Appendix 6.10-1: Hydrology Studies

Kimley»Horn

TECHNICAL MEMORANDUM

To: Amanda Acuna and Lisa Kranitz, City of Gardena

From: Bryant Yang

Date: October 17, 2023

Subject: **Hydrology Study for 1610 W Artesia Boulevard Project Peer Review Update**

Kimley-Horn has conducted a follow-up third-party peer review of the Project's Hydrology Study on behalf of the City of Gardena to verify that Kimley-Horn's October 2, 2023 third-party peer review recommendations have been incorporated. The revised October 2023 Hydrology Study addressed the third-party peer review comments. The analysis, as revised, meets the applicable provisions of CEQA and the State CEQA Guidelines and is adequate for inclusion in the Project SCEA.

Please do not hesitate to contact Bryant Yang at 213-631-5543 or Bryant.Yang@kimley-horn.com with any questions.

Kimley»Horn

TECHNICAL MEMORANDUM

To: Amanda Acuna and Lisa Kranitz, City of Gardena

From: Bryant Yang

Date: October 17, 2023

Subject: **Low Impact Development Plan for 1610 W Artesia Boulevard Project Peer Review Update**

Kimley-Horn has conducted a follow-up third-party peer review of the Project's Low Impact Development Plan (LID) on behalf of the City of Gardena to verify that Kimley-Horn's October 2, 2023 third-party peer review recommendations have been incorporated. The revised October 2023 LID addressed the third-party peer review comments. The analysis, as revised, meets the applicable provisions of CEQA and the State CEQA Guidelines and is adequate for inclusion in the Project SCEA.

Please do not hesitate to contact Bryant Yang at 213-631-5543 or Bryant.Yang@kimley-horn.com with any questions.

Hydrology Study

For

1610 W Artesia Boulevard

Gardena, CA 90248

1610 Artesia

October 13, 2023

This Hydrology and Hydraulic Analysis Study has been prepared by, and under the direction of, the undersigned, a duly Registered Civil Engineer in the State of California. Except as noted, the undersigned attests to the technical information contained herein, and has judged to be acceptable the qualifications of any technical specialists providing engineering data for this report, upon which findings, conclusions, and recommendations are based.

Ryan Haskin

Ryan Haskin, PE
Registered Civil Engineer No. C84850
Exp.: 3/31/2024

RYAN HASKIN
No. 84850
Exp. 3/31/24

Prepared for:

The Picerne Group
5000 Birch Street, Suite 600
Newport Beach, CA 92660
(949) 910-3428

Prepared by:

Tait & Associates, Inc.
701 N. Parkcenter Drive
Santa Ana, CA 92705
(714) 560-8200

TAIT JOB # SP8994

Table of Contents

Section 1 Purpose and Scope

This hydrology study presents an analysis of the hydrologic effects of the development of 3.43-acre commercial project in the City of Gardena.

This hydrology study addresses runoff from the project site and its impact to the existing downstream drainage system. The study includes calculations for the 50-year for the existing and proposed condition. The study also details the general project characteristics, the design, criteria and methodology applied to the analysis of the project.

This Hydrology Study fulfills the requirements of the Los Angeles County Hydrology Manual and the County of Los Angeles Department of Public Works.

The plans and specifications in the Hydrology Study are not for construction purposes; the contractor shall refer to final approved construction documents for plans and specifications.

Section 2 Project Information

2.1 Project Description

The project consists of the redevelopment of an existing 3.43-acre area of a commercial/business center currently composed of a car wash and auto center. The proposed project will consist of constructing of a 5-level apartment complex totaling approximately 360 units. The project also includes the construction of a basement level parking structure, leasing office, fitness club, and community pool.

2.1.1 Project Location

The project is in the City of Gardena, County of Los Angeles, California, as graphically shown in Figure 1, below.

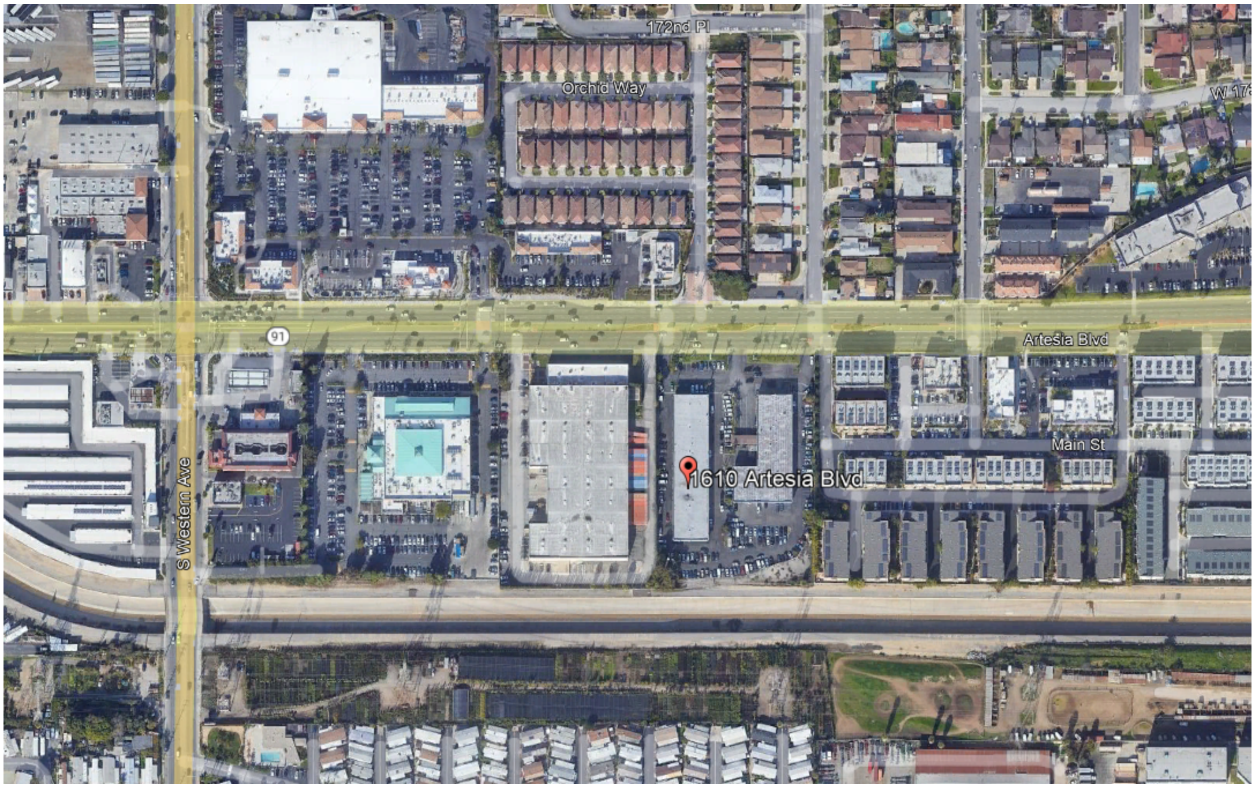


Figure 1 – Vicinity Map (Not To Scale)

2.2 Hydrologic Setting

This section summarizes the project's size and location in the context of the larger watershed perspective, topography, soil and vegetation conditions, percent impervious area, natural and infrastructure drainage features, and other relevant hydrologic and environmental factors to be protected specific to the project area's watershed.

2.2.1 Watershed

Drainage from the site exits via storm drain into the lined portion of the Dominguez Channel flowing east before making its way into the unlined Dominguez Channel Estuary, then flows southeast until reaching the Los Angeles River Consolidated Slip, eventually discharging into the Los Angeles/Long Beach Inner and Outer Harbor.

2.2.2 Existing Topography and Facilities

The site features a gradual slope from the northwest corner at Artesia Blvd down to the southeast corner of the property with a difference of roughly 8 feet.

2.2.3 Adjacent Land Use

Per the latest Zoning Map, the project is zoned Very High Density Residential. The project area is bounded by Dominguez Channel to the south, Very High Density Residential to the west, and Artesia Mixed Use to the east.

2.2.4 Soil Conditions

The project site location is graphically shown on the Los Angeles County Department of Public Works (LACDPW) website which has been included in *Appendix A* of this report. The map shows the project to be in the soils classification 013, Ramona Loam.

2.2.5 Downstream Conditions

The project surface flows to a drop inlet connects to a private storm drain approximately 80 feet south and exits the property through a headwall to the LACFCD Dominguez Channel. The Dominguez Channel flows east to west and bounds the southern property line.

2.2.6 Impervious Cover

The existing site is approximately 93% impervious and is a developed parking lot and building. The proposed site is approximately 85% impervious and will decrease the impervious area in the developed condition, therefore no hydrologic peak flow mitigation is required.

2.2.7 Existing Drainage Patterns

The site features a gradual slope from the northwest corner at Artesia Blvd down to the southeast corner of the property with a difference of roughly 8 feet. The existing drainage pattern consists of overland flow to gutters that flow to the southeastern portion of the property and discharge to a single drop inlet.

The existing Hydrology map is graphically shown in *Appendix B*.

2.2.8 Proposed Drainage Patterns

The proposed project will maintain the existing drainage pattern with site runoff discharging to the existing site outlet which connects to the Dominguez channel.

The proposed Hydrology map is graphically shown in *Appendix C*.

Section 3 Design Criteria and Methodology

This section summarizes the design criteria and methodology applied to the drainage analysis of the project site. The design criteria and methodology follow the LA County Hydrology Manual requirements.

3.1 Design Criteria

3.1.1 Drainage Design Criteria

The project storm drain facilities have been designed to conform to the Los Angeles County standards.

3.1.2 Runoff Calculation Method

The Modified Rational Method per the Los Angeles County Department of Public Works Hydrology Manual, January 2006 is the methodology selected for the project. LACDPW Modified Rational Method was utilized for the hydrologic analysis to calculate time of concentration and runoff discharge flow rates using Isohyet depths, impervious percentage, soil class, tributary area, slope and the distance of water travel. The County of LA has developed a software called HydroCalc. HydroCalc allows the user to utilize a regression equation to calculate the time of concentration which simplifies routing and flow conveyance modeling as a function of the overall flow path length and slope of each sub-area. HydroCalc uses a design storm and a time of concentration to calculate runoff at different times throughout the storm and produce a hydrograph for each area. Design criteria utilized entered into HydroCalc is as follows:

Design Storm	50-year storm event
Precipitation Depth	5.9” 50-year 24-hour provided by LACDPW
Runoff Coefficient (C)	Calculated HydroCalc provided by LACDPW, based on Imperviousness and soil group 013.

3.1.3 Runoff Calculations

The proposed runoff for this project is limited to 50 year, 24 hour storm event.

The existing peak flow rate is 8.74 cfs. Proposed peak flow rate is 8.27 cfs.

$$\text{Difference in peak flow } (Q_{50\text{yr Proposed}} - Q_{50\text{yr Existing}})$$

$$8.27\ (\text{cfs}) - 8.74\ (\text{cfs}) = -0.47\ (\text{cfs})$$

Section 4 Hydrology and Drainage Analysis

This section summarizes the quantitative hydrologic analysis of the existing and proposed conditions of the site.

4.1 Drainage Delineation and Hydraulic Analysis

The *Appendix C* section of this report contains the existing condition hydrology map, which shows the existing drainage subareas and quantifies the peak flow for 24-hour, 50-year storm event.

A hydrology map for the proposed condition has also been provided in the *Appendix D* section of this report, depicting subareas and quantifies the peak flow for 24-hour, 50-year storm event.

4.2 Summary of Results

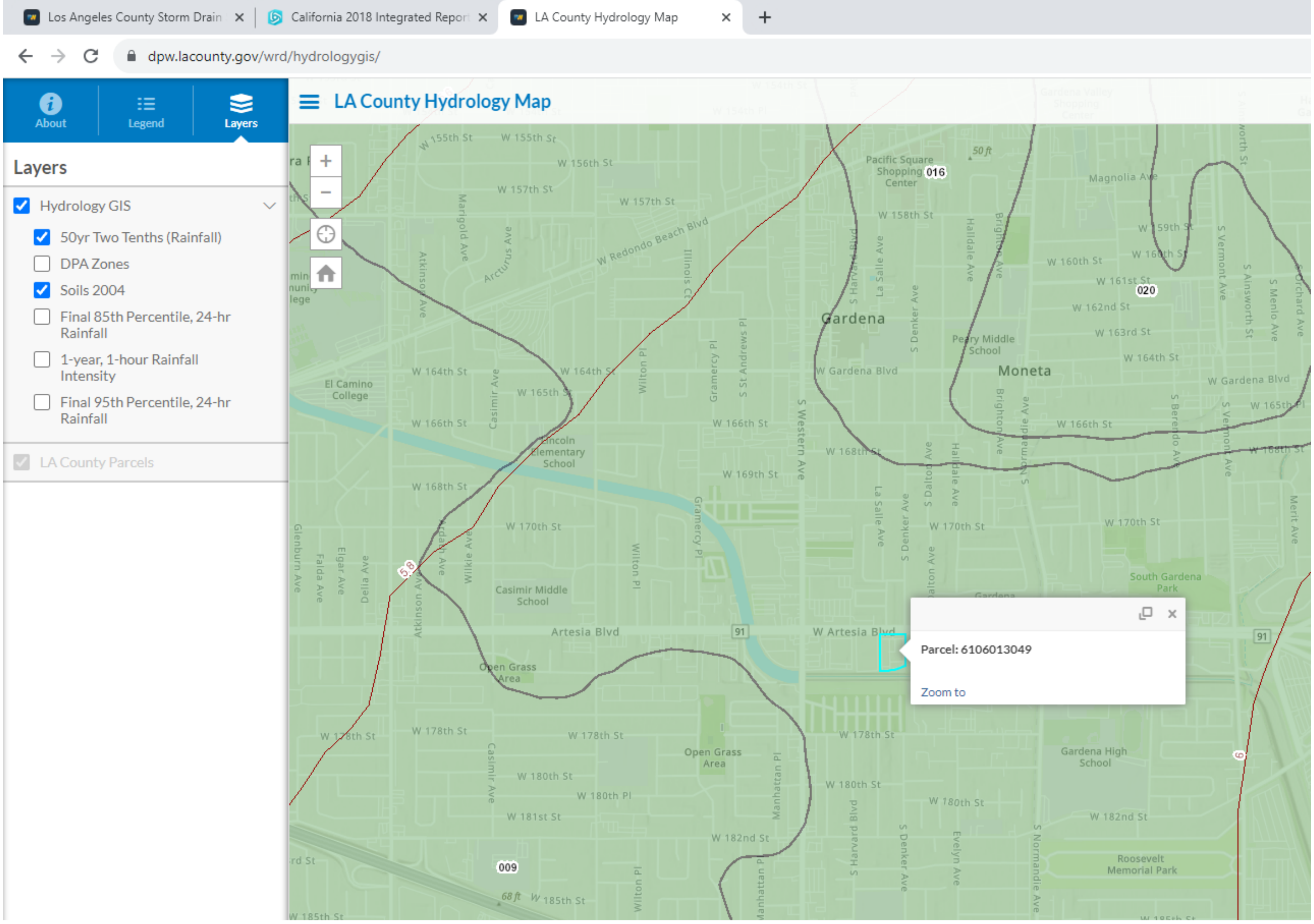
50 yr Storm Event Calculations			
Drainage Area	**Impervious %**	**Area (ac)**	**Q50 (cfs)**
Existing – A	93	3.44	8.74
Proposed – A	85	3.44	8.27

This study has determined the proposed peak flow rate will be 0.47cfs less than the existing peak flow rate, therefore the project will not increase runoff in the proposed developed condition.

APPENDICES

Appendix A – Soils Identification Map

LA County Soils Map



Los Angeles County Storm Drain ×

California 2018 Integrated Report ×

LA County Hydrology Map ×

dpw.lacounty.gov/wrd/hydrologygis/

LA County Hydrology Map

Layers

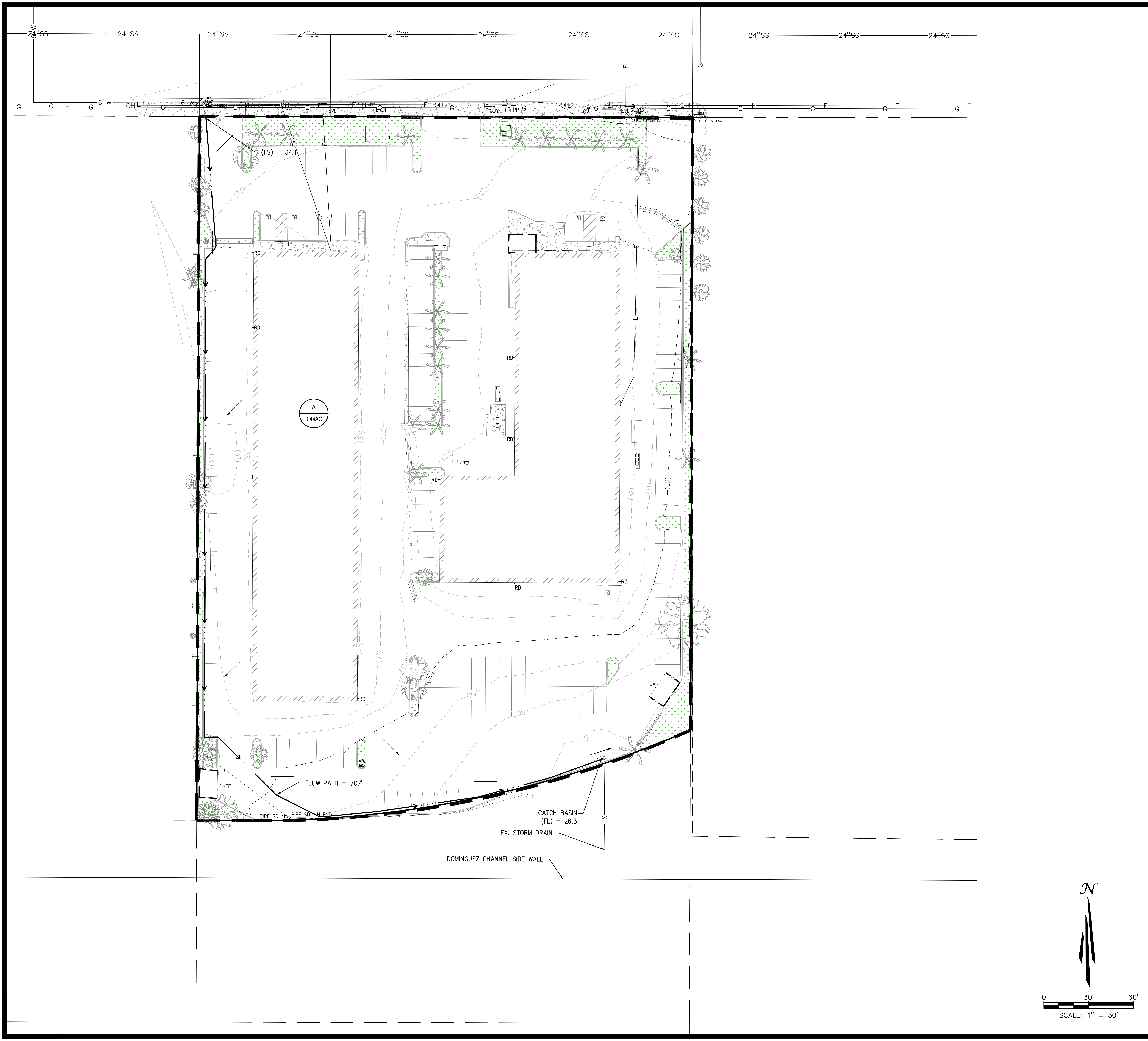
- ☑ Hydrology GIS
  - ☑ 50yr Two Tenths (Rainfall)
  - ☐ DPA Zones
  - ☑ Soils 2004
  - ☐ Final 85th Percentile, 24-hr Rainfall
  - ☐ 1-year, 1-hour Rainfall Intensity
  - ☐ Final 95th Percentile, 24-hr Rainfall
- ☑ LA County Parcels

Parcel: 6106013049

Zoom to

Appendix B – Existing Hydrological Condition Map

Existing Hydrological Condition
See Attached Exhibit



AREA

PERVIOUS AREA:	11,024 SF/0.25 AC
IMPERVIOUS AREA:	138,658 SF/3.18 AC
TOTAL AREA:	149,682 SF/3.43 AC

LEGEND

— — —180— — —	EXISTING CONTOUR
—— · · · ←	FLOW LINE
←	SLOPE
▬ ▬ ▬	AREA BOUNDARY
— — — —	SUB-AREA BOUNDARY
#	NODE
X-# #.##AC	AREA ID AREA (AC)
🟩	PERVIOUS AREA

EXISTING CONDITIONS HYDROLOGY MAP

1610 ARTESIA
1610 W ARTESIA BOULEVARD
GARDENA, CA 90248
THE PICERNE GROUP

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OF
1

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& ASSOCIATES
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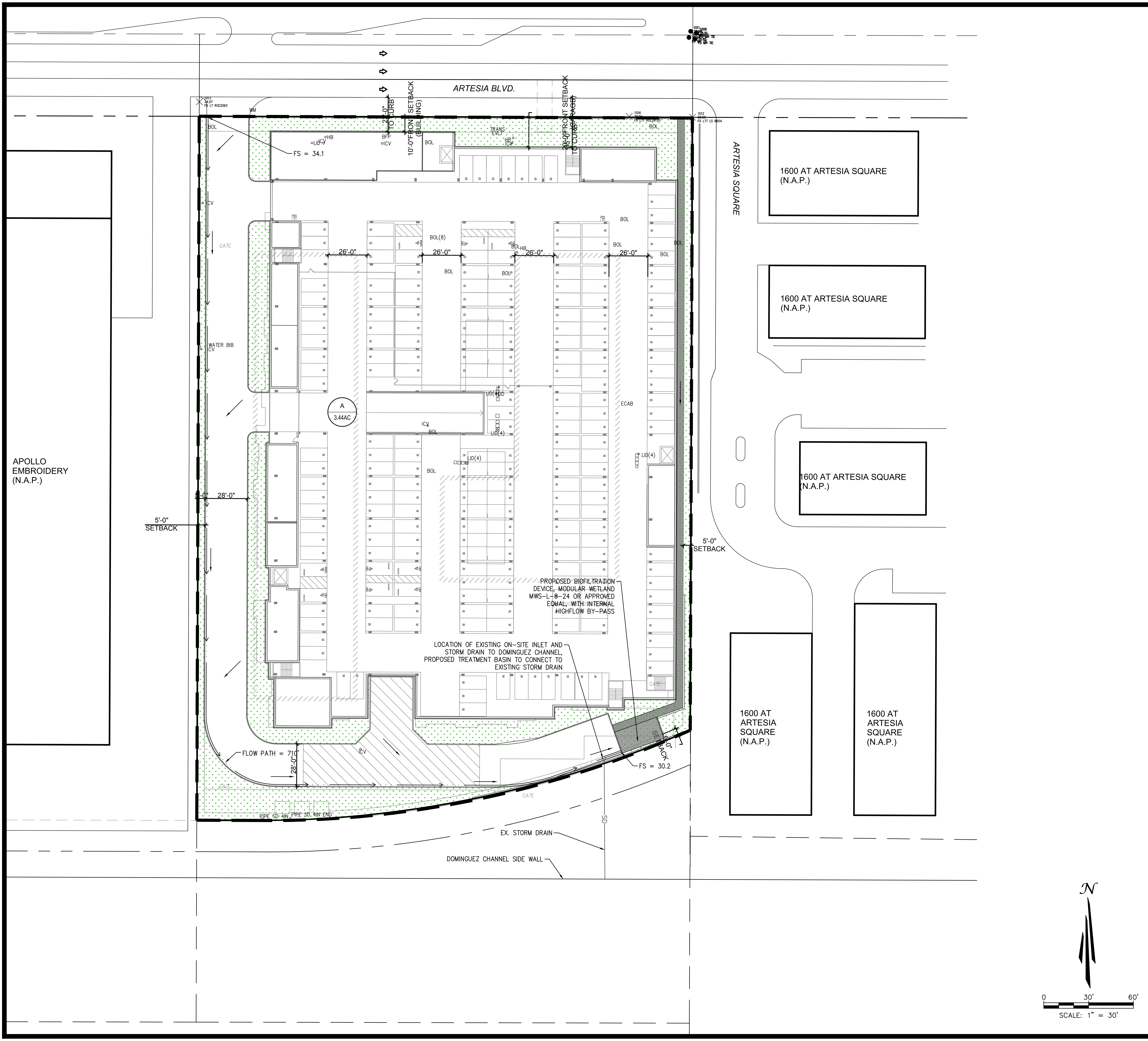
CHECKED: PM
DATE: 07/04/2020
JOB NO: AB1234X

Oct 13, 2023 – 6:23pm by rhaskin K:\Drawings\SP\SP8994 – Gardena\ENG\Hydrology\SP8994–Pre Hyd.dwg

12/20/2022 Exhibit XX

Appendix C – Proposed Hydrological Condition Map

Proposed Hydrological Condition
See Attached Exhibit



AREA

PERVIOUS AREA:	22,638 SF/0.52 AC
IMPERVIOUS AREA:	127,044 SF/2.91 AC
TOTAL AREA:	149,682 SF/3.43 AC

LEGEND

— — —180— — —	EXISTING CONTOUR
——— · · · ←	FLOW LINE
←	SLOPE
▬ ▬ ▬	AREA BOUNDARY
▬ ▬ ▬ ▬	SUB-AREA BOUNDARY
⬡#	NODE
X-# / #.##AC	AREA ID AREA (AC)
🟩	PERVIOUS AREA

DRAWN: CAD1
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POST CONSTRUCTION HYDROLOGY MAP

1610 ARTESIA
1610 W ARTESIA BOULEVARD
GARDENA, CA 90248
THE PICERNE GROUP

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OF
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12/20/2022 Exhibit XX

Oct 13, 2023 – 6:15pm by rhaskin K:\Drawings\SP\SP8994 – Gardena\ENG\Hydrology\SP8994–Post Hyd.dwg

Appendix D – Existing 50-year Storm Event Calculations

Existing Condition
50-year Storm Event Results Summary

Peak Flow Hydrologic Analysis

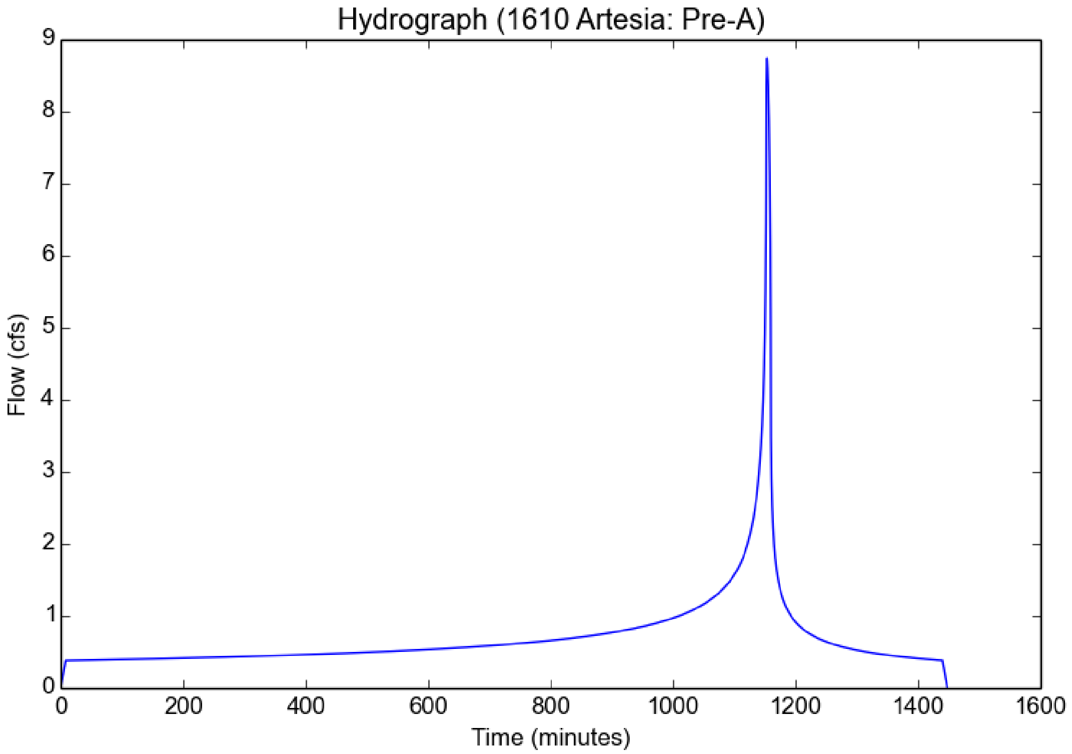
File location: C:/Users/RHaskin/Desktop/Z/1610 Artesia - Pre-A.pdf
Version: HydroCalc 1.0.3

Input Parameters

Project Name	1610 Artesia
Subarea ID	Pre-A
Area (ac)	3.44
Flow Path Length (ft)	707.0
Flow Path Slope (vft/hft)	0.011
50-yr Rainfall Depth (in)	5.9
Percent Impervious	0.93
Soil Type	13
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.9
Peak Intensity (in/hr)	2.8224
Undeveloped Runoff Coefficient (Cu)	0.9
Developed Runoff Coefficient (Cd)	0.9
Time of Concentration (min)	8.0
Clear Peak Flow Rate (cfs)	8.7382
Burned Peak Flow Rate (cfs)	8.7382
24-Hr Clear Runoff Volume (ac-ft)	1.4255
24-Hr Clear Runoff Volume (cu-ft)	62093.6366



Appendix E – Proposed 50-year Storm Event Calculations

Proposed Condition
50-year Storm Event Results Summary

Peak Flow Hydrologic Analysis

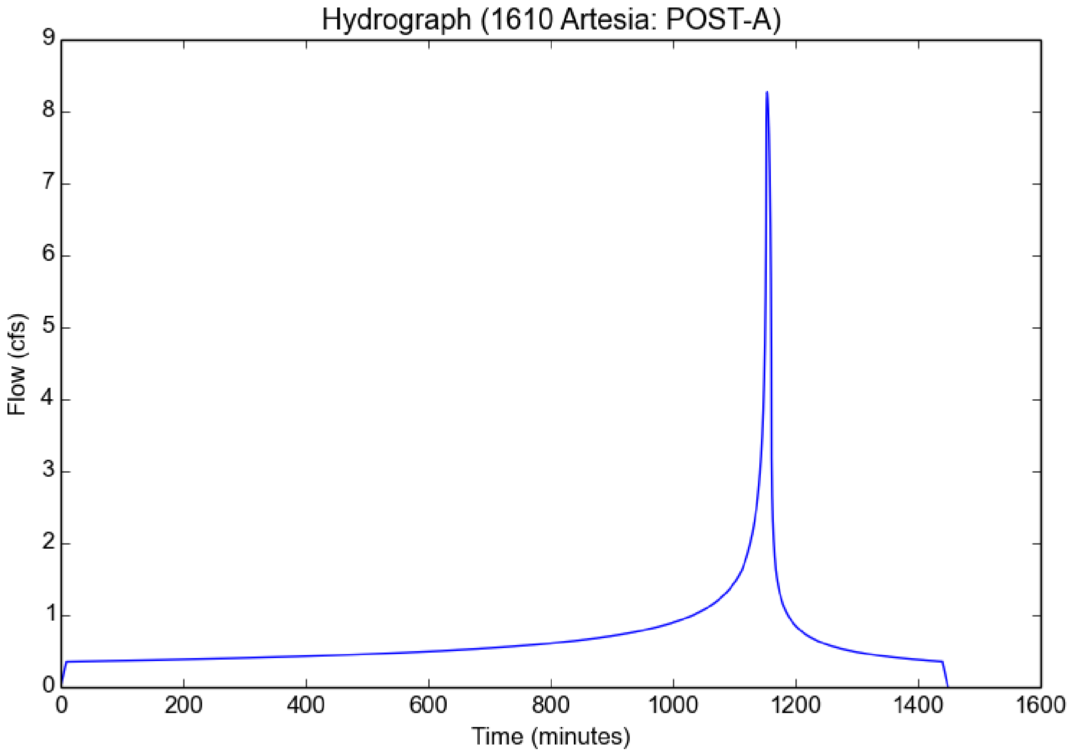
File location: C:/Users/RHaskin/Desktop/Z/1610 Artesia - POST-A.pdf
Version: HydroCalc 1.0.3

Input Parameters

Project Name	1610 Artesia
Subarea ID	POST-A
Area (ac)	3.44
Flow Path Length (ft)	710.0
Flow Path Slope (vft/hft)	0.006
50-yr Rainfall Depth (in)	5.9
Percent Impervious	0.85
Soil Type	13
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.9
Peak Intensity (in/hr)	2.6704
Undeveloped Runoff Coefficient (Cu)	0.9
Developed Runoff Coefficient (Cd)	0.9
Time of Concentration (min)	9.0
Clear Peak Flow Rate (cfs)	8.2676
Burned Peak Flow Rate (cfs)	8.2676
24-Hr Clear Runoff Volume (ac-ft)	1.3294
24-Hr Clear Runoff Volume (cu-ft)	57908.2



Appendix F – Reference Plans and Reports

Reference Plans and Reports

KCG KLING
Consulting
Group, Inc.

MEMORANDUM

To: Tommy Eckes- The Picerne Group

CC: Ryan Haskin- Tait and Associates

From: Kling Consulting Group

PN: 22027-01

Date: October 6, 2023

Re: 1610 W. Artesia Boulevard, Gardena, California. Low Impact Development (LID) report, City Plan Check Comments

---

Our findings from subsurface exploration, laboratory testing, and geotechnical analyses were presented in our Preliminary Geotechnical report dated October 31, 2022. The findings concluded that the underlying soils at this site are susceptible to liquefaction. It is our understanding that due to site constraints, the southeast corner of the site is the low point and therefore the one logical location to place the surface stormwater BMPs. Given the proximity and vertical orientation of this location to the basement walls, and in light of potential liquefaction, it is our opinion that an infiltration based BMP at this location and at ground level should not be allowed or considered. In our professional opinion, these site conditions are not compatible with infiltrating water into the subsurface soils and performing percolation testing to confirm this opinion is considered unnecessary.

Sincerely,

KLING CONSULTING GROUP, INC.

REGISTERED PROFESSIONAL ENGINEER
HENRY F. KLING
No. 2205
GEOTECHNICAL
STATE OF CALIFORNIA

Henry Kling

GE 2205, Expires 3/31/2024

Preliminary Geotechnical Investigation Report for Feasibility Purposes, 1610 W. Artesia Boulevard, Gardena, California 90248.

PN 22027-00
October 31, 2022

KCG KLING
Consulting
Group, Inc.

KCG KLING Consulting Group, Inc.

October 31, 2022 **PN 22027-00**

Mr. Satish Lion
The Picerne Group
5000 Birch St., Suite 600
Newport Beach, California 92660

Subject: Preliminary Geotechnical Investigation Report for Feasibility Purposes, 1610 W. Artesia Boulevard, Gardena, California 90248

Dear Mr. Lion,

At your request and authorization, Kling Consulting Group, Inc. (KCG) has performed a preliminary geotechnical investigation report for feasibility purposes at the subject property located at 1610 W. Artesia Boulevard, Gardena, California (**see Figure 1 - Site Location Map**). The purpose of our evaluation is to review site geologic/geotechnical conditions and assess constraints for the development of the site. Subsurface field exploration consisting of four Cone Penetrometer (CPT) soundings and one Hollow-Stem Auger (HSA) boring, was completed to characterize the site conditions, determine engineering properties and develop feasibility-level geotechnical conclusions and recommendations. We expect our findings, opinions and recommendations would assist in formulating preliminary costs and budgets for the project.

We appreciate this opportunity to be of continued service and to work with you on this project. Should you have any questions regarding this report, please do not hesitate to call.

Respectfully,

KLING CONSULTING GROUP

John Holder

John C. Holder
Staff Engineer

HENRY F. KLING
No. 2205

Henry F. Kling
Principal Geotechnical Engineer
GE 2205 Expires 3/31/22

JEFFREY P. BLAKE
No. EG 2248
Exp. 10/31/23

Jeffrey P. Blake
Associate Engineering Geologist
CEG 2248 Expires 10/31/23

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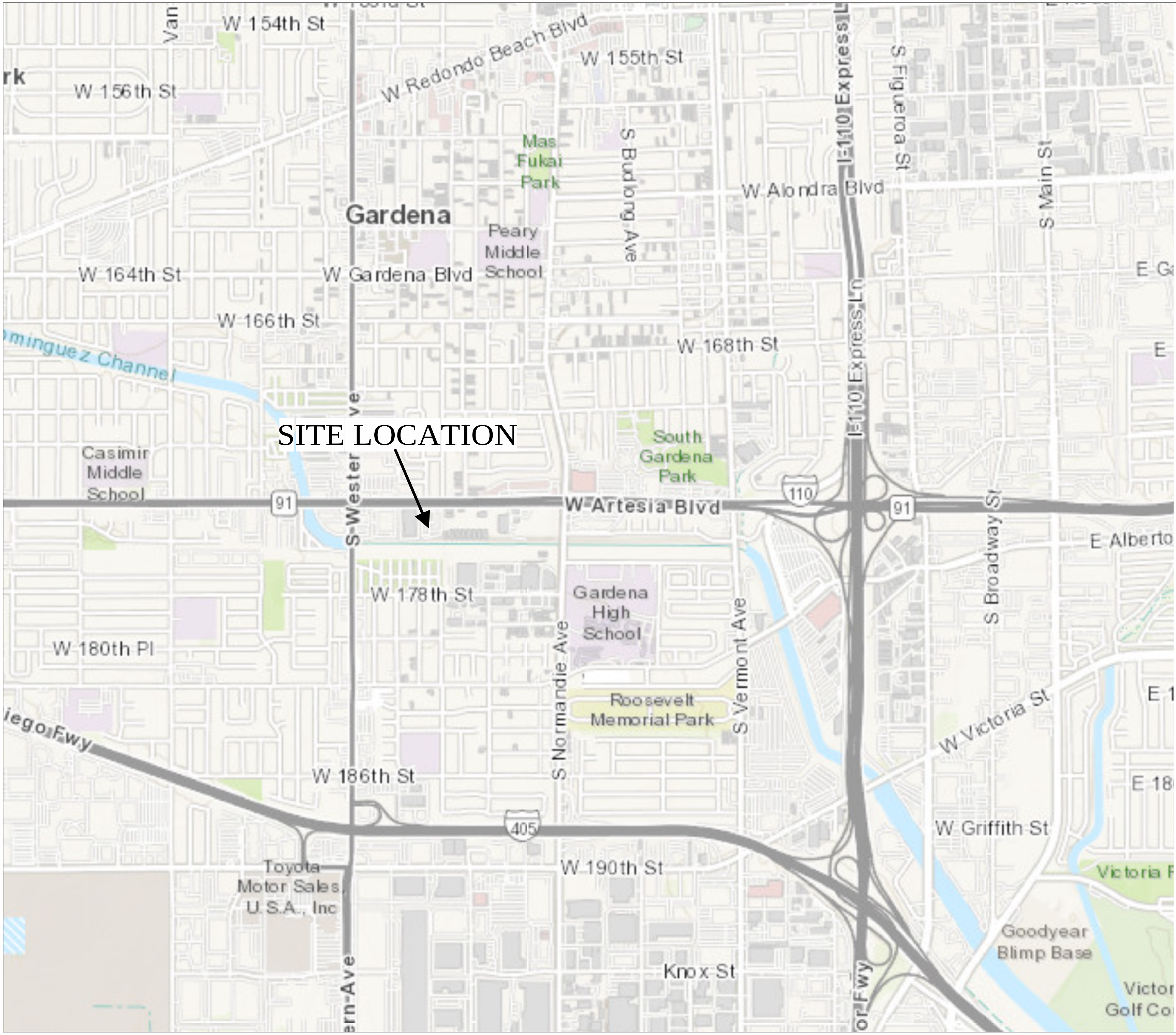

Notes:

Scale: 1”: 1850’

0 925 ft 1850 ft

KCG KLING Consulting Group, Inc.

Client:

Picerne Group

Address:

1610 W. Artesia Boulevard,
Gardena, CA 90248

Site Location Map

Drawn: J.H.

Date: 10/31/2022

P/N: 22027-00

Figure: 1

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Attachments:

Figure 1 – Site Location Map
Figure 2 – Geotechnical Map

Appendix A - References
Appendix B - CPT Soundings and Boring Log
Appendix C - Summary of Laboratory Test Results
Appendix D - Liquefaction and Seismic Settlement Analysis

1.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of our preliminary geotechnical investigation has been to evaluate subsurface conditions at the site relative to the proposed development and provide feasibility level geotechnical recommendations to aid in project planning. Our subsurface exploration consisted of four Cone-Penetrometer Soundings (CPTs) and one Hollow-Stem Auger (HSA) boring located within the vicinity of the proposed development. The boring and CPT tests locations are shown on **Figure 2 – Geotechnical Map**.

1.2 Site Description

The subject property is located at 1610 W. Artesia Boulevard in Gardena, California. The site location (Longitude -118.305367°, Latitude 33.872132°) and surrounding area are presented on Figure 1. The Los Angeles County Office of the Assessor identifies the site as Assessor's ID Number 6106-013-049.

The subject site is currently occupied by two commercial buildings and is approximately 3.8-acres in size. Existing residential and commercial properties surround the site. The site is bordered on the north by Artesia Boulevard, east and west by residential and commercial buildings, and south by the Dominguez Channel. According to the United States Geological Survey (USGS) 7.5-Minute Torrance Quadrangle (USGS, 2021), the site surface is generally flat. The approximate elevation on the site is 25 feet above mean sea level.

Based on a review of historic aerial photos (NETR, 2022) dating back to 1952, it appears the site was originally used for agricultural purposes before being developed sometime between 1972 and 1980. The commercial developments established to the east and west of the site appear to have been built in this same time period. The Dominguez Channel appears to have been constructed prior to the exitising commercial developments between 1952 and 1963.

1.3 Proposed Development

Our understanding of the project is based on reviewing the TPG Stein Yield Study prepared by TCA Architects. The proposed development comprises a five story residential structure (podium) with one subterranean level planned. No other specific information is available regarding the proposed development at this time.

Notes:

⊕ - Boring Hole Location

▲ - Cone Penetration Testing Location

0.94" - Amount of Vertical Liquefaction Settlement

KCG KLING Consulting Group, Inc.

Client:
Picerne Group

Address:
1610 W. Artesia Boulevard,
Gardena, CA 90248

Geotechnical Map

Drawn: J.H.	**Date:** 10/31/2022
P/N: 22027-00	**Figure:** 2

2.0 GEOLOGIC CONDITIONS

2.1 Regional Geologic Setting

The subject site is located within the Los Angeles Basin in Gardena, California. This area resides on the northwestern margin of the Peninsular Range Geomorphic Province. The Los Angeles Basin terminates abruptly, forming coastal hills and mesas associated with the Newport-Inglewood Uplift. The dominant geologic structures of the province, near the subject site, include the Newport-Inglewood-Rose Canyon fault zone to the northeast.

Geological mapping of the area indicates near-surface native soil deposits consist of Pleistocene aged alluvial sediments comprised of varying sediments of sand and silt of valley deposits.

2.2 Site Geologic Units

The native soils underlying the surface of the subject site consist of Old Alluvial Valley Deposits of late Quaternary age. A general description of these alluvial deposits is presented as follows:

Old Alluvial Valley Deposits (Qoa): The Pleistocene age alluvial deposits in the vicinity of the site are mapped as anticipated to consist of predominantly dense to very dense silty sand.

2.3 Subsurface Conditions

2.3.1 Asphalt and Base

The site is mantled by asphalt concrete and aggregate base to a depths of between 2 – 4 inches from the existing ground in the vicinity of borehole KHSA-1.

2.3.2 Artifical Fill (Af)

The site is underlain by artificial fill consisting of clayey sand and silty clay to a depth of 10 feet below the ground surface within the vicinity of borehole KHSA-1, and CPT-1, CPT-2, CPT-3 and CPT-4.

The silty clay and clayey sand are dark brown, moist and fine to medium grained. Concrete and brick debris of up to 1 foot in diameter were observed within the vicinity of KHSA-1 at a depth of 5 feet below ground surface.

2.3.3 Old Alluvial Valley Deposits (Qoa)

The site is underlain by Old Alluvial Valley Deposits of Quaternary age which was encountered during our subsurface exploration between depths of 10 to 50 feet below the ground surface.

The late to middle Pleistocene age alluvial deposits comprised primarily clayey sand and silty clay. The clayey sand and silty clay were generally brown, fine grained, and moist to saturated. The clayey sand ranged from loose to medium dense and the silty clay is stiff in nature.

2.4 Groundwater

Groundwater was encountered within the single hollow stem boring at a depth of 21.5 feet below ground surface and in all CPT soundings based on pore water dissipation readings at depths between approximately 19 and 23 feet below the existing ground surface. The Los Angeles County Department of Public Works established Groundwater Level Data web application, indicates the nearest groundwater well in the vicinity of the subject site's highest ever recorded depth to water table surface was 16 feet below ground surface (bgs) recorded in April 1978.

According to the Seismic Hazard Zone Report for the Torrance 7.5-Minute Quadrangle, the historically highest groundwater level mapped for the subject site is 10 feet below ground surface (bgs).

3.0 GEOTECHNICAL ENGINEERING

3.1 Expansive Soil Characteristics

Expansion Index (EI) laboratory testing on a shallow soil sample from KB-1 resulted in an Expansion Index of 57, which is considered "medium" expansion potential (EI 51-90) according to the CBC.

3.2 Sulfate Content

Sulfate testing was performed on representative samples of the soil. The soils tested during this investigation indicated a class "S0" sulfate per ACI-318 (Reference 2), with a soluble sulfate content of 147 ppm or 0.0147%.

3.3 Moisture and Density

Samples were retrieved at various depths below the ground surface from the hollow-stem boring location and used to determine in-place dry density and moisture content. Moisture results indicate the sampled soils have a moisture content of ranging from 14.3 to 30.6 percent and a dry density ranging from 94.1 to 113.4 pcf. Laboratory test results of dry density and moisture content are recorded on the boring log in Appendix B.

3.4 Surface Fault Rupture

The subject site is not located within the State of California designated Fault-Rupture Hazard Zone (formerly known as Alquist-Priolo Zones), where a site-specific investigation to determine the locations of any active faults would be required.

However, the Southern California region is seismically active. Active and potentially active faults within Southern California can produce seismic shaking at the site. It is anticipated that the site will periodically experience ground acceleration due to exposure to moderate to large magnitude earthquakes occurring on distant faults. However, no active faults are known to exist at the site, and the risk of surface fault rupture is considered low. The closest active fault zone to the subject site is the Newport-Inglewood-Rose Canyon Fault Zone, located approximately 2.5 miles to the northeast.

3.5 Seismic Design Parameters

Presented below are the site seismic parameters utilizing generic geologic, seismic, and geotechnical data gathered for the site and the SEAC Seismic Design Tool (Reference 14). All structures should be designed for earthquake-induced strong ground motions in accordance with the 2019 CBC procedures utilizing the following parameters:

2019 CBC Seismic Design Parameters

Site Class (Soil Profile)	D
Latitude	33.872132
Longitude	-118.305367
Short Period Spectral Acceleration, Ss:	1.771
1-Second Period Spectral Acceleration, S1:	0.63
Site Coefficient, Fa:	1.0
Site Coefficient, Fv:	1.7
Maximum Considered Earthquake Spectral Response Acceleration, SMS:	1.771
Maximum Considered Earthquake Spectral Response Acceleration, SM1:	1.071
Design Spectral Response Acceleration, SDS:	1.181
Design Spectral Response Acceleration, SD1:	0.714
Site modified peak ground acceleration PGA_M	0.845
Seismic Design Category	D

Note: A site-specific ground motion analysis was not included in the scope of this investigation. Per ASCE 7-16, 11.4.8, structures on Site Class D with S_1 greater than or equal to 0.2 may require Site-Specific Ground Motion Analysis. However, a site-specific ground motion analysis may not be required based on exceptions listed in ASCE 7-16, 11.4.8. The project structural engineer should verify whether exceptions are valid for this site and if a Site-Specific Ground Motion Analysis is required.

3.6 Liquefaction Potential

Based on our review of published geologic data, subsurface data, the presence of a shallow static groundwater table, and the overall relatively loose nature of shallower on-site soils, it is our opinion that the site is susceptible to liquefaction. The state of California has also established a seismic hazard zone for liquefaction at the site.

Liquefaction was evaluated in accordance with California Geologic Survey *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, 2008 (Reference 7) based on site peak ground acceleration, earthquake magnitude, and source characteristics relative to the mapped maximum considered geometric mean (MCEG) peak ground acceleration. The parameters used in our analysis included a probabilistic 2,475-year modal earthquake of 7.3 magnitude and a corresponding peak ground acceleration adjusted for site class effects of 0.85 g. Our analysis was performed utilizing the software program “CLiq v.1.7” by GeoLogismiki (Reference 9). The results of our analysis are presented below in Section 3.6, and a summary of the liquefaction analysis is presented in **Appendix C**- Liquefaction and Seismic Settlement Analysis.

The liquefaction analysis was performed utilizing a historic high groundwater level at 10-feet as presented in *The Seismic Hazard Zone Report for the Torrance 7.5-Minute Quadrangle, Los Angeles County, California* (Appendix A).

In addition, the analysis included the following parameters and assumptions:

- Factor of Safety = 1.3 (Chapter 6 California Geologic Survey *Guidelines for Evaluating and Mitigating Seismic Hazards in California*)
- “Dry” seismic settlements calculated (Section 3.5.5 Los Angeles Department of Public Works *Manual for Preparation of Geotechnical Reports)*
- Soil Behavior Type Index (Ic) = 2.60[18].
- Weighting factor for volumetric strain applied[11].
- Cn limit value applied.

3.7 Seismically-Induced Settlement

The liquefaction analyses results for seismically induced vertical ground settlement is presented below. The analysis was based on both existing conditions and with 10-foot basement excavation and assumed high ground water level of 10 feet below ground surface (bgs) .

CPT	Settlement Without Basement (Inches)	Settlement With Basement (Inches)
1	1.30	1.0
2	0.20	0.90
3	1.50	1.40
4	1.80	1.40

The overall vertical settlement calculations include seismically induced “dry” settlements.

Based on this analysis, the seismic induced settlements range from approximately 0.2 inches to 1.8 inches for existing conditions. It should be noted the majority of the vertical ground settlement (>1 inch) and up to approximately 1.6 inches occurs in the upper 20 feet of the soil column. Vertical ground settlements at depths between 22 and 50 feet are less than 0.2 inches. Additionally, seismically induced differential settlement is variable across the site, with an estimated differential settlement of 1.3-inches over a horizontal distance of 170 feet (between CPT-2 and CPT-3). When seismic settlement is analyzed assuming the upper ten feet is excavated for the proposed basement, the calculated seismic settlement ranged from 0.9 inches to 1.4 inches between CPT-2 and CPT-3 with a differential of approximately 0.50 inches over 170 feet horizontally which is equivalent to approximately 0.3 inches over 100 feet.

3.8 Seismically-Induced Lateral Displacements

Lateral spreading, a phenomenon associated with seismically induced soil liquefaction, is the lateral displacement of soils due to inertial motion and lack of lateral support during or post liquefaction. Lateral spreading generally occurs on gently sloping ground or level ground with nearby free surface faces such as a drainage or stream channel. Dominguez Channel is considered a “free surface” in the vicinity of the site. As such, seismically induced lateral spreading was evaluated as part of the liquefaction assessment.

In consideration of the close proximity to the concrete-lined Domingquez Channel and liquefaction settlement, the potential for lateral spreading to occur exists at the site. However, the exact amount of lateral spreading requires additional data and analysis beyond the scope of this preliminary investigation. Nonetheless, we believe the impact to the proposed apartment development would be mostly limited to surface ground improvements. The magnitude of horizontal displacement from spreading would decrease at further distances from the channel. The proposed podium structure with one level of basement would likely resist lateral movement due to its structural integrity. More specific estimates of lateral spreading would be evaluated in the final (Supplemental) investigation.

3.9 Seismically-Induced Landsliding

The State of California Seismic Hazard Zone Map for the Torrance Quadrangle has not designated the subject site for landsliding hazard potential. The potential for seismically-induced landsliding to occur at the site is considered very low due to the relatively flat topography and absence of significant slopes on or adjacent to the site. Slopes planned as part of the development should be engineered and constructed at a gradient of 2:1 (horizontal: vertical) or flatter.

4.0 CONCLUSIONS

The following preliminary conclusions are based upon our analysis and data review obtained during our subsurface field investigation. It is our opinion that the subject site is considered geotechnically suitable for the proposed development discussed above, provided the recommendations presented herein are implemented during design and construction. Additional subsurface exploration, laboratory testing and geotechnical analysis should be performed to confirm site conditions and to finalize the geotechnical investigation report.

- Based upon our review of the site, the underlying soils on-site are considered to have sufficient bearing capacity to support the proposed development, provided the preliminary recommendations herein are implemented.

- Geroundwater was encountered in our Boring B-1 at a depth of approximately 21.5 feet belwo the exsiting ground surface. Apparent groundwater recorded with pore water dissipation measurements in the CPT Soundings was encountered in all of our tests at depths of between approximately 19 and 23 feet below the existing ground surface during our subsurface exploration.

- Our geotechnical evaluation indicates that the upper 20 feet of the alluvial deposits that underlie the site are susceptible to liquefaction and seismic induced settlement due to a design-level earthquake incorporating the historical high groundwater level of 10 feet below existing grades (CGS, 1998). We estimate that liquefaction-induced vertical settlement for the subject apartment site would range from approximately 0.2 to 1.8 inches, with approximately 1.6 inches of estimated differential settlement over 350 feet. However, the seismic settlement analyzed beneath the proposed basement ranged from 0.9 inches to 1.4 inches resulting in differential settlement of 0.3 inches over 100 feet. This differential settlement of 0.3 inches over 100 feet should be incorporated into the overall design.

- KCG's professional opinion is that seismic and liquefaction-induced ground displacements can be mitigated by incorporating the differential settlement into the structural design of the building and employing a mat foundation system in the basement to support the proposed structure.

- Seismically induced lateral spreading is likely to occur at the site during significant seismic events; however, the spreading would likely affect surface improvements more than the proposed podium structure. Further analysis during the supplemental investigation should better predict the actual magnitude and extent of spreading

- Preliminarily, the soils underlying the site should be considered to have moderate expansion potential.

- No active fault is known to exist at the site, and the risk of surface fault rupture is considered to be very low.

- The proposed development should not adversely affect neighboring properties if proper care is taken during the construction of proposed improvements.

5.0 PRELIMINARY RECOMMENDATIONS

Preliminary recommendations presented below are based on information obtained from the client, and the preliminary geotechnical information gathered and analyzed to date.

5.1 Supplemental Subsurface Exploration

During this preliminary investigation phase, our CPT Soundings were primarily utilized to analyze the susceptibility of the underlying soil to seismic induced settlement and liquefaction potential. Due to existing buildings and improvements, CPT and boring locations were limited to readily accessible areas. We recommend that a supplemental geotechnical investigation be performed that includes both additional CPT soundings and soil borings to further characterize subsurface conditions, confirm groundwater levels and perform additional laboratory testing on obtained soil samples collected. The supplemental investigation would further refine our conclusions and recommendations and to comply with the Los Angeles Department of Public Works *Manual for Preparation of Geotechnical Reports*.

5.2 Earthwork Specifications

All grading should be performed in accordance with the General Earthwork and Grading Specifications presented in Appendix E, unless specifically revised or amended below. Grading should also conform to all applicable governing agency requirements. Prior to the commencement of grading operations, all vegetation, organic topsoil, and man-made structures (i.e., tanks, pipes, fences, etc.) should be cleared and disposed of off-site. Any undocumented fill or backfill encountered should be removed and re-compacted. All areas receiving fill should be scarified to 6 inches and/or over-excavated, moisture-conditioned between optimum moisture and two to four percent above optimum moisture content, and re-compacted to a minimum of 90 percent relative compaction as determined by ASTM D1557. Soil material excavated from the site should be adequate for re-use as compacted fill provided it is free of oversize rock, trash, vegetation, and other deleterious material. All earthwork and grading operations should be performed under the observation and testing of the geotechnical consultant of record.

5.3 Preliminary Remedial Earthwork and Over-Excavation

To provide uniform soil support for the proposed structures and reduce the potential for liquefaction induced settlement and settlement due to underlying potentially compressible soils, we recommend that the underlying soils be mitigated through ground improvement methods in those areas to receive buildings or other settlement-sensitive improvements, where not removed by planned excavations. It is our understanding that the proposed podium apartment structure would be supported entirely on a one-level parking basement. No remedial grading is anticipated for soil exposed after basement excavation is performed.

Should any at-grade structures be planned, we preliminarily anticipate remedial earthwork would involve over-excavation of the upper soils to maintain a minimum thickness of at least five (5) feet of fill below finish grade elevation, or a minimum of two (2) feet below proposed footings, whichever is deeper. The removal depth may vary laterally. As such, the recommended excavation depth may vary; this will need to be observed during construction. At a minimum, the removals should extend laterally beyond the building footprint five feet, where practical. In proposed pavement or flatwork areas, the depth of the removals should extend at least 12-inches below existing grade, or 12-inches below finish subgrade (whichever is deeper).

5.4 Preliminary Proposed Building Foundations Options

All foundation criteria are considered minimum requirements that may be superseded by more stringent requirements from the architect, structural engineer, or governing agencies. The preliminary recommended geotechnical design parameters are being provided for conventional spread footings and reinforced mat slab foundation systems with remedial earthwork for the at-grade residential buildings, if any**.**

5.4.1 Residential Apartment Building

5.4.1.1 Conventional Foundations

The following preliminary geotechnical parameters are provided for design of proposed conventional foundations at one level subterreanean parking. In general, the insitu soil at one level deep should provide support for proposed foundations. An allowable bearing pressure of 4000 pounds per square foot for square pad and continuous footings may be assumed. The minimum width and depth for continuous and square pad footings should be 24 inches and 24 inches, respectively. The depth is relative to finish slab elevation. Bearing pressures may be increased by 250 pounds per square foot per additional foot of width or depth to a maximum allowable bearing pressure of 5000 pounds per square foot. A coefficient of friction of 0.38 may be used, along with a passive lateral resistance of 250 pounds per square foot per foot of embedment. Footings should bear on either approved natural ground or compacted fill in the event localized areas of soft or disturbed soil is exposed after excavation.

If normal code requirements are used for seismic design, the allowable bearing value and coefficient of friction may be increased by 1/3 for short duration loads, such as the effect of wind or seismic forces. Static settlement of foundations supporting the proposed one three story buildings is not expected to exceed one inch and ¼-inch over fifty horizontal feet.

If any utility lines are within a 1:1 (horizontal: vertical) projection from the bottom of a footing, they may be within the influence zone of the proposed footing load. If this condition exists, the proposed footing should be deepened so that the utility is outside the zone of influence; the utility line could also be relocated or encased with concrete slurry. These conditions should be evaluated on a case by case basis.

5.4.1.2 Mat Foundation

A rigid mat foundation may be used for upport of the building at one level of subterranean basement. In general, the insitu soil should provide adequate support for proposed mat foundation. The subgrade should be evaluated upon completion of basement excavation. Any localized areas of soft or disturbed soil should be removed and recompacted prior to foundation constructioin. Mat foundations should be properly reinforced to form a relatively rigid structural unit in accordance with the structural engineering design. For designing a mat foundation, we preliminarily recommend a modulus of subgrade reaction of 100 pounds per square inch per inch (pci). This value can be further refined as part of the supplemental investigation. A maximum bearing pressure of 3000 psf is also recommended. For localized areas of higher pressure (often required for seismic design) further evaluation is warranted to evaluate the increase in pressure and resulting settlement.

5.5 Settlement

Static settlement of proposed foundations is dependent on the actual foundation system selected and actual bearing pressures. For preliminary planning purposes foundation settlement is expected to not exceed one inch in total and one-half inch differential over 50 horizontal feet. Anticipated liquefaction and seismic-induced settlement for the overall site ranges froms 0.2 to 1.8 inches. However, after basement excavation and loading, the seismically induced settlement is expected on the order of 0.30 inches over 100 horizontal feet. This is considered minor settlement, however it should be refined and verified during the recommended supplemental investigation.

5.6 Footing Setbacks

All footings should maintain a minimum 7-foot horizontal setback from the base of the footing to any descending slope. This distance is measured from the outside footing face at the bearing elevation. Footings should maintain a minimum horizontal setback of H/3 (H=slope height) from the base of the footing to the descending slope face and should be no less than 7 feet, and it need not be greater than 40 feet.

5.7 Slab-On-Grade

These recommendations are considered minimum requirements that may be superseded by more stringent requirements from the architect, structural engineer, or governing agencies.

Concrete slabs should be at least 4-inches in thickness. Actual slab thickness and reinforcement should be determined by the structural engineer based on structural loads and soil interaction. Our recommendations should be superseded by the recommendations of the structural engineer or architect.

New slabs-on-grade should minimally conform to the design procedure contained in Section 1808 of the 2019 California Building Code. The project structural engineer should consider these recommendations as minimum requirements and modify these recommendations as appropriate.

Slab subgrade soil moisture should be at least optimum moisture prior to placement of concrete or vapor barrier. If the moisture content of the existing subgrade soil is less than optimum, pre-saturation may be required to achieve optimum prior to placing the capillary layer or Stego.

Interior concrete slab-on-grade floors (if any) should be at least 4-inches in thickness underlain by a minimum 4-inch capillary break using ½-inch open graded gravel or material approved by the geotechnical engineer. The 4-inch capillary layer should be underlain by a 15-mil Stego Wrap vapor retarder or equivalent product with a permeance rate of 0.012 perms (or less) and puncture resistance of Class “A” or “B” per ASTM E 1745-11. As per the manufacturer recommendations, all seams should overlap a minimum of 6 inches and should be sealed in accordance with the specifications provided by the vapor retarder manufacturer. All penetrations must be sealed using a combination of Stego Wrap, Stego Tape and/or Stego Mastic or approved equivalent. The vapor retarder should be lapped downward a minimum of 12 inches where the vapor retarder encounters an interior footing or exterior thickened edge or footing. The vapor retarder must be placed on top of the capillary layer if it is expected to become wet prior to the concrete pour. If the capillary layer can be kept dry before pouring concrete, the vapor retarder may be placed under the capillary layer. The water-cement ratio of structural concrete should be not greater than 0.50. The actual slab thickness and reinforcement should be determined by the project structural engineer.

If moisture-sensitive floor coverings are utilized, interior concrete slabs should be designed and constructed in accordance with the applicable floor manufacturer's specifications. The flooring installer should conduct all applicable testing to determine if concrete slabs have sufficiently cured to receive flooring materials.

The basement slab on grade, if used exclusively for vehicular parking, may not require a moisture retarder. However, an aggregate layer of some thickness could be considered to reduce moisture vapor accumulating in the basement.

5.8 Retaining Walls

General guidelines are provided below for retaining walls up to twelve feet in retained height. Please note that drainage recommendations are provided only as a means to create a drained condition behind proposed retaining walls. Surface drains should not be connected to retaining wall sub-drainage. These drains are not intended as a means of waterproofing. If moisture or salt deposition is not desired, or if stone facing, stucco, or paint is to be applied to the wall outer surface, the wall should be provided with suitable waterproofing. The waterproofing system for the wall should be designed by a qualified waterproofing consultant. Any waterproofing or drainage system damaged by soil placement and compaction efforts should be repaired prior to completion of backfilling.

Foundations for proposed retaining and perimeter (non-retaining) walls which are to be founded into compacted fill materials may be designed utilizing an allowable bearing pressure as presented above for conventional foundations.

Cantilevered retaining walls should be designed to resist equivalent fluid pressures as indicated in the tables below:

Case 1 – Select (Clean Sand) Backfill Condition[1]

Backfill Condition (Active)	**Equivalent Fluid Pressure (psf/ft)**
Level	35
2:1 Slope	55

[1] Assumes clean sand (Sand Equivalent >30) backfill see attached detail RW-1.

Case 2 – Native Backfill Condition[2]

Backfill Condition (Active)	**Equivalent Fluid Pressure (psf/ft)**
Level	55
2:1 Slope	65

[2] Assumes drained native soil backfill see attached detail RW-1.

Both the clean sand and native backfill conditions provided above assume a drained condition behind the proposed retaining wall. A backdrain consisting of 4-inch perforated plastic pipe SDR 35 or Schedule 40, encased in ¾-inch gravel wrapped in Mirafi 140N or equivalent filter fabric, and properly outletted. Details for retaining wall drainage are provided in our attached Retaining Wall Detail RW-1 (Appendix E). A seismic surcharge of

19H should be applied at mid-height of the wall, where H= the retained height of the wall greater than 6 feet.

Additional surcharge loading considerations are not incorporated into the above values. If the project structural engineer wishes to incorporate additional loading due to these factors, the additional loads should be added to the values provided above. Foundations for proposed retaining walls may be designed by utilizing the recommendations for conventional foundations. However, when combining both frictional and passive lateral resistance, one or the other should be reduced by one-half.

Active earth pressure can be assumed for temporary shoring systems such as H-beam and lagging that can safely deflect sufficiently to initiate an active pressure condition. More detailed recommendations and design parameters for shoring should be evaluated as part of the supplemental investigation based on selected shoring systems.

5.8.1 Basement Walls

Basement walls should be designed for at-rest earth pressure. For preliminary design purposes, an at-rest earth pressure should be assumed equal to 75 pounds per cubic foot. Basement walls should be provided with backdrains consisting of drainage composites or sand backfill in connection with an aggregate wrapped in filter fabric with 4-inch diameter perforated pipe. In general, the basement wall drainage system should be based on the recommendation for drains presented in the previous section.

5.9 Preliminary Pavement Design

Pavement section design is provided below based on anticipated near surface soil conditions encountered during our investigation and assumed traffic loading.

5.9.1 Asphalt Concrete Pavement

R value testing was not performed as part of this investigation and should be performed during the supplemental investigation. However, we are assuming an R-Value of 30 for preliminary design purposes.

Based on an assumed R-value of 30 the parameters below are provided for preliminary design purposes. Pavement sections were calculated for traffic indices of 4.0 and 5.5, which are commonly used for parking stalls and drive aisles subject to passenger vehicles and service trucks, respectively. However, the selection of actual traffic index should be the purview of the project civil or traffic engineer.

Pavement Section Design

Location	R-Value	Traffic Index	Multiple Layered	
			Asphalt Concrete (inches)	Aggregate Base* (inches)
Parking Stall	30	4.0	3.0	6.0
Drive Aisles	30	5.5	3.0	8.0

*Aggregate base material should consist of Class 2 aggregate base materials or Crushed Miscellaneous Base (CMB).

The upper 12 inches of the subgrade soils should be compacted to at least 90 percent of the laboratory maximum dry density (ASTM D1557). All base materials should be compacted to at least 95 percent of the laboratory maximum dry density (ASTM D1557).

5.9.2 Portland Cement Concrete Pavement

For preliminary design of concrete pavement, it is recommended that a concrete pavement section consisting of 6-inches of concrete underlain by at least 4-inches of either Class 2 aggregate base or crushed miscellaneous base (CMB) be used for preliminary design. Concrete Compressive strength should be 4000 psi or greater. Aggregate base material should be compacted to a minimum of 95 percent relative compaction as per ASTM D1557. Subgrade soil should be compacted to at least 90 percent of the laboratory maximum dry density in accordance with ASTM D1557. If concrete crack control is desired, the slabs should be minimally reinforced with No. 4 rebar, placed every 24 inches on center, both ways. A 10-foot square or less grid system should be used in the construction of continuous sections of concrete pavement or as recommended by the structural engineer.

For trash enclosures, concrete pavement should consist of a minimum 8-inch thick concrete slab placed over a minimum of 6-inches of either Class 2 or crushed miscellaneous base material, compacted to 95 percent relative compaction. Concrete should have a minimum strength of 4000 psi and be reinforced with a minimum of No. 4 bars placed at 24 inches on center, in each direction, positively supported (with concrete chairs or other devices) at mid-height in the slab. Crack control joints should be placed at a 10-foot maximum spacing in each direction in the slab or as recommended by the structural engineer. Concrete mix design should incorporate the recommendations presented in the slab on grade section of this report for improved geotechnical performance.

5.10 Exterior Flatwork

The following general recommendations may be considered for concrete hardscape including expansive soils mitigation and may be superseded by the requirements of Los Angeles County.

5.10.1 Sidewalk, Pedestrian Walkways

Expansion Potential	**Minimum Concrete Thickness**	**Subgrade Pre-Soaking Depth**	**Reinforcement**	**Joint * Spacing**
Medium	4 (Full)	120% of Optimum to 18”	#3 @ 18" OC, EW	4-5 Feet

* Joints at curves and angle points are recommended.

5.10.2 Driveways, Patios, Entryways

Expansion Potential	**Minimum Concrete Thickness (in)**	**Subgrade Pre-Soaking Depth**	**Reinforcement**	**Joint[3] Spacing (Max)**
Medium	General Flatwork 4 (Full) Driveways 6 (Full)	120% of Optimum to 18”	#3 @ 18" OC, EW	4-5 Feet

[3] Joints at curves and angle points are recommended.

The above recommendations may be superseded by the project architect, structural engineer or the governing agency’s requirements. These recommendations are not intended to mitigate cracking caused by shrinkage and temperature warping.

5.11 Drainage

Positive drainage should be maintained away from any building or graded slope face and directed to suitable areas via non-erosive devices, as designed by the project civil engineer. For drainage over soil and paved areas immediately adjacent to structures, please refer to Section 1804.4 of the 2019 CBC.

5.12 Geotechnical Observation and Testing

Geotechnical observation and testing should be conducted during the following stages of grading:

- During all phases of rough and precise grading, footing excavations, etc.
- During slab and flatwork subgrade pre-saturation and moisture conditioning.
- During shoring system installation.
- During utility trench excavation and compaction.
- During placement of retaining wall sub-drainage, backfill, and compaction.

For any unusual conditions encountered during grading.

6.0 PROFESSIONAL LIMITATIONS

Geotechnical services are provided by KCG in accordance with generally accepted professional engineering and geologic practice in the area where these services are to be rendered. Client acknowledges that the present standard in the engineering and geologic and environmental profession does not include a guarantee of perfection and, except as expressly set forth in the conditions above, no warranty, expressed or implied, is extended by KCG.

Geotechnical reports are based on the project description and proposed scope of work as described in the proposal. Our conclusions and recommendations are based on the results of the field, laboratory, and office studies, combined with an interpolation and extrapolation of soil conditions as described in the report. The results reflect our geotechnical interpretation of the limited direct evidence obtained. Our conclusions and recommendations are made contingent upon the opportunity for KCG to continue to provide geotechnical services beyond the scope in the proposal to include all geotechnical services. If parties other than KCG are engaged to provide such services, they must be notified that they will be required to assume complete responsibility for the geotechnical work of the project by concurring with the recommendations in our report or providing alternate recommendations.

It is the reader's responsibility to verify the correct interpretation and intention of the recommendations presented herein. KCG assumes no responsibility for misunderstandings or improper interpretations that result in unsatisfactory or unsafe work products. It is the reader's further responsibility to acquire copies of any supplemental reports, addenda, or responses to public agency reviews that may supersede recommendations in this report.

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

1. American Society for Testing and Materials (ASTM), 2018, Annual Book of ASTM Standards, Volume 04.08, Construction: Soil and Rock (I), Standards D 420 - D 5876

2. American Concrete Institute, 2014, Manual of Concrete Practice, Volume 1 through 6.

3. California Building Standards Commission, 2019, California Building Code, Volume 2.

4. California Geologic Survey (CGS), Compilation of Quaternary Surficial Deposits: https://maps.conservation.ca.gov/cgs/qsd/app/, accessed October 2022.

5. California Geological Survey, Department of Conservation, Division of Mines of Geology, 1998, *Seismic Hazard Zone Report for the Torrance 7.5-Minute Quadrangle, Seismic Hazard Zone Report 035, Los Angeles County, CA.*

6. California Geological Survey (CGS), Earthquake Zones of Required Investigation Web Application, https://maps.conservation.ca.gov/cgs/eqzapp/app/, accessed October, 2022.

7. California Geological Survey, Special Publication 117A, *Guidelines for Evaluating and Mitigation Seismic Hazards in California. 2008*

8. County of Los Angeles Department of Public Works *Manual for Preparation of Geotechnical Reports. 2013*

9. Geologismiki, 2007, CLiq, Liquefaction Software, Version 1.7.

10. Google Earth. (January 3, 2020). Gardena. 33.872132, -118.305367, Accessed October, 2022.

11. Historical Aerials (NETR Online), 2020, website: https://www.historicaerials.com/viewer, accessed October, 2022.

12. LA County Department of Public Works, 2019, Groundwater Level Data, accessed October, 2022 URL: https://dpw.lacounty.gov/general/wells/

13. Robertson, P. (1998). *Evaluating cyclic liquefaction potential using the cone penetration test.* Canadian Geotechnical Journal - Can Geotech J. 35. 442-459.

14. Structural Engineers Association of California (SEAC)/Office of Statewide Health Planning and Development OSHPD: Seismic Design Maps: https://oshpd.ca.gov/seismic maps.org, accessed October, 2022.

APPENDIX A

REFERENCES
(CONTINUED)

15. TCA Architects, TPG Stein Yield Study, 1610 W. Artesia Blvd., Gardena, California. Dated June 2, 2021.

16. USGS, National Geologic Map Data Base (NGMDB), https://ngmdb.usgs.gov/mapview/, accessed October, 2022.

17. USGS, topoView, https://ngmdb.usgs.gov/topoview/, accessed October, 2022.

18. USGS, Unified Hazard Tool, https://earthquake.usgs.gov/hazards/interactive/, accessed October, 2022.

19. USGS, U.S. Quaternary Faults, https://www.usgs.gov/natural-hazards/earthquake-hazards/faults, accessed October, 2022.

20. USGS, 2019, US Seismic Design Maps, accessed October, 2022. URL: https://earthquake.usgs.gov/designmaps/us/application.php?

APPENDIX B

CPT SOUNDINGS AND BORING LOGS

LOG OF EXPLORATORY BORING

Sheet **1** of **3**

Project: **1610 W. Artesia Blvd, Gardena, CA**
Project Number: **22027-00**
Date Drilled: **9/30/22**
Logged By: **J.H**

Boring No.: **KHSA-1**
Driller: **Bc2 Environmental**
Drill Type: **Hollow-Stem Auger**
Hammer Wt. / Drop: **140lb / 18in**
Ground Elev. [ft]: **---**

◩ Standard Split Spoon
■ Shelby Tube
▽ Water Level ATD
⧗ California
☒ Bulk Sample
▼ Static Water Table

Depth [ft]	Graphic Log	Sample Type	Blows/6"	Moisture Content [%]	Dry Density, [pcf]	SOIL DESCRIPTION and CLASSIFICATION (USCS)	Pocket Pen. [tsf]	Lab Tests	Remarks
						@ **0 feet** - **Asphalt:** 3-4 inches thick			
						Artificial Fill (Af):			
						@ **0.5 feet** - **Clayey Sand (SC):** dark brown, medium grained, moist, medium dense.		EI SO4	
						@ **4.0 feet** - trash debris including concrete and brick, up to 1 foot diameter			
5		⧗	6 8 6						No recovery.
						@ **6.0 feet** - **Silty Clay (CL):** dark brown, moist, fat.			
10		⧗	5 7 13 [13]	19.2	111.2	@ **10.0 feet** - **Silty Clay (CL):** dark brown, moist, fat, stiff.	> 4.5		
						Old Alluvial Valley Deposits (Qoa):			
		⧗	6 14 16 [24]	18.1	113.4	@ **12.5 feet** - **Clayey Sand (SC):** brown, fine to medium grained, moist, medium dense.	> 4.5		
15		⧗	3 12 13 [18]	14.3	110.8	@ **15.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, moist, medium dense.	> 4.5	CN	
20		⧗		22.2	104.3	@ **20.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, moist/almost wet.	1.50		Blowcount N/A. ▽
		⧗	5 10 12 [13]	30.6	94.1	@ **22.5 feet** - **Clayey Sand (SC):** brown, fine to medium grained, wet, medium dense.	2.00	DS	

Blow count in bracket represents (N1)60 value.
LaCroix & Horn conversion factor of 0.64 used to convert California Sampler blow counts to SPT values.

KCG KLING Consulting Group, Inc.

LOG OF EXPLORATORY BORING

Sheet **2** of **3**

Project: **1610 W. Artesia Blvd, Gardena, CA**
Project Number: **22027-00**
Date Drilled: **9/30/22**
Logged By: **J.H**
Boring No.: **KHSA-1**
Driller: **Bc2 Environmental**
Drill Type: **Hollow-Stem Auger**
Hammer Wt. / Drop: **140lb / 18in**
Ground Elev. [ft]: **---**

◩ Standard Split Spoon
■ Shelby Tube
▽ Water Level ATD
⧗ California
☒ Bulk Sample
▼ Static Water Table

Depth [ft]	Graphic Log	Sample Type	Blows/6"	Moisture Content [%]	Dry Density, [pcf]	SOIL DESCRIPTION and CLASSIFICATION (USCS)	Pocket Pen. [tsf]	Lab Tests	Remarks
25		⧗		24.8	102.3	**Old Alluvial Valley Deposits (Qoa):** @ **25.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, wet.	1.25		Blowcount N/A.
30		⧗	6 7 9 [8]	24.2	102.9	@ **30.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, wet, medium dense.	1.50		
35		⧗	5 5 6 [4]	24.0	104.8	@ **35.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, wet, loose.	1.00		
40		⧗	4 5 6 [4]	23.8	101.8	@ **40.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, wet, loose.	0.50		
45		⧗	5 5 6 [4]	23.1	104.7	@ **45.0 feet** - **Clayey Sand (SC):** brown, fine to medium grained, wet, loose.	1.50		

Blow count in bracket represents (N1)60 value.
LaCroix & Horn conversion factor of 0.64 used to convert California Sampler blow counts to SPT values.

LOG OF EXPLORATORY BORING

Sheet **3** of **3**

Project:	**1610 W. Artesia Blvd, Gardena, CA**	Boring No.:	**KHSA-1**
Project Number:	**22027-00**	Driller:	**Bc2 Environmental**
Date Drilled:	**9/30/22**	Drill Type:	**Hollow-Stem Auger**
Logged By:	**J.H**	Hammer Wt. / Drop:	**140lb / 18in**
		Ground Elev. [ft]:	**---**

◩ Standard Split Spoon
■ Shelby Tube
▽ Water Level ATD
⧓ California
⊠ Bulk Sample
▼ Static Water Table

Depth [ft]	Graphic Log	Sample Type	Blows/6"	Moisture Content [%]	Dry Density, [pcf]	SOIL DESCRIPTION and CLASSIFICATION (USCS)	Pocket Pen. [tsf]	Lab Tests	Remarks
50	▨	⧓		27.7	96.4	@ **50.0 feet - Clayey Sand (SC):** light gray, fine to medium grained, wet.	1.00		Blowcount N/A.

End of Boring @ 51.5 ft below ground surface.
Groundwater encountered @ 21.5 feet below ground surface.
No Caving

Blow count in bracket represents (N1)60 value.
LaCroix & Horn conversion factor of 0.64 used to convert California Sampler blow counts to SPT values.

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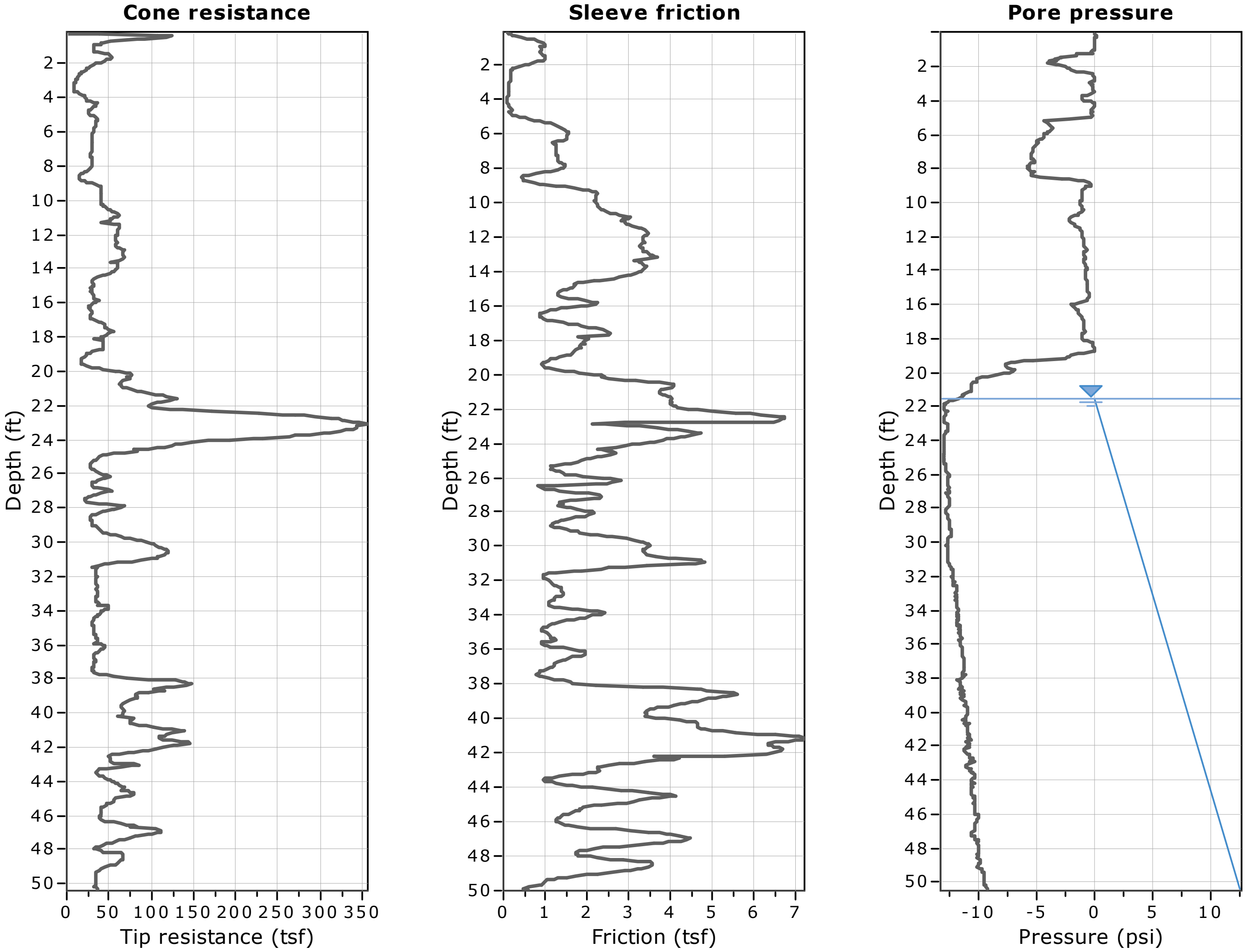
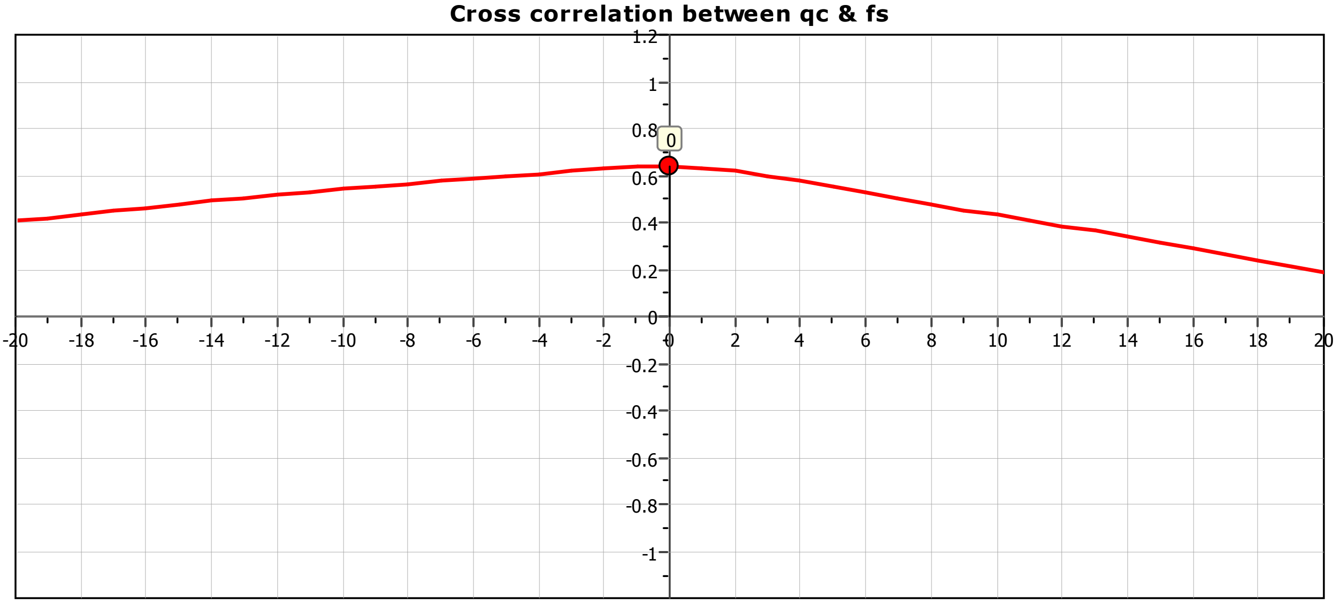
CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

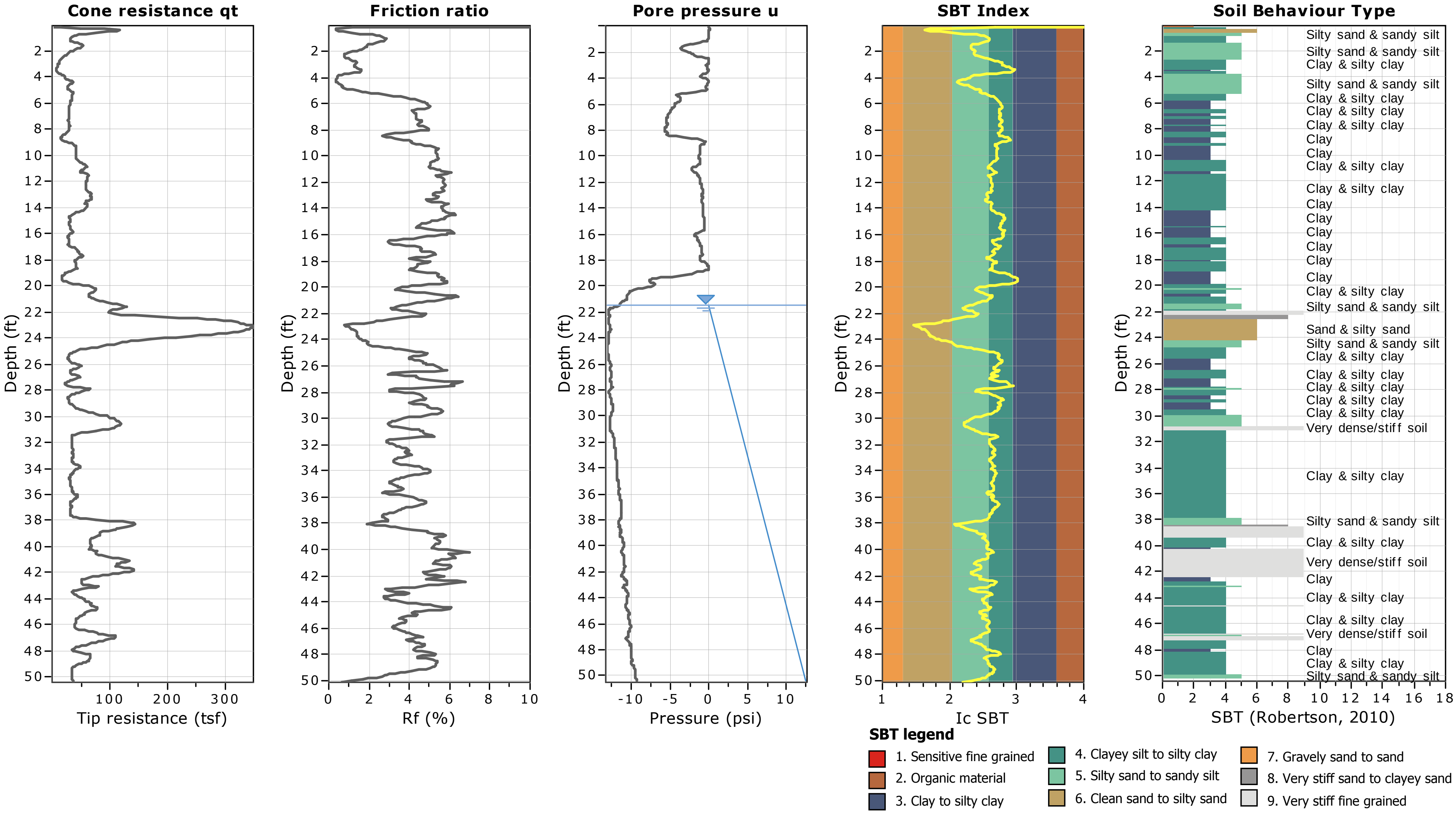


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



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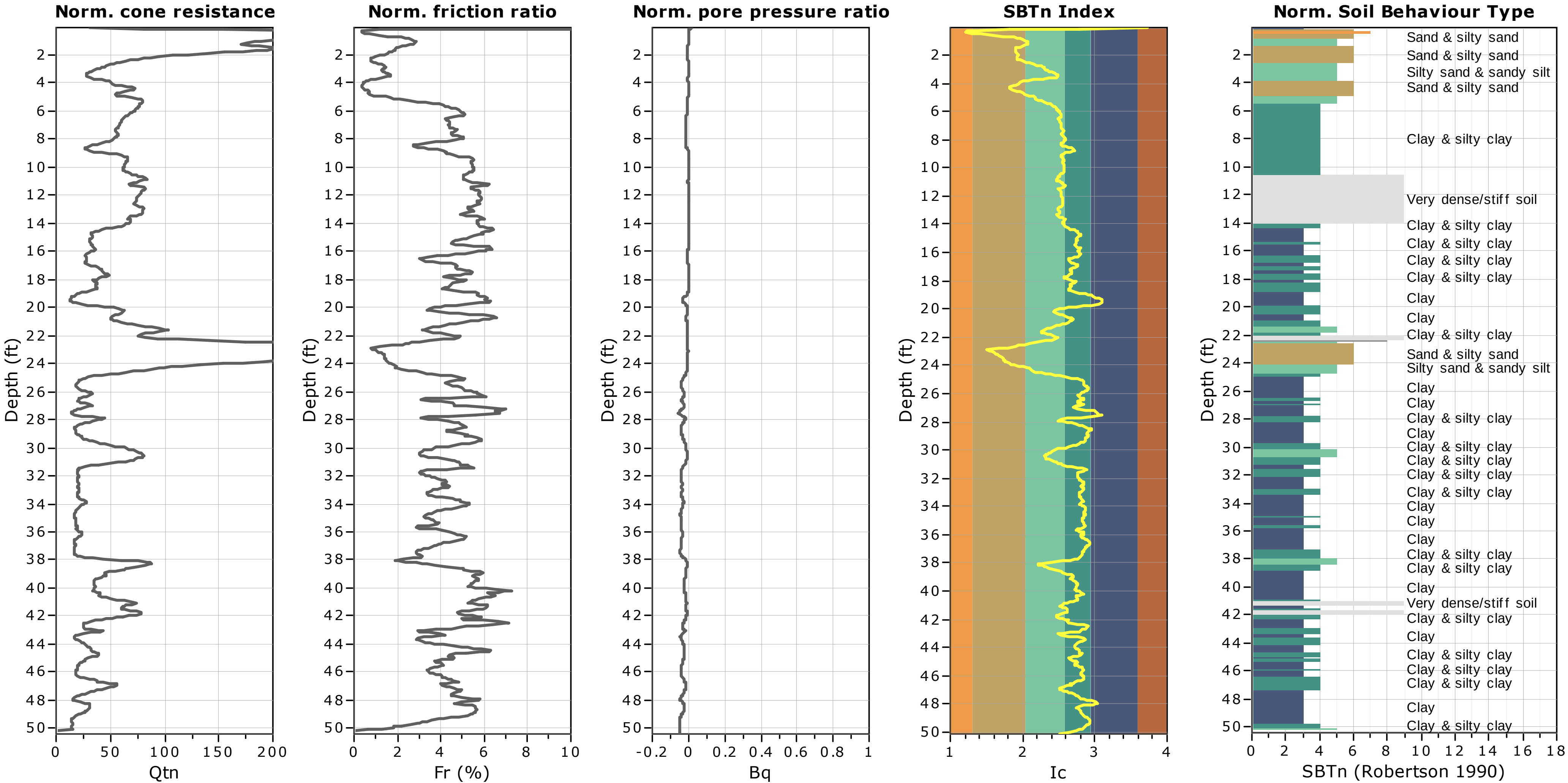
CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



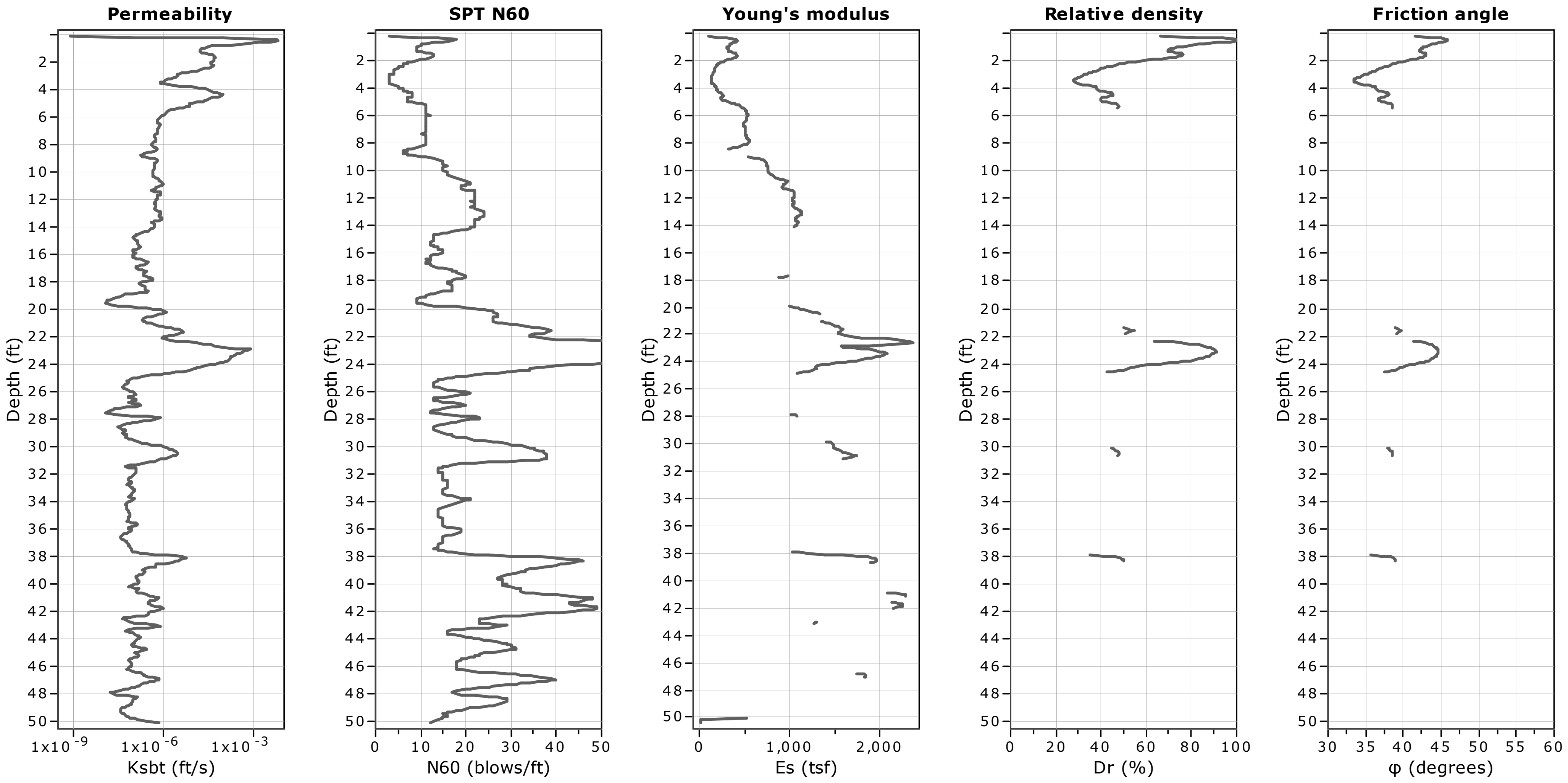
SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty clay
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to clayey sand
⬜ 9. Very stiff fine grained

CPT: CPT-01

Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
● User defined estimation data

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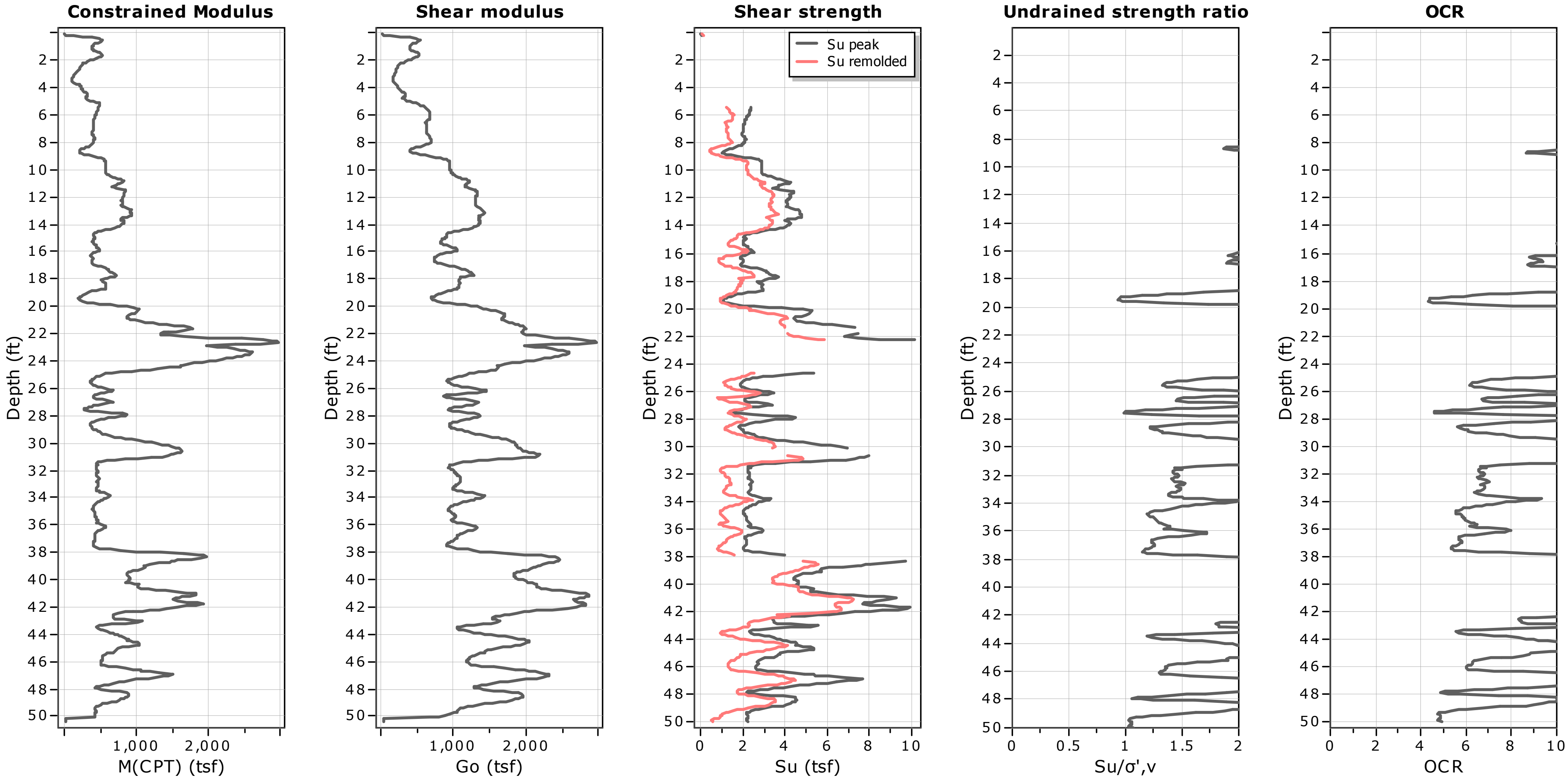
CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



Calculation parameters
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
● User defined estimation data

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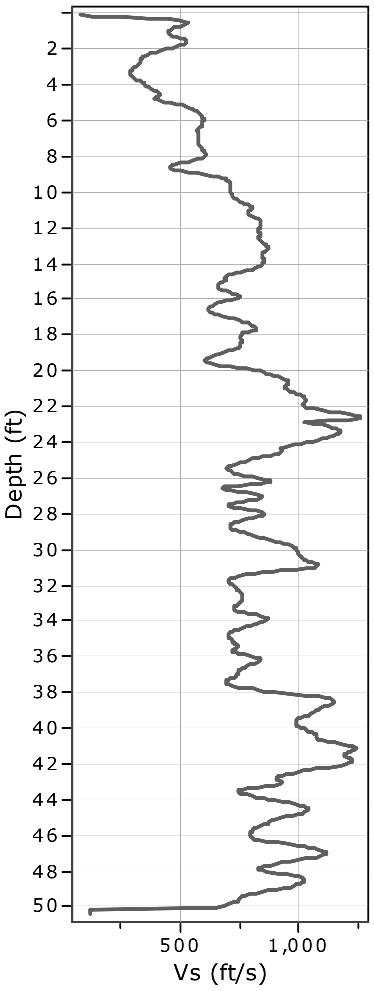
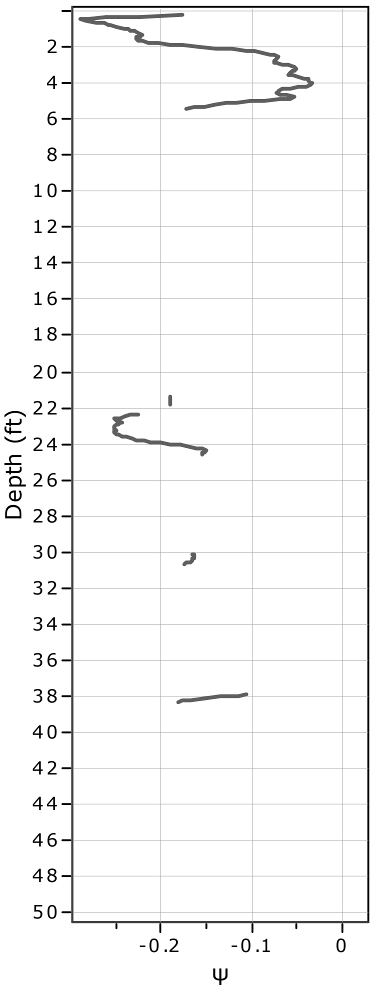
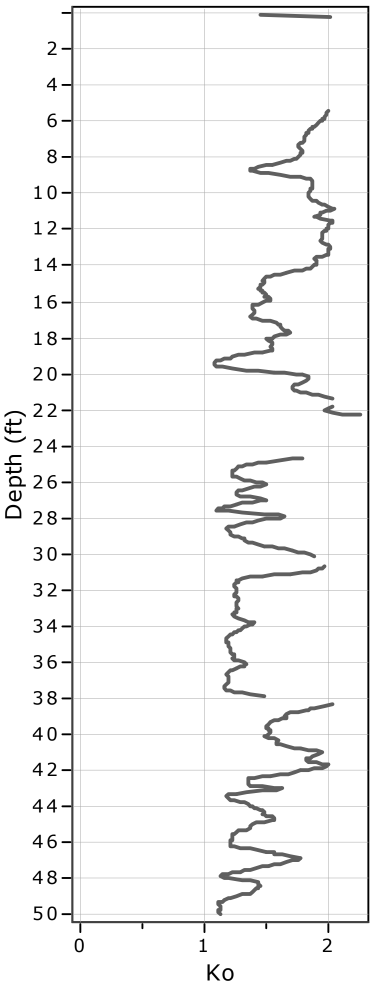
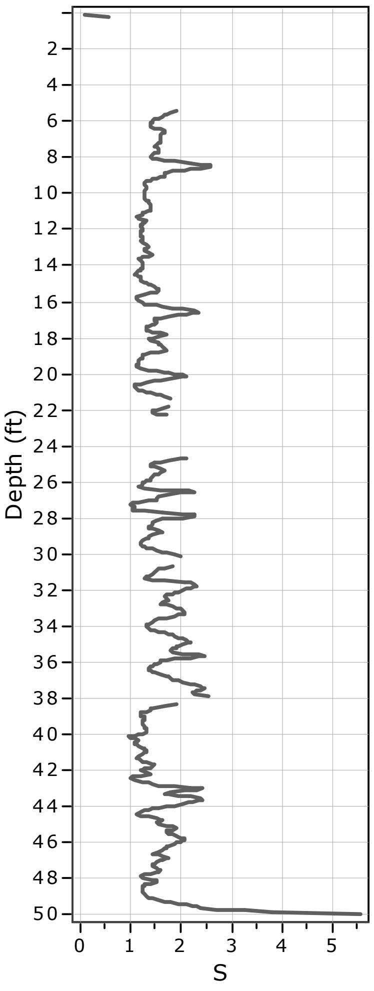
Project:
Location:

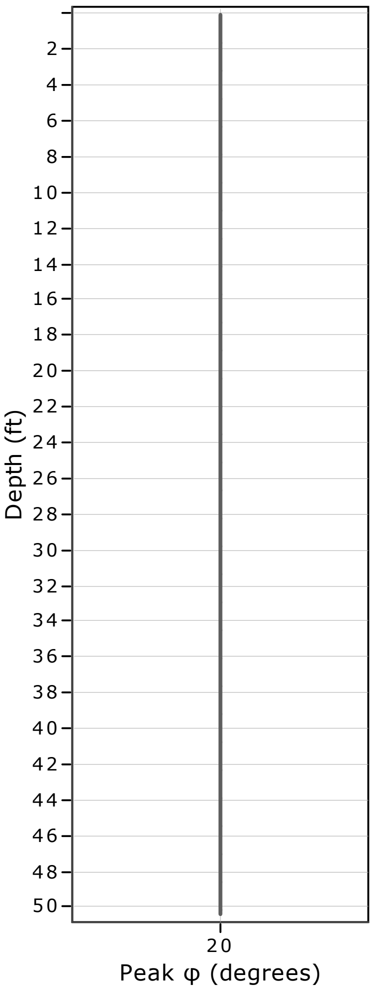
CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown


Shear Wave velocity


State parameter


In-situ stress ratio


Soil sensitivity


Effective friction angle

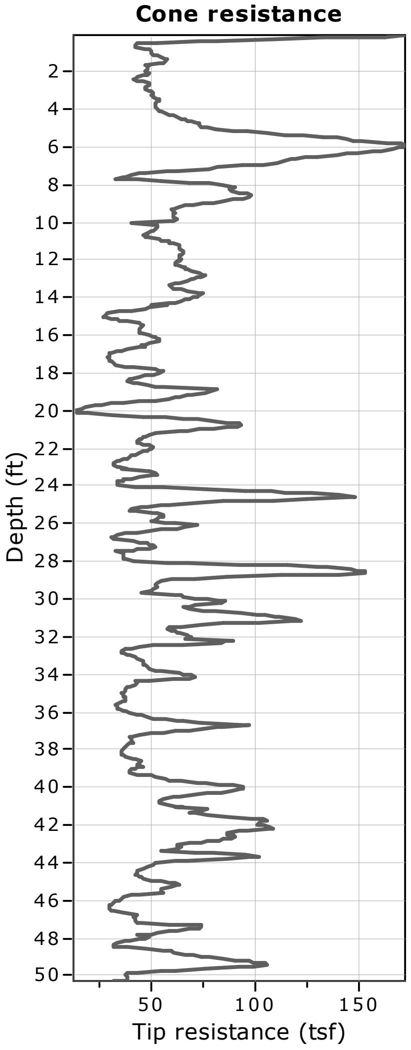
Calculation parameters

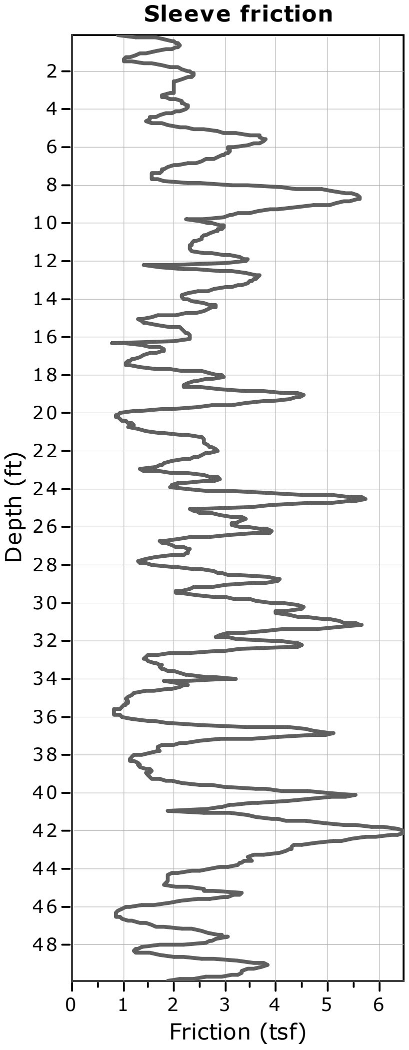
Soil Sensitivity factor, N_S: 7.00

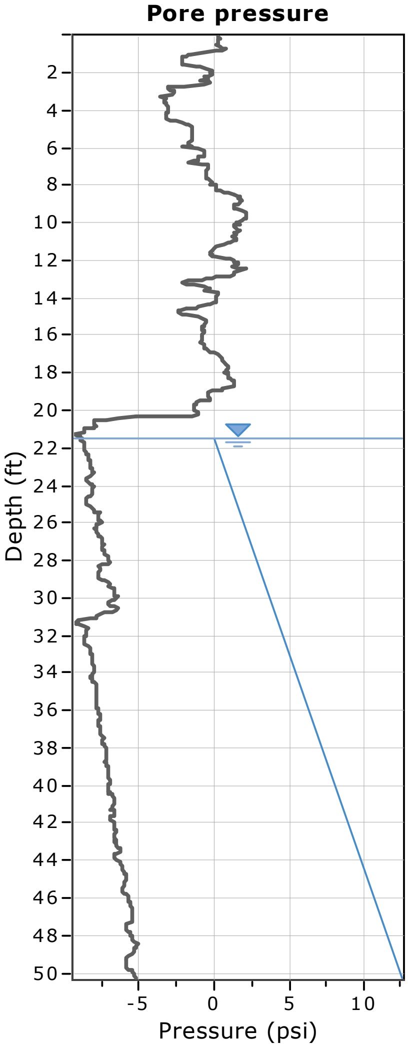
● User defined estimation data

CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

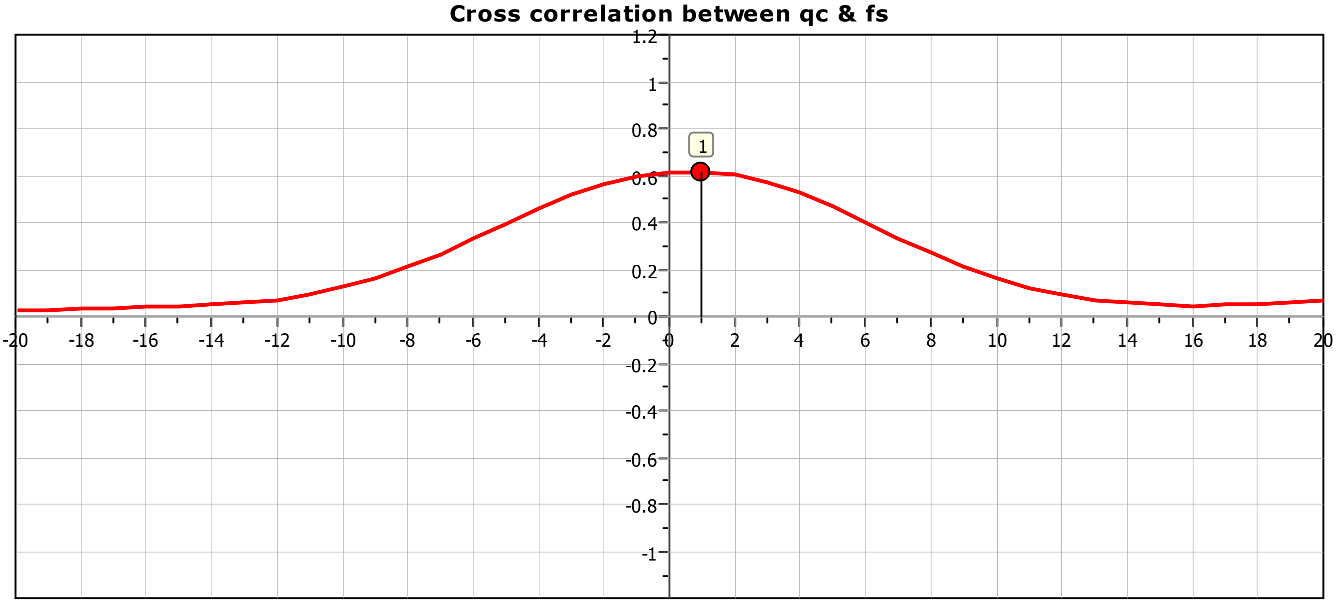
Project:
Location:


Cone resistance


Sleeve friction


Pore pressure

The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).


Cross correlation between qc & fs

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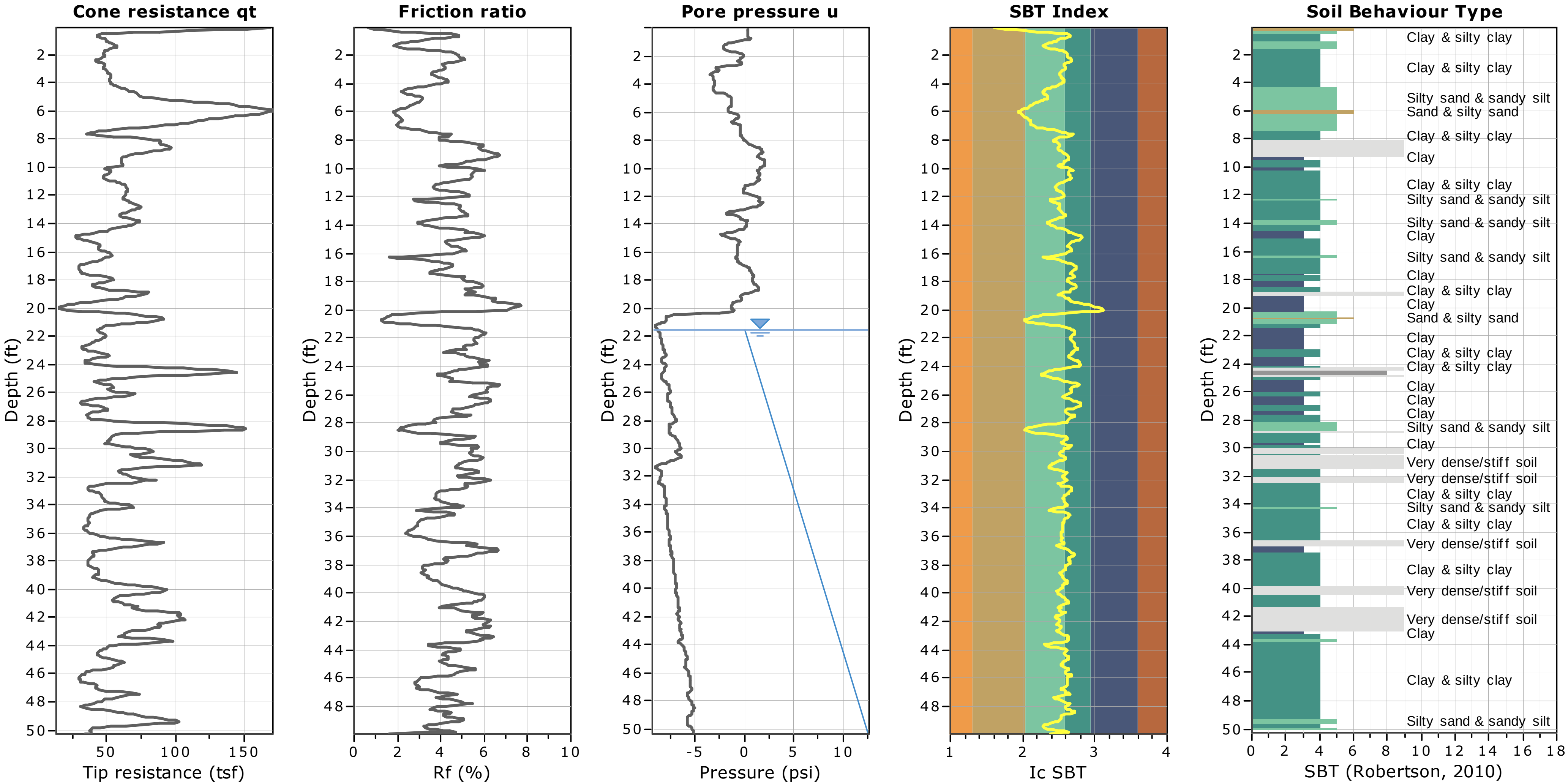
Project:
Location:

CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

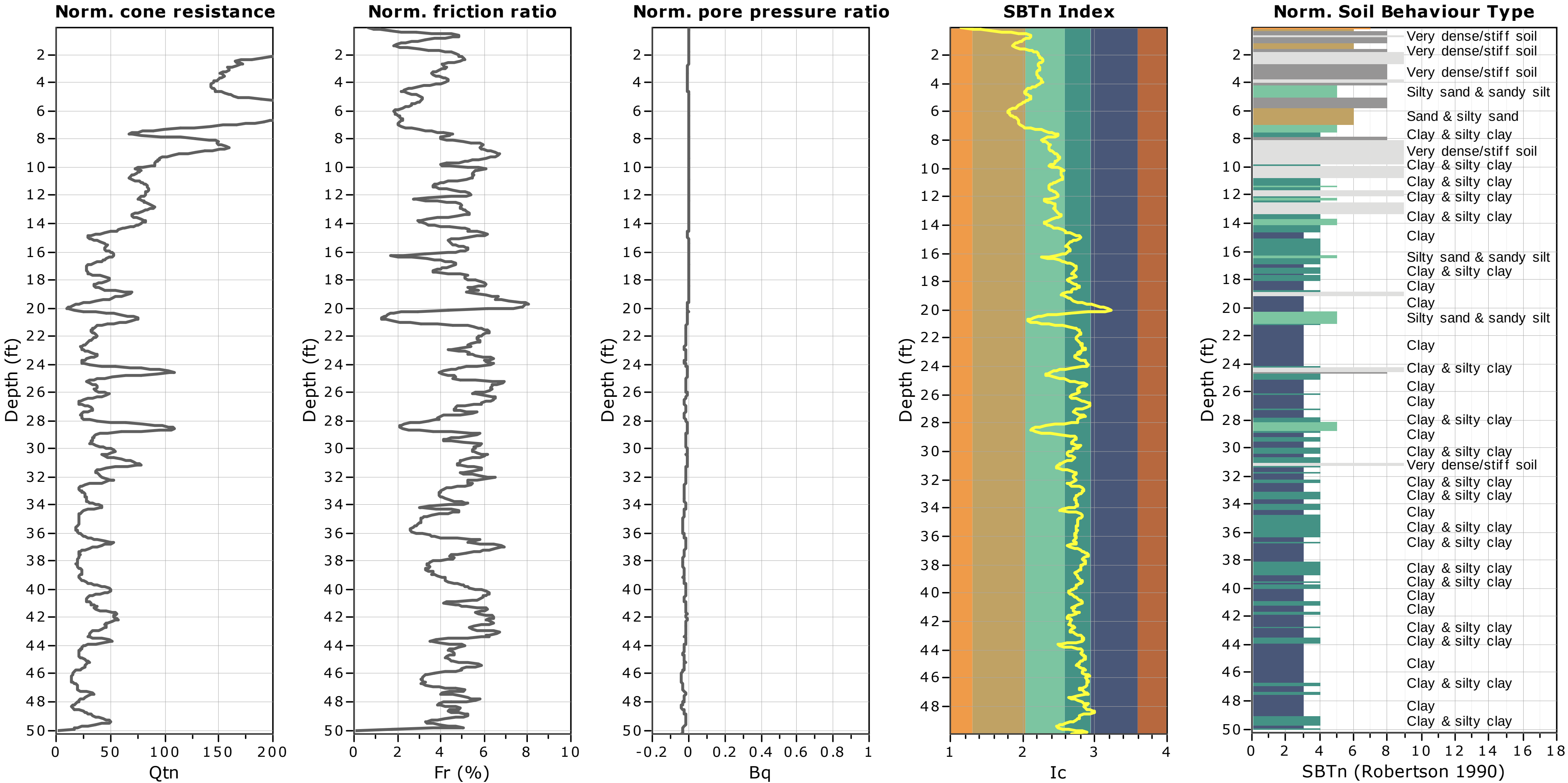


SBT legend

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

CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

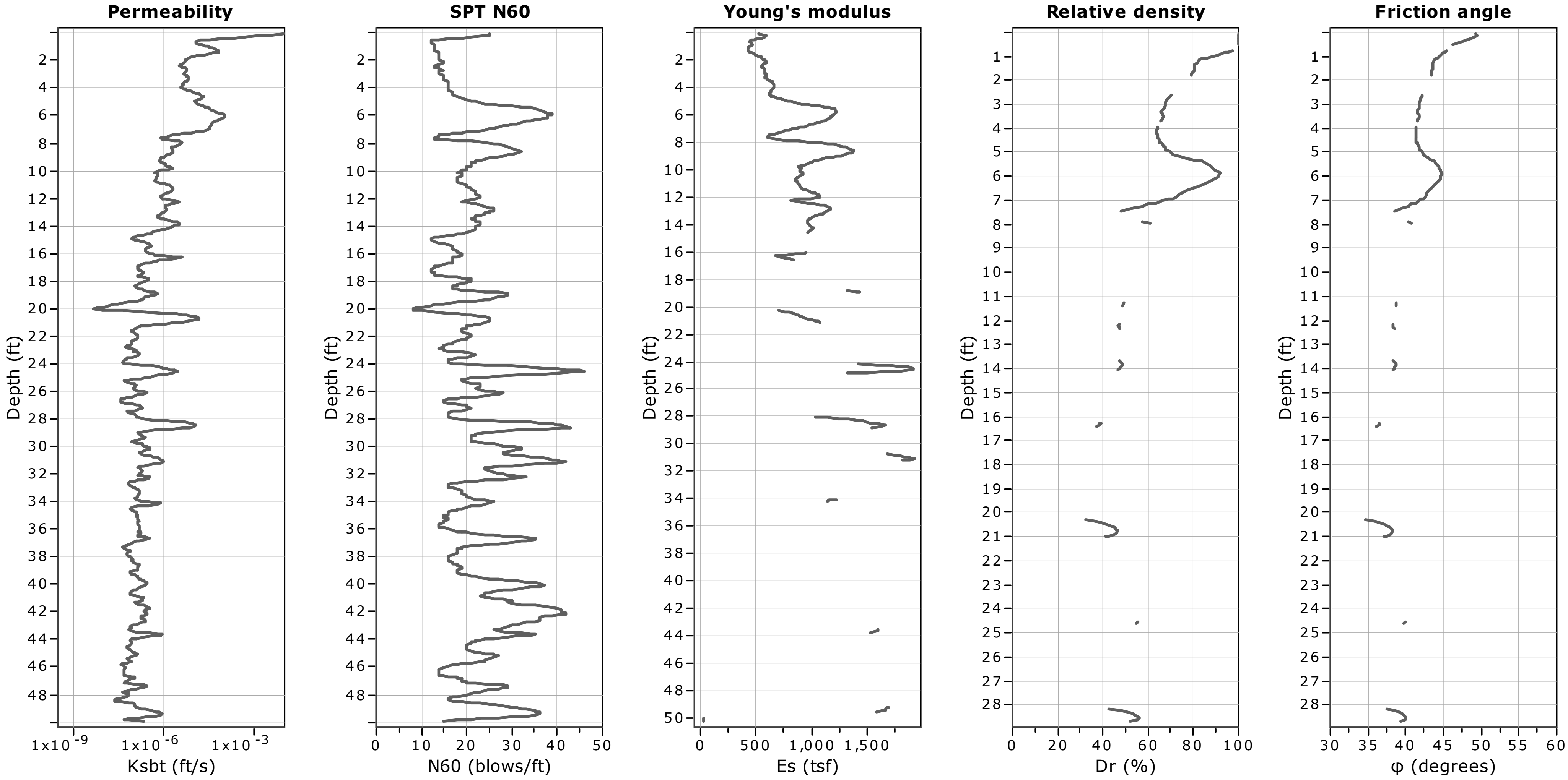


SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty clay
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬜ 8. Very stiff sand to clayey sand
⬜ 9. Very stiff fine grained

CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

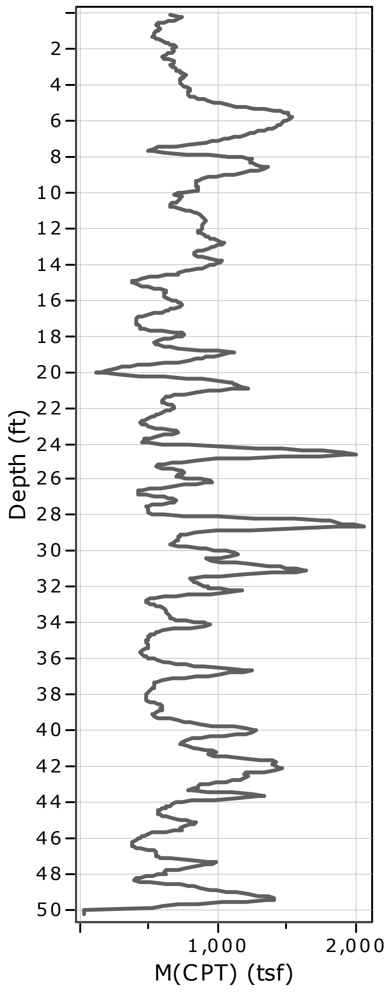


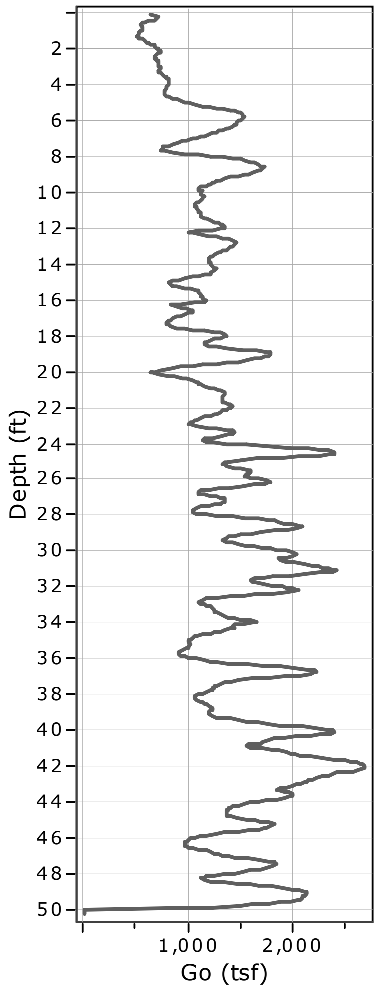
Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)

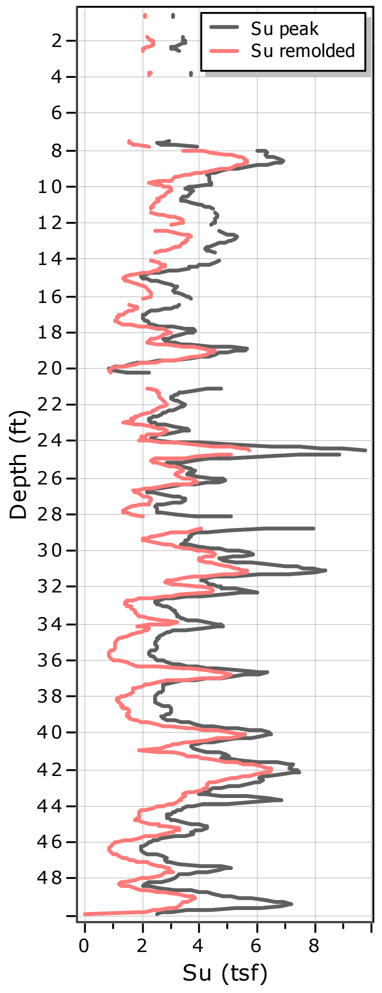
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
● User defined estimation data

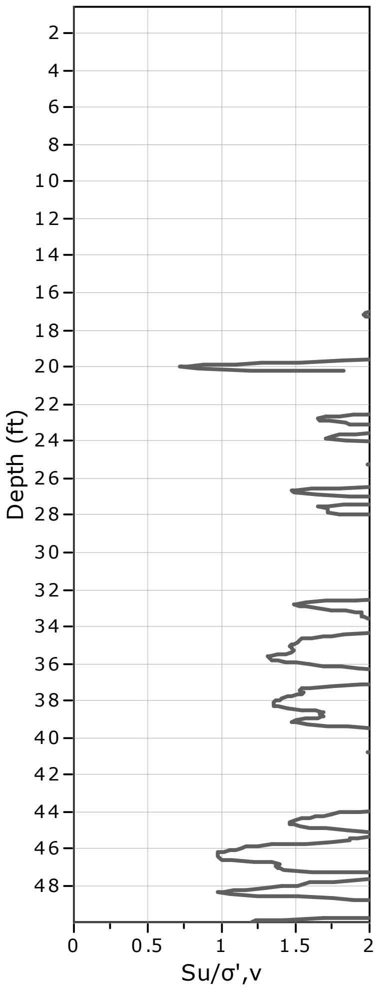
CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

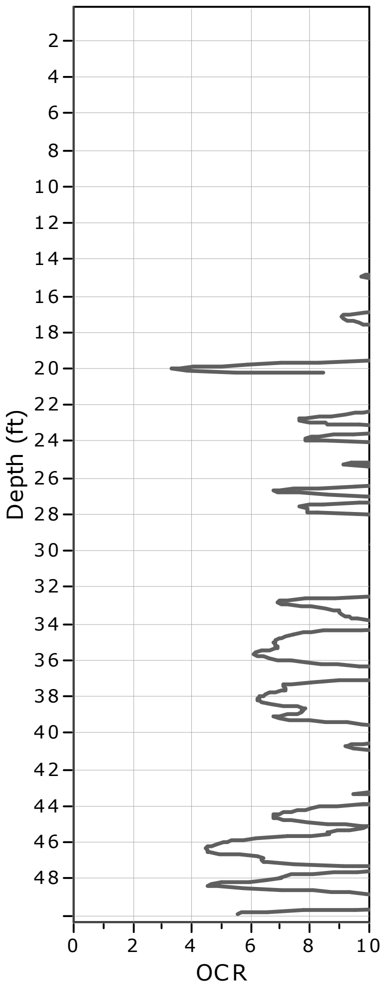
Project:
Location:


Constrained Modulus


Shear modulus


Shear strength


Undrained strength ratio


OCR

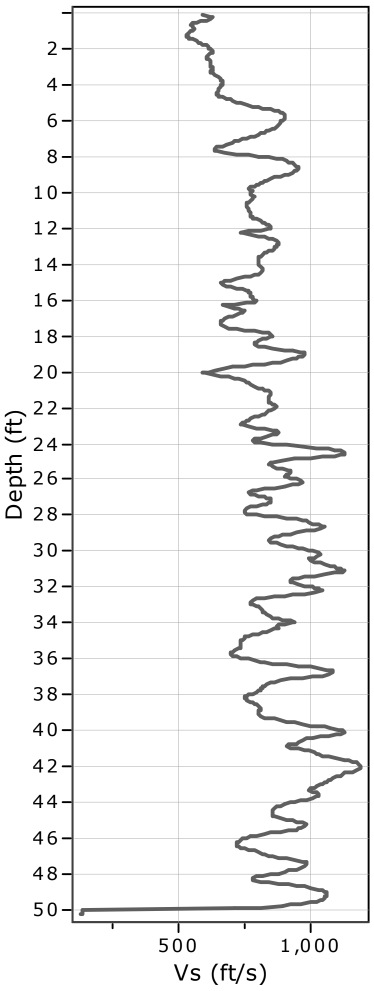
Calculation parameters
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
● User defined estimation data

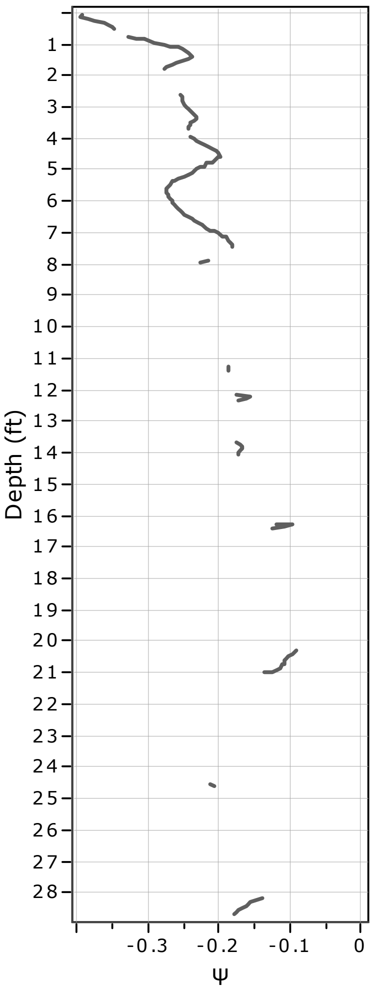
CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

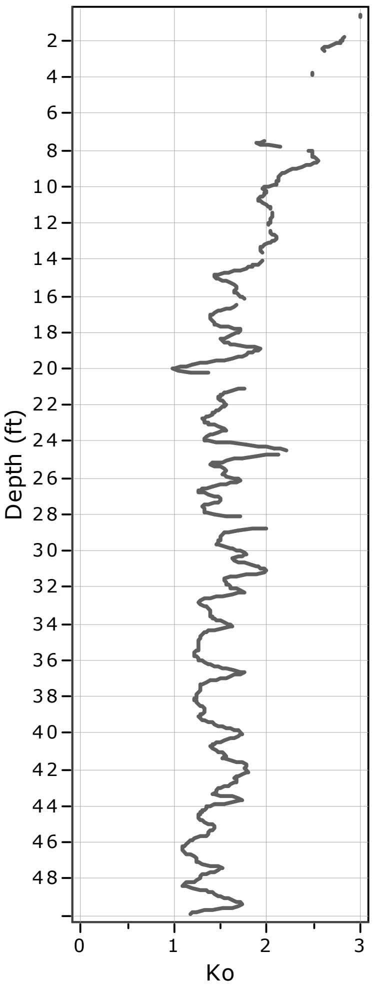
Shear Wave velocity



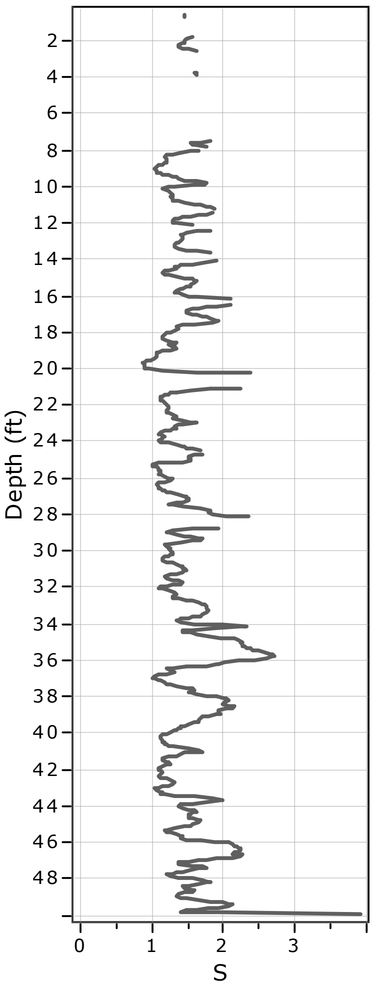
State parameter



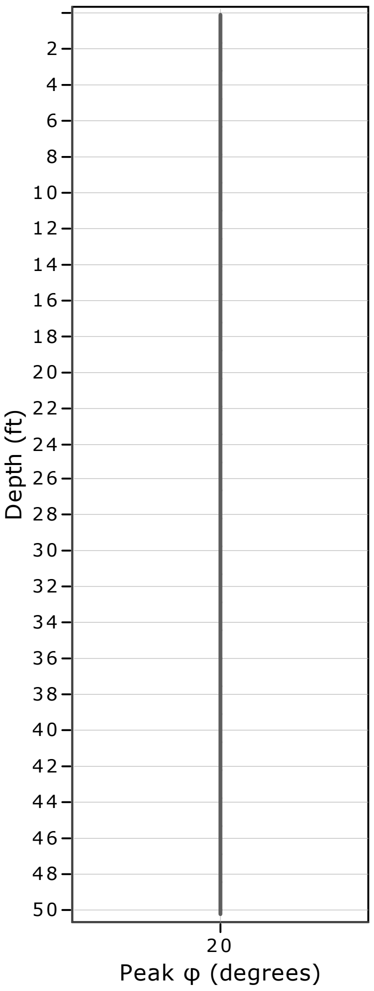
In-situ stress ratio



Soil sensitivity



Effective friction angle



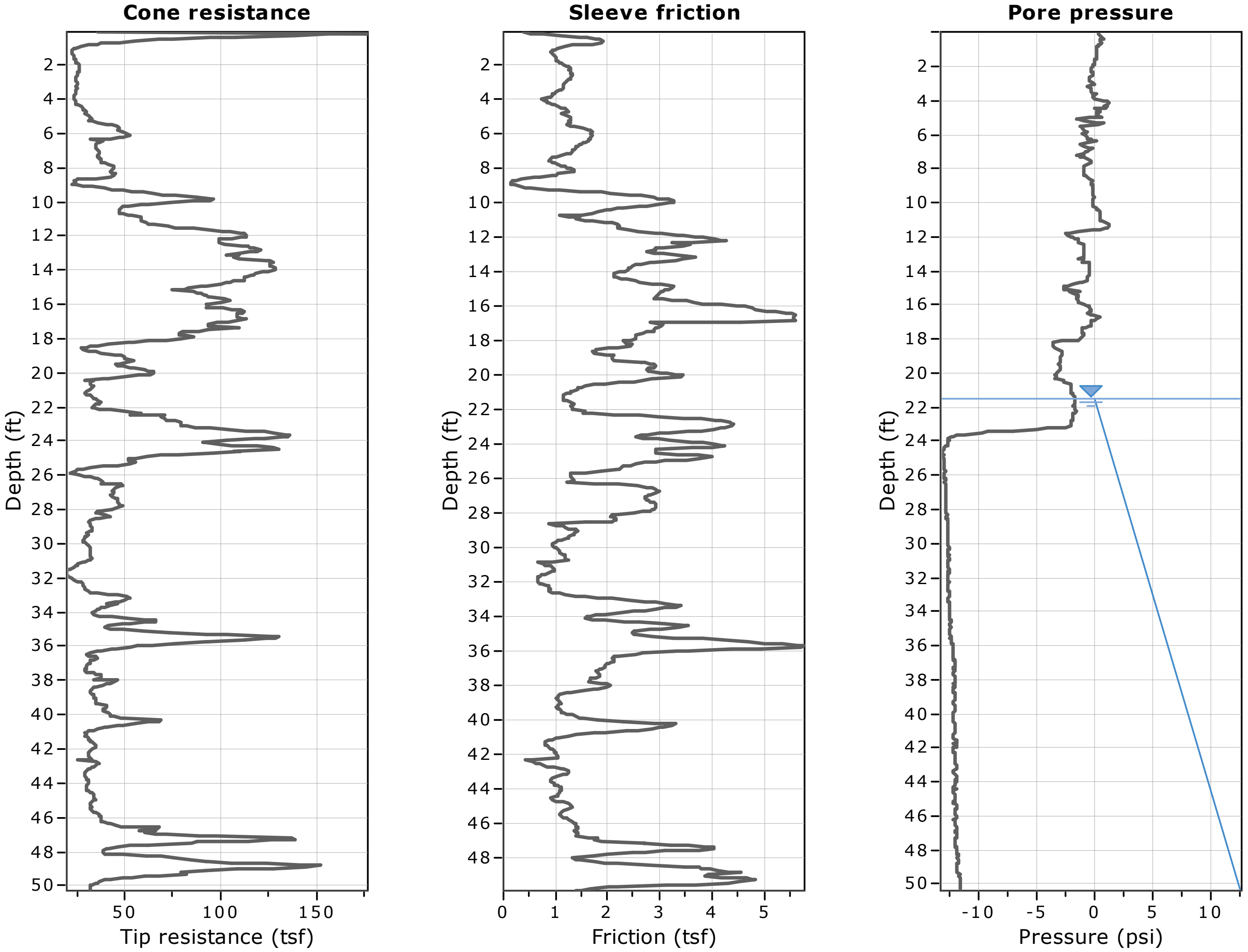
Calculation parameters

Soil Sensitivity factor, N_S: 7.00

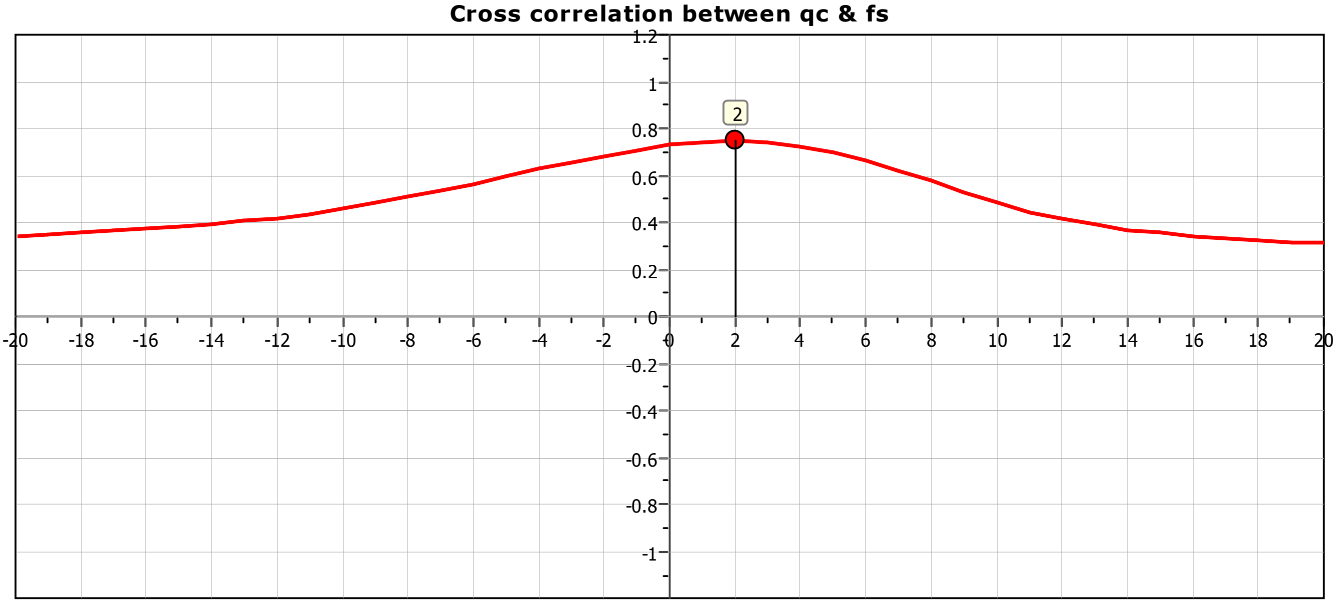
● User defined estimation data

CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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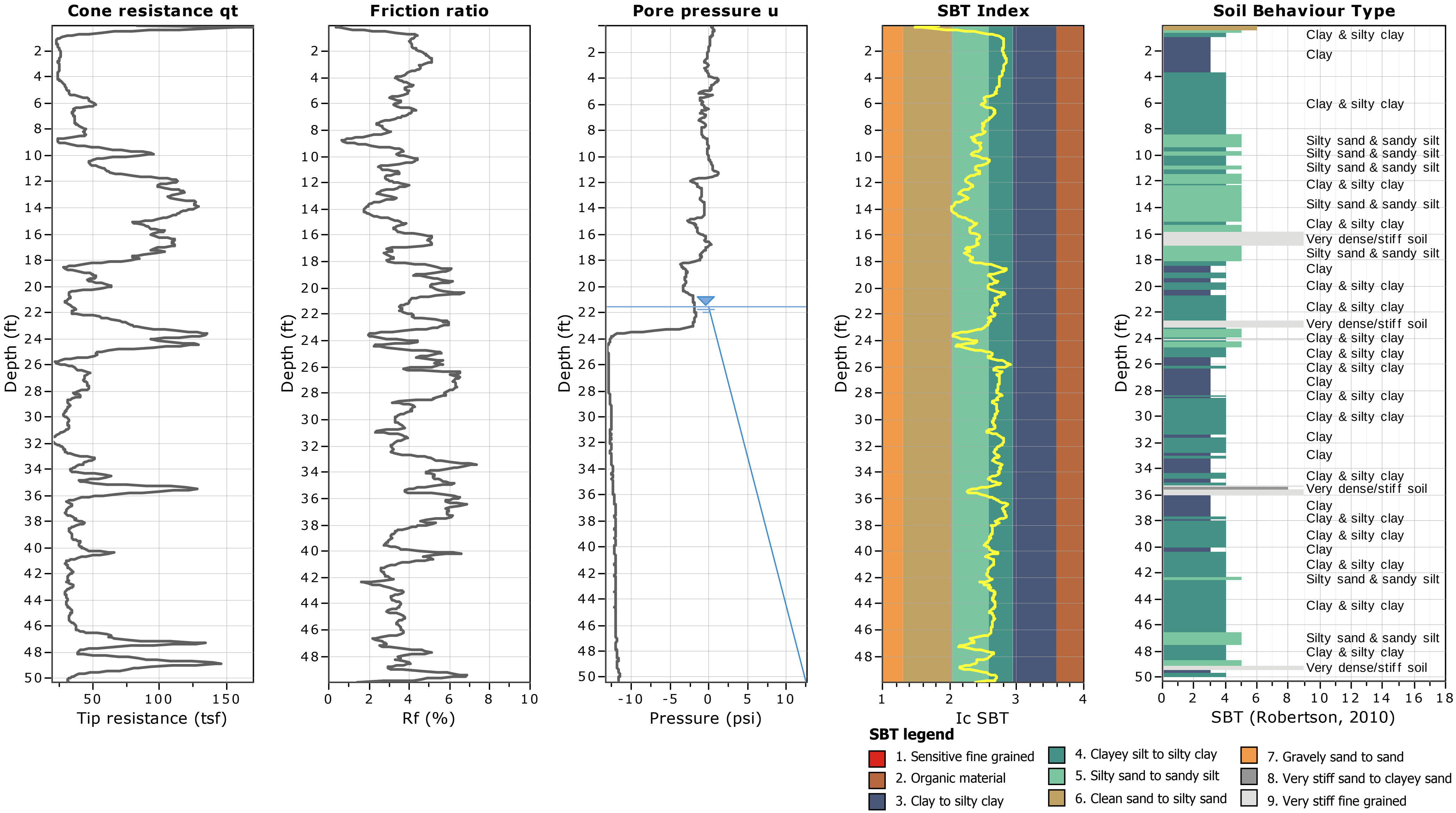
CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



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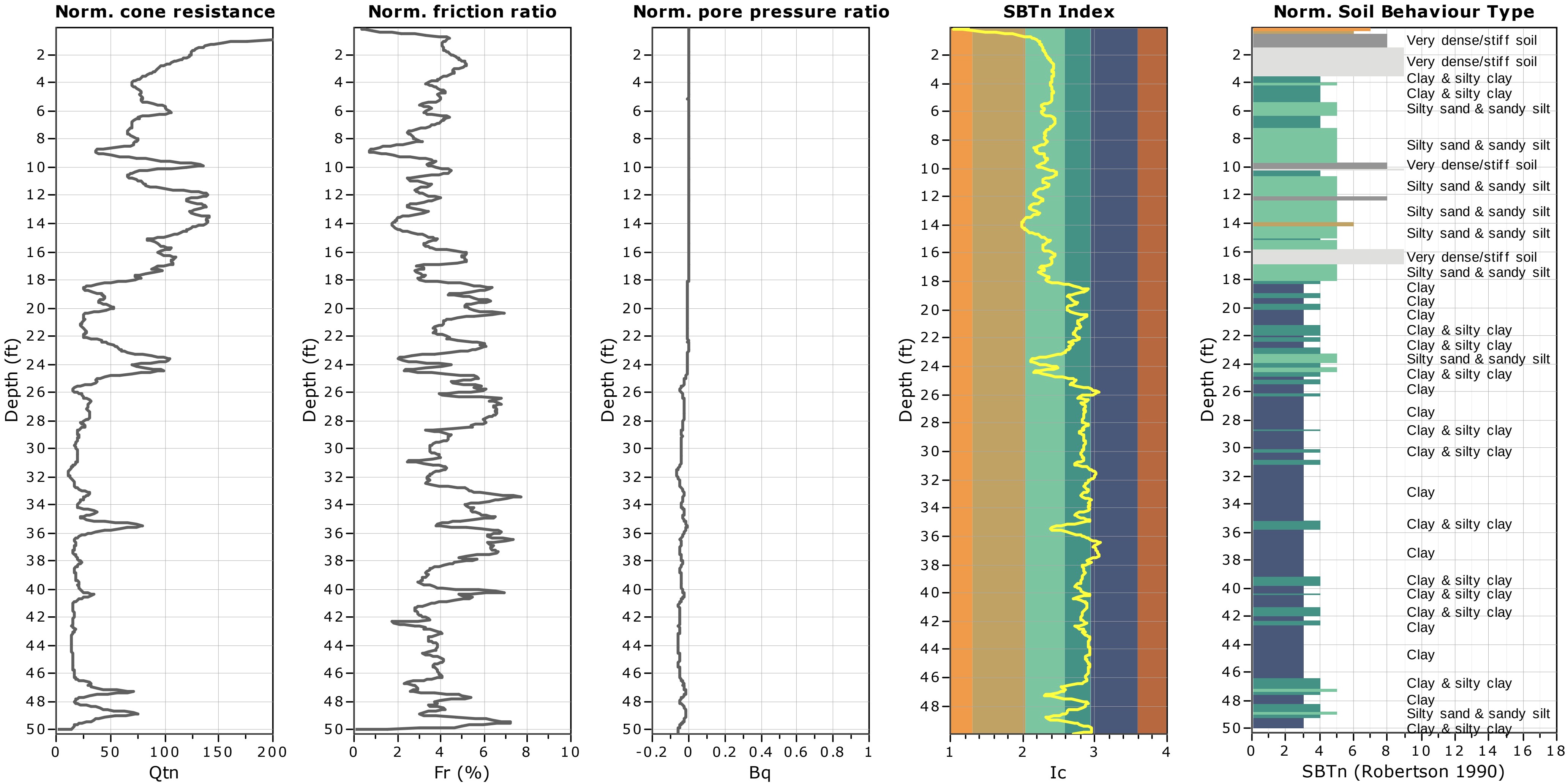
CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:

Location:

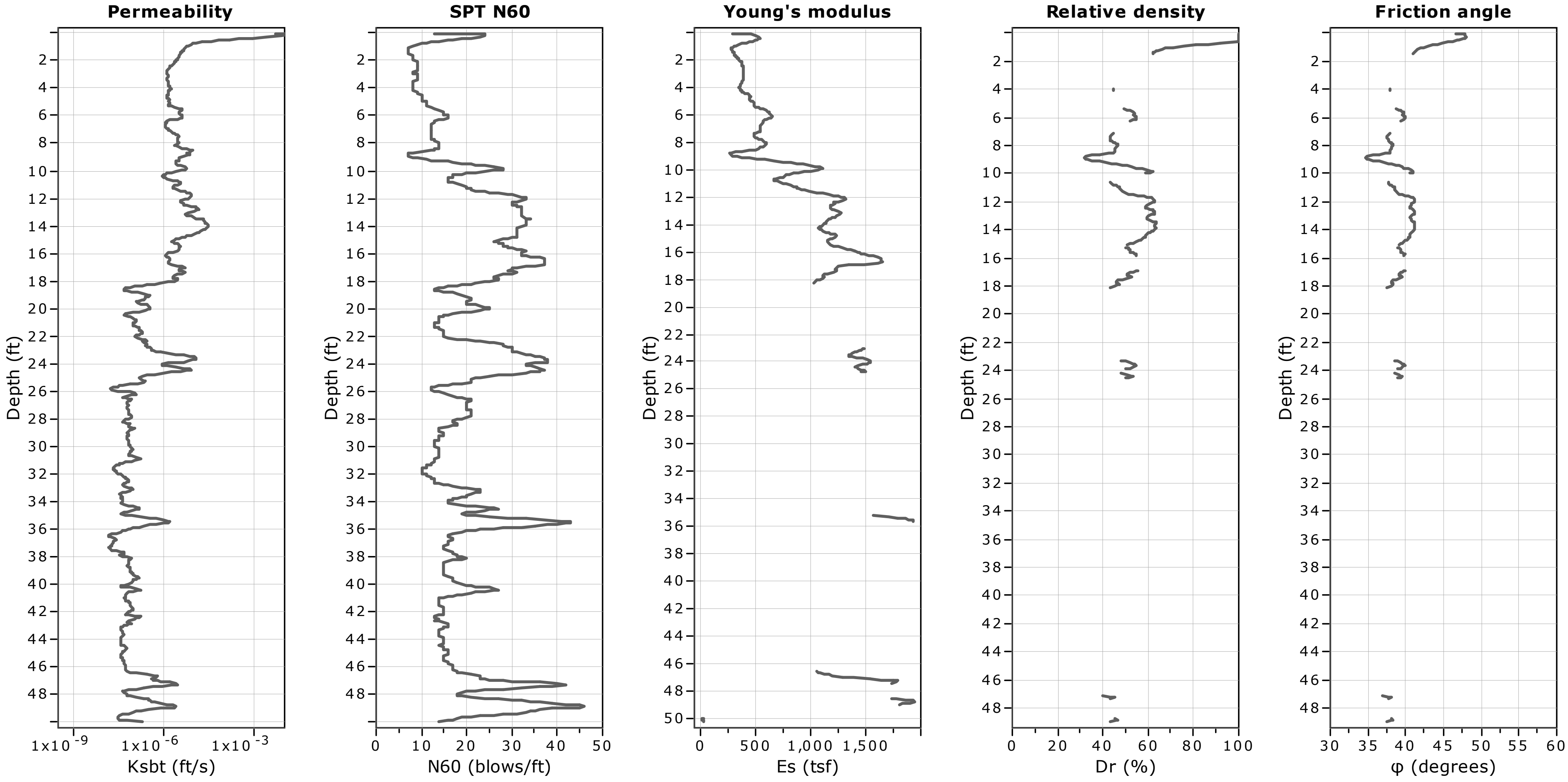


SBTn legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty clay	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to clayey sand
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

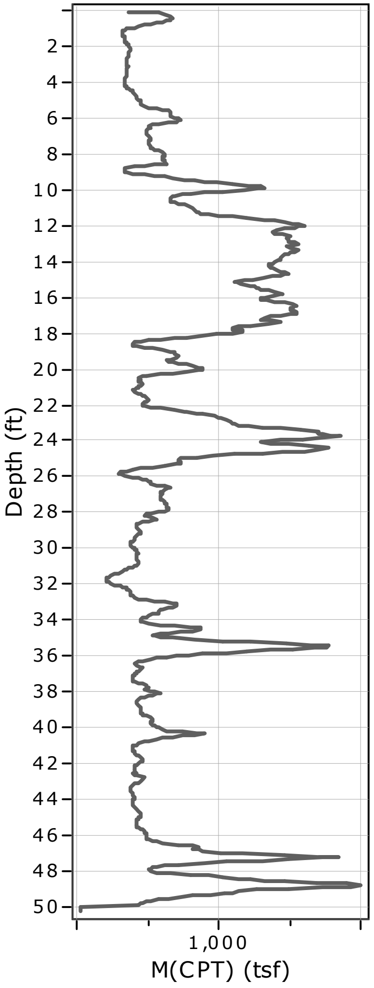
Project:
Location:

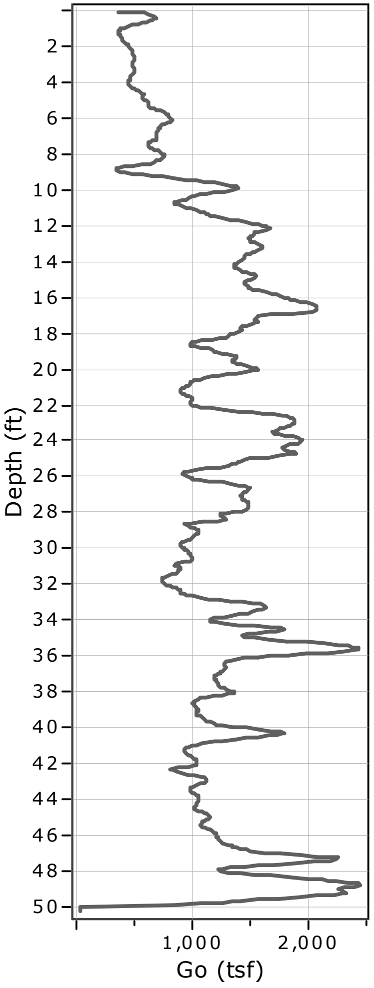


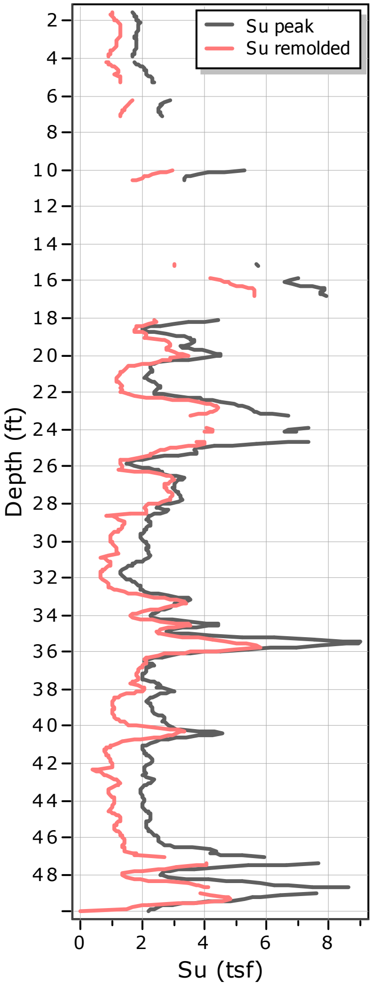
Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
● User defined estimation data

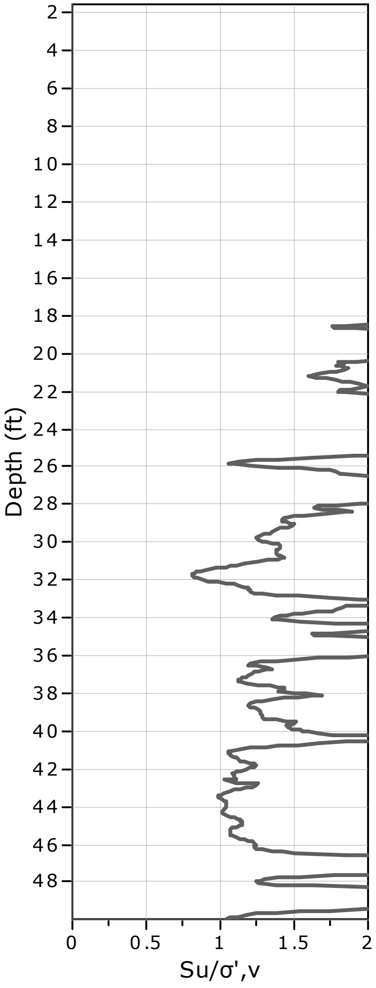
CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

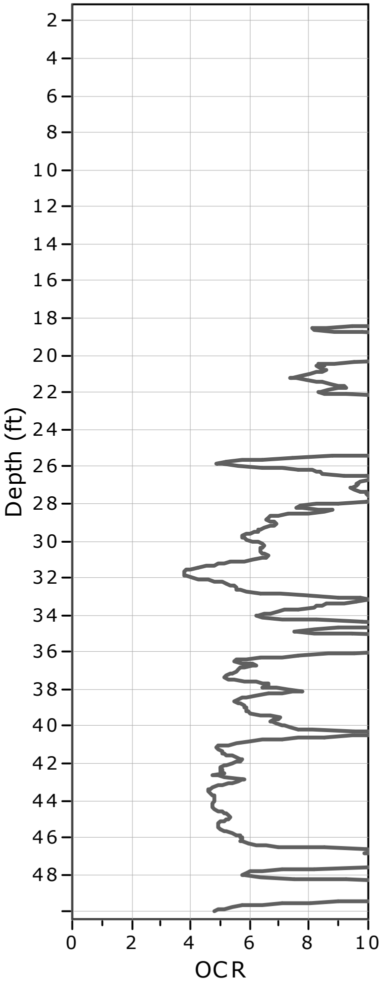
Project:
Location:


Constrained Modulus


Shear modulus


Shear strength


Undrained strength ratio


OCR

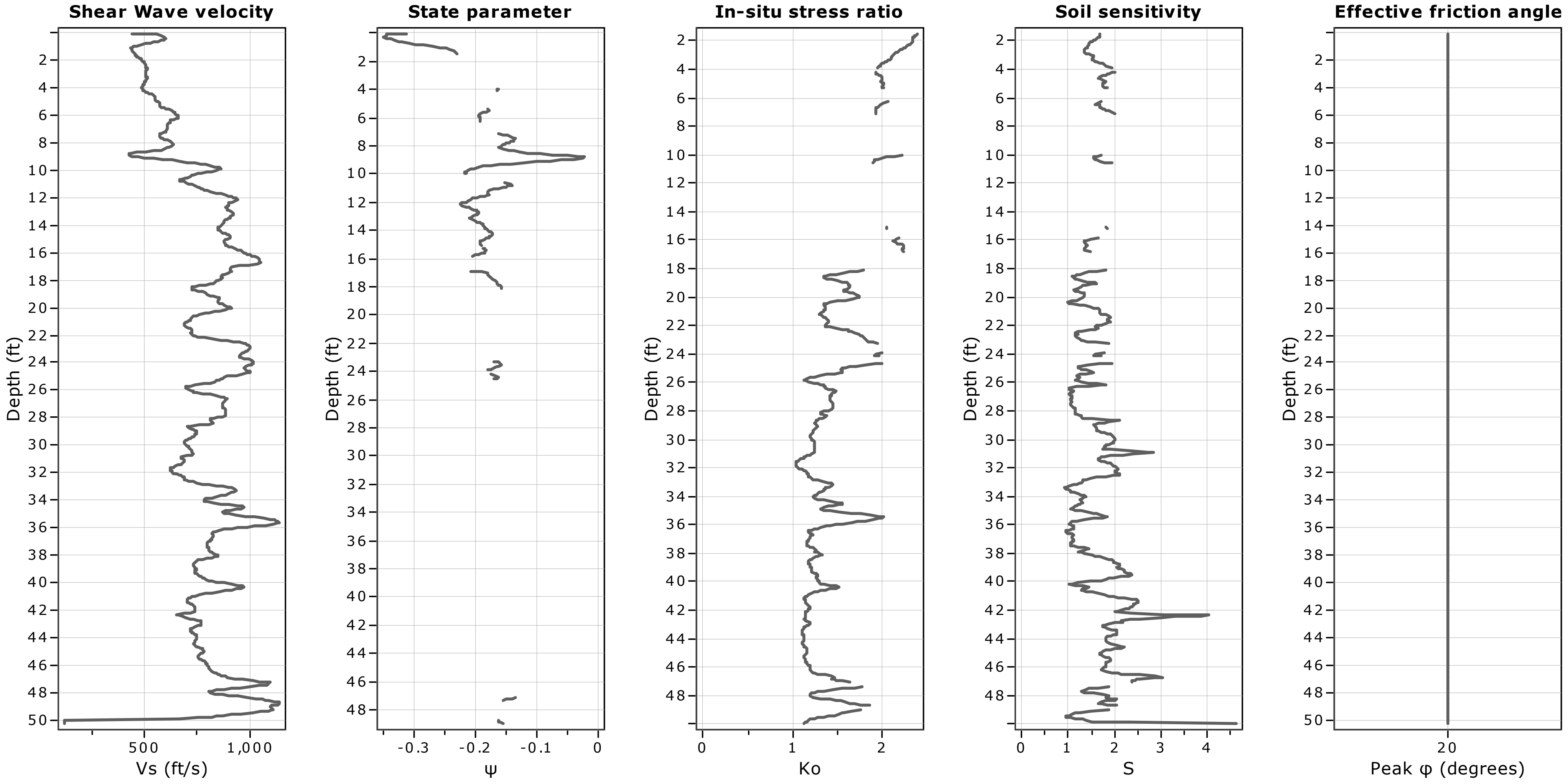
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
—●— User defined estimation data

CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



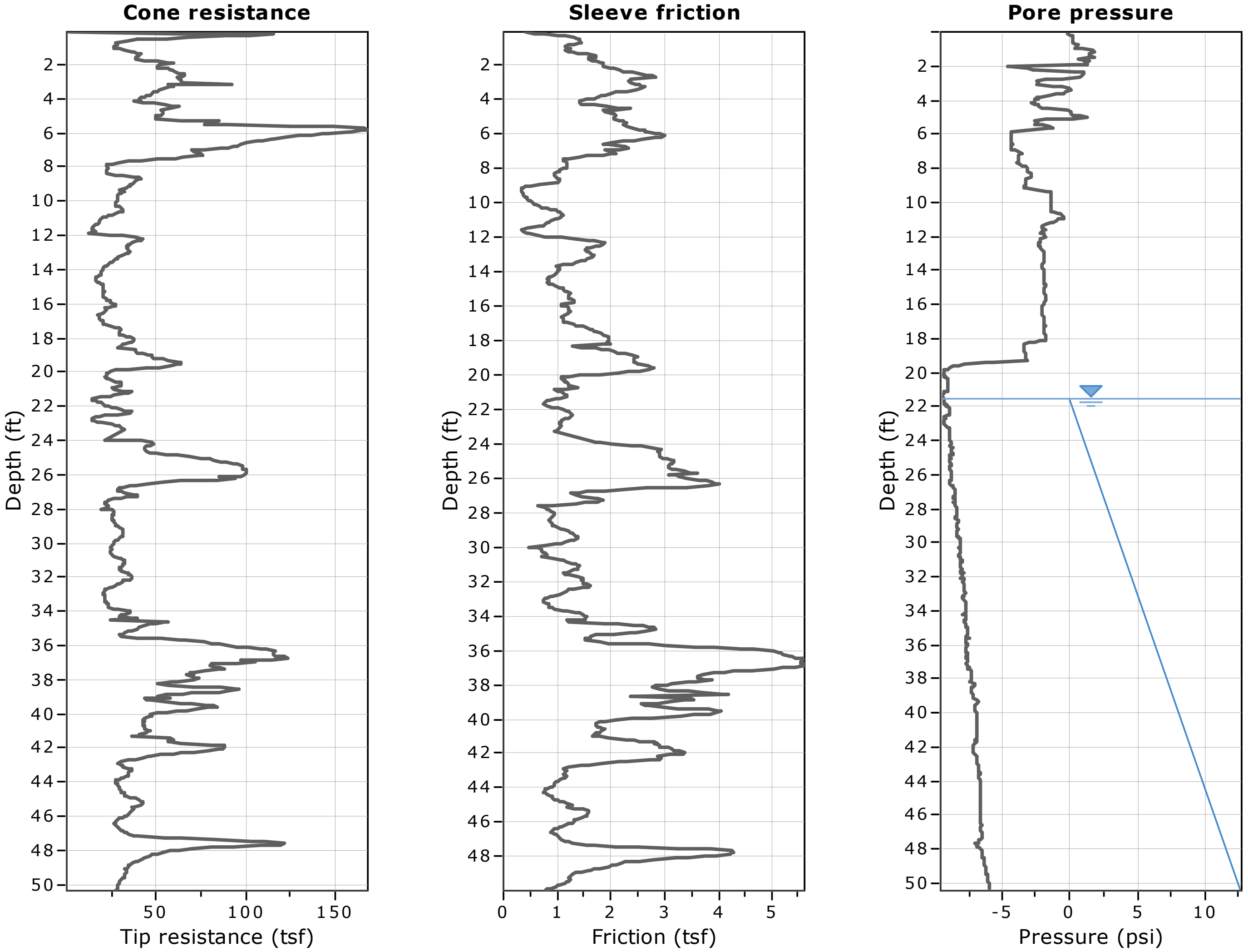
Calculation parameters

Soil Sensitivity factor, N_S: 7.00

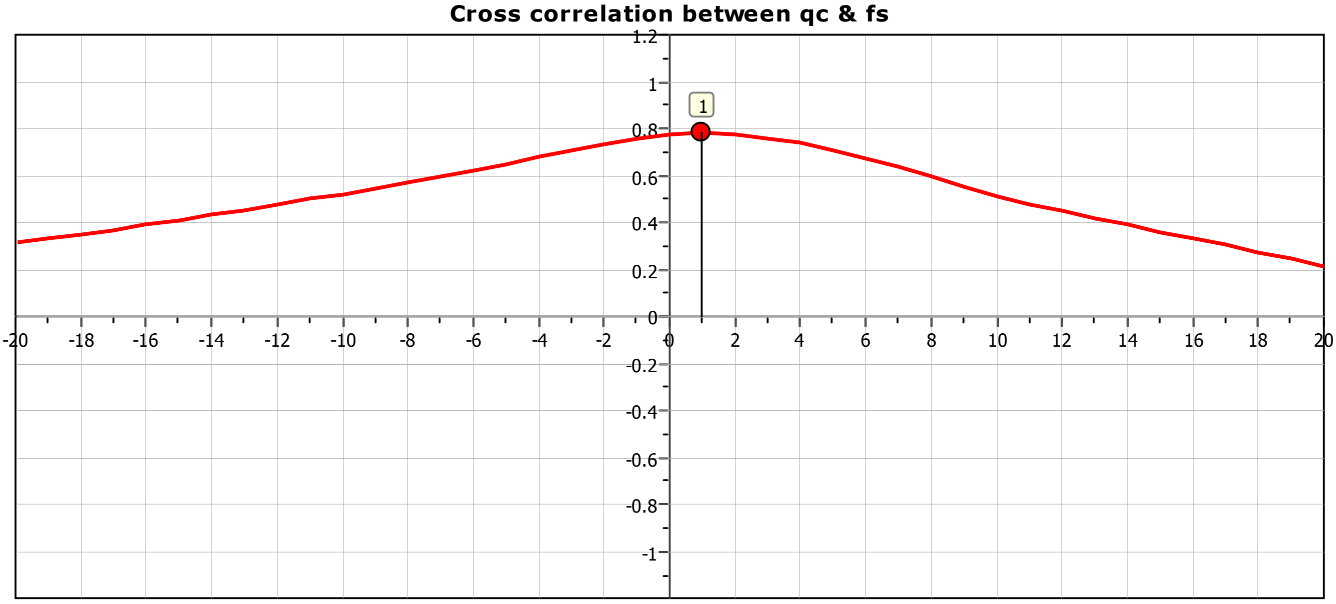
● User defined estimation data

CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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Irvine, California 92614
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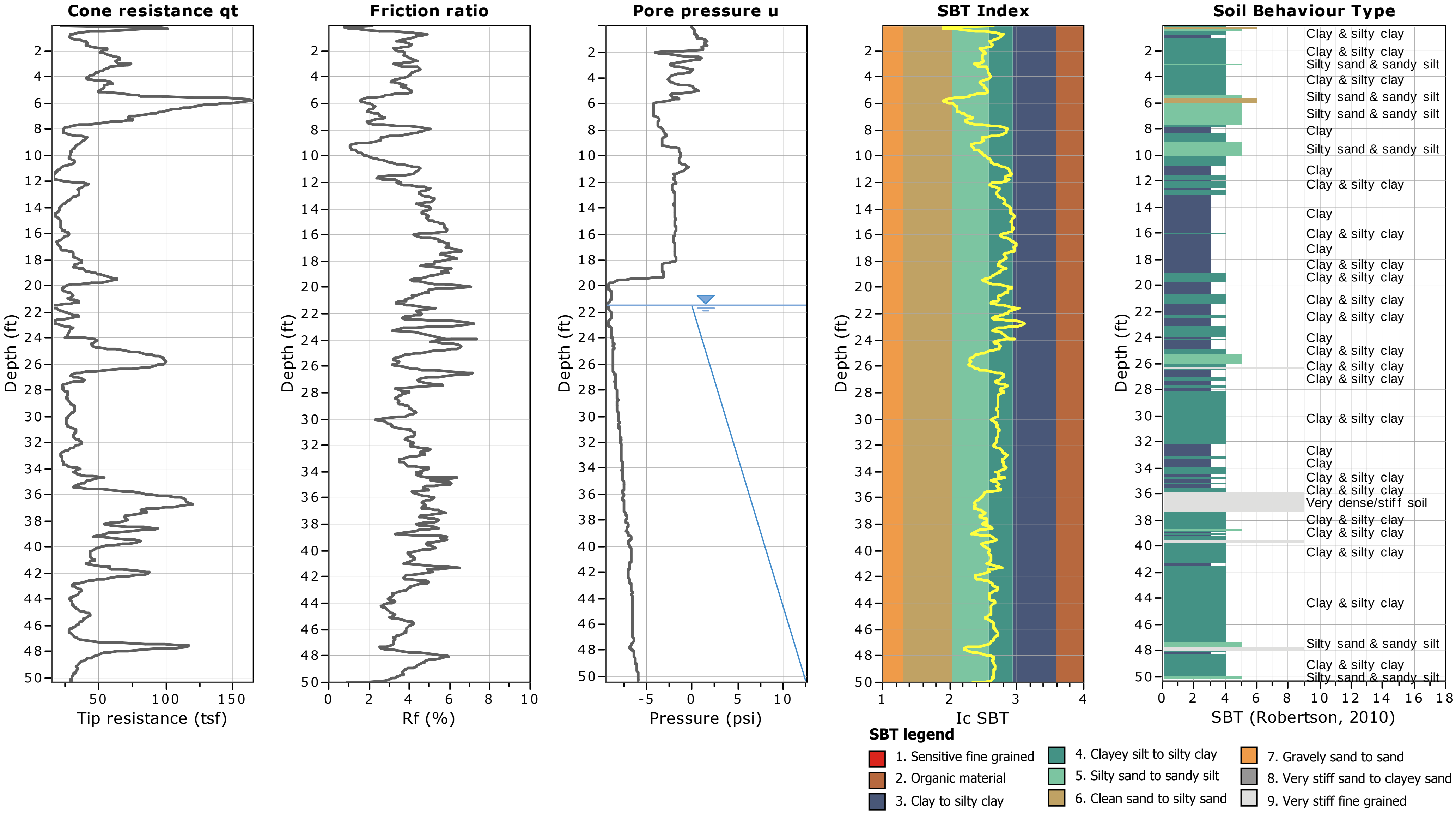
CPT: CPT-04

Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:

Location:



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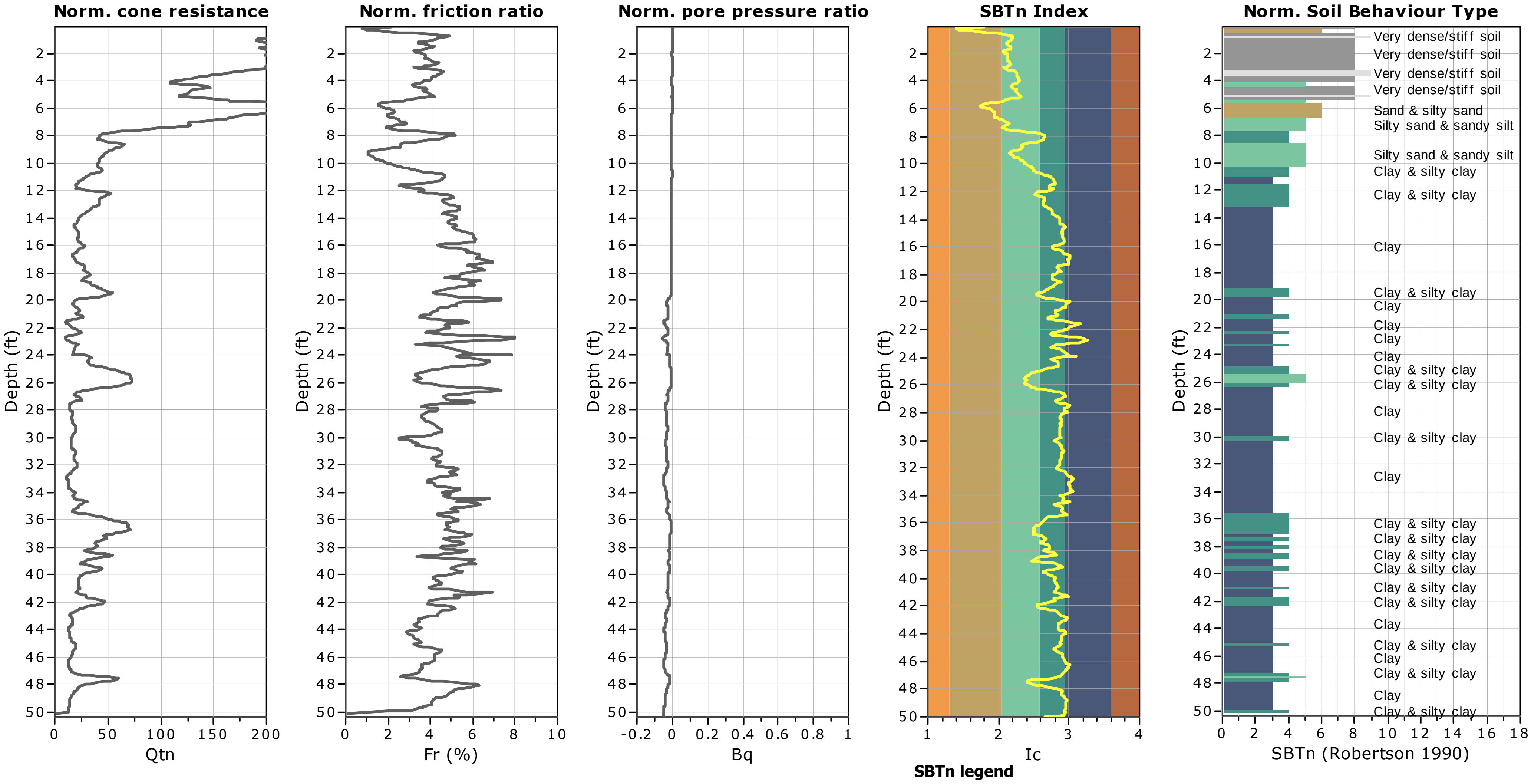
CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty clay
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to clayey sand
⬜ 9. Very stiff fine grained

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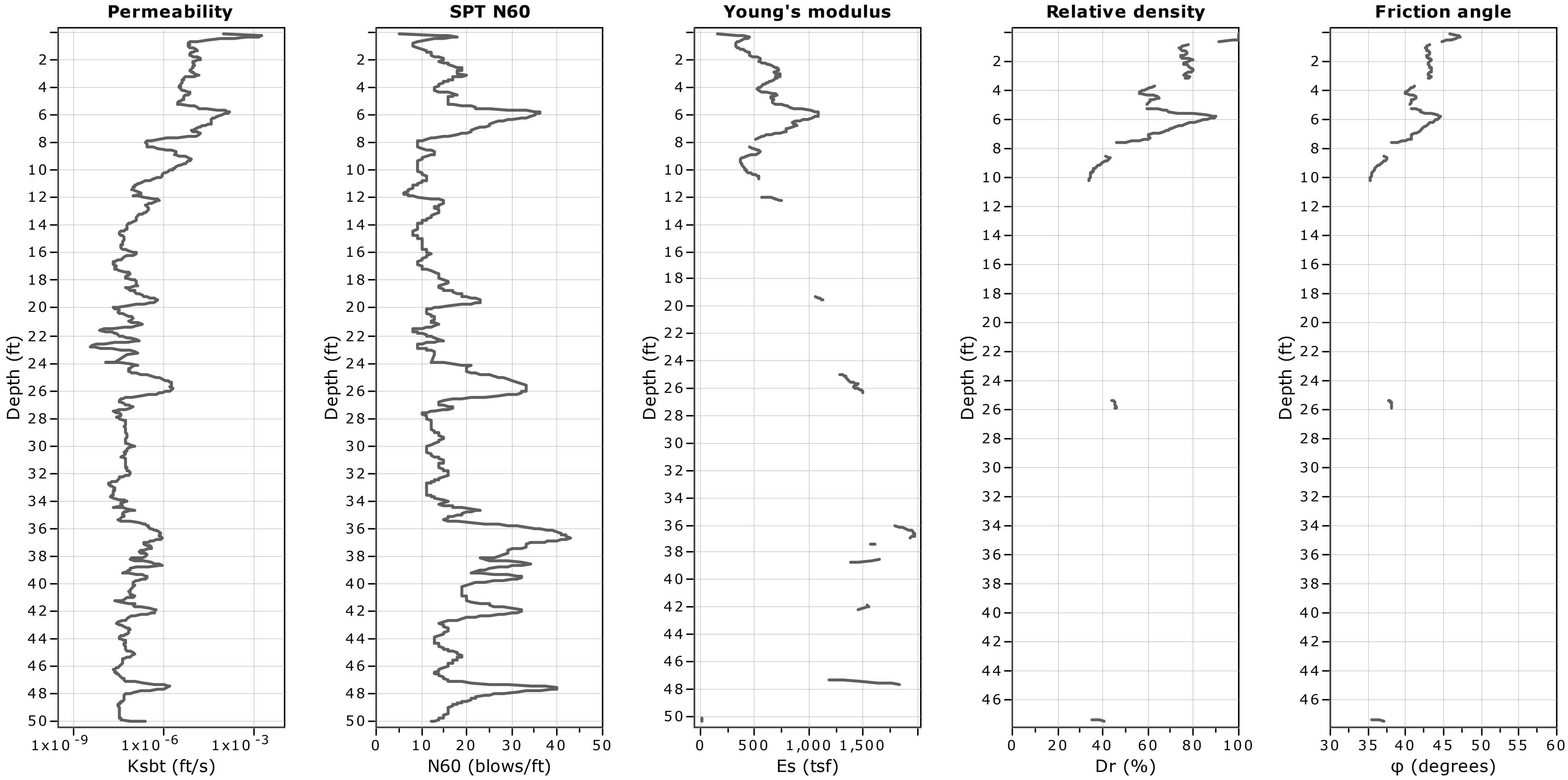
CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
—●— User defined estimation data

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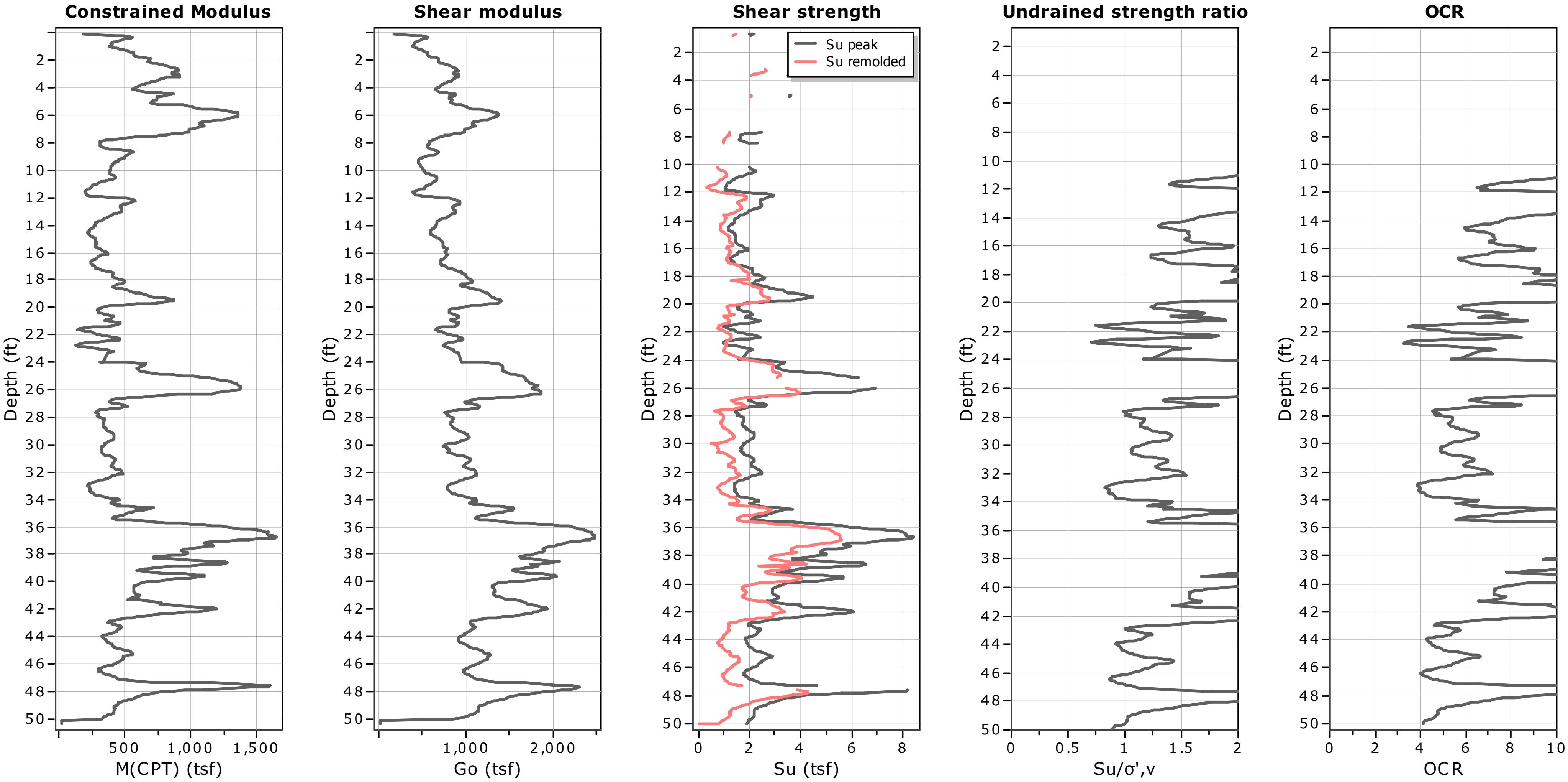
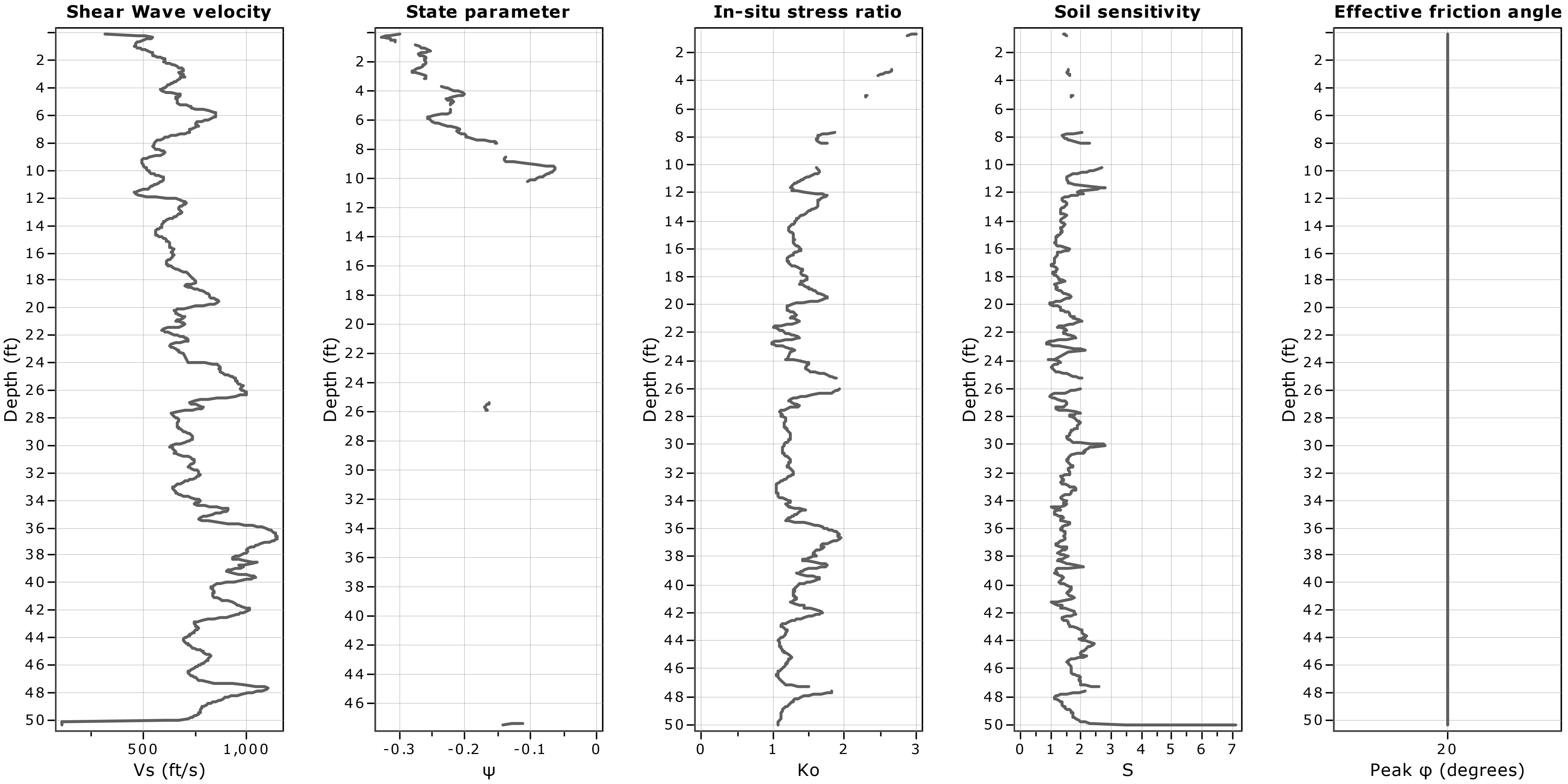
CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



Calculation parameters
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
—●— User defined estimation data



Calculation parameters

Soil Sensitivity factor, N_S: 7.00

● User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236\right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$$I_c < 3.27 \text{ and } I_c > 1.00 \text{ then } k = 10^{0.952-3.04 \cdot I_c}$$

$$I_c \leq 4.00 \text{ and } I_c > 3.27 \text{ then } k = 10^{-4.52-1.37 \cdot I_c}$$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a}\right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$

(applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

$$\text{If } I_c > 2.20$$
$$\alpha = 14 \text{ for } Q_{tn} > 14$$
$$\alpha = Q_{tn} \text{ for } Q_{tn} \leq 14$$
$$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$$

$$\text{If } I_c \leq 2.20$$
$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho}\right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$$N_{kt} = 10.50 + 7 \cdot \log(F_r) \text{ or user defined}$$

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$$S_{u(rem)} = f_s$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot + 7 \cdot \log(F_r))}\right]^{1.25} \text{ or user defined}$$

$$OCR = k_{OCR} \cdot Q_{tn}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5^\circ \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

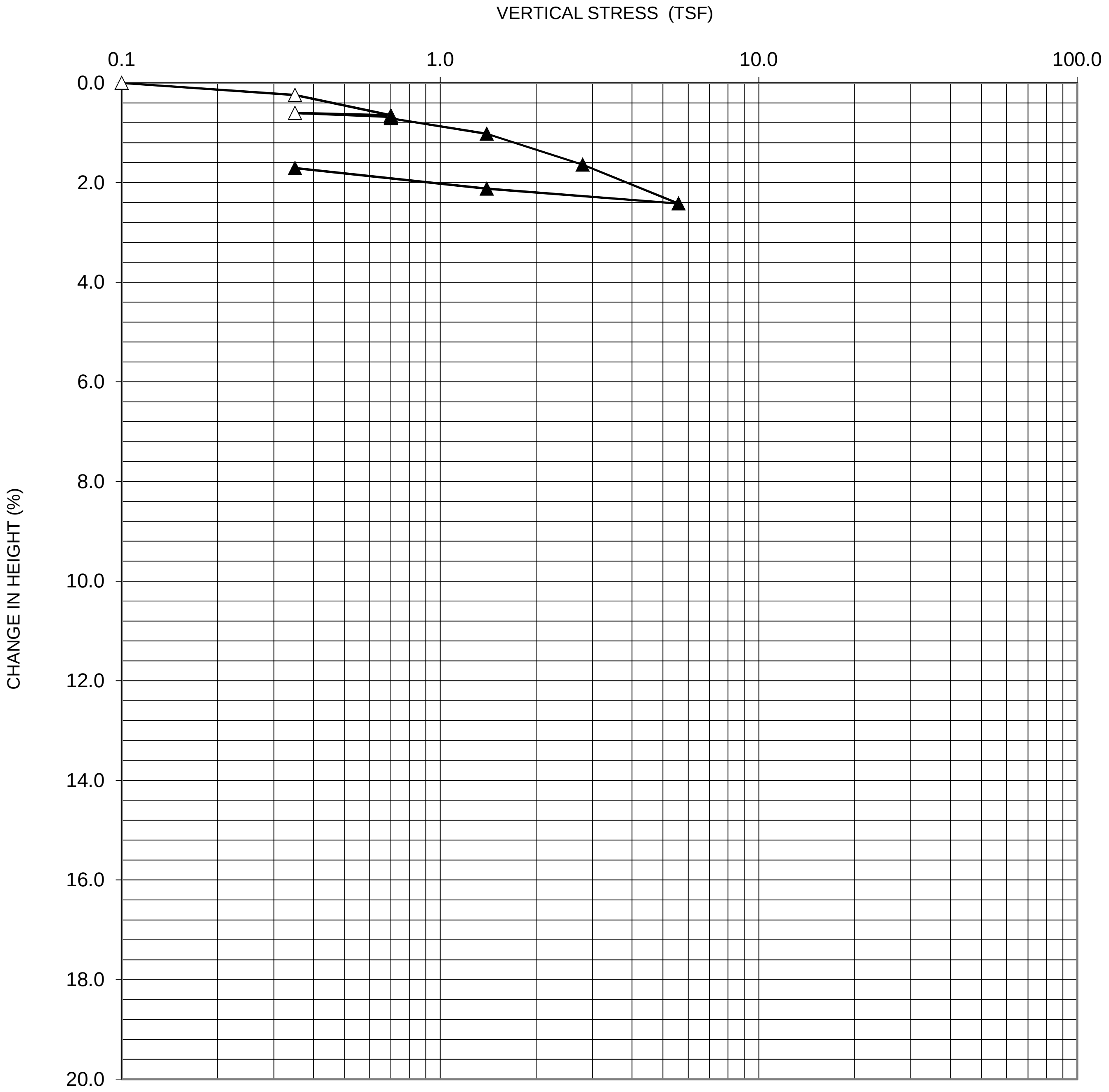
(applicable for $0.10 < B_q < 1.00$)

References

- Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012
- Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

APPENDIX C

SUMMARY OF LABORATORY TEST RESULTS



PROJECT NO.: 22027-00

SOIL DESCRIPTIONS: DK. BR. SILTY FINE SAND W/ TRACE OF CLAY (SM)

BORING NO./LOCATION : KB - 1

DEPTH / ELEV. : 15'

LIQUID LIMIT : -

SPECIFIC GRAVITY : 2.68 (Assumed)

PLASTIC LIMIT: -

REMARKS :

	SPECIMEN HEIGHT (INCHES)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
INITIAL	1.0000	15.3	112.7	85.0	0.484
FINAL	0.9829	16.7	114.6	97.3	0.459

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CONSOLIDATION TEST CURVE

Project Name : PICERNE GARDENA
Project No. : 22027-00
Boring / Sample No : KB - 1
Depth : 22.5' (ft.)
Tested By : RB
Date: 7-Oct-22
Sample Descriptions / Classification : DK. BROWN SANDY CLAY (CL)

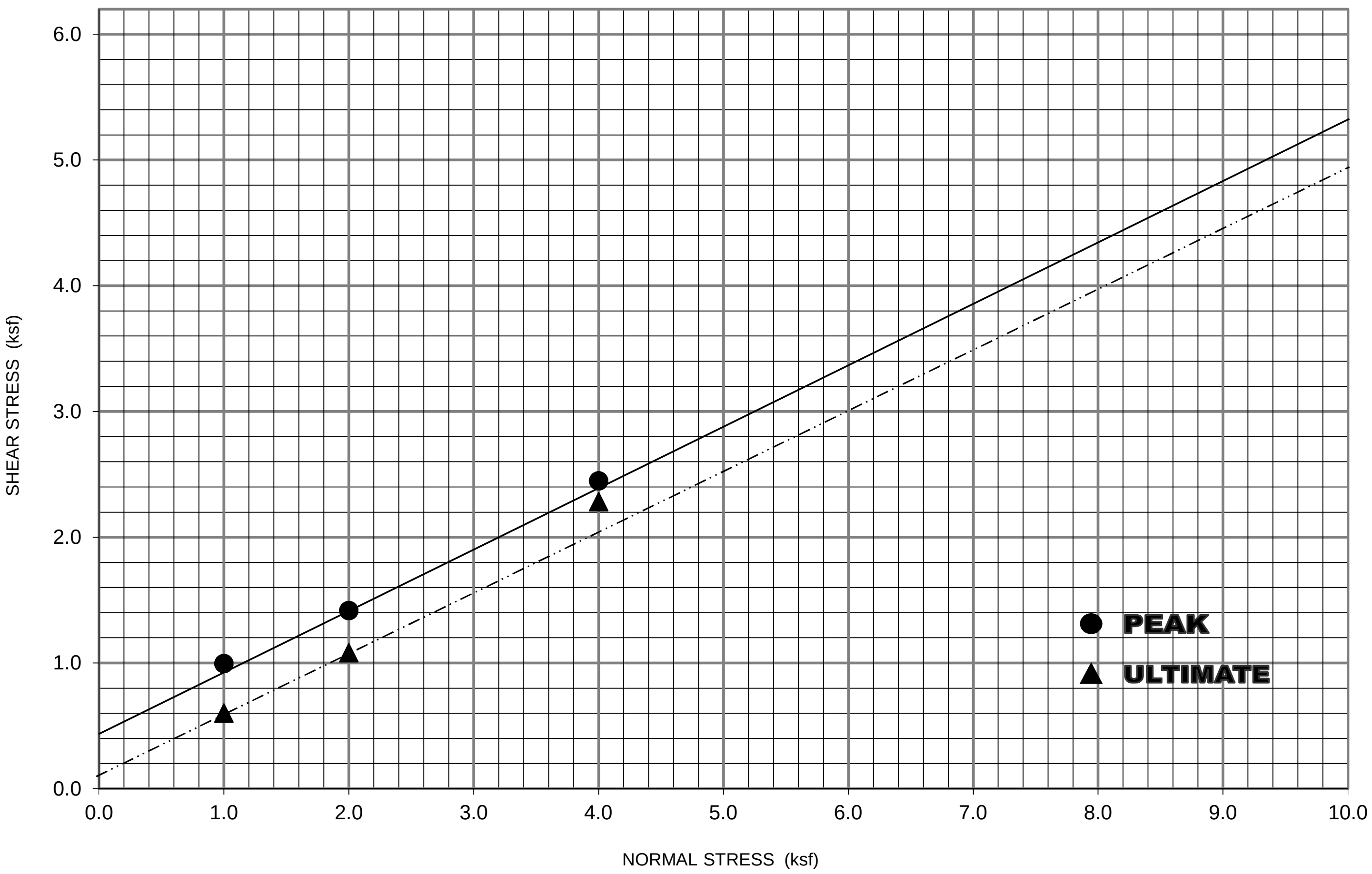
Applied Normal Load (ksf)	1.0		2.0		4.0	
Shear Stress,(Peak) (ksf)	0.996		1.416		2.448	
Shear Stress,(Ultimate) (ksf)	0.600		1.080		2.280	
Density and Saturation	Initial	Final	Initial	Final	Initial	Final
Wet Weight of Soil + Ring (gms)	186.93	186.77	189.19	188.86	194.16	193.3
Dry Weight of Soil + Ring (gms)		153.53		155.16		159.16
Weight of Water (gms)	-	46.54	-	47.28	-	45.81
Weight of Ring (gms)	-	44.36	-	43.93	-	44.78
Weight of Dry Soil (gms)	-	109.17	-	111.23	-	114.38
Moisture Content (%)	30.6	42.6	30.6	42.5	30.6	40.1
Wet Density (pcf)	119.0	118.9	121.3	121.0	124.7	124.0
Dry Density (pcf)	-	83.3	-	84.9	-	88.5
Specific Gravity,G_s (Assumed)	2.68					
Thickness of Specimen, (in.)	1.00					
Degree of Saturation, (%)	81.5	113.5	84.5	117.4	92.2	120.7
Void Ratio	-	1.007	-	0.970	-	0.889

Lateral Displacement, d_h 0.36 (in.)
Displacement Rate, d_r 0.05 (in./min.)
Elapsed Time of Test, t_e 7.20 (min.)

Specimen : Undisturbed : X
Remolded : -
Reconstituted : -

	PEAK	ULTIMATE
Cohesion,c (psf)	450	100
Friction Angle, ϕ	26	25

Remarks : LOAD 1000 & 2000 SANDY CLAY LOAD 4000 CLAYEY SAND



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DIRECT SHEAR TEST

(ASTM D3080)

PROJECT NAME : PICERNE GARDENA

PROJECT NUMBER : 22027-00

TRACT NUMBER :

TESTED BY : RB DATE : 11-Oct-22

LOT NUMBER :

SAMPLED BY: JH DATE : 30-Sep-22

SAMPLE NO. :

LOCATION : KB - 1 @ 0 - 5'

SOIL DESCRIPTIONS / CLASSIFICATION : DK. BROWN CLAYEY SAND (SC)

TRIAL NUMBER		1	2	3	4
WET WT. OF SOIL + RING	(g)	592.63	604.39		
WEIGHT OF RING	(g)	204.36	204.36		
WET WEIGHT OF SOIL	(g)	388.27	400.03		
FACTOR		0.3030	0.3030		
WET DENSITY	(pcf)	117.6	121.2		
DRY DENSITY	(pcf)	108.3	110.7		
DEGREE OF SATURATION	(%)	#DIV/0!	#DIV/0!		

MOISTURE DETERMINATION

WET WEIGHT OF SOIL	(g)	319.52	307.42		
DRY WEIGHT OF SOIL	(g)	294.19	280.75		
MOISTURE CONTENT	(%)	8.6	9.5		

RACK NO. : 2

SURCHARGE : 144 psf

FINAL DENSITY & SATURATION

WET WT. + RING	(g)	
DRY WT. + RING	(g)	
MOISTURE CONTENT	(%)	
SAMPLE LENGTH	(cm)	
SAMPLE AREA	(cm^2)	
VOLUME	(cc)	
WT. OF RING	(g)	
DRY DENSITY	(pcf)	
SPEC.GRAVITY (assumed)		
SATURATION	(%)	#DIV/0!
% RETAINED ON #4 SIEVE		

DATE	TIME	ELAPSED TIME (min.)	DIAL READING (in.)	DEFLECTION (in.)
10-Oct	8:00		0.314	
10-Oct	11:00		0.369	
11-Oct	10:25		0.371	0.057

E. I. 57

SO_4 147 ppm

REMARKS :

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EXPANSION INDEX

(UBC 18-2)

APPENDIX D

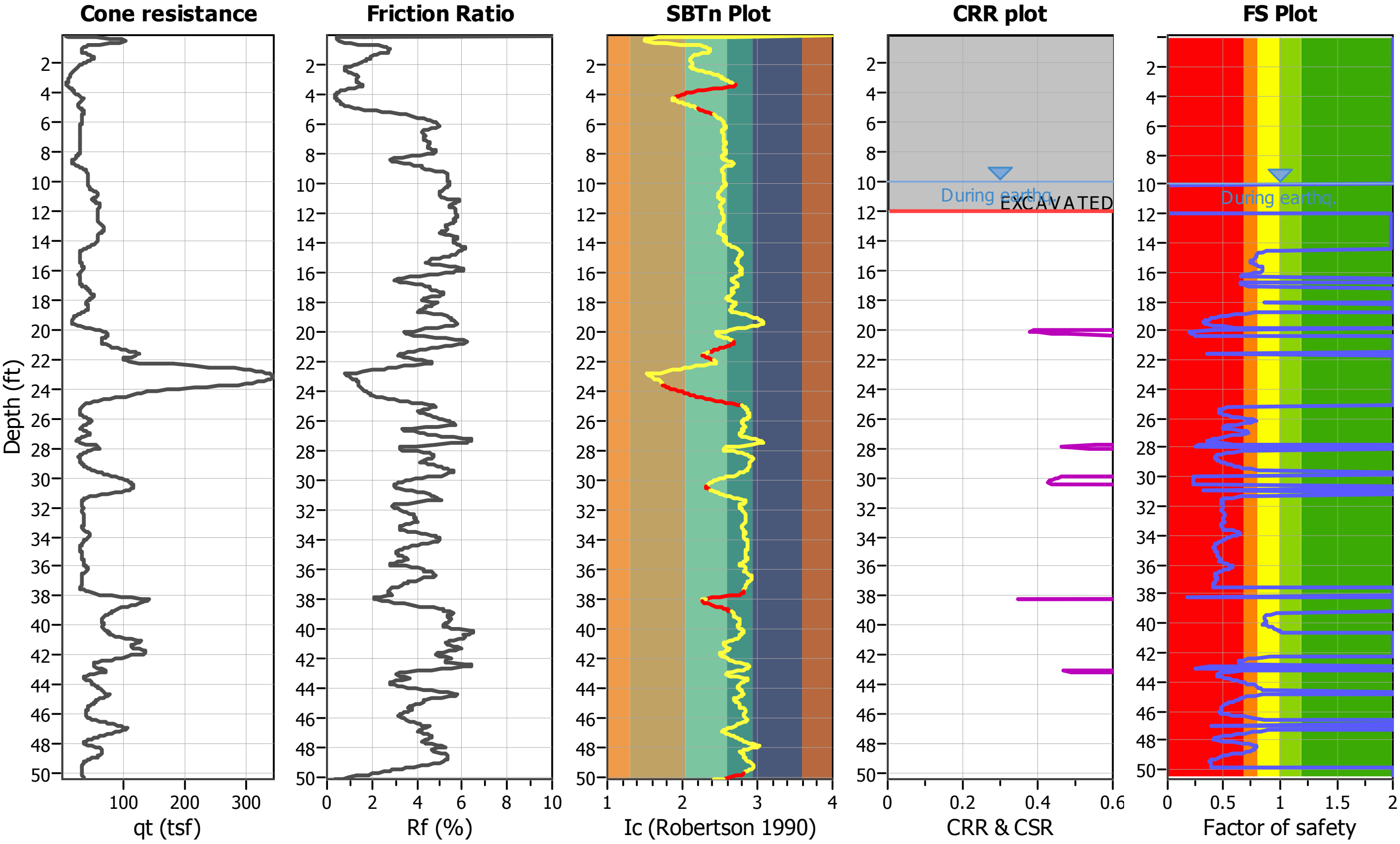
LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS

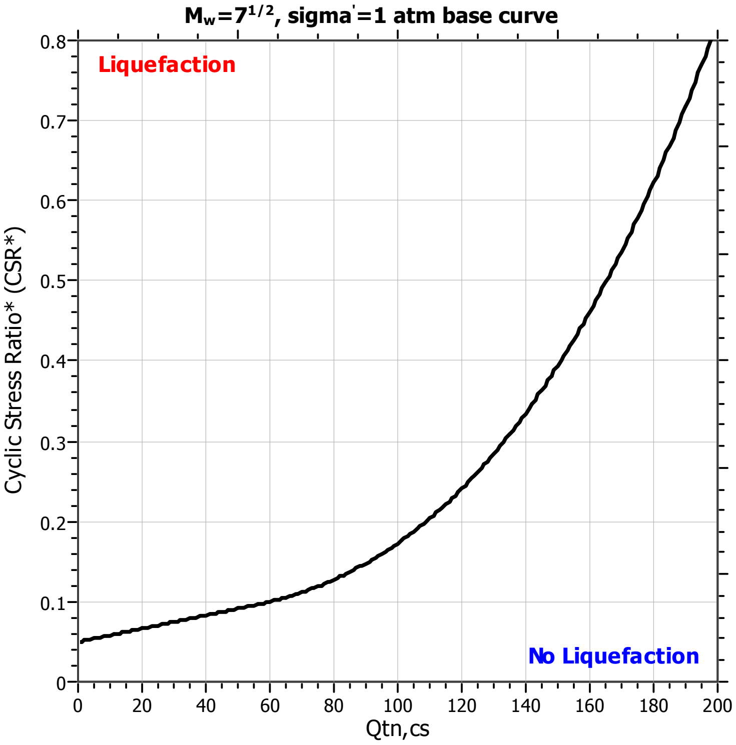
Project title : **Location :**

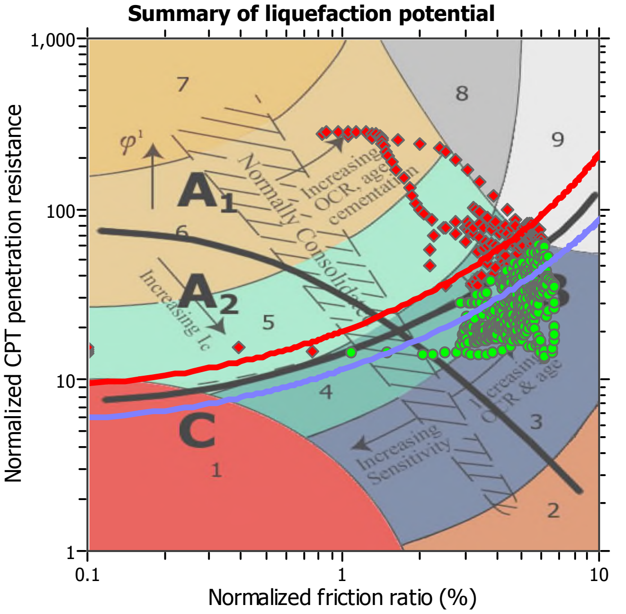
CPT file : CPT-1

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

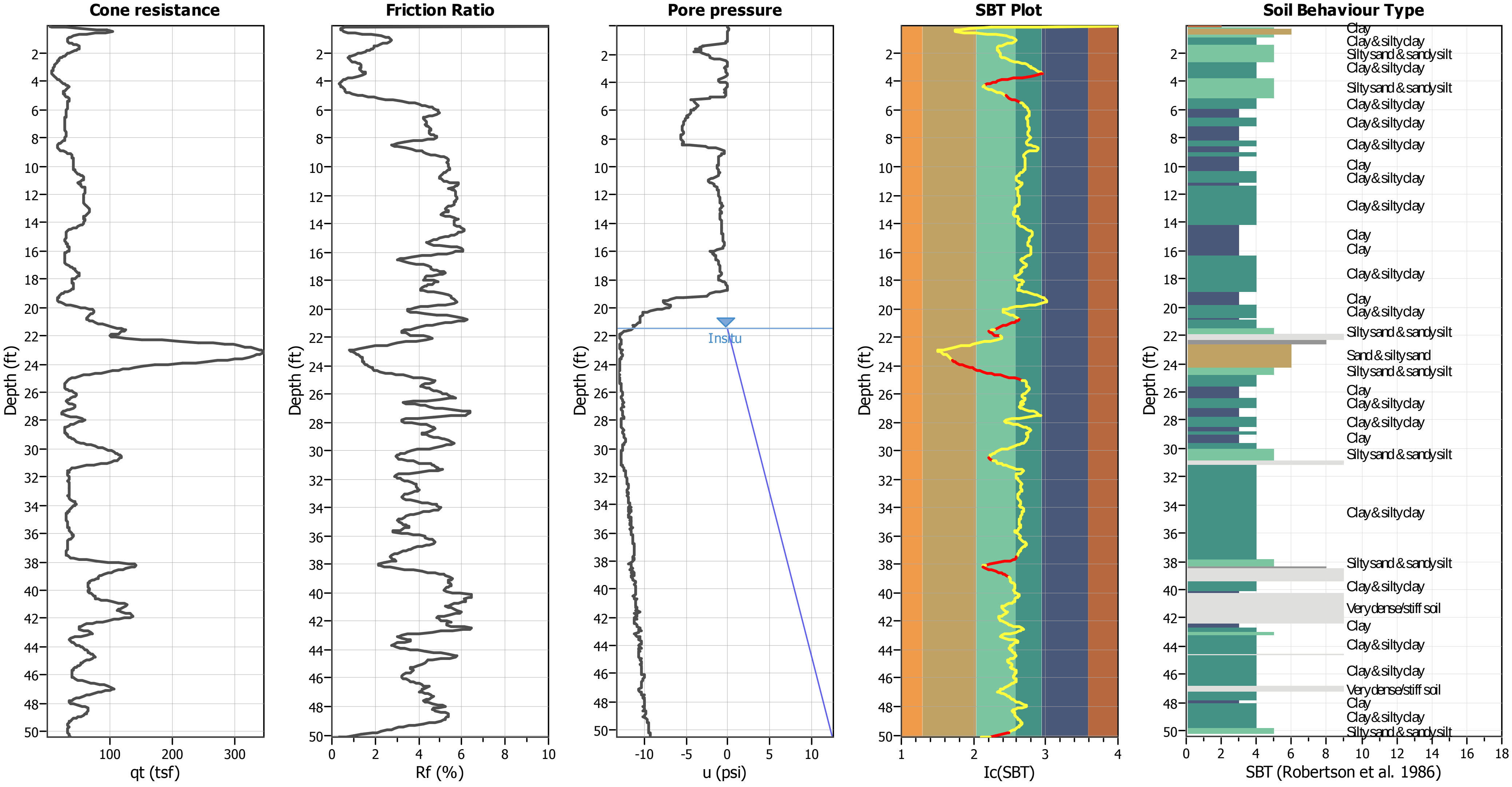






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



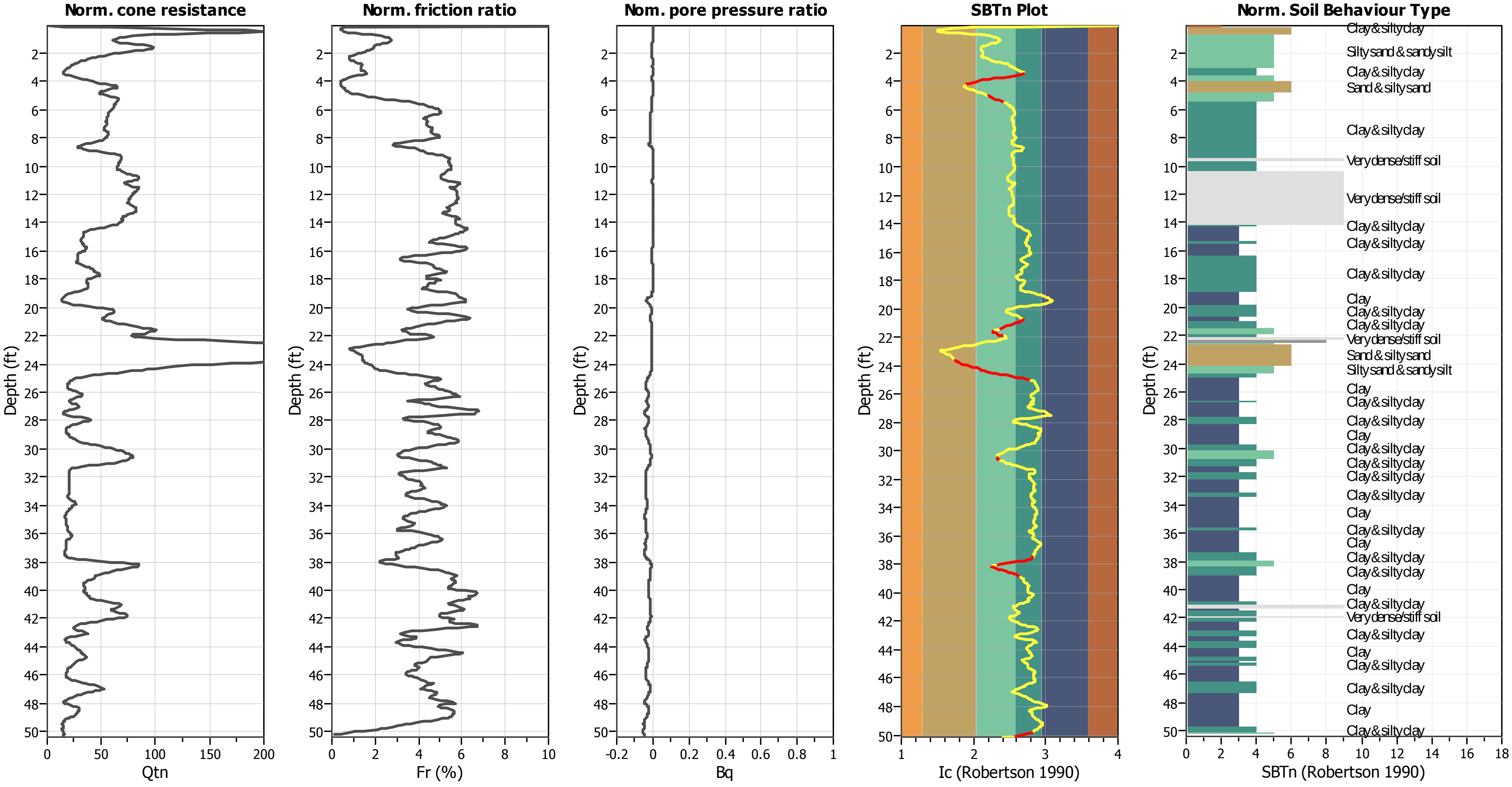
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

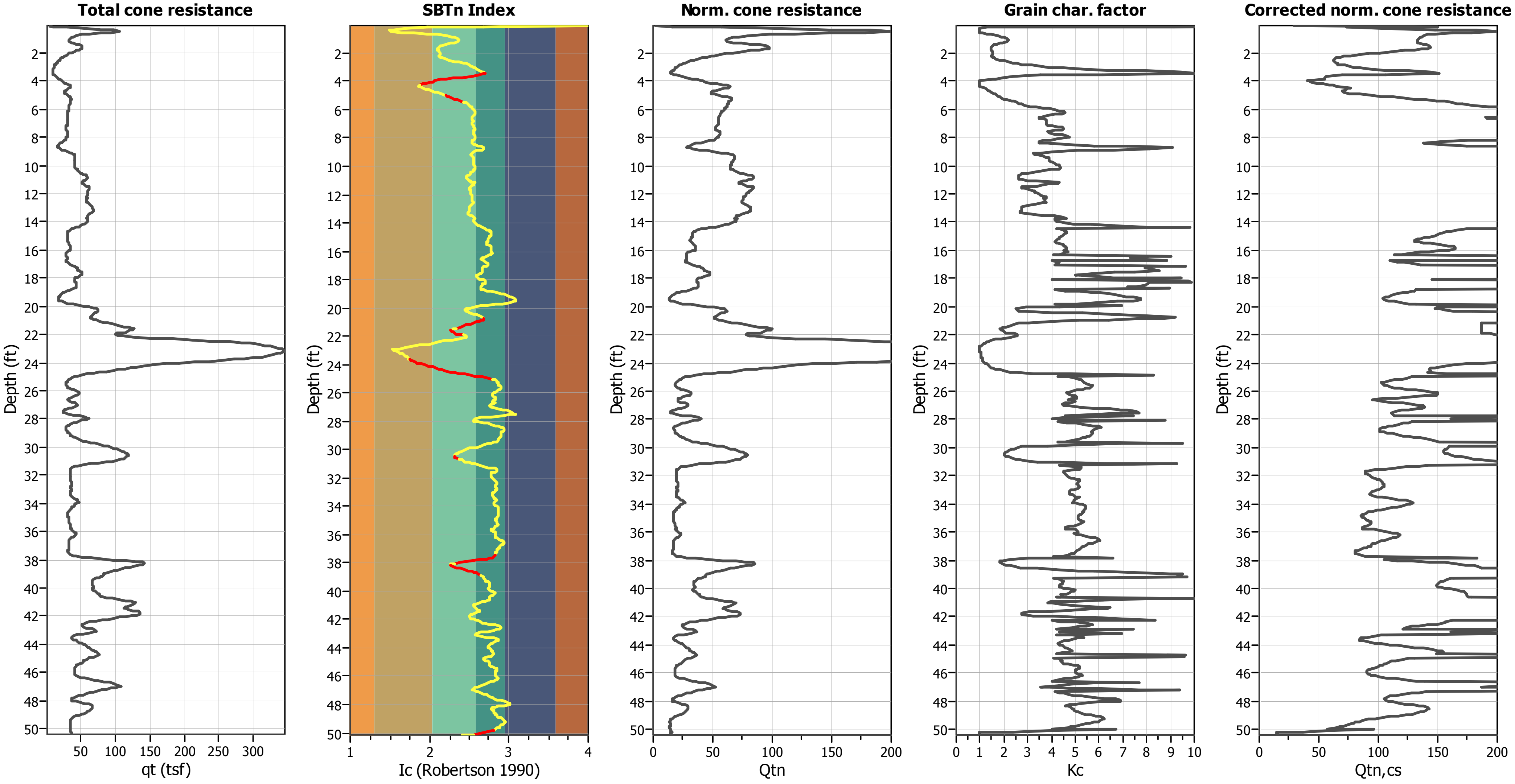
Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

SBTn legend

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

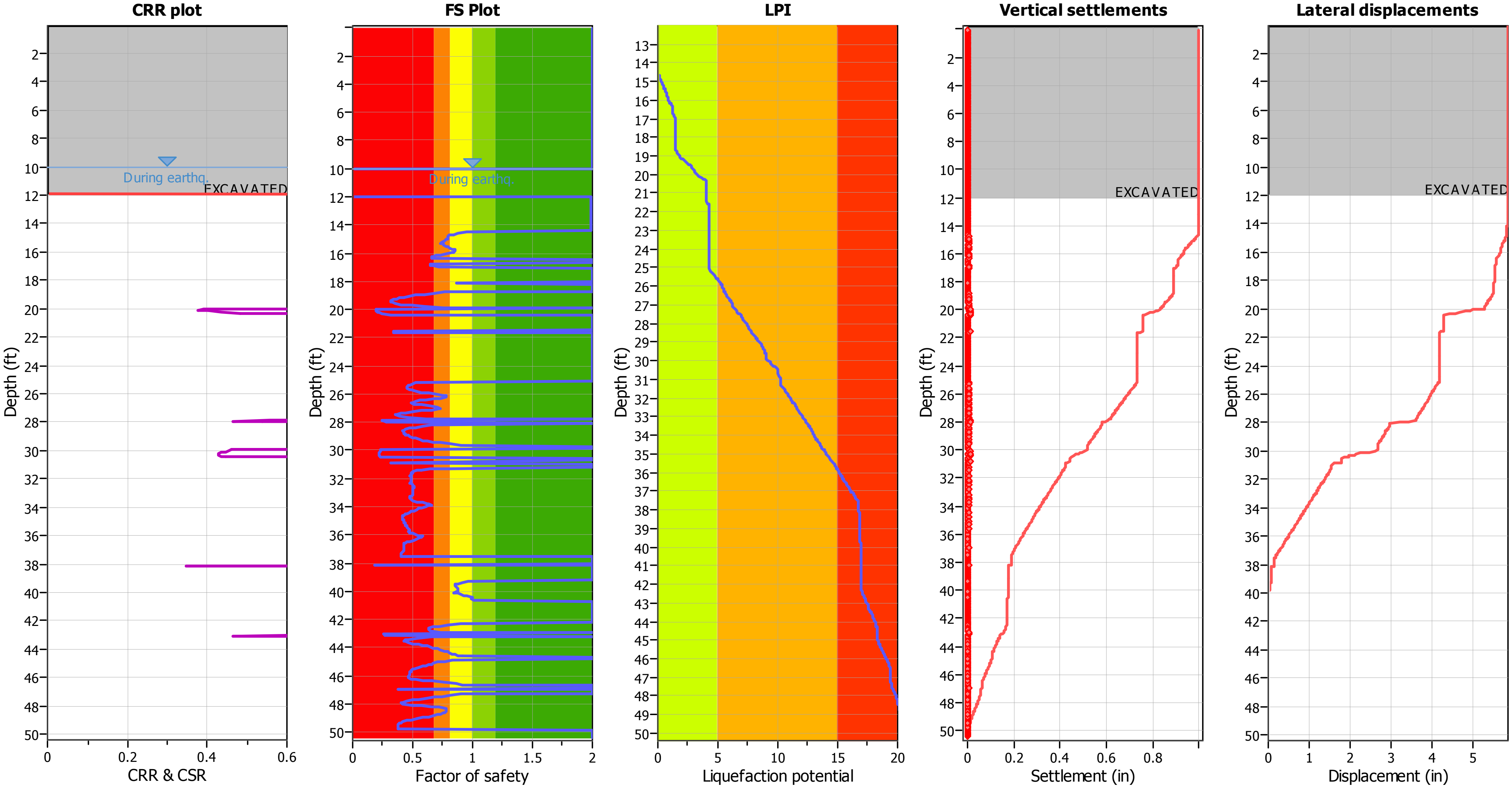
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

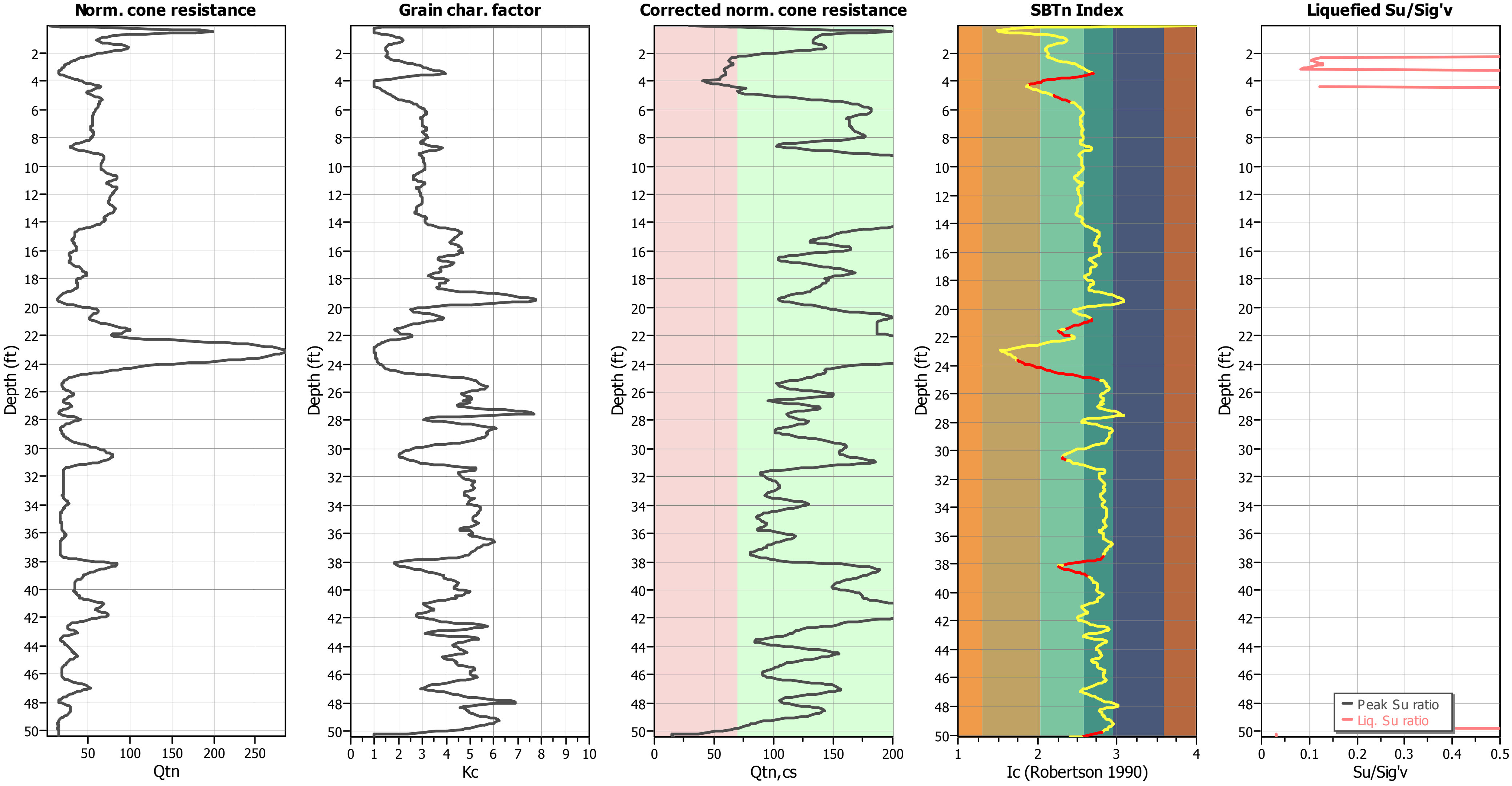
- ☐ Very high risk
- ☐ High risk
- ☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

:: Liquefaction Potential Index calculation data ::

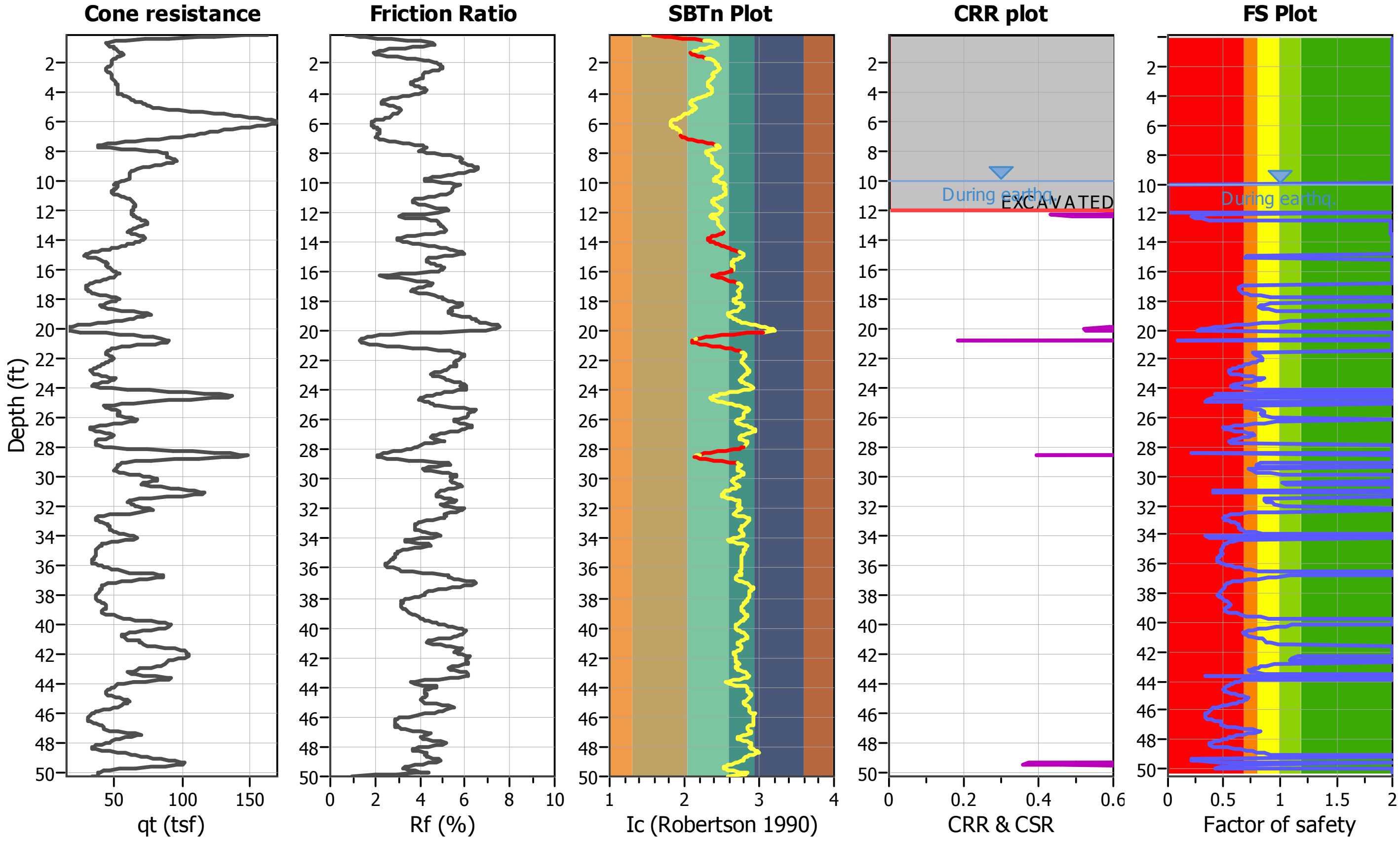
Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

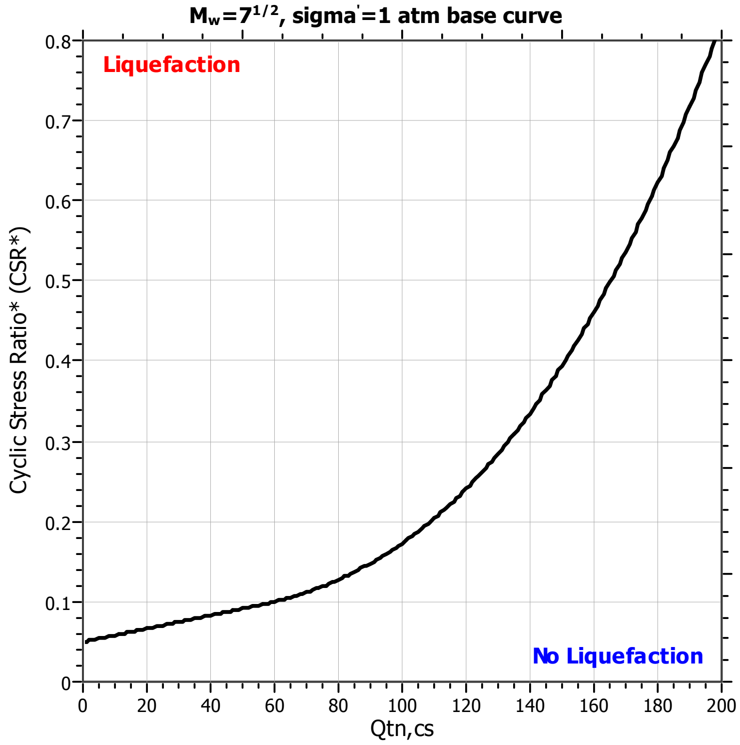
Project title : **Location :**

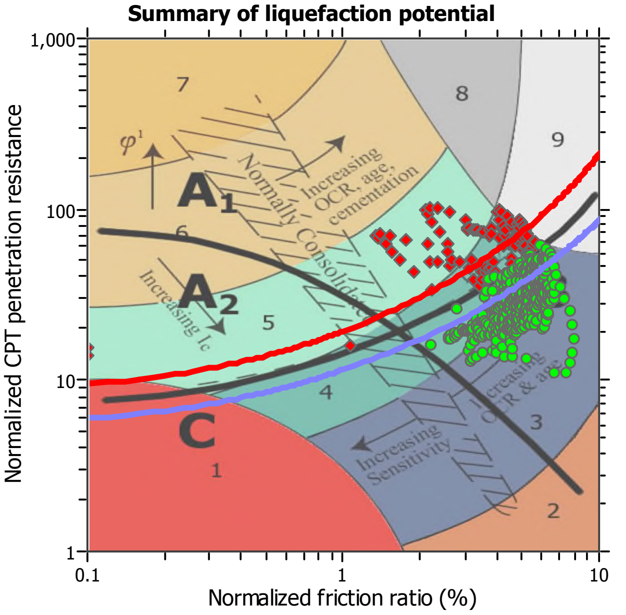
CPT file : CPT-2

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

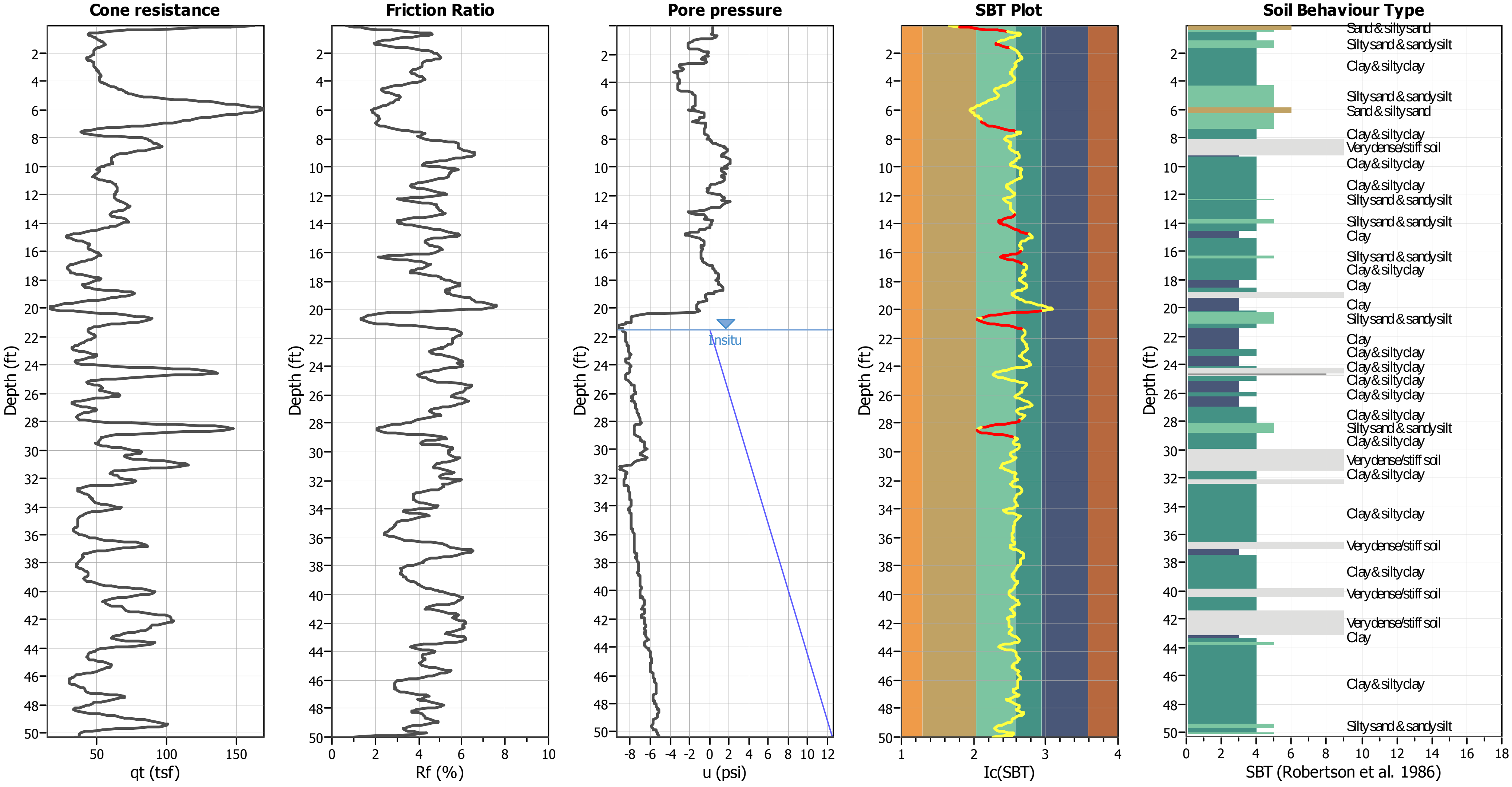






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



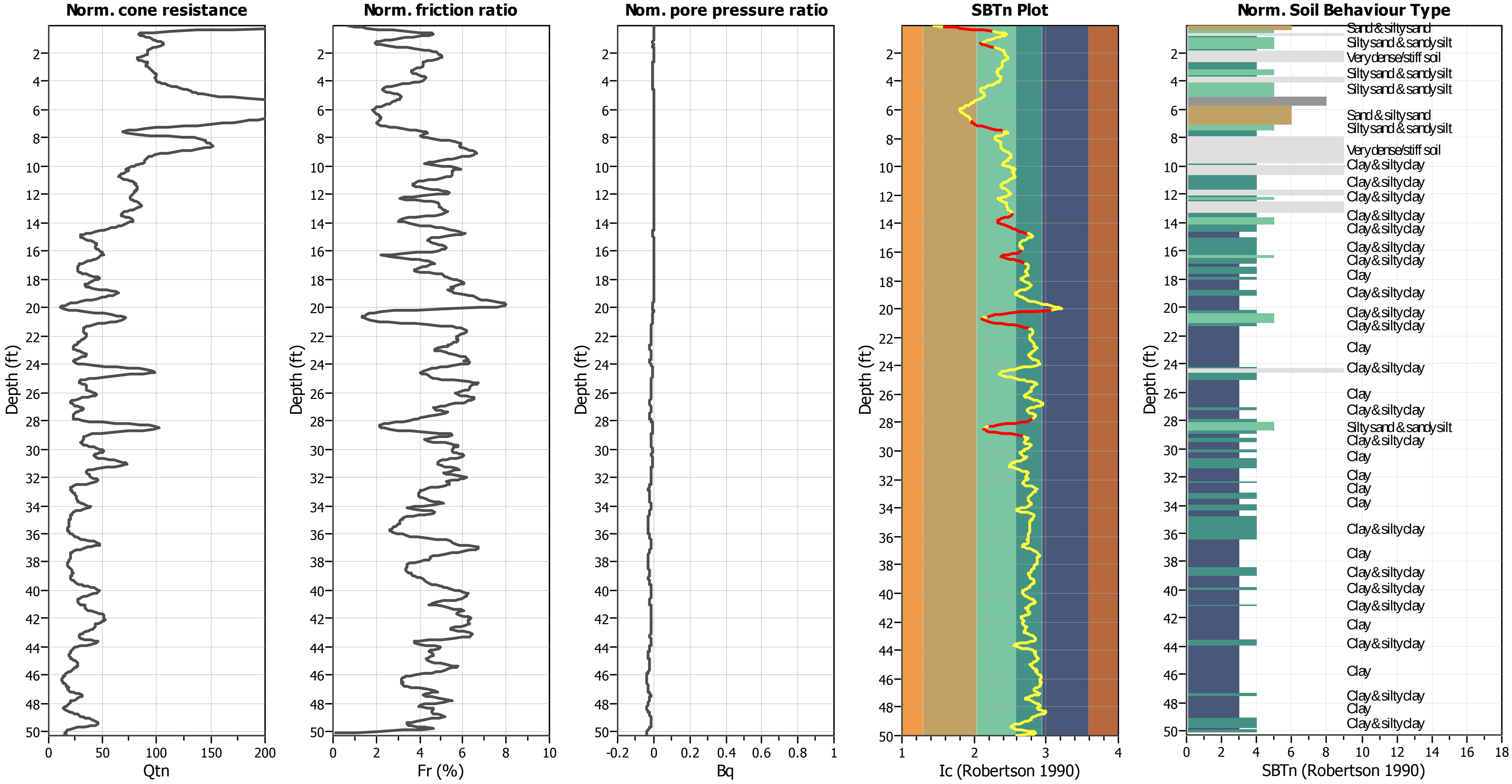
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



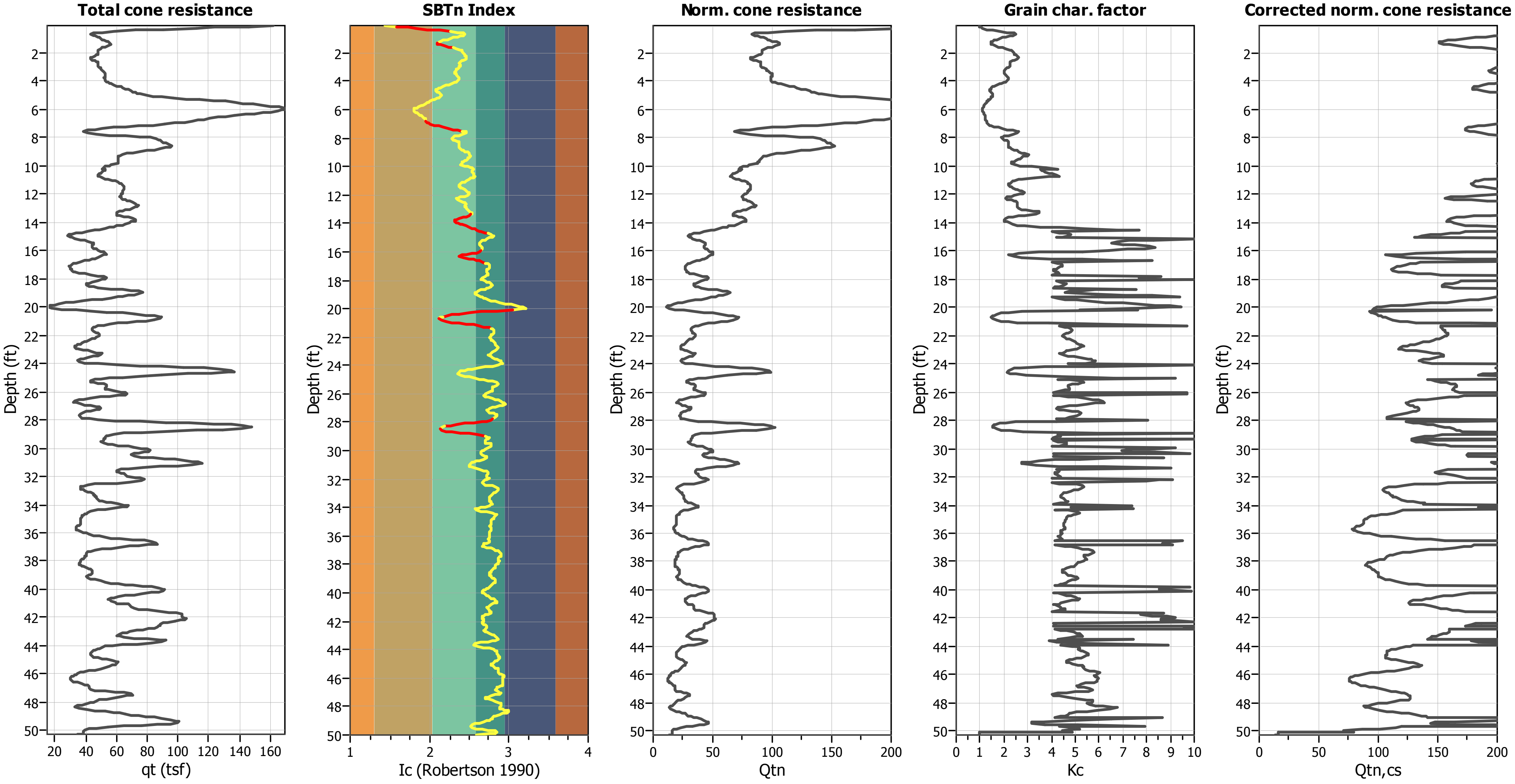
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBTn legend

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

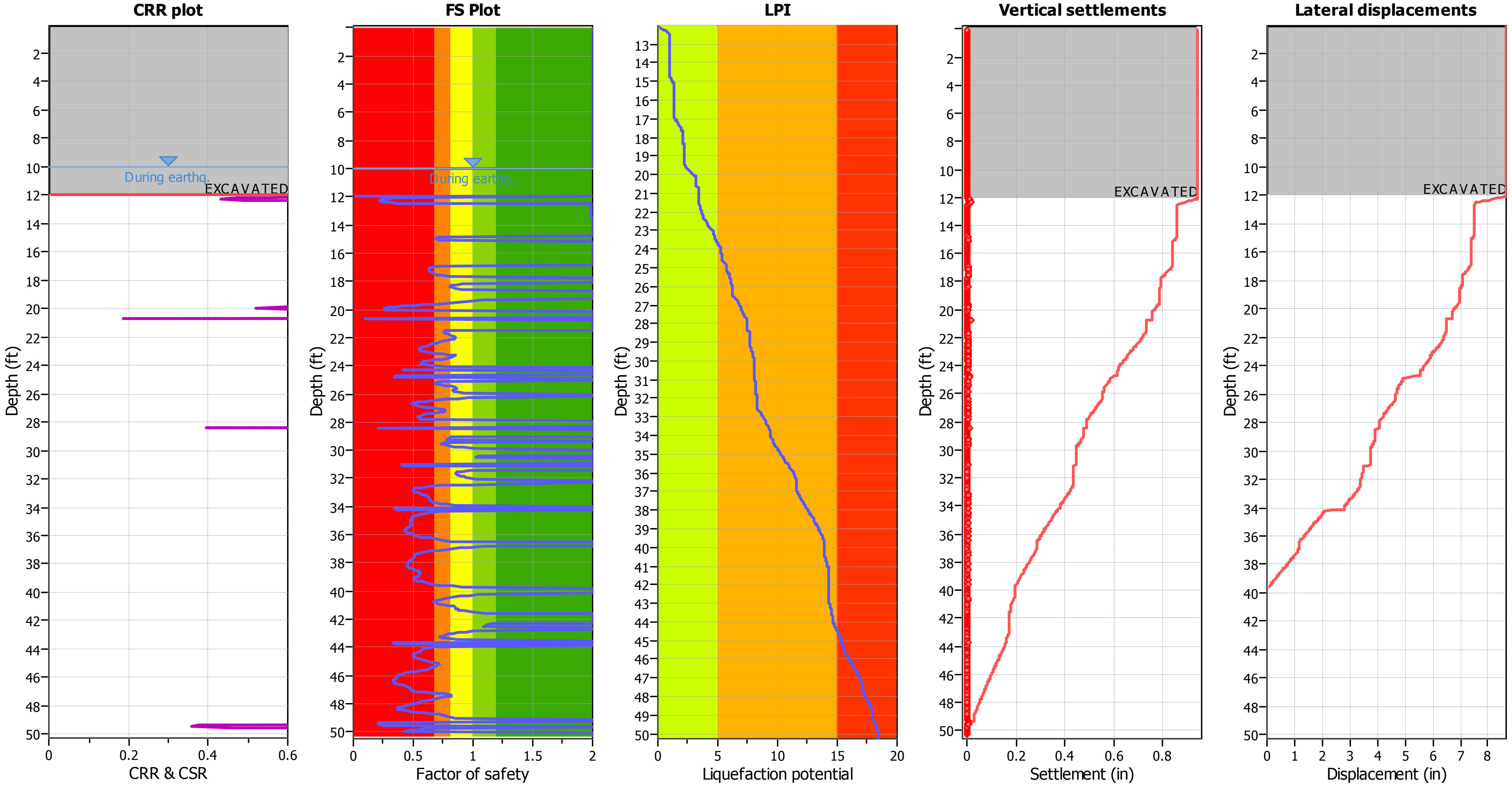
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

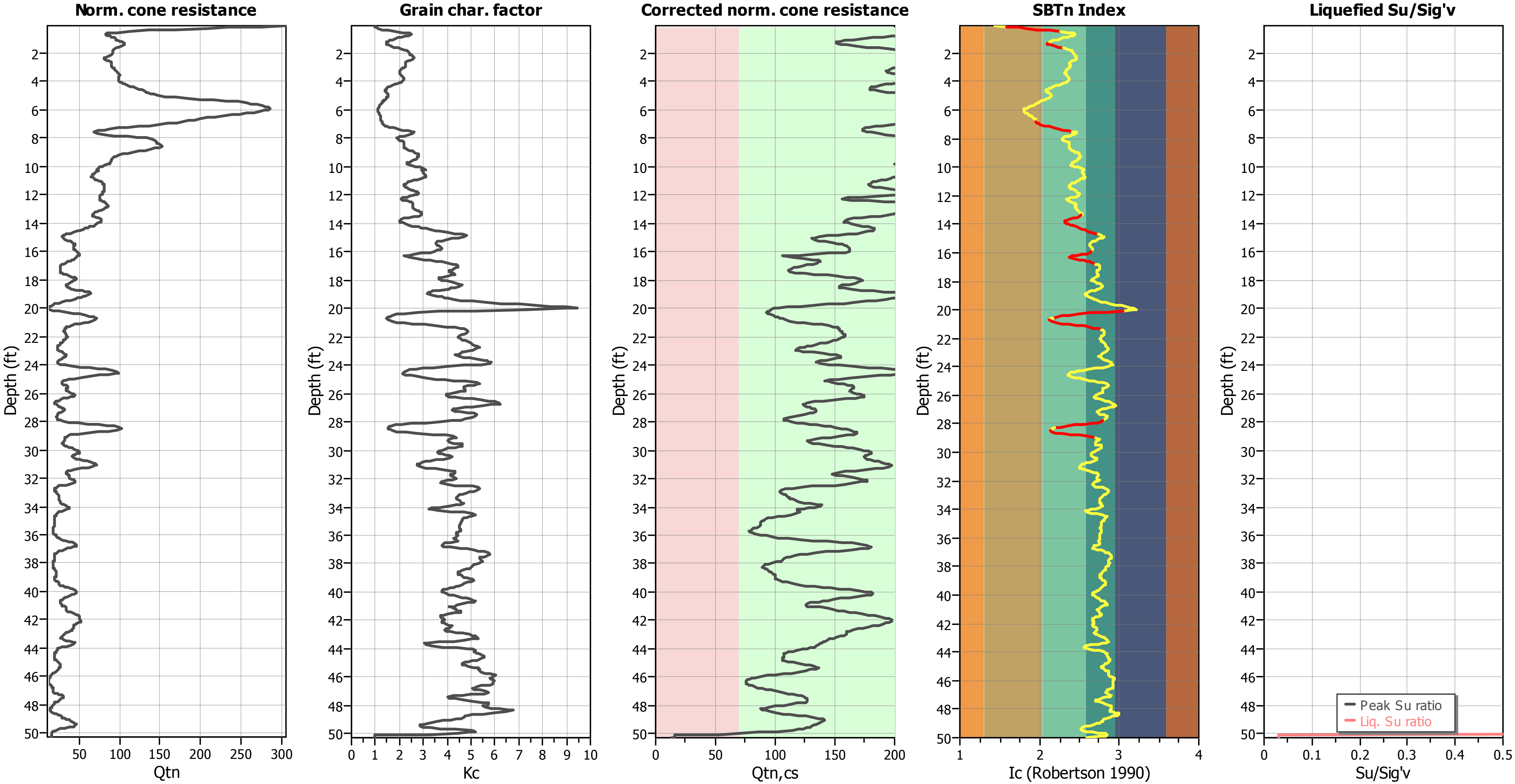
- ☐ Very high risk
- ☐ High risk
- ☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

:: Liquefaction Potential Index calculation data ::

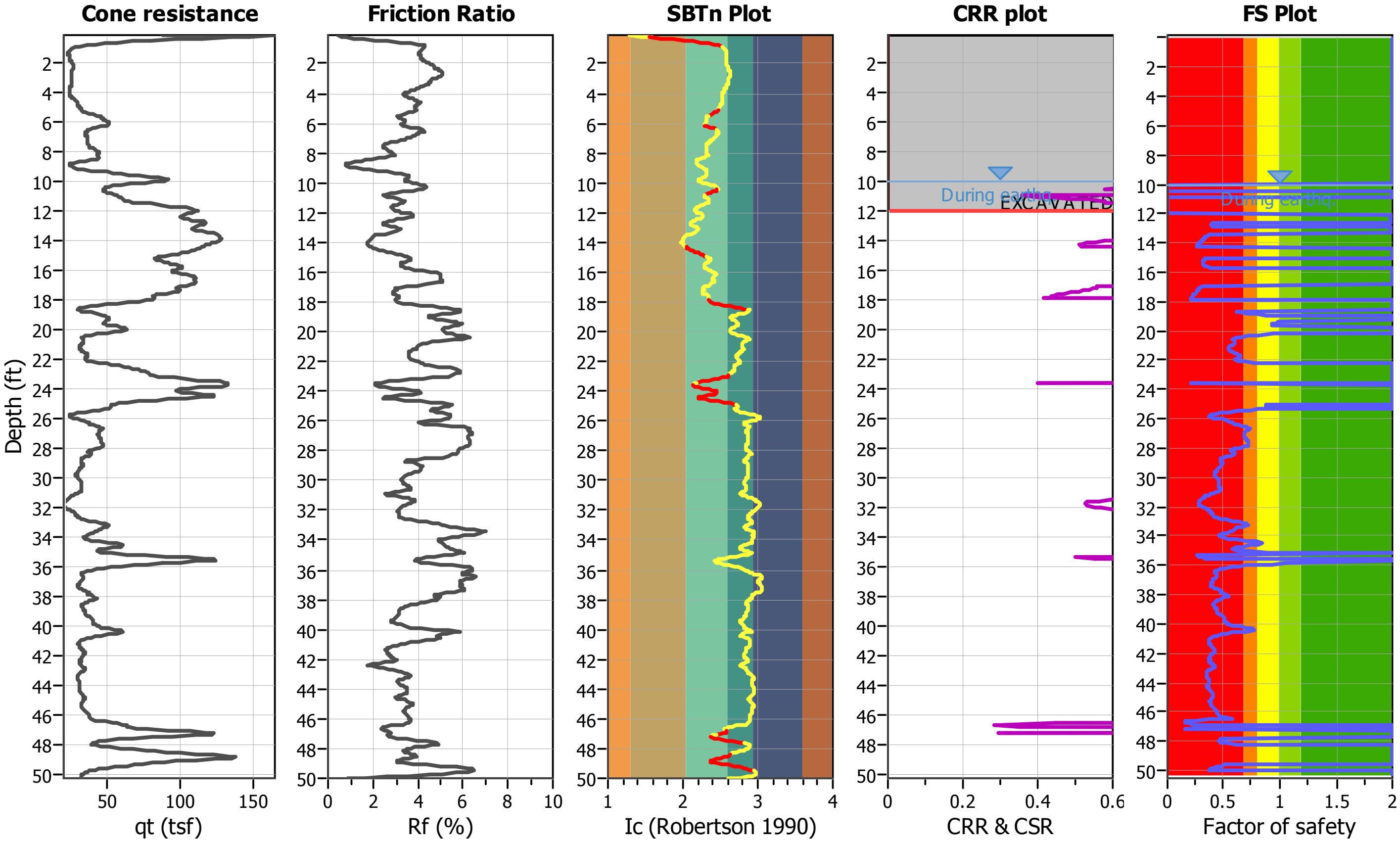
Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

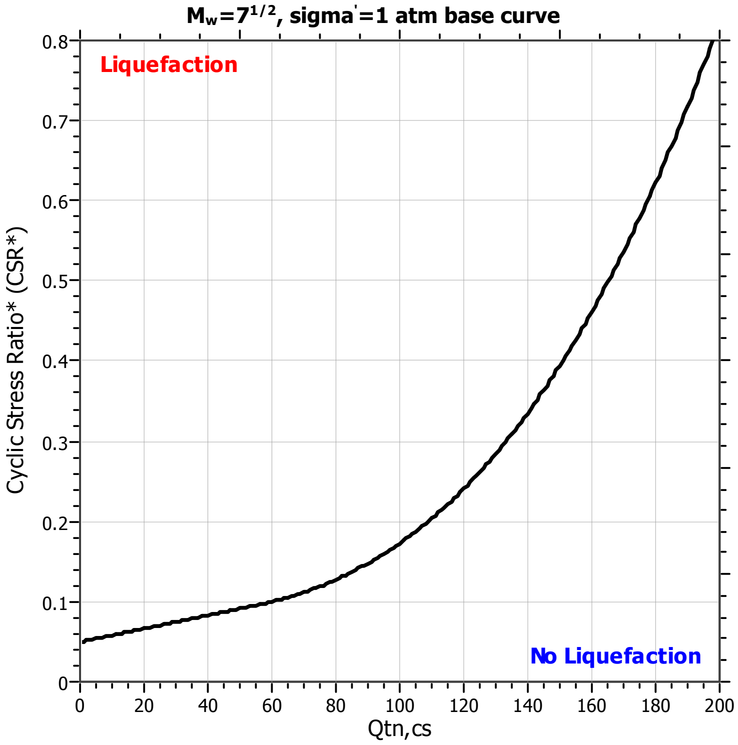
Project title : **Location :**

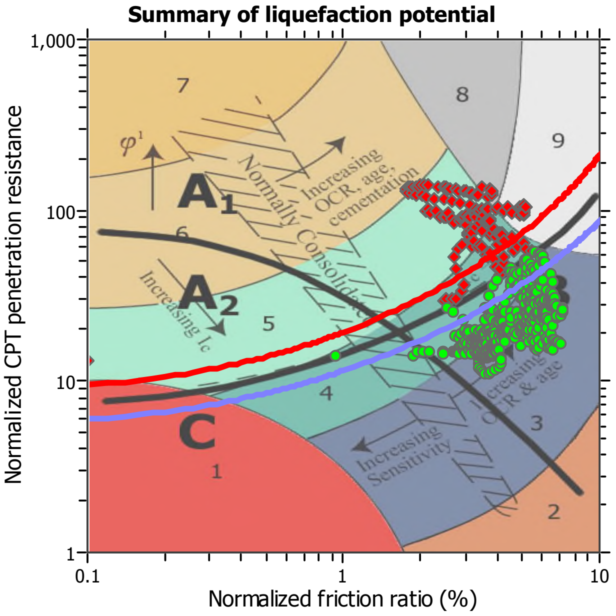
CPT file : CPT-3

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

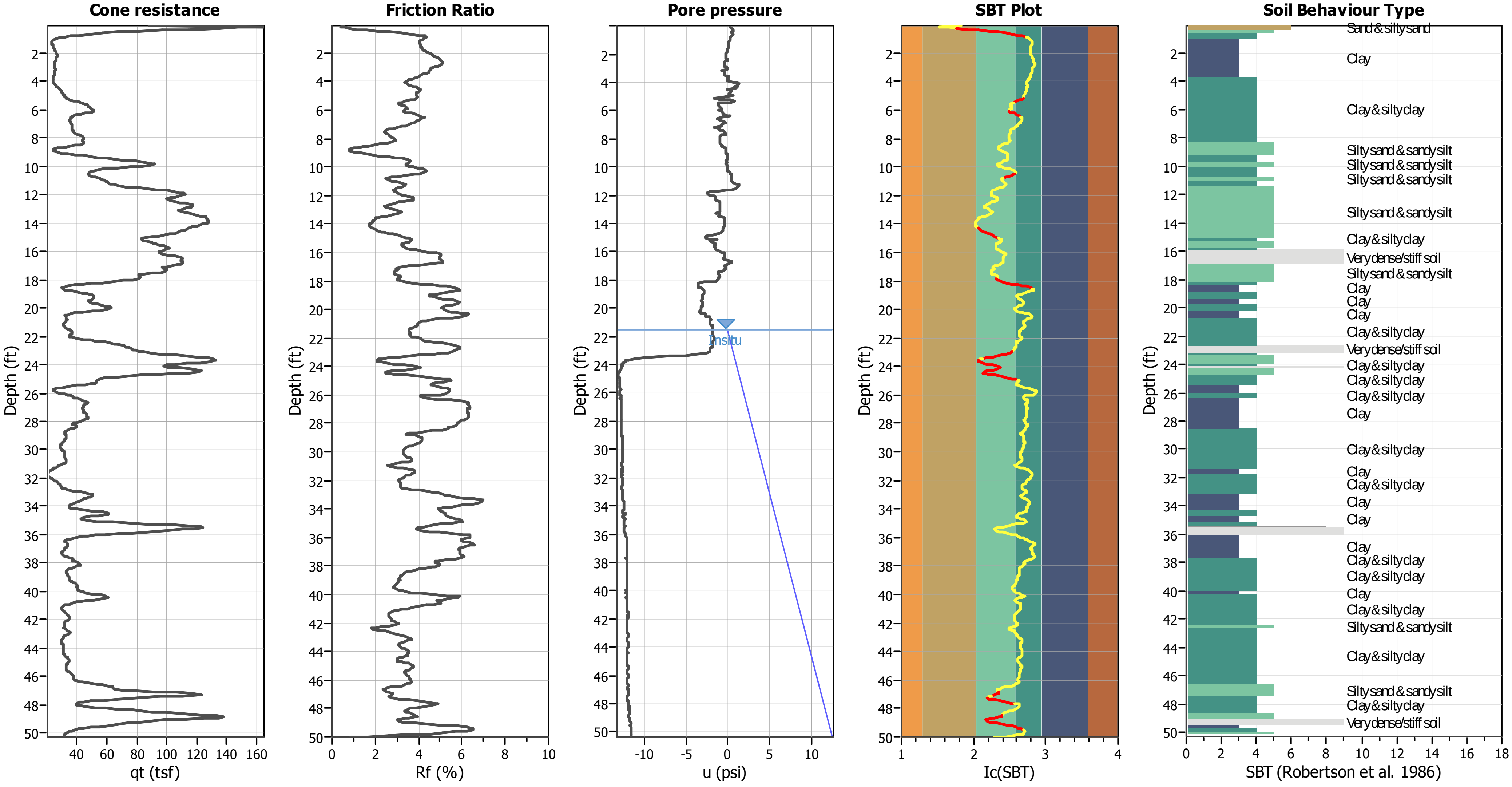






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

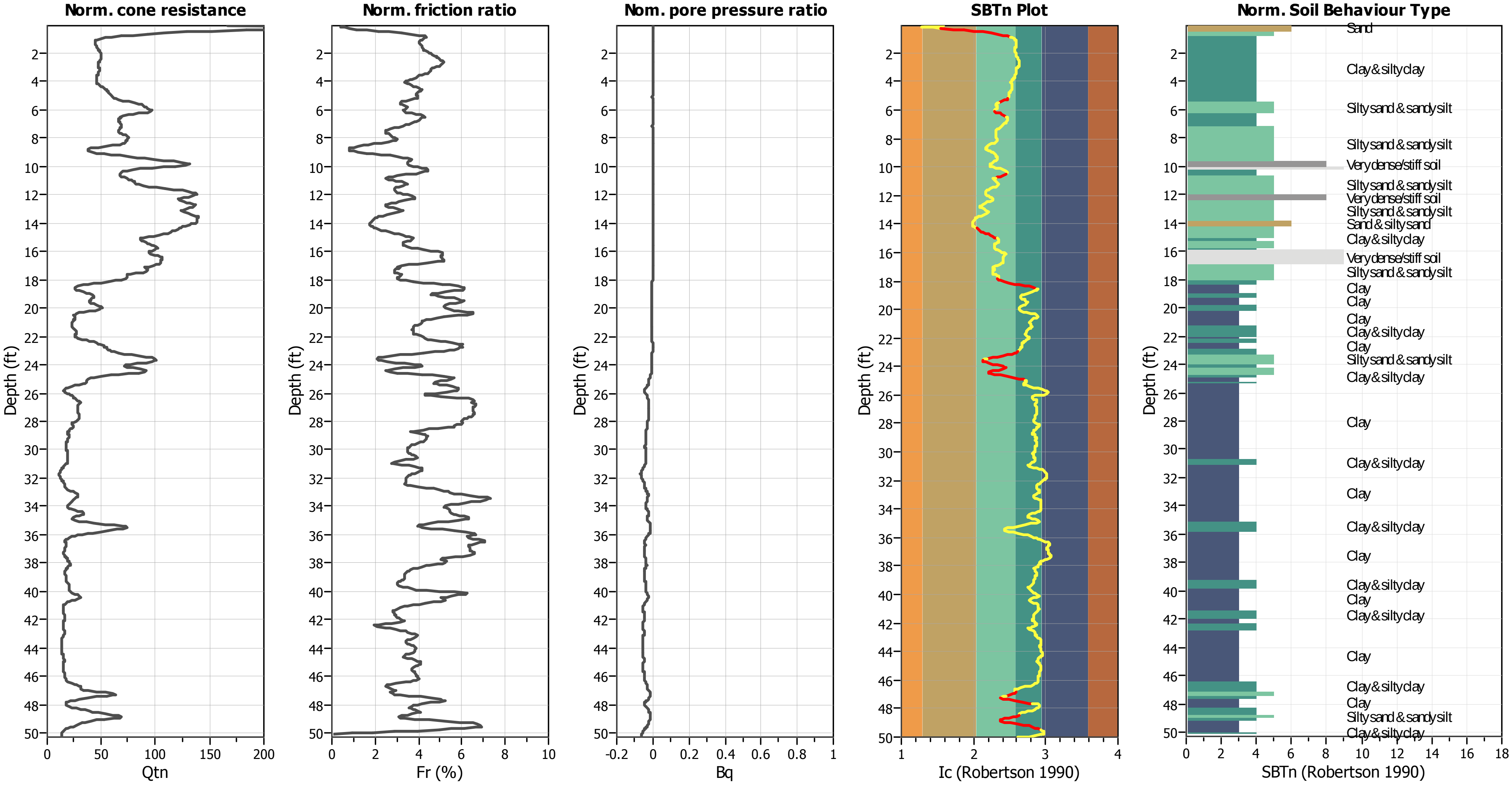
Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

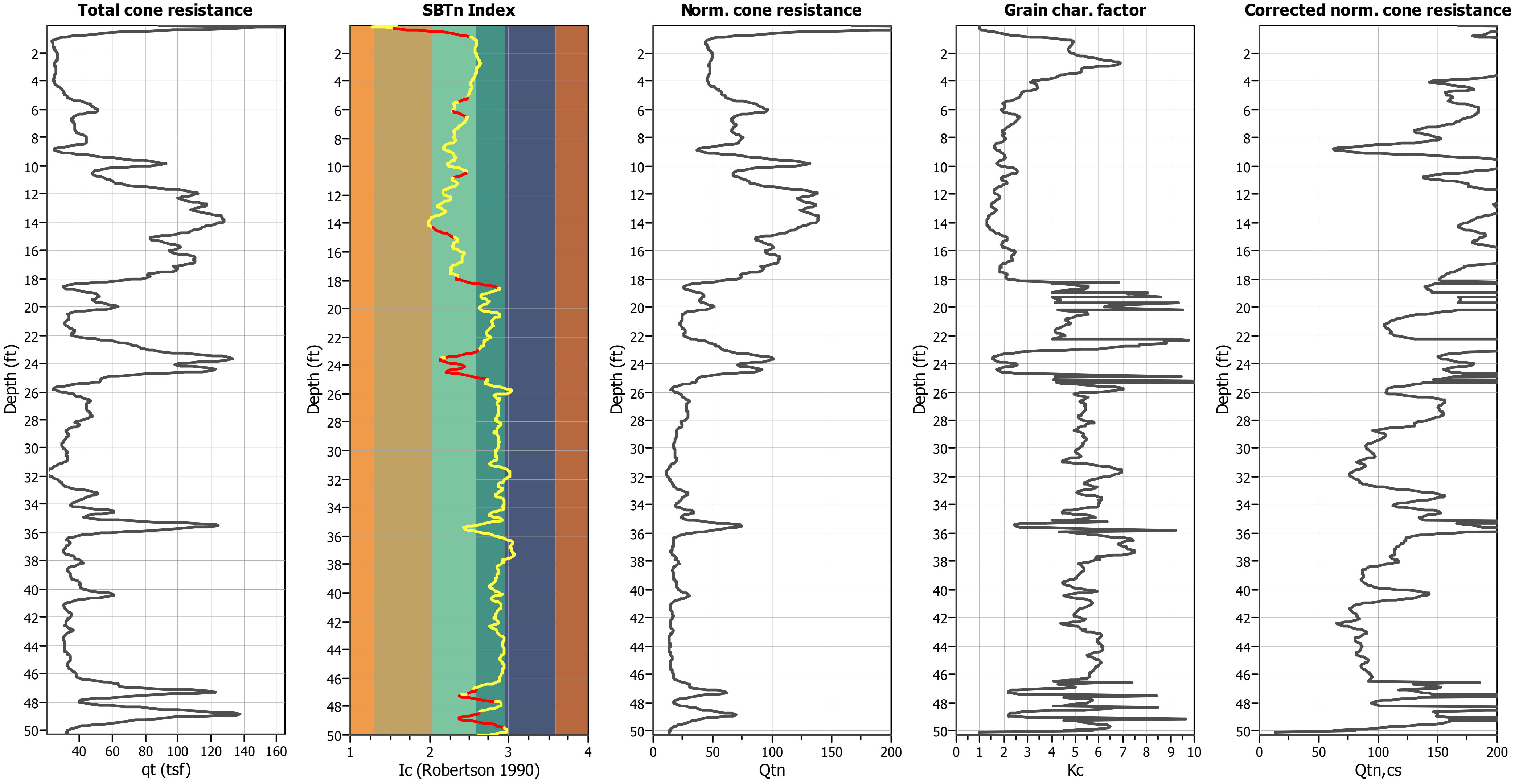
Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

SBTn legend

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

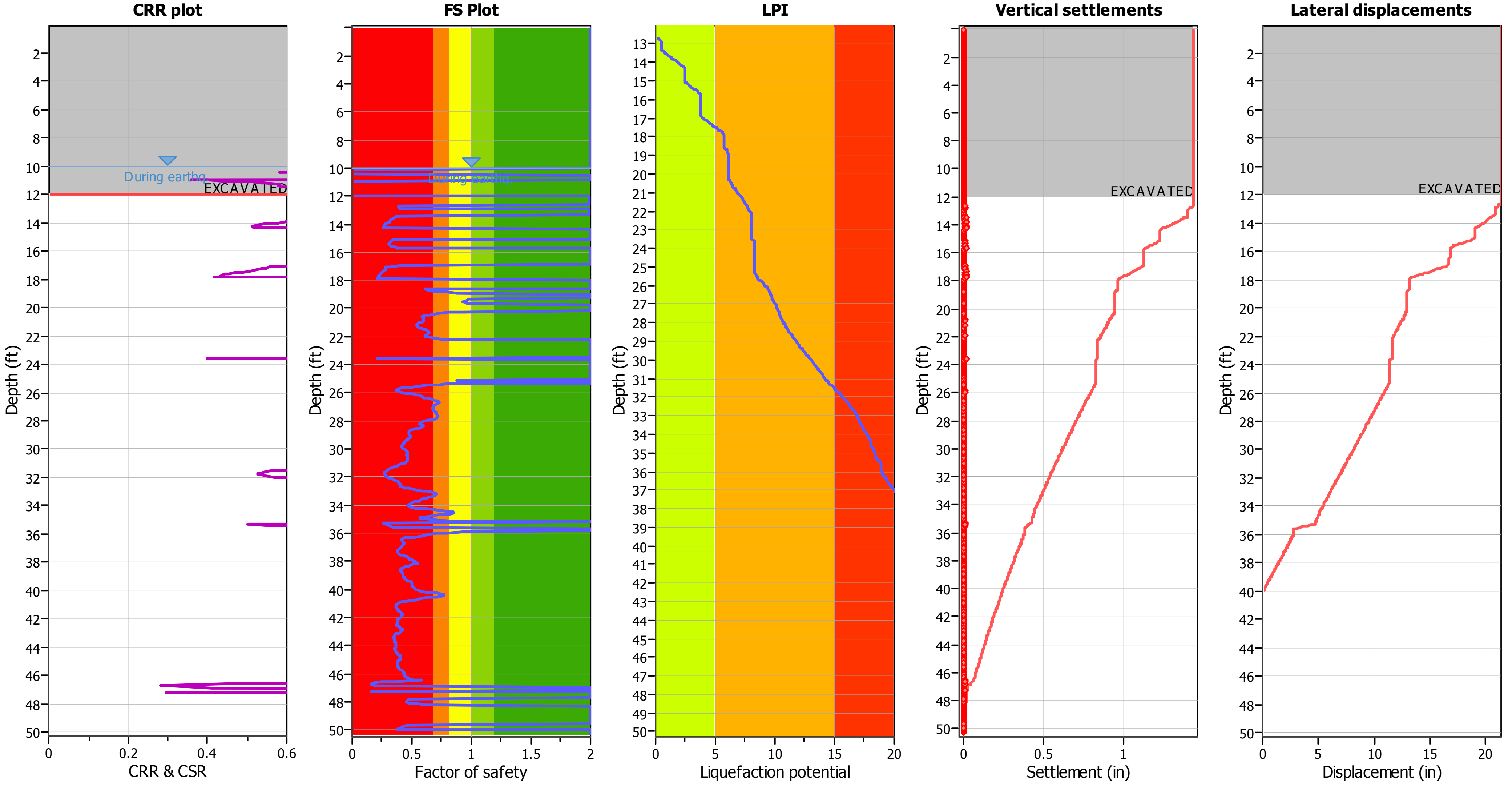
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

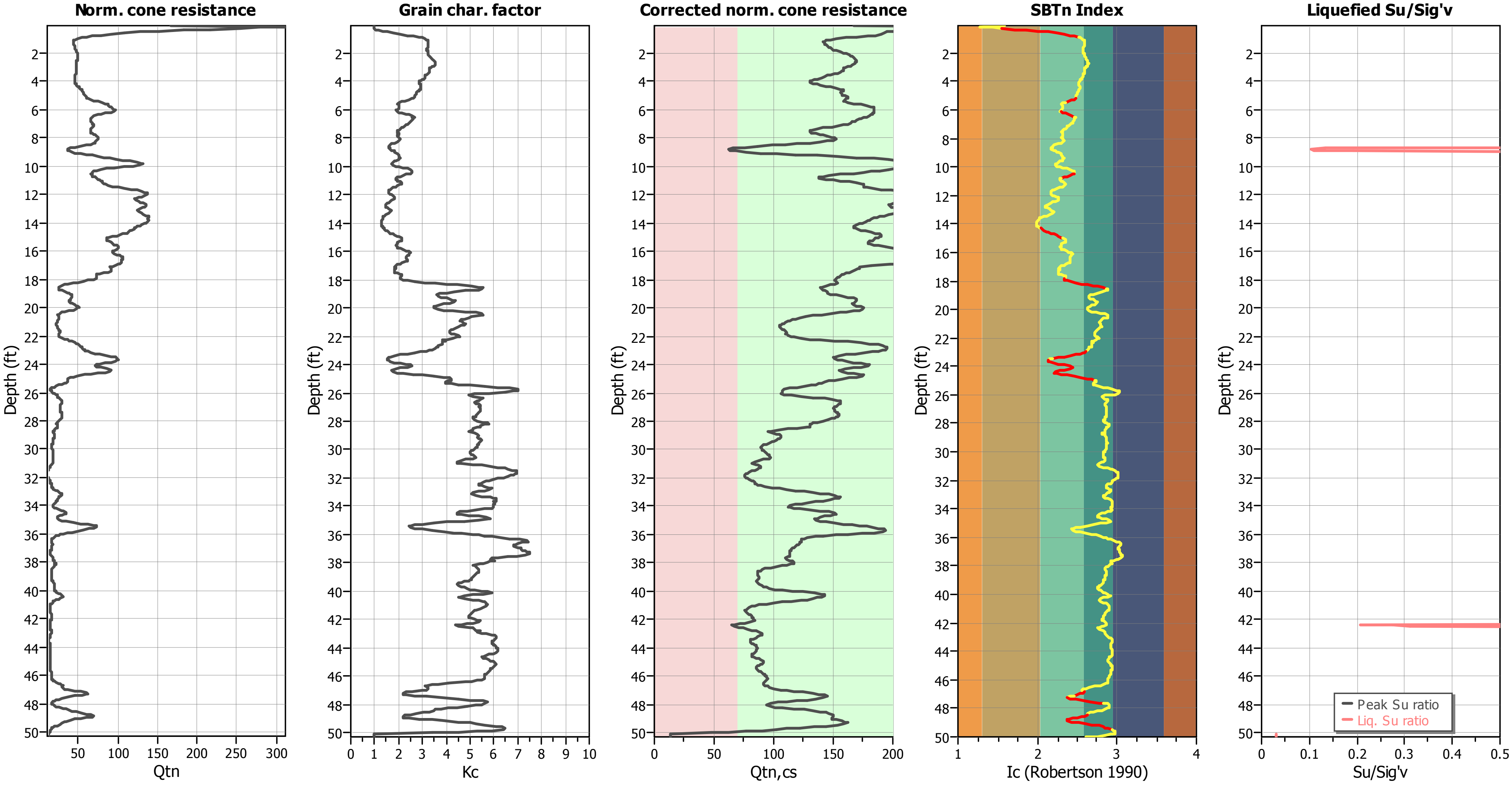
☐ Very high risk
☐ High risk
☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft
Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft
Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

:: Liquefaction Potential Index calculation data ::

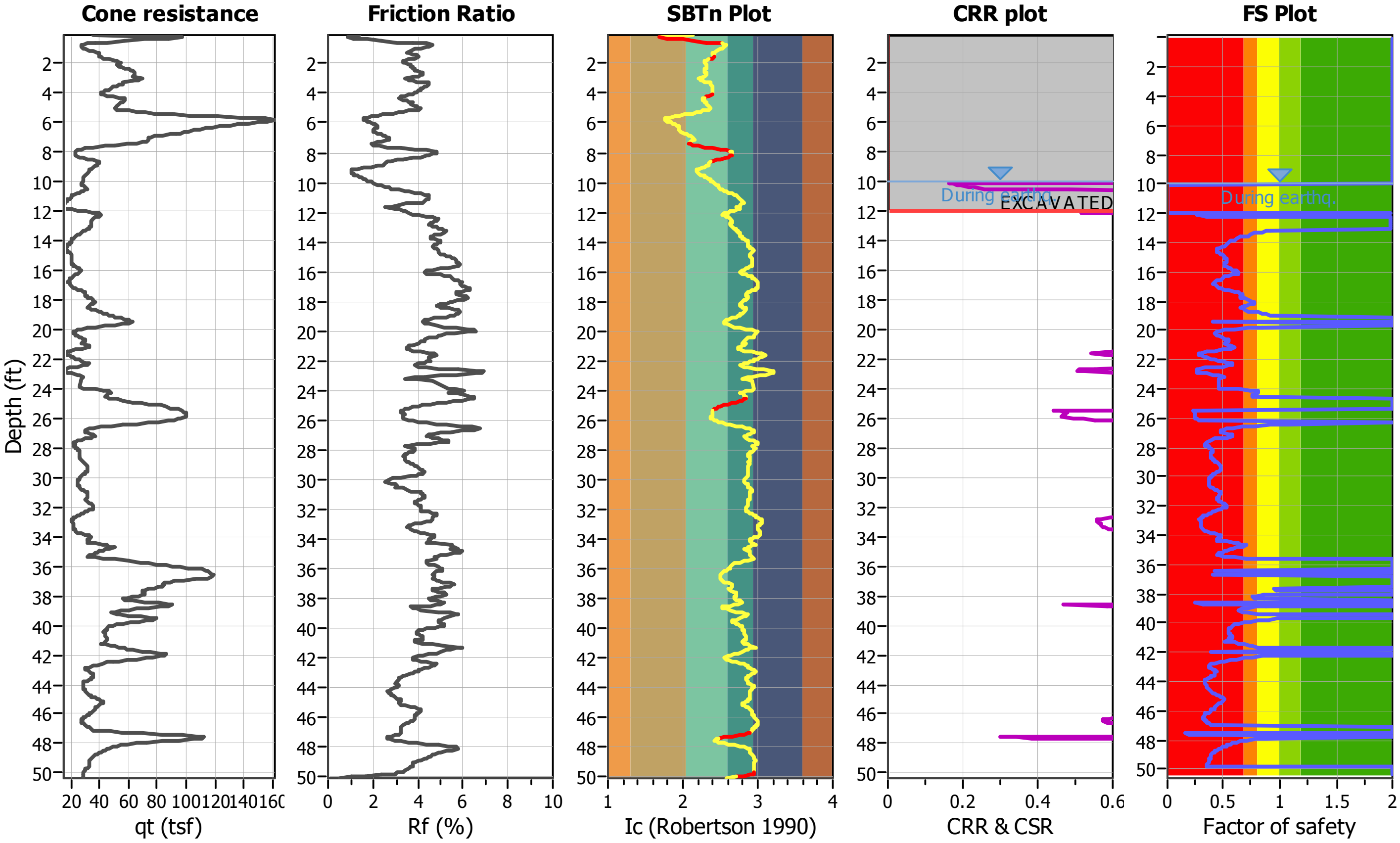
Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

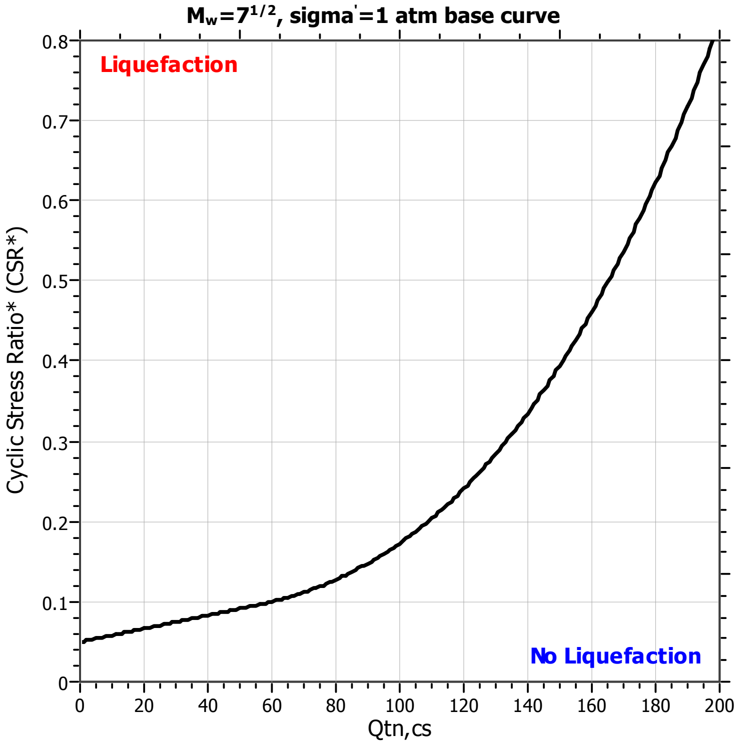
Project title : **Location :**

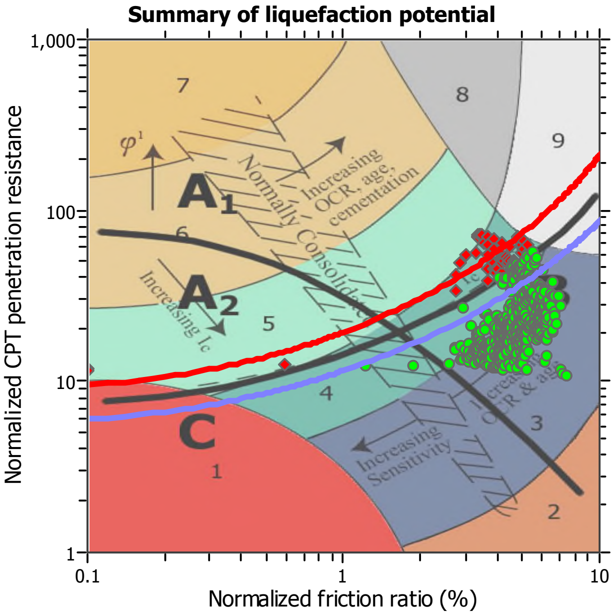
CPT file : CPT-4

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

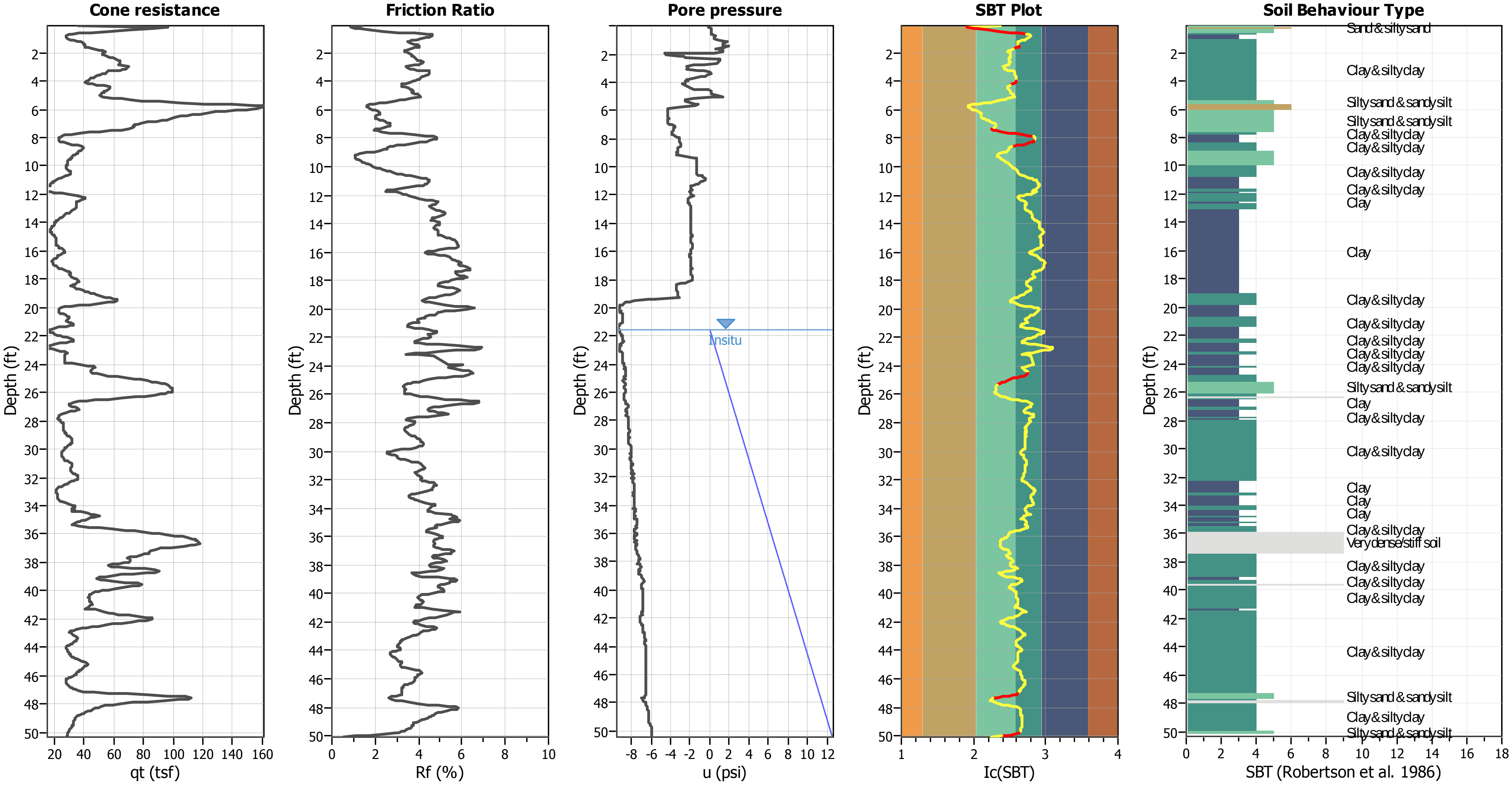






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



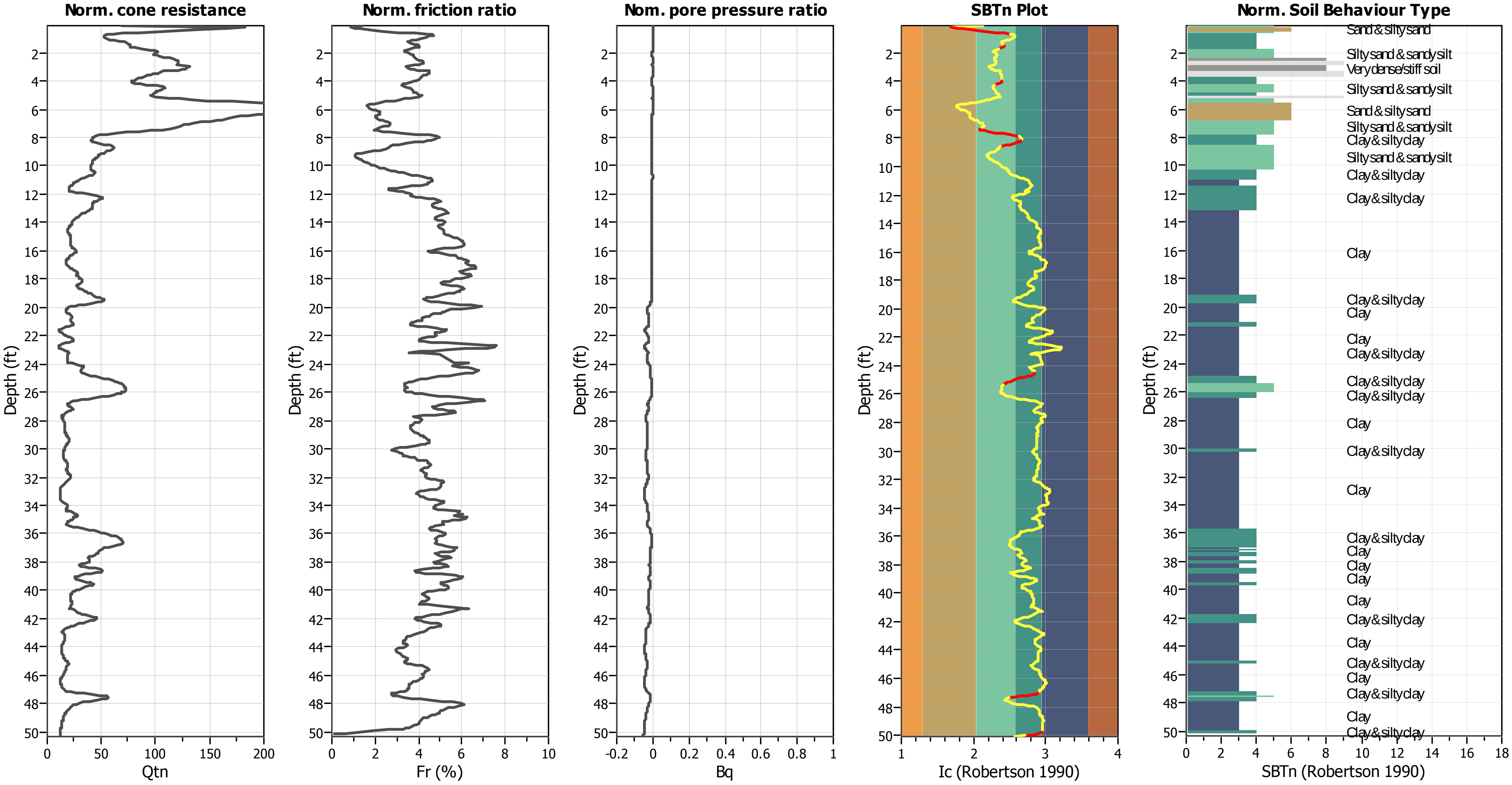
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



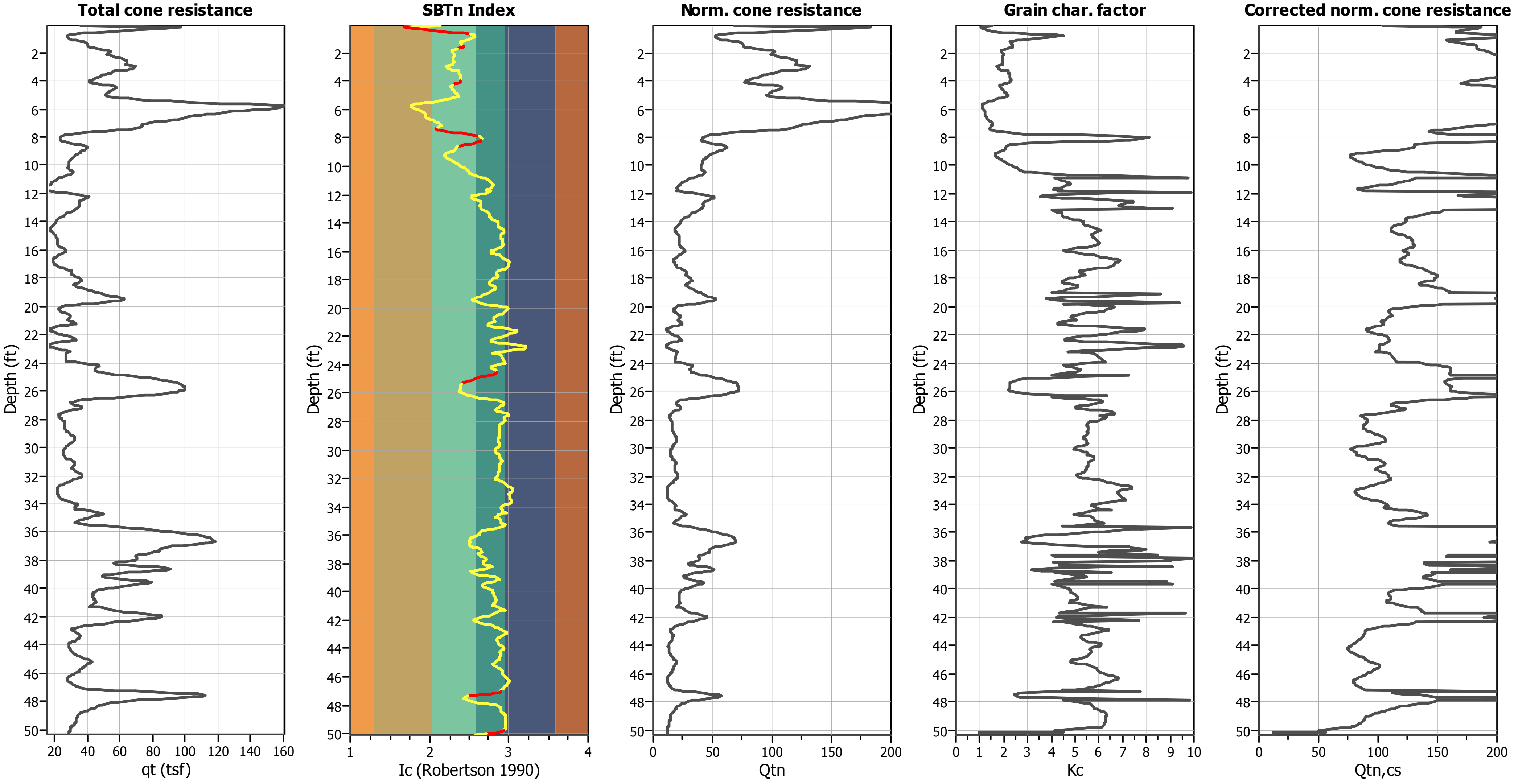
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBTn legend

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

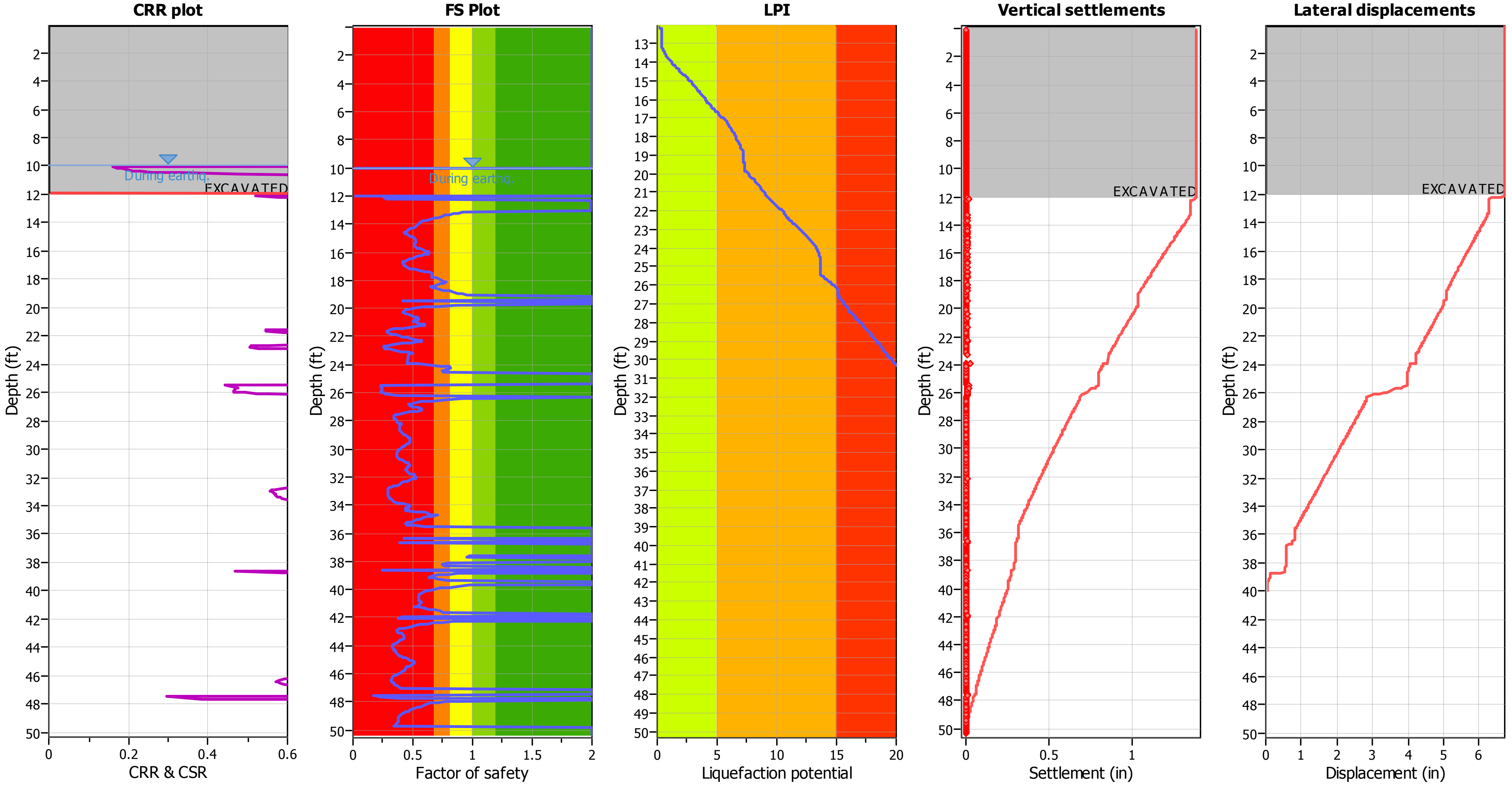
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

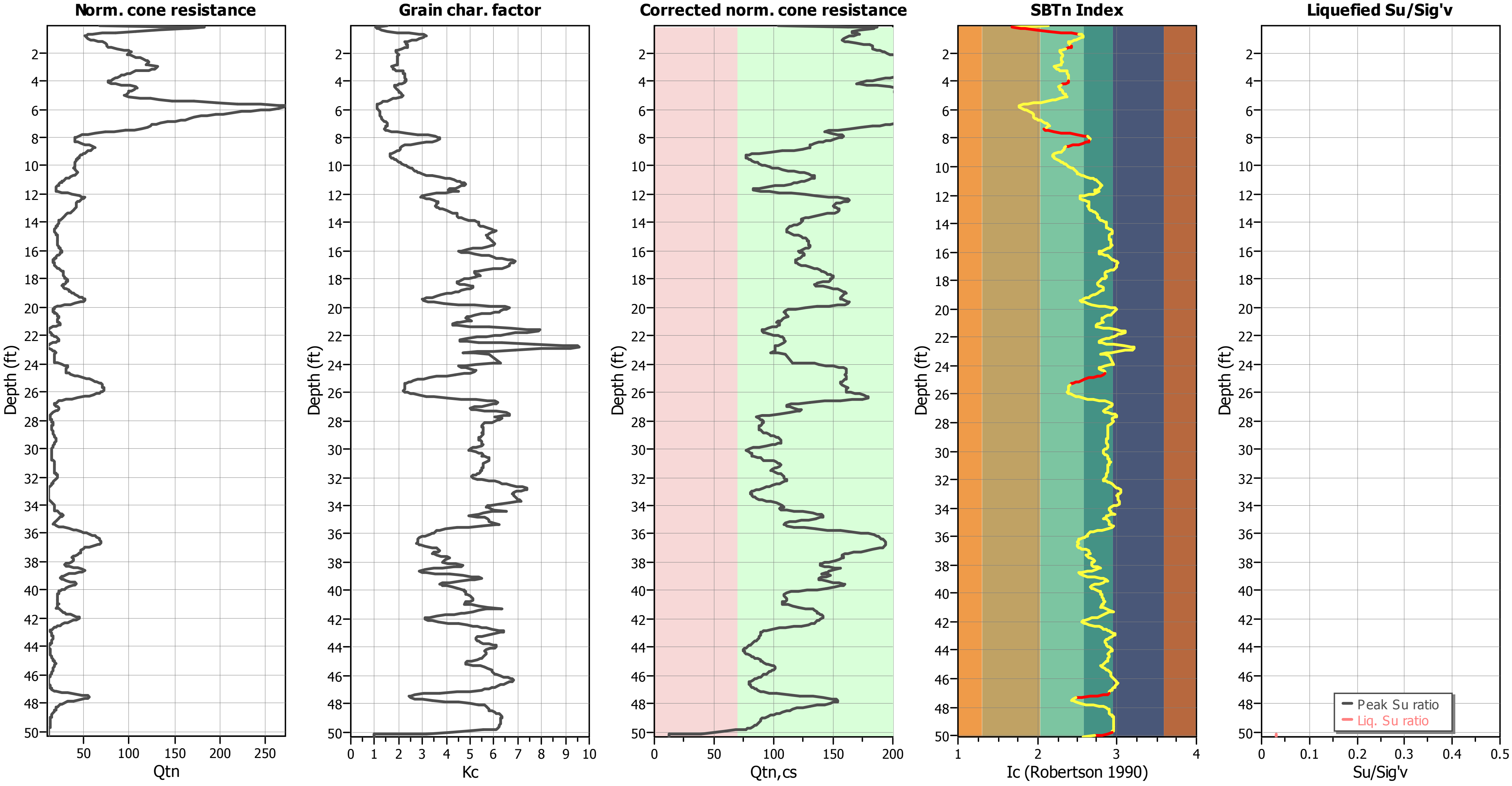
- ☐ Very high risk
- ☐ High risk
- ☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

Low Impact Development Plan (LID)

Project Name:

1610 Artesia

1610 W Artesia Boulevard

Gardena, CA 90248

Prepared for:

The Picerne Group

5000 Birch Street, Suite 600
Newport Beach, CA 92660
Attn: Satish Lion
949-910-3428

Submitted to:

The County of Los Angeles Public Works

900 S. Fremont Avenue
Alhambra, CA 91803
(626) 458-5100

Prepared by:

Tait & Associates, Inc.

Engineer: Ryan Haskin, PE   Registration No.: 84850
701 N. Parkcenter Drive
Santa Ana , CA. 92705
(714)560-8200

Date: 10/13/2023
Revised Date: Click here to enter a date.

OWNER'S CERTIFICATION

Owner Certification	
Owner's Name: Satish Lion	
Company	The Picerne Group
Address	5000 Birch Street, Suite 600, Newport Beach, CA 92660
Email	slion@picernegroup.com
Telephone	949-910-3428

This Low Impact Development (LID) Plan is intended to comply with the requirements of County of Los Angeles for CAS004001, ORDER NO R4-2012-0175 which includes the requirement for the preparation and implementation of a LID Plan.

The undersigned, while owning the property/project described in the preceding paragraph, shall be responsible for the implementation and funding of this LID Plan and will ensure that this LID Plan is amended as appropriate to reflect up-to-date conditions on the site. In addition, the property owner accepts responsibility for interim operation and maintenance of Stormwater BMPs until such time as this responsibility is formally transferred to a subsequent owner. This LID Plan will be reviewed with the facility operator, facility supervisors, employees, tenants, maintenance and service contractors, or any other party (or parties) having responsibility for implementing portions of this LID. At least one copy of this LID Plan will be maintained at the project site or project office in perpetuity. The undersigned is authorized to certify and to approve implementation of this LID Plan. The undersigned is aware that implementation of this LID Plan is enforceable under County of Los Angeles Water Quality Ordinance (Municipal Code Section CAS004001, ORDER NO R4-2012-0175).

"I, the undersigned, certify under penalty of law that the provisions of this LID have been reviewed and accepted and that the LID will be transferred to future successors in interest."

Owner's Signature		Date	Click here to enter a date.

PREPARER'S CERTIFICATION

Preparer (Engineer) Certification			
Preparer (Engineer): Ryan Haskin, PE			
Title	Project Manager	RCE #:84860	Click here to enter text.
Company	Tait & Associates		
Address	701 N. Parkcenter Drive, Santa Ana, CA 92705		
Email	rhaskin@tait.com		
Telephone	714-560-8200		

I hereby certify that this Low Impact Development (LID) Plan is in compliance with, and meets the requirements of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit for stormwater and non-stormwater discharges from the MS4 within the coastal watersheds of Los Angeles County (CAS004001, Order No R4-2012-0175).

I certify under penalty of law that this document and all attachments were prepared under my jurisdiction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, to the best of my knowledge and belief, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations

Preparer Signature	Ryan Haskin	Date	10/13/2023
Place Stamp Here	REGISTERED PROFESSIONAL ENGINEER RYAN HASKIN No.84850 Exp. 3/31/24 CIVIL STATE OF CALIFORNIA		

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APPENDICES

A. LID REQUIREMENTS

A.1 LID Background

In 1987, The Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA] was amended to provide that the discharge of pollutants to waters of the United States from stormwater is effectively prohibited, unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) Permit. The 1987 amendments to the CWA added Section 402 (p), which established a framework for regulating municipal, industrial and construction stormwater discharges under the NPDES program. In California, these permits are issued through the State Water Resources Control Board - (SWRCB) and the nine Regional Water Quality Control Boards.

On November 8, 2012, the Regional Water Quality Control Board, Los Angeles Region (RWQCB), adopted Order No.R4-2012-0175. This Order is the NPDES Permit (NPDES No. CAS004001) for municipal stormwater and urban runoff discharges within the County of Los Angeles.

As adopted in November 2012, the requirements of Order No. R4-2012-0175 (the "Permit') cover 84 cities and the unincorporated areas of Los Angeles County. Under the Permit, the Los Angeles County Flood Control District is designated as the Principal Permittee; the County of Los Angeles along with the 84 incorporated cities is designated as Permittees.

In compliance with the Permit, the Permittees have implemented a stormwater quality management program (SQMP) with the ultimate goal of accomplishing the requirements of the Permit and reducing the amount of pollutants in stormwater and urban runoff wherein new development/redevelopment projects are required to prepare a Low Impact Development (LID) report.

A.2 Designated Priority Project Categories

The project is classified as category item(s) 1, 11a, and 11b as listed in Table 1 below and is therefore classified as a Designated Project.

TABLE 1
PROJECT PRIORITY CATEGORIES

ITEM	APPLICABLE	DESCRIPTION
1	X	All development projects equal to 1 acre or greater of disturbed area that adds more than 10,000 square feet of impervious surface area.
2		Industrial parks 10,000 square feet or more of surface area.
3		Commercial malls 10,000 square feet or more of surface area.
4		Retail gasoline outlets with 5,000 square feet or more of surface area.
5		Restaurants (Standard Industrial Classification (SIC) of 5812) with 5,000 Square feet or more of surface area.
6		Parking lots with 5,000 square feet or more of impervious surface area, or with 25 or more parking spaces.
7		Streets and roads construction of 10,000 square feet or more of impervious surface area. Street and road construction applies to standalone streets, roads, highways, and freeway projects, and also applies to streets within larger projects.
8		Automotive service facilities (Standard Industrial Classification (SIC) of 5013, 5014, 5511, 5541, 7532-7534 and 7536-7539) 5,000 square feet or more of surface area.
9		Projects located in or directly adjacent to, or discharging directly to an Environmentally Sensitive Area (ESA), where the development will:
		a. Discharge stormwater runoff that is likely to impact a sensitive biological species or habitat; and
		b. Create 2,500 square feet or more of impervious surface area
10		Single-family hillside homes.
11		Redevelopment Projects:
	x	a. Land disturbing activity that results in the creation or addition or replacement of 5,000 square feet or more of impervious surface area on an already developed site on Planning Priority Project categories.
	x	b. Where Redevelopment results in an alteration to more than fifty percent of impervious surfaces of a previously existing development, and the existing development was not subject to post-construction stormwater quality control requirements, the entire project must be mitigated.
		c. Where Redevelopment results in an alteration of less than fifty percent of impervious surfaces of a previously existing development, and the existing development was not subject to post-construction stormwater quality control requirements, only the alteration must be mitigated, and not the entire development.

		d. Redevelopment does not include routine maintenance activities that are conducted to maintain original line and grade, hydraulic capacity, original purpose of facility or emergency redevelopment activity required to protect public health and safety. Impervious surface replacement, such as the reconstruction of parking lots and roadways which does not disturb additional area and maintains the original grade and alignment, is considered a routine maintenance activity. Redevelopment does not include the repaving of existing roads to maintain original line and grade.
		e. Existing single-family dwelling and accessory structures are exempt from the Redevelopment requirements unless such projects create, add or replace 1,000 square feet of impervious surface area.

B. PROJECT AND SITE INFORMATION

B.1 Project Site Summary

The project consists of the redevelopment of an existing 3.43-acre area of a commercial/business center currently composed of a car wash and auto center. The proposed project will consist of a 5-level apartment complex totaling approximately 360 units. The project also includes the construction of a basement level parking structure, leasing office, fitness club, and community pool. The existing site features a gradual slope from the northwest corner at Artesia Blvd down to the southeast corner of the property with a difference of roughly 8 feet. The existing drainage pattern consists of overland flow to gutters that flow to the southeastern portion of the property and discharge to a single drop inlet and private storm drain line that runs south approximately 80 feet to the concrete side wall of the Dominguez Channel. The proposed project will maintain the existing drainage pattern with overland flow to the southeast corner of the site. Stormwater will surface flow into a proprietary biofiltration treatment device. The treatment device will have a pipe connection to the existing storm drain that runs to the Domiguez Channel that will convey all project runoff.

Table B.1

PROJECT INFORMATION	
Type of Project:	Commercial (e.g., commercial, residential, etc.)
Planning Area:	County of Los Angeles
Community Name:	N/A
Development Name:	TPG Stein
PROJECT LOCATION	
Latitude & Longitude (DMS): 33.87220748287393°, -118.30573998047986°	
Project Watershed and Sub-Watershed: Dominguez Channel/Long Beach Inner Harbor – Wilmington Drain	
APN(s): 6106-013-049	
Map Book and Page No.: N/A	
PROJECT CHARACTERISTICS	
Proposed or Potential Land Use(s)	Commercial Development
Area of Impervious Project Footprint (SF)	127,044
Total Area of <u>proposed</u> Impervious Surfaces within the Project Limits (SF)/or Replacement	x
Does the project consist of offsite road improvements?	☒ Y ☐ N
Does the project propose to construct unpaved roads?	☐ Y ☒ N
Is the project part of a larger common plan of development (phased project)?	☐ Y ☒ N
EXISTING SITE CHARACTERISTICS	
Total area of <u>existing</u> Impervious Surfaces within the project limits (SF)	138,658
Are there any natural hydrologic features on the project site?	☐ Y ☒ N

Total Project area = 149,602 sf
Total Disturbed area = 149,602 sf
Total Existing Impervious area = 138,658 sf
Total Proposed Impervious area = 127,044 sf

B.2 Receiving Waters

Table B.2 below lists the stormwater runoff discharge points from the project site, classified as either a storm drain system or receiving waters. The table lists the receiving waters in order of travel, starting with the most upstream discharge point.

Table B.2

STORM DRAIN SYSTEM OR RECEIVING WATER	EPA APPROVED 303(D) LIST IMPAIRMENTS	DESIGNATED BENEFICIAL USES
Dominguez Channel (lined portion above Vermont Ave)	Copper (72474) , Lead (98867) , Toxicity (76424) , Zinc (68450) , Indicator Bacteria (68243)	n/a
Dominguez Channel Estuary (unlined portion below Vermont Ave)	Benzo(a)anthracene (69189) , Benzo(a)pyrene (68354) , Chlordane (tissue) (98920) , Chrysene (C1-C4) (69124) , DDT (tissue & sediment) (99361) , Lead (70528) , PCBs (Polychlorinated biphenyls) (68139) , Phenanthrene (69111) , Pyrene (68839) , Toxicity (76061) , Benthic Community Effects (72640) , Copper (98921) , Dieldrin (tissue) (69913) , Indicator Bacteria (70163)	Commercial and Sport Fishing, Estuarine Habitat, Marine Habitat, Migration of Aquatic Organisms, Navigation, Rare, Threatened, or Endangered Species, Spawning, Reproduction, and/or Early Development, Wildlife Habitat
Los Angeles Harbor - Consolidated Slip	Cadmium (sediment) (69589) , Chlordane (tissue & sediment) (69038) , Chromium (68144) , Copper (sediment) (68746) , DDT (tissue & sediment) (73200) , Dieldrin (68898) , Lead (sediment) (99089) , Mercury (sediment) (68647) , PCBs (Polychlorinated biphenyls) (tissue & sediment) (78282) , Toxaphene (tissue) (68148) , Zinc (sediment) (68286) , 2-Methylnaphthalene (69972) , Benthic Community Effects (70615) , Benzo(a)pyrene (77763) , Chrysene (C1-C4) (72296) , Phenanthrene (68795) , Pyrene (70764) , Toxicity (77601) , Benzo(a)anthracene (69973)	Commercial and Sport Fishing, Estuarine Habitat, Marine Habitat, Migration of Aquatic Organisms, Navigation, Rare, Threatened, or Endangered Species, Spawning, Reproduction, and/or Early Development, Wildlife Habitat
Los Angeles/Long Beach Inner Harbor	Copper (69723) , DDT (Dichlorodiphenyltrichloroethane) (68696) , PCBs (Polychlorinated biphenyls) (69055) , Toxicity (70284) , Zinc (99194) , Benthic Community Effects (68874) , Benzo(a)pyrene (76674) , Chrysene (C1-C4) (76126)	Commercial and Sport Fishing, Estuarine Habitat, Marine Habitat, Migration of Aquatic Organisms, Navigation, Rare, Threatened, or Endangered Species, Spawning, Reproduction, and/or Early Development, Wildlife Habitat
Los Angeles/Long Beach Outer Harbor (inside breakwater)	DDT (Dichlorodiphenyltrichloroethane) (69745) , PCBs (Polychlorinated biphenyls) (69174) , Toxicity (100045)	Commercial and Sport Fishing, Estuarine Habitat, Marine Habitat, Migration of Aquatic Organisms, Navigation, Rare, Threatened, or Endangered Species, Spawning, Reproduction, and/or Early Development, Wildlife Habitat

B.3 Geotechnical Conditions

a. Topography

Existing Drainage Condition:

The site features a gradual slope from the northwest corner at Artesia Blvd down to the southeast corner of the property with a difference of roughly 8 feet. The existing drainage pattern consists of overland flow to gutters that flow to the southeastern portion of the property and discharge to a single drop inlet. The drop inlet connects to a private storm drain approximately 80 feet south and exits the property through a headwall to the LACFCD Dominguez Channel. The Dominguez Channel flows east and then south to the Los Angeles/Long Beach Harbor.

Proposed Drainage Condition:

The proposed project will maintain the existing drainage pattern with site runoff discharging to the existing site outlet which connects to the Dominguez channel.

b. Soil Type:

In accordance with Los Angeles County Public Works Soil Classification Maps, the project site is designated as soil classification 13. The referenced map is provided in Appendix 1.

c. Groundwater:

Per the Los Angeles County Department of Public Works establish Groundwater Level Data web application, groundwater per nearest groundwater well is at a depth of 16 feet below ground surface. Groundwater was encountered per boring at a depth of 21.5 feet below ground surface per Geotechnical Investigation prepared by Kling Consulting Ground, Inc.

d. Other Geotechnical Issues:

Table B.3.d

OTHER GEOTECHNICAL ISSUES	
Collapsible Soil	☐ Y ☒ N
Expansive Soil	☒ Y ☐ N
Liquefaction	☒ Y ☐ N

B.4 Other Site Considerations

a. Off-site Drainage:

The project site does not anticipate any off-site run-on.

Click here to enter text.

b. Significant Ecological Areas (SEAs)

The project's Significant Ecological Areas (SEAs) are listed in Table B.4.b below and require a separate regulatory permit.

Table B.4.b

Agency	Permit Required	
State Department of Fish and Game, 1602 Streambed Alteration Agreement	☐ Y	☒ N
State Water Resources Control Board, Clean Water Act (CWA) Section 401 Water Quality Cert.	☐ Y	☒ N
US Army Corps of Engineers, CWA Section 404 Permit	☐ Y	☒ N
US Fish and Wildlife, Endangered Species Act Section 7 Biological Opinion	☐ Y	☒ N

C. On-site utilities.

All existing on-site utilities will be demolished and removed for the proposed development, except for the existing storm drain leaving the site at the southeast portion of the property. This storm drain will be re-used as the site runoff discharge location.

D. BEST MANAGEMENT PRACTICES

D.1 Site Design Principles

a. Natural Areas:

Table c.1.a

Natural Area Design Criteria	Implemented		
Preserve historically undisturbed areas.	☐ Y	☐ N	☒ N/A
Maintain surface flow patterns of undeveloped sites, including water body alignments, sizes and shapes	☐ Y	☐ N	☒ N/A
Reserve areas with high permeability soils for either open space or retention-based stormwater quality control measures.	☐ Y	☐ N	☒ N/A
Incorporate existing trees into site layout	☐ Y	☐ N	☒ N/A
Identify areas that may be restored or revegetated either during or post-construction	☐ Y	☐ N	☒ N/A
Identify and avoid areas susceptible to erosion and sediment loss.	☐ Y	☐ N	☒ N/A
Concentrate or cluster development on less sensitive areas of the project site, while leaving the remaining land in a natural, undisturbed state. Less sensitive areas may include, but are not limited to, areas that are not adjacent to receiving waters or areas where erosion may be an issue.	☐ Y	☐ N	☒ N/A
Protect slopes from erosion by safely conveying stormwater runoff from the tops of slopes.	☐ Y	☐ N	☒ N/A
Limit clearing and grading of native vegetation at the project site to minimum amount needed to build lots, allow access, and provide fire protection.	☐ Y	☐ N	☒ N/A
Maintain existing topography and existing drainage divides to encourage dispersed flow.	☒ Y	☐ N	☐ N/A
Maximize trees and other vegetation at the project site by planting additional vegetation, clustering tree areas, and promoting use of native and/or drought tolerant plants.	☒ Y	☐ N	☐ N/A
Promote natural vegetation by using parking lot islands and other landscaped areas. Integrate vegetation-based stormwater quality control measures within parking lot islands and landscaped areas.	☒ Y	☐ N	☐ N/A

b. Minimize Land Disturbance:

To maintain the native soil compaction and infiltration rates, the following measures shall be applied where practical on the construction site. These measures are not to supersede compaction requirements associated with the applicable building codes.

- Delineate and mark the development envelope for the project site on the site plan and physically demarcate the development envelope at the project site using temporary orange construction fencing or flagging. The development envelope is established by identifying the minimum area needed to build lots, allow access, provide fire protection, and protect and buffer sensitive features such as streams, floodplains, steep slopes, and wetlands. Concentrate building and paved areas on the least permeable soils, with the least intact habitat.

- Restrict equipment access and construction equipment storage to the development envelope.
- Consider soil amendments to restore permeability and organic content.

c. Minimize Impervious Area:

The project will comply with all applicable building and fire codes and ordinances. Additional consideration was given to minimize the project site impervious area by implementing the following site designs where applicable and site feasible:

- Use minimum allowable roadway and sidewalk cross sections, driveway lengths, and parking stall sizes.
- Use two-track/ribbon alleyways/driveways or shared driveways.
- Include landscape islands in cul-de-sacs streets (where approved). Consider alternatives to cul-de-sacs to increase connectivity.
- Reduce building and parking lot footprints. Building footprints may be reduced by building taller.
- Use pervious pavement material, such as modular paving blocks, turf blocks, porous concrete and asphalt, brick, and gravel or cobble, to accommodate overflow parking, if feasible.
- Cluster buildings and paved areas to maximize pervious area.
- Maximize tree preservation or tree planting.
- Avoid compacting or paving over soils with high infiltration rates (see Minimize Land Disturbance section).
- Use vegetated swales to convey stormwater runoff instead of paved gutters.
- Build compactly at redevelopment sites to avoid disturbing natural and agricultural lands and to reduce per capita impacts.

d. Protect and Restore Natural Areas:

If feasible, and consistent with applicable General Plan or Local Area Plan policies, for the project site, the following design features or elements must be included:

- Preserve historically undisturbed areas. Identify and cordon off streams and their buffers, floodplains, wetlands, and steep slopes.
- Maintain surface flow patterns of undeveloped sites, including water body alignments, sizes, and shapes.
- Reserve areas with high permeability soils for either open space or retention-based stormwater quality control measures.
- Incorporate existing tree into site layout.
- Identify areas that may be restored or revegetated either during or post-construction.
- Identify and avoid areas susceptible to erosion and sediment loss.
- Concentrate or cluster development on less sensitive areas of the project site, while leaving the remaining land in a natural state, undisturbed state. Less sensitive areas may include, but are not limited to, areas that are not adjacent to receiving waters or areas where erosion may be an issue.

- Protect slopes from erosion by safely conveying stormwater runoff from the tops of slopes.
    - Vegetate slopes with native or drought-tolerant species.
    - Ensure slope protection practices conform to the applicable local erosion and sediment control standards and design standards. The design criteria described in this section are intended to enhance and be consistent with these local standards.
- Limit clearing and grading of native vegetation at the project site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maintain existing topography and existing drainage divides to encourage dispersed flow.
- Maximize trees and other vegetation at the project site by planting additional vegetation, clustering tree areas, and promoting use of native and/or drought-tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas. Integrate vegetation-based stormwater quality control measures within parking lot islands and landscaped areas.

D.2 Source Control Measures

Per the Los Angeles County Public Works Low Impact Development Manual, the following source control measures shall be implemented in the project design and as listed per LID Manual Table 5-1, also referenced in Appendix 9.

Fact sheets for each of the source control measures listed in Table C.2 below can be found in Appendix 9. The source controls shall be designed and implemented in accordance with these fact sheets.

Table C.2

Source Control Measures	Implemented		
Storm drain message and signage (S-1)	☐ Y	☐ N	☒ N/A
Outdoor Material Storage Areas (S-2)	☐ Y	☐ N	☒ N/A
Outdoor Trash Storage/Waste Handling Areas (S-3)	☒ Y	☐ N	☐ N/A
Outdoor Loading/Unloading Dock Areas (S-4)	☒ Y	☐ N	☐ N/A
Outdoor Vehicle/Equipment Repair/Maintenance Areas (S-5)	☐ Y	☐ N	☒ N/A
Outdoor Vehicle/Equipment/Accessory Wash Areas (S-6)	☐ Y	☐ N	☒ N/A
Fuel & Maintenance Areas (S-7)	☐ Y	☐ N	☒ N/A
Landscape Irrigation Practices (S-8)	☒ Y	☐ N	☐ N/A
Building Materials (S-9)	☒ Y	☐ N	☐ N/A
Animal Care and Handling Facilities (S-10)	☐ Y	☐ N	☒ N/A
Outdoor Horticulture Areas (S-11)	☐ Y	☐ N	☒ N/A

E. STORMWATER QUALITY DESIGN VOLUME CALCULATION

The design storm, from which the Stormwater Quality Design Volume (SWQDv) is calculated, is defined as the **greater of**:

The 0.75-inch, 24 hour storm rain event, or
The 85th percentile, 24 hour rain event as determined from Los Angeles County 85th percentile precipitation isoheytal map, as provided in Appendix 5.

D.1 Project Rainfall Depth:

85th Percentile, 24 Hour Rain Event = 0.9 Inches

D.2 Project Calculated SWQDv:

Per County of Los Angeles HydroCalc Program, the input and output values as calculated for the site SWQDv is provided in Appendix 5.

Below is a provided summary of the SWQDv calculated.

Table D.2

DMA NAME OR ID	AREA (SQFT)	SOIL TYPE	FLOW PATH	PERCENT IMPERVIOUS	SWQDv	t_c
A	149,682	13	700	85	8694	34
				TOTAL SWQDv=	8694	

F. STORMWATER QUALITY CONTROL MEASURES –LID BMPs

Stormwater Quality Control Measures must be designed and implemented to detain the calculated SWQDv in the following order:

1) **Infiltration (On-site Retention**)
2) **Runoff Harvest and Use**
3) **On-site biofiltration**, off-site groundwater replenishment, off-site infiltration and/or bioretention, and off-site retrofit.

Additionally, pretreatment must be provided for stormwater quality control measures whose function may be adversely affected by sediment or other pollutants.

E.1 Infiltration (On-Site Retention):

Table E.1

Infiltration Infeasibility		
The corrected in-situ infiltration rate is less than 0.3 inches per hour, as determined according to the most recent GMED Policy GS 200.1, and it is not technically feasible to amend the in-situ soils to attain an infiltration rate necessary to achieve reliable infiltration. *SEE NOTE BELOW	☒ Y	☐ N
Locations where the seasonal high groundwater level is within 10 feet of the surface, as determined according to the most recent GMED Policy GS 200.1;	☐ Y	☒ N
Locations within 100 feet of a groundwater well used for drinking water;	☐ Y	☒ N
Brownfield development sites where infiltration poses a risk of pollutant mobilization;	☐ Y	☒ N
Other locations where pollutant mobilization is a documented concern (e.g., at or near properties that are contaminated or store hazardous substances underground);	☐ Y	☒ N
Locations with potential geotechnical hazards; *SEE NOTE BELOW	☒ Y	☐ N
Smart growth and infill or redevelopment locations where the density and/or nature of the project would create significant difficulty for compliance with the onsite retention requirement;	☐ Y	☒ N
Locations where infiltration may adversely impact biological resources; or	☐ Y	☒ N
Locations where infiltration may cause health and safety concerns.	☐ Y	☒ N
Other:___________	☐ Y	☐ N

If yes has been checked for any of the above questions, then infiltration BMPs will not be used for the site and Harvest and Use will be assessed next for site feasibility. Additional Infiltration Infeasibility narrative is provided below.

If no has been checked for all above questions, then site infiltration is feasible and Table E.2 below lists the implemented Infiltration based BMPs.

Additional Infiltration Infeasibility Narrative:

*NOTE: Statement from the Geotechnial Engineer reads as follows:
Our findings from subsurface exploration, laboratory testing, and geotechnical analyses were presented in our Preliminary Geotechnical report dated October 31, 2022. The findings concluded that the underlying soils at this site are susceptible to liquefaction. It is our understanding that due to site constraints, the southeast corner of the site is the low point and therefore the one logical location to place the surface stormwater BMPs. Given the proximity and vertical orientation of this location to the basement walls, and in light of potential liquefaction, it is our opinion that an infiltration based BMP at this location and at ground level should not be allowed or considered. In our professional opinion, these site conditions are not compatible with infiltrating water into the subsurface soils and performing percolation testing to confirm this opinion is considered unnecessary.

Implemented Infiltration BMPs

Table E.1

Infiltration based BMPs	Implemented	
Bioretention (RET-1)	☐ Y	☒ N
Infiltration Basin (RET-2)	☐ Y	☒ N
Infiltration Trench (RET-3)	☐ Y	☒ N
Dry Well (RET-4)	☐ Y	☒ N
Permeable Pavement without an Underdrain (RET-5)	☐ Y	☒ N
Other:_________________	☐ Y	☒ N

Infiltration BMP Narrative:

Infiltration is assumed to be infeasible for this project site.

E.2 Runoff Harvest and Reuse Assessment:

Does the site capture 100% of the SWQDv through Infiltration based BMPs as listed above? ☐ **Y** ☒ **N**

If yes has been checked, Harvest and Reuse BMP assessment is not required.

If no has been checked, Harvest and Reuse assessment is required. See feasibility analysis provided in Appendix 4. The following Harvest and Use BMPs have been implemented on-site.

A. Harvest and Reuse- Indoor Use

Per the 2014 California Department of Public Health Regulations Related to Recycled Water- Article 5. Dual Plumbed Recycled Water Systems 60313 (a), no person other than a recycled water agency shall deliver recycled water to a dual plumbed facility. In conclusion, the reuse of water for internal plumbing use is considered infeasible per the CDPH Regulations.

B. Harvest and Reuse- Outdoor Use (Irrigation)

Table E.2B

Capture and Use Infeasibility		
Projects that would not provide sufficient irrigation or (where permitted) domestic grey water demand for use of stored stormwater runoff due to limited landscaping or extensive use of low water use plant palettes in landscaped areas; In order to implement successful stormwater capture and reuse, the project should have sufficient amount of landscape planting in order to support the reuse of stormwater runoff. The proposed site includes minor landscaping along the perimeter of the project and will utilize drought tolerant planting. The available area is too small for capture and use implementation, leaving no space for above or underground storage tanks.	☒ Y	☐ N
Projects that are required to use recycled water for landscape irrigation;	☐ Y	☒ N
Projects in which the harvest and use of stormwater runoff would conflict with local, state, or federal ordinances or building codes;	☐ Y	☒ N
Locations where storage facilities may cause potential geotechnical hazards as outlined in the geotechnical report; or	☐ Y	☒ N
Locations where storage facilities may cause health and safety concerns.	☐ Y	☒ N

If yes has been checked for any of the above questions, then Harvest and Use BMPs will not be used for the site and Alternative Compliance is required.

If no has been checked for all above questions, then site Capture and Use is feasible and Table E 2.B below lists the implemented Capture and Use BMPs.

Implemented Capture and Use BMPs

Table E. 2.B

Harvest & Use BMPs	Implemented	
Rain Barrel/Cistern (RET-6)	☐ Y	☒ N

Green Roof (RET-7)	☐ Y	☒ N
Other: ______________________	☐ Y	☐ N

Additional Capture and Use Narrative:

Capture and Use BMPs are considered infeasible.

E.3 Alternative Compliance:

Does the site capture 100% of the SWQDv through Infiltration and/or Runoff Harvest and Use based BMPs as listed above? ☐ **Y** ☒ **N**

If yes has been checked, Alternative Compliance is not required.

If no has been checked, Alternative Compliance is required.

A. Implemented Alternative Compliance Measures:

Table E.3.A

Alternative Compliance Measures	Implemented	
On-site biofiltration of 1.5 times the volume of the SWQDv that is not reliably retained on-site; Biofiltration system treating 8694 x 1.5 = 13041 CF	☒ Y	☐ N
On-site treatment and off-site infiltration/bioretention for the volume of the SWQDv that is not reliably retained on-site	☐ Y	☒ N
Replenishment of groundwater supplies that have a designated beneficial use in the Water Quality Control Plan: Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan), which was most recently adopted in June 1994 by the Regional Water Board and subsequently amended; or	☐ Y	☒ N
On-site treatment and off-site infiltration/bioretention or stormwater runoff harvest and use of the volume of SWQDv that is not reliably retained on-site through retrofit an existing development with similar land uses as the project.	☐ Y	☒ N
Other:	☐ Y	☒ N

Acceptable Alternative Compliance BMPs are listed and implemented on-site as listed below in Table E.3.B.

On-site Biofiltration and Vegetation based Stormwater Quality Control Measures	Implemented	
Biofiltration (BIO-1)	☒ Y	☐ N
Stormwater Planter (VEG-1)	☐ Y	☒ N
Tree-well Filter (VEG-2)	☐ Y	☒ N
Vegetated Filter Strips (VEG-3)	☐ Y	☒ N
Vegetated Swales (VEG-4)	☐ Y	☒ N

Other:	☐ Y	☒ N

Table E.3.B

Additional Alternative Compliance Narrative:
A Biofiltration device such as Modular Wetlands or Filterra is proposed to treat project stormwater.

E.4 Pretreatment BMPs:

Is pretreatment required for the project site? ☐ **Y** ☒ **N**

If yes has been checked, the following Pretreatment BMPs will be implemented on-site.

Table E.4

Treatment-based Stormwater Quality Control Measures		
Sand Filters (T-1)	☐ Y	☒ N
Constructed Wetlands (T-2)	☐ Y	☒ N
Extended Detention Basins (T-3)	☐ Y	☒ N
Wet Pond (T-4)	☐ Y	☒ N
Permeable Pavement with an Underdrain (T-5)	☐ Y	☒ N
Proprietary Devices (T-6)	☐ Y	☒ N
Other:_______________________	☐ Y	☒ N

G. HYDROMODIFICATION

Projects may be exempt from implementation of hydromodication control measures where assessment of downstream channel conditions and proposed discharge hydrology indicate the adverse hydromodiciation effects to beneficial uses of natural drainage systems are unlikely.

Table F.1

Exemptions		
The replacement, maintenance, or repair of an existing permitted publicly-maintained flood control facility, storm drain, or transportation network	☐ Y	☒ N
Redevelopment of a previously developed site in an urbanized area that does not increase the effective impervious area or decrease the infiltration capacity of pervious areas compared to the pre-project conditions _______93__% Pre Development Imperviousness _______85__% Post Development Imperviousness	☒ Y	☐ N
Projects that have any increased discharge directly or through a storm drain to a sump, lake, area under tidal influence, into a waterway that has an estimated hundred year peak flow of 25,000 cfs or more, or other receiving water that is not susceptible to hydromodification impacts	☐ Y	☒ N
Projects that discharge directly or through a storm drain into concrete or otherwise engineered channel (channelized or armored with rip-rap, shotcrete), which in turn, discharge into receiving water that is not susceptible to hydromodification impacts. ____________ Receiving water ____________ Receiving water ____________ Receiving water (Reference Appendix 10 for map showing receiving waters)	☐ Y	☒ N
Non-designated project disturbing less than 1 acre or creating less than 10,000 square feet of new impervious area; or	☐ Y	☒ N
Single-family homes that incorporate LID BMPs in accordance with the LID Standards Manual	☐ Y	☒ N

If yes has been checked, Hydromodification control measures are not required. Refer to additional Hydromodification exemption narrative given below.

If no has been checked, Hydromodification control measures are required and must meet the design criteria set forth by the Los Angeles County LID Manual and as given below.

Additional Hydromodification Exemption Narrative:

H. STORMWATER BMP MAINTENANCE

Maintenance Plan Requirements

A Maintenance Plan is provided in Appendix X for each individual stormwater BMP.
The Maintenance plan includes the following items:

Table G.1

Maintenance Plan		
Operation plan and schedule, including a site map	☒ Y	☐ N
Maintenance and cleaning activities and schedule	☒ Y	☐ N
Equipment and resource requirements necessary to operate and maintain stormwater quality control measure	☒ Y	☐ N
Responsible party for operation and maintenance.	☒ Y	☐ N

Table G.2

Site Map		
Provide a site map showing boundaries of the site, acreage, and drainage patterns/contour lines. Show each discharge location from the project site and any drainage flowing onto the site. Distinguish between pervious and impervious surfaces on the map.	☒ Y	☐ N
Identify locations of existing and proposed storm drain facilities, private sanitary sewer systems, and grade breaks for purposes of pollution preventions.	☒ Y	☐ N
With a legend, identify locations of expected sources of pollution generation (e.g. outdoor work and storage areas, heavy traffic areas, delivery areas, trash enclosures, fueling areas, industrial clarifies, and wash-racks). Identify any areas having contaminated soil or where pollutants are stored or have been stored/disposed of in the past.	☒ Y	☐ N
With a legend, indicate types and locations of stormwater quality control measures that will be built to permanently control stormwater pollution, including Global Positioning System X and Y coordinates. Distinguish between pollution prevention, treatment, sewer diversion, and contaminated devices.	☒ Y	☐ N

Table G.3

Baseline Descriptions		
List property owners and persons responsible for operation and maintenance of the on-site stormwater quality control measures. Include phone numbers and addresses.	☒ Y	☐ N
Identify the intended method of funding (i.e., homeowners association fees) for operation, inspection, routine maintenance, and upkeep of stormwater quality control measures.	☒ Y	☐ N
List all permanent stormwater quality control measures. Provide a brief description of each stormwater quality control measure and, if appropriate, fact sheets or additional	☒ Y	☐ N

information.		
A written description and checklist of all maintenance and waste disposal activities that will be performed. Distinguish between the maintenance appropriate for a 2-year establishment period and expected long-term maintenance. For example, maintenance requirements for vegetation in a constructed wetland may be more intensive during the first few years until the vegetation is established. The post-establishment maintenance plan must address maintenance needs (e.g., pruning, irrigation, weeding) for a larger, more stable system. Include maintenance performance procedures for facility components that require relatively unique maintenance knowledge, such as specific plant removal/replacement, landscape features, or constructed wetland maintenance. These procedures must provide sufficient detail to a person unfamiliar with maintenance to perform the activity or identify the specific skills or knowledge to perform and document the maintenance.	☒ Y	☐ N
A description of site inspection procedures and documentation system, including recordkeeping and retention requirements.	☒ Y	☐ N
An inspection and maintenance schedule, preferably in the form of a table or matrix, for each activity for all facility components. The schedule must show how it will satisfy the specified level of performance and how maintenance/inspection activities relate to storm events and seasonal issues.	☒ Y	☐ N
Identification of equipment and materials required to perform maintenance.	☒ Y	☐ N
As appropriate, list all housekeeping procedures for prohibiting illicit discharges or potential illicit discharges to the storm drain system. Identify housekeeping BMPs that reduce maintenance of stormwater quality control measures.	☒ Y	☐ N

Table G.4

Spill Plan		
Provide emergency notification procedures (phone and agency/persons to contact).	☐ Y	☒ N
As appropriate for site, provide emergency containment and cleaning procedures.	☐ Y	☒ N
Note downstream receiving waters, wetlands, or SEAs that may be affected by spills or chronic untreated discharges.	☐ Y	☒ N
As appropriate, create an emergency sampling procedure for spills. Emergency sampling can protect the property owner from erroneous liability for downstream receiving area cleanups.	☐ Y	☒ N

Identify appropriate persons to be properly trained and assure documentation of training. Training should include:

Table G.5

Training		
Good housekeeping procedures defined in the Maintenance Plan;	☒ Y	☐ N
Proper maintenance of all pollution mitigation devices	☒ Y	☐ N

Identification and cleanup procedures for spills and overflows	☒ Y	☐ N
Large-scale spill or hazardous material response; and	☐ Y	☒ N
Safety concerns when maintain devices and cleaning spills.	☐ Y	☒ N

Table G.6

Basic Inspection and Maintenance Activities		
Create and maintain on-site, a log for inspector names, dates, and stormwater quality control measure to be inspected and maintained. Provide a checklist for each inspection and maintenance category.	☒ Y	☐ N
Perform and document annual testing of any mechanical or electrical devices prior to wet weather.	☒ Y	☐ N
Report any significant changes in stormwater quality control measures to the site management. As appropriate, assure mechanical devices are working properly and/or landscaped plants are irrigated and nurtured to promote thick growth.	☒ Y	☐ N
Note any significant maintenance requirements due to spills or unexpected discharges.	☒ Y	☐ N
As appropriate, perform maintenance and replacement as scheduled or as needed in a timely manner to assure stormwater quality control measures are performing as designed and approved.	☒ Y	☐ N
Assure unauthorized low-flow discharges from the property do not bypass stormwater quality control measures.	☒ Y	☐ N
Perform an annual assessment of each pollution-generating operation and its associated stormwater quality control measures to determine if any part of the pollution reduction train can be improved. Annual assessment reports must be submitted to LACDPW.	☒ Y	☐ N

Operational or facility conditions or changes that significantly affect the character or quantity of pollutants discharging into the stormwater quality control measures may require modifications to the Maintenance Plan and/or additional stormwater quality control measures.

If future correction or modification of past stormwater quality control measures or procedures is required, the owner must obtain approval from LACDPW prior to commencing any work. Corrective measures or modifications must not cause discharges to bypass or otherwise impede existing stormwater quality control measures.

Maintenance Agreement:

Verification of maintenance provisions is required for all stormwater quality control measures. If required, verification, at a minimum, must include:

Table G.7

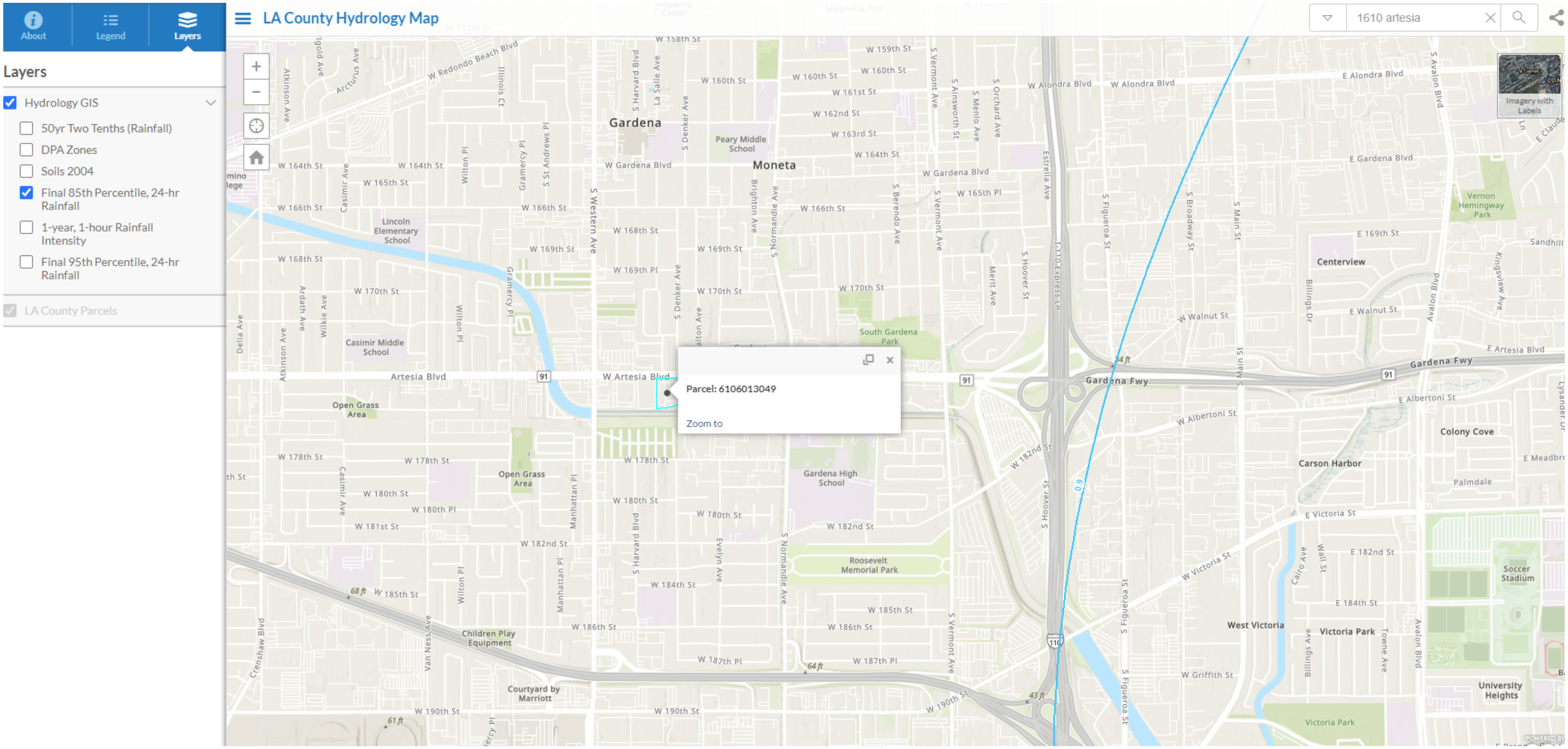
Verification of Maintenance Provisions		
The owner/developer's signed statement accepting responsibility for inspection and maintenance until the responsibility is legally transferred. An example Owners Certification Statement is provided in Appendix G; and either	☒ Y	☐ N
A signed statement from the public entity assuming responsibility for	☒ Y	☐ N

stormwater quality control measure inspection and maintenance and certifying that it meets all design standards; or		
Written conditions in the sales or lease agreement that require the recipient to assume responsibility for inspection and maintenance activities and to conduct a maintenance inspection at least once a year; or	☒ Y	☐ N
Written text in project conditions, covenants, and restrictions for residential properties that assign maintenance responsibilities to a Home Owners Association for inspection and maintenance of stormwater quality control measures; or	☒ Y	☐ N
A legally enforceable maintenance agreement that assigns responsibility for inspection and maintenance of stormwater quality control measures to the owner/operator. A Maintenance Agreement with LACDPW must be executed by the owner/operator before occupancy of the project is approved.	☒ Y	☐ N

APPENDICES

APPENDIX 1

MAPS AND SITE PLANS



LA County Hydrology Map

1610 artesia

Layers

☑ Hydrology GIS

☐ 50yr Two Tenths (Rainfall)

☐ DPA Zones

☐ Soils 2004

☑ Final 85th Percentile, 24-hr Rainfall

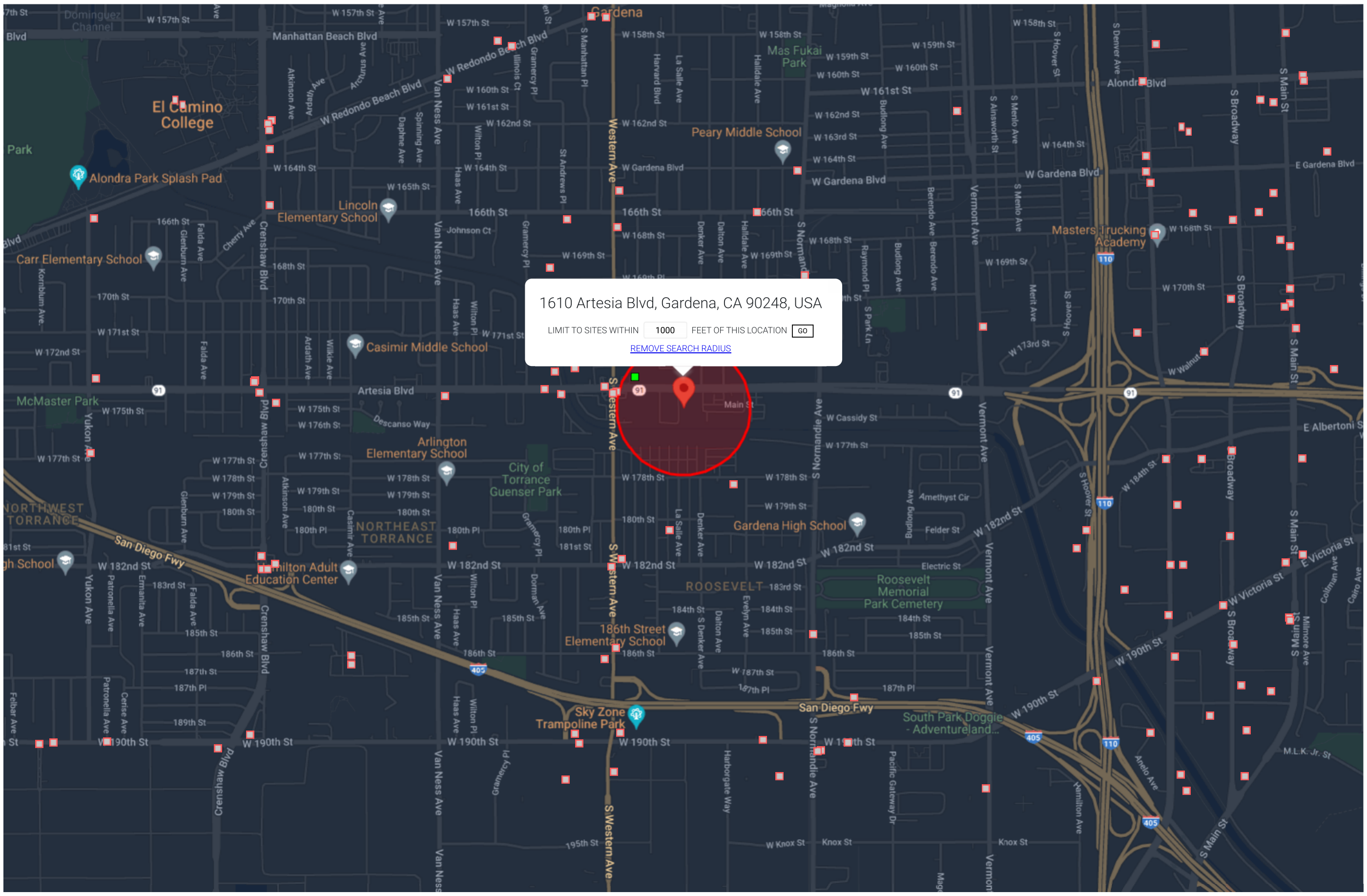
☐ 1-year, 1-hour Rainfall Intensity

☐ Final 95th Percentile, 24-hr Rainfall

☑ LA County Parcels

Parcel: 6106013049

Zoom to



1610 Artesia Blvd, Gardena, CA 90248, USA

LIMIT TO SITES WITHIN 1000 FEET OF THIS LOCATION GO

REMOVE SEARCH RADIUS

LEGEND - CHOOSE MORE SITES ✕

🟥 LUST Cleanup Sites - REMOVE

🟩 Cleanup Program Sites - REMOVE

🟨 Military Cleanup Sites - REMOVE

🟨 Military Privatized Sites - REMOVE

🟨 Military UST Sites - REMOVE

☒ *Signifies a Closed Site*

ACTIVE MAP COVERAGES:

• Military Bases - REMOVE

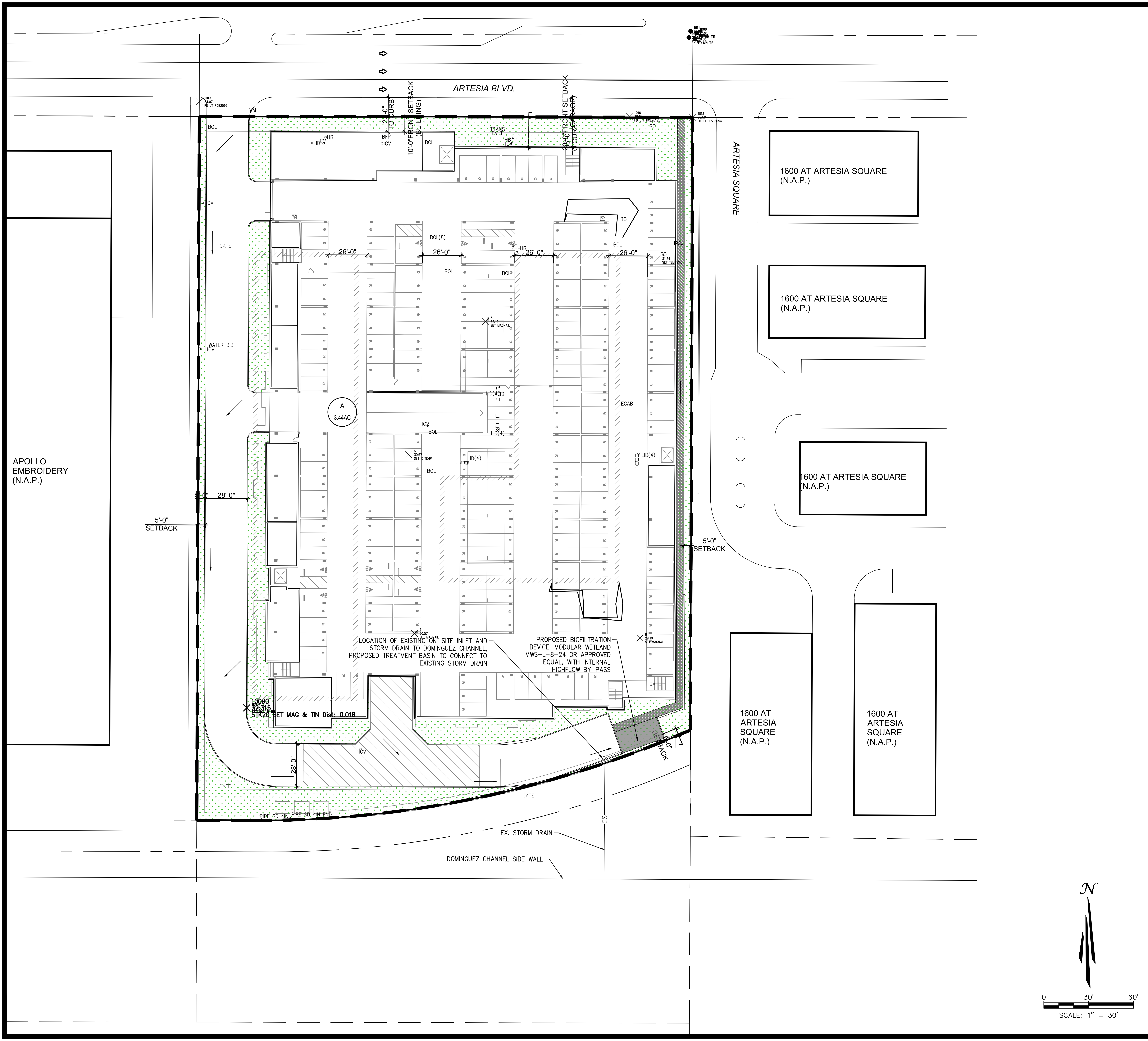
LIST SITES VISIBLE ON MAP

Map data ©2023 Google 200 m

Sites Shown on Map: 5 Total Sites 3 Open Sites 2 Closed Sites 1 Sites w/Water Quality Data

APPENDIX 2

CONSTRUCTION PLANS



LID

85TH PERCENTILE RAINFALL DEPTH = 0.9"
85TH PERCENTILE SWQDV = 8,694 CF
85TH PERCENTILE PEAK FLOW RATE = 0.585 CFS
LID BMP = MODULAR WETLAND SYSTEM MWS-L-8-24
OR APPROVED EQUAL
LID PROVIDED TREATMENT CAPACITY = 0.693 CFS

AREA

PERVIOUS AREA:	22,638 SF/0.52 AC
IMPERVIOUS AREA:	127,044 SF/2.91 AC
TOTAL AREA:	149,602 SF/3.43 AC

LEGEND

— — —180— — —	EXISTING CONTOUR
——— · · · ←——	FLOW LINE
←——	SLOPE
▬ ▬ ▬	AREA BOUNDARY
— — — —	SUB-AREA BOUNDARY
X-# #.##AC	AREA ID AREA (AC)
🟩	PERVIOUS AREA

LOW IMPACT DEVELOPMENT PLAN

1610 ARTESIA
1610 W ARTESIA BOULEVARD
GARDENA, CA 90248
THE PICERNE GROUP

TAIT
& ASSOCIATES
Since 1964
701 North Parkcenter Drive
Santa Ana, CA 92705
p: 714.560.8200
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ENGINEERING ENVIRONMENTAL BUILDING LAND
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DRAWN: CAD1
DATE: 04/01/2020
CHECKED: PM
DATE: 07/04/2020
JOB NO: AB1234X

1
OF
1

12/20/2022 Exhibit XX

Oct 13, 2023 – 4:21pm by rhaskin K:\Drawings\SP\SP8994 – Gardena\ENG\LID\SP8994–LID.dwg

APPENDIX 3

SOILS INFORMATION/REPORT

KCG KLING
Consulting
Group, Inc.

MEMORANDUM

To: Tommy Eckes- The Picerne Group

CC: Ryan Haskin- Tait and Associates

From: Kling Consulting Group

PN: 22027-01

Date: October 6, 2023

Re: 1610 W. Artesia Boulevard, Gardena, California. Low Impact Development (LID) report, City Plan Check Comments

---

Our findings from subsurface exploration, laboratory testing, and geotechnical analyses were presented in our Preliminary Geotechnical report dated October 31, 2022. The findings concluded that the underlying soils at this site are susceptible to liquefaction. It is our understanding that due to site constraints, the southeast corner of the site is the low point and therefore the one logical location to place the surface stormwater BMPs. Given the proximity and vertical orientation of this location to the basement walls, and in light of potential liquefaction, it is our opinion that an infiltration based BMP at this location and at ground level should not be allowed or considered. In our professional opinion, these site conditions are not compatible with infiltrating water into the subsurface soils and performing percolation testing to confirm this opinion is considered unnecessary.

Sincerely,

KLING CONSULTING GROUP, INC.

REGISTERED PROFESSIONAL ENGINEER
HENRY F. KLING
No. 2205
GEOTECHNICAL
STATE OF CALIFORNIA

Henry Kling

GE 2205, Expires 3/31/2024

Preliminary Geotechnical Investigation Report for Feasibility Purposes, 1610 W. Artesia Boulevard, Gardena, California 90248.

PN 22027-00
October 31, 2022

KCG KLING Consulting Group, Inc.

KCG KLING
Consulting
Group, Inc.

October 31, 2022 **PN 22027-00**

Mr. Satish Lion
The Picerne Group
5000 Birch St., Suite 600
Newport Beach, California 92660

Subject: Preliminary Geotechnical Investigation Report for Feasibility Purposes, 1610 W. Artesia Boulevard, Gardena, California 90248

Dear Mr. Lion,

At your request and authorization, Kling Consulting Group, Inc. (KCG) has performed a preliminary geotechnical investigation report for feasibility purposes at the subject property located at 1610 W. Artesia Boulevard, Gardena, California (**see Figure 1 - Site Location Map**). The purpose of our evaluation is to review site geologic/geotechnical conditions and assess constraints for the development of the site. Subsurface field exploration consisting of four Cone Penetrometer (CPT) soundings and one Hollow-Stem Auger (HSA) boring, was completed to characterize the site conditions, determine engineering properties and develop feasibility-level geotechnical conclusions and recommendations. We expect our findings, opinions and recommendations would assist in formulating preliminary costs and budgets for the project.

We appreciate this opportunity to be of continued service and to work with you on this project. Should you have any questions regarding this report, please do not hesitate to call.

Respectfully,

KLING CONSULTING GROUP

John Holder

John C. Holder
Staff Engineer

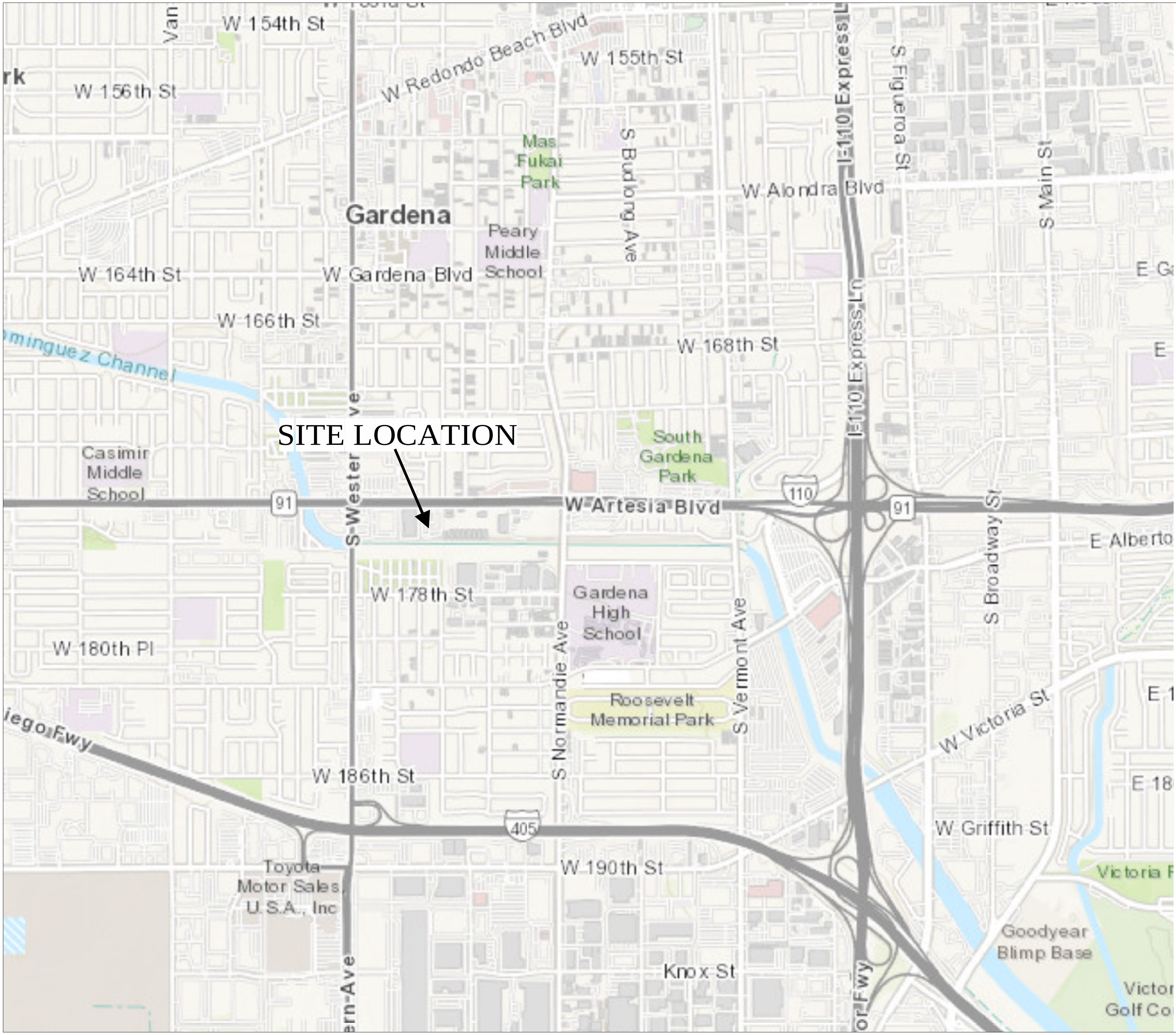
HENRY F. KLING
No. 2205

Henry F. Kling
Principal Geotechnical Engineer
GE 2205 Expires 3/31/22

JEFFREY P. BLAKE
No. EG 2248
Exp. 10/31/23

Jeffrey P. Blake
Associate Engineering Geologist
CEG 2248 Expires 10/31/23

Dist: (3) one electronic PDF



Notes:

Scale: 1": 1850'

0 925 ft 1850 ft

Client:

Picerne Group

Address:

1610 W. Artesia Boulevard,
Gardena, CA 90248

Site Location Map

Drawn: J.H.	**Date:** 10/31/2022
P/N: 22027-00	**Figure:** 1

TABLE OF CONTENTS

Attachments:

Figure 1	**–**	**Site Location Map**
Figure 2	**–**	**Geotechnical Map**

Appendix A	**-**	**References**
Appendix B	**-**	**CPT Soundings and Boring Log**
Appendix C	**-**	**Summary of Laboratory Test Results**
Appendix D	**-**	**Liquefaction and Seismic Settlement Analysis**

1.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of our preliminary geotechnical investigation has been to evaluate subsurface conditions at the site relative to the proposed development and provide feasibility level geotechnical recommendations to aid in project planning. Our subsurface exploration consisted of four Cone-Penetrometer Soundings (CPTs) and one Hollow-Stem Auger (HSA) boring located within the vicinity of the proposed development. The boring and CPT tests locations are shown on **Figure 2 – Geotechnical Map**.

1.2 Site Description

The subject property is located at 1610 W. Artesia Boulevard in Gardena, California. The site location (Longitude -118.305367°, Latitude 33.872132°) and surrounding area are presented on Figure 1. The Los Angeles County Office of the Assessor identifies the site as Assessor's ID Number 6106-013-049.

The subject site is currently occupied by two commercial buildings and is approximately 3.8-acres in size. Existing residential and commercial properties surround the site. The site is bordered on the north by Artesia Boulevard, east and west by residential and commercial buildings, and south by the Dominguez Channel. According to the United States Geological Survey (USGS) 7.5-Minute Torrance Quadrangle (USGS, 2021), the site surface is generally flat. The approximate elevation on the site is 25 feet above mean sea level.

Based on a review of historic aerial photos (NETR, 2022) dating back to 1952, it appears the site was originally used for agricultural purposes before being developed sometime between 1972 and 1980. The commercial developments established to the east and west of the site appear to have been built in this same time period. The Dominguez Channel appears to have been constructed prior to the exitising commercial developments between 1952 and 1963.

1.3 Proposed Development

Our understanding of the project is based on reviewing the TPG Stein Yield Study prepared by TCA Architects. The proposed development comprises a five story residential structure (podium) with one subterranean level planned. No other specific information is available regarding the proposed development at this time.

Notes:

⊕ - Boring Hole Location

▲ - Cone Penetration Testing Location

0.94” - Amount of Vertical Liquefaction Settlement

Scale: 1’’: 60’

0 30 ft 60 ft

KCG KLING Consulting Group, Inc.

Client:

Picerne Group

Address:

1610 W. Artesia Boulevard,
Gardena, CA 90248

Geotechnical Map

Drawn: J.H.	**Date:** 10/31/2022
P/N: 22027-00	**Figure:** 2

2.0 GEOLOGIC CONDITIONS

2.1 Regional Geologic Setting

The subject site is located within the Los Angeles Basin in Gardena, California. This area resides on the northwestern margin of the Peninsular Range Geomorphic Province. The Los Angeles Basin terminates abruptly, forming coastal hills and mesas associated with the Newport-Inglewood Uplift. The dominant geologic structures of the province, near the subject site, include the Newport-Inglewood-Rose Canyon fault zone to the northeast.

Geological mapping of the area indicates near-surface native soil deposits consist of Pleistocene aged alluvial sediments comprised of varying sediments of sand and silt of valley deposits.

2.2 Site Geologic Units

The native soils underlying the surface of the subject site consist of Old Alluvial Valley Deposits of late Quaternary age. A general description of these alluvial deposits is presented as follows:

Old Alluvial Valley Deposits (Qoa): The Pleistocene age alluvial deposits in the vicinity of the site are mapped as anticipated to consist of predominantly dense to very dense silty sand.

2.3 Subsurface Conditions

2.3.1 Asphalt and Base

The site is mantled by asphalt concrete and aggregate base to a depths of between 2 – 4 inches from the existing ground in the vicinity of borehole KHSA-1.

2.3.2 Artifical Fill (Af)

The site is underlain by artificial fill consisting of clayey sand and silty clay to a depth of 10 feet below the ground surface within the vicinity of borehole KHSA-1, and CPT-1, CPT-2, CPT-3 and CPT-4.

The silty clay and clayey sand are dark brown, moist and fine to medium grained. Concrete and brick debris of up to 1 foot in diameter were observed within the vicinity of KHSA-1 at a depth of 5 feet below ground surface.

2.3.3 Old Alluvial Valley Deposits (Qoa)

The site is underlain by Old Alluvial Valley Deposits of Quaternary age which was encountered during our subsurface exploration between depths of 10 to 50 feet below the ground surface.

The late to middle Pleistocene age alluvial deposits comprised primarily clayey sand and silty clay. The clayey sand and silty clay were generally brown, fine grained, and moist to saturated. The clayey sand ranged from loose to medium dense and the silty clay is stiff in nature.

2.4 Groundwater

Groundwater was encountered within the single hollow stem boring at a depth of 21.5 feet below ground surface and in all CPT soundings based on pore water dissipation readings at depths between approximately 19 and 23 feet below the existing ground surface. The Los Angeles County Department of Public Works established Groundwater Level Data web application, indicates the nearest groundwater well in the vicinity of the subject site's highest ever recorded depth to water table surface was 16 feet below ground surface (bgs) recorded in April 1978.

According to the Seismic Hazard Zone Report for the Torrance 7.5-Minute Quadrangle, the historically highest groundwater level mapped for the subject site is 10 feet below ground surface (bgs).

3.0 GEOTECHNICAL ENGINEERING

3.1 Expansive Soil Characteristics

Expansion Index (EI) laboratory testing on a shallow soil sample from KB-1 resulted in an Expansion Index of 57, which is considered "medium" expansion potential (EI 51-90) according to the CBC.

3.2 Sulfate Content

Sulfate testing was performed on representative samples of the soil. The soils tested during this investigation indicated a class "S0" sulfate per ACI-318 (Reference 2), with a soluble sulfate content of 147 ppm or 0.0147%.

3.3 Moisture and Density

Samples were retrieved at various depths below the ground surface from the hollow-stem boring location and used to determine in-place dry density and moisture content. Moisture results indicate the sampled soils have a moisture content of ranging from 14.3 to 30.6 percent and a dry density ranging from 94.1 to 113.4 pcf. Laboratory test results of dry density and moisture content are recorded on the boring log in Appendix B.

3.4 Surface Fault Rupture

The subject site is not located within the State of California designated Fault-Rupture Hazard Zone (formerly known as Alquist-Priolo Zones), where a site-specific investigation to determine the locations of any active faults would be required.

However, the Southern California region is seismically active. Active and potentially active faults within Southern California can produce seismic shaking at the site. It is anticipated that the site will periodically experience ground acceleration due to exposure to moderate to large magnitude earthquakes occurring on distant faults. However, no active faults are known to exist at the site, and the risk of surface fault rupture is considered low. The closest active fault zone to the subject site is the Newport-Inglewood-Rose Canyon Fault Zone, located approximately 2.5 miles to the northeast.

3.5 Seismic Design Parameters

Presented below are the site seismic parameters utilizing generic geologic, seismic, and geotechnical data gathered for the site and the SEAC Seismic Design Tool (Reference 14). All structures should be designed for earthquake-induced strong ground motions in accordance with the 2019 CBC procedures utilizing the following parameters:

2019 CBC Seismic Design Parameters

Site Class (Soil Profile)	D
Latitude	33.872132
Longitude	-118.305367
Short Period Spectral Acceleration, Ss:	1.771
1-Second Period Spectral Acceleration, S1:	0.63
Site Coefficient, Fa:	1.0
Site Coefficient, Fv:	1.7
Maximum Considered Earthquake Spectral Response Acceleration, SMS:	1.771
Maximum Considered Earthquake Spectral Response Acceleration, SM1:	1.071
Design Spectral Response Acceleration, SDS:	1.181
Design Spectral Response Acceleration, SD1:	0.714
Site modified peak ground acceleration PGA_M	0.845
Seismic Design Category	D

Note: A site-specific ground motion analysis was not included in the scope of this investigation. Per ASCE 7-16, 11.4.8, structures on Site Class D with S_1 greater than or equal to 0.2 may require Site-Specific Ground Motion Analysis. However, a site-specific ground motion analysis may not be required based on exceptions listed in ASCE 7-16, 11.4.8. The project structural engineer should verify whether exceptions are valid for this site and if a Site-Specific Ground Motion Analysis is required.

3.6 Liquefaction Potential

Based on our review of published geologic data, subsurface data, the presence of a shallow static groundwater table, and the overall relatively loose nature of shallower on-site soils, it is our opinion that the site is susceptible to liquefaction. The state of California has also established a seismic hazard zone for liquefaction at the site.

Liquefaction was evaluated in accordance with California Geologic Survey *Guidelines for Evaluating and Mitigating Seismic Hazards in California*, 2008 (Reference 7) based on site peak ground acceleration, earthquake magnitude, and source characteristics relative to the mapped maximum considered geometric mean (MCEG) peak ground acceleration. The parameters used in our analysis included a probabilistic 2,475-year modal earthquake of 7.3 magnitude and a corresponding peak ground acceleration adjusted for site class effects of 0.85 g. Our analysis was performed utilizing the software program "CLiq v.1.7" by GeoLogismiki (Reference 9). The results of our analysis are presented below in Section 3.6, and a summary of the liquefaction analysis is presented in **Appendix C**- Liquefaction and Seismic Settlement Analysis.

The liquefaction analysis was performed utilizing a historic high groundwater level at 10-feet as presented in *The Seismic Hazard Zone Report for the Torrance 7.5-Minute Quadrangle, Los Angeles County, California* (Appendix A).

In addition, the analysis included the following parameters and assumptions:

- Factor of Safety = 1.3 (Chapter 6 California Geologic Survey *Guidelines for Evaluating and Mitigating Seismic Hazards in California*)
- "Dry" seismic settlements calculated (Section 3.5.5 Los Angeles Department of Public Works *Manual for Preparation of Geotechnical Reports)*
- Soil Behavior Type Index (Ic) = 2.60[18].
- Weighting factor for volumetric strain applied[11].
- Cn limit value applied.

3.7 Seismically-Induced Settlement

The liquefaction analyses results for seismically induced vertical ground settlement is presented below. The analysis was based on both existing conditions and with 10-foot basement excavation and assumed high ground water level of 10 feet below ground surface (bgs) .

CPT	Settlement Without Basement (Inches)	Settlement With Basement (Inches)
1	1.30	1.0
2	0.20	0.90
3	1.50	1.40
4	1.80	1.40

The overall vertical settlement calculations include seismically induced "dry" settlements.

Based on this analysis, the seismic induced settlements range from approximately 0.2 inches to 1.8 inches for existing conditions. It should be noted the majority of the vertical ground settlement (>1 inch) and up to approximately 1.6 inches occurs in the upper 20 feet of the soil column. Vertical ground settlements at depths between 22 and 50 feet are less than 0.2 inches. Additionally, seismically induced differential settlement is variable across the site, with an estimated differential settlement of 1.3-inches over a horizontal distance of 170 feet (between CPT-2 and CPT-3). When seismic settlement is analyzed assuming the upper ten feet is excavated for the proposed basement, the calculated seismic settlement ranged from 0.9 inches to 1.4 inches between CPT-2 and CPT-3 with a differential of approximately 0.50 inches over 170 feet horizontally which is equivalent to approximately 0.3 inches over 100 feet.

3.8 Seismically-Induced Lateral Displacements

Lateral spreading, a phenomenon associated with seismically induced soil liquefaction, is the lateral displacement of soils due to inertial motion and lack of lateral support during or post liquefaction. Lateral spreading generally occurs on gently sloping ground or level ground with nearby free surface faces such as a drainage or stream channel. Dominguez Channel is considered a “free surface” in the vicinity of the site. As such, seismically induced lateral spreading was evaluated as part of the liquefaction assessment.

In consideration of the close proximity to the concrete-lined Domingquez Channel and liquefaction settlement, the potential for lateral spreading to occur exists at the site. However, the exact amount of lateral spreading requires additional data and analysis beyond the scope of this preliminary investigation. Nonetheless, we believe the impact to the proposed apartment development would be mostly limited to surface ground improvements. The magnitude of horizontal displacement from spreading would decrease at further distances from the channel. The proposed podium structure with one level of basement would likely resist lateral movement due to its structural integrity. More specific estimates of lateral spreading would be evaluated in the final (Supplemental) investigation.

3.9 Seismically-Induced Landsliding

The State of California Seismic Hazard Zone Map for the Torrance Quadrangle has not designated the subject site for landsliding hazard potential. The potential for seismically-induced landsliding to occur at the site is considered very low due to the relatively flat topography and absence of significant slopes on or adjacent to the site. Slopes planned as part of the development should be engineered and constructed at a gradient of 2:1 (horizontal: vertical) or flatter.

4.0 CONCLUSIONS

The following preliminary conclusions are based upon our analysis and data review obtained during our subsurface field investigation. It is our opinion that the subject site is considered geotechnically suitable for the proposed development discussed above, provided the recommendations presented herein are implemented during design and construction. Additional subsurface exploration, laboratory testing and geotechnical analysis should be performed to confirm site conditions and to finalize the geotechnical investigation report.

- Based upon our review of the site, the underlying soils on-site are considered to have sufficient bearing capacity to support the proposed development, provided the preliminary recommendations herein are implemented.

- Geroundwater was encountered in our Boring B-1 at a depth of approximately 21.5 feet belwo the exsiting ground surface. Apparent groundwater recorded with pore water dissipation measurements in the CPT Soundings was encountered in all of our tests at depths of between approximately 19 and 23 feet below the existing ground surface during our subsurface exploration.

- Our geotechnical evaluation indicates that the upper 20 feet of the alluvial deposits that underlie the site are susceptible to liquefaction and seismic induced settlement due to a design-level earthquake incorporating the historical high groundwater level of 10 feet below existing grades (CGS, 1998). We estimate that liquefaction-induced vertical settlement for the subject apartment site would range from approximately 0.2 to 1.8 inches, with approximately 1.6 inches of estimated differential settlement over 350 feet. However, the seismic settlement analyzed beneath the proposed basement ranged from 0.9 inches to 1.4 inches resulting in differential settlement of 0.3 inches over 100 feet. This differential settlement of 0.3 inches over 100 feet should be incorporated into the overall design.

- KCG's professional opinion is that seismic and liquefaction-induced ground displacements can be mitigated by incorporating the differential settlement into the structural design of the building and employing a mat foundation system in the basement to support the proposed structure.

- Seismically induced lateral spreading is likely to occur at the site during significant seismic events; however, the spreading would likely affect surface improvements more than the proposed podium structure. Further analysis during the supplemental investigation should better predict the actual magnitude and extent of spreading

- Preliminarily, the soils underlying the site should be considered to have moderate expansion potential.

- No active fault is known to exist at the site, and the risk of surface fault rupture is considered to be very low.

- The proposed development should not adversely affect neighboring properties if proper care is taken during the construction of proposed improvements.

5.0 PRELIMINARY RECOMMENDATIONS

Preliminary recommendations presented below are based on information obtained from the client, and the preliminary geotechnical information gathered and analyzed to date.

5.1 Supplemental Subsurface Exploration

During this preliminary investigation phase, our CPT Soundings were primarily utilized to analyze the susceptibility of the underlying soil to seismic induced settlement and liquefaction potential. Due to existing buildings and improvements, CPT and boring locations were limited to readily accessible areas. We recommend that a supplemental geotechnical investigation be performed that includes both additional CPT soundings and soil borings to further characterize subsurface conditions, confirm groundwater levels and perform additional laboratory testing on obtained soil samples collected. The supplemental investigation would further refine our conclusions and recommendations and to comply with the Los Angeles Department of Public Works *Manual for Preparation of Geotechnical Reports*.

5.2 Earthwork Specifications

All grading should be performed in accordance with the General Earthwork and Grading Specifications presented in Appendix E, unless specifically revised or amended below. Grading should also conform to all applicable governing agency requirements. Prior to the commencement of grading operations, all vegetation, organic topsoil, and man-made structures (i.e., tanks, pipes, fences, etc.) should be cleared and disposed of off-site. Any undocumented fill or backfill encountered should be removed and re-compacted. All areas receiving fill should be scarified to 6 inches and/or over-excavated, moisture-conditioned between optimum moisture and two to four percent above optimum moisture content, and re-compacted to a minimum of 90 percent relative compaction as determined by ASTM D1557. Soil material excavated from the site should be adequate for re-use as compacted fill provided it is free of oversize rock, trash, vegetation, and other deleterious material. All earthwork and grading operations should be performed under the observation and testing of the geotechnical consultant of record.

5.3 Preliminary Remedial Earthwork and Over-Excavation

To provide uniform soil support for the proposed structures and reduce the potential for liquefaction induced settlement and settlement due to underlying potentially compressible soils, we recommend that the underlying soils be mitigated through ground improvement methods in those areas to receive buildings or other settlement-sensitive improvements, where not removed by planned excavations. It is our understanding that the proposed podium apartment structure would be supported entirely on a one-level parking basement. No remedial grading is anticipated for soil exposed after basement excavation is performed.

Should any at-grade structures be planned, we preliminarily anticipate remedial earthwork would involve over-excavation of the upper soils to maintain a minimum thickness of at least five (5) feet of fill below finish grade elevation, or a minimum of two (2) feet below proposed footings, whichever is deeper. The removal depth may vary laterally. As such, the recommended excavation depth may vary; this will need to be observed during construction. At a minimum, the removals should extend laterally beyond the building footprint five feet, where practical. In proposed pavement or flatwork areas, the depth of the removals should extend at least 12-inches below existing grade, or 12-inches below finish subgrade (whichever is deeper).

5.4 Preliminary Proposed Building Foundations Options

All foundation criteria are considered minimum requirements that may be superseded by more stringent requirements from the architect, structural engineer, or governing agencies. The preliminary recommended geotechnical design parameters are being provided for conventional spread footings and reinforced mat slab foundation systems with remedial earthwork for the at-grade residential buildings, if any**.**

5.4.1 Residential Apartment Building

5.4.1.1 Conventional Foundations

The following preliminary geotechnical parameters are provided for design of proposed conventional foundations at one level subterreanean parking. In general, the insitu soil at one level deep should provide support for proposed foundations. An allowable bearing pressure of 4000 pounds per square foot for square pad and continuous footings may be assumed. The minimum width and depth for continuous and square pad footings should be 24 inches and 24 inches, respectively. The depth is relative to finish slab elevation. Bearing pressures may be increased by 250 pounds per square foot per additional foot of width or depth to a maximum allowable bearing pressure of 5000 pounds per square foot. A coefficient of friction of 0.38 may be used, along with a passive lateral resistance of 250 pounds per square foot per foot of embedment. Footings should bear on either approved natural ground or compacted fill in the event localized areas of soft or disturbed soil is exposed after excavation.

If normal code requirements are used for seismic design, the allowable bearing value and coefficient of friction may be increased by 1/3 for short duration loads, such as the effect of wind or seismic forces. Static settlement of foundations supporting the proposed one three story buildings is not expected to exceed one inch and ¼-inch over fifty horizontal feet.

If any utility lines are within a 1:1 (horizontal: vertical) projection from the bottom of a footing, they may be within the influence zone of the proposed footing load. If this condition exists, the proposed footing should be deepened so that the utility is outside the zone of influence; the utility line could also be relocated or encased with concrete slurry. These conditions should be evaluated on a case by case basis.

5.4.1.2 Mat Foundation

A rigid mat foundation may be used for upport of the building at one level of subterranean basement. In general, the insitu soil should provide adequate support for proposed mat foundation. The subgrade should be evaluated upon completion of basement excavation. Any localized areas of soft or disturbed soil should be removed and recompacted prior to foundation constructioin. Mat foundations should be properly reinforced to form a relatively rigid structural unit in accordance with the structural engineering design. For designing a mat foundation, we preliminarily recommend a modulus of subgrade reaction of 100 pounds per square inch per inch (pci). This value can be further refined as part of the supplemental investigation. A maximum bearing pressure of 3000 psf is also recommended. For localized areas of higher pressure (often required for seismic design) further evaluation is warranted to evaluate the increase in pressure and resulting settlement.

5.5 Settlement

Static settlement of proposed foundations is dependent on the actual foundation system selected and actual bearing pressures. For preliminary planning purposes foundation settlement is expected to not exceed one inch in total and one-half inch differential over 50 horizontal feet. Anticipated liquefaction and seismic-induced settlement for the overall site ranges froms 0.2 to 1.8 inches. However, after basement excavation and loading, the seismically induced settlement is expected on the order of 0.30 inches over 100 horizontal feet. This is considered minor settlement, however it should be refined and verified during the recommended supplemental investigation.

5.6 Footing Setbacks

All footings should maintain a minimum 7-foot horizontal setback from the base of the footing to any descending slope. This distance is measured from the outside footing face at the bearing elevation. Footings should maintain a minimum horizontal setback of H/3 (H=slope height) from the base of the footing to the descending slope face and should be no less than 7 feet, and it need not be greater than 40 feet.

5.7 Slab-On-Grade

These recommendations are considered minimum requirements that may be superseded by more stringent requirements from the architect, structural engineer, or governing agencies.

Concrete slabs should be at least 4-inches in thickness. Actual slab thickness and reinforcement should be determined by the structural engineer based on structural loads and soil interaction. Our recommendations should be superseded by the recommendations of the structural engineer or architect.

New slabs-on-grade should minimally conform to the design procedure contained in Section 1808 of the 2019 California Building Code. The project structural engineer should consider these recommendations as minimum requirements and modify these recommendations as appropriate.

Slab subgrade soil moisture should be at least optimum moisture prior to placement of concrete or vapor barrier. If the moisture content of the existing subgrade soil is less than optimum, pre-saturation may be required to achieve optimum prior to placing the capillary layer or Stego.

Interior concrete slab-on-grade floors (if any) should be at least 4-inches in thickness underlain by a minimum 4-inch capillary break using ½-inch open graded gravel or material approved by the geotechnical engineer. The 4-inch capillary layer should be underlain by a 15-mil Stego Wrap vapor retarder or equivalent product with a permeance rate of 0.012 perms (or less) and puncture resistance of Class “A” or “B” per ASTM E 1745-11. As per the manufacturer recommendations, all seams should overlap a minimum of 6 inches and should be sealed in accordance with the specifications provided by the vapor retarder manufacturer. All penetrations must be sealed using a combination of Stego Wrap, Stego Tape and/or Stego Mastic or approved equivalent. The vapor retarder should be lapped downward a minimum of 12 inches where the vapor retarder encounters an interior footing or exterior thickened edge or footing. The vapor retarder must be placed on top of the capillary layer if it is expected to become wet prior to the concrete pour. If the capillary layer can be kept dry before pouring concrete, the vapor retarder may be placed under the capillary layer. The water-cement ratio of structural concrete should be not greater than 0.50. The actual slab thickness and reinforcement should be determined by the project structural engineer.

If moisture-sensitive floor coverings are utilized, interior concrete slabs should be designed and constructed in accordance with the applicable floor manufacturer's specifications. The flooring installer should conduct all applicable testing to determine if concrete slabs have sufficiently cured to receive flooring materials.

The basement slab on grade, if used exclusively for vehicular parking, may not require a moisture retarder. However, an aggregate layer of some thickness could be considered to reduce moisture vapor accumulating in the basement.

5.8 Retaining Walls

General guidelines are provided below for retaining walls up to twelve feet in retained height. Please note that drainage recommendations are provided only as a means to create a drained condition behind proposed retaining walls. Surface drains should not be connected to retaining wall sub-drainage. These drains are not intended as a means of waterproofing. If moisture or salt deposition is not desired, or if stone facing, stucco, or paint is to be applied to the wall outer surface, the wall should be provided with suitable waterproofing. The waterproofing system for the wall should be designed by a qualified waterproofing consultant. Any waterproofing or drainage system damaged by soil placement and compaction efforts should be repaired prior to completion of backfilling.

Foundations for proposed retaining and perimeter (non-retaining) walls which are to be founded into compacted fill materials may be designed utilizing an allowable bearing pressure as presented above for conventional foundations.

Cantilevered retaining walls should be designed to resist equivalent fluid pressures as indicated in the tables below:

Case 1 – Select (Clean Sand) Backfill Condition[1]

Backfill Condition (Active)	**Equivalent Fluid Pressure (psf/ft)**
Level	35
2:1 Slope	55

[1]Assumes clean sand (Sand Equivalent >30) backfill see attached detail RW-1.

Case 2 – Native Backfill Condition[2]

Backfill Condition (Active)	**Equivalent Fluid Pressure (psf/ft)**
Level	55
2:1 Slope	65

[2]Assumes drained native soil backfill see attached detail RW-1.

Both the clean sand and native backfill conditions provided above assume a drained condition behind the proposed retaining wall. A backdrain consisting of 4-inch perforated plastic pipe SDR 35 or Schedule 40, encased in ¾-inch gravel wrapped in Mirafi 140N or equivalent filter fabric, and properly outletted. Details for retaining wall drainage are provided in our attached Retaining Wall Detail RW-1 (Appendix E). A seismic surcharge of

19H should be applied at mid-height of the wall, where H= the retained height of the wall greater than 6 feet.

Additional surcharge loading considerations are not incorporated into the above values. If the project structural engineer wishes to incorporate additional loading due to these factors, the additional loads should be added to the values provided above. Foundations for proposed retaining walls may be designed by utilizing the recommendations for conventional foundations. However, when combining both frictional and passive lateral resistance, one or the other should be reduced by one-half.

Active earth pressure can be assumed for temporary shoring systems such as H-beam and lagging that can safely deflect sufficiently to initiate an active pressure condition. More detailed recommendations and design parameters for shoring should be evaluated as part of the supplemental investigation based on selected shoring systems.

5.8.1 Basement Walls

Basement walls should be designed for at-rest earth pressure. For preliminary design purposes, an at-rest earth pressure should be assumed equal to 75 pounds per cubic foot. Basement walls should be provided with backdrains consisting of drainage composites or sand backfill in connection with an aggregate wrapped in filter fabric with 4-inch diameter perforated pipe. In general, the basement wall drainage system should be based on the recommendation for drains presented in the previous section.

5.9 Preliminary Pavement Design

Pavement section design is provided below based on anticipated near surface soil conditions encountered during our investigation and assumed traffic loading.

5.9.1 Asphalt Concrete Pavement

R value testing was not performed as part of this investigation and should be performed during the supplemental investigation. However, we are assuming an R-Value of 30 for preliminary design purposes.

Based on an assumed R-value of 30 the parameters below are provided for preliminary design purposes. Pavement sections were calculated for traffic indices of 4.0 and 5.5, which are commonly used for parking stalls and drive aisles subject to passenger vehicles and service trucks, respectively. However, the selection of actual traffic index should be the purview of the project civil or traffic engineer.

Pavement Section Design

Location	R-Value	Traffic Index	Multiple Layered	
			Asphalt Concrete (inches)	Aggregate Base* (inches)
Parking Stall	30	4.0	3.0	6.0
Drive Aisles	30	5.5	3.0	8.0

*Aggregate base material should consist of Class 2 aggregate base materials or Crushed Miscellaneous Base (CMB).

The upper 12 inches of the subgrade soils should be compacted to at least 90 percent of the laboratory maximum dry density (ASTM D1557). All base materials should be compacted to at least 95 percent of the laboratory maximum dry density (ASTM D1557).

5.9.2 Portland Cement Concrete Pavement

For preliminary design of concrete pavement, it is recommended that a concrete pavement section consisting of 6-inches of concrete underlain by at least 4-inches of either Class 2 aggregate base or crushed miscellaneous base (CMB) be used for preliminary design. Concrete Compressive strength should be 4000 psi or greater. Aggregate base material should be compacted to a minimum of 95 percent relative compaction as per ASTM D1557. Subgrade soil should be compacted to at least 90 percent of the laboratory maximum dry density in accordance with ASTM D1557. If concrete crack control is desired, the slabs should be minimally reinforced with No. 4 rebar, placed every 24 inches on center, both ways. A 10-foot square or less grid system should be used in the construction of continuous sections of concrete pavement or as recommended by the structural engineer.

For trash enclosures, concrete pavement should consist of a minimum 8-inch thick concrete slab placed over a minimum of 6-inches of either Class 2 or crushed miscellaneous base material, compacted to 95 percent relative compaction. Concrete should have a minimum strength of 4000 psi and be reinforced with a minimum of No. 4 bars placed at 24 inches on center, in each direction, positively supported (with concrete chairs or other devices) at mid-height in the slab. Crack control joints should be placed at a 10-foot maximum spacing in each direction in the slab or as recommended by the structural engineer. Concrete mix design should incorporate the recommendations presented in the slab on grade section of this report for improved geotechnical performance.

5.10 Exterior Flatwork

The following general recommendations may be considered for concrete hardscape including expansive soils mitigation and may be superseded by the requirements of Los Angeles County.

5.10.1 Sidewalk, Pedestrian Walkways

Expansion Potential	**Minimum Concrete Thickness**	**Subgrade Pre-Soaking Depth**	**Reinforcement**	**Joint * Spacing**
Medium	4 (Full)	120% of Optimum to 18”	#3 @ 18" OC, EW	4-5 Feet

* Joints at curves and angle points are recommended.

5.10.2 Driveways, Patios, Entryways

Expansion Potential	**Minimum Concrete Thickness (in)**	**Subgrade Pre-Soaking Depth**	**Reinforcement**	**Joint[3] Spacing (Max)**
Medium	General Flatwork 4 (Full) Driveways 6 (Full)	120% of Optimum to 18”	#3 @ 18" OC, EW	4-5 Feet

[3] Joints at curves and angle points are recommended.

The above recommendations may be superseded by the project architect, structural engineer or the governing agency’s requirements. These recommendations are not intended to mitigate cracking caused by shrinkage and temperature warping.

5.11 Drainage

Positive drainage should be maintained away from any building or graded slope face and directed to suitable areas via non-erosive devices, as designed by the project civil engineer. For drainage over soil and paved areas immediately adjacent to structures, please refer to Section 1804.4 of the 2019 CBC.

5.12 Geotechnical Observation and Testing

Geotechnical observation and testing should be conducted during the following stages of grading:

- During all phases of rough and precise grading, footing excavations, etc.
- During slab and flatwork subgrade pre-saturation and moisture conditioning.
- During shoring system installation.
- During utility trench excavation and compaction.
- During placement of retaining wall sub-drainage, backfill, and compaction.

For any unusual conditions encountered during grading.

6.0 PROFESSIONAL LIMITATIONS

Geotechnical services are provided by KCG in accordance with generally accepted professional engineering and geologic practice in the area where these services are to be rendered. Client acknowledges that the present standard in the engineering and geologic and environmental profession does not include a guarantee of perfection and, except as expressly set forth in the conditions above, no warranty, expressed or implied, is extended by KCG.

Geotechnical reports are based on the project description and proposed scope of work as described in the proposal. Our conclusions and recommendations are based on the results of the field, laboratory, and office studies, combined with an interpolation and extrapolation of soil conditions as described in the report. The results reflect our geotechnical interpretation of the limited direct evidence obtained. Our conclusions and recommendations are made contingent upon the opportunity for KCG to continue to provide geotechnical services beyond the scope in the proposal to include all geotechnical services. If parties other than KCG are engaged to provide such services, they must be notified that they will be required to assume complete responsibility for the geotechnical work of the project by concurring with the recommendations in our report or providing alternate recommendations.

It is the reader's responsibility to verify the correct interpretation and intention of the recommendations presented herein. KCG assumes no responsibility for misunderstandings or improper interpretations that result in unsatisfactory or unsafe work products. It is the reader's further responsibility to acquire copies of any supplemental reports, addenda, or responses to public agency reviews that may supersede recommendations in this report.

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

1. American Society for Testing and Materials (ASTM), 2018, Annual Book of ASTM Standards, Volume 04.08, Construction: Soil and Rock (I), Standards D 420 - D 5876

2. American Concrete Institute, 2014, Manual of Concrete Practice, Volume 1 through 6.

3. California Building Standards Commission, 2019, California Building Code, Volume 2.

4. California Geologic Survey (CGS), Compilation of Quaternary Surficial Deposits: https://maps.conservation.ca.gov/cgs/qsd/app/, accessed October 2022.

5. California Geological Survey, Department of Conservation, Division of Mines of Geology, 1998, *Seismic Hazard Zone Report for the Torrance 7.5-Minute Quadrangle, Seismic Hazard Zone Report 035, Los Angeles County, CA.*

6. California Geological Survey (CGS), Earthquake Zones of Required Investigation Web Application, https://maps.conservation.ca.gov/cgs/eqzapp/app/, accessed October, 2022.

7. California Geological Survey, Special Publication 117A, *Guidelines for Evaluating and Mitigation Seismic Hazards in California. 2008*

8. County of Los Angeles Department of Public Works *Manual for Preparation of Geotechnical Reports. 2013*

9. Geologismiki, 2007, CLiq, Liquefaction Software, Version 1.7.

10. Google Earth. (January 3, 2020). Gardena. 33.872132, -118.305367, Accessed October, 2022.

11. Historical Aerials (NETR Online), 2020, website: https://www.historicaerials.com/viewer, accessed October, 2022.

12. LA County Department of Public Works, 2019, Groundwater Level Data, accessed October, 2022 URL: https://dpw.lacounty.gov/general/wells/

13. Robertson, P. (1998). *Evaluating cyclic liquefaction potential using the cone penetration test.* Canadian Geotechnical Journal - Can Geotech J. 35. 442-459.

14. Structural Engineers Association of California (SEAC)/Office of Statewide Health Planning and Development OSHPD: Seismic Design Maps: https://oshpd.ca.gov/seismic maps.org, accessed October, 2022.

APPENDIX A

REFERENCES
(CONTINUED)

15. TCA Architects, TPG Stein Yield Study, 1610 W. Artesia Blvd., Gardena, California. Dated June 2, 2021.

16. USGS, National Geologic Map Data Base (NGMDB), https://ngmdb.usgs.gov/mapview/, accessed October, 2022.

17. USGS, topoView, https://ngmdb.usgs.gov/topoview/, accessed October, 2022.

18. USGS, Unified Hazard Tool, https://earthquake.usgs.gov/hazards/interactive/, accessed October, 2022.

19. USGS, U.S. Quaternary Faults, https://www.usgs.gov/natural-hazards/earthquake-hazards/faults, accessed October, 2022.

20. USGS, 2019, US Seismic Design Maps, accessed October, 2022. URL: https://earthquake.usgs.gov/designmaps/us/application.php?

APPENDIX B

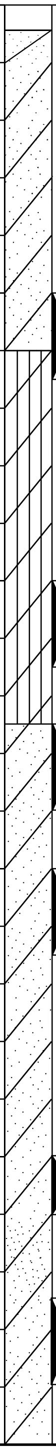
CPT SOUNDINGS AND BORING LOGS

LOG OF EXPLORATORY BORING

Sheet **1** of **3**

Project: **1610 W. Artesia Blvd, Gardena, CA**
Project Number: **22027-00**
Date Drilled: **9/30/22**
Logged By: **J.H**
Boring No.: **KHSA-1**
Driller: **Bc2 Environmental**
Drill Type: **Hollow-Stem Auger**
Hammer Wt. / Drop: **140lb / 18in**
Ground Elev. [ft]: **---**

◩ Standard Split Spoon
■ Shelby Tube
∇ Water Level ATD
⧗ California
☒ Bulk Sample
▼ Static Water Table



Depth [ft]	Sample Type	Blows/6"	Moisture Content [%]	Dry Density, [pcf]	SOIL DESCRIPTION and CLASSIFICATION (USCS)	Pocket Pen. [tsf]	Lab Tests	Remarks
					@ **0 feet - Asphalt:** 3-4 inches thick			
					Artificial Fill (Af):			
					@ **0.5 feet - Clayey Sand (SC):** dark brown, medium grained, moist, medium dense.		EI SO4	
					@ **4.0 feet -** trash debris including concrete and brick, up to 1 foot diameter			
5	⧗	6 8 6			@ **6.0 feet - Silty Clay (CL):** dark brown, moist, fat.			No recovery.
10	⧗	5 7 13 [13]	19.2	111.2	@ **10.0 feet - Silty Clay (CL):** dark brown, moist, fat, stiff.	> 4.5		
					Old Alluvial Valley Deposits (Qoa):			
	⧗	6 14 16 [24]	18.1	113.4	@ **12.5 feet - Clayey Sand (SC):** brown, fine to medium grained, moist, medium dense.	> 4.5		
15	⧗	3 12 13 [18]	14.3	110.8	@ **15.0 feet - Clayey Sand (SC):** brown, fine to medium grained, moist, medium dense.	> 4.5	CN	
20	⧗		22.2	104.3	@ **20.0 feet - Clayey Sand (SC):** brown, fine to medium grained, moist/almost wet.	1.50		Blowcount N/A. ∇
	⧗	5 10 12 [13]	30.6	94.1	@ **22.5 feet - Clayey Sand (SC):** brown, fine to medium grained, wet, medium dense.	2.00	DS	

Blow count in bracket represents (N1)60 value.
LaCroix & Horn conversion factor of 0.64 used to convert California Sampler blow counts to SPT values.

LOG OF EXPLORATORY BORING

Sheet **2** of **3**

Project: **1610 W. Artesia Blvd, Gardena, CA**
Project Number: **22027-00**
Date Drilled: **9/30/22**
Logged By: **J.H**
Boring No.: **KHSA-1**
Driller: **Bc2 Environmental**
Drill Type: **Hollow-Stem Auger**
Hammer Wt. / Drop: **140lb / 18in**
Ground Elev. [ft]: **---**

◩ Standard Split Spoon
■ Shelby Tube
∇ Water Level ATD
⧓ California
☒ Bulk Sample
▼ Static Water Table

Depth [ft]	Graphic Log	Sample Type	Blows/6"	Moisture Content [%]	Dry Density, [pcf]	SOIL DESCRIPTION and CLASSIFICATION (USCS)	Pocket Pen. [tsf]	Lab Tests	Remarks
25	▨	⧓		24.8	102.3	**Old Alluvial Valley Deposits (Qoa):** @ **25.0 feet - Clayey Sand (SC):** brown, fine to medium grained, wet.	1.25		Blowcount N/A.
30	▨	⧓	6 7 9 [8]	24.2	102.9	@ **30.0 feet - Clayey Sand (SC):** brown, fine to medium grained, wet, medium dense.	1.50		
35	▨	⧓	5 5 6 [4]	24.0	104.8	@ **35.0 feet - Clayey Sand (SC):** brown, fine to medium grained, wet, loose.	1.00		
40	▨	⧓	4 5 6 [4]	23.8	101.8	@ **40.0 feet - Clayey Sand (SC):** brown, fine to medium grained, wet, loose.	0.50		
45	▨	⧓	5 5 6 [4]	23.1	104.7	@ **45.0 feet - Clayey Sand (SC):** brown, fine to medium grained, wet, loose.	1.50		

Blow count in bracket represents (N1)60 value.
LaCroix & Horn conversion factor of 0.64 used to convert California Sampler blow counts to SPT values.

LOG OF EXPLORATORY BORING

Sheet **3** of **3**

Project:	**1610 W. Artesia Blvd, Gardena, CA**	Boring No.:	**KHSA-1**
Project Number:	**22027-00**	Driller:	**Bc2 Environmental**
Date Drilled:	**9/30/22**	Drill Type:	**Hollow-Stem Auger**
Logged By:	**J.H**	Hammer Wt. / Drop:	**140lb / 18in**
		Ground Elev. [ft]:	**---**

◩ Standard Split Spoon
■ Shelby Tube
▽ Water Level ATD
⧓ California
⊠ Bulk Sample
▼ Static Water Table

Depth [ft]	Graphic Log	Sample Type	Blows/6"	Moisture Content [%]	Dry Density, [pcf]	SOIL DESCRIPTION and CLASSIFICATION (USCS)	Pocket Pen. [tsf]	Lab Tests	Remarks
50	▨	⧓		27.7	96.4	@ **50.0 feet - Clayey Sand (SC):** light gray, fine to medium grained, wet.	1.00		Blowcount N/A.

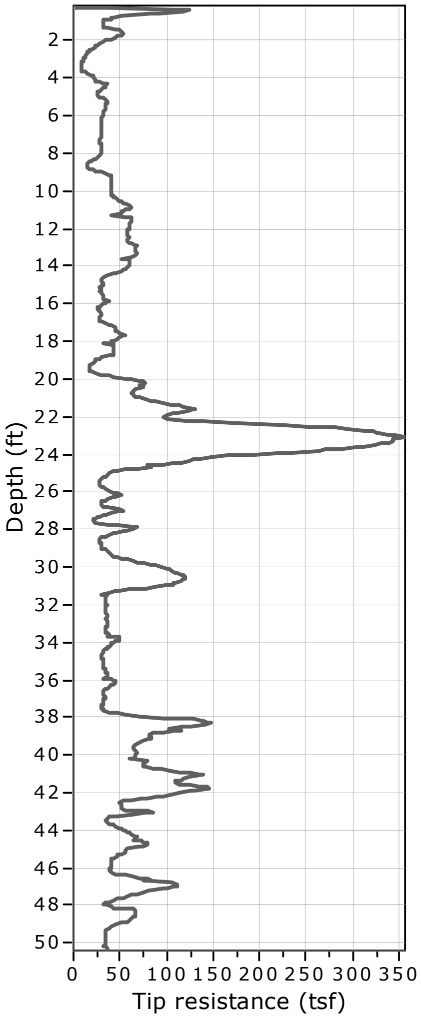
End of Boring @ 51.5 ft below ground surface.
Groundwater encountered @ 21.5 feet below ground surface.
No Caving

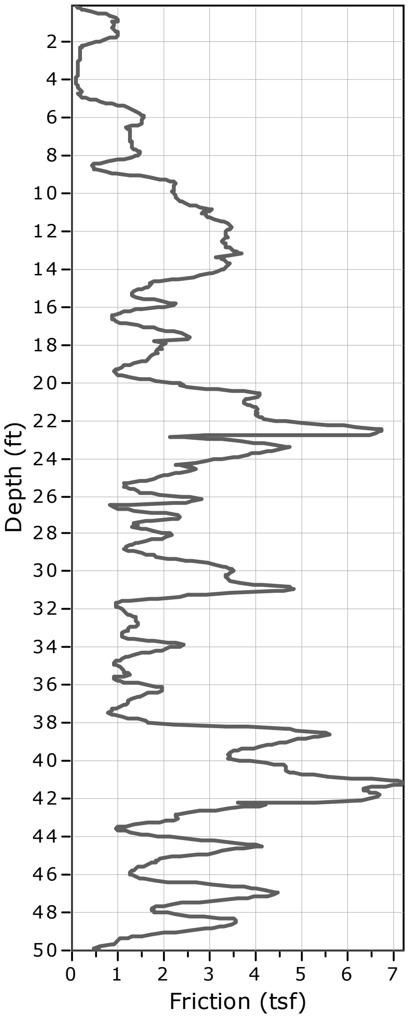
Blow count in bracket represents (N1)60 value.
LaCroix & Horn conversion factor of 0.64 used to convert California Sampler blow counts to SPT values.

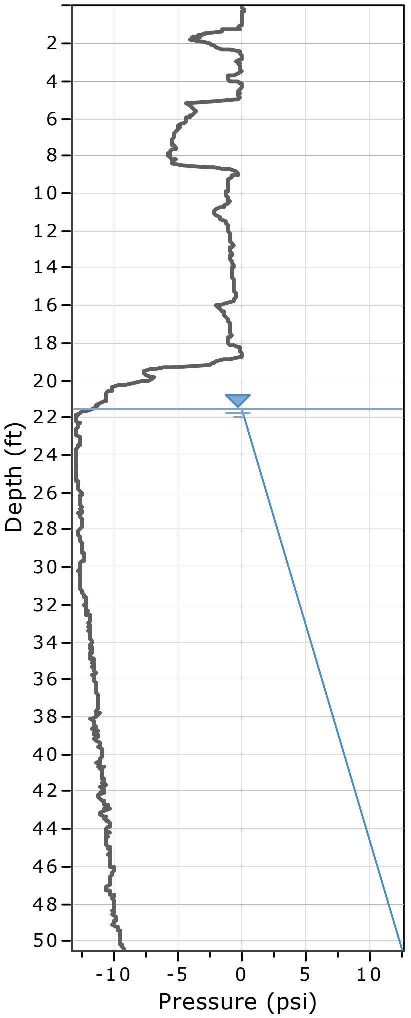
KLING Consulting Group, Inc.
18008 Sky Park Circle, Suite 250
Irvine, California 92614
www.klingconsultinggroup.com

CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

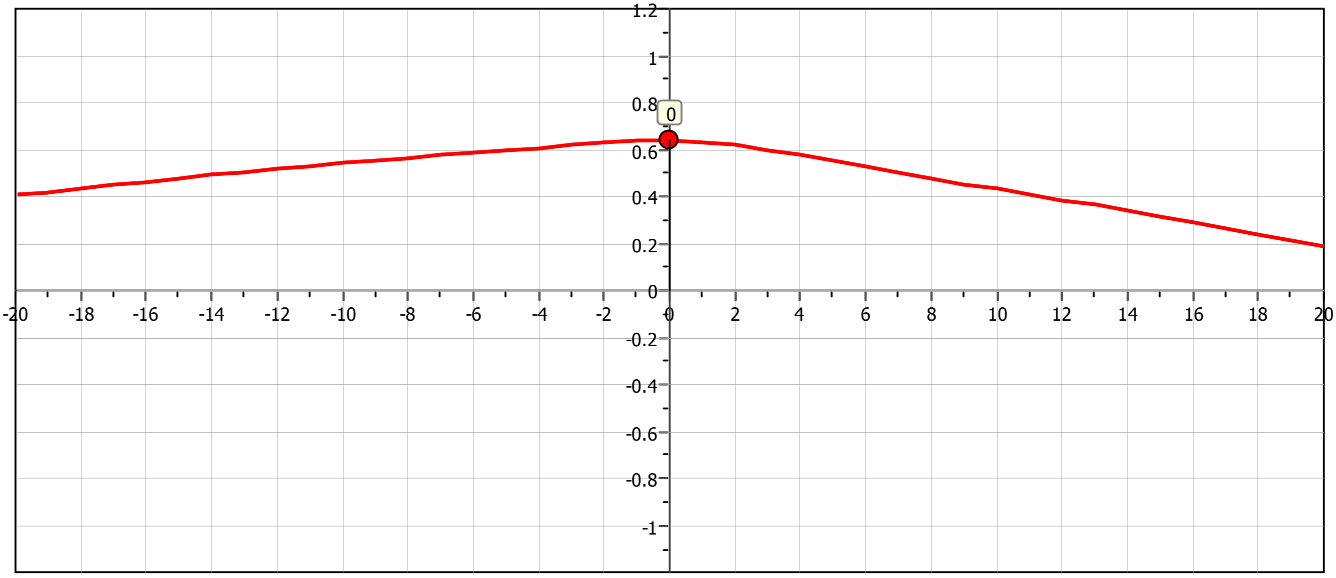

Cone resistance


Sleeve friction


Pore pressure

The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

Cross correlation between qc & fs



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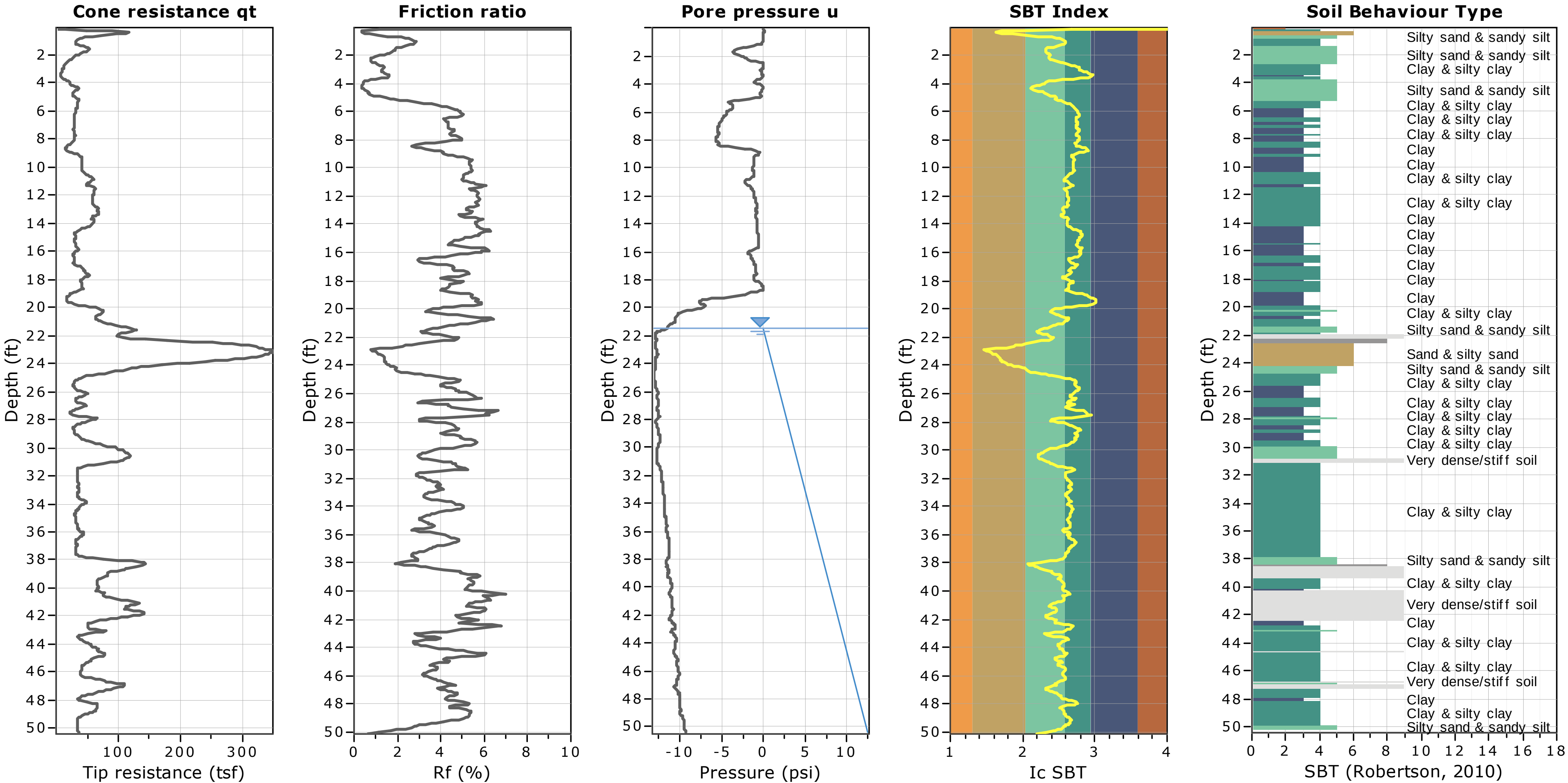
CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



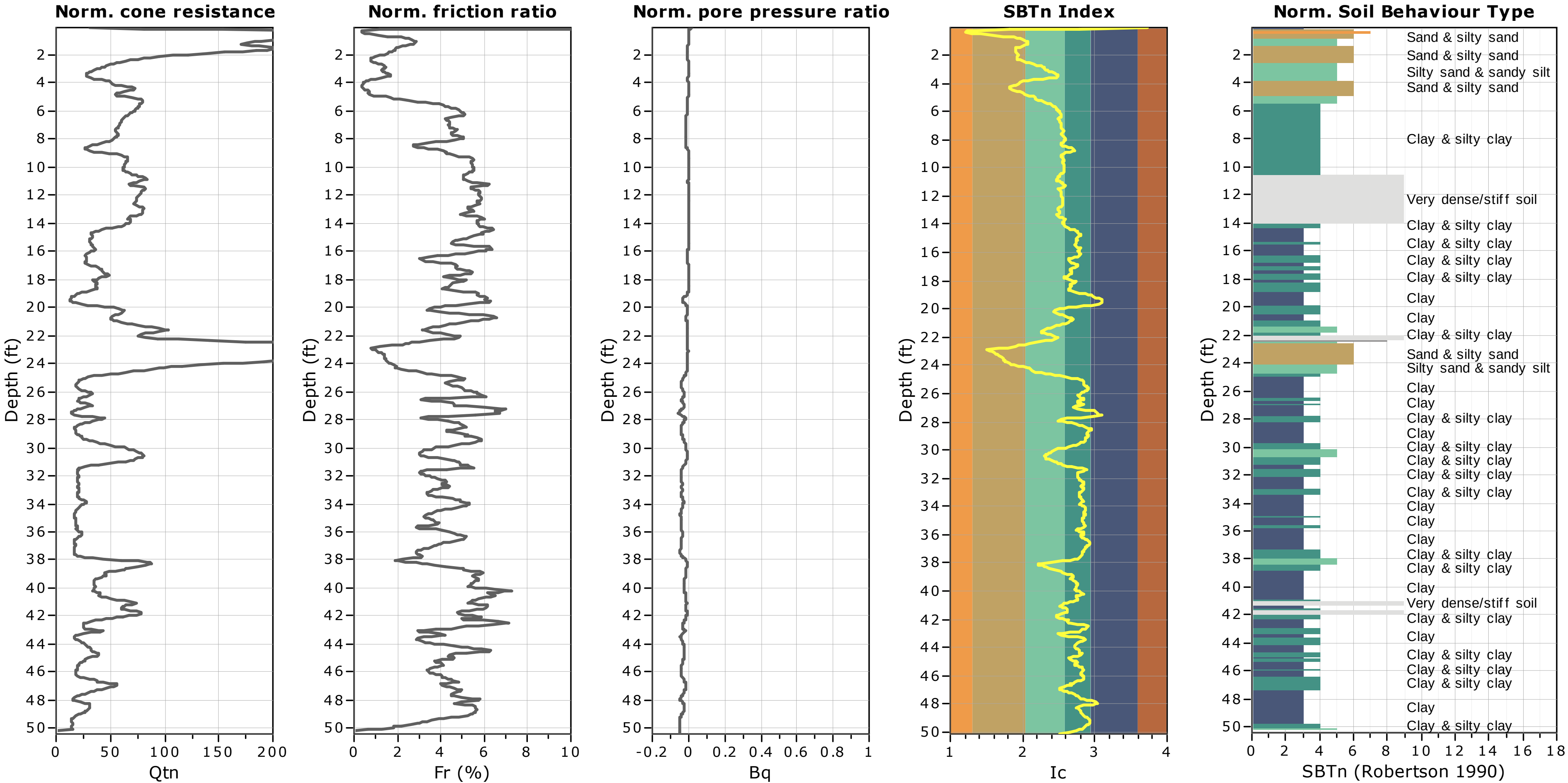
SBT legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty clay
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to clayey sand
⬜ 9. Very stiff fine grained

CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:

Location:



SBTn legend

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

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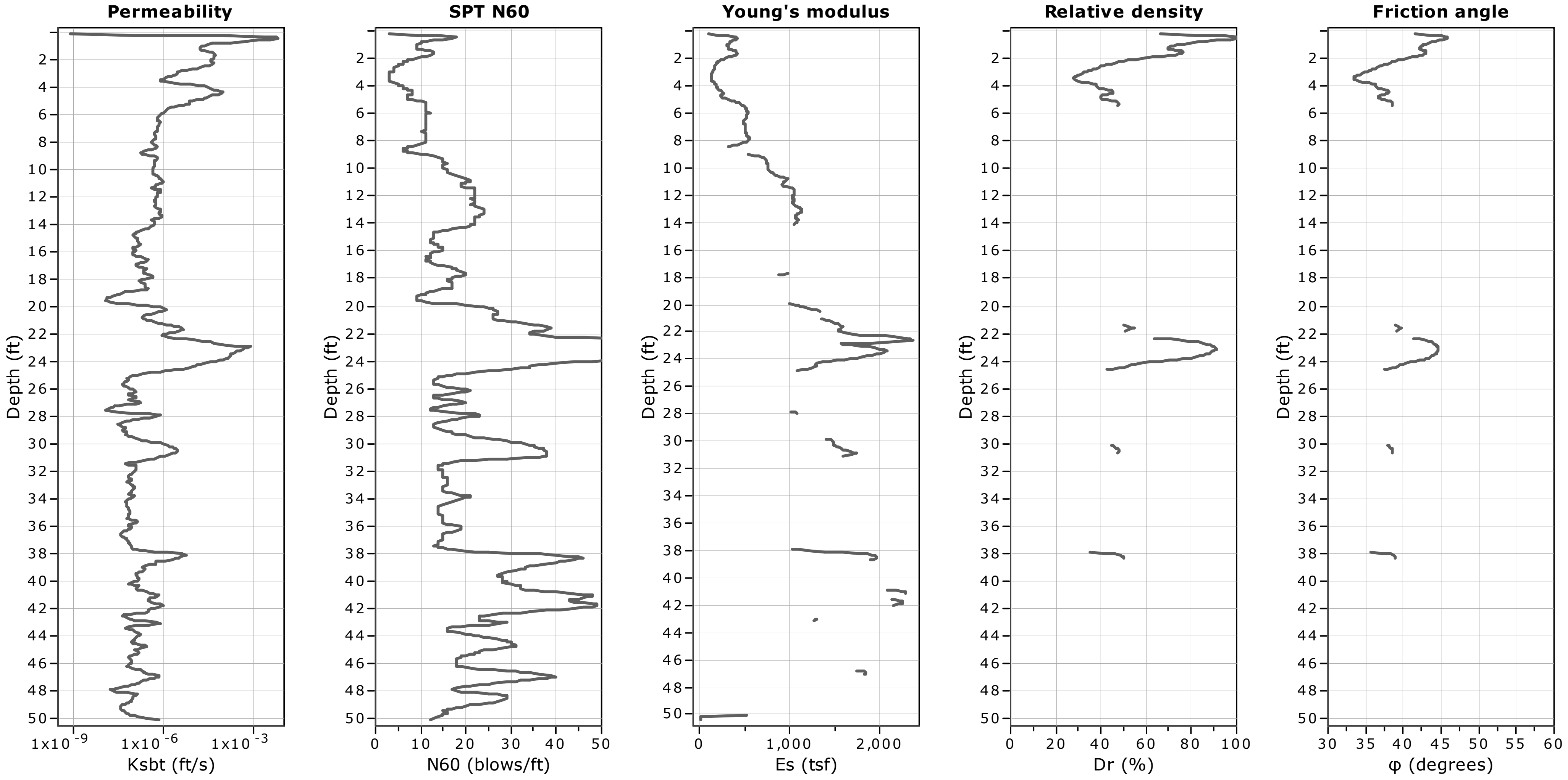
CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

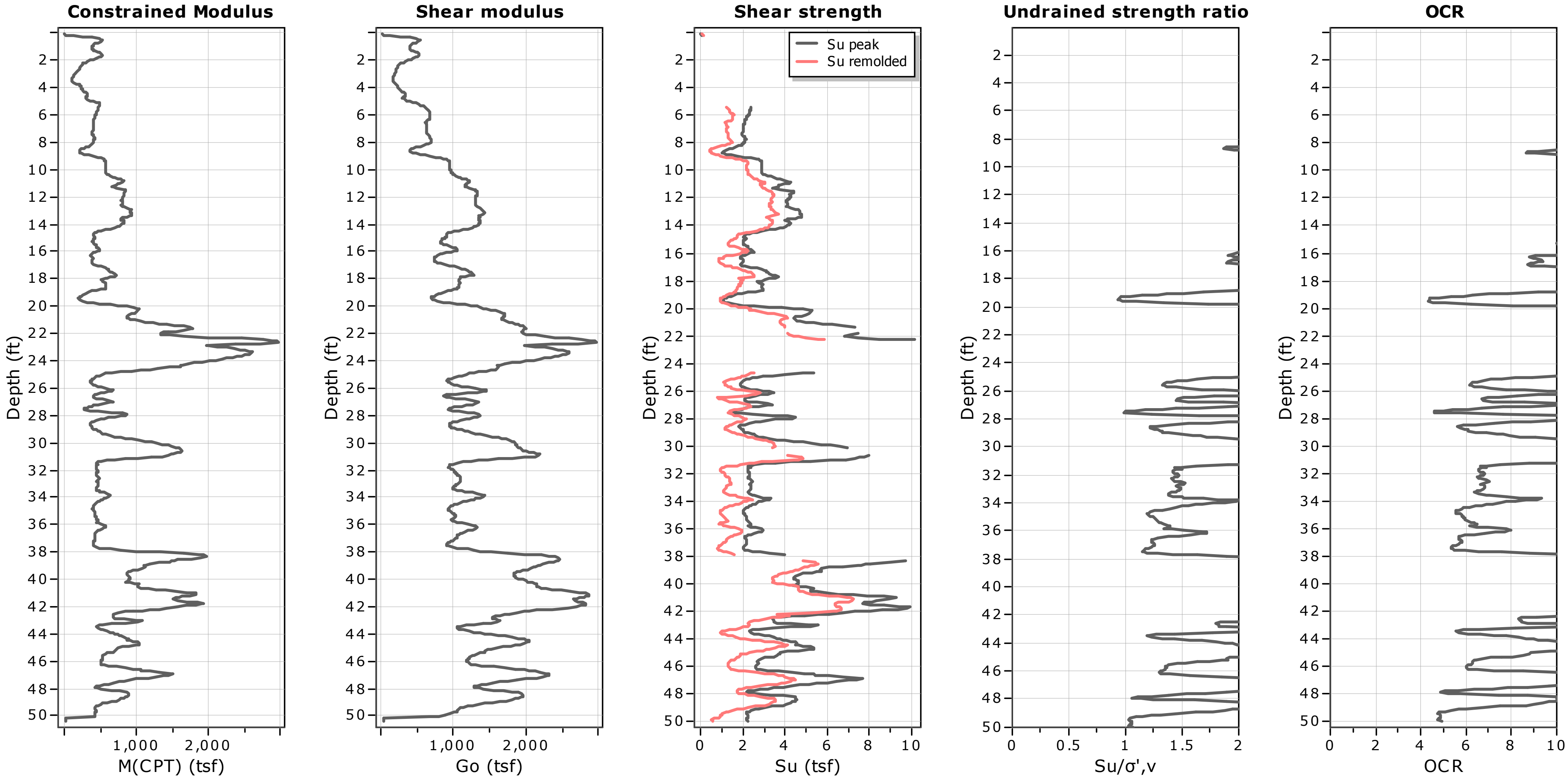
Project:
Location:



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
—●— User defined estimation data

CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

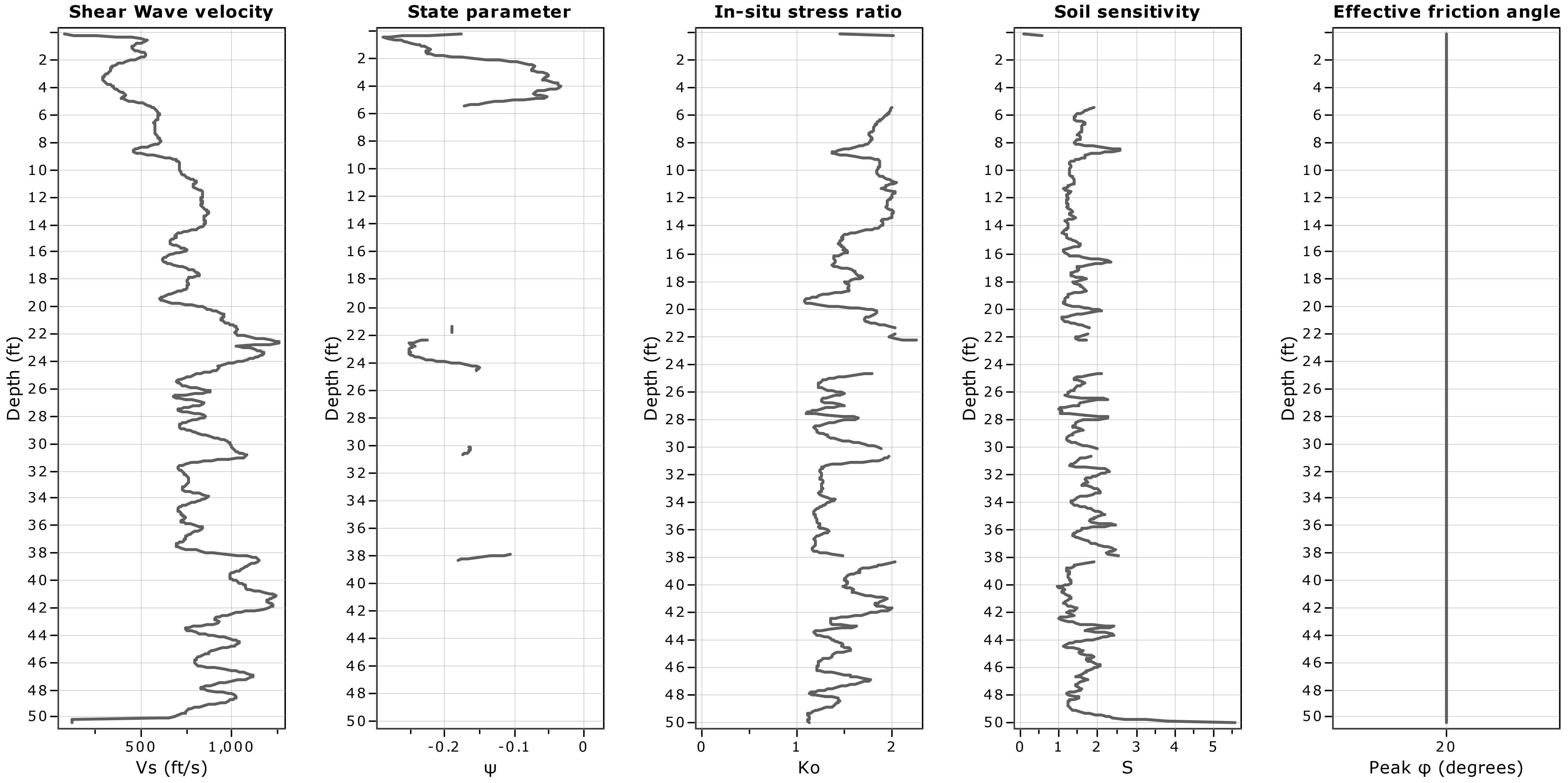


Calculation parameters
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
—●— User defined estimation data

CPT: CPT-01
Total depth: 50.39 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

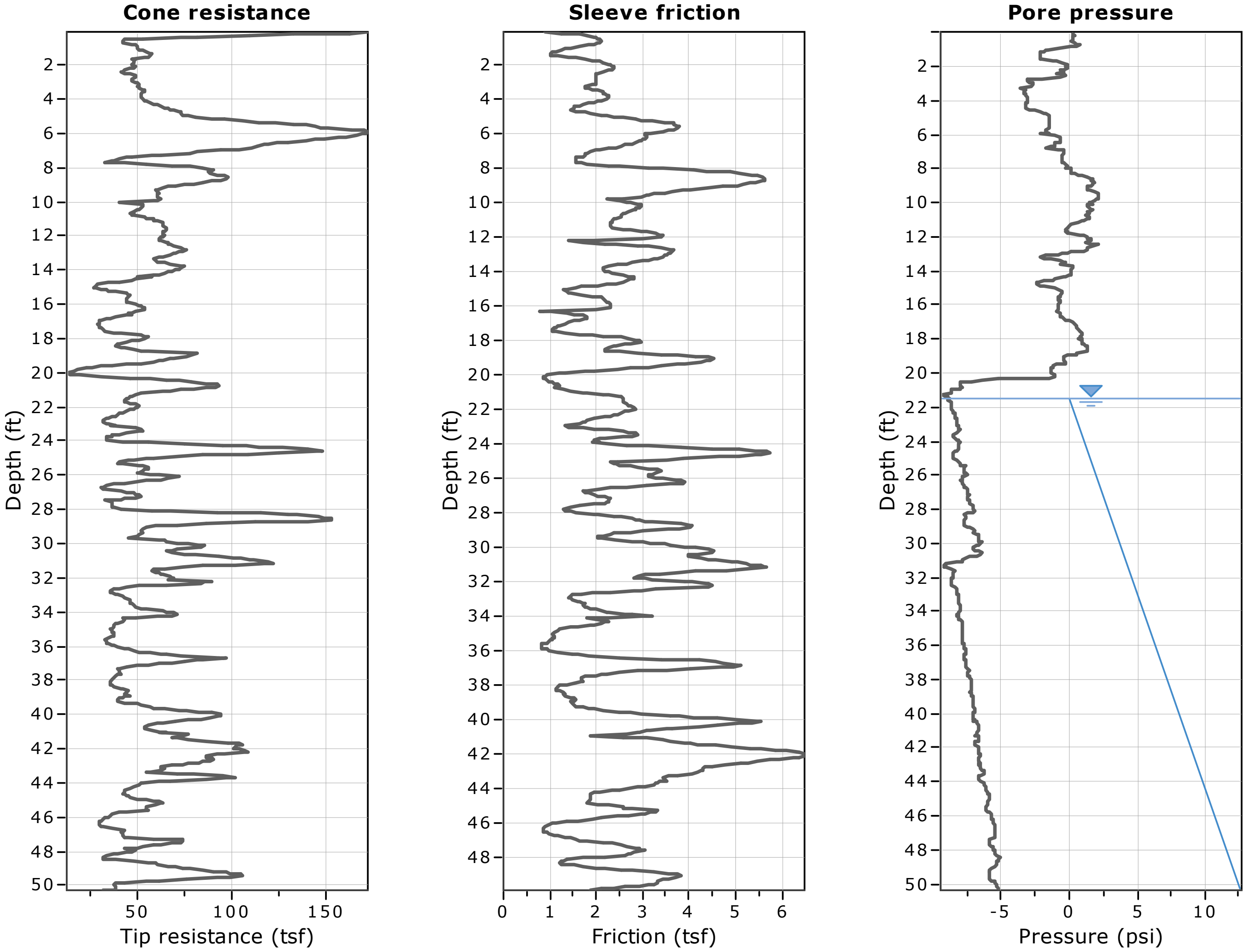


Calculation parameters

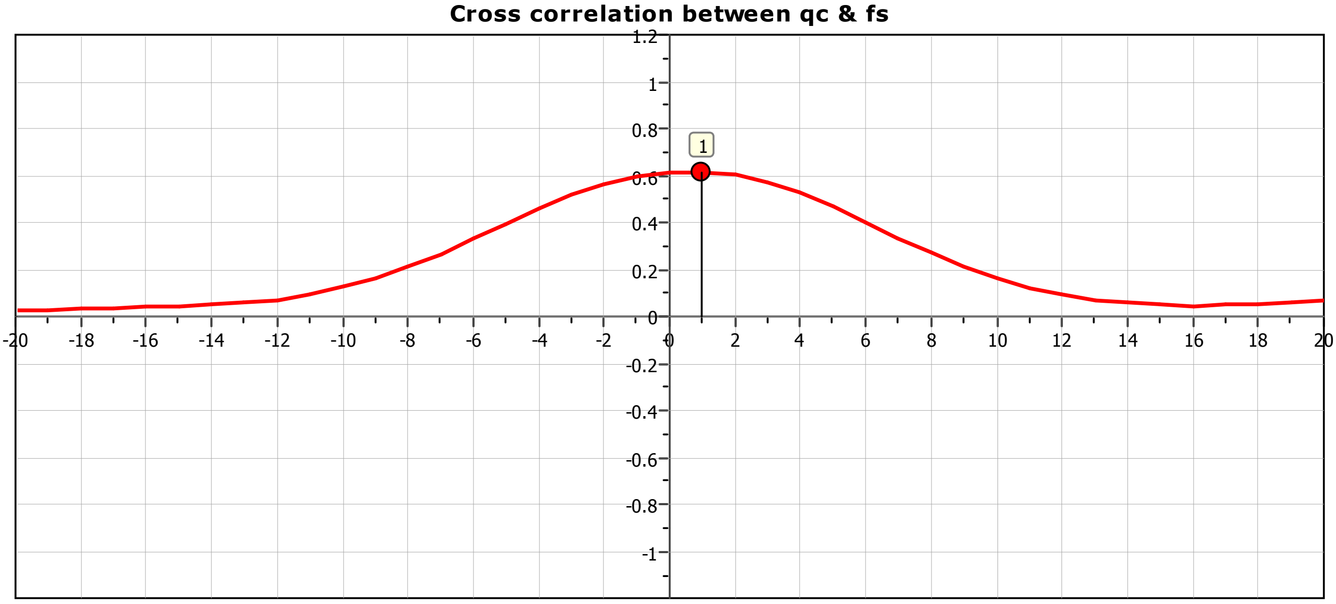
Soil Sensitivity factor, N_S: 7.00
● User defined estimation data

CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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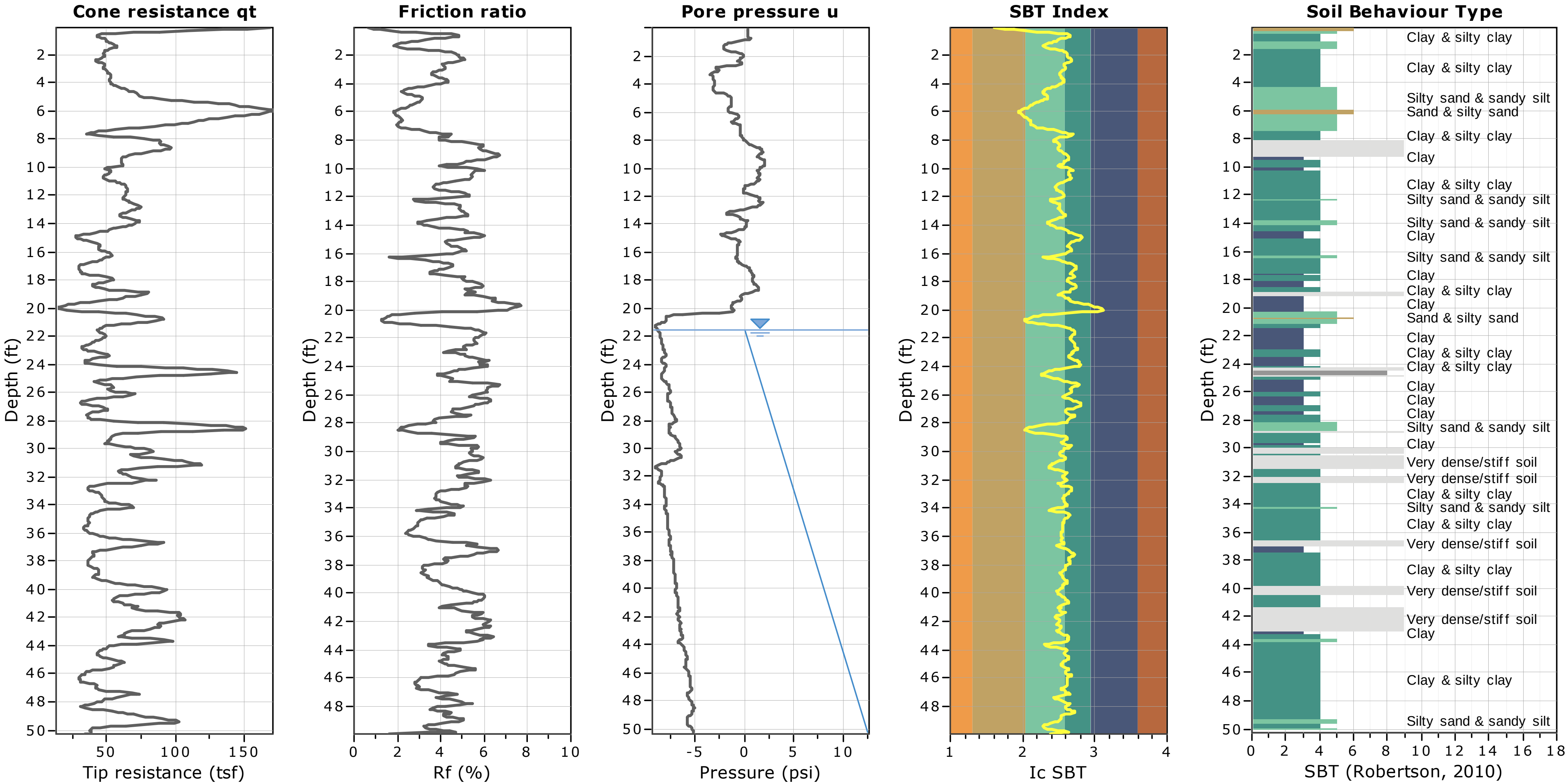
Project:
Location:

CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

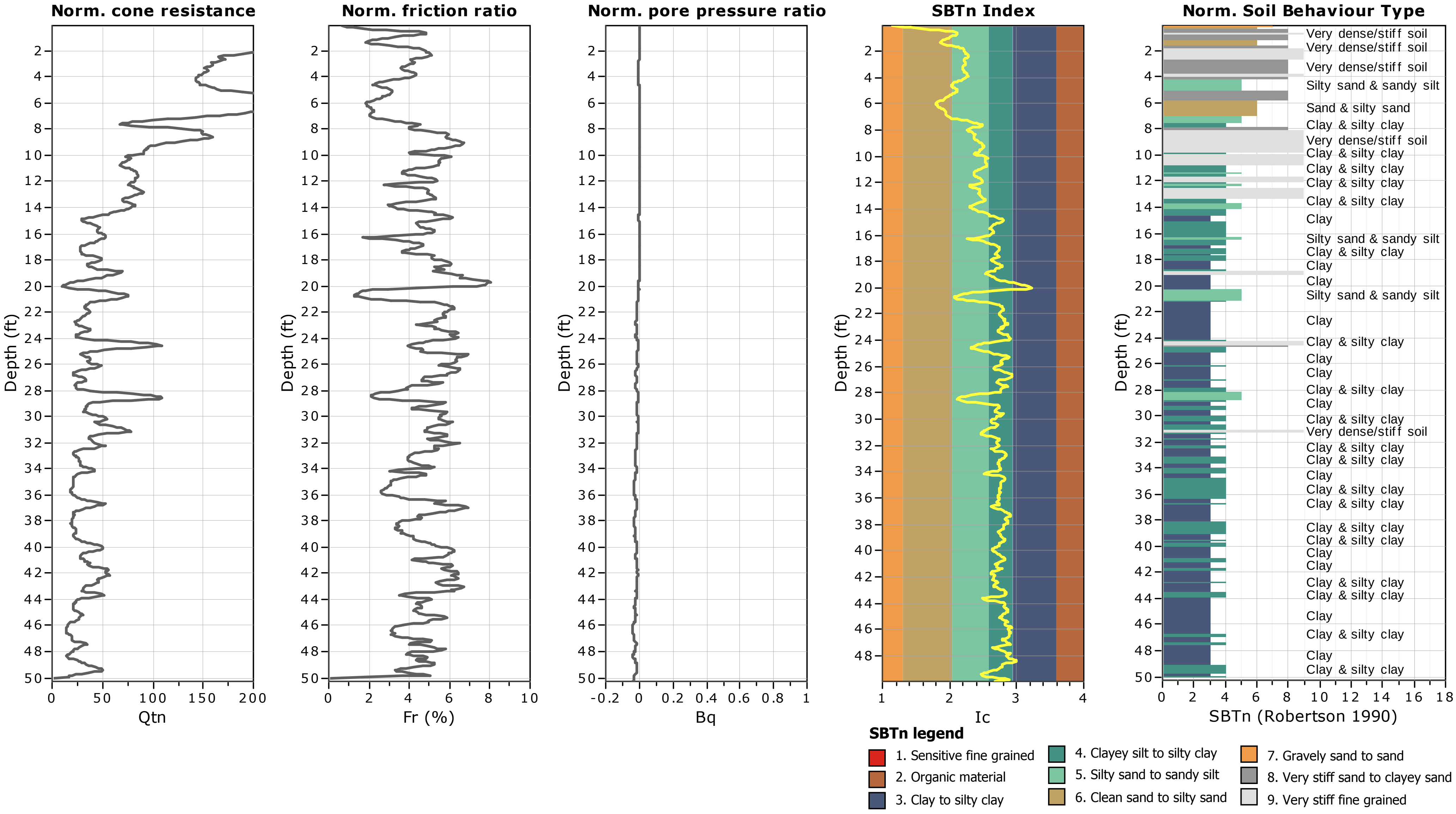


SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty clay	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to clayey sand
🟦 3. Clay to silty clay	🟨 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

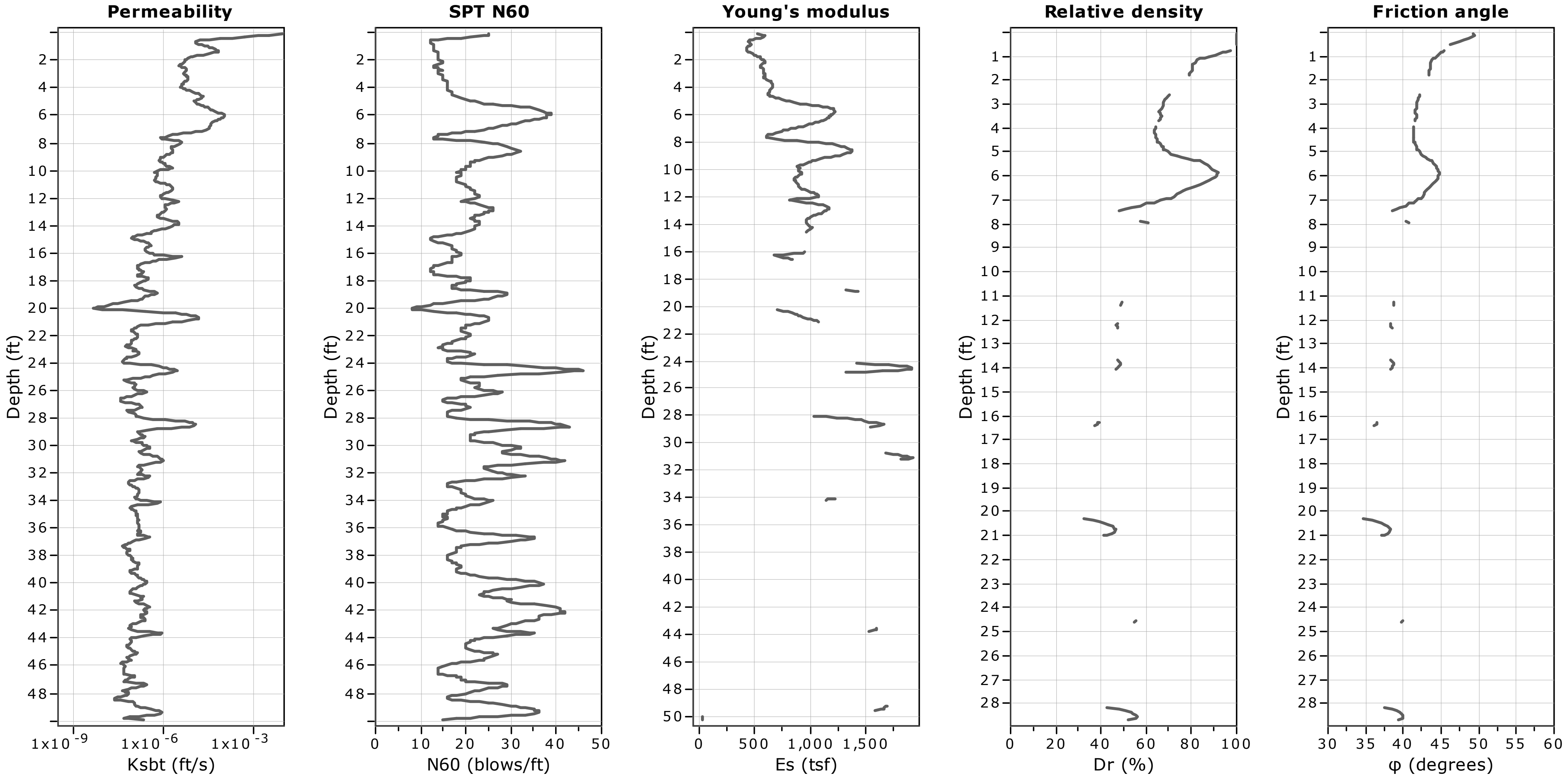
CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
● User defined estimation data

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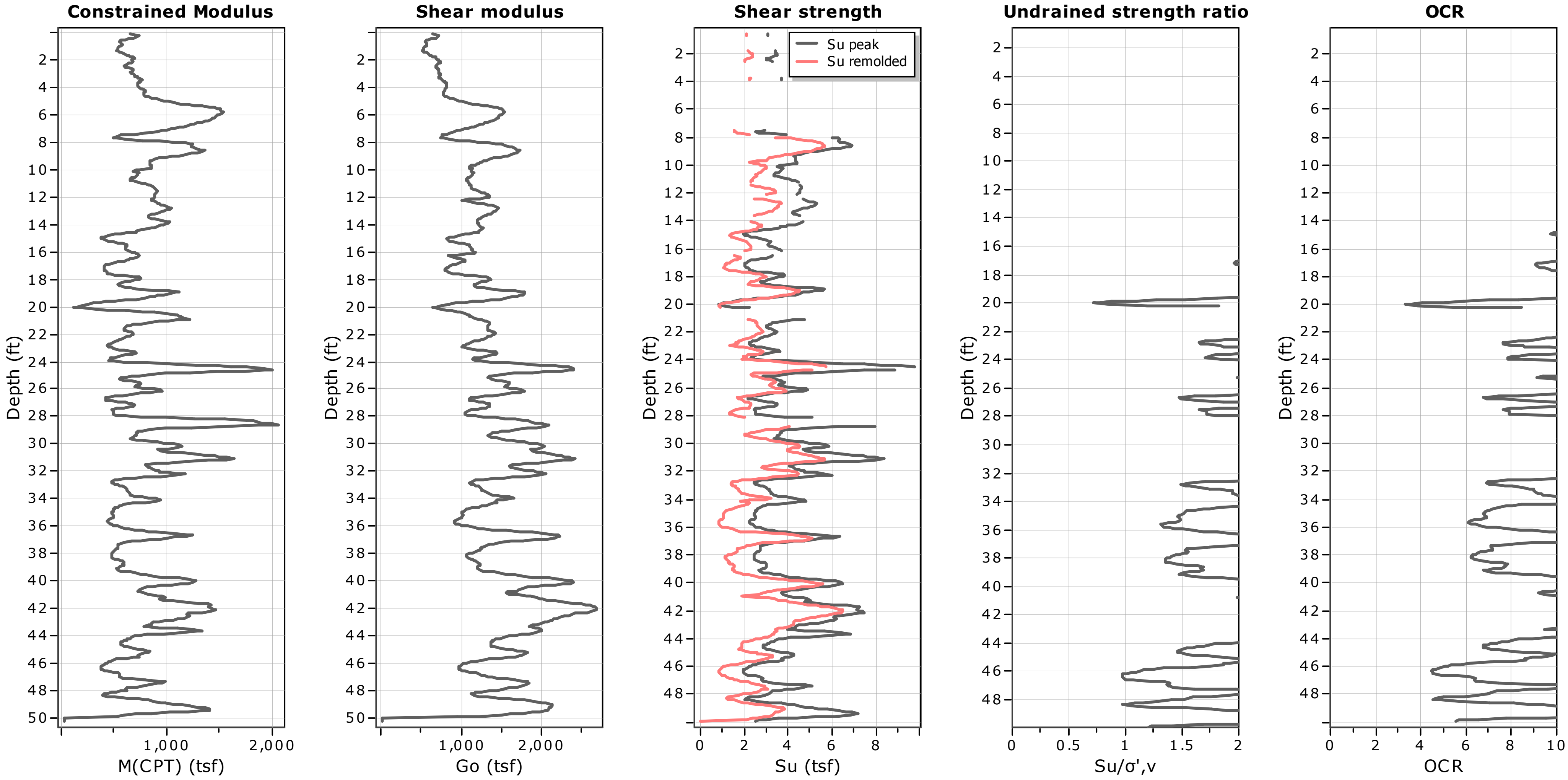
CPT: CPT-02
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

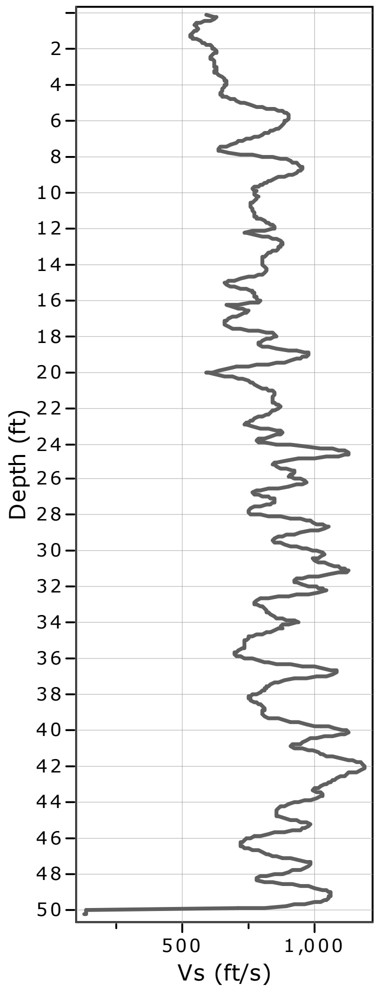
Project:
Location:



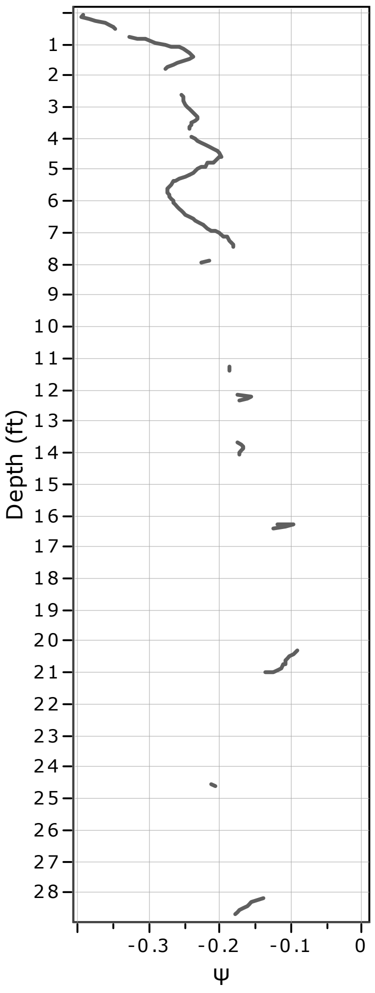
Calculation parameters
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
User defined estimation data

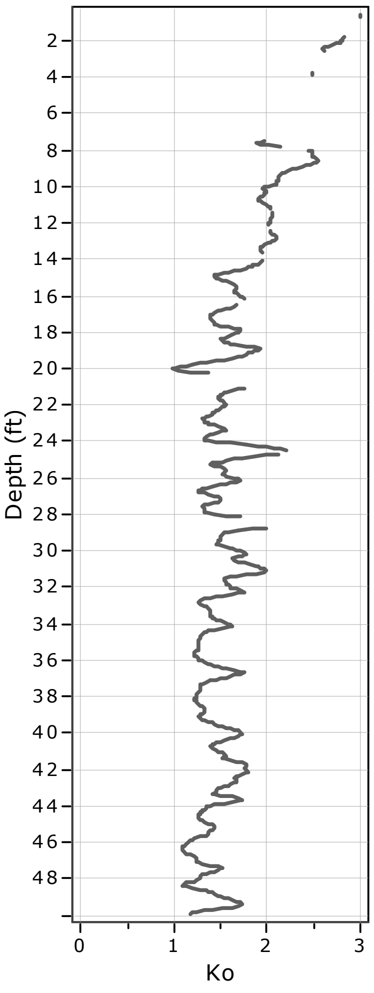
Shear Wave velocity



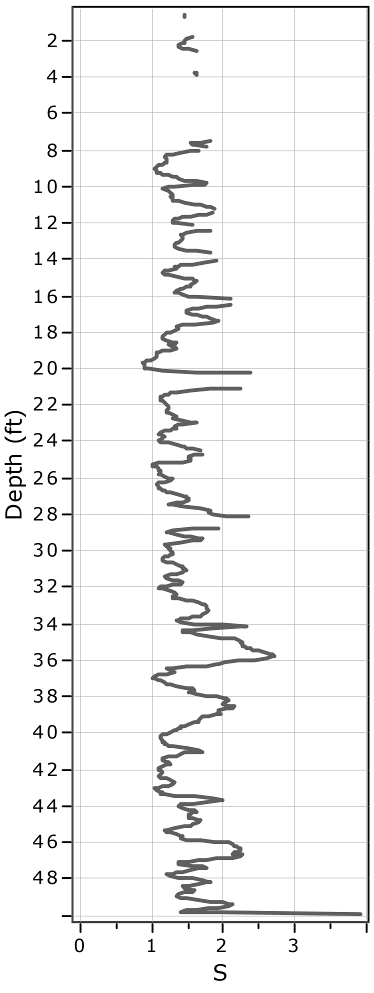
State parameter



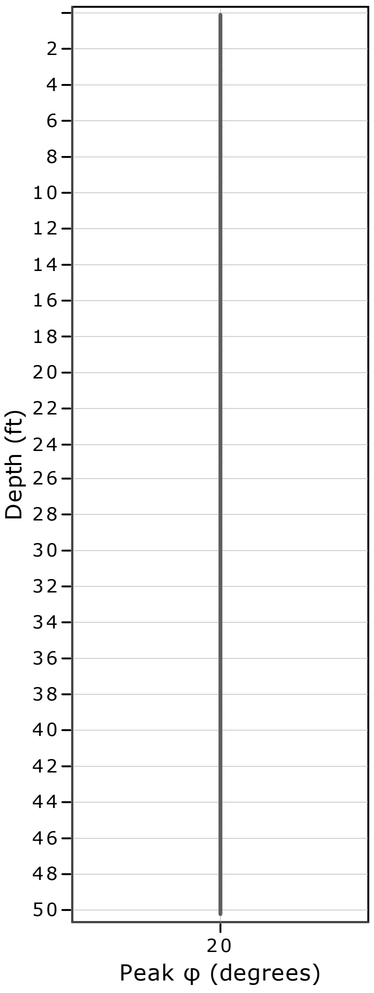
In-situ stress ratio



Soil sensitivity



Effective friction angle



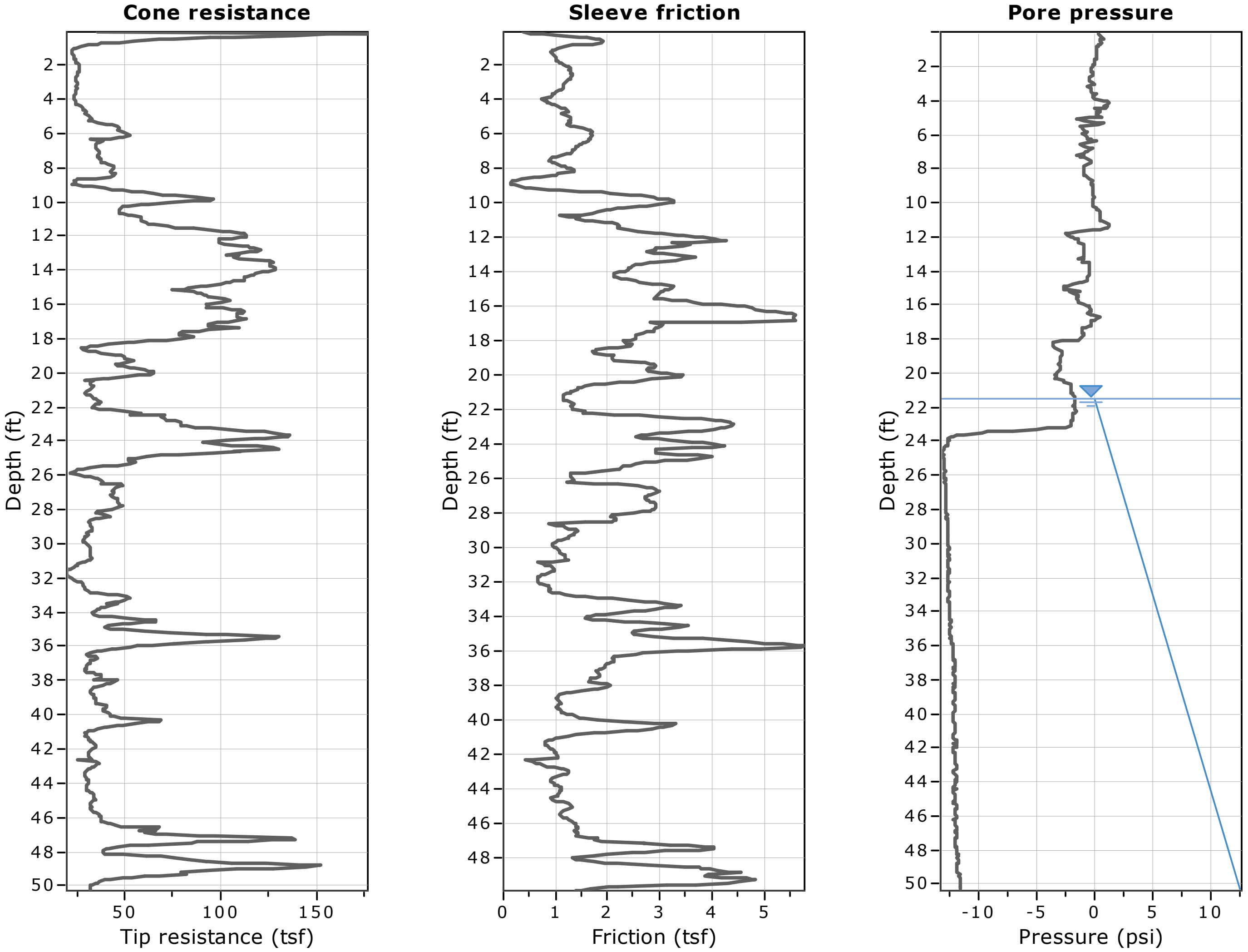
Calculation parameters

Soil Sensitivity factor, N_S: 7.00

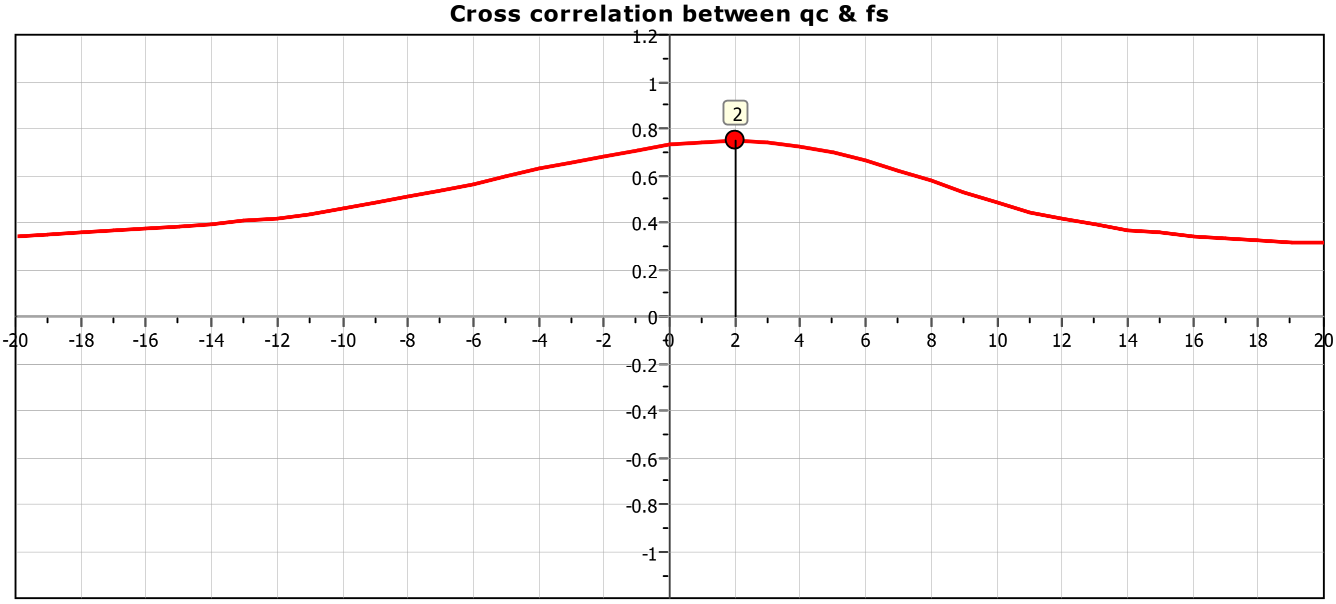
—●— User defined estimation data

CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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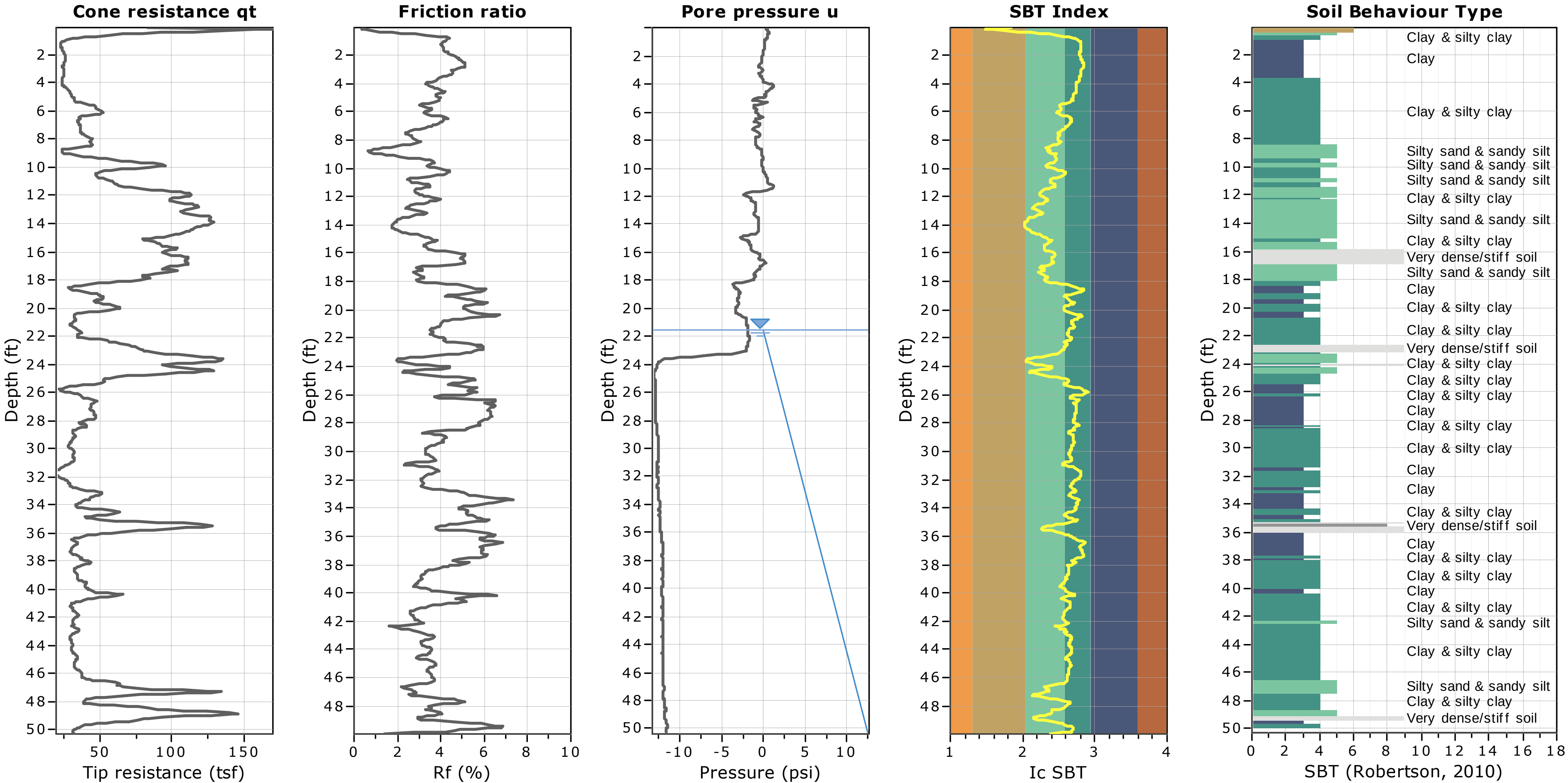
CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



SBT legend

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

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CPT: CPT-03
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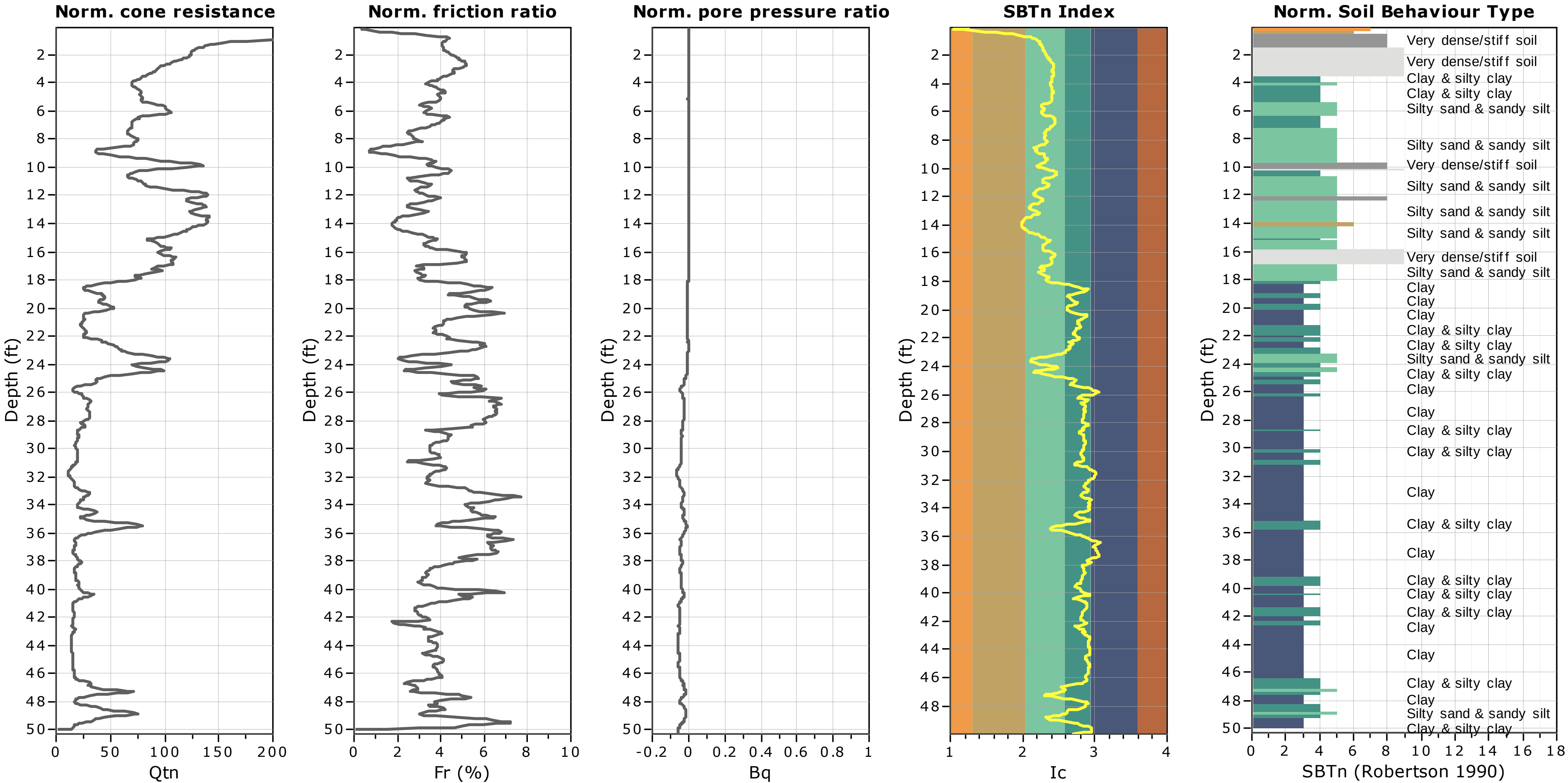
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

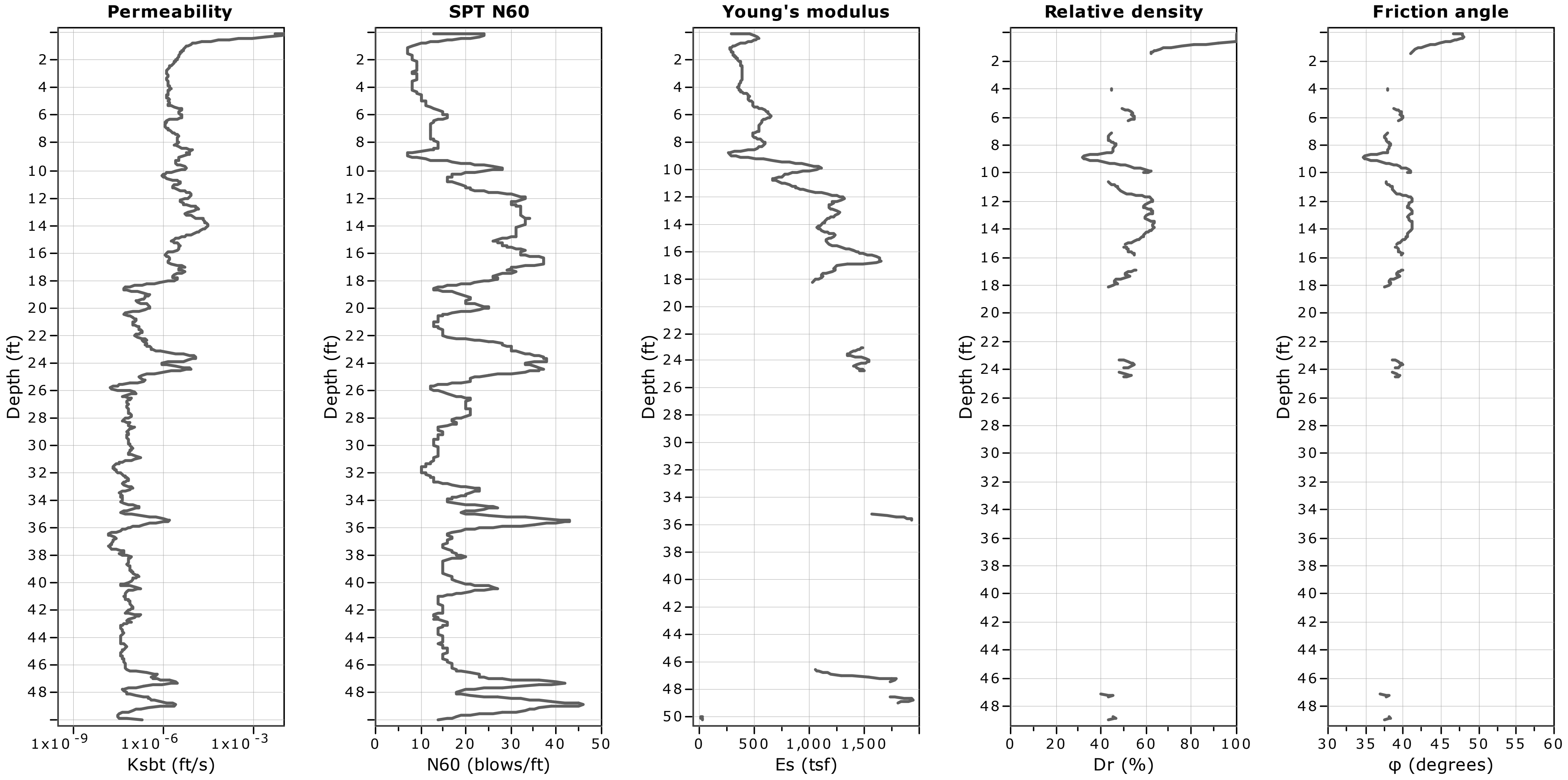


SBTn legend

🟥 1. Sensitive fine grained
🟫 2. Organic material
🟦 3. Clay to silty clay
🟩 4. Clayey silt to silty clay
🟩 5. Silty sand to sandy silt
🟨 6. Clean sand to silty sand
🟧 7. Gravely sand to sand
⬛ 8. Very stiff sand to clayey sand
⬜ 9. Very stiff fine grained

CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

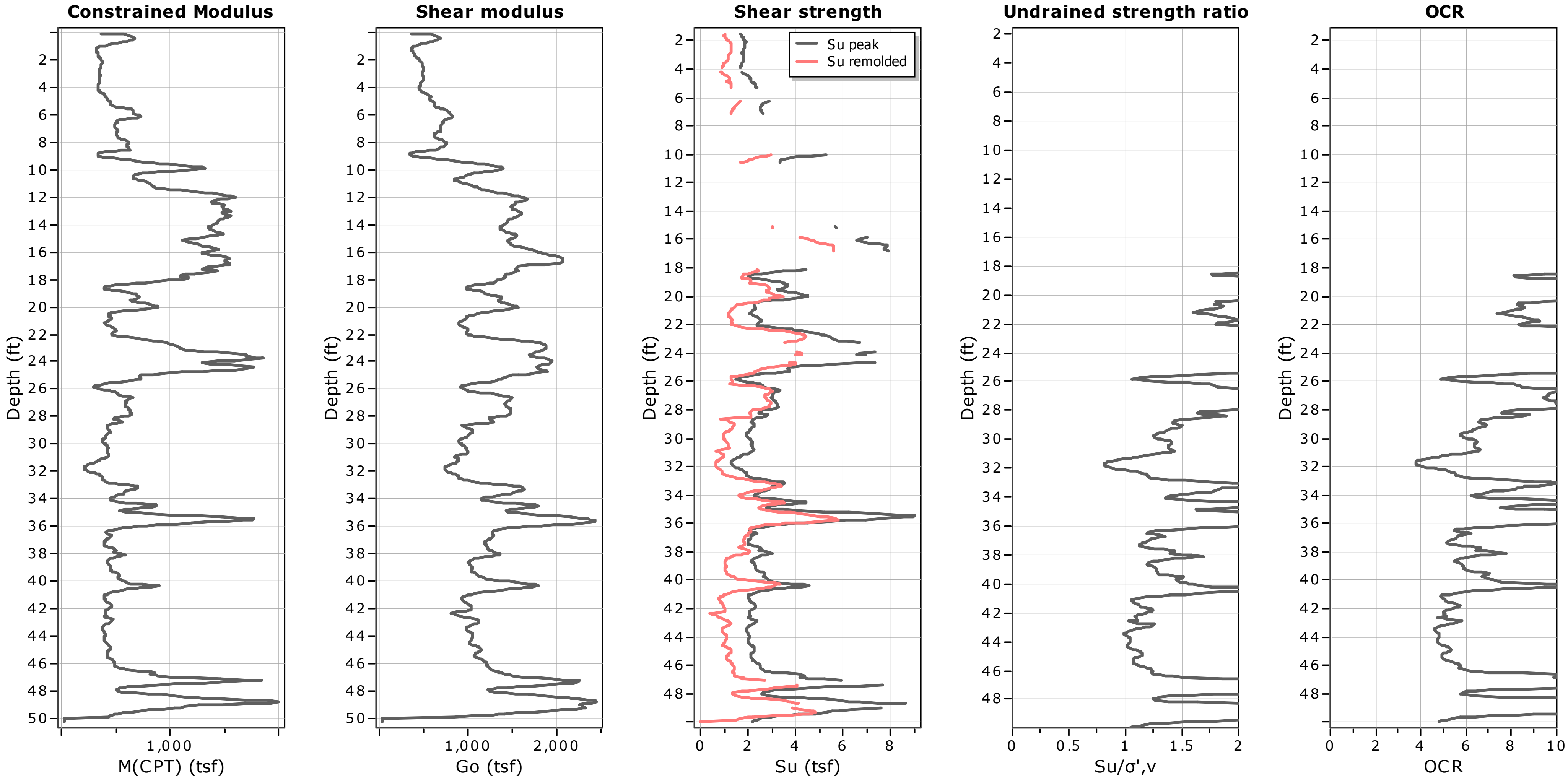
Project:
Location:



Calculation parameters
Permeability: Based on SBT$_n$
SPT N$_{60}$: Based on I$_c$ and q$_t$
Young's modulus: Based on variable alpha using I$_c$ (Robertson, 2009)
Relative desnisty constant, C$_{Dr}$: 350.0
Phi: Based on Kulhawy & Mayne (1990)
● User defined estimation data

CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



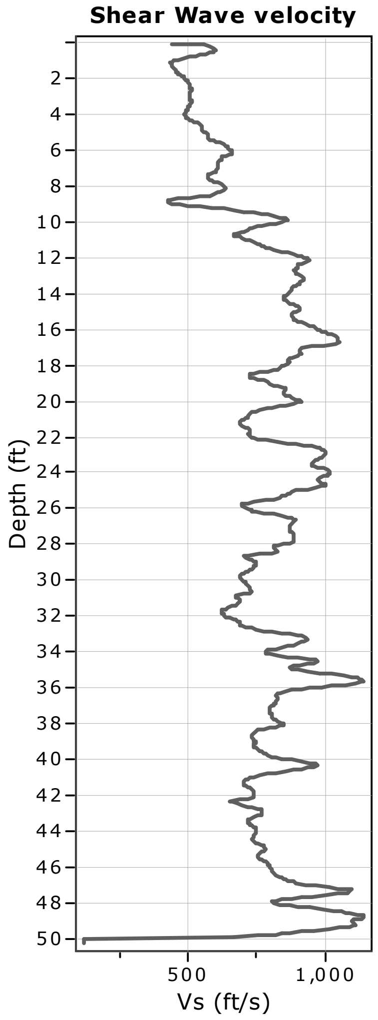
Calculation parameters

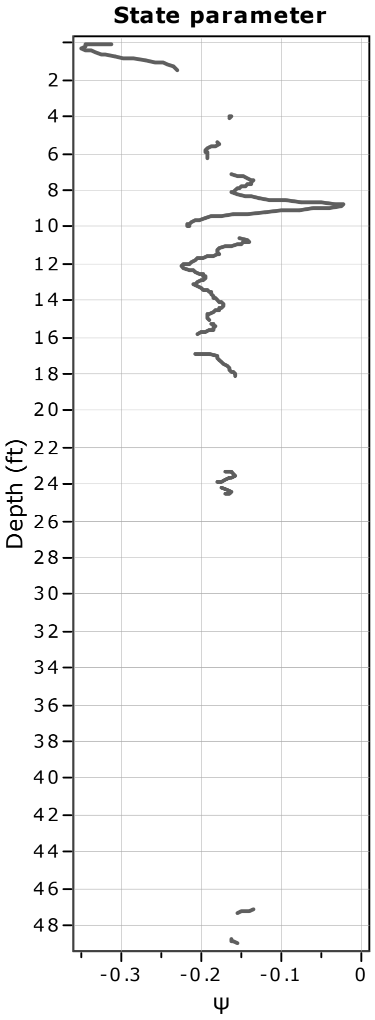
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

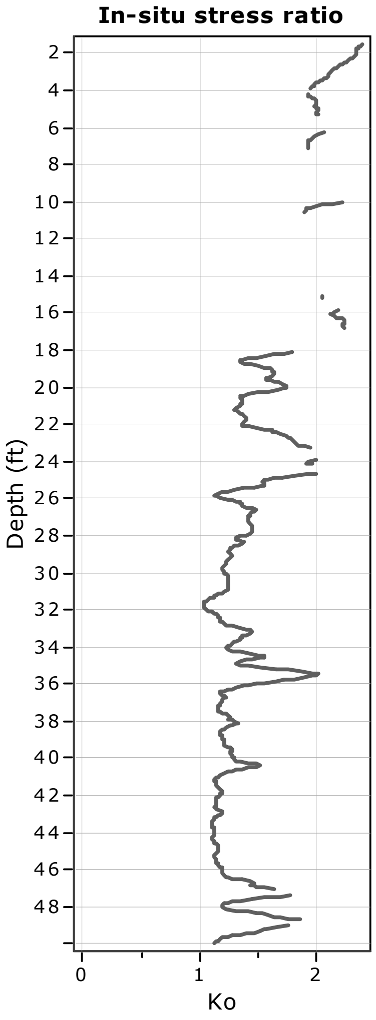
OCR factor for clays, N_{kt}: 0.33
● User defined estimation data

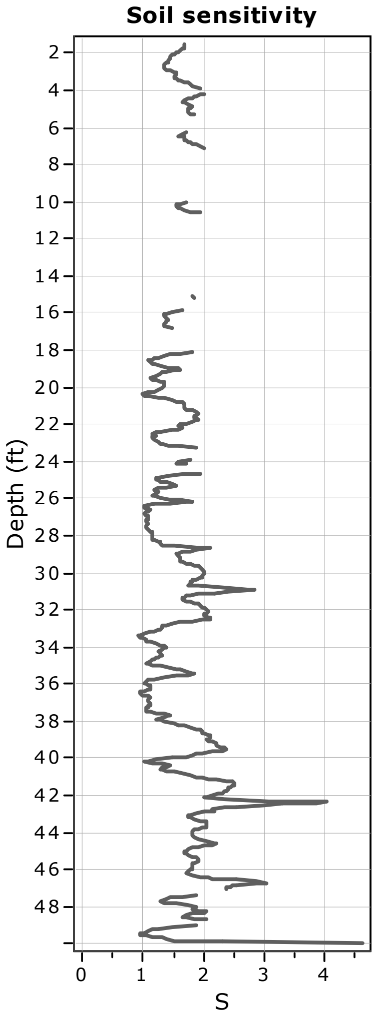
CPT: CPT-03
Total depth: 50.27 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

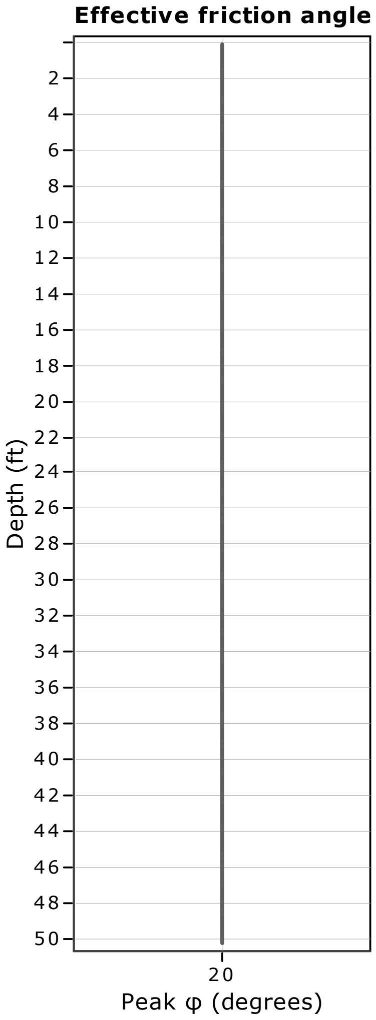
Project:
Location:


Shear Wave velocity


State parameter


In-situ stress ratio


Soil sensitivity


Effective friction angle

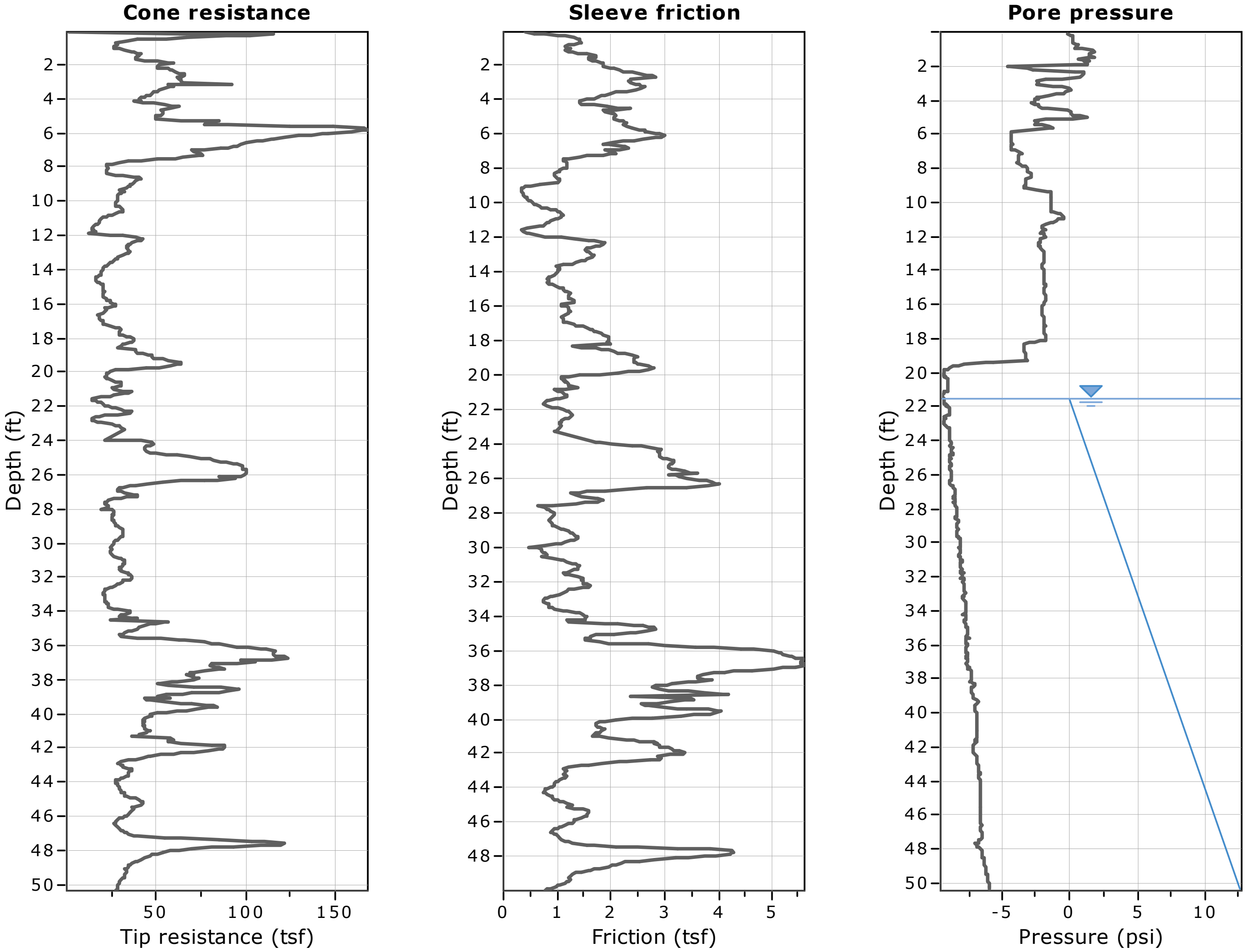
Calculation parameters

Soil Sensitivity factor, N_S: 7.00

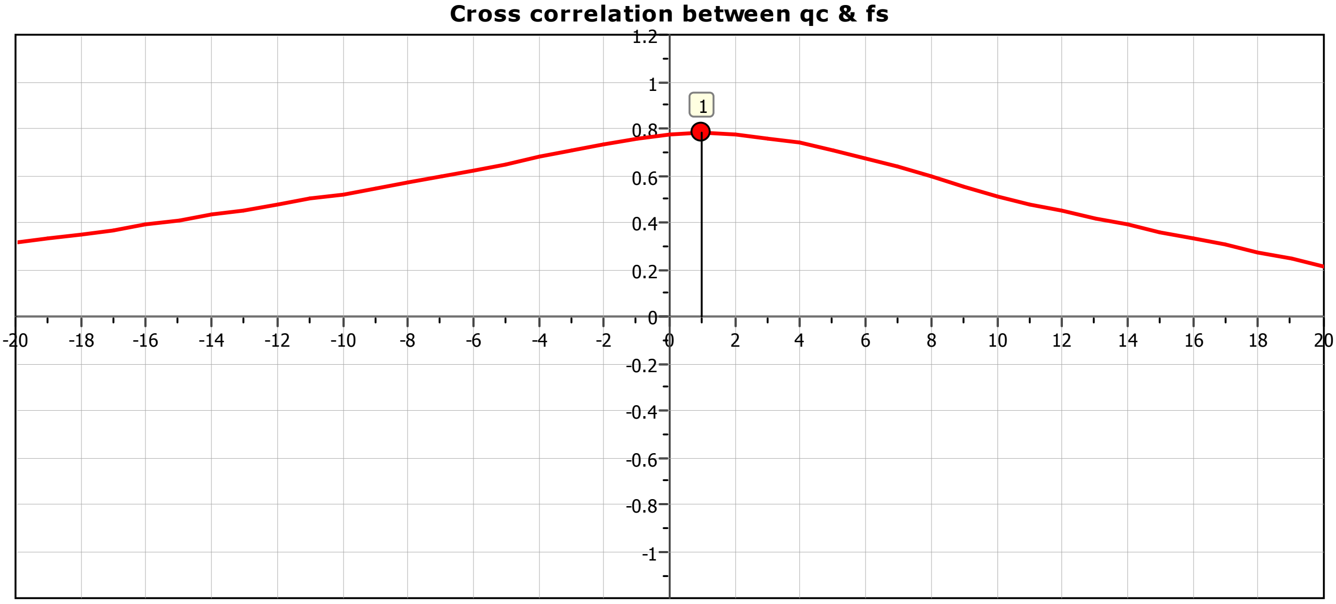
● User defined estimation data

CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



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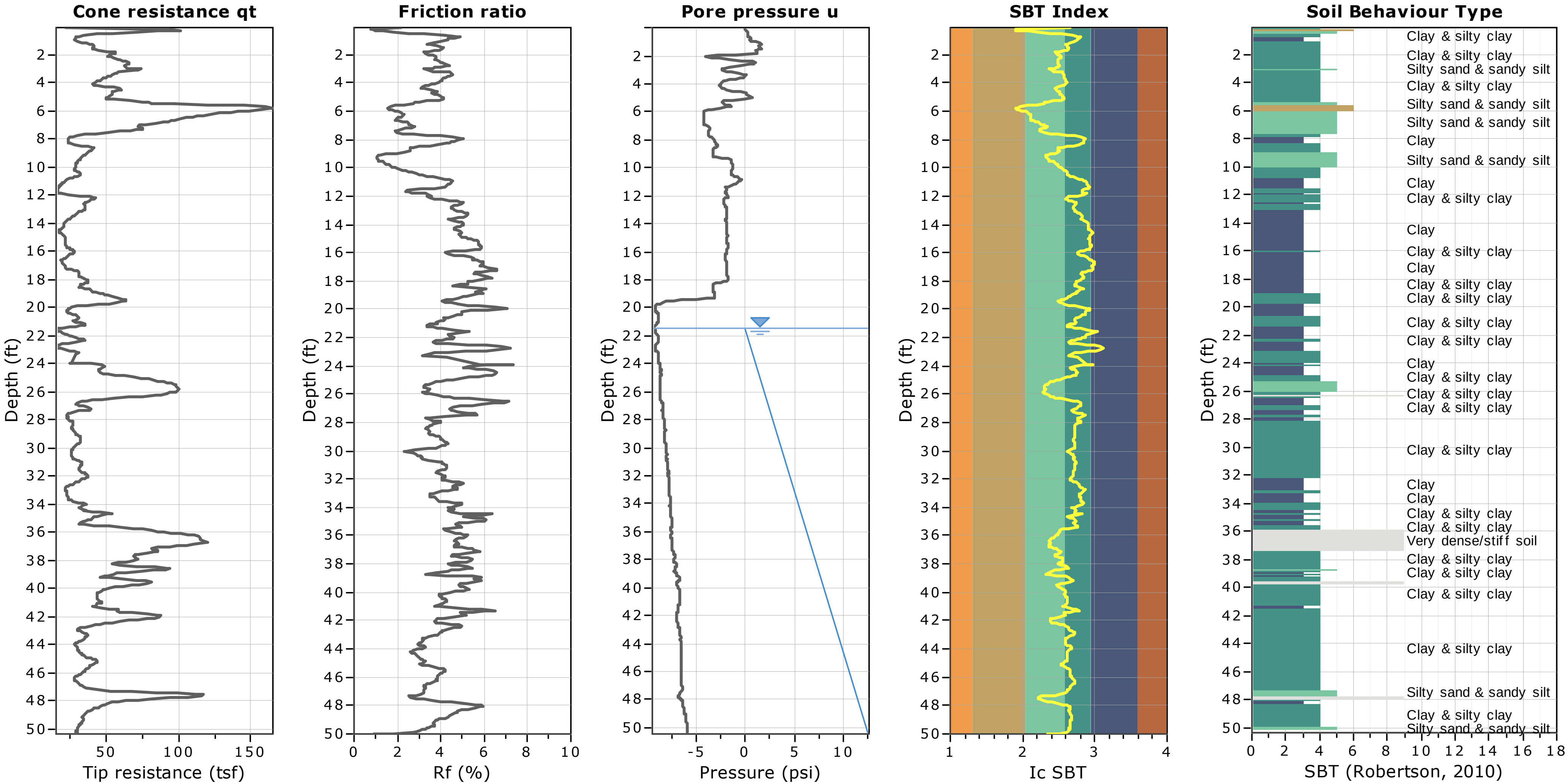
CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

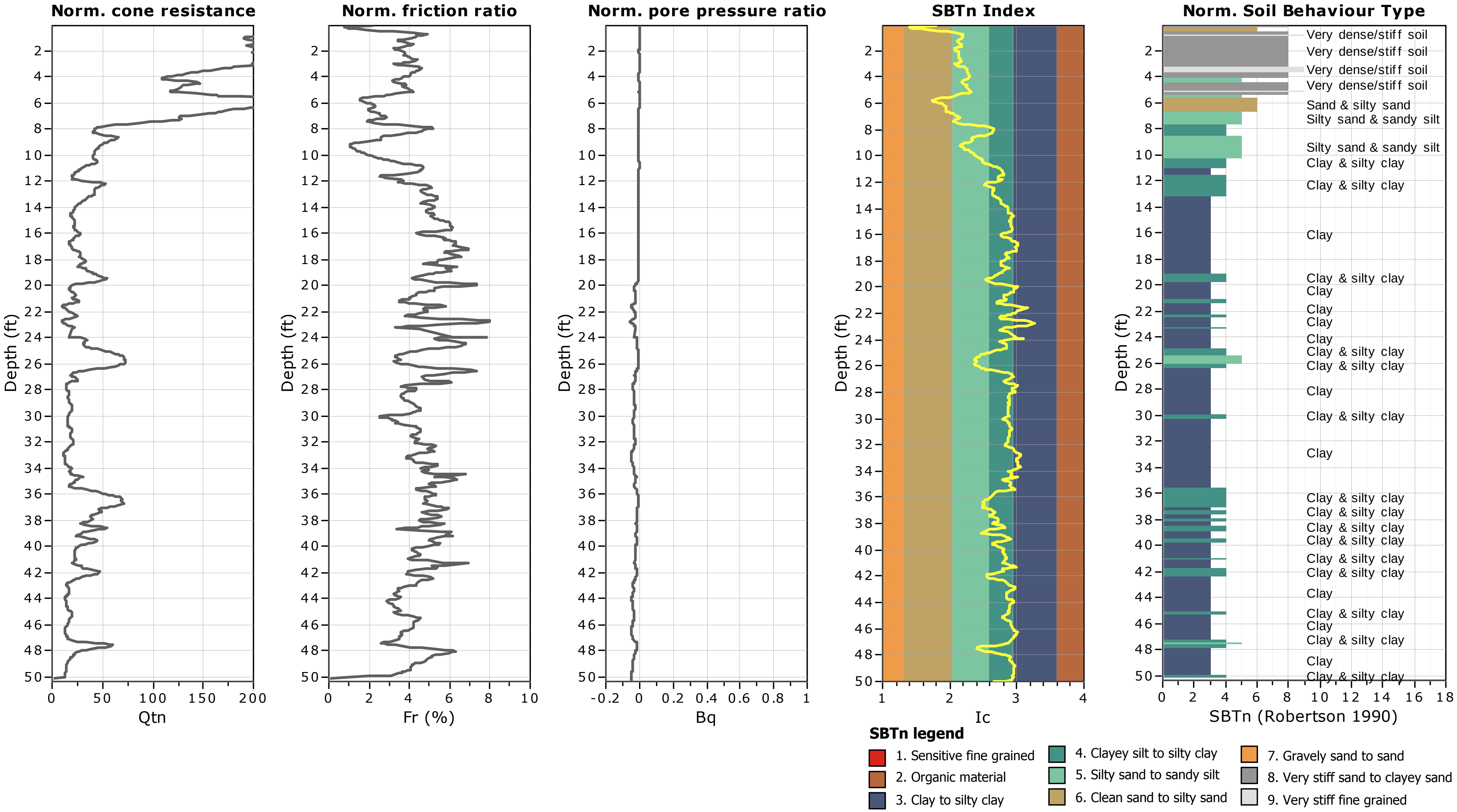


SBT legend
- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty clay
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬜ 8. Very stiff sand to clayey sand
- ⬜ 9. Very stiff fine grained

CPT: CPT-04

Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



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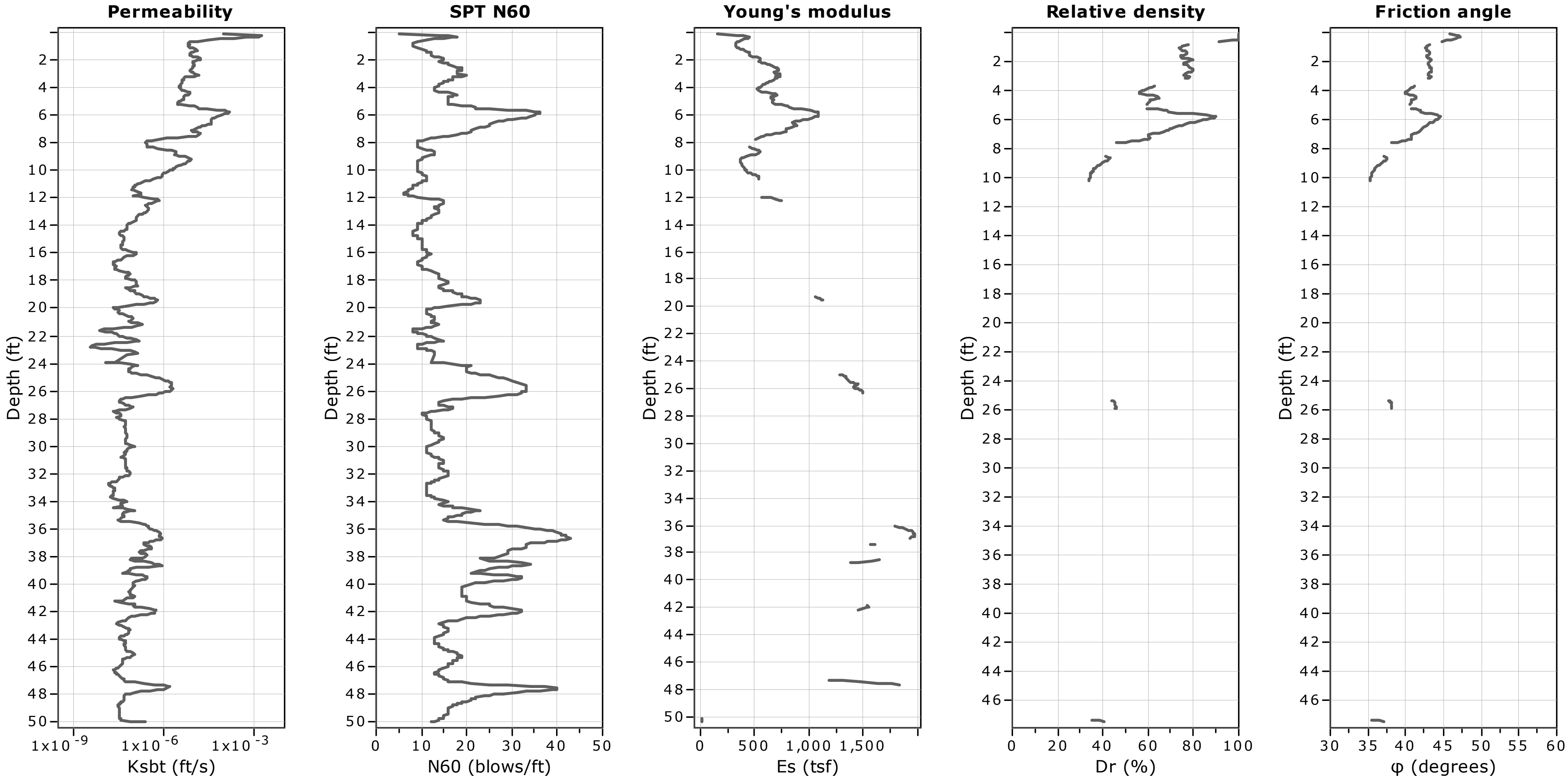
CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

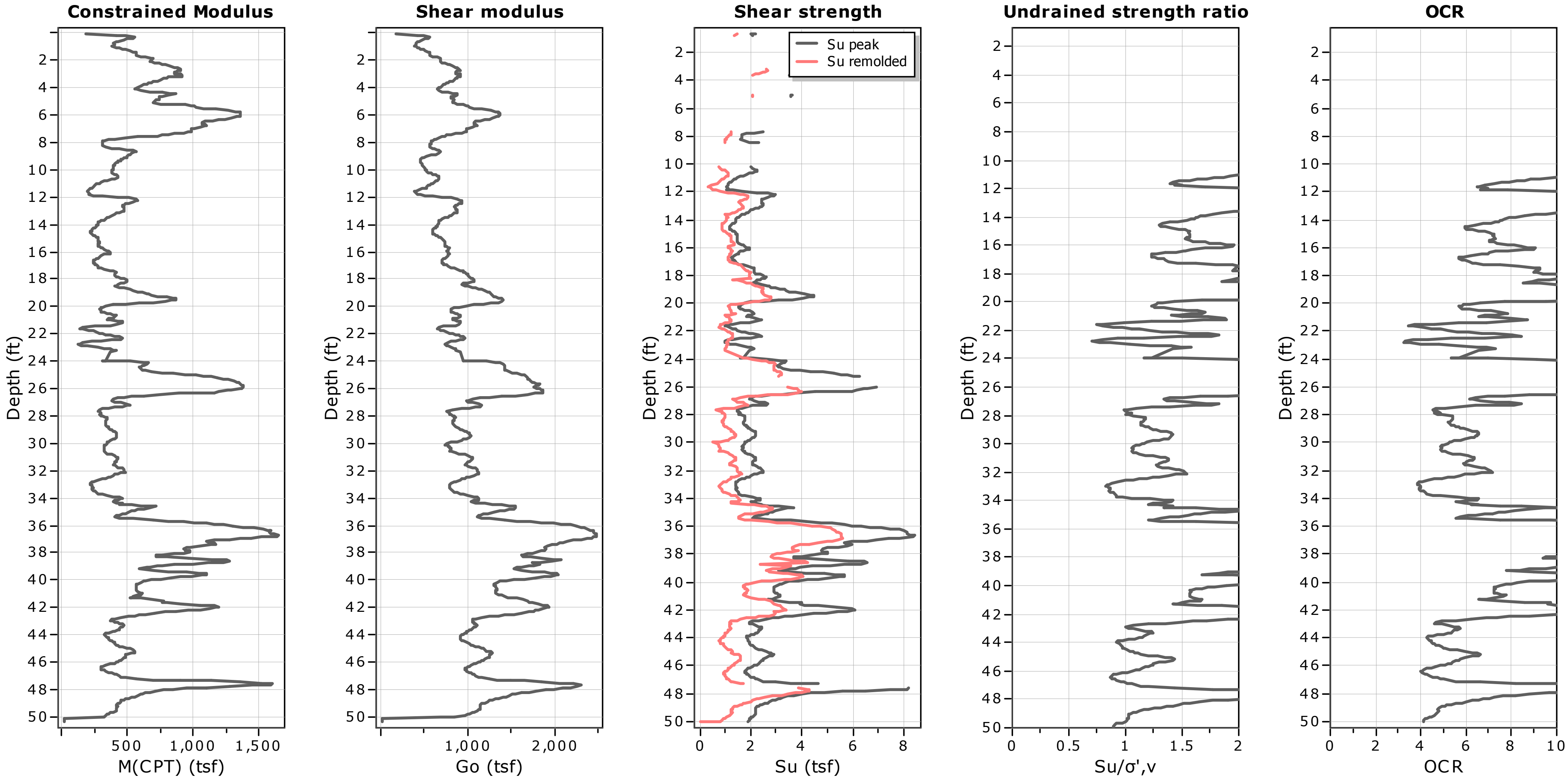
Project:
Location:



Calculation parameters
Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
● User defined estimation data

CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:

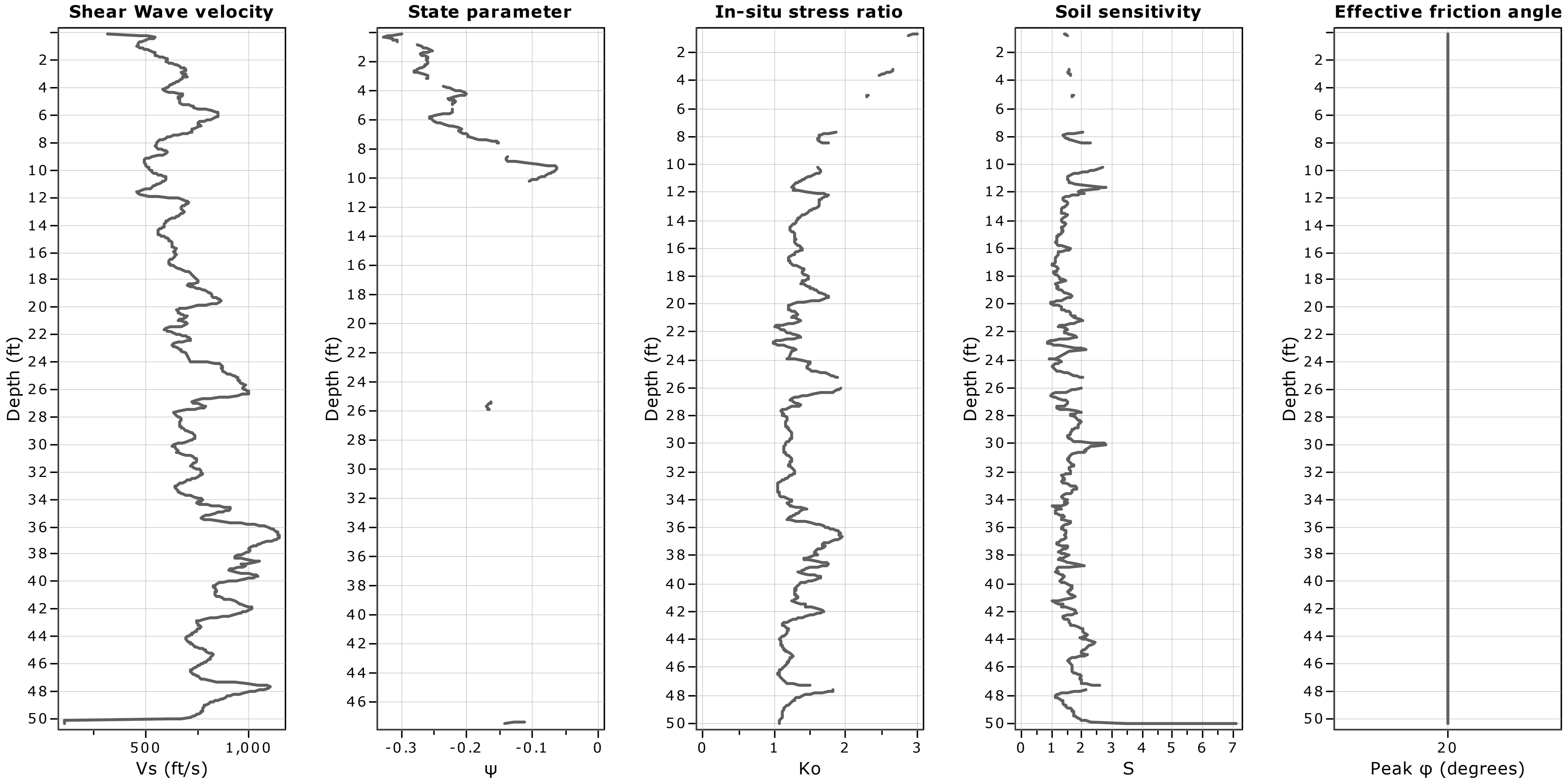


Calculation parameters
Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14

OCR factor for clays, N_{kt}: 0.33
●— User defined estimation data

CPT: CPT-04
Total depth: 50.34 ft, Date: 10/31/2022
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project:
Location:



Calculation parameters

Soil Sensitivity factor, N_S: 7.00
● User defined estimation data

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952\text{-}3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52\text{-}1.37 \cdot I_c}$

:: N$_{SPT}$ (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$$

(applicable only to SBT$_n$: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

:: Peak drained friction angle, φ (°) ::

$$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT$_n$: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT$_n$: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT$_n$: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot + 7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$$OCR = k_{OCR} \cdot Q_{tn}$$

(applicable only to SBT$_n$: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT$_n$: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S$_t$ ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT$_n$: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$$\varphi' = 29.5^\circ \cdot B_q^{0.121} \cdot \left(0.256 + 0.336 \cdot B_q + \log Q_t\right)$$

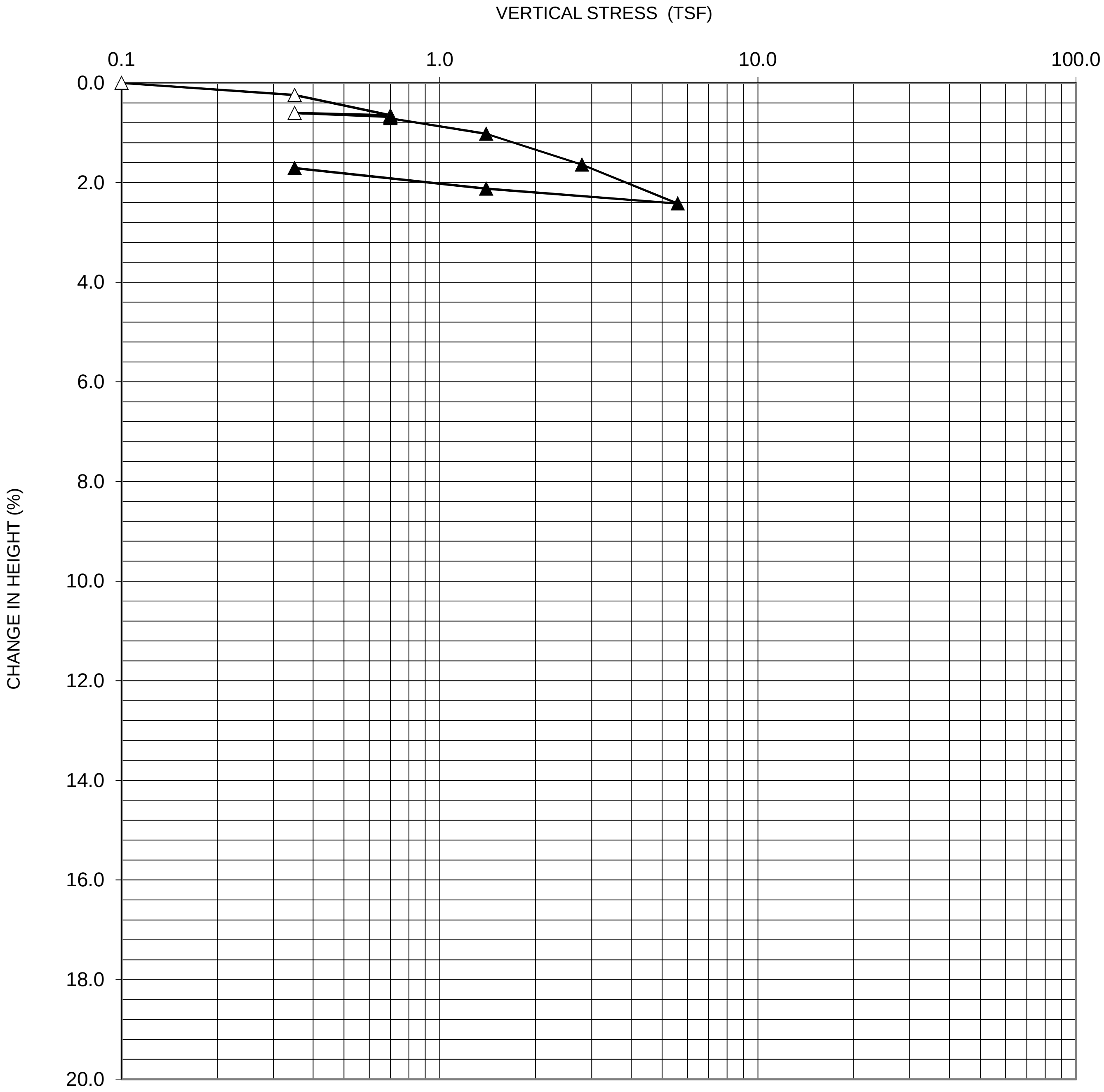
(applicable for $0.10 < B_q < 1.00$)

References

- Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012
- Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)

APPENDIX C

SUMMARY OF LABORATORY TEST RESULTS



PROJECT NO.: 22027-00

SOIL DESCRIPTIONS: DK. BR. SILTY FINE SAND W/ TRACE OF CLAY (SM)

BORING NO./LOCATION : KB - 1

DEPTH / ELEV. : 15'

LIQUID LIMIT : -

SPECIFIC GRAVITY : 2.68 (Assumed)

PLASTIC LIMIT: -

REMARKS :

	SPECIMEN HEIGHT (INCHES)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SATURATION (%)	VOID RATIO
INITIAL	1.0000	15.3	112.7	85.0	0.484
FINAL	0.9829	16.7	114.6	97.3	0.459

CONSOLIDATION TEST CURVE

Project Name : PICERNE GARDENA
Project No. : 22027-00
Boring / Sample No : KB - 1
Depth : 22.5' (ft.)
Tested By : RB
Date: 7-Oct-22
Sample Descriptions / Classification : DK. BROWN SANDY CLAY (CL)

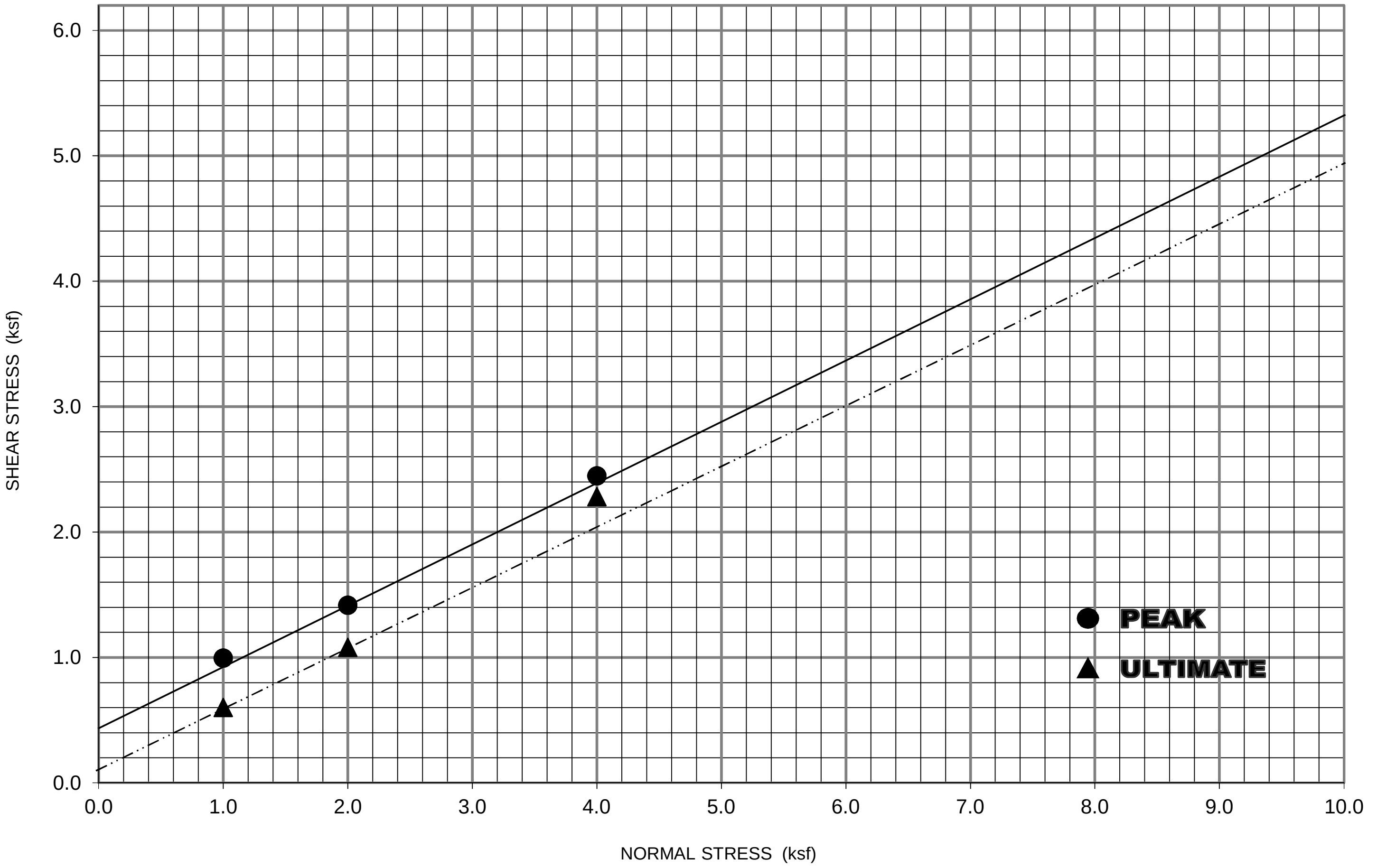
Applied Normal Load (ksf)	1.0		2.0		4.0	
Shear Stress,(Peak) (ksf)	0.996		1.416		2.448	
Shear Stress,(Ultimate) (ksf)	0.600		1.080		2.280	
Density and Saturation	Initial	Final	Initial	Final	Initial	Final
Wet Weight of Soil + Ring (gms)	186.93	186.77	189.19	188.86	194.16	193.3
Dry Weight of Soil + Ring (gms)		153.53		155.16		159.16
Weight of Water (gms)	-	46.54	-	47.28	-	45.81
Weight of Ring (gms)	-	44.36	-	43.93	-	44.78
Weight of Dry Soil (gms)	-	109.17	-	111.23	-	114.38
Moisture Content (%)	30.6	42.6	30.6	42.5	30.6	40.1
Wet Density (pcf)	119.0	118.9	121.3	121.0	124.7	124.0
Dry Density (pcf)	-	83.3	-	84.9	-	88.5
Specific Gravity,G_s (Assumed)	2.68					
Thickness of Specimen, (in.)	1.00					
Degree of Saturation, (%)	81.5	113.5	84.5	117.4	92.2	120.7
Void Ratio	-	1.007	-	0.970	-	0.889

Lateral Displacement, d_h 0.36 (in.)
Displacement Rate, d_r 0.05 (in./min.)
Elapsed Time of Test, t_e 7.20 (min.)

Specimen : Undisturbed : X
Remolded : -
Reconstituted : -

	PEAK	ULTIMATE
Cohesion,c (psf)	450	100
Friction Angle, ϕ	26	25

Remarks : LOAD 1000 & 2000 SANDY CLAY LOAD 4000 CLAYEY SAND



KCG KLING Consulting Group, Inc.

8008 Sky Park Circle, Suite 250
Irvine, Ca. 92614
Tel: (949)797-6241 Fax: (949)797-6260

DIRECT SHEAR TEST

(ASTM D3080)

PROJECT NAME : PICERNE GARDENA

PROJECT NUMBER : 22027-00

TRACT NUMBER :

TESTED BY : RB DATE : 11-Oct-22

LOT NUMBER :

SAMPLED BY: JH DATE : 30-Sep-22

SAMPLE NO. :

LOCATION : KB - 1 @ 0 - 5'

SOIL DESCRIPTIONS / CLASSIFICATION : DK. BROWN CLAYEY SAND (SC)

TRIAL NUMBER		1	2	3	4
WET WT. OF SOIL + RING	(g)	592.63	604.39		
WEIGHT OF RING	(g)	204.36	204.36		
WET WEIGHT OF SOIL	(g)	388.27	400.03		
FACTOR		0.3030	0.3030		
WET DENSITY	(pcf)	117.6	121.2		
DRY DENSITY	(pcf)	108.3	110.7		
DEGREE OF SATURATION	(%)	#DIV/0!	#DIV/0!		

MOISTURE DETERMINATION

WET WEIGHT OF SOIL	(g)	319.52	307.42		
DRY WEIGHT OF SOIL	(g)	294.19	280.75		
MOISTURE CONTENT	(%)	8.6	9.5		

RACK NO. : 2

SURCHARGE : 144 psf

FINAL DENSITY & SATURATION

WET WT. + RING	(g)	
DRY WT. + RING	(g)	
MOISTURE CONTENT	(%)	
SAMPLE LENGTH	(cm)	
SAMPLE AREA	(cm^2)	
VOLUME	(cc)	
WT. OF RING	(g)	
DRY DENSITY	(pcf)	
SPEC.GRAVITY (assumed)		
SATURATION	(%)	#DIV/0!
% RETAINED ON #4 SIEVE		

DATE	TIME	ELAPSED TIME (min.)	DIAL READING (in.)	DEFLECTION (in.)
10-Oct	8:00		0.314	
10-Oct	11:00		0.369	
11-Oct	10:25		0.371	0.057

E. I. 57

SO_4 147 ppm

REMARKS :

KCG KLING Consulting Group, Inc.

18008 Sky Park Circle, Suite 250
Irvine, Ca. 92614
Tel: (949)797-6241 Fax: (949)797-6260

EXPANSION INDEX

(UBC 18-2)

APPENDIX D

LIQUEFACTION AND SEISMIC SETTLEMENT ANALYSIS

Kling Consulting Group, Inc.
18008 Sky Park Circle, Suite 250
Irvine, CA 92614
www.klingconsultinggroup.com

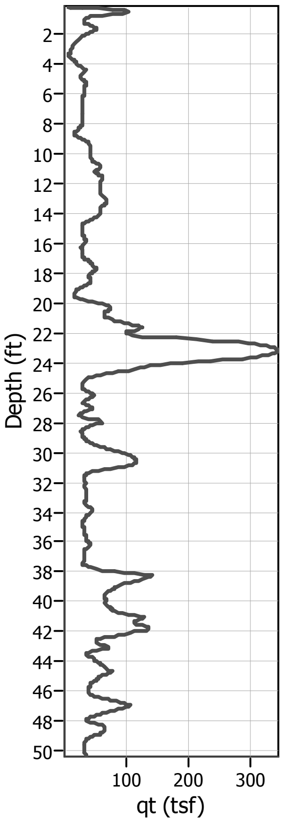
Project title : **Location :**

CPT file : CPT-1

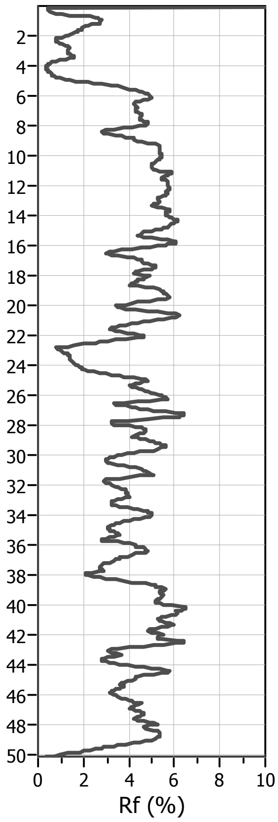
Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

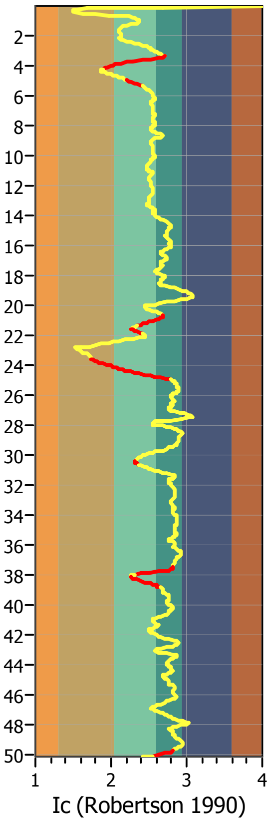
Cone resistance



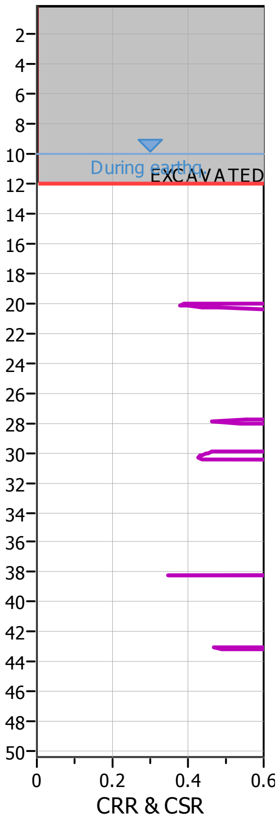
Friction Ratio



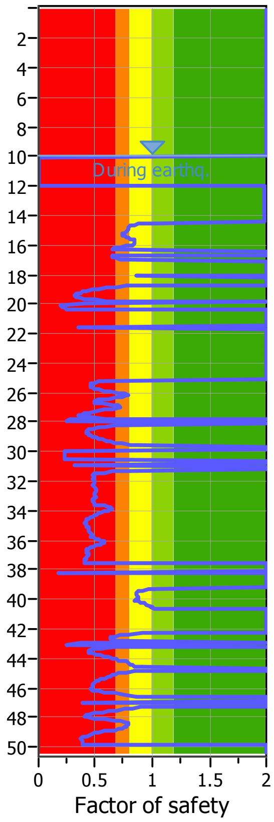
SBTn Plot



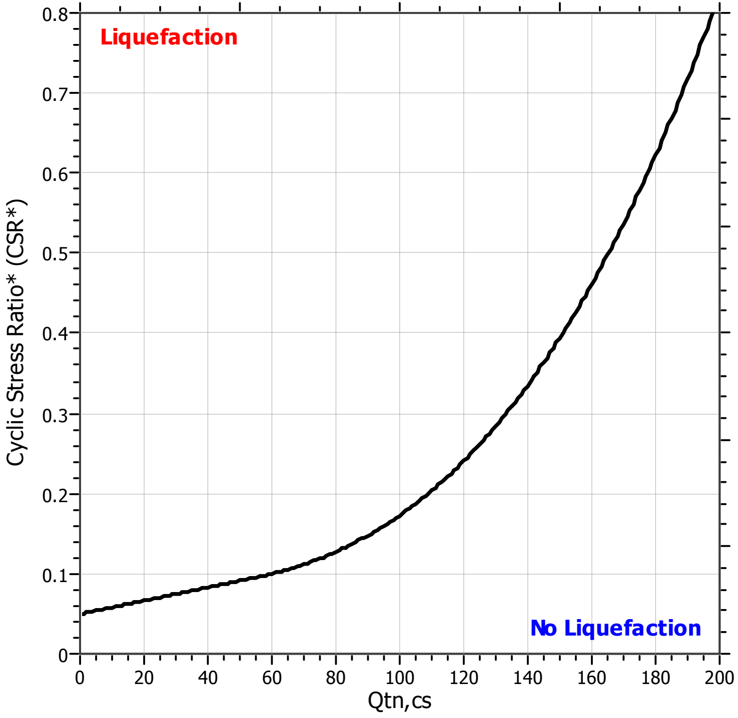
CRR plot



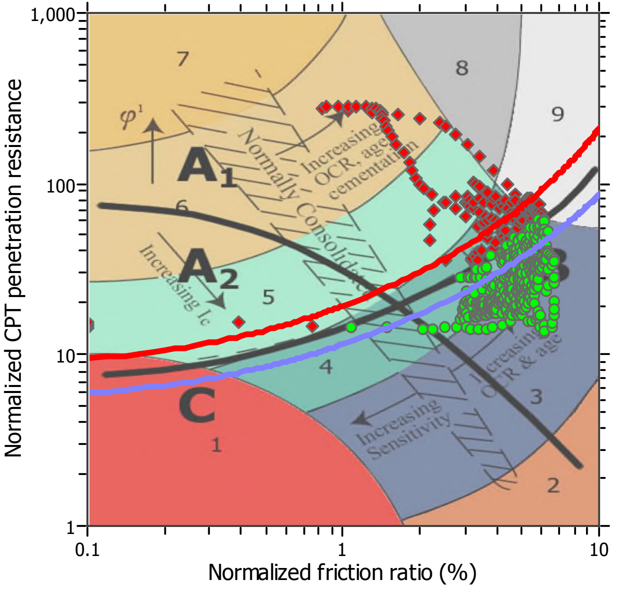
FS Plot



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

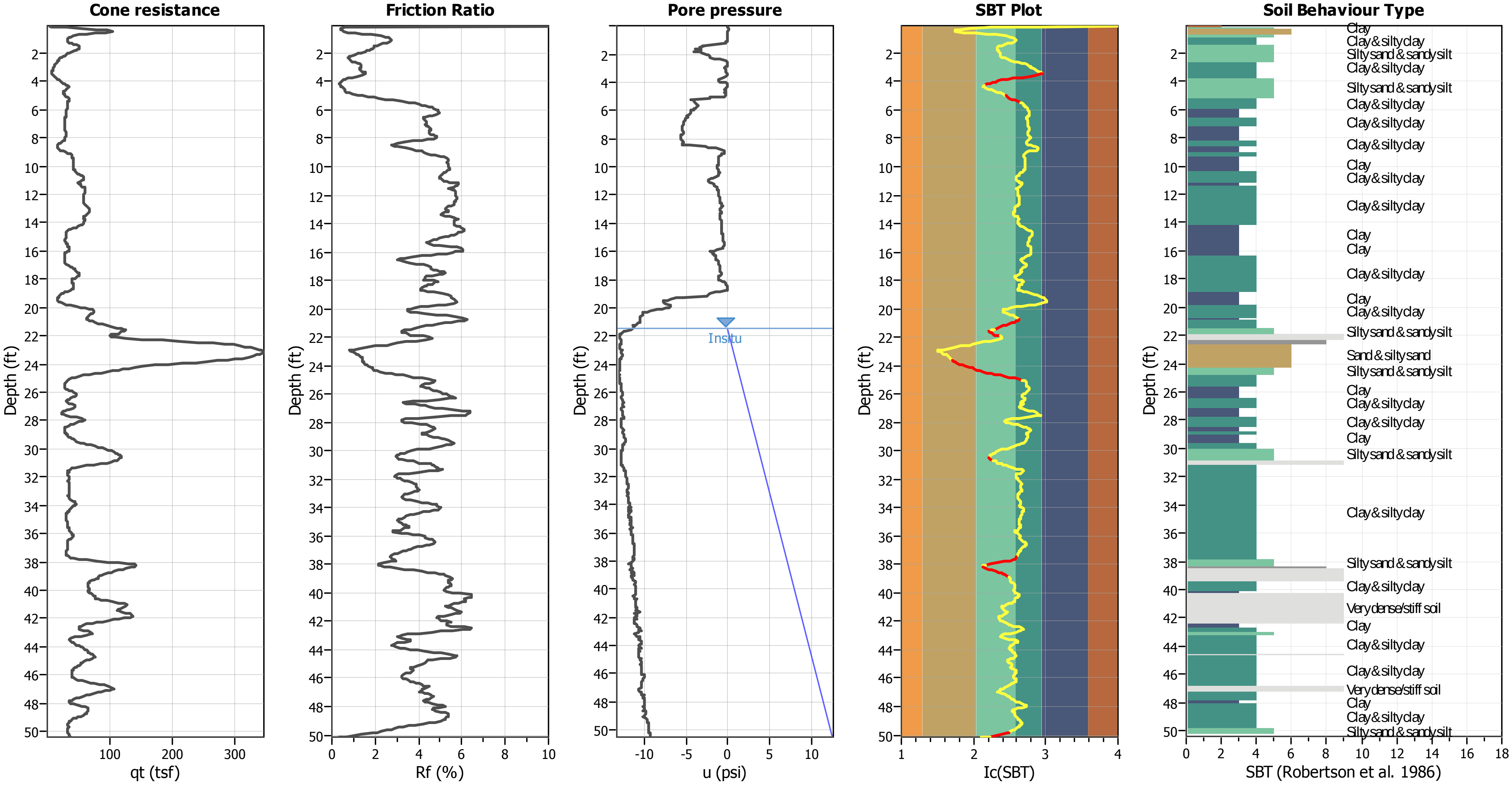


Summary of liquefaction potential



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

CPT basic interpretation plots



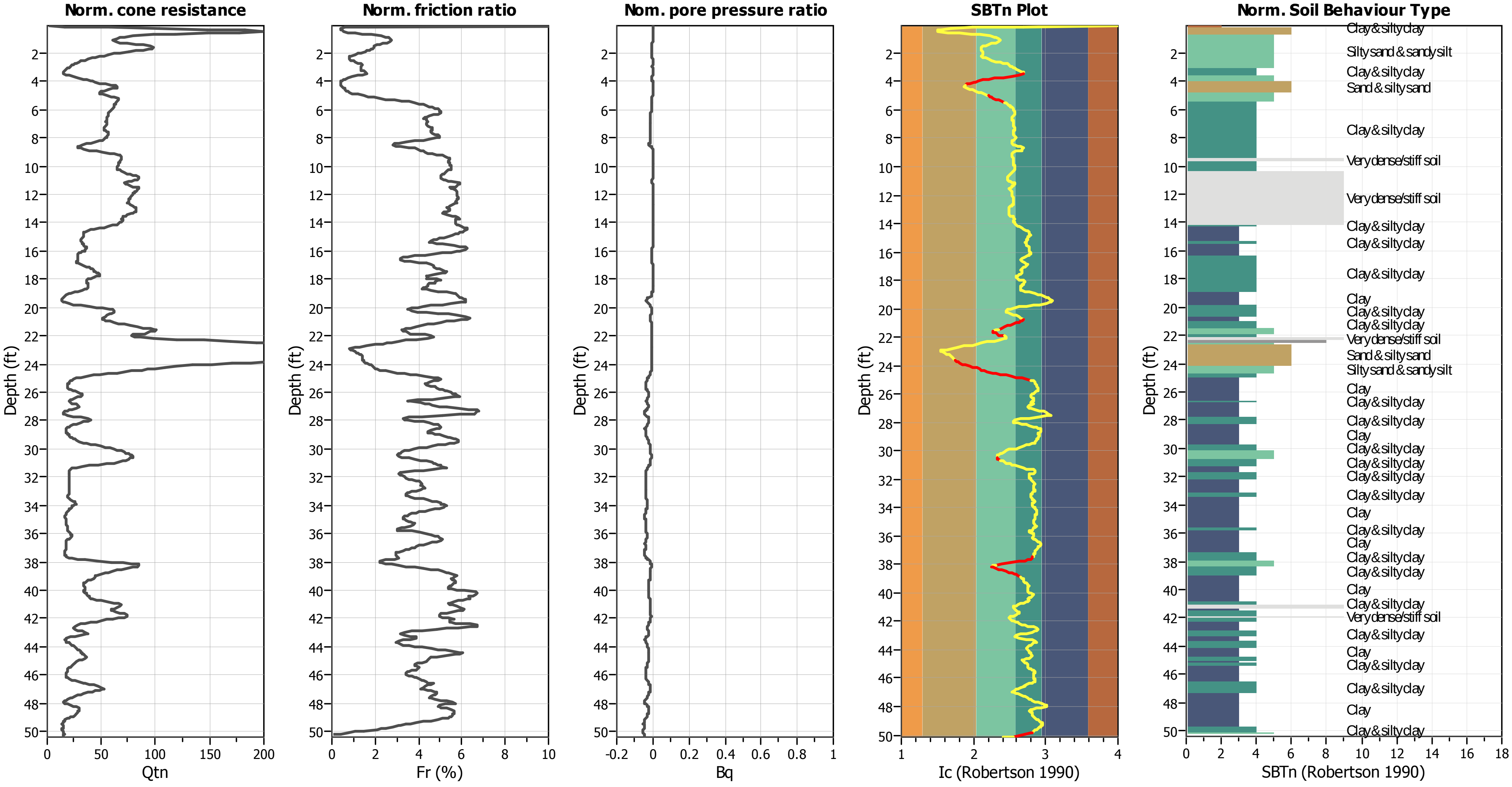
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
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SBTn legend

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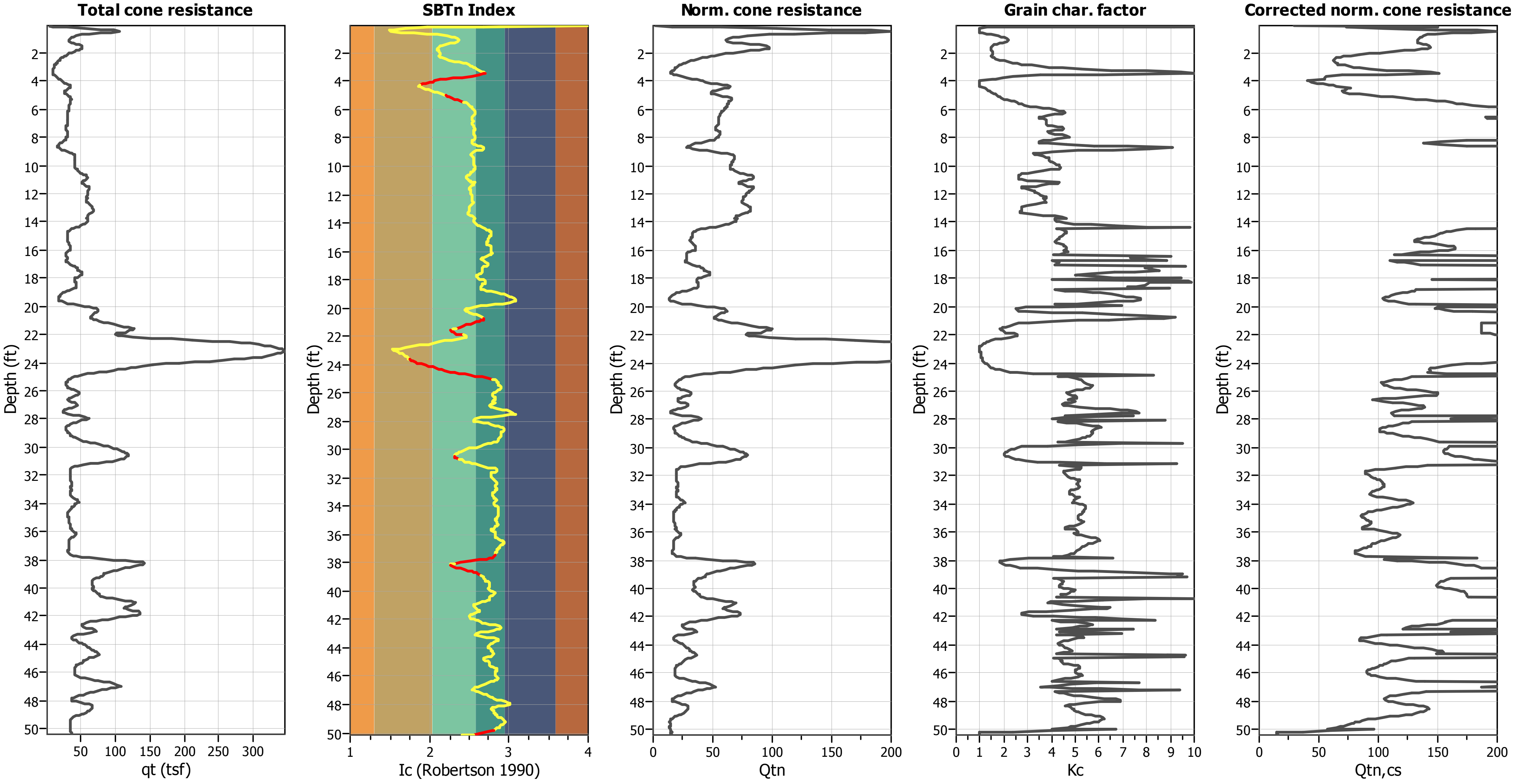
☐ 6. Clean sand to silty sand
☐ 7. Gravely sand to sand
☐ 8. Very stiff sand to
☐ 9. Very stiff fine grained

Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
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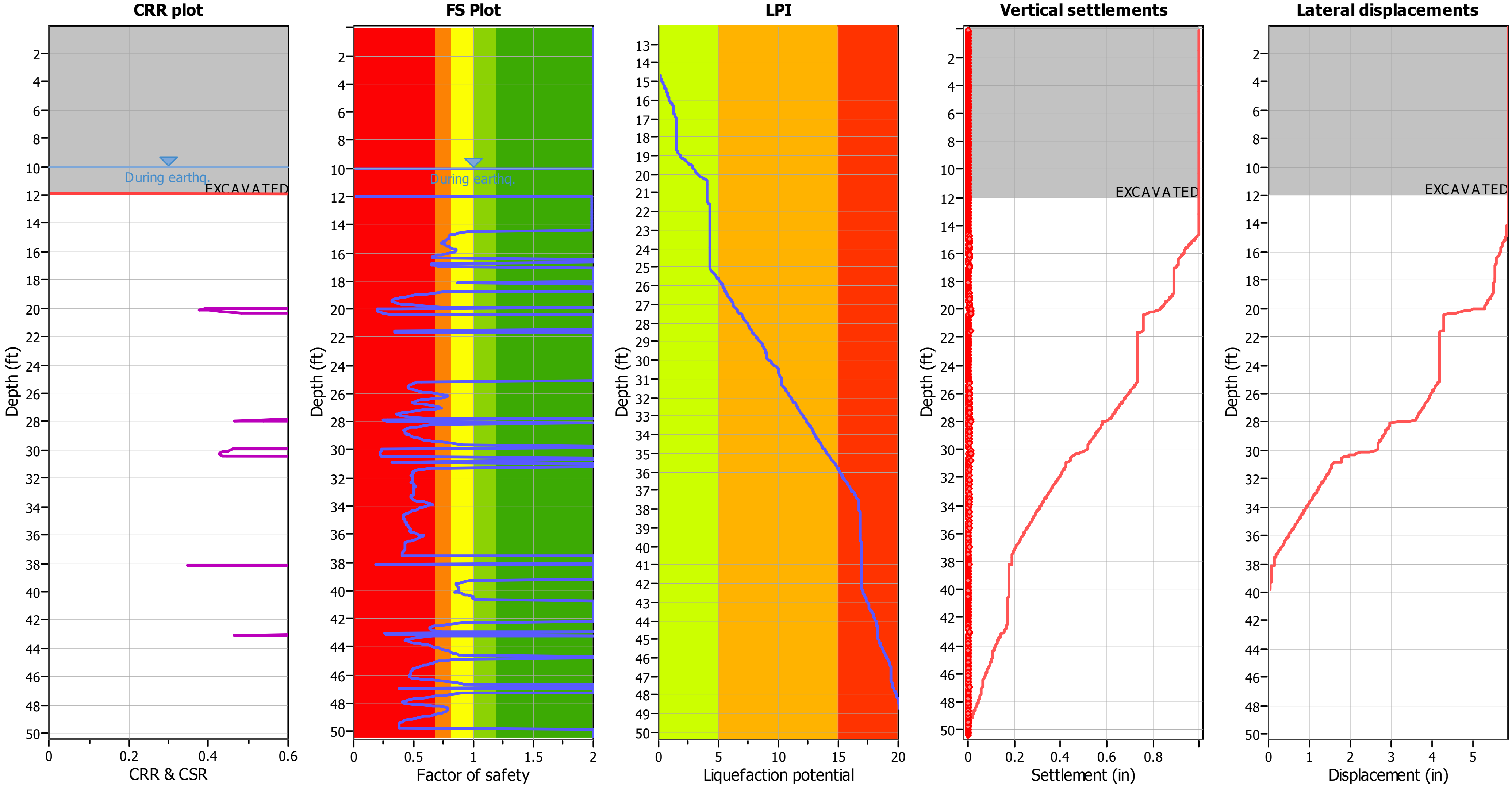
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

F.S. color scheme

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

LPI color scheme

☐ Very high risk
☐ High risk
☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
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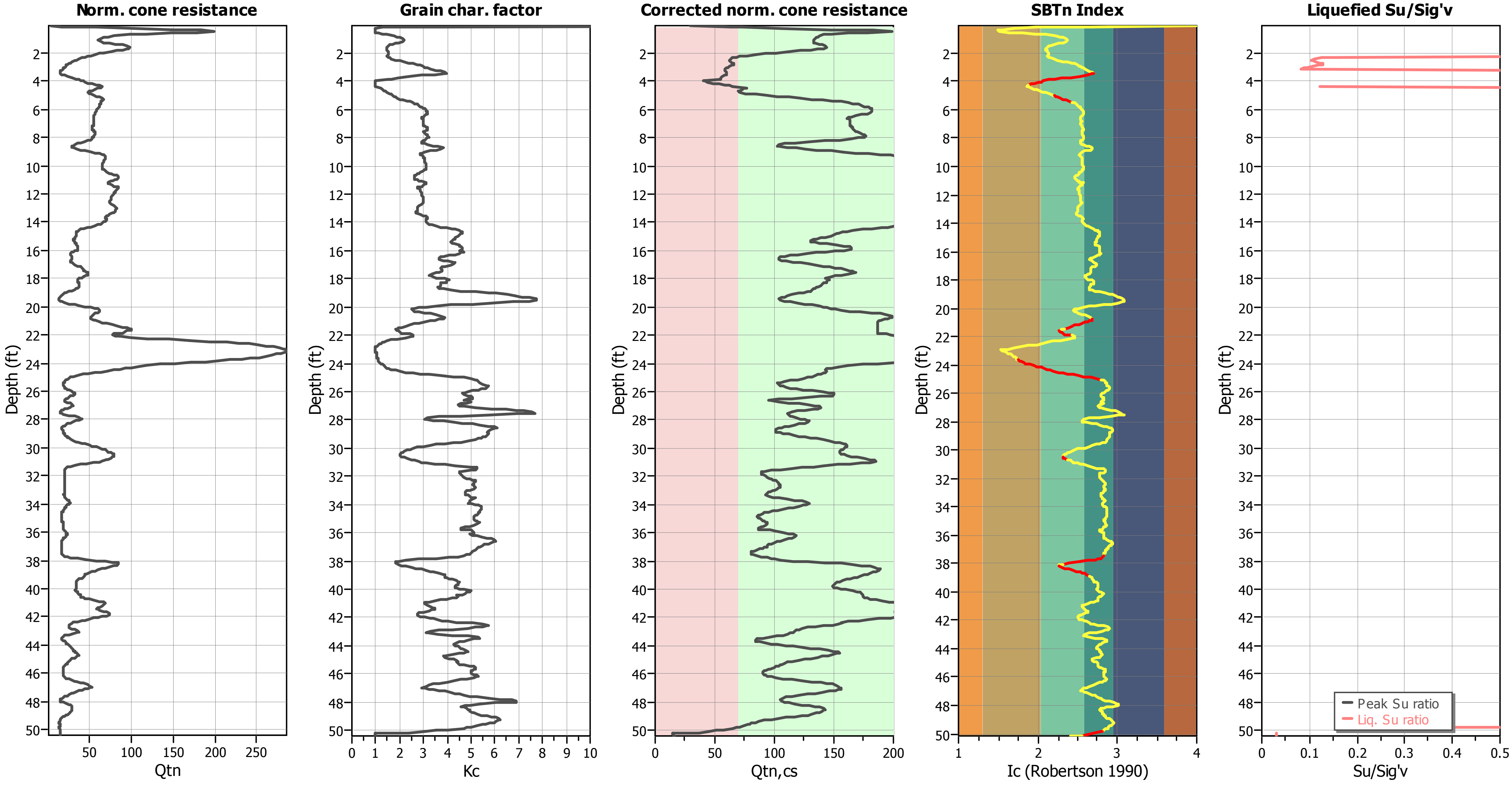
Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
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Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

:: Liquefaction Potential Index calculation data ::

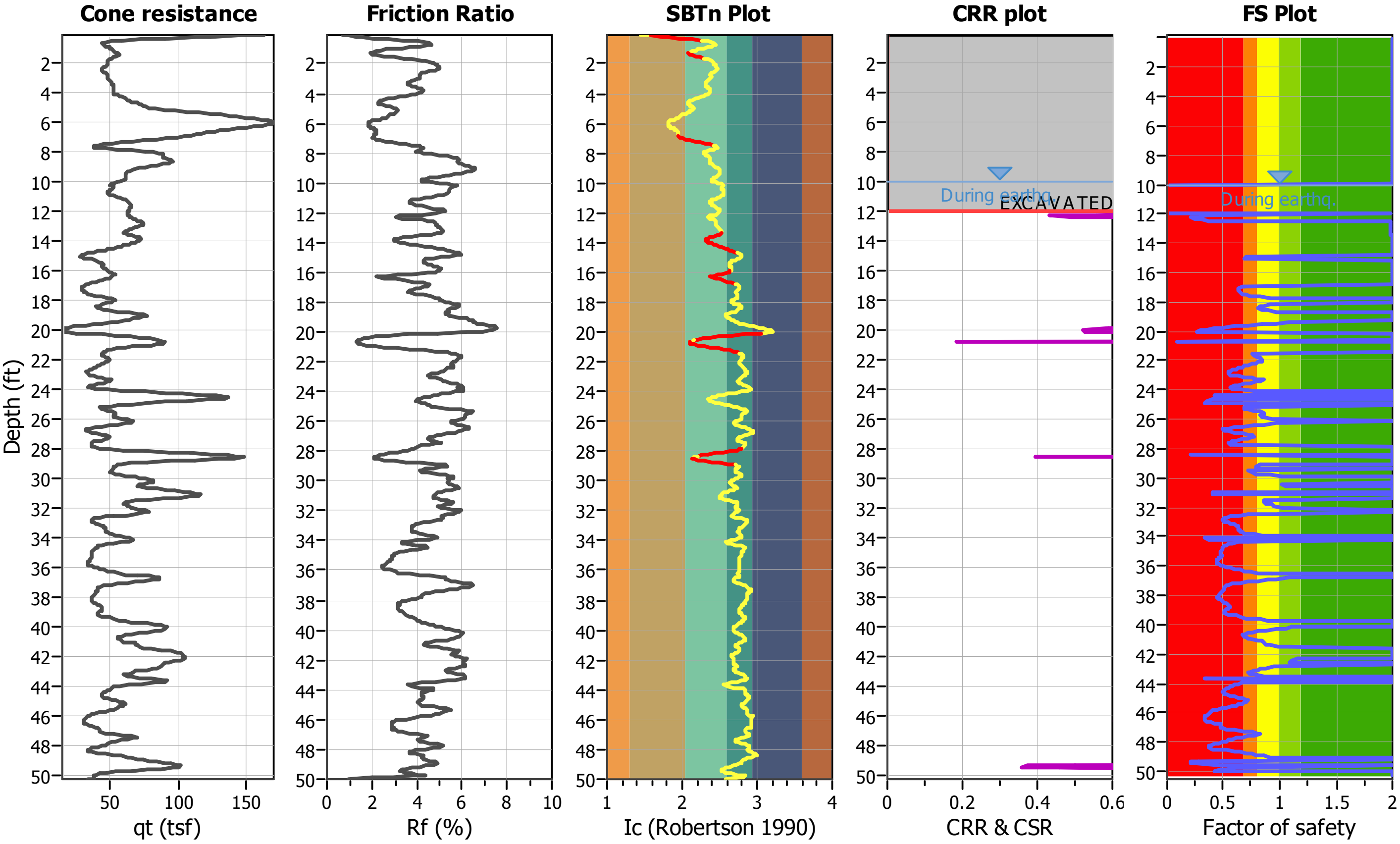
Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

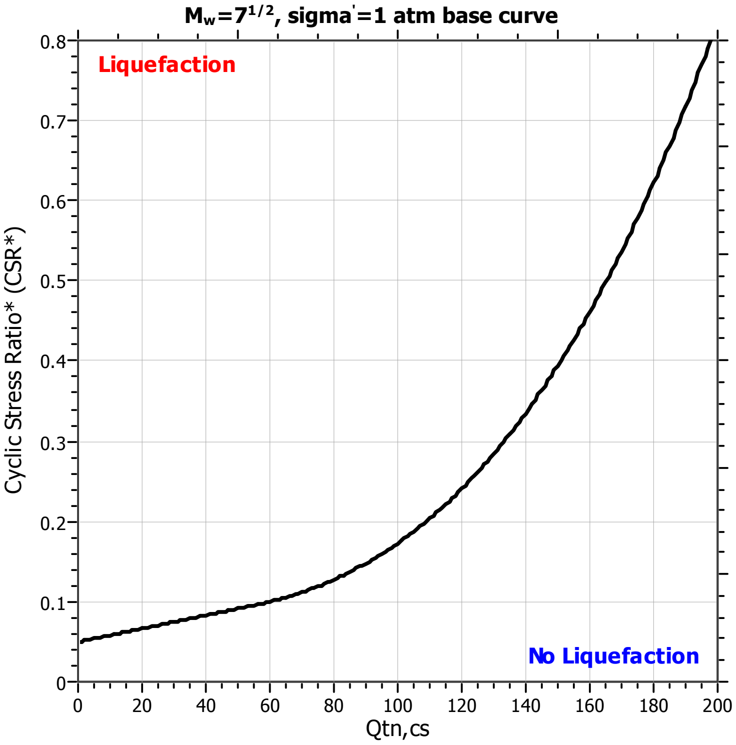
Project title : **Location :**

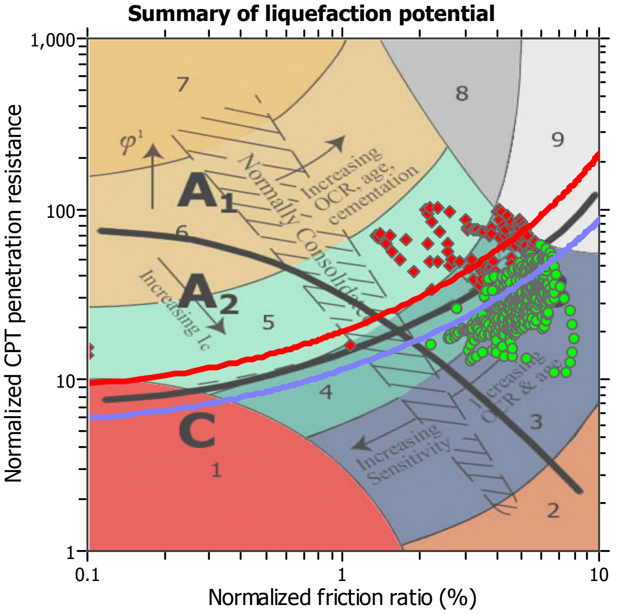
CPT file : CPT-2

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior	
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	applied:	All soils
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth applied:	Yes
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	50.00 ft
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
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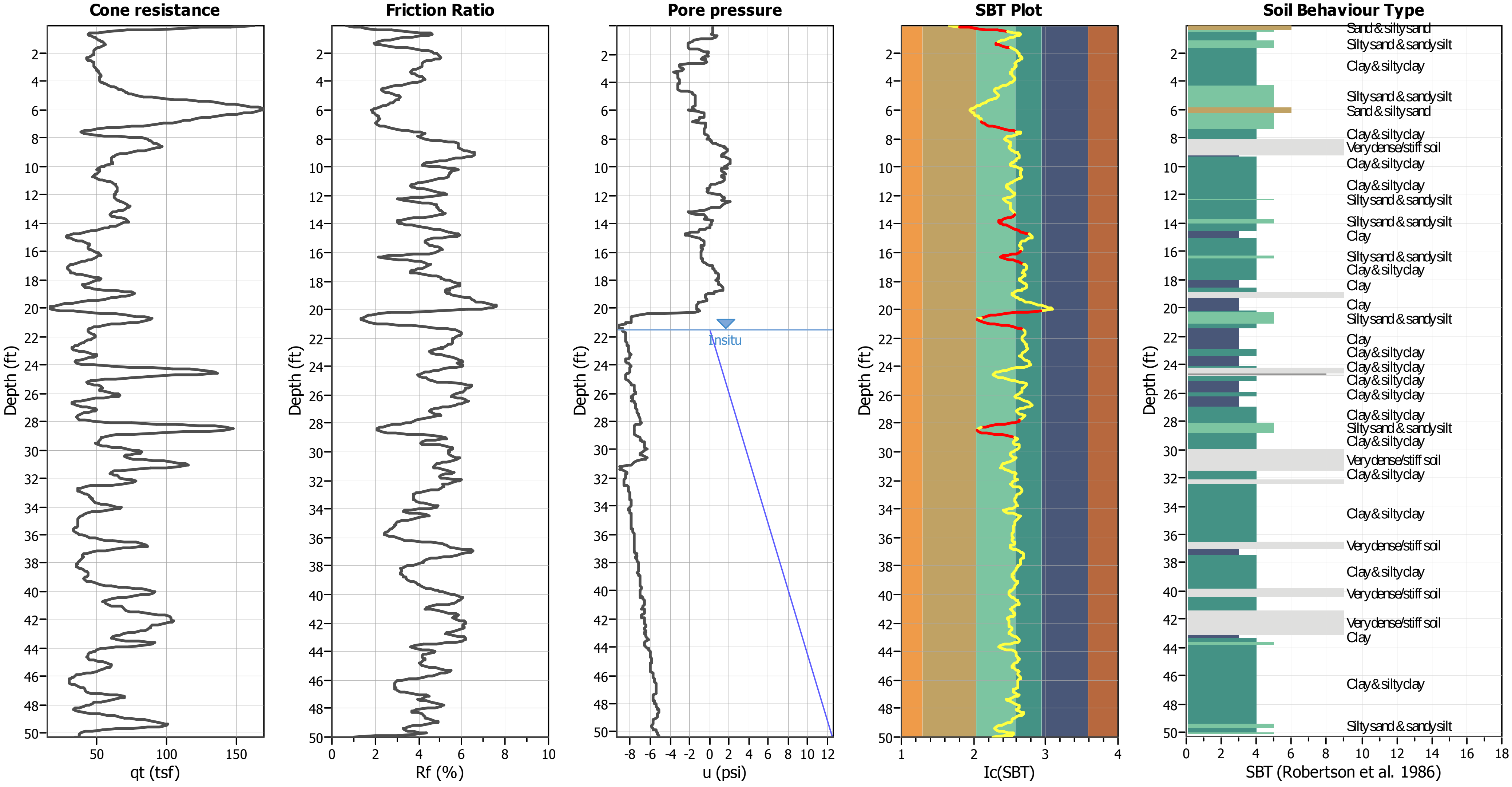
CPT basic interpretation plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBT legend

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☐ 2. Organic material
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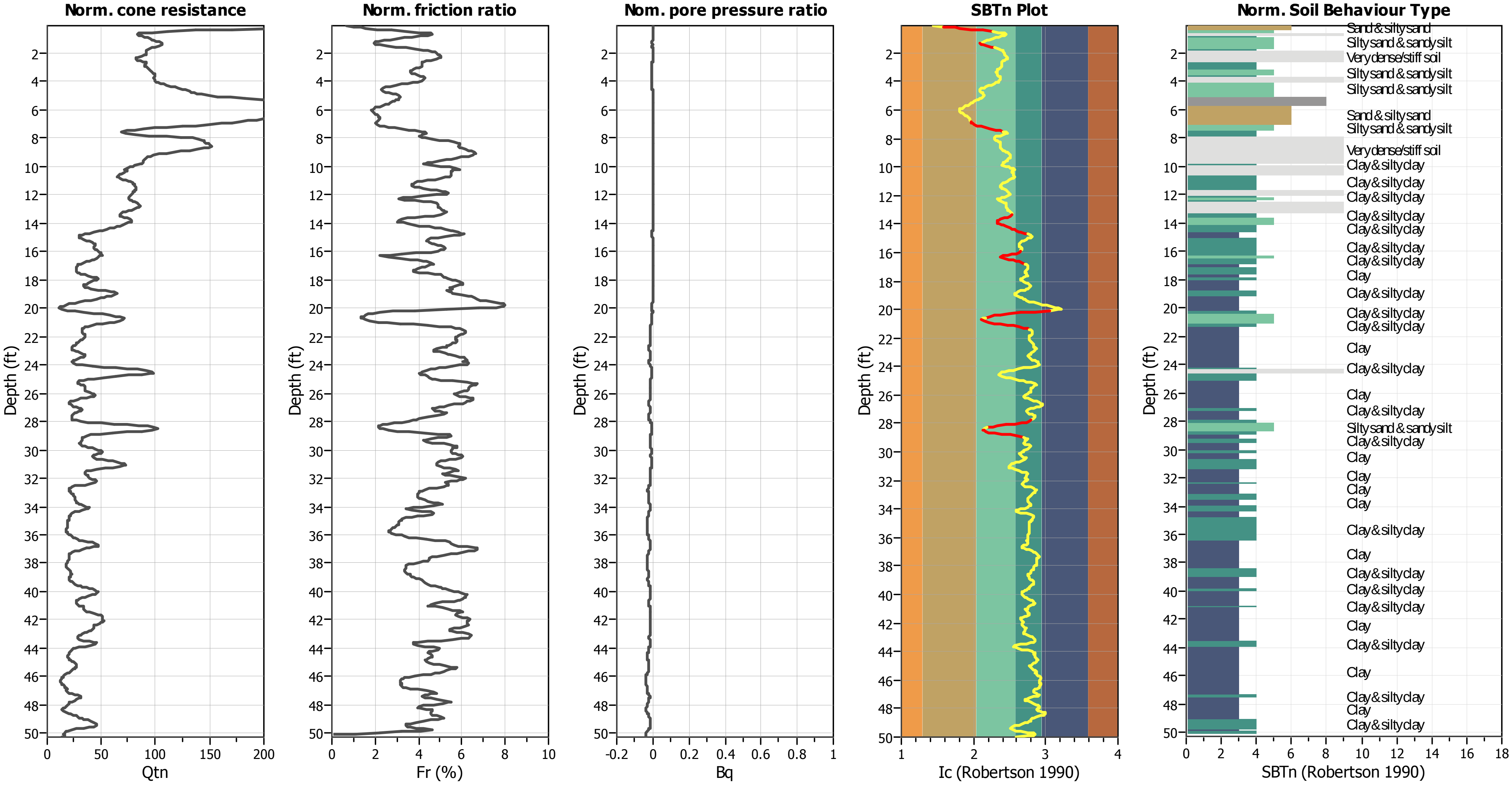
☐ 6. Clean sand to silty sand
☐ 7. Gravely sand to sand
☐ 8. Very stiff sand to
☐ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

SBTn legend

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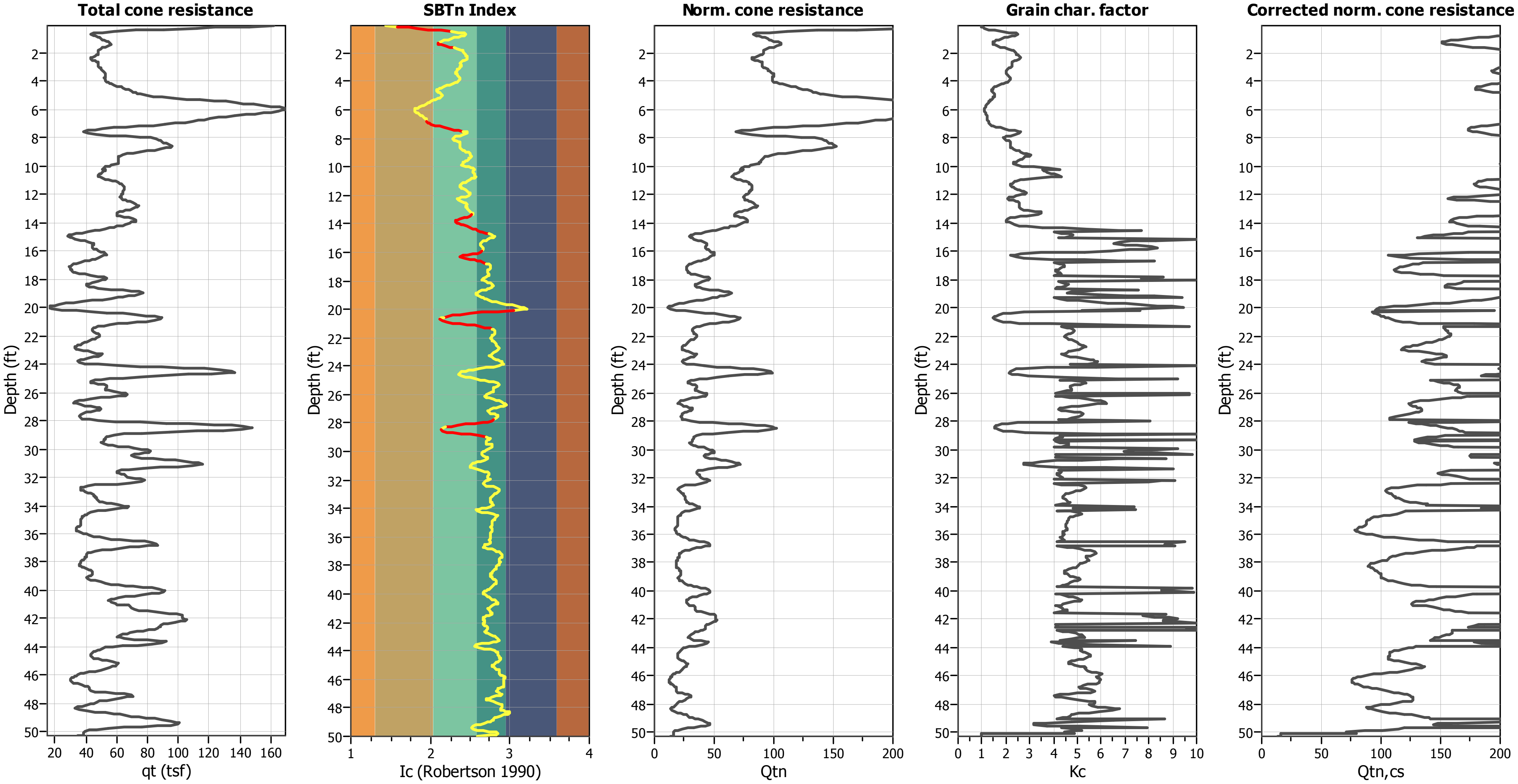
☐ 9. Very stiff fine grained

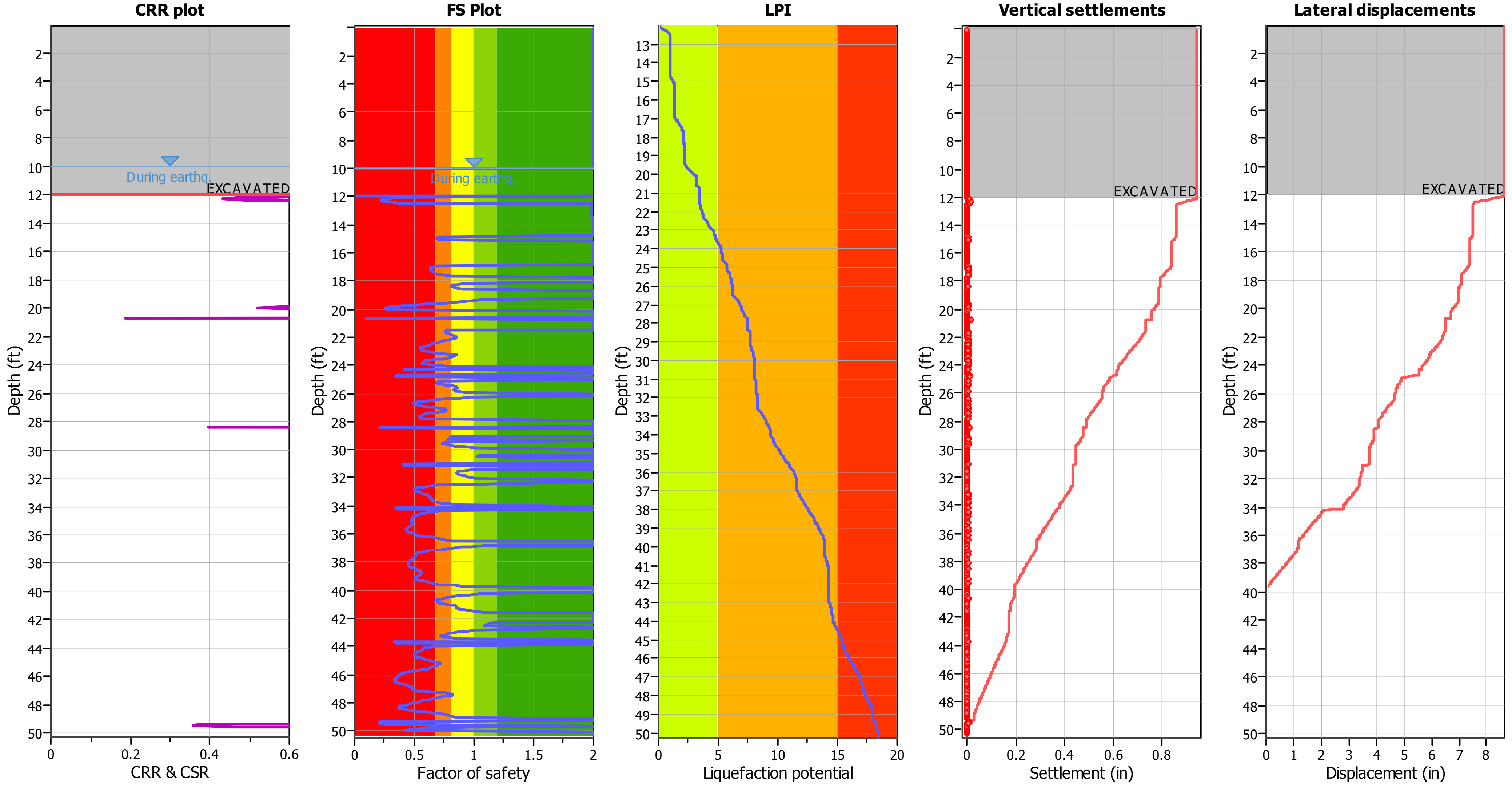
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

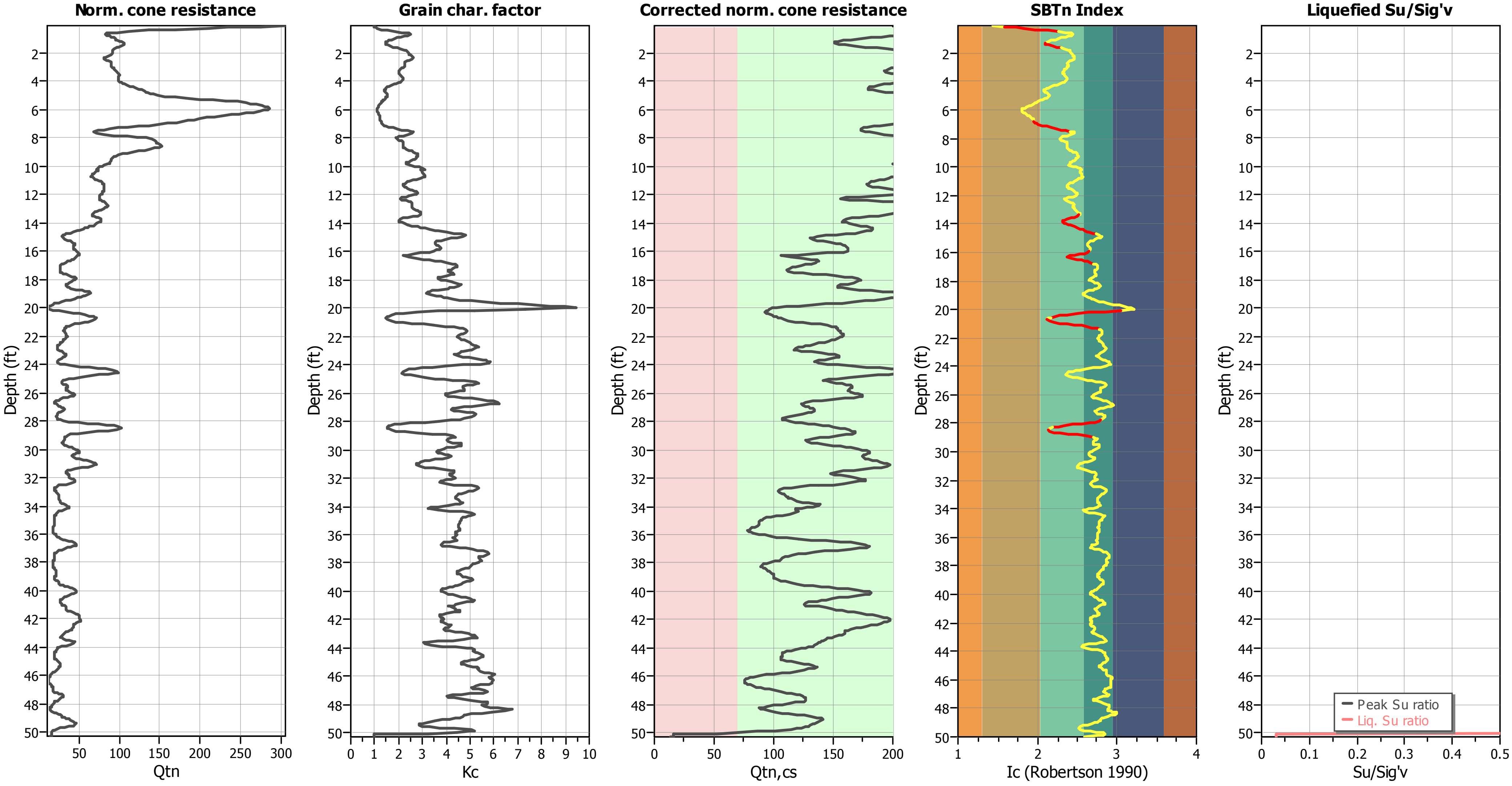
- ☐ Very high risk
- ☐ High risk
- ☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

:: Liquefaction Potential Index calculation data ::

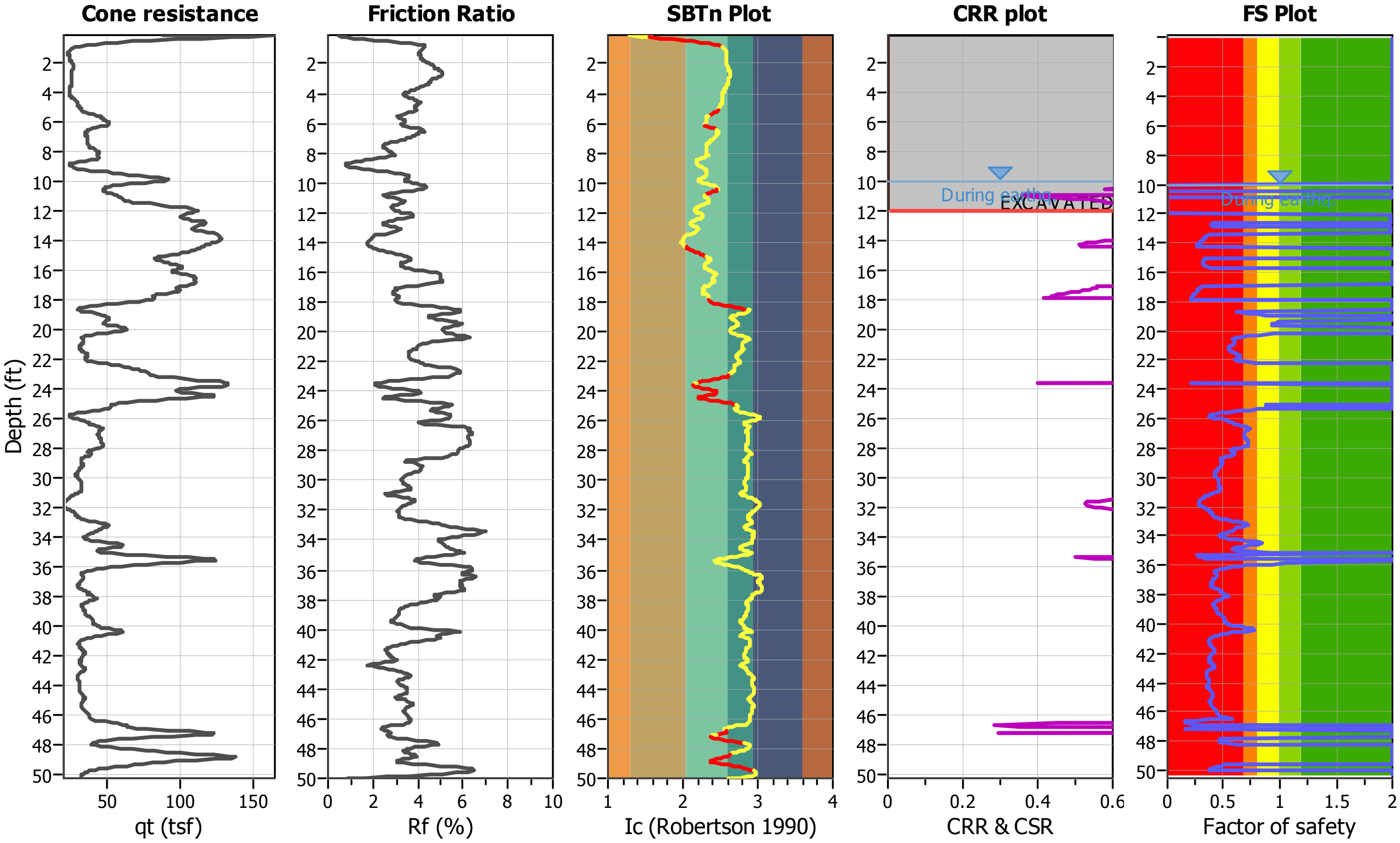
Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

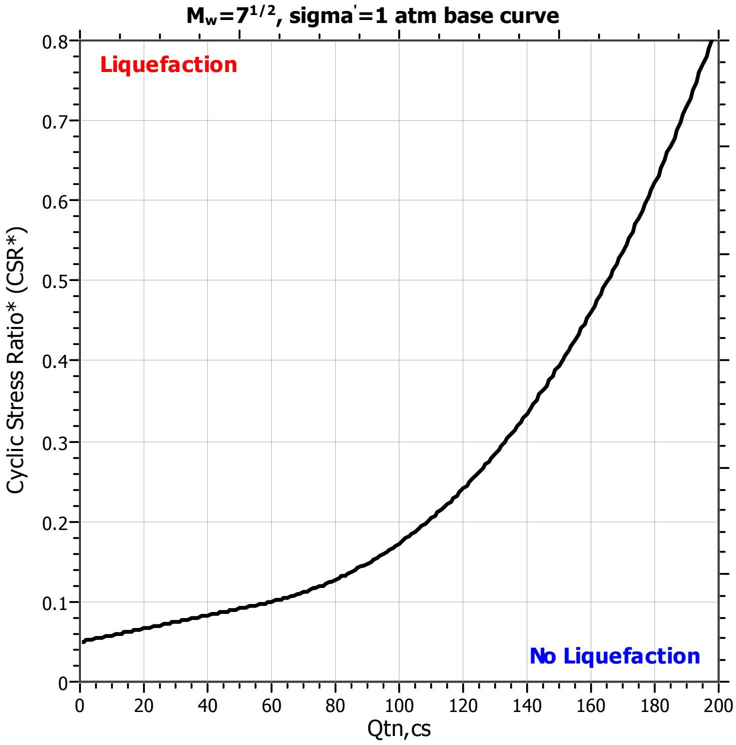
Project title : **Location :**

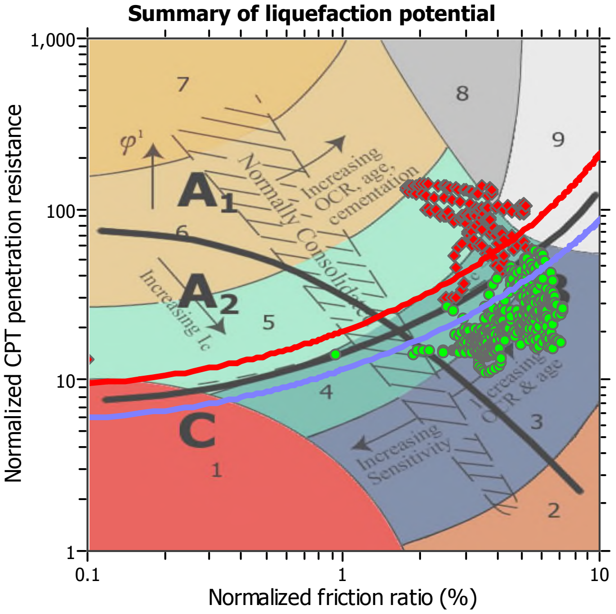
CPT file : CPT-3

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

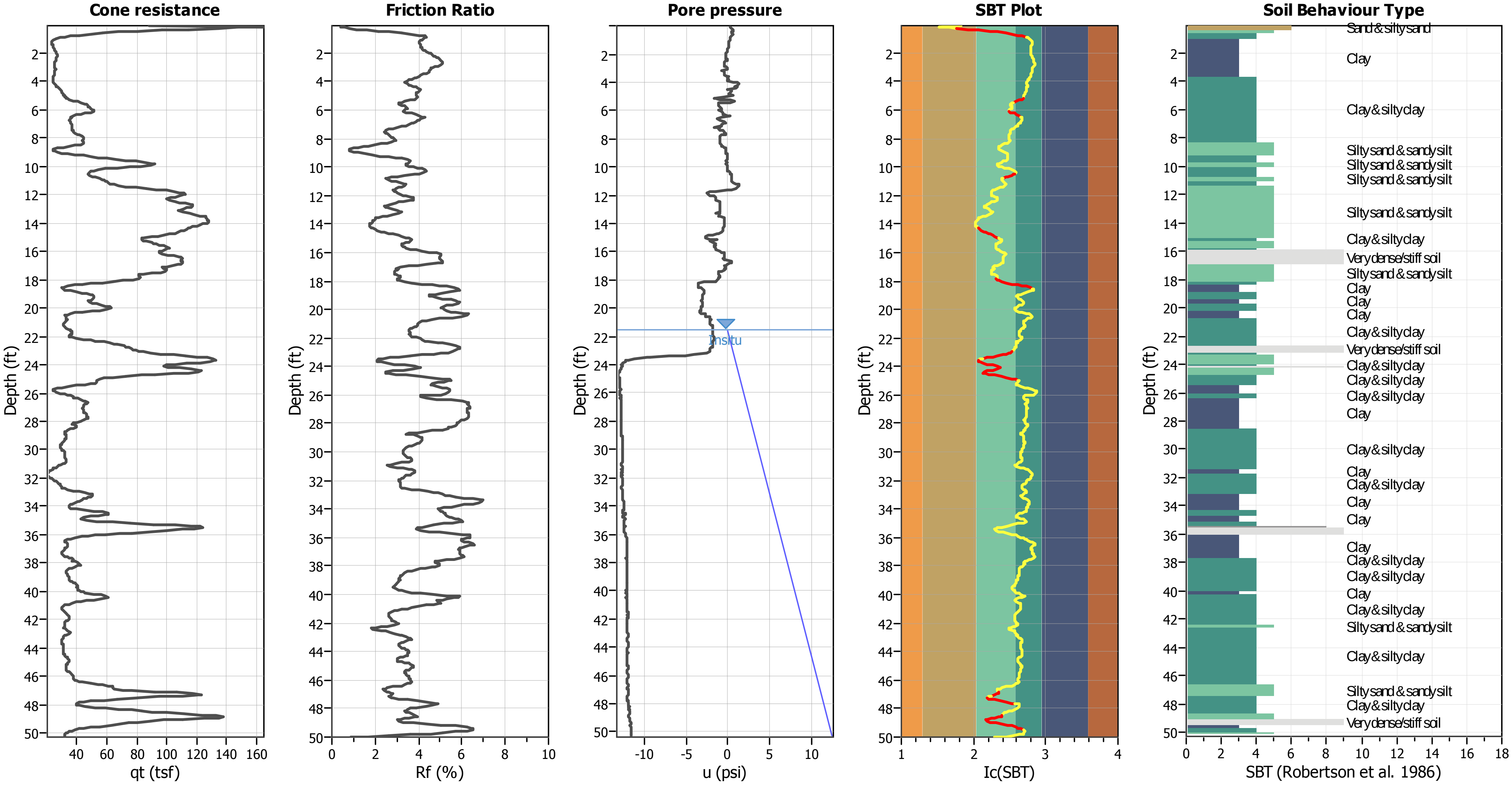






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



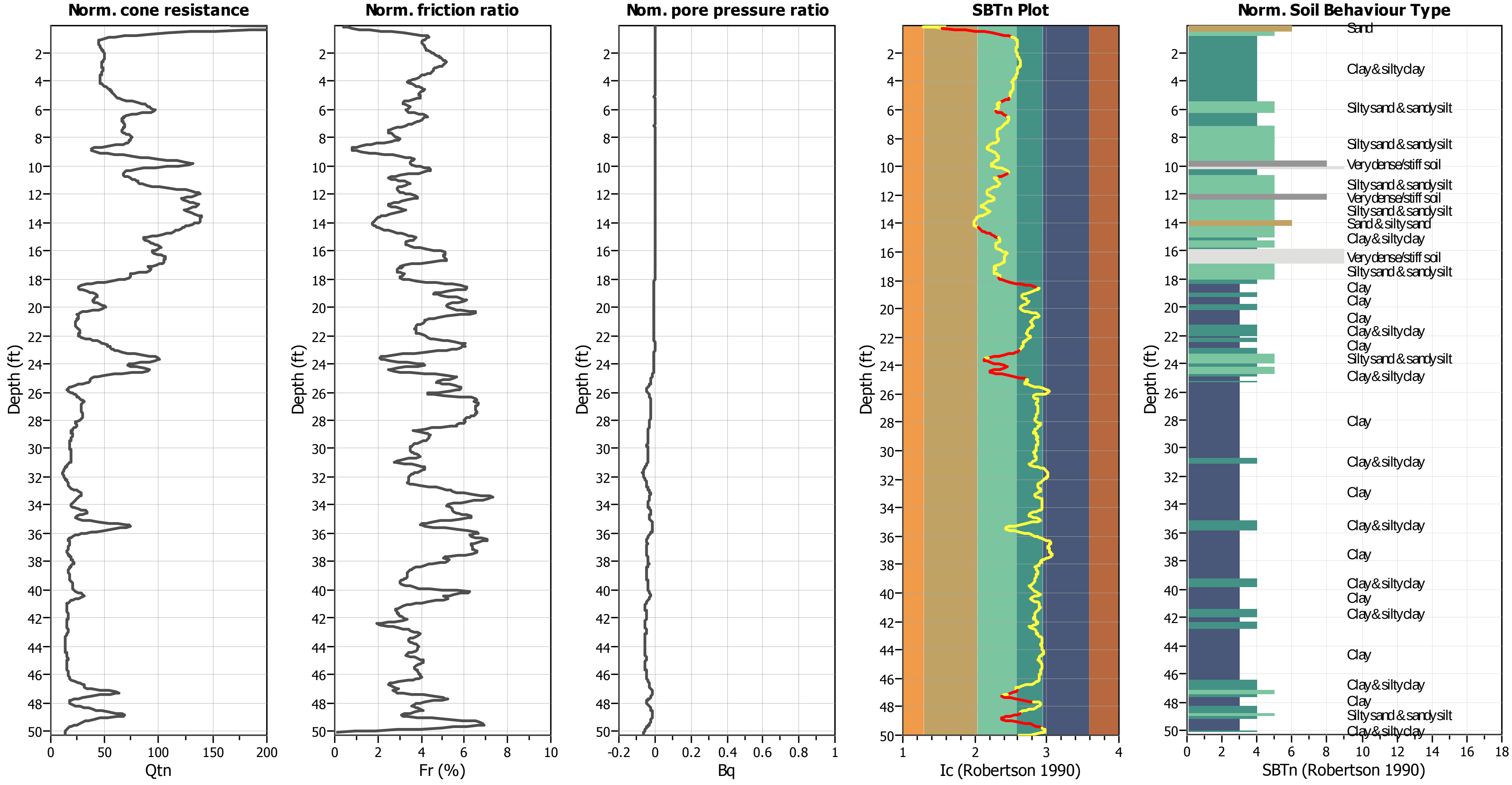
Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBTn legend

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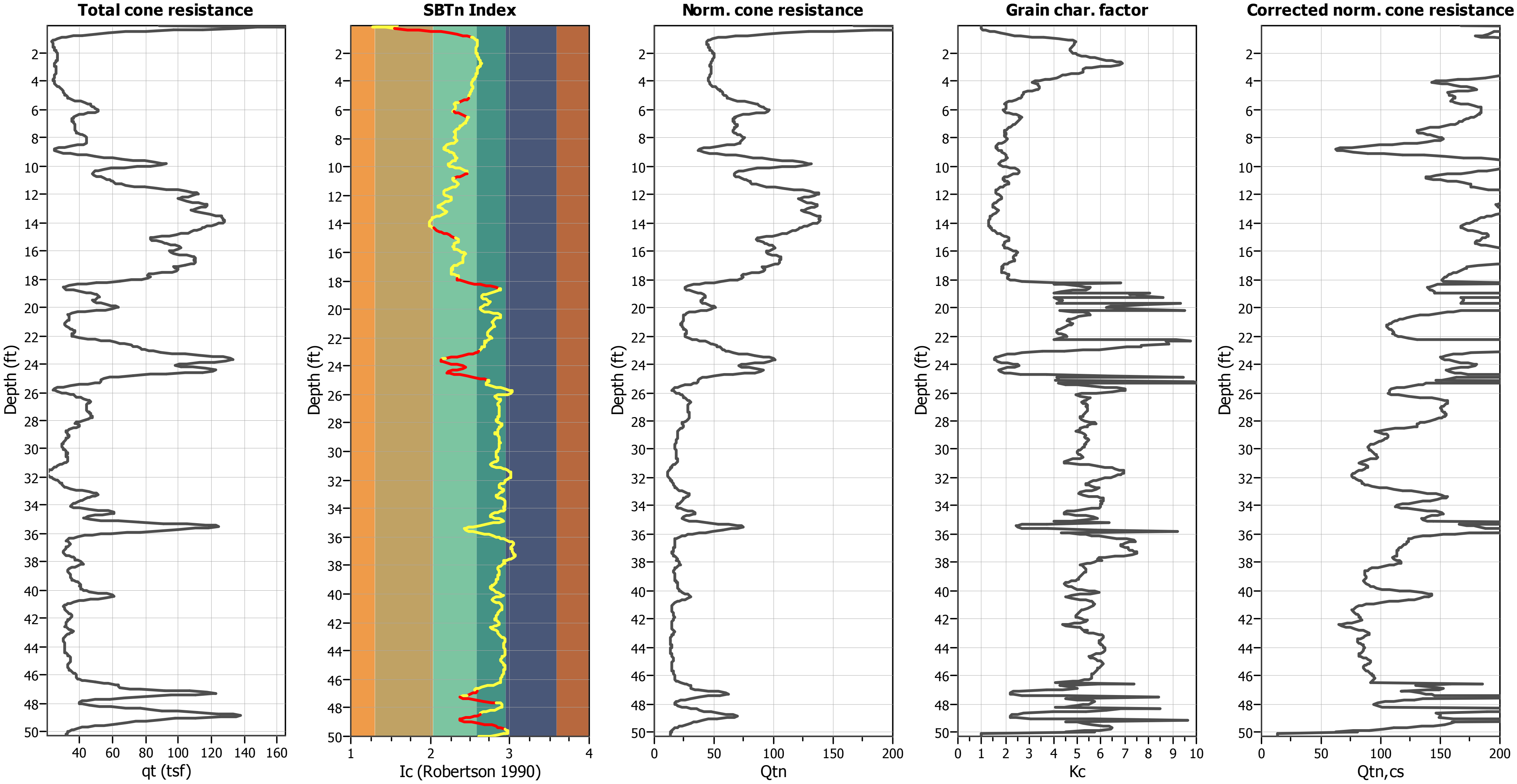
- ☐ 4. Clayey silt to silty
- ☐ 5. Silty sand to sandy silt
- ☐ 6. Clean sand to silty sand
- ☐ 7. Gravely sand to sand
- ☐ 8. Very stiff sand to
- ☐ 9. Very stiff fine grained

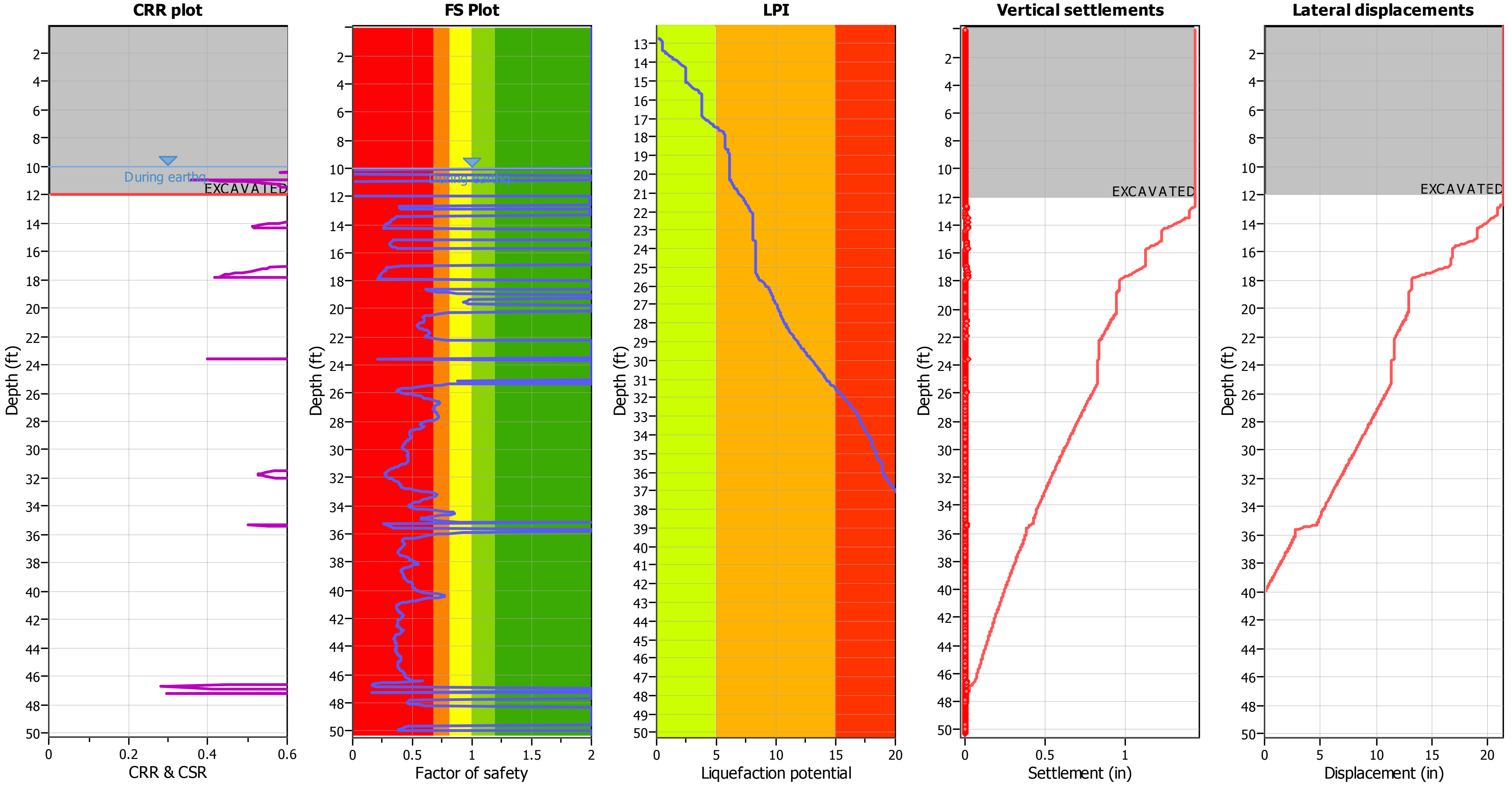
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

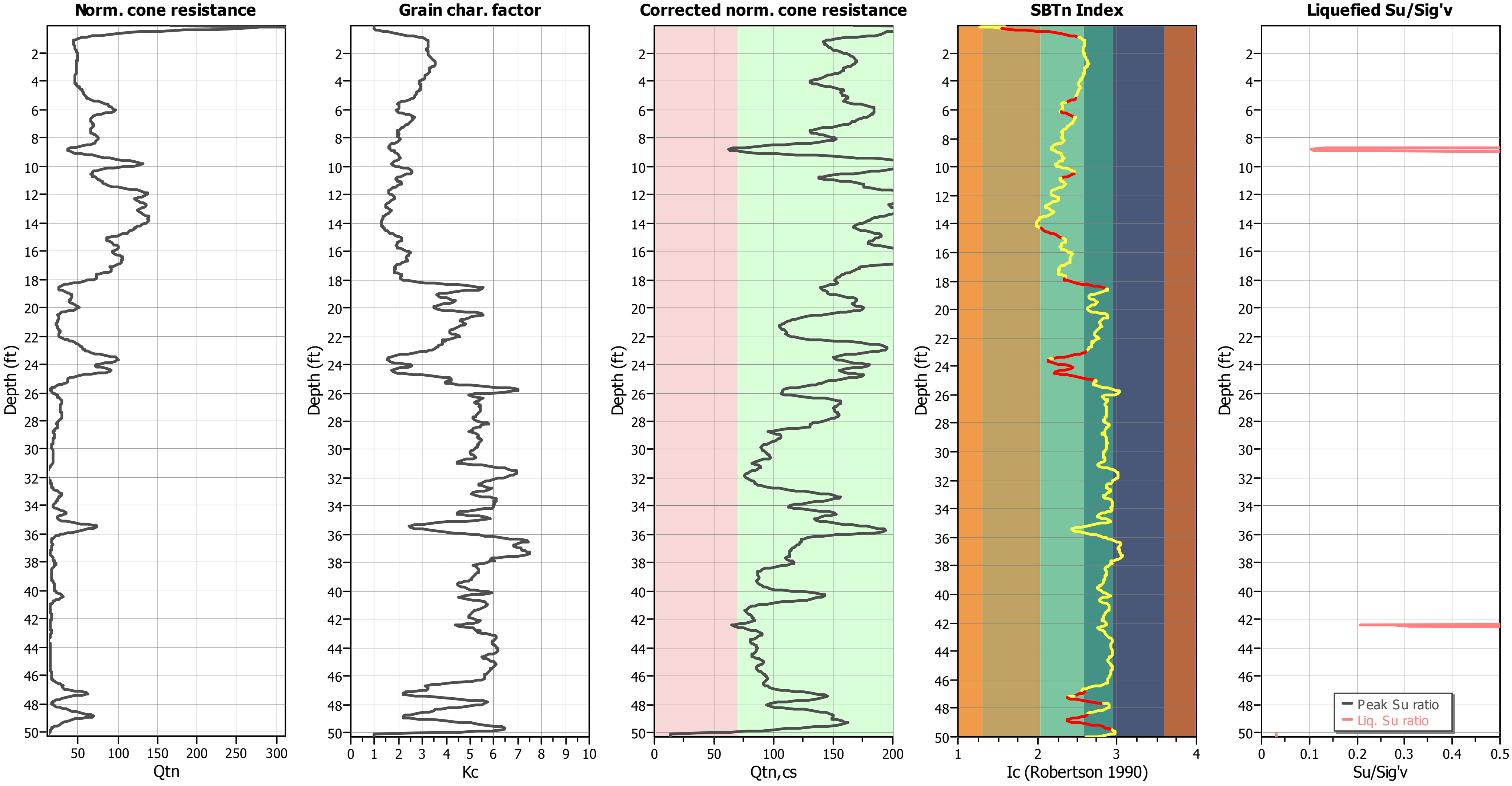
☐ Very high risk
☐ High risk
☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

:: Liquefaction Potential Index calculation data ::

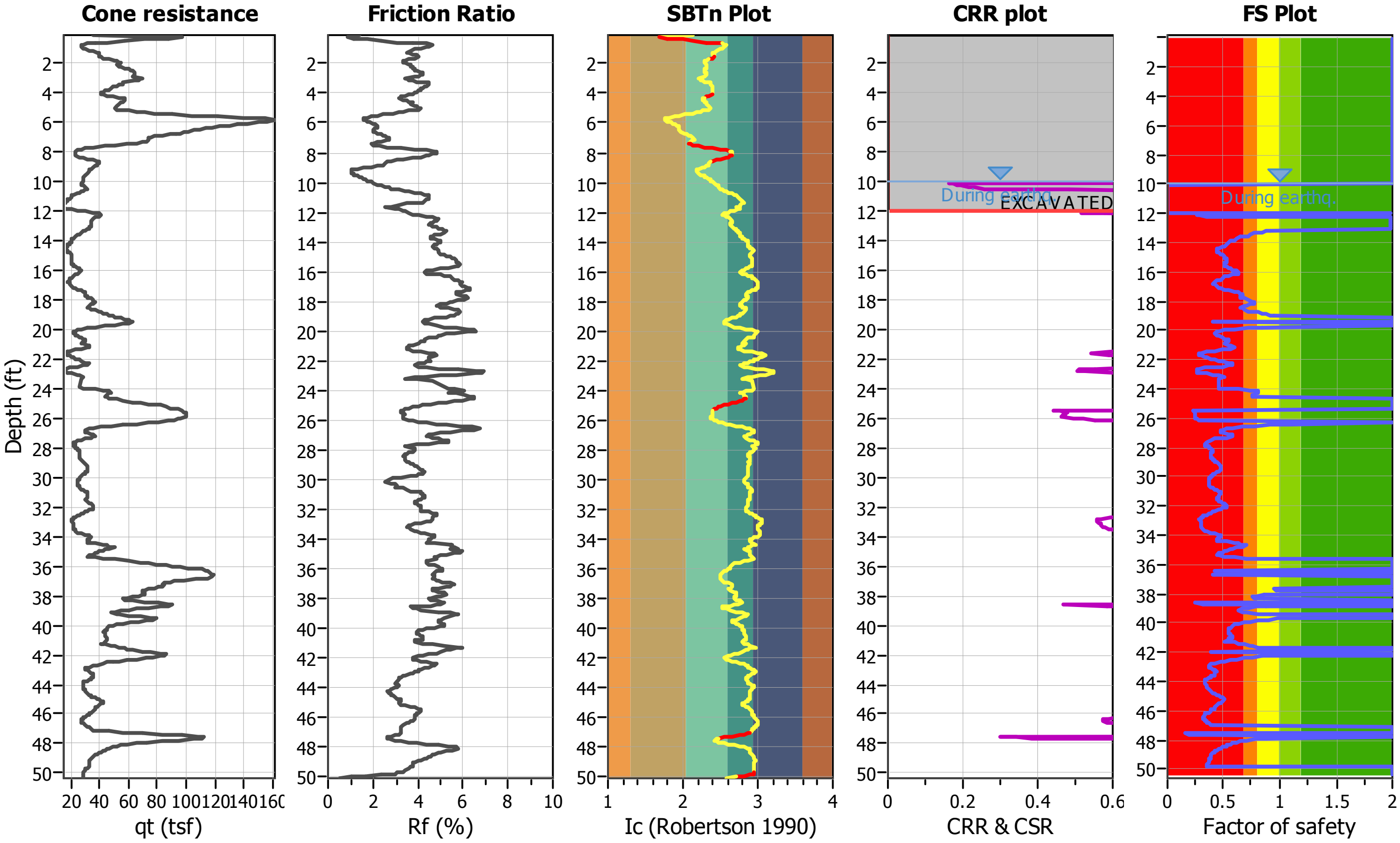
Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

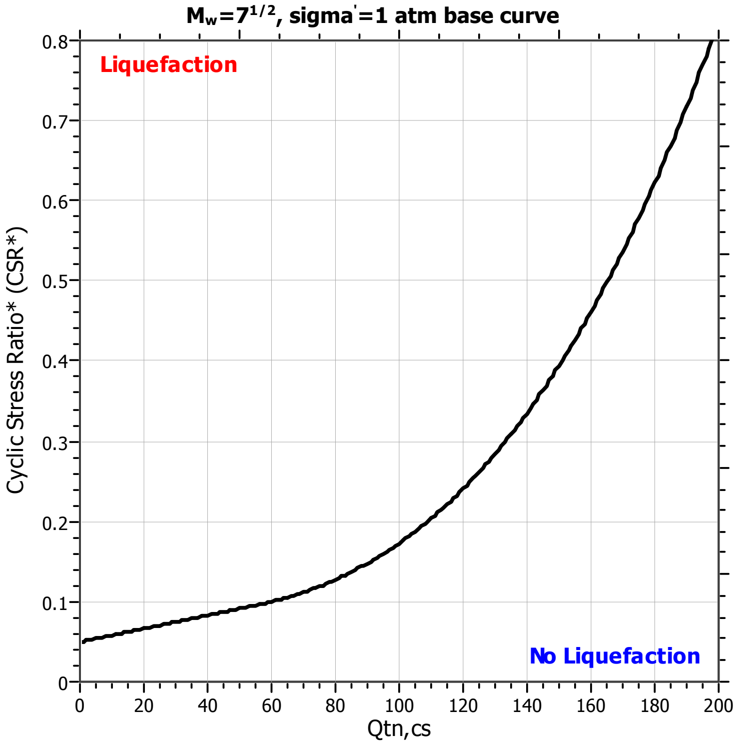
Project title : **Location :**

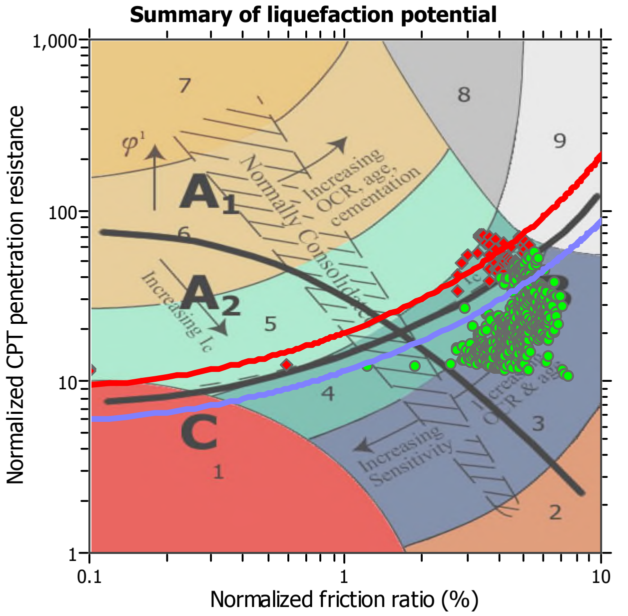
CPT file : CPT-4

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	21.50 ft	Excavation:	Yes	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	10.00 ft	Excavation depth:	12.00 ft	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Footing load:	2.00 tsf	Limit depth:	50.00 ft
Earthquake magnitude M_w:	7.30	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.85	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

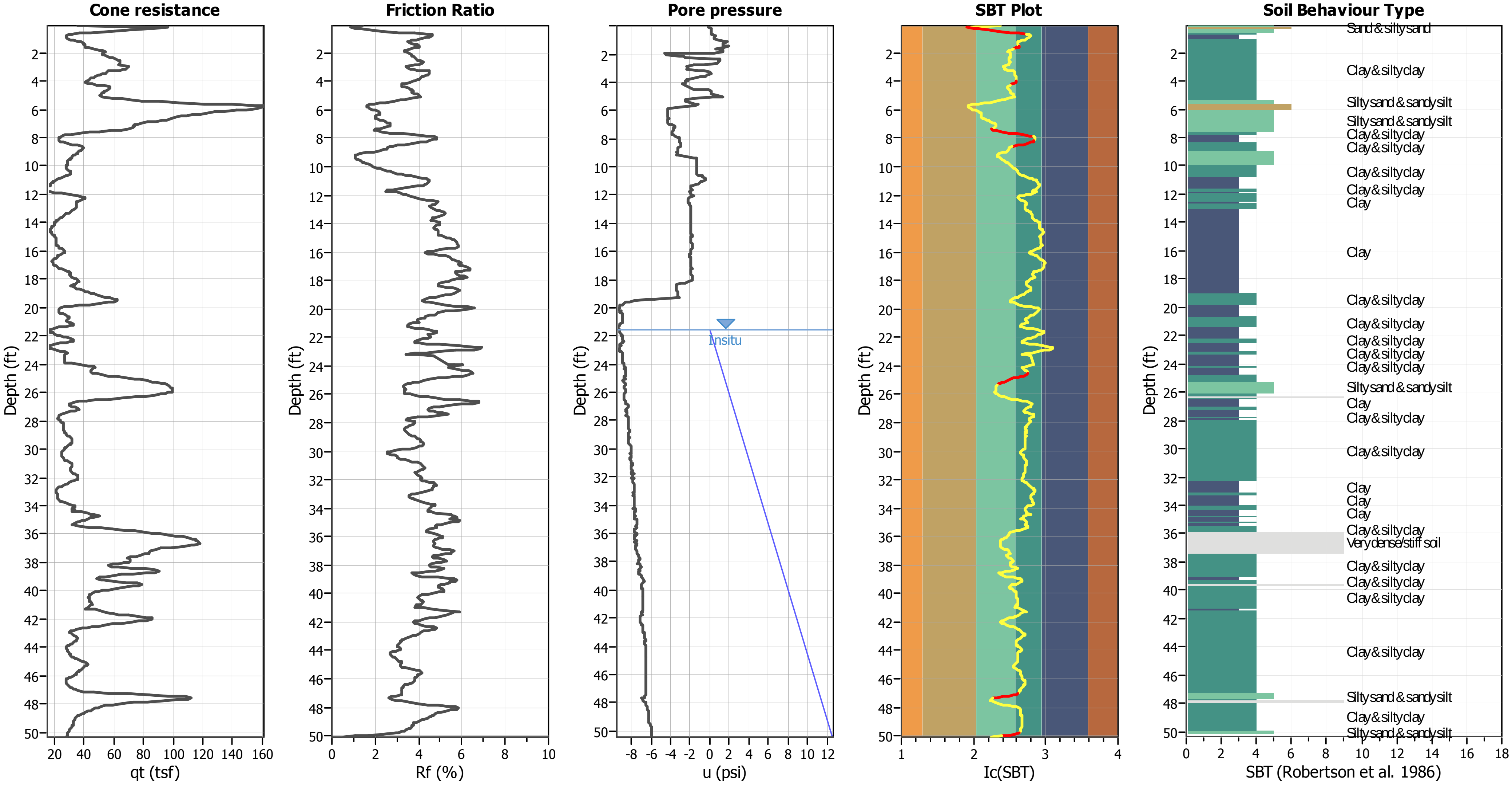






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and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

CPT basic interpretation plots



Input parameters and analysis data

Analysis method: Robertson (2009)
Fines correction method: Robertson (2009)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.30
Peak ground acceleration: 0.85
Depth to water table (insitu): 21.50 ft

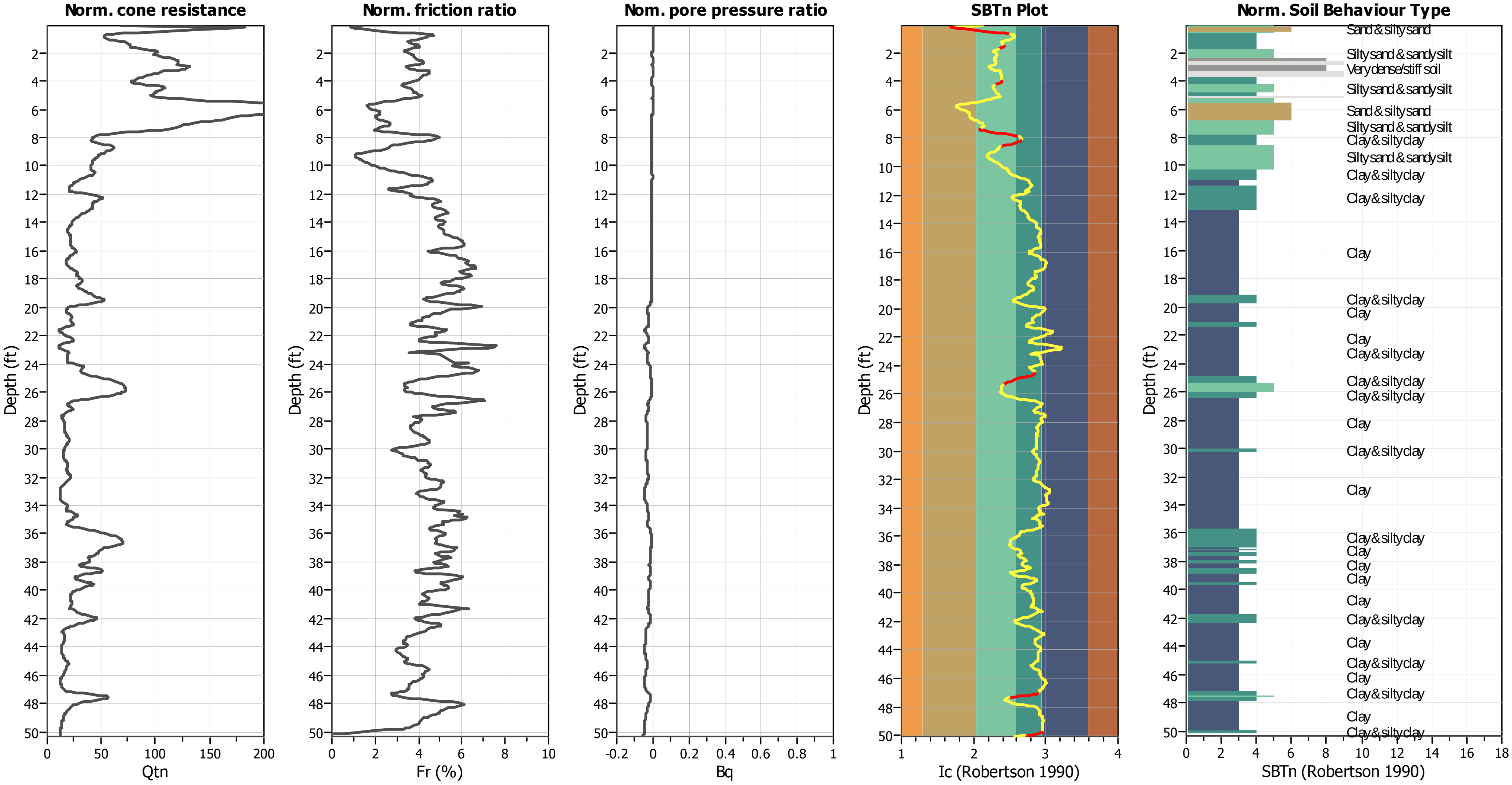
Depth to water table (erthq.): 10.00 ft
Average results interval: 5
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Excavation: Yes
Excavation depth: 12.00 ft

Footing load: 2.00 tsf
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: All soils
Limit depth applied: Yes
Limit depth: 50.00 ft

SBT legend

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

CPT basic interpretation plots (normalized)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

SBTn legend

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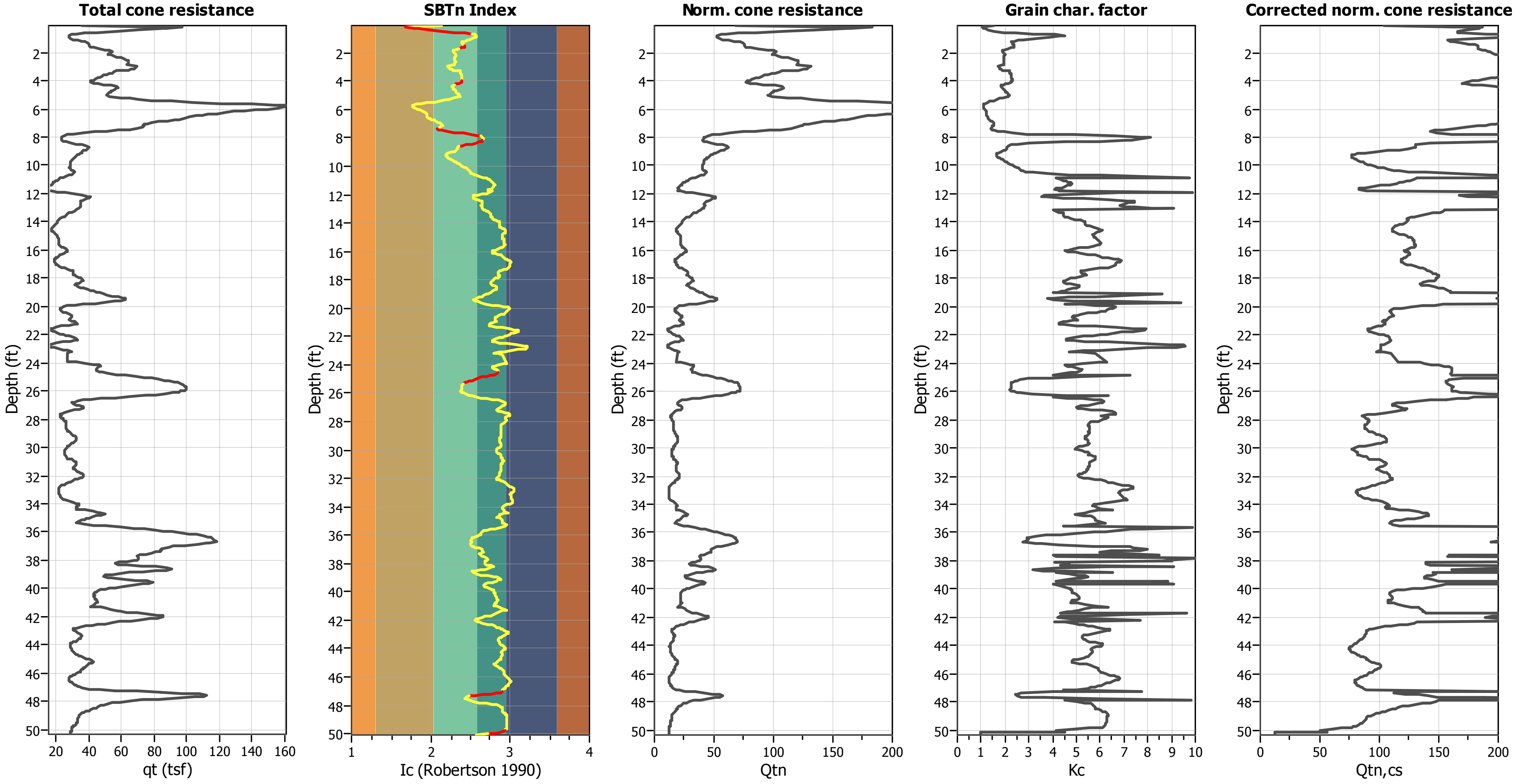
- ☐ 5. Silty sand to sandy silt
- ☐ 6. Clean sand to silty sand
- ☐ 7. Gravely sand to sand
- ☐ 8. Very stiff sand to
- ☐ 9. Very stiff fine grained

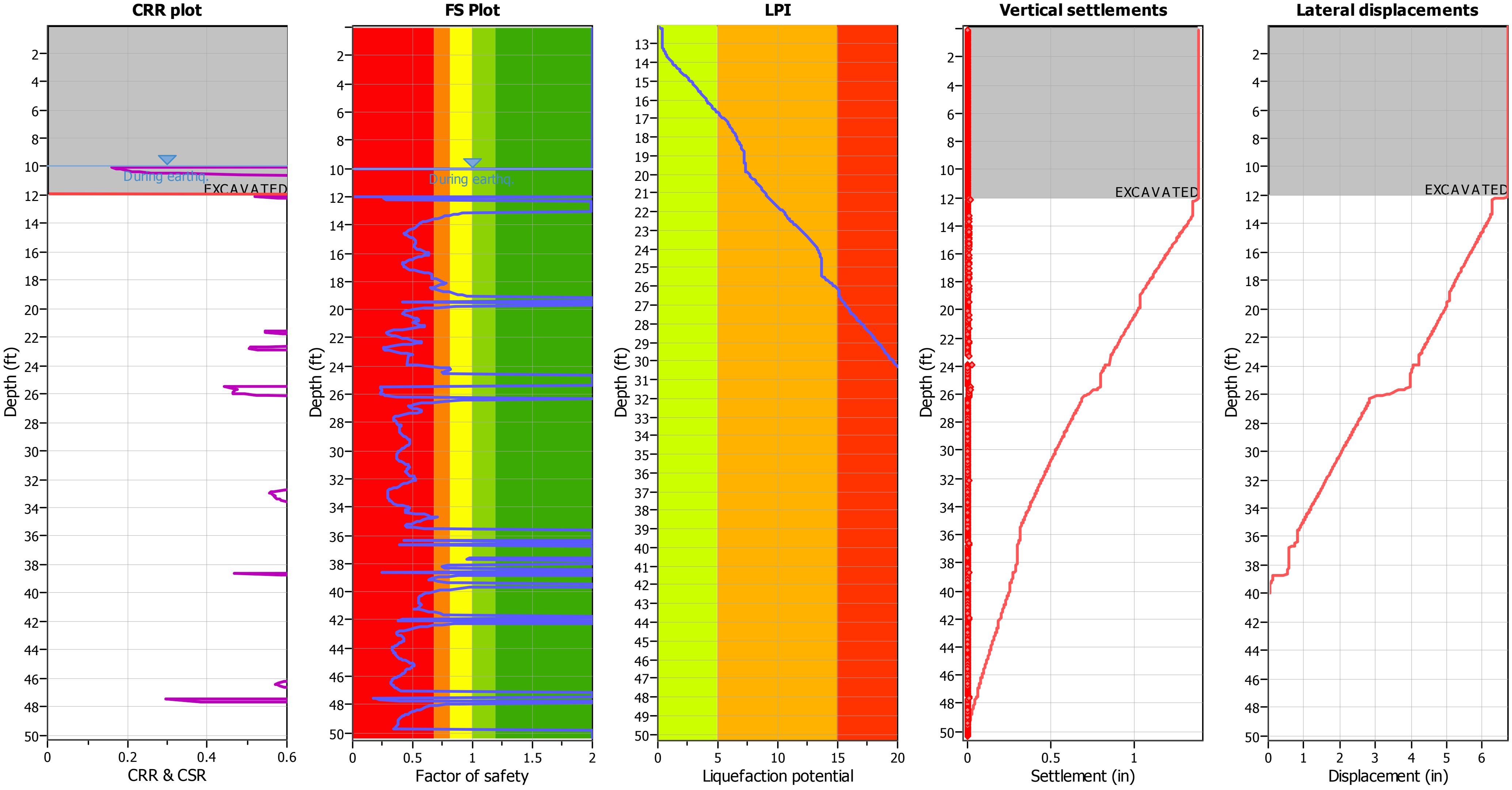
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

F.S. color scheme

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

LPI color scheme

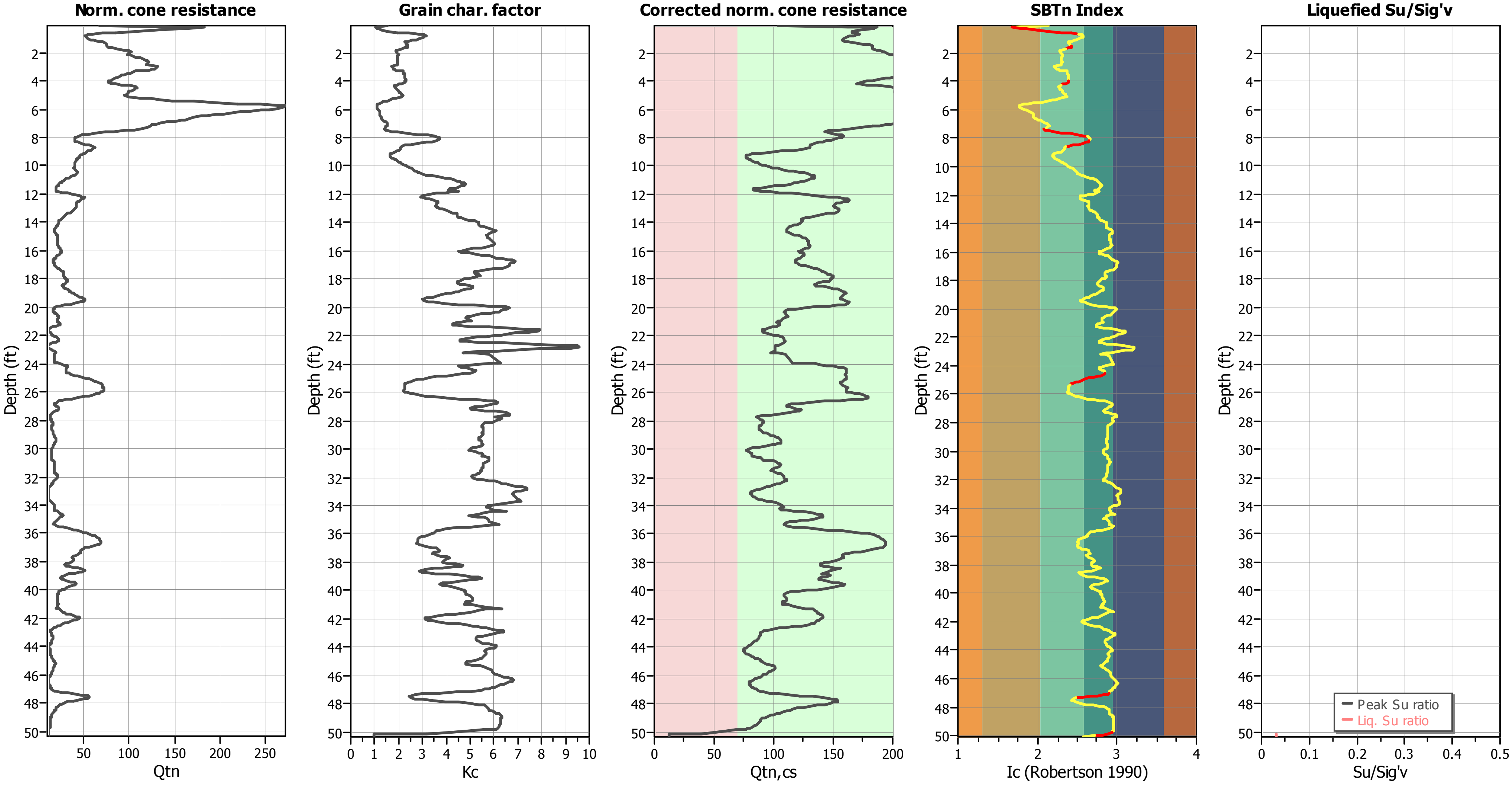
- ☐ Very high risk
- ☐ High risk
- ☐ Low risk

Liquefaction analysis summary plots

Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

Check for strength loss plots (Robertson (2010))



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	10.00 ft	Footing load:	2.00 tsf
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.30	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.85	Excavation:	Yes	Limit depth applied:	Yes
Depth to water table (insitu):	21.50 ft	Excavation depth:	12.00 ft	Limit depth:	50.00 ft

:: Liquefaction Potential Index calculation data ::

Depth (ft)	FS	F_L	w_z	d_z	LPI	Depth (ft)	FS	F_L	w_z	d_z	LPI

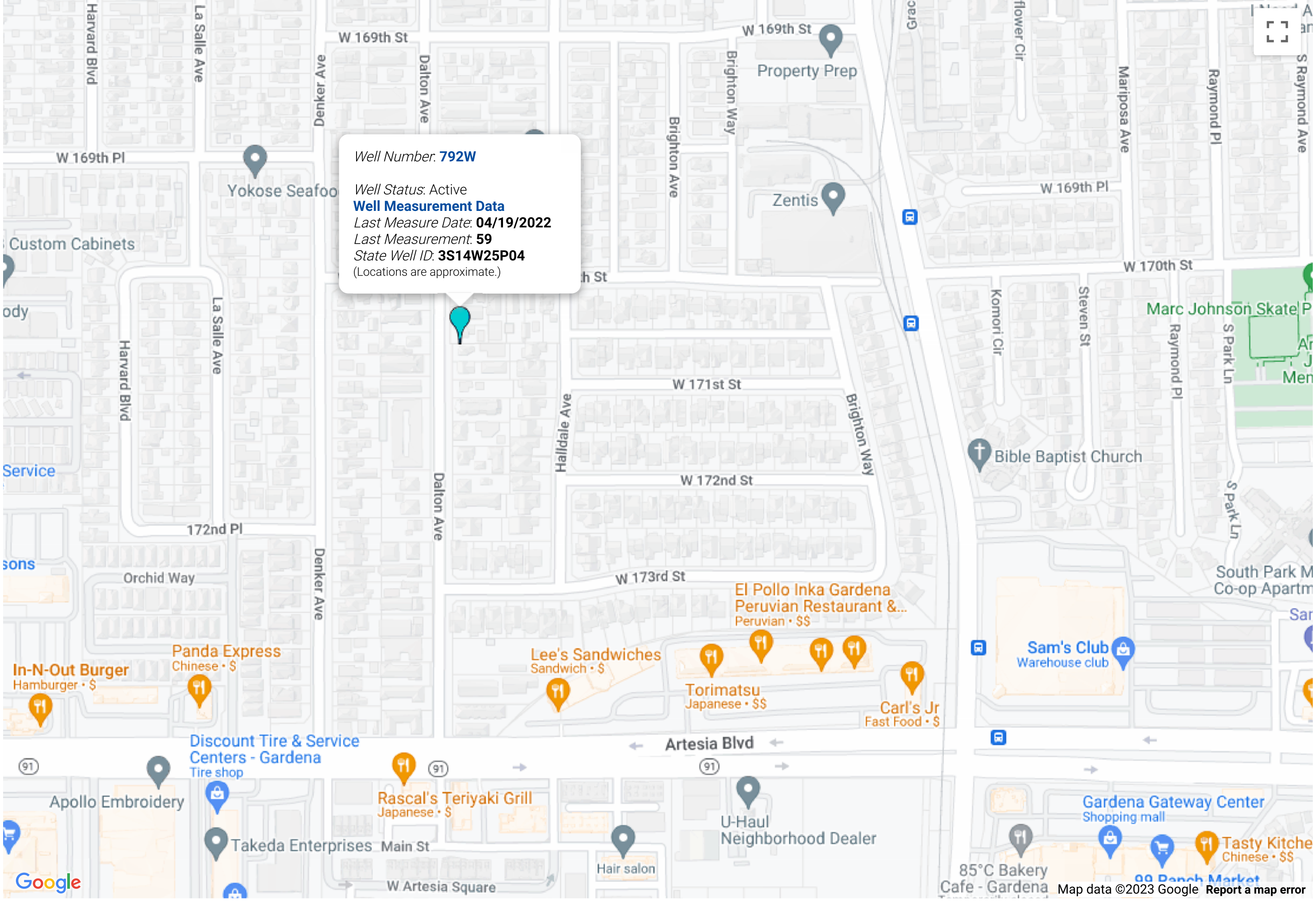
Service Locator Report a Problem Translate

Search

LOS ANGELES COUNTY

Primary Menu

Search By: Address/Intersection Search **Buffer:** None ☑ Active Wells ☐ Inactive Wells



Well Number: **792W**

Well Status: Active

Well Measurement Data

Last Measure Date: **04/19/2022**

Last Measurement: **59**

State Well ID: **3S14W25P04**

(Locations are approximate.)

SITE INFO

Accessibility

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EXPLORE

Do Business with Public Works

Organizational Chart

Careers

Projects

NEED HELP?

211 LA County

Contact Public Works

Public Works FAQ

Report a Problem

Submit Feedback

County of Los Angeles Enterprise GIS

Soil Types Feature Layer

Private Member
County of Los Angeles

Summary

This layer was created to represent soil types in Los Angeles County.

View Full Details

Download

Details

Dataset
Feature Layer

June 7, 2023
Info Updated

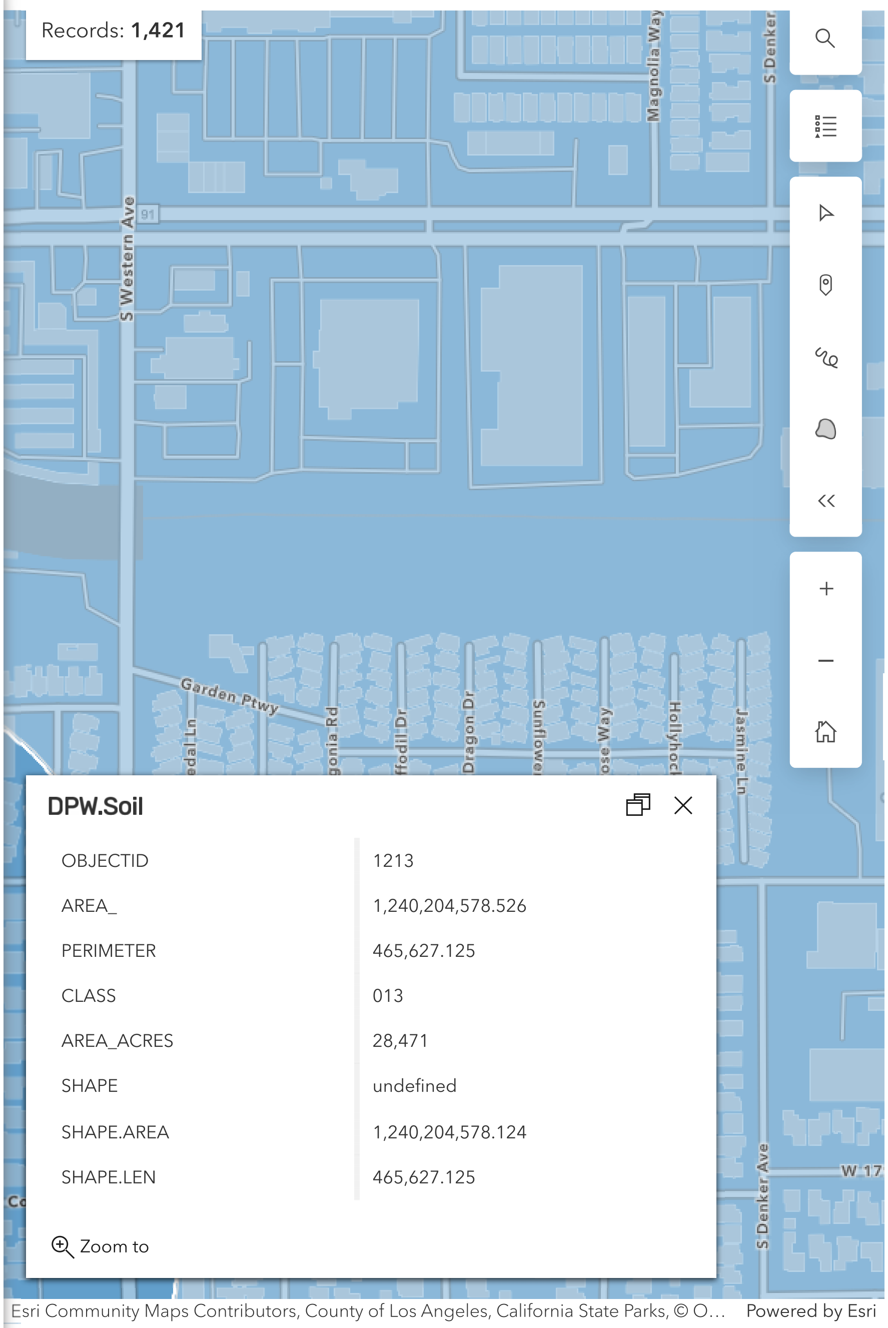
June 7, 2023
Data Updated

June 22, 2020
Published Date

Records: 1,421
View data table

Public
Anyone can see this content

Custom License
View license details



DPW.Soil

OBJECTID	1213
AREA_	1,240,204,578.526
PERIMETER	465,627.125
CLASS	013
AREA_ACRES	28,471
SHAPE	undefined
SHAPE.AREA	1,240,204,578.124
SHAPE.LEN	465,627.125

Zoom to

I want to use this

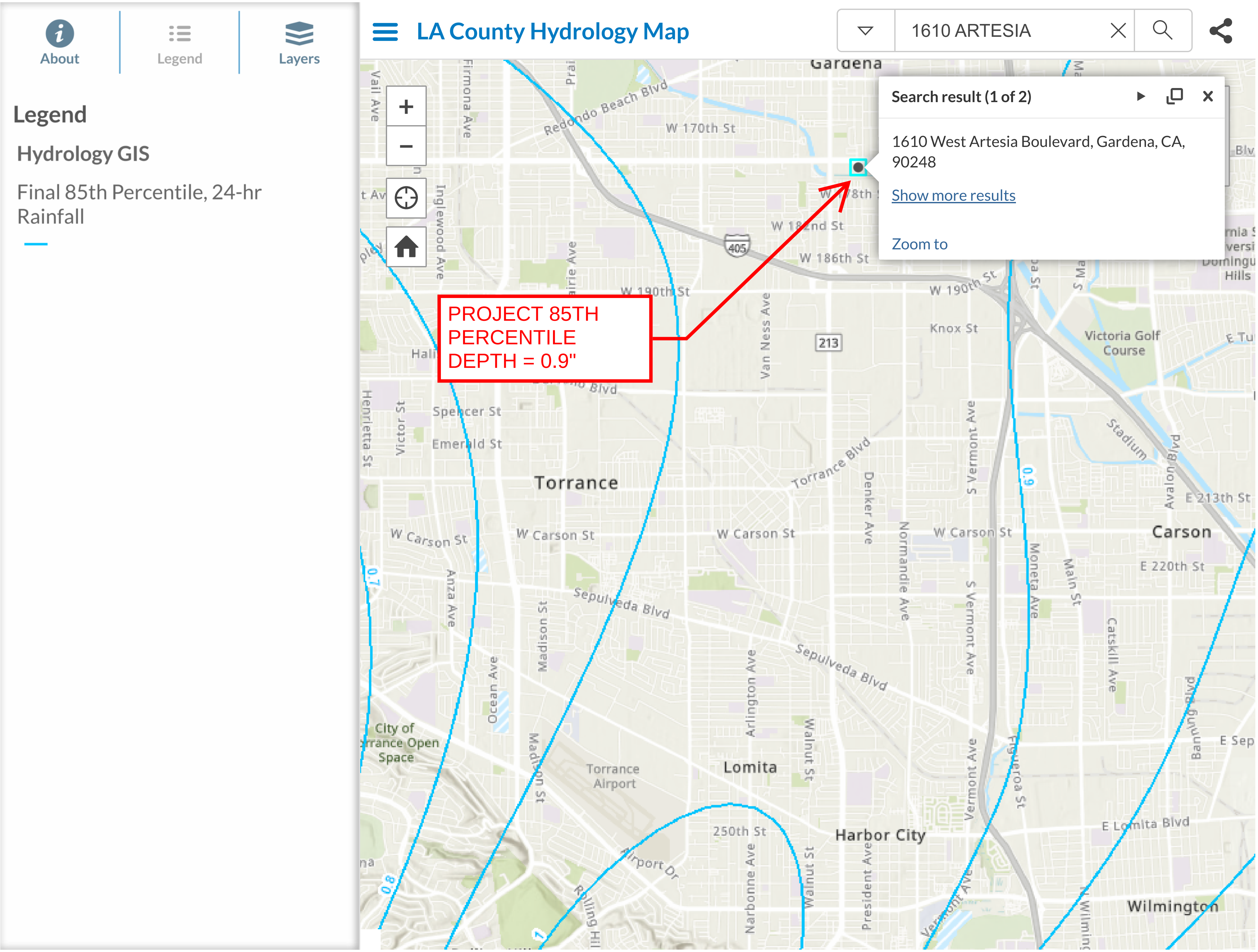
APPENDIX 4

LID INFEASIBILITY

This project is able to meet all LID treatment requirements, infeasibility is not applicable.

APPENDIX 5

BMP CALCULATIONS



Legend

Hydrology GIS

Final 85th Percentile, 24-hr Rainfall

Search result (1 of 2)

1610 West Artesia Boulevard, Gardena, CA, 90248

Show more results

Zoom to

PROJECT 85TH PERCENTILE DEPTH = 0.9"

Peak Flow Hydrologic Analysis

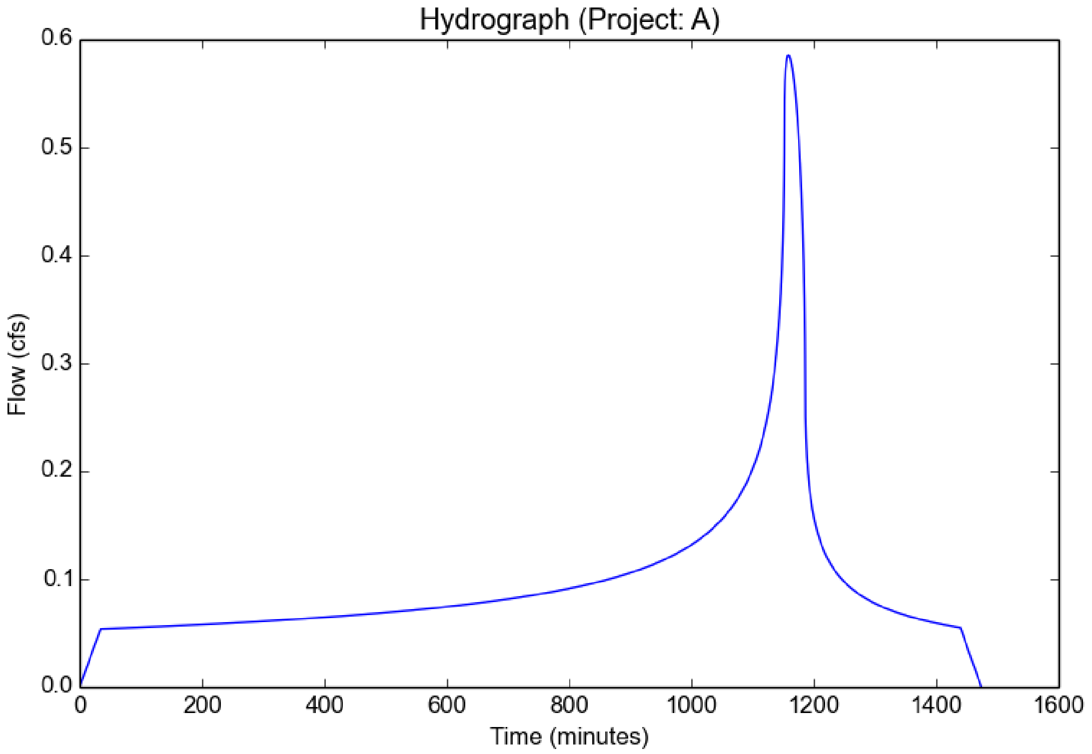
File location: K:/Drawings/SP/SP8994 - Gardena/Docs/Reports/LID/Appendix 5 - BMP Calculations/SP9018 - Torrance - Subarea A.pdf
Version: HydroCalc 0.3.1-beta

Input Parameters

Project Name	Project
Subarea ID	A
Area (ac)	3.44
Flow Path Length (ft)	700.0
Flow Path Slope (vft/hft)	0.01
85th Percentile Rainfall Depth (in)	0.9
Percent Impervious	0.85
Soil Type	13
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.9
Peak Intensity (in/hr)	0.2181
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.78
Time of Concentration (min)	34.0
Clear Peak Flow Rate (cfs)	0.5852
Burned Peak Flow Rate (cfs)	0.5852
24-Hr Clear Runoff Volume (ac-ft)	0.1996
24-Hr Clear Runoff Volume (cu-ft)	8693.6965



MWS LINEAR 2.0 HGL SIZING CALCULATIONS

MWS MODEL SIZE	WETLAND PERMITER LENGTH	LOADING RATE GPM/SF	HGL HEIGHT																													
			SHALLOW MODELS																				STANDARD HEIGHT MODEL	HIGH CAPACITY MODELS								
			1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	**3.4**	3.5	3.6	3.65	3.70	3.75	3.80	3.85	3.90	3.95
MWS-L-4-4	6.70	1.0	0.022	0.023	0.025	0.026	0.028	0.029	0.031	0.032	0.034	0.035	0.037	0.038	0.040	0.042	0.043	0.045	0.046	0.048	0.049	0.051	**0.052**	0.054	0.055	0.056	0.057	0.058	0.058	0.059	0.060	0.061
MWS-L-3-6	10.06	1.0	0.032	0.035	0.037	0.039	0.042	0.044	0.046	0.048	0.051	0.053	0.055	0.058	0.060	0.062	0.065	0.067	0.069	0.072	0.074	0.076	**0.078**	0.081	0.083	0.084	0.085	0.087	0.088	0.089	0.090	0.091
MWS-L-4-6	9.30	1.0	0.030	0.032	0.034	0.036	0.038	0.041	0.043	0.045	0.047	0.049	0.051	0.053	0.055	0.058	0.060	0.062	0.064	0.066	0.068	0.070	**0.073**	0.075	0.077	0.078	0.079	0.080	0.081	0.082	0.083	0.084
MWS-L-4-8	14.80	1.0	0.048	0.051	0.054	0.058	0.061	0.065	0.068	0.071	0.075	0.078	0.082	0.085	0.088	0.092	0.095	0.099	0.102	0.105	0.109	0.112	**0.115**	0.119	0.122	0.124	0.126	0.127	0.129	0.131	0.132	0.134
MWS-L-4-13	18.40	1.0	0.059	0.063	0.068	0.072	0.076	0.080	0.084	0.089	0.093	0.097	0.101	0.106	0.110	0.114	0.118	0.122	0.127	0.131	0.135	0.139	**0.144**	0.148	0.152	0.154	0.156	0.158	0.160	0.163	0.165	0.167
MWS-L-4-15	22.40	1.0	0.072	0.077	0.082	0.087	0.093	0.098	0.103	0.108	0.113	0.118	0.123	0.129	0.134	0.139	0.144	0.149	0.154	0.159	0.165	0.170	**0.175**	0.180	0.185	0.188	0.190	0.193	0.195	0.198	0.200	0.203
MWS-L-4-17	26.40	1.0	0.085	0.091	0.097	0.103	0.109	0.115	0.121	0.127	0.133	0.139	0.145	0.151	0.158	0.164	0.170	0.176	0.182	0.188	0.194	0.200	**0.206**	0.212	0.218	0.221	0.224	0.227	0.230	0.233	0.236	0.239
MWS-L-4-19	30.40	1.0	0.098	0.105	0.112	0.119	0.126	0.133	0.140	0.147	0.153	0.160	0.167	0.174	0.181	0.188	0.195	0.202	0.209	0.216	0.223	0.230	**0.237**	0.244	0.251	0.255	0.258	0.262	0.265	0.269	0.272	0.276
MWS-L-4-21	34.40	1.0	0.111	0.118	0.126	0.134	0.142	0.150	0.158	0.166	0.174	0.182	0.189	0.197	0.205	0.213	0.221	0.229	0.237	0.245	0.253	0.261	**0.268**	0.276	0.284	0.288	0.292	0.296	0.300	0.304	0.308	0.312
MWS-L-6-8	18.80	1.0	0.060	0.065	0.069	0.073	0.078	0.082	0.086	0.091	0.095	0.099	0.104	0.108	0.112	0.116	0.121	0.125	0.129	0.134	0.138	0.142	**0.147**	0.151	0.155	0.157	0.160	0.162	0.164	0.166	0.168	0.170
MWS-L-8-8	29.60	1.0	0.095	0.102	0.109	0.115	0.122	0.129	0.136	0.143	0.149	0.156	0.163	0.170	0.177	0.183	0.190	0.197	0.204	0.211	0.217	0.224	**0.231**	0.238	0.245	0.248	0.251	0.255	0.258	0.262	0.265	0.268
MWS-L-8-12	44.40	1.0	0.143	0.153	0.163	0.173	0.183	0.194	0.204	0.214	0.224	0.234	0.245	0.255	0.265	0.275	0.285	0.296	0.306	0.316	0.326	0.336	**0.346**	0.357	0.367	0.372	0.377	0.382	0.387	0.392	0.397	0.402
MWS-L-8-16	59.20	1.0	0.190	0.204	0.217	0.231	0.245	0.258	0.272	0.285	0.299	0.312	0.326	0.340	0.353	0.367	0.380	0.394	0.408	0.421	0.435	0.448	**0.462**	0.476	0.489	0.496	0.503	0.509	0.516	0.523	0.530	0.537
MWS-L-8-20	74.00	1.0	0.238	0.255	0.272	0.289	0.306	0.323	0.340	0.357	0.374	0.391	0.408	0.425	0.442	0.459	0.476	0.493	0.509	0.526	0.543	0.560	**0.577**	0.594	0.611	0.620	0.628	0.637	0.645	0.654	0.662	0.671
MWS-L-10-20 or MWS-L-8-24	88.80	1.0	0.285	0.306	0.326	0.346	0.367	0.387	0.408	0.428	0.448	0.469	0.489	0.509	0.530	0.550	0.571	0.591	0.611	0.632	0.652	0.673	**0.693**	0.713	0.734	0.744	0.754	0.764	0.774	0.785	0.795	0.805
4'x'4 media cage	14.80	1.0	0.048	0.051	0.054	0.058	0.061	0.065	0.068	0.071	0.075	0.078	0.082	0.085	0.088	0.092	0.095	0.099	0.102	0.105	0.109	0.112	**0.115**	0.119	0.122	0.124						

Required treatment
flow rate = 0.585 cfs

APPENDIX 6

BMP DETAIL AND FACT SHEETS

CONTECH®
ENGINEERED SOLUTIONS

Modular Wetlands® Linear Stormwater Biofiltration

The experts you need to solve your stormwater challenges

Contech is the leader in stormwater solutions, helping engineers, contractors and owners with infrastructure and land development projects throughout North America.

With our responsive team of stormwater experts, local regulatory expertise and flexible solutions, Contech is the trusted partner you can count on for stormwater management solutions.

Your Contech Team

STORMWATER CONSULTANT

It's my job to recommend the best solution to meet permitting requirements.

STORMWATER DESIGN ENGINEER

I work with consultants to design the best approved solution to meet your project's needs.

REGULATORY MANAGER

I understand the local stormwater regulations and what solutions will be approved.

SALES ENGINEER

I make sure our solutions meet the needs of the contractor during construction.

Contech is your partner in stormwater management solutions

Restoring Nature's Presence in Urban Areas – Modular Wetlands® Linear

The Modular Wetlands® Linear is the only biofiltration system to utilize patented horizontal flow, allowing for a small footprint, high treatment capacity, and design versatility. It is also the only biofiltration system that can be routinely installed downstream of storage for additional volume control and treatment.

With numerous regulatory approvals, the system's aesthetic appeal and superior pollutant removal make it the ideal solution for a wide range of stormwater applications, including urban development projects, commercial parking lots, residential streets, mixed-use developments, streetscapes, and more.

As cities grow, there is less space for natural solutions to treat stormwater. Contech understands this and is committed to providing compact, Low Impact Development (LID) solutions like the Modular Wetlands Linear to protect our nation's waterways.

How the Modular Wetlands® Linear Works

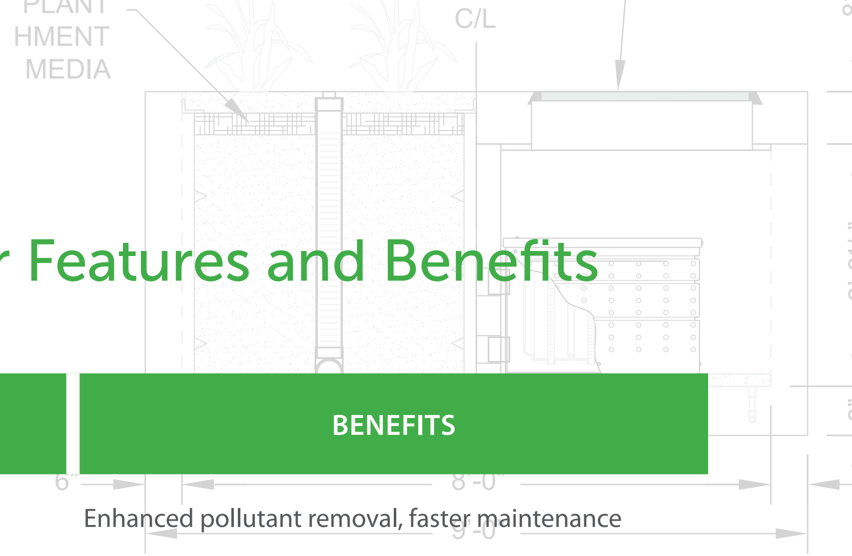
① **PRETREATMENT** | Stormwater enters the pretreatment chamber where total suspended solids settle, and trash and debris are contained within the chamber. Stormwater then travels through the pretreatment filter boxes that provide additional treatment.

② **BIOFILTRATION** | As water enters the biofiltration chamber, it fills the void space in the chamber's perimeter. Horizontal forces push the water inward through the biofiltration media, where nutrients and metals are captured. The water then enters the drain pipe to be discharged.

③ **DISCHARGE** | The specially designed vertical drain pipe and orifice control plate control the flow of water through the media to a level lower than the media's capacity, ensuring media effectiveness. The water then enters the horizontal drain pipe to be discharged.

④ **BYPASS** | During peak flows, an internal weir in the side-by-side configuration allows high flows to bypass treatment, eliminating flooding and the need for a separate bypass structure. Bypass is not provided in the end-to end configuration.

Using horizontal flow to improve performance



Modular Wetlands® Linear Features and Benefits

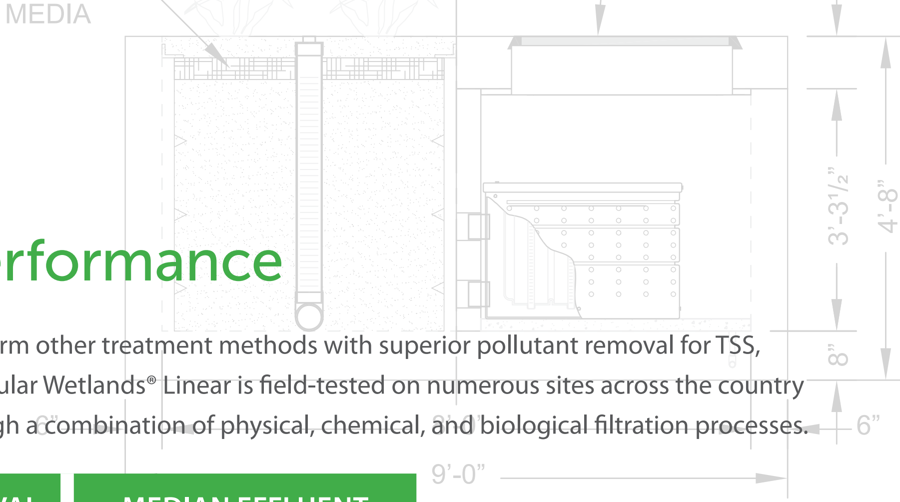
FEATURE	BENEFITS
Pretreatment chamber	Enhanced pollutant removal, faster maintenance
Horizontal flow biofiltration	Greater filter surface area
Performance verified by both the WA DOE and NJ DEP	Superior pollutant capture with confidence
Built-in high flow bypass	Eliminates flooding and the need for a separate bypass structure
Available in multiple configurations and sizes	Flexibility to meet site-specific needs

The Modular Wetlands system offers many different configurations.

Select Modular Wetlands® Linear Approvals

Modular Wetlands Linear is approved through numerous local, state and federal programs, including but not limited to:

- Washington State Department of Ecology TAPE
- California Water Resources Control Board, Full Capture Certification
- Virginia Department of Environmental Quality (VA DEQ)
- New Jersey Department of Environmental Protection (NJDEP)
- Maryland Department of the Environment - Environmental Site Design (ESD)
- Rhode Island Department of Environmental Management BMP
- Texas Commission on Environmental Quality (TCEQ)
- Atlanta Regional Commission Certification



Modular Wetlands® Performance

The Modular Wetlands® Linear continues to outperform other treatment methods with superior pollutant removal for TSS, heavy metals, nutrients, and hydrocarbons. The Modular Wetlands® Linear is field-tested on numerous sites across the country and is proven to effectively remove pollutants through a combination of physical, chemical, and biological filtration processes.

POLLUTANT OF CONCERN	MEDIAN REMOVAL EFFICIENCY	MEDIAN EFFLUENT CONCENTRATION (MG/L)
Total Suspended Solids (TSS)	89%	12
Total Phosphorus - TAPE (TP)	61%	0.041
Nitrogen (TN)	23%	1
Total Copper (TCu)	50%	0.006
Total Dissolved Copper	37%	0.006
Total Zinc (TZn)	66%	0.019
Dissolved Zinc	60%	0.0148
Motor Oil	79%	0.8

Sources:
TAPE Field Study - 2012
TAPE Field Study - 2013

Note: Some jurisdictions recognize higher removal rates. Contact your Contech Stormwater Consultant for performance expectations.

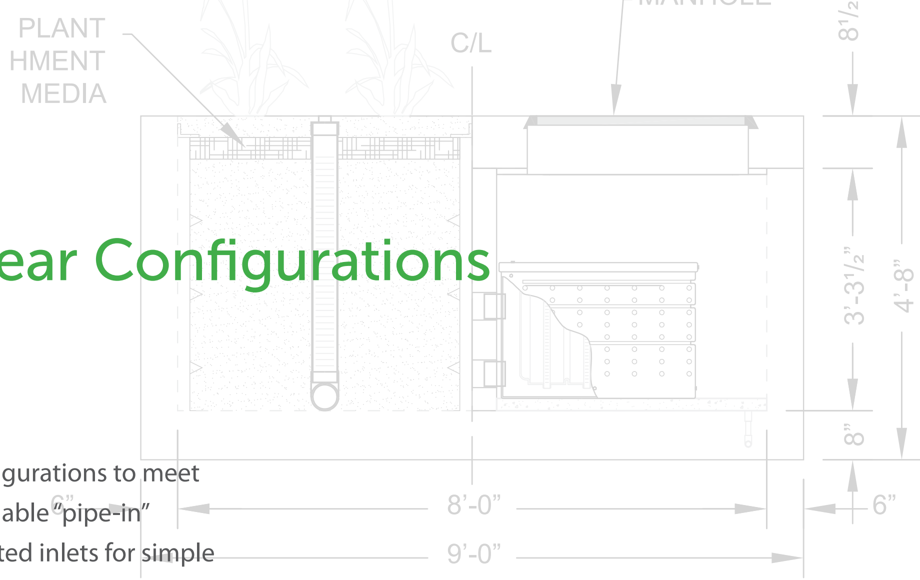
Modular Wetlands® Linear Maintenance

The Modular Wetlands® Linear is a self-contained treatment train. Maintenance requirements for the unit consist of five simple steps that can be completed using a vacuum truck. The system can also be cleaned by hand.

- Remove trash from the screening device
- Remove sediment from the separation chamber
- Periodically replace the pretreatment cartridge filter media
- Replace the drain down filter media
- Trim vegetation

Most Modular Wetland Linear systems can be cleaned in about thirty minutes.

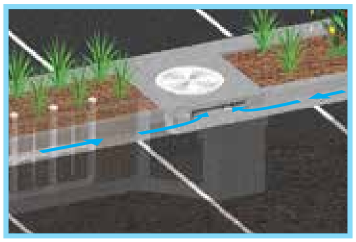
Multiple configurations allow for easy site integration



Modular Wetlands® Linear Configurations

Multiple system configurations integrate with site hydraulic design and layout ...

The Modular Wetlands Linear is offered in multiple configurations to meet site specific needs. This highly versatile system has available "pipe-in" options on most models, along with built-in curb or grated inlets for simple integration into your storm drain design.

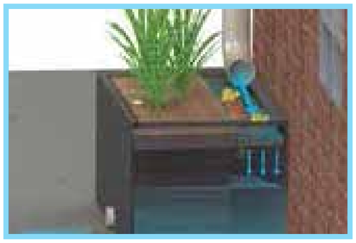


Curb Inlet

The Curb Inlet configuration accepts sheet flow through a curb opening and is commonly used along roadways and parking lots. It can be used in sump or flow-by conditions.

Vault

The Vault configuration can be used in end-of-the-line installations. Another benefit of the "pipe-in" design is the ability to install the system downstream of underground detention systems to meet water quality volume requirements, or for traffic-rated designs (no plants).



Downspout

The Downspout configuration is designed to accept a vertical downspout pipe from rooftop and podium areas. Some models have the option of utilizing an internal bypass, simplifying the overall design. The system can be installed as a raised planter, and the exterior can be stuccoed or covered with other finishes to match the look of adjacent buildings.

A partner you can rely on

STORMWATER SOLUTIONS

PIPE SOLUTIONS

STRUCTURES SOLUTIONS

Few companies offer the wide range of high-quality stormwater resources you can find with us — state-of-the-art products, decades of expertise, and all the maintenance support you need to operate your system cost-effectively.

THE CONTECH WAY

Contech® Engineered Solutions provides innovative, cost-effective site solutions to engineers, contractors, and developers on projects across North America. Our portfolio includes bridges, drainage, erosion control, retaining wall, sanitary sewer and stormwater management products.

TAKE THE NEXT STEP

For more information: www.ContechES.com

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S-1: Storm Drain Message and Signage

Purpose

Waste material dumped into storm drain inlets can adversely impact surface and ground waters. In fact, any material discharged into the storm drain system has the potential to significantly impact downstream receiving waters. Storm drain messages have become a popular method of alerting and reminding the public about the effects of and the prohibitions against waste disposal into the storm drain system. The signs are typically stenciled or affixed near the storm drain inlet or catch basin. The message simply informs the public that dumping of wastes into storm drain inlets is prohibited and/or that the drain ultimately discharges into receiving waters.

General Guidance

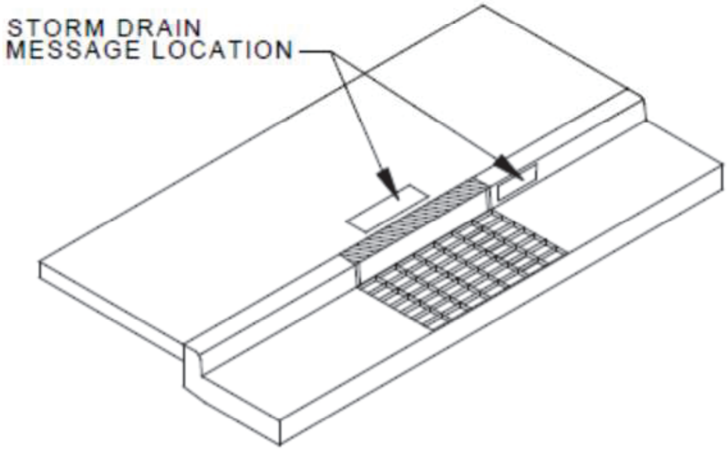
- The signs must be placed so they are easily visible to the public.
- Be aware that signs placed on sidewalk will be worn by foot traffic.

Design Specifications

- Signs with language and/or graphical icons that prohibit illegal dumping, must be posted at designated public access points along channels and streams within the project area. Consult with Los Angeles County Department of Public Works (LACDPW) staff to determine specific signage requirements for channels and streams.
- Storm drain message markers, placards, concrete stamps, or stenciled language/icons (e.g., “No Dumping – Drains to the Ocean”) are required at all storm drain inlets and catch basins within the project area to discourage illegal or inadvertent dumping. Signs should be placed in clear sight facing anyone approaching the storm drain inlet or catch basin from either side (see Figure D-1 and Figure D-2). LACDPW staff should be contacted to determine specific requirements for types of signs and methods of application. A stencil can be purchased for a nominal fee from LACDPW Building and Safety Office by calling (626) 458-3171. All storm drain inlet and catch basin locations must be identified on the project site map.

Maintenance Requirements

Legibility and visibility of markers and signs should be maintained (e.g., signs should be repainted or replaced as necessary). If required by LACDPW, the owner/operator or homeowner’s association shall enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards and signs.



NOTES:

1. STORM DRAIN MESSAGE SHALL BE APPLIED IN SUCH A WAY AS TO PROVIDE A CLEAR, LEGIBLE IMAGE.
2. STORM DRAIN MESSAGE SHALL BE PERMANENTLY APPLIED DURING THE CONSTRUCTION OF THE CURB AND GUTTER USING A METHOD APPROVED BY THE LOCAL AGENCY.

Figure D-1. Storm Drain Message Location – Curb Type Inlet

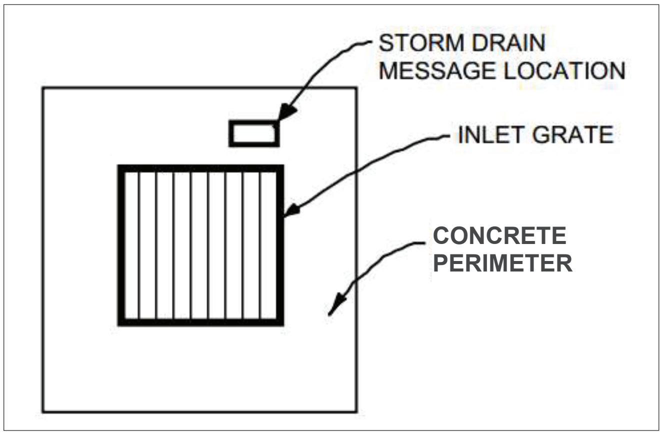


Figure D-2. Storm Drain Message Location – Catch Basin/Area Type Inlet

S-2: Outdoor Material Storage Area

Purpose

The County defines outdoor material storage areas as areas or facilities whose sole purpose is the storage of materials. Materials, including raw materials, by-products, finished products, and waste products, stored outdoors can become sources of pollutants in stormwater runoff if not handled or stored properly. The type of pollutants associated with the materials will vary depending on the type of commercial or industrial activity present.

Materials may be stored in a variety of ways, including bulk piles, containers, shelving, stacking, and tanks. Contamination of stormwater runoff may be prevented by eliminating the possibility of stormwater runoff contact with the material storage areas either through diversion, cover, or capture of the stormwater runoff. Design considerations may also include minimizing the storage area. The source control measures presented in this fact sheet must meet local permitting requirements.

Some materials, such as those containing heavy metals or toxic compounds, are of more concern than other materials. Toxic and hazardous materials must be prevented from coming in contact with stormwater runoff. Non-toxic or non-hazardous materials, such as debris and sediment, can also have significant impacts on receiving waters. Contact between non-toxic or non-hazardous materials and stormwater runoff should be limited, and such materials prevented from being discharged with stormwater runoff.

Materials are classified into three categories based on the potential risk of pollutant release associated with stormwater runoff contact – high risk, medium risk, and low risk. General types of materials under each category are presented in Table D-1. The categorization of the potential pollutant risk is used to determine the design specifications, which are presented in Table D-2, for design features at the project site.

Table D-1. Classification of Materials for Potential Pollutant Risk

High Risk Materials	Medium Risk Materials	Low Risk Materials
• Recycled materials with discharge potential • Corrosives • Food items • Chalk/gypsum products • Scrap or salvage goods • Feedstock/grain • Fertilizers • Pesticides • Compost • Asphalt • Lime/lye/soda ash • Animal/human wastes • Rubber and plastic pellets or other small pieces • Uncured concrete/cement • Lead and copper, and any metals with oil/grease coating	• Clean recycled materials without discharge potential • Metal (excluding lead and copper, and any metals with oil/grease coating) • Sawdust/bark chips • Sand/soil • Unwashed gravel/rock	• Washed gravel/rock • Finished lumber (non-pressure treated) • Rubber or plastic products (excluding small pieces) • Clean, precast concrete products • Glass products (new) • Inert products • Gaseous products • Products in containers that prevent contact with stormwater (fertilizers and pesticides excluded)

Design Specifications

Design specifications for material storage areas are regulated by local building and fire codes, ordinances, and zoning requirements. Source control measures presented in this fact sheet are intended to enhance and be consistent with local code and ordinance requirements while addressing stormwater runoff concerns. The design specifications, presented in Table D-2, must be incorporated into the design of outdoor material storage areas when stored materials could contribute pollutants to the storm drain system. The level of controls required varies relative to the risk category of the material stored.

As general guidance, downspouts and roofs should be directed away from outdoor materials storage areas, and such storage areas should slope towards a dead-end sump to collect stormwater runoff, non-stormwater runoff, and spills. Stormwater runoff, non-stormwater runoff, and spills must be disposed of in accordance with local, state, and federal laws. Locations of design features, including the features presented in Table D-2, must be included on site maps or plans. Additionally, site maps or plans must show all storage areas for chemicals and/or waste materials, with a tank/drum schedule indicating tank capacities, materials of construction, and contents.

Table D-2. Design Specifications for Outdoor Material Storage Areas

Design Feature	Design Specifications
Surfacing	• High-Risk Materials: o Construct/pave outdoor material storage areas with Portland cement concrete or an equivalent impervious surface. Ensure that the surfacing material is chemically-resistant to the materials being stored. • Medium-Risk Materials: o Construct/pave outdoor material storage areas with Portland cement concrete. • Low-Risk Materials: o There are no requirements for surfacing.
Enclosures and Covers	• High-Risk Materials: o Place materials in an enclosure such as a shed, cabinet, or other structure that prevents contact with stormwater runoff; or o Cover entire storage area with a permanent canopy, roof, or awning to prevent precipitation from making direct contact with and collecting within the storage area. Direct stormwater runoff from the cover away from the storage area to a stormwater runoff disposal point that meets all applicable code, ordinance, and LID Standards Manual requirements. For cover structures that do not include sidewalls, include a roof overhang that extends beyond the grade break. o Covers 10 feet high or less should extend a minimum of 3 feet beyond the perimeter of the hydraulically-isolated storage area. o Covers higher than 10 feet should extend a minimum of either 20 percent of the cover’s height or 5 feet beyond the perimeter of the hydraulically-isolated storage area, whichever is greater. o LACDPW may grant waivers for covers on a case-by-case basis. • Medium-Risk Materials: o At a minimum, completely cover material with temporary plastic sheeting during storm events. • Low-Risk Materials: o There are no requirements for enclosures or covers.

Table D-2. Design Specifications for Outdoor Material Storage Areas (continued)

Hydraulic Isolation and Drainage	• High-Risk Materials: o Hydraulically-isolate storage area with grading, berms, drains, dikes, or curbs to prevent stormwater run-on from surrounding areas or roof drains. o Direct stormwater runoff from surrounding areas away from the hydraulically-isolated storage area to a stormwater runoff disposal point that meets all applicable LID Standards Manual requirements. o Drainage facilities are not required for the hydraulically-isolated storage area. However, if drainage facilities are provided, drainage from the hydraulically-isolated storage area must be directed to a stormwater runoff disposal point as determined by LACDPW. • Medium-Risk Materials: o Drainage from storage area may be allowed, on a case-by-case basis with approval from LACDPW, to a treatment control measure or standard storm drain(s). o For erodible material, provide grading and a structural containment barrier on at least three sides of each stockpile to prevent stormwater run-on from surrounding areas and migration of material due to wind erosion. • Low-Risk Materials: o Provide appropriate drainage from the storage area to minimize contact with materials.
Spill Containment	• All Materials: o Implement spill containment measures where materials are stored in tanks, drums, or similar containers and that may potentially enter the storm drain system, sanitary sewer system, or contaminate the soil. Spill containment must be designed for the volume of the largest tank/drum or 10 percent of the tank/drum total (whichever is greater). o Separate spill containment systems for all tanks containing incompatible materials such as acids, bases, reactive or flammable materials. o Clean, repair, and seal (using epoxy or equivalent sealant compatible with the stored materials) the interior wall and floors within all spill containment areas. Identify the areas to be sealed on the site maps. o Bond the contact joint for spill containment walls or dikes constructed on existing concrete, masonry or asphalt to the existing surface. Identify the areas to be bonded on the site maps. o Cover the spill containment areas with a roof or awning to minimize collection of stormwater runoff within. o Store materials collected in spill containment areas until its quality and an appropriate approved disposal method have been determined.

Accumulated Water

Stormwater runoff, non-stormwater runoff, and spills will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and regulations, and cannot be discharged directly to the storm drain or sanitary sewer system without appropriate permitting. Contact LACDPW (1-888-CLEAN-LA) for information regarding discharge of contaminated accumulated water.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Outdoor material storage areas must be checked periodically to ensure containment of accumulated water and prevention of stormwater run-on. Any enclosures and secondary/spill containment areas should be checked periodically to ensure spills are contained efficiently. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

S-3: Outdoor Trash Storage and Waste Handling Area

Purpose

Stormwater runoff from areas where trash is stored or handled can be polluted. Loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or receiving waters. Waste handling operations (i.e., dumpsters, litter control, waste piles) may be sources of stormwater pollution.

Design Specifications

Wastes from commercial and industrial sites are typically hauled away for disposal by either public or commercial carriers that may have design or access requirements for waste storage areas. Design specifications for waste handling areas are regulated by local building and fire codes and by current County ordinances and zoning requirements. The design specifications, listed below in Table D-3, are recommendations and are not intended to conflict with requirements established by the waste hauler. The design specifications are intended to enhance local codes and ordinances while addressing stormwater runoff concerns. The waste hauler should be contacted prior to the design of trash storage and collection areas to determine established and accepted guidelines for designing trash collection areas. All hazardous waste must be handled in accordance with the legal requirements established in Title 22 of the California Code of Regulations. Conflicts or issues should be discussed with LACDPW staff.

Table D-3. Design Specifications for Outdoor Trash Storage and Waste Handling Area

Design Feature	Design Specifications
Surfacing	• Construct/pave outdoor trash storage and waste handling area with Portland cement concrete or an equivalent impervious surface.
Screens/Covers	• Install a screen or wall around trash storage area to prevent off-site transport of loose trash. • Use lined bins or dumpsters to reduce leaking of liquid wastes. • Use waterproof lids on bins/dumpsters or provide a roof to cover storage area enclosure (LACDPW discretion) to prevent precipitation from entering containers.
Grading/Drainage	• Berm and/or grade waste handling area to prevent stormwater run-on. • Locate waste handling area at least 35 feet from storm drains. • Divert drainage from adjoining roofs and pavement away from adjacent trash storage areas.
Signs	• Post signs on all dumpsters and/or inside enclosures prohibiting disposal of liquids and hazardous materials in accordance with any waste disposal ordinance.

Accumulated Water

Stormwater runoff, non-stormwater runoff, and spills will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and regulations, and cannot be discharged directly to the storm drain or sanitary sewer system without appropriate permitting. Contact LACDPW (1-888-CLEAN-LA) for information regarding discharge of contaminated accumulated water.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Outdoor trash storage and waste handling areas must be checked periodically to ensure containment of accumulated water and prevention of stormwater run-on. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

S-8: Landscape Irrigation Practices

Purpose

Irrigation runoff provides a pathway for pollutants (i.e., nutrients, bacteria, organics, sediment) to enter the storm drain system. By effectively irrigating, less runoff is produced resulting in less potential for pollutants to enter the storm drain system.

General Guidance

- Do not allow irrigation runoff from the landscaped area to drain directly to storm drain system.
- Minimize use of fertilizer, pesticides, and herbicides on landscaped areas.
- Plan sites with sufficient landscaped area and dispersal capacity (e.g., ability to receive irrigation water without generating runoff).
- Consult a landscape professional regarding appropriate plants, fertilizer, mulching applications, and irrigation requirements (if any) to ensure healthy vegetation growth.

Design Specifications

- Choose plants that minimize the need for fertilizer and pesticides.
- Group plants with similar water requirements and water accordingly.
- Use mulch to minimize evaporation and erosion.
- Include a vegetative boundary around project site to act as a filter.
- Design the irrigation system to only water areas that need it.
- Install an approved subsurface drip, pop-up, or other irrigation system.[1] The irrigation system should employ effective energy dissipation and uniform flow spreading methods to prevent erosion and facilitate efficient dispersion.
- Install rain sensors to shut off the irrigation system during and after storm events.
- Include pressure sensors to shut off flow-through system in case of sudden pressure drop. A sudden pressure drop may indicate a broken irrigation head or water line.
- If the hydraulic conductivity in the soil is not sufficient for the necessary water application rate, implement soil amendments to avoid potential geotechnical hazards (i.e., liquefaction, landslide, collapsible soils, and expansive soils).

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[1] If alternative distribution systems (e.g., spray irrigation) are approved, the County will establish guidelines to implement these new systems.

- For sites located on or within 50 feet of a steep slope (15% or greater), do not irrigate landscape within three days of a storm event to avoid potential geotechnical instability.[2]
- Implement Integrated Pest Management practices.

For additional guidelines and requirements, refer to the Los Angeles County Department of Health Services.

Maintenance Requirements

Maintain irrigation areas to remove trash and debris and loose vegetation. Rehabilitate areas of bare soil. If a rain or pressure sensor is installed, it should be checked periodically to ensure proper function. Inspect and maintain irrigation equipment and components to ensure proper functionality. Clean equipment as necessary to prevent algae growth and vector breeding. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

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[2] As determined by the City of Los Angeles, Building and Safety Division

S-9: Building Materials Selection

Purpose

Building materials can potentially contribute pollutants of concern to stormwater runoff through leaching. For example, metal buildings, roofing, and fencing materials may be significant sources of metals in stormwater runoff, especially due to acidic precipitation. The use of alternative building materials can reduce pollutant sources in stormwater runoff by eliminating compounds that can leach into stormwater runoff. Alternative building materials may also reduce the need to perform maintenance activities (i.e., painting) that involve pollutants of concern, and may reduce the volume of stormwater runoff. Alternative materials are available to replace lumber and paving.

Design Specifications

Lumber

Decks and other house components constructed using pressure-treated wood that is typically treated using arsenate, copper, and chromium compounds are hazardous to the environment. Pressure-treated wood may be replaced with cement-fiber or vinyl.

Roofs, Fencing, and Metals

Minimizing the use of copper and galvanized (zinc-coated) metals on buildings and fencing can reduce leaching of these pollutants into stormwater runoff. The following building materials are conventionally made of galvanized metals:

- Metal roofs;
- Chain-link fencing and siding; and
- Metal downspouts, vents, flashing, and trim on roofs.

Architectural use of copper for roofs and gutters should be avoided. As an alternative to copper and galvanized materials, coated metal products are available for both roofing and gutter application. Vinyl-coated fencing is an alternative to traditional galvanized chain-link fences. These products eliminate contact of bare metal with precipitation or stormwater runoff, and reduce the potential for stormwater runoff contamination. Roofing materials are also made of recycled rubber and plastic.

Green roofs may be an option. Green roofs use vegetation such as grasses and other plants as an exterior surface. The plants reduce the velocity of stormwater runoff and absorb water to reduce the volume of stormwater runoff. One potential problem with using green roofs in the Los Angeles County area is the long, hot and dry summers, which may kill the plants if they are not watered. See the Green Roof Fact Sheet (RET-7) in Appendix E.

Pesticides

The use of pesticides around foundations can be reduced through the use of alternative barriers. Sand barriers can be applied around foundations to deter termites, as they cannot tunnel through sand. Metal shields also block termites from tunneling. Additionally, diatomaceous earth can be used to repel or kill a wide variety of other pests.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., signs) must be maintained by the owner/operator as required by local codes and ordinances. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

Table 5-1. Source Control Measures Selection Matrix

Project Type	**Source Control Measure**										
	Storm Drain Message and Signage (S-1)	**Outdoor Material Storage Area (S-2)**	**Outdoor Trash Storage/ Waste Handling Area (S-3)**	**Outdoor Loading/Unloading Dock Area (S-4)**	**Outdoor Vehicle/Equipment Repair/Maintenance Area (S-5)**	**Outdoor Vehicle/ Equipment/ Accessory Wash Area (S-6)**	**Fuel & Maintenance Area (S-7)**	**Landscape Irrigation Practices (S-8)**	**Building Materials (S-9)**	**Animal Care and Handling Facilities (S-10)**	**Outdoor Horticulture Areas (S-11)**
Designated Projects – New Development											
Development ≥1 acre and ≥10,000 ft^2 new impervious area	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	R^1	R^1
Industrial parks (≥10,000 ft^2)	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	–	–
Commercial malls (≥10,000 ft^2)	R	R^1	R^1	R^1	R^1	R^1	–	R	R	R^1	R^1
Retail gasoline outlets (≥5,000 ft^2)	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	–	–
Restaurants (≥5,000 ft^2)	R	R^1	R^1	R^1	–	–	–	R	R	–	–
Parking lots (≥5,000 ft^2 or ≥25 parking spaces)	R	R^1	R^1	R^1	–	–	–	R	R	R^1	R^1
Automotive service facilities (5,000 ft^2)	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	–	–
Projects in/around Significant Ecologic Areas	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	R^1	R^1
Projects potentially impacting sensitive biological species or habitats	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	R^1	R^1
Projects adding ≥2,500 ft^2 of impervious area	R	R^1	R^1	R^1	R^1	R^1	R^1	R	R	R^1	R^1

R = required; R^1 = required if outdoor activity area is included in project; R^2 = required for multi-family dwellings

APPENDIX 7

OPERATION AND MAINTENANCE PLAN
BMP INSPECTION MAINTENANCE RECORDS

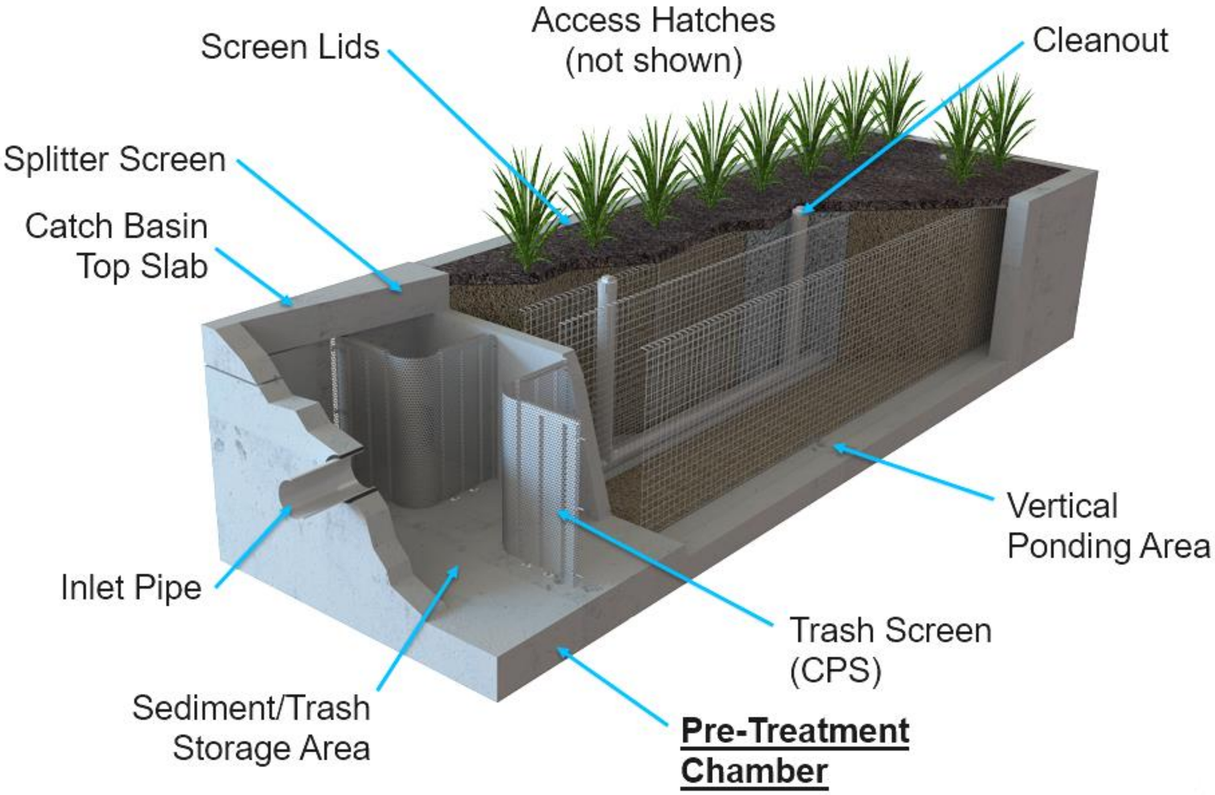
MAINTENANCE AND COVENANT
AGREEMENT TO BE PROVIDED
BEFORE FINAL LID APPOVAL

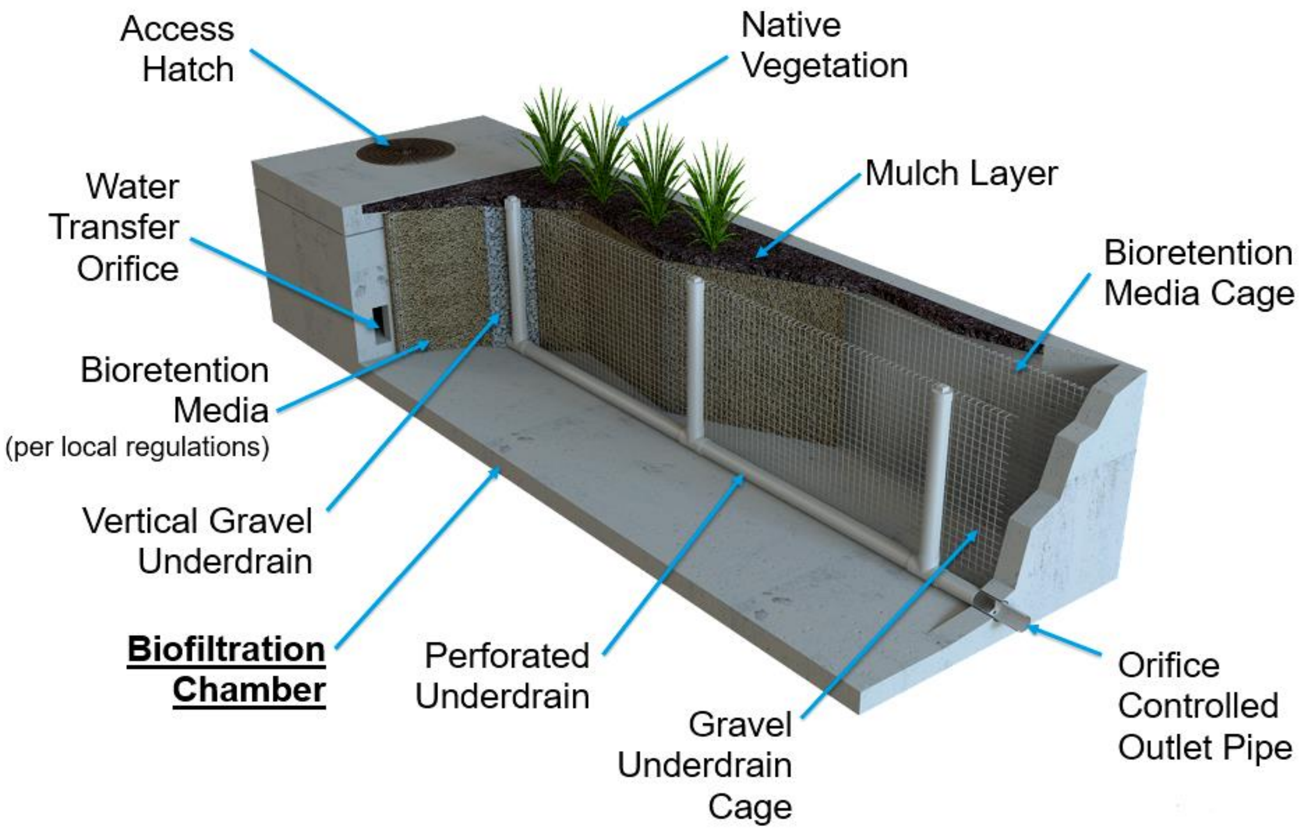
Inspection Guidelines for WetlandMOD

Inspection Summary

- <u>Inspect Pre-Treatment Chamber</u> – average inspection interval is 6 to 12 months.
    - (5-*minute average inspection time*).
- <u>Inspect Biofiltration Chamber</u> – average inspection interval is 6 to 12 months.
    - (10-*minute average inspection time*).
- <u>NOTE:</u> Pollutant loading varies greatly from site to site and no two sites are the same. Therefore, the first year requires inspection monthly during the wet season and every other month during the dry season in order to observe and record the amount of pollutant loading the system is receiving.

System Diagram





Inspection Overview

As with all stormwater BMPs inspection and maintenance on the WetlandMOD is necessary. Stormwater regulations require that all BMPs be inspected and maintained to ensure they are operating as designed to allow for effective pollutant removal and provide protection to receiving water bodies. It is recommended that inspections be performed multiple times during the first year to assess the site specific loading conditions. This is recommended because pollutant loading and pollutant characteristics can vary greatly from site to site. Variables such as nearby soil erosion or construction sites, winter sanding on roads, amount of daily traffic and land use can increase pollutant loading on the system. The first year of inspections can be used to set inspection and maintenance intervals for subsequent years to ensure appropriate maintenance is provided. Without appropriate maintenance a BMP will exceed its storage capacity which can negatively affect its continued performance in removing and retaining captured pollutants.

Inspection Equipment

Following is a list of equipment to allow for simple and effective inspection of the WetlandMOD:

- WetlandMOD Inspection Form
- Flashlight
- Manhole hook or appropriate tools to remove access hatches and covers (if applicable)
- Appropriate traffic control signage and procedures
- Measuring pole and/or tape measure.
- Protective clothing and eye protection.

- Note: entering a confined space requires appropriate safety and certification. It is generally not required for routine inspections of the system.

Inspection Steps

The core to any successful stormwater BMP maintenance program is routine inspections. The inspection steps required on the WetlandMOD are quick and easy. As mentioned above the first year should be seen as the maintenance interval establishment phase. During the first year more frequent inspections should occur in order to gather loading data and maintenance requirements for that specific site. This information can be used to establish a base for long-term inspection and maintenance interval requirements.

The WetlandMOD can be inspected though visual observation without entry into the system. All necessary pre-inspection steps must be carried out before inspection occurs, especially traffic control and other safety measures to protect the inspector and near-by pedestrians from any dangers associated with an open access. Once the top tray is removed the following apply:

- Prepare the inspection form by writing in the necessary information including project name, location, date & time, unit number and other info (see inspection form).
- Observe the inside of the pre-treatment chamber and biofiltration chamber once the access hatch is removed. If minimal light is available and vision into the unit is impaired utilize a flashlight to see inside the system and all of its chambers.
- Look for any out of the ordinary obstructions in the inflow pipe, around the trash screen (CPS), on the surface of the media, or in the drain down riser. Write down any observations on the inspection form.
- Through observation and/or digital photographs estimate the amount of trash, debris and sediment accumulated in the chamber. Utilizing a tape measure or measuring stick estimate the amount of trash, debris and sediment on the floor of each chamber. Record this depth on the inspection form.
- Finalize inspection report for analysis by the maintenance manager to determine if maintenance is required.

Maintenance Indicators

Based upon observations made during inspection, maintenance of the system may be required based on the following indicators:

- Missing or damaged internal components.
- Obstructions in the system or its inlet or outlet.

- Excessive accumulation of floatables more than 12” in depth in the pre-treatment chamber.
- Excessive accumulation of sediment of more than 6” in depth in the biofiltration chamber.
- Excessive build up on the vertical surface of the biofiltration media.
- Overgrown vegetation.
- Storage area around media cage has standing water 72 hours after a storm event.

Inspection Notes

1. Following maintenance and/or inspection, it is recommended the maintenance operator prepare a maintenance/inspection record. The record should include any maintenance activities performed, amount and description of debris collected, and condition of the system and its various filter mechanisms.

2. The owner should keep maintenance/inspection record(s) for a minimum of five years from the date of maintenance. These records should be made available to the governing municipality for inspection upon request at any time.

3. Transport all debris, trash, organics and sediments to approved facility for disposal in accordance with local and state requirements.

4. Entry into chambers may require confined space training based on state and local regulations.

5. No fertilizer shall be used in the Biofiltration Media.

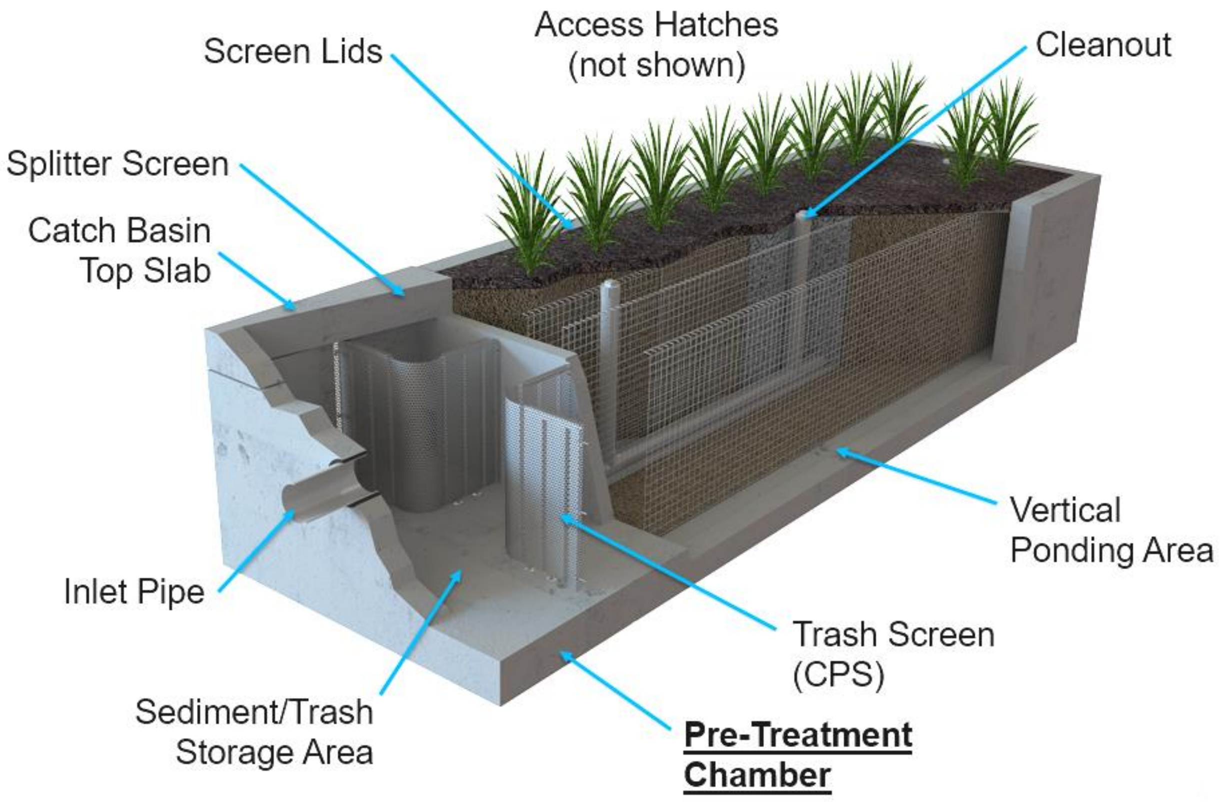
6. Irrigation should be provided as recommended by manufacturer and/or landscape architect. Amount of irrigation required is dependent on plant species. Some plants may not require irrigation after initial establishment.

Maintenance Guidelines for WetlandMOD

Maintenance Summary

- Remove Sediment and Trash from Pre-Treatment Chamber – average maintenance interval is 6 to 12 months.
    - *(15 minute average service time).*
- Removed Sediment and Pressure Wash Biofiltration Media Surface – average maintenance interval 12 to 24 months.
    - *(15-60 minutes depending on size of system).*
- Trim Vegetation – average maintenance interval is 6 to 12 months.
    - *(Service time varies).*

System Diagram



Maintenance Overview

The time has come to maintain your WetlandMOD. To ensure successful and efficient maintenance on the system we recommend the following. The WetlandMod can be maintained by removing the access hatches. The mulch over the top tray should be removed prior to removing the top hatch over the biofiltration chamber. All necessary pre-maintenance steps must be carried out before maintenance occurs, especially traffic control and other safety measures to protect the inspector and near-by pedestrians from any dangers associated with an open access hatch or manhole. Once traffic control has been set up per local and state regulations and access covers have been safely opened the maintenance process can begin. It should be noted that no maintenance activities require confined space entry but if entry is done all confined space requirements must be strictly followed before entry into the system. In addition the following is recommended:

- Prepare the maintenance form by writing in the necessary information including project name, location, date & time, unit number and other info (see maintenance form).
- Set up all appropriate safety and cleaning equipment.
- Ensure traffic control is set up and properly positioned.
- Prepare a pre-checks (OSHA, safety, confined space entry) are performed.

Maintenance Equipment

Following is a list of equipment required for maintenance of the WetlandMOD:

- WetlandMOD Maintenance Form
- Manhole hook or appropriate tools to access hatches and covers (if applicable)
- Protective clothing, flashlight and eye protection.
- Vacuum assisted truck with pressure washer.
- Replacement pre-filter wraps (order from manufacturer).

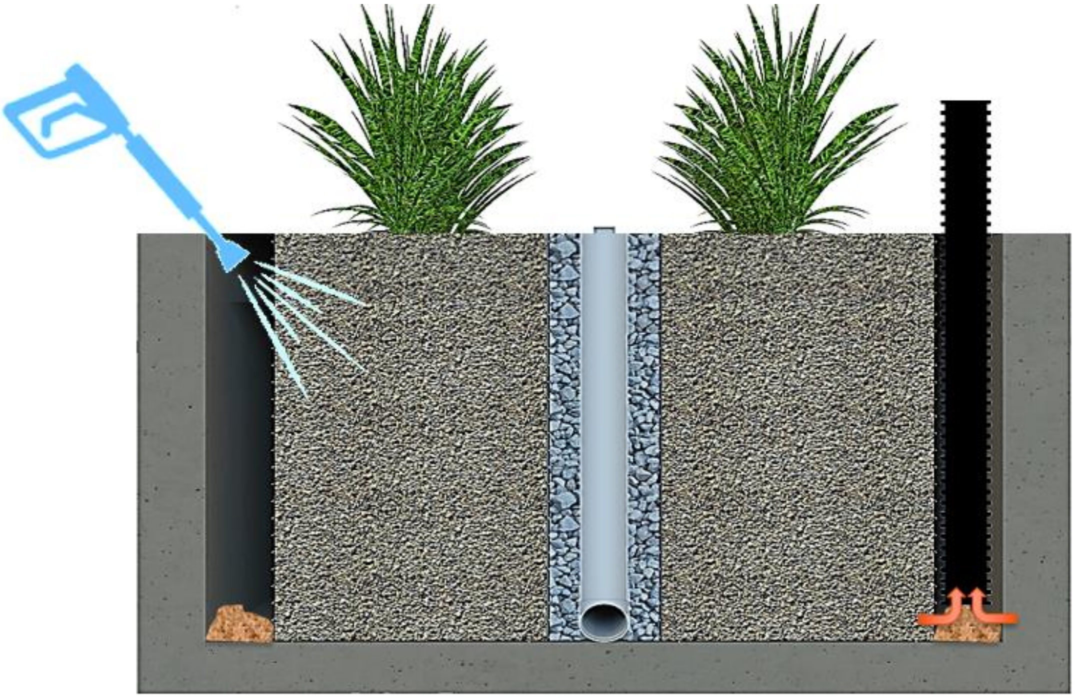
Maintenance Steps

1. Pre-Treatment Chamber (first chamber that contains trash screens)

   A. Remove access hatch and position vacuum truck accordingly.
   B. With a pressure washer spray down pollutants accumulated on trash screens.
   C. Vacuum out all accumulated pollutants including trash, debris and sediments. Be sure to vacuum the floor, screens, and walls along with outlet side of screens.

2. Biofiltration Chamber (vegetated chamber)

   A. Remove the mulch along each side of the unit. Rake away from side walls. Remove top covers to gain access to void areas.
   B. Pressure wash off the vertical surface of the media be using a pressure washer and a vacuum hose to collect and material on the floor around the cage. Pressure wash down into the media to allow accumulated sediments to flow back into the surrounding perimeter separation area for collection with the vac hose.
   C. Replace the top covers.
   D. Trim any vegetation that is overgrown.
   E. Replace the mulch to cover the top covers.



Maintenance Notes

1. Transport all debris, trash, organics and sediments to approved facility for disposal in accordance with local and state requirements.
2. Entry into chambers may require confined space training based on state and local regulations.
3. No fertilizer shall be used in the Biofiltration Chamber.
4. Irrigation should be provided as recommended by manufacturer and/or landscape architect. Amount of irrigation required is dependent on plant species. Some plants may not require irrigation after initial establishment

Inspection Form

Bio Clean, A Forterra Company
P. 760.433-7640
F. 760-433-3176
E. stormwater@forterrabp.com

www.biocleanenvironmental.com

Bio Clean
A Forterra Company

Inspection Report
WetlandMOD System

Project Name

Project Address

(city) (Zip Code)

Owner / Management Company

Contact

Phone ( ) –

Inspector Name

Date / /

Time AM / PM

Type of Inspection ☐ Routine ☐ Follow Up ☐ Complaint ☐ Storm

Storm Event in Last 72-hours? ☐ No ☐ Yes

Weather Condition

Additional Notes

For Office Use Only
(Reviewed By)
(Date) Office personnel to complete section to the left.

Inspection Checklist

WetlandMod System:

Size (Model):

Structural Integrity:	**Yes**	**No**	**Comments**
Damage to pre-treatment access cover (manhole cover/grate) or cannot be opened using normal lifting pressure?			
Damage to discharge chamber access cover (manhole cover/grate) or cannot be opened using normal lifting pressure?			
Does the MWS unit show signs of structural deterioration (cracks in the wall, damage to frame)?			
Is the inlet/outlet pipe or drain down pipe damaged or otherwise not functioning properly?			
Working Condition:			
Is there evidence of illicit discharge or excessive oil, grease, or other automobile fluids entering and clogging the unit?			
Is there standing water in inappropriate areas after a dry period?			
Is the filter insert (if applicable) at capacity and/or is there an accumulation of debris/trash on the shelf system?			
Does the depth of sediment/trash/debris suggest a blockage of the inflow pipe, bypass or cartridge filter? If yes, specify which one in the comments section. Note depth of accumulation in in pre-treatment chamber.			Depth:
Does the cartridge filter media need replacement in pre-treatment chamber and/or discharge chamber?			Chamber:
Any signs of improper functioning in the discharge chamber? Note issues in comments section.			
Other Inspection Items:			
Is there an accumulation of sediment/trash/debris in the wetland media (if applicable)?			
Is it evident that the plants are alive and healthy (if applicable)? Please note Plant Information below.			
Is there a septic or foul odor coming from inside the system?			

Waste:	**Yes**	**No**
Sediment / Silt / Clay		
Trash / Bags / Bottles		
Green Waste / Leaves / Foliage		

Recommended Maintenance	
No Cleaning Needed	
Schedule Maintenance as Planned	
Needs Immediate Maintenance	

Plant Information	
Damage to Plants	
Plant Replacement	
Plant Trimming	

Additional Notes:

Maintenance Report

Bio Clean, A Forterra Company
P. 760.433-7640
F. 760-433-3176
E. stormwater@forterrabp.com

www.biocleanenvironmental.com

Bio Clean
A Forterra Company

Cleaning and Maintenance Report
WetlandMOD System

Project Name ______________________________

Project Address ______________________________ (city) (Zip Code)

Owner / Management Company ______________________________

Contact ______________________________ Phone ( ) –

Inspector Name ______________________________ Date ______ / ______ / __________ Time ______________ AM / PM

Type of Inspection ☐ Routine ☐ Follow Up ☐ Complaint ☐ Storm Storm Event in Last 72-hours? ☐ No ☐ Yes

Weather Condition ______________________________ Additional Notes ______________________________

For Office Use Only

(Reviewed By)

(Date)

Office personnel to complete section to the left.

Site Map #	GPS Coordinates of Insert	Manufacturer / Description / Sizing	Trash Accumulation	Foliage Accumulation	Sediment Accumulation	Total Debris Accumulation	Condition of Media 25/50/75/100 (will be changed @ 75%)	Operational Per Manufactures' Specifications (If not, why?)
	Lat: Long:	WM Catch Basins						
		WM Sedimentation Basin						
		CPS Filter Condition						
		Plant Condition						
		Drain Down Media Condition						
		Discharge Chamber Condition						
		Drain Down Pipe Condition						
		Inlet and Outlet Pipe Condition						

Comments:

APPENDIX 8

SOURCE CONTROL MEASURES

Spill Prevention, Control & Cleanup SC-11

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	
Nutrients	✓
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Spills and leaks, if not properly controlled, can adversely impact the storm drain system and receiving waters. Due to the type of work or the materials involved, many activities that occur either at a municipal facility or as a part of municipal field programs have the potential for accidental spills and leaks. Proper spill response planning and preparation can enable municipal employees to effectively respond to problems when they occur and minimize the discharge of pollutants to the environment.

Approach

- An effective spill response and control plan should include:
  - Spill/leak prevention measures;
  - Spill response procedures;
  - Spill cleanup procedures;
  - Reporting; and
  - Training
- A well thought out and implemented plan can prevent pollutants from entering the storm drainage system and can be used as a tool for training personnel to prevent and control future spills as well.

Pollution Prevention

- Develop and implement a Spill Prevention Control and Response Plan. The plan should include:

CASQA
California
Stormwater
Quality
Association

  - A description of the facility, the address, activities and materials involved
  - Identification of key spill response personnel
  - Identification of the potential spill areas or operations prone to spills/leaks
  - Identification of which areas should be or are bermed to contain spills/leaks
  - Facility map identifying the key locations of areas, activities, materials, structural BMPs, etc.
  - Material handling procedures
  - Spill response procedures including:
    - Assessment of the site and potential impacts
    - Containment of the material
    - Notification of the proper personnel and evacuation procedures
    - Clean up of the site
    - Disposal of the waste material and
    - Proper record keeping

- Product substitution – use less toxic materials (i.e. use water based paints instead of oil based paints)
- Recycle, reclaim, or reuse materials whenever possible. This will reduce the amount of materials that are brought into the facility or into the field.

Suggested Protocols

Spill/Leak Prevention Measures

- If possible, move material handling indoors, under cover, or away from storm drains or sensitive water bodies.
- Properly label all containers so that the contents are easily identifiable.
- Berm storage areas so that if a spill or leak occurs, the material is contained.
- Cover outside storage areas either with a permanent structure or with a seasonal one such as a tarp so that rain can not come into contact with the materials.
- Check containers (and any containment sumps) often for leaks and spills. Replace containers that are leaking, corroded, or otherwise deteriorating with containers in good condition. Collect all spilled liquids and properly dispose of them.

- Store, contain and transfer liquid materials in such a manner that if the container is ruptured or the contents spilled, they will not discharge, flow or be washed into the storm drainage system, surface waters, or groundwater.

- Place drip pans or absorbent materials beneath all mounted taps and at all potential drip and spill locations during the filling and unloading of containers. Any collected liquids or soiled absorbent materials should be reused/recycled or properly disposed of.

- For field programs, only transport the minimum amount of material needed for the daily activities and transfer materials between containers at a municipal yard where leaks and spill are easier to control.

- If paved, sweep and clean storage areas monthly, do not use water to hose down the area unless all of the water will be collected and disposed of properly.

- Install a spill control device (such as a tee section) in any catch basins that collect runoff from any storage areas if the materials stored are oil, gas, or other materials that separate from and float on water. This will allow for easier cleanup if a spill occurs.

- If necessary, protect catch basins while conducting field activities so that if a spill occurs, the material will be contained.

Training

- Educate employees about spill prevention, spill response and cleanup on a routine basis.

- Well-trained employees can reduce human errors that lead to accidental releases or spills:

  - The employees should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

  - Employees should be familiar with the Spill Prevention Control and Countermeasure Plan if one is available.

- Training of staff from all municipal departments should focus on recognizing and reporting potential or current spills/leaks and who they should contact.

- Employees responsible for aboveground storage tanks and liquid transfers for large bulk containers should be thoroughly familiar with the Spill Prevention Control and Countermeasure Plan and the plan should be readily available.

Spill Response and Prevention

- Identify key spill response personnel and train employees on who they are.

- Store and maintain appropriate spill cleanup materials in a clearly marked location near storage areas; and train employees to ensure familiarity with the site's spill control plan and/or proper spill cleanup procedures.

- Locate spill cleanup materials, such as absorbents, where they will be readily accessible (e.g. near storage and maintenance areas, on field trucks).

- Follow the Spill Prevention Control and Countermeasure Plan if one is available.
- If a spill occurs, notify the key spill response personnel immediately. If the material is unknown or hazardous, the local fire department may also need to be contacted.
- If safe to do so, attempt to contain the material and block the nearby storm drains so that the area impacted is minimized. If the material is unknown or hazardous wait for properly trained personnel to contain the materials.
- Perform an assessment of the area where the spill occurred and the downstream area that it could impact. Relay this information to the key spill response and clean up personnel.

Spill Cleanup Procedures

- Small non-hazardous spills
    - Use a rag, damp cloth or absorbent materials for general clean up of liquids
    - Use brooms or shovels for the general clean up of dry materials
    - If water is used, it must be collected and properly disposed of. The wash water can not be allowed to enter the storm drain.
    - Dispose of any waste materials properly
    - Clean or dispose of any equipment used to clean up the spill properly
- Large non-hazardous spills
    - Use absorbent materials for general clean up of liquids
    - Use brooms, shovels or street sweepers for the general clean up of dry materials
    - If water is used, it must be collected and properly disposed of. The wash water can not be allowed to enter the storm drain.
    - Dispose of any waste materials properly
    - Clean or dispose of any equipment used to clean up the spill properly
- For hazardous or very large spills, a private cleanup company or Hazmat team may need to be contacted to assess the situation and conduct the cleanup and disposal of the materials.
- Chemical cleanups of material can be achieved with the use of absorbents, gels, and foams. Remove the adsorbent materials promptly and dispose of according to regulations.
- If the spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to a certified laundry (rags) or disposed of as hazardous waste.

Reporting

- Report any spills immediately to the identified key municipal spill response personnel.

- Report spills in accordance with applicable reporting laws. Spills that pose an immediate threat to human health or the environment must be reported immediately to the Office of Emergency Service (OES)

- Spills that pose an immediate threat to human health or the environment may also need to be reported within 24 hours to the Regional Water Quality Control Board.

- Federal regulations require that any oil spill into a water body or onto an adjoining shoreline be reported to the National Response Center (NRC) at 800-424-8802 (24 hour)

- After the spill has been contained and cleaned up, a detailed report about the incident should be generated and kept on file (see the section on Reporting below). The incident may also be used in briefing staff about proper procedures

Other Considerations

- State regulations exist for facilities with a storage capacity of 10,000 gallons or more of petroleum to prepare a Spill Prevention Control and Countermeasure Plan (SPCC) Plan (Health & Safety Code Chapter 6.67).

- State regulations also exist for storage of hazardous materials (Health & Safety Code Chapter 6.95), including the preparation of area and business plans for emergency response to the releases or threatened releases.

- Consider requiring smaller secondary containment areas (less than 200 sq. ft.) to be connected to the sanitary sewer, if permitted to do so, prohibiting any hard connections to the storm drain.

Requirements

Costs

- Will vary depending on the size of the facility and the necessary controls.

- Prevention of leaks and spills is inexpensive. Treatment and/or disposal of wastes, contaminated soil and water is very expensive

Maintenance

- This BMP has no major administrative or staffing requirements. However, extra time is needed to properly handle and dispose of spills, which results in increased labor costs

Supplemental Information

Further Detail of the BMP

Reporting

Record keeping and internal reporting represent good operating practices because they can increase the efficiency of the response and containment of a spill. A good record keeping system helps the municipality minimize incident recurrence, correctly respond with appropriate containment and cleanup activities, and comply with legal requirements.

A record keeping and reporting system should be set up for documenting spills, leaks, and other discharges, including discharges of hazardous substances in reportable quantities. Incident records describe the quality and quantity of non-stormwater discharges to the storm drain.

These records should contain the following information:

- Date and time of the incident
- Weather conditions
- Duration of the spill/leak/discharge
- Cause of the spill/leak/discharge
- Response procedures implemented
- Persons notified
- Environmental problems associated with the spill/leak/discharge

Separate record keeping systems should be established to document housekeeping and preventive maintenance inspections, and training activities. All housekeeping and preventive maintenance inspections should be documented. Inspection documentation should contain the following information:

- The date and time the inspection was performed
- Name of the inspector
- Items inspected
- Problems noted
- Corrective action required
- Date corrective action was taken

Other means to document and record inspection results are field notes, timed and dated photographs, videotapes, and drawings and maps.

Examples

The City of Palo Alto includes spill prevention and control as a major element of its highly effective program for municipal vehicle maintenance shops.

References and Resources

King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr/dss/spcm.htm

Orange County Stormwater Program
http://www.ocwatersheds.com/stormwater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Parking/Storage Area Maintenance SC-43

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Parking lots and storage areas can contribute a number of substances, such as trash, suspended solids, hydrocarbons, oil and grease, and heavy metals that can enter receiving waters through stormwater runoff or non-stormwater discharges. The following protocols are intended to prevent or reduce the discharge of pollutants from parking/storage areas and include using good housekeeping practices, following appropriate cleaning BMPs, and training employees.

Approach

Pollution Prevention

- Encourage alternative designs and maintenance strategies for impervious parking lots. (See New Development and Redevelopment BMP Handbook).

- Keep accurate maintenance logs to evaluate BMP implementation.

Suggested Protocols

General

- Keep the parking and storage areas clean and orderly. Remove debris in a timely fashion.

- Allow sheet runoff to flow into biofilters (vegetated strip and swale) and/or infiltration devices.

- Utilize sand filters or oleophilic collectors for oily waste in low concentrations.

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- Arrange rooftop drains to prevent drainage directly onto paved surfaces.
- Design lot to include semi-permeable hardscape.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide an adequate number of litter receptacles.
- Clean out and cover litter receptacles frequently to prevent spillage.
- Provide trash receptacles in parking lots to discourage litter.
- Routinely sweep, shovel and dispose of litter in the trash.

Surface cleaning

- Use dry cleaning methods (e.g. sweeping or vacuuming) to prevent the discharge of pollutants into the stormwater conveyance system.
- Establish frequency of public parking lot sweeping based on usage and field observations of waste accumulation.
- Sweep all parking lots at least once before the onset of the wet season.
- If water is used follow the procedures below:
  - Block the storm drain or contain runoff.
  - Wash water should be collected and pumped to the sanitary sewer or discharged to a pervious surface, do not allow wash water to enter storm drains.
  - Dispose of parking lot sweeping debris and dirt at a landfill.
- When cleaning heavy oily deposits:
  - Use absorbent materials on oily spots prior to sweeping or washing.
  - Dispose of used absorbents appropriately.

Surface Repair

- Pre-heat, transfer or load hot bituminous material away from storm drain inlets.
- Apply concrete, asphalt, and seal coat during dry weather to prevent contamination form contacting stormwater runoff.
- Cover and seal nearby storm drain inlets (with waterproof material or mesh) and manholes before applying seal coat, slurry seal, etc., where applicable. Leave covers in place until job is complete and until all water from emulsified oil sealants has drained or evaporated. Clean any debris from these covered manholes and drains for proper disposal.

- Use only as much water as necessary for dust control, to avoid runoff.

- Catch drips from paving equipment that is not in use with pans or absorbent material placed under the machines. Dispose of collected material and absorbents properly.

Inspection

- Have designated personnel conduct inspections of the parking facilities and stormwater conveyance systems associated with them on a regular basis.

- Inspect cleaning equipment/sweepers for leaks on a regular basis.

Training

- Provide regular training to field employees and/or contractors regarding cleaning of paved areas and proper operation of equipment.

- Train employees and contractors in proper techniques for spill containment and cleanup.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.

- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, nad implement accordingly.

- Have spill cleanup materials readily available and in a known location.

- Cleanup spills immediately and use dry methods if possible.

- Properly dispose of spill cleanup material.

Other Considerations

- Limitations related to sweeping activities at large parking facilities may include high equipment costs, the need for sweeper operator training, and the inability of current sweeper technology to remove oil and grease.

Requirements

Costs

Cleaning/sweeping costs can be quite large, construction and maintenance of stormwater structural controls can be quite expensive as well.

Maintenance

- Sweep parking lot to minimize cleaning with water.

- Clean out oil/water/sand separators regularly, especially after heavy storms.

- Clean parking facilities on a regular basis to prevent accumulated wastes and pollutants from being discharged into conveyance systems during rainy conditions.

Supplemental Information

Further Detail of the BMP

Surface Repair

Apply concrete, asphalt, and seal coat during dry weather to prevent contamination form contacting stormwater runoff. Where applicable, cover and seal nearby storm drain inlets (with waterproof material or mesh) and manholes before applying seal coat, slurry seal, etc. Leave covers in place until job is complete and until all water from emulsified oil sealants has drained or evaporated. Clean any debris from these covered manholes and drains for proper disposal. Use only as much water as necessary for dust control, to avoid runoff.

References and Resources

http://www.stormwatercenter.net/

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality control Board. July 1998 (Revised February 2002 by the California Coastal Commission).

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Association (BASMAA) http://www.basma.org

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Housekeeping Practices SC-60

Description

Promote efficient and safe housekeeping practices (storage, use, and cleanup) when handling potentially harmful materials such as fertilizers, pesticides, cleaning solutions, paint products, automotive products, and swimming pool chemicals. Related information is provided in BMP fact sheets SC-11 Spill Prevention, Control & Cleanup and SC-34 Waste Handling & Disposal.

Approach

Pollution Prevention

- Purchase only the amount of material that will be needed for foreseeable use. In most cases this will result in cost savings in both purchasing and disposal. See SC-61 Safer Alternative Products for additional information.

- Be aware of new products that may do the same job with less environmental risk and for less or the equivalent cost. Total cost must be used here; this includes purchase price, transportation costs, storage costs, use related costs, clean up costs and disposal costs.

Suggested Protocols

General

- Keep work sites clean and orderly. Remove debris in a timely fashion. Sweep the area.

- Dispose of wash water, sweepings, and sediments, properly.

- Recycle or dispose of fluids properly.

- Establish a daily checklist of office, yard and plant areas to confirm cleanliness and adherence to proper storage and security. Specific employees should be assigned specific inspection responsibilities and given the authority to remedy any problems found.

- Post waste disposal charts in appropriate locations detailing for each waste its hazardous nature (poison, corrosive, flammable), prohibitions on its disposal (dumpster, drain, sewer) and the recommended disposal method (recycle, sewer, burn, storage, landfill).

- Summarize the chosen BMPs applicable to your operation and post them in appropriate conspicuous places.

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	☑
Nutrients	☑
Trash	☑
Metals	☑
Bacteria	☑
Oil and Grease	☑
Organics	☑
Oxygen Demanding	☑

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- Require a signed checklist from every user of any hazardous material detailing amount taken, amount used, amount returned and disposal of spent material.
- Do a before audit of your site to establish baseline conditions and regular subsequent audits to note any changes and whether conditions are improving or deteriorating.
- Keep records of water, air and solid waste quantities and quality tests and their disposition.
- Maintain a mass balance of incoming, outgoing and on hand materials so you know when there are unknown losses that need to be tracked down and accounted for.
- Use and reward employee suggestions related to BMPs, hazards, pollution reduction, work place safety, cost reduction, alternative materials and procedures, recycling and disposal.
- Have, and review regularly, a contingency plan for spills, leaks, weather extremes etc. Make sure all employees know about it and what their role is so that it comes into force automatically.

Training

- Train all employees, management, office, yard, manufacturing, field and clerical in BMPs and pollution prevention and make them accountable.
- Train municipal employees who handle potentially harmful materials in good housekeeping practices.
- Train personnel who use pesticides in the proper use of the pesticides. The California Department of Pesticide Regulation license pesticide dealers, certify pesticide applicators and conduct onsite inspections.
- Train employees and contractors in proper techniques for spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and Countermeasure (SPCC) plant up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- There are no major limitations to this best management practice.
- There are no regulatory requirements to this BMP. Existing regulations already require municipalities to properly store, use, and dispose of hazardous materials

Requirements

Costs

- Minimal cost associated with this BMP. Implementation of good housekeeping practices may result in cost savings as these procedures may reduce the need for more costly BMPs.

Maintenance

- Ongoing maintenance required to keep a clean site. Level of effort is a function of site size and type of activities.

Supplemental Information

Further Detail of the BMP

- The California Integrated Waste Management Board's Recycling Hotline, 1-800-553-2962, provides information on household hazardous waste collection programs and facilities.

Examples

There are a number of communities with effective programs. The most pro-active include Santa Clara County and the City of Palo Alto, the City and County of San Francisco, and the Municipality of Metropolitan Seattle (Metro).

References and Resources

British Columbia Lake Stewardship Society. Best Management Practices to Protect Water Quality from Non-Point Source Pollution. March 2000.
http://www.nalms.org/bclss/bmphome.html#bmp

King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr/dss/spcm.htm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities, Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July, 1998, Revised by California Coastal Commission, February 2002.

Orange County Stormwater Program
http://www.ocwatersheds.com/stormwater/swp_introduction.asp

San Mateo STOPPP - (http://stoppp.tripod.com/bmp.html)

Road and Street Maintenance SC-70

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	☑
Nutrients	
Trash	☑
Metals	☑
Bacteria	
Oil and Grease	☑
Organics	☑
Oxygen Demanding	☑

Description

Streets, roads, and highways are significant sources of pollutants in stormwater discharges, and operation and maintenance (O&M) practices, if not conducted properly, can contribute to the problem. Stormwater pollution from roadway and bridge maintenance should be addressed on a site-specific basis. Use of the procedures outlined below, that address street sweeping and repair, bridge and structure maintenance, and unpaved roads will reduce pollutants in stormwater.

Approach

Pollution Prevention

- Use the least toxic materials available (e.g. water based paints, gels or sprays for graffiti removal)
- Recycle paint and other materials whenever possible.
- Enlist the help of citizens to keep yard waste, used oil, and other wastes out of the gutter.

Suggested Protocols

Street Sweeping and Cleaning

- Maintain a consistent sweeping schedule. Provide minimum monthly sweeping of curbed streets.
- Perform street cleaning during dry weather if possible.

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- Avoid wet cleaning or flushing of street, and utilize dry methods where possible.
- Consider increasing sweeping frequency based on factors such as traffic volume, land use, field observations of sediment and trash accumulation, proximity to water courses, etc. For example:
  - Increase the sweeping frequency for streets with high pollutant loadings, especially in high traffic and industrial areas.
  - Increase the sweeping frequency just before the wet season to remove sediments accumulated during the summer.
  - Increase the sweeping frequency for streets in special problem areas such as special events, high litter or erosion zones.
- Maintain cleaning equipment in good working condition and purchase replacement equipment as needed. Old sweepers should be replaced with new technologically advanced sweepers (preferably regenerative air sweepers) that maximize pollutant removal.
- Operate sweepers at manufacturer requested optimal speed levels to increase effectiveness.
- To increase sweeping effectiveness consider the following:
  - Institute a parking policy to restrict parking in problematic areas during periods of street sweeping.
  - Post permanent street sweeping signs in problematic areas; use temporary signs if installation of permanent signs is not possible.
  - Develop and distribute flyers notifying residents of street sweeping schedules.
- Regularly inspect vehicles and equipment for leaks, and repair immediately.
- If available use vacuum or regenerative air sweepers in the high sediment and trash areas (typically industrial/commercial).
- Keep accurate logs of the number of curb-miles swept and the amount of waste collected.
- Dispose of street sweeping debris and dirt at a landfill.
- Do not store swept material along the side of the street or near a storm drain inlet.
- Keep debris storage to a minimum during the wet season or make sure debris piles are contained (e.g. by berming the area) or covered (e.g. with tarps or permanent covers).

Street Repair and Maintenance

Pavement marking

- Schedule pavement marking activities for dry weather.

- Develop paint handling procedures for proper use, storage, and disposal of paints.
- Transfer and load paint and hot thermoplastic away from storm drain inlets.
- Provide drop cloths and drip pans in paint mixing areas.
- Properly maintain application equipment.
- Street sweep thermoplastic grindings. Yellow thermoplastic grindings may require special handling as they may contain lead.
- Paints containing lead or tributyltin are considered a hazardous waste and must be disposed of properly.
- Use water based paints whenever possible. If using water based paints, clean the application equipment in a sink that is connected to the sanitary sewer.
- Properly store leftover paints if they are to be kept for the next job, or dispose of properly.

Concrete installation and repair

- Schedule asphalt and concrete activities for dry weather.
- Take measures to protect any nearby storm drain inlets and adjacent watercourses, prior to breaking up asphalt or concrete (e.g. place san bags around inlets or work areas).
- Limit the amount of fresh concrete or cement mortar mixed, mix only what is needed for the job.
- Store concrete materials under cover, away from drainage areas. Secure bags of cement after they are open. Be sure to keep wind-blown cement powder away from streets, gutters, storm drains, rainfall, and runoff.
- Return leftover materials to the transit mixer. Dispose of small amounts of hardened excess concrete, grout, and mortar in the trash.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile, or dispose in the trash.
- When making saw cuts in pavement, use as little water as possible and perform during dry weather. Cover each storm drain inlet completely with filter fabric or plastic during the sawing operation and contain the slurry by placing straw bales, sandbags, or gravel dams around the inlets. After the liquid drains or evaporates, shovel or vacuum the slurry residue from the pavement or gutter and remove from site. Alternatively, a small onsite vacuum may be used to pick up the slurry as this will prohibit slurry from reaching storm drain inlets.
- Wash concrete trucks off site or in designated areas on site designed to preclude discharge of wash water to drainage system.

Patching, resurfacing, and surface sealing

- Schedule patching, resurfacing and surface sealing for dry weather.
- Stockpile materials away from streets, gutter areas, storm drain inlets or watercourses. During wet weather, cover stockpiles with plastic tarps or berm around them if necessary to prevent transport of materials in runoff.
- Pre-heat, transfer or load hot bituminous material away from drainage systems or watercourses.
- Where applicable, cover and seal nearby storm drain inlets (with waterproof material or mesh) and maintenance holes before applying seal coat, slurry seal, etc. Leave covers in place until job is complete and until all water from emulsified oil sealants has drained or evaporated. Clean any debris from covered maintenance holes and storm drain inlets when the job is complete.
- Prevent excess material from exposed aggregate concrete or similar treatments from entering streets or storm drain inlets. Designate an area for clean up and proper disposal of excess materials.
- Use only as much water as necessary for dust control, to avoid runoff.
- Sweep, never hose down streets to clean up tracked dirt. Use a street sweeper or vacuum truck. Do not dump vacuumed liquid in storm drains.
- Catch drips from paving equipment that is not in use with pans or absorbent material placed under the machines. Dispose of collected material and absorbents properly.

Equipment cleaning maintenance and storage

- Inspect equipment daily and repair any leaks. Place drip pans or absorbent materials under heavy equipment when not in use.
- Perform major equipment repairs at the corporation yard, when practical.
- If refueling or repairing vehicles and equipment must be done onsite, use a location away from storm drain inlets and watercourses.
- Clean equipment including sprayers, sprayer paint supply lines, patch and paving equipment, and mud jacking equipment at the end of each day. Clean in a sink or other area (e.g. vehicle wash area) that is connected to the sanitary sewer.

Bridge and Structure Maintenance

Paint and Paint Removal

- Transport paint and materials to and from job sites in containers with secure lids and tied down to the transport vehicle.
- Do not transfer or load paint near storm drain inlets or watercourses.

- Test and inspect spray equipment prior to starting to paint. Tighten all hoses and connections and do not overfill paint container.
- Plug nearby storm drain inlets prior to starting painting where there is significant risk of a spill reaching storm drains. Remove plugs when job is completed.
- If sand blasting is used to remove paint, cover nearby storm drain inlets prior to starting work.
- Perform work on a maintenance traveler or platform, or use suspended netting or tarps to capture paint, rust, paint removing agents, or other materials, to prevent discharge of materials to surface waters if the bridge crosses a watercourse. If sanding, use a sander with a vacuum filter bag.
- Capture all clean-up water, and dispose of properly.
- Recycle paint when possible (e.g. paint may be used for graffiti removal activities). Dispose of unused paint at an appropriate household hazardous waste facility.

Graffiti Removal

- Schedule graffiti removal activities for dry weather.
- Protect nearby storm drain inlets prior to removing graffiti from walls, signs, sidewalks, or other structures needing graffiti abatement. Clean up afterwards by sweeping or vacuuming thoroughly, and/or by using absorbent and properly disposing of the absorbent.
- When graffiti is removed by painting over, implement the procedures under Painting and Paint Removal above.
- Direct runoff from sand blasting and high pressure washing (with no cleaning agents) into a landscaped or dirt area. If such an area is not available, filter runoff through an appropriate filtering device (e.g. filter fabric) to keep sand, particles, and debris out of storm drains.
- If a graffiti abatement method generates wash water containing a cleaning compound (such as high pressure washing with a cleaning compound), plug nearby storm drains and vacuum/pump wash water to the sanitary sewer.
- Consider using a waterless and non-toxic chemical cleaning method for graffiti removal (e.g. gels or spray compounds).

Repair Work

- Prevent concrete, steel, wood, metal parts, tools, or other work materials from entering storm drains or watercourses.
- Thoroughly clean up the job site when the repair work is completed.
- When cleaning guardrails or fences follow the appropriate surface cleaning methods (depending on the type of surface) outlined in SC-71 Plaza & Sidewalk Cleaning fact sheet.

- If painting is conducted, follow the painting and paint removal procedures above.
- If graffiti removal is conducted, follow the graffiti removal procedures above.
- If construction takes place, see the Construction Activity BMP Handbook.
- Recycle materials whenever possible.

Unpaved Roads and Trails

- Stabilize exposed soil areas to prevent soil from eroding during rain events. This is particularly important on steep slopes.
- For roadside areas with exposed soils, the most cost-effective choice is to vegetate the area, preferably with a mulch or binder that will hold the soils in place while the vegetation is establishing. Native vegetation should be used if possible.
- If vegetation cannot be established immediately, apply temporary erosion control mats/blankets; a comma straw, or gravel as appropriate.
- If sediment is already eroded and mobilized in roadside areas, temporary controls should be installed. These may include: sediment control fences, fabric-covered triangular dikes, gravel-filled burlap bags, biobags, or hay bales staked in place.

Non-Stormwater Discharges

Field crews should be aware of non-stormwater discharges as part of their ongoing street maintenance efforts.

- Refer to SC-10 Non-Stormwater Discharges
- Identify location, time and estimated quantity of discharges.
- Notify appropriate personnel.

Training

- Train employees regarding proper street sweeping operation and street repair and maintenance.
- Instruct employees and subcontractors to ensure that measures to reduce the stormwater impacts of roadway/bridge maintenance are being followed.
- Require engineering staff and/or consulting A/E firms to address stormwater quality in new bridge designs or existing bridge retrofits.
- Use a training log or similar method to document training.
- Train employees on proper spill containment and clean up, and in identifying non-stormwater discharges.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Densely populated areas or heavily used streets may require parking regulations to clear streets for cleaning.
- No currently available conventional sweeper is effective at removing oil and grease. Mechanical sweepers are not effective at removing finer sediments.
- Limitations may arise in the location of new bridges. The availability and cost of land and other economic and political factors may dictate where the placement of a new bridge will occur. Better design of the bridge to control runoff is required if it is being placed near sensitive waters.

Requirements

Costs

- The maintenance of local roads and bridges is already a consideration of most community public works or transportation departments. Therefore, the cost of pollutant reducing management practices will involve the training and equipment required to implement these new practices.
- The largest expenditures for street sweeping programs are in staffing and equipment. The capital cost for a conventional street sweeper is between $60,000 and $120,000. Newer technologies might have prices approaching $180,000. The average useful life of a conventional sweeper is about four years, and programs must budget for equipment replacement. Sweeping frequencies will determine equipment life, so programs that sweep more often should expect to have a higher cost of replacement.
- A street sweeping program may require the following.
    - Sweeper operators, maintenance, supervisory, and administrative personnel are required.
    - Traffic control officers may be required to enforce parking restrictions.
    - Skillful design of cleaning routes is required for program to be productive.
    - Arrangements must be made for disposal of collected wastes.

- If investing in newer technologies, training for operators must be included in operation and maintenance budgets. Costs for public education are small, and mostly deal with the need to obey parking restrictions and litter control. Parking tickets are an effective reminder to obey parking rules, as well as being a source of revenue.

Maintenance

- Not applicable

Supplemental Information

Further Detail of the BMP

Street sweeping

There are advantages and disadvantages to the two common types of sweepers. The best choice depends on your specific conditions. Many communities find it useful to have a compliment of both types in their fleet.

Mechanical Broom Sweepers - More effective at picking up large debris and cleaning wet streets. Less costly to purchase and operate. Create more airborne dust.

Vacuum Sweepers - More effective at removing fine particles and associated heavy metals. Ineffective at cleaning wet streets. Noisier than mechanical broom sweepers which may restrict areas or times of operation. May require an advance vehicle to remove large debris.

Street Flushers - Not affected by biggest interference to cleaning, parked cars. May remove finer sediments, moving them toward the gutter and stormwater inlets. For this reason, flushing fell out of favor and is now used primarily after sweeping. Flushing may be effective for combined sewer systems. Presently street flushing is not allowed under most NPDES permits.

Cross-Media Transfer of Pollutants

The California Air Resources Board (ARB) has established state ambient air quality standards including a standard for respirable particulate matter (less than or equal to 10 microns in diameter, symbolized as PM10). In the effort to sweep up finer sediments to remove attached heavy metals, municipalities should be aware that fine dust, that cannot be captured by the sweeping equipment and becomes airborne, could lead to issues of worker and public safety.

Bridges

Bridges that carry vehicular traffic generate some of the more direct discharges of runoff to surface waters. Bridge scupper drains cause a direct discharge of stormwater into receiving waters and have been shown to carry relatively high concentrations of pollutants. Bridge maintenance also generates wastes that may be either directly deposited to the water below or carried to the receiving water by stormwater. The following steps will help reduce the stormwater impacts of bridge maintenance:

- Site new bridges so that significant adverse impacts to wetlands, sensitive areas, critical habitat, and riparian vegetation are minimized.

- Design new bridges to avoid the use of scupper drains and route runoff to land for treatment control. Existing scupper drains should be cleaned on a regular basis to avoid sediment/debris accumulation.

- Reduce the discharge of pollutants to surface waters during maintenance by using suspended traps, vacuums, or booms in the water to capture paint, rust, and paint removing agents. Many of these wastes may be hazardous. Properly dispose of this waste by referring to CA21 (Hazardous Waste Management) in the Construction Handbook.

- Train employees and subcontractors to reduce the discharge of wastes during bridge maintenance.

De-icing

- Do not over-apply deicing salt and sand, and routinely calibrate spreaders.

- Near reservoirs, restrict the application of deicing salt and redirect any runoff away from reservoirs.

- Consider using alternative deicing agents (less toxic, biodegradable, etc.).

References and Resources

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July. 1998.

Orange County Stormwater Program
http://www.ocwatersheds.com/stormwater/swp_introduction.asp

Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 1997 Urban Runoff Management Plan. September 1997, updated October 2000.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 2001. Fresh Concrete and Mortar Application Best Management Practices for the Construction Industry. June.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 2001. Roadwork and Paving Best Management Practices for the Construction Industry. June.

United States Environmental Protection Agency (USEPA). 2002. Pollution Prevention/Good Housekeeping for Municipal Operations Roadway and Bridge Maintenance. On-line http://www.epa.gov/npdes/menuofbmps/poll_13.htm

Landscape Maintenance SC-73

Description

Landscape maintenance activities include vegetation removal; herbicide and insecticide application; fertilizer application; watering; and other gardening and lawn care practices. Vegetation control typically involves a combination of chemical (herbicide) application and mechanical methods. All of these maintenance practices have the potential to contribute pollutants to the storm drain system. The major objectives of this BMP are to minimize the discharge of pesticides, herbicides and fertilizers to the storm drain system and receiving waters; prevent the disposal of landscape waste into the storm drain system by collecting and properly disposing of clippings and cuttings, and educating employees and the public.

Approach

Pollution Prevention

- Implement an integrated pest management (IPM) program. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools.
- Choose low water using flowers, trees, shrubs, and groundcover.
- Consider alternative landscaping techniques such as naturescaping and xeriscaping.
- Conduct appropriate maintenance (i.e. properly timed fertilizing, weeding, pest control, and pruning) to help preserve the landscapes water efficiency.

Objectives

- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	☑
Nutrients	☑
Trash	☑
Metals	
Bacteria	
Oil and Grease	
Organics	
Oxygen Demanding	☑

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- Consider grass cycling (grass cycling is the natural recycling of grass by leaving the clippings on the lawn when mowing. Grass clippings decompose quickly and release valuable nutrients back into the lawn).

Suggested Protocols

Mowing, Trimming, and Weeding

- Whenever possible use mechanical methods of vegetation removal (e.g mowing with tractor-type or push mowers, hand cutting with gas or electric powered weed trimmers) rather than applying herbicides. Use hand weeding where practical.
- Avoid loosening the soil when conducting mechanical or manual weed control, this could lead to erosion. Use mulch or other erosion control measures when soils are exposed.
- Performing mowing at optimal times. Mowing should not be performed if significant rain events are predicted.
- Mulching mowers may be recommended for certain flat areas. Other techniques may be employed to minimize mowing such as selective vegetative planting using low maintenance grasses and shrubs.
- Collect lawn and garden clippings, pruning waste, tree trimmings, and weeds. Chip if necessary, and compost or dispose of at a landfill (see waste management section of this fact sheet).
- Place temporarily stockpiled material away from watercourses, and berm or cover stockpiles to prevent material releases to storm drains.

Planting

- Determine existing native vegetation features (location, species, size, function, importance) and consider the feasibility of protecting them. Consider elements such as their effect on drainage and erosion, hardiness, maintenance requirements, and possible conflicts between preserving vegetation and the resulting maintenance needs.
- Retain and/or plant selected native vegetation whose features are determined to be beneficial, where feasible. Native vegetation usually requires less maintenance (e.g., irrigation, fertilizer) than planting new vegetation.
- Consider using low water use groundcovers when planting or replanting.

Waste Management

- Compost leaves, sticks, or other collected vegetation or dispose of at a permitted landfill. Do not dispose of collected vegetation into waterways or storm drainage systems.
- Place temporarily stockpiled material away from watercourses and storm drain inlets, and berm or cover stockpiles to prevent material releases to the storm drain system.
- Reduce the use of high nitrogen fertilizers that produce excess growth requiring more frequent mowing or trimming.

- Avoid landscape wastes in and around storm drain inlets by either using bagging equipment or by manually picking up the material.

Irrigation

- Where practical, use automatic timers to minimize runoff.

- Use popup sprinkler heads in areas with a lot of activity or where there is a chance the pipes may be broken. Consider the use of mechanisms that reduce water flow to sprinkler heads if broken.

- Ensure that there is no runoff from the landscaped area(s) if re-claimed water is used for irrigation.

- If bailing of muddy water is required (e.g. when repairing a water line leak), do not put it in the storm drain; pour over landscaped areas.

- Irrigate slowly or pulse irrigate to prevent runoff and then only irrigate as much as is needed.

- Apply water at rates that do not exceed the infiltration rate of the soil.

Fertilizer and Pesticide Management

- Utilize a comprehensive management system that incorporates integrated pest management (IPM) techniques. There are many methods and types of IPM, including the following:

  - Mulching can be used to prevent weeds where turf is absent, fencing installed to keep rodents out, and netting used to keep birds and insects away from leaves and fruit.

  - Visible insects can be removed by hand (with gloves or tweezers) and placed in soapy water or vegetable oil. Alternatively, insects can be sprayed off the plant with water or in some cases vacuumed off of larger plants.

  - Store-bought traps, such as species-specific, pheromone-based traps or colored sticky cards, can be used.

  - Slugs can be trapped in small cups filled with beer that are set in the ground so the slugs can get in easily.

  - In cases where microscopic parasites, such as bacteria and fungi, are causing damage to plants, the affected plant material can be removed and disposed of (pruning equipment should be disinfected with bleach to prevent spreading the disease organism).

  - Small mammals and birds can be excluded using fences, netting, tree trunk guards.

  - Beneficial organisms, such as bats, birds, green lacewings, ladybugs, praying mantis, ground beetles, parasitic nematodes, trichogramma wasps, seed head weevils, and spiders that prey on detrimental pest species can be promoted.

- Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of fertilizers and pesticides and training of applicators and pest control advisors.

- Use pesticides only if there is an actual pest problem (not on a regular preventative schedule).

- Do not use pesticides if rain is expected. Apply pesticides only when wind speeds are low (less than 5 mph).

- Do not mix or prepare pesticides for application near storm drains.

- Prepare the minimum amount of pesticide needed for the job and use the lowest rate that will effectively control the pest.

- Employ techniques to minimize off-target application (e.g. spray drift) of pesticides, including consideration of alternative application techniques.

- Fertilizers should be worked into the soil rather than dumped or broadcast onto the surface.

- Calibrate fertilizer and pesticide application equipment to avoid excessive application.

- Periodically test soils for determining proper fertilizer use.

- Sweep pavement and sidewalk if fertilizer is spilled on these surfaces before applying irrigation water.

- Purchase only the amount of pesticide that you can reasonably use in a given time period (month or year depending on the product).

- Triple rinse containers, and use rinse water as product. Dispose of unused pesticide as hazardous waste.

- Dispose of empty pesticide containers according to the instructions on the container label.

Inspection

- Inspect irrigation system periodically to ensure that the right amount of water is being applied and that excessive runoff is not occurring. Minimize excess watering, and repair leaks in the irrigation system as soon as they are observed.

- Inspect pesticide/fertilizer equipment and transportation vehicles daily.

Training

- Educate and train employees on use of pesticides and in pesticide application techniques to prevent pollution. Pesticide application must be under the supervision of a California qualified pesticide applicator.

- Train/encourage municipal maintenance crews to use IPM techniques for managing public green areas.

- Annually train employees within departments responsible for pesticide application on the appropriate portions of the agency's IPM Policy, SOPs, and BMPs, and the latest IPM techniques.

- Employees who are not authorized and trained to apply pesticides should be periodically (at least annually) informed that they cannot use over-the-counter pesticides in or around the workplace.

- Use a training log or similar method to document training.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup

- Have spill cleanup materials readily available and in a know in location

- Cleanup spills immediately and use dry methods if possible.

- Properly dispose of spill cleanup material.

Other Considerations

- The Federal Pesticide, Fungicide, and Rodenticide Act and California Title 3, Division 6, Pesticides and Pest Control Operations place strict controls over pesticide application and handling and specify training, annual refresher, and testing requirements. The regulations generally cover: a list of approved pesticides and selected uses, updated regularly; general application information; equipment use and maintenance procedures; and record keeping. The California Department of Pesticide Regulations and the County Agricultural Commission coordinate and maintain the licensing and certification programs. All public agency employees who apply pesticides and herbicides in "agricultural use" areas such as parks, golf courses, rights-of-way and recreation areas should be properly certified in accordance with state regulations. Contracts for landscape maintenance should include similar requirements.

- All employees who handle pesticides should be familiar with the most recent material safety data sheet (MSDS) files.

- Municipalities do not have the authority to regulate the use of pesticides by school districts, however the California Healthy Schools Act of 2000 (AB 2260) has imposed requirements on California school districts regarding pesticide use in schools. Posting of notification prior to the application of pesticides is now required, and IPM is stated as the preferred approach to pest management in schools.

Requirements

Costs

Additional training of municipal employees will be required to address IPM techniques and BMPs. IPM methods will likely increase labor cost for pest control which may be offset by lower chemical costs.

Maintenance

Not applicable

Supplemental Information

Further Detail of the BMP

Waste Management

Composting is one of the better disposal alternatives if locally available. Most municipalities either have or are planning yard waste composting facilities as a means of reducing the amount of waste going to the landfill. Lawn clippings from municipal maintenance programs as well as private sources would probably be compatible with most composting facilities

Contractors and Other Pesticide Users

Municipal agencies should develop and implement a process to ensure that any contractor employed to conduct pest control and pesticide application on municipal property engages in pest control methods consistent with the IPM Policy adopted by the agency. Specifically, municipalities should require contractors to follow the agency's IPM policy, SOPs, and BMPs; provide evidence to the agency of having received training on current IPM techniques when feasible; provide documentation of pesticide use on agency property to the agency in a timely manner.

References and Resources

King County Stormwater Pollution Control Manual. Best Management Practices for Businesses. 1995. King County Surface Water Management. July. On-line: http://dnr.metrokc.gov/wlr/dss/spcm.htm

Los Angeles County Stormwater Quality Model Programs. Public Agency Activities http://ladpw.org/wmd/npdes/model_links.cfm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July. 1998.

Orange County Stormwater Program http://www.ocwatersheds.com/StormWater/swp_introduction.asp

Santa Clara Valley Urban Runoff Pollution Prevention Program. 1997 Urban Runoff Management Plan. September 1997, updated October 2000.

United States Environmental Protection Agency (USEPA). 2002. Pollution Prevention/Good Housekeeping for Municipal Operations Landscaping and Lawn Care. Office of Water. Office of Wastewater Management. On-line: http://www.epa.gov/npdes/menuofbmps/poll_8.htm

Drainage System Maintenance SC-74

Photo Credit: Geoff Brosseau

Objectives

- Contain
- Educate
- Reduce/Minimize

Targeted Constituents

Sediment	☑
Nutrients	☑
Trash	☑
Metals	☑
Bacteria	☑
Oil and Grease	☑
Organics	☑
Oxygen Demanding	☑

Description

As a consequence of its function, the stormwater conveyance system collects and transports urban runoff that may contain certain pollutants. Maintaining catch basins, stormwater inlets, and other stormwater conveyance structures on a regular basis will remove pollutants, prevent clogging of the downstream conveyance system, restore catch basins' sediment trapping capacity, and ensure the system functions properly hydraulically to avoid flooding.

Approach

Suggested Protocols

Catch Basins/Inlet Structures

- Municipal staff should regularly inspect facilities to ensure the following:
  - Immediate repair of any deterioration threatening structural integrity.
  - Cleaning before the sump is 40% full. Catch basins should be cleaned as frequently as needed to meet this standard.
  - Stenciling of catch basins and inlets (see SC-75 Waste Handling and Disposal).
- Clean catch basins, storm drain inlets, and other conveyance structures in high pollutant load areas just before the wet season to remove sediments and debris accumulated during the summer.

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- Conduct inspections more frequently during the wet season for problem areas where sediment or trash accumulates more often. Clean and repair as needed.

- Keep accurate logs of the number of catch basins cleaned.

- Record the amount of waste collected.

- Store wastes collected from cleaning activities of the drainage system in appropriate containers or temporary storage sites in a manner that prevents discharge to the storm drain.

- Dewater the wastes with outflow into the sanitary sewer if permitted. Water should be treated with an appropriate filtering device prior to discharge to the sanitary sewer. If discharge to the sanitary sewer is not allowed, water should be pumped or vacuumed to a tank and properly disposed of. Do not dewater near a storm drain or stream.

- Except for small communities with relatively few catch basins that may be cleaned manually, most municipalities will require mechanical cleaners such as eductors, vacuums, or bucket loaders.

Storm Drain Conveyance System

- Locate reaches of storm drain with deposit problems and develop a flushing schedule that keeps the pipe clear of excessive buildup.

- Collect flushed effluent and pump to the sanitary sewer for treatment.

Pump Stations

- Clean all storm drain pump stations prior to the wet season to remove silt and trash.

- Do not allow discharge from cleaning a storm drain pump station or other facility to reach the storm drain system.

- Conduct quarterly routine maintenance at each pump station.

- Inspect, clean, and repair as necessary all outlet structures prior to the wet season.

- Sample collected sediments to determine if landfill disposal is possible, or illegal discharges in the watershed are occurring.

Open Channel

- Consider modification of storm channel characteristics to improve channel hydraulics, to increase pollutant removals, and to enhance channel/creek aesthetic and habitat value.

- Conduct channel modification/improvement in accordance with existing laws. Any person, government agency, or public utility proposing an activity that will change the natural (emphasis added) state of any river, stream, or lake in California, must enter into a steam or Lake Alteration Agreement with the Department of Fish and Game. The developer-applicant should also contact local governments (city, county, special districts), other state agencies

(SWRCB, RWQCB, Department of Forestry, Department of Water Resources), and Federal Corps of Engineers and USFWS

Illicit Connections and Discharges

- During routine maintenance of conveyance system and drainage structures field staff should look for evidence of illegal discharges or illicit connections:
    - Is there evidence of spills such as paints, discoloring, etc.
    - Are there any odors associated with the drainage system
    - Record locations of apparent illegal discharges/illicit connections
    - Track flows back to potential dischargers and conduct aboveground inspections. This can be done through visual inspection of up gradient manholes or alternate techniques including zinc chloride smoke testing, fluorometric dye testing, physical inspection testing, or television camera inspection.
    - Once the origin of flow is established, require illicit discharger to eliminate the discharge.
- Stencil storm drains, where applicable, to prevent illegal disposal of pollutants. Storm drain inlets should have messages such as "Dump No Waste Drains to Stream" stenciled next to them to warn against ignorant or intentional dumping of pollutants into the storm drainage system.
- Refer to fact sheet SC-10 Non-Stormwater Discharges.

Illegal Dumping

- Regularly inspect and clean up hot spots and other storm drainage areas where illegal dumping and disposal occurs.
- Establish a system for tracking incidents. The system should be designed to identify the following:
    - Illegal dumping hot spots
    - Types and quantities (in some cases) of wastes
    - Patterns in time of occurrence (time of day/night, month, or year)
    - Mode of dumping (abandoned containers, "midnight dumping" from moving vehicles, direct dumping of materials, accidents/spills)
    - Responsible parties
- Post "No Dumping" signs in problem areas with a phone number for reporting dumping and disposal. Signs should also indicate fines and penalties for illegal dumping.
- Refer to fact sheet SC-10 Non-Stormwater Discharges.

- The State Department of Fish and Game has a hotline for reporting violations called Cal TIP (1-800-952-5400). The phone number may be used to report any violation of a Fish and Game code (illegal dumping, poaching, etc.).

- The California Department of Toxic Substances Control's Waste Alert Hotline, 1-800-69TOXIC, can be used to report hazardous waste violations.

Training

- Train crews in proper maintenance activities, including record keeping and disposal.

- Only properly trained individuals are allowed to handle hazardous materials/wastes.

- Train municipal employees from all departments (public works, utilities, street cleaning, parks and recreation, industrial waste inspection, hazardous waste inspection, sewer maintenance) to recognize and report illegal dumping.

- Train municipal employees and educate businesses, contractors, and the general public in proper and consistent methods for disposal.

- Train municipal staff regarding non-stormwater discharges (See SC-10 Non-Stormwater Discharges).

Spill Response and Prevention

- Refer to SC-11, Prevention, Control & Cleanup

- Have spill cleanup materials readily available and in a known location.

- Cleanup spills immediately and use dry methods if possible.

- Properly dispose of spill cleanup material.

Other Considerations

- Cleanup activities may create a slight disturbance for local aquatic species. Access to items and material on private property may be limited. Trade-offs may exist between channel hydraulics and water quality/riparian habitat. If storm channels or basins are recognized as wetlands, many activities, including maintenance, may be subject to regulation and permitting.

- Storm drain flushing is most effective in small diameter pipes (36-inch diameter pipe or less, depending on water supply and sediment collection capacity). Other considerations associated with storm drain flushing may include the availability of a water source, finding a downstream area to collect sediments, liquid/sediment disposal, and disposal of flushed effluent to sanitary sewer may be prohibited in some areas.

- Regulations may include adoption of substantial penalties for illegal dumping and disposal.

- Municipal codes should include sections prohibiting the discharge of soil, debris, refuse, hazardous wastes, and other pollutants into the storm drain system.

- Private property access rights may be needed to track illegal discharges up gradient.

- Requirements of municipal ordinance authority for suspected source verification testing for illicit connections necessary for guaranteed rights of entry.

Requirements

Costs

- An aggressive catch basin cleaning program could require a significant capital and O&M budget. A careful study of cleaning effectiveness should be undertaken before increased cleaning is implemented. Catch basin cleaning costs are less expensive if vacuum street sweepers are available; cleaning catch basins manually can cost approximately twice as much as cleaning the basins with a vacuum attached to a sweeper.

- Methods used for illicit connection detection (smoke testing, dye testing, visual inspection, and flow monitoring) can be costly and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and type of land use will determine the level of investigation necessary. Encouraging reporting of illicit discharges by employees can offset costs by saving expense on inspectors and directing resources more efficiently. Some programs have used funds available from "environmental fees" or special assessment districts to fund their illicit connection elimination programs.

Maintenance

- Two-person teams may be required to clean catch basins with vactor trucks.

- Identifying illicit discharges requires teams of at least two people (volunteers can be used), plus administrative personnel, depending on the complexity of the storm sewer system.

- Arrangements must be made for proper disposal of collected wastes.

- Requires technical staff to detect and investigate illegal dumping violations, and to coordinate public education.

Supplemental Information

Further Detail of the BMP

Storm Drain flushing

Sanitary sewer flushing is a common maintenance activity used to improve pipe hydraulics and to remove pollutants in sanitary sewer systems. The same principles that make sanitary sewer flushing effective can be used to flush storm drains. Flushing may be designed to hydraulically convey accumulated material to strategic locations, such as to an open channel, to another point where flushing will be initiated, or over to the sanitary sewer and on to the treatment facilities, thus preventing re-suspension and overflow of a portion of the solids during storm events. Flushing prevents "plug flow" discharges of concentrated pollutant loadings and sediments. The deposits can hinder the designed conveyance capacity of the storm drain system and potentially cause backwater conditions in severe cases of clogging.

Storm drain flushing usually takes place along segments of pipe with grades that are too flat to maintain adequate velocity to keep particles in suspension. An upstream manhole is selected to place an inflatable device that temporarily plugs the pipe. Further upstream, water is pumped into the line to create a flushing wave. When the upstream reach of pipe is sufficiently full to cause a flushing wave, the inflated device is rapidly deflated with the assistance of a vacuum pump, releasing the backed up water and resulting in the cleaning of the storm drain segment.

To further reduce the impacts of stormwater pollution, a second inflatable device, placed well downstream, may be used to re-collect the water after the force of the flushing wave has dissipated. A pump may then be used to transfer the water and accumulated material to the sanitary sewer for treatment. In some cases, an interceptor structure may be more practical or required to re-collect the flushed waters.

It has been found that cleansing efficiency of periodic flush waves is dependent upon flush volume, flush discharge rate, sewer slope, sewer length, sewer flow rate, sewer diameter, and population density. As a rule of thumb, the length of line to be flushed should not exceed 700 feet. At this maximum recommended length, the percent removal efficiency ranges between 65-75 percent for organics and 55-65 percent for dry weather grit/inorganic material. The percent removal efficiency drops rapidly beyond that. Water is commonly supplied by a water truck, but fire hydrants can also supply water. To make the best use of water, it is recommended that reclaimed water be used or that fire hydrant line flushing coincide with storm drain flushing.

Flow Management

Flow management has been one of the principal motivations for designing urban stream corridors in the past. Such needs may or may not be compatible with the stormwater quality goals in the stream corridor.

Downstream flood peaks can be suppressed by reducing through flow velocity. This can be accomplished by reducing gradient with grade control structures or increasing roughness with boulders, dense vegetation, or complex banks forms. Reducing velocity correspondingly increases flood height, so all such measures have a natural association with floodplain open space. Flood elevations laterally adjacent to the stream can be lowered by increasing through flow velocity.

However, increasing velocity increases flooding downstream and inherently conflicts with channel stability and human safety. Where topography permits, another way to lower flood elevation is to lower the level of the floodway with drop structures into a large but subtly excavated bowl where flood flows we allowed to spread out.

Stream Corridor Planning

Urban streams receive and convey stormwater flows from developed or developing watersheds. Planning of stream corridors thus interacts with urban stormwater management programs. If local programs are intended to control or protect downstream environments by managing flows delivered to the channels, then it is logical that such programs should be supplemented by management of the materials, forms, and uses of the downstream riparian corridor. Any proposal for steam alteration or management should be investigated for its potential flow and stability effects on upstream, downstream, and laterally adjacent areas. The timing and rate of flow from various tributaries can combine in complex ways to alter flood hazards. Each section of channel is unique, influenced by its own distribution of roughness elements, management activities, and stream responses.

Flexibility to adapt to stream features and behaviors as they evolve must be included in stream reclamation planning. The amenity and ecology of streams may be enhanced through the landscape design options of 1) corridor reservation, 2) bank treatment, 3) geomorphic restoration, and 4) grade control.

Corridor reservation - Reserving stream corridors and valleys to accommodate natural stream meandering, aggradation, degradation, and over bank flows allows streams to find their own form and generate less ongoing erosion. In California, open stream corridors in recent urban developments have produced recreational open space, irrigation of streamside plantings, and the aesthetic amenity of flowing water.

Bank treatment - The use of armoring, vegetative cover, and flow deflection may be used to influence a channel's form, stability, and biotic habitat. To prevent bank erosion, armoring can be done with rigid construction materials, such as concrete, masonry, wood planks and logs, riprap, and gabions. Concrete linings have been criticized because of their lack of provision of biotic habitat. In contrast, riprap and gabions make relatively porous and flexible linings. Boulders, placed in the bed reduce velocity and erosive power.

Riparian vegetation can stabilize the banks of streams that are at or near a condition of equilibrium. Binding networks of roots increase bank shear strength. During flood flows, resilient vegetation is forced into erosion-inhibiting mats. The roughness of vegetation leads to lower velocity, further reducing erosive effects. Structural flow deflection can protect banks from erosion or alter fish habitat. By concentrating flow, a deflector causes a pool to be scoured in the bed.

Geomorphic restoration – Restoration refers to alteration of disturbed streams so their form and behavior emulate those of undisturbed streams. Natural meanders are retained, with grading to gentle slopes on the inside of curves to allow point bars and riffle-pool sequences to develop. Trees are retained to provide scenic quality, biotic productivity, and roots for bank stabilization, supplemented by plantings where necessary.

A restorative approach can be successful where the stream is already approaching equilibrium. However, if upstream urbanization continues new flow regimes will be generated that could disrupt the equilibrium of the treated system.

Grade Control - A grade control structure is a level shelf of a permanent material, such as stone, masonry, or concrete, over which stream water flows. A grade control structure is called a sill, weir, or drop structure, depending on the relation of its invert elevation to upstream and downstream channels.

A sill is installed at the preexisting channel bed elevation to prevent upstream migration of nick points. It establishes a firm base level below which the upstream channel can not erode.

A weir or check dam is installed with invert above the preexisting bed elevation. A weir raises the local base level of the stream and causes aggradation upstream. The gradient, velocity, and erosive potential of the stream channel are reduced. A drop structure lowers the downstream invert below its preexisting elevation, reducing downstream gradient and velocity. Weirs and drop structure control erosion by dissipating energy and reducing slope velocity.

When carefully applied, grade control structures can be highly versatile in establishing human and environmental benefits in stabilized channels. To be successful, application of grade control structures should be guided by analysis of the stream system both upstream and downstream from the area to he reclaimed.

Examples

The California Department of Water Resources began the Urban Stream Restoration Program in 1985. The program provides grant funds to municipalities and community groups to implement stream restoration projects. The projects reduce damages from streambank aid watershed instability arid floods while restoring streams' aesthetic, recreational, and fish and wildlife values.

In Buena Vista Park, upper floodway slopes are gentle and grassed to achieve continuity of usable park land across the channel of small boulders at the base of the slopes.

The San Diego River is a large, vegetative lined channel, which was planted in a variety of species to support riparian wildlife while stabilizing the steep banks of the floodway.

References and Resources

Ferguson, B.K. 1991. Urban Stream Reclamation, p. 324-322, Journal of Soil and Water Conservation.

Los Angeles County Stormwater Quality. Public Agency Activities Model Program. On-line: http://ladpw.org/wmd/npdes/public_TC.cfm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July. 1998.

Orange County Stormwater Program http://www.ocwatersheds.com/StormWater/swp_introduction.asp

Santa Clara Valley Urban Runoff Pollution Prevention Program. 1997 Urban Runoff Management Plan. September 1997, updated October 2000.

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP) Municipal Activities Model Program Guidance. 2001. Project Clean Water. November.

United States Environmental Protection Agency (USEPA). 1999. Stormwater Management Fact Sheet Non-stormwater Discharges to Storm Sewers. EPA 832-F-99-022. Office of Water, Washington, D.C. September.

United States Environmental Protection Agency (USEPA). 1999. Stormwater O&M Fact Sheet Catch Basin Cleaning. EPA 832-F-99-011. Office of Water, Washington, D.C. September.

United States Environmental Protection Agency (USEPA). 2002. Pollution Prevention/Good Housekeeping for Municipal Operations Illegal Dumping Control. On line: http://www.epa.gov/npdes/menuofbmps/poll_7.htm

United States Environmental Protection Agency (USEPA). 2002. Pollution Prevention/Good Housekeeping for Municipal Operations Storm Drain System Cleaning. On line: http://www.epa.gov/npdes/menuofbmps/poll_16.htm