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Prepared for **BRIDGE Housing Corporation**

PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT AT BALBOA RESERVOIR
PHELAN AND OCEAN AVENUES
SAN FRANCISCO, CALIFORNIA

January 22, 20118
Project No. 17-1425

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January 22, 2018
Project No. 17-1425

Mr. Justin Lai
Investment Analyst
BRIDGE Housing Corporation
600 California Street, Suite 900
San Francisco, California 94108

Subject: Preliminary Geotechnical Investigation
Proposed Residential Development at Balboa Reservoir Site
Phelan and Ocean Avenues
San Francisco, California

Dear Mr. Lai:

We are pleased to present the results of our preliminary geotechnical investigation for the proposed residential development to be constructed at the Balboa Reservoir site in San Francisco. Our services were provided in accordance with our proposal dated October 26, 2017 and a Budget Increase Request dated January 2, 2018.

The project site consists of a rectangular-shaped, 17-acre lot on the western side of Phelan Avenue, north of its intersection with Ocean Avenue. The site is bordered by Riordan High School to the north, single-family residential developments to the west, multi-story mixed-used buildings to the south, and a parking lot and multi-use building for the City College of San Francisco (CCSF). The site, which was previously excavated up to 15 feet below original grades for a planned reservoir, is currently an asphalt-paved parking lot used for CCSF student parking.

Current plans are to construct a 1,100-unit residential development which will consist of clusters of residential buildings separated by landscaped areas, walkways and parks. The buildings will be constructed near the existing grades and will consist of residential units of Type 5 construction over one-story concrete (Type I) podiums.

From a geotechnical standpoint, we conclude the site can be developed as planned, provided the recommendations presented in this report are incorporated into the project plans and specifications and implemented during construction. The primary geotechnical issues affecting the proposed development include site grading and support of the proposed structures. We preliminarily conclude the proposed buildings should be supported on conventional spread footings that gain support on undisturbed native soil or engineered fill.

This report presents our preliminary conclusions and recommendations regarding foundation design, earthwork and grading, seismic design, and other geotechnical aspects of the project. The recommendations contained in our report are based on limited subsurface exploration and review of available data for the site, and are not intended for final design. Final geotechnical design values should be confirmed by a detailed geotechnical investigation. In addition, variations between expected and actual soil conditions may be found in localized areas during construction. Therefore, we should be engaged to observe shoring and foundation installation, and fill placement, during which time we may make changes in our recommendations, if deemed necessary.

We appreciate the opportunity to provide our services to you on this project. If you have any questions, please call.

Sincerely,
ROCKRIDGE GEOTECHNICAL, INC.

DRAFT	**DRAFT**
Clayton J. Proto, P.E. Project Engineer	Craig S. Shields, P.E., G.E. Principal Engineer

Enclosure

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PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT AT BALBOA RESERVOIR
PHELAN AND OCEAN AVENUES
San Francisco, California

1.0 INTRODUCTION

This report presents the results of the preliminary geotechnical investigation performed by Rockridge Geotechnical, Inc. (Rockridge) for the proposed residential development to be constructed at the Balboa Reservoir site in San Francisco, California.

The project site consists of a rectangular-shaped, 17-acre lot on the western side of Phelan Avenue, north of its intersection with Ocean Avenue, as shown on Figure 1, Site Location Map. The site is bordered by Riordan High School to the north, single-family residences to the west, multi-story mixed-used buildings to the south, and a parking lot and multi-use building for the City College of San Francisco (CCSF) to the east. The site is currently an asphalt-paved parking lot used for CCSF student parking. The central portion of the site was previously excavated up to 15 feet below original grades for a planned reservoir, and an embankment up to about 30 feet tall was constructed along the western portion of the site.

Plans are to construct a 1,100-unit residential development which will consist of clusters of residential buildings separated by landscaped areas, walkways and parks. The buildings will consist of residential units of Type 5 construction over one-story concrete (Type I) podiums.

2.0 SCOPE OF SERVICES

Our investigation was performed in accordance with our Proposal for Preliminary Geotechnical Investigation with BRIDGE Housing, dated October 27, 2017, and a subsequent Budget Increase Request dated January 2, 2018. Our scope of services consisted of reviewing available geologic maps and geotechnical reports of the site and vicinity, exploring subsurface conditions at the site by performing six cone penetration tests (CPTs), advancing four exploratory borings, and performing engineering analyses to develop preliminary conclusions and recommendations regarding:

- site seismicity and seismic hazards, including the potential for liquefaction and liquefaction-induced ground failure
- the most appropriate foundation type(s) for the proposed structures
- preliminary design criteria for the recommended foundation type(s)
- estimates of foundation settlement
- 2016 San Francisco Building Code (SFBC) site class and design spectral response acceleration parameters
- construction considerations.

3.0 FIELD INVESTIGATION

Prior to performing the subsurface field investigation, we obtained a permit from the San Francisco Department of Public Health (SFDPH) and contacted Underground Service Alert (USA) to notify them of our work, as required by law. We also retained Precision Locating LLC, a private utility locator, to minimize the likelihood that an underground utility was encountered during our investigation. Details of the field exploration are described below.

3.1 Test Borings

Four borings, designated B-1 through B-4, were drilled on January 3, 2018 by Benevent Building of Concord, California at the approximate locations shown on Figure 2. Borings B-1, B-2, B-3, and B-4 were drilled to depths of about 26, 26, 11, and 6 feet bgs, respectively, using a limited-access drill rig equipped with solid flight augers. During drilling, our field engineer logged the soil encountered and obtained representative samples for visual classification and laboratory testing. The logs of the borings are presented on Figures A-1 through A-4 in Appendix A. The soil encountered in the borings was classified in accordance with the classification chart shown on Figure A-5.

Soil samples were obtained using a Standard Penetration Test (SPT) split-barrel sampler with a 2.0-inch outside and 1.5-inch inside diameter, without liners. The sampler was driven with an above-ground, 140-pound, hammer falling 30 inches per drop using a rope and cathead. The samplers were driven up to 18 inches and the hammer blows required to drive the samplers were recorded every six inches and are presented on the boring logs. A “blow count” is defined as the number of hammer blows per six inches of penetration or 50 blows for six inches or less of penetration. The blow counts required to drive the SPT samplers were converted to approximate SPT N-values using factors of 1.2, respectively, to account for approximate hammer energy and the fact that the sampler was sized to accommodate liners, but was driven without liners. The blow counts used for this conversion were: (1) the last two blow counts if the sampler was driven more than 12 inches, (2) the last one blow count if the sampler was driven more than six inches but less than 12 inches, and (3) the only blow count if the sampler was driven six inches or less. The converted SPT N-values are presented on the boring logs.

Upon completion of drilling, the boreholes were backfilled with cement grout in accordance with SFDPH standards. The soil cuttings generated by the borings were spread in landscaping areas.

3.2 Cone Penetration Tests

Six CPTs, designated CPT-1 through CPT-6, were advanced on January 3, 2017 by Middle Earth GeoTesting of Orange, California at the approximate locations shown on the Site Plan, Figure 2. The CPTs were advanced until practical refusal was met in very dense sand, which occurred at depths ranging from approximately 5 to 46 feet below ground surface (bgs). The CPTs were performed with a truck-mounted rig hydraulically pushing a 1.7-inch-diameter cone-tipped probe into the ground. The probe measured tip resistance, pore water pressure, and frictional resistance on a sleeve behind the cone tip. Electrical sensors within the cone continuously measured these parameters for the entire depth advanced, and the readings were digitized and recorded by a computer. Accumulated data were processed by computer to provide engineering information such as soil behavior types, correlated strength characteristics, and estimated liquefaction resistance of the soil encountered. The CPT logs, showing tip resistance, friction ratio, pore water pressure, and soil behavior type, are shown on Figures A-6 through A-12 in Appendix A. Upon completion, the CPT holes backfilled with neat cement grout in accordance with SFDPH requirements.

4.0 SITE AND SUBSURFACE CONDITIONS

We understand the site is currently owned by the San Francisco Public Utilities Commission, and was originally planned for use as a municipal water reservoir. Although the site was never used as a reservoir, the central portion of the site was excavated down approximately 15 feet and an embankment approximately 30 feet tall was constructed along the western and southern boundary. The southern embankment was removed in 2008, and a new embankment was constructed along the eastern site boundary between 2008 and 2009. The central, depressed portion of the site is currently occupied by an asphalt parking lot.

As presented on the Regional Geologic Map (Figure 3), the site is mapped in a zone of early-Pleistocene alluvium (Qoa) (Graymer, 2006). Based on the results of our investigation and our understanding of the site history, we conclude the non-embankment portion of the site is underlain by a deposit of medium dense to very dense silty sand with occasional clay interbeds, known locally as the Colma formation. The Colma formation extends to a depth of at least 46 feet bgs at location CPT-6, the maximum depth explored. The embankment consists of sand fill which was likely excavated onsite and re-worked. Documentation of the embankment construction was not available; however, the results of our investigation indicates that the fill appears to have been well-compacted and is generally dense to very dense in consistency.

Free groundwater was not observed in our borings. We reviewed the results of a 2010 geotechnical investigation performed by Fugro, Inc for a development on Phelan Loop immediately southeast of the site. In this investigation, groundwater was encountered in one boring at a depth of about 22 feet bgs, while a second boring drilled to 40 feet did not encounter groundwater. To better estimate the highest potential groundwater level at the site, we also reviewed information on the State of California Water Resources Control Board GeoTracker website (http://geotracker.waterboards.ca.gov/). The closest site with groundwater information on the GeoTracker website is at 1490 Ocean Avenue, which is about 600 feet west of the subject property. Recorded depths to groundwater at the 1490 Ocean Avenue site has fluctuated from about 18 to 33 feet bgs during the time period of 2002 to 2012. Ground surface elevations at 1490 Ocean Avenue are approximately 20 feet below existing grades at the Balboa Reservoir site. The groundwater level at the site is expected to fluctuate several feet seasonally with potentially larger fluctuations annually, depending on the amount of rainfall. Based on available data, we conclude a design high groundwater level of 20 feet bgs could be used for preliminary design.

5.0 SEISMIC CONSIDERATIONS

The San Francisco Bay Area is considered to be one of the more seismically active regions in the world. We preliminarily evaluated the potential for earthquake-induced geologic hazards including ground shaking, ground surface rupture, liquefaction,[1] lateral spreading,[2] and cyclic densification[3]. The results of our evaluation regarding seismic considerations for the project site are presented in the following sections.

5.1 Regional Seismicity and Faulting

The major active faults in the area are the Hayward, San Andreas, and Calaveras faults. These and other faults of the region are shown on Figure 4. The fault systems in the Bay Area consist of several major right-lateral strike-slip faults that define the boundary zone between the Pacific and the North American tectonic plates. Numerous damaging earthquakes have occurred along these fault systems in recorded time. For these and other active faults within a 50-kilometer radius of the site, the distance from the site and estimated mean characteristic moment magnitude[4] [Working Group on California Earthquake Probabilities (WGCEP, 2008) and Cao et al. (2003)] are summarized in Table 2.

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[1] Liquefaction is a phenomenon where loose, saturated, cohesionless soil experiences temporary reduction in strength during cyclic loading such as that produced by earthquakes.

[2] Lateral spreading is a phenomenon in which surficial soil displaces along a shear zone that has formed within an underlying liquefied layer. Upon reaching mobilization, the surficial blocks are transported downslope or in the direction of a free face by earthquake and gravitational forces.

[3] Cyclic densification is a phenomenon in which non-saturated, cohesionless soil is compacted by earthquake vibrations, causing ground-surface settlement.

[4] Moment magnitude is an energy-based scale and provides a physically meaningful measure of the size of a faulting event. Moment magnitude is directly related to average slip and fault rupture area.

TABLE 2
Regional Faults and Seismicity

Fault Segment	Approximate Distance from Site (km)	Direction from Site	Mean Characteristic Moment Magnitude
N. San Andreas - Peninsula	5	West	7.20
N. San Andreas (1906 event)	5	West	8.05
San Gregorio Connected	12	West	7.50
N. San Andreas - North Coast	12	West	7.51
Total Hayward	24	Northeast	7.00
Total Hayward-Rodgers Creek	24	Northeast	7.33
Monte Vista-Shannon	37	Southeast	6.50
Mount Diablo Thrust	40	East	6.70
Rodgers Creek	40	North	7.07
Total Calaveras	41	East	7.03
Point Reyes	41	Northwest	6.90
Green Valley Connected	45	East	6.80

Since 1800, four major earthquakes (i.e., Magnitude > 6) have been recorded on the San Andreas fault. In 1836, an earthquake with an estimated maximum intensity of VII on the Modified Mercalli (MM) Intensity Scale occurred east of Monterey Bay on the San Andreas fault (Toppozada and Borchardt 1998). The estimated moment magnitude, M_w, for this earthquake is about 6.25. In 1838, an earthquake occurred on the Peninsula segment of the San Andreas fault. Severe shaking occurred with an MM of about VIII-IX, corresponding to an M_w of about 7.5. The San Francisco Earthquake of 1906 caused the most significant damage in the history of the Bay Area in terms of loss of lives and property damage. This earthquake created a surface rupture along the San Andreas fault from Shelter Cove to San Juan Bautista approximately 470 kilometers in length. It had a maximum intensity of XI (MM), an M_w of about 7.9, and was felt 560 kilometers away in Oregon, Nevada, and Los Angeles. The Loma Prieta Earthquake of

October 17, 1989 had an M_w of 6.9 and occurred about 92 kilometers southeast of the site. On August 24, 2014 an earthquake with an estimated maximum intensity of VIII (severe) on the MM scale occurred on the West Napa fault. This earthquake was the largest earthquake event in the San Francisco Bay Area since the Loma Prieta Earthquake. The M_w of the 2014 South Napa Earthquake was 6.0.

In 1868, an earthquake with an estimated maximum intensity of X on the MM scale occurred on the southern segment (between San Leandro and Fremont) of the Hayward fault. The estimated M_w for the earthquake is 7.0. In 1861, an earthquake of unknown magnitude (probably an M_w of about 6.5) was reported on the Calaveras fault. The most recent significant earthquake on this fault was the 1984 Morgan Hill earthquake ($M_w = 6.2$).

The U.S. Geological Survey's 2014 Working Group on California Earthquake Probabilities has compiled the earthquake fault research for the San Francisco Bay area in order to estimate the probability of fault segment rupture. They have determined that the overall probability of moment magnitude 6.7 or greater earthquake occurring in the San Francisco Region during the next 30 years (starting from 2014) is 72 percent. The highest probabilities are assigned to the Hayward fault, Calaveras fault, and the northern segment of the San Andreas fault. These probabilities are 14.3, 7.4, and 6.4 percent, respectively.

5.2 Geologic Hazards

During a major earthquake on a segment of one of the nearby faults, strong to very strong ground shaking is expected to occur at the project site. Strong shaking during an earthquake can result in ground failure such as that associated with soil liquefaction, lateral spreading, and cyclic densification. We used the results of the CPTs and borings performed for this investigation to evaluate the potential of these phenomena occurring at the project site.

5.2.1 Ground Shaking

The ground shaking intensity felt at the project site will depend on: 1) the size of the earthquake (magnitude), 2) the distance from the site to the fault source, 3) the directivity (focusing of earthquake energy along the fault in the direction of the rupture), and 4) site-specific soil conditions. The site is 5 kilometers from the San Andreas fault. Therefore, the potential exists for a large earthquake to induce strong to violent ground shaking at the site during the life of the project.

5.2.2 Liquefaction and Liquefaction-Induced Settlement

When a saturated, cohesionless soil liquefies, it experiences a temporary loss of shear strength created by a transient rise in excess pore pressure generated by strong ground motion. Soil susceptible to liquefaction includes loose to medium dense sand and gravel, low-plasticity silt, and some low-plasticity clay deposits. Flow failure, lateral spreading, differential settlement, loss of bearing strength, ground fissures and sand boils are evidence of excess pore pressure generation and liquefaction. The site mapped outside of a liquefaction hazard zone, as shown on Figure 5 from the map titled *State of California, Seismic Hazard Zones, City and County of San Francisco, Official Map*, prepared by the California Geological Survey (CGS) and dated November 17, 2000.

Liquefaction susceptibility was assessed using the software CLiq v2.1 (GeoLogismiki, 2017). CLiq uses measured field CPT data and assesses liquefaction potential, including post-earthquake vertical settlement, given a user-defined earthquake magnitude and peak ground acceleration (PGA). We performed a liquefaction triggering analysis using our CPT data in accordance with the methodology by Boulanger and Idriss (2014).

Our analyses were performed using a “during earthquake” groundwater depth of 20 feet bgs. In accordance with the 2016 San Francisco Building Code (SFBC), we used a peak ground acceleration of 0.76 times gravity (g) in our liquefaction evaluation; this peak ground acceleration is consistent with the Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration adjusted for site effects (PGA_M). We also used a moment magnitude of 8.05, corresponding to the mean characteristic moment magnitude of the San Andreas fault (Table 2).

The results of our liquefaction analysis indicate the soil at the site is sufficiently dense to resist liquefaction. Therefore, we preliminarily conclude that the potential for liquefaction and associated surface manifestations, such as settlement, loss of bearing capacity, sand boils, and lateral spreading, are nil.

5.2.3 Cyclic Densification

Cyclic densification (also referred to as differential compaction) of non-saturated sand (sand above groundwater table) can occur during an earthquake, resulting in settlement of the ground surface and overlying improvements. The CPTs indicate that the soil above the groundwater table at the site consists predominantly of dense to very dense silty sand, which is not susceptible to cyclic densification. Therefore, we preliminarily conclude that the potential for cyclic densification is nil.

5.2.4 Ground Surface Rupture

Historically, ground surface displacements closely follow the trace of geologically young faults. The site is not within an Earthquake Fault Zone, as defined by the Alquist-Priolo Earthquake Fault Zoning Act, and no known active or potentially active faults exist on the site. We therefore conclude the risk of fault offset at the site from a known active fault is very low. In a seismically active area, the remote possibility exists for future faulting in areas where no faults previously existed; however, we conclude the risk of surface faulting and consequent secondary ground failure from previously unknown faults is also very low.

6.0 PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our engineering analyses using the data from the CPTs, we conclude there are no major geotechnical or geological issues that would preclude development of the site as proposed. The primary geotechnical issues affecting the proposed development include site grading and support of the proposed structures. These issues, as well as construction considerations and seismic design, are discussed in more detail in the following sections.

6.1 Foundations and Settlement

The results of borings and CPTs performed at the site indicate the central portion of the site is underlain by dense to very dense silty sand of the Colma formation. The western portion of the site is currently occupied by an embankment which measures approximately 30 feet high and has a footprint approximately 180 feet wide (east-west) and 1000 feet long (north-south). The embankment was likely constructed using soil excavated from the central portion of the site. We understand that current plans are to remove the western embankment and use the material to raise grades across the site. If spread uniformly, we estimate that this grading would raise site grades by approximately 4 to 5 feet; therefore, it is likely that some or all of the proposed structures will bottom in the newly placed fill. Provided that this fill is properly placed and well-compacted, we conclude conventional spread footings are appropriate for foundation support.

We preliminarily recommend that spread footings be designed using an allowable bearing pressure of 7,000 pounds per square foot (psf) for dead-plus-live loads; this pressure may be increased by one-third for total design loads, which include wind or seismic forces. Estimated total settlements will be on the order of 3/4 inch and differential settlement will be on the order of 1/2 inch over a 30-foot horizontal distance. Continuous footings should be at least 18 inches wide and isolated spread footings should be at least 36 inches wide. Footings should extend at least 18 inches below the lowest adjacent soil subgrade.

Lateral loads may be resisted by a combination of friction along the base of the footing and passive resistance against the vertical faces of the footing. To compute lateral resistance, we recommend using an equivalent fluid weight of 330 pounds per cubic foot (pcf); the upper foot of soil should be ignored unless confined by a slab or pavement. Frictional resistance should be computed using a base friction coefficient of 0.40 where the footing is in direct contact with soil. The passive pressure and frictional resistance values include a factor of safety of at least 1.5 and may be used in combination without reduction.

6.2 Construction Considerations

Site demolition should include the removal of all existing improvements, including pavements, underground utilities, and buried foundations. In general, abandoned underground utilities should be removed to the property line or service connections and properly capped or plugged with concrete. Where existing utility lines are outside of the proposed building footprint and will not interfere with the proposed construction, they may be abandoned in-place provided the lines are filled with lean concrete or cement grout to the property line. Voids resulting from demolition activities should be properly backfilled with compacted fill following the recommendations provided later in this section.

The exposed soil subgrade is expected to generally consist of dense to very dense sand. However, if loose sand or weak clay is encountered, those materials should be removed and replaced with either properly compacted fill or lean concrete.

In areas that will receive fill, the soil subgrade exposed should be scarified to a depth of at least eight inches, moisture-conditioned to above optimum moisture content, and compacted to at least 90 percent relative compaction[5]. The soil subgrade should be compacted to at least 95 percent relative compaction if the soil consists of clean sand or gravel (defined as soil with less than 10 percent fines passing the No. 200 sieve). The soil subgrade should be kept moist until it is covered by fill.

Fill should consist of on-site soil or imported soil (select fill) that is free of organic matter, contains no rocks or lumps larger than three inches in greatest dimension, has a liquid limit of

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[5] Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same material, as determined by the ASTM D1557 laboratory compaction procedure.

less than 40 and a plasticity index lower than 12, and is approved by the Geotechnical Engineer. It is anticipated that the embankment material will meet these criteria. Samples of proposed imported fill material should be submitted to the Geotechnical Engineer at least three business days prior to use at the site. The grading contractor should provide analytical test results or other suitable environmental documentation indicating the imported fill is free of hazardous materials at least three days before use at the site. If this data is not available, up to two weeks should be allowed to perform analytical testing on the proposed imported material.

Fill should be placed in horizontal lifts not exceeding eight inches in uncompacted thickness, moisture-conditioned to above optimum moisture content, and compacted to at least 90 percent relative compaction. Fill consisting of clean sand or gravel (defined as soil with less than 10 percent fines by weight) should be compacted to at least 95 percent relative compaction. Fill greater than five feet in thickness, fill placed below proposed foundations, or fill placed within the upper foot of vehicular pavement soil subgrade should also be compacted to at least 95 percent relative compaction.

6.3 Soil Corrosivity

Corrosivity analyses were performed by Project X Corrosion Engineering on a sample of the native soil from boring B-2 at a depth of 15 feet bgs. The results of the tests are presented in Appendix B of this report. Based on the results of the laboratory corrosivity analyses performed on the samples, we conclude the soil is “negligibly corrosive” to metal with respect to resistivity, sulfate ion concentration, and pH. The chloride ion concentration classifies as “mildly corrosive”. Accordingly, all buried metallic structures and reinforcing steel in concrete structures should be protected against corrosion depending upon the critical nature of the structure. If it is necessary to have metal in contact with soil, a corrosion engineer should be consulted to provide recommendations for corrosion protection.

6.4 Seismic Design

We anticipate the proposed building will be designed using the seismic provisions in the 2016 San Francisco Building Code (SFBC). We preliminarily conclude a Site Class D designation should be used for seismic design. The latitude and longitude of the site are 37.7238° and -122.4553°, respectively. In accordance with the 2016 CBC, we recommend the following:

- $S_S = 1.937g$, $S_1 = 0.907g$
- $S_{MS} = 1.937g$, $S_{M1} = 1.361g$
- $S_{DS} = 1.291g$, $S_{D1} = 0.907g$
- Seismic Design Category E for Risk Categories I, II, and III.

7.0 ADDITIONAL GEOTECHNICAL SERVICES

The preliminary conclusions and recommendations presented within are based on a preliminary field investigation and not intended for final design. Prior to final design, we should be retained to provide a final geotechnical report based on a supplemental field investigation. Additional borings and CPTs will be required to further evaluate the subsurface conditions beneath the site and develop final foundation design recommendations. After our final report has been completed and the design team has selected a foundation system, we should review the project plans and specifications prior to construction to check their conformance with the intent of our final recommendations. During construction, we should observe site preparation, foundation installation, and the placement and compaction of backfill. These observations will allow us to compare the actual with the anticipated soil conditions and to check if the contractor's work conforms with the geotechnical aspects of the plans and specifications.

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FIGURES

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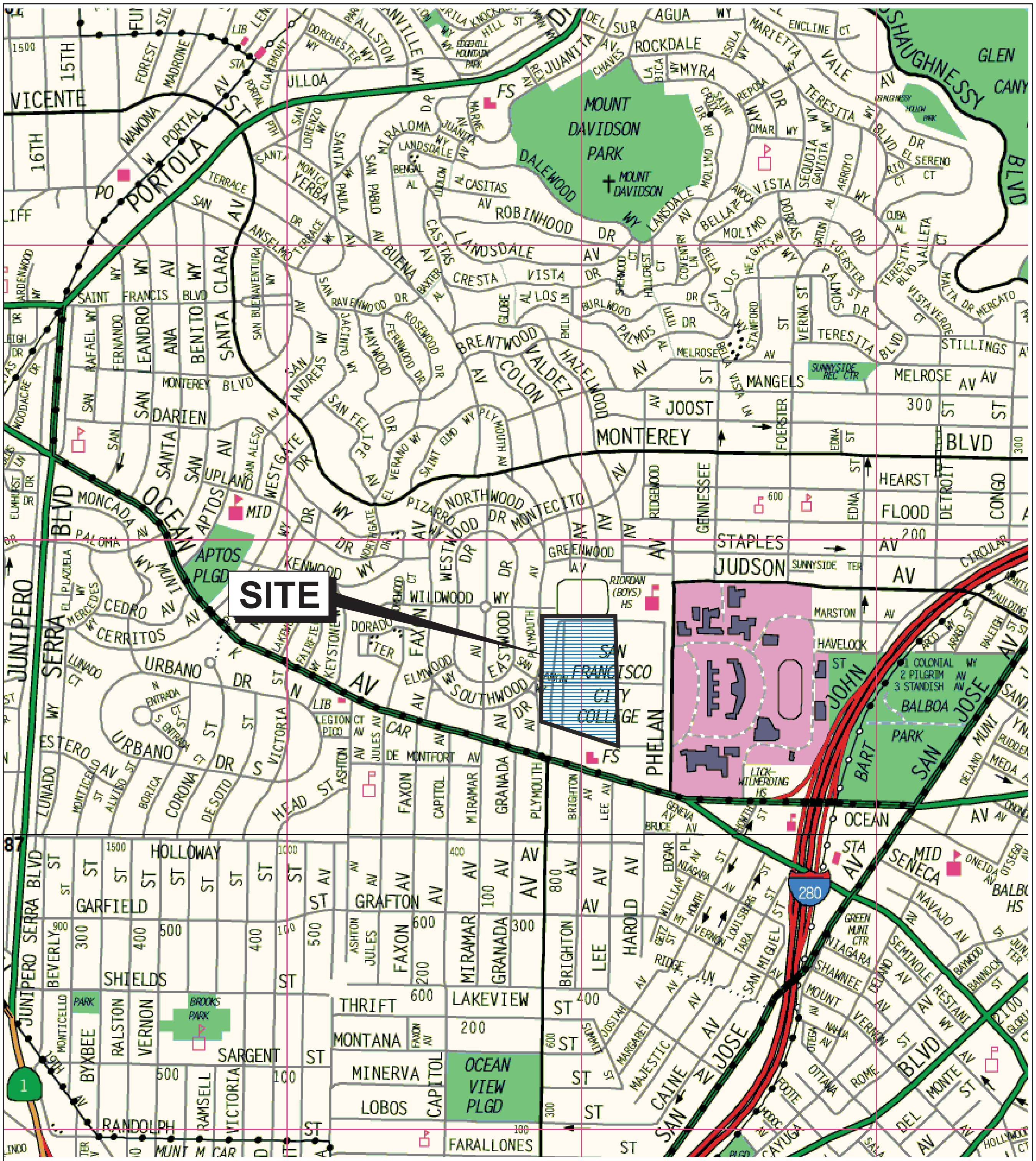

Base map: The Thomas Guide
San Francisco County
2002

0 1/4 1/2 Mile
Approximate scale

BALBOA RESERVOIR
San Francisco, California

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SITE LOCATION MAP

Date 01/05/18	Project No. 17-1425	Figure 1

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EXPLANATION

B-1 ⊕ Approximate location of boring by Rockridge Geotechnical Inc., January 3, 2018

CPT-1 ▲ Approximate location of cone penetration test by Rockridge Geotechnical Inc., January 3, 2018

Project limits

N

0 150 Feet

Approximate scale

Base map: Google Earth, 2017.

BALBOA RESERVOIR
San Francisco, California

SITE PLAN

Date 01/10/18
Project No. 17-1425
Figure 2

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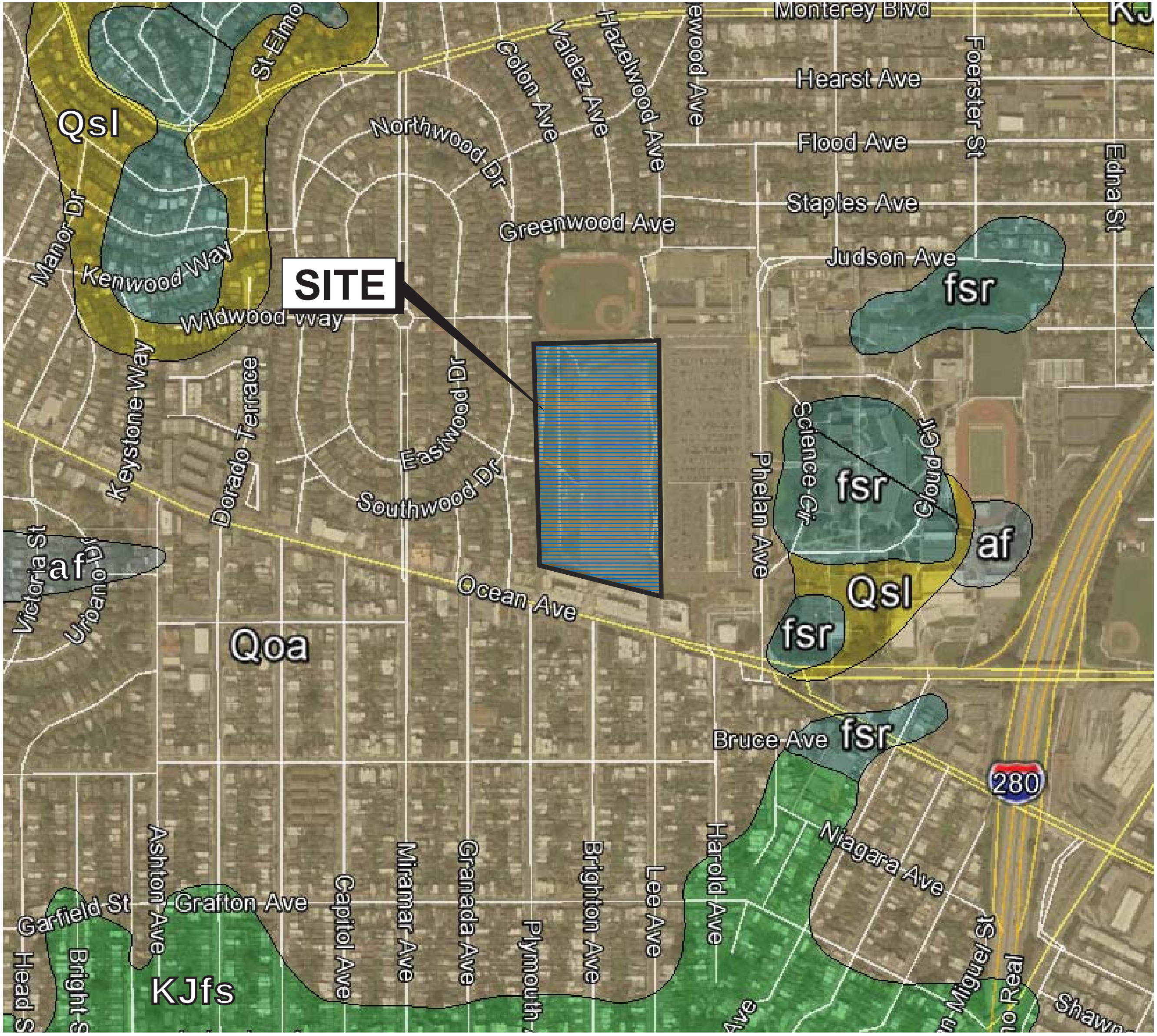

Base map: Google Earth with U.S. Geological Survey (USGS), San Francisco County, 2016.

EXPLANATION

af	Artificial Fill
Qsl	Hillslope Deposits (Quaternary)
Qoa	Alluvium (early Pleistocene)
KJfs	Franciscan Complex sedimentary rocks (Early Cretaceous and (or) Late Jurassic)
fsr	Franciscan Complex melange (Eocene, Paleocene, and (or) Late Cretaceous)

Geologic contact: dashed where approximate and dotted where concealed, queried where uncertin

N

0 800 1600 Feet

Approximate Scale

BALBOA RESERVOIR
San Francisco, California

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REGIONAL GEOLOGIC MAP

Date 01/05/18 | Project No. 17-1425 | Figure 3

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Base Map: U.S. Geological Survey (USGS), National Seismic Hazards Maps - Fault Sources, 2008.

EXPLANATION

Strike slip

Thrust (Reverse)

Normal

0 5 10 Miles

Approximate scale

BALBOA RESERVOIR
San Francisco, California

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REGIONAL FAULT MAP

Date 01/05/18	Project No. 17-1425	Figure 4

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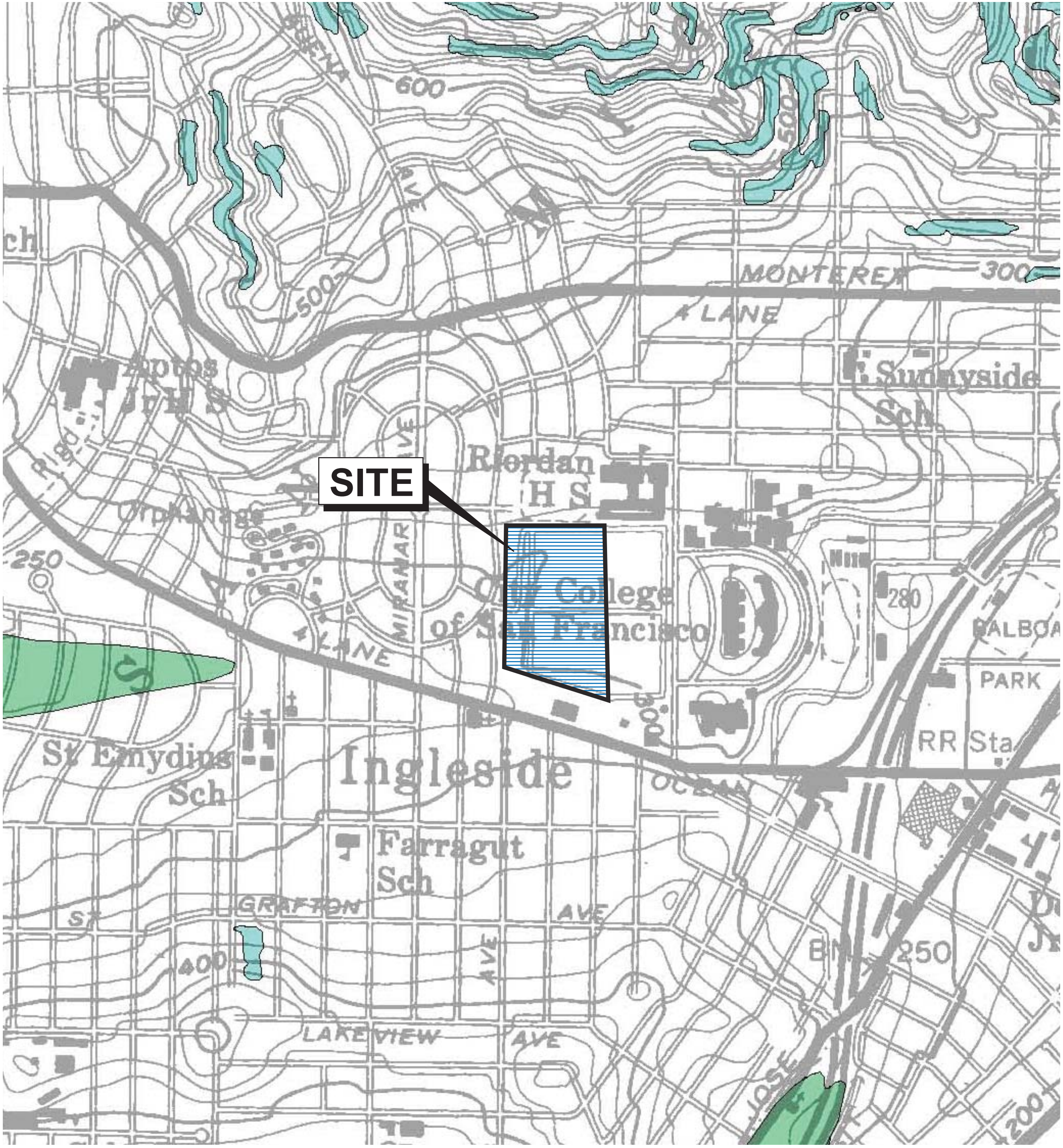

EXPLANATION

🟩 **Liquefaction;** Areas where historic occurence of liquefaction, or local topographic, geological, geotechnical, and subsurface water conditions indicate a potential for permanent ground displacements.

🟦 **Earthquake-Induced Landslides;** Areas where previous occurence of landslide movement, or local topographic, geological, geotechnical, and subsurface water conditions indicate a potential for permanent ground displacements.

0 1,000 2,000 Feet

Approximate scale

Reference:
State of California "Seismic Hazard Zones"
City and County of San Francisco
Released on November 17, 2000

BALBOA RESERVOIR
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SEISMIC HAZARDS ZONE MAP

Date 01/05/18 Project No. 17-1425 Figure 5

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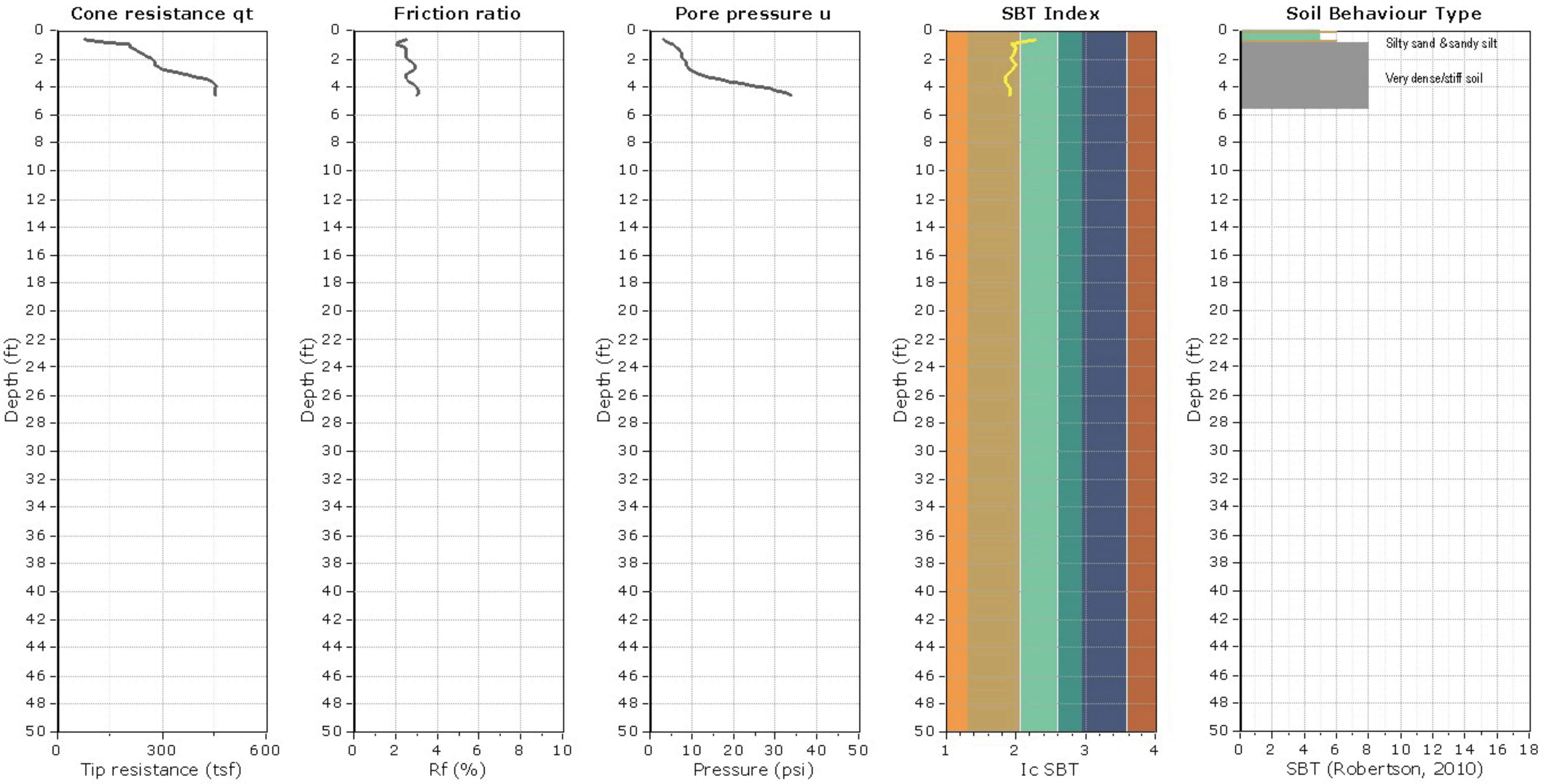
APPENDIX A

Cone Penetration Test Results and Logs of Borings

DRAFT



Total depth: 4.59 ft, Date: 1/3/2018 (Refusal at 4.6 on second attempt)
Groundwater not measured
Cone Operator: Middle Earth Geo Testing, Inc.

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

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San Francisco, California

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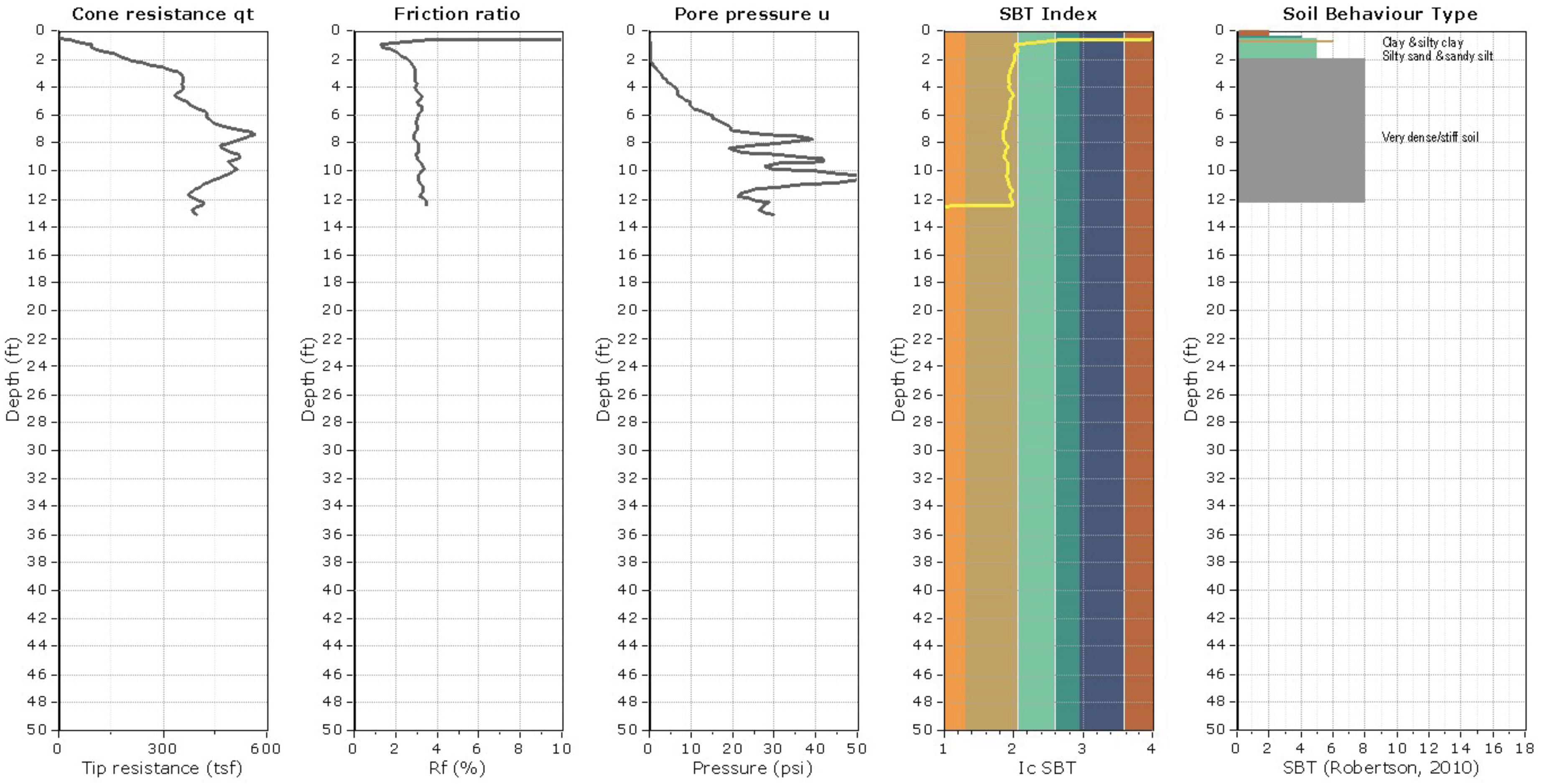
CONE PENETRATION TEST RESULTS
CPT-1

Date 01/16/18	Project No. 17-1425	Figure A-1

DRAFT



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

Total depth: 13.12 ft, Date: 1/3/2018
Groundwater not measured
Cone Operator: Middle Earth Geo Testing, Inc.

BALBOA RESERVOIR
San Francisco, California

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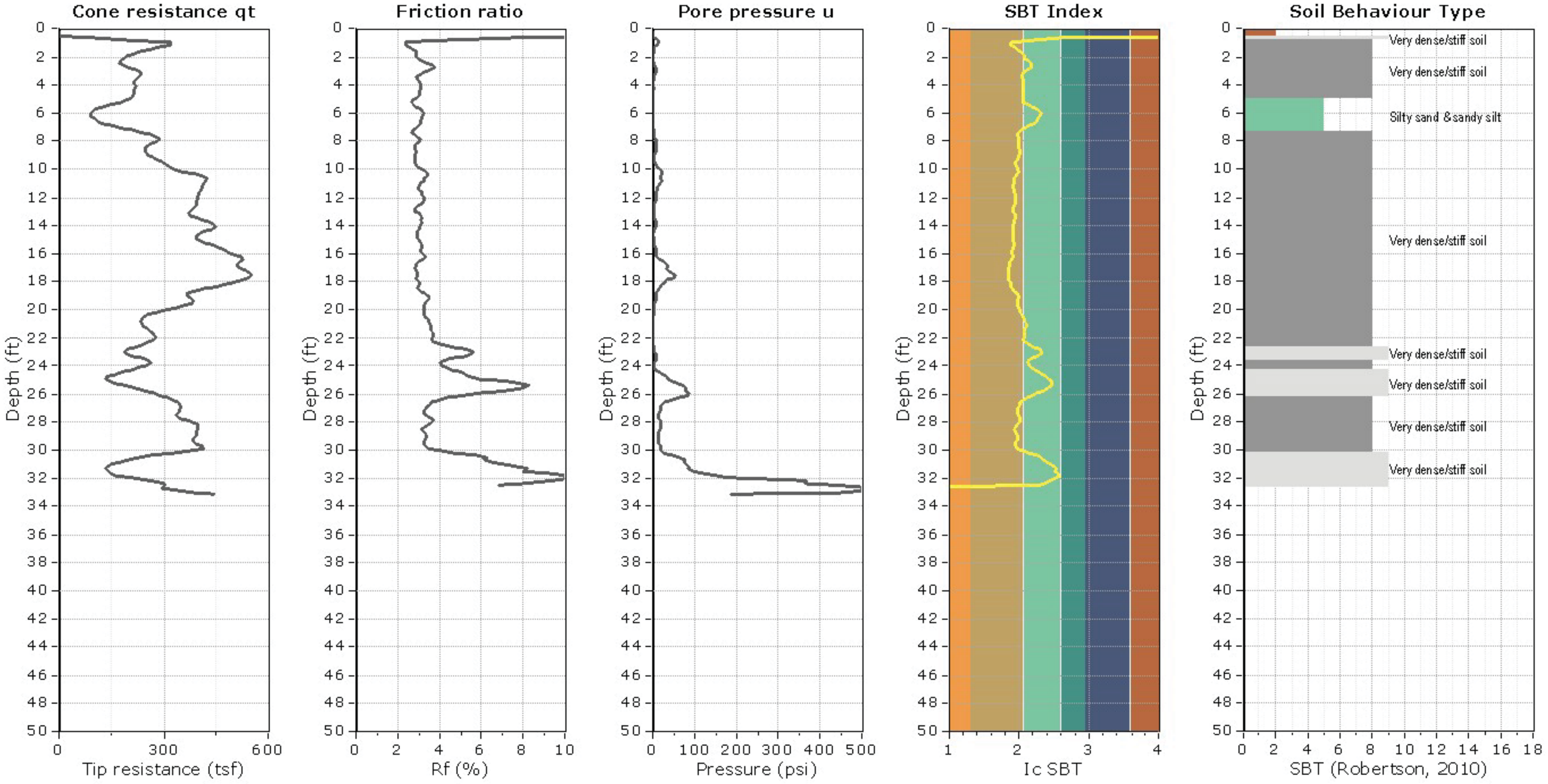
CONE PENETRATION TEST RESULTS
CPT-2

Date 01/16/18	Project No. 17-1425	Figure A-2

DRAFT



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

Total depth: 33.14 ft, Date: 1/3/2018
Groundwater not measured
Cone Operator: Middle Earth Geo Testing, Inc.

BALBOA RESERVOIR
San Francisco, California

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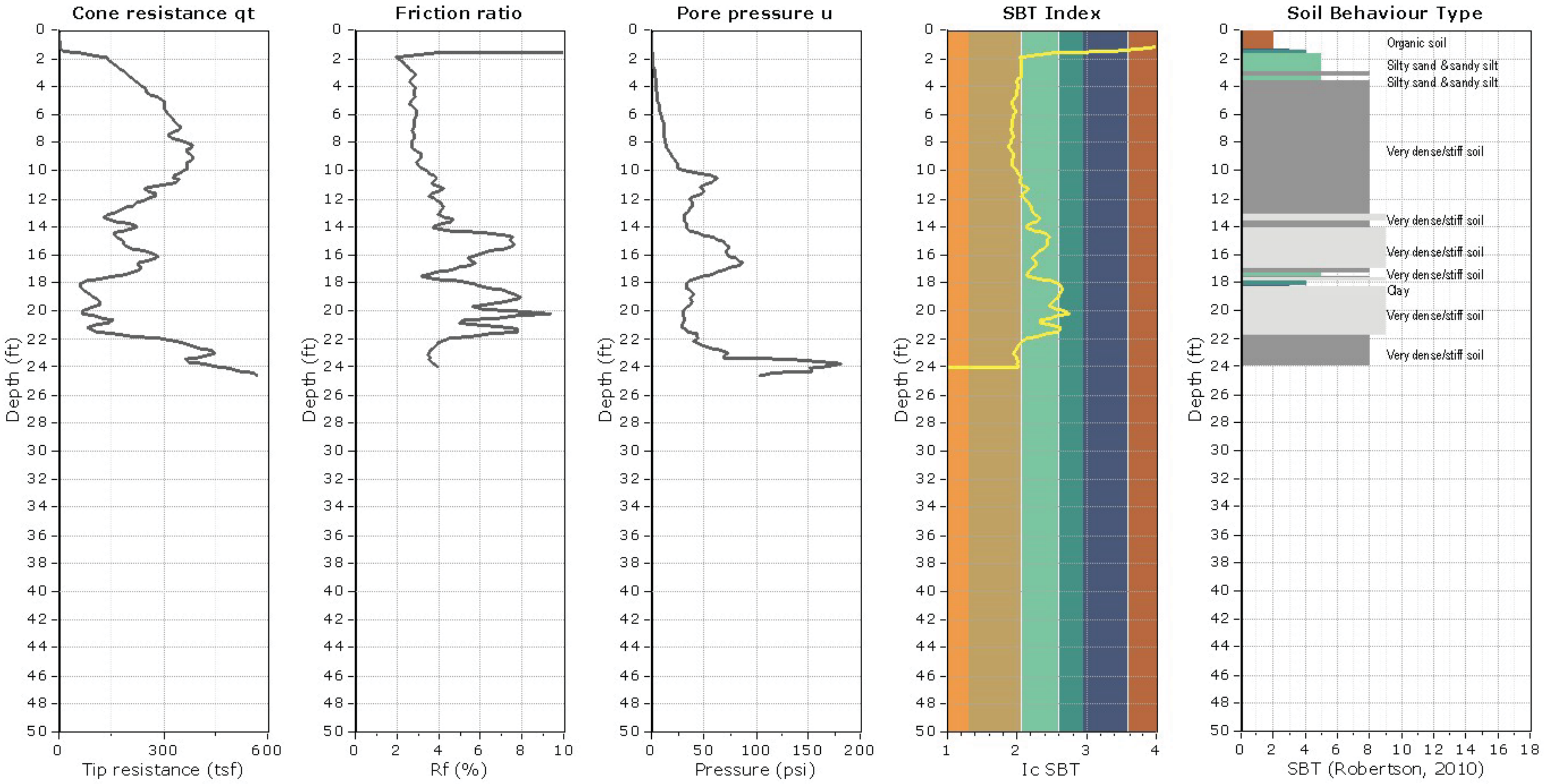
CONE PENETRATION TEST RESULTS
CPT-3

Date 01/16/18 | Project No. 17-1425 | Figure A-3



Total depth: 24.61 ft, Date: 1/3/2018
Groundwater not measured
Cone Operator: Middle Earth Geo Testing, Inc.

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

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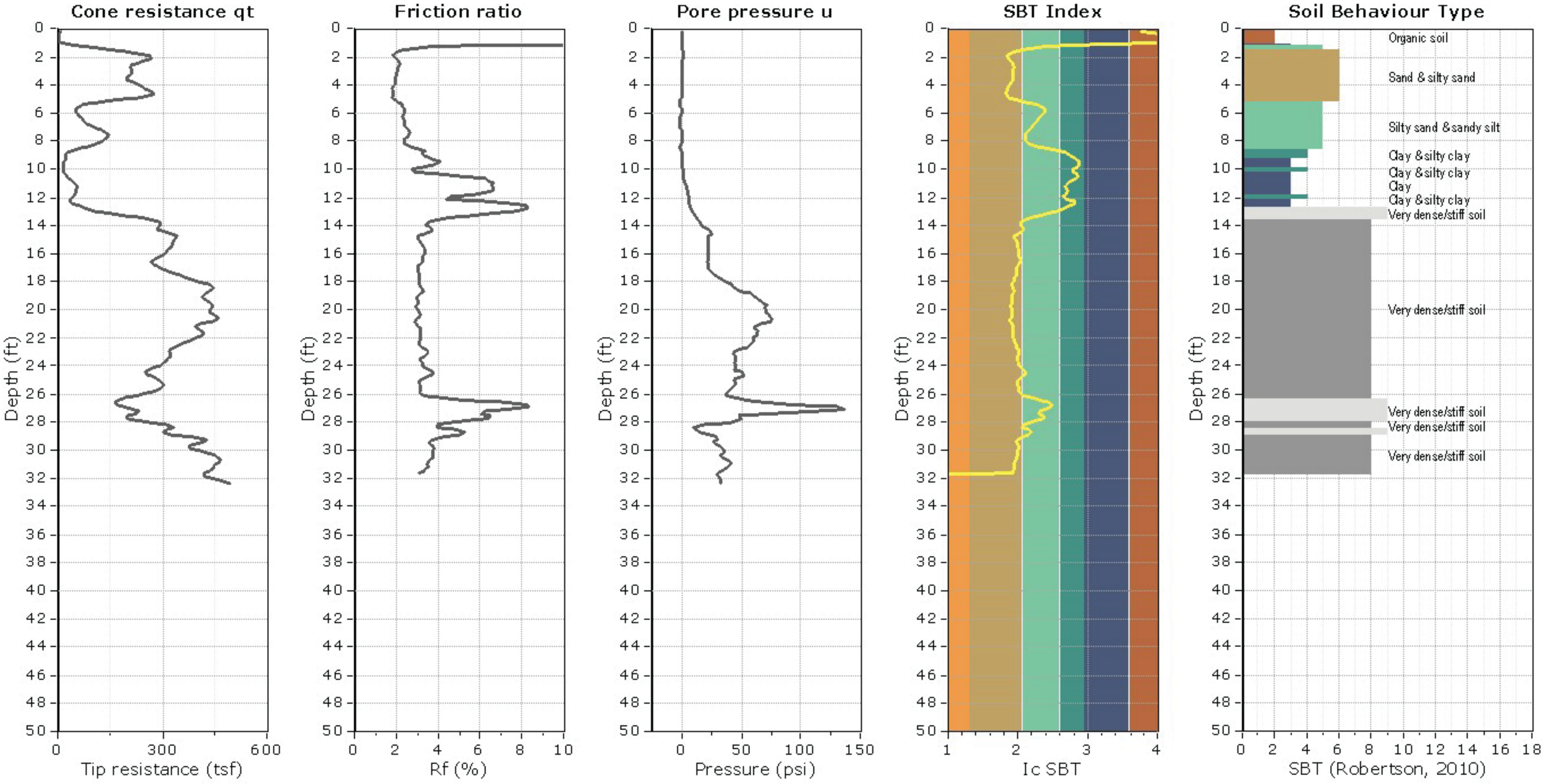
CONE PENETRATION TEST RESULTS
CPT-4

Date 01/16/18	Project No. 17-1425	Figure A-4

DRAFT



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

Total depth: 32.32 ft, Date: 1/3/2018
Groundwater not measured
Cone Operator: Middle Earth Geo Testing, Inc.

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San Francisco, California

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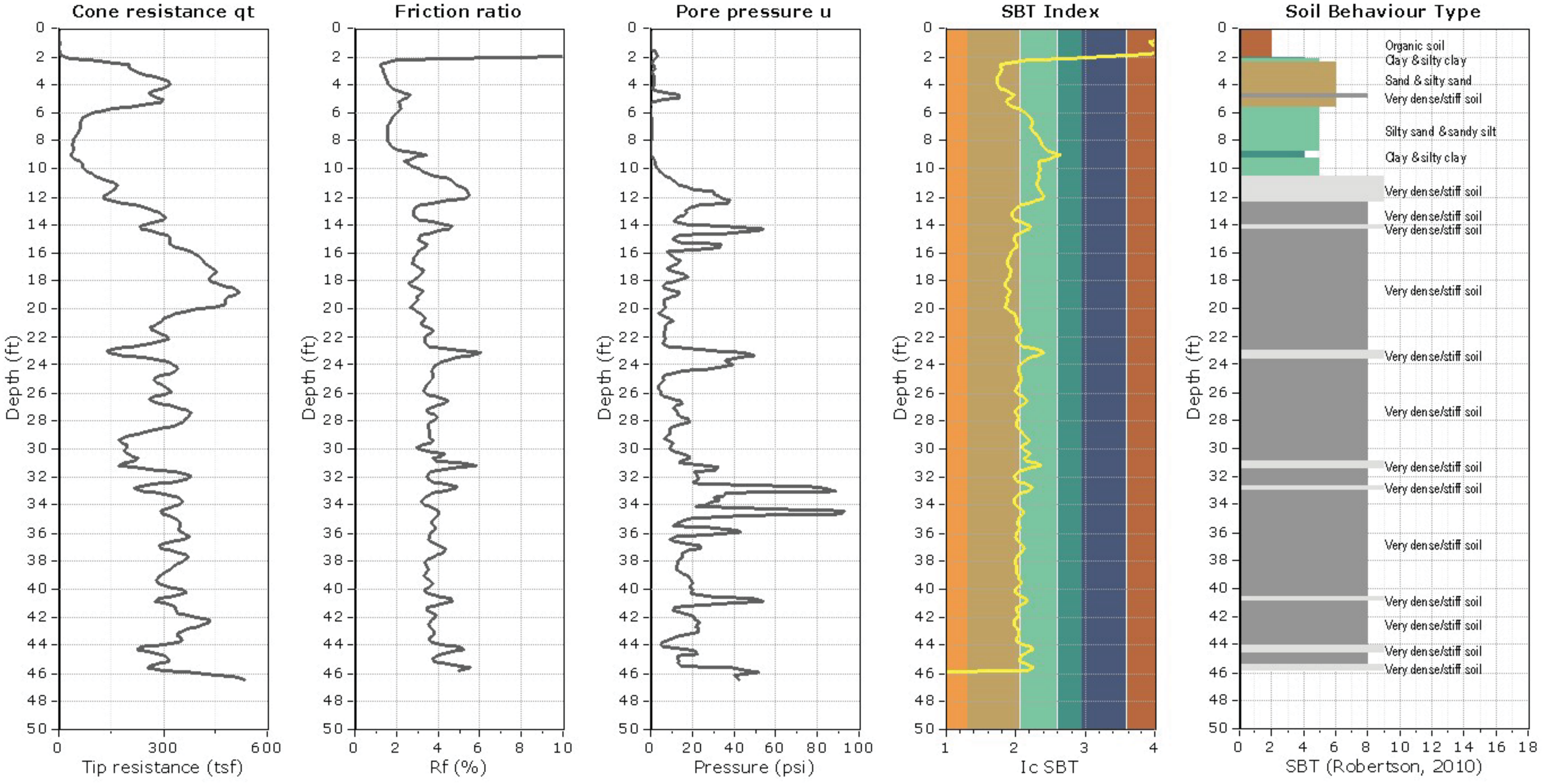
CONE PENETRATION TEST RESULTS
CPT-5

Date 01/16/18	Project No. 17-1425	Figure A-5

DRAFT



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

Total depth: 46.42 ft, Date: 1/3/2018
Groundwater not measured
Cone Operator: Middle Earth Geo Testing, Inc.

BALBOA RESERVOIR
San Francisco, California

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CONE PENETRATION TEST RESULTS
CPT-6

Date 01/16/18	Project No. 17-1425	Figure A-6

PROJECT: **BALBOA RESERVOIR**
San Francisco, California

Log of Boring B-1

PAGE 1 OF 1

Boring location: See Site Plan, Figure 2
Date started: 1/3/18
Date finished: 1/3/18
Drilling method: Solid Stem Auger
Hammer weight/drop: 140 lbs./30 inches
Hammer type: Safety/Rope & Cathead
Sampler: Standard Penetration Test (SPT)
Logged by: D. Landkamer

DEPTH (feet)	SAMPLES Sampler Type	SAMPLES Sample	SAMPLES Blows/ 6"	SAMPLES SPT N-Value[1]	LITHOLOGY	MATERIAL DESCRIPTION	LABORATORY TEST DATA Type of Strength Test	LABORATORY TEST DATA Confining Pressure Lbs/Sq Ft	LABORATORY TEST DATA Shear Strength Lbs/Sq Ft	LABORATORY TEST DATA Fines %	LABORATORY TEST DATA Natural Moisture Content, %	LABORATORY TEST DATA Dry Density Lbs/Cu Ft
						SILTY SAND (SM) olive-brown, dense, dry, fine-grained sand, with clay, weak cementation, trace rootlets						
1												
2	SPT	◪	13 22 18	48								
3						orange-brown						
4	SPT	◪	16 21 23	53		6 inches gravel layer very dense, moist, no cementation						
5												
6	SPT	◪	13 16 14	36		dense						
7												
8												
9												
10						red-brown, medium dense, decreased silt content, no clay						
11	SPT	◪	6 5 7	14								
12												
13					SM							
14												
15						orange-brown, dense						
16	SPT	◪	13 14 15	35								
17												
18												
19												
20						very dense, increased silt content						
21	SPT	◪	18 20 28	58								
22												
23												
24												
25						yellow-brown						
26	SPT	◪	24 30 38	82								
27												
28												
29												
30												

Boring terminated at a depth of 26.5 feet below ground surface.
Boring backfilled with cement grout.
Groundwater not encountered during drilling.

[1] SPT blow counts for the last two increments were converted to SPT N-Values using a factor of 1.2 to account for sampler type and hammer energy.

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Project No.: 17-1425
Figure: A-7

DRAFT

PROJECT: **BALBOA RESERVOIR**
San Francisco, California

Log of Boring B-2

PAGE 1 OF 1

Boring location: See Site Plan, Figure 2

Logged by: D. Landkamer

Date started: 1/3/18

Date finished: 1/3/18

Drilling method: Solid Stem Auger

Hammer weight/drop: 140 lbs./30 inches

Hammer type: Safety/Rope & Cathead

Sampler: Standard Penetration Test (SPT)

DEPTH (feet)	SAMPLES Sampler Type	Sample	Blows/ 6"	SPT N-Value[1]	LITHOLOGY	MATERIAL DESCRIPTION	LABORATORY TEST DATA Type of Strength Test	Confining Pressure Lbs/Sq Ft	Shear Strength Lbs/Sq Ft	Fines %	Natural Moisture Content, %	Dry Density Lbs/Cu Ft
						SILTY SAND (SM) orange-brown, very dense, moist, fine-grained sand, trace clay						
1												
2	SPT	◩	21 22 21	52								
3												
4	SPT	◩	11 22 22	53		trace gravel						
5						no gravel						
6	SPT	◩	17 23 26	54								
7												
8												
9					SM							
10												
11	SPT	◩	10 19 23	50								
12												
13												
14												
15						dense, with clay, trace gravel						
16	SPT	◩	14 16 22	46								
17												
18												
19					SC	CLAYEY SAND (SC) brown to red-brown, dense, moist, fine- to coarse-grained sand, trace gravel						
20												
21	SPT	◩	16 18 27	54		SILTY SAND (SM) orange-brown, very dense, moist, fine-grained sand, with clay, trace fine gravel						
22												
23					SM							
24												
25												
26	SPT	◩	10 13 22	42		dense, with clayey sand inclusions						
27												
28												
29												
30												

Boring terminated at a depth of 26.5 feet below ground surface.
Boring backfilled with cement grout.
Groundwater not encountered during drilling.

[1] SPT blow counts for the last two increments were converted to SPT N-Values using a factor of 1.2 to account for sampler type and hammer energy.

ROCKRIDGE GEOTECHNICAL

Project No.: 17-1425

Figure: A-8

DRAFT

PROJECT: **BALBOA RESERVOIR**
San Francisco, California

Log of Boring B-3

PAGE 1 OF 1

Boring location: See Site Plan, Figure 2

Date started: 1/3/18

Date finished: 1/3/18

Drilling method: Solid Stem Auger

Hammer weight/drop: 140 lbs./30 inches

Hammer type: Safety/Rope & Cathead

Sampler: Standard Penetration Test (SPT)

Logged by: D. Landkamer

DEPTH (feet)	SAMPLES				LITHOLOGY	MATERIAL DESCRIPTION	LABORATORY TEST DATA					
	Sampler Type	Sample	Blows/ 6"	SPT N-Value[1]			Type of Strength Test	Confining Pressure Lbs/Sq Ft	Shear Strength Lbs/Sq Ft	Fines %	Natural Moisture Content, %	Dry Density Lbs/Cu Ft
1						SAND with SILT (SP-SM) olive gray, dense, dry to moist, fine-grained sand						
2	SPT	◪	7 13 20	40								
3												
4	SPT	◪	13 13 15	34		yellow-brown and olive-gray						
5												
6	SPT	◪	15 21 25	55	SP-SM	very dense, moist						
7												
8												
9												
10												
11	SPT	◪	21 23 26	59								
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

Boring terminated at a depth of 11.5 feet below ground surface.
Boring backfilled with cement grout.
Groundwater not encountered during drilling.

---

[1] SPT blow counts for the last two increments were converted to SPT N-Values using a factor of 1.2 to account for sampler type and hammer energy.

ROCKRIDGE GEOTECHNICAL

Project No.: 17-1425

Figure: A-9

PROJECT: **BALBOA RESERVOIR**
San Francisco, California

Log of Boring B-4

PAGE 1 OF 1

Boring location: See Site Plan, Figure 2

Date started: 1/3/18

Date finished: 1/3/18

Drilling method: Solid Stem Auger

Hammer weight/drop: 140 lbs./30 inches

Hammer type: Safety/Rope & Cathead

Sampler: Standard Penetration Test (SPT)

Logged by: D. Landkamer

	SAMPLES						LABORATORY TEST DATA					
DEPTH (feet)	Sampler Type	Sample	Blows/ 6"	SPT N-Value[1]	LITHOLOGY	MATERIAL DESCRIPTION	Type of Strength Test	Confining Pressure Lbs/Sq Ft	Shear Strength Lbs/Sq Ft	Fines %	Natural Moisture Content, %	Dry Density Lbs/Cu Ft
1					SC	CLAYEY SAND with GRAVEL (SC) brown to red-brown, medium dense, moist, fine- to medium-grained sand						
2	SPT	◪	7 14 18	38		SILTY SAND (SM) brown, dense, moist, fine- to medium-grained sand						
3												
4	SPT	◪	6 7 12	23	SM	orange-brown, medium dense, with clay						
5						mottled dark brown, dense, weak cementation						
6	SPT	◪	14 20 20	48		brown, no clay						
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

Boring terminated at a depth of 6.5 feet below ground surface.
Boring backfilled with cement grout.
Groundwater not encountered during drilling.

[1] SPT blow counts for the last two increments were converted to SPT N-Values using a factor of 1.2 to account for sampler type and hammer energy.

ROCKRIDGE GEOTECHNICAL

Project No. 17-1425

Figure A-10

UNIFIED SOIL CLASSIFICATION SYSTEM

Major Divisions		Symbols	Typical Names
Coarse-Grained Soils (more than half of soil > no. 200 sieve size)	Gravels (More than half of coarse fraction > no. 4 sieve size)	**GW**	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	Sands (More than half of coarse fraction < no. 4 sieve size)	**SW**	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly-graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
Fine -Grained Soils (more than half of soil < no. 200 sieve size)	Silts and Clays LL = < 50	**ML**	Inorganic silts and clayey silts of low plasticity, sandy silts, gravelly silts
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	Silts and Clays LL = > 50	**MH**	Inorganic silts of high plasticity
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic silts and clays of high plasticity
Highly Organic Soils		**PT**	Peat and other highly organic soils

GRAIN SIZE CHART

Classification	Range of Grain Sizes	
	U.S. Standard Sieve Size	Grain Size in Millimeters
Boulders	Above 12"	Above 305
Cobbles	12" to 3"	305 to 76.2
Gravel coarse fine	3" to No. 4 3" to 3/4" 3/4" to No. 4	76.2 to 4.76 76.2 to 19.1 19.1 to 4.76
Sand coarse medium fine	No. 4 to No. 200 No. 4 to No. 10 No. 10 to No. 40 No. 40 to No. 200	4.76 to 0.075 4.76 to 2.00 2.00 to 0.420 0.420 to 0.075
Silt and Clay	Below No. 200	Below 0.075

▽	Unstabilized groundwater level
▼	Stabilized groundwater level

SAMPLE DESIGNATIONS/SYMBOLS

⬒	Sample taken with Sprague & Henwood split-barrel sampler with a 3.0-inch outside diameter and a 2.43-inch inside diameter. Darkened area indicates soil recovered
◩	Classification sample taken with Standard Penetration Test sampler
◨	Undisturbed sample taken with thin-walled tube
☒	Disturbed sample
⊙	Sampling attempted with no recovery
◫	Core sample
●	Analytical laboratory sample
▥	Sample taken with Direct Push sampler
▥	Sonic

SAMPLER TYPE

C	Core barrel
CA	California split-barrel sampler with 2.5-inch outside diameter and a 1.93-inch inside diameter
D&M	Dames & Moore piston sampler using 2.5-inch outside diameter, thin-walled tube
O	Osterberg piston sampler using 3.0-inch outside diameter, thin-walled Shelby tube
PT	Pitcher tube sampler using 3.0-inch outside diameter, thin-walled Shelby tube
S&H	Sprague & Henwood split-barrel sampler with a 3.0-inch outside diameter and a 2.43-inch inside diameter
SPT	Standard Penetration Test (SPT) split-barrel sampler with a 2.0-inch outside diameter and a 1.5-inch inside diameter
ST	Shelby Tube (3.0-inch outside diameter, thin-walled tube) advanced with hydraulic pressure

BALBOA RESERVOIR
San Francisco, California

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GEOTECHNICAL

CLASSIFICATION CHART

Date 01/05/18 | Project No. 17-1425 | Figure A-11

APPENDIX B

Corrosivity Test Results

Results Only Soil Testing for Balboa Reservoir

January 15, 2018

Prepared for:
Clayton Proto
Rockridge Geotechnical
270 Grand Ave,
Oakland, CA 94610
cjproto@rockridgegeo.com

Project X Job#: S180112A
Client Job or PO#: 17-1425

Soil Analysis Lab Results

Client: Rockridge Geotechnical
Job Name: Balboa Reservoir
Client Job Number: 17-1425
Project X Job Number: S180112A
January 15, 2018

	Method	ASTM G187		ASTM D516		ASTM D512B		SM 4500-NO3-E	SM 4500-NH3-C	SM 4500-S2-D	ASTM G200	ASTM G51
Bore# / Description	**Depth**	**Resistivity**		**Sulfates**		**Chlorides**		**Nitrate**	**Ammonia**	**Sulfide**	**Redox**	**pH**
		As Rec'd	Minimum									
	(ft)	(Ohm-cm)	(Ohm-cm)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(mg/kg)	(mg/kg)	(mg/kg)	(mV)	
B-2 #5	15.0	12,060	10,050	120	0.0120	255	0.0255	165	97.5	5.70	211	7.99

Unk = Unknown
NT = Not Tested
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
mg/L - milligrams per liter of liquid volume
Chemical Analysis performed on 1:3 Soil-To-Water extract

Please call if you have any questions.

Prepared by,

Nathan Jacob,
Lab Technician

Respectfully Submitted,

Eddie Hernandez, M.Sc., P.E.
Sr. Corrosion Consultant
NACE Corrosion Technologist #16592
Professional Engineer
California No. M37102
ehernandez@projectxcorrosion.com

REGISTERED PROFESSIONAL ENGINEER
EDUARDO HERNANDEZ
No. M37102
MECHANICAL
STATE OF CALIFORNIA

Project X
Corrosion Engineering
Corrosion Control - Soil, Water, and Metallurgy Lab

S180112A ROCKRIDGE 17-1425 1 FULL

Lab Request Sheet Chain of Custody
Phone: (213) 928-7213 · Fax (951) 226-1720 · www.projectxcorrosion.com
Ship Samples To: 29970 Technology Dr, Suite 105F, Murrieta, CA 92563

IMPORTANT: Please complete Project and Sample Identification Data as you would like it to appear in report & include this form with samples.

Project X Job #:
Date:

Company Name: Rockridge Geotechnical
Contact Name: Clayton Proto
Phone No. : 510-420-5738 x 120
Mailing Address: 270 Grand Avenue, Oakland California
Contact Email: cjproto@rockridgegeo.com
Accounting Contact: Kate Schenk
Invoice Email: kaschenk@rockridgegeo.com
Project Name: Balboa Reservoir
Client Project No: 17-1425
P.O. #:

	5 Day Normal	3 Day RUSH 75% mark-up	2 Day RUSH 100% mark-up
Turn Around Time:	X		

Results By: ☐ Phone ☐ Fax ☒ Email ☒ Mail ☐ Overnight Mail (charges apply)

Received by:

Default Method

SPECIAL INSTRUCTIONS:

ANALYSIS REQUESTED (Please circle)

	SAMPLE ID - BORE #	DESCRIPTION	DEPTH (ft)	DATE COLLECTED	CORROSION SERIES Min. Resistivity, Sulfate, Chloride, Sulfide, Redox, pH, Ammonia, Nitrate.	Soil Resistivity Caltrans CTM643 ASTM G57 ASTM G187	pH Caltrans CTM643 AASHTO T 289 ASTM G 51	Sulfate Caltrans CTM417 AASHTO T 290 ASTM D516	Chloride Caltrans CTM422 AASHTO T 291 ASTM D512B	Redox Potential SM 2580B	BiCarbonate SM 2320B	Alkalinity SM 2520B	Acidity SM 2510B	Nitrate SM 4500-NO3 Hach 835	Ammonia SM 4500-NH3 Hach 830	Sulfide SM 4500-S2 SM 4500-S2	Moisture Content ASTM D2216	Soil Corrosivity Evaluation Report	Metallurgical Analysis	NOTES
1	B-2 #5	Silty Sand (SM)	15'	1/3/18	X															
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				