Geotechnical Evaluation

Cyclic Sewer Replacement, Phase 15
Alameda, California

City of Alameda

950 W Mall Square, Room 110 | Alameda, California 94501

December 8, 2017 | Project No. 403144001

Geotechnical | Environmental | Construction Inspection & Testing | Forensic Engineering & Expert Witness

Geophysics | Engineering Geology | Laboratory Testing | Industrial Hygiene | Occupational Safety | Air Quality | GIS

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

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December 8, 2017
Project No. 403144001

Mr. Philip Lee
City of Alameda
950 W. Mall Square, Room 110
Alameda, California 94501

Subject: Geotechnical Evaluation
Cyclic Sewer Replacement Phase 15
Alameda, California

Dear Mr. Lee:

In accordance with your authorization, we have performed a geotechnical evaluation for Phase 15 of Cyclic Sewer Replacement Project on various streets in Alameda, California. This report presents the findings from our subsurface exploration, and our conclusions and geotechnical recommendations regarding the proposed project.

As an integral part of our role as the geotechnical engineer-of-record, we request the opportunity to review the construction plans before they go to bid and to provide follow-up construction observation and testing services.

Ninyo & Moore appreciates the opportunity to be of service to you on this project.

Sincerely,
NINYO & MOORE

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1 INTRODUCTION

In accordance with your request, Ninyo & Moore has performed a geotechnical evaluation for Phase 15 of the sanitary sewer replacement project in Alameda, California. The segments under consideration for this phase of the project are listed in Table 1 and highlighted on Figure 1. The purpose of our study was to evaluate the near-surface soil conditions within the proposed sanitary sewer corridors and provide recommendations for the design and construction of the proposed sewer replacement. This report presents the findings from our subsurface exploration, the results of our geotechnical laboratory testing, our conclusions regarding the geotechnical conditions at the subject site, and our geotechnical recommendations for the project.

2 SCOPE OF SERVICES

Ninyo & Moore's scope of services for this phase of the project included review of pertinent background data, performance of a geotechnical reconnaissance, subsurface evaluation, laboratory testing, and engineering analysis with regard to the proposed construction. Specifically, we performed following tasks:

- Review of readily available background materials, including topographic maps, geologic data and maps, and fault and seismic hazard maps.
- Geotechnical Site reconnaissance to observe the surficial geologic conditions and to select and mark the boring locations for utility mark-out services.
- Coordination with Underground Service Alert (USA) to locate the underground utilities in the vicinity of the proposed borings. A private utility survey was also conducted to further evaluate subsurface conflicts.
- Preparation of a traffic control plan for data collection activities. Providing an arrow board, signs, cones, and a flagman, as-needed, to divert traffic around the work area while data is being collected.
- A subsurface drilling permit was obtained from Alameda County Public Works Agency (ACPWA), and exploratory borings were backfilled in conformance with the ACPWA drilling permit.
- Subsurface exploration consisting of 19 solid-stem auger borings using truck-mounted drilling equipment and 4 hand auger borings. A representative of Ninyo & Moore logged the subsurface conditions exposed and collected soil samples for laboratory testing.
- Coring the pavement at the boring locations to check for petromat within the asphalt concrete.
- Soil cuttings from the subsurface exploration were collected in buckets and disposed in a landfill accepting non-hazardous waste.
- Laboratory testing of selected soil samples was performed to evaluate geotechnical characteristics.

- Data compilation and geotechnical analysis of field and laboratory data.

- Preparation of this report presenting the findings and conclusions from our field exploration laboratory testing, and engineering analyses, as well as our geotechnical recommendations for the design and construction of the proposed sanitary sewer improvements.

Table 1 – Segments Under Consideration

Segment No.	Streets	Segment Length	Street Segment	
			From	To
1	Brush Street	393 feet	2nd Street	3rd Street
2	Cypress Street	421 feet	3rd Street	End
3	Haight Avenue	743 feet	Pacific Avenue	3rd Street
4	Taylor Avenue	659 feet	3rd Street	5th Street
5	Road (203' east of 6th Street)	173 feet	Pacific Avenue	End
6	8th Street	620 feet	Stewart Court	Buena Vista Avenue
7	Buena Vista Avenue	654 feet	9th Street	Chapin Street
8	Pacific Avenue	1332 feet	Chapin Street	Sherman Street
9	Eagle Avenue	1367 feet	Chapin Street	Sherman Street
10	Sherman Street	372 feet	200' North of Eagle Avenue	200' South of Eagle Avenue
11	Buena Vista Avenue	11 feet	Jay Street	Jay Street
12	Minturn Street	398 feet	Lincoln Avenue	End
13	Schiller Street	360 feet	Buena Vista Avenue	Pacific Avenue
14	Lafayette Street	305 feet	Santa Clara Avenue	Lincoln Avenue
15	Union Street	876 feet	San Antonio Avenue	End
16	Noble Avenue	621 feet	Everett Street	Broadway
17	Foley Street	436 feet	Buena Vista Avenue	Tilden Way
18	Briggs Avenue	1271 feet	High Street	Fernside Boulevard
19	Jackson Street	416 feet	Mound Street	Grove Street
20	Chester Street	467 feet	Regent Street	Broadway
21	Washington Street	566 feet	Doris Court	Versailles Avenue
22	Clay Street	437 feet	Versailles Avenue	Mound Street
23	Post Street	1220 feet	San Jose Avenue	End
24	Toyon Terrace	141 feet	Post Street	End
25	Adams Street	166 feet	Post Street	Peach Street
26	Oyster Pond Road	514 feet	Basinside Way	Robert Davey Jr. Drive

3 PROJECT AND SITE DESCRIPTION

The proposed project consists of sanitary sewer replacement at 26 alignments in the City of Alameda (Figure 1). The sewer replacement work involves the removal and replacement of the sanitary sewer main and laterals within the public right-of-way on the streets provided in Table 1. We understand that sewer mains will be replaced with Polyvinyl Chloride (PVC) pipes, and that the laterals will be replaced with High Density Polyethylene (HDPE) pipes. We also understand that the alignment depth will range between approximately 2 and 20 feet below the existing grade.

The proposed alignments for the project are under asphalt-paved streets that are partially tree-lined. Drainage is controlled by gutters and storm drains. Except for Cypress Street, Sherman Street, Minturn Street, Foley Street, Toyon Terrace, and Oyster Pond Road, the street segments along the proposed alignments are two-way streets, approximately 30 to 40 feet wide, with one lane for travel in each direction and a parking lane on both sides of the street. Ground elevations range from approximately 8 to 32 feet above mean sea level (Google Earth, 2017). The portions of Minturn Street and Sherman Street along the proposed alignments are two-way streets, approximately 20 to 40 feet wide, with one lane for travel in each direction and a parking lane on one side of the street. Ground elevations range between approximately 10 to 11 feet above mean sea level (MSL) along Sherman Street and 27 to 30 feet above MSL along Minturn Street (Google Earth, 2017). The portions of Cypress Street, Toyon Terrace, and Oyster Pond Road along the proposed alignments are two-way streets, approximately 20 to 35 feet wide, with one lane for travel in each direction but no parking lane. Ground elevations range from approximately 9 to 13 feet above MSL (Google Earth, 2017). Foley Street near the proposed alignment is a one-way street, approximately 20 feet wide, with one lane for travel and a parking lane. Ground elevations along Foley Street near the alignment range between approximately 22 and 25 feet above MSL (Google Earth, 2017).

4 SUBSURFACE EVALUATION AND LABORATORY TESTING

Our field exploration included a site reconnaissance and a subsurface exploration conducted between October 23 and 27, 2017. The subsurface exploration consisted of drilling, logging, and sampling nineteen (19) solid-stem auger exploratory borings and four (4) hand auger exploratory borings. The solid-stem auger borings were advanced to depths of approximately 11½ to 26½ feet below ground surface using a truck-mounted drill rig. The hang auger borings were advanced to depths of approximately 5 to 7½ feet below ground surface. The locations of the borings are presented on Figures 2A through 2D. A representative of Ninyo & Moore logged the subsurface conditions exposed in the borings and collected representative soil samples for laboratory testing. Descriptions of the subsurface materials encountered are presented in the following sections. Detailed boring logs are presented in Appendix A.

The laboratory testing for this study included tests to evaluate in-situ moisture content and dry density, percentage of particles finer than the No. 200 sieve, direct shear strength, unconfined compressive strength, and sand equivalent index. The results of the in-situ moisture content and dry density tests are presented on the boring logs in Appendix A. The results of the other laboratory tests performed are presented in Appendix B.

5 GEOLOGIC AND SUBSURFACE CONDITIONS

5.1 Regional Geologic Setting

The site is located on the eastern side of San Francisco Bay in the Coast Ranges Province of California. The Coast Ranges are comprised of several mountain ranges and structural valleys stretching approximately 600 miles from the Oregon border to the Santa Ynez River. They are formed by tectonic processes commonly found around the Circum-Pacific belt. Basement rocks have been sheared, faulted, metamorphosed, and uplifted, and are separated by thick blankets of Cretaceous and Cenozoic sediments that fill structural valleys and line continental margins. The San Francisco Bay Area has several ranges that trend northwest-southeast, parallel to major strike-slip faults such as the San Andreas, Hayward, and Calaveras. Major tectonic activity associated with these and other faults consists primarily of right-lateral strike-slip movement.

5.2 Site Geology

Radbruch (1959) indicates that, based on unpublished data from 1856, project alignments on Clay Street, Toyon Terrace, Oyster Pond Road, the southern portion of Post Street, the eastern portion of Briggs Avenue, and the eastern portion of Adams Street are located on reclaimed land which extended from former shoreline to the present bay margin. The project alignments on the other streets and the remaining portions of Post Street, Briggs Avenue, and Adams Avenue are within the limits of the former shoreline of the San Francisco Bay, and therefore are located within the boundaries of the original Alameda peninsula.

Published geologic maps indicate that the alignments not located on reclaimed land are underlain by Holocene to Pleistocene dune sand (Graymer, 2000; Witter et al, 2006; Knudsen et al, 2000), designated as Merritt Sand by Helley & Graymer (1997), Radbruch & Case (1967), and Radbruch (1957). Project alignments on reclaimed land are underlain by artificial fill (Graymer, 2000; Helley & Graymer, 1997; Radbruch & Case, 1967; Radbruch, 1957). Knudsen et al (2000), and Witter et al (2006) indicate that the artificial fill is underlain by bay mud.

Helley & Graymer (1997) described the Merritt Sand as fine-grained, very well sorted, well-drained eolian deposits, while Radbruch (1957) described the Merritt Sand as fine-grained, silty, clayey, with lenses of sandy clay and clay, wind- and water- deposited beach and near-shore deposits. Graymer (2000) described the dune sand as fine-grained, very well sorted, well-drained, eolian deposits, and indicates that it is probably time-correlative with the Merritt Sand. Radbruch (1959) indicates that most artificial fill along the east shore of San Francisco Bay consists of Merritt Sand that has been dredged or pumped from offshore underwater borrow areas, but in some places it may consist of bay mud, materials from the Temescal formation, broken rock, or miscellaneous refuse. Graymer (2000) described the bay mud as water-saturated estuarine mud of Holocene age that contains a few lenses of well-sorted, fine sand and silt with shelly layers and peat.

5.3 Subsurface Conditions

The exploratory borings were advanced through pavement and fill. Other materials encountered during our subsurface evaluation included Merritt Sand, and Bay Deposits. Generalized descriptions of the units encountered are provided in the subsequent sections. More detailed descriptions are presented on the boring logs in Appendix A.

5.3.1 Pavement Section

The pavement sections encountered in our borings consisted of asphalt concrete over an aggregate base section. The thicknesses of the asphalt concrete and aggregate base for each street are listed in Table 2. Petromat was encountered within the asphalt concrete section in Borings B-1, B-5, B-6, B-8, B-9, B-10, B-13, B-15, and B-16.

Variations in the thickness of asphalt concrete, and aggregate base layers within and beyond the range observed may be encountered due to past maintenance, utility work or other factors.

Table 2 – Thickness of Asphalt Concrete and Aggregate Base				
Boring	Streets	Asphalt Concrete (inches)	Depth to Petromat (inches)	Aggregate Base (inches)
B-1	Brush Street	4	2	5
B-2	Cypress Street	5		11
B-3	Haight Avenue	3½		4
B-4	Taylor Avenue	4½		4
B-5	Road (203' east of 6th Street)	8	3½	4
B-6	8th Street	2½	2½	16
B-7	Buena Vista Avenue	2½		10½
B-8	Pacific Avenue	4	2	5
B-9	Eagle Avenue	5½	2½	5
B-10	Buena Vista Avenue	4	3	5
B-11	Minturn Street	4¼		5
B-12	Schiller Street	1½		5½
B-13	Lafayette Street	3	1½	4½
B-14	Union Street	2½		5½
B-15	Noble Avenue	6	2	3½
B-16	Briggs Avenue	5	1½	5
B-17	Jackson Street	1½		6
B-18	Chester Street	1½		7½
B-19	Washington Street	1½		6
B-20	Clay Street	4		5½
B-21	Toyon Terrace	3¼		7
B-22	Adams Street	2½		6½
B-23	Oyster Pond Road	3		4

5.3.2 Fill

Fill was encountered below the pavement section in Borings B-1, B-3, B-4, B-5, B-7, B-9, B-12, B-13, B-14, B-20, B-21, B-22, and B-23. The depth to the bottom of the fill ranges from approximately 2¼ feet to 12 feet. The fill, as encountered, generally consisted of moist to wet, loose to medium dense silty sand with lenses of clay.

5.3.3 Merritt Sand

Merritt Sand was encountered from below the pavement section to the depths explored in Boring B-2, B-6, B-8, B-10, B-11, B-15, B-16, B-17, B-18, and B-19 or below the fill in the other borings with the exception of Borings B-22 and B-23. The Merritt Sand, as encountered, generally consisted of moist to wet, loose to very dense, silty sand, poorly graded sand with silt, and clayey sand.

5.3.4 Bay Deposits

Bay deposits were encountered from below the fill to the depths explored in Boring B-23. The Bay Deposits generally consisted of wet, stiff, fat clay.

5.4 Groundwater

Groundwater was generally encountered during the subsurface exploration for this study except in Borings B-7, B-21, and B-22. The groundwater was encountered at depths ranging from approximately 4 to 10 feet below the ground surface. The Seismic Hazard Zone Reports for the Oakland East Quadrangle (CGS, 2003a), Oakland West Quadrangle (CGS, 2003b), and San Leandro Quadrangle (CGS, 2003c) indicate that the historic high groundwater level is generally between 5 and 10 feet below the ground surface except for the alignment on Chester Street where the historic high groundwater level is around 10 feet deep, and the alignments on Oyster Pond Road, Toyon Terrace, Taylor Avenue, Clay Street, and Union Street where the depth to historic high groundwater is around 5 feet or less.

The depth to groundwater within the limits of the study area is subject to spatial variations in topography and subsurface hydrogeologic conditions. Groundwater may rise to a higher elevation than was encountered in our exploratory borings due to the short time available for seepage of water into the borings. Furthermore, groundwater levels may fluctuate in response to seasonal variations in precipitation, tidal influences, groundwater pumping/dewatering nearby, changes in irrigation practices adjacent to or within the study area, or other factors.

6 GEOLOGIC HAZARDS AND GEOTECHNICAL ISSUES

This study addressed a number of potential issues relevant to the proposed construction, including seismic hazards, static settlement, expansive soils, material suitability, excavation characteristics, and uplift considerations. These issues are discussed in the following subsections.

6.1 Seismic Hazards

The project alignments are within a seismically active region and may experience a relatively high degree of ground shaking following a significant seismic event on a nearby fault. The alignments are not located within an Alquist-Priolo Fault Rupture Hazard Zone established by the state of geologist to delineate regions of potential ground surface rupture adjacent to active faults (CGS, 1982a; 1982b; 1982c). The closest fault to the sites known to be active is the Hayward fault to the east. The lateral distance between the Hayward fault and the various project alignments ranges between approximately 3¼ and 5½ miles.

Strong ground shaking may induce liquefaction and related hazards such as sand-boils and dynamic settlement in susceptible soils. The study alignment is within a liquefaction seismic hazard zone as mapped by the CGS (2003d; 2003e; 2003f), and is generally mapped as having moderately susceptibility to liquefaction (Kundsen, et al., 2000; Witter et al., 2006) except for the alignments on reclaimed land (Clay Street, Toyon Terrace, Oyster Pond Road, the southern portion of Post Street, the eastern portion of Briggs Avenue, and the eastern portion of Adams Street) that are in a mapped area of very high susceptibility to liquefaction.

Consequently, differential settlement of the sewer from liquefaction, sand-boils, and dynamic settlement should be anticipated following a significant seismic event. A rigorous evaluation of liquefaction and related phenomena was not part of our scope of work for this project. Based upon previous experience in the City of Alameda, the replacement sewer may undergo a few inches of differential dynamic settlement. Flexible couplings and increased pipeline gradients can mitigate some of the consequence of the differential dynamic settlement. In general, remedial grading and paving is the economically preferred alternative to mitigating liquefaction and related hazards for city streets and should be anticipated for the project improvements.

6.2 Static Settlement

We anticipate that the loads associated with the new pipelines and related manholes or vaults will be balanced by the weight of the displaced soil such that the net load will be negligible. As such, we do not regard post-construction settlement due to static loads as a design consideration.

6.3 Expansive Soils

Some clay minerals undergo volume changes upon wetting or drying. Unsaturated soils containing those minerals will shrink/swell with the removal/addition of water. The heaving pressures associated with this expansion can damage structures and flatwork. We do not regard expansive soils as a design consideration given the predominantly granular nature of the subsurface materials encountered in the study area.

6.4 Material Suitability

In general, based on the findings from our subsurface exploration, we anticipate that the soil materials excavated for the new sewer alignments, with the exception of the bay deposits, will be suitable, from a geotechnical perspective, for re-use in some capacity as trench backfill, provided that the materials are not too wet to inhibit compaction or get mixed with deleterious or otherwise unsuitable material. Trench spoils, particularly from below the groundwater table, may be too wet to compact when excavated. The spoils may need to be spread out to dry before being reused as backfill.

The material encountered in our subsurface exploration, with the exception of the bay deposits, generally consisted of silty sand. This material may be classified as Class III backfill as per American Society for Testing and Materials (ASTM) Standard D 2321 and may be suitable in a dry or dewatered trench, for use as pipe bedding, initial backfill, and general trench backfill. At locations where the trench is above the groundwater table, this material may be suitable for use as foundation material and for replacing overexcavated trench bottom. The allowable thickness of the foundation section is 12 inches for Class III material. Class III material should not be used as foundation material or for replacing overexcavated trench bottom at locations where the trench bottom is below the groundwater table. The bay deposits encountered during our subsurface exploration at Boring B-23, consisted of fat clay, which may be classified as Class IVB material that is unsuitable for use as bedding or pipe zone fill. The bay deposits that do not contain organic material may be used to trench backfill above the pipe zone fill provided that the material is moisture conditioned to near the optimum moisture content.

6.5 Excavatability

We anticipate that the proposed project will involve excavations of up to about 20 feet for installation of new pipelines. The geologic units encountered during our subsurface evaluation within this interval consisted primarily of loose to dense silty sand. We anticipate that backhoes, excavators, or other trenching equipment in good working condition should be able to make the proposed excavations.

6.6 Excavation Wall Stability

The geologic units encountered during our subsurface evaluation generally consisted of loose to dense silty sand. Our subsurface evaluation encountered a relatively shallow groundwater table. Cuts in these deposits or excavations below the groundwater table may not remain stable without appropriate inclination of side slopes or shoring. Precipitation on the trench sidewalls or surface runoff over the trench sidewalls may further adversely impact the stability of the excavation walls. Dewatering measures may be needed to provide a dry excavation in which to work. Temporary surface drainage improvements may also be advisable. Recommendations for dewatering and drainage improvements are presented in Sections 8.1.4 and 8.1.5.

Techniques for trench shoring may consist of movable trench boxes or shields, sheeting and hydraulic or mechanical jacks, or driven sheet piling. Appropriately-sized trench boxes or shields should protect workers but may allow movement of the excavation wall which will result in subsidence at the ground surface. Tight sheeting (without gaps) with appropriately-sized hydraulic or mechanical jacks to provide positive pressure against the face of the excavation should reduce the horizontal deflection of the sidewall and resulting subsidence at the ground surface. Driven sheet piles may be needed to support the excavation sidewall if the unsupported wall cannot remain stable long enough to install trench shields or sheeting. Recommendations for excavation stabilization are presented in Section 8.1.3.

6.7 Excavation Bottom Stability

In general, we anticipate that the bottom of the pipeline trenches will remain stable and provide suitable support for compaction of backfill. However, excavations that extend near or below the water table may experience “quick” conditions or bottom instability. Unstable bottom conditions may warrant overexcavation and replacement with crushed, angular rock. Recommendations for stabilizing excavation bottoms should be based on evaluation in the field by the geotechnical consultant at the time of construction.

6.8 Uplift Considerations

The groundwater table is relatively shallow with respect to the proposed depth for some of the new alignments. We anticipate that the overburden pressures at the proposed depths of the new pipeline alignments will balance the buoyancy-related uplift forces due to submergence. Manholes and access vaults below the groundwater table; however, might be impacted by uplift forces. Recommendations for design parameters to resist buoyancy-related uplift forces are presented in Section 8.3.

7 CONCLUSIONS

Based on our review of the referenced documents, field reconnaissance, subsurface evaluation, and laboratory testing, it is our opinion that the proposed improvements are feasible from a geotechnical standpoint. Geotechnical considerations of note on this project include the following:

- The site could experience a relatively large degree of ground shaking due to a significant earthquake event resulting in liquefaction and dynamic settlement. The replacement sewer may be designed with flexible couplings and an increased gradient to accommodate a few inches of differential dynamic settlement.

- On-site material, with the exception of the bay deposits encountered near Oyster Pond Road, generally conforms to the requirements for Class III backfill and may be re-used as bedding, initial backfill, general backfill, and foundation material. Some of the on-site material may be too wet after excavation and will need to be dried out before placement as fill. The bay deposits encountered may be considered a Class IVB material and are unsuitable for use as bedding or pipe zone fill. Bay deposits that do not contain organic material may be used to trench backfill above the pipe zone fill provided that the material is moisture conditioned to near the optimum moisture content.

- Our subsurface exploration encountered a relatively shallow groundwater table. We anticipate that the proposed excavations will encounter groundwater and some of the pipes and manholes will be partially or wholly submerged. Recommendations for dewatering of excavations and parameters for modeling the uplift resistance of submerged manholes or vaults are presented in Sections 8.1.4 and 8.3, respectively.

- We anticipate that excavations may need to be shored or sloped appropriately to remain stable. Recommendations for excavation stabilization are presented in Section 8.1.3. Trench bottoms may be unstable due to the shallow groundwater table.

8 RECOMMENDATIONS

The following guidelines should be used in the preparation of the construction plans. The geotechnical consultant should review the proposed plans prior to construction.

8.1 Earthwork

The earthwork should be conducted in accordance with the relevant grading ordinances having jurisdiction and the following recommendations. The geotechnical engineer should observe earthwork operations. Evaluations performed by the geotechnical engineer during the course of operations may result in new recommendations, which could supersede the recommendations in this section.

8.1.1 Abandonment of Existing Utilities

We anticipate that the existing main sewer lines will largely be removed and disposed of during the sewer replacement work. If sewer mains and laterals are to be abandoned in place, the pipes should be crushed, or plugged with pumpable grout or concrete mix. If plugged in place, the grout or concrete should be pumped from the high end of the pipe, with the low end plugged, until concrete completely fills the pipe. Excavations made to remove existing utilities should be backfilled in accordance with our recommendations in Section 8.1.8. Pavement and aggregate base debris generated during the abandonment should be removed from the project site and disposed of at a legal dumpsite. Excavated soil materials may be re-used as engineered fill provided that the materials comply with, or are processed to comply with, the recommendations in Section 8.1.6.

8.1.2 Observation and Removals

Prior to placement of bedding material, the client should request an evaluation of the exposed subgrade by the geotechnical consultant. Materials that are considered unsuitable shall be excavated under the observation of the geotechnical consultant in accordance with the recommendations in this section or the field recommendations of the geotechnical consultant.

Unsuitable materials include, but may not be limited to dry, loose, soft, wet, expansive, organic, or compressible natural soils; fractured, weathered, or soft bedrock; and undocumented or otherwise deleterious fill materials.

Unsuitable materials should be removed from the bottom of the trench to the depth of suitable material as evaluated by the geotechnical consultant in the field. Foundation material should be placed and compacted to get back to the design grade. The allowable thickness of ASTM D 2321 Class III foundation material is 12 inches. If thicker sections of foundation material are needed, Class IA foundation material with a filter fabric cover or Class IB foundation material should be used.

The subgrade of trenches excavated near or below the groundwater table may become unstable. Recommendations for stabilizing excavation bottoms should be based on an evaluation by the geotechnical consultant during construction. Stabilization recommendations might include installing additional sumps or well points, or overexcavating to install a drainage blanket or place suitable Class IA/IB foundation material.

8.1.3 Excavation Stabilization and Temporary Slopes

Excavations, including trench excavations, shall be stabilized in accordance with the Excavation Rules and Regulations (29 Code of Federal Regulations, Part 1926) stipulated by the Occupational Safety and Health Administration (OSHA, 1989). Stabilization shall consist of shoring sidewalls or laying slopes back. Table 3 lists the OSHA material type classifications and corresponding allowable temporary slope layback inclinations for soil deposits that may be encountered on site. Alternatively, a shoring system may be used to stabilize excavation sidewalls during construction. Potential shoring systems include trench boxes/shields, sheeting with hydraulic or mechanical jacks, cantilever sheet piles, or sheet piles with internal braces. Trench boxes/shields and sheeting may be used to stabilized excavations above groundwater. The lateral earth pressures listed in Table 3 may be used to design or select the trench box/shield or sheeting system in accordance with the criteria listed in the OSHA Excavation Rules and Regulations (29 CFR Part 1926).

The recommendations presented in this table are based on the limited subsurface data provided by our exploratory borings and reflect the influence of the environmental conditions that existed at the time of our exploration. Excavation stability, material classifications, allowable slopes, and shoring pressures should be re-evaluated and revised, as-needed, during construction. Excavations, shoring systems and the surrounding areas should be evaluated daily by a competent person for indications of possible instability or collapse.

Table 3 – Recommended OSHA Material Classifications and Allowable Slopes

Formation	OSHA Classification	Allowable Temporary Slope[1,2,3]	Lateral Earth Pressure on Shoring[4] (psf)
Cohesive Bay Deposits (above groundwater)	Type B	1 h:1 v (45°)	45×D + 72
Fill and Merritt Sand (above groundwater)	Type C	1 ½ h:1 v (34°)	80×D + 72

1 Allowable slope for excavations less than 20 feet deep. Excavation sidewalls in cohesive soil may be benched to meet the allowable slope criteria (measured from the bottom edge of the excavation). The allowable bench height is 4 feet. The bench at the bottom of the excavation may protrude above the allowable slope criteria.
2 In layered soil, layers shall not be sloped steeper than the layer below.
3 Temporary excavations less than 5 feet deep may be made with vertical side slopes and remain unshored if judged to be stable by a competent person (29 CFR, Part 1926.650).
4 'D' is depth of excavation for excavations up to 20 feet deep. Includes a surface surcharge equivalent to two feet of soil.

Sheet piles that extend below the mudline may be needed for excavations below the groundwater table to reduce the potential for "quick" conditions or bottom instability. We anticipate that an embedment depth equivalent to 125 percent of the head differential after dewatering may be needed to provide a suitable factor of safety against piping. The earth pressure diagrams presented in Figure 3 may be used to design a cantilever sheet pile shoring system. The earth pressures listed in Figure 3 do not include a factor of safety. Once the depth of embedment and point of rotation are selected to meet shear and moment equilibrium at the tip of the sheet pile, the depth of embedment should be increased by 20 to 40 percent for an approximate factor of safety of 1.5 to 2.0 and checked against the embedment depth needed to resist piping. Alternatively, the sheet pile shoring may be supported by internal braces. The earth pressure diagrams presented in Figure 4 may be used to design an internally-braced, sheet pile shoring system. The designer should select an appropriate factor of safety to use with the earth pressure diagrams presented in Figure 4.

The shoring system should be designed or selected by a suitably qualified individual or specialty subcontractor with consideration for the tolerable settlement of ground adjacent to the excavation. Potential causes of settlement that should be addressed include loss of lateral support following excavation, vibration during the installation of sheet piles, other construction induced vibrations, dewatering, and removal of the support system. Shoring should be sufficiently tight to reduce washout from behind the shoring. The shoring parameters presented in this report are preliminary design criteria, and the designer should evaluate the adequacy of these parameters and make appropriate modifications for their design. We recommend that the contractor take appropriate measures to protect workers. OSHA requirements pertaining to worker safety should be observed.

We understand that the proposed excavations will not be in close proximity to existing structures. Excavations made in close proximity to existing structures may undermine the foundation of those structures and/or cause soil movement related distress to the existing structures. Stabilization techniques for excavations in close proximity to existing structures will need to account for the additional loads imposed on the shoring system and appropriate setback distances for temporary slopes. The geotechnical engineer should be consulted for additional recommendations if the proposed excavations cross below a plane extending down and away from the foundation bearing surfaces of adjacent structures at an angle of 1:1 (horizontal to vertical).

8.1.4 Construction Dewatering

Groundwater was encountered in our exploratory borings at depths ranging from approximately 4 to 10 feet below the ground surface. However, significant fluctuations in the groundwater level may occur as a result of variations in seasonal precipitation and other factors. Water intrusion into the excavations may occur as a result of groundwater intrusion or surface runoff. The contractor should be prepared to take appropriate dewatering measures in the event that water intrudes into the excavations. Considerations for construction dewatering should include anticipated drawdown, volume of pumping, potential for settlement, and groundwater discharge. Disposal of groundwater should be performed in accordance with the guidelines of the Regional Water Quality Control Board.

When excavating near or below the groundwater table, the dewatering system should depress the water level below the bottom of the cut to reduce the potential for subgrade instability and washout from behind sheeting or sloughing of exposed trench walls. The dewatering system should maintain the water level about 2 feet below the pipe bedding and foundation material to provide a stable trench bottom. Sump pumps, well points, deep wells, geotextile-geonet composites, perforated underdrains, or stone blankets should be used, as appropriate, to drain water from below the bedding and foundation material. Perforated underdrains and open-graded stone blankets should be wrapped in a suitable geotextile filter to reduce the potential for the removal of fines and subsequent creation of voids in the overlying and adjacent materials. The operation of the dewatering system should continue during and after the installation of the pipe and embedment until sufficient backfill has been placed to balance the uplift forces.

8.1.5 Drainage

Temporary swales or cutoff barriers should be provided to divert surface water away from the excavation. Dams, cutoffs, or other barriers should be constructed on the bottom of the trench to reduce the velocity of subdrain discharge or runoff along the trench bottom thereby reducing the potential for erosion or undermining of trench walls, subgrade, bedding, or foundation materials.

8.1.6 Material Requirements

Materials used during earthwork, grading, and paving operations should comply with the requirements listed in Table 4. Materials should be evaluated by the geotechnical consultant for suitability prior to use. The contractor should notify the geotechnical consultant 72 hours prior to import of materials or use of on-site materials to permit time for sampling, testing, and evaluation of the proposed materials. On-site materials may need to be dried out before re-use as fill.

Table 4 – Recommended Material Requirements		
Material and Use	**Source**	**Requirements[1,2]**
Foundation below bedding material and pipe zone fill	Import	1½ inch open-graded crushed rock meeting ASTM D2321 Class IA with filter fabric (Mirafi 140 N); 1½ inch angular, dense graded, fine & coarse aggregate mixture meeting ASTM D2321 Class IB
	On-site borrow	No additional requirements[1]
Pipe Bedding Material and Pipe Zone Fill	Import	As per manufacturer's recommendations; or well-graded sand or sand gravel mixture with 5 percent fines or less and nominal size 3/4" or less
	On-site borrow	No additional requirements[1]
Trench Backfill above pipe zone fill	Import	Expansion Index less than 50; Free from rocks/lumps in excess of 2" diameter
	On-site borrow	No additional requirements[1]

[1] In general, fill should not consist of pea-gravel and should be free of rocks or lumps in excess of 6-inches diameter, trash, debris, roots, vegetation or other deleterious material.
[2] In general, import fill should be tested or documented to be non-corrosive[3] and free from hazardous materials in concentrations above levels of concern.
[3] Non-corrosive as defined by the Corrosion Guidelines (Caltrans, 2012).

8.1.7 Subgrade Preparation

Subgrade should be prepared as per the recommendations in Table 5. Prepared subgrade should be maintained in a moist (but not saturated) condition by the periodic sprinkling of water prior to placement of additional overlying fill or construction of pavements. Subgrade that has been permitted to dry out and loosen or develop desiccation cracking, should be scarified, moisture conditioned, and recompacted.

Table 5 – Subgrade Preparation Recommendations	
Subgrade Location	**Preparation Recommendations**
Sewer Trenches	• Check for and remove unsuitable materials as per Section 8.1.2. • Do not scarify. Compact as per Section 8.1.8 if disturbed. Remove or compact loose/soft material.

8.1.8 Fill Placement and Compaction

Fill and backfill should be compacted in horizontal lifts to meet the criteria listed in Table 6. The allowable uncompacted thickness of each lift of fill depends on the type of compaction equipment utilized, but generally should not exceed 8 inches in loose thickness. The allowable compacted thickness of Class III foundation material is 12 inches. The thickness of the bedding material placed below the pipe should be 4 inches or more. Where rock or other unyielding materials are exposed in the trench bottom, or the pipe crosses other utilities or buried structures, the thickness of the bedding material should be increased to 6 inches. The pipe barrel should rest on the bedding material. Small holes should be excavated in the bedding material to provide room for bells. The bedding and initial backfill should be carefully placed by hand under the pipe haunches and in the bell holes to avoid creating voids below the pipe. Trenches should be wide enough to provide room to operate compaction equipment and wide enough to provide lateral clearance between the pipe and trench wall equivalent to half the pipe diameter. If the native soils cannot sustain a vertical cut or if the trench walls are sloped back for stability, the lateral clearance should be increased to a distance equivalent to the pipe diameter.

Bedding and pipe zone fill should be shoveled under pipe haunches and compacted by manual or mechanical, hand-held tampers. Trench backfill should be compacted by mechanical means. Densification of trench backfill, bedding and pipe zone fill by flooding or jetting is not recommended. Loose material that has sloughed off of trench sidewalls during pipeline installation, backfill placement, or compaction should be removed before placing and compacting additional fill. Special care should be exercised to avoid damaging the pipe during compaction of the backfill. Before allowing vehicles or typical construction equipment to cross over pipe, 36 inches of embedment cover should be placed and compacted over the pipe. Hydro-hammers should not be used for compaction.

Table 6 – Recommended Compaction Requirements

Fill Type	Location	Compacted Density[1]	Moisture Content[2]
Aggregate Base	Pavement sections	95 percent	At or near optimum
Trench Backfill	Within 3 feet from top of pavement	95 percent	At or near optimum
	In locations not already specified	90 percent	At or near optimum
Pipe Zone Fill	Material above bedding to 12 inches above pipe	90 percent	At or near optimum
Bedding	Material below conduit invert	90 percent	At or near optimum

[1] Expressed as percent relative compaction or ratio of field density to reference density (typically on a dry density basis for soil). The reference density of soil should be evaluated by the latest version of ASTM D 1557.

[2] Optimum moisture should be evaluated by latest version of ASTM D 1557.

Compacted fill should be maintained in a moist (but not saturated) condition by the periodic sprinkling of water prior to placement of additional overlying fill or construction of the pavement section. Fill that has been permitted to dry out and loosen or develop desiccation cracking, should be scarified, moisture conditioned, and recompacted as per the requirements above.

8.1.9 Rainy Weather Considerations

We recommend that construction be performed during the period between approximately April 15 and October 15, to avoid the rainy season. In the event that grading is performed through the rainy season, the plans for the project should be supplemented to include a stormwater management plan prepared in accordance with the requirements of the relevant agency having jurisdiction. The plan should include details of measures to protect the subject property and adjoining off-site properties from damage by erosion, flooding or the deposition of mud, debris, or construction-related pollutants, which may originate from the site or result from the grading operation. The protective measures should be installed by the commencement of grading, or prior to the start of the rainy season. The protective measures should be maintained in good working order unless the drainage system is installed by that date and approval has been granted by the building official to remove the temporary devices.

In addition, construction activities performed during rainy weather may impact the stability of excavation subgrade and exposed ground. The geotechnical engineer should be consulted for recommendations to stabilize the site as-needed.

8.2 Thermoplastic Pipe

Thermoplastic pipe, consisting of either PVC or HDPE, is considered to be a flexible conduit. Flexible conduits should be designed or specified with particular consideration of (1) the load on the pipe including traffic and soil overburden, (2) soil stiffness in the pipe zone, and (3) stiffness of the pipe material. The thermoplastic pipes on this project should be designed or specified with due consideration for these factors.

The modulus of soil reaction is used to characterize the stiffness of soil backfill placed at the sides of buried flexible pipelines for the purpose of evaluating lateral deflection caused by the weight of the backfill above the pipe. We recommend that a modulus of soil reaction of 1000 pounds per square inch be used for design, provided that the pipe embedment material (including bedding and pipe zone backfill) and general trench backfill conform to and are compacted in accordance with the recommendations provided in this report.

As discussed in Section 6.1, the proposed alignments traverse areas that may liquefy and undergo dynamic settlement on the order of a few inches. The civil engineer should consider specifying flexible connections where possible and increasing the hydraulic gradient of the alignment to allow for some differential dynamic settlement.

8.3 Uplift Resistance

Underground structures, including manholes or pipelines, that extend below the groundwater table will experience buoyancy-related uplift forces that might lead to upward movement. Groundwater was encountered in our exploratory borings at depths ranging from approximately 4 to 10 feet below the ground surface. However, groundwater levels may fluctuate with seasonal precipitation, tidal effects, or other factors. Underground structures below the groundwater table should be designed to resist uplift forces related to the buoyancy effect. Uplift forces may be resisted by the weight of the manhole or vault plus contents, the weight of soil above the vault, and friction along the sides of the manhole or vault. The unit weight of the soil may be considered to be 120 pounds per cubic foot (pcf) above the groundwater table and 62 pcf below the groundwater table. Frictional uplift resistance is the product of the friction coefficient and the effective contact pressure. A friction coefficient of 0.30 may be assumed for uplift resistance for mass or formed concrete against silty sand or clayey sand. The effective contact pressure may be calculated using an equivalent fluid pressure of 60 pcf above the groundwater table and 32 pcf below the groundwater table. We do not anticipate that static uplift will be a design consideration for pipelines with embedment equivalent to twice the pipe diameter due to the magnitude of the overburden pressures.

Uplift resistance may be reduced during a seismic event if the material around the pipe, manhole, or underground vault liquefies. Frictional uplift resistance should be neglected below the groundwater table to model the reduction in uplift resistance due to liquefaction. Pipelines installed by trenchless methods may be impacted by liquefaction and associated uplift. Liquefaction related uplift should not be a design consideration for pipelines installed in open trenches and backfilled with appropriately compacted material due to the relative density of the backfill material. Similarly, liquefaction related uplift should not be a design consideration for underground vaults or manholes installed in an oversize excavation backfilled with appropriately compacted material.

8.4 Pavement Resurfacing

We understand that the pavement will be repaired along the proposed sewer alignments to conform to the existing pavement structural sections. An independent evaluation of the traffic index and pavement design was not undertaken for the subject project. Existing pavement that has been undermined by excavation activities should be removed and replaced.

8.5 Review of Construction Plans

The recommendations provided in this report are based on preliminary design information for the proposed construction. We recommend that the geotechnical consultant review project plans. It should be noted that, upon review of these documents, some recommendations presented in this report might be revised or modified to meet the project requirements.

8.6 Pre-Construction Conference

We recommend that a pre-construction conference be held. City representatives, the civil engineer, the geotechnical consultant, and the contractor should be in attendance to discuss the plans, the project, and the proposed construction schedule.

8.7 Construction Observation and Testing

The recommendations provided in this report are based on subsurface conditions disclosed by discrete exploratory borings. The geotechnical consultant in the field during construction should check the interpolated subsurface conditions. During construction, the geotechnical consultant should:

- Observe trench subgrade for stability and removal of unsuitable materials.
- Observe excavation shoring.
- Check and test imported materials prior to their use as fill.
- Observe trench backfill and compaction.
- Perform field density tests to evaluate trench backfill and aggregate base compaction.

The recommendations provided in this report assume that Ninyo & Moore will be retained as the geotechnical consultant during the construction phase of the project. If another geotechnical consultant is selected, we request that the selected consultant provide a letter to the architect and the owner (with a copy to Ninyo & Moore) indicating that they fully understand Ninyo & Moore's recommendations, and that they are in full agreement with the recommendations contained in this report.

9 LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

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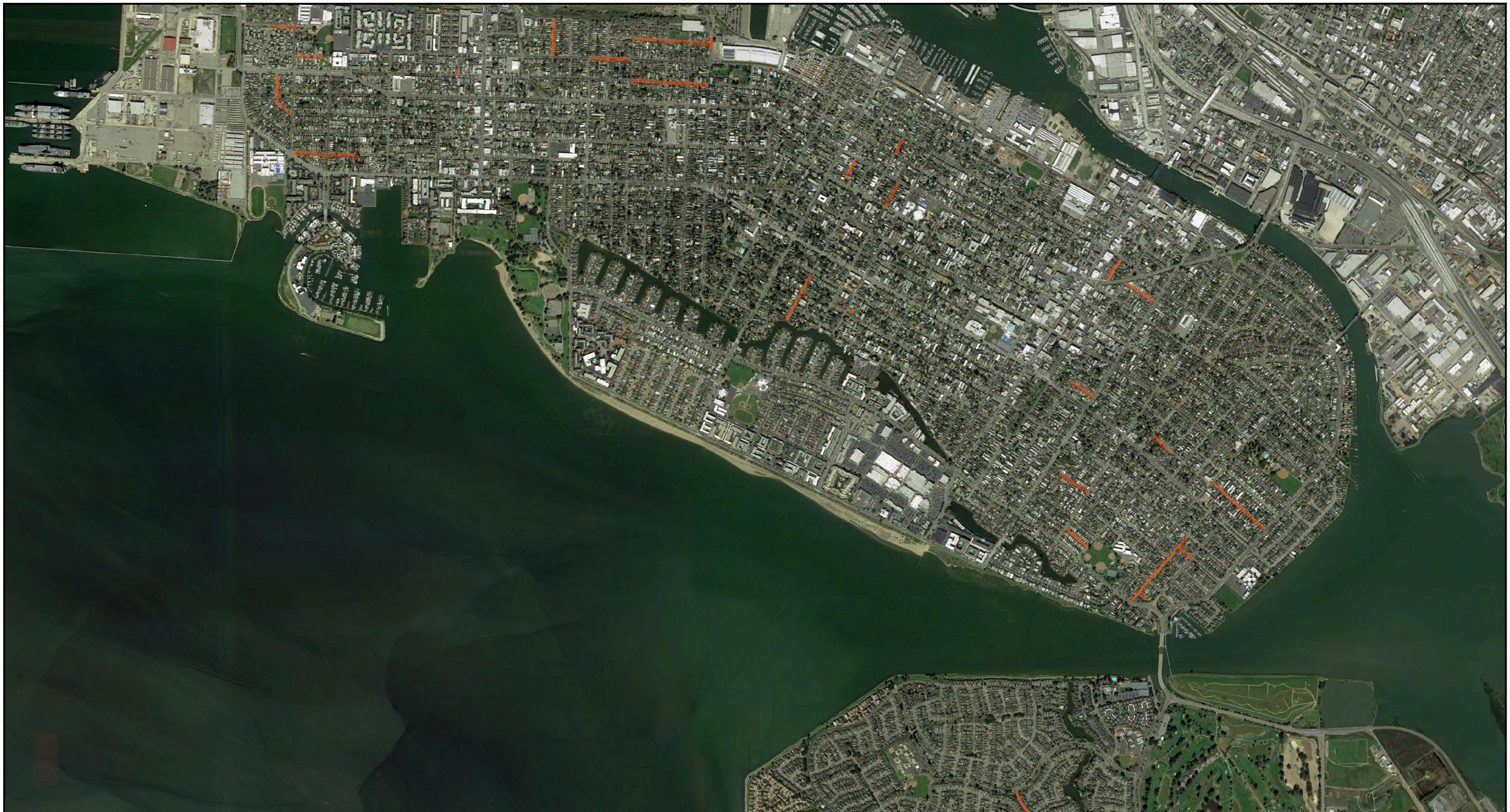
FIGURES



LEGEND

SEWER MAIN REHABILITATION

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE. I REFERENCE: GOOGLE EARTH, 2017.

N

FEET

0 2,500 5,000

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FIGURE 1

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

SITE LOCATION

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17

LEGEND

SEWER MAIN REHABILITATION

B-10 TD=11.5 BORING; TD=TOTAL DEPTH IN FEET

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE. I REFERENCE: GOOGLE EARTH, 2017.

N

FEET 0 1,000 2,000

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FIGURE 2A

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

BORING LOCATIONS

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17

LEGEND

SEWER MAIN REHABILITATION

B-15 TD=21.5 BORING;
TD=TOTAL DEPTH IN FEET

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE. I REFERENCE: GOOGLE EARTH, 2017.

N

FEET
0 1,000 2,000

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FIGURE 2B

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

BORING LOCATIONS

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE. I REFERENCE: GOOGLE EARTH, 2017.

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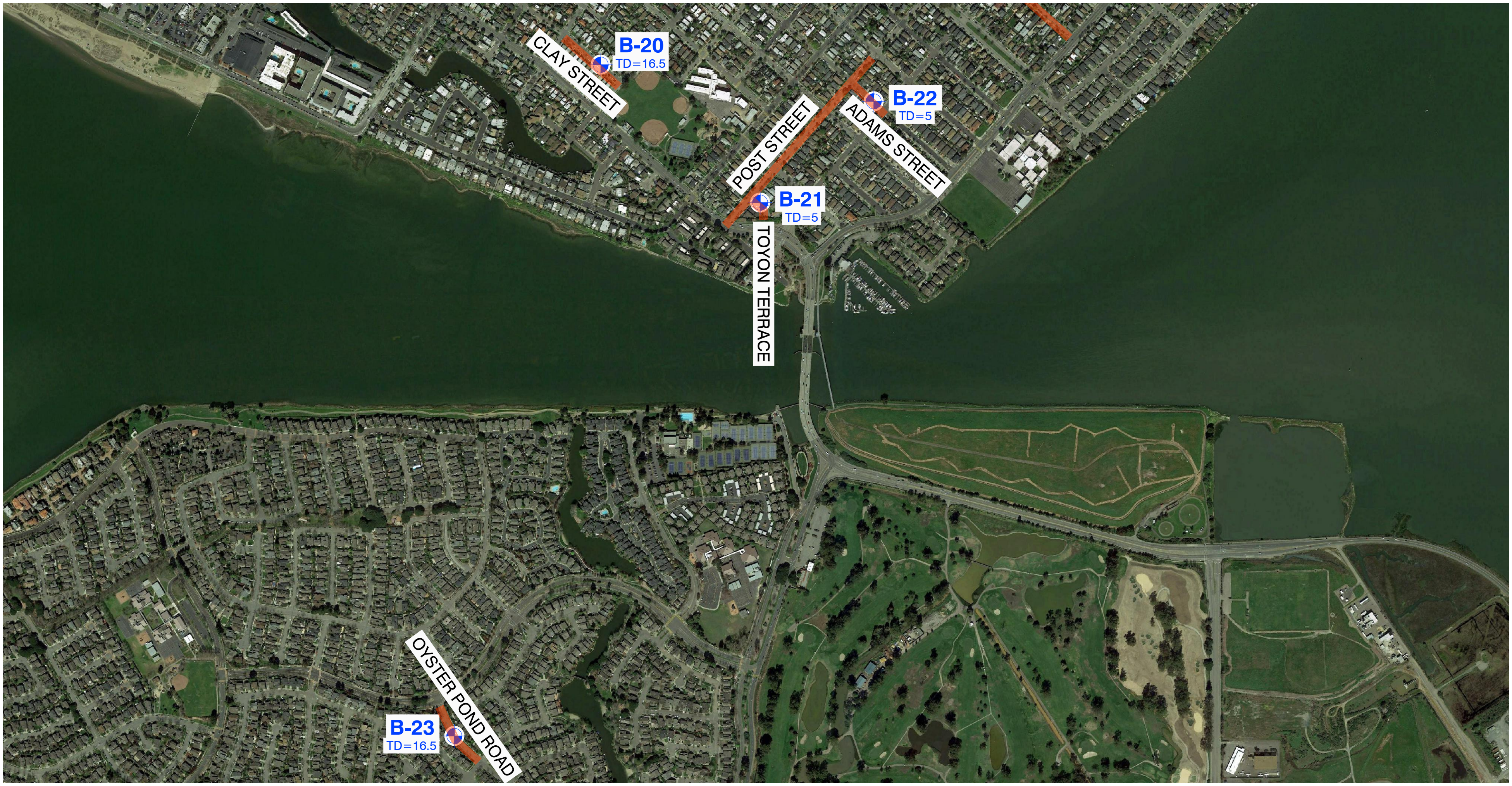
FIGURE 2C

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

BORING LOCATIONS

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17



LEGEND

SEWER MAIN REHABILITATION

B-23 TD=16.5 BORING;
TD=TOTAL DEPTH IN FEET

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE. I REFERENCE: GOOGLE EARTH, 2017.

N

FEET
0 1,000 2,000

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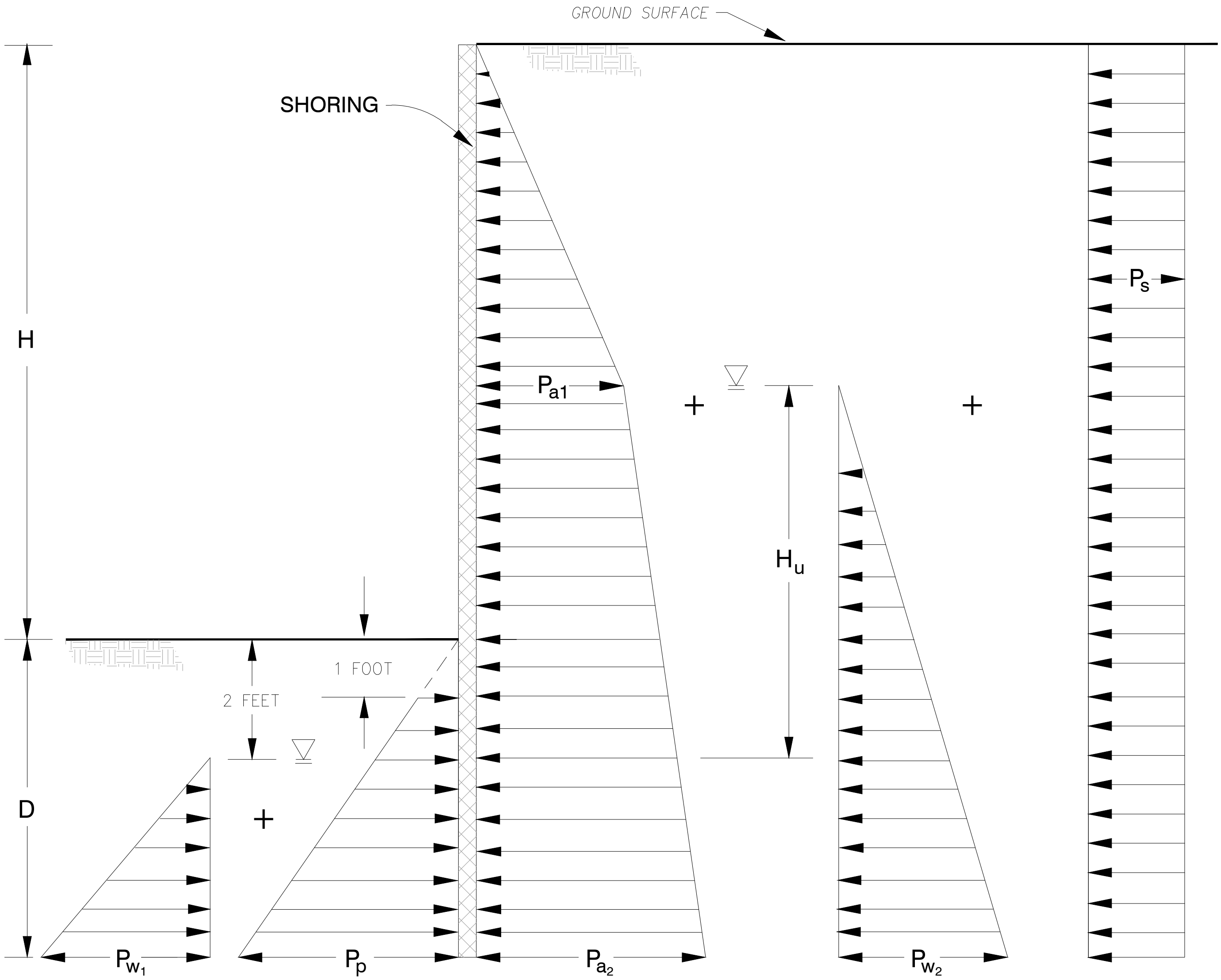
FIGURE 2D

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

BORING LOCATIONS

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17



NOTES:

1. ACTIVE LATERAL EARTH PRESSURE, P_a
   P_{a_1} = 40 (H - H_u + 2) psf; P_{a_2} = 0.33 [125 (H_u - 2+D) - P_{w_2}] + P_{a_1} psf
2. PASSIVE LATERAL EARTH PRESSURE, P_p
   P_p = 3 [240+125 (D - 2) - P_{w_1}] psf
3. NEGLECT PASSIVE LATERAL EARTH PRESSURE FOR 1 FOOT BELOW MUDLINE
4. HYDROSTATIC PRESSURE WITH SEEPAGE
   $P_{w_1} = P_{w_2}$ = 124.8 (H_u+D-2)(D-2)/(2D+H_u - 4) psf
5. LATERAL EARTH PRESSURE DUE TO CONSTRUCTION OR LIVE LOAD SURCHARGE, P_s = 72 psf
6. NEGLECT DYNAMIC EARTH PRESSURES FOR TEMPORARY CONDITION
7. H, H_u , AND D IN FEET

NOT TO SCALE

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

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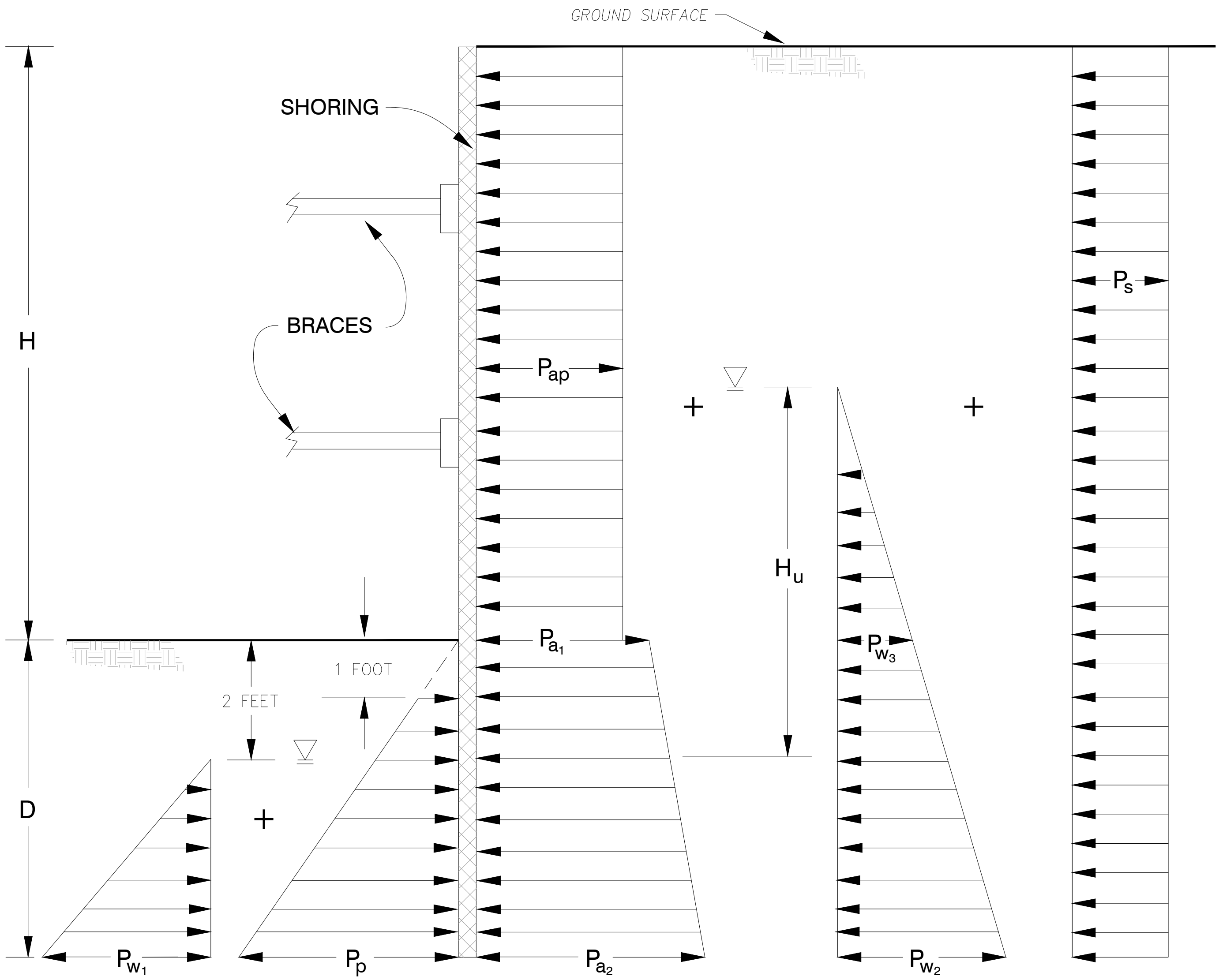
FIGURE 3

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

LATERAL EARTH PRESSURES FOR CANTILEVERED SHORING

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17



NOTES:

1. APPARENT LATERAL EARTH PRESSURE, P_{ap}
   $P_{ap} = 26H$ psf
2. ACTIVE LATERAL EARTH PRESSURE, P_a
   $P_{a_1} = 0.33\ [120\ (H - H_u + 2) + 125\ (H_u - 2) - P_{w_3}]$ psf; $P_{a_2} = 0.33\ [120\ (H - H_u + 2) + 125\ (H_u - 2 + D) - P_{w_2}]$ psf
3. PASSIVE LATERAL EARTH PRESSURE, P_p
   $P_p = 3\ [240 + 125\ (D - 2) - P_{w_1}]$ psf
4. NEGLECT PASSIVE LATERAL EARTH PRESSURE FOR 1 FOOT BELOW MUDLINE
5. HYDROSTATIC PRESSURE WITH SEEPAGE
   $P_{w_1} = P_{w_2} = 124.8\ (H_u + D - 2)(D - 2)/(2D + H_u - 4)$ psf; $P_{w_3} = P_{w_2}\ (H_u - 2)/(H_u - 2 + D)$ psf
6. LATERAL EARTH PRESSURE DUE TO CONSTRUCTION OR LIVE LOAD SURCHARGE, $P_s = 72$ psf
7. NEGLECT DYNAMIC EARTH PRESSURES FOR TEMPORARY CONDITION
8. H, H_u, AND D IN FEET

NOT TO SCALE

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

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FIGURE 4

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

LATERAL EARTH PRESSURES FOR BRACED EXCAVATION

CYCLIC SEWER REPLACEMENT
PHASE 15
ALAMEDA, CALIFORNIA
403144001 I 12/17

APPENDIX A

Boring Logs

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples
Disturbed soil samples were obtained in the field using the following methods.

Bulk Samples
Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

The Standard Penetration Test (SPT) Sampler
Disturbed drive samples of earth materials were obtained by means of a Standard Penetration Test sampler. The sampler is composed of a split barrel with an external diameter of 2 inches and an unlined internal diameter of 1-3/8 inches. The sampler was driven into the ground 18 inches with a 140-pound hammer falling freely from a height of 30 inches in general accordance with ASTM D 1586. The blow counts were recorded for every 6 inches of penetration; the blow counts reported on the logs are those for the last 12 inches of penetration. Soil samples were observed and removed from the sampler, bagged, sealed and transported to the laboratory for testing.

Field Procedure for the Collection of Relatively Undisturbed Samples
Relatively undisturbed soil samples were obtained in the field using the following method.

The Modified Split-Barrel Drive Sampler
The sampler, with an external diameter of 3 inches, was lined with 6-inch-long, thin brass liners with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer in general accordance with ASTM D 3550-01. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass liners, sealed, and transported to the laboratory for testing.

Field Testing
The following tests were performed in the field to evaluate soil properties.

Static Cone Penetrometer
A penetrometer with a conical tip having an apex angle of 60 degrees and a cone base area of 1.5 square centimeters was manually pushed 6 inches into the soil. The penetrometer was instrumented to measure the Cone Penetration Index (Qc) computed as the peak force on the cone divided by the cone base area. The Cone Penetration Index is reported in kilograms per square centimeter (ksc) on the boring log at the depth of the test as a measure of the relative density or consistency of the soil encountered.

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
15								
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

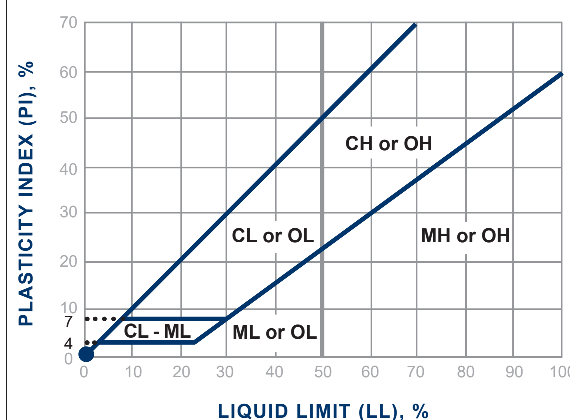
Soil Classification Chart Per ASTM D 2488

Primary Divisions			Secondary Divisions: Group Symbol	Secondary Divisions: Group Name
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

Grain Size

Description		Sieve Size	Grain Size	Approximate Size
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

Plasticity Chart



Apparent Density - Coarse-Grained Soil

Apparent Density	Spooling Cable or Cathead: SPT (blows/foot)	Spooling Cable or Cathead: Modified Split Barrel (blows/foot)	Automatic Trip Hammer: SPT (blows/foot)	Automatic Trip Hammer: Modified Split Barrel (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

Consistency - Fine-Grained Soil

Consis-tency	Spooling Cable or Cathead: SPT (blows/foot)	Spooling Cable or Cathead: Modified Split Barrel (blows/foot)	Automatic Trip Hammer: SPT (blows/foot)	Automatic Trip Hammer: Modified Split Barrel (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

USCS METHOD OF SOIL CLASSIFICATION

DATE DRILLED	10/23/17	BORING NO.	B-1
GROUND ELEVATION	10' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'		
DRIVE WEIGHT	140 LBS (safety & cathead)	DROP	30 inches
SAMPLED BY SPS	LOGGED BY SPS	REVIEWED BY	PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick. Petromat located approximately 2 inches from top of pavement.
							SP	AGGREGATE BASE: Approximately 5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X		Q_S=37				SM	FILL: Dark gray, moist, loose, silty SAND; little silt.
				▼			SM	MERRITT SAND: Brown, moist, loose, silty SAND; little silt.
		X	8					Light brown, wet.
10		X	26	20				Medium dense.
								Total Depth = 11.5 feet.
								Backfilled with Portland cement grout on 10/23/17.
20								Notes: Groundwater was measured at a depth of approximately 4 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 10/23/17 BORING NO. B-2

GROUND ELEVATION 12' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 5 inches thick.
							SP	AGGREGATE BASE: Approximately 11 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	Bulk		Q_S=50				SM	MERRITT SAND: Brown, moist, medium dense, silty SAND; little silt.
		Driven	30	▼ 18.4			SC	Brown, moist, medium dense, clayey SAND; little clay. Wet.
10		Driven	25					
20								Total Depth = 11.5 feet. Backfilled with Portland cement grout on 10/23/17.
30								
40								

Total Depth = 11.5 feet.

Backfilled with Portland cement grout on 10/23/17.

Notes:
Groundwater was measured at a depth of approximately 5.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED 10/23/17 BORING NO. B-3

GROUND ELEVATION 13' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 3.5 inches thick.
	X						SM	AGGREGATE BASE: Approximately 4 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X		Q_S=12					FILL: Dark gray, moist, very loose, silty SAND; little silt.
		X	37				SM	MERRITT SAND: Brown, moist, medium dense, silty SAND; little silt.
				▼			SC	Brown, moist, dense, clayey SAND; little clay. Wet.
10		X	35	19.4				
								Total Depth = 11.5 feet.
								Backfilled with Portland cement grout on 10/23/17.
								Notes: Groundwater was measured at a depth of approximately 7.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
20								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED	10/23/17
BORING NO.	B-4
GROUND ELEVATION	14' ± (MSL)
SHEET	1 OF 1
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'
DRIVE WEIGHT	140 LBS (safety & cathead)
DROP	30 inches
SAMPLED BY	SPS
LOGGED BY	SPS
REVIEWED BY	PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4.5 inches thick.
	X						SP	AGGREGATE BASE: Approximately 4 inches thick.
	X		Q_S=35	8.1			SM	Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X						SM	FILL: Dark brown, moist, loose, silty SAND; little silt.
								MERRITT SAND: Light brown, moist, loose to medium dense, silty SAND; little silt.
		X	34				CL	Light brown, moist, hard, sandy CLAY.
				▽				Wet.
10		X	51					

Total Depth = 11.5 feet.

Backfilled with Portland cement grout on 10/23/17.

Notes:
Groundwater was measured at a depth of approximately 7.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/23/17	BORING NO.	B-5
GROUND ELEVATION	17' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'		
DRIVE WEIGHT	140 LBS (safety & cathead)	DROP	30 inches
SAMPLED BY	SPS	LOGGED BY SPS	REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 8 inches thick. Petromat located approximately 3.5 inches from top of pavement.
							SP	AGGREGATE BASE: Approximately 4 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
							SM	FILL: Dark brown, moist, loose, silty SAND; little silt.
			14				SM	MERRITT SAND: Brown, moist, loose, silty SAND; little silt. Medium dense.
				▼			SP-SC	Brown, moist, medium dense, poorly graded SAND; few clay.
								Wet.
10			36	20.5				Dense.
			28					Medium dense.
								Total Depth = 16.5 feet.
								Backfilled with Portland cement grout on 10/23/17.
20								Notes: Groundwater was measured at a depth of approximately 8 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 10/24/17 BORING NO. B-6

GROUND ELEVATION 10' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 2.5 inches thick. Petromat located at the bottom of the concrete.
							SM	AGGREGATE BASE: Approximately 16 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
								MERRITT SAND: Brown, moist, loose, silty SAND; little silt.
			30	17.7				Medium dense.
							SC	Brown, wet, dense, clayey SAND.
10			33					
								Total Depth = 11.5 feet.
								Backfilled with Portland cement grout on 10/24/17.
20								Notes: Groundwater was measured at a depth of approximately 8 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
30								
40								

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 2.5 inches thick.
	X		Q_S=35				SM	AGGREGATE BASE: Approximately 10.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X						SM	FILL: Dark brown, moist, loose, silty SAND; little silt.
		X	39	13				MERRITT SAND: Brown, moist, medium dense, silty SAND; little silt. Dense.
10		X	23				SC	Brown, moist, medium dense, clayey SAND; trace clay.
20								
30								
40								

DATE DRILLED 10/24/17 BORING NO. B-7

GROUND ELEVATION 14' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

Total Depth = 11.5 feet.

Backfilled with Portland cement grout on 10/24/17.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/24/17	BORING NO.	B-8
GROUND ELEVATION	18' ± (MSL)	SHEET	1 OF 1
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'		
DRIVE WEIGHT	140 LBS (safety & cathead)	DROP	30 inches
SAMPLED BY	SPS	LOGGED BY	SPS
REVIEWED BY	PCC		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick. Petromat located approximately 2 inches from top of pavement.
	X						SP	AGGREGATE BASE: Approximately 5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X		Q_S=35				SM	MERRITT SAND: Brown, moist, loose, silty SAND; little silt.
		X	42				SC	Brown, moist, dense, clayey SAND; little clay.
10		X	39	▼				Wet.
		X	36	19.4			SP-SC	Brown, wet, dense, poorly graded SAND; few clay.
20								
30								
40								

Total Depth = 16.5 feet.

Backfilled with Portland cement grout on 10/24/17.

Notes:

Groundwater was measured at a depth of approximately 9.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED 10/24/17	BORING NO. B-9	
GROUND ELEVATION 10' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'		
DRIVE WEIGHT 140 LBS (safety & cathead)	DROP 30 inches	
SAMPLED BY SPS	LOGGED BY SPS	REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 5.5 inches thick. Petromat located approximately 2.5 inches from top of pavement.
	X						SP	AGGREGATE BASE: Approximately 5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X		Q_S=35				SM	FILL: Dark gray, moist, loose, silty SAND; little silt.
		X	14				SM	MERRITT SAND: Brown, moist, loose, silty SAND; little silt.
				▼			SC	Brown, moist, medium dense, clayey SAND. Wet.
10		X	15	20.3			SM	Brown, wet, medium dense, silty SAND.
20								
30								
40								

Total Depth = 11.5 feet.

Backfilled with Portland cement grout on 10/24/17.

Notes:
Groundwater was measured at a depth of approximately 7.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

FIGURE A- 9

DATE DRILLED	10/24/17
BORING NO.	B-10
GROUND ELEVATION	12' ± (MSL)
SHEET	1 OF 1
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'
DRIVE WEIGHT	140 LBS (safety & cathead)
DROP	30 inches
SAMPLED BY	SPS
LOGGED BY	SPS
REVIEWED BY	PCC

DEPTH (feet)	SAMPLES (Bulk / Driven)	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							ASPHALT CONCRETE: Approximately 4 inches thick.
						SP	Petromat located approximately 3 inches from top of pavement.
	Bulk	Q_S=35				SM	AGGREGATE BASE: Approximately 5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
						SC	MERRITT SAND: Brown, moist, loose, silty SAND; little silt.
	Driven	24					Brown, moist, medium dense, clayey SAND; little clay.
			▼ (groundwater)			SM	Brown, wet, medium dense, silty SAND; little silt.
10	Driven	19	20.2				
20							
30							
40							

Total Depth = 11.5 feet.

Backfilled with Portland cement grout on 10/24/17.

Notes:

Groundwater was measured at a depth of approximately 7 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/27/17	BORING NO.	B-11
GROUND ELEVATION	28' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	3" hand auger		
DRIVE WEIGHT	N/A	DROP	N/A
SAMPLED BY	PCC	LOGGED BY PCC	REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4.25 inches thick.
	X						SP	AGGREGATE BASE: Approximately 5 inches thick. Dark brown, dry to moist, medium dense, poorly graded SAND; little fine to coarse (1 inch) gravel; trace silt.
			Q_S=33				SM	MERRITT SAND: Brown, moist, very loose to loose, silty SAND.
	X		Q_S=20					
			Q_S=28				CL	Brown and gray, moist, stiff, lean CLAY; some sand.
				▼			SC	Brown, wet, loose, clayey SAND.
10								
20								
30								
40								

Total Depth = 7.8 feet.

Backfilled with Portland cement grout on 10/27/17.

Notes:

Groundwater was measured at a depth of approximately 7.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED 10/25/17 BORING NO. B-12

GROUND ELEVATION 24' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 1.5 inches thick.
							SM	AGGREGATE BASE: Approximately 5.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
			Q_S=37				SM	FILL: Dark brown, moist, loose, silty SAND; little silt.
			28	16.1	111.1			MERRITT SAND: Brown, moist, medium dense, silty SAND; little silt. Low plasticity.
				▼				Wet.
10			50					
			30					
							SP-SM	Brown, wet, dense, poorly graded SAND; few silt.
20			40	21.5				
30								
40								

Total Depth = 21.5 feet.

Backfilled with Portland cement grout on 10/25/17.

Notes:
Groundwater was measured at a depth of approximately 8.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED: 10/25/17 BORING NO.: B-13

GROUND ELEVATION: 30' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING: 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT: 140 LBS (safety & cathead) DROP: 30 inches

SAMPLED BY: SPS LOGGED BY: SPS REVIEWED BY: PCC

DEPTH (feet)	SAMPLES (Bulk / Driven)	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						SP	<u>ASPHALT CONCRETE:</u> Approximately 3 inches thick. Petromat located approximately 1.5 inches from top of pavement.
						SM	<u>AGGREGATE BASE:</u> Approximately 4.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
		Q_S=29				SM	<u>FILL:</u> Dark brown, moist, loose, silty SAND; little silt.
		12	9.3	100.4			<u>MERRITT SAND:</u> Brown, moist, loose to medium dense, silty SAND; little silt.
10		48	▼				Wet, medium dense.
						SP-SM	Brown, wet, dense to very dense, poorly graded SAND; few silt.
		52/5"	17.5				
20		91/11"	23.7	104.6			
		70					
30							Total Depth = 26.5 feet. Backfilled with Portland cement grout on 10/25/17. <u>Notes:</u> Groundwater was measured at a depth of approximately 10 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
40							

DATE DRILLED 10/25/17 BORING NO. B-14

GROUND ELEVATION 20' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 2.5 inches thick.
	Bulk		Q_S=28				SM	AGGREGATE BASE: Approximately 5.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
							SM	FILL: Dark brown, moist, loose, silty SAND; little silt.
		Driven	32	16.9	112.1			MERRITT SAND: Brown, moist, medium dense, silty SAND; little silt. Low plasticity.
				▼ (groundwater)				
10		Driven	56	18.9	110.3			Wet.
		Driven	89					Dense.
20		Driven	35	17.4				

Total Depth = 21.5 feet.

Backfilled with Portland cement grout on 10/25/17.

Notes:
Groundwater was measured at a depth of approximately 8.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/26/17	BORING NO.	B-15
GROUND ELEVATION	24' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'		
DRIVE WEIGHT	140 LBS (safety & cathead)	DROP	30 inches
SAMPLED BY	SPS	LOGGED BY SPS	REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 6 inches thick. Petromat located approximately 2 inches from top of pavement.
	X						SP	AGGREGATE BASE: Approximately 3.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X		Q_S=18				SM	MERRITT SAND: Brown, moist, very loose, silty SAND; little silt. Low plasticity.
		X	44	17.3	108.4			Medium dense.
				▼ (groundwater)				Wet.
10		X	77					Dense.
		X	31					
20		X	56				SC	Brown, wet, very dense, clayey SAND.

Total Depth = 21.5 feet.

Backfilled with Portland cement grout on 10/26/17.

Notes:
Groundwater was measured at a depth of approximately 7.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

30

40

DATE DRILLED 10/27/17	BORING NO. B-16
GROUND ELEVATION 14' ± (MSL)	SHEET 1 OF 1
METHOD OF DRILLING 3" hand auger	
DRIVE WEIGHT N/A	DROP N/A
SAMPLED BY PCC LOGGED BY PCC	REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 5 inches thick. Petromat located approximately 1.5 inches from top of pavement.
							SP	AGGREGATE BASE: Approximately 5 inches thick. Dark brown, dry to moist, medium dense, poorly graded SAND; little fine to coarse (2 inches) gravel; trace silt.
			Q_S=34				SM	MERRITT SAND: Brown, dry to moist, loose to medium dense, silty SAND.
			Q_S=47					
				24.4			SC	Brown to gray, wet, loose, clayey SAND; little clay.
10								Total Depth = 7.5 feet.
								Backfilled with Portland cement grout on 10/27/17.
								Notes: Groundwater was measured at a depth of approximately 6 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
20								
30								
40								

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 1.5 inches thick.
	■						SM	AGGREGATE BASE: Approximately 6 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
								MERRITT SAND: Dark brown, moist, loose, silty SAND; little silt.
		▼	7				SC	Dark gray, moist, loose, clayey SAND; little clay.
				▼ (groundwater)				Brown.
								Wet.
10		▼	34				SP-SM	Brown, wet, dense, poorly graded SAND; few silt.
		▼	44	18.3				
20		▼	95/11"					Very dense.
30								
40								

DATE DRILLED 10/26/17 BORING NO. B-17

GROUND ELEVATION 23' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

Total Depth = 21.5 feet.

Backfilled with Portland cement grout on 10/26/17.

Notes:
Groundwater was measured at a depth of approximately 7.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/26/17	BORING NO.	B-18
GROUND ELEVATION	30' ± (MSL)	SHEET	1 OF 1
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'		
DRIVE WEIGHT	140 LBS (safety & cathead)	DROP	30 inches
SAMPLED BY	SPS	LOGGED BY	SPS
REVIEWED BY	PCC		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 1.5 inches thick.
	X		Q_S=38				SM	AGGREGATE BASE: Approximately 7.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
								MERRITT SAND: Dark brown, moist, loose to medium dense, silty SAND; little silt.
		X	30	15.1	106.5		SC	Brown, moist, medium dense, clayey SAND.
				▼			SM	Brown, wet, dense, silty SAND; little silt.
10		X	65					
		X	53					Very dense.
20		X	85					
		X	48					Dense.
30								Total Depth = 26.5 feet. Backfilled with Portland cement grout on 10/26/17.
40								

Notes:
Groundwater was measured at a depth of approximately 9 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/26/17	BORING NO.	B-19	
GROUND ELEVATION	18' ± (MSL)	SHEET	1	OF 1
METHOD OF DRILLING	4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'			
DRIVE WEIGHT	140 LBS (safety & cathead)	DROP	30 inches	
SAMPLED BY	SPS	LOGGED BY SPS	REVIEWED BY	PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 1.5 inches thick.
							SM	AGGREGATE BASE: Approximately 6 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
								MERRITT SAND: Brown, moist, loose, silty SAND; little silt.
			17	16				Medium dense.
				▼				Wet.
10			34					Dense.
			67					Dark gray, very dense.
20								Total Depth = 16.5 feet.
								Backfilled with Portland cement grout on 10/26/17.
30								
40								

Notes:

Groundwater was measured at a depth of approximately 8 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 4 inches thick.
	X		Q_S=52				CL	AGGREGATE BASE: Approximately 5.5 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
								FILL: Dark gray, moist, soft, lean CLAY; organic; little gravel; trace glass. Organic odor.
		X	9	25.6 ▼			SM	Dark gray, moist, loose to medium dense, silty SAND; little silt.
								Wet.
10		X	14					Medium dense.
		X	30				SM	MERRITT SAND: Brown, wet, medium dense, silty SAND; little silt.
20								
30								
40								

DATE DRILLED 10/26/17 BORING NO. B-20

GROUND ELEVATION 8' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

Total Depth = 16.5 feet.

Backfilled with Portland cement grout on 10/26/17.

Notes:
Groundwater was measured at a depth of approximately 6.5 feet in borehole about 5 minutes after completion of drilling. Groundwater may rise to a level higher than that measured in borehole due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	10/26/17	BORING NO.	B-21
GROUND ELEVATION	9' ± (MSL)	SHEET 1 OF 1	
METHOD OF DRILLING	3" hand auger		
DRIVE WEIGHT	N/A	DROP	N/A
SAMPLED BY	PCC	LOGGED BY PCC	REVIEWED BY PCC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 3.25 inches thick.
							GP	AGGREGATE BASE: Approximately 7 inches thick. Brown, dry to moist, medium dense, poorly graded GRAVEL; little sand; trace silt.
							SC	FILL: Brown, moist, medium dense, clayey SAND.
							CL	Dark brown to gray, moist, firm, lean CLAY.
							SC	Dark brown, moist, medium dense, clayey SAND.
	■			29.2			SC	MERRITT SAND: Dark brown, moist, medium dense, clayey SAND; some clay. Wet; organic odor; scattered rootlets.
10								
20								
30								
40								

Total Depth = 5 feet.

Backfilled with Portland cement grout on 10/26/17.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.

DATE DRILLED 10/26/17 BORING NO. B-22

GROUND ELEVATION 10' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 3" hand auger

DRIVE WEIGHT N/A DROP N/A

SAMPLED BY PCC LOGGED BY PCC REVIEWED BY PCC

DESCRIPTION/INTERPRETATION

Depth (feet)	Bulk	Driven	Blows/Foot	Moisture (%)	Dry Density (PCF)	U.S.C.S.	Description/Interpretation
0						SP-SM	ASPHALT CONCRETE: Approximately 2.5 inches thick.
							AGGREGATE BASE: Approximately 6.5 inches thick. Dark brown, dry to moist, medium dense, poorly graded SAND with silt; some gravel.
						SC	FILL: Dark gray, dry to moist, medium dense, clayey SAND; few gravel.
	■			12.9		SM	Dark gray to dark brown, moist, loose, silty SAND; little silt; trace gravel. Wet.
10							
20							
30							
40							

Total Depth = 5 feet.

Backfilled with Portland cement grout on 10/26/17.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SP	ASPHALT CONCRETE: Approximately 3 inches thick.
	X						SM	AGGREGATE BASE: Approximately 4 inches thick. Brown, dry to moist, medium dense, poorly graded SAND; little to some gravel; trace silt.
	X						SP-SM	FILL: Dark brown, moist, loose, silty SAND; little silt; trace gravel.
		X	3	21.5				Dark gray, moist, very loose, poorly graded SAND; few silt; trace gravel.
				▽				Wet.
10		X	3					
	X			64.8			CH	BAY DEPOSITS: Dark gray, wet, stiff, fat CLAY. Hole obstructed to a depth of 10 feet by caving soil or squeezing soil on removal of auger.
20								
30								
40								

DATE DRILLED 10/25/17 BORING NO. B-23

GROUND ELEVATION 10' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 4" Solid Stem, Mobile B-24 (Cal Geotech), 3" hand auger top 5'

DRIVE WEIGHT 140 LBS (safety & cathead) DROP 30 inches

SAMPLED BY SPS LOGGED BY SPS REVIEWED BY PCC

Total Depth = 16.5 feet.

Backfilled with Portland cement grout on 10/25/17.

Notes:

Groundwater was encountered at a depth of approximately 8 to 10 feet in borehole during drilling. Groundwater may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

Classification
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488-00. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

Moisture Content
The moisture content of samples obtained from the exploratory borings was evaluated in accordance with ASTM D 2216. The test results are presented on the boring logs in Appendix A.

In-Place Density Tests
The in-place dry density of relatively undisturbed samples obtained from the exploratory borings was evaluated in general accordance with ASTM D 2937. The test results are presented on the logs of the exploratory borings in Appendix A.

Gradation Analysis
Gradation analysis tests were performed on selected representative soil samples in general accordance with ASTM D 422. The grain-size distribution curves are shown on Figures B-1 through B-13. These test results were utilized in evaluating the soil classifications in accordance with the USCS.

200 Wash
An evaluation of the percentage of particles finer than the No. 200 sieve in selected soil samples was performed in general accordance with ASTM D 1140. The results of the tests are presented on Figure B-14.

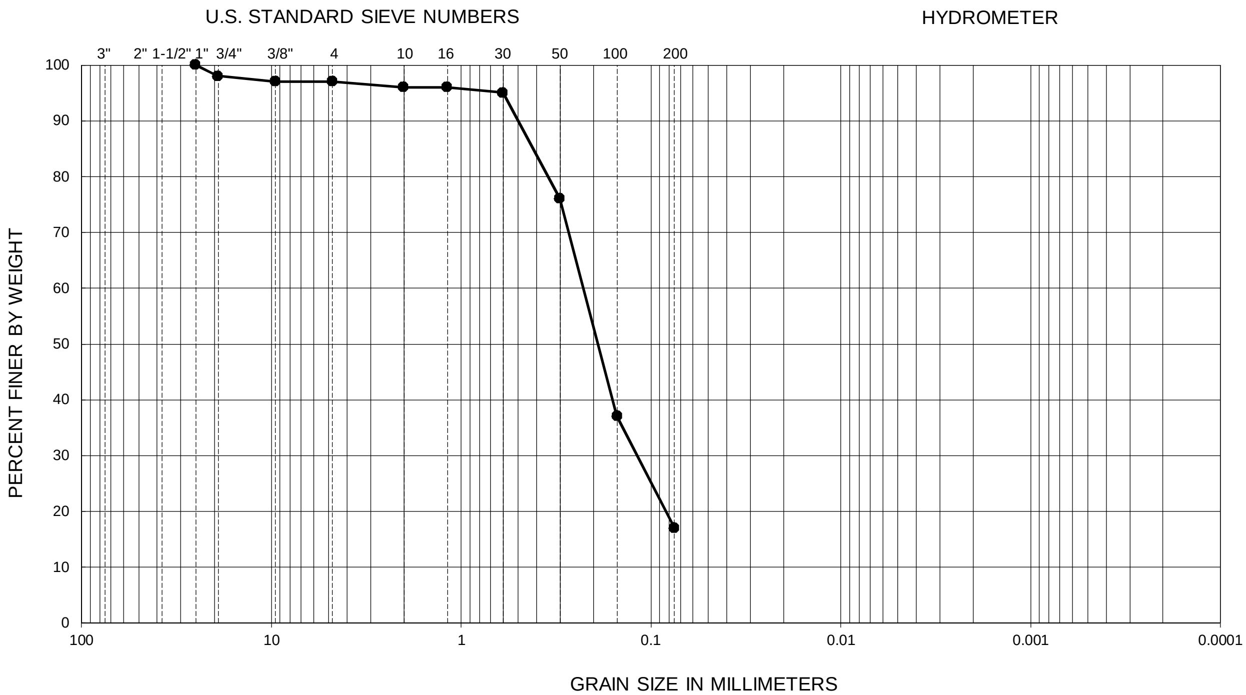
Atterberg Limits
Tests were performed on selected representative soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the Unified Soil Classification System (USCS). The test results and classifications are shown on Figure B-15.

Direct Shear Tests
Direct shear tests were performed on relatively undisturbed samples in general accordance with ASTM D 3080 to evaluate the shear strength characteristics of selected materials. The samples were inundated during shearing to represent adverse field conditions. The results are shown on Figures B-16 through B-19.

Sand Equivalent
Sand equivalent (SE) tests were performed on selected representative samples in general accordance with California Test (CT) 217. The SE value reported on Figure B-20 is the ratio of the coarse- to fine-grained particles in the selected samples.

Unconfined Compression Tests
Unconfined compression tests were performed on relatively undisturbed samples in general accordance with ASTM D 2166. The test results are shown on Figure B-21.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-4	1.0-4.0	--	--	--	--	0.13	0.22	--	--	17	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-1

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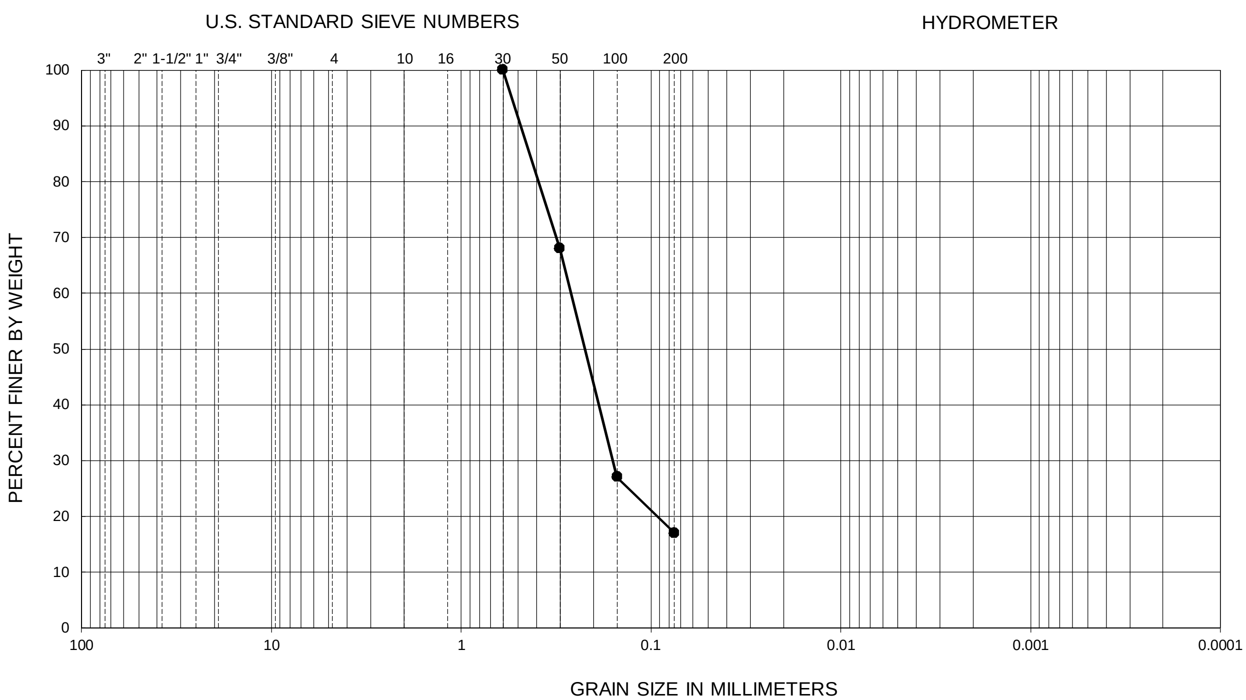
GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

403144001 | 12/17

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-7	5.0-6.5	--	--	--	--	0.17	0.26	--	--	17	SM

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FIGURE B-2

GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

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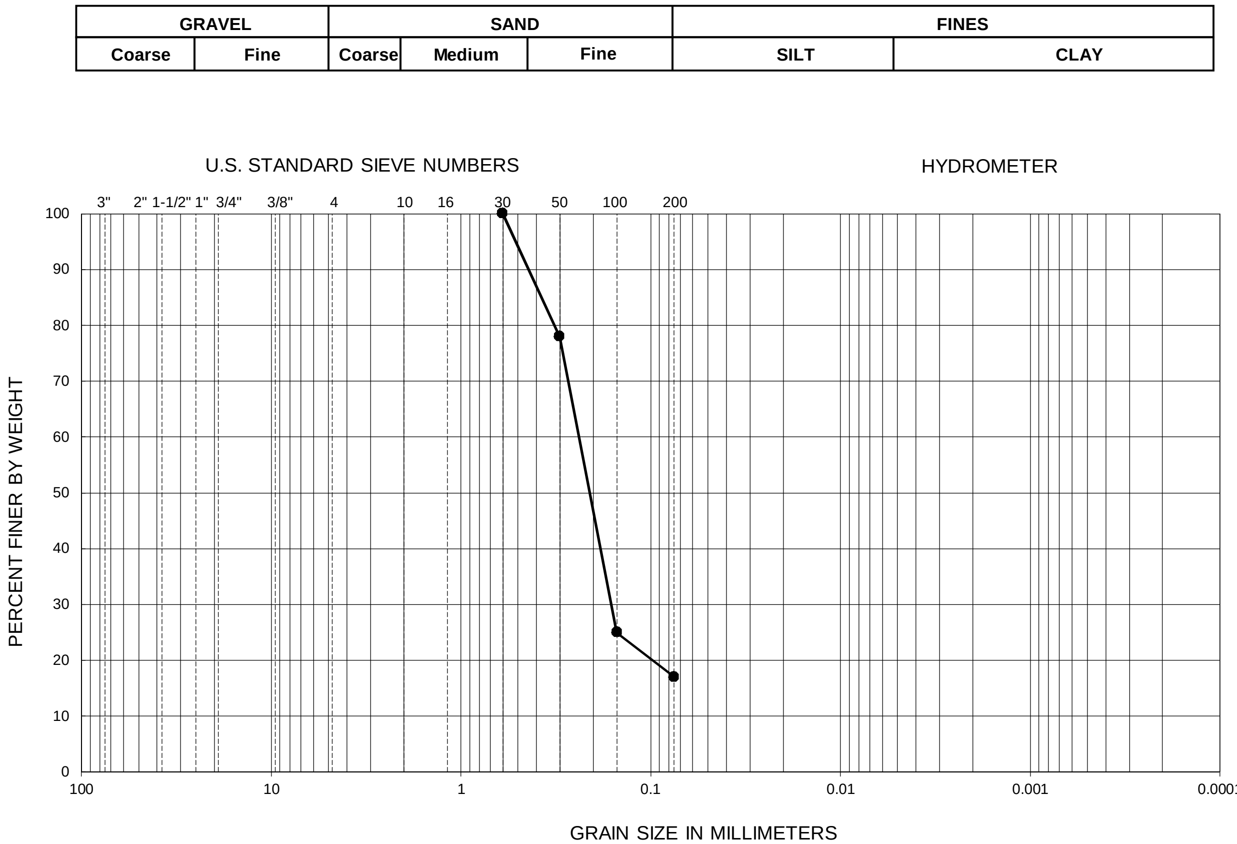

Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-10	10.0-11.5	--	--	--	--	0.17	0.24	--	--	17	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-3

GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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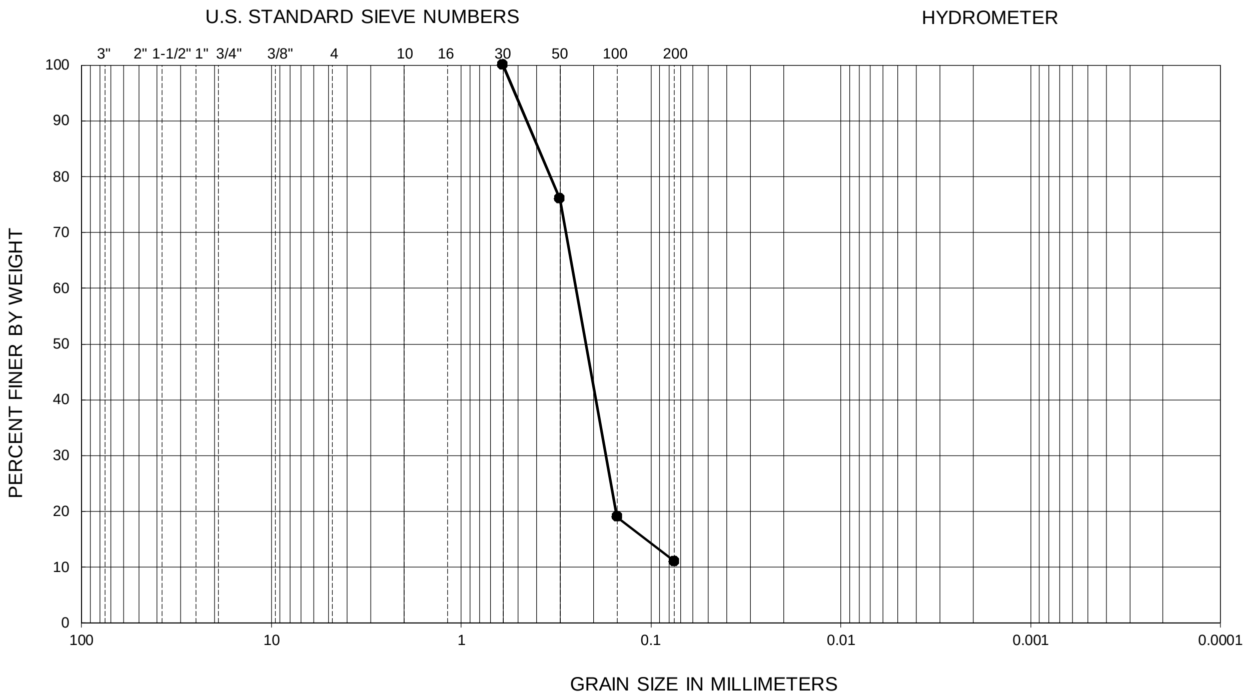
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-12	20.0-21.5	--	--	--	--	0.18	0.25	--	--	11	SP-SM

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FIGURE B-4

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GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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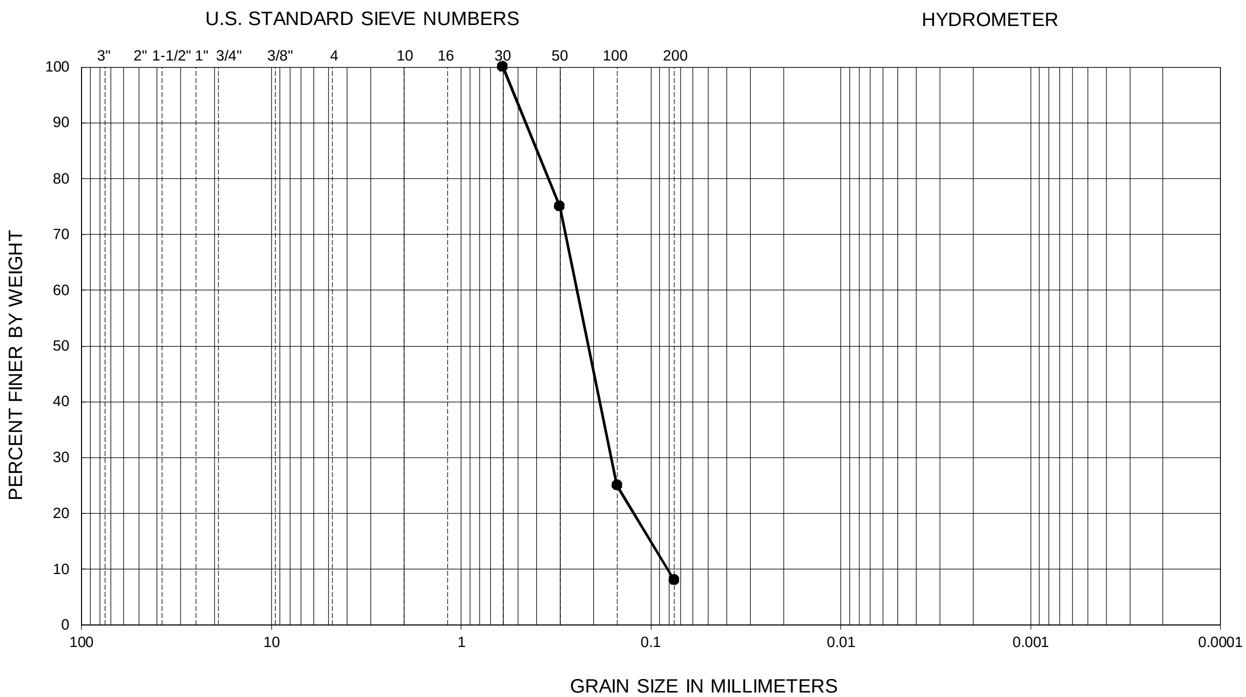
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-13	15.5-16.0	--	--	--	0.08	0.17	0.24	3.0	1.5	8	SP-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

NP - INDICATES NON-PLASTIC

FIGURE B-5

GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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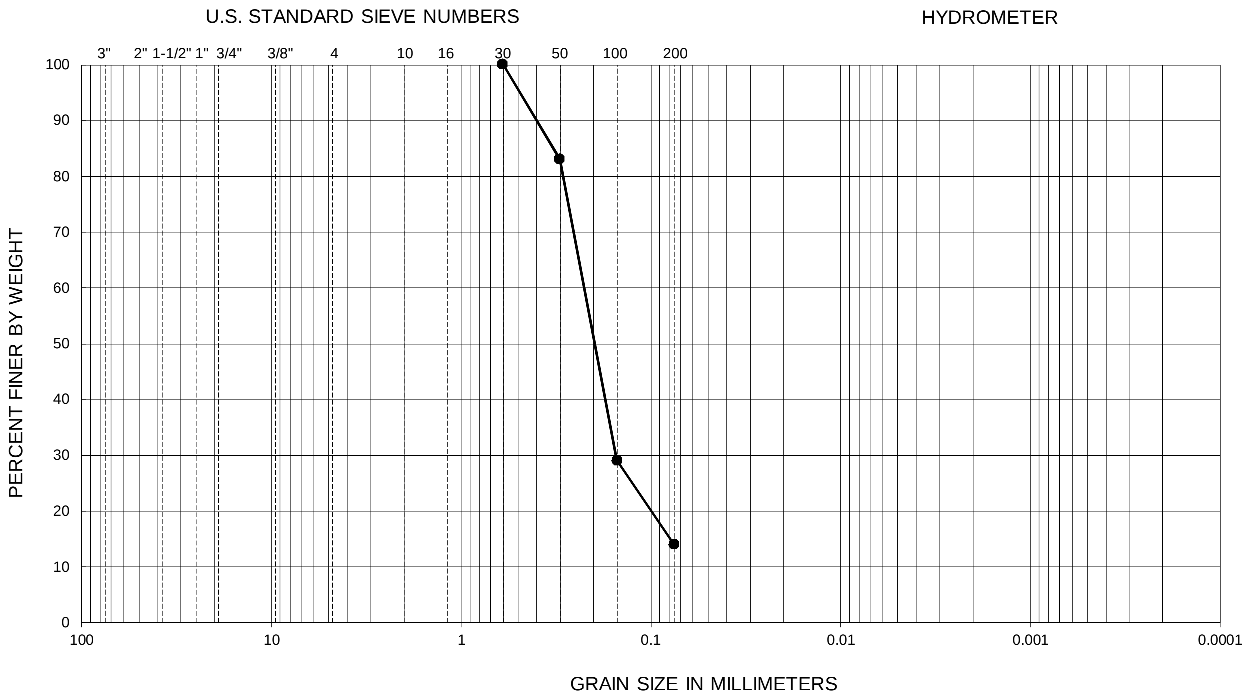
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-14	20.0-21.5	--	--	--	--	0.16	0.23	--	--	14	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-6

GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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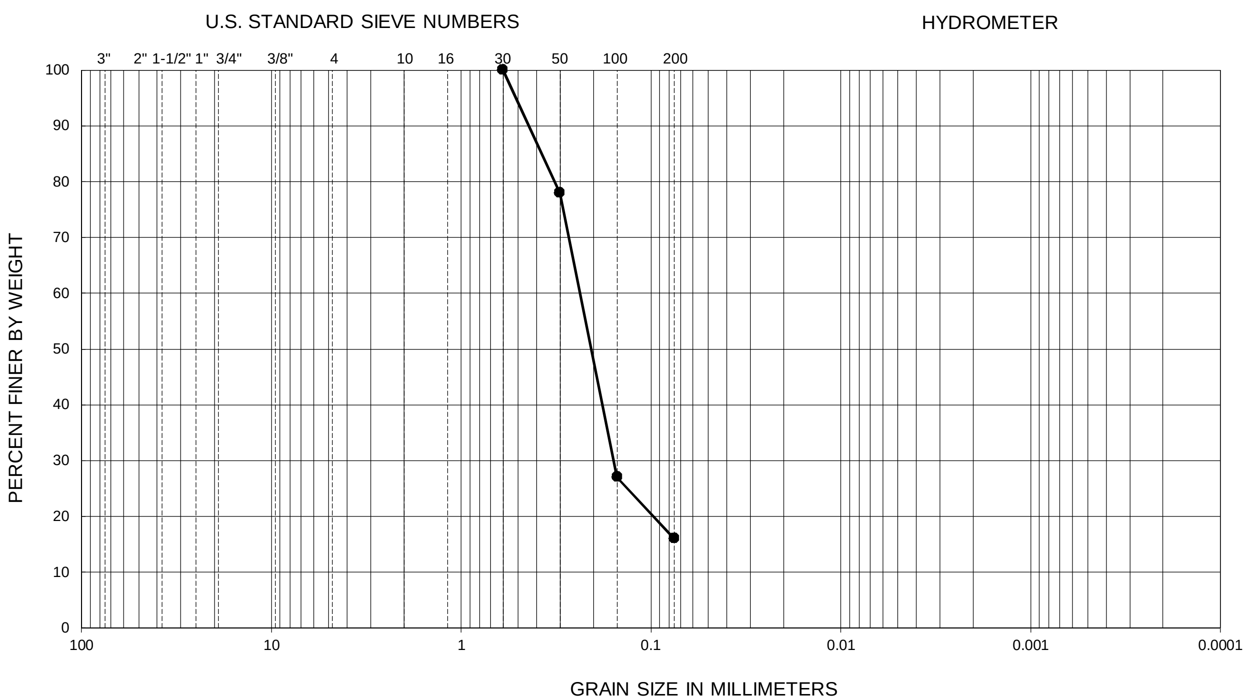
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-15	5.75-6.0	--	--	--	--	0.17	0.24	--	--	16	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-7

GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

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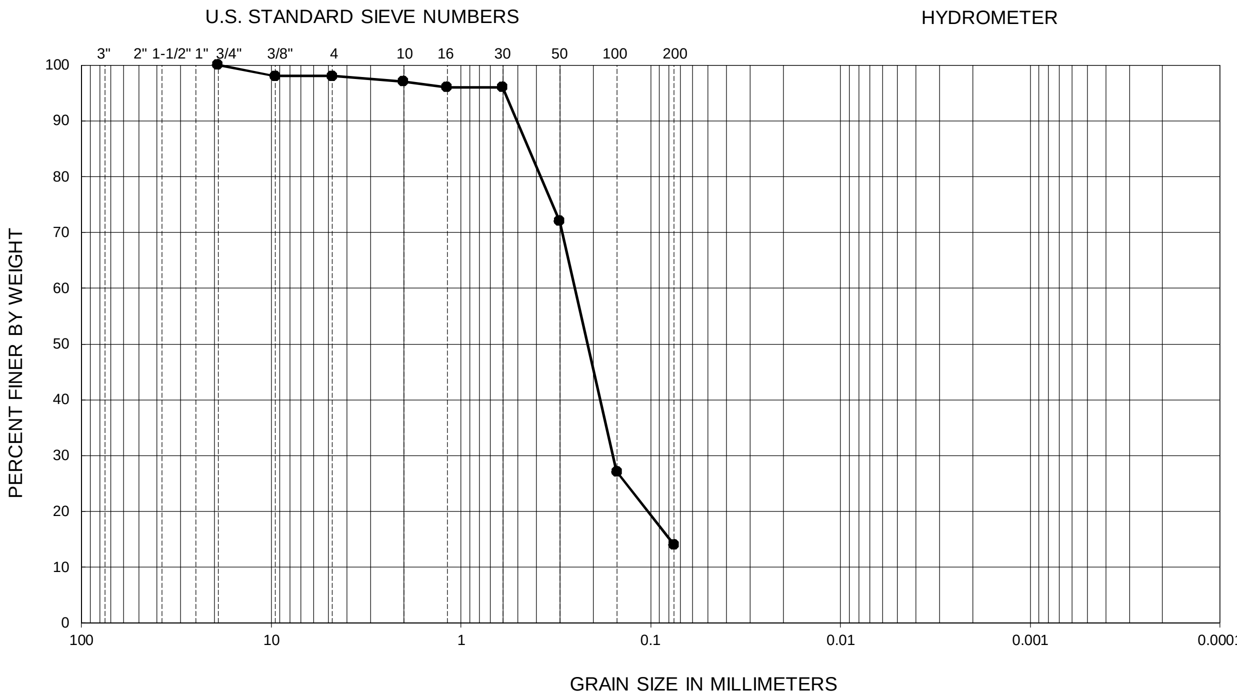
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-16	1.8-2.6	--	--	--	--	0.16	0.26	--	--	14	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-8

GRADATION TEST RESULTS

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CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

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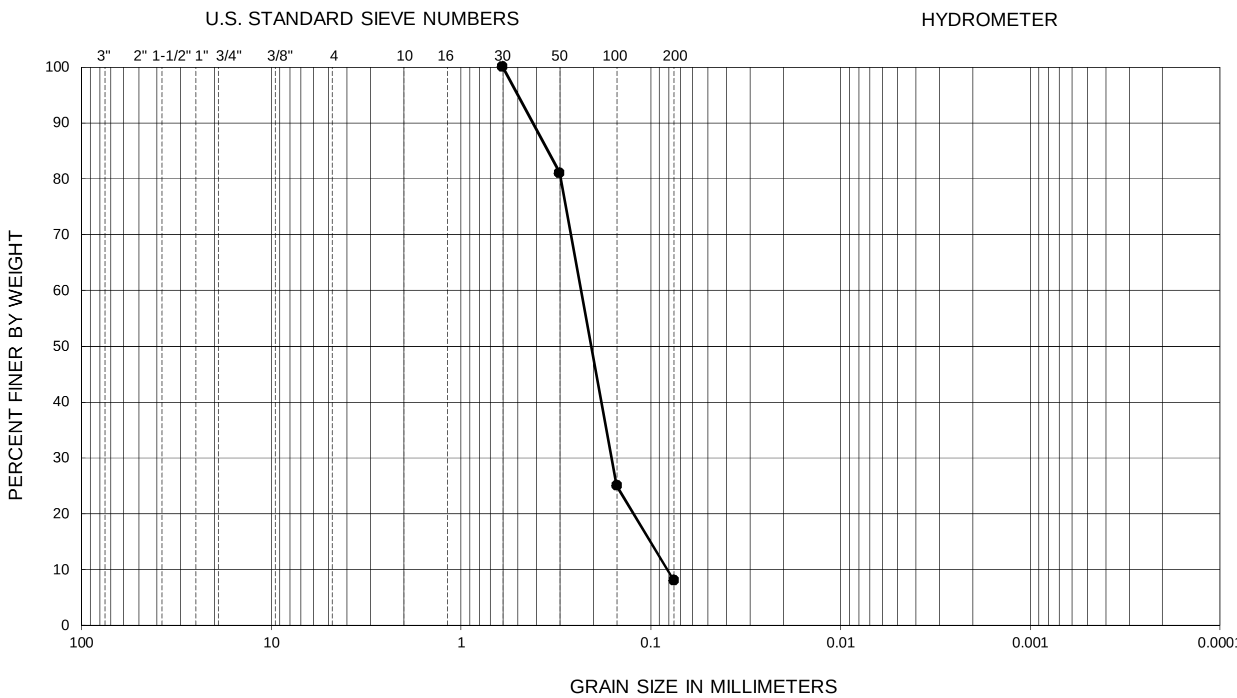
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-17	15.0-16.5	--	--	--	0.08	0.17	0.24	3.0	1.5	8	SP-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-9

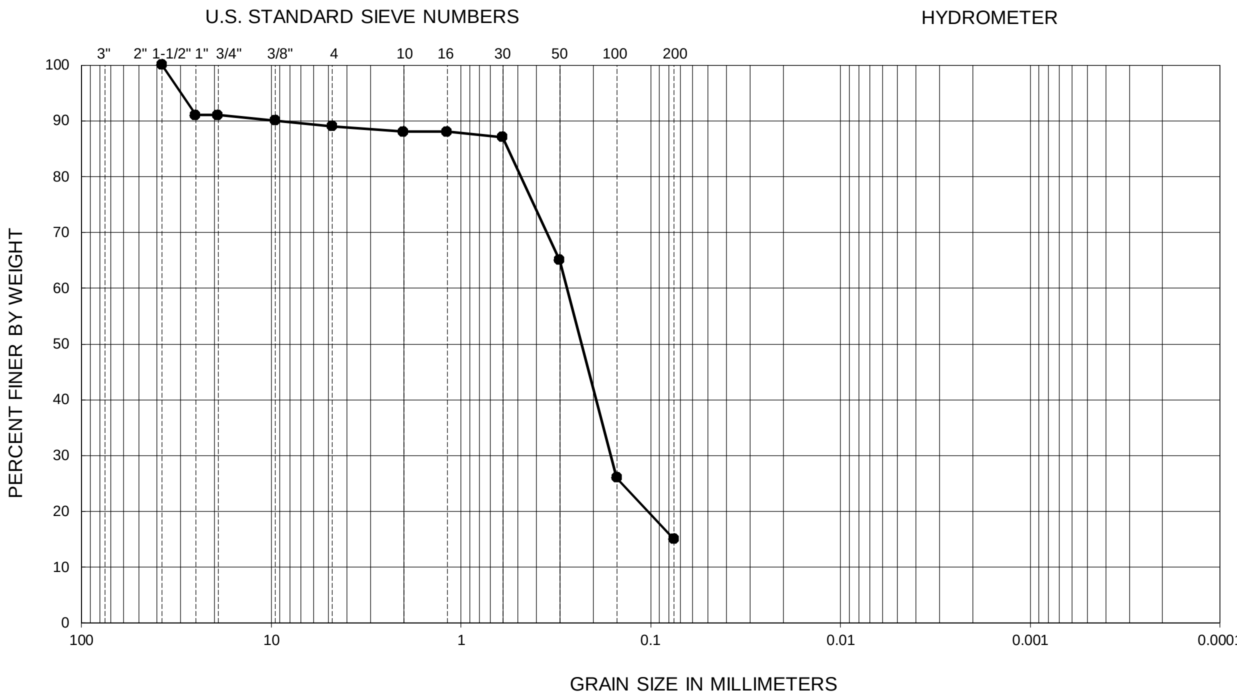
GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

403144001 | 12/17

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-18	1.0-5.0	--	--	--	--	0.17	0.28	--	--	15	SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-10

GRADATION TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

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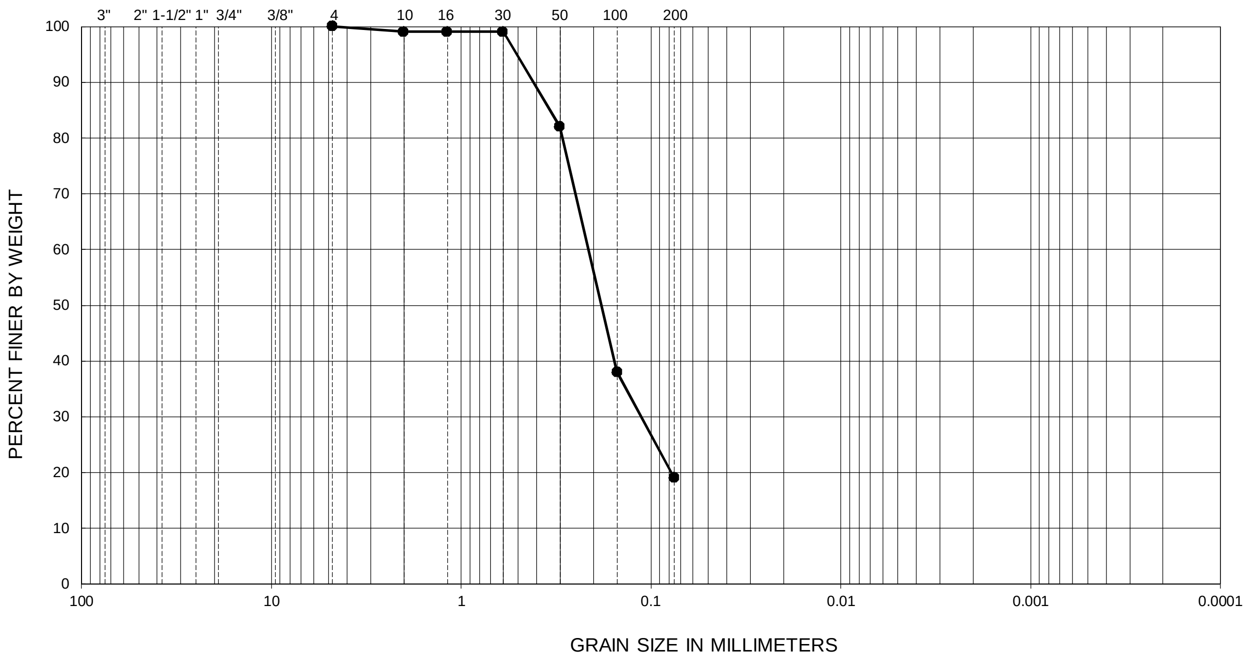
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-19	5.0-6.5	--	--	--	--	0.13	0.22	--	--	19	SM

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FIGURE B-11

GRADATION TEST RESULTS

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CYCLIC SEWER REPLACEMENT PHASE 15
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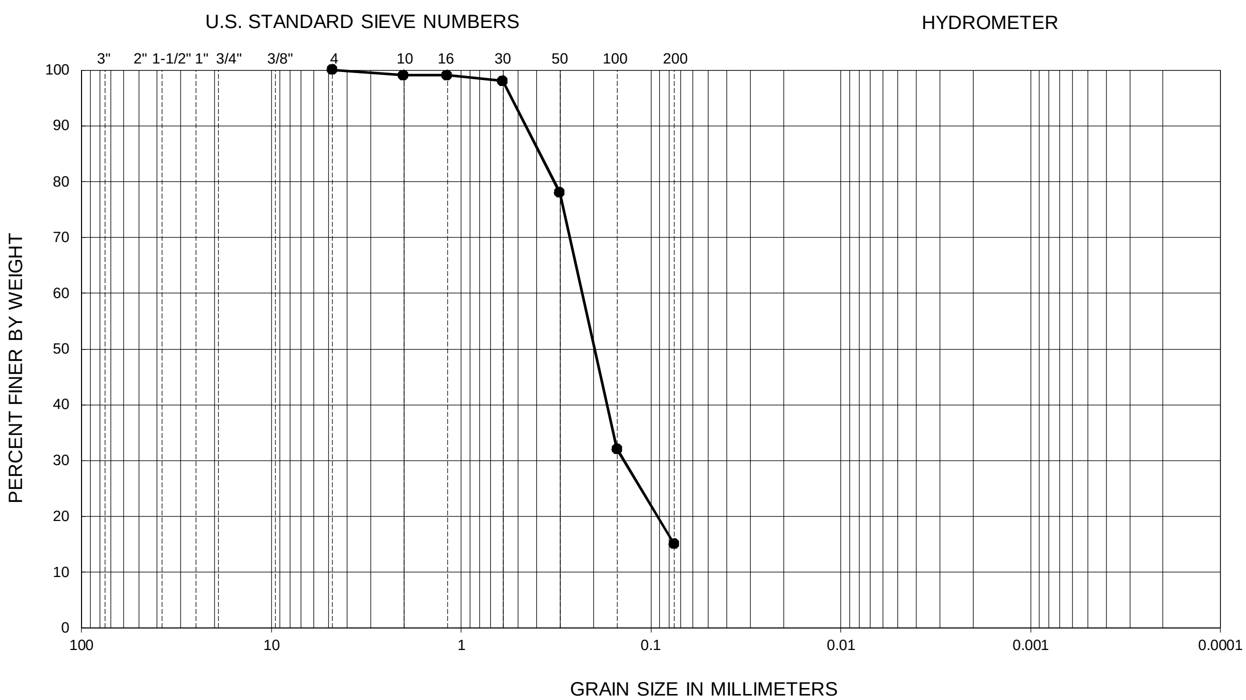
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-20	5.0-6.5	--	--	--	--	0.14	0.23	--	--	15	SM

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FIGURE B-12

GRADATION TEST RESULTS

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CYCLIC SEWER REPLACEMENT PHASE 15
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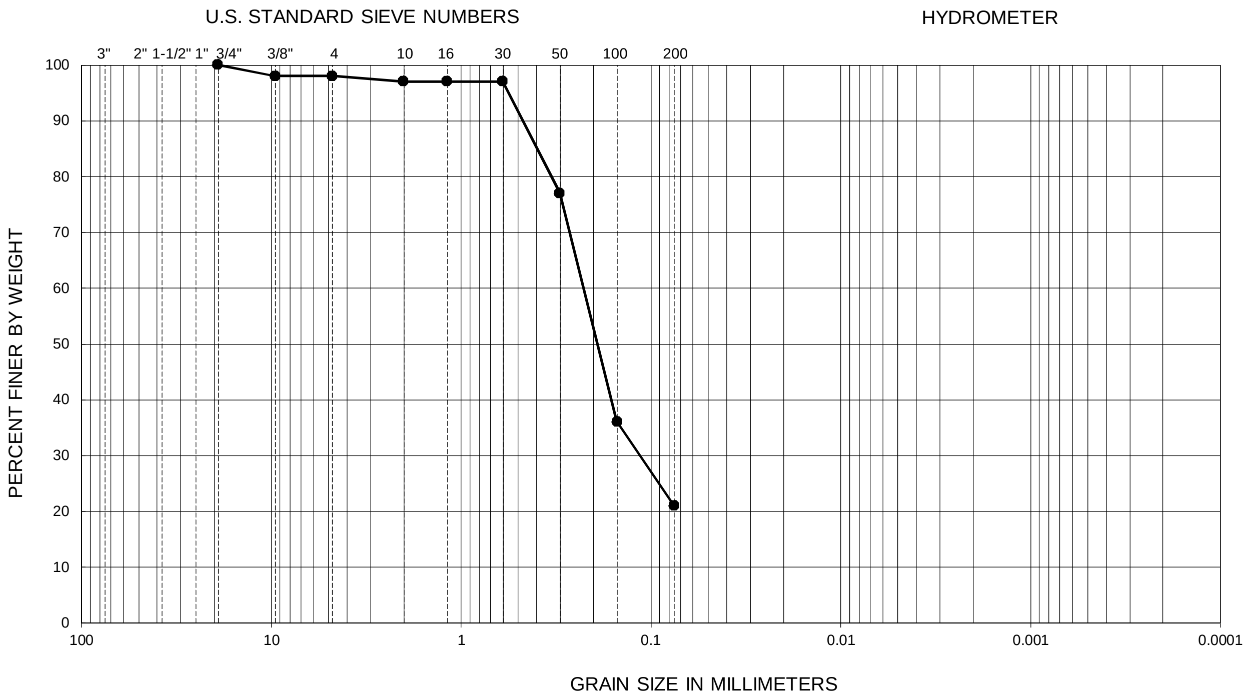
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-22	2.3-3.0	--	--	--	--	0.13	0.22	--	--	21	SM

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FIGURE B-13

GRADATION TEST RESULTS

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SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	USCS (TOTAL SAMPLE)
B-1	10.0-11.5	Silty SAND; little silt	100	16	SM
B-2	5.0-6.5	Clayey SAND; little clay	100	16	SC
B-3	10.0-11.5	Clayey SAND; little clay	100	14	SC
B-5	10.0-11.5	Poorly graded SAND; few clay	100	12	SP-SC
B-6	5.0-6.5	Silty SAND; little silt	100	15	SM
B-8	15.0-16.5	Poorly graded SAND; few clay	100	12	SP-SC
B-16	5.5-6.0	Clayey SAND; little clay	100	22	SC
B-21	3.5-4.0	Clayey SAND; some clay	100	36	SC
B-23	5.0-6.5	Poorly graded SAND; few silt; trace gravel	95	8	SP-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140

FIGURE B-14

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NO. 200 SIEVE ANALYSIS TEST RESULTS

CYCLIC SEWER REPLAEMENT PHASE 15
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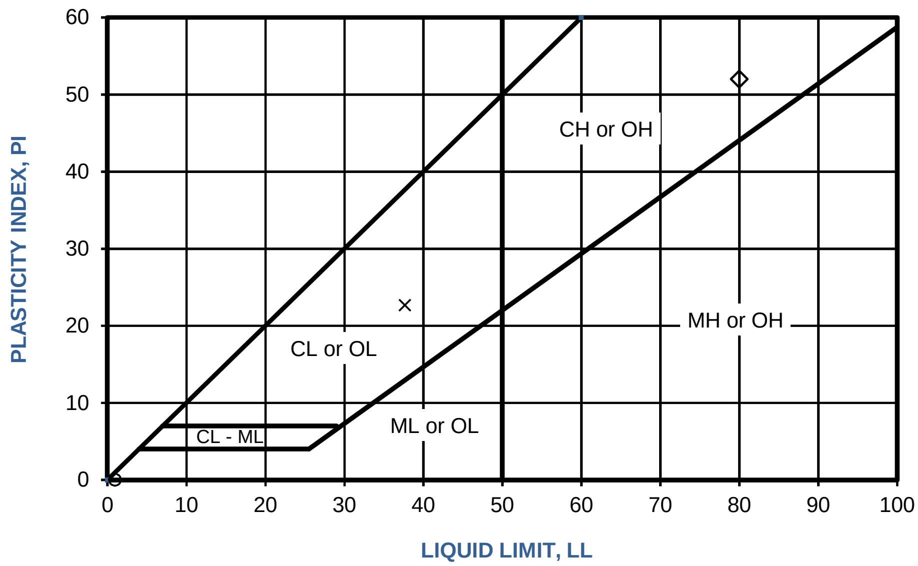
SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	B-1	10.0-11.5	NP	NP	NP	NP	SM
■	B-6	5.0-6.5	NP	NP	NP	NP	SM
◆	B-9	10.0-11.5	NP	NP	NP	NP	SM
○	B-12	6.0-6.5	NP	NP	NP	NP	SM
□	B-14	6.0-6.5	NP	NP	NP	NP	SM
Δ	B-15	5.5-6.0	NP	NP	NP	NP	SM
X	B-21	3.5-4.0	38	15	23	CL	SC
+	B-23	5.0-6.5	NP	NP	NP	NP	SP-SM
◇	B-23	12.0-15.0	80	28	52	CH	CH

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-15

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ATTERBERG LIMITS TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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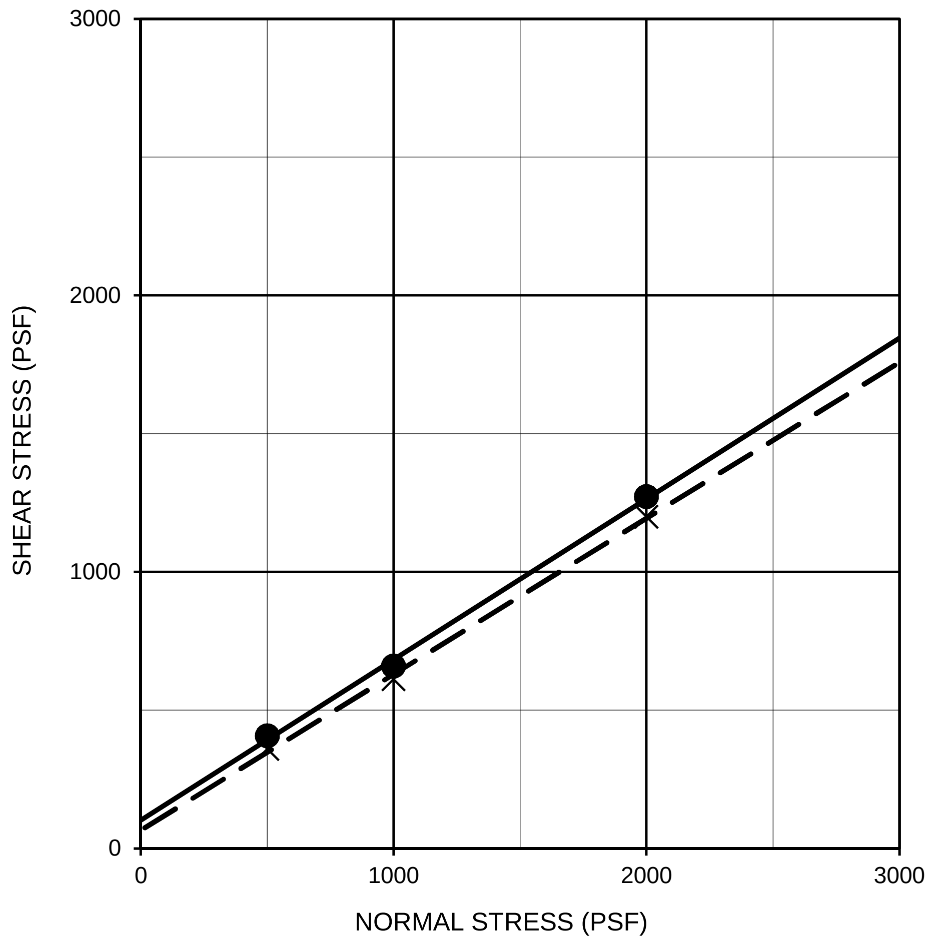

Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion (psf)	Friction Angle (degrees)	Soil Type
Silty SAND	——●——	B-13	6.0-6.5	Peak	100	30	SM
Silty SAND	– – X – –	B-13	6.0-6.5	Ultimate	70	29	SM

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FIGURE B-16

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DIRECT SHEAR TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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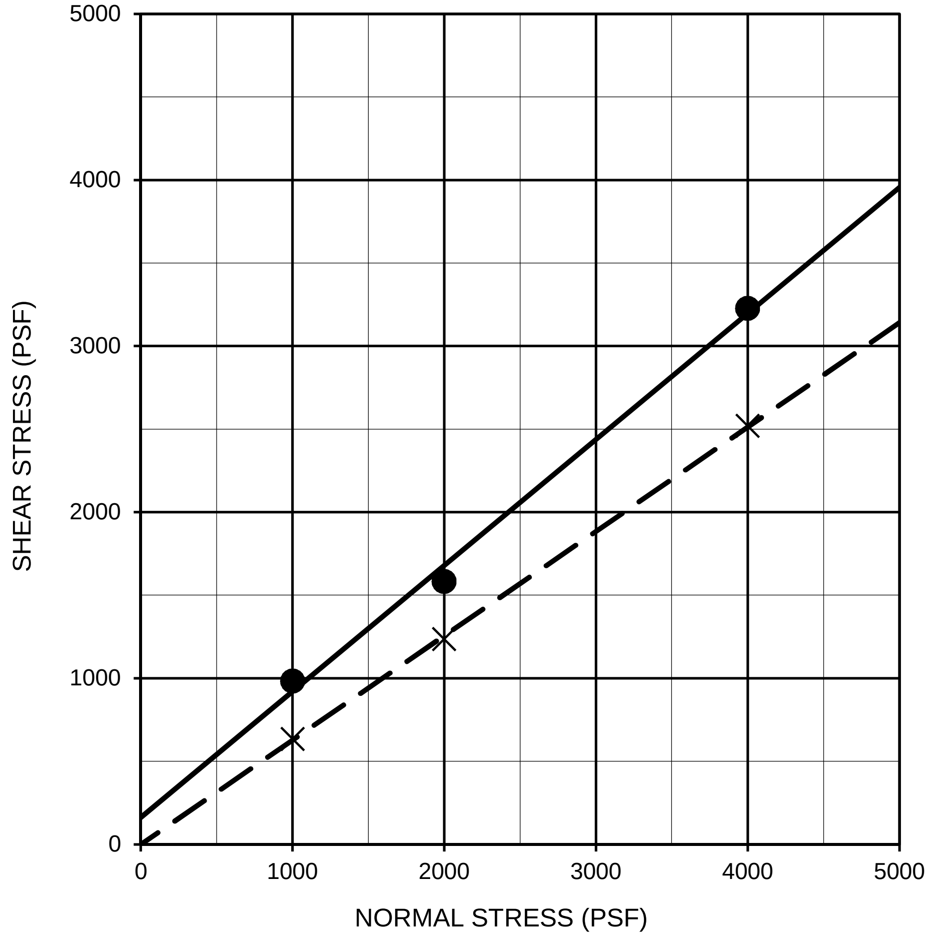

Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion (psf)	Friction Angle (degrees)	Soil Type
SAND; few silt	—●—	B-13	21.0-21.5	Peak	160	37	SP-SM
SAND; few silt	– – X – –	B-13	21.0-21.5	Ultimate	0	32	SP-SM

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FIGURE B-17

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DIRECT SHEAR TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

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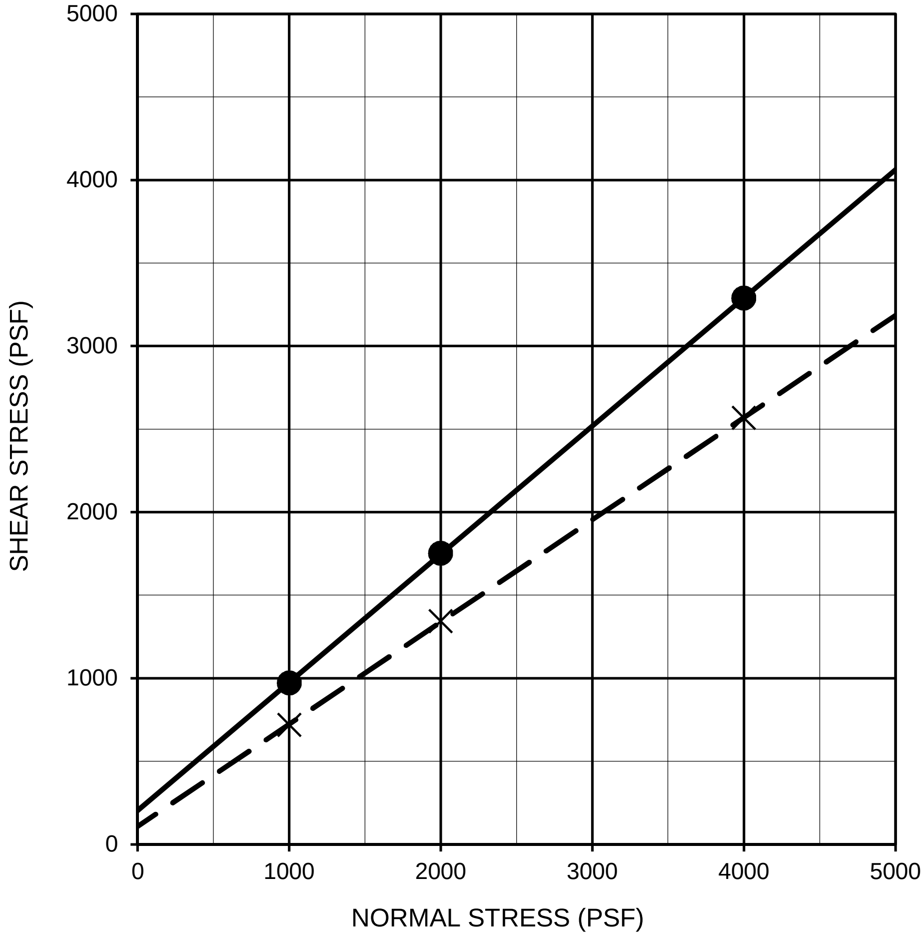

Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion (psf)	Friction Angle (degrees)	Soil Type
Silty SAND	—●—	B-14	11.0-11.5	Peak	200	38	SM
Silty SAND	– – X – –	B-14	11.0-11.5	Ultimate	110	32	SM

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FIGURE B-18

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DIRECT SHEAR TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
ALAMEDA, CALIFORNIA

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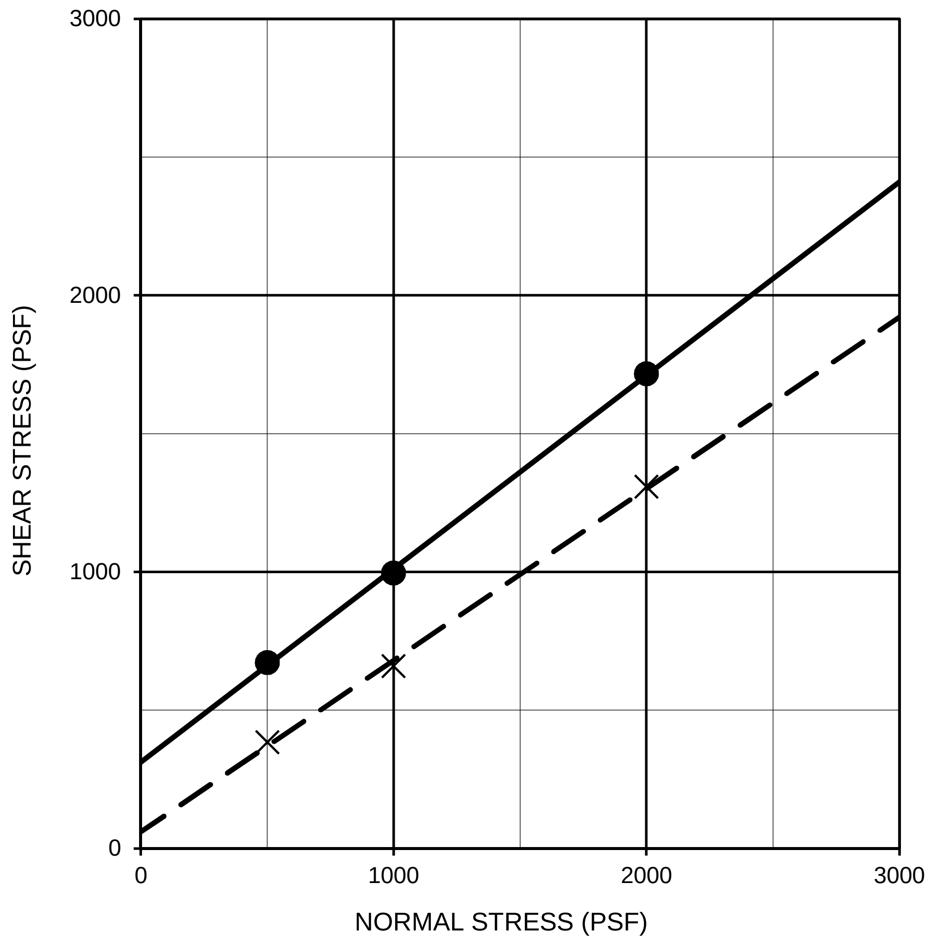

Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion (psf)	Friction Angle (degrees)	Soil Type
Silty SAND	—●—	B-15	6.0-6.5	Peak	310	35	SM
Silty SAND	- - X - -	B-15	6.0-6.5	Ultimate	60	32	SM

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FIGURE B-19

DIRECT SHEAR TEST RESULTS

CYCLIC SEWER REPLACEMENT PHASE 15
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SAMPLE LOCATION	SAMPLE DEPTH (ft)	SOIL TYPE	SAND EQUIVALENT
B-1	5.0-6.5	SM	19
B-2	10.0-11.5	SC	21
B-3	1.0-3.5	SM	24
B-4	10.0-11.5	CL	15
B-6	1.5-4.0	SM	27
B-8	10.0-11.5	SC	22
B-9	1.0-4.0	SM	23
B-12	1.5-4.0	SM	25
B-13	15.0-15.5	SP-SM	40
B-14	15.5-16.0	SM	38
B-15	1.0-5.0	SM	19
B-16	1.8-2.6	SM	25
B-17	20.0-21.5	SP-SM	30
B-18	1.0-5.0	SM	26
B-19	10.0-11.5	SM	34
B-20	10.0-11.5	SM	24
B-22	2.3-3.0	SM	21

PERFORMED IN GENERAL ACCORDANCE WITH AASHTO T176/CT 217

FIGURE B-20

SAND EQUIVALENT VALUE

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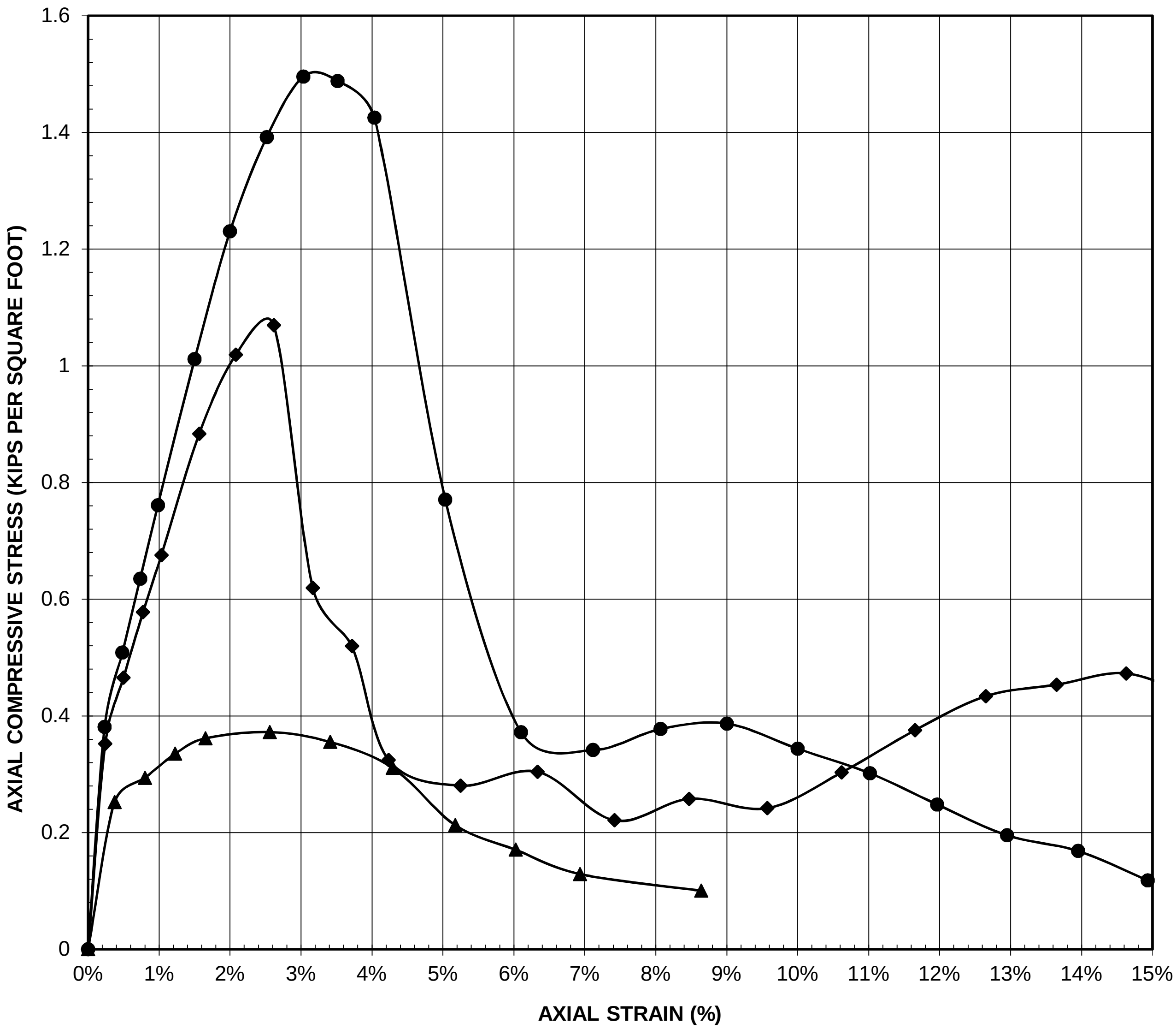

SYMBOL	DESCRIPTION	SOIL TYPE	SAMPLE LOCATION	SAMPLE DEPTH (ft.)	MOISTURE CONTENT w, (%)	DRY DENSITY γ_d, (pcf)	STRAIN RATE (%/min.)	UNDRAINED SHEAR STR s_u, (ksf)
◆	Silty SAND; little silt	SM	B-12	6.0-6.5	16.1	111.1	1.04	0.53
●	Silty SAND; little silt	SM	B-14	6.0-6.5	16.9	112.1	1.00	0.75
▲	Clayey SAND	SC	B-18	6.0-6.5	15.1	106.4	1.73	0.19

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FIGURE B-21

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UNCONFINED COMPRESSION RESULTS

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