Geotechnical Engineering Report

Riverside Apartment Complex
SWC Riverside Boulevard & Captain's Table Road
Sacramento, California

February 26, 2016
Terracon Project No. NB165014

Prepared for:
Bulluck Townhouses
Merced, California

Prepared by:
Terracon Consultants, Inc.
Sacramento, California

February 26, 2016

Bulluck Townhouses
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Re: **Geotechnical Engineering Report**
Riverside Apartment Complex
SWC Riverside Boulevard and Captain's Table Road
Sacramento, California
Terracon Project No. NB165014

Dear Ms. Bulluck:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering report for the above referenced project. This study was performed in general accordance with our proposal dated January 20, 2016 with proposal number PNB165014. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of the proposed apartment complex.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

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Enclosures
cc: 1 – Client (PDF)
1 – File

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the proposed Riverside Apartment Complex to be located at the southwest corner of Riverside Boulevard and Captain's Table Road in Sacramento, California. The project consists of four (4) to six (6) two to three story wood-framed single-family residential structures. Two (2) borings were drilled to depths of approximately 21½ feet below ground surface (bgs) within the footprint of the proposed apartment complex. The geotechnical considerations identified included the following:

- The subsurface soils were relatively consistent between locations. The subsurface soil consisted of 15 feet of soft to stiff silt with trace sand underlain by soft to medium silt with sand to the maximum depth explored of 21½ feet. Groundwater was encountered between 8 and 9 feet bgs during our exploration.

- The upper sitly soils at this site are loose and prone to settlement. Therefore, the proposed buildings shall be supported by a post tensioned slab foundation bearing on 18 inches of scarified and recompacted native soils. The perimeter of the slab should extend to a depth of at least 12 inches below the lowest adjacent finished soil grade. The near surface silt soils are suitable for reuse as engineered fill for this project.

- Deep seeded post-seismic liquefaction may cause differential settlement at this site due to loose, saturated non-plastic soils.

- Several mature trees have been removed from this site in locations that may be developed with building pads. Areas where trees have been located should be over-excavated and recompacted as engineered fill.

- The 2013 California Building Code (CBC) Seismic Site Classification for this site is E. Liquefiable soils are present at this site, therefore the potential for liquefaction induced settlement should be considered in the design.

- Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that Terracon be retained to monitor this portion of the work.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
RIVERSIDE APARTMENT COMPLEX
RIVERSIDE BOULEVARD AND CAPTAINS TABLE ROAD
SACRAMENTO, CALIFORNIA

Terracon Project No. NB165014
February 26, 2016

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed Riverside Apartment Complex to be located at the southwest corner of Riverside Boulevard and Captain's Table Road in Sacramento, California. The Site Location Map (Exhibit A-1) is included in Appendix A of this report. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- seismic considerations
- earthwork
- groundwater conditions
- foundation design and construction
- floor slab design and construction
- pavement design and construction

Our geotechnical engineering scope of work for this project included the advancement of two (2) borings to a maximum depth of 21½ feet below ground surface (bgs) within the footprint of the proposed buildings.

Logs of borings along with a Boring Location Diagram (Exhibit A-2) are included in Appendix A of this report. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included in Appendix B of this report. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-1 and A-2: Site Location and Exploration Plan.
Structures	The proposed development consists of four (4) to six (6), two to three story, wood framed single-family structures. The buildings are anticipated to be smaller than 1500 square feet.
Construction	We anticipate construction to consist of conventional wood framed structures founded on post-tensioned slab foundations.

Item	Description
Maximum loads	■ Maximum Column Loads: 10 to 20 kips (assumed) ■ Maximum Wall Loads: less than 2 kips/ft. (assumed) ■ Maximum Floor Loads: less than 50 psf (assumed)
Grading	Based upon site topography, cuts and fills on the order of approximately one (1) foot are anticipated to provide a level building pad.

2.2 Site Location and Description

Item	Description
Location	Southwest corner of Riverside Boulevard and Captain's Table Road, Sacramento, California.
Existing site features	The site is currently undeveloped. Though development history is unknown, aerial photographs from Google Earth dating back to 1993 do not show any signs of development.
Surrounding developments	This development is located in the Little Pocket residential neighborhood in Sacramento. The general area is highly developed residential. North: Captain's Table Road followed by the Le Rivage Hotel. West: Captain's Table Apartments followed by the Sacramento River. South: Residential structure followed by Rio Lane East: Riverside Boulevard followed by the I-5 Freeway.
Current ground cover	The site is currently covered by natural vegetation with multiple mature trees.
Existing topography	Site topography is relatively flat with changes in elevation on the order of 1 foot across the site.
Existing Seismic Hazards	Based on our review of the State of California Seismic Hazards Zones maps, the site is not shown to be within an Alquist-Priolo special studies zone for earthquake faults. However, during our investigation liquefiable soils were encountered. The potential for liquefaction induced settlement at this site should be considered.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

The project area is located in the Great Valley Geomorphic Province California. The southern portion of the Great Valley is situated along the western flank of the Sierra Nevada Mountains and is bounded by the Coast Ranges to the west. The topography consists of relatively flat alluviated valleys. As a result of erosion, the Great Valley has experienced substantial infilling with sedimentary material deposited as alluvial fans.

The native soils underlying the site are considered to consist of basin deposits (Q_b) as described in the geologic map of the area[1]. Basin deposits are Quaternary in age (2.6 million years ago to present) and consist of sands, silts, and clays of valley areas. The surficial mapped geology is consistent with the materials encountered throughout the borings.

3.2 Typical Subsurface Profile

Specific conditions encountered at the boring locations are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soils types; in-situ, the transition between materials may be gradual. Details for the borings can be found on the attached boring logs.

The site conditions generally encountered are as follows:

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1	15 feet bgs	Silt	Soft to Stiff
Stratum 2	21½ feet bgs (Maximum Depth of Exploration)	Silt with Sand	Soft to Medium Stiff

Laboratory tests were conducted on selected soil samples and the test results are presented in Appendix B. The upper soils encountered at the site generally consisted of silt with trace sand. The silts exhibited low plasticity, and were found to have the following characteristics:

Sample Location	Depth (feet)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	< No. 200 Sieve (%)

[1] Wagner, D.L., Jennings C.W., Geologic Map of the Sacramento Quadrangle, California, 1981, California Geological Survey, 1:250,000

Boring B-2	10 to 11½	34	25	9	89

Based on a review of aerial photographs of the site, it appears that a number of trees were removed within the footprint of the proposed building between 2014 and 2015. Voids from backfill of root balls can settle, causing damage to the building and other improvements. Recompaction of excavations due to tree roots should follow recommendations set forth in Section 4.2.1.

3.3 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was encountered in both borings at an approximate depth of 10 feet bgs while drilling. At completion of drilling groundwater was measured at 8 feet bgs in Boring No. 1 and 9 feet bgs in Boring No. 2.

This project site is located less than 200 yds east of the Sacramento River. Groundwater level fluctuations are driven by the seasonal fluctuations in the river. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs.

3.4 Seismic Considerations

The site is located in Northern California, which is a seismically active area. The type and magnitude of seismic hazards affecting the site are dependent on the distance to causative faults, the intensity, and the magnitude of the seismic event. The table below indicates the distance of the fault zones and the associated maximum credible earthquake that can be produced by nearby seismic events, as calculated using the USGS Earthquake Hazard Program 2008 interactive deaggregations.

Characteristics and Estimated Earthquakes for Regional Faults			
Fault Name	**Approximate Distance to Site**	**Percent Contribution**	**Maximum Considered Earthquake (MCE) Magnitude**
Hunting Creek-Berryessa Char	59.7 km	7.58%	7.0
Green Valley Connected Char	60.0 km	5.70%	6.71
Great Valley 4a, Trout Creek Cha	42.8 km	4.53%	6.51

Based on nearby faults within the proximity of the site, the Maximum Considered Earthquake (MCE) peak ground acceleration at the subject site for a 2% Probability of Exceedance in 50 years is expected to be about 0.3827g per the 2008 USGS Interactive Deaggregations. The site is not located within an Alquist-Priolo Earthquake Fault Zone based on our review of the State Fault Hazard Maps.[2]

The following table provides the seismic design criteria in accordance with the 2013 California Building Code at the approximate center of the site, obtained from the USGS Earthquake Hazards website (http://geohazards.usgs.gov/designmaps/us/application.php):

Code Used	Site Classification
2013 California Building Code (CBC)[1]	E [2]
Site Latitude	38.5332°
Site Longitude	-121.5183°
S_S Spectral Acceleration for a Short Period	0.717g
S_1 Spectral Acceleration for a 1-Second Period	0.303g
Seismic Site Coefficient F_a	1.267
Seismic Site Coefficient F_v	2.787
Geometric Mean Peak Ground Acceleration PGA	0.361g

1. In general accordance with the *2013 California Building Code,* Table 1613.5.2.
2. The 2013 California Building Code requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100 foot soil profile determination. Borings for this report extended to a maximum depth of approximately 21.5 feet and this seismic site class assignment considers that hard native sandy clay continues below the maximum depth of the subsurface exploration. Additional exploration to greater depths could be considered to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a more favorable seismic site class.

3.5 Liquefaction

Liquefaction is a mode of ground failure that results from the generation of excess pore-water pressures during earthquake ground shaking, causing loss of shear strength. This phenomenon generally occurs in areas of high seismicity, where groundwater is shallow, and loose granular soils or relatively non-plastic fine-grained soils are present. The California Geologic Survey (CGS) has designated certain areas within California as potential liquefaction hazard zones. These are areas considered at a risk of liquefaction-related ground failure during a seismic event, based upon mapped surficial deposits and the likely presence of a relatively shallow water table. The project site is not located within a mapped potential liquefaction hazard zone as indicated by the CGS.

Though the site is not mapped in a liquefaction hazard zone, liquefiable soils are present at this site. Groundwater was encountered between 8 and 9 feet during our investigation and subgrade soils are soft and relatively non-plastic. Additionally, liquefiable soils may be present below the

[2] California Department of Conservation Division of Mines and Geology (CDMG), *"Digital Images of Official Maps of Alquist-Priolo Earthquake Fault Zones of California, Southern Region"*, CDMG Compact Disc 2000-003, 2000.

maximum depth explored of 21½ feet. As a result, some differential settlement is likely to developif liquefaction occurs during a major seismic event. Our preliminary analysis indicates that total and differential settlement may be up to 7 and 3 inches, respectively. Based on the depth to groundwater, and the soft nature of the underlying strata, the potential for seismically induced liquefaction at this site should be considered in the design of the structures.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Subgrade soils encountered at foundation depths consist of soft and weak compressible soils. There is also a risk of additional settlement due to seismically induced liquefaction Based on the results of the subsurface exploration, laboratory testing, and our analysis, it is our opinion that the proposed buildings should be supported on a post tensioned slab foundation bearing on scarified and recompacted native soils.

4.1.1 Liquefaction Potential of Subgrade Soils

Potentially liquefiable soils were identified at this site. It is important to note that using a post-tensioned slab foundation system to support these buildings will not prevent settlement or damage from a liquefaction event. The post-tensioned slab is intended to reduce differential settlement and associated damage, not eliminate it. A deep driven pile foundation system may be considered if the risk of liquefaction induced settlement is not acceptable. Based on our experience in this area, we anticipate piles will be on the order of 40 to 60 feet deep.

Post tensioned slab foundations should bear on 18 inches of scarified and recompacted native soil. The native silt soils located at this site are suitable for use as engineered fill.

Geotechnical engineering recommendations for foundation systems and other earth connected phases of the project are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing (which are presented in Appendices A and B), engineering analyses, and our current understanding of the proposed project.

4.2 Earthwork

The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. The recommendations presented are for the design and construction of earth supported elements including foundations and concrete slabs on grade and are contingent upon following the recommendations outlined in this section. All grading for the structure should incorporate the limits of the proposed structure plus a lateral distance of at least five feet beyond the outside perimeter (the building pad).

Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project. Such evaluation is considered an extension of this study.

4.2.1 Site Preparation

Strip and remove vegetation, trees, and other deleterious materials within the footprint of the proposed construction. Exposed native soils should be free of mounds and depressions which could prevent uniform compaction. Near surface silt soils are suitable for use as engineered fill for this project.

Based on a review of aerial photographs of the site, it appears that a number of trees were removed within the footprint of the proposed building between 2014 and 2015. Voids from backfill of root balls can settle, causing damage to the building and other improvements. The depth of the root system was not determined in our investigation. Soil containing heavy vegetation and root matter can suffer post-construction settlement, and are not suitable to support the structure. We recommend over excavating the areas where trees were removed to a depth of 30 inches in order to remove the all roots greater than ½ inch in diameter and any other organic matter. Over excavated material may be stockpiled for reuse.

Once the building area has been over excavated to remove vegetation, the resulting subgrade should be scarified to a minimum depth of 12 inches, moisture conditioned and recompacted as specified in **Section 4.2.4**. After scarification and recompaction of the subgrade, stockpiled soils removed from the building pad may be placed and compacted as engineered fill. The onsite soil, provided they are clean of vegetation and deleterious materials are suitable for use as engineered fill. Any additional fill material should be non-expansive and conform to the criteria for engineered fill specified in **Section 4.2.3** of this report.

4.2.2 Subgrade Preparation

Post tensioned slab foundations should bear on 18 inches of scarified and recompacted native soil. During grading operations, exposed soils should be proof rolled and approved by the Engineer prior to the placement of engineered fill. Any soft spots, where the Contractor may have difficulty in obtaining the desired compaction, shall be removed and replaced with compacted engineered fill as described in this report.

4.2.3 Fill Material Requirements

All fill materials from any source should be inorganic soils free of vegetation, debris, and fragments larger than three inches in size. Pea gravel or other similar non-cementitious, poorly-graded materials should not be used as fill or backfill without the prior approval of the geotechnical engineer.

Native silt soils are suitable to be used as engineered fill. Import materials for use as engineered fill should be pre-approved by our representative during construction.

Import soils for use as compacted engineered fill material within the proposed building areas should conform to low volume change materials as indicated as follows:

Gradation	**Percent Finer by Weight (ASTM C 136)**
3"	100
No. 4 Sieve	50-100
No. 200 Sieve	20 - 40

- Liquid Limit .... 30 (max)
- Plasticity Index .... 12 (max)
- Maximum expansive index* .... 20 (max)

*ASTM D4829

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Fill lifts should not exceed ten inches loose thickness.

4.2.4 Compaction Requirements

Recommended compaction and moisture content criteria for engineered fill materials are as follows:

Material Type and Location	Per the Modified Proctor Test (ASTM D 1557)		
	Minimum Compaction Requirement (%)	Range of Moisture Contents for Compaction Above Optimum	
		Minimum	Maximum
Approved import engineered fill soils:			
Beneath foundations:	90	+1	+3
Beneath exterior slabs:	90	+1	+3
Utility trenches (structural areas):	90	+1	+3
On site Soils:		+1	+3
Bottom of excavation receiving fill:	90	+1	+3
Miscellaneous backfill:	90	+1	+3
Utility trenches (Landscape areas):	90	+1	+3
Beneath asphalt pavements:	95	+1	+3
Beneath concrete pavements:	95	+1	+3
Beneath exterior slabs:	90	+1	+3

Material Type and Location	Per the Modified Proctor Test (ASTM D 1557)		
	Minimum Compaction Requirement (%)	Range of Moisture Contents for Compaction Above Optimum	
		Minimum	Maximum
Aggregate base (beneath pavements):	95	+1	+3

4.2.5 Grading and Drainage

All final grades must provide effective drainage away from the building during and after construction. Water permitted to pond next to the building can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential movements, cracks, and leaks. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Exposed ground should be sloped at least 2 percent away from the building extending a minimum of 5 feet beyond the perimeter of the building. After building construction and landscaping, we recommend the Civil Engineer/Surveyor verify final grades to document that effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary, as part of the structure maintenance program.

Locate sprinkler mains and spray heads a minimum of 5 feet away from the building lines. Collect roof runoff in drains or gutters. Discharge roof drains and downspouts onto pavements which slope away from the building or extend down spouts a minimum of 10 feet away from the structure.

Downspouts, roof drains or scuppers should discharge into splash blocks or extensions when the ground surface beneath such features is not protected by exterior slabs or paving. Sprinkler systems should not be installed within 5 feet of foundation walls. Landscaped irrigation adjacent to the foundation systems should be minimized or eliminated.

4.2.6 Earthwork Construction Considerations

At the time of our study, moisture contents of the surface soils ranged from 30 to 41 percent. Based on these moisture contents, some moisture conditioning for the subgrade material may be needed for the project. The soil moisture contents may need to be dried by aeration or wetted to achieve the moisture content range per **Section 4.2.4**.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively workable. The workability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unworkable conditions develop, workability may be improved by scarifying and drying. If the construction schedule does not allow for scarifying and drying by aeration in place, Terracon should be consulted to evaluate the situation as needed.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and re-compacted.

The contractor is responsible for designing and constructing stable, temporary excavations (including utility trenches) as required to maintain stability of both the excavation sides and bottom. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations to the completed subgrade.

We recommend that the earthwork portion of this project be completed during extended periods of dry weather if possible. If earthwork is completed during the wet season it may be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork may require additional mitigative measures beyond that which would be expected during the drier summer and fall months. This could include diversion of surface runoff around exposed soils and draining of ponded water on the site. Once subgrades are established, it may be necessary to protect the exposed subgrade soils from construction traffic.

4.3 Foundations

4.3.1 Foundation Design Recommendations

The proposed building can be supported by a post tensioned slab foundation system bearing on a minimum of 18 inches of scarified and recompacted native soil. Post tensioned foundations should consist of a monolithic slab with deepened areas for concentrated column loads. Design recommendations for shallow foundations for the proposed structure are presented in the following paragraphs.

DESCRIPTION	RECOMMENDATION
Foundation Type	Post Tensioned Slab
Bearing Material	18 inches of scarified and recompacted native soil
Slab Thickness	Appropriate thickness as determined by Structural Engineer
Allowable Bearing Pressure	2,000 psf

DESCRIPTION	RECOMMENDATION
Minimum Plan View Dimensions	
Minimum Embedment Below Finished Grade	
Total Estimated Settlement	1-inch (up to 7 inches for liquefaction)
Lateral Resistance	Passive: 375 pcf Coefficient of Friction: 0.35
Estimated Differential Settlement	½ inch over 40 feet (up to 3 inches for liquefaction)
Coefficient of Friction	0.5
Exterior Slabs (Concrete Sidewalks)	4 inches of crushed gravel under a 5-inch slab with minimum reinforcement of #4 bars at 24 inches on center

The structural engineer should be allowed to calculate the most feasible slab for the given soil conditions and design parameters presented herein. Design parameters provided in this report are based on the Third Editions of the Post Tensioning Institute manual for “Design and Construction of Post-Tensioned Slabs-on-Ground.”

4.3.2 Foundation Construction Considerations

Finished grade is defined as the lowest adjacent grade within five feet of the foundations. The allowable foundation bearing pressures apply to dead loads plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include transient conditions, such as wind or seismic. The weight of the foundation concrete below grade may be neglected in dead load computations. Passive and friction may be combined to resist lateral loads provided the passive resistance is reduced by half.

Total and differential settlements should not exceed predicted values, provided that:

- Foundations are constructed as recommended, and
- Essentially no changes occur in water contents of foundation soils.

Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design and during construction.

Footings and foundations should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

Foundation excavations and bearing soils should be observed by the geotechnical engineer. If the soil conditions encountered differ significantly from those presented in this report, then supplemental recommendations will be required.

The base of all foundation excavations should be free of water, loose soil, and gravel prior to placing concrete. Concrete should be placed soon after excavating and placement of engineered fill to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed, or saturated, the affected soil should be removed prior to placing concrete. In addition, as previously described, unsuitable soils should be completely removed from any proposed construction areas prior to construction. We recommend that Terracon be retained to observe and test the soil foundation bearing materials exposed in the over excavation.

4.4 Lateral Earth Pressures

For on-site native soils and fill materials, or imported granular fill materials above any free water surface, recommended equivalent fluid pressures for foundation elements are:

ITEM	Onsite Soils	Fill Soils
Active Case (psf/ft)	40	40
Passive Case (psf/ft)	300	300
At-Rest Case (psf/ft)	65	65
Coefficient of Friction	0.30	0.30

The lateral earth pressures herein do not include any factor of safety and are not applicable for submerged soils/hydrostatic loading. These values assume a level backfill. Additional recommendations may be necessary if such conditions are to be included in the design.

Fill against foundation and retaining walls should be compacted to densities recommended in the Earthwork section of this report. Compaction of each lift adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors.

4.5 Pavements

Exterior vehicular pavements may be constructed with asphalt pavements. Design recommendations are presented in the following paragraphs.

4.5.1 Subgrade Preparation

The proposed pavement sections should be supported on a minimum of 18 inches of scarified and recompacted native soil. On most project sites, the site grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, rainfall and surface water saturates some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade and many surface irregularities are filled in with loose soils to improve trafficability temporarily. As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches.

We recommend the moisture content and density of the top 12 inches of the subgrade be evaluated and the pavement subgrades be proof rolled within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

4.5.2 Design Considerations

Anticipated loading conditions were not available at the time that this report was prepared. However, we anticipate that traffic loads will be low and consist primarily of light vehicles and an occasional trash truck. If it is anticipated that pavements will be subjected to heavy truck traffic, pavement thickness should be determined using expected traffic volumes, vehicle types, and vehicle loads and should be in accordance with local, city or county ordinances.

Near surface materials at the site consisted of native silt with trace sand in all borings. A bulk sample collected within the upper 2 feet during our investigation was subjected to R-Value testing. Based on the results of this test a design R-value of 27 was used to calculate the asphalt concrete pavement thickness sections.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to drives should slope down from pavement edges at a minimum 2%;
- The subgrade and the pavement surface should have a minimum ¼ inch per foot slope to promote proper surface drainage;
- Install pavement drainage surrounding areas anticipated for frequent wetting (e.g., garden centers, wash racks);
- Install joint sealant and seal cracks immediately;
- Seal all landscaped areas in, or adjacent to pavements to reduce moisture migration to subgrade soils;
- Place compacted, low permeability backfill against the exterior side of curb and gutter; and,
- Place curb, gutter and/or sidewalk directly on low permeability subgrade soils rather than on unbound granular base course materials.

4.5.3 Estimates of Minimum Pavement Thickness

Assuming the pavement subgrades will be prepared as recommended within this report, the following pavement sections should be considered minimums for this project for the traffic indices assumed in the table below.

Typical Pavement Section (inches)						
Traffic Area	**Assumed Traffic Index (TI)**	**Alternative**	**Asphalt Concrete (AC) Surface Course**	**Portland Cement Concrete (PCC) [1]**	**Aggregate Base (AB) Course**	**Total Thickness**
Parking Spaces	4.0	PCC	--	4.0	4.0	8.0
		AC	3.0	--	4.0	7.0
Drive Areas	5.0	PCC	--	6.0	4.0	10.0
		AC	3.0	--	6.0	9.0

1. 3,000 psi at 28 days, 4-inch maximum slump, 6-sack min. mix. PCC pavements are recommended for trash container pads and in any other areas subjected to heavy wheel loads and/or turning traffic.

These pavement sections are considered minimal sections based upon the expected traffic and the existing subgrade conditions. However, they are expected to function with periodic maintenance and overlays if good drainage is provided and maintained. Base course or pavement materials should not be placed when the surface is wet. Surface drainage should be provided away from the edge of paved areas to minimize lateral moisture transmission into the subgrade.

We recommend a Portland cement concrete (PCC) pavement be utilized in entrance and exit sections, dumpster pads, loading dock areas, or other areas where extensive wheel maneuvering are expected. The dumpster pad should be large enough to support the wheels of the truck which will bear the load of the dumpster. We recommend a minimum of 6 inches of PCC underlain by 4 inches of AB. Although not required for structural support, the base course layer is recommended to help reduce potentials for slab curl, shrinkage cracking, and subgrade "pumping" through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. All joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

Portland cement concrete should be designed to have a minimum compressive strength of 3,000 psi after 28 days of laboratory curing. Adequate reinforcement and number of longitudinal and transverse control joints should be placed in the rigid pavement in accordance with ACI requirements. The joints should be sealed as soon as possible (in accordance with sealant manufacturer's instructions) to minimize infiltration of water into the soil.

4.5.4 Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section.

4.5.5 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore preventive maintenance should be planned and provided through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

5.0 GENERAL COMMENTS

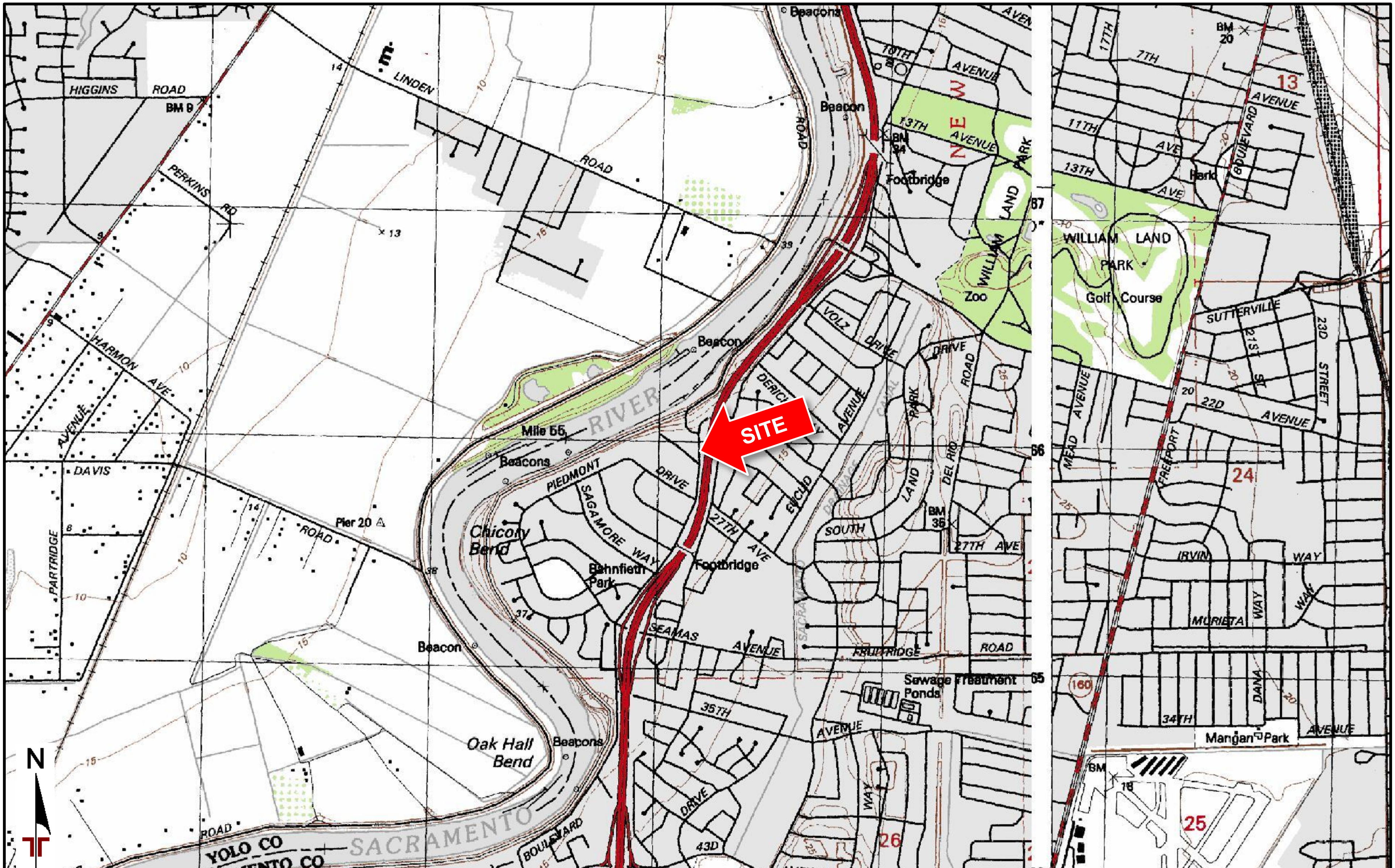
Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: SACRAMENTO WEST, CA (1/1/1992) and SACRAMENTO EAST, CA (1/1/1992).

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: GL	**Project No.** NB165014
Drawn by: NN	**Scale:** 1"=2,000'
Checked by: GI	**File Name:** A-1
Approved by: RH	**Date:** Feb 2016

Terracon

50 Goldenland Ct. Ste. 100

Sacramento, CA 95834

SITE LOCATION

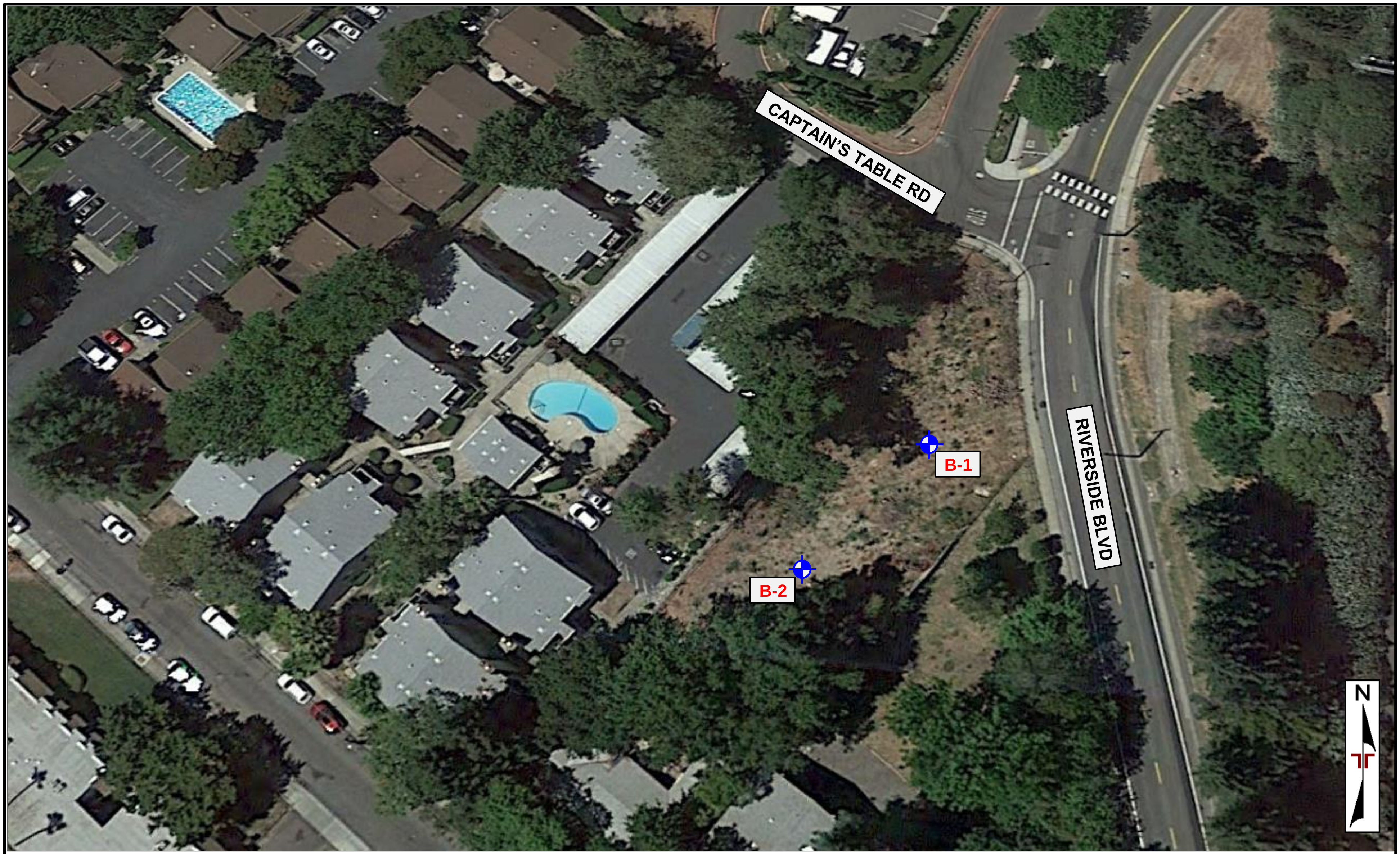
Riverside Apartments

SWC Riverside Blvd. & Captain's Table Rd

Sacramento, CA

Exhibit

A-1



LEGEND	Project Manager: GL	Project No. NA165014	Terracon	SITE DIAGRAM	EXHIBIT
APPROXIMATE BORING LOCATION	Drawn by: NN	Scale: N.T.S.	50 Goldenland Court, suite 100	Riverside Apartments	A-2
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES	Checked by: GL	File Name: A-2	Sacramento, CA 95834	SWC Riverside Blvd. & Captain's Table Rd	
	Approved by: RH	Date: Feb 2016		Sacramento, CA	

Field Exploration Description

Our field exploration for this project included performing two (2) test borings to approximate a maximum depth of 21½ feet bgs on February 2, 2016. The approximate exploration locations are shown on the Field Exploration Plan, Exhibit A-2. Exploration locations were located in the field by measuring from the existing site features shown on an aerial photo. The exploration locations should only be considered accurate to the degree implied by the means and methods used to define them.

The test borings were advanced with a truck mounted Simco drill rig which utilized 4-inch diameter solid-stem auger. A continuous log of the borings was recorded by the field geologist during drilling operations. At selected intervals, samples of the subsurface materials were taken by driving 2-inch diameter split-spoon samplers. These logs included visual classifications of the materials encountered during drilling as well as the field geologist's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the geologist's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

Samples of the soils encountered in the borings were obtained using the split barrel sampling procedures described below. The samples were stored in moisture tight containers and transported to our laboratory for further visual classification and testing.

Penetration resistance measurements were obtained by driving the split-spoon and Modified California sampler into the subsurface materials with a 140-pound hammer falling 30 inches. This test is referred to as the standard penetration test (SPT) and displayed on the logs as an "N" value when the standard 2-inch outer diameter sampler is used. The penetration resistance value is a useful index in estimating the consistency or relative density of materials encountered.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the borings logs attached to this report includes soil descriptions, consistency evaluations, borings depths, sampling intervals, and groundwater conditions. The borings were backfilled with soil cuttings and cold patched with asphalt upon completion.

BORING LOG NO. B-1

PROJECT: Riverside Apartment Complex

CLIENT: Bullock Townhouses
Merced, CA

SITE: SWC Roverside Blvd. & Captain's Table Road
Sacramento, CA

LOCATION See Exhibit A-2

Latitude: 38.5332° Longitude: -121.5182°

GRAPHIC LOG	DEPTH / Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILT (ML), trace sand, fine grained, low plasticity, light brown to brown, soft, micaceous									
					2-1-2	1.25 (HP)	30	76		87
	stiff	5			4-6-6	2.25 (HP)	30	86		
			▽							
	soft to medium stiff	10	▽		1-2-2 N=4	1.5 (HP)	41	76		
	15.0 **SILT WITH SAND (ML)**, fine grained, low plasticity, gray, soft, micaceous	15			1-1-1 N=2		34	87		81
	black mottling	20			1-2-1 N=3		35	81		
	21.5 ***Boring Terminated at 21.5 Feet***									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope & Cathead

Advancement Method:
4 inch solid stem auger

Abandonment Method:
Borings backfilled with neat cement grout

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by Google Earth

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

▽ *At completion of drilling*

Terracon
50 Goldenland Ct., Ste. 100
Sacramento, California

Boring Started: 2/2/2016	Boring Completed: 2/2/2016
Drill Rig: Simco	Driller: R. Anderson
Project No.: NB165014	Exhibit: A-4

BORING LOG NO. B-2

PROJECT: Riverside Apartment Complex

CLIENT: Bullock Townhouses
Merced, CA

SITE: SWC Roverside Blvd. & Captain's Table Road
Sacramento, CA

LOCATION See Exhibit A-2

Latitude: 38.53308° Longitude: -121.5184°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILT (ML), trace sand, fine grained, low plasticity, light brown to brown, soft, micaceous									
					2-2-3	1.5 (HP)	30	76		
	medium stiff	5			4-4-5	1.5 (HP)	31	81		
			▽ (While drilling)							
	soft	10	▽ (At completion of drilling)		2-2-1 N=3	1.0 (HP)	41	67	34-25-9	89
15.0	**SILT WITH SAND (ML)**, fine grained, low plasticity, gray to dark brown, medium stiff, micaceous	15			2-3-3 N=6		38	66		
	gray, soft to medium stiff	20			2-2-2 N=4		36	75		73
21.5	***Boring Terminated at 21.5 Feet***									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope & Cathead

Advancement Method:
4 inch solid stem auger

Abandonment Method:
Borings backfilled with neat cement grout

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by Google Earth

Notes:

WATER LEVEL OBSERVATIONS

▽ *While drilling*

▽ *At completion of drilling*

Terracon
50 Goldenland Ct., Ste. 100
Sacramento, California

Boring Started: 2/2/2016	Boring Completed: 2/2/2016
Drill Rig: Simco	Driller: R. Anderson
Project No.: NB165014	Exhibit: A-5

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

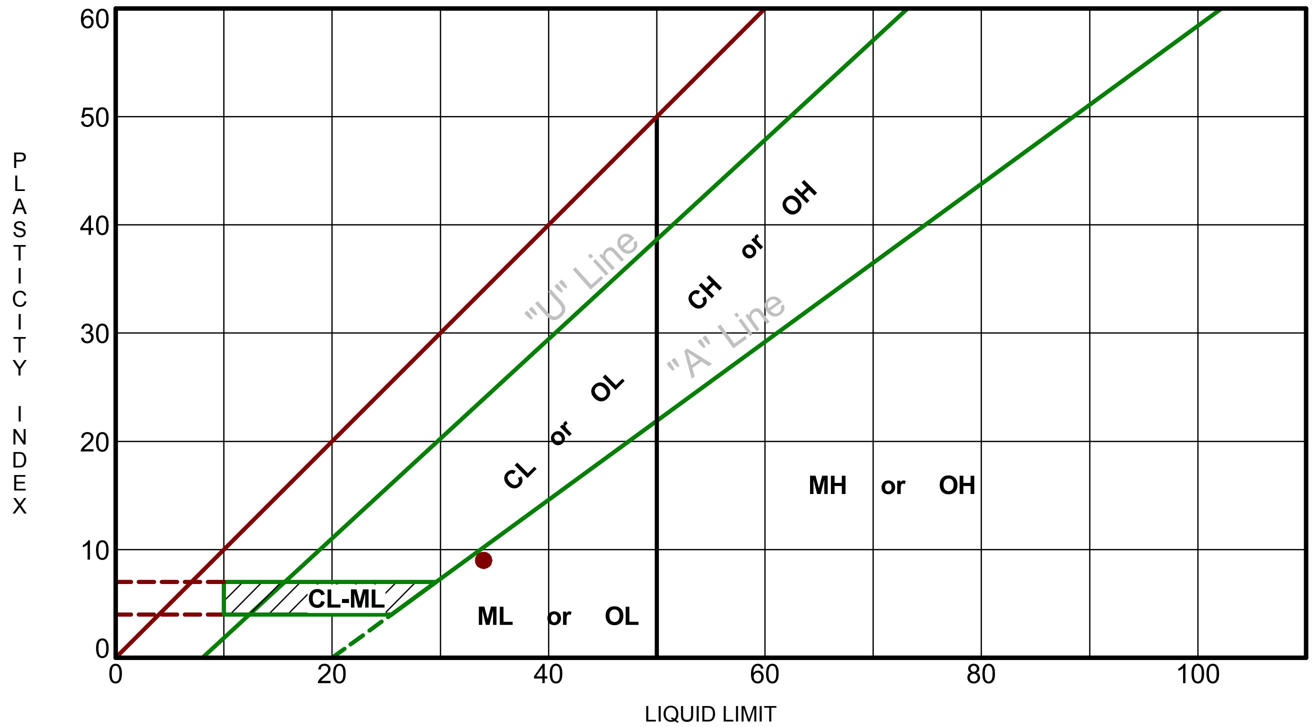
Laboratory tests were conducted on selected soil samples and the test results are presented on the logs of the borings or in the body of the report. The laboratory test results were used for the geotechnical engineering analyses, and the development of engineering, earthwork, and construction recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local, or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- In-situ Water Content
- Unit Weight
- R-Value
- Grain Size Analysis
- Atterberg Limits

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● **B-2**	**10 - 11.5**	**34**	**25**	**9**	**89**	**ML**	**SILT**

PROJECT: Riverside Apartment Complex

SITE: SWC Roverside Blvd. & Captain's Table Road
Sacramento, CA

Terracon
50 Goldenland Ct., Ste. 100
Sacramento, California

PROJECT NUMBER: NB165014

CLIENT: Bullock Townhouses
Merced, CA

EXHIBIT: B-2

Terracon

R VALUE

CALIFORNIA TEST 301

JOB NAME:	Riverside Apartments	DATE RECEIVED:	02-Feb-16
JOB NUMBER:	NB165014	DATE BATCHED:	02-Feb-16
SAMPLE NUMBER:	B1 (0-2 feet)	TECHNICIAN:	C.Coyle
SAMPLE SOURCE:	Boring B-1		
SAMPLE CLASSIFICATION:	Sandy silt		

BATCH & MOISTURE DAY ONE:

TARE	A1	BATCH WEIGHT	**1200**
TARE WEIGHT	110		
WET WEIGHT	414		
DRY WEIGHT	365		
MOISTURE	19.2%		

COMPACTION DAY TWO:

DATE	2/3	2/3	2/3	
MOLD ID	759	Q4	12	
MOLD WT (g)	2097	2097	2088	
INITIAL WATER ADDED (ml)	-45	-30	-15	
ADDITIONAL WATER ADDED (ml)	0	0	0	
TOTAL WATER ADDED (ml)	-45	-30	-15	
COMPACTION AIR PRESSURE (350 psi)	350	350	300	
EXUDIATION FORCE (lbs @ 5 Lights)	7090	4730	3410	
SPECIMEN & MOLD WT (g)	3142.5	3130.8	3114.4	
SAMPLE HEIGHT (2.45"-2.55")	2.46	2.45	2.47	
EXPANSION DIAL INITIAL READING	0.0000	0.0000	0.0000	

STABILOMETER DAY THREE:

DATE	2/4	2/4	2/4	
EXPANSION DIAL FINAL READING	72.0000	0.0002	0.0002	
STABILOMETER @ 2000 LBS (psi)	51	70	106	
TURNS INDICATOR (.001" ex .245)	0.410	0.435	0.458	

CALCULATIONS:

EXUDATION PRESSURE (psi)	564	377	271	
EXPANSION DISTANCE (in)	72.0000	0.0002	0.0002	
EXPANSION PRESSURE (psf)	3117600	8.66	8.66	
RESISTANCE VALUE ("R")	56.6	42.5	21.8	
% MOISTURE AT TEST	15.5%	16.7%	18.0%	
DRY DENSITY AT TEST (pcf)	111.5	109.5	106.7	
ADJUSTED "R" VALUE	55.6	41.2	21.3	

R-VALUE: 27

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Modified Cal	Macro Core
Ring Sampler	Rock Core
Grab Sample	No Recovery

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$PI > 7$ and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			$PI < 4$ or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \qquad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains $\geq$ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.