GEOTECHNICAL STUDY REPORT

2008 GRANT STREET SUBDIVISION
2008 GRANT STREET
CALISTOGA, CALIFORNIA

Project Number:

7548.01.04.2

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INTRODUCTION

This report presents the results of our geotechnical study for the subdivision to be constructed at 2008 Grant Street in Calistoga, California. The property extends over relatively level terrain and contains a residence with some detached structures. The site location is shown on Plate 1, Appendix A.

We understand it is planned to construct a 15-unit subdivision at the project site. Actual foundation loads are not known at this time. We anticipate the loads will be typical for the light type of construction planned. Grading plans are not available, but we anticipate that, the planned grading will be the minimum amount needed to construct level building pads and provide the building sites and paved areas with positive drainage.

SCOPE

The purpose of our study, as outlined in our work order dated October 4, 2021, was to generate geotechnical information for the design and construction of the project. Our scope of services included reviewing selected published geologic data pertinent to the site; evaluating the subsurface conditions with borings and laboratory tests; analyzing the field and laboratory data; and presenting this report with the following geotechnical information:

1. A brief description of the soil and groundwater conditions observed during our study;

2. A discussion of seismic hazards that may affect the proposed improvements; and

3. Conclusions and recommendations regarding:

   a. Primary geotechnical engineering concerns and mitigating measures, as applicable;

   b. Site preparation and grading including remedial grading of weak, porous, compressible and expansive surface soil;

   c. Foundation type(s), design criteria, and estimated settlement behavior;

   d. Lateral loads for retaining wall design;

   e. Support of concrete slabs-on-grade;

   f. Preliminary pavement thickness based on our experience with similar soil and projects and the results of an R-value test on the anticipated subgrade soil;

   g. Utility trench backfill;

   h. Geotechnical engineering drainage improvements; and

   i. Supplemental geotechnical engineering services.

STUDY

Site Exploration

We reviewed our previous geotechnical studies in the vicinity and selected geologic references pertinent to the site. The geologic literature reviewed is listed in Appendix B. On November 15 and 16, 2021, we performed a geotechnical reconnaissance of the site and explored the subsurface conditions by drilling seven borings to depths ranging from about 5 to 20½ feet. The borings were drilled with a track-mounted drill rig equipped with 4-inch diameter, solid stem augers at the approximate locations shown on the Exploration Plan, Plate 2. The boring locations were determined approximately by pacing their distance from features shown on the Exploration Plan and should be considered accurate only to the degree implied by the method used. Our staff engineer located and logged the borings and obtained samples of the materials encountered for visual examination, classification, and laboratory testing.

Relatively undisturbed samples were obtained from the borings at selected intervals by driving a 2.43-inch inside diameter, split spoon sampler, containing 6-inch long brass liners, using a 140-pound hammer dropping approximately 30 inches. The sampler was driven 12 to 18 inches. The blows required to drive each 6-inch increment were recorded and the blows required to drive the last 12 inches, or portion thereof, were converted to equivalent Standard Penetration Test (SPT) blow counts for correlation with empirical data. Disturbed samples were also obtained at selected depths by driving a 1.375-inch inside diameter (2-inch outside diameter) SPT sampler, without liners or rings, using a 140-pound hammer dropping approximately 30 inches. The sampler was driven 12 to 18 inches, the blows to drive each 6-inch increment were recorded, and the blows required to drive the final 12 inches, or portion thereof, are provided on the boring logs. A disturbed "bulk" sample of anticipated subgrade soil was also obtained from boring B-3 and placed in a bucket.

The logs of the borings showing the materials encountered, groundwater conditions, converted blow counts, and sample depths are presented on Plates 3 through 9. The soil is described in accordance with the Unified Soil Classification System, outlined on Plate 10.

The boring logs show our interpretation of the subsurface soil and groundwater conditions on the date and at the locations indicated. Subsurface conditions may vary at other locations and times. Our interpretation is based on visual inspection of soil samples, laboratory test results, and interpretation of drilling and sampling resistance. The location of the soil boundaries should be considered approximate. The transition between soil types may be gradual.

Laboratory Testing

The samples obtained from the borings were transported to our office and re-examined to verify soil classifications, evaluate characteristics, and assign tests pertinent to our analysis. Selected samples were laboratory tested to determine their classification (Atterberg Limits, percent of silt and clay), expansion potential (Expansion Index - EI) and R-value. The test results are presented on the boring logs and on Plates 11 and 12.

SITE CONDITIONS

General

Napa County is located within the California Coast Range geomorphic province. This province is a geologically complex and seismically active region characterized by sub-parallel northwest-trending faults, mountain ranges and valleys. The oldest bedrock units are the Jurassic-Cretaceous Franciscan Complex and Great Valley sequence sediments originally deposited in a marine environment. Subsequently, younger rocks such as the Tertiary-age Sonoma Volcanics group, the Plio-Pleistocene-age Clear Lake Volcanics and sedimentary rocks such as the Guinda, Domengine, Petaluma, Wilson Grove, Cache, Huichica, and Glen Ellen formations were deposited throughout the province. Extensive folding and thrust faulting during late Cretaceous through early Tertiary geologic time created complex geologic conditions that underlie the highly varied topography of today. In valleys, the bedrock is covered by thick alluvial soil.

Geology

Published geologic maps (Delattre et al., 2013) indicate the property is underlain by undifferentiated alluvial deposits. The alluvial deposits are shown to consist of poorly to moderately sorted sand, silt, and gravel.

Landslides

Published landslide maps (Dwyer, 1976) do not indicate large-scale slope instability at the site, and we did not observe active landslides at the site during our study.

Surface

The property extends primarily over relatively level terrain. The vegetation consists of seasonal grasses and mature trees. In general, the ground surface is soft and spongy. This is a condition generally associated with weak, porous surface soil. Natural drainage consists of sheet flow over the ground surface that concentrates in man made surface drainage elements such as roadside ditches, canals and gutters, and natural drainage elements such as swales.

Subsurface

Our borings and laboratory tests indicate that the portion of the site we studied is blanketed by about 2 feet of weak, porous, compressible, clayey soil. Porous soil appears hard and strong when dry but becomes weak and compressible as its moisture content increases towards saturation. This soil exhibits high plasticity (LL = 59.6; PI = 34.3) and moderate expansion potential (EI = 84). These surface materials are underlain by clay with varying amounts of sand.

A detailed description of the subsurface conditions found in our borings is given on Plates 3 through 9, Appendix A. Based on Table 20.3-1 of American Society of Civil Engineers (ASCE) Standard 7-16, titled "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (2017), we have determined a Site Class of D should be used for the site.

Corrosion Potential

Mapping by the Natural Resources Conservation Service (2021) indicates that the corrosion potential of the near surface soil is high for uncoated steel and low for concrete. Performing corrosivity tests to verify these values was not part of our requested and/or proposed scope of work. Should the need arise, we would be pleased to provide a proposal to evaluate these characteristics.

Groundwater

Free groundwater was detected in our borings at depths ranging from 8 to 14½ feet below the ground surface at the time of drilling. Fluctuation in the groundwater level typically occurs because of a variation in rainfall intensity, duration and other factors such as flooding and periodic irrigation.

DISCUSSION AND CONCLUSIONS

Seismic Hazards

Faulting and Seismicity

We did not observe landforms within the area that would indicate the presence of active faults and the site is not within a current Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007). Therefore, we believe the risk of fault rupture at the site is low. However, the site is within an area affected by strong seismic activity and future seismic shaking should be anticipated at the site. It will be necessary to design and construct the proposed improvements in strict adherence with current standards for earthquake-resistant construction.

Liquefaction

Liquefaction is a rapid loss of shear strength experienced in saturated, predominantly granular soil below the groundwater level during strong earthquake ground shaking due to an increase in pore water pressure. The occurrence of this phenomenon is dependent on many complex factors including the intensity and duration of ground shaking, particle size distribution and density of the soil.

Granular soil was encountered at the site below the groundwater table. Therefore, we performed an analysis of the blow count data from our borings using the methods of Seed and Idriss (1982), Seed and others (1985), Youd and Idriss (2001), Idriss and Boulanger (2004) and Idriss and Boulanger (2008). These procedures normalize the blow counts to account for overburden pressure, rod length, hammer energy, and fines (percent of silt and clay) content. Once the blow counts are normalized and adjusted to a clean sand blow count, the cyclic resistance ratio (CRR) for each blow count is then determined using the same procedures referenced above. The CRR is compared to the cyclic stress ratio (CSR) induced by the earthquake. Calculating the CSR requires a peak ground acceleration and design earthquake magnitude.

Peak ground acceleration (PGA) was determined using the methods in the 2019 California Building Code (CBC) and the American Society of Civil Engineers (ASCE) Standard 7-16, titled "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (2017). Using the site-specific seismic criteria developed in accordance with Chapter 21 of ASCE 7-16, the site's latitude and longitude of 38.5889°N and 122.5842°W, respectively, and a site soil Class of D, the PGA for the site is 0.724g. Using this information, the CSR for a M_M 7.5 earthquake at the site ranges from 0.46 to 0.59. The West Napa fault is most likely controlling the ground motions at the site. According to the Building Seismic Safety Council Earthquake Scenario Event Set (BSSC, 2014) and the USGS Earthquake Scenario Map (available at http://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=14d2f75c7c4f4619936dac0d14e1e468), the West Napa fault is capable of a M_M 7.6 earthquake. Therefore, the CRR values at the site must be scaled to account for the difference between M_M 7.6 and M_M 7.5. When the scaling factor for magnitude and confining stress corrections presented in Idriss and Boulanger (2004) are applied, the CRR values at the site do not exceed the CSR values from 11 to 18 feet in boring B-1, 12 to 13½ feet in boring B-4, 8 to 17 feet in boring B-5, and 10 to 13 feet in boring B-6. Therefore, we judge that there is potential for liquefaction at the site.

There are three potential consequences of liquefaction: bearing capacity failure, lateral spreading toward a free face (e.g. riverbank), and settlement. Bearing capacity failure is sudden and extreme settlement of foundations that typically occurs when the liquefied layer is relatively close (typically within two times the footing width, depending on the loads) to the bottom of the foundation. Because the liquefiable layer is 8 feet below the ground surface, we judge that the potential for bearing capacity failure is low.

Lateral spreading can occur where continuous layers of liquefiable soil extend to a free face, such as a creek bank. There are no significant free faces in the vicinity of the site. Therefore, we judge the potential for liquefaction-induced lateral spreading at the site is low.

The third potential consequence of liquefaction is settlement due to densification of the liquefied soil. Potential settlements based on the blow count data and cyclic stress ratio were calculated using the methods of Ishihara and Yoshimine (1992). For the layers encountered at 8 feet below the surface, we calculated total settlement ranging from ¼ to 3¼ inches. Differential settlement could also range from ¼ to 3¼ inches.

Densification

Densification is the settlement of loose, granular soil above the groundwater level due to earthquake shaking. Typically, granular soil that would be susceptible to liquefaction, if saturated, are susceptible to densification if not saturated. Granular materials susceptible to liquefaction if saturated were encountered above the groundwater table. Settlements were estimated using the procedures described in Tokimatsu and Seed (1987). Densification-related settlements could range from ¼ to 1 inch in addition to the liquefaction-induced settlements. Provided remedial grading is performed and the foundations are designed as recommended herein, we judge there is a low potential for densification to impact structures at the site.

Geotechnical Issues

General

Based on our study, we judge the proposed improvements can be built as planned, provided the recommendations presented in this report are incorporated into their design and construction. The primary geotechnical concerns during design and construction of the project are:

1. The presence of 2 feet of weak, porous, compressible, moderately expansive clayey surface soil and the potential presence of heterogenous fill;

2. The presence of soils susceptible to liquefaction and densification;

3. The detrimental effects of uncontrolled surface runoff and groundwater seepage on the long-term satisfactory performance of residences; and

4. The strong ground shaking predicted to impact the site during the life of the project.

Potentially Liquefiable and Densifiable Soil

As discussed previously, there are layers of the subsurface soil that are susceptible to liquefaction and densification. Potentially liquefiable soils present at the site are susceptible to settlement due to the densification of the liquefied soils below the groundwater table. Potentially densifiable soils present at the site are susceptible to settlement due to the densification of granular soils above the groundwater table. Our analysis found that the total settlements could range from ¼ to 3¼ inches.

Weak, Porous Surface Soil

Weak, porous surface soil, such as that found at the site, appears hard and strong when dry but will lose strength rapidly and settle under the load of fills, foundations, slabs, and pavements as its moisture content increases and approaches saturation. The moisture content of this soil can increase as the result of rainfall, periodic irrigation or when the natural upward migration of water vapor through the soil is impeded by, and condenses under fills, foundations, slabs, and pavements. The detrimental effects of such movements can be reduced by strengthening the soil during grading. This can be achieved by excavating the weak soil and replacing it as properly compacted (engineered) fill. Alternatively, satisfactory foundation support could be obtained below the weak surface soil.

Expansive Soil

Expansive surface soil shrinks and swells as it loses and gains moisture throughout the yearly weather cycle. Near the surface, the resulting movements can heave and crack lightly loaded shallow foundations (spread footings) and slabs. The zone of significant moisture variation (active layer) is dependent on the expansion potential of the soil and the extent of the dry season. In the structural area, the active layer is generally considered to range in thickness from about 2 to 3 feet. Due to the potential for liquefaction in conjunction with the effects of expansive soil we judge that foundation support should be obtained from a rigid foundation system.

Heterogeneous Fill

We anticipate that much of the surface soil will become loose and disturbed during the clearing process and foundation removal of the existing structures onsite. Heterogeneous fills of unknown quality and unknown method of placement, such as those likely to be created during the lot clearing, can settle and/or heave erratically under the load of new fills, structures, slabs, and pavements. Foundations, slabs, and pavements supported on heterogeneous fill could also crack as a result of such erratic movements. Thus, where not removed by planned grading, the heterogeneous fill must be excavated and replaced as an engineered fill if it is to be used for structural support.

Foundation and Slab Support - After remedial grading, satisfactory foundation support for the residences can be obtained from a rigid structural concrete system. These options include a mat slab, a post-tension (PT) slab, or gridded spread footings.

Exterior Slabs and Pavements

Exterior slabs and pavements will heave and crack as the expansive soil shrinks and swells through the yearly weather cycle. Slab and pavement cracking and distress are typically concentrated along edges where moisture content variation is more prevalent within subgrade soil. Slab and pavement performance can be improved and the incidence of repair can be reduced, but not eliminated, by covering the pre-swelled expansive soil with at least 12 inches of select fill (see "On-Site Soil Quality" section) prior to constructing the slab or pavement required to carry the anticipated traffic.

On-Site Soil Quality

All fill materials used in the upper 12 inches of exterior slab and pavement subgrade must be select, as subsequently described in "Recommendations." We anticipate that, with the exception of organic matter and of rocks or lumps larger than 6 inches in diameter, the excavated material will be suitable for re-use as general fill but will not be suitable for use as select fill unless stabilized with lime.

Select Fill

The select fill can consist of approved on-site soil or import materials with a low expansion potential or lime stabilized on-site clayey soil. Lime stabilized soil may prevent the growth of landscape vegetation due to the inherent elevated pH level of the soil. The geotechnical engineer must approve the use of on-site soil as select fill during grading.

Settlement

If remedial grading is performed and the rigid foundation system is installed in accordance with the recommendations presented in this report, we estimate that post-construction differential settlements across the building will be about ½ inch. Earthquake-induced total settlement could be as high as 3¼ inches, but differential settlement should be accommodated by the design of the rigid foundation system.

Surface Drainage

Surface runoff typically sheet flows over the ground surface but can be concentrated by the planned site grading, landscaping, and drainage. The surface runoff can pond against structures and seep into the crawl space. Therefore, strict control of surface runoff is necessary to provide long-term satisfactory performance of projects. It will be necessary to divert surface runoff around improvements, provide positive drainage away from structures, and install energy dissipaters at discharge points of concentrated runoff. This can be achieved by constructing the building pad several inches above the surrounding area and conveying the runoff into man made drainage elements or natural swales that lead downgradient of the site.

RECOMMENDATIONS

Seismic Design

Seismic design parameters presented below are based on Section 1613 titled "Earthquake Loads" of the 2019 California Building Code (CBC). Based on Table 20.3-1 of American Society of Civil Engineers (ASCE) Standard 7-16, titled "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (2017), we have determined a Site Class of D should be used for the site. Using a site latitude and longitude of 38.5889°N and 122.5842°W, respectively, and the procedures outlined in Chapter 21 of ASCE Standard 7-16, we recommend that the following site-specific seismic design criteria be used for applicable structures at the site.

2019 CBC Seismic Criteria	
Spectral Response Parameter	**Acceleration (g)**
S_S (0.2 second period)	1.755
S_1 (1 second period)	0.647
S_{MS} (0.2 second period)	1.708
S_{M1} (1 second period)	1.650
S_{DS} (0.2 second period)	1.139
S_{D1} (1 second period)	1.100

Grading

Site Preparation

Areas to be developed should be cleared of vegetation and debris including that left by the removal of obsolete structures. Trees and shrubs that will not be part of the proposed development should be removed and their primary root systems grubbed. Cleared and grubbed material should be removed from the site and disposed of in accordance with County Health Department guidelines. We did not observe septic tanks, leach lines or underground fuel tanks during our study. Any such appurtenances found during grading should be capped and sealed and/or excavated and removed from the site, respectively, in accordance with established guidelines and requirements of the County Health Department. Voids created during clearing should be backfilled with engineered fill as recommended herein.

Stripping

Areas to be graded should be stripped of the upper few inches of soil containing organic matter. Soil containing more than two percent by weight of organic matter should be considered organic. Actual stripping depth should be determined by a representative of the geotechnical engineer in the field at the time of stripping. The strippings should be removed from the site, or if suitable, stockpiled for re-use as topsoil in landscaping.

Excavations

Following initial site preparation, excavation should be performed as recommended herein. Excavations extending below the proposed finished grade should be backfilled with suitable materials compacted to the requirements given below.

Within building areas, the weak, porous, compressible surface soil should be excavated to within 6 inches of its entire depth (about 2 feet in our borings). On site native soil is suitable for backfill beneath rigid foundation systems. The excavation of weak, compressible, expansive soil should also extend at least 12 inches below exterior slab and pavement subgrade (where planned excavations do not completely remove the weak soil) to allow space for the installation of the select fill blanket discussed in the conclusions section of this report

The excavation of weak, porous, compressible, expansive, surface materials should extend at least 5 feet beyond the outside edge of the exterior of the foundation of the proposed buildings and 3 feet beyond the edge of exterior slabs. The excavated materials should be stockpiled for later use as compacted fill, or removed from the site, as applicable.

At all times, temporary construction excavations should conform to the regulations of the State of California, Department of Industrial Relations, Division of Industrial Safety or other stricter governing regulations. The stability of temporary cut slopes, such as those constructed during the installation of underground utilities, should be the responsibility of the contractor. Depending on the time of year when grading is performed, and the surface conditions exposed, temporary cut slopes may need to be excavated to 1½:1, or flatter. The tops of the temporary cut slopes should be rounded back to 2:1 in weak soil zones.

Fill Quality

All fill materials should be free of perishable matter and rocks or lumps over 6 inches in diameter and must be approved by the geotechnical engineer prior to use. The 12 inches of fill beneath and within 3 feet of exterior slabs and/or pavement edges should be select fill. We judge the on-site soil is generally suitable for use as general fill but will not be suitable for use as select fill unless they are stabilized with lime. Lime stabilized soil may prevent the growth of landscape vegetation due to the inherent elevated pH level of the soil. The suitability of the on-site soil for use as select fill should be verified during grading.

Select Fill

Select fill should be free of organic matter, have a low expansion potential, and conform in general to the following requirements:

SIEVE SIZE	PERCENT PASSING (by dry weight)
6 inch	100
4 inch	90 – 100
No. 200	10 – 60

Liquid Limit – 40 Percent Maximum
Plasticity Index – 15 Percent Maximum

Expansive on-site soil may be used as select fill if it is stabilized with lime. In general, imported fill, if needed, should be select. Material not conforming to these requirements may be suitable for use as import fill; however, it shall be the contractor's responsibility to demonstrate that the proposed material will perform in an equivalent manner. The geotechnical engineer should approve imported materials prior to use as compacted fill. The grading contractor is responsible for submitting, at least 72 hours (3 days) in advance of its intended use, samples of the proposed import materials for laboratory testing and approval by the soils engineer.

Lime Stabilization

For preliminary planning purposes, we estimate that high calcium lime mixed at a minimum of 5½ percent (dry weight) will stabilize the expansive site soil. This percentage of lime needs to be verified prior to construction with engineering analysis and laboratory Atterberg Limits and/or pH testing using lime from the same source as that planned for use on the project and a sample of the soil to be treated. Laboratory test results and engineering analysis may indicate that a higher percentage of lime is required. The contractor should allow a minimum of 5 business days for the laboratory tests to be completed.

The lime stabilization should be performed in accordance with Section 24 of the Caltrans Standard Specifications except that a curing seal will not be required, provided the moisture content of the lime-stabilized material is maintained at or above optimum moisture content until it is permanently covered with subsequent construction. Lime stabilized materials are generally not suitable for reuse as general fill, select fill or backfill after compaction has taken place.

Fill Placement

The surface exposed by stripping and removal of heterogeneous fill and weak, compressible, expansive surface soil should be scarified to a depth of at least 6 inches, uniformly moisture-conditioned to near optimum at least 4 percent above optimum and compacted to at least 90 percent of the maximum dry density of the materials as determined by ASTM Test Method D-1557. In expansive soil areas, moisture conditioning should be sufficient to completely close all shrinkage cracks for their full depth within pavement, exterior slab, and building areas. If grading is performed during the dry season, the shrinkage cracks may extend to a few feet below the surface. Therefore, it may be necessary to excavate a portion of the cracked soil to obtain the proper moisture condition and degree of compaction. Approved fill material should then be spread in thin lifts, uniformly moisture-conditioned to near optimum and properly compacted. All structural fills, including those placed to establish site surface drainage, should be compacted to at least 90 percent relative compaction.

SUMMARY OF COMPACTION RECOMMENDATIONS

Area	Compaction Recommendation (ASTM D-1557)
Preparation for areas to receive fill	After preparation in accordance with this report, compact upper 6 inches to a minimum of 90 percent relative compaction.
General fill (native or import)	Compact to a minimum of 90 percent relative compaction.
Structural fill beneath buildings, extending outward to 5' beyond building perimeter	Compact to a minimum of 90 percent relative compaction.
Trenches	Compact to a minimum of 90 percent relative compaction. Compact the top 6 inches below vehicle pavement subgrade to a minimum of 95 percent relative compaction.
Retaining wall backfill	Compact to a minimum of 90 percent relative compaction, but not more than 95 percent.
Pavements, extending outward to 3' beyond edge of pavement	Compact upper 6 inches of subgrade to a minimum of 95 percent relative compaction.
Concrete flatwork and exterior slabs, extending outward to 3' beyond edge of slab	Compact subgrade to a minimum of 90 percent relative compaction. Where subject to vehicle traffic, compact upper 6 inches of subgrade to at least 95 percent relative compaction.
Aggregate Base	Compact aggregate base to at least 95 percent relative compaction.

Permanent Cut and Fill Slopes

In general, cut and fill slopes should be designed and constructed at slope gradients of 2:1 (horizontal to vertical) or flatter, unless otherwise approved by the geotechnical engineer in specified areas. Where steeper slopes are required, retaining walls should be used. Fill slopes should be constructed by overfilling and cutting the slope to final grade. "Track walking" of a slope to achieve slope compaction is not an acceptable procedure for slope construction. The geotechnical engineer is not responsible for measuring the angles of these slopes.

Wet Weather Grading

Generally, grading is performed more economically during the summer months when the on-site soil is usually dry of optimum moisture content. Delays should be anticipated in site grading performed during the rainy season or early spring due to excessive moisture in on-site soil. Special and relatively expensive construction procedures, including dewatering of excavations and importing granular soil, should be anticipated if grading must be completed during the winter and early spring or if localized areas of soft saturated soil are found during grading in the summer and fall.

Open excavations also tend to be more unstable during wet weather as groundwater seeps towards the exposed cut slope. Severe sloughing and occasional slope failures should be anticipated. The occurrence of these events will require extensive clean up and the installation of slope protection measures, thus delaying projects. The general contractor is responsible for the performance, maintenance and repair of temporary cut slopes.

Foundation Support

Due to the high liquefaction-related settlement expected at the site and expansive soils, the structures should be supported on a rigid foundation system consisting of either a post-tension (PT) slab, a mat slab, or gridded spread footings.

Post-Tension Slab, Mat Slab, or Gridded Spread Footings

A PT slab, mat slab, or gridded spread footings installed in accordance with the recommendations presented herein may be designed using allowable bearing pressures of 2000, 3000, and 4000 pounds per square foot (psf), for dead loads, dead plus code live loads, and total loads (including wind and seismic), respectively. In addition, a modulus of subgrade reaction (k) of 100 pounds per cubic inch (pci) may be used for design. The portion of the foundation extending into engineered fill may impose a passive equivalent fluid pressure and a friction factor of 350 pounds per cubic foot (pcf) and 0.35, respectively, to resist sliding. Passive pressure should be neglected within the upper 6 inches, unless the soils are confined by concrete slabs. The PT slab, mat slab, or gridded spread footings should be designed for non-seismic differential settlement of ½-inch across the building and earthquake-induced differential settlement of 1 inch over a cantilevered unsupported distance of 7 feet.

Excavations for thickened areas of the PT Slab, mat slab, or gridded spread footings should be thoroughly cleaned out, wetted, and compacted prior to placing steel and concrete. This will remove the soils disturbed during excavations, restore their adequate bearing capacity, and reduce post-construction settlements.

With the exception of the thickened areas, the PT slab, mat slab, or gridded spread footings should be underlain with a capillary moisture break consisting of at least 4 inches of clean, free-draining crushed rock or gravel (excluding pea gravel) at least ¼-inch and no larger than ¾-inch in size. A vapor barrier should be provided where moisture-sensitive floor coverings, coatings, underlayments, adhesives, moisture sensitive goods, humidity-controlled environments, or climate-cooled environments are anticipated initially, or in the future. The vapor barrier should consist of a minimum 15 mil extruded polyolefin plastic (no recycled content or woven materials permitted); permeance as tested before and after mandatory conditioning (ASTM E1745 Section 7.1 and sub-paragraphs 7.1.1 – 7.1.5): less than 0.01 Perms [grains/(ft2 hr inhg)] and comply with the ASTM E1745 Class A requirements. The vapor barrier should also meet paragraph's 8.1 and 9.3 of ASTM E1745; subsequent documentation should be provided by the vapor barrier manufacturer. Install vapor barrier in accordance with ASTM E1643, including proper perimeter seal.

RGH does not practice in the field of moisture vapor transmission evaluation or mitigation. Therefore, we recommend that a qualified person be consulted to evaluate the general and specific moisture vapor transmission paths and any impact on the proposed construction. This person should provide recommendations for mitigation of the potential adverse impact of moisture vapor transmission on various components of the structure as deemed appropriate.

Retaining Walls

Retaining walls constructed at the site must be designed to resist lateral earth pressures plus additional lateral pressures that may be caused by surcharge loads applied at the ground surface behind the walls. Retaining walls free to rotate (yielding greater than 0.1 percent of the wall height at the top of the backfill) should be designed for active lateral earth pressures. If walls are restrained by rigid elements to prevent rotation, they should be designed for "at rest" lateral earth pressures.

Retaining walls should be designed to resist the following earth equivalent fluid pressures (triangular distribution):

EARTH EQUIVALENT FLUID PRESSURES		
Loading Condition	**Pressure (pcf)**	**Additional Seismic Pressure (pcf)***
Active - Level Backfill	42	13
Active - Sloping Backfill 3:1 or Flatter	53	28
At Rest - Level Backfill	63	30

* If required

These pressures do not consider additional loads resulting from adjacent foundations or other loads. If these additional surcharge loadings are anticipated, we can assist in evaluating their effects. Where retaining wall backfill is subject to vehicular traffic, the walls should be designed to resist an additional surcharge pressure equivalent to two feet of additional backfill.

Retaining walls will yield slightly during backfilling. Therefore, walls should be backfilled prior to building on, or adjacent to, the walls. Backfill against retaining walls should be compacted to at least 90 and not more than 95 percent relative compaction. Over-compaction or the use of large compaction equipment should be avoided because increased compactive effort can result in lateral pressures higher than those recommended above.

Foundation Support

Retaining walls should be supported on foundations designed in accordance with the recommendations presented in this report. Retaining wall foundations should be designed by the project civil or structural engineer to resist the lateral forces set forth in this section.

Wall Drainage and Backfill

Retaining walls should be backdrained as shown on Plate 13, Appendix A. The backdrains should consist of 4-inch diameter, rigid perforated pipe embedded in Class 2 permeable material. The pipe should be PVC Schedule 40 or ABS with SDR 35 or better, and the pipe should be sloped to drain to outlets by gravity. The top of the pipe should be at least 8 inches below lowest adjacent grade. The Class 2 permeable material should extend to within 1½ feet of the surface. The upper 1½ feet should be backfilled with compacted soil to exclude surface water. Expansive soil should not be used for wall backfill. Where expansive soil is present in the excavation made to install the retaining wall, the excavation should be sloped back 1:1 from the back of the footing or grade beam. The ground surface behind retaining walls should be sloped to drain. Where migration of moisture through retaining walls would be detrimental, retaining walls should be waterproofed.

Slab-On-Grade

Provided grading is performed in accordance with the recommendations presented herein, interior and exterior slabs should be underlain by engineered fill. Slab-on-grade subgrade should be rolled to produce a dense, uniform surface. The future expansion potential of the subgrade soil should be reduced by thoroughly presoaking the slab subgrade prior to concrete placement. The moisture condition of the subgrade soil should be checked by the geotechnical engineer no more than 24 hours prior to placing the capillary moisture break. The slabs should be underlain with a capillary moisture break consisting of at least 4 inches of clean, free-draining crushed rock or gravel (excluding pea gravel) at least ¼-inch and no larger than ¾-inch in size. Interior slabs subject to vehicular traffic may be underlain by Class 2 aggregate base. The use of Class 2 aggregate base should be reviewed on a case by case basis. Class 2 aggregate base can be used for slab rock under exterior slabs. Interior area slabs should be provided with an underdrain system. The installation of this subdrain system is discussed in the “Geotechnical Drainage” section.

Slabs should be designed by the project civil or structural engineer to support the anticipated loads, reduce cracking and provide protection against the infiltration of moisture vapor. A vapor barrier should be incorporated into the floor slab design in all areas where moisture-sensitive floor coverings, coatings, underlayments, adhesives, moisture sensitive goods, humidity-controlled environments, or climate-cooled environments are anticipated initially, or in the future. Vapor barrier should consist of a minimum 15 mil extruded polyolefin plastic (no recycled content or woven materials permitted); permeance as tested before and after mandatory conditioning (ASTM E1745 Section 7.1 and Sub-paragraphs 7.1.1 – 7.1.5): less than 0.01 perms [grains/(ft2 per hour in Hg)] and comply with the ASTM E1745 class a requirements. The vapor barrier should also meet paragraph's 8.1 and 9.3 of ASTM E1745; subsequent documentation should be provided by the vapor barrier manufacturer. Install vapor barrier in accordance with ASTM E1643, including proper perimeter seal.

Utility Trenches

The shoring and safety of trench excavations is solely the responsibility of the contractor. Attention is drawn to the State of California Safety Orders dealing with "Excavations and Trenches."

Unless otherwise specified by the City of Calistoga, on-site, inorganic soil may be used as (general) utility trench backfill. Where utility trenches support pavements, slabs and foundations, trench backfill should consist of aggregate baserock. The baserock should comply with the minimum requirements in Caltrans Standard Specifications, Section 26 for Class 2 Aggregate Base. Trench backfill should be moisture-conditioned as necessary, and placed in horizontal layers not exceeding 8 inches in thickness, before compaction. Each layer should be compacted to at least 90 percent relative compaction as determined by ASTM Test Method D-1557. The top 6 inches of trench backfill below vehicle pavement subgrades should be moisture-conditioned as necessary and compacted to at least 95 percent relative compaction. Jetting or ponding of trench backfill to aid in achieving the recommended degree of compaction should not be attempted.

Pavements

Based on our study, we believe the near-surface soil will have a low supporting capacity, after proper compaction, when used as a pavement subgrade. An R-value of 7 was measured on a bulk sample of near-surface soil obtained in boring B-3 where the planned driveway is. Provided the site grading is performed to remediate expansive soil heave, as recommended herein, the uppermost 12-inches of pavement subgrade soil will be either imported select fill with a minimum R-value of 20 or lime stabilized site soil that generally has an R-value of at least 50. Based on those R-values we recommend the pavement sections listed in the tables below be used.

PAVEMENT SECTIONS WITH IMPORTED SELECT FILL SUBGRADE			
TI	ASPHALT CONCRETE (feet)	CLASS 2 AGGREGATE BASE (feet)	IMPORTED SELECT FILL* (feet)
7.0	0.30	1.15	1.0
6.0	0.25	1.05	1.0
5.0	0.20	0.90	1.0

* R-value ≥ 20

PAVEMENT SECTIONS WITH LIME STABILIZED SELECT FILL SUBGRADE			
TI	ASPHALT CONCRETE (feet)	CLASS 2 AGGREGATE BASE (feet)	LIME STABILIZED SELECT FILL* (feet)
7.0	0.35	0.50	1.0
6.0	0.30	0.50	1.0
5.0	0.20	0.50	1.0

* R-value ≥ 50

Pavement thicknesses were computed using the Caltrans Highway Design Manual and are based on a pavement life of 20 years. These recommendations are intended to provide support for traffic represented by the indicated Traffic Indices. They are not intended to provide pavement sections for heavy concentrated construction storage or wheel loads such as forklifts, parked truck-trailers and concrete trucks or for post-construction concentrated wheel loads such as self-loading dumpster trucks. In areas where heavy construction storage and wheel loads are anticipated, the pavements should be designed to support these loads. Support could be provided by increasing pavement sections or by providing reinforced concrete slabs. Alternatively, paving can be deferred until heavy construction storage and wheel loads are no longer present. Loading areas for self-loading dumpster trucks should be provided with reinforced concrete slabs.

Because of the expansion potential of the soil at the site and the difficulty in controlling seasonal moisture variation beneath and adjacent to the driveway, significant cracking may develop in the pavement even if 12-inches of select fill is installed. Increasing the thickness of select fill or installing moisture cutoffs may reduce but not eliminate the potential for cracks to develop. It should be understood that pavements will likely require regular maintenance including crack sealing and the aesthetics may not be desirable.

Prior to placement of aggregate base, the upper 6 inches of the pavement subgrade soil (excluding lime stabilized soil) should be scarified, uniformly moisture-conditioned to near optimum, and compacted to at least 95 percent relative compaction to form a firm, non-yielding surface. Lime stabilized select fill subgrade soil should be compacted as specified in Section 24 of the Caltrans Standard Specifications. Aggregate base materials should be spread in thin layers, uniformly moisture-conditioned, and compacted to at least 95 percent relative compaction to form a firm, non-yielding surface. The materials and methods used should conform to the requirements of the City of Calistoga and the current edition of the Caltrans Standard Specifications, except that compaction requirements should be based on ASTM Test Method D-1557. Aggregate used for the base course should comply with the minimum requirements specified in Caltrans Standard Specifications, Section 26 for Class 2 Aggregate Base.

Wet Weather Paving

In general, the pavements should be constructed during the dry season to avoid the saturation of the subgrade and base materials, which often occurs during the wet winter months. If pavements are constructed during the winter, a cost increase relative to drier weather construction should be anticipated. Unstable areas may have to be overexcavated to remove soft soil. The excavations will probably require backfilling with imported crushed (ballast) rock. The geotechnical engineer should be consulted for recommendations at the time of construction.

Geotechnical Drainage

Surface water should be diverted away from slopes, foundations, and edges of pavements. Surface drainage gradients should slope away from building foundations in accordance with the requirements of the CBC or local governing agency. Where a gradient flatter than 2 percent for paved areas and 4 percent for unpaved areas is required to satisfy design constraints, area drains should be installed within the rear and side yard swales with a spacing no greater than about 20 feet. Roofs should be provided with gutters and the downspouts should be connected to closed (glued Schedule 40 PVC or ABS with SDR of 35 or better) conduits discharging well away from foundations, onto paved areas or erosion resistant natural drainages or into the site's surface drainage system. Roof downspouts and surface drains must be maintained entirely separate from the slab underdrains recommended hereinafter.

Water seepage or the spread of extensive root systems into the soil subgrade of footings, slabs or pavements could cause differential movements and consequent distress in these structural elements. Landscaping should be planned with consideration for these potential problems.

Perimeter Foundation Drains

Where interior crawl spaces are lower than adjacent exterior grade, subdrains should be installed adjacent to perimeter foundations, except on the downhill side, to prevent surface runoff from entering the crawl space. Foundation drains should consist of trenches that are at least 10 inches below the crawl space surface and are sloped to drain by gravity. Four-inch diameter perforated pipe sloped to drain to outlets by gravity should be placed in the bottom of the trenches. The top of subdrain pipes should be at least 6 inches lower than the adjacent crawl space. The perimeter subdrain trenches should be backfilled to within 6 inches of the surface with Class 2 permeable material. The upper 6 inches should be backfilled with compacted soil to exclude surface water. An illustration of this system is shown on Plate 14. Where perimeter foundation drains are not used, water ponding in the crawl space should be anticipated. Where retaining walls are used for perimeter foundations, retaining wall backdrains may be used in lieu of foundation drains.

Slab Underdrains

Where interior slab subgrades are less than 6 inches above adjacent exterior grade and where migration of moisture through the slab would be detrimental, slab underdrains should be installed to dispose of surface and/or groundwater that may seep and collect in the slab rock. Slab underdrains should consist of 6-inch wide trenches that extend at least 6 inches below the bottom of the slab rock and slope to drain by gravity. The slab underdrain trenches should be spaced no further than 15 feet, both ways. Additional drain trenches should be installed, as necessary, to drain all isolated under slab areas. Four-inch diameter perforated pipe (SDR 35 or better) sloped to drain to outlets by gravity should be placed in the bottom of the trenches. Slab underdrain trenches should be backfilled to subgrade level with clean, free draining slab rock. An illustration of this system is shown on Plate 14. If slab underdrains are not used, it should be anticipated that water will enter the slab rock, permeate through the concrete slab and ruin floor coverings.

Maintenance

Periodic land maintenance will be required. Surface and subsurface drainage facilities should be checked frequently, and cleaned and maintained as necessary or at least annually. A dense growth of deep-rooted ground cover must be maintained on all slopes to reduce sloughing and erosion. Sloughing and erosion that occurs must be repaired promptly before it can enlarge.

Supplemental Services

Pre-Bid Meeting

It has been our experience that contractors bidding on the project often contact us to discuss the geotechnical aspects. Informal contacts between RGH Consultants (RGH) and an individual contractor could result in incomplete or misinterpreted information being provided to the contractor. Therefore, we recommend a pre-bid meeting be held to answer any questions about the report prior to submittal of bids. If this is not possible, questions or clarifications regarding this report should be directed to the project owner or their designated representative. After consultation with RGH, the project owner or their representative should provide clarifications or additional information to all contractors bidding the job.

Plan and Specifications Review

Coordination between the design team and the geotechnical engineer is recommended to assure that the design is compatible with the soil, geologic and groundwater conditions encountered during our study. RGH recommends that we be retained to review the project plans and specifications to determine if they are consistent with our recommendations. In the event we are not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

Construction Observation and Testing

Prior to construction, a meeting should be held at the site that includes, but is not limited to, the owner or owner's representative, the general contractor, the grading contractor, the foundation contractor, the underground contractor, any specialty contractors, the project civil engineer, other members of the project design team and RGH. This meeting should serve as a time to discuss and answer questions regarding the recommendations presented herein and to establish the coordination procedure between the contractors and RGH.

In addition, we should be retained to monitor all soil related work during construction, including, but not limited to:

- Site stripping, over-excavation, grading, and compaction of near surface soil;
- Placement of all engineered fill and trench backfill with verification field and laboratory testing;
- Observation of all foundation excavations; and
- Observation of foundation and subdrain installations.

If, during construction, we observe subsurface conditions different from those encountered during the explorations, we should be allowed to amend our recommendations accordingly. If different conditions are observed by others, or appear to be present beneath excavations, RGH should be advised at once so that these conditions may be evaluated and our recommendations reviewed and updated, if warranted. The validity of recommendations made in this report is contingent upon our being notified and retained to review the changed conditions.

If more than 18 months have elapsed between the submission of this report and the start of work at the site, or if conditions have changed because of natural causes or construction operations at, or adjacent to, the site, the recommendations made in this report may no longer be valid or appropriate. In such case, we recommend that we be retained to review this report and verify the applicability of the conclusions and recommendations or modify the same considering the time lapsed or changed conditions. The validity of recommendations made in this report is contingent upon such review.

These supplemental services are performed on an as-requested basis and are in addition to this geotechnical study. We cannot accept responsibility for items that we are not notified to observe or for changed conditions we are not allowed to review.

LIMITATIONS

This report has been prepared by RGH for the exclusive use of the property owner and their consultants as an aid in the design and construction of the proposed improvements described in this report.

The validity of the recommendations contained in this report depends upon an adequate testing and monitoring program during the construction phase. Unless the construction monitoring and testing program is provided by our firm, we will not be held responsible for compliance with design recommendations presented in this report and other addendum submitted as part of this report.

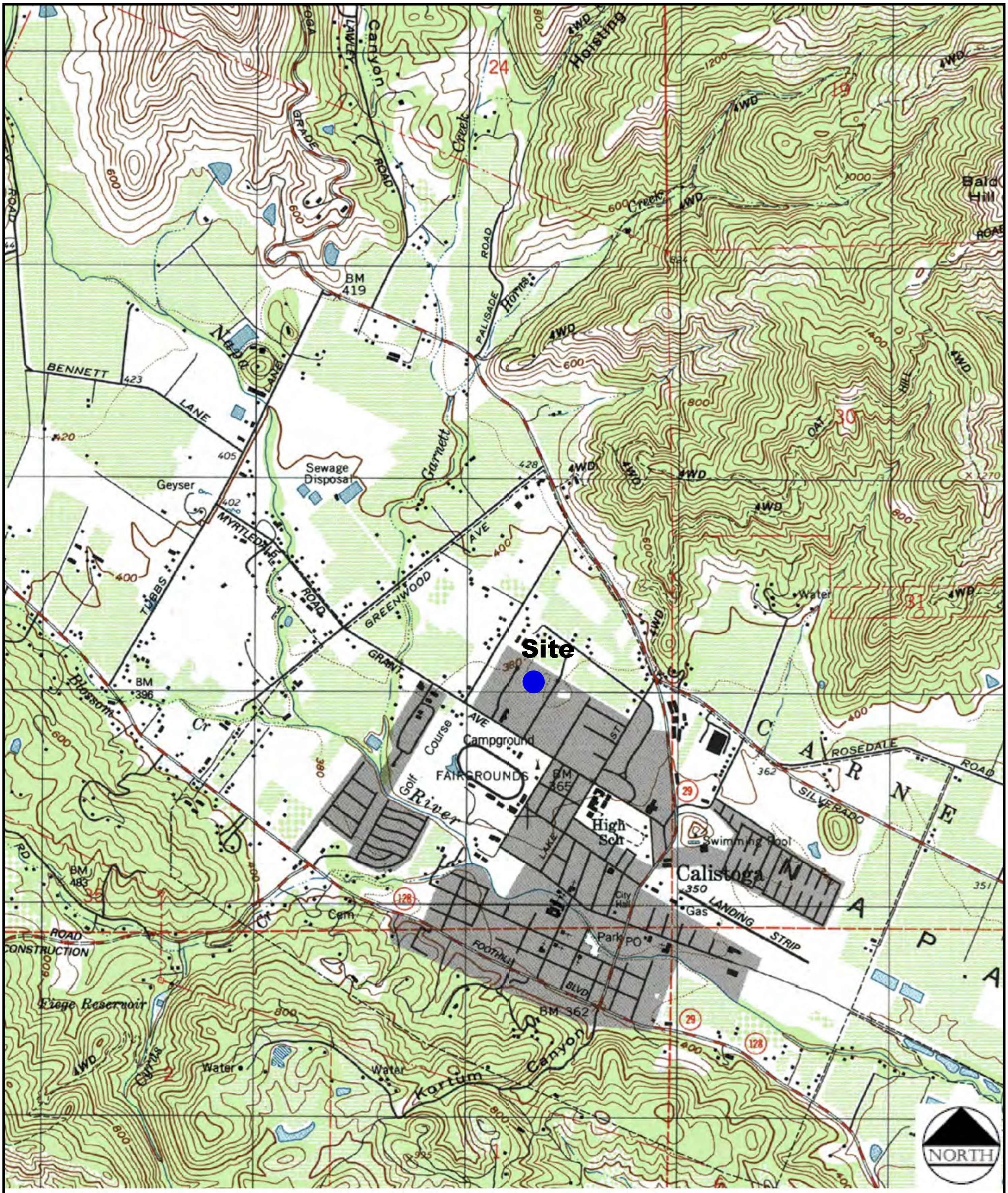
Our services consist of professional opinions and conclusions developed in accordance with generally accepted geotechnical engineering principles and practices. We provide no warranty, either expressed or implied. Our conclusions and recommendations are based on the information provided to us regarding the proposed construction, the results of our field exploration, laboratory testing program, and professional judgment. Verification of our conclusions and recommendations is subject to our review of the project plans and specifications, and our observation of construction.

The borings represent the subsurface conditions at the locations and on the date indicated. It is not warranted that they are representative of such conditions elsewhere or at other times. Site conditions and cultural features described in the text of this report are those existing at the time of our field exploration and may not necessarily be the same or comparable at other times.

The scope of our services did not include an environmental assessment or a study of the presence or absence of toxic mold and/or hazardous, toxic or corrosive materials in the soil, surface water, groundwater or air (on, below or around this site), nor did it include an evaluation or study for the presence or absence of wetlands. These studies should be conducted under separate cover, scope and fee and should be provided by a qualified expert in those fields.

APPENDIX A - PLATES

LIST OF PLATES



Reference: Maptech Topoquad, Calistoga, California Quadrangle

Scale: 1" = 2000'

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Job No: 7548.01.04.2 | Date: DEC 2021

SITE LOCATION MAP
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE
1

EXPLANATION

B-3 Boring Location and Number

80 0 80 feet

N

Reference: Site Plan Titled 2008 Grant Street by CBG Civil Engineers, Sheet C-2

Scale: 1" = 80'

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EXPLORATION PLAN
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE 2

Date Drilled **11/15/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **20 1/2 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **11 feet**	Sampling Method(s) **Modified California, SPT**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sampling Resistance, blows/ft	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0		DARK BROWN CLAY WITH SAND (CH), medium stiff, moist								
	8									
		DARK BROWN CLAY WITH SAND (CH), stiff, moist								
	12									
5										
		GRAY SANDY CLAY (CH), very stiff, moist								
	20									
		GRAY BROWN SANDY CLAY (CH), stiff, moist, trace gravel								
10	8									
		GRAY CLAYEY SAND (SC), loose, wet, trace gravel ▽								
15	4				47.9					
	9									
		GRAY SANDY CLAY (CH), stiff, wet								
20	11									
		Boring terminated at 20 1/2 feet Groundwater encountered at 11 feet								

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Job No: 7548.01.04.2 Date: DEC 2021

LOG OF BORING B-1
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE **3**

Date Drilled **11/15/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **13 1/2 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **12 feet**	Sampling Method(s) **Modified California, SPT**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0				DARK BROWN CLAY WITH SAND (CH), medium stiff, moist								
	Modified California	5										
4				DARK BROWN CLAY WITH SAND (CH), stiff, moist								
5	Modified California	14										
7				BROWN CLAY WITH SAND (CH), very stiff, moist								
	Modified California	17										
10												
12	SPT	4		BROWN SANDY CLAY (CH), soft to medium stiff, wet ▽								
13.5				Boring terminated at 13 1/2 feet Groundwater encountered at 12 feet								
15												
20												

Date Drilled **11/15/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **5 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **No Groundwater Encountered**	Sampling Method(s) **Bulk**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0	Bulk		CH	DARK BROWN CLAY WITH SAND (CH), medium stiff to stiff, moist								R Value = 7
5				Boring terminated at 5 feet No groundwater encountered								
10												
15												
20												

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Job No: 7548.01.04.2 | Date: DEC 2021

LOG OF BORING B-3
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE **5**

Date Drilled **11/15/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **13 1/2 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **9 feet**	Sampling Method(s) **Modified California**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0				DARK BROWN CLAY WITH SAND (CH), stiff, moist, medium stiff in upper 2-1/2 feet								
		9										
5		8		BROWN CLAYEY SAND WITH GRAVEL (SC), loose, moist			34.1					
		5		BROWN SANDY CLAY (CH), medium stiff, moist								
10												
		28		BROWN CLAYEY GRAVEL WITH SAND (GC), medium dense, wet								
				Boring terminated at 13 1/2 feet Groundwater encountered at 9 feet								
15												
20												

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Job No: 7548.01.04.2 Date: DEC 2021

LOG OF BORING B-4
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE **6**

Date Drilled **11/16/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **18 1/2 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **8 feet**	Sampling Method(s) **Modified California, SPT**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sampling Resistance, blows/ft	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0		DARK BROWN SANDY CLAY (CH), medium stiff, moist, porous with rootlets								
	8				66.4	34.3	59.6	84		
		GRAY BROWN SANDY CLAY (CH), medium stiff to stiff, moist, root at 2-1/2 feet, medium stiff to 2-1/2 feet								
	8	GRAY BROWN CLAYEY SAND WITH GRAVEL (SC), loose to medium dense, moist, loose to 5-1/2 feet								
5										
	20									
		BROWN SAND WITH CLAY, GRAVEL, AND COBBLES (SP-SC), dense, wet								
10	31									
		BROWN SAND WITH CLAY AND GRAVEL (SP-SC), loose to medium dense, wet								
		BROWN CLAYEY SAND (SC), very loose to loose, wet								
15	4				23.3					
	10	GRAY CLAY WITH SAND (CH), stiff, wet								
		Boring terminated at 18 1/2 feet Groundwater encountered at 8 feet								
20										

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LOG OF BORING B-5

2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE 7

Job No: 7548.01.04.2 | Date: DEC 2021

Date Drilled **11/16/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **14 1/2 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **10 feet**	Sampling Method(s) **Modified California, SPT**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0				DARK BROWN CLAY WITH SAND (CH), medium stiff to stiff, moist, rootlets, medium stiff to 3 feet								
		10										
				GRAY BROWN SANDY CLAY (CH), stiff, moist								
5		12										
				BROWN CLAYEY SAND WITH GRAVEL (SC), medium dense, moist to wet, trace gravel								
		18										
10				∇								
		12					16.0					
				BROWN CLAYEY GRAVEL (GC), dense, wet								
		38										
15				Boring terminated at 14 1/2 feet Groundwater encountered at 10 feet								
20												

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Job No: 7548.01.04.2 Date: DEC 2021

LOG OF BORING B-6

2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE

8

Date Drilled **11/16/2021**	Logged By **AKU**	Checked By **REP**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **4 inch**	Total Depth of Borehole **16 feet**
Drill Rig Type **Bobcat Mounted**	Drilling Contractor **Stapleton**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **14 1/2 feet**	Sampling Method(s) **Modified California, SPT**	Hammer Data **140 lb 30" drop**

Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
0				DARK BROWN CLAY WITH SAND (CH), medium stiff to stiff, moist, medium stiff to 2 feet, rootlets								
		9										
		8		BROWN SANDY CLAY (CH), stiff, moist, trace gravel								
5												
		19		BROWN CLAYEY GRAVEL WITH SAND (GC), medium dense, moist								
				BROWN CLAY WITH SAND (CL), medium stiff, moist								
10		6										
15		6		GRAY SANDY CLAY (CL), medium stiff, wet								
				Boring terminated at 16 feet Groundwater encountered at 14 1/2 feet								
20												

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Job No: 7548.01.04.2 Date: DEC 2021

LOG OF BORING B-7
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE
9

Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13

COLUMN DESCRIPTIONS

1 Depth (feet): Depth in feet below the ground surface.
2 Sample Type: Type of soil sample collected at the depth interval shown.
3 Sampling Resistance, blows/ft: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
4 Graphic Log: Graphic depiction of the subsurface material encountered.
5 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
6 Dry Density (pcf): Dry density, in pcf.
7 Water Content (%): Water content, percent.
8 % <#200 Sieve: % <#200 Sieve
9 PI, %: Plasticity Index, expressed as a water content.
10 LL, %: Liquid Limit, expressed as a water content.
11 Expansion Index (EI): Expansion Index (EI)
12 UC, ksf: Unconfined compressive strength, in kips per square foot.
13 REMARKS AND OTHER TESTS: Comments and observations regarding drilling or sampling made by driller or field personnel. Su, psf: Undrained Shear Strength, in pounds per square foot (psf)

FIELD AND LABORATORY TEST ABBREVIATIONS

LL: Liquid Limit, percent
PI: Plasticity Index, percent
SA: Sieve analysis (percent passing No. 200 Sieve)
Su: Undrained Shear Strength, in pounds per square foot (psf)

MATERIAL GRAPHIC SYMBOLS

Fat CLAY, CLAY w/SAND, SANDY CLAY (CH)
Lean CLAY, CLAY w/SAND, SANDY CLAY (CL)
Clayey GRAVEL (GC)
Clayey SAND (SC)
Poorly graded SAND with Clay (SP-SC)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Bulk Sample
2.5-inch-ID Modified California w/ brass liners
2-inch-OD unlined split spoon (SPT)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

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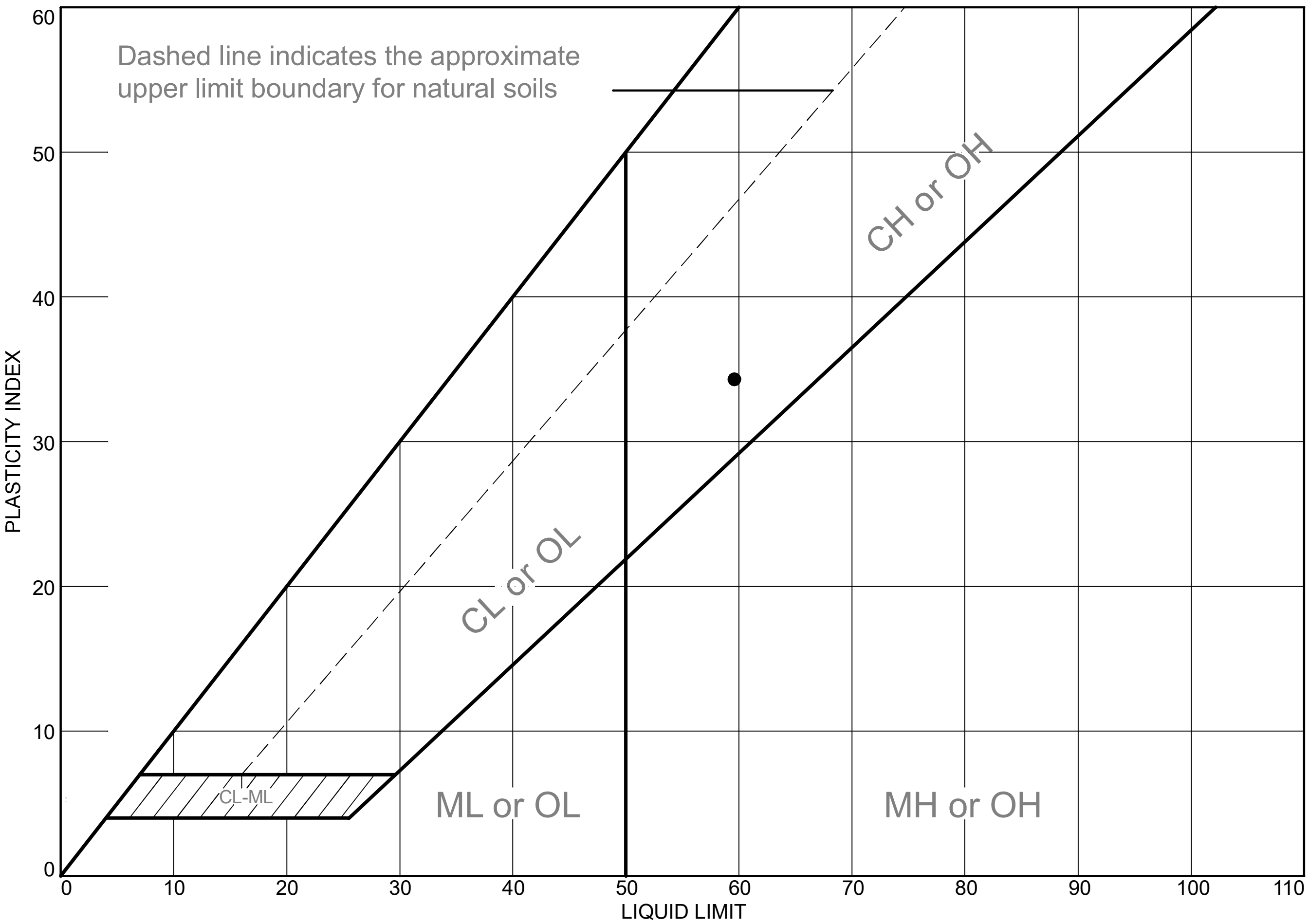
Job No: 7548.01.04.2 | Date: DEC 2021

SOIL CLASSIFICATION AND KEY TO TEST DATA
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE
10

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Dark Brown Sandy Clay (CH)	59.6	25.3	34.3		66.4	CH

Project No. 7548.01.04.2

Project: 2008 Grant Street Subdivision

● Source of Sample: B-5 Depth: 1.5' & 2.0'

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Remarks:

● Expansion Index= 84 (Medium)

Figure

Tested By: SCW Checked By: SEF

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Job No: 7548.01.04.2 Date: DEC 2021

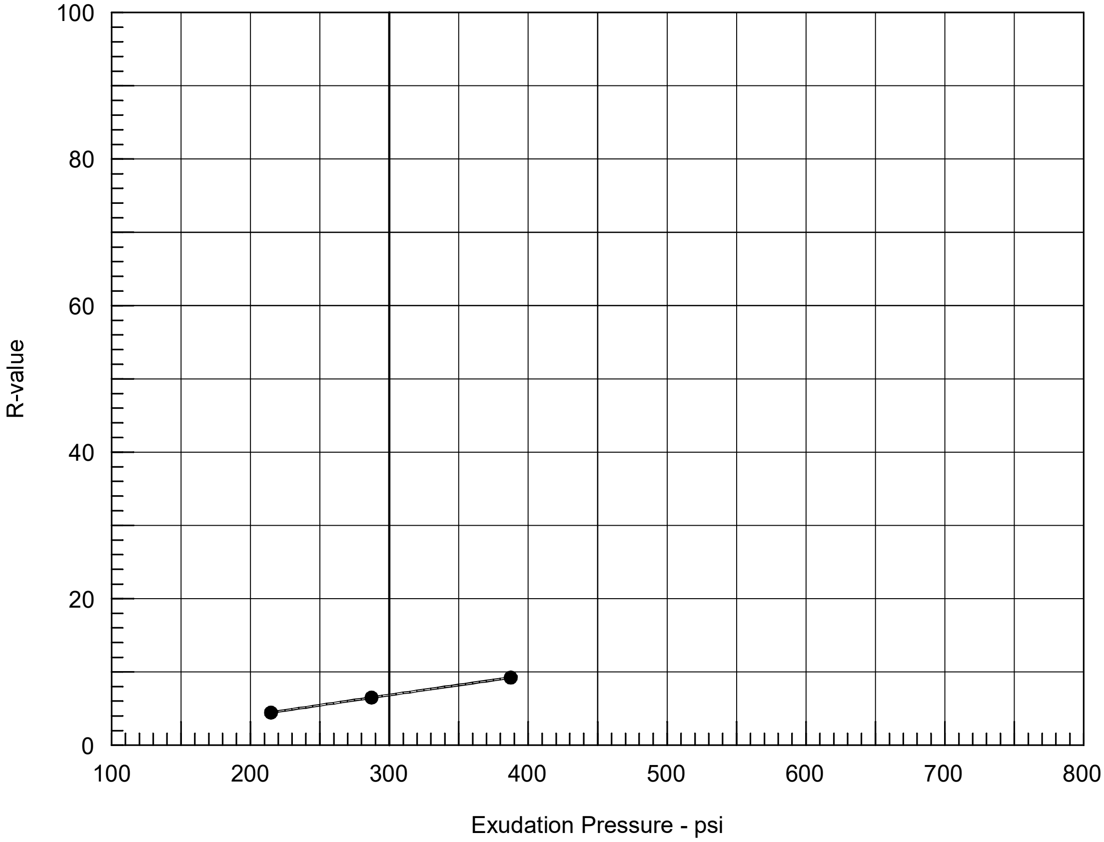
CLASSIFICATION TEST DATA

2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE

11

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - ASTM D2844

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psf	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	30	93.3	27.9	0	145	2.56	215	4	4
2	40	95.2	26.1	0	140	2.57	287	6	6
3	65	97.8	24.0	0	137	2.61	387	9	9

Test Results	Material Description
R-value at 300 psi exudation pressure = 7	Brown Clay W/ Sand (CH)

Project No.: 7548.01.04.2

Project: 2008 Grant Street Subdivision

Source of Sample: B-3 Depth: 0.0'-5.0'

Date:

RGH CONSULTANTS

Tested by: SAM

Checked by: SEF

Remarks:

Figure ________

RGH CONSULTANTS

Job No: 7548.01.04.2 | Date: DEC 2021

RESISTANCE (R) VALUE DATA

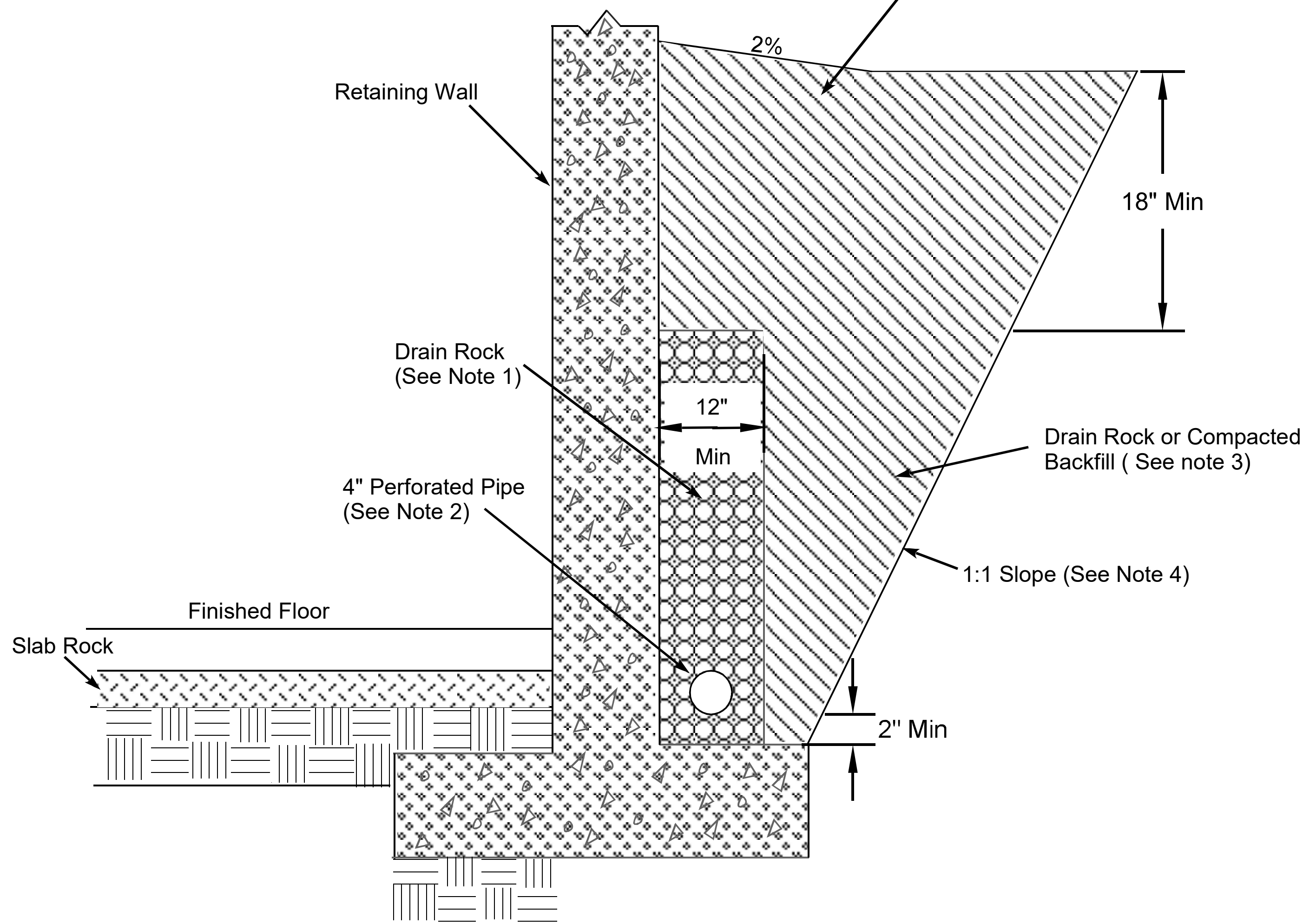
2008 Grant Street Subdivision

2008 Grant Street

Calistoga, California

PLATE

12



Notes:

1. Drain rock should meet the requirements for Class 2 Permeable Material, Section 68, State of California "Caltrans" Standard Specification, latest edition. Drain rock should be placed to approximately three-quarters the height of the retaining wall.

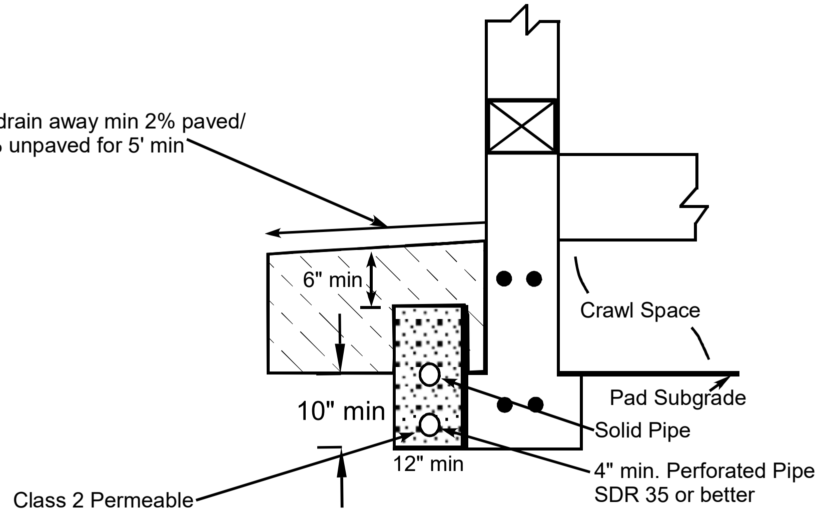
2. Pipe should conform to the requirements of Section 68 of State of California "Caltrans" Standards, perforations placed down, sloped at 1% for gravity flow to outlet or sump with automatic pump. The pipe invert should be located at least 8 inches below the lowest adjacent finished surface.

3. During construction the contractor should use appropriate methods such as temporary bracing and/or light compaction equipment to avoid overstressing the walls. Non-expansive soils to be used as backfill.

4. Slope excavation back at a 1:1 gradient from the back of footing where expansive materials are exposed.

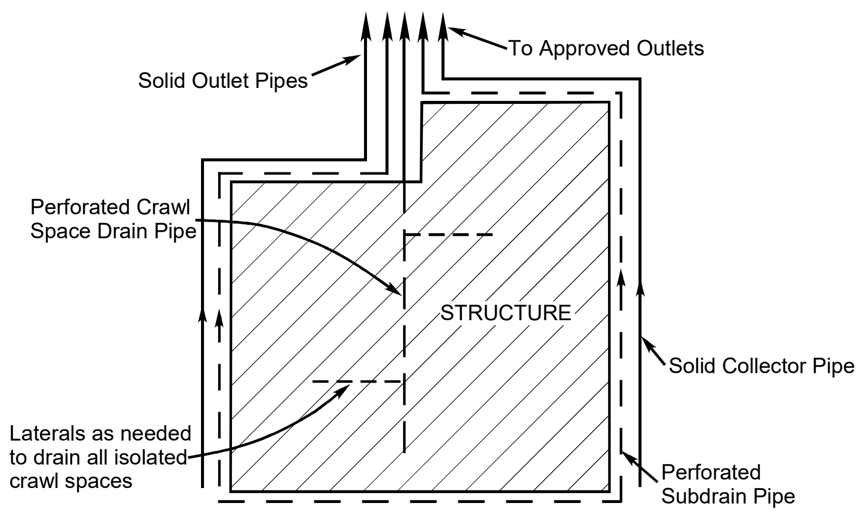
Not to Scale

RGH CONSULTANTS	**RETAINING WALL BACKDRAIN ILLUSTRATION** 2008 Grant Street Subdivision 2008 Grant Street Calistoga, California	PLATE **13**
Job No: 7548.01.04.2 — Date: DEC 2021		

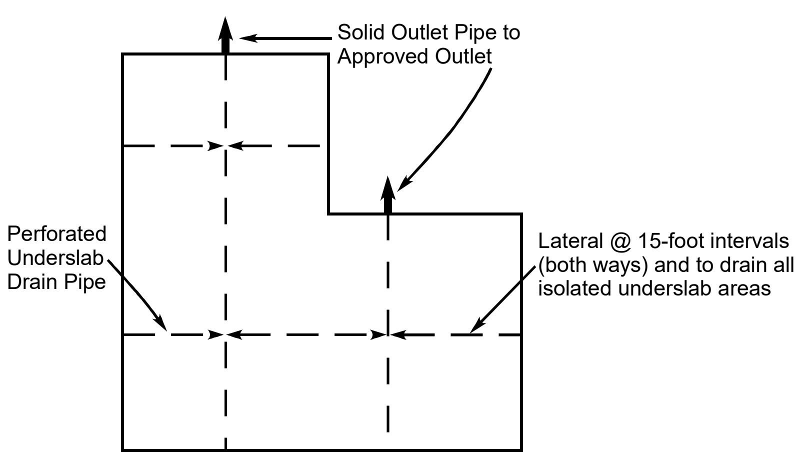


Spread Footing

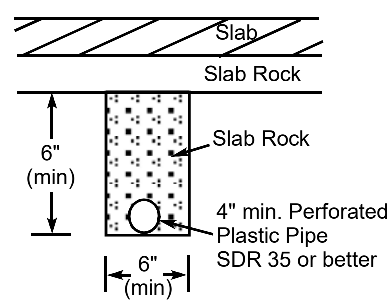
PERIMETER FOUNDATION DRAINS



TYPICAL FOUNDATION DRAIN PLAN



TYPICAL UNDERSLAB DRAIN PLAN



SLAB UNDERDRAIN

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CONSULTANTS

Job No: 7548.01.04.2 | Date: DEC 2021

TYPICAL SUBDRAIN DETAILS
2008 Grant Street Subdivision
2008 Grant Street
Calistoga, California

PLATE
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APPENDIX B - REFERENCES

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Youd, T.L., and Idriss, I.M., and 19 others, 2001, Liquefaction Resistance of Soils: summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils: ASCE Geotechnical and Geoenvironmental Journal, v. 127, no. 10, p. 817-833.

APPENDIX C - DISTRIBUTION

DeNova Homes, Inc. (e)
Attention: Kerri Watt
1500 Willow Pass Court
Concord, CA 94520
kwatt@denovahomes.com

REP:TAW:aku:brw

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one - not even you* - should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from alight industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes - even minor ones - and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ-sometimes significantly from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the express purpose of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in-this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely on Your ASFE-Member Geotechnical Engineer For Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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