GEOTECHNICAL AND INFILTRATION EVALUATION
PROPOSED 189-UNIT RESIDENTIAL DEVELOPMENT
NWC EAST HIGHLAND AVENUE & PALM AVENUE
SAN BERNARDINO, SAN BERNARDINO COUNTY, CALIFORNIA

PREPARED FOR

WARMINGTON RESIDENTIAL
3090 PULLMAN STREET
COSTA MESA, CALIFORNIA 92626

PREPARED BY

GEOTEK, INC.
1548 NORTH MAPLE STREET
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PROJECT NO. 2813-CR **JULY 30, 2021**

GEOTEK

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July 30, 2021
Project No. 2813-CR

Warmington Residential
3090 Pullman Street
Costa Mesa, California 92626

Attention: Mr. Bret Ilich

Subject: Geotechnical and Infiltration Evaluation
Proposed 189-Unit Residential Development
NWC East Highland Avenue & Palm Avenue
San Bernardino, San Bernardino County, California

Dear Mr. Ilich:

We are pleased to provide herein the results of our geotechnical and infiltration evaluation for the subject site located in San Bernardino, San Bernardino County, California. This report presents a discussion of our evaluation and provides preliminary geotechnical recommendations for earthwork, foundation design, and construction.

In our opinion, site development appears feasible from a geotechnical viewpoint provided that the recommendations included herein are incorporated into the design and construction phases of site development.

The opportunity to be of service is sincerely appreciated. If you should have any questions, please do not hesitate to call our office.

Respectfully submitted,
GeoTek, Inc.

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1. PURPOSE AND SCOPE OF SERVICES

The purpose of this study was to complete an evaluation of the existing geotechnical conditions at the project site, as outlined in our proposal P-0604221-CR, dated June 24, 2021. Services provided for this study included the following:

- Research and review of available geologic and geotechnical data, and general information pertinent to the site,
- Perform a site reconnaissance,
- Site exploration consisting of the excavation and sampling of five exploratory borings observed and logged by a geologist from our firm,
- Excavation of two additional shallow borings for infiltration testing and performance of percolation testing in these borings,
- Collection of representative soil samples from the test borings and performing laboratory testing on select samples,
- Review and evaluation of site seismicity, and
- Compilation of this updated geotechnical report which presents our recommendations for site development.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

2.1 SITE DESCRIPTION

The approximate 14.5-acre site is located adjacent to the northwest corner of the intersection of E. Highland Avenue and Palm Avenue in San Bernardino, San Bernardino County, California. The site is also identified as Assessor Parcel Numbers (APN) 0285-211-05, -21, -23, and -25. The site is currently undeveloped vacant land. Existing developments adjacent to the southeast corner and southwest corner of the site are not part of the subject site. A drainage channel, about 10 feet deep, is situated along the northwest property boundary. The site slopes downward to the southwest with about 50 feet of elevation differential. The site is bordered by residential properties to the north, east and south with the Patton State Hospital Museum property to the west, on the west side of Orange Street. The location of the site is indicated on Figure 1.

2.2 PROPOSED DEVELOPMENT

Based on a review of the Conceptual Density Study, prepared by KTGY, dated June 28, 2021, we understand that the site development will consist of 57-unit single-family residential lots, 132 cluster units, street improvements, open spaces, surface improvements, and underground utilities.

We have assumed that the structures will consist of 1 to 2-story buildings and will be supported by post-tensioned or a conventional shallow foundations and will incorporate slab on-grade floor systems. Although structural loading information has not been provided, we have assumed maximum column and wall laods of less than 40 kips and 3 kips per foot, respectively. Once actual structural loads are known, that information should be provided to GeoTek to determine if revisions to the recommendations presented in this report are warranted.

Based on the current site topography, we anticipate that the maximum depths of cut and fill will be about 10 to 15 feet, not including any remedial grading. If site development differs from the assumptions made herein, the recommendations included in this report should be subject to further review and evaluation. Site development plans should be reviewed by GeoTek when they become available.

3. FIELD EXPLORATION & LABORATORY TESTING

3.1 FIELD EXPLORATION

The field exploration for GeoTek's evaluation was conducted on July 1, 2021 and consisted of excavating five (5) geotechnical exploratory borings extended to depths ranging from about 20 to 43 feet below ground surface. Boring B-1 was terminated at a depth shallower than initially planned due to auger refusal on suspected cobbles or boulders. Two shallow borings were also drilled to a depth of about 5 feet for percolation testing. The approximate locations of the GeoTek excavations are shown on the Boring Location Map (Figure 2). Logs of the GeoTek borings are included in Appendix A.

Relatively undisturbed soil samples were recovered at various intervals in the geotechnical borings with a California sampler. The California sampler is a 3-inch outside diameter, 2.4-inch inside diameter, split barrel sampler lined with brass rings. The sampler was 18 inches long. The sampler conformed to the requirements of ASTM D 3550. Standard Penetration Tests (SPT) were also performed in Boring B-1 per ASTM D-1586. A 140-pound automatic trip hammer was utilized, dropping 30 inches for each blow. The relatively undisturbed samples, together with bulk samples of representative soil types, were returned to the laboratory for testing and evaluation. The California ring and SPT sampler data is presented on the boring logs.

3.2 LABORATORY TESTING

Laboratory testing was performed by GeoTek on selected soil samples obtained from the borings. The purpose of the laboratory testing was to confirm the field classification of the soils encountered and to evaluate the physical properties of the soils for use in engineering design and analysis.

Included in our laboratory testing were moisture-density determination testing on selected relatively undisturbed samples. Grain-size analysis (percent passing the No. 200 sieve) were performed to aid in the soil classification. Collapse testing was performed on two representative "undisturbed' samples to assess the hydro-consolidation potential of the near-surface soils. The optimum moisture content-maximum dry density relationship was established for a typical soil type so that the relative compaction of the subsoils could be determined. Direct shear testing was performed on selected samples to help evaluate the bearing capacity of the soils. Expansion index testing was performed on one selected sample to evaluate the expansion potential of the site soils. Chemical testing comprised of pH, soluble sulfate, chloride and resistivity testing was conducted on selected samples. The moisture-density data and grain-size data are presented on the exploration logs in Appendix A. The maximum density, direct shear, collapse tests, expansion index and chemical test data are presented in Appendix B.

3.3 PERCOLATION TESTING

Percolation testing was performed at boring locations I-1 and I-2, in the area anticipated to be used for stormwater infiltration, to assess the infiltration characteristics of the site soils within the future stormwater management basin. The borings were excavated to approximately 5 feet below the existing grade. The boring diameters were approximately eight inches. Subsequent to pre-soaking, percolation testing was performed, in accordance with the methods approved by San Bernardino County, within the lower approximately 20 inches in the borings. The percolation rates were then corrected to account for discharge of water from both the sides and bottom of the borings. This correction was performed using the Porchet Method, obtaining the infiltration rates tabulated below:

SUMMARY OF RESULTS		
Boring	Measured Field Percolation Rate (minutes per inch)	Calculated Infiltration Rate (inches per hour)
I-1	3.33	1.76
I-2	3.70	1.57

Copies of the field data sheet and infiltration conversion sheet (Porchet Method) are included in Appendix C. The reported infiltration rates are the measured rate without any factor of safety applied. Over the lifetime of the detention basin, the infiltration rate may be affected by silt build up and biological activities, as well as local variations in near surface soil conditions. A suitable factor of safety should be applied to the field rates in design the infiltration system.

It should be noted that the infiltration rate provided above was performed in relatively undisturbed native soils. Infiltration rates will vary and are mostly dependent on the underlying consistency of the site soils and relative density. Infiltration rates will be impacted by weight of equipment travelling over the soils, placement of engineered fill and other various factors. GeoTek, Inc. assumes no responsibility or liability for the ultimate design or performance of the storm water facility.

4. GEOLOGIC AND SOILS CONDITIONS

4.1 REGIONAL SETTING

The subject property is situated in the Peninsular Ranges geomorphic province near the border with the Transverse Ranges. The Peninsular Ranges province is one of the largest geomorphic units in western North America. Basically, it extends roughly 975 miles from the north and extends from the Transverse Ranges geomorphic province to the tip of Baja California, from north to south. This province varies in width from about 30 to 100 miles. It is bounded on the west by the Pacific Ocean, on the south by the Gulf of California and on the east by the Colorado Desert Province.

The Peninsular Ranges are essentially a series of northwest-southeast oriented fault blocks. Several major fault zones are found in this province. The Elsinore Fault zone and the San Jacinto Fault zone trend northwest-southeast and are found in the near the middle of the province. The San Andreas Fault zone borders the northeasterly margin of the province.

More specific to the subject property, the site is located in an area geologically mapped to be underlain by alluvium (Dibblee, T. W. and Minch, J.A., 2004), described as sand and clay.

4.2 GENERAL SOIL/GEOLOGIC CONDITIONS

A brief description of the earth materials encountered below the site and within the area of anticipated construction is presented in the following section. Based on our field exploration, the area of anticipated improvements is underlain by alluvium.

4.2.1 Alluvium

Alluvium was encountered beneath the ground surface in all geotechnical borings and extended to the maximum depth explored. The alluvium encountered consisted of a loose to very dense silty sand with variable clay content, clayey sand, slightly silty sand and a very stiff to hard sandy silt.

According to the results of the laboratory testing performed on one sample of the near surface fill, the near surface soils have a "very low" expansion potential (EI=1) when tested and classified in accordance with ASTM D 4829. The test results are provided in Appendix B.

4.3 SURFACE AND GROUNDWATER

4.3.1 Surface Water

If encountered during the earthwork construction, surface water on this site is the result of precipitation or surface run-off from surrounding sites. Provisions for surface drainage will need to be accounted for by the project civil engineer.

4.3.2 Groundwater

Groundwater was not encountered within any of the GeoTek borings which extended to a maximum depth of about 51.5 feet below grade. A review of groundwater depth information noted on the State Department of Water Resources Water Data Library website indicates a depth to groundwater is greater than about 150 feet below grade within wells in the site vicinity.

It is possible that seasonal variations (temperature, rainfall, etc.) will cause fluctuations in the groundwater level. Additionally, perched water may be encountered at shallow depths following extensive rain events. If shallow perched water is encountered, we anticipate that it can be managed with conventional sump pumps.

4.4 FAULTING AND SEISMICITY

The geologic structure of the entire southern California area is dominated mainly by northwest-trending faults associated with the San Andreas system. The site is in a seismically active region. No active or potentially active fault is known to exist at this site nor is the site situated within an *"Alquist-Priolo"* Earthquake Fault Zone. The subject property is located within an area that has not yet been evaluated by the CGS for earthquake induced landsliding or liquefaction. However, the site is not within a seismic hazard area as identified on the San Bernardino County Geologic Hazards Overlay Map (Sheet FH23_C). The nearest zoned fault is the San Andreas fault zone, located about 0.4 mile to the northeast.

4.4.1 Seismic Design Parameters

The site is located at approximately 34.1368 degrees Latitude and -117.2109 degrees Longitude. Site spectral accelerations (S_a and S_1), for 0.2 and 1.0 second periods for a Class "D" site, was determined from the SEAOC/OSHPD web interface that utilizes the USGS web services and retrieves the seismic design data and presents that information in a report format. Using the ASCE 7-16 option on the SEAOC/OSHPD website results in the values for S_{M1} and S_{D1} reported as "null-See Section 11.4.8" (of ASCE 7-16). As noted in ASCE 7-16, Section 11.4.8, a site-specific ground motion procedure is recommended for Site Class D when the value S_1 exceeds 0.2. The value S_1 for the subject site exceeds 0.2.

For a site Class D, an exception to performing a site-specific ground motion analysis is allowed in ASCE 7-16 where S_1 exceeds 0.2 provided the value of the seismic response coefficient, Cs, is conservatively calculated by Eq 12.8-2 of ASCE 7-16 for values of $T \leq 1.5Ts$ and taken as equal to 1.5 times the value computed in accordance with either Eq. 12.8-3 for $T_L \geq T > 1.5Ts$ or Eq. 12.8-4 for $T > T_L$.

The results, based on the 2015 NEHRP and the 2019 CBC, are presented in the following table and we have assumed that the exception as allowed in ASCE 7-16 is applicable. If the exception is deemed not appropriate, a site-specific ground motion analysis will be required.

SITE SEISMIC PARAMETERS	
Mapped 0.2 sec Period Spectral Acceleration, S_s	2.602g
Mapped 1.0 sec Period Spectral Acceleration, S_1	1.031g
Site Coefficient for Site Class "D", F_a	1.0
Site Coefficient for Site Class "D", F_v	1.7
Maximum Considered Earthquake Spectral Response Acceleration for 0.2 Second, S_{MS}	2.602g
Maximum Considered Earthquake Spectral Response Acceleration for 1.0 Second, S_{M1}	1.753g
5% Damped Design Spectral Response Acceleration Parameter at 0.2 Second, S_{DS}	1.735g
5% Damped Design Spectral Response Acceleration Parameter at 1 second, S_{D1}	1.168g
Peak Ground Acceleration Adjusted for Site Class Effects, PGA_M	1.186g
Seismic Design Category	E

4.5 LIQUEFACTION CONSIDERATIONS

A review of the San Bernardino County Geologic Hazard Maps (Map FH23-C) indicates the site is not situated within an area that is designated as possessing a liquefaction hazard. Due to the current mapping and the great depth to groundwater (150+ feet), it is our opinion that the potential for liquefaction at this site due to nearby seismic activity is nil.

An assessment of the "dry" settlement (i.e. settlement above the water table) resulting from seismic shaking was also evaluated. For this analysis we used a groundwater depth of 150 feet, a ground acceleration (PGA_M) of 1.186g and a mean earthquake magnitude of 7.3. The ground acceleration and earthquake magnitude were obtained from the USGS websites. The computer software program LiquefyPro and the soil profiled from Boring B-1 were used in the analysis. The results of this analysis indicate a potential ground surface settlement of about 2 inches is possible. A differential seismic settlement of about 1 inch over a 40 foot span is estimated. Based on these estimated magnitudes, ground modification or special foundation design is not deemed necessary. The results of the seismic dry settlement analysis are presented in Appendix D.

4.6 OTHER SEISMIC HAZARDS

Evidence of ancient landslides or slope instabilities at this site was not observed during our investigation. Thus, the potential for landslides is considered negligible for design purposes. The potential for secondary seismic hazards such as a seiche or tsunami is considered negligible due to site elevation and distance to an open body of water.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL

Development of the site appears feasible from a geotechnical viewpoint. The following recommendations should be incorporated into the design and construction phases of development.

5.2 EARTHWORK CONSIDERATIONS

Earthwork and grading should be performed in accordance with the applicable grading ordinances of the City of San Bernardino, the 2019 California Building Code (CBC) and recommendations contained in this report. Site grading plans should be reviewed by this office when they become available. Additional recommendations may be offered subsequent to review of these plans. The General Grading Guidelines included in Appendix E outline general procedures and do not anticipate all site-specific situations. In the event of conflict, the recommendations presented in the text of this report should supersede those contained in Appendix E.

5.2.1 Site Clearing & Demolition

Initial site preparation should include removal of all vegetation and any other deleterious materials within the planned development area of the site. The horizontal limits of the clearing should extend at least 8 feet beyond the new buildings and beneath any new improvements.

Voids resulting from removing any materials should be replaced with engineered fill materials with expansion characteristics similar to the onsite materials.

5.2.2 Site Preparation

Following site clearing and lowering of site grades, where necessary, we recommend that any encountered undocumented fill and the upper four feet of the native alluvium be removed below existing or finished grade, whichever is deeper, and stockpiled on-site for future use. The lateral extent of the recommended over-excavation should extend at least 5 feet beyond all buildings and beneath adjacent patio slabs. The soils exposed at the base of the over-excavation should then be examined by a GeoTek representative to confirm that the exposed soils are suitable for structural support. If unsuitable soils are encountered, those materials should be removed as recommended by GeoTek. Once approved, the exposed soils should be scarified to a depth of about 12 inches, be moisture treated to slightly above the soil's maximum dry density, per ASTM D1557, and then be compacted to at least 90% of the soil's maximum dry density (ASTM D1557).

Beneath new roadways, pavements, other surface improvements and areas to receive new fill, we recommend that the exposed soils, prior to fill placement, be proof rolled in the presence of a GeoTek representative. Proof rolling equipment should possess a minimum static weight of 10 tons and proof rolling should consist of at least four passes, two in each perpendicular direction. Any soil that ruts or excessively deflects during proof rolling should be removed as recommended by the GeoTek representative. Following proof rolling, the exposed soils should be scarified, moisture treated and compacted as recommended in the prior paragraph.

5.2.3 Fills

On-site materials are generally considered suitable for reuse as engineered fill, provided they are free from vegetation, roots, and other deleterious material. Rock fragments (i.e. cobbles or boulders) greater than 6 inches in maximum dimension should not be incorporated into engineered fill. The fill materials should also be placed so that void resulting from nesting of cobbles does not occur.

Engineered fill materials should be placed in horizontal lifts not exceeding 8 inches in loose thickness, moisture conditioned to slightly over the optimum moisture content and compacted to a minimum relative compaction of 90 percent (ASTM D 1557).

5.2.4 Excavation Characteristics

Excavation in the on-site soils is expected to be feasible utilizing heavy-duty grading equipment in good operating condition. All temporary excavations for grading purposes and installation of underground utilities should be constructed in accordance with local and Cal-OSHA guidelines. Temporary excavations within the on-site materials should be stable at 1:1 (h:v) inclinations for cuts less than 5 feet in height.

5.2.5 Shrinkage & Subsidence Estimates

Several factors will impact earthwork balancing on the site, including shrinkage, subsidence, trench spoil from utilities and footing excavations, as well as the accuracy of topography.

Shrinkage is primarily dependent upon the degree of compactive effort achieved during construction. For planning purposes, a shrinkage factor of approximately 5 to 10 percent may be considered for the materials requiring recompaction. Subsidence of about 0.1 feet may also occur as a result of preparation of exposed ground. Site balance may also be impacted if over-sized materials are exported from the site.

5.2.6 Trench Excavations and Backfill

Temporary excavations within the onsite materials should be stable at 1:1 inclinations for short durations during construction, and where cuts do not exceed 10 feet in height. Temporary cuts to a maximum height of 4 feet can be excavated vertically, but local sloughing and/or failure could occur due to the granulated nature of the soils at this site. Increased caution should be applied when working near or within any excavations at this site.

Trench excavations should conform to Cal-OSHA regulations. The contractor should have a competent person, per OSHA requirements, on site during construction to observe conditions and to make the appropriate recommendations.

Utility trench backfill should be compacted to at least 90 percent relative compaction (as determined per ASTM D 1557). Under-slab trenches should also be compacted to project specifications. Onsite materials are not considered suitable for use as bedding material but should be suitable as backfill, provided over-sized materials are removed.

Compaction should be achieved with a mechanical compaction device. Ponding or jetting of trench backfill is not recommended. If backfill soils have dried out, they should be thoroughly moisture conditioned prior to placement in trenches.

5.3 DESIGN RECOMMENDATIONS

The soils are classified as having a "very low" expansion potential in accordance with ASTM D 4829. We understand that post-tensioned foundations may be used for this site. Since the CBC indicates Post Tensioning Institute (PTI) design methodology is intended for expansive soils conditions, which do not apply, no e_m or y_m parameters as used in the PTI methodology are provided. The foundation elements for the proposed structures should bear entirely in engineered fill soils and should be designed in accordance with the *2019 California Building Code (CBC)*.

MINIMUM DESIGN REQUIREMENTS FOR POST-TENSIONED FOUNDATIONS	
Foundation Design Parameter	"Very Low" Expansion Potential
Foundation Depth or Minimum Perimeter Beam Depth/Turned Down Edge (inches below lowest adjacent grade)	One and Two-Stories – 12 inches*
Minimum Beam/Wall Foundation Width	One and Two-Stories – 12 inches*
Minimum Slab Thickness (actual)	4 inches
Presaturation of Subgrade Soil (Percent of Optimum)	Minimum 100% to a depth of 12 inches

*Greater depths and widths may be required per the structural design. Interior footing depths should be at least 12 inches below interior finished grade for 1-2 story buildings. Interior pad footings should possess a minimum width of 18 inches.

Foundation design criteria for a conventional foundation system, in general conformance with the 2019 CBC, are also presented below. The soils are classified as having a "very low" expansion potential in accordance with ASTM D 4829. Typical design criteria for the site based upon a "very low" expansion potential are tabulated below. These are minimal recommendations and are not intended to supersede the design by the project structural engineer. Once structural loading information is provided, revisions to the recommendations provided in this report may be necessary.

The conventional foundation elements for the proposed permanent buildings should bear entirely in engineered fill soils. Foundations should be designed in accordance with the 2019 CBC.

Expansion index and soluble sulfate evaluation of the soils should be performed during construction to evaluate the as-graded conditions. Final recommendations should be based upon the as-graded soils conditions.

A summary of our foundation design recommendations is presented in the following table:

GEOTECHNICAL RECOMMENDATIONS FOR FOUNDATION DESIGN

Design Parameter	"Very Low" Expansion Potential
Foundation Depth or Minimum Perimeter Beam Depth (inches below lowest adjacent grade)	12-1 & 2 story
Minimum Foundation Width (Inches)*	12-1 story 15-2 story
Minimum Slab Thickness (actual)	4 – Actual
Minimum Slab Reinforcing	6" x 6" – W1.4/W1.4 welded wire fabric placed in middle of slab or No. 3 bars at 24 inch centers
Minimum Footing Reinforcement	Two No. 4 reinforcing bars, one placed near the top and one near the bottom
Effective Plasticity Index	PI<15
Presaturation of Subgrade Soil (Percent of Optimum)	Minimum of 100% of the optimum moisture content to a depth of at least 12 inches prior to placing concrete

* Code minimums per Table 1809.7 of the 2019 CBC

An allowable bearing capacity of 2,500 pounds per square foot (psf) may be used for design of building foundations for footing depths and widths of 12 inches. This allowable soil bearing capacity can be increased by 750 psf and 400 psf for each additional foot of footing depth or width to a maximum value of 3,500 psf. The allowable bearing capacity may also be increased by one-third when considering short-term wind and seismic loads.

For footings designed in accordance with the recommendations presented in this report, we would anticipate a maximum static settlement of less than one inch and a maximum differential static settlement of less than ½-inch in a 40-foot span.

The passive earth pressure may be computed as an equivalent fluid having a density of 295 psf per foot of depth, to a maximum earth pressure of 3,000 psf for footings cast adjacent to compacted fill. A coefficient of friction between soil and concrete of 0.45 may be used with dead load forces. The upper one foot of soil below the adjacent grade should not be used in calculating passive pressure unless the ground surface is covered with pavement. When combining passive and frictional resistance, the passive pressure component should be reduced by one-third.

A moisture and vapor retarding system should be placed below slabs-on-grade where moisture migration through the slab is undesirable. Guidelines for these are provided in the 2019 California Green Building Standards Code (CALGreen) Section 4.505.2 and the 2019 CBC Section 1907.1 and ACI 360R-10. The vapor retarder design and construction should also meet the requirements of ASTM E1643. A portion of the vapor retarder design should be the implementation of a moisture vapor retardant membrane.

It should be realized that the effectiveness of the vapor retarding membrane can be adversely impacted as a result of construction related punctures (e.g. stake penetrations, tears, punctures from walking on the aggregate layer, etc.). These occurrences should be limited as much as possible during construction. Thicker membranes are generally more resistant to accidental puncture than thinner ones. Products specifically designed for use as moisture/vapor retarders may also be more puncture resistant. Although the CBC specifies a six-mil vapor retarder membrane, it is GeoTek's opinion that a minimum 10 mil thick membrane with joints properly overlapped and sealed should be considered, unless otherwise specified by the slab design professional. The membrane should consist of Stego wrap or the equivalent.

Moisture and vapor retarding systems are intended to provide a certain level of resistance to vapor and moisture transmission through the concrete, but do not eliminate it. The acceptable level of moisture transmission through the slab is to a large extent based on the type of flooring used and environmental conditions. Ultimately, the vapor retarding system should be comprised of suitable elements to limit migration of water and reduce transmission of water vapor through the slab to acceptable levels. The selected elements should have suitable properties (i.e., thickness, composition, strength, and permeability) to achieve the desired performance level. Consideration should be given to consulting with an individual possessing specific expertise in this area for additional evaluation.

Moisture retarders can reduce, but not eliminate, moisture vapor rise from the underlying soils up through the slab. Moisture retarders should be designed and constructed in accordance with applicable American Concrete Institute, Portland Cement Association, Post-Tensioning Concrete Institute, ASTM and California Building Code requirements and guidelines.

GeoTek recommends that a qualified person, such as the flooring contractor, structural engineer, and/or architect be consulted to evaluate the general and specific moisture vapor transmission paths and associated potential impact.

In addition, the recommendations in this report and our services in general are not intended to address mold prevention, since we along with geotechnical consultants in general, do not practice in areas of mold prevention. If specific recommendations are desired, a professional mold prevention consultant should be contacted.

5.3.1 Miscellaneous Foundation Recommendations

5.3.1.1 To minimize moisture penetration beneath the slab on grade areas, utility trenches should be backfilled with engineered fill, lean concrete or concrete slurry where they intercept the perimeter footing or thickened slab edge.

5.3.1.2 Soils from the footing excavations should not be placed in the slab-on-grade areas unless properly compacted and tested. The excavations should be free of loose/sloughed materials and be neatly trimmed at the time of concrete placement.

5.3.1.3 Under-slab utility trenches should be compacted to project specifications. Compaction should be achieved with a mechanical compaction device. If backfill soils have dried out, they should be thoroughly moisture conditioned prior to placement in trenches.

5.3.1.4 Utility trench excavations should be shored or laid back in accordance with applicable CAL/OSHA standards.

5.3.1.5 On-site materials may not be suitable for use as bedding material but will be suitable as backfill. Jetting of native soils will not be acceptable.

5.3.2 Foundation Setbacks

Foundations should comply with the following setbacks. Improvements not conforming to these setbacks are subject to the increased likelihood of excessive lateral movements and/or differential settlements. If large enough, these movements can compromise the integrity of the improvements. The following recommendations are presented:

- The outside bottom edge of all footings should be set back a minimum of H/3 (where H is the slope height) from the face of any descending slope. The setback should be at least 7 feet and need not exceed 40 feet.
- The bottom of all footings for structures near retaining walls should be deepened so as to extend below a 1:1 projection upward from the bottom inside edge of the wall stem.
- The bottom of any existing foundations for structures should be deepened so as to extend below a 1:1 projection upward from the bottom of the nearest excavation.

5.4 RETAINING WALL DESIGN AND CONSTRUCTION

5.4.1 General Design Criteria

Recommendations presented in this report apply to typical masonry or concrete vertical retaining walls. These are typical design criteria and are not intended to supersede the design by the structural engineer.

Retaining wall foundations should be designed in accordance with *Section 5.3* of this report. A minimum foundation embedment of 12 inches into engineered compacted fill with "very low" expansion potential is recommended. Structural needs may govern and should be evaluated by the project structural engineer.

All earth retention structure plans, as applicable, should be reviewed by this office prior to finalization.

The backfill material placement for all earth retention structures should meet the requirement of *Section 5.4.4* in this report.

In general, cantilever earth retention structures, which are designed to yield at least 0.001H, where H is equal to the height of the wall to the base of the footing, may be designed using the active condition. Rigid earth retention structures (including but not limited to rigid walls, and walls braced at top, such as typical basement walls) should be designed using the at-rest condition.

In addition to the design lateral forces due to retained earth, surcharges due to improvements, such as an adjacent building or traffic loading, should be considered in the design of the earth retention structures. Loads applied within a 1:1 (h:v) projection from the surcharge on the stem of the earth retention structure should be considered in the design.

Final selection of the appropriate design parameters should be made by the designer of the earth retention structures.

5.4.2 Cantilevered Walls

The recommendations presented below are for cantilevered retaining walls. Active earth pressure may be used for retaining wall design, provided the top of the wall is not restrained from minor deflections. An equivalent fluid pressure approach may be used to compute the horizontal pressure against the wall. Appropriate fluid unit weights are given below for specific slope gradients of the retained material. These do not include other superimposed loading conditions such as traffic, structures, seismic events, or adverse geologic conditions.

Surface Slope of Retained Materials (h:v)	Equivalent Fluid Pressure (pcf) Native Backfill*
Level	32
2:1	50

* The design pressures assume the backfill material has an expansion index less than or equal to 20. Backfill zone includes area between the back of the wall and footing to a plane (1:1 h:v) up from the bottom of the wall foundation to the ground surface.

For walls with a retained height greater than 6 feet, an incremental seismic pressure must also be included within the wall design. Based on a ground acceleration (PGA_M) of 1.186g, we recommend that an incremental seismic pressure of 35.6 pcf be used, where required by code. This seismic pressure may be applied as a conventional triangular distribution.

5.4.3 Restrained Retaining Walls

Retaining walls that will be restrained prior to placing and compacting backfill material, or that have reentrant or male corners, should be designed for an at-rest equivalent fluid pressure of 55 pcf, plus any applicable surcharge loading, for very low expansive backfill (EI<20) and level back slope condition. For areas of male or reentrant corners, the restrained wall design should extend a minimum distance of twice the height of the wall laterally from the corner, or a distance otherwise determined by the project structural engineer.

5.4.4 Retaining Wall Backfill and Drainage

Retaining wall backfill should consist of materials with an expansion index (EI) ≤ 20 and free of deleterious and/or oversized materials. The wall backfill should also include a minimum one-foot wide section of ¾- to 1-inch clean crushed rock (or approved equivalent). The rock should be placed immediately adjacent to the back of wall and extend up from the back drain to within approximately 12 inches of finish grade. The upper 12 inches should consist of compacted onsite materials or pavements. Presence of other materials might necessitate revision to the parameters provided and modification of wall designs. The backfill materials should be placed in lifts no greater than 8-inches in thickness and compacted to a minimum of 90 percent relative compaction in accordance with ASTM Test Method D 1557. Proper surface drainage needs to be provided and maintained. Bracing of the walls during backfilling and compaction may also be necessary.

All earth retention structures should be provided with an adequate pipe and gravel back drain system to reduce the potential for hydrostatic pressure build up. As a minimum, backdrains should consist of a four-inch diameter perforated collector pipe (Schedule 40, SDR 35, or approved equivalent) embedded in a minimum of one cubic foot per lineal foot of ¾- to 1-inch clean crushed rock or equivalent, wrapped in filter fabric (Mirafi 140N or approved equivalent). The drain system should be connected to a suitable outlet, as determined by the civil engineer. Drain outlets should be maintained over the life of the project and should not be obstructed or plugged by adjacent improvements. Waterproofing of site walls should be performed where moisture migration through the wall is undesirable.

Proper surface drainage needs to be provided and maintained. Water should not be allowed to pond behind retaining walls. Waterproofing of site walls should be performed where moisture migration through the wall is undesirable.

5.5 SOIL CORROSIVITY

Based on the chemical test results performed on one sample collected from the site as presented in Appendix B, the corrosivity test results indicate that the on-site soils are "moderately corrosive" to buried ferrous metal. This corrosion classification is obtained from "Handbook of Corrosion Engineering," by Pierre R. Roberge, 2nd Edition, 2000. Recommendations for protection of buried ferrous metal should be provided by a corrosion engineer. Additional corrosion testing should be performed at the time of site grading to assess the corrosion of potential of the as-graded soils.

5.5.1 Soil Sulfate Content

The sulfate content was determined in the laboratory for one representative onsite soil sample. The results indicate that the water-soluble sulfate is less than 0.1 percent by weight which is considered "not applicable" (i.e. negligible) as per Table 4.2.1 of ACI 318. Based upon the test results, no special concrete mix design is required by Code for sulfate attack resistance.

5.5.2 Import Soils

Import soils (if needed) should have an Expansion Index of less than 20 (very low) and should not possess oversized or deleterious materials. GeoTek also recommends that, as a minimum, any proposed import soils be tested for soluble sulfate content. GeoTek should be notified a minimum of 72 hours of potential import sources so that appropriate sampling and laboratory testing can be performed.

5.6 PRELIMINARY PAVEMENT DESIGN

Preliminary pavement design for proposed street improvements was conducted per Caltrans *Highway Design Manual* guidelines for flexible pavements. Based on an assumed design R-value of 40 and for Traffic Indices (TIs) of 5.0 and 6.0, the following preliminary sections were calculated:

PRELIMINARY MINIMUM PAVEMENT SECTION		
Traffic Index	Thickness of Asphalt Concrete (inches)	Thickness of Aggregate Base (inches)
5.0	3	4
6.0	3-½	6

Traffic Indices (TIs) used in our pavement design are considered reasonable values for the proposed residential street areas and should provide a pavement life of approximately 20 years with a normal amount of flexible pavement maintenance. Irrigation adjacent to pavements, without a deep curb or other cutoff to separate landscaping from the paving may result in premature pavement failure. Traffic parameters used for design were selected based upon engineering judgment and not upon information furnished to us such as an equivalent wheel load analysis or a traffic study.

The recommended pavement sections provided are intended as a minimum guideline and final selection of pavement cross section parameters should be made by the project civil engineer, based upon the local laws and ordinates, expected subgrade and pavement response, and desired level of conservatism. If thinner or highly variable pavement sections are constructed, increased maintenance and repair could be expected. Final pavement design should be checked by testing of soils exposed at subgrade (the upper five feet) after final grading has been completed.

Asphalt concrete and aggregate base should conform to current Caltrans Standard Specifications Section 39 and 26-1.02, respectively. As an alternative, asphalt concrete can conform to Section 203-6 of the current Standard Specifications for Public Work (Green Book). Crushed aggregate base or crushed miscellaneous base can conform to Section 200-2.2 and 200-2.4 of the Green Book, respectively. Pavement base should be compacted to at least 95 percent of the ASTM D1557 laboratory maximum dry density (modified proctor).

All pavement installation, including preparation and compaction of subgrade, compaction of base material, placement and rolling of asphaltic concrete should be done in accordance with the City of San Bernardino specifications, and under the observation and testing of GeoTek and a City

Inspector where required. Jurisdictional minimum compaction requirements in excess of the aforementioned minimums may govern.

Deleterious material, excessive wet or dry pockets, oversized rock fragments, and other unsuitable yielding materials encountered during grading should be removed. Once existing compacted fill are brought to the proposed pavement subgrade elevations, the subgrade should be proof-rolled in order to check for a uniform and unyielding surface. The upper 12 inches of pavement subgrade soils should be scarified, moisture conditioned at or near optimum moisture content, and recompacted to at least 95 percent of the laboratory maximum dry density (ASTM D1557). If loose or yielding materials are encountered during construction, additional evaluation of these areas should be carried out by GeoTek. All pavement section changes should be properly transitioned.

5.7 CONCRETE FLATWORK

5.7.1 Exterior Concrete Slabs and Sidewalks

Exterior concrete slabs and sidewalks should be designed using a four (4) inch minimum thickness. No specific reinforcement is required due to the non-structural nature and the very low expansive nature of the site soils. However, the use of some reinforcement should be considered. Recommendations can be provided upon request. Some shrinkage and cracking of the concrete should be anticipated as a result of typical mix designs and curing practices commonly utilized in residential construction.

Sidewalks and driveways may be under the jurisdiction of the governing agency. If so, jurisdictional design and construction criteria would apply, if more restrictive than the recommendations presented herein.

Subgrade soils, classified as having “very low” expansion potential, should be pre-moistened prior to placing concrete. The subgrade soils below exterior slabs, sidewalks, driveways, etc. at the subject site should be pre-saturated to a minimum of 100% of optimum moisture content to a depth of 12 inches for “very low” expansive soils.

All concrete installation, including preparation and compaction of subgrade, should be done in accordance with City of San Bernardino specifications, and under the observation and testing of GeoTek and a City Inspector, if necessary.

5.7.2 Concrete Performance

Concrete cracks should be expected. These cracks can vary from sizes that are essentially unnoticeable to more than 1/8 inch in width. Most cracks in concrete, while unsightly, do not significantly impact long-term performance. While it is possible to take measures (proper concrete mix, placement, curing, control joints, etc.) to reduce the extent and size of cracks that occur, some cracking will occur despite the best efforts to minimize it. Concrete can also undergo chemical processes that are dependent on a wide range of variables, which are difficult, at best, to control. Concrete, while seemingly a stable material, is also subject to internal expansion and contraction due to external changes over time.

One of the simplest means to control cracking is to provide weakened control joints for cracking to occur along. These do not prevent cracks from developing; they simply provide a relief point for the stresses that develop. These joints are a widely accepted means to control cracks but are not always effective. Control joints are more effective the more closely spaced they are. GeoTek suggests that control joints be placed in two directions and located a distance apart roughly equal to 24 to 36 times the slab thickness.

Exterior concrete flatwork (patios, walkways, driveways, etc.) is often some of the most visible aspects of site development. They are typically given the least level of quality control, being considered "non-structural" components. We suggest that the same standards of care be applied to these features as to the structure itself.

5.8 POST CONSTRUCTION CONSIDERATIONS

5.8.1 Landscape Maintenance and Planting

Water has been shown to weaken the inherent strength of soil, and slope stability is significantly reduced by overly wet conditions. Positive surface drainage away from graded slopes should be maintained and only the amount of irrigation necessary to sustain plant life should be provided for planted slopes. Controlling surface drainage and runoff and maintaining a suitable vegetation cover can minimize erosion. Plants selected for landscaping should be lightweight, deep-rooted types that require little water and are capable of surviving the prevailing climate.

Overwatering should be avoided. The soils should be maintained in a solid to semi-solid state as defined by the materials Atterberg Limits. Care should be taken when adding soil amendments to avoid excessive watering. Leaching as a method of soil preparation prior to planting is not recommended. An abatement program to control ground-burrowing rodents should be implemented and maintained. This is critical as burrowing rodents can decreased the long-term performance of slopes.

It is common for planting to be placed adjacent to structures in planter or lawn areas. This will result in the introduction of water into the ground adjacent to the foundation. This type of landscaping should be avoided. If used, then extreme care should be exercised with regard to the irrigation and drainage in these areas.

5.8.2 Drainage

The need to maintain proper surface drainage and subsurface systems cannot be overly emphasized. Positive site drainage should be maintained at all times. Drainage should not flow uncontrolled down any descending slope. Water should be directed away from foundations and not allowed to pond or seep into the ground. Pad drainage should be directed toward approved areas and not be blocked by other improvements.

It is the owner's responsibility to maintain and clean drainage devices on or contiguous to their lot. In order to be effective, maintenance should be conducted on a regular and routine schedule and necessary corrections made prior to each rainy season.

5.9 PLAN REVIEW AND CONSTRUCTION OBSERVATIONS

We recommend that site foundation plans and relevant project specifications be reviewed by this office prior to construction to check for conformance with the recommendations of this report. We also recommend that GeoTek representatives be present during site grading and foundation construction to check for proper implementation of the geotechnical recommendations. The owner/developer should verify that GeoTek representatives perform at least the following duties:

- Observe site clearing and grubbing operations for proper removal of unsuitable materials.
- Observe and test bottom of removals prior to fill placement.
- Evaluate the suitability of onsite and import materials for fill placement and collect soil samples for laboratory testing where necessary.
- Observe the fill for uniformity during placement, including utility trenches.
- Perform field density testing of the fill materials.
- Observe and probe foundation excavations to confirm suitability of bearing materials.

If requested, a construction observation and compaction report can be provided by GeoTek, which can comply with the requirements of the governmental agencies having jurisdiction over the project. We recommend that these agencies be notified prior to commencement of construction so that necessary grading permits can be obtained.

6. INTENT

It is the intent of this report to aid in the design and construction of the proposed development. Implementation of the advice presented in Section 5 of this report is intended to reduce risk associated with construction projects. The professional opinions and geotechnical advice contained in this report are not intended to imply total performance of the project or guarantee that unusual or variable conditions will not be discovered during or after construction.

The scope of our evaluation is limited to the boundaries of the subject residential lot. This review does not and should in no way be construed to encompass any areas beyond the specific area of the proposed construction as indicated to us by the client. Further, no evaluation of any existing site improvements is included. The scope is based on our understanding of the project and the client's needs, our fee estimate (P-0604221-CR) dated June 24, 2021 and geotechnical engineering standards normally used on similar projects in this region.

7. LIMITATIONS

The materials observed on the project site appear to be representative of the area; however, soil and bedrock materials vary in character between excavations and natural outcrops or conditions exposed during site construction. Site conditions may vary due to seasonal changes or other factors. GeoTek, Inc. assumes no responsibility or liability for work, testing or recommendations performed or provided by others.

Since our recommendations are based on the site conditions observed and encountered, and laboratory testing, our conclusion and recommendations are professional opinions that are limited to the extent of the available data. Observations during construction are important to allow for any change in recommendations found to be warranted. These opinions have been derived in accordance with current standards of practice and no warranty is expressed or implied. Standards of practice are subject to change with time.

8. SELECTED REFERENCES

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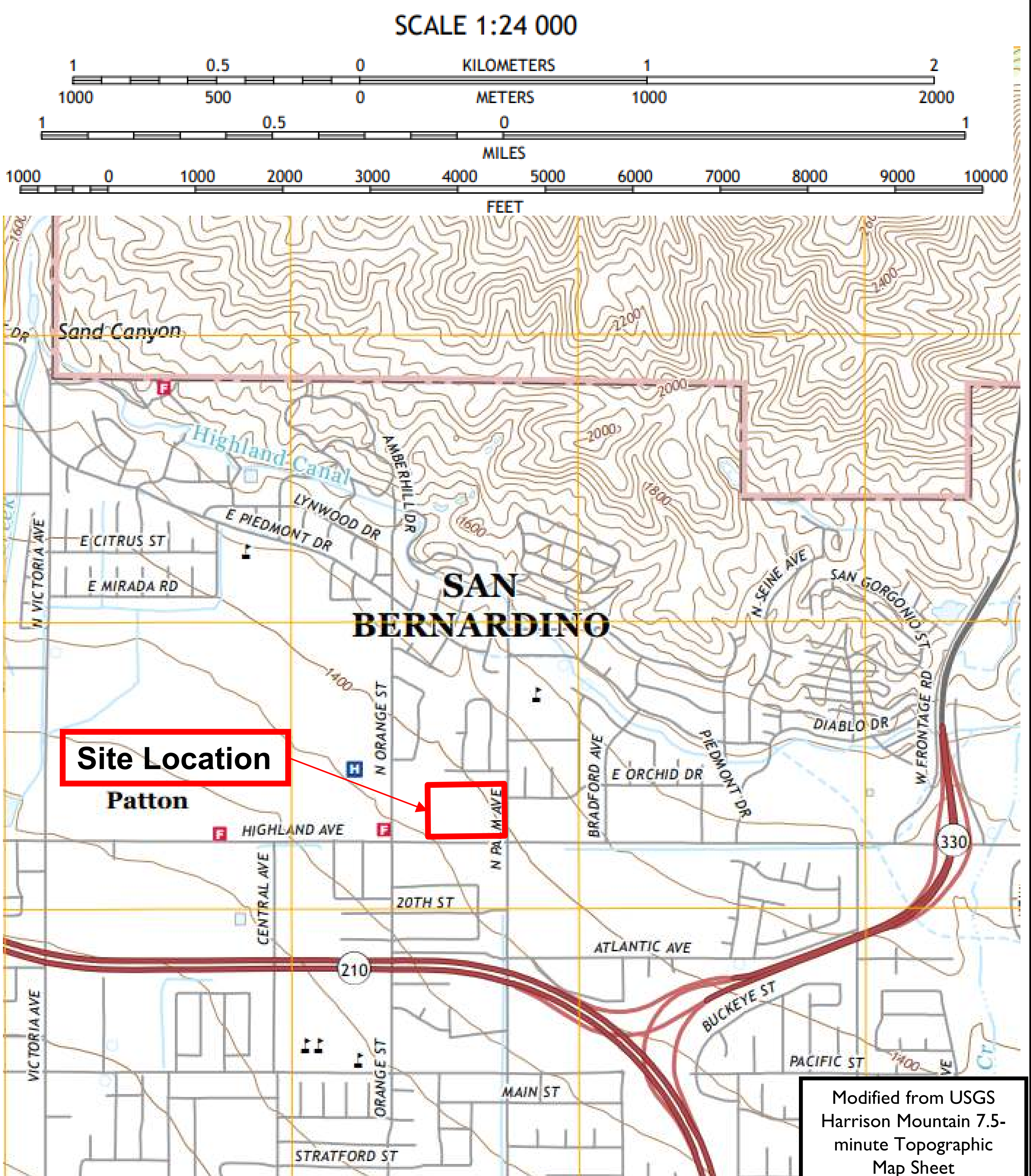


Warmington Residential
APNs 0285-211-05, -21, -23, and -25
San Bernardino, San Bernardino County, California

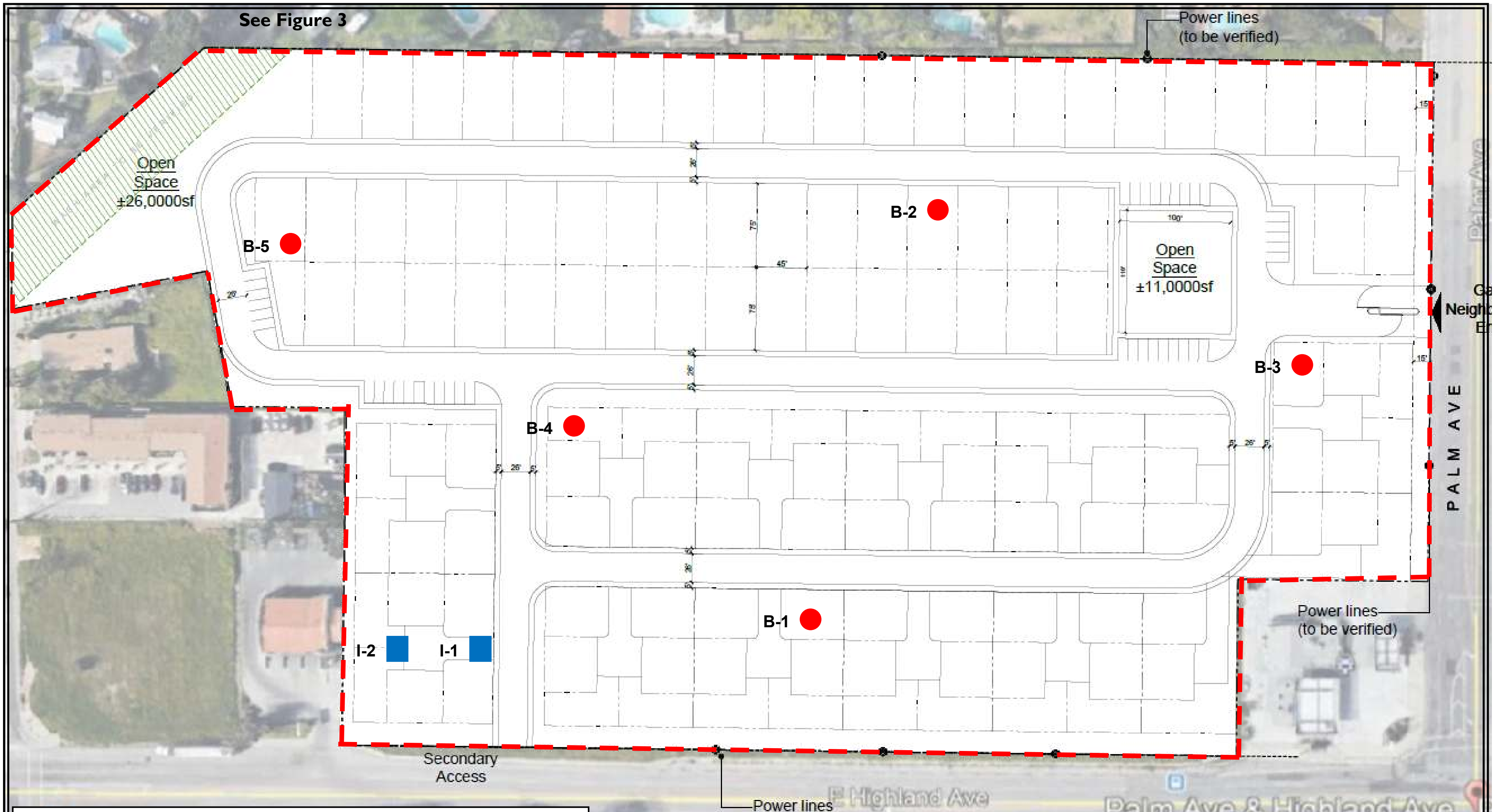
Project No. 2813-CR

NORTH

Figure 1

Site Location Map

GEOTEK



LEGEND

(Locations are Approximate)

I-2 Approximate Infiltration Test Location

B-5 Approximate Boring Location

Limits of the Site

Warmington Residential
APNs 0285-211-05, -21, -23, and -25
San Bernardino, San Bernardino County, California

Project No. 2813-CR

Scale: As Shown

0 25 50 100

Figure 2

Boring Location Map

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APPENDIX A

LOGS OF EXPLORATORY BORINGS

189-Unit Residential Development
San Bernardino, San Bernardino County, California
Project No. 2813-CR

GEOTEK

A - FIELD TESTING AND SAMPLING PROCEDURES

The Modified Split-Barrel Sampler (Ring)
The ring sampler is driven into the ground in accordance with ASTM Test Method D 3550. The sampler, with an external diameter of 3.0 inches, is lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sampler is typically driven into the ground 12 or 18 inches with a 140-pound hammer free falling from a height of 30 inches. Blow counts are recorded for every 6 inches of penetration as indicated on the log of boring. The samples are removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

Bulk Samples (Large)
These samples are normally large bags of earth materials over 20 pounds in weight collected from the field by means of hand digging or exploratory cuttings.

B – BORING/TRENCH LOG LEGEND

The following abbreviations and symbols often appear in the classification and description of soil and rock on the logs of borings/trenches:

SOILS

USCS	Unified Soil Classification System
f-c	Fine to coarse
f-m	Fine to medium

GEOLOGIC

B: Attitudes	Bedding: strike/dip
J: Attitudes	Joint: strike/dip
C: Contact line	
………..	Dashed line denotes USCS material change
———	Solid Line denotes unit / formational change
━━━	Thick solid line denotes end of boring/trench

(Additional denotations and symbols are provided on the log of borings/trenches)

GeoTek, Inc.
LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: B-1

Depth (ft)	Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Water Content (%)	Dry Density (pcf)	Others
					Alluvium:			MD, SH
		3 5 10		SM	Silty f-c SAND, brown, dry, loose, trace gravel	1.6	117.0	
5		6 11 13			Same as above, becomes medium dense, some gravel	1.6	111.3	
		14 18 21		ML/SM	F-c sandy SILT to silty f-c SAND, brown, slightly moist, medium dense/very stiff	4.4	105.2	
10		13 18 23		SM	Silty f-c SAND, brown, slightly moist, medium dense	4.8	121.7	
15		21 28 26			Silty f-c SAND, brwon, moist, dense, trace gravel			
20		12 16 23		SM/SP	Silty f-c SAND to f-c SAND, light brown, slightly moist, medium dense			
25		16 21 32			Silty gravelly f-c SAND, graysih brown, slightly moist, very dense			
30		12 7 11		SM	Silty f-c SAND, light brown, slightly moist, medium dense			% Passing #200 = 36.8

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing: AL = Atterberg Limits; EI = Expansion Index; SA = Sieve Analysis; RV = R-Value Test; SR = Sulfate/Resisitivity Test; SH = Shear Test; HC= Consolidation; MD = Maximum Density

GeoTek, Inc.

LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: B-1

Depth (ft)	SAMPLES: Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Laboratory Testing: Water Content (%)	Dry Density (pcf)	Others
35	SPT	22 50/5"		SM	Silty f-c SAND, light brown, slightly moist, very dense, some gravel, trace cobbles Cobble zone approximately 1.5 feet thick			
40	SPT	13 13 23			Silty f-c SAND, light brown, slightly moist to moist, dense, some gravel, trace cobbles			% Passing #200 = 31.6
					BORING TERMINATED AT 42 FEET (REFUSAL) No groundwater encountered Boring backfilled with soil cuttings			
45								
50								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing: AL = Atterberg Limits EI = Expansion Index SA = Sieve Analysis RV = R-Value Test SR = Sulfate/Resisitivity Test SH = Shear Test HC= Consolidation MD = Maximum Density

GeoTek, Inc.

LOG OF EXPLORATORY BORING

CLIENT: Warmington Residential
PROJECT NAME: APNs 0285-211-05, -21, -23, and -25
PROJECT NO.: 2813-CR
LOCATION: See Boring Location Map
DRILLER: 2R Drilling Inc.
DRILL METHOD: Hollw stem Auger
HAMMER: 140lbs/30in.
LOGGED BY: DRW
OPERATOR: Jorge
RIG TYPE: CME 75
DATE: 7/1/2021

BORING NO.: B-2

Depth (ft)	Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Water Content (%)	Dry Density (pcf)	Others
					Alluvium:			
	Ring	9 13 20		SM/ML	Silty f-c SAND to f-c sandy SILT, brown, slightly moist, medium dense/very stiff	3.2	120.3	
5	Ring	12 27 34			Same as above, becomes dense/hard, trace gravel	4.4	113.1	
	Ring	22 30 36		SM/SC	Silty clayey f-c SAND, brown, slightly moist, dense, trace gravel	4.4	124.1	
10	Ring	20 25 25		SC/SP	Clayey gravelly f-c SAND, grayish brown, slightly moist, dense	2.4	105.5	
15	Ring	14 22 24			Same as above			
	Ring	14 20 25		SM	Silty f-c SAND, brown, moist, medium dense to dense			
20					**BORING TERMINATED AT 20 FEET**			
					No groundwater encountered Boring backfilled with soil cuttings			
25								
30								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing: AL = Atterberg Limits; EI = Expansion Index; SA = Sieve Analysis; RV = R-Value Test; SR = Sulfate/Resisitivity Test; SH = Shear Test; HC= Consolidation; MD = Maximum Density

GeoTek, Inc.
LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: B-3

Depth (ft)	Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Water Content (%)	Dry Density (pcf)	Others
					Alluvium:			
	Large Bulk							SR
	Ring	6 6 7		SM	Silty f-c SAND, brown, slightly moist, loose, trace gravel	2.4	107.4	Collapse
5	Ring	4 5 5			Same as above, becomes moist	8.3	109.7	
	Ring	7 7 4		SM/SC	Silty clayey f-c SAND, brown, moist, loose, trace gravel	8.4	124.3	
10	Ring	4 4 9			Same as above	8.6	113.6	
15	Ring	14 15 17		SM	Silty f-c SAND, brown, moist, medium dense, some gravel			
20	Ring	14 17 27			Same as above			
					BORING TERMINATED AT 21.5 FEET No groundwater encountered Boring backfilled with soil cuttings			
25								
30								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing:
AL = Atterberg Limits; EI = Expansion Index; SA = Sieve Analysis; RV = R-Value Test
SR = Sulfate/Resisitivity Test; SH = Shear Test; HC= Consolidation; MD = Maximum Density

GeoTek, Inc.

LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: B-4

Depth (ft)	SAMPLES: Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Laboratory Testing: Water Content (%)	Dry Density (pcf)	Others
					Alluvium:			
	Ring	6 6 7		SM	Silty f-c SAND, light brown, slightly moist, loose, trace gravel	3.3	114.5	
5	Ring	12 12 13		SM/SC	Silty clayey f-c SAND, brown, slightly moist, medium dense	4.8	115.8	
	Ring	15 26 30		SC/SM	Clayey silty f-c SAND, brown, slightly moist, dense, trace gravel	4.6	126.9	
10	Ring	18 18 24		SC/SP	Clayey gravelly f-c SAND, brown, moist, medium dense	7.2	127.5	
15	Ring	9 13 17		SM/SC	Silty clayey f-c SAND, brown, moist, medium dense			
	Ring	8 10 15		SC	Clayey f-c SAND, brown, moist, medium dense, trace gravel			
20					**BORING TERMINATED AT 20 FEET** No groundwater encountered Boring backfilled with soil cuttings			
25								
30								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing:

AL = Atterberg Limits | EI = Expansion Index | SA = Sieve Analysis | RV = R-Value Test
SR = Sulfate/Resisitivity Test | SH = Shear Test | HC= Consolidation | MD = Maximum Density

GeoTek, Inc.

LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: B-5

Depth (ft)	SAMPLES: Sample Type	SAMPLES: Blows/ 6 in	SAMPLES: Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Laboratory Testing: Water Content (%)	Laboratory Testing: Dry Density (pcf)	Laboratory Testing: Others
					Alluvium:			
	Large Bulk / Ring	8 10 12		SM/SC	Silty clayey f-c SAND< brown, slightly moist, medium dense	3.8	119.8	EI=1
5	Ring	9 14 17		SM	Silty f-c SAND, brown, slightly moist to moist, medium dense	6.8	114.4	
	Ring	25 30 32			Silty f-c SAND, brown, moist, dense	6.4	130.0	Collapse
10	Ring	13 16 13		SM/SP	Silty f-c SAND to f-c SAND, brown, slightly moist, medium dense, some gravel	3.7	110.7	
15	Ring	13 19 22			Same as above			
20	Ring	13 13 15		SM/SC	Silty clayey f-c SAND, brown, moist, medium dense			
					BORING TERMINATED AT 21.5 FEET No groundwater encountered Boring backfilled with soil cuttings			
25								
30								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing:
AL = Atterberg Limits; EI = Expansion Index; SA = Sieve Analysis; RV = R-Value Test
SR = Sulfate/Resisitivity Test; SH = Shear Test; HC= Consolidation; MD = Maximum Density

GeoTek, Inc.
LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: I-1

Depth (ft)	SAMPLES: Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Laboratory Testing: Water Content (%)	Dry Density (pcf)	Others
					Alluvium:			
				SM/ML	Silty f SAND to f sandy SILT, brown, moist, some rootlets			
				SM	Silty f-c SAND, brown, moist			
5					**BORING TERMINATED AT 5 FEET**			
					No groundwater encountered Boring backfilled with soil cuttings			
10								
15								
20								
25								
30								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing: AL = Atterberg Limits; EI = Expansion Index; SA = Sieve Analysis; RV = R-Value Test; SR = Sulfate/Resisitivity Test; SH = Shear Test; HC= Consolidation; MD = Maximum Density

GeoTek, Inc.
LOG OF EXPLORATORY BORING

CLIENT:	Warmington Residential	**DRILLER:**	2R Drilling Inc.	**LOGGED BY:**	DRW
PROJECT NAME:	APNs 0285-211-05, -21, -23, and -25	**DRILL METHOD:**	Hollw stem Auger	**OPERATOR:**	Jorge
PROJECT NO.:	2813-CR	**HAMMER:**	140lbs/30in.	**RIG TYPE:**	CME 75
LOCATION:	See Boring Location Map			**DATE:**	7/1/2021

BORING NO.: I-2

Depth (ft)	SAMPLES: Sample Type	Blows/ 6 in	Sample Number	USCS Symbol	MATERIAL DESCRIPTION AND COMMENTS	Laboratory Testing: Water Content (%)	Dry Density (pcf)	Others
					Alluvium:			
				SM/ML	Silty f SAND to f sandy SILT, brown, moist, some rootlets			
				SM	Silty f-c SAND, brown, moist			
5					**BORING TERMINATED AT 5 FEET**			
					No groundwater encountered Boring backfilled with soil cuttings			
10								
15								
20								
25								
30								

LEGEND

Sample type: ---Ring ---SPT ---Small Bulk ---Large Bulk ---No Recovery ---Water Table

Lab testing:
AL = Atterberg Limits; EI = Expansion Index; SA = Sieve Analysis; RV = R-Value Test
SR = Sulfate/Resisitivity Test; SH = Shear Test; HC= Consolidation; MD = Maximum Density

APPENDIX B

LABORATORY TEST RESULTS

189-Unit Residential Development

San Bernardino, San Bernardino County, California

Project No. 2813-CR

GEOTEK

SUMMARY OF LABORATORY TESTING

Classification
Soils were classified visually in general accordance with the Unified Soil Classification System (ASTM Test Method D 2487). The soil classifications by GeoTek are shown on the logs of exploratory borings in Appendix A.

Consolidation/Collapse
Consolidation/collapse testing was performed on selected samples of the site soils according to ASTM Test Method D 4546. The results of this testing are presented in Appendix B.

Percent Passing No. 200 Sieve
The amount of soil particles passing No. 200 Sieve was estimated in accordance with ASTM D 1140. The test results are summarized on the boring logs.

Direct Shear
Shear testing was performed in a direct shear machine of the strain-control type in general accordance with ASTM Test Method D 3080. The rate of deformation is approximately 0.035 inch per minute. The samples were sheared under varying confining loads in order to determine the coulomb shear strength parameters, angle of internal friction and cohesion. The results of the testing are presented graphically in Appendix B.

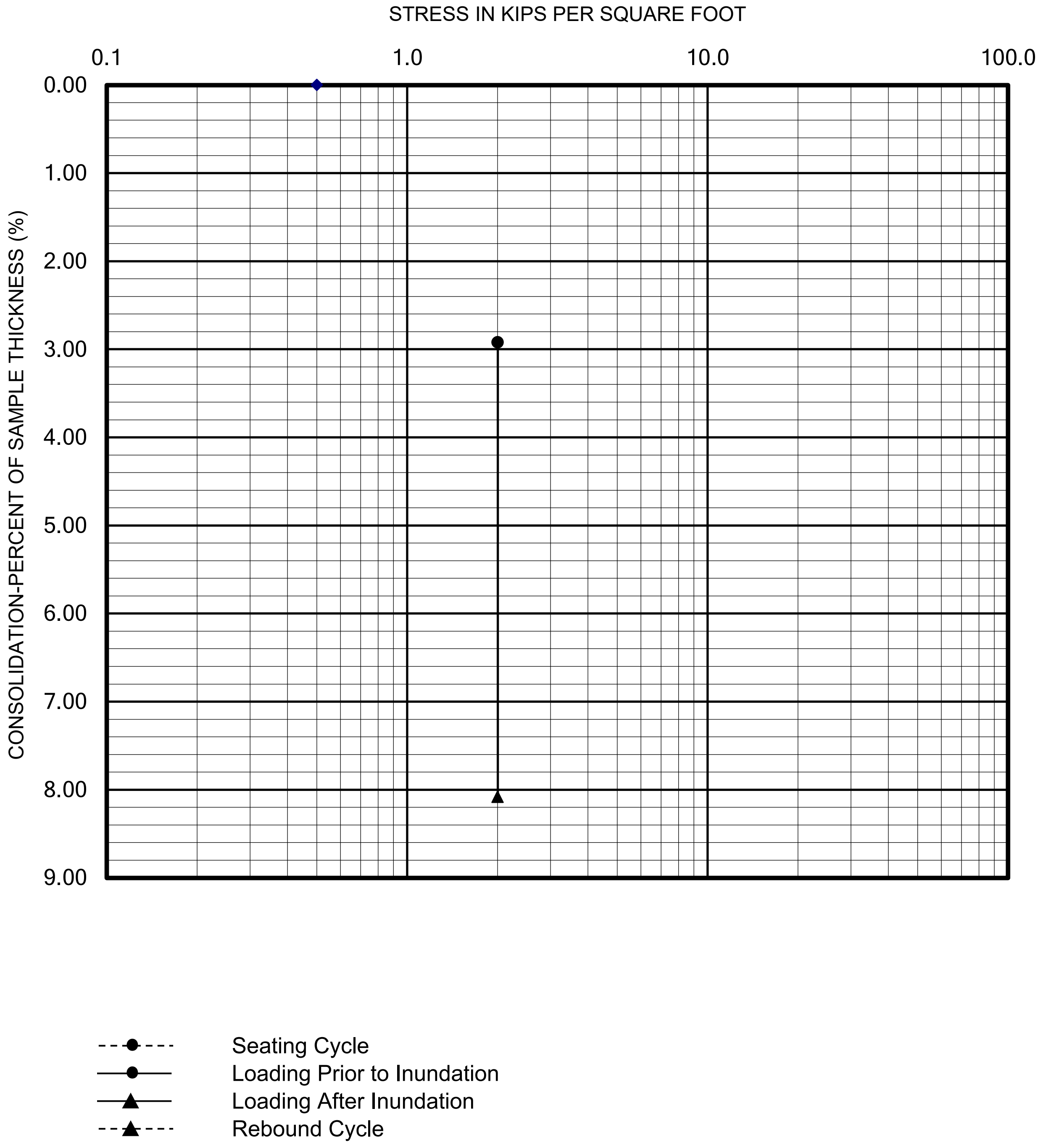
Expansion Index
Expansion Index testing was performed on one representative soil sample. Testing was performed in general accordance with ASTM Test Method D 4829. The results of the testing is provided below.

Boring No.	Depth (ft.)	Soil Type	Expansion Index	Classification
B-5	0-5	Silty Sand	1	Very Low

Moisture-Density Relationship
Laboratory testing was performed on two representative site samples collected during the recent subsurface exploration. The laboratory maximum dry density and optimum moisture content for the samples tested were determined in general accordance with test method ASTM Test Procedure D 1557. The results are included in Appendix B.

Sulfate Content, Resistivity and Chloride Content
Testing to determine the water-soluble sulfate content, resistivity testing and the chloride content was performed by others. The results of the testing are provided below and in Appendix B.

Boring No.	Depth (ft.)	pH ASTM G51	Chloride ASTM D4327 (ppm)	Sulfate ASTM D4327 (% by weight)	Resistivity ASTM G187 (ohm-cm)
B-3	1-5	7.1	22.1	0.0047	5,561



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

GEOTEK

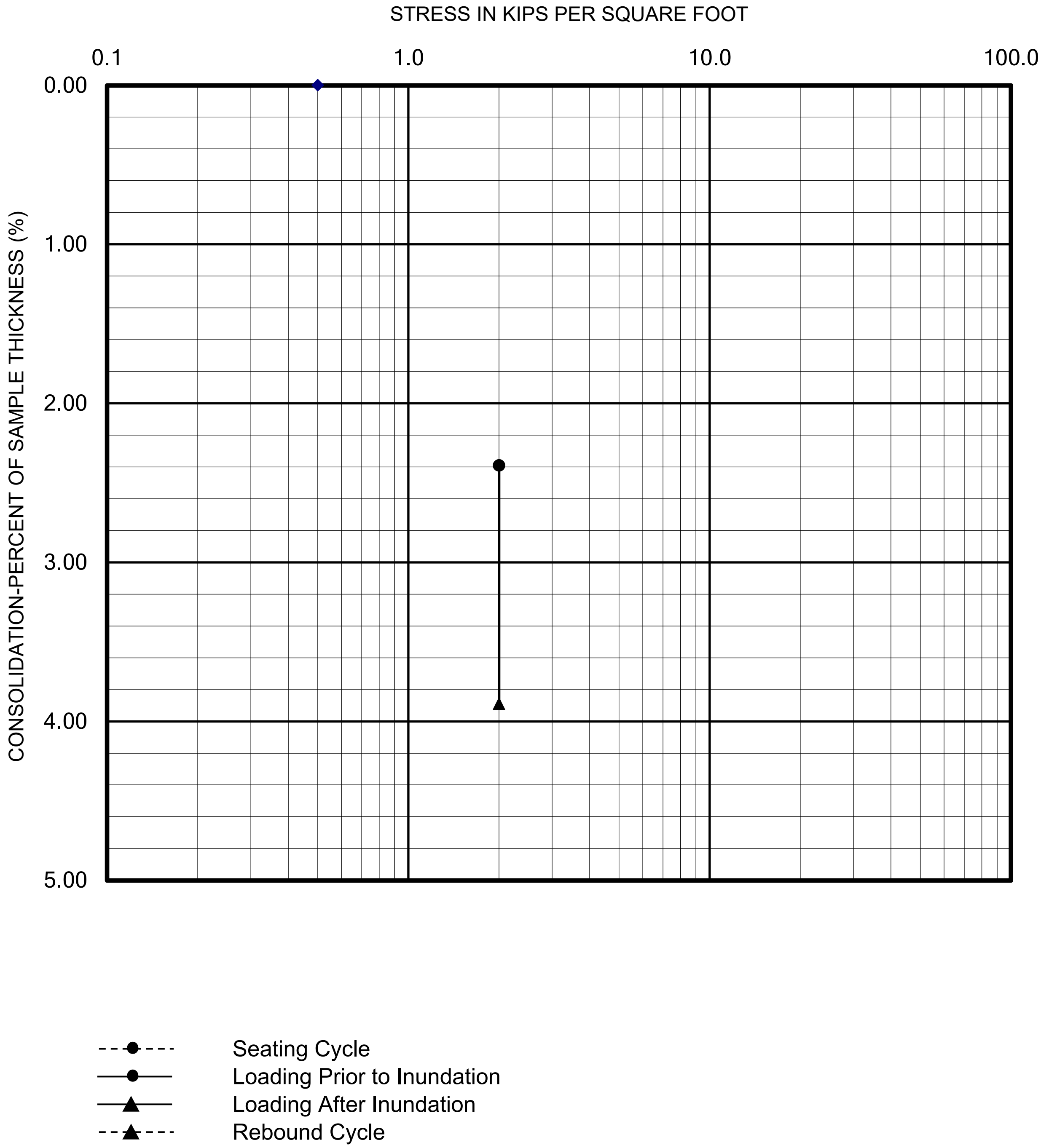
CHECKED BY: RJ	Lab: Corona
PROJECT NO.: 2813-CR	Date: 7-28-21

COLLAPSE REPORT

Sample: B-3 @ 2 feet

189-Unit Residential Development
San Bernardino, California

Plate B-1



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

GEOTEK

COLLAPSE REPORT

Sample: B-5 @ 7 feet

189-Unit Residential Development
San Bernardino, California

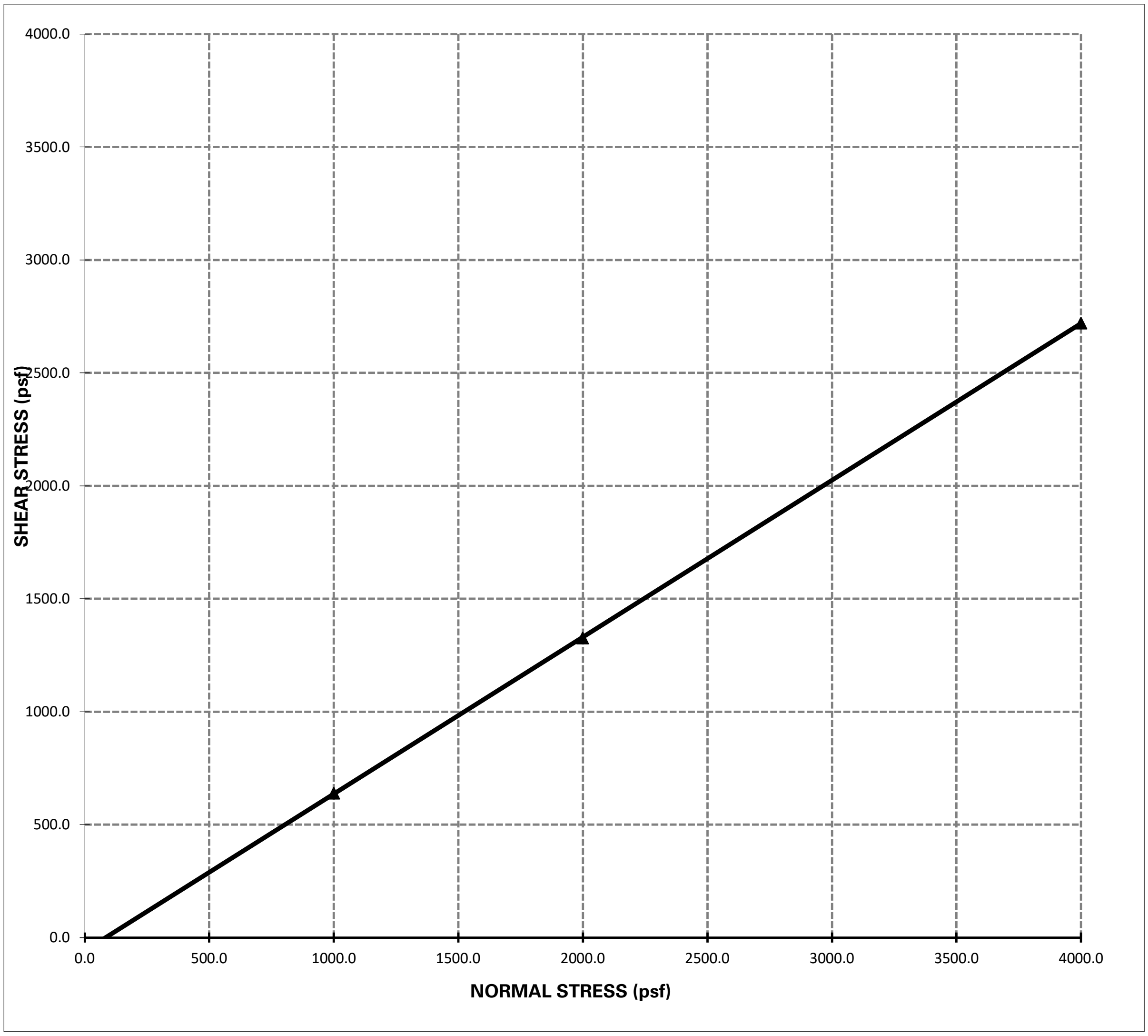
Plate B-2

CHECKED BY: RJ	Lab: Corona
PROJECT NO.: 2813-CR	Date: 7-29-21

DIRECT SHEAR TEST

Project Name:	Warmington Residential	***Sample Location:***	B1 @ 1-5'
Project Number:	2813-CR	***Date Tested:***	7/29/2021

ULTIMATE STRENGTH



Shear Strength: **Φ = 35 °** , **C = 59 psf**

Notes: 1 - The soil specimen used in the shear box was a ring sample remolded to approximately 90% relative compaction from a bulk sample collected during the field investigation.

2 - The above reflect direct shear strength at saturated conditions.

3 - The tests were run at a shear rate of 0.035 in/min.

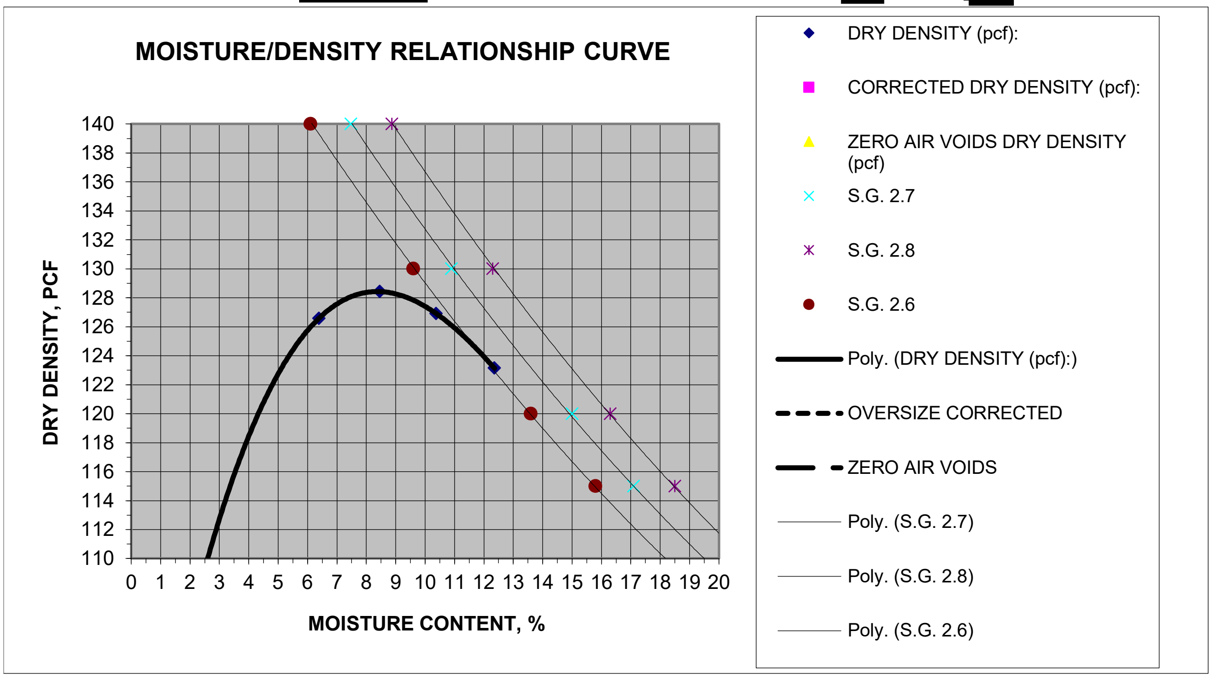
MOISTURE/DENSITY RELATIONSHIP

Client: Warmington Residential
Project: NWC Highland Ave & Palm Ave
Location: San Bernardino
Material Type: Brown Silty Sand w/ Gravel
Material Supplier: -
Material Source: -
Sample Location: B1 @ 1-5'
-
Sampled By: DRW
Received By: RJ
Tested By: RL
Reviewed By: RJ

Job No.: 2813-CR
Lab No.: Corona

Date Sampled: 7/6/2021
Date Received: 7/6/2021
Date Tested: 7/21/2021
Date Reviewed: 7/22/2021

Test Procedure: ASTM D1557 **Method:** A
Oversized Material (%): 19.6 **Correction Required:** **yes** **no**



MOISTURE DENSITY RELATIONSHIP VALUES

Maximum Dry Density, pcf	128.5	**@ Optimum Moisture, %**	8.5
Corrected Maximum Dry Density, pcf		**@ Optimum Moisture, %**	

MATERIAL DESCRIPTION

Grain Size Distribution:

	% Gravel (retained on No. 4)
	% Sand (Passing No. 4, Retained on No. 200)
	% Silt and Clay (Passing No. 200)

Atterberg Limits:

	Liquid Limit, %
	Plastic Limit, %
	Plasticity Index, %

Classification:

Unified Soils Classification:

AASHTO Soils Classification:

Results Only Soil Testing for NWC Highland Ave, Palm Ave, San Bernardino

July 22, 2021

Prepared for:

Anna Scott
GeoTek, Inc.
1548 North Maple Street
Corona, CA 92280
ascott@geotekusa.com

Project X Job#: S210720D
Client Job or PO#: 2813-CR Warmington Residential

Respectfully Submitted,

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

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

Soil Analysis Lab Results

Client: GeoTek, Inc.
Job Name: NWC Highland Ave, Palm Ave, San Bernardino
Client Job Number: 2813-CR Warmington Residential
Project X Job Number: S210720D
July 22, 2021

	Method	ASTM D4327		ASTM D4327		ASTM G187		ASTM D4972	ASTM G200	ASTM D4658	ASTM D4327	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D4327	ASTM D4327
Bore# / Description	**Depth**	**Sulfates** SO_4^{2-}		**Chlorides** Cl^-		**Resistivity** As Rec'd	Minimum	**pH**	**Redox**	**Sulfide** S^{2-}	**Nitrate** NO_3^-	**Ammonium** NH_4^+	**Lithium** Li^+	**Sodium** Na^+	**Potassium** K^+	**Magnesium** Mg^{2+}	**Calcium** Ca^{2+}	**Fluoride** F_2^-	**Phosphate** PO_4^{3-}
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)		(mV)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
2813-CR B 3 @	1-5	46.9	0.0047	22.1	0.0022	355,100	5,561	7.1	103	<0.01	66.9	23.3	0.09	27.5	9.0	34.4	226.9	1.4	10.0

Cations and Anions, except Sulfide and Bicarbonate, tested with Ion Chromatography
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
ND = 0 = Not Detected | NT = Not Tested | Unk = Unknown
Chemical Analysis performed on 1:3 Soil-To-Water extract
PPM = mg/kg (soil) = mg/L (Liquid)

APPENDIX C

INFILTRATION TEST DATA

189-Unit Residential Development
San Bernardino, San Bernardino County, California
Project No. 2813-CR

GEOTEK

PERCOLATION DATA SHEET

Project: HIGHLAND AVE / PALM AVE WARMINGTON RES. Job No.: 2813-CR

Test Hole No.: I-1 Tested By: DRW Date: 7/8/21

Depth of Hole As Drilled: 60" Before Test: 60" After Test: 60"

Reading No.	Time	Time Interval (Min)	Total Depth of Hole (Inches)	Initial Water Level (Inches)	Final Water Level (Inches)	Δ In Water Level (Inches)	Rate (minutes per inch)	Comments
1	8:15 8:40	25	60	20	8.5	11.5		
2	8:40 9:05	25	60	20	9.75	10.25		
3	9:05 9:15	10	60	20	16.4	3.6		
4	9:15 9:25	10	60	20	16.6	3.4		
5	9:25 9:35	10	60	20	16.7	3.3		
6	9:35 9:45	10	60	20	16.9	3.1		
7	9:45 9:55	10	60	20	17.0	3.0		
8	9:55 10:05	10	60	20	17.0	3.0		

PERCOLATION DATA SHEET

Project: HIGHLAND AVE / PALM AVE WARMINGTON RES. Job No.: 2813-CR

Test Hole No.: I-2 Tested By: DRW Date: 7/8/21

Depth of Hole As Drilled: 60" Before Test: 60" After Test: 60"

Reading No.	Time	Time Interval (Min)	Total Depth of Hole (Inches)	Initial Water Level (Inches)	Final Water Level (Inches)	Δ In Water Level (Inches)	Rate (minutes per inch)	Comments
1	8:18 / 8:43	25	60	20	9.7	10.3		
2	8:43 / 9:08	25	60	20	9.9	10.1		
3	9:08 / 9:18	10	60	20	16.6	3.4		
4	9:18 / 9:28	10	60	20	16.9	3.1		
5	9:28 / 9:38	10	60	20	17.0	3.0		
6	9:38 / 9:48	10	60	20	17.2	2.8		
7	9:48 / 9:58	10	60	20	17.3	2.7		
8	9:58 / 10:08	10	60	20	17.3	2.7		

Client:	**Warmington Residential**
Project:	**San Bernardino**
Project No:	**2813-CR**
Date:	**7/8/2021**

Boring No. **I-1**

Percolation Rate (Porchet Method)

Time Interval, Δt =	10
Final Depth to Water, D_F =	43
Test Hole Radius, r =	4
Initial Depth to Water, D_O =	40
Total Test Hole Depth, D_T =	60

Equation - $I_t = \dfrac{\Delta H\ (60r)}{\Delta t\ (r+2H_{avg})}$

$H_O = D_T - D_O$ =	20
$H_F = D_T - D_F$ =	17
$\Delta H = \Delta D = H_O - H_F$ =	3
Havg = $(H_O+H_F)/2$ =	18.5

I_t = 1.76 **Inches per Hour**

GEOTEK

Client:	**Warmington Residential**
Project:	**San Bernardino**
Project No:	**2813-CR**
Date:	**7/8/2021**

Boring No. **I-2**

Percolation Rate (Porchet Method)

Time Interval, Δt =	10
Final Depth to Water, D_F =	42.7
Test Hole Radius, r =	4
Initial Depth to Water, D_O =	40
Total Test Hole Depth, D_T =	60

Equation - $I_t = \dfrac{\Delta H\ (60r)}{\Delta t\ (r+2H_{avg})}$

$H_O = D_T - D_O$ =	20
$H_F = D_T - D_F$ =	17.3
$\Delta H = \Delta D = H_O - H_F$ =	2.7
$Havg = (H_O+H_F)/2$ =	18.65

I_t = 1.57 **Inches per Hour**

APPENDIX D

SEISMIC SETTLEMENT ANALYSIS

189-Unit Residential Development
San Bernardino, San Bernardino County, California
Project No. 2813-CR

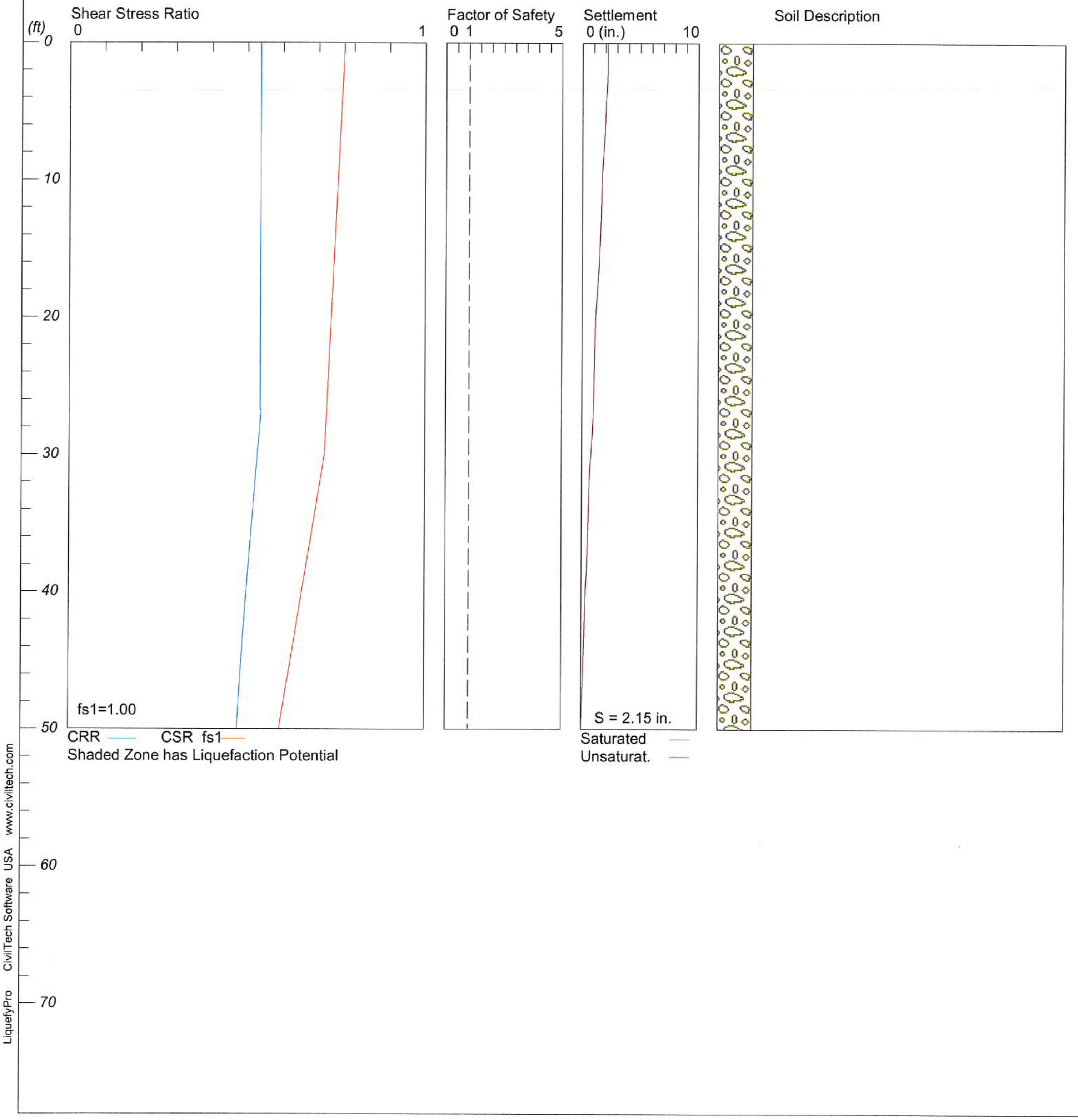
GEOTEK

LIQUEFACTION ANALYSIS

2813-CR

Hole No.=B-1 Water Depth=150 ft

Magnitude=7.3
Acceleration=1.186g



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*******************************************************************************************
LIQUEFACTION ANALYSIS SUMMARY

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*******************************************************************************************
Font: Courier New, Regular, Size 8 is recommended for this report.
Licensed to ,   7/30/2021      7:58:37 AM

Input File Name: UNTITLED
Title:  2813-CR
Subtitle:  San Bernardino

Surface Elev.=
Hole No.=B-1
Depth of Hole= 50.00 ft
Water Table during Earthquake= 150.00 ft
Water Table during In-Situ Testing= 150.00 ft
Max. Acceleration= 1.19 g
Earthquake Magnitude= 7.30

Input Data:
Surface Elev.=
Hole No.=B-1
Depth of Hole=50.00 ft
Water Table during Earthquake= 150.00 ft
Water Table during In-Situ Testing= 150.00 ft
Max. Acceleration=1.19 g
Earthquake Magnitude=7.30
No-Liquefiable Soils:   CL, OL are Non-Liq. Soil

1. SPT or BPT Calculation.
2. Settlement Analysis Method: Ishihara / Yoshimine
3. Fines Correction for Liquefaction: Idriss/Seed
4. Fine Correction for Settlement: During Liquefaction*
5. Settlement Calculation in: All zones*
6. Hammer Energy Ratio,                               Ce = 1.25
7. Borehole Diameter,                                     Cb= 1.15
8. Sampling Method,                                      Cs= 1.2
9. User request factor of safety (apply to CSR) ,   User= 1
   Plot one CSR curve (fs1=User)
10. Use Curve Smoothing: Yes*
* Recommended Options

In-Situ Test Data:
Depth   SPT    gamma   Fines
```

ft		pcf	%
0.00	20.00	120.00	20.00
5.00	16.00	115.00	20.00
7.00	26.00	110.00	50.00
10.00	27.00	125.00	20.00
15.00	36.00	125.00	20.00
20.00	26.00	125.00	36.00
25.00	53.00	125.00	36.00
30.00	18.00	125.00	36.00
35.00	100.00	125.00	31.00
40.00	36.00	125.00	31.00
50.00	36.00	125.00	31.00

Output Results:

Settlement of Saturated Sands=0.00 in.
Settlement of Unsaturated Sands=2.15 in.
Total Settlement of Saturated and Unsaturated Sands=2.15 in.
Differential Settlement=1.077 to 1.422 in.

Depth ft	CRRm	CSRfs	F.S.	S_sat. in.	S_dry in.	S_all in.
0.00	0.54	0.77	5.00	0.00	2.15	2.15
1.00	0.54	0.77	5.00	0.00	2.15	2.15
2.00	0.54	0.77	5.00	0.00	2.15	2.15
3.00	0.54	0.77	5.00	0.00	2.12	2.12
4.00	0.54	0.76	5.00	0.00	2.04	2.04
5.00	0.54	0.76	5.00	0.00	2.00	2.00
6.00	0.54	0.76	5.00	0.00	1.94	1.94
7.00	0.54	0.76	5.00	0.00	1.90	1.90
8.00	0.54	0.76	5.00	0.00	1.82	1.82
9.00	0.54	0.75	5.00	0.00	1.75	1.75
10.00	0.54	0.75	5.00	0.00	1.68	1.68
11.00	0.54	0.75	5.00	0.00	1.66	1.66
12.00	0.54	0.75	5.00	0.00	1.63	1.63
13.00	0.54	0.75	5.00	0.00	1.60	1.60
14.00	0.54	0.75	5.00	0.00	1.56	1.56
15.00	0.54	0.74	5.00	0.00	1.51	1.51
16.00	0.54	0.74	5.00	0.00	1.46	1.46
17.00	0.54	0.74	5.00	0.00	1.39	1.39
18.00	0.54	0.74	5.00	0.00	1.31	1.31
19.00	0.54	0.74	5.00	0.00	1.23	1.23
20.00	0.54	0.73	5.00	0.00	1.16	1.16
21.00	0.54	0.73	5.00	0.00	1.12	1.12
22.00	0.54	0.73	5.00	0.00	1.09	1.09
23.00	0.54	0.73	5.00	0.00	1.07	1.07
24.00	0.54	0.73	5.00	0.00	1.05	1.05
25.00	0.54	0.73	5.00	0.00	1.02	1.02

26.00	0.54	0.72	5.00	0.00	1.00	1.00
27.00	0.54	0.72	5.00	0.00	0.97	0.97
28.00	0.53	0.72	5.00	0.00	0.92	0.92
29.00	0.53	0.72	5.00	0.00	0.85	0.85
30.00	0.53	0.72	5.00	0.00	0.76	0.76
31.00	0.53	0.71	5.00	0.00	0.68	0.68
32.00	0.52	0.70	5.00	0.00	0.63	0.63
33.00	0.52	0.70	5.00	0.00	0.60	0.60
34.00	0.52	0.69	5.00	0.00	0.57	0.57
35.00	0.51	0.69	5.00	0.00	0.54	0.54
36.00	0.51	0.68	5.00	0.00	0.51	0.51
37.00	0.51	0.67	5.00	0.00	0.47	0.47
38.00	0.50	0.67	5.00	0.00	0.44	0.44
39.00	0.50	0.66	5.00	0.00	0.39	0.39
40.00	0.50	0.65	5.00	0.00	0.33	0.33
41.00	0.50	0.65	5.00	0.00	0.30	0.30
42.00	0.49	0.64	5.00	0.00	0.27	0.27
43.00	0.49	0.64	5.00	0.00	0.24	0.24
44.00	0.49	0.63	5.00	0.00	0.20	0.20
45.00	0.49	0.62	5.00	0.00	0.17	0.17
46.00	0.48	0.62	5.00	0.00	0.14	0.14
47.00	0.48	0.61	5.00	0.00	0.10	0.10
48.00	0.48	0.60	5.00	0.00	0.07	0.07
49.00	0.48	0.60	5.00	0.00	0.04	0.04
50.00	0.47	0.59	5.00	0.00	0.00	0.00

* F.S.<1, Liquefaction Potential Zone
(F.S. is limited to 5, CRR is limited to 2, CSR is limited to 2)

Units: Unit: qc, fs, Stress or Pressure = atm (1.0581tsf); Unit Weight = pcf; Depth = ft; Settlement = in.

---

1 atm (atmosphere) = 1 tsf (ton/ft2)

CRRm	Cyclic resistance ratio from soils
CSRsf	Cyclic stress ratio induced by a given earthquake (with user request factor of safety)
F.S.	Factor of Safety against liquefaction, F.S.=CRRm/CSRsf
S_sat	Settlement from saturated sands
S_dry	Settlement from Unsaturated Sands
S_all	Total Settlement from Saturated and Unsaturated Sands
NoLiq	No-Liquefy Soils

APPENDIX E

GENERAL GRADING GUIDELINES

189-Unit Residential Development

San Bernardino, San Bernardino County, California

Project No. 2813-CR

GEOTEK

GENERAL GRADING GUIDELINES

Guidelines presented herein are intended to address general construction procedures for earthwork construction. Specific situations and conditions often arise which cannot reasonably be discussed in general guidelines, when anticipated these are discussed in the text of the report. Often unanticipated conditions are encountered which may necessitate modification or changes to these guidelines. It is our hope that these will assist the contractor to more efficiently complete the project by providing a reasonable understanding of the procedures that would be expected during earthwork and the testing and observation used to evaluate those procedures.

General

Grading should be performed to at least the minimum requirements of governing agencies, Chapters 18 and 33 of the Uniform Building Code, CBC (2019) and the guidelines presented below.

Preconstruction Meeting

A preconstruction meeting should be held prior to site earthwork. Any questions the contractor has regarding our recommendations, general site conditions, apparent discrepancies between reported and actual conditions and/or differences in procedures the contractor intends to use should be brought up at that meeting. The contractor (including the main onsite representative) should review our report and these guidelines in advance of the meeting. Any comments the contractor may have regarding these guidelines should be brought up at that meeting.

Grading Observation and Testing

1. Observation of the fill placement should be provided by our representative during grading. Verbal communication during the course of each day will be used to inform the contractor of test results. The contractor should receive a copy of the "Daily Field Report" indicating results of field density tests that day. If our representative does not provide the contractor with these reports, our office should be notified.
2. Testing and observation procedures are, by their nature, specific to the work or area observed and location of the tests taken, variability may occur in other locations. The contractor is responsible for the uniformity of the grading operations; our observations and test results are intended to evaluate the contractor's overall level of efforts during grading. The contractor's personnel are the only individuals participating in all aspect of site work. Compaction testing and observation should not be considered as relieving the contractor's responsibility to properly compact the fill.
3. Cleanouts, processed ground to receive fill, key excavations, and subdrains should be observed by our representative prior to placing any fill. It will be the contractor's responsibility to notify our representative or office when such areas are ready for observation.

4. Density tests may be made on the surface material to receive fill, as considered warranted by this firm.
5. In general, density tests would be made at maximum intervals of two feet of fill height or every 1,000 cubic yards of fill placed. Criteria will vary depending on soil conditions and size of the fill. More frequent testing may be performed. In any case, an adequate number of field density tests should be made to evaluate the required compaction and moisture content is generally being obtained.
6. Laboratory testing to support field test procedures will be performed, as considered warranted, based on conditions encountered (e.g. change of material sources, types, etc.) Every effort will be made to process samples in the laboratory as quickly as possible and in progress construction projects are our first priority. However, laboratory workloads may cause in delays and some soils may require a **minimum of 48 to 72 hours to complete test procedures**. Whenever possible, our representative(s) should be informed in advance of operational changes that might result in different source areas for materials.
7. Procedures for testing of fill slopes are as follows:
   a) Density tests should be taken periodically during grading on the flat surface of the fill, three to five feet horizontally from the face of the slope.
   b) If a method other than over building and cutting back to the compacted core is to be employed, slope compaction testing during construction should include testing the outer six inches to three feet in the slope face to determine if the required compaction is being achieved.
8. Finish grade testing of slopes and pad surfaces should be performed after construction is complete.

Site Clearing

1. All vegetation, and other deleterious materials, should be removed from the site. If material is not immediately removed from the site it should be stockpiled in a designated area(s) well outside of all current work areas and delineated with flagging or other means. Site clearing should be performed in advance of any grading in a specific area.
2. Efforts should be made by the contractor to remove all organic or other deleterious material from the fill, as even the most diligent efforts may result in the incorporation of some materials. This is especially important when grading is occurring near the natural grade. All equipment operators should be aware of these efforts. Laborers may be required as root pickers.
3. Nonorganic debris or concrete may be placed in deeper fill areas provided the procedures used are observed and found acceptable by our representative.

Treatment of Existing Ground

1. Following site clearing, all surficial deposits of alluvium and colluvium as well as weathered or creep effected bedrock, should be removed unless otherwise specifically indicated in the text of this report.
2. In some cases, removal may be recommended to a specified depth (e.g. flat sites where partial alluvial removals may be sufficient). The contractor should not exceed these depths unless directed otherwise by our representative.
3. Groundwater existing in alluvial areas may make excavation difficult. Deeper removals than indicated in the text of the report may be necessary due to saturation during winter months.
4. Subsequent to removals, the natural ground should be processed to a depth of six inches, moistened to near optimum moisture conditions and compacted to fill standards.
5. Exploratory back hoe or dozer trenches still remaining after site removal should be excavated and filled with compacted fill if they can be located.

Fill Placement

1. Unless otherwise indicated, all site soil and bedrock may be reused for compacted fill; however, some special processing or handling may be required (see text of report).
2. Material used in the compacting process should be evenly spread, moisture conditioned, processed, and compacted in thin lifts six (6) to eight (8) inches in compacted thickness to obtain a uniformly dense layer. The fill should be placed and compacted on a nearly horizontal plane, unless otherwise found acceptable by our representative.
3. If the moisture content or relative density varies from that recommended by this firm, the contractor should rework the fill until it is in accordance with the following:
   a) Moisture content of the fill should be at or above optimum moisture. Moisture should be evenly distributed without wet and dry pockets. Pre-watering of cut or removal areas should be considered in addition to watering during fill placement, particularly in clay or dry surficial soils. The ability of the contractor to obtain the proper moisture content will control production rates.
   b) Each six-inch layer should be compacted to at least 90 percent of the maximum dry density in compliance with the testing method specified by the controlling governmental agency. In most cases, the testing method is ASTM Test Designation D 1557.
4. Rock fragments less than eight inches in diameter may be utilized in the fill, provided:
   a) They are not placed in concentrated pockets;
   b) There is a sufficient percentage of fine-grained material to surround the rocks;
   c) The distribution of the rocks is observed by, and acceptable to, our representative.

5. Rocks exceeding eight (8) inches in diameter should be taken off site, broken into smaller fragments, or placed in accordance with recommendations of this firm in areas designated suitable for rock disposal. On projects where significant large quantities of oversized materials are anticipated, alternate guidelines for placement may be included. If significant oversize materials are encountered during construction, these guidelines should be requested.
6. In clay soil, dry or large chunks or blocks are common. If in excess of eight (8) inches minimum dimension, then they are considered as oversized. Sheepsfoot compactors or other suitable methods should be used to break up blocks. When dry, they should be moisture conditioned to provide a uniform condition with the surrounding fill.

Slope Construction

1. The contractor should obtain a minimum relative compaction of 90 percent out to the finished slope face of fill slopes. This may be achieved by either overbuilding the slope and cutting back to the compacted core, or by direct compaction of the slope face with suitable equipment.
2. Slopes trimmed to the compacted core should be overbuilt by at least three (3) feet with compaction efforts out to the edge of the false slope. Failure to properly compact the outer edge results in trimming not exposing the compacted core and additional compaction after trimming may be necessary.
3. If fill slopes are built "at grade" using direct compaction methods, then the slope construction should be performed so that a constant gradient is maintained throughout construction. Soil should not be "spilled" over the slope face nor should slopes be "pushed out" to obtain grades. Compaction equipment should compact each lift along the immediate top of slope. Slopes should be back rolled or otherwise compacted at approximately every 4 feet vertically as the slope is built.
4. Corners and bends in slopes should have special attention during construction as these are the most difficult areas to obtain proper compaction.
5. Cut slopes should be cut to the finished surface. Excessive undercutting and smoothing of the face with fill may necessitate stabilization.

UTILITY TRENCH CONSTRUCTION AND BACKFILL

Utility trench excavation and backfill is the contractors responsibility. The geotechnical consultant typically provides periodic observation and testing of these operations. While efforts are made to make sufficient observations and tests to verify that the contractors' methods and procedures are adequate to achieve proper compaction, it is typically impractical to observe all backfill procedures. As such, it is critical that the contractor use consistent backfill procedures.

Compaction methods vary for trench compaction and experience indicates many methods can be successful. However, procedures that "worked" on previous projects may or may not prove effective on a given site. The contractor(s) should outline the procedures proposed, so that we may discuss them **prior** to construction. We will offer comments based on our knowledge of site conditions and experience.

1. Utility trench backfill in slopes, structural areas, in streets and beneath flat work or hardscape should be brought to at least optimum moisture and compacted to at least 90 percent of the laboratory standard. Soil should be moisture conditioned prior to placing in the trench.
2. Flooding and jetting are not typically recommended or acceptable for native soils. Flooding or jetting may be used with select sand having a Sand Equivalent (SE) of 30 or higher. This is typically limited to the following uses:
   a) shallow (12 + inches) under slab interior trenches and,
   b) as bedding in pipe zone.

   The water should be allowed to dissipate prior to pouring slabs or completing trench compaction.
3. Care should be taken not to place soils at high moisture content within the upper three feet of the trench backfill in street areas, as overly wet soils may impact subgrade preparation. Moisture may be reduced to 2% below optimum moisture in areas to be paved within the upper three feet below sub grade.
4. Sand backfill should not be allowed in exterior trenches adjacent to and within an area extending below a 1:1 projection from the outside bottom edge of a footing, unless it is similar to the surrounding soil.
5. Trench compaction testing is generally at the discretion of the geotechnical consultant. Testing frequency will be based on trench depth and the contractors procedures. A probing rod would be used to assess the consistency of compaction between tested areas and untested areas. If zones are found that are considered less compact than other areas, this would be brought to the contractors attention.

JOB SAFETY

General

Personnel safety is a primary concern on all job sites. The following summaries are safety considerations for use by all our employees on multi-employer construction sites. On ground personnel are at highest risk of injury and possible fatality on grading construction projects. The company recognizes that construction activities will vary on each site and that job site safety is the contractor's responsibility. However, it is, imperative that all personnel be safety conscious to avoid accidents and potential injury.

In an effort to minimize risks associated with geotechnical testing and observation, the following precautions are to be implemented for the safety of our field personnel on grading and construction projects.

1. Safety Meetings: Our field personnel are directed to attend the contractor's regularly scheduled safety meetings.
2. Safety Vests: Safety vests are provided for and are to be worn by our personnel while on the job site.
3. Safety Flags: Safety flags are provided to our field technicians; one is to be affixed to the vehicle when on site, the other is to be placed atop the spoil pile on all test pits.

In the event that the contractor's representative observes any of our personnel not following the above, we request that it be brought to the attention of our office.

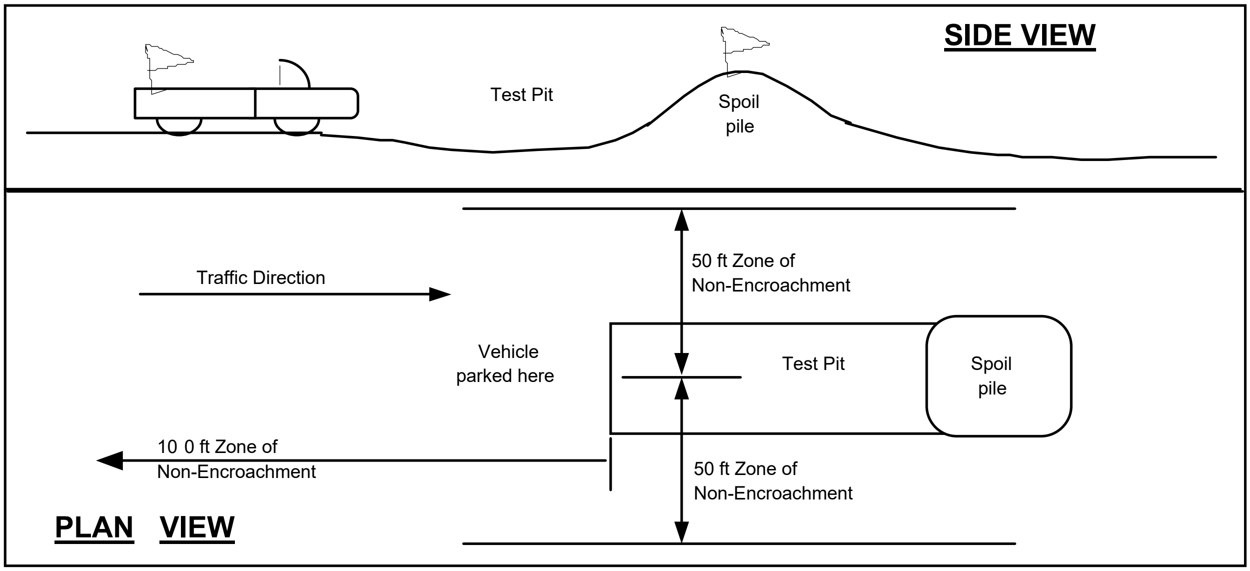
Test Pits Location, Orientation and Clearance

The technician is responsible for selecting test pit locations. The primary concern is the technician's safety. However, it is necessary to take sufficient tests at various locations to obtain a representative sampling of the fill. As such, efforts will be made to coordinate locations with the grading contractors authorized representatives (e.g. dump man, operator, supervisor, grade checker, etc.), and to select locations following or behind the established traffic pattern, preferably outside of current traffic. The contractors authorized representative should direct excavation of the pit and safety during the test period. Again, safety is the paramount concern.

Test pits should be excavated so that the spoil pile is placed away from oncoming traffic. The technician's vehicle is to be placed next to the test pit, opposite the spoil pile. This necessitates that the fill be maintained in a drivable condition. Alternatively, the contractor may opt to park a piece of equipment in front of test pits, particularly in small fill areas or those with limited access.

A zone of non-encroachment should be established for all test pits (see diagram below). No grading equipment should enter this zone during the test procedure. The zone should extend outward to the sides approximately 50 feet from the center of the test pit and 100 feet in the direction of traffic flow. This zone is established both for safety and to avoid excessive ground vibration, which typically decreases test results.

TEST PIT SAFETY PLAN



Slope Tests

When taking slope tests, the technician should park their vehicle directly above or below the test location on the slope. The contractor's representative should effectively keep all equipment at a safe operation distance (e.g. 50 feet) away from the slope during testing.

The technician is directed to withdraw from the active portion of the fill as soon as possible following testing. The technician's vehicle should be parked at the perimeter of the fill in a highly visible location.

Trench Safety

It is the contractor's responsibility to provide safe access into trenches where compaction testing is needed. Trenches for all utilities should be excavated in accordance with CAL-OSHA and any other applicable safety standards. Safe conditions will be required to enable compaction testing of the trench backfill.

All utility trench excavations in excess of 5 feet deep, which a person enters, are to be shored or laid back. Trench access should be provided in accordance with OSHA standards. Our personnel are directed not to enter any trench by being lowered or "riding down" on the equipment.

Our personnel are directed not to enter any excavation which;

1. is 5 feet or deeper unless shored or laid back,
2. exit points or ladders are not provided,
3. displays any evidence of instability, has any loose rock or other debris which could fall into the trench, or

4. displays any other evidence of any unsafe conditions regardless of depth.

If the contractor fails to provide safe access to trenches for compaction testing, our company policy requires that the soil technician withdraws and notifies their supervisor. The contractors representative will then be contacted in an effort to effect a solution. All backfill not tested due to safety concerns or other reasons is subject to reprocessing and/or removal.

Procedures

In the event that the technician's safety is jeopardized or compromised as a result of the contractor's failure to comply with any of the above, the technician is directed to inform both the developer's and contractor's representatives. If the condition is not rectified, the technician is required, by company policy, to immediately withdraw and notify their supervisor. The contractor's representative will then be contacted in an effort to effect a solution. No further testing will be performed until the situation is rectified. Any fill placed in the interim can be considered unacceptable and subject to reprocessing, recompaction or removal.

In the event that the soil technician does not comply with the above or other established safety guidelines, we request that the contractor bring this to technicians attention and notify our project manager or office. Effective communication and coordination between the contractors' representative and the field technician(s) is strongly encouraged in order to implement the above safety program and safety in general.

The safety procedures outlined above should be discussed at the contractor's safety meetings. This will serve to inform and remind equipment operators of these safety procedures particularly the zone of non-encroachment.

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