GEOTECHNICAL INVESTIGATION
REDWOOD HIGH SCHOOL MODULAR CLASSROOMS
TAMALPAIS UNION HIGH SCHOOL DISTRICT
LARKSPUR, CALIFORNIA

June 23, 2017

Project 867.185

Prepared for:
Tamalpais Union High School District
395 Doherty Drive
Larkspur, California 94939

CERTIFICATION

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MILLER PACIFIC ENGINEERING GROUP
(A California corporation)

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1.0 INTRODUCTION

This report summarizes Miller Pacific Engineering Group's (MPEG) Geotechnical Investigation for the planned modular classrooms and restroom building at Redwood High School in Larkspur, California. As shown on Figure 1, the site is located at 395 Doherty Drive, in the eastern part of Larkspur.

The purpose of our current Geotechnical Investigation is to explore subsurface conditions, evaluate geotechnical hazards that may affect the planned development, and provide geotechnical design criteria for the project. The scope of our Investigation is described in our professional services agreement dated March 29, 2017 and includes the following:

- Exploration of subsurface conditions with 4 exploratory soil borings and 2 cone penetration tests (CPTs);
- Laboratory testing of select samples to determine the pertinent engineering properties of the soil layers;
- Evaluation of geologic hazards and development of conceptual mitigation measures;
- Development of geotechnical recommendations and design criteria (i.e., site grading, seismic, foundation, etc.) for the project; and,
- Preparation of this report summarizing our findings.

2.0 PROJECT DESCRIPTION

The planned project includes the placement of three approximately 23- foot by 37- foot modular classrooms located south of the gymnasium and west of the tennis courts, and placement of a new 12- foot by 40- foot modular restroom building located adjacent to building 'A' east, immediately south of Doherty Drive. The planned buildings will consist of portable structures, designed to be transported by truck and supported on shallow at-grade wood blocks placed on asphalt pavement. The project will be constructed as shown on the Site Plans, Figures 2 and 3.

3.0 SITE CONDITIONS

3.1 Regional Geology

The project site lies within the Coast Ranges geomorphic province of California. The regional bedrock geology consists of complexly folded, faulted, sheared, and altered sedimentary, igneous, and metamorphic rock of the Franciscan Complex. Bedrock is characterized by a diverse assemblage of greenstone, sandstone, shale, chert, and mélange, with lesser amounts of conglomerate, calc-silicate rock, schist and other metamorphic rocks.

Regional topography within the Coast Ranges province is characterized by northwest-southeast trending mountain ridges and intervening valleys that parallel the major geologic structures, including the San Andreas Fault System. Continued deformation and erosion during the late Tertiary and Quaternary Age (the last several million years) formed the prominent Marin coastal ridges and the inland depression that is now the San Francisco Bay. The more recent seismic activity within the Coast Range Geomorphic Province is concentrated along the San Andreas Fault zone, a complex group of generally north to northwest trending faults.

Regional geologic mapping (Rice and Smith, 1976) shows the project site is located on or very near a geologic contact separating a localized area of Cretaceous-age Franciscan sandstone and shale (Ks) surrounded by artificial fill over Bay Mud (Qaf/Qm). The sandstone and shale bedrock is typically fractured and of variable hardness. Fill is typically composed of varying proportions of rock, soil, debris and/or Bay Mud placed by man. Bay Mud typically consists of unconsolidated, low-density, highly compressible, highly impermeable silty clay. Lenses of peat and sand are also commonly encountered within Bay Mud deposits. A regional geologic map is shown on Figure 6.

3.2 Surface Conditions

The campus is located adjacent to residential subdivisions within the eastern portion of Larkspur. The project site is currently developed as a high school campus with several buildings, parking lots, athletic fields, a swimming pool, and other features. The modular classrooms will be placed on a currently asphalt paved area in the southern portion of the campus. The restroom structure will be constructed in a currently landscaped area in the northern portion of the campus. Elevations in the immediate site vicinity of the buildings range from about +9 to +11 feet MSL.

3.3 Field Exploration and Laboratory Testing

Subsurface exploration for the project included 2 CPTs on April 26, 2017, excavation of 2 soil borings on May 10, 2017, and excavation of 2 additional borings on May 26, 2017. CPTs were pushed to maximum explored depths between about 22.5- and 28.5- feet. Borings were excavated to maximum explored depths between about 10.0- and 31.0- feet below the ground surface. Borings 1 and 2 were drilled using a truck-mounted drill rig equipped with 6-inch hollow-stem augers, and Borings 3 and 4 were drilled using portable, hydraulic-powered equipment and 4-inch solid-stem augers. Each boring was logged in the field by our Geologist, and samples of soil and rock materials were collected at select intervals for laboratory testing. Brief explanations of the terms and methodology used in classifying earth materials are shown on the attached Soil and Rock Classification Charts, Figures A-1 and A-2, respectively. Exploratory Boring Logs are presented on Figures A-4 through A-8.

CPTs were advanced using a 20- ton truck-mounted direct-push rig. The CPT cylindrical probe, 35 mm in diameter, is pushed into the ground at a constant rate of 2 cm/sec. 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 on a 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." A CPT Soil Interpretation Chart is shown on Figure A-3 and CPT plots are shown on Figures A-9 & A-10. A Soil Classification Chart and Rock Classification Chart are shown on Figures A-1 and A-2, respectively. The Boring Logs are presented on Figures A-4 through A-8. The subsurface exploration program is discussed in greater detail in Appendix A.

Laboratory testing of select soil samples included determination of moisture content, dry density, unconfined compressive strength and Caltrans corrosion testing. The results of the moisture content, dry density and unconfined compressive strength are presented on the Boring Logs, Figures A-4 through A-8. The results of our Caltrans corrosion testing are shown on Figure 11.
Our subsurface exploration and laboratory testing program is discussed in further detail in Appendix A.

3.4 Subsurface Conditions

3.4.1 - Modular Classrooms

Our subsurface exploration generally confirms the regionally-mapped geologic conditions at the site. CPT-1 encountered about 4- feet of medium dense to dense gravelly fill over 3.5- feet of soft clay over 20- feet of stiff, clayey alluvium. CPT-1 encountered equipment refusal at 28.2- feet on stiff to very stiff clay. CPT-2 encountered about 5.5- feet of medium dense to dense gravelly fill over 2- feet of soft clay over 14- feet of stiff, clayey alluvium. CPT-2 was terminated at 22.3- feet on similar stiff/very stiff alluvium. Additional site exploration was performed with two borings. Borings 1 and 2 are located adjacent to our CPTs and encountered similar conditions. In Boring 1 we encountered a pavement section of 4- inches of asphalt concrete over 20- inches of aggregate base rock underlain by fill consisting of medium dense, clayey Gravel with sand to a depth of 5- feet. Below that we encountered 3.5- feet of soft clay underlain by about 10- feet of stiff, sandy clay and then 12.5- feet of stiff, gravelly clay. Boring 1 was terminated at 31.0- feet. In Boring 2 we encountered a pavement section of 4- inches of asphalt concrete over 18- inches of aggregate base rock underlain by fill consisting of medium dense, clayey gravel with sand to a depth of 5- feet. Below that we encountered 3.5- feet of stiff, gravelly clay underlain by about 12- feet of stiff to very stiff, sandy clay and then 1.5- feet of stiff, gravelly clay. Boring 2 was terminated at 21.5- feet. A simplified geologic cross-section is shown on Figure 4.

3.4.2 – Portable Restroom

Again, our subsurface exploration generally confirms the regionally-mapped geologic conditions at the site. In Boring 3 we encountered about 1.5- feet of medium dense to dense silty sand with gravel over 1- foot of rocky fill underlain by less than a foot of dense, sandy residual soil over sandstone bedrock. Boring 1 was terminated at 10.1- feet in hard Sandstone bedrock. In boring 2 we encountered about 1.5- feet of very stiff gravelly clay fill over 2- foot of stiff, sandy residual soil over Sandstone bedrock. Boring 4 was terminated at 10.5- feet in hard sandstone bedrock. A simplified geologic cross-section is shown on Figure 5.

3.4.3 – Groundwater

Groundwater was encountered in Boring 1 at a depth of 9- feet and in Boring 2 at a depth of 13- feet. Groundwater was not encountered in Borings 3 and 4. Because the borings were not left open for an extended period of time, a stabilized depth to groundwater was not observed. Given the relatively low site elevations and immediate proximity to the tidally-influenced Corte Madera Creek, highest historic groundwater elevation is taken as a depth of 2- feet for the purpose of project engineering.

3.5 Seismicity

Active Faults in the Region – The project site is located within a seismically active region that includes the Central and Northern Coast Mountain Ranges. Several active faults are present in the area including the Maacama, Healdsburg, Rodgers Creek, San Andreas, and Hayward Faults, among others. An “active” fault is defined as one that shows displacement within the last 11,000 years and, therefore, is considered more likely to generate a future earthquake than a fault that shows no evidence of recent rupture. The California Department of Conservation, Division of Mines and Geology has mapped various active and inactive faults in the region (CDMG, 1972 and 2000). These faults, defined as either California Building Code Source Type “A” or “B,” are shown in relation to the project site on the attached Active Fault Map, Figure 7. The San Andreas Fault is the nearest known active fault and is located approximately 12.8 kilometers (7.9 miles) southwest of the site (Caltrans, 2014).

Historic Fault Activity – Numerous earthquakes have occurred in the region within historic times. Earthquakes (magnitude 2.0 and greater) that have occurred in the San Francisco Bay Area since 1985 have been plotted on a map shown on Figure 8.

Probability of Future Earthquakes – The site will likely experience moderate to strong ground shaking from future earthquakes originating on any of several active faults in the San Francisco Bay region. The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probabilities in California, the USGS has assembled a group of researchers into the “Working Group on California Earthquake Probabilities” (USGS 2016) to estimate the probabilities of earthquakes on active faults. These studies have been published cooperatively by the USGS, CGS, and

Southern California Earthquake Center (SCEC) as the Uniform California Earthquake Rupture Forecast, Versions 1, 2, and 3. In these studies, potential seismic sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, micro-seismicity, and other factors to arrive at estimates of earthquakes of various magnitudes on a variety of faults in California.

The study specifically analyzed fault sources and earthquake probabilities for the seven major regional fault systems in the Bay Area region, and the entire state of California and updated some of the analytical methods and models. The most recent 2016 study (UCERF3) further expanded the database of faults considered and allowed for consideration of multi-fault ruptures, among other improvements.

Conclusions from the most recent UCERF3 and USGS (Aagaard, et. al., 2016) indicate the highest probability of a M>6.7 earthquake on any of the active faults in the San Francisco Bay region by 2043 is assigned to the Hayward/Rodgers Creek Fault system, located approximately 20.7-kilometers west of the site, at 33%. The San Andreas Fault is the nearest known active fault, approximately 12.8 kilometers (7.9 miles) southwest of the site, and is assigned a 22% probability of a M>6.7 earthquake by 2043. Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

4.0 GEOLOGIC HAZARDS EVALUATION

4.1 General

The principal geologic hazards which could potentially affect the project site are strong seismic shaking from future earthquakes in the San Francisco Bay Region and flooding. Other hazards, such as fault rupture, tsunami or slope instability are not considered significant at the site. Geologic hazards, their impacts, and recommended mitigation measures are discussed below.

4.2 Fault Surface Rupture

Under the Alquist-Priolo Earthquake Fault Zoning Act, the California Geological Survey (CDMG)/California Geologic Survey (CGS) (1972, 2000) produced 1:24,000 scale maps showing all known active faults and defining zones within which special fault studies are required. Based on currently available published geologic information, the project site is not located within an Alquist-Priolo Earthquake Fault Zone (CGS, 2000). The potential for fault surface rupture on the campus is therefore considered to be low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.3 Seismic Shaking

The site will likely experience seismic ground shaking from future earthquakes in the San Francisco Bay Area. Earthquakes along several active faults in the region, as shown on Figure 7, could cause moderate to strong ground shaking at the site.

Deterministic Seismic Hazard Analysis – Deterministic Seismic Hazard Analysis (DSHA) predicts the intensity of earthquake ground motions by analyzing the characteristics of nearby faults, distance to the faults and rupture zones, earthquake magnitudes, earthquake durations, and site-specific geologic conditions. Empirical relations (Campbell and Borzognia, Chiou and Youngs, (2008)) for the stiff subsurface conditions were utilized to provide approximate estimates of median peak site accelerations. A summary of the principal active faults affecting the site, their closest distance, moment magnitude of characteristic earthquake and probable peak ground accelerations (PGA), which an earthquake on the fault could generate at the site are shown in Table A.

TABLE A
DETERMINISTIC PEAK GROUND ACCELERATION
Redwood High School
Modular Classrooms & Restroom
Larkspur, California

Fault	Approx. Distance to Fault (km)	Max. Moment Magnitude	Peak Ground Acceleration (g)
San Andreas - North	13	8.0	0.28
San Gregorio	14	7.4	0.24
Hayward	15	7.3	0.23
Rodgers Creek	25	7.3	0.16

Reference: Caltrans ARS (2017)
Campbell and Borzognia (2008)
Chiou and Youngs (2008)

Probabilistic Seismic Hazard Analysis – Probabilistic Seismic Hazard Analysis (PSHA) analyzes all possible earthquake scenarios while incorporating the probability of each individual event to occur. The probability is determined in the form of the recurrence interval, which is the average time for a specific earthquake acceleration to be exceeded. The design earthquake is not solely dependent on the fault with the closest distance to the site and/or the largest magnitude, but rather the probability of given seismic events occurring on both known and unknown faults.

We calculated the PGA for two separate probabilistic conditions, the 2% chance of exceedance in 50 years (2,475 year statistical return period) and the 10% chance of exceedance in 50 years

(475-year statistical return period), utilizing the 2008 Interactive Deaggregation (USGS, 2008). The results of the probabilistic analyses are presented below in Table B.

TABLE B
PROBABILISTIC SEISMIC HAZARD ANALYSES
Redwood High School
Modular Classrooms & Restroom
Larkspur, California

	Statistical Return Period	Magnitude	PGA
2% in 50 years	2,475 years	7.2	0.66 g
10% in 50 years	475 years	7.0	0.43 g

Reference: USGS 2008 Interactive Deaggregation (2008)

The potential for strong seismic shaking at the project site is moderate to high. Due to its close proximity, the San Andreas Fault (approximately 7.9-miles southwest) presents the highest potential for strong ground shaking. The most significant adverse impact associated with strong seismic shaking is potential damage to structures and improvements.

Evaluation: *Less than significant with mitigation.*
Mitigation: *Minimum mitigation measures should include designing the structures and foundations in accordance with the most recent version (2016) of the California Building Code. Recommended seismic coefficients are provided in Section V-B of this report.*

4.4 Liquefaction Potential and Related Impacts

Liquefaction refers to the sudden, temporary loss of soil shear strength during strong ground shaking. Liquefaction-related phenomena include liquefaction-induced settlement, flow failure, and lateral spreading. These phenomena can occur where there are saturated, loose, granular deposits. Recent advances in liquefaction studies indicate that liquefaction can occur in granular materials with a high, 35 to 50%, fines content (soil particles that pass the #200 sieve), provided the fines exhibit a plasticity less than 7. The site is mapped by the Association of Bay Area Governments (ABAG) as having a potentially high susceptibility to liquefaction, as shown on Figure 9. However, loose, saturated granular soils were not encountered during our subsurface exploration. Therefore, the risk of damage to improvements at the site due to liquefaction is generally low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.5 Seismically Induced Ground Settlement

Seismic ground shaking can induce settlement of loose, unsaturated granular soils. Settlement occurs as the loose soil particles rearrange into a denser configuration when subjected to seismic ground shaking. Varying degrees of settlement can occur throughout a deposit, resulting in differential settlement of structures founded on such deposits. However, loose, unsaturated granular soils were not encountered during our subsurface exploration. Therefore, the risk of damage to improvements at the site due to seismically-induced settlement is generally low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.6 Lurching and Ground Cracking

Lurching and associated ground cracking can occur during strong ground shaking. The ground cracking generally occurs along the tops of slopes where stiff soils are underlain by soft deposits or along steep slopes or channel banks. These conditions do not exist at the site, therefore the risk of lurching and ground cracking at the project site is low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.7 Erosion

Sandy soils on moderate slopes or clayey soils on steep slopes are susceptible to erosion when exposed to concentrated water runoff. These conditions do not exist at the site as the project area is surfaced with asphalt concrete.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.8 Seiche and Tsunami

Seiche and tsunamis are short duration, earthquake-generated water waves in large enclosed bodies of water and the open ocean, respectively. The extent and severity of a seiche or tsunami would be dependent upon ground motions and fault offset from nearby active faults. The site is mapped by the California Emergency Managements Agency (2009), the site lies within a zone of potential seiche/tsunami inundation as shown on Figure 10.

Evaluation: *Less than significant.*
Mitigation: *Given the scope of the proposed project, we judge that providing mitigation for potential inundation by seiche or tsunami is likely neither warranted nor cost-efficient.*

4.9 Flooding

The site is located at a low elevation in a developed section of Larkspur and based on FEMA flood hazard maps, both sites are located within the 500-year flood zone (ABAG, 2014) and very close to the100-year flood zone boundary as shown on Figure 10; therefore, large scale flooding is a considered a significant geologic hazard at the site. The adverse impact from flooding is water damage to structures and its contents.

Evaluation: *Less than significant with mitigation*
Mitigation: *Mitigation measures include designing finished floors above the expected flood elevation. Consideration should also be given to design of finished grades at the site so that adverse drainage conditions do not allow water to pond around the structures.*

4.10 Dam Failure Inundation

The nearest dam to the project site is Phoenix Lake Dam, owned and operated by Marin Municipal Water District and located in Ross, about 3.5-miles northwest of the site. The anticipated inundation zone associated with potential failure of Phoenix Lake Dam is generally confined to areas immediately proximal to Corte Madera Creek, about ¼ mile north of the site (ABAG, 1995). Therefore, the risk of damage due to dam failure inundation at the site is low.

Evaluation: *No significant Impact.*
Mitigation: *No mitigation measures are required.*

4.11 Expansive Soil

Expansive soils will shrink and swell with fluctuations in moisture content and are capable of exerting significant expansion pressures on building foundations, interior floor slabs and exterior flatwork. Distress from expansive soil movement can include cracking of brittle wall coverings (stucco, plaster, drywall, etc.), racked door and/or window frames, and uneven floors and cracked slabs. Flatwork, pavements, and concrete slabs-on-grade are particularly vulnerable to distress due to their low bearing pressures. Our exploration did not encounter plastic or expansive soils near the ground surface. Therefore, expansive soils are not considered to be a significant hazard at the site.

Evaluation: *No significant impact.*
Mitigation: No mitigation measures are required.

4.12 Settlement/Subsidence

Significant settlement can occur when new loads are placed at sites due to consolidation of soft compressible clays (i.e., Bay Mud) or compression of loose soils. Settlement can also occur or continue if existing fill has not been in place for an extended length of time. Based on our interpretation of site conditions, there is up to 3- feet of soft clay below the modular classroom buildings. Although the soft clay is compressible under moderate loads, the classrooms are very light and not expected to experience more than 1- inch of settlement.

Evaluation: *Less than significant.*
Mitigation: *No mitigation measures are required.*

4.13 Slope Instability/Landsliding

Slope instability generally occurs on relatively steep slopes and/or on slopes underlain by weak materials. The school campus lies on level terrain in the eastern portion of Larkspur. Therefore, slope instability/landsliding is not considered a significant geologic hazard at the project site.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.14 Soil Corrosion

Corrosive soil can damage buried metallic structures, cause concrete spalling and deteriorate rebar reinforcement. Laboratory testing was performed on samples of near-surface soils obtained during our subsurface exploration. Testing included pH, electrical resistivity, chloride and sulfate contents. These laboratory test results are presented in Appendix A.

The results of our recent corrosivity testing indicate the upper soil layer has a pH of 10.79, a chloride concentration of 1500 parts per million (ppm), and a sulfate concentration of 825 ppm. Per Caltrans Corrosion Guidelines (2003) a soil is considered corrosive if the pH level is less than 5.5, the chloride concentration is greater than 500 ppm, and/or the sulfate concentration is 2,000 ppm or greater. High alkalinity measured in the sample could cause accelerated corrosion of metallic improvements, therefore, based on the results of the corrosion testing, the soil should be considered moderately corrosive.

Evaluation: *Less than significant with mitigation.*
Mitigation: *The project Structural Engineer should specify materials that are resistant to corrosive soil or provide cathodic corrosion protection. At a minimum, concrete for reinforced concrete structures should utilize Type V Portland Cement with a water-cement ratio of 0.45 or less and minimum compressive strength of 4,000 psi. Underground utilities should be constructed of plastic or PVC pipe; metallic piping should be avoided.*

4.15 Radon-222 Gas

Radon-222 is a product of the radioactive decay of uranium-238 and raduim-226, which occur naturally in a variety of rock types, mainly phosphatic shales, but also in other igneous, metamorphic, and sedimentary rocks. While low levels of radon gas are common, very high levels, which are typically caused by a combination of poor ventilation and high concentrations of uranium and radium in the underlying geologic materials, can be hazardous to human health. The project site is located in Marin County, California, which is mapped in radon gas Zone 3 by the United States Environmental Protection Agency (USEPA, 2014). Zone 3 is classified by the EPA as exhibiting a "low" potential for Radon-222 gas with average predicted indoor screening levels less than 2 pCi/L. Therefore, the potential for hazardous levels of radon at the project site is low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.16 Volcanic Eruption

Several active volcanoes with the potential for future eruptions exist within northern California, including Mount Shasta, Lassen Peak, and Medicine Lake in extreme northern California, the Mono Lake-Long Valley Caldera complex in east-central California, and the Clear Lake Volcanic Field, located in Lake County approximately 70 miles north of the project site. The most recent volcanic eruption in northern California was at Lassen Peak in 1917, while the most recent eruption at the nearest volcanic center to the project site, the Clear Lake Volcanic Field, was about 10,000 years ago. All of northern California's volcanic centers are currently listed under "normal" volcanic alert levels by the USGS California Volcano Observatory (USGS, 2015a). While the aforementioned volcanic centers are considered "active" by the USGS, the likelihood of damage to the proposed improvements due to volcanic eruption is generally low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.17 Naturally Occurring Asbestos (NOA)

Naturally occurring asbestos is commonly found in association with serpentinite and associated ultramafic rock types. These rocks are a major constituent of the Franciscan Complex, which underlies vast portions of the greater San Francisco Bay Area. The site is underlain by fill and variably thick Bay Mud and, while it lies in a region dominated in part by Franciscan Complex bedrock, no evidence suggesting the presence of serpentinite or related rock types at the site was observed during our exploration. Therefore, the likelihood of naturally-occurring asbestos existing at the site is low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.18 Hazardous Materials

Hazardous materials were not observed during our subsurface exploration. While environmental testing for hazardous materials was beyond the scope of our services, based on visual inspection of the subsurface soils, it is our opinion the potential of significant hazardous materials located at the project site is low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 General

Based on our experience with similar projects at Redwood High School, we conclude that, from a geotechnical standpoint, the site is suitable for the planned improvements. The primary geotechnical issues to address in design of the project are designing structures to withstand strong seismic shaking and flooding.

5.2 Seismic Design

The project site is located in a seismically active area. Therefore, the structure should be designed in conformance with the seismic provisions of the California Building Code (CBC) to mitigate the potential effects of strong seismic ground shaking to the proposed structures. As previously discussed, the modular classrooms are underlain by moderately deep alluvium whereas the modular restroom is underlain by shallow bedrock. Therefore, it is our opinion a Site Class “D” is appropriate for the modular classrooms, and Site Class “C” is appropriate for the restroom structure. At a minimum, we recommend the project Structural Engineer utilize the 2016 CBC coefficients shown in Table C below to determine the base shear values.

TABLE C
2016 CBC FACTORS
Redwood High School
Modular Classrooms & Restroom
Larkspur, California

Modular Classrooms

Factor Name	Coefficient	2013/2016 CBC Site Specific Value
Site Class[1]	$S_{A,B,C,D,E,\text{ or }F}$	S_D
Site Coefficient	F_a	1.00
Site Coefficient	F_v	1.50
Spectral Acc. (short)	S_S	1.5 g
Spectral Acc. (1-sec)	S_1	0.6 g
Spectral Response (short)	SM_S	1.5 g
Spectral Response (1-sec)	SM_1	0.9 g
Design Spectral Response (short)	SD_S	1.00 g
Design Spectral Response (1-sec)	SD_1	0.60 g
Seismic Design Category	A,B,C,D, or E	D

Restroom Structure

Factor Name	Coefficient	2013/2016 CBC Site Specific Value
Site Class[1]	$S_{A,B,C,D,E,\text{ or }F}$	S_C
Site Coefficient	F_a	1.00
Site Coefficient	F_v	1.30
Spectral Acc. (short)	S_S	1.5 g
Spectral Acc. (1-sec)	S_1	0.6 g
Spectral Response (short)	SM_S	1.5 g
Spectral Response (1-sec)	SM_1	0.78 g
Design Spectral Response (short)	SD_S	1.00 g
Design Spectral Response (1-sec)	SD_1	0.52 g
Seismic Design Category	A,B,C,D, or E	C

1. Site Class D, Description: stiff soil profile with shear wave velocities between 600 and 1,200 ft/sec, standard penetration blow counts between 15 and 50, and undrained shear strength between 1,000 and 2,000 psf.
2. Site Class C, Description: very dense soil / soft rock profile with shear wave velocities between 1,200 and 2,500 ft/sec, standard penetration blow counts greater than 50 blows per foot, and undrained shear strength greater than 2,000 psf.

5.3 Site Preparation and Grading

The general grading recommendations presented below are appropriate for construction in the late spring through fall months. From winter through the early spring months, on-site soils may be saturated due to rainfall and may be difficult to compact without drying by aeration or the addition of lime and/or cement (or a similar product) to dry the soils. Site preparation and grading should conform to the recommendations and criteria outlined below. General recommendations for wintertime construction are provided later in this report.

5.3.1 Surface Preparation

Clear all trees, brush, roots, over-sized debris, and organic material from areas to be graded. Trees that will be removed (in structural areas) must also include removal of stumps and roots larger than two inches in diameter. Excavated areas (i.e., excavations for stump removal) should be restored with properly moisture conditioned and compacted fill as described in the following sections. Any loose soil or rock at subgrade will need to be excavated to expose firm natural soils or bedrock. Debris, rocks larger than six inches and vegetation are not suitable for structural fill and should be removed from the site. Alternatively, vegetation strippings may be used in landscape areas.

Where fills or other structural improvements are planned on level ground, the subgrade surface should be scarified to a depth of about eight inches, moisture conditioned to at least 3% above the optimum moisture content, and compacted to a minimum of 90% relative compaction (ASTM D-1557). Relative compaction should be increased to a minimum of 95% where new asphalt pavements are planned. Relative compaction, maximum dry density, and optimum moisture content of fill materials should be determined in accordance with ASTM Test Method D 1557, "Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using a 10-lb. Rammer and 18-in. Drop." If soft, wet or otherwise unsuitable materials are encountered at the subgrade elevation during construction, we will provide supplemental recommendations/field directives to address the specific condition.

5.3.2 Materials

If imported fill is required, the material shall consist of soil and rock mixtures that: (1) are free of organic material, (2) have a Liquid Limit less than 40 and a Plasticity Index of less than 20, and (3) have a maximum particle size of 6 inches. Any imported fill material needs to be tested to determine its suitability for use as fill material.

5.4 Foundation Design

The proposed one story portable classroom buildings and restroom structure are designed to withstand minor differential movement, and are constructed on frames designed to be moved on the highway. The portable buildings will be supported on pressure treated wood foundations bearing on the ground surface. Settlement of the ground surface of up to one inch caused by minor consolidation settlement would not be expected to cause structural damage to the portable buildings, or result if life safety concerns. If differential settlement were to occur, the portable buildings could be relatively easily re-leveled.

In our opinion, it is acceptable and appropriate to support the proposed portable buildings on typical pressure treated wood foundations bearing on an asphalt paved surface.

5.5 Exterior Concrete Slabs

Exterior concrete should be at least 4- thick and reinforced with steel. Exterior concrete slabs shall be underlain with 6-inches or more of Caltrans Class 2 Aggregate Base compacted to at least 92 percent relative compaction. Some movement should be expected for exterior concrete slabs as the underlying soils react to seasonal moisture changes. For improved performance, the exterior slabs can be thickened to 5- inches and/or underlain with a thicker aggregate base layer.

5.6 Site and Foundation Drainage

The site is relatively flat and there is a possibility that new grading could result in adverse drainage patterns and water ponding around buildings. Careful consideration should therefore be given to design of finished grades at the site. We recommend that landscaped areas adjoining new structures be sloped downward at least 0.25 feet for 5 feet (5%) from the perimeter of building foundations. Where hard surfaces such as concrete or asphalt adjoin foundations, slope these surfaces at least 0.10 feet in the first 5 feet (2%). Roof gutter downspouts may discharge onto the pavements, but should not discharge onto any landscaped areas. Provide area drains for landscape planters adjacent to buildings and parking areas and collect downspout discharges into a tight pipe collection system. Site drainage improvements should be connected into the existing campus storm drainage system.

5.7 Asphalt Pavement

We understand asphalt pavement areas, mostly for pedestrian use will be constructed. Typically, asphalt pavement sections are designed utilizing two variables, the R-Value (a measure of the subgrade resistance) and the Traffic Index (a measure of the amount of daily traffic). Based on the subsurface conditions we judge an R-Value of 10 is appropriate for the site. We have calculated pavement sections for the project site in accordance with Caltrans procedures for flexible pavement design utilizing the values described above and various Traffic Index (T.I.) values. The recommended pavement sections are presented in Table D below.

TABLE D
ASPHALT PAVEMENT SECTION
Redwood High School
Modular Classrooms & Restroom
Larkspur, California

T.I.	Asphalt Concrete	Aggregate Baserock
4.0	2.5 inches	6 inches
5.0	3.0 inches	8 inches

The aggregate baserock should conform to Caltrans Class 2 Aggregate Baserock (Class 2 AB) outlined in Section 26 of the Caltrans Standard Specifications. The Class 2 AB shall be placed in layers on a properly prepared and firm and unyielding subgrade as described in the previously discussed grading recommendations. The Class 2 AB should be compacted to at least 95% relative compaction. Additionally, the Class 2 AB section should be firm and unyielding under heavy construction equipment.

5.9 Utility Trench Excavations and Backfills

Excavations for utilities will most likely extend into to medium dense granular soils. Trench excavations having a depth of five feet or more that will be entered by workers must be sloped, braced, or shored in accordance with current Cal/OSHA regulations. On-site soils appear to be Type C. All excavations where collapse of excavation sidewall, slope or bottom could result in injury or death of workers, should be evaluated by the contractor’s safety officer and designated competent person prior to entering in accordance with current Cal/OSHA regulations.

Bedding materials for utility pipes should be well graded sand with 90 to 100% of particles passing the No. 4 sieve and no more than 5% finer than the No. 200 sieve. Provide the minimum bedding beneath the pipe in accordance with the manufacturer’s recommendation, typically 3 to 6 inches. Trench backfill may consist of on-site soils, moisture conditioned to within 2% of the optimum moisture content, placed in thin lifts and compacted to a minimum of 90% relative compaction. Backfill for trenches within pavement areas should consist of non-expansive granular fill. Use equipment and methods that are suitable for work in confined areas without damaging utility conduits. Where utility lines cross under or through perimeter footings, they should be sealed to reduce moisture intrusion into the areas under the slabs and/or footings.

5.10 Wintertime Construction

Wintertime/wet weather site work is feasible during the construction phase of this project provided weather conditions do not adversely impact the planned grading, and proper erosion control measures are implemented to prevent excessive silt and mud from entering the storm drain system. High soil moisture contents and muddy site conditions may impact placing fills, compacting subgrades, and excavating foundation trenches. Several alternatives may be considered to improve the site conditions to allow site work to proceed in rainy conditions:

- Prior to the onset of winter rains, maintain a drier site by covering the work area and any stockpiled materials with plastic visqueen sheeting or other impermeable membrane. Where asphalt pavements, other hardscape or drainage improvements currently exist in work areas, consider leaving these improvements in place until the last possible moment to maintain a drier subgrade condition.
- Lime treat the subgrade soils when site work commences to “weatherproof” the site. The disadvantage to this alternative is that future landscaping will likely require excavation and replacement of the treated soils for acceptable plant growth.
- Finally, imported, drier fill materials could be used to stabilize the site. Soft or wet on-site materials could be excavated to firm materials and drier (preferably granular) soils with good drainage characteristics would be imported to restore site grades. This alternative might also require future excavation and replacement of landscaping soils.

If construction occurs relatively early in the winter, we judge the first option (covering the site prior to winter rains) could be an effective method of maintaining a workable site. When the construction schedule and weather conditions are known, we can meet with the project team to further discuss alternatives to continuing wintertime construction.

6.0 SUPPLEMENTAL GEOTECHNICAL SERVICES

We must review the plans and specifications for the project when they are nearing completion to confirm that the intent of our geotechnical recommendations has been incorporated and provide supplemental recommendations, if needed. During construction, we must observe and test site grading, foundation excavations for the structures and associated improvements to confirm that the soils encountered during construction are consistent with the design criteria.

7.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in the San Francisco Bay Area at the time the report was prepared. This report has been prepared for the exclusive use of Tamalpais Union High School District and/or its assignees specifically for this project. No other warranty, expressed or implied, is made. Our evaluations and recommendations are based on the data obtained during our subsurface exploration program and our experience with soils in this geographic area.

Our approved scope of work did not include an environmental assessment of the site. Consequently, this report does not contain information regarding the presence or absence of toxic or hazardous wastes.

The evaluations and recommendations do not reflect variations in subsurface conditions that may exist between boring locations or in unexplored portions of the site. Should such variations become apparent during construction, the general recommendations contained within this report will not be considered valid unless MPEG is given the opportunity to review such variations and revise or modify our recommendations accordingly. No changes may be made to the general recommendations contained herein without the written consent of MPEG.

We recommend that this report, in its entirety, be made available to project team members, contractors, and subcontractors for informational purposes and discussion. We intend that the information presented within this report be interpreted only within the context of the report as a whole. No portion of this report should be separated from the rest of the information presented herein. No single portion of this report shall be considered valid unless it is presented with and as an integral part of the entire report.

8.0 LIST OF REFERENCES

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APPENDIX A
SUBSURFACE EXPLORATION AND LABORATORY TESTING

1.0 Subsurface Exploration

We explored subsurface conditions at the site by drilling 4-test borings utilizing truck mounted drilling equipment with 6-inch hollow stem augers and portable hydraulic drilling equipment with 4-inch sold flight augers on May 10^{th} and 26^{th}, 2017. On April 26, 2017, we explored conditions with 2-CPTs using a 20-ton direct push truck mounted rig. The approximate boring and CPT locations are shown on Figures 2 and 3. The borings and CPTs were drilled to a maximum depth of 31-feet and 28-feet below the ground surface.

The soils encountered were logged and identified in the field in general accordance with ASTM Standard D 2487, "Field Identification and Description of Soils (Visual-Manual Procedure)." This standard is briefly explained on Figures A-1 and A-2, Soil Classification Chart and Rock Classification Chart, respectively. The boring logs are presented on Figures A-3 through A-12.

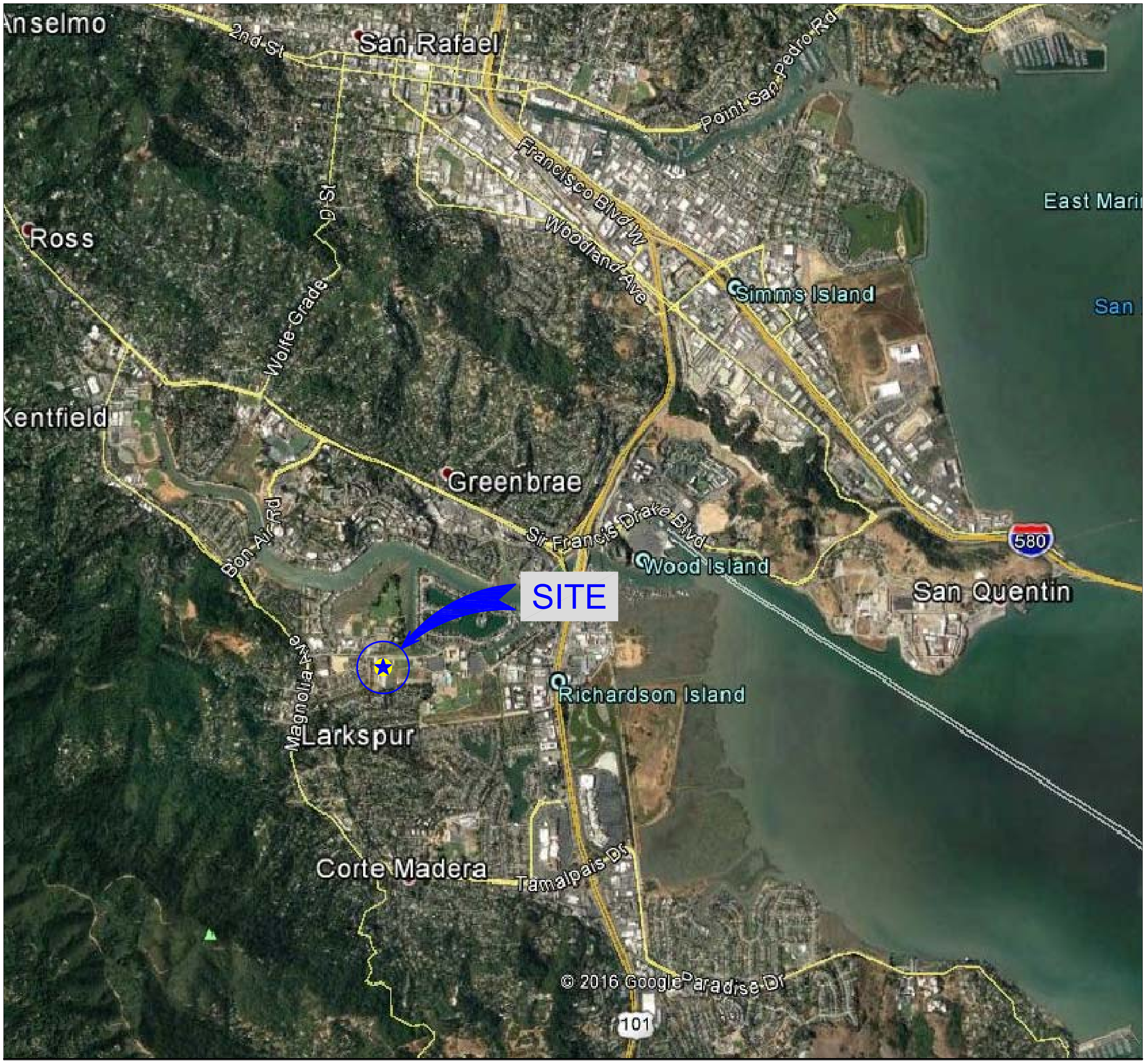
We obtained “undisturbed” samples using a 3-inch diameter, split-barrel modified California sampler with 2.5 by 6-inch brass tube liners or with a 2-inch diameter, split-barrel Standard Penetration Test (SPT) sampler. The sampler was driven with a 140-pound hammer falling 30 inches. The number of blows 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 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;
- pH in soil, EPA 9040;
- Resistivity in Soil, SM 2510; and
- Anions in soil (sulfate and chloride), EPA 300.

The moisture content, dry density, unconfined compressive strength, are shown on the exploratory Boring Logs. Results of Corrosion testing are presented on Figure 11. The exploratory boring logs, CPT 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.



SITE: LATITUDE, 37.9378°
LONGITUDE, -122.5293°

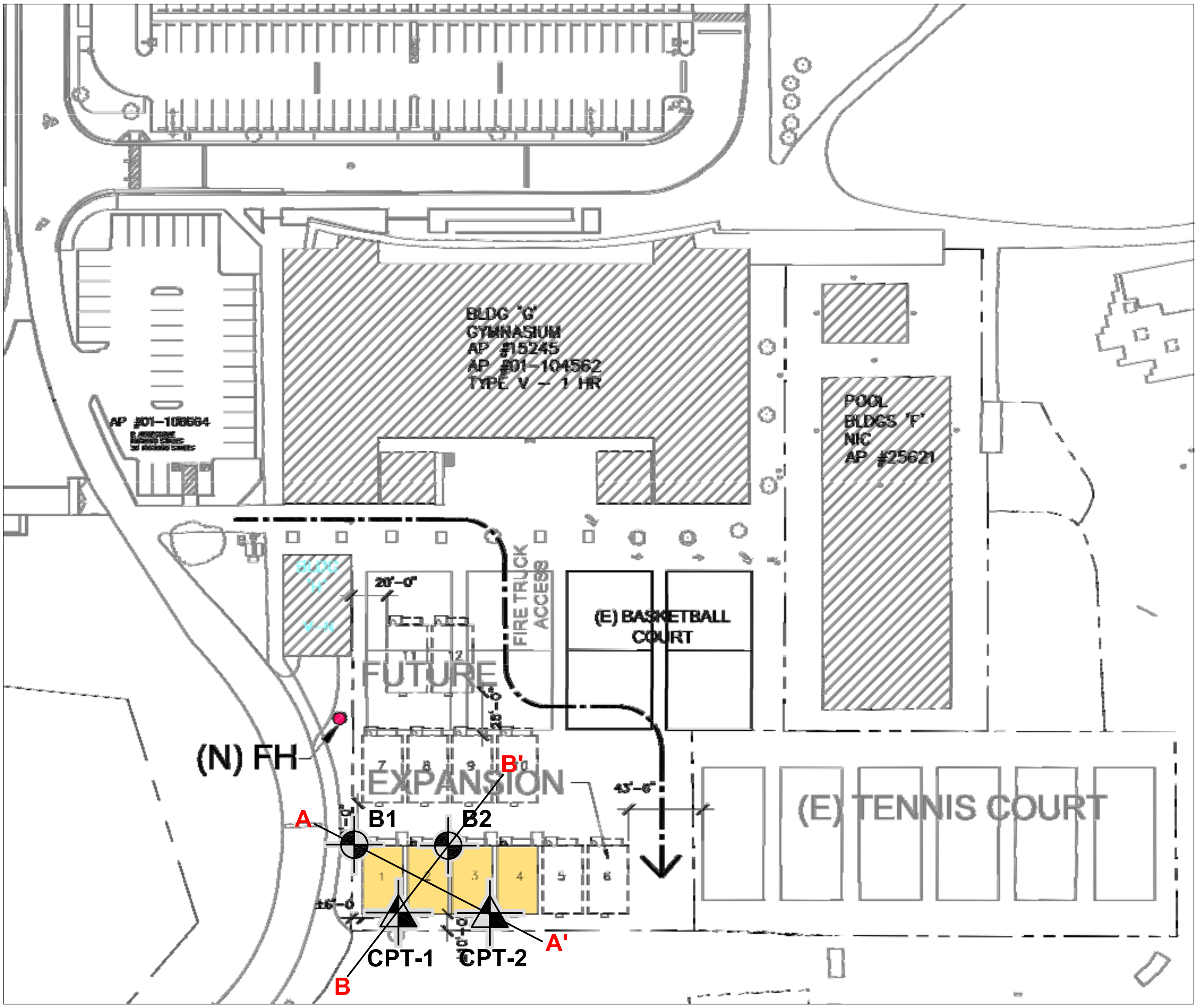
SITE LOCATION

N.T.S.

NORTH

REFERENCE: Google Earth, 2017

MILLER PACIFIC ENGINEERING GROUP	504 Redwood Blvd. Suite 220 Novato, CA 94947 T 415 / 382-3444 F 415 / 382-3450 www.millerpac.com	SITE LOCATION MAP		
A CALIFORNIA CORPORATION, © 2017, ALL RIGHTS RESERVED FILENAME: 867.185 STD FIGS.dwg		Redwood High School Modular Classrooms Larkspur, California Project No. 867.185 Date: 5/25/2017	Drawn ENE Checked	1 FIGURE



SITE PLAN MODULAR CLASSROOMS

SCALE

0 50 100 200 FEET

NORTH

Approximate CPT location completed by MPEG, 2017

Approximate boring location completed by MPEG, 2017

Note: Building '4' is not a part of this project.

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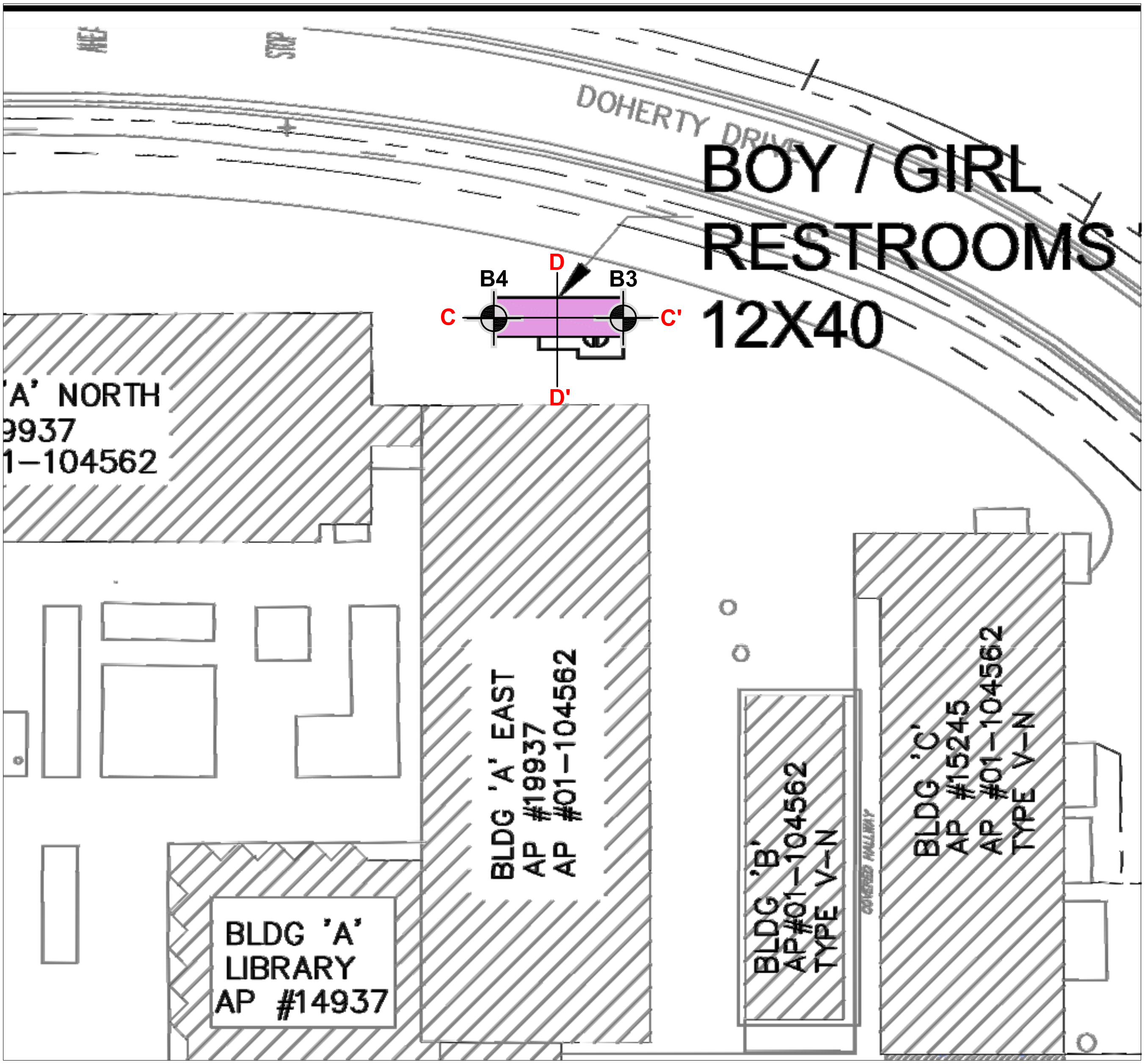
SITE PLAN MODULAR CLASROOMS

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

Drawn ENE
Checked

2
FIGURE



SITE PLAN RESTROOM

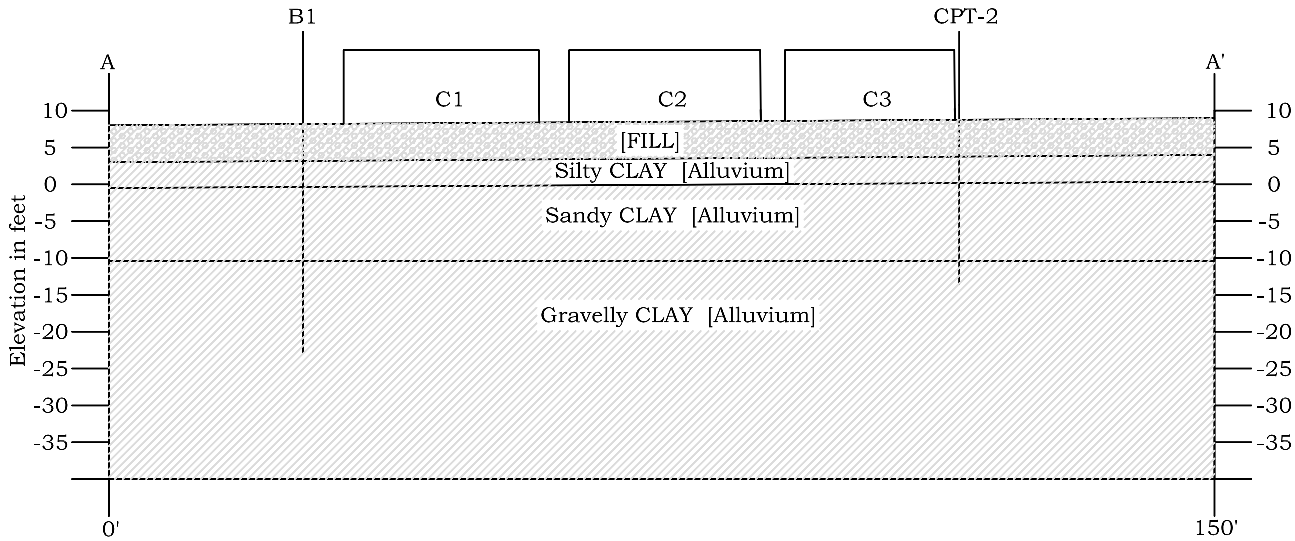
SCALE

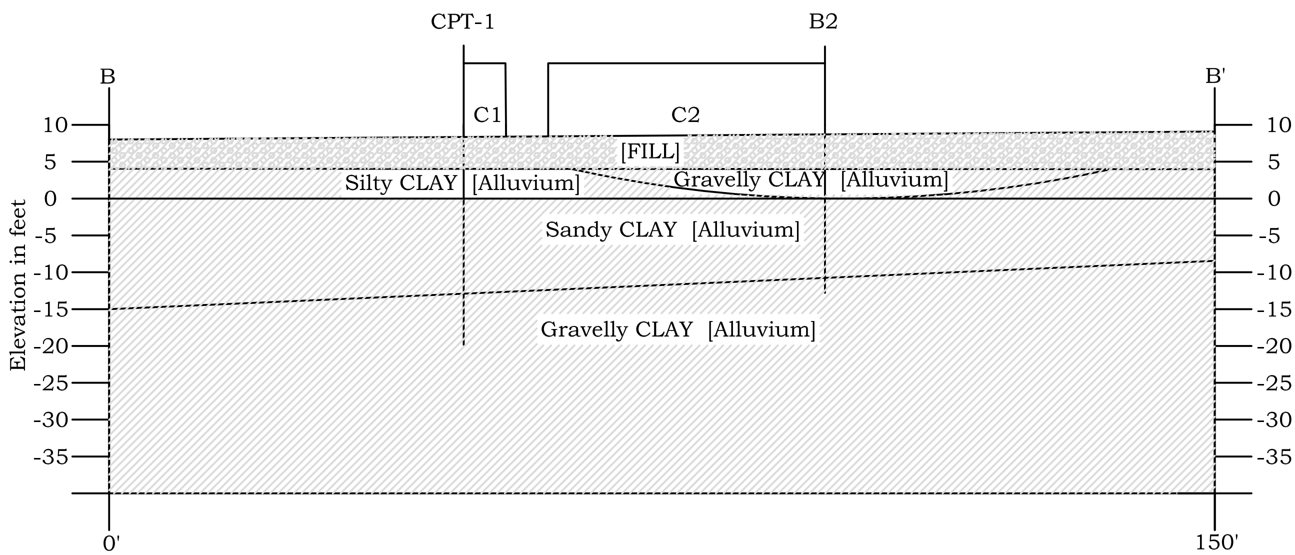
0 25 50 100 FEET

NORTH

Approximate boring location completed by MPEG, 2017

MPEG MILLER PACIFIC ENGINEERING GROUP	504 Redwood Blvd. Suite 220 Novato, CA 94947 T 415 / 382-3444 F 415 / 382-3450 www.millerpac.com	SITE PLAN RESTROOM Redwood High School Modular Classrooms Larkspur, California Project No. 867.185 Date: 5/25/2017	Drawn ENE Checked
A CALIFORNIA CORPORATION, © 2017, ALL RIGHTS RESERVED FILENAME: 867.185 STD FIGS.dwg			3 FIGURE





GEOLOGIC CROSS SECTION
CLASSROOMS

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GEOLOGIC CROSS SECTION A

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

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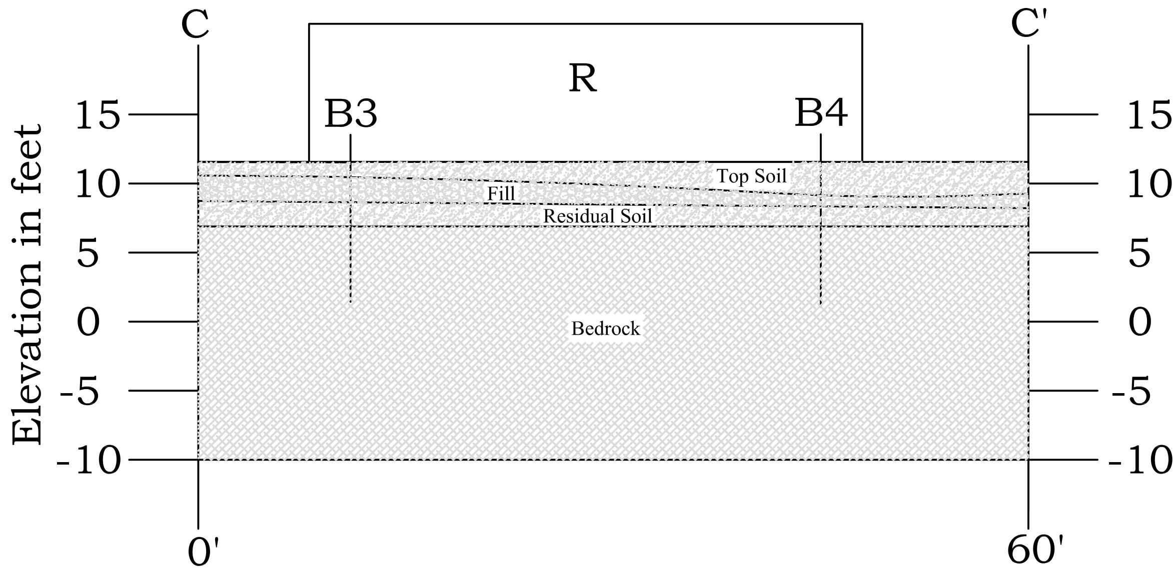
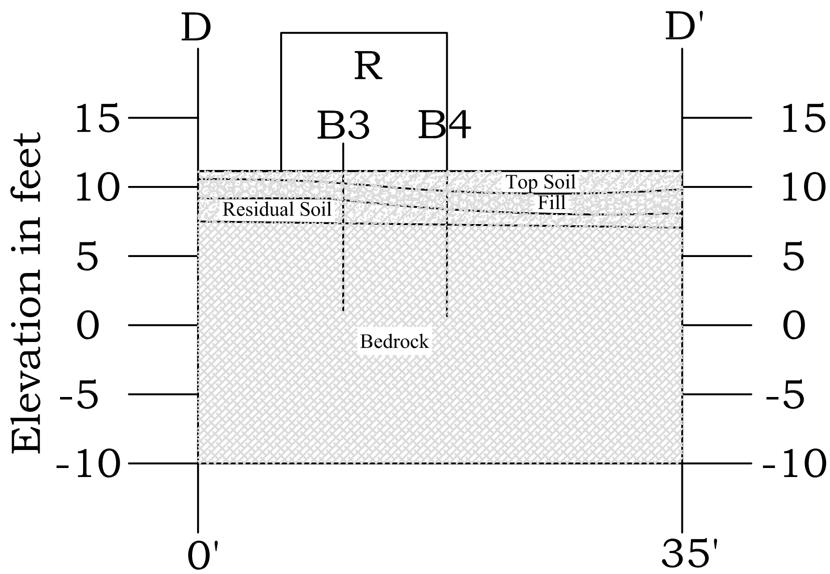
4
FIGURE

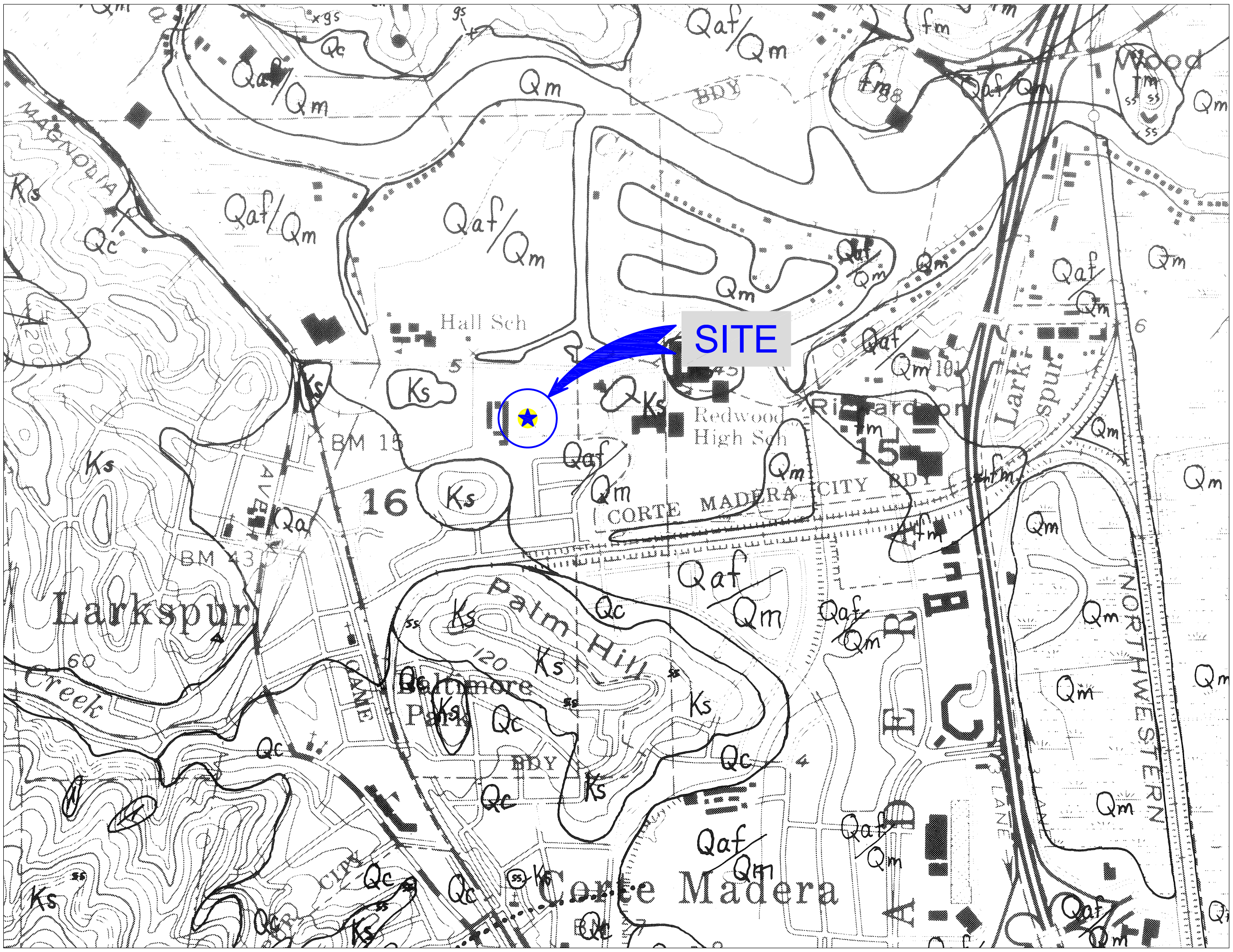




GEOLOGIC CROSS SECTION
RESTROOM

MILLER PACIFIC ENGINEERING GROUP	504 Redwood Blvd. Suite 220 Novato, CA 94947 T 415 / 382-3444 F 415 / 382-3450 www.millerpac.com	GEOLOGIC CROSS SECTION B		
		Redwood High School Modular Classrooms Larkspur, California	Drawn ENE Checked	5 FIGURE
		Project No. 867.185 Date: 5/25/2017		

FILENAME: 867.185 STD FIGS.dwg



REGIONAL GEOLOGIC MAP

(NOT TO SCALE)

NORTH

LEGEND

Qa	Quaternary Alluvium
Qaf/Qm	Artificial fill over Quaternary Bay Mud
Qc	Quaternary Colluvium
Ks	Cretaceous Sandstone and Shale bedrock
fm	Franciscan Melange

REFERENCE: Rice, S.J. and Smith, T.C. (1976), "Geology of the Lower Ross Valley, Corte Madera, Homestead Valley, Tamalpais Valley, Tennessee Valley, and Adjacent Areas, Marin County, California" in Geology for Planning in Central and Southeastern Marin County, California, California Department of Conservation, Division of Mines and Geology Open-File Report 76-2, Plate 1D, Map Scale 1:12,000.

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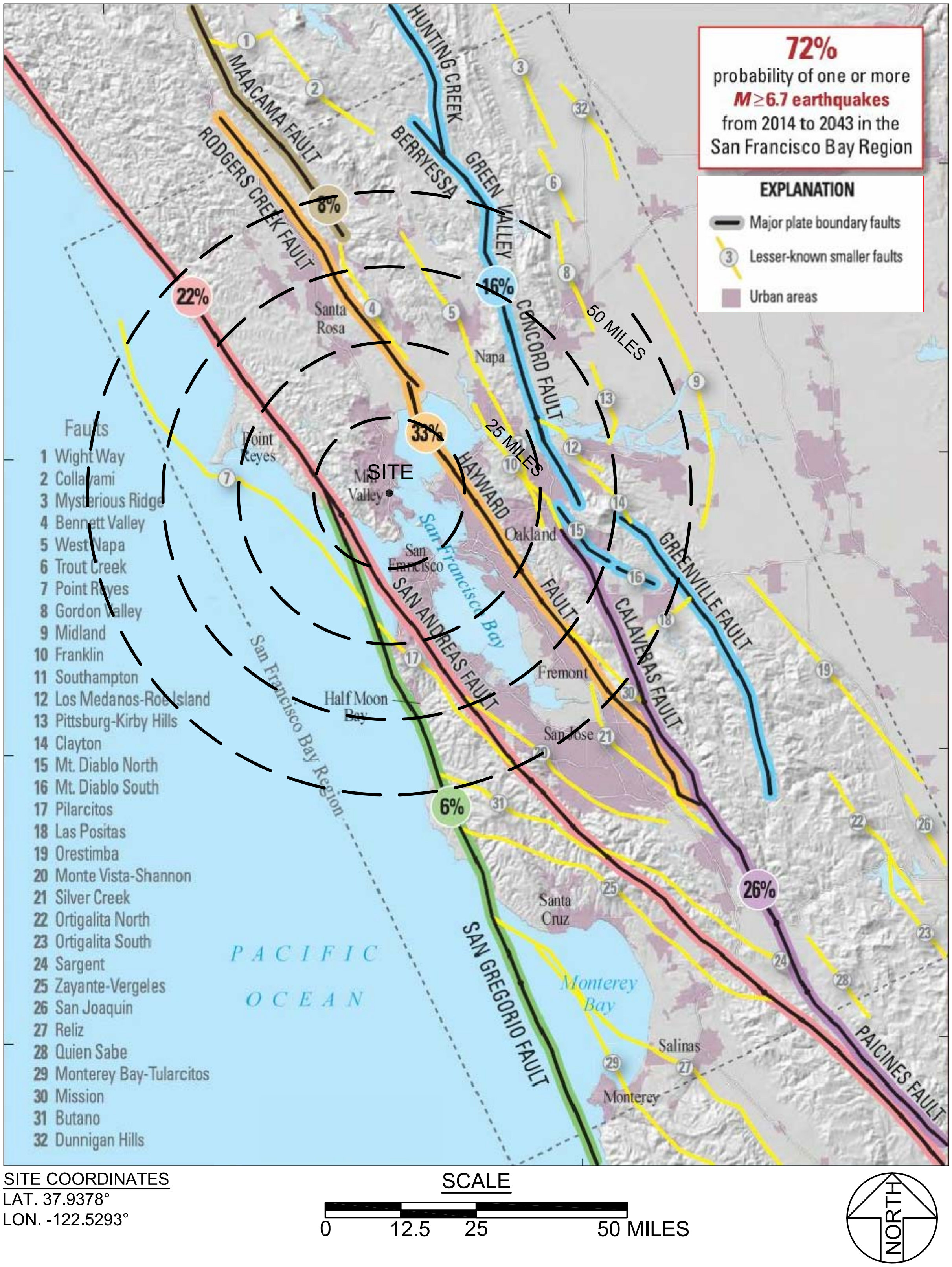
REGIONAL GEOLOGY MAP

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

Drawn ENE
Checked

6
FIGURE



SITE COORDINATES
LAT. 37.9378°
LON. -122.5293°

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Known Active Faults in the San Francisco Bay Region, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

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ACTIVE FAULT MAP

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

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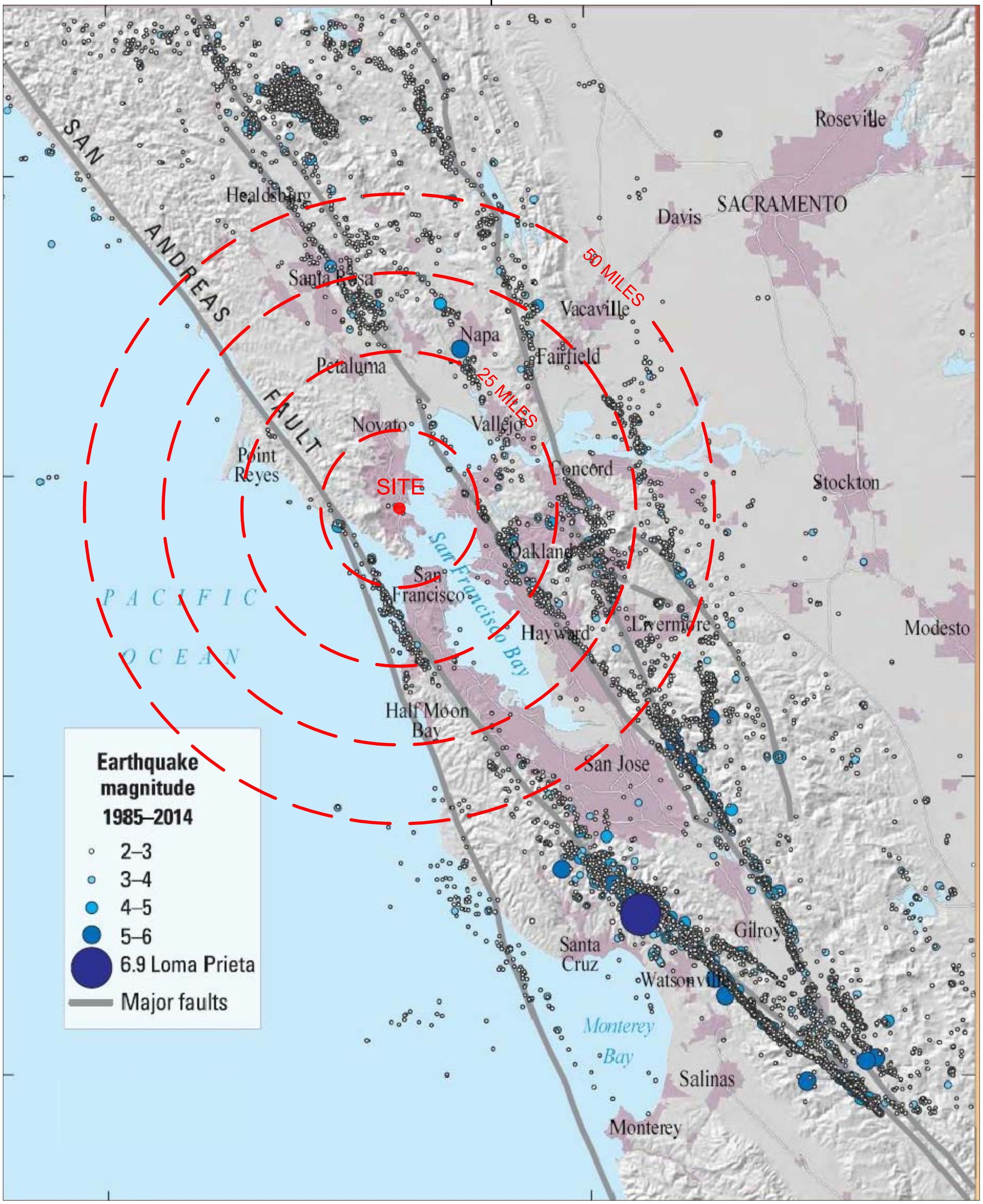
Checked

7
FIGURE



SITE COORDINATES
LAT. 37.9378°
LON. -122.5293°

SCALE
0 12.5 25 50 MILES

NORTH

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Earthquakes Greater Than Magnitude 2.0 in the San Francisco Bay Region from 1985-2014, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

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HISTORICAL FAULT MAP

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

Drawn ENE
Checked

8
FIGURE

Susceptibility Level:

Very High | Moderate | Very Low | Local Road

High | Low | Major Road

Not to Scale

NORTH

Map Reference: ABAG Geographic Information System.

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LIQUEFACTION MAP

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

Drawn ENE

Checked

9

FIGURE

Flood Hazard Area:

Zone V- 100yr.
Zone X - 500yr.
Zone A - 100yr.
Urbanized Area

Not to Scale

Zone V: This code identifies an area inundated by 1% annual chance flooding with velocity hazard (wave action).
Zone A: This code identifies an area inundated by 1% annual chance flooding.

Zone X 500yr: This code identifies an area inundated by .02% annual chance flooding and area inundated by 1% annual chance of flooding with average depth of less than 1 foot of with drainage areas less than 1 square mile or an area protected by levees form 1% annual chance flooding.

NORTH

Map Reference: ABAG Geographic Information System.

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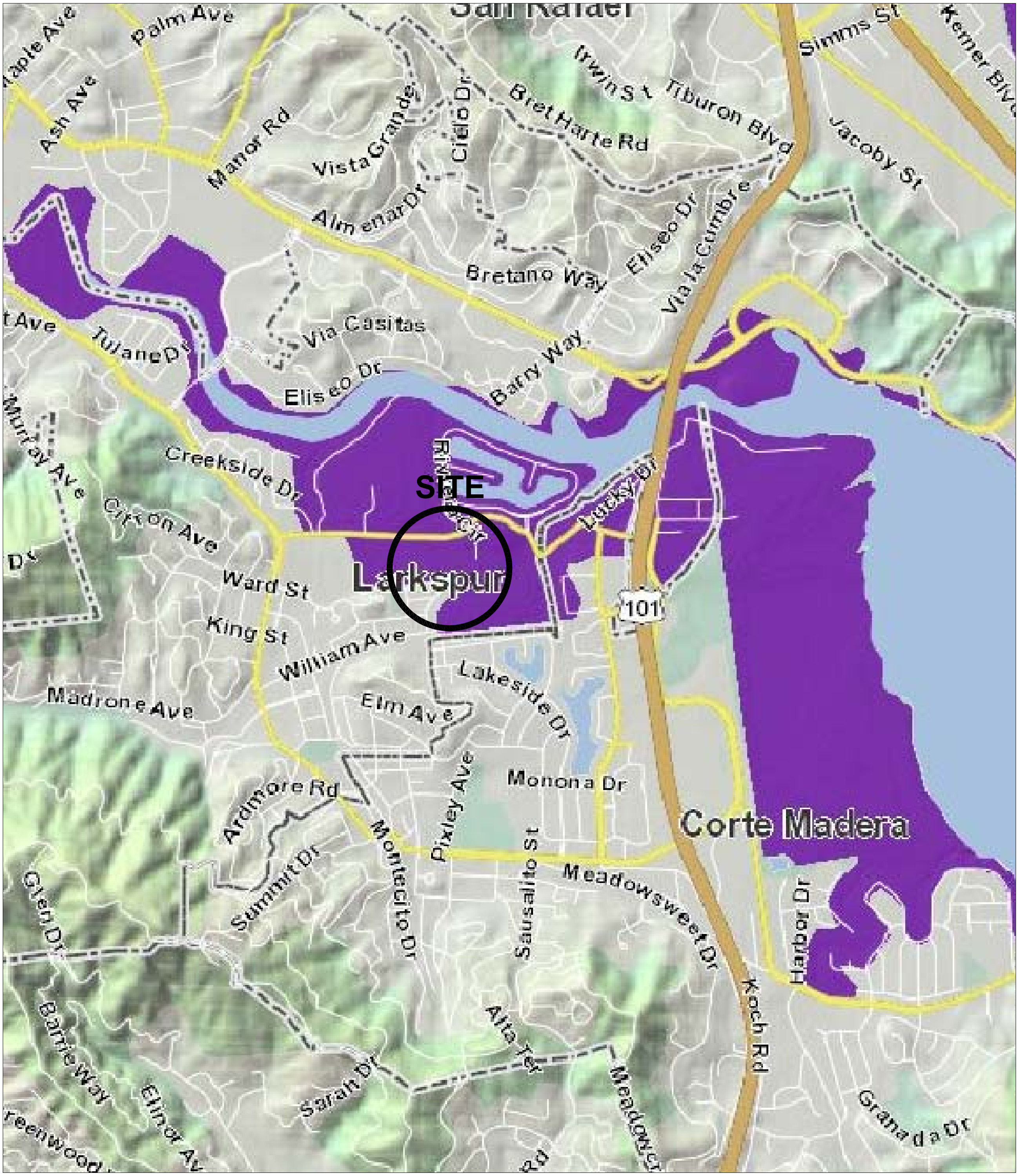
FLOOD HAZARD MAP

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/25/2017

Drawn ENE
Checked

10
FIGURE



Tsunami Inundation:

No Scale

- Tsunami Inundation Area
- Urbanized Area

NORTH

Map Reference: ABAG Geographic Information System.

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TSUNAMI INUNDATION MAP

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 7/5/2017

Drawn ENE
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11
FIGURE

E T S

Environmental Technical Services

-Soil, Water & Air Testing & Monitoring
-Analytical Labs
-Technical Support

975 Transport Way, Suite 2
Petaluma, CA 94954
(707) 778-9605/FAX 778-9612
e-mail: *entech@pacbell.net*

Serving people and the environment so that both benefit.

COMPANY: Miller Pacific Engineering Group, 504 Redwood Blvd., Suite 220, Novato, CA			ANALYST(S)	SUPERVISOR
ATTN: Eric Dabanian		DATE of	S. Santos	D. Jacobson
JOB SITE: Redwood High School Modular Classrooms,	DATE RECEIVED	COMPLETION	G. Hernandez	LAB DIRECTOR
PROJ NO.: 867.185 Larkspur, California	5/18/2017	5/30/2017		G.S. Conrad PhD

LAB SAMPLE NUMBER	SAMPLE ID	DESCRIPTION of SOIL and/or SEDIMENT	SOIL pH -log[H+]	NOMINAL RESISTIVITY ohm-cm	ELECTRICAL CONDUCTIVITY µmhos/cm	SULFATE SO4 ppm	CHLORIDE Cl ppm
07356-1	RHS1-MC/MV	B1+B2 @ 1'-2' (composite)	**10.79**	**1,027**	**[974]**	**825**	**1,500**
Method	Detection	Limits --->	---	1	0.1	1	1

LAB SAMPLE NUMBER	SAMPLE ID	DESCRIPTION of SOIL and/or SEDIMENT	SALINITY ECe mmhos/cm	SOLUBLE SULFIDES (S=) ppm	SOLUBLE CYANIDES (CN=) ppm	REDOX mV	PERCENT MOISTURE %
Method	Detection	Limits --->	---	0.1	0.1	-400 -> +800	0.1

COMMENTS

Resistivity is <1,250 ohm-cm, i.e., very low, and soil reaction (i.e., pH) is stronlgy alkaline (@ ~10.8); sulfate is moderately elevated (@ >500 ppm), as is chloride is (i.e., @ 1,500 ppm) [see table below on right for assigned points and ranges]. The CalTrans (CT) times to perforation of galvanized steel and full depth pitting times (following Uhlig) for this soil material are determined based on pertinent parameters [see table at left below]. **But these values assume that pH that does not exceed 8.5** or so. Sulfate could be a minor issue for concrete, cement, mortar or grout; and chloride could have an adverse impact on rebar or buried steel. Treatment to reduce pH to <8.5 would be beneficial. But there are other problems as well. The CalTrans calculation of time to failure of rebar in standard cement type and depth is at 30.5 yrs for the level of Cl present. To increase metals longevity in this soil would require steel upgrading or other actions. At times, structural strength considerations may require heavier gauge steel than is used in the presented examples such that perf and pitting times can be beyond specified life span. Where this is not the case, cathodic protection along with coating or wrapping steel assets is one potential solution. Other options include increased and/or specialized engineering fill, use of a polymer coating, or use of plastic, fiberglass or concrete assets. Based on these results, standard concrete mixes would not be acceptable in this soil and upgrading to account for both elevated sulfate and chloride would be prudent an advatageous in the absence of removal and repalcement (i.e., ASTM Type II or increased thickness to rebar with low water content, or some combination of these).

SAMPLE ID	CT 18 ga	CT 12 ga	2 mm (Uhlig)	PARAMETER/ID	RHS1-MC/MV		
RHS1-MC/MV	~25 yrs	~55.5 yrs	<20 yrs	pH	3		
treated	-	-	---	Rs	5-10		
				SO4	0-2		
				Cl	3		
				Redox	-		
				TOTAL POINTS	11-18		

\\\\NOTES: Methods are from following sources: extractions by Cal Trans protocols as per Cal Test 417 (SO4), 422 (Cl), and 532/643 (pH & resistivity); &/or by ASTM Vol. 4.08 & ASTM Vol. 11.01 (=EPA Methods of Chemical Analysis, or Standard Methods); pH - ASTM G 51; Spec. Cond. - ASTM D 1125; resistivity - ASTM G 57; redox - Pt probe/ISE; sulfate - extraction Title 22, detection ASTM D 516 (=EPA 375.4); chloride - extraction Title 22, detection ASTM D 512 (=EPA 325.3); sulfides - extraction by Title 22, and detection EPA 376.2 (= SMEWW 4500-S D); cyanides - extraction by Title 22, and detection by ASTM D 4374 (=EPA 335.2).

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 gravelly sands, little or no fines
		SP	Poorly-graded sands or gravelly 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

PI	PLASTICITY INDEX
LL	LIQUID LIMIT
SA	SIEVE ANALYSIS
HYD	HYDROMETER ANALYSIS
P200	PERCENT PASSING NO. 200 SIEVE
P4	PERCENT PASSING NO. 4 SIEVE

SAMPLER TYPE

- MODIFIED CALIFORNIA
- STANDARD PENETRATION TEST
- THIN-WALLED / FIXED PISTON
- HAND SAMPLER
- ROCK CORE
- X DISTURBED OR BULK SAMPLE

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the excavation location during the time of exploration. Subsurface rock, soil or water conditions may vary in different locations within the project site and with the passage of time. Boundaries between differing soil or rock descriptions are approximate and may indicate a gradual transition.

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 DRIVING RESISTANCE

Modified California and Standard Penetration Test samplers are driven 18 inches with a 140-pound hammer falling 30 inches per blow. Blows for the initial 6-inch drive seat the sampler. Blows for the final 12-inch drive are recorded onto the logs. Sampler refusal is defined as 50 blows during a 6-inch drive. Examples of blow records are as follows:

25	sampler driven 12 inches with 25 blows after initial 6-inch drive
85/7"	sampler driven 7 inches with 85 blows after initial 6-inch drive
50/3"	sampler driven 3 inches with 50 blows during initial 6-inch drive or beginning of final 12-inch drive

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SOIL CLASSIFICATION CHART

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/24/2017

Drawn ENE
Checked

A-1
FIGURE

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.

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ROCK CLASSIFICATION CHART

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Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/24/2017

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A-2
FIGURE

BORING 1

EQUIPMENT: Truck Mounted B-53 Mobile Drill Rig with 6.0-inch Hollow Stem Auger
DATE: 5/10/2017
ELEVATION: 8 - feet*
*REFERENCE: Google Earth, 2017

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)	DESCRIPTION	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0	0			4 inches Asphaltic Concrete						
				20 inches Aggregate Base Rock						
1				Clayey GRAVEL with Sand (GC) Gray, black, Medium dense to dense, angular gravels up to 3 inches, with ~25% medium plasticity clay, with ~10% fine to medium grained sand. [Fill]	19	129	8.0			
2	5			Silty CLAY (CH) Dark gray, soft to medium stiff, moist to wet, high plasticity clay, with ~5-10% pebble sized, highly to completely weathered gravels. [Alluvium]	6	81	23.6			
3	10			Sandy CLAY (CL) Orange, tan, mottled yellow, red, stiff to very stiff, moist, medium plasticity clay, with ~25% fine to medium grained sand. [Alluvium]	38	113	17.9	UC 3200		
4, 5	15				23	104	22.6			
6	20			Gravelly CLAY (CL) Orange, tan, mottled black, medium stiff to stiff, moist, medium plasticity clay, with ~40% rounded to angular gravels up to 1 1/2 inches. [Alluvium]	17	108	20.7			

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/24/2017

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Checked

A-4
FIGURE

BORING 1 (CONTINUED)

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)	DESCRIPTION	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
	20			Gravelly CLAY (CL) Orange, tan, mottled black, medium stiff to stiff, moist, medium plasticity clay, with ~40% rounded to angular gravels up to 1 1/2 inches. [Alluvium]	17	108	20.7			
7										
	25									
8										
9	30			No sample recovered.	43/6"					
				Boring terminated at 31 feet. Groundwater encountered at 9 feet.						
10										
	35									
11										
12	40									

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 5/24/2017

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A-5
FIGURE

BORING 2

EQUIPMENT: Truck Mounted B-53 Mobile Drill Rig with 6.0-inch Hollow Stem Auger
DATE: 5/10/2017
ELEVATION: 9 - feet*
*REFERENCE: Google Earth, 2017

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)	DESCRIPTION	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0	0			4 inches Asphaltic Concrete						
				18 inches Aggregate Base Rock						
1				Clayey GRAVEL with Sand (GC) Gray, black, Medium dense to dense, angular gravels up to 3 inches, with ~20% medium plasticity clay, with ~10% fine to medium grained sand. [Fill]	40	132	6.0			
2	5			Gravelly CLAY (CL) Orange, tan, mottled black, medium stiff to stiff, moist, medium plasticity clay, with ~40% rounded to angular gravels up to 1 1/2 inches. [Alluvium]	9	92	13.7			
3	10			Sandy CLAY (CL) Medium brown, orange, mottled tan, black, stiff to very stiff, moist, medium plasticity clay, with ~5-10% fine to medium grained sand. [Alluvium]	26					
4		▽								
5	15				36	110	20.4	UC 3700		
				Grades to contain ~25% sand.						
6	20			Gravelly CLAY (CL) Orange, tan, mottled black, medium stiff, moist, medium plasticity clay, with ~40% rounded to angular gravels up to 1 1/2 inches. [Alluvium]						
				Boring terminated at 21 feet 6 inches. Groundwater encountered at 13 feet.	20	107	20.5			

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
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BORING LOG

Redwood High School
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Larkspur, California

Project No. 867.185 Date: 5/24/2017

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A-6
FIGURE

BORING 3

EQUIPMENT: Portable Hydraulic Drill Rig with 4.0-inch Solid Flight Auger
DATE: 5/26/2017
ELEVATION: 8 - feet*
*REFERENCE: Google Earth, 2017

DEPTH meters	DEPTH feet	SAMPLE	DESCRIPTION	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0	0		Silty SAND with Gravel (SC) Light brown, moist, medium dense to dense, low plasticity silty sand, with ~10-15% sub rounded to sub angular gravels up to 1 inch. [Top Soil]	50	131	11.3	UC 4250		
			Mixed Rock and Concrete (GW) [Fill]						
			Clayey SAND with Gravel (SC) [Residual Soil]						
1			SANDSTONE Yellow, brown, low hardness, weak, highly weathered, fine to coarse grained Sandstone. [Bedrock]	50/6"	110	10.6			
	5			36					
2									
			Grades moderately hard, strong.	50/4"					
3	10			50/1"					
			Boring terminated at 10 feet 1 inches. No groundwater encountered during drilling.						
4									
	15								
5									
6	20								

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 6/5/2017

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A-7
FIGURE

BORING 4

EQUIPMENT: Portable Hydraulic Drill Rig with 4.0-inch Solid Flight Auger
DATE: 5/26/2017
ELEVATION: 8 - feet*
*REFERENCE: Google Earth, 2017

DEPTH meters / feet	SAMPLE	SYMBOL (4)	Description	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0 – 0			**Gravelly CLAY (CL)** Dark brown, moist, medium dense, medium plasticity clay, with ~50% angular gravels up to 1 inch. [Fill]	53	131	12.0	UC 1700		
			Clayey SAND with Gravel (SC) Yellow, brown, moist, dense, fine to medium grained sand, with ~25% clay, with ~20% weathered sandstone gravels. [Residual Soil]						
1 / 5			**SANDSTONE** Yellow, brown, low to moderately hard, strong, moderately to highly weathered, fine to coarse grained Sandstone. [Bedrock]	50/4"	120	11.9			
2				50/6"					
3 / 10				50/5"					
			Boring terminated at 10 feet 5 inches. No groundwater encountered during drilling.						
4									
15									
5									
6 / 20									

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
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BORING LOG

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 6/5/2017

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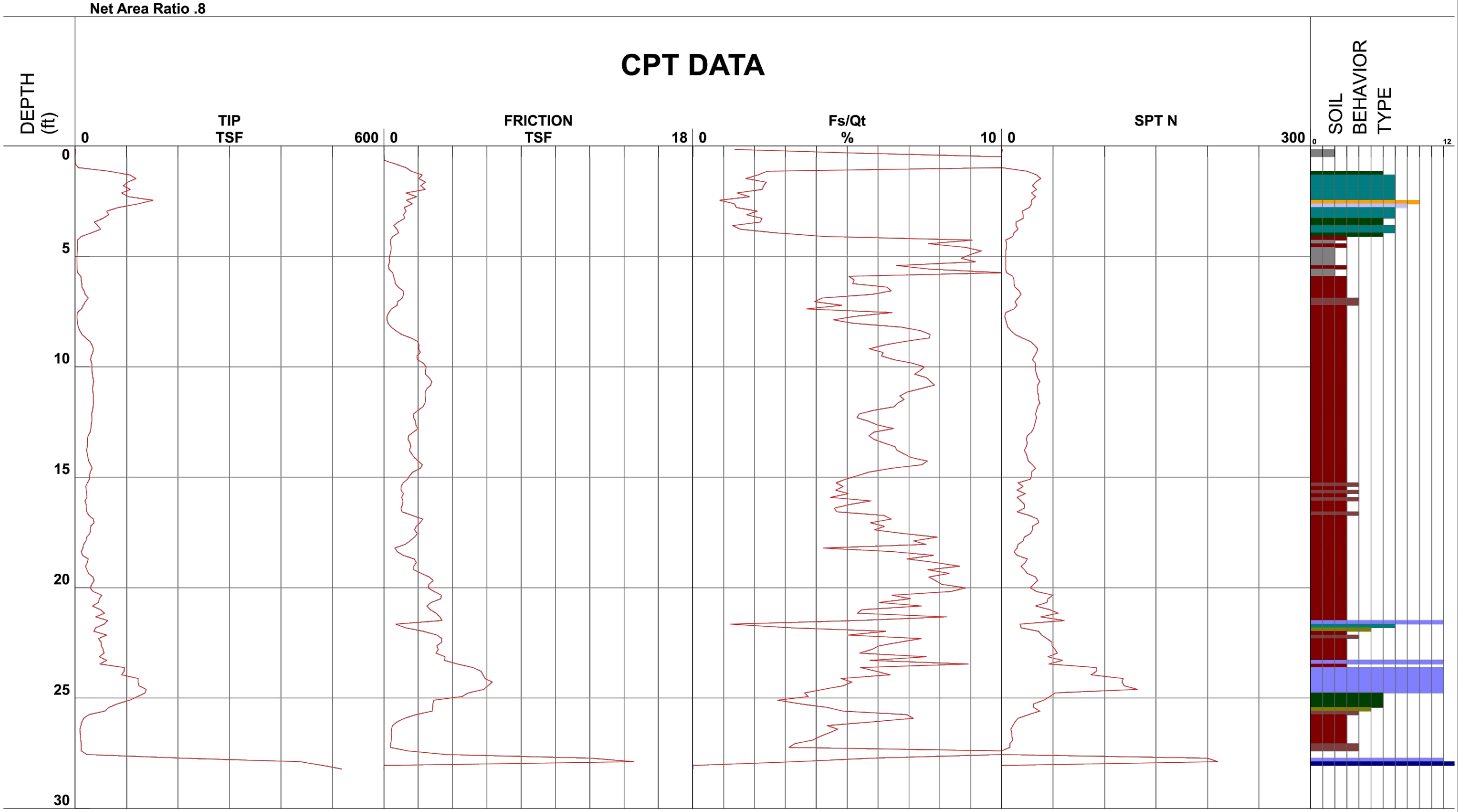
A-8
FIGURE

Miller Pacific Engineers

Project	Redwood High School Modular Classroom	Operator	RB KK	Filename	SDF(034).cpt
Job Number	867-185	Cone Number	DDG1379	GPS	
Hole Number	CPT-01	Date and Time	4/26/2017 12:12:58 PM	Maximum Depth	28.21 ft
EST GW Depth During Test			5.00 ft		

Net Area Ratio .8

CPT DATA



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

Cone Size 10cm squared

S*Soil behavior type and SPT based on data from UBC-1983

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CONE PENETRATION TEST LOG

Redwood High School
Modular Classrooms
Larkspur, California

Project No. 867.185 Date: 6/1/2017

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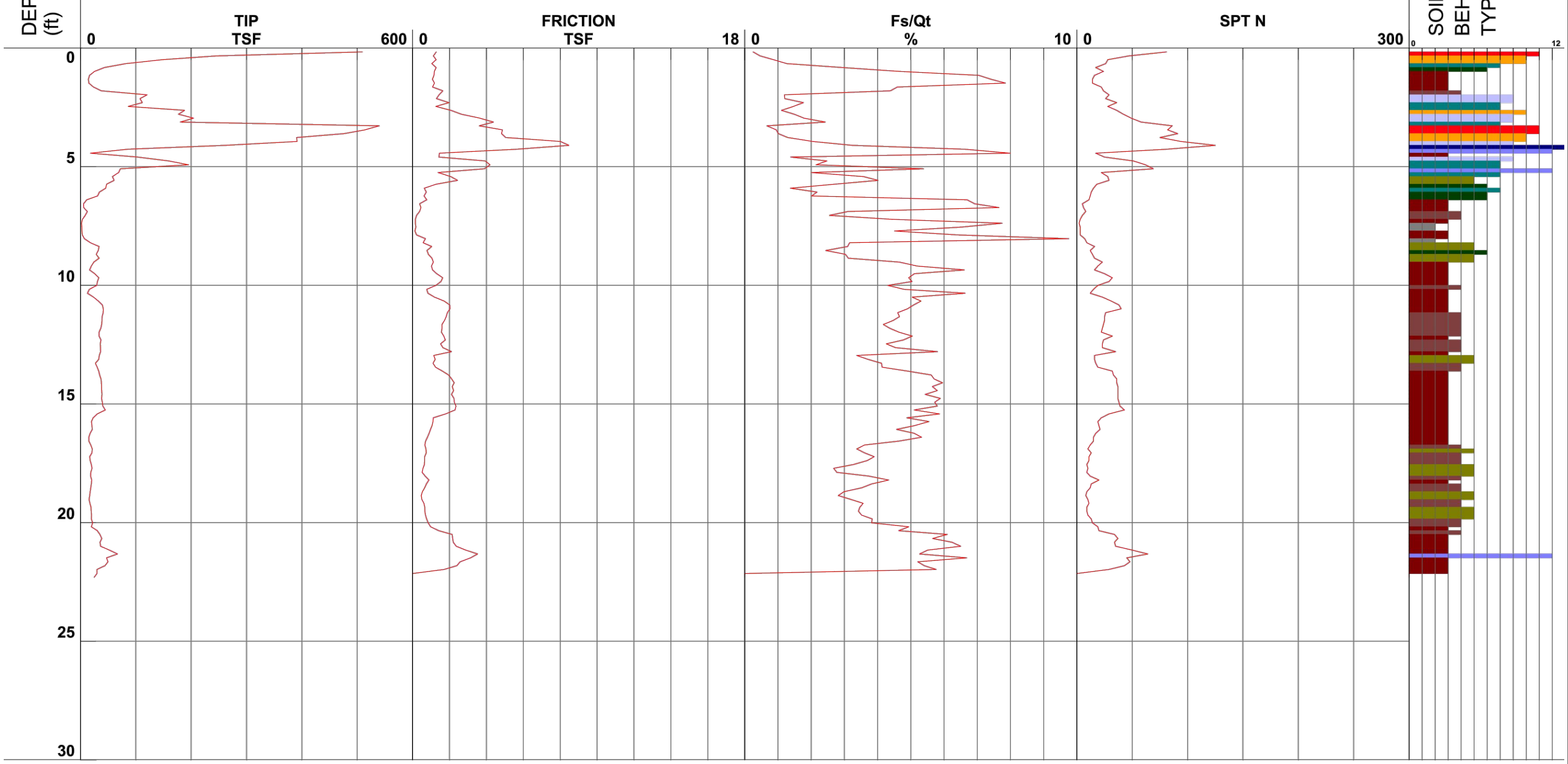
A-9
FIGURE

Miller Pacific Engineers

Project	Redwood High School Modular Classroon	Operator	RB KK	Filename	SDF(033).cpt
Job Number	867-185	Cone Number	DDG1333	GPS	
Hole Number	CPT-02	Date and Time	4/26/2017 11:15:09 AM	Maximum Depth	22.31 ft
EST GW Depth During Test			5.00 ft		

Net Area Ratio .8

CPT DATA



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

Cone Size 10cm squared

S*Soil behavior type and SPT based on data from UBC-1983

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CONE PENETRATION TEST LOG

Redwood High School
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Project No. 867.185 Date: 6/1/2017

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A-10
FIGURE