GEOTECHNICAL INVESTIGATION
Proposed Single Family Residence
634 Palomar Drive
Redwood City, California

Prepared for:
Mr. Robert Kirk
P.O. Box 796
Mi Wuk Village, California 95346

Dated: October 17, 2013
Job 2537.01.00

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Earth Investigations Consultants

October 17, 2013
Job 2537.01.00

Mr. Robert Kirk
P.O. Box 796
Mi Wuk Village, California 95346

RE: GEOTECHNICAL INVESTIGATION
Proposed Single Family Residence
634 Palomar Drive
Redwood City, California

Dear Mr. Kirk:

INTRODUCTION

Site Location and Proposed Project

Pursuant to your authorization, we have completed the referenced project, located in the Palomar Park residential area of San Mateo County, California (Plate 1, Vicinity Map). The purpose of this report is characterize the site geotechnical setting, and provide pertinent recommendations for a future single family residence development on the currently vacant lot. We understand there is a stop work order associated with a grading violation imposed by the County of San Mateo Planning and Building Department (County File No. 2012-00127). This report contains remedial grading and drainage recommendations that are responsive to the County requirements defined in their December 12, 2013 letter.

Scope of Services

The scope of services undertaken to arrive at the findings, conclusions and recommendations included:

- Review of pertinent geologic and geotechnical literature and maps. Plate 3 contains an excerpt of a regional geologic map covering the site area;
- Site observations and drilling 6 borings on September 16, 2013 at selected site areas with a portable percussion rig. A continuous sample of the earth materials encountered was obtained by advancing a 1 ½ -inch O.D., split spoon sampler with a gas-powered Wacker BHF 30S hammer that imparts 35 ft. lbs. of axial force on the sampler at a rate of 1270 blows

per minute. The borings were advanced to a depth of practical refusal in bedrock. The locations of the borings are illustrated on Plate 2. The Logs of Borings are contained on Plates 4 through 6. Plates 7 and 8 contain descriptions of the terms and symbols used on the logs;

- Laboratory testing of the samples collected from the explorations. Tests included moisture content, dry density, Atterberg limits, particle size passing the ASTM #200 sieve, and pocket penetrometer unconfined compressive strength. Moisture and dry density test results are tabulated on the Logs of Borings at the respective sample depths. Plate 9 contains the results of the Atterberg limit and particle size testing;
- Analysis of the data and preparation of this report. Plate 10 depicts a representative cross section across the project site.

FINDINGS

Geologic Setting

The site is at an approximate elevation of 450 feet above mean sea level on the northern flank of a dissected spur ridge (Plate 1). This area drains to a seasonal drainage channel tributary to Cordilleras Creek.

According to Brabb and others (1998), this area is underlain by tightly folded, Juro-Cretaceous, Franciscan sandstone. In the site area, a strata dip steeply to the southwest. Leighton and Associates (1976) describe this bedrock material to include sandstone, siltstone and shale, and locally conglomerate. Relative stability of slopes ranged from poor to good depending on orientation of discontinuities relative to slopes. Earthquake stability is generally considered good relative to the capacity to support slopes.

There are no landslides affecting the site, nor was there observed evidence slope instability at the time of our site investigation.

The site lies in a tectonic block between the active San Andreas fault, mapped approximately 2 miles to the southwest and the Hayward fault mapped approximately 18 miles to the northeast. The active San Gregorio fault is mapped approximately 9 miles to the southwest. There are no active faults mapped across the site.

According to the Working Group (2008), there is a 63 percent chance of a magnitude 6.7 or greater earthquake occurring in the next 23 years. The percent probability for the aforementioned faults producing a major earthquake over this period is as follows: 3% for the San Gregorio-Seal Cove fault; 21% for the San Andreas fault; and 31% for the Hayward. Very strong to very violent ground shaking in the site area could occur during a major earthquake on one of these faults, however the potential for fault rupture on the site is nil given the relative distance to the nearest active fault trace. Similarly, very strong earthquake shaking can result in landslides and liquefaction; however, these secondary features are not expected in the site area given the mapped favorable orientation, and shallow depth to bedrock as indicated by the nearby roadcut exposures.

Site Characteristics

Surface Features

The site occupies a graded, moderately steep to steep northeasterly slope uphill of Palomar Drive (Plate 2, Site Plan). Undocumented grading that we understand occurred in 2012 created a benched topographic profile with an approximately 2-foot high vertical cut supported by post-supported plywood sheeting on the uphill margin of a gently sloping bench made for the proposed residence. A gently sloping gravel-surfaced bench separated from the upper bench by a steep fill slope (approx. 30 degrees) represents the proposed driveway extending across the eastern property line to the upper bench. There is another steep fill slope (approx. 25-35 degrees), which occurs on the downhill side of the driveway. Beyond the toe of the driveway fill slope, there is a steep, native slope (approx. 25 degrees) that extends to the northern property line adjoining Los Cerros Road.

Runoff across the site is generally uncontrolled. There was no evidence of seepage or landsliding. Significant erosion or siltation was not observed, owing the erosion control measures in place.

Explorations

The borings encountered wedges of undocumented fill overlying native colluvium that mantles bedrock (Plates 4-6 and Plate 10). The fill, up to 6 feet thick at the downslope side of the gravel driveway, consisted of medium dense, silty sand with variable gravel content. The colluvium encountered in Borings 1 and 2-5 consisted of a ½- to 4-foot layer of medium dense, silty sand over a 1- to 2 ½-foot layer of firm to very stiff, highly plastic, sandy clay with gravel. Boring 3 met refusal at the base of the fill, and 1 ½ feet of colluvium encountered in Boring 6 consisted of stiff, highly plastic, sandy clay. Soft, very weathered, and closely fractured Franciscan sandstone and shale was encountered beneath colluvium.

The soils encountered at the boring locations were moist to damp. Free ground water was not encountered in the borings.

CONCLUSIONS

The results of this investigation indicate that the proposed residential development if feasible from a geotechnical standpoint. The site is constrained by steep slopes underlain by undocumented fill and colluvium. There was no evidence of landslides of active faults constraining the project area. However, very strong to very violent ground shaking should be expected in the event of nearby, major earthquake. We judge the risk nil for the occurrence of ground rupture during a major earthquake. The risk of earthquake induced liquefaction is also nil given the condition of the soil profile, absence of ground water and shallow depth to competent bedrock. The risk of landsliding will be mitigated by adherence to the grading, drainage and retaining wall recommendations in the following section of this report.

RECOMMENDATIONS

Seismic Design

The proposed structures should be designed for the following seismic design criteria derived from the subsurface exploration data and the 2010 California Building Code (CBC):

- Site Location: Latitude = 37.481; Longitude = -122.2692
- Site Soil Class: D
- Spectral Response Acceleration Values: Ss = 2.207; S1 = 1.256; Fa = 1.0; Fv = 1.5; SMs = 2.207; SM1 = 1.884; SDs = 1.472; SD1 = 1.256

Site Preparation, Grading and Compaction

All construction and organic debris should be removed from the proposed development area. It will be necessary to remove all undocumented fill from the slopes and replace it as required for the project as engineered fill. If the bedrock surface is disturbed during surface soil removal, we recommend that it be scarified to a minimum depth of 8 inches and thorough compacted, as assessed by the soil engineer during grading.

Engineered fill planned for slopes greater than 10 degrees will require an equipment-width (min. 8 feet) base key extending at least 3 feet in the bedrock materials, and inclined at least 2 percent into the hillside. Key subdrainage will be assessed during grading, however plan to install on the uphill side a minimum 4-inch diameter, Schedule 40 perforated PVC pipe sloped at least 2 percent in the direction of discharge and embedded in 3/4– to 1 ½-inch clean crushed rock wrapped in Mirafi 140N filter fabric. With exception of the expansive colluvium, site soils will be an acceptable source for engineered fill. Import fill, if required, should be non-expansive, with a plasticity index of 15 or less.

Once the subdrainage is installed in key, loose soil should be placed in lifts of 6 to 8 inches thick, moisture conditioned to near optimum and then compacted to at least 90 percent of the maximum dry density (MDD) of the materials as assessed by the ASTM D1557 laboratory compaction test procedure. After the key is filled, level benches should be excavated into bedrock to support the engineered fill as it rises above the key to finished grade. Plan to install 2 bench subdrains, one a midway bench the other at the uppermost bench. The upper foot of engineered fill to support pavements should be compacted to at least 95 percent MDD. Engineered fill and cut slopes in bedrock should be no steeper than 2H:1V. Cut slopes in native colluvium should be no steeper than 3H:1V. Steeper cut and fill slopes will require retaining wall support.

Utility Trenches

Vertical trench excavations up to 5 feet deep should be capable of standing with minimal bracing for short duration (less than 30 days). However, contractors should be alert to potential instability. Trench walls deeper than 5 feet should be cut and braced in accordance with the State of California Safety Ordinance treating excavations and trenches.

Utility trenches should be designed to prevent the transportation of water into the foundations, and slabs or pavement subgrade soils. Care should be taken to assure that uncontrolled, concentrated runoff is not conducted toward the existing slopes. In particular, where utilities cross foundations, trenches should be plugged with compacted clayey soil for their full depth, and for a distance of at least 5 feet on either side of the foundations.

On-site, inorganic soil may be used as utility trench backfill. Special compaction of trench backfill will be necessary under and to within 3 feet of proposed structures, concrete slabs, asphalt pavements, and engineered fill. In these areas, backfill should be conditioned to approximately 3 percent above optimum and placed in horizontal lifts, each not exceeding 4 inches in loose thickness. Each layer should then be compacted to at least 90 percent MDD. The top 2 feet of trench backfill under pavements should be non-expansive, granular soil compacted to at least 90 percent MDD.

Foundations

We recommend that project structures be supported by drilled, cast-in-place reinforced concrete piers. Piers should be at least 16 inches in diameter, and extend at least 12 feet into the bedrock materials. Actual depths should be confirmed by the field engineer during drilling. As such, piers should be designed for an allowable skin friction value of 500 pounds per square foot (psf) beginning at the top of the bedrock surface. The skin friction value should be increased by 1/3 to account for wind and seismic loads. End bearing of piers should be neglected in design because of the difficulty in cleaning out small diameter holes. Resistance to lateral loads can be achieved by applying a passive equivalent fluid pressure of 500 pounds per cubic foot (pcf) acting over 1 ½ pier diameters beginning at the top of the bedrock. Piers on slopes steeper than 3H:1V should be designed to resist and equivalent fluid creep load of 50 pcf acting over 1 ½ pier diameters in the upper 3 feet of the soil profile.

Where not supporting a foundation retaining wall, we recommend that piers be interconnected by grade beams. Isolated deck piers are acceptable.

It has been our experience that potentially hard drilling conditions may be met in the bedrock. Hence, it is important that the foundation contractor be prepared by employing drilling equipment with adequate "down pressure" and equipped with rock bits.

In the event ground water is encountered in the pier holes, it may be necessary to remove standing water by the tremie method. If pier holes cave, it will be necessary to install casing to maintain the holes open until concrete is placed.

Retaining Walls

Retaining walls should be supported on the foundations recommended above. Retaining walls should be designed for an active equivalent fluid pressure of 55 pounds pcf for level backfill and 70 pcf for compacted backfill sloping up to 2H:1V. Interpolation can be made between the minimum and maximum active pressures that are assumed to act in a triangular distribution. Any wall that is restrained from rotation should be designed to resist a uniform pressure of 100 psf, acting in a rectangular distribution. Design of walls to resist seismic forces, per the 2010 CBC, should be evaluated using a seismic pressure equal to 15H psf, where H is the height of the retained soil. The seismic component should be considered a load acting at a point 0.5 times the wall height above the wall base.

Retaining walls should be fully backdrained. Retaining wall backdrains should consist of either a geosynthetic drainage mat and properly placed perforated pipe (as specified by the manufacturer, i.e., Miradrain 5000 or equivalent), or of 4-inch diameter, high crush strength, perforated SDR 35 or better PVC pipe embedded in crushed rock and sloped to drain at least 2 percent to outlet by gravity. Perforated pipes behind uphill and sidehill building foundation walls, and the upslope driveway retaining wall perforated pipes should be located at least 8 inches below the proposed crawl space, and slab elevations. If the crushed rock alternative is chosen, it should consist of a prism no less than 12 inches wide that extends to within 1 foot of the surface. The upper foot should be backfilled with compacted soil to exclude surface water. Drainrock should be separated from the soil by filter fabric. Retaining wall backdrainage should be directed to the storm drain.

Foundation retaining walls should be thoroughly waterproofed to prevent detrimental migration of moisture. Retaining walls will yield slightly during backfilling. Therefore, walls should be backfilled prior to building on or adjacent to them.

We recommend that the ground surface behind retaining walls be sloped to drain in a positive manner so that ponding and erosion does not occur. If necessary to achieve this, open, reinforced concrete lined gutters should be designed. Each gutter should drain to a grate-covered catch basin designed by the project engineer. Given the potential for tree leave accumulation, we recommend that a provision be made to avert clogging of the basin inlet and associated drainpipes. In turn, the basin should be connected to a solid pipe that carries water from the catch basin to the storm drain. Surface water should not be diverted into any subdrain.

Slabs-on-Grade

Slab subgrade should be prepared as recommended in the Grading section above. All concrete slabs should be at least 5 inches thick and underlain with a capillary moisture break consisting of at least 5 inches of clean, free-draining, crushed rock or gravel. Where migration of moisture vapor through the slabs would be detrimental, an impermeable moisture vapor barrier (15-mil Stego wrap or better) should be provided between the gravel and the slab. It may be prudent to place an additional 2 inches of clean sand over the membrane to protect it during construction. Slabs should be reinforced with at least no. 4 bars with an 18-inch orthogonal, center to center spacing. The slabs should contain control joints to help control the distribution of cracking should it occur.

Pavements

We anticipate that the driveway pavement will be reinforced concrete supported on engineered fill as recommended in the grading section. We recommend the driveway pavement should contain a section of 5 inches of reinforced concrete supported on the engineered fill by 6 inches of Class II baserock compacted to at least 95 percent MDD.

Drainage

Positive surface drainage gradients of at least 3 percent should be provided for a distance of at least 5 feet away from all structures. The driveway and paved parking areas should drain positively away from pavement subgrades and building foundations to an approved discharge location.

Where the upslope side of a building foundation is not designed as a drained retaining wall, we recommend that a perimeter foundation drain be installed to intercept potential seepage. The foundation drain should extend to a depth of at least 12 inches below the crawl space elevation, and at least 8 inches below a pavement of slab section. The foundation drainage trench should have a minimum width of 12 inches and the exposed soil surfaced with Mirafi 140N or better filter fabric. A minimum 4-inch diameter perforated, SDR 35 PVC drainpipe or better, laid holes down, should be placed at the bottom of the trench with a minimum slope of 2 percent to drain by gravity to outlet. The trench should then be filled to within 12 inches of the surface with ¾- to 1 ½ -inch drainrock. Place filter fabric over the top of the drainrock and fill the balance of the trench with compacted site soil with a finished slope away from the foundation. Once outside the crushed rock section of the trench, the perforated pipe should be connected to a solid SDR 35 drainpipe or better to carry water to the storm drainage system. Cleanouts should be of solid SDR 35 PVC pipe connected to the subdrainage system with sweep fitting at all bends greater than 45 degrees and intervals no greater than 50 feet.

Areas where foundation subdrainage is not feasible should be provided with a well-developed surface drainage basin seated in a concentric depression. The outer margin of the drainage depression should be located no less than 3 inches higher than the catch basin rim elevation so that positive sheet flow to the inlet is maintained.

We recommend that the house and garage roofs be provided with gutters and downspouts. The downspouts should be connected to solid SDR 35 PVC pipes and these pipes should carry water to the storm drain. Care should be taken to avoid discharge of drainpipes on unprotected slopes.

Erosion Control

Following construction, barren soil surface should be protected from erosion. An erosion control plan should be prepared.

SUPPLEMENTAL SERVICES

We recommend that we review the final foundation, grading and drainage plans for conformance with the intent of our recommendations. During construction, we should observe the rough and finished grading operations, foundation excavations prior to steel placement, and the installation of all drainage facilities prior to burial to ascertain that our recommendations are followed. Upon completion of the project, we should perform a site observation and report the results of our work in a final report. These services are outside the present scope and will be billed on a time and materials basis, in accordance with the fee schedule current at that time. These services will be performed only if we are provided with sufficient notice to perform the work. We do not accept responsibility for items that we are not notified to observe. We recommend that the Owner be responsible for notification, no less than 48 hours before the requested site visit.

INVESTIGATION LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering principles and practices, and is in accordance with the standards and practices set by the geotechnical consultants in the area. We offer no warranties or guarantees.

Subsurface conditions could vary between those indicated by the test borings and interpreted from surface features. A representative from this office should be present to provide construction observation services, to observe the exposed geotechnical conditions, to modify recommendations, if necessary, and to ascertain that the project is constructed in accordance with the recommendations.

This report is submitted with the understanding that it is the responsibility of the Client (Owner) to ensure that the applicable provisions of the recommendations contained herein are made known to all design professionals involved with the project; that they are incorporated into the construction drawings; and that the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations in the field.

If conditions different from those described in this report are encountered during construction, or if the project is revised, we should be notified immediately so that we may modify our recommendations, if warranted.

The practice of geotechnical engineering changes, and, therefore, we should be consulted to update this report if construction is not performed within 12 months.

MAINTENANCE

Periodic land maintenance will be required. Surface and subsurface drainage facilities should be checked frequently, and cleaned and maintained as necessary.

REFERENCES

Brabb, E.E., Graymer, R.W., Jones, D.L., 1998, Geology of the onshore part of San Mateo County, California: A digital database, U.S. Geological Survey Open-File Report 98-137, map scale 1:62,500.

Leighton and Associates, 1976, Geotechnical hazard synthesis map of San Mateo County, California: Geotechnical consultant's report to the San Mateo County Planning Department, map scale 1:24,000.

Petersen, M. and others, 1999, Seismic shaking maps of California: California Division of Mines and Geology Map 48.

Wagner, D.L., Bortugno, E.J. and McJunkin, R.D., 1991, Geologic map of the San Francisco – San Jose quadrangle, California Division of Mines and Geology, map scale 1:250,000.

Working Group on California earthquake probabilities, 2008, The uniform California earthquake rupture forecast, version 2 (UCERF 2): U.S. Geological Survey Open File Report 2007-1437.

The following plates are attached and complete this report:

- Plate 1 – Vicinity Map
- Plate 2 – Site Plan
- Plate 3 – Geologic Map
- Plate 4 – Logs of Borings 1 & 2
- Plate 5 – Logs of Borings 3 & 4
- Plate 6 – Logs of Borings 5 & 6
- Plate 7 – Key to Borings
- Plate 8 – Rock Hardness Criteria
- Plate 9 – Plasticity Chart
- Plate 10 – Generalized Cross Section A-A'

We trust that this provides you with the information you require at this time. If you have any questions, please call.

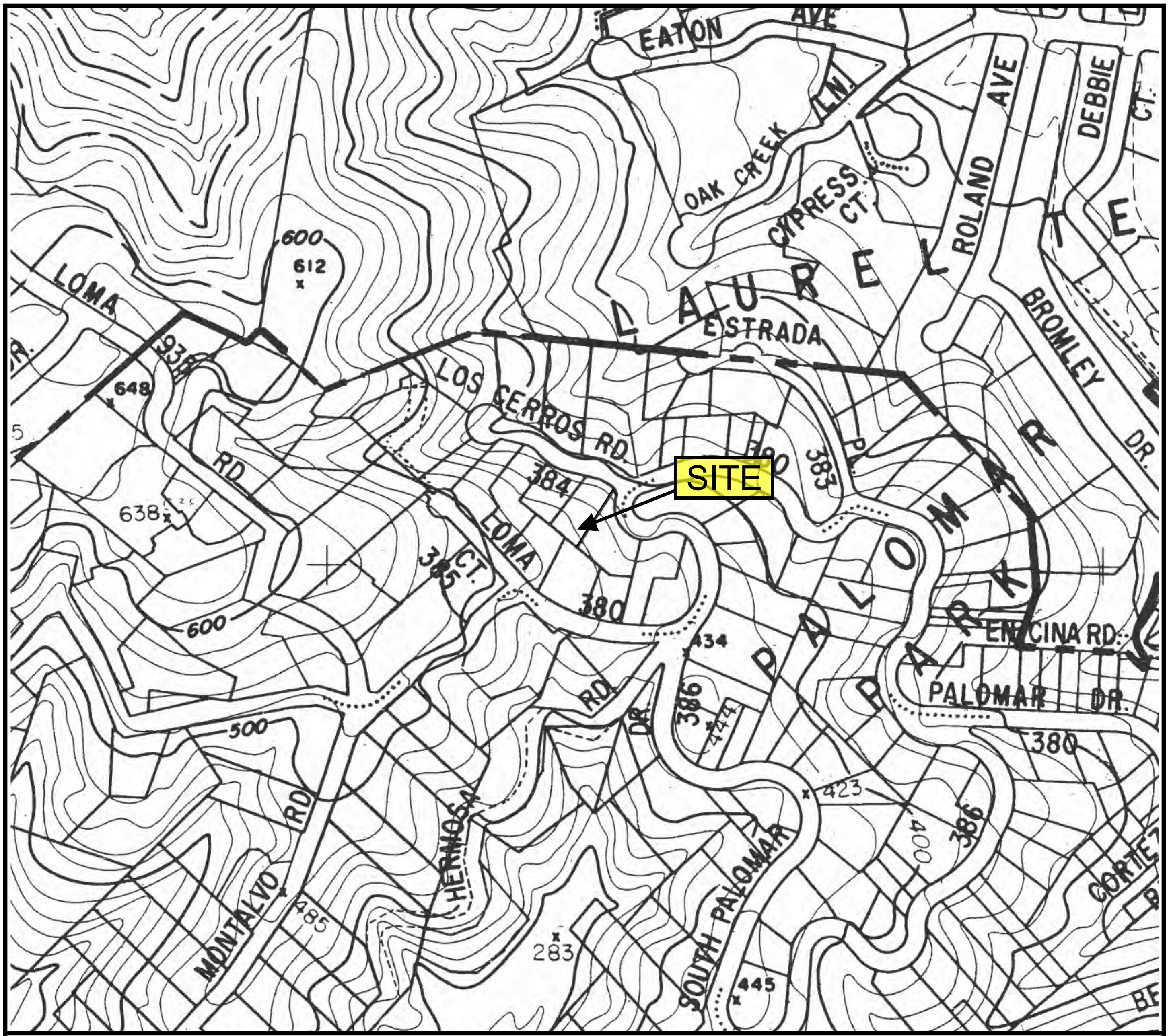
Very truly yours,

Earth Investigations Consultants

Joel E. Baldwin, II
Engineering Geologist 1132 (Renewal date 2/28/15)

David W. Buckley
Civil Engineer 34386 (Renewal date 9/30/15)

JEB:DWB:jb:gi
Distribution: e-file and 3 bound copies to addressee



N

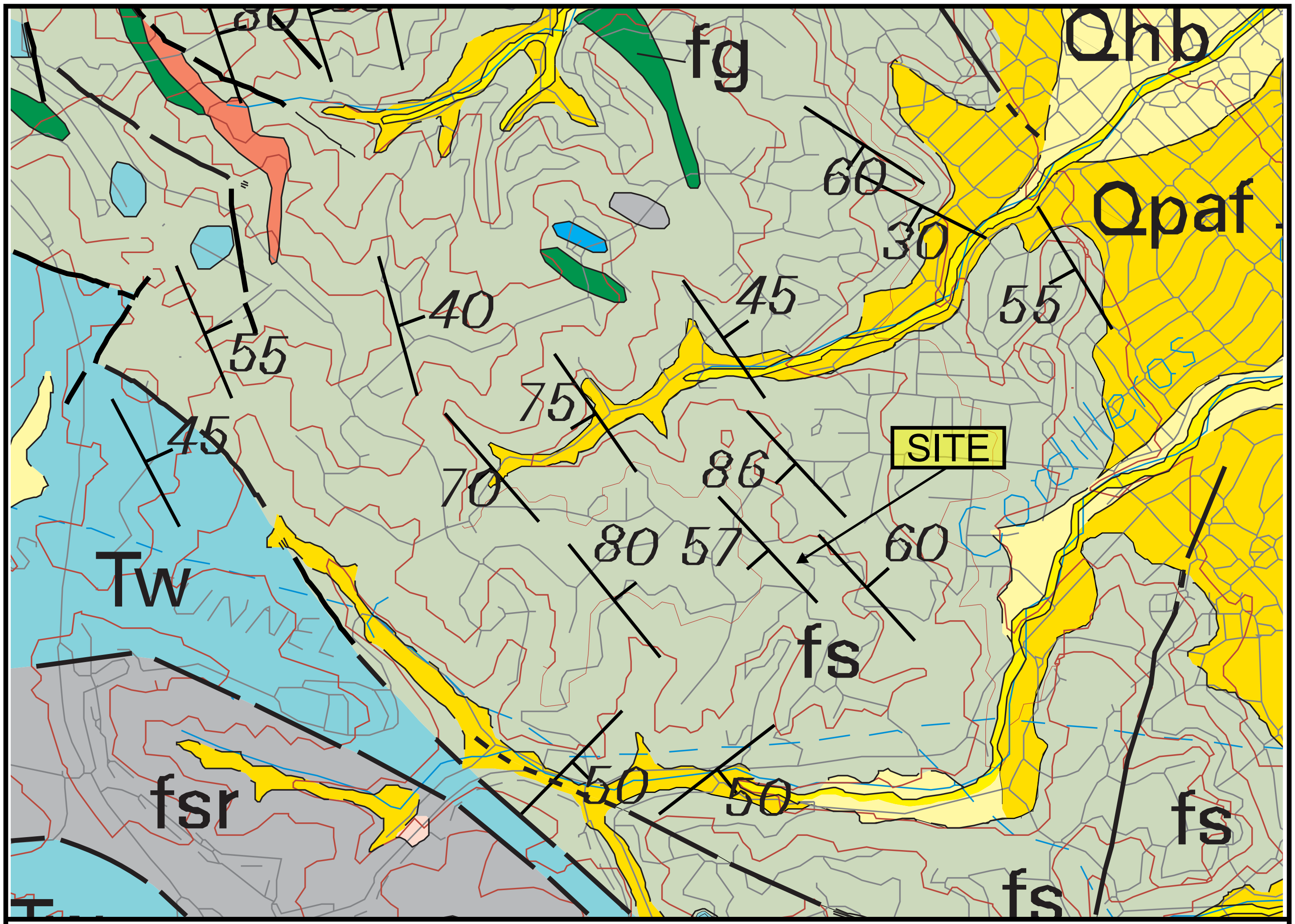
400 ft.

Scale

Contour interval = 20'

San Mateo County Topographic Map 11G (1/1/96)

Earth Investigations Consultants	**Job No.**	2537.01.00	**VICINITY MAP**	**Plate**
	Date	10/4/13	634 Palomar Drive Redwood City, California	1



EXPLANATION

Qhb	**Basin deposits (Holocene)**
Qpaf	**Alluvial fan and fluvial deposits (Pleistocene)**
Tw	**Whiskey Hill Formation (middle and lower Eocene)**

Franciscan Complex

fs	**Sandstone**
fg	**Greenstone**
fsr	**Sheared rock (melange)**

Contact –Depositional or intrusive contact, dashed where approximately located, dotted where concealed

Fault –Dashed where approximately located, small dashes where inferred, dotted where concealed, queried where location is uncertain.

35 **Strike and dip of bedding**

N

2000 ft.

Scale

Brabb & others (1998)

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Date 10/4/13

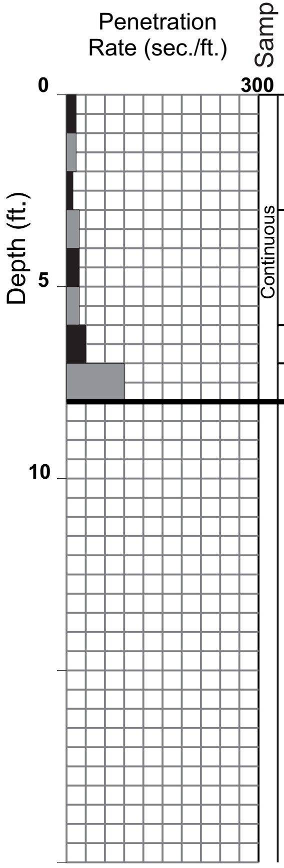
GEOLOGIC MAP

634 Palomar Drive
Redwood City, California

Plate
3

SOIL PROBE 1

Equipment Portable Percussion Rig
Elevation✦ ~108' Date 9/16/2013



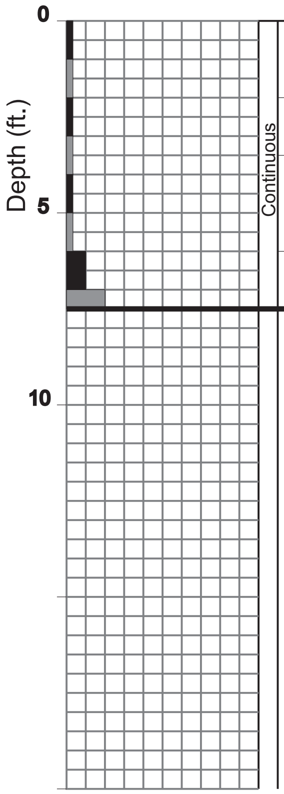
Dry Density (pcf) *	Moisture Content (%)
105.9	11.1
108.7	9.3
115.4	13.8

USCS	
SM	Yellowish brown and dark yellowish brown Silty SAND with Gravel, moist, medium dense (**af**)
SM	Dark brown Silty SAND with Gravel, moist, medium dense (**COL**)
CL	Yellowish brown and strong brown Sandy CLAY with Gravel, damp, stiff (**COL**)
ROCK	Dark yellowish brown SHALE, very weathered, closely fractured, soft (**BEDROCK**)

Terminated at 8'

SOIL PROBE 2

Elevation✦ ~108' Date 9/16/2013



Dry Density (pcf) *	Moisture Content (%)
107.8	10.2
103.6	11.2
111.4	16.7

USCS	
SM	Dark yellowish brown Silty SAND with Gravel, moist, medium dense (FILL)
SM	Dark brown Silty SAND with Gravel, moist, medium dense (COLLUVIUM)
CL	Dark brown Sandy CLAY with Gravel, damp, firm to stiff (COLLUVIUM)
ROCK	Dark yellowish brown and dark brown SHALE, very weathered, closely fractured, soft (BEDROCK)

Terminated at 7 ½'

EXPLANATION

✦ Elevation from Plate 2 - Site Plan
* Disturbed sample

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Date 10/4/13

LOGS OF SOIL PROBES

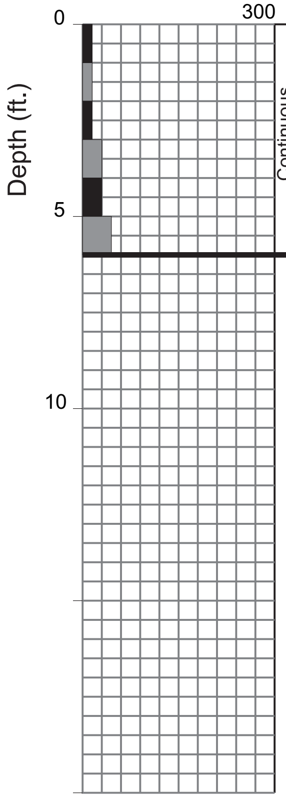
634 Palomar Drive
Redwood City, California

Plate 4

SOIL PROBE 3

Equipment Portable Percussion Rig

Elevation✦ ~99' Date 9/16/2013

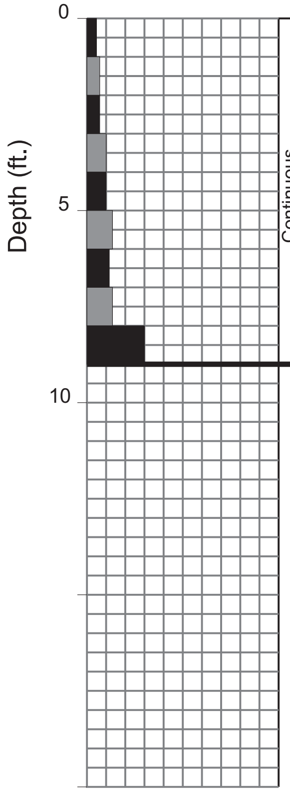


Dry Density (pcf)*	Moisture Content (%)	Sample	USCS	
102.9	8.0	Continuous	SM	Dark yellowish brown Gravelly Silty SAND, moist, medium dense (FILL)
108.4	9.9			

Terminated at 6'

SOIL PROBE 4

Elevation✦ ~97' Date 9/16/2013



Dry Density (pcf)*	Moisture Content (%)	Sample	USCS	
98.1	10.7	Continuous	SM	Dark yellowish brown Gravelly Silty SAND, moist, medium dense (FILL)
111.3	6.5		SM	Yellowish brown Silty SAND, moist, medium dense (COLLUVIUM)
			CL	Dark yellowish brown Sandy CLAY, moist, very stiff (COLLUVIUM)
107.3	12.2		ROCK	Dark yellowish brown SHALE, very weathered, closely fractured, soft (BEDROCK)

Terminated at 9'

EXPLANATION

✦ Elevation from Plate 2 - Site Plan

* Disturbed sample

Earth Investigations Consultants

Job No. 2537.01.00

Date 10/4/13

LOGS OF SOIL PROBES

634 Palomar Drive
Redwood City, California

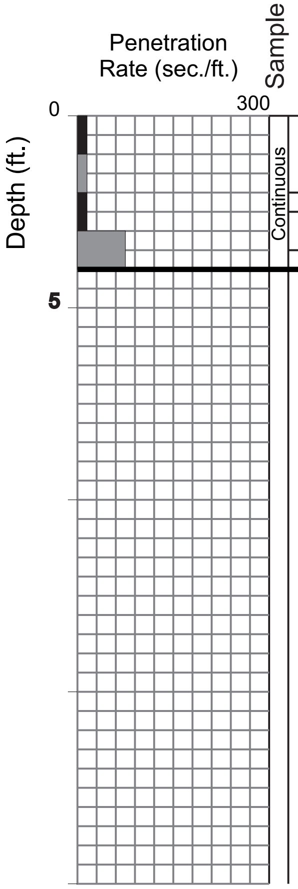
Plate 5

SOIL PROBE 5

Equipment Portable Percussion Rig

Elevation✦ ~92' Date 9/16/2013

Dry Density (pcf)*	Moisture Content (%)
113.8	19.4



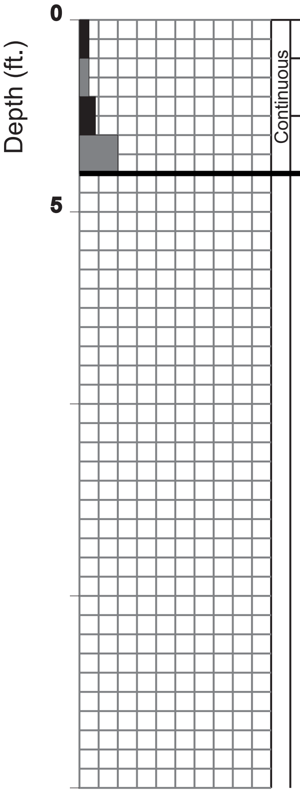
USCS	
SM	Dark yellowish brown Silty SAND with Gravel, moist, medium dense (FILL)
SM	Dark yellowish brown Silty SAND, moist, medium dense (COLLUVIUM)
CL	Yellowish brown Sandy CLAY with Gravel, moist, very stiff (COLLUVIUM)
ROCK	Yellowish brown SANDSTONE, very weathered, closely fractured, soft (BEDROCK)

Refusal at 4'

SOIL PROBE 6

Elevation✦ ~90' Date 9/16/2013

Dry Density (pcf)*	Moisture Content (%)
123.7	8.3
108.4	14.8



USCS	
SM	Yellowish brown Silty SAND, moist, medium dense (FILL)
CL	Dark yellowish brown Sandy CLAY with Gravel, damp, stiff (COLLUVIUM)
ROCK	Yellowish brown SANDSTONE, very weathered, closely fractured, soft (BEDROCK)

Refusal at 4'

EXPLANATION

✦ Elevation from Plate 2 - Site Plan
★ Disturbed sample

Earth Investigations Consultants

Job No. 2537.01.00

Date 10/4/13

LOGS OF SOIL PROBES

634 Palomar Drive
Redwood City, California

Plate 6