Raising Cane's C991

Geotechnical Engineering Report

January 13, 2022 | Terracon Project No. ND225125

Prepared for:

Raising Cane's Restaurants LLC
6800 Bishop Road
Plano, Texas 75024-4274

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January 13, 2022

Raising Cane's Restaurants LLC
6800 Bishop Road
Plano, Texas 75024-4274

Attn: Jay Higgins/Kristen Roberts
P: (805) 637-6670
E: jayd@higginsland.com

Re: Geotechnical Engineering Report
Raising Cane's C991
Butterfield Blvd and Cochrane Rd
Morgan Hill, Santa Clara County, CA
Terracon Project No. ND225125

Dear Mr. Higgins:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PND225125 dated November 10, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed project.

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

REGISTERED PROFESSIONAL ENGINEER
NOAH T. SMITH
No. 2758
EXP. 1/13/2023
GEOTECHNICAL
STATE OF CALIFORNIA

Nicholas Jamison
Field Geologist

Noah T. Smith, PE., GE.
Principal

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Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Report Summary

Topic [1]	Overview Statement [2]
Project Description	The project will consist of the construction of an approximately 2,899 square foot Raising Cane's restaurant building, a drive-thru with a canopy, a menu sign, trash enclosure, hardscape, paved parking and drive, and landscaping. Estimated maximum loads: ▪ Column: 40 to 80 kips ▪ Walls: 1 to 2 kips per linear foot (klf)
Geotechnical Characterization	Subgrade soil conditions in our borings generally consisted of medium dense to very dense gravels with variable amounts of sand, silt, and clay with interbedded layers of medium dense to dense silty sand and poorly graded sand to the maximum depth explored of 21½ feet below existing grade (bgs). Approximately 2 feet of medium dense clayey sand FILL was encountered at the surface of boring B-01 and practical auger refusal was encountered at a depth of 6½ feet bgs in boring B-03. Free water was encountered in boring B-04 at a depth of 2½ feet bgs at the time of our field exploration.

Topic [1]	Overview Statement [2]
Earthwork	Preliminary grading plans were not available for review at the time this report was prepared. We have assumed site grades will generally remain the same as existing at the time this report was prepared and that cuts and fills on the order of 2 feet or less will be required to develop final grades. Grading should be conducted in accordance with the **Earthwork** section of this report.
Shallow Foundations	Shallow foundations are recommended for the building and drive-thru canopy support. Allowable bearing pressure = 4,000 psf Expected settlements: < 1-inch total, < 1/2-inch differential over 50 feet
Pavements	Pavement sections are provided for both rigid and flexible pavements.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed Raising Cane's Restaurant, to be located at the corner of Butterfield Blvd and Cochrane Rd in Morgan Hill, Santa Clara County, CA. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Seismic site classification per the 2022 California Building Code (CBC)
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Pavement design and construction
- Stormwater detention considerations

The geotechnical engineering Scope of Services for this project included the advancement of test borings, percolation testing, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are presented on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email request for proposal was provided by Trey Lay (CSRS) on November 3, 2022. The request included a Site Plan; a Context Site Plan; a conceptual plan with existing and proposed utility locations; a Dry Utility Due Diligence Report, prepared by E4 Utility Design, dated September 8, 2022; and a site plan with preferred percolation test locations, prepared by Kimley-Horn.
Project Description	The project will consist of the construction of a Raising Cane's Restaurant with associated vehicle access, parking, and landscaped areas. A drive-thru canopy will also be included in the project. Some type of storm water control system will be included (e.g., bioswales or basins).
Proposed Structure	Structures associated with the project include a 2,899 square foot, single-story restaurant building a 4-car canopy on the northeast side of the building covering a portion of the drive-thru.
Building Construction	The building will be wood-framed with a concrete slab-on-grade floor. We anticipate the canopy will consist of steel frame.
Finished Floor Elevation	Preliminary plans were not available for review at the time this report was prepared. We have assumed the finished floor elevation will be within 2 feet of existing grades.
Maximum Loads	The following loads were used in estimating settlement based on our experience with similar project: ▪ Columns: 40 to 80 kips ▪ Walls: 1 to 2 kips per linear foot (klf)

Item	Description
Grading	A preliminary grading plan was not available for review at the time this report was prepared. We have assumed cuts and fills on the order of 2 feet or less will be required to develop final grade.
Pavements	We understand both rigid (concrete) and flexible (asphalt) pavement sections will be considered. Anticipated Traffic Indices (Tis) are as follows: ▪ Auto Parking Areas: TI = 5.0 ▪ Auto Road: TI = 5.5 ▪ Truck Parking Areas: TI = 6.0 ▪ Truck Ramps and Roads: TI = 8.0 Anticipated Average Daily Truck Traffic (ADTT) for rigid pavements: ▪ Car Parking and Access Lanes: ADTT = 1 (Category A) ▪ Truck Parking: ADTT = 25 (Category B) ▪ Garbage/Fire Truck Lanes & Dumpster Pads: Per Category E The pavements design period is 20 years.
Building Code	2022 California Building Code (CBC)

Terracon should be notified if any of the above information is inconsistent with the planned construction as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at the southeast corner of Butterfield Blvd and Cochrane Rd in Morgan Hill, Santa Clara County, CA. Assessor Parcel Numbers (APN): 726-58-001 and 726-58-002 The project area is approximately 1.96 acres Latitude/Longitude (approximate) 37.1475°N, 121.6604°W See **Site Location**
Existing Improvements	The site has been mass graded in anticipation of retail development.

Item	Description
Current Ground Cover	Earthen with light vegetation
Existing Topography	The site is relatively flat.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**FILL**	Medium dense clayey sand
2	**Poorly graded GRAVEL**	Medium dense to dense gravel with variable amounts of sand, clay, and silt
3	**Silty GRAVEL**	Medium dense to very dense gravel with variable amounts of sand, clay, and silt
4	**Poorly graded SAND**	Medium dense to dense sand with variable amounts of gravel and fines
5	**Silty SAND**	Dense sand with variable amounts of gravel, clays, and silt

Practical auger refusal was encountered in Boring B-03 at a depth of 6½ feet bgs. Refusal is defined as the depth below the ground surface at which a boring can no longer be advanced with the soil drilling technique being used. Refusal is subjective and is based upon the type of drilling equipment used, the types of augers used, and the effort exerted by the driller. We anticipate refusal was encountered on a layer of very dense gravel.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results** and are summarized below.

Boring Number	Approximate Depth to Free water while Drilling/Testing[1] (feet)	Approximate Depth to Free water immediately after Drilling[1] (feet)
B-04	2½	2½

1. Below ground surface.

Water was not encountered in the remaining borings at the time of our field exploration. Based on our observations in the other six (6) borings, as well as our experience in the area, we believe the free water encountered in Boring B-04 is water from recent rain events perched above a dense silty sand with gravel layer. The Seismic Hazard Zone Report (096) for the Morgan Hill 7.5-Minute Quadrangle, Santa Clara County, California indicates the historical high groundwater level in the vicinity of the site is about 30 to 40 feet bgs.

Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time the borings were performed. 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. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Geologic Hazards

According to published maps[1], the site is underlain by Holocene-age alluvial gravel, sand, and clay soil of valley areas. The subgrade soils encountered in our borings were generally consistent with mapped geology.

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[1] *Dibblee, T.W, and Minch, J.A. (2005); Geologic map of the San Jose East quadrangle, Santa Clara County, California; Dibblee Geologic Foundation; Dibblee Foundation Map DF-155; Scale 1:24,000.*

Faulting and Estimated Ground Motions

The site is located in the San Francisco Bay area of California, which is a relatively high seismicity region. 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 following table 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 Unified Hazard Tool. Segments of the Calaveras fault, which is located approximately 7½ kilometers from the site, are considered to have the most significant effect at the site from a design standpoint.

Fault Name	Approximate Contribution (%)	Approximate Distance to Site (kilometers)	Maximum Credible Earthquake (MCE) Magnitude
UC33brAvg_FM31: Calaveras (Central) [3]	24.6	7.64	7.13
UC33br_FM32: Calaveras (Central) [3]	25.0	7.64	7.13

Based on the ASCE 7-16 Standard, the peak ground acceleration (PGA_M) at the subject site is approximately 0.836g. Based on the USGS 2014 interactive deaggregations, the PGA at the subject site for a 2% probability of exceedance in 50 years (return period of 2475 years) is expected to be about 1.014g. The site is not located within an Alquist-Priolo Earthquake Fault Zone based on our review of the State Fault Hazard Maps.[1]

Liquefaction

Liquefaction is a mode of ground failure that results from the generation of high pore water pressures during earthquake ground shaking, causing loss of shear strength. Liquefaction is typically a hazard where loose sandy soils or low plasticity fine grained soils exist below groundwater. The California Geological 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

[1] California Geological Survey (CGS), *"California Earthquakes Hazards Zone Application (EQ Zapp)", September 23, 2021, https://maps.conservation.ca.gov/cgs/EQZApp/app/*.

upon mapped surficial deposits and the presence of a relatively shallow water table. The project site and surrounding area is not located within a liquefaction hazard zone designated as having susceptibility to liquefaction. Therefore, a liquefaction analysis was not performed

Seismic Considerations

The 2022 California Building Code (CBC) Seismic Design Parameters have been generated using the SEAOC/OSHPD Seismic Design Maps Tool. This web-based software application calculates seismic design parameters in accordance with ASCE 7, and 2022 CBC. The 2022 CBC requires that a site-specific ground motion study be performed in accordance with Section 11.4.8 of ASCE 7 for Site Class D sites with a mapped S_s value greater than or equal 0.2.

However, Section 11.4.8 of ASCE 7 includes an exception from such analysis for specific structures on Site Class D sites. The commentary for Section 11 of ASCE 7 (Page 534 of Section C11 of ASCE 7) states that "In general, this exception effectively limits the requirements for site-specific hazard analysis to very tall and or flexible structures at Site Class D sites." Based on our understanding of the proposed structures, it is our assumption that the exception in Section 11.4.8 applies to the proposed structure. However, the structural engineer should verify the applicability of this exception.

Based on this exception, the spectral response accelerations presented below were calculated using the site coefficients (F_a and F_v) from Tables 1613.2.3(1) and 1613.2.3(2) presented in Section 16.4.4 of the 2022 CBC.

Description	Value
2022 California Building Code (CBC) Site Classification[1]	D[2]
Site Latitude[3]	37.1475°
Site Longitude[3]	-121.6604°
S_S, Spectral Acceleration for a Short Period[4]	1.671
S_1, Spectral Acceleration for a 1-Second Period[4]	0.611
Fa, Site Coefficient[4]	1.2
Fv, Site Coefficient (1-Second Period)[4]	1.7
S_{DS}, Spectral Acceleration for a Short Period[4]	1.337
S_{D1}, Spectral Acceleration for a 1-Second Period[4]	0.692

1. Seismic site soil classification in general accordance with the *2022 California Building Code*, which refers to ASCE 7. Site Classification is required to determine the Seismic Design Category for a structure.
2. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the CBC. Subsurface explorations at this site were extended to a maximum depth of approximately 21½ feet bgs and standard penetration resistance values were used to determine the Site Classification. The site properties below the maximum exploration depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper exploration or geophysical testing may be performed to confirm the conditions below the current maximum depth of exploration.
3. Provided coordinates represent a point located at the general center of the site.
4. These Values were obtained using online seismic design maps and tools provided by SEAOC/OSHPD (https://www.seismicmaps.org/)

Typically, a site-specific ground motion study may reduce construction costs. We recommend consulting with a structural engineer to evaluate the need for such a study and its potential impact on construction costs. Terracon should be contacted if a site-specific ground motion study is desired.

Percolation/Infiltration

We performed two percolation tests within the proposed site development for use by the project civil engineer in the design of the storm water retention system. The percolation tests were performed using borings B-05 and B-06 drilled to a depth of about 6½ feet bgs. The approximate locations of the test holes are shown on the **Exploration Plan**.

After drilling the test holes, we placed approximately 2 inches of gravel in the bottom of each hole, then placed a slotted PVC pipe in each hole, and filled the annular space around the pipe with gravel. The test holes were filled with water and left to saturate for a minimum 24 hours. We then filled the shallow holes with water to depths ranging from about 3 feet and measured the drop-in water surface over a period varying from approximately 15 minutes to 1 hour depending on the hole, refilling the holes as necessary to maintain the desired head.

The measured percolation rates and calculated infiltration rates are summarized in the following table.

Perc. Test Location	Depth (ft)	Avg. Head (ft)	Perc. Rate (min/inch)	Perc. Rate (inch/hr)	Infiltration Rate (inch/hr)
B-05	6½	4.40	25.3	2.19	1.84
B-06	6½	6.32	400	0.15	0.13

Since we used test borings to perform percolation testing, we have used the Porchet formula (aka Inverse Borehole Formula) to calculate the test infiltration rate which takes into account sidewall area of the bore hole. Storm water runoff may likely contain materials such as silt, leaves, oil residues, and other matter that may reduce the percolation characteristics of the soil. We therefore recommend that a filtration system be implemented into the design and installed. An appropriate safety factor should be applied to the measured infiltration rates by the designer for use in design and be based on the amount of filtration designed into the system, at a minimum a Safety Factor of 2 shall be utilized. The values above are clear water rates and do not have a safety factor applied. In addition, we recommend a regular maintenance program be implemented to monitor the storm drainage/filtration system prior to the beginning of each wet weather season.

We have provided the following considerations for the design and construction of the retention/detention facilities. Planned retention/detention facilities should be located no closer than 10 feet to structural site improvements.

The long-term infiltration rates will depend on many factors, and can vary or be reduced if the following conditions are present:

- Fill placement,
- Variability of site soils,
- Fine layering of soils, or
- Maintenance and pre-treatment (filtration) of the influent are not performed regularly

Fill Placement: We anticipate earthwork required to develop the site may consist of cuts and fills of 2 feet or less. It is unknown whether final grades will consist of native material or imported fill. As a result, the percolation tests performed may not be representative of the final soil conditions depending on the blend of soils utilized as structural fill and native soils exposed where cuts and fills are made. Additional percolation testing may be warranted following rough grading to confirm the values utilized in design are appropriate.

Subsurface Soil Variation: Variations in subsurface soil conditions can affect the infiltration rate of the receptor soils.

Construction Considerations: The infiltration rate of the receptor soils will be reduced in the event that fine sediment, organic materials, and/or oil residue are allowed to accumulate in the retention facilities. The use of a filtration system is highly recommended as well as a maintenance program.

Operation of heavy equipment during construction may densify the receptor soils below the infiltration facility. The soils exposed in the bottom of the infiltration facility should not be compacted and should remain in their native condition. This may require scarification of the soils prior to construction.

Maintenance of Facilities: Satisfactory long-term performance of an infiltration facility will require some degree of maintenance. Accumulations of sediment, organic materials, or other material that serve to reduce their permeability of the receptor soils should be removed from the filtration system on a regular basis so as not to enter the retention system. The filtration system shall have a rigorous maintenance program, debris from the filtration maintenance should be disposed of at an approved facility in accordance with applicable regulation.

Corrosivity

The following table lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary

Boring	Sample Depth (feet)	Soil Description	Soluble Sulfate (%)	Soluble Chloride (%)	Electrical Resistivity (Ω-cm)	pH
B-02	1.0-2.5	GM-Silty Gravel	0.01	0.0047	5,820	7.34

Results of soluble sulfate testing can be classified in accordance with ACI 318 – Building Code Requirements for Structural Concrete. Numerous sources are available to characterize corrosion potential to buried metals using the parameters above. ANSI/AWWA is commonly used for ductile iron, while threshold values for evaluating the effect on steel can be specific to the buried feature (e.g., piling, culverts, welded wire reinforcement, etc.) or agency for which the work is performed. Imported fill materials may have significantly different properties than the site materials noted above and should be evaluated if expected to be in contact with metals used for construction. Consultation with a NACE certified corrosion professional is recommended for buried metals on the site.

Mapping by the NRCS includes qualitative severity of corrosion to concrete and steel. Based on this source, the near-surface materials are rated "Moderate" for corrosion to concrete and "Low" for corrosion of steel.

Geotechnical Overview

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, provided that the recommendations provided in this report are implemented in the design and construction phases of this project.

Earthwork

We anticipate grading for this project will consist of cuts and fills on the order of 2 feet or less to develop final grades. If greater cuts and fills are required, Terracon should be contacted to determine if additional earthwork recommendations are warranted. Earthwork is anticipated to include clearing and grubbing, excavations, and engineered fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Site Preparation

Prior to placing fill, existing vegetation and root mat should be removed. Complete stripping of the topsoil should be performed in the proposed building and parking/driveway areas. Any existing debris or other deleterious materials should also be removed. Stripping and removals should extend laterally a minimum of 5 feet beyond the limits of proposed improvements. All material derived from the removal of deleterious material should be removed from the site and should not be allowed for use as on-site fill.

Although no evidence of underground facilities (such as septic tanks, cesspools, basements, or utilities) was observed during the exploration and site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Subgrade Preparation

After clearing, any required cuts and over-excavation should be made. Terracon should be present to observe the subgrade conditions during any over-excavation. The presence of over-sized debris or a high volume of organic material may warrant additional over-excavation at the time of grading operations.

Approximately 2 feet of pre-existing clayey sand fill was encountered at the surface of Boring B-01. Specific excavation, backfill, and site grading details for the fill are not known. The thickness of fill across the site may vary, and the thicknesses of fill encountered in our boring should not be construed as a minimum or maximum. Additional fill may be present in areas where borings were not performed. No compaction records were located or made available for review for the fill. As a result, we have considered the fill to uncontrolled. Such uncontrolled fill can result in excessive erratic and differential settlements causing damage to proposed structures supported on shallow foundations, hardscapes, and pavements relying on the fill for structural support. Subsequently, pre-existing surficial uncontrolled fills across the site are not suitable for the support of shallow spread footing foundations and floor slabs, which would be subject to unacceptable amounts of settlement. As a result, we recommend the pre-existing fill be overexcavated during grading, and placed and compacted as engineered fill per the recommendations provide in the ***Fill Placement and Compaction Requirements*** section of this report. A representative from Terracon should be present during grading to verify all fill has been overexcavated down to firm native soil.

Once any required cuts and over-excavation operations are complete, the resulting subgrade should be proofrolled with an adequately loaded vehicle such as a fully loaded tandem axle dump truck. The proof-rolling should be performed under the observation of the Geotechnical Engineer or their representative. Areas excessively deflecting under the proof-roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by stabilizing as noted in the ***Soil Stabilization*** section. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted.

Exposed surfaces should be free of mounds and depressions which could prevent uniform compaction. The site should be initially graded to create a relatively level surface to receive fill and provide for a relatively uniform thickness of fill beneath the proposed building if required.

Excavated material may be stockpiled for use as fill provided it is cleaned of organic material, debris, and any other deleterious material and meets the criteria for general or structural fill specified in the ***Fill Material Types*** section of this report.

Once proof rolling has been performed, all exposed areas which will receive fill, once properly cleared where necessary, should be scarified to a depth of 12 inches, moisture conditioned as necessary, and compacted per the compaction requirement in this report. A representative from Terracon should be present to observe the exposed subgrade and confirm the depth of scarification and moisture conditioning required.

Following scarification, moisture conditioning, and compaction of the subgrade soils, compacted fill soils should then be placed to the proposed design grade and the moisture content and compaction of subgrade soils should be maintained until foundation, slab, and pavement construction.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively workable; however, 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.

Soil Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics), and chemical stabilization. The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size of area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help reduce the amount of subgrade stabilization required.

If the exposed subgrade is unstable during proofrolling operations, it could be stabilized using one of the methods outlined below.

- **Scarification and Recompaction** - It may be feasible to scarify, dry, and recompact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot or if construction is performed during a period of wet or cool weather when drying is difficult.
- **Aggregate Base** - The use of Caltrans Class II aggregate base is a common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 6 to 18 inches below finished subgrade elevation. The use of high modulus geosynthetics (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the fabric or geogrid, we recommend that all below grade construction, such as utility line installation, be completed to avoid damaging the fabric or geogrid. Equipment should not be operated above the fabric or geogrid until one full lift of aggregate base is placed above it. The maximum particle size of granular material placed over geotextile fabric or geogrid should meet the manufacturer's specifications.
- **Chemical Stabilization** - Improvement of subgrades with Portland cement could be considered for improving unstable soils. Chemical stabilization should be performed by a pre-qualified contractor having experience with successfully stabilizing subgrades in the project area on similar sized projects with similar soil conditions. The hazards of chemicals blowing across the site or onto adjacent property should also be considered. Additional testing would be needed to develop specific recommendations to improve subgrade stability by blending chemicals with the site soils. Additional testing could include, but not be limited to, determining the most suitable stabilizing agent, the optimum amounts required, and the presence of sulfates in the soil. If this method is chosen to stabilize subgrade soils the actual amount of Portland cement to be used should be determined by Terracon and by laboratory testing **at least three weeks prior** to the start of grading operations.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 5 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas.

Reuse of On-Site Soil: Excavated on-site soil may be selectively reused as general or structural fill. Material property requirements for on-site soil for use as general fill and structural fill are noted in the following table:

Property	General Fill	Structural Fill
Composition	Free of deleterious material	Free of deleterious material
Maximum particle size	6 inches (or 2/3 of the lift thickness)	3 inches
Fines content	Not limited	Less than 25% Passing No. 200 sieve
Plasticity	Not limited	Maximum plasticity index of 10
GeoModel Layer Expected to be Suitable[1]	2, 3, 4, 5	2, 3, 4, 5

1. Based on subsurface exploration. Actual material suitability should be determined in the field at time of construction.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. For all import material, the contractor shall submit current verified reports from a recognized analytical laboratory indicating that the import has a "not applicable" (Class S0) potential for sulfate attack based upon current ACI criteria and is "mildly corrosive" to ferrous metal and copper. The reports shall be accompanied by a written statement from the contractor that the laboratory test results are representative of all import material that will be brought to the project.

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Low Plasticity	CL, SC	Liquid Limit less than 30 Plasticity index less than 10
Granular[2]	GW, GM, SW, SM	Less than 40% passing No. 200 sieve

1. Structural and general fill should consist of approved materials free of organic matter and debris and should contain no material larger than 3 inches in greatest dimension. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation at least two weeks prior to use on this site.
2. Caltrans Class II aggregate base may be used for this material. Recycled aggregate base should not be used without prior approval by the Geotechnical Engineer.

Fill Placement and Compaction Requirements

Compacted native soil and structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used	Same as structural fill
Minimum Compaction Requirements [1,2]	95% of max: Upper 12 inches of subgrade in pavement areas, for aggregate base, and below slabs and foundations. 90% of max: All other locations	90% of max.
Water Content Range [1]	Low plasticity cohesive: +1% to +3% above optimum Granular: -2% to +2% of optimum	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the Modified Proctor test (ASTM D 1557).
2. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed full time by the Geotechnical Engineer or representative.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the specification for structural fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cementitious flowable fill or cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill. Attempts should also be made to limit the amount of fines migration into the clean granular material. Fines migration into clean granular fill may result in unanticipated localized settlements over a period of time. To help limit the amount of fines migration, Terracon recommends the use of a geotextile fabric that is designed to prevent fines migration in areas of contact between clean granular material and fine-grained soils. Terracon also recommends that clean granular fill be tracked or tamped in place where possible in order to limit the amount of future densification which may cause localized settlements over time.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building, onto pavements, or are tied to tight lines that discharge into a storm drainage system.

Exposed ground should be sloped and maintained at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building. If a minimum 5 percent slope cannot be achieved due to site grades, a minimum 2½ percent slope could be used provided pavement or hardscape surrounds and extends to the building, or a subdrain could be installed around the perimeter of the foundations that carries water away from the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary as part of the structure's maintenance program. Where paving or flatwork abuts the structure a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Any planters and/or bio-swales located within 10 feet of the building should be self-contained or lined with an impermeable membrane to prevent water from accessing subgrade soils below the building. Sprinkler mains and spray heads should be located a minimum of 5 feet away from the foundation lines.

No vegetation over six feet in height shall be planted within 20 feet of the building perimeter unless a root barrier is provided between the structure and tree to limit roots within 10 feet of building. Roots can draw additional moisture from the soils and cause excessive volume changes in the soil resulting in building movement.

Implementation of adequate drainage for this project can affect the surrounding developments. Consequently, in addition to designing and constructing drainage for this project, the effects of site drainage should be taken into consideration for the planned structures on this property, the undeveloped portions of this property, and surrounding sites. Extra care should be taken to ensure irrigation and drainage from adjacent areas do not drain onto the project site or saturate the construction area.

Earthwork Construction Considerations

Excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as foundations, floor slabs, exterior hardscape, and pavements. Construction traffic over the completed subgrades 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. Water collecting over or adjacent to construction areas should be removed. If the subgrade should become desiccated, saturated, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to construction.

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 (typically November through April) it may be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork operations may require additional mitigation measures beyond that which would be expected during the drier summer and fall months. This could include ground stabilization utilizing chemical treatment of the subgrade, 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.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations. Stockpiles of soil, construction materials, and construction equipment should not be placed near trenches or excavations. ***The Contractor is responsible for maintaining the stability of adjacent structures during construction.***

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, debris, and pavements), evaluation and remediation of existing fill materials, as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 1,500 square feet of compacted fill in the building areas and 2,000 square feet in pavement areas. Where not specified by local ordinance, one density and water content test should be performed for every 50 linear feet of compacted utility trench backfill a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

The proposed building and drive-thru canopy may be supported by spread footings provided the footings extend through any fill and bear on firm native soil. If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1,2]	4,000 psf
Required Bearing Stratum [3]	Undisturbed firm native soil
Minimum Foundation Dimensions	Per CBC 1809.7
Passive Resistance[4,8] **(equivalent fluid pressures)**	350 pcf
Sliding Resistance [5,8]	0.35 allowable coefficient of friction - granular material
Minimum Embedment below Finished Grade [6]	12 inches
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch
Estimated Differential Settlement [2,7]	About ½ inch of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This bearing pressure can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. Assumes no hydrostatic pressure.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations.
6. Embedment necessary to minimize the effects of seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
7. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet.
8. Passive Resistance and Sliding Resistance may be combined to resist sliding provided the Passive Resistance is reduced by 50 percent.

Design Parameters – Overturning and Uplift Loads

Proposed drive-thru canopy foundations subjected to overturning loads should be proportioned such that the resultant eccentricity is maintained in the center-third of the foundation (e.g., e < b/6, where b is the foundation width). This requirement is intended to keep the entire foundation area in compression during the extreme lateral/overturning load event. Foundation oversizing may be required to satisfy this condition.

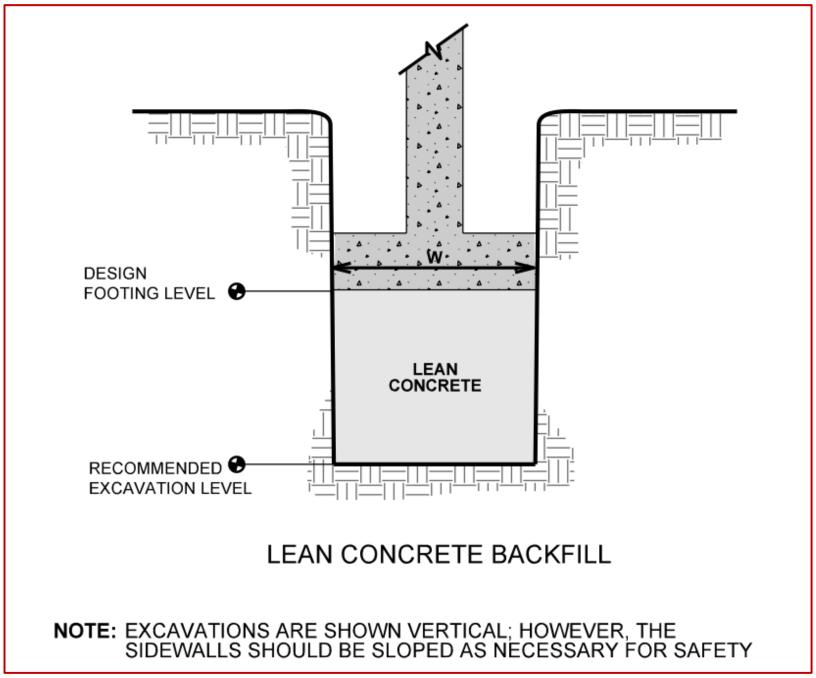
Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils with consideration to the CBC basic load combinations.

Item	Description
Soil Moist Unit Weight	110 pcf (compacted backfill)
Soil weight included in uplift resistance	Soil included within the prism extending up from the top perimeter of the footing at an angle of 20 degrees from vertical to ground surface

Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are observed at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The lean concrete replacement zone is illustrated on the following sketch.



To ensure foundations have adequate support, special care should be taken when footings are located adjacent to trenches. The bottom of such footings should be at least 1 foot below an imaginary plane with an inclination of 1½ horizontal to 1.0 vertical extending upward from the nearest edge of the adjacent trench.

Floor Slabs

We understand that the building will be constructed with a concrete slab-on-floor. Design parameters for floor slabs assume the requirements provided for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the floor slab support course beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support[1]	4 inches of ¾ inch free draining crushed rock[3] over subgrade prepared and compacted to the recommendations in **Earthwork.**
Estimated Modulus of Subgrade Reaction [2]	150 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.
3. Free-draining granular material should have less than 5% fines (material passing the No. 200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing, or other means.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Pavements

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section.

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 proofrolled 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. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills.

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.

Pavement Design Parameters

Design of Asphaltic Concrete (AC) pavement sections were calculated using the Caltrans Highway Design Manual, latest edition, and a 20-year design life. Design of Portland Cement Concrete (PCC) pavement sections were designed using ACI 330R-21, "Guide for the Design and Construction of Concrete Parking Lots."

Bulk samples of the near surface native soils were collected to perform Hveem Stabilometer (R-Value) testing. A representative/composite bulk sample from Boring B-01 was selected for testing. The testing resulted in an R-Value of 66. Subsequently, an R-Value of 40 was used for the subgrade for the asphaltic concrete (AC) pavement designs. A modulus of subgrade reaction of 175 pci was used for the Portland cement concrete (PCC) pavement designs. The value was empirically derived based upon our experience with the sand and sand-gravel with moderate silt/clay subgrade soils and our expectation of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**. A modulus of rupture of 550 psi was used in design for the concrete (based on correlations with a minimum 28-day compressive strength of 4,500 psi).

As more specific traffic information becomes available for the project specific and project traffic indexes are determined, we should be contacted to reevaluate the pavement calculations.

Recommendations for conventional pavement sections are presented next. The recommendations are based on the subgrade being in a firm and unyielding condition.

Pavement Section Thicknesses

The following table provides our opinion of minimum thickness for AC sections:

Asphaltic Concrete Design

Layer	Thickness (inches)			
	Auto Parking Areas (TI=5.0)[1]	Auto Road (TI=5.5)[1]	Truck Parking Areas (TI=6.0)[1]	Truck Parking Areas (TI=8.0)[1]
AC [2, 3]	3.0	3.5	3.5	5.0
Aggregate Base[2]	4.0	4.5	5.5	8.0

1. See **Project Description** for more specifics regarding traffic assumptions.
2. All materials should meet the current Caltrans Highway Design Manual specifications.
   - Base – Caltrans Class 2 aggregate base
3. A minimum 1.5-inch surface course should be used on ACC pavements.

The following table provides our estimated minimum thickness of PCC pavements.

Portland Cement Concrete Design

Layer	Thickness (inches)		
	Traffic Category A [1]	Traffic Category B [1]	Traffic Category E [1]
PCC [2]	4.25	5.50	6.75
Aggregate Base	4.0	6.0	6.0

1. See **Project Description** for more specifics regarding traffic classifications.
2. All materials should meet the current Caltrans Highway Design Manual specifications.

Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e. concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles.

Although not required for structural support, a minimum 4-inch-thick base course layer is recommended to help reduce potential 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. Joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. PCC pavement details for joint spacing, joint reinforcement, and joint sealing should be prepared in accordance with ACI 330 and ACI 325.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are particular areas of concern. The civil design for the pavements with these conditions should include features to restrict or collect and discharge excess water from the islands. Examples of features are edge drains connected to the stormwater collection system, longitudinal subdrains, or other suitable outlets and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g., crack, and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

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 paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install pavement drainage systems surrounding areas anticipated for frequent wetting.

- 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.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations 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. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services 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.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

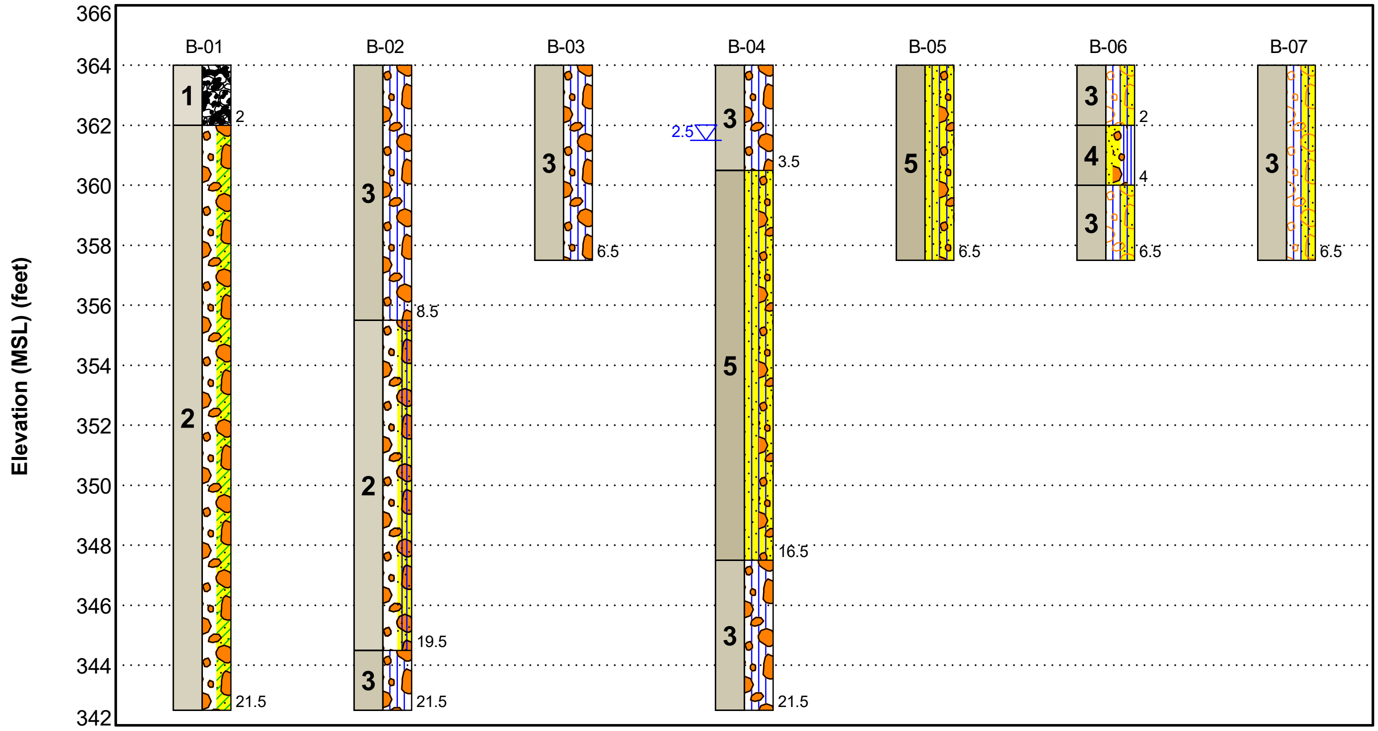
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing. This report should not be used after 3 years without written authorization from Terracon.

Figures

Contents:

Terracon
1220 Concord Ave, Ste 450
Concord, CA

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	FILL	Medium dense clayey sand
2	Poorly graded GRAVEL	Medium dense to dense gravel with variable amounts of sand, clay, and silt
3	Silty GRAVEL	Medium dense to very dense gravel with variable amounts of sand, clays, and silt
4	Poorly graded SAND	Medium dense to dense sand with variable amounts of gravel, clays, and silt
5	Silty SAND	Dense sand with variable amounts of gravel, clays, and silt

LEGEND

- Fill
- Poorly-graded Gravel with Clay and Sand
- Silty Gravel
- Poorly-graded Gravel with Silt and Sand
- Silty Sand with Gravel
- Silty Gravel with Sand
- Poorly-graded Sand with Silt and Gravel

First Water Observation

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

The groundwater levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
3	21½	building footprint
1	6½	canopy area
3	6½	pavement and landscaping areas

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±20 feet) and referencing existing site features. Approximate ground surface elevations were estimated using Google Earth. If elevations and a more precise boring layout are desired, we recommend the exploration locations be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using continuous solid flight augers. Three (3) samples were obtained in the upper 5 feet of each boring and at intervals of 5 feet thereafter. Sampling was performed using either a standard split-barrel sampler, or a Modified California Sampler (MCS), depending on the soil conditions. In the standard split-barrel sampling procedure, a standard 2-inch-outside-diameter (OD) split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. Blow counts are recorded in 6-inch intervals for a total of 18 inches of penetration. The blows required to drive the sampler the final 12 inches are recorded as Standard Penetration Test (SPT) resistance value, also referred to as the N-value. The sampling procedure using the MCS is similar to the standard procedure but uses a 3-inch OD thick-walled split-barrel sampler lined with 6-inch-long, 2½-inch OD tubes instead of the standard 2-inch OD sampling spoon. In each case, the blow counts and N-values are included in the boring logs at the associated sample depths. For safety purposes, all borings were backfilled with auger cuttings after their completion.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. The groundwater levels are shown on the attached boring logs.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Dry Unit Weight
- Grain Size Analysis
- Corrosion Analysis
- R-Value

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

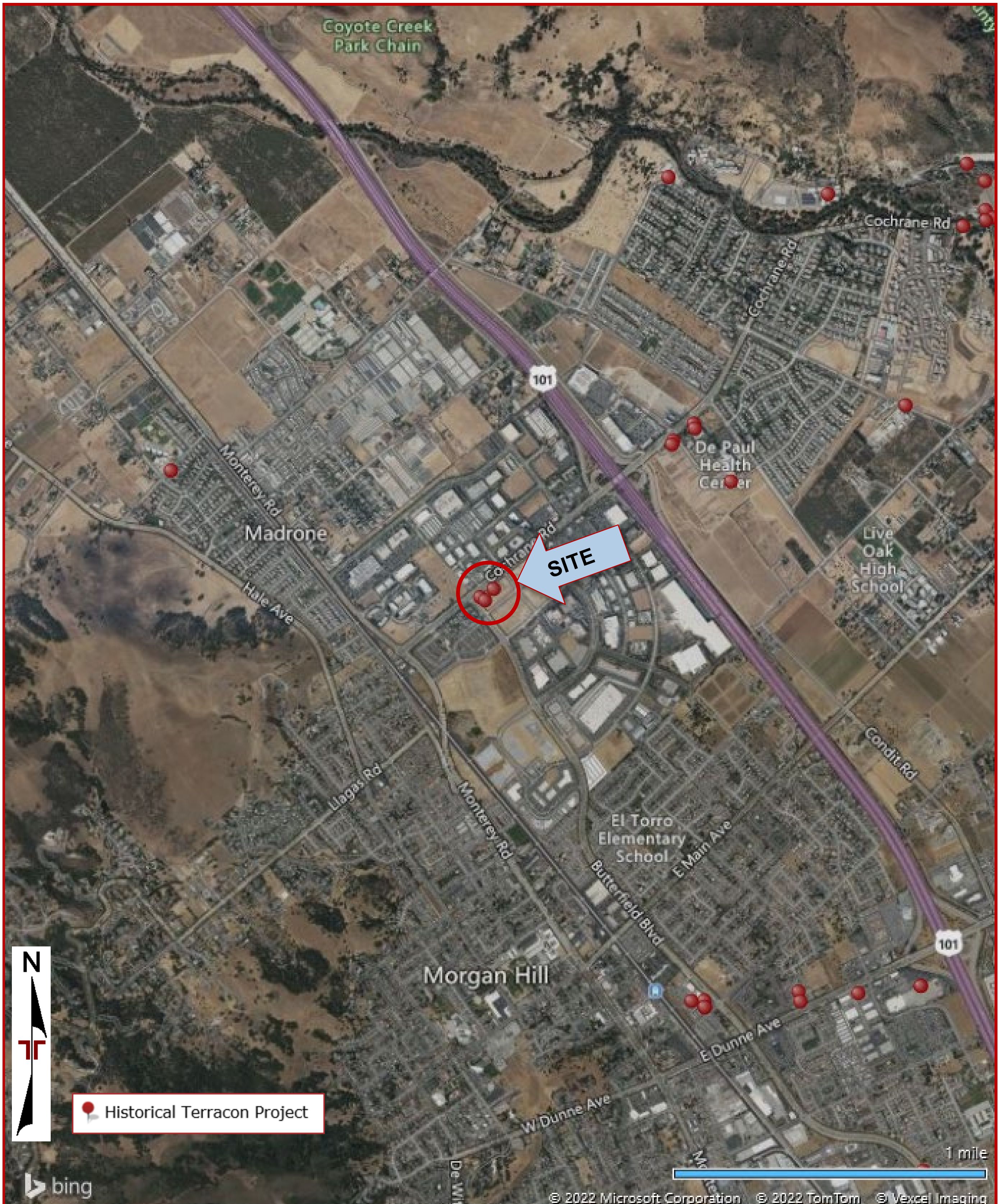


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

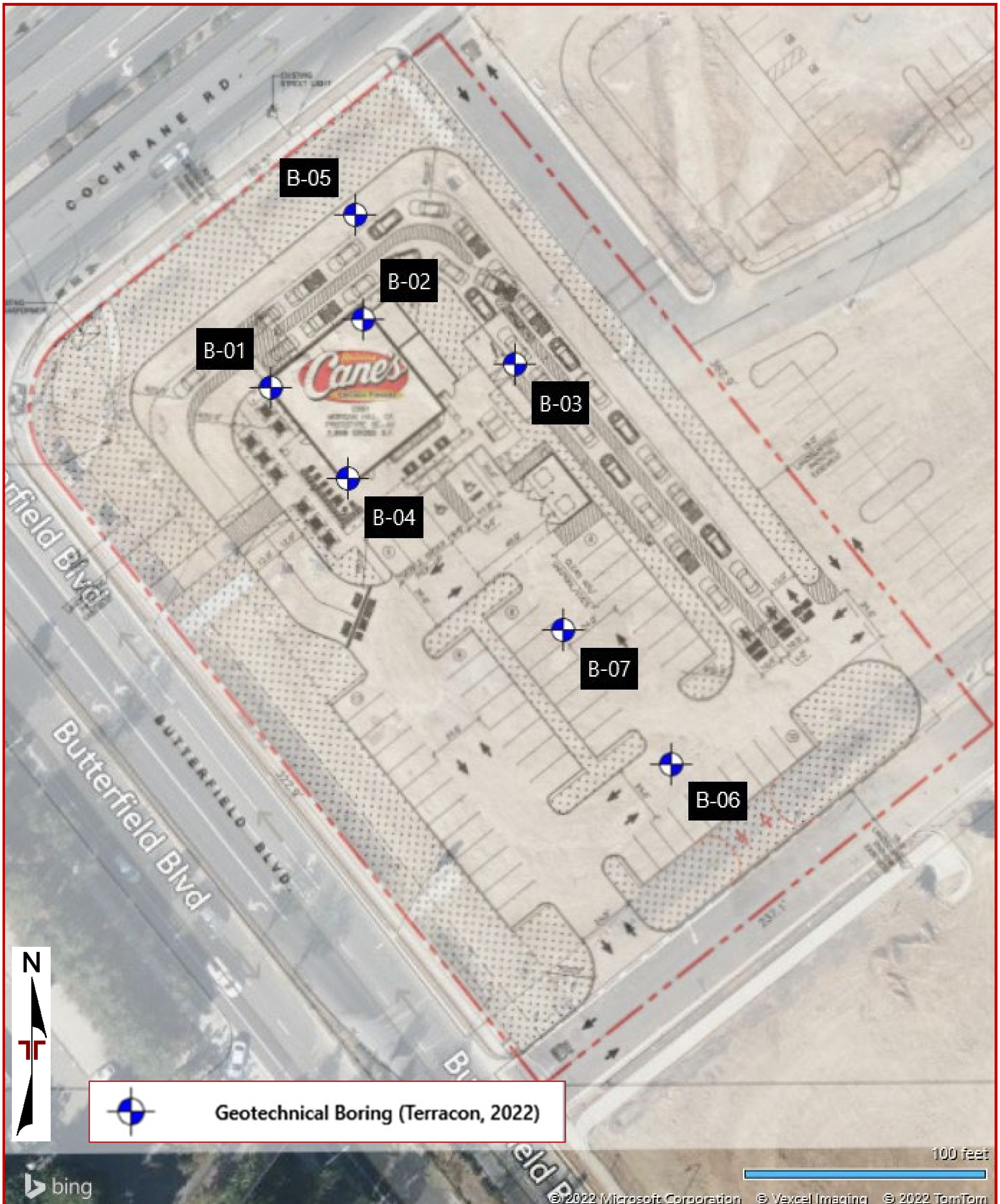


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Terracon
1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-01

Location: See Exploration Plan

Latitude: 37.1475° Longitude: -121.6604°

Model Layer	Depth (Ft.)	Material Description	Elevation: 364 (Ft.) +/-	Sample Depth (Ft.)	Water Level Observations	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	2.0	**FILL - CLAYEY SAND (SC)**, gray to brown, medium dense	362	1.0–2.5		14-11-10	11.1	116		
2		**POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC)**, brown, medium dense, coarse gravel, up to 2" in largest dimension		2.5–4.0		5-9-9	13.9			
		dense, trace cobbles		5.0–6.5		18-28-29	8.1			10
		grayish brown		10.0–11.5		21-28-40	10.0	137		
		brown		15.0–16.5		22-24-28	9.8	125		
	21.5		342.5	20.0–21.5		17-22-21	9.5			

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations

Groundwater not observed at time of drilling

Advancement Method
4" Solid-Flight Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

Boring Started
12-14-2022

Boring Completed
12-14-2022

Raising Canes C991
Cochrane Rd and Butterfield Blvd | Morgan Hill, CA
Terracon Project No. ND225125

Terracon
1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-02

Location: See Exploration Plan

Latitude: 37.1475° Longitude: -121.6603°

Elevation: 364 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation	Sample Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
3	0 – 8.5	**SILTY GRAVEL (GM)**, with sand, brown, dense, gravel up to about 0.5" in dimension		1 – 2.5			6-26-27	14.1	116		
		light brown to brown, medium dense, gravel up to about 1.5" in dimension		2.5 – 4			14-16-15	9.6	114		
		light brown, dense, gravel up to about 1" in dimension		5 – 6.5			18-24-27	11.3	115		
	8.5		355.5								
2	8.5 – 19.5	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)**, light brown to brown, dense, gravel up to about 1" in dimension		10 – 11.5			12-20-30	8.4	118		
		medium dense		15 – 16.5			15-18-19	13.2	121		
	19.5		344.5								
3	19.5 – 21.5	**SILTY GRAVEL (GM)**, with sand, light brown to brown, dense, gravel up to about 1" in dimension		20 – 21.5			22-24-46	12.0	118		
	21.5		342.5								

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations
Groundwater not observed at time of drilling

Advancement Method
4" Solid-Flight Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

Boring Started
12-14-2022

Boring Completed
12-14-2022

Terracon
1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-03

Location: See Exploration Plan

Latitude: 37.1475° Longitude: -121.6601°

Depth (Ft.) Elevation: 364 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
3		**SILTY GRAVEL (GM)**, with sand, light brown to brown, medium dense, gravel up to about 1.5" in dimension				12-13-19	10.2	125		
		medium dense to dense				17-19-23	9.8			
		very dense	5			13-40-50	6.0			
		6.5 — 357.5								
		Auger Refusal at 6.5 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations
Groundwater not observed at time of drilling

Advancement Method
4" Solid-Flight Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

Boring Started
12-14-2022

Boring Completed
12-14-2022

Terracon
1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-04

Location: See Exploration Plan

Latitude: 37.1473° Longitude: -121.6603°

Elevation: 364 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation	Sample Depth (Ft.)	Water Level Observations	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
3	0 - 3.5	**SILTY GRAVEL (GM)**, with sand, brown to light brown, medium dense, gravel up to about 1.5" in dimension; light brown, dense, gravel/cobbles up to about 2" in dimension	360.5	1 - 2.5	▽ While drilling (~2 ft)	3-23-8	7.0	116		
				2.5 - 4		18-32-35	9.2			
5	3.5 - 16.5	**SILTY SAND WITH GRAVEL (SM)**, light brown, dense, fine- to coarse-grained sand, gravel up to about 0.5" in dimension	347.5	5 - 6.5		12-19-20 N=39	9.5			14
				10 - 11.5		15-20-24 N=44	14.9			
				15 - 16.5		12-15-16 N=31				
3	16.5 - 21.5	**SILTY GRAVEL (GM)**, light brown to brown, dense, gravel up to about 1" in dimension	342.5	20 - 21.5		12-26-20 N=46	12.8			

Boring Terminated at 21.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations

▽ While drilling

Advancement Method
4" Solid-Flight Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

Boring Started
12-14-2022

Boring Completed
12-14-2022

Terracon
1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-05

Location: See Exploration Plan

Latitude: 37.1476° Longitude: -121.6603°

Depth (Ft.) Elevation: 364 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
5		**SILTY SAND WITH GRAVEL (SM)**, light brown to brown, dense, fine- to medium-grained sand, gravel up to about 1.75" in dimension				16-30-31	8.8			
						16-30-32	9.3	114		
		brown with reddish brown	5			23-25-13	8.3			21
		6.5 — 357.5								
		Boring Terminated at 6.5 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations

Groundwater not observed at time of drilling

Advancement Method

4" Solid-Flight Auger

Abandonment Method

Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

Boring Started
12-14-2022

Boring Completed
12-14-2022

1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-06

Location: See Exploration Plan

Latitude: 37.1470° Longitude: -121.6599°

Depth (Ft.) Elevation: 364 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
3		**SILTY GRAVEL WITH SAND (GM)**, brown to light brown, medium dense; 2.0 / 362				7-9-10	9.0			
4		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)**, brown to light brown with orangish brown, medium dense; 4.0 / 360				9-18-17	11.0	113		11
3		**SILTY GRAVEL WITH SAND (GM)**, light brown with orangish brown, very dense; 6.5 / 357.5	5			18-50	10.6			

Boring Terminated at 6.5 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes
Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations
Groundwater not observed at time of drilling

Advancement Method
4" Solid-Flight Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

Boring Started
12-14-2022

Boring Completed
12-14-2022

Terracon
1220 Concord Ave, Ste 450
Concord, CA

Boring Log No. B-07

Location: See Exploration Plan

Latitude: 37.1472° Longitude: -121.6600°

Depth (Ft.) — Elevation: 364 (Ft.) +/-

Model Layer	Graphic Log	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
3		**SILTY GRAVEL WITH SAND (GM)**, orangish brown, medium dense, gravel up to about 1.5" in dimension								
						12-14-18	6.2			
		brown to light brown				16-15-15	6.0	125		
		brown to light orangish brown, dense, gravel up to about 2.5" in dimension, sand lense	5			20-24-27	10.0	124		
		6.5 — 357.5								
		Boring Terminated at 6.5 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes
Elevation Reference: Elevations interpreted from Google Earth Pro

Water Level Observations
Groundwater not observed at time of drilling

Advancement Method
4" Solid-Flight Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
B-24 Little Beaver

Hammer Type
Rope and Cathead

Driller
CalGeo

Logged by
N. Jamison

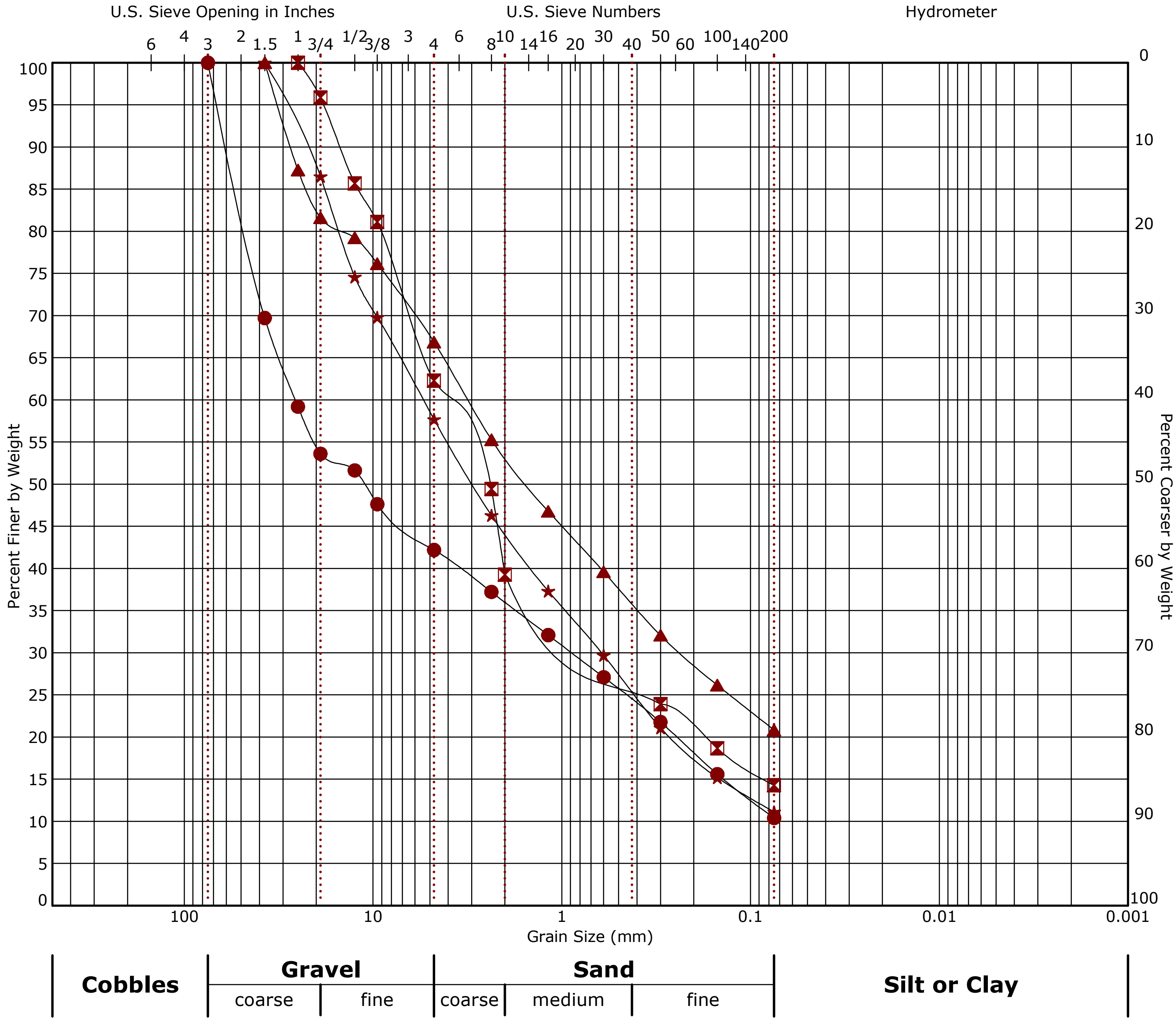
Boring Started
12-14-2022

Boring Completed
12-14-2022

1220 Concord Ave, Ste 450
Concord, CA

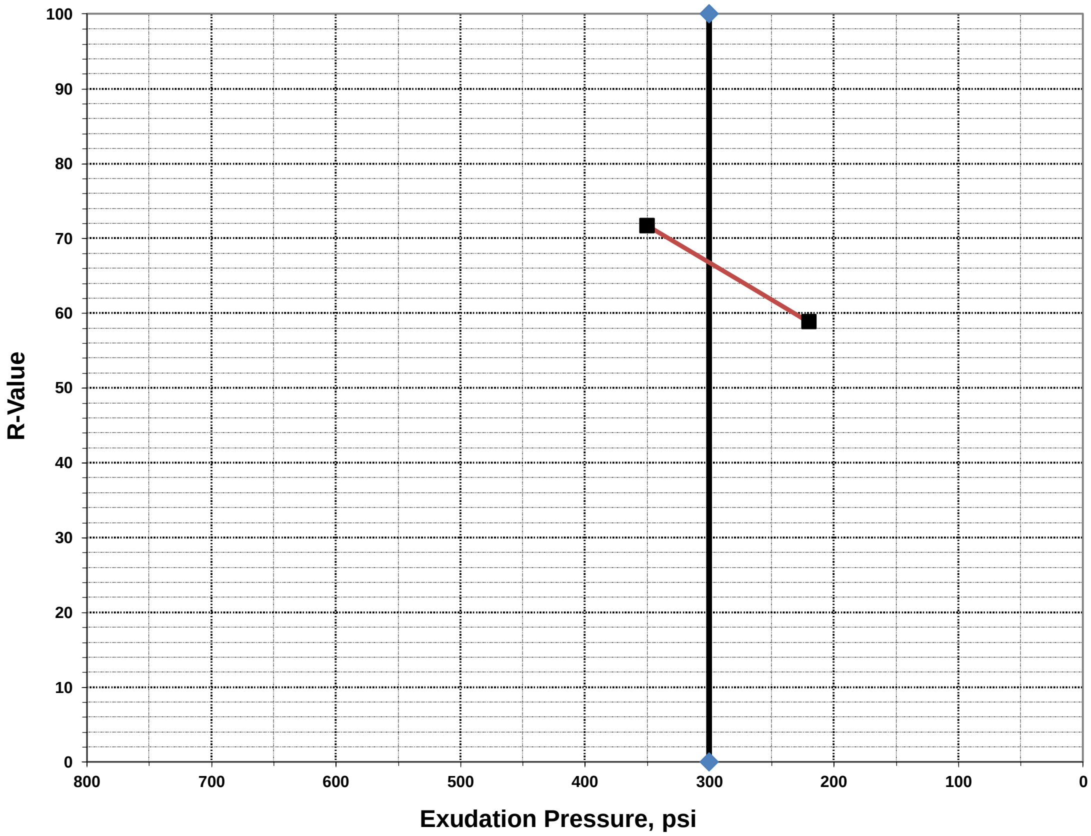
Grain Size Distribution

ASTM D422 / ASTM C136



Boring ID		Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	B-01	5 - 6.5						0.43	362.78
⊠	B-04	5 - 6.5							
▲	B-05	5 - 6.5							
★	B-06	2.5 - 4						1.13	87.65

Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-01	5 - 6.5	75	25.79	0.889		0.0	57.8	31.8	10.4		
⊠	B-04	5 - 6.5	25	4.195	0.637		0.0	37.7	48.0	14.3		
▲	B-05	5 - 6.5	37.5	3.139	0.235		0.0	33.1	46.0	20.8		
★	B-06	2.5 - 4	37.5	5.421	0.616		0.0	42.3	46.6	11.1		



Specimen Identification	Compaction Pressure (psi)	R-Value at 300 psi
B-01	**290.0**	**66**

R-Value Test

Client: Raising Cane's Restaurant, LLC
Project: Raising Cane's C991
Site:
Project No.: ND225125

750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393

Client
Raising Cane's Restaurants, LLC

Project
Raising Cane's RC 991 Morgan Hill (Cochrane & ButterField), CA

Sample Submitted By: Terracon (ND) **Date Received:** 12/21/2022 **Lab No.: 22-0833**

Results of Corrosion Analysis

Sample Number	1
Sample Location	B-02
Sample Depth (ft.)	1.0-2.5
pH Analysis, ASTM G 51	7.34
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	100
Sulfides, AWWA 4500-S D, (mg/kg)	Nil
Chlorides, ASTM D 512, (mg/kg)	47
Red-Ox, ASTM G 200, (mV)	+736
Total Salts, AWWA 2520 B, (mg/kg)	135
Saturated Minimum Resistivity, ASTM G 57, (ohm-cm)	5820

Analyzed By: N. Campo

Nathan Campo
Engineering Technician II

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
1220 Concord Ave, Ste 450
Concord, CA

General Notes

Sampling

- Modified Dames & Moore Ring Sampler
- Grab Sample
- Standard Penetration Test

Water Level

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

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

N	Standard Penetration Test Resistance (Blows/Ft.)
(HP)	Hand Penetrometer
(T)	Torvane
(DCP)	Dynamic Cone Penetrometer
UC	Unconfined Compressive Strength
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. 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		**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		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**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≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [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≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [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 above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					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:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					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] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 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 ≥ 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 ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 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.