# APPENDIX E

## *Draft Geotechnical Evaluation: College Boulevard Widening Between Waring Road and Olive Drive*

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants

**GEOTECHNICAL EVALUATION**
**COLLEGE BOULEVARD**
**IMPROVEMENT PROJECT**
**OCEANSIDE, CALIFORNIA**

**PREPARED FOR:**
RBF Consulting
9755 Clairemont Mesa Boulevard
San Diego, California 92124

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**PREPARED BY:**
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April 21, 2014
Project No. 107675001

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Mr. Tim Thiele
RBF Consulting
9755 Clairemont Mesa Boulevard
San Diego, California 92124

Subject: Geotechnical Evaluation
College Boulevard Improvement Project
Oceanside, California

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Dear Mr. Thiele:

In accordance with your authorization, we have performed a geotechnical evaluation for the proposed College Boulevard Improvement Project in Oceanside, California. This report presents our geotechnical findings, conclusions, and recommendations regarding the proposed project. Our report was prepared in accordance with our agreement dated February 13, 2014. We appreciate the opportunity to be of service on this project.

Sincerely,
**NINYO & MOORE**

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## 1. INTRODUCTION

In accordance with your request and our proposal dated July 30, 2013, we have performed a geotechnical evaluation for the proposed segment of the College Boulevard Improvement project located between Olive Drive and Waring Road in Oceanside, California (Figure 1). This report presents our conclusions regarding the geotechnical conditions at the subject site and our recommendations for the design of this project.

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## 2. SCOPE OF SERVICES

The scope of our geotechnical services included the following:

- Reviewing readily available published and in-house geotechnical literature pertaining to the site and the general site area, including geologic and fault maps.
- Coordinating and mobilizing for a geotechnical reconnaissance to observe the existing site conditions and to mark-out boring locations for utility clearance by Underground Service Alert (USA).
- Obtaining a right-of-way permit from the City of Oceanside to access our boring locations.
- Performing a subsurface exploration program consisting of excavating, logging, and sampling of four exploratory borings.
- Performing geotechnical laboratory testing on selected soil samples to evaluate geotechnical design parameters.
- Performing geotechnical analysis of the data obtained from our site reconnaissance, subsurface exploration, and laboratory testing.
- Preparing this report presenting our findings, conclusions, and recommendations pertaining to the design and construction of the proposed project.

## 3. PROJECT AND SITE DESCRIPTION

College Boulevard is a major thoroughfare extending north-south in Oceanside, California (Figure 1). The project portion of College Boulevard that extends between the intersections with Waring Road and Olive Drive consists of four traffic lanes, a center median, and bike and turn lanes. We understand that the project will consist of the widening of College Boulevard and will include construction of an additional lane, extended bike lanes, and new sidewalks. As part of the proposed construction, new single- and multi-tier retaining walls up to 12 feet high will be constructed near the intersection with Waring Road. Vegetation generally consists of grass, shrubs, and several medium sized trees along the sides of the widening project. Elevations range from approximately 210 feet above mean sea level (MSL) at Waring Road to approximately 360 feet MSL at Thunder Drive.

## 4. FIELD EXPLORATION AND LABORATORY TESTING

Our subsurface exploration was conducted on March 14, 2014 and consisted of drilling, logging, and sampling four borings. The borings were drilled to depths of up to approximately 11 feet below existing grades with a limited access, continuous flight auger drill rig. Soil samples were obtained at intervals from the borings. The samples were then transported to our in-house geotechnical laboratory for testing. The approximate locations of the exploratory borings are shown on Figure 2. Logs of the borings are included in Appendix A.

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Laboratory testing of representative soil samples included in-situ dry density and moisture content, gradation, direct shear strength, soil corrosivity, and R-value. The results of the in-situ dry density and moisture content tests are presented on the boring logs in Appendix A. The results of the other laboratory tests are presented in Appendix B.

## 5. GEOLOGY AND SUBSURFACE CONDITIONS

Our findings regarding regional and site geology and groundwater conditions at the project site are provided in the following sections.

### 5.1. Regional Geologic Setting

The project area is situated in the coastal foothill section of the Peninsular Ranges Geomorphic Province. This geomorphic province encompasses an area that extends approximately 900 miles from the Transverse Ranges and the Los Angeles Basin south to the southern tip of Baja California (Norris and Webb, 1990; Harden, 2004). The province varies in width from approximately 30 to 100 miles. In general, the province consists of rugged mountains underlain by Jurassic metavolcanic and metasedimentary rocks, and Cretaceous igneous rocks of the southern California batholith. The portion of the province in San Diego County that includes the project area, is underlain by Tertiary age sedimentary rock (Figure 3).

The Peninsular Ranges Province is traversed by a group of sub-parallel faults and fault zones trending roughly northwest. Several of these faults, which are shown on Figure 4, are considered active faults. The Elsinore, San Jacinto, and San Andreas faults are active fault systems located northeast of the project area and the Newport-Inglewood, Rose Canyon, Coronado Bank, San Diego Trough, and San Clemente faults are active faults located west of the project area. The Newport-Inglewood Fault Zone, the nearest active fault system, has been mapped approximately 8 miles west of the project site (Figure 4). Major tectonic activity associated with these and other faults within this regional tectonic framework consists primarily of right-lateral, strike-slip movement. Further discussion of faulting relative to the site is provided in the Faulting and Seismicity and Seismic Hazards section of this report.

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## 5.2. Site Geology

Geologic units encountered during our subsurface evaluation include fill and Santiago Formation materials. Generalized descriptions of the earth units encountered are provided in the subsequent sections. Additional descriptions of the subsurface units are provided on the boring logs in Appendix A.

### 5.2.1. Fill

Fill associated with the construction of College Boulevard was encountered in borings B-1, B-2, and B-4 to depths of up to 5 feet. As encountered, the fill consists of damp to wet, loose to medium dense, clayey and silty sand. A cobble up to 7" in diameter was encountered in the fill materials.

### 5.2.2. Santiago Formation

Santiago Formation was encountered from the surface in boring B-2, and beneath fill in borings B-1, B-3, and B-4 to the depths explored. As encountered, the Santiago Formation generally consisted of damp to wet, poorly to moderately cemented, silty and clayey fine-grained sandstone. While not encountered in our borings, scattered strongly cemented zones or "concretions" are anticipated within the Santiago Formation in the project area.

### 5.3. Groundwater

Groundwater was not encountered during our subsurface exploration. However, seepage due to perched water was encountered in borings B-1, B-3, and B-4 near the contact between fill and the underlying Santiago Formation. Based on our experience, groundwater is expected at a depth of more than 10 feet. However, it should be noted that fluctuations in groundwater typically occur due to variations in precipitation, ground surface topography, subsurface stratification, irrigation, and groundwater pumping and other factors.

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## 6. GEOLOGIC HAZARDS

In general, hazards associated with seismic activity include strong ground motion, ground surface rupture, and liquefaction. These considerations and other geologic hazards such as landsliding are discussed in the following sections.

### 6.1. Faulting and Seismicity

The project area is considered to be seismically active. Based on our review of the referenced geologic maps as well as on our geologic field mapping, the subject site is not underlain by known active or potentially active faults (i.e., faults that exhibit evidence of ground displacement in the last 11,000 years and 2,000,000 years, respectively). However, the site is located in a seismically active area, as is the majority of southern California, and the potential for strong ground motion is considered significant during the design life of the proposed structures. The nearest known active fault is the maximum moment magnitude 7.1 Newport Inglewood Fault located approximately 8 miles west of the site (Figure 4). The approximate fault to site distance was calculated by the computer program FRISKSP (Blake, 2001).

### 6.1.1. Ground Rupture

There are no known active faults crossing the subject site, and the potential for ground rupture due to faulting or lateral spreading is considered low. Surface ground cracking related to shaking from distant events is considered a hazard.

### 6.1.2. Strong Ground Motions

The 2013 California Building Code (CBC) recommends that the design of structures be based on the horizontal peak ground acceleration having a 1 percent probability of exceedance in 50 years, which is defined as the Maximum Considered Earthquake (MCE). The statistical return period for Peak Ground Acceleration ($PGA_{MCE}$) is approximately 4,975 years. The probabilistic $PGA_{MCE}$ for the site was calculated as 0.46 using the United States Geological Survey web-based ground motion calculator (USGS, 2013). The mapped and design PGA were estimated to be 0.44g and 0.30g, respectively, using the USGS (2013) calculator and the American Society of Civil Engineers (ASCE) 7-10 Standard.

### 6.1.3. Liquefaction

Liquefaction is the phenomenon in which loosely deposited granular soils with silt and clay contents of less than approximately 35 percent and non-plastic silts located below the water table undergo rapid loss of shear strength when subjected to strong earthquake-induced ground shaking. Ground shaking of sufficient duration results in the loss of grain-to-grain contact due to a rapid rise in pore water pressure, and causes the soil to behave as a fluid for a short period of time. Liquefaction is known generally to occur in saturated or near-saturated cohesionless soils at depths shallower than 50 feet below the ground surface. Factors known to influence liquefaction potential include composition and thickness of soil layers, grain size, relative density, groundwater level, degree of saturation, and both intensity and duration of ground shaking. Based on the relatively dense nature of the soils underlying the project alignment, liquefaction is not a design consideration.

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### 6.2. Landsliding

Based on our review of published maps (Tan and Giffen, 1995; Kennedy and Tan, 2008) and as shown on Figure 3, landslides are mapped in close proximity west of the project site near Olive Drive. However, based on our review of aerial photographs and our field observations, the mapped landslides do not underlie the project area.

## 7. CONCLUSIONS AND RECOMMENDATIONS

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Based on our geotechnical evaluation, it is our opinion that construction of the proposed project is feasible from a geotechnical standpoint, provided the following conclusions and recommendations are incorporated into the design and construction of the project. The following includes geotechnical considerations and conclusions for the project:

- The near surface soils are in a loose condition and not suitable for structural support or placement of fill materials. These soils should be recompacted as recommended herein.
- Based on the results of our exploratory borings and our experience with similar soils, it is our opinion that the on-site materials can be excavated using heavy duty earthmoving equipment in good working condition. While not encountered in our borings, scattered strongly cemented zones or "concretions" are anticipated within the Santiago Formation in the project area.
- Granular material generated from excavations may be reused as backfill. However, where excavations generate expansive clay materials, these materials should be removed from the site.
- Groundwater was not encountered during our subsurface exploration and is expected to be at a depth greater than 10 feet. However, seepage due to water perched near the top of the Santiago Formation should be anticipated which may result in wet excavation bottoms, fill materials, and loss of stability of temporary cuts over time.
- Based on the laboratory test results and Caltrans criteria, the on site soils are considered corrosive.

## 8. RECOMMENDATIONS

Based on our understanding of the project, the following recommendations are provided for the design and construction of the proposed project.

### 8.1. Earthwork

In general, earthwork should be performed in accordance with the recommendations presented in this report. Ninyo & Moore should be contacted for questions regarding the recommendations or guidelines presented herein.

#### 8.1.1. Pre-Construction Conference

We recommend that a pre-construction conference be held. The owner and/or their representative, the governing agencies' representatives, the civil engineer, the architect, Ninyo & Moore, and the contractor should be in attendance to discuss the work plan and project schedule and earthwork requirements.

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#### 8.1.2. Site Preparation

Prior to performing excavations or other earthwork, the site should be cleared of trash, debris, vegetation, and loose or otherwise unsuitable soils. Existing utilities should be relocated and protected from damage by construction activities. Obstructions that extend below the finished grade, if encountered, should be removed and the resulting holes filled with compacted fill. Materials generated from the demolition and clearing operations should be removed from the project site and disposed of at a legal dump site.

#### 8.1.3. Excavation Characteristics

Based on the results of our exploratory borings and our experience with similar soils, it is our opinion that the on-site materials can be excavated using heavy-duty earthmoving equipment in good working condition.

#### 8.1.4. Remedial Grading of Surficial Soils

Surficial soils are relatively loose. In areas where shallow, spread footings and/or surface hardscapes may be constructed, remedial grading of these materials should be performed. Remedial grading in these locations should include the overexcavation of the existing loose site soils to a depth of 1 foot below the pavement, sidewalk, or other exterior flatwork sections and 2 feet below the bottom of structural spread footings or to a depth that exposes bedrock, whichever is shallower. The overexcavation should extend laterally a horizontal distance equal to the depth of overexcavation below the finished surface grade beyond the limits of the shallow, spread footings and/or surface hardscapes. The resulting removal surface should then be scarified approximately 8 inches, moisture-conditioned to near optimum moisture content, and recompacted to a relative compaction of 90 percent as evaluated by the ASTM International (ASTM) Test Method D 1557. The resultant excavation should then be backfilled with compacted fill. The actual limits and depths of removals should be evaluated by Ninyo & Moore's representative in the field based on the materials exposed.

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### 8.1.5. Fill Material

The soils encountered at the project site should be generally suitable for reuse as fill or backfill provided they are free of organic material, clay, and rocks or debris greater than 4 inches in diameter. Cobbles or rock chunks, if generated during excavation, may be broken into acceptably sized pieces or disposed of off site. However, where excavations generate expansive clay materials, these materials should be removed from the site.

Potential fill soil imported to the site should consist of granular material with a low potential for expansion as evaluated by the ASTM D 4829 and a low corrosivity potential. Ninyo & Moore should evaluate materials before importation or reuse.

### 8.1.6. Compacted Fill

Prior to placement of compacted fill the contractor should request an evaluation of the exposed ground surface by Ninyo & Moore. Unless otherwise recommended, the exposed ground surface should then be scarified to a depth of approximately 8 inches and watered or dried, as needed, to achieve moisture contents generally above the laboratory optimum moisture content. The scarified materials should then be compacted to a relative compaction of 90 percent as evaluated in accordance with ASTM D 1557. The evaluation of compaction by the geotechnical consultant should not be considered to preclude any requirements for observation or approval by governing agencies. It is the contractor's responsibility to notify the geotechnical consultant and the appropriate governing agency when project areas are ready for observation, and to provide reasonable time for that review.

Fill materials should be moisture conditioned to generally above the laboratory optimum moisture content prior to placement. The optimum moisture content will vary with material type and other factors. Moisture conditioning of fill soils should be generally consistent within the soil mass.

Prior to placement of additional compacted fill material following a delay in the grading operations, the exposed surface of previously compacted fill should be prepared to receive fill. Preparation may include scarification, moisture conditioning, and recompaction.

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Compacted fill should be placed in horizontal lifts of approximately 8 inches in loose thickness. Prior to compaction, each lift should be watered or dried as needed to achieve a moisture content generally above the laboratory optimum, mixed, and then compacted by mechanical methods, using sheepsfoot rollers, multiple-wheel pneumatic-tired rollers or other appropriate compacting rollers, to a relative compaction of 90 percent as evaluated by ASTM D 1557. Successive lifts should be treated in a like manner until the desired finished grades are achieved.

### 8.1.7. Temporary Excavations

We recommend that trenches and excavations be designed and constructed in accordance with Occupational Safety and Health Administration (OSHA) regulations. These regulations provide trench sloping and shoring design parameters for trenches up to 20 feet deep based on the soil types encountered. Trenches over 20 feet deep should be designed by the contractor’s engineer based on site-specific geotechnical analyses. For planning purposes, we recommend that the following OSHA soil classifications be used:

| | |
|---|---|
| *Fill and Santiago Formation* | *Type C* |

Temporary excavations should be constructed in accordance with OSHA recommendations. For trench or other excavations, OSHA requirements regarding personnel safety should be met by using appropriate shoring (including trench boxes) or by laying back the slopes no steeper than 1½:1 in fill and Santiago Formation materials. Temporary excavations that encounter seepage may need shoring or may be mitigated by placing sandbags or gravel along the base of the seepage zone. Excavations encountering seepage should be evaluated on a case-by-case basis. On-site safety of personnel is the responsibility of the contractor.

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### 8.1.8. Slopes

Unless otherwise recommended by Ninyo & Moore and approved by the regulating agencies, fill and cut slopes should not be steeper than 2:1. Compaction of the face of fill slopes should be performed by backrolling at intervals of 4 feet or less in vertical slope height or as dictated by the capability of the available equipment, whichever is less. Fill slopes should be backrolled utilizing a sheepsfoot-type roller. Care should be taken in maintaining the desired moisture conditions and/or reestablishing them, as needed, prior to backrolling. The placement, moisture conditioning, and compaction of fill slope materials should be done in accordance with the recommendations presented in the Compacted Fill section of this report.

Site runoff should not be permitted to flow over the tops of slopes. Positive drainage should be established away from the slopes. This may be accomplished by incorporating brow ditches placed at the top of the slopes to divert surface runoff away from the slope face where drainage devices are not otherwise available.

The on-site soils are susceptible to erosion. Therefore, the project plans and specifications should contain design features and construction requirements to mitigate erosion of on-site soils during and after construction. Imported fill materials should be evaluated for suitability by Ninyo & Moore prior to their use in constructing fill slopes.

## 8.2. Seismic Design Considerations

The proposed improvements should be designed in accordance with the requirements of governing jurisdictions and applicable building codes. Table 1 presents the seismic design parameters for the site, in accordance with CBC (2013) guidelines and adjusted MCE spectral response acceleration parameters (United States Geological Survey [USGS], 2013).

**Table 1 – Seismic Design Parameters**

| Parameter | Value |
|---|---|
| Site Class | D |
| Site Coefficient, $F_a$ | 1.08 |
| Site Coefficient, $F_v$ | 1.59 |
| Mapped Short Period Spectral Acceleration, $S_S$ | 1.06g |
| Mapped One-Second Period Spectral Acceleration, $S_1$ | 0.41g |
| Short Period Spectral Acceleration Adjusted For Site Class, $S_{MS}$ | 1.14g |
| One-Second Period Spectral Acceleration Adjusted For Site Class, $S_{M1}$ | 0.65g |
| Design Short Period Spectral Acceleration, $S_{DS}$ | 0.76g |
| Design One-Second Period Spectral Acceleration, $S_{D1}$ | 0.44g |

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## 8.3. Conventional Retaining Wall

The proposed walls may be supported on spread footings bearing on compacted fill or competent Santiago Formation materials. Foundations should be designed in accordance with structural considerations and the following recommendations. In addition, requirements of the appropriate governing jurisdictions and applicable building codes should be considered in the design of the structures.

### 8.3.1. Footings

Spread footings bearing on compacted fill soils prepared in accordance with this report, may be designed using a net allowable bearing capacity of 4,000 pounds per square foot (psf). This allowable value is based on a factor of safety of roughly three. Conventional spread footings should be 12 inches deep where planned adjacent to paved surfaces, and 18 inches deep otherwise. Spread footings should be 24 inches wide or more. From a geotechnical standpoint, continuous footings should be reinforced with four No. 4 steel reinforcing bars, two placed near the top and two placed near the bottom of the footings, and further detailed in accordance with the recommendations of the structural engineer.

Footings bearing on compacted fill may be designed using a coefficient of friction of 0.35, where the total frictional resistance equals the coefficient of friction times the dead load. The footings may be designed using a passive resistance of 300 psf per foot of depth up to a value of 3,000 psf. The allowable lateral resistance can be taken as the sum of the frictional resistance and passive resistance, provided the passive resistance does not exceed one-half of the total allowable resistance. The passive resistance may be increased by one-third when considering loads of short duration, such as wind or seismic forces. These values are considered allowable values based on limit state of the soils.

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Trenches should not be excavated adjacent to spread footings. If trenches are to be excavated near a spread footing, the bottom of the trench should be located above a 2:1 plane projected downward from the bottom of the footing. Utility lines that cross beneath footings should be encased in lean concrete below the footing.

### 8.3.2. Lateral Earth Pressures

Based on the relatively dense, granular nature of the materials underlying the site, retaining walls up to 12 feet high proposed at the subject site are considered grossly stable provided the foundation excavations are observed by a representative of Ninyo & Moore. Recommended design parameters for conventional retaining walls are provided in Figure 5. These pressures assume granular backfill material free of clayey, expansive fill materials. A drain should be provided behind the retaining wall as shown on Figure 6. The drain should be connected to an appropriate outlet.

### 8.3.3. Settlement

Based on criteria provided by the project structural engineer, total settlement of foundations designed and constructed as recommended herein is estimated to be on the order of 1 inch. Differential settlement is estimated to be 1/2 inch over a horizontal span of 50 feet and 1 inch in 100 feet.

### 8.4. Underground Utilities

For the construction of new underground utility pipelines, we anticipate that they will be supported on fill or Santiago Formation materials. The depths of the pipelines are not known but generally anticipated to be less than 10 feet deep.

#### 8.4.1. Pipe Bedding

For new piping, we recommend that bedding material be placed around pipe zones to 1 foot or more above the top of the pipe. The bedding material should be classified as sand, be free of organic material, and have a sand equivalent of 30 or more. If gravel is used for bedding material, the gravel should be wrapped in overlapped filter fabric to mitigate fines migration into the voids.

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Special care should be taken not to allow voids beneath and around the pipe. Compaction of the bedding material and backfill should proceed up both sides of the pipe. Trench backfill, including bedding material, should be compacted in accordance with the recommendations presented in this report.

#### 8.4.2. Trench Zone Backfill

For the purpose of this report, the trench zone is considered to extend from 1 foot above the top of the pipe to the top of the trench. The backfill material should not generally contain rocks or lumps greater than approximately 3 inches, and particles not more than approximately 40 percent larger than ¾ inch. Soils classified as silts or clays should not be used for trench backfill.

Backfill should be moisture conditioned to within 2 percent of the laboratory optimum, placed, and compacted to a relative compaction of 95 percent as evaluated by ASTM D 1557. Wet soils should be allowed to dry to moisture contents near the optimum prior to their placement as backfill. Backfill lift thickness will be dependent upon the type of compaction equipment utilized. Backfill should generally be placed in lifts not exceeding 8 inches in loose thickness. Care should be taken to not damage utilities during the backfill process.

### 8.5. Preliminary Pavement Design

For design of asphalt concrete pavements in the planned pavement areas, we have estimated a Traffic Index (TI) of 10.0 for College Boulevard widened pavements. If traffic loads are different from those assumed, the pavement design should be re-evaluated. Actual pavement recommendations should be based on R-value tests performed on bulk samples of the soils exposed at the finished subgrade elevations once grading operations have been performed.

The resistance (R-value) characteristics of the subgrade soils were evaluated by conducting laboratory testing on a representative soil sample obtained from our exploratory borings. The test results indicated an R-value of 49. Considering the variability of near-surface soil anticipated at the site and the results of laboratory testing, we used a design R-value of 40 in our analysis. The preliminary recommended pavement section is as follows:

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**Table 2 – Recommended Pavement Sections**

| Traffic Index | Asphalt Concrete (inches) | Class 2 Aggregate Base (inches) |
|---|---|---|
| 10.0 | 7.0 | 10.0 |

We recommend that the upper 12 inches of the subgrade be compacted to 95 percent relative compaction as evaluated by ASTM D 1557. If traffic loads are different from those assumed, the pavement design should be re-evaluated.

### 8.6. Corrosivity

Laboratory testing was performed on a representative sample of near-surface soil to evaluate soil pH, electrical resistivity, water-soluble chloride content, and water-soluble sulfate content. The soil pH and electrical resistivity tests were performed in general accordance with CT 643. Chloride content tests were performed in general accordance with CT 422. Sulfate testing was performed in general accordance with CT 417. The laboratory test results are presented in Appendix B.

The pH of the tested sample was 7.2. The electrical resistivity of the tested sample was approximately 490 ohm-centimeters. The chloride content of the tested sample was approximately 540 ppm. The sulfate content of the tested sample was approximately 0.017 percent by weight (i.e., 1700 ppm). Based on the laboratory test results and Caltrans (2003) corrosion criteria, the project site would be classified as corrosive, which is defined as having earth materials with an electrical resistivity of less than 2,000 ohm-centimeters, more than 500 ppm chlorides, more than 0.20 percent sulfates (i.e., 2,000 ppm), or a pH of 5.5 or less.

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### 8.7. Concrete Placement

Concrete in contact with soil or water that contains high concentrations of soluble sulfates can be subject to chemical deterioration. Laboratory testing indicated a sulfate content of approximately 0.017 percent for the tested sample, which is considered to represent a negligible potential for sulfate attack (ACI, 2010). Type II cement may be used, however, due to the potential for variability of soils, consideration should be given to using Type II/V cement for concrete structures in contact with soil. In addition, we recommend a water-to-cement ratio of no more than 0.45.

### 8.8. Drainage

Proper surface drainage is imperative for satisfactory site performance. Positive drainage should be provided and maintained to direct surface water away from foundations and off-site. Positive drainage is defined as a gradient of 2 percent or more over a distance of 10 feet away from the foundations, or less if covered with concrete. Runoff should then be directed by the use of non-erosive swales or pipes into a collective drainage system. Surface waters should not be allowed to pond adjacent to footings or on top of pavements. Area drains for landscaped and paved areas are recommended. The on-site soils are susceptible to erosion. Therefore, the project plans and specifications should contain design features and construction requirements to mitigate erosion of on-site soils during and after construction.

## 9. CONSTRUCTION OBSERVATION

The recommendations provided in this report are based on our understanding of the proposed project and on our evaluation of the data collected based on subsurface conditions disclosed by widely spaced exploratory borings. It is imperative that the interpolated subsurface conditions be checked by our representative during construction. Observation and testing of compacted fill and backfill should be performed by our representative during construction. In addition, we should review the project plans and specifications prior to construction. It should be noted that, upon review of these documents, some recommendations presented in this report might be revised or modified.

During construction we recommend that our duties include, but not be limited to:

- Observing removals and excavation bottoms.
- Observing the placement and compaction of fill, including trench backfill.
- Evaluating on-site and imported materials prior to their use as fill.
- Performing laboratory and field tests to evaluate fill compaction.
- Observing and testing foundation excavations for bearing materials, compaction and cleaning prior to placement of reinforcing steel or concrete.

The recommendations provided in this report assume that Ninyo & Moore will be retained as the geotechnical consultant during the construction phase of this project. If another geotechnical consultant is selected, we request that the selected consultant indicate to RBF or the City of Oceanside and to our firm in writing that our recommendations are understood and that they are in full agreement with our recommendations.

## 10. 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

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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.

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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 RBF Consulting, the City of Oceanside, and their respective successors or assigns. 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.

## 11. REFERENCES

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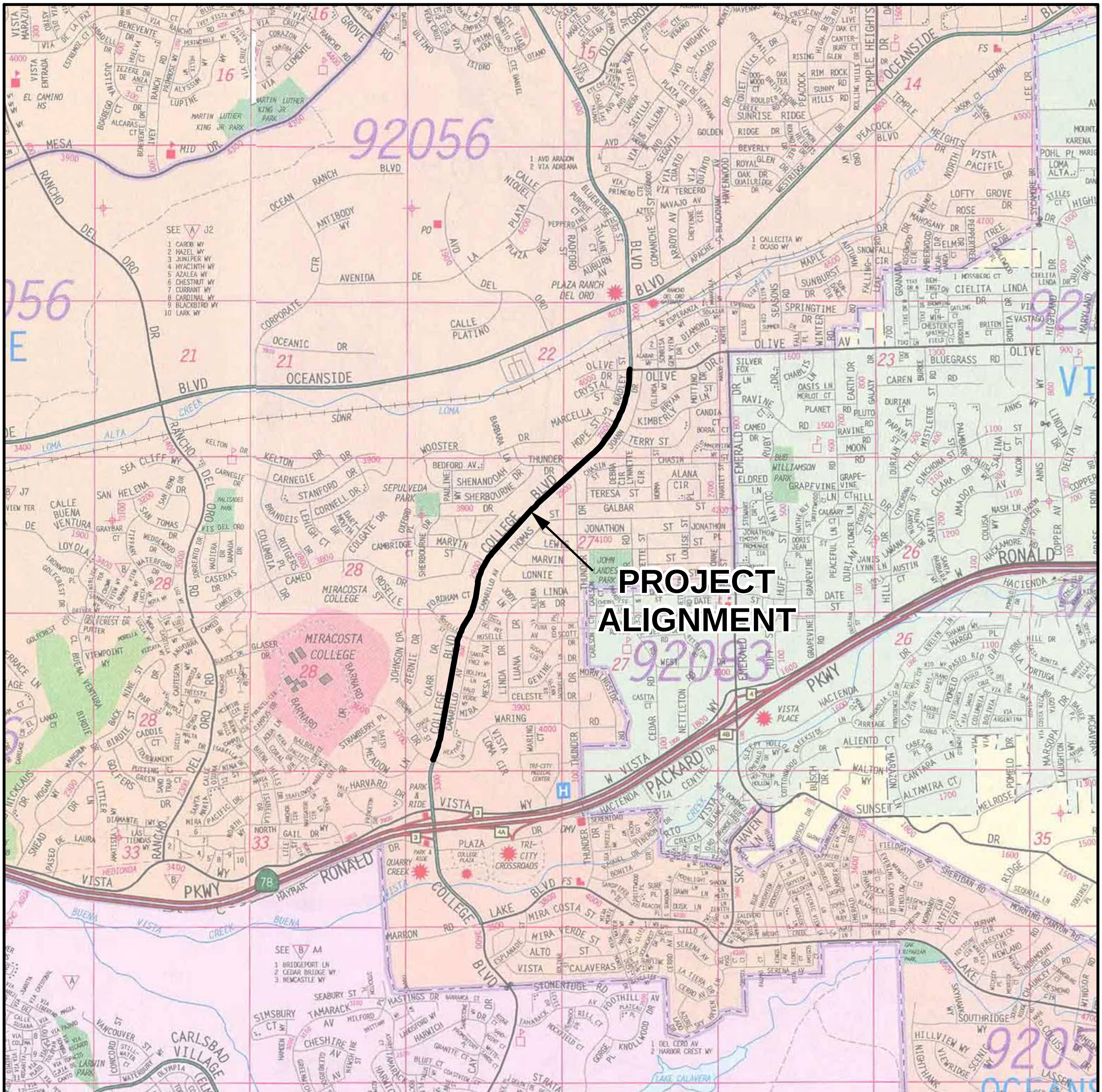
DRAFT

| AERIAL PHOTOGRAPHS | | | | |
|---|---|---|---|---|
| **Source** | **Date** | **Flight** | **Numbers** | **Scale** |
| USDA | 4-11-53 | AXN-8M | 66, 67, and 68 | 1:20,000 |




SOURCE: 2009 THOMAS GUIDE FOR SAN DIEGO COUNTY, STREET GUIDE AND DIRECTORY; MAP © RAND MCNALLY, R.L.07-S-129


MAP EXTENT

SCALE IN FEET

0 2,400 4,800

N

NOTE: DIRECTIONS, DIMENSIONS AND LOCATIONS ARE APPROXIMATE

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# SITE LOCATION

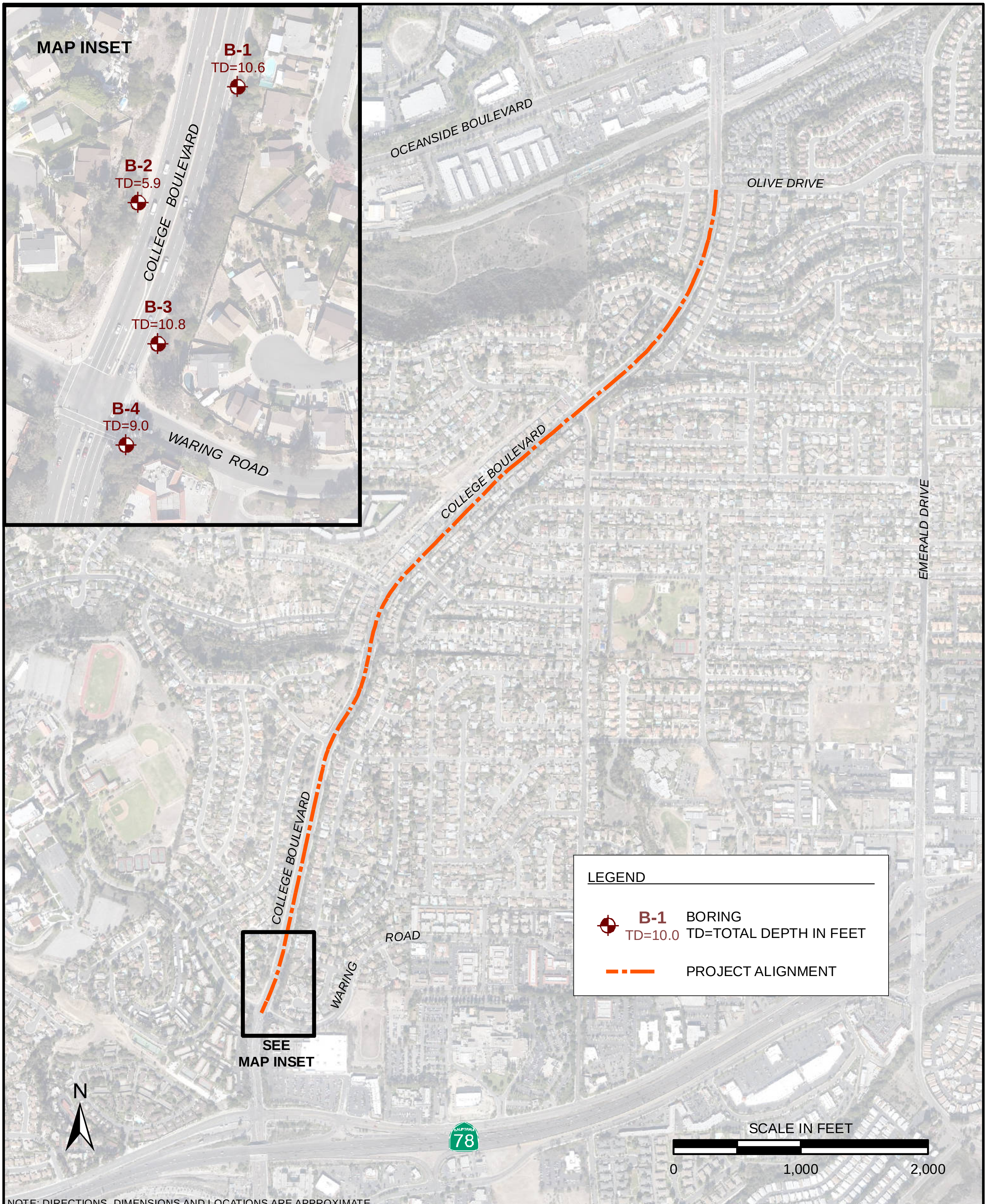
COLLEGE BOULEVARD IMPROVEMENT PROJECT
OCEANSIDE, CALIFORNIA

| PROJECT NO. | DATE |
|---|---|
| 107675001 | 4/14 |

FIGURE

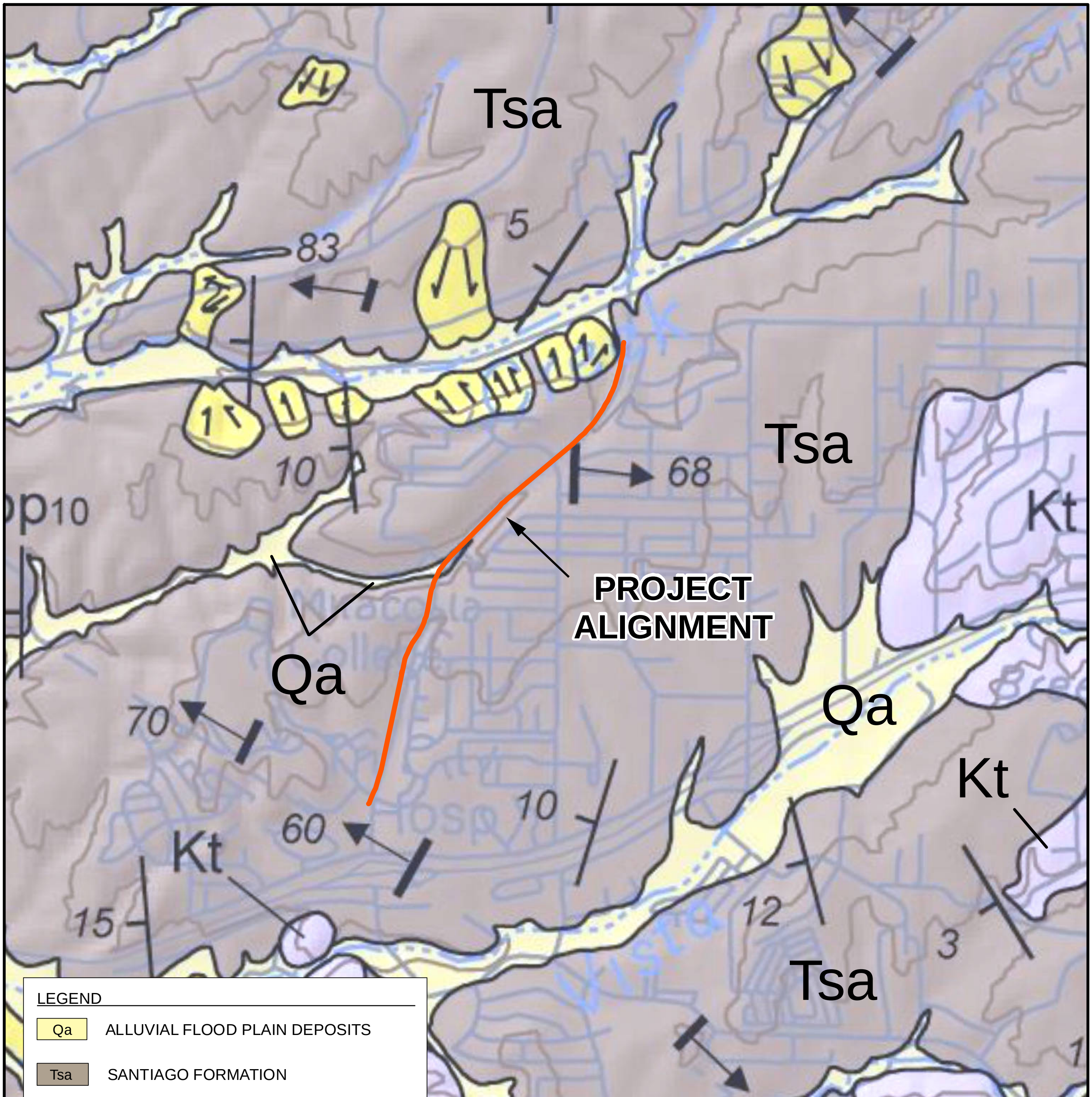
1

1_107675001_SL.mxd 4/17/2014 3:21:33 PM JDL




2_107675001_GM.mxd 4/17/2014 JDL

| Ninyo & Moore | | GEOTECHNICAL MAP | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENT PROJECT<br>OCEANSIDE, CALIFORNIA | 2 |
| 107675001 | 4/14 | | |




LEGEND

- Qa — ALLUVIAL FLOOD PLAIN DEPOSITS
- Tsa — SANTIAGO FORMATION
- Kt — TONALITE, UNDIVIDED
- Qls? — LANDSLIDE - ARROWS INDICATE PRINCIPAL DIRECTION OF MOVEMENT, QUERIED WHERE EXISTENCE IS QUESTIONABLE
- 83 — FAULT - SOLID WHERE ACCURATELY LOCATED; DASHED WHERE APPROXIMATELY LOCATED
- 8 — STRIKE AND DIP OF BEDS, INCLINED

SOURCE: KENNEDY, M.P., TAN, S.S., BOVARD, K.R., ALVAREZ, R.M., WATSON, M.J., AND GUTIERREZ, C.I., 2007, GEOLOGIC MAP OF THE OCEANSIDE 30' X 60' QUADRANGLE, CALIFORNIA.

SCALE IN FEET

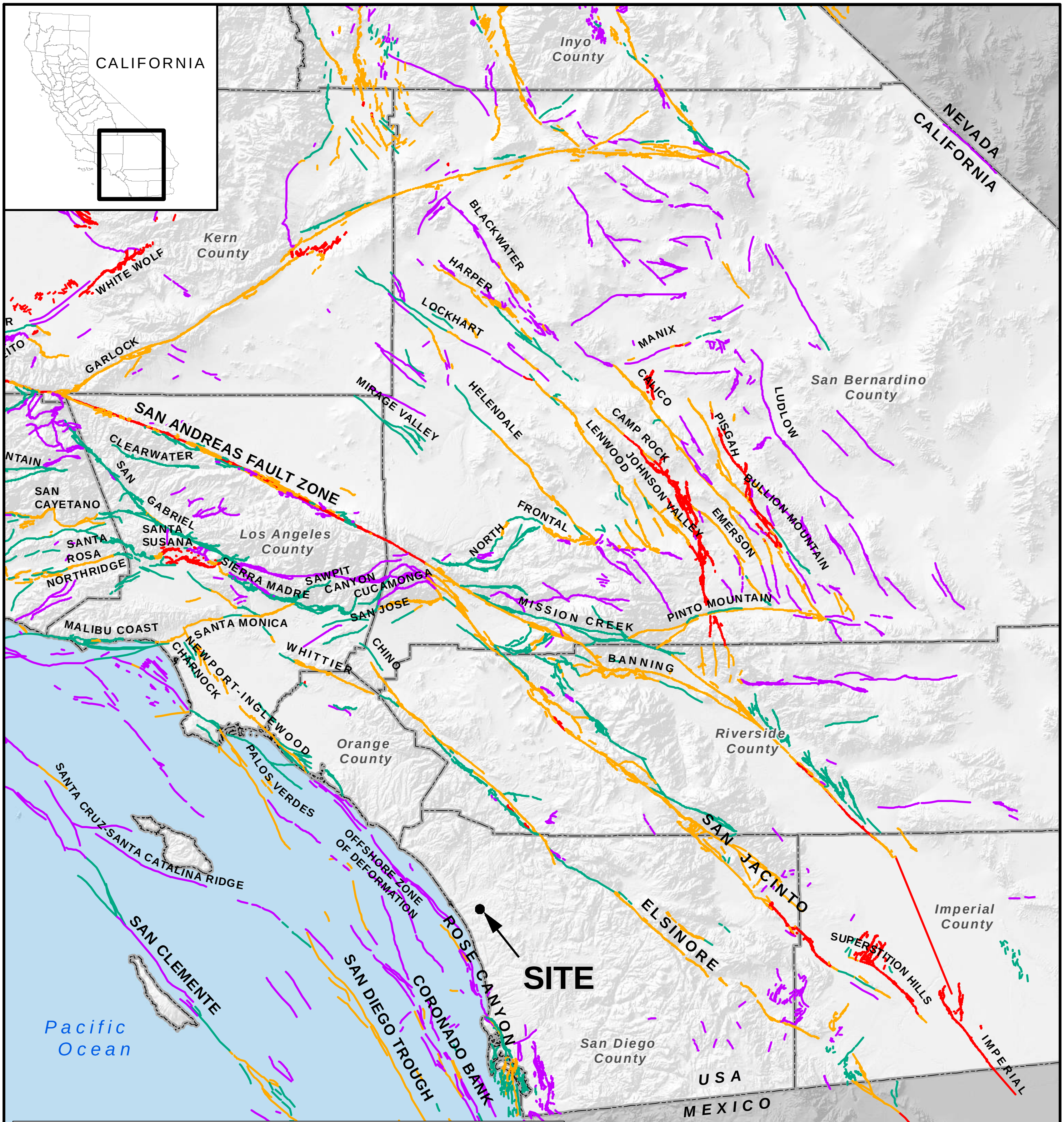
0 2,000 4,000

N

NOTES: DIRECTIONS, DIMENSIONS AND LOCATIONS ARE APPROXIMATE

| Ninyo & Moore | | REGIONAL GEOLOGY | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENT PROJECT<br>OCEANSIDE, CALIFORNIA | 3 |
| 107675001 | 4/14 | | |

3_107675001_G.mxd 4/17/2014 3:25:46 PM JDL




LEGEND

CALIFORNIA FAULT ACTIVITY

- HISTORICALLY ACTIVE
- HOLOCENE ACTIVE
- LATE QUATERNARY (POTENTIALLY ACTIVE)
- QUATERNARY (POTENTIALLY ACTIVE)
- STATE/COUNTY BOUNDARY

SOURCE: U.S. GEOLOGICAL SURVEY AND CALIFORNIA GEOLOGICAL SURVEY, 2006, QUATERNARY FAULT AND FOLD DATABASE FOR THE UNITED STATES, ACCESSED 2011, FROM USGS WEB SITE: HTTP//EARTHQUAKES.USGS.GOV/REGIONAL/QFAULTS/.

SCALE IN MILES

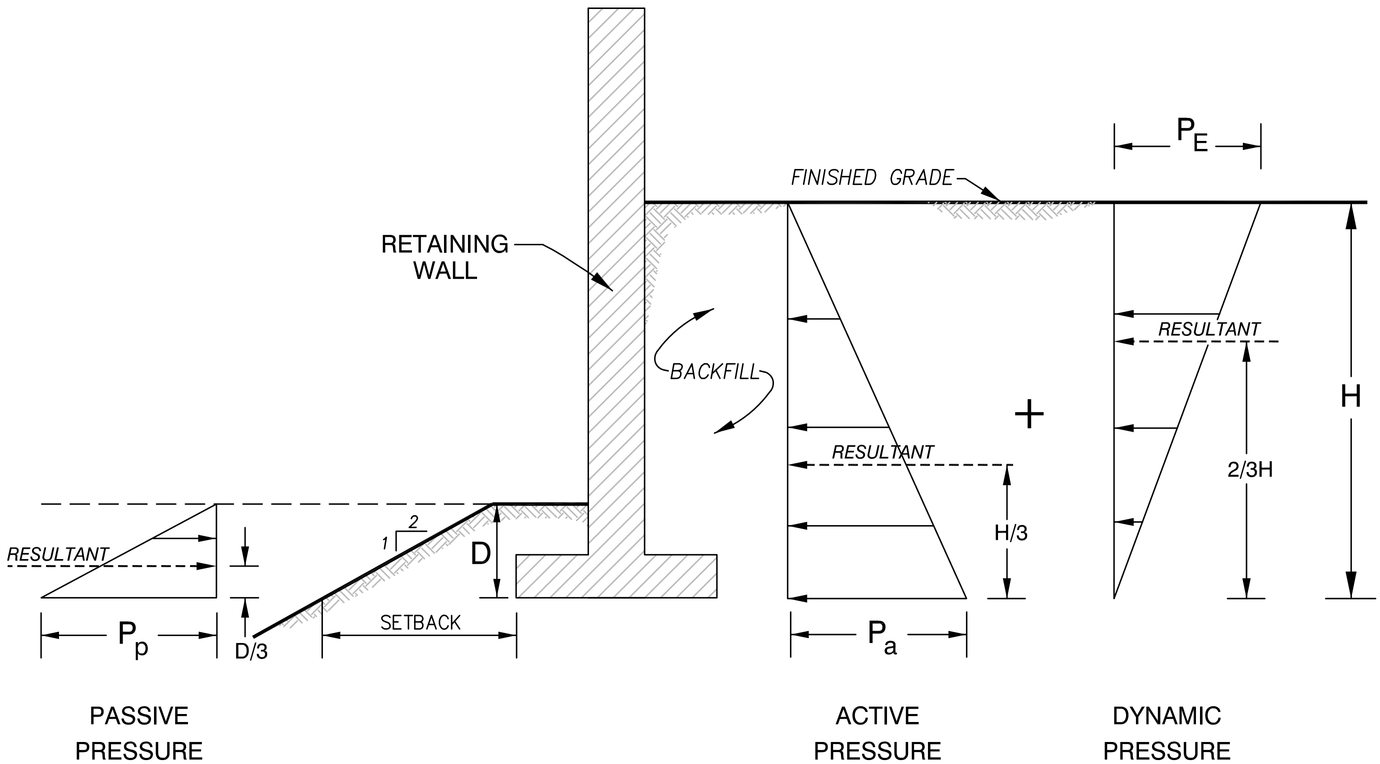
0 30 60

N

NOTE: DIRECTIONS, DIMENSIONS AND LOCATIONS ARE APPROXIMATE.

| Ninyo & Moore | | REGIONAL FAULTING | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENT PROJECT<br>OCEANSIDE, CALIFORNIA | 4 |
| 107675001 | 4/14 | | |

4_107675001_F.mxd 4/17/2014 12:09:09 PM JDL




NOTES:

1. ASSUMES NO HYDROSTATIC PRESSURE BUILD-UP BEHIND THE RETAINING WALL
2. GRANULAR BACKFILL MATERIALS SHOULD BE USED FOR RETAINING WALL BACKFILL
3. DRAINS AS RECOMMENDED IN THE RETAINING WALL DRAINAGE DETAIL SHOULD BE INSTALLED BEHIND THE RETAINING WALL
4. DYNAMIC LATERAL EARTH PRESSURE IS BASED ON A PEAK GROUND ACCELERATION OF 0.30g
5. SURCHARGE PRESSURES CAUSED BY VEHICLES OR NEARBY STRUCTURES ARE NOT INCLUDED
6. H AND D ARE IN FEET
7. SETBACK SHOULD BE IN ACCORDANCE WITH CBC (2013)

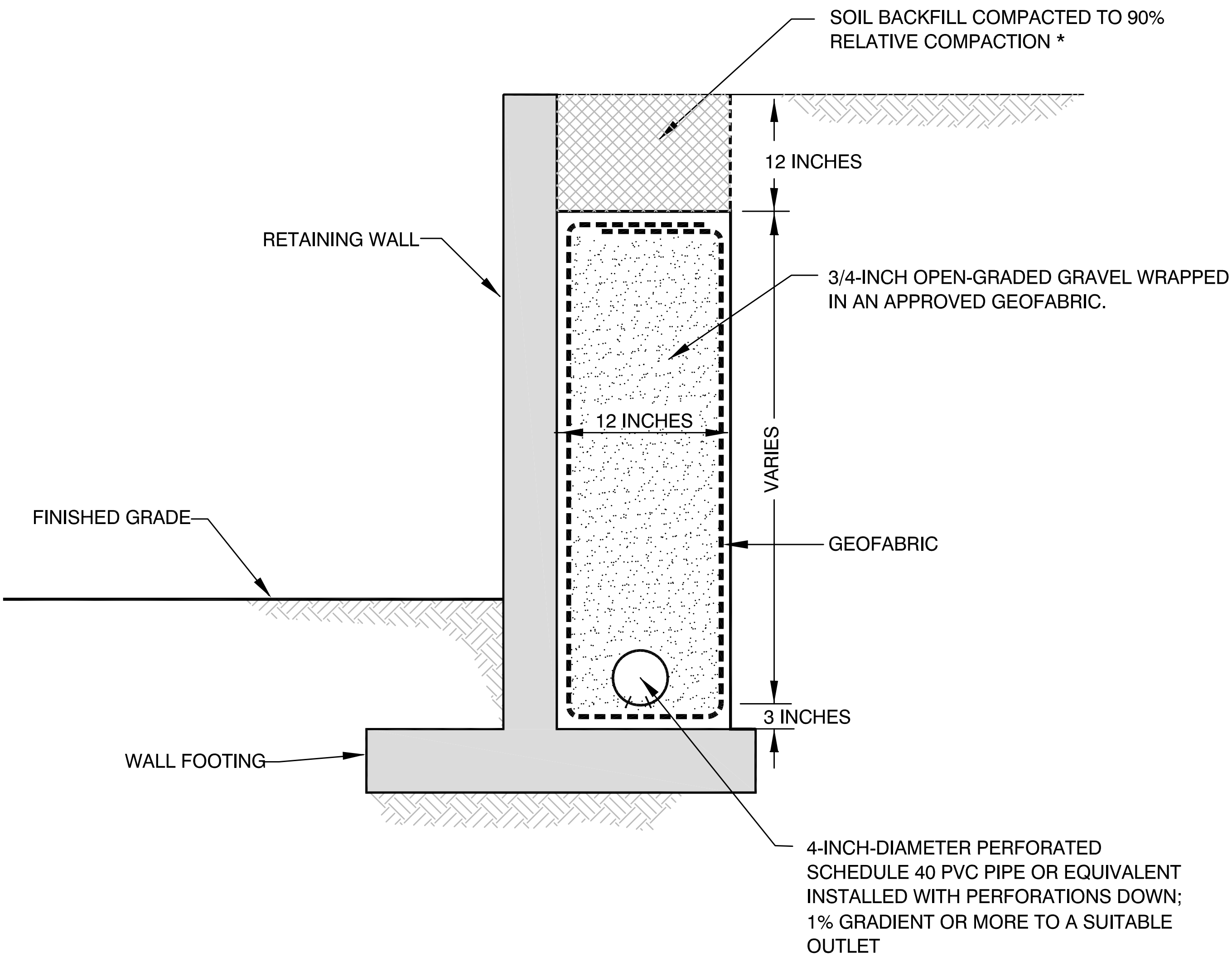
RECOMMENDED GEOTECHNICAL DESIGN PARAMETERS

| Lateral Earth Pressure | Equivalent Fluid Pressure ($lb/ft^2/ft$)(1) | |
|---|---|---|
| $P_a$ | Level Backfill with Granular Soils (2) | 2H:1V Sloping Backfill with Granular Soils (2) |
| | 40 H | 60 H |
| $P_E$ | 10 H | 23 H |
| $P_p$ | Level Ground | 2H:1V Descending Ground |
| | 300 D | 175 D |

*NOT TO SCALE*

5_107675001_d-yrw.dwg

| Ninyo & Moore | LATERAL EARTH PRESSURES FOR YIELDING RETAINING WALLS | FIGURE |
|---|---|---|
| PROJECT NO. 107675001 | DATE 4/14 | COLLEGE BOULEVARD IMPROVEMENT PROJECT OCEANSIDE, CALIFORNIA | 5 |




*BASED ON ASTM D1557

*NOT TO SCALE*

6_107675001_d-rw.dwg

NOTE: AS AN ALTERNATIVE, AN APPROVED GEOCOMPOSITE DRAIN SYSTEM MAY BE USED.

| Ninyo & Moore | | RETAINING WALL DRAINAGE DETAIL | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENT PROJECT<br>OCEANSIDE, CALIFORNIA | 6 |
| 107675001 | 4/14 | | |

## 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 cuttings of the exploratory borings. The samples were bagged and transported to the laboratory for testing.

DRAFT

**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 1-⅜ inches. The sampler was driven into the ground 12 to 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 a modified split-barrel drive sampler. The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a 140-pound hammer, in general accordance with ASTM D 3550. 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 rings, sealed, and transported to the laboratory for testing.

# BORING LOG EXPLANATION SHEET

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

| Depth (feet) | Blows/Foot | Classification U.S.C.S. | Explanation |
|---|---|---|---|
| 0 | | | Bulk sample. |
| | | | Modified split-barrel drive sampler. |
| | | | 2-inch inner diameter split-barrel drive sampler. |
| | | | No recovery with modified split-barrel drive sampler, or 2-inch inner diameter split-barrel drive sampler. |
| | | | Sample retained by others. |
| 5 | | | Standard Penetration Test (SPT). |
| | | | 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. |
| 10 | | | Seepage. |
| | | | Groundwater encountered during drilling. |
| | | | Groundwater measured after drilling. |
| | | SM | <u>MAJOR MATERIAL TYPE (SOIL)</u>:<br>Solid line denotes unit change. |
| | | CL | Dashed line denotes material change. |
| 15 | | | Attitudes: Strike/Dip<br>b: Bedding<br>c: Contact<br>j: Joint<br>f: Fracture<br>F: Fault<br>cs: Clay Seam<br>s: Shear<br>bss: Basal Slide Surface<br>sf: Shear Fracture<br>sz: Shear Zone<br>sbs: Shear Bedding Surface |
| 20 | | | The total depth line is a solid line that is drawn at the bottom of the boring. |

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## BORING LOG

Explanation of Boring Log Symbols

| PROJECT NO. | DATE | FIGURE |
|---|---|---|
| | | |

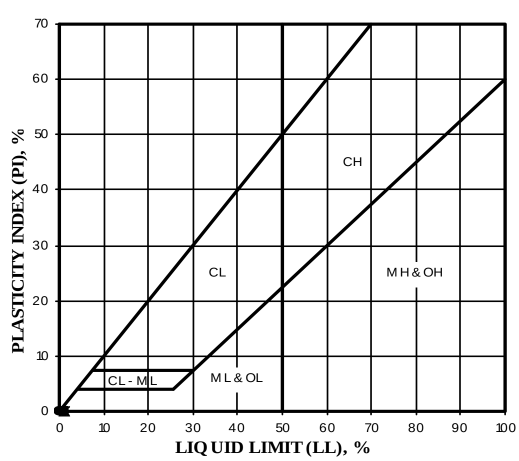
# U.S.C.S. METHOD OF SOIL CLASSIFICATION

| MAJOR DIVISIONS | | SYMBOL | TYPICAL NAMES |
|---|---|---|---|
| COARSE-GRAINED SOILS (More than 1/2 of soil > No. 200 Sieve Size) | GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size | GW | Well graded gravels or gravel-sand mixtures, little or no fines |
| | | GP | Poorly graded gravels or gravel-sand mixtures, little or no fines |
| | | GM | Silty gravels, gravel-sand-silt mixtures |
| | | GC | Clayey gravels, gravel-sand-clay mixtures |
| | SANDS (More than 1/2 of coarse fraction < No. 4 sieve size | SW | Well graded sands or gravelly sands, little or no fines |
| | | SP | Poorly graded sands or gravelly sands, little or no fines |
| | | SM | Silty sands, sand-silt mixtures |
| | | SC | Clayey sands, sand-clay mixtures |
| FINE-GRAINED SOILS (More than 1/2 of soil < No. 200 sieve size) | SILTS & CLAYS Liquid Limit <50 | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts 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 of low plasticity |
| | SILTS & CLAYS Liquid Limit >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, organic silty clays, organic silts |
| HIGHLY ORGANIC SOILS | | Pt | Peat and other highly organic soils |

## GRAIN SIZE CHART

| CLASSIFICATION | RANGE OF GRAIN | |
|---|---|---|
| | U.S. Standard Sieve Size | Grain Size in Millimeters |
| BOULDERS | Above 12" | Above 305 |
| COBBLES | 12" to 3" | 306 to 76.2 |
| GRAVEL | 3" to No. 4 | 76.2 to 4.76 |
| Coarse | 3" to 3/4" | 76.2 to 19.1 |
| Fine | 3/4" to No. 4 | 19.1 to 4.76 |
| SAND | No. 4 to No. 200 | 4.76 to 0.075 |
| Coarse | No. 4 to No. 10 | 4.76 to 2.00 |
| Medium | No. 10 to No. 40 | 2.00 to 0.420 |
| Fine | No. 40 to No. 200 | 0.420 to 0.075 |
| SILT & CLAY | Below No. 200 | Below 0.075 |

## PLASTICITY CHART

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**U.S.C.S. METHOD OF SOIL CLASSIFICATION**

Updated Nov. 2011

DATE DRILLED 3/14/14 BORING NO. B-1

GROUND ELEVATION 240' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 6" Diameter Solid-Stem Auger (Pacific Drilling)

DRIVE WEIGHT 140 lbs. (Cathead) DROP 30"

SAMPLED BY NMM LOGGED BY NMM REVIEWED BY FOM

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SC | FILL: Light brownish gray and grayish brown, damp to moist, medium dense, clayey fine SAND; few clay. |
| | | | | ♀ | | | | Wet. Seepage. |
| | | | | | | | | SANTIAGO FORMATION: Light brownish gray, moist, weakly cemented, clayey fine-grained SANDSTONE; iron oxide staining. |
| 5 | | | 23 | 23.3 | 101.7 | | | |
| 10 | | | 50/2" | | | | | |
| | | | | | | | | Total Depth = 10.7 feet.<br>Groundwater not encountered during drilling.<br>Seepage encountered at approximately 2.5 feet during drilling.<br>Backfilled with bentonite shortly after drilling on 3/14/14.<br><br>Note:<br>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. |
| 15 | | | | | | | | |
| 20 | | | | | | | | |

Ninyo & Moore

**BORING LOG**

COLLEGE BOULEVARD IMPROVEMENT PROJECT
OCEANSIDE, CALIFORNIA

| PROJECT NO. | DATE | FIGURE |
|---|---|---|
| 107675001 | 4/14 | A-1 |

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | SANTIAGO FORMATION: Light grayish brown, damp to moist, weakly to moderately cemented, silty fine-grained SANDSTONE; iron oxide staining; upper 1 foot disturbed. |
| | | | 50/6" | | | | | |
| 5 | | | 50/5" | | | | | |
| | | | | | | | | Total Depth = 5.9 feet. Groundwater not encountered during drilling. Backfilled with bentonite shortly after drilling on 3/14/14. |
| | | | | | | | | Note: 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. |
| 10 | | | | | | | | |
| 15 | | | | | | | | |
| 20 | | | | | | | | |

DATE DRILLED 3/14/14 BORING NO. B-2

GROUND ELEVATION 220' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 6" Diameter Solid-Stem Auger (Pacific Drilling)

DRIVE WEIGHT 140 lbs. (Cathead) DROP 30"

SAMPLED BY NMM LOGGED BY NMM REVIEWED BY FOM

Ninyo & Moore

## BORING LOG

COLLEGE BOULEVARD IMPROVEMENT PROJECT
OCEANSIDE, CALIFORNIA

| PROJECT NO. | DATE | FIGURE |
|---|---|---|
| 107675001 | 4/14 | A-2 |

DATE DRILLED 3/14/14 BORING NO. B-3

GROUND ELEVATION 210' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 6" Diameter Solid-Stem Auger (Pacific Drilling)

DRIVE WEIGHT 140 lbs. (Cathead) DROP 30"

SAMPLES BY NMM LOGGED BY NMM REVIEWED BY FOM

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SM | FILL: Brown and grayish brown, moist, loose to medium dense, silty fine SAND; few clay; cobble up to approximately 7 inches in diameter. |
| | | | | | | | | SANTIAGO FORMATION: Light grayish brown, moist, weakly cemented, silty fine SANDSTONE. |
| | | | | ♀ | | | | Gray; wet; clayey sandstone. Seepage. |
| 5 | | ■ | 16 | | | | | |
| 10 | | ■ | 50/4" | | | | | Gray and light gray; weakly to moderately cemented. |
| | | | | | | | | Total Depth = 10.8 feet. Groundwater not encountered during drilling. Seepage encountered at approximately 4 feet during drilling. Backfilled with bentonite shortly after drilling on 3/14/14. |
| | | | | | | | | Note: 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. |
| 15 | | | | | | | | |
| 20 | | | | | | | | |

Ninyo & Moore

**BORING LOG**

COLLEGE BOULEVARD IMPROVEMENT PROJECT
OCEANSIDE, CALIFORNIA

| PROJECT NO. | DATE | FIGURE |
|---|---|---|
| 107675001 | 4/14 | A-3 |

DATE DRILLED 3/14/14 BORING NO. B-4

GROUND ELEVATION 210' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 6" Diameter Solid-Stem Auger (Pacific Drilling)

DRIVE WEIGHT 140 lbs. (Cathead) DROP 30"

SAMPLED BY NMM LOGGED BY NMM REVIEWED BY FOM

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 0 | Bulk 0–5 | | | | | | SC | FILL: Brown, brownish gray, and light gray, loose to medium dense, clayey SAND; roots. |
| | | | | ♀ | | | | Seepage. |
| 5 | | Driven | 35 | 8.9 | 115.1 | | | SANTIAGO FORMATION: Brown and light grayish brown, moist, weakly cemented, clayey SANDSTONE; weathered. |
| | | Driven | 20 | | | | | Brown and grayish brown; wet; carbonate deposits. |
| 10 | | | | | | | | Total Depth = 9 feet.<br>Groundwater not encountered during drilling.<br>Seepage encountered at approximately 5 feet during drilling.<br>Backfilled with bentonite shortly after drilling on 3/14/14.<br><br>Note:<br>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. |
| 15 | | | | | | | | |
| 20 | | | | | | | | |

Ninyo & Moore

**BORING LOG**

COLLEGE BOULEVARD IMPROVEMENT PROJECT
OCEANSIDE, CALIFORNIA

| PROJECT NO. | DATE | FIGURE |
|---|---|---|
| 107675001 | 4/14 | A-4 |

# 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. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

DRAFT

**In-Place Moisture and Density Tests**

The moisture content and dry density of relatively undisturbed samples obtained from the exploratory borings were 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 and B-2. The test results were utilized in evaluating the soil classifications in accordance with the USCS.

**Direct Shear Tests**

One direct shear test was performed on a sample in general accordance with ASTM D 3080 to evaluate the shear strength characteristics of the selected material. The sample was inundated during shearing to represent adverse field conditions. The test results are shown on Figure B-3.

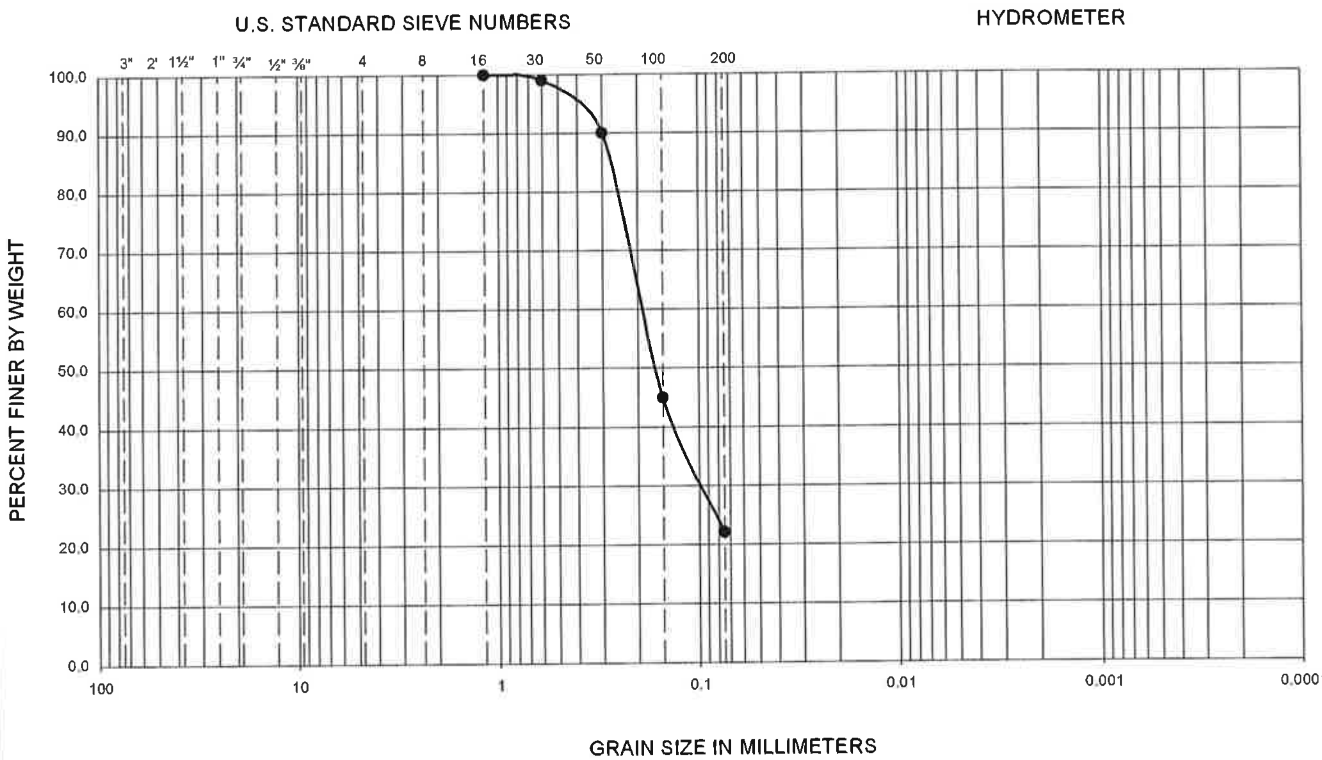
**R-Value**

The resistance value, or R-value, for near-surface site soils was evaluated in general accordance with CT 301. Samples were prepared and evaluated for exudation pressure and expansion pressure. The equilibrium R-value is reported as the lesser or more conservative of the two calculated results. The test results are shown on Figure B-4.

**Soil Corrosivity Tests**

Soil pH, and electrical resistivity tests were performed on a representative sample in general accordance with CT 643. The chloride content of the selected sample was evaluated in general accordance with CT 422. The sulfate content of the selected sample was evaluated in general accordance with CT 417. The test results are presented on Figure B-5.

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |



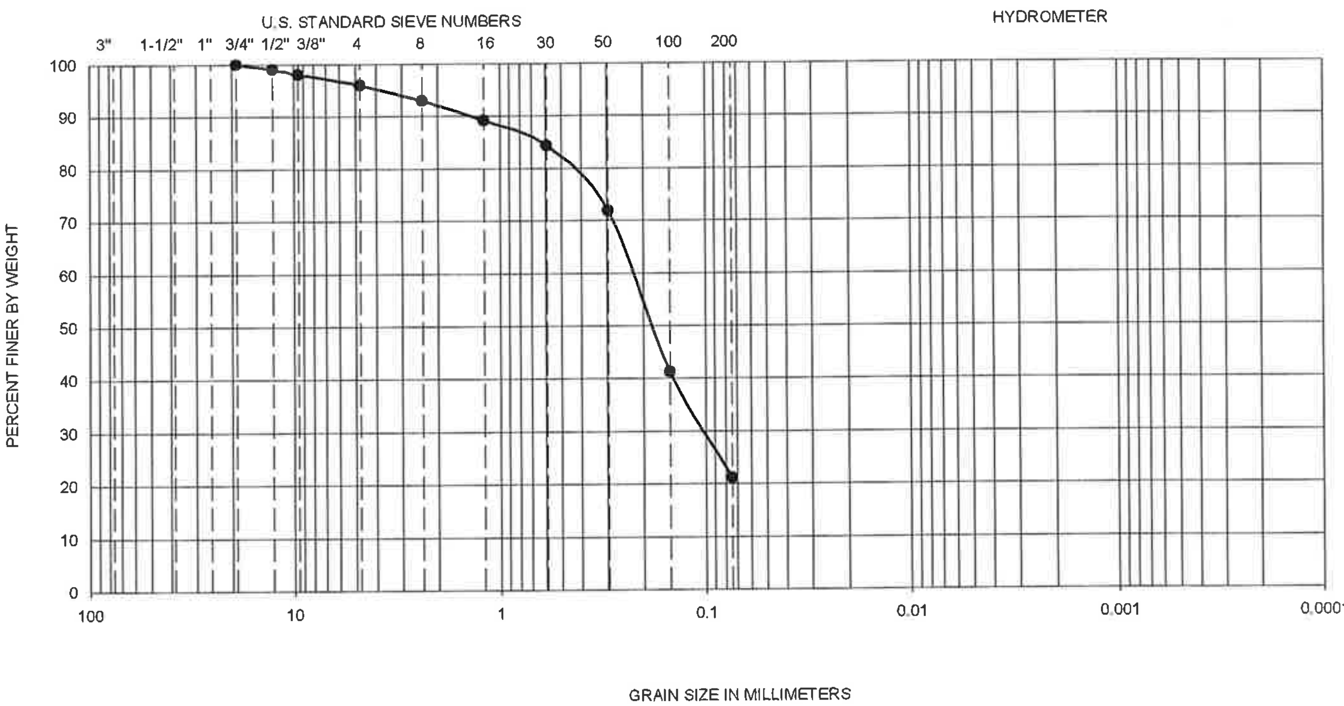

| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (%) | Equivalent USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-2 | 0.0-5.0 | -- | -- | -- | -- | -- | -- | -- | -- | 22 | SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

| Ninyo & Moore | | GRADATION TEST RESULTS | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENTS PROJECT<br>OCEANSIDE, CALIFORNIA | B-1 |
| 107675001 | 4/14 | | |

107675001_SIEVE B-2 @ 0.0-5.0.xls

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |

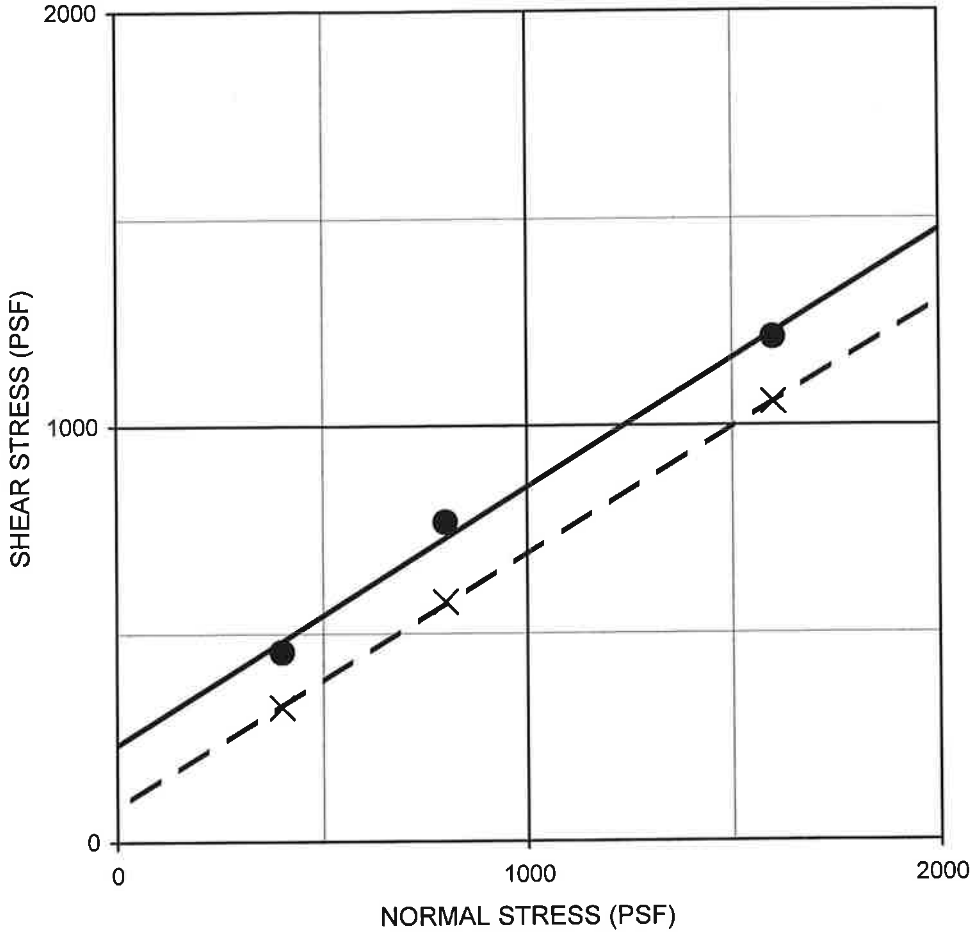



| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (%) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-4 | 0.0-5.0 | -- | -- | -- | -- | -- | -- | -- | -- | 21 | SC |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

| Ninyo & Moore | | GRADATION TEST RESULTS | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENTS PROJECT<br>OCEANSIDE, CALIFORNIA | B-2 |
| 107675001 | 4/14 | | |

107675001_SIEVE B-4 @ 0.0-5.0.xls




| Description | Symbol | Sample Location | Depth (ft) | Shear Strength | Cohesion, c (psf) | Friction Angle, ϕ (degrees) | Soil Type |
|---|---|---|---|---|---|---|---|
| Clayey SANDSTONE | —●— | B-3 | 5.0-6.5 | Peak | 230 | 32 | Formation |
| Clayey SANDSTONE | - - X - - | B-3 | 5.0-6.5 | Ultimate | 80 | 31 | Formation |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 3080

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# DIRECT SHEAR TEST RESULTS

FIGURE

**B-3**

| PROJECT NO. | DATE |
|---|---|
| 107675001 | 4/14 |

COLLEGE BOULEVARD IMPROVEMENTS PROJECT
OCEANSIDE, CALIFORNIA

| SAMPLE LOCATION | SAMPLE DEPTH (FT) | pH [1] | RESISTIVITY [1] (Ohm-cm) | SULFATE CONTENT [2] | | CHLORIDE CONTENT [3] (ppm) |
|---|---|---|---|---|---|---|
| | | | | (ppm) | (%) | |
| B-2 | 0.0-5.0 | 7.2 | 490 | 170 | 0.017 | 540 |

[1] PERFORMED IN GENERAL ACCORDANCE WITH CALIFORNIA TEST METHOD 643
[2] PERFORMED IN GENERAL ACCORDANCE WITH CALIFORNIA TEST METHOD 417
[3] PERFORMED IN GENERAL ACCORDANCE WITH CALIFORNIA TEST METHOD 422

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# CORROSIVITY TEST RESULTS

| PROJECT NO. | DATE |
|---|---|
| 107675001 | 3/14 |

COLLEGE BOULEVARD IMPROVEMENTS PROJECT
OCEANSIDE, CALIFORNIA

FIGURE
**B-4**

| SAMPLE LOCATION | SAMPLE DEPTH (FT) | SOIL TYPE | R-VALUE |
|---|---|---|---|
| B-4 | 0.0-5.0 | Clayey SAND (SC) | 49 |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2844/CT 301

| Ninyo & Moore | | R-VALUE TEST RESULTS | FIGURE |
|---|---|---|---|
| PROJECT NO. | DATE | COLLEGE BOULEVARD IMPROVEMENTS PROJECT<br>OCEANSIDE, CALIFORNIA | B-5 |
| 107675001 | 4/14 | | |