GeoEngineers
8410 154th Avenue NE
Redmond, Washington 98052
425.861.6000

May 18, 2012

City of Seattle Department of Transportation
c/o HNTB Corporation
600 108th Avenue NE, Suite 900
Bellevue, Washington 98004

Attention: Salima Hamlin, PE

Subject: Supplemental Geotechnical Explorations and Geotechnical Report
Airport Way South Viaduct over ARGO Railroad Yard
Seattle, Washington
File No. 0129-141-01

INTRODUCTION

The purpose of this letter is to present the results of our supplemental geotechnical explorations for the Airport Way South Viaduct over ARGO Railroad Yard project in Seattle, Washington. The project site is located along Airport Way South between South Edmunds Street and South Lucile Street. The site is shown relative to surrounding physical features on the Vicinity Map, Figure 1.

Based on the supplemental geotechnical explorations, we completed additional geotechnical evaluations for comparison to those evaluations provided by Shannon & Wilson, Inc. (S&W) in their report titled "Final Geotechnical Report, Plans, Specifications, and Estimates Phase, Airport Way South Viaduct over ARGO Railroad Yard, Seattle, Washington" dated June 8, 2010. The recommendations provided in this letter supplement and/or supersede those provided in the S&W report.

Based upon the recommendation or comments provided in this Supplemental Geotechnical Report, GeoEngineers will become the Geotechnical Engineer of Record and accepts the full responsibilities associated with this role. GeoEngineers is also in the process of developing deep soil mixing (DSM) design, plans and specifications for the project, the results of which will be provided under separate cover.

PROJECT DESCRIPTION

The project consists of replacing the north and south timber trestle approach structures with additional bridge spans and mechanically stabilized earth (MSE) fill approaches. The new bridge spans are currently designed to be supported on deep foundations. The MSE fill approaches, which range up to about 25 feet in height, are currently designed to be supported on improved ground. Additionally, the existing center bridge main span will be seismically retrofitted. The existing center bridge main span is supported on deep foundations consisting of timber piles. The seismic retrofit will not result in modifications to the center bridge main span foundations.

Construction activities associated with compaction grouting ground improvement were started at the north approach area. Compaction grouting was essentially completed in the eastern two-thirds of the north approach area. Grout return depths (defined as the distance between the grout pipe tip when grout was observed at the ground surface) were highly variable during construction; ranging from 5 to 25 feet. This has resulted in the upper soils not being adequately improved for static or seismic performance of the approach fills. A couple of compaction grout points were also installed along the west perimeter but this resulted in unacceptable ground movements near the existing Puget Sound Energy (PSE) gas main. Due to highly variable grout return depths, ground movements during grouting and the presence of sensitive utilities in the area, DSM has been identified as a more suitable method to complete ground improvement, both in the partially completed north approach area and in the south approach area.

GeoEngineers will assume full responsibility as Geotechnical Engineer of Record for the project. This includes confirming/modifying the existing geotechnical design, developing final design for DSM ground improvement, and completing geotechnical construction observations throughout the duration of the project.

SUBSURFACE EXPLORATIONS

We completed 13 additional explorations at the project site to supplement the existing subsurface and groundwater information in the previous geotechnical report. The explorations consist of cone penetration test (CPT) probes and were completed on April 16 and 17, 2012. Seven of the CPT probes were completed in the south approach area to evaluate variability of subsurface soils and depth to bedrock/competent soils. The remaining six CPT probes were completed in the north approach area to evaluate variability of subsurface soils, depth to bedrock/competent soils and effectiveness of compaction grouting. The locations of the additional explorations are shown on the Site Plans, Figures 2 and 3. The logs of the CPT probes are provided in Appendix A.

The additional explorations encountered subsurface conditions consistent with the existing geotechnical information. The subsurface conditions appear to consist of fill, alluvium, estuarine, beach and colluvium deposits overlying the Blakely formation (bedrock). Detailed descriptions of these units are provided in the previous geotechnical report. The CPT probes encountered refusal, most likely at the bedrock surface. Table 1 provides a summary of CPT probe refusal depths.

TABLE 1. DEPTH OF REFUSAL OF CPT PROBES

CPT	Depth to Refusal (feet)
CPT-S01	56.6
CPT-S02	55.1
CPT-S03	63.0
CPT-S04	80.9
CPT-S05	79.7

CPT	Depth to Refusal (feet)
CPT-S06	74.8
CPT-S07	78.1
CPT-N01	8.5
CPT-N02	25.3
CPT-N03	38.3
CPT-N04	34.1
CPT-N05	28.7
CPT-N06	42.7

Groundwater was interpreted at depths ranging from 8 to 9 feet below the ground surface at the south approach area and from 4 to 9 feet below the ground surface at the north approach area. Groundwater conditions are expected to vary locally based on season, precipitation, and other factors.

CONCLUSIONS AND RECOMMENDATIONS

General

Based on the results of our additional explorations and our review of the previous geotechnical report, we conclude that the majority of the geotechnical recommendations presented in the previous geotechnical report dated June 8, 2010 are appropriate for design of the Airport Way South Viaduct over ARGO Railroad Yard project. The explorations completed by S&W (presented in the June 8, 2010 report) were not completed within the construction areas (approach fill areas or bridge span foundation areas) because the existing timber trestle approach structures had not been removed. Our supplemental CPT probe explorations were completed in the construction areas, which allowed us to optimize the geotechnical design for the project. In our opinion, the consolidation settlement estimates, the liquefaction-induced settlement estimates and pile foundation recommendations provided by S&W were overly conservative, in large part due to the lack of subsurface information in the immediate construction areas. Our supplemental evaluations and recommendations for each of these are presented below, along with a comparison to S&W's recommendations.

The results of our consolidation settlement and liquefaction analyses are being used to develop the ground improvement design using DSM columns, particularly with regards to the DSM column spacing and layout. The DSM column design will be provided under separate technical memorandum.

Earthquake Engineering

The ground motions and response spectra provided in the S&W geotechnical report are based on the General Procedure outlined in the 2009 AASHTO LRFD Bridge Design Specifications. Additionally, near fault effects were included in scaling of the response spectra due to the project location relative to the Seattle Fault Zone.

In our opinion, the near fault scaling factors used in development of the S&W response spectra were conservatively applied for the project for the following reasons:

1. The adjustment factor applied by S&W is higher than the factor calculated using the latest NGA attenuation relationships.
2. The adjustment factor computed by S&W is based on the Seattle Fault event, which has a return period of about 2,000 years or more. If the factor is applied deterministically, the resulting design spectra will have a higher risk level than the AASHTO event (1,000 year return period). There is an approach that can be used to calculate risk level compatible adjustment factors such that the bridge is designed with uniform seismic hazard that has 1,000-year return period.

Using realistic scaling factors for a 1,000 year return period earthquake, our design response spectra for the project would be the same or slightly less than that presented in the S&W report for short periods and approximately 20 to 25 percent less than that presented in the S&W report for long periods.

We understand that the bridge (center main span and approach spans) has been designed using the more conservative response spectra provided in the S&W report. Since the project is under construction, it is desired to not change the bridge design. As such, it is our opinion that additional analysis and design optimization are not warranted at this time. Therefore, we are in agreement with the response spectra provided in the S&W report and used in the design of the project.

Consolidation Settlement Analysis

The soft to medium stiff clayey silt layers (alluvium and estuarine deposits) are prone to consolidation settlement. These soils were encountered at depths ranging from 30 to 70 feet below the ground surface. Based on our consolidation settlement analyses and the planned roadway profiles, we estimate that the long term post-construction consolidation settlement due to the new embankment weights will be up to 2 inches at the south approach and less than 1 inch at the north approach. These estimates are for no ground improvement below the approach areas. We understand that the performance criteria for the approach areas is less than 1 inch of settlement for static loading conditions. Therefore, DSM column ground improvement is required for the south approach to meet the design criteria for static loading conditions.

For comparison, consolidation settlements on unimproved ground were estimated in the S&W report to be 4 inches at the south approach and 4½ inches at the north approach. Our DSM column design and layout will be optimized to take into account the revised settlement estimates.

The results of our consolidation settlement analysis are presented in Appendix B. These results will be used in development of the DSM column design, which will be provided under separate cover.

Liquefaction Analyses

Soil liquefaction refers to the condition by which vibration or shaking of the ground, usually from earthquake forces, results in the development of excess pore pressure in saturated soils with subsequent loss of strength. In general, soils that are susceptible to liquefaction at this site include very loose to medium dense, clean to silty sands and non-plastic silts that are below the water table.

The evaluation of liquefaction potential is complex and dependent on numerous parameters, including soil type, grain-size distribution, soil density, depth to groundwater, in-situ static ground stresses, earthquake-induced ground stresses and excess pore water pressure generated during seismic shaking.

We evaluated liquefaction potential of the site soils for the 2009 AASHTO design earthquake event (provided in the S&W report) using the supplemental subsurface data and information obtained from the CPTs. We evaluated liquefaction potential using the simplified method proposed by Youd et al (2001). The seismic design parameters used in our liquefaction analyses are based on those presented in the S&W geotechnical report and are provided in Table 2 below.

TABLE 2. SEISMIC DESIGN PARAMETERS[1]

Design Earthquake	Magnitude	Peak Ground Acceleration (g)
AASHTO Event	6.8	0.47

Notes:

[1] Seismic parameters were taken from S&W's Geotechnical report, dated June 8, 2010.

Based on our analyses, the site soils are highly susceptible to liquefaction under the AASHTO design earthquake event. The results of our analysis indicate that at the south approach approximately 6 to 12 inches of liquefaction-induced settlement may occur after a design earthquake, and approximately 4 to 6 inches of liquefaction-induced settlement may be expected at the north approach. These estimates are for no ground improvement below the approach areas. We understand that the performance criteria for the approach areas is less than 1 inch of settlement for seismic loading conditions. Therefore, ground improvement is required for both the north approach and the south approach for seismic loading conditions.

For comparison, liquefaction-induced settlements on unimproved ground were estimated in the S&W report to be 12 to 20 inches at the south approach and 2 to 19 inches at the north approach. Our DSM column design and layout will be optimized to take into account the revised settlement estimates.

The results of our soil liquefaction analysis are presented in Appendix C. These results will be used in development of the DSM column design, which will be provided under separate cover.

Pile Foundations

Axial Capacity

Axial pile capacity in compression will be developed from a combination of side frictional resistance and end bearing capacity. The majority of the capacity will be developed primarily in the underlying Blakely formation (bedrock). We understand that 18-inch-diameter steel pipe piles are being used for the project. We recommend that the piles be driven open-ended to facilitate pile penetration into the Blakely formation (bedrock). Estimated axial downward and uplift capacity of 18-inch steel pipe piles and the resistance for extreme and strength limit states are shown on Figures 4 and 5, for the south and north approach areas, respectively. The analyses were completed in accordance with the 2010 AASHTO LRFD Bridge Design Specifications, which are identical to the 2009 AASHTO Bridge Design Specifications for design of pile foundations.

The pile capacities were determined based on the α-method for cohesive soils and Nordlund/Thurman method for frictional soils as described in the AASHTO Section 10.7.3.8.6 and include the resistance factors shown on Figures 4 and 5.

Downdrag loads due to liquefaction-induced ground settlement should be included in the design for the extreme limit state. Downdrag loads are provided on Figures 4 and 5.

The capacities apply to single piles. If piles are spaced at least three pile diameters on center, as recommended, no reduction for group action is needed.

Pile Settlement

The piles will be embedded within the Blakely formation (bedrock). Pile settlements are expected to be essentially elastic in nature and occur as loads are applied. We estimate that the post-construction settlement of piles constructed as recommended will be on the order of ½ inch or less.

Lateral Capacity

We take no exception to the lateral capacity recommendations provided in the S&W geotechnical report for the project. The lateral capacity recommendations are appropriate for design of the project.

Construction Considerations

Difficult driving should be expected during installation of the piles due to the required penetration and embedment into the Blakely formation (bedrock). The steel piles should be driven to the minimum tip elevation and bearing in accordance with the Project Manual.

The piles should be installed using an appropriately sized pile driving hammer. The pile driving hammer should be of sufficient size to drive the piling to the required nominal (ultimate) capacity and/or minimum embedment depth without damaging the pile. Because the contractor has control of the pile/hammer configuration and the driving equipment, we recommend that the pile contractor be made responsible for selecting the appropriate pile-driving hammer and installing the piles to the design embedment depth without damaging the piles. Pile driveability analyses, such as WEAP, for the specific pile type and pile driving hammer should be completed by the contractor and provided to GeoEngineers for review.

The discussions provided in the previous geotechnical report for pile driving vibrations, movement monitoring, and noise levels are still appropriate for this project. We take no exception to these recommendations.

LIMITATIONS

We have prepared this addendum report for the exclusive use of the City of Seattle, HNTB Corporation and their authorized agents for the Airport Way South Viaduct over ARGO Railroad Yard project located in Seattle, Washington. The data and preliminary report should be provided to prospective contractors for their bidding or estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions express or implied should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Appendix D titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

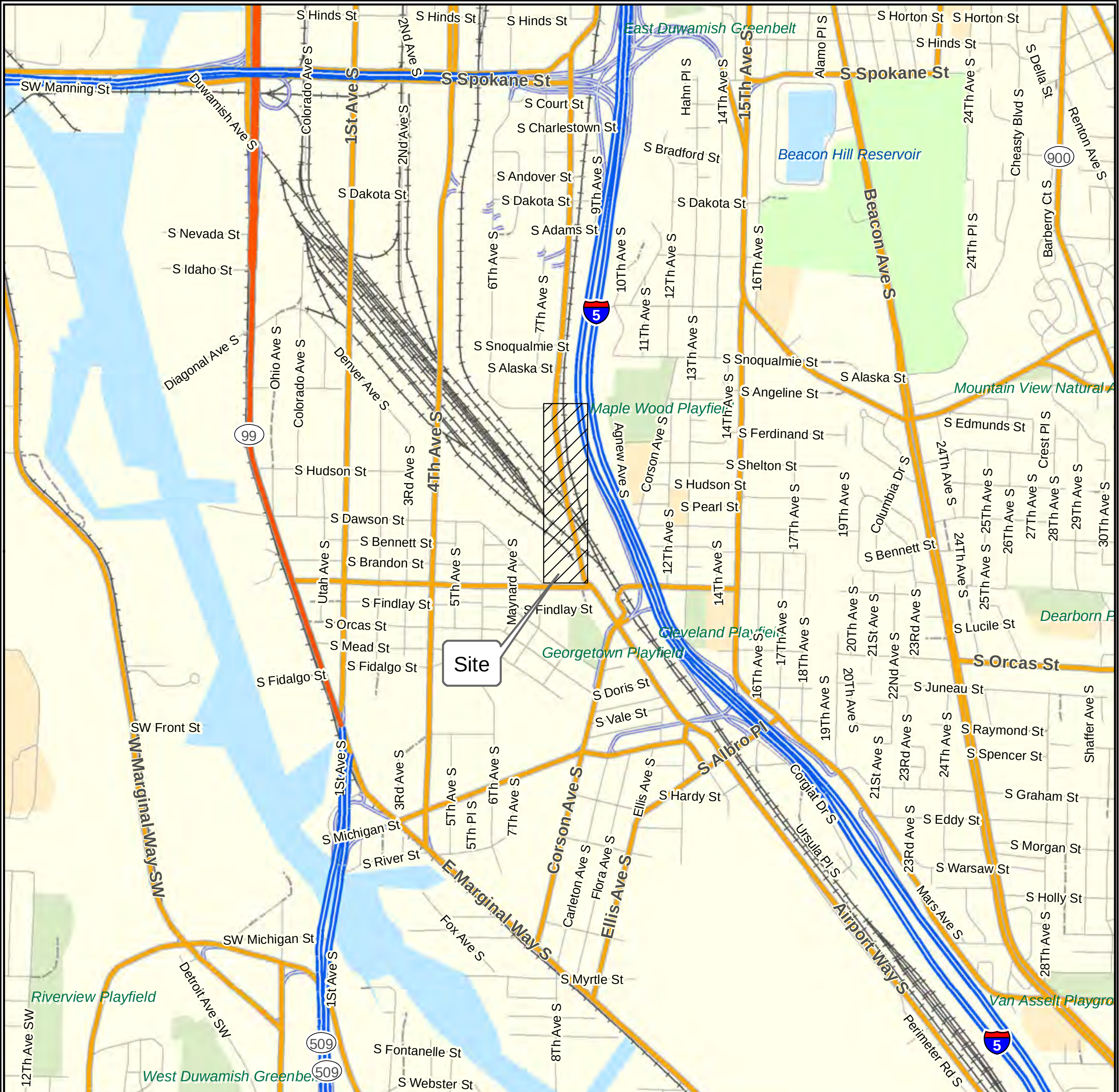
Sincerely,
GeoEngineers, Inc.

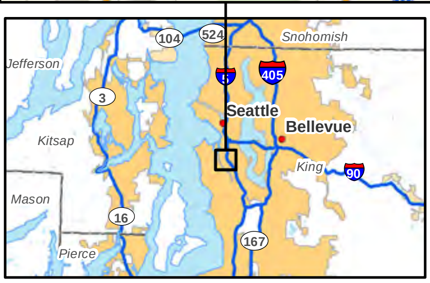
Heidi P. Disla
Geotechnical Engineer

Shaun D. Stauffer, PE, LEEP AP
Associate

HPD:SDS:nlu

Attachments:
Figure 1. Vicinity Map
Figure 2. Site Plan – North Abutment
Figure 3. Site Plan – South Abutment
Figure 4. AASHTO Driven Pile Capacity – South Approach
Figure 5. AASHTO Driven Pile Capacity – North Approach
Appendix A. Subsurface Explorations
Figures A-1 through A-13 – Log of CPTs
Appendix B. Results of Consolidation Settlement Analysis
Appendix C. Results of Liquefaction Analysis
Figures C-1 through C-13 – Factor of Safety Against Liquefaction based on CPT's
Appendix D. Report Limitations and Guidelines for Use





N
W E
S

2,000 0 2,000

Feet

Notes:
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Data Sources: ESRI Data & Maps, Street Maps 2005

Transverse Mercator, Zone 10 N North, North American Datum 1983
North arrow oriented to grid north

Vicinity Map

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, Washington

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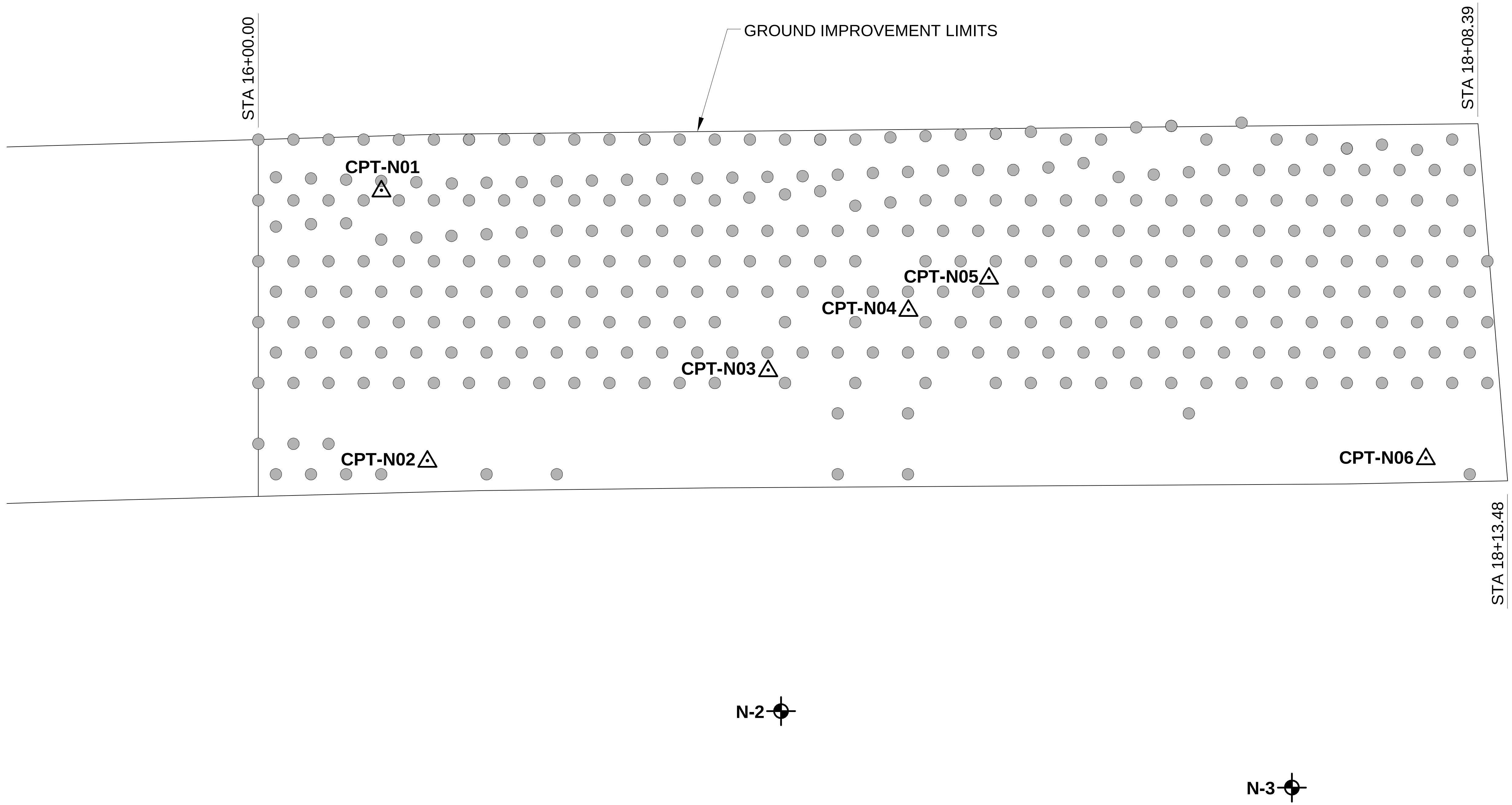
Figure 1

Office: Redmond Path: \\red\projects\0\0129141\GIS\012914100_F1_VicinityMap.mxd Map Revised: April 25, 2012 EL



Notes

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Reference: GeoEngineers staff sketch.

Legend

- Compaction Grouting Column Installed
- CPT-N01 Cone Penetration Test by GeoEngineers, April 2012
- N-2 Boring by Shannon & Wilson, June 2010

20 0 20
FEET

Site Plan - North Abutment

Airport Way South Viaduct
over ARGO Railroad Yard
Seattle, Washington

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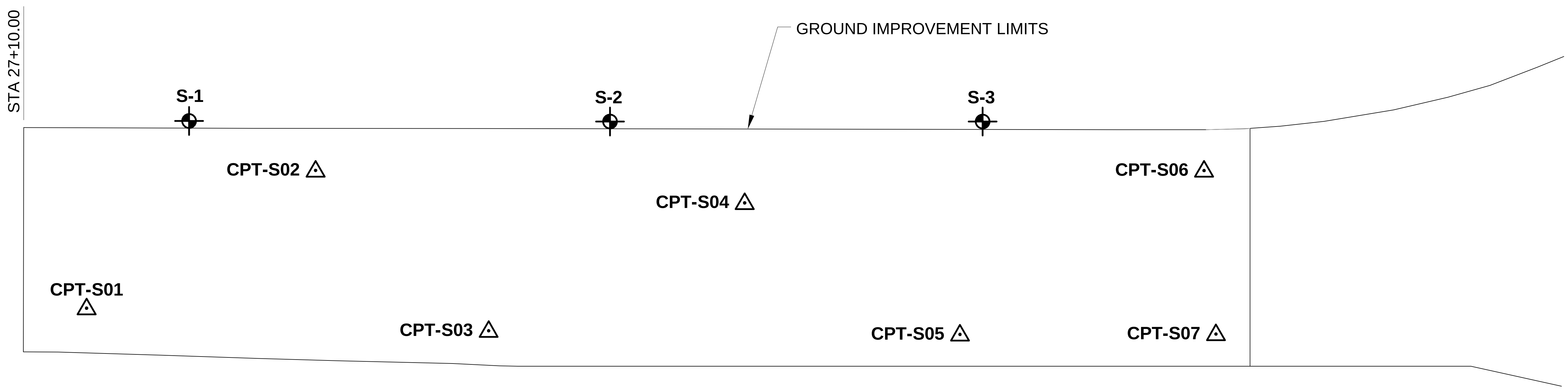
Figure 2



Notes

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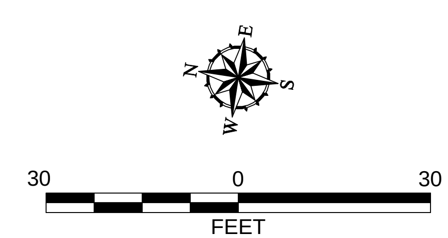
Reference: GeoEngineers staff sketch.

Legend

CPT-S01 — Cone Penetration Tests by GeoEngineers, April 2012

S-1 — Boring by Shannon & Wilson, June 2010



Site Plan - South Abutment

Airport Way South Viaduct
over ARGO Railroad Yard
Seattle, Washington

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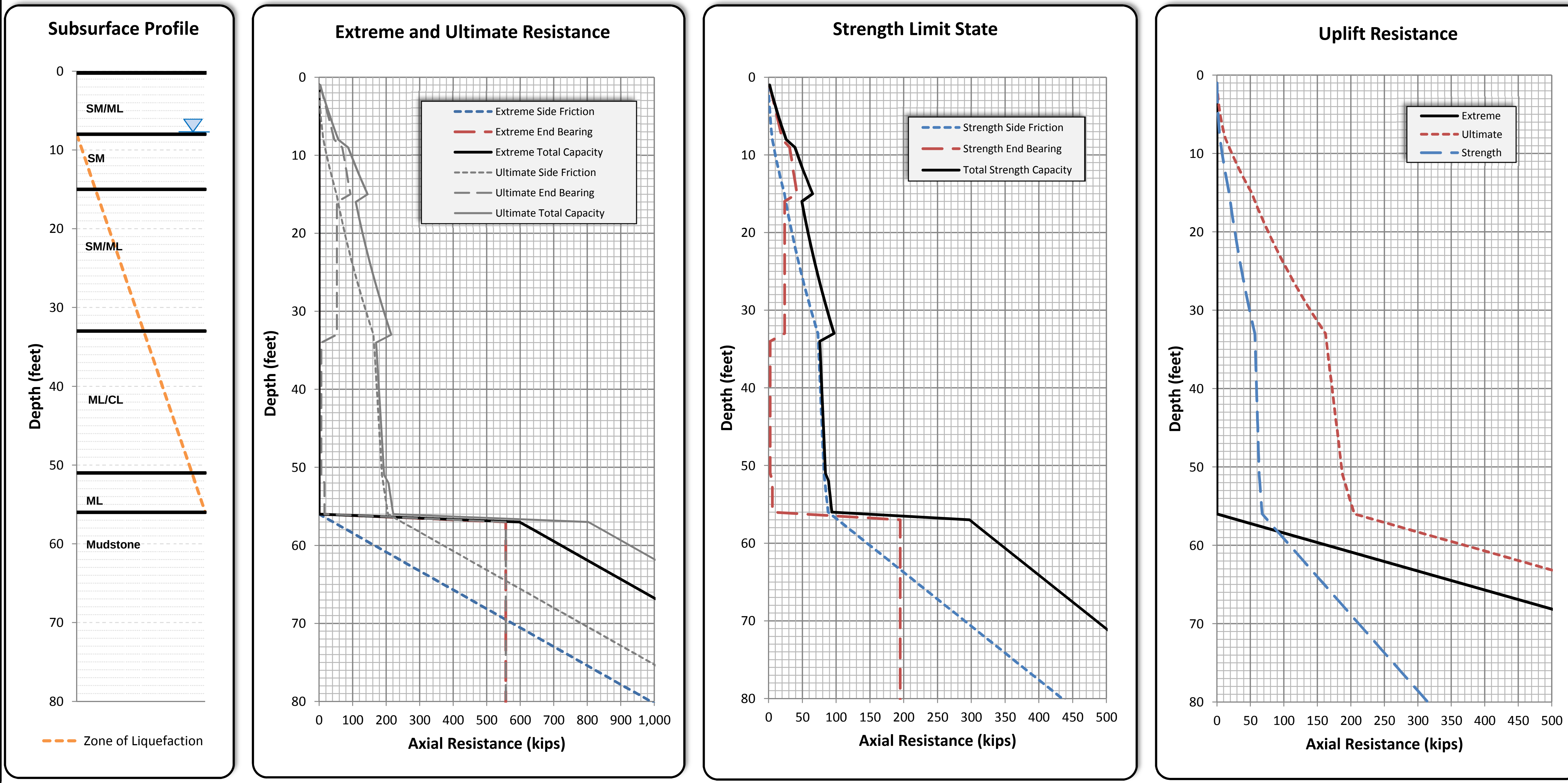
Figure 3

AASHTO DRIVEN PILE CAPACITY

18-inch Steel Pipe Pile



General Notes

1. The pile capacities were developed in accordance with the 2010 AASHTO LRFD Bridge Design Manual and the 2010 WSDOT Geotechnical Design Manual (GDM) following the α-method for cohesive soil and Nordland/Thurman method for frictional soil.
2. The plots are based on a single pile and do not consider group effects of closely spaced piles.
3. The service case for single piles is assumed to be equivalent to the ultimate (unfactored) resistance.
4. The appropriate LRFD resistance factors, as presented in the "Resistance Factors" table are included in the plots presented above.
5. The soils at this site are susceptible to liquefaction. An unfactored downdrag load of 69 kips should be used in accordance with Section 3.11.8 of the AASHTO LRFD Manual.

Resistance Factors		
	Downward	Uplift
α–Method	0.35	0.25
N/T-Method	0.45	0.35

South Approach

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, Washington

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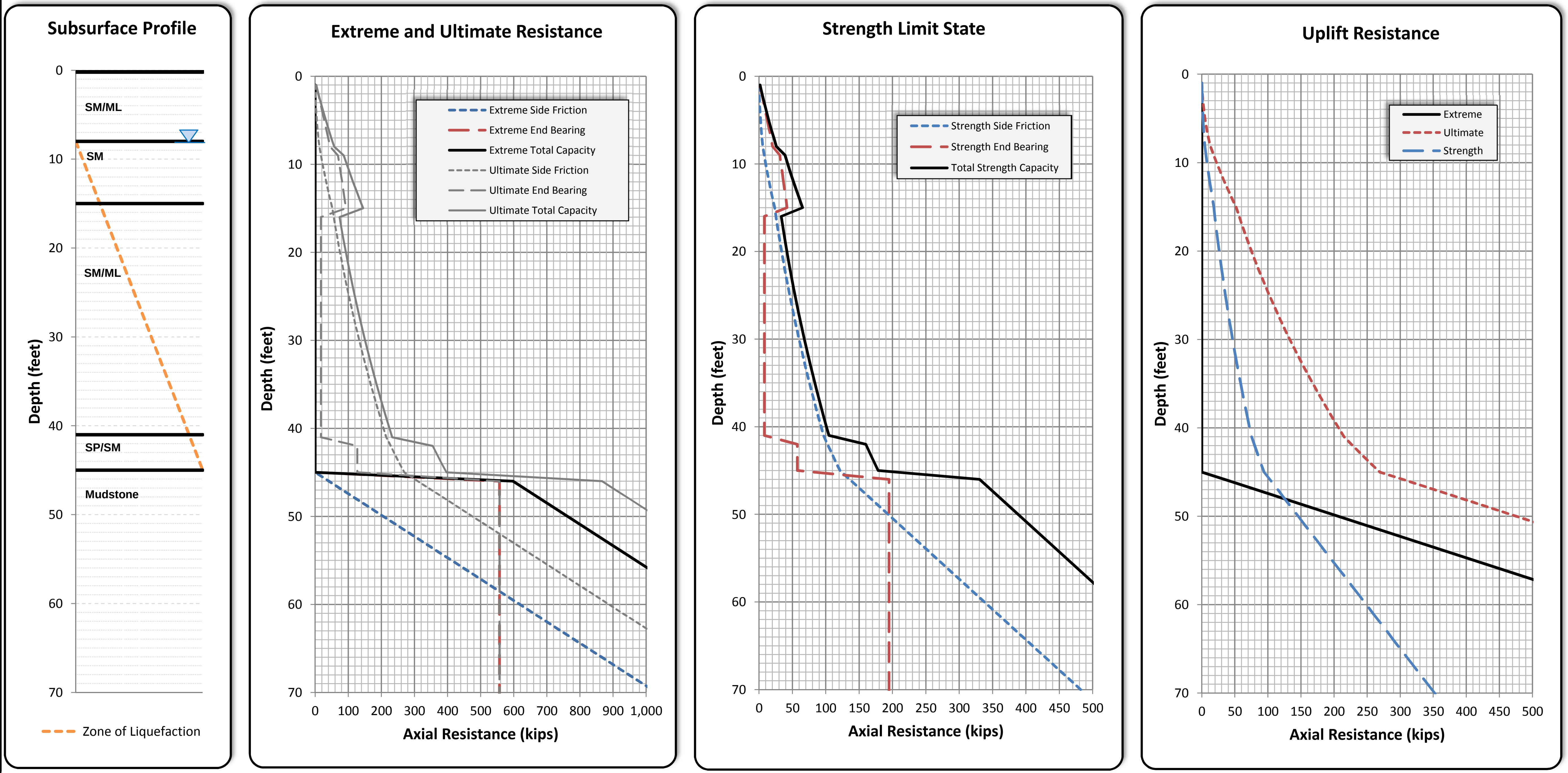
Figure 4

AASHTO DRIVEN PILE CAPACITY

18-inch Steel Pipe Pile



General Notes

1. The pile capacities were developed in accordance with the 2010 AASHTO LRFD Bridge Design Manual and the 2010 WSDOT Geotechnical Design Manual (GDM) following the α-method for cohesive soil and Nordland/Thurman method for frictional soil.
2. The plots are based on a single pile and do not consider group effects of closely spaced piles.
3. The service case for single piles is assumed to be equivalent to the ultimate (unfactored) resistance.
4. The appropriate LRFD resistance factors, as presented in the "Resistance Factors" table are included in the plots presented above.
5. The soils at this site are susceptible to liquefaction. An unfactored downdrag load of 56 kips should be used in accordance with Section 3.11.8 of the AASHTO LRFD Manual.

Resistance Factors		
	Downward	Uplift
α–Method	0.35	0.25
N/T-Method	0.45	0.35

North Approach

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, Washington

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Figure 5

APPENDIX A
Subsurface Explorations

APPENDIX A
SUBSURFACE EXPLORATIONS

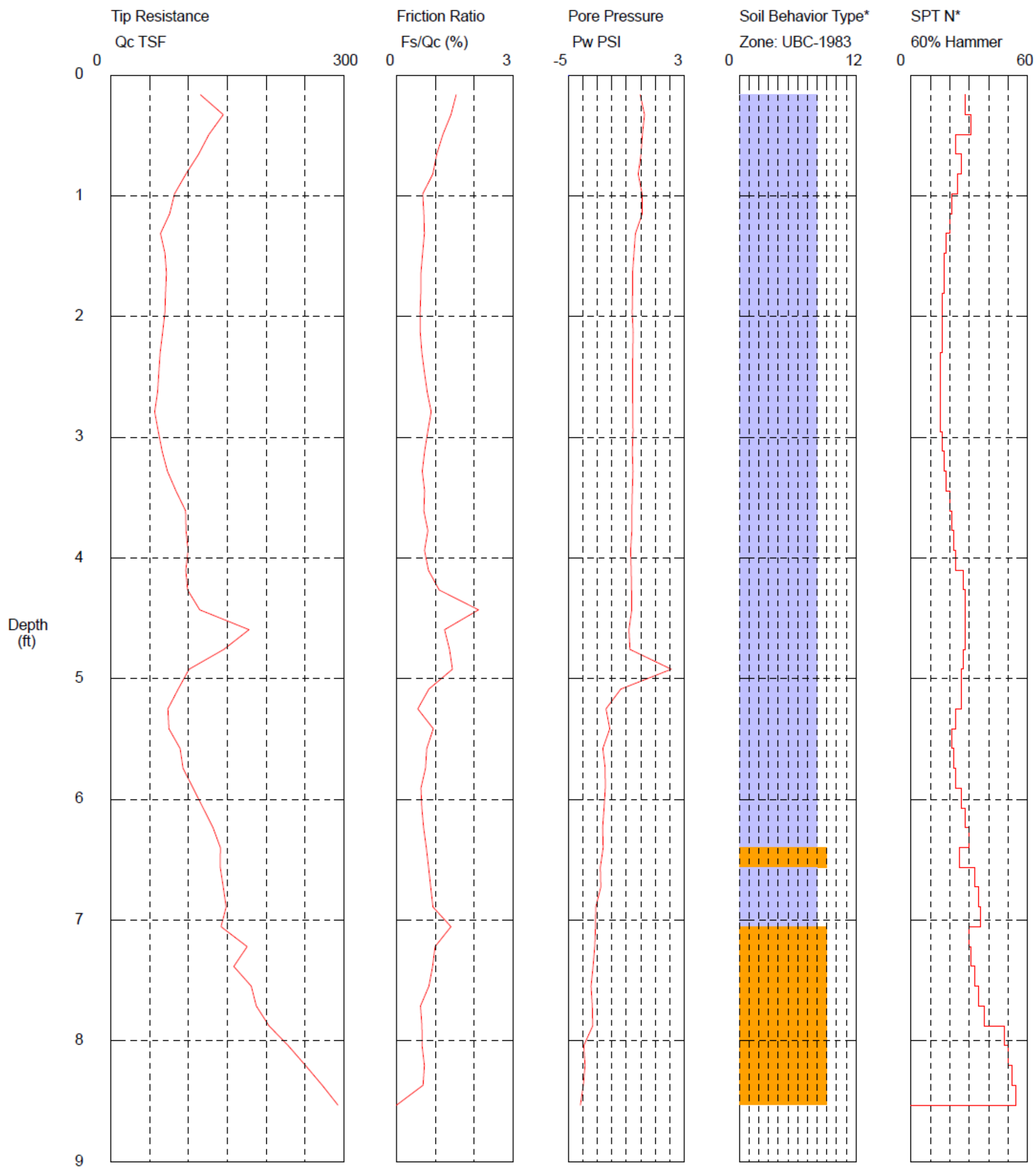
We explored subsurface conditions at the site by advancing 13 additional explorations/CPT soundings. The CPT is a subsurface exploration technique in which a small-diameter steel tip with adjacent sleeve is continuously advanced with hydraulically operated equipment. Measurements of tip and sleeve resistance allow interpretation of the soil profile and the consistency of the strata penetrated. The tip resistance, friction ratio and pore water pressure are recorded on the CPT logs. The logs of the CPT soundings are presented in Figures A-1 through A-13.

In situ Engineering of Snohomish, Washington completed the CPT soundings using track-mounted CPT equipment. The CPT soundings were advanced to depths ranging from 9 to 43 feet below the existing ground surface at the north approach, and to depths ranging from 55 to 81 feet below the existing ground surface at the south approach. The CPT soundings were backfilled in general accordance with procedures outlined by the Washington State Department of Ecology.

GeoEngineers

Operator: Gerdes
Sounding: CPT-N01
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 3:45:19 PM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 8.53 feet

Depth Increment = 0.164 feet

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

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Note:

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Log of CPT-N01

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

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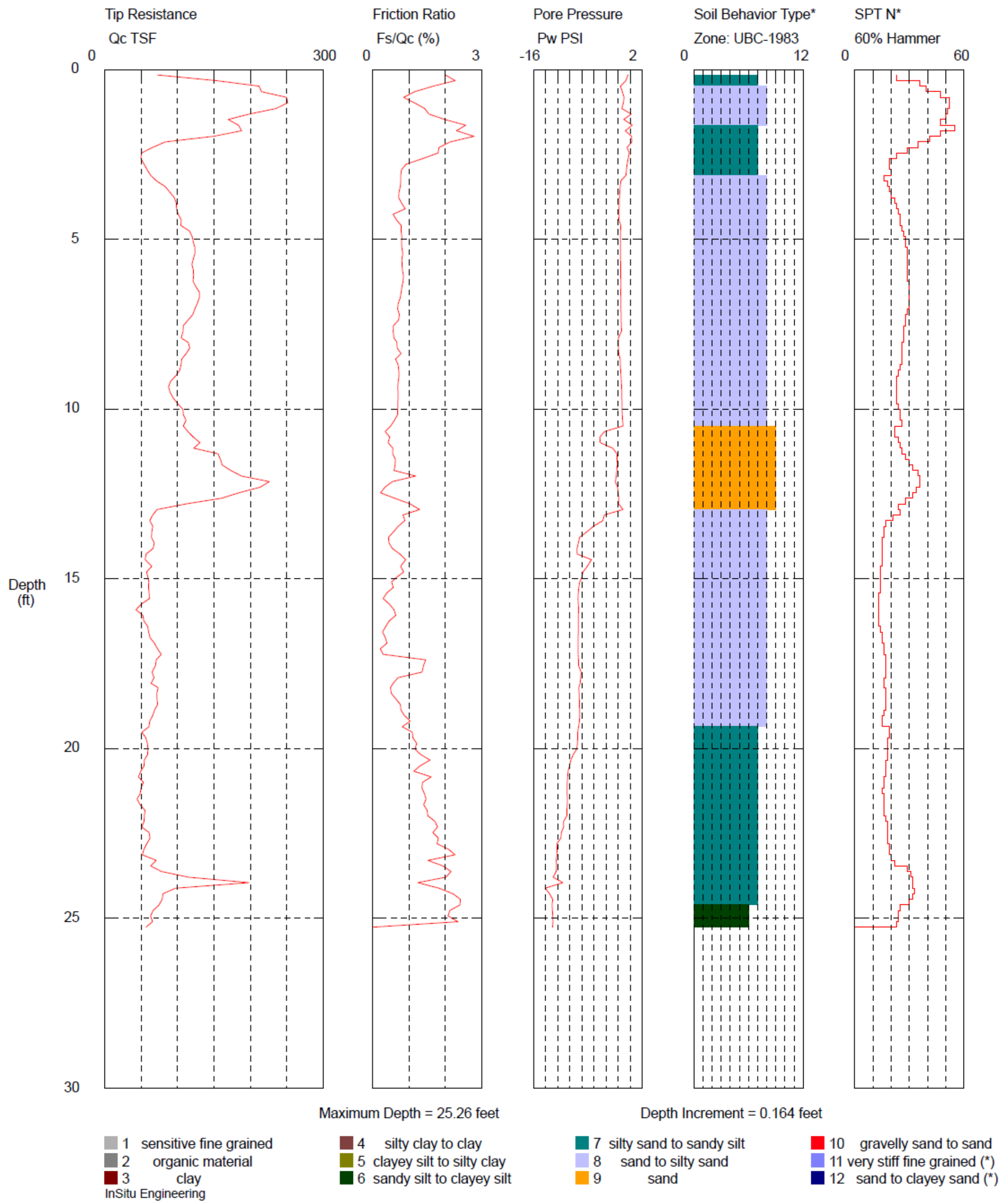
Figure A-1

GeoEngineers

Operator: Gerdes
Sounding: CPT-N02
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 3:09:25 PM
Location: S Lucille Street
Job Number: 01239-141-00



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Log of CPT-N02

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

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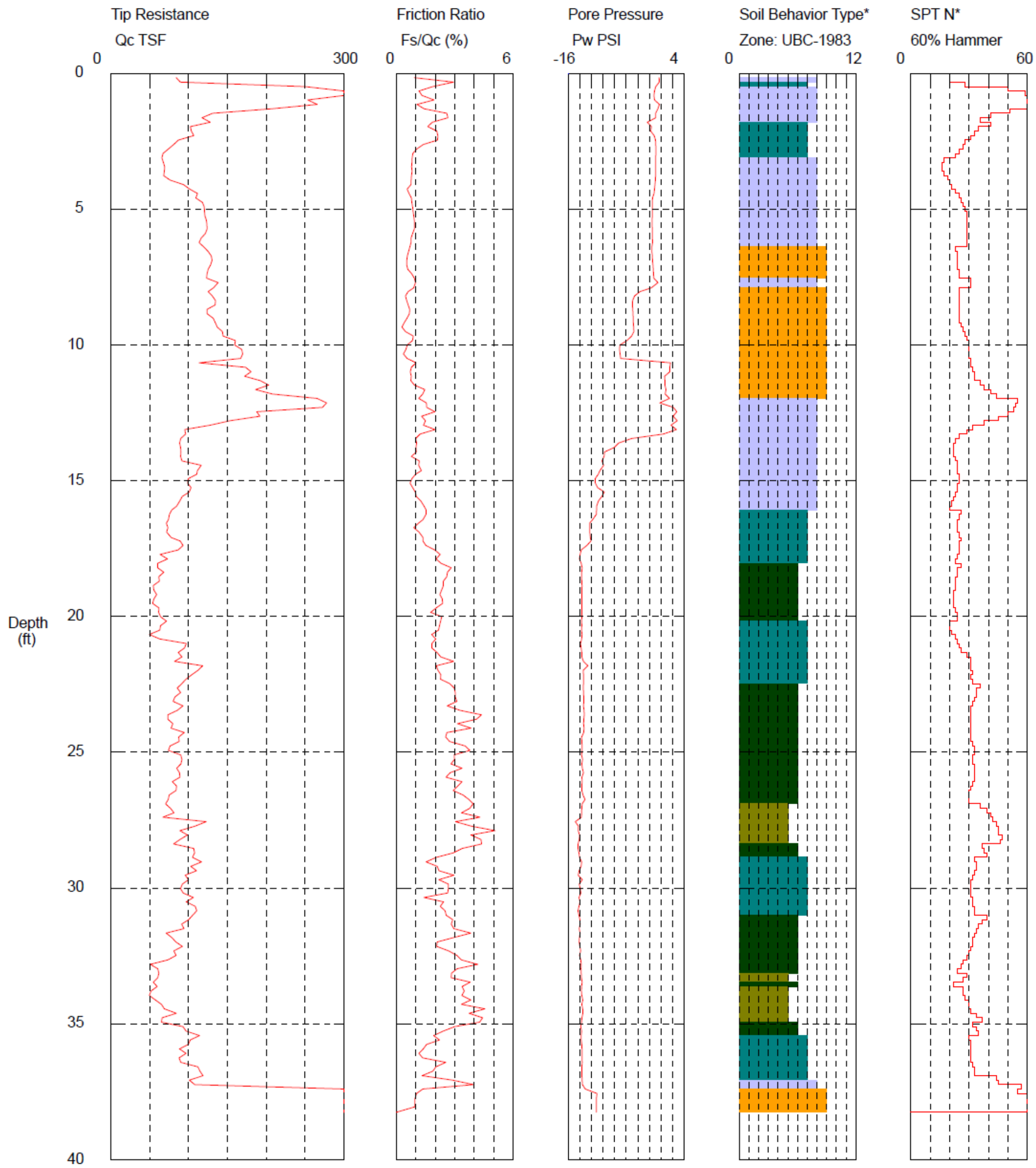
Figure A-2

GeoEngineers

Operator: Gerdes
Sounding: CPT-N03
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 1:36:44 PM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 38.25 feet

Depth Increment = 0.164 feet

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

InSitu Engineering

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Log of CPT-N03

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

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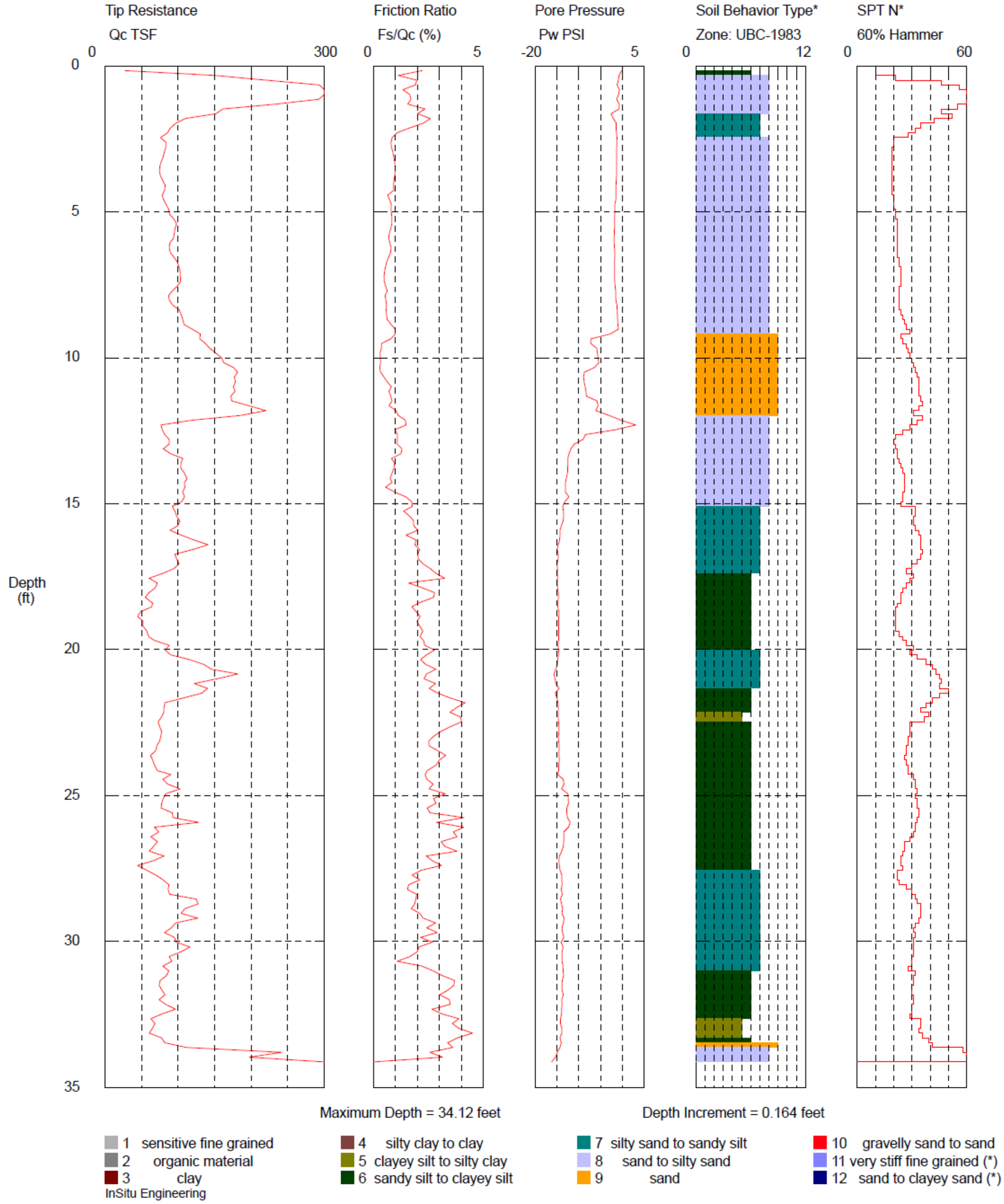
Figure A-3

GeoEngineers

Operator: Gerdes
Sounding: CPT-N04
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 12:40:04 PM
Location: S Lucille Street
Job Number: 01239-141-00



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Log of CPT-N04

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

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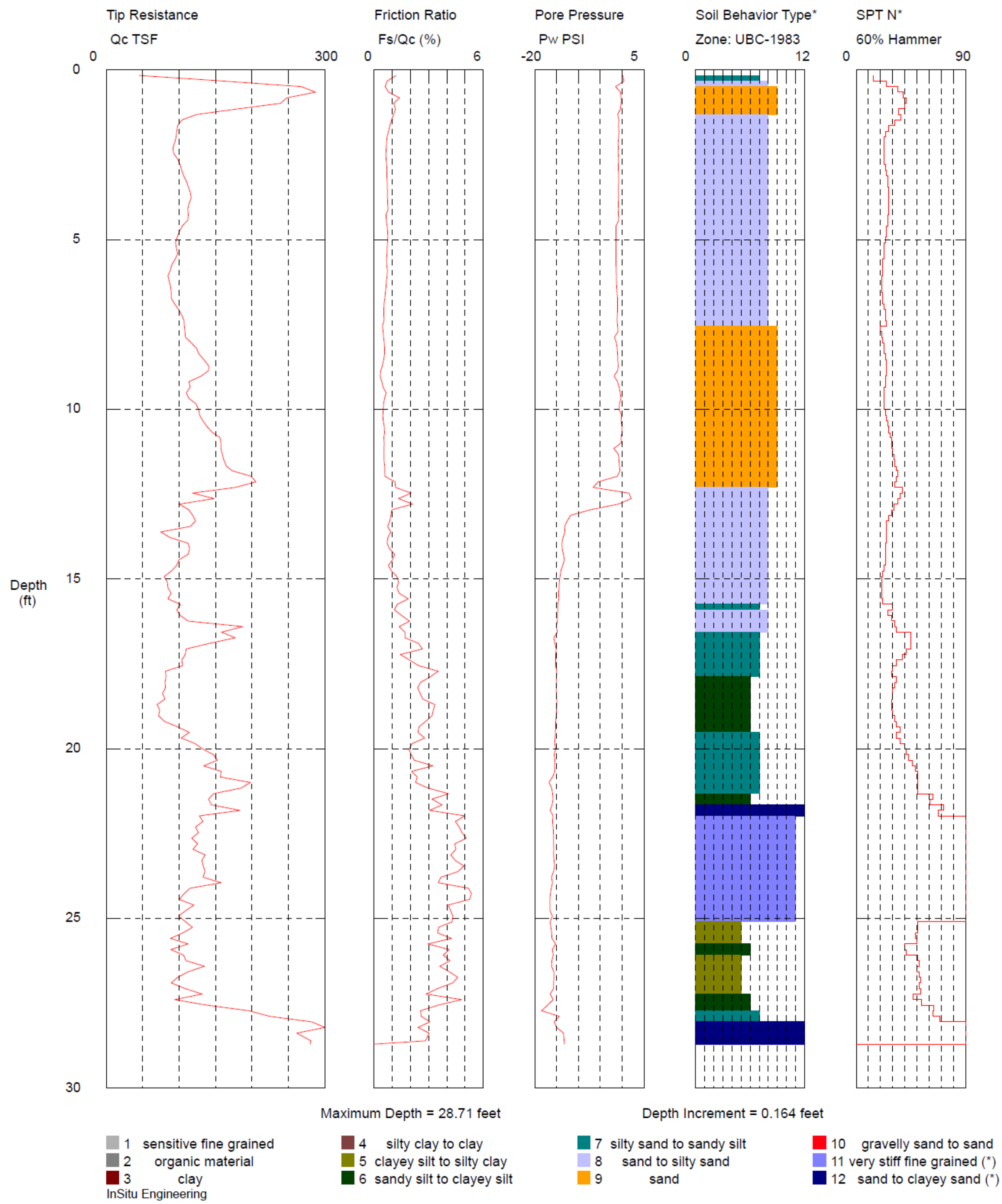
Figure A-4

Sharepoint: 00129-141-00\Technical Analysis\CPT North\Airport Way Viaduct-N04.PDF hpd:frv 04/30/2012

GeoEngineers

Operator: Gerdes
Sounding: CPT-N05
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 11:39:57 AM
Location: S Lucille Street
Job Number: 01239-141-00



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Log of CPT-N05

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

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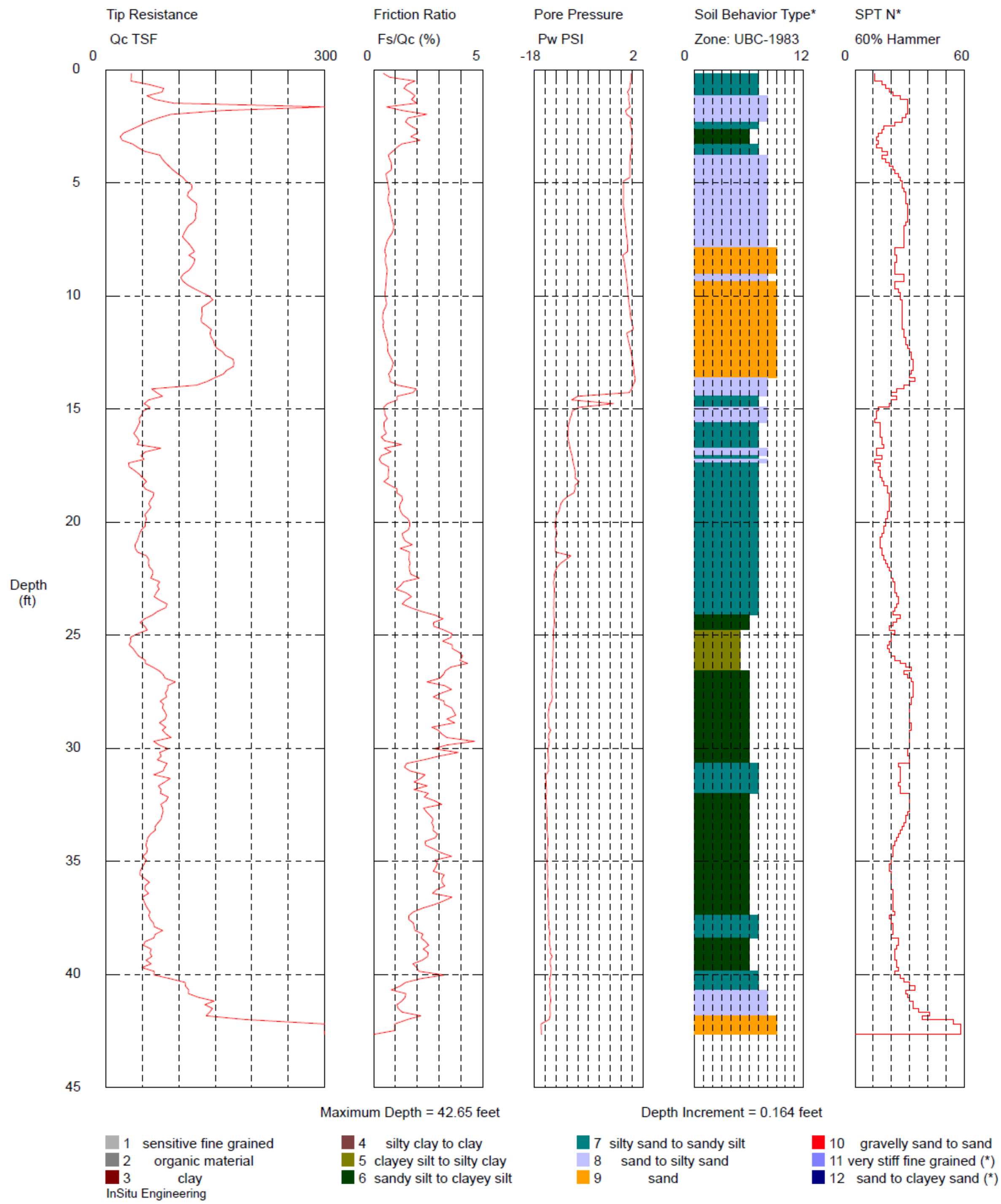
Figure A-5

GeoEngineers

Operator: Gerdes
Sounding: CPT-N06
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 10:39:43 AM
Location: S Lucille Street
Job Number: 01239-141-00



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Log of CPT-N06

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GeoEngineers

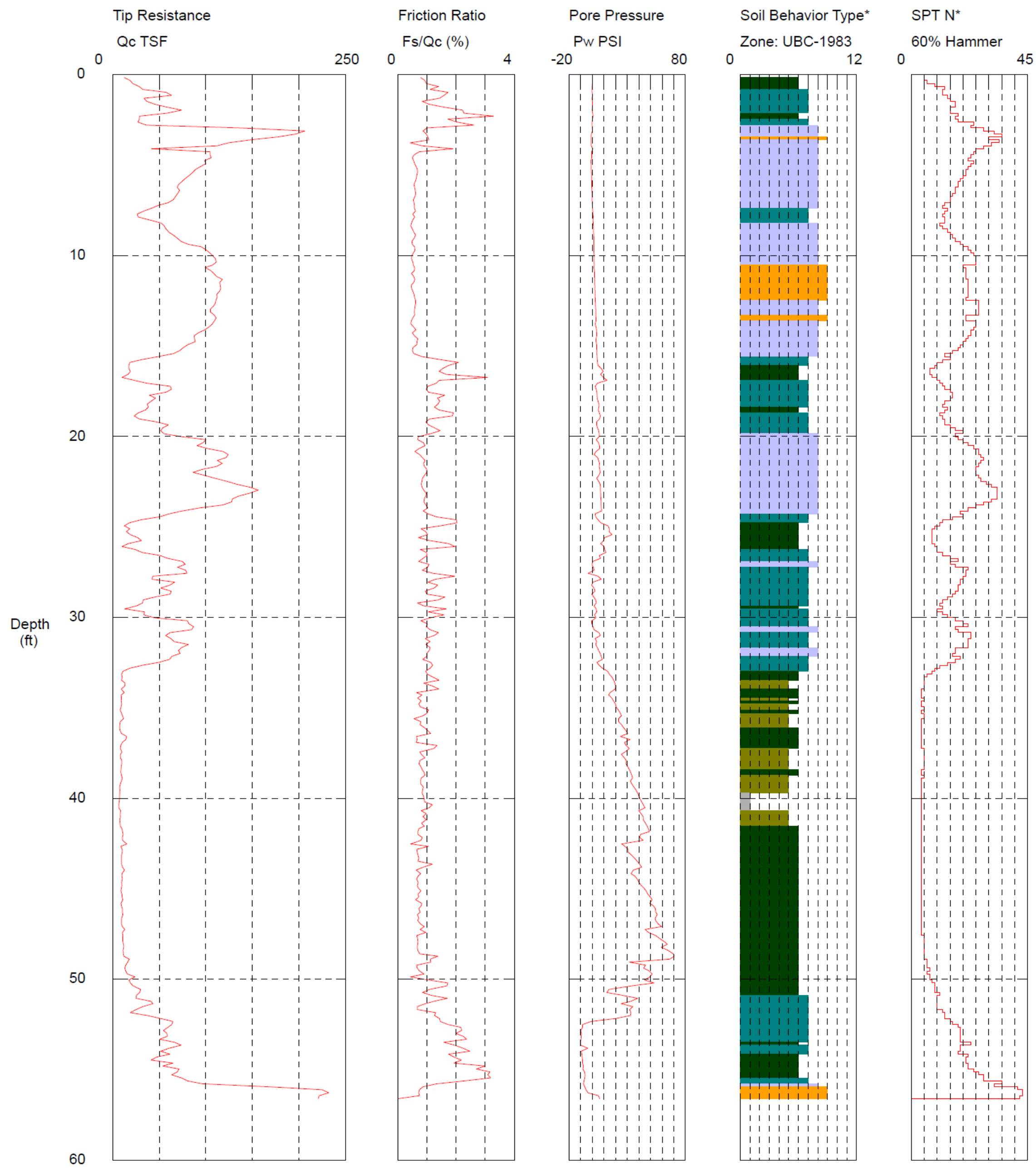
Figure A-6

Sharepoint: 00129-141-00\Technical Analysis\CPT North\Airport Way Viaduct-N06.PDF hpd:frv 04/30/2012

GeoEngineers

Operator: Gerdes
Sounding: CPT-S01
Cone Used: DPG1186

CPT Date/Time: 4/16/2012 9:35:00 AM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 56.59 feet

Depth Increment = 0.164 feet

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 (*)

InSitu Engineering

Note:

1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Log of CPT-S01

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

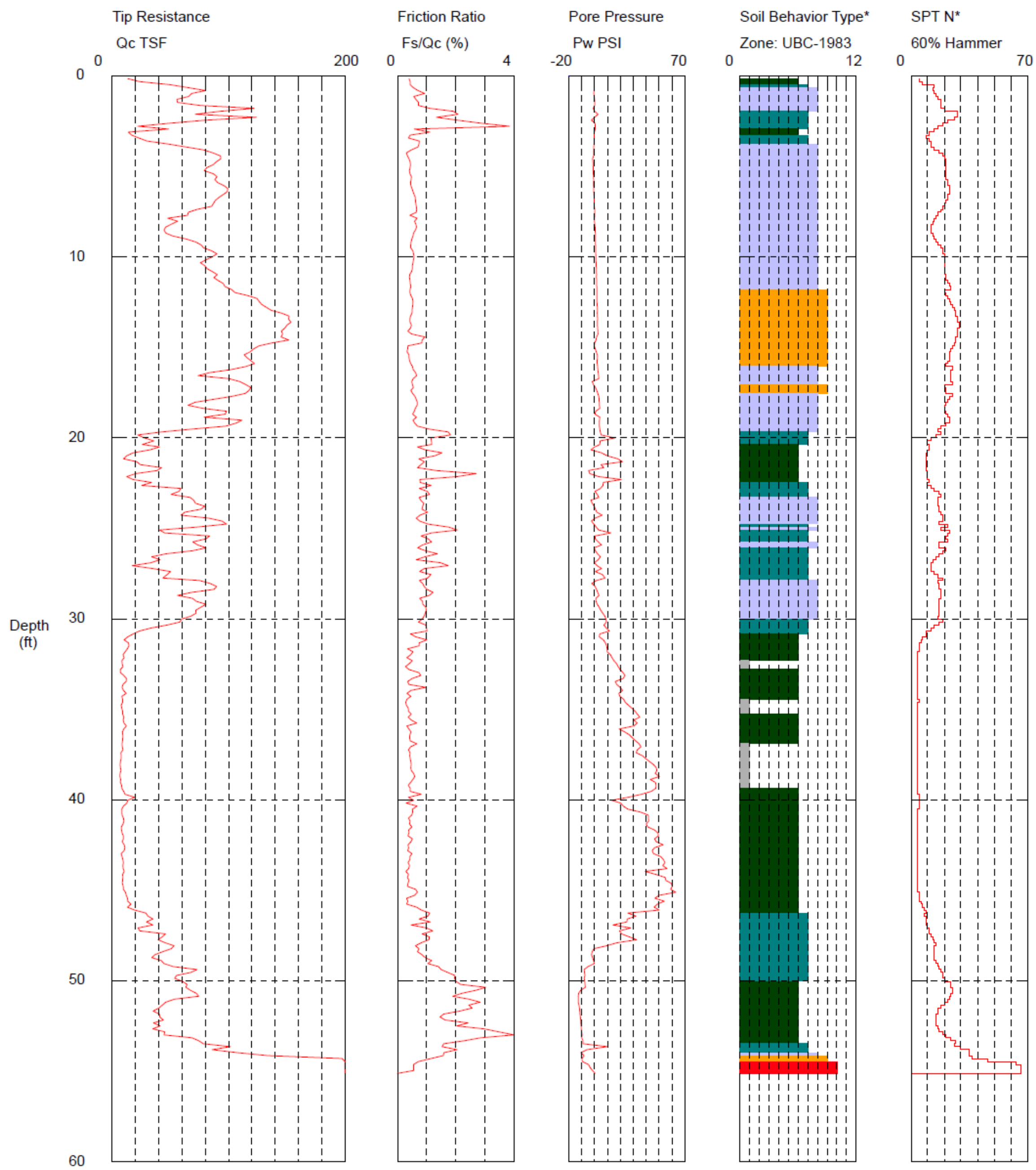
GEOENGINEERS

Figure A-7

GeoEngineers

Operator: Gerdes
Sounding: CPT-S02
Cone Used: DPG1186

CPT Date/Time: 4/16/2012 8:34:53 AM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 55.12 feet

Depth Increment = 0.164 feet

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 (*)

InSitu Engineering

Note:

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Log of CPT-S02

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

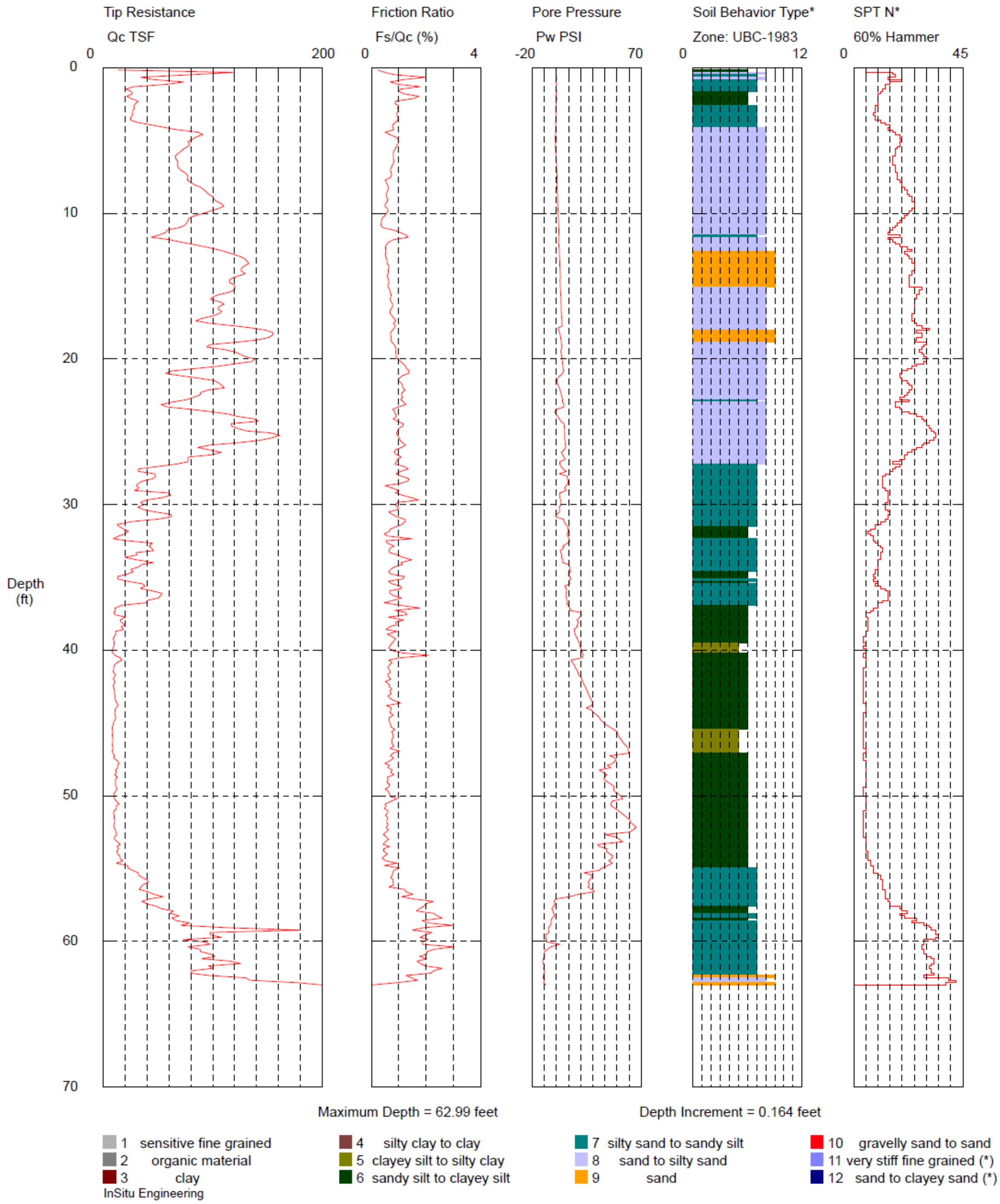
Figure A-8

Sharepoint: 00129-141-00\Technical Analysis\CPT South\Airport Way Viaduct-S02.PDF hpd:frv 04/30/2012

GeoEngineers

Operator: Gerdes
Sounding: CPT-S03
Cone Used: DPG1186

CPT Date/Time: 4/16/2012 10:40:19 AM
Location: S Lucille Street
Job Number: 01239-141-00



Note:

1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Log of CPT-S03

Airport Way South over Viaduct ARGO Railroad Yard
Seattle, WA

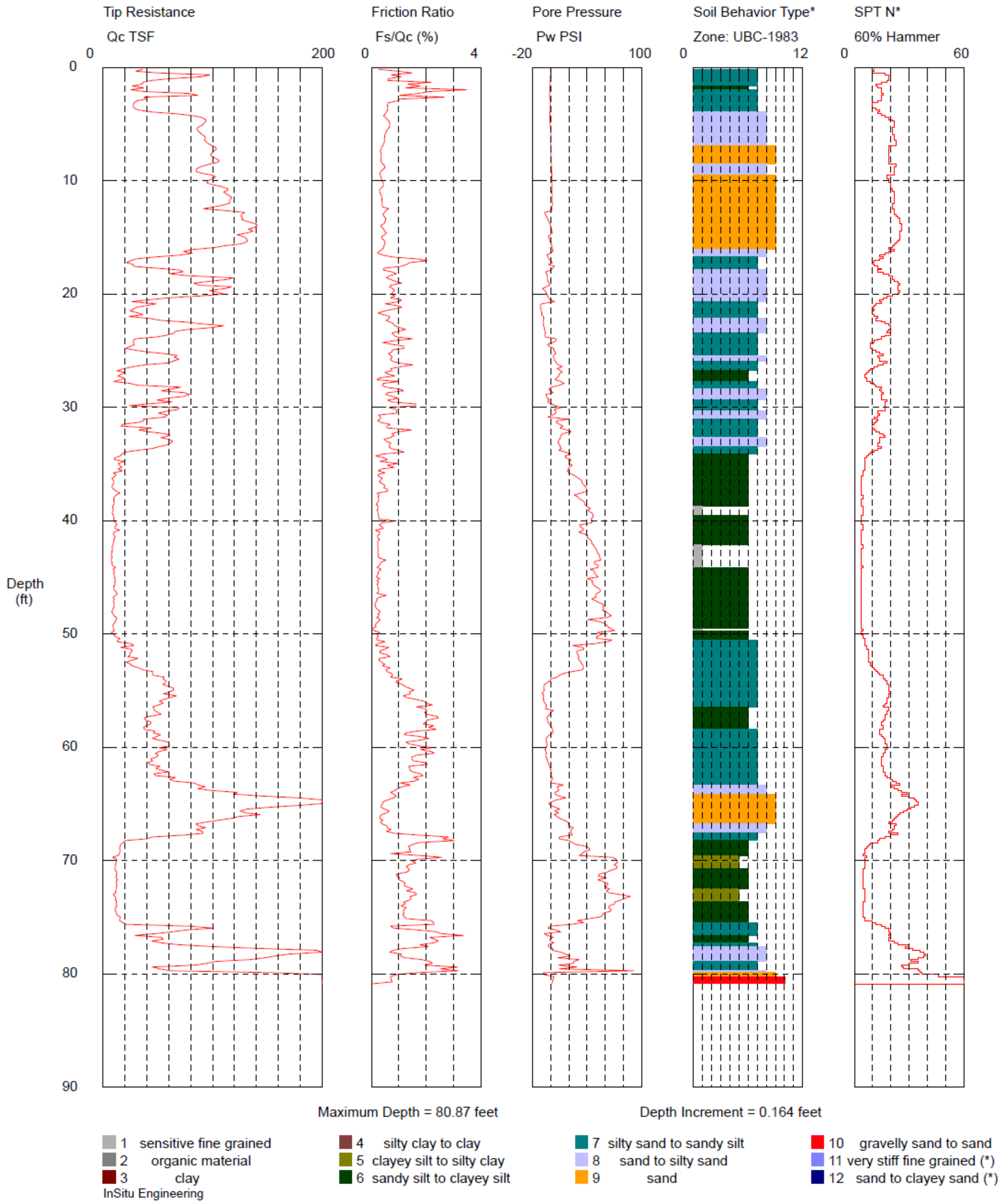
GEOENGINEERS

Figure A-9

GeoEngineers

Operator: Gerdes
Sounding: CPT-S04
Cone Used: DPG1186

CPT Date/Time: 4/16/2012 12:02:30 PM
Location: S Lucille Street
Job Number: 01239-141-00



Note:

1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Log of CPT-S04

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

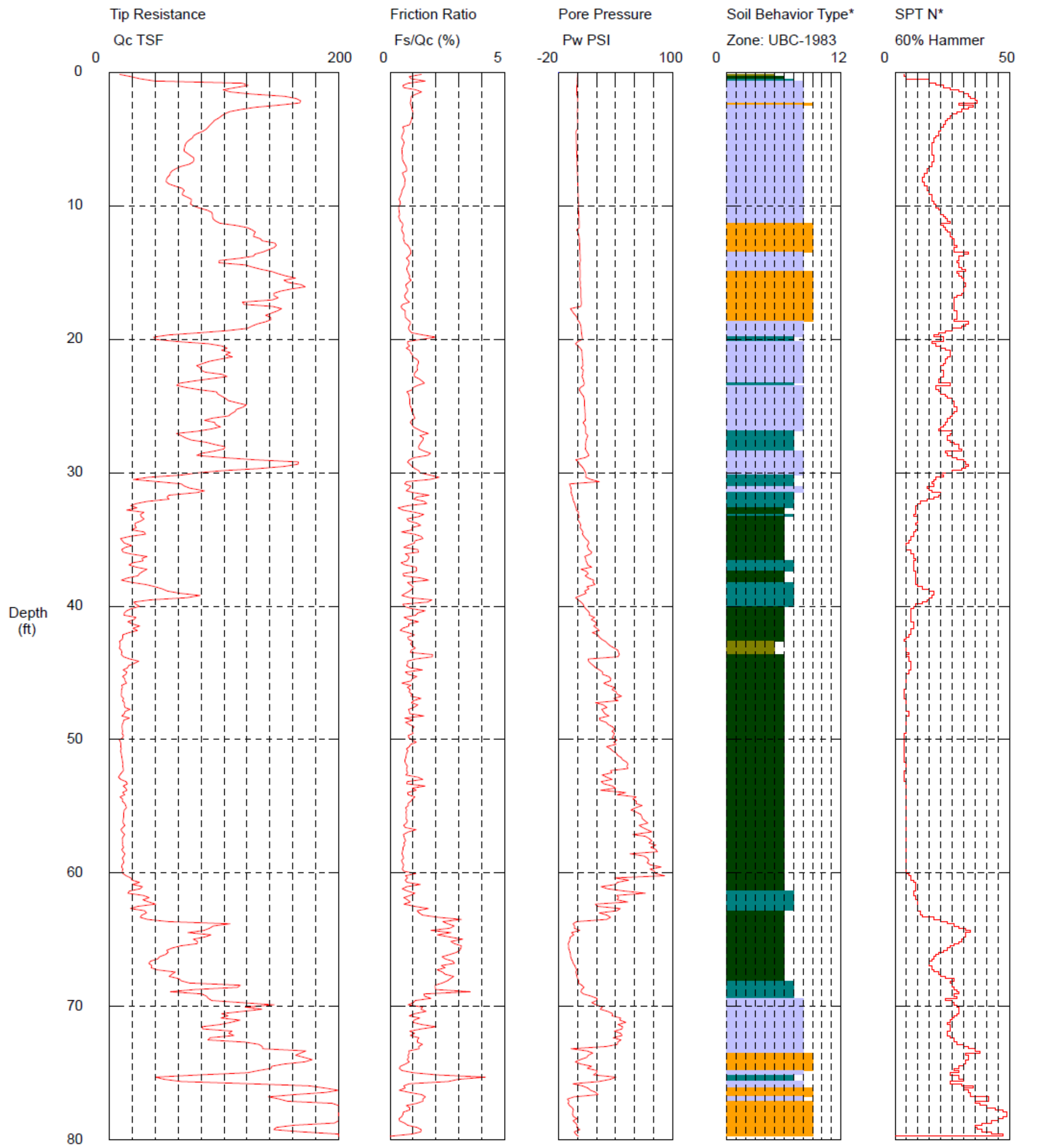
GEOENGINEERS

Figure A-10

GeoEngineers

Operator: Gerdes
Sounding: CPT-S05
Cone Used: DPG1186

CPT Date/Time: 4/16/2012 1:15:58 PM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 79.72 feet
Depth Increment = 0.164 feet

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 (*)

InSitu Engineering

Note:

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Log of CPT-S05

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

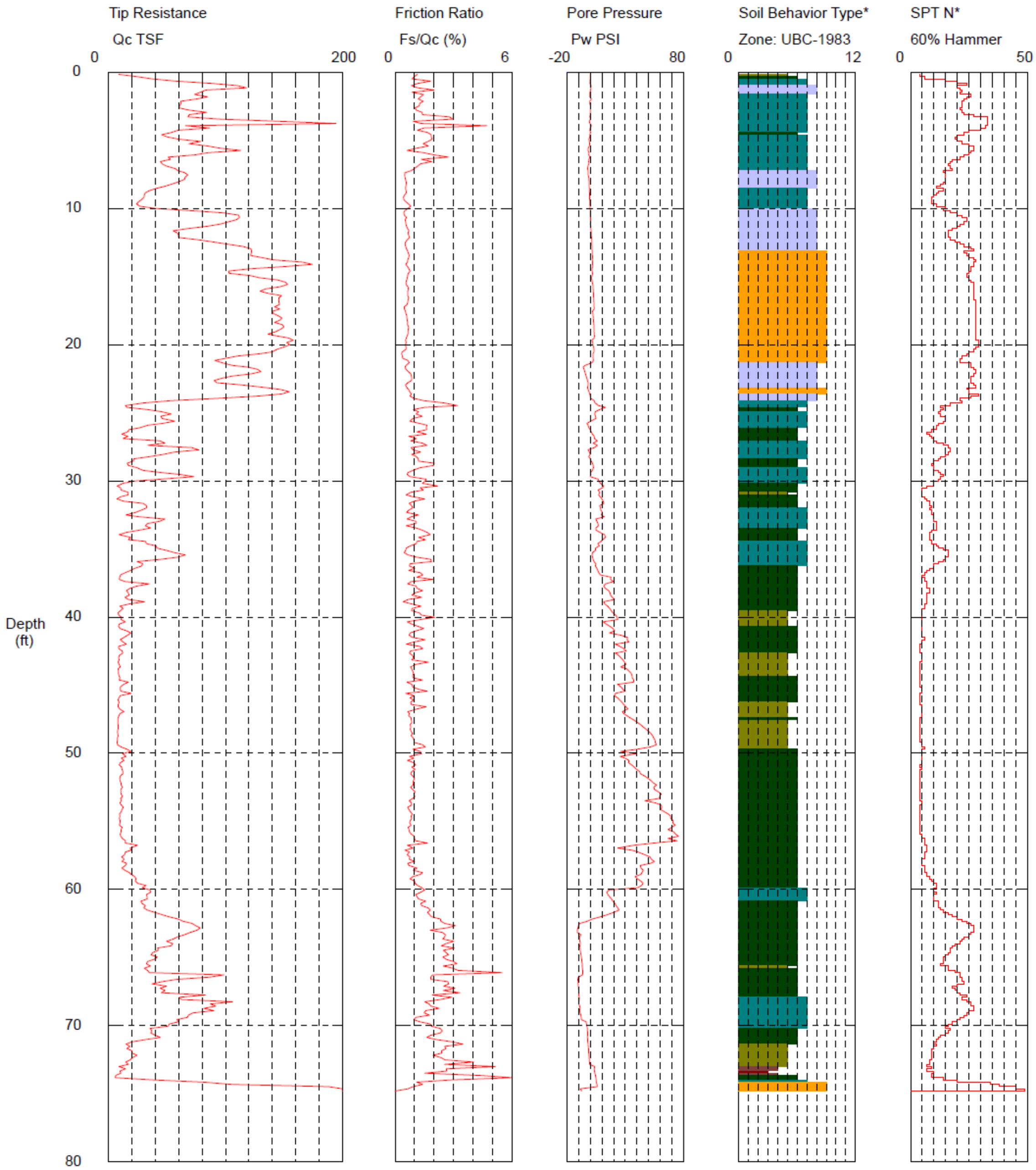
GeoEngineers

Figure A-11

GeoEngineers

Operator: Gerdes
Sounding: CPT-S06
Cone Used: DPG1186

CPT Date/Time: 4/16/2012 2:41:06 PM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 74.80 feet

Depth Increment = 0.164 feet

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 (*)

InSitu Engineering

Note:

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Log of CPT-S06

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

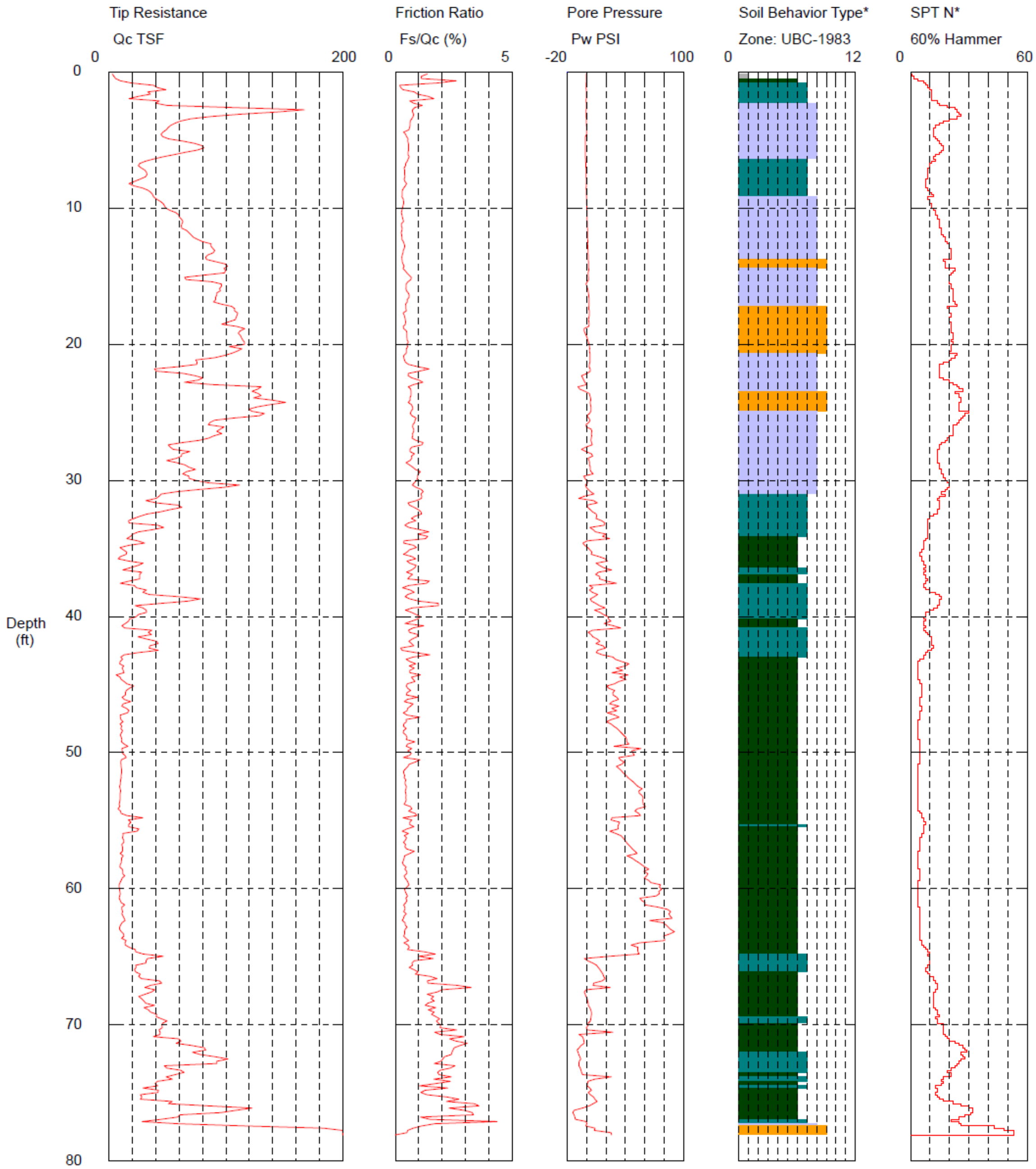
GeoEngineers

Figure A-12

GeoEngineers

Operator: Gerdes
Sounding: CPT-S07
Cone Used: DPG1186

CPT Date/Time: 4/17/2012 8:11:14 AM
Location: S Lucille Street
Job Number: 01239-141-00



Maximum Depth = 78.08 feet

Depth Increment = 0.164 feet

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

InSitu Engineering

Note:

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Log of CPT-S07

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure A-13

APPENDIX B
Results of Consolidation Settlement Analysis

APPENDIX B
RESULTS OF CONSOLIDATION SETTLEMENT ANALYSIS

The soft to medium stiff clayey silt layers (alluvium and estuarine deposits) are prone to consolidation settlement. Based on our consolidation settlement analyses and the planned roadway profiles, we estimate that the long term post-construction consolidation settlement due to the new embankment weights will be up to 2 inches at the south approach and less than 1 inch at the north approach. These estimates are for no ground improvement below the approach areas. The estimated consolidation settlement associated with the identified compressible layers is presented in Table B-1.

TABLE B-1. ESTIMATED CONSOLIDATION SETTLEMENT

Embankment Height (feet)	Representative CPT's	Settlement (inches)
21 – 25	CPT-S01	1.5 – 2.0
	CPT-S02	
14 – 18	CPT-S03	Less than 1.0
	CPT-S04	
7 – 11	CPT-S05	Less than 1.0
	CPT-S06	
	CPT-S07	
7 – 11	CPT-N02	Less than 1.0
18 – 24	CPT-N06	Less than 1.0

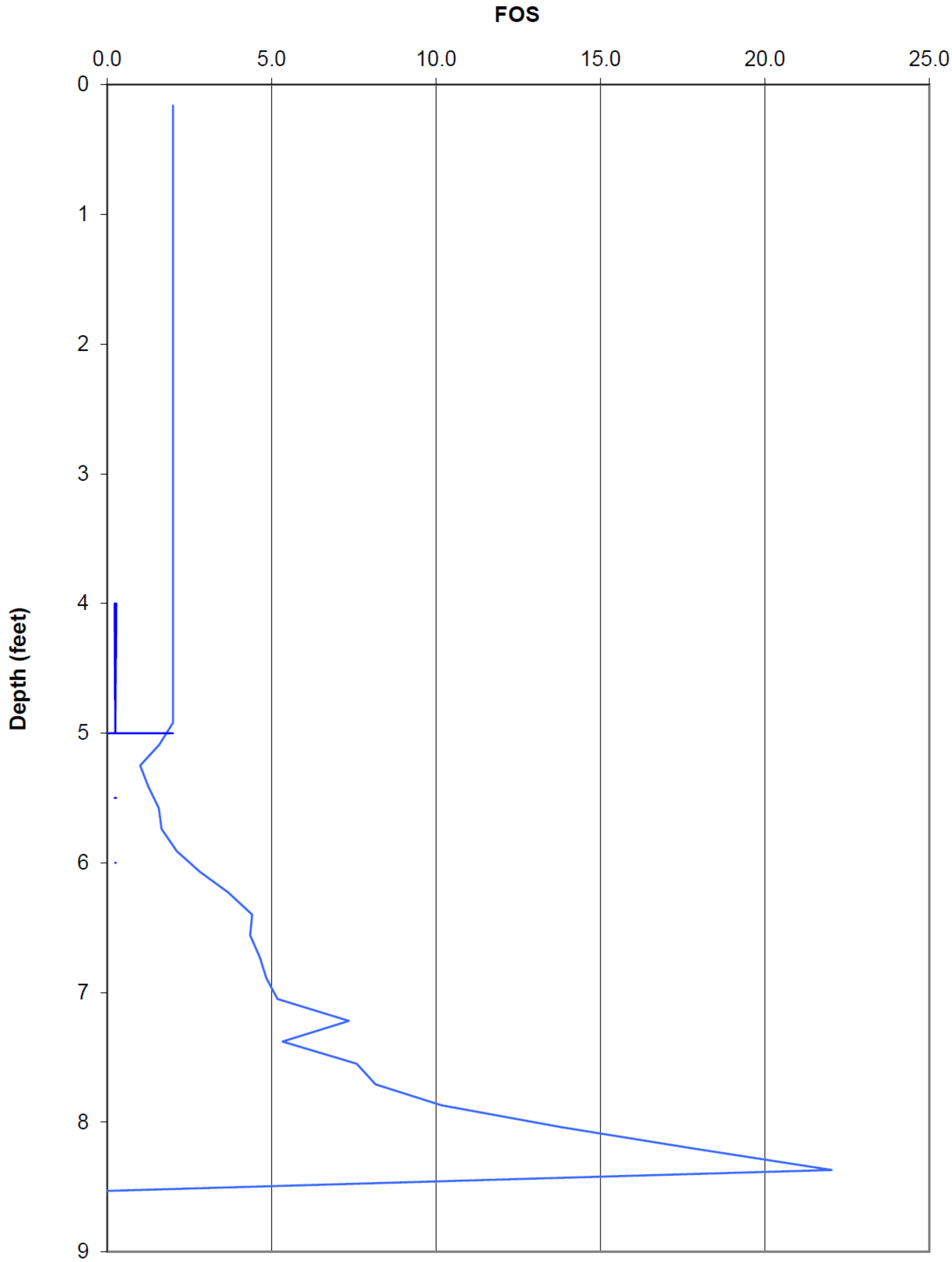
APPENDIX C
Results of Liquefaction Analysis

APPENDIX C
RESULTS OF LIQUEFACTION ANALYSIS

The liquefaction potential at the site was evaluated by using the simplified method proposed by Youd et al (2001). Liquefaction analyses were completed using the subsurface data obtained from each of the cone penetrometer test (CPT) probes. The calculated factor of safety against liquefaction for each of the CPT probes is presented on Figures C-1 through C-13, respectively. The estimated ground surface settlement associated with liquefaction is presented in Table C-1.

TABLE C-1. ESTIMATED LIQUEFACTION-INDUCED SETTLEMENT

CPT	Settlement (inches)	Comments
CPT-S01	6.5	
CPT-S02	7.0	
CPT-S03	7.4	
CPT-S04	11.2	
CPT-S05	8.1	
CPT-S06	5.9	
CPT-S07	10.0	
CPT-N01	0.0	Completed between compaction grouting points with grout return at 10 feet
CPT-N02	3.5	
CPT-N03	1.5	Completed in area at edge of compaction grouting points
CPT-N04	1.0	Completed in an area surrounded by compaction grouting points
CPT-N05	0.25	Completed between compaction grouting points with grout return at 15 to 25 feet
CPT-N06	5.4	



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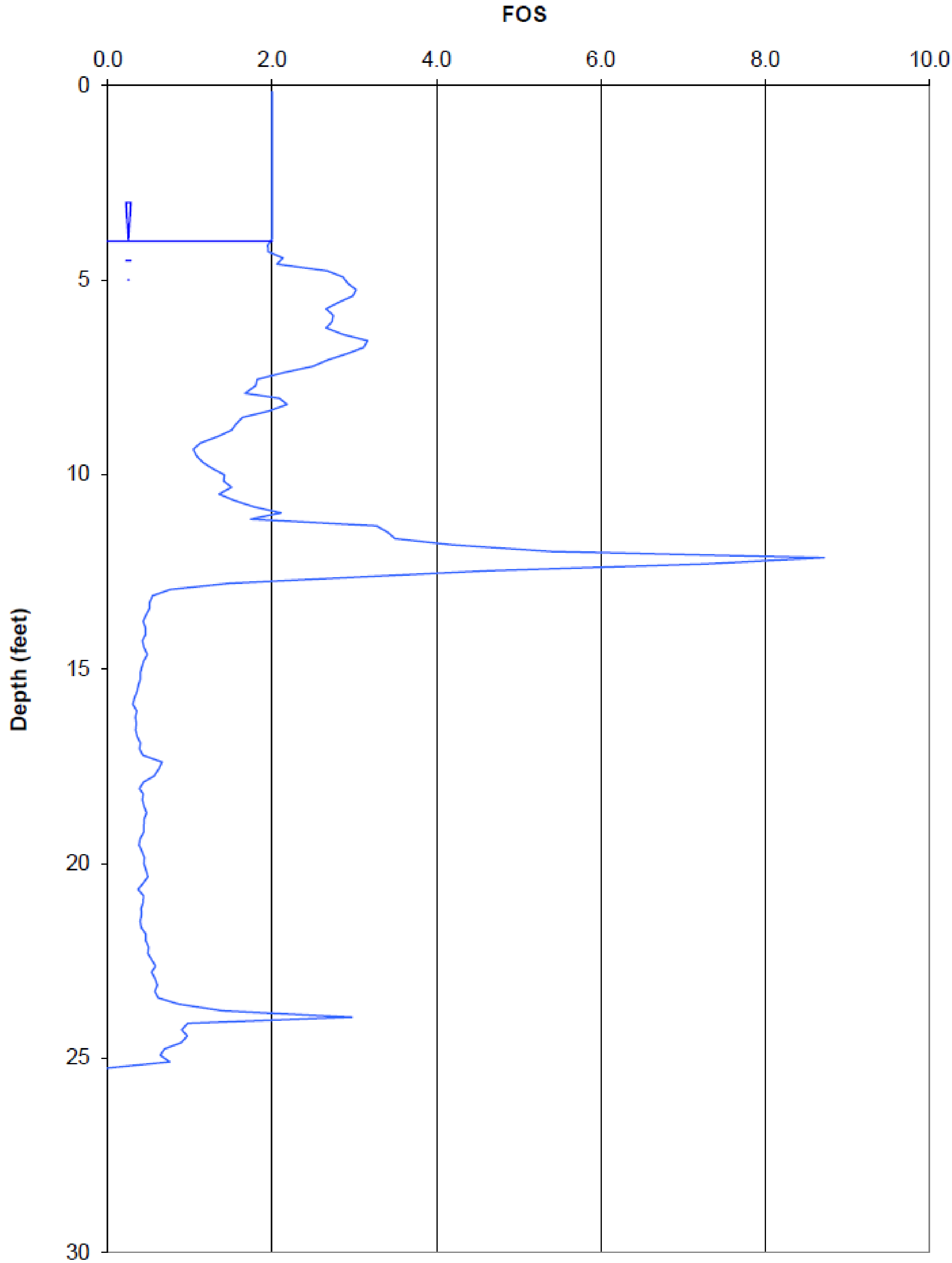
Factor of Safety Against Liquefaction CPT-N01

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-1



Note:

1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

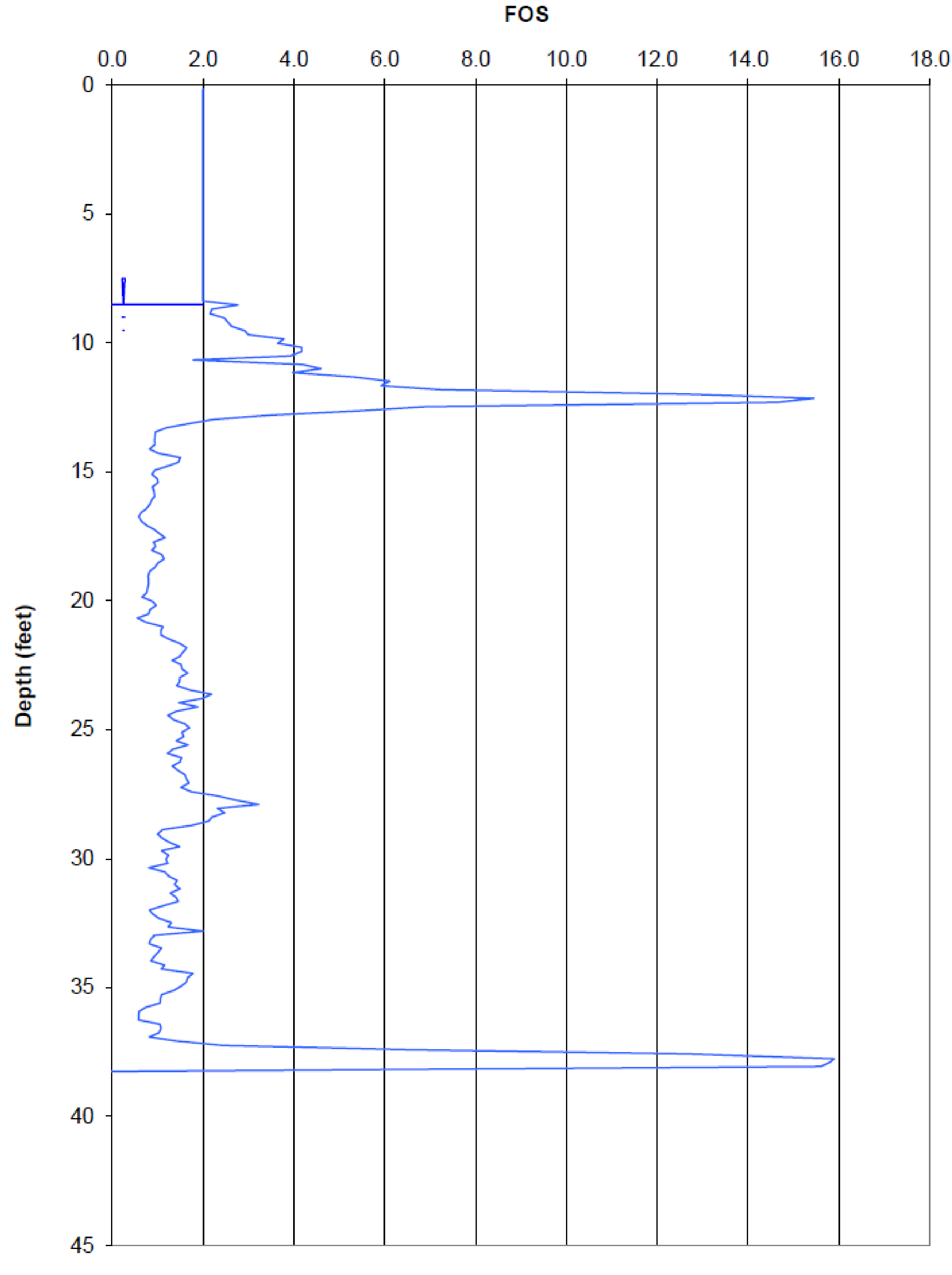
Factor of Safety Against Liquefaction CPT-N02

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GeoEngineers

Figure C-2

Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\North Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-N02.xls hpd:frv 04/30/2012



Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\North Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-N03.xls hpd:frv 04/30/2012

Note:

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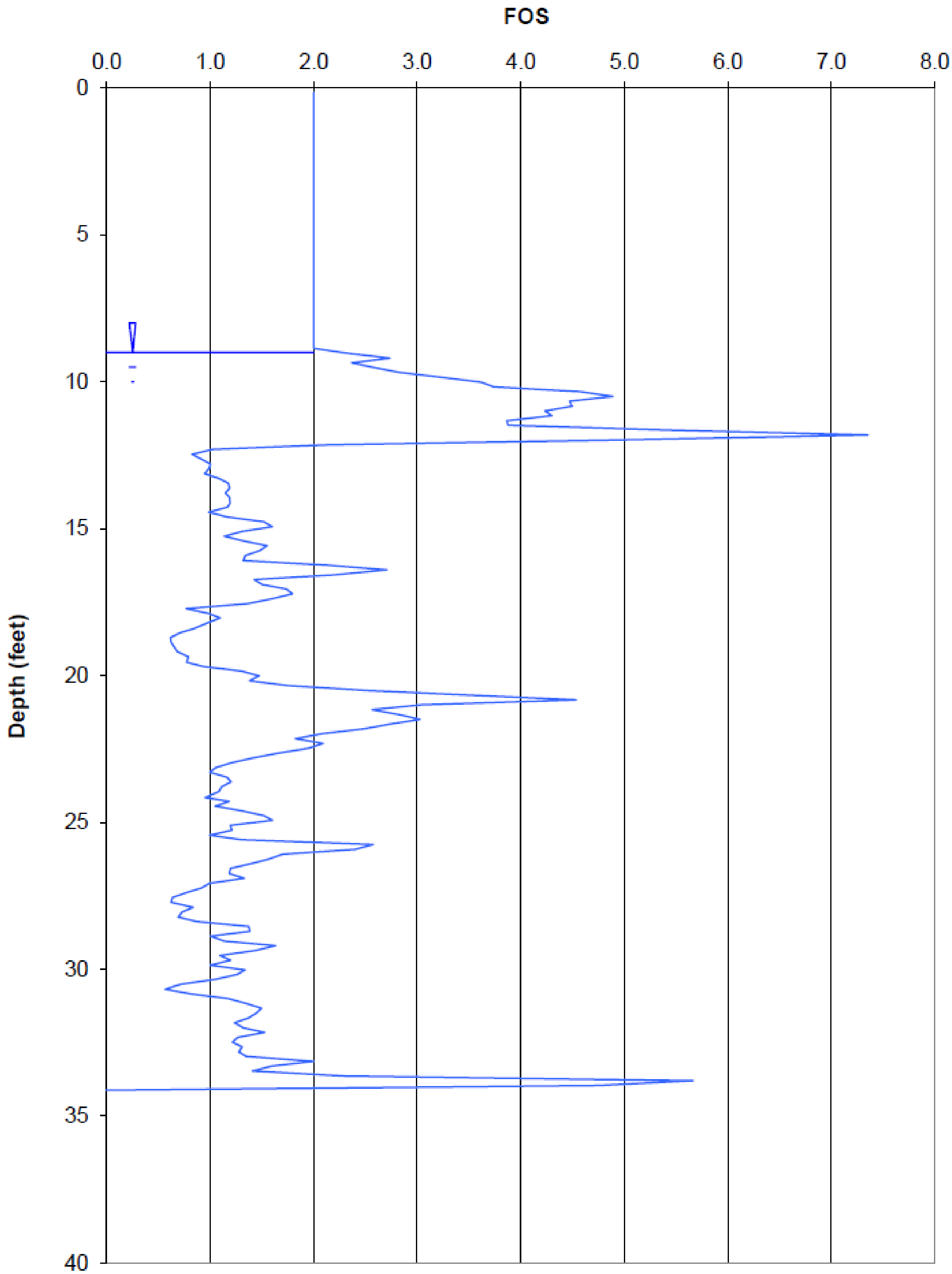
Factor of Safety Against Liquefaction
CPT-N03

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-3



Note:

1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

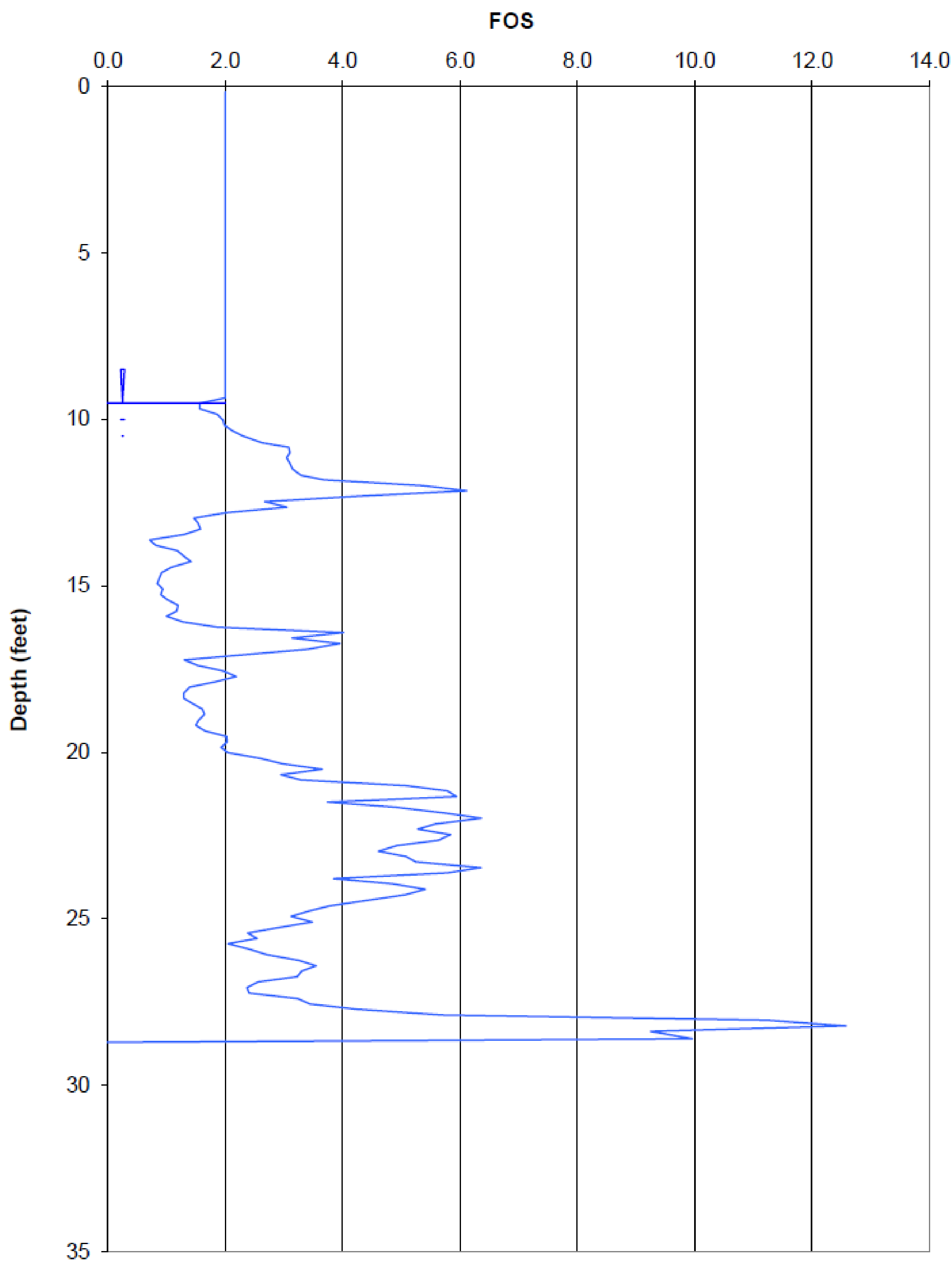
Factor of Safety Against Liquefaction CPT-N04

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-4

Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\North Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-N04.xls hpd:frv 04/30/2012



Note:

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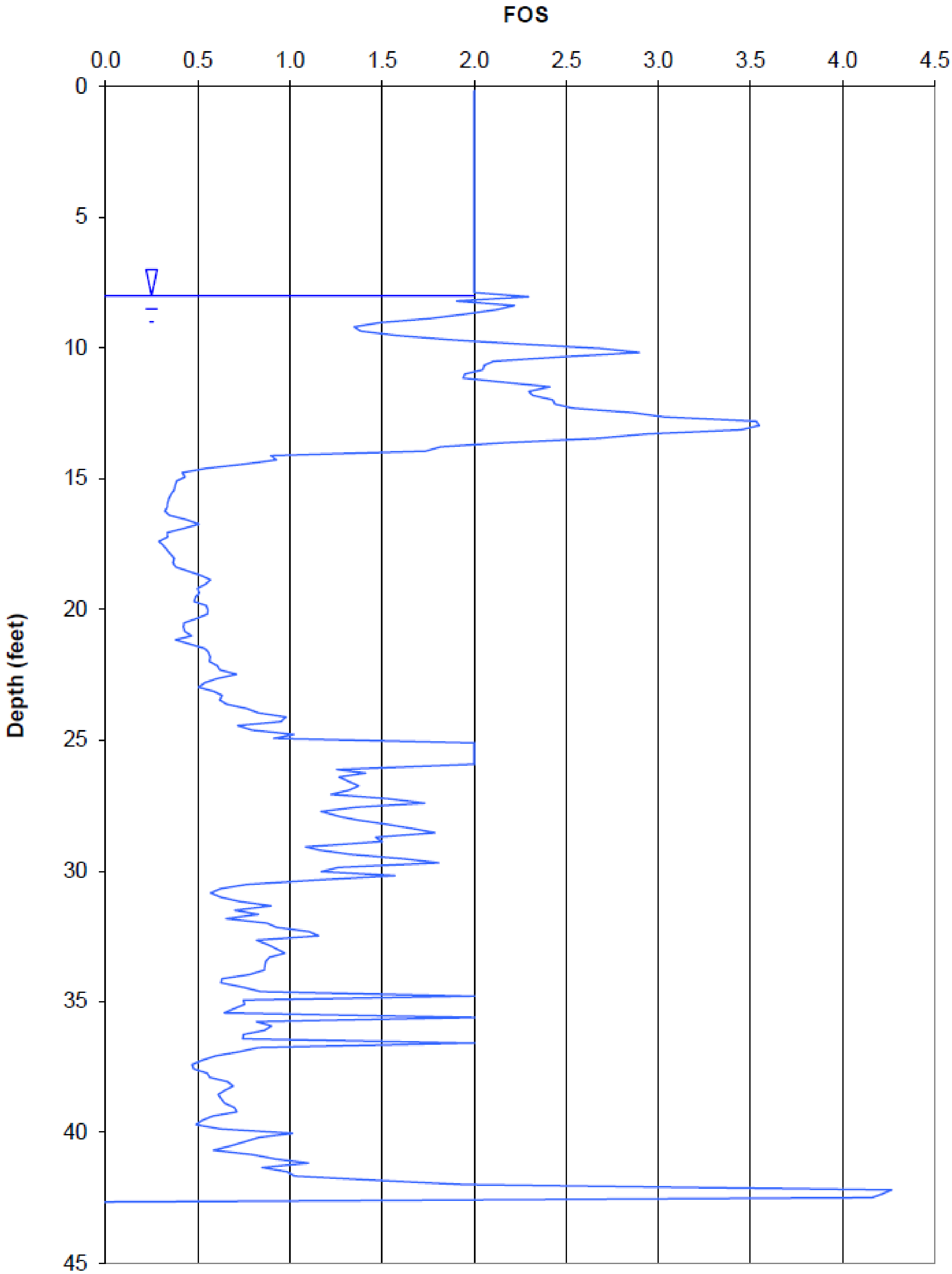
Factor of Safety Against Liquefaction CPT-N05

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GeoEngineers

Figure C-5



Note:

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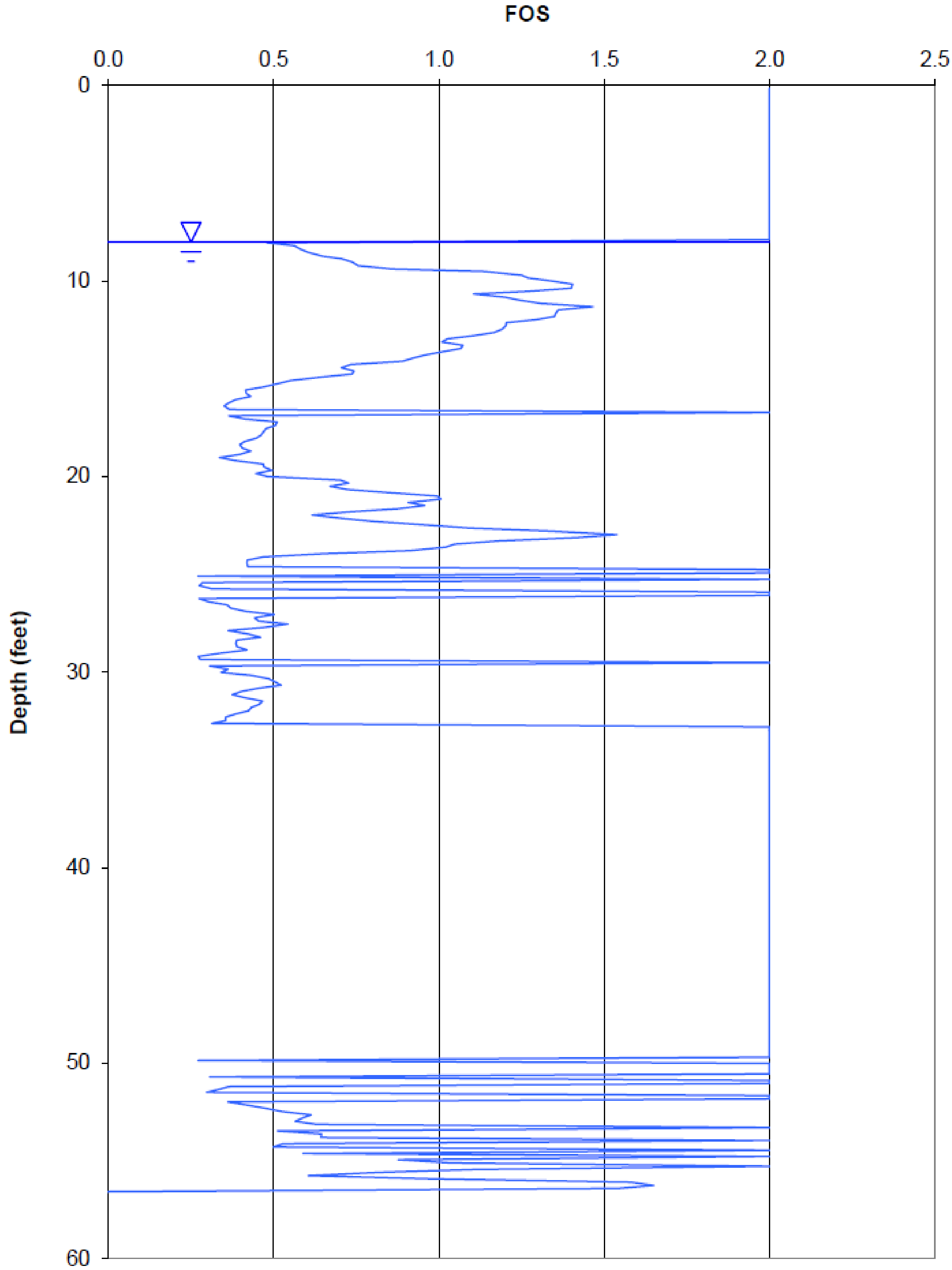
Factor of Safety Against Liquefaction
CPT-N06

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-6



Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\South Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-S01.xls hpd:frv 04/30/2012

Note:

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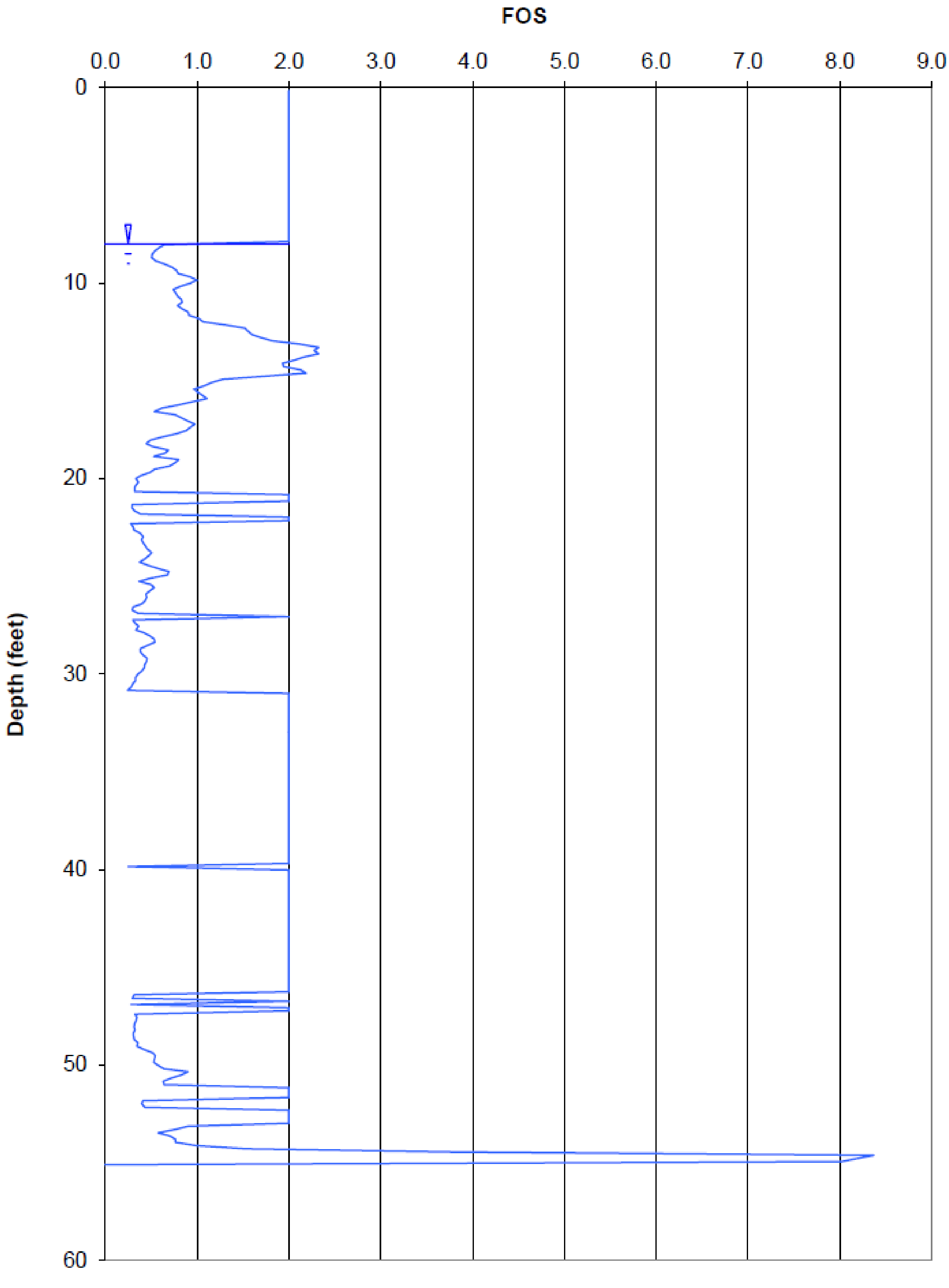
Factor of Safety Against Liquefaction CPT-S01

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GeoEngineers

Figure C-7



Note:

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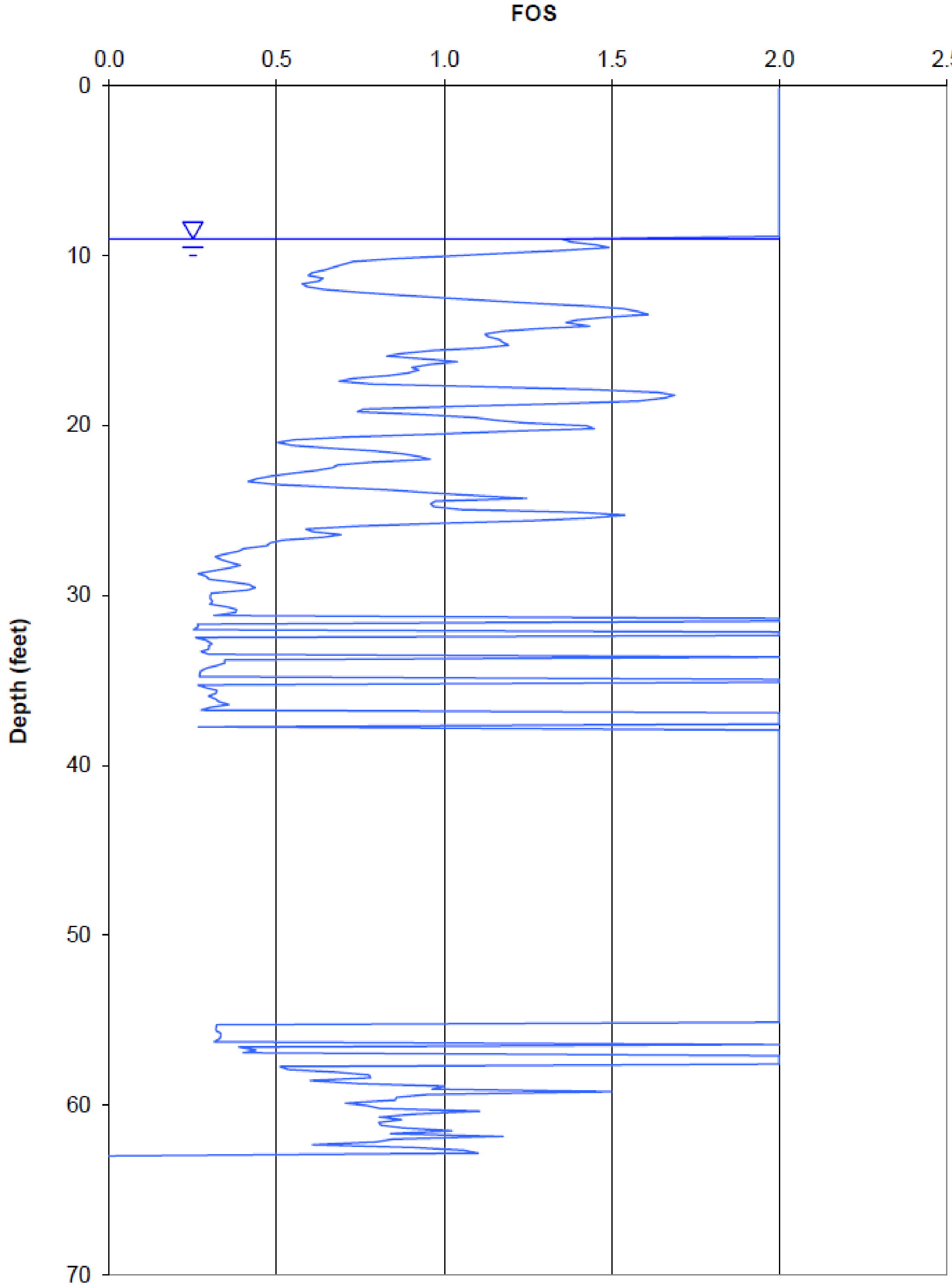
Factor of Safety Against Liquefaction CPT-S02

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GeoEngineers

Figure C-8



Note:

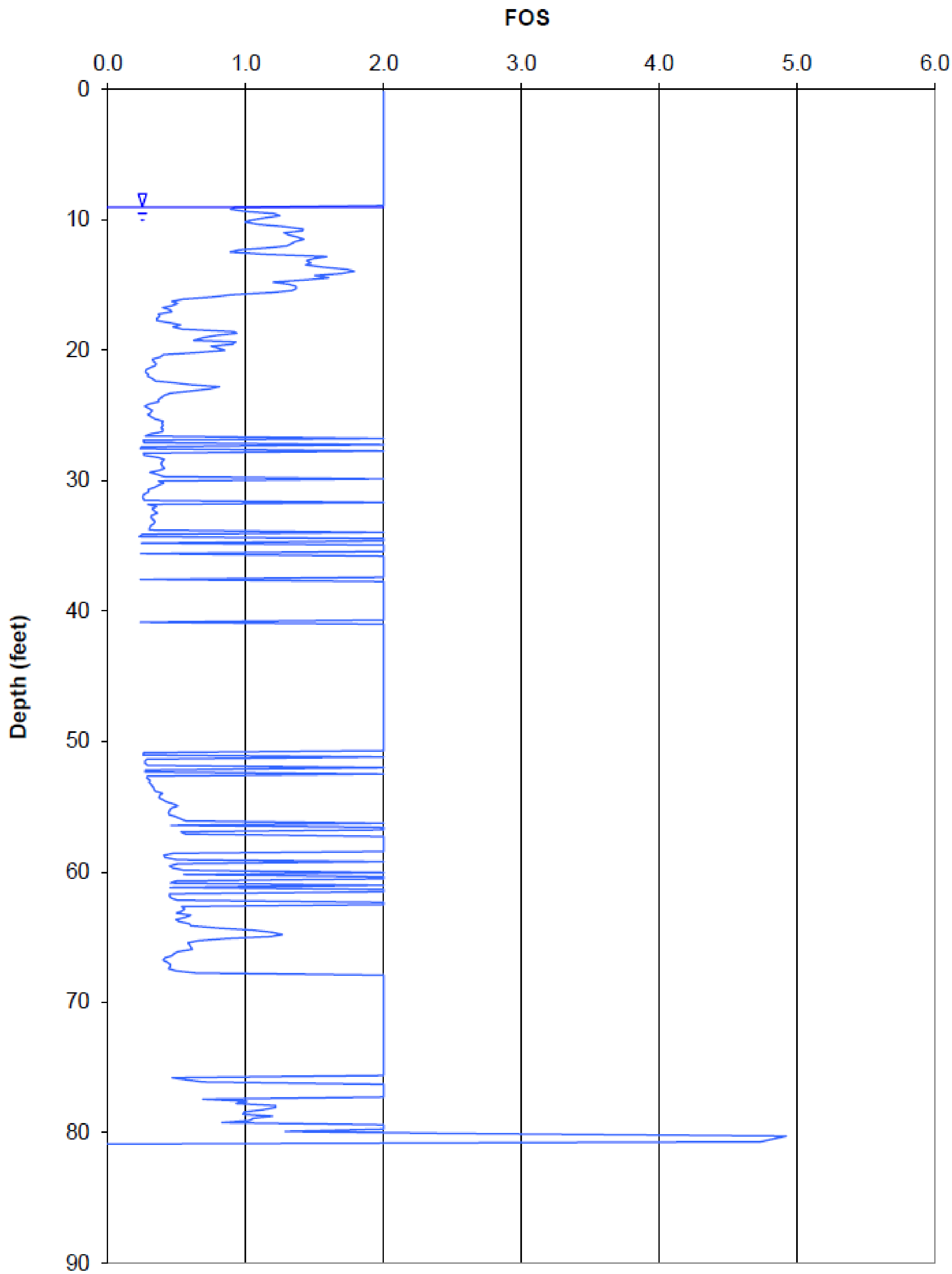
1. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Factor of Safety Against Liquefaction CPT-S03

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GeoEngineers

Figure C-9



Note:

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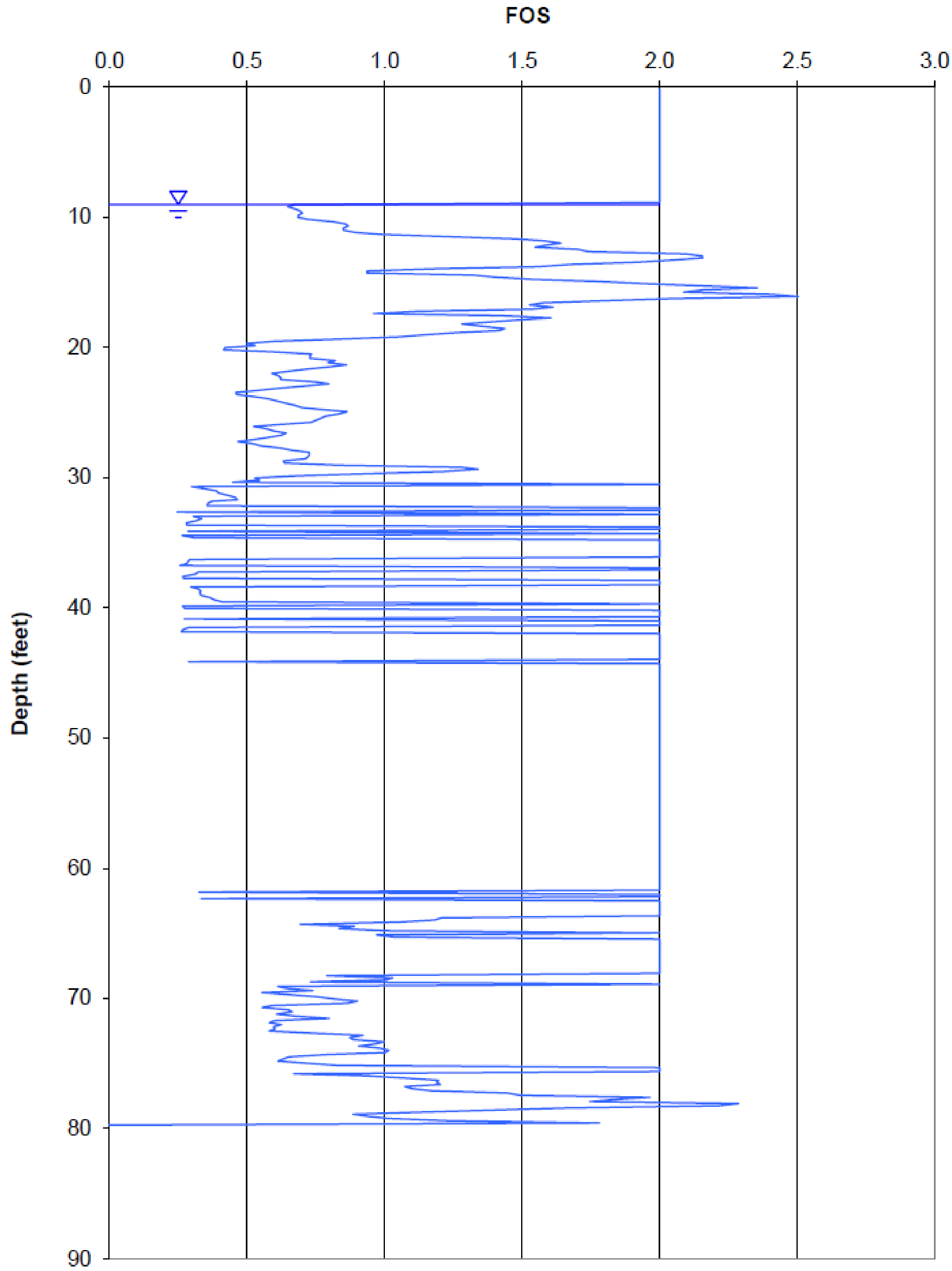
Factor of Safety Against Liquefaction CPT-S04

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-10

Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\South Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-S04.xls hpd:frv 04/30/2012



Note:

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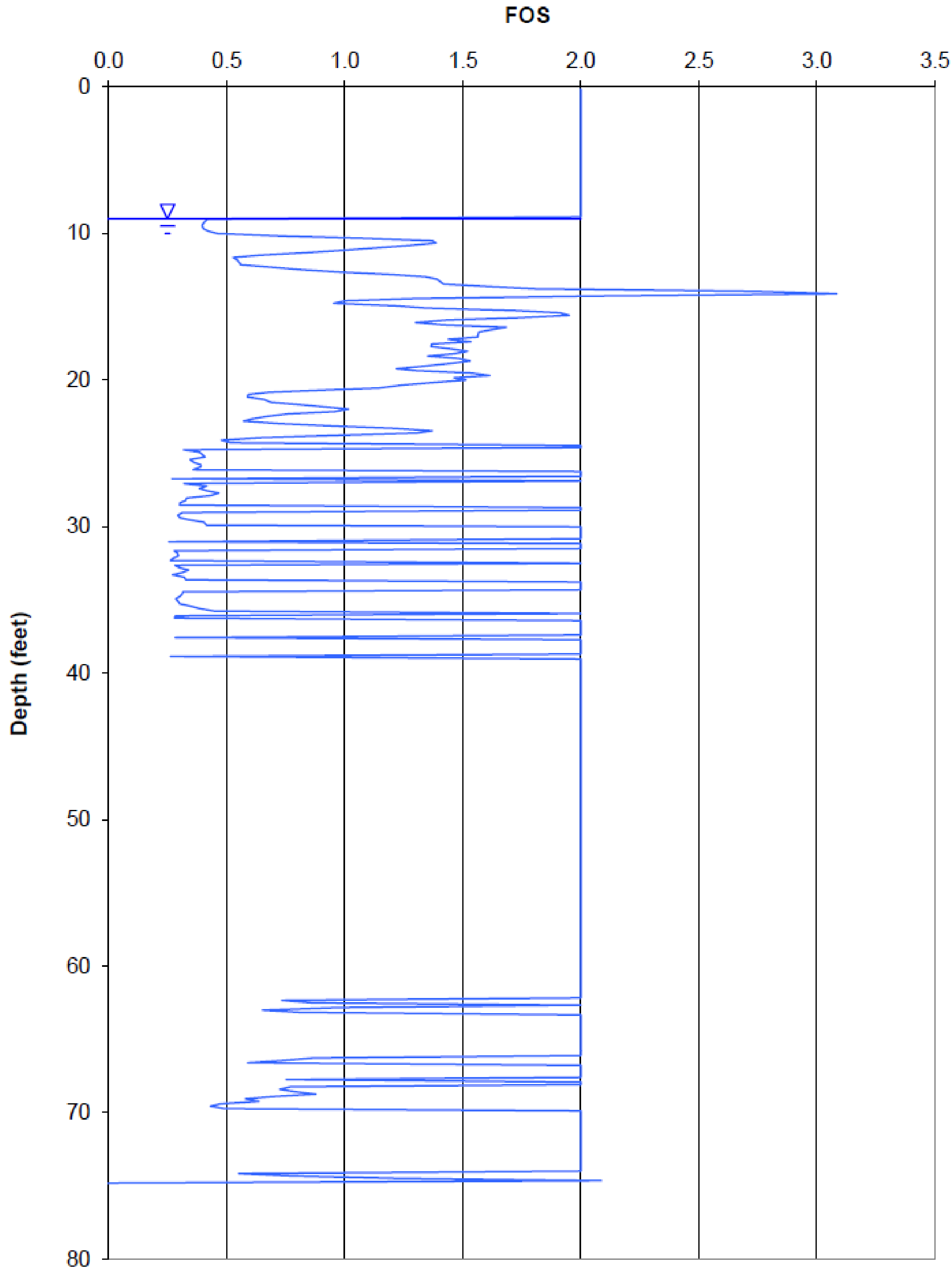
Factor of Safety Against Liquefaction CPT-S05

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-11

Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\South Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-S05.xls hpd:frv 04/30/2012



Note:

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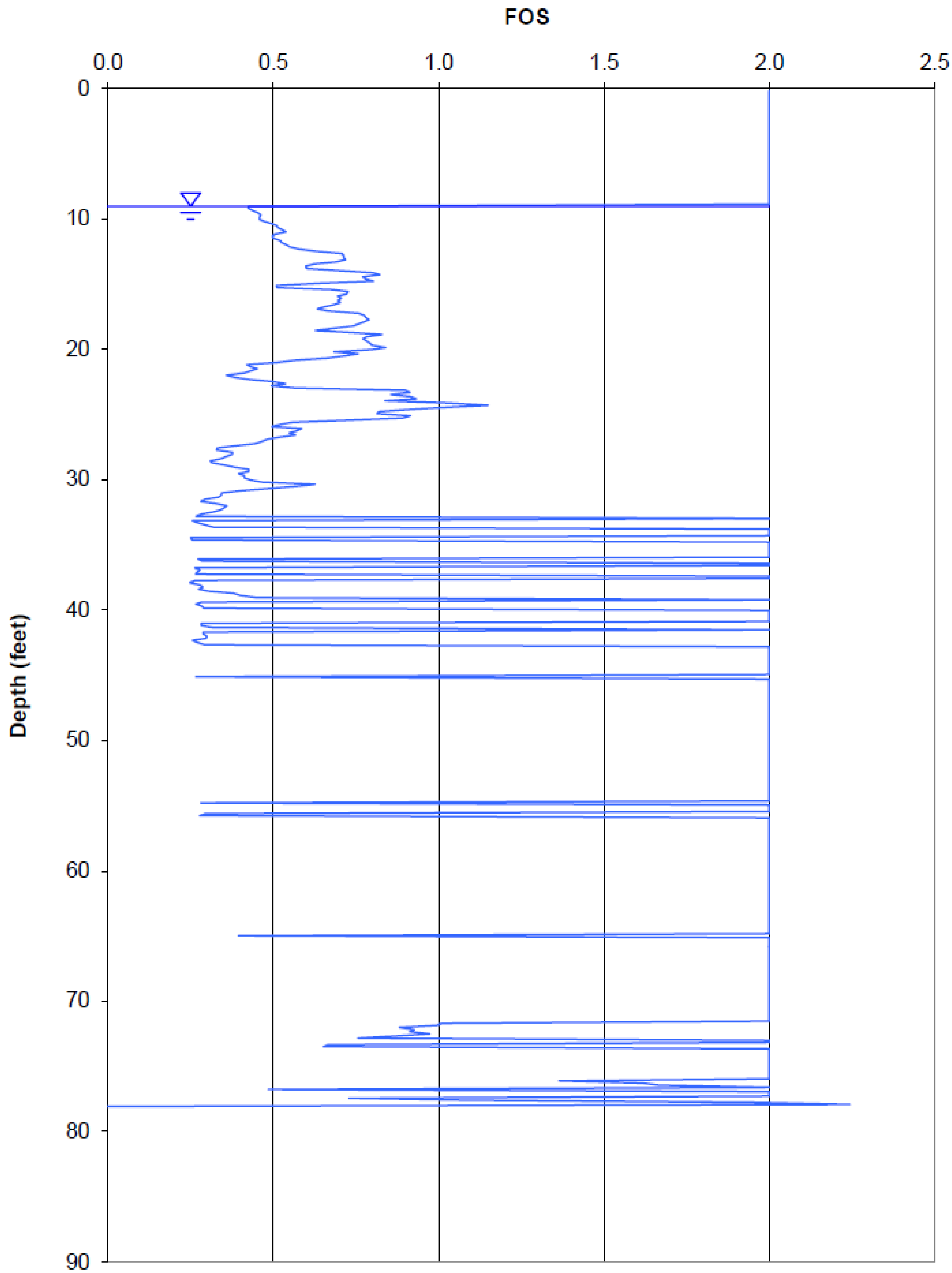
Factor of Safety Against Liquefaction
CPT-S06

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-12



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Factor of Safety Against Liquefaction CPT-S07

Airport Way South Viaduct over ARGO Railroad Yard
Seattle, WA

GEOENGINEERS

Figure C-13

Sharepoint: 00129-141-00\Technical Analysis\Liquefaction Analysis\South Approach\CPT-LIQ Ver 1.3_AirportWy_CPT-S07.xls hpd:frv 04/30/2012

APPENDIX D
Report Limitations and Guidelines for Use

APPENDIX D
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the exclusive use of the City of Seattle, HNTB, and their authorized agents. This report may be made available to prospective contractors for their bidding or estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with which there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A Geotechnical Engineering or Geologic Report Is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Airport Way South Viaduct over ARGO Railroad Yard in Seattle, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject To Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical, Geologic and Environmental Reports Should Not Be Interchanged

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.