Alan Kropp & Associates
Memorandum

Date: May 29, 2009 **AKA Project No.:** 2335-12
Project: Slide Investigation Building 25 Area Project
(LBNL Subcontract No. 6881630)
To: Sheree Swanson
From: Wayne Magnusen, G.E.
R.E.: Summary of Preliminary Investigation and Analyses

This memorandum summarizes the results of our preliminary investigation and analyses of a previously-mapped "paleolandslide" beneath Building 25 at the Lawrence Berkeley National Laboratory (LBNL). Alan Kropp & Associates (AKA) and William Lettis & Associates, Inc. (WLA) provided services in general accordance with AKA's May 7, 2009 proposal, which was authorized under LBNL Subcontract No. 6881630. This memorandum has been prepared for the exclusive use of LBNL and their consultants for specific application to the proposed project in accordance with generally accepted geologic and geotechnical engineering practices. No other warranty, expressed or implied, is made.

Purpose and Scope

LBNL is considering various scenarios under which a new building would be constructed at the general location now occupied by Building 25. The purpose of our preliminary study was essentially threefold:

- To confirm or refute the existence of a previously mapped landslide beneath Building 25;
- To develop preliminary interpretations of geologic conditions in the Building 25 area; and
- To analyze slope stability and seismic deformations based on the preliminary geologic interpretations.

The preliminary study was conducted over a two week-period in order to meet LBNL schedule objectives. For this reason, the scope of our investigation and analyses were limited to what could be reasonably completed within the targeted timeframe.

The scope of the investigation included a preliminary review of existing data, geologic field reconnaissance, drilling three test borings (AKA-1 to AKA-3), and detailed geologic review and interpretation of the retrieved core (hand-edited logs of the borings are attached). The scope of the geologic analyses included developing a conceptual model of probable geologic conditions (preliminary geologic map and cross sections attached). The scope of our engineering analyses included evaluating slope stability and seismic deformations using simplified limit-equilibrium and pseudostatic-based methods (printouts from computer analyses are attached). The scope of our reporting consisted of a meeting with LBNL representatives (on May 28, 2009) to present the preliminary results, and this brief summary memorandum with attachments. It is understood by LBNL that additional data review, investigation, analyses, consultation, and design-level reporting would be needed to augment this preliminary study if LBNL proceeds with the design of a new building at the subject Building 25 site.

Summary of Key Findings

The key findings of this preliminary study include the following:

1. The geologic conditions encountered in the borings are considered generally consistent with the pre-existing paleolandslide hypothesis. For instance, sheared bedrock materials were encountered at or near the target depths we established using information presented in the RCRA Facility Investigation (RFI) report.

2. The vertical and lateral dimensions of the interpreted paleolandslide shown on the attached figures is based on the subsurface investigation, data compilation and review of previous boreholes in the vicinity of Building 25, geologic mapping and interpretation of historical aerial photography. The interpreted landslide geometry from this study differs somewhat from that presented in the RFI report; most significantly, it is permissible to interpret the Orinda Formation beneath Lawrence Road as potentially a part of the paleolandslide rather than "in-place" bedrock.

3. Our qualitative evaluation of historic aerial photography did not identify any geomorphic features suggestive of recent landsliding. We consider absence of such features together with our observation of generally rounded and subdued surface topography to be generally consistent with the hypothesis that the paleolandslide deposits are geologically stable.

4. Our geologic reconnaissance confirmed the general absence of kinematic indicators and landslide-related geomorphology that show the paleolandslide landslide to be active since the site was developed. Curb offsets noted in the road between Building 25 and Building 4 were found to be inconclusive with respect to evaluating historic landslide activity.

5. Backcalculation of shear strength using pre—grading topography and groundwater levels about 5 feet above their current elevations resulted in a slide plane friction angle of 15 degrees assuming zero cohesion. This value is low relative to laboratory tests performed on samples from nearby LBNL sites (typically closer to 20 degrees).

6. Our quantitative evaluation of slope stability using the 15 degree friction angle value resulted in very low factors of safety for the existing condition (FS<1.03). We judged this analysis to be overly conservative based on existing site geologic and geomorphic conditions.

7. Our quantitative evaluation of slope stability using a 20 degree friction angle resulted in a static factor of safety of 1.39. We judged this result to be generally reasonable and noted that strength values higher than about 20 degrees could not be justified based on our visual review of the retrieved core samples (note that no geotechnical laboratory testing was performed as part of this preliminary study).

8. Our quantitative evaluation of yield acceleration of the slide mass (the out-of-slope horizontal pseudostatic acceleration at which the factor of safety equals 1.0) resulted in a value of 0.118 times the acceleration of gravity (g). This is the acceleration value at which the landslide would start to slide incrementally during a seismic event.

9. Our quantitative evaluation of deviatoric slope displacements (cumulative slope movement during an earthquake) using the 0.118 yield acceleration and ground motions obtained from the 2008 URS spectra for a 475-year return period level of hazard at an LBNL rock site resulted in a median displacement value of about 3.5 feet.

10. We re-evaluated slope stability and deviatoric slope displacements using an alternate and more favorable slide plane geometry where the Orinda Formation beneath Lawrence Road is "in-place" and not a part of the paleolandslide. These quantitative evaluations resulted in a static factor of safety of about 3.0, a yield acceleration of about 0.24, and a median seismic displacement value of about 1.3 feet.

Discussion

The calculated median displacement values for the site (1.3 to 3.5 feet) obtained from the two hypothetical basal slide plane geometries is likely greater than that which could be tolerated by a new building straddling the landslide headscarp or lateral margins. The methodology used to arrive at this value is among the generally-accepted procedures currently used to evaluate seismic slope displacements in California. The principal researcher that developed the method (Dr. Jonathan Bray, also a member of the University's Seismic Review Committee) generally stands behind this approach and views the analysis results of an index of seismic slope performance. He also commonly notes that displacements may be half or twice the calculated median value. This observation is generally consistent with the 16th and 84th percentile lines (below and above the mean, respectively) shown on the attached yield acceleration (k_Y) vs. displacement plot.

The calculated displacement values, however, appear to differ from what would be expected by the review and preliminary analysis of historic photography and geomorphic mapping. In the opinion of the geologists, vertical and lateral displacements of several feet or more occurring periodically (~150 years) over many cycles of triggering earthquakes on the Hayward fault would probably be able to be discerned on the 1935 and 1939 pre-development photographs. However, these photographs exhibit very subdued landslide-related geomorphic relations in the region of the mapped paleolandslide with the exception of smaller, shallow, and younger-appearing slumps and debris flows at the margins of the paleolandslide. This apparent inconsistency is unresolvable using only the data from this preliminary study. In our opinion, reasonable "next steps" to further evaluate the suitability of this site include:

A. Additional geologic investigation (i.e. trenching) might be performed to evaluate the recency of landslide movement and provide a more substantive quantitative geologic argument showing that the landslide deposits have not experienced downslope movements over one or more large earthquake events on the Hayward fault. This type of geologic assessment my prove advantageous (if conclusive evidence is found showing that movement <u>has not</u> occurred across the paleolandslide margin over thousands of years); disadvantageous (if conclusive evidence is found showing that movement <u>has</u> occurred across the paleolandslide margin in relatively recent times); or may be inconclusive (if movement cannot be confirmed, disconfirmed or age-dated).

B. If additional geologic investigation yields advantageous results, supplemental investigations, laboratory testing and engineering analyses may be warranted to "close the gap" between the geologic interpretation showing the site to be historically stable and the preliminary engineering evaluations suggesting that it is not.

C. If additional geologic investigation yields disadvantageous or inconclusive results, an engineering evaluation might be performed to evaluate what types of slope stabilization measures could feasibly be implemented to reduce seismic slope displacements to "tolerable" levels. We anticipate that such measures might include both structural (e.g piers, tiebacks and retaining walls) and geotechnical (e.g shear pins and ground improvement) methods.

The additional investigations and analyses outlined above were outside of the scope of this initial preliminary study.

List of Attachments

1. Boring Logs
2. Geologic Map
3. Interpretive Cross Sections
4. Limit-Equilibrium Analysis Results
5. Deviatoric Slope Displacement Analysis Results

PHOTOS 11 – 19

WLA

BORING LOG

Project: LBNL Bldg 25	Job No: 2072	Boring No: ~~WLA-B-1~~ AKA-1	Boring Location: Bldg 25, ~B-1, Meridian
Type & Diameter of Boring: HQ Mud rotary		Elevation @ Top of Hole / Total Depth: /465'	
Sampling Method: ModCal (3.00"); 101 Continuous		Sample Driving Hammer and Drop: Auto 30"	
Drilling Contractor and Rig: Pitcher - Frosto Multidrill XL		Date Started: 5/18/09	Date Completed: 5/18/09
		Depth to groundwater: NA	Logged By: S. Sundermann
		Notes: KDHS Review 5/21/2009 ; JNB 5.22.09	

SPT N_1(60) 0 10 20 30 40 50 60	Uncorrected Blows per 6-inch drive	Depth (feet)	Soil Type (USCS)	Sampler Type	Recovery (inches)	Pocket Pen. (TSF)	Shear Torvane (TSF)	Description	Remarks
		0						ASPHALT GRAVEL, sandy; lt. brown; well compacted; dry; no plasticity; (AB Road base)	Begin: 10:25 PID: 0.1 Background Pop asphalt cap w/rig Hand Auger: 5.0 PID 10:40 0.0 ppm
		1							
		2							
		3							
		4						Increasing sand, decreasing gravel at 4.0 feet (approximate)	Difficult augering; switch to rig w/ Tim approval @ ~ 2.5'
		5			15/18 83%			SAND, gravelly to GRAVEL, sandy; damp to dry; lt. yellowish brown (10YR 6/4); moderately well graded; fine to medium sand, trace silt; gravel is subrounded, up to 2cm diameter (FILL)	PID 11:00 0.0 ppm
	14 16 15	6							
		7							
		8						8.0'	
	8 11 17	9						CLAY; moist; dark reddish gray (2.5YR 4/1), mottled red (2.5YR 4/6); very stiff to stiff; 70% clay matrix, medium to low plasticity; (Colluvium)	Color change to reddish clay @ 8.0'
		10							
		11							PID 11:34 0.0 ppm
		12			15			11.8 Silt/clay, Red-tan, color banding .01-.1' thick sub-horiz. Hardens w/ depth + dry.	Switch to 101 coring at 11.5';
		13			14			red clay at gradual contact (.1' interbedded). Prominent banded REDDISH clay with thin grayish silty clay laths NEAR contact; ↳ hard and stiff clay looks similar to Tm/To contact but not soft and weak; Appears to interfinger	PID 11:55 0.0 ppm
		14							PHOTO 11
		15							

Box 1 Run 1 (5'-15')

In Box 5 (5'-10')

4.3' WAVY + UNDULATORY CLAY SEAMS 10° to 25° (LITHOLOGIC CHANGE ABOVE + BELOW)

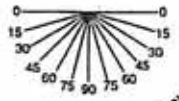
* Look @ again @ TWA-2 Tm/To contact.

3.0-inch O.D. split spoon sampler | ModCal 2.5-inch O.D. split spoon sampler | Standard Penetration Test (SPT) sampler

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/18/09	B-1

WLA



Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
15	Box 1	1.0/1.0	Run 2	1.0/1.0	100	0		4.0 P.P.		0.5' Slough? Siltstone - green w/ hard thick clasts ~.2'-.5' thick, w/ lenses of .01' thick red clay. GRAVEL, sandy, clayey GLEY 2 (Channel deposits) - large. 1"-2" sub-ang. cobbles of qtz + volc.	SILTSTONE OVERLYING Qc? NEED TO RECONCILE - OR WORD TO conglomerate. SILTSTONE CONGLOMERATE OR QUARTZ VEIN CLASTS to Tm. - GRAVEL possibly similar to outcrop at WP 64. Channel	PID 12:17 0.0 ppm PID 12:24 0.0 ppm No recovery 18' Gray sandy gravel cuttings. Possibly chasing cobble
16													
17													
18		0.9/4.0		22	0								
19										(contact between 16.0 & 20.0			No recovery 19'
20			Run 3							CLAY, w/ gravel; dk. reddish gray (2.5YR 4/1); mottled red (2.5 YR 4/6); very stiff to stiff; fat clay matrix; mod. to low plasticity; Some to little angular fine size, subrounded to fine pebble sized clasts of Moraga. Matrix?	at 21.3' (0.05-1' thick) V. WEAK and soft gravelly clay, gray SOFT and moist to low strength; no concentrated clay seams; MATERIAL WEAKER above than below seam ↑ Qc - WEAK MATERIAL.	(SLIDE RELATED TO HLA Repair?)
21		1.6/2.5	Run 4	6.4	1.0/1.6			0.5 P.P.					
22	Box 1 / Box 2									increased Silt (olive) at base ↓ ? — ? — ? — ?	TOR Between 22 & 25'		PID 12:54 - 0.0 ppm Siltstone cuttings at 22.8'
23			Run 5	0	0	0							PID 13:30 0.0 ppm No recovery Rock lodged
24													
25		1.8/1.8	Run 6	1.8	100%	0.5/1.5	HW	1.5 F.V.		ORINDA Fm. Siltstone, HW, large clay seams up to 1.5cm in thickness; Fat clay, high plasticity; some v. Fine Sand; Medium to dark bluish gray (5B 5/1) weak to very weak (R2-R1); moderately to slightly fractured	* 26' - 27' (CLAY RICH) ↑ ABOVE 2" thick clay - FRACTURED SILTSTONE. Red tinted clay rich zone — Break may be due to drilling Shear on Soft red material & red clay Sub. Horiz; polished slickensides	NO CHANGE IN ROLL TIDE. polished slickensides; PHOTO 12
26													
27		2.0/2.0	Run 7	2.0	100%	1.0/2.0							
28	Box 2					50	HW	2.0' Abrupt		ORINDA Fm. Conglomerate, HW-CW, up to 70% clasts w/clay and sand matrix			
29		0.8/1.0	Run 8	80	0		HW	2.2' 0.8		ORINDA Fm. Siltstone, HW, same as above ✓ clasts .2'-.5' thick			PID 13:50
30													

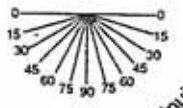
↓ 13:14 (V-thin Resin 0.05 THICK clay seam), polished surface.. 27.6 - SHIFT TO GRADATIONAL 10°; SAME MATERIAL BOTH SIDES OF SEAM.

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL	2072	5/18/09	WLA B-1

WLA



Depth (feet) | Log | Drill Rate (min/ft) | Run No. | Recovery/Cut | % Recovery | RQD | Weathering | Fracture Spacing | Strength | Lithologic Description | Discontinuities | Description of Discontinuities | Remarks

PHOTO 15

Box 2 Box 3 Box 2 Box 3 Box 4

Run 10 Run 11 Run 12 Run 13 Run 14 Run 15

Lithologic Description:

ORINDA FM. ON SITE: HW.

Matrix grades to fine sl. sdy silt w/ calcite stringers (sub. Vert). Clast size reduced to .1–.01'. More rounded.

31.5' Abrupt ~0.1' sub. Horiz. contact. No color change.

Siltstone, fine-grained to massive, reacts to HCl, mild gradual apparent coarsening due to calcite x-tals

32.4'

33.0' color change to red sdy. Mdst. Thin green (0.05') seam.

CONTACT ~ 10° dip

→ Alt. colors in ← zones 2–3' thick. Bands ~45° angles clay partings/ block structure.

35'

36'

clay rich/soft zone, Red 36.5'

37.1–37.3' Cobble?

Siltstone, Green, Massive

37.3' charcoal – MnO_2

40' large subrounded cobble Below which is softened clay rich material

41.7–42' clay lense (NO INTRUSION OF DIFFERENT CLASTS).

42.8–44.0' red clay

Alt. colors

Discontinuities:

RI-RO, R1 R0, 4.0 P.P, 2.0 P.P, 3.5 P.P., 2.0 P.P

Description of Discontinuities:

30'

BECOMES HARD + CEMENTED WITH DEPTH

PHOTO 16

REDDISH SILTSTONE W/ small conchoidal fractures

HIGHLY VARIEGATED RED TO GRAY SILTSTONE.

PHOTO 17+18

PID 14.42 0.0

- HOOKS LIKE SLIGHTLY SLT – sedimentary clay; not highly suggestive of shearing.

V. SOFT BROWNISH CLAY MAKING UP CLAY MATRIX. TOO DISTURBED TO MAKE OUT SLIDE PLANE – WEAK MATRIX MIXED TO DRILLING FLUIDS. CLASTS ARE VOLCANIC + HOOK LIKE Tm.; CLASTS V angular + NOT ROUNDED TYPICAL OF a To conglom.

SLOUGH + FLUIDS FROM ABOVE?

PHOTO 19

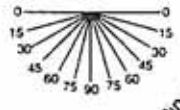
VARIEGATED RED (OXIDIZED) TO GRAY (REDUCED) SILTSTONE

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/18/09	B-1

WLA



Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
45										ORINDA Siltstone (same as above)			
Boring 46	5	15								B.O.H. 5/18/09 15:30			BoH ~ 46.5'
47		↓ 46.5'											Grouting: ~6 bags Portland cement (47lbs/bag) ~½ bag Bentonite (50 lbs/bag)
48													
49													
50													
1													
2													
3													
4													
5													
6													
7													
8													
9													
0													

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

(a) 92.6 becomes thinnly laminated again with ~~reddish soft~~ clay seams bounded by greyish siltstone; dip _____. clay seams sedimentary and occupied by QIs or entirely QIs-related?

PHOTOS 1 – 10

WLA

BORING LOG

Project: LBNL Bldg 25	Job No: 2072	Boring No: AKA-2 ~~WLA-B-2~~	Boring Location: B28, B-2, B25
Type & Diameter of Boring: HQ mud rotary		Elevation @ Top of Hole / Total Depth: /106.2' bgs	
Sampling Method: ModCal; 101 Continuous; SPT (NQ Rod)		Sample Driving Hammer and Drop: Auto, 30-inch	
Drilling Contractor and Rig: Pitcher - Fraste Multidrill XL		Date Started: 5/19/09	Date Completed: 5/20/09
		Depth to groundwater: N/A	Logged By: S. Sundermann
		Notes: reviewed by K.D. Krug 5/21/09-5/22/09 JNB 5.22.09.	

SPT N_1(60): 0 10 20 30 40 50 60

Uncorrected Blows per 6-inch drive | Depth (feet) | Soil Type (USCS) | Sampler Type | Recovery (inches) | Pocket Pen. (TSF) | Shear Torvane (TSF)

Depth (feet)	Description	Remarks
0	ASPHALT	Drillers on-site: 6:45
	GRAVEL, sandy; lt. brown; well compacted; dry; no plasticity (AB Road Base)	Begin drilling 8:12
		PID 8:15 0.0 ppm
		PID 9:00 0.0 ppm
4	MORAGA FM. Volcanics	
5	Rhyolite, dry; moderate yellowish brown (10YR 5/4 Rock); highly weathered (HW); GSI 25 to 40, blocky/scaly to crushed; larger cobbles are weak (R2); surface condition poor to fair; breaks into indiscernible rubble during drilling	
5	50 / 30	
6		Shutdown 9:15 for decontamination & barrel transfer
7		Restart 10:03
8		PID 10:04 0.0 ppm
10	50	PID 10:35 0.0 ppm
11		
12		
13		
14		
15		

Bag sample

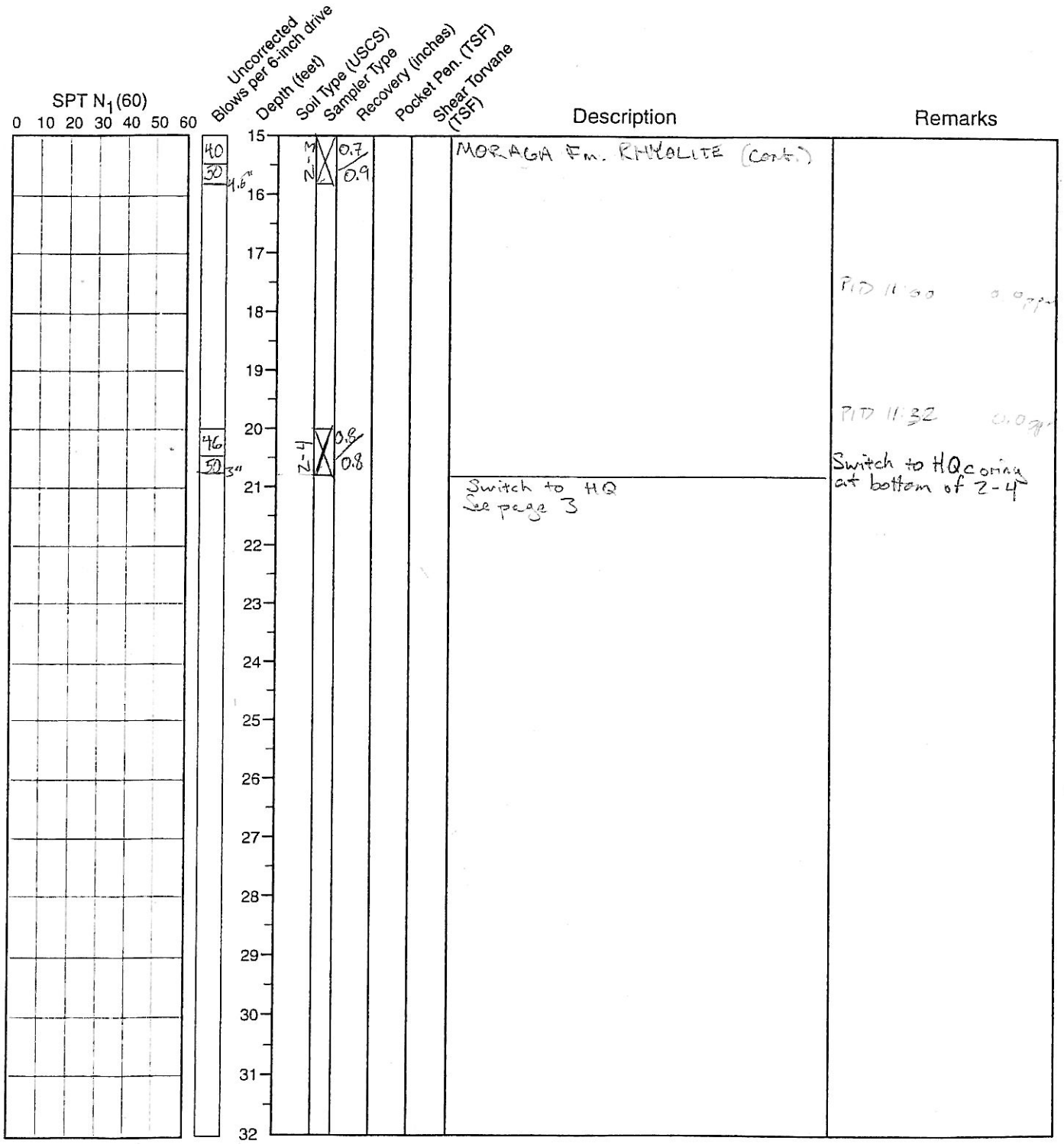
Missing

3.0-inch O.D. split spoon sampler | 2.5-inch O.D. split spoon sampler | Standard Penetration Test (SPT) sampler

WLA

BORING LOG

Project	Job No.	Boring No.
LBNL Bldg 25	2072	WLA-B-2



3.0-inch O.D. split spoon sampler | 2.5-inch I.D. split spoon sampler | Standard Penetration Test (SPT) sampler

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/19/09	B-2

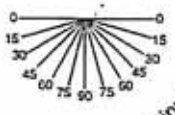
WLA

Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
Box1 20										MORAGA Fm ANDESITE (cont.)			
21		Run 1	0	0	0								
22													No recovery Run 1
23		Run 2	1.5/2.5	60	0								Switch to 101 PID 11:53 or 0ppm
24													
25													
26		Run 3	1.6/3.0	53	0								
27													PID 12:27 0.0ppm
28													
29		Run 4	0.5/3.0	17									
30													
31													
32													
33	2-5	15 33 50	SPT 0.7/1.3	45						RHYOLITE, w/ mineralization including hornblende, grayish green (10G 4/2 - 10GY 4/4) and a dusky red (5R 3/4) beryl(?) (~~Hard to kill~~)		HARD FRACTURED ROCK W/ WK granular WXRD ROCK MATRIX	Refusal @ 33.8
34													
35													

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/19/09	2



WLA

Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
35										MORAGA Fm RHYOLITE (Cont.) w/ mineralization			PID 13:01 0.0ppm
36													
37													Box 1
38	2-6	24 / 27 / 48	SPT	1.0/1.5	66								PID 13:17 0.0ppm
39													
40													
41													
42													
43	2-7	50	SPT	0.1/0.25	40								Refusal @ 43.3 PID 13:39 0.0ppm
44													Box 2
45										SAME Above..			
46										?			
47										?			
48	2-8	23 / 30 / 42	SPT	1.1/1.3	73					-Volcanics- Heavily weathered, crushed -Massive, Blocky Fractures into .01'-.05' pieces w/ clay and gravel - Moist material on fracture surfaces.		CLAY LINED FRACTURES MIXED w/ Jm Rx blocks, NOT CONTINUOUS - IN ROCK FRAGMENTS. CLASSIC Moraga - brownish w/ manganese staining	
49													PID 14:10 0.0ppm
50										? ? ? ?		? loss of clays	

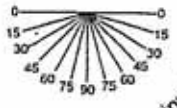
Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

53 46 4"

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/19/09	2

WLA



Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
50	2-9	46 / 50	SPT	0.5/.75	66					MORAGA RHYOLITE w/ mineralization (cont) – clay & grain lining reduced (washed out?) Less wxrd & competent pieces of rock ~.1-.15' diam.		DARK ADMANTIC volcanics – basalt? greenish brown. v. fine-grained.	PID 14:43 0.0ppm PHOTO 1
51													
52													
53													
54													
55													
56													
57												BOX 2	
58													
59	2-10	40 / 50	SPT	0.6/1.0	60							NO ABOVE	PID 15:20 0.0ppm Refusal @ 59.5 Dropped tricomb bit to try breaking thru rock
60													
61													
62													
63	2-11	50	SPT	0.3/0.4	75							✓	PID 15:56 0.0ppm Refusal @ 63.4'
64													
65										—? —? —? —? —?		return to clays (2-8 [illegible])	

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/19/09	2

WLA

Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
65										MORAGA RHYOLITE w/ mineralization (cont.) (see prev. ps)		basalt?	
66													
67													
68	2-12	50	SPT	0.3/0.4	75					① Hard-heavily wxrd volc. in .1-.05' pieces w/ clay & granular material between blocky breaks - ~~Tan~~ Incolor-black		basalt?	Refusal @ 68.4' PID 16:12 0.0ppm
69													
70													
71													
72													
73	2-13	35 / 50	SPT	0.4/0.8	50					.2-.1' pieces of sub-angular clasts of ~~cobbles~~ fractured volc. basalt			PID @ 16:34 0.0ppm Refusal @ 73.8 End of Day 5/19
74													Drillers on site 7:20 Begin drilling 7:45 Safety meeting 7:30 PID 7:55 0.0ppm
75			Run 5	0.7/4.2	17	0							
76													
77													
78	2-14	24 / 32 / 36	SPT	1.2/1.5 80%	Run 6	1.0/2.3 43%				~~More competent~~ bedrock Andesite(?). flecks of basalt; ~~moderate to~~ highly weathered (MW-HW) Damp-wet		Return to Previous ① (Pieces held by clay)	WXRD w/ FeO_2 zones along bedrx FRACTURES. No CONTINUOUS clay seams. FRACT. BASALT .2 to .8' diam. PID 8:34 0.0ppm
79													
80													

BOX 2

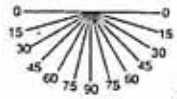
PHOTO 2

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

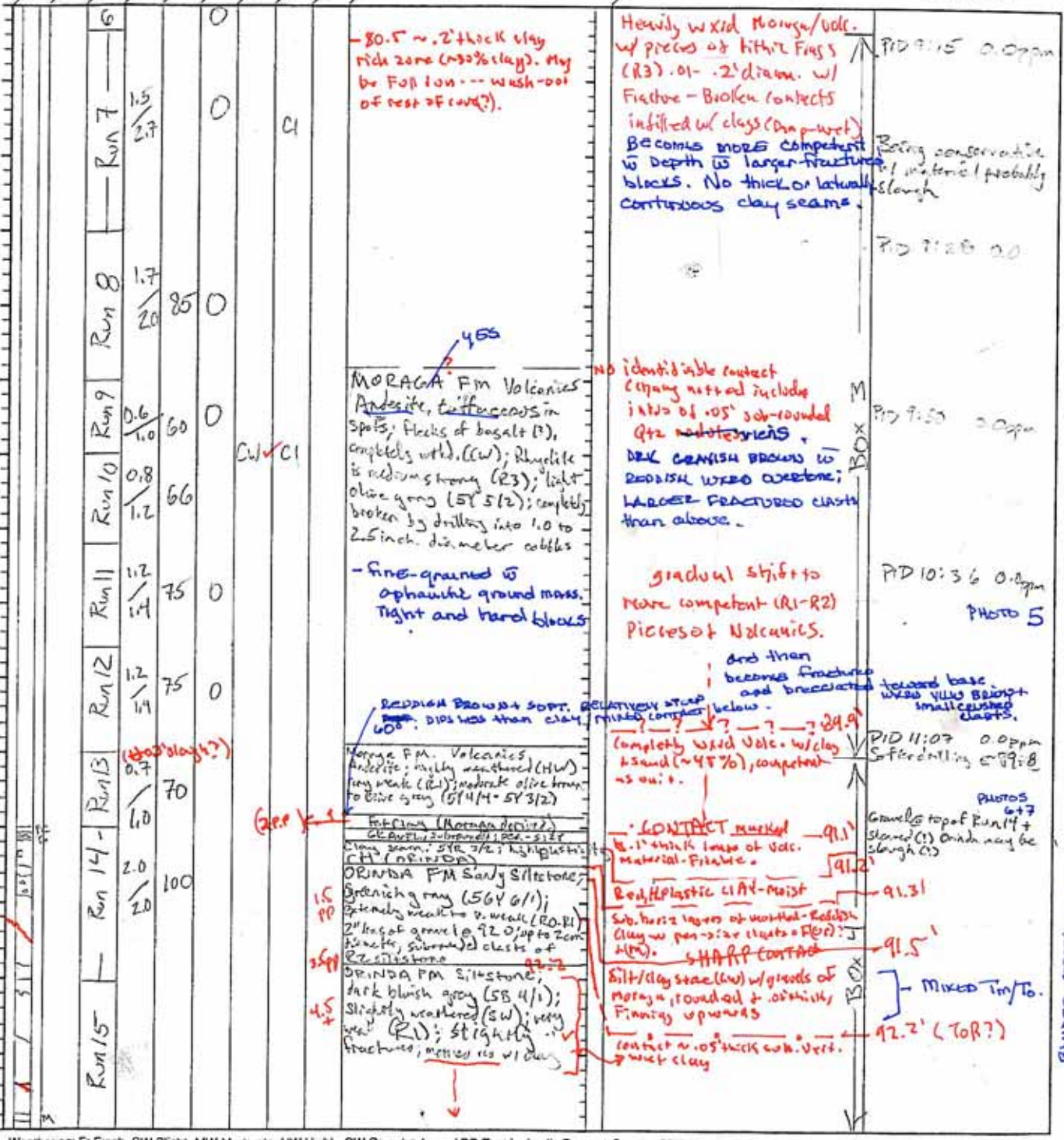
ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/20/09	2

WLA



Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks

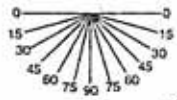


Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Ma-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, Ha-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL	2072	5/20/09	2

WLA



Depth (feet) | Log | Drill Rate (min/ft) | Run No. | Recovery/Cut | % Recovery | RQD | Weathering | Fracture Spacing | Strength | Lithologic Description | Discontinuities | Description of Discontinuities | Remarks

95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110

Rock us

Run 16 — 15 — 2.8/2.5 — 100 — 1.1/2.5

Run 17 — 2.5/2.5 — 100

Run 18 — 1.6/1.7 — 0/1.7

19 — 0.1/0.1

Run 20 — 1.7/1.7 — 100 — 0

Triconed

Core Box 5

Lithologic Description

~~No contact~~ →

ORANGE FM. Siltstone; greenish gray (5G 6/1 - N8); some v. fine grained to fine sand; R1 - R2 (v. weak - weak); apertures on sides of core up to 2mm, discontinuous through core, medium orientation. Large calcite filled veins ~.05' diam.; MASSIVE + NO LAMINATION OR BEDDING.

@ 99.5 SILTY CLAY TO CLAYEY SILT separating a competent SILTSTONE. HOOLS LEG BEDDING.

~~SANDSTONE~~ Silt; RZ (weak); medium dark gray (N4); moderately to slightly weathered (MW-SW); fine to v. fine grained

SILTSTONE; R3 - R2 (med. strong; medium grey (N5); slightly weathered (SW)

CLAYSTONE; R2 - R1 (weak, to v. weak), moderately fractured along bed planes; med. bluish gray (5B 5/1); some harder clasts of calcite, up to 1cm diameter embedded

B.O.H. 5/20/09 13:11
106.2 Ft

Discontinuities

F 28°, Pl, Sm, Sf (parting) Bedding?
F
F 0° Wa, Sl, Op
F 0°, Wa, Sl, Op
F 5°
F 20° St
F 31
F 5°, Wa, Ro, Op
F 15°; Pl, Fi
F 0°, Pl, Sl-Ro, Fi
F 20°, St, Sl, Op
F 0°; Pl, Sm, Op, Fresh

Remarks

PID 11:43 0.0
PHOTO 9 competent and hard
B@5'
PID 12:23 0.0 ppm
PHOTO ID 100.5 @ TOOL.
PID 13:04 0.0 ppm
V. difficult drilling. Dropped tricomb bit to break thru. Rec'd 10-inches thick
PID 13:56 0.0 ppm

Grouting:
~ 12 bags Portland Cement (47 lb/bag)
~ ½ bag Bentonite (50 lbs/bag)

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

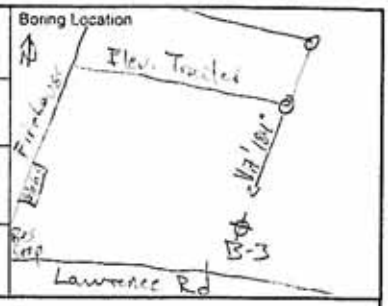
PHOTOS 20-25

WLA

BORING LOG

AKA-3 (was AKA-4)

Page 1 of 5

Project	Job No.	Boring No.	Boring Location
LBNL Bldg 25	2072	~~WLA-B-3~~	
Type & Diameter of Boring		**Elevation @ Top of Hole / Total Depth**	
HQ Mud rotary		165'	
Sampling Method		**Sample Driving Hammer and Drop**	
ModCal (2.5"I.D.); 10' Continuous Core		Autohammer 30"	
Drilling Contractor and Rig		**Date Started** / **Date Completed**	
Pitcher Frank Multidrill XL		5/21/09	
Depth to groundwater	**Logged By**		
NA	S. Sundermann		
Notes: KD. Krug (Redtop) 5/22/09		JNB 5-22-09.	

SPT N_1(60) 0 10 20 30 40 50 60	Uncorrected Blows per 6-inch drive	Depth (feet)	Soil Type (USCS)	Sampler Type	Recovery (inches)	Pocket Pen. (TSF)	Shear Torvane (TSF)	Description	Remarks
		0						ASPHALT AB Road Base; Gravel w/ sand	
		1						ORINDA Fm. SILTSTONE damp to moist; grayish red (10R 4/2); extremely weak to v. weak (R0-R1); undisturbed (from sampling) clay lenses, high plasticity (CH), slow dilatancy, minor clay sheen on larger blocks; mottled set of redox depletions to medium gray; slightly weathered (SW); appears massive; cuts well w/ hand auger & moderate blow counts, acts like stiff soil (ToS)	
		2							
		3							
		4							
		5							
		6		RUN 1	1.2/1.5				
		7			1.1/2.5	0.5		REDDISH DK BROWN SANDY SILTSTONE	Switch to 101 Continuous Avg. borehole pressure 500 psi
		8			44%				
		9		RUN 2	2.4/2.5				
		10			96%	2.0		Clay Filaments throughout sample, moist; grayish red; high plasticity; clay content potentially up to 50% (Siltstone - Claystone)	
		11							
		12		RUN 3	1.5/2.0				V. WEAK AND SOFTISH CLAYEY SILTSTONE. V. CLAY RICH.
		13				* 4.5+		contact between 12' & 12.5'	B, 17° Cl, contact M, 3° F, St, 15°
		14		RUN 4	N/A	N/A		ORINDA Fm. SILTSTONE; medium bluish gray (5B 5/1); V. weak (R1); Slightly weathered (SW); wide to moderate fracture spacing; upper contact w/ redox siltstone gradual over ~ 6 inches of interbedded claystone & siltstone (ToS)	B, 34° Cl.
		15			2.0	2.5			

BOX 1

* CHECK MODEL A SHEAR SURFACE THRU THIS WK MAT'L WOULD EXPECT TO SEE SEAMS OF GRAY ORINDA-TONE.

R-13.8' Y-Green clay stringers

ND

PHOTO 20

3.0-inch O.D. split spoon sampler | 2.5-inch O.D. split spoon sampler | Standard Penetration Test (SPT) sampler

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/21/09	3

WLA

Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
15–16		Run 4	3.0/3.0	100	1.2/3.0				R1-R2	ORINDA Fm SILTSTONE; medium bluish gray (5B 5/1); v. weak (Z1); slightly weathered (SW); wide to moderate fracture spacing; strength increases within redox deduction beds, decreases within reddish redox zones; redox beds are grayish red (10R 4/2) with nodules of blue-gray deduction; clay filaments are pervasive in redox zones; apparent subparallel orientation in p lines, dipping up to 60°; global orientation unknown. (ToS) COLOR Δ		Contact @ 14.3' ORINDA Fm SILTSTONE grayish brown (5YR 3/2) to grayish red (10R 4/2); with 30% nodules of med. bluish gray (5B 5/1) siltstone; increased grain size up to v. fine grained sandstone; non-plastic; color to greenish gray; v. weak to weak (R1-R2); Redox zone, slightly weathered (SW) (ToS)	Box 1	HARD & COMPETENT SILTSTONE. ✓ GRY, RED, YLLW BRWN.
17–18		Run 5	2.5/2.5	100	2.5 100%								@ 16.1 - poss. bedding - Δ change CLAYEY SILTSTONE (RED) and yellowish siltstone 50°
19										CONTACT @ 14.3' (19.3)		F 25°, Op, Sm, Pl; F 10°, Cl, Fi, Pl; F 27°, Op, Sm, Pl	✓
20		Run 6	2.5/2.5	100	2.0/2.5 80%	SI	No-Wi		R1-R0	Siltstone competent - red ✓		F 0°, Wa, Op, Sm; F 4°, St, Cl; F 7°, Op, Pl, Sm	Box 2
21												F 18°, Pl, Sl, Op	
22		Run 7	2.5/2.5	100	1.0/2.5 40%	MW	Cl-VC		R1-R0	contact @ 22' ORINDA Fm. SILTSTONE; medium blue gray (5B 5/1); very weak to extremely weak (R1-R0); some v. fine gr. sand; zones of more competent rock (up to 1.5 ft thick); in general v. weak, not competent rock w/ massive fractures; moderately weathered (MW); decreased grain size from coarse siltstone to claystone (ToS)		F 5°, Pl, Fi?	PHOTO 21
23												* (POSSIBLE MODEL ZONE) 22.2 to 23.1 - V. SOFT CLAY separates RED brown SILTSTONE ABOVE FROM blue-grn SILTSTONE below HARD ABOVE + BELOW	YES. V WEAK CLAYEY SILTSTONE TO CLAYSTONE. NO SEAMS @ upper contact. NO OBVIOUS SEAMS in SECTION. Contains 10% fnsnd. HIGHLY SUSPICIOUS.
24									R1 (1.0)			F 43°, Sl, Op, 15°	
25		Run 8	2.2/2.5	88	1.2 55%							sandy siltstone; Clayey siltstone	MASSIVE - V. THICK SANDY SILTSTONE. V. HEALED FRACTURES RARE TO OCCASIONAL - OTHERWISE COMPETENT.
26										Competent beds are increased grain size up to v. fine or fine grained sand; slightly darker bluish gray (5B 4/1); fracture spacing increases to moderate to wide; very weak to weak (R1-R2)			
27		Run 9	2.5/2.5	100	2.1/2.5 64%				R1-R2	Sandy SILTSTONE (ToS) Sub. vert. stringers of clays (*)		sandy siltstone	Box 3
28												F 5°, Pl, Sm, Cl; Sandy siltstone; Clayey siltstone	Photo incorrect run # (marked 8) ← PHOTO 22
29		Run 10	2.0/2.0	100	1.1/2.0							sandy siltstone	
30													

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2077	5/21/09	3

WLA

Depth (feet) | Log | Drill Rate (min/ft) | Run No. | Recovery/Cut | % Recovery | RQD | Weathering | Fracture Spacing | Strength | Lithologic Description | Discontinuities | Description of Discontinuities | Remarks

cont. from Prev. pg.

Solid colors past 32.2

ORINDA Fm Siltstone same as above, with no redox very weak (R1); slightly weathered (SW); sandy siltstone; moderately close fracture spacing

P.P. 3.0

R1–R2

P.P. 3.5

32.8

ORINDA Fm SILTSTONE grayish brown (5YR 3/2) to grayish red (10R 4/2) with 30% pebbles of med bluish gray (5B 5/1) siltstone; grain size up to v. fine grained sandy mudstone; slightly weathered (SW); very weak to weak (R1-R2) (T0S)

Same as above w/ clay filaments; redox deposition observed along filament surfaces

41.3 high angle contact

ORINDA Fm SILTSTONE dark bluish gray (5B 4/1) to v. dusky red (R1); slightly weathered (SW); with moderate fracture spacing; minor to no redox; soft, very homogeneous, sandy Siltstone; fine grained; moderately wide fracture spacing (Sandy Siltstone) (T0S)

GRAYISH BLUE

BACK TO SANDY SILTSTONE

Clay

Clay 2

Clay

Run 10 | 3.0/3.0 | 100 | 6.8 | 20%

Run 11 | 2.5/2.5 | 100 | 20 | 80%

Run 12 | 3.0/3.0 | 100 | 0

Run 13 | 2.0/2.0 | 100 | 0

Run 14 | 3.0/3.0 | 100 | 2.1 | 70

Run 15 | 3.0/3.0 | 100

Run 16

Sandy siltstone

clayey siltstone

sandy siltstone

F 25°/St-Wa, sl

clayey siltstone

Soft siltstone

MASSIVE SANDY SILTSTONE - V. HOMOGENEOUS. COMPETENT. NO CLAY SEAMS

F St, Sm

↑ GRAY

32.8

↓ RED + SAND BEDS OUT.

CONTACT @ 38.1

① Clay layer Brown at steep high angle contact w/ Purple & green siltstone below

F St, Sm, 35°

60° Clay seam (CH)

F, Fi, 20

Wa, Sm, 35°, op

F St, Sm, 20° open

Box 3

Box 4

Box 5

V. competent w/ v. fn sand @ 10-15%.

Photo in exact pair # (marked 11)

Photo in exact pair # (marked 12)

PHOTO 23

0.04" - 0.2" seam

CLASSIC RED BROWN CLAYEY SILTSTONE TO CLAYSTONE CONTACT W/ GRAY SILTSTONE. POSS. CLAY SEAM BASED ON MILLING. BUT V. HIGH ANGLE PRESENT AT TOE? 55°-60°; SOFT. BUT DRY - SOME FRACTURING/GRAVISH SILTSTO BELOW. GOOD ABRUPT + SHARP CONTACT + SOME MILLING ABOVE (0.1" MIXED ZONE)

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/21/	3

WLA

Depth (feet) | Log | Drill Rate (min/ft) | Run No. | Recovery/Cut | % Recovery | RQD | Weathering | Fracture Spacing | Strength | Lithologic Description | Discontinuities | Description of Discontinuities | Remarks

Run 16 3.0/3.0 100 50%
Run 17 2.0/2.1 60 0 SW
Run 18 SW
Run 19 3.7/3.7 100 1.6 40%
Run 20

clay seam
clay
clay
clay

48.6

Increase in clay stringers/seams

Contact @ 47.2

ORINDA Fm SILTSTONE- w/sand; greenish gray; V. weak to weak (R1-R2); parts of rock; sand is fine grained angular grains; minor gravel up to 1cm diameter at contact (upper); two basis of gravel, well compacted w/ matrix (wash pit?) gravels up to 3cm diameter of Orinda ss, medium strong (R3); 2 gravel bed/lens divided by fat clay w/ gravel, highly plastic; lower gravel mixed w/ fine size gravel; gravel is subrounded to subangular; slightly weathered (SW)

48.6

ORINDA Fm SILTSTONE bluish gray (5B 5/1); v. weak (R1); slightly weathered (SW); wide to moderate fracture spacing; more competent in places up to 2 inches thick; calcite stringers + Full crystal lenses. grandes fine-v. fine sand 10-15%.

5B 5/1 - Mottled olive gray (clay rich bands) Softer material & harder alt. (R0-R1).

becomes grandes and dive gry w depth - at base of core

gravel bed/lens CH gravel lens/bed

soft and moist; FAT NO REACTION ABOVE + BELOW gravel lenses to suggest major shear zone. poss. drill mud?

possible silicified siltstone w CaCO3 of SiO2 cement.

PHOTOS 24 + 25

Box 5
Box 6
Box 7

F 5°, C1, P1

laminated silts and clays from gray to purplish red (sed structures of Tor.)

- reduced + oxidized mottled beds of Tor.

St, 20°, C1
Wa, 10° Sm
F, 5°, P1,

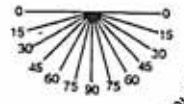
- V. HARD GRAYISH BLUE SILTSTONE.

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.

ROCK BORING LOG

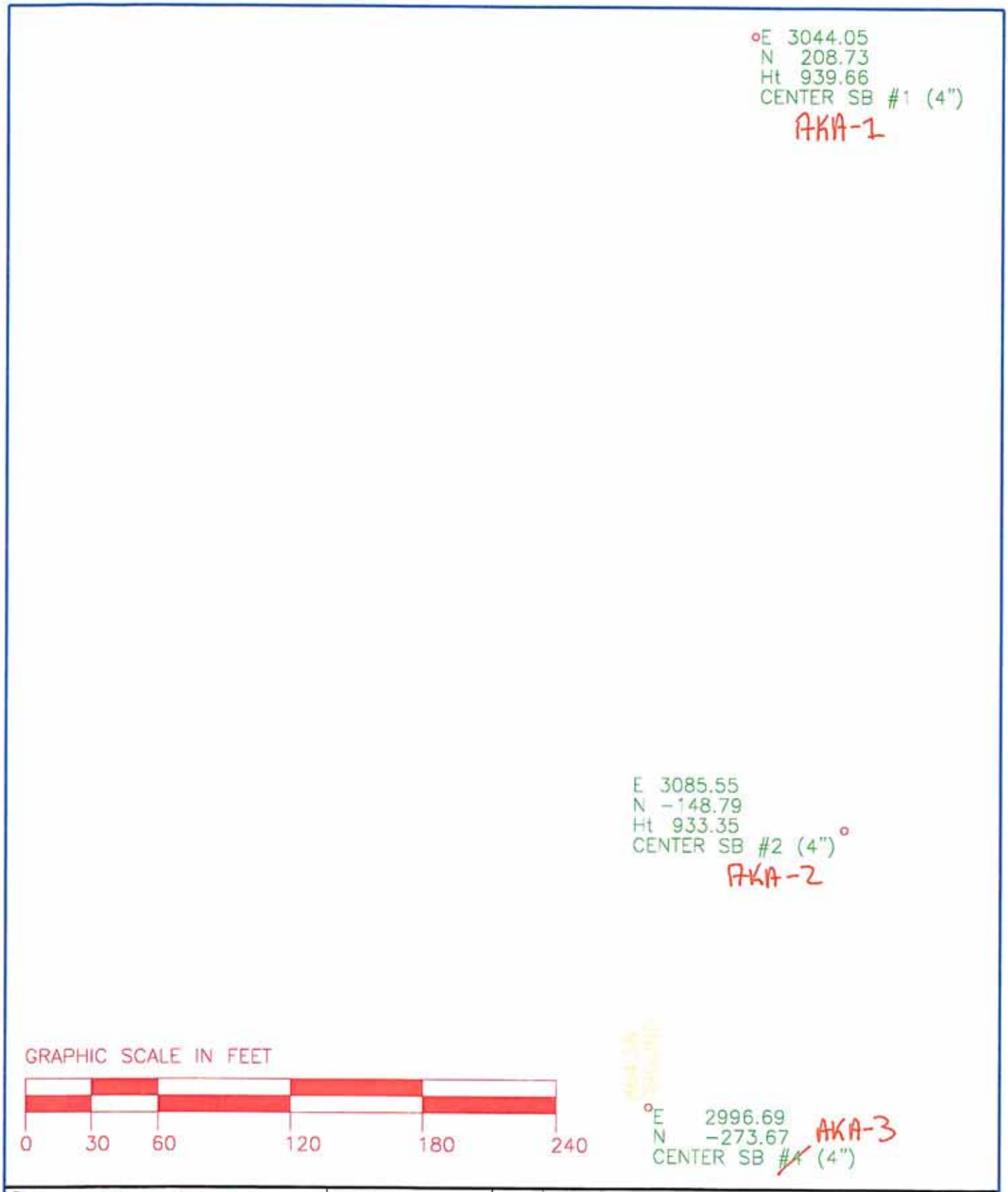
Project	Job Number	Date	Boring No.
LBNL Bldg 25	2072	5/21/09	3

WLA



Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Discontinuities	Description of Discontinuities	Remarks
60												- V. HARD COMPETENT ROCK - BLU GRY SANDY SILTSTONE	
61			Run 21	2.5/2.5	100	1.0 72							
62										Buckto Siltstone, Dark Red,		62.5 color change and softer.	
63			Run 22	2.5/2.5	100	0.5 20%		RO-R1				- SAMPLE APPEARS TWISTED AND FRACTURED. 3. V. thin clay seams (subhor.) w/in RED TO BRANCH mottled SILTSTONE.	EOH 7
64													Note clay "Bands" may be introduced during drilling "twisted" fluid inj.
65										B.O.H 5/21/09			- LOOKS LIKE DRILLING MUD or poss. sed structs.
66													
67													
68													Grouting: ~6 bags Portland Cement (47lbs/bag) ~½ bag Bentonite (50 lbs/bag)
69													
70													
1													
2													
3													
4													
5													

Weathering: Fr-Fresh, SW-Slight, MW-Moderate, HW-Highly, CW-Completely, and RS-Residual soil. Fracture Spacing: VW -Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (0.3'-1'), Cl-Close (0.1'-0.3'), and VC-Very Close (<0.1'). Strength: R6-Extremely Strong, R5-Very Strong, R4-Strong, R3-Medium Strong, R2-Weak, R1-Very Weak, and R0-Extremely Weak. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough), Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc.



For: LAWRENCE BERKELEY NATIONAL LABORATORY	Scale: AS SHOWN	Job #: 15661	BATES AND BAILEY LAND SURVEYORS 15 SHATTUCK SQ., BERKELEY, CA 94704 (510) 843-2007
Survey of: Soil Boring Locations Near Bldg's 25 & 48	Date: 5-21-2009		

William Lettis & Associates, Inc.

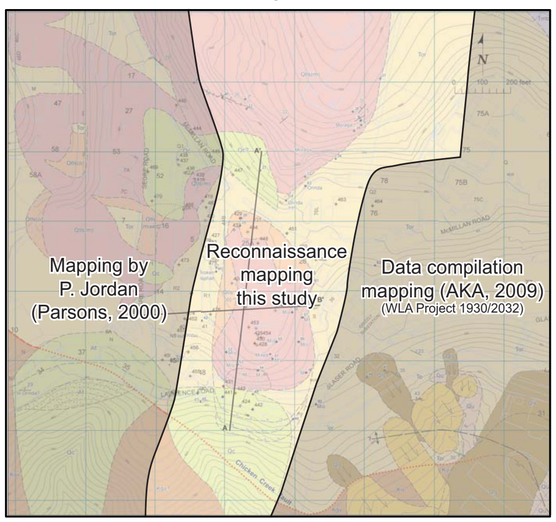
Explanation

- Geologic contact, dotted where buried
- Fault projected from depth, dashed where approximate, dotted where concealed and uncertain
- Potentially active Quaternary landslide
- Quaternay landslide
- Af — Artificial fill (RCRA)
- Qc — Colluvium, Quaternary
- QTls(m) — Moraga paleolandslide unit
- QTls(o) — Orinda paleolandslide unit
- Tmb — Moraga Formation, Tertiary
- Tor — Orinda Formation, Tertiary
- Ku — Great Valley Group, Creataeous
- Strike and dip
- Bedding within Moraga Formation
- Anticline
- Location of outcrop
- Slope parallel cracks/scarps
- Location of cross section
- Reconnaissance waypoints (03.18.2009)
- Buildings, roads, and structures (10.2007)
- 10-foot contour interval (2003)

Geologic Borings

- This sudy (AKA, 2009)
- RCRA (2000), no data provided
- RCRA (2000), data provided
- HLA (1966)
- HLA (1982)
- SCI (1991)

Index Map of Sources

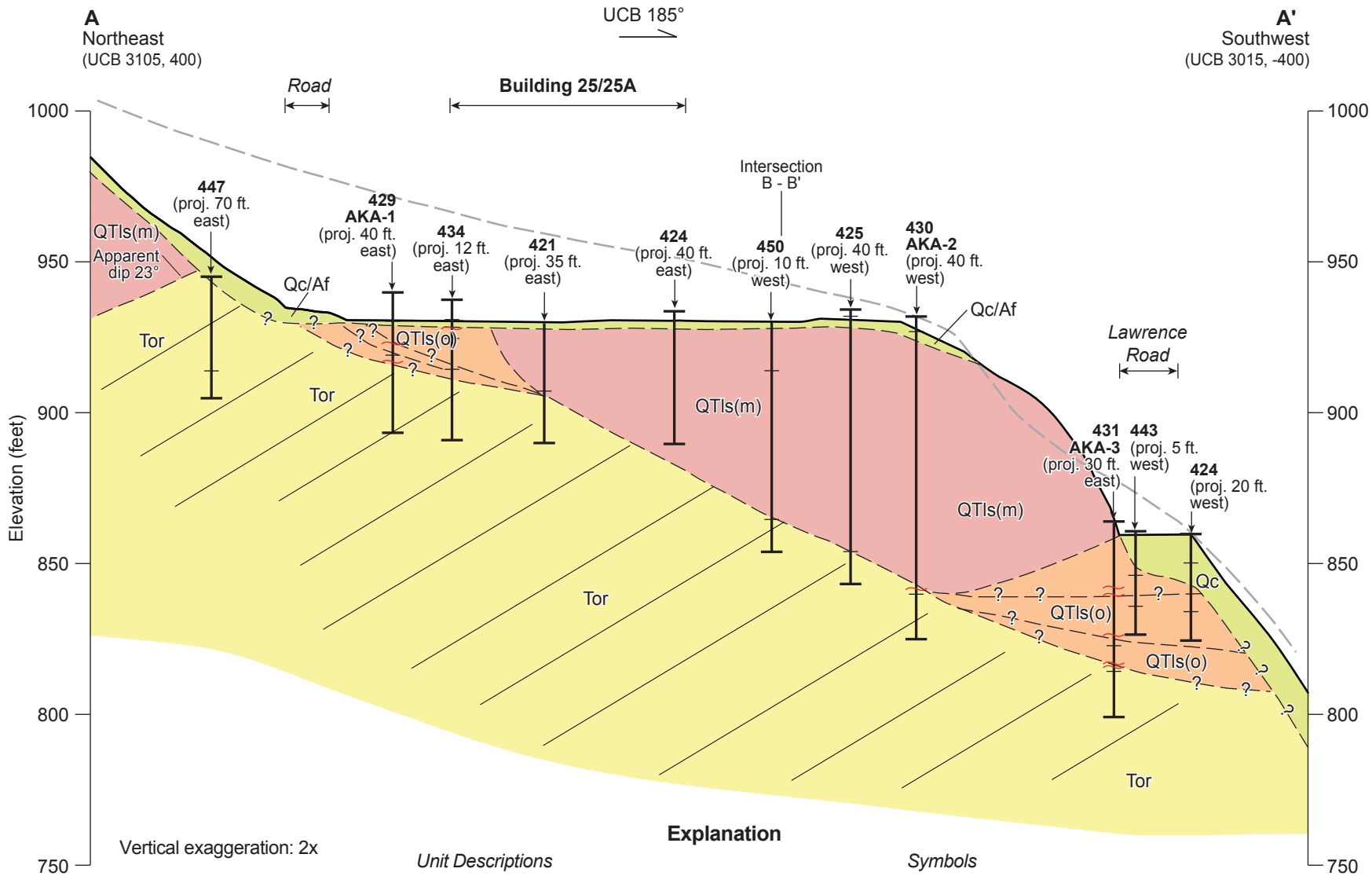


BUILDING 25 GEOLOGIC MAP

PLATE X

Graphics, Active Projects, 2072.000

Graphics, Active Projects, 2072.000



Vertical exaggeration: 2x

Explanation

Unit Descriptions

Qc	Colluvium, Quaternary
QTls(m)	Potential slide body in Moraga Formation
QTls(o)	Potential slide body in Orinda Formation
Tor	Orinda Formation, Tertiary

Symbols

- ?— — — Contact is approximate; queried where uncertain
- — — — 1922 - 23 UCB 20-ft. contour interval (approximate)
- ~ Potential shear
- 447 I Boring with GIS ID number for project 2072 (05.18.09) data compilation

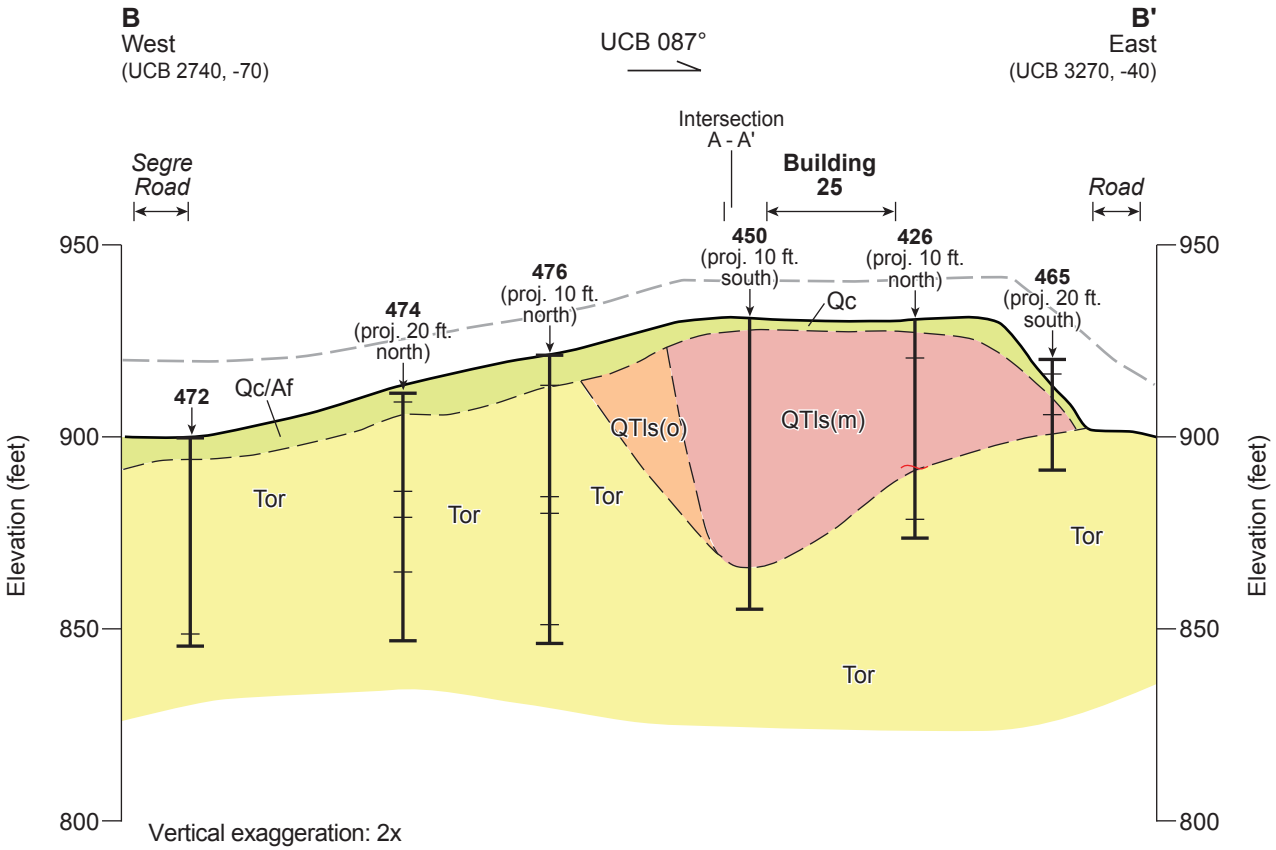
Note: Topographic data from 2003.

SECTION A - A'

FIGURE X

Fugro WLA
Project No. 2072.000

William Lettis & Associates, Inc.



Explanation

Unit Descriptions

Qc	Colluvium, Quaternary
QTls(m)	Potential slide body in Moraga Formation
QTls(o)	Potential slide body in Orinda Formation
Tor	Orinda Formation, Tertiary

Symbols

- Contact is approximate
- 1922 - 23 UCB 20-ft. contour interval (approximate)
- Potential shear
- 472 — Boring with GIS ID number for project 2072 (05.18.09) data compilation

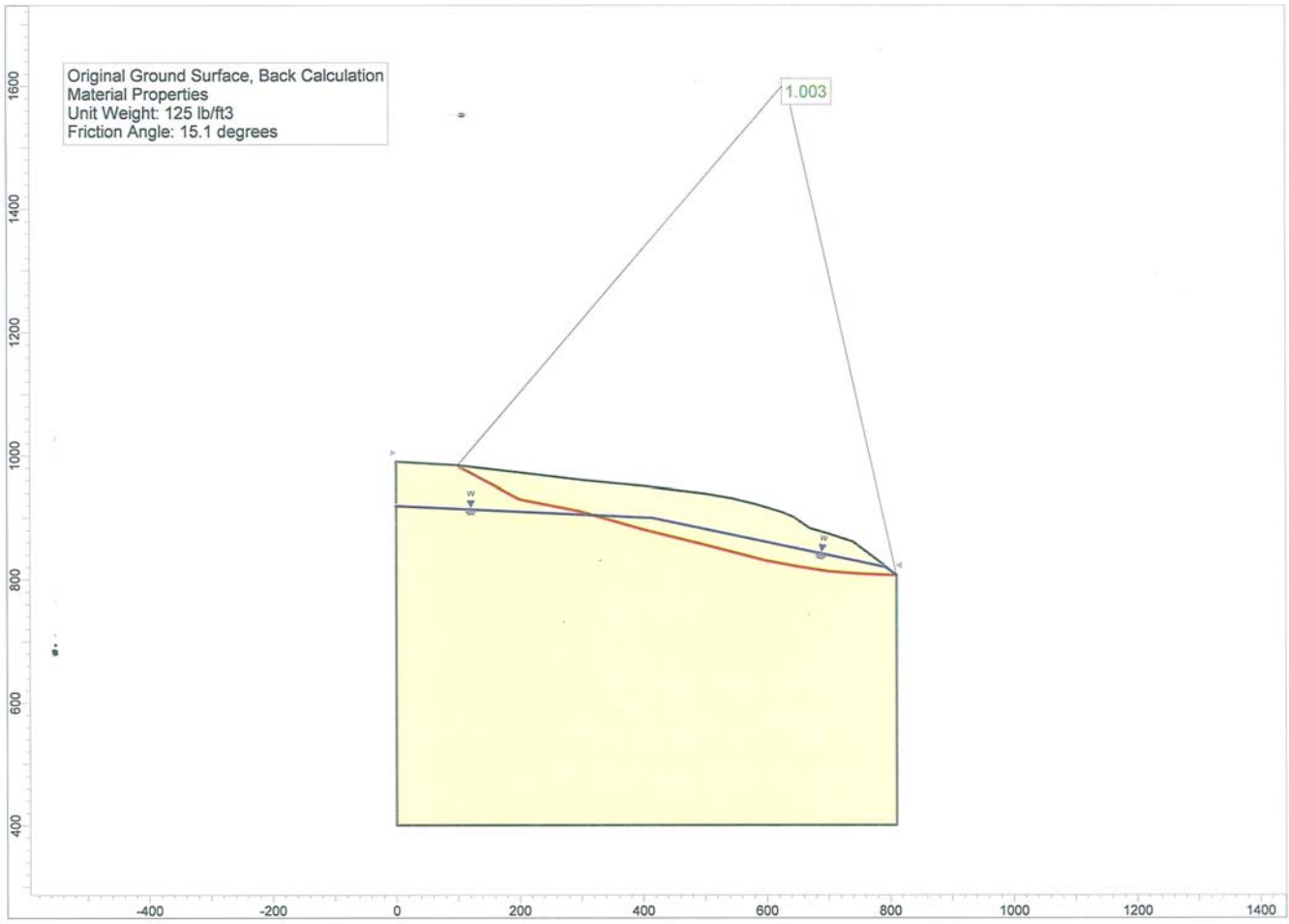
Note: Topographic data from 2003.

SECTION B - B'

FIGURE X

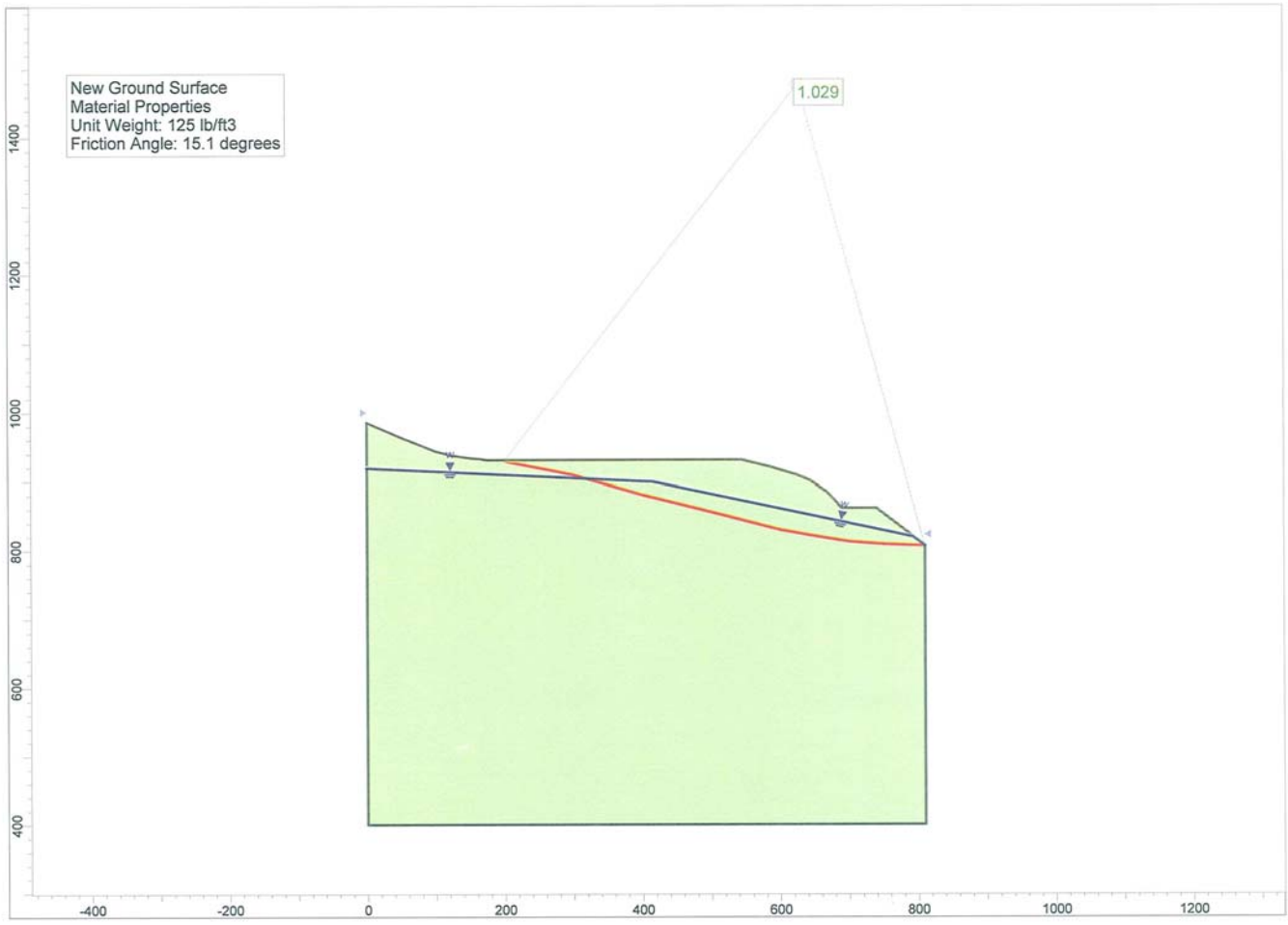
Fugro WLA
Project No. 2072.000

William Lettis & Associates, Inc.



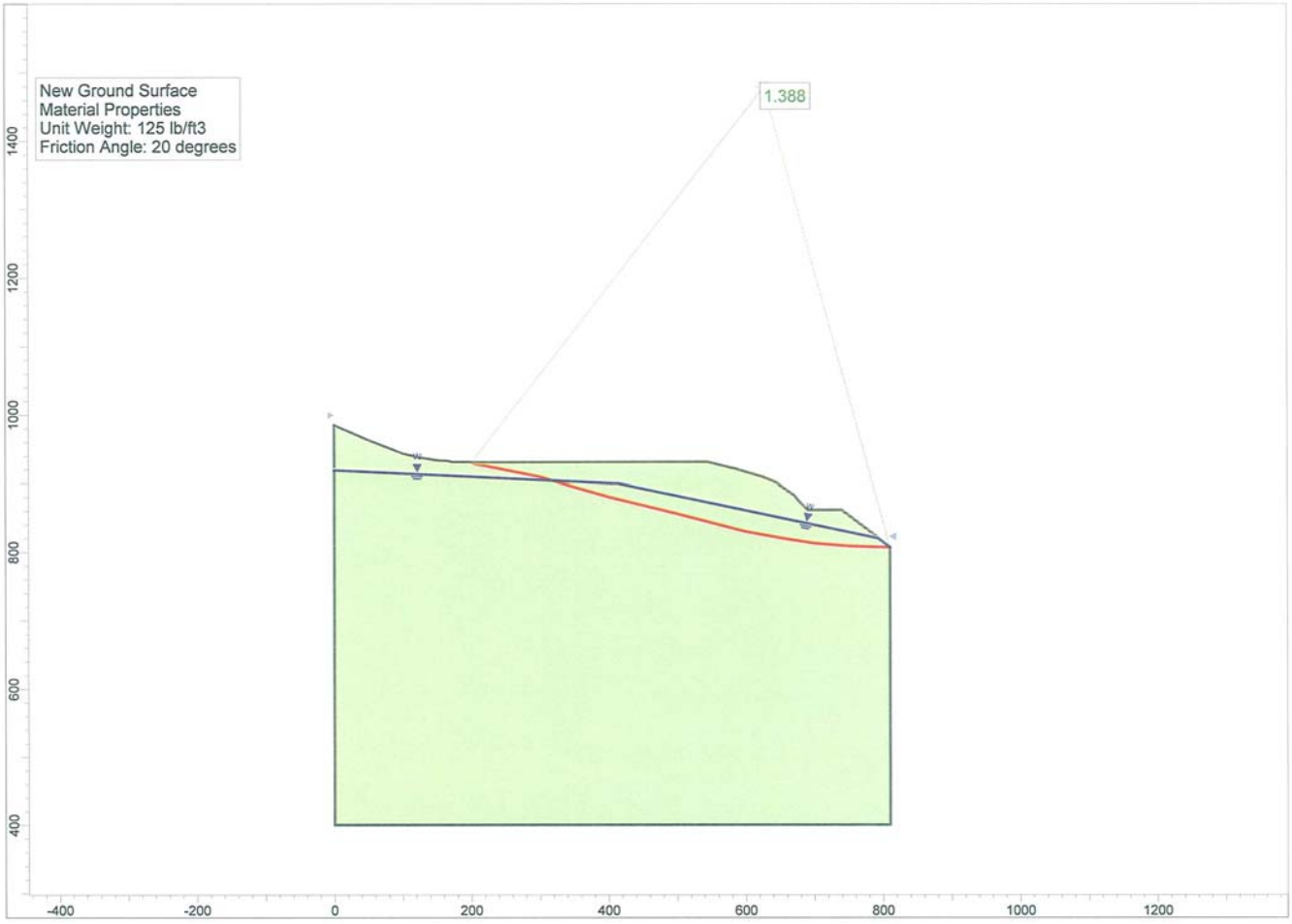
ANALYSIS EXPLANATION:

Backcalculation of slide plane shear strength using pre-grading topography



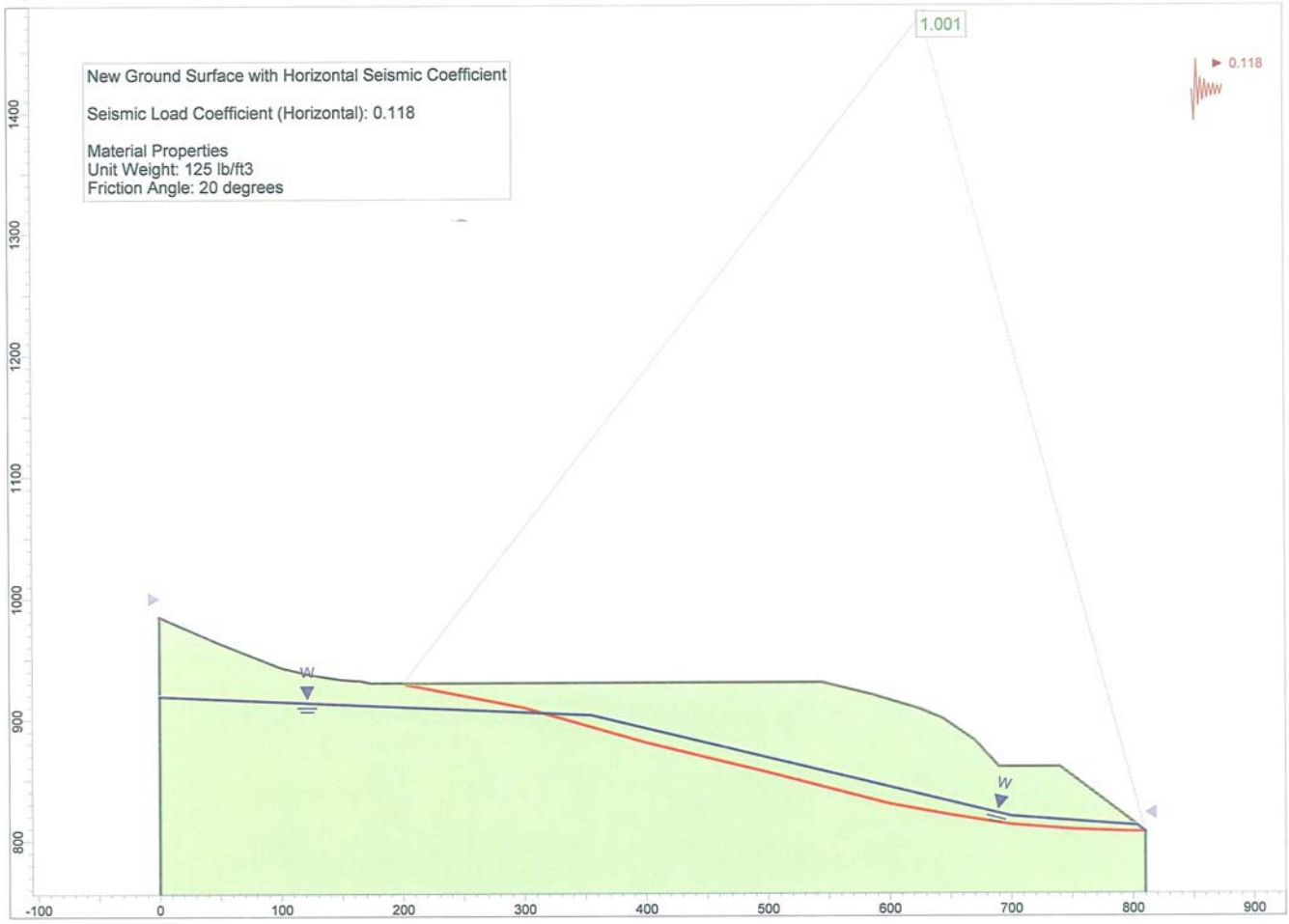
ANALYSIS EXPLANATION:

Static factor of safety for current topography using backcalculated 15.1 degree friction angle



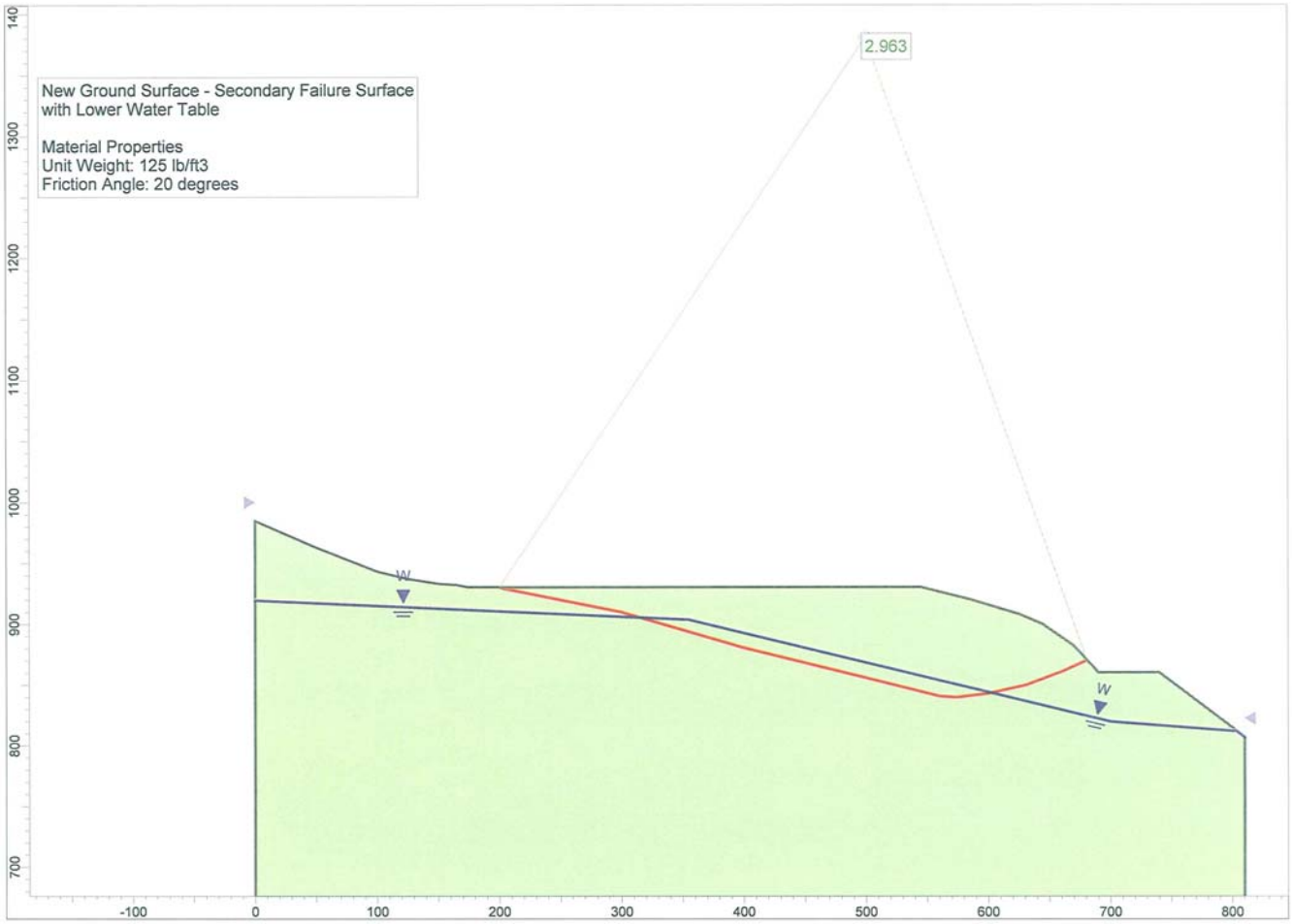
ANALYSIS EXPLANATION:

Static factor of safety for current topography using 20 degree friction angle
(consistent with drained residual torsional ring shear tests from nearby LBNL sites)



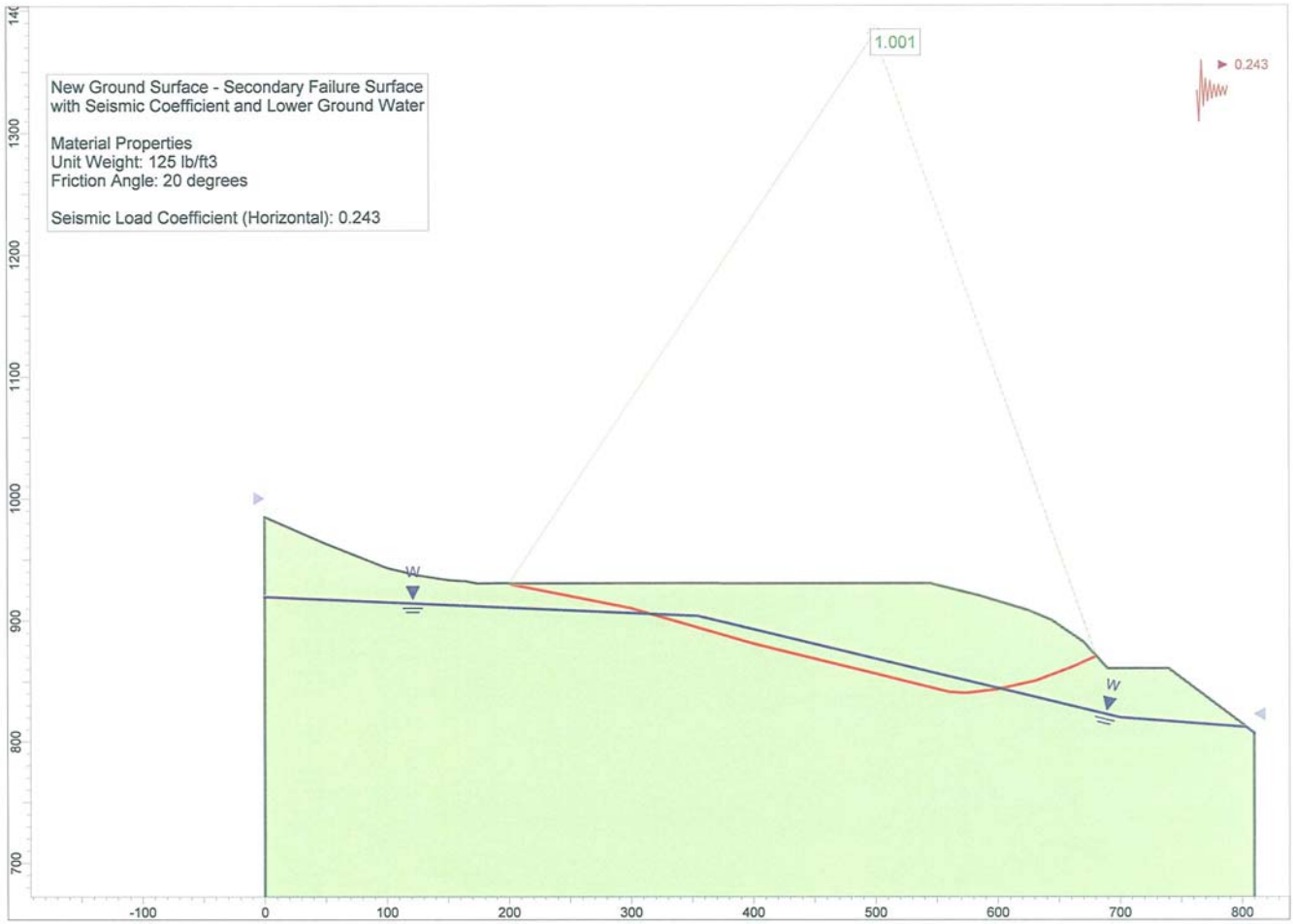
ANALYSIS EXPLANATION:

Yield acceleration for current topography using 20 degree friction angle



ANALYSIS EXPLANATION:

Static factor of safety for current topography using 20 degree friction angle – alternate toe geometry



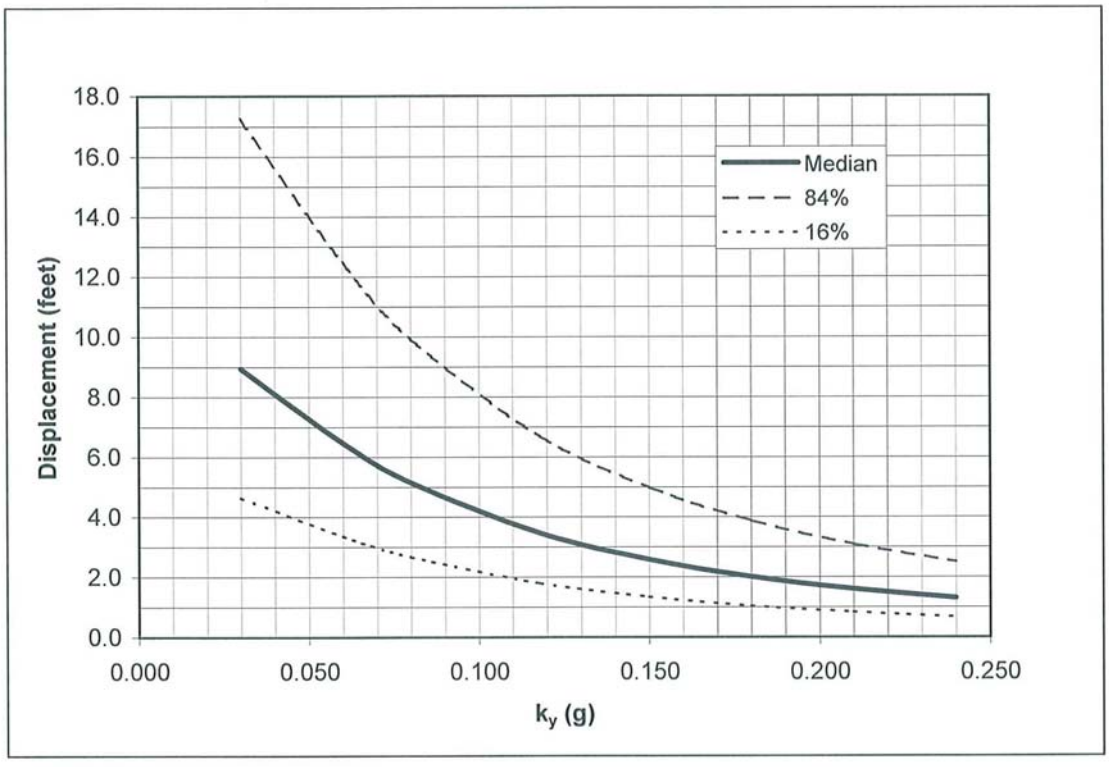
ANALYSIS EXPLANATION:

Yield acceleration for current topography using 20 degree friction angle – alternate toe geometry

LBNL Building 25
AKA Project # 2335-12
27-May-09 by: DKM

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

ky	Dmedian (cm)	D1 (cm)	D3 (cm)	Dmedian (ft)	D1 (ft)	D3 (ft)
0.030	272.7	525.7	141.5	8.95	17.25	4.64
0.060	197.4	380.5	102.4	6.48	12.48	3.36
0.080	157.1	302.9	81.5	5.15	9.94	2.67
0.118	105.8	203.9	54.9	3.47	6.69	1.80
0.150	78.8	151.8	40.9	2.58	4.98	1.34
0.180	61.4	118.3	31.8	2.01	3.88	1.04
0.210	48.9	94.2	25.3	1.60	3.09	0.83
0.240	39.6	76.3	20.5	1.30	2.50	0.67



ANALYSIS EXPLANATION:

Deviatoric slope displacement analysis using:

1. Shear wave velocity = 1200 fps;
2. Landslide thickness = 85 feet
3. Horizontal Uniform Hazard Spectra at 475-year return period, LBNL rock site (URS, 2008)