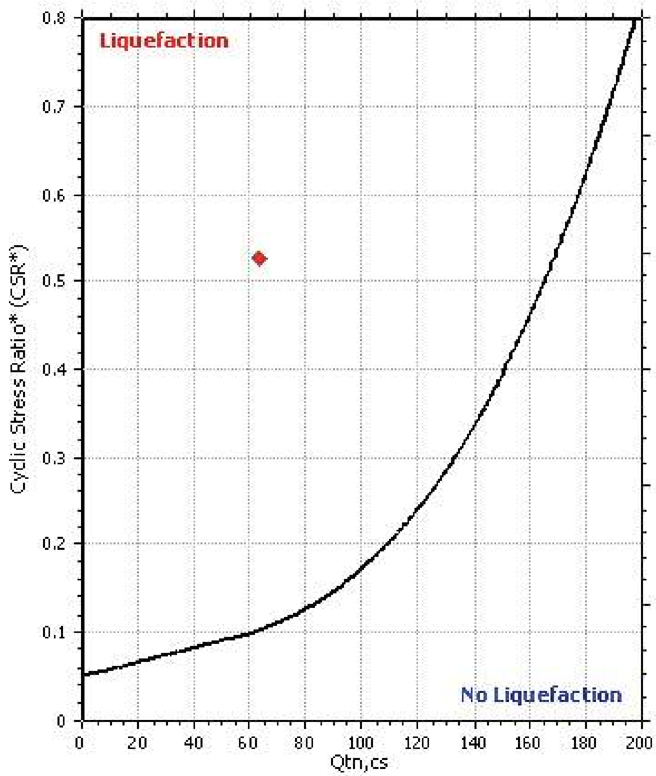
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

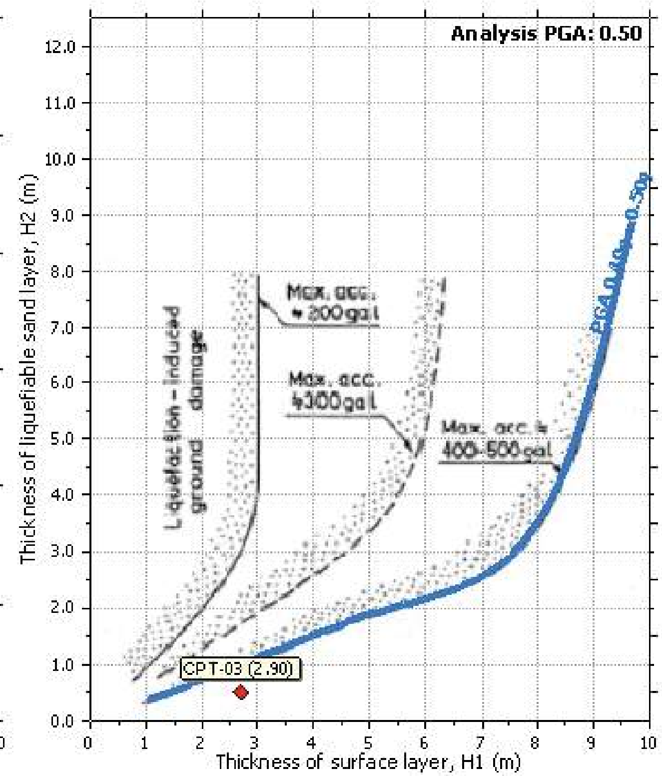
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo



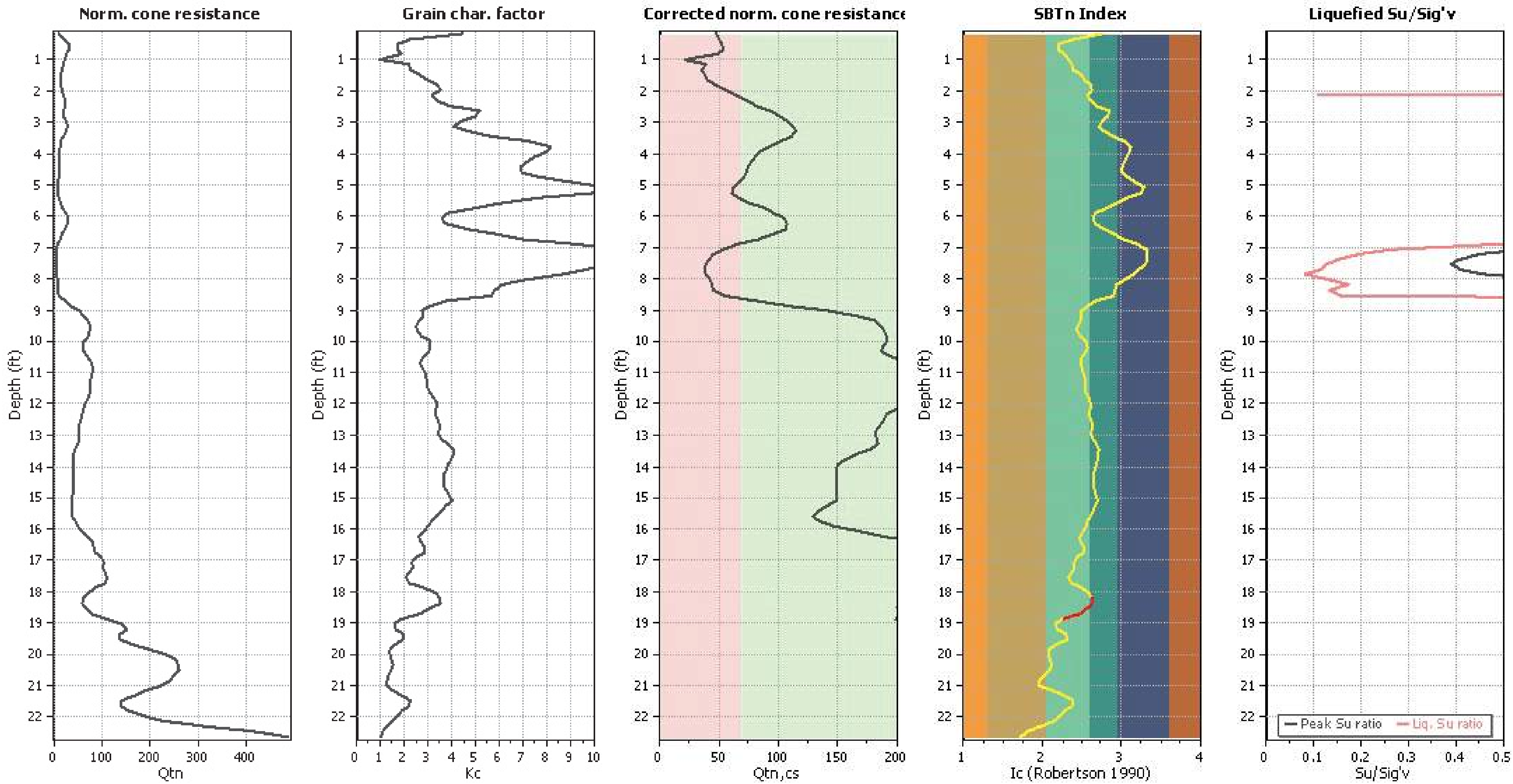




Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

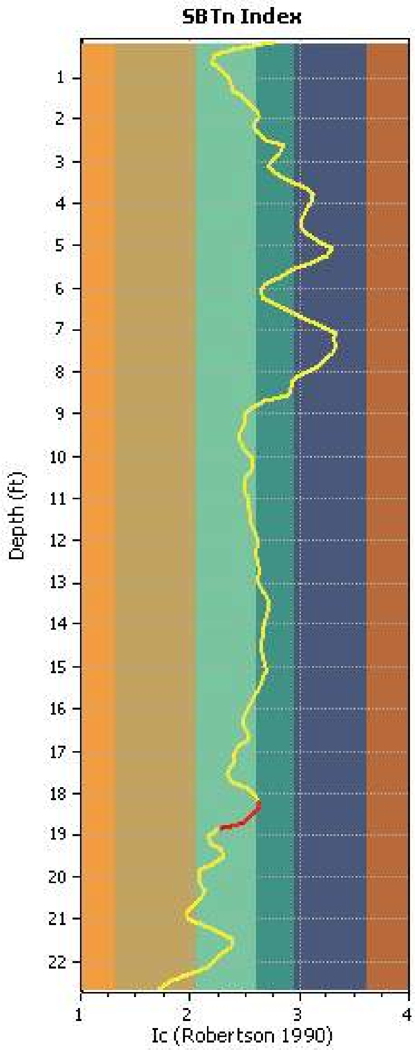
Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

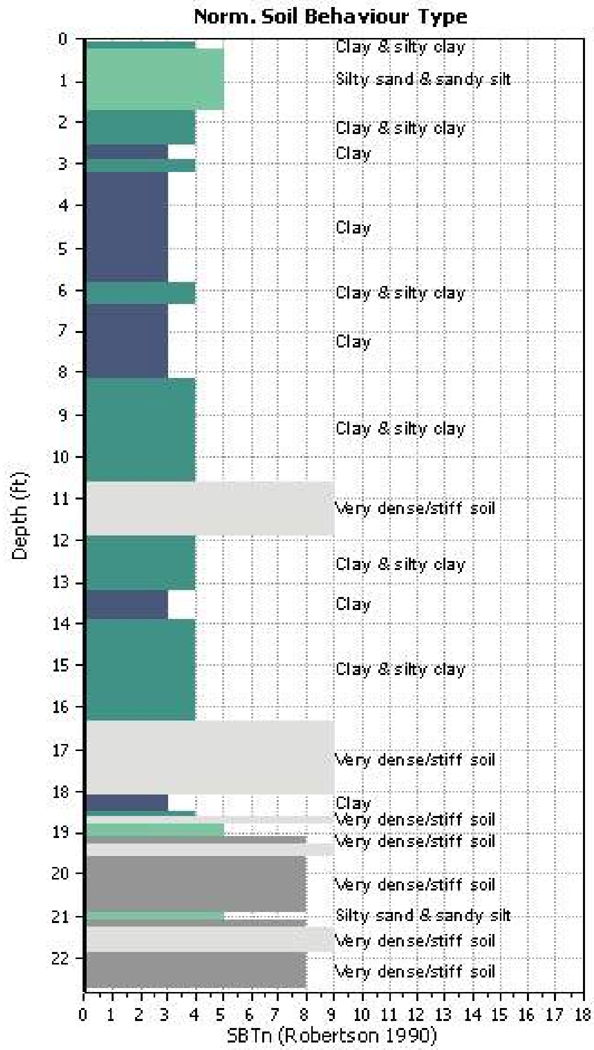
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties		**General statistics**	
I_c minimum check value:	1.70	Total points in CPT file:	138
I_c maximum check value:	3.00	Total points excluded:	5
I_c change ratio value:	0.0250	Exclusion percentage:	3.62%
Minimum number of points in layer:	5	Number of layers detected:	1

Transition layer No	Number of points	Depth	SBT_n number	SBT_n description
Transition layer 1	5	Start depth: 18.37 (ft)	3	Clay
		End depth: 19.03 (ft)	5	Silty sand & sandy silt

Start depth: Depth where the transition layer begins
End depth: Depth where the transition layer ends

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.16	2.35	0.07	2.87	43.68	96.24
2	0.33	15.13	0.09	8.14	25.91	99.67
3	0.49	23.10	0.13	10.74	19.49	101.74
4	0.66	19.52	0.12	7.78	19.25	101.82
5	0.82	16.05	0.10	3.02	21.81	99.79
6	0.98	12.81	0.06	0.44	5.00	96.40
7	1.15	10.43	0.03	2.91	25.33	93.32
8	1.31	9.73	0.04	1.68	25.98	90.50
9	1.48	9.14	0.03	1.41	29.63	91.86
10	1.64	7.69	0.05	0.51	32.45	93.84
11	1.80	8.98	0.08	0.91	35.72	96.86
12	1.97	9.45	0.10	1.06	36.97	101.11
13	2.13	11.77	0.22	0.77	34.24	103.93
14	2.30	16.11	0.22	2.23	35.50	106.66
15	2.46	13.12	0.33	1.77	39.79	108.38
16	2.63	10.38	0.43	0.89	48.84	109.62
17	2.79	10.12	0.47	1.42	47.45	111.26
18	2.95	17.42	0.57	2.91	43.50	112.79
19	3.12	17.87	0.67	2.23	41.09	113.99
20	3.28	16.30	0.69	1.14	44.97	113.86
21	3.45	12.33	0.61	-0.36	51.87	112.61
22	3.61	8.39	0.49	-1.60	61.13	110.49
23	3.77	6.49	0.38	-2.34	66.91	108.45
24	3.94	7.02	0.33	-2.50	66.14	106.88
25	4.10	7.02	0.28	-2.58	63.03	105.80
26	4.27	6.63	0.24	-2.55	60.87	104.96
27	4.43	7.08	0.24	-2.36	59.37	104.41
28	4.59	7.10	0.23	-2.07	59.61	104.05
29	4.76	6.18	0.22	-1.93	64.42	103.24
30	4.92	4.53	0.20	-1.99	73.00	101.87
31	5.09	3.55	0.16	-2.10	80.16	100.53
32	5.25	3.80	0.15	-2.07	77.27	100.30
33	5.41	5.01	0.17	-1.91	64.60	102.03
34	5.58	8.03	0.23	-1.50	54.22	105.23
35	5.74	11.24	0.35	-1.03	48.20	108.55
36	5.91	13.54	0.49	0.99	39.06	111.65
37	6.07	23.69	0.59	0.70	37.33	113.39
38	6.23	18.51	0.65	-0.24	38.42	113.60
39	6.40	12.58	0.55	-0.51	45.58	112.48
40	6.56	11.89	0.46	-0.75	52.71	109.89
41	6.73	7.38	0.28	-0.89	60.27	106.62
42	6.89	3.78	0.18	-0.66	72.32	101.79
43	7.05	3.44	0.10	0.00	83.55	97.49
44	7.22	2.80	0.07	0.55	82.84	94.00
45	7.38	2.52	0.06	1.16	83.07	92.17
46	7.55	2.80	0.05	1.81	81.14	90.85
47	7.71	2.63	0.05	2.59	74.68	89.76
48	7.87	3.05	0.03	3.63	69.74	90.42

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	8.04	3.78	0.06	5.09	60.08	92.44
50	8.20	5.40	0.07	10.46	54.86	93.85
51	8.37	5.17	0.06	12.64	52.72	94.48
52	8.53	4.75	0.07	15.20	51.77	98.63
53	8.69	8.61	0.20	20.95	39.26	107.75
54	8.86	25.70	0.63	17.75	33.73	114.79
55	9.02	32.02	1.15	8.74	30.54	119.68
56	9.19	38.90	1.63	9.49	30.96	122.46
57	9.35	41.75	1.95	6.10	29.48	124.05
58	9.51	49.30	2.02	9.19	27.95	124.74
59	9.68	51.45	2.01	7.06	28.54	124.84
60	9.84	40.02	2.06	4.86	30.27	124.73
61	10.01	41.00	2.06	5.87	33.44	124.27
62	10.17	36.07	1.87	6.65	33.82	123.90
63	10.34	36.07	1.83	8.98	33.13	123.92
64	10.50	43.37	2.03	13.12	30.94	124.98
65	10.66	52.18	2.48	14.88	30.04	126.23
66	10.83	50.70	2.74	12.90	30.28	126.97
67	10.99	49.33	2.71	13.28	31.58	127.04
68	11.16	46.84	2.65	19.65	32.03	126.80
69	11.32	46.39	2.55	22.63	32.77	126.63
70	11.48	44.72	2.61	18.81	32.65	126.67
71	11.65	47.62	2.68	24.17	33.54	126.71
72	11.81	43.23	2.66	20.01	34.67	126.51
73	11.98	38.79	2.52	16.32	35.91	125.63
74	12.14	36.49	2.00	18.92	35.77	124.79
75	12.30	37.58	1.98	23.98	35.20	123.97
76	12.47	34.84	1.89	25.18	35.84	123.70
77	12.63	32.80	1.85	20.09	36.72	123.38
78	12.80	33.11	1.82	21.47	36.52	123.17
79	12.96	34.54	1.75	22.47	36.21	123.20
80	13.12	34.20	1.84	23.07	37.37	123.16
81	13.29	29.78	1.85	19.31	39.44	122.91
82	13.45	27.94	1.69	14.93	41.21	122.11
83	13.62	26.01	1.43	19.81	40.95	121.09
84	13.78	25.62	1.27	24.81	40.26	120.26
85	13.94	25.67	1.25	26.18	39.44	119.89
86	14.11	26.20	1.23	28.40	38.88	119.90
87	14.27	27.10	1.26	30.33	38.10	120.04
88	14.44	28.27	1.28	29.19	37.71	120.17
89	14.60	28.05	1.27	28.47	37.87	120.18
90	14.76	26.99	1.26	32.46	38.75	120.15
91	14.93	26.26	1.30	33.41	39.66	120.05
92	15.09	25.67	1.25	34.20	40.45	119.91
93	15.26	24.86	1.23	34.99	38.41	119.41
94	15.42	28.61	1.01	40.81	37.40	118.82
95	15.58	25.45	0.98	39.05	35.78	118.62
96	15.75	27.60	1.10	62.41	34.21	119.58

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	15.91	37.25	1.33	73.92	32.80	121.49
98	16.08	40.88	1.78	47.66	31.28	123.94
99	16.24	51.01	2.40	48.29	29.62	126.40
100	16.40	67.84	3.02	26.75	30.05	128.33
101	16.57	59.84	3.62	16.65	31.57	129.71
102	16.73	59.17	4.13	15.00	31.52	130.42
103	16.90	77.49	3.93	23.47	28.09	130.92
104	17.06	90.69	3.85	24.37	26.47	131.02
105	17.22	74.05	4.03	26.10	26.98	130.90
106	17.39	71.95	3.83	30.99	25.10	130.91
107	17.55	107.66	3.60	22.24	24.17	130.95
108	17.72	84.23	3.94	14.31	25.02	130.99
109	17.88	65.52	4.00	13.11	30.99	130.35
110	18.05	52.80	3.50	13.29	35.38	129.26
111	18.21	47.51	3.03	20.56	36.67	128.00
112	18.37	47.46	2.67	31.74	37.03	127.46
113	18.54	46.39	2.97	44.58	33.82	127.33
114	18.70	59.56	2.64	84.80	30.18	128.38
115	18.87	77.41	3.40	75.89	20.73	129.59
116	19.03	141.47	3.21	78.83	17.74	131.49
117	19.19	138.73	4.43	97.90	18.57	133.31
118	19.36	109.82	6.12	50.86	22.28	133.99
119	19.52	102.99	5.08	76.11	22.88	134.29
120	19.69	136.41	5.10	245.24	18.81	134.48
121	19.85	176.20	5.58	181.99	15.39	135.66
122	20.01	214.24	6.44	94.33	15.25	137.28
123	20.18	220.42	9.29	77.67	15.59	137.28
124	20.34	250.84	10.57	85.13	16.55	137.28
125	20.51	218.74	9.00	81.21	15.76	137.28
126	20.67	232.58	7.96	46.03	13.66	137.28
127	20.83	228.72	4.38	31.64	12.05	136.35
128	21.00	207.33	5.12	19.35	12.30	135.34
129	21.16	180.93	6.12	13.12	17.12	136.43
130	21.33	138.45	7.87	12.72	22.20	137.06
131	21.49	127.50	8.01	11.80	25.77	136.71
132	21.65	118.09	6.19	16.22	25.02	136.31
133	21.82	138.98	6.70	12.27	21.66	136.27
134	21.98	177.91	7.06	13.66	19.30	137.28
135	22.15	217.81	9.48	18.99	17.36	137.28
136	22.31	240.72	9.64	25.96	12.08	137.28
137	22.47	467.87	9.88	88.97	8.72	137.28
138	22.64	482.05	9.95	87.42	6.59	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.16	0.01	0.00	0.01	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
2	0.33	0.02	0.00	0.02	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
3	0.49	0.02	0.00	0.02	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
4	0.66	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
5	0.82	0.04	0.00	0.04	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
6	0.98	0.05	0.00	0.05	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
7	1.15	0.06	0.00	0.06	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
8	1.31	0.06	0.00	0.06	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
9	1.48	0.07	0.00	0.07	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
10	1.64	0.08	0.00	0.08	1.00	0.324	0.83	0.389	1.00	1.30	2.000	No
11	1.80	0.09	0.00	0.09	1.00	0.324	0.83	0.389	1.00	1.30	2.000	No
12	1.97	0.10	0.00	0.10	1.00	0.324	0.83	0.389	1.00	1.30	2.000	No
13	2.13	0.10	0.00	0.10	1.00	0.338	0.83	0.405	1.00	1.30	0.526	No
14	2.30	0.11	0.01	0.10	1.00	0.353	0.83	0.423	1.00	1.30	0.550	No
15	2.46	0.12	0.01	0.11	1.00	0.367	0.83	0.440	1.00	1.30	0.572	No
16	2.63	0.13	0.02	0.11	1.00	0.380	0.83	0.456	1.00	1.30	0.593	No
17	2.79	0.14	0.02	0.12	1.00	0.393	0.83	0.471	1.00	1.30	0.612	No
18	2.95	0.15	0.03	0.12	1.00	0.404	0.83	0.484	1.00	1.30	0.630	No
19	3.12	0.16	0.03	0.12	0.99	0.415	0.83	0.497	1.00	1.30	0.646	No
20	3.28	0.17	0.04	0.13	0.99	0.424	0.83	0.509	1.00	1.30	0.661	No
21	3.45	0.18	0.05	0.13	0.99	0.434	0.83	0.520	1.00	1.30	0.676	No
22	3.61	0.19	0.05	0.14	0.99	0.442	0.83	0.530	1.00	1.30	0.689	No
23	3.77	0.19	0.06	0.14	0.99	0.451	0.83	0.540	1.00	1.30	0.703	No
24	3.94	0.20	0.06	0.14	0.99	0.459	0.83	0.550	1.00	1.30	0.715	No
25	4.10	0.21	0.07	0.15	0.99	0.467	0.83	0.559	1.00	1.30	0.727	No
26	4.27	0.22	0.07	0.15	0.99	0.474	0.83	0.568	1.00	1.30	0.739	No
27	4.43	0.23	0.08	0.15	0.99	0.481	0.83	0.577	1.00	1.30	0.750	No
28	4.59	0.24	0.08	0.16	0.99	0.488	0.83	0.585	1.00	1.30	0.761	No
29	4.76	0.25	0.09	0.16	0.99	0.495	0.83	0.593	1.00	1.30	0.771	No
30	4.92	0.25	0.09	0.16	0.99	0.501	0.83	0.601	1.00	1.30	0.781	No
31	5.09	0.26	0.10	0.17	0.99	0.507	0.83	0.608	1.00	1.30	0.791	No
32	5.25	0.27	0.10	0.17	0.99	0.514	0.83	0.616	1.00	1.30	0.801	No
33	5.41	0.28	0.11	0.17	0.99	0.519	0.83	0.623	1.00	1.30	0.809	No
34	5.58	0.29	0.11	0.18	0.99	0.524	0.83	0.629	1.00	1.30	0.818	No
35	5.74	0.30	0.12	0.18	0.99	0.529	0.83	0.634	1.00	1.30	0.825	No
36	5.91	0.31	0.12	0.18	0.99	0.533	0.83	0.639	1.00	1.30	0.831	No
37	6.07	0.32	0.13	0.19	0.99	0.537	0.83	0.644	1.00	1.30	0.837	No
38	6.23	0.32	0.13	0.19	0.99	0.541	0.83	0.648	1.00	1.30	0.843	No
39	6.40	0.33	0.14	0.20	0.99	0.544	0.83	0.653	1.00	1.30	0.848	No
40	6.56	0.34	0.14	0.20	0.99	0.548	0.83	0.657	1.00	1.30	0.854	No
41	6.73	0.35	0.15	0.20	0.99	0.552	0.83	0.661	1.00	1.30	0.860	No
42	6.89	0.36	0.15	0.21	0.99	0.556	0.83	0.666	1.00	1.30	0.866	No
43	7.05	0.37	0.16	0.21	0.99	0.560	0.83	0.672	1.00	1.30	0.873	No
44	7.22	0.38	0.16	0.21	0.99	0.565	0.83	0.677	1.00	1.30	0.880	No
45	7.38	0.38	0.17	0.22	0.98	0.569	0.83	0.683	1.00	1.30	0.887	No
46	7.55	0.39	0.17	0.22	0.98	0.574	0.83	0.688	1.00	1.30	0.895	No
47	7.71	0.40	0.18	0.22	0.98	0.579	0.83	0.694	1.00	1.30	0.902	No
48	7.87	0.41	0.18	0.22	0.98	0.583	0.83	0.699	1.00	1.30	0.909	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
49	8.04	0.41	0.19	0.22	0.98	0.587	0.83	0.704	1.00	1.30	0.915	No
50	8.20	0.42	0.19	0.23	0.98	0.591	0.83	0.709	1.00	1.30	0.921	No
51	8.37	0.43	0.20	0.23	0.98	0.595	0.83	0.713	1.00	1.30	0.927	No
52	8.53	0.44	0.20	0.23	0.98	0.598	0.83	0.717	1.00	1.30	0.932	No
53	8.69	0.45	0.21	0.24	0.98	0.601	0.83	0.720	1.00	1.30	0.936	No
54	8.86	0.46	0.21	0.24	0.98	0.602	0.83	0.722	1.00	1.30	0.938	No
55	9.02	0.46	0.22	0.25	0.98	0.603	0.83	0.723	1.00	1.30	0.940	No
56	9.19	0.47	0.22	0.25	0.98	0.604	0.83	0.724	1.00	1.30	0.941	No
57	9.35	0.49	0.23	0.26	0.98	0.604	0.83	0.725	1.00	1.30	0.942	No
58	9.51	0.50	0.23	0.26	0.98	0.605	0.83	0.725	1.00	1.30	0.943	No
59	9.68	0.51	0.24	0.27	0.98	0.605	0.83	0.726	1.00	1.30	0.943	No
60	9.84	0.52	0.24	0.27	0.98	0.606	0.83	0.726	1.00	1.30	0.944	No
61	10.01	0.53	0.25	0.28	0.98	0.606	0.83	0.727	1.00	1.30	0.945	No
62	10.17	0.54	0.25	0.28	0.98	0.606	0.83	0.727	1.00	1.30	0.945	No
63	10.34	0.55	0.26	0.29	0.98	0.607	0.83	0.728	1.00	1.30	0.946	No
64	10.50	0.56	0.27	0.29	0.98	0.607	0.83	0.728	1.00	1.30	0.946	No
65	10.66	0.57	0.27	0.30	0.98	0.607	0.83	0.728	1.00	1.30	0.946	No
66	10.83	0.58	0.28	0.30	0.98	0.607	0.83	0.728	1.00	1.30	0.947	No
67	10.99	0.59	0.28	0.31	0.98	0.607	0.83	0.728	1.00	1.30	0.947	No
68	11.16	0.60	0.29	0.31	0.98	0.607	0.83	0.728	1.00	1.30	0.947	No
69	11.32	0.61	0.29	0.32	0.98	0.608	0.83	0.728	1.00	1.30	0.947	No
70	11.48	0.62	0.30	0.32	0.98	0.608	0.83	0.729	1.00	1.30	0.947	No
71	11.65	0.63	0.30	0.33	0.98	0.608	0.83	0.729	1.00	1.30	0.947	No
72	11.81	0.64	0.31	0.33	0.98	0.608	0.83	0.729	1.00	1.30	0.947	No
73	11.98	0.65	0.31	0.34	0.97	0.608	0.83	0.729	1.00	1.30	0.948	No
74	12.14	0.66	0.32	0.34	0.97	0.608	0.83	0.729	1.00	1.30	0.948	No
75	12.30	0.67	0.32	0.35	0.97	0.608	0.83	0.729	1.00	1.30	0.948	No
76	12.47	0.68	0.33	0.35	0.97	0.608	0.83	0.730	1.00	1.30	0.948	No
77	12.63	0.69	0.33	0.36	0.97	0.609	0.83	0.730	1.00	1.30	0.949	No
78	12.80	0.70	0.34	0.36	0.97	0.609	0.83	0.730	1.00	1.30	0.949	No
79	12.96	0.71	0.34	0.37	0.97	0.609	0.83	0.730	1.00	1.30	0.950	No
80	13.12	0.72	0.35	0.37	0.97	0.609	0.83	0.731	1.00	1.30	0.950	No
81	13.29	0.73	0.35	0.38	0.97	0.610	0.83	0.731	1.00	1.30	0.950	No
82	13.45	0.74	0.36	0.38	0.97	0.610	0.83	0.731	1.00	1.30	0.951	No
83	13.62	0.75	0.36	0.39	0.97	0.610	0.83	0.732	1.00	1.30	0.951	No
84	13.78	0.76	0.37	0.39	0.97	0.610	0.83	0.732	1.00	1.30	0.952	No
85	13.94	0.77	0.37	0.40	0.97	0.611	0.83	0.732	1.00	1.30	0.952	No
86	14.11	0.78	0.38	0.40	0.97	0.611	0.83	0.733	1.00	1.30	0.953	No
87	14.27	0.79	0.38	0.41	0.97	0.611	0.83	0.733	1.00	1.30	0.953	No
88	14.44	0.80	0.39	0.41	0.97	0.612	0.83	0.734	1.00	1.30	0.954	No
89	14.60	0.81	0.39	0.42	0.97	0.612	0.83	0.734	1.00	1.30	0.954	No
90	14.76	0.82	0.40	0.42	0.97	0.612	0.83	0.734	1.00	1.30	0.954	No
91	14.93	0.83	0.40	0.43	0.97	0.613	0.83	0.734	1.00	1.30	0.955	No
92	15.09	0.84	0.41	0.43	0.97	0.613	0.83	0.735	1.00	1.30	0.955	No
93	15.26	0.85	0.41	0.44	0.97	0.613	0.83	0.735	1.00	1.30	0.956	No
94	15.42	0.86	0.42	0.44	0.97	0.613	0.83	0.735	1.00	1.30	0.956	No
95	15.58	0.87	0.42	0.45	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
96	15.75	0.88	0.43	0.45	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
97	15.91	0.89	0.43	0.45	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
98	16.08	0.90	0.44	0.46	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
99	16.24	0.91	0.44	0.47	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
100	16.40	0.92	0.45	0.47	0.97	0.614	0.83	0.736	1.00	1.30	0.956	No
101	16.57	0.93	0.45	0.48	0.97	0.613	0.83	0.735	1.00	1.30	0.956	No
102	16.73	0.94	0.46	0.48	0.96	0.613	0.83	0.735	1.00	1.30	0.955	No
103	16.90	0.95	0.46	0.49	0.96	0.612	0.83	0.734	1.00	1.30	0.955	No
104	17.06	0.96	0.47	0.49	0.96	0.612	0.83	0.734	1.00	1.30	0.954	No
105	17.22	0.97	0.47	0.50	0.96	0.612	0.83	0.733	1.00	1.30	0.953	No
106	17.39	0.98	0.48	0.50	0.96	0.611	0.83	0.733	1.00	1.30	0.953	No
107	17.55	0.99	0.49	0.51	0.96	0.611	0.83	0.732	1.00	1.30	0.952	No
108	17.72	1.01	0.49	0.52	0.96	0.611	0.83	0.732	1.00	1.30	0.952	No
109	17.88	1.02	0.50	0.52	0.96	0.610	0.83	0.732	1.00	1.30	0.951	No
110	18.05	1.03	0.50	0.53	0.96	0.610	0.83	0.731	1.00	1.30	0.951	No
111	18.21	1.04	0.51	0.53	0.96	0.610	0.83	0.731	1.00	1.30	0.950	No
112	18.37	1.05	0.51	0.54	0.96	0.609	0.83	0.731	1.00	1.30	2.000	Yes
113	18.54	1.06	0.52	0.54	0.96	0.609	0.83	0.730	1.00	1.30	2.000	Yes
114	18.70	1.07	0.52	0.55	0.96	0.609	0.83	0.730	1.00	1.30	2.000	Yes
115	18.87	1.08	0.53	0.55	0.96	0.609	0.83	0.730	1.00	1.30	2.000	Yes
116	19.03	1.09	0.53	0.56	0.96	0.608	0.83	0.729	1.00	1.30	2.000	Yes
117	19.19	1.10	0.54	0.56	0.96	0.608	0.83	0.729	1.00	1.30	0.947	No
118	19.36	1.11	0.54	0.57	0.96	0.607	0.83	0.728	1.00	1.30	0.946	No
119	19.52	1.12	0.55	0.58	0.96	0.607	0.83	0.727	1.00	1.30	0.946	No
120	19.69	1.13	0.55	0.58	0.96	0.606	0.83	0.727	1.00	1.30	0.945	No
121	19.85	1.15	0.56	0.59	0.96	0.606	0.83	0.726	1.00	1.30	0.944	No
122	20.01	1.16	0.56	0.59	0.96	0.605	0.83	0.725	1.00	1.30	0.943	No
123	20.18	1.17	0.57	0.60	0.96	0.604	0.83	0.725	1.00	1.30	0.942	No
124	20.34	1.18	0.57	0.61	0.96	0.604	0.83	0.724	1.00	1.30	0.941	No
125	20.51	1.19	0.58	0.61	0.96	0.603	0.83	0.723	1.00	1.30	0.940	No
126	20.67	1.20	0.58	0.62	0.96	0.602	0.83	0.722	1.00	1.30	0.939	No
127	20.83	1.21	0.59	0.63	0.95	0.602	0.83	0.722	1.00	1.30	0.938	No
128	21.00	1.22	0.59	0.63	0.95	0.601	0.83	0.721	1.00	1.30	0.937	No
129	21.16	1.24	0.60	0.64	0.95	0.601	0.83	0.720	1.00	1.30	0.936	No
130	21.33	1.25	0.60	0.64	0.95	0.600	0.83	0.720	1.00	1.30	0.936	No
131	21.49	1.26	0.61	0.65	0.95	0.600	0.83	0.719	1.00	1.30	0.935	No
132	21.65	1.27	0.61	0.66	0.95	0.599	0.83	0.718	1.00	1.30	0.934	No
133	21.82	1.28	0.62	0.66	0.95	0.599	0.83	0.718	1.00	1.30	0.933	No
134	21.98	1.29	0.62	0.67	0.95	0.598	0.83	0.717	1.00	1.30	0.932	No
135	22.15	1.30	0.63	0.67	0.95	0.597	0.83	0.716	1.00	1.30	0.931	No
136	22.31	1.31	0.63	0.68	0.95	0.597	0.83	0.716	1.00	1.30	0.930	No
137	22.47	1.32	0.64	0.69	0.95	0.596	0.83	0.715	1.00	1.30	0.929	No
138	22.64	1.34	0.64	0.69	0.95	0.596	0.83	0.714	1.00	1.30	0.928	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.16	6.68	2.76	1.17	0.93	10.71	4.45	47.65	4.000	No	Yes	2.00
2	0.33	13.63	2.39	0.72	0.78	21.87	2.26	49.49	4.000	No	No	2.00
3	0.49	19.38	2.21	0.60	0.72	31.09	1.70	52.98	4.000	No	No	2.00
4	0.66	19.66	2.21	0.59	0.72	31.53	1.69	53.16	4.000	No	No	2.00
5	0.82	16.18	2.28	0.58	0.74	25.93	1.89	48.97	4.000	No	No	2.00
6	0.98	13.13	2.33	0.49	0.76	21.01	1.00	21.01	4.000	No	No	2.00
7	1.15	11.01	2.37	0.40	0.78	17.60	2.21	38.84	4.000	No	No	2.00
8	1.31	9.80	2.39	0.32	0.79	15.64	2.27	35.49	4.000	No	No	2.00
9	1.48	8.87	2.48	0.44	0.82	14.14	2.65	37.48	4.000	No	No	2.00
10	1.64	8.62	2.54	0.61	0.84	13.72	2.97	40.77	4.000	No	No	2.00
11	1.80	8.72	2.61	0.90	0.87	13.87	3.37	46.76	4.000	No	Yes	2.00
12	1.97	10.08	2.63	1.33	0.88	16.04	3.53	56.67	4.000	No	Yes	2.00
13	2.13	12.46	2.58	1.47	0.86	19.86	3.19	63.31	0.104	No	No	0.20
14	2.30	13.69	2.60	1.88	0.87	21.81	3.35	72.96	4.000	No	Yes	2.00
15	2.46	13.22	2.69	2.49	0.90	21.05	3.91	82.22	4.000	No	Yes	2.00
16	2.63	11.22	2.85	3.68	0.96	17.82	5.21	92.88	4.000	No	Yes	2.00
17	2.79	12.67	2.83	3.92	0.95	20.12	5.00	100.64	4.000	No	Yes	2.00
18	2.95	15.17	2.76	3.80	0.93	24.13	4.42	106.71	4.000	No	Yes	2.00
19	3.12	17.23	2.71	3.77	0.91	27.43	4.08	112.00	4.000	No	Yes	2.00
20	3.28	15.52	2.78	4.27	0.94	24.66	4.63	114.29	4.000	No	Yes	2.00
21	3.45	12.34	2.90	4.90	0.98	19.54	5.68	110.93	4.000	No	Yes	2.00
22	3.61	9.05	3.04	5.58	1.00	14.24	7.19	102.33	4.000	No	Yes	2.00
23	3.77	7.27	3.12	5.69	1.00	11.36	8.17	92.89	4.000	No	Yes	2.00
24	3.94	6.81	3.11	5.03	1.00	10.61	8.04	85.30	4.000	No	Yes	2.00
25	4.10	6.85	3.07	4.30	1.00	10.67	7.51	80.08	4.000	No	Yes	2.00
26	4.27	6.87	3.03	3.83	1.00	10.68	7.14	76.30	4.000	No	Yes	2.00
27	4.43	6.90	3.01	3.53	1.00	10.72	6.89	73.87	4.000	No	Yes	2.00
28	4.59	6.76	3.02	3.47	1.00	10.47	6.93	72.58	4.000	No	Yes	2.00
29	4.76	5.91	3.09	3.74	1.00	9.10	7.74	70.45	4.000	No	Yes	2.00
30	4.92	4.72	3.20	4.23	1.00	7.18	9.25	66.43	4.000	No	Yes	2.00
31	5.09	3.93	3.29	4.56	1.00	5.89	10.55	62.19	4.000	No	Yes	2.00
32	5.25	4.09	3.25	4.19	1.00	6.14	10.02	61.49	4.000	No	Yes	2.00
33	5.41	5.59	3.09	3.44	1.00	8.52	7.78	66.28	4.000	No	Yes	2.00
34	5.58	8.07	2.94	3.22	0.99	12.50	6.05	75.65	4.000	No	Yes	2.00
35	5.74	10.93	2.84	3.35	0.96	17.08	5.11	87.34	4.000	No	Yes	2.00
36	5.91	16.16	2.67	3.01	0.89	25.47	3.81	96.94	4.000	No	Yes	2.00
37	6.07	18.58	2.64	3.16	0.88	29.35	3.58	105.06	4.000	No	Yes	2.00
38	6.23	18.26	2.66	3.34	0.89	28.82	3.72	107.25	4.000	No	Yes	2.00
39	6.40	14.32	2.79	3.98	0.94	22.47	4.72	106.13	4.000	No	Yes	2.00
40	6.56	10.61	2.91	4.21	0.98	16.49	5.81	95.81	4.000	No	Yes	2.00
41	6.73	7.67	3.03	4.20	1.00	11.76	7.04	82.77	4.000	No	Yes	2.00
42	6.89	4.86	3.19	4.12	1.00	7.23	9.13	65.97	4.000	No	Yes	2.00
43	7.05	3.34	3.33	3.93	1.00	4.77	11.18	53.29	4.000	No	Yes	2.00
44	7.22	2.93	3.32	2.97	1.00	4.10	11.04	45.25	4.000	No	Yes	2.00
45	7.38	2.72	3.32	2.58	1.00	3.75	11.09	41.62	4.000	No	Yes	2.00
46	7.55	2.67	3.30	2.22	1.00	3.67	10.73	39.35	4.000	No	Yes	2.00
47	7.71	2.86	3.22	1.73	1.00	3.96	9.55	37.82	4.000	No	Yes	2.00
48	7.87	3.20	3.16	1.61	1.00	4.50	8.67	38.99	4.000	No	Yes	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
49	8.04	4.17	3.02	1.45	1.00	6.03	7.01	42.26	4.000	No	Yes	2.00
50	8.20	4.92	2.95	1.39	1.00	7.22	6.15	44.45	4.000	No	Yes	2.00
51	8.37	5.29	2.91	1.36	0.98	7.81	5.81	45.42	4.000	No	Yes	2.00
52	8.53	6.41	2.90	1.83	0.98	9.60	5.66	54.38	4.000	No	Yes	2.00
53	8.69	13.28	2.68	2.33	0.90	20.62	3.83	79.06	4.000	No	Yes	2.00
54	8.86	22.34	2.57	3.01	0.85	35.16	3.13	109.90	0.203	No	No	0.22
55	9.02	32.38	2.50	3.56	0.83	51.27	2.75	141.15	0.342	No	No	0.36
56	9.19	37.67	2.51	4.24	0.83	59.76	2.80	167.34	0.516	No	No	0.55
57	9.35	43.44	2.47	4.35	0.82	69.01	2.63	181.83	0.639	No	No	0.68
58	9.51	47.61	2.44	4.23	0.80	75.70	2.47	187.01	0.688	No	No	0.73
59	9.68	47.03	2.45	4.36	0.81	74.74	2.53	189.27	0.711	No	No	0.75
60	9.84	44.24	2.49	4.67	0.82	70.25	2.72	191.24	0.730	No	No	0.77
61	10.01	39.11	2.56	5.17	0.85	61.99	3.09	191.59	0.734	No	No	0.78
62	10.17	37.82	2.57	5.15	0.85	59.90	3.14	187.91	0.697	No	No	0.74
63	10.34	38.64	2.55	5.01	0.85	61.21	3.05	186.90	0.687	No	No	0.73
64	10.50	44.05	2.51	4.86	0.83	69.88	2.80	195.51	0.775	No	No	0.82
65	10.66	48.95	2.49	5.00	0.82	77.73	2.70	209.55	4.000	No	No	2.00
66	10.83	50.93	2.49	5.25	0.82	80.90	2.72	220.32	4.000	No	No	2.00
67	10.99	49.18	2.52	5.56	0.84	78.06	2.87	224.14	4.000	No	No	2.00
68	11.16	47.79	2.53	5.59	0.84	75.82	2.92	221.61	4.000	No	No	2.00
69	11.32	46.28	2.55	5.71	0.85	73.37	3.01	220.87	4.000	No	No	2.00
70	11.48	46.56	2.54	5.69	0.84	73.81	3.00	221.15	4.000	No	No	2.00
71	11.65	45.49	2.56	5.91	0.85	72.08	3.10	223.67	4.000	No	No	2.00
72	11.81	43.50	2.59	6.11	0.86	68.87	3.24	223.20	4.000	No	No	2.00
73	11.98	39.77	2.61	6.11	0.87	62.85	3.40	213.44	4.000	No	Yes	2.00
74	12.14	37.91	2.61	5.81	0.87	59.84	3.38	202.18	4.000	No	Yes	2.00
75	12.30	36.63	2.60	5.44	0.86	57.78	3.31	191.06	0.729	No	No	0.77
76	12.47	35.41	2.61	5.49	0.87	55.80	3.39	189.01	4.000	No	Yes	2.00
77	12.63	33.91	2.63	5.58	0.88	53.36	3.50	186.77	4.000	No	Yes	2.00
78	12.80	33.79	2.62	5.45	0.87	52.72	3.47	183.20	4.000	No	Yes	2.00
79	12.96	34.27	2.62	5.37	0.87	53.00	3.43	182.01	4.000	No	Yes	2.00
80	13.12	33.15	2.64	5.59	0.88	51.10	3.58	183.18	4.000	No	Yes	2.00
81	13.29	30.91	2.68	5.94	0.90	47.63	3.86	183.78	4.000	No	Yes	2.00
82	13.45	28.17	2.71	6.04	0.91	43.27	4.10	177.43	4.000	No	Yes	2.00
83	13.62	26.81	2.71	5.63	0.91	40.77	4.06	165.67	4.000	No	Yes	2.00
84	13.78	26.10	2.70	5.21	0.90	39.27	3.97	155.92	4.000	No	Yes	2.00
85	13.94	26.21	2.68	4.92	0.90	39.02	3.86	150.56	4.000	No	Yes	2.00
86	14.11	26.73	2.67	4.81	0.89	39.45	3.78	149.24	4.000	No	Yes	2.00
87	14.27	27.61	2.65	4.69	0.89	40.38	3.68	148.61	4.000	No	Yes	2.00
88	14.44	28.23	2.65	4.63	0.88	40.96	3.63	148.61	4.000	No	Yes	2.00
89	14.60	28.20	2.65	4.65	0.89	40.66	3.65	148.40	4.000	No	Yes	2.00
90	14.76	27.55	2.67	4.78	0.89	39.54	3.77	148.94	4.000	No	Yes	2.00
91	14.93	26.79	2.68	4.90	0.90	38.27	3.89	148.80	4.000	No	Yes	2.00
92	15.09	26.09	2.70	4.98	0.90	37.09	4.00	148.20	4.000	No	Yes	2.00
93	15.26	26.91	2.66	4.47	0.89	37.76	3.72	140.51	4.000	No	Yes	2.00
94	15.42	26.86	2.64	4.13	0.88	37.30	3.59	133.85	4.000	No	Yes	2.00
95	15.58	27.90	2.61	3.82	0.87	38.33	3.38	129.57	4.000	No	Yes	2.00
96	15.75	30.94	2.58	3.78	0.86	42.13	3.18	134.17	0.305	No	No	0.32

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
97	15.91	36.13	2.55	3.98	0.85	48.83	3.01	147.20	0.377	No	No	0.39
98	16.08	43.86	2.51	4.27	0.83	58.82	2.84	166.83	0.512	No	No	0.53
99	16.24	53.83	2.48	4.53	0.82	71.55	2.65	189.60	0.714	No	No	0.75
100	16.40	60.00	2.49	5.10	0.82	79.49	2.70	214.43	4.000	No	No	2.00
101	16.57	62.57	2.52	5.82	0.84	82.83	2.87	237.71	4.000	No	No	2.00
102	16.73	65.77	2.52	6.00	0.84	86.52	2.86	247.78	4.000	No	No	2.00
103	16.90	76.08	2.44	5.28	0.81	98.41	2.49	244.58	4.000	No	No	2.00
104	17.06	81.10	2.40	4.91	0.79	103.68	2.32	240.39	4.000	No	No	2.00
105	17.22	79.29	2.41	4.98	0.80	100.88	2.37	239.09	4.000	No	No	2.00
106	17.39	84.94	2.37	4.55	0.78	106.75	2.18	233.16	4.000	No	No	2.00
107	17.55	88.27	2.34	4.34	0.77	109.94	2.10	230.53	4.000	No	No	2.00
108	17.72	86.04	2.37	4.52	0.78	106.80	2.18	232.43	4.000	No	No	2.00
109	17.88	67.71	2.51	5.72	0.83	84.90	2.80	238.03	4.000	No	No	2.00
110	18.05	55.50	2.60	6.45	0.87	69.79	3.33	232.39	4.000	No	Yes	2.00
111	18.21	49.57	2.63	6.32	0.88	62.00	3.49	216.56	4.000	No	Yes	2.00
112	18.37	47.58	2.63	6.21	0.88	59.14	3.54	209.30	4.000	Yes	Yes	2.00
113	18.54	51.91	2.57	5.43	0.85	63.70	3.14	199.80	4.000	Yes	No	2.00
114	18.70	62.11	2.49	4.92	0.82	75.25	2.71	204.07	4.000	Yes	No	2.00
115	18.87	93.96	2.25	3.32	0.73	110.63	1.80	199.06	4.000	Yes	No	2.00
116	19.03	120.42	2.16	3.08	0.70	139.91	1.58	220.86	4.000	Yes	No	2.00
117	19.19	131.10	2.19	3.53	0.71	152.06	1.64	248.74	4.000	No	No	2.00
118	19.36	118.26	2.29	4.45	0.75	137.93	1.93	265.92	4.000	No	No	2.00
119	19.52	118.19	2.31	4.64	0.76	137.32	1.98	271.83	4.000	No	No	2.00
120	19.69	140.95	2.19	3.76	0.71	161.11	1.65	266.39	4.000	No	No	2.00
121	19.85	178.12	2.09	3.22	0.67	200.58	1.43	286.80	4.000	No	No	2.00
122	20.01	205.32	2.08	3.48	0.67	230.10	1.42	327.10	4.000	No	No	2.00
123	20.18	229.73	2.09	3.84	0.67	256.60	1.44	369.90	4.000	No	No	2.00
124	20.34	231.17	2.12	4.18	0.68	257.68	1.50	386.61	4.000	No	No	2.00
125	20.51	235.07	2.10	3.92	0.67	260.09	1.45	377.51	4.000	No	No	2.00
126	20.67	227.44	2.03	3.14	0.65	248.74	1.34	332.13	4.000	No	No	2.00
127	20.83	223.34	1.97	2.62	0.62	241.83	1.26	304.22	4.000	No	No	2.00
128	21.00	205.97	1.98	2.54	0.63	222.10	1.27	281.99	4.000	No	No	2.00
129	21.16	175.79	2.14	3.65	0.69	191.06	1.54	293.63	4.000	No	No	2.00
130	21.33	149.14	2.29	4.96	0.75	162.97	1.92	313.15	4.000	No	No	2.00
131	21.49	128.21	2.38	5.79	0.78	140.13	2.25	315.11	4.000	No	No	2.00
132	21.65	128.39	2.37	5.48	0.78	139.36	2.18	303.26	4.000	No	No	2.00
133	21.82	145.20	2.28	4.62	0.74	155.96	1.88	292.51	4.000	No	No	2.00
134	21.98	178.45	2.21	4.37	0.72	190.13	1.69	321.23	4.000	No	No	2.00
135	22.15	212.43	2.15	4.13	0.69	224.60	1.55	348.79	4.000	No	No	2.00
136	22.31	309.44	1.97	3.14	0.62	322.54	1.26	406.27	4.000	No	No	2.00
137	22.47	397.85	1.83	2.48	0.57	409.87	1.13	462.00	4.000	No	No	2.00
138	22.64	478.59	1.72	2.08	0.53	488.54	1.05	515.21	4.000	No	No	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
I_c: Soil behavior type index
Fr: Normalized friction ratio (%)
n: Stress exponent
Q_{tn}: Normalized cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.16	2.00	0.00	9.98	0.16	0.00	0.33	2.00	0.00	9.95	0.16	0.00
0.49	2.00	0.00	9.93	0.16	0.00	0.66	2.00	0.00	9.90	0.16	0.00
0.82	2.00	0.00	9.88	0.16	0.00	0.98	2.00	0.00	9.85	0.16	0.00
1.15	2.00	0.00	9.83	0.16	0.00	1.31	2.00	0.00	9.80	0.16	0.00
1.48	2.00	0.00	9.78	0.16	0.00	1.64	2.00	0.00	9.75	0.16	0.00
1.80	2.00	0.00	9.73	0.16	0.00	1.97	2.00	0.00	9.70	0.17	0.00
2.13	0.20	0.80	9.67	0.16	0.39	2.30	2.00	0.00	9.65	0.16	0.00
2.46	2.00	0.00	9.62	0.16	0.00	2.63	2.00	0.00	9.60	0.16	0.00
2.79	2.00	0.00	9.57	0.16	0.00	2.95	2.00	0.00	9.55	0.16	0.00
3.12	2.00	0.00	9.52	0.16	0.00	3.28	2.00	0.00	9.50	0.16	0.00
3.45	2.00	0.00	9.47	0.16	0.00	3.61	2.00	0.00	9.45	0.16	0.00
3.77	2.00	0.00	9.42	0.16	0.00	3.94	2.00	0.00	9.40	0.16	0.00
4.10	2.00	0.00	9.38	0.16	0.00	4.27	2.00	0.00	9.35	0.16	0.00
4.43	2.00	0.00	9.33	0.16	0.00	4.59	2.00	0.00	9.30	0.16	0.00
4.76	2.00	0.00	9.28	0.16	0.00	4.92	2.00	0.00	9.25	0.16	0.00
5.09	2.00	0.00	9.23	0.16	0.00	5.25	2.00	0.00	9.20	0.16	0.00
5.41	2.00	0.00	9.18	0.16	0.00	5.58	2.00	0.00	9.15	0.16	0.00
5.74	2.00	0.00	9.13	0.16	0.00	5.91	2.00	0.00	9.10	0.17	0.00
6.07	2.00	0.00	9.07	0.16	0.00	6.23	2.00	0.00	9.05	0.16	0.00
6.40	2.00	0.00	9.02	0.16	0.00	6.56	2.00	0.00	9.00	0.16	0.00
6.73	2.00	0.00	8.97	0.16	0.00	6.89	2.00	0.00	8.95	0.16	0.00
7.05	2.00	0.00	8.92	0.16	0.00	7.22	2.00	0.00	8.90	0.16	0.00
7.38	2.00	0.00	8.87	0.16	0.00	7.55	2.00	0.00	8.85	0.16	0.00
7.71	2.00	0.00	8.82	0.16	0.00	7.87	2.00	0.00	8.80	0.16	0.00
8.04	2.00	0.00	8.78	0.16	0.00	8.20	2.00	0.00	8.75	0.16	0.00
8.37	2.00	0.00	8.73	0.16	0.00	8.53	2.00	0.00	8.70	0.16	0.00
8.69	2.00	0.00	8.68	0.16	0.00	8.86	0.22	0.78	8.65	0.16	0.34
9.02	0.36	0.64	8.63	0.16	0.27	9.19	0.55	0.45	8.60	0.16	0.19
9.35	0.68	0.32	8.58	0.16	0.14	9.51	0.73	0.27	8.55	0.16	0.12
9.68	0.75	0.25	8.53	0.16	0.11	9.84	0.77	0.23	8.50	0.16	0.10
10.01	0.78	0.22	8.47	0.16	0.09	10.17	0.74	0.26	8.45	0.16	0.11
10.34	0.73	0.27	8.42	0.16	0.12	10.50	0.82	0.18	8.40	0.16	0.08
10.66	2.00	0.00	8.37	0.16	0.00	10.83	2.00	0.00	8.35	0.16	0.00
10.99	2.00	0.00	8.32	0.16	0.00	11.16	2.00	0.00	8.30	0.16	0.00
11.32	2.00	0.00	8.27	0.16	0.00	11.48	2.00	0.00	8.25	0.16	0.00
11.65	2.00	0.00	8.22	0.16	0.00	11.81	2.00	0.00	8.20	0.16	0.00
11.98	2.00	0.00	8.18	0.16	0.00	12.14	2.00	0.00	8.15	0.16	0.00
12.30	0.77	0.23	8.13	0.16	0.09	12.47	2.00	0.00	8.10	0.16	0.00
12.63	2.00	0.00	8.08	0.16	0.00	12.80	2.00	0.00	8.05	0.16	0.00
12.96	2.00	0.00	8.03	0.16	0.00	13.12	2.00	0.00	8.00	0.16	0.00
13.29	2.00	0.00	7.98	0.16	0.00	13.45	2.00	0.00	7.95	0.16	0.00
13.62	2.00	0.00	7.93	0.16	0.00	13.78	2.00	0.00	7.90	0.16	0.00
13.94	2.00	0.00	7.87	0.16	0.00	14.11	2.00	0.00	7.85	0.16	0.00
14.27	2.00	0.00	7.82	0.16	0.00	14.44	2.00	0.00	7.80	0.16	0.00
14.60	2.00	0.00	7.77	0.16	0.00	14.76	2.00	0.00	7.75	0.16	0.00
14.93	2.00	0.00	7.72	0.16	0.00	15.09	2.00	0.00	7.70	0.16	0.00
15.26	2.00	0.00	7.67	0.16	0.00	15.42	2.00	0.00	7.65	0.16	0.00
15.58	2.00	0.00	7.62	0.16	0.00	15.75	0.32	0.68	7.60	0.16	0.26

:: Liquefaction Potential Index calculation data :: (continued)

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
15.91	0.39	0.61	7.58	0.16	0.23	16.08	0.53	0.47	7.55	0.16	0.18
16.24	0.75	0.25	7.53	0.16	0.10	16.40	2.00	0.00	7.50	0.16	0.00
16.57	2.00	0.00	7.48	0.16	0.00	16.73	2.00	0.00	7.45	0.16	0.00
16.90	2.00	0.00	7.43	0.16	0.00	17.06	2.00	0.00	7.40	0.16	0.00
17.22	2.00	0.00	7.38	0.16	0.00	17.39	2.00	0.00	7.35	0.16	0.00
17.55	2.00	0.00	7.33	0.16	0.00	17.72	2.00	0.00	7.30	0.16	0.00
17.88	2.00	0.00	7.27	0.16	0.00	18.05	2.00	0.00	7.25	0.16	0.00
18.21	2.00	0.00	7.22	0.16	0.00	18.37	2.00	0.00	7.20	0.16	0.00
18.54	2.00	0.00	7.17	0.16	0.00	18.70	2.00	0.00	7.15	0.16	0.00
18.87	2.00	0.00	7.12	0.16	0.00	19.03	2.00	0.00	7.10	0.16	0.00
19.19	2.00	0.00	7.07	0.16	0.00	19.36	2.00	0.00	7.05	0.16	0.00
19.52	2.00	0.00	7.02	0.16	0.00	19.69	2.00	0.00	7.00	0.16	0.00
19.85	2.00	0.00	6.98	0.16	0.00	20.01	2.00	0.00	6.95	0.16	0.00
20.18	2.00	0.00	6.93	0.16	0.00	20.34	2.00	0.00	6.90	0.16	0.00
20.51	2.00	0.00	6.88	0.16	0.00	20.67	2.00	0.00	6.85	0.16	0.00
20.83	2.00	0.00	6.83	0.16	0.00	21.00	2.00	0.00	6.80	0.16	0.00
21.16	2.00	0.00	6.78	0.16	0.00	21.33	2.00	0.00	6.75	0.16	0.00
21.49	2.00	0.00	6.72	0.16	0.00	21.65	2.00	0.00	6.70	0.16	0.00
21.82	2.00	0.00	6.67	0.16	0.00	21.98	2.00	0.00	6.65	0.16	0.00
22.15	2.00	0.00	6.62	0.16	0.00	22.31	2.00	0.00	6.60	0.16	0.00
22.47	2.00	0.00	6.57	0.16	0.00	22.64	2.00	0.00	6.55	0.16	0.00

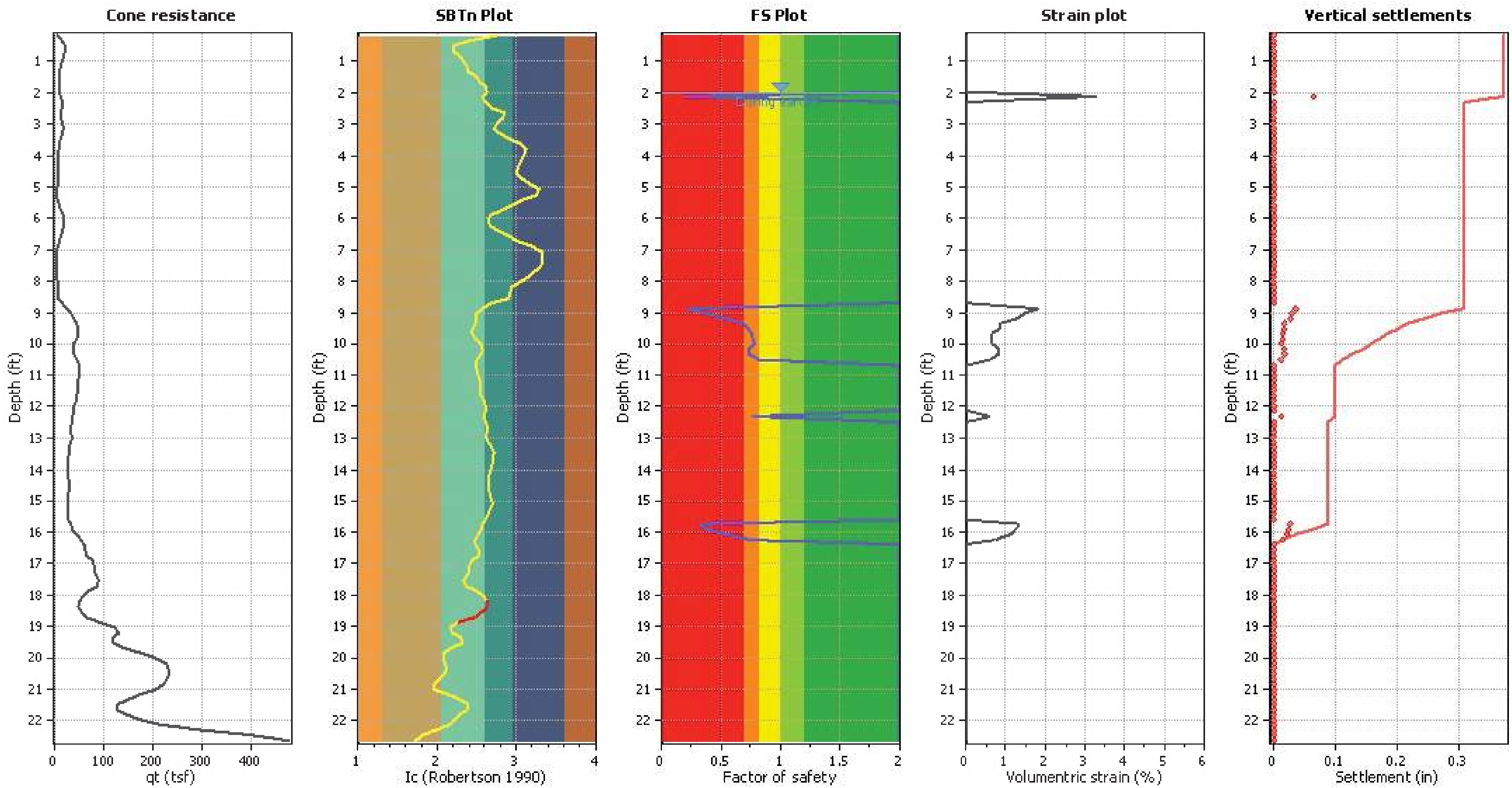
Overall liquefaction potential: 2.90

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
2.13	63.31	0.20	3.28	0.96	0.06	2.30	72.96	2.00	0.00	0.96	0.00
2.46	82.22	2.00	0.00	0.96	0.00	2.63	92.88	2.00	0.00	0.96	0.00
2.79	100.64	2.00	0.00	0.95	0.00	2.95	106.71	2.00	0.00	0.95	0.00
3.12	112.00	2.00	0.00	0.95	0.00	3.28	114.29	2.00	0.00	0.94	0.00
3.45	110.93	2.00	0.00	0.94	0.00	3.61	102.33	2.00	0.00	0.94	0.00
3.77	92.89	2.00	0.00	0.94	0.00	3.94	85.30	2.00	0.00	0.93	0.00
4.10	80.08	2.00	0.00	0.93	0.00	4.27	76.30	2.00	0.00	0.93	0.00
4.43	73.87	2.00	0.00	0.92	0.00	4.59	72.58	2.00	0.00	0.92	0.00
4.76	70.45	2.00	0.00	0.92	0.00	4.92	66.43	2.00	0.00	0.92	0.00
5.09	62.19	2.00	0.00	0.91	0.00	5.25	61.49	2.00	0.00	0.91	0.00
5.41	66.28	2.00	0.00	0.91	0.00	5.58	75.65	2.00	0.00	0.91	0.00
5.74	87.34	2.00	0.00	0.90	0.00	5.91	96.94	2.00	0.00	0.90	0.00
6.07	105.06	2.00	0.00	0.90	0.00	6.23	107.25	2.00	0.00	0.89	0.00
6.40	106.13	2.00	0.00	0.89	0.00	6.56	95.81	2.00	0.00	0.89	0.00
6.73	82.77	2.00	0.00	0.89	0.00	6.89	65.97	2.00	0.00	0.88	0.00
7.05	53.29	2.00	0.00	0.88	0.00	7.22	45.25	2.00	0.00	0.88	0.00
7.38	41.62	2.00	0.00	0.87	0.00	7.55	39.35	2.00	0.00	0.87	0.00
7.71	37.82	2.00	0.00	0.87	0.00	7.87	38.99	2.00	0.00	0.87	0.00
8.04	42.26	2.00	0.00	0.86	0.00	8.20	44.45	2.00	0.00	0.86	0.00
8.37	45.42	2.00	0.00	0.86	0.00	8.53	54.38	2.00	0.00	0.86	0.00
8.69	79.06	2.00	0.00	0.85	0.00	8.86	109.90	0.22	1.84	0.85	0.04
9.02	141.15	0.36	1.49	0.85	0.03	9.19	167.34	0.55	1.29	0.84	0.03
9.35	181.83	0.68	0.89	0.84	0.02	9.51	187.01	0.73	0.85	0.84	0.02
9.68	189.27	0.75	0.67	0.84	0.01	9.84	191.24	0.77	0.66	0.83	0.01
10.01	191.59	0.78	0.65	0.83	0.01	10.17	187.91	0.74	0.83	0.83	0.02
10.34	186.90	0.73	0.83	0.82	0.02	10.50	195.51	0.82	0.63	0.82	0.01
10.66	209.55	2.00	0.00	0.82	0.00	10.83	220.32	2.00	0.00	0.82	0.00
10.99	224.14	2.00	0.00	0.81	0.00	11.16	221.61	2.00	0.00	0.81	0.00
11.32	220.87	2.00	0.00	0.81	0.00	11.48	221.15	2.00	0.00	0.81	0.00
11.65	223.67	2.00	0.00	0.80	0.00	11.81	223.20	2.00	0.00	0.80	0.00
11.98	213.44	2.00	0.00	0.80	0.00	12.14	202.18	2.00	0.00	0.79	0.00
12.30	191.06	0.77	0.62	0.79	0.01	12.47	189.01	2.00	0.00	0.79	0.00
12.63	186.77	2.00	0.00	0.79	0.00	12.80	183.20	2.00	0.00	0.78	0.00
12.96	182.01	2.00	0.00	0.78	0.00	13.12	183.18	2.00	0.00	0.78	0.00
13.29	183.78	2.00	0.00	0.77	0.00	13.45	177.43	2.00	0.00	0.77	0.00
13.62	165.67	2.00	0.00	0.77	0.00	13.78	155.92	2.00	0.00	0.77	0.00
13.94	150.56	2.00	0.00	0.76	0.00	14.11	149.24	2.00	0.00	0.76	0.00
14.27	148.61	2.00	0.00	0.76	0.00	14.44	148.61	2.00	0.00	0.76	0.00
14.60	148.40	2.00	0.00	0.75	0.00	14.76	148.94	2.00	0.00	0.75	0.00
14.93	148.80	2.00	0.00	0.75	0.00	15.09	148.20	2.00	0.00	0.74	0.00
15.26	140.51	2.00	0.00	0.74	0.00	15.42	133.85	2.00	0.00	0.74	0.00
15.58	129.57	2.00	0.00	0.74	0.00	15.75	134.17	0.32	1.35	0.73	0.03
15.91	147.20	0.39	1.24	0.73	0.02	16.08	166.83	0.53	1.12	0.73	0.02
16.24	189.60	0.75	0.72	0.72	0.01	16.40	214.43	2.00	0.00	0.72	0.00
16.57	237.71	2.00	0.00	0.72	0.00	16.73	247.78	2.00	0.00	0.72	0.00
16.90	244.58	2.00	0.00	0.71	0.00	17.06	240.39	2.00	0.00	0.71	0.00
17.22	239.09	2.00	0.00	0.71	0.00	17.39	233.16	2.00	0.00	0.71	0.00
17.55	230.53	2.00	0.00	0.70	0.00	17.72	232.43	2.00	0.00	0.70	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
17.88	238.03	2.00	0.00	0.70	0.00	18.05	232.39	2.00	0.00	0.69	0.00
18.21	216.56	2.00	0.00	0.69	0.00	18.37	209.30	2.00	0.00	0.69	0.00
18.54	199.80	2.00	0.00	0.69	0.00	18.70	204.07	2.00	0.00	0.68	0.00
18.87	199.06	2.00	0.00	0.68	0.00	19.03	220.86	2.00	0.00	0.68	0.00
19.19	248.74	2.00	0.00	0.67	0.00	19.36	265.92	2.00	0.00	0.67	0.00
19.52	271.83	2.00	0.00	0.67	0.00	19.69	266.39	2.00	0.00	0.67	0.00
19.85	286.80	2.00	0.00	0.66	0.00	20.01	327.10	2.00	0.00	0.66	0.00
20.18	369.90	2.00	0.00	0.66	0.00	20.34	386.61	2.00	0.00	0.66	0.00
20.51	377.51	2.00	0.00	0.65	0.00	20.67	332.13	2.00	0.00	0.65	0.00
20.83	304.22	2.00	0.00	0.65	0.00	21.00	281.99	2.00	0.00	0.64	0.00
21.16	293.63	2.00	0.00	0.64	0.00	21.33	313.15	2.00	0.00	0.64	0.00
21.49	315.11	2.00	0.00	0.64	0.00	21.65	303.26	2.00	0.00	0.63	0.00
21.82	292.51	2.00	0.00	0.63	0.00	21.98	321.23	2.00	0.00	0.63	0.00
22.15	348.79	2.00	0.00	0.62	0.00	22.31	406.27	2.00	0.00	0.62	0.00
22.47	462.00	2.00	0.00	0.62	0.00	22.64	515.21	2.00	0.00	0.62	0.00

Total estimated settlement: 0.37

Abbreviations

$Q_{tn,cs}$: Equivalent clean sand normalized cone resistance
FS: Factor of safety against liquefaction
e_v (%): Post-liquefaction volumentric strain
DF: e_v depth weighting factor
Settlement: Calculated settlement

:: Strength loss calculation (Robertson (2009) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.16	6.68	10.71	4.45	47.65	2.76	N/A	N/A
0.33	13.63	21.87	2.26	49.49	2.39	N/A	N/A
0.49	19.38	31.09	1.70	52.98	2.21	N/A	N/A
0.66	19.66	31.53	1.69	53.16	2.21	N/A	N/A
0.82	16.18	25.93	1.89	48.97	2.28	N/A	N/A
0.98	13.13	21.01	1.00	21.01	2.33	N/A	N/A
1.15	11.01	17.60	2.21	38.84	2.37	N/A	N/A
1.31	9.80	15.64	2.27	35.49	2.39	N/A	N/A
1.48	8.87	14.14	2.65	37.48	2.48	N/A	N/A
1.64	8.62	13.72	2.97	40.77	2.54	N/A	N/A
1.80	8.72	13.87	3.37	46.76	2.61	N/A	N/A
1.97	10.08	16.04	3.53	56.67	2.63	N/A	N/A
2.13	12.46	19.86	3.19	63.31	2.58	0.11	0.62
2.30	13.69	21.81	3.35	72.96	2.60	8.03	8.03
2.46	13.22	21.05	3.91	82.22	2.69	7.18	7.18
2.63	11.22	17.82	5.21	92.88	2.85	5.66	5.66
2.79	12.67	20.12	5.00	100.64	2.83	5.98	5.98
2.95	15.17	24.13	4.42	106.71	2.76	6.72	6.72
3.12	17.23	27.43	4.08	112.00	2.71	7.19	7.19
3.28	15.52	24.66	4.63	114.29	2.78	6.10	6.10
3.45	12.34	19.54	5.68	110.93	2.90	4.58	4.58
3.61	9.05	14.24	7.19	102.33	3.04	3.18	3.18
3.77	7.27	11.36	8.17	92.89	3.12	2.42	2.42
3.94	6.81	10.61	8.04	85.30	3.11	2.16	2.16
4.10	6.85	10.67	7.51	80.08	3.07	2.09	2.09
4.27	6.87	10.68	7.14	76.30	3.03	2.01	2.01
4.43	6.90	10.72	6.89	73.87	3.01	1.94	1.94
4.59	6.76	10.47	6.93	72.58	3.02	1.83	1.83
4.76	5.91	9.10	7.74	70.45	3.09	1.53	1.53
4.92	4.72	7.18	9.25	66.43	3.20	0.77	1.17
5.09	3.93	5.89	10.55	62.19	3.29	0.60	0.93
5.25	4.09	6.14	10.02	61.49	3.25	0.55	0.94
5.41	5.59	8.52	7.78	66.28	3.09	0.62	1.26
5.58	8.07	12.50	6.05	75.65	2.94	1.80	1.80
5.74	10.93	17.08	5.11	87.34	2.84	2.38	2.38
5.91	16.16	25.47	3.81	96.94	2.67	3.45	3.45
6.07	18.58	29.35	3.58	105.06	2.64	3.86	3.86
6.23	18.26	28.82	3.72	107.25	2.66	3.68	3.68
6.40	14.32	22.47	4.72	106.13	2.79	2.79	2.79
6.56	10.61	16.49	5.81	95.81	2.91	1.99	1.99
6.73	7.67	11.76	7.04	82.77	3.03	1.39	1.39
6.89	4.86	7.23	9.13	65.97	3.19	0.50	0.83
7.05	3.34	4.77	11.18	53.29	3.33	0.26	0.54
7.22	2.93	4.10	11.04	45.25	3.32	0.20	0.45
7.38	2.72	3.75	11.09	41.62	3.32	0.15	0.41
7.55	2.67	3.67	10.73	39.35	3.30	0.13	0.39
7.71	2.86	3.96	9.55	37.82	3.22	0.11	0.41
7.87	3.20	4.50	8.67	38.99	3.16	0.08	0.46

:: Strength loss calculation (Robertson (2009) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
8.04	4.17	6.03	7.01	42.26	3.02	0.14	0.61
8.20	4.92	7.22	6.15	44.45	2.95	0.17	0.71
8.37	5.29	7.81	5.81	45.42	2.91	0.13	0.76
8.53	6.41	9.60	5.66	54.38	2.90	0.16	0.91
8.69	13.28	20.62	3.83	79.06	2.68	1.92	1.92
8.86	22.34	35.16	3.13	109.90	2.57	0.69	0.69
9.02	32.38	51.27	2.75	141.15	2.50	0.74	0.74
9.19	37.67	59.76	2.80	167.34	2.51	0.76	0.76
9.35	43.44	69.01	2.63	181.83	2.47	0.78	0.78
9.51	47.61	75.70	2.47	187.01	2.44	0.79	0.79
9.68	47.03	74.74	2.53	189.27	2.45	0.79	0.79
9.84	44.24	70.25	2.72	191.24	2.49	0.78	0.78
10.01	39.11	61.99	3.09	191.59	2.56	0.76	0.76
10.17	37.82	59.90	3.14	187.91	2.57	0.76	0.76
10.34	38.64	61.21	3.05	186.90	2.55	0.76	0.76
10.50	44.05	69.88	2.80	195.51	2.51	0.78	0.78
10.66	48.95	77.73	2.70	209.55	2.49	0.79	0.79
10.83	50.93	80.90	2.72	220.32	2.49	0.80	0.80
10.99	49.18	78.06	2.87	224.14	2.52	0.79	0.79
11.16	47.79	75.82	2.92	221.61	2.53	0.79	0.79
11.32	46.28	73.37	3.01	220.87	2.55	0.78	0.78
11.48	46.56	73.81	3.00	221.15	2.54	0.79	0.79
11.65	45.49	72.08	3.10	223.67	2.56	0.78	0.78
11.81	43.50	68.87	3.24	223.20	2.59	0.78	0.78
11.98	39.77	62.85	3.40	213.44	2.61	4.68	4.68
12.14	37.91	59.84	3.38	202.18	2.61	4.42	4.42
12.30	36.63	57.78	3.31	191.06	2.60	0.75	0.75
12.47	35.41	55.80	3.39	189.01	2.61	4.04	4.04
12.63	33.91	53.36	3.50	186.77	2.63	3.83	3.83
12.80	33.79	52.72	3.47	183.20	2.62	3.79	3.79
12.96	34.27	53.00	3.43	182.01	2.62	3.81	3.81
13.12	33.15	51.10	3.58	183.18	2.64	3.65	3.65
13.29	30.91	47.63	3.86	183.78	2.68	3.37	3.37
13.45	28.17	43.27	4.10	177.43	2.71	3.04	3.04
13.62	26.81	40.77	4.06	165.67	2.71	2.86	2.86
13.78	26.10	39.27	3.97	155.92	2.70	2.76	2.76
13.94	26.21	39.02	3.86	150.56	2.68	2.75	2.75
14.11	26.73	39.45	3.78	149.24	2.67	2.78	2.78
14.27	27.61	40.38	3.68	148.61	2.65	2.86	2.86
14.44	28.23	40.96	3.63	148.61	2.65	2.90	2.90
14.60	28.20	40.66	3.65	148.40	2.65	2.87	2.87
14.76	27.55	39.54	3.77	148.94	2.67	2.78	2.78
14.93	26.79	38.27	3.89	148.80	2.68	2.68	2.68
15.09	26.09	37.09	4.00	148.20	2.70	2.59	2.59
15.26	26.91	37.76	3.72	140.51	2.66	2.65	2.65
15.42	26.86	37.30	3.59	133.85	2.64	2.63	2.63
15.58	27.90	38.33	3.38	129.57	2.61	2.72	2.72
15.75	30.94	42.13	3.18	134.17	2.58	0.71	0.71

:: Strength loss calculation (Robertson (2009) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
15.91	36.13	48.83	3.01	147.20	2.55	0.73	0.73
16.08	43.86	58.82	2.84	166.83	2.51	0.76	0.76
16.24	53.83	71.55	2.65	189.60	2.48	0.78	0.78
16.40	60.00	79.49	2.70	214.43	2.49	0.80	0.80
16.57	62.57	82.83	2.87	237.71	2.52	0.80	0.80
16.73	65.77	86.52	2.86	247.78	2.52	0.81	0.81
16.90	76.08	98.41	2.49	244.58	2.44	0.83	0.83
17.06	81.10	103.68	2.32	240.39	2.40	0.83	0.83
17.22	79.29	100.88	2.37	239.09	2.41	0.83	0.83
17.39	84.94	106.75	2.18	233.16	2.37	0.84	0.84
17.55	88.27	109.94	2.10	230.53	2.34	0.84	0.84
17.72	86.04	106.80	2.18	232.43	2.37	0.84	0.84
17.88	67.71	84.90	2.80	238.03	2.51	0.80	0.80
18.05	55.50	69.79	3.33	232.39	2.60	4.88	4.88
18.21	49.57	62.00	3.49	216.56	2.63	4.31	4.31
18.37	47.58	59.14	3.54	209.30	2.63	4.11	4.11
18.54	51.91	63.70	3.14	199.80	2.57	0.77	0.77
18.70	62.11	75.25	2.71	204.07	2.49	0.79	0.79
18.87	93.96	110.63	1.80	199.06	2.25	0.84	0.84
19.03	120.42	139.91	1.58	220.86	2.16	0.88	0.88
19.19	131.10	152.06	1.64	248.74	2.19	0.89	0.89
19.36	118.26	137.93	1.93	265.92	2.29	0.87	0.87
19.52	118.19	137.32	1.98	271.83	2.31	0.87	0.87
19.69	140.95	161.11	1.65	266.39	2.19	0.90	0.90
19.85	178.12	200.58	1.43	286.80	2.09	0.93	0.93
20.01	205.32	230.10	1.42	327.10	2.08	0.95	0.95
20.18	229.73	256.60	1.44	369.90	2.09	0.97	0.97
20.34	231.17	257.68	1.50	386.61	2.12	0.97	0.97
20.51	235.07	260.09	1.45	377.51	2.10	0.97	0.97
20.67	227.44	248.74	1.34	332.13	2.03	0.96	0.96
20.83	223.34	241.83	1.26	304.22	1.97	0.96	0.96
21.00	205.97	222.10	1.27	281.99	1.98	0.95	0.95
21.16	175.79	191.06	1.54	293.63	2.14	0.92	0.92
21.33	149.14	162.97	1.92	313.15	2.29	0.90	0.90
21.49	128.21	140.13	2.25	315.11	2.38	0.88	0.88
21.65	128.39	139.36	2.18	303.26	2.37	0.87	0.87
21.82	145.20	155.96	1.88	292.51	2.28	0.89	0.89
21.98	178.45	190.13	1.69	321.23	2.21	0.92	0.92
22.15	212.43	224.60	1.55	348.79	2.15	0.95	0.95
22.31	309.44	322.54	1.26	406.27	1.97	1.01	1.01
22.47	397.85	409.87	1.13	462.00	1.83	1.05	1.05
22.64	478.59	488.54	1.05	515.21	1.72	1.08	1.08

Abbreviations

q_t:	Total cone resistance
K_c:	Cone resistance correction factor due to fines
$Q_{tn,cs}$:	Adjusted and corrected cone resistance due to fines
I_c:	Soil behavior type index
$S_{u(liq)}/\sigma'_v$:	Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$:	Calculated peak undrained strength ratio

A3GEO, Inc.
Geoconsultants
Berkeley, CA
www.a3geo.com

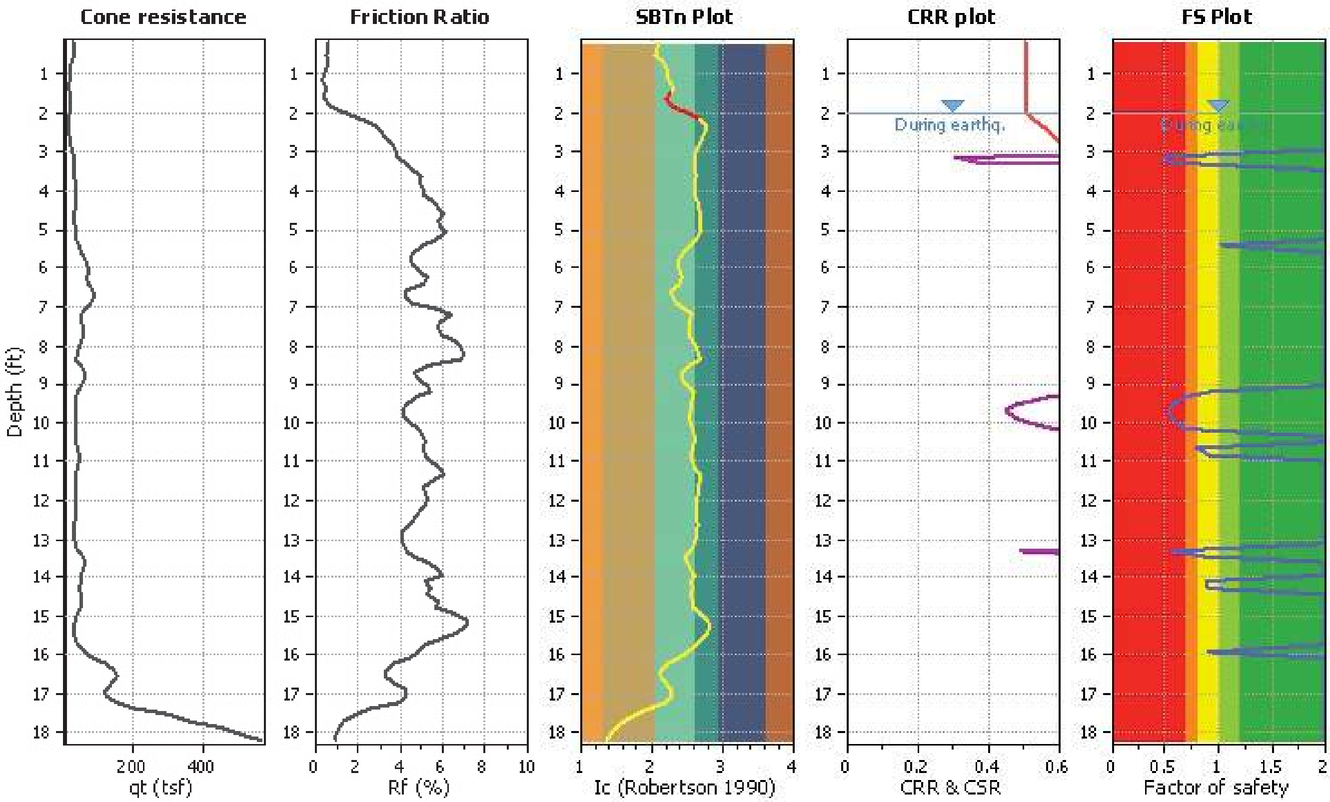
LIQUEFACTION ANALYSIS REPORT

Project title : Terra Linda High School **Location : San Rafael, CA**

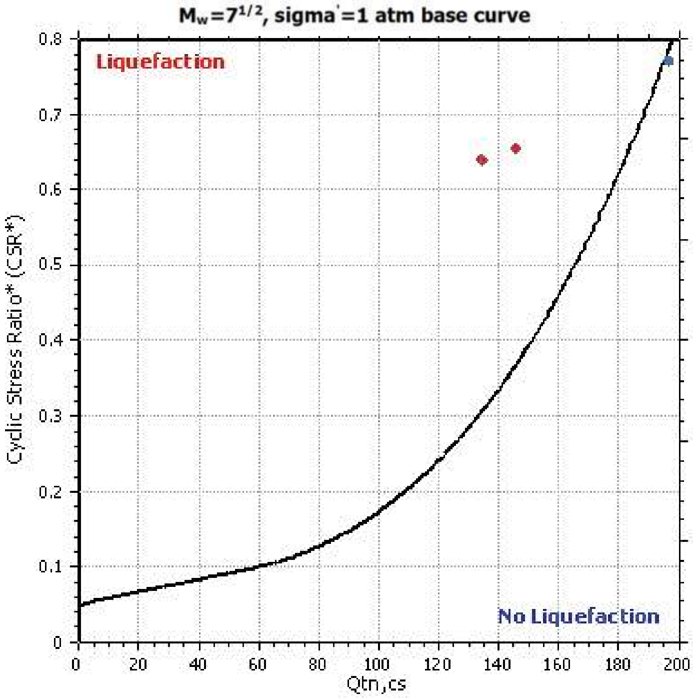
CPT file : CPT-04

Input parameters and analysis data

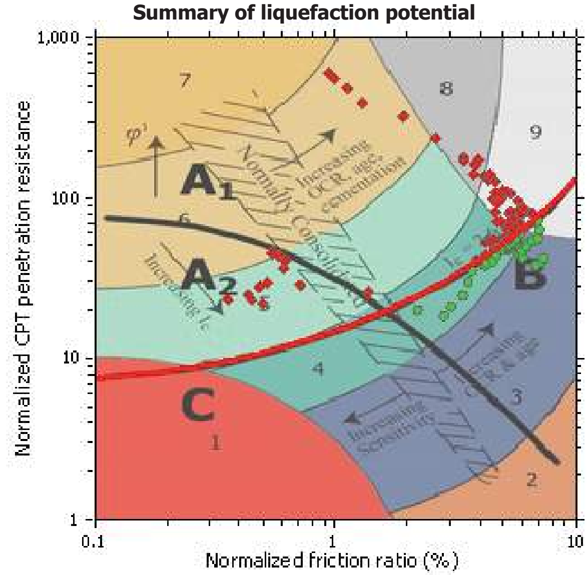
Analysis method:	NCEER (1998)	G.W.T. (in-situ):	9.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		



$M_w=7^{1/2}$, sigma'=1 atm base curve

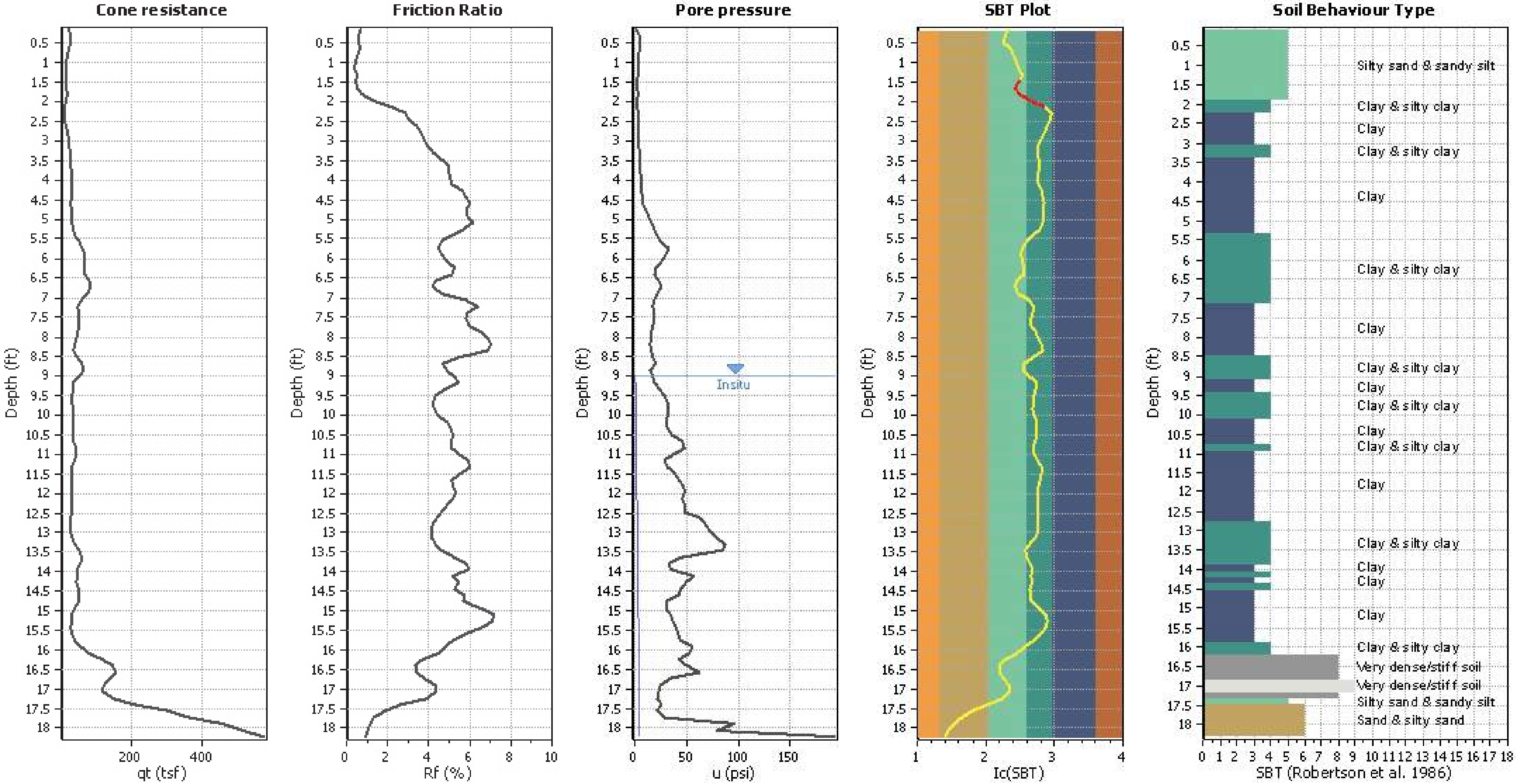


Summary of liquefaction potential



Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



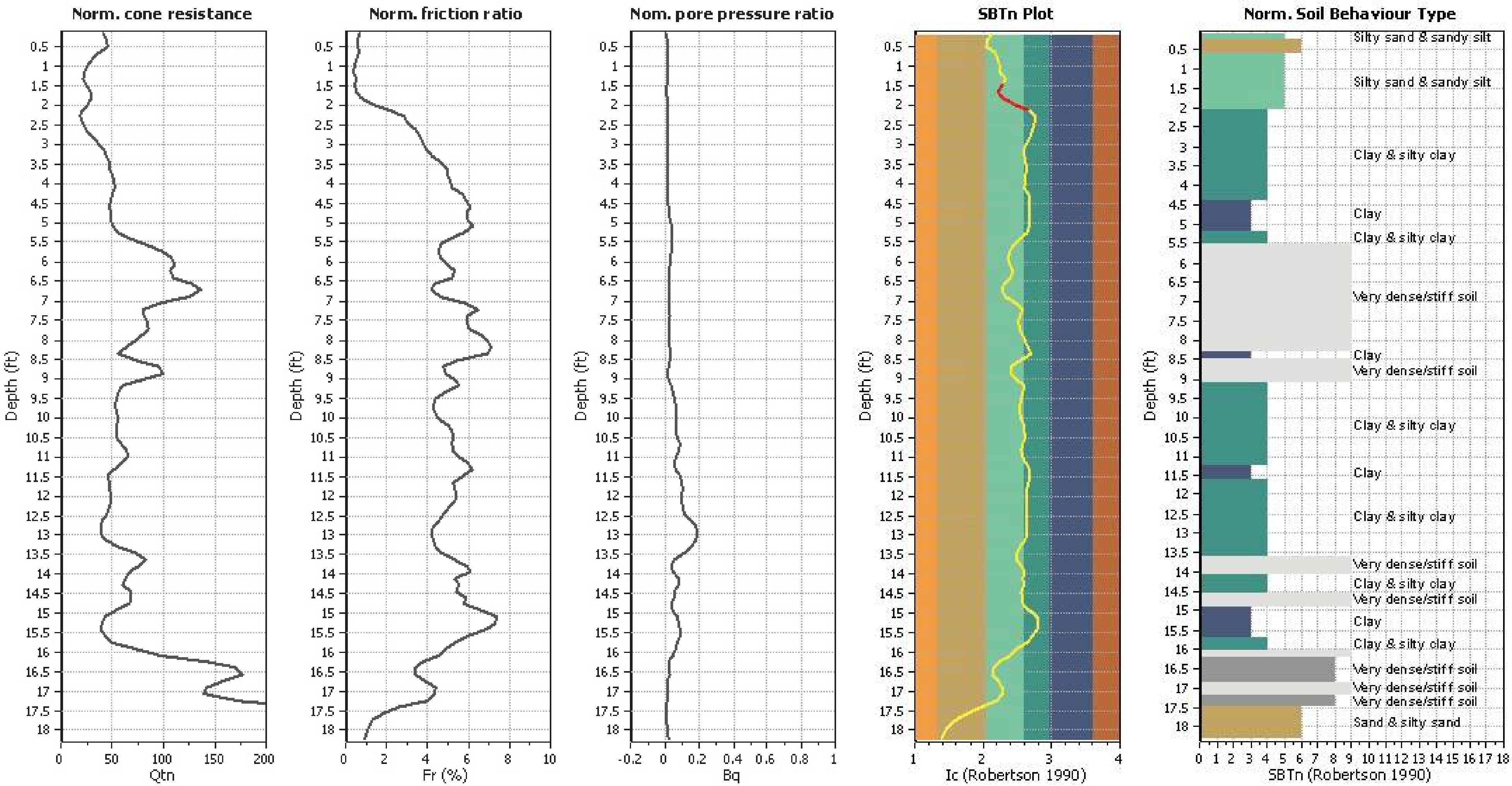
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normaliz



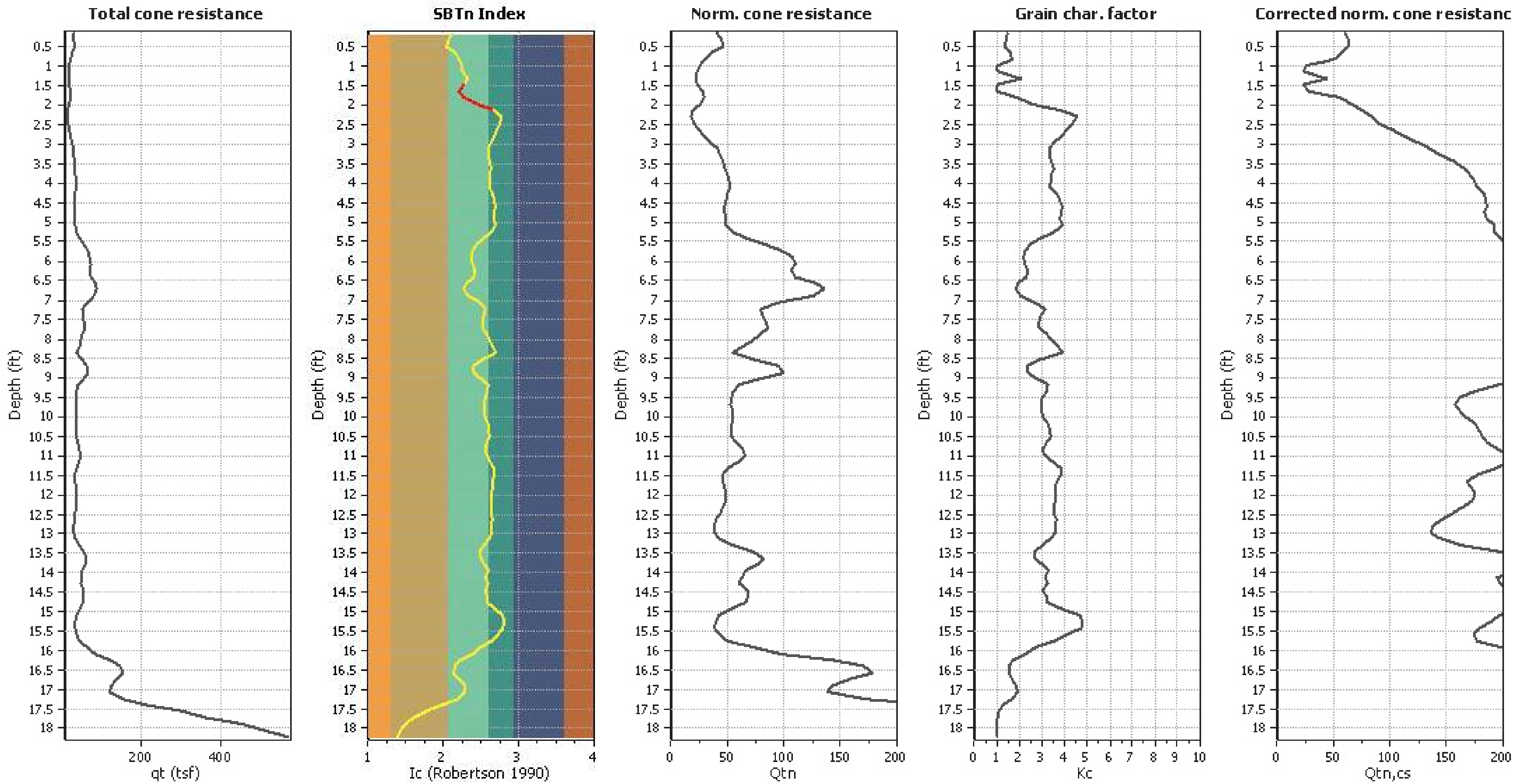
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

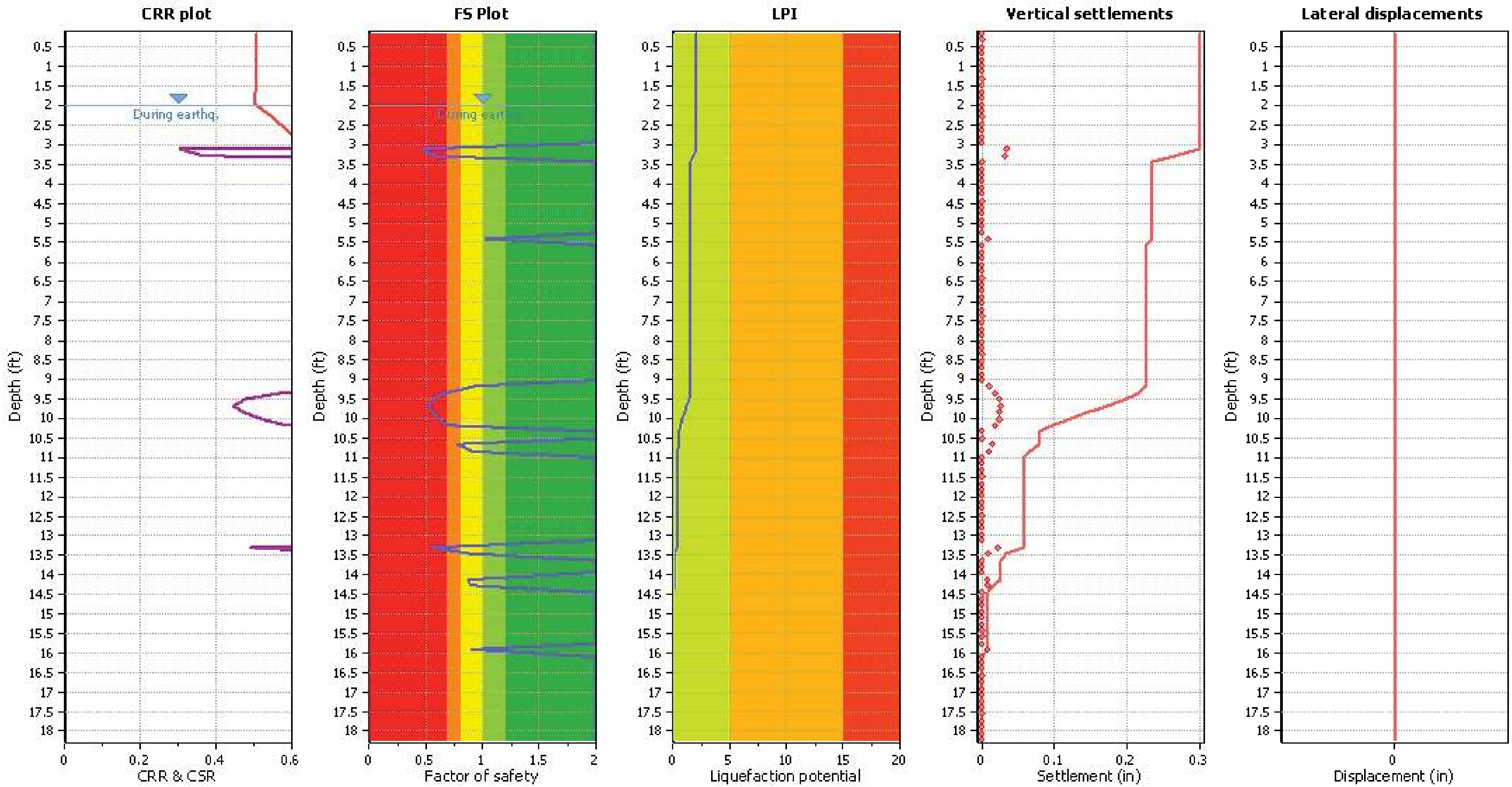
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

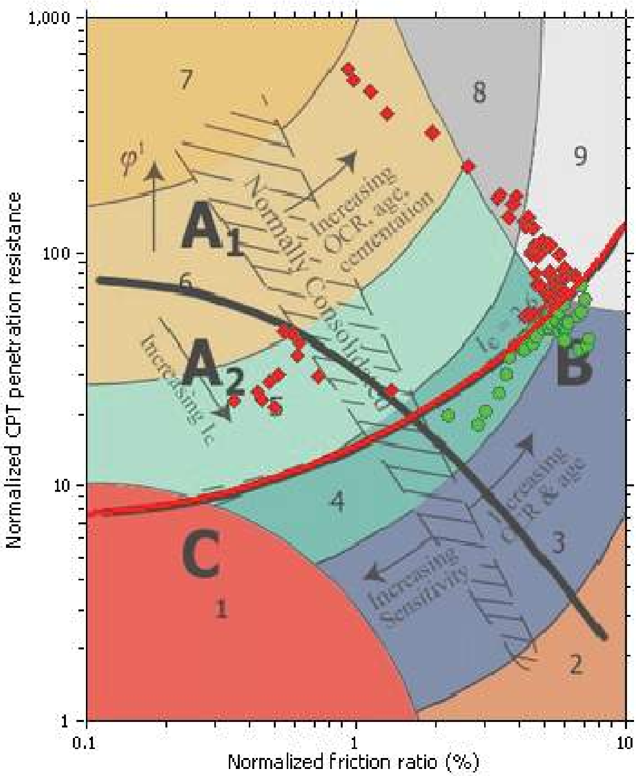
F.S. color scheme

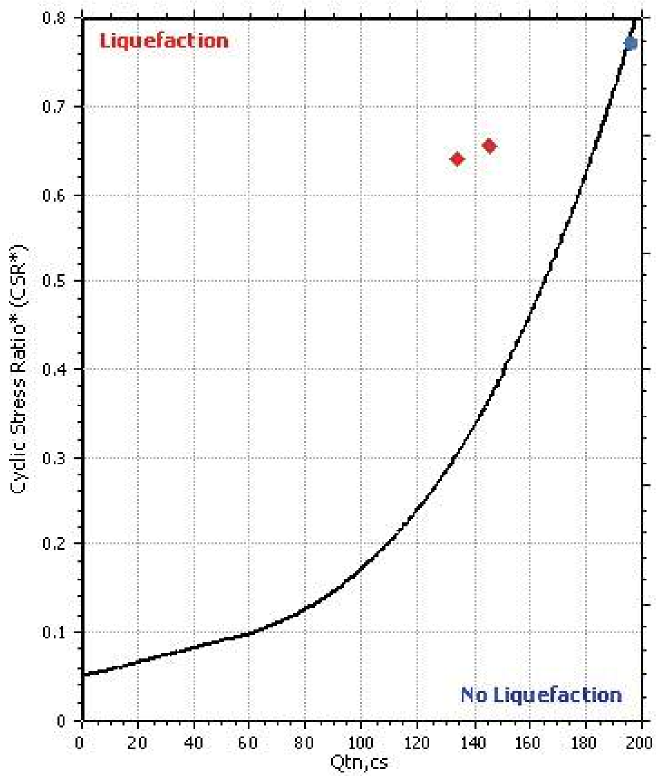
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

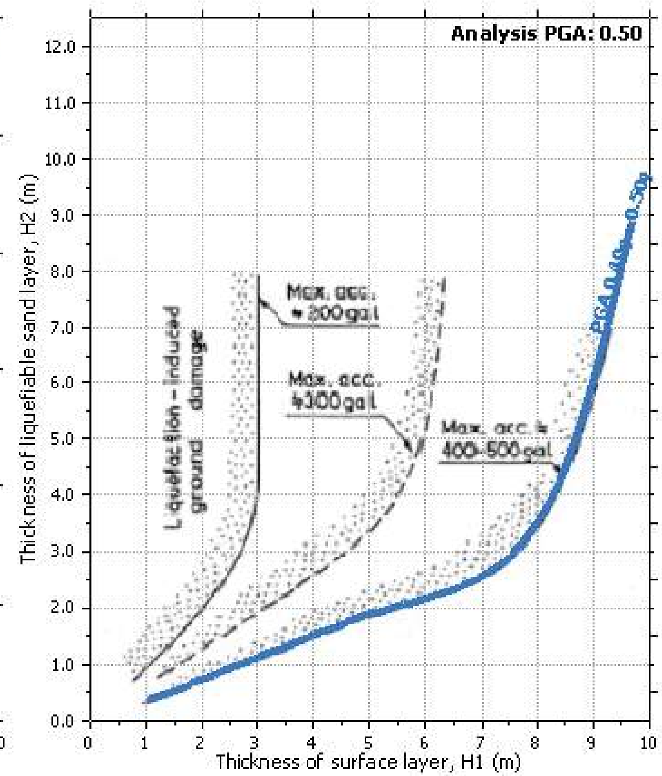
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo



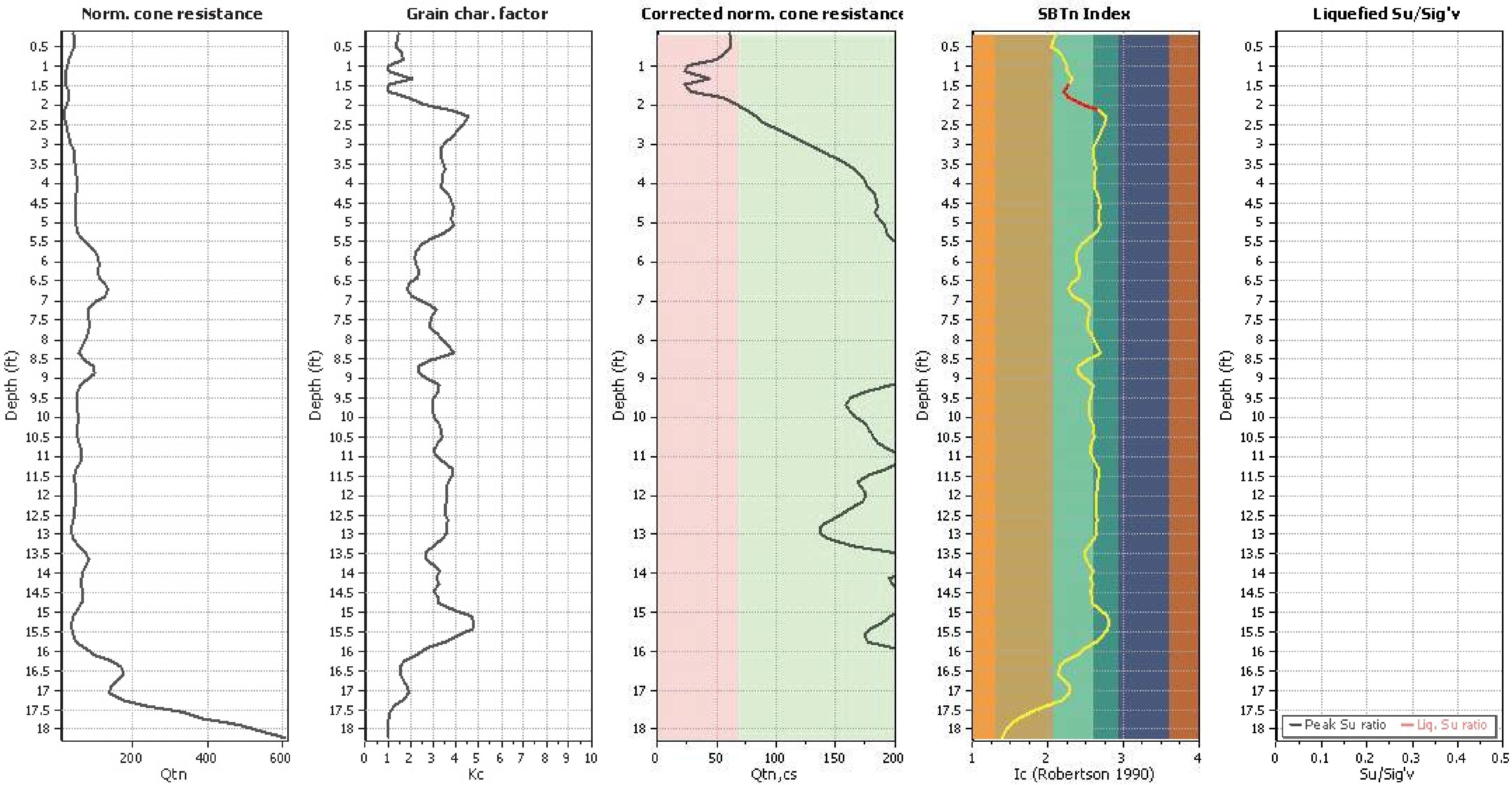




Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

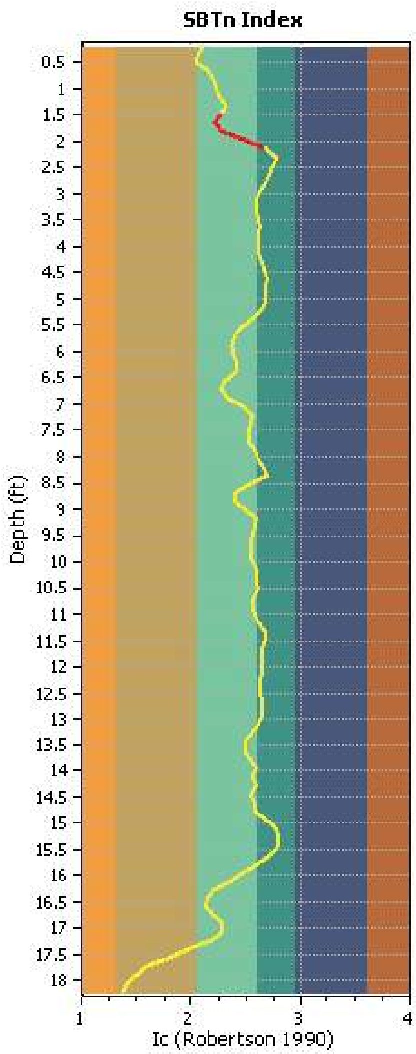
Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

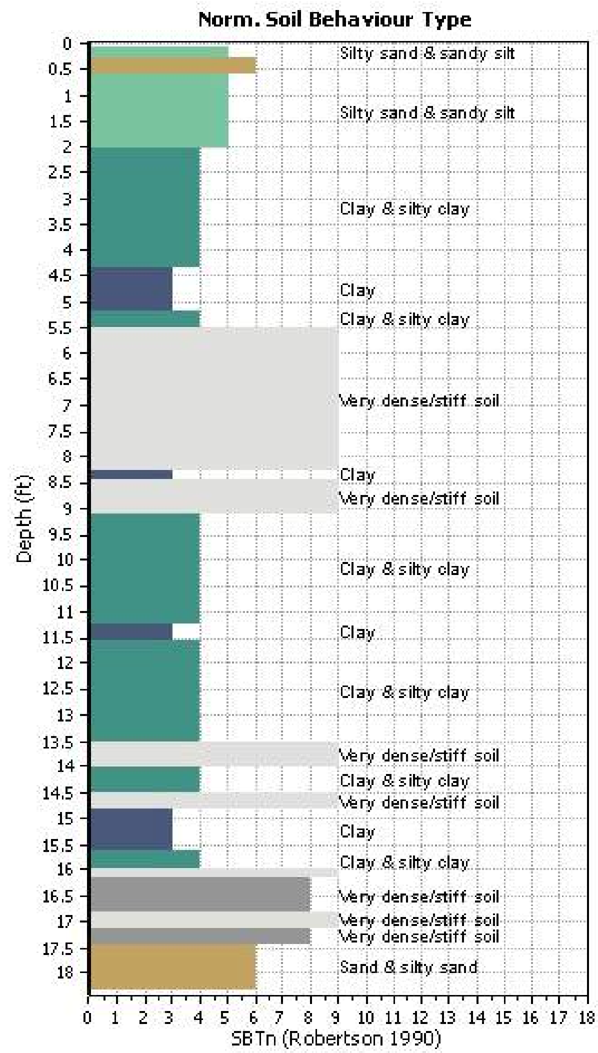
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0250
Minimum number of points in layer:	5

General statistics

Total points in CPT file:	111
Total points excluded:	5
Exclusion percentage:	4.50%
Number of layers detected:	1

Transition layer No	Number of points	Depth	SBT_n number	SBT_n description
Transition layer 1	5	Start depth: 1.64 (ft)	5	Silty sand & sandy silt
		End depth: 2.30 (ft)	4	Clay & silty clay

Start depth: Depth where the transition layer begins
End depth: Depth where the transition layer ends

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.16	20.75	0.15	1.89	16.34	104.64
2	0.33	34.59	0.17	4.02	14.90	105.05
3	0.49	27.96	0.17	4.19	14.27	104.78
4	0.66	22.54	0.13	4.11	17.68	103.42
5	0.82	17.20	0.12	3.20	19.17	100.25
6	0.98	15.72	0.04	2.83	5.00	97.32
7	1.15	14.04	0.05	3.30	5.00	94.95
8	1.31	13.26	0.07	2.20	23.35	96.97
9	1.48	13.48	0.09	1.73	5.00	96.98
10	1.64	17.34	0.04	1.61	5.00	99.09
11	1.80	21.45	0.12	2.38	21.71	102.50
12	1.97	15.80	0.23	2.07	29.24	105.87
13	2.13	10.74	0.30	2.00	39.31	106.91
14	2.30	10.65	0.28	2.12	44.62	107.89
15	2.46	12.61	0.38	2.35	43.22	109.71
16	2.63	15.46	0.52	2.73	41.36	112.23
17	2.79	18.40	0.67	2.65	39.15	114.48
18	2.95	21.90	0.82	2.67	36.93	116.39
19	3.12	25.67	0.98	2.99	35.27	118.01
20	3.28	28.30	1.14	3.61	35.16	119.43
21	3.45	28.64	1.35	3.93	35.69	120.53
22	3.61	29.92	1.48	4.08	36.74	121.32
23	3.77	29.92	1.57	4.10	35.75	121.94
24	3.94	34.54	1.63	5.10	35.74	122.31
25	4.10	32.13	1.69	5.51	35.66	122.61
26	4.27	31.94	1.74	6.00	37.82	122.84
27	4.43	30.06	1.87	6.73	38.90	122.85
28	4.59	29.53	1.75	7.16	39.92	122.77
29	4.76	29.06	1.74	9.40	39.20	122.65
30	4.92	31.01	1.75	12.30	39.11	122.95
31	5.09	31.35	1.93	15.00	39.81	123.34
32	5.25	29.42	2.02	17.77	36.86	123.79
33	5.41	41.33	1.90	21.79	32.50	124.83
34	5.58	52.63	2.42	24.55	28.36	126.14
35	5.74	58.25	2.75	33.13	25.81	127.81
36	5.91	73.46	3.17	29.64	25.19	128.82
37	6.07	69.52	3.39	25.15	25.83	129.57
38	6.23	63.95	3.66	20.29	27.29	129.70
39	6.40	65.35	3.49	18.07	26.55	129.80
40	6.56	75.98	3.43	22.60	22.58	130.01
41	6.73	98.18	3.43	25.35	21.66	130.35
42	6.89	79.45	3.77	20.88	23.63	130.28
43	7.05	57.05	3.60	17.68	29.48	129.44
44	7.22	45.89	3.10	16.93	33.78	128.31
45	7.38	45.75	2.89	17.77	32.33	127.84
46	7.55	58.95	2.97	18.38	31.53	128.11
47	7.71	52.35	3.31	17.17	31.68	128.49
48	7.87	48.99	3.32	15.85	34.19	128.40

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	8.04	46.67	3.10	14.99	36.29	127.80
50	8.20	38.59	2.84	14.44	38.47	126.77
51	8.37	33.22	2.44	15.97	40.02	125.29
52	8.53	31.77	1.88	16.61	31.84	126.33
53	8.69	74.02	3.17	19.58	26.88	127.77
54	8.86	72.60	3.34	13.60	26.86	128.53
55	9.02	40.88	2.65	16.27	30.58	126.90
56	9.19	36.41	1.90	18.65	35.07	124.42
57	9.35	34.98	1.64	23.53	34.19	122.58
58	9.51	31.32	1.41	27.54	33.06	121.61
59	9.68	33.67	1.33	31.31	32.50	121.29
60	9.84	34.62	1.45	30.64	32.42	121.68
61	10.01	33.89	1.61	31.15	33.19	122.20
62	10.17	34.62	1.64	29.50	34.84	122.64
63	10.34	32.44	1.78	31.66	35.47	122.81
64	10.50	33.19	1.74	35.06	35.72	123.14
65	10.66	35.99	1.84	44.46	34.46	123.83
66	10.83	41.11	2.15	47.99	33.06	125.07
67	10.99	47.65	2.52	38.77	33.90	125.69
68	11.16	38.20	2.38	28.43	36.22	125.33
69	11.32	30.45	2.01	30.54	39.16	123.87
70	11.48	29.28	1.60	38.77	39.43	122.53
71	11.65	29.89	1.53	42.98	37.81	122.02
72	11.81	31.88	1.63	46.69	37.65	122.43
73	11.98	32.22	1.82	47.24	37.50	122.92
74	12.14	33.45	1.81	45.13	37.28	122.82
75	12.30	32.13	1.55	48.26	37.06	122.10
76	12.47	28.97	1.39	47.66	37.08	121.06
77	12.63	27.66	1.25	62.99	37.74	120.03
78	12.80	25.28	1.10	67.09	37.53	119.21
79	12.96	25.48	1.04	72.20	37.32	119.10
80	13.12	27.69	1.20	77.55	35.85	120.31
81	13.29	34.84	1.55	87.72	32.55	123.23
82	13.45	53.97	2.40	84.88	30.02	126.55
83	13.62	67.59	3.43	45.49	30.27	128.72
84	13.78	57.80	3.67	32.93	32.72	128.86
85	13.94	43.18	2.80	34.07	35.06	127.64
86	14.11	44.63	2.33	56.48	33.64	126.16
87	14.27	50.81	2.17	49.58	34.92	126.16
88	14.44	38.14	2.89	43.60	32.92	127.16
89	14.60	62.75	3.06	41.73	34.15	127.95
90	14.76	53.38	3.06	29.98	34.26	127.60
91	14.93	34.90	2.54	29.10	39.80	126.35
92	15.09	31.46	2.28	33.57	45.24	124.82
93	15.26	28.36	2.08	36.71	46.17	124.10
94	15.42	28.86	2.02	39.37	45.53	123.39
95	15.58	29.25	1.74	41.30	41.72	123.56
96	15.75	38.42	2.00	43.91	36.87	124.61

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	15.91	49.97	2.49	54.46	30.68	127.59
98	16.08	82.44	3.79	52.02	25.93	130.28
99	16.24	105.96	4.44	41.73	19.85	132.79
100	16.40	166.47	5.01	48.90	17.18	134.00
101	16.57	159.87	5.19	61.73	16.87	134.50
102	16.73	128.05	5.22	34.16	19.09	134.26
103	16.90	118.90	5.07	24.17	21.79	134.08
104	17.06	114.51	5.42	22.00	21.98	133.86
105	17.22	121.14	4.86	21.75	18.80	135.48
106	17.39	214.65	7.40	25.10	12.29	135.69
107	17.55	288.14	4.06	20.72	7.74	136.90
108	17.72	389.52	5.63	27.57	4.34	136.02
109	17.88	410.27	4.50	95.89	2.80	137.08
110	18.05	548.86	5.14	79.43	1.72	137.28
111	18.21	576.04	5.48	193.16	1.27	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.16	0.01	0.00	0.01	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
2	0.33	0.02	0.00	0.02	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
3	0.49	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
4	0.66	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
5	0.82	0.04	0.00	0.04	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
6	0.98	0.05	0.00	0.05	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
7	1.15	0.06	0.00	0.06	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
8	1.31	0.07	0.00	0.07	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
9	1.48	0.07	0.00	0.07	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
10	1.64	0.08	0.00	0.08	1.00	0.324	0.83	0.389	1.00	1.30	2.000	Yes
11	1.80	0.09	0.00	0.09	1.00	0.324	0.83	0.389	1.00	1.30	2.000	Yes
12	1.97	0.10	0.00	0.10	1.00	0.324	0.83	0.389	1.00	1.30	2.000	Yes
13	2.13	0.11	0.00	0.10	1.00	0.337	0.83	0.404	1.00	1.30	2.000	Yes
14	2.30	0.12	0.01	0.11	1.00	0.352	0.83	0.422	1.00	1.30	2.000	Yes
15	2.46	0.13	0.01	0.11	1.00	0.365	0.83	0.438	1.00	1.30	0.570	No
16	2.63	0.14	0.02	0.12	1.00	0.378	0.83	0.453	1.00	1.30	0.590	No
17	2.79	0.14	0.02	0.12	1.00	0.390	0.83	0.467	1.00	1.30	0.608	No
18	2.95	0.15	0.03	0.12	1.00	0.401	0.83	0.480	1.00	1.30	0.625	No
19	3.12	0.16	0.03	0.13	0.99	0.411	0.83	0.492	1.00	1.30	0.640	No
20	3.28	0.17	0.04	0.13	0.99	0.420	0.83	0.503	1.00	1.30	0.654	No
21	3.45	0.18	0.05	0.14	0.99	0.428	0.83	0.513	1.00	1.30	0.667	No
22	3.61	0.19	0.05	0.14	0.99	0.436	0.83	0.523	1.00	1.30	0.680	No
23	3.77	0.20	0.06	0.15	0.99	0.443	0.83	0.532	1.00	1.30	0.691	No
24	3.94	0.21	0.06	0.15	0.99	0.450	0.83	0.540	1.00	1.30	0.701	No
25	4.10	0.22	0.07	0.16	0.99	0.456	0.83	0.547	1.00	1.30	0.711	No
26	4.27	0.23	0.07	0.16	0.99	0.462	0.83	0.554	1.00	1.30	0.720	No
27	4.43	0.24	0.08	0.17	0.99	0.468	0.83	0.561	1.00	1.30	0.729	No
28	4.59	0.25	0.08	0.17	0.99	0.473	0.83	0.567	1.00	1.30	0.737	No
29	4.76	0.26	0.09	0.18	0.99	0.478	0.83	0.573	1.00	1.30	0.745	No
30	4.92	0.27	0.09	0.18	0.99	0.482	0.83	0.578	1.00	1.30	0.752	No
31	5.09	0.28	0.10	0.19	0.99	0.487	0.83	0.584	1.00	1.30	0.759	No
32	5.25	0.29	0.10	0.19	0.99	0.491	0.83	0.588	1.00	1.30	0.765	No
33	5.41	0.30	0.11	0.20	0.99	0.494	0.83	0.593	1.00	1.30	0.771	No
34	5.58	0.31	0.11	0.20	0.99	0.498	0.83	0.597	1.00	1.30	0.776	No
35	5.74	0.33	0.12	0.21	0.99	0.501	0.83	0.601	1.00	1.30	0.781	No
36	5.91	0.34	0.12	0.21	0.99	0.504	0.83	0.604	1.00	1.30	0.786	No
37	6.07	0.35	0.13	0.22	0.99	0.507	0.83	0.608	1.00	1.30	0.790	No
38	6.23	0.36	0.13	0.23	0.99	0.509	0.83	0.611	1.00	1.30	0.794	No
39	6.40	0.37	0.14	0.23	0.99	0.512	0.83	0.614	1.00	1.30	0.798	No
40	6.56	0.38	0.14	0.24	0.99	0.514	0.83	0.616	1.00	1.30	0.801	No
41	6.73	0.39	0.15	0.24	0.99	0.516	0.83	0.619	1.00	1.30	0.805	No
42	6.89	0.40	0.15	0.25	0.99	0.518	0.83	0.621	1.00	1.30	0.808	No
43	7.05	0.41	0.16	0.25	0.99	0.520	0.83	0.624	1.00	1.30	0.811	No
44	7.22	0.42	0.16	0.26	0.99	0.522	0.83	0.626	1.00	1.30	0.814	No
45	7.38	0.43	0.17	0.26	0.98	0.524	0.83	0.628	1.00	1.30	0.817	No
46	7.55	0.44	0.17	0.27	0.98	0.526	0.83	0.631	1.00	1.30	0.820	No
47	7.71	0.45	0.18	0.27	0.98	0.528	0.83	0.633	1.00	1.30	0.822	No
48	7.87	0.46	0.18	0.28	0.98	0.529	0.83	0.635	1.00	1.30	0.825	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
49	8.04	0.47	0.19	0.29	0.98	0.531	0.83	0.636	1.00	1.30	0.827	No
50	8.20	0.48	0.19	0.29	0.98	0.532	0.83	0.638	1.00	1.30	0.830	No
51	8.37	0.49	0.20	0.30	0.98	0.534	0.83	0.640	1.00	1.30	0.832	No
52	8.53	0.50	0.20	0.30	0.98	0.536	0.83	0.642	1.00	1.30	0.835	No
53	8.69	0.51	0.21	0.31	0.98	0.537	0.83	0.644	1.00	1.30	0.837	No
54	8.86	0.53	0.21	0.31	0.98	0.538	0.83	0.645	1.00	1.30	0.839	No
55	9.02	0.54	0.22	0.32	0.98	0.539	0.83	0.647	1.00	1.30	0.841	No
56	9.19	0.55	0.22	0.32	0.98	0.541	0.83	0.648	1.00	1.30	0.843	No
57	9.35	0.56	0.23	0.33	0.98	0.542	0.83	0.650	1.00	1.30	0.845	No
58	9.51	0.57	0.23	0.33	0.98	0.544	0.83	0.652	1.00	1.30	0.848	No
59	9.68	0.58	0.24	0.34	0.98	0.545	0.83	0.654	1.00	1.30	0.850	No
60	9.84	0.59	0.24	0.34	0.98	0.546	0.83	0.655	1.00	1.30	0.852	No
61	10.01	0.60	0.25	0.35	0.98	0.548	0.83	0.657	1.00	1.30	0.854	No
62	10.17	0.61	0.25	0.35	0.98	0.549	0.83	0.658	1.00	1.30	0.856	No
63	10.34	0.62	0.26	0.36	0.98	0.550	0.83	0.660	1.00	1.30	0.858	No
64	10.50	0.63	0.27	0.36	0.98	0.551	0.83	0.661	1.00	1.30	0.859	No
65	10.66	0.64	0.27	0.37	0.98	0.552	0.83	0.662	1.00	1.30	0.861	No
66	10.83	0.65	0.28	0.37	0.98	0.553	0.83	0.663	1.00	1.30	0.862	No
67	10.99	0.66	0.28	0.38	0.98	0.554	0.83	0.664	1.00	1.30	0.864	No
68	11.16	0.67	0.29	0.38	0.98	0.555	0.83	0.665	1.00	1.30	0.865	No
69	11.32	0.68	0.29	0.39	0.98	0.556	0.83	0.666	1.00	1.30	0.866	No
70	11.48	0.69	0.30	0.39	0.98	0.557	0.83	0.668	1.00	1.30	0.868	No
71	11.65	0.70	0.30	0.40	0.98	0.558	0.83	0.669	1.00	1.30	0.869	No
72	11.81	0.71	0.31	0.40	0.98	0.559	0.83	0.670	1.00	1.30	0.871	No
73	11.98	0.72	0.31	0.41	0.97	0.559	0.83	0.671	1.00	1.30	0.872	No
74	12.14	0.73	0.32	0.41	0.97	0.560	0.83	0.672	1.00	1.30	0.873	No
75	12.30	0.74	0.32	0.42	0.97	0.561	0.83	0.673	1.00	1.30	0.875	No
76	12.47	0.75	0.33	0.42	0.97	0.562	0.83	0.674	1.00	1.30	0.876	No
77	12.63	0.76	0.33	0.43	0.97	0.563	0.83	0.675	1.00	1.30	0.877	No
78	12.80	0.77	0.34	0.43	0.97	0.564	0.83	0.676	1.00	1.30	0.879	No
79	12.96	0.78	0.34	0.44	0.97	0.565	0.83	0.677	1.00	1.30	0.880	No
80	13.12	0.79	0.35	0.44	0.97	0.565	0.83	0.678	1.00	1.30	0.881	No
81	13.29	0.80	0.35	0.44	0.97	0.566	0.83	0.679	1.00	1.30	0.882	No
82	13.45	0.81	0.36	0.45	0.97	0.567	0.83	0.679	1.00	1.30	0.883	No
83	13.62	0.82	0.36	0.46	0.97	0.567	0.83	0.680	1.00	1.30	0.884	No
84	13.78	0.83	0.37	0.46	0.97	0.567	0.83	0.680	1.00	1.30	0.884	No
85	13.94	0.84	0.37	0.47	0.97	0.568	0.83	0.681	1.00	1.30	0.885	No
86	14.11	0.85	0.38	0.47	0.97	0.568	0.83	0.681	1.00	1.30	0.885	No
87	14.27	0.86	0.38	0.48	0.97	0.568	0.83	0.682	1.00	1.30	0.886	No
88	14.44	0.87	0.39	0.48	0.97	0.569	0.83	0.682	1.00	1.30	0.887	No
89	14.60	0.88	0.39	0.49	0.97	0.569	0.83	0.682	1.00	1.30	0.887	No
90	14.76	0.89	0.40	0.49	0.97	0.569	0.83	0.683	1.00	1.30	0.888	No
91	14.93	0.90	0.40	0.50	0.97	0.570	0.83	0.683	1.00	1.30	0.888	No
92	15.09	0.91	0.41	0.50	0.97	0.570	0.83	0.684	1.00	1.30	0.889	No
93	15.26	0.92	0.41	0.51	0.97	0.571	0.83	0.684	1.00	1.30	0.889	No
94	15.42	0.93	0.42	0.51	0.97	0.571	0.83	0.685	1.00	1.30	0.890	No
95	15.58	0.94	0.42	0.52	0.97	0.571	0.83	0.685	1.00	1.30	0.891	No
96	15.75	0.95	0.43	0.52	0.97	0.572	0.83	0.686	1.00	1.30	0.891	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
97	15.91	0.96	0.43	0.53	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
98	16.08	0.97	0.44	0.53	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
99	16.24	0.98	0.44	0.54	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
100	16.40	1.00	0.45	0.55	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
101	16.57	1.01	0.45	0.55	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
102	16.73	1.02	0.46	0.56	0.96	0.572	0.83	0.686	1.00	1.30	0.891	No
103	16.90	1.03	0.46	0.56	0.96	0.572	0.83	0.686	1.00	1.30	0.891	No
104	17.06	1.04	0.47	0.57	0.96	0.572	0.83	0.686	1.00	1.30	0.891	No
105	17.22	1.05	0.47	0.58	0.96	0.572	0.83	0.685	1.00	1.30	0.891	No
106	17.39	1.06	0.48	0.58	0.96	0.571	0.83	0.685	1.00	1.30	0.891	No
107	17.55	1.07	0.49	0.59	0.96	0.571	0.83	0.685	1.00	1.30	0.891	No
108	17.72	1.08	0.49	0.59	0.96	0.571	0.83	0.685	1.00	1.30	0.890	No
109	17.88	1.10	0.50	0.60	0.96	0.571	0.83	0.685	1.00	1.30	0.890	No
110	18.05	1.11	0.50	0.61	0.96	0.571	0.83	0.684	1.00	1.30	0.890	No
111	18.21	1.12	0.51	0.61	0.96	0.571	0.83	0.684	1.00	1.30	0.889	No

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.16	25.40	2.12	0.62	0.68	40.80	1.49	60.67	4.000	No	No	2.00
2	0.33	27.82	2.07	0.58	0.66	44.66	1.40	62.61	4.000	No	No	2.00
3	0.49	28.42	2.05	0.54	0.66	45.63	1.37	62.39	4.000	No	No	2.00
4	0.66	22.62	2.16	0.61	0.70	36.29	1.57	57.12	4.000	No	No	2.00
5	0.82	18.53	2.21	0.52	0.72	29.71	1.68	49.90	4.000	No	No	2.00
6	0.98	15.70	2.24	0.43	0.73	25.14	1.00	25.14	4.000	No	No	2.00
7	1.15	14.38	2.24	0.35	0.73	23.00	1.00	23.00	4.000	No	No	2.00
8	1.31	13.63	2.32	0.50	0.76	21.78	2.02	44.03	4.000	No	No	2.00
9	1.48	14.72	2.27	0.45	0.74	23.53	1.00	23.53	4.000	No	No	2.00
10	1.64	17.45	2.22	0.48	0.72	27.90	1.00	27.90	4.000	Yes	No	2.00
11	1.80	18.22	2.28	0.72	0.74	29.13	1.88	54.76	4.000	Yes	No	2.00
12	1.97	16.03	2.47	1.36	0.82	25.59	2.61	66.75	4.000	Yes	No	2.00
13	2.13	12.43	2.68	2.21	0.90	19.79	3.84	76.03	4.000	Yes	Yes	2.00
14	2.30	11.37	2.78	2.86	0.93	18.07	4.58	82.83	4.000	Yes	Yes	2.00
15	2.46	12.94	2.75	3.08	0.92	20.59	4.38	90.26	4.000	No	Yes	2.00
16	2.63	15.53	2.72	3.40	0.91	24.73	4.12	101.91	4.000	No	Yes	2.00
17	2.79	18.63	2.68	3.63	0.89	29.69	3.82	113.42	4.000	No	Yes	2.00
18	2.95	22.03	2.63	3.76	0.88	35.14	3.53	123.97	4.000	No	Yes	2.00
19	3.12	25.33	2.60	3.90	0.87	40.44	3.32	134.08	0.304	No	No	0.48
20	3.28	27.59	2.60	4.22	0.86	44.04	3.30	145.44	0.366	No	No	0.56
21	3.45	29.01	2.61	4.59	0.87	46.31	3.37	156.03	4.000	No	Yes	2.00
22	3.61	29.55	2.63	4.99	0.88	47.17	3.50	165.19	4.000	No	Yes	2.00
23	3.77	31.52	2.61	4.98	0.87	50.32	3.38	169.91	4.000	No	Yes	2.00
24	3.94	32.27	2.61	5.08	0.87	51.50	3.38	173.82	4.000	No	Yes	2.00
25	4.10	32.95	2.61	5.15	0.87	52.57	3.36	176.88	4.000	No	Yes	2.00
26	4.27	31.46	2.65	5.65	0.88	50.18	3.64	182.81	4.000	No	Yes	2.00
27	4.43	30.60	2.67	5.87	0.89	48.78	3.79	184.66	4.000	No	Yes	2.00
28	4.59	29.66	2.69	6.07	0.90	47.25	3.92	185.37	4.000	No	Yes	2.00
29	4.76	30.00	2.68	5.87	0.89	47.78	3.83	182.80	4.000	No	Yes	2.00
30	4.92	30.65	2.67	5.95	0.89	48.80	3.81	186.11	4.000	No	Yes	2.00
31	5.09	30.81	2.69	6.23	0.90	49.04	3.91	191.70	4.000	No	Yes	2.00
32	5.25	34.29	2.63	5.74	0.88	54.63	3.52	192.17	4.000	No	Yes	2.00
33	5.41	41.43	2.54	5.14	0.84	66.08	2.98	196.80	0.789	No	No	1.02
34	5.58	51.12	2.45	4.64	0.81	81.62	2.51	205.15	4.000	No	No	2.00
35	5.74	61.87	2.39	4.51	0.78	98.87	2.25	222.73	4.000	No	No	2.00
36	5.91	67.50	2.37	4.62	0.78	107.91	2.19	236.63	4.000	No	No	2.00
37	6.07	69.34	2.39	4.93	0.78	110.85	2.26	249.97	4.000	No	No	2.00
38	6.23	66.58	2.42	5.30	0.80	106.40	2.40	255.54	4.000	No	No	2.00
39	6.40	68.72	2.40	5.16	0.79	109.82	2.33	255.49	4.000	No	No	2.00
40	6.56	80.16	2.30	4.32	0.75	128.17	1.95	250.47	4.000	No	No	2.00
41	6.73	84.87	2.28	4.19	0.74	135.73	1.88	254.53	4.000	No	No	2.00
42	6.89	78.53	2.33	4.60	0.76	125.53	2.05	256.96	4.000	No	No	2.00
43	7.05	61.06	2.47	5.75	0.82	97.44	2.63	256.66	4.000	No	No	2.00
44	7.22	49.81	2.57	6.47	0.85	79.36	3.13	248.57	4.000	No	No	2.00
45	7.38	50.45	2.54	5.97	0.84	80.36	2.96	237.80	4.000	No	No	2.00
46	7.55	52.61	2.52	5.86	0.83	83.81	2.86	240.11	4.000	No	No	2.00
47	7.71	53.68	2.52	6.01	0.84	85.51	2.88	246.50	4.000	No	No	2.00
48	7.87	49.57	2.58	6.61	0.86	78.90	3.18	251.08	4.000	No	No	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
49	8.04	44.97	2.62	6.93	0.87	71.49	3.44	246.23	4.000	No	Yes	2.00
50	8.20	39.71	2.66	7.12	0.89	63.03	3.73	234.97	4.000	No	Yes	2.00
51	8.37	34.75	2.69	6.96	0.90	55.04	3.94	216.71	4.000	No	Yes	2.00
52	8.53	46.59	2.53	5.42	0.84	74.04	2.90	214.83	4.000	No	No	2.00
53	8.69	59.70	2.41	4.73	0.79	95.09	2.36	224.34	4.000	No	No	2.00
54	8.86	62.74	2.41	4.91	0.79	99.95	2.36	235.65	4.000	No	No	2.00
55	9.02	50.20	2.50	5.30	0.83	79.79	2.76	219.97	4.000	No	No	2.00
56	9.19	37.71	2.59	5.55	0.86	59.70	3.29	196.44	0.785	No	No	0.93
57	9.35	34.57	2.58	4.85	0.86	54.65	3.18	173.88	0.569	No	No	0.67
58	9.51	33.72	2.55	4.40	0.85	53.27	3.04	162.17	0.477	No	No	0.56
59	9.68	33.63	2.54	4.22	0.84	53.11	2.98	158.16	0.448	No	No	0.53
60	9.84	34.51	2.54	4.31	0.84	54.50	2.97	161.83	0.474	No	No	0.56
61	10.01	34.82	2.55	4.57	0.85	54.98	3.06	168.29	0.523	No	No	0.61
62	10.17	34.09	2.59	4.99	0.86	53.80	3.26	175.54	0.583	No	No	0.68
63	10.34	33.88	2.60	5.16	0.87	53.36	3.34	178.25	4.000	No	Yes	2.00
64	10.50	34.41	2.61	5.28	0.87	53.85	3.37	181.59	4.000	No	Yes	2.00
65	10.66	37.38	2.58	5.20	0.86	57.80	3.22	185.85	0.677	No	No	0.79
66	10.83	42.21	2.55	5.22	0.85	64.47	3.04	196.31	0.784	No	No	0.91
67	10.99	42.87	2.57	5.57	0.85	65.25	3.15	205.32	4.000	No	No	2.00
68	11.16	39.24	2.62	5.97	0.87	59.79	3.44	205.47	4.000	No	Yes	2.00
69	11.32	33.11	2.68	6.16	0.89	50.53	3.82	193.05	4.000	No	Yes	2.00
70	11.48	30.41	2.68	5.76	0.90	46.03	3.86	177.57	4.000	No	Yes	2.00
71	11.65	30.97	2.65	5.24	0.88	46.24	3.64	168.40	4.000	No	Yes	2.00
72	11.81	31.99	2.65	5.31	0.88	47.42	3.62	171.67	4.000	No	Yes	2.00
73	11.98	33.18	2.64	5.40	0.88	48.84	3.60	175.84	4.000	No	Yes	2.00
74	12.14	33.28	2.64	5.31	0.88	48.58	3.57	173.58	4.000	No	Yes	2.00
75	12.30	32.19	2.63	5.04	0.88	46.59	3.54	165.15	4.000	No	Yes	2.00
76	12.47	30.35	2.63	4.73	0.88	43.56	3.55	154.49	4.000	No	Yes	2.00
77	12.63	28.16	2.65	4.55	0.88	40.16	3.63	145.85	4.000	No	Yes	2.00
78	12.80	27.11	2.64	4.29	0.88	38.33	3.60	138.17	4.000	No	Yes	2.00
79	12.96	27.19	2.64	4.21	0.88	38.16	3.58	136.52	4.000	No	Yes	2.00
80	13.12	30.47	2.61	4.25	0.87	42.40	3.39	143.68	4.000	No	Yes	2.00
81	13.29	40.03	2.54	4.38	0.84	54.99	2.98	164.10	0.491	No	No	0.56
82	13.45	53.18	2.49	4.70	0.82	72.20	2.69	194.52	0.764	No	No	0.87
83	13.62	60.57	2.49	5.30	0.82	81.91	2.72	222.99	4.000	No	No	2.00
84	13.78	56.73	2.54	5.90	0.85	76.81	3.00	230.82	4.000	No	No	2.00
85	13.94	49.13	2.59	6.07	0.86	66.45	3.29	218.58	4.000	No	No	2.00
86	14.11	46.88	2.56	5.29	0.85	62.63	3.11	195.06	0.770	No	No	0.87
87	14.27	45.25	2.59	5.55	0.86	60.26	3.27	197.22	0.793	No	No	0.90
88	14.44	51.22	2.55	5.37	0.85	67.46	3.03	204.25	4.000	No	No	2.00
89	14.60	51.98	2.58	5.87	0.86	68.30	3.18	216.99	4.000	No	No	2.00
90	14.76	50.83	2.58	5.77	0.86	66.34	3.19	211.69	4.000	No	No	2.00
91	14.93	40.36	2.69	6.65	0.90	52.95	3.91	206.86	4.000	No	Yes	2.00
92	15.09	32.05	2.79	7.38	0.94	42.12	4.67	196.83	4.000	No	Yes	2.00
93	15.26	30.08	2.80	7.29	0.94	39.28	4.81	188.97	4.000	No	Yes	2.00
94	15.42	29.39	2.79	6.84	0.94	38.02	4.72	179.30	4.000	No	Yes	2.00
95	15.58	32.77	2.72	6.03	0.91	41.87	4.17	174.61	4.000	No	Yes	2.00
96	15.75	39.88	2.63	5.33	0.88	50.25	3.52	176.84	4.000	No	Yes	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
97	15.91	57.67	2.50	4.87	0.83	71.47	2.77	197.81	0.800	No	No	0.90
98	16.08	80.17	2.39	4.51	0.79	97.79	2.26	221.43	4.000	No	No	2.00
99	16.24	118.97	2.23	3.74	0.72	141.86	1.73	245.54	4.000	No	No	2.00
100	16.40	144.83	2.14	3.39	0.69	170.26	1.54	262.39	4.000	No	No	2.00
101	16.57	152.16	2.13	3.40	0.69	177.76	1.52	270.31	4.000	No	No	2.00
102	16.73	136.18	2.20	3.82	0.71	159.40	1.67	266.77	4.000	No	No	2.00
103	16.90	120.87	2.28	4.37	0.74	141.83	1.89	267.54	4.000	No	No	2.00
104	17.06	118.51	2.29	4.36	0.75	138.33	1.90	263.20	4.000	No	No	2.00
105	17.22	150.43	2.19	3.95	0.71	173.18	1.65	286.27	4.000	No	No	2.00
106	17.39	208.30	1.98	2.63	0.63	233.46	1.27	296.23	4.000	No	No	2.00
107	17.55	297.79	1.78	1.92	0.55	326.05	1.09	356.62	4.000	No	No	2.00
108	17.72	363.33	1.60	1.31	0.50	390.78	1.00	390.78	4.000	No	No	2.00
109	17.88	450.52	1.50	1.13	0.50	483.00	1.00	483.00	4.000	No	No	2.00
110	18.05	513.49	1.42	0.98	0.50	548.60	1.00	548.60	4.000	No	No	2.00
111	18.21	569.21	1.38	0.94	0.50	606.00	1.00	606.00	4.000	No	No	2.00

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
I_c: Soil behavior type index
Fr: Normalized friction ratio (%)
n: Stress exponent
Q_{tn}: Normalized cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.16	2.00	0.00	9.98	0.16	0.00	0.33	2.00	0.00	9.95	0.16	0.00
0.49	2.00	0.00	9.93	0.16	0.00	0.66	2.00	0.00	9.90	0.16	0.00
0.82	2.00	0.00	9.88	0.16	0.00	0.98	2.00	0.00	9.85	0.16	0.00
1.15	2.00	0.00	9.83	0.16	0.00	1.31	2.00	0.00	9.80	0.16	0.00
1.48	2.00	0.00	9.78	0.16	0.00	1.64	2.00	0.00	9.75	0.16	0.00
1.80	2.00	0.00	9.73	0.16	0.00	1.97	2.00	0.00	9.70	0.17	0.00
2.13	2.00	0.00	9.67	0.16	0.00	2.30	2.00	0.00	9.65	0.16	0.00
2.46	2.00	0.00	9.62	0.16	0.00	2.63	2.00	0.00	9.60	0.16	0.00
2.79	2.00	0.00	9.57	0.16	0.00	2.95	2.00	0.00	9.55	0.16	0.00
3.12	0.48	0.52	9.52	0.16	0.25	3.28	0.56	0.44	9.50	0.16	0.21
3.45	2.00	0.00	9.47	0.16	0.00	3.61	2.00	0.00	9.45	0.16	0.00
3.77	2.00	0.00	9.42	0.16	0.00	3.94	2.00	0.00	9.40	0.16	0.00
4.10	2.00	0.00	9.38	0.16	0.00	4.27	2.00	0.00	9.35	0.16	0.00
4.43	2.00	0.00	9.33	0.16	0.00	4.59	2.00	0.00	9.30	0.16	0.00
4.76	2.00	0.00	9.28	0.16	0.00	4.92	2.00	0.00	9.25	0.16	0.00
5.09	2.00	0.00	9.23	0.16	0.00	5.25	2.00	0.00	9.20	0.16	0.00
5.41	1.02	0.00	9.18	0.16	0.00	5.58	2.00	0.00	9.15	0.16	0.00
5.74	2.00	0.00	9.13	0.16	0.00	5.91	2.00	0.00	9.10	0.17	0.00
6.07	2.00	0.00	9.07	0.16	0.00	6.23	2.00	0.00	9.05	0.16	0.00
6.40	2.00	0.00	9.02	0.16	0.00	6.56	2.00	0.00	9.00	0.16	0.00
6.73	2.00	0.00	8.97	0.16	0.00	6.89	2.00	0.00	8.95	0.16	0.00
7.05	2.00	0.00	8.92	0.16	0.00	7.22	2.00	0.00	8.90	0.16	0.00
7.38	2.00	0.00	8.87	0.16	0.00	7.55	2.00	0.00	8.85	0.16	0.00
7.71	2.00	0.00	8.82	0.16	0.00	7.87	2.00	0.00	8.80	0.16	0.00
8.04	2.00	0.00	8.78	0.16	0.00	8.20	2.00	0.00	8.75	0.16	0.00
8.37	2.00	0.00	8.73	0.16	0.00	8.53	2.00	0.00	8.70	0.16	0.00
8.69	2.00	0.00	8.68	0.16	0.00	8.86	2.00	0.00	8.65	0.16	0.00
9.02	2.00	0.00	8.63	0.16	0.00	9.19	0.93	0.07	8.60	0.16	0.03
9.35	0.67	0.33	8.58	0.16	0.14	9.51	0.56	0.44	8.55	0.16	0.19
9.68	0.53	0.47	8.53	0.16	0.20	9.84	0.56	0.44	8.50	0.16	0.19
10.01	0.61	0.39	8.47	0.16	0.16	10.17	0.68	0.32	8.45	0.16	0.13
10.34	2.00	0.00	8.42	0.16	0.00	10.50	2.00	0.00	8.40	0.16	0.00
10.66	0.79	0.21	8.37	0.16	0.09	10.83	0.91	0.09	8.35	0.16	0.04
10.99	2.00	0.00	8.32	0.16	0.00	11.16	2.00	0.00	8.30	0.16	0.00
11.32	2.00	0.00	8.27	0.16	0.00	11.48	2.00	0.00	8.25	0.16	0.00
11.65	2.00	0.00	8.22	0.16	0.00	11.81	2.00	0.00	8.20	0.16	0.00
11.98	2.00	0.00	8.18	0.16	0.00	12.14	2.00	0.00	8.15	0.16	0.00
12.30	2.00	0.00	8.13	0.16	0.00	12.47	2.00	0.00	8.10	0.16	0.00
12.63	2.00	0.00	8.08	0.16	0.00	12.80	2.00	0.00	8.05	0.16	0.00
12.96	2.00	0.00	8.03	0.16	0.00	13.12	2.00	0.00	8.00	0.16	0.00
13.29	0.56	0.44	7.98	0.16	0.18	13.45	0.87	0.13	7.95	0.16	0.05
13.62	2.00	0.00	7.93	0.16	0.00	13.78	2.00	0.00	7.90	0.16	0.00
13.94	2.00	0.00	7.87	0.16	0.00	14.11	0.87	0.13	7.85	0.16	0.05
14.27	0.90	0.10	7.82	0.16	0.04	14.44	2.00	0.00	7.80	0.16	0.00
14.60	2.00	0.00	7.77	0.16	0.00	14.76	2.00	0.00	7.75	0.16	0.00
14.93	2.00	0.00	7.72	0.16	0.00	15.09	2.00	0.00	7.70	0.16	0.00
15.26	2.00	0.00	7.67	0.16	0.00	15.42	2.00	0.00	7.65	0.16	0.00
15.58	2.00	0.00	7.62	0.16	0.00	15.75	2.00	0.00	7.60	0.16	0.00

:: Liquefaction Potential Index calculation data :: (continued)

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
15.91	0.90	0.10	7.58	0.16	0.04	16.08	2.00	0.00	7.55	0.16	0.00
16.24	2.00	0.00	7.53	0.16	0.00	16.40	2.00	0.00	7.50	0.16	0.00
16.57	2.00	0.00	7.48	0.16	0.00	16.73	2.00	0.00	7.45	0.16	0.00
16.90	2.00	0.00	7.43	0.16	0.00	17.06	2.00	0.00	7.40	0.16	0.00
17.22	2.00	0.00	7.38	0.16	0.00	17.39	2.00	0.00	7.35	0.16	0.00
17.55	2.00	0.00	7.33	0.16	0.00	17.72	2.00	0.00	7.30	0.16	0.00
17.88	2.00	0.00	7.27	0.16	0.00	18.05	2.00	0.00	7.25	0.16	0.00
18.21	2.00	0.00	7.22	0.16	0.00						

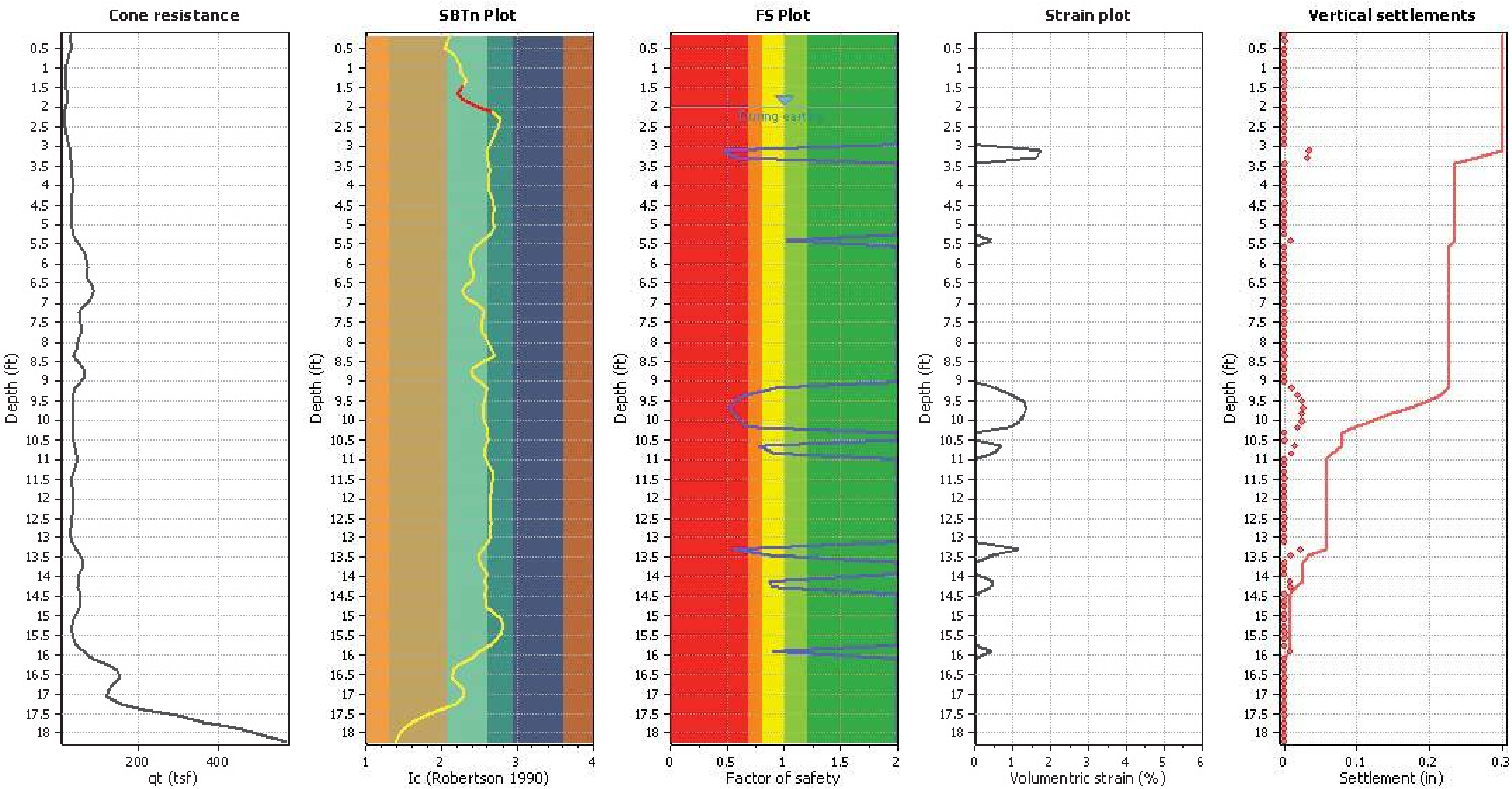
Overall liquefaction potential: 1.99

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: **Post-earthquake settlement due to soil liquefaction** ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
2.13	76.03	2.00	0.00	0.96	0.00	2.30	82.83	2.00	0.00	0.96	0.00
2.46	90.26	2.00	0.00	0.96	0.00	2.63	101.91	2.00	0.00	0.96	0.00
2.79	113.42	2.00	0.00	0.95	0.00	2.95	123.97	2.00	0.00	0.95	0.00
3.12	134.08	0.48	1.74	0.95	0.03	3.28	145.44	0.56	1.62	0.94	0.03
3.45	156.03	2.00	0.00	0.94	0.00	3.61	165.19	2.00	0.00	0.94	0.00
3.77	169.91	2.00	0.00	0.94	0.00	3.94	173.82	2.00	0.00	0.93	0.00
4.10	176.88	2.00	0.00	0.93	0.00	4.27	182.81	2.00	0.00	0.93	0.00
4.43	184.66	2.00	0.00	0.92	0.00	4.59	185.37	2.00	0.00	0.92	0.00
4.76	182.80	2.00	0.00	0.92	0.00	4.92	186.11	2.00	0.00	0.92	0.00
5.09	191.70	2.00	0.00	0.91	0.00	5.25	192.17	2.00	0.00	0.91	0.00
5.41	196.80	1.02	0.43	0.91	0.01	5.58	205.15	2.00	0.00	0.91	0.00
5.74	222.73	2.00	0.00	0.90	0.00	5.91	236.63	2.00	0.00	0.90	0.00
6.07	249.97	2.00	0.00	0.90	0.00	6.23	255.54	2.00	0.00	0.89	0.00
6.40	255.49	2.00	0.00	0.89	0.00	6.56	250.47	2.00	0.00	0.89	0.00
6.73	254.53	2.00	0.00	0.89	0.00	6.89	256.96	2.00	0.00	0.88	0.00
7.05	256.66	2.00	0.00	0.88	0.00	7.22	248.57	2.00	0.00	0.88	0.00
7.38	237.80	2.00	0.00	0.87	0.00	7.55	240.11	2.00	0.00	0.87	0.00
7.71	246.50	2.00	0.00	0.87	0.00	7.87	251.08	2.00	0.00	0.87	0.00
8.04	246.23	2.00	0.00	0.86	0.00	8.20	234.97	2.00	0.00	0.86	0.00
8.37	216.71	2.00	0.00	0.86	0.00	8.53	214.83	2.00	0.00	0.86	0.00
8.69	224.34	2.00	0.00	0.85	0.00	8.86	235.65	2.00	0.00	0.85	0.00
9.02	219.97	2.00	0.00	0.85	0.00	9.19	196.44	0.93	0.49	0.84	0.01
9.35	173.88	0.67	0.94	0.84	0.02	9.51	162.17	0.56	1.26	0.84	0.02
9.68	158.16	0.53	1.34	0.84	0.03	9.84	161.83	0.56	1.26	0.83	0.02
10.01	168.29	0.61	1.18	0.83	0.02	10.17	175.54	0.68	0.92	0.83	0.02
10.34	178.25	2.00	0.00	0.82	0.00	10.50	181.59	2.00	0.00	0.82	0.00
10.66	185.85	0.79	0.67	0.82	0.01	10.83	196.31	0.91	0.47	0.82	0.01
10.99	205.32	2.00	0.00	0.81	0.00	11.16	205.47	2.00	0.00	0.81	0.00
11.32	193.05	2.00	0.00	0.81	0.00	11.48	177.57	2.00	0.00	0.81	0.00
11.65	168.40	2.00	0.00	0.80	0.00	11.81	171.67	2.00	0.00	0.80	0.00
11.98	175.84	2.00	0.00	0.80	0.00	12.14	173.58	2.00	0.00	0.79	0.00
12.30	165.15	2.00	0.00	0.79	0.00	12.47	154.49	2.00	0.00	0.79	0.00
12.63	145.85	2.00	0.00	0.79	0.00	12.80	138.17	2.00	0.00	0.78	0.00
12.96	136.52	2.00	0.00	0.78	0.00	13.12	143.68	2.00	0.00	0.78	0.00
13.29	164.10	0.56	1.15	0.77	0.02	13.45	194.52	0.87	0.45	0.77	0.01
13.62	222.99	2.00	0.00	0.77	0.00	13.78	230.82	2.00	0.00	0.77	0.00
13.94	218.58	2.00	0.00	0.76	0.00	14.11	195.06	0.87	0.44	0.76	0.01
14.27	197.22	0.90	0.44	0.76	0.01	14.44	204.25	2.00	0.00	0.76	0.00
14.60	216.99	2.00	0.00	0.75	0.00	14.76	211.69	2.00	0.00	0.75	0.00
14.93	206.86	2.00	0.00	0.75	0.00	15.09	196.83	2.00	0.00	0.74	0.00
15.26	188.97	2.00	0.00	0.74	0.00	15.42	179.30	2.00	0.00	0.74	0.00
15.58	174.61	2.00	0.00	0.74	0.00	15.75	176.84	2.00	0.00	0.73	0.00
15.91	197.81	0.90	0.42	0.73	0.01	16.08	221.43	2.00	0.00	0.73	0.00
16.24	245.54	2.00	0.00	0.72	0.00	16.40	262.39	2.00	0.00	0.72	0.00
16.57	270.31	2.00	0.00	0.72	0.00	16.73	266.77	2.00	0.00	0.72	0.00
16.90	267.54	2.00	0.00	0.71	0.00	17.06	263.20	2.00	0.00	0.71	0.00
17.22	286.27	2.00	0.00	0.71	0.00	17.39	296.23	2.00	0.00	0.71	0.00
17.55	356.62	2.00	0.00	0.70	0.00	17.72	390.78	2.00	0.00	0.70	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
17.88	483.00	2.00	0.00	0.70	0.00	18.05	548.60	2.00	0.00	0.69	0.00
18.21	606.00	2.00	0.00	0.69	0.00						

Total estimated settlement: 0.30

Abbreviations

$Q_{tn,cs}$: Equivalent clean sand normalized cone resistance
FS: Factor of safety against liquefaction
e_v (%): Post-liquefaction volumentric strain
DF: e_v depth weighting factor
Settlement: Calculated settlement

:: Strength loss calculation (Robertson (2009) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.16	25.40	40.80	1.49	60.67	2.12	N/A	N/A
0.33	27.82	44.66	1.40	62.61	2.07	N/A	N/A
0.49	28.42	45.63	1.37	62.39	2.05	N/A	N/A
0.66	22.62	36.29	1.57	57.12	2.16	N/A	N/A
0.82	18.53	29.71	1.68	49.90	2.21	N/A	N/A
0.98	15.70	25.14	1.00	25.14	2.24	N/A	N/A
1.15	14.38	23.00	1.00	23.00	2.24	N/A	N/A
1.31	13.63	21.78	2.02	44.03	2.32	N/A	N/A
1.48	14.72	23.53	1.00	23.53	2.27	N/A	N/A
1.64	17.45	27.90	1.00	27.90	2.22	N/A	N/A
1.80	18.22	29.13	1.88	54.76	2.28	N/A	N/A
1.97	16.03	25.59	2.61	66.75	2.47	N/A	N/A
2.13	12.43	19.79	3.84	76.03	2.68	7.59	7.59
2.30	11.37	18.07	4.58	82.83	2.78	6.41	6.41
2.46	12.94	20.59	4.38	90.26	2.75	6.78	6.78
2.63	15.53	24.73	4.12	101.91	2.72	7.59	7.59
2.79	18.63	29.69	3.82	113.42	2.68	8.52	8.52
2.95	22.03	35.14	3.53	123.97	2.63	9.46	9.46
3.12	25.33	40.44	3.32	134.08	2.60	0.71	0.71
3.28	27.59	44.04	3.30	145.44	2.60	0.72	0.72
3.45	29.01	46.31	3.37	156.03	2.61	10.47	10.47
3.61	29.55	47.17	3.50	165.19	2.63	10.12	10.12
3.77	31.52	50.32	3.38	169.91	2.61	10.26	10.26
3.94	32.27	51.50	3.38	173.82	2.61	10.01	10.01
4.10	32.95	52.57	3.36	176.88	2.61	9.76	9.76
4.27	31.46	50.18	3.64	182.81	2.65	8.91	8.91
4.43	30.60	48.78	3.79	184.66	2.67	8.31	8.31
4.59	29.66	47.25	3.92	185.37	2.69	7.73	7.73
4.76	30.00	47.78	3.83	182.80	2.68	7.52	7.52
4.92	30.65	48.80	3.81	186.11	2.67	7.39	7.39
5.09	30.81	49.04	3.91	191.70	2.69	7.17	7.17
5.25	34.29	54.63	3.52	192.17	2.63	7.71	7.71
5.41	41.43	66.08	2.98	196.80	2.54	0.77	0.77
5.58	51.12	81.62	2.51	205.15	2.45	0.80	0.80
5.74	61.87	98.87	2.25	222.73	2.39	0.83	0.83
5.91	67.50	107.91	2.19	236.63	2.37	0.84	0.84
6.07	69.34	110.85	2.26	249.97	2.39	0.84	0.84
6.23	66.58	106.40	2.40	255.54	2.42	0.84	0.84
6.40	68.72	109.82	2.33	255.49	2.40	0.84	0.84
6.56	80.16	128.17	1.95	250.47	2.30	0.86	0.86
6.73	84.87	135.73	1.88	254.53	2.28	0.87	0.87
6.89	78.53	125.53	2.05	256.96	2.33	0.86	0.86
7.05	61.06	97.44	2.63	256.66	2.47	0.82	0.82
7.22	49.81	79.36	3.13	248.57	2.57	0.80	0.80
7.38	50.45	80.36	2.96	237.80	2.54	0.80	0.80
7.55	52.61	83.81	2.86	240.11	2.52	0.80	0.80
7.71	53.68	85.51	2.88	246.50	2.52	0.81	0.81
7.87	49.57	78.90	3.18	251.08	2.58	0.79	0.79

:: Strength loss calculation (Robertson (2009) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
8.04	44.97	71.49	3.44	246.23	2.62	6.27	6.27
8.20	39.71	63.03	3.73	234.97	2.66	5.41	5.41
8.37	34.75	55.04	3.94	216.71	2.69	4.62	4.62
8.53	46.59	74.04	2.90	214.83	2.53	0.79	0.79
8.69	59.70	95.09	2.36	224.34	2.41	0.82	0.82
8.86	62.74	99.95	2.36	235.65	2.41	0.83	0.83
9.02	50.20	79.79	2.76	219.97	2.50	0.80	0.80
9.19	37.71	59.70	3.29	196.44	2.59	0.76	0.76
9.35	34.57	54.65	3.18	173.88	2.58	0.75	0.75
9.51	33.72	53.27	3.04	162.17	2.55	0.74	0.74
9.68	33.63	53.11	2.98	158.16	2.54	0.74	0.74
9.84	34.51	54.50	2.97	161.83	2.54	0.75	0.75
10.01	34.82	54.98	3.06	168.29	2.55	0.75	0.75
10.17	34.09	53.80	3.26	175.54	2.59	0.74	0.74
10.34	33.88	53.36	3.34	178.25	2.60	3.86	3.86
10.50	34.41	53.85	3.37	181.59	2.61	3.89	3.89
10.66	37.38	57.80	3.22	185.85	2.58	0.75	0.75
10.83	42.21	64.47	3.04	196.31	2.55	0.77	0.77
10.99	42.87	65.25	3.15	205.32	2.57	0.77	0.77
11.16	39.24	59.79	3.44	205.47	2.62	4.28	4.28
11.32	33.11	50.53	3.82	193.05	2.68	3.57	3.57
11.48	30.41	46.03	3.86	177.57	2.68	3.25	3.25
11.65	30.97	46.24	3.64	168.40	2.65	3.28	3.28
11.81	31.99	47.42	3.62	171.67	2.65	3.36	3.36
11.98	33.18	48.84	3.60	175.84	2.64	3.46	3.46
12.14	33.28	48.58	3.57	173.58	2.64	3.45	3.45
12.30	32.19	46.59	3.54	165.15	2.63	3.30	3.30
12.47	30.35	43.56	3.55	154.49	2.63	3.09	3.09
12.63	28.16	40.16	3.63	145.85	2.65	2.84	2.84
12.80	27.11	38.33	3.60	138.17	2.64	2.71	2.71
12.96	27.19	38.16	3.58	136.52	2.64	2.69	2.69
13.12	30.47	42.40	3.39	143.68	2.61	3.01	3.01
13.29	40.03	54.99	2.98	164.10	2.54	0.75	0.75
13.45	53.18	72.20	2.69	194.52	2.49	0.78	0.78
13.62	60.57	81.91	2.72	222.99	2.49	0.80	0.80
13.78	56.73	76.81	3.00	230.82	2.54	0.79	0.79
13.94	49.13	66.45	3.29	218.58	2.59	0.77	0.77
14.11	46.88	62.63	3.11	195.06	2.56	0.76	0.76
14.27	45.25	60.26	3.27	197.22	2.59	0.76	0.76
14.44	51.22	67.46	3.03	204.25	2.55	0.77	0.77
14.60	51.98	68.30	3.18	216.99	2.58	0.78	0.78
14.76	50.83	66.34	3.19	211.69	2.58	0.77	0.77
14.93	40.36	52.95	3.91	206.86	2.69	3.67	3.67
15.09	32.05	42.12	4.67	196.83	2.79	2.88	2.88
15.26	30.08	39.28	4.81	188.97	2.80	2.68	2.68
15.42	29.39	38.02	4.72	179.30	2.79	2.59	2.59
15.58	32.77	41.87	4.17	174.61	2.72	2.88	2.88
15.75	39.88	50.25	3.52	176.84	2.63	3.50	3.50

:: Strength loss calculation (Robertson (2009) :: (continued)

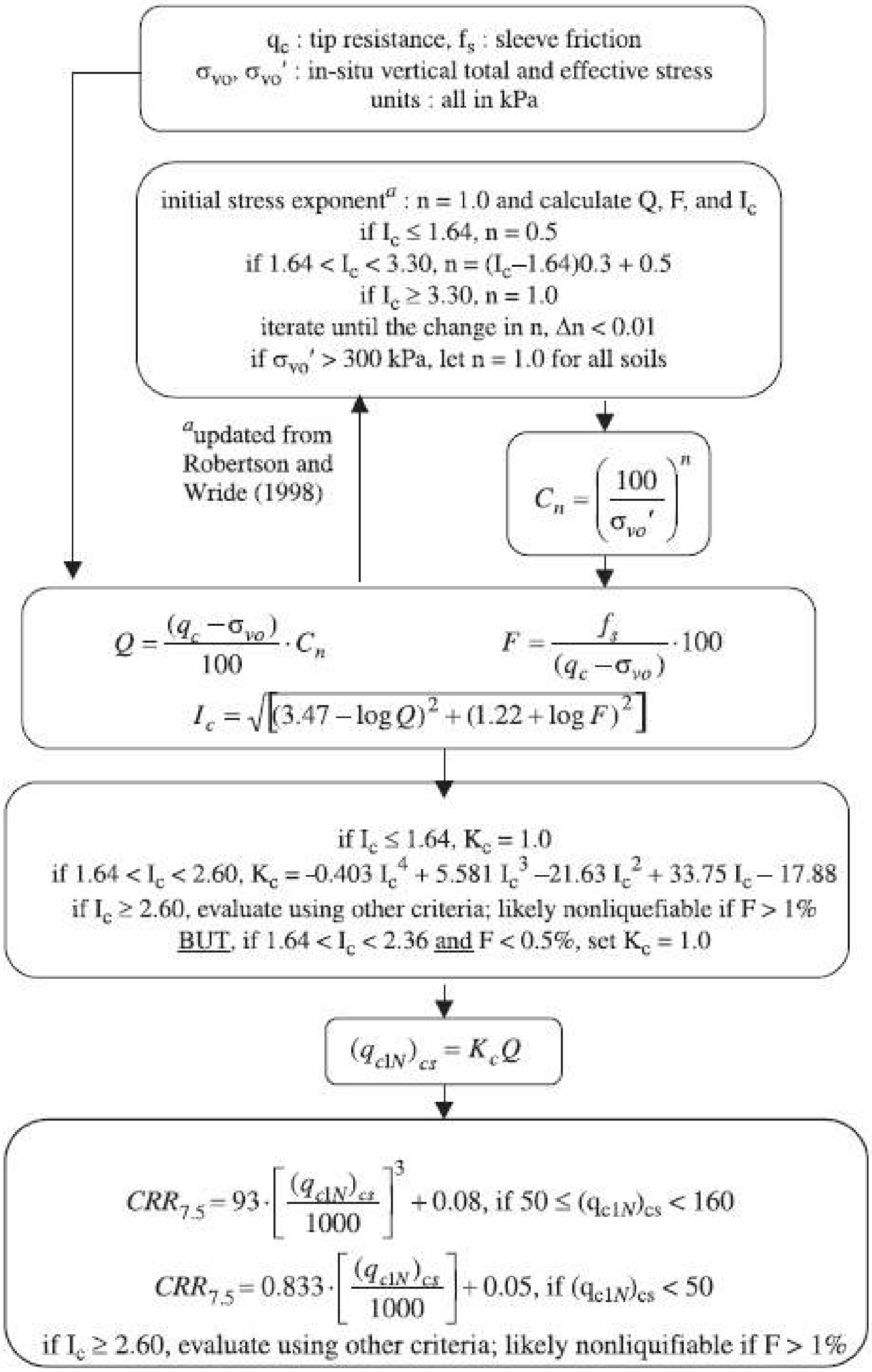
Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
15.91	57.67	71.47	2.77	197.81	2.50	0.78	0.78
16.08	80.17	97.79	2.26	221.43	2.39	0.82	0.82
16.24	118.97	141.86	1.73	245.54	2.23	0.88	0.88
16.40	144.83	170.26	1.54	262.39	2.14	0.90	0.90
16.57	152.16	177.76	1.52	270.31	2.13	0.91	0.91
16.73	136.18	159.40	1.67	266.77	2.20	0.89	0.89
16.90	120.87	141.83	1.89	267.54	2.28	0.88	0.88
17.06	118.51	138.33	1.90	263.20	2.29	0.87	0.87
17.22	150.43	173.18	1.65	286.27	2.19	0.91	0.91
17.39	208.30	233.46	1.27	296.23	1.98	0.95	0.95
17.55	297.79	326.05	1.09	356.62	1.78	1.01	1.01
17.72	363.33	390.78	1.00	390.78	1.60	1.04	1.04
17.88	450.52	483.00	1.00	483.00	1.50	1.08	1.08
18.05	513.49	548.60	1.00	548.60	1.42	1.10	1.10
18.21	569.21	606.00	1.00	606.00	1.38	1.12	1.12

Abbreviations

q_t: Total cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Adjusted and corrected cone resistance due to fines
I_c: Soil behavior type index
$S_{u(liq)}/\sigma'_v$: Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$: Calculated peak undrained strength ratio

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

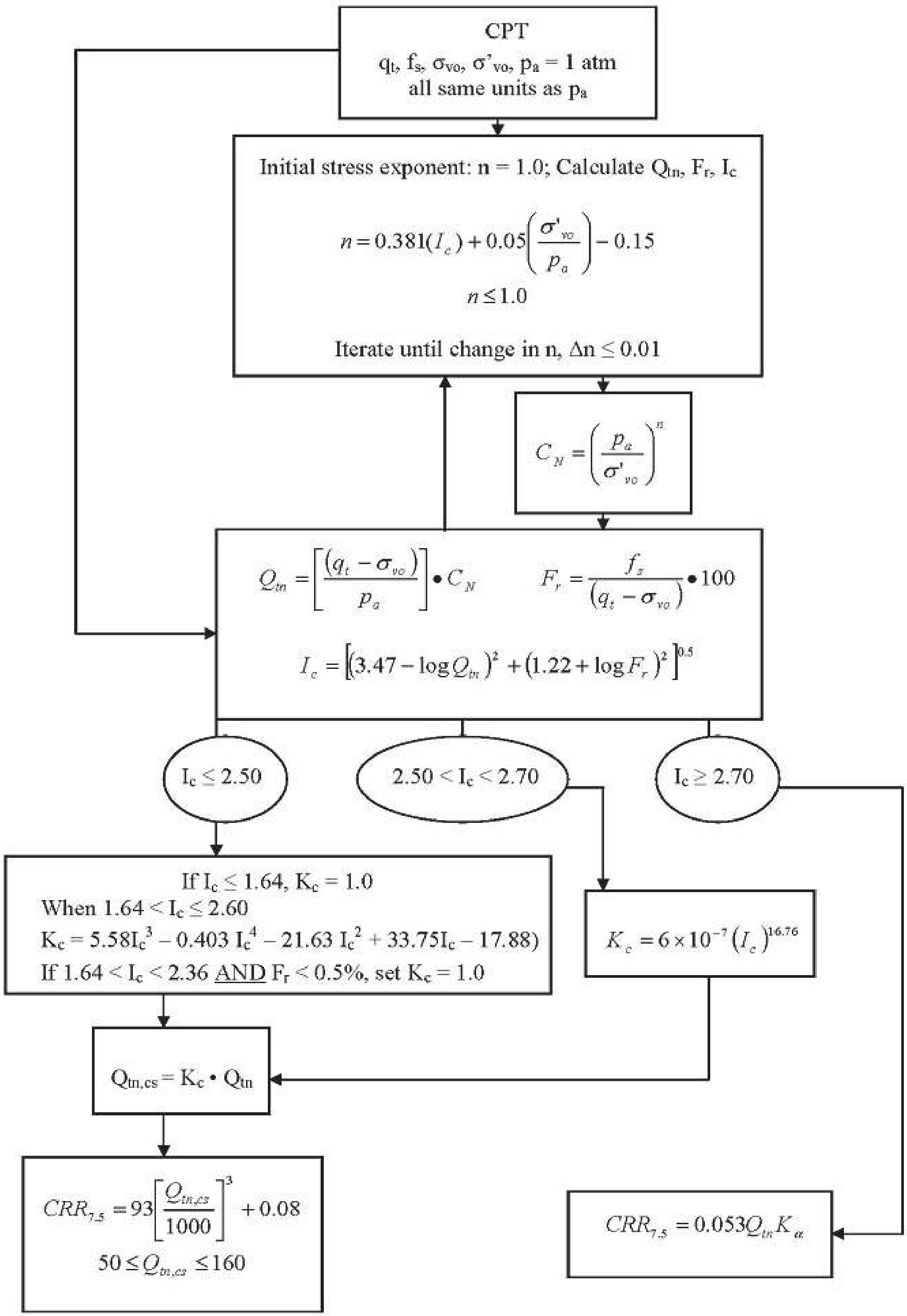
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

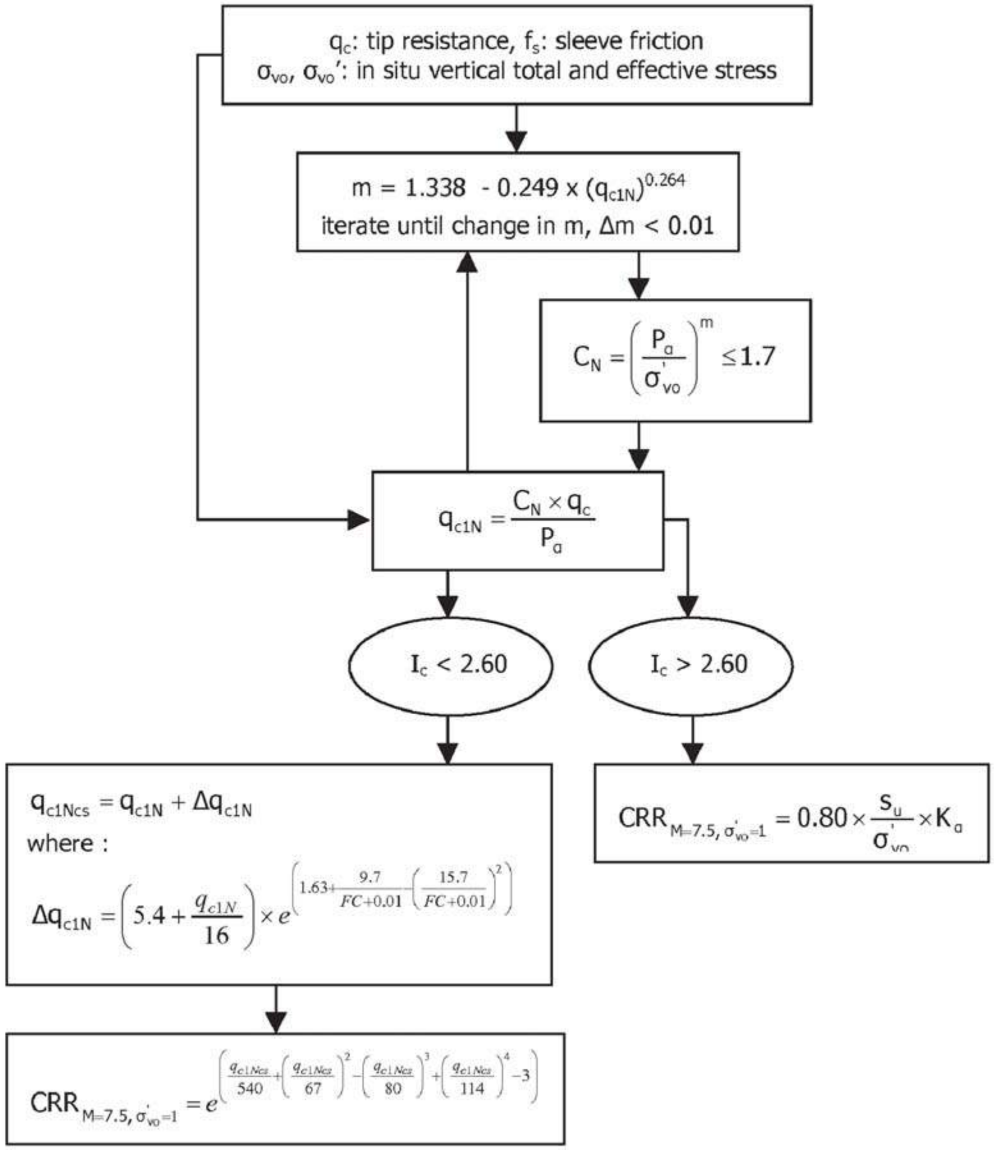
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

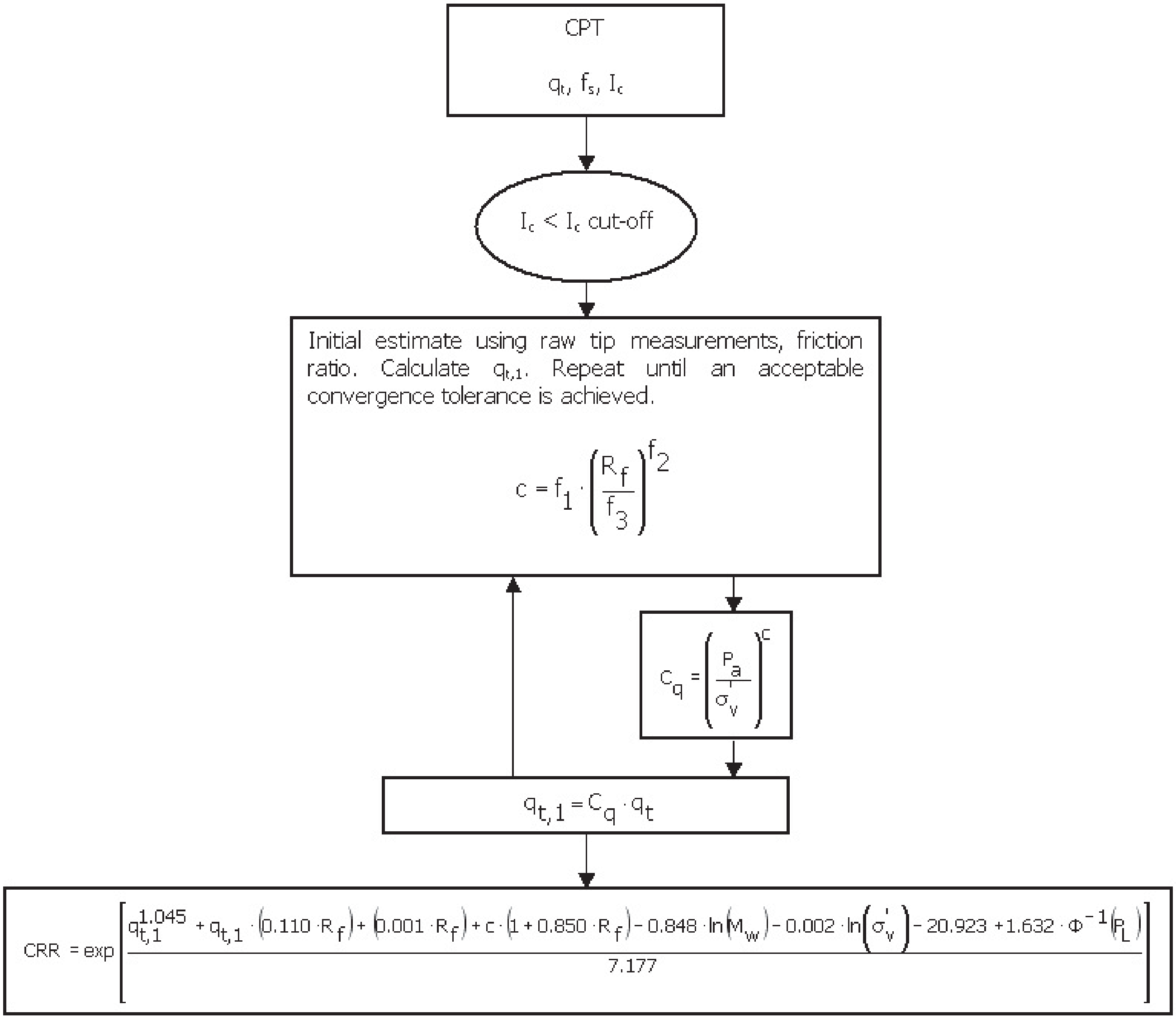


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)

$$FS_{liq} = \frac{CRR_{M=7.5,\sigma'_v=1atm}}{CSR_{M=7.5,\sigma'_v=1atm}}$$

$$CSR_{M=7.5,\sigma'_v=1atm} = 0.65 \frac{\sigma_v}{\sigma'_v} \frac{a_{max}}{g} r_d \frac{1}{MSF} \frac{1}{K_\sigma}$$

$$r_d = \exp\left[\alpha(z) + \beta(z) \cdot M\right]$$

$$\alpha(z) = -1.012 - 1.126 \sin\left(\frac{z}{11.73} + 5.133\right)$$

$$\beta(z) = 0.106 + 0.118 \sin\left(\frac{z}{11.28} + 5.142\right)$$

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_v}{P_a}\right) \le 1.1$$

$$C_\sigma = \frac{1}{37.3 - 8.27\left(q_{c1Ncs}\right)^{0.264}} \le 0.3$$

$$MSF = 1 + \left(MSF_{max} - 1\right)\left(8.64 \exp\left(\frac{-M}{4}\right) - 1.325\right)$$

$$MSF_{max} = 1.09 + \left(\frac{q_{c1Ncs}}{180}\right)^3 \le 2.2$$

σ'_v *and* σ_v *at start of earthquake shaking*

$$CRR_{M=7.5,\sigma'_v=1atm} = \exp\left(\frac{q_{c1Ncs}}{113} + \left(\frac{q_{c1Ncs}}{1000}\right)^2 - \left(\frac{q_{c1Ncs}}{140}\right)^3 + \left(\frac{q_{c1Ncs}}{137}\right)^4 - 2.80\right)$$

$$q_{c1Ncs} = q_{c1N} + \Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(11.9 + \frac{q_{c1N}}{14.6}\right) \exp\left(1.63 - \frac{9.7}{FC+2} - \left(\frac{15.7}{FC+2}\right)^2\right)$$

$$q_{c1N} = C_{Ne} \frac{q_c}{P_a}$$

$$C_{Ne} = \left(\frac{P_a}{\sigma'_v}\right)^m \le 1.7$$

$$m = 1.338 - 0.249\left(q_{c1Ncs}\right)^{0.264} \quad with \quad 0.264 \le m \le 0.782$$

$$FC = 80\left(I_C + C_{FC}\right) - 137 \quad with \quad 0\% \le FC \le 100\%$$

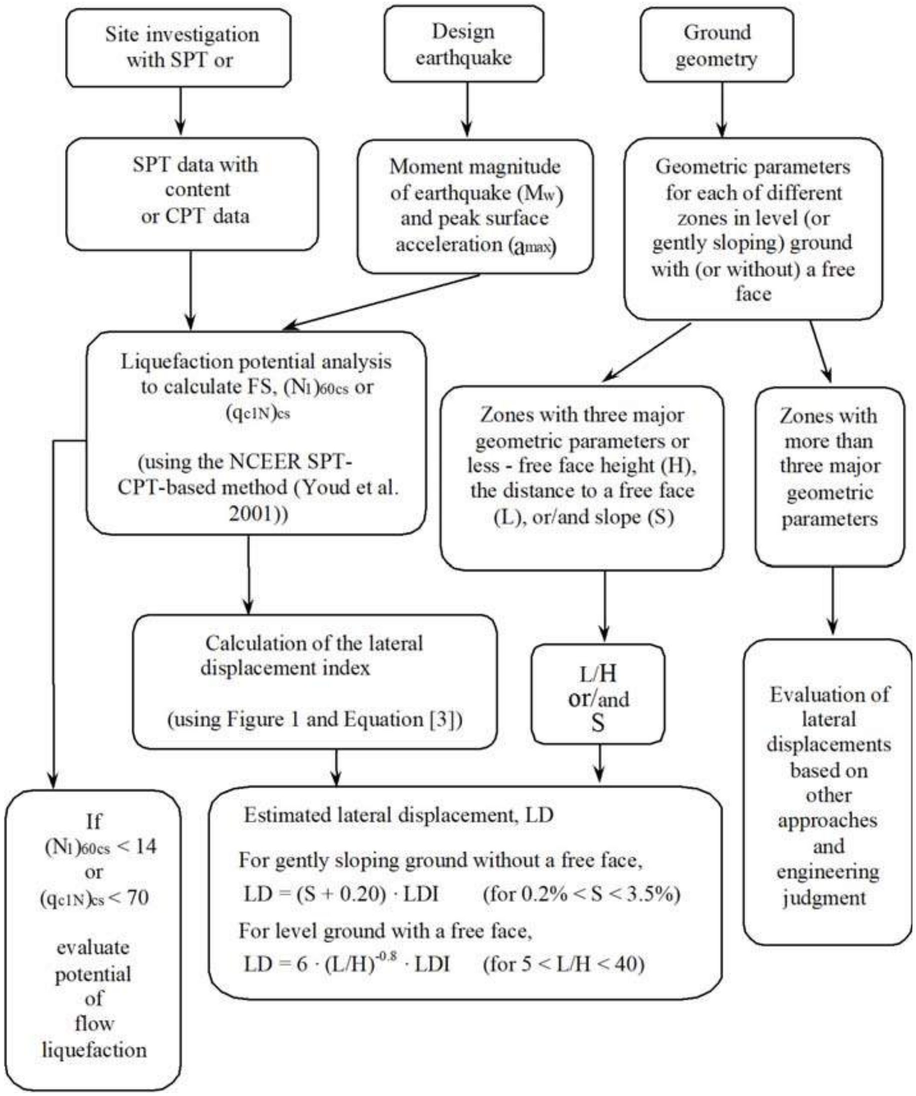
$$I_c = \left[\left(3.47 - \log(Q)\right)^2 + \left(1.22 + \log(F)\right)^2\right]^{0.5}$$

$$Q = \left(\frac{q_c - \sigma_{vc}}{P_a}\right)\left(\frac{P_a}{\sigma'_{vc}}\right)^n \quad with\ 0.5 \le n \le 1.0\ per\ Robertson\ \&\ Wride\ (1998)$$

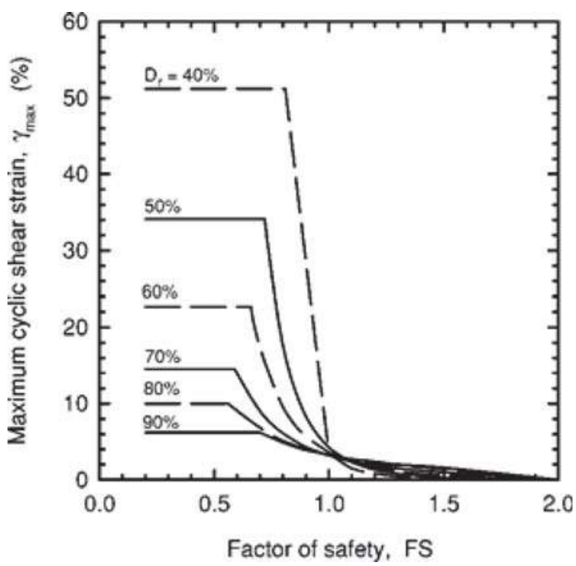
$$F = \left(\frac{f_s}{q_c - \sigma_{vc}}\right) \cdot 100\%$$

σ'_v *at time of CPT sounding*

Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



[1] **Figure 1**

$$LDI = \int_0^{Z_{max}} \gamma_{max} dz$$

[1] **Equation [3]**

[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands

Average shear stress, τ_{av}

$$\tau_{av} = CSR^{*} \cdot \sigma_{v0}' = 0.65 \cdot \frac{a_{max}}{g} \cdot \sigma_{v0} \cdot \tau_a$$

↓

Estimate small shear strain modulus, G_0

$$G_0 = 0.0188 \cdot \left[10^{(0.55 I_c - 1.68)}\right] \cdot (q_t - \sigma_v)$$

↓

Estimate shear strain amplitude, γ

(based on Pradel (1998))

$$\gamma = \left[\frac{1 + \alpha \cdot e^{bR}}{1 + \alpha}\right] \cdot R \cdot 100\ (\%)$$

$$R = \frac{\tau_{av}}{G_0} \text{ (Note } \tau_{av} \text{ and } G_0 \text{ same units)}$$

$$\alpha = 0.0389 \cdot \left(\frac{\sigma_v}{p_a}\right) + 0.124$$

$$b = 6400 \cdot \left(\frac{\sigma_v}{p_a}\right)$$

↓

Estimate volumetric strain in 15 cycles

$$\varepsilon_{vol(15)} = \gamma \cdot \left[\frac{(N_1)_{60,cs}}{20}\right]^{-1.20}$$

$$(N_1)_{60,cs} = \frac{Q_{tn,cs}}{8.5 \cdot \left[1 - \frac{I_c}{4.6}\right]}$$

↓

Volumetric strain in design earthquake

$$\Sigma_{vol} = \varepsilon_{vol(15)} \cdot \left[\frac{N_c}{15}\right]^{0.45}$$

$$N_c = (M - 4)^{2.17}$$

↓

Seismic settlement, s

$$s = 2 \cdot \int_0^{GWT} \Sigma_{vol} \cdot dz$$

Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

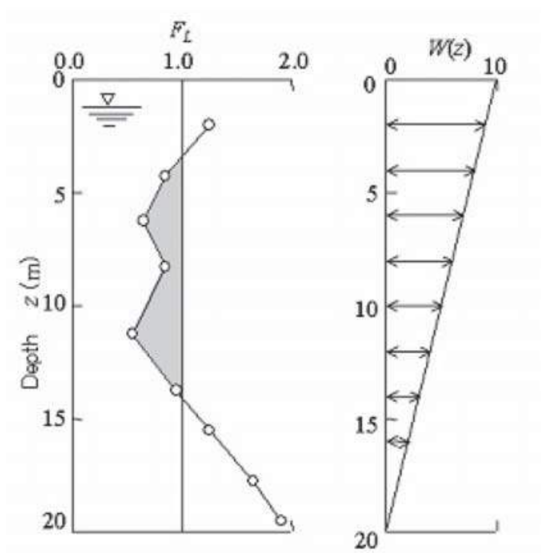
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_{0}^{20} (10 - 0{,}5_Z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

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APPENDIX J-2

Liquefaction Report for New Gymnasium – Youd et al., 2001; Robertson, 2009

T A B L E   O F   C O N T E N T S

A3GEO, Inc.
Geoconsultants
Berkeley, CA
www.a3geo.com

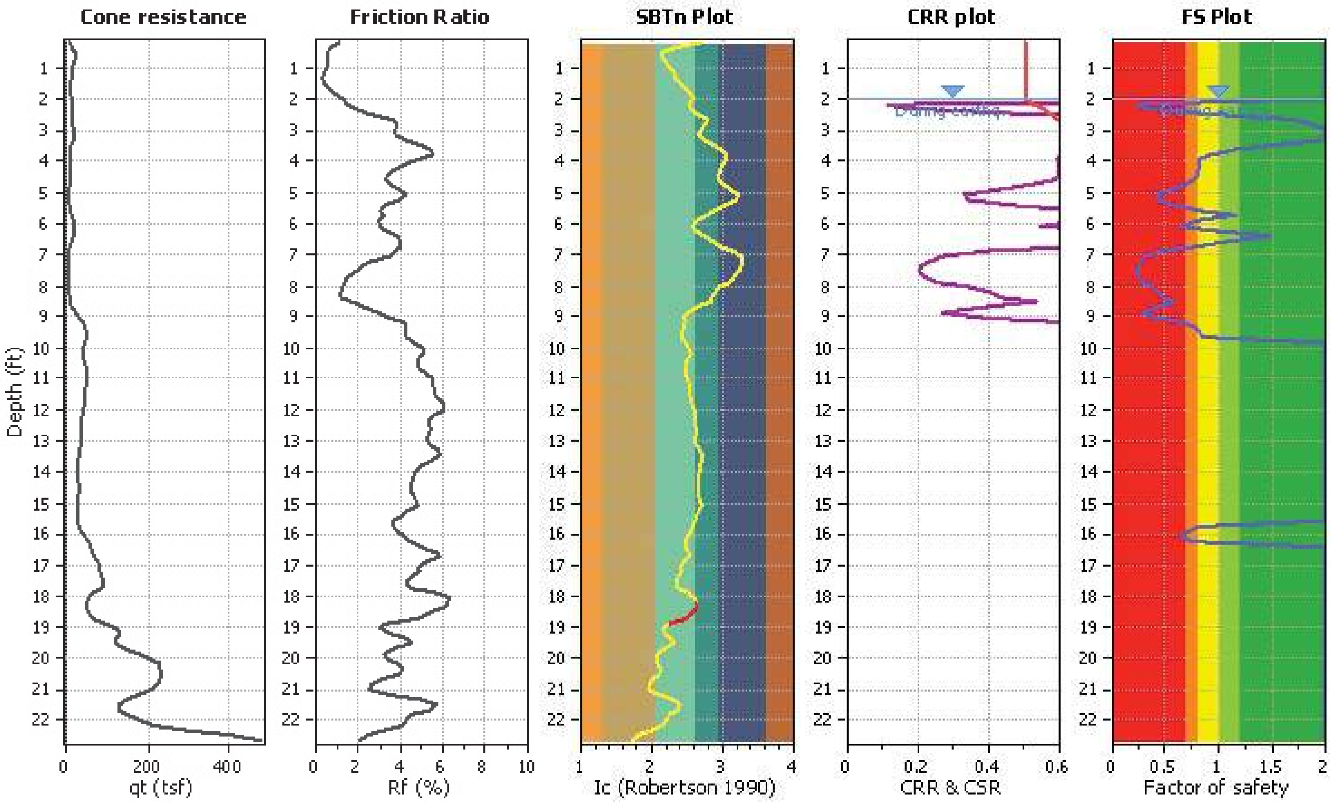
LIQUEFACTION ANALYSIS REPORT

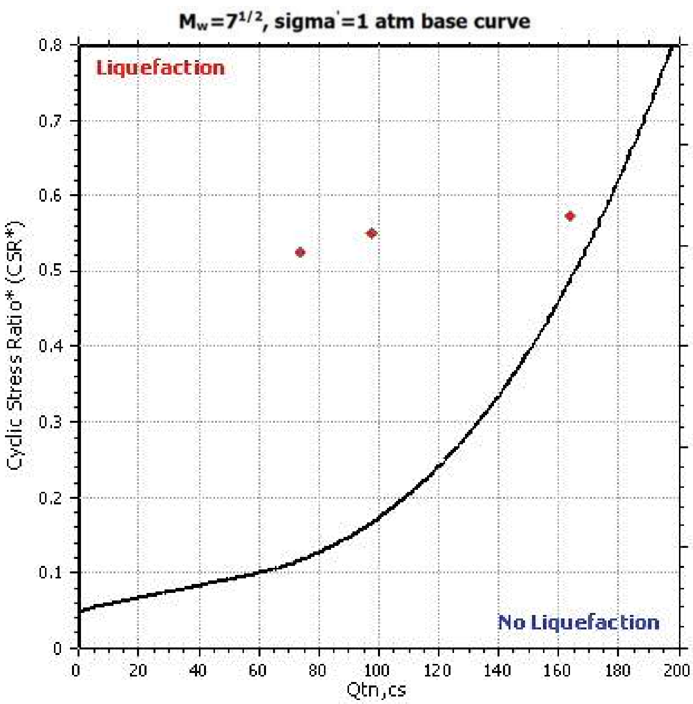
Project title : Terra Linda High School **Location : San Rafael, CA**

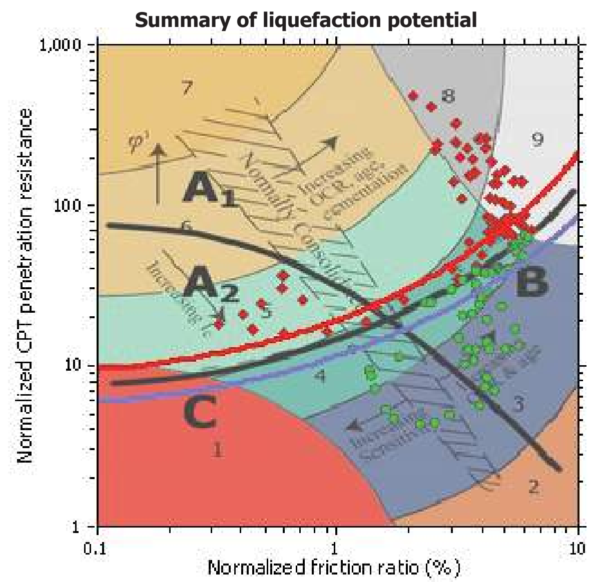
CPT file : CPT-03

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	9.00 ft	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	No		

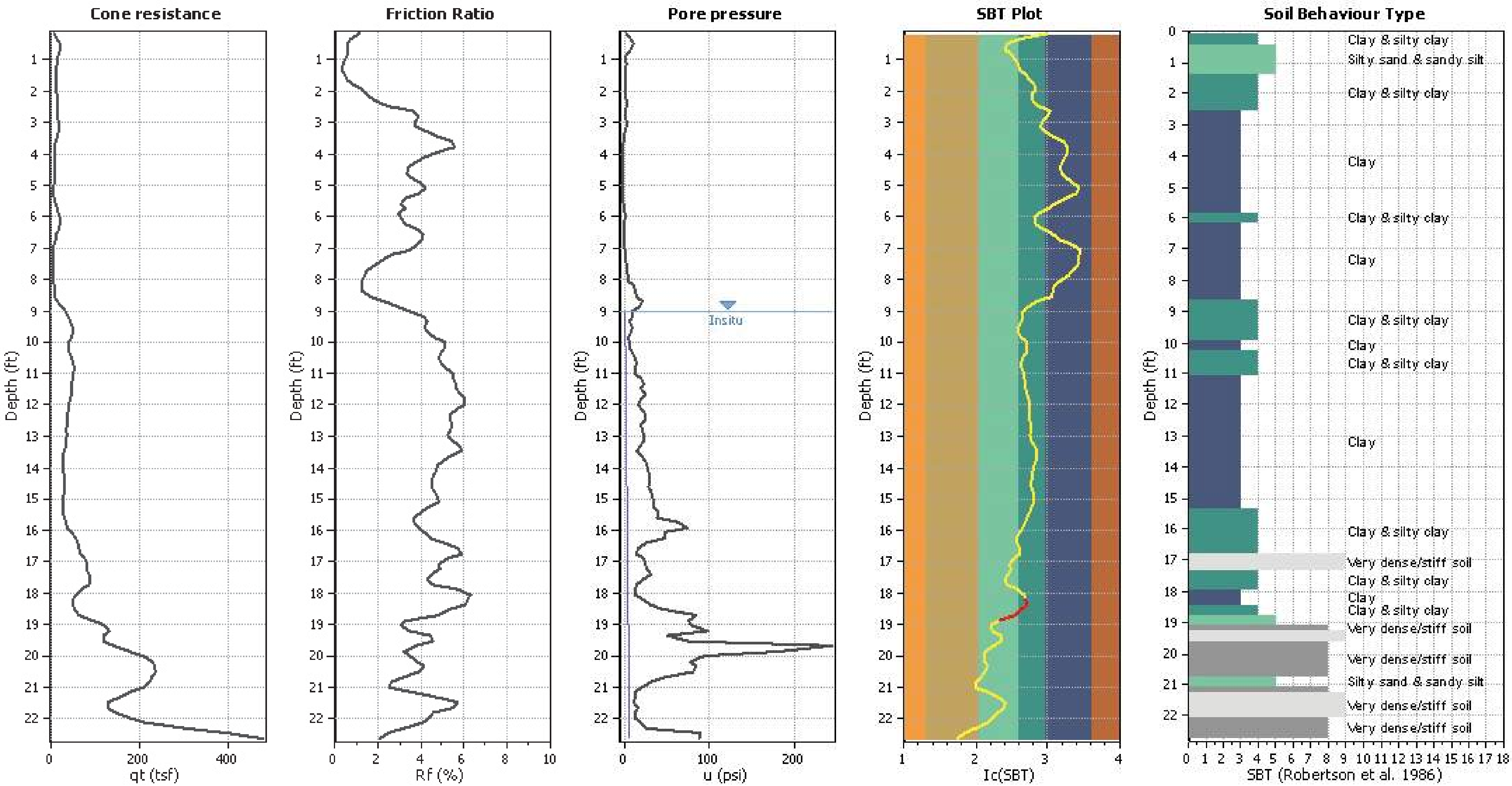






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



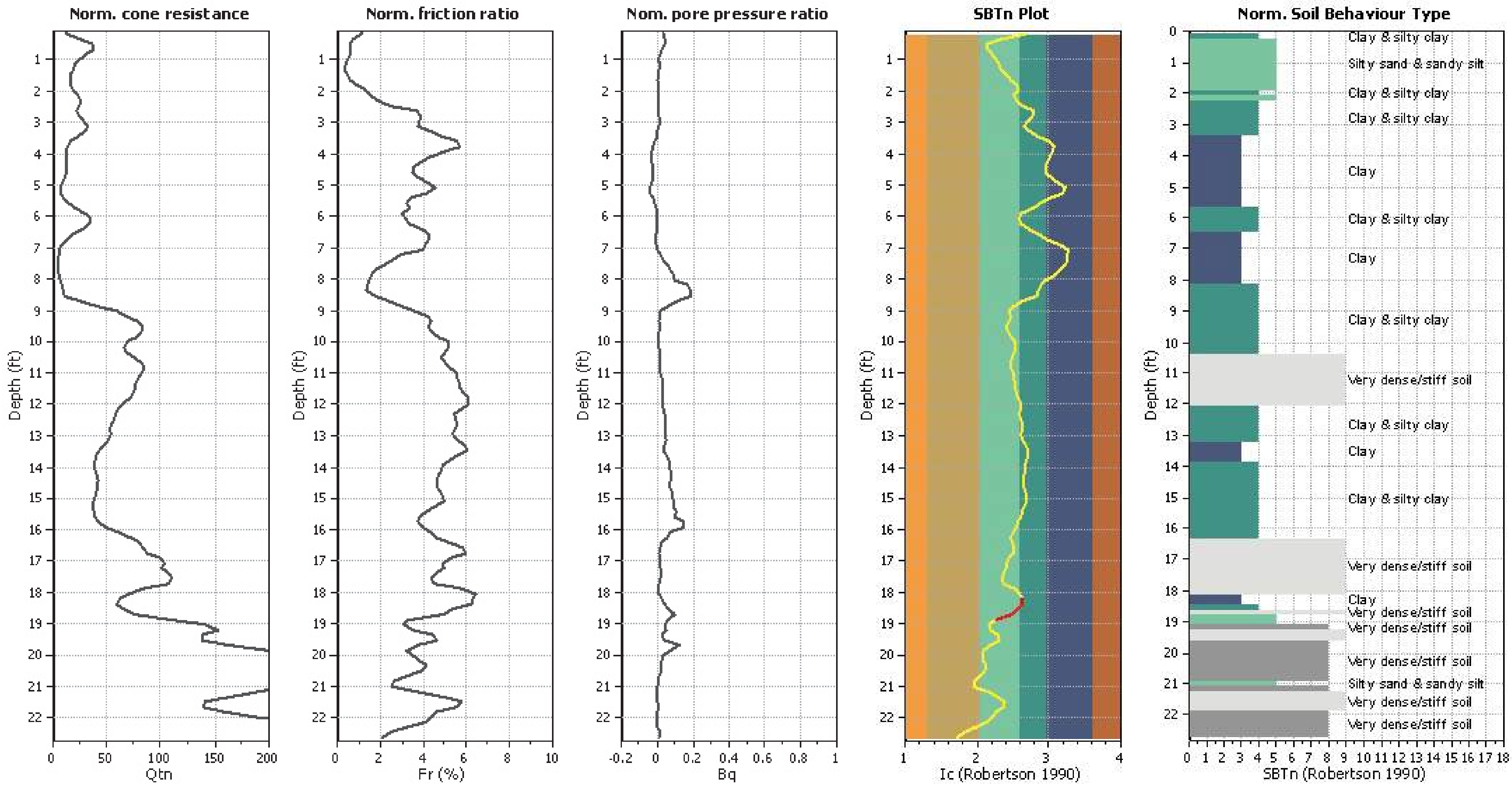
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normaliz



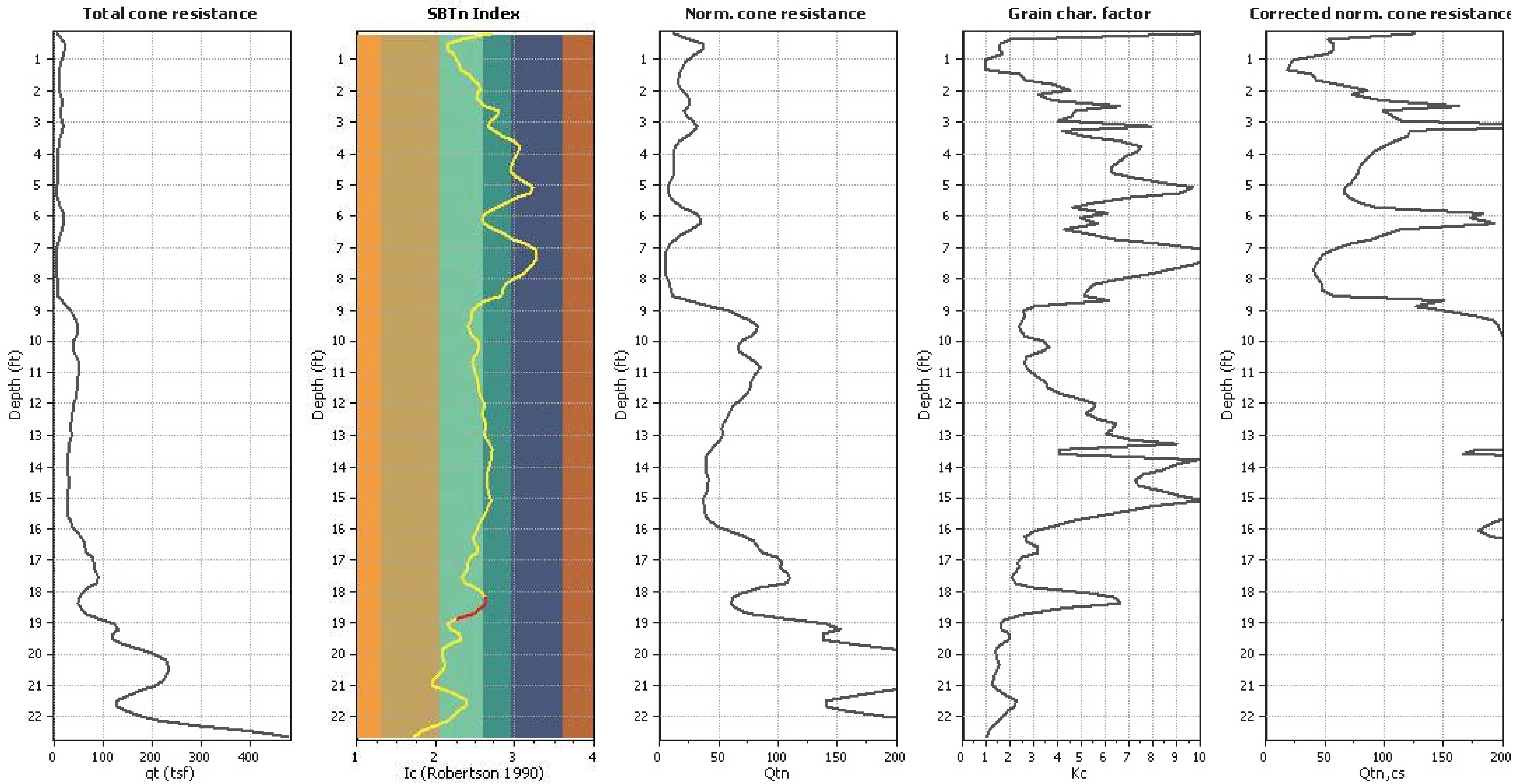
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

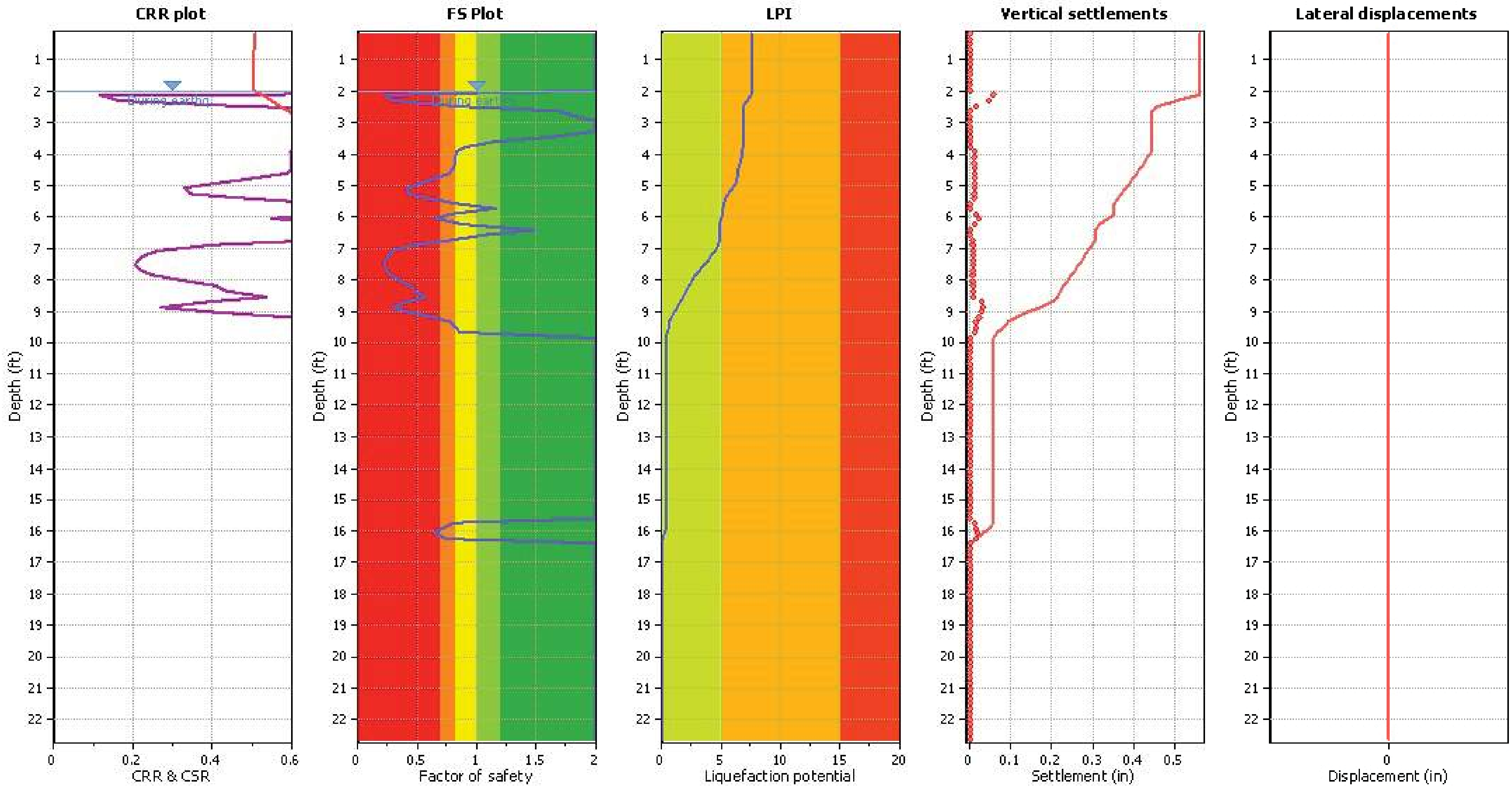
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

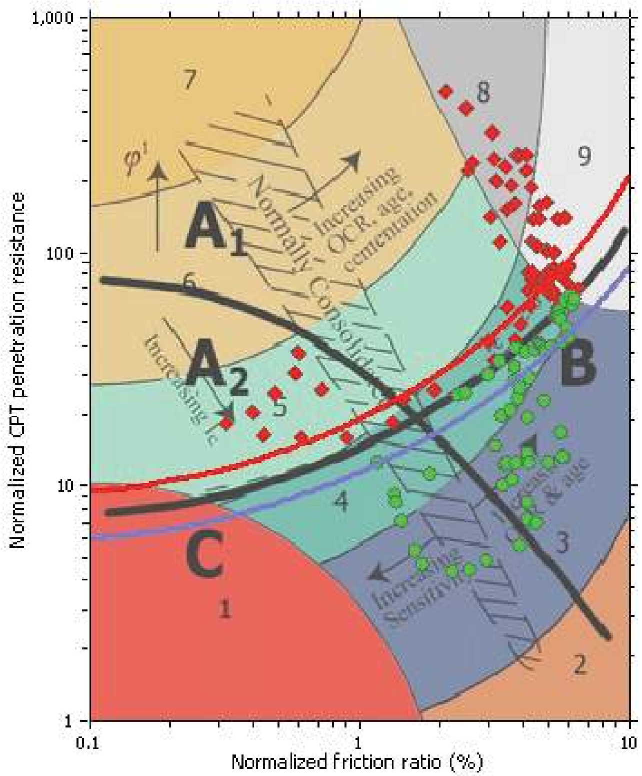
F.S. color scheme

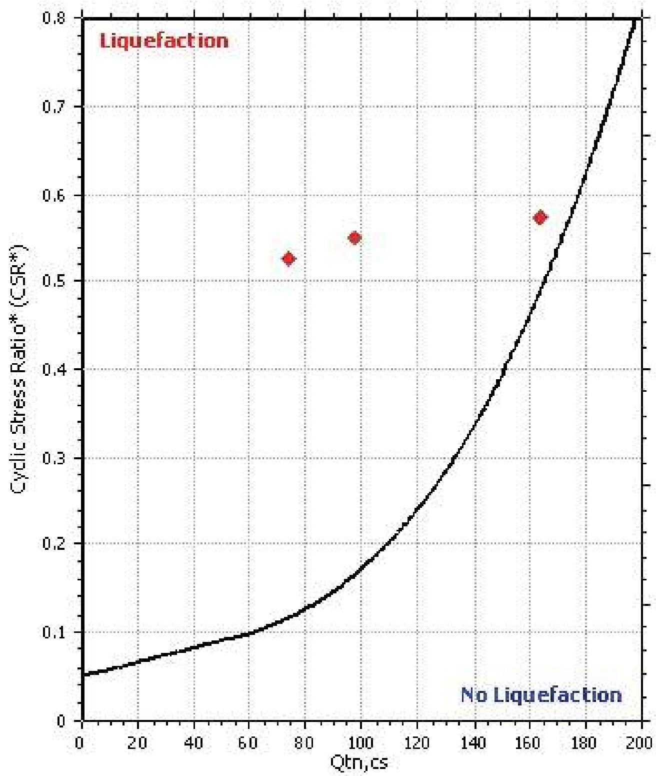
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

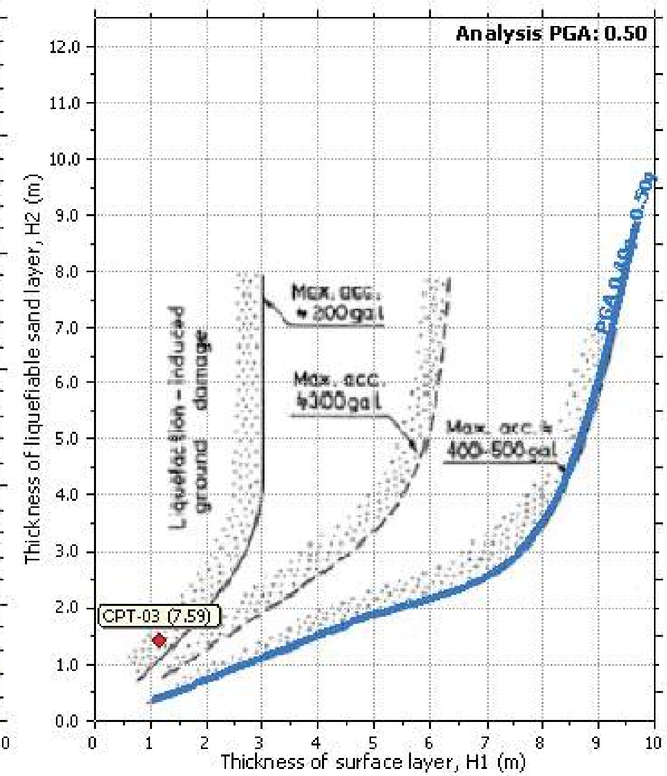
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo



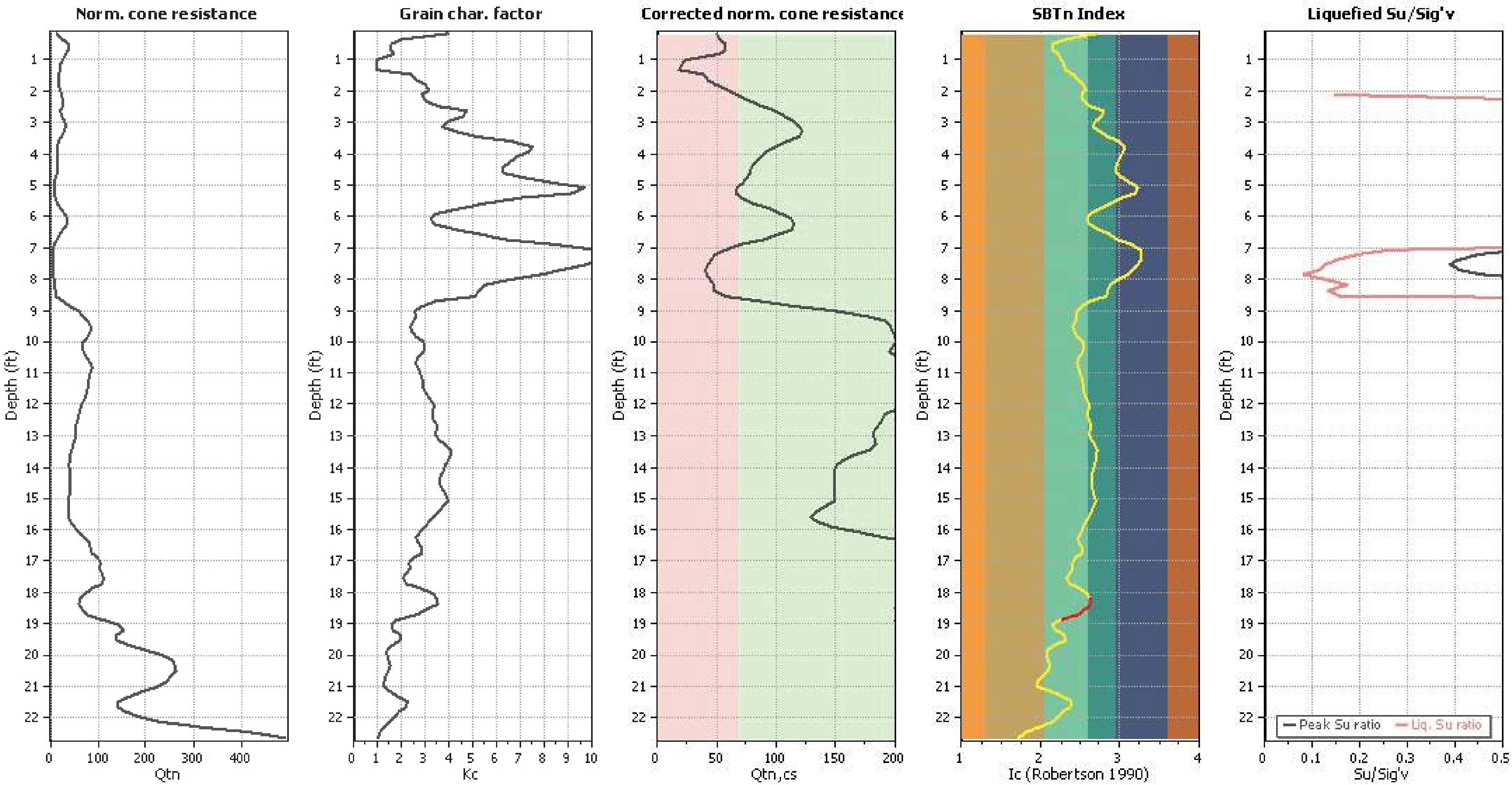




Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

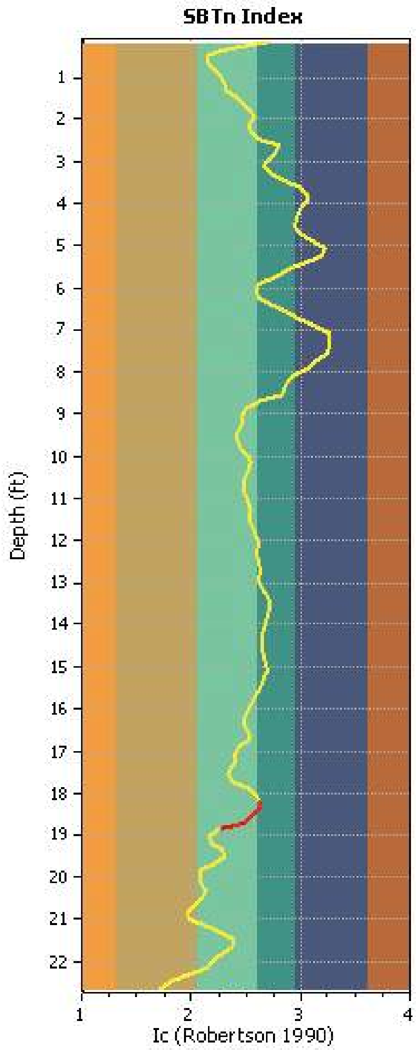
Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

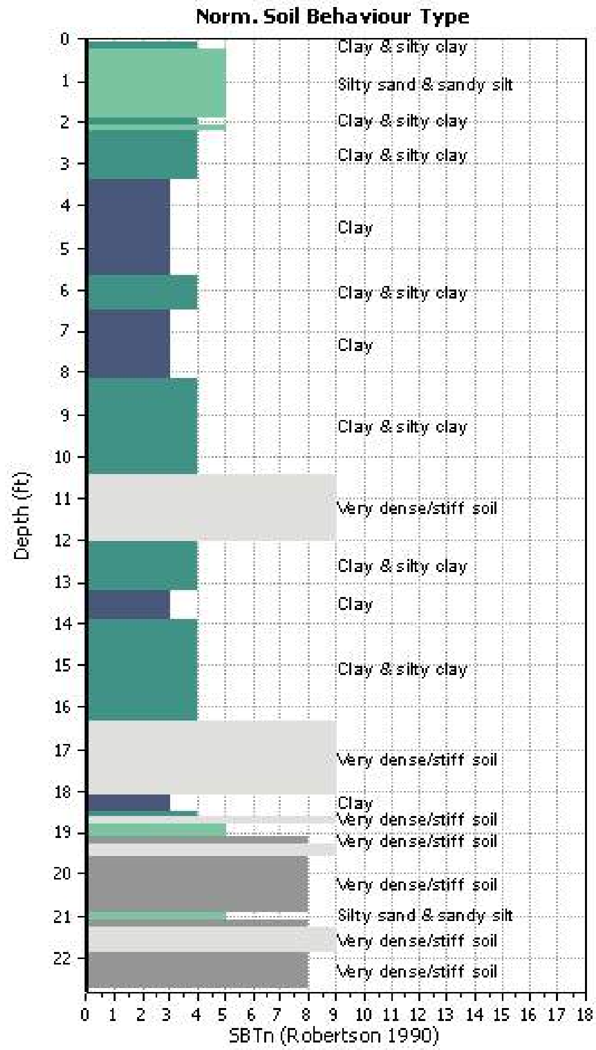
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties

I_c minimum check value:	1.70
I_c maximum check value:	3.00
I_c change ratio value:	0.0250
Minimum number of points in layer:	5

General statistics

Total points in CPT file:	138
Total points excluded:	5
Exclusion percentage:	3.62%
Number of layers detected:	1

Transition layer No	Number of points	Depth	SBT_n number	SBT_n description
Transition layer 1	5	Start depth: 18.37 (ft)	3	Clay
		End depth: 19.03 (ft)	5	Silty sand & sandy silt

Start depth: Depth where the transition layer begins
End depth: Depth where the transition layer ends

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.16	2.35	0.07	2.87	40.30	96.24
2	0.33	15.13	0.09	8.14	23.46	99.67
3	0.49	23.10	0.13	10.74	17.42	101.74
4	0.66	19.52	0.12	7.78	17.20	101.82
5	0.82	16.05	0.10	3.02	19.58	99.79
6	0.98	12.81	0.06	0.44	5.00	96.40
7	1.15	10.43	0.03	2.91	5.00	93.32
8	1.31	9.73	0.04	1.68	5.00	90.50
9	1.48	9.14	0.03	1.41	26.83	91.86
10	1.64	7.69	0.05	0.51	29.54	93.84
11	1.80	8.98	0.08	0.91	32.71	96.86
12	1.97	9.45	0.10	1.06	34.02	101.11
13	2.13	11.77	0.22	0.77	31.48	103.93
14	2.30	16.11	0.22	2.23	32.76	106.66
15	2.46	13.12	0.33	1.77	36.91	108.38
16	2.63	10.38	0.43	0.89	45.64	109.62
17	2.79	10.12	0.47	1.42	44.36	111.26
18	2.95	17.42	0.57	2.91	40.61	112.79
19	3.12	17.87	0.67	2.23	38.34	113.99
20	3.28	16.30	0.69	1.14	42.06	113.86
21	3.45	12.33	0.61	-0.36	48.65	112.61
22	3.61	8.39	0.49	-1.60	57.50	110.49
23	3.77	6.49	0.38	-2.34	62.99	108.45
24	3.94	7.02	0.33	-2.50	62.19	106.88
25	4.10	7.02	0.28	-2.58	59.16	105.80
26	4.27	6.63	0.24	-2.55	57.05	104.96
27	4.43	7.08	0.24	-2.36	55.58	104.41
28	4.59	7.10	0.23	-2.07	55.81	104.05
29	4.76	6.18	0.22	-1.93	60.40	103.24
30	4.92	4.53	0.20	-1.99	68.62	101.87
31	5.09	3.55	0.16	-2.10	75.47	100.53
32	5.25	3.80	0.15	-2.07	72.67	100.30
33	5.41	5.01	0.17	-1.91	60.54	102.03
34	5.58	8.03	0.23	-1.50	50.66	105.23
35	5.74	11.24	0.35	-1.03	44.99	108.55
36	5.91	13.54	0.49	0.99	36.31	111.65
37	6.07	23.69	0.59	0.70	34.71	113.39
38	6.23	18.51	0.65	-0.24	35.76	113.60
39	6.40	12.58	0.55	-0.51	42.60	112.48
40	6.56	11.89	0.46	-0.75	49.36	109.89
41	6.73	7.38	0.28	-0.89	56.52	106.62
42	6.89	3.78	0.18	-0.66	67.96	101.79
43	7.05	3.44	0.10	0.00	78.62	97.49
44	7.22	2.80	0.07	0.55	77.82	94.00
45	7.38	2.52	0.06	1.16	77.97	92.17
46	7.55	2.80	0.05	1.81	76.07	90.85
47	7.71	2.63	0.05	2.59	69.82	89.76
48	7.87	3.05	0.03	3.63	65.10	90.42

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	8.04	3.78	0.06	5.09	55.89	92.44
50	8.20	5.40	0.07	10.46	50.92	93.85
51	8.37	5.17	0.06	12.64	48.89	94.48
52	8.53	4.75	0.07	15.20	48.10	98.63
53	8.69	8.61	0.20	20.95	36.38	107.75
54	8.86	25.70	0.63	17.75	31.30	114.79
55	9.02	32.02	1.15	8.74	28.75	119.68
56	9.19	38.90	1.63	9.49	29.28	122.46
57	9.35	41.75	1.95	6.10	28.10	124.05
58	9.51	49.30	2.02	9.19	26.83	124.74
59	9.68	51.45	2.01	7.06	27.44	124.84
60	9.84	40.02	2.06	4.86	29.10	124.73
61	10.01	41.00	2.06	5.87	32.04	124.27
62	10.17	36.07	1.87	6.65	32.48	123.90
63	10.34	36.07	1.83	8.98	31.95	123.92
64	10.50	43.37	2.03	13.12	30.08	124.98
65	10.66	52.18	2.48	14.88	29.36	126.23
66	10.83	50.70	2.74	12.90	29.68	126.97
67	10.99	49.33	2.71	13.28	30.97	127.04
68	11.16	46.84	2.65	19.65	31.47	126.80
69	11.32	46.39	2.55	22.63	32.25	126.63
70	11.48	44.72	2.61	18.81	32.24	126.67
71	11.65	47.62	2.68	24.17	33.16	126.71
72	11.81	43.23	2.66	20.01	34.30	126.51
73	11.98	38.79	2.52	16.32	35.54	125.63
74	12.14	36.49	2.00	18.92	35.51	124.79
75	12.30	37.58	1.98	23.98	35.07	123.97
76	12.47	34.84	1.89	25.18	35.77	123.70
77	12.63	32.80	1.85	20.09	36.70	123.38
78	12.80	33.11	1.82	21.47	36.50	123.17
79	12.96	34.54	1.75	22.47	36.18	123.20
80	13.12	34.20	1.84	23.07	37.35	123.16
81	13.29	29.78	1.85	19.31	39.41	122.91
82	13.45	27.94	1.69	14.93	41.18	122.11
83	13.62	26.01	1.43	19.81	40.92	121.09
84	13.78	25.62	1.27	24.81	40.23	120.26
85	13.94	25.67	1.25	26.18	39.41	119.89
86	14.11	26.20	1.23	28.40	38.84	119.90
87	14.27	27.10	1.26	30.33	38.07	120.04
88	14.44	28.27	1.28	29.19	37.68	120.17
89	14.60	28.05	1.27	28.47	37.84	120.18
90	14.76	26.99	1.26	32.46	38.72	120.15
91	14.93	26.26	1.30	33.41	39.62	120.05
92	15.09	25.67	1.25	34.20	40.41	119.91
93	15.26	24.86	1.23	34.99	38.37	119.41
94	15.42	28.61	1.01	40.81	37.36	118.82
95	15.58	25.45	0.98	39.05	35.74	118.62
96	15.75	27.60	1.10	62.41	34.17	119.58

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	15.91	37.25	1.33	73.92	32.76	121.49
98	16.08	40.88	1.78	47.66	31.24	123.94
99	16.24	51.01	2.40	48.29	29.58	126.40
100	16.40	67.84	3.02	26.75	30.01	128.33
101	16.57	59.84	3.62	16.65	31.53	129.71
102	16.73	59.17	4.13	15.00	31.48	130.42
103	16.90	77.49	3.93	23.47	28.06	130.92
104	17.06	90.69	3.85	24.37	26.44	131.02
105	17.22	74.05	4.03	26.10	26.95	130.90
106	17.39	71.95	3.83	30.99	25.07	130.91
107	17.55	107.66	3.60	22.24	24.14	130.95
108	17.72	84.23	3.94	14.31	24.98	130.99
109	17.88	65.52	4.00	13.11	30.95	130.35
110	18.05	52.80	3.50	13.29	35.34	129.26
111	18.21	47.51	3.03	20.56	36.62	128.00
112	18.37	47.46	2.67	31.74	36.98	127.46
113	18.54	46.39	2.97	44.58	33.77	127.33
114	18.70	59.56	2.64	84.80	30.14	128.38
115	18.87	77.41	3.40	75.89	20.69	129.59
116	19.03	141.47	3.21	78.83	17.71	131.49
117	19.19	138.73	4.43	97.90	18.54	133.31
118	19.36	109.82	6.12	50.86	22.25	133.99
119	19.52	102.99	5.08	76.11	22.84	134.29
120	19.69	136.41	5.10	245.24	18.78	134.48
121	19.85	176.20	5.58	181.99	15.36	135.66
122	20.01	214.24	6.44	94.33	15.22	137.28
123	20.18	220.42	9.29	77.67	15.57	137.28
124	20.34	250.84	10.57	85.13	16.53	137.28
125	20.51	218.74	9.00	81.21	15.73	137.28
126	20.67	232.58	7.96	46.03	13.64	137.28
127	20.83	228.72	4.38	31.64	12.03	136.35
128	21.00	207.33	5.12	19.35	12.28	135.34
129	21.16	180.93	6.12	13.12	17.09	136.43
130	21.33	138.45	7.87	12.72	22.18	137.06
131	21.49	127.50	8.01	11.80	25.74	136.71
132	21.65	118.09	6.19	16.22	24.99	136.31
133	21.82	138.98	6.70	12.27	21.63	136.27
134	21.98	177.91	7.06	13.66	19.28	137.28
135	22.15	217.81	9.48	18.99	17.34	137.28
136	22.31	240.72	9.64	25.96	12.07	137.28
137	22.47	467.87	9.88	88.97	8.70	137.28
138	22.64	482.05	9.95	87.42	6.58	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.16	0.01	0.00	0.01	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
2	0.33	0.02	0.00	0.02	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
3	0.49	0.02	0.00	0.02	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
4	0.66	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
5	0.82	0.04	0.00	0.04	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
6	0.98	0.05	0.00	0.05	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
7	1.15	0.06	0.00	0.06	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
8	1.31	0.06	0.00	0.06	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
9	1.48	0.07	0.00	0.07	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
10	1.64	0.08	0.00	0.08	1.00	0.324	0.83	0.389	1.00	1.30	2.000	No
11	1.80	0.09	0.00	0.09	1.00	0.324	0.83	0.389	1.00	1.30	2.000	No
12	1.97	0.10	0.00	0.10	1.00	0.324	0.83	0.389	1.00	1.30	2.000	No
13	2.13	0.10	0.00	0.10	1.00	0.338	0.83	0.405	1.00	1.30	0.526	No
14	2.30	0.11	0.01	0.10	1.00	0.353	0.83	0.423	1.00	1.30	0.550	No
15	2.46	0.12	0.01	0.11	1.00	0.367	0.83	0.440	1.00	1.30	0.572	No
16	2.63	0.13	0.02	0.11	1.00	0.380	0.83	0.456	1.00	1.30	0.593	No
17	2.79	0.14	0.02	0.12	1.00	0.393	0.83	0.471	1.00	1.30	0.612	No
18	2.95	0.15	0.03	0.12	1.00	0.404	0.83	0.484	1.00	1.30	0.630	No
19	3.12	0.16	0.03	0.12	0.99	0.415	0.83	0.497	1.00	1.30	0.646	No
20	3.28	0.17	0.04	0.13	0.99	0.424	0.83	0.509	1.00	1.30	0.661	No
21	3.45	0.18	0.05	0.13	0.99	0.434	0.83	0.520	1.00	1.30	0.676	No
22	3.61	0.19	0.05	0.14	0.99	0.442	0.83	0.530	1.00	1.30	0.689	No
23	3.77	0.19	0.06	0.14	0.99	0.451	0.83	0.540	1.00	1.30	0.703	No
24	3.94	0.20	0.06	0.14	0.99	0.459	0.83	0.550	1.00	1.30	0.715	No
25	4.10	0.21	0.07	0.15	0.99	0.467	0.83	0.559	1.00	1.30	0.727	No
26	4.27	0.22	0.07	0.15	0.99	0.474	0.83	0.568	1.00	1.30	0.739	No
27	4.43	0.23	0.08	0.15	0.99	0.481	0.83	0.577	1.00	1.30	0.750	No
28	4.59	0.24	0.08	0.16	0.99	0.488	0.83	0.585	1.00	1.30	0.761	No
29	4.76	0.25	0.09	0.16	0.99	0.495	0.83	0.593	1.00	1.30	0.771	No
30	4.92	0.25	0.09	0.16	0.99	0.501	0.83	0.601	1.00	1.30	0.781	No
31	5.09	0.26	0.10	0.17	0.99	0.507	0.83	0.608	1.00	1.30	0.791	No
32	5.25	0.27	0.10	0.17	0.99	0.514	0.83	0.616	1.00	1.30	0.801	No
33	5.41	0.28	0.11	0.17	0.99	0.519	0.83	0.623	1.00	1.30	0.809	No
34	5.58	0.29	0.11	0.18	0.99	0.524	0.83	0.629	1.00	1.30	0.818	No
35	5.74	0.30	0.12	0.18	0.99	0.529	0.83	0.634	1.00	1.30	0.825	No
36	5.91	0.31	0.12	0.18	0.99	0.533	0.83	0.639	1.00	1.30	0.831	No
37	6.07	0.32	0.13	0.19	0.99	0.537	0.83	0.644	1.00	1.30	0.837	No
38	6.23	0.32	0.13	0.19	0.99	0.541	0.83	0.648	1.00	1.30	0.843	No
39	6.40	0.33	0.14	0.20	0.99	0.544	0.83	0.653	1.00	1.30	0.848	No
40	6.56	0.34	0.14	0.20	0.99	0.548	0.83	0.657	1.00	1.30	0.854	No
41	6.73	0.35	0.15	0.20	0.99	0.552	0.83	0.661	1.00	1.30	0.860	No
42	6.89	0.36	0.15	0.21	0.99	0.556	0.83	0.666	1.00	1.30	0.866	No
43	7.05	0.37	0.16	0.21	0.99	0.560	0.83	0.672	1.00	1.30	0.873	No
44	7.22	0.38	0.16	0.21	0.99	0.565	0.83	0.677	1.00	1.30	0.880	No
45	7.38	0.38	0.17	0.22	0.98	0.569	0.83	0.683	1.00	1.30	0.887	No
46	7.55	0.39	0.17	0.22	0.98	0.574	0.83	0.688	1.00	1.30	0.895	No
47	7.71	0.40	0.18	0.22	0.98	0.579	0.83	0.694	1.00	1.30	0.902	No
48	7.87	0.41	0.18	0.22	0.98	0.583	0.83	0.699	1.00	1.30	0.909	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
49	8.04	0.41	0.19	0.22	0.98	0.587	0.83	0.704	1.00	1.30	0.915	No
50	8.20	0.42	0.19	0.23	0.98	0.591	0.83	0.709	1.00	1.30	0.921	No
51	8.37	0.43	0.20	0.23	0.98	0.595	0.83	0.713	1.00	1.30	0.927	No
52	8.53	0.44	0.20	0.23	0.98	0.598	0.83	0.717	1.00	1.30	0.932	No
53	8.69	0.45	0.21	0.24	0.98	0.601	0.83	0.720	1.00	1.30	0.936	No
54	8.86	0.46	0.21	0.24	0.98	0.602	0.83	0.722	1.00	1.30	0.938	No
55	9.02	0.46	0.22	0.25	0.98	0.603	0.83	0.723	1.00	1.30	0.940	No
56	9.19	0.47	0.22	0.25	0.98	0.604	0.83	0.724	1.00	1.30	0.941	No
57	9.35	0.49	0.23	0.26	0.98	0.604	0.83	0.725	1.00	1.30	0.942	No
58	9.51	0.50	0.23	0.26	0.98	0.605	0.83	0.725	1.00	1.30	0.943	No
59	9.68	0.51	0.24	0.27	0.98	0.605	0.83	0.726	1.00	1.30	0.943	No
60	9.84	0.52	0.24	0.27	0.98	0.606	0.83	0.726	1.00	1.30	0.944	No
61	10.01	0.53	0.25	0.28	0.98	0.606	0.83	0.727	1.00	1.30	0.945	No
62	10.17	0.54	0.25	0.28	0.98	0.606	0.83	0.727	1.00	1.30	0.945	No
63	10.34	0.55	0.26	0.29	0.98	0.607	0.83	0.728	1.00	1.30	0.946	No
64	10.50	0.56	0.27	0.29	0.98	0.607	0.83	0.728	1.00	1.30	0.946	No
65	10.66	0.57	0.27	0.30	0.98	0.607	0.83	0.728	1.00	1.30	0.946	No
66	10.83	0.58	0.28	0.30	0.98	0.607	0.83	0.728	1.00	1.30	0.947	No
67	10.99	0.59	0.28	0.31	0.98	0.607	0.83	0.728	1.00	1.30	0.947	No
68	11.16	0.60	0.29	0.31	0.98	0.607	0.83	0.728	1.00	1.30	0.947	No
69	11.32	0.61	0.29	0.32	0.98	0.608	0.83	0.728	1.00	1.30	0.947	No
70	11.48	0.62	0.30	0.32	0.98	0.608	0.83	0.729	1.00	1.30	0.947	No
71	11.65	0.63	0.30	0.33	0.98	0.608	0.83	0.729	1.00	1.30	0.947	No
72	11.81	0.64	0.31	0.33	0.98	0.608	0.83	0.729	1.00	1.30	0.947	No
73	11.98	0.65	0.31	0.34	0.97	0.608	0.83	0.729	1.00	1.30	0.948	No
74	12.14	0.66	0.32	0.34	0.97	0.608	0.83	0.729	1.00	1.30	0.948	No
75	12.30	0.67	0.32	0.35	0.97	0.608	0.83	0.729	1.00	1.30	0.948	No
76	12.47	0.68	0.33	0.35	0.97	0.608	0.83	0.730	1.00	1.30	0.948	No
77	12.63	0.69	0.33	0.36	0.97	0.609	0.83	0.730	1.00	1.30	0.949	No
78	12.80	0.70	0.34	0.36	0.97	0.609	0.83	0.730	1.00	1.30	0.949	No
79	12.96	0.71	0.34	0.37	0.97	0.609	0.83	0.730	1.00	1.30	0.950	No
80	13.12	0.72	0.35	0.37	0.97	0.609	0.83	0.731	1.00	1.30	0.950	No
81	13.29	0.73	0.35	0.38	0.97	0.610	0.83	0.731	1.00	1.30	0.950	No
82	13.45	0.74	0.36	0.38	0.97	0.610	0.83	0.731	1.00	1.30	0.951	No
83	13.62	0.75	0.36	0.39	0.97	0.610	0.83	0.732	1.00	1.30	0.951	No
84	13.78	0.76	0.37	0.39	0.97	0.610	0.83	0.732	1.00	1.30	0.952	No
85	13.94	0.77	0.37	0.40	0.97	0.611	0.83	0.732	1.00	1.30	0.952	No
86	14.11	0.78	0.38	0.40	0.97	0.611	0.83	0.733	1.00	1.30	0.953	No
87	14.27	0.79	0.38	0.41	0.97	0.611	0.83	0.733	1.00	1.30	0.953	No
88	14.44	0.80	0.39	0.41	0.97	0.612	0.83	0.734	1.00	1.30	0.954	No
89	14.60	0.81	0.39	0.42	0.97	0.612	0.83	0.734	1.00	1.30	0.954	No
90	14.76	0.82	0.40	0.42	0.97	0.612	0.83	0.734	1.00	1.30	0.954	No
91	14.93	0.83	0.40	0.43	0.97	0.613	0.83	0.734	1.00	1.30	0.955	No
92	15.09	0.84	0.41	0.43	0.97	0.613	0.83	0.735	1.00	1.30	0.955	No
93	15.26	0.85	0.41	0.44	0.97	0.613	0.83	0.735	1.00	1.30	0.956	No
94	15.42	0.86	0.42	0.44	0.97	0.613	0.83	0.735	1.00	1.30	0.956	No
95	15.58	0.87	0.42	0.45	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
96	15.75	0.88	0.43	0.45	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
97	15.91	0.89	0.43	0.45	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
98	16.08	0.90	0.44	0.46	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
99	16.24	0.91	0.44	0.47	0.97	0.614	0.83	0.736	1.00	1.30	0.957	No
100	16.40	0.92	0.45	0.47	0.97	0.614	0.83	0.736	1.00	1.30	0.956	No
101	16.57	0.93	0.45	0.48	0.97	0.613	0.83	0.735	1.00	1.30	0.956	No
102	16.73	0.94	0.46	0.48	0.96	0.613	0.83	0.735	1.00	1.30	0.955	No
103	16.90	0.95	0.46	0.49	0.96	0.612	0.83	0.734	1.00	1.30	0.955	No
104	17.06	0.96	0.47	0.49	0.96	0.612	0.83	0.734	1.00	1.30	0.954	No
105	17.22	0.97	0.47	0.50	0.96	0.612	0.83	0.733	1.00	1.30	0.953	No
106	17.39	0.98	0.48	0.50	0.96	0.611	0.83	0.733	1.00	1.30	0.953	No
107	17.55	0.99	0.49	0.51	0.96	0.611	0.83	0.732	1.00	1.30	0.952	No
108	17.72	1.01	0.49	0.52	0.96	0.611	0.83	0.732	1.00	1.30	0.952	No
109	17.88	1.02	0.50	0.52	0.96	0.610	0.83	0.732	1.00	1.30	0.951	No
110	18.05	1.03	0.50	0.53	0.96	0.610	0.83	0.731	1.00	1.30	0.951	No
111	18.21	1.04	0.51	0.53	0.96	0.610	0.83	0.731	1.00	1.30	0.950	No
112	18.37	1.05	0.51	0.54	0.96	0.609	0.83	0.731	1.00	1.30	2.000	Yes
113	18.54	1.06	0.52	0.54	0.96	0.609	0.83	0.730	1.00	1.30	2.000	Yes
114	18.70	1.07	0.52	0.55	0.96	0.609	0.83	0.730	1.00	1.30	2.000	Yes
115	18.87	1.08	0.53	0.55	0.96	0.609	0.83	0.730	1.00	1.30	2.000	Yes
116	19.03	1.09	0.53	0.56	0.96	0.608	0.83	0.729	1.00	1.30	2.000	Yes
117	19.19	1.10	0.54	0.56	0.96	0.608	0.83	0.729	1.00	1.30	0.947	No
118	19.36	1.11	0.54	0.57	0.96	0.607	0.83	0.728	1.00	1.30	0.946	No
119	19.52	1.12	0.55	0.58	0.96	0.607	0.83	0.727	1.00	1.30	0.946	No
120	19.69	1.13	0.55	0.58	0.96	0.606	0.83	0.727	1.00	1.30	0.945	No
121	19.85	1.15	0.56	0.59	0.96	0.606	0.83	0.726	1.00	1.30	0.944	No
122	20.01	1.16	0.56	0.59	0.96	0.605	0.83	0.725	1.00	1.30	0.943	No
123	20.18	1.17	0.57	0.60	0.96	0.604	0.83	0.725	1.00	1.30	0.942	No
124	20.34	1.18	0.57	0.61	0.96	0.604	0.83	0.724	1.00	1.30	0.941	No
125	20.51	1.19	0.58	0.61	0.96	0.603	0.83	0.723	1.00	1.30	0.940	No
126	20.67	1.20	0.58	0.62	0.96	0.602	0.83	0.722	1.00	1.30	0.939	No
127	20.83	1.21	0.59	0.63	0.95	0.602	0.83	0.722	1.00	1.30	0.938	No
128	21.00	1.22	0.59	0.63	0.95	0.601	0.83	0.721	1.00	1.30	0.937	No
129	21.16	1.24	0.60	0.64	0.95	0.601	0.83	0.720	1.00	1.30	0.936	No
130	21.33	1.25	0.60	0.64	0.95	0.600	0.83	0.720	1.00	1.30	0.936	No
131	21.49	1.26	0.61	0.65	0.95	0.600	0.83	0.719	1.00	1.30	0.935	No
132	21.65	1.27	0.61	0.66	0.95	0.599	0.83	0.718	1.00	1.30	0.934	No
133	21.82	1.28	0.62	0.66	0.95	0.599	0.83	0.718	1.00	1.30	0.933	No
134	21.98	1.29	0.62	0.67	0.95	0.598	0.83	0.717	1.00	1.30	0.932	No
135	22.15	1.30	0.63	0.67	0.95	0.597	0.83	0.716	1.00	1.30	0.931	No
136	22.31	1.31	0.63	0.68	0.95	0.597	0.83	0.716	1.00	1.30	0.930	No
137	22.47	1.32	0.64	0.69	0.95	0.596	0.83	0.715	1.00	1.30	0.929	No
138	22.64	1.34	0.64	0.69	0.95	0.596	0.83	0.714	1.00	1.30	0.928	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.16	6.68	2.70	1.17	0.88	12.60	9.99	125.96	4.000	No	No	2.00
2	0.33	13.63	2.32	0.72	0.74	25.73	2.03	52.27	4.000	No	No	2.00
3	0.49	19.38	2.15	0.60	0.67	36.58	1.56	56.96	4.000	No	No	2.00
4	0.66	19.66	2.14	0.59	0.67	37.10	1.54	57.21	4.000	No	No	2.00
5	0.82	16.18	2.22	0.58	0.70	30.50	1.71	52.17	4.000	No	No	2.00
6	0.98	13.13	2.27	0.49	0.72	24.72	1.00	24.72	4.000	No	No	2.00
7	1.15	11.01	2.31	0.40	0.73	20.71	1.00	20.71	4.000	No	No	2.00
8	1.31	9.80	2.32	0.32	0.74	18.40	1.00	18.40	4.000	No	No	2.00
9	1.48	8.87	2.41	0.44	0.77	16.64	2.35	39.16	4.000	No	No	2.00
10	1.64	8.62	2.47	0.61	0.80	16.14	2.64	42.62	4.000	No	No	2.00
11	1.80	8.72	2.54	0.90	0.82	16.31	3.77	61.48	4.000	No	No	2.00
12	1.97	10.08	2.57	1.33	0.83	18.87	4.52	85.25	4.000	No	No	2.00
13	2.13	12.46	2.52	1.47	0.81	23.36	3.15	73.68	0.117	No	No	0.22
14	2.30	13.69	2.55	1.88	0.83	25.66	3.79	97.34	0.166	No	No	0.30
15	2.46	13.22	2.63	2.49	0.86	24.76	6.62	163.87	0.489	No	No	0.85
16	2.63	11.22	2.79	3.68	0.92	20.97	4.73	99.22	1.000	No	Yes	1.69
17	2.79	12.67	2.77	3.92	0.91	23.68	4.55	107.61	1.129	No	Yes	1.84
18	2.95	15.17	2.70	3.80	0.89	28.39	4.02	114.05	1.354	No	Yes	2.00
19	3.12	17.23	2.66	3.77	0.87	32.26	7.90	254.99	4.000	No	No	2.00
20	3.28	15.52	2.73	4.27	0.90	29.01	4.22	122.39	1.384	No	Yes	2.00
21	3.45	12.34	2.85	4.90	0.94	22.99	5.18	119.10	1.096	No	Yes	1.62
22	3.61	9.05	2.99	5.58	1.00	16.75	6.58	110.27	0.799	No	Yes	1.16
23	3.77	7.27	3.07	5.69	1.00	13.37	7.50	100.27	0.638	No	Yes	0.91
24	3.94	6.81	3.05	5.03	1.00	12.48	7.36	91.91	0.595	No	Yes	0.83
25	4.10	6.85	3.01	4.30	1.00	12.55	6.86	86.03	0.599	No	Yes	0.82
26	4.27	6.87	2.98	3.83	1.00	12.57	6.51	81.80	0.600	No	Yes	0.81
27	4.43	6.90	2.96	3.53	0.99	12.61	6.27	79.07	0.602	No	Yes	0.80
28	4.59	6.76	2.96	3.47	0.99	12.32	6.31	77.68	0.588	No	Yes	0.77
29	4.76	5.91	3.03	3.74	1.00	10.70	7.06	75.59	0.511	No	Yes	0.66
30	4.92	4.72	3.14	4.23	1.00	8.45	8.47	71.59	0.403	No	Yes	0.52
31	5.09	3.93	3.23	4.56	1.00	6.93	9.70	67.23	0.331	No	Yes	0.42
32	5.25	4.09	3.20	4.19	1.00	7.22	9.19	66.36	0.344	No	Yes	0.43
33	5.41	5.59	3.03	3.44	1.00	10.03	7.09	71.06	0.478	No	Yes	0.59
34	5.58	8.07	2.88	3.22	0.96	14.71	5.49	80.75	0.702	No	Yes	0.86
35	5.74	10.93	2.78	3.35	0.92	20.09	4.64	93.17	0.958	No	Yes	1.16
36	5.91	16.16	2.62	3.01	0.86	29.96	6.12	183.42	0.654	No	No	0.79
37	6.07	18.58	2.59	3.16	0.85	34.53	4.96	171.37	0.548	No	No	0.65
38	6.23	18.26	2.61	3.34	0.86	33.90	5.70	193.25	0.751	No	No	0.89
39	6.40	14.32	2.74	3.98	0.91	26.44	4.29	113.51	1.261	No	Yes	1.49
40	6.56	10.61	2.86	4.21	0.95	19.40	5.29	102.63	0.925	No	Yes	1.08
41	6.73	7.67	2.97	4.20	1.00	13.83	6.42	88.83	0.660	No	Yes	0.77
42	6.89	4.86	3.13	4.12	1.00	8.50	8.36	71.06	0.406	No	Yes	0.47
43	7.05	3.34	3.27	3.93	1.00	5.61	10.27	57.61	0.268	No	Yes	0.31
44	7.22	2.93	3.26	2.97	1.00	4.82	10.12	48.78	0.230	No	Yes	0.26
45	7.38	2.72	3.26	2.58	1.00	4.42	10.15	44.82	0.211	No	Yes	0.24
46	7.55	2.67	3.24	2.22	1.00	4.31	9.80	42.30	0.206	No	Yes	0.23
47	7.71	2.86	3.16	1.73	1.00	4.66	8.69	40.45	0.222	No	Yes	0.25
48	7.87	3.20	3.09	1.61	1.00	5.29	7.86	41.59	0.252	No	Yes	0.28

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
49	8.04	4.17	2.96	1.45	1.00	7.09	6.32	44.82	0.338	No	Yes	0.37
50	8.20	4.92	2.88	1.39	0.97	8.50	5.53	47.00	0.405	No	Yes	0.44
51	8.37	5.29	2.85	1.36	0.96	9.19	5.22	47.97	0.438	No	Yes	0.47
52	8.53	6.41	2.84	1.83	0.95	11.30	5.10	57.60	0.539	No	Yes	0.58
53	8.69	13.28	2.62	2.33	0.87	24.26	6.18	149.98	0.394	No	No	0.42
54	8.86	22.34	2.51	3.01	0.83	41.36	3.07	127.06	0.271	No	No	0.29
55	9.02	32.38	2.46	3.56	0.81	58.68	2.56	149.96	0.394	No	No	0.42
56	9.19	37.67	2.47	4.24	0.81	68.09	2.61	177.93	0.604	No	No	0.64
57	9.35	43.44	2.44	4.35	0.80	77.31	2.49	192.18	0.740	No	No	0.79
58	9.51	47.61	2.41	4.23	0.79	83.33	2.35	196.18	0.782	No	No	0.83
59	9.68	47.03	2.42	4.36	0.80	81.97	2.42	198.14	0.803	No	No	0.85
60	9.84	44.24	2.46	4.67	0.81	77.29	2.59	200.40	4.000	No	No	2.00
61	10.01	39.11	2.53	5.17	0.84	68.95	3.42	235.97	4.000	No	No	2.00
62	10.17	37.82	2.54	5.15	0.84	66.25	3.64	241.48	4.000	No	No	2.00
63	10.34	38.64	2.53	5.01	0.84	66.93	3.38	226.12	4.000	No	No	2.00
64	10.50	44.05	2.49	4.86	0.82	74.87	2.70	202.21	4.000	No	No	2.00
65	10.66	48.95	2.47	5.00	0.82	82.23	2.62	215.54	4.000	No	No	2.00
66	10.83	50.93	2.48	5.25	0.82	85.06	2.66	225.98	4.000	No	No	2.00
67	10.99	49.18	2.51	5.56	0.83	82.04	2.93	240.16	4.000	No	No	2.00
68	11.16	47.79	2.52	5.59	0.83	79.27	3.15	249.84	4.000	No	No	2.00
69	11.32	46.28	2.53	5.71	0.84	76.43	3.53	269.66	4.000	No	No	2.00
70	11.48	46.56	2.53	5.69	0.84	76.26	3.52	268.47	4.000	No	No	2.00
71	11.65	45.49	2.55	5.91	0.85	74.25	4.01	297.97	4.000	No	No	2.00
72	11.81	43.50	2.58	6.11	0.86	70.81	4.70	332.63	4.000	No	No	2.00
73	11.98	39.77	2.60	6.11	0.87	64.54	5.54	357.82	4.000	No	No	2.00
74	12.14	37.91	2.60	5.81	0.87	60.97	5.52	336.55	4.000	No	No	2.00
75	12.30	36.63	2.59	5.44	0.87	58.30	5.21	303.68	4.000	No	No	2.00
76	12.47	35.41	2.61	5.49	0.87	56.06	5.71	320.25	4.000	No	No	2.00
77	12.63	33.91	2.63	5.58	0.88	53.45	6.44	344.02	4.000	No	No	2.00
78	12.80	33.79	2.62	5.45	0.88	52.81	6.28	331.49	4.000	No	No	2.00
79	12.96	34.27	2.62	5.37	0.88	53.09	6.03	319.87	4.000	No	No	2.00
80	13.12	33.15	2.64	5.59	0.88	51.19	6.99	357.83	4.000	No	No	2.00
81	13.29	30.91	2.68	5.94	0.90	47.71	9.00	429.64	4.000	No	No	2.00
82	13.45	28.17	2.71	6.04	0.91	43.35	4.10	177.58	2.068	No	Yes	2.00
83	13.62	26.81	2.71	5.63	0.91	40.85	4.06	165.82	1.948	No	Yes	2.00
84	13.78	26.10	2.70	5.21	0.91	39.35	9.92	390.40	4.000	No	No	2.00
85	13.94	26.21	2.68	4.92	0.90	39.10	8.99	351.74	4.000	No	No	2.00
86	14.11	26.73	2.67	4.81	0.90	39.54	8.41	332.33	4.000	No	No	2.00
87	14.27	27.61	2.65	4.69	0.89	40.47	7.65	309.46	4.000	No	No	2.00
88	14.44	28.23	2.65	4.63	0.89	41.05	7.28	298.91	4.000	No	No	2.00
89	14.60	28.20	2.65	4.65	0.89	40.75	7.43	302.82	4.000	No	No	2.00
90	14.76	27.55	2.67	4.78	0.90	39.64	8.28	328.12	4.000	No	No	2.00
91	14.93	26.79	2.68	4.90	0.90	38.37	9.23	354.04	4.000	No	No	2.00
92	15.09	26.09	2.70	4.98	0.91	37.19	10.13	376.67	4.000	No	No	2.00
93	15.26	26.91	2.66	4.47	0.89	37.86	7.94	300.45	4.000	No	No	2.00
94	15.42	26.86	2.64	4.13	0.89	37.40	7.00	261.79	4.000	No	No	2.00
95	15.58	27.90	2.61	3.82	0.88	38.44	5.69	218.62	4.000	No	No	2.00
96	15.75	30.94	2.58	3.78	0.86	42.24	4.61	194.94	0.769	No	No	0.80

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
97	15.91	36.13	2.55	3.98	0.85	48.96	3.80	185.85	0.677	No	No	0.71
98	16.08	43.86	2.51	4.27	0.84	58.99	3.05	179.64	0.619	No	No	0.65
99	16.24	53.83	2.48	4.53	0.83	71.76	2.65	189.88	0.717	No	No	0.75
100	16.40	60.00	2.48	5.10	0.83	79.73	2.69	214.75	4.000	No	No	2.00
101	16.57	62.57	2.52	5.82	0.84	83.08	3.18	264.14	4.000	No	No	2.00
102	16.73	65.77	2.52	6.00	0.84	86.79	3.16	273.83	4.000	No	No	2.00
103	16.90	76.08	2.44	5.28	0.81	98.73	2.48	244.99	4.000	No	No	2.00
104	17.06	81.10	2.40	4.91	0.80	104.02	2.32	240.80	4.000	No	No	2.00
105	17.22	79.29	2.41	4.98	0.80	101.21	2.37	239.50	4.000	No	No	2.00
106	17.39	84.94	2.37	4.55	0.79	107.10	2.18	233.58	4.000	No	No	2.00
107	17.55	88.27	2.34	4.34	0.78	110.31	2.09	230.95	4.000	No	No	2.00
108	17.72	86.04	2.36	4.52	0.79	107.16	2.17	232.86	4.000	No	No	2.00
109	17.88	67.71	2.51	5.72	0.84	85.19	2.92	248.60	4.000	No	No	2.00
110	18.05	55.50	2.60	6.45	0.88	70.03	5.40	377.79	4.000	No	No	2.00
111	18.21	49.57	2.63	6.32	0.89	62.21	6.37	396.44	4.000	No	No	2.00
112	18.37	47.58	2.63	6.21	0.89	59.34	6.67	395.80	4.000	Yes	No	2.00
113	18.54	51.91	2.57	5.43	0.86	63.92	4.37	279.28	4.000	Yes	No	2.00
114	18.70	62.11	2.49	4.92	0.83	75.51	2.71	204.42	4.000	Yes	No	2.00
115	18.87	93.96	2.25	3.32	0.74	111.01	1.80	199.45	4.000	Yes	No	2.00
116	19.03	120.42	2.16	3.08	0.71	140.39	1.58	221.34	4.000	Yes	No	2.00
117	19.19	131.10	2.19	3.53	0.72	152.59	1.63	249.29	4.000	No	No	2.00
118	19.36	118.26	2.29	4.45	0.76	138.41	1.93	266.46	4.000	No	No	2.00
119	19.52	118.19	2.31	4.64	0.77	137.79	1.98	272.38	4.000	No	No	2.00
120	19.69	140.95	2.19	3.76	0.72	161.66	1.65	266.97	4.000	No	No	2.00
121	19.85	178.12	2.09	3.22	0.68	201.27	1.43	287.50	4.000	No	No	2.00
122	20.01	205.32	2.08	3.48	0.68	230.89	1.42	327.91	4.000	No	No	2.00
123	20.18	229.73	2.09	3.84	0.69	257.47	1.44	370.82	4.000	No	No	2.00
124	20.34	231.17	2.12	4.18	0.70	258.55	1.50	387.54	4.000	No	No	2.00
125	20.51	235.07	2.10	3.92	0.69	260.96	1.45	378.44	4.000	No	No	2.00
126	20.67	227.44	2.03	3.14	0.66	249.56	1.33	332.96	4.000	No	No	2.00
127	20.83	223.34	1.97	2.62	0.64	242.62	1.26	304.99	4.000	No	No	2.00
128	21.00	205.97	1.98	2.54	0.64	222.82	1.27	282.69	4.000	No	No	2.00
129	21.16	175.79	2.14	3.65	0.71	191.67	1.54	294.26	4.000	No	No	2.00
130	21.33	149.14	2.29	4.96	0.76	163.49	1.92	313.75	4.000	No	No	2.00
131	21.49	128.21	2.38	5.79	0.80	140.57	2.25	315.67	4.000	No	No	2.00
132	21.65	128.39	2.36	5.48	0.79	139.78	2.17	303.80	4.000	No	No	2.00
133	21.82	145.20	2.28	4.62	0.76	156.43	1.87	293.04	4.000	No	No	2.00
134	21.98	178.45	2.21	4.37	0.73	190.68	1.69	321.84	4.000	No	No	2.00
135	22.15	212.43	2.15	4.13	0.71	225.24	1.55	349.48	4.000	No	No	2.00
136	22.31	309.44	1.97	3.14	0.64	323.44	1.26	407.18	4.000	No	No	2.00
137	22.47	397.85	1.83	2.48	0.59	410.99	1.13	463.08	4.000	No	No	2.00
138	22.64	478.59	1.72	2.08	0.55	489.84	1.05	516.41	4.000	No	No	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
I_c: Soil behavior type index
Fr: Normalized friction ratio (%)
n: Stress exponent
Q_{tn}: Normalized cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.16	2.00	0.00	9.98	0.16	0.00	0.33	2.00	0.00	9.95	0.16	0.00
0.49	2.00	0.00	9.93	0.16	0.00	0.66	2.00	0.00	9.90	0.16	0.00
0.82	2.00	0.00	9.88	0.16	0.00	0.98	2.00	0.00	9.85	0.16	0.00
1.15	2.00	0.00	9.83	0.16	0.00	1.31	2.00	0.00	9.80	0.16	0.00
1.48	2.00	0.00	9.78	0.16	0.00	1.64	2.00	0.00	9.75	0.16	0.00
1.80	2.00	0.00	9.73	0.16	0.00	1.97	2.00	0.00	9.70	0.17	0.00
2.13	0.22	0.78	9.67	0.16	0.38	2.30	0.30	0.70	9.65	0.16	0.34
2.46	0.85	0.15	9.62	0.16	0.07	2.63	1.69	0.00	9.60	0.16	0.00
2.79	1.84	0.00	9.57	0.16	0.00	2.95	2.00	0.00	9.55	0.16	0.00
3.12	2.00	0.00	9.52	0.16	0.00	3.28	2.00	0.00	9.50	0.16	0.00
3.45	1.62	0.00	9.47	0.16	0.00	3.61	1.16	0.00	9.45	0.16	0.00
3.77	0.91	0.09	9.42	0.16	0.04	3.94	0.83	0.17	9.40	0.16	0.08
4.10	0.82	0.18	9.38	0.16	0.08	4.27	0.81	0.19	9.35	0.16	0.09
4.43	0.80	0.20	9.33	0.16	0.09	4.59	0.77	0.23	9.30	0.16	0.11
4.76	0.66	0.34	9.28	0.16	0.16	4.92	0.52	0.48	9.25	0.16	0.22
5.09	0.42	0.58	9.23	0.16	0.27	5.25	0.43	0.57	9.20	0.16	0.26
5.41	0.59	0.41	9.18	0.16	0.19	5.58	0.86	0.14	9.15	0.16	0.06
5.74	1.16	0.00	9.13	0.16	0.00	5.91	0.79	0.21	9.10	0.17	0.10
6.07	0.65	0.35	9.07	0.16	0.16	6.23	0.89	0.11	9.05	0.16	0.05
6.40	1.49	0.00	9.02	0.16	0.00	6.56	1.08	0.00	9.00	0.16	0.00
6.73	0.77	0.23	8.97	0.16	0.10	6.89	0.47	0.53	8.95	0.16	0.24
7.05	0.31	0.69	8.92	0.16	0.31	7.22	0.26	0.74	8.90	0.16	0.33
7.38	0.24	0.76	8.87	0.16	0.34	7.55	0.23	0.77	8.85	0.16	0.34
7.71	0.25	0.75	8.82	0.16	0.33	7.87	0.28	0.72	8.80	0.16	0.32
8.04	0.37	0.63	8.78	0.16	0.28	8.20	0.44	0.56	8.75	0.16	0.24
8.37	0.47	0.53	8.73	0.16	0.23	8.53	0.58	0.42	8.70	0.16	0.18
8.69	0.42	0.58	8.68	0.16	0.25	8.86	0.29	0.71	8.65	0.16	0.31
9.02	0.42	0.58	8.63	0.16	0.25	9.19	0.64	0.36	8.60	0.16	0.15
9.35	0.79	0.21	8.58	0.16	0.09	9.51	0.83	0.17	8.55	0.16	0.07
9.68	0.85	0.15	8.53	0.16	0.06	9.84	2.00	0.00	8.50	0.16	0.00
10.01	2.00	0.00	8.47	0.16	0.00	10.17	2.00	0.00	8.45	0.16	0.00
10.34	2.00	0.00	8.42	0.16	0.00	10.50	2.00	0.00	8.40	0.16	0.00
10.66	2.00	0.00	8.37	0.16	0.00	10.83	2.00	0.00	8.35	0.16	0.00
10.99	2.00	0.00	8.32	0.16	0.00	11.16	2.00	0.00	8.30	0.16	0.00
11.32	2.00	0.00	8.27	0.16	0.00	11.48	2.00	0.00	8.25	0.16	0.00
11.65	2.00	0.00	8.22	0.16	0.00	11.81	2.00	0.00	8.20	0.16	0.00
11.98	2.00	0.00	8.18	0.16	0.00	12.14	2.00	0.00	8.15	0.16	0.00
12.30	2.00	0.00	8.13	0.16	0.00	12.47	2.00	0.00	8.10	0.16	0.00
12.63	2.00	0.00	8.08	0.16	0.00	12.80	2.00	0.00	8.05	0.16	0.00
12.96	2.00	0.00	8.03	0.16	0.00	13.12	2.00	0.00	8.00	0.16	0.00
13.29	2.00	0.00	7.98	0.16	0.00	13.45	2.00	0.00	7.95	0.16	0.00
13.62	2.00	0.00	7.93	0.16	0.00	13.78	2.00	0.00	7.90	0.16	0.00
13.94	2.00	0.00	7.87	0.16	0.00	14.11	2.00	0.00	7.85	0.16	0.00
14.27	2.00	0.00	7.82	0.16	0.00	14.44	2.00	0.00	7.80	0.16	0.00
14.60	2.00	0.00	7.77	0.16	0.00	14.76	2.00	0.00	7.75	0.16	0.00
14.93	2.00	0.00	7.72	0.16	0.00	15.09	2.00	0.00	7.70	0.16	0.00
15.26	2.00	0.00	7.67	0.16	0.00	15.42	2.00	0.00	7.65	0.16	0.00
15.58	2.00	0.00	7.62	0.16	0.00	15.75	0.80	0.20	7.60	0.16	0.07

:: Liquefaction Potential Index calculation data :: (continued)

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
15.91	0.71	0.29	7.58	0.16	0.11	16.08	0.65	0.35	7.55	0.16	0.13
16.24	0.75	0.25	7.53	0.16	0.09	16.40	2.00	0.00	7.50	0.16	0.00
16.57	2.00	0.00	7.48	0.16	0.00	16.73	2.00	0.00	7.45	0.16	0.00
16.90	2.00	0.00	7.43	0.16	0.00	17.06	2.00	0.00	7.40	0.16	0.00
17.22	2.00	0.00	7.38	0.16	0.00	17.39	2.00	0.00	7.35	0.16	0.00
17.55	2.00	0.00	7.33	0.16	0.00	17.72	2.00	0.00	7.30	0.16	0.00
17.88	2.00	0.00	7.27	0.16	0.00	18.05	2.00	0.00	7.25	0.16	0.00
18.21	2.00	0.00	7.22	0.16	0.00	18.37	2.00	0.00	7.20	0.16	0.00
18.54	2.00	0.00	7.17	0.16	0.00	18.70	2.00	0.00	7.15	0.16	0.00
18.87	2.00	0.00	7.12	0.16	0.00	19.03	2.00	0.00	7.10	0.16	0.00
19.19	2.00	0.00	7.07	0.16	0.00	19.36	2.00	0.00	7.05	0.16	0.00
19.52	2.00	0.00	7.02	0.16	0.00	19.69	2.00	0.00	7.00	0.16	0.00
19.85	2.00	0.00	6.98	0.16	0.00	20.01	2.00	0.00	6.95	0.16	0.00
20.18	2.00	0.00	6.93	0.16	0.00	20.34	2.00	0.00	6.90	0.16	0.00
20.51	2.00	0.00	6.88	0.16	0.00	20.67	2.00	0.00	6.85	0.16	0.00
20.83	2.00	0.00	6.83	0.16	0.00	21.00	2.00	0.00	6.80	0.16	0.00
21.16	2.00	0.00	6.78	0.16	0.00	21.33	2.00	0.00	6.75	0.16	0.00
21.49	2.00	0.00	6.72	0.16	0.00	21.65	2.00	0.00	6.70	0.16	0.00
21.82	2.00	0.00	6.67	0.16	0.00	21.98	2.00	0.00	6.65	0.16	0.00
22.15	2.00	0.00	6.62	0.16	0.00	22.31	2.00	0.00	6.60	0.16	0.00
22.47	2.00	0.00	6.57	0.16	0.00	22.64	2.00	0.00	6.55	0.16	0.00

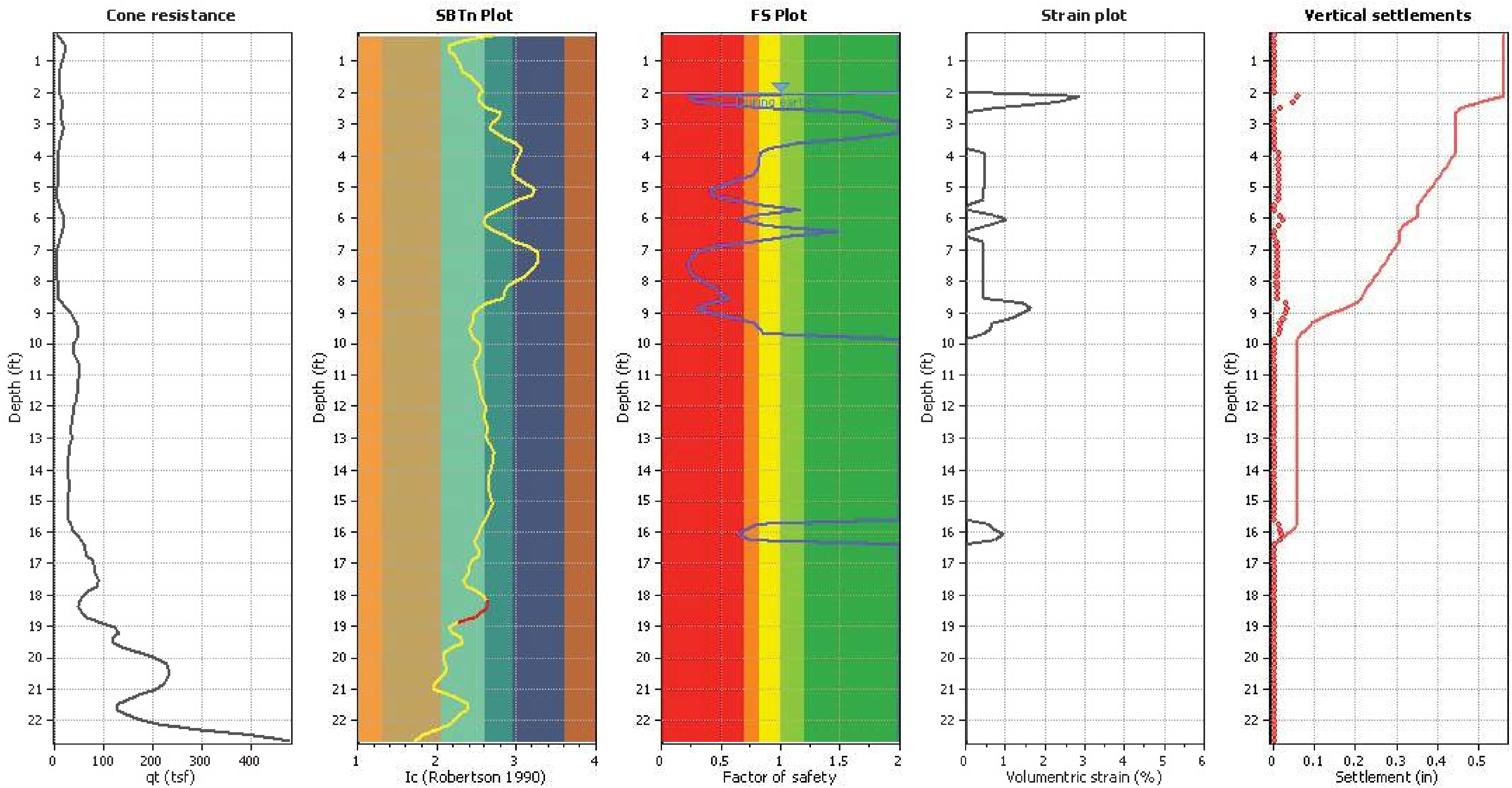
Overall liquefaction potential: 7.59

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
2.13	73.68	0.22	2.89	0.96	0.06	2.30	97.34	0.30	2.30	0.96	0.05
2.46	163.87	0.85	0.72	0.96	0.01	2.63	99.22	1.69	0.00	0.96	0.00
2.79	107.61	1.84	0.00	0.95	0.00	2.95	114.05	2.00	0.00	0.95	0.00
3.12	254.99	2.00	0.00	0.95	0.00	3.28	122.39	2.00	0.00	0.94	0.00
3.45	119.10	1.62	0.00	0.94	0.00	3.61	110.27	1.16	0.01	0.94	0.00
3.77	100.27	0.91	0.03	0.94	0.00	3.94	91.91	0.83	0.47	0.93	0.01
4.10	86.03	0.82	0.47	0.93	0.01	4.27	81.80	0.81	0.46	0.93	0.01
4.43	79.07	0.80	0.46	0.92	0.01	4.59	77.68	0.77	0.46	0.92	0.01
4.76	75.59	0.66	0.46	0.92	0.01	4.92	71.59	0.52	0.46	0.92	0.01
5.09	67.23	0.42	0.46	0.91	0.01	5.25	66.36	0.43	0.46	0.91	0.01
5.41	71.06	0.59	0.45	0.91	0.01	5.58	80.75	0.86	0.02	0.91	0.00
5.74	93.17	1.16	0.01	0.90	0.00	5.91	183.42	0.79	0.75	0.90	0.01
6.07	171.37	0.65	1.03	0.90	0.02	6.23	193.25	0.89	0.53	0.89	0.01
6.40	113.51	1.49	0.00	0.89	0.00	6.56	102.63	1.08	0.01	0.89	0.00
6.73	88.83	0.77	0.44	0.89	0.01	6.89	71.06	0.47	0.44	0.88	0.01
7.05	57.61	0.31	0.44	0.88	0.01	7.22	48.78	0.26	0.44	0.88	0.01
7.38	44.82	0.24	0.44	0.87	0.01	7.55	42.30	0.23	0.44	0.87	0.01
7.71	40.45	0.25	0.43	0.87	0.01	7.87	41.59	0.28	0.43	0.87	0.01
8.04	44.82	0.37	0.43	0.86	0.01	8.20	47.00	0.44	0.43	0.86	0.01
8.37	47.97	0.47	0.43	0.86	0.01	8.53	57.60	0.58	0.43	0.86	0.01
8.69	149.98	0.42	1.43	0.85	0.03	8.86	127.06	0.29	1.63	0.85	0.03
9.02	149.96	0.42	1.42	0.85	0.03	9.19	177.93	0.64	1.11	0.84	0.02
9.35	192.18	0.79	0.66	0.84	0.01	9.51	196.18	0.83	0.64	0.84	0.01
9.68	198.14	0.85	0.48	0.84	0.01	9.84	200.40	2.00	0.00	0.83	0.00
10.01	235.97	2.00	0.00	0.83	0.00	10.17	241.48	2.00	0.00	0.83	0.00
10.34	226.12	2.00	0.00	0.82	0.00	10.50	202.21	2.00	0.00	0.82	0.00
10.66	215.54	2.00	0.00	0.82	0.00	10.83	225.98	2.00	0.00	0.82	0.00
10.99	240.16	2.00	0.00	0.81	0.00	11.16	249.84	2.00	0.00	0.81	0.00
11.32	269.66	2.00	0.00	0.81	0.00	11.48	268.47	2.00	0.00	0.81	0.00
11.65	297.97	2.00	0.00	0.80	0.00	11.81	332.63	2.00	0.00	0.80	0.00
11.98	357.82	2.00	0.00	0.80	0.00	12.14	336.55	2.00	0.00	0.79	0.00
12.30	303.68	2.00	0.00	0.79	0.00	12.47	320.25	2.00	0.00	0.79	0.00
12.63	344.02	2.00	0.00	0.79	0.00	12.80	331.49	2.00	0.00	0.78	0.00
12.96	319.87	2.00	0.00	0.78	0.00	13.12	357.83	2.00	0.00	0.78	0.00
13.29	429.64	2.00	0.00	0.77	0.00	13.45	177.58	2.00	0.00	0.77	0.00
13.62	165.82	2.00	0.00	0.77	0.00	13.78	390.40	2.00	0.00	0.77	0.00
13.94	351.74	2.00	0.00	0.76	0.00	14.11	332.33	2.00	0.00	0.76	0.00
14.27	309.46	2.00	0.00	0.76	0.00	14.44	298.91	2.00	0.00	0.76	0.00
14.60	302.82	2.00	0.00	0.75	0.00	14.76	328.12	2.00	0.00	0.75	0.00
14.93	354.04	2.00	0.00	0.75	0.00	15.09	376.67	2.00	0.00	0.74	0.00
15.26	300.45	2.00	0.00	0.74	0.00	15.42	261.79	2.00	0.00	0.74	0.00
15.58	218.62	2.00	0.00	0.74	0.00	15.75	194.94	0.80	0.56	0.73	0.01
15.91	185.85	0.71	0.74	0.73	0.01	16.08	179.64	0.65	0.94	0.73	0.02
16.24	189.88	0.75	0.72	0.72	0.01	16.40	214.75	2.00	0.00	0.72	0.00
16.57	264.14	2.00	0.00	0.72	0.00	16.73	273.83	2.00	0.00	0.72	0.00
16.90	244.99	2.00	0.00	0.71	0.00	17.06	240.80	2.00	0.00	0.71	0.00
17.22	239.50	2.00	0.00	0.71	0.00	17.39	233.58	2.00	0.00	0.71	0.00
17.55	230.95	2.00	0.00	0.70	0.00	17.72	232.86	2.00	0.00	0.70	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
17.88	248.60	2.00	0.00	0.70	0.00	18.05	377.79	2.00	0.00	0.69	0.00
18.21	396.44	2.00	0.00	0.69	0.00	18.37	395.80	2.00	0.00	0.69	0.00
18.54	279.28	2.00	0.00	0.69	0.00	18.70	204.42	2.00	0.00	0.68	0.00
18.87	199.45	2.00	0.00	0.68	0.00	19.03	221.34	2.00	0.00	0.68	0.00
19.19	249.29	2.00	0.00	0.67	0.00	19.36	266.46	2.00	0.00	0.67	0.00
19.52	272.38	2.00	0.00	0.67	0.00	19.69	266.97	2.00	0.00	0.67	0.00
19.85	287.50	2.00	0.00	0.66	0.00	20.01	327.91	2.00	0.00	0.66	0.00
20.18	370.82	2.00	0.00	0.66	0.00	20.34	387.54	2.00	0.00	0.66	0.00
20.51	378.44	2.00	0.00	0.65	0.00	20.67	332.96	2.00	0.00	0.65	0.00
20.83	304.99	2.00	0.00	0.65	0.00	21.00	282.69	2.00	0.00	0.64	0.00
21.16	294.26	2.00	0.00	0.64	0.00	21.33	313.75	2.00	0.00	0.64	0.00
21.49	315.67	2.00	0.00	0.64	0.00	21.65	303.80	2.00	0.00	0.63	0.00
21.82	293.04	2.00	0.00	0.63	0.00	21.98	321.84	2.00	0.00	0.63	0.00
22.15	349.48	2.00	0.00	0.62	0.00	22.31	407.18	2.00	0.00	0.62	0.00
22.47	463.08	2.00	0.00	0.62	0.00	22.64	516.41	2.00	0.00	0.62	0.00

Total estimated settlement: 0.56

Abbreviations

$Q_{tn,cs}$: Equivalent clean sand normalized cone resistance
FS: Factor of safety against liquefaction
e_v (%): Post-liquefaction volumentric strain
DF: e_v depth weighting factor
Settlement: Calculated settlement

:: Strength loss calculation (Robertson (2009) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.16	6.68	12.60	3.97	50.09	2.70	N/A	N/A
0.33	13.63	25.73	2.03	52.27	2.32	N/A	N/A
0.49	19.38	36.58	1.56	56.96	2.15	N/A	N/A
0.66	19.66	37.10	1.54	57.21	2.14	N/A	N/A
0.82	16.18	30.50	1.71	52.17	2.22	N/A	N/A
0.98	13.13	24.72	1.00	24.72	2.27	N/A	N/A
1.15	11.01	20.71	1.00	20.71	2.31	N/A	N/A
1.31	9.80	18.40	1.00	18.40	2.32	N/A	N/A
1.48	8.87	16.64	2.35	39.16	2.41	N/A	N/A
1.64	8.62	16.14	2.64	42.62	2.47	N/A	N/A
1.80	8.72	16.31	3.00	49.01	2.54	N/A	N/A
1.97	10.08	18.87	3.16	59.65	2.57	N/A	N/A
2.13	12.46	23.36	2.86	66.80	2.52	0.15	0.64
2.30	13.69	25.66	3.01	77.22	2.55	0.65	0.65
2.46	13.22	24.76	3.53	87.29	2.63	7.18	7.18
2.63	11.22	20.97	4.73	99.22	2.79	5.66	5.66
2.79	12.67	23.68	4.55	107.61	2.77	5.98	5.98
2.95	15.17	28.39	4.02	114.05	2.70	6.72	6.72
3.12	17.23	32.26	3.71	119.74	2.66	7.19	7.19
3.28	15.52	29.01	4.22	122.39	2.73	6.10	6.10
3.45	12.34	22.99	5.18	119.10	2.85	4.58	4.58
3.61	9.05	16.75	6.58	110.27	2.99	3.18	3.18
3.77	7.27	13.37	7.50	100.27	3.07	2.42	2.42
3.94	6.81	12.48	7.36	91.91	3.05	2.16	2.16
4.10	6.85	12.55	6.86	86.03	3.01	2.09	2.09
4.27	6.87	12.57	6.51	81.80	2.98	2.01	2.01
4.43	6.90	12.61	6.27	79.07	2.96	1.94	1.94
4.59	6.76	12.32	6.31	77.68	2.96	1.83	1.83
4.76	5.91	10.70	7.06	75.59	3.03	1.53	1.53
4.92	4.72	8.45	8.47	71.59	3.14	1.17	1.17
5.09	3.93	6.93	9.70	67.23	3.23	0.60	0.93
5.25	4.09	7.22	9.19	66.36	3.20	0.55	0.94
5.41	5.59	10.03	7.09	71.06	3.03	1.26	1.26
5.58	8.07	14.71	5.49	80.75	2.88	1.80	1.80
5.74	10.93	20.09	4.64	93.17	2.78	2.38	2.38
5.91	16.16	29.96	3.45	103.27	2.62	3.45	3.45
6.07	18.58	34.53	3.25	112.09	2.59	0.69	0.69
6.23	18.26	33.90	3.38	114.48	2.61	3.68	3.68
6.40	14.32	26.44	4.29	113.51	2.74	2.79	2.79
6.56	10.61	19.40	5.29	102.63	2.86	1.99	1.99
6.73	7.67	13.83	6.42	88.83	2.97	1.39	1.39
6.89	4.86	8.50	8.36	71.06	3.13	0.83	0.83
7.05	3.34	5.61	10.27	57.61	3.27	0.26	0.54
7.22	2.93	4.82	10.12	48.78	3.26	0.20	0.45
7.38	2.72	4.42	10.15	44.82	3.26	0.15	0.41
7.55	2.67	4.31	9.80	42.30	3.24	0.13	0.39
7.71	2.86	4.66	8.69	40.45	3.16	0.11	0.41
7.87	3.20	5.29	7.86	41.59	3.09	0.08	0.46

:: Strength loss calculation (Robertson (2009) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
8.04	4.17	7.09	6.32	44.82	2.96	0.14	0.61
8.20	4.92	8.50	5.53	47.00	2.88	0.17	0.71
8.37	5.29	9.19	5.22	47.97	2.85	0.13	0.76
8.53	6.41	11.30	5.10	57.60	2.84	0.16	0.91
8.69	13.28	24.26	3.46	83.86	2.62	1.92	1.92
8.86	22.34	41.36	2.84	117.41	2.51	0.71	0.71
9.02	32.38	58.68	2.56	149.96	2.46	0.76	0.76
9.19	37.67	68.09	2.61	177.93	2.47	0.77	0.77
9.35	43.44	77.31	2.49	192.18	2.44	0.79	0.79
9.51	47.61	83.33	2.35	196.18	2.41	0.80	0.80
9.68	47.03	81.97	2.42	198.14	2.42	0.80	0.80
9.84	44.24	77.29	2.59	200.40	2.46	0.79	0.79
10.01	39.11	68.95	2.92	201.65	2.53	0.78	0.78
10.17	37.82	66.25	2.98	197.17	2.54	0.77	0.77
10.34	38.64	66.93	2.91	195.05	2.53	0.77	0.77
10.50	44.05	74.87	2.70	202.21	2.49	0.79	0.79
10.66	48.95	82.23	2.62	215.54	2.47	0.80	0.80
10.83	50.93	85.06	2.66	225.98	2.48	0.80	0.80
10.99	49.18	82.04	2.80	229.84	2.51	0.80	0.80
11.16	47.79	79.27	2.86	226.61	2.52	0.80	0.80
11.32	46.28	76.43	2.95	225.42	2.53	0.79	0.79
11.48	46.56	76.26	2.95	224.79	2.53	0.79	0.79
11.65	45.49	74.25	3.06	227.01	2.55	0.79	0.79
11.81	43.50	70.81	3.20	226.30	2.58	0.78	0.78
11.98	39.77	64.54	3.35	216.24	2.60	4.68	4.68
12.14	37.91	60.97	3.35	204.00	2.60	4.42	4.42
12.30	36.63	58.30	3.29	191.87	2.59	0.75	0.75
12.47	35.41	56.06	3.38	189.43	2.61	4.04	4.04
12.63	33.91	53.45	3.50	186.91	2.63	3.83	3.83
12.80	33.79	52.81	3.47	183.33	2.62	3.79	3.79
12.96	34.27	53.09	3.43	182.15	2.62	3.81	3.81
13.12	33.15	51.19	3.58	183.33	2.64	3.65	3.65
13.29	30.91	47.71	3.85	183.93	2.68	3.37	3.37
13.45	28.17	43.35	4.10	177.58	2.71	3.04	3.04
13.62	26.81	40.85	4.06	165.82	2.71	2.86	2.86
13.78	26.10	39.35	3.97	156.06	2.70	2.76	2.76
13.94	26.21	39.10	3.85	150.70	2.68	2.75	2.75
14.11	26.73	39.54	3.78	149.38	2.67	2.78	2.78
14.27	27.61	40.47	3.68	148.75	2.65	2.86	2.86
14.44	28.23	41.05	3.62	148.76	2.65	2.90	2.90
14.60	28.20	40.75	3.65	148.55	2.65	2.87	2.87
14.76	27.55	39.64	3.76	149.10	2.67	2.78	2.78
14.93	26.79	38.37	3.88	148.96	2.68	2.68	2.68
15.09	26.09	37.19	3.99	148.37	2.70	2.59	2.59
15.26	26.91	37.86	3.72	140.67	2.66	2.65	2.65
15.42	26.86	37.40	3.58	134.00	2.64	2.63	2.63
15.58	27.90	38.44	3.37	129.72	2.61	2.72	2.72
15.75	30.94	42.24	3.18	134.33	2.58	0.71	0.71

:: Strength loss calculation (Robertson (2009) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
15.91	36.13	48.96	3.01	147.38	2.55	0.73	0.73
16.08	43.86	58.99	2.83	167.06	2.51	0.76	0.76
16.24	53.83	71.76	2.65	189.88	2.48	0.78	0.78
16.40	60.00	79.73	2.69	214.75	2.48	0.80	0.80
16.57	62.57	83.08	2.87	238.08	2.52	0.80	0.80
16.73	65.77	86.79	2.86	248.18	2.52	0.81	0.81
16.90	76.08	98.73	2.48	244.99	2.44	0.83	0.83
17.06	81.10	104.02	2.32	240.80	2.40	0.83	0.83
17.22	79.29	101.21	2.37	239.50	2.41	0.83	0.83
17.39	84.94	107.10	2.18	233.58	2.37	0.84	0.84
17.55	88.27	110.31	2.09	230.95	2.34	0.84	0.84
17.72	86.04	107.16	2.17	232.86	2.36	0.84	0.84
17.88	67.71	85.19	2.80	238.44	2.51	0.81	0.81
18.05	55.50	70.03	3.32	232.78	2.60	0.78	0.78
18.21	49.57	62.21	3.49	216.92	2.63	4.31	4.31
18.37	47.58	59.34	3.53	209.65	2.63	4.11	4.11
18.54	51.91	63.92	3.13	200.14	2.57	0.77	0.77
18.70	62.11	75.51	2.71	204.42	2.49	0.79	0.79
18.87	93.96	111.01	1.80	199.45	2.25	0.84	0.84
19.03	120.42	140.39	1.58	221.34	2.16	0.88	0.88
19.19	131.10	152.59	1.63	249.29	2.19	0.89	0.89
19.36	118.26	138.41	1.93	266.46	2.29	0.87	0.87
19.52	118.19	137.79	1.98	272.38	2.31	0.87	0.87
19.69	140.95	161.66	1.65	266.97	2.19	0.90	0.90
19.85	178.12	201.27	1.43	287.50	2.09	0.93	0.93
20.01	205.32	230.89	1.42	327.91	2.08	0.95	0.95
20.18	229.73	257.47	1.44	370.82	2.09	0.97	0.97
20.34	231.17	258.55	1.50	387.54	2.12	0.97	0.97
20.51	235.07	260.96	1.45	378.44	2.10	0.97	0.97
20.67	227.44	249.56	1.33	332.96	2.03	0.96	0.96
20.83	223.34	242.62	1.26	304.99	1.97	0.96	0.96
21.00	205.97	222.82	1.27	282.69	1.98	0.95	0.95
21.16	175.79	191.67	1.54	294.26	2.14	0.92	0.92
21.33	149.14	163.49	1.92	313.75	2.29	0.90	0.90
21.49	128.21	140.57	2.25	315.67	2.38	0.88	0.88
21.65	128.39	139.78	2.17	303.80	2.36	0.88	0.88
21.82	145.20	156.43	1.87	293.04	2.28	0.89	0.89
21.98	178.45	190.68	1.69	321.84	2.21	0.92	0.92
22.15	212.43	225.24	1.55	349.48	2.15	0.95	0.95
22.31	309.44	323.44	1.26	407.18	1.97	1.01	1.01
22.47	397.85	410.99	1.13	463.08	1.83	1.05	1.05
22.64	478.59	489.84	1.05	516.41	1.72	1.08	1.08

Abbreviations

q_t: Total cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Adjusted and corrected cone resistance due to fines
I_c: Soil behavior type index
$S_{u(liq)}/\sigma'_v$: Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$: Calculated peak undrained strength ratio

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Geoconsultants
Berkeley, CA
www.a3geo.com

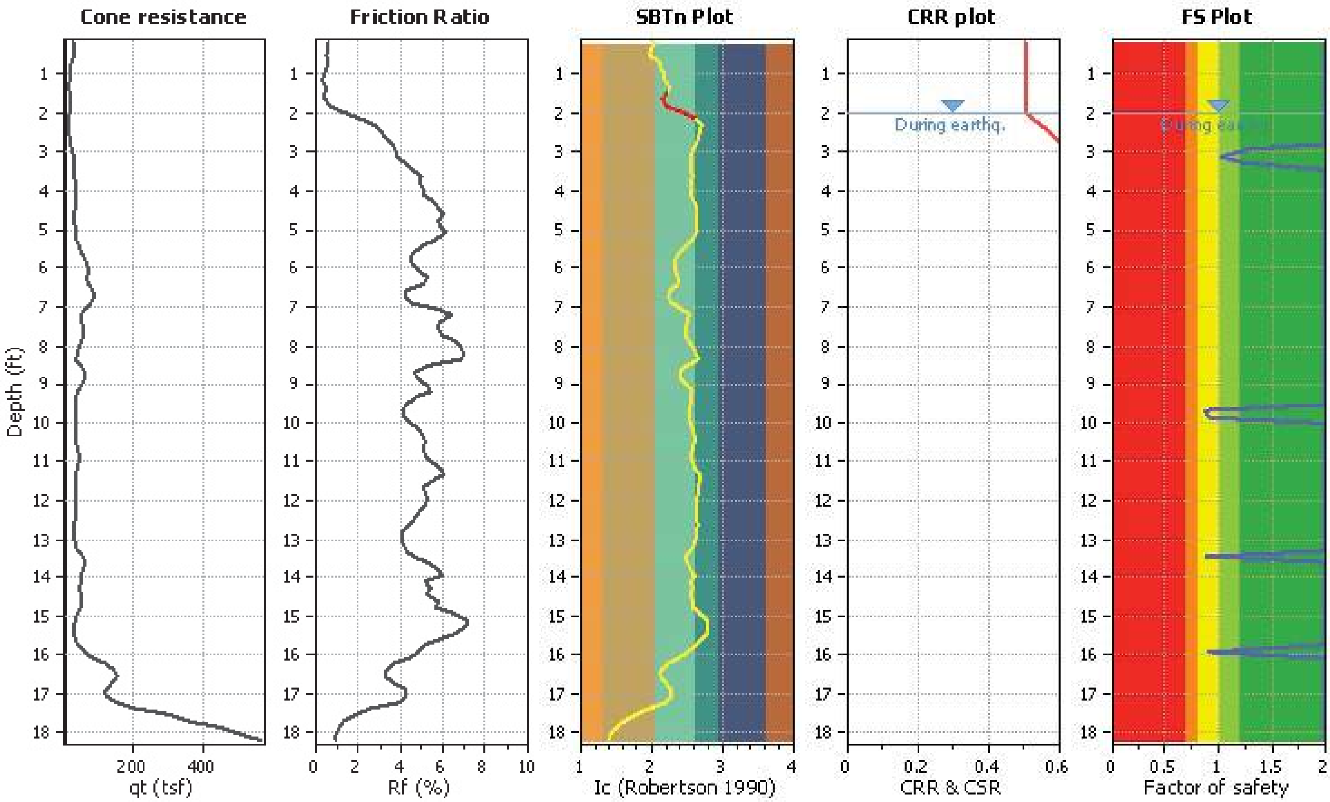
LIQUEFACTION ANALYSIS REPORT

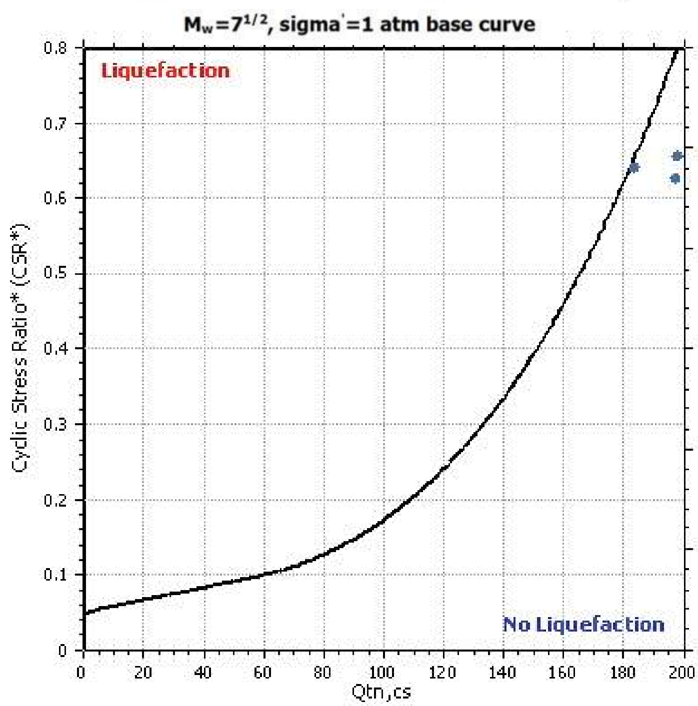
Project title : Terra Linda High School **Location : San Rafael, CA**

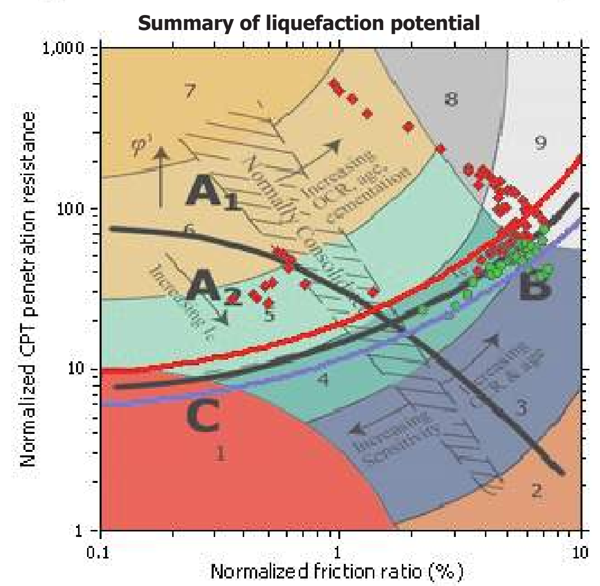
CPT file : CPT-04

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	9.00 ft	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	No		

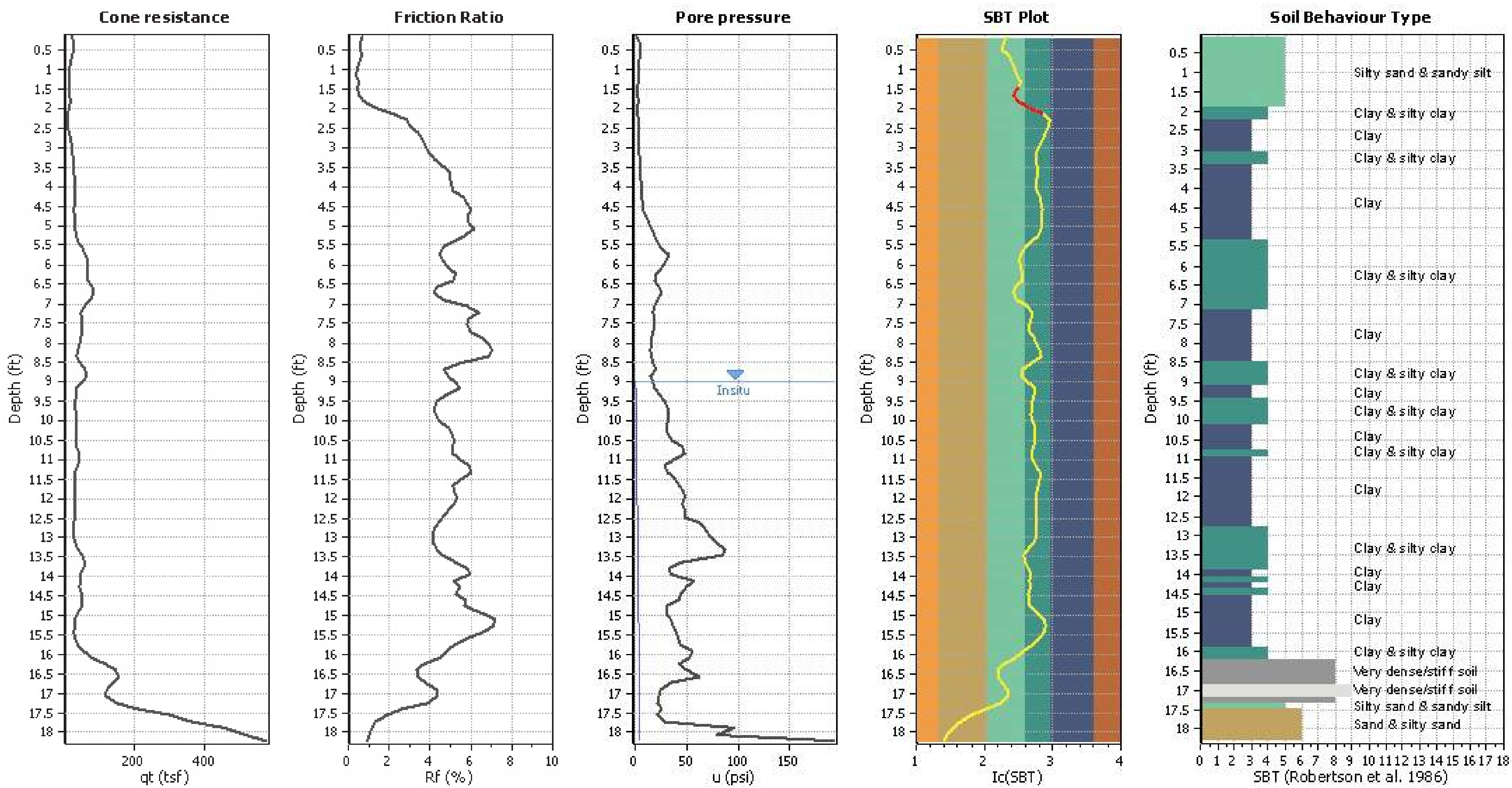






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



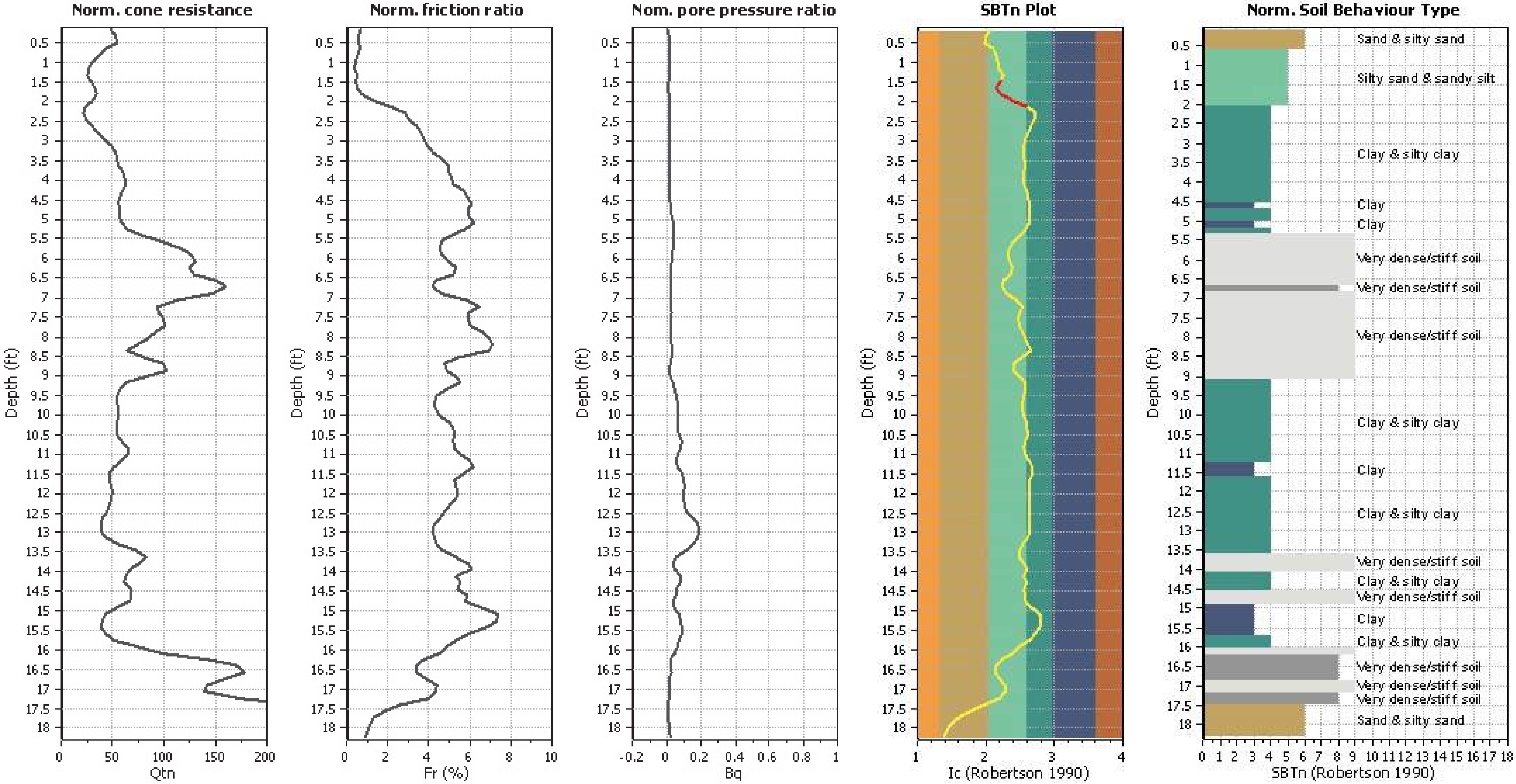
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

CPT basic interpretation plots (normaliz



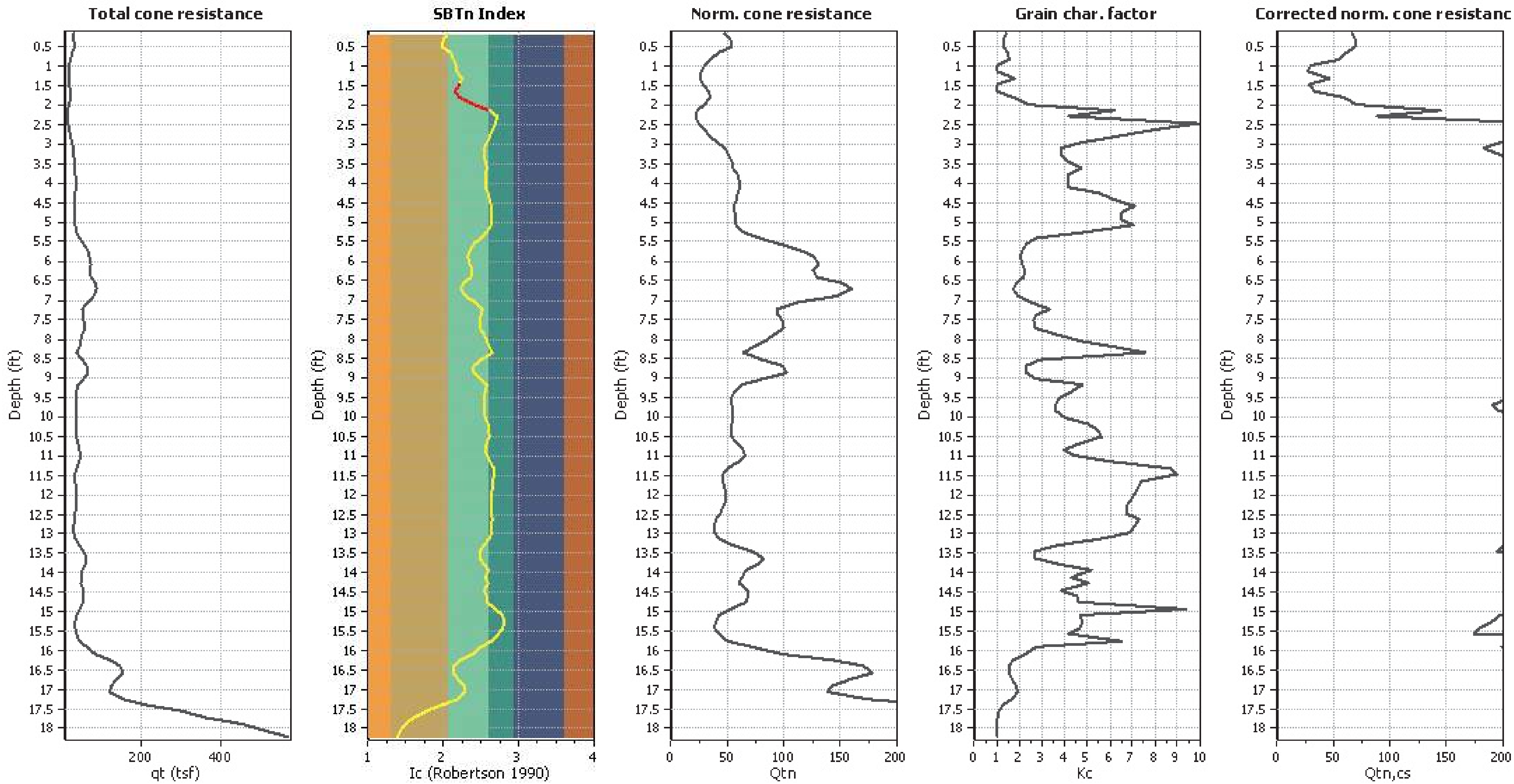
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

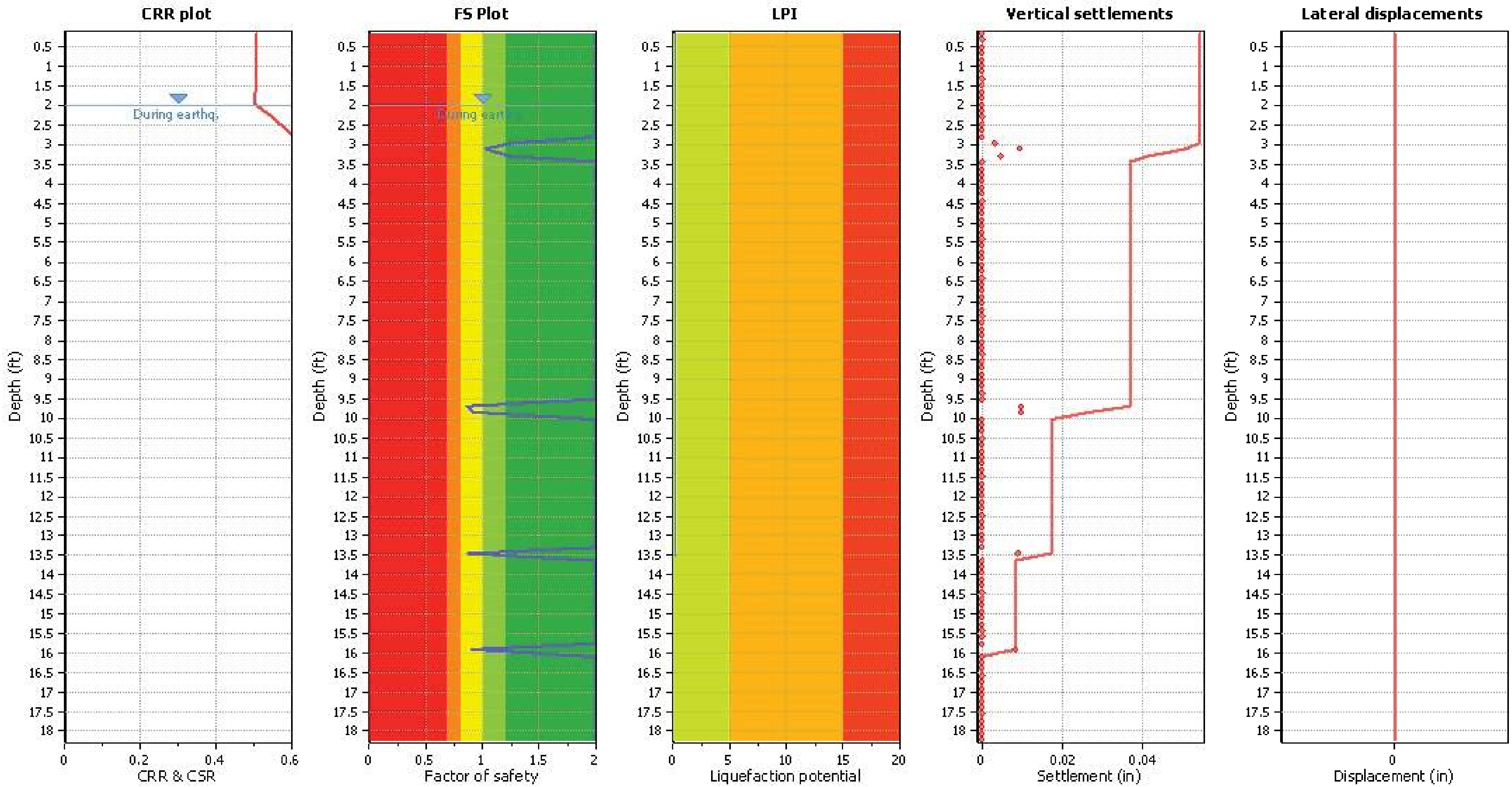
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

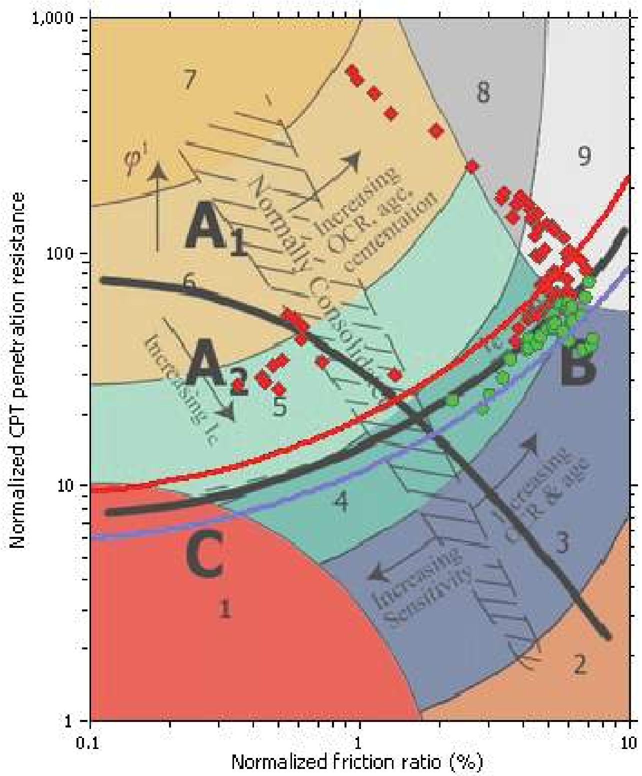
F.S. color scheme

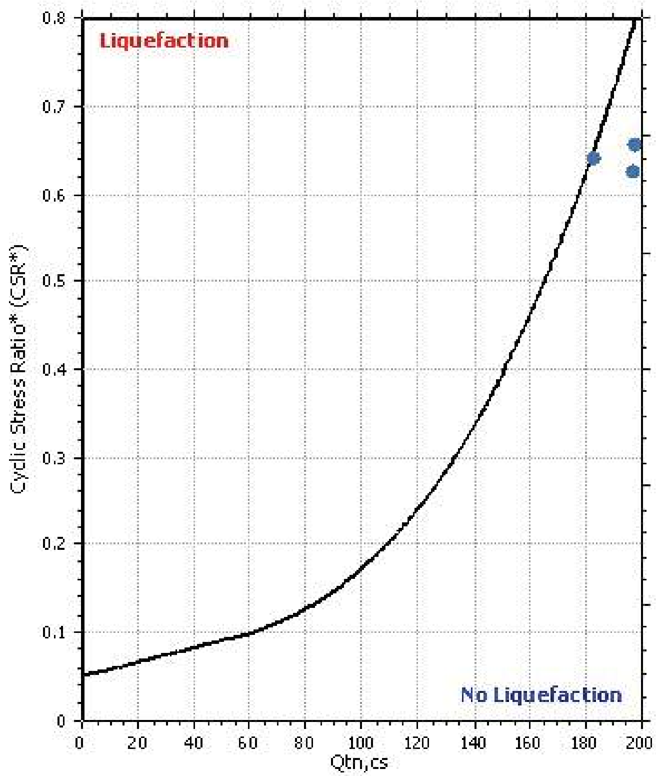
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

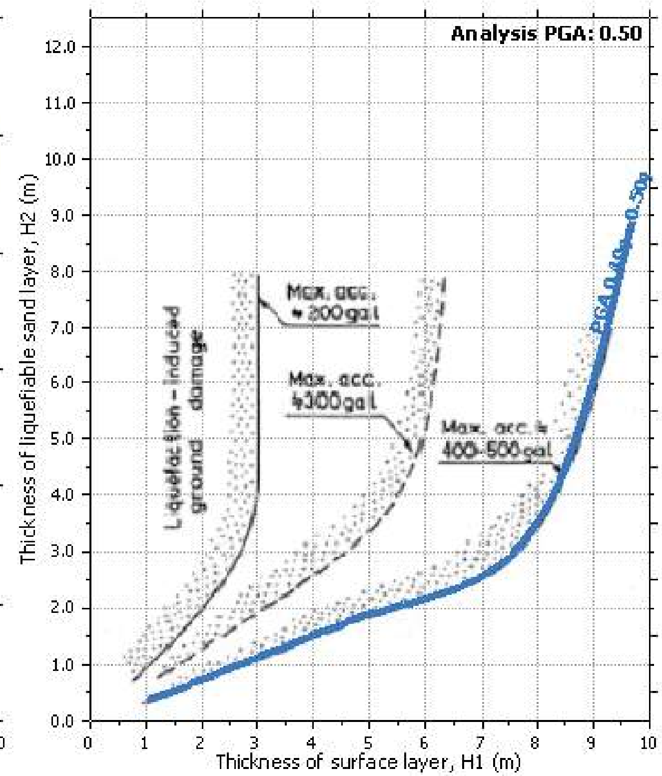
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo



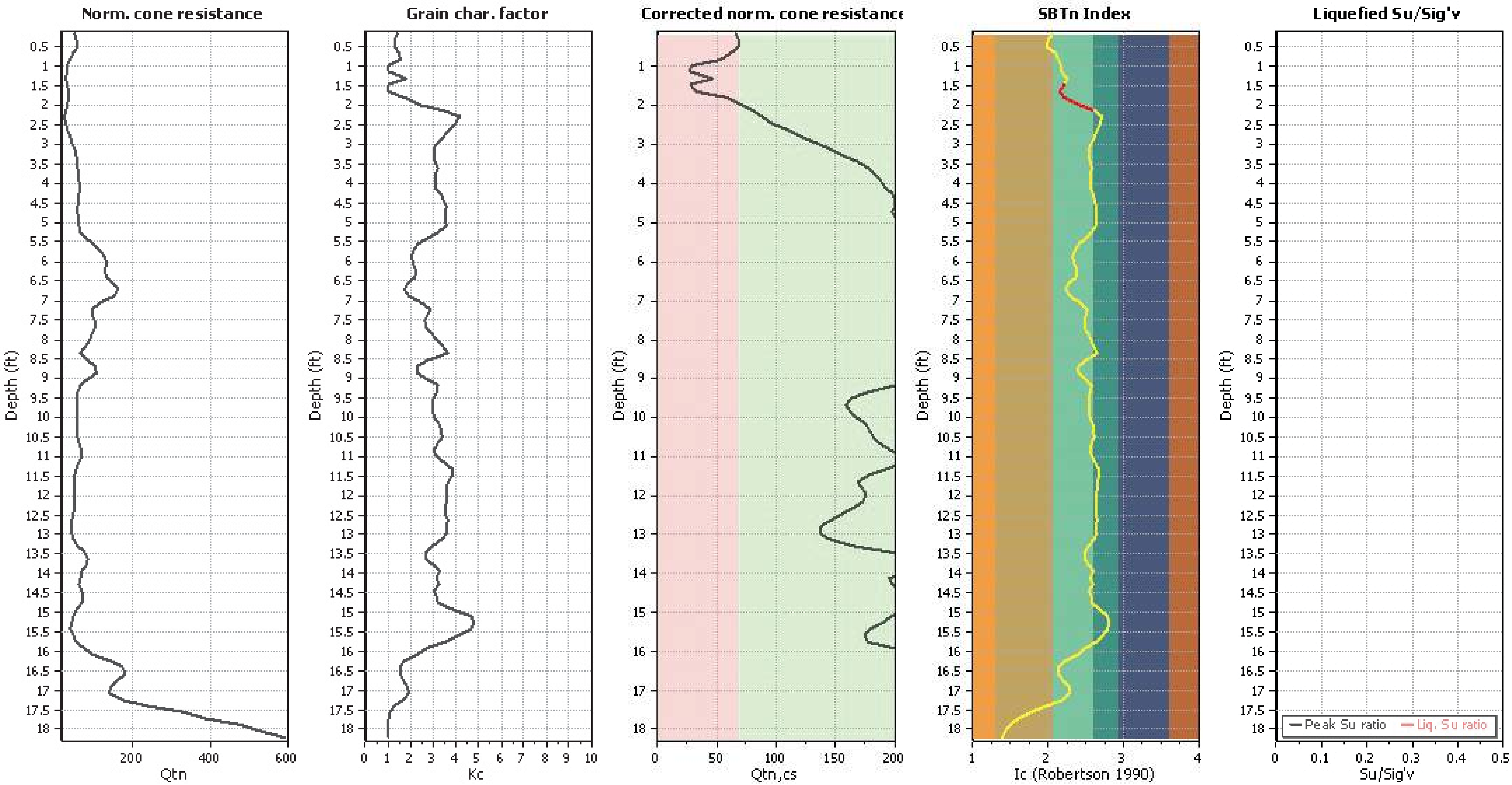




Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

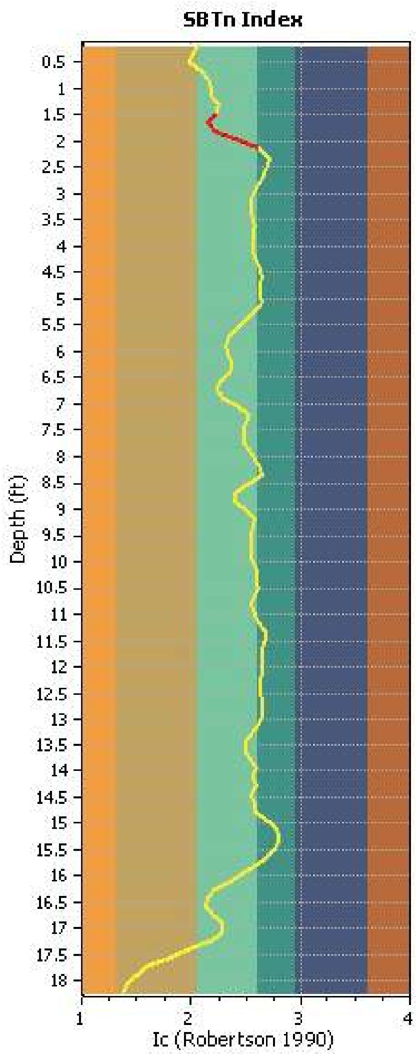
Analysis method:	Robertson (2009)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

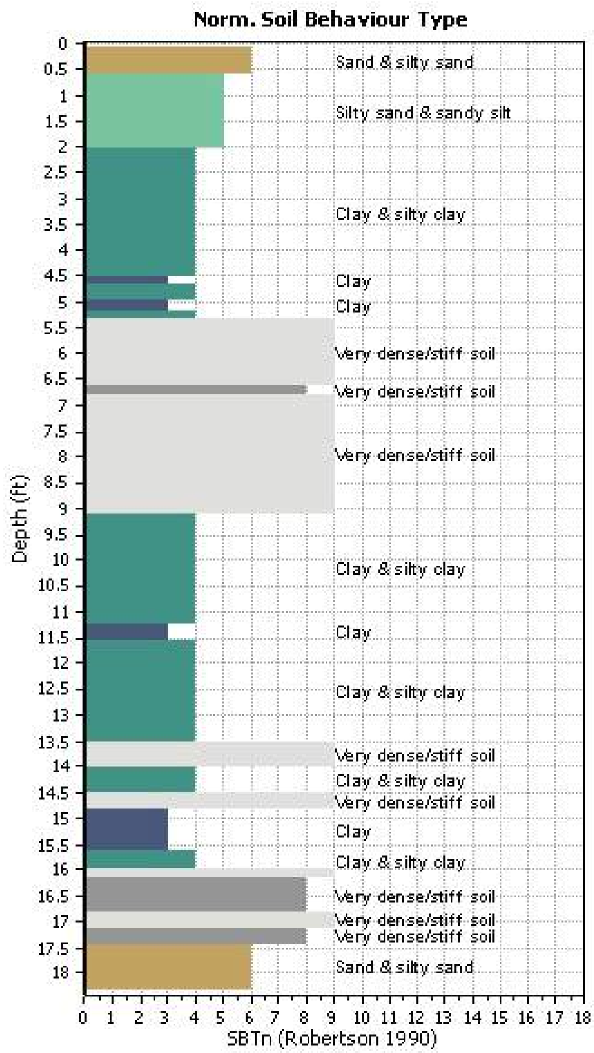
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties		General statistics	
I_c minimum check value:	1.70	Total points in CPT file:	111
I_c maximum check value:	3.00	Total points excluded:	5
I_c change ratio value:	0.0250	Exclusion percentage:	4.50%
Minimum number of points in layer:	5	Number of layers detected:	1

Transition layer No	Number of points	Depth	SBT_n number	SBT_n description
Transition layer 1	5	Start depth: 1.64 (ft)	5	Silty sand & sandy silt
		End depth: 2.30 (ft)	4	Clay & silty clay

Start depth: Depth where the transition layer begins
End depth: Depth where the transition layer ends

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.16	20.75	0.15	1.89	14.50	104.64
2	0.33	34.59	0.17	4.02	13.15	105.05
3	0.49	27.96	0.17	4.19	12.56	104.78
4	0.66	22.54	0.13	4.11	15.74	103.42
5	0.82	17.20	0.12	3.20	17.09	100.25
6	0.98	15.72	0.04	2.83	5.00	97.32
7	1.15	14.04	0.05	3.30	5.00	94.95
8	1.31	13.26	0.07	2.20	20.97	96.97
9	1.48	13.48	0.09	1.73	5.00	96.98
10	1.64	17.34	0.04	1.61	5.00	99.09
11	1.80	21.45	0.12	2.38	19.53	102.50
12	1.97	15.80	0.23	2.07	26.76	105.87
13	2.13	10.74	0.30	2.00	36.41	106.91
14	2.30	10.65	0.28	2.12	41.53	107.89
15	2.46	12.61	0.38	2.35	40.24	109.71
16	2.63	15.46	0.52	2.73	38.53	112.23
17	2.79	18.40	0.67	2.65	36.49	114.48
18	2.95	21.90	0.82	2.67	34.42	116.39
19	3.12	25.67	0.98	2.99	32.88	118.01
20	3.28	28.30	1.14	3.61	32.82	119.43
21	3.45	28.64	1.35	3.93	33.37	120.53
22	3.61	29.92	1.48	4.08	34.40	121.32
23	3.77	29.92	1.57	4.10	33.47	121.94
24	3.94	34.54	1.63	5.10	33.48	122.31
25	4.10	32.13	1.69	5.51	33.40	122.61
26	4.27	31.94	1.74	6.00	35.50	122.84
27	4.43	30.06	1.87	6.73	36.53	122.85
28	4.59	29.53	1.75	7.16	37.51	122.77
29	4.76	29.06	1.74	9.40	36.81	122.65
30	4.92	31.01	1.75	12.30	36.74	122.95
31	5.09	31.35	1.93	15.00	37.43	123.34
32	5.25	29.42	2.02	17.77	34.60	123.79
33	5.41	41.33	1.90	21.79	30.44	124.83
34	5.58	52.63	2.42	24.55	26.51	126.14
35	5.74	58.25	2.75	33.13	24.11	127.81
36	5.91	73.46	3.17	29.64	23.56	128.82
37	6.07	69.52	3.39	25.15	24.20	129.57
38	6.23	63.95	3.66	20.29	25.60	129.70
39	6.40	65.35	3.49	18.07	24.89	129.80
40	6.56	75.98	3.43	22.60	21.09	130.01
41	6.73	98.18	3.43	25.35	20.21	130.35
42	6.89	79.45	3.77	20.88	22.10	130.28
43	7.05	57.05	3.60	17.68	27.69	129.44
44	7.22	45.89	3.10	16.93	31.80	128.31
45	7.38	45.75	2.89	17.77	30.39	127.84
46	7.55	58.95	2.97	18.38	29.62	128.11
47	7.71	52.35	3.31	17.17	29.78	128.49
48	7.87	48.99	3.32	15.85	32.21	128.40

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	8.04	46.67	3.10	14.99	34.27	127.80
50	8.20	38.59	2.84	14.44	36.40	126.77
51	8.37	33.22	2.44	15.97	37.98	125.29
52	8.53	31.77	1.88	16.61	30.82	126.33
53	8.69	74.02	3.17	19.58	26.46	127.77
54	8.86	72.60	3.34	13.60	26.61	128.53
55	9.02	40.88	2.65	16.27	30.21	126.90
56	9.19	36.41	1.90	18.65	34.43	124.42
57	9.35	34.98	1.64	23.53	33.70	122.58
58	9.51	31.32	1.41	27.54	32.74	121.61
59	9.68	33.67	1.33	31.31	32.32	121.29
60	9.84	34.62	1.45	30.64	32.34	121.68
61	10.01	33.89	1.61	31.15	33.15	122.20
62	10.17	34.62	1.64	29.50	34.79	122.64
63	10.34	32.44	1.78	31.66	35.45	122.81
64	10.50	33.19	1.74	35.06	35.69	123.14
65	10.66	35.99	1.84	44.46	34.44	123.83
66	10.83	41.11	2.15	47.99	33.03	125.07
67	10.99	47.65	2.52	38.77	33.88	125.69
68	11.16	38.20	2.38	28.43	36.20	125.33
69	11.32	30.45	2.01	30.54	39.13	123.87
70	11.48	29.28	1.60	38.77	39.40	122.53
71	11.65	29.89	1.53	42.98	37.78	122.02
72	11.81	31.88	1.63	46.69	37.62	122.43
73	11.98	32.22	1.82	47.24	37.46	122.92
74	12.14	33.45	1.81	45.13	37.25	122.82
75	12.30	32.13	1.55	48.26	37.03	122.10
76	12.47	28.97	1.39	47.66	37.05	121.06
77	12.63	27.66	1.25	62.99	37.70	120.03
78	12.80	25.28	1.10	67.09	37.49	119.21
79	12.96	25.48	1.04	72.20	37.28	119.10
80	13.12	27.69	1.20	77.55	35.81	120.31
81	13.29	34.84	1.55	87.72	32.51	123.23
82	13.45	53.97	2.40	84.88	29.98	126.55
83	13.62	67.59	3.43	45.49	30.24	128.72
84	13.78	57.80	3.67	32.93	32.69	128.86
85	13.94	43.18	2.80	34.07	35.02	127.64
86	14.11	44.63	2.33	56.48	33.60	126.16
87	14.27	50.81	2.17	49.58	34.88	126.16
88	14.44	38.14	2.89	43.60	32.87	127.16
89	14.60	62.75	3.06	41.73	34.11	127.95
90	14.76	53.38	3.06	29.98	34.22	127.60
91	14.93	34.90	2.54	29.10	39.75	126.35
92	15.09	31.46	2.28	33.57	45.18	124.82
93	15.26	28.36	2.08	36.71	46.12	124.10
94	15.42	28.86	2.02	39.37	45.47	123.39
95	15.58	29.25	1.74	41.30	41.66	123.56
96	15.75	38.42	2.00	43.91	36.82	124.61

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	15.91	49.97	2.49	54.46	30.63	127.59
98	16.08	82.44	3.79	52.02	25.89	130.28
99	16.24	105.96	4.44	41.73	19.82	132.79
100	16.40	166.47	5.01	48.90	17.16	134.00
101	16.57	159.87	5.19	61.73	16.84	134.50
102	16.73	128.05	5.22	34.16	19.06	134.26
103	16.90	118.90	5.07	24.17	21.76	134.08
104	17.06	114.51	5.42	22.00	21.95	133.86
105	17.22	121.14	4.86	21.75	18.78	135.48
106	17.39	214.65	7.40	25.10	12.26	135.69
107	17.55	288.14	4.06	20.72	7.72	136.90
108	17.72	389.52	5.63	27.57	4.34	136.02
109	17.88	410.27	4.50	95.89	2.83	137.08
110	18.05	548.86	5.14	79.43	1.77	137.28
111	18.21	576.04	5.48	193.16	1.32	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.16	0.01	0.00	0.01	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
2	0.33	0.02	0.00	0.02	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
3	0.49	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
4	0.66	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
5	0.82	0.04	0.00	0.04	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
6	0.98	0.05	0.00	0.05	1.00	0.325	0.83	0.390	1.00	1.30	2.000	No
7	1.15	0.06	0.00	0.06	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
8	1.31	0.07	0.00	0.07	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
9	1.48	0.07	0.00	0.07	1.00	0.325	0.83	0.389	1.00	1.30	2.000	No
10	1.64	0.08	0.00	0.08	1.00	0.324	0.83	0.389	1.00	1.30	2.000	Yes
11	1.80	0.09	0.00	0.09	1.00	0.324	0.83	0.389	1.00	1.30	2.000	Yes
12	1.97	0.10	0.00	0.10	1.00	0.324	0.83	0.389	1.00	1.30	2.000	Yes
13	2.13	0.11	0.00	0.10	1.00	0.337	0.83	0.404	1.00	1.30	2.000	Yes
14	2.30	0.12	0.01	0.11	1.00	0.352	0.83	0.422	1.00	1.30	2.000	Yes
15	2.46	0.13	0.01	0.11	1.00	0.365	0.83	0.438	1.00	1.30	0.570	No
16	2.63	0.14	0.02	0.12	1.00	0.378	0.83	0.453	1.00	1.30	0.590	No
17	2.79	0.14	0.02	0.12	1.00	0.390	0.83	0.467	1.00	1.30	0.608	No
18	2.95	0.15	0.03	0.12	1.00	0.401	0.83	0.480	1.00	1.30	0.625	No
19	3.12	0.16	0.03	0.13	0.99	0.411	0.83	0.492	1.00	1.30	0.640	No
20	3.28	0.17	0.04	0.13	0.99	0.420	0.83	0.503	1.00	1.30	0.654	No
21	3.45	0.18	0.05	0.14	0.99	0.428	0.83	0.513	1.00	1.30	0.667	No
22	3.61	0.19	0.05	0.14	0.99	0.436	0.83	0.523	1.00	1.30	0.680	No
23	3.77	0.20	0.06	0.15	0.99	0.443	0.83	0.532	1.00	1.30	0.691	No
24	3.94	0.21	0.06	0.15	0.99	0.450	0.83	0.540	1.00	1.30	0.701	No
25	4.10	0.22	0.07	0.16	0.99	0.456	0.83	0.547	1.00	1.30	0.711	No
26	4.27	0.23	0.07	0.16	0.99	0.462	0.83	0.554	1.00	1.30	0.720	No
27	4.43	0.24	0.08	0.17	0.99	0.468	0.83	0.561	1.00	1.30	0.729	No
28	4.59	0.25	0.08	0.17	0.99	0.473	0.83	0.567	1.00	1.30	0.737	No
29	4.76	0.26	0.09	0.18	0.99	0.478	0.83	0.573	1.00	1.30	0.745	No
30	4.92	0.27	0.09	0.18	0.99	0.482	0.83	0.578	1.00	1.30	0.752	No
31	5.09	0.28	0.10	0.19	0.99	0.487	0.83	0.584	1.00	1.30	0.759	No
32	5.25	0.29	0.10	0.19	0.99	0.491	0.83	0.588	1.00	1.30	0.765	No
33	5.41	0.30	0.11	0.20	0.99	0.494	0.83	0.593	1.00	1.30	0.771	No
34	5.58	0.31	0.11	0.20	0.99	0.498	0.83	0.597	1.00	1.30	0.776	No
35	5.74	0.33	0.12	0.21	0.99	0.501	0.83	0.601	1.00	1.30	0.781	No
36	5.91	0.34	0.12	0.21	0.99	0.504	0.83	0.604	1.00	1.30	0.786	No
37	6.07	0.35	0.13	0.22	0.99	0.507	0.83	0.608	1.00	1.30	0.790	No
38	6.23	0.36	0.13	0.23	0.99	0.509	0.83	0.611	1.00	1.30	0.794	No
39	6.40	0.37	0.14	0.23	0.99	0.512	0.83	0.614	1.00	1.30	0.798	No
40	6.56	0.38	0.14	0.24	0.99	0.514	0.83	0.616	1.00	1.30	0.801	No
41	6.73	0.39	0.15	0.24	0.99	0.516	0.83	0.619	1.00	1.30	0.805	No
42	6.89	0.40	0.15	0.25	0.99	0.518	0.83	0.621	1.00	1.30	0.808	No
43	7.05	0.41	0.16	0.25	0.99	0.520	0.83	0.624	1.00	1.30	0.811	No
44	7.22	0.42	0.16	0.26	0.99	0.522	0.83	0.626	1.00	1.30	0.814	No
45	7.38	0.43	0.17	0.26	0.98	0.524	0.83	0.628	1.00	1.30	0.817	No
46	7.55	0.44	0.17	0.27	0.98	0.526	0.83	0.631	1.00	1.30	0.820	No
47	7.71	0.45	0.18	0.27	0.98	0.528	0.83	0.633	1.00	1.30	0.822	No
48	7.87	0.46	0.18	0.28	0.98	0.529	0.83	0.635	1.00	1.30	0.825	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
49	8.04	0.47	0.19	0.29	0.98	0.531	0.83	0.636	1.00	1.30	0.827	No
50	8.20	0.48	0.19	0.29	0.98	0.532	0.83	0.638	1.00	1.30	0.830	No
51	8.37	0.49	0.20	0.30	0.98	0.534	0.83	0.640	1.00	1.30	0.832	No
52	8.53	0.50	0.20	0.30	0.98	0.536	0.83	0.642	1.00	1.30	0.835	No
53	8.69	0.51	0.21	0.31	0.98	0.537	0.83	0.644	1.00	1.30	0.837	No
54	8.86	0.53	0.21	0.31	0.98	0.538	0.83	0.645	1.00	1.30	0.839	No
55	9.02	0.54	0.22	0.32	0.98	0.539	0.83	0.647	1.00	1.30	0.841	No
56	9.19	0.55	0.22	0.32	0.98	0.541	0.83	0.648	1.00	1.30	0.843	No
57	9.35	0.56	0.23	0.33	0.98	0.542	0.83	0.650	1.00	1.30	0.845	No
58	9.51	0.57	0.23	0.33	0.98	0.544	0.83	0.652	1.00	1.30	0.848	No
59	9.68	0.58	0.24	0.34	0.98	0.545	0.83	0.654	1.00	1.30	0.850	No
60	9.84	0.59	0.24	0.34	0.98	0.546	0.83	0.655	1.00	1.30	0.852	No
61	10.01	0.60	0.25	0.35	0.98	0.548	0.83	0.657	1.00	1.30	0.854	No
62	10.17	0.61	0.25	0.35	0.98	0.549	0.83	0.658	1.00	1.30	0.856	No
63	10.34	0.62	0.26	0.36	0.98	0.550	0.83	0.660	1.00	1.30	0.858	No
64	10.50	0.63	0.27	0.36	0.98	0.551	0.83	0.661	1.00	1.30	0.859	No
65	10.66	0.64	0.27	0.37	0.98	0.552	0.83	0.662	1.00	1.30	0.861	No
66	10.83	0.65	0.28	0.37	0.98	0.553	0.83	0.663	1.00	1.30	0.862	No
67	10.99	0.66	0.28	0.38	0.98	0.554	0.83	0.664	1.00	1.30	0.864	No
68	11.16	0.67	0.29	0.38	0.98	0.555	0.83	0.665	1.00	1.30	0.865	No
69	11.32	0.68	0.29	0.39	0.98	0.556	0.83	0.666	1.00	1.30	0.866	No
70	11.48	0.69	0.30	0.39	0.98	0.557	0.83	0.668	1.00	1.30	0.868	No
71	11.65	0.70	0.30	0.40	0.98	0.558	0.83	0.669	1.00	1.30	0.869	No
72	11.81	0.71	0.31	0.40	0.98	0.559	0.83	0.670	1.00	1.30	0.871	No
73	11.98	0.72	0.31	0.41	0.97	0.559	0.83	0.671	1.00	1.30	0.872	No
74	12.14	0.73	0.32	0.41	0.97	0.560	0.83	0.672	1.00	1.30	0.873	No
75	12.30	0.74	0.32	0.42	0.97	0.561	0.83	0.673	1.00	1.30	0.875	No
76	12.47	0.75	0.33	0.42	0.97	0.562	0.83	0.674	1.00	1.30	0.876	No
77	12.63	0.76	0.33	0.43	0.97	0.563	0.83	0.675	1.00	1.30	0.877	No
78	12.80	0.77	0.34	0.43	0.97	0.564	0.83	0.676	1.00	1.30	0.879	No
79	12.96	0.78	0.34	0.44	0.97	0.565	0.83	0.677	1.00	1.30	0.880	No
80	13.12	0.79	0.35	0.44	0.97	0.565	0.83	0.678	1.00	1.30	0.881	No
81	13.29	0.80	0.35	0.44	0.97	0.566	0.83	0.679	1.00	1.30	0.882	No
82	13.45	0.81	0.36	0.45	0.97	0.567	0.83	0.679	1.00	1.30	0.883	No
83	13.62	0.82	0.36	0.46	0.97	0.567	0.83	0.680	1.00	1.30	0.884	No
84	13.78	0.83	0.37	0.46	0.97	0.567	0.83	0.680	1.00	1.30	0.884	No
85	13.94	0.84	0.37	0.47	0.97	0.568	0.83	0.681	1.00	1.30	0.885	No
86	14.11	0.85	0.38	0.47	0.97	0.568	0.83	0.681	1.00	1.30	0.885	No
87	14.27	0.86	0.38	0.48	0.97	0.568	0.83	0.682	1.00	1.30	0.886	No
88	14.44	0.87	0.39	0.48	0.97	0.569	0.83	0.682	1.00	1.30	0.887	No
89	14.60	0.88	0.39	0.49	0.97	0.569	0.83	0.682	1.00	1.30	0.887	No
90	14.76	0.89	0.40	0.49	0.97	0.569	0.83	0.683	1.00	1.30	0.888	No
91	14.93	0.90	0.40	0.50	0.97	0.570	0.83	0.683	1.00	1.30	0.888	No
92	15.09	0.91	0.41	0.50	0.97	0.570	0.83	0.684	1.00	1.30	0.889	No
93	15.26	0.92	0.41	0.51	0.97	0.571	0.83	0.684	1.00	1.30	0.889	No
94	15.42	0.93	0.42	0.51	0.97	0.571	0.83	0.685	1.00	1.30	0.890	No
95	15.58	0.94	0.42	0.52	0.97	0.571	0.83	0.685	1.00	1.30	0.891	No
96	15.75	0.95	0.43	0.52	0.97	0.572	0.83	0.686	1.00	1.30	0.891	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
97	15.91	0.96	0.43	0.53	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
98	16.08	0.97	0.44	0.53	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
99	16.24	0.98	0.44	0.54	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
100	16.40	1.00	0.45	0.55	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
101	16.57	1.01	0.45	0.55	0.97	0.572	0.83	0.686	1.00	1.30	0.892	No
102	16.73	1.02	0.46	0.56	0.96	0.572	0.83	0.686	1.00	1.30	0.891	No
103	16.90	1.03	0.46	0.56	0.96	0.572	0.83	0.686	1.00	1.30	0.891	No
104	17.06	1.04	0.47	0.57	0.96	0.572	0.83	0.686	1.00	1.30	0.891	No
105	17.22	1.05	0.47	0.58	0.96	0.572	0.83	0.685	1.00	1.30	0.891	No
106	17.39	1.06	0.48	0.58	0.96	0.571	0.83	0.685	1.00	1.30	0.891	No
107	17.55	1.07	0.49	0.59	0.96	0.571	0.83	0.685	1.00	1.30	0.891	No
108	17.72	1.08	0.49	0.59	0.96	0.571	0.83	0.685	1.00	1.30	0.890	No
109	17.88	1.10	0.50	0.60	0.96	0.571	0.83	0.685	1.00	1.30	0.890	No
110	18.05	1.11	0.50	0.61	0.96	0.571	0.83	0.684	1.00	1.30	0.890	No
111	18.21	1.12	0.51	0.61	0.96	0.571	0.83	0.684	1.00	1.30	0.889	No

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.16	25.40	2.06	0.62	0.63	48.00	1.38	66.23	4.000	No	No	2.00
2	0.33	27.82	2.01	0.58	0.62	52.55	1.31	68.83	4.000	No	No	2.00
3	0.49	28.42	1.99	0.54	0.61	53.68	1.28	68.79	4.000	No	No	2.00
4	0.66	22.62	2.10	0.61	0.65	42.69	1.45	61.94	4.000	No	No	2.00
5	0.82	18.53	2.14	0.52	0.67	34.95	1.54	53.66	4.000	No	No	2.00
6	0.98	15.70	2.18	0.43	0.68	29.57	1.00	29.57	4.000	No	No	2.00
7	1.15	14.38	2.18	0.35	0.68	27.06	1.00	27.06	4.000	No	No	2.00
8	1.31	13.63	2.26	0.50	0.71	25.63	1.82	46.62	4.000	No	No	2.00
9	1.48	14.72	2.21	0.45	0.70	27.68	1.00	27.68	4.000	No	No	2.00
10	1.64	17.45	2.15	0.48	0.67	32.83	1.00	32.83	4.000	Yes	No	2.00
11	1.80	18.22	2.22	0.72	0.70	34.28	1.71	58.50	4.000	Yes	No	2.00
12	1.97	16.03	2.41	1.36	0.77	30.10	2.35	70.69	4.000	Yes	No	2.00
13	2.13	12.43	2.62	2.21	0.85	23.28	6.21	144.49	4.000	Yes	No	2.00
14	2.30	11.37	2.72	2.86	0.89	21.26	4.14	88.11	4.000	Yes	Yes	2.00
15	2.46	12.94	2.70	3.08	0.88	24.23	9.93	240.68	4.000	No	No	2.00
16	2.63	15.53	2.66	3.40	0.87	29.10	8.09	235.52	4.000	No	No	2.00
17	2.79	18.63	2.62	3.63	0.86	34.93	6.27	219.00	4.000	No	No	2.00
18	2.95	22.03	2.58	3.76	0.84	41.35	4.77	197.38	0.795	No	No	1.27
19	3.12	25.33	2.55	3.90	0.83	47.57	3.86	183.45	0.654	No	No	1.02
20	3.28	27.59	2.55	4.22	0.83	51.81	3.83	198.27	0.805	No	No	1.23
21	3.45	29.01	2.56	4.59	0.83	54.48	4.13	225.11	4.000	No	No	2.00
22	3.61	29.55	2.58	4.99	0.84	55.49	4.76	264.06	4.000	No	No	2.00
23	3.77	31.52	2.56	4.98	0.84	59.20	4.19	248.14	4.000	No	No	2.00
24	3.94	32.27	2.56	5.08	0.84	60.59	4.19	254.05	4.000	No	No	2.00
25	4.10	32.95	2.56	5.15	0.84	61.85	4.15	256.74	4.000	No	No	2.00
26	4.27	31.46	2.60	5.65	0.85	59.03	5.51	325.21	4.000	No	No	2.00
27	4.43	30.60	2.62	5.87	0.86	57.39	6.30	361.60	4.000	No	No	2.00
28	4.59	29.66	2.64	6.07	0.87	55.58	7.14	396.64	4.000	No	No	2.00
29	4.76	30.00	2.63	5.87	0.86	56.21	6.53	367.16	4.000	No	No	2.00
30	4.92	30.65	2.63	5.95	0.86	57.41	6.47	371.43	4.000	No	No	2.00
31	5.09	30.81	2.64	6.23	0.87	57.70	7.06	407.45	4.000	No	No	2.00
32	5.25	34.29	2.58	5.74	0.85	64.27	4.89	314.34	4.000	No	No	2.00
33	5.41	41.43	2.49	5.14	0.81	77.74	2.74	213.10	4.000	No	No	2.00
34	5.58	51.12	2.40	4.64	0.78	96.03	2.32	222.99	4.000	No	No	2.00
35	5.74	61.87	2.34	4.51	0.76	116.32	2.09	243.27	4.000	No	No	2.00
36	5.91	67.50	2.33	4.62	0.75	126.95	2.04	259.03	4.000	No	No	2.00
37	6.07	69.34	2.34	4.93	0.76	130.41	2.10	273.71	4.000	No	No	2.00
38	6.23	66.58	2.38	5.30	0.77	125.17	2.23	279.45	4.000	No	No	2.00
39	6.40	68.72	2.36	5.16	0.77	129.20	2.16	279.64	4.000	No	No	2.00
40	6.56	80.16	2.26	4.32	0.73	150.79	1.83	275.74	4.000	No	No	2.00
41	6.73	84.87	2.24	4.19	0.72	159.68	1.76	280.83	4.000	No	No	2.00
42	6.89	78.53	2.29	4.60	0.74	147.68	1.91	282.50	4.000	No	No	2.00
43	7.05	61.06	2.43	5.75	0.80	114.64	2.44	280.12	4.000	No	No	2.00
44	7.22	49.81	2.52	6.47	0.83	93.36	3.31	308.63	4.000	No	No	2.00
45	7.38	50.45	2.49	5.97	0.82	94.54	2.74	258.62	4.000	No	No	2.00
46	7.55	52.61	2.48	5.86	0.81	98.60	2.65	261.29	4.000	No	No	2.00
47	7.71	53.68	2.48	6.01	0.82	100.60	2.67	268.39	4.000	No	No	2.00
48	7.87	49.57	2.53	6.61	0.84	92.71	3.51	325.32	4.000	No	No	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
49	8.04	44.97	2.58	6.93	0.85	83.60	4.68	390.87	4.000	No	No	2.00
50	8.20	39.71	2.62	7.12	0.87	73.33	6.20	454.55	4.000	No	No	2.00
51	8.37	34.75	2.65	6.96	0.88	63.48	7.56	479.98	4.000	No	No	2.00
52	8.53	46.59	2.50	5.42	0.83	80.43	2.86	230.05	4.000	No	No	2.00
53	8.69	59.70	2.40	4.73	0.79	98.74	2.32	228.82	4.000	No	No	2.00
54	8.86	62.74	2.40	4.91	0.79	102.28	2.33	238.55	4.000	No	No	2.00
55	9.02	50.20	2.49	5.30	0.82	82.28	2.72	223.40	4.000	No	No	2.00
56	9.19	37.71	2.58	5.55	0.86	62.55	4.78	298.89	4.000	No	No	2.00
57	9.35	34.57	2.57	4.85	0.85	56.60	4.33	244.84	4.000	No	No	2.00
58	9.51	33.72	2.55	4.40	0.85	54.48	3.78	206.17	4.000	No	No	2.00
59	9.68	33.63	2.54	4.22	0.84	53.81	3.56	191.60	0.734	No	No	0.86
60	9.84	34.51	2.54	4.31	0.84	54.82	3.57	195.90	0.779	No	No	0.91
61	10.01	34.82	2.55	4.57	0.85	55.14	4.01	221.00	4.000	No	No	2.00
62	10.17	34.09	2.59	4.99	0.86	54.00	5.02	270.92	4.000	No	No	2.00
63	10.34	33.88	2.60	5.16	0.87	53.44	5.47	292.45	4.000	No	No	2.00
64	10.50	34.41	2.61	5.28	0.87	53.94	5.65	304.94	4.000	No	No	2.00
65	10.66	37.38	2.58	5.20	0.86	57.89	4.79	277.06	4.000	No	No	2.00
66	10.83	42.21	2.55	5.22	0.85	64.58	3.94	254.63	4.000	No	No	2.00
67	10.99	42.87	2.57	5.57	0.86	65.37	4.43	289.69	4.000	No	No	2.00
68	11.16	39.24	2.62	5.97	0.88	59.90	6.04	361.63	4.000	No	No	2.00
69	11.32	33.11	2.67	6.16	0.90	50.63	8.70	440.51	4.000	No	No	2.00
70	11.48	30.41	2.68	5.76	0.90	46.12	8.99	414.75	4.000	No	No	2.00
71	11.65	30.97	2.65	5.24	0.89	46.33	7.38	341.92	4.000	No	No	2.00
72	11.81	31.99	2.65	5.31	0.89	47.52	7.23	343.47	4.000	No	No	2.00
73	11.98	33.18	2.64	5.40	0.89	48.95	7.09	347.09	4.000	No	No	2.00
74	12.14	33.28	2.64	5.31	0.89	48.69	6.91	336.23	4.000	No	No	2.00
75	12.30	32.19	2.63	5.04	0.88	46.70	6.71	313.59	4.000	No	No	2.00
76	12.47	30.35	2.63	4.73	0.88	43.66	6.73	293.77	4.000	No	No	2.00
77	12.63	28.16	2.65	4.55	0.89	40.26	7.30	294.04	4.000	No	No	2.00
78	12.80	27.11	2.64	4.29	0.89	38.43	7.11	273.35	4.000	No	No	2.00
79	12.96	27.19	2.64	4.21	0.89	38.26	6.93	265.09	4.000	No	No	2.00
80	13.12	30.47	2.61	4.25	0.88	42.51	5.74	243.98	4.000	No	No	2.00
81	13.29	40.03	2.54	4.38	0.85	55.14	3.66	201.87	4.000	No	No	2.00
82	13.45	53.18	2.48	4.70	0.83	72.41	2.69	194.79	0.767	No	No	0.87
83	13.62	60.57	2.49	5.30	0.83	82.15	2.72	223.32	4.000	No	No	2.00
84	13.78	56.73	2.54	5.90	0.85	77.04	3.75	289.17	4.000	No	No	2.00
85	13.94	49.13	2.59	6.07	0.87	66.65	5.17	344.62	4.000	No	No	2.00
86	14.11	46.88	2.56	5.29	0.86	62.82	4.26	267.82	4.000	No	No	2.00
87	14.27	45.25	2.59	5.55	0.87	60.45	5.08	306.97	4.000	No	No	2.00
88	14.44	51.22	2.55	5.37	0.85	67.67	3.85	260.86	4.000	No	No	2.00
89	14.60	51.98	2.57	5.87	0.86	68.52	4.57	313.42	4.000	No	No	2.00
90	14.76	50.83	2.58	5.77	0.87	66.55	4.64	309.12	4.000	No	No	2.00
91	14.93	40.36	2.69	6.65	0.91	53.12	9.37	497.91	4.000	No	No	2.00
92	15.09	32.05	2.79	7.38	0.95	42.26	4.67	197.14	2.016	No	Yes	2.00
93	15.26	30.08	2.80	7.29	0.95	39.41	4.80	189.27	1.880	No	Yes	2.00
94	15.42	29.39	2.79	6.84	0.95	38.15	4.71	179.58	1.820	No	Yes	2.00
95	15.58	32.77	2.72	6.03	0.92	42.01	4.16	174.88	2.004	No	Yes	2.00
96	15.75	39.88	2.63	5.33	0.89	50.42	6.54	329.68	4.000	No	No	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
97	15.91	57.67	2.50	4.87	0.84	71.72	2.76	198.14	0.803	No	No	0.90
98	16.08	80.17	2.39	4.51	0.80	98.12	2.26	221.84	4.000	No	No	2.00
99	16.24	118.97	2.22	3.74	0.73	142.35	1.73	246.06	4.000	No	No	2.00
100	16.40	144.83	2.14	3.39	0.70	170.85	1.54	262.99	4.000	No	No	2.00
101	16.57	152.16	2.13	3.40	0.70	178.37	1.52	270.93	4.000	No	No	2.00
102	16.73	136.18	2.20	3.82	0.73	159.96	1.67	267.36	4.000	No	No	2.00
103	16.90	120.87	2.28	4.37	0.76	142.32	1.88	268.09	4.000	No	No	2.00
104	17.06	118.51	2.28	4.36	0.76	138.81	1.90	263.74	4.000	No	No	2.00
105	17.22	150.43	2.19	3.95	0.72	173.78	1.65	286.91	4.000	No	No	2.00
106	17.39	208.30	1.97	2.63	0.64	234.27	1.27	297.02	4.000	No	No	2.00
107	17.55	297.79	1.78	1.92	0.57	327.17	1.09	357.66	4.000	No	No	2.00
108	17.72	363.33	1.60	1.31	0.50	390.52	1.00	390.52	4.000	No	No	2.00
109	17.88	450.52	1.50	1.13	0.46	478.05	1.00	478.05	4.000	No	No	2.00
110	18.05	513.49	1.42	0.98	0.43	539.10	1.00	539.10	4.000	No	No	2.00
111	18.21	569.21	1.38	0.94	0.42	593.84	1.00	593.84	4.000	No	No	2.00

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
I_c: Soil behavior type index
Fr: Normalized friction ratio (%)
n: Stress exponent
Q_{tn}: Normalized cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.16	2.00	0.00	9.98	0.16	0.00	0.33	2.00	0.00	9.95	0.16	0.00
0.49	2.00	0.00	9.93	0.16	0.00	0.66	2.00	0.00	9.90	0.16	0.00
0.82	2.00	0.00	9.88	0.16	0.00	0.98	2.00	0.00	9.85	0.16	0.00
1.15	2.00	0.00	9.83	0.16	0.00	1.31	2.00	0.00	9.80	0.16	0.00
1.48	2.00	0.00	9.78	0.16	0.00	1.64	2.00	0.00	9.75	0.16	0.00
1.80	2.00	0.00	9.73	0.16	0.00	1.97	2.00	0.00	9.70	0.17	0.00
2.13	2.00	0.00	9.67	0.16	0.00	2.30	2.00	0.00	9.65	0.16	0.00
2.46	2.00	0.00	9.62	0.16	0.00	2.63	2.00	0.00	9.60	0.16	0.00
2.79	2.00	0.00	9.57	0.16	0.00	2.95	1.27	0.00	9.55	0.16	0.00
3.12	1.02	0.00	9.52	0.16	0.00	3.28	1.23	0.00	9.50	0.16	0.00
3.45	2.00	0.00	9.47	0.16	0.00	3.61	2.00	0.00	9.45	0.16	0.00
3.77	2.00	0.00	9.42	0.16	0.00	3.94	2.00	0.00	9.40	0.16	0.00
4.10	2.00	0.00	9.38	0.16	0.00	4.27	2.00	0.00	9.35	0.16	0.00
4.43	2.00	0.00	9.33	0.16	0.00	4.59	2.00	0.00	9.30	0.16	0.00
4.76	2.00	0.00	9.28	0.16	0.00	4.92	2.00	0.00	9.25	0.16	0.00
5.09	2.00	0.00	9.23	0.16	0.00	5.25	2.00	0.00	9.20	0.16	0.00
5.41	2.00	0.00	9.18	0.16	0.00	5.58	2.00	0.00	9.15	0.16	0.00
5.74	2.00	0.00	9.13	0.16	0.00	5.91	2.00	0.00	9.10	0.17	0.00
6.07	2.00	0.00	9.07	0.16	0.00	6.23	2.00	0.00	9.05	0.16	0.00
6.40	2.00	0.00	9.02	0.16	0.00	6.56	2.00	0.00	9.00	0.16	0.00
6.73	2.00	0.00	8.97	0.16	0.00	6.89	2.00	0.00	8.95	0.16	0.00
7.05	2.00	0.00	8.92	0.16	0.00	7.22	2.00	0.00	8.90	0.16	0.00
7.38	2.00	0.00	8.87	0.16	0.00	7.55	2.00	0.00	8.85	0.16	0.00
7.71	2.00	0.00	8.82	0.16	0.00	7.87	2.00	0.00	8.80	0.16	0.00
8.04	2.00	0.00	8.78	0.16	0.00	8.20	2.00	0.00	8.75	0.16	0.00
8.37	2.00	0.00	8.73	0.16	0.00	8.53	2.00	0.00	8.70	0.16	0.00
8.69	2.00	0.00	8.68	0.16	0.00	8.86	2.00	0.00	8.65	0.16	0.00
9.02	2.00	0.00	8.63	0.16	0.00	9.19	2.00	0.00	8.60	0.16	0.00
9.35	2.00	0.00	8.58	0.16	0.00	9.51	2.00	0.00	8.55	0.16	0.00
9.68	0.86	0.14	8.53	0.16	0.06	9.84	0.91	0.09	8.50	0.16	0.04
10.01	2.00	0.00	8.47	0.16	0.00	10.17	2.00	0.00	8.45	0.16	0.00
10.34	2.00	0.00	8.42	0.16	0.00	10.50	2.00	0.00	8.40	0.16	0.00
10.66	2.00	0.00	8.37	0.16	0.00	10.83	2.00	0.00	8.35	0.16	0.00
10.99	2.00	0.00	8.32	0.16	0.00	11.16	2.00	0.00	8.30	0.16	0.00
11.32	2.00	0.00	8.27	0.16	0.00	11.48	2.00	0.00	8.25	0.16	0.00
11.65	2.00	0.00	8.22	0.16	0.00	11.81	2.00	0.00	8.20	0.16	0.00
11.98	2.00	0.00	8.18	0.16	0.00	12.14	2.00	0.00	8.15	0.16	0.00
12.30	2.00	0.00	8.13	0.16	0.00	12.47	2.00	0.00	8.10	0.16	0.00
12.63	2.00	0.00	8.08	0.16	0.00	12.80	2.00	0.00	8.05	0.16	0.00
12.96	2.00	0.00	8.03	0.16	0.00	13.12	2.00	0.00	8.00	0.16	0.00
13.29	2.00	0.00	7.98	0.16	0.00	13.45	0.87	0.13	7.95	0.16	0.05
13.62	2.00	0.00	7.93	0.16	0.00	13.78	2.00	0.00	7.90	0.16	0.00
13.94	2.00	0.00	7.87	0.16	0.00	14.11	2.00	0.00	7.85	0.16	0.00
14.27	2.00	0.00	7.82	0.16	0.00	14.44	2.00	0.00	7.80	0.16	0.00
14.60	2.00	0.00	7.77	0.16	0.00	14.76	2.00	0.00	7.75	0.16	0.00
14.93	2.00	0.00	7.72	0.16	0.00	15.09	2.00	0.00	7.70	0.16	0.00
15.26	2.00	0.00	7.67	0.16	0.00	15.42	2.00	0.00	7.65	0.16	0.00
15.58	2.00	0.00	7.62	0.16	0.00	15.75	2.00	0.00	7.60	0.16	0.00

:: Liquefaction Potential Index calculation data :: (continued)

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
15.91	0.90	0.10	7.58	0.16	0.04	16.08	2.00	0.00	7.55	0.16	0.00
16.24	2.00	0.00	7.53	0.16	0.00	16.40	2.00	0.00	7.50	0.16	0.00
16.57	2.00	0.00	7.48	0.16	0.00	16.73	2.00	0.00	7.45	0.16	0.00
16.90	2.00	0.00	7.43	0.16	0.00	17.06	2.00	0.00	7.40	0.16	0.00
17.22	2.00	0.00	7.38	0.16	0.00	17.39	2.00	0.00	7.35	0.16	0.00
17.55	2.00	0.00	7.33	0.16	0.00	17.72	2.00	0.00	7.30	0.16	0.00
17.88	2.00	0.00	7.27	0.16	0.00	18.05	2.00	0.00	7.25	0.16	0.00
18.21	2.00	0.00	7.22	0.16	0.00						

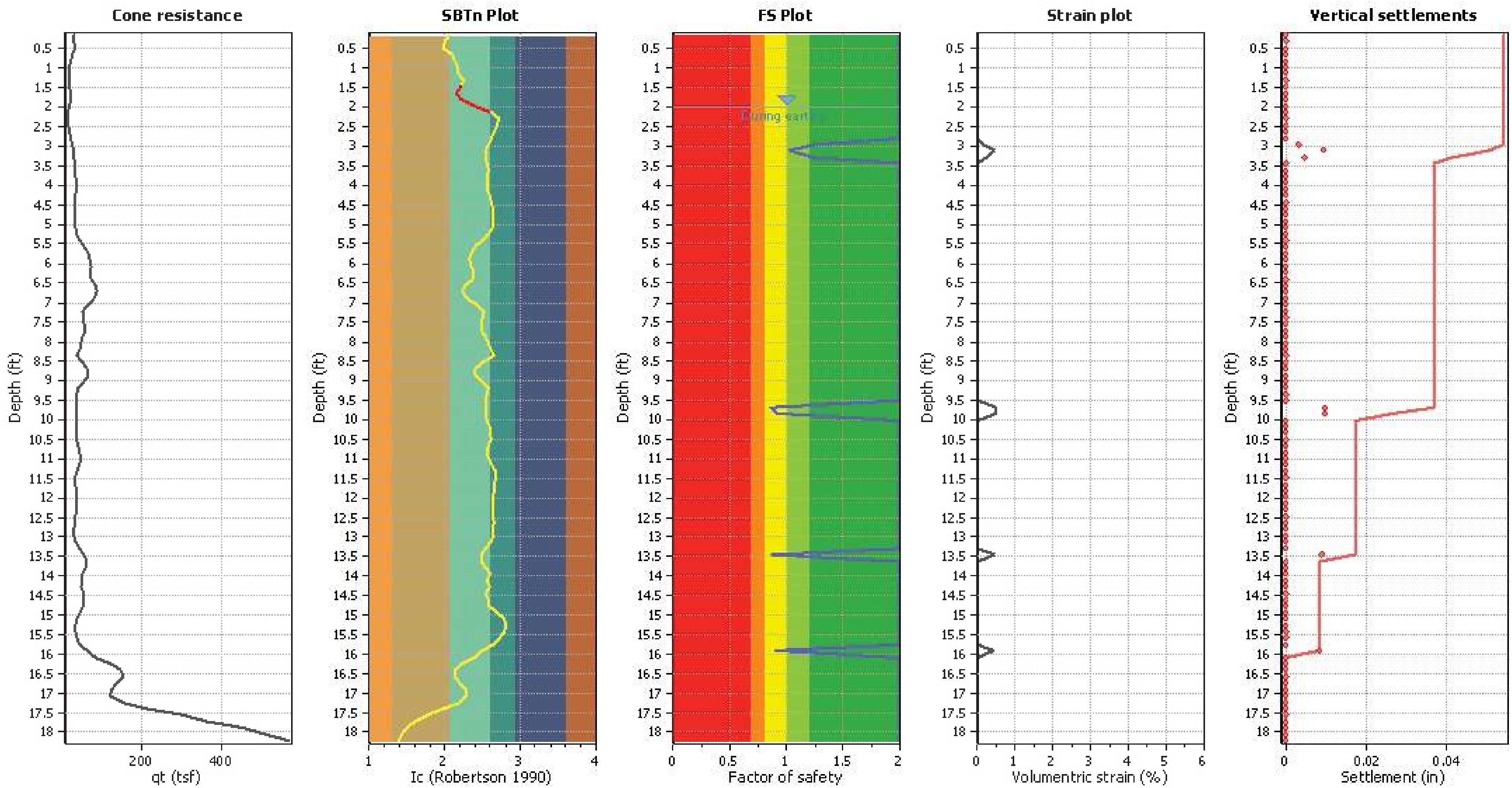
Overall liquefaction potential: 0.18

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
FS: Calculated Factor of Safety against liquefaction
Volumentric strain: Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
2.13	144.49	2.00	0.00	0.96	0.00	2.30	88.11	2.00	0.00	0.96	0.00
2.46	240.68	2.00	0.00	0.96	0.00	2.63	235.52	2.00	0.00	0.96	0.00
2.79	219.00	2.00	0.00	0.95	0.00	2.95	197.38	1.27	0.17	0.95	0.00
3.12	183.45	1.02	0.48	0.95	0.01	3.28	198.27	1.23	0.24	0.94	0.00
3.45	225.11	2.00	0.00	0.94	0.00	3.61	264.06	2.00	0.00	0.94	0.00
3.77	248.14	2.00	0.00	0.94	0.00	3.94	254.05	2.00	0.00	0.93	0.00
4.10	256.74	2.00	0.00	0.93	0.00	4.27	325.21	2.00	0.00	0.93	0.00
4.43	361.60	2.00	0.00	0.92	0.00	4.59	396.64	2.00	0.00	0.92	0.00
4.76	367.16	2.00	0.00	0.92	0.00	4.92	371.43	2.00	0.00	0.92	0.00
5.09	407.45	2.00	0.00	0.91	0.00	5.25	314.34	2.00	0.00	0.91	0.00
5.41	213.10	2.00	0.00	0.91	0.00	5.58	222.99	2.00	0.00	0.91	0.00
5.74	243.27	2.00	0.00	0.90	0.00	5.91	259.03	2.00	0.00	0.90	0.00
6.07	273.71	2.00	0.00	0.90	0.00	6.23	279.45	2.00	0.00	0.89	0.00
6.40	279.64	2.00	0.00	0.89	0.00	6.56	275.74	2.00	0.00	0.89	0.00
6.73	280.83	2.00	0.00	0.89	0.00	6.89	282.50	2.00	0.00	0.88	0.00
7.05	280.12	2.00	0.00	0.88	0.00	7.22	308.63	2.00	0.00	0.88	0.00
7.38	258.62	2.00	0.00	0.87	0.00	7.55	261.29	2.00	0.00	0.87	0.00
7.71	268.39	2.00	0.00	0.87	0.00	7.87	325.32	2.00	0.00	0.87	0.00
8.04	390.87	2.00	0.00	0.86	0.00	8.20	454.55	2.00	0.00	0.86	0.00
8.37	479.98	2.00	0.00	0.86	0.00	8.53	230.05	2.00	0.00	0.86	0.00
8.69	228.82	2.00	0.00	0.85	0.00	8.86	238.55	2.00	0.00	0.85	0.00
9.02	223.40	2.00	0.00	0.85	0.00	9.19	298.89	2.00	0.00	0.84	0.00
9.35	244.84	2.00	0.00	0.84	0.00	9.51	206.17	2.00	0.00	0.84	0.00
9.68	191.60	0.86	0.50	0.84	0.01	9.84	195.90	0.91	0.48	0.83	0.01
10.01	221.00	2.00	0.00	0.83	0.00	10.17	270.92	2.00	0.00	0.83	0.00
10.34	292.45	2.00	0.00	0.82	0.00	10.50	304.94	2.00	0.00	0.82	0.00
10.66	277.06	2.00	0.00	0.82	0.00	10.83	254.63	2.00	0.00	0.82	0.00
10.99	289.69	2.00	0.00	0.81	0.00	11.16	361.63	2.00	0.00	0.81	0.00
11.32	440.51	2.00	0.00	0.81	0.00	11.48	414.75	2.00	0.00	0.81	0.00
11.65	341.92	2.00	0.00	0.80	0.00	11.81	343.47	2.00	0.00	0.80	0.00
11.98	347.09	2.00	0.00	0.80	0.00	12.14	336.23	2.00	0.00	0.79	0.00
12.30	313.59	2.00	0.00	0.79	0.00	12.47	293.77	2.00	0.00	0.79	0.00
12.63	294.04	2.00	0.00	0.79	0.00	12.80	273.35	2.00	0.00	0.78	0.00
12.96	265.09	2.00	0.00	0.78	0.00	13.12	243.98	2.00	0.00	0.78	0.00
13.29	201.87	2.00	0.00	0.77	0.00	13.45	194.79	0.87	0.45	0.77	0.01
13.62	223.32	2.00	0.00	0.77	0.00	13.78	289.17	2.00	0.00	0.77	0.00
13.94	344.62	2.00	0.00	0.76	0.00	14.11	267.82	2.00	0.00	0.76	0.00
14.27	306.97	2.00	0.00	0.76	0.00	14.44	260.86	2.00	0.00	0.76	0.00
14.60	313.42	2.00	0.00	0.75	0.00	14.76	309.12	2.00	0.00	0.75	0.00
14.93	497.91	2.00	0.00	0.75	0.00	15.09	197.14	2.00	0.00	0.74	0.00
15.26	189.27	2.00	0.00	0.74	0.00	15.42	179.58	2.00	0.00	0.74	0.00
15.58	174.88	2.00	0.00	0.74	0.00	15.75	329.68	2.00	0.00	0.73	0.00
15.91	198.14	0.90	0.42	0.73	0.01	16.08	221.84	2.00	0.00	0.73	0.00
16.24	246.06	2.00	0.00	0.72	0.00	16.40	262.99	2.00	0.00	0.72	0.00
16.57	270.93	2.00	0.00	0.72	0.00	16.73	267.36	2.00	0.00	0.72	0.00
16.90	268.09	2.00	0.00	0.71	0.00	17.06	263.74	2.00	0.00	0.71	0.00
17.22	286.91	2.00	0.00	0.71	0.00	17.39	297.02	2.00	0.00	0.71	0.00
17.55	357.66	2.00	0.00	0.70	0.00	17.72	390.52	2.00	0.00	0.70	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
17.88	478.05	2.00	0.00	0.70	0.00	18.05	539.10	2.00	0.00	0.69	0.00
18.21	593.84	2.00	0.00	0.69	0.00						

Total estimated settlement: 0.05

Abbreviations

$Q_{tn,cs}$: Equivalent clean sand normalized cone resistance
FS: Factor of safety against liquefaction
e_v (%): Post-liquefaction volumentric strain
DF: e_v depth weighting factor
Settlement: Calculated settlement

:: Strength loss calculation (Robertson (2009) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.16	25.40	48.00	1.38	66.23	2.06	N/A	N/A
0.33	27.82	52.55	1.31	68.83	2.01	N/A	N/A
0.49	28.42	53.68	1.28	68.79	1.99	N/A	N/A
0.66	22.62	42.69	1.45	61.94	2.10	N/A	N/A
0.82	18.53	34.95	1.54	53.66	2.14	N/A	N/A
0.98	15.70	29.57	1.00	29.57	2.18	N/A	N/A
1.15	14.38	27.06	1.00	27.06	2.18	N/A	N/A
1.31	13.63	25.63	1.82	46.62	2.26	N/A	N/A
1.48	14.72	27.68	1.00	27.68	2.21	N/A	N/A
1.64	17.45	32.83	1.00	32.83	2.15	N/A	N/A
1.80	18.22	34.28	1.71	58.50	2.22	N/A	N/A
1.97	16.03	30.10	2.35	70.69	2.41	N/A	N/A
2.13	12.43	23.28	3.46	80.57	2.62	7.59	7.59
2.30	11.37	21.26	4.14	88.11	2.72	6.41	6.41
2.46	12.94	24.23	3.97	96.12	2.70	6.78	6.78
2.63	15.53	29.10	3.74	108.73	2.66	7.59	7.59
2.79	18.63	34.93	3.47	121.23	2.62	8.52	8.52
2.95	22.03	41.35	3.21	132.75	2.58	0.71	0.71
3.12	25.33	47.57	3.02	143.83	2.55	0.73	0.73
3.28	27.59	51.81	3.02	156.31	2.55	0.74	0.74
3.45	29.01	54.48	3.08	167.93	2.56	0.75	0.75
3.61	29.55	55.49	3.21	178.00	2.58	0.75	0.75
3.77	31.52	59.20	3.09	183.21	2.56	0.76	0.76
3.94	32.27	60.59	3.10	187.52	2.56	0.76	0.76
4.10	32.95	61.85	3.09	190.90	2.56	0.76	0.76
4.27	31.46	59.03	3.34	197.41	2.60	8.91	8.91
4.43	30.60	57.39	3.48	199.45	2.62	8.31	8.31
4.59	29.66	55.58	3.60	200.25	2.64	7.73	7.73
4.76	30.00	56.21	3.51	197.41	2.63	7.52	7.52
4.92	30.65	57.41	3.50	201.06	2.63	7.39	7.39
5.09	30.81	57.70	3.59	207.24	2.64	7.17	7.17
5.25	34.29	64.27	3.23	207.76	2.58	0.77	0.77
5.41	41.43	77.74	2.74	213.10	2.49	0.79	0.79
5.58	51.12	96.03	2.32	222.99	2.40	0.82	0.82
5.74	61.87	116.32	2.09	243.27	2.34	0.85	0.85
5.91	67.50	126.95	2.04	259.03	2.33	0.86	0.86
6.07	69.34	130.41	2.10	273.71	2.34	0.87	0.87
6.23	66.58	125.17	2.23	279.45	2.38	0.86	0.86
6.40	68.72	129.20	2.16	279.64	2.36	0.86	0.86
6.56	80.16	150.79	1.83	275.74	2.26	0.89	0.89
6.73	84.87	159.68	1.76	280.83	2.24	0.90	0.90
6.89	78.53	147.68	1.91	282.50	2.29	0.88	0.88
7.05	61.06	114.64	2.44	280.12	2.43	0.85	0.85
7.22	49.81	93.36	2.90	270.43	2.52	0.82	0.82
7.38	50.45	94.54	2.74	258.62	2.49	0.82	0.82
7.55	52.61	98.60	2.65	261.29	2.48	0.83	0.83
7.71	53.68	100.60	2.67	268.39	2.48	0.83	0.83
7.87	49.57	92.71	2.94	273.03	2.53	0.82	0.82

:: Strength loss calculation (Robertson (2009) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
8.04	44.97	83.60	3.19	266.83	2.58	0.80	0.80
8.20	39.71	73.33	3.46	253.67	2.62	5.41	5.41
8.37	34.75	63.48	3.66	232.56	2.65	4.62	4.62
8.53	46.59	80.43	2.78	223.90	2.50	0.80	0.80
8.69	59.70	98.74	2.32	228.82	2.40	0.83	0.83
8.86	62.74	102.28	2.33	238.55	2.40	0.83	0.83
9.02	50.20	82.28	2.72	223.40	2.49	0.80	0.80
9.19	37.71	62.55	3.21	200.87	2.58	0.76	0.76
9.35	34.57	56.60	3.12	176.73	2.57	0.75	0.75
9.51	33.72	54.48	3.01	163.85	2.55	0.75	0.75
9.68	33.63	53.81	2.96	159.10	2.54	0.74	0.74
9.84	34.51	54.82	2.96	162.26	2.54	0.75	0.75
10.01	34.82	55.14	3.06	168.51	2.55	0.75	0.75
10.17	34.09	54.00	3.26	175.85	2.59	0.74	0.74
10.34	33.88	53.44	3.34	178.38	2.60	3.86	3.86
10.50	34.41	53.94	3.37	181.72	2.61	3.89	3.89
10.66	37.38	57.89	3.21	185.99	2.58	0.75	0.75
10.83	42.21	64.58	3.04	196.47	2.55	0.77	0.77
10.99	42.87	65.37	3.14	205.50	2.57	0.77	0.77
11.16	39.24	59.90	3.43	205.65	2.62	4.28	4.28
11.32	33.11	50.63	3.82	193.23	2.67	3.57	3.57
11.48	30.41	46.12	3.85	177.73	2.68	3.25	3.25
11.65	30.97	46.33	3.64	168.56	2.65	3.28	3.28
11.81	31.99	47.52	3.62	171.83	2.65	3.36	3.36
11.98	33.18	48.95	3.60	176.02	2.64	3.46	3.46
12.14	33.28	48.69	3.57	173.76	2.64	3.45	3.45
12.30	32.19	46.70	3.54	165.32	2.63	3.30	3.30
12.47	30.35	43.66	3.54	154.66	2.63	3.09	3.09
12.63	28.16	40.26	3.63	146.01	2.65	2.84	2.84
12.80	27.11	38.43	3.60	138.32	2.64	2.71	2.71
12.96	27.19	38.26	3.57	136.67	2.64	2.69	2.69
13.12	30.47	42.51	3.38	143.84	2.61	3.01	3.01
13.29	40.03	55.14	2.98	164.31	2.54	0.75	0.75
13.45	53.18	72.41	2.69	194.79	2.48	0.78	0.78
13.62	60.57	82.15	2.72	223.32	2.49	0.80	0.80
13.78	56.73	77.04	3.00	231.16	2.54	0.79	0.79
13.94	49.13	66.65	3.28	218.90	2.59	0.77	0.77
14.11	46.88	62.82	3.11	195.34	2.56	0.76	0.76
14.27	45.25	60.45	3.27	197.51	2.59	0.76	0.76
14.44	51.22	67.67	3.02	204.56	2.55	0.77	0.77
14.60	51.98	68.52	3.17	217.33	2.57	0.78	0.78
14.76	50.83	66.55	3.19	212.02	2.58	0.77	0.77
14.93	40.36	53.12	3.90	207.19	2.69	3.67	3.67
15.09	32.05	42.26	4.67	197.14	2.79	2.88	2.88
15.26	30.08	39.41	4.80	189.27	2.80	2.68	2.68
15.42	29.39	38.15	4.71	179.58	2.79	2.59	2.59
15.58	32.77	42.01	4.16	174.88	2.72	2.88	2.88
15.75	39.88	50.42	3.51	177.11	2.63	3.50	3.50

:: Strength loss calculation (Robertson (2009) :: (continued)

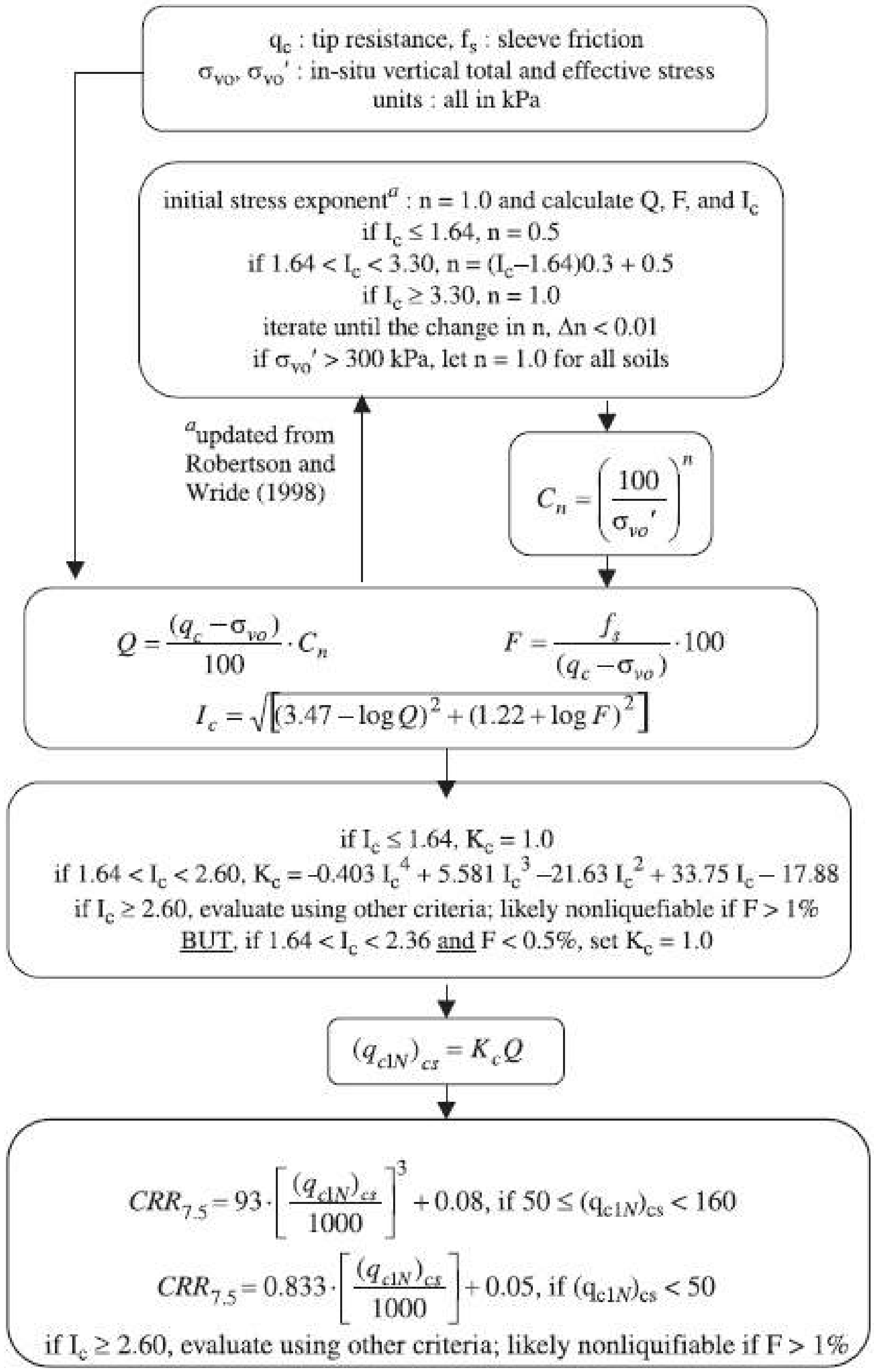
Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
15.91	57.67	71.72	2.76	198.14	2.50	0.78	0.78
16.08	80.17	98.12	2.26	221.84	2.39	0.82	0.82
16.24	118.97	142.35	1.73	246.06	2.22	0.88	0.88
16.40	144.83	170.85	1.54	262.99	2.14	0.91	0.91
16.57	152.16	178.37	1.52	270.93	2.13	0.91	0.91
16.73	136.18	159.96	1.67	267.36	2.20	0.90	0.90
16.90	120.87	142.32	1.88	268.09	2.28	0.88	0.88
17.06	118.51	138.81	1.90	263.74	2.28	0.87	0.87
17.22	150.43	173.78	1.65	286.91	2.19	0.91	0.91
17.39	208.30	234.27	1.27	297.02	1.97	0.95	0.95
17.55	297.79	327.17	1.09	357.66	1.78	1.01	1.01
17.72	363.33	390.52	1.00	390.52	1.60	1.04	1.04
17.88	450.52	478.05	1.00	478.05	1.50	1.08	1.08
18.05	513.49	539.10	1.00	539.10	1.42	1.10	1.10
18.21	569.21	593.84	1.00	593.84	1.38	1.11	1.11

Abbreviations

q_t:	Total cone resistance
K_c:	Cone resistance correction factor due to fines
$Q_{tn,cs}$:	Adjusted and corrected cone resistance due to fines
I_c:	Soil behavior type index
$S_{u(liq)}/\sigma'_v$:	Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$:	Calculated peak undrained strength ratio

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

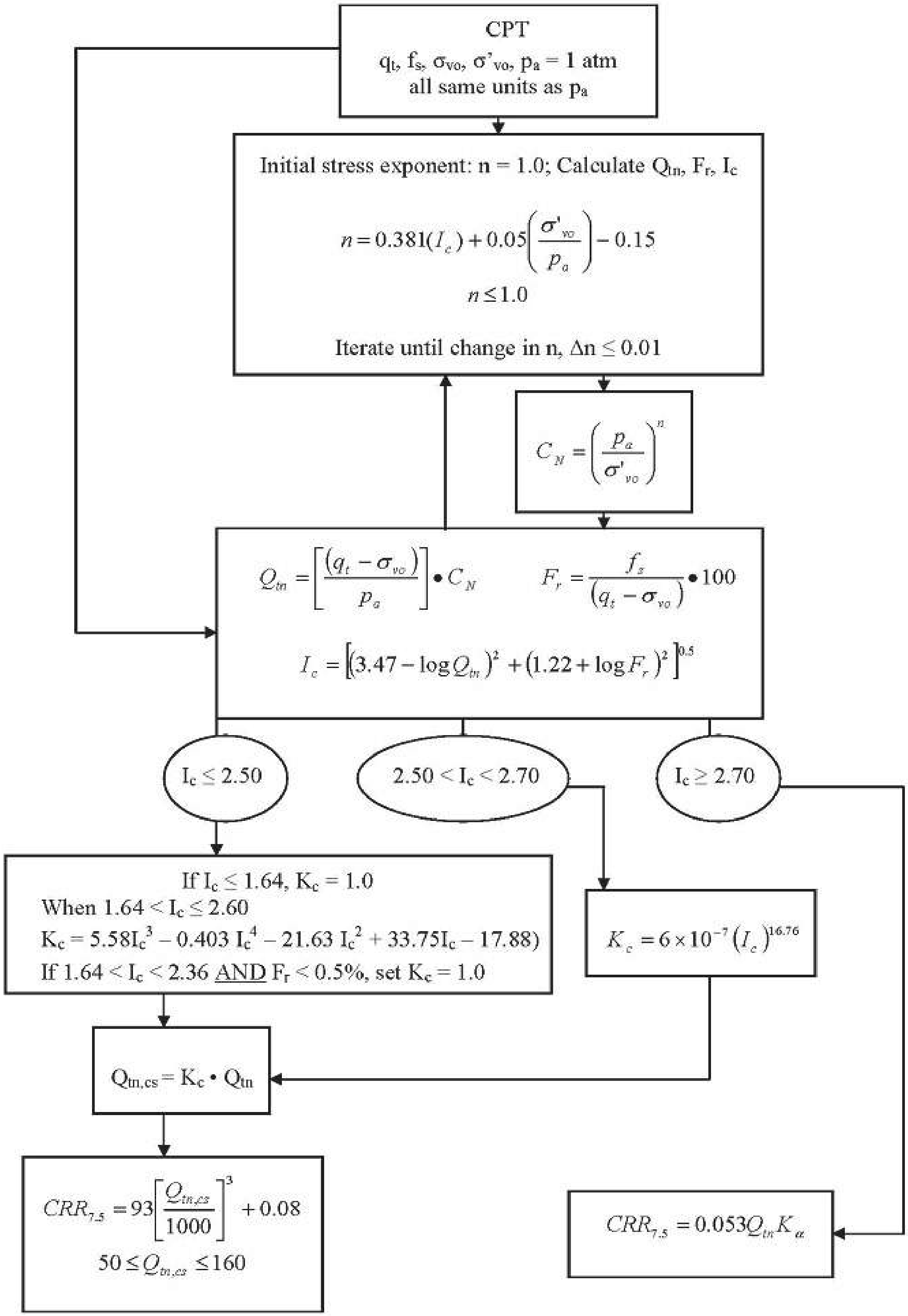
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

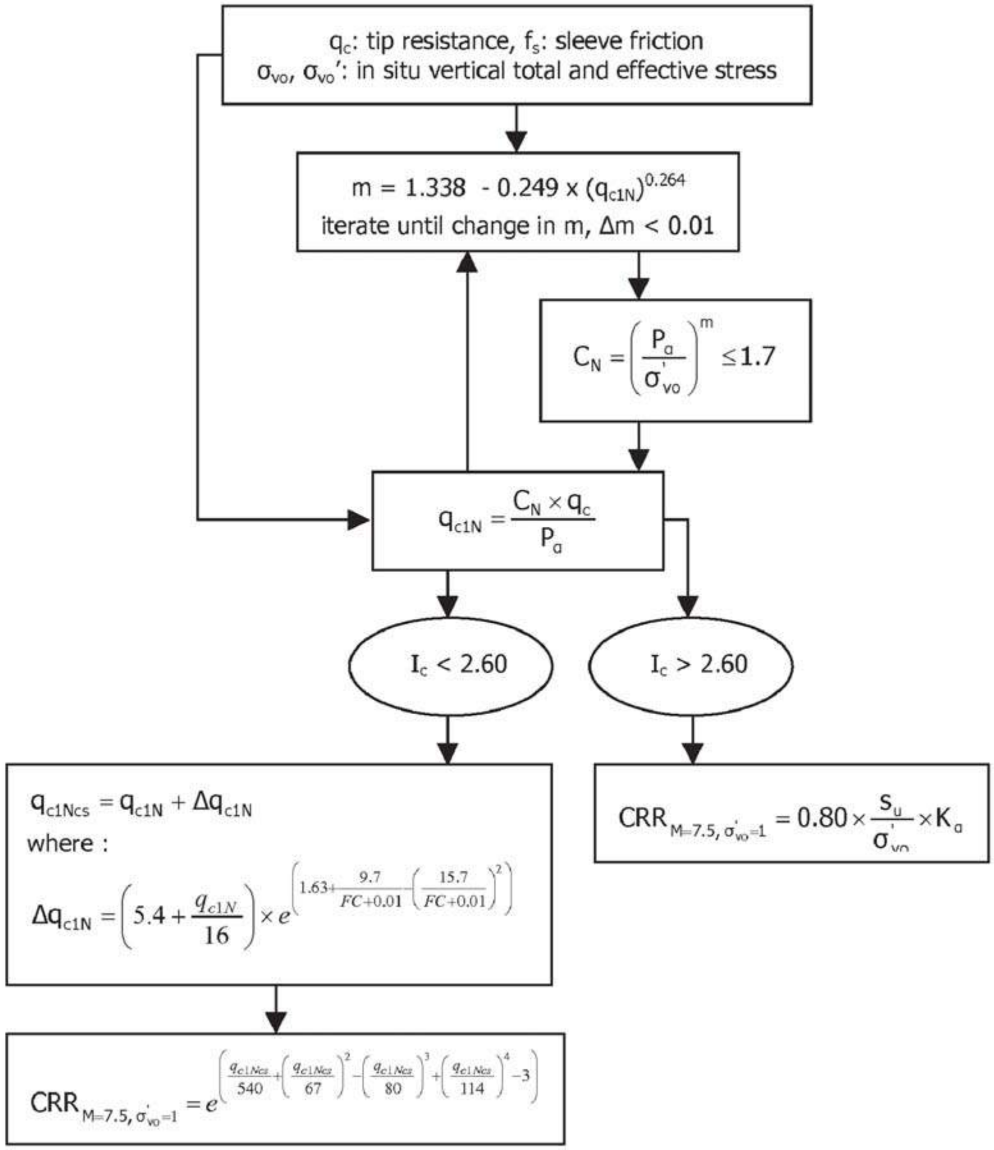
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

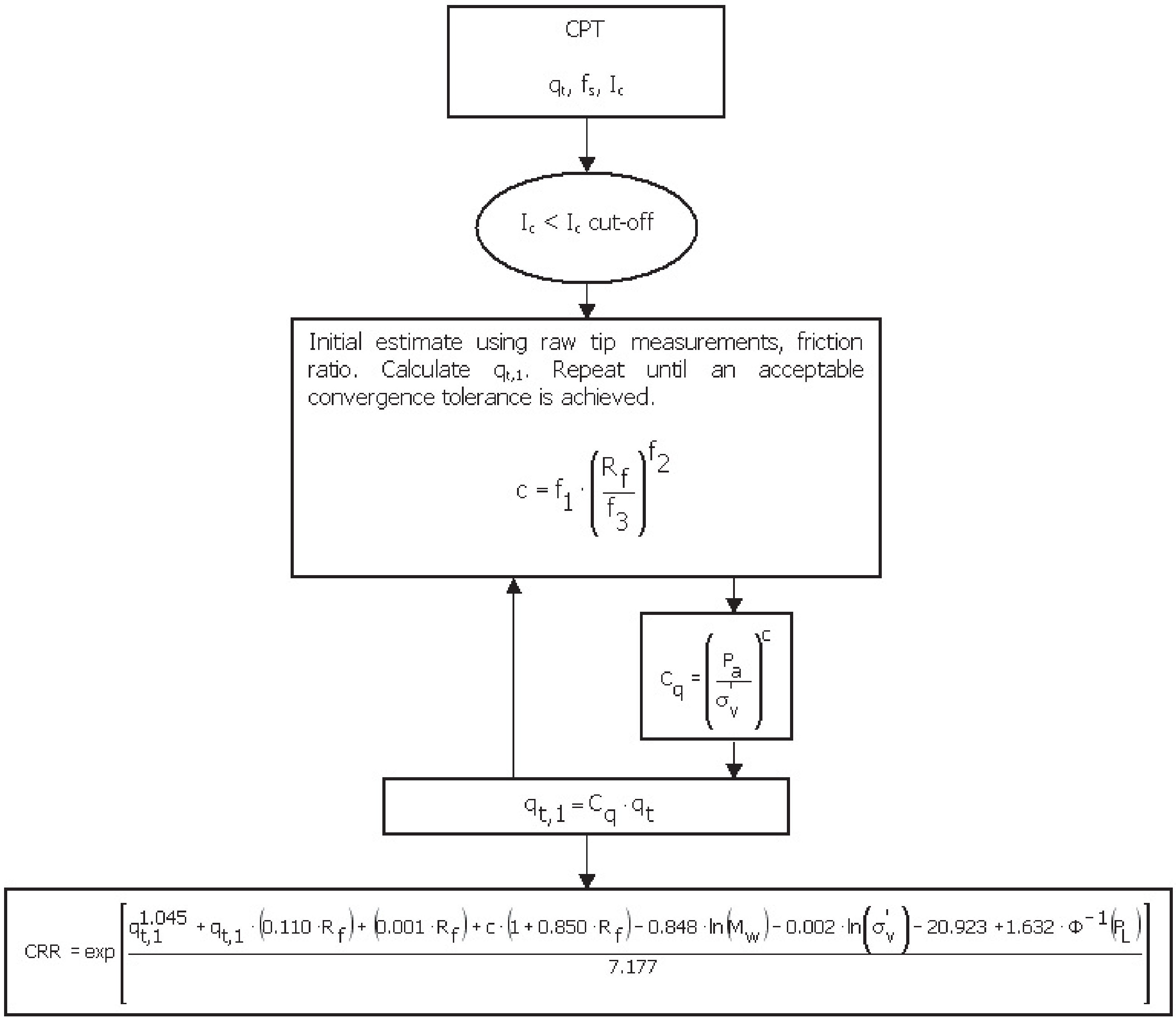


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)

$$FS_{liq} = \frac{CRR_{M=7.5,\sigma'_v=1atm}}{CSR_{M=7.5,\sigma'_v=1atm}}$$

$$CSR_{M=7.5,\sigma'_v=1atm} = 0.65\frac{\sigma_v}{\sigma'_v}\frac{a_{\max}}{g}r_d\frac{1}{MSF}\frac{1}{K_\sigma}$$

$$r_d = \exp\left[\alpha(z)+\beta(z)\cdot M\right]$$

$$\alpha(z) = -1.012-1.126\sin\left(\frac{z}{11.73}+5.133\right)$$

$$\beta(z) = 0.106+0.118\sin\left(\frac{z}{11.28}+5.142\right)$$

$$K_\sigma = 1-C_\sigma \ln\left(\frac{\sigma'_v}{P_a}\right)\le 1.1$$

$$C_\sigma = \frac{1}{37.3-8.27\left(q_{c1Ncs}\right)^{0.264}}\le 0.3$$

$$MSF = 1+\left(MSF_{max}-1\right)\left(8.64\exp\left(\frac{-M}{4}\right)-1.325\right)$$

$$MSF_{max} = 1.09+\left(\frac{q_{c1Ncs}}{180}\right)^3\le 2.2$$

σ'_v *and* σ_v *at start of earthquake shaking*

$$CRR_{M=7.5,\sigma'_v=1atm} = \exp\left(\frac{q_{c1Ncs}}{113}+\left(\frac{q_{c1Ncs}}{1000}\right)^2-\left(\frac{q_{c1Ncs}}{140}\right)^3+\left(\frac{q_{c1Ncs}}{137}\right)^4-2.80\right)$$

$$q_{c1Ncs} = q_{c1N}+\Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(11.9+\frac{q_{c1N}}{14.6}\right)\exp\left(1.63-\frac{9.7}{FC+2}-\left(\frac{15.7}{FC+2}\right)^2\right)$$

$$q_{c1N} = C_{Ne}\frac{q_c}{P_a}$$

$$C_{Ne} = \left(\frac{P_a}{\sigma'_v}\right)^m\le 1.7$$

$$m = 1.338-0.249\left(q_{c1Ncs}\right)^{0.264} \quad with \quad 0.264\le m\le 0.782$$

$$FC = 80\left(I_C+C_{FC}\right)-137 \quad with \quad 0\%\le FC\le 100\%$$

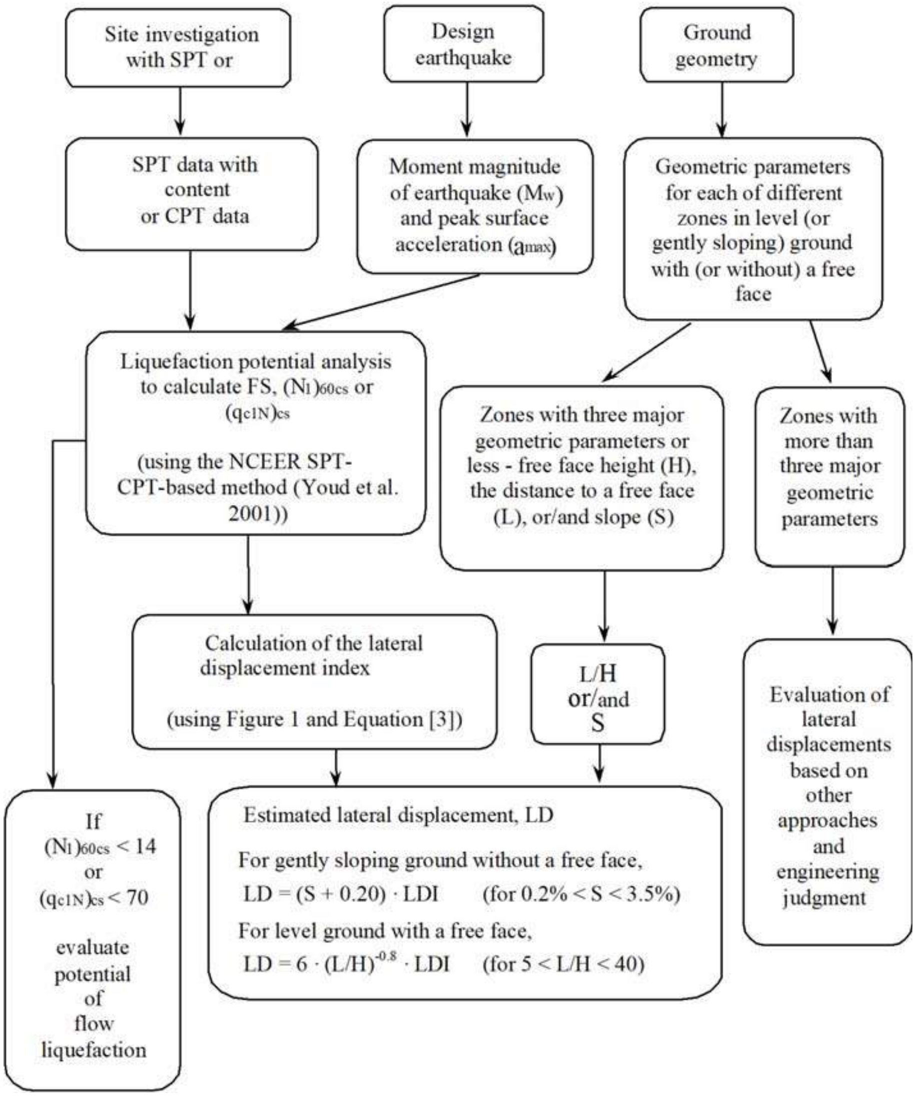
$$I_c = \left[\left(3.47-\log(Q)\right)^2+\left(1.22+\log(F)\right)^2\right]^{0.5}$$

$$Q = \left(\frac{q_c-\sigma_{vc}}{P_a}\right)\left(\frac{P_a}{\sigma'_{vc}}\right)^n \quad with\ 0.5\le n\le 1.0\ per\ Robertson\ \&\ Wride\ (1998)$$

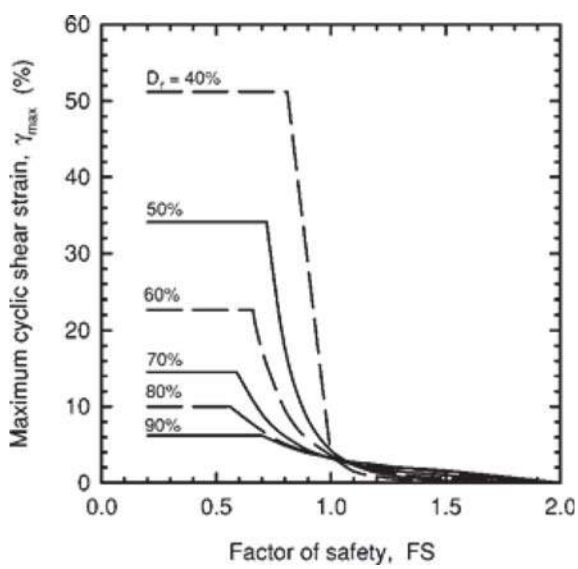
$$F = \left(\frac{f_s}{q_c-\sigma_{vc}}\right)\cdot 100\%$$

σ'_v *at time of CPT sounding*

Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



[1] **Figure 1**

$$LDI = \int_0^{Z_{max}} \gamma_{max} dz$$

[1] **Equation [3]**

[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands

Average shear stress, τ_{av}

$$\tau_{av} = CSR^{*} \cdot \sigma_{v0}' = 0.65 \cdot \frac{\alpha_{max}}{g} \cdot \sigma_{v0} \cdot \tau_d$$

↓

Estimate small shear strain modulus, G_0

$$G_0 = 0.0188 \cdot \left[10^{(0.55 I_c - 1.68)}\right] \cdot (q_t - \sigma_v)$$

↓

Estimate shear strain amplitude, γ (based on Pradel (1998))

$$\gamma = \left[\frac{1 + \alpha \cdot e^{bR}}{1 + \alpha}\right] \cdot R \cdot 100\ (\%)$$

$$R = \frac{\tau_{av}}{G_0} \text{ (Note } \tau_{av} \text{ and } G_0 \text{ same units)}$$

$$\alpha = 0.0389 \cdot \left(\frac{\sigma_v}{p_a}\right) + 0.124$$

$$b = 6400 \cdot \left(\frac{\sigma_v}{p_a}\right)$$

↓

Estimate volumetric strain in 15 cycles

$$\varepsilon_{vol(15)} = \gamma \cdot \left[\frac{(N_1)_{60,cs}}{20}\right]^{-1.20}$$

$$(N_1)_{60,cs} = \frac{Q_{tn,cs}}{8.5 \cdot \left[1 - \frac{I_c}{4.6}\right]}$$

↓

Volumetric strain in design earthquake

$$\Sigma_{vol} = \varepsilon_{vol(15)} \cdot \left[\frac{N_c}{15}\right]^{0.45}$$

$$N_c = (M - 4)^{2.17}$$

↓

Seismic settlement, s

$$s = 2 \cdot \int_0^{GWT} \Sigma_{vol} \cdot dz$$

Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

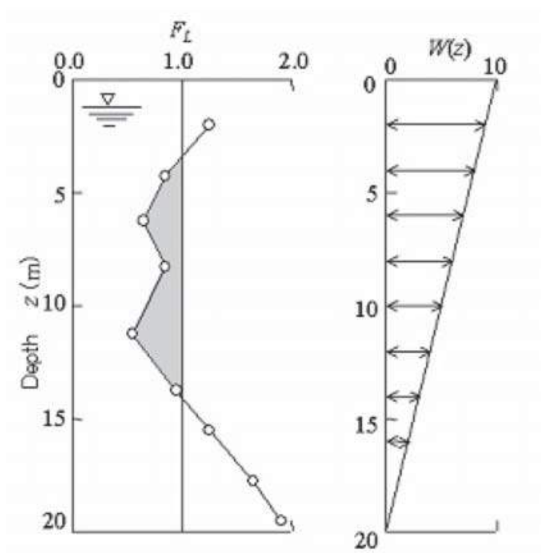
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_0^{20} (10 - 0{,}5_z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

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APPENDIX J-3

Liquefaction Report for New Gymnasium – Idriss and Boulanger, 2008

A3GEO

T A B L E   O F   C O N T E N T S

A3GEO, Inc.
Geoconsultants
Berkeley, CA
www.a3geo.com

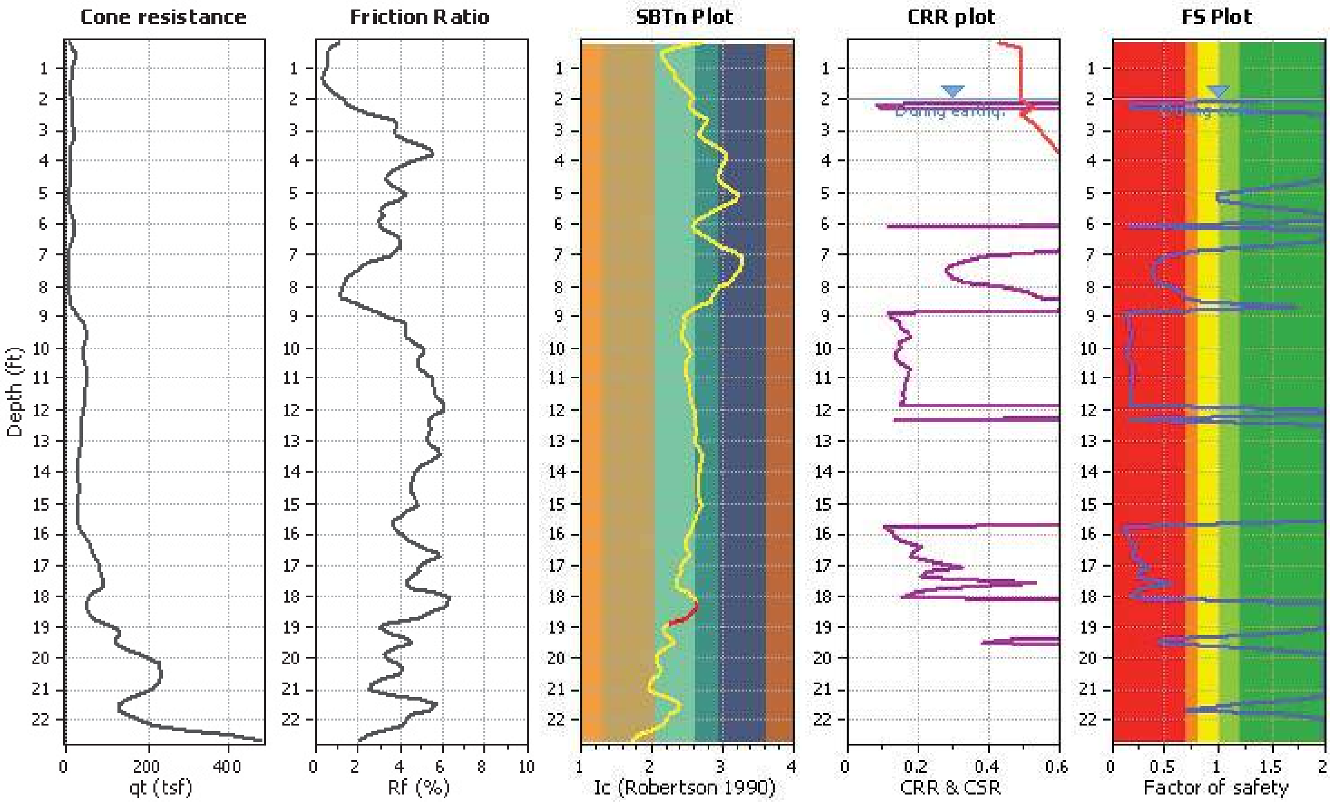
LIQUEFACTION ANALYSIS REPORT

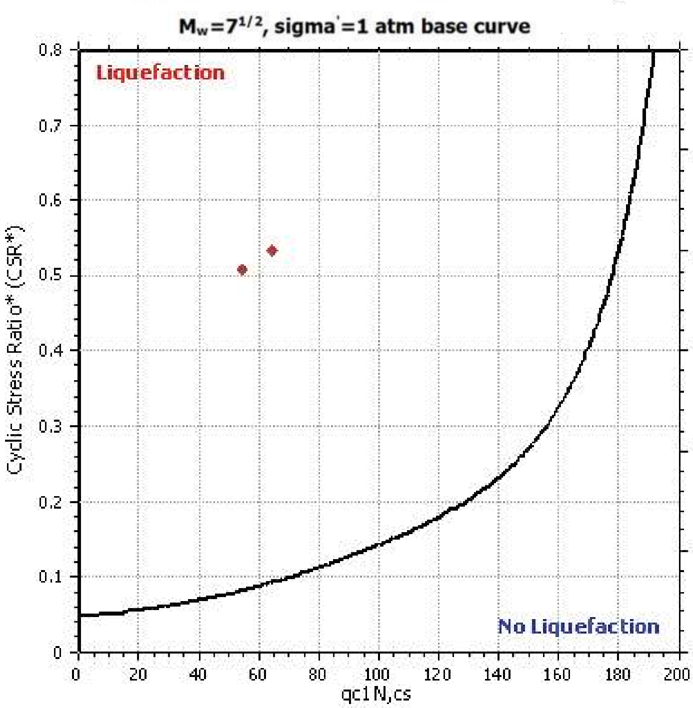
Project title : Terra Linda High School **Location : San Rafael, CA**

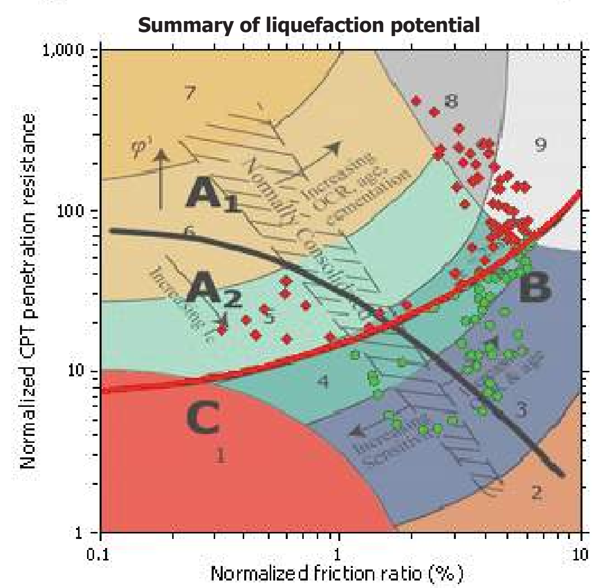
CPT file : CPT-03

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	9.00 ft	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

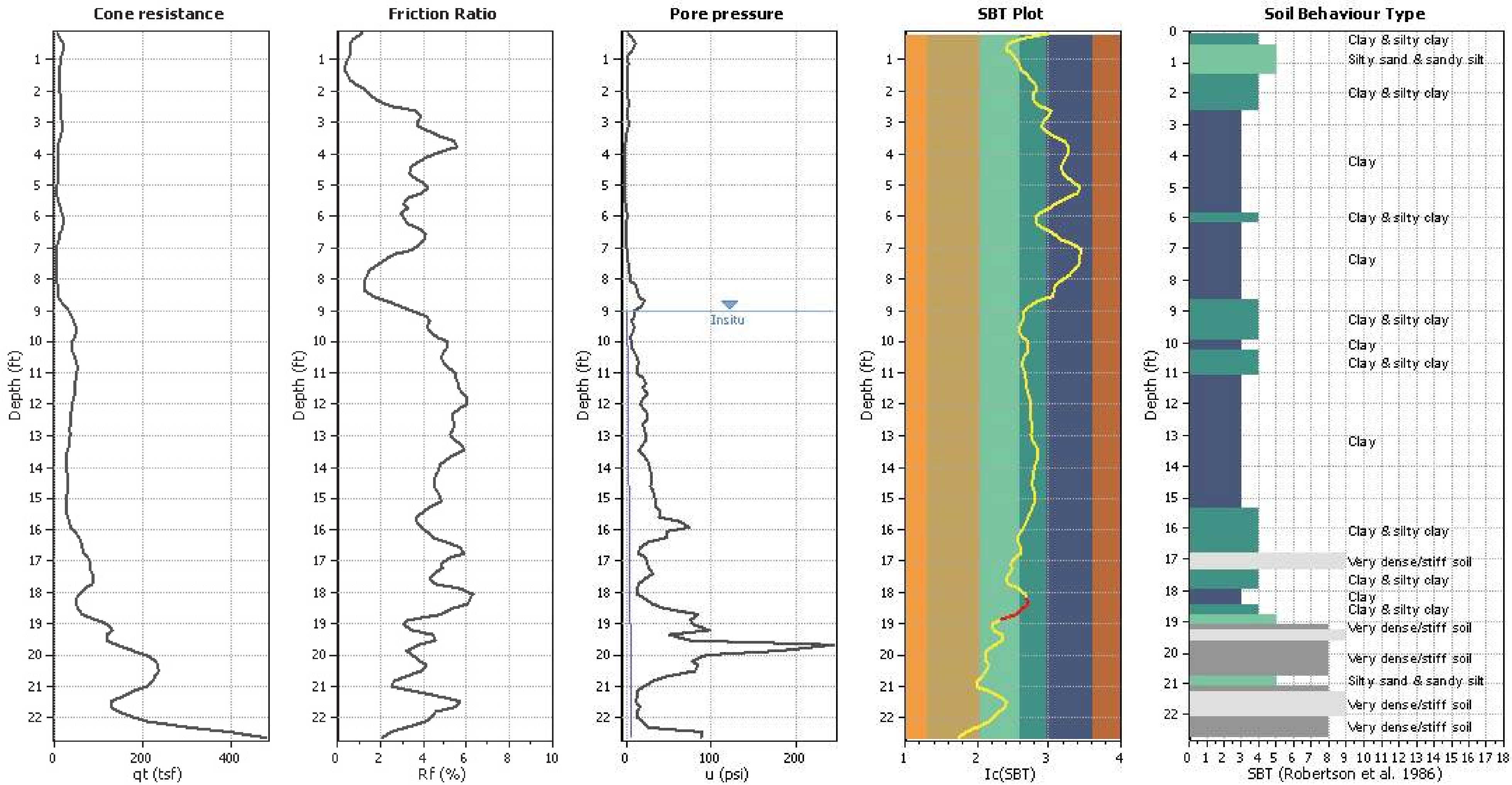






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



Input parameters and analysis data

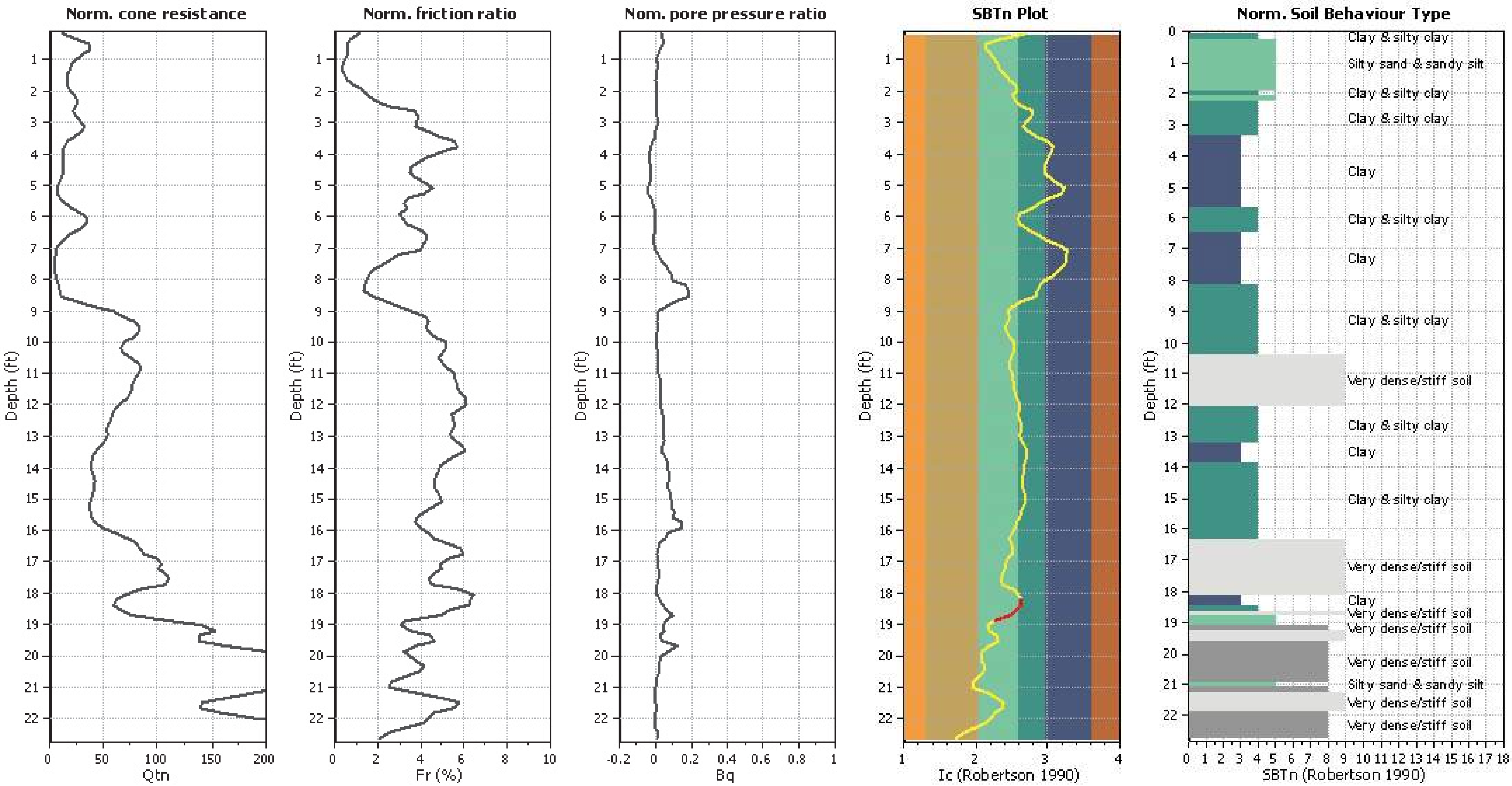
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Project file: \\A3geo\a3geo\A3GEO Projects\1150 - San Rafael City Schools\1150-1B Terra Linda HS\6-Working Files\Calculations\Liquefaction\2018_0117_A3GEO_TLHS New Gymnasium Liquefaction.clq

CPT basic interpretation plots (normaliz



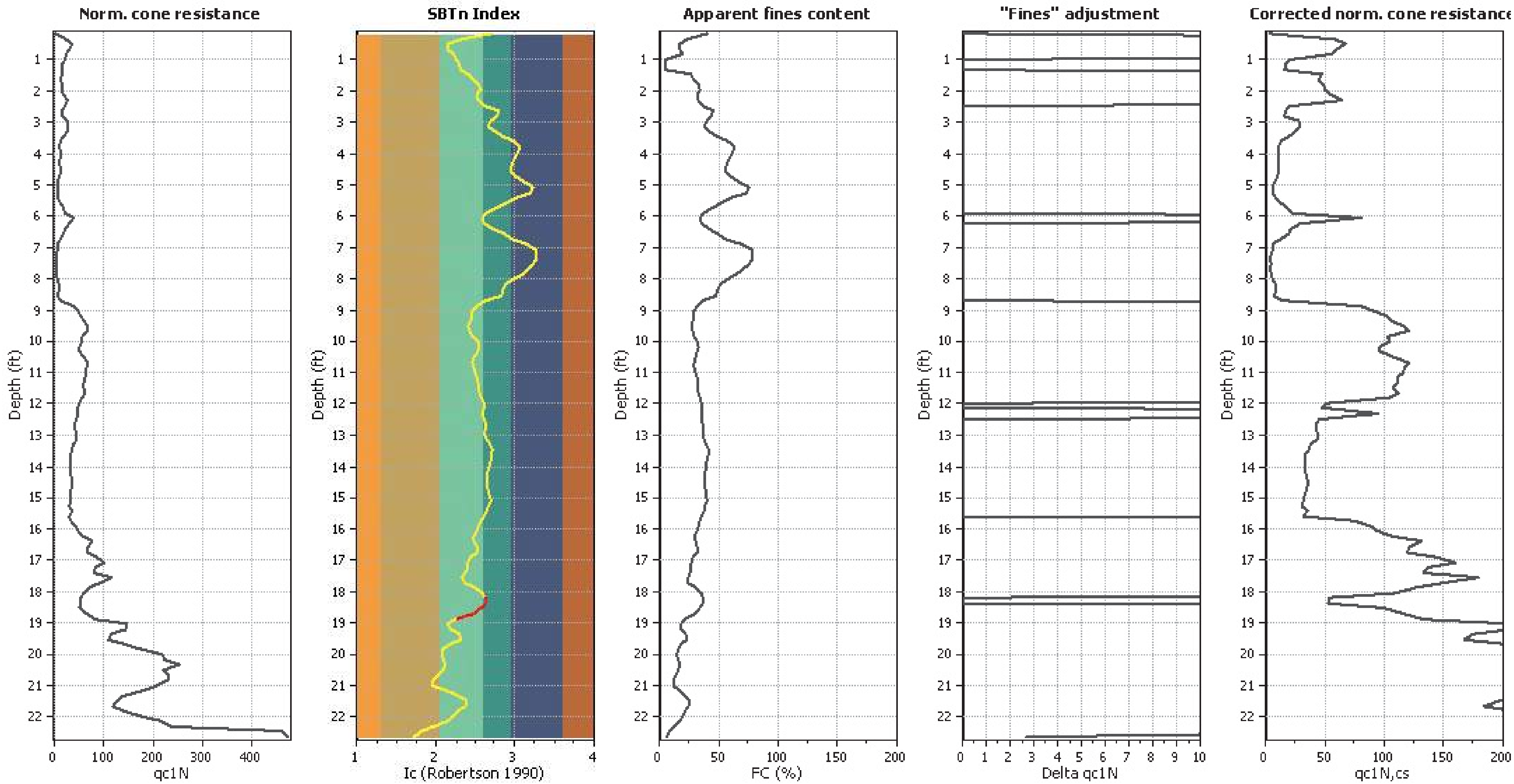
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

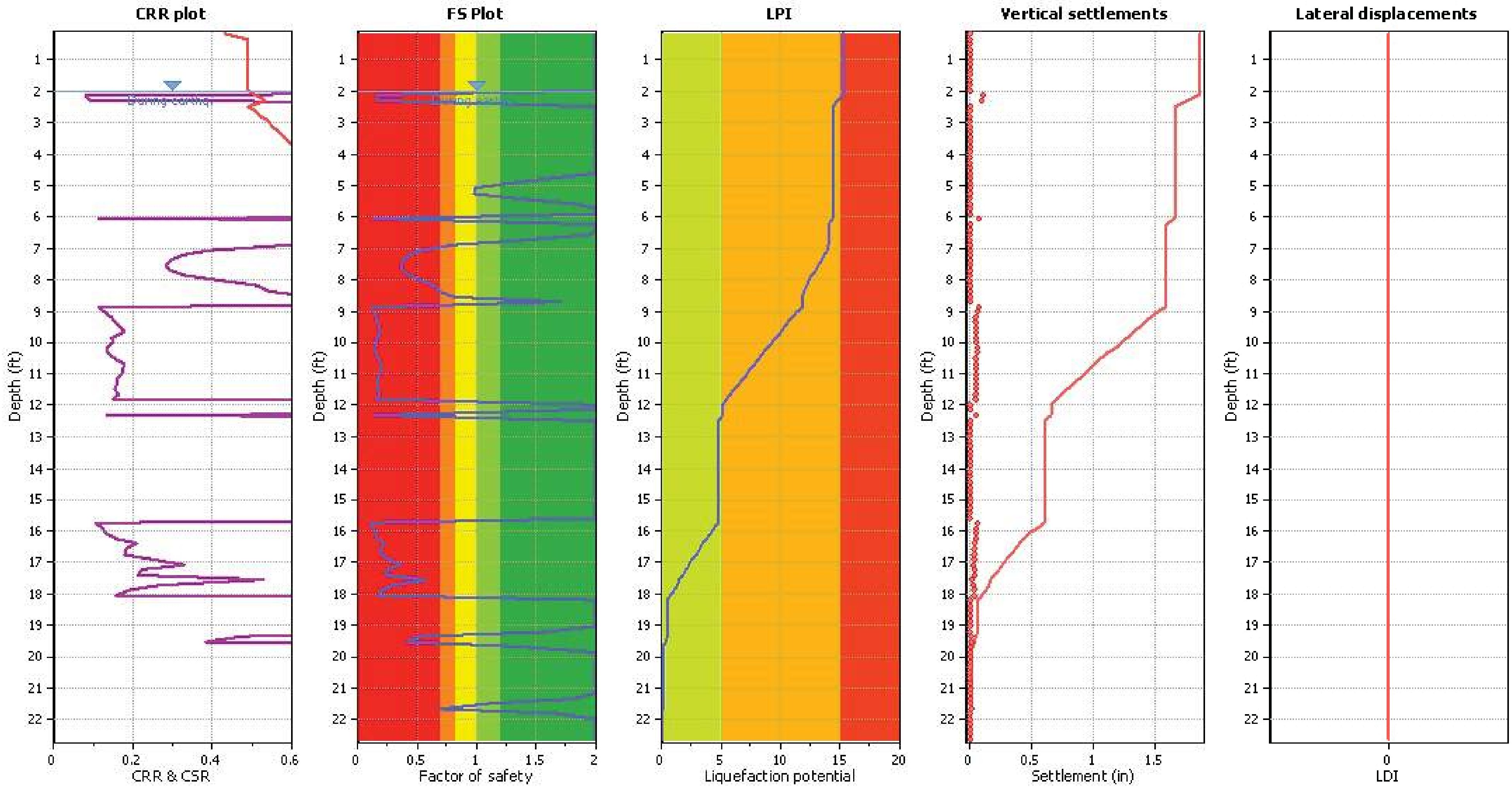
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

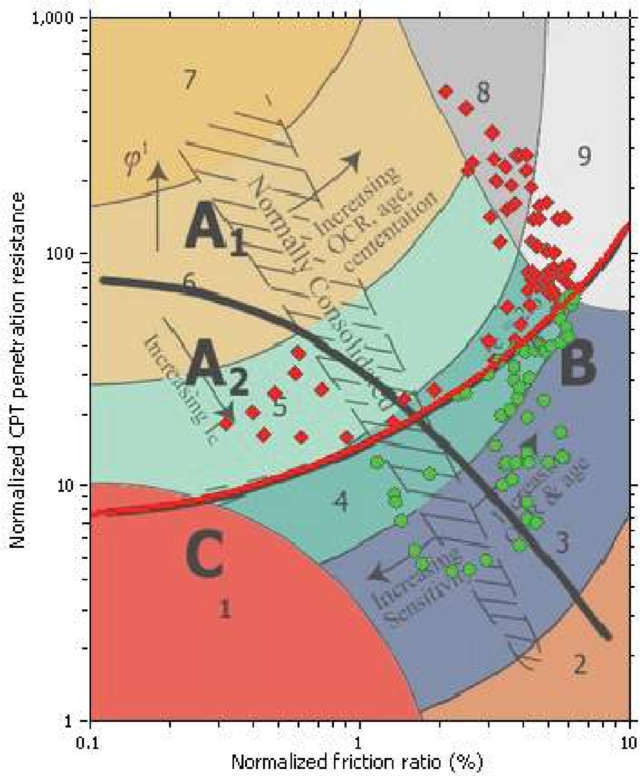
F.S. color scheme

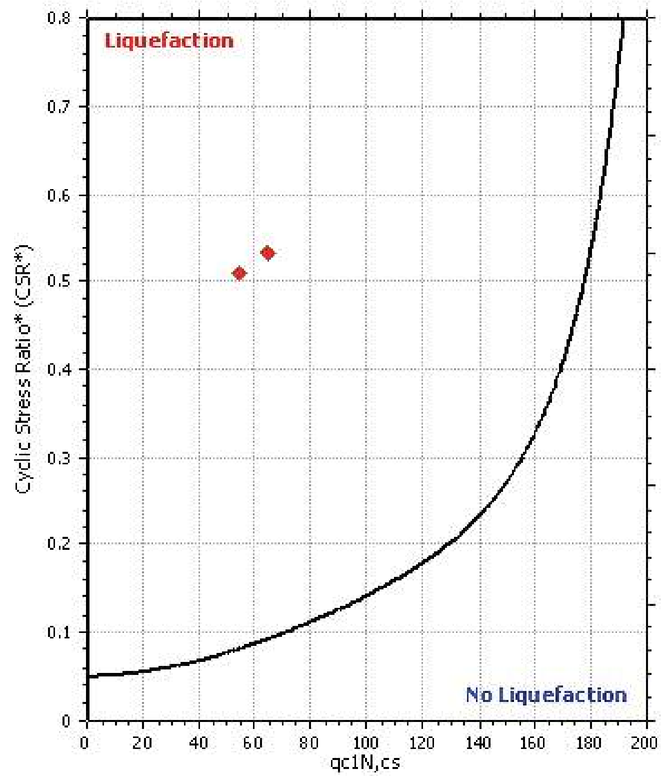
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

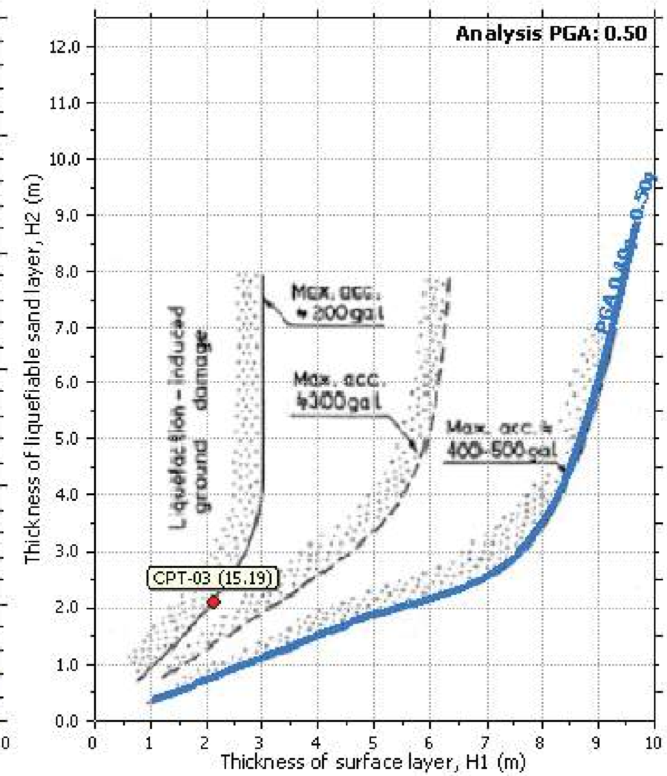
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo



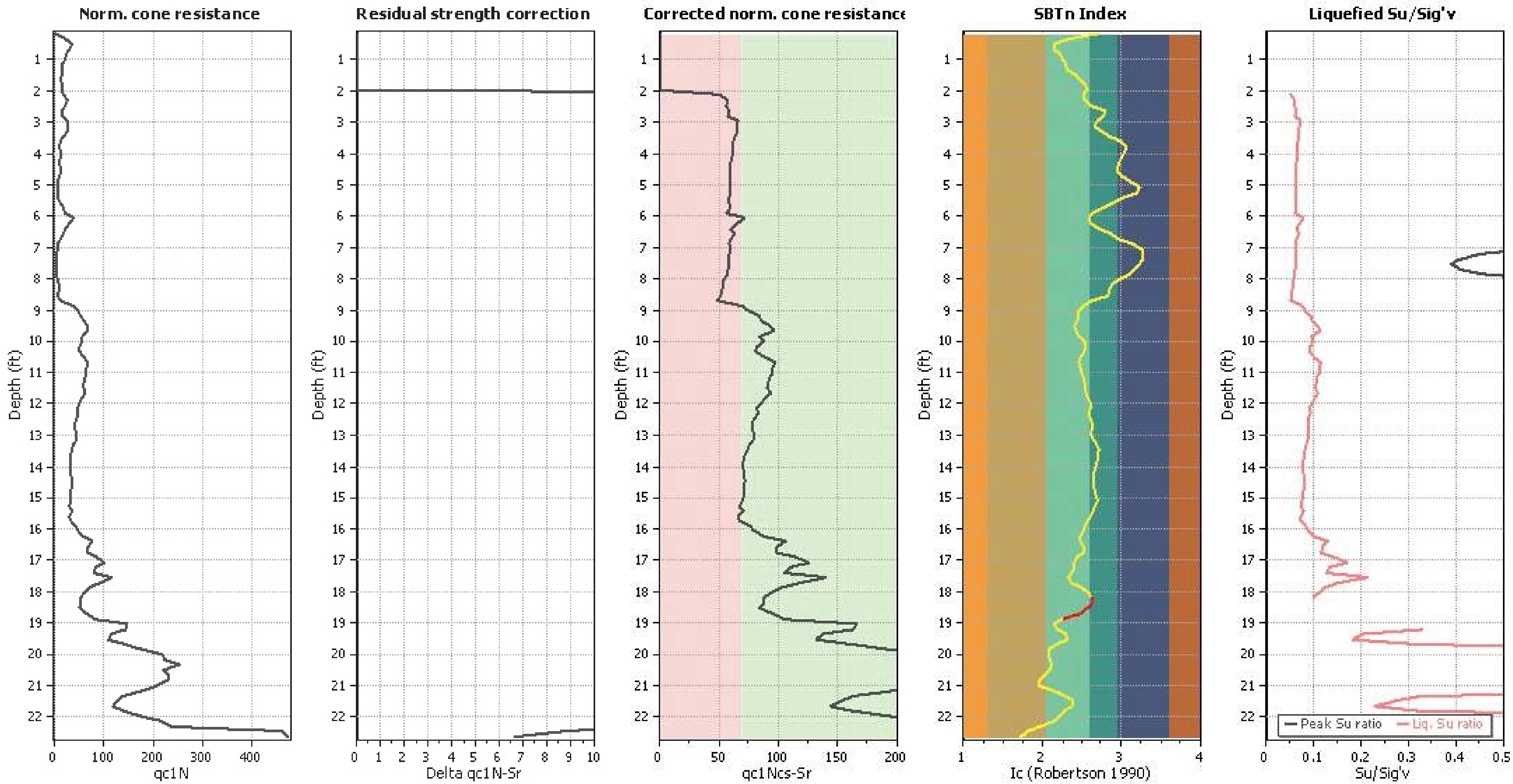




Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

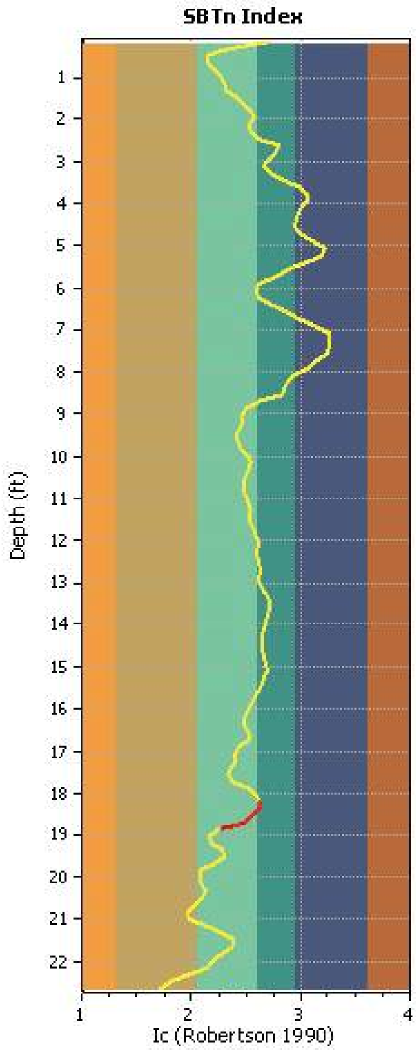
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

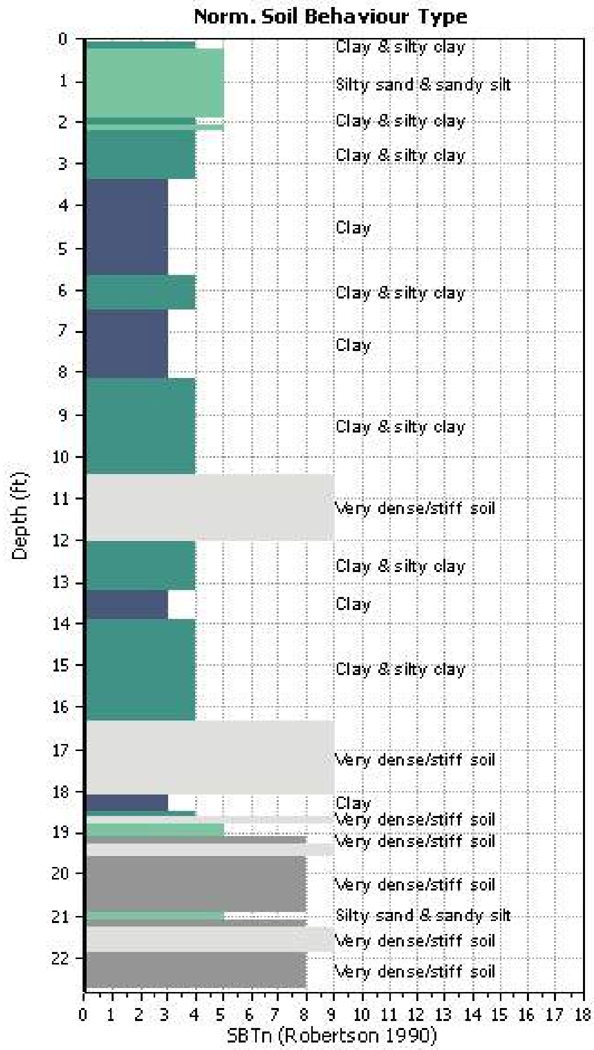
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties		**General statistics**	
I_c minimum check value:	1.70	Total points in CPT file:	138
I_c maximum check value:	3.00	Total points excluded:	5
I_c change ratio value:	0.0250	Exclusion percentage:	3.62%
Minimum number of points in layer:	5	Number of layers detected:	1

Transition layer No	Number of points	Depth	SBT_n number	SBT_n description
Transition layer 1	5	Start depth: 18.37 (ft)	3	Clay
		End depth: 19.03 (ft)	5	Silty sand & sandy silt

Start depth: Depth where the transition layer begins
End depth: Depth where the transition layer ends

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.16	2.35	0.07	2.87	40.30	96.24
2	0.33	15.13	0.09	8.14	23.46	99.67
3	0.49	23.10	0.13	10.74	17.42	101.74
4	0.66	19.52	0.12	7.78	17.20	101.82
5	0.82	16.05	0.10	3.02	19.58	99.79
6	0.98	12.81	0.06	0.44	5.00	96.40
7	1.15	10.43	0.03	2.91	5.00	93.32
8	1.31	9.73	0.04	1.68	5.00	90.50
9	1.48	9.14	0.03	1.41	26.83	91.86
10	1.64	7.69	0.05	0.51	29.54	93.84
11	1.80	8.98	0.08	0.91	32.71	96.86
12	1.97	9.45	0.10	1.06	34.02	101.11
13	2.13	11.77	0.22	0.77	31.48	103.93
14	2.30	16.11	0.22	2.23	32.76	106.66
15	2.46	13.12	0.33	1.77	36.91	108.38
16	2.63	10.38	0.43	0.89	45.64	109.62
17	2.79	10.12	0.47	1.42	44.36	111.26
18	2.95	17.42	0.57	2.91	40.61	112.79
19	3.12	17.87	0.67	2.23	38.34	113.99
20	3.28	16.30	0.69	1.14	42.06	113.86
21	3.45	12.33	0.61	-0.36	48.65	112.61
22	3.61	8.39	0.49	-1.60	57.50	110.49
23	3.77	6.49	0.38	-2.34	62.99	108.45
24	3.94	7.02	0.33	-2.50	62.19	106.88
25	4.10	7.02	0.28	-2.58	59.16	105.80
26	4.27	6.63	0.24	-2.55	57.05	104.96
27	4.43	7.08	0.24	-2.36	55.58	104.41
28	4.59	7.10	0.23	-2.07	55.81	104.05
29	4.76	6.18	0.22	-1.93	60.40	103.24
30	4.92	4.53	0.20	-1.99	68.62	101.87
31	5.09	3.55	0.16	-2.10	75.47	100.53
32	5.25	3.80	0.15	-2.07	72.67	100.30
33	5.41	5.01	0.17	-1.91	60.54	102.03
34	5.58	8.03	0.23	-1.50	50.66	105.23
35	5.74	11.24	0.35	-1.03	44.99	108.55
36	5.91	13.54	0.49	0.99	36.31	111.65
37	6.07	23.69	0.59	0.70	34.71	113.39
38	6.23	18.51	0.65	-0.24	35.76	113.60
39	6.40	12.58	0.55	-0.51	42.60	112.48
40	6.56	11.89	0.46	-0.75	49.36	109.89
41	6.73	7.38	0.28	-0.89	56.52	106.62
42	6.89	3.78	0.18	-0.66	67.96	101.79
43	7.05	3.44	0.10	0.00	78.62	97.49
44	7.22	2.80	0.07	0.55	77.82	94.00
45	7.38	2.52	0.06	1.16	77.97	92.17
46	7.55	2.80	0.05	1.81	76.07	90.85
47	7.71	2.63	0.05	2.59	69.82	89.76
48	7.87	3.05	0.03	3.63	65.10	90.42

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	8.04	3.78	0.06	5.09	55.89	92.44
50	8.20	5.40	0.07	10.46	50.92	93.85
51	8.37	5.17	0.06	12.64	48.89	94.48
52	8.53	4.75	0.07	15.20	48.10	98.63
53	8.69	8.61	0.20	20.95	36.38	107.75
54	8.86	25.70	0.63	17.75	31.30	114.79
55	9.02	32.02	1.15	8.74	28.75	119.68
56	9.19	38.90	1.63	9.49	29.28	122.46
57	9.35	41.75	1.95	6.10	28.10	124.05
58	9.51	49.30	2.02	9.19	26.83	124.74
59	9.68	51.45	2.01	7.06	27.44	124.84
60	9.84	40.02	2.06	4.86	29.10	124.73
61	10.01	41.00	2.06	5.87	32.04	124.27
62	10.17	36.07	1.87	6.65	32.48	123.90
63	10.34	36.07	1.83	8.98	31.95	123.92
64	10.50	43.37	2.03	13.12	30.08	124.98
65	10.66	52.18	2.48	14.88	29.36	126.23
66	10.83	50.70	2.74	12.90	29.68	126.97
67	10.99	49.33	2.71	13.28	30.97	127.04
68	11.16	46.84	2.65	19.65	31.47	126.80
69	11.32	46.39	2.55	22.63	32.25	126.63
70	11.48	44.72	2.61	18.81	32.24	126.67
71	11.65	47.62	2.68	24.17	33.16	126.71
72	11.81	43.23	2.66	20.01	34.30	126.51
73	11.98	38.79	2.52	16.32	35.54	125.63
74	12.14	36.49	2.00	18.92	35.51	124.79
75	12.30	37.58	1.98	23.98	35.07	123.97
76	12.47	34.84	1.89	25.18	35.77	123.70
77	12.63	32.80	1.85	20.09	36.70	123.38
78	12.80	33.11	1.82	21.47	36.50	123.17
79	12.96	34.54	1.75	22.47	36.18	123.20
80	13.12	34.20	1.84	23.07	37.35	123.16
81	13.29	29.78	1.85	19.31	39.41	122.91
82	13.45	27.94	1.69	14.93	41.18	122.11
83	13.62	26.01	1.43	19.81	40.92	121.09
84	13.78	25.62	1.27	24.81	40.23	120.26
85	13.94	25.67	1.25	26.18	39.41	119.89
86	14.11	26.20	1.23	28.40	38.84	119.90
87	14.27	27.10	1.26	30.33	38.07	120.04
88	14.44	28.27	1.28	29.19	37.68	120.17
89	14.60	28.05	1.27	28.47	37.84	120.18
90	14.76	26.99	1.26	32.46	38.72	120.15
91	14.93	26.26	1.30	33.41	39.62	120.05
92	15.09	25.67	1.25	34.20	40.41	119.91
93	15.26	24.86	1.23	34.99	38.37	119.41
94	15.42	28.61	1.01	40.81	37.36	118.82
95	15.58	25.45	0.98	39.05	35.74	118.62
96	15.75	27.60	1.10	62.41	34.17	119.58

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	15.91	37.25	1.33	73.92	32.76	121.49
98	16.08	40.88	1.78	47.66	31.24	123.94
99	16.24	51.01	2.40	48.29	29.58	126.40
100	16.40	67.84	3.02	26.75	30.01	128.33
101	16.57	59.84	3.62	16.65	31.53	129.71
102	16.73	59.17	4.13	15.00	31.48	130.42
103	16.90	77.49	3.93	23.47	28.06	130.92
104	17.06	90.69	3.85	24.37	26.44	131.02
105	17.22	74.05	4.03	26.10	26.95	130.90
106	17.39	71.95	3.83	30.99	25.07	130.91
107	17.55	107.66	3.60	22.24	24.14	130.95
108	17.72	84.23	3.94	14.31	24.98	130.99
109	17.88	65.52	4.00	13.11	30.95	130.35
110	18.05	52.80	3.50	13.29	35.34	129.26
111	18.21	47.51	3.03	20.56	36.62	128.00
112	18.37	47.46	2.67	31.74	36.98	127.46
113	18.54	46.39	2.97	44.58	33.77	127.33
114	18.70	59.56	2.64	84.80	30.14	128.38
115	18.87	77.41	3.40	75.89	20.69	129.59
116	19.03	141.47	3.21	78.83	17.71	131.49
117	19.19	138.73	4.43	97.90	18.54	133.31
118	19.36	109.82	6.12	50.86	22.25	133.99
119	19.52	102.99	5.08	76.11	22.84	134.29
120	19.69	136.41	5.10	245.24	18.78	134.48
121	19.85	176.20	5.58	181.99	15.36	135.66
122	20.01	214.24	6.44	94.33	15.22	137.28
123	20.18	220.42	9.29	77.67	15.57	137.28
124	20.34	250.84	10.57	85.13	16.53	137.28
125	20.51	218.74	9.00	81.21	15.73	137.28
126	20.67	232.58	7.96	46.03	13.64	137.28
127	20.83	228.72	4.38	31.64	12.03	136.35
128	21.00	207.33	5.12	19.35	12.28	135.34
129	21.16	180.93	6.12	13.12	17.09	136.43
130	21.33	138.45	7.87	12.72	22.18	137.06
131	21.49	127.50	8.01	11.80	25.74	136.71
132	21.65	118.09	6.19	16.22	24.99	136.31
133	21.82	138.98	6.70	12.27	21.63	136.27
134	21.98	177.91	7.06	13.66	19.28	137.28
135	22.15	217.81	9.48	18.99	17.34	137.28
136	22.31	240.72	9.64	25.96	12.07	137.28
137	22.47	467.87	9.88	88.97	8.70	137.28
138	22.64	482.05	9.95	87.42	6.58	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.16	0.01	0.00	0.01	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
2	0.33	0.02	0.00	0.02	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
3	0.49	0.02	0.00	0.02	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
4	0.66	0.03	0.00	0.03	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
5	0.82	0.04	0.00	0.04	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
6	0.98	0.05	0.00	0.05	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
7	1.15	0.06	0.00	0.06	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
8	1.31	0.06	0.00	0.06	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
9	1.48	0.07	0.00	0.07	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
10	1.64	0.08	0.00	0.08	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
11	1.80	0.09	0.00	0.09	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
12	1.97	0.10	0.00	0.10	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
13	2.13	0.10	0.00	0.10	1.00	0.339	0.86	0.392	1.00	1.30	0.509	No
14	2.30	0.11	0.01	0.10	1.00	0.354	0.86	0.410	1.00	1.30	0.533	No
15	2.46	0.12	0.01	0.11	1.00	0.369	0.86	0.427	1.00	1.30	0.490	No
16	2.63	0.13	0.02	0.11	1.00	0.382	0.86	0.442	1.00	1.30	0.508	No
17	2.79	0.14	0.02	0.12	1.00	0.395	0.86	0.457	1.00	1.30	0.525	No
18	2.95	0.15	0.03	0.12	1.00	0.406	0.86	0.470	1.00	1.30	0.540	No
19	3.12	0.16	0.03	0.12	1.00	0.417	0.86	0.482	1.00	1.30	0.554	No
20	3.28	0.17	0.04	0.13	1.00	0.427	0.86	0.494	1.00	1.30	0.567	No
21	3.45	0.18	0.05	0.13	1.00	0.436	0.86	0.505	1.00	1.30	0.580	No
22	3.61	0.19	0.05	0.14	1.00	0.445	0.86	0.515	1.00	1.30	0.592	No
23	3.77	0.19	0.06	0.14	1.00	0.454	0.86	0.525	1.00	1.30	0.604	No
24	3.94	0.20	0.06	0.14	1.00	0.462	0.86	0.535	1.00	1.30	0.615	No
25	4.10	0.21	0.07	0.15	1.00	0.470	0.86	0.544	1.00	1.30	0.625	No
26	4.27	0.22	0.07	0.15	1.00	0.478	0.86	0.553	1.00	1.30	0.635	No
27	4.43	0.23	0.08	0.15	1.00	0.485	0.86	0.561	1.00	1.30	0.645	No
28	4.59	0.24	0.08	0.16	1.00	0.492	0.86	0.569	1.00	1.30	0.654	No
29	4.76	0.25	0.09	0.16	1.00	0.499	0.86	0.577	1.00	1.30	0.663	No
30	4.92	0.25	0.09	0.16	1.00	0.505	0.86	0.585	1.00	1.30	0.672	No
31	5.09	0.26	0.10	0.17	1.00	0.512	0.86	0.592	1.00	1.30	0.680	No
32	5.25	0.27	0.10	0.17	1.00	0.518	0.86	0.599	1.00	1.30	0.689	No
33	5.41	0.28	0.11	0.17	1.00	0.524	0.86	0.606	1.00	1.30	0.696	No
34	5.58	0.29	0.11	0.18	1.00	0.529	0.86	0.612	1.00	1.30	0.703	No
35	5.74	0.30	0.12	0.18	1.00	0.534	0.86	0.618	1.00	1.30	0.710	No
36	5.91	0.31	0.12	0.18	1.00	0.538	0.86	0.623	1.00	1.30	0.716	No
37	6.07	0.32	0.13	0.19	1.00	0.542	0.86	0.627	1.00	1.30	0.815	No
38	6.23	0.32	0.13	0.19	1.00	0.546	0.86	0.631	1.00	1.30	0.726	No
39	6.40	0.33	0.14	0.20	1.00	0.549	0.86	0.636	1.00	1.30	0.730	No
40	6.56	0.34	0.14	0.20	1.00	0.553	0.86	0.640	1.00	1.30	0.735	No
41	6.73	0.35	0.15	0.20	1.00	0.557	0.86	0.644	1.00	1.30	0.741	No
42	6.89	0.36	0.15	0.21	1.00	0.561	0.86	0.649	1.00	1.30	0.746	No
43	7.05	0.37	0.16	0.21	1.00	0.566	0.86	0.654	1.00	1.30	0.752	No
44	7.22	0.38	0.16	0.21	0.99	0.570	0.86	0.660	1.00	1.30	0.758	No
45	7.38	0.38	0.17	0.22	0.99	0.575	0.86	0.665	1.00	1.30	0.765	No
46	7.55	0.39	0.17	0.22	0.99	0.580	0.86	0.671	1.00	1.30	0.771	No
47	7.71	0.40	0.18	0.22	0.99	0.584	0.86	0.676	1.00	1.30	0.777	No
48	7.87	0.41	0.18	0.22	0.99	0.589	0.86	0.682	1.00	1.30	0.783	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
49	8.04	0.41	0.19	0.22	0.99	0.593	0.86	0.686	1.00	1.30	0.789	No
50	8.20	0.42	0.19	0.23	0.99	0.597	0.86	0.691	1.00	1.30	0.794	No
51	8.37	0.43	0.20	0.23	0.99	0.601	0.86	0.696	1.00	1.30	0.799	No
52	8.53	0.44	0.20	0.23	0.99	0.605	0.86	0.699	1.00	1.30	0.804	No
53	8.69	0.45	0.21	0.24	0.99	0.607	0.86	0.702	1.00	1.30	0.807	No
54	8.86	0.46	0.21	0.24	0.99	0.608	0.86	0.704	1.00	1.30	0.915	No
55	9.02	0.46	0.22	0.25	0.99	0.610	0.86	0.705	1.00	1.30	0.917	No
56	9.19	0.47	0.22	0.25	0.99	0.610	0.86	0.706	1.00	1.30	0.918	No
57	9.35	0.49	0.23	0.26	0.99	0.611	0.86	0.707	1.00	1.30	0.919	No
58	9.51	0.50	0.23	0.26	0.99	0.611	0.86	0.707	1.00	1.30	0.920	No
59	9.68	0.51	0.24	0.27	0.99	0.612	0.86	0.708	1.00	1.30	0.920	No
60	9.84	0.52	0.24	0.27	0.99	0.612	0.86	0.708	1.00	1.30	0.921	No
61	10.01	0.53	0.25	0.28	0.99	0.613	0.86	0.709	1.00	1.30	0.922	No
62	10.17	0.54	0.25	0.28	0.99	0.613	0.86	0.709	1.00	1.30	0.922	No
63	10.34	0.55	0.26	0.29	0.99	0.614	0.86	0.710	1.00	1.30	0.923	No
64	10.50	0.56	0.27	0.29	0.99	0.614	0.86	0.710	1.00	1.30	0.923	No
65	10.66	0.57	0.27	0.30	0.99	0.614	0.86	0.710	1.00	1.30	0.924	No
66	10.83	0.58	0.28	0.30	0.99	0.614	0.86	0.711	1.00	1.30	0.924	No
67	10.99	0.59	0.28	0.31	0.99	0.614	0.86	0.711	1.00	1.30	0.924	No
68	11.16	0.60	0.29	0.31	0.99	0.614	0.86	0.711	1.00	1.30	0.924	No
69	11.32	0.61	0.29	0.32	0.99	0.614	0.86	0.711	1.00	1.30	0.924	No
70	11.48	0.62	0.30	0.32	0.99	0.615	0.86	0.711	1.00	1.30	0.924	No
71	11.65	0.63	0.30	0.33	0.99	0.615	0.86	0.711	1.00	1.30	0.925	No
72	11.81	0.64	0.31	0.33	0.99	0.615	0.86	0.711	1.00	1.30	0.925	No
73	11.98	0.65	0.31	0.34	0.99	0.615	0.86	0.711	1.00	1.30	0.818	No
74	12.14	0.66	0.32	0.34	0.99	0.615	0.86	0.712	1.00	1.30	0.818	No
75	12.30	0.67	0.32	0.35	0.99	0.615	0.86	0.712	1.00	1.30	0.926	No
76	12.47	0.68	0.33	0.35	0.99	0.616	0.86	0.712	1.00	1.30	0.818	No
77	12.63	0.69	0.33	0.36	0.98	0.616	0.86	0.713	1.00	1.30	0.819	No
78	12.80	0.70	0.34	0.36	0.98	0.616	0.86	0.713	1.00	1.30	0.819	No
79	12.96	0.71	0.34	0.37	0.98	0.616	0.86	0.713	1.00	1.30	0.819	No
80	13.12	0.72	0.35	0.37	0.98	0.616	0.86	0.713	1.00	1.30	0.820	No
81	13.29	0.73	0.35	0.38	0.98	0.617	0.86	0.714	1.00	1.30	0.820	No
82	13.45	0.74	0.36	0.38	0.98	0.617	0.86	0.714	1.00	1.30	0.820	No
83	13.62	0.75	0.36	0.39	0.98	0.617	0.86	0.714	1.00	1.30	0.821	No
84	13.78	0.76	0.37	0.39	0.98	0.618	0.86	0.715	1.00	1.30	0.821	No
85	13.94	0.77	0.37	0.40	0.98	0.618	0.86	0.715	1.00	1.30	0.822	No
86	14.11	0.78	0.38	0.40	0.98	0.618	0.86	0.715	1.00	1.30	0.822	No
87	14.27	0.79	0.38	0.41	0.98	0.619	0.86	0.716	1.00	1.30	0.823	No
88	14.44	0.80	0.39	0.41	0.98	0.619	0.86	0.716	1.00	1.30	0.823	No
89	14.60	0.81	0.39	0.42	0.98	0.619	0.86	0.717	1.00	1.30	0.823	No
90	14.76	0.82	0.40	0.42	0.98	0.619	0.86	0.717	1.00	1.30	0.824	No
91	14.93	0.83	0.40	0.43	0.98	0.620	0.86	0.717	1.00	1.30	0.824	No
92	15.09	0.84	0.41	0.43	0.98	0.620	0.86	0.717	1.00	1.30	0.824	No
93	15.26	0.85	0.41	0.44	0.98	0.620	0.86	0.718	1.00	1.30	0.825	No
94	15.42	0.86	0.42	0.44	0.98	0.621	0.86	0.718	1.00	1.30	0.825	No
95	15.58	0.87	0.42	0.45	0.98	0.621	0.86	0.718	1.00	1.30	0.826	No
96	15.75	0.88	0.43	0.45	0.98	0.621	0.86	0.719	1.00	1.30	0.934	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
97	15.91	0.89	0.43	0.45	0.98	0.621	0.86	0.719	1.00	1.30	0.935	No
98	16.08	0.90	0.44	0.46	0.98	0.621	0.86	0.719	1.00	1.30	0.935	No
99	16.24	0.91	0.44	0.47	0.98	0.621	0.86	0.719	1.00	1.30	0.934	No
100	16.40	0.92	0.45	0.47	0.98	0.621	0.86	0.718	1.00	1.30	0.934	No
101	16.57	0.93	0.45	0.48	0.98	0.620	0.86	0.718	1.00	1.30	0.933	No
102	16.73	0.94	0.46	0.48	0.98	0.620	0.86	0.718	1.00	1.30	0.933	No
103	16.90	0.95	0.46	0.49	0.98	0.620	0.86	0.717	1.00	1.30	0.932	No
104	17.06	0.96	0.47	0.49	0.98	0.619	0.86	0.717	1.00	1.30	0.932	No
105	17.22	0.97	0.47	0.50	0.98	0.619	0.86	0.716	1.00	1.30	0.931	No
106	17.39	0.98	0.48	0.50	0.97	0.619	0.86	0.716	1.00	1.30	0.930	No
107	17.55	0.99	0.49	0.51	0.97	0.618	0.86	0.715	1.00	1.30	0.930	No
108	17.72	1.01	0.49	0.52	0.97	0.618	0.86	0.715	1.00	1.30	0.929	No
109	17.88	1.02	0.50	0.52	0.97	0.617	0.86	0.714	1.00	1.30	0.929	No
110	18.05	1.03	0.50	0.53	0.97	0.617	0.86	0.714	1.00	1.30	0.928	No
111	18.21	1.04	0.51	0.53	0.97	0.617	0.86	0.714	1.00	1.30	0.820	No
112	18.37	1.05	0.51	0.54	0.97	0.617	0.86	0.714	1.00	1.30	2.000	Yes
113	18.54	1.06	0.52	0.54	0.97	0.616	0.86	0.713	1.00	1.30	2.000	Yes
114	18.70	1.07	0.52	0.55	0.97	0.616	0.86	0.713	1.00	1.30	2.000	Yes
115	18.87	1.08	0.53	0.55	0.97	0.616	0.86	0.713	1.00	1.30	2.000	Yes
116	19.03	1.09	0.53	0.56	0.97	0.616	0.86	0.712	1.00	1.30	2.000	Yes
117	19.19	1.10	0.54	0.56	0.97	0.615	0.86	0.712	1.00	1.30	0.925	No
118	19.36	1.11	0.54	0.57	0.97	0.615	0.86	0.711	1.00	1.30	0.924	No
119	19.52	1.12	0.55	0.58	0.97	0.614	0.86	0.711	1.00	1.30	0.924	No
120	19.69	1.13	0.55	0.58	0.97	0.614	0.86	0.710	1.00	1.30	0.923	No
121	19.85	1.15	0.56	0.59	0.97	0.613	0.86	0.709	1.00	1.30	0.922	No
122	20.01	1.16	0.56	0.59	0.97	0.612	0.86	0.709	1.00	1.30	0.921	No
123	20.18	1.17	0.57	0.60	0.97	0.612	0.86	0.708	1.00	1.30	0.920	No
124	20.34	1.18	0.57	0.61	0.97	0.611	0.86	0.707	1.00	1.30	0.919	No
125	20.51	1.19	0.58	0.61	0.97	0.611	0.86	0.707	1.00	1.30	0.918	No
126	20.67	1.20	0.58	0.62	0.97	0.610	0.86	0.706	1.00	1.30	0.918	No
127	20.83	1.21	0.59	0.63	0.97	0.609	0.86	0.705	1.00	1.30	0.917	No
128	21.00	1.22	0.59	0.63	0.97	0.609	0.86	0.705	1.00	1.30	0.916	No
129	21.16	1.24	0.60	0.64	0.97	0.608	0.86	0.704	1.00	1.30	0.915	No
130	21.33	1.25	0.60	0.64	0.97	0.608	0.86	0.703	1.00	1.30	0.914	No
131	21.49	1.26	0.61	0.65	0.97	0.607	0.86	0.703	1.00	1.30	0.914	No
132	21.65	1.27	0.61	0.66	0.96	0.607	0.86	0.702	1.00	1.30	0.913	No
133	21.82	1.28	0.62	0.66	0.96	0.606	0.86	0.702	1.00	1.30	0.912	No
134	21.98	1.29	0.62	0.67	0.96	0.606	0.86	0.701	1.00	1.30	0.911	No
135	22.15	1.30	0.63	0.67	0.96	0.605	0.86	0.700	1.00	1.30	0.910	No
136	22.31	1.31	0.63	0.68	0.96	0.605	0.86	0.700	1.00	1.30	0.910	No
137	22.47	1.32	0.64	0.69	0.96	0.604	0.86	0.699	1.00	1.30	0.909	No
138	22.64	1.34	0.64	0.69	0.96	0.604	0.86	0.698	1.00	1.30	0.908	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.16	6.68	40.30	2.70	0.70	1.70	3.77	0.00	3.77	4.000	No	Yes	2.00
2	0.33	13.63	23.46	2.32	0.61	1.70	24.31	34.13	58.43	4.000	No	No	2.00
3	0.49	19.38	17.42	2.15	0.58	1.70	37.11	30.55	67.66	4.000	No	No	2.00
4	0.66	19.66	17.20	2.14	0.60	1.70	31.36	28.71	60.08	4.000	No	No	2.00
5	0.82	16.18	19.58	2.22	0.62	1.70	25.79	30.89	56.68	4.000	No	No	2.00
6	0.98	13.13	5.00	2.27	0.78	1.70	20.58	0.01	20.59	4.000	No	No	2.00
7	1.15	11.01	5.00	2.31	0.78	1.70	16.76	0.01	16.77	4.000	No	No	2.00
8	1.31	9.80	5.00	2.32	0.78	1.70	15.63	0.01	15.65	4.000	No	No	2.00
9	1.48	8.87	26.83	2.41	0.65	1.70	14.69	32.87	47.56	4.000	No	No	2.00
10	1.64	8.62	29.54	2.47	0.66	1.70	12.36	32.98	45.34	4.000	No	No	2.00
11	1.80	8.72	32.71	2.54	0.64	1.70	14.42	34.36	48.78	4.000	No	No	2.00
12	1.97	10.08	34.02	2.57	0.64	1.70	15.19	34.83	50.02	4.000	No	No	2.00
13	2.13	12.46	31.48	2.52	0.62	1.70	18.91	35.65	54.57	0.082	No	No	0.16
14	2.30	13.69	32.76	2.55	0.59	1.70	25.88	38.28	64.16	0.093	No	No	0.17
15	2.46	13.22	36.91	2.63	0.61	1.70	21.07	0.00	21.07	4.000	No	Yes	2.00
16	2.63	11.22	45.64	2.79	0.63	1.70	16.67	0.00	16.67	4.000	No	Yes	2.00
17	2.79	12.67	44.36	2.77	0.63	1.70	16.26	0.00	16.26	4.000	No	Yes	2.00
18	2.95	15.17	40.61	2.70	0.58	1.70	27.99	0.00	27.99	4.000	No	Yes	2.00
19	3.12	17.23	38.34	2.66	0.58	1.70	28.71	0.00	28.71	4.000	No	Yes	2.00
20	3.28	15.52	42.06	2.73	0.59	1.70	26.19	0.00	26.19	4.000	No	Yes	2.00
21	3.45	12.34	48.65	2.85	0.61	1.70	19.81	0.00	19.81	3.300	No	Yes	2.00
22	3.61	9.05	57.50	2.99	0.64	1.70	13.48	0.00	13.48	2.288	No	Yes	2.00
23	3.77	7.27	62.99	3.07	0.66	1.70	10.42	0.00	10.42	1.743	No	Yes	2.00
24	3.94	6.81	62.19	3.05	0.66	1.70	11.28	0.00	11.28	1.557	No	Yes	2.00
25	4.10	6.85	59.16	3.01	0.66	1.70	11.28	0.00	11.28	1.501	No	Yes	2.00
26	4.27	6.87	57.05	2.98	0.66	1.70	10.65	0.00	10.65	1.445	No	Yes	2.00
27	4.43	6.90	55.58	2.96	0.66	1.70	11.37	0.00	11.37	1.396	No	Yes	2.00
28	4.59	6.76	55.81	2.96	0.65	1.70	11.41	0.00	11.41	1.315	No	Yes	2.00
29	4.76	5.91	60.40	3.03	0.66	1.70	9.93	0.00	9.93	1.103	No	Yes	1.66
30	4.92	4.72	68.62	3.14	0.68	1.70	7.28	0.00	7.28	0.842	No	Yes	1.25
31	5.09	3.93	75.47	3.23	0.69	1.70	5.71	0.00	5.71	0.670	No	Yes	0.98
32	5.25	4.09	72.67	3.20	0.69	1.70	6.11	0.00	6.11	0.676	No	Yes	0.98
33	5.41	5.59	60.54	3.03	0.67	1.70	8.04	0.00	8.04	0.911	No	Yes	1.31
34	5.58	8.07	50.66	2.88	0.65	1.70	12.89	0.00	12.89	1.296	No	Yes	1.84
35	5.74	10.93	44.99	2.78	0.62	1.70	18.06	0.00	18.06	1.717	No	Yes	2.00
36	5.91	16.16	36.31	2.62	0.61	1.70	21.75	0.00	21.75	2.484	No	Yes	2.00
37	6.07	18.58	34.71	2.59	0.54	1.70	38.05	42.79	80.84	0.114	No	No	0.14
38	6.23	18.26	35.76	2.61	0.57	1.70	29.74	0.00	29.74	2.649	No	Yes	2.00
39	6.40	14.32	42.60	2.74	0.61	1.70	20.22	0.00	20.22	2.009	No	Yes	2.00
40	6.56	10.61	49.36	2.86	0.62	1.70	19.09	0.00	19.09	1.435	No	Yes	1.95
41	6.73	7.67	56.52	2.97	0.65	1.70	11.86	0.00	11.86	0.998	No	Yes	1.35
42	6.89	4.86	67.96	3.13	0.69	1.70	6.07	0.00	6.07	0.599	No	Yes	0.80
43	7.05	3.34	78.62	3.27	0.69	1.70	5.53	0.00	5.53	0.387	No	Yes	0.51
44	7.22	2.93	77.82	3.26	0.70	1.70	4.49	0.00	4.49	0.326	No	Yes	0.43
45	7.38	2.72	77.97	3.26	0.70	1.70	4.04	0.00	4.04	0.292	No	Yes	0.38
46	7.55	2.67	76.07	3.24	0.70	1.70	4.49	0.00	4.49	0.280	No	Yes	0.36
47	7.71	2.86	69.82	3.16	0.70	1.70	4.22	0.00	4.22	0.297	No	Yes	0.38
48	7.87	3.20	65.10	3.09	0.69	1.70	4.90	0.00	4.90	0.331	No	Yes	0.42

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
49	8.04	4.17	55.89	2.96	0.69	1.70	6.07	0.00	6.07	0.436	No	Yes	0.55
50	8.20	4.92	50.92	2.88	0.67	1.70	8.67	0.00	8.67	0.513	No	Yes	0.65
51	8.37	5.29	48.89	2.85	0.67	1.70	8.31	0.00	8.31	0.544	No	Yes	0.68
52	8.53	6.41	48.10	2.84	0.68	1.70	7.64	0.00	7.64	0.657	No	Yes	0.82
53	8.69	13.28	36.38	2.62	0.64	1.70	13.84	0.00	13.84	1.382	No	Yes	1.71
54	8.86	22.34	31.30	2.51	0.54	1.58	38.43	42.21	80.64	0.114	No	No	0.12
55	9.02	32.38	28.75	2.46	0.52	1.53	46.43	44.07	90.50	0.128	No	No	0.14
56	9.19	37.67	29.28	2.47	0.49	1.49	54.89	47.09	101.98	0.146	No	No	0.16
57	9.35	43.44	28.10	2.44	0.49	1.48	58.26	47.70	105.96	0.153	No	No	0.17
58	9.51	47.61	26.83	2.41	0.46	1.44	67.23	49.96	117.19	0.174	No	No	0.19
59	9.68	47.03	27.44	2.42	0.46	1.43	69.48	51.05	120.52	0.181	No	No	0.20
60	9.84	44.24	29.10	2.46	0.49	1.46	55.25	47.14	102.39	0.146	No	No	0.16
61	10.01	39.11	32.04	2.53	0.49	1.45	56.17	48.42	104.58	0.150	No	No	0.16
62	10.17	37.82	32.48	2.54	0.51	1.46	49.88	46.40	96.28	0.137	No	No	0.15
63	10.34	38.64	31.95	2.53	0.51	1.46	49.67	46.19	95.86	0.136	No	No	0.15
64	10.50	44.05	30.08	2.49	0.48	1.42	58.34	48.54	106.89	0.154	No	No	0.17
65	10.66	48.95	29.36	2.47	0.46	1.39	68.53	51.67	120.20	0.180	No	No	0.19
66	10.83	50.93	29.68	2.48	0.46	1.39	66.50	51.13	117.63	0.175	No	No	0.19
67	10.99	49.18	30.97	2.51	0.47	1.39	64.59	50.95	115.54	0.170	No	No	0.18
68	11.16	47.79	31.47	2.52	0.47	1.39	61.39	50.03	111.42	0.162	No	No	0.18
69	11.32	46.28	32.25	2.53	0.48	1.38	60.59	49.98	110.57	0.161	No	No	0.17
70	11.48	46.56	32.24	2.53	0.48	1.38	58.36	49.22	107.58	0.155	No	No	0.17
71	11.65	45.49	33.16	2.55	0.47	1.37	61.50	50.52	112.02	0.164	No	No	0.18
72	11.81	43.50	34.30	2.58	0.49	1.37	56.10	48.92	105.02	0.151	No	No	0.16
73	11.98	39.77	35.54	2.60	0.50	1.38	50.62	0.00	50.62	3.369	No	Yes	2.00
74	12.14	37.91	35.51	2.60	0.51	1.38	47.66	0.00	47.66	3.179	No	Yes	2.00
75	12.30	36.63	35.07	2.59	0.51	1.37	48.79	46.54	95.34	0.135	No	No	0.15
76	12.47	35.41	35.77	2.61	0.52	1.38	45.30	0.00	45.30	2.912	No	Yes	2.00
77	12.63	33.91	36.70	2.63	0.53	1.38	42.67	0.00	42.67	2.761	No	Yes	2.00
78	12.80	33.79	36.50	2.62	0.53	1.37	42.86	0.00	42.86	2.727	No	Yes	2.00
79	12.96	34.27	36.18	2.62	0.52	1.36	44.38	0.00	44.38	2.742	No	Yes	2.00
80	13.12	33.15	37.35	2.64	0.52	1.35	43.79	0.00	43.79	2.628	No	Yes	2.00
81	13.29	30.91	39.41	2.68	0.54	1.36	38.36	0.00	38.36	2.425	No	Yes	2.00
82	13.45	28.17	41.18	2.71	0.55	1.36	35.98	0.00	35.98	2.186	No	Yes	2.00
83	13.62	26.81	40.92	2.71	0.56	1.36	33.52	0.00	33.52	2.060	No	Yes	2.00
84	13.78	26.10	40.23	2.70	0.56	1.36	32.91	0.00	32.91	1.988	No	Yes	2.00
85	13.94	26.21	39.41	2.68	0.56	1.35	32.85	0.00	32.85	1.980	No	Yes	2.00
86	14.11	26.73	38.84	2.67	0.56	1.35	33.35	0.00	33.35	2.005	No	Yes	2.00
87	14.27	27.61	38.07	2.65	0.56	1.34	34.29	0.00	34.29	2.057	No	Yes	2.00
88	14.44	28.23	37.68	2.65	0.55	1.33	35.54	0.00	35.54	2.087	No	Yes	2.00
89	14.60	28.20	37.84	2.65	0.55	1.33	35.14	0.00	35.14	2.069	No	Yes	2.00
90	14.76	27.55	38.72	2.67	0.56	1.32	33.75	0.00	33.75	2.004	No	Yes	2.00
91	14.93	26.79	39.62	2.68	0.56	1.32	32.77	0.00	32.77	1.932	No	Yes	2.00
92	15.09	26.09	40.41	2.70	0.56	1.32	31.95	0.00	31.95	1.866	No	Yes	2.00
93	15.26	26.91	38.37	2.66	0.57	1.31	30.88	0.00	30.88	1.912	No	Yes	2.00
94	15.42	26.86	37.36	2.64	0.55	1.30	35.13	0.00	35.13	1.894	No	Yes	2.00
95	15.58	27.90	35.74	2.61	0.57	1.30	31.34	0.00	31.34	1.955	No	Yes	2.00
96	15.75	30.94	34.17	2.58	0.56	1.29	33.73	41.22	74.95	0.106	No	No	0.11

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
97	15.91	36.13	32.76	2.55	0.52	1.27	44.60	44.66	89.25	0.126	No	No	0.13
98	16.08	43.86	31.24	2.51	0.51	1.26	48.51	45.60	94.12	0.133	No	No	0.14
99	16.24	53.83	29.58	2.48	0.48	1.23	59.48	48.74	108.22	0.157	No	No	0.17
100	16.40	60.00	30.01	2.48	0.43	1.21	77.26	54.86	132.13	0.209	No	No	0.22
101	16.57	62.57	31.53	2.52	0.46	1.21	68.51	52.46	120.97	0.182	No	No	0.19
102	16.73	65.77	31.48	2.52	0.46	1.21	67.57	52.12	119.69	0.179	No	No	0.19
103	16.90	76.08	28.06	2.44	0.41	1.18	86.63	57.03	143.66	0.245	No	No	0.26
104	17.06	81.10	26.44	2.40	0.39	1.17	99.94	60.30	160.25	0.328	No	No	0.35
105	17.22	79.29	26.95	2.41	0.42	1.18	82.57	55.02	137.60	0.225	No	No	0.24
106	17.39	84.94	25.07	2.37	0.43	1.18	80.21	52.88	133.09	0.211	No	No	0.23
107	17.55	88.27	24.14	2.34	0.36	1.14	116.31	63.32	179.63	0.530	No	No	0.57
108	17.72	86.04	24.98	2.36	0.41	1.16	92.34	56.65	148.99	0.267	No	No	0.29
109	17.88	67.71	30.95	2.51	0.45	1.17	72.64	53.66	126.30	0.194	No	No	0.21
110	18.05	55.50	35.34	2.60	0.48	1.18	59.03	50.11	109.14	0.158	No	No	0.17
111	18.21	49.57	36.62	2.63	0.49	1.19	53.23	0.00	53.23	3.106	No	Yes	2.00
112	18.37	47.58	36.98	2.63	0.50	1.18	52.99	0.00	52.99	4.000	Yes	Yes	2.00
113	18.54	51.91	33.77	2.57	0.50	1.18	51.71	47.31	99.02	4.000	Yes	No	2.00
114	18.70	62.11	30.14	2.49	0.46	1.16	65.39	50.93	116.32	4.000	Yes	No	2.00
115	18.87	93.96	20.69	2.25	0.43	1.15	83.88	48.83	132.70	4.000	Yes	No	2.00
116	19.03	120.42	17.71	2.16	0.32	1.10	147.61	58.88	206.49	4.000	Yes	No	2.00
117	19.19	131.10	18.54	2.19	0.32	1.10	144.48	60.68	205.16	1.462	No	No	1.58
118	19.36	118.26	22.25	2.29	0.36	1.11	115.47	60.54	176.01	0.477	No	No	0.52
119	19.52	118.19	22.84	2.31	0.38	1.11	108.38	59.25	167.64	0.385	No	No	0.42
120	19.69	140.95	18.78	2.19	0.33	1.10	141.22	60.54	201.76	1.236	No	No	1.34
121	19.85	178.12	15.36	2.09	0.28	1.08	179.87	56.26	236.13	4.000	No	No	2.00
122	20.01	205.32	15.22	2.08	0.26	1.07	217.06	63.25	280.31	4.000	No	No	2.00
123	20.18	229.73	15.57	2.09	0.26	1.07	222.88	66.58	289.45	4.000	No	No	2.00
124	20.34	231.17	16.53	2.12	0.26	1.07	253.14	79.07	332.21	4.000	No	No	2.00
125	20.51	235.07	15.73	2.10	0.26	1.07	220.31	67.02	287.33	4.000	No	No	2.00
126	20.67	227.44	13.64	2.03	0.26	1.06	233.80	55.35	289.15	4.000	No	No	2.00
127	20.83	223.34	12.03	1.97	0.26	1.06	229.48	41.14	270.63	4.000	No	No	2.00
128	21.00	205.97	12.28	1.98	0.27	1.06	207.93	40.44	248.37	4.000	No	No	2.00
129	21.16	175.79	17.09	2.14	0.27	1.06	181.21	64.81	246.03	4.000	No	No	2.00
130	21.33	149.14	22.18	2.29	0.32	1.07	139.74	67.70	207.43	1.647	No	No	1.80
131	21.49	128.21	25.74	2.38	0.33	1.07	128.72	68.96	197.68	1.025	No	No	1.12
132	21.65	128.39	24.99	2.36	0.35	1.07	119.35	65.21	184.57	0.620	No	No	0.68
133	21.82	145.20	21.63	2.28	0.32	1.06	139.38	66.62	206.00	1.527	No	No	1.67
134	21.98	178.45	19.28	2.21	0.27	1.05	176.42	71.47	247.89	4.000	No	No	2.00
135	22.15	212.43	17.34	2.15	0.26	1.05	215.33	74.24	289.57	4.000	No	No	2.00
136	22.31	309.44	12.07	1.97	0.26	1.04	237.54	42.56	280.10	4.000	No	No	2.00
137	22.47	397.85	8.70	1.83	0.26	1.04	460.86	20.69	481.55	4.000	No	No	2.00
138	22.64	478.59	6.58	1.72	0.26	1.04	473.98	2.68	476.65	4.000	No	No	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
FC: Fines content (%)
I_c: Soil behavior type index
m: Stress exponent
C_N: Overburden correction factor
q_{c1N}: Normalized and adjusted cone resistance
Δq_{c1N}: Cone resistance correction factor due to fines
$q_{c1N,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.16	2.00	0.00	9.98	0.16	0.00	0.33	2.00	0.00	9.95	0.16	0.00
0.49	2.00	0.00	9.93	0.16	0.00	0.66	2.00	0.00	9.90	0.16	0.00
0.82	2.00	0.00	9.88	0.16	0.00	0.98	2.00	0.00	9.85	0.16	0.00
1.15	2.00	0.00	9.83	0.16	0.00	1.31	2.00	0.00	9.80	0.16	0.00
1.48	2.00	0.00	9.78	0.16	0.00	1.64	2.00	0.00	9.75	0.16	0.00
1.80	2.00	0.00	9.73	0.16	0.00	1.97	2.00	0.00	9.70	0.17	0.00
2.13	0.16	0.84	9.67	0.16	0.41	2.30	0.17	0.83	9.65	0.16	0.40
2.46	2.00	0.00	9.62	0.16	0.00	2.63	2.00	0.00	9.60	0.16	0.00
2.79	2.00	0.00	9.57	0.16	0.00	2.95	2.00	0.00	9.55	0.16	0.00
3.12	2.00	0.00	9.52	0.16	0.00	3.28	2.00	0.00	9.50	0.16	0.00
3.45	2.00	0.00	9.47	0.16	0.00	3.61	2.00	0.00	9.45	0.16	0.00
3.77	2.00	0.00	9.42	0.16	0.00	3.94	2.00	0.00	9.40	0.16	0.00
4.10	2.00	0.00	9.38	0.16	0.00	4.27	2.00	0.00	9.35	0.16	0.00
4.43	2.00	0.00	9.33	0.16	0.00	4.59	2.00	0.00	9.30	0.16	0.00
4.76	1.66	0.00	9.28	0.16	0.00	4.92	1.25	0.00	9.25	0.16	0.00
5.09	0.98	0.02	9.23	0.16	0.01	5.25	0.98	0.02	9.20	0.16	0.01
5.41	1.31	0.00	9.18	0.16	0.00	5.58	1.84	0.00	9.15	0.16	0.00
5.74	2.00	0.00	9.13	0.16	0.00	5.91	2.00	0.00	9.10	0.17	0.00
6.07	0.14	0.86	9.07	0.16	0.39	6.23	2.00	0.00	9.05	0.16	0.00
6.40	2.00	0.00	9.02	0.16	0.00	6.56	1.95	0.00	9.00	0.16	0.00
6.73	1.35	0.00	8.97	0.16	0.00	6.89	0.80	0.20	8.95	0.16	0.09
7.05	0.51	0.49	8.92	0.16	0.22	7.22	0.43	0.57	8.90	0.16	0.25
7.38	0.38	0.62	8.87	0.16	0.27	7.55	0.36	0.64	8.85	0.16	0.28
7.71	0.38	0.62	8.82	0.16	0.27	7.87	0.42	0.58	8.80	0.16	0.25
8.04	0.55	0.45	8.78	0.16	0.20	8.20	0.65	0.35	8.75	0.16	0.16
8.37	0.68	0.32	8.73	0.16	0.14	8.53	0.82	0.18	8.70	0.16	0.08
8.69	1.71	0.00	8.68	0.16	0.00	8.86	0.12	0.88	8.65	0.16	0.38
9.02	0.14	0.86	8.63	0.16	0.37	9.19	0.16	0.84	8.60	0.16	0.36
9.35	0.17	0.83	8.58	0.16	0.36	9.51	0.19	0.81	8.55	0.16	0.35
9.68	0.20	0.80	8.53	0.16	0.34	9.84	0.16	0.84	8.50	0.16	0.36
10.01	0.16	0.84	8.47	0.16	0.35	10.17	0.15	0.85	8.45	0.16	0.36
10.34	0.15	0.85	8.42	0.16	0.36	10.50	0.17	0.83	8.40	0.16	0.35
10.66	0.19	0.81	8.37	0.16	0.34	10.83	0.19	0.81	8.35	0.16	0.34
10.99	0.18	0.82	8.32	0.16	0.34	11.16	0.18	0.82	8.30	0.16	0.34
11.32	0.17	0.83	8.27	0.16	0.34	11.48	0.17	0.83	8.25	0.16	0.34
11.65	0.18	0.82	8.22	0.16	0.34	11.81	0.16	0.84	8.20	0.16	0.34
11.98	2.00	0.00	8.18	0.16	0.00	12.14	2.00	0.00	8.15	0.16	0.00
12.30	0.15	0.85	8.13	0.16	0.35	12.47	2.00	0.00	8.10	0.16	0.00
12.63	2.00	0.00	8.08	0.16	0.00	12.80	2.00	0.00	8.05	0.16	0.00
12.96	2.00	0.00	8.03	0.16	0.00	13.12	2.00	0.00	8.00	0.16	0.00
13.29	2.00	0.00	7.98	0.16	0.00	13.45	2.00	0.00	7.95	0.16	0.00
13.62	2.00	0.00	7.93	0.16	0.00	13.78	2.00	0.00	7.90	0.16	0.00
13.94	2.00	0.00	7.87	0.16	0.00	14.11	2.00	0.00	7.85	0.16	0.00
14.27	2.00	0.00	7.82	0.16	0.00	14.44	2.00	0.00	7.80	0.16	0.00
14.60	2.00	0.00	7.77	0.16	0.00	14.76	2.00	0.00	7.75	0.16	0.00
14.93	2.00	0.00	7.72	0.16	0.00	15.09	2.00	0.00	7.70	0.16	0.00
15.26	2.00	0.00	7.67	0.16	0.00	15.42	2.00	0.00	7.65	0.16	0.00
15.58	2.00	0.00	7.62	0.16	0.00	15.75	0.11	0.89	7.60	0.16	0.34

:: Liquefaction Potential Index calculation data :: (continued)

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
15.91	0.13	0.87	7.58	0.16	0.33	16.08	0.14	0.86	7.55	0.16	0.32
16.24	0.17	0.83	7.53	0.16	0.31	16.40	0.22	0.78	7.50	0.16	0.29
16.57	0.19	0.81	7.48	0.16	0.30	16.73	0.19	0.81	7.45	0.16	0.30
16.90	0.26	0.74	7.43	0.16	0.27	17.06	0.35	0.65	7.40	0.16	0.24
17.22	0.24	0.76	7.38	0.16	0.28	17.39	0.23	0.77	7.35	0.16	0.28
17.55	0.57	0.43	7.33	0.16	0.16	17.72	0.29	0.71	7.30	0.16	0.26
17.88	0.21	0.79	7.27	0.16	0.29	18.05	0.17	0.83	7.25	0.16	0.30
18.21	2.00	0.00	7.22	0.16	0.00	18.37	2.00	0.00	7.20	0.16	0.00
18.54	2.00	0.00	7.17	0.16	0.00	18.70	2.00	0.00	7.15	0.16	0.00
18.87	2.00	0.00	7.12	0.16	0.00	19.03	2.00	0.00	7.10	0.16	0.00
19.19	1.58	0.00	7.07	0.16	0.00	19.36	0.52	0.48	7.05	0.16	0.17
19.52	0.42	0.58	7.02	0.16	0.20	19.69	1.34	0.00	7.00	0.16	0.00
19.85	2.00	0.00	6.98	0.16	0.00	20.01	2.00	0.00	6.95	0.16	0.00
20.18	2.00	0.00	6.93	0.16	0.00	20.34	2.00	0.00	6.90	0.16	0.00
20.51	2.00	0.00	6.88	0.16	0.00	20.67	2.00	0.00	6.85	0.16	0.00
20.83	2.00	0.00	6.83	0.16	0.00	21.00	2.00	0.00	6.80	0.16	0.00
21.16	2.00	0.00	6.78	0.16	0.00	21.33	1.80	0.00	6.75	0.16	0.00
21.49	1.12	0.00	6.72	0.16	0.00	21.65	0.68	0.32	6.70	0.16	0.11
21.82	1.67	0.00	6.67	0.16	0.00	21.98	2.00	0.00	6.65	0.16	0.00
22.15	2.00	0.00	6.62	0.16	0.00	22.31	2.00	0.00	6.60	0.16	0.00
22.47	2.00	0.00	6.57	0.16	0.00	22.64	2.00	0.00	6.55	0.16	0.00

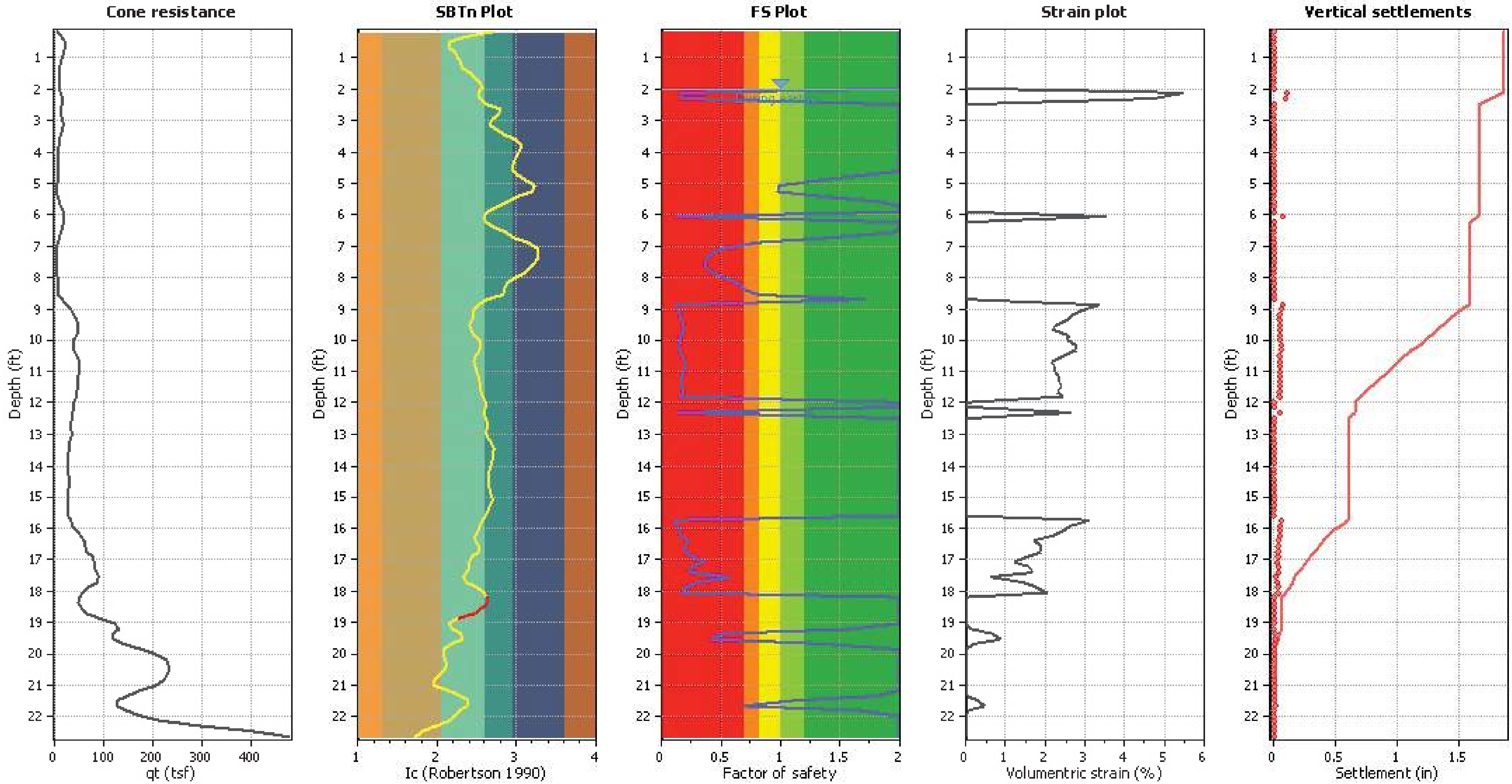
Overall liquefaction potential: 15.19

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)
2.13	54.57	0.16	5.49	0.96	0.11	2.30	64.16	0.17	4.74	0.96	0.09
2.46	21.07	2.00	0.00	0.96	0.00	2.63	16.67	2.00	0.00	0.96	0.00
2.79	16.26	2.00	0.00	0.95	0.00	2.95	27.99	2.00	0.00	0.95	0.00
3.12	28.71	2.00	0.00	0.95	0.00	3.28	26.19	2.00	0.00	0.94	0.00
3.45	19.81	2.00	0.00	0.94	0.00	3.61	13.48	2.00	0.00	0.94	0.00
3.77	10.42	2.00	0.00	0.94	0.00	3.94	11.28	2.00	0.00	0.93	0.00
4.10	11.28	2.00	0.00	0.93	0.00	4.27	10.65	2.00	0.00	0.93	0.00
4.43	11.37	2.00	0.00	0.92	0.00	4.59	11.41	2.00	0.00	0.92	0.00
4.76	9.93	1.66	0.00	0.92	0.00	4.92	7.28	1.25	0.00	0.92	0.00
5.09	5.71	0.98	0.00	0.91	0.00	5.25	6.11	0.98	0.00	0.91	0.00
5.41	8.04	1.31	0.00	0.91	0.00	5.58	12.89	1.84	0.00	0.91	0.00
5.74	18.06	2.00	0.00	0.90	0.00	5.91	21.75	2.00	0.00	0.90	0.00
6.07	80.84	0.14	3.56	0.90	0.07	6.23	29.74	2.00	0.00	0.89	0.00
6.40	20.22	2.00	0.00	0.89	0.00	6.56	19.09	1.95	0.00	0.89	0.00
6.73	11.86	1.35	0.00	0.89	0.00	6.89	6.07	0.80	0.00	0.88	0.00
7.05	5.53	0.51	0.00	0.88	0.00	7.22	4.49	0.43	0.00	0.88	0.00
7.38	4.04	0.38	0.00	0.87	0.00	7.55	4.49	0.36	0.00	0.87	0.00
7.71	4.22	0.38	0.00	0.87	0.00	7.87	4.90	0.42	0.00	0.87	0.00
8.04	6.07	0.55	0.00	0.86	0.00	8.20	8.67	0.65	0.00	0.86	0.00
8.37	8.31	0.68	0.00	0.86	0.00	8.53	7.64	0.82	0.00	0.86	0.00
8.69	13.84	1.71	0.00	0.85	0.00	8.86	80.64	0.12	3.38	0.85	0.07
9.02	90.50	0.14	3.01	0.85	0.06	9.19	101.98	0.16	2.66	0.84	0.05
9.35	105.96	0.17	2.55	0.84	0.05	9.51	117.19	0.19	2.28	0.84	0.04
9.68	120.52	0.20	2.21	0.84	0.04	9.84	102.39	0.16	2.61	0.83	0.05
10.01	104.58	0.16	2.55	0.83	0.05	10.17	96.28	0.15	2.76	0.83	0.05
10.34	95.86	0.15	2.77	0.82	0.05	10.50	106.89	0.17	2.47	0.82	0.05
10.66	120.20	0.19	2.17	0.82	0.04	10.83	117.63	0.19	2.21	0.82	0.04
10.99	115.54	0.18	2.25	0.81	0.04	11.16	111.42	0.18	2.33	0.81	0.05
11.32	110.57	0.17	2.34	0.81	0.05	11.48	107.58	0.17	2.40	0.81	0.05
11.65	112.02	0.18	2.29	0.80	0.05	11.81	105.02	0.16	2.44	0.80	0.05
11.98	50.62	2.00	0.00	0.80	0.00	12.14	47.66	2.00	0.00	0.79	0.00
12.30	95.34	0.15	2.67	0.79	0.05	12.47	45.30	2.00	0.00	0.79	0.00
12.63	42.67	2.00	0.00	0.79	0.00	12.80	42.86	2.00	0.00	0.78	0.00
12.96	44.38	2.00	0.00	0.78	0.00	13.12	43.79	2.00	0.00	0.78	0.00
13.29	38.36	2.00	0.00	0.77	0.00	13.45	35.98	2.00	0.00	0.77	0.00
13.62	33.52	2.00	0.00	0.77	0.00	13.78	32.91	2.00	0.00	0.77	0.00
13.94	32.85	2.00	0.00	0.76	0.00	14.11	33.35	2.00	0.00	0.76	0.00
14.27	34.29	2.00	0.00	0.76	0.00	14.44	35.54	2.00	0.00	0.76	0.00
14.60	35.14	2.00	0.00	0.75	0.00	14.76	33.75	2.00	0.00	0.75	0.00
14.93	32.77	2.00	0.00	0.75	0.00	15.09	31.95	2.00	0.00	0.74	0.00
15.26	30.88	2.00	0.00	0.74	0.00	15.42	35.13	2.00	0.00	0.74	0.00
15.58	31.34	2.00	0.00	0.74	0.00	15.75	74.95	0.11	3.13	0.73	0.06
15.91	89.25	0.13	2.63	0.73	0.05	16.08	94.12	0.14	2.49	0.73	0.05
16.24	108.22	0.17	2.15	0.72	0.04	16.40	132.13	0.22	1.73	0.72	0.03
16.57	120.97	0.19	1.89	0.72	0.04	16.73	119.69	0.19	1.91	0.72	0.04
16.90	143.66	0.26	1.56	0.71	0.03	17.06	160.25	0.35	1.22	0.71	0.02
17.22	137.60	0.24	1.62	0.71	0.03	17.39	133.09	0.23	1.67	0.71	0.03
17.55	179.63	0.57	0.61	0.70	0.01	17.72	148.99	0.29	1.46	0.70	0.03

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)
17.88	126.30	0.21	1.75	0.70	0.03	18.05	109.14	0.17	2.04	0.69	0.04
18.21	53.23	2.00	0.00	0.69	0.00	18.37	52.99	2.00	0.00	0.69	0.00
18.54	99.02	2.00	0.00	0.69	0.00	18.70	116.32	2.00	0.00	0.68	0.00
18.87	132.70	2.00	0.00	0.68	0.00	19.03	206.49	2.00	0.00	0.68	0.00
19.19	205.16	1.58	0.13	0.67	0.00	19.36	176.01	0.52	0.66	0.67	0.01
19.52	167.64	0.42	0.89	0.67	0.02	19.69	201.76	1.34	0.23	0.67	0.00
19.85	236.13	2.00	0.00	0.66	0.00	20.01	280.31	2.00	0.00	0.66	0.00
20.18	289.45	2.00	0.00	0.66	0.00	20.34	332.21	2.00	0.00	0.66	0.00
20.51	287.33	2.00	0.00	0.65	0.00	20.67	289.15	2.00	0.00	0.65	0.00
20.83	270.63	2.00	0.00	0.65	0.00	21.00	248.37	2.00	0.00	0.64	0.00
21.16	246.03	2.00	0.00	0.64	0.00	21.33	207.43	1.80	0.05	0.64	0.00
21.49	197.68	1.12	0.28	0.64	0.01	21.65	184.57	0.68	0.46	0.63	0.01
21.82	206.00	1.67	0.09	0.63	0.00	21.98	247.89	2.00	0.00	0.63	0.00
22.15	289.57	2.00	0.00	0.62	0.00	22.31	280.10	2.00	0.00	0.62	0.00
22.47	481.55	2.00	0.00	0.62	0.00	22.64	476.65	2.00	0.00	0.62	0.00

Total estimated settlement: 1.87

Abbreviations

$Q_{tn,cs}$: Equivalent clean sand normalized cone resistance
FS: Factor of safety against liquefaction
e_v (%): Post-liquefaction volumentric strain
DF: e_v depth weighting factor
Settlement: Calculated settlement

:: Strength loss calculation Idriss & Boulanger (2008) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.16	6.68	12.60	3.97	50.09	2.70	N/A	N/A
0.33	13.63	25.73	2.03	52.27	2.32	N/A	N/A
0.49	19.38	36.58	1.56	56.96	2.15	N/A	N/A
0.66	19.66	37.10	1.54	57.21	2.14	N/A	N/A
0.82	16.18	30.50	1.71	52.17	2.22	N/A	N/A
0.98	13.13	24.72	1.00	24.72	2.27	N/A	N/A
1.15	11.01	20.71	1.00	20.71	2.31	N/A	N/A
1.31	9.80	18.40	1.00	18.40	2.32	N/A	N/A
1.48	8.87	16.64	2.35	39.16	2.41	N/A	N/A
1.64	8.62	16.14	2.64	42.62	2.47	N/A	N/A
1.80	8.72	16.31	3.00	49.01	2.54	N/A	N/A
1.97	10.08	18.87	3.16	59.65	2.57	N/A	N/A
2.13	12.46	23.36	2.86	66.80	2.52	0.05	0.64
2.30	13.69	25.66	3.01	77.22	2.55	0.06	0.65
2.46	13.22	24.76	3.53	87.29	2.63	0.06	7.18
2.63	11.22	20.97	4.73	99.22	2.79	0.06	5.66
2.79	12.67	23.68	4.55	107.61	2.77	0.06	5.98
2.95	15.17	28.39	4.02	114.05	2.70	0.07	6.72
3.12	17.23	32.26	3.71	119.74	2.66	0.07	7.19
3.28	15.52	29.01	4.22	122.39	2.73	0.07	6.10
3.45	12.34	22.99	5.18	119.10	2.85	0.07	4.58
3.61	9.05	16.75	6.58	110.27	2.99	0.07	3.18
3.77	7.27	13.37	7.50	100.27	3.07	0.07	2.42
3.94	6.81	12.48	7.36	91.91	3.05	0.07	2.16
4.10	6.85	12.55	6.86	86.03	3.01	0.07	2.09
4.27	6.87	12.57	6.51	81.80	2.98	0.06	2.01
4.43	6.90	12.61	6.27	79.07	2.96	0.06	1.94
4.59	6.76	12.32	6.31	77.68	2.96	0.06	1.83
4.76	5.91	10.70	7.06	75.59	3.03	0.07	1.53
4.92	4.72	8.45	8.47	71.59	3.14	0.07	1.17
5.09	3.93	6.93	9.70	67.23	3.23	0.06	0.93
5.25	4.09	7.22	9.19	66.36	3.20	0.06	0.94
5.41	5.59	10.03	7.09	71.06	3.03	0.06	1.26
5.58	8.07	14.71	5.49	80.75	2.88	0.06	1.80
5.74	10.93	20.09	4.64	93.17	2.78	0.06	2.38
5.91	16.16	29.96	3.45	103.27	2.62	0.06	3.45
6.07	18.58	34.53	3.25	112.09	2.59	0.08	0.69
6.23	18.26	33.90	3.38	114.48	2.61	0.07	3.68
6.40	14.32	26.44	4.29	113.51	2.74	0.06	2.79
6.56	10.61	19.40	5.29	102.63	2.86	0.07	1.99
6.73	7.67	13.83	6.42	88.83	2.97	0.07	1.39
6.89	4.86	8.50	8.36	71.06	3.13	0.06	0.83
7.05	3.34	5.61	10.27	57.61	3.27	0.06	0.54
7.22	2.93	4.82	10.12	48.78	3.26	0.06	0.45
7.38	2.72	4.42	10.15	44.82	3.26	0.06	0.41
7.55	2.67	4.31	9.80	42.30	3.24	0.06	0.39
7.71	2.86	4.66	8.69	40.45	3.16	0.06	0.41
7.87	3.20	5.29	7.86	41.59	3.09	0.06	0.46

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
8.04	4.17	7.09	6.32	44.82	2.96	0.06	0.61
8.20	4.92	8.50	5.53	47.00	2.88	0.06	0.71
8.37	5.29	9.19	5.22	47.97	2.85	0.06	0.76
8.53	6.41	11.30	5.10	57.60	2.84	0.05	0.91
8.69	13.28	24.26	3.46	83.86	2.62	0.05	1.92
8.86	22.34	41.36	2.84	117.41	2.51	0.08	0.71
9.02	32.38	58.68	2.56	149.96	2.46	0.08	0.76
9.19	37.67	68.09	2.61	177.93	2.47	0.10	0.77
9.35	43.44	77.31	2.49	192.18	2.44	0.10	0.79
9.51	47.61	83.33	2.35	196.18	2.41	0.11	0.80
9.68	47.03	81.97	2.42	198.14	2.42	0.11	0.80
9.84	44.24	77.29	2.59	200.40	2.46	0.10	0.79
10.01	39.11	68.95	2.92	201.65	2.53	0.10	0.78
10.17	37.82	66.25	2.98	197.17	2.54	0.09	0.77
10.34	38.64	66.93	2.91	195.05	2.53	0.09	0.77
10.50	44.05	74.87	2.70	202.21	2.49	0.10	0.79
10.66	48.95	82.23	2.62	215.54	2.47	0.12	0.80
10.83	50.93	85.06	2.66	225.98	2.48	0.11	0.80
10.99	49.18	82.04	2.80	229.84	2.51	0.11	0.80
11.16	47.79	79.27	2.86	226.61	2.52	0.11	0.80
11.32	46.28	76.43	2.95	225.42	2.53	0.11	0.79
11.48	46.56	76.26	2.95	224.79	2.53	0.10	0.79
11.65	45.49	74.25	3.06	227.01	2.55	0.11	0.79
11.81	43.50	70.81	3.20	226.30	2.58	0.10	0.78
11.98	39.77	64.54	3.35	216.24	2.60	0.10	4.68
12.14	37.91	60.97	3.35	204.00	2.60	0.09	4.42
12.30	36.63	58.30	3.29	191.87	2.59	0.09	0.75
12.47	35.41	56.06	3.38	189.43	2.61	0.09	4.04
12.63	33.91	53.45	3.50	186.91	2.63	0.09	3.83
12.80	33.79	52.81	3.47	183.33	2.62	0.09	3.79
12.96	34.27	53.09	3.43	182.15	2.62	0.09	3.81
13.12	33.15	51.19	3.58	183.33	2.64	0.09	3.65
13.29	30.91	47.71	3.85	183.93	2.68	0.08	3.37
13.45	28.17	43.35	4.10	177.58	2.71	0.08	3.04
13.62	26.81	40.85	4.06	165.82	2.71	0.08	2.86
13.78	26.10	39.35	3.97	156.06	2.70	0.08	2.76
13.94	26.21	39.10	3.85	150.70	2.68	0.08	2.75
14.11	26.73	39.54	3.78	149.38	2.67	0.08	2.78
14.27	27.61	40.47	3.68	148.75	2.65	0.08	2.86
14.44	28.23	41.05	3.62	148.76	2.65	0.08	2.90
14.60	28.20	40.75	3.65	148.55	2.65	0.08	2.87
14.76	27.55	39.64	3.76	149.10	2.67	0.08	2.78
14.93	26.79	38.37	3.88	148.96	2.68	0.08	2.68
15.09	26.09	37.19	3.99	148.37	2.70	0.08	2.59
15.26	26.91	37.86	3.72	140.67	2.66	0.07	2.65
15.42	26.86	37.40	3.58	134.00	2.64	0.08	2.63
15.58	27.90	38.44	3.37	129.72	2.61	0.07	2.72
15.75	30.94	42.24	3.18	134.33	2.58	0.07	0.71

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
15.91	36.13	48.96	3.01	147.38	2.55	0.09	0.73
16.08	43.86	58.99	2.83	167.06	2.51	0.09	0.76
16.24	53.83	71.76	2.65	189.88	2.48	0.10	0.78
16.40	60.00	79.73	2.69	214.75	2.48	0.13	0.80
16.57	62.57	83.08	2.87	238.08	2.52	0.12	0.80
16.73	65.77	86.79	2.86	248.18	2.52	0.12	0.81
16.90	76.08	98.73	2.48	244.99	2.44	0.14	0.83
17.06	81.10	104.02	2.32	240.80	2.40	0.17	0.83
17.22	79.29	101.21	2.37	239.50	2.41	0.14	0.83
17.39	84.94	107.10	2.18	233.58	2.37	0.13	0.84
17.55	88.27	110.31	2.09	230.95	2.34	0.21	0.84
17.72	86.04	107.16	2.17	232.86	2.36	0.15	0.84
17.88	67.71	85.19	2.80	238.44	2.51	0.12	0.81
18.05	55.50	70.03	3.32	232.78	2.60	0.11	0.78
18.21	49.57	62.21	3.49	216.92	2.63	0.10	4.31
18.37	47.58	59.34	3.53	209.65	2.63	0.10	4.11
18.54	51.91	63.92	3.13	200.14	2.57	0.10	0.77
18.70	62.11	75.51	2.71	204.42	2.49	0.11	0.79
18.87	93.96	111.01	1.80	199.45	2.25	0.13	0.84
19.03	120.42	140.39	1.58	221.34	2.16	0.35	0.88
19.19	131.10	152.59	1.63	249.29	2.19	0.33	0.89
19.36	118.26	138.41	1.93	266.46	2.29	0.20	0.87
19.52	118.19	137.79	1.98	272.38	2.31	0.18	0.87
19.69	140.95	161.66	1.65	266.97	2.19	0.31	0.90
19.85	178.12	201.27	1.43	287.50	2.09	0.81	0.93
20.01	205.32	230.89	1.42	327.91	2.08	0.95	0.95
20.18	229.73	257.47	1.44	370.82	2.09	0.97	0.97
20.34	231.17	258.55	1.50	387.54	2.12	0.97	0.97
20.51	235.07	260.96	1.45	378.44	2.10	0.97	0.97
20.67	227.44	249.56	1.33	332.96	2.03	0.96	0.96
20.83	223.34	242.62	1.26	304.99	1.97	0.96	0.96
21.00	205.97	222.82	1.27	282.69	1.98	0.95	0.95
21.16	175.79	191.67	1.54	294.26	2.14	0.90	0.92
21.33	149.14	163.49	1.92	313.75	2.29	0.32	0.90
21.49	128.21	140.57	2.25	315.67	2.38	0.27	0.88
21.65	128.39	139.78	2.17	303.80	2.36	0.23	0.88
21.82	145.20	156.43	1.87	293.04	2.28	0.32	0.89
21.98	178.45	190.68	1.69	321.84	2.21	0.82	0.92
22.15	212.43	225.24	1.55	349.48	2.15	0.95	0.95
22.31	309.44	323.44	1.26	407.18	1.97	1.01	1.01
22.47	397.85	410.99	1.13	463.08	1.83	1.05	1.05
22.64	478.59	489.84	1.05	516.41	1.72	1.08	1.08

Abbreviations

q_t:	Total cone resistance
K_c:	Cone resistance correction factor due to fines
$Q_{tn,cs}$:	Adjusted and corrected cone resistance due to fines
I_c:	Soil behavior type index
$S_{u(liq)}/\sigma'_v$:	Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$:	Calculated peak undrained strength ratio

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Berkeley, CA
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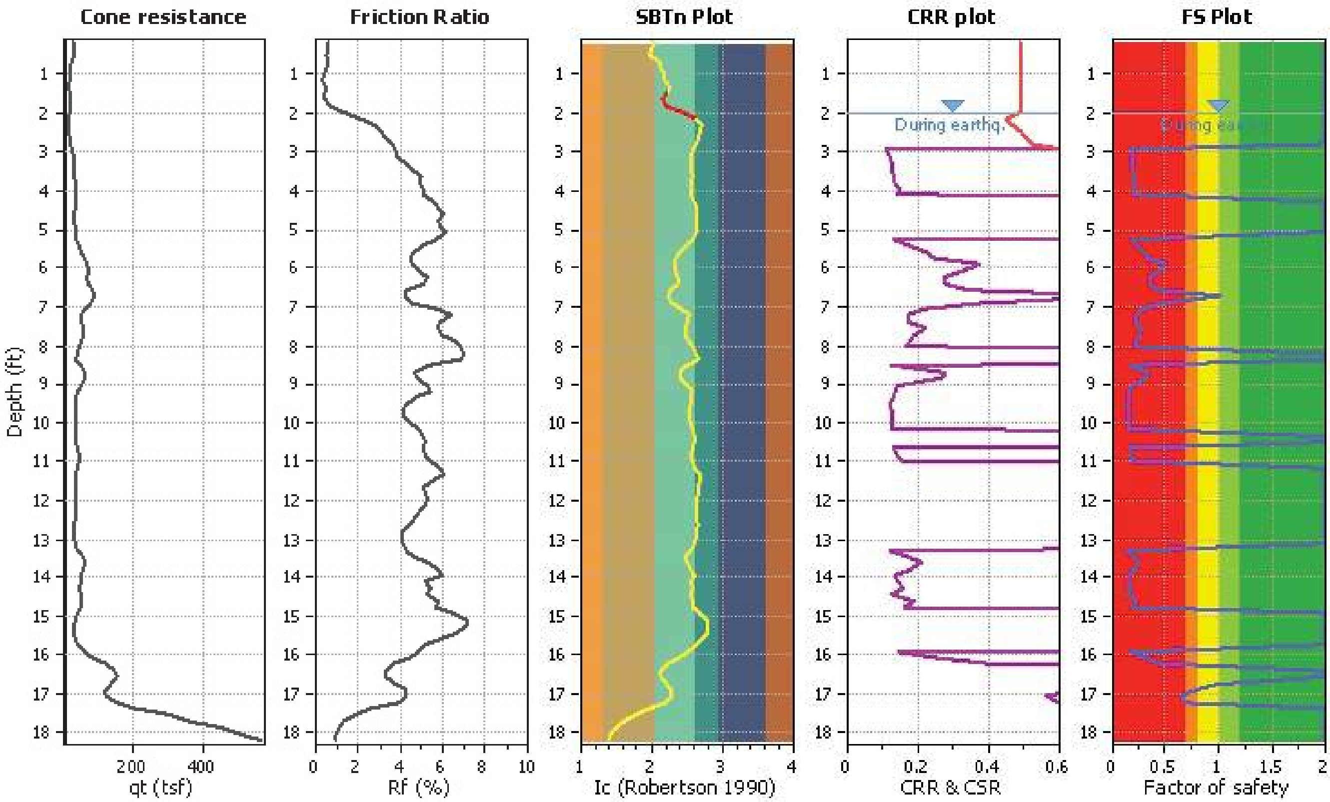
LIQUEFACTION ANALYSIS REPORT

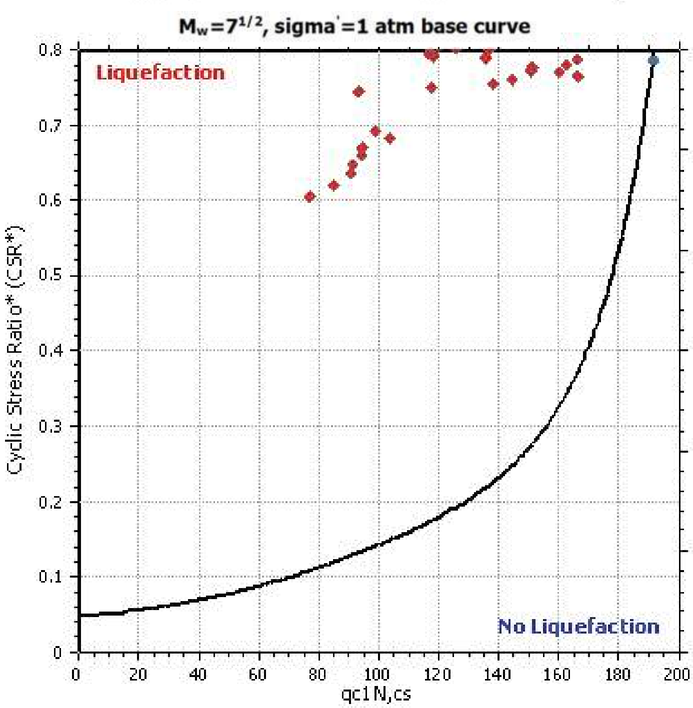
Project title : Terra Linda High School **Location : San Rafael, CA**

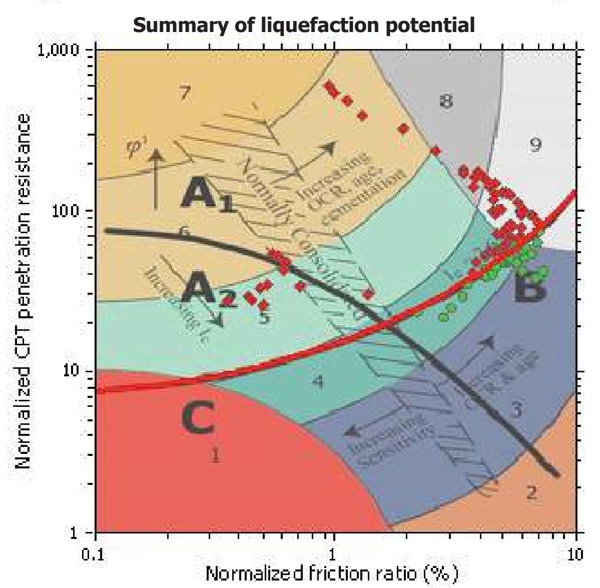
CPT file : CPT-04

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	9.00 ft	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

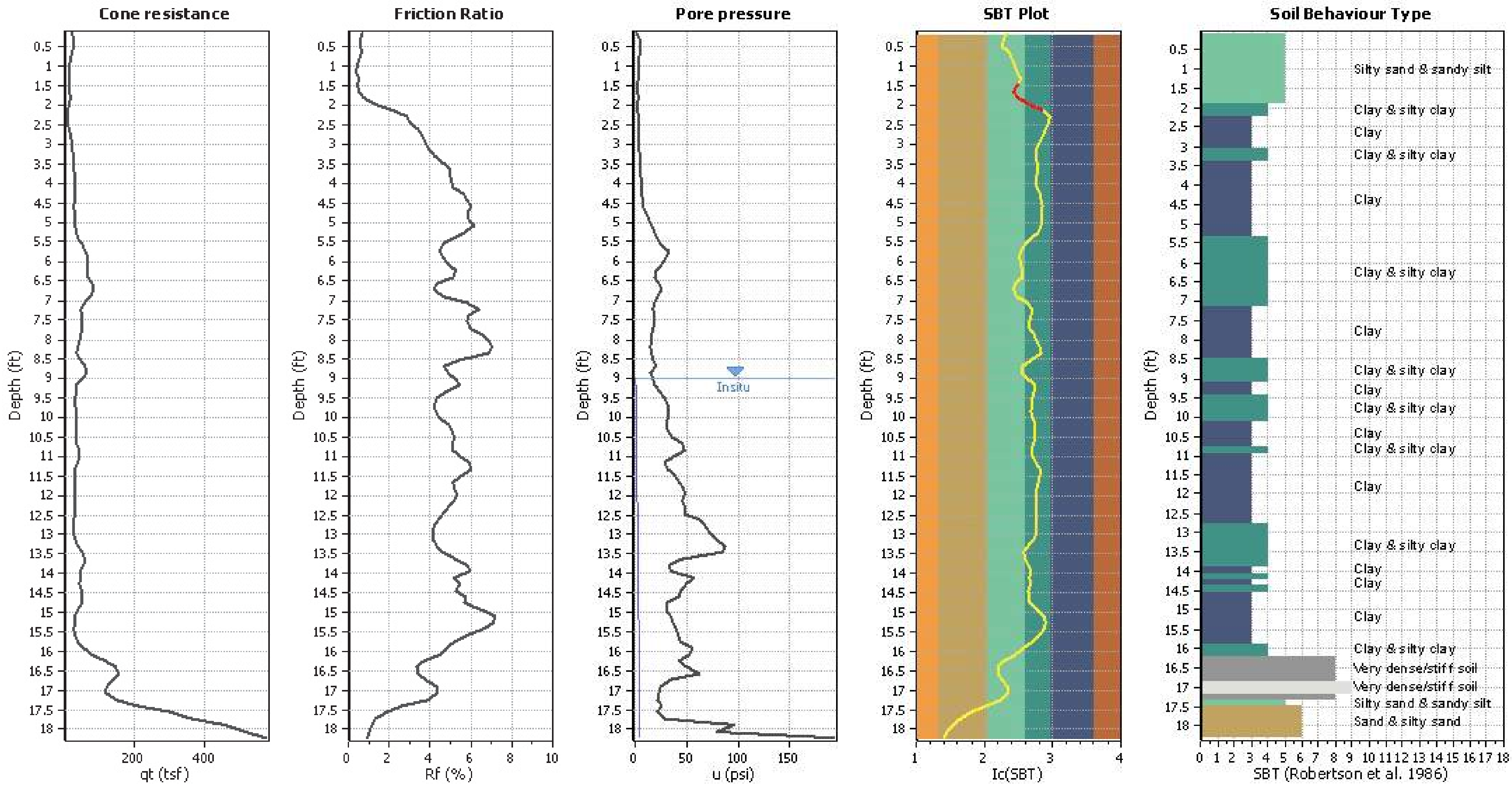






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



Input parameters and analysis data

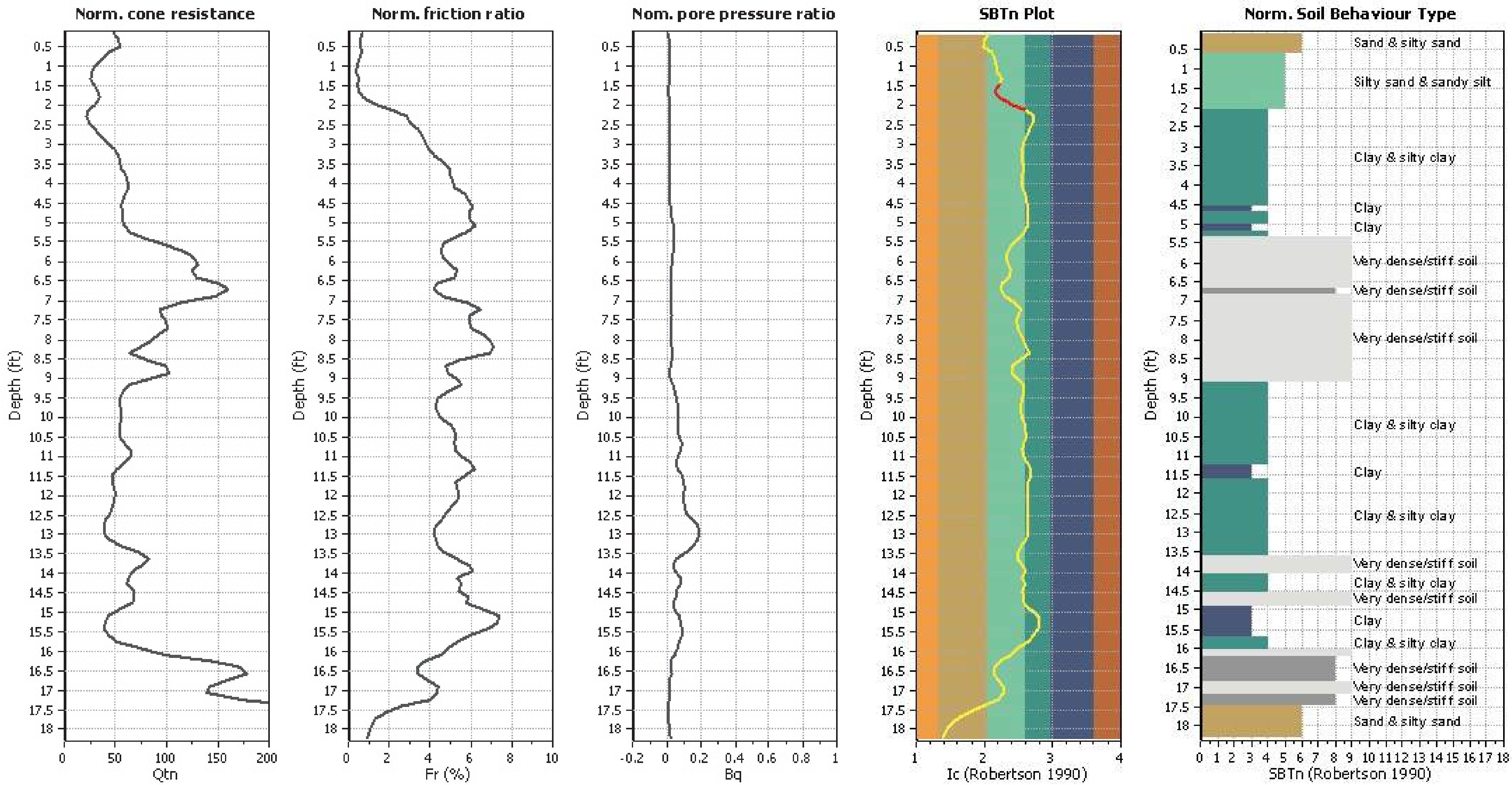
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to
- 9. Very stiff fine grained

Project file: \\A3geo\a3geo\A3GEO Projects\1150 - San Rafael City Schools\1150-1B Terra Linda HS\6-Working Files\Calculations\Liquefaction\2018_0117_A3GEO_TLHS New Gymnasium Liquefaction.clq

CPT basic interpretation plots (normaliz



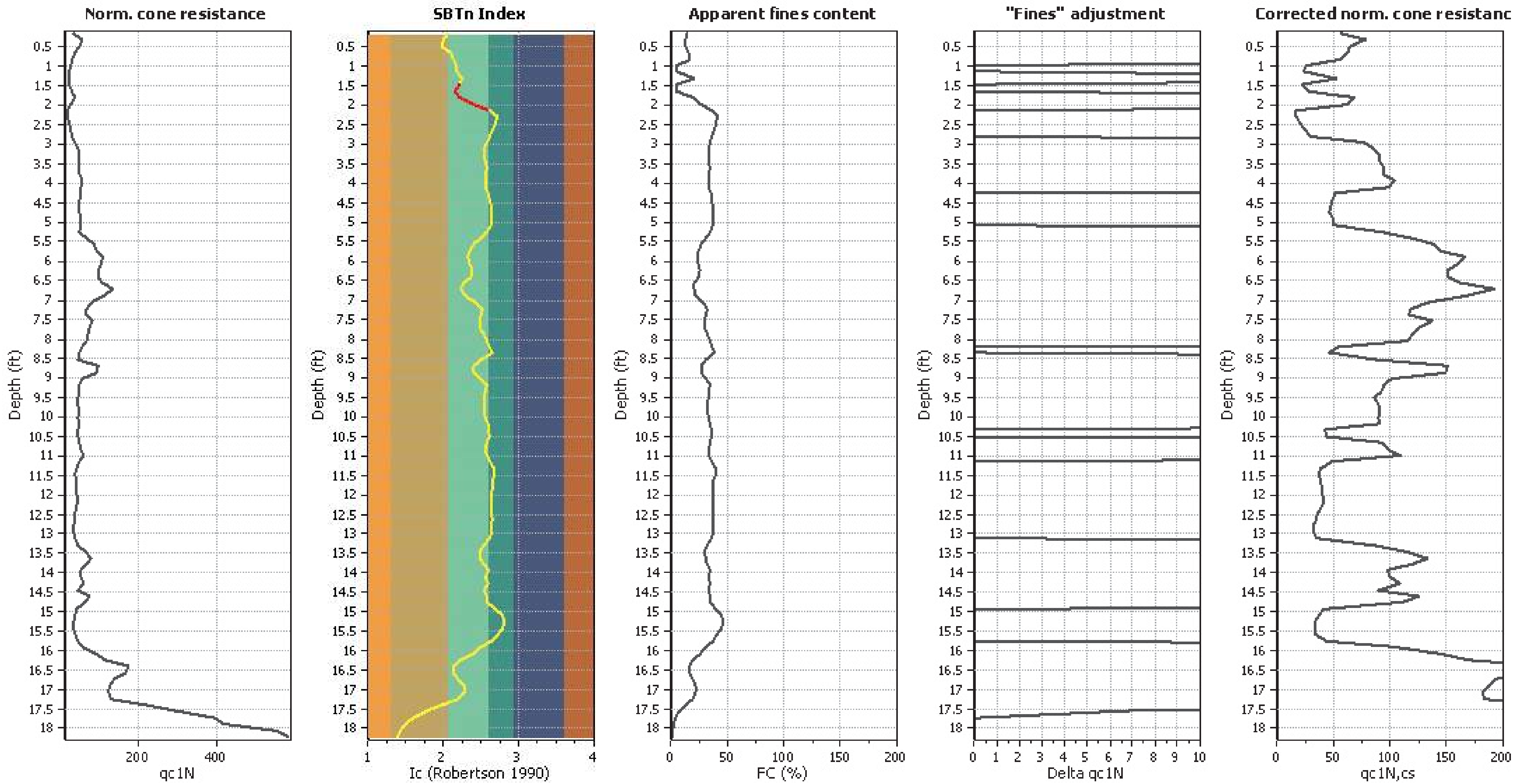
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

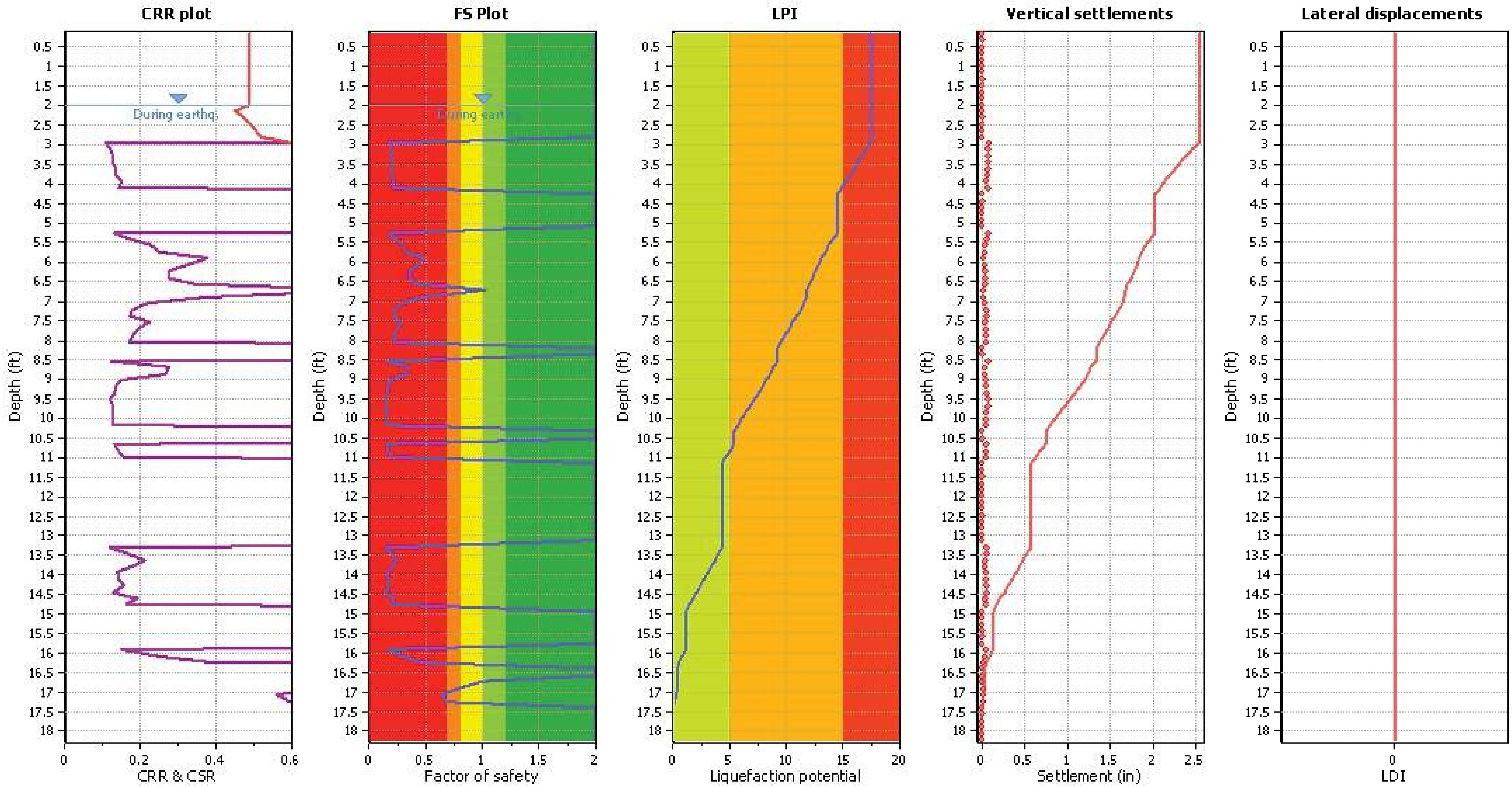
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

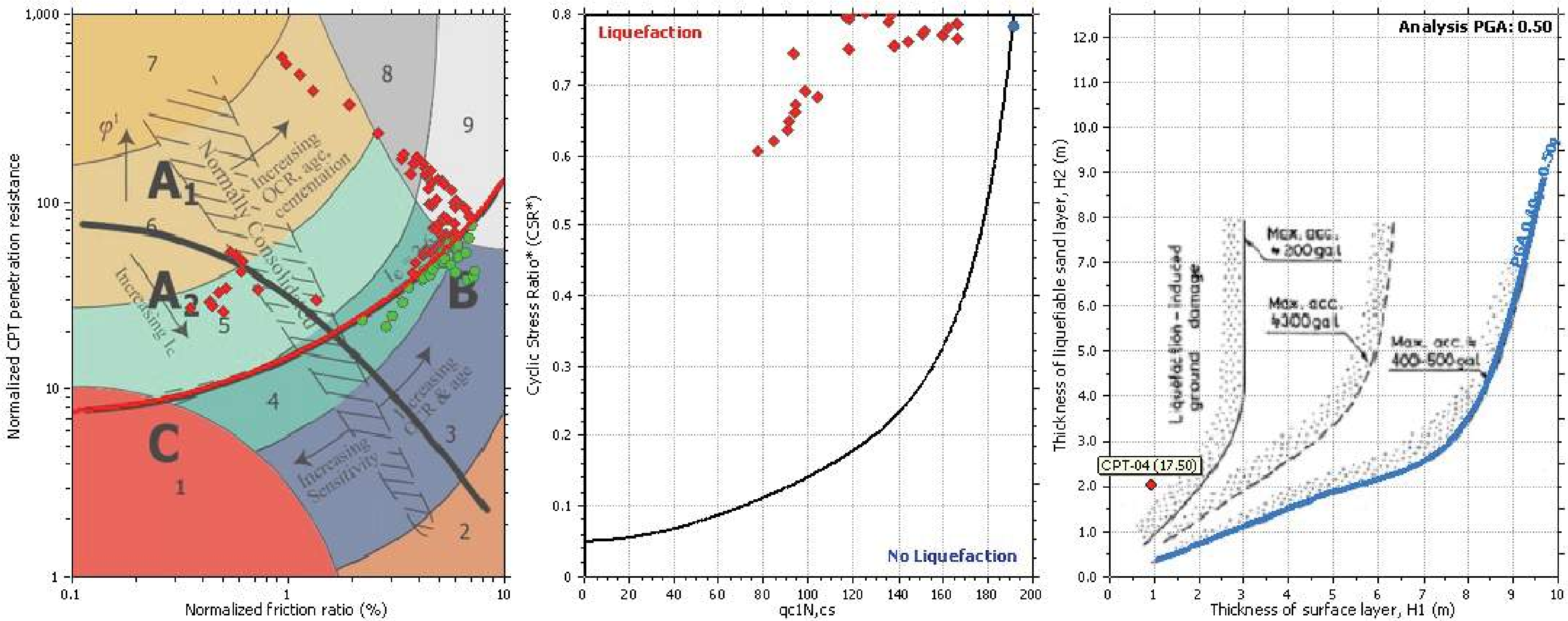
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

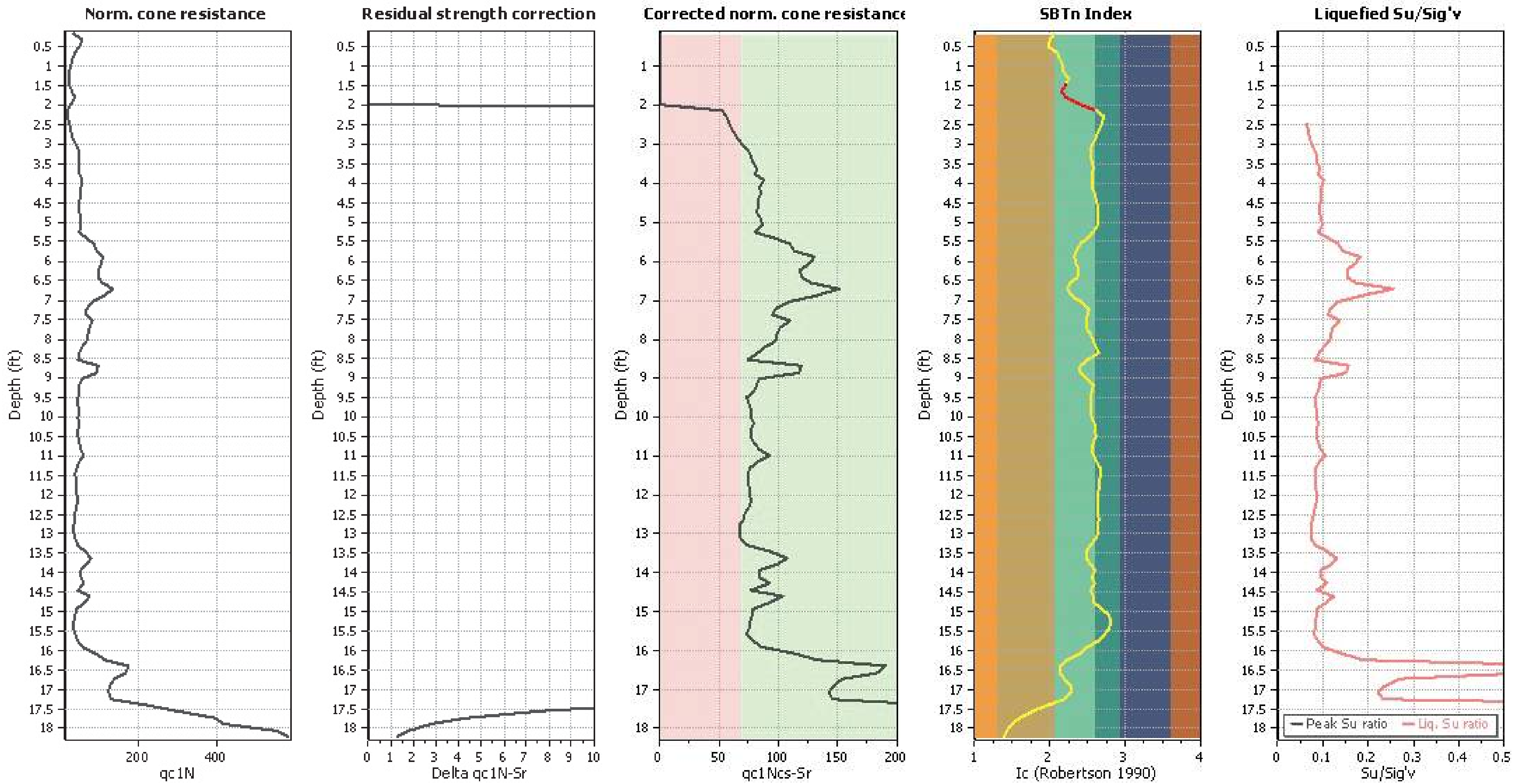
Liquefaction analysis summary plo



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

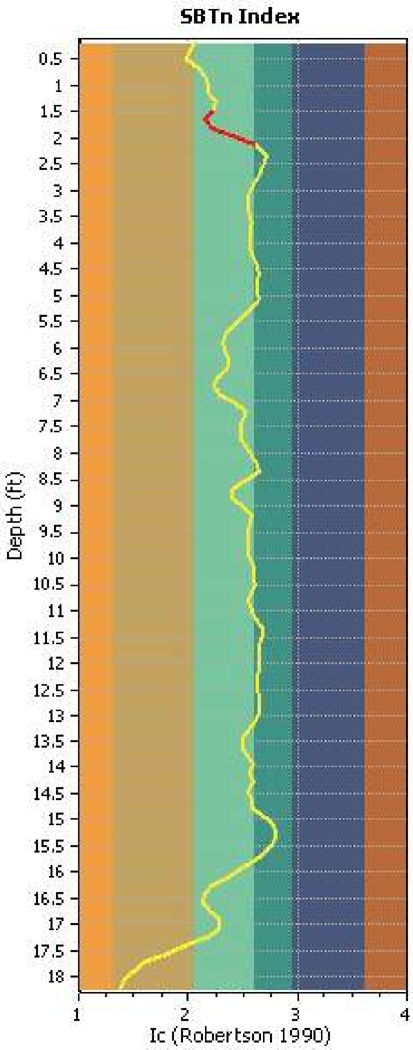
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	9.00 ft	Fill height:	N/A	Limit depth:	N/A

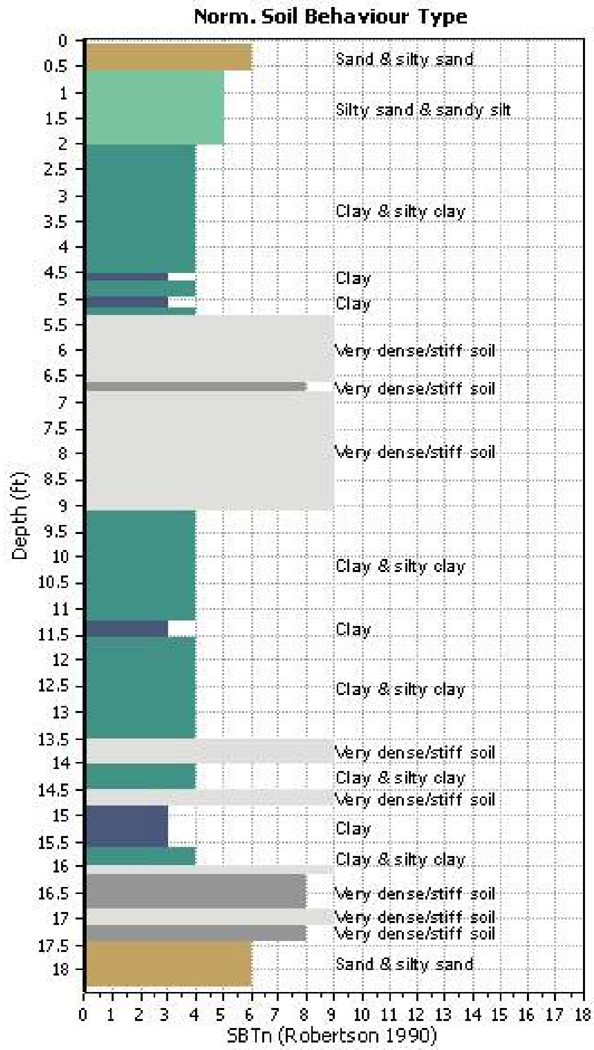
TRANSITION LAYER DETECTION ALGORITHM REPORT
Summary Details & Plots

Short description

The software will delete data when the cone is in transition from either clay to sand or vise-versa. To do this the software requires a range of I_c values over which the transition will be defined (typically somewhere between $1.80 < I_c < 3.0$) and a rate of change of I_c. Transitions typically occur when the rate of change of I_c is fast (i.e. delta I_c is small).

The SBT_n plot below, displays in red the detected transition layers based on the parameters listed below the graphs.





Transition layer algorithm properties		**General statistics**	
I_c minimum check value:	1.70	Total points in CPT file:	111
I_c maximum check value:	3.00	Total points excluded:	5
I_c change ratio value:	0.0250	Exclusion percentage:	4.50%
Minimum number of points in layer:	5	Number of layers detected:	1

Transition layer No	Number of points	Depth	SBT_n number	SBT_n description
Transition layer 1	5	Start depth: 1.64 (ft)	5	Silty sand & sandy silt
		End depth: 2.30 (ft)	4	Clay & silty clay

Start depth: Depth where the transition layer begins
End depth: Depth where the transition layer ends

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.16	20.75	0.15	1.89	14.50	104.64
2	0.33	34.59	0.17	4.02	13.15	105.05
3	0.49	27.96	0.17	4.19	12.56	104.78
4	0.66	22.54	0.13	4.11	15.74	103.42
5	0.82	17.20	0.12	3.20	17.09	100.25
6	0.98	15.72	0.04	2.83	5.00	97.32
7	1.15	14.04	0.05	3.30	5.00	94.95
8	1.31	13.26	0.07	2.20	20.97	96.97
9	1.48	13.48	0.09	1.73	5.00	96.98
10	1.64	17.34	0.04	1.61	5.00	99.09
11	1.80	21.45	0.12	2.38	19.53	102.50
12	1.97	15.80	0.23	2.07	26.76	105.87
13	2.13	10.74	0.30	2.00	36.41	106.91
14	2.30	10.65	0.28	2.12	41.53	107.89
15	2.46	12.61	0.38	2.35	40.24	109.71
16	2.63	15.46	0.52	2.73	38.53	112.23
17	2.79	18.40	0.67	2.65	36.49	114.48
18	2.95	21.90	0.82	2.67	34.42	116.39
19	3.12	25.67	0.98	2.99	32.88	118.01
20	3.28	28.30	1.14	3.61	32.82	119.43
21	3.45	28.64	1.35	3.93	33.37	120.53
22	3.61	29.92	1.48	4.08	34.40	121.32
23	3.77	29.92	1.57	4.10	33.47	121.94
24	3.94	34.54	1.63	5.10	33.48	122.31
25	4.10	32.13	1.69	5.51	33.40	122.61
26	4.27	31.94	1.74	6.00	35.50	122.84
27	4.43	30.06	1.87	6.73	36.53	122.85
28	4.59	29.53	1.75	7.16	37.51	122.77
29	4.76	29.06	1.74	9.40	36.81	122.65
30	4.92	31.01	1.75	12.30	36.74	122.95
31	5.09	31.35	1.93	15.00	37.43	123.34
32	5.25	29.42	2.02	17.77	34.60	123.79
33	5.41	41.33	1.90	21.79	30.44	124.83
34	5.58	52.63	2.42	24.55	26.51	126.14
35	5.74	58.25	2.75	33.13	24.11	127.81
36	5.91	73.46	3.17	29.64	23.56	128.82
37	6.07	69.52	3.39	25.15	24.20	129.57
38	6.23	63.95	3.66	20.29	25.60	129.70
39	6.40	65.35	3.49	18.07	24.89	129.80
40	6.56	75.98	3.43	22.60	21.09	130.01
41	6.73	98.18	3.43	25.35	20.21	130.35
42	6.89	79.45	3.77	20.88	22.10	130.28
43	7.05	57.05	3.60	17.68	27.69	129.44
44	7.22	45.89	3.10	16.93	31.80	128.31
45	7.38	45.75	2.89	17.77	30.39	127.84
46	7.55	58.95	2.97	18.38	29.62	128.11
47	7.71	52.35	3.31	17.17	29.78	128.49
48	7.87	48.99	3.32	15.85	32.21	128.40

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	8.04	46.67	3.10	14.99	34.27	127.80
50	8.20	38.59	2.84	14.44	36.40	126.77
51	8.37	33.22	2.44	15.97	37.98	125.29
52	8.53	31.77	1.88	16.61	30.82	126.33
53	8.69	74.02	3.17	19.58	26.46	127.77
54	8.86	72.60	3.34	13.60	26.61	128.53
55	9.02	40.88	2.65	16.27	30.21	126.90
56	9.19	36.41	1.90	18.65	34.43	124.42
57	9.35	34.98	1.64	23.53	33.70	122.58
58	9.51	31.32	1.41	27.54	32.74	121.61
59	9.68	33.67	1.33	31.31	32.32	121.29
60	9.84	34.62	1.45	30.64	32.34	121.68
61	10.01	33.89	1.61	31.15	33.15	122.20
62	10.17	34.62	1.64	29.50	34.79	122.64
63	10.34	32.44	1.78	31.66	35.45	122.81
64	10.50	33.19	1.74	35.06	35.69	123.14
65	10.66	35.99	1.84	44.46	34.44	123.83
66	10.83	41.11	2.15	47.99	33.03	125.07
67	10.99	47.65	2.52	38.77	33.88	125.69
68	11.16	38.20	2.38	28.43	36.20	125.33
69	11.32	30.45	2.01	30.54	39.13	123.87
70	11.48	29.28	1.60	38.77	39.40	122.53
71	11.65	29.89	1.53	42.98	37.78	122.02
72	11.81	31.88	1.63	46.69	37.62	122.43
73	11.98	32.22	1.82	47.24	37.46	122.92
74	12.14	33.45	1.81	45.13	37.25	122.82
75	12.30	32.13	1.55	48.26	37.03	122.10
76	12.47	28.97	1.39	47.66	37.05	121.06
77	12.63	27.66	1.25	62.99	37.70	120.03
78	12.80	25.28	1.10	67.09	37.49	119.21
79	12.96	25.48	1.04	72.20	37.28	119.10
80	13.12	27.69	1.20	77.55	35.81	120.31
81	13.29	34.84	1.55	87.72	32.51	123.23
82	13.45	53.97	2.40	84.88	29.98	126.55
83	13.62	67.59	3.43	45.49	30.24	128.72
84	13.78	57.80	3.67	32.93	32.69	128.86
85	13.94	43.18	2.80	34.07	35.02	127.64
86	14.11	44.63	2.33	56.48	33.60	126.16
87	14.27	50.81	2.17	49.58	34.88	126.16
88	14.44	38.14	2.89	43.60	32.87	127.16
89	14.60	62.75	3.06	41.73	34.11	127.95
90	14.76	53.38	3.06	29.98	34.22	127.60
91	14.93	34.90	2.54	29.10	39.75	126.35
92	15.09	31.46	2.28	33.57	45.18	124.82
93	15.26	28.36	2.08	36.71	46.12	124.10
94	15.42	28.86	2.02	39.37	45.47	123.39
95	15.58	29.25	1.74	41.30	41.66	123.56
96	15.75	38.42	2.00	43.91	36.82	124.61

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	15.91	49.97	2.49	54.46	30.63	127.59
98	16.08	82.44	3.79	52.02	25.89	130.28
99	16.24	105.96	4.44	41.73	19.82	132.79
100	16.40	166.47	5.01	48.90	17.16	134.00
101	16.57	159.87	5.19	61.73	16.84	134.50
102	16.73	128.05	5.22	34.16	19.06	134.26
103	16.90	118.90	5.07	24.17	21.76	134.08
104	17.06	114.51	5.42	22.00	21.95	133.86
105	17.22	121.14	4.86	21.75	18.78	135.48
106	17.39	214.65	7.40	25.10	12.26	135.69
107	17.55	288.14	4.06	20.72	7.72	136.90
108	17.72	389.52	5.63	27.57	4.34	136.02
109	17.88	410.27	4.50	95.89	2.83	137.08
110	18.05	548.86	5.14	79.43	1.77	137.28
111	18.21	576.04	5.48	193.16	1.32	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.16	0.01	0.00	0.01	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
2	0.33	0.02	0.00	0.02	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
3	0.49	0.03	0.00	0.03	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
4	0.66	0.03	0.00	0.03	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
5	0.82	0.04	0.00	0.04	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
6	0.98	0.05	0.00	0.05	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
7	1.15	0.06	0.00	0.06	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
8	1.31	0.07	0.00	0.07	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
9	1.48	0.07	0.00	0.07	1.00	0.325	0.86	0.376	1.00	1.30	2.000	No
10	1.64	0.08	0.00	0.08	1.00	0.325	0.86	0.376	1.00	1.30	2.000	Yes
11	1.80	0.09	0.00	0.09	1.00	0.325	0.86	0.376	1.00	1.30	2.000	Yes
12	1.97	0.10	0.00	0.10	1.00	0.325	0.86	0.376	1.00	1.30	2.000	Yes
13	2.13	0.11	0.00	0.10	1.00	0.338	0.86	0.391	1.00	1.30	2.000	Yes
14	2.30	0.12	0.01	0.11	1.00	0.353	0.86	0.408	1.00	1.30	2.000	Yes
15	2.46	0.13	0.01	0.11	1.00	0.367	0.86	0.425	1.00	1.30	0.488	No
16	2.63	0.14	0.02	0.12	1.00	0.380	0.86	0.439	1.00	1.30	0.505	No
17	2.79	0.14	0.02	0.12	1.00	0.392	0.86	0.453	1.00	1.30	0.521	No
18	2.95	0.15	0.03	0.12	1.00	0.403	0.86	0.466	1.00	1.30	0.606	No
19	3.12	0.16	0.03	0.13	1.00	0.413	0.86	0.478	1.00	1.30	0.621	No
20	3.28	0.17	0.04	0.13	1.00	0.422	0.86	0.489	1.00	1.30	0.635	No
21	3.45	0.18	0.05	0.14	1.00	0.431	0.86	0.499	1.00	1.30	0.648	No
22	3.61	0.19	0.05	0.14	1.00	0.439	0.86	0.508	1.00	1.30	0.660	No
23	3.77	0.20	0.06	0.15	1.00	0.446	0.86	0.516	1.00	1.30	0.671	No
24	3.94	0.21	0.06	0.15	1.00	0.453	0.86	0.525	1.00	1.30	0.682	No
25	4.10	0.22	0.07	0.16	1.00	0.460	0.86	0.532	1.00	1.30	0.692	No
26	4.27	0.23	0.07	0.16	1.00	0.466	0.86	0.539	1.00	1.30	0.619	No
27	4.43	0.24	0.08	0.17	1.00	0.471	0.86	0.545	1.00	1.30	0.627	No
28	4.59	0.25	0.08	0.17	1.00	0.477	0.86	0.552	1.00	1.30	0.634	No
29	4.76	0.26	0.09	0.18	1.00	0.482	0.86	0.557	1.00	1.30	0.640	No
30	4.92	0.27	0.09	0.18	1.00	0.486	0.86	0.563	1.00	1.30	0.647	No
31	5.09	0.28	0.10	0.19	1.00	0.491	0.86	0.568	1.00	1.30	0.653	No
32	5.25	0.29	0.10	0.19	1.00	0.495	0.86	0.573	1.00	1.30	0.745	No
33	5.41	0.30	0.11	0.20	1.00	0.499	0.86	0.577	1.00	1.30	0.750	No
34	5.58	0.31	0.11	0.20	1.00	0.502	0.86	0.581	1.00	1.30	0.756	No
35	5.74	0.33	0.12	0.21	1.00	0.506	0.86	0.585	1.00	1.30	0.761	No
36	5.91	0.34	0.12	0.21	1.00	0.509	0.86	0.589	1.00	1.30	0.765	No
37	6.07	0.35	0.13	0.22	1.00	0.511	0.86	0.592	1.00	1.30	0.769	No
38	6.23	0.36	0.13	0.23	1.00	0.514	0.86	0.595	1.00	1.30	0.773	No
39	6.40	0.37	0.14	0.23	1.00	0.516	0.86	0.598	1.00	1.30	0.777	No
40	6.56	0.38	0.14	0.24	1.00	0.519	0.86	0.600	1.00	1.30	0.780	No
41	6.73	0.39	0.15	0.24	1.00	0.521	0.86	0.603	1.00	1.30	0.784	No
42	6.89	0.40	0.15	0.25	1.00	0.523	0.86	0.605	1.00	1.30	0.787	No
43	7.05	0.41	0.16	0.25	1.00	0.525	0.86	0.608	1.00	1.30	0.790	No
44	7.22	0.42	0.16	0.26	0.99	0.527	0.86	0.610	1.00	1.30	0.793	No
45	7.38	0.43	0.17	0.26	0.99	0.529	0.86	0.612	1.00	1.30	0.796	No
46	7.55	0.44	0.17	0.27	0.99	0.531	0.86	0.615	1.00	1.30	0.799	No
47	7.71	0.45	0.18	0.27	0.99	0.533	0.86	0.617	1.00	1.30	0.802	No
48	7.87	0.46	0.18	0.28	0.99	0.535	0.86	0.619	1.00	1.30	0.804	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
49	8.04	0.47	0.19	0.29	0.99	0.536	0.86	0.621	1.00	1.30	0.807	No
50	8.20	0.48	0.19	0.29	0.99	0.538	0.86	0.622	1.00	1.30	0.715	No
51	8.37	0.49	0.20	0.30	0.99	0.540	0.86	0.624	1.00	1.30	0.717	No
52	8.53	0.50	0.20	0.30	0.99	0.541	0.86	0.626	1.00	1.30	0.814	No
53	8.69	0.51	0.21	0.31	0.99	0.543	0.86	0.628	1.00	1.30	0.816	No
54	8.86	0.53	0.21	0.31	0.99	0.544	0.86	0.629	1.00	1.30	0.818	No
55	9.02	0.54	0.22	0.32	0.99	0.545	0.86	0.631	1.00	1.30	0.820	No
56	9.19	0.55	0.22	0.32	0.99	0.547	0.86	0.633	1.00	1.30	0.822	No
57	9.35	0.56	0.23	0.33	0.99	0.548	0.86	0.634	1.00	1.30	0.825	No
58	9.51	0.57	0.23	0.33	0.99	0.550	0.86	0.636	1.00	1.30	0.827	No
59	9.68	0.58	0.24	0.34	0.99	0.551	0.86	0.638	1.00	1.30	0.829	No
60	9.84	0.59	0.24	0.34	0.99	0.552	0.86	0.639	1.00	1.30	0.831	No
61	10.01	0.60	0.25	0.35	0.99	0.554	0.86	0.641	1.00	1.30	0.833	No
62	10.17	0.61	0.25	0.35	0.99	0.555	0.86	0.642	1.00	1.30	0.835	No
63	10.34	0.62	0.26	0.36	0.99	0.556	0.86	0.644	1.00	1.30	0.740	No
64	10.50	0.63	0.27	0.36	0.99	0.557	0.86	0.645	1.00	1.30	0.741	No
65	10.66	0.64	0.27	0.37	0.99	0.558	0.86	0.646	1.00	1.30	0.840	No
66	10.83	0.65	0.28	0.37	0.99	0.559	0.86	0.647	1.00	1.30	0.842	No
67	10.99	0.66	0.28	0.38	0.99	0.560	0.86	0.648	1.00	1.30	0.843	No
68	11.16	0.67	0.29	0.38	0.99	0.561	0.86	0.649	1.00	1.30	0.746	No
69	11.32	0.68	0.29	0.39	0.99	0.562	0.86	0.651	1.00	1.30	0.747	No
70	11.48	0.69	0.30	0.39	0.99	0.563	0.86	0.652	1.00	1.30	0.749	No
71	11.65	0.70	0.30	0.40	0.99	0.564	0.86	0.653	1.00	1.30	0.750	No
72	11.81	0.71	0.31	0.40	0.99	0.565	0.86	0.654	1.00	1.30	0.751	No
73	11.98	0.72	0.31	0.41	0.99	0.566	0.86	0.655	1.00	1.30	0.752	No
74	12.14	0.73	0.32	0.41	0.99	0.567	0.86	0.656	1.00	1.30	0.754	No
75	12.30	0.74	0.32	0.42	0.99	0.568	0.86	0.657	1.00	1.30	0.755	No
76	12.47	0.75	0.33	0.42	0.99	0.568	0.86	0.658	1.00	1.30	0.756	No
77	12.63	0.76	0.33	0.43	0.98	0.569	0.86	0.659	1.00	1.30	0.757	No
78	12.80	0.77	0.34	0.43	0.98	0.570	0.86	0.660	1.00	1.30	0.758	No
79	12.96	0.78	0.34	0.44	0.98	0.571	0.86	0.661	1.00	1.30	0.759	No
80	13.12	0.79	0.35	0.44	0.98	0.572	0.86	0.662	1.00	1.30	0.761	No
81	13.29	0.80	0.35	0.44	0.98	0.573	0.86	0.663	1.00	1.30	0.861	No
82	13.45	0.81	0.36	0.45	0.98	0.573	0.86	0.663	1.00	1.30	0.862	No
83	13.62	0.82	0.36	0.46	0.98	0.574	0.86	0.664	1.00	1.30	0.863	No
84	13.78	0.83	0.37	0.46	0.98	0.574	0.86	0.664	1.00	1.30	0.863	No
85	13.94	0.84	0.37	0.47	0.98	0.574	0.86	0.664	1.00	1.30	0.864	No
86	14.11	0.85	0.38	0.47	0.98	0.575	0.86	0.665	1.00	1.30	0.864	No
87	14.27	0.86	0.38	0.48	0.98	0.575	0.86	0.665	1.00	1.30	0.865	No
88	14.44	0.87	0.39	0.48	0.98	0.575	0.86	0.666	1.00	1.30	0.866	No
89	14.60	0.88	0.39	0.49	0.98	0.576	0.86	0.666	1.00	1.30	0.866	No
90	14.76	0.89	0.40	0.49	0.98	0.576	0.86	0.667	1.00	1.30	0.867	No
91	14.93	0.90	0.40	0.50	0.98	0.576	0.86	0.667	1.00	1.30	0.766	No
92	15.09	0.91	0.41	0.50	0.98	0.577	0.86	0.668	1.00	1.30	0.767	No
93	15.26	0.92	0.41	0.51	0.98	0.577	0.86	0.668	1.00	1.30	0.768	No
94	15.42	0.93	0.42	0.51	0.98	0.578	0.86	0.669	1.00	1.30	0.768	No
95	15.58	0.94	0.42	0.52	0.98	0.578	0.86	0.669	1.00	1.30	0.769	No
96	15.75	0.95	0.43	0.52	0.98	0.579	0.86	0.669	1.00	1.30	0.769	No

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data :: (continued)

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
97	15.91	0.96	0.43	0.53	0.98	0.579	0.86	0.670	1.00	1.30	0.871	No
98	16.08	0.97	0.44	0.53	0.98	0.579	0.86	0.670	1.00	1.30	0.871	No
99	16.24	0.98	0.44	0.54	0.98	0.579	0.86	0.670	1.00	1.30	0.871	No
100	16.40	1.00	0.45	0.55	0.98	0.579	0.86	0.670	1.00	1.30	0.871	No
101	16.57	1.01	0.45	0.55	0.98	0.579	0.86	0.670	1.00	1.30	0.871	No
102	16.73	1.02	0.46	0.56	0.98	0.579	0.86	0.670	1.00	1.30	0.870	No
103	16.90	1.03	0.46	0.56	0.98	0.579	0.86	0.670	1.00	1.30	0.870	No
104	17.06	1.04	0.47	0.57	0.98	0.579	0.86	0.669	1.00	1.30	0.870	No
105	17.22	1.05	0.47	0.58	0.98	0.578	0.86	0.669	1.00	1.30	0.870	No
106	17.39	1.06	0.48	0.58	0.97	0.578	0.86	0.669	1.00	1.30	0.870	No
107	17.55	1.07	0.49	0.59	0.97	0.578	0.86	0.669	1.00	1.30	0.870	No
108	17.72	1.08	0.49	0.59	0.97	0.578	0.86	0.669	1.00	1.30	0.869	No
109	17.88	1.10	0.50	0.60	0.97	0.578	0.86	0.669	1.00	1.30	0.869	No
110	18.05	1.11	0.50	0.61	0.97	0.578	0.86	0.668	1.00	1.30	0.869	No
111	18.21	1.12	0.51	0.61	0.97	0.577	0.86	0.668	1.00	1.30	0.869	No

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.16	25.40	14.50	2.06	0.62	1.70	33.34	23.13	56.46	4.000	No	No	2.00
2	0.33	27.82	13.15	2.01	0.55	1.70	55.58	22.81	78.39	4.000	No	No	2.00
3	0.49	28.42	12.56	1.99	0.59	1.70	44.93	19.05	63.98	4.000	No	No	2.00
4	0.66	22.62	15.74	2.10	0.59	1.70	36.21	26.81	63.02	4.000	No	No	2.00
5	0.82	18.53	17.09	2.14	0.62	1.70	27.63	27.62	55.25	4.000	No	No	2.00
6	0.98	15.70	5.00	2.18	0.75	1.70	25.25	0.01	25.26	4.000	No	No	2.00
7	1.15	14.38	5.00	2.18	0.77	1.70	22.55	0.01	22.57	4.000	No	No	2.00
8	1.31	13.63	20.97	2.26	0.63	1.70	21.30	31.16	52.46	4.000	No	No	2.00
9	1.48	14.72	5.00	2.21	0.78	1.70	21.66	0.01	21.67	4.000	No	No	2.00
10	1.64	17.45	5.00	2.15	0.74	1.70	27.86	0.01	27.87	4.000	Yes	No	2.00
11	1.80	18.22	19.53	2.22	0.58	1.70	34.46	33.22	67.67	4.000	Yes	No	2.00
12	1.97	16.03	26.76	2.41	0.60	1.70	25.38	36.32	61.71	4.000	Yes	No	2.00
13	2.13	12.43	36.41	2.62	0.63	1.70	17.25	0.00	17.25	4.000	Yes	Yes	2.00
14	2.30	11.37	41.53	2.72	0.63	1.70	17.12	0.00	17.12	4.000	Yes	Yes	2.00
15	2.46	12.94	40.24	2.70	0.61	1.70	20.26	0.00	20.26	4.000	No	Yes	2.00
16	2.63	15.53	38.53	2.66	0.59	1.70	24.85	0.00	24.85	4.000	No	Yes	2.00
17	2.79	18.63	36.49	2.62	0.57	1.70	29.56	0.00	29.56	4.000	No	Yes	2.00
18	2.95	22.03	34.42	2.58	0.55	1.70	35.18	41.75	76.93	0.109	No	No	0.18
19	3.12	25.33	32.88	2.55	0.53	1.70	41.24	43.54	84.78	0.119	No	No	0.19
20	3.28	27.59	32.82	2.55	0.52	1.70	45.47	44.97	90.44	0.128	No	No	0.20
21	3.45	29.01	33.37	2.56	0.52	1.70	46.01	45.27	91.28	0.129	No	No	0.20
22	3.61	29.55	34.40	2.58	0.51	1.70	48.07	46.18	94.25	0.133	No	No	0.20
23	3.77	31.52	33.47	2.56	0.51	1.70	48.07	46.00	94.07	0.133	No	No	0.20
24	3.94	32.27	33.48	2.56	0.49	1.70	55.49	48.54	104.02	0.149	No	No	0.22
25	4.10	32.95	33.40	2.56	0.50	1.70	51.62	47.20	98.82	0.141	No	No	0.20
26	4.27	31.46	35.50	2.60	0.50	1.70	51.31	0.00	51.31	4.000	No	Yes	2.00
27	4.43	30.60	36.53	2.62	0.51	1.70	48.30	0.00	48.30	4.000	No	Yes	2.00
28	4.59	29.66	37.51	2.64	0.51	1.70	47.44	0.00	47.44	4.000	No	Yes	2.00
29	4.76	30.00	36.81	2.63	0.51	1.70	46.68	0.00	46.68	4.000	No	Yes	2.00
30	4.92	30.65	36.74	2.63	0.50	1.70	49.83	0.00	49.83	4.000	No	Yes	2.00
31	5.09	30.81	37.43	2.64	0.50	1.70	50.36	0.00	50.36	4.000	No	Yes	2.00
32	5.25	34.29	34.60	2.58	0.51	1.70	47.26	45.94	93.20	0.132	No	No	0.18
33	5.41	41.43	30.44	2.49	0.46	1.70	66.40	51.38	117.79	0.175	No	No	0.23
34	5.58	51.12	26.51	2.40	0.42	1.67	83.20	54.93	138.14	0.226	No	No	0.30
35	5.74	61.87	24.11	2.34	0.41	1.63	89.50	54.92	144.42	0.248	No	No	0.33
36	5.91	67.50	23.56	2.33	0.38	1.54	106.83	59.69	166.52	0.375	No	No	0.49
37	6.07	69.34	24.20	2.34	0.39	1.54	101.12	58.64	159.75	0.324	No	No	0.42
38	6.23	66.58	25.60	2.38	0.40	1.55	93.39	57.52	150.92	0.276	No	No	0.36
39	6.40	68.72	24.89	2.36	0.40	1.53	94.24	57.17	151.40	0.278	No	No	0.36
40	6.56	80.16	21.09	2.26	0.38	1.48	106.36	55.98	162.33	0.342	No	No	0.44
41	6.73	84.87	20.21	2.24	0.34	1.41	130.55	61.19	191.74	0.802	No	No	1.02
42	6.89	78.53	22.10	2.29	0.38	1.44	108.25	58.16	166.41	0.374	No	No	0.48
43	7.05	61.06	27.69	2.43	0.43	1.50	80.80	54.90	135.70	0.219	No	No	0.28
44	7.22	49.81	31.80	2.52	0.46	1.53	66.36	51.81	118.18	0.176	No	No	0.22
45	7.38	50.45	30.39	2.49	0.46	1.52	65.58	51.09	116.67	0.173	No	No	0.22
46	7.55	52.61	29.62	2.48	0.43	1.45	80.78	55.88	136.66	0.222	No	No	0.28
47	7.71	53.68	29.78	2.48	0.45	1.46	72.37	53.13	125.50	0.192	No	No	0.24
48	7.87	49.57	32.21	2.53	0.46	1.46	67.60	52.35	119.96	0.179	No	No	0.22

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
49	8.04	44.97	34.27	2.58	0.47	1.45	64.15	51.67	115.82	0.171	No	No	0.21
50	8.20	39.71	36.40	2.62	0.49	1.47	53.63	0.00	53.63	3.892	No	Yes	2.00
51	8.37	34.75	37.98	2.65	0.51	1.48	46.47	0.00	46.47	3.328	No	Yes	2.00
52	8.53	46.59	30.82	2.50	0.52	1.48	44.29	44.06	88.35	0.124	No	No	0.15
53	8.69	59.70	26.46	2.40	0.40	1.33	93.34	58.18	151.52	0.278	No	No	0.34
54	8.86	62.74	26.61	2.40	0.41	1.33	91.10	57.57	148.67	0.265	No	No	0.32
55	9.02	50.20	30.21	2.49	0.49	1.40	54.13	47.18	101.31	0.145	No	No	0.18
56	9.19	37.71	34.43	2.58	0.51	1.41	48.47	46.32	94.79	0.134	No	No	0.16
57	9.35	34.57	33.70	2.57	0.52	1.41	46.55	45.52	92.07	0.130	No	No	0.16
58	9.51	33.72	32.74	2.55	0.53	1.42	41.91	43.74	85.65	0.121	No	No	0.15
59	9.68	33.63	32.32	2.54	0.52	1.40	44.60	44.56	89.15	0.126	No	No	0.15
60	9.84	34.51	32.34	2.54	0.52	1.39	45.56	44.89	90.45	0.128	No	No	0.15
61	10.01	34.82	33.15	2.55	0.52	1.39	44.48	44.70	89.19	0.126	No	No	0.15
62	10.17	34.09	34.79	2.59	0.52	1.38	45.15	45.24	90.39	0.127	No	No	0.15
63	10.34	33.88	35.45	2.60	0.53	1.38	42.34	0.00	42.34	2.779	No	Yes	2.00
64	10.50	34.41	35.69	2.61	0.53	1.37	43.07	0.00	43.07	2.798	No	Yes	2.00
65	10.66	37.38	34.44	2.58	0.52	1.36	46.22	45.55	91.77	0.130	No	No	0.15
66	10.83	42.21	33.03	2.55	0.50	1.34	52.03	47.26	99.28	0.141	No	No	0.17
67	10.99	42.87	33.88	2.57	0.48	1.32	59.32	49.93	109.25	0.158	No	No	0.19
68	11.16	39.24	36.20	2.62	0.51	1.34	48.21	0.00	48.21	3.085	No	Yes	2.00
69	11.32	33.11	39.13	2.67	0.54	1.35	38.91	0.00	38.91	2.573	No	Yes	2.00
70	11.48	30.41	39.40	2.68	0.54	1.35	37.35	0.00	37.35	2.339	No	Yes	2.00
71	11.65	30.97	37.78	2.65	0.54	1.34	37.94	0.00	37.94	2.363	No	Yes	2.00
72	11.81	31.99	37.62	2.65	0.54	1.33	40.12	0.00	40.12	2.422	No	Yes	2.00
73	11.98	33.18	37.46	2.64	0.53	1.33	40.37	0.00	40.37	2.494	No	Yes	2.00
74	12.14	33.28	37.25	2.64	0.53	1.32	41.63	0.00	41.63	2.481	No	Yes	2.00
75	12.30	32.19	37.03	2.63	0.54	1.32	39.95	0.00	39.95	2.379	No	Yes	2.00
76	12.47	30.35	37.05	2.63	0.55	1.32	36.11	0.00	36.11	2.222	No	Yes	2.00
77	12.63	28.16	37.70	2.65	0.56	1.32	34.44	0.00	34.44	2.041	No	Yes	2.00
78	12.80	27.11	37.49	2.64	0.57	1.32	31.52	0.00	31.52	1.948	No	Yes	2.00
79	12.96	27.19	37.28	2.64	0.57	1.31	31.63	0.00	31.63	1.940	No	Yes	2.00
80	13.12	30.47	35.81	2.61	0.56	1.30	34.09	0.00	34.09	2.165	No	Yes	2.00
81	13.29	40.03	32.51	2.54	0.53	1.28	42.19	43.78	85.98	0.121	No	No	0.14
82	13.45	53.18	29.98	2.48	0.47	1.24	63.29	50.17	113.46	0.166	No	No	0.19
83	13.62	60.57	30.24	2.49	0.43	1.22	77.67	55.09	132.76	0.210	No	No	0.24
84	13.78	56.73	32.69	2.54	0.46	1.23	66.93	52.25	119.18	0.178	No	No	0.21
85	13.94	49.13	35.02	2.59	0.50	1.24	50.78	47.22	98.00	0.139	No	No	0.16
86	14.11	46.88	33.60	2.56	0.50	1.24	52.21	47.44	99.64	0.142	No	No	0.16
87	14.27	45.25	34.88	2.59	0.48	1.22	58.73	49.93	108.66	0.157	No	No	0.18
88	14.44	51.22	32.87	2.55	0.52	1.24	44.71	44.72	89.44	0.126	No	No	0.15
89	14.60	51.98	34.11	2.57	0.45	1.20	71.07	54.01	125.09	0.191	No	No	0.22
90	14.76	50.83	34.22	2.58	0.47	1.21	60.90	50.55	111.45	0.163	No	No	0.19
91	14.93	40.36	39.75	2.69	0.53	1.23	40.61	0.00	40.61	2.643	No	Yes	2.00
92	15.09	32.05	45.18	2.79	0.55	1.23	36.65	0.00	36.65	2.071	No	Yes	2.00
93	15.26	30.08	46.12	2.80	0.56	1.23	33.07	0.00	33.07	1.926	No	Yes	2.00
94	15.42	29.39	45.47	2.79	0.56	1.23	33.51	0.00	33.51	1.866	No	Yes	2.00
95	15.58	32.77	41.66	2.72	0.56	1.22	33.82	0.00	33.82	2.074	No	Yes	2.00
96	15.75	39.88	36.82	2.63	0.52	1.20	43.74	0.00	43.74	2.519	No	Yes	2.00

:: Cyclic Resistance Ratio (CRR) calculation data :: (continued)

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
97	15.91	57.67	30.63	2.50	0.49	1.19	56.00	47.95	103.94	0.149	No	No	0.17
98	16.08	80.17	25.89	2.39	0.41	1.15	89.59	56.54	146.13	0.255	No	No	0.29
99	16.24	118.97	19.82	2.22	0.37	1.13	113.42	55.54	168.96	0.397	No	No	0.46
100	16.40	144.83	17.16	2.14	0.28	1.10	172.60	62.98	235.57	4.000	No	No	2.00
101	16.57	152.16	16.84	2.13	0.30	1.10	165.99	60.10	226.09	4.000	No	No	2.00
102	16.73	136.18	19.06	2.20	0.34	1.11	134.37	59.46	193.82	0.871	No	No	1.00
103	16.90	120.87	21.76	2.28	0.35	1.11	124.79	62.53	187.32	0.681	No	No	0.78
104	17.06	118.51	21.95	2.28	0.35	1.11	120.16	61.47	181.63	0.563	No	No	0.65
105	17.22	150.43	18.78	2.19	0.35	1.11	126.68	56.66	183.34	0.595	No	No	0.68
106	17.39	208.30	12.26	1.97	0.26	1.08	218.41	41.73	260.14	4.000	No	No	2.00
107	17.55	297.79	7.72	1.78	0.26	1.07	292.60	6.88	299.48	4.000	No	No	2.00
108	17.72	363.33	4.34	1.60	0.26	1.07	394.75	0.00	394.76	4.000	No	No	2.00
109	17.88	450.52	2.83	1.50	0.26	1.07	414.96	0.00	414.96	4.000	No	No	2.00
110	18.05	513.49	1.77	1.42	0.26	1.07	554.04	0.00	554.04	4.000	No	No	2.00
111	18.21	569.21	1.32	1.38	0.26	1.07	580.34	0.00	580.34	4.000	No	No	2.00

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
FC: Fines content (%)
I_c: Soil behavior type index
m: Stress exponent
C_N: Overburden correction factor
q_{c1N}: Normalized and adjusted cone resistance
Δq_{c1N}: Cone resistance correction factor due to fines
$q_{c1N,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.16	2.00	0.00	9.98	0.16	0.00	0.33	2.00	0.00	9.95	0.16	0.00
0.49	2.00	0.00	9.93	0.16	0.00	0.66	2.00	0.00	9.90	0.16	0.00
0.82	2.00	0.00	9.88	0.16	0.00	0.98	2.00	0.00	9.85	0.16	0.00
1.15	2.00	0.00	9.83	0.16	0.00	1.31	2.00	0.00	9.80	0.16	0.00
1.48	2.00	0.00	9.78	0.16	0.00	1.64	2.00	0.00	9.75	0.16	0.00
1.80	2.00	0.00	9.73	0.16	0.00	1.97	2.00	0.00	9.70	0.17	0.00
2.13	2.00	0.00	9.67	0.16	0.00	2.30	2.00	0.00	9.65	0.16	0.00
2.46	2.00	0.00	9.62	0.16	0.00	2.63	2.00	0.00	9.60	0.16	0.00
2.79	2.00	0.00	9.57	0.16	0.00	2.95	0.18	0.82	9.55	0.16	0.39
3.12	0.19	0.81	9.52	0.16	0.38	3.28	0.20	0.80	9.50	0.16	0.38
3.45	0.20	0.80	9.47	0.16	0.38	3.61	0.20	0.80	9.45	0.16	0.38
3.77	0.20	0.80	9.42	0.16	0.38	3.94	0.22	0.78	9.40	0.16	0.37
4.10	0.20	0.80	9.38	0.16	0.37	4.27	2.00	0.00	9.35	0.16	0.00
4.43	2.00	0.00	9.33	0.16	0.00	4.59	2.00	0.00	9.30	0.16	0.00
4.76	2.00	0.00	9.28	0.16	0.00	4.92	2.00	0.00	9.25	0.16	0.00
5.09	2.00	0.00	9.23	0.16	0.00	5.25	0.18	0.82	9.20	0.16	0.38
5.41	0.23	0.77	9.18	0.16	0.35	5.58	0.30	0.70	9.15	0.16	0.32
5.74	0.33	0.67	9.13	0.16	0.31	5.91	0.49	0.51	9.10	0.17	0.23
6.07	0.42	0.58	9.07	0.16	0.26	6.23	0.36	0.64	9.05	0.16	0.29
6.40	0.36	0.64	9.02	0.16	0.29	6.56	0.44	0.56	9.00	0.16	0.25
6.73	1.02	0.00	8.97	0.16	0.00	6.89	0.48	0.52	8.95	0.16	0.23
7.05	0.28	0.72	8.92	0.16	0.32	7.22	0.22	0.78	8.90	0.16	0.35
7.38	0.22	0.78	8.87	0.16	0.35	7.55	0.28	0.72	8.85	0.16	0.32
7.71	0.24	0.76	8.82	0.16	0.34	7.87	0.22	0.78	8.80	0.16	0.34
8.04	0.21	0.79	8.78	0.16	0.35	8.20	2.00	0.00	8.75	0.16	0.00
8.37	2.00	0.00	8.73	0.16	0.00	8.53	0.15	0.85	8.70	0.16	0.37
8.69	0.34	0.66	8.68	0.16	0.29	8.86	0.32	0.68	8.65	0.16	0.29
9.02	0.18	0.82	8.63	0.16	0.36	9.19	0.16	0.84	8.60	0.16	0.36
9.35	0.16	0.84	8.58	0.16	0.36	9.51	0.15	0.85	8.55	0.16	0.37
9.68	0.15	0.85	8.53	0.16	0.36	9.84	0.15	0.85	8.50	0.16	0.36
10.01	0.15	0.85	8.47	0.16	0.36	10.17	0.15	0.85	8.45	0.16	0.36
10.34	2.00	0.00	8.42	0.16	0.00	10.50	2.00	0.00	8.40	0.16	0.00
10.66	0.15	0.85	8.37	0.16	0.35	10.83	0.17	0.83	8.35	0.16	0.35
10.99	0.19	0.81	8.32	0.16	0.34	11.16	2.00	0.00	8.30	0.16	0.00
11.32	2.00	0.00	8.27	0.16	0.00	11.48	2.00	0.00	8.25	0.16	0.00
11.65	2.00	0.00	8.22	0.16	0.00	11.81	2.00	0.00	8.20	0.16	0.00
11.98	2.00	0.00	8.18	0.16	0.00	12.14	2.00	0.00	8.15	0.16	0.00
12.30	2.00	0.00	8.13	0.16	0.00	12.47	2.00	0.00	8.10	0.16	0.00
12.63	2.00	0.00	8.08	0.16	0.00	12.80	2.00	0.00	8.05	0.16	0.00
12.96	2.00	0.00	8.03	0.16	0.00	13.12	2.00	0.00	8.00	0.16	0.00
13.29	0.14	0.86	7.98	0.16	0.34	13.45	0.19	0.81	7.95	0.16	0.32
13.62	0.24	0.76	7.93	0.16	0.30	13.78	0.21	0.79	7.90	0.16	0.32
13.94	0.16	0.84	7.87	0.16	0.33	14.11	0.16	0.84	7.85	0.16	0.33
14.27	0.18	0.82	7.82	0.16	0.32	14.44	0.15	0.85	7.80	0.16	0.33
14.60	0.22	0.78	7.77	0.16	0.30	14.76	0.19	0.81	7.75	0.16	0.31
14.93	2.00	0.00	7.72	0.16	0.00	15.09	2.00	0.00	7.70	0.16	0.00
15.26	2.00	0.00	7.67	0.16	0.00	15.42	2.00	0.00	7.65	0.16	0.00
15.58	2.00	0.00	7.62	0.16	0.00	15.75	2.00	0.00	7.60	0.16	0.00

:: Liquefaction Potential Index calculation data :: (continued)

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
15.91	0.17	0.83	7.58	0.16	0.31	16.08	0.29	0.71	7.55	0.16	0.27
16.24	0.46	0.54	7.53	0.16	0.20	16.40	2.00	0.00	7.50	0.16	0.00
16.57	2.00	0.00	7.48	0.16	0.00	16.73	1.00	0.00	7.45	0.16	0.00
16.90	0.78	0.22	7.43	0.16	0.08	17.06	0.65	0.35	7.40	0.16	0.13
17.22	0.68	0.32	7.38	0.16	0.12	17.39	2.00	0.00	7.35	0.16	0.00
17.55	2.00	0.00	7.33	0.16	0.00	17.72	2.00	0.00	7.30	0.16	0.00
17.88	2.00	0.00	7.27	0.16	0.00	18.05	2.00	0.00	7.25	0.16	0.00
18.21	2.00	0.00	7.22	0.16	0.00						

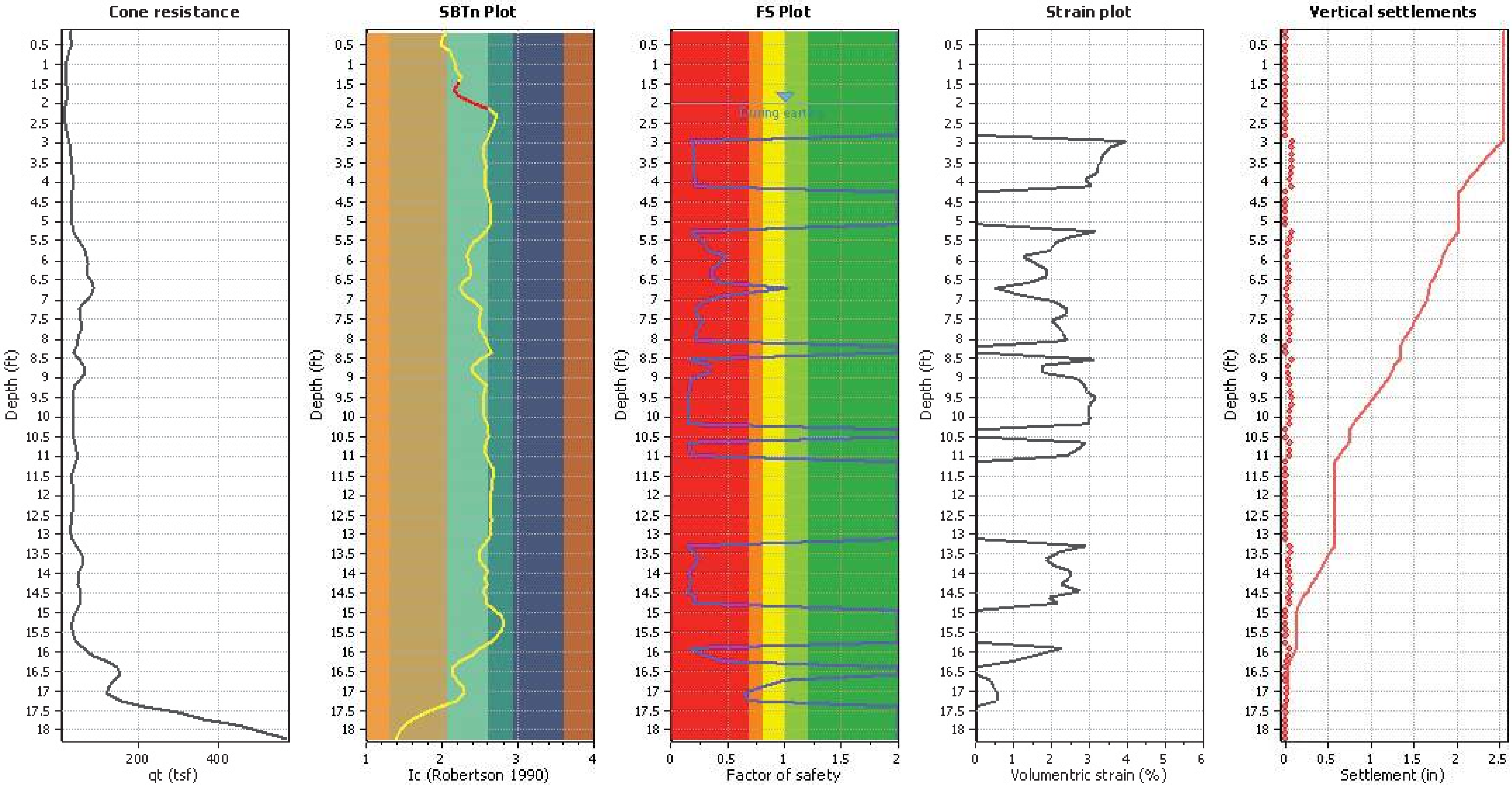
Overall liquefaction potential: 17.50

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
FS: Calculated Factor of Safety against liquefaction
Volumentric strain: Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)
2.13	17.25	2.00	0.00	0.96	0.00	2.30	17.12	2.00	0.00	0.96	0.00
2.46	20.26	2.00	0.00	0.96	0.00	2.63	24.85	2.00	0.00	0.96	0.00
2.79	29.56	2.00	0.00	0.95	0.00	2.95	76.93	0.18	3.95	0.95	0.08
3.12	84.78	0.19	3.59	0.95	0.07	3.28	90.44	0.20	3.36	0.94	0.07
3.45	91.28	0.20	3.32	0.94	0.07	3.61	94.25	0.20	3.20	0.94	0.06
3.77	94.07	0.20	3.20	0.94	0.06	3.94	104.02	0.22	2.88	0.93	0.06
4.10	98.82	0.20	3.03	0.93	0.06	4.27	51.31	2.00	0.00	0.93	0.00
4.43	48.30	2.00	0.00	0.92	0.00	4.59	47.44	2.00	0.00	0.92	0.00
4.76	46.68	2.00	0.00	0.92	0.00	4.92	49.83	2.00	0.00	0.92	0.00
5.09	50.36	2.00	0.00	0.91	0.00	5.25	93.20	0.18	3.14	0.91	0.06
5.41	117.79	0.23	2.46	0.91	0.05	5.58	138.14	0.30	2.06	0.91	0.04
5.74	144.42	0.33	1.96	0.90	0.04	5.91	166.52	0.49	1.24	0.90	0.02
6.07	159.75	0.42	1.56	0.90	0.03	6.23	150.92	0.36	1.84	0.89	0.04
6.40	151.40	0.36	1.83	0.89	0.04	6.56	162.33	0.44	1.42	0.89	0.03
6.73	191.74	1.02	0.49	0.89	0.01	6.89	166.41	0.48	1.22	0.88	0.02
7.05	135.70	0.28	2.04	0.88	0.04	7.22	118.18	0.22	2.37	0.88	0.05
7.38	116.67	0.22	2.39	0.87	0.05	7.55	136.66	0.28	2.01	0.87	0.04
7.71	125.50	0.24	2.20	0.87	0.04	7.87	119.96	0.22	2.30	0.87	0.05
8.04	115.82	0.21	2.38	0.86	0.05	8.20	53.63	2.00	0.00	0.86	0.00
8.37	46.47	2.00	0.00	0.86	0.00	8.53	88.35	0.15	3.11	0.86	0.06
8.69	151.52	0.34	1.75	0.85	0.03	8.86	148.67	0.32	1.78	0.85	0.04
9.02	101.31	0.18	2.69	0.85	0.05	9.19	94.79	0.16	2.86	0.84	0.06
9.35	92.07	0.16	2.94	0.84	0.06	9.51	85.65	0.15	3.15	0.84	0.06
9.68	89.15	0.15	3.01	0.84	0.06	9.84	90.45	0.15	2.96	0.83	0.06
10.01	89.19	0.15	2.99	0.83	0.06	10.17	90.39	0.15	2.94	0.83	0.06
10.34	42.34	2.00	0.00	0.82	0.00	10.50	43.07	2.00	0.00	0.82	0.00
10.66	91.77	0.15	2.87	0.82	0.06	10.83	99.28	0.17	2.64	0.82	0.05
10.99	109.25	0.19	2.39	0.81	0.05	11.16	48.21	2.00	0.00	0.81	0.00
11.32	38.91	2.00	0.00	0.81	0.00	11.48	37.35	2.00	0.00	0.81	0.00
11.65	37.94	2.00	0.00	0.80	0.00	11.81	40.12	2.00	0.00	0.80	0.00
11.98	40.37	2.00	0.00	0.80	0.00	12.14	41.63	2.00	0.00	0.79	0.00
12.30	39.95	2.00	0.00	0.79	0.00	12.47	36.11	2.00	0.00	0.79	0.00
12.63	34.44	2.00	0.00	0.79	0.00	12.80	31.52	2.00	0.00	0.78	0.00
12.96	31.63	2.00	0.00	0.78	0.00	13.12	34.09	2.00	0.00	0.78	0.00
13.29	85.98	0.14	2.90	0.77	0.06	13.45	113.46	0.19	2.18	0.77	0.04
13.62	132.76	0.24	1.83	0.77	0.04	13.78	119.18	0.21	2.05	0.77	0.04
13.94	98.00	0.16	2.50	0.76	0.05	14.11	99.64	0.16	2.45	0.76	0.05
14.27	108.66	0.18	2.24	0.76	0.04	14.44	89.44	0.15	2.72	0.76	0.05
14.60	125.09	0.22	1.91	0.75	0.04	14.76	111.45	0.19	2.15	0.75	0.04
14.93	40.61	2.00	0.00	0.75	0.00	15.09	36.65	2.00	0.00	0.74	0.00
15.26	33.07	2.00	0.00	0.74	0.00	15.42	33.51	2.00	0.00	0.74	0.00
15.58	33.82	2.00	0.00	0.74	0.00	15.75	43.74	2.00	0.00	0.73	0.00
15.91	103.94	0.17	2.26	0.73	0.04	16.08	146.13	0.29	1.56	0.73	0.03
16.24	168.96	0.46	0.92	0.72	0.02	16.40	235.57	2.00	0.00	0.72	0.00
16.57	226.09	2.00	0.00	0.72	0.00	16.73	193.82	1.00	0.37	0.72	0.01
16.90	187.32	0.78	0.47	0.71	0.01	17.06	181.63	0.65	0.57	0.71	0.01
17.22	183.34	0.68	0.54	0.71	0.01	17.39	260.14	2.00	0.00	0.71	0.00
17.55	299.48	2.00	0.00	0.70	0.00	17.72	394.76	2.00	0.00	0.70	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$q_{c1N,cs}$	FS	e_v (%)	DF	Settlement (in)
17.88	414.96	2.00	0.00	0.70	0.00	18.05	554.04	2.00	0.00	0.69	0.00
18.21	580.34	2.00	0.00	0.69	0.00						

Total estimated settlement: 2.54

Abbreviations

$Q_{tn,cs}$: Equivalent clean sand normalized cone resistance
FS: Factor of safety against liquefaction
e_v (%): Post-liquefaction volumentric strain
DF: e_v depth weighting factor
Settlement: Calculated settlement

:: **Strength loss calculation Idriss & Boulanger (2008)** ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.16	25.40	48.00	1.38	66.23	2.06	N/A	N/A
0.33	27.82	52.55	1.31	68.83	2.01	N/A	N/A
0.49	28.42	53.68	1.28	68.79	1.99	N/A	N/A
0.66	22.62	42.69	1.45	61.94	2.10	N/A	N/A
0.82	18.53	34.95	1.54	53.66	2.14	N/A	N/A
0.98	15.70	29.57	1.00	29.57	2.18	N/A	N/A
1.15	14.38	27.06	1.00	27.06	2.18	N/A	N/A
1.31	13.63	25.63	1.82	46.62	2.26	N/A	N/A
1.48	14.72	27.68	1.00	27.68	2.21	N/A	N/A
1.64	17.45	32.83	1.00	32.83	2.15	N/A	N/A
1.80	18.22	34.28	1.71	58.50	2.22	N/A	N/A
1.97	16.03	30.10	2.35	70.69	2.41	N/A	N/A
2.13	12.43	23.28	3.46	80.57	2.62	0.06	7.59
2.30	11.37	21.26	4.14	88.11	2.72	0.06	6.41
2.46	12.94	24.23	3.97	96.12	2.70	0.06	6.78
2.63	15.53	29.10	3.74	108.73	2.66	0.07	7.59
2.79	18.63	34.93	3.47	121.23	2.62	0.07	8.52
2.95	22.03	41.35	3.21	132.75	2.58	0.08	0.71
3.12	25.33	47.57	3.02	143.83	2.55	0.08	0.73
3.28	27.59	51.81	3.02	156.31	2.55	0.09	0.74
3.45	29.01	54.48	3.08	167.93	2.56	0.09	0.75
3.61	29.55	55.49	3.21	178.00	2.58	0.09	0.75
3.77	31.52	59.20	3.09	183.21	2.56	0.09	0.76
3.94	32.27	60.59	3.10	187.52	2.56	0.10	0.76
4.10	32.95	61.85	3.09	190.90	2.56	0.10	0.76
4.27	31.46	59.03	3.34	197.41	2.60	0.10	8.91
4.43	30.60	57.39	3.48	199.45	2.62	0.09	8.31
4.59	29.66	55.58	3.60	200.25	2.64	0.09	7.73
4.76	30.00	56.21	3.51	197.41	2.63	0.09	7.52
4.92	30.65	57.41	3.50	201.06	2.63	0.10	7.39
5.09	30.81	57.70	3.59	207.24	2.64	0.10	7.17
5.25	34.29	64.27	3.23	207.76	2.58	0.09	0.77
5.41	41.43	77.74	2.74	213.10	2.49	0.11	0.79
5.58	51.12	96.03	2.32	222.99	2.40	0.14	0.82
5.74	61.87	116.32	2.09	243.27	2.34	0.14	0.85
5.91	67.50	126.95	2.04	259.03	2.33	0.18	0.86
6.07	69.34	130.41	2.10	273.71	2.34	0.17	0.87
6.23	66.58	125.17	2.23	279.45	2.38	0.15	0.86
6.40	68.72	129.20	2.16	279.64	2.36	0.15	0.86
6.56	80.16	150.79	1.83	275.74	2.26	0.17	0.89
6.73	84.87	159.68	1.76	280.83	2.24	0.26	0.90
6.89	78.53	147.68	1.91	282.50	2.29	0.18	0.88
7.05	61.06	114.64	2.44	280.12	2.43	0.13	0.85
7.22	49.81	93.36	2.90	270.43	2.52	0.12	0.82
7.38	50.45	94.54	2.74	258.62	2.49	0.11	0.82
7.55	52.61	98.60	2.65	261.29	2.48	0.14	0.83
7.71	53.68	100.60	2.67	268.39	2.48	0.12	0.83
7.87	49.57	92.71	2.94	273.03	2.53	0.12	0.82

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
8.04	44.97	83.60	3.19	266.83	2.58	0.11	0.80
8.20	39.71	73.33	3.46	253.67	2.62	0.10	5.41
8.37	34.75	63.48	3.66	232.56	2.65	0.09	4.62
8.53	46.59	80.43	2.78	223.90	2.50	0.08	0.80
8.69	59.70	98.74	2.32	228.82	2.40	0.16	0.83
8.86	62.74	102.28	2.33	238.55	2.40	0.15	0.83
9.02	50.20	82.28	2.72	223.40	2.49	0.10	0.80
9.19	37.71	62.55	3.21	200.87	2.58	0.09	0.76
9.35	34.57	56.60	3.12	176.73	2.57	0.09	0.75
9.51	33.72	54.48	3.01	163.85	2.55	0.08	0.75
9.68	33.63	53.81	2.96	159.10	2.54	0.08	0.74
9.84	34.51	54.82	2.96	162.26	2.54	0.09	0.75
10.01	34.82	55.14	3.06	168.51	2.55	0.09	0.75
10.17	34.09	54.00	3.26	175.85	2.59	0.09	0.74
10.34	33.88	53.44	3.34	178.38	2.60	0.09	3.86
10.50	34.41	53.94	3.37	181.72	2.61	0.09	3.89
10.66	37.38	57.89	3.21	185.99	2.58	0.09	0.75
10.83	42.21	64.58	3.04	196.47	2.55	0.10	0.77
10.99	42.87	65.37	3.14	205.50	2.57	0.11	0.77
11.16	39.24	59.90	3.43	205.65	2.62	0.09	4.28
11.32	33.11	50.63	3.82	193.23	2.67	0.08	3.57
11.48	30.41	46.12	3.85	177.73	2.68	0.08	3.25
11.65	30.97	46.33	3.64	168.56	2.65	0.08	3.28
11.81	31.99	47.52	3.62	171.83	2.65	0.08	3.36
11.98	33.18	48.95	3.60	176.02	2.64	0.08	3.46
12.14	33.28	48.69	3.57	173.76	2.64	0.09	3.45
12.30	32.19	46.70	3.54	165.32	2.63	0.08	3.30
12.47	30.35	43.66	3.54	154.66	2.63	0.08	3.09
12.63	28.16	40.26	3.63	146.01	2.65	0.08	2.84
12.80	27.11	38.43	3.60	138.32	2.64	0.07	2.71
12.96	27.19	38.26	3.57	136.67	2.64	0.07	2.69
13.12	30.47	42.51	3.38	143.84	2.61	0.08	3.01
13.29	40.03	55.14	2.98	164.31	2.54	0.08	0.75
13.45	53.18	72.41	2.69	194.79	2.48	0.11	0.78
13.62	60.57	82.15	2.72	223.32	2.49	0.13	0.80
13.78	56.73	77.04	3.00	231.16	2.54	0.12	0.79
13.94	49.13	66.65	3.28	218.90	2.59	0.10	0.77
14.11	46.88	62.82	3.11	195.34	2.56	0.10	0.76
14.27	45.25	60.45	3.27	197.51	2.59	0.11	0.76
14.44	51.22	67.67	3.02	204.56	2.55	0.09	0.77
14.60	51.98	68.52	3.17	217.33	2.57	0.13	0.78
14.76	50.83	66.55	3.19	212.02	2.58	0.11	0.77
14.93	40.36	53.12	3.90	207.19	2.69	0.09	3.67
15.09	32.05	42.26	4.67	197.14	2.79	0.09	2.88
15.26	30.08	39.41	4.80	189.27	2.80	0.08	2.68
15.42	29.39	38.15	4.71	179.58	2.79	0.08	2.59
15.58	32.77	42.01	4.16	174.88	2.72	0.08	2.88
15.75	39.88	50.42	3.51	177.11	2.63	0.09	3.50

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

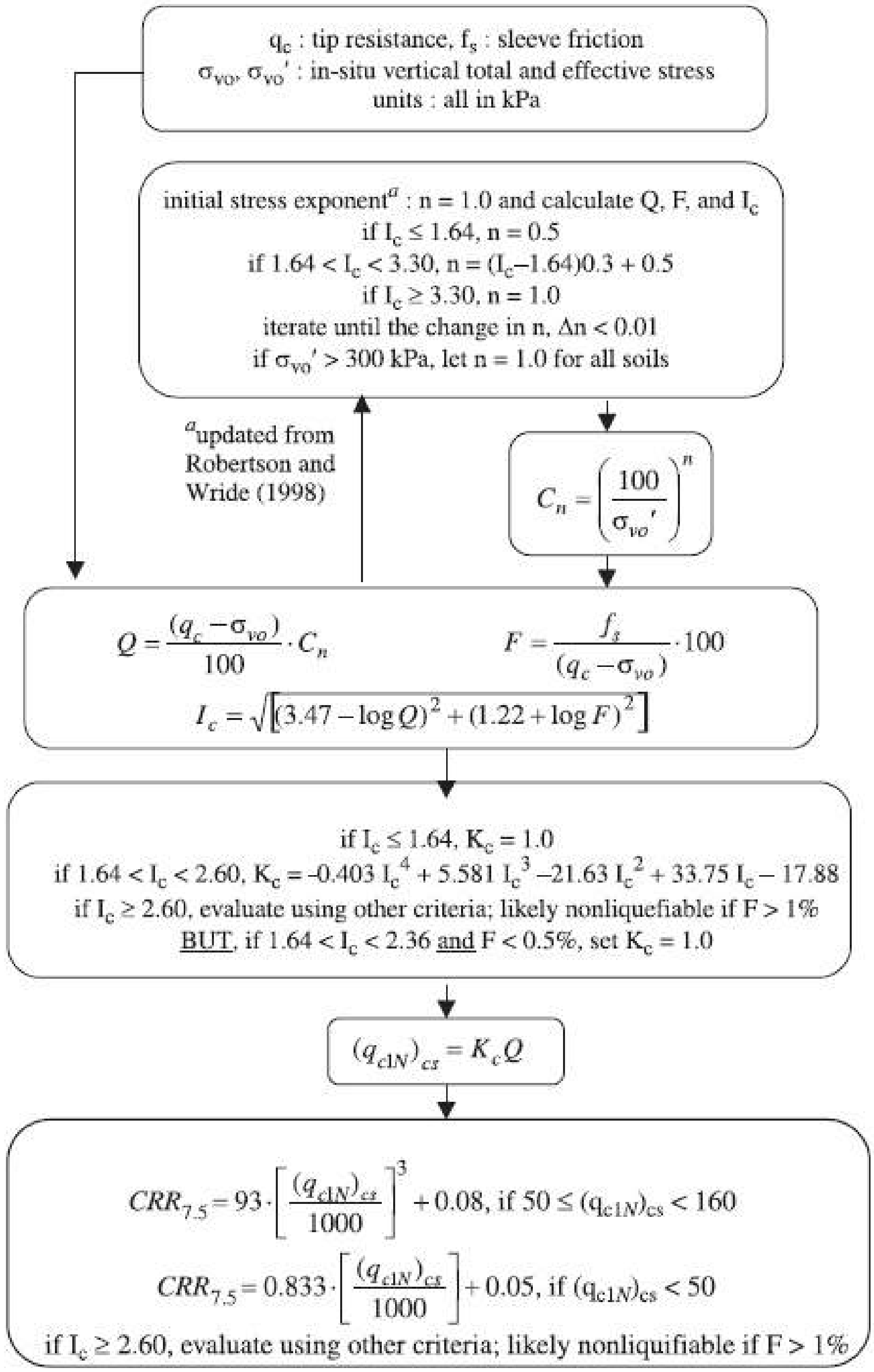
Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
15.91	57.67	71.72	2.76	198.14	2.50	0.10	0.78
16.08	80.17	98.12	2.26	221.84	2.39	0.15	0.82
16.24	118.97	142.35	1.73	246.06	2.22	0.19	0.88
16.40	144.83	170.85	1.54	262.99	2.14	0.68	0.91
16.57	152.16	178.37	1.52	270.93	2.13	0.55	0.91
16.73	136.18	159.96	1.67	267.36	2.20	0.27	0.90
16.90	120.87	142.32	1.88	268.09	2.28	0.24	0.88
17.06	118.51	138.81	1.90	263.74	2.28	0.22	0.87
17.22	150.43	173.78	1.65	286.91	2.19	0.23	0.91
17.39	208.30	234.27	1.27	297.02	1.97	0.95	0.95
17.55	297.79	327.17	1.09	357.66	1.78	1.01	1.01
17.72	363.33	390.52	1.00	390.52	1.60	1.04	1.04
17.88	450.52	478.05	1.00	478.05	1.50	1.08	1.08
18.05	513.49	539.10	1.00	539.10	1.42	1.10	1.10
18.21	569.21	593.84	1.00	593.84	1.38	1.11	1.11

Abbreviations

q_t: Total cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Adjusted and corrected cone resistance due to fines
I_c: Soil behavior type index
$S_{u(liq)}/\sigma'_v$: Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$: Calculated peak undrained strength ratio

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

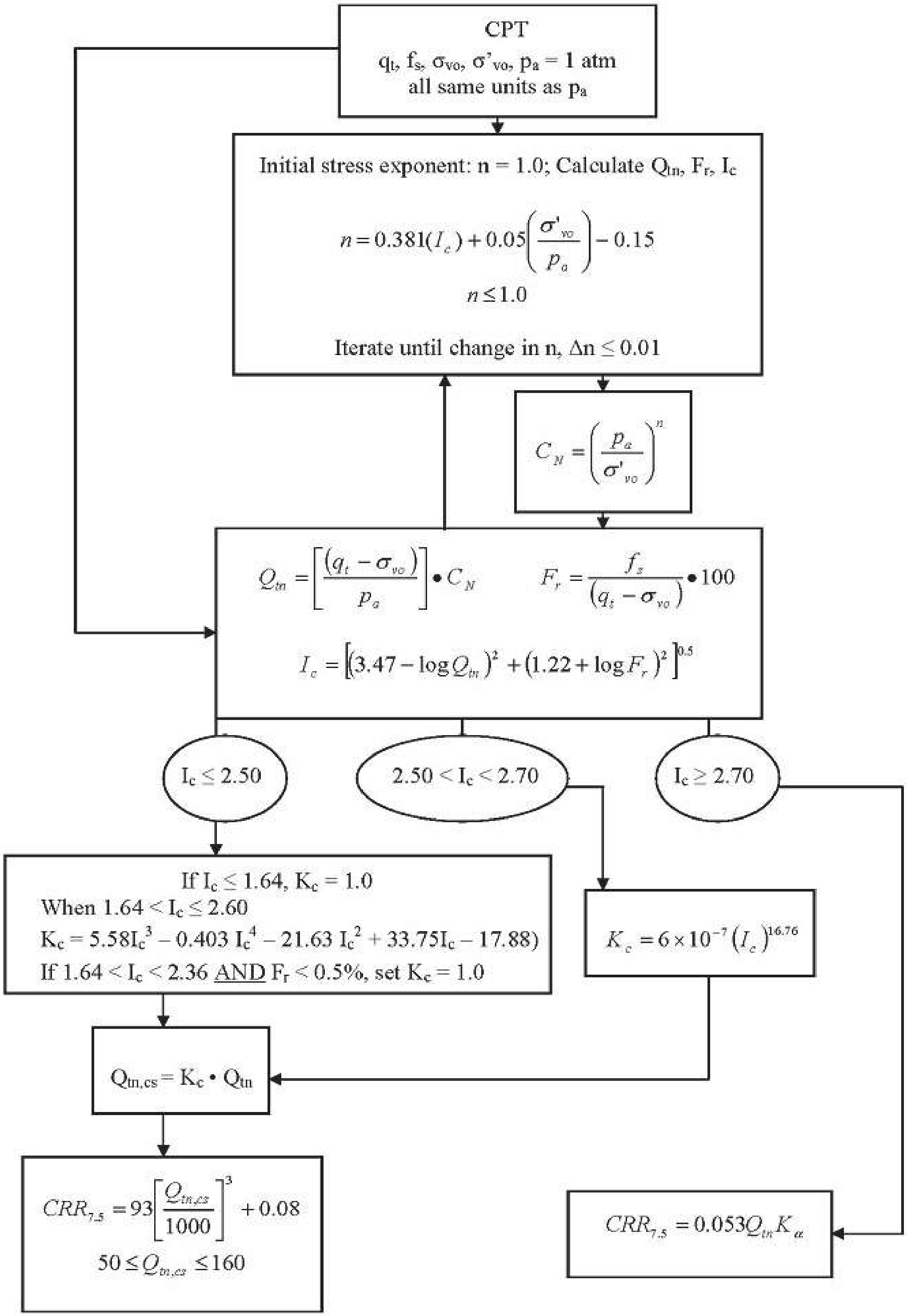
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

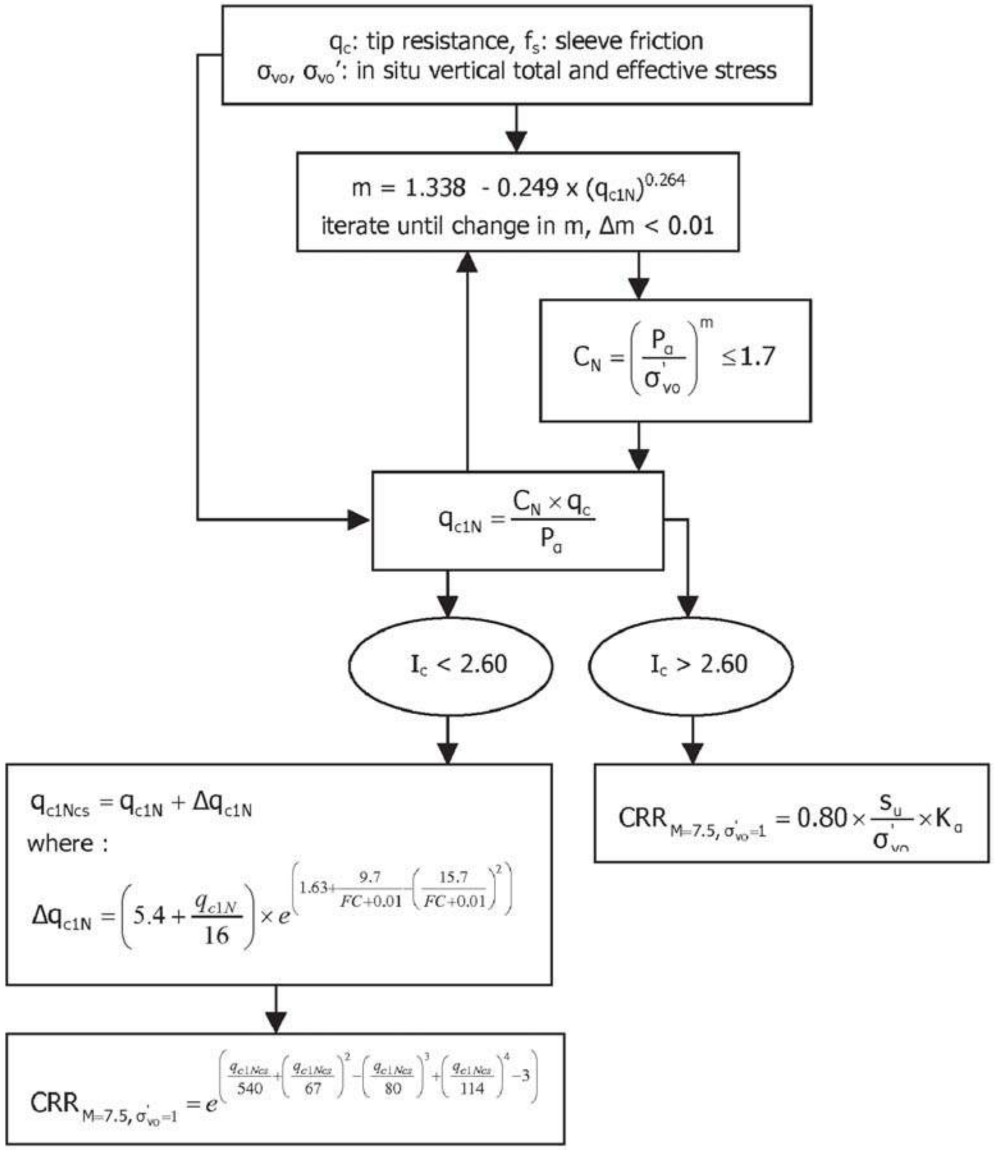
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

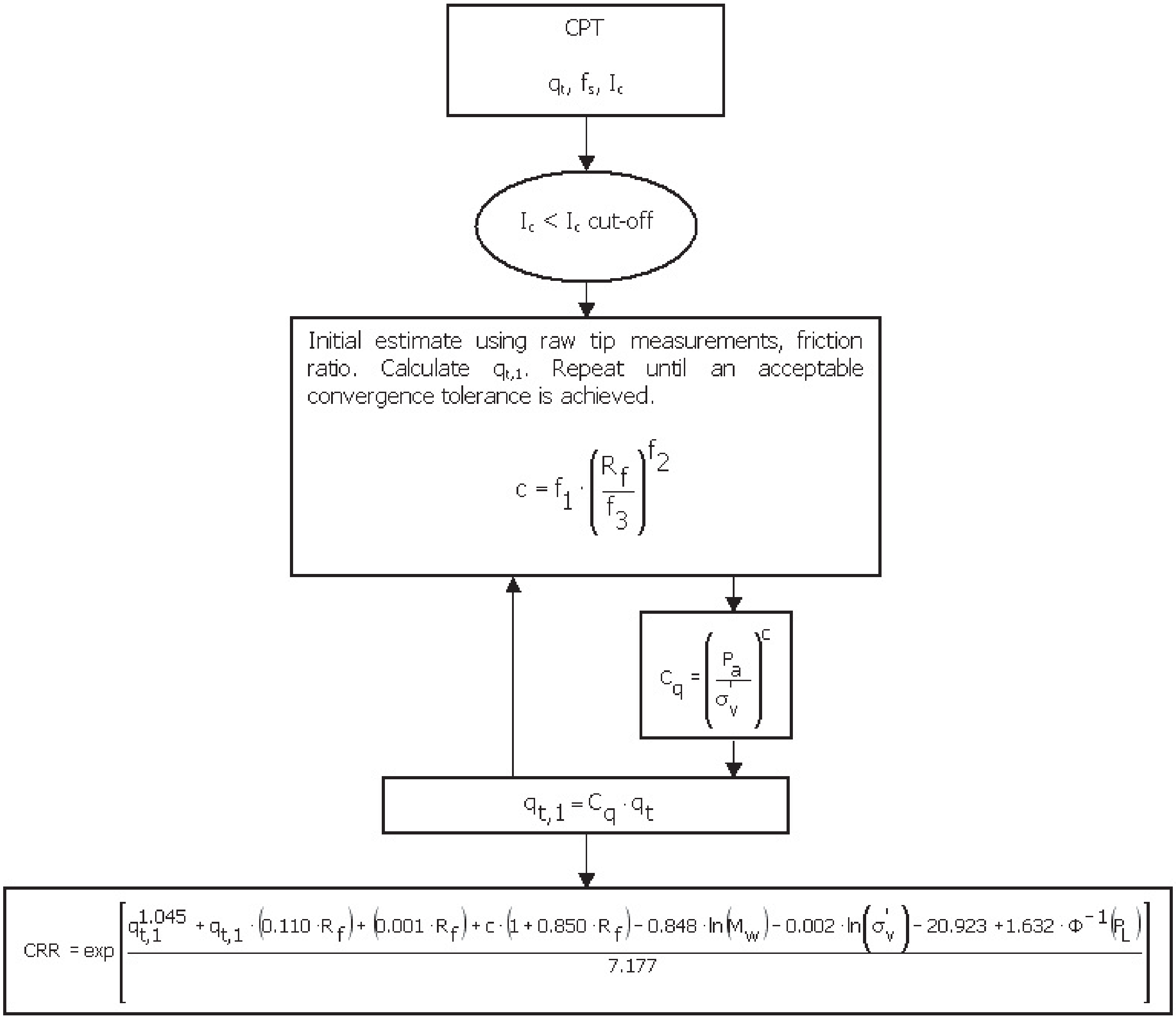


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)

$$FS_{liq} = \frac{CRR_{M=7.5,\sigma'_v=1atm}}{CSR_{M=7.5,\sigma'_v=1atm}}$$

$$CSR_{M=7.5,\sigma'_v=1atm} = 0.65\frac{\sigma_v}{\sigma'_v}\frac{a_{\max}}{g} r_d \frac{1}{MSF}\frac{1}{K_\sigma}$$

$$r_d = \exp\left[\alpha(z)+\beta(z)\cdot M\right]$$

$$\alpha(z) = -1.012 - 1.126\sin\left(\frac{z}{11.73}+5.133\right)$$

$$\beta(z) = 0.106 + 0.118\sin\left(\frac{z}{11.28}+5.142\right)$$

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_v}{P_a}\right) \le 1.1$$

$$C_\sigma = \frac{1}{37.3 - 8.27\left(q_{c1Ncs}\right)^{0.264}} \le 0.3$$

$$MSF = 1 + \left(MSF_{max} - 1\right)\left(8.64\exp\left(\frac{-M}{4}\right) - 1.325\right)$$

$$MSF_{max} = 1.09 + \left(\frac{q_{c1Ncs}}{180}\right)^3 \le 2.2$$

σ'_v *and* σ_v *at start of earthquake shaking*

$$CRR_{M=7.5,\sigma'_v=1atm} = \exp\left(\frac{q_{c1Ncs}}{113} + \left(\frac{q_{c1Ncs}}{1000}\right)^2 - \left(\frac{q_{c1Ncs}}{140}\right)^3 + \left(\frac{q_{c1Ncs}}{137}\right)^4 - 2.80\right)$$

$$q_{c1Ncs} = q_{c1N} + \Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(11.9 + \frac{q_{c1N}}{14.6}\right)\exp\left(1.63 - \frac{9.7}{FC+2} - \left(\frac{15.7}{FC+2}\right)^2\right)$$

$$q_{c1N} = C_{N\sigma}\frac{q_c}{P_a}$$

$$C_{N\sigma} = \left(\frac{P_a}{\sigma'_v}\right)^m \le 1.7$$

$$m = 1.338 - 0.249\left(q_{c1Ncs}\right)^{0.264} \quad with \quad 0.264 \le m \le 0.782$$

$$FC = 80\left(I_C + C_{FC}\right) - 137 \quad with \quad 0\% \le FC \le 100\%$$

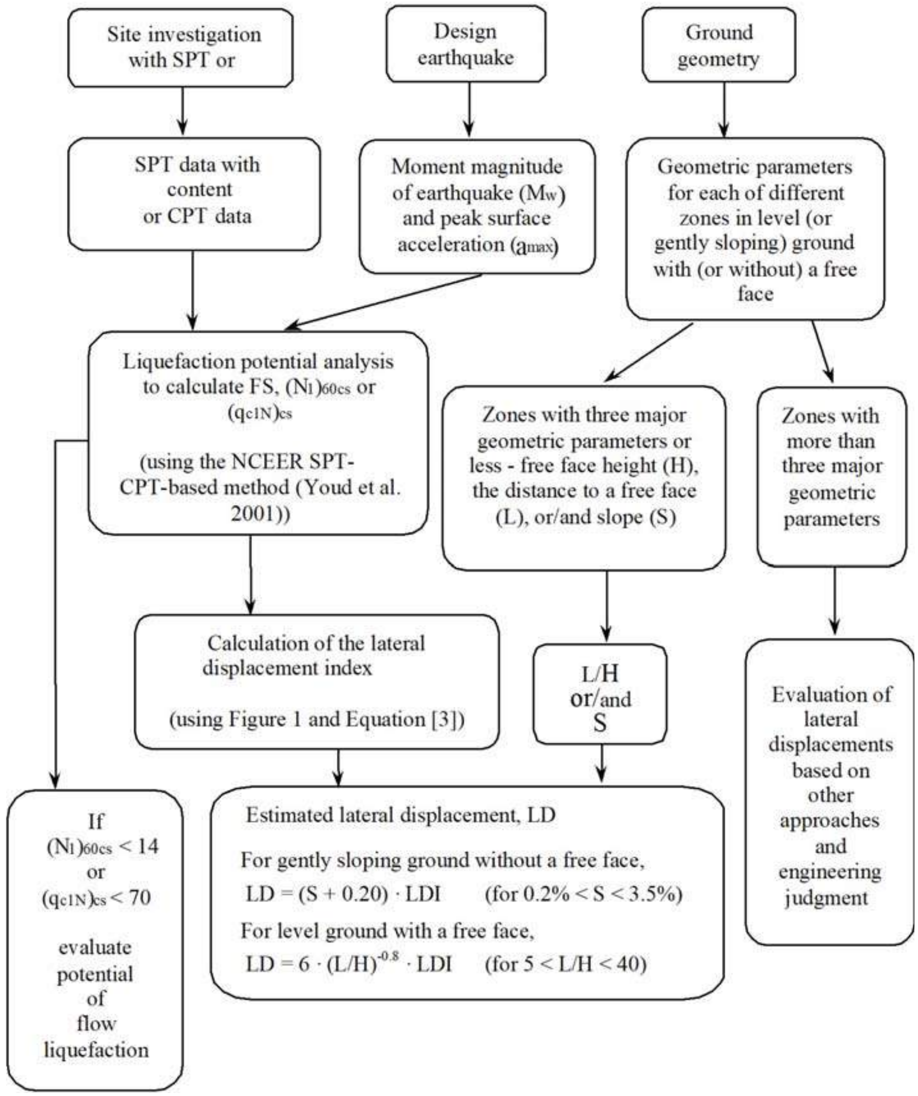
$$I_c = \left[\left(3.47 - \log(Q)\right)^2 + \left(1.22 + \log(F)\right)^2\right]^{0.5}$$

$$Q = \left(\frac{q_c - \sigma_{vc}}{P_a}\right)\left(\frac{P_a}{\sigma'_{vc}}\right)^n \quad with\ 0.5 \le n \le 1.0\ per\ Robertson\ \&\ Wride\ (1998)$$

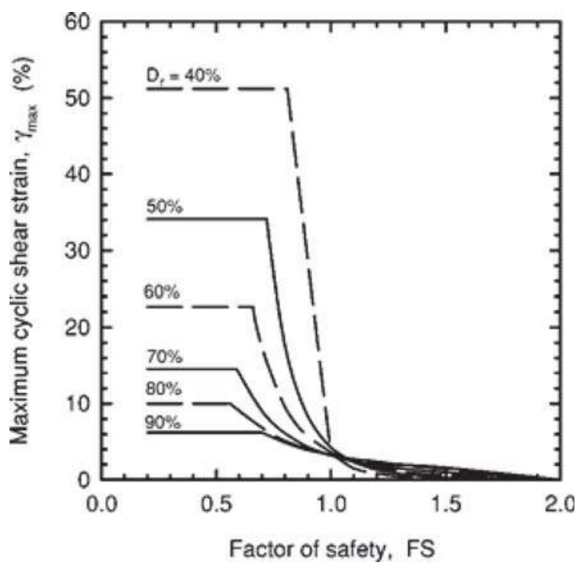
$$F = \left(\frac{f_s}{q_c - \sigma_{vc}}\right)\cdot 100\%$$

σ'_v *at time of CPT sounding*

Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



[1] **Figure 1**

$$LDI = \int_{0}^{Z_{max}} \gamma_{max} dz$$

[1] **Equation [3]**

[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands

Average shear stress, τ_{av}

$$\tau_{av} = CSR^{*} \cdot \sigma_{v0}' = 0.65 \cdot \frac{a_{max}}{g} \cdot \sigma_{v0} \cdot \tau_d$$

↓

Estimate small shear strain modulus, G_0

$$G_0 = 0.0188 \cdot \left[10^{(0.55 I_c - 1.68)}\right] \cdot (q_t - \sigma_v)$$

↓

Estimate shear strain amplitude, γ
(based on Pradel (1998))

$$\gamma = \left[\frac{1 + \alpha \cdot e^{bR}}{1 + \alpha}\right] \cdot R \cdot 100\ (\%)$$

$$R = \frac{\tau_{av}}{G_0} \text{ (Note } \tau_{av} \text{ and } G_0 \text{ same units)}$$

$$\alpha = 0.0389 \cdot \left(\frac{\sigma_v}{p_a}\right) + 0.124$$

$$b = 6400 \cdot \left(\frac{\sigma_v}{p_a}\right)$$

↓

Estimate volumetric strain in 15 cycles

$$\varepsilon_{vol(15)} = \gamma \cdot \left[\frac{(N_1)_{60cs}}{20}\right]^{-1.20}$$

$$(N_1)_{60cs} = \frac{Q_{tn,cs}}{8.5 \cdot \left[1 - \frac{I_c}{4.6}\right]}$$

↓

Volumetric strain in design earthquake

$$\Sigma_{vol} = \varepsilon_{vol(15)} \cdot \left[\frac{N_c}{15}\right]^{0.45}$$

$$N_c = (M - 4)^{2.17}$$

↓

Seismic settlement, s

$$s = 2 \cdot \int_0^{GWT} \Sigma_{vol} \cdot dz$$

Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

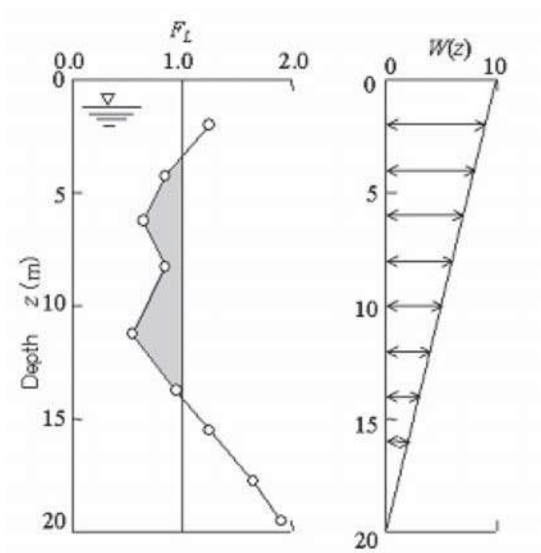
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_{0}^{20} (10 - 0{,}5_Z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

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- Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, *Symposium in honor of professor I. M. Idriss,* SAN diego, CA

- R. E. S. Moss, R. B. Seed, R. E. Kayen, J. P. Stewart, A. Der Kiureghian, K. O. Cetin, CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 1, 2006

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APPENDIX J-4

Liquefaction Report for Student Commons & Art Building – Youd et al., 2001; Robertson, 2009

TABLE OF CONTENTS

A3GEO, Inc.
Geoconsultants
Berkeley, CA
www.a3geo.com

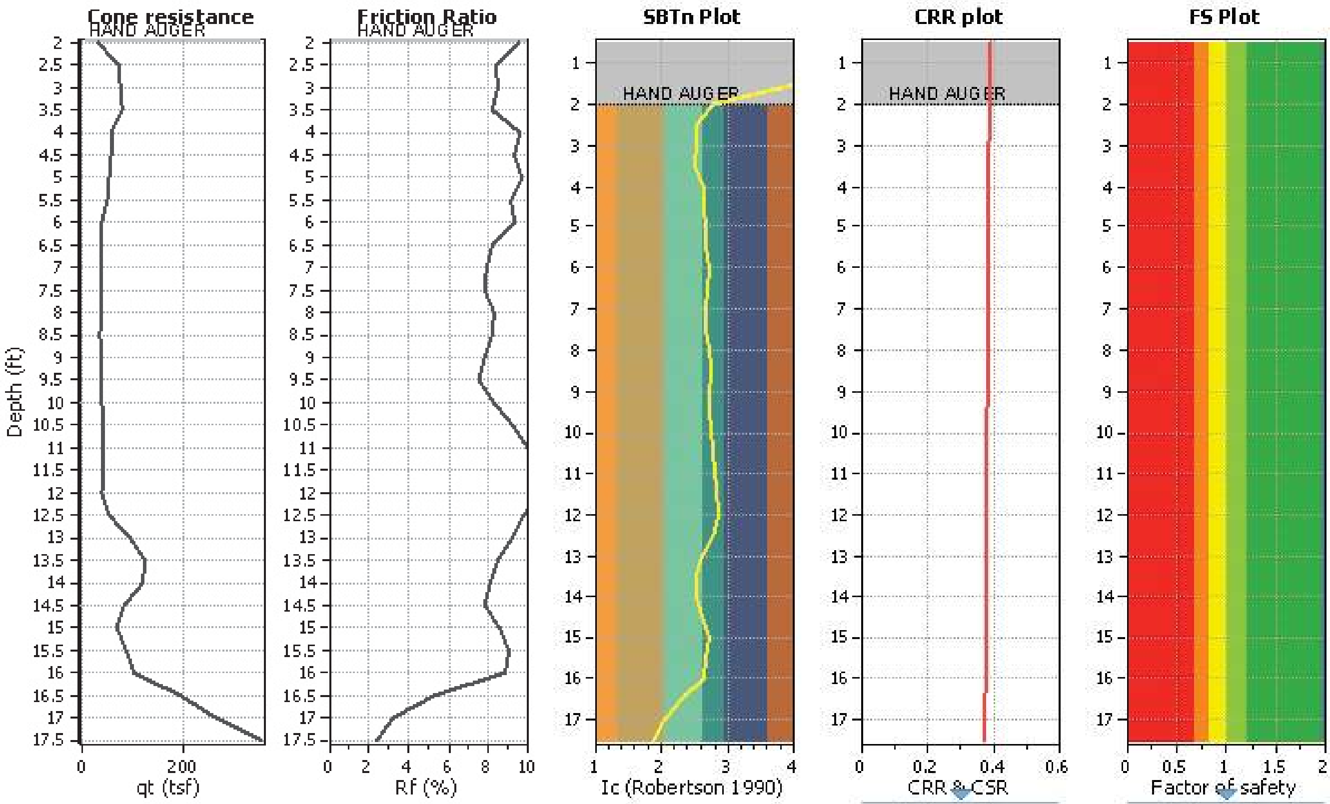
LIQUEFACTION ANALYSIS REPORT

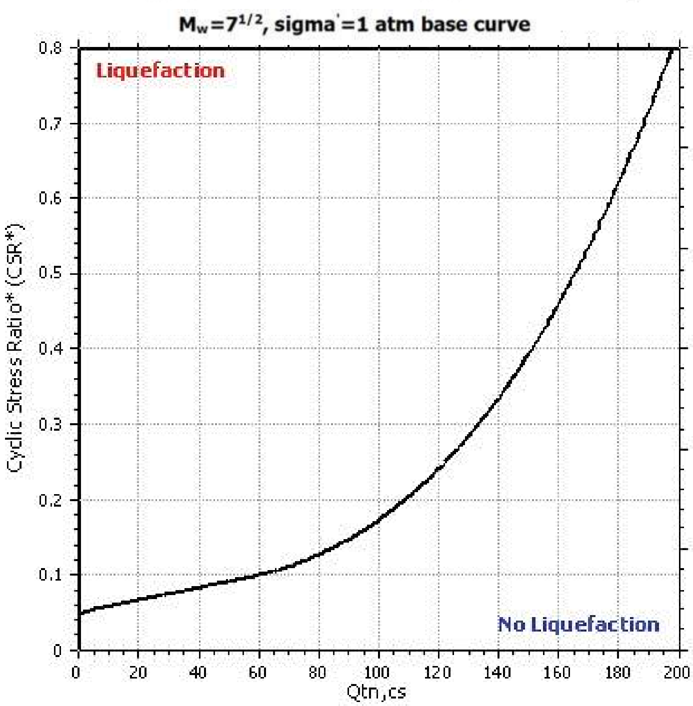
Project title : Terra Linda High School Student Commons and Art Building **Location : San Rafael, California**

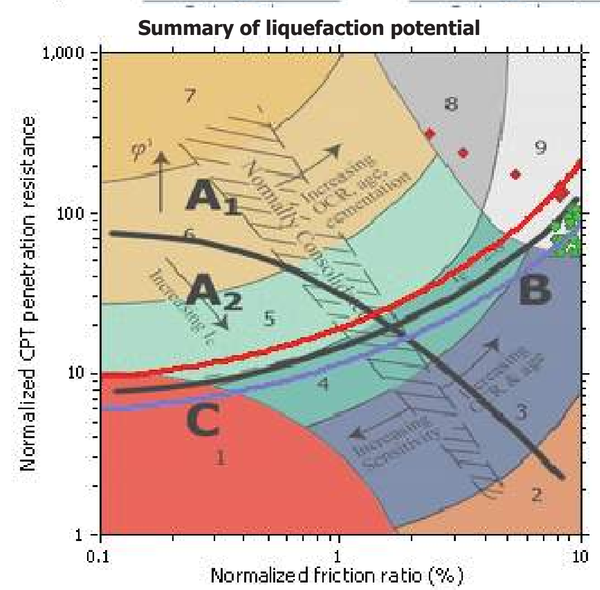
CPT file : MPEG CPT-01

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	19.00 ft	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	19.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	No		

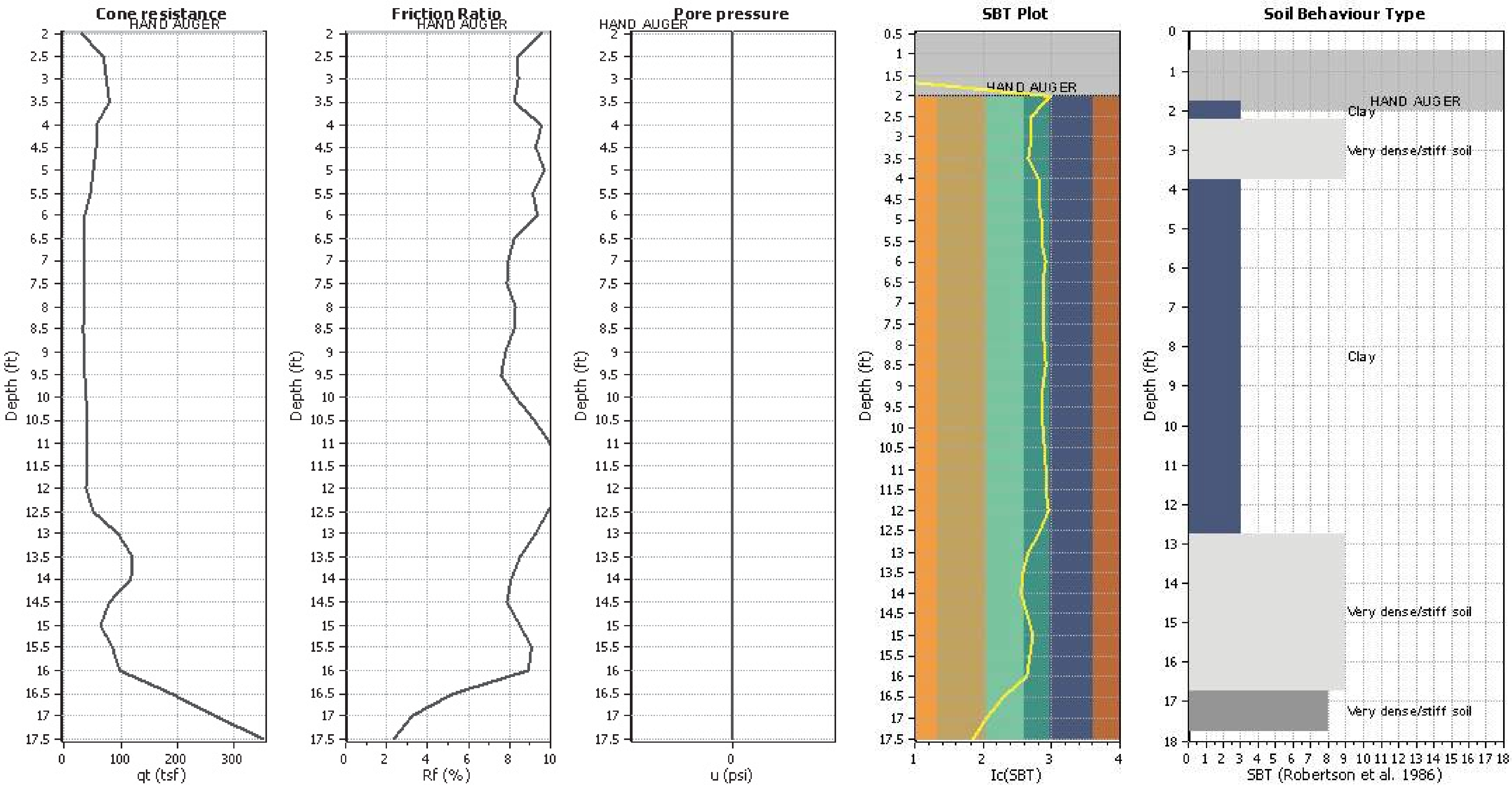






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



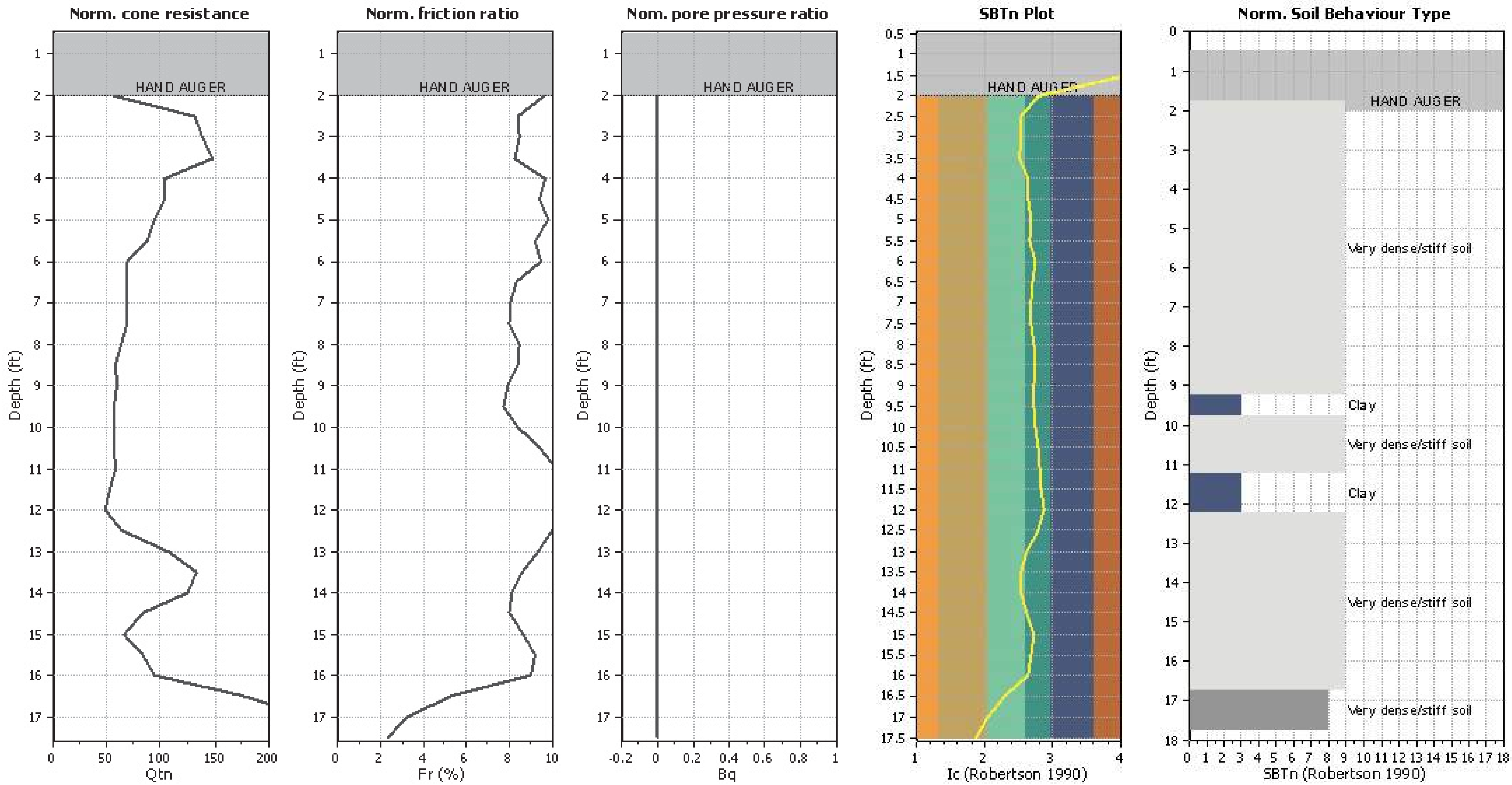
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normaliz



Input parameters and analysis data

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Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
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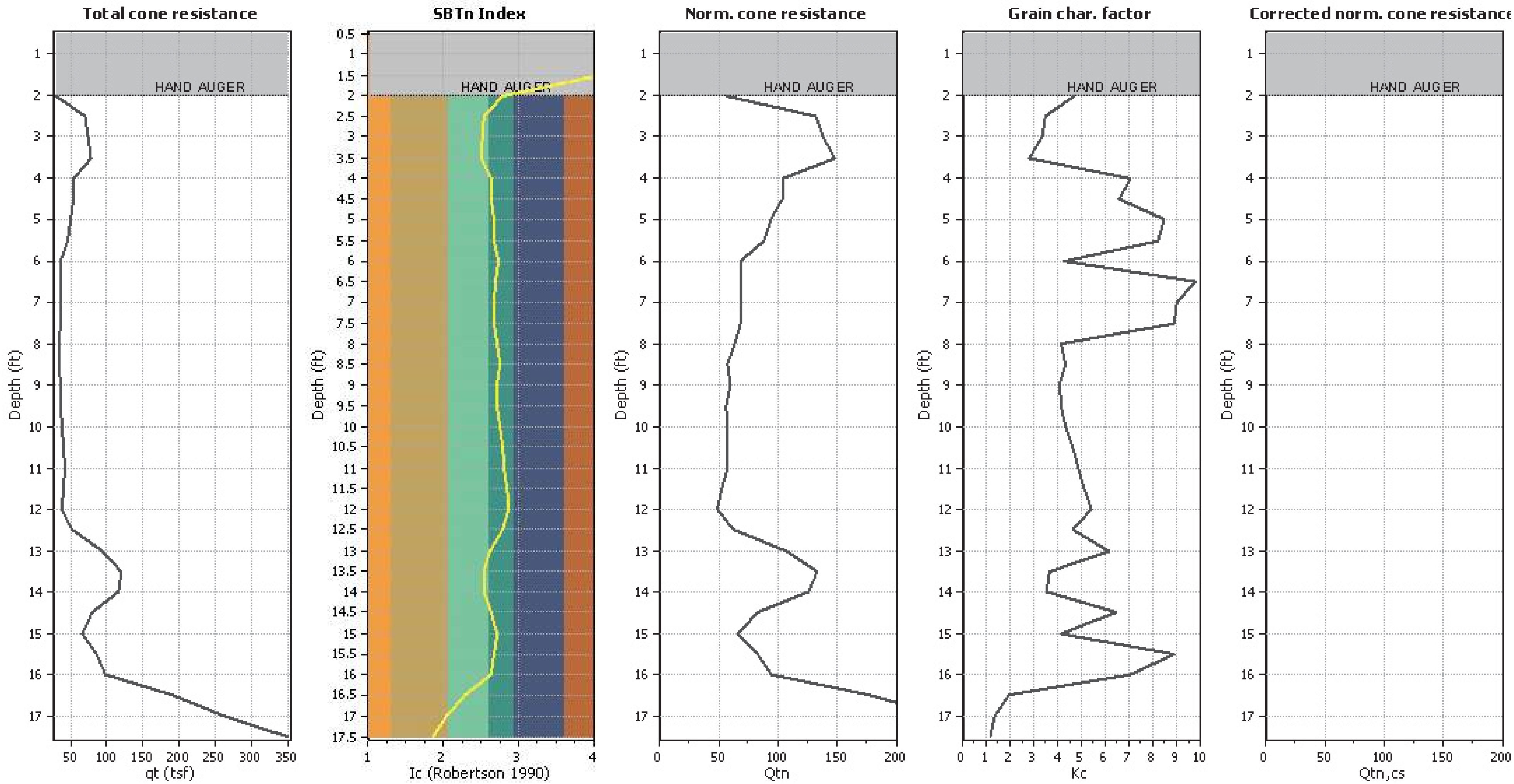
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

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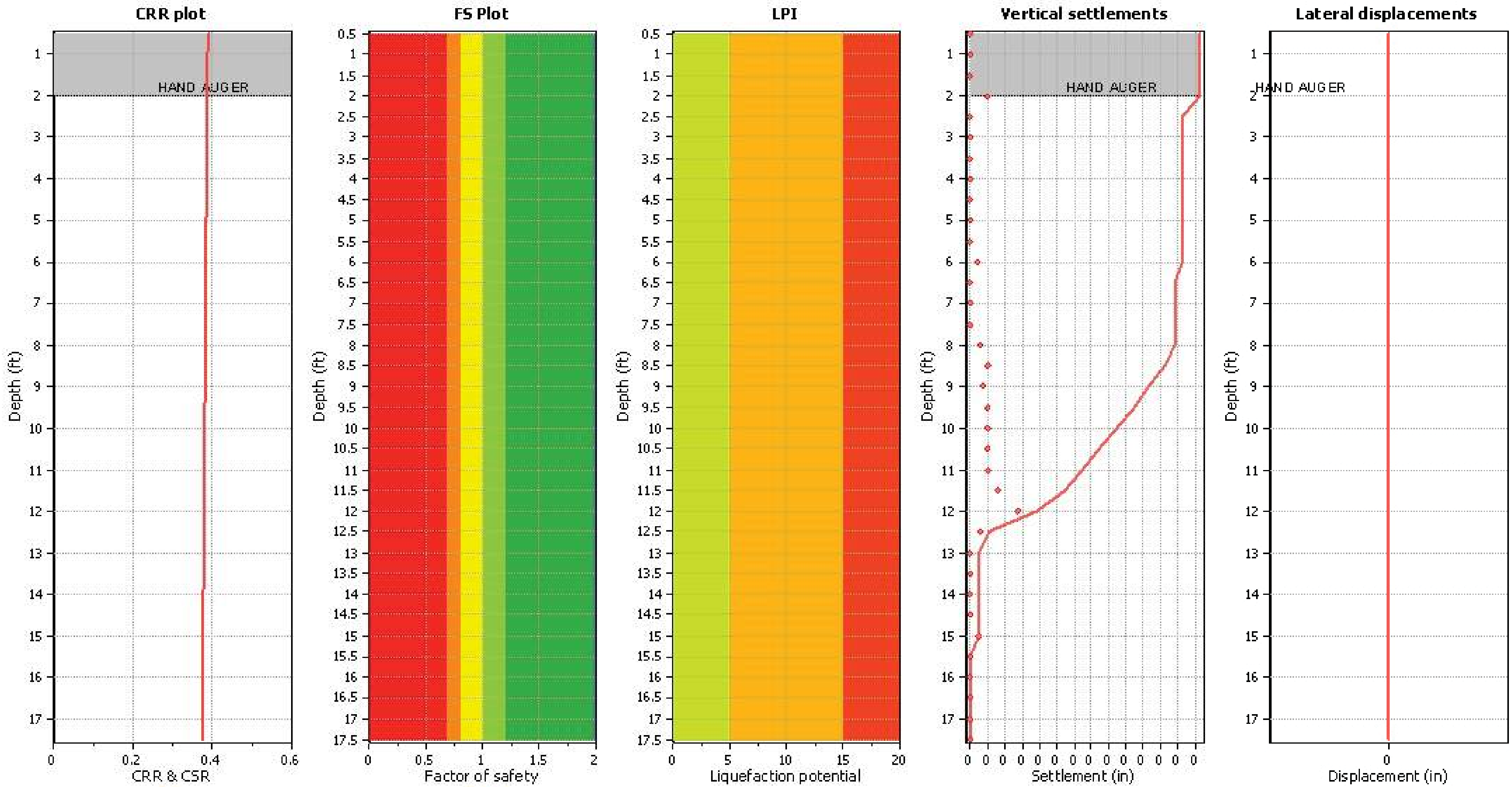
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

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Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
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Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

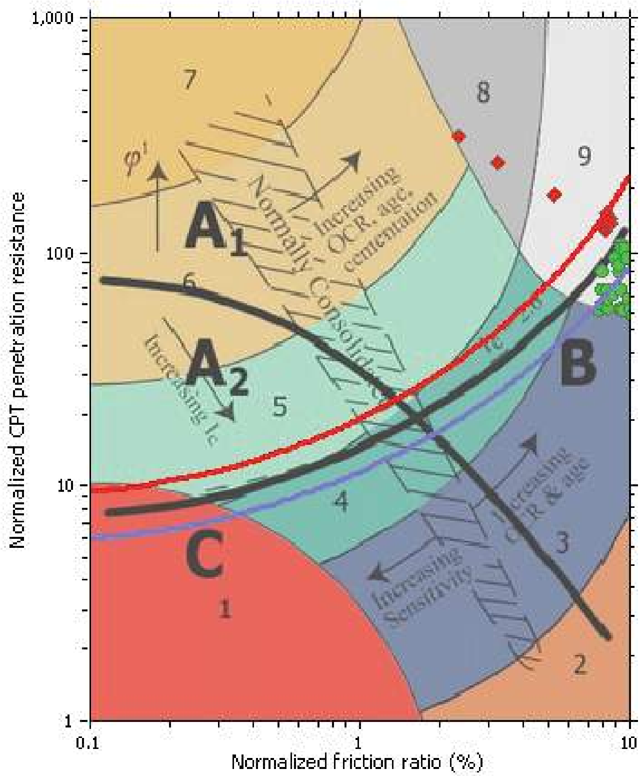
F.S. color scheme

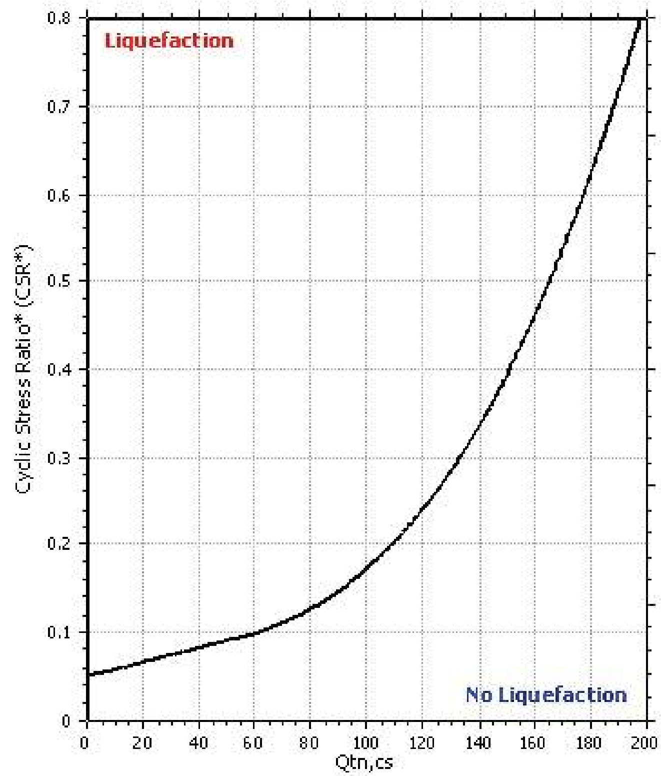
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

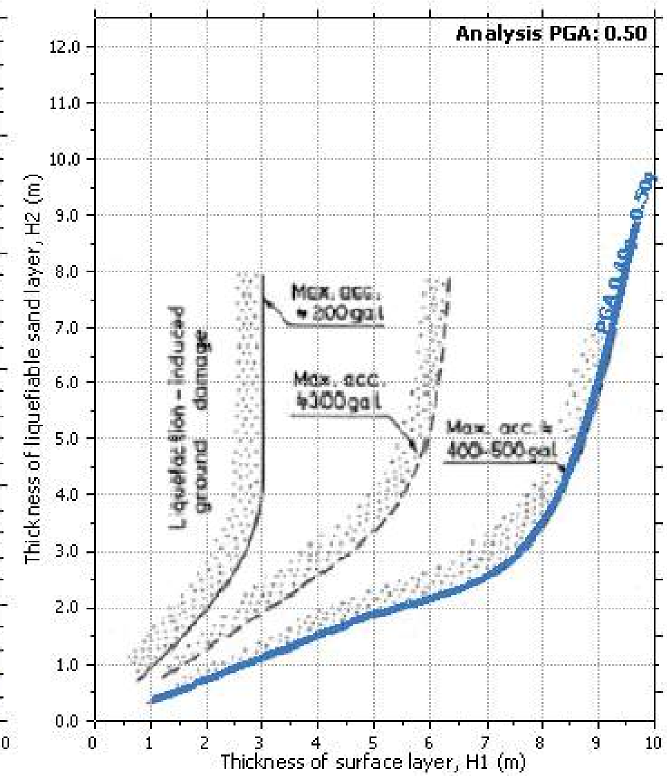
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	19.00 ft	Fill weight:	N/A
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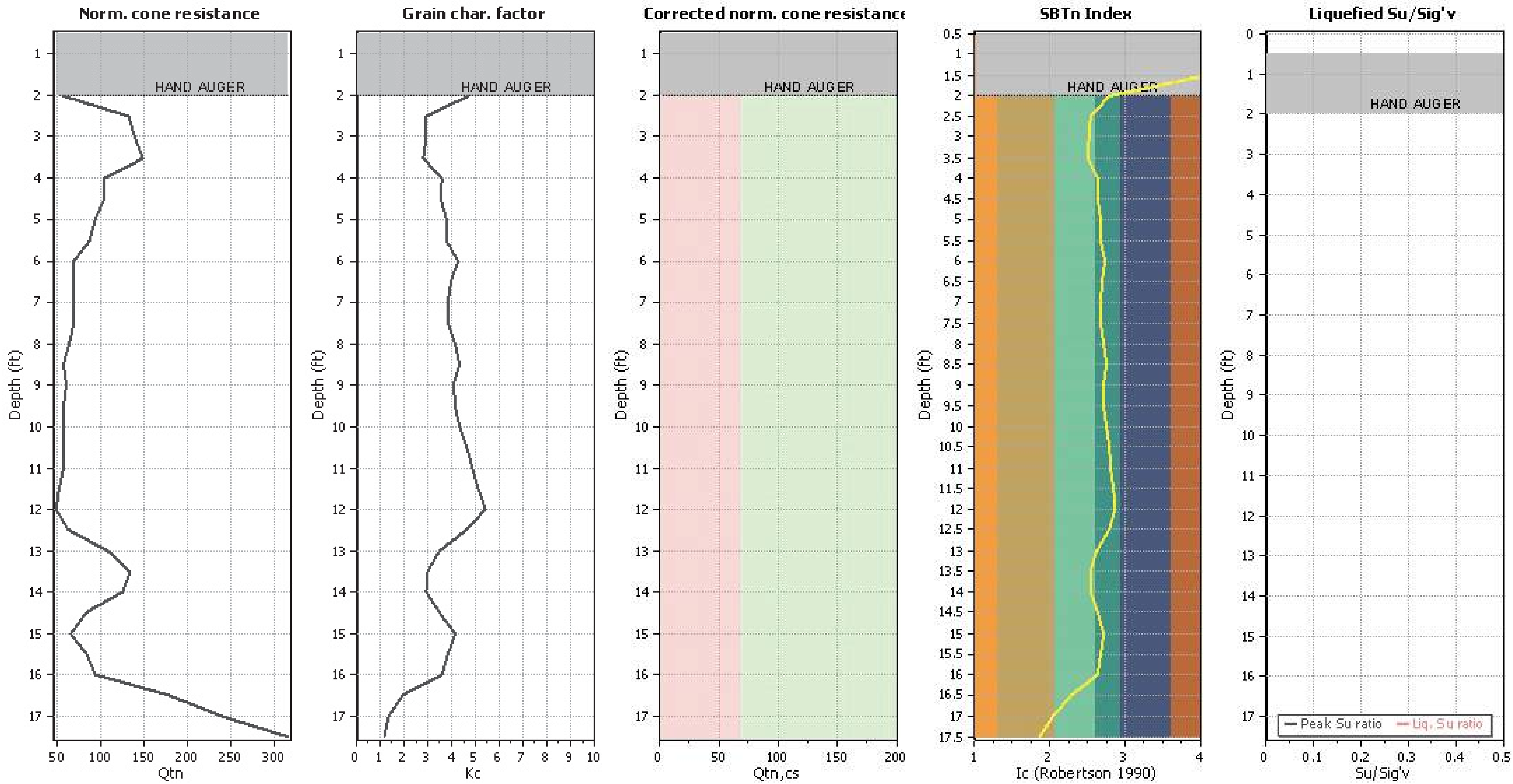
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	No
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.50	-9999.00	-9999.00	-9999.00	100.00	120.90
2	1.00	-9999.00	-9999.00	-9999.00	100.00	120.90
3	1.50	-9999.00	-9999.00	-9999.00	100.00	120.90
4	2.00	50.00	4.40	0.00	45.59	126.27
5	2.50	40.00	4.20	0.00	32.20	133.58
6	3.00	120.00	9.00	0.00	31.87	134.10
7	3.50	60.00	5.40	0.00	30.76	134.55
8	4.00	55.00	4.95	0.00	37.42	132.22
9	4.50	50.00	5.50	0.00	36.88	132.00
10	5.00	60.00	4.92	0.00	38.92	131.40
11	5.50	40.00	4.20	0.00	38.65	130.26
12	6.00	40.00	3.68	0.00	42.42	128.07
13	6.50	30.00	2.40	0.00	40.13	127.16
14	7.00	40.00	3.00	0.00	39.43	126.86
15	7.50	40.00	3.32	0.00	39.33	126.81
16	8.00	30.00	2.34	0.00	41.54	126.77
17	8.50	35.00	3.08	0.00	42.77	126.20
18	9.00	35.00	2.80	0.00	41.27	126.76
19	9.50	40.00	2.72	0.00	41.39	126.52
20	10.00	35.00	2.80	0.00	43.00	127.61
21	10.50	40.00	4.00	0.00	45.02	128.83
22	11.00	45.00	4.28	0.00	46.62	129.82
23	11.50	40.00	4.24	0.00	48.26	129.55
24	12.00	35.00	3.71	0.00	50.43	129.42
25	12.50	40.00	4.24	0.00	44.84	131.78
26	13.00	80.00	7.28	0.00	36.35	137.11
27	13.50	160.00	14.40	0.00	32.49	137.28
28	14.00	120.00	9.00	0.00	32.27	137.28
29	14.50	70.00	4.90	0.00	36.71	134.43
30	15.00	50.00	5.00	0.00	41.46	132.99
31	15.50	75.00	6.75	0.00	39.30	136.07
32	16.00	130.00	11.44	0.00	37.43	137.28
33	16.50	90.00	8.10	0.00	22.42	137.28
34	17.00	350.00	10.50	0.00	14.25	137.28
35	17.50	350.00	7.00	0.00	9.53	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.50	0.03	0.00	0.03	1.00	0.325	0.83	0.390	1.00	1.00	2.000	No
2	1.00	0.06	0.00	0.06	1.00	0.325	0.83	0.390	1.00	1.00	2.000	No
3	1.50	0.09	0.00	0.09	1.00	0.325	0.83	0.389	1.00	1.00	2.000	No
4	2.00	0.12	0.00	0.12	1.00	0.324	0.83	0.389	1.00	1.00	2.000	No
5	2.50	0.16	0.00	0.16	1.00	0.324	0.83	0.388	1.00	1.00	2.000	No
6	3.00	0.19	0.00	0.19	0.99	0.323	0.83	0.388	1.00	1.00	2.000	No
7	3.50	0.22	0.00	0.22	0.99	0.323	0.83	0.387	1.00	1.00	2.000	No
8	4.00	0.26	0.00	0.26	0.99	0.323	0.83	0.387	1.00	1.00	2.000	No
9	4.50	0.29	0.00	0.29	0.99	0.322	0.83	0.386	1.00	1.00	2.000	No
10	5.00	0.32	0.00	0.32	0.99	0.322	0.83	0.386	1.00	1.00	2.000	No
11	5.50	0.35	0.00	0.35	0.99	0.321	0.83	0.385	1.00	1.00	2.000	No
12	6.00	0.39	0.00	0.39	0.99	0.321	0.83	0.385	1.00	1.00	2.000	No
13	6.50	0.42	0.00	0.42	0.99	0.321	0.83	0.385	1.00	1.00	2.000	No
14	7.00	0.45	0.00	0.45	0.99	0.320	0.83	0.384	1.00	1.00	2.000	No
15	7.50	0.48	0.00	0.48	0.98	0.320	0.83	0.384	1.00	1.00	2.000	No
16	8.00	0.51	0.00	0.51	0.98	0.320	0.83	0.383	1.00	1.00	2.000	No
17	8.50	0.54	0.00	0.54	0.98	0.319	0.83	0.383	1.00	1.00	2.000	No
18	9.00	0.58	0.00	0.58	0.98	0.319	0.83	0.382	1.00	1.00	2.000	No
19	9.50	0.61	0.00	0.61	0.98	0.319	0.83	0.382	1.00	1.00	2.000	No
20	10.00	0.64	0.00	0.64	0.98	0.318	0.83	0.382	1.00	1.00	2.000	No
21	10.50	0.67	0.00	0.67	0.98	0.318	0.83	0.381	1.00	1.00	2.000	No
22	11.00	0.70	0.00	0.70	0.98	0.318	0.83	0.381	1.00	1.00	2.000	No
23	11.50	0.74	0.00	0.74	0.98	0.317	0.83	0.380	1.00	1.00	2.000	No
24	12.00	0.77	0.00	0.77	0.97	0.317	0.83	0.380	1.00	1.00	2.000	No
25	12.50	0.80	0.00	0.80	0.97	0.317	0.83	0.380	1.00	1.00	2.000	No
26	13.00	0.84	0.00	0.84	0.97	0.316	0.83	0.379	1.00	1.00	2.000	No
27	13.50	0.87	0.00	0.87	0.97	0.316	0.83	0.379	1.00	1.00	2.000	No
28	14.00	0.91	0.00	0.91	0.97	0.315	0.83	0.378	1.00	1.00	2.000	No
29	14.50	0.94	0.00	0.94	0.97	0.315	0.83	0.378	1.00	1.00	2.000	No
30	15.00	0.97	0.00	0.97	0.97	0.315	0.83	0.377	1.00	1.00	2.000	No
31	15.50	1.01	0.00	1.01	0.97	0.314	0.83	0.377	1.00	1.00	2.000	No
32	16.00	1.04	0.00	1.04	0.97	0.314	0.83	0.377	1.00	1.00	2.000	No
33	16.50	1.07	0.00	1.07	0.97	0.314	0.83	0.376	1.00	1.00	2.000	No
34	17.00	1.11	0.00	1.11	0.96	0.313	0.83	0.376	1.00	1.00	2.000	No
35	17.50	1.14	0.00	1.14	0.96	0.313	0.83	0.375	1.00	1.00	2.000	No

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	I_c	Fr (%)	n	Q_{tn}	K_c	$Q_{tn,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.50	0.00	4.06	0.00	1.00	-1.00	26.61	-26.61	4.000	No	Yes	2.00
2	1.00	0.00	4.06	0.00	1.00	-1.00	26.61	-26.61	4.000	No	Yes	2.00
3	1.50	0.00	4.06	0.00	1.00	-1.00	26.61	-26.61	4.000	No	Yes	2.00
4	2.00	30.00	2.79	9.59	0.92	56.47	4.73	266.85	4.000	No	Yes	2.00
5	2.50	70.00	2.53	8.40	0.82	132.02	3.50	462.55	4.000	No	No	2.00
6	3.00	73.33	2.53	8.48	0.82	138.25	3.34	461.65	4.000	No	No	2.00
7	3.50	78.33	2.50	8.26	0.81	147.64	2.83	418.41	4.000	No	No	2.00
8	4.00	55.00	2.64	9.65	0.87	103.48	7.05	729.89	4.000	No	No	2.00
9	4.50	55.00	2.63	9.36	0.87	103.41	6.59	681.17	4.000	No	No	2.00
10	5.00	50.00	2.67	9.81	0.88	93.90	8.49	797.01	4.000	No	No	2.00
11	5.50	46.67	2.67	9.21	0.88	87.54	8.22	719.18	4.000	No	No	2.00
12	6.00	36.67	2.74	9.44	0.91	68.58	4.27	292.78	4.000	No	Yes	2.00
13	6.50	36.67	2.69	8.35	0.90	68.52	9.81	671.88	4.000	No	No	2.00
14	7.00	36.67	2.68	8.03	0.89	68.46	9.02	617.42	4.000	No	No	2.00
15	7.50	36.67	2.68	7.98	0.89	68.40	8.92	609.81	4.000	No	No	2.00
16	8.00	35.00	2.72	8.45	0.91	63.01	4.15	261.18	4.000	No	Yes	2.00
17	8.50	33.33	2.74	8.36	0.92	57.12	4.32	246.71	4.000	No	Yes	2.00
18	9.00	36.67	2.72	7.94	0.91	59.36	4.11	243.86	4.000	No	Yes	2.00
19	9.50	36.67	2.72	7.69	0.91	56.56	4.13	233.33	4.000	No	Yes	2.00
20	10.00	38.33	2.75	8.42	0.93	56.78	4.35	247.07	4.000	No	Yes	2.00
21	10.50	40.00	2.78	9.39	0.94	57.00	4.64	264.58	4.000	No	Yes	2.00
22	11.00	41.67	2.81	10.18	0.95	57.06	4.88	278.25	4.000	No	Yes	2.00
23	11.50	40.00	2.84	10.38	0.97	52.63	5.12	269.64	4.000	No	Yes	2.00
24	12.00	38.33	2.87	10.82	0.98	48.54	5.45	264.73	4.000	No	Yes	2.00
25	12.50	51.67	2.78	9.98	0.95	62.48	4.62	288.39	4.000	No	Yes	2.00
26	13.00	93.33	2.62	9.34	0.89	107.69	6.16	662.90	4.000	No	No	2.00
27	13.50	120.00	2.54	8.58	0.86	133.08	3.65	485.65	4.000	No	No	2.00
28	14.00	116.67	2.53	8.15	0.86	125.09	3.54	442.57	4.000	No	No	2.00
29	14.50	80.00	2.63	7.97	0.90	83.16	6.45	536.03	4.000	No	No	2.00
30	15.00	65.00	2.72	8.67	0.93	65.49	4.13	270.78	4.000	No	Yes	2.00
31	15.50	85.00	2.68	9.20	0.92	83.14	8.89	738.85	4.000	No	No	2.00
32	16.00	98.33	2.64	9.01	0.91	93.36	7.06	659.10	4.000	No	No	2.00
33	16.50	190.00	2.30	5.30	0.78	176.40	1.94	342.19	4.000	No	No	2.00
34	17.00	263.33	2.05	3.25	0.68	240.00	1.37	327.84	4.000	No	No	2.00
35	17.50	350.00	1.86	2.34	0.61	314.38	1.16	363.47	4.000	No	No	2.00

Abbreviations

Depth:	Depth from free surface, at which CPT was performed (ft)
q_t:	Total cone resistance
I_c:	Soil behavior type index
Fr:	Normalized friction ratio (%)
n:	Stress exponent
Q_{tn}:	Normalized cone resistance
K_c:	Cone resistance correction factor due to fines
$Q_{tn,cs}$:	Normalized and adjusted cone resistance
$CRR_{7.5}$:	Cyclic resistance ratio for M_w=7.5
FS:	Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.50	2.00	0.00	0.00	0.00	0.00	1.00	2.00	0.00	0.00	0.00	0.00
1.50	2.00	0.00	0.00	0.00	0.00	2.00	2.00	0.00	9.70	0.50	0.00
2.50	2.00	0.00	9.62	0.50	0.00	3.00	2.00	0.00	9.54	0.50	0.00
3.50	2.00	0.00	9.47	0.50	0.00	4.00	2.00	0.00	9.39	0.50	0.00
4.50	2.00	0.00	9.31	0.50	0.00	5.00	2.00	0.00	9.24	0.50	0.00
5.50	2.00	0.00	9.16	0.50	0.00	6.00	2.00	0.00	9.09	0.50	0.00
6.50	2.00	0.00	9.01	0.50	0.00	7.00	2.00	0.00	8.93	0.50	0.00
7.50	2.00	0.00	8.86	0.50	0.00	8.00	2.00	0.00	8.78	0.50	0.00
8.50	2.00	0.00	8.70	0.50	0.00	9.00	2.00	0.00	8.63	0.50	0.00
9.50	2.00	0.00	8.55	0.50	0.00	10.00	2.00	0.00	8.48	0.50	0.00
10.50	2.00	0.00	8.40	0.50	0.00	11.00	2.00	0.00	8.32	0.50	0.00
11.50	2.00	0.00	8.25	0.50	0.00	12.00	2.00	0.00	8.17	0.50	0.00
12.50	2.00	0.00	8.10	0.50	0.00	13.00	2.00	0.00	8.02	0.50	0.00
13.50	2.00	0.00	7.94	0.50	0.00	14.00	2.00	0.00	7.87	0.50	0.00
14.50	2.00	0.00	7.79	0.50	0.00	15.00	2.00	0.00	7.71	0.50	0.00
15.50	2.00	0.00	7.64	0.50	0.00	16.00	2.00	0.00	7.56	0.50	0.00
16.50	2.00	0.00	7.49	0.50	0.00	17.00	2.00	0.00	7.41	0.50	0.00
17.50	2.00	0.00	7.33	0.50	0.00						

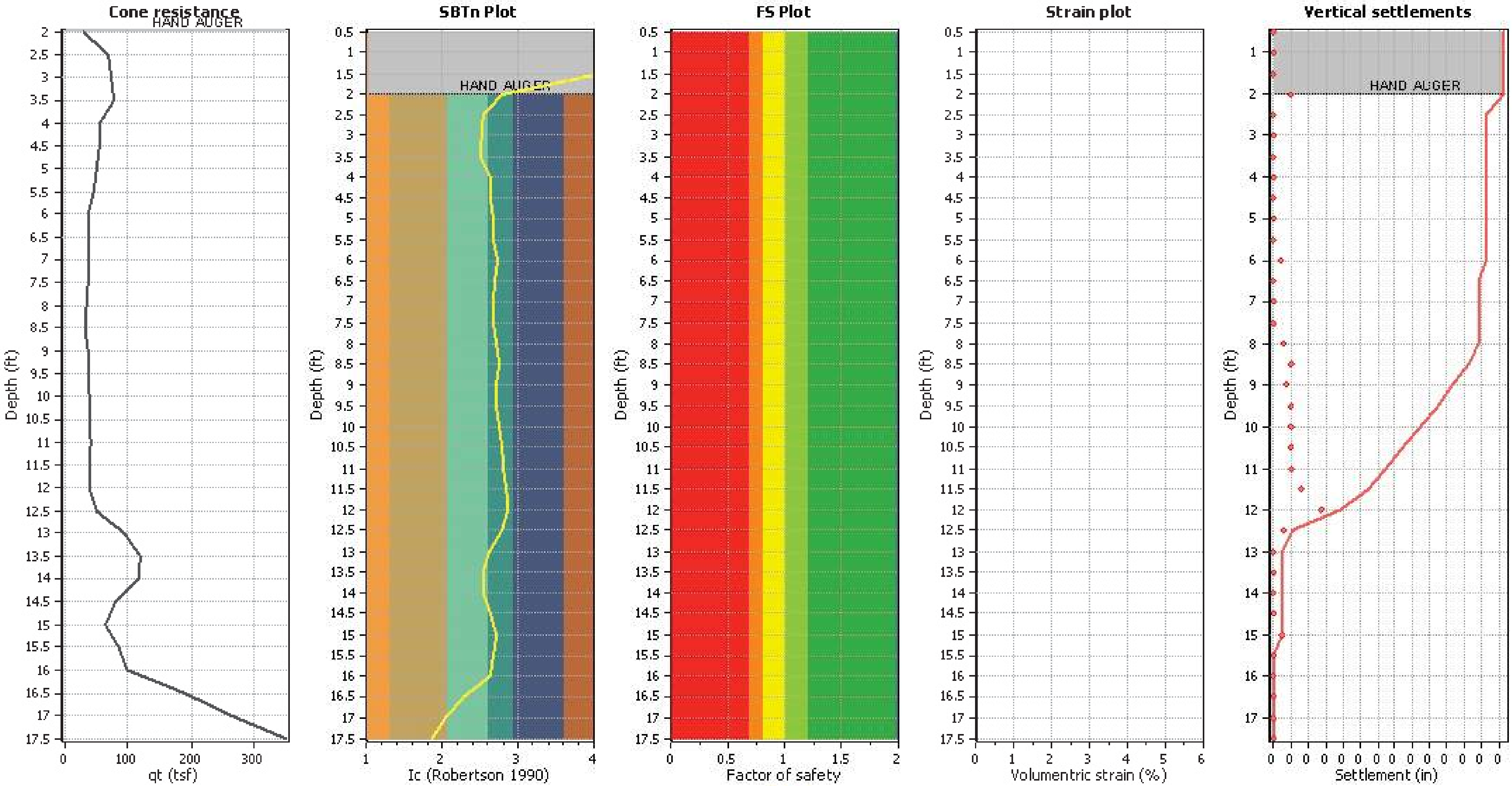
Overall liquefaction potential: 0.00

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

Estimation of post-earthquake settlements

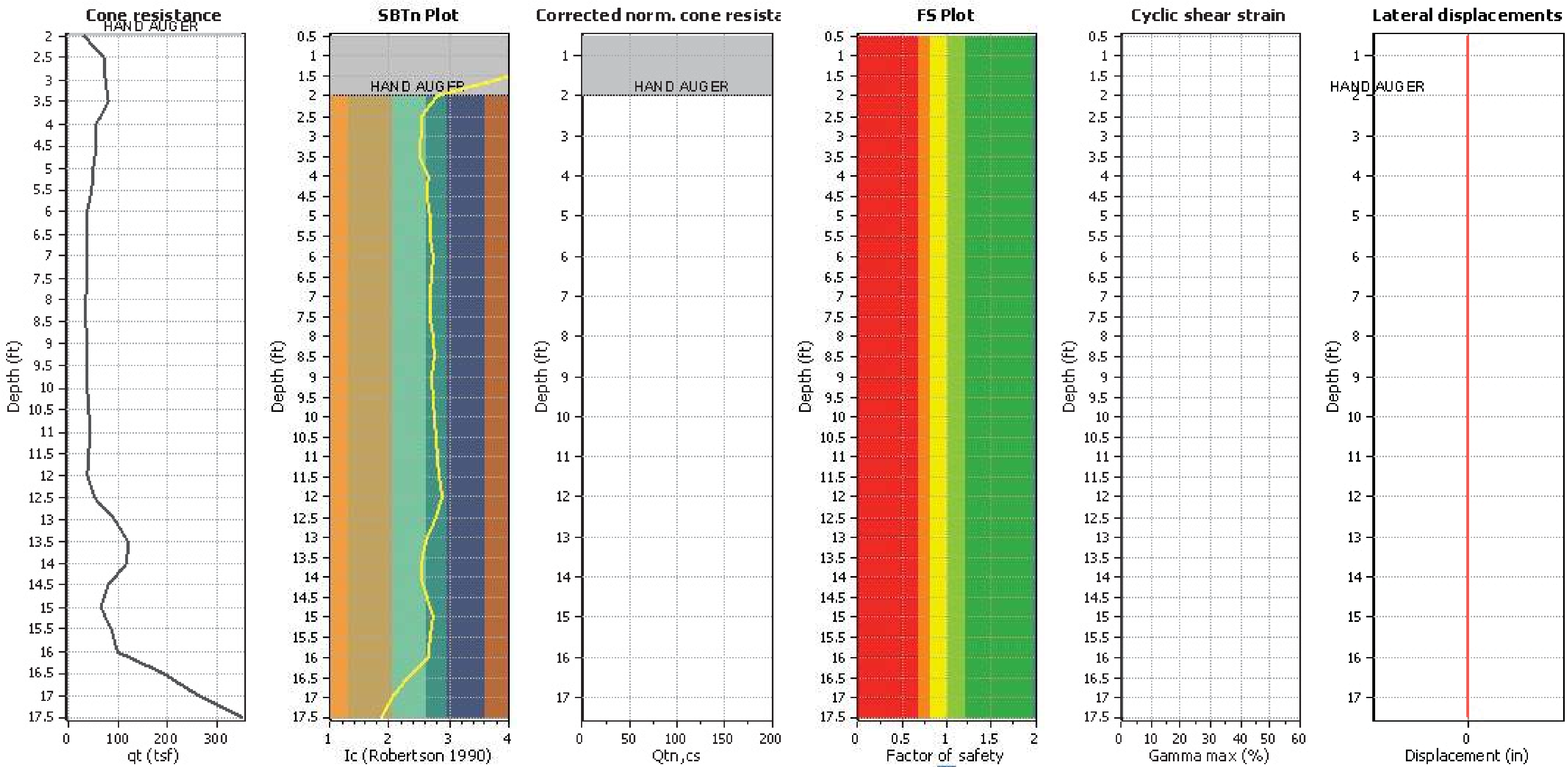


Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements

Geometric parameters: Gently sloping ground without free face (Slope 1.00 %)



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$Q_{tn,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

Surface condition

:: Strength loss calculation (Robertson (2009) ::

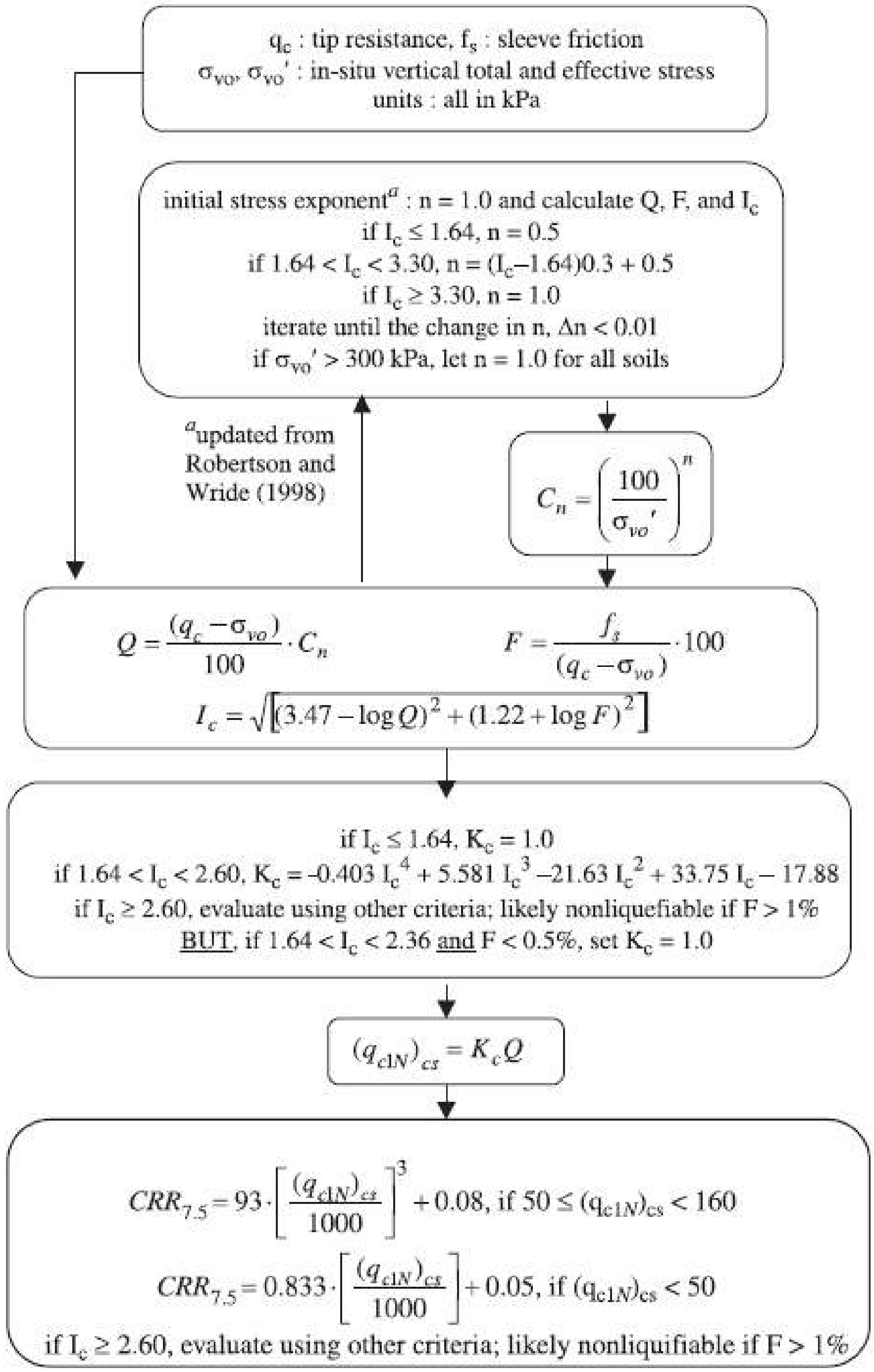
Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.50	0.00	-1.00	26.61	-26.61	4.06	N/A	N/A
1.00	0.00	-1.00	26.61	-26.61	4.06	N/A	N/A
1.50	0.00	-1.00	26.61	-26.61	4.06	N/A	N/A
2.00	30.00	56.47	4.73	266.85	2.79	N/A	N/A
2.50	70.00	132.02	2.94	388.61	2.53	N/A	N/A
3.00	73.33	138.25	2.90	401.59	2.53	N/A	N/A
3.50	78.33	147.64	2.78	409.96	2.50	N/A	N/A
4.00	55.00	103.48	3.59	371.55	2.64	N/A	N/A
4.50	55.00	103.41	3.52	364.05	2.63	N/A	N/A
5.00	50.00	93.90	3.79	355.79	2.67	N/A	N/A
5.50	46.67	87.54	3.75	328.55	2.67	N/A	N/A
6.00	36.67	68.58	4.27	292.78	2.74	N/A	N/A
6.50	36.67	68.52	3.95	270.80	2.69	N/A	N/A
7.00	36.67	68.46	3.86	264.02	2.68	N/A	N/A
7.50	36.67	68.40	3.84	262.90	2.68	N/A	N/A
8.00	35.00	63.01	4.15	261.18	2.72	N/A	N/A
8.50	33.33	57.12	4.32	246.71	2.74	N/A	N/A
9.00	36.67	59.36	4.11	243.86	2.72	N/A	N/A
9.50	36.67	56.56	4.13	233.33	2.72	N/A	N/A
10.00	38.33	56.78	4.35	247.07	2.75	N/A	N/A
10.50	40.00	57.00	4.64	264.58	2.78	N/A	N/A
11.00	41.67	57.06	4.88	278.25	2.81	N/A	N/A
11.50	40.00	52.63	5.12	269.64	2.84	N/A	N/A
12.00	38.33	48.54	5.45	264.73	2.87	N/A	N/A
12.50	51.67	62.48	4.62	288.39	2.78	N/A	N/A
13.00	93.33	107.69	3.45	371.78	2.62	N/A	N/A
13.50	120.00	133.08	2.98	396.20	2.54	N/A	N/A
14.00	116.67	125.09	2.95	369.22	2.53	N/A	N/A
14.50	80.00	83.16	3.50	290.94	2.63	N/A	N/A
15.00	65.00	65.49	4.13	270.78	2.72	N/A	N/A
15.50	85.00	83.14	3.84	319.27	2.68	N/A	N/A
16.00	98.33	93.36	3.59	335.32	2.64	N/A	N/A
16.50	190.00	176.40	1.94	342.19	2.30	N/A	N/A
17.00	263.33	240.00	1.37	327.84	2.05	N/A	N/A
17.50	350.00	314.38	1.16	363.47	1.86	N/A	N/A

Abbreviations

q_t:	Total cone resistance
K_c:	Cone resistance correction factor due to fines
$Q_{tn,cs}$:	Adjusted and corrected cone resistance due to fines
I_c:	Soil behavior type index
$S_{u(liq)}/\sigma'_v$:	Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$:	Calculated peak undrained strength ratio

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

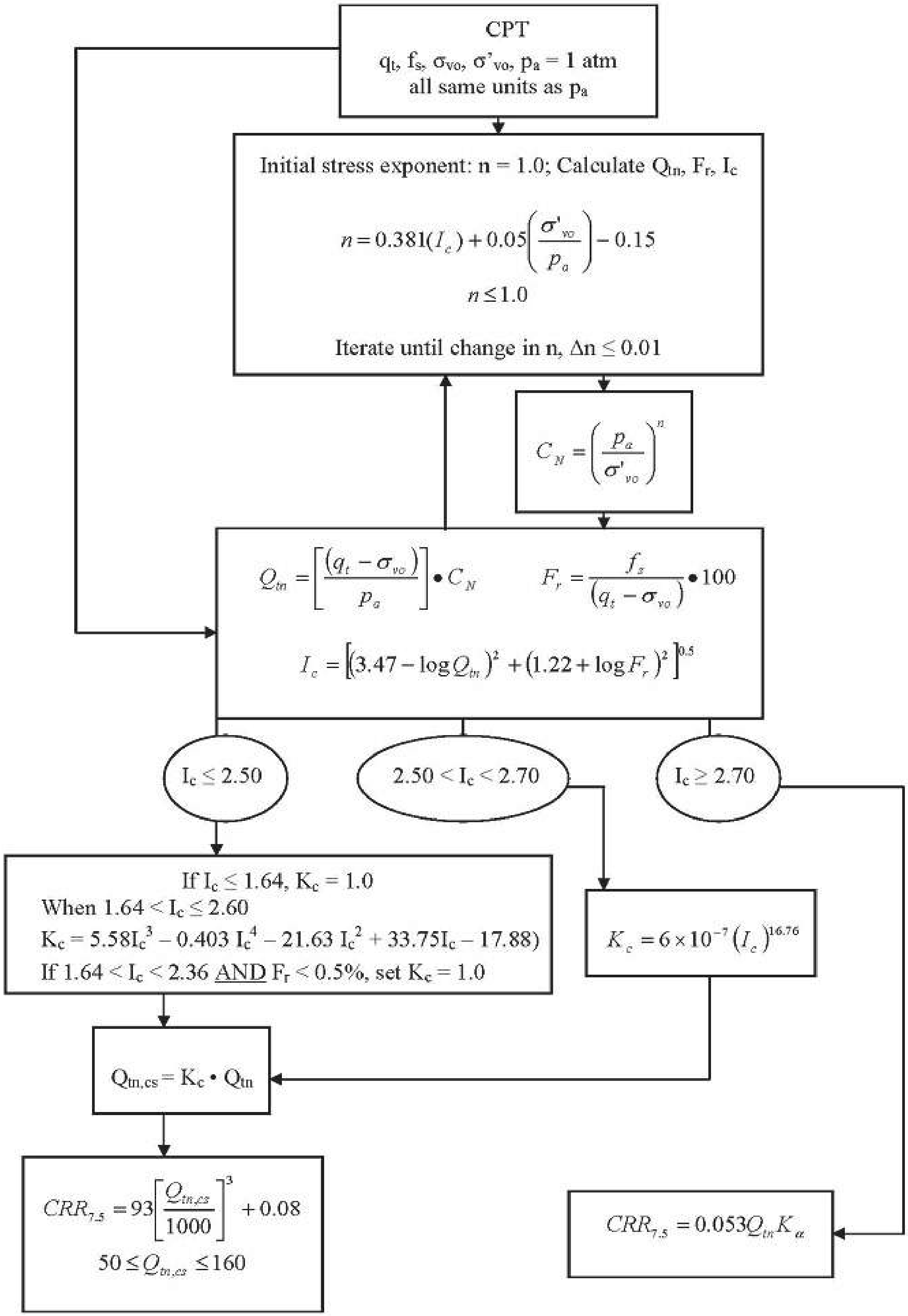
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

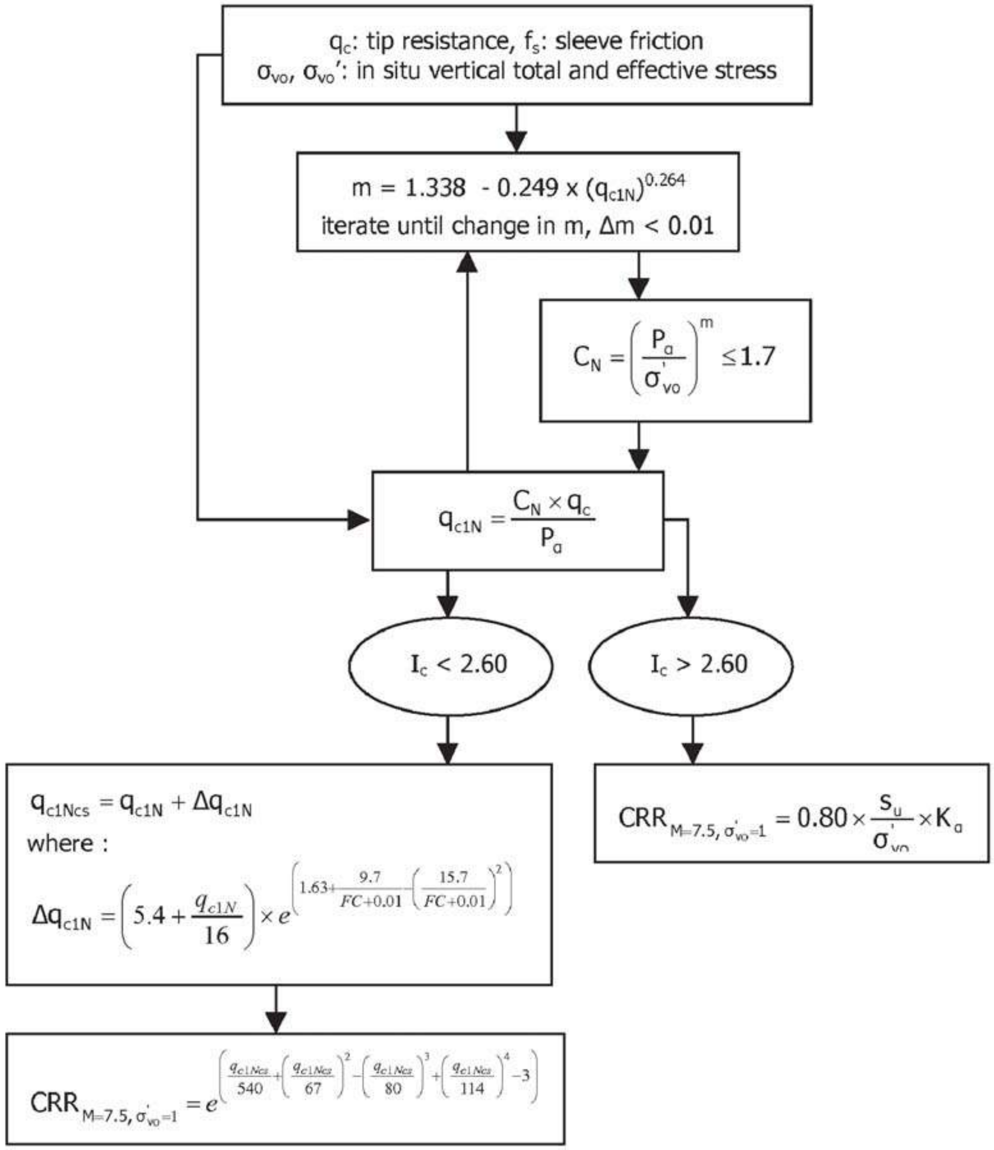
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

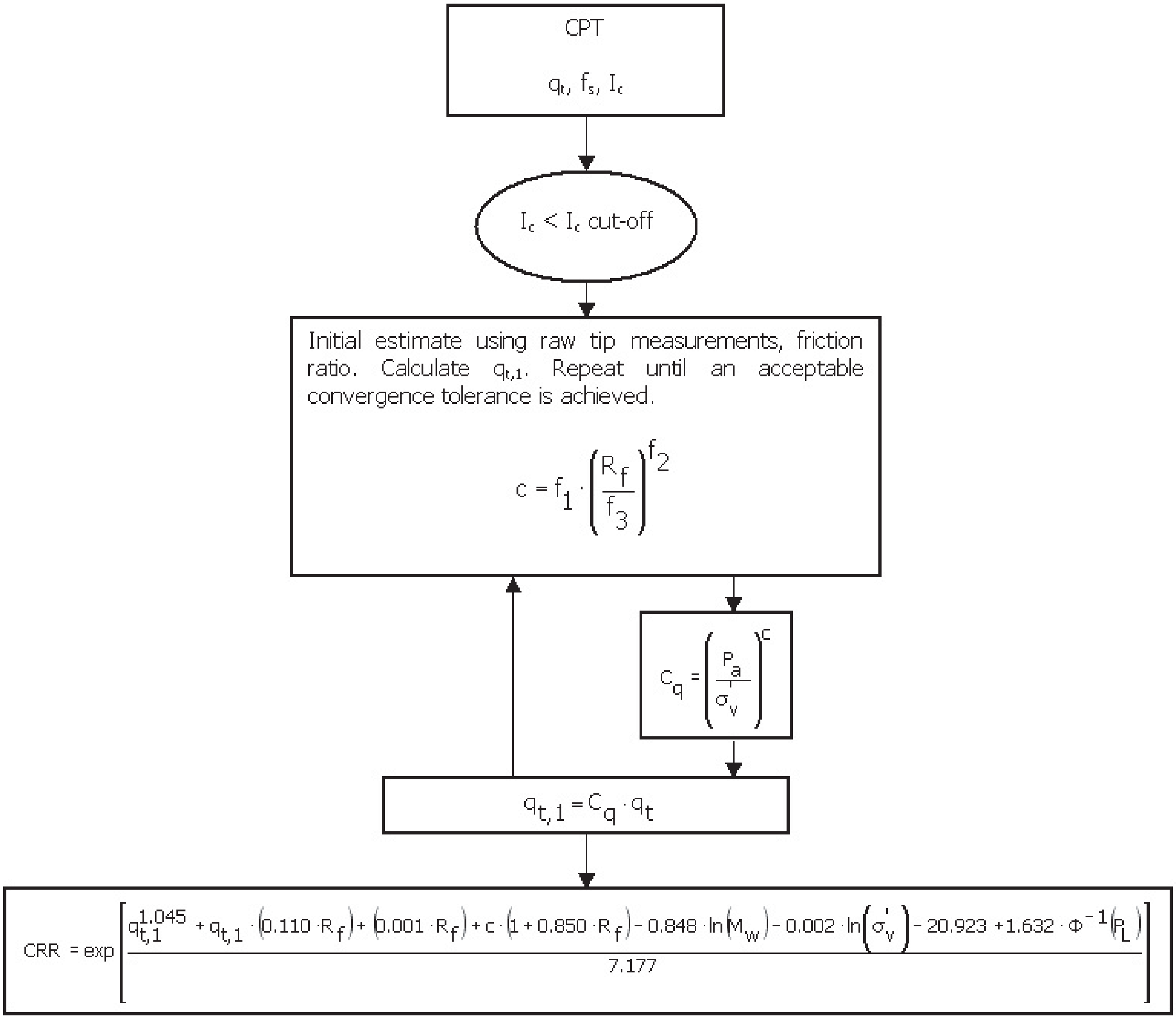


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)

$$FS_{liq} = \frac{CRR_{M=7.5,\sigma'_v=1atm}}{CSR_{M=7.5,\sigma'_v=1atm}}$$

$$CSR_{M=7.5,\sigma'_v=1atm} = 0.65 \frac{\sigma_v}{\sigma'_v} \frac{a_{\max}}{g} r_d \frac{1}{MSF} \frac{1}{K_\sigma}$$

$$r_d = \exp\left[\alpha(z) + \beta(z) \cdot M\right]$$

$$\alpha(z) = -1.012 - 1.126 \sin\left(\frac{z}{11.73} + 5.133\right)$$

$$\beta(z) = 0.106 + 0.118 \sin\left(\frac{z}{11.28} + 5.142\right)$$

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_v}{P_a}\right) \leq 1.1$$

$$C_\sigma = \frac{1}{37.3 - 8.27\left(q_{c1Ncs}\right)^{0.264}} \leq 0.3$$

$$MSF = 1 + \left(MSF_{max} - 1\right)\left(8.64 \exp\left(\frac{-M}{4}\right) - 1.325\right)$$

$$MSF_{max} = 1.09 + \left(\frac{q_{c1Ncs}}{180}\right)^3 \leq 2.2$$

σ'_v *and* σ_v *at start of earthquake shaking*

$$CRR_{M=7.5,\sigma'_v=1atm} = \exp\left(\frac{q_{c1Ncs}}{113} + \left(\frac{q_{c1Ncs}}{1000}\right)^2 - \left(\frac{q_{c1Ncs}}{140}\right)^3 + \left(\frac{q_{c1Ncs}}{137}\right)^4 - 2.80\right)$$

$$q_{c1Ncs} = q_{c1N} + \Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(11.9 + \frac{q_{c1N}}{14.6}\right) \exp\left(1.63 - \frac{9.7}{FC+2} - \left(\frac{15.7}{FC+2}\right)^2\right)$$

$$q_{c1N} = C_{N\sigma} \frac{q_c}{P_a}$$

$$C_{N\sigma} = \left(\frac{P_a}{\sigma'_v}\right)^m \leq 1.7$$

$$m = 1.338 - 0.249\left(q_{c1Ncs}\right)^{0.264} \quad with \quad 0.264 \leq m \leq 0.782$$

$$FC = 80\left(I_C + C_{FC}\right) - 137 \quad with \quad 0\% \leq FC \leq 100\%$$

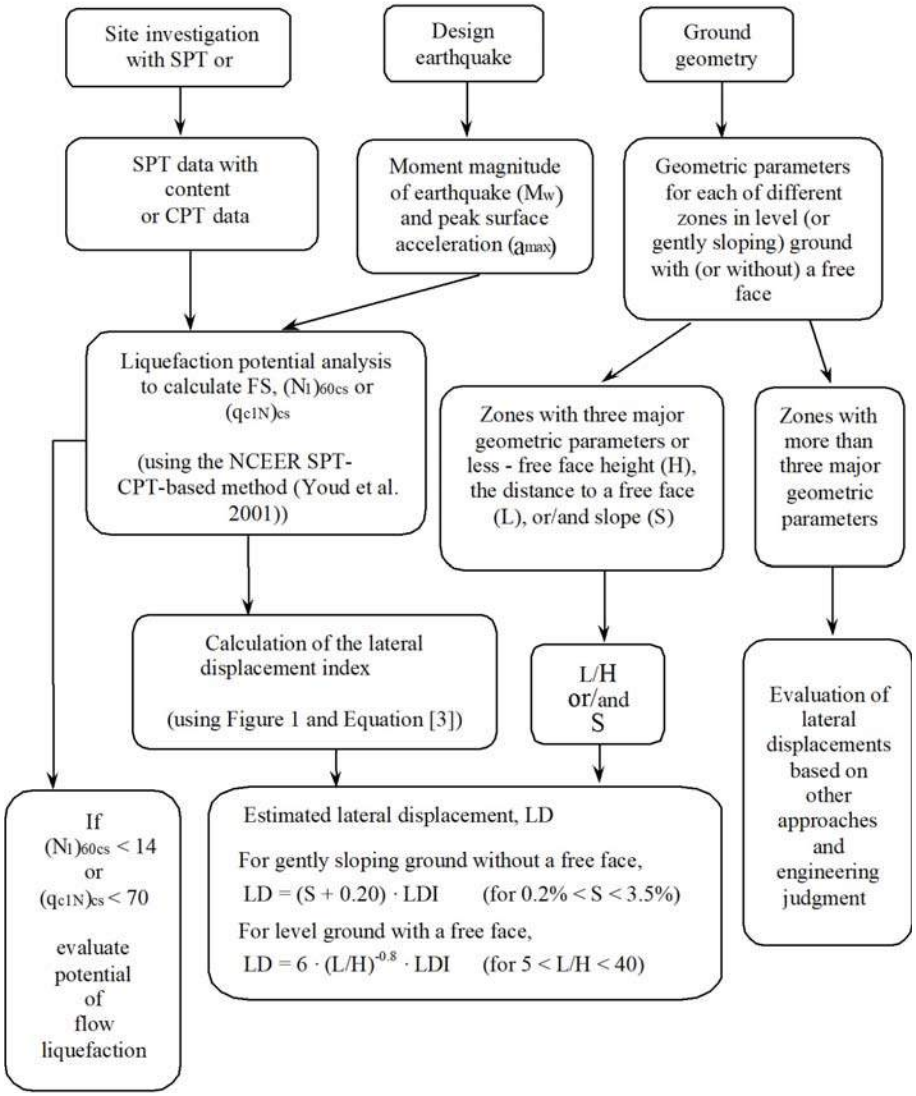
$$I_c = \left[\left(3.47 - \log(Q)\right)^2 + \left(1.22 + \log(F)\right)^2\right]^{0.5}$$

$$Q = \left(\frac{q_c - \sigma_{vc}}{P_a}\right)\left(\frac{P_a}{\sigma'_{vc}}\right)^n \quad with\ 0.5 \leq n \leq 1.0\ per\ Robertson\ \&\ Wride\ (1998)$$

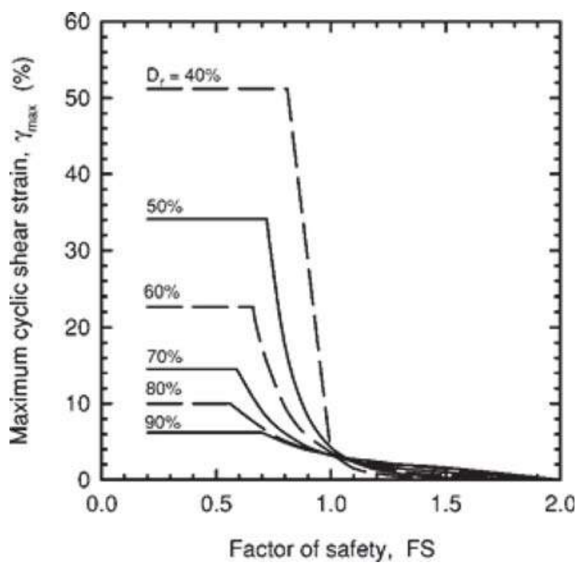
$$F = \left(\frac{f_s}{q_c - \sigma_{vc}}\right) \cdot 100\%$$

σ'_v *at time of CPT sounding*

Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



[1] **Figure 1**

$$\mathrm{LDI} = \int_0^{Z_{\max}} \gamma_{\max}\, dz$$

[1] **Equation [3]**

[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands

Average shear stress, τ_{av}

$$\tau_{av} = CSR^{*} \cdot \sigma_{v0}' = 0.65 \cdot \frac{a_{max}}{g} \cdot \sigma_{v0} \cdot r_d$$

↓

Estimate small shear strain modulus, G_0

$$G_0 = 0.0188 \cdot \left[10^{(0.55 I_c - 1.68)}\right] \cdot (q_t - \sigma_v)$$

↓

Estimate shear strain amplitude, γ

(based on Pradel (1998))

$$\gamma = \left[\frac{1 + a \cdot e^{bR}}{1 + a}\right] \cdot R \cdot 100\ (\%)$$

$$R = \frac{\tau_{av}}{G_0} \text{ (Note } \tau_{av} \text{ and } G_0 \text{ same units)}$$

$$a = 0.0389 \cdot \left(\frac{\sigma_v}{p_a}\right) + 0.124$$

$$b = 6400 \cdot \left(\frac{\sigma_v}{p_a}\right)$$

↓

Estimate volumetric strain in 15 cycles

$$\varepsilon_{vol(15)} = \gamma \cdot \left[\frac{(N_1)_{60,cs}}{20}\right]^{-1.20}$$

$$(N_1)_{60,cs} = \frac{Q_{tn,cs}}{8.5 \cdot \left[1 - \frac{I_c}{4.6}\right]}$$

↓

Volumetric strain in design earthquake

$$\varepsilon_{vol} = \varepsilon_{vol(15)} \cdot \left[\frac{N_c}{15}\right]^{0.45}$$

$$N_c = (M - 4)^{2.17}$$

↓

Seismic settlement, s

$$s = 2 \cdot \int_0^{GWT} \varepsilon_{vol} \cdot dz$$

Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

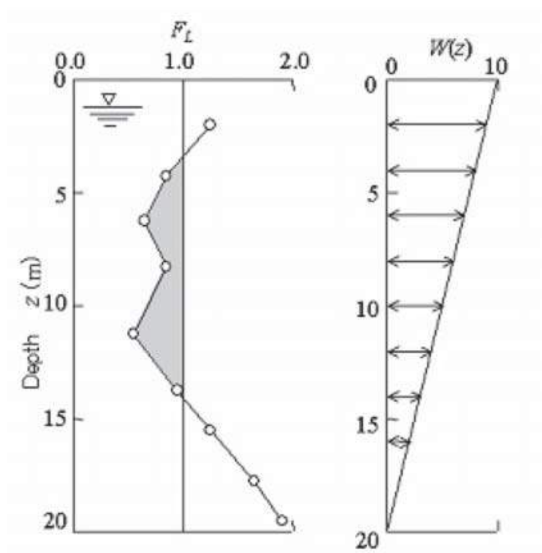
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_0^{20} (10 - 0{,}5_Z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

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- R. E. S. Moss, R. B. Seed, R. E. Kayen, J. P. Stewart, A. Der Kiureghian, K. O. Cetin, CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 1, 2006
- I. M. Idriss and R. W. Boulanger, 2008. Soil liquefaction during earthquakes, Earthquake Engineering Research Institute

APPENDIX J-5

Liquefaction Report for Student Commons & Art Building – Idriss and Boulanger, 2008

TABLE OF CONTENTS

A3GEO, Inc.
Geoconsultants
Berkeley, CA
www.a3geo.com

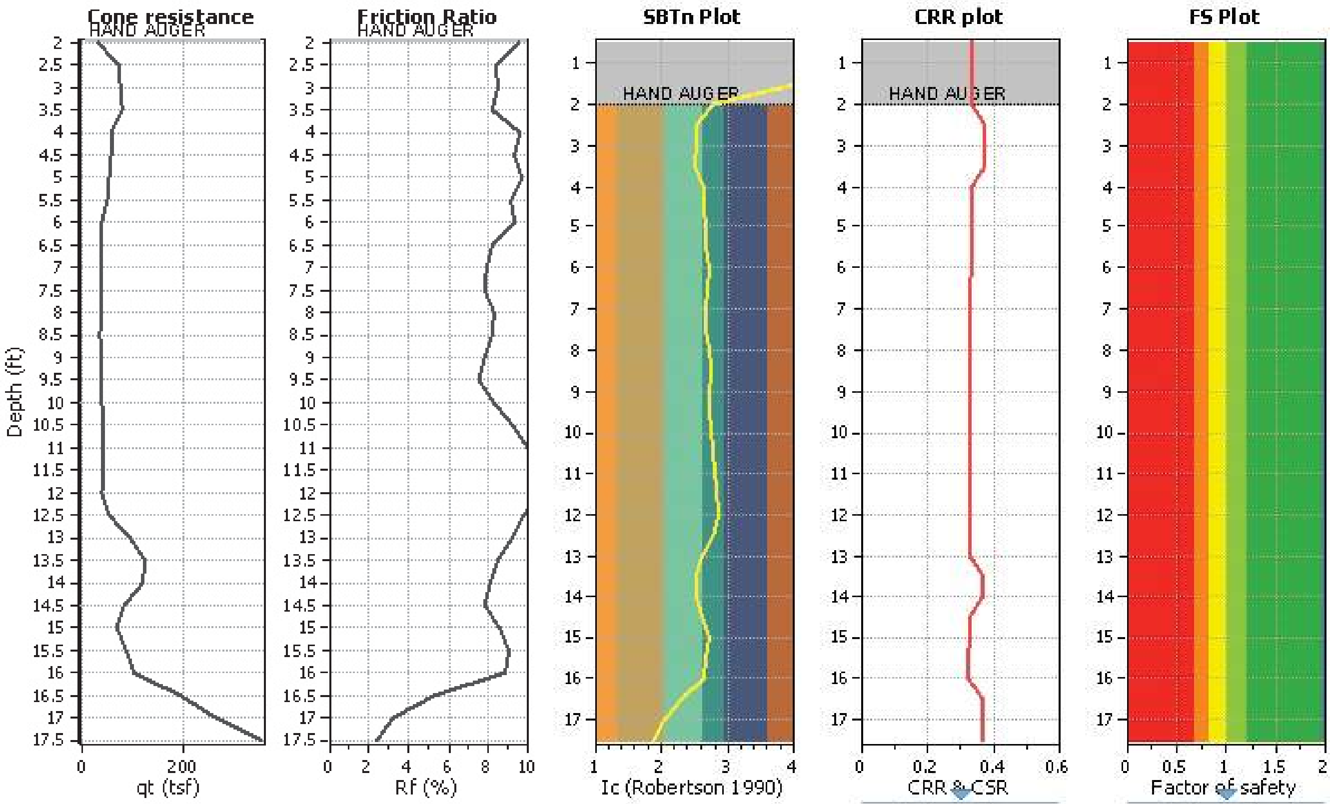
LIQUEFACTION ANALYSIS REPORT

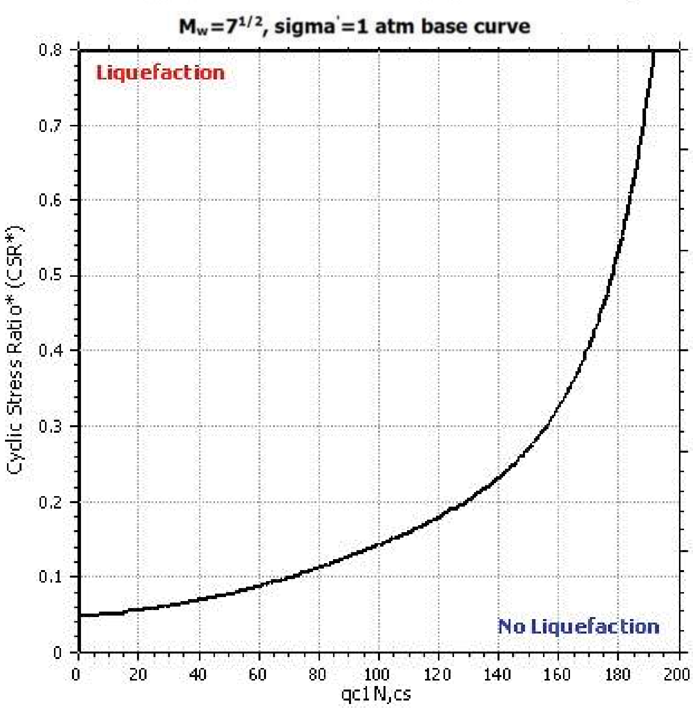
Project title : Terra Linda High School Student Commons and Art Building **Location : San Rafael, California**

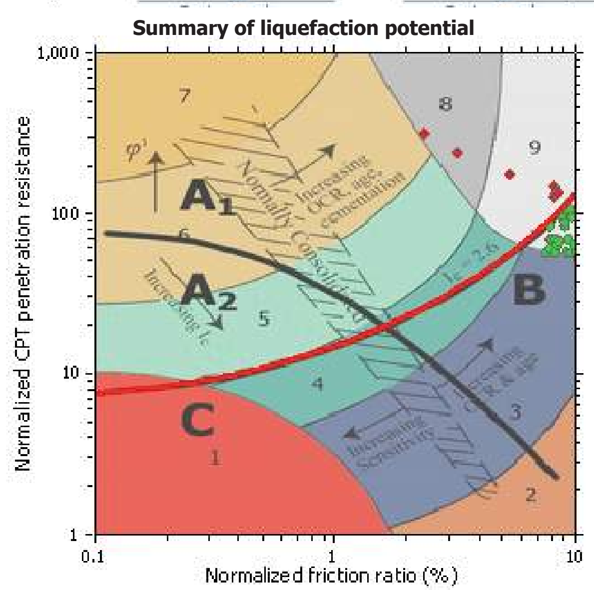
CPT file : MPEG CPT-01

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	19.00 ft	Use fill:	No	Clay like behavior applied:	Sand & Clay
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	19.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	8.05	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

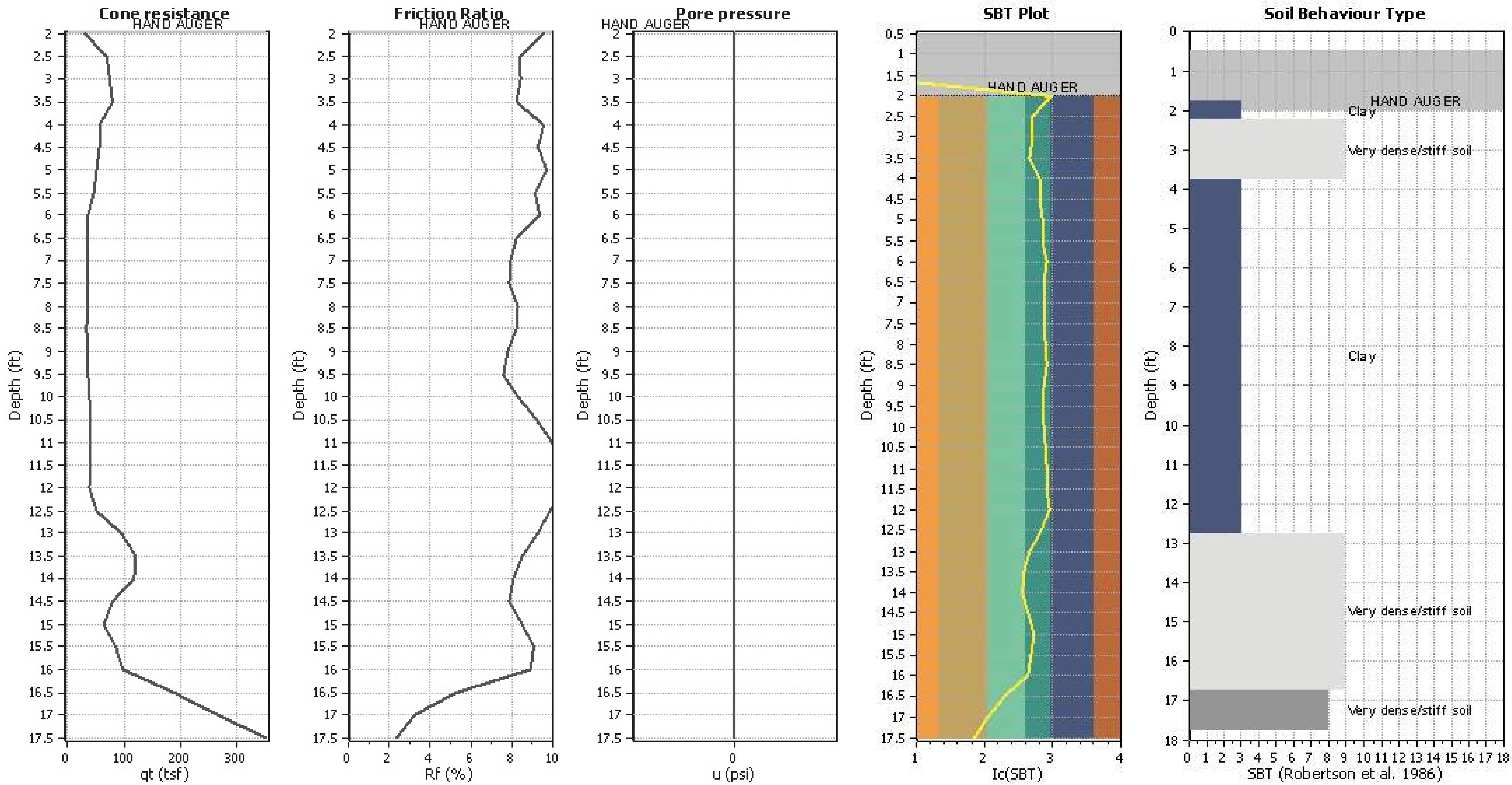






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plo



Input parameters and analysis data

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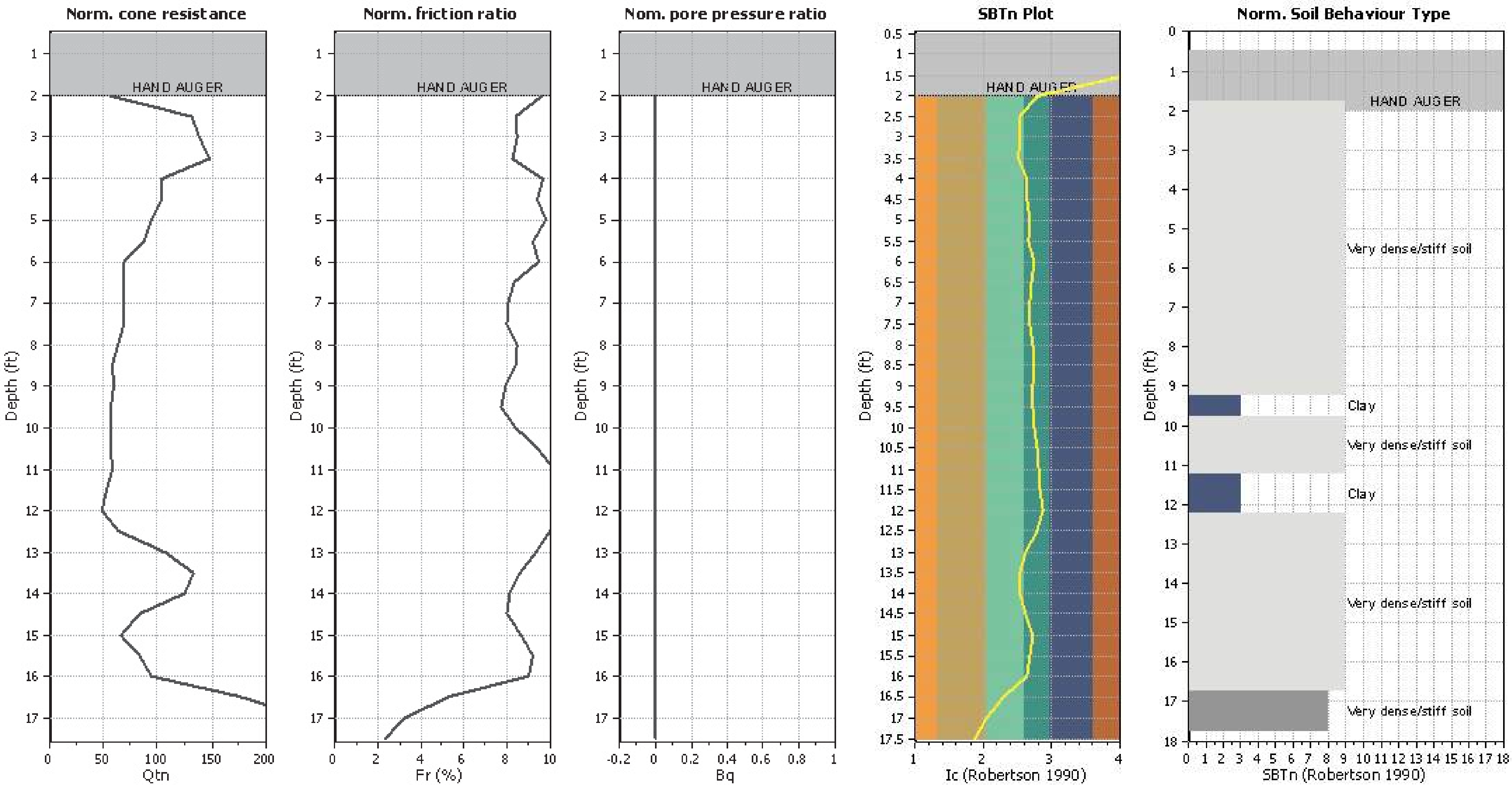
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normaliz



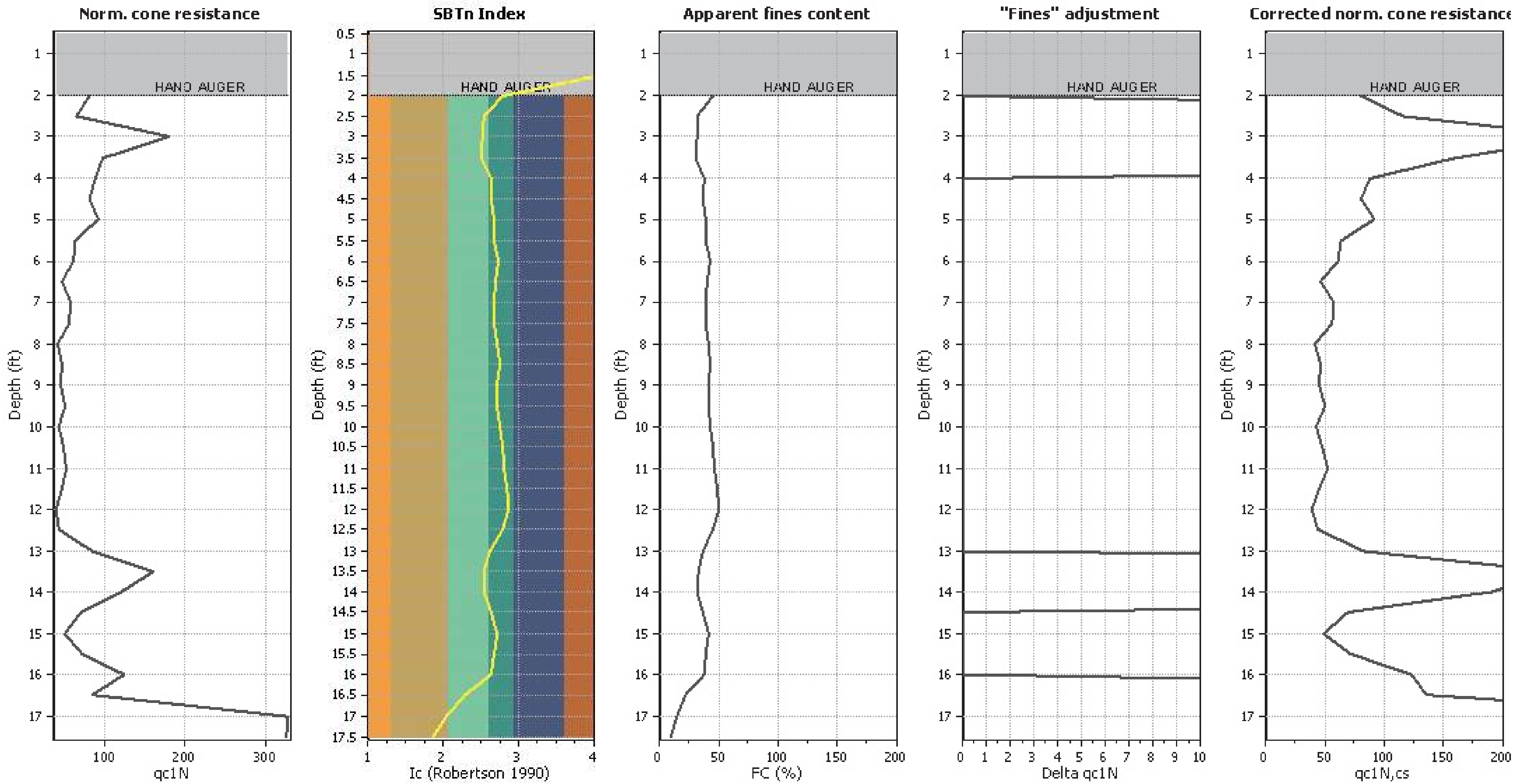
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

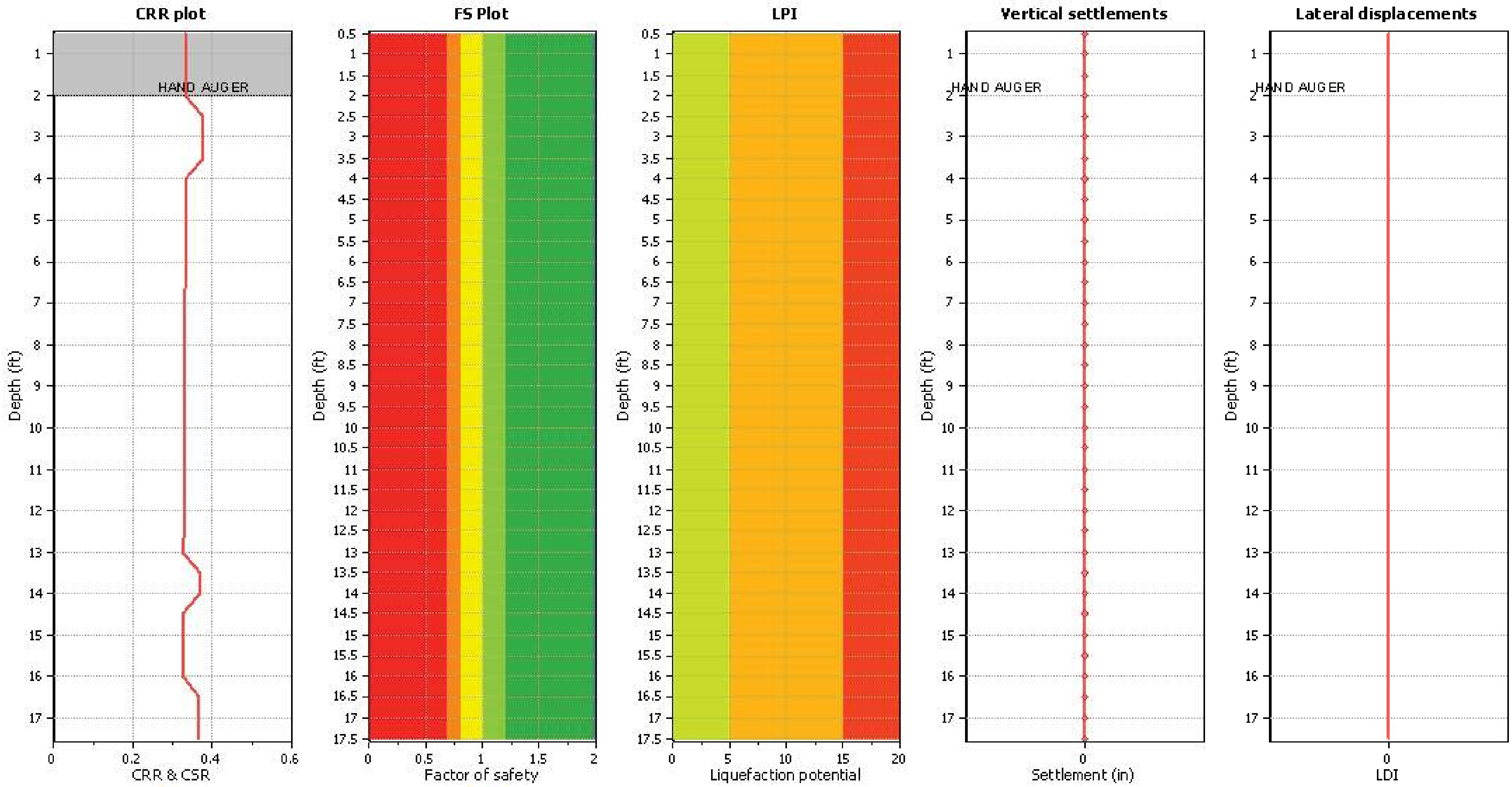
Liquefaction analysis overall plots (intermediate resu



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plot



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

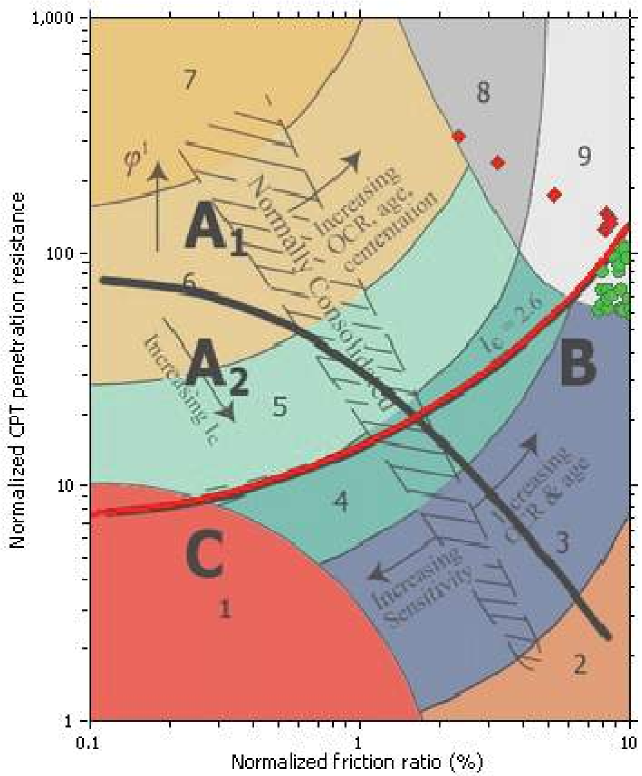
F.S. color scheme

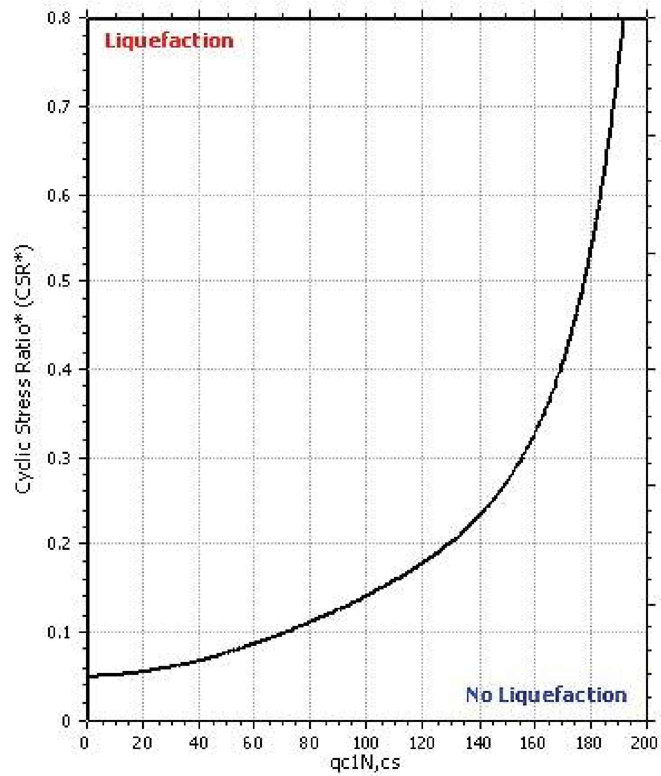
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

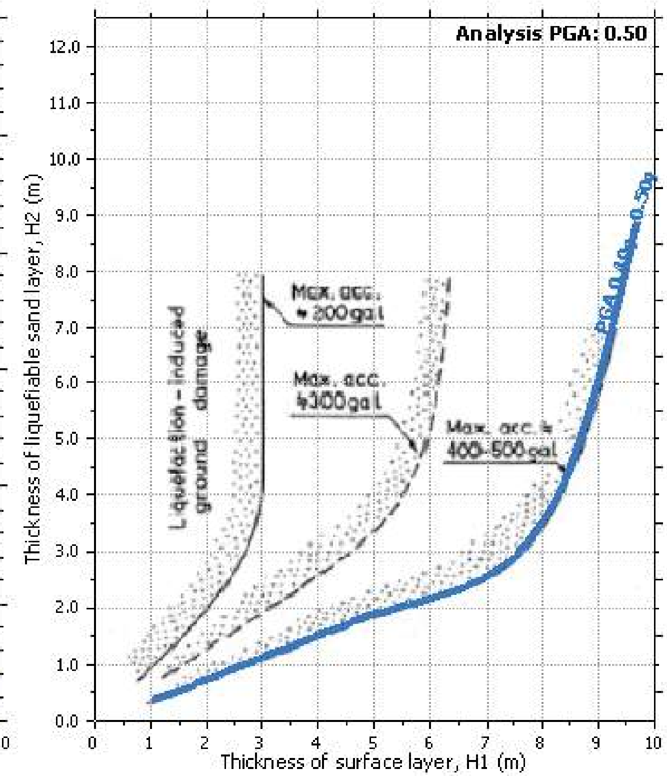
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plo



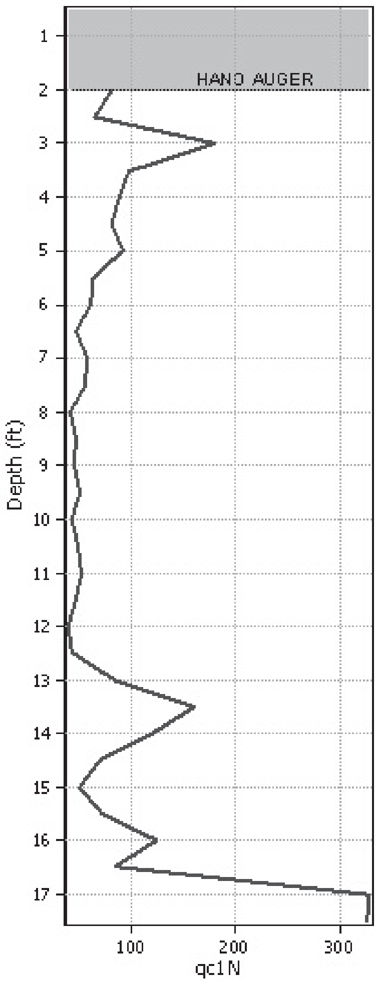


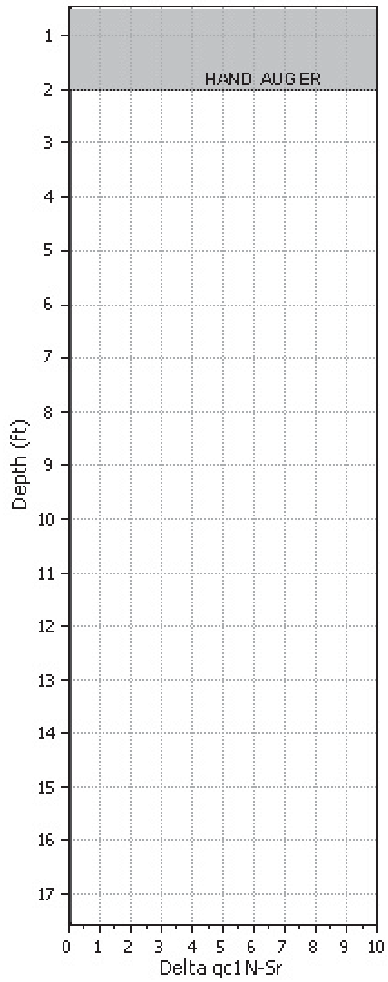


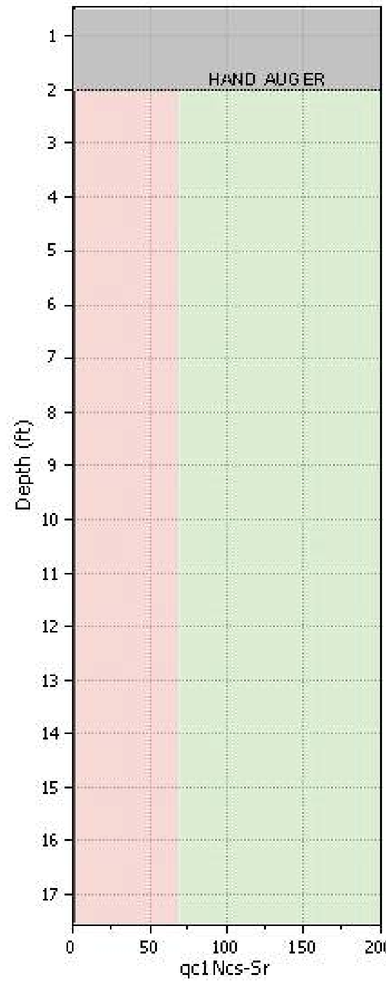
Input parameters and analysis data

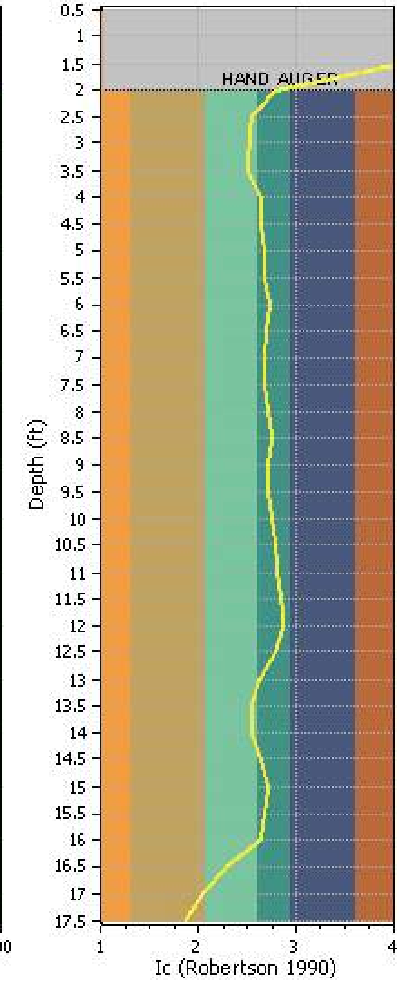
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

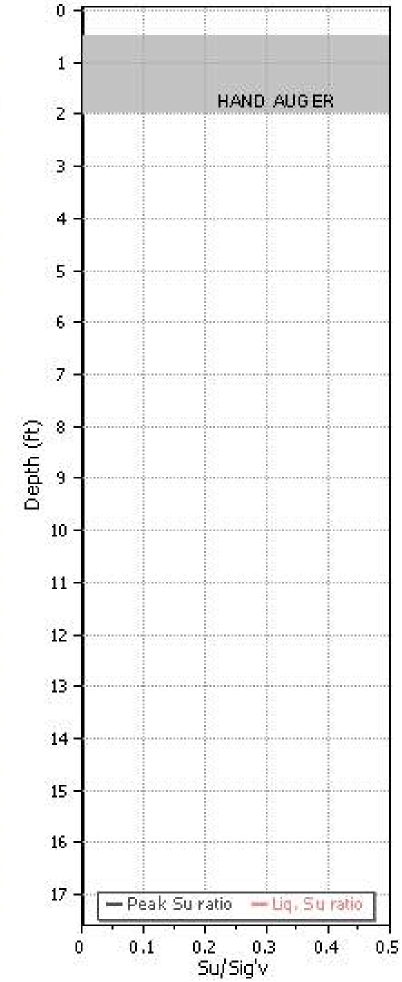
Check for strength loss plots (Idriss & Boulanger (2008))











Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	19.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	8.05	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	19.00 ft	Fill height:	N/A	Limit depth:	N/A

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	0.50	-9999.00	-9999.00	-9999.00	100.00	120.90
2	1.00	-9999.00	-9999.00	-9999.00	100.00	120.90
3	1.50	-9999.00	-9999.00	-9999.00	100.00	120.90
4	2.00	50.00	4.40	0.00	45.59	126.27
5	2.50	40.00	4.20	0.00	32.20	133.58
6	3.00	120.00	9.00	0.00	31.87	134.10
7	3.50	60.00	5.40	0.00	30.76	134.55
8	4.00	55.00	4.95	0.00	37.42	132.22
9	4.50	50.00	5.50	0.00	36.88	132.00
10	5.00	60.00	4.92	0.00	38.92	131.40
11	5.50	40.00	4.20	0.00	38.65	130.26
12	6.00	40.00	3.68	0.00	42.42	128.07
13	6.50	30.00	2.40	0.00	40.13	127.16
14	7.00	40.00	3.00	0.00	39.43	126.86
15	7.50	40.00	3.32	0.00	39.33	126.81
16	8.00	30.00	2.34	0.00	41.54	126.77
17	8.50	35.00	3.08	0.00	42.77	126.20
18	9.00	35.00	2.80	0.00	41.27	126.76
19	9.50	40.00	2.72	0.00	41.39	126.52
20	10.00	35.00	2.80	0.00	43.00	127.61
21	10.50	40.00	4.00	0.00	45.02	128.83
22	11.00	45.00	4.28	0.00	46.62	129.82
23	11.50	40.00	4.24	0.00	48.26	129.55
24	12.00	35.00	3.71	0.00	50.43	129.42
25	12.50	40.00	4.24	0.00	44.84	131.78
26	13.00	80.00	7.28	0.00	36.35	137.11
27	13.50	160.00	14.40	0.00	32.49	137.28
28	14.00	120.00	9.00	0.00	32.27	137.28
29	14.50	70.00	4.90	0.00	36.71	134.43
30	15.00	50.00	5.00	0.00	41.46	132.99
31	15.50	75.00	6.75	0.00	39.30	136.07
32	16.00	130.00	11.44	0.00	37.43	137.28
33	16.50	90.00	8.10	0.00	22.42	137.28
34	17.00	350.00	10.50	0.00	14.25	137.28
35	17.50	350.00	7.00	0.00	9.53	137.28

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Cyclic Stress Ratio fully adjusted (CSR*) calculation data ::

Point ID	Depth (ft)	σ_v (tsf)	u_0 (tsf)	σ_v' (tsf)	r_d	CSR	MSF	CSR_{eq}	K_σ	User FS	CSR^*	Belongs to transition
1	0.50	0.03	0.00	0.03	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
2	1.00	0.06	0.00	0.06	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
3	1.50	0.09	0.00	0.09	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
4	2.00	0.12	0.00	0.12	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
5	2.50	0.16	0.00	0.16	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
6	3.00	0.19	0.00	0.19	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
7	3.50	0.22	0.00	0.22	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
8	4.00	0.26	0.00	0.26	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
9	4.50	0.29	0.00	0.29	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
10	5.00	0.32	0.00	0.32	1.00	0.325	0.86	0.376	1.00	1.00	2.000	No
11	5.50	0.35	0.00	0.35	1.00	0.324	0.86	0.375	1.00	1.00	2.000	No
12	6.00	0.39	0.00	0.39	1.00	0.324	0.86	0.375	1.00	1.00	2.000	No
13	6.50	0.42	0.00	0.42	1.00	0.324	0.86	0.375	1.00	1.00	2.000	No
14	7.00	0.45	0.00	0.45	1.00	0.323	0.86	0.374	1.00	1.00	2.000	No
15	7.50	0.48	0.00	0.48	0.99	0.323	0.86	0.374	1.00	1.00	2.000	No
16	8.00	0.51	0.00	0.51	0.99	0.323	0.86	0.374	1.00	1.00	2.000	No
17	8.50	0.54	0.00	0.54	0.99	0.323	0.86	0.373	1.00	1.00	2.000	No
18	9.00	0.58	0.00	0.58	0.99	0.322	0.86	0.373	1.00	1.00	2.000	No
19	9.50	0.61	0.00	0.61	0.99	0.322	0.86	0.373	1.00	1.00	2.000	No
20	10.00	0.64	0.00	0.64	0.99	0.322	0.86	0.372	1.00	1.00	2.000	No
21	10.50	0.67	0.00	0.67	0.99	0.321	0.86	0.372	1.00	1.00	2.000	No
22	11.00	0.70	0.00	0.70	0.99	0.321	0.86	0.372	1.00	1.00	2.000	No
23	11.50	0.74	0.00	0.74	0.99	0.321	0.86	0.371	1.00	1.00	2.000	No
24	12.00	0.77	0.00	0.77	0.99	0.320	0.86	0.371	1.00	1.00	2.000	No
25	12.50	0.80	0.00	0.80	0.99	0.320	0.86	0.370	1.00	1.00	2.000	No
26	13.00	0.84	0.00	0.84	0.98	0.320	0.86	0.370	1.00	1.00	2.000	No
27	13.50	0.87	0.00	0.87	0.98	0.320	0.86	0.370	1.00	1.00	2.000	No
28	14.00	0.91	0.00	0.91	0.98	0.319	0.86	0.369	1.00	1.00	2.000	No
29	14.50	0.94	0.00	0.94	0.98	0.319	0.86	0.369	1.00	1.00	2.000	No
30	15.00	0.97	0.00	0.97	0.98	0.318	0.86	0.369	1.00	1.00	2.000	No
31	15.50	1.01	0.00	1.01	0.98	0.318	0.86	0.368	1.00	1.00	2.000	No
32	16.00	1.04	0.00	1.04	0.98	0.318	0.86	0.368	1.00	1.00	2.000	No
33	16.50	1.07	0.00	1.07	0.98	0.317	0.86	0.367	1.00	1.00	2.000	No
34	17.00	1.11	0.00	1.11	0.98	0.317	0.86	0.367	1.00	1.00	2.000	No
35	17.50	1.14	0.00	1.14	0.97	0.317	0.86	0.366	1.00	1.00	2.000	No

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
σ_v: Total overburden pressure at test point (tsf)
u_0: Water pressure at test point (tsf)
σ_v': Effective overburden pressure based on GWT during earthquake (tsf)
r_d: Nonlinear shear mass factor
CSR: Cyclic Stress Ratio
MSF: Magnitude Scaling Factor
CSR_{eq}: CSR adjusted for M=7.5
K_σ: Effective overburden stress factor
CSR^*: CSR fully adjusted

:: Cyclic Resistance Ratio (CRR) calculation data ::

Point ID	Depth (ft)	q_t (tsf)	FC (%)	Ic	m	C_N	q_{c1N}	Δq_{c1N}	$q_{c1N,cs}$	$CRR_{7.5}$	Belongs to trans. layer	Clay-like behaviour	FS
1	0.50	0.00	100.00	4.06	0.78	1.70	-16064.81	0.00	-16064.81	4.000	No	Yes	2.00
2	1.00	0.00	100.00	4.06	0.78	1.70	-16064.81	0.00	-16064.81	4.000	No	Yes	2.00
3	1.50	0.00	100.00	4.06	0.78	1.70	-16064.81	0.00	-16064.81	4.000	No	Yes	2.00
4	2.00	30.00	45.59	2.79	0.42	1.70	80.33	0.00	80.33	4.000	No	Yes	2.00
5	2.50	70.00	32.20	2.53	0.47	1.70	64.27	51.22	115.48	4.000	No	No	2.00
6	3.00	73.33	31.87	2.53	0.26	1.58	178.67	89.94	268.61	4.000	No	No	2.00
7	3.50	78.33	30.76	2.50	0.39	1.70	96.40	61.60	158.00	4.000	No	No	2.00
8	4.00	55.00	37.42	2.64	0.40	1.70	88.37	0.00	88.37	4.000	No	Yes	2.00
9	4.50	55.00	36.88	2.63	0.42	1.70	80.33	0.00	80.33	4.000	No	Yes	2.00
10	5.00	50.00	38.92	2.67	0.40	1.61	91.07	0.00	91.07	4.000	No	Yes	2.00
11	5.50	46.67	38.65	2.67	0.47	1.67	63.04	0.00	63.04	4.000	No	Yes	2.00
12	6.00	36.67	42.42	2.74	0.47	1.61	60.88	0.00	60.88	4.000	No	Yes	2.00
13	6.50	36.67	40.13	2.69	0.52	1.62	45.80	0.00	45.80	4.000	No	Yes	2.00
14	7.00	36.67	39.43	2.68	0.48	1.51	57.15	0.00	57.15	4.000	No	Yes	2.00
15	7.50	36.67	39.33	2.68	0.49	1.47	55.50	0.00	55.50	4.000	No	Yes	2.00
16	8.00	35.00	41.54	2.72	0.53	1.47	41.60	0.00	41.60	4.000	No	Yes	2.00
17	8.50	33.33	42.77	2.74	0.51	1.41	46.53	0.00	46.53	4.000	No	Yes	2.00
18	9.00	36.67	41.27	2.72	0.52	1.37	45.31	0.00	45.31	4.000	No	Yes	2.00
19	9.50	36.67	41.39	2.72	0.50	1.32	49.97	0.00	49.97	4.000	No	Yes	2.00
20	10.00	38.33	43.00	2.75	0.53	1.30	43.07	0.00	43.07	4.000	No	Yes	2.00
21	10.50	40.00	45.02	2.78	0.51	1.26	47.65	0.00	47.65	4.000	No	Yes	2.00
22	11.00	41.67	46.62	2.81	0.50	1.22	52.04	0.00	52.04	4.000	No	Yes	2.00
23	11.50	40.00	48.26	2.84	0.52	1.21	45.57	0.00	45.57	4.000	No	Yes	2.00
24	12.00	38.33	50.43	2.87	0.54	1.19	39.26	0.00	39.26	4.000	No	Yes	2.00
25	12.50	51.67	44.84	2.78	0.52	1.16	43.69	0.00	43.69	4.000	No	Yes	2.00
26	13.00	93.33	36.35	2.62	0.42	1.10	83.38	0.00	83.38	4.000	No	Yes	2.00
27	13.50	120.00	32.49	2.54	0.28	1.06	159.56	83.74	243.30	4.000	No	No	2.00
28	14.00	116.67	32.27	2.53	0.34	1.06	119.66	70.07	189.73	4.000	No	No	2.00
29	14.50	80.00	36.71	2.63	0.45	1.06	69.81	0.00	69.81	4.000	No	Yes	2.00
30	15.00	65.00	41.46	2.72	0.51	1.04	49.32	0.00	49.32	4.000	No	Yes	2.00
31	15.50	85.00	39.30	2.68	0.44	1.02	72.48	0.00	72.48	4.000	No	Yes	2.00
32	16.00	98.33	37.43	2.64	0.33	1.01	123.56	0.00	123.56	4.000	No	Yes	2.00
33	16.50	190.00	22.42	2.30	0.43	0.99	84.49	51.47	135.96	4.000	No	No	2.00
34	17.00	263.33	14.25	2.05	0.26	0.99	326.70	77.38	404.07	4.000	No	No	2.00
35	17.50	350.00	9.53	1.86	0.26	0.98	324.08	24.10	348.18	4.000	No	No	2.00

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_t: Total cone resistance
FC: Fines content (%)
I_c: Soil behavior type index
m: Stress exponent
C_N: Overburden correction factor
q_{c1N}: Normalized and adjusted cone resistance
Δq_{c1N}: Cone resistance correction factor due to fines
$q_{c1N,cs}$: Normalized and adjusted cone resistance
$CRR_{7.5}$: Cyclic resistance ratio for M_w=7.5
FS: Factor of safety against soil liquefaction

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI
0.50	2.00	0.00	0.00	0.00	0.00	1.00	2.00	0.00	0.00	0.00	0.00
1.50	2.00	0.00	0.00	0.00	0.00	2.00	2.00	0.00	9.70	0.50	0.00
2.50	2.00	0.00	9.62	0.50	0.00	3.00	2.00	0.00	9.54	0.50	0.00
3.50	2.00	0.00	9.47	0.50	0.00	4.00	2.00	0.00	9.39	0.50	0.00
4.50	2.00	0.00	9.31	0.50	0.00	5.00	2.00	0.00	9.24	0.50	0.00
5.50	2.00	0.00	9.16	0.50	0.00	6.00	2.00	0.00	9.09	0.50	0.00
6.50	2.00	0.00	9.01	0.50	0.00	7.00	2.00	0.00	8.93	0.50	0.00
7.50	2.00	0.00	8.86	0.50	0.00	8.00	2.00	0.00	8.78	0.50	0.00
8.50	2.00	0.00	8.70	0.50	0.00	9.00	2.00	0.00	8.63	0.50	0.00
9.50	2.00	0.00	8.55	0.50	0.00	10.00	2.00	0.00	8.48	0.50	0.00
10.50	2.00	0.00	8.40	0.50	0.00	11.00	2.00	0.00	8.32	0.50	0.00
11.50	2.00	0.00	8.25	0.50	0.00	12.00	2.00	0.00	8.17	0.50	0.00
12.50	2.00	0.00	8.10	0.50	0.00	13.00	2.00	0.00	8.02	0.50	0.00
13.50	2.00	0.00	7.94	0.50	0.00	14.00	2.00	0.00	7.87	0.50	0.00
14.50	2.00	0.00	7.79	0.50	0.00	15.00	2.00	0.00	7.71	0.50	0.00
15.50	2.00	0.00	7.64	0.50	0.00	16.00	2.00	0.00	7.56	0.50	0.00
16.50	2.00	0.00	7.49	0.50	0.00	17.00	2.00	0.00	7.41	0.50	0.00
17.50	2.00	0.00	7.33	0.50	0.00						

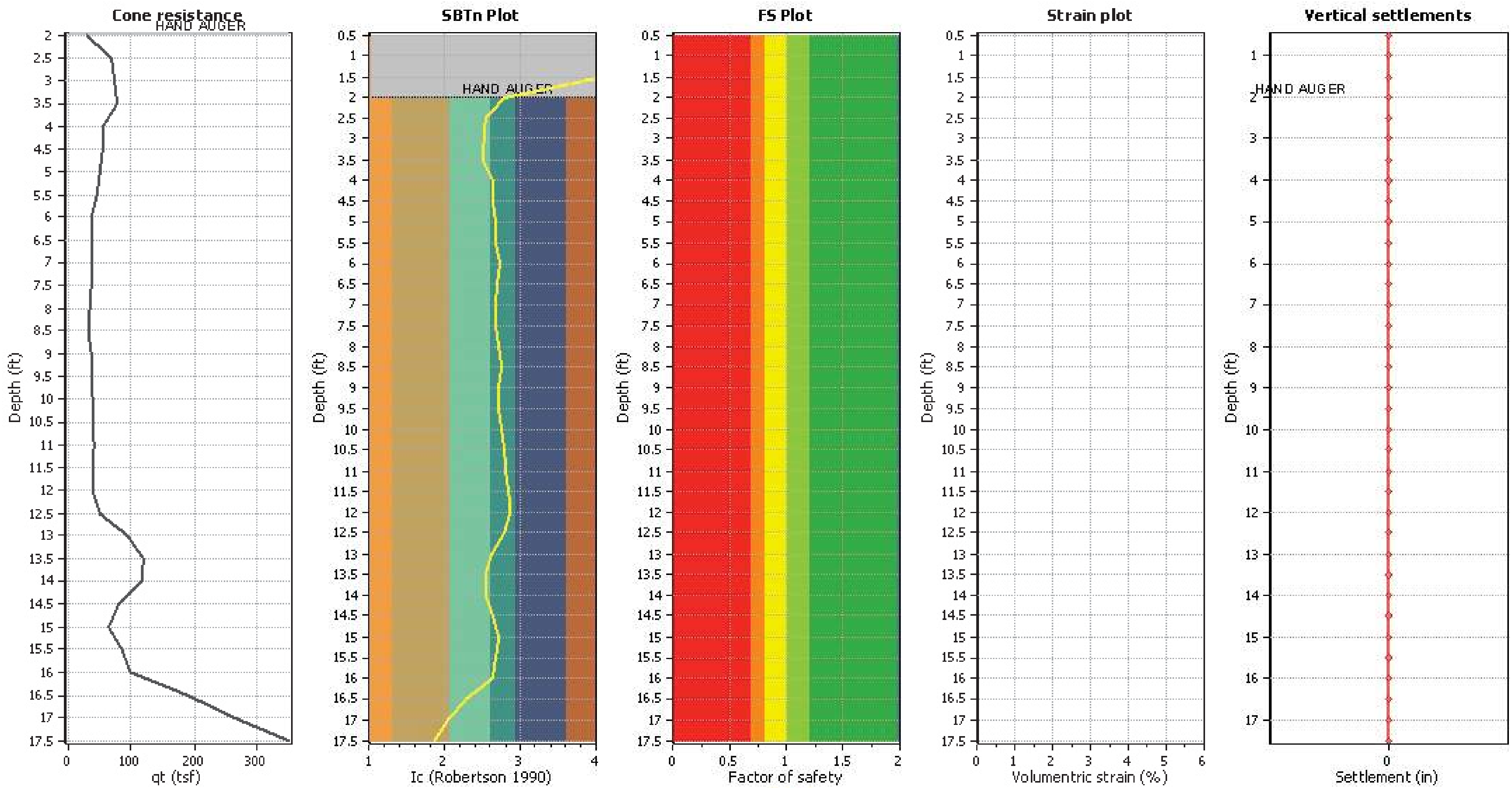
Overall liquefaction potential: 0.00

LPI = 0.00 - Liquefaction risk very low
LPI between 0.00 and 5.00 - Liquefaction risk low
LPI between 5.00 and 15.00 - Liquefaction risk high
LPI > 15.00 - Liquefaction risk very high

Abbreviations

FS: Calculated factor of safety for test point
F_L: 1 - FS
w_z: Function value of the extend of soil liquefaction according to depth
d_z: Layer thickness (ft)
LPI: Liquefaction potential index value for test point

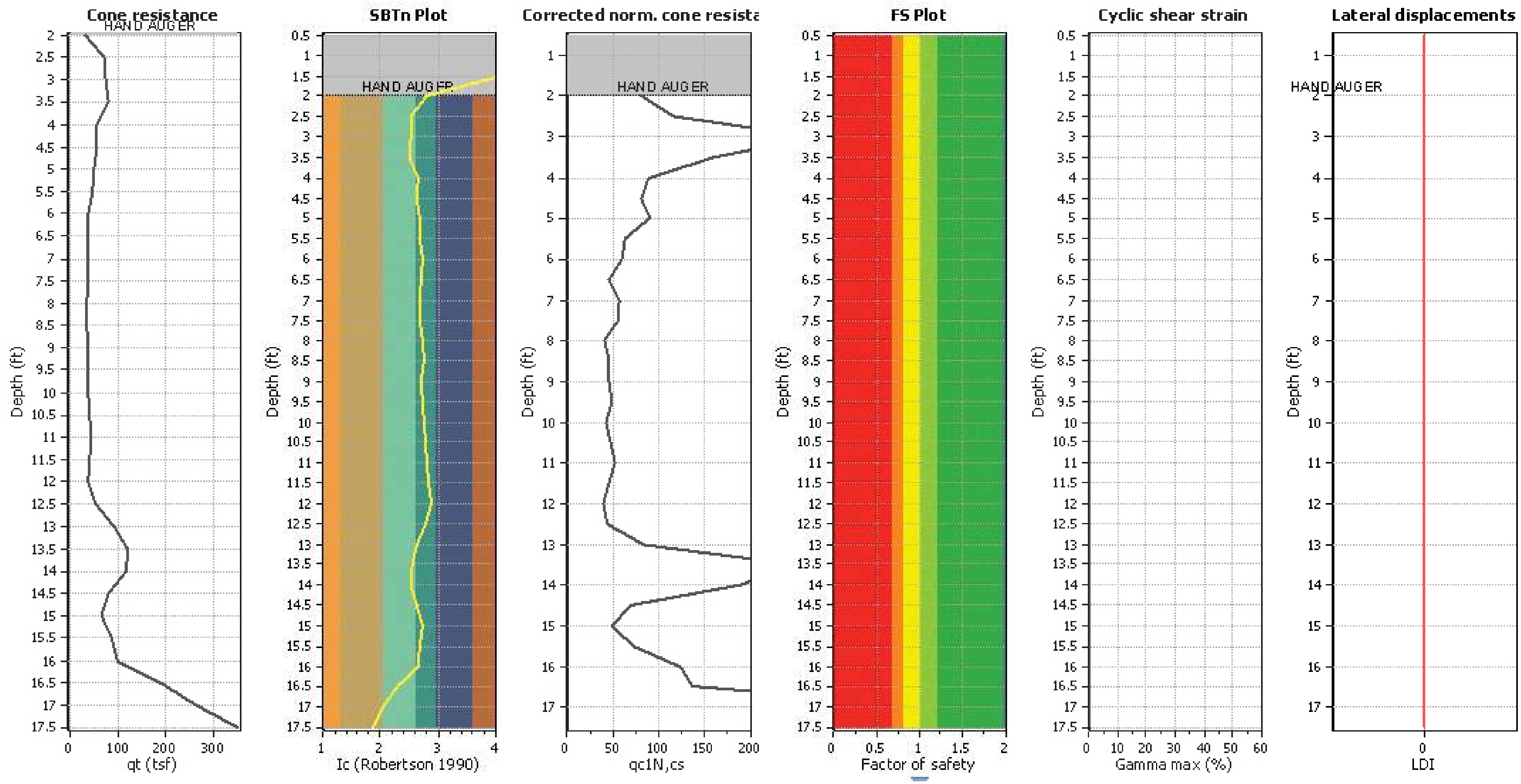
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance

F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

:: Strength loss calculation Idriss & Boulanger (2008) ::

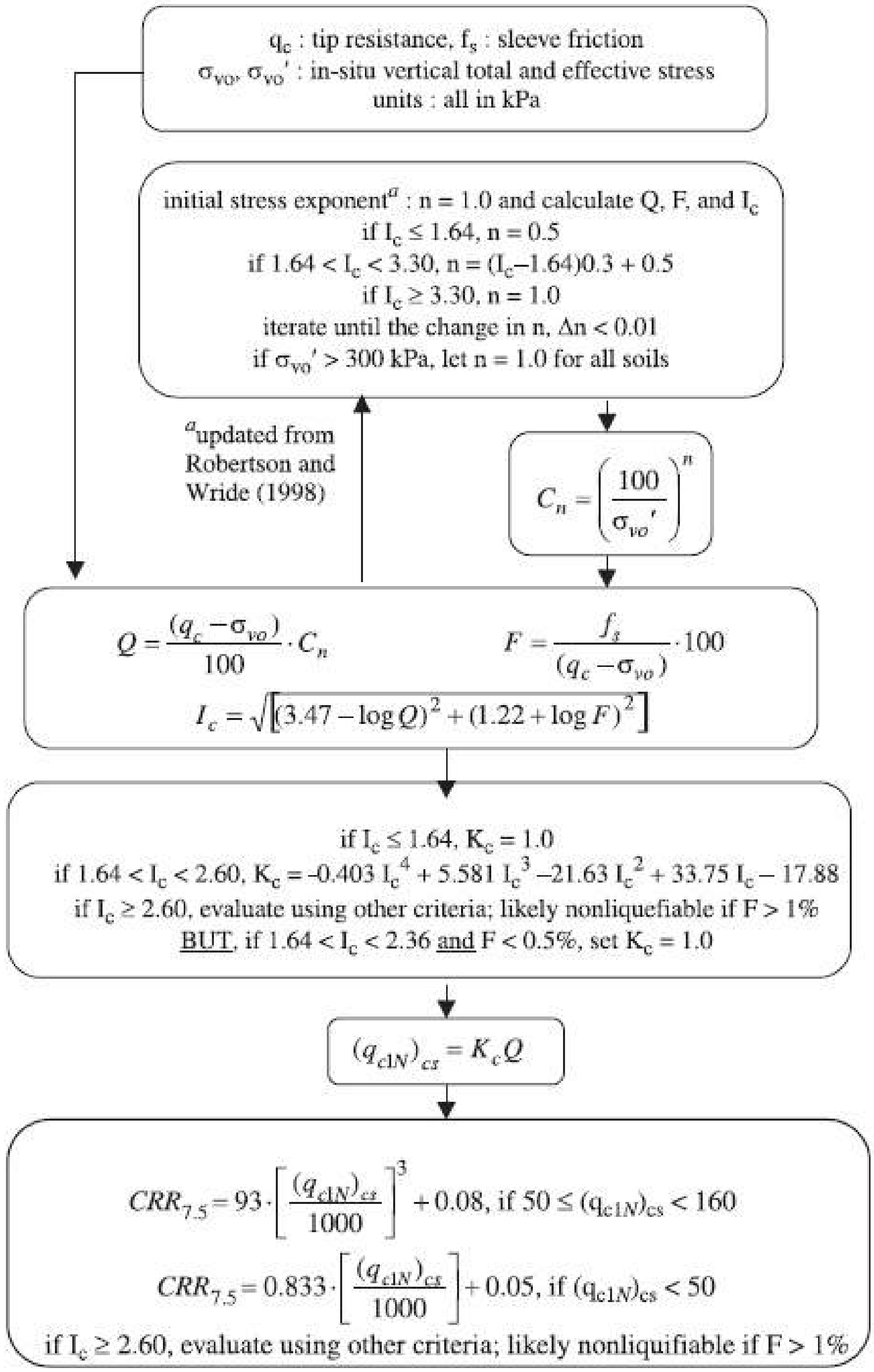
Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
0.50	0.00	-1.00	26.61	-26.61	4.06	N/A	N/A
1.00	0.00	-1.00	26.61	-26.61	4.06	N/A	N/A
1.50	0.00	-1.00	26.61	-26.61	4.06	N/A	N/A
2.00	30.00	56.47	4.73	266.85	2.79	N/A	N/A
2.50	70.00	132.02	2.94	388.61	2.53	N/A	N/A
3.00	73.33	138.25	2.90	401.59	2.53	N/A	N/A
3.50	78.33	147.64	2.78	409.96	2.50	N/A	N/A
4.00	55.00	103.48	3.59	371.55	2.64	N/A	N/A
4.50	55.00	103.41	3.52	364.05	2.63	N/A	N/A
5.00	50.00	93.90	3.79	355.79	2.67	N/A	N/A
5.50	46.67	87.54	3.75	328.55	2.67	N/A	N/A
6.00	36.67	68.58	4.27	292.78	2.74	N/A	N/A
6.50	36.67	68.52	3.95	270.80	2.69	N/A	N/A
7.00	36.67	68.46	3.86	264.02	2.68	N/A	N/A
7.50	36.67	68.40	3.84	262.90	2.68	N/A	N/A
8.00	35.00	63.01	4.15	261.18	2.72	N/A	N/A
8.50	33.33	57.12	4.32	246.71	2.74	N/A	N/A
9.00	36.67	59.36	4.11	243.86	2.72	N/A	N/A
9.50	36.67	56.56	4.13	233.33	2.72	N/A	N/A
10.00	38.33	56.78	4.35	247.07	2.75	N/A	N/A
10.50	40.00	57.00	4.64	264.58	2.78	N/A	N/A
11.00	41.67	57.06	4.88	278.25	2.81	N/A	N/A
11.50	40.00	52.63	5.12	269.64	2.84	N/A	N/A
12.00	38.33	48.54	5.45	264.73	2.87	N/A	N/A
12.50	51.67	62.48	4.62	288.39	2.78	N/A	N/A
13.00	93.33	107.69	3.45	371.78	2.62	N/A	N/A
13.50	120.00	133.08	2.98	396.20	2.54	N/A	N/A
14.00	116.67	125.09	2.95	369.22	2.53	N/A	N/A
14.50	80.00	83.16	3.50	290.94	2.63	N/A	N/A
15.00	65.00	65.49	4.13	270.78	2.72	N/A	N/A
15.50	85.00	83.14	3.84	319.27	2.68	N/A	N/A
16.00	98.33	93.36	3.59	335.32	2.64	N/A	N/A
16.50	190.00	176.40	1.94	342.19	2.30	N/A	N/A
17.00	263.33	240.00	1.37	327.84	2.05	N/A	N/A
17.50	350.00	314.38	1.16	363.47	1.86	N/A	N/A

Abbreviations

- q_t: Total cone resistance
- K_c: Cone resistance correction factor due to fines
- $Q_{tn,cs}$: Adjusted and corrected cone resistance due to fines
- I_c: Soil behavior type index
- $S_{u(liq)}/\sigma'_v$: Calculated liquefied undrained strength ratio
- $S_{u(peak)}/\sigma'_v$: Calculated peak undrained strength ratio

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

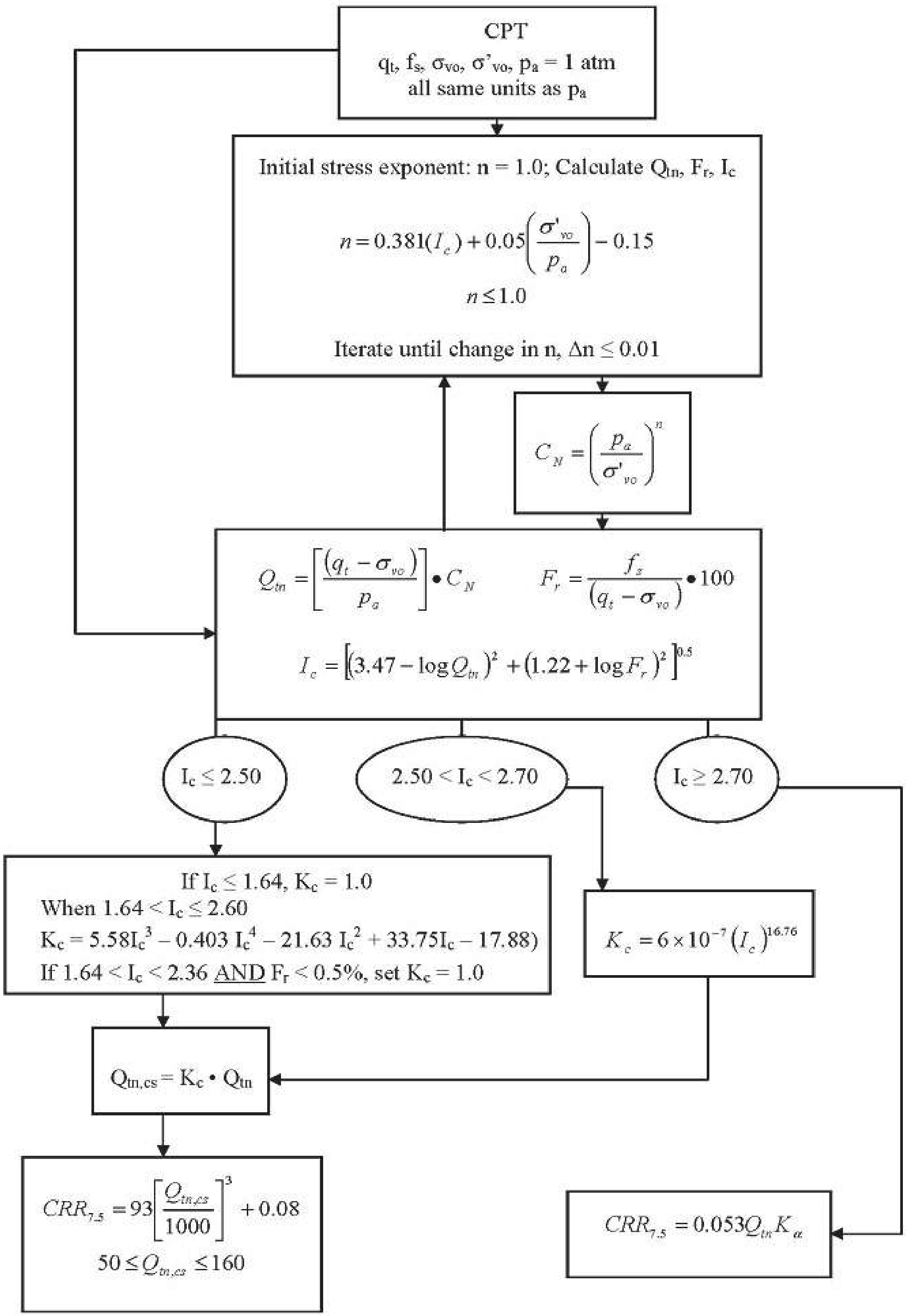
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

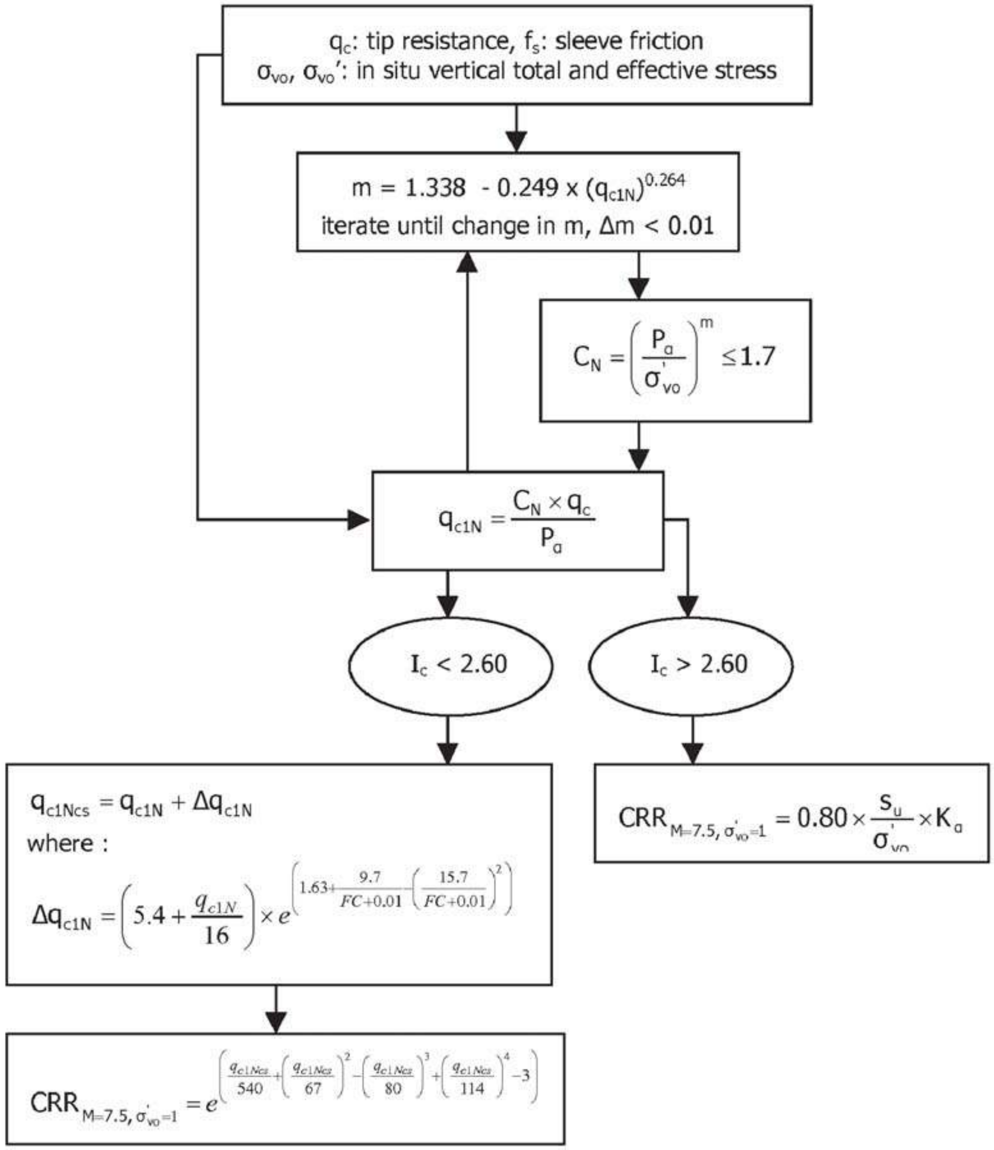
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

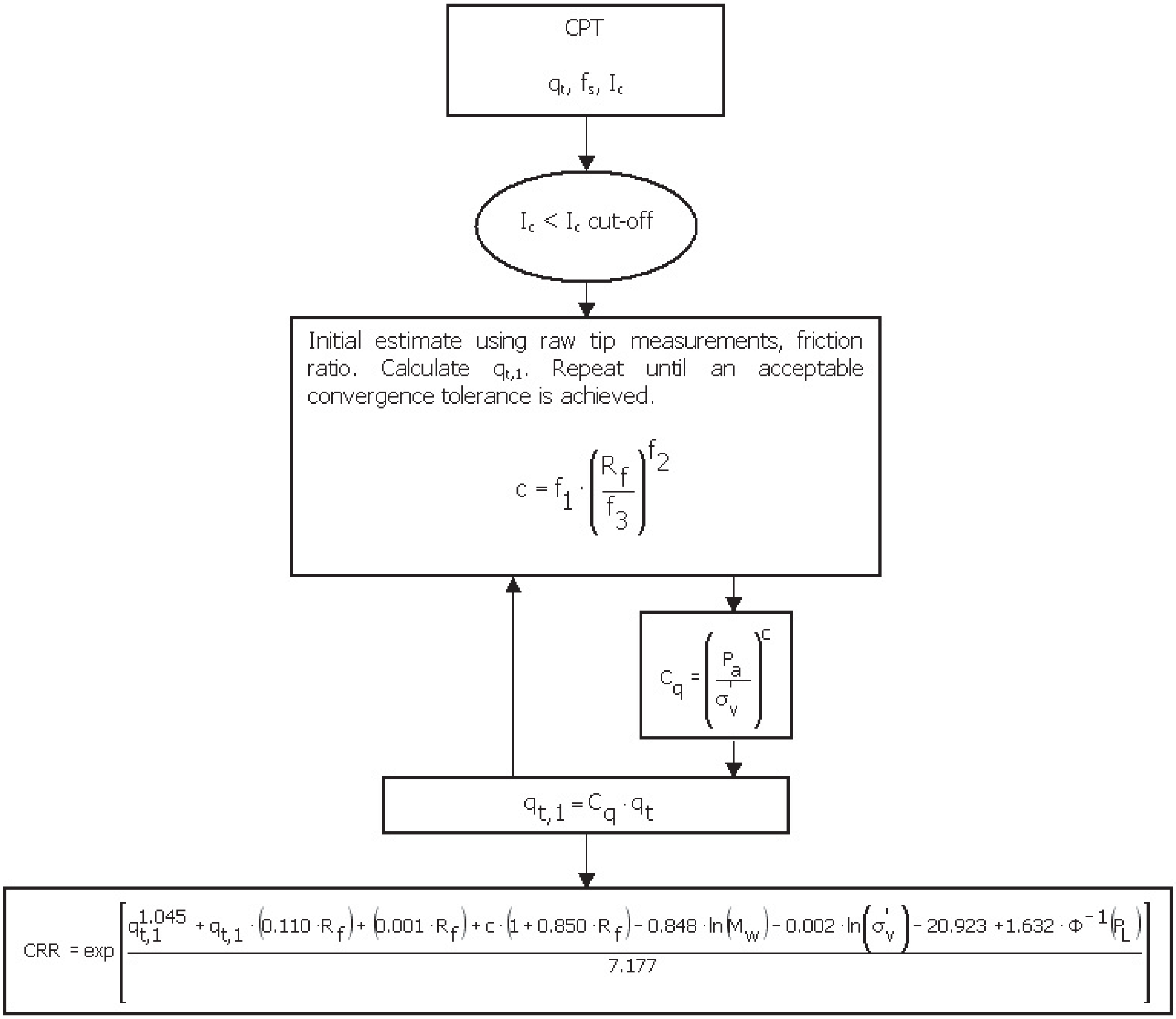


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)

$$FS_{liq} = \frac{CRR_{M=7.5,\sigma'_v=1atm}}{CSR_{M=7.5,\sigma'_v=1atm}}$$

$$CSR_{M=7.5,\sigma'_v=1atm} = 0.65 \frac{\sigma_v}{\sigma'_v} \frac{a_{\max}}{g} r_d \frac{1}{MSF} \frac{1}{K_\sigma}$$

$$r_d = \exp\left[\alpha(z) + \beta(z) \cdot M\right]$$

$$\alpha(z) = -1.012 - 1.126 \sin\left(\frac{z}{11.73} + 5.133\right)$$

$$\beta(z) = 0.106 + 0.118 \sin\left(\frac{z}{11.28} + 5.142\right)$$

$$K_\sigma = 1 - C_\sigma \ln\left(\frac{\sigma'_v}{P_a}\right) \le 1.1$$

$$C_\sigma = \frac{1}{37.3 - 8.27\left(q_{c1Ncs}\right)^{0.264}} \le 0.3$$

$$MSF = 1 + \left(MSF_{max} - 1\right)\left(8.64 \exp\left(\frac{-M}{4}\right) - 1.325\right)$$

$$MSF_{max} = 1.09 + \left(\frac{q_{c1Ncs}}{180}\right)^3 \le 2.2$$

σ'_v and σ_v at start of earthquake shaking

$$CRR_{M=7.5,\sigma'_v=1atm} = \exp\left(\frac{q_{c1Ncs}}{113} + \left(\frac{q_{c1Ncs}}{1000}\right)^2 - \left(\frac{q_{c1Ncs}}{140}\right)^3 + \left(\frac{q_{c1Ncs}}{137}\right)^4 - 2.80\right)$$

$$q_{c1Ncs} = q_{c1N} + \Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(11.9 + \frac{q_{c1N}}{14.6}\right) \exp\left(1.63 - \frac{9.7}{FC+2} - \left(\frac{15.7}{FC+2}\right)^2\right)$$

$$q_{c1N} = C_{Ne} \frac{q_c}{P_a}$$

$$C_{Ne} = \left(\frac{P_a}{\sigma'_v}\right)^m \le 1.7$$

$$m = 1.338 - 0.249\left(q_{c1Ncs}\right)^{0.264} \quad with \quad 0.264 \le m \le 0.782$$

$$FC = 80\left(I_C + C_{FC}\right) - 137 \quad with \quad 0\% \le FC \le 100\%$$

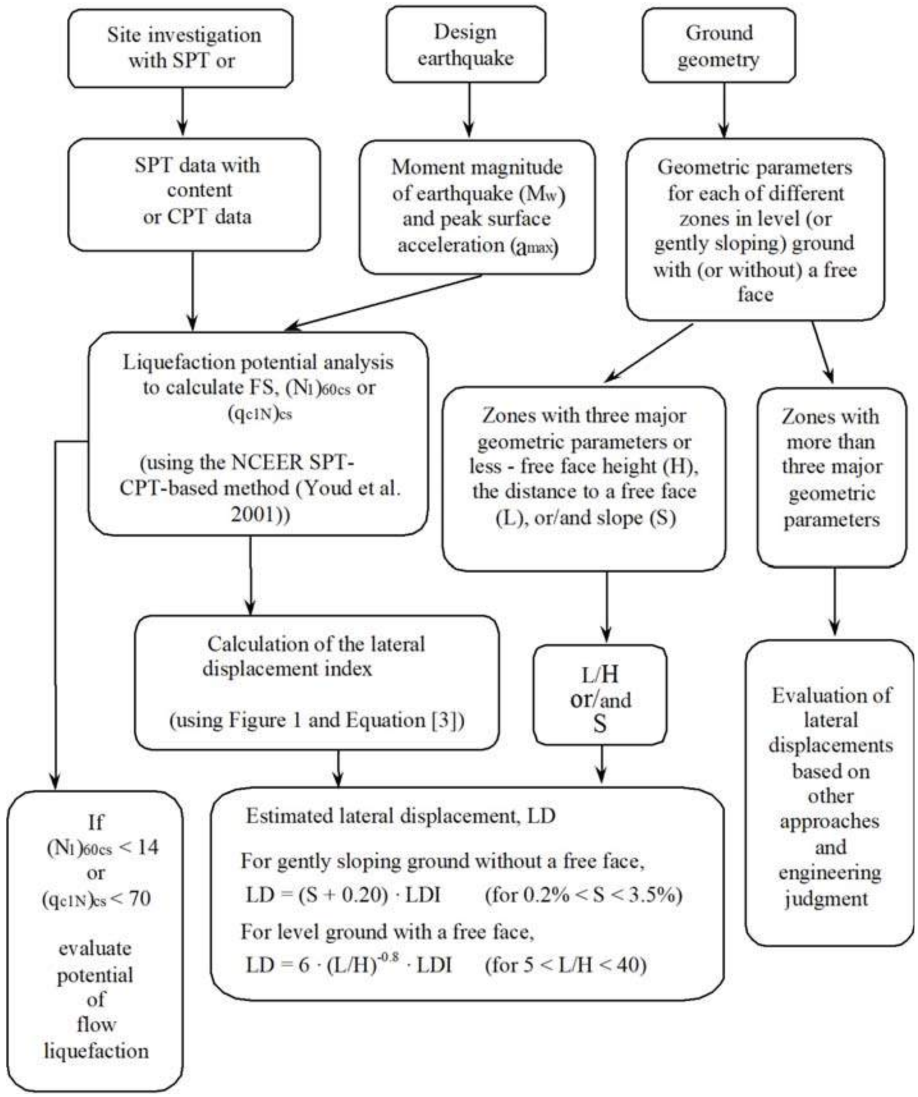
$$I_c = \left[\left(3.47 - \log(Q)\right)^2 + \left(1.22 + \log(F)\right)^2\right]^{0.5}$$

$$Q = \left(\frac{q_c - \sigma_{vc}}{P_a}\right)\left(\frac{P_a}{\sigma'_{vc}}\right)^n \quad with\ 0.5 \le n \le 1.0\ per\ Robertson\ \&\ Wride\ (1998)$$

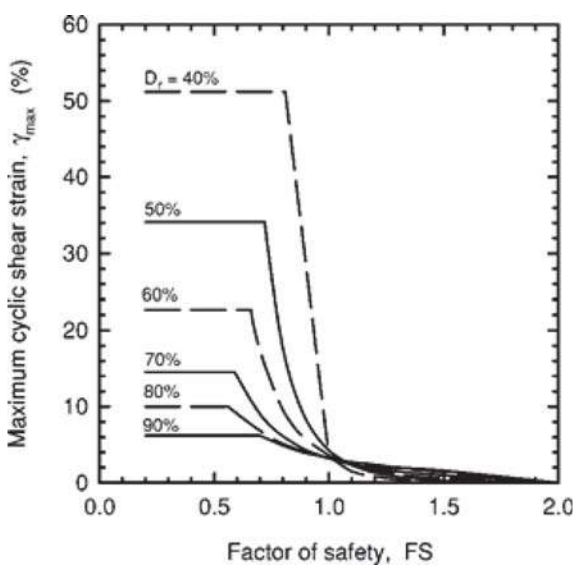
$$F = \left(\frac{f_s}{q_c - \sigma_{vc}}\right) \cdot 100\%$$

σ'_v at time of CPT sounding

Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



[1] **Figure 1**

$$\mathrm{LDI} = \int_0^{Z_{\max}} \gamma_{\max} \, dz$$

[1] **Equation [3]**

[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands

Average shear stress, τ_{av}

$$\tau_{av} = CSR^{*} \cdot \sigma_{v0}' = 0.65 \cdot \frac{a_{max}}{g} \cdot \sigma_{v0} \cdot r_d$$

↓

Estimate small shear strain modulus, G_0

$$G_0 = 0.0188 \cdot \left[10^{(0.55 I_c - 1.68)}\right] \cdot (q_t - \sigma_v)$$

↓

Estimate shear strain amplitude, γ

(based on Pradel (1998))

$$\gamma = \left[\frac{1 + \alpha \cdot e^{bR}}{1 + \alpha}\right] \cdot R \cdot 100\ (\%)$$

$$R = \frac{\tau_{av}}{G_0}\ \text{(Note } \tau_{av} \text{ and } G_0 \text{ same units)}$$

$$\alpha = 0.0389 \cdot \left(\frac{\sigma_v}{p_a}\right) + 0.124$$

$$b = 6400 \cdot \left(\frac{\sigma_v}{p_a}\right)$$

↓

Estimate volumetric strain in 15 cycles

$$\varepsilon_{vol(15)} = \gamma \cdot \left[\frac{(N_1)_{60,cs}}{20}\right]^{-1.20}$$

$$(N_1)_{60,cs} = \frac{Q_{tn,cs}}{8.5 \cdot \left[1 - \frac{I_c}{4.6}\right]}$$

↓

Volumetric strain in design earthquake

$$\Sigma_{vol} = \varepsilon_{vol(15)} \cdot \left[\frac{N_c}{15}\right]^{0.45}$$

$$N_c = (M - 4)^{2.17}$$

↓

Seismic settlement, s

$$s = 2 \cdot \int_0^{GWT} \Sigma_{vol} \cdot dz$$

Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

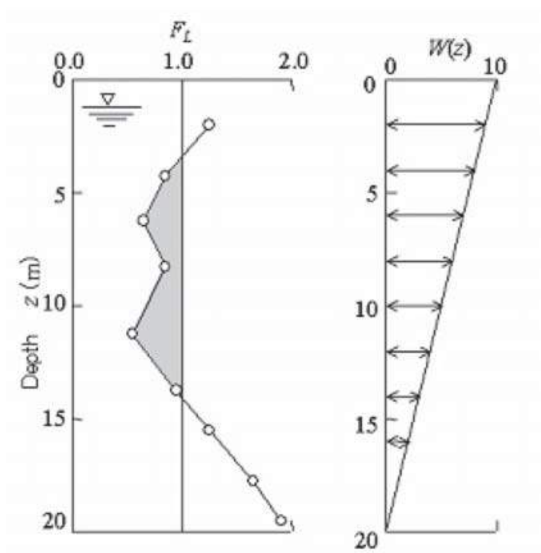
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_0^{20} (10 - 0{,}5_z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

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END OF REPORT