



August 4, 2017  
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Alameda Unified School District  
2060 Challenger Drive  
Alameda, California 94501

Attention: Chad Pimentel, Legal Counsel for AUSD

Re: Geotechnical Engineering Investigation  
Evaluation of Liquefaction Risk and Liquefaction Induced Settlement Potential  
Paden Elementary School Campus  
444 Central Avenue  
Alameda, California

### Introduction

This letter summarizes our geotechnical investigation of the Paden Elementary School campus located at 444 Central Avenue in Alameda, California. The approximate site location is presented on Figure 1, Site Location Map. The purpose of our geotechnical investigation is to evaluate the site soil and groundwater conditions and to assess the liquefaction risk and liquefaction induced settlement potential across the school campus. Our scope includes exploring the subsurface conditions with four Cone Penetration Tests (CPTs), conducting engineering analyses to evaluate the liquefaction risk and liquefaction induced settlement potential, and presentation of our geotechnical conclusions in this letter report.

### Site Description

The Paden Elementary School campus is located on the southerly side of Central Avenue, east of Ballena Boulevard, as shown on the Site Location Map, Figure 1. The existing campus consists of numerous permanent and portable buildings, paved driveways, parking areas, and play areas, and landscaping improvements, as shown on the Site Plan, Figure 2. The ground surface at the project site and the surrounding area is characterized by nearly level to slightly sloping terrain.

### Regional Geology

The site is located within the Coast Range 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 melange, with lesser amounts of conglomerate, calc-silicate rock, schist and other metamorphic rocks.

The regional topography is characterized by northwest-southeast trending mountain ridges and intervening valleys that were formed by movement between the North American and the Pacific Plates. Continued deformation and erosion during the late Tertiary and Quaternary Age (the last several million years) formed the prominent 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.

Geologic mapping<sup>1</sup> indicates the site is located in an area underlain by artificial fill sands, as shown on Figure 3. These artificial (manmade) fills were placed over older dune sands and soft clay (Bay Mud).

### Surface Conditions

The site is currently developed as an elementary school campus. The attached Site Plan, Figure 2, shows the locations of existing buildings, driveways, and play areas. Most of the ground surface immediately around the existing buildings consists of asphalt paved surfaces.

### Seismicity

The San Francisco Bay Region is located in a seismically active area and the proposed improvements will therefore experience the effects of future earthquakes. Such earthquakes could occur on any of several active faults within the region. These faults are shown on the Active Fault Map, Figure 4.

### Subsurface Exploration and Laboratory Testing

Miller Pacific Engineering Group explored the subsurface soil and groundwater conditions with four Cone Penetration Tests (CPTs) at the approximate locations shown on the Site Plan, Figure 2. The CPTs were conducted with truck-mounted equipment on April 12, 2017. The CPTs were extended to depths of about 32 feet to 60 feet below the ground surface. A schematic of the CPT apparatus is provided on Figure A-1 and a CPT Soil Interpretation Chart is provided on Figure A-2. CPT logs are shown on Figures A-3 through A-6.

### Subsurface Conditions

The subsurface conditions are consistent with the mapped geology. Review of subsurface data collected from the CPTs conducted at the site indicate that the campus is generally underlain by approximately seven to ten feet of loose to medium-dense sandy fill. Beneath the fill, each CPT encountered predominantly medium-dense to dense silty sand and sandy silt extending to a depth of 50 feet or more.

Groundwater was measured at approximately eleven to twelve feet below the ground surface during our CPT investigations. It is anticipated that the groundwater level beneath the site is influenced by tidal activity in the nearby San Francisco Bay.

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<sup>1</sup> Graymer, R. W., "Geologic Map and Map Database of the Oakland Metropolitan Area, Alameda, Contra Costa, and San Francisco Counties, California", 2000, USGS, MF-2342 Version 1.0., Scale 1:50,000.

Given the low site elevations and proximity to San Francisco Bay, the highest historic groundwater elevation is assumed to coincide with the ground surface.

#### Liquefaction Risk and Liquefaction Induced Settlement Potential

The project site lies within a California Seismic Hazard Zone of Required Investigation for Liquefaction, as mapped by CGS (2003).

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 fines content (35 to 50% clayey and silty materials that pass the #200 sieve) provided the fines exhibit a plasticity less than 7. Granular layers with a potential for liquefaction were observed during our subsurface exploration.

To evaluate soil liquefaction, the seismic energy from an earthquake is compared with the ability of the soil to resist pore pressure generation. The earthquake energy is termed the cyclic stress ratio (CSR) and is a function of the maximum credible earthquake peak ground acceleration (PGA) and depth. The soil resistance to liquefaction is based on the relative density, and the amount and plasticity of the fines (silts and clays). The relative density of cohesionless soil is correlated with Cone Penetration Test data measured in the field.

We analyzed the potential for liquefaction utilizing the CPT Liquefaction Assessment software program CLiq (2007, ver. 2.1.6.9), and the procedures outlined by Idriss and Boulanger (2014). The design seismic conditions consisted of a magnitude 7.3 earthquake producing a PGA of 0.54g, which corresponds to the  $PGA_M$  per ASCE 7-10 Section 11.8.3, and assuming groundwater at the ground surface. The results of our liquefaction analyses are presented on Figures 5 through 8, and indicate granular soil layers observed between roughly one and nine feet, and discontinuous lenses between roughly 28 and 52 feet below the ground surface classify as liquefiable during the design seismic event. Therefore, we judge the risk of liquefaction at the site is high.

Potential liquefaction of sandy layers between one and nine feet below the ground surface may result in ground surface settlement of between roughly 0.5-inch to 1.5-inches, based on the liquefaction analyses discussed above, and as shown on Figures 5 through 8. Potential liquefaction induced differential ground surface settlement within a given building footprint area is estimated to be approximately one half of the total settlement (approximately 0.5 to 1.0-inches).

Alameda Unified School District  
Page 4 of 4

August 4, 2017

Based on procedures outlined by Idriss and Boulanger, 2014, the discontinuous and relatively thin layers of potentially liquefiable soil observed 28-feet to 52-feet below the ground surface in the CPT's may experience 0.5-inch to 1.0-inch of post-liquefaction settlement. However, because there is a significant non-liquefiable soil "cap" overlying these deeper potentially liquefiable soil layers, we utilized the procedures outlined by Youd and Garriss (1995) to determine if post-liquefaction settlement will be manifested in the form of ground surface settlement. As shown on Figure 9, based on the relative thicknesses of the non-liquefiable "cap" and the liquefiable layers, post-liquefaction settlements are not expected to result in ground surface settlement from the potentially liquefiable layers located below a depth of 28-feet.

If you have any questions, or if we can be of further assistance, please call us at your convenience.

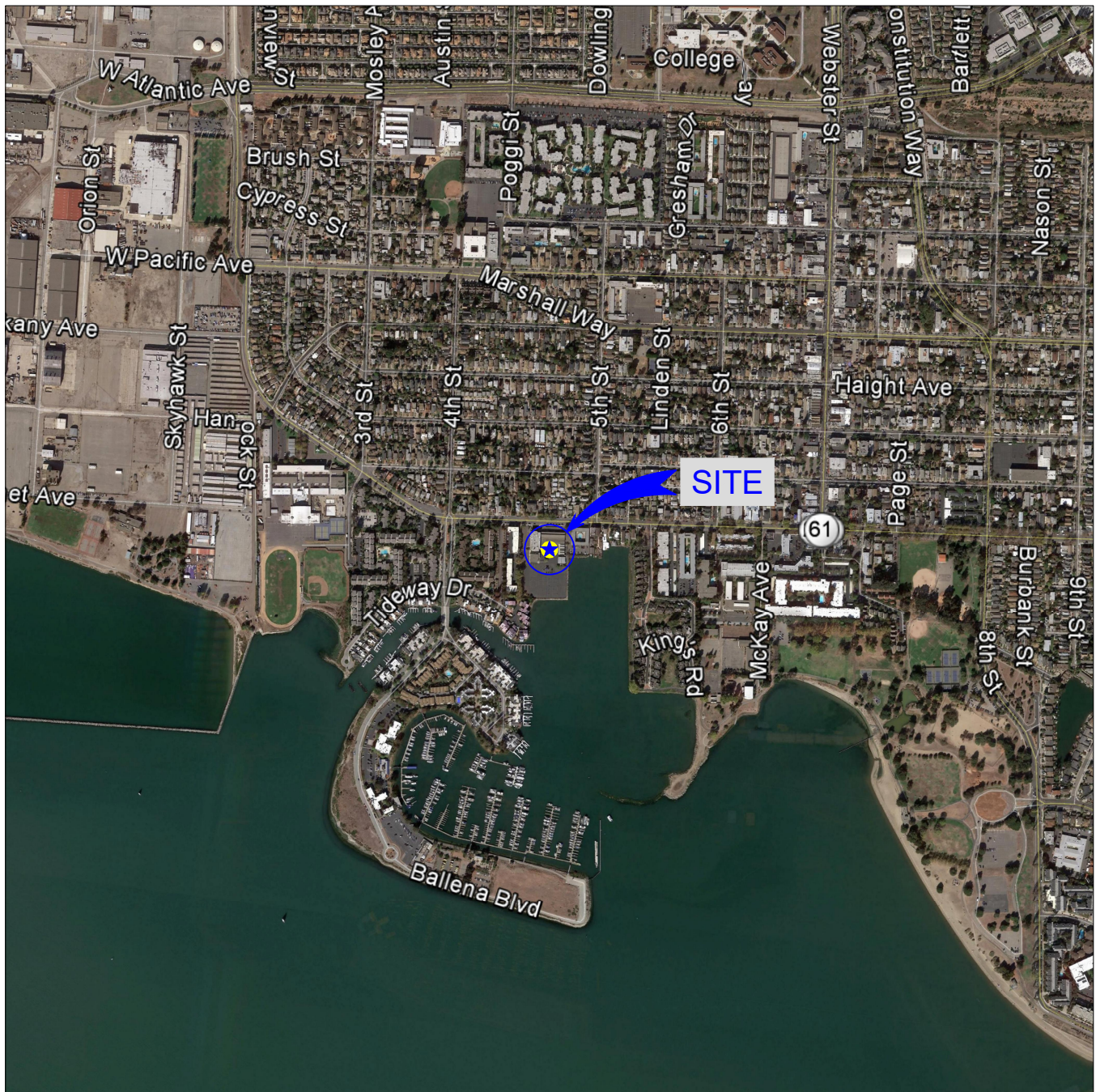
Yours very truly,  
MILLER PACIFIC ENGINEERING GROUP



Daniel S. Caldwell  
Geotechnical Engineer #2006  
(Expires 9/30/17)

Attachments: Figures 1 through 9, A-1 through A-6





SITE: LATITUDE, 37.7710°  
LONGITUDE, -122.2836°

SITE LOCATION  
N.T.S.



REFERENCE: Google Earth, 2017



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## SITE LOCATION MAP

Paden Elementary School  
444 Central Avenue  
Alameda, California

Project No. 1911.034

Date: 4/3/2017

Drawn \_\_\_\_\_  
Checked \_\_\_\_\_  
MMT

**1**  
FIGURE







## REGIONAL GEOLOGIC MAP

(NOT TO SCALE)



### LEGEND

- af** ARTIFICIAL FILL (HOLOCENE)  
Man made deposit of various materials and ages. Some are compacted and quite firm, but fills made before 1865 are nearly everywhere not compacted and consist simply of dumped materials.
- Qds** DUNE SAND (HOLOCENE AND PLEISTOCENE)  
Fine-grained, very well sorted, well-drained, eolian deposits. They occur mainly in large sheets, as well as many small hills, most displaying Barchan morphology. Dunes display as much as 30 m of erosional relief and are presently being buried by basin deposits (Qhb) and bay mud (Qhbm). They probably began accumulating after the last interglacial high stand of sea level began to recede about 71 ka, continued to form when sea level dropped to its Wisconsin minimum about 18 ka, and probably ceased to accumulate after sea level reached its present elevation (about 6 ka). Atwater (1982) recognized buried paleosols in the dunes, indicating periods of nondeposition

REFERENCE: Graymer, R.W. (2000), "Geologic Map of the Oakland Metropolitan Area, Alameda, Contra Costa, and San Francisco Counties, California", United States Geological Survey Miscellaneous Field Studies Map MF-2342, Version 1.0, Map Scale 1:50,000.



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### REGIONAL GEOLOGIC MAP

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444 Central Avenue  
Alameda, California

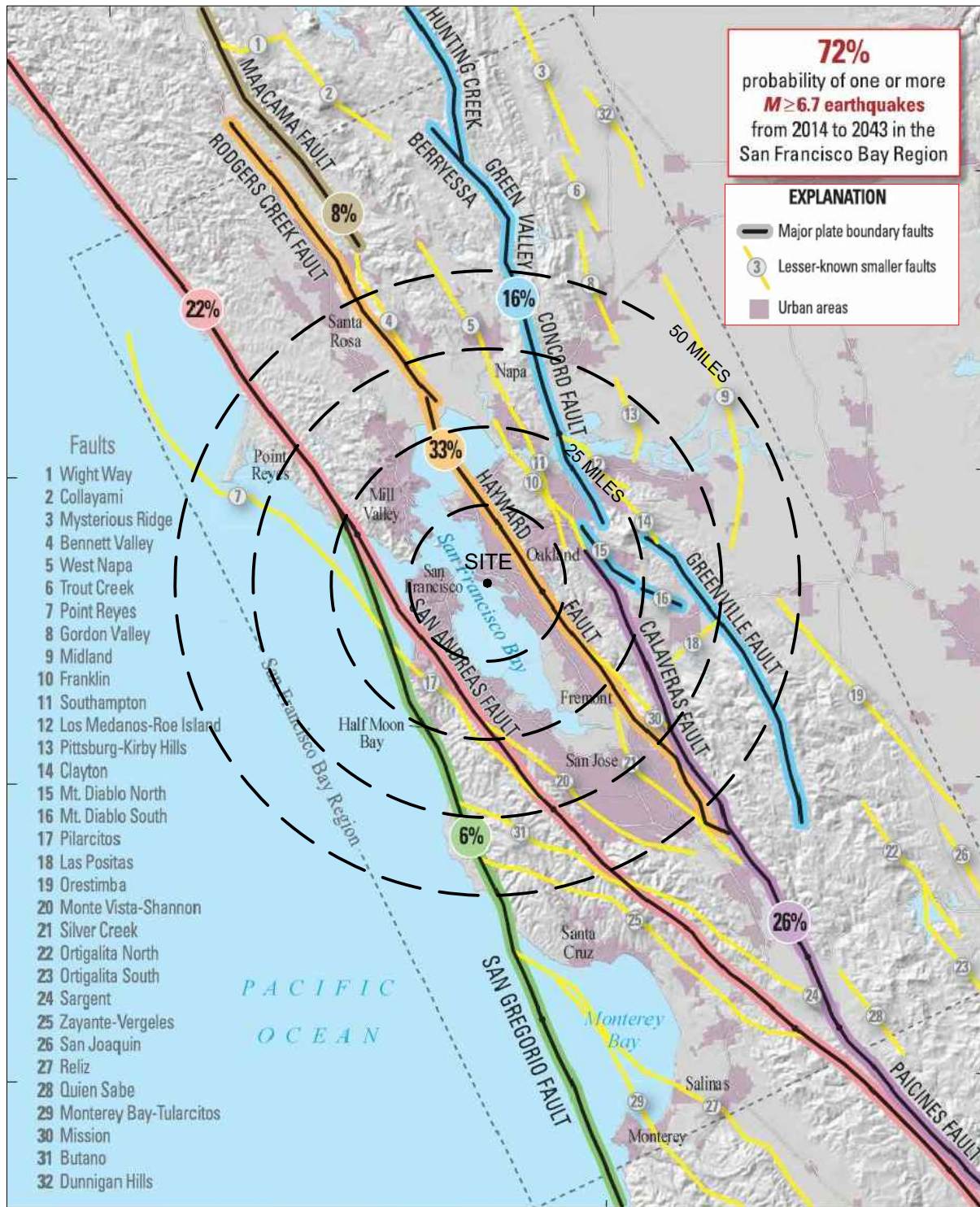
Project No. 1911.034

Date: 4/25/2017

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Checked MMT

3

FIGURE



**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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444 Central Avenue  
Alameda, California

Project No. 1911.034

Date: 4/25/2017

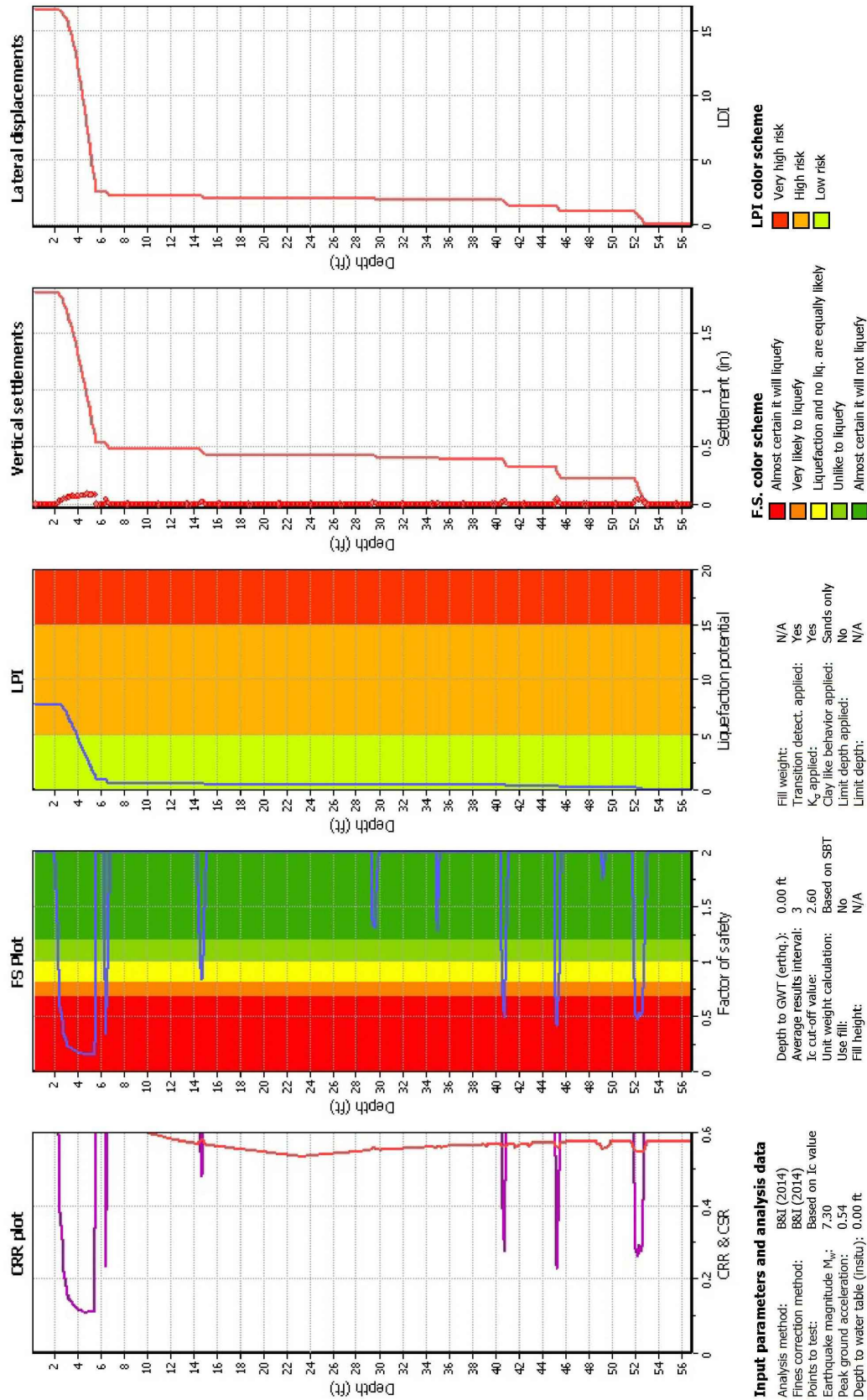
Drawn MMT  
Checked

**4**

FIGURE



# Liquefaction analysis overall plot





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## CPT-2 LIQUEFACTION ANALYSIS

Paden Elementary School  
444 Central Avenue  
Alameda, California

Project No. 1911.034

Date: 4/25/2017

Drawn  
Checked

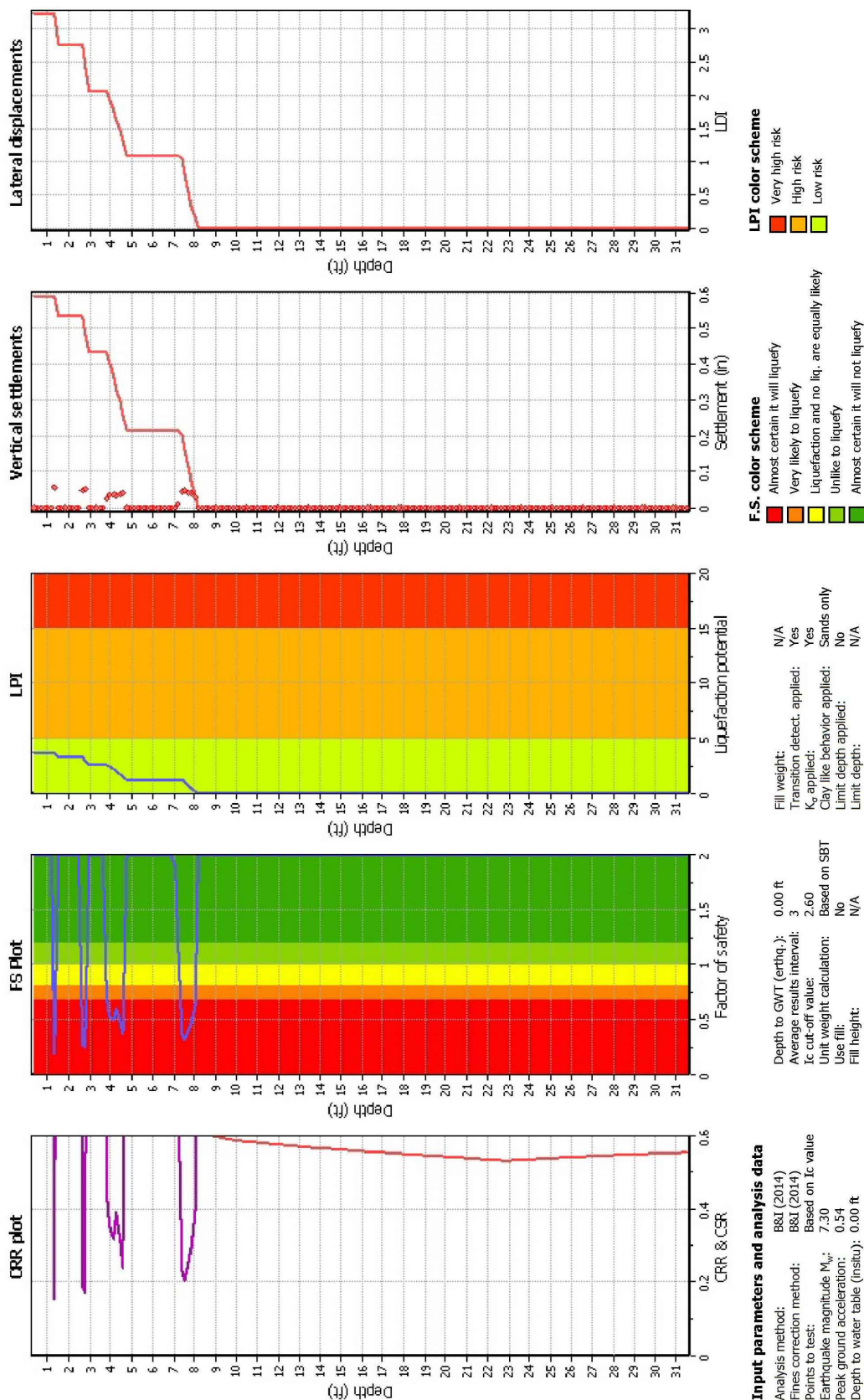
MMT

6  
FIGURE

This software is licensed to: Miller Pacific Engineering Group

CPT name: CPT-02

### Liquefaction analysis overall plot

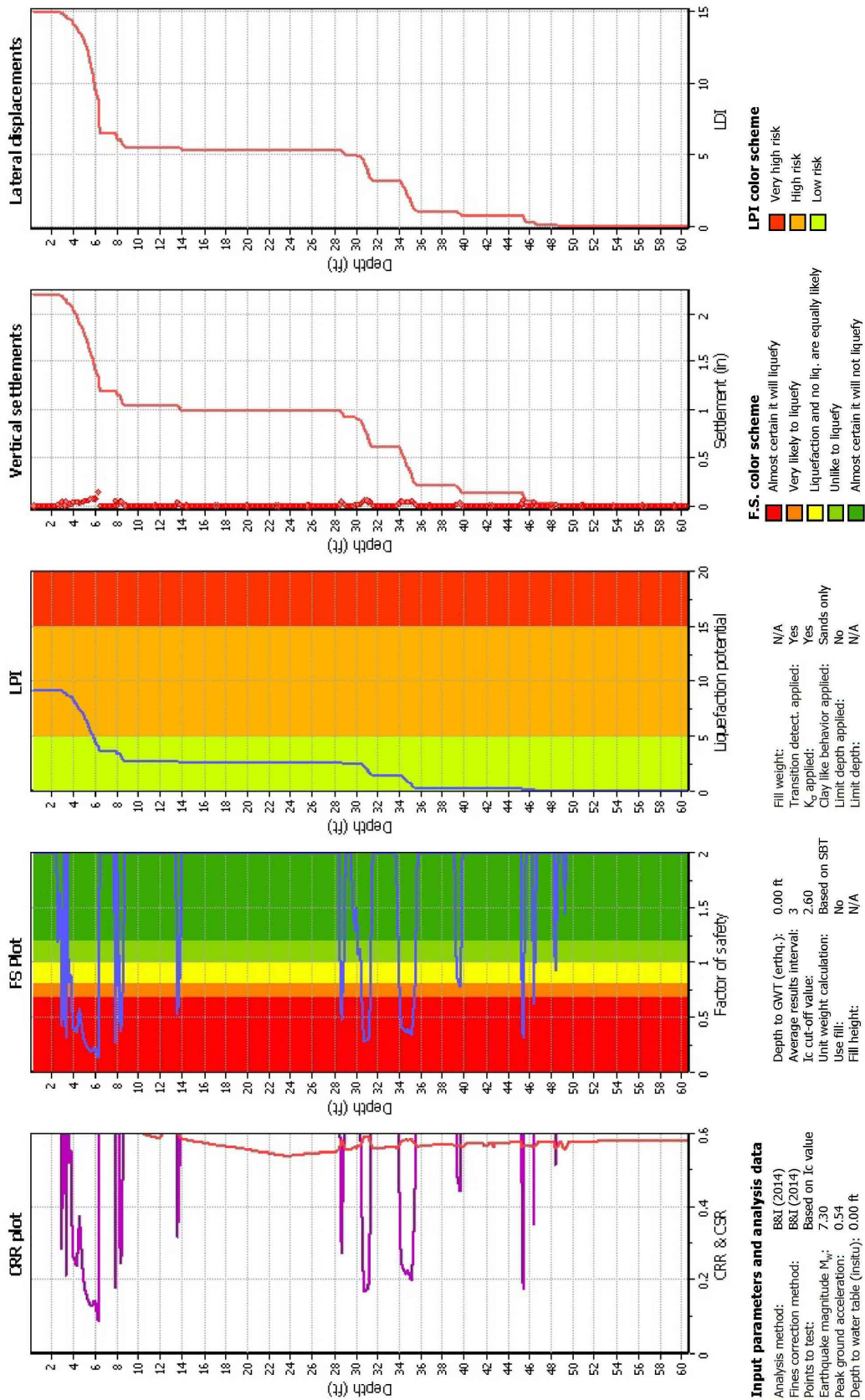


CLiq v.2.1.6.9 - CPT Liquefaction Assessment Software - Report created on: 4/19/2017, 11:26:59 AM

Project file: H:\Jobs\1900-1999\1911.034 Paden ES Classrooms\Analyses\1911.034 CPTLiq.cq



## Liquefaction analysis overall plot



CLiQ v.2.1.6.9 - CPT Liquefaction Assessment Software - Report created on: 4/19/2017, 11:26:59 AM

Project file: H:\jobs\1900-1999\1911.034 Paden ES Classrooms\Analyses\1911.034 CPTLiq.ciq



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## CPT-3 LIQUEFACTION ANALYSIS

Paden Elementary School  
 444 Central Avenue  
 Alameda, California

Project No. 1911.034

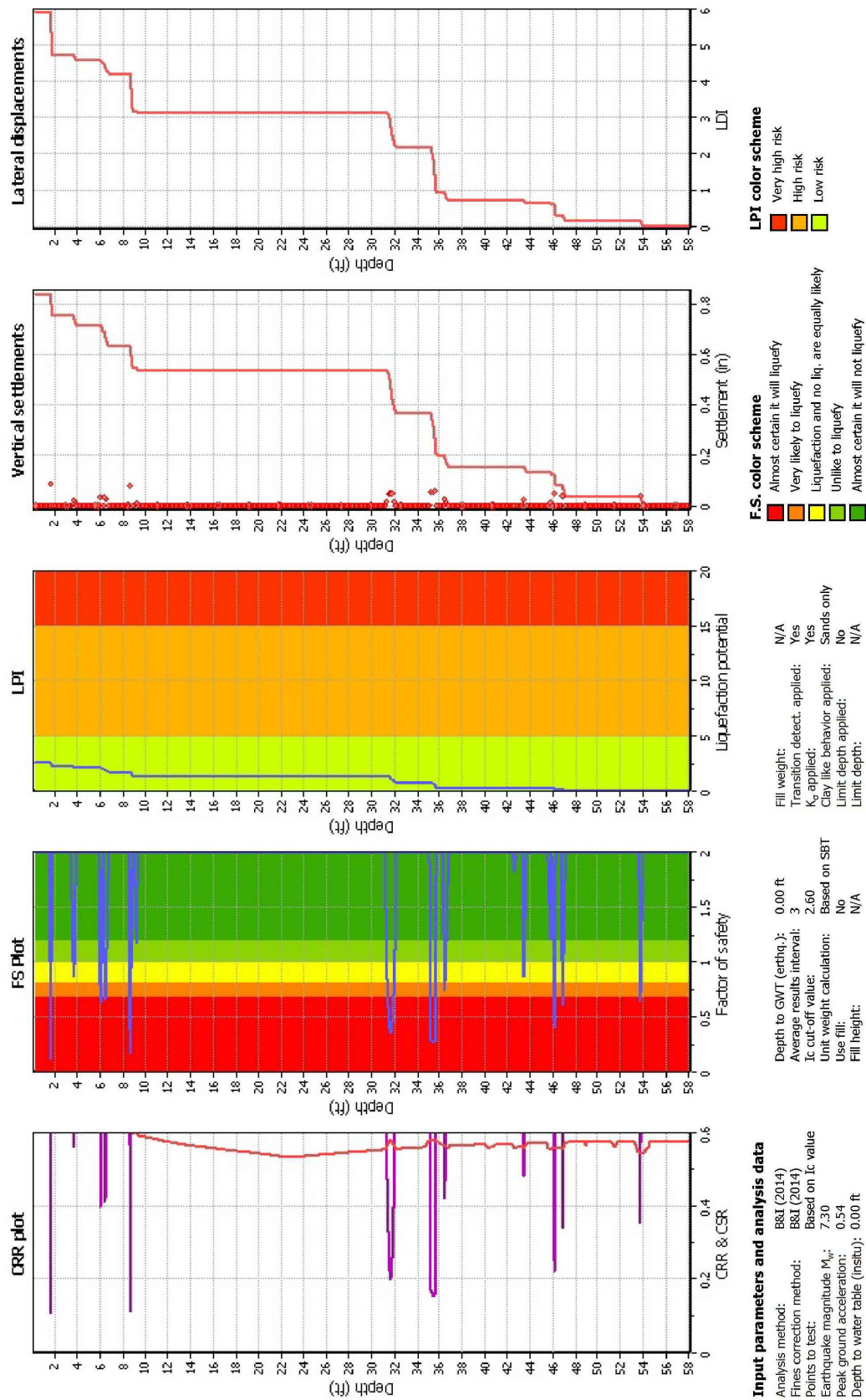
Date: 4/25/2017

Drawn: MMT  
 Checked:

**7**  
FIGURE



# Liquefaction analysis overall plot



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## CPT-4 LIQUEFACTION ANALYSIS

Paden Elementary School  
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Alameda, California

Project No. 1911.034

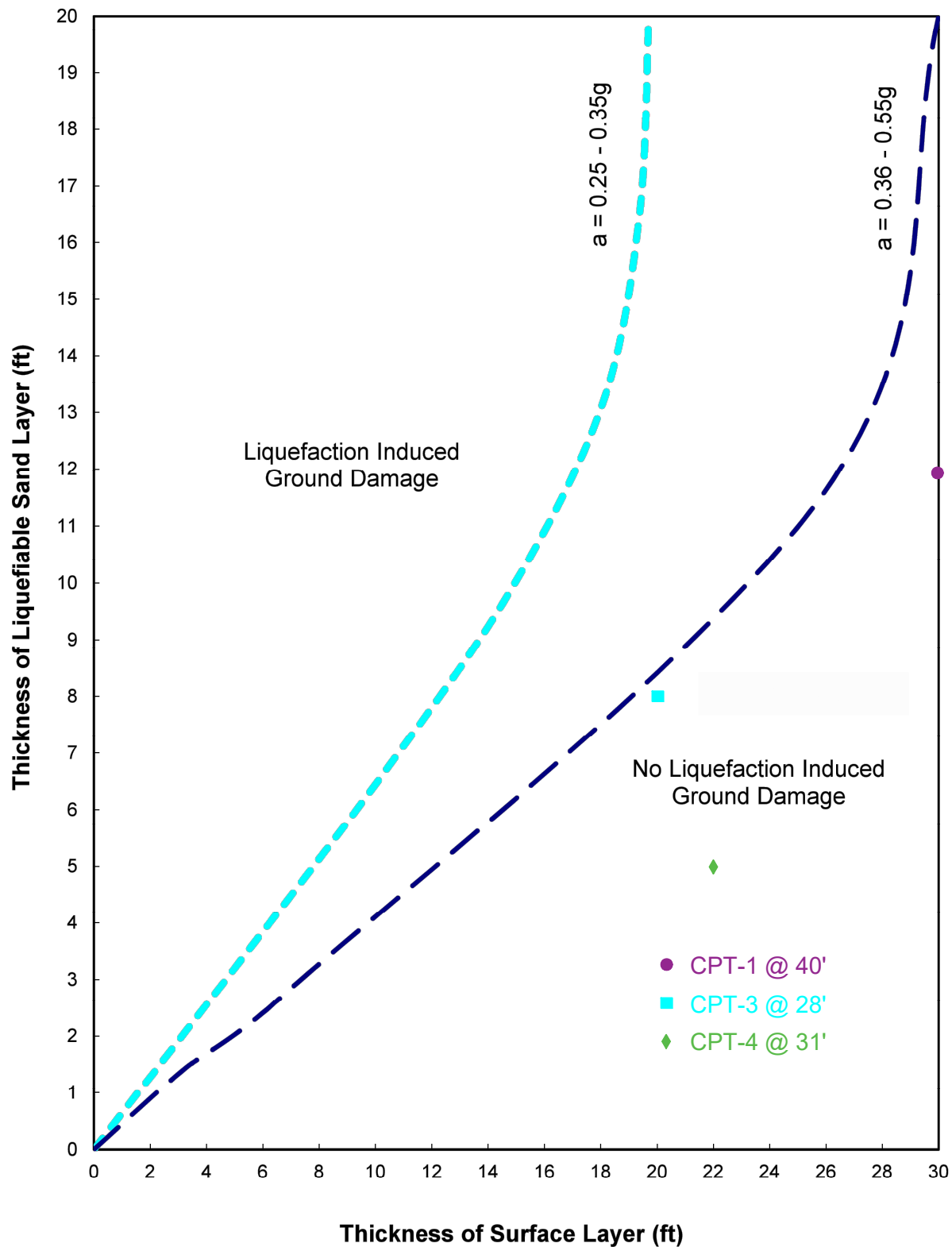
Date: 4/25/2017

Drawn: MMT  
Checked:

8

FIGURE

**Liquefaction-Induced Ground-Surface Distribution**  
(Youd and Garris, 1995)



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**LIQUEFACTION ANALYSIS - SURFACE EFFECTS**

Paden Elementary School  
444 Central Avenue  
Alameda, California

Project No. 1911.034

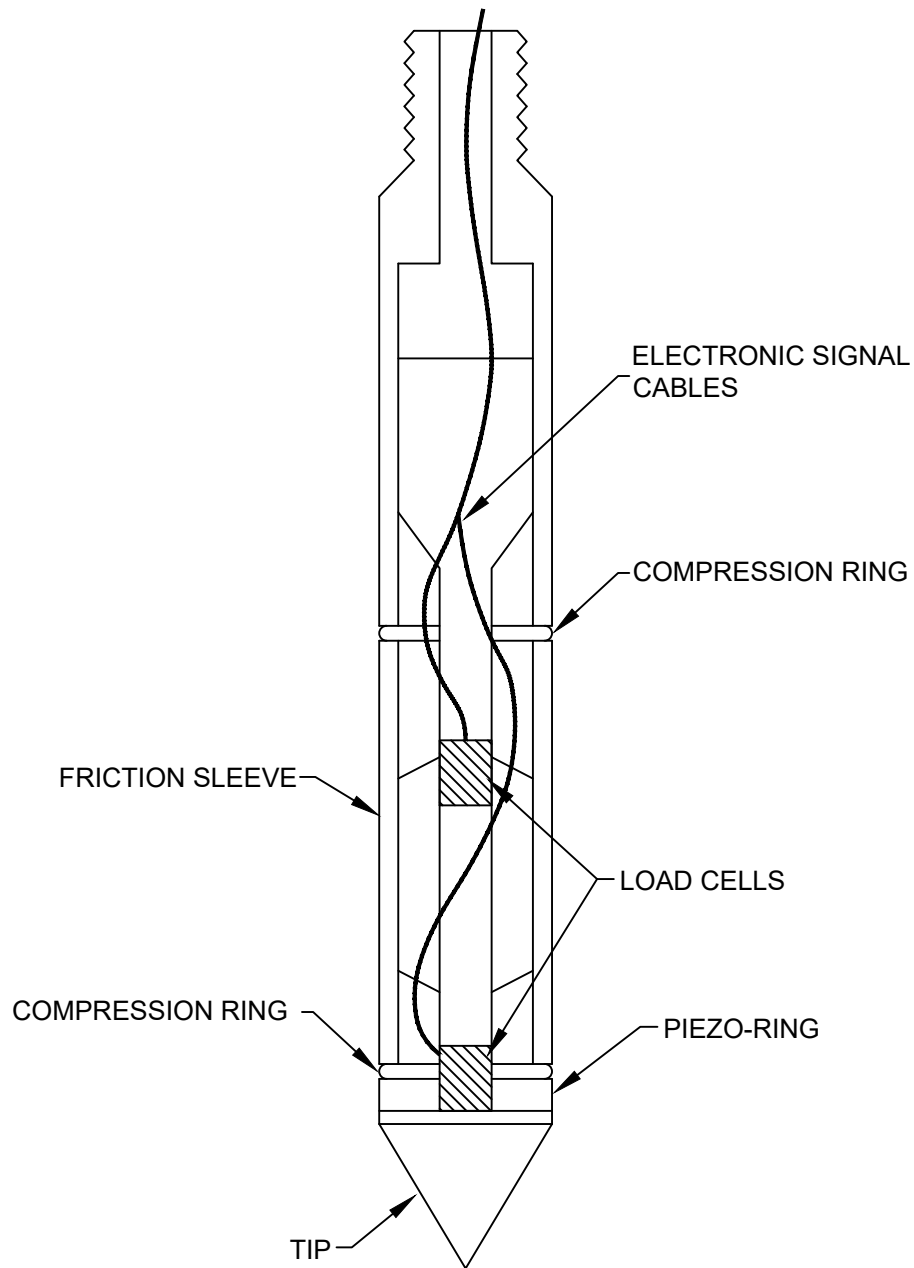
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**9**

FIGURE

## APPENDIX A



## CONE PENETROMETER

(NO SCALE)



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### CONE PENETROMETER

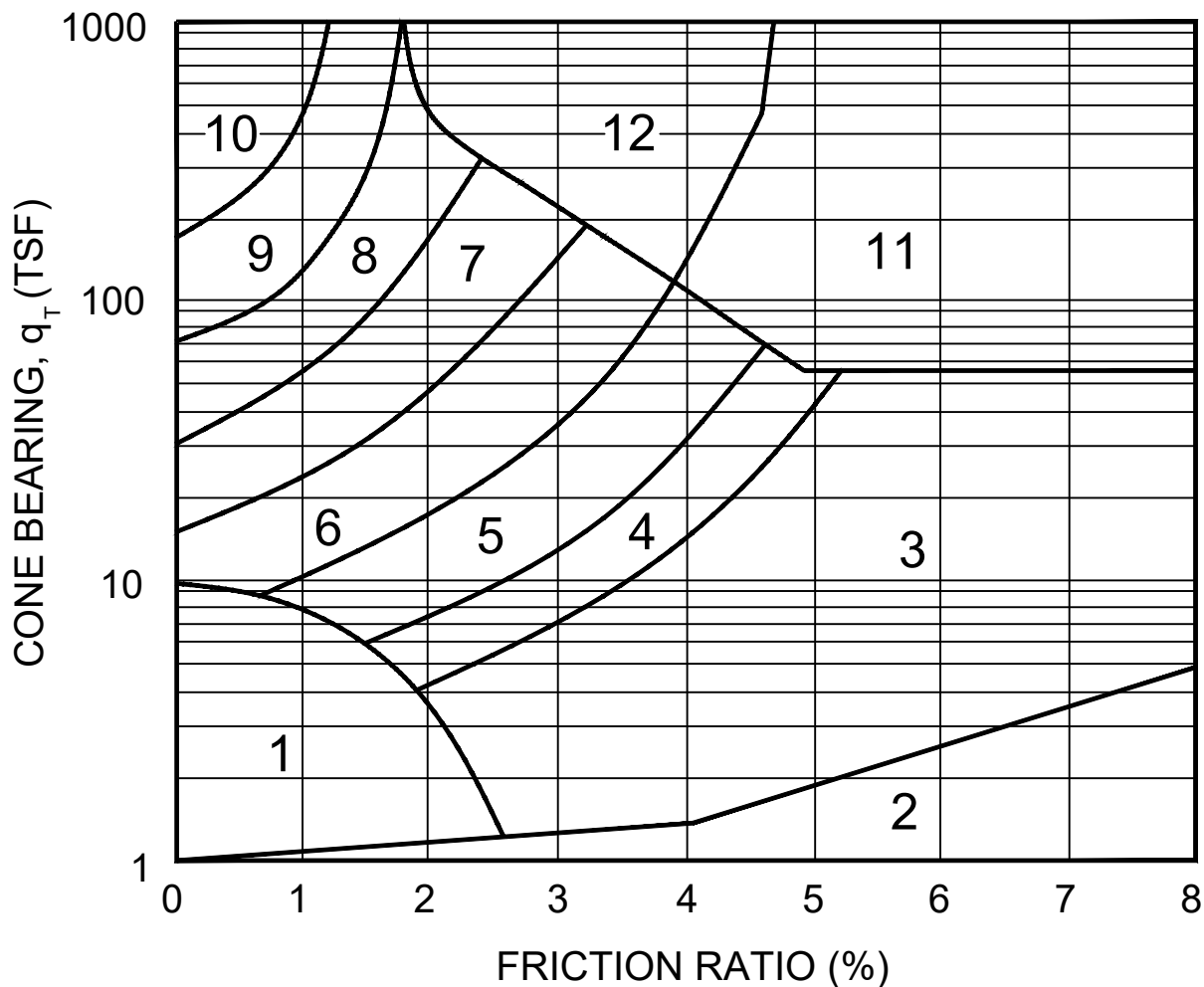
Paden Elementary School  
444 Central Avenue  
Alameda, California

Project No. 1911.034

Date: 4/7/17

Drawn \_\_\_\_\_  
Checked MMT

**A-1**  
FIGURE



Zone:	Qc/N	Soil Behavior Type:
1)	2	Sensitive Fine Grained
2)	1	Organic Material
3)	1	Clay
4)	1.5	Silty Clay to Clay
5)	2	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	Very Stiff Fine Grained (*)
12)	2	Sand to Clayey Sand (*)

(\*) Overconsolidated or Cemented

Reference: Robertson, P.K. (1986), "In-Situ Testing and Its Application to Geotechnical Engineering," Canadian Geotechnical Journal, Vol. 23; No. 23; No. 4, pp. 573-594



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#### CPT SOIL INTERPRETATION CHART

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Project No. 1911.034

Date: 4/7/17

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 Checked

**A-2**  
 FIGURE

# Miller Pacific Engineering



Project  
Job Number  
Hole Number  
EST GW Depth During Test

Paden Elementary School  
1911.034  
CPT-01

Operator  
Cone Number  
Date and Time

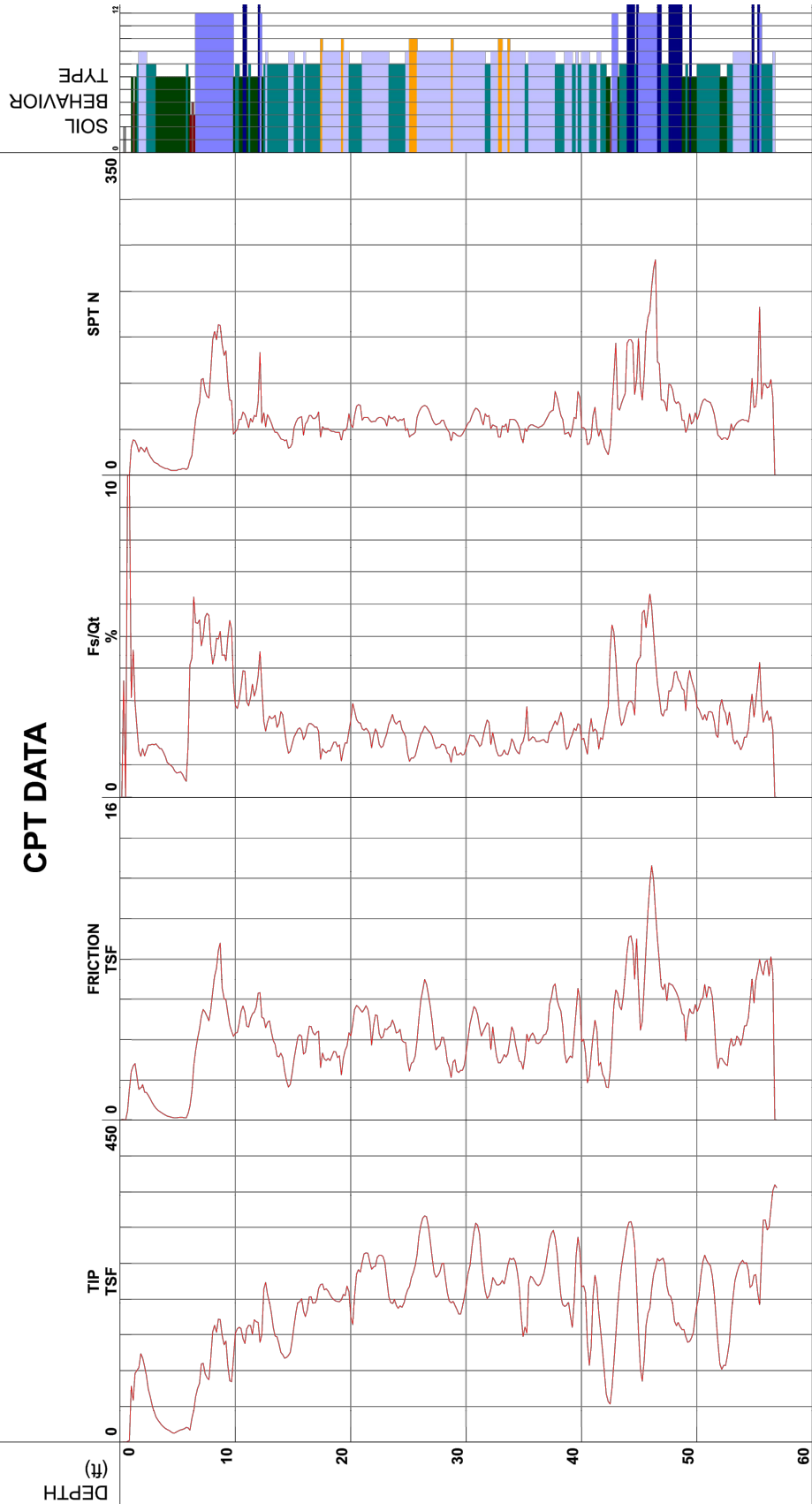
RB KK  
DDG1379  
4/12/2017 2:48:11 PM

Filename  
GPS  
Maximum Depth

SDF(037).cpt  
56.92 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 (\*)

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

Cone Size 10cm squared



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## CPT-1 PLOT

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Alameda, California  
Project No. 1911.034 Date: 4/7/17

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**A-3**  
FIGURE



# Miller Pacific Engineering

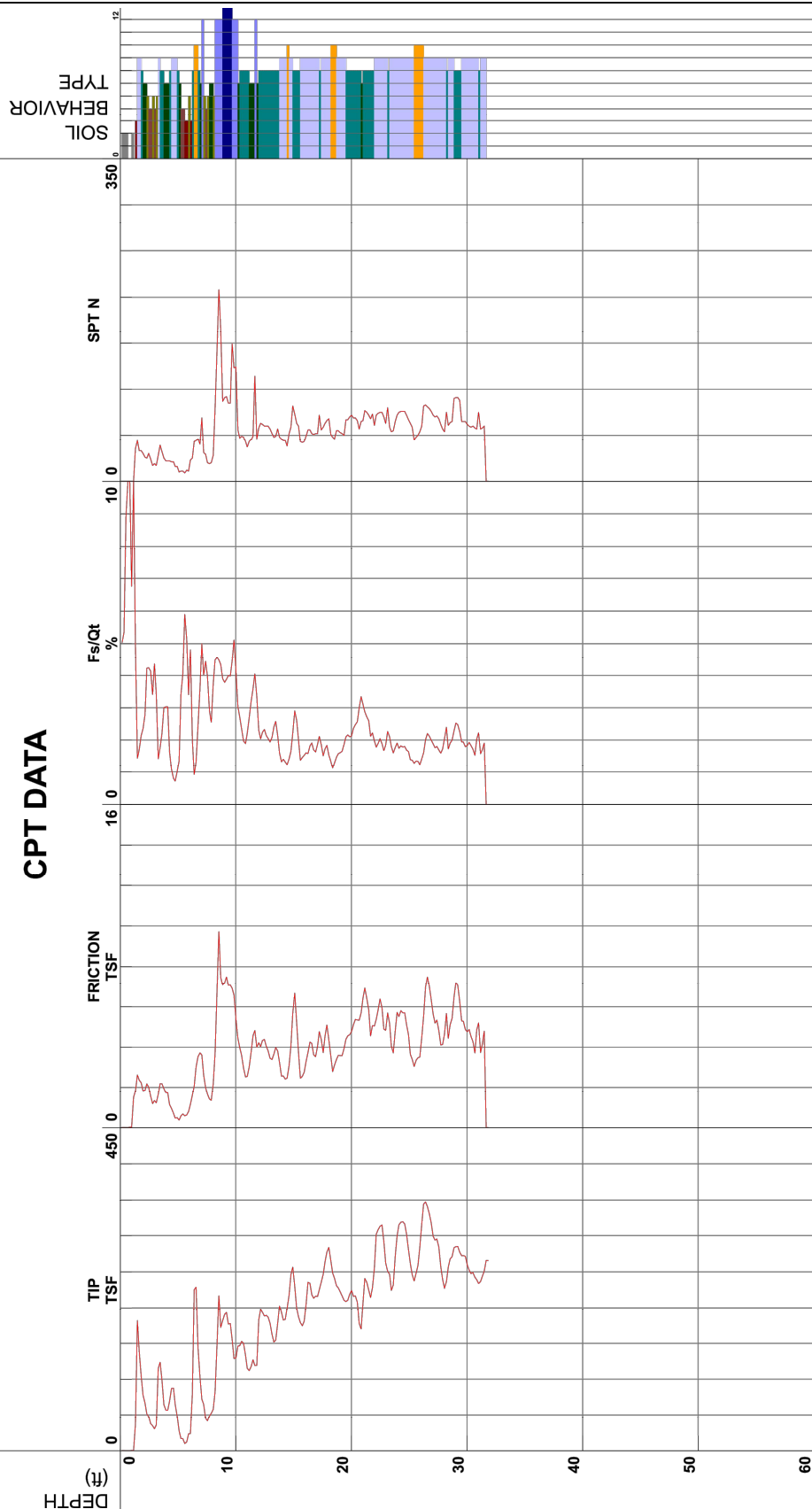
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GPS  
Maximum Depth 31.82 ft

Project Job Number 1911.034  
Hole Number CPT-02  
EST GW Depth During Test 11.00 ft

Operator RB KK  
Cone Number DDG1379  
Date and Time 4/12/2017 12:58:34 PM

Net Area Ratio .8

## CPT DATA



S<sup>o</sup>Soil behavior type and SPT based on data from UBC-1983

Cone Size 10cm squared



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## CPT-2 PLOT

Paden Elementary School  
444 Central Avenue  
Alameda, California  
Project No. 1911.034 Date: 4/7/17

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Checked

A-4  
FIGURE



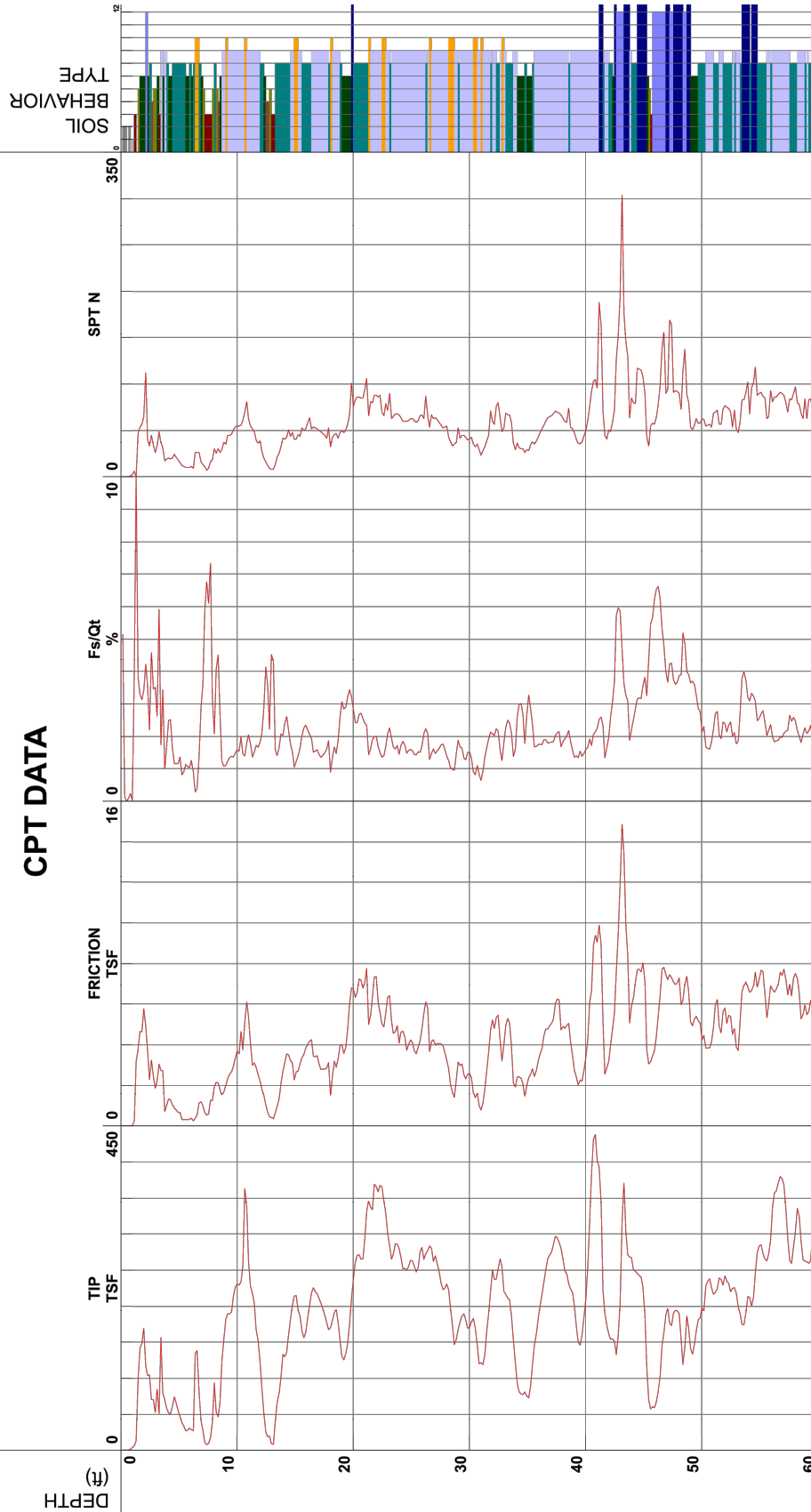
# Miller Pacific Engineering



Project	Operator	Filename
Job Number	Cone Number	GPS
Hole Number	Date and Time	Maximum Depth
EST GW Depth During Test	11.90 ft	60.69 ft
		SDF(034).cpt

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 (\*)

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

Cone Size 10cm squared

## CPT-3 PLOT

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Project No. 1911.034

Date: 4/7/17

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**A-5**  
FIGURE



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Project  
Job Number  
Hole Number  
EST GW Depth During Test

Paden Elementary School  
1911.034  
CPT-04

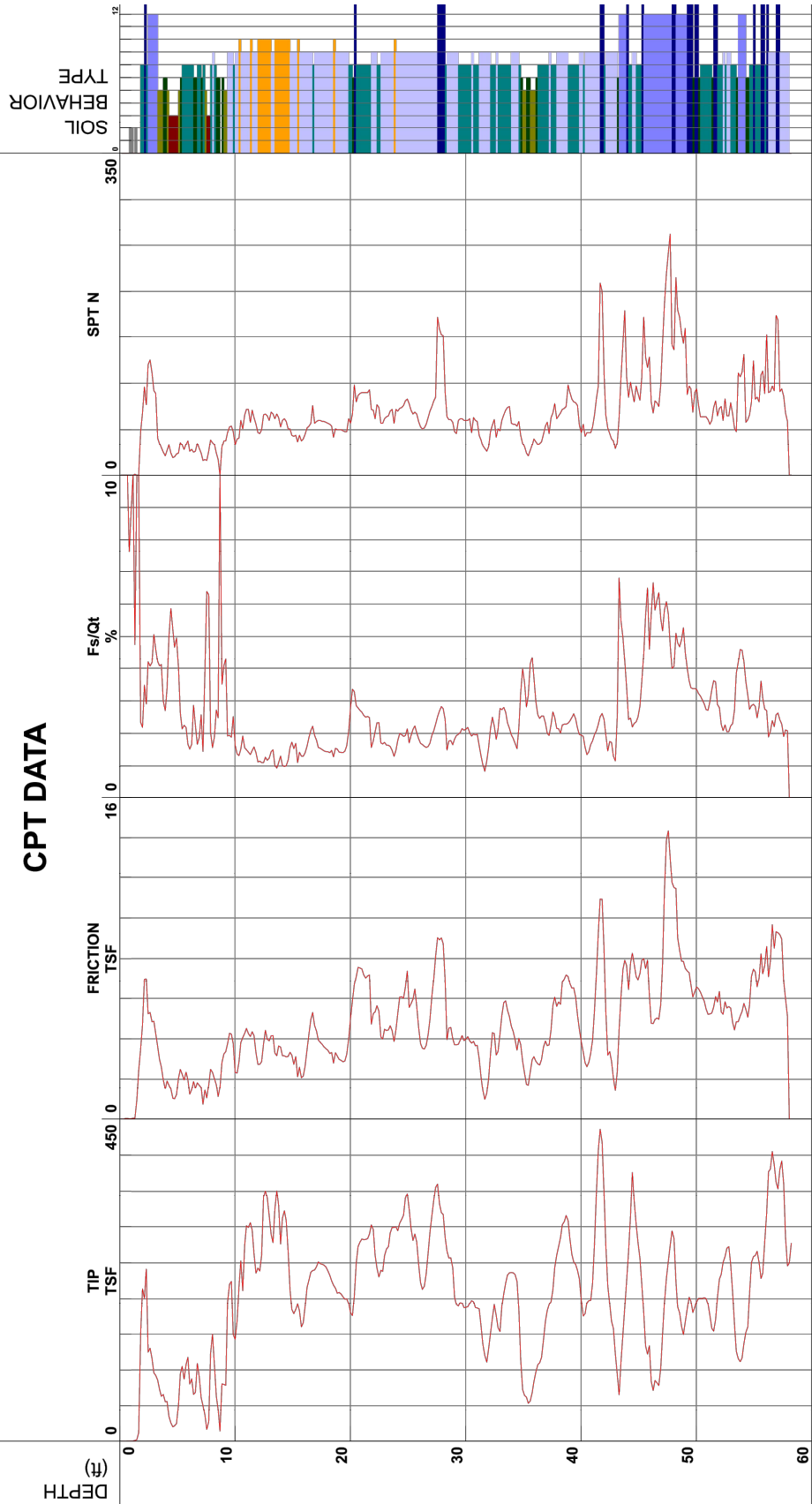
Operator  
Cone Number  
Date and Time  
11.00 ft

Filename  
GPS  
Maximum Depth

SDF(036).cpt  
58.23 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 (\*)

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

Cone Size 10cm squared



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## CPT-4 PLOT

Paden Elementary School  
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Alameda, California  
Project No. 1911.034 Date: 4/7/17

Drawn MMT  
Checked

**A-6**  
FIGURE