UPDATED GEOTECHNICAL INVESTIGATION
CITY OF CARLSBAD ORION CENTER

2600 Orion Way
Carlsbad, California

Prepared By:
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SCST
— AN ATLAS COMPANY —

GEOTECHNICAL INVESTIGATION

March 28, 2019

SCST No. 180396P4
Report No. 1

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363 Fifth Avenue, Suite 202
San Diego, CA 92101

Subject: UPDATED GEOTECHNICAL INVESTIGATION
CITY OF CARLSBAD ORION CENTER
2600 ORION WAY
CARLSBAD, CALIFORNIA

Dear Rick:

SCST, LLC (SCST) is pleased to present our report describing the geotechnical investigations performed for the subject project. We conducted our original and supplemental geotechnical investigations in general conformance with the scopes of work presented in our proposals dated May 17, 2016 and January 10, 2017. Based on the results of our investigations, we consider the planned construction feasible from a geotechnical standpoint provided the recommendations of this report are followed. If you have any questions, please call us at (619) 280-4321.

Respectfully submitted,
SCST, LLC

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EXECUTIVE SUMMARY

This report presents the results of the geotechnical investigation SCST, LLC (SCST) performed for the subject project. We understand the project will consist of the design and construction of a two-story operations building, warehouse/shop buildings, a parking structure, outdoor covered storage, a vehicle wash station, pavements for fire access and parking, and stormwater BMP facilities. The purpose of our work is to provide conclusions and recommendations regarding the geotechnical aspects of the project.

Our current field investigation consisted of drilling five borings to depths between about 2½ and 7½ feet below the existing ground surface using a truck-mounted drill rig equipped with a hollow-stem auger or a hand auger. We previously drilled six borings and four percolation test borings to depths between about 3 and 19 feet below the existing ground surface using a truck-mounted drill rig equipped with a hollow-stem auger (SCST, 2016). Auger refusal was encountered in several of the borings. An SCST geologist or engineer logged the borings and collected samples of the materials encountered for laboratory testing. SCST tested selected samples from the borings to evaluate pertinent soil classification and engineering properties to assist in developing geotechnical conclusions and recommendations.

The materials encountered in the borings consist of fill and the Lusardi Formation. The fill extends to depths up to about 11½ feet below the existing ground surface and consists of medium dense to dense silty to clayey sand with varying amounts of gravel and cobbles. The Lusardi Formation consists of very dense, weakly to strongly cemented silty to clayey sandstone and conglomerate with varying amounts of gravel, cobbles, and boulders. Groundwater was encountered in one of the borings (B-7) at a depth of about 2 feet below the existing ground surface. The groundwater is believed to be a localized perched condition and not a regional groundwater table.

We performed four borehole percolation tests. The test results indicate infiltration rates between 0.0 and 0.1 inch per hour. The infiltration rate of the actual soils that will be encountered at the bottom of stormwater retention basins could vary significantly subsequent to grading.

The main geotechnical considerations affecting the planned construction are the presence of potentially compressible fill, cut/fill transitions, expansive soils, and difficult excavations. To reduce the potential for settlement, the existing fill should be excavated in its entirety below the planned structures, settlement sensitive improvements and new fill. The proposed structures should not be underlain by cut/fill transitions. Individual structures should be supported either entirely on compacted fill or entirely on formation. To reduce the potential for expansive heave, material with an expansion index less than 50 should be placed from 3 feet below the deepest planned footing bottom level to the finished pad grade elevation. Hardscape should be underlain by at least 2 feet of material with an expansion index less than 50. Based on our laboratory test results, some of the on-site soils will not meet the expansion index criteria. Strongly cemented zones should be expected within the formational materials. Gravel, cobbles, and boulders should also be anticipated. The planned structures can be supported on shallow spread footings with bottoms levels either entirely on compacted fill or entirely on formation.

1. INTRODUCTION

This report presents the results of the geotechnical investigation SCST, LLC (SCST) performed for the subject project. We performed a geotechnical investigation in 2016 for the planned operations building, warehouse/shop buildings, pavements, and stormwater BMP facilities to be constructed as part of the project. Subsequently, a parking structure was added to the project. We performed this supplemental investigation to address the parking structure and overall project. The purpose of our work is to provide conclusions and recommendations regarding the geotechnical aspects of the project. Figure 1 presents a site vicinity map. Figure 2 presents the site location on the United States Geologic Survey 7½-Minute Topographic Map.

2. SCOPE OF WORK

2.1 FIELD INVESTIGATION

Our current field investigation consisted of drilling five borings to depths between about 2½ and 7½ feet below the existing ground surface using a truck-mounted drill rig equipped with a hollow-stem auger or a hand auger. We previously drilled six borings and four percolation test borings to depths between about 3 and 19 feet below the existing ground surface using a truck-mounted drill rig equipped with a hollow-stem auger (SCST, 2016). Auger refusal was encountered in several of the borings. Figure 3 shows the approximate locations of the borings. An SCST geologist or engineer logged the borings and collected samples of the materials encountered for laboratory testing. Logs of the borings and test holes are presented in Appendix I. Soils are classified according to the Unified Soil Classification System illustrated on Figure I-1.

2.2 LABORATORY TESTING

Selected samples obtained from the borings were tested to evaluate pertinent soil classification and engineering properties and enable development of geotechnical conclusions and recommendations. The laboratory tests consisted of in situ moisture and density, particle-size distribution, Atterberg limits, R-value, expansion index, corrosivity, and direct shear. The results of the laboratory tests and brief explanations of the test procedures are presented in Appendix II.

2.3 ANALYSIS AND REPORT

The results of the field and laboratory tests were evaluated to develop conclusions and recommendations regarding:

- Subsurface conditions beneath the site
- Potential geologic hazards

- Criteria for seismic design in accordance with the 2016 California Building Code (CBC)
- Site preparation and grading
- Excavation characteristics
- Foundation alternatives and geotechnical engineering criteria for design of the foundations
- Estimated foundation settlements
- Support for concrete slabs-on-grade
- Lateral pressures for the design of retaining walls
- Pavement sections
- Soil corrosivity
- Infiltration test results and feasibility

3. SITE DESCRIPTION

The site is located northeast of Orion Street and Orion Way in the City of Carlsbad, California. The site is located on the top of a mesa, southwest of a southeast-northwest-trending tributary canyon to Los Monos Canyon. Existing improvements at the site consist of pavements. The site generally slopes towards the southwest. Site elevations range from about 375 feet at the northern portion of the site to about 359 feet at the southwestern portion of the site.

4. PROPOSED DEVELOPMENT

We understand the project will consist of the design and construction of a two-story operations building, warehouse/shop buildings, a four-level parking structure, outdoor covered storage, a vehicle wash station, pavements for fire access and parking, hardscape, and stormwater BMP facilities. The buildings and parking structure will be supported on shallow spread footings with concrete slab-on-grade floors. Grading plans indicate that cuts and fills less than about 5 feet will be required to achieve finish site grades.

5. GEOLOGY AND SUBSURFACE CONDITIONS

The site is located within the Peninsular Ranges Geomorphic Province of California, which stretches from the Los Angeles basin to the tip of Baja California. This province is characterized as a series of northwest trending mountain ranges separated by subparallel fault zones and a coastal plain of subdued landforms. The mountain ranges are underlain primarily by Mesozoic metamorphic rocks that were intruded by plutonic rocks of the Southern California Batholith, while the coastal plain is underlain by subsequently deposited marine and non-marine sedimentary formations. The site is located in the coastal plain and is underlain by fill and

Lusardi Formation. Descriptions of the materials are presented below. Figure 3 presents the site-specific geology. Figures 4A and 4B present geologic cross-sections. Figure 5 presents the regional geology in the vicinity of the site.

Fill: The fill consists of medium dense to dense silty to clayey sand with varying amounts of gravel and cobbles. The fill was encountered to depths up to about 11½ feet below the existing ground surface. Auger refusal on rocks occurred in borings P-3 and B-4.

Lusardi Formation: The fill is underlain by Cretaceous-age Lusardi Formation. The Lusardi Formation consists of very dense, silty to clayey sandstone and conglomerate with varying amounts of gravel, cobbles, and boulders. Auger refusal on strongly cemented material and/or rocks occurred in borings B-1, B-2, B-3, B-5, B-6, B-8, B-9, and B-10.

Groundwater: Groundwater was observed in boring B-7 at a depth of about 2 feet below the existing ground surface. The groundwater is believed to be a localized perched condition and not a regional groundwater table. Groundwater levels may fluctuate in the future due to rainfall, irrigation, broken pipes, or changes in site drainage. Because groundwater rise or seepage is difficult to predict, such conditions are typically mitigated if and when they occur.

6. GEOLOGIC HAZARDS

6.1 FAULTING AND SURFACE RUPTURE

The closest known active fault is the Rose Canyon (Oceanside section) fault zone located about 7½ miles (12 km) southwest of the site. The site is not located in an Alquist-Priolo Earthquake Fault Zone. No active faults are known to underlie or project toward the site. Therefore, the probability of fault rupture is low.

6.2 CBC SEISMIC DESIGN PARAMETERS

A geologic hazard likely to affect the project is ground shaking as a result of movement along an active fault zone in the vicinity of the subject site. The site coefficients and adjusted maximum considered earthquake spectral response accelerations in accordance with the 2013 CBC are presented below:

Site Coordinates: Latitude 33.13872°
Longitude -117.26622°

Site Class: C

Site Coefficients, F_a = 1.000
F_v = 1.393

Mapped Spectral Response Acceleration at Short Period, S_s = 1.051g

Mapped Spectral Response Acceleration at 1-Second Period, S_1 = 0.407g

Design Spectral Acceleration at Short Period, S_{DS} = 0.701g

Design Spectral Acceleration at 1-Second Period, S_{D1} = 0.378g

Site Peak Ground Acceleration, PGA_M = 0.402g

6.3 LIQUEFACTION AND DYNAMIC SETTLEMENT

Liquefaction occurs when loose, saturated, generally fine sands and silts are subjected to strong ground shaking. The soils lose shear strength and become liquid; potentially resulting in large total and differential ground surface settlements as well as possible lateral spreading during an earthquake. Given the relatively dense nature of the materials beneath the site, the potential for liquefaction and dynamic settlement to occur is low.

6.4 TSUNAMIS, SEICHES, AND FLOODING

The site is not located within a mapped area on the State of California Tsunami Inundation Maps (Cal EMA, 2009); therefore, damage due to tsunamis is considered negligible. Seiches are periodic oscillations in large bodies of water such as lakes, harbors, bays, or reservoirs. The site is not located adjacent to any lakes or confined bodies of water; therefore, the potential for a seiche to affect the site is low. The site is not located within a flood zone or dam inundation area (County of San Diego, 2012).

6.5 LANDSLIDES AND SLOPE STABILITY

Evidence of landslides or slope instabilities was not observed. The potential for landslides or slope instabilities to occur at the site is considered low.

6.6 SUBSIDENCE

The site is not located in an area of known subsidence associated with fluid withdrawal (groundwater or petroleum); therefore, the potential for subsidence due to the extraction of fluids is negligible.

6.7 HYDRO-CONSOLIDATION

Hydro-consolidation can occur in recently deposited (less than 10,000 years old) sediments that were deposited in a semi-arid environment. Examples of such sediments are aeolian sands, alluvial fan deposits, and mudflow sediments deposited during flash floods. The pore space between particle grains can re-adjust when inundated by groundwater causing the material to consolidate. The relatively dense materials underlying the site are not susceptible to hydro-consolidation.

7. CONCLUSIONS

Based on the results of our investigation, we consider the planned construction feasible from a geotechnical standpoint provided the recommendations of this report are followed. The main geotechnical considerations affecting the planned development are the presence of potentially compressible fill, cut/fill transitions, expansive soils, and difficult excavations. Remedial grading will need to be performed to reduce the potential for distress to the planned structures and improvements. Remedial grading recommendations are provided in the following sections of this report. The planned buildings and parking structure can be supported on shallow spread footings with bottoms levels either entirely on compacted fill or entirely on formation, as discussed below.

8. RECOMMENDATIONS

8.1 SITE PREPARATION AND GRADING

8.1.1 Site Preparation

Site preparation should begin with the removal of existing improvements, topsoil, vegetation, and debris. Subsurface improvements that are to be abandoned should be removed, and the resulting excavations should be backfilled and compacted in accordance with the recommendations of this report. Pipeline abandonment can consist of capping or rerouting at the project perimeter and removal within the project perimeter. If appropriate, abandoned pipelines can be filled with grout or slurry as recommended by and observed by the geotechnical consultant.

8.1.2 Compressible Soils

The existing fill should be excavated in its entirety beneath the planned structures, settlement sensitive improvements and new fills. Excavations up to 11½ feet deep are anticipated. Horizontally, the excavations should extend at least 5 feet outside the planned perimeter foundations, at least 2 feet outside the planned hardscape and pavements, or up to existing improvements, whichever is less. An SCST representative should observe conditions exposed in the bottom of the excavation to determine if additional excavation is required.

8.1.3 Cut/Fill Transitions

The planned buildings should not be underlain by cut/fill transitions or transitions from shallow fill to deep fill. Where such transitions are encountered, the formational materials should be over-excavated and replaced with compacted fill to provide a relatively uniform layer of compacted fill beneath the entire structure and reduce the potential for differential settlement. The over-excavation depth should be at least 3 feet below the planned finished pad elevation, at least 2 feet below the deepest planned footing bottom elevation, or to a depth of H/2, whichever is deeper, where H is the greatest depth of fill beneath the structure. Horizontally, the over-excavation should extend at least 5 feet outside the planned footing perimeter or up to existing improvements, whichever is less. Where practical, the bottom of excavations should be sloped toward the fill portion of the site and away from its center. An SCST representative should observe the conditions exposed in the bottom of excavations to determine if additional excavation is required.

We encountered relatively shallow formational materials in the area of the proposed parking structure. Accordingly, the parking structure can be supported entirely on spread footings with bottom levels on formational materials. If isolated deep fills are encountered beneath the parking structure, 3-sack sand/cement slurry can be placed between the bottom of footing and the formational materials.

8.1.4 Expansive Soil - Building Areas

The on-site materials tested have expansion indexes ranging from 2 to 66. To reduce the potential for expansive heave, soils with an expansion index (EI) of 50 or less determined in accordance with ASTM D4829 should be placed from 3 feet below the deepest planned footing bottom level to the finished pad grade elevation. Horizontally, the soils having an EI of 50 or less should extend at least 5 feet outside the planned footing perimeter or up to existing improvements, whichever is less. An SCST representative should observe conditions exposed in the bottom of excavations to assess whether additional excavation is required. We anticipate that some of the on-site soils will not meet the expansion index criteria and that imported material will be needed.

8.1.5 Expansive Soil - Hardscape Areas

Hardscape should be underlain by at least 2 feet of material with an EI of 50 or less. Horizontally, the soils having an EI of 50 or less should extend at least 2 feet outside the planned hardscape or up to existing improvements, whichever is less.

8.1.6 Compacted Fill

Excavated material, except for roots, debris, and rocks greater than 6 inches, can be used as compacted fill. Material with an EI of 50 or less should be placed from 3 feet below the deepest planned footing bottom level to finished pad grade. Hardscape should be underlain by at least 2 feet of material with an expansion index of 50 or less.

Fill should be placed in horizontal lifts at a thickness appropriate for the equipment spreading, mixing, and compacting the material, but generally should not exceed 8 inches in loose thickness. Fill should be moisture conditioned to near optimum moisture content and compacted to at least 90% relative compaction. The maximum dry density and optimum moisture content for evaluating relative compaction should be determined in accordance with ASTM D 1557. Utility trench backfill beneath structures, pavements and hardscape should be compacted to at least 90% relative compaction. The top 12 inches of subgrade beneath pavements should be compacted to at least 95%.

8.1.7 Imported Soil

Imported soil should consist of predominately granular soil free of organic matter and rocks greater than 6 inches. Imported soil should be observed and, if appropriate, tested by SCST prior to transport to the site to determine suitability for the intended use.

8.1.8 Excavation Characteristics

It is anticipated that excavations can be achieved with conventional earthwork equipment in good working order. Difficult excavation should be anticipated in cemented zones within the Lusardi Formation. Abundant gravel, cobbles, and boulders should also be anticipated. Contract documents should specify that the contractor mobilize equipment capable of excavating and compacting strongly cemented materials and materials with gravel, cobbles, and boulders.

8.1.9 Temporary Excavations

Temporary excavations 3 feet deep or less can be made vertically. Deeper temporary excavations in fill should be laid back no steeper than 1:1 (horizontal:vertical) and in formational materials no steeper than ¾:1 (horizontal:vertical). The faces of temporary slopes should be inspected daily by the contractor's Competent Person before personnel are allowed to enter the excavation. Any zones of potential instability, sloughing, or raveling should be brought to the attention of the Engineer and corrective action implemented before personnel begin working in the excavation. Excavated soils should not be stockpiled behind temporary excavations within a distance equal to the depth of the excavation. SCST should be notified if other surcharge loads are anticipated so that lateral load criteria can be developed for the specific situation. If temporary slopes are to be maintained during the rainy season, berms are recommended along the tops of slopes to prevent runoff water from entering the excavation and eroding the slope faces.

Slopes steeper than those described above will require shoring. Additionally, temporary excavations that extend below a plane inclined at 1½:1 (horizontal:vertical) downward from the outside bottom edge of existing structures or improvements will require shoring. Soldier piles and lagging, internally braced shoring, or trench boxes could be used. If trench boxes are used, the soil immediately adjacent to the trench box is not directly supported. Ground surface deformations immediately adjacent to the pit or trench could be greater where trench boxes are used compared to other methods of shoring.

As an alternative to shoring/underpinning, maximum 10-foot-wide slots can be excavated and immediately backfilled adjacent to existing structures and improvements. Care should be taken to not undermine existing footings. Slot excavations should be filled prior to performing adjacent excavations.

8.1.10 Temporary Shoring

For design of cantilevered shoring, an active soil pressure equal to a fluid weighing 35 pcf can be used for level retained ground or 55 pcf for 2:1 (horizontal:vertical) sloping ground. The surcharge loads on shoring from traffic and construction equipment adjacent to the excavation can be modeled by assuming an additional 2 feet of soil behind the shoring. For design of soldier piles, an allowable passive pressure of 350 psf per foot of embedment over twice the pile diameter up to a maximum of 5,000 psf can be used. Soldier piles should be spaced at least three pile diameters, center to center. Continuous lagging will be required throughout. The soldier piles should be designed for the full anticipated lateral pressure; however, the pressure on the lagging will be less due to arching in the soils. For design of lagging, the earth pressure can be limited to a maximum value of 400 psf.

8.1.11 Temporary Dewatering

Groundwater seepage may occur locally due to broken pipes, local irrigation, or following heavy rain. Groundwater should be anticipated in the planned excavations. Dewatering can be accomplished by sloping the excavation bottom to a sump and pumping from the sump. A layer of gravel about 6 inches thick placed in the bottom of the excavation will facilitate groundwater flow and can be used as a working platform.

8.1.12 Oversized Material

Excavations may generate oversized material. Oversized material is defined as rocks or cemented clasts greater than 6 inches in largest dimension. Oversized material should be broken down to no greater than 6 inches in largest dimension for use in fill, used as landscape material, or disposed of offsite.

8.1.13 Slopes

All permanent slopes should be constructed no steeper than 2:1 (horizontal:vertical). Faces of fill slopes should be compacted either by rolling with a sheepsfoot roller or other suitable equipment or by overfilling and cutting back to design grade. Fills should be benched into sloping ground inclined steeper than 5:1 (horizontal:vertical). It is our opinion that cut slopes constructed no steeper than 2:1 (horizontal:vertical) will possess an adequate factor of safety. An engineering geologist should observe all cut slopes during grading to ascertain that no unforeseen adverse geologic conditions are encountered that require revised recommendations. All slopes are susceptible to surficial slope failure and erosion. Water should not be allowed to flow over the top of slope. Additionally, slopes should be planted with vegetation that will reduce the potential for erosion.

8.1.14 Surface Drainage

Final surface grades around structures should be designed to collect and direct surface water away from the structure and toward appropriate drainage facilities. The ground around the structure should be graded so that surface water flows rapidly away from the structure without ponding. In general, we recommend that the ground adjacent to the structure slope away at a gradient of at least 2%. Densely vegetated areas where runoff can be impaired should have a minimum gradient of at least 5% within the first 5 feet from the structure. Roof gutters with downspouts that discharge directly into a closed drainage system are recommended on structures. Drainage patterns established at the time of fine grading should be maintained throughout the life of the proposed structures.

Site irrigation should be limited to the minimum necessary to sustain landscape growth. Should excessive irrigation, impaired drainage, or unusually high rainfall occur, saturated zones of perched groundwater can develop.

8.1.15 Grading Plan Review

SCST should review the grading plans and earthwork specifications to ascertain whether the intent of the recommendations contained in this report have been implemented and that no revised recommendations are needed due to changes in the development scheme.

8.2 FOUNDATIONS

8.2.1 Shallow Spread Footings

The proposed structures can be supported on spread footings with bottom levels on compacted fill or formational materials. Individual buildings should be supported either entirely on compacted fill or entirely on formation. To accommodate bearing on formation, 3-sack sand/cement slurry can be placed between the formation and design bottom of footing. Footings should extend at least 24 inches below lowest adjacent finished grade. A minimum width of 12 inches is recommended for continuous footings and 24 inches for isolated or wall footings. An allowable bearing capacity of 2,500 psf can be used for footings supported on compacted fill. An allowable bearing capacity of 5,000 psf can be used for footings supported on formation. The allowable bearing capacity can be increased by 500 psf for each foot of depth below the minimum and 250 psf for each foot of width beyond the minimum up to a maximum of 5,000 psf on compacted fill or 7,500 psf on formation. The bearing value can be increased by ⅓ when considering the total of all loads, including wind or seismic forces. Footings located adjacent to or within slopes should be extended to a depth such that a minimum horizontal distance of 7 feet exists between the lower outside footing edge and the face of the slope.

Lateral loads will be resisted by friction between the bottoms of footings and passive pressure on the faces of footings and other structural elements below grade. An allowable coefficient of friction of 0.35 can be used. Passive pressure can be computed using an allowable lateral pressure of 350 psf per foot of depth below the ground surface for level ground conditions. The passive pressure can be increased by ⅓ when considering the total of all loads, including wind or seismic forces. The upper 1 foot of soil should not be relied on for passive support unless the ground is covered with pavements or slabs.

8.2.2 Settlement Characteristics

Total foundation settlements are estimated to be less than 1 inch. Differential settlements between adjacent columns and across continuous footings are estimated to be less than ¾ inch over a distance of 40 feet. Settlements should be completed shortly after structural loads are applied.

8.2.3 Foundation Plan Review

SCST should review the foundation plans to ascertain that the intent of the recommendations in this report has been implemented and that revised recommendations are not necessary as a result of changes after this report was completed.

8.2.4 Foundation Excavation Observations

A representative from SCST should observe the foundation excavations prior to forming or placing reinforcing steel.

8.3 SLABS-ON-GRADE

8.3.1 Building Slabs-on-Grade

The project structural engineer should design the interior concrete slab-on-grade floors. However, we recommend that building slabs be at least 5 inches thick and reinforced with at least No. 4 bars at 18 inches on center each way.

Moisture protection should be installed beneath slabs where moisture sensitive floor coverings will be used. The project architect should review the tolerable moisture transmission rate of the proposed floor covering and specify an appropriate moisture protection system. Typically, a plastic vapor barrier is used. Minimum 10-mil plastic is recommended. The plastic should comply with ASTM E1745. The vapor barrier installation should comply with ASTM E1643. The slab can be placed directly on the vapor barrier.

8.3.2 Parking Structure Slab-on-Grade

We recommend that the parking structure slab-on-grade be at least 6 inches thick and reinforced with at least No. 4 bars at 18 inches on center each way. Concrete should have a minimum compressive strength of 3,250 pounds per square inch (psi).

8.3.3 Exterior Slabs-on-Grade

Exterior slabs should be at least 4 inches thick and reinforced with at least No. 3 bars at 18 inches on center each way. Slabs should be provided with weakened plane joints. Joints should be placed in accordance with the American Concrete Institute (ACI) guidelines. The project architect should select the final joint patterns. A 1-inch maximum size aggregate mix is recommended for concrete for exterior slabs. The corrosion potential of on-site soils with respect to reinforced concrete will need to be taken into account in concrete mix design. Coarse and fine aggregate in concrete should conform to the “Greenbook” Standard Specifications for Public Works Construction.

8.4 CONVENTIONAL RETAINING WALLS

8.4.1 Foundations

The recommendations provided in the foundation section of this report are also applicable to conventional retaining walls.

8.4.2 Lateral Earth Pressures

The active earth pressure for the design of unrestrained retaining walls with level backfill can be taken as equivalent to the pressure of a fluid weighing 35 pcf. The at-rest earth pressure for the design of restrained retaining walls with level backfills can be taken as equivalent to the pressure of a fluid weighing 55 pcf. These values assume a granular and drained backfill condition. Higher lateral earth pressures would apply if walls retain clay soils. An additional 20 pcf should be added to these values for walls with a 2:1 (horizontal:vertical) sloping backfill. An increase in earth pressure equivalent to an additional 2 feet of retained soil can be used to account for surcharge loads from light traffic. The above values do not include a factor of safety. Appropriate factors of safety should be incorporated into the design. If any other surcharge loads are anticipated, SCST should be contacted for the necessary increase in soil pressure.

Retaining walls should be designed to resist hydrostatic pressures or be provided with a backdrain to reduce the accumulation of hydrostatic pressures. The backdrain can consist of a 2-foot-wide zone of ¾-inch crushed rock. The backdrain should be separated from the adjacent soils using a non-woven filter fabric, such as Mirafi 140N or equivalent. Weep holes should be provided, or a perforated pipe should be installed at the base of the backdrain and sloped to discharge to a suitable storm drain facility. As an alternative, a geocomposite drainage system such as Miradrain 6000 or equivalent placed behind the wall and connected to a suitable storm drain facility can be used. The project architect should provide dampproofing specifications and details. Figure 6 presents typical conventional retaining wall backdrain details.

8.4.3 Seismic Earth Pressure

If required, the seismic earth pressure can be taken as equivalent to the pressure of a fluid weighing 15 pcf. This value is for level backfill and does not include a factor of safety. Appropriate factors of safety should be incorporated into the design. This pressure is in addition to the un-factored, static active earth pressure. The passive pressure and bearing capacity can be increased by ⅓ in determining the seismic stability of the wall.

8.4.4 Backfill

Wall backfill should consist of granular, free-draining material having a sand equivalent of 20 or more. The backfill zone is defined by a 1:1 plane projected upward from the heel of the wall. Expansive or clayey soil should not be used. Additionally, backfill within 3 feet from the back of the wall should not contain rocks greater than 3 inches in dimension. Backfill should be compacted to at least 90% relative compaction. Backfill should not be placed until walls have achieved adequate structural strength. Compaction of wall backfill will be necessary to minimize settlement of the backfill and overlying settlement sensitive improvements. However, some settlement should still be anticipated. Provisions should be made for some settlement of concrete slabs and pavements supported on backfill. Additionally, any utilities supported on backfill should be designed to tolerate differential settlement.

8.5 MECHANICALLY STABILIZED EARTH RETAINING WALLS

The following soil parameters can be used for design of mechanically stabilized earth (MSE) retaining walls.

MSE Wall Design Parameters

Soil Parameter	Reinforced Soil	Retained Soil	Foundation Soil
Internal Friction Angle	32°	32°	32°
Cohesion	0	0	0
Moist Unit Weight	125 pcf	125 pcf	125 pcf

The reinforced soil should consist of granular, free-draining material with an expansion index of 20 or less. The bottom of MSE walls should extend to such a depth that a total of 5 feet exists between the bottom of the wall and the face of the slope. Figure 7 presents a typical MSE retaining wall backdrain detail. MSE retaining walls may experience lateral movement over time. The wall engineer should review the configuration of proposed improvements adjacent to the wall and provide measures to help reduce the potential for distress to these improvements from lateral movement.

8.6 PIPELINES

8.6.1 Thrust Blocks

For level ground conditions, a passive earth pressure of 350 psf per foot of depth below the lowest adjacent final grade can be used to compute allowable thrust block resistance. A value of 150 psf per foot should be used below groundwater level if encountered.

8.6.2 Modulus of Soil Reaction

A modulus of soil reaction (E’) of 2,000 psi can be used to evaluate the deflection of buried flexible pipelines. This value assumes that granular bedding material is placed adjacent to the pipe and is compacted to at least 90% relative compaction.

8.6.3 Pipe Bedding

Pipe bedding as specified in the “Greenbook” Standard Specifications for Public Works Construction can be used. Bedding material should consist of clean sand having a sand equivalent not less than 20 and should extend to at least 12 inches above the top of pipe. Alternative materials meeting the intent of the bedding specifications are also acceptable. Samples of materials proposed for use as bedding should be provided to the engineer for inspection and testing before the material is imported for use on the project. The on-site materials are not expected to meet “Greenbook” bedding specifications. The pipe bedding material should be placed over the full width of the trench. After placement of the pipe, the bedding should be brought up uniformly on both sides of the pipe to reduce the potential for unbalanced loads. No voids or uncompacted areas should be left beneath the pipe haunches. Ponding or jetting the pipe bedding should not be allowed.

8.6.4 Cutoff Walls

Where pipeline inclinations exceed 15 percent, cutoff walls may be necessary in trench excavations. Additionally, we do not recommend that open-graded rock be used for pipe bedding or backfill because of the potential for piping erosion. The recommended bedding is sand having a sand equivalent not less than 20. Alternatively, 2-sack sand-cement slurry can be used for the pipe bedding. If sand-cement slurry is used for pipe bedding to at least 1 foot over the top of the pipe, cutoff walls are not considered necessary. The need for cutoff walls should be further evaluated by the project civil engineer designing the pipeline.

8.6.5 Backfill

Excavated material free of organic debris and rocks greater than 6 inches in any dimension are generally expected to be suitable for use as backfill unless beneath buildings or hardscape. Imported material should not contain rocks greater than 4 inches in any dimension or organic debris. Imported material should have an expansion index of 20 or less. SCST should observe and, if appropriate, test proposed imported materials before they are delivered to the site. Backfill should be placed in lifts 8 inches or less in loose thickness, moisture conditioned to optimum moisture content or slightly above, and compacted to at least 90% relative compaction. The top 12 inches of soil beneath pavement subgrade should be compacted to at least 95% relative compaction.

8.7 PAVEMENT SECTION RECOMMENDATIONS

The pavement support characteristics of the soils encountered during our investigation are considered low to medium. An R-value of 20 was assumed for design of preliminary pavement sections. The actual R-value of the subgrade soils should be determined after grading and final pavement sections are provided. Based on an R-value of 20, the following pavement structural sections are recommended for the assumed Traffic Indexes.

Traffic Type	Traffic Index	Asphalt Concrete (inches)	Portland Cement Concrete (inches)
Parking Stalls	5.0	3 AC / 7 AB	6 PCC
Driveways	6.0	4 AC / 9 AB	6 PCC / 6AB
Fire Lanes	7.5	5 AC / 12 AB	7 PCC / 6 AB

AC - Asphalt Concrete
AB - Aggregate Base
PCC - Portland Cement Concrete

The top 12 inches of subgrade should be scarified, moisture conditioned to near optimum moisture content, and compacted to at least 95% relative compaction. All soft or yielding areas should be stabilized or removed and replaced with compacted fill or aggregate base. Aggregate base and asphalt concrete should conform to the Caltrans Standard Specifications or the "Greenbook" and should be compacted to at least 95% relative compaction. Aggregate base should have an R-value of not less than 78. All materials and methods of construction should conform to good engineering practices and the minimum standards of City of Carlsbad.

8.8 PERVIOUS PAVEMENT SECTION RECOMMENDATIONS

Pervious pavement section recommendations are based on Caltrans (2014) pavement structural design guidelines. The pavement sections below are based on the strength of the materials. However, the actual thickness of the sections may be controlled by the reservoir layer design, which the project civil engineer should determine.

Pervious Asphalt Pavement

Traffic Type	Category	*Asphalt Treated Permeable Base (ATPB) (inches)	Class 4 Aggregate Base (inches)
Parking Stalls	B	4½	7

***1¼ inches of an open-graded friction course (OGFC) should be placed on top of the ATPB.**

Pervious Concrete Pavement

Traffic Type	Category	Pervious Concrete (inches)	Class 4 Aggregate Base (inches)
Parking Stalls	B	5½	8½

Permeable Interlocking Concrete Pavers (PICP)

Traffic Type	Category	PICP (inches)	Class 3 Permeable (inches)	Class 4 Aggregate Base (inches)
Parking Stalls	B	3⅛	4½	8½

The top 12 inches of subgrade should be scarified, moisture conditioned to near optimum moisture content, and compacted to at least 95% relative compaction. All soft or yielding subgrade areas should be stabilized or removed and replaced with compacted fill or permeable base. All materials and methods of construction should conform to good engineering practices and the minimum local standards.

Deepened curbs or vertical cutoff membranes consisting of 30 mil HDPE or PVC should be installed at the edges of pervious pavements to reduce the potential for water-related distress to adjacent structures or improvements. The membrane should extend below the reservoir section. If infiltration is not used, the membrane should also extend horizontally between the subgrade and pervious base, and a suitable subdrain system should be installed.

8.9 SOIL CORROSIVITY

Representative samples of the on-site soils were tested to evaluate corrosion potential. The test results are presented in Appendix II. The project design engineer can use the sulfate results in conjunction with ACI 318 to specify the water/cement ratio, compressive strength and cementitious material types for concrete exposed to soil. A corrosion engineer should be contacted to provide specific corrosion control recommendations.

8.10 INFILTRATION

We performed four borehole percolation tests at the approximate locations shown in Figure 2 to assess stormwater infiltration feasibility. Appendix III presents the field data and test results. The table below presents the tested infiltration rates.

Infiltration Rate Test Results

Test Location	Test Depth (feet)	Material at Test Depth	Infiltration Rate (inch/hour)
P-1	5	Fill: Clayey Sand	0.0
P-2	5	Fill: Clayey Sand	0.1
P-3	3	Fill: Silty Sand with Gravel	0.0
P-4	4	Fill: Clayey Sand	<0.1

The tested infiltration rates do not support stormwater infiltration in any appreciable quantity. The feasibility screening category is considered No Infiltration. BMP facilities should be lined with an impermeable geomembrane to reduce the potential for water-related distress to adjacent structures or improvements. A subdrain system should be installed at the bottom of BMP facilities. Foundations should be set back at least 10 feet from BMP facilities, or the foundation should be deepened to a depth that extends below the bottom of the BMP.

9. GEOTECHNICAL ENGINEERING DURING CONSTRUCTION

The geotechnical engineer should review project plans and specifications prior to bidding and construction to check that the intent of the recommendations in this report has been incorporated. Observations and tests should be performed during construction. If the conditions encountered during construction differ from those anticipated based on the subsurface exploration program, the presence of the geotechnical engineer during construction will enable an evaluation of the exposed conditions and modifications of the recommendations in this report or development of additional recommendations in a timely manner.

10. CLOSURE

SCST should be advised of any changes in the project scope so that the recommendations contained in this report can be evaluated with respect to the revised plans. Changes in recommendations will be verified in writing. The findings in this report are valid as of the date of this report. Changes in the condition of the site can, however, occur with the passage of time, whether they are due to natural processes or work on this or adjacent areas. In addition, changes in the standards of practice and government regulations can occur. Thus, the findings in this report may be invalidated wholly or in part by changes beyond our control. This report should not be relied upon after a period of two years without a review by us verifying the suitability of the conclusions and recommendations to site conditions at that time.

In the performance of our professional services, we comply with that level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions and in the same locality. The client recognizes that subsurface conditions may vary from those encountered at the boring locations and that our data, interpretations, and recommendations are based solely on the information obtained by us. We will be responsible for those data, interpretations, and recommendations, but shall not be responsible for interpretations by others of the information developed. Our services consist of professional consultation and observation only, and no warranty of any kind whatsoever, express or implied, is made or intended in connection with the work performed or to be performed by us, or by our proposal for consulting or other services, or by our furnishing of oral or written reports or findings.

11. REFERENCES

American Concrete Institute (ACI) (2012), Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary, August.

California Emergency Management Agency, California Geological Survey, University of Southern California (Cal EMA) (2009), Tsunami Inundation Map for Emergency Planning, June 1.

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International Code Council (2015), 2016 California Building Code, California Code of Regulations, Title 24, Part 2, Volume 2 of 2, Based on the 2015 International Existing Building Code, Effective January 1, 2017.

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Public Works Standards, Inc. (2015), The “Greenbook,” Standard Specifications for Public Works Construction, 2015 Edition.

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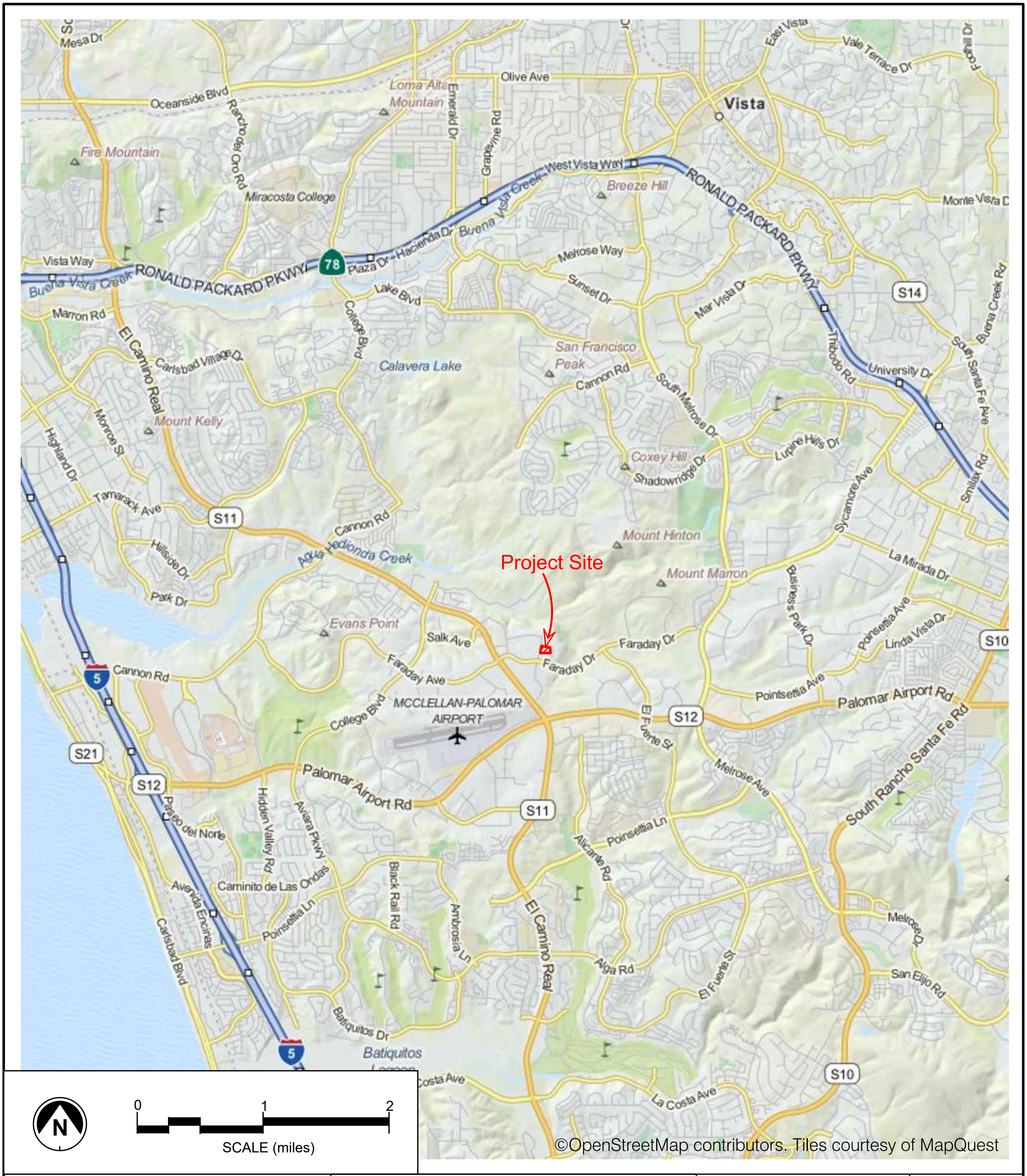

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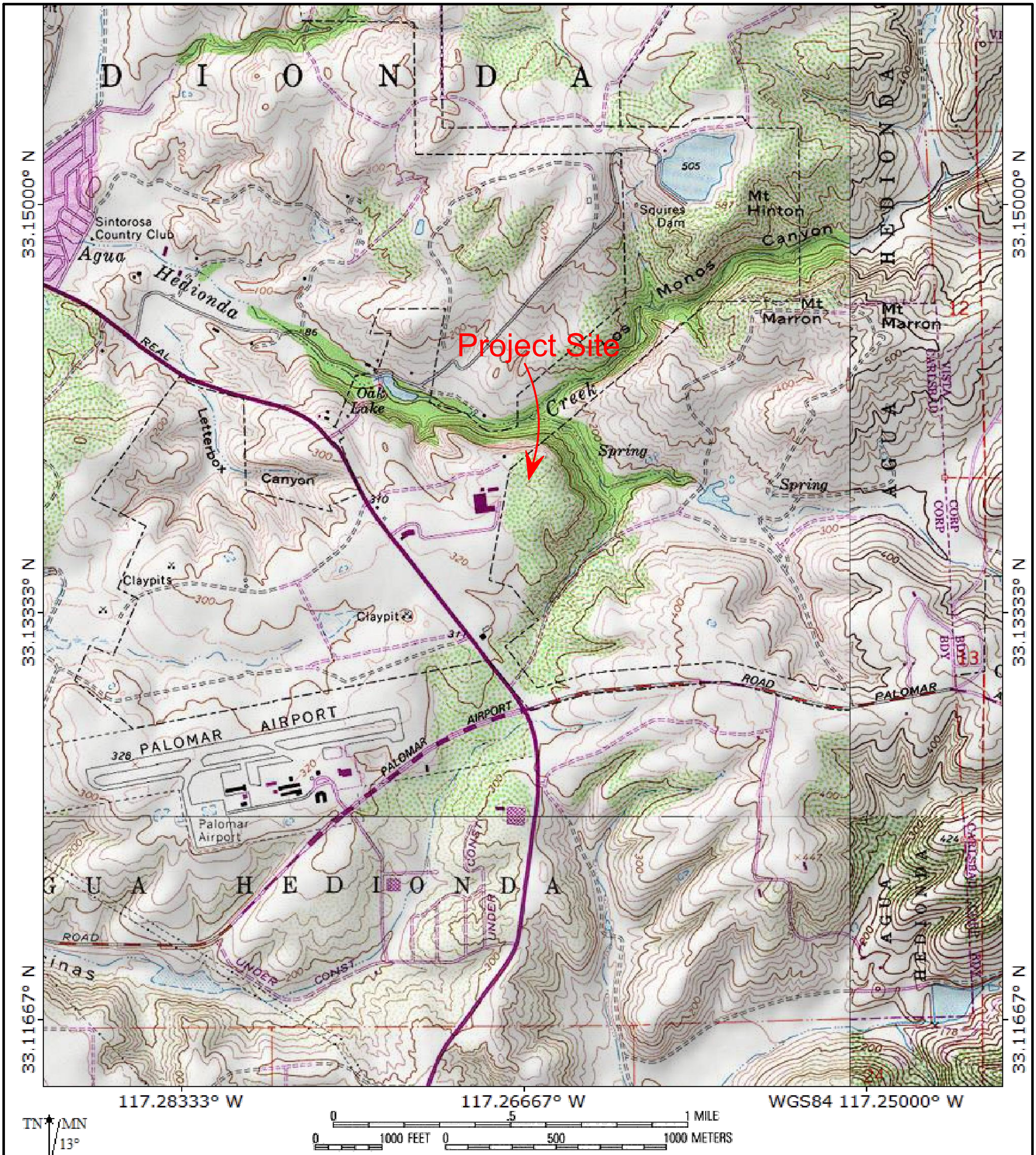
SITE VICINITY MAP

City of Carlsbad Orion Center
Carlsbad, California

Date: March, 2019
By: JCU/DTC
Job No.: 180396P4-1

Figure:
1



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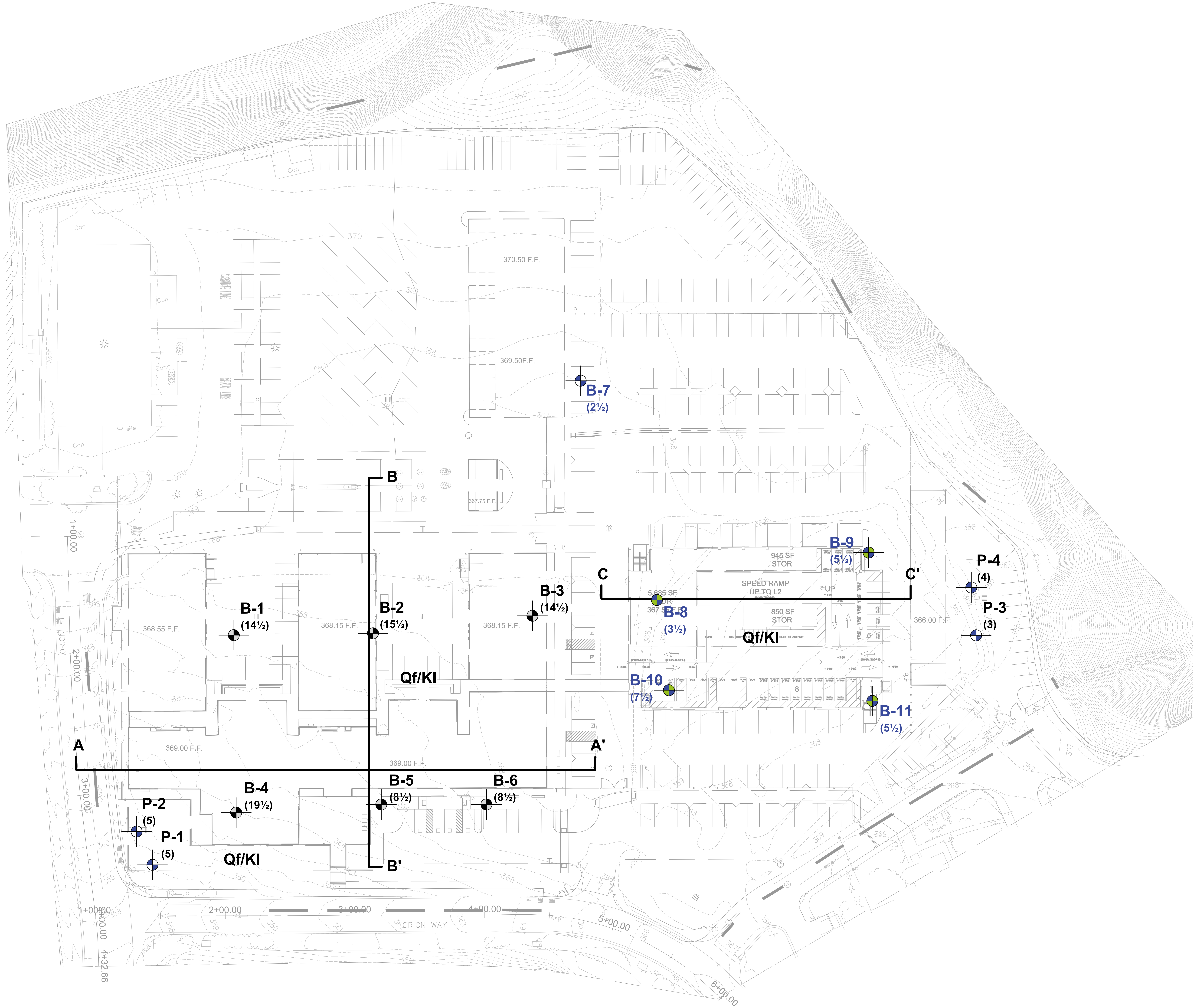
USGS TOPOGRAPHY MAP

City of Carlsbad Orion Center
Carlsbad, California

Date:	March, 2019
By:	JCU/DTC
Job No.:	180396P4-1

Figure:
2



SCST LEGEND:

B-11 (5½)	Approximate Location of Additional Boring (Depth of Fill)
B-6 (8½)	Approximate Location of Previous Boring (SCST, 2016) (Depth in Feet)
P-4 (4)	Approximate Location of Previous Percolation Test (SCST, 2016) (Depth in Feet)
C C'	Approximate Location of Geologic Cross Section
Qf/Kl	Fill Underlain by Lusardi Formation

N

0 40 80
SCALE (feet)

SCST, LLC

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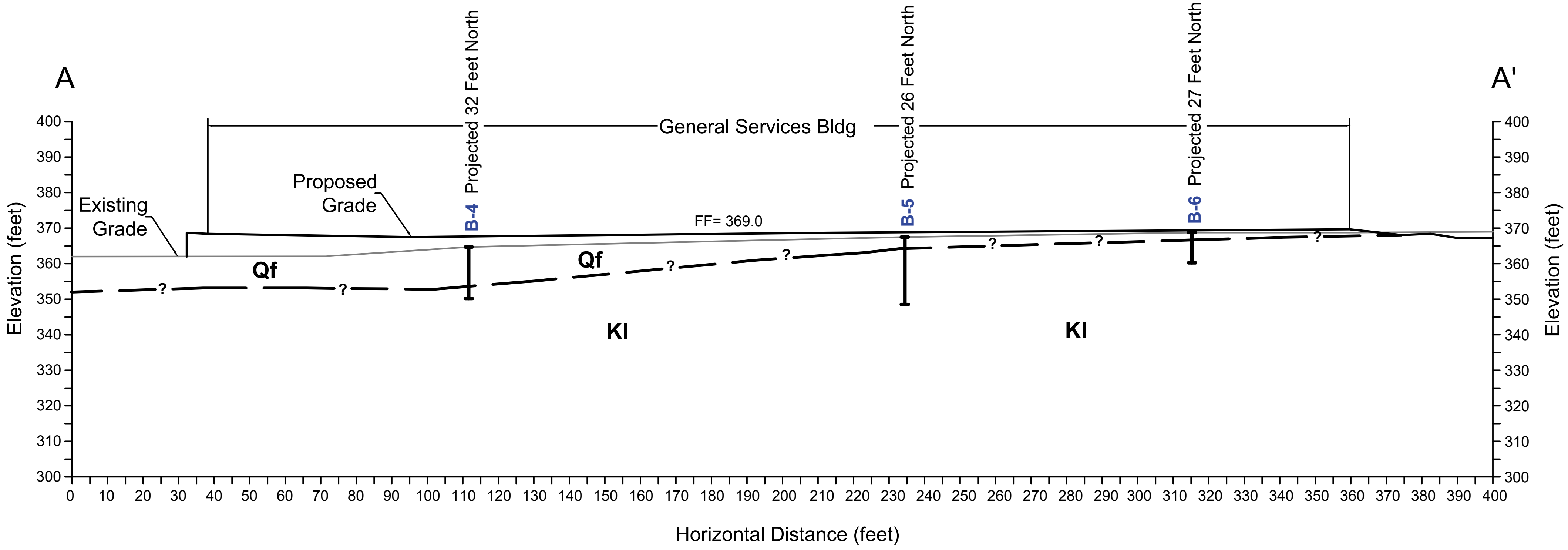
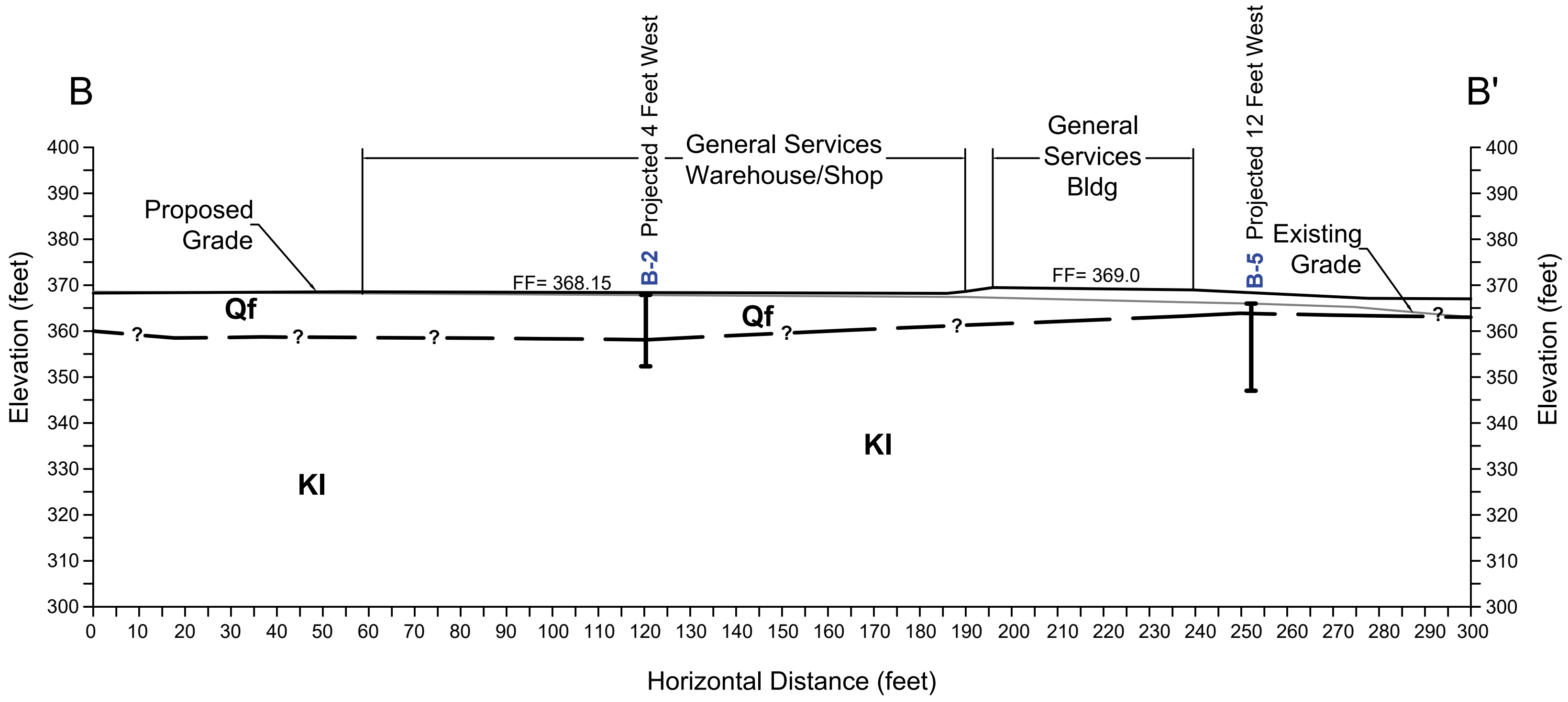
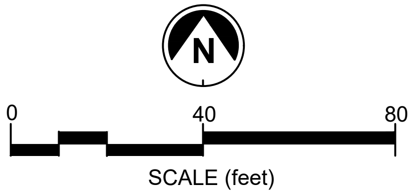
GEOTECHNICAL MAP

City of Carlsbad, Orion Center
Carlsbad, California

By:	JCU/DTC/EW	Date:	March, 2019
Job No.:	180396P4-1	Figure:	3







SCST LEGEND:

B-4 I	Approximate Location of Boring
—?—	Approximate Location of Geologic Contact, Queried Where Uncertain
Qf	Fill
Kl	Lusardi Formation

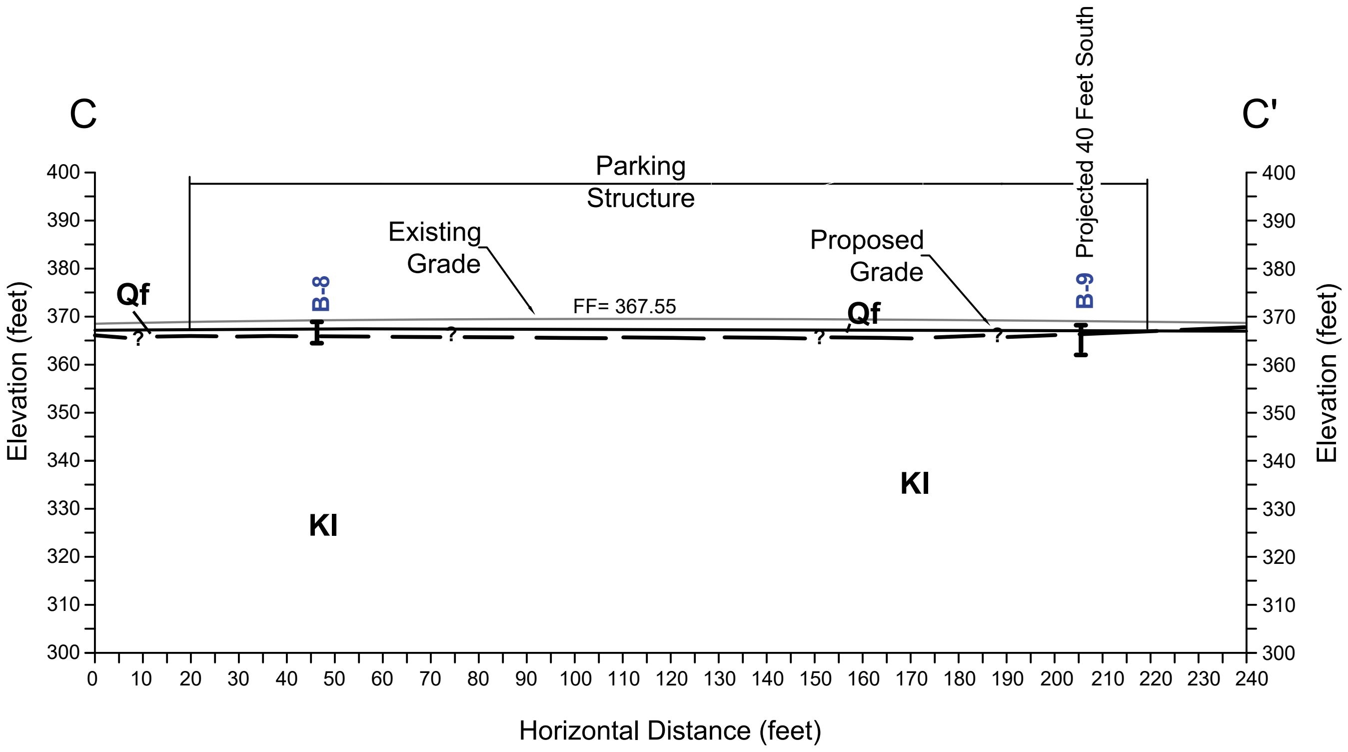
SCST, LLC

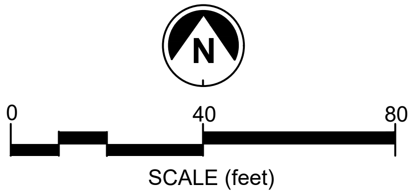
GEOLOGIC CROSS-SECTIONS

City of Carlsbad Orion Center
Carlsbad, California

Date: March, 2019
By: JCU/DTC
Job No.: 180396P4-1

Figure:
4A





SCST LEGEND:

B-9	Approximate Location of Boring
?	Approximate Location of Geologic Contact, Queried Where Uncertain
Qf	Fill
KI	Lusardi Formation

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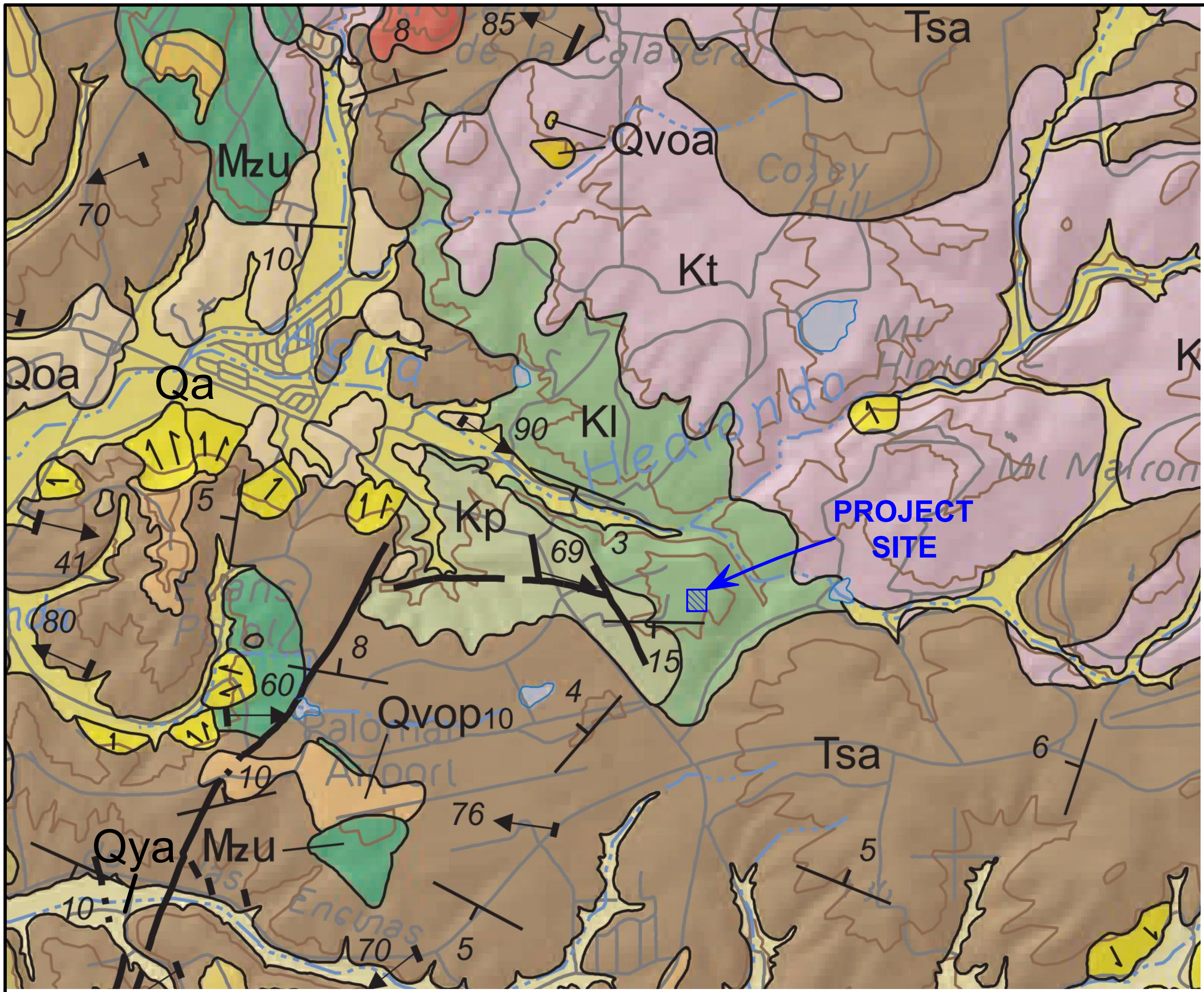
GEOLOGIC CROSS-SECTIONS

City of Carlsbad Orion Center
Carlsbad, California

Date: March, 2019
By: JCU/DTC
Job No.: 180396P4-1

Figure:
4B



EXPLANATION:

Qa	Alluvial flood-plain deposits
Qya	Young alluvial flood-plain deposits
Qoa	Old alluvial flood-plain deposits
Qvoa	Very old alluvial deposits
Qvop	Very old paralic deposits
Tsa	Santiago Formation
Kl	Lusardi Formation
Kt	Tonalite
Mzu	Metasedimentary and metavolcanic rocks,

Strike and **dip** of metamorphic foliation
Inclined

4
Strike and **dip** of beds
Inclined

Qls?
Landslide - Arrows indicate principal direction of movement. Queried where existence is questionable.

N

0 3,000 6,000
SCALE (feet)

Note: All locations are approximate

Reference:
Kennedy, M.P. and Tan, S.S. (2008), Geologic Map of the Oceanside 30' x 60' Quadrangle, California, California Geological Survey, Scale 1:100,000

SCST
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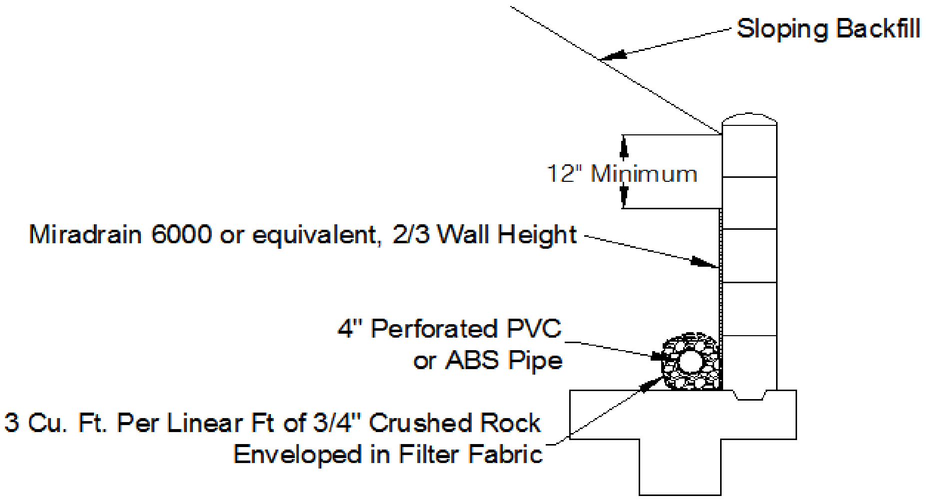
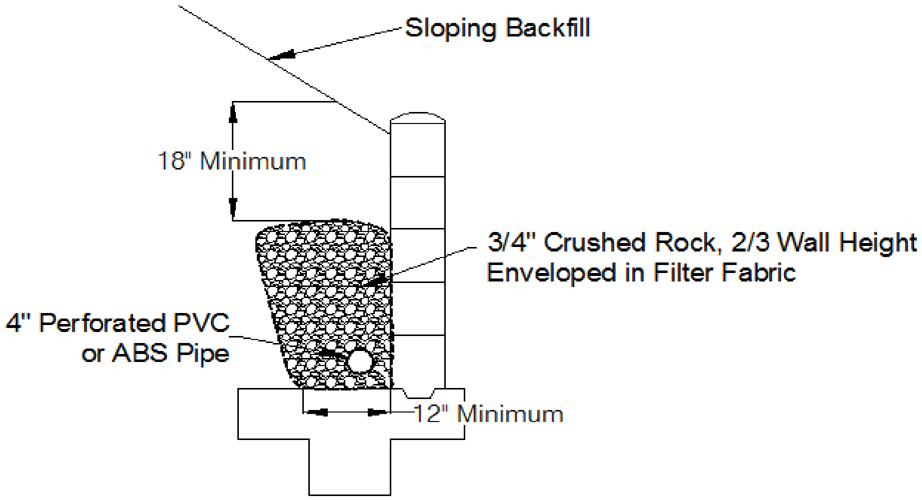
SCST, LLC

REGIONAL GEOLOGY MAP
City of Carlsbad Orion Center
Carlsbad, California

Date: March, 2019
By: DTC
Job No.: 180396P-1

Figure:
5





Not to Scale

NOTES

1) Waterproof back of wall following architect's specifications.

2) 4" minimum perforated pipe, SDR35 or equivalent, holes down, 1% fall to outlet. Provide solid outlet pipe at suitable locations.

3) Drain instalation and outlet connection should be observed by the geotechnical consultant.

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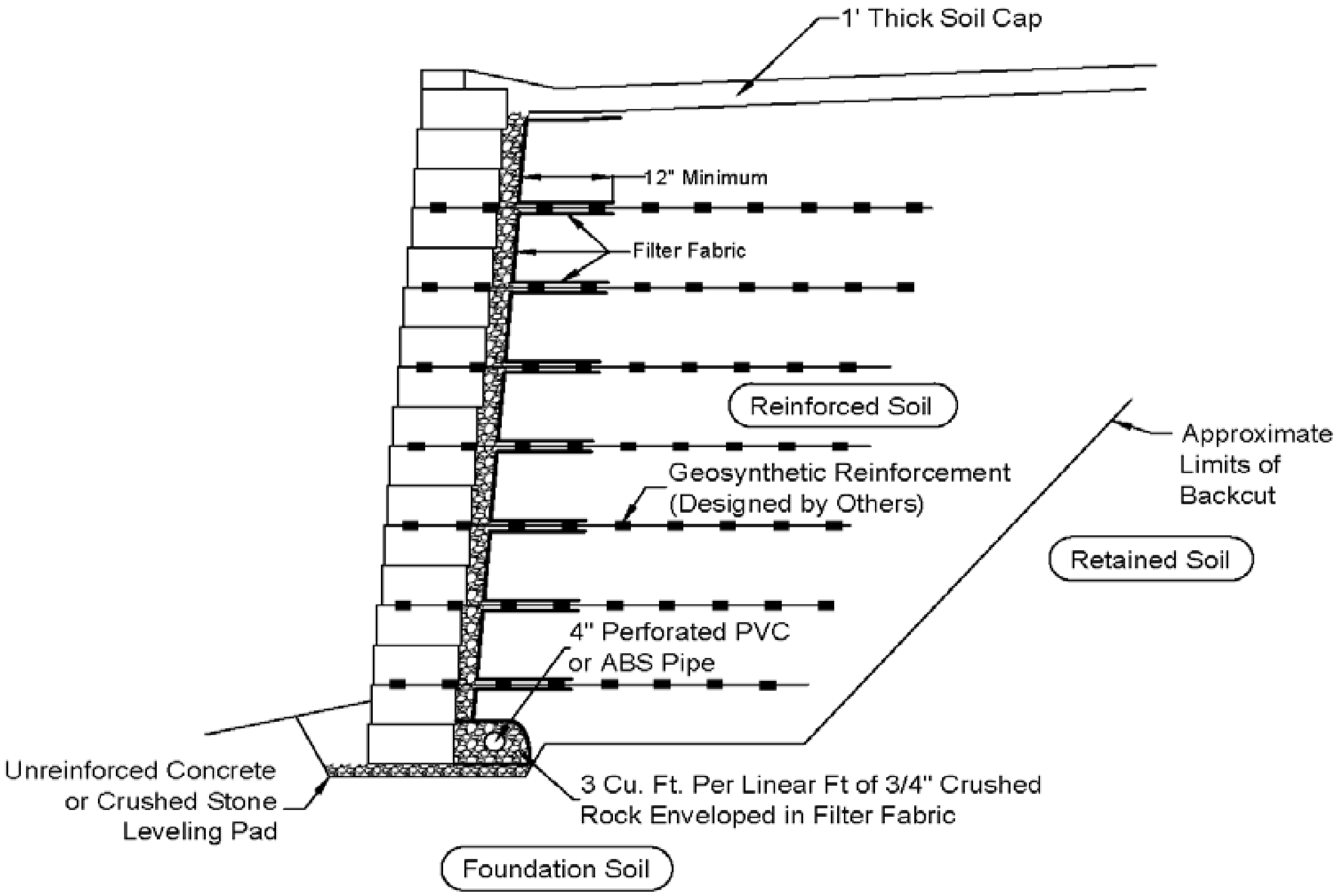
TYPICAL RETAINING WALL BACKDRAIN DETAILS
City of Carlsbad Orion Center
Carlsbad, California

By:	JCU	Date:	March, 2019
Job Number:	180396P4-1	Figure:	6



Not to Scale

NOTES

1) Backcut as recommended by the geotechnical report or field evaluation.
2) Additional drain at excavation backcut may be recommended based on conditions observed during construction.
3) Filter fabric should be installed between crushed rock and soil. Filter fabric should consist of Mirafi 140N or equivalent. Filter fabric should be overlapped approximately 6 inches.
4) Perforated pipe should outlet through a solid pipe to an appropriate gravity outfall. Perforated pipe and outlet pipe should have a fall of at least 1%.
5) Drain installation and outlet connection should be observed by the geotechnical consultant.

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TYPICAL MSE RETAINING WALL DETAIL
City of Carlsbad Orion Center
Carlsbad, California

By:	JCU	Date:	March, 2019
Job No:	180396P4-1	Figure:	7

APPENDIX I

APPENDIX I
FIELD INVESTIGATION

Our current field investigation consisted of drilling 5 borings on March 4, 2019 to depths between about 2½ and 7½ feet below the existing ground surface using a truck-mounted drill rig equipped with a hollow-stem auger or a hand auger. We previously drilled 6 borings and 4 percolation test borings on June 1 and 2, 2016 to depths between about 3 and 19 feet below the existing ground surface using a truck-mounted drill rig equipped with a hollow-stem auger (SCST, 2016). Auger refusal was encountered in several of the borings. The field investigations were performed under the observation of an SCST geologist or engineer who also logged the borings and obtained samples of the materials encountered.

Relatively undisturbed samples were obtained using a modified California (CAL) sampler, which is a ring-lined split tube sampler with a 3-inch outer diameter and 2½-inch inner diameter. Standard Penetration Tests (SPT) were performed using a 2-inch outer diameter and 1⅜-inch inner diameter split tube sampler. The CAL and SPT samplers were driven with a 140-pound weight dropping 30 inches. The number of blows needed to drive the samplers the final 12 inches of an 18-inch drive is noted on the boring logs as “Driving Resistance (blows/ft of drive).” SPT and CAL sampler refusal was encountered when 50 blows were applied during any one of the three 6-inch intervals, a total of 100 blows was applied, or there was no discernible sampler advancement during the application of 10 successive blows. The SPT penetration resistance was normalized to a safety hammer (cathead and rope) with a 60% energy transfer ratio in accordance with ASTM D6066. The normalized SPT penetration resistance is noted on the boring logs as “N_{60}.” Disturbed bulk samples were obtained from the SPT sampler and the drill cuttings.

The soils are classified in accordance with the Unified Soil Classification System as illustrated on Figure I-1. Logs of the current borings are presented in the following Figures I-2 through I-6. Logs of the previous borings are also included.

SUBSURFACE EXPLORATION LEGEND

UNIFIED SOIL CLASSIFICATION CHART

SOIL DESCRIPTION		GROUP SYMBOL	TYPICAL NAMES
I. COARSE GRAINED, more than 50% of material is larger than No. 200 sieve size.			
GRAVELS More than half of coarse fraction is larger than No. 4 sieve size but smaller than 3".	CLEAN GRAVELS	GW	Well graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels, gravel sand mixtures, little or no fines.
	GRAVELS WITH FINES (Appreciable amount of fines)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		GC	Clayey gravels, poorly graded gravel-sand, clay mixtures.
SANDS More than half of coarse fraction is smaller than No. 4 sieve size.	CLEAN SANDS	SW	Well graded sand, gravelly sands, little or no fines.
		SP	Poorly graded sands, gravelly sands, little or no fines.
		SM	Silty sands, poorly graded sand and silty mixtures.
		SC	Clayey sands, poorly graded sand and clay mixtures.
II. FINE GRAINED, more than 50% of material is smaller than No. 200 sieve size.			
	SILTS AND CLAYS (Liquid Limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, sandy silt or clayey-silt-sand mixtures with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty clays or low plasticity.
	SILTS AND CLAYS (Liquid Limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity.
III. HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils.

SAMPLE SYMBOLS

☒	- Bulk Sample
CAL	- Modified California Sampler
CK	- Undisturbed Chunk sample
MS	- Maximum Size of Particle
ST	- Shelby Tube
SPT	- Standard Penetration Test sampler

GROUNDWATER SYMBOLS

▽	- Water level at time of excavation or as indicated
≀≀	- Water seepage at time of excavation or as indicated

LABORATORY TEST SYMBOLS

AL	- Atterberg Limits
CON	- Consolidation
COR	- Corrosivity Tests (Resistivity, pH, Chloride, Sulfate)
DS	- Direct Shear
EI	- Expansion Index
MAX	- Maximum Density
RV	- R-Value
SA	- Sieve Analysis

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	JPS/EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	I-1

LOG OF BORING B-7

Date Drilled: 3/4/2019
Equipment: 6-inch Diameter Hand Auger
Elevation (ft): 368

Logged by: EMW
Reviewed by: TBC
Depth to Groundwater (ft): 2

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		4 inches of Asphalt Concrete over 6 inches of Aggregate Base.							
1	SM	**<u>FILL (Qf)</u>:** SILTY SAND with GRAVEL, brown, fine to medium grained, moist, medium dense. ▽ Groundwater encountered at 2 feet. Wet.							
2									
3		**<u>LUSARDI FORMATION (Kl)</u>:** SILTY SANDSTONE, light brown, fine to medium grained, wet, weakly cemented.							
4		**BORING TERMINATED AT 2½ FEET**							
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	JPS/EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	I-2

LOG OF BORING B-8

Date Drilled: 3/4/2019
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 369

Logged by: EMW
Reviewed by: TBC
Depth to Groundwater (ft): Not encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		4 inches of Asphalt Concrete.							
1	SM	**<u>FILL (Qf)</u>:** SILTY SAND with GRAVEL, brown, fine to medium grained, moist, medium dense.		☒					
2		Light brown, trace gravel and cobbles.		☒					
3		**<u>LUSARDI FORMATION (Kl)</u>:** CONGLOMERATE, gray, silty sandstone matrix, moist, very dense, abundant gravel, cobbles and boulders.	CAL		50/4"		--	--	
4		**AUGER REFUSAL AT 3½ FEET**							
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	JPS/EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	I-3

LOG OF BORING B-9

Date Drilled: 3/4/2019
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 370

Logged by: EMW
Reviewed by: TBC
Depth to Groundwater (ft): Not encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	 BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
	SM	**FILL (Qf)**: SILTY SAND, brown, fine to coarse grained, moist, medium dense, some gravel.		☒					SA AL EI COR
1									
2		**LUSARDI FORMATION (Kl)**: CONGLOMERATE, gray to light brown, silty sand matrix, moist, very dense, strongly cemented, abundant gravel, cobbles and boulders.	SPT	☒	50/4"	65/4"			
3									
4									
5			SPT	☒	50/2"	65/2"			
		AUGER REFUSAL AT 5½ FEET							
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By: JPS/EMW
Date: March, 2019
Job Number: 180396P4-1
Figure: I-4

LOG OF BORING B-10

Date Drilled: 3/4/2019
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 369½
Logged by: EMW
Reviewed by: TBC
Depth to Groundwater (ft): Not encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		5 inches of Asphalt Concrete.							
1	SC	**FILL (Qf):** CLAYEY SAND, brown, fine to coarse grained, moist, medium dense, trace gravel.		☒					
2		**LUSARDI FORMATION (Kl):** CONGLOMERATE, light gray, clayey sandstone matrix, moist, very dense, strongly cemented, abundant gravel, cobbles and boulders.							
3			CAL		50/3"		10.7	120.0	SA AL EI RV
4									
5			SPT		50/3"	65/3"			
6			SPT		50/2"	65/2"			
7									
8		**AUGER REFUSAL AT 7½ FEET**							
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By: JPS/EMW
Date: March, 2019
Job Number: 180396P4-1
Figure: I-5

LOG OF BORING B-11

Date Drilled: 3/4/2019
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 368

Logged by: EMW
Reviewed by: TBC
Depth to Groundwater (ft): Not encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		4 inches of Asphalt Concrete.							
1	SM	**FILL (Qf):** SILTY SAND, brown, fine to coarse grained, moist, medium dense		☒					EI COR
2		**LUSARDI FORMATION (Kl):** CONGLOMERATE, gray to light brown, silty sandstone matrix, moist, very dense, strongly cemented, abundant gravel, cobbles and boulders.	CAL	☒	50/2"		--	--	
3				☒					
4									
5			SPT	☒	50/2"	65/2"			
6		**BORING TERMINATED AT 5½ FEET**							
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	JPS/EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	I-6

APPENDIX I
LOGS OF PREVIOUS BORINGS

Logs of the previous SCST (2016) borings are provided in the following figures.

LOG OF BORING B-1

Date Drilled: 6/1/2016
Equipment: CME-45 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 367½
Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		2 inches of asphalt concrete.							
1	SC	**FILL (Qf)**: CLAYEY SAND, brown, fine to medium grained, moist, medium dense.		☒					SA AL EI COR
2		Dark brown.							
3			SPT		12	15			
4									
5									
6			CAL		22		27.6	93.3	
7									
8									
9									
10		Gravel and pieces of asphalt concrete, organic odor.							
11			SPT		87/9"	109/9"			
12		**LUSARDI FORMATION (Kl)**: SILTY SANDSTONE, light orangish brown, fine to medium grained, moist, very dense, strongly cemented.							
13									
14			SPT		50/6"	63/6"			
15		**AUGER REFUSAL AT 14½ FEET**							
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By: EM
Date: June, 2016
Job Number: 160287P3-1
Figure: I-2

LOG OF BORING B-2

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 368
Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		2 inches of asphalt concrete.							
1	SC	**FILL (Qf)**: CLAYEY SAND, light brown, fine to medium grained, moist, medium dense.		☒					
2		Dark brown, dense.							
3			CAL		49		16.5	109.7	
4									
5		Gravel and cobbles, sampler refusal.	SPT		50/4"	67/4"			
6									
7		**LUSARDI FORMATION (Kl)**: SILTY SANDSTONE, light brown, fine to medium grained, moist, very dense, weakly cemented.							
8									
9									
10			SPT		50/2"	67/2"			
11									
12									
13									
14									
15		Strongly cemented.	SPT		50/5"	67/5"			
16		**AUGER REFUSAL AT 15½ FEET**							
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By: EM
Date: June, 2016
Job Number: 160287P3-1
Figure: I-3

LOG OF BORING B-3

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 368½

Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		2 inches of asphalt concrete.							
1	SM	**FILL (Qf)**: SILTY SAND, light brown, fine to medium grained, moist, medium dense to dense.		☒					RV
2									
		LUSARDI FORMATION (Kl): SILTY SANDSTONE, fine to coarse grained, moist, very dense, moderately cemented.	CAL		50/4"		--	--	
3									
4									
5									
		Light grayish brown, fine to medium grained, strongly cemented.	SPT		50/5"	67/5"			
6									
7									
8									
9									
10		Orangish brown, fine to coarse grained.	SPT		50/6"	67/6"			
11									
12									
13									
14			SPT		50/2"	67/2"			
		AUGER REFUSAL AT 14½ FEET							
15									
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-3	Figure:	I-4

LOG OF BORING B-4

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 364
Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		2 inches of aggregate base.							
1	SC	**Fill (Qf)**: CLAYEY SAND, brown, fine to medium grained, moist, medium dense.		☒					SA AL EI COR
2		Dark brown, some gravel, dense.							
3			SPT		30	40			
4									
5		Medium dense.							
6			CAL		25		27.8	93.0	
7									
8									
9									
10									
11			SPT		40	53			
		LUSARDI FORMATION (Kl): SILTY SANDSTONE, orangish brown, fine to coarse grained, moist, very dense, strongly cemented.							
12									
13									
14									
15			SPT		50/2"	67/2"			
16									
17									
18									
19			SPT		50/4"	67/4"			
		BORING TERMINATED AT 19 FEET							
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-3	Figure:	I-5

LOG OF BORING B-5

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 366
Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES		DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
			DRIVEN	BULK					
		2 inches of aggregate base.							
1	SC	**FILL (Qf)**: CLAYEY SAND, brown, fine to medium grained, moist, medium dense.		☒					
2		**LUSARDI FORMATION (Kl)**: SILTY SANDSTONE, brown, fine to coarse grained, moist, very dense, strongly cemented.							
3			CAL		91/9"		12.9	113.0	DS
4									
5		Reddish brown.	SPT		50/4"	67/4"			
6									
7									
8		Brown.	SPT		50/4"	67/4"			
		AUGER REFUSAL AT 8½ FEET							
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-1	Figure:	I-6

LOG OF BORING B-6

Date Drilled: 6/2/2016

Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger

Elevation (ft): 367½

Logged by: EM

Project Manager: TBC

Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES		DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
			DRIVEN	BULK					
		2 inches of aggregate base.							
1	SC	**FILL (Qf)**: CLAYEY SAND, light brown, fine to medium grained, moist, dense.		☒					SA AL EI COR
2		**LUSARDI FORMATION (Kl)**: SILTY SANDSTONE, reddish brown, fine to coarse grained, moist, very dense, strongly cemented.							
3			SPT		47	63			
4									
5			CAL		50/3"				
6									
7									
8			SPT		50/2"	67/2"			
9		**AUGER REFUSAL AT 8½ FEET**							
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-1	Figure:	I-7

LOG OF PERCOLATION TEST HOLE P-1

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 360½

Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
	SM	**FILL (Qf)**: SILTY SAND, brown, fine to medium grained, moist, medium dense.							
1									
2	SC	CLAYEY SAND, light brown, fine to medium grained, moist, medium dense.							
3									
4		Dark brown.		☒					SA AL
5		**PERCOLATION TEST HOLE TERMINATED AT 5 FEET**							
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-1	Figure:	I-8

LOG OF PERCOLATION TEST HOLE P-2

Date Drilled: 6/2/2016
Logged by: EM
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Project Manager: TBC
Elevation (ft): 361½
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES		DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
			DRIVEN	BULK					
	SM	**FILL (Qf)**: SILTY SAND, brown, fine to medium grained, moist, medium dense.							
1									
2	SC	CLAYEY SAND, light brown, fine to medium grained, moist, medium dense.							
3									
4		Dark brown.							
5		**PERCOLATION TEST HOLE TERMINATED AT 5 FEET**							
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-1	Figure:	I-9

LOG OF PERCOLATION TEST HOLE P-3

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 367

Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES		DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
			DRIVEN	BULK					
		6 inches of mulch and associated topsoil.							
1	SM	**<u>FILL (Qf)</u>**: SILTY SAND with GRAVEL, light brown, fine to medium grained, moist, dense.							
2				☒					RV
3									
		AUGER REFUSAL AT 3 FEET							
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST ENGINEERING

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-1	Figure:	I-10

LOG OF PERCOLATION TEST HOLE P-4

Date Drilled: 6/2/2016
Equipment: CME-95 with 8-inch Diameter Hollow-Stem Auger
Elevation (ft): 365½

Logged by: EM
Project Manager: TBC
Depth to Groundwater (ft): Not Encountered

DEPTH (ft)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES DRIVEN	SAMPLES BULK	DRIVING RESISTANCE (blows/ft of drive)	N_{60}	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LABORATORY TESTS
		6 inches of mulch and associated topsoil.							
1	SM	**FILL (Qf)**: SILTY SAND with GRAVEL, brown, fine to medium grained, moist, dense.							
2									
3	SC	CLAYEY SAND, light brown, fine to medium grained, moist, medium dense.		☒					SA AL
4		**AUGER REFUSAL AT 4 FEET**							
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

SCST, Inc.

City of Carlsbad Maintenance & Operations Center
Carlsbad, California

By:	EM	Date:	June, 2016
Job Number:	160287P3-1	Figure:	I-11

APPENDIX II
LABORATORY TESTING

Laboratory tests were performed to provide geotechnical parameters for engineering analyses. The following tests were performed:

- **CLASSIFICATION:** Field classifications were verified in the laboratory by visual examination. The final soil classifications are in accordance with the Unified Soil Classification System.

- **IN SITU MOISTURE AND DENSITY:** The in situ moisture content and dry unit weight were determined on samples collected from the borings. The test results are presented on the boring logs in Appendix I.

- **PARTICLE-SIZE DISTRIBUTION:** The particle-size distribution was determined on selected soil samples in accordance with ASTM D6913. Figures II-1 through II-7 present the test results.

- **ATTERBERG LIMITS:** The Atterberg limits were determined on selected soil samples in accordance with ASTM D4318. Figures II-1 through II-7 present the test results.

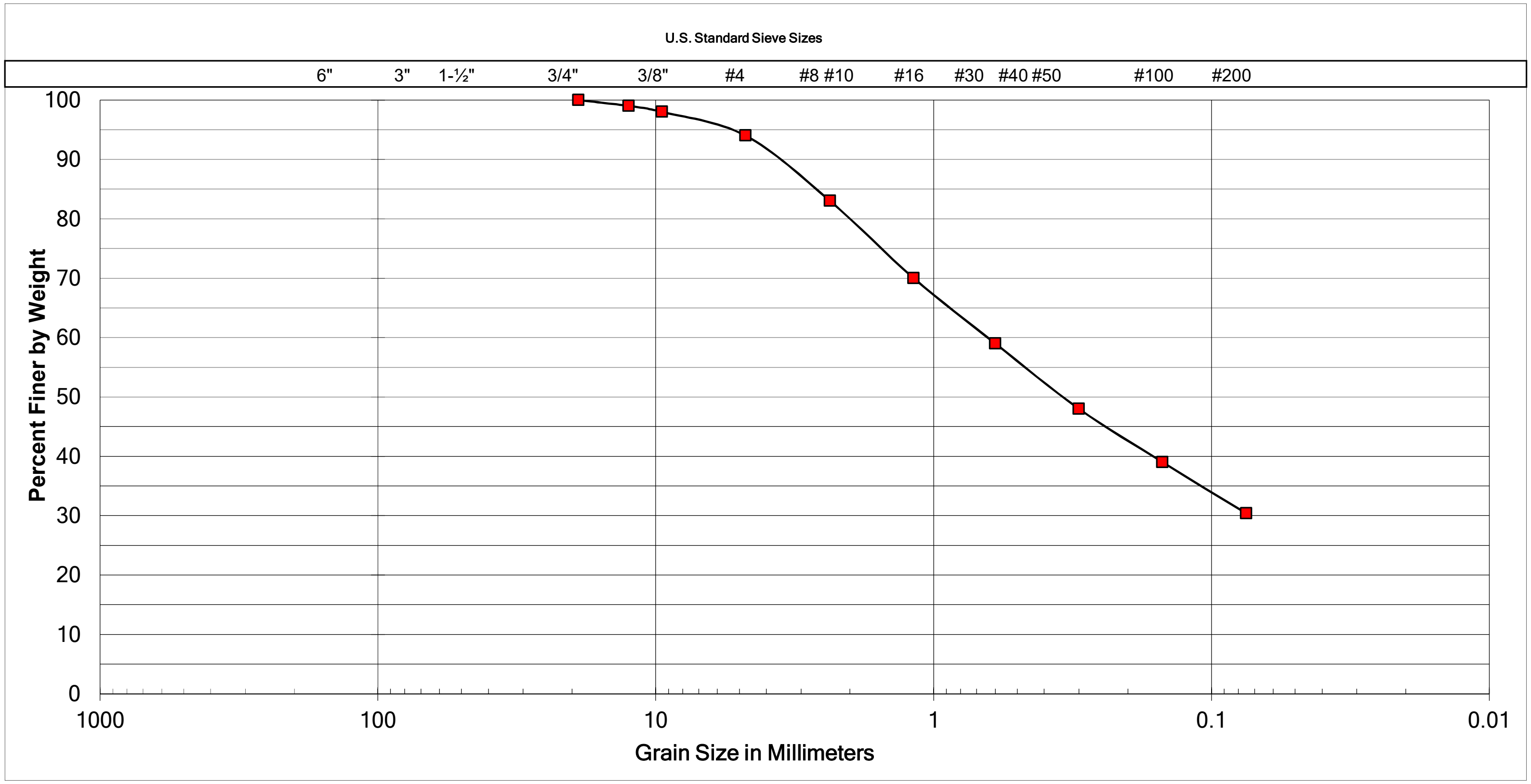
- **R-VALUE:** R-value tests were performed on selected soil samples in accordance with California Test Method 301. Figure II-8 presents the test result.

- **EXPANSION INDEX:** The expansion index was determined on selected soil samples in accordance with ASTM D4829. Figure II-8 presents the test results.

- **CORROSIVITY**: Corrosivity tests were performed on selected soil samples. The pH and minimum resistivity were determined in accordance with California Test 643 and ASTM G51. The soluble chloride content was determined in accordance with California Test 422. The soluble sulfate content was determined in accordance with California Test 417. Figure II-8 presents the test results.

- **DIRECT SHEAR:** A direct shear test was performed on a selected soil sample in accordance with ASTM D3080. The shear stress was applied at a constant rate of strain of 0.003 inch per minute. Figure II-9 presents the test results.

Soil samples not tested are now stored in our laboratory for future reference and analysis, if needed. Unless notified to the contrary, all samples will be disposed of 30 days from the date of this report.



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
B-1 at ½ to 2 feet

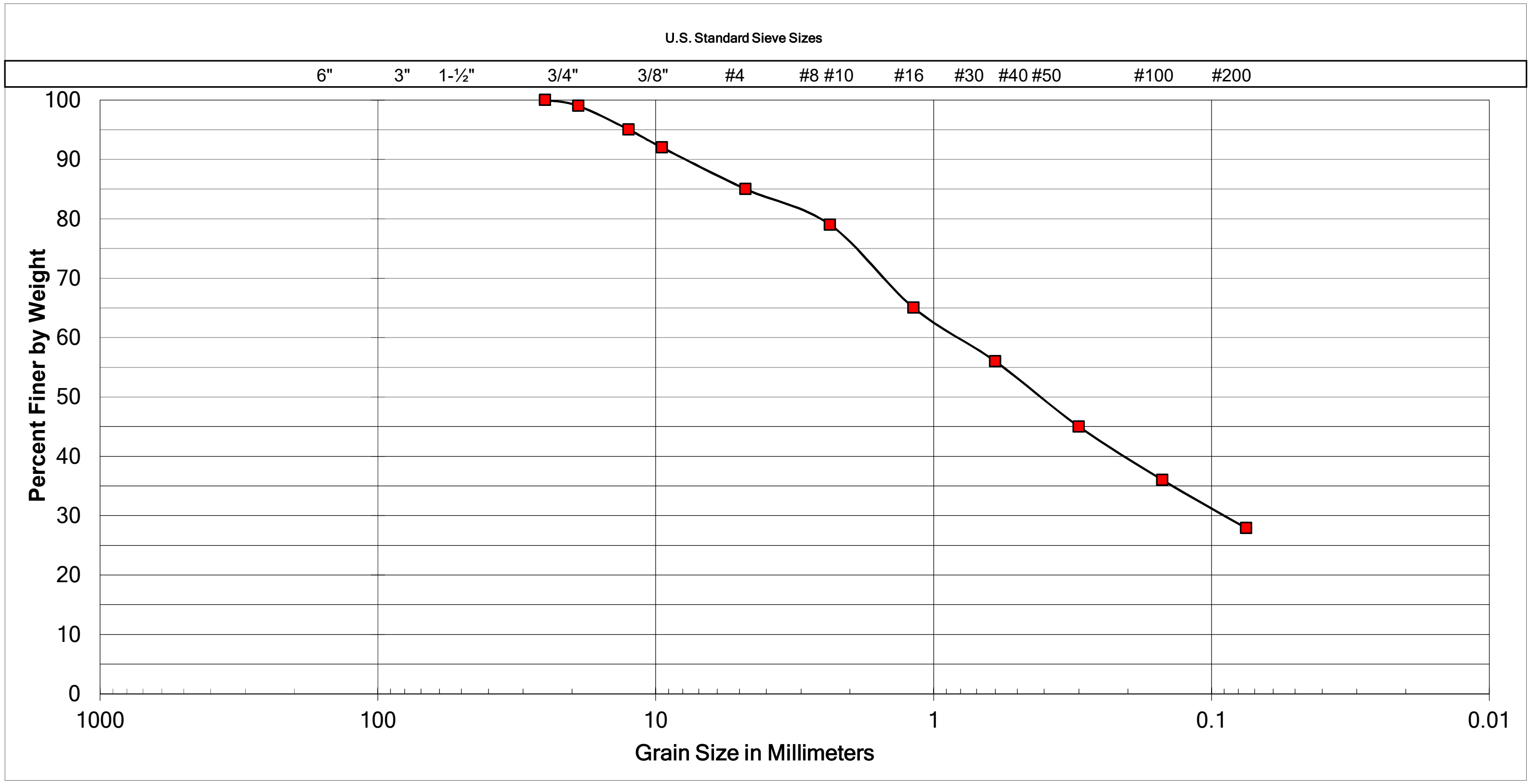
UNIFIED SOIL CLASSIFICATION:	SC
DESCRIPTION	CLAYEY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	42
PLASTIC LIMIT	23
PLASTICITY INDEX	19

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-1



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
B-4 at ½ to 2 Feet

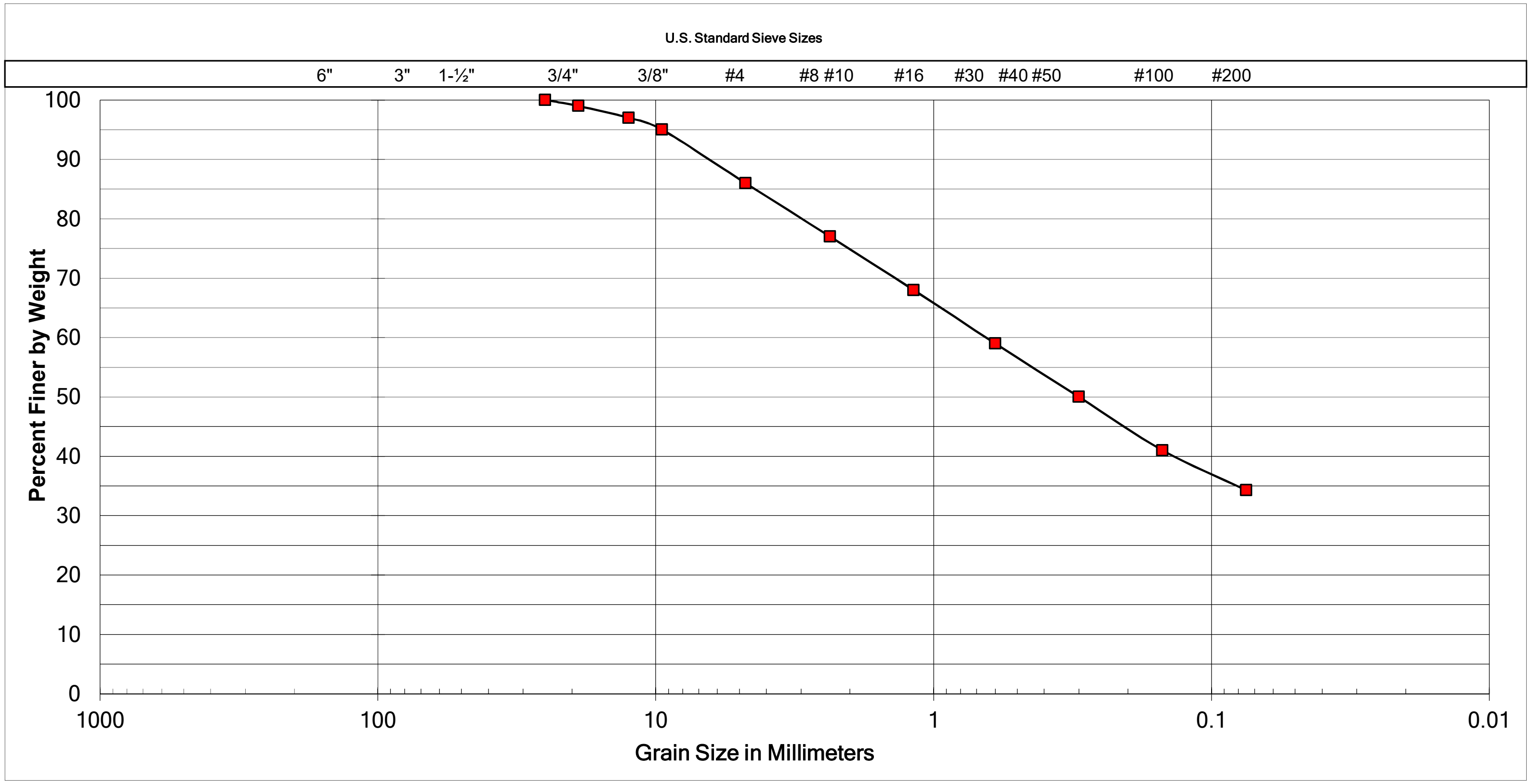
UNIFIED SOIL CLASSIFICATION:	SC
DESCRIPTION	CLAYEY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	38
PLASTIC LIMIT	18
PLASTICITY INDEX	20

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-2



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
B-6 at ½ to 2 feet

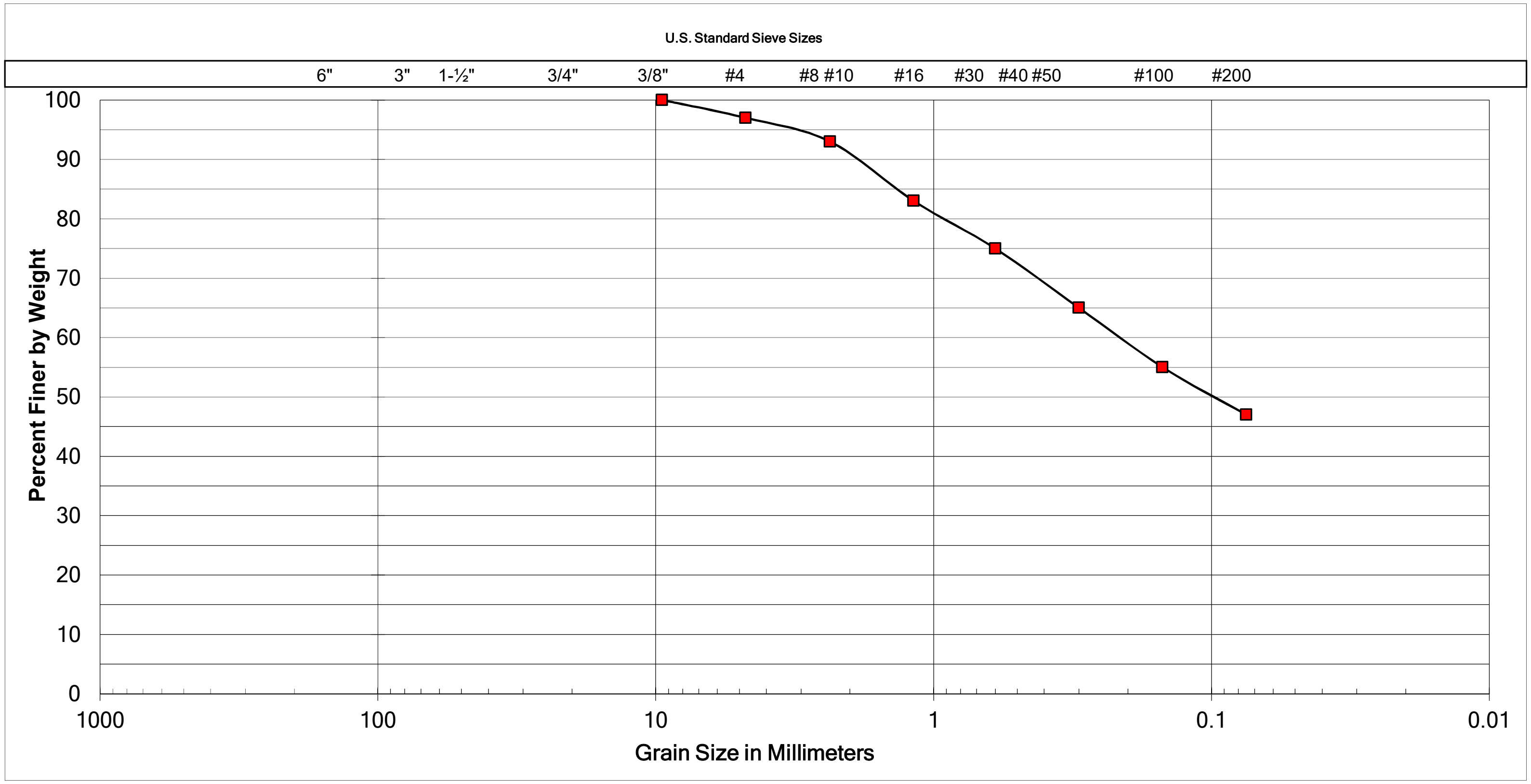
UNIFIED SOIL CLASSIFICATION:	SC
DESCRIPTION	CLAYEY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	44
PLASTIC LIMIT	19
PLASTICITY INDEX	25

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-3



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
P-1 at 4 to 5 feet

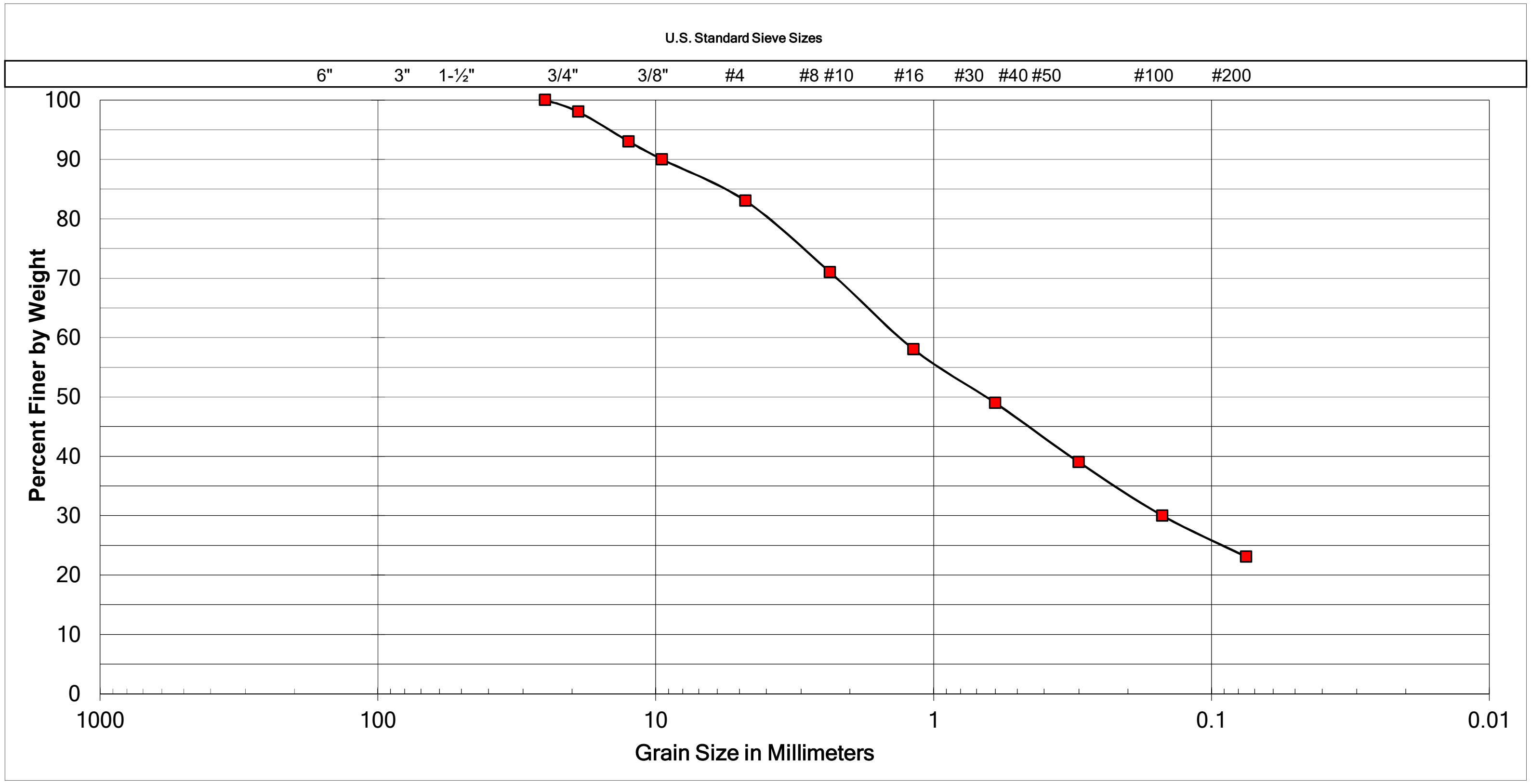
UNIFIED SOIL CLASSIFICATION:	SC
DESCRIPTION	CLAYEY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	40
PLASTIC LIMIT	18
PLASTICITY INDEX	22

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-4



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
P-4 at 2½ to 4 Feet

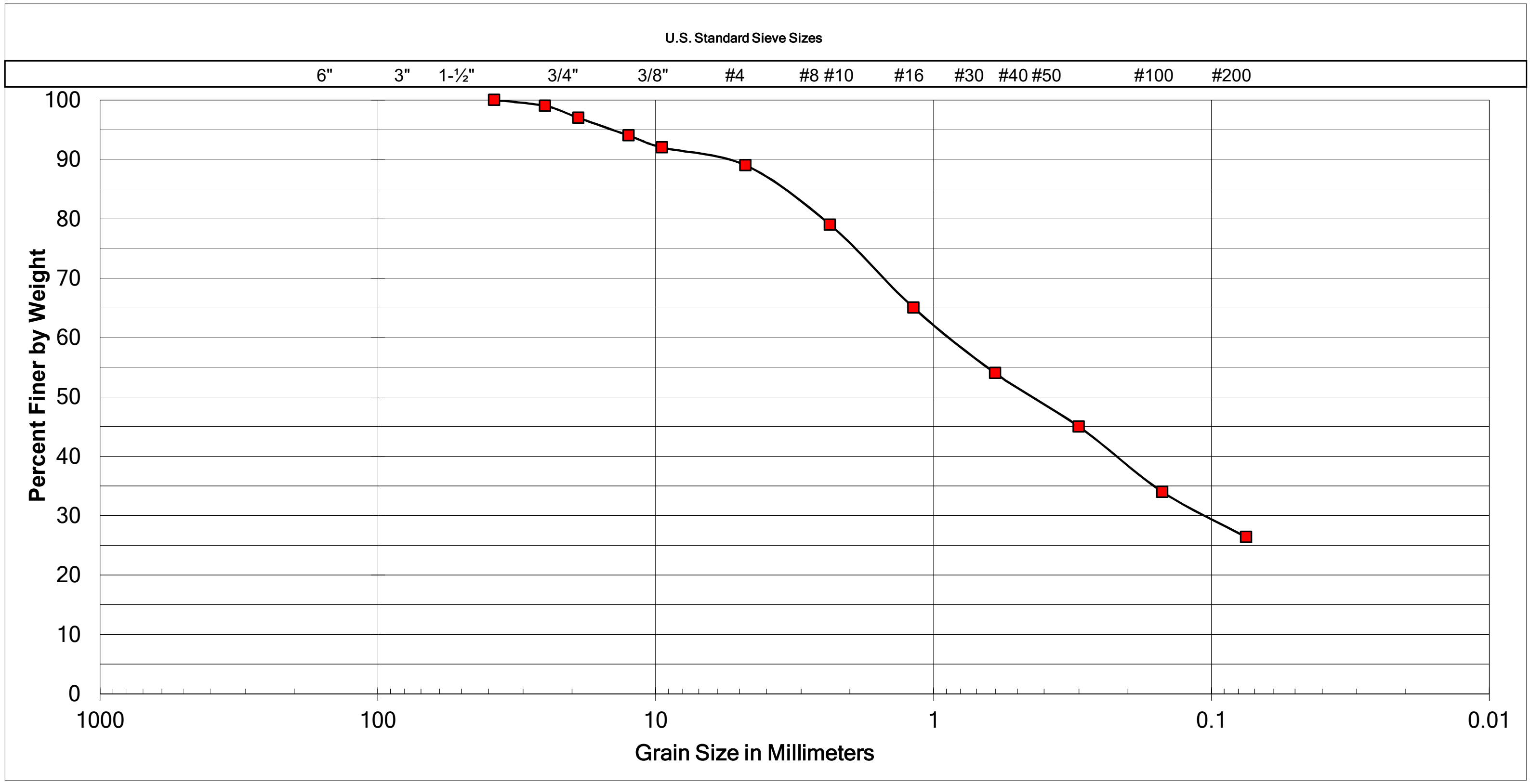
UNIFIED SOIL CLASSIFICATION:	SC
DESCRIPTION	CLAYEY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	42
PLASTIC LIMIT	23
PLASTICITY INDEX	19

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-5



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
B-9 at 0 to 2 feet

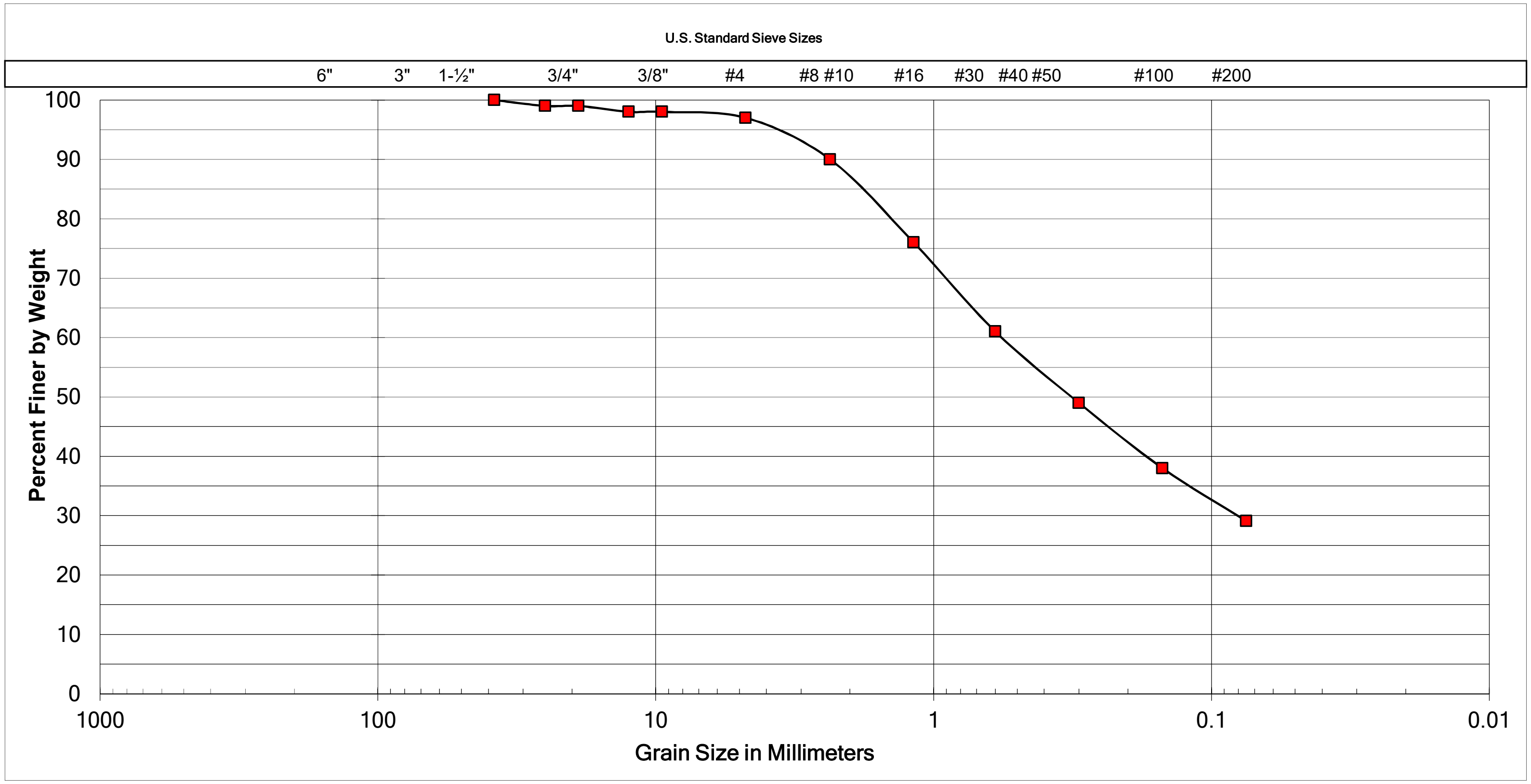
UNIFIED SOIL CLASSIFICATION:	SM
DESCRIPTION	SILTY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	45
PLASTIC LIMIT	27
PLASTICITY INDEX	18

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-6



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

SAMPLE LOCATION
B-10 at ½ to 5 feet

UNIFIED SOIL CLASSIFICATION:	SC
DESCRIPTION	CLAYEY SAND

ATTERBERG LIMITS	
LIQUID LIMIT	34
PLASTIC LIMIT	20
PLASTICITY INDEX	14

SCST, LLC

City of Carlasbad, Orion Center
Carlsbad, California

By:	EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-7

R-VALUE

CALIFORNIA TEST 301

SAMPLE	DESCRIPTION	R-VALUE
B-3 at ½ to 2 Feet	SILTY SAND	60
P-3 at 1½ to 3 Feet	SILTY SAND with GRAVEL	50
B-10 at ½ to 5 feet	CLAYEY SAND	20

EXPANSION INDEX

ASTM D2489

SAMPLE	DESCRIPTION	EI
B-1 at ½ to 2 Feet	CLAYEY SAND	35
B-4 at ½ to 2 Feet	CLAYEY SAND	35
B-6 at ½ to 2 Feet	CLAYEY SAND	66
B-9 at 0 to 2 feet	SILTY SAND	39
B-10 at ½ to 5 feet	CLAYEY SAND	14
B-11 at ½ to 5 feet	SILTY SAND	2

Classification of Expansive Soil[1]

EXPANSIVE INDEX	POTENTIAL EXPANSION
1-20	Very Low
21-50	Low
51-90	Medium
91-130	High
Above 130	Very High

1. ASTM - D4829

RESISTIVITY, pH, SOLUBLE CHLORIDE and SOLUBLE SULFATE

pH & Resistivity (Cal 643, ASTM G51)

Soluble Chlorides (Cal 422)

Soluble Sulfate (Cal 417)

SAMPLE	RESISTIVITY (Ω-cm)	pH	CHLORIDE (%)	SULFATE (%)
B-1 at ½ to 2 Feet	372	6.2	0.076	0.009
B-4 at ½ to 2 feet	420	6.1	0.070	0.009
B-9 at 0 to 2 feet	1600	7.6	0.004	0.002
B-11 at ½ to 5 feet	1180	7.4	0.026	0.009

WATER-SOLUBLE SULFATE (SO_4^{2-}) EXPOSURE

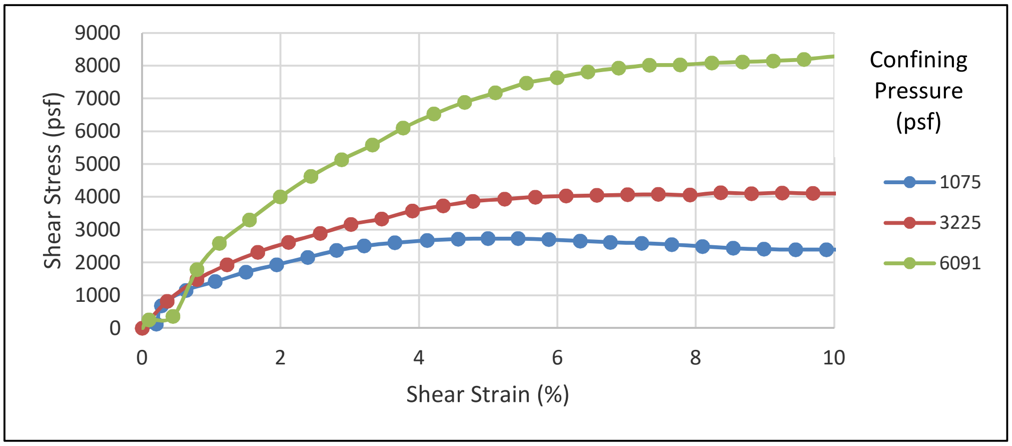
Modified from ACI 318-14 Table 19.3.1.1 and Table 19.3.2.1

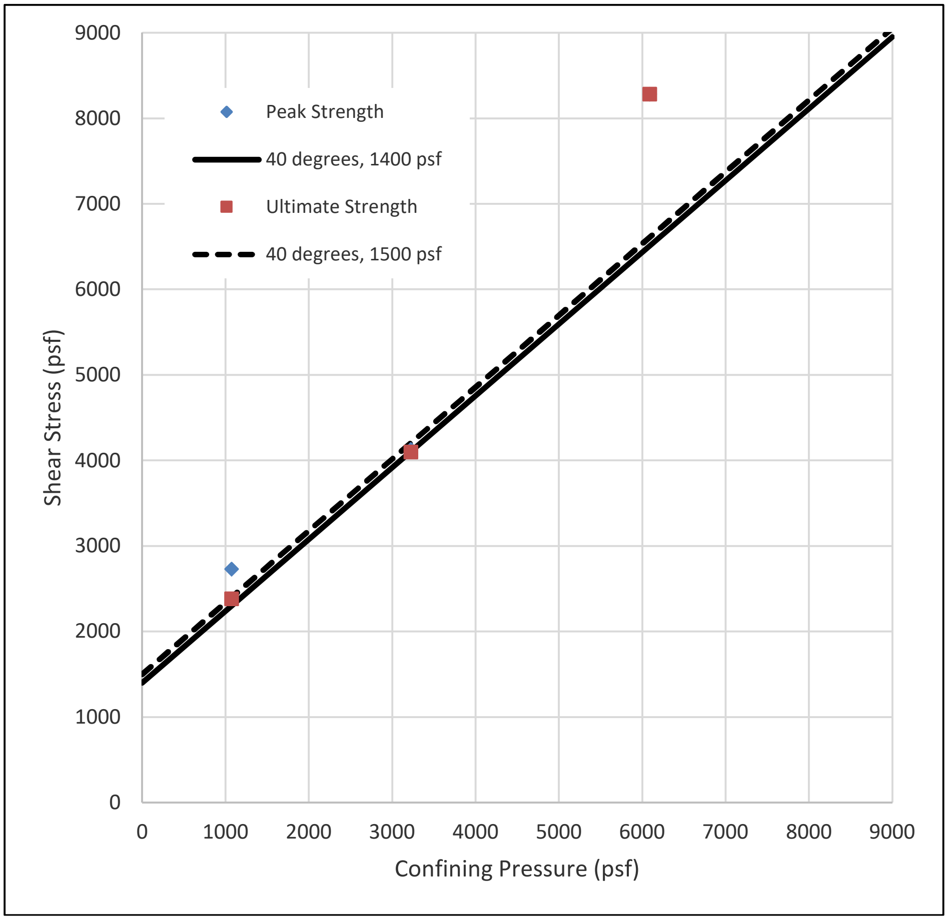
Water-soluble sulfate (SO_4^{2-}) in soil, percent by weight	**Exposure Severity**	**Exposure Class**	**Cement Type (ASTM C150)**	**Max. w/cm**	**Min. f_c' (psi)**
$SO_4^{2-} < 0.10$	Not applicable	S0	No type restriction	N/A	2,500
$0.10 \le SO_4^{2-} < 0.20$	Moderate	S1	II	0.50	4,000
$0.20 \le SO_4^{2-} < 2.00$	Severe	S2	V	0.45	4,500
$SO_4^{2-} > 2.00$	Very Severe	S3	V plus pozzolan or slag cement	0.45	4,500

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EMW	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-8





SAMPLE ID: B-5 at 2 to 3½ feet

SILTY SANDSTONE, brown

NOTES: In situ

Strain Rate: 0.003 in/min

Sample was consolidated and drained

	Peak	Ultimate
Φ	40 °	40 °
c	1400 psf	1500 psf

	Initial	Final
γ_d	113.0 pcf	113.0 pcf
w_c	12.9 %	19.1 %
Saturation	72 %	100 %

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, CA

By:	EM	Date:	March, 2019
Job Number:	180396P4-1	Figure:	II-9

APPENDIX III

APPENDIX III
BOREHOLE PERCOLATION TESTING

We performed borehole percolation testing at four locations (P-1 through P-4) in general conformance with Appendix C of the Model BMP Design Manual for the San Diego Region. The boreholes were prepared for percolation testing by placing about 6 inches of pea gravel in the bottom of the test hole and then installing a 4-inch diameter solid PVC pipe from the top of the pea gravel to about the ground surface. Pea gravel was placed in the annular space between the PVC pipe and the boring sidewall up to the depths of about 1 to 2 feet below the ground surface; hydrated bentonite chips were placed above about 1 to 2 feet. Prior to starting the percolation testing, the test hole was presoaked by filling the hole with water. The percolation testing was performed immediately after presoaking by filling the test hole with clean potable water to the top of the PVC pipe and measuring the drop in the water level. Figures III-1 through III-4 present the results of the testing.

Report of Falling Head Borehole Percolation Testing

Storm Water Infiltration

Project Name: City of Carlsbad Orion Center
Job Number: 180396P4-1
Date Drilled: 6/2/2016
Drilling Method: CME-95 Drill Rig
Drilled Depth: 5 feet
Solid Pipe Interval: 0-5 feet
Solid Pipe Diameter: 4 Inches
Hole Diameter: 8 Inches

Test Location Number: P-1
Tested By: EM
Date Tested: 6/3/2016
Presoak Time: 15 Hours

Reading	Time	Interval (min)	Initial Level (in)	Final Level (in)	Change in Level (in)	Percolation Rate (min/in)
1	8:32 9:02	0:30	14	14	0.0	0
2	9:02 9:32	0:30	14	14	0.0	0
3	9:32 10:02	0:30	14	14	0.0	0
4	10:02 10:32	0:30	14	14	0.0	0
5	10:32 11:02	0:30	14	14	0.0	0
6	11:02 11:32	0:30	14	14	0.0	0
7	11:32 12:02	0:30	14	14	0.0	0
8	12:02 12:32	0:30	14	14	0.0	0
Uncorrected Percolation Rate:						0 min/in 0.0 in/hr

Gravel Correction Factor: 1.95

Corrected Percolation Rate: 0.0 min/in
0.0 in/hr

Estimated Infiltation Rate*: 0.0 in/hr

* Infiltration rates estimated using the Prochet Method on borehole percolation data.

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job No:	180396P4-1	Figure:	III-1

Report of Falling Head Borehole Percolation Testing

Storm Water Infiltration

Project Name: City of Carlsbad Orion Center
Job Number: 180396P4-1
Date Drilled: 6/2/2016
Drilling Method: CME-95 Drill Rig
Drilled Depth: 5 feet
Solid Pipe Interval: 0-5 feet
Solid Pipe Diameter: 4 Inches
Hole Diameter: 8 Inches

Test Location Number: P-2
Tested By: EM
Date Tested: 6/3/2016
Presoak Time: 15 Hours

Reading	Time	Interval (min)	Initial Level (in)	Final Level (in)	Change in Level (in)	Percolation Rate (min/in)
1	8:34 9:04	0:30	16	15 1/4	0.8	40
2	9:04 9:34	0:30	15 1/4	14 1/2	0.8	40
3	9:34 10:04	0:30	16	15 1/2	0.5	60
4	10:04 10:34	0:30	15 1/2	15 1/4	0.3	120
5	10:34 11:04	0:30	15 1/4	15	0.3	120
6	11:04 11:34	0:30	15	14 3/4	0.3	120
7	11:34 12:04	0:30	14 3/4	14 1/2	0.3	120
8	12:04 12:34	0:30	14 1/2	14 1/4	0.3	120
Uncorrected Percolation Rate:						93 min/in 0.5 in/hr

Gravel Correction Factor: 1.95

Corrected Percolation Rate: 47.4 min/in
0.3 in/hr

Estimated Infiltation Rate*: 0.1 in/hr

* Infiltration rates estimated using the Prochet Method on borehole percolation data.

SCST, LLC

City of Carlsbad Orion Center
Carlsbad, California

By:	EM	Date:	March, 2019
Job No:	180396P4-1	Figure:	III-2

Report of Falling Head Borehole Percolation Testing

Storm Water Infiltration

Project Name: City of Carlsbad Orion Center
Job Number: 180396P4-1
Date Drilled: 6/2/2016
Drilling Method: CME-95 Drill Rig
Drilled Depth: 3 feet
Solid Pipe Interval: 0-3 feet
Solid Pipe Diameter: 4 Inches
Hole Diameter: 8 Inches

Test Location Number: P-3
Tested By: EM
Date Tested: 6/3/2016
Presoak Time: 15 Hours

Reading	Time	Interval (min)	Initial Level (in)	Final Level (in)	Change in Level (in)	Percolation Rate (min/in)
1	8:44 9:14	0:30	18	18	0.0	0
2	9:14 9:44	0:30	18	18	0.0	0
3	9:44 10:14	0:30	18	17 7/8	0.1	240
4	10:14 10:44	0:30	17 7/8	17 7/8	0.0	0
5	10:44 11:14	0:30	17 7/8	17 3/4	0.1	240
6	11:14 11:44	0:30	17 3/4	17 3/4	0.0	0
7	11:44 12:14	0:30	17 3/4	17 3/4	0.0	0
8	12:14 12:44	0:30	17 3/4	17 3/4	0.0	0
Uncorrected Percolation Rate:					60 min/in 0.0 in/hr	

Gravel Correction Factor: 1.95

Corrected Percolation Rate: 30.8 min/in
0.0 in/hr

Estimated Infiltation Rate*: 0.0 in/hr

* Infiltration rates estimated using the Prochet Method on borehole percolation data.

SCST, LLC

City of Carlsbad Orion Center Carlsbad, California			
By:	EM	Date:	March, 2019
Job No:	180396P4-1	Figure:	III-3

Report of Falling Head Borehole Percolation Testing

Storm Water Infiltration

Project Name: City of Carlsbad Orion Center
Job Number: 180396P4-1
Date Drilled: 6/2/2016
Drilling Method: CME-95 Drill Rig
Drilled Depth: 4 feet
Solid Pipe Interval: 0-4 feet
Solid Pipe Diameter: 4 Inches
Hole Diameter: 8 Inches

Test Location Number: P-4
Tested By: EM
Date Tested: 6/3/2016
Presoak Time: 15 Hours

Reading	Time	Interval (min)	Initial Level (in)	Final Level (in)	Change in Level (in)	Percolation Rate (min/in)
1	8:46 9:16	0:30	32	31 7/8	0.1	240
2	9:16 9:46	0:30	31 7/8	31 3/4	0.1	240
3	9:46 10:16	0:30	31 3/4	31 5/8	0.1	240
4	10:16 10:46	0:30	31 5/8	31 1/2	0.1	240
5	10:46 11:16	0:30	31 1/2	31 3/8	0.1	240
6	11:16 11:46	0:30	31 3/8	31 1/4	0.1	240
7	11:46 12:16	0:30	31 1/4	31 1/8	0.1	240
8	12:16 12:46	0:30	31 1/8	31	0.1	240
Uncorrected Percolation Rate:					240 min/in 0.3 in/hr	

Gravel Correction Factor: 1.95

Corrected Percolation Rate: 123.0 min/in
0.1 in/hr

Estimated Infiltation Rate*: <0.1 in/hr

* Infiltration rates estimated using the Prochet Method on borehole percolation data.

SCST, LLC	City of Carlsbad Orion Center Carlsbad, California		
	By: EM	Date:	March, 2019
	Job No: 180396P4-1	Figure:	III-4