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**ENGINEERING GROUP**

October 30, 2017  
File: 1911.028altr.doc

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  
Will C. Wood Middle School Campus  
420 Grand Street  
Alameda, California

### Introduction

This letter summarizes our geotechnical investigation of the Will C. Wood Middle School Campus located at 420 Grand Street 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 seven 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 Will C. Wood Middle School campus is located on the southeasterly side of Grand Street, south of Otis Drive in Alameda, as shown on the Site Location Map, Figure 1. The campus consists of numerous permanent and portable buildings, paved driveways, parking areas, and play areas, grass play fields, and landscaping improvements, as shown on the Site Plan, Figure 2. The ground surface at the project site and the immediately 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 a middle school campus. The attached Site Plan, Figure 2, shows the locations of existing buildings, driveways, and play areas. Most of the ground surface around the existing buildings consists of asphalt paved surfaces and grass play fields.

### Seismicity

The San Francisco Bay Region is located in a seismically active area and the existing 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

We explored the subsurface soil and groundwater conditions with seven Cone Penetration Tests (CPTs) at the approximate locations shown on the Site Plan, Figure 2. The CPTs were conducted with truck-mounted equipment on February 16, 2017. The CPTs were extended to depths of 50 feet to 116 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-9.

### 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 twenty feet of loose to dense sandy fill over a layer (variable thickness) of soft clay and organic material, interpreted as Bay Mud or similar marsh deposits. Beneath the soft clay, predominantly medium-dense to dense silty sand and sandy silt was encountered, extending to the maximum depth explored.

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

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

---

<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.

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 0.57 g, which corresponds to the  $PGA_M$  per ASCE 7-10 Section 11.8.3, and assuming groundwater at a depth of five feet below the ground surface. The results of our liquefaction analyses are presented on Figures 5 through 11, and indicate numerous granular soil layers observed between roughly the ground surface and 60 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 the ground surface and a depth of 60 feet may result in ground surface settlement of between roughly 1 to 3-inches (CPTs-2, 4, and 6) and roughly 6 to 7-inches (CPTs 1, 3, 5 and 7), based on the liquefaction analyses discussed above, and as shown on Figures 5 through 11. 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 1.5-inches at CPTs 2, 4, and 6, and approximately 3.0 to 3.5-inches at CPTs 1, 3, 5, and 7).

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

Alameda Unified School District  
Page 4 of 4

October 30, 2017

Yours very truly,  
MILLER PACIFIC ENGINEERING GROUP



Daniel S. Caldwell  
Geotechnical Engineer #2006  
(Expires 9/30/19)

Attachments: Figures 1 through 11, A-1 through A-9



SITE: LATITUDE, 37.7612°  
LONGITUDE, -122.2622°

SITE LOCATION  
N.T.S.



REFERENCE: Google Earth, 2017



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#### SITE LOCATION MAP

Wood Middle School  
420 Grand Street  
Alameda, California

Project No. 1911.028

Date: 3/1/17

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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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Date: 3/1/17

Drawn  
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MMT

3

FIGURE



SITE COORDINATES: LAT. 38.7612° LON. -122.2622°

**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**

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**4**  
FIGURE



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## CPT-1 LIQUEFACTION ANALYSIS

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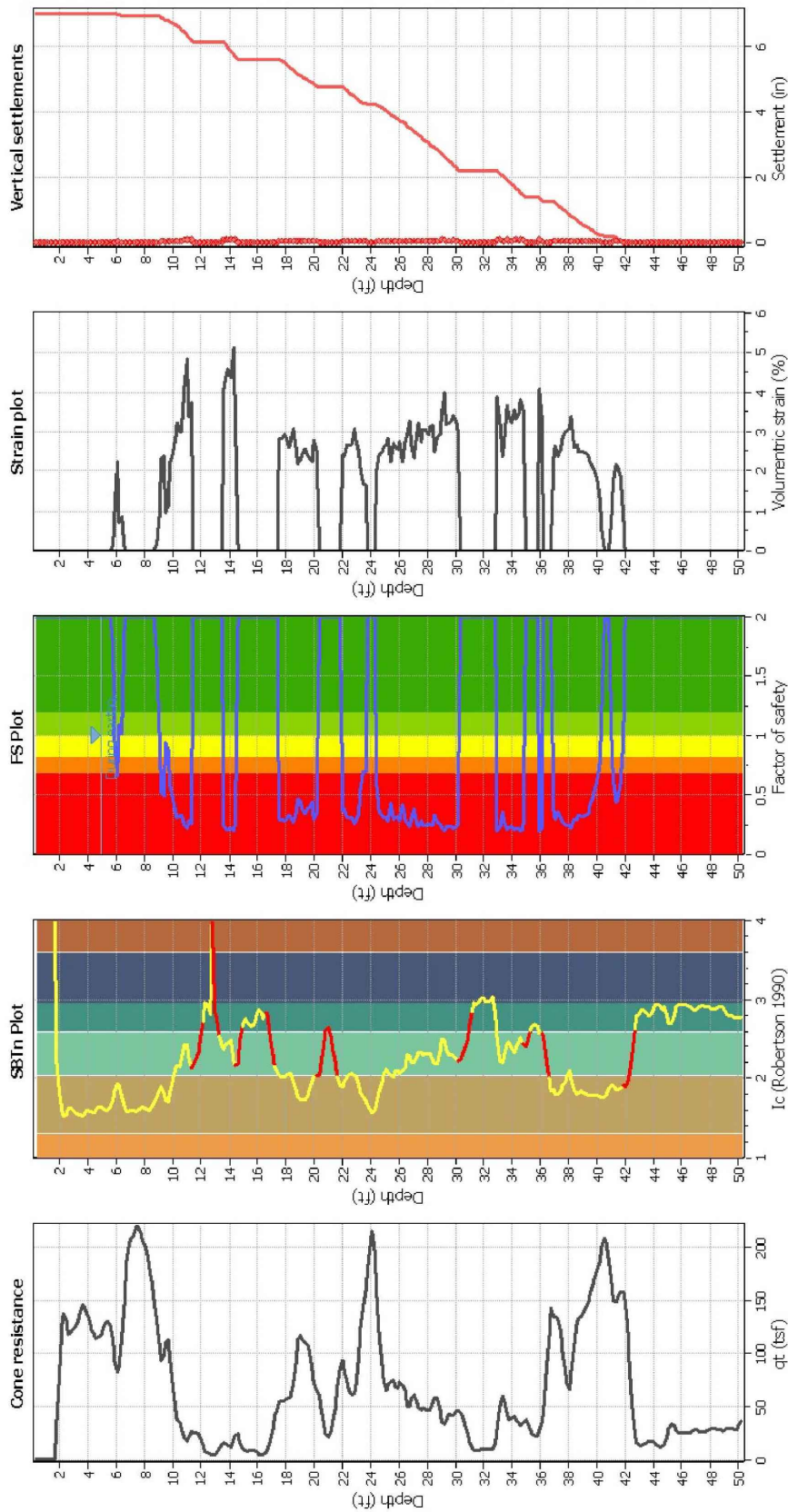
MMT

5  
FIGURE

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CPT name: CPT-01

### Estimation of post-earthquake settlements



#### Abbreviations

qc: Total cone resistance (cone resistance  $q_c$  corrected for pore water effects)  
I<sub>c</sub>: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

CLiQ v.2.0.6.94 - CPT Liquefaction Assessment Software - Report created on: 2/28/2017, 2:58:50 PM  
Project file:



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## CPT-2 LIQUEFACTION ANALYSIS

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Date: 3/1/17

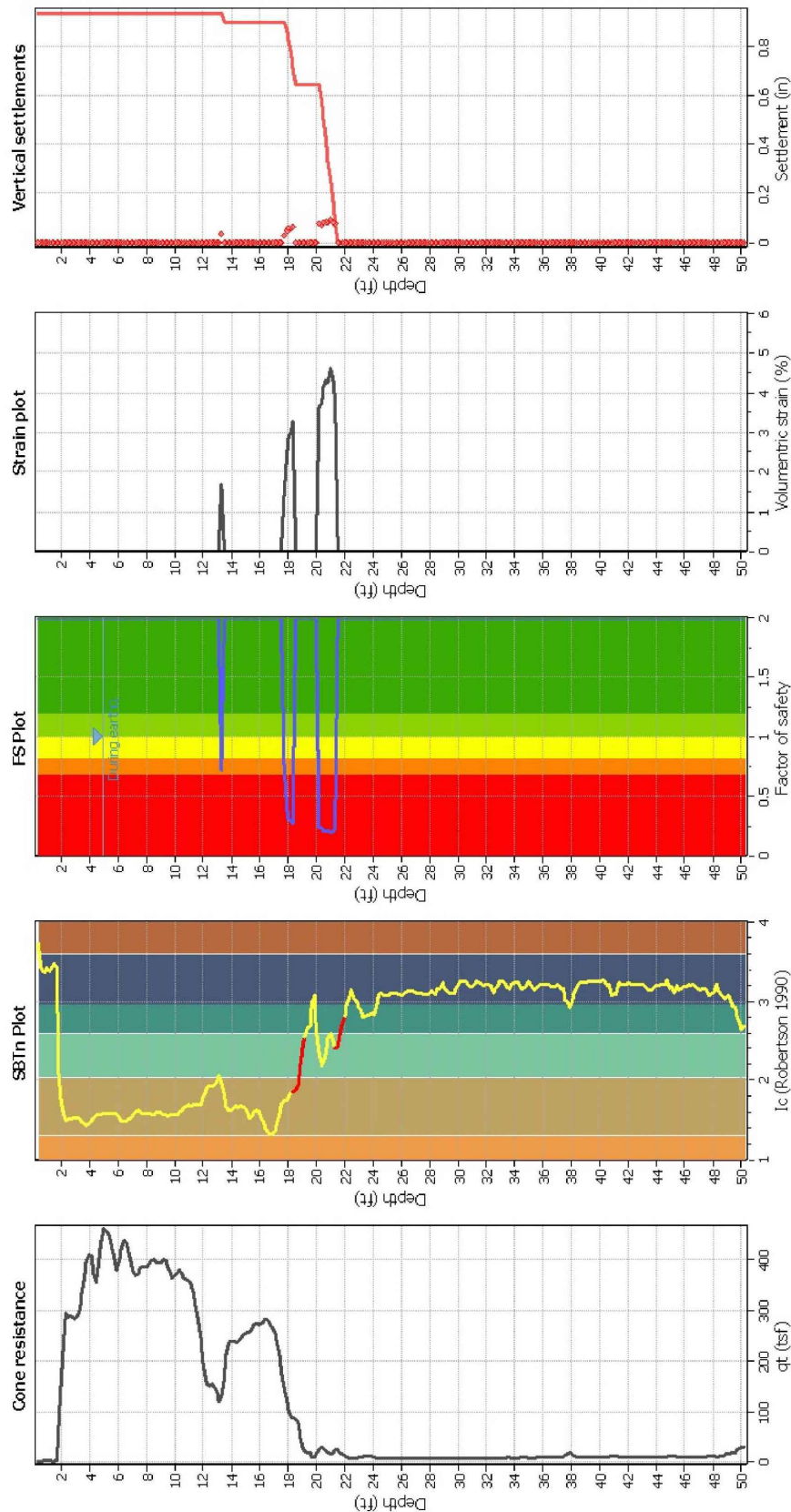
Drawn MMT  
Checked

6  
FIGURE

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CPT name: CPT-02

### Estimation of post-earthquake settlements



#### Abbreviations

qt: Total cone resistance (cone resistance  $q_c$  corrected for pore water effects)  
Ic: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

CLiQ v.2.0.6.94 - CPT Liquefaction Assessment Software - Report created on: 2/28/2017, 2:58:50 PM  
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## CPT-3 LIQUEFACTION ANALYSIS

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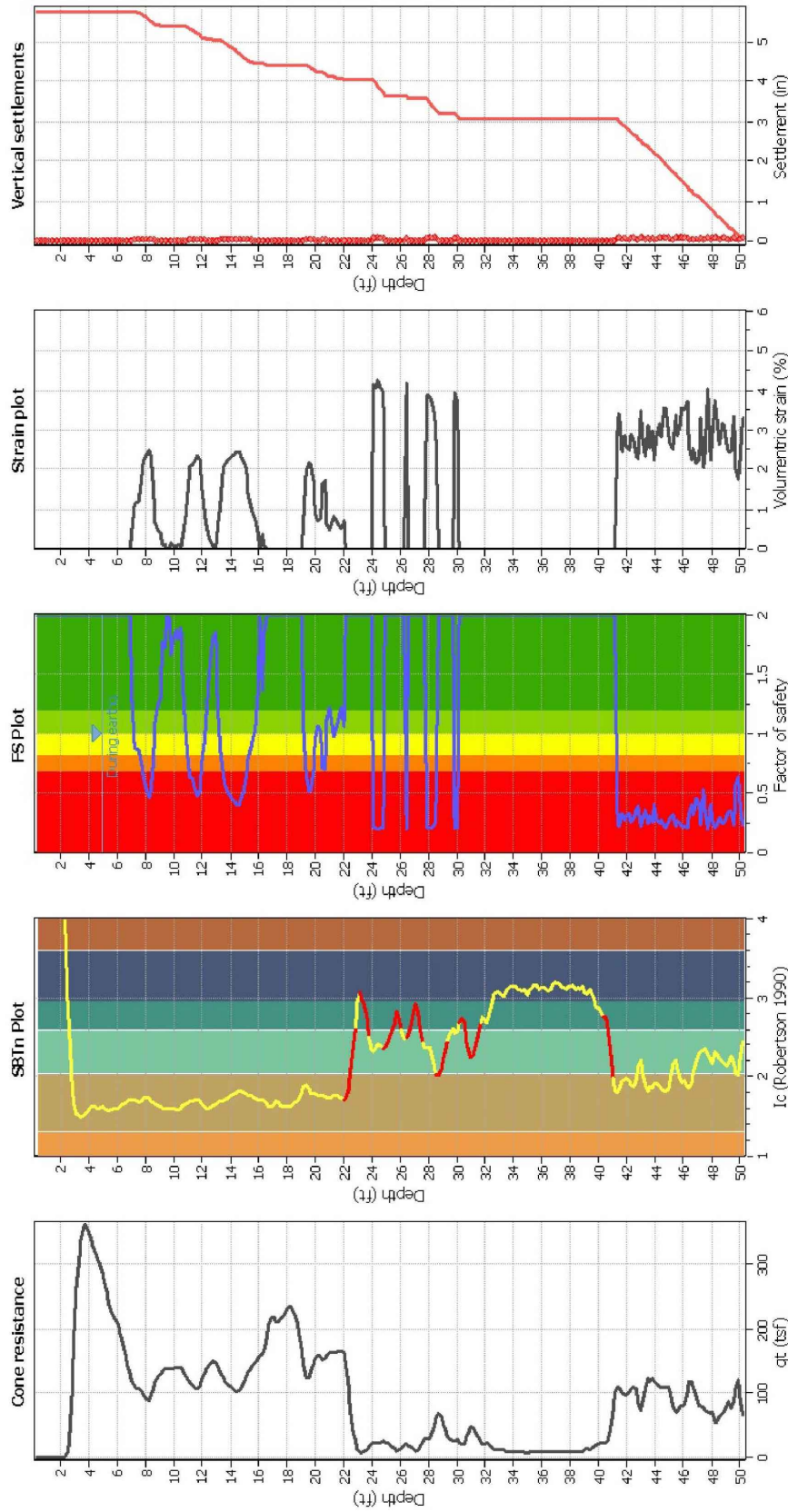
Drawn MMT  
Checked

7  
FIGURE

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CPT name: CPT-03

### Estimation of post-earthquake settlements



#### Abbreviations

qc: Total cone resistance (cone resistance  $q_c$  corrected for pore water effects)  
Ic: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

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## CPT-4 LIQUEFACTION ANALYSIS

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Date: 3/1/17

Drawn  
Checked

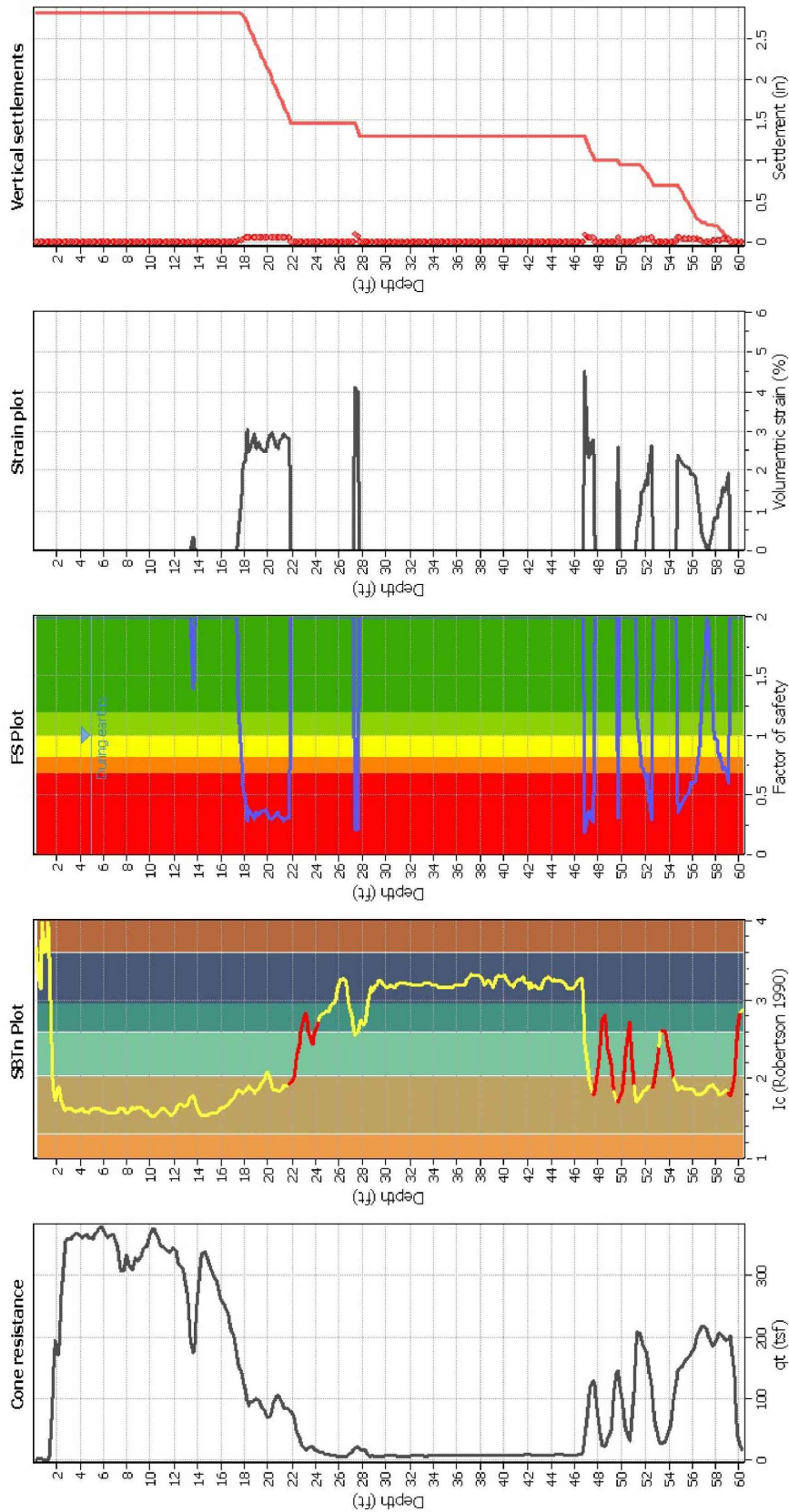
MMT

8  
FIGURE

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CPT name: CPT-04

### Estimation of post-earthquake settlements



#### Abbreviations

q<sub>c</sub>: Total cone resistance (cone resistance q<sub>c</sub> corrected for pore water effects)  
I<sub>c</sub>: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

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## CPT-5 LIQUEFACTION ANALYSIS

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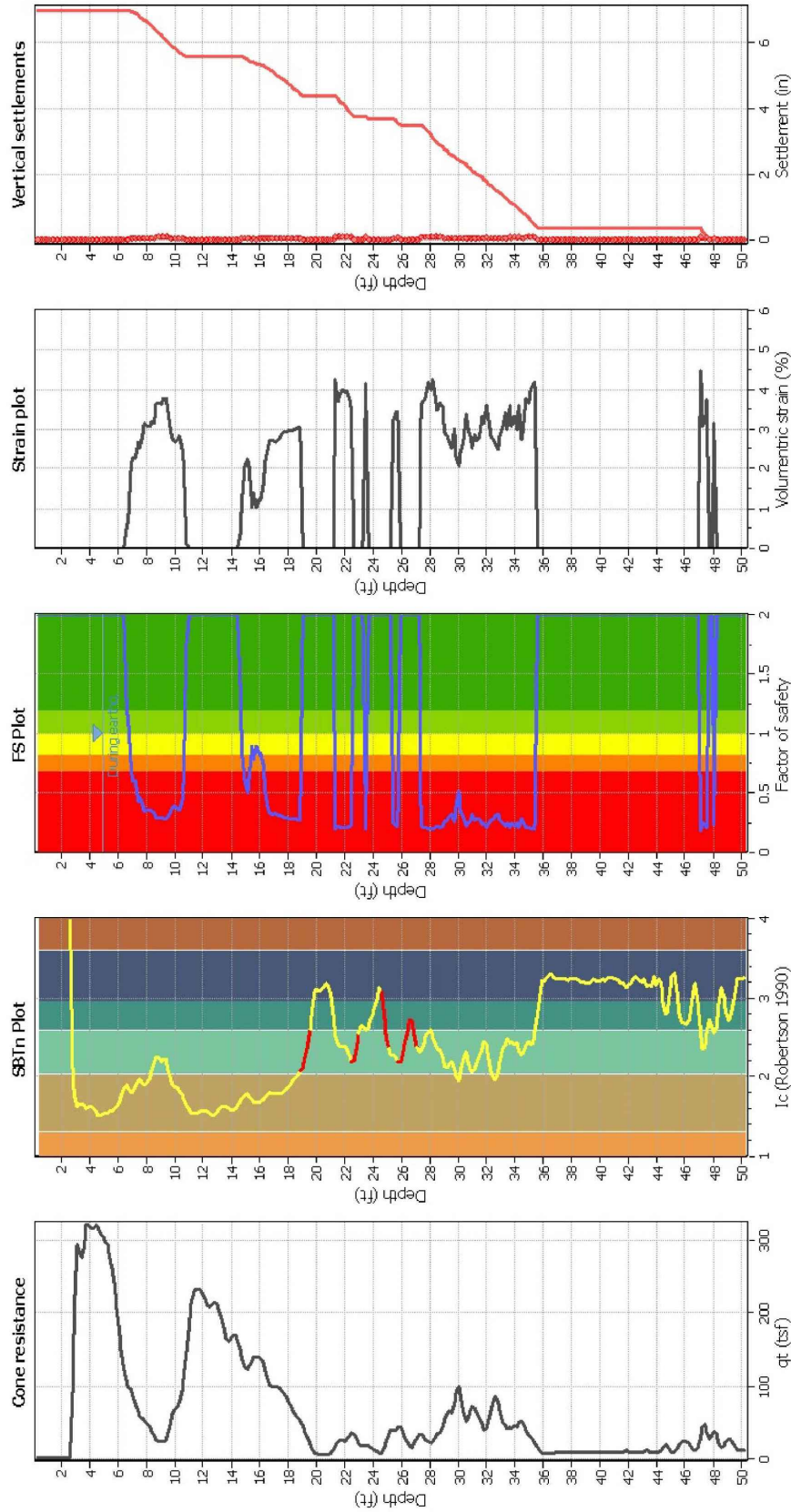
MMT

9  
FIGURE

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CPT name: CPT-05

### Estimation of post-earthquake settlements



#### Abbreviations

qt: Total cone resistance (cone resistance  $q_c$  corrected for pore water effects)  
Ic: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

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## CPT-6 LIQUEFACTION ANALYSIS

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Date: 3/1/17

Drawn  
Checked

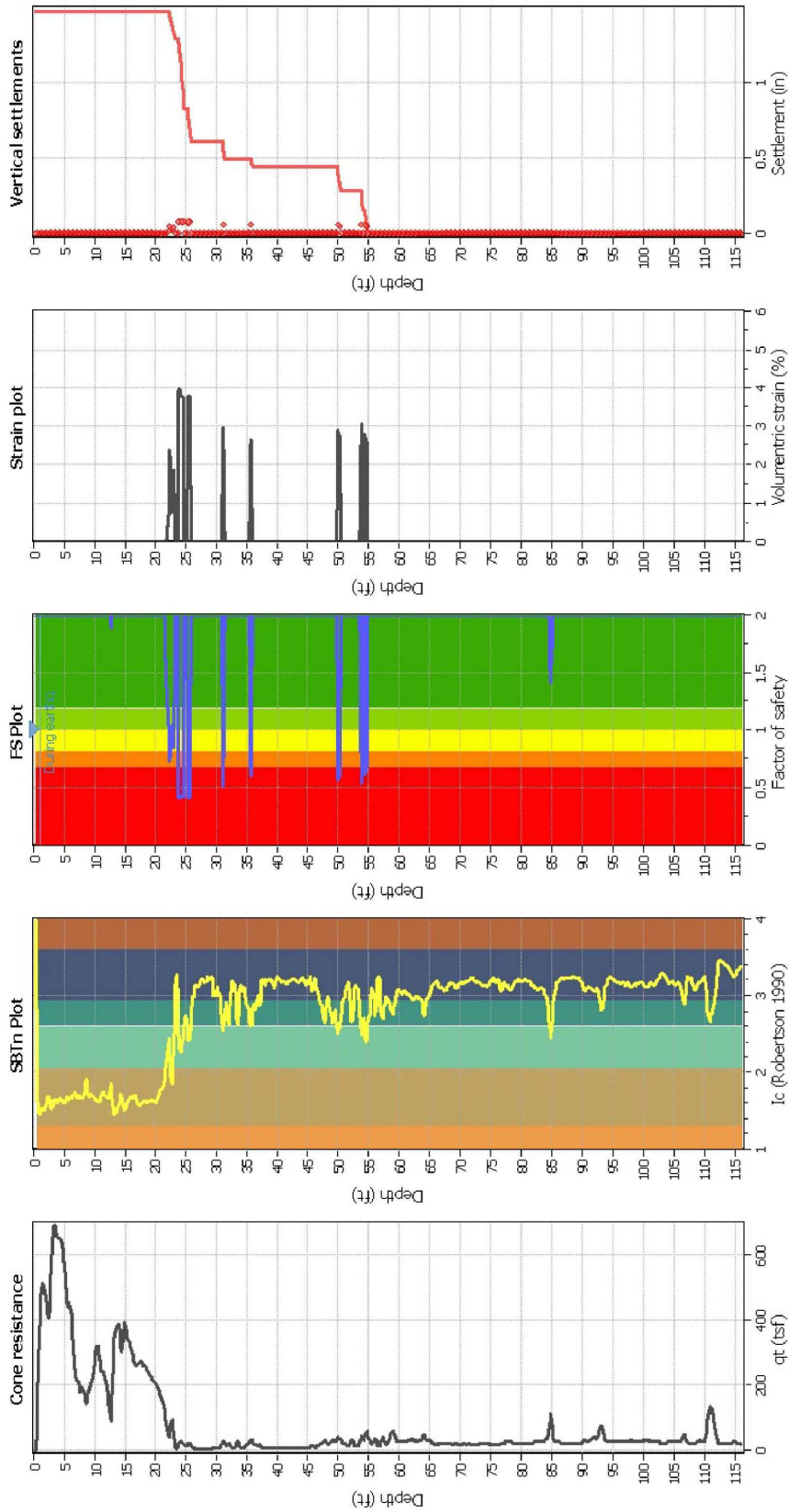
MMT

10  
FIGURE

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CPT name: CPT-06

### Estimation of post-earthquake settlements



#### Abbreviations

qt: Total cone resistance (cone resistance  $q_c$  corrected for pore water effects)  
Ic: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

CLiq v.2.0.6.94 - CPT Liquefaction Assessment Software - Report created on: 2/28/2017, 2:58:56 PM  
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## CPT-7 LIQUEFACTION ANALYSIS

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Date: 3/1/17

Drawn  
Checked

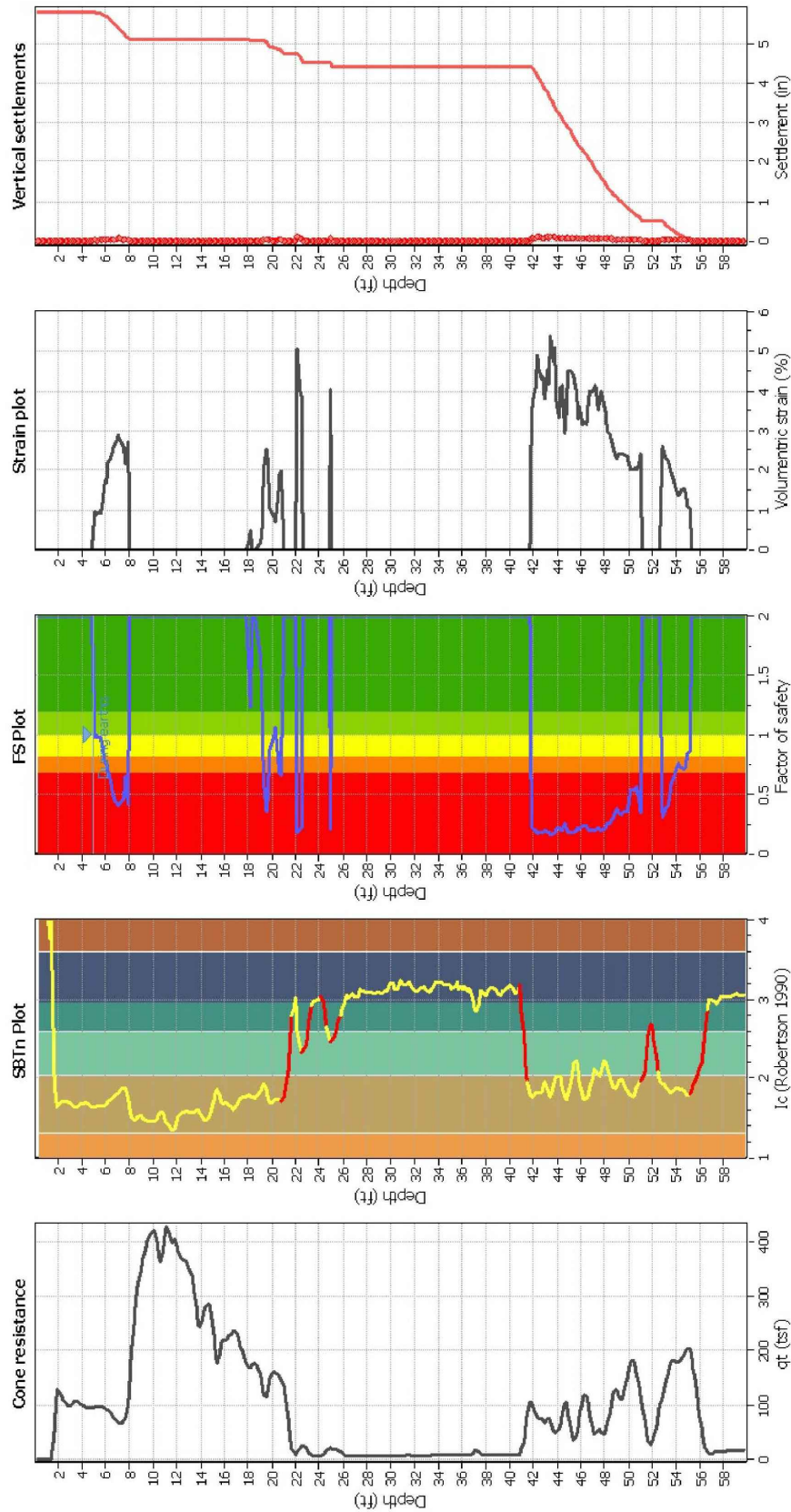
MMT

11  
FIGURE

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### Estimation of post-earthquake settlements

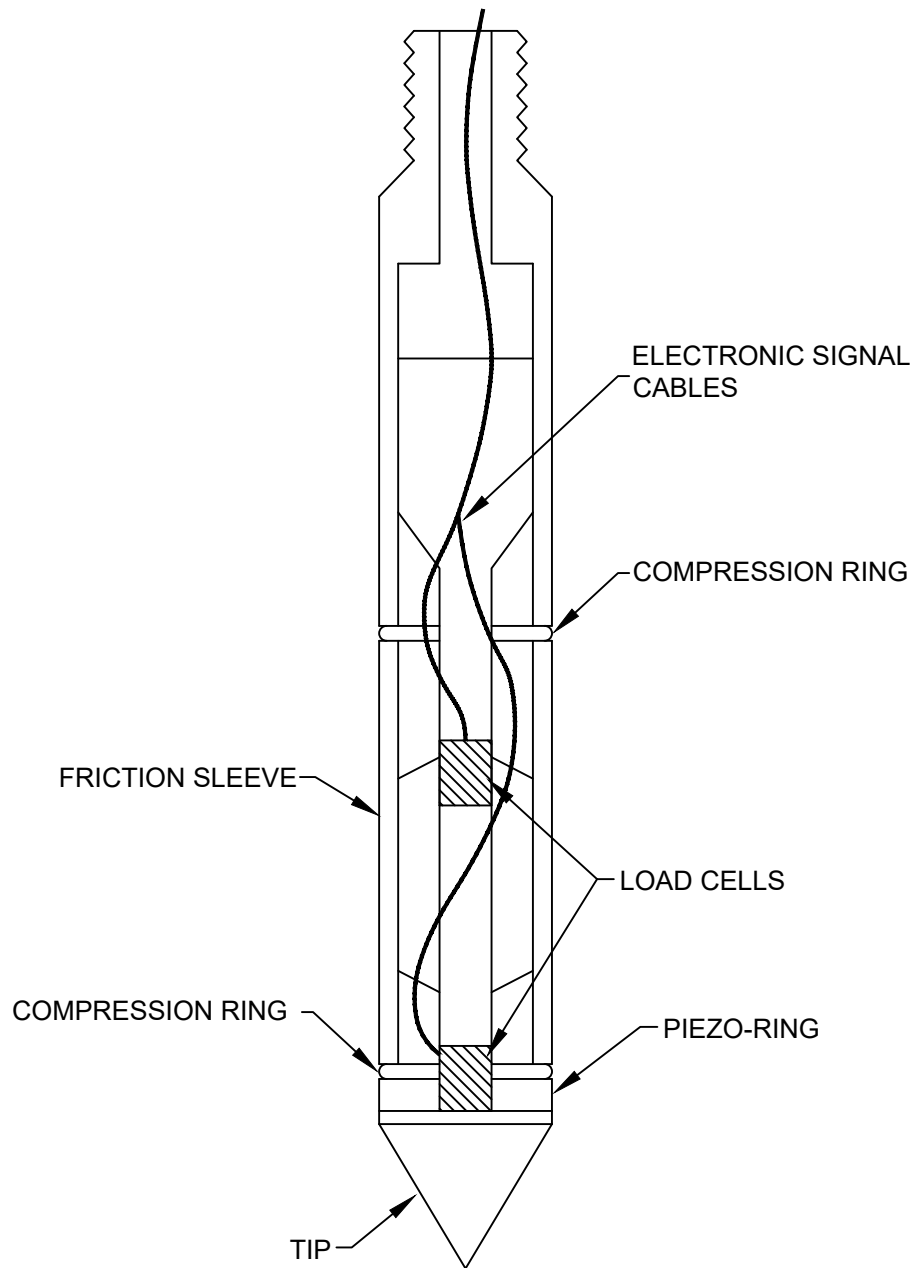


#### Abbreviations

q<sub>c</sub>: Total cone resistance (cone resistance q<sub>c</sub> corrected for pore water effects)  
I<sub>c</sub>: Soil Behaviour Type Index  
FS: Calculated Factor of Safety against liquefaction  
Volumetric strain: Post-liquefaction volumetric strain

CLiq v.2.0.6.94 - CPT Liquefaction Assessment Software - Report created on: 2/28/2017, 2:58:54 PM  
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## APPENDIX A



# **CONE PENETROMETER**

(NO SCALE)



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## **CONE PENETROMETER**

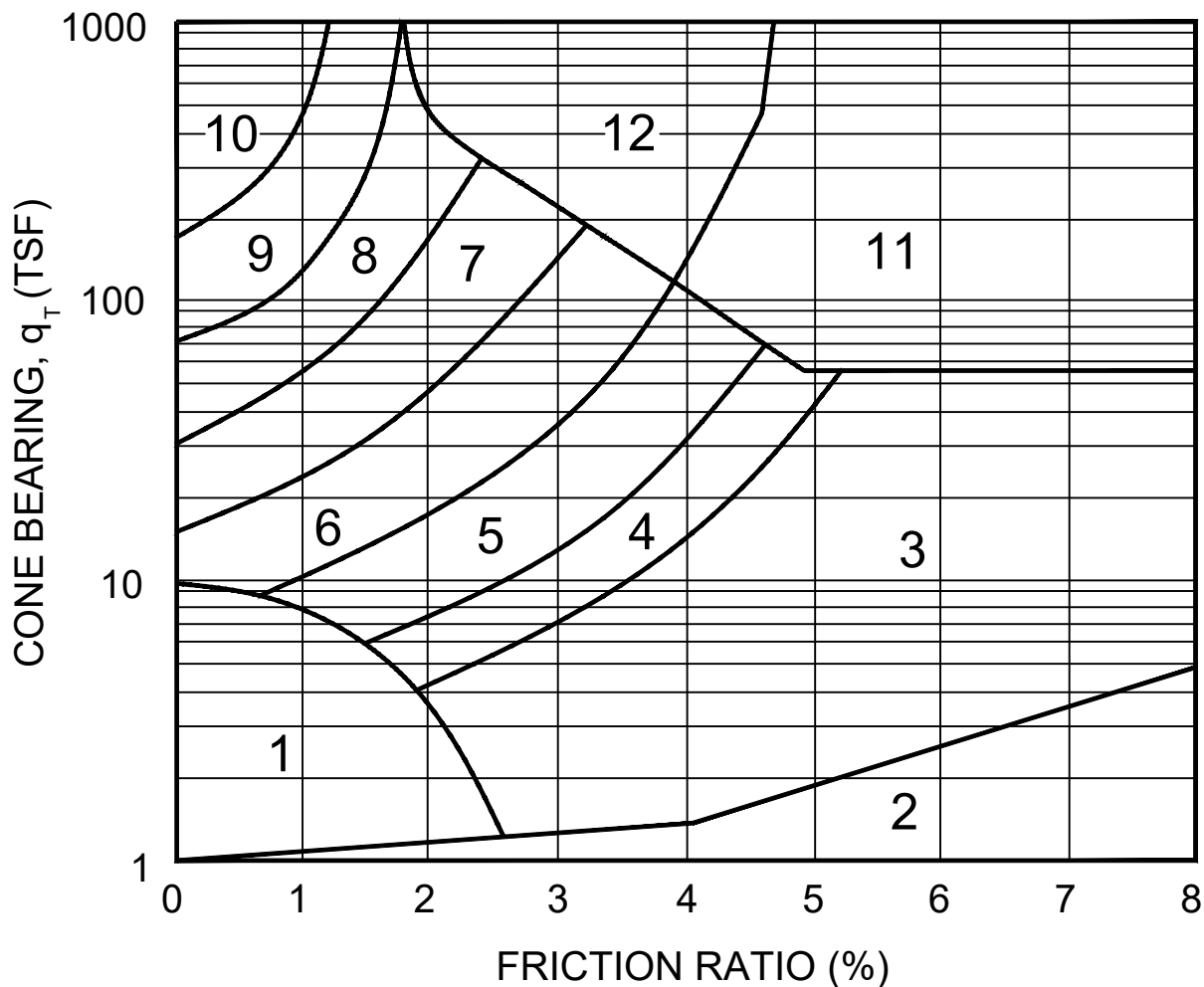
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Alameda, California

Project No. 1911.028

Date: 2/24/17

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

**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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Date: 2/24/17

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**A-2**  
FIGURE

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Project  
Job Number  
Hole Number  
EST GW Depth During Test

Wood Middle School  
1911.028  
CPT-01

Operator  
Cone Number  
Date and Time  
5.00 ft

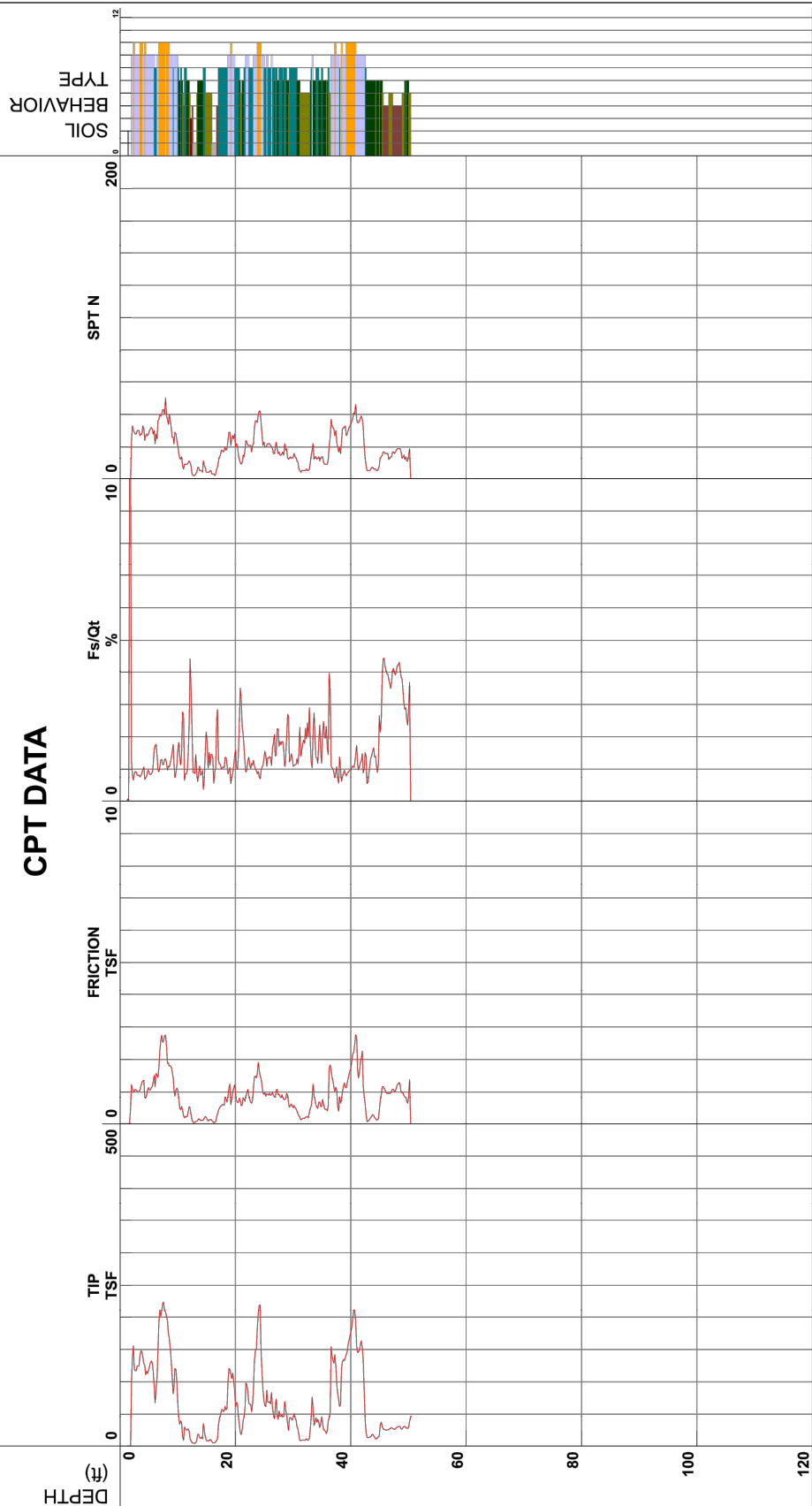
RB KK  
DDG1333  
2/16/2017 2:00:55 PM

Filename  
GPS  
Maximum Depth

SDF(120).cpt  
50.52 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-1 PLOT

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Date: 2/24/17

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**A-3**  
FIGURE



## Miller Pacific Engineering Group

Project  
Job Number  
Hole Number  
EST GW Depth During Test

Wood Middle School  
1911.028  
CPT-02

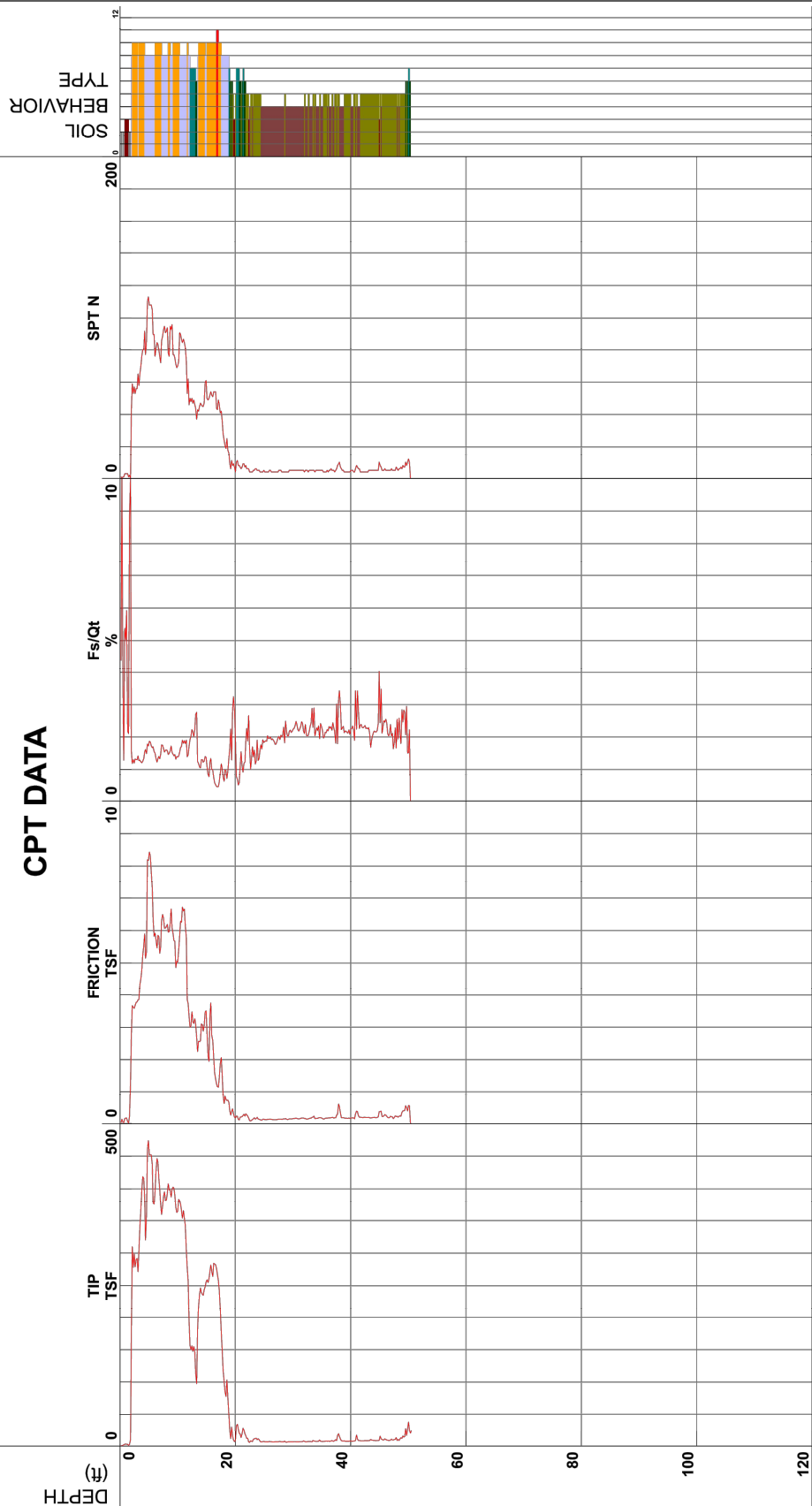
Operator  
Cone Number  
Date and Time  
5.00 ft

Filename  
GPS  
Maximum Depth

SDF(114).cpt  
50.52 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<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

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**A-4**  
FIGURE

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Project  
Job Number  
Hole Number  
EST GW Depth During Test

Wood Middle School  
1911.028  
CPT-03

Operator  
Cone Number  
Date and Time  
5.00 ft

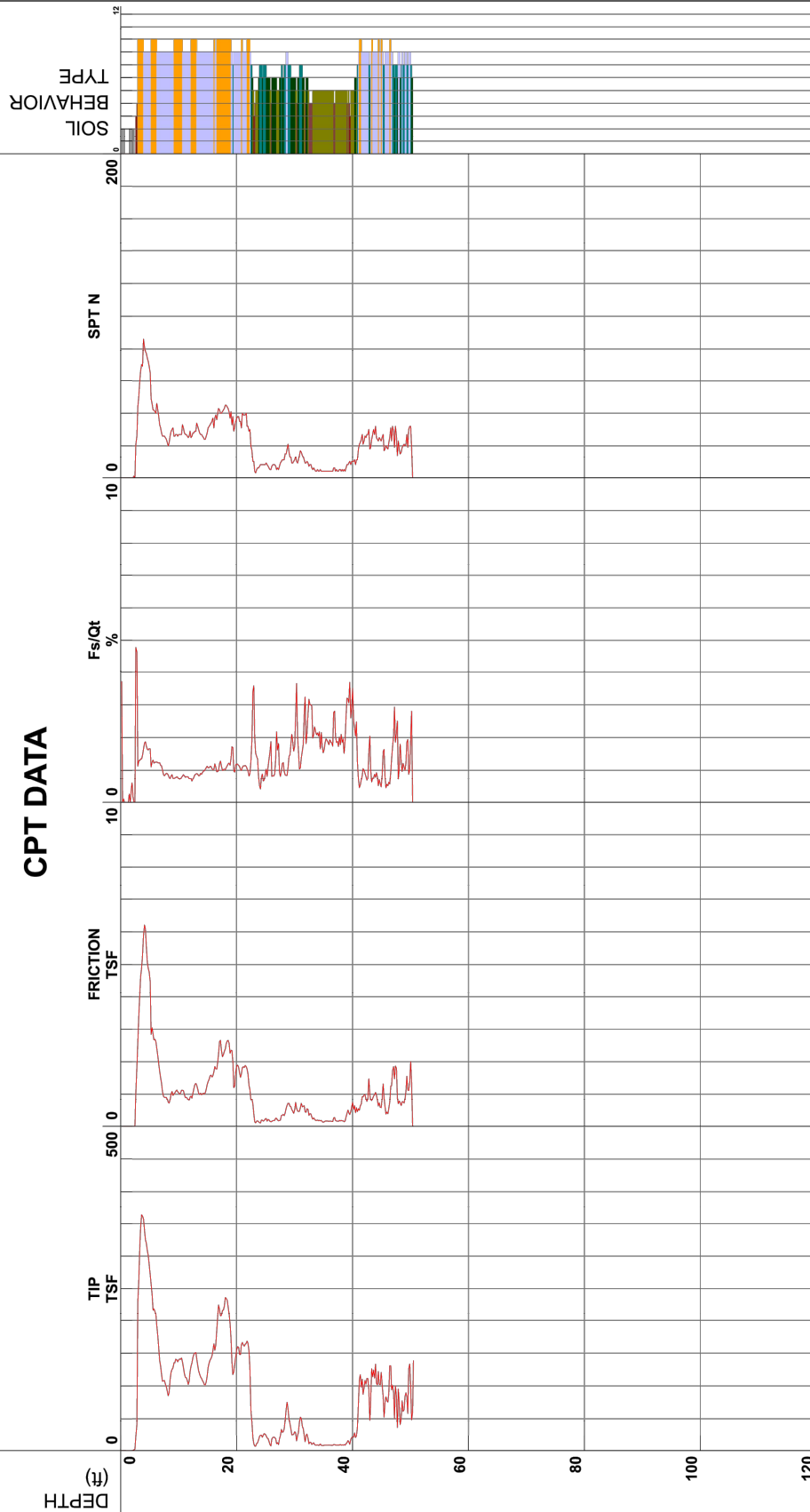
RB KK  
DDG1333  
2/16/2017 1:08:30 PM

Filename  
GPS  
Maximum Depth

SDF(119).cpt  
50.52 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-3 PLOT

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A-5  
FIGURE

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Project  
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Hole Number  
EST GW Depth During Test

Wood Middle School  
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CPT-04

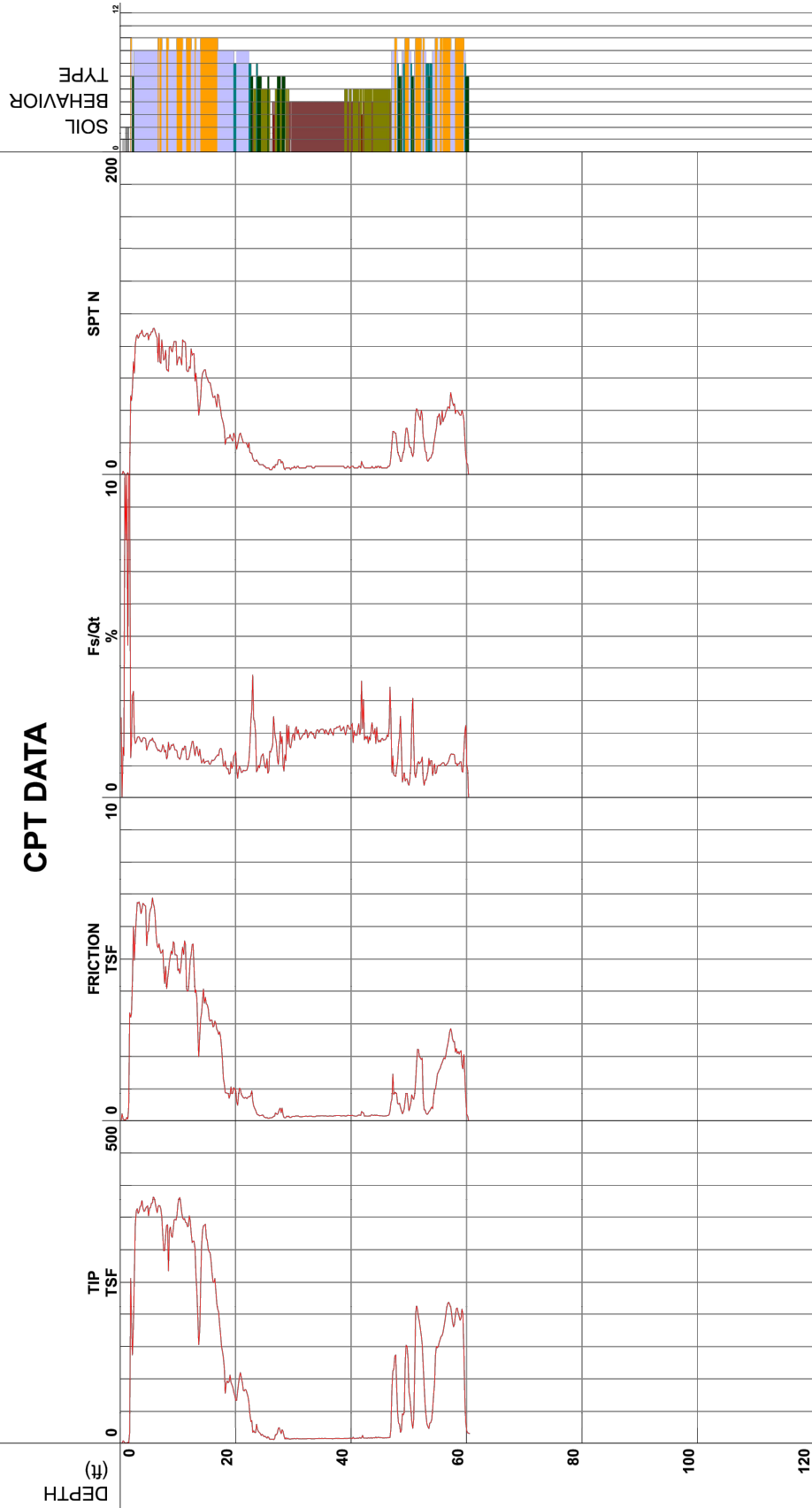
Operator  
Cone Number  
Date and Time  
5.00 ft

Filename  
GPS  
Maximum Depth

SDF(118).cpt  
60.53 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<sup>o</sup>Soil behavior type and SPT based on data from UBC-1983



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**ENGINEERING GROUP**

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FILENAME: 1911.028 CPT.dwg

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Novato, CA 94947  
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F 415 / 382-3450  
www.millerpac.com

## CPT-4 PLOT

Wood Middle School  
420 Grand Street  
Alameda, California

Project No. 1911.028

Date: 2/24/17

Drawn  
Checked

MMT

**A-6**  
FIGURE



## Miller Pacific Engineering Group

Project  
Job Number  
Hole Number  
EST GW Depth During Test

Wood Middle School  
1911.028  
CPT-05

Operator  
Cone Number  
Date and Time  
5.00 ft

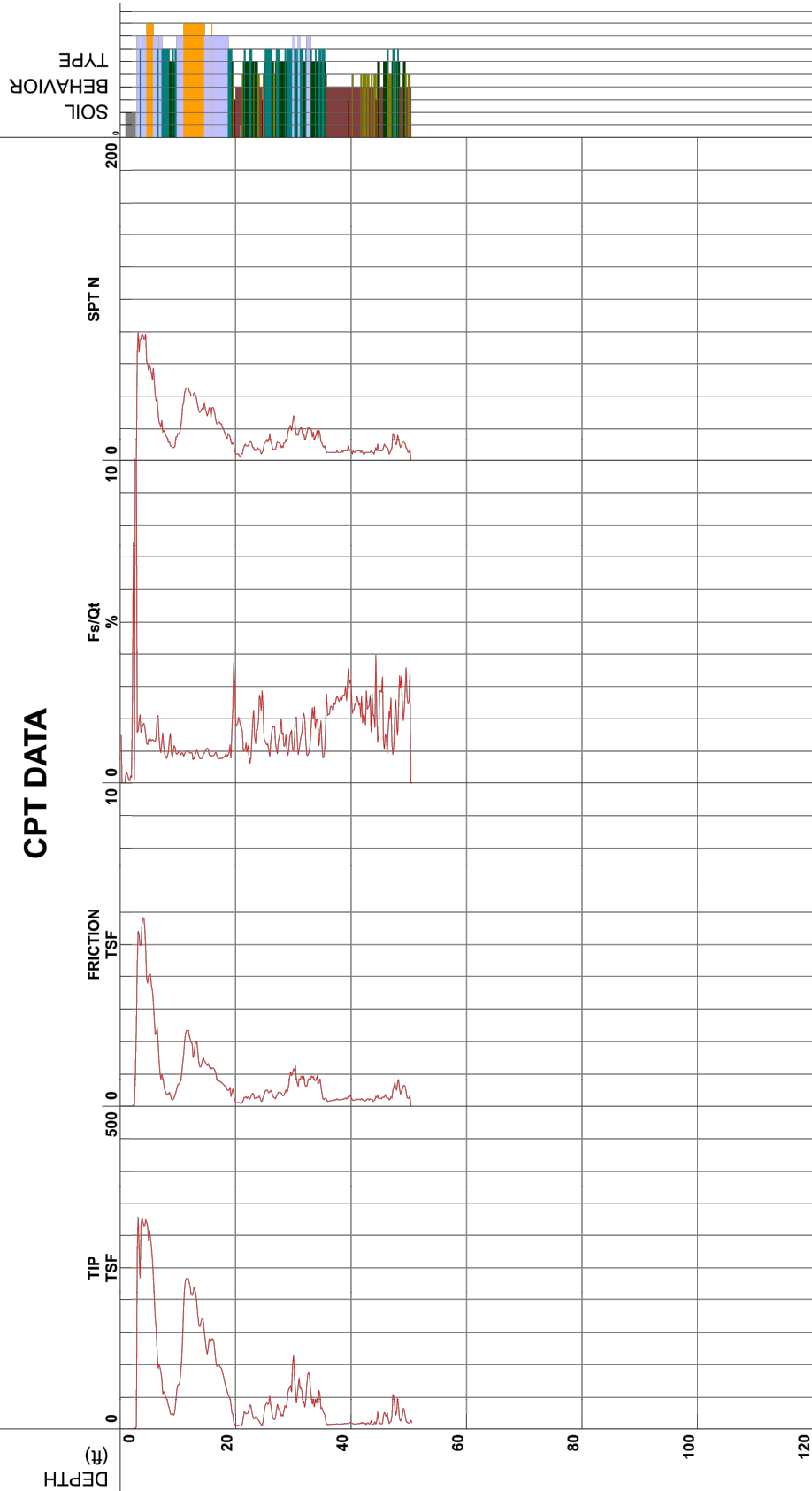
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DDG1333  
2/16/2017 8:10:37 AM

Filename  
GPS  
Maximum Depth

SDF(115).cpt  
50.52 ft

Net Area Ratio .8

### CPT DATA



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### CPT-5 PLOT

Wood Middle School  
420 Grand Street  
Alameda, California

Project No. 1911.028

Date: 2/24/17

Drawn  
Checked

MMT

**A-7**  
FIGURE

# Miller Pacific Engineering Group



Project  
Job Number  
Hole Number  
EST GW Depth During Test

Wood Middle School  
1911.028  
CPT-06

Operator  
Cone Number  
Date and Time  
5.00 ft

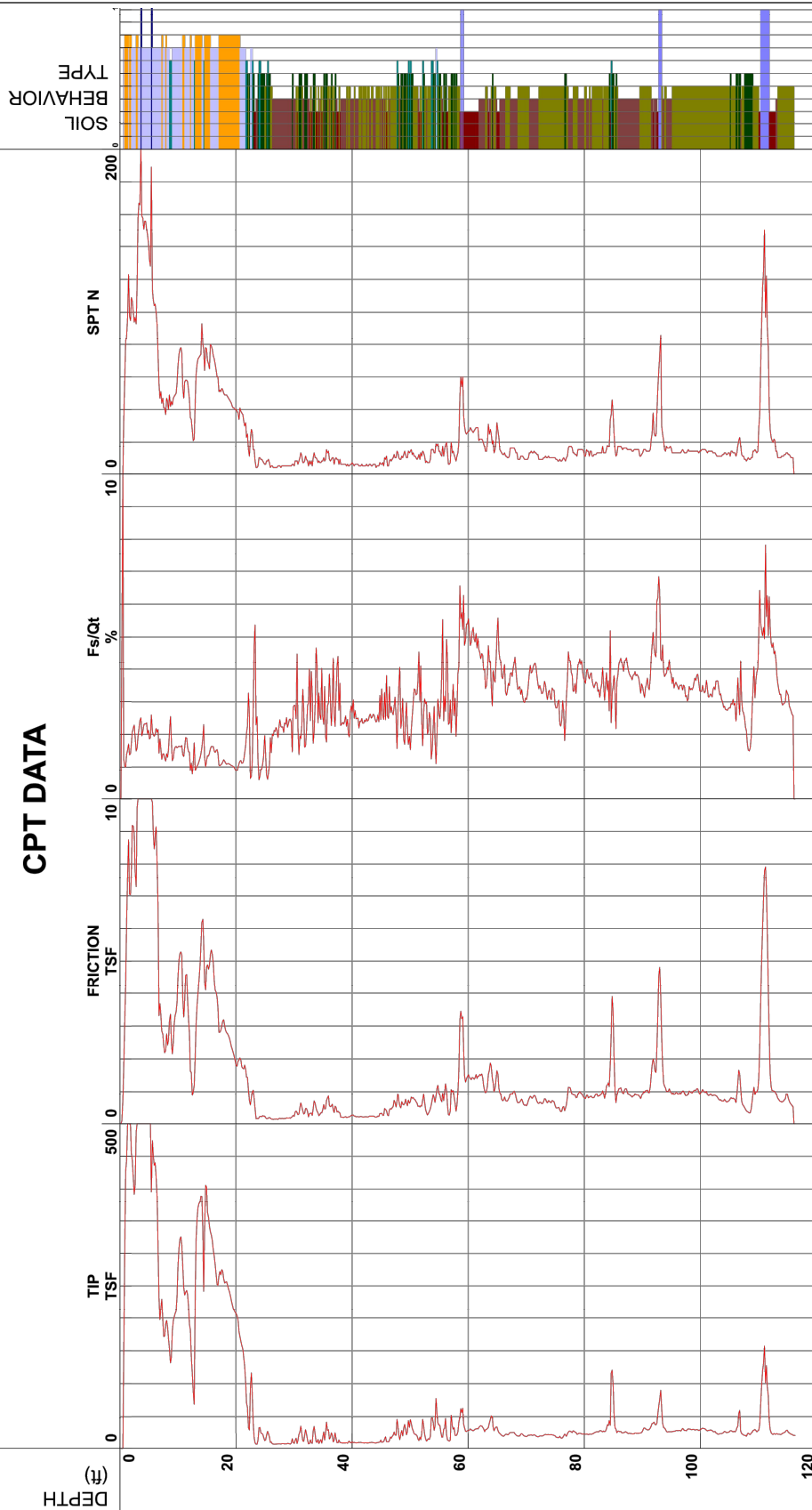
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2/16/2017 9:05:46 AM

Filename  
GPS  
Maximum Depth

SDF(116).cpt  
116.30 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-6 PLOT

Wood Middle School  
420 Grand Street  
Alameda, California

Project No. 1911.028

Date: 2/24/17

Drawn  
Checked

MMT

**A-8**  
FIGURE

# Miller Pacific Engineering Group



Project  
Job Number  
Hole Number  
EST GW Depth During Test

Wood Middle School  
1911.028  
CPT-07

Operator  
Cone Number  
Date and Time  
5.00 ft

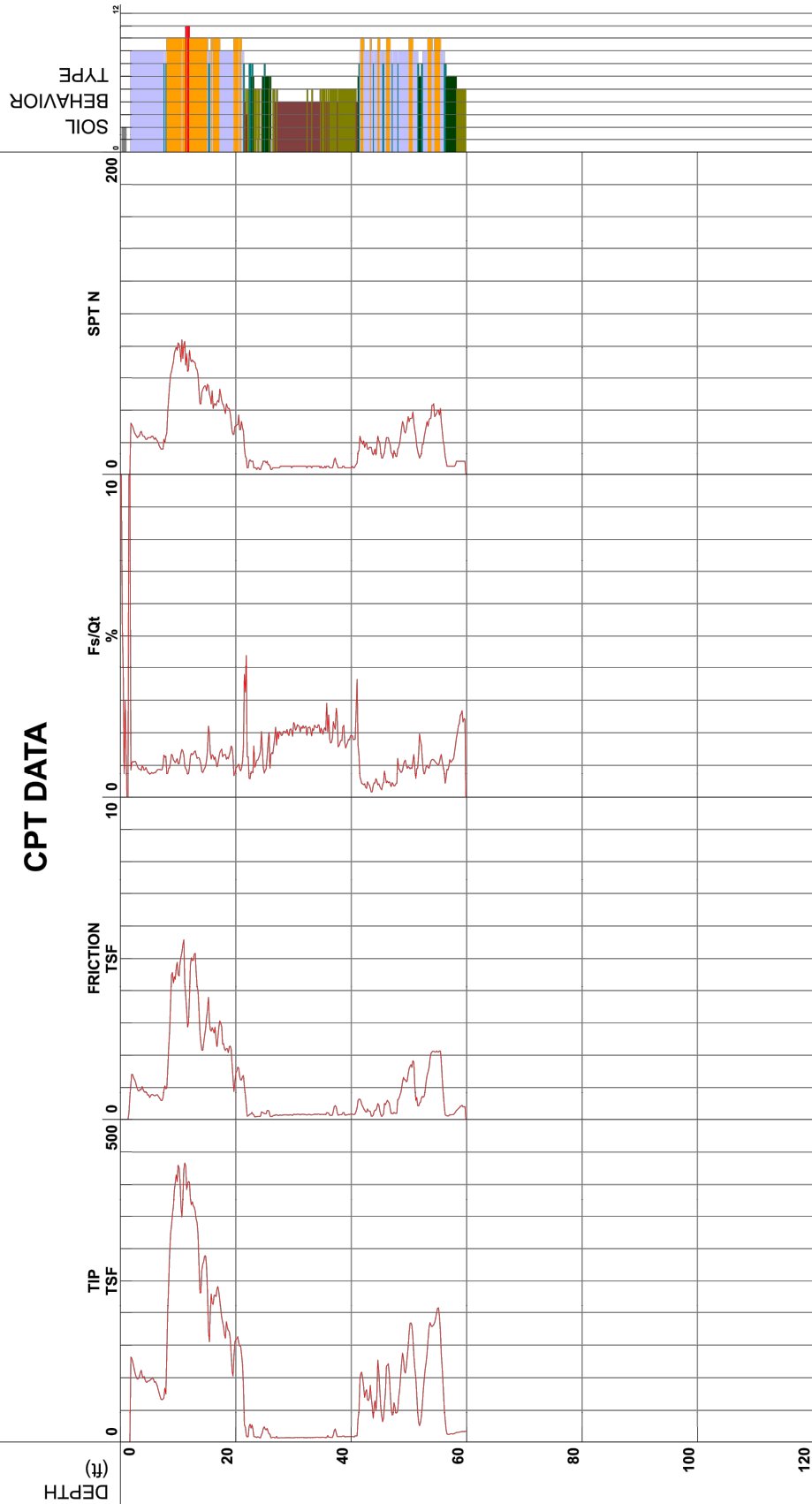
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DDG1333  
2/16/2017 11:23:55 AM

Filename  
GPS  
Maximum Depth

SDF(117).cpt  
60.04 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-7 PLOT

Wood Middle School  
420 Grand Street  
Alameda, California

Project No. 1911.028

Date: 2/24/17

Drawn  
Checked

MMT

**A-9**  
FIGURE