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April 2, 2010
2335-12B, L-28881

Mr. Richard Stanton
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One Cyclotron Road, MS 76-225
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RE: Geotechnical Investigation Report
General Purpose Laboratory at B25 Site
Lawrence Berkeley National Laboratory
Berkeley, California
(Subcontract No. 6859200)

Dear Mr. Stanton:

The attached final report presents the results of our geotechnical investigation for the proposed General Purpose Laboratory at the Lawrence Berkeley National Laboratory. The accompanying report presents information regarding geologic and geotechnical conditions at the site and presents conclusions and recommendations pertaining to the design of the project. The interpretations, conclusions and recommendations presented in this report were developed in accordance with generally accepted professional principles and practices at the time that the report was prepared.

Should you have questions or comments concerning our findings, the geotechnical design concepts discussed, or our recommendations, please do not hesitate to call.

Very truly yours,

ALAN KROPP & ASSOCIATES, INC.

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2335-12B B25 GPL - ltr of trans FINAL

TABLE OF CONTENTS

1.00 INTRODUCTION 1
1.01 Project Description 1
1.02 Geologic Considerations 1
1.03 Purpose and Scope of Services 2

2.00 METHODS OF INVESTIGATION 3
2.01 Review of Published Geologic References 3
2.02 Review of Site-Specific Subsurface Data 3
2.02.1 Geotechnical and Geologic Reports by AKA/WLA 3
2.02.2 Geotechnical and Geologic Reports by Others 3
2.02.3 Environmental Boring/Well Logs 4
2.03 Previous AKA/WLA Borings 4

3.00 GEOLOGIC AND SEISMIC SETTING 5
3.01 Berkeley Hills Geology 5
3.02 Bay Area Active Faults 5
3.03 Regional Seismicity 6

4.00 LOCAL GEOLOGIC CONDITIONS 8
4.01 Topography and Geomorphology 8
4.02 Local Bedrock Units 8
4.02.1 Cretaceous Great Valley Group 8
4.02.2 Tertiary Orinda Formation (Miocene) 8
4.02.3 Tertiary Moraga Formation (Miocene) 9
4.03 Local Faults 9
4.04 Landslides 10

5.00 GEOTECHNICAL SITE CONDITIONS 11
5.01 Surface Conditions 11
5.02 Subsurface Conditions 11
5.02.1 Generalized Description of Subsurface Conditions 11
5.02.2 Summary of Bedrock Depth/Elevation Data 12
5.02.3 Summary of Groundwater Data 13
5.02.4 Summary of Plasticity Test Data 14

6.00 GEOLOGIC AND GEOTECHNICAL HAZARDS 15
6.01 Ground Shaking 15
6.01.1 CBC Site Class 15
6.01.2 Campus Ground Motions 15
6.02 Surface Fault Rupture 15
6.03 Geologic Stability 16
6.04 Inundation 16
6.05 Liquefaction and Densification 16

7.00 GEOTECHNICAL EVALUATIONS AND CONCLUSIONS 17
7.01 Foundation Support 17
7.02 Existing Fill Materials 17
7.03 Uplift Resistance 17
7.04 Expansive Soils 18

TABLE OF CONTENTS

7.05 Construction Considerations 18
7.05.1 Excavation and Shoring 18
7.05.2 Dewatering and Soil Moisture 18
7.05.3 Construction Monitoring 18
7.05.4 Wet Weather Construction 19

8.00 GEOTECHNICAL RECOMMENDATIONS 20
8.01 General 20
8.02 Seismic Design 20
8.02.1 2007 California Building Code Seismic Parameters 20
8.02.2 LBNL/UCB Campus Probabilistic Ground Motions 21
8.03 Foundation Design 21
8.03.1 General 21
8.03.2 Footing Bearing Pressures 21
8.03.3 Lateral Resistance 22
8.03.4 Tiedowns 22
8.04 Retaining Walls 23
8.04.1 General 23
8.04.2 Lateral Pressures 23
8.04.3 Wall Drainage 24
8.05 Earthwork 24
8.05.1 Site Preparation 24
8.05.2 Excavation 24
8.05.3 Fill Materials 25
8.05.4 Fill Placement 25
8.05.5 Utility Trenches 26
8.06 Concrete Slabs-on-Grade 26
8.06.1 Interior Slabs 26
8.06.2 Exterior Slabs 27
8.07 Pavements 27
8.07.1 Flexible Pavements 27
8.07.2 Rigid Pavements 28
8.08 Future Geotechnical Services 28

9.00 LIMITATIONS 30

10.00 REFERENCES 31
10.01 Published References 31
10.02 Consulting Reports 32

TABLE OF CONTENTS

LIST OF FIGURES

Figure 1 Vicinity Map
Figure 2 Site Plan
Figure 3 AP Fault Zone Map
Figure 4 Regional Geologic Map
Figure 5 Bedrock Surface Contour Map

LIST OF APPENDICES

Appendix A Logs of Previous Borings by AKA/WLA
Appendix B Logs of Borings from Previous Geotechnical Reports by Others
Appendix C Logs of Previous Environmental Borings by LBNL

1.00 INTRODUCTION

This report presents the results of a design-level geotechnical study by Alan Kropp and Associates, Inc. (AKA) for the General Purpose Lab (GPL) project at the Lawrence Berkeley National Laboratory (LBNL). The GPL will be situated near the eastern limit of LBNL's "Old Town" area at the site currently occupied by Building 25. This location is shown on the attached Vicinity Map (Figure 1). Our services on this project were performed in general accordance with LBNL Architect-Engineer Subcontract No. 6859200, Modification No. 3.

We obtained information about the proposed GPL project primarily from: (1) Stanley Lew of RMW, the project architects; and (2) René Vignos and Geoff Bomba of Forell/Elsesser (F/E), the project structural engineers. The information provided to us included schematic drawings from the project master plan studies (dated August 20, 2009) and an October 21, 2009 letter from Mr. Bomba outlining F/E's recommended geotechnical scope of work.

1.01 Project Description

The GPL will be located at the site currently occupied by Building 25 (B25), which will be demolished prior to the construction of the project. As shown on the architectural schematics, the GPL will be a three-story building measuring about 90 feet by 160 feet in overall plan dimensions. The building will be situated on a nearly level building pad with a ground floor level at or near the elevation of the existing ground surface. It is anticipated that column loads will be fairly typical for modern three-story construction.

Parts of the GPL are being designed to house sensitive equipment and special geotechnical and/or structural measures may be needed to reduce the potential for post-construction vibrations (from traffic and the like). We understand that the design team is currently working with a specialty consultant to develop a mitigation design, but that specific recommendations pertaining to vibration mitigation are not yet available. However, the possibility of using either ground anchors or ground improvement to stiffen the dynamic response of soil beneath foundations was discussed.

The project will also include relatively minor grading and paving to construct/improve existing adjacent driveways and parking areas, as well as installing subsurface utilities. We understand that the project may also include retaining walls within the GPL building or in other adjacent areas of the site.

1.02 Geologic Considerations

Geologic conditions in the general area of the GPL site were investigated and characterized in two previous phases of study, which were conducted by AKA in association with William Lettis & Associates, Inc. (WLA), engineering geologists. Site-specific subsurface explorations performed during these previous phases included: (1) two exploratory borings drilled north and south of Building 25 (identified as AKA-1 and AKA-2, respectively); and (2) two exploratory trenches excavated west and east of Building 25 (identified as T-1 and T-2, respectively). The locations of our previous explorations are shown on the attached Site Plan (Figure 2) together with the locations of previous exploratory borings by others.

Our previous phases of study were conducted to evaluate the geologic feasibility of constructing a new building at the B25 site. A stand-alone geologic report was prepared for the site by WLA (WLA 2009), which concluded that the B25 site was generally suitable for development from a geologic stability (i.e.,

landsliding) perspective. Some of the geologic descriptions within WLA's 2009 report, prepared under subcontract to AKA, have been included within this geotechnical investigation report.

The site is not within a previous or current State of California Earthquake Fault Zone, as delineated under the Alquist-Priolo Earthquake Fault Zoning Act (AP Act). The closest active fault is the Hayward fault, which is located about 1,700 feet west of the site as shown on the attached AP Fault Zone Map (Figure 3). The California Geological Survey (CGS) Special Publication 42 (SP42, CGS 1999) provides guidelines for evaluating and mitigating fault rupture hazards within designated Earthquake Fault Zones. Although our overall geologic characterization of the site includes information on various faults in the project vicinity, it was not our objective to investigate or document these features in accordance with the rigorous SP42 guidelines, as the faults in the direct vicinity of the site are not zoned as active.

1.03 Purpose and Scope of Services

The primary purpose of our design-level geotechnical study was to document the geotechnical conditions present at the proposed GPL site and provide geotechnical conclusions and recommendations for the project. The scope of our services included:

- Compiling and reviewing existing geotechnical and geologic information;
- Characterizing subsurface conditions at the proposed GPL site;
- Performing geotechnical engineering analyses;
- Developing geotechnical engineering recommendations; and
- Preparing this design-level geotechnical investigation report.

Please note that it was not the purpose of this study to discuss chemical constituents in the onsite soil or groundwater, or to provide recommendations pertaining to soil handling/disposal, or other environmental aspects of the proposed work.

2.00 METHODS OF INVESTIGATION

2.01 Review of Published Geologic References

We reviewed published geologic maps and literature pertaining to geologic and seismic conditions in the general GPL area. These references were used primarily to determine site-to-source distances to principal active faults and to check for previously mapped fault traces and landslides in the vicinity of the site. A list of selected references is presented in Section 10.00.

2.02 Review of Site-Specific Subsurface Data

We compiled and reviewed site-specific subsurface data from a variety of sources, which were used to evaluate and characterize subsurface conditions at the proposed GPL site. Specific sources of data are introduced in the following subsections. The original source materials used to characterize local geotechnical conditions are attached in Appendices A through C.

2.02.1 Geotechnical and Geologic Reports by AKA/WLA

Our previous phases of study included performing subsurface explorations in the vicinity of the proposed GPL site; the site-specific data and interpretations previously developed were originally presented in the following documents:

- Alan Kropp & Associates, Inc. (AKA), 2009, "Summary of Preliminary Investigation and Analyses...Building 25 Area Project," May 29, 2009 memorandum (primarily Borings AKA-1 and AKA-2).

- William Lettis & Associates, Inc. (WLA), 2009, "Paleolandslide Investigation, Building 25," August 31, 2009 report (Trenches T-1 and T-2).

The locations of explorations performed during our previous phases of study are shown on the Site Plan (Figure 2); logs for Borings AKA-1 and AKA-2 are attached in Appendix A.

2.02.2 Geotechnical and Geologic Reports by Others

We reviewed the following geotechnical and geologic reports by others, which include data from previous subsurface explorations in the direct vicinity of the site:

- Harding Associates (HA), 1963, "Foundation Investigation, Proposed Building 26," (Borings 1, 2 and 3).

- Harding Miller Lawson & Associates (HML&A), 1966, "Progress Report, Soil Investigation, Omnitron Site," (primarily Borings 10, 11, 12, 13, and 14).

- Harding Lawson Associates (HLA), 1988, "Foundation Investigation, Building 26 Addition," October 31, 1988 report (Borings 1 and 2).

The locations of previous borings by others are shown on the Site Plan (Figure 2). Logs of previous borings by others are presented in Appendix B.

2.02.3 Environmental Boring/Well Logs

We reviewed relevant portions of the following environmental report, which includes interpretive geologic sections depicting the subsurface materials encountered in nearby monitoring well installations:

- Lawrence Berkeley National Laboratory Environmental Health and Safety (EH&S) Division and Earth Sciences Division with Parsons Engineering Science, Inc. (LBNL/Parsons), 2000, "RCRA Facility Investigation Report for the Lawrence Berkeley National Laboratory Environmental Restoration Program," unpublished consulting report dated September 2000.

As part of our study, WLA geologists also met with Mr. Preston Jordan of LBNL's EH&S Division and: (1) obtained copies of relevant boring/well logs from monitoring well installations in the vicinity of the B25 site; and (2) reviewed selected samples retrieved from well boreholes (which have been archived by the EH&S Division). The locations of previous environmental borings/wells are shown on the Site Plan (Figure 2); selected boring logs provided by LBNL's EH&S Division are included in Appendix C together with WLA's letter documenting the results of the geologic core review.

2.03 Previous AKA/WLA Borings

As part of an earlier phase of study, we explored subsurface conditions in the general vicinity of the B25 site with two borings (AKA-1 and AKA-2). At that time, we also drilled a boring (AKA-3) approximately 200 feet southwest of the B25 site adjacent to Building 48. The borings were drilled to explore geologic relationships and contacts for the purposes of evaluating geologic stability. As such, the borings were logged in detail and annotated in the laboratory by WLA's Certified Engineering Geologist (CEG). The logs of Borings AKA-1 and AKA-2 are attached in Appendix A, for reference.

All of the previous AKA/WLA borings were drilled in May 2009 by Pitcher Drilling Company of East Palo Alto, California, using rotary wash drilling methods. Borings AKA-1 and AKA-2 extended to depths of approximately 46 feet and 106 feet, respectively. The locations and elevations of the borings were surveyed by Bates & Bailey Land Surveyors, Inc. (B&B) of Berkeley, California, an LBNL subcontractor.

A WLA geologist supervised the drilling of AKA-1 and AKA-2, logged the soils and bedrock encountered, and obtained samples of the subsurface materials for subsequent evaluation. The field logs and soil/rock samples were reviewed by WLA's lead engineering geologist for the project, Mr. John Baldwin (CEG). The annotated logs of the borings are attached in Appendix A. The soils are logged in general accordance with the Unified Soil Classification System (ASTM D-2487-06).

Samples were obtained using: (1) a 1½-inch inside diameter Standard Penetration Test (SPT) split barrel drive sampler; (2) a 2½-inch inside diameter Modified California split barrel drive sampler equipped with brass liners; and (3) a "101-type" wireline core barrel sampler. Drive samplers were advanced using a standard 140-pound automatic hammer falling 30 inches. The upper portions of the borings were sampled at approximately 5-foot vertical intervals. Zones of geologic interest within the borings were sampled continuously. The intervals of sampling are shown on the boring logs presented in Appendix A.

3.00 GEOLOGIC AND SEISMIC SETTING

3.01 Berkeley Hills Geology

The proposed GPL building site is situated on the west side of the northwest-trending Berkeley Hills and is characterized by gentle to steep topography. Bedrock geology in the Berkeley Hills is complex and includes a variety of moderately to highly deformed (faulted and folded) sedimentary, volcanic and metamorphic rock units.

The Regional Geologic Map presented on Figure 4 is based on a published geologic map of this area from the United States Geological Survey (Graymer 2000). Bedrock units mapped in the general area of the GPL site area include the Tertiary-age Orinda Formation (map symbol Tor) and Moraga Volcanics (Tmb). Areas within Strawberry Canyon south of the site are mapped as Cretaceous-age Great Valley Complex (Ku). Information on the relative ages of these units is presented below (Ma = millions of years ago):

Ages of Geologic Units (Jones and Curtis 1991)

Stratigraphic Unit	Period/Epoch	Age
Moraga Formation	Tertiary/Late Miocene	10.2 – 8.4 Ma
Orinda Formation	Tertiary/Middle to Late Miocene	13.5 – 10.5 Ma
Great Valley Sequence	Upper Jurassic – Lower Cretaceous	159 – 99 Ma

During the late Miocene and early Pliocene (11.2 to 3.6 million years ago) an extended period of compression occurred that resulted in the folding, faulting and uplifting of the Berkeley Hills. The Berkeley Hills are thought to be currently experiencing uplift at a much slower rate (as much as 1mm/year) based on geodetic studies (Graymer 2000).

3.02 Bay Area Active Faults

The San Francisco Bay Area lies within a broad region of deformation near the boundary between the North American and Pacific tectonic plates. This seismic regime includes a series of major active northwest-trending faults, which include the San Andreas, Hayward, Rodgers Creek, Calaveras, San Gregorio, Concord-Green Valley, West Napa, and Greenville faults. These major faults are near-vertical and generally exhibit right-lateral strike-slip movement (which means that the movement is predominantly horizontal and when viewed from one side of the fault, the opposite side of the fault is observed as being displaced to the right).

Various researchers and government agencies have mapped the locations of active and potentially active faults in California. Faults that are defined as active exhibit one or more of the following: (1) evidence of Holocene-age (within about the past 11,000 years) displacement, (2) measurable aseismic fault creep, (3) close proximity to linear concentrations or trends of earthquake epicenters, and (4) prominent tectonic-related aseismic geomorphology. Potentially active faults are defined as those that are not known to be active, but have evidence of Quaternary-age displacement (within about the past 2 million years). The closest known active fault to the project site is the Hayward fault, which has been mapped by the California Division of Mines and Geology (CDMG, 1982) approximately 1,700 feet southwest of the site on the UCB Campus (Figure 3). The CDMG is now known as the California Geological Survey (CGS).

The CGS has also developed Active Fault Near-Source Zone Maps to be used in conjunction with previous (pre-2008) versions of the Uniform Building Code (UBC). The Active Fault Near-Source Zone Maps were developed to be used with the UBC to characterize earthquake ground shaking for code-based structural design. The following table shows approximate distances and direction from the site to major Bay Area active faults, based on the CGS/UBC mapping.

Principal Bay Area Active Faults, Site to Seismic Source Distances

Seismic Source	Approximate Distance from Site	Approximate Direction from Site
San Andreas	31 km	Southwest
San Gregorio	33 km	Southwest
Hayward/Rodgers Creek	~ 0.5 km	Southwest
Northern Calaveras	21 km	East
Concord-Green Valley	23 km	Northeast
West Napa	34 km	North

3.03 Regional Seismicity

The San Francisco Bay region is seismically active. Since 1800, five earthquakes of M≥6.5 have occurred in the Bay Area (Bakun 1999). These include the: 1836 M6.5 event east of Monterey Bay; 1838 M6.8 event on the Peninsula section of the San Andreas fault; 1868 M6.8-7.0 Hayward event on the southern Hayward fault; 1906 M7.9 San Francisco earthquake on the San Andreas fault; and 1989 M6.9 Loma Prieta event in the Santa Cruz Mountains.

In 2003, The Working Group on California Earthquake Probabilities (WGCEP 2003), in conjunction with the United States Geological Survey (USGS), published an updated report evaluating the probabilities of significant earthquakes occurring in the Bay Area over the next three decades (2002-2031), which has since been updated on a state-wide scale in 2008 for the time span of 2007-2036. The WGCEP (2008) report indicates that there is a 0.63 (63 percent) probability that at least one magnitude 6.7 or greater earthquake will occur in the San Francisco Bay region before 2037. This probability is an aggregate value that considers seven principal Bay Area fault systems and unknown faults (background values - WGCEP 2003). The findings of the WGCEP (2008) report are summarized in the following table:

WGCEP (2008) Probabilities

Fault System	Probability of At Least One Magnitude 6.7 or Larger Earthquake in 2007-2036
Hayward/Rodgers Creek	0.31
San Andreas	0.21
Calaveras	0.07
San Gregorio	0.07
Concord-Green Valley	0.03
Greenville	0.03
Mount Diablo Thrust	0.01
Background *(2002-2031)	0.14*

The published background values are not explicitly stated in the WGCEP (2008) and thus the WGCEP (2003) values were used. The background values indicate that between 2002 and 2031 there is a 14 percent chance that an earthquake with a magnitude of greater than 6.7 may occur in the Bay Area on a fault system not characterized in the study. It should be noted differences between the 2008 and 2003 WGCEP generally fall within the magnitude of error, and major differences in background values are not expected.

4.00 LOCAL GEOLOGIC CONDITIONS

4.01 Topography and Geomorphology

The proposed GPL site is located on a north-south trending ridge that divides two natural watersheds. Areas east of the site are within Chicken Creek Canyon, which generally drains south towards Strawberry Creek. The western margin of the site is bounded by a broad west-sloping surface that drains northwest toward Blackberry Creek. Early maps (Lawson and Palache, 1901) and historical photographs (1935 and 1939) of the site area depict pre-development morphology, and show what appears to be a gently sloping and rounded north/south-trending bedrock ridge with southwest-trending and southeast-trending bedrock spurs. These early depictions show the ridge continuing northward and steepening toward the present-day Lawrence Hall of Science. Highly resistant andesitic and basalt units of the Moraga Formation form the steep ridges and cliff faces upslope of the site (north of McMillan Road).

The natural topography of the area has since been altered by grading. Most significantly, the northern portion of the GPL site is within an area that was cut (lowered) first to construct the building pad for B25 and later during the realignment of McMillan Road.

4.02 Local Bedrock Units

Bedrock within the general project area consists of Cretaceous Great Valley Group and Tertiary Orinda Formation and Moraga Volcanics. Descriptions of the three principal bedrock units in the general vicinity of the site follow.

4.02.1 Cretaceous Great Valley Group

The Cretaceous sedimentary deposits are present at LBNL as part of a Mesozoic rock complex that includes the Coast Range ophiolite and the Great Valley Group. Although the Great Valley Group is usually separated from the ophiolite, it is known from regional mapping that the Great Valley Group sedimentary rocks were originally deposited on the ophiolitic rocks (Graymer 2000).

Sandstone and shale of the Great Valley Group are the oldest rocks that crop out in this general area of LBNL. In the vicinity of the GPL, the contact between the Great Valley Group and the overlying Orinda Formation generally runs along the northern side of Strawberry Canyon. The contact between the Great Valley Group and overlying Orinda Formation generally dips back into the slope (i.e., towards the northeast). Although not encountered in boreholes in the Building 25 area, the Great Valley Group would project beneath the site at considerable depth and would lie below the Orinda Formation.

4.02.2 Tertiary Orinda Formation (Miocene)

The Miocene Orinda Formation is a non-marine sedimentary formation composed of well- to poorly-bedded siltstone, claystone, fine lithic sandstone, and pebble conglomerate. Regionally, the Orinda Formation can be up to about 2,400 feet thick. The conglomerate contains a high percentage of detritus derived from the Franciscan Assemblage (Graymer, et al. 1996). The coarse-grained conglomerate was deposited under alluvial fan conditions, while the sandstone, mudstone and finer-grained conglomerate were deposited as flood plain and channel material (Jones and Curtis 1992). In the vicinity of the GPL site, Lawson and Palache (1901) and Lawson (1900) interpret the sedimentary lacustrine deposits as interfingering with volcanic deposits of the Moraga Formation at or near the interplay between eruptive and fluvial deposition.

Locally, the Orinda Formation consists of well-bedded to massive siltstone and claystone and occasional lenses of coarse-grained sandstone and conglomerate. The top of bedrock consists of fluid-stained, yellowish/reddish brown, weathered, silty sandstone to siltstone. With increasing depth, the Orinda Formation gradually becomes less weathered and maintains coloration more indicative of the deposit, such as, greenish-gray, gray, olive gray and grayish-blue colors with discontinuous lenses of sand and gravel lenses.

4.02.3 Tertiary Moraga Formation (Miocene)

The Miocene Moraga Formation consists of as many as five distinct flows typically defined by basaltic and andesitic composition (Wahrhaftig and Sloan 1989). The thickness of the Moraga Formation in the vicinity of LBNL is estimated at about 800 to 1000 feet (Lawson and Palache 1901). The source vent is believed to be the Round Top volcanic complex, which is located several miles southeast of LBNL. Early studies by Lawson and Palache (1901) refer to the volcanic deposits in the project vicinity as the Campan series and are described as fresh-water deposits interbedded with lavas and tuffs. Others also describe similar clastic deposits at or near the base of eruptive sequences (Lawson 1901; Wahrhaftig and Sloan 1989; and Clements 1963). The Moraga Formation is exposed in multiple cut slopes along Centennial Drive and Grizzly Peak Boulevard north of the site and in several abandoned quarries at LBNL (i.e., northwest of Building 78). Moraga Formation also is exposed in the Lawrence Road cut directly east of Building 48 (south and downslope of the GPL site).

In the site area, the Moraga Formation consists of andesitic and basaltic flows, tuff, and volcaniclastics (locally described as agglomerate or volcanic breccia). Potassium-argon ages of the volcanic flows vary from 10.2 million years (Ma) to 8.5 Ma (Curtis 1989). The basal member of the volcanics, defined as an amygdaloidal andesite is interpreted to have been deposited over a broad alluvial flood plain with later flows and tuffs being confined to narrow channels, ravines and valleys (Lawson and Palache 1901; Wahrhaftig and Sloan 1989). Locally, the Moraga Formation rests depositionally on the Orinda Formation, or is present as intact translated slide bodies (LBNL/Parsons 2000). At the site, the Moraga Formation typically consists of highly fractured and weathered, subangular to subrounded cobble to large, boulder-size agglomerate to andesite with a predominantly silty to fine gravelly matrix. Minor amounts of weathered and altered ash and tuff also are present.

4.03 Local Faults

Regional mapping generally shows the Orinda Formation in fault contact with the older Great Valley Complex south of the site. The map presented on Figure 4 (Graymer 2000) interprets faulting in this general area of LBNL as complex, with two north-striking faults in Chicken Creek Canyon (east of the GPL site) and several northwest-striking faults in Old Town (proximate to and west of the GPL site).

The location of the Orinda-Great Valley contact is reasonably well-established within the lower Chicken Creek Canyon area (in the vicinity of LBNL Building 31) and west of the Advanced Light Source (LBNL Building 6) based on borehole data. The Great Valley Complex was not encountered in previous borings drilled in the vicinity at the GPL site and south of the site the surface trace of the contact is interpreted to run along the steep natural slopes on the north side of Strawberry Canyon. Great Valley rocks near the fault zone are described as a dark gray to black, sheared and brecciated fine-grained shale and siltstone (Jordan & Javandel 2007; Kleinfelder 2004). Orinda-Great Valley contact juxtaposes rocks of vastly different ages (younger than 13.5 million years versus older than about 100 million years, respectively). From a geologic perspective, the Orinda-Great Valley contact is of structural significance, but it is not considered an active fault.

In addition to Graymer (2000), various other consultants and researchers (e.g. HLA 1982, LBNL/Parsons 2000, WLA 2009) have interpreted faults in the vicinity of the site; however, none of the faults that have been mapped locally are zoned as active (Figure 3) and some probably do not exist, as mapped.

4.04 Landslides

Regional landslide mapping by Nilsen (1975) shows no landslides in the general vicinity of the GPL site. A geologic map prepared by HLA for the LBNL campus (HLA 1982) generally shows the GPL site as underlain by Orinda and Moraga Formation rock and maps a small landslide (indicated by an asterisk) southwest of the GPL site directly upslope of LBNL Buildings 45 and 48. The landslide inventory map prepared by the CGS (2003) generally shows landslides east and west of the site, but no landslides within the ridge area occupied by Building 25. In general, the previous published maps and maps prepared by consultants prior to 2000 generally show the GPL site to be underlain by bedrock unaffected by large-scale landsliding.

In the 1990s, LBNL geologists participated in the preparation of a Resource Conservation and Recovery Act (RCRA) Facility Investigation report, pursuant to the permitting requirements of the California Environmental Protection Agency (Cal-EPA) and Department of Toxic Substances Control (DTSC). The resulting report (LBNL/Parsons 2000), commonly referred to as the "RFI Report", is a public document that includes detailed information pertaining to the geology and hydrogeology of LBNL. The RFI report postulates the existence of a number of large-scale "paleolandslides" at LBNL, all of which are mapped as lying topographically below a belt of in-place Moraga Formation rock that generally caps the Berkeley Hills. The postulated paleolandslides are interpreted by LBNL/Parsons (2000) to be "younger than the Moraga Formation but older than historically active landslides at LBNL." In the 2000 RFI Report, the Moraga Formation rock that underlies B25 is interpreted to be a paleolandslide overlying in-place Orinda Formation bedrock. More recent data developed by WLA (2009) indicates that: (1) the B25 ridge area has been stable for perhaps tens of thousands of years; and (2) Moraga formation rocks are in depositional contact with underlying Orinda Formation rocks southeast of the GPL site (at the location of Trench T-2). These new data have been used by WLA (2009) to generally refute the paleolandslide model of LBNL/Parsons (2000), as discussed further in Section 6.03.

5.00 GEOTECHNICAL SITE CONDITIONS

5.01 Surface Conditions

B25 is an irregularly-shaped building with multiple small additions and is abutted at its northern end by B25A (Figure 2). The B25/B25A complex is located near the eastern limits of Old Town south of McMillan Road and is generally surrounded by gently-sloping paved driveways and parking areas. The complex is bordered on the east by LBNL Building 26 (B26), on the south by a small building (B28) and communications tower, and on the west by B4, B5 and a small redwood grove. Surface grades in the area of the buildings vary from about +933 feet (in the parking lot south of B25) to +940 feet (in the parking lot north of B25A).

Although the B25 site is nearly level (sloping only very gently towards the south), it is located along a ridgeline and adjacent areas slope more steeply down towards the east, south and west. East and south of the B25 complex, surface grades generally slope steeply down away from the site at gradients of between about 2.5:1 (horizontal to vertical) and 1.5:1. West of the B25 complex, surface grades slope more gently down away from the site at gradients flatter than about 8:1. As currently envisioned, these nearby sloping areas are not considered part of the GPL site.

5.02 Subsurface Conditions

5.02.1 Generalized Description of Subsurface Conditions

In general, the northern portion of the GPL site is underlain directly by bedrock while the southern portion is underlain by soil up to about 13 feet deep. This condition exists as a result of the undulatory nature of the bedrock surface and grading that was performed to develop the B25/B25A complex, which appears to have included: (1) excavating and removing soil and bedrock at the north end of the site; and (2) placing fill within a colluvium-filled hollow in the southern portion of the site. An interpretive map depicting current elevation contours on the top of the bedrock surface in the area of the planned GPL is presented on Figure 5. The subsurface materials encountered in borings at the site are described briefly below.

Bedrock – The bedrock materials encountered in borings at the site consist of Orinda Formation (including siltstone, sandstone, claystone and conglomerate) and Moraga Volcanics (including andesite and tuff or agglomerate breccias). The bedrock layers that exist within the Moraga Formation are highly variable and include materials that are harder and more resistant than the Orinda Formation. The logs of borings presented in Appendices A through C frequently show Standard Penetration Test (SPT) blow counts of 50 blows for 6 inches or less of penetration within Moraga Formation materials. SPT blow counts between about 20 and 50 blows per foot are commonly reported within Orinda Formation materials.

Colluvium – Colluvium is a geologic term that refers to soil that has moved downslope by gravity. The data we reviewed indicates that colluvium is present beneath the southern portion of the site (in the area of environmental borings/wells MW25-93-15 and MW25-95-26) within buried west-east trending bedrock hollow. The colluvium encountered in Boring MW25-93-15 extends to a depth of about 13 feet and is logged as stiff, dark brown, sandy clay with generally high plasticity. An SPT blow count of 31 blows per foot was reported in this layer. A second west- to northwest-facing colluvium-filled bedrock hollow is interpreted to exist north of Building 25A (in the area of Boring AKA-1) that is not within the planned GPL site.

Fill – Most of the borings drilled at the site did not account for appreciable amounts of fill overlying natural colluvium and/or bedrock. An exception is Environmental Boring MW25-93-15, which was drilled along the western side of the planned GPL site within the central portion of the interpreted former colluvium-filled bedrock hollow. The log of this boring (attached in Appendix C) generally shows between 7 and 8 feet of stiff, lean clay fill overlying colluvium. The fill materials present at the site are considered *undocumented* in that no records have been found to show that the fill was placed in accordance with geotechnical engineering recommendations.

Groundwater – The boring logs presented in Appendices A through C provide only limited data on groundwater conditions in the area of the planned GPL site. However, a significant body of data exists within LBNL's EH&S Division pertaining to groundwater elevations and subsurface flow for the site area in general; data which was developed to address groundwater contaminant transport issues. In general, groundwater is not present in the near surface at the GPL site. Previous data and interpretations developed by LBNL's EH&S Division generally indicate that groundwater is present beneath the site at depth above the contact between the Moraga Formation (which is highly permeable) and the underlying Orinda Formation (which is relatively less permeable).

Summaries of the data and related information used to develop the above generalized descriptions follow.

5.02.2 Summary of Bedrock Depth/Elevation Data

The bedrock depth/elevation data used to develop Figure 5 are summarized in the tables that follow. The original source materials (boring logs) on which the tabular summaries are based are presented in Appendices A through C.

Bedrock Depth/Elevation Data from Geotechnical and Geologic Reports

Source of Data	Boring No.	Surface Elevation (feet)	Depth to Bedrock (feet)	Elevation of Bedrock (feet)	Top of Bedrock Description
AKA (2009)	AKA-1	939.7	≤10.7	>929.0	Orinda (siltstone)
AKA (2009)	AKA-2	933.4	3.5	929.9	Moraga Volcanics
HLA (1988)	1	~920	8	912	Moraga (andesite)
HLA (1988)	2	~923	8	915	Moraga (andesite)
HMLA (1966)	10	927	6	921	Orinda (siltstone)
HMLA (1966)	11	930	1.5	928.5	Orinda (siltstone)
HMLA (1966)	12	922	8	914	Orinda (siltstone)
HMLA (1966)	13	933	7	926	Moraga (basalt)
HMLA (1966)	14	932	3.5	928.5	Moraga (basalt)
HA (1963)	1	937.6	17.5	920.1	Orinda (siltstone)
HA (1963)	2	936.5	18	918.5	Orinda (siltstone)
HA (1963)	3	906.5	>15	<891.5	not encountered

Bedrock Depth/Elevation Data from Environmental Boring Logs

Boring No.	Surface Elevation (feet)	Depth to Bedrock (feet)	Elevation of Bedrock (feet)	Top of Bedrock Description
MW25-93-15	935.4	~13	922.4	Moraga (breccia)
MW25-94-12	937.93	~2	937.9	Orinda (siltstone)
MW25-95-5	933.24	~0	933.2	Moraga (andesite)
MW25-95-26	936.17	~15	921.2	Moraga (andesite)
MW25-98-10	935	~4	931	Moraga (andesite)
MW25A-95-4	938.67	~1	937.7	Moraga (andesite)
MW25A-95-15	932.14	~6	926.1	Orinda (siltstone)
MW25A-98-1	934.70	~2	932.7	Orinda (silty sandstone)
MW25A-98-3	940.00	~0	940.0	Moraga (andesite)
MW25A-98-6	940.70	~2	938.7	Moraga (tuff breccia)
MW25A-98-7	940.10	~2.5	937.6	Orinda (siltstone)
MW25A-99-5	940.60	~1	939.6	Orinda (silty sandstone)
MW25A-99-2	940.69	~1.5	939.2	Orinda (siltstone)
MW25A-00-5	933.37	~2	931.4	Orinda (sandstone and siltstone)
SB25A-96-1	932.55	~6	926.6	Orinda (silty sandstone)
SB25A-96-2	937.29	~1.5	935.8	Orinda (silty sandstone)
SB25A-96-3	939	~2	937	Orinda (tuffaceous siltstone)
MW26-92-11	941	~8.5	932.5	Orinda (sandy claystone)

Bedrock Depth/Elevation Data from Environmental Borings without Logs

Boring No.	Surface Elevation (feet)	Depth to Bedrock (feet)	Elevation of Bedrock (feet)	Top of Bedrock Description
SB25-95-1	937	~8	~929	Moraga
SB25-95-2	941	~1	~940	Moraga
SB25-95-3	940	~0	~940	Moraga
SB25-95-4	935	~3	~932	Moraga
SB25-95-5	934	~9	~925	Moraga
SB25A-95-1	933	~2	~931	Orinda

5.02.3 Summary of Groundwater Data

Borings AKA-1 and AKA-2 were drilled using rotary wash drilling methods in which borehole stability is maintained through the use of drilling fluids; this technique generally precludes the accurate measurement of natural groundwater levels either during or immediately after drilling. Information on the depth and elevation of groundwater reported in previous borings by others is presented in the following tables.

Groundwater Depth/Elevation Data from Geotechnical and Geologic Reports

Source of Data	Boring No.	Surface Elevation (feet)	Depth to Groundwater (feet)	Elevation of Groundwater (feet)	Date of Groundwater Measurement
HA (1966)	11	930	23	907	8/30/66
HA (1966)	12	922	17	905	8/4/66
HA (1966)	15	863	7	856	7/20/66

Groundwater Depth/Elevation Data from Environmental Borings

Boring No.	Surface Elevation (feet)	Depth to Groundwater (feet)	Elevation of Groundwater (feet)	Date of Groundwater Measurement
MW25-93-15	935.4	~60	~975.4	11/93
26-92-11	~941	~18	~923	3/9/92

The RFI Report includes a water level contour map of the Old Town area for the fourth quarter of fiscal year 1999 (LBNL/Parsons 2000, Figure B2.4-2) and groundwater depth/elevation data is depicted graphically on the RFI Report cross sections. In general, these sources of information show a groundwater surface that slopes down from north to south across the site. The north/south-trending cross section presented in the RFI Report Section (LBNL/Parsons 2000, Figure B2.3-9) generally shows groundwater levels that are near Elevation +920 in the vicinity of B25A and below Elevation +875 south of B25.

5.02.4 Summary of Plasticity Test Data

The results of laboratory Atterberg Limits determinations performed during previous site investigations by others are summarized in the following table.

Atterberg Limits Test Results

Source of Data	Boring No.	Approximate Depth of Sample (feet)	Liquid Limit	Plasticity Index	Material (Soil Classification)
HLA (1988)	1	2.5	37	14	(ML)
HMLA (1966)	12	30.4	31	10	Siltstone (CL-ML)
HMLA (1966)	12	47.6	33	13	Siltstone (CL-ML)
HMLA (1966)	13	31.9	43	13	Basalt (ML)

Onsite soils having a PI of 15 or less are generally considered to have a sufficiently low expansion potential to be used as non-expansive fill.

6.00 GEOLOGIC AND GEOTECHNICAL HAZARDS

We conclude that the proposed project is generally feasible from a geologic and geotechnical hazard standpoint provided that the geotechnical recommendations outlined in this report are appropriately addressed in the project design. The principal geologic and geotechnical hazard considerations for the project are discussed in the sections that follow.

6.01 Ground Shaking

The San Francisco Bay Area is seismically active and strong ground shaking is likely to occur at the site within the life of the project as a result of future earthquakes. For this reason, structures at the site should be designed to resist strong ground shaking in accordance with the requirements of the California Building Code (CBC) and local design practice.

6.01.1 CBC Site Class

The seismic design provisions of the 2007 CBC include a methodology by which sites are classified as A through F in order to quantify site-specific ground shaking effects. As previously discussed, the proposed GPL site is underlain by variable conditions with portions of the site underlain by 15 or more feet of soil. Based on the available information, we judge a Class C designation (very dense soil and soft rock) to be most appropriate for the design of the GPL building. Associated location-specific seismic design parameters for use with the 2007 California Building Code (CBC) are presented in Section 8.02.1 of this report.

6.01.2 Campus Ground Motions

The seismic design provisions of the 2007 CBC also allow the use of earthquake ground motions developed through a site-specific probabilistic seismic hazard assessment (PSHA). PSHA-derived design ground motions (response spectra and time histories) have been developed for the LBNL campus by URS Corporation (URS). The latest ground motions developed by URS take advantage of "next generation" attenuation models (NGA models), which can predict lower levels of ground shaking than previous PSHA models. We anticipate that the LBNL design ground motions would potentially be used in the structural design of the GPL building, if: (1) the LBNL design ground motions are found to be significantly lower than the CBC-derived ground motions over the period(s) of interest; or (2) if earthquake time histories are needed for dynamic analysis. Recommendations concerning the application of the campus ground motions developed by URS are included in Section 8.02.2.

6.02 Surface Fault Rupture

Historically, earthquake fault rupture most often occurs along pre-existing active faults. The GPL site is not located within an AP Zone (Figure 3), and the references that we reviewed indicate the closest mapped active fault is more than 1/4 mile away. Based on this information, we consider the overall risk of surface fault rupture at the site to be low.

6.03 Geologic Stability

Our previous phases of study at the GPL site (AKA 2009 and WLA 2009) were performed to check the paleolandslide hypothesis of LBNL/Parsons (2000), as it relates to this specific site. Based on a detailed review of existing information, geologic field reconnaissance and mapping, three test borings (AKA-1 through AKA-3) and two exploratory trenches (T-1 and T-2), WLA concluded that: (1) the trench and geomorphic data provide evidence for long-term (thousands of years) stability of the bedrock ridge upon which the GPL site is to be located; and (2) if a paleolandslide exists beneath the site it is geologically stable as previously mapped.

The presence of localized landsliding in the area upslope of Buildings 45 and 48 (as previously identified by HLA 1982) was generally confirmed by WLA. Although this feature is not considered a concern relative to the GPL site, WLA cautions that the areas southwest of Building 25 should not be developed without further characterizing the upslope limits of this known area of local instability.

The stability of materials within the west/east-trending colluvial-filled bedrock hollow that underlies the southern portion of the GPL site has not been previously addressed. In general, within the area of the planned GPL site the hollow does not slope steeply in the out-of-slope direction (as evidenced by the bedrock surface elevations reported in environmental borings/wells MW25-93-15 and MW25-95-26). In addition, it appears that the contact between the colluvium and underlying volcanic breccia bedrock may have been sampled (in environmental boring/well MW25-93-15) and there is no direct indication on the logs of a possible shear zone at this location or depth. Also, previous geologic review of historic aerial photographs did not identify geomorphology suggestive of landsliding in the area of the planned GPL building. Consequently, we currently consider there to be a relatively low likelihood that future deep-seated slope movements would potentially occur within the colluvial-filled hollow that underlies the southern portion of the GPL site. We do, however, recommend that this tentative conclusion be revisited and confirmed by direct observation of subsurface conditions exposed during construction, as discussed later in this report.

6.04 Inundation

The site is located in the hills upslope of the city of Berkeley near Elevation +800 feet; inundation by tsunami or seiche is therefore not a concern. To our knowledge, there are no dams or large reservoirs upslope of the site that could pose an inundation hazard to the GPL facility. In our opinion, there is essentially no risk of significant inundation at the planned GPL site.

6.05 Liquefaction and Densification

The soils generally considered most susceptible to liquefaction are saturated (i.e., below groundwater) clean sands, silts and gravels having little or no cohesion. Densification can occur where these types of low-cohesion soils are above groundwater. Current and ongoing research has demonstrated that cohesive silts and clays of low plasticity can also exhibit seismic strength degradation behavior that is in some ways similar to liquefaction. The range of conditions over which this behavior occurs is the subject of continuing research. There appears to be general agreement that soils having a PI of 7 or less are susceptible to earthquake-induced strength loss, whereas soils having a PI of 18 or greater are not.

In general, the GPL site is underlain by bedrock and soils of moderate plasticity that are not submerged. Consequently, we judge there to be little to no potential for seismically-induced liquefaction or densification at the planned GPL site.

7.00 GEOTECHNICAL EVALUATIONS AND CONCLUSIONS

7.01 Foundation Support

Based on the available existing data, we conclude that the GPL building can be supported on conventional spread footing foundations. Spread footings can be founded upon: (1) bedrock and/or firm natural colluvium, or (2) appropriately engineered materials founded upon bedrock and/or firm colluvium. The existing undocumented fill materials that exist in localized areas of the site are considered generally unsuitable for the support of spread footings.

Post-construction static settlement of properly constructed spread footings under allowable loads should be very small; less than about ½ inch. Recommendations for the design and construction of spread footings are presented in Section 8.03.

7.02 Existing Fill Materials

All existing undocumented fill materials beneath future spread footing foundations will need to be removed and replaced with appropriately engineered fill. Based on the available data, old fill materials are known to be present within the southern portion of the GPL site; however, fill materials may also be present in other areas not explored by borings.

The removal and replacement of existing fill materials is a critical aspect of the proposed GPL project. Following the excavation of existing materials, it will be necessary for AKA (and WLA, if appropriate) to observe the bottom of the overexcavated area to check that: (1) the underlying materials are capable of supporting future foundation loads; and (2) any areas of questionable geologic stability (e.g. possible adverse bedding, fractures, or shear zones) are appropriately addressed. Recommendations for the overexcavation and removal of existing fill materials and associated geologic/geotechnical observations are presented in Section 8.05.2.

7.03 Uplift Resistance

Drilled and grouted ground anchors (tiedowns) can be used to resist uplift. Tiedowns typically consist of a vertical steel element (usually a high-strength steel bar or tendons) that is secured in place with cement grout. Tiedowns resist axial loads primarily through skin friction between the grout and the subsurface soil and/or rock materials. The axial capacity of tiedowns can be increased by: (1) increasing the surface area of the grout contact (by lengthening the tiedown or drilling a larger hole); or (2) increasing the skin friction (by pressure grouting or post-grouting). Once the grout has appropriately set, tiedowns are load tested to confirm their axial capacity and load-deformation behavior. Following foundation construction, tiedowns are typically: (1) tensioned against the top of the completed footing or other foundation element; and (2) locked off at a specific design load (determined by the structural engineer). The upper portion of the tiedown (stressing tail and anchorage) is then permanently covered and protected to resist corrosion. Tiedowns are considered a permanent part of the structure and the corrosion resistance of the reinforcing element and anchorage connection is a critical aspect of the tiedown design.

Specialty contractors have developed a variety of techniques and proprietary systems to construct tiedowns and, therefore, these elements are commonly constructed under a design-build approach. Based on our experience, we judge that tiedowns that penetrate the bedrock materials that underlie the site can be designed to have allowable axial capacities of 200 kips or greater. Geotechnical recommendations pertaining to tiedown design are presented in Section 8.03.4.

7.04 Expansive Soils

The onsite soils and bedrock do not appear to include significant quantities of materials that are considered expansive (expansive materials tend to shrink and swell with changes in moisture content and therefore have the potential to damage improvements that are supported directly upon them unless appropriately mitigated). As a precaution, it will be necessary for AKA to observe and test, as appropriate, the following materials to check their expansion potential: (1) soils and bedrock exposed in near-surface site excavations; (2) onsite materials proposed to be re-used as engineered fill; and (3) proposed import fill materials. Geotechnical recommendations pertaining to earthwork and expansive soils are presented in Section 8.05.

7.05 Construction Considerations

7.05.1 Excavation and Shoring

We anticipate that most of the near-surface soil and bedrock at the site can be excavated with conventional earth-moving equipment. However, it is possible that locally harder bedrock could be encountered that would require jack-hammering or hoe-ramming to excavate, particularly in confined areas such as trenches or keyway excavations. In addition, the existing fill materials at the site may include subsurface obstructions. Removal of buried obstructions could require equipment capable of breaking concrete.

As currently envisioned, the GPL building will be supported near the level of the existing grade and, consequently, deep excavations are not currently anticipated. All excavations deeper than 4 feet that will be entered by workers will need to be shored or sloped for safety in accordance with the applicable: (1) California Occupational Safety and Health Administration (Cal-OSHA) standards; and (2) site-specific health and safety protocols and procedures required by LBNL.

7.05.2 Dewatering and Soil Moisture

Although groundwater at the site is generally thought to be deeper than anticipated site excavations, the control of groundwater during construction is the responsibility of the contractor. The contractor should anticipate that site excavations may need to be dewatered and depending upon the water source (i.e., surface versus subsurface), there may be environmental aspects to the appropriate collection, storage and disposal of onsite water. The design, permitting, installation, monitoring, and abandonment of site dewatering and discharge systems are the contractor's responsibility.

The onsite soils may include materials that are wet of optimum, from an earthwork compaction standpoint. Deeper excavations at the site could encounter soils that are saturated. The contractor should anticipate that soils obtained from site excavations will include clayey soil and clayey rock materials that will need to be processed (e.g. by air drying) prior to being placed as engineered fill.

7.05.3 Construction Monitoring

The contractor's responsibilities should include: (1) documenting the condition of the adjacent improvements prior to the commencement of site demolition and excavation activities; (2) designing demolition, excavation and construction programs that will keep surface settlements and vibrations within acceptable limits set by LBNL; and (3) coordinating with LBNL and providing settlement and vibration monitoring, as needed, to assure that adjacent facilities are not adversely affected during the geotechnical aspects of construction.

7.05.4 Wet Weather Construction

Although it is possible for excavation and/or construction to proceed during or immediately following the wet winter months, a number of geotechnical problems may occur which may increase costs and cause project delays. The water content of onsite soils may increase during the winter and rise significantly above optimum moisture content for compaction of subgrade or backfill materials. If this occurs, the contractor may be unable to achieve the specified levels of compaction. Dewatering requirements will potentially increase due to rainfall, surface runoff, seepage and rises in groundwater level. The stability of temporary slopes will decrease, potentially increasing the lateral extent of excavation required. If utility or footing trenches are open during winter rains, caving of the trench walls may occur. Subgrade preparation beneath footings, mat foundations, slabs-on-grade and pavement sections may prove difficult or infeasible. In general, we note that it has also been our experience that increased clean-up costs may be incurred, and greater safety hazards may exist, if the work proceeds during the wet winter months.

8.00 GEOTECHNICAL RECOMMENDATIONS

8.01 General

Contractors responsible for the geotechnical aspects of the project (e.g. general, shoring, grading, foundation) should become familiar with the contents of this report and acknowledge:

- The site conditions, as described in this report and the attached Appendices;
- The construction considerations discussed in Section 7.05 of this report; and
- LBNL requirements for excavations, safety and vibrations.

We recommend that these and all other contractor responsibilities be clearly defined in the project plans and specifications.

8.02 Seismic Design

8.02.1 2007 California Building Code Seismic Parameters

Structures at the site should be designed to resist strong ground shaking in accordance with the applicable building codes and local design practice. This section provides location-specific seismic design parameters for use with the 2007 California Building Code (CBC 2007). Based on our review of the subsurface conditions and the 2007 California Building Code (CBC), we judge that a "C" Site Class is applicable.

Site Location
Latitude = 37.8760 degrees
Longitude = -122.2466 degrees

Mapped Spectral Accelerations
Short Period, (S_S, Site Class B) = 2.008g
1-Second Period, (S_1, Site Class B) = 0.783g

Maximum Considered Earthquake Spectral Response Accelerations
Short Period, (SM_S, Site Class C) = 2.008g
1-Second Period (SM_1, Site Class C) = 1.018g

Design Spectral Response Accelerations
Short Period (SD_S, Site Class C) = 1.339g
1-Second Period (SD_1, Site Class C) = 0.679g

The acceleration parameters presented above were obtained using the United States Geological Survey's Java-based website application (http://earthquake.usgs.gov/research/hazmaps/design/), which we accessed on December 3, 2009. The Maximum Considered Earthquake Spectral Response Accelerations are associated with 2 percent probability of exceedence in 50 years level-of-hazard. The Design Spectral Response Accelerations are two-thirds of the Maximum Considered Earthquake values.

8.02.2 LBNL/UCB Campus Probabilistic Ground Motions

In 2000, a suite of probabilistically-derived ground motions were developed for the UCB campus as a whole. This standardized suite of ground motions (response spectra and acceleration time histories) was updated by URS Corporation (URS) in 2003 and again in 2008. The 2008 update (URS 2008) included ground motions for LBNL for four return periods (72, 475, 949 and 2,475 years). The results for a 475-year return period (10 percent probability of exceedence in 50 years) are summarized in the following table.

LBNL PSHA Ground Motions

475-year Return Period Spectral Accelerations		
0.01-Second Period	**0.2-Second Period**	**1-Second Period**
0.86g	2.02g	0.40g

If use of the URS ground motions is being considered, we recommend that the project design team obtain the most current version of the ground motion report directly from LBNL. AKA would be pleased to consult with the design team pertaining to the applicability of the ground motions to the GPL site; however, we would also recommend that URS be consulted to verify that any assumptions and/or restrictions pertaining to the application of the ground motions were appropriately considered.

8.03 Foundation Design

8.03.1 General

New spread footings should be designed to bear upon firm, natural soil or bedrock or on appropriately engineered materials (e.g. engineered fill or improved ground). All footings should be designed to bear at least 18 inches below lowest adjacent firm finished grade. Continuous and isolated spread footings should have minimum widths of 18 inches and 24 inches, respectively. Footings that extend at least 12 inches into undisturbed bedrock can be designed for higher bearing pressures; the bedrock surface contour map presented on Figure 5 can be used to evaluate the approximate elevation of the top of bedrock at the GPL site. All footing excavations should be checked by AKA for proper depth, bearing, and cleanout prior to the placement of reinforcing steel. Footing excavations should be kept moist and free of loose material and standing water prior to concrete placement.

8.03.2 Footing Bearing Pressures

Shallow spread footings bearing on stiff natural soil or engineered fill can be designed using the following bearing pressures:

Bearing Pressures for Shallow Spread Footings on Soil

Load Case	Bearing Pressure (psf)	Factor of Safety
Dead Load Allowable	2000	3.0
Deal Plus Live Load Allowable	3000	2.0
Total Allowable	4500	1.5
Ultimate	6000	1.0

Shallow footings that extend at least 12 inches into bedrock or deepened spread footings bearing on stiff natural soil or engineered fill can be evaluated using the higher bearing values presented in the following table.

Bearing Pressures for Shallow Spread Footings in Rock and Deepened Spread Footings on Soil

Load Case	Bearing Pressure (psf)	Factor of Safety
Dead Load Allowable	3000	3.0
Deal Plus Live Load Allowable	4500	2.0
Total Allowable	6000	1.5
Ultimate	9000	1.0

Deepened spread footings should be founded at least 48 inches below lowest adjacent firm finished grade.

Higher bearing pressures could be warranted for footings that bear upon improved ground. We recommend that we review any recommendations and/or plans for vibration mitigation that involve ground improvement, so that we can provide supplemental geotechnical recommendations, if appropriate.

8.03.3 Lateral Resistance

Resistance to lateral loads can be provided by friction along the base of foundations and by passive pressures developing on the sides of below-grade structural elements. Passive resistance in soil can be estimated using an equivalent fluid weight of 350 pounds per cubic foot (pcf). Passive resistance in bedrock can be estimated using an equivalent fluid weight of 450 pcf. These values can be increased by one-third for dynamic loading.

Where pavements cover the adjacent ground surface or floor slabs, passive resistance can be assumed to begin at the ground surface. In areas not confined by slabs or pavements, passive resistance should be neglected within 1 foot of the ground surface.

A friction coefficient of 0.35 can be used to evaluate frictional resistance along the bottoms of spread footing foundations. The above passive and frictional resistance values include a factor of safety of at least 1.5 and can be fully mobilized with deformations of less than 1/2- and 1/4-inch, respectively.

8.03.4 Tiedowns

This section presents preliminary recommendations for grouted anchors (tiedowns). We recommend that we provide more detailed (supplemental) recommendations in the event that tiedowns are to be incorporated into the final project design after: (1) the purpose of the tiedowns has been established; and (2) information regarding capacities and desired load/deflection behavior are established.

Tiedowns (if used) should be anchored in bedrock. All tiedowns that are designed to be post-tensioned should have an unbonded length of at least 15 feet. For estimating the lengths of tiedowns grouted or post-grouted under pressure, we recommend using an allowable skin friction value of 2,000 pounds per square foot (psf) in bedrock. A lesser allowable skin friction value of 1,200 psf should be used where pressure grouting or post-grouting is not performed. All tiedowns should be tested to at least 1.25 times the design load and should be sized such that the magnitude of the test load does not exceed 80 percent of the guaranteed ultimate strength of the tendons or bars. Permanent tiedowns should be equipped with

double corrosion protection. Appropriate corrosion protection should also be provided at the anchorage connection. Tiedowns that are locked off at higher than nominal loads will exert a downward force on spread footings; the resulting increase in footing bearing pressure should be accounted for in the foundation design.

AKA and the project Structural Engineer should review and approve all submittals from the contractor pertaining to the design, installation and testing of tiedowns. AKA should also observe during tiedown installation and load testing.

8.04 Retaining Walls

8.04.1 General

All retaining walls should be designed to be fully drained to prevent the build-up of hydrostatic pressures behind the wall. A moisture barrier or waterproofing should be applied to the rear face of retaining walls in all areas where seepage or moisture transmission through the walls would be considered objectionable. The specification of the type of moisture barrier or waterproofing and observation during its installation should be provided by the architect and/or structural engineer.

Walls that are not free to rotate at their tops should be designed to resist higher lateral soil pressures than unrestrained walls that are considered free to rotate. Walls that retain sloping backfill (i.e., where the ground surface slopes up behind the wall) will also need to be designed for higher lateral pressures. Earthquake shaking can also increase lateral pressures on retaining walls, in some cases. Retaining wall foundations should be designed in accordance with the recommendations presented in the previous section (Section 8.03).

8.04.2 Lateral Pressures

Retaining walls should be designed to resist lateral pressures as well as any increases in lateral pressure caused by vehicle loadings and/or other surcharges that may be applied at the ground surface. The following lateral pressure distributions can be used for the design of retaining walls for a level backfill condition under normal (i.e., non-earthquake) loads.

Static Lateral Pressures – Level Backfill

Load Condition	Lateral Pressure
Lateral Pressure, Restrained Walls	60 (psf per foot of depth)
Lateral Pressure, Free-to-Rotate Walls	45 (psf per foot of depth)
Surcharge (vehicles)	100 psf (uniform) – applied over the upper 10 feet of the wall height
Surcharge (general)	0.5 times anticipated surcharge load (uniform)

A uniform seismic load of 18H (in psf for H in feet) can be used to evaluate increases in lateral loads caused by earthquake shaking. In general, the seismic load increase: (1) should be added to the lateral pressure distribution presented above for free-to-rotate walls; and (2) can be neglected for restrained

basement, sump or elevator pit walls where the ground surface surrounding the basement, sump or pit is nearly level (i.e., a "balanced" basement-type condition).

8.04.3 Wall Drainage

The above lateral pressures are based on the assumption that retaining walls will be fully drained to prevent the build-up of hydrostatic pressure. Wall drainage may consist of either: (1) holes, slots or gaps in the wall that allow water to freely drain through the wall face; or (2) a wall backdrainage system that collects water from behind the wall and drains it, by gravity, to an appropriate discharge location.

Backdrainage should consist of either: (1) prefabricated drainage material (Miradrain or an approved alternative) installed in accordance with the manufacturer's recommendations, or (2) a drain rock layer at least 12 inches thick. Prefabricated drainage material should drain to a perforated plastic pipe or an approved prefabricated drainage conduit. Backdrainage should drain into a perforated plastic pipe installed (with perforations down) along the base of the walls on a 2-inch-thick bed of drain rock. Plastic pipe should be sloped to drain by gravity to a sump, relief wells or other suitable discharge and a cleanout should be provided at the pipe's upslope end. Perforated and non-perforated plastic pipe used in the drainage system should consist of 4-inch diameter Schedule 40 PVC or an approved equivalent. Drain rock should conform to Caltrans specifications for Class 2 permeable material. Alternatively, locally available, clean, ½- to ¾-inch maximum size crushed rock or gravel could be used, provided it is encapsulated in a non-woven geotextile filter fabric, such as Mirafi 140N or an approved alternative. The upper 2 feet of retaining wall backfill (above backdrainage) should be comprised of low-permeability soil to limit surface water infiltration into the retaining wall backdrainage system.

8.05 Earthwork

8.05.1 Site Preparation

The site limits, as defined on the plans, should be clearly marked in the field. Prior to demolition and site clearing, all active subsurface utilities in and immediately surrounding the site limits should be located, marked and protected or relocated. Areas within the site limits should be cleared of structures, foundations, pavements, aggregate base, slabs-on-grade, catch basins, storm drains, sewers, utilities and all other near-surface improvements. Any soils containing vegetation and/or organic matter should be stripped. Cleared materials should be removed from the site unless they are specifically identified as suitable for re-use by LBNL and AKA. Stripped materials are not suitable for re-use as engineered fill and should be removed from the site or stockpiled for later use as landscape material (at LBNL's discretion).

The contractor should document the condition of existing improvements located outside of the site limits, and should perform any and all monitoring activities required by LBNL (which may include monitoring construction vibrations). We recommend that AKA and LBNL review the contractor's proposed construction monitoring plans prior to the start of demolition and site preparation activities.

8.05.2 Excavation

Any existing fill materials within and surrounding planned building areas should be excavated to expose firm natural materials (colluvium or bedrock). Where fill materials are encountered that extend below planned spread footing foundations, all of the existing fill materials should be removed within a zone extended down from the external edge of the footing(s) at an inclination of ½:1 (horizontal to vertical), or flatter.

AKA should observe the condition of the exposed subgrade following fill removal to: (1) check that suitable geotechnical bearing materials are exposed; and (2) determine whether additional observation is necessary to evaluate the geologic stability of the underlying colluvium and bedrock.

8.05.3 Fill Materials

Fill materials should conform to the requirements presented below:

General Fill – General fill material should have an organic content of less than 3 percent by volume and should not contain rocks or lumps larger than 6 inches in greatest dimension.

Non-Expansive Fill – Non-expansive fill material should:

- Be free of 6-inch plus material with no more than 15 percent of material larger than 2.5 inches;
- Be free of organic material, debris and environmental contaminants;
- Have a Plasticity Index of 15 or less; and
- Have a Liquid Limit of 40 or less.

Import Fill – We recommend that import fill conform to the requirements for non-expansive fill and have a Plasticity Index of 12 or less.

All proposed fill materials should be approved by AKA prior to their use. Much of the material cleared or excavated from the site may be suitable for re-use as non-expansive fill, from a geotechnical standpoint; although some materials may need to be processed (i.e., by crushing and/or blending) to meet the above requirements. LBNL should review and approve proposed fill materials to be used beneath the GPL building to check that they are suitable from an environmental perspective. Any proposed import fill material should be evaluated by our firm prior to its importation to the site.

8.05.4 Fill Placement

AKA should observe the condition of the subgrade upon which fill will be placed to check that it is firm and non-yielding and that no old fill or other unsuitable material is present. Prepared subgrades should be relatively level prior to fill placement. Where fill is to be placed adjacent to areas of sloping ground, it should be appropriately keyed and benched into the slope. We recommend that AKA evaluate whether subdrainage (e.g. permeable material, perforated plastic pipe, non-perforated cleanout and outlet pipes, and a suitable gravity discharge) should be installed prior to filling based on conditions observed following excavation. Any required subdrainage should be installed in accordance with AKA's supplemental recommendations.

Fill materials should be placed in a manner that minimizes lenses, pockets and/or layers of materials differing substantially in texture or gradation from the surrounding fill materials. The soils should be spread in uniform layers not exceeding 8 inches in loose thickness prior to compaction. Each layer should be compacted using mechanical means. The fill should be constructed in layers such that the surface of each layer is nearly level.

AKA should observe fill placement and test compaction, as appropriate, to confirm and document that the work was performed in accordance with the specifications and the intent of our geotechnical recommendations.

8.05.5 Utility Trenches

Utility trenches should be backfilled with fill placed in lifts not exceeding 8 inches in uncompacted thickness. Trenches should be filled by placing a granular shading layer beneath and around the pipe, and then 6 to 12 inches of shading should be carefully placed and tamped above the pipe. The remaining portion of the trench should be backfilled with onsite or import soil. The backfill (above shading layers) should be placed and compacted to a minimum relative degree of compaction of 90 percent based on ASTM D-1557. The compaction requirements given above should be considered minimum recommended requirements. If LBNL and/or utility company specifications require different or more stringent backfill requirements, those specifications should be followed.

If imported granular soil is used, sufficient water should be added during the trench backfilling operations to prevent the soil from "bulking" during compaction. All compaction operations should be performed by mechanical means only. We recommend against jetting.

Where granular backfill is used in utility trenches, we recommend an impermeable plug or mastic sealant be used where utilities enter the building to minimize the potential for free water or moisture to enter below the building. Finally, because of the potential for collapse of trench walls, we recommend the contractor carefully evaluate the stability of all trenches and use temporary shoring, where appropriate. The design and installation of the temporary shoring should be wholly the responsibility of the contractor. In addition, all state and local regulations governing safety around such excavations should be carefully followed.

AKA should observe utility trench backfilling and test compaction, as appropriate, to confirm and document that the work was performed in accordance with the specifications and the intent of our geotechnical recommendations.

8.06 Concrete Slabs-on-Grade

8.06.1 Interior Slabs

We recommend that interior slabs that are cast on-grade be underlain by a moisture retarder that includes a crushed rock layer and a plastic membrane. Either of the two alternative moisture barrier systems described below are considered acceptable:

- 4 inches of free-draining gravel overlain by a vapor retardant membrane (Class A Vapor Retarder [ASTM E1745, latest revision]), covered with 2 inches of sand, or
- 6 inches of compacted aggregate base overlain by a heavy-duty impermeable membrane (Stego® wrap 15-mil or an approved equivalent) installed and taped in accordance with the manufacturer's recommendations.

The subgrade beneath the moisture retarder should be proof-rolled under our observation and confirmed to be uniform and non-yielding prior to the placement of the crushed rock layer. Where naturally non-expansive materials are present at subgrade level, the moisture barrier can be placed directly upon the prepared, proof-rolled and approved subgrade (colluvium or bedrock). Where existing fill is present at subgrade level, it should be overexcavated to expose firm natural materials and replaced with engineered non-expansive fill compacted to at least 90 percent relative compaction. In all cases, the upper 18 inches of material beneath the bottom of interior slabs on grade should consist of non-expansive material (i.e., have a PI of 15 or less).

Slab reinforcing should be provided in accordance with the anticipated use and loading of the slab. We recommend that interior slabs-on-grade be at least 5 inches thick and be reinforced with steel bar reinforcement. We also recommend that the specifications for slab-on-grade floors require that moisture emission tests be performed on the slab prior to the installation of flooring. No flooring should be installed until safe moisture emission levels are recorded for the type of flooring to be used.

8.06.2 Exterior Slabs

Subgrades beneath exterior slabs-on-grade should be proof-rolled under our observation and confirmed to be uniform and non-yielding prior to the placement of the slab reinforcement. Concrete slabs that may be subject to vehicle loadings should be designed in accordance with Section 8.07.2, "Rigid Pavements." Where non-expansive materials are present at subgrade level, exterior slabs can be cast directly upon the prepared, proof-rolled and approved subgrade. In all cases, the upper 12 inches of material beneath the bottom of exterior slabs-on-grade should consist of non-expansive material (i.e., have a PI of 15 or less).

Slab reinforcing should be provided in accordance with the anticipated use and loading of the slab. We recommend that exterior slabs-on-grade be at least 4 inches thick and be reinforced with steel bar reinforcement. Exterior slabs should be structurally independent from buildings and be free-floating. Score cuts or construction joints should be provided and minor movement and cracking of the slab should be expected. Steps to the building from exterior slab areas should include a gap between the steps and the building foundations. The recommendations presented above, if properly implemented, should help reduce the magnitude of exterior slab cracking.

8.07 Pavements

8.07.1 Flexible Pavements

Flexible asphalt concrete (AC) pavements may be used for parking areas and driveways. We developed the following recommended pavement sections for various traffic indices using the Caltrans R-value design method for flexible pavements. The sections below are based on an assumed subgrade R-value of 30 for non-expansive soil. The R-value of the soil beneath the aggregate base should be confirmed during construction.

Flexible Pavement Thickness Design for Subgrade R-Value = 30

Traffic Index	Asphalt Concrete (inches)	Caltrans Class 2 Aggregate Base (inches)	Total Thickness (inches)
4	2	6	8
5	3	6	9
6	3	9	12
7	3	12	15

The upper 12 inches of material beneath the bottom of the aggregate base should consist of non-expansive material (i.e., have a PI of 15 or less).

The assumed traffic indices of 4.0 and 5.0 are commonly used for automobile and light truck parking areas and access driveways, respectively. Traffic indices of 6.0 and 7.0 are commonly used for moderate truck access and parking areas. A traffic study has not been conducted by our firm for this project and our opinion regarding the applicability of the assumed traffic indices is experience-based and judgmental. The

project civil engineer should choose the appropriate traffic indices for the pavement areas of the site and then use the given section for that traffic index.

The upper 6 inches of subgrade beneath planned pavements should be compacted to at least 95 percent relative compaction per ASTM D-1557. Pavement subgrades should be proof-rolled and confirmed to be uniformly firm and non-yielding prior to the placement of aggregate base. Aggregate base for use in pavements should conform to Caltrans Standard Specifications for Class 2 Aggregate Base. The aggregate base used in pavement sections should be compacted to at least 95 percent relative compaction as determined by ASTM D-1557.

8.07.2 Rigid Pavements

Rigid Portland cement concrete (PCC) pavements may also be used in driveway/loading areas. This section provides recommendations for Caltrans jointed plain concrete pavement (JPCP), which is engineered with longitudinal and transverse joints to control where cracking occurs. JPCPs do not contain steel reinforcement, other than tie bars and dowel bars. The project civil engineer should design and detail the JPCP per Caltrans specifications.

We developed the following pavement thickness design using the Caltrans R-value design method for rigid pavements and an assumed traffic index. The section below is for subgrade soils with an R-value between 10 and 40. We have assumed an R-value between 10 and 40 for the lime-treated soil or non-expansive fill required beneath the aggregate base. Once the non-expansive material has been selected by the contractor, the R-value should be verified.

Portland Cement Concrete Pavement Thickness Design

Traffic Index	Portland Cement Concrete (inches)	Caltrans Class 2 Aggregate Base (inches)	Total Thickness (inches)
< 9	9	12	21

The upper 12 inches of material beneath the bottom of the aggregate base should consist of non-expansive material (i.e., have a PI of 15 or less).

The upper 6 inches of subgrade beneath planned pavements should be compacted to at least 95 percent relative compaction per ASTM D-1557. Pavement subgrades should be proof-rolled and confirmed to be uniformly firm and non-yielding prior to the placement of aggregate base. Aggregate base for use in pavements should conform to Caltrans Standard Specifications for Class 2 Aggregate Base. The aggregate base used in pavement sections should be compacted to at least 95 percent relative compaction as determined by ASTM D-1557.

8.08 Future Geotechnical Services

We recommend we be provided the opportunity to review the project plans and specifications as they are being developed in order to check conformance with the intent of our geotechnical recommendations and to provide timely input, in the event that revisions are needed. We should also perform a general review of the geotechnical aspects of the final plans and specifications, the results of which we should document in a formal plan review letter.

It is critical that we be retained to provide geotechnical engineering services during the construction phases of the work in order to observe compliance with the design concepts, specifications, and recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction. The scope of our construction-phase observation and testing services should include (but not necessarily be limited to): site preparation, excavation, subsurface drainage installation (if needed), fill placement and compaction, footing excavation/construction, retaining wall drainage and backfill, tiedown installation and testing (if used), pavement and slab-on-grade subgrade preparation, aggregate base, and utility installation.

9.00 LIMITATIONS

This report has been prepared for the exclusive use of the LBNL and its consultants for specific application to the proposed General Purpose Lab (GPL) project in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made. Note that the findings presented in this report are based, in part, upon data collected by previous investigators. We cannot accept responsibility for the accuracy of the data obtained from others or (consequently) for interpretations that we have made based on existing available data. In the event that any changes in the nature or design of the building are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing.

The findings of this report are valid as of the present date. However, the passing of time will likely change the conditions of the existing property due to natural processes or the works of man. In addition, due to legislation or the broadening of knowledge, changes in applicable or appropriate standards may occur. Accordingly, the findings of this report may be invalidated, wholly or partly, by changes beyond our control. Therefore, this report should not be relied upon after a period of three years without being reviewed by this office.

10.00 REFERENCES

10.01 Published References

Bakun, W.H., 1999, "Seismic Activity of the San Francisco Bay Region," Bulletin of the Seismological Society of America; June 1999; V.89, No.3, p. 764-784.

California Building Standards Commission (CBSC), 2007, "2007 California Building Code, California Code of Regulations, Title 24," *Effective January 1, 2008.*

California Division of Mines and Geology (CDMG), 1982, Special Studies Zone Map, Oakland West Quadrangle.

CDMG, 1997, Special Publication 117, "Guidelines for Evaluating and Mitigating Seismic Hazards in California."

CDMG, 1999, Special Publication 42, "Fault-Rupture Hazard Zones in California," Revised 1997, with Supplement 1 and 2 added 1999.

CDMG, 2000, Seismic Hazards Zones, Parts of Oakland East, Briones Valley, and Las Trampas Ridge Quadrangle.

California Geological Survey (CGS), 2003, "Seismic Hazard Zone Report of the Briones Valley 7.5-Minute Quadrangle, Alameda County, California," Seismic Hazards Zone Report 084.

Dibblee, Thomas W., Jr., 1980, "Preliminary Geologic Map of the Briones Valley Quadrangle, Alameda and Contra Costa Counties, California," U.S. Geological Survey, Open File Report 80-539.

Graymer, R.W., 2000, "Geologic Map and Map Database of the Oakland Metropolitan Area, Alameda, Contra Costa and San Francisco Counties, California" U.S. Geological Survey, Miscellaneous Field Studies MF-2342.

International Conference of Building Officials (ICBO), 1998, "Maps of Known Active Fault Near-Source Zones in California and Adjacent Portions of Nevada," California Division of Mines and Geology.

Jones, David L. and Curtis, Garniss, 1991, "Guide to the Geology of the Berkeley Hills, Central Ranges, California," in Geologic Excursions in Northern California: San Francisco to the Sierra Nevada, California Division of Mines and Geology, Special Publication 109.

Lienkaemper, J.J., 1992, "Map of Recently Active Traces of the Hayward Fault, Alameda and Contra Costa Counties, California," United States Geological Survey, Map MF-2196.

Nilsen, T.H., 1975, "Preliminary Photointerpretation Map of Landslide and Other Surficial Deposits of the Briones Valley 7½' Quadrangle, Contra Costa and Alameda Counties, California," U.S. Geological Survey, Open File Map 75-277-08.

Radbruch-Hall, D.H., 1974, "Maps Showing Recently Active Breaks Along the Hayward Fault Zone and the Southern Part of the Calaveras Fault Zone, California," U.S. Geological Survey, Map I-813.

Wakabayashi, J., Smith, D. L., and Hamilton, D. H., 1992, "The Miller Creek Fault and related structures: Neogene kinematics of a potentially active thrust system in the East Bay Hills", California: in Borchardt, G., ed., Proceedings of the 2nd Conference on Earthquake Hazards in the eastern San Francisco Bay Area, Calif. Div. Mines and Geology Special Publication 113, p. 345-354.

(WGCEP) Working Group on California Earthquake Probabilities, 2003, "Earthquake Probabilities in the San Francisco Bay Region: 2002–2031", USGS Open-File Report 2003-214.

(WGCEP) Working Group on California Earthquake Probabilities, 2008, "The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2): for 2007–2036": USGS Open-File Report 2007-1437; CGS Special Report 203 and; SCEC Contribution #1138.

10.02 Consulting Reports

Alan Kropp & Associates, Inc. (AKA), 2009, "Summary of Preliminary Investigation and Analyses, Slide Investigation Building 25 Area Project," May 29, 2009 memorandum.

Harding Associates (HA), 1963, "Foundation Investigation, Proposed Building 26, Lawrence Radiation Laboratory, Berkeley 4, California," report dated July 1, 1963 (LBNL File #075).

Harding Miller Lawson & Associates (HMLA), 1966, "Progress Report, Soil Investigation, Omnitron Site, Lawrence Radiation Laboratory, Berkeley 4, California" report dated August 20, 1966 (LBNL File #008).

Harding Lawson Associates (HLA), 1982, "Geology of Lawrence Berkeley Laboratory," Prepared for Lawrence Berkeley National Laboratory, dated July 31, 1975, Job #2000, 104.01.

Harding Lawson Associates (HLA), 1988, "Foundation Investigation, Building 26 Addition, Lawrence Berkeley National Laboratory, Berkeley California" report dated October 31, 1988 (LBNL File #269).

Lawrence Berkeley National Laboratory Environmental Health and Safety (EH&S) Division and Earth Sciences Division with Parsons Engineering Science, Inc. (LBNL/Parsons), 2000, "RCRA Facility Investigation Report for the Lawrence Berkeley National Laboratory Environmental Restoration Program," report dated September 2000.

URS Corporation, 2008, "Updated Probabilistic Seismic Hazard Evaluation and Development of Seismic Design Ground Motions for the University of California, Berkeley and the Lawrence Berkeley National Laboratory," report dated 9 September 2008.

William Lettis & Associates, Inc. (WLA), 2009, "Paleolandslide Investigation, Building 25," report dated August 31, 2009.

FIGURES

LEGEND

Approximate location of Lawrence Berkeley National Laboratory boundary

Source: U.S. Geological Survey, Topographic Map of the Oakland East, Oakland West, Briones Vally and Richmond Quadrangles,1993.

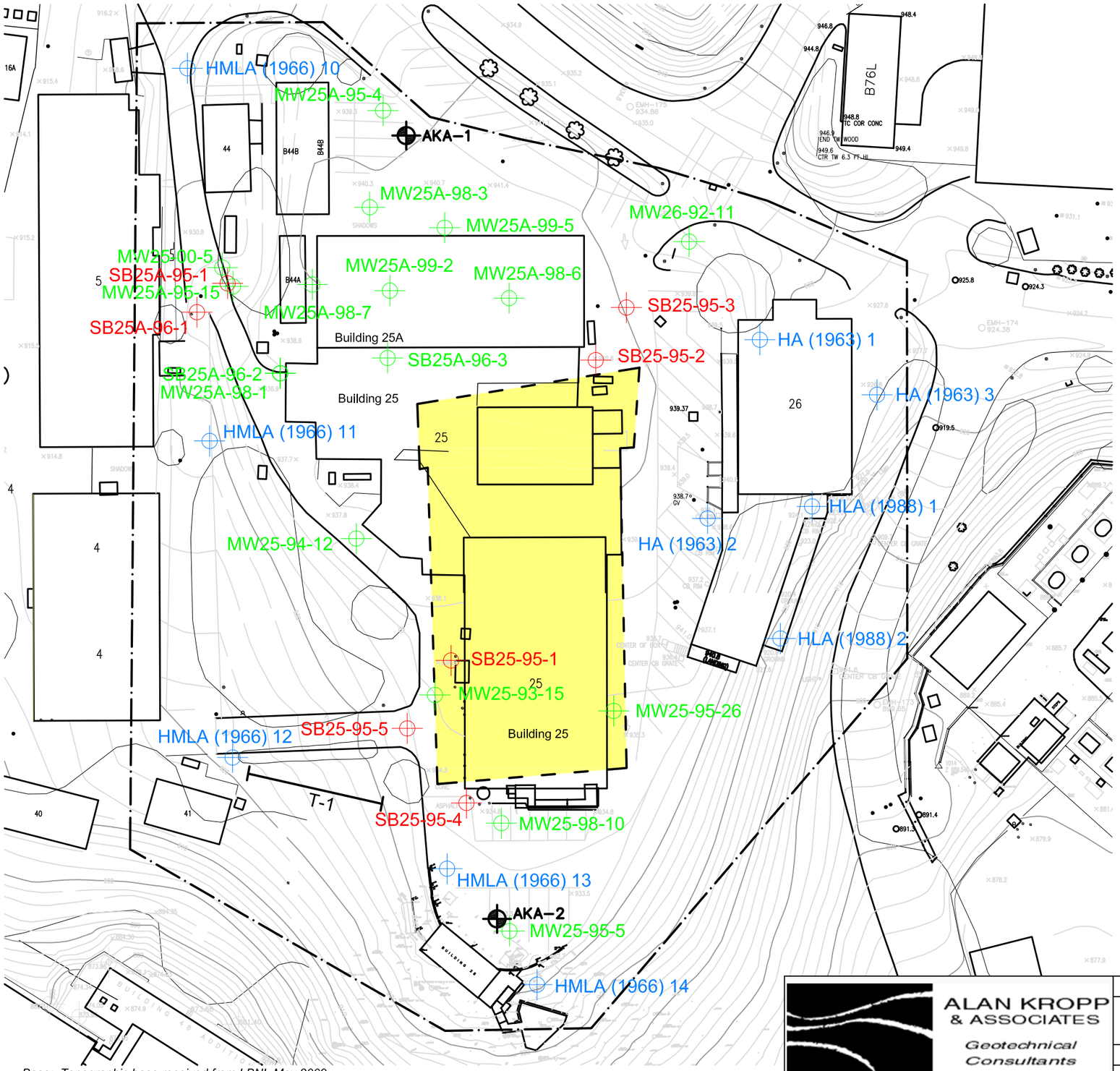
0 1,000 2,000 Feet

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

VICINITY MAP

LBNL GENERAL PURPOSE LAB
Berkeley, California

PROJECT NO.	DATE	FIGURE
2335-12B	**April 2010**	**1**



LEGEND

AKA–1	Approximate location of AKA/WLA boring (AKA-2009) Appendix A
HLA (1988) 1	Approximate location of previous geotechnical/geologic boring by others (HA 1963; HMLA 1966; HLA 1988) Appendix B
HLA (1988) 1	Approximate location of previous environmental boring/well by LBNL Appendix C
HLA (1988) 1	Approximate location of previous environmental boring/well by LBNL for which logs are not available
T-1	Approximate location of exploratory test pit or trench
	Approximate footprint of General Purpose Lab
	Approximate limits of study area (borings and trenches outside study area not shown)

50 0 50 100
APPROXIMATE SCALE FEET

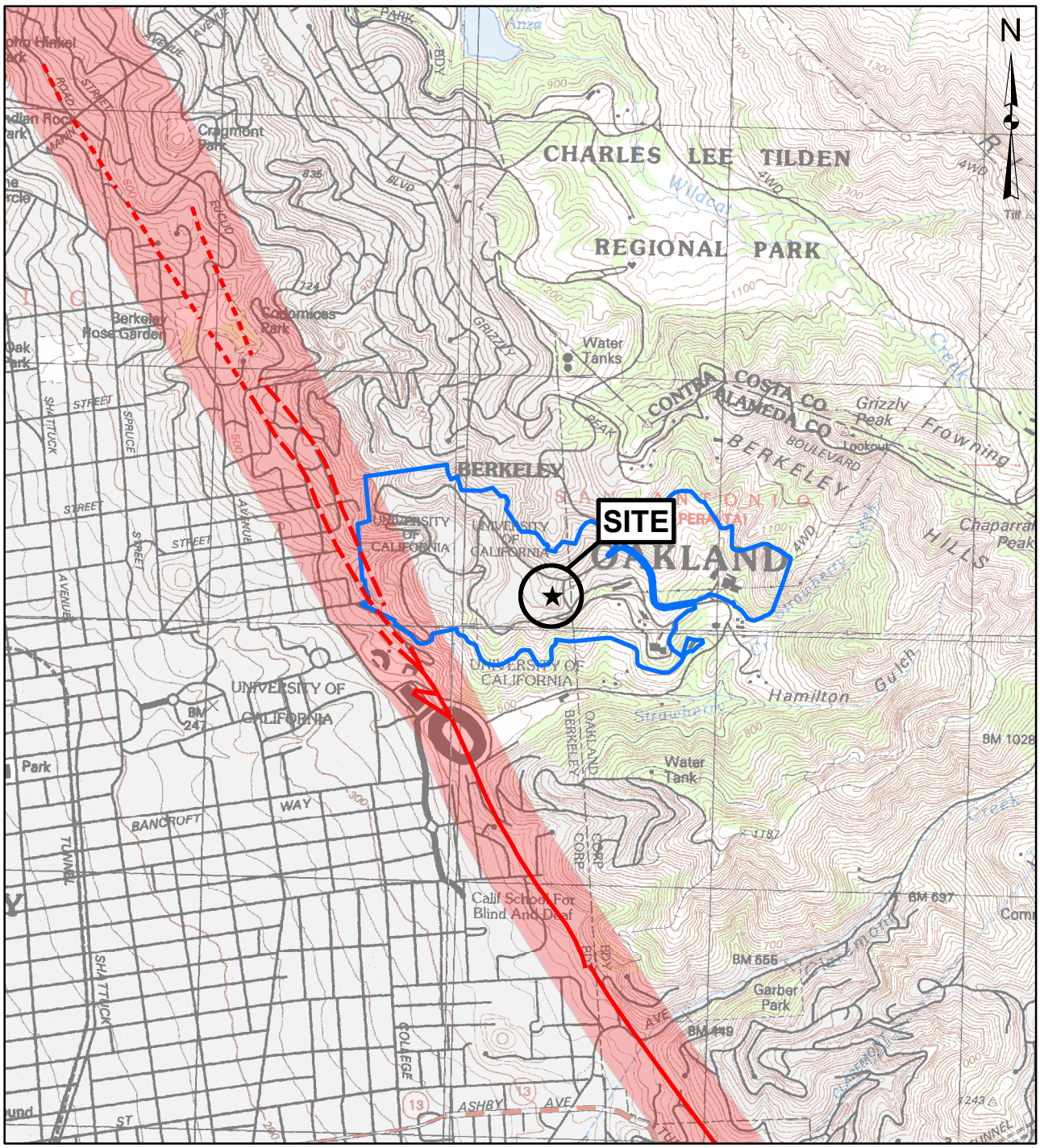
Base: Topographic base received from LBNL May 2009.

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

SITE PLAN

LBNL GENERAL PURPOSE LAB
Berkeley, California

PROJECT NO.	DATE	FIGURE
2335-12B	**April 2010**	**2**



LEGEND

Approximate location of Lawrence Berkeley National Laboratory boundary

Source: The California Geological Survey, 2001, CD's 2001-04, 2001-05, and 2001-06: GIS Files of Official Alquist-Priolo Earthquake Fault Zones (http://www.consrv.ca.gov/CGS/geologic_hazards/regulatory_hazard_zones/ap_cd_htm.htm).

0 1,000 2,000 Feet

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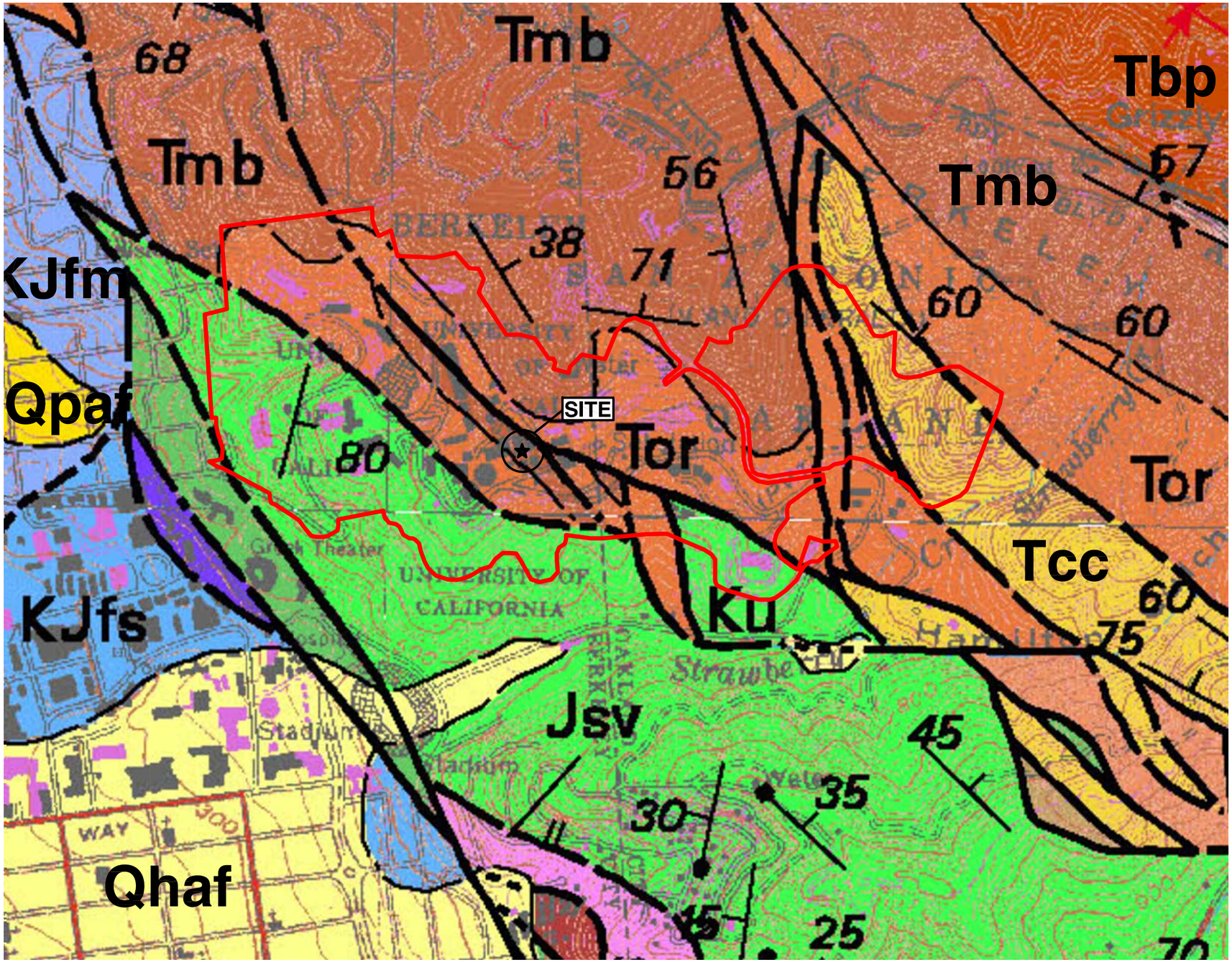
Geotechnical Consultants

AP FAULT ZONE MAP

LBNL GENERAL PURPOSE LAB
Berkeley, California

PROJECT NO.	DATE	FIGURE
2335-12B	**April 2010**	**3**



-N-

LEGEND

Surficial Deposits

Qhaf	Alluvial fan and fluvial deposits (Holocene)
Qpaf	Alluvial fan and fluvial deposits (Pleistocene)

Assemblage I

Tbp	Bald Peak Basalt (late Miocene)
Tmb	Moraga Formation (late Miocene)
Tor	Orinda Formation (late Miocene)
Tcc	Claremont chert (late to middle Miocene)

Great Valley Complex

Ku	Unnamed sedimentary rocks (Late Cretaceous, Turonian and Cenomanion)
Jsv	Keratophyre and quartz keratophyre (Late Jurassic)

Franciscan Complex

KJfs	Franciscan complex sandstone, undivided (Late Cretaceous to Late Jurassic)
KJfm	Franciscan complex, mélange (Cretaceous Late Jurassic), includes mapped locally:
fs	Graywacke and meta-graywacke blocks

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

35 **Strike and dip of bedding**

48 **Strike and dip of bedding, top indicator observed**

Approximate boundary of Lawrence Berkeley National Laboratory

400 0 800 1600
APPROXIMATE SCALE FEET

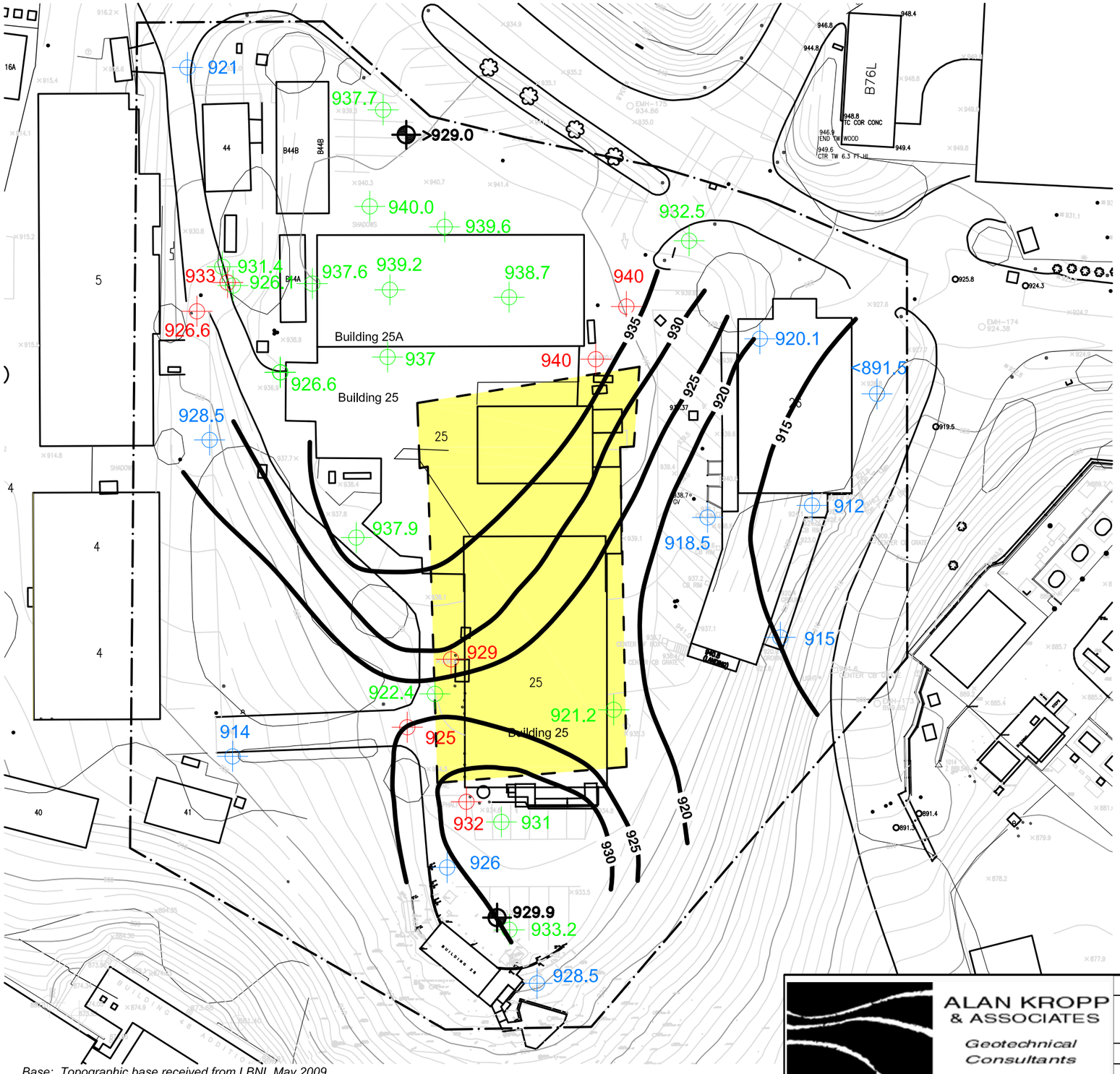
Base: "Geologic Map and Map Database of the Oakland Metropolitan Area, Alameda, Contra Costa and San Francisco Counties, California" by Graymer, R.W., U.S. Geological Survey, Miscellaneous Field Studies MF-2342, 2000.

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

SIMPLIFIED REGIONAL GEOLOGIC MAP

LBNL GENERAL PURPOSE LAB
Berkeley, California

PROJECT NO.	DATE	FIGURE
2335-12B	April 2010	4



LEGEND

- 936 — Bedrock surface elevation reported on log of boring (in feet)
- 395 — Interpreted bedrock surface contours (elevation in feet)
- Approximate footprint of General Purpose Lab
- Approximate limits of study area (borings and trenches outside study area not shown)

NOTE: Bedrock surface elevation contours are interpreted based on data from existing borings and should be considered approximate.

50 0 50 100
APPROXIMATE SCALE FEET

Base: Topographic base received from LBNL May 2009.

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

BEDROCK SURFACE CONTOUR MAP

LBNL GENERAL PURPOSE LAB
Berkeley, California

PROJECT NO.	DATE	FIGURE
2335-12B	**April 2010**	**5**

APPENDIX A

Logs of Previous Borings by AKA/WLA

SOIL CLASSIFICATION CHART

PRIMARY DIVISIONS			SECONDARY DIVISIONS		
			CRITERIA *	GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS MORE THAN 50% RETAINED ON NO.200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	$Cu \geq 4$ AND $1 \leq Cc \leq 3$ [A]	GW	Well-graded gravel
			$Cu < 4$ AND/OR $1 > Cc > 3$	GP	Poorly-graded gravel
		GRAVELS WITH FINES - MORE THAN 12% FINES	FINES CLASSIFY AS ML OR MH	GM	Silty gravel
			FINES CLASSIFY AS CL OR CH	GC	Clayey gravel
	SANDS 50% OR MORE OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	$Cu \geq 6$ AND $1 \leq Cc \leq 3$	SW	Well-graded sand
			$Cu < 6$ AND/OR $1 > Cc > 3$	SP	Poorly-graded sand
		SANDS WITH FINES - MORE THAN 12% FINES	FINES CLASSIFY AS ML OR MH	SM	Silty sand
			FINES CLASSIFY AS CL OR CH	SC	Clayey sand
FINE-GRAINED SOILS 50% OR MORE PASSES THE NO.200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50%	INORGANIC	PI > 7 AND PLOTS ON OR ABOVE "A" LINE	CL	Lean clay
			PI < 4 OR PLOTS BELOW "A" LINE	ML	Silt
		ORGANIC	$\frac{\text{LIQUID LIMIT - OVEN DRIED}}{\text{LIQUID LIMIT - NOT DRIED}} < 0.75$	OL	Organic Clay & Organic Silt
	SILTS AND CLAYS LIQUID LIMIT 50% OR MORE	INORGANIC	PI PLOTS ON OR ABOVE "A" LINE	CH	Fat clay
			PI PLOTS BELOW "A" LINE	MH	Elastic silt
		ORGANIC	$\frac{\text{LIQUID LIMIT - OVEN DRIED}}{\text{LIQUID LIMIT - NOT DRIED}} < 0.75$	OH	Organic Clay & Organic Silt
	HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR	PT	Peat

REFERENCE: Unified Soil Classification System (ASTM D 2487-06)

* Criteria may be done on visual basis, not necessarily based on lab testing

A – $C_u = D_{60}/D_{100}$ & $C_c = (D_{30})^2 / (D_{10} \times D_{60})$

GRAIN SIZES

U. S. STANDARD SERIES SIEVE				CLEAR SQUARE SIEVE OPENINGS				
200		40	10	4	3/4"		3"	12"
SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS	
	FINE	MEDIUM	COARSE	FINE	COARSE			

ABBREVIATIONS

INDEX TESTS

LL - Liquid Limit (%) (ASTM D 4318-05)

PI - Plasticity Index (%) (ASTM D 4318-05)

-200 - Passing No. 200 Sieve (%) (ASTM D 1140-00)

STRENGTH TESTS

PP - Field Pocket Penetrometer test of unconfined compressive strength (tsf)

TV - Field Torvane test of shear strength (psf)

UC - Laboratory unconfined compressive strength (psf) (ASTM D 2166-06)

TXUU - Laboratory unconsolidated, undrained triaxial test of undrained shear strength (psf) (ASTM D 2850-03a)

MISCELLANEOUS

ATOD - At time of drilling

psf/tsf - pounds per square foot / tons per square foot

psi - pounds per square inch (indicates relative force required to advance Shelby tube sampler)

SYMBOLS

Standard Penetration Test Split Spoon (2-inch O.D.)

Modified California Sampler (3-inch O.D.)

Thin-walled Sampler Tube (either Pitcher or Shelby) (3-inch O.D.)

Rock Core

Bag Sample

Groundwater Level

ALAN KROPP & ASSOCIATES

Geotechnical Consultants

KEY TO EXPLORATORY BORING LOGS

LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	FIGURE
2335-12	May 2009	A1

CONSOLIDATION OF SEDIMENTARY ROCKS; usually determined from unweathered samples. Largely dependent on cementation.

- **U** = unconsolidated
- **P** = poorly consolidated
- **M** = moderately consolidated
- **W** = well consolidated

BEDDING OF SEDIMENTARY ROCK

Splitting Property	Thickness	Stratification
Massive	Greater than 4.0 feet	Very thick-bedded
Blocky	2.0 to 4.0 feet	Thick-bedded
Slabby	0.2 to 2.0 feet	Thin-bedded
Flaggy	0.05 to 0.2 feet	Very thin-bedded
Shaly or platy	0.01 to 0.05 feet	Laminated
Papery	Less than 0.01 feet	Thinly laminated

FRACTURING

Intensity	Size of Pieces in Feet
Very little fractured	Greater than 4.0 feet
Occasionally fractured	1.0 to 4.0 feet
Moderately fractured	0.5 to 1.0 feet
Closely fractured	0.1 to 0.5 feet
Intensely fractured	0.05 to 0.1 feet
Crushed	Less than 0.05 feet

HARDNESS

1. **Soft** - Reserved for plastic material alone.
2. **Low Hardness** - Can be gouged deeply or carved easily by a knife blade.
3. **Moderately Hard** - Can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and is readily visible after the powder has been blown away.
4. **Hard** - Can be scratched by a knife blade with difficulty; scratch produces little powder and is often faintly visible.
5. **Very Hard** - Cannot be scratched by a knife blade; leaves a metallic streak

STRENGTH

1. **Plastic -** Very low strength.
2. **Friable** - Crumbles easily by rubbing with fingers.
3. **Weak** - An unfractured specimen of such material will crumble under light hammer blows.
4. **Moderately Strong** - Specimen will withstand a few heavy hammer blows before breaking.
5. **Strong** -Specimen will withstand a few heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.
6. **Very Strong** -Specimen will resist heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.

WEATHERING - the physical and chemical disintegration and decomposition of rocks and minerals by natural processes such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing.

- **D. Deep** - Moderate to complete mineral decomposition; extensive disintegration; deep and thorough discoloration; many fractures, all extensively coated or filled with oxides, carbonates and/or clay or silt.
- **M. Moderate** - Slight change or partial decomposition of minerals; little disintegration; cementation little to unaffected. Moderate to occasionally intense discoloration. Moderately coated fractures.
- **L. Little** - No megascopic decomposition of minerals; little or no effect on normal cementation. Slight and intermittent, or localized discoloration. Few stains on fracture surfaces.
- **F. Fresh** - Unaffected by weathering agents. No disintegration or discoloration. Fractures usually less numerous than joints.

DRILL RIG: Fraste Multidrill XL, Rotary Wash	SURFACE ELEVATION: 939.7 feet (see notes)	LOGGED BY: SS
DEPTH TO GROUNDWATER: (see notes)	BORING DIAMETER: 4 7/8 inches	DATE DRILLED: 5/18/09

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
ASPHALT CONCRETE - 2-inches									
GRAVEL, Well-Graded - sandy, dry	Light Brown	Medium Dense	GW	1					
				2					
				3					
-increasing sand, decreasing gravel at 4 feet				4					
(Interval Not Sampled)				5					
SAND, Gravelly to GRAVEL, Sandy - well graded, fine to medium grained sand with trace silt, dry to moist	Yellowish Brown	Medium Dense	SW-GW	6		[31]			
				7					
				8					
CLAY, Lean - 70% clay matrix, medium to low plasticity, moist (Colluvium or Possible Bedrock)	Reddish Gray	Stiff to Very Stiff	CL	9					
				10					
SILTSTONE/CLAYSTONE - finely laminated, friable, with thin grayish laminations, low hardness (start of continuous geologic logging at 10.5 feet)	Gray to Reddish Gray		BED ROCK	11		[28]			PP = 1.5 tsf
				12					
				13					PP = 3.5 tsf
				14					PP = >4.5 tsf
-with very fine sandstone gravel, hard clasts	Gray to Brown			15					PP = 4.0 tsf
-with calcite and quartzite angular clasts at 16 feet				16					
				17					
-with volcanic clasts at 18 feet				18					
	Reddish Gray			19					

(Continued on Next Page)

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
-very weak mixed zone of clayey gravels (volcanics and siltstone) from 19.5 to 21 feet	Brown		BED ROCK	21					
				22					
				23					
				24					
-fractured and crushed rock at 25.2 feet				25					PP = 1.5 tsf
-clay rich from 26 to 27 feet	Bluish Gray			26					
				27					
CONGLOMERATE - with up to 70% clasts, with clay and sand matrix, with volcanic clasts	Greenish Gray		BED ROCK	28					
SILTSTONE - with vertical veins of re-crystalized calcite, moderately hard to hard	Red to Gray		BED ROCK	29					
				30					
-becomes coarser with depth and more conglomerate				31					
-becomes hard and cemented with depth				32					
				33					
				34					
-block structure at 35 feet				35					
-clayey at 36 to 36.5 feet				36					PP = 1.5 tsf
				37					
				38					
-massive	Green			39					PP = 4.0 tsf
				40					PP = 2.0 tsf
				41					
				42					PP = 3.5 tsf

(Continued on Next Page)

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG

LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	**May 2009**	**2 of 3**	**AKA-1**

AKA BORING LOG 2335-12 LBNL B25 AREA AKA 1-3.GPJ AKA_TEMPLATE.GDT 4/1/10

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
SILTSTONE	Red to Gray		BED ROCK	43 44 45 46					PP = 2.0 tsf

Bottom of boring at 46.5 feet.

NOTES:

1. Groundwater levels were obscured due to rotary wash drilling method. (See report for discussion.)
2. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
3. Penetration resistance values (blow counts) enclosed in brackets ([ ]) were recorded with a 3.0-inch O.D. Modified California sampler; these are not standard penetration resistance values.
4. Elevations were determined from survey performed by LBNL subcontractor.
5. Approximate unconfined compressive strength values were recorded in the field using a pocket penetrometer. These values are shown on the logs and are preceded by the symbol "PP".

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG
LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	**May 2009**	**3 of 3**	**AKA-1**

DRILL RIG: Fraste Multidrill XL, Rotary Wash	**SURFACE ELEVATION:** 929.9 (see notes)	**LOGGED BY:** SS
DEPTH TO GROUNDWATER: (see notes)	**BORING DIAMETER:** 4 7/8 inches	**DATE DRILLED:** 5/19/09

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
Asphalt Concrete - 2-inches **GRAVEL, Poorly Graded** - sandy, well compacted, no plasticity, dry (Road Aggregate Base) **FILL**	Light Brown	Medium Dense	GP	1 2 3					
VOLCANICS - Rhyolite, moderately weathered, weak, breaks into indiscernable rubble during drilling, dry	Yellowish Brown		BED ROCK	4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19		[30]/3" [50]/3" [50]/4.5"			

(Continued on Next Page)

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG
LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	**May 2009**	**1 of 5**	**AKA-2**

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
-Andesite, moderately weathered, weak	Yellowish Brown		BED ROCK	21		[50]/3"			
				22					
				23					
				24					
				25					
				26					
				27					
				28					
				29					
				30					
				31					
				32					
-Rhyolite, with mineralization, hard, fractured, with weak granular weathered rock matrix	Grayish Green with Red			33					
				34		83			
				35					
				36					
				37					
				38					
				39					
				40		75			
				41					
				42					

(Continued on Next Page)

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG

LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	**May 2009**	**2 of 5**	**AKA-2**

AKA BORING LOG 2335-12 LBNL B25 AREA AKA 2.GPJ AKA_TEMPLATE.GDT 4/1/10

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
	Grayish Green with Red		BED ROCK	43		50/4.5"			
				44					
				45					
				46					
				47					
-clay lined fractures mixed with volcanic rock blocks, not continuous, brownish with manganese staining				48					
				49		72			
-Andesite, volcanics, very fine grained (Basalt?)	Greenish Brown			50					
				51		50/5"			
				52					
				53					
				54					
				55					
				56					
				57					
				58					
				59		50/5"			
				60					
				61					
				62					
				63		50/4.5"			
				64					
-Rhyolite, with mineralization, volcanics (Basalt?)				65					

(Continued on Next Page)

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG
LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	**May 2009**	**3 of 5**	**AKA-2**

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
	Greenish Brown		BED ROCK	66					
				67					
-hard, heavily weathered volcanics (Basalt?)	Black			68		50/4.5"			
				69					
				70					
				71					
				72					
-0.2 to 0.1 foot pieces of subangular clasts of fractured volcanic Basalt from 72.5 to 74 feet				73					
				74		50/3.5"			
				75					
				76					
				77					
-weathered with iron oxide zones along fractures, no continuous clay seams, fractured Basalt 0.2 to 0.3 foot diameter, moist to wet				78					
				79					
-becomes more competent with depth, larger fracturing blocks, no thick or laterally continuous clay seams				80		68			
				81					
				82					
				83					
				84					
-Andesite, tuffacious in spots, flecks of Basalt, deeply weathered, quartz veins, Rhyolite, larger clasts than above	Dark Grayish Brown with Reddish Overtone			85					
				86					
				87					
-more competent, fine grained				88					

(Continued on Next Page)

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG

LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	May 2009	4 of 5	**AKA-2**

DESCRIPTION AND REMARKS	COLOR	CONSISTENCY	SOIL TYPE	DEPTH (ft)	SAMPLER TYPE	SAMPLER BLOW COUNTS	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	OTHER TESTS
(Continued from Previous Page)									
-becomes fractured and brecciated, smaller clasts	Dark Grayish Brown with Reddish Overtone		BED ROCK	89					
-deeply weathered				90					
SILTSTONE/CLAYSTONE - with volcanic gravels	Reddish Brown		BED ROCK	91					
SILTSTONE - little weathering, weak, slightly fractured	Dark Bluish Gray		BED ROCK	92					
				93					
				94					
-competent and hard	Greenish Gray			95					
				96					
-massive				97					
				98					
				99					
				100					
				101					
				102					
				103					
CLAYSTONE - friable to weak, moderately fractured along planes, some harder clasts of calcite	Bluish Gray		BED ROCK	104					
				105					
				106					

Bottom of boring at 106.2 feet.

NOTES:

1. Groundwater levels were obscured due to rotary was drilling method (See report for discussion).
2. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
3. Penetration resistance values (blow counts) enclosed in brackets ([ ]) were recorded with a 3.0-inch O.D. Modified California sampler; these are not standard penetration resistance values.
4. Elevations were determined from survey performed by LBNL subcontractor.

ALAN KROPP & ASSOCIATES
Geotechnical Consultants

EXPLORATORY BORING LOG

LBNL B25 AREA PROJECT
Berkeley, California

PROJECT NO.	DATE	SHEET	BORING
2335-12	**May 2009**	**5 of 5**	**AKA-2**

AKA BORING LOG 2335-12 LBNL B25 AREA AKA 2.GPJ AKA_TEMPLATE.GDT 4/1/10

APPENDIX B

Logs of Borings from Previous Geotechnical Reports by Others

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

RICHARD S. HARDING, CIVIL ENGINEER
EUGENE A. MILLER, CIVIL ENGINEER
OLIVER E. MERWIN
ROBERT T. LAWSON, CIVIL ENGINEER

56 HARBOR ST. • P.O. BOX 1169 • SAN RAFAEL, CALIF.
GLENWOOD 4-1720

July 1, 1963

University of California
Lawrence Radiation Laboratory
Berkeley 4, California

Attention: Mr. Ernest Sykes, Plant Engineering

Gentlemen:

Report
Foundation Investigation
Proposed Building 26
Lawrence Radiation Laboratory
Berkeley, California

INTRODUCTION

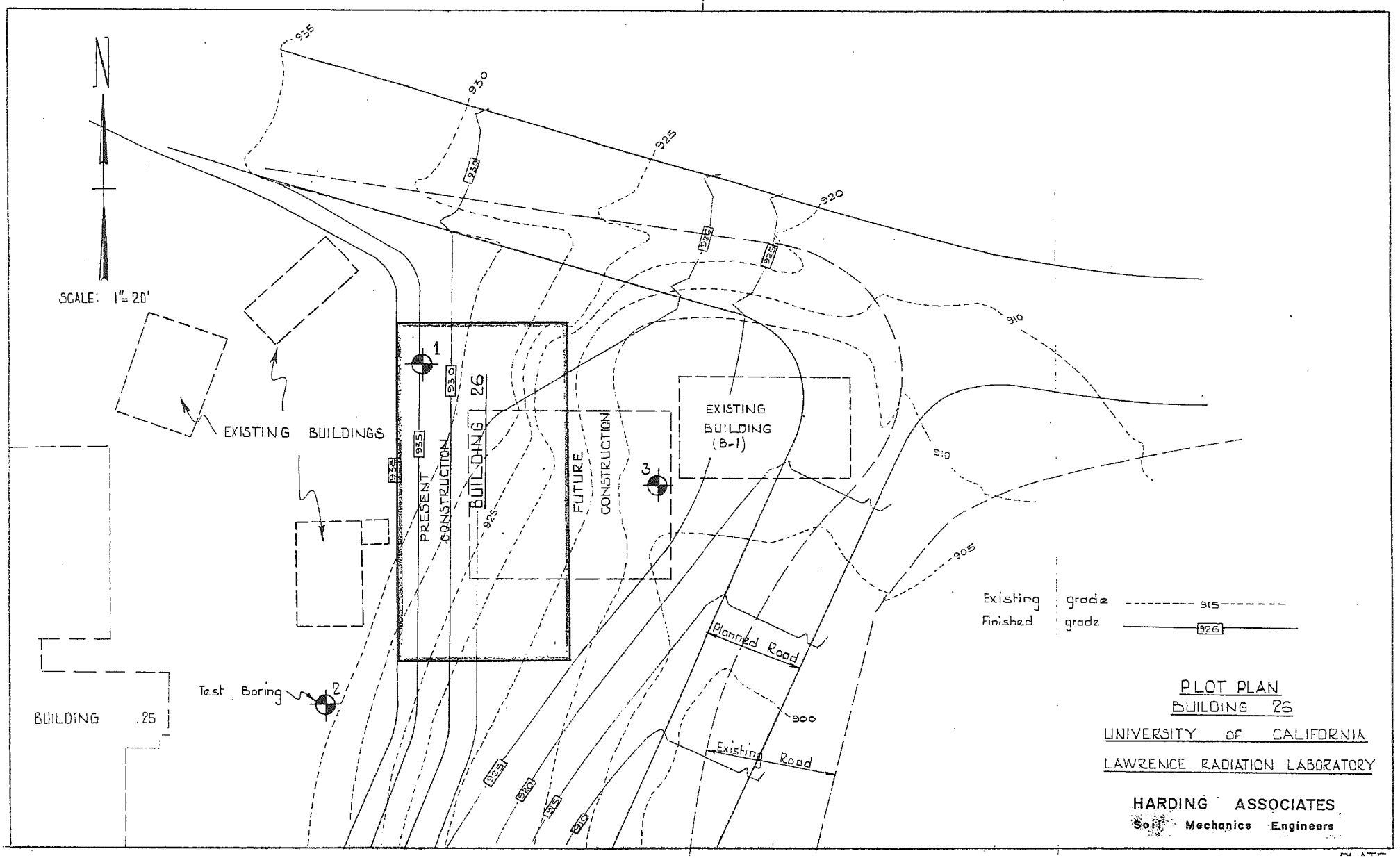
This report presents the results of our foundation investigation for Building 26, to be constructed on sloping terrain between Buildings 25 and B-1, at the Lawrence Radiation Laboratory, Berkeley, California. The structure will be a single-story building about 40 feet by 80 feet in plan dimensions with provisions for a future addition partially beneath the initial construction. We understand that the westerly foundation wall load will be about 3000 pounds per linear foot and that the intermediate bearing wall loads will be about 4000 pounds per linear foot. The easterly side of the building will be supported on columns with loads of about 50 kips each. As shown by the existing and finished grade contours on the attached Plot Plan, Plate 1, the grading for the building site will require the placement of fill ranging up to about 15 feet deep.

The purpose of our investigation was to evaluate the soil conditions underlying the site and to provide foundation design criteria for the planned structure.

SUBSURFACE CONDITIONS

The results of three test borings, drilled in the locations shown on the Plot Plan, indicate that the site is blanketed by weak clayey surface soils and poorly compacted fills ranging up to eight feet in depth. These upper materials were underlain by firmer clayey and silty soils and weathered siltstone and conglomerate rock. There is an existing unstable area in the slope west of Building B-1 that has been partially excavated. The upper soils in the test borings were wet but no free water was encountered.

075_00032



PLOT PLAN
BUILDING 26
UNIVERSITY OF CALIFORNIA
LAWRENCE RADIATION LABORATORY

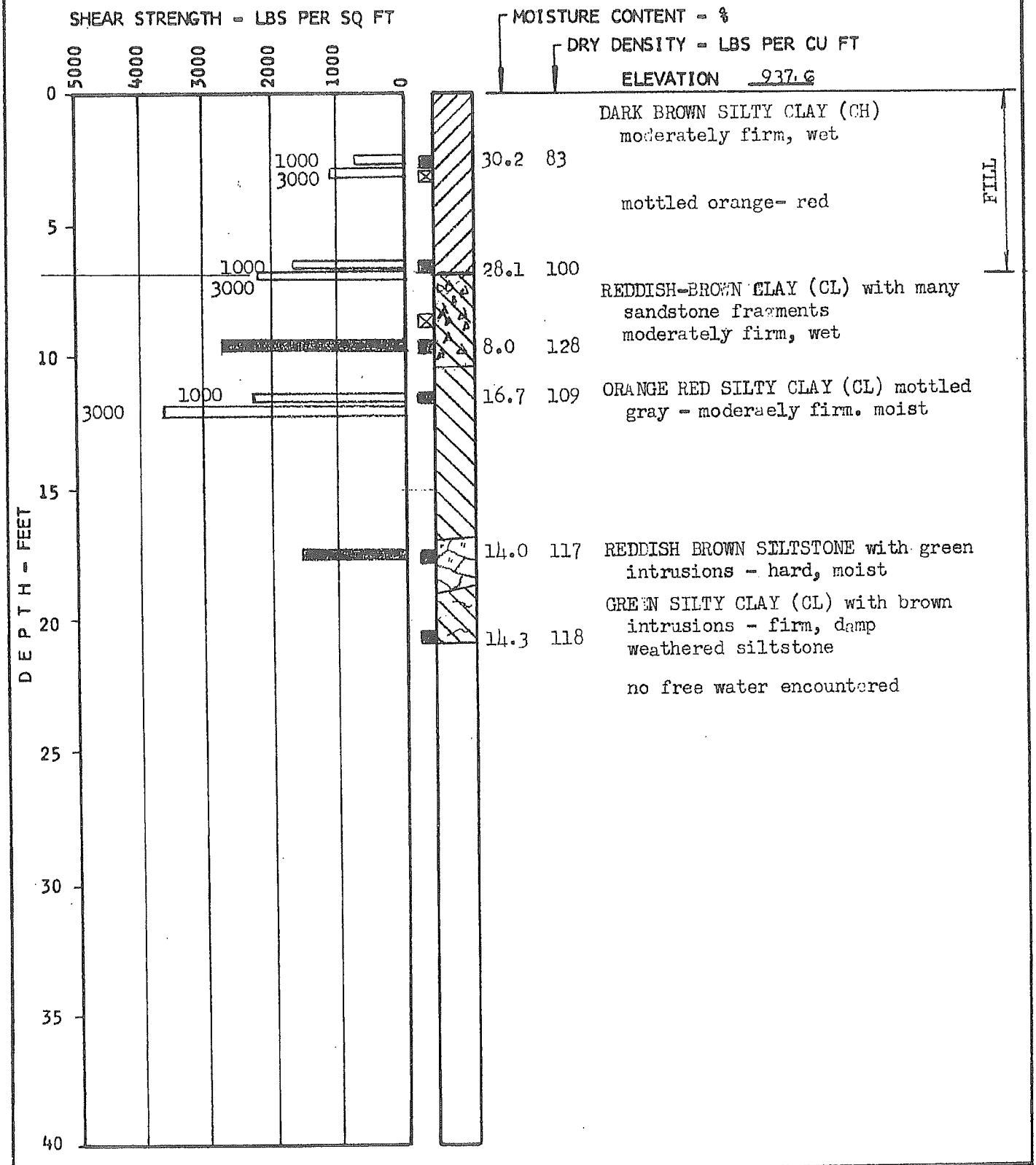
HARDING ASSOCIATES
Soil Mechanics Engineers

PLATE 1

075_00036

JOB RADIATION LABORATORY - BLDG. 26 NO 2000.3 BY wea DATE 5-28-63

BORING 1



HARDING ASSOCIATES
Soil Mechanics Engineers

LOG OF BORING

EQUIPMENT 20" Bucket

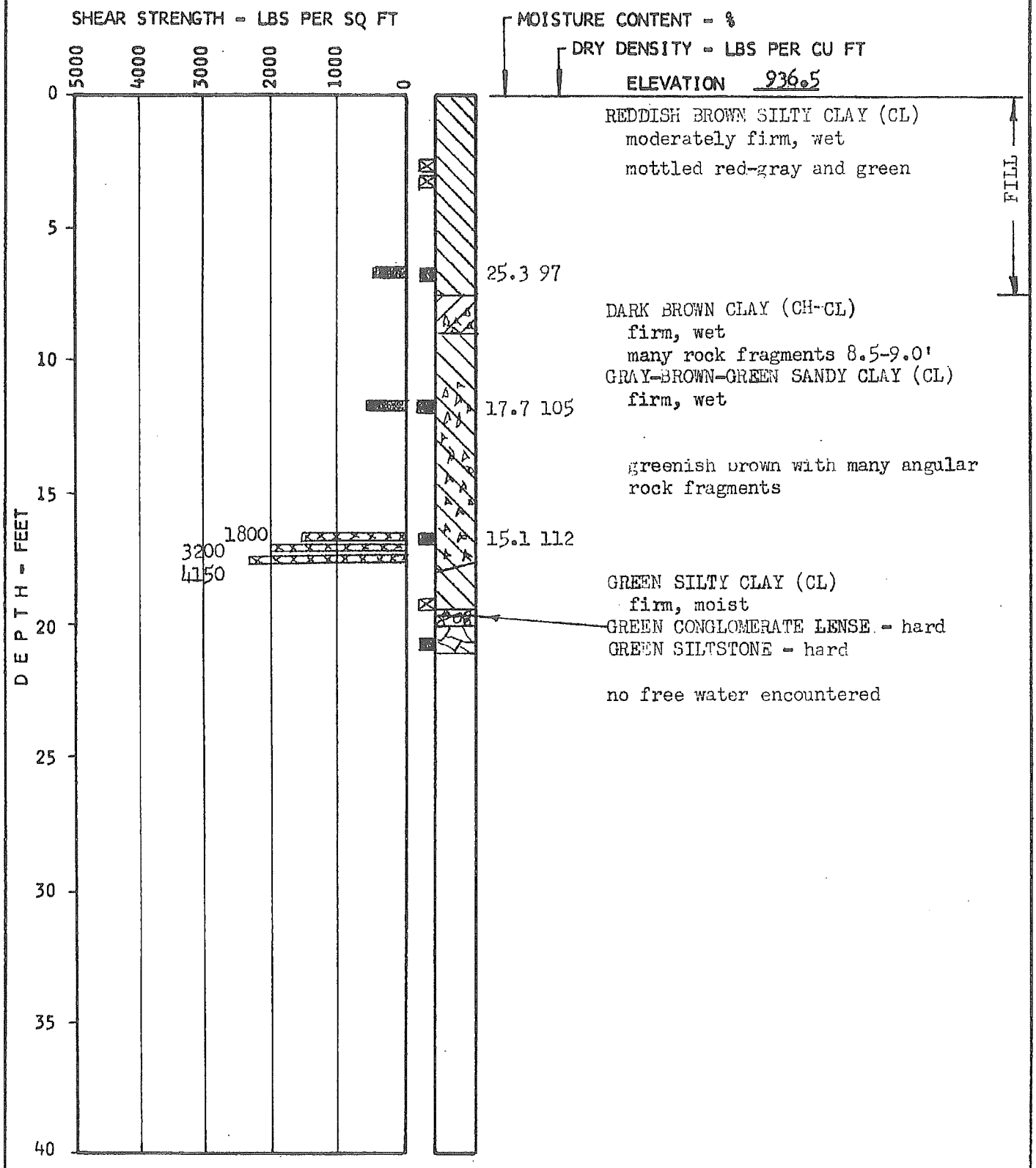
DRILLED 5-16-63

PLATE A-1

075_00038

JOB RADIATION LABORATORY BLDG. 26 NO 2000.3 BY wea DATE 5-29-63

BORING 2



HARDING ASSOCIATES
Soil Mechanics Engineers

LOG OF BORING

EQUIPMENT 20" Bucket

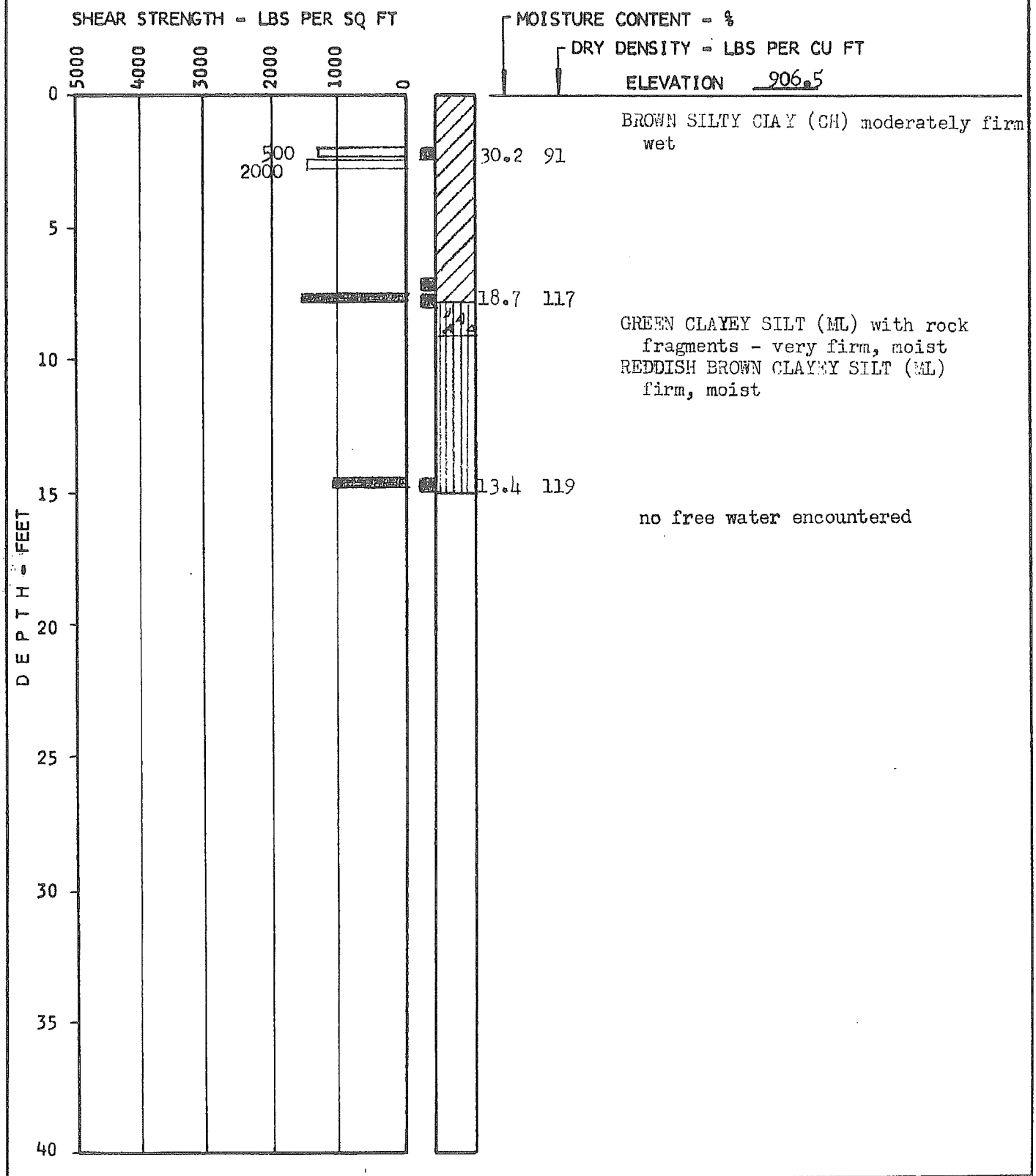
DRILLED 5-17-63

PLATE A-2

075_00039

JOB RADIATION LABORATORY Bldg. 26 NO 2000.3 BY wea DATE 5-29-63

BORING 3



BROWN SILTY CLAY (CH) moderately firm wet

GREEN CLAYEY SILT (ML) with rock fragments - very firm, moist

REDDISH BROWN CLAYEY SILT (ML) firm, moist

no free water encountered

HARDING ASSOCIATES
Soil Mechanics Engineers

LOG OF BORING

EQUIPMENT 20" Bucket

DRILLED 5-17-63

PLATE A-3

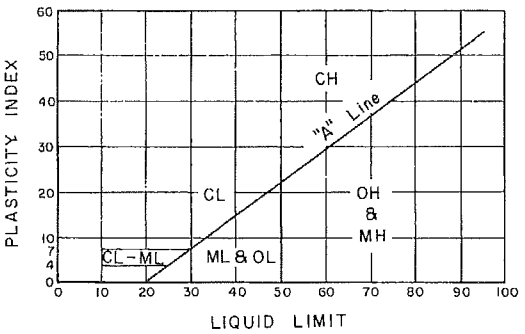
075_00040

MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than 1/2 of soil > no. 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > no. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than 1/2 of coarse fraction < no. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (More than 1/2 of soil < no. 200 sieve size)	SILTS & CLAYS LL < 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays .
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS LL > 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

CLASSIFICATION CHART

CLASSIFICATION	RANGE OF GRAIN SIZES	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL	3" to No. 4	76.2 to 4.76
coarse	3" to 3/4"	76.2 to 19.1
fine	3/4" to No. 4	19.1 to 4.76
SAND	No. 4 to No. 200	4.76 to 0.074
coarse	No. 4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No. 200	0.420 to 0.074
SILT & CLAY	Below No. 200	Below 0.074

GRAIN SIZE CHART



PLASTICITY CHART

HARDING ASSOCIATES
Soil Mechanics Engineers

UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE 4-4

075_00041

SAMPLE DESIGNATION

UNDISTURBED CORE SAMPLE

REMOLDED SAMPLE OR BULK SAMPLE

STRAIN CONTROLLED TESTS AT FIELD MOISTURE CONTENT

UNCONFINED COMPRESSION TEST

1000 DIRECT SHEAR TEST

1000 TRIAXIAL COMPRESSION TEST

VANE SHEAR TEST

STRAIN CONTROLLED TESTS AT INCREASED MOISTURE CONTENT

1000 (14.5) DIRECT SHEAR TEST

1000 (14.5) TRIAXIAL COMPRESSION TEST

BAR LENGTH REPRESENTS SHEAR STRENGTH

MOISTURE CONTENT WHEN TESTED (PER CENT)

STRESS NORMAL TO THE SHEAR PLANE (LBS. PER SQ. FT.)

INDICATES OBSERVED WATER LEVEL

HARDING ASSOCIATES Soil Mechanics Engineers	KEY TO TEST DATA

PLATE A-5

075_00042

HARDING • MILLER • LAWSON & ASSOCIATES
SOIL MECHANICS ENGINEERS

RICHARD S. HARDING, CIVIL ENGINEER
EUGENE A. MILLER, CIVIL ENGINEER
OLIVER E. MERWIN
ROBERT T. LAWSON, CIVIL ENGINEER
HENRY T. TAYLOR, CIVIL ENGINEER

64 WOODLAND AVENUE • P.O. BOX 1169
SAN RAFAEL, CALIFORNIA 94902
TELEPHONE (415) 454-1720

August 20, 1966

2000.37

University of California
Lawrence Radiation Laboratory
Berkeley 4, California

Attention: Mr. Ernest L. Sykes

Gentlemen:

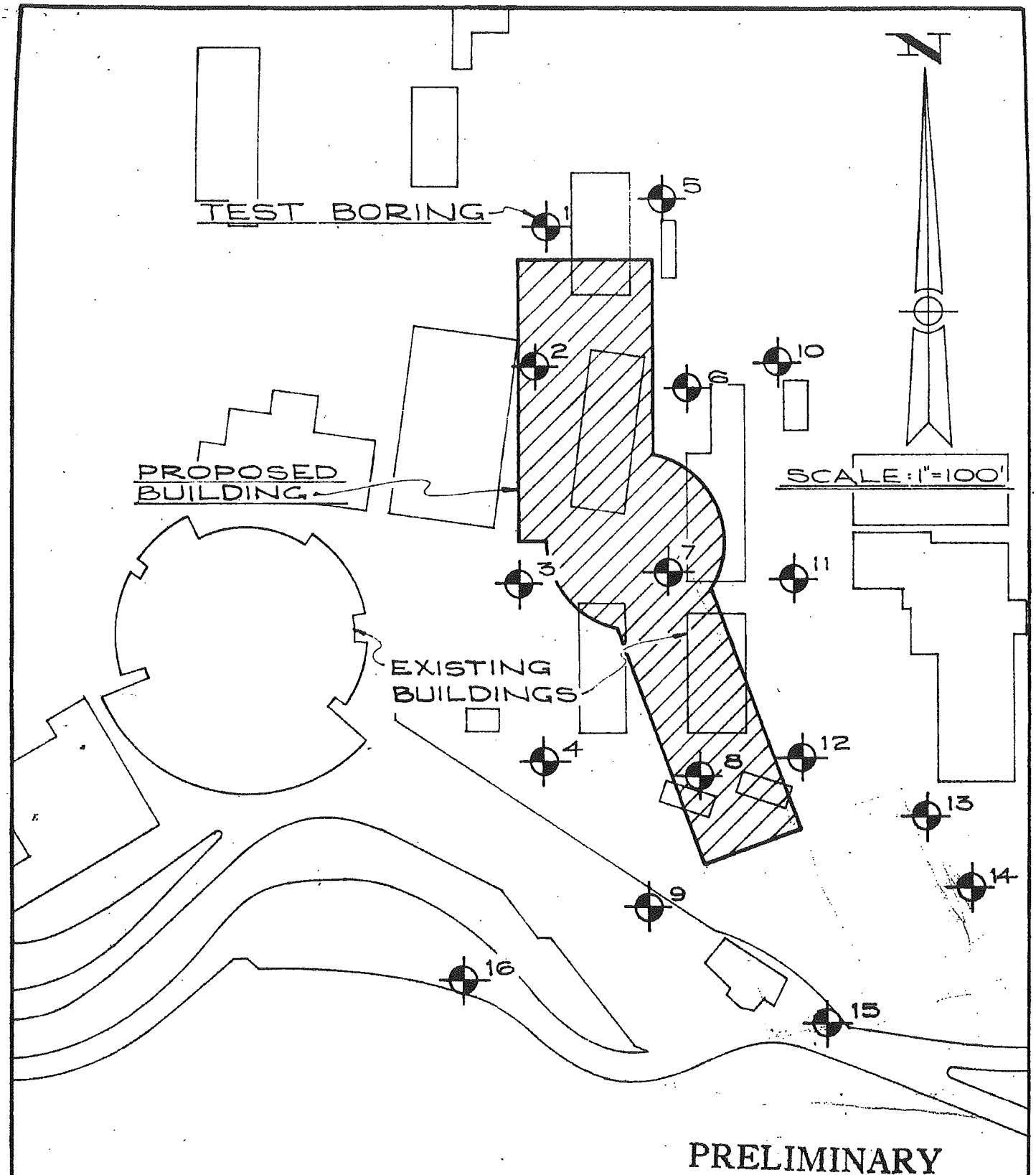
Progress Report
Soil Investigation
Omnitron Site
Lawrence Radiation Laboratory
Berkeley 4, California

This progress report summarizes the results to date of our soil investigation at the Omnitron Site, Lawrence Radiation Laboratory, Berkeley, California as shown on the Plot Plan, Plate 1.

Our field exploration, which started July 1 and was completed August 15, 1966, consisted of drilling, logging and sampling 16 test borings ranging from 35 to 84 feet in depth. In addition to the field exploration, a comprehensive laboratory testing program is now in progress (about 90 percent complete) to provide data on the engineering properties of the soil and rock underlying the site. A detailed discussion of the field investigation and laboratory testing is presented in the Appendix.

Our field exploration disclosed that the site is underlain by a shallow mantle of clayey soils and then weathered and fractured bedrock to the depths explored. Most of the bedrock in the building area consists of interbedded sandstone, siltstone, claystone and conglomerate; however, hard and fractured basalt was encountered in the north and east portions of the site.

Ground water was present in most of the borings. Typical of seepage conditions in fractured rock, the water levels in the borings were erratic and flow occurred at random locations.



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

PLOT PLAN
OMNITRON SITE
UNIVERSITY OF CALIFORNIA
LAWRENCE RADIATION LABORATORY
Berkeley, California

PLATE 1

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 7/25/66

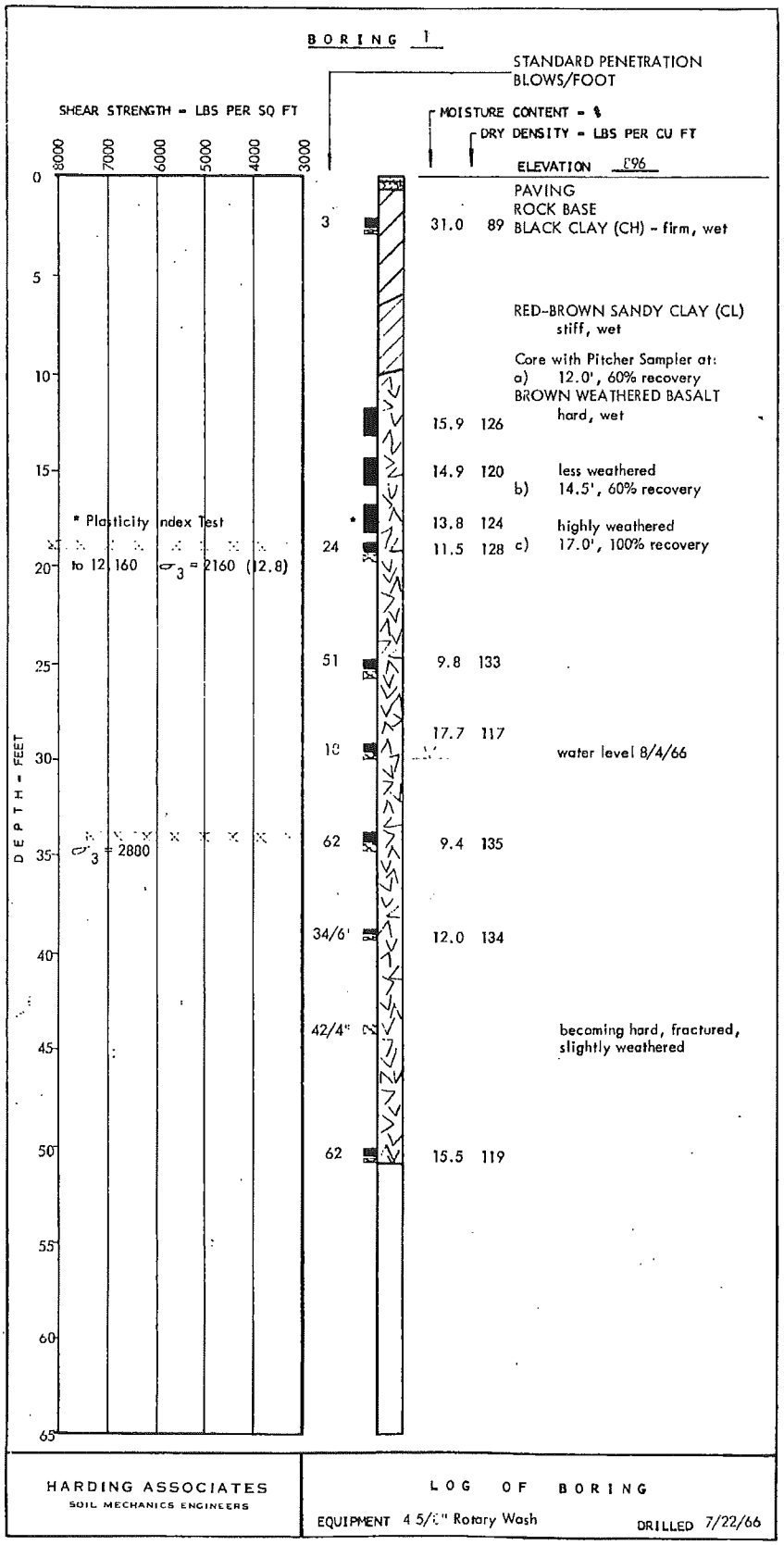
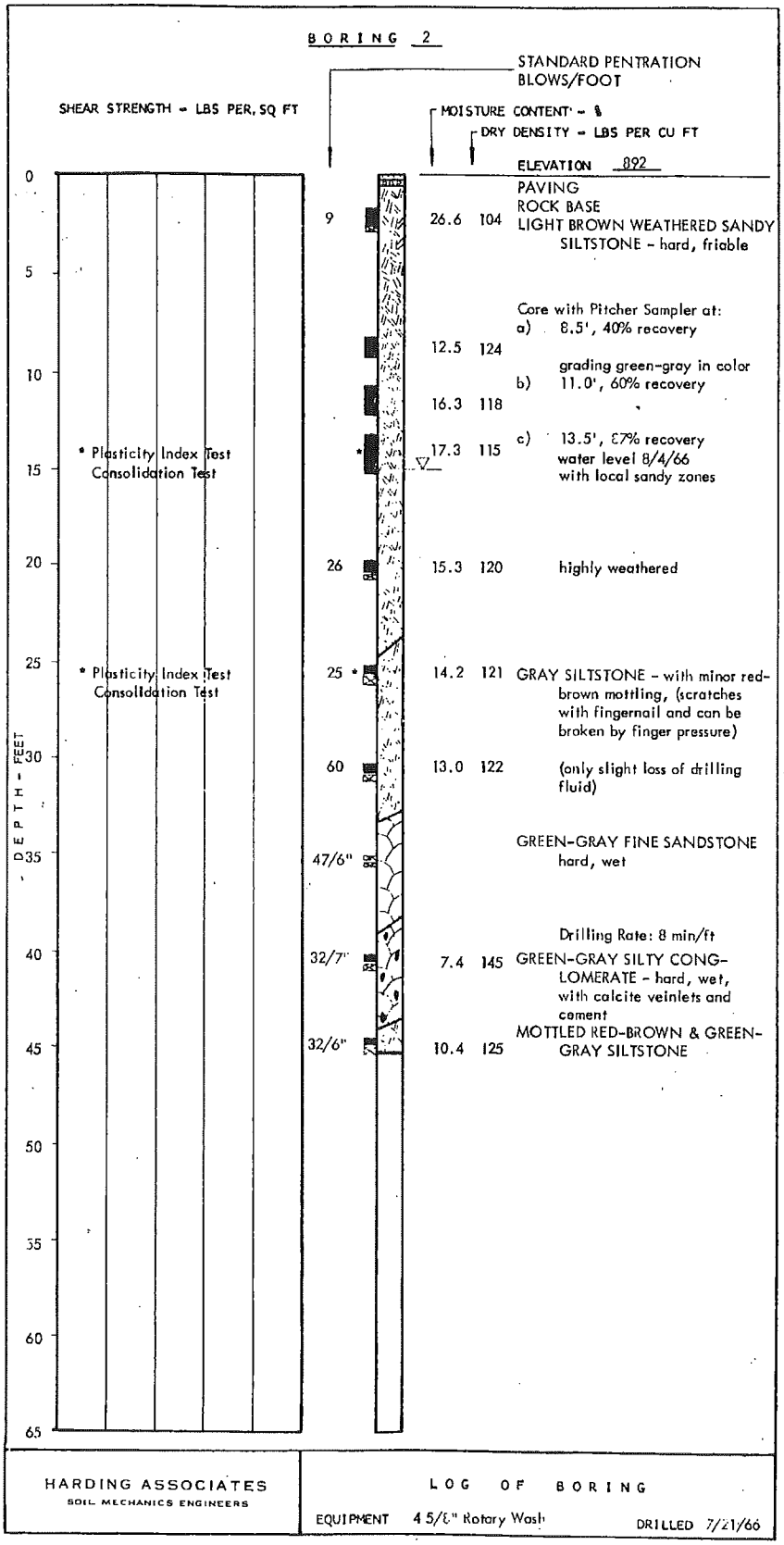


PLATE A-1

MUB-13795

008_00008

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 7/25/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

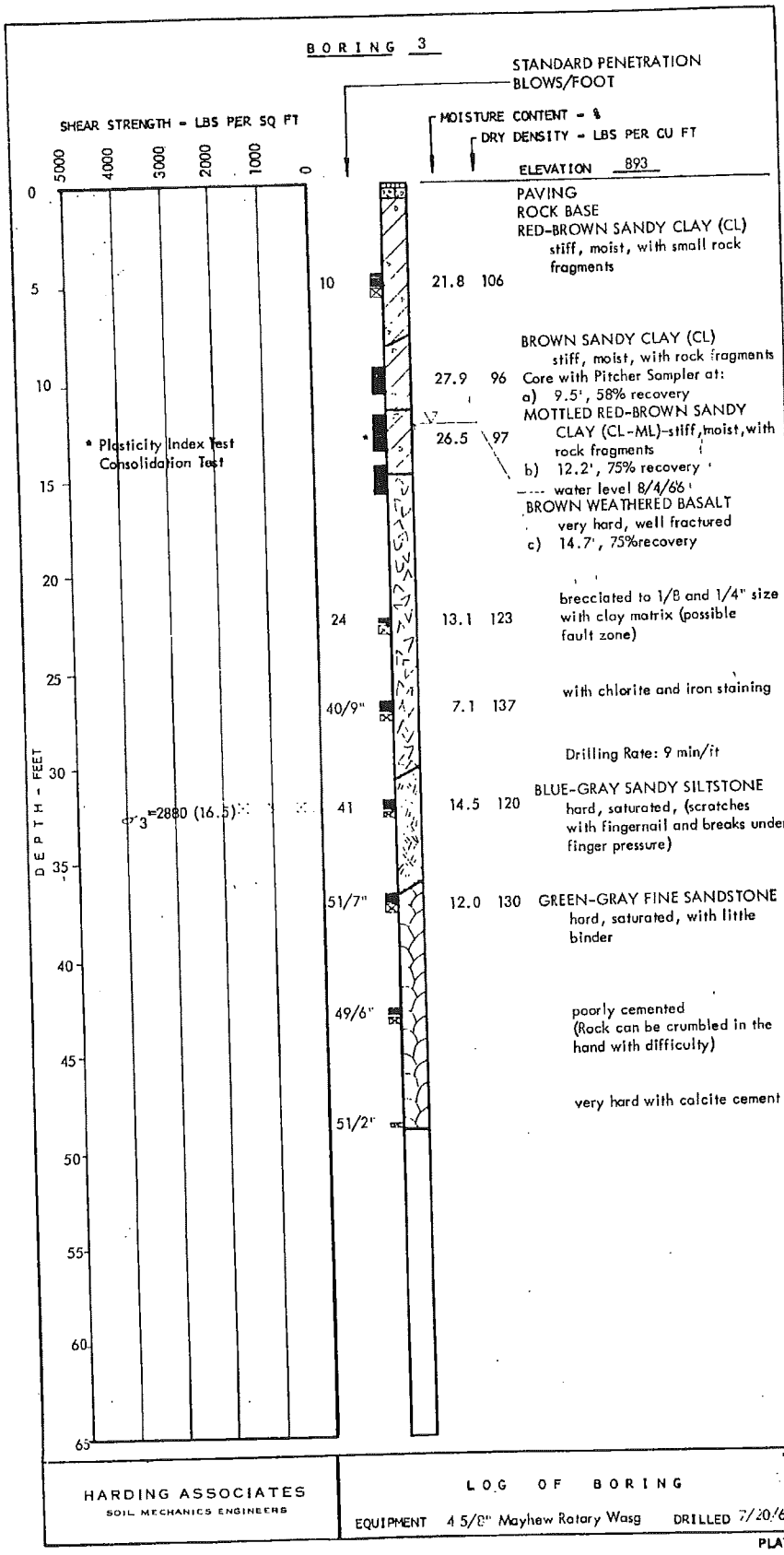
EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/21/66

PLATE A-2

MUB 13796

008_00009

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 7/22/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

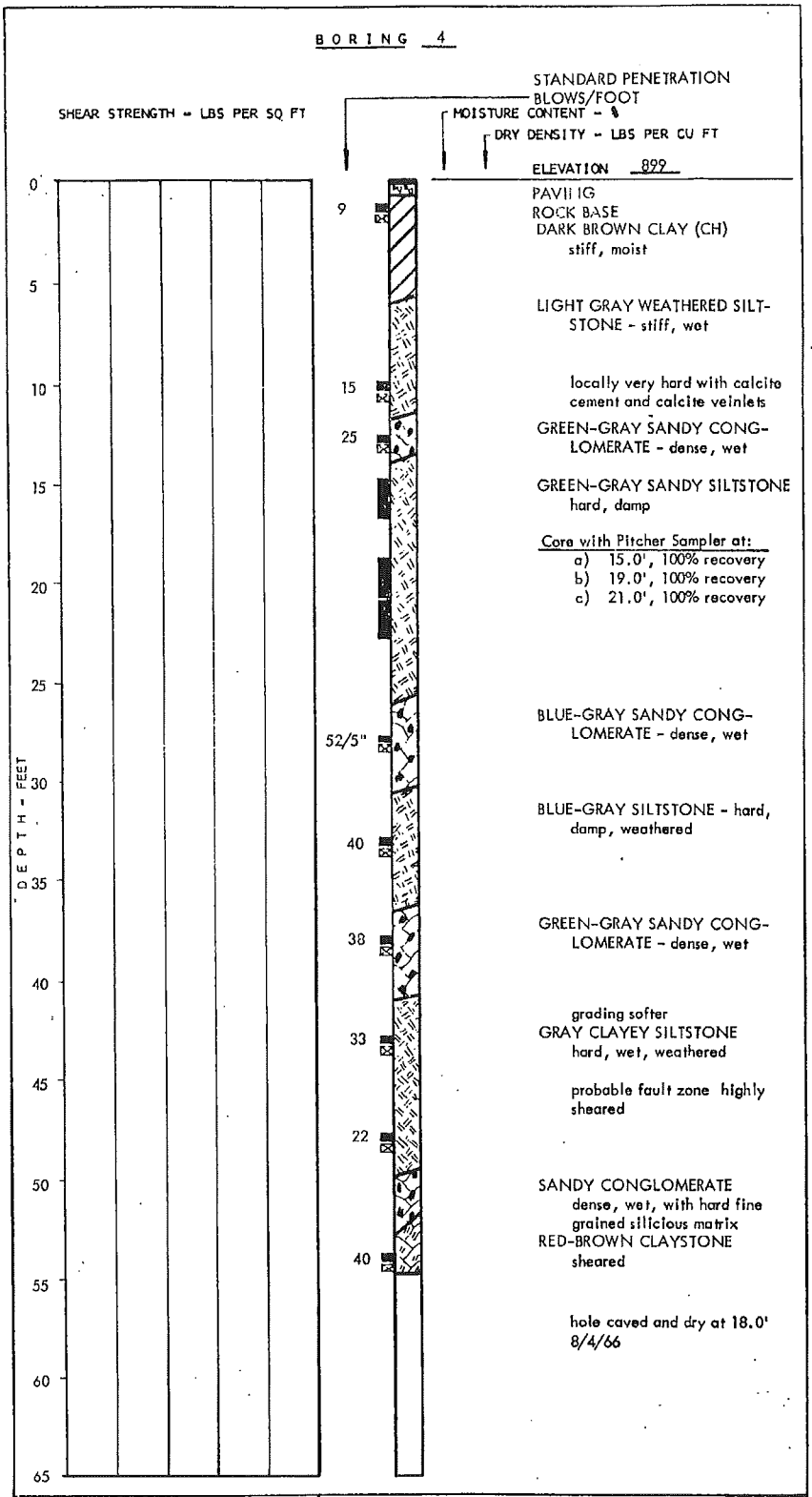
EQUIPMENT 4 5/8" Mayhew Rotary Wasg DRILLED 7/20/66

PLATE A-3

MUB-13797

008_00010

JOB U. C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 7/15/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

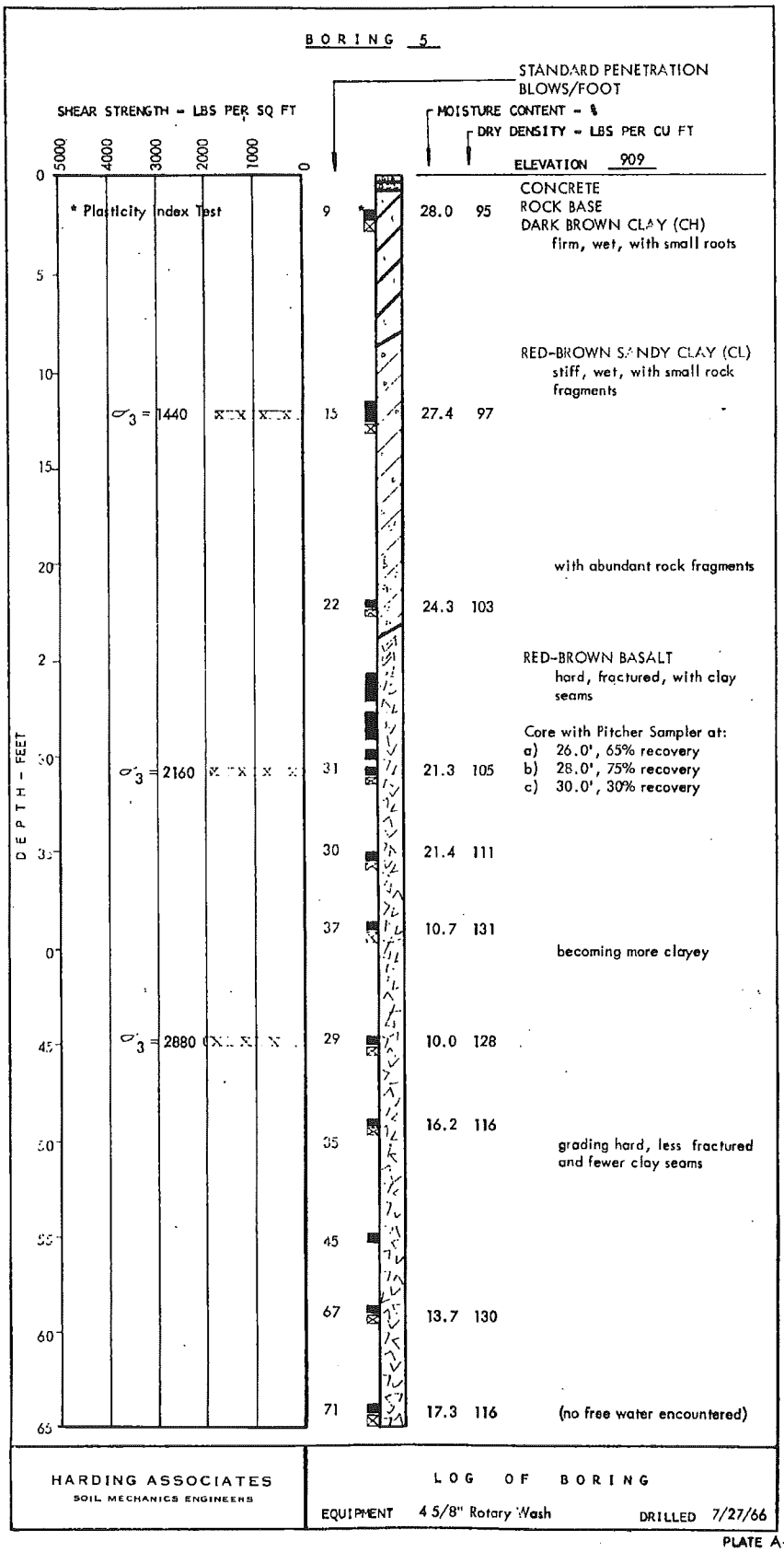
EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/13-14/66

PLATE A-4

MUB-13798

008_00011

JOB U. C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 9/3/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/27/66

PLATE A-5

MUB 13799

008_00012

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 8/3/66

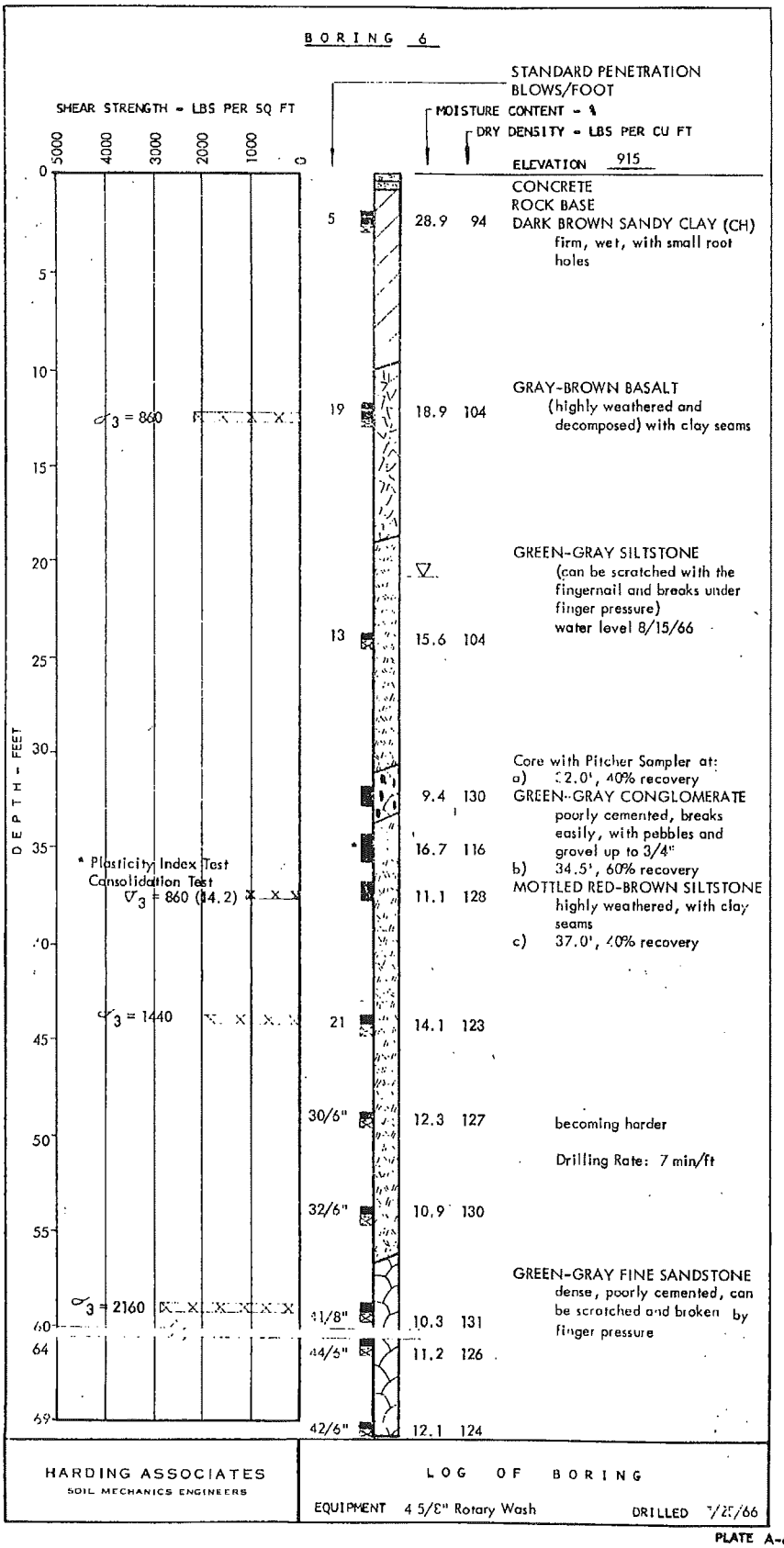


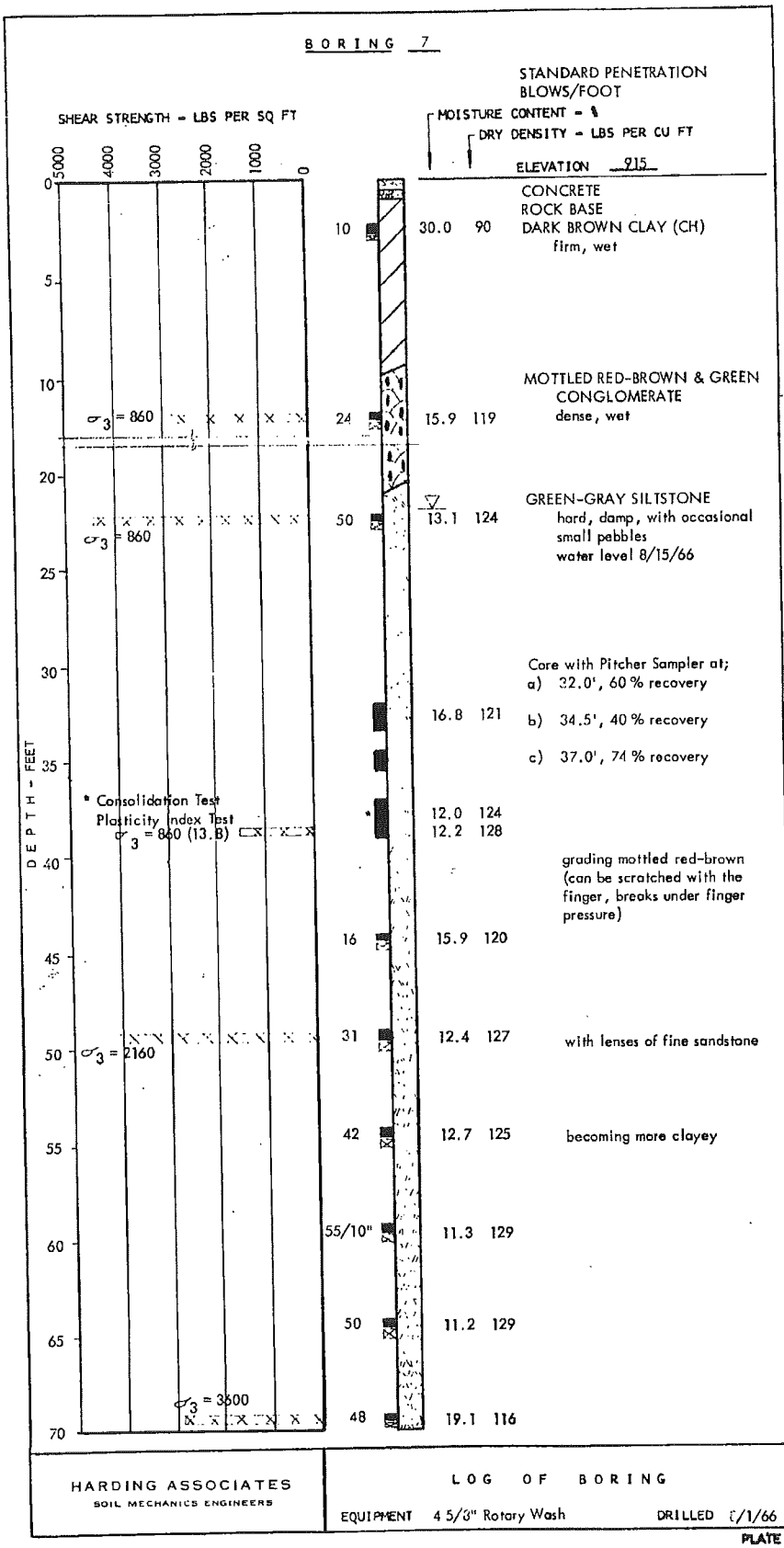
PLATE A-6

MUB 13800

008_00013

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 8/3/66

BORING 7



STANDARD PENETRATION BLOWS/FOOT

MOISTURE CONTENT - %

DRY DENSITY - LBS PER CU FT

ELEVATION 915

			CONCRETE
			ROCK BASE
10	30.0	90	DARK BROWN CLAY (CH) firm, wet
24	15.9	119	MOTTLED RED-BROWN & GREEN CONGLOMERATE dense, wet
50	13.1	124	GREEN-GRAY SILTSTONE hard, damp, with occasional small pebbles water level 8/15/66
			Core with Pitcher Sampler at; a) 32.0', 60 % recovery
	16.8	121	b) 34.5', 40 % recovery
			c) 37.0', 74 % recovery
*	12.0	124	
	12.2	128	grading mottled red-brown (can be scratched with the finger, breaks under finger pressure)
16	15.9	120	
31	12.4	127	with lenses of fine sandstone
42	12.7	125	becoming more clayey
55/10"	11.3	129	
50	11.2	129	
48	19.1	116	

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

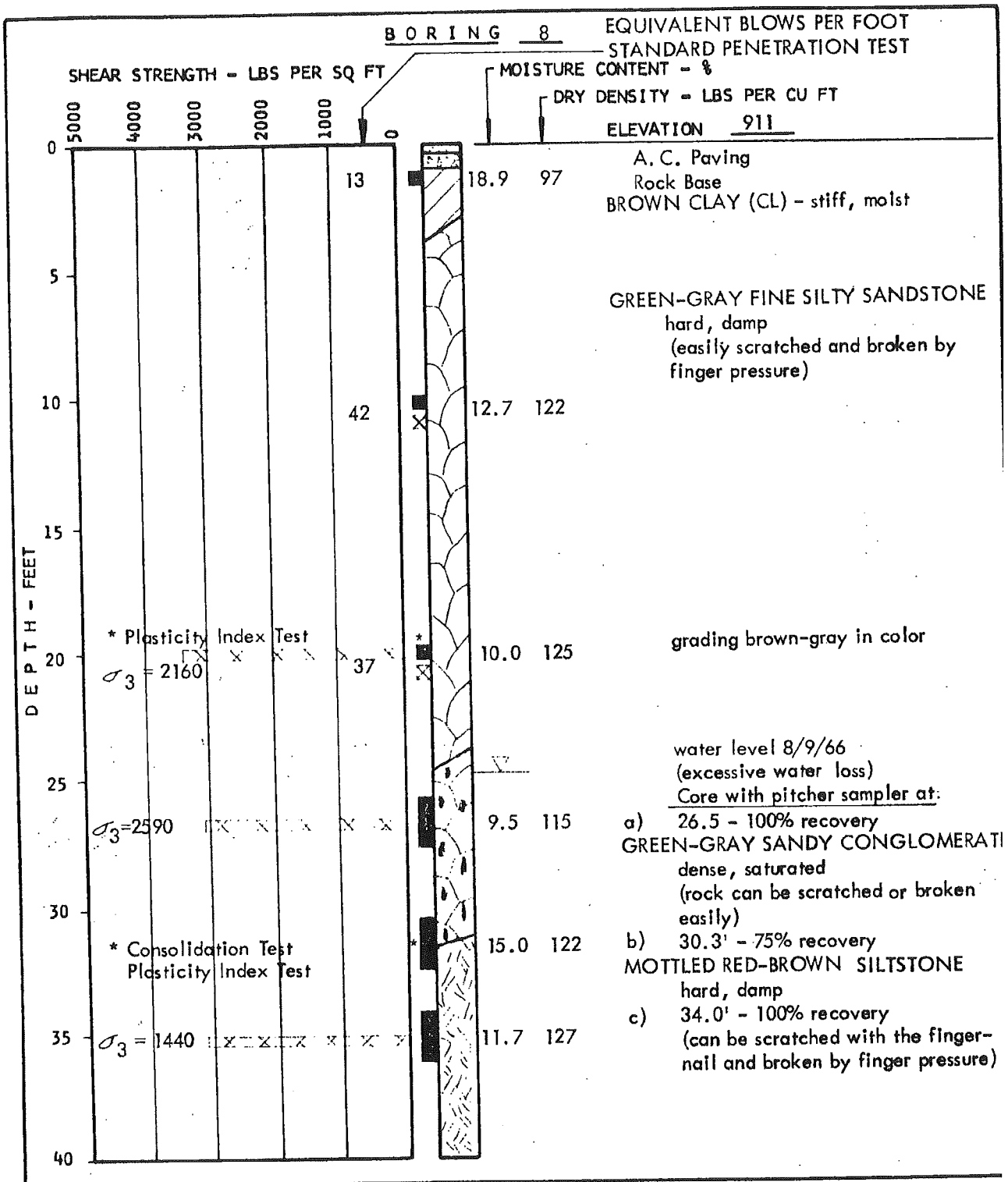
EQUIPMENT 4 5/3" Rotary Wash DRILLED 7/1/66

PLATE A-7

MUB-13801

008_00014

JOB U. C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gkr DATE 7/19/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

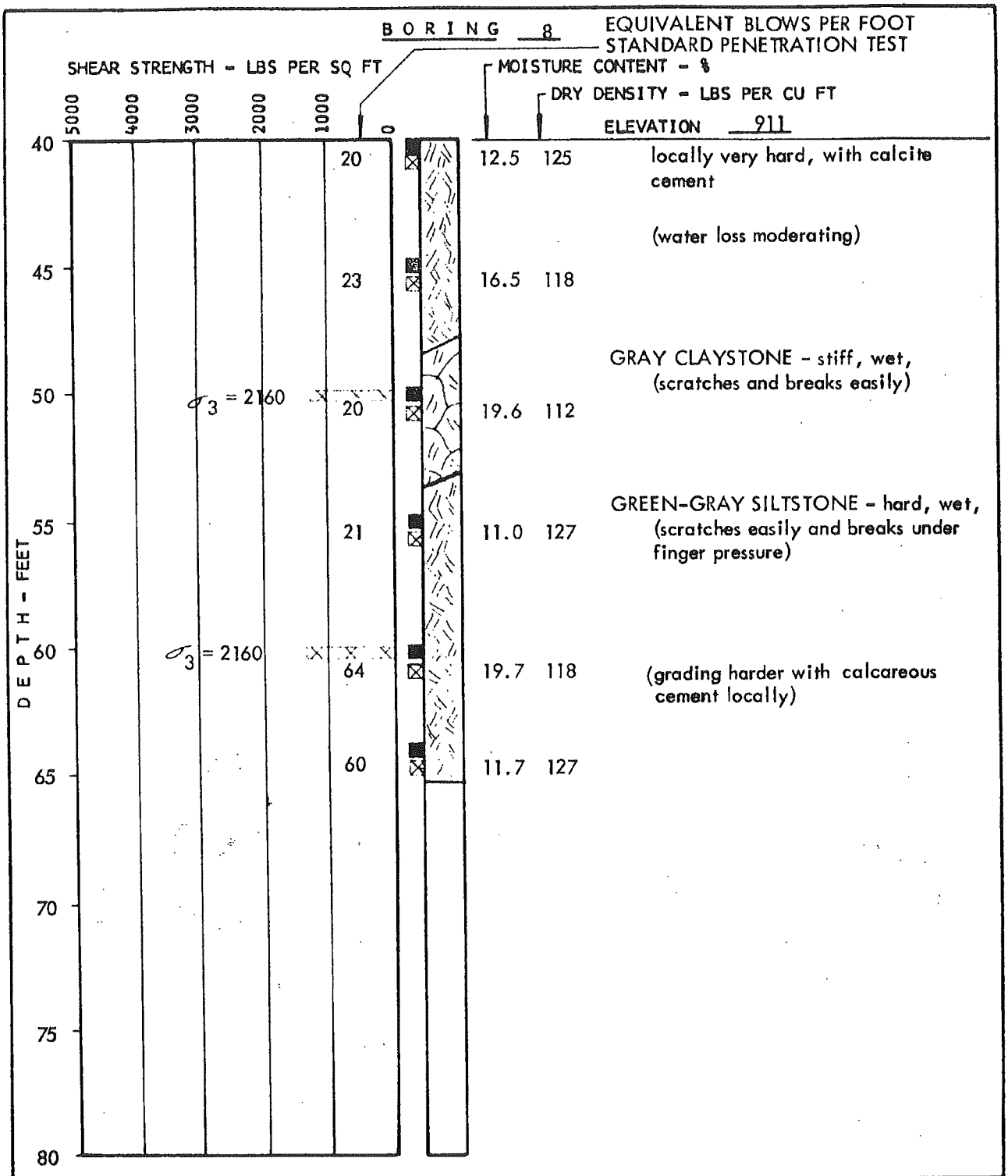
LOG OF BORING

EQUIPMENT 4 5/8" Mayhew Rotary Wash DRILLED 7/15-18/

PLATE

MUB-131

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gkr DATE 7/19/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

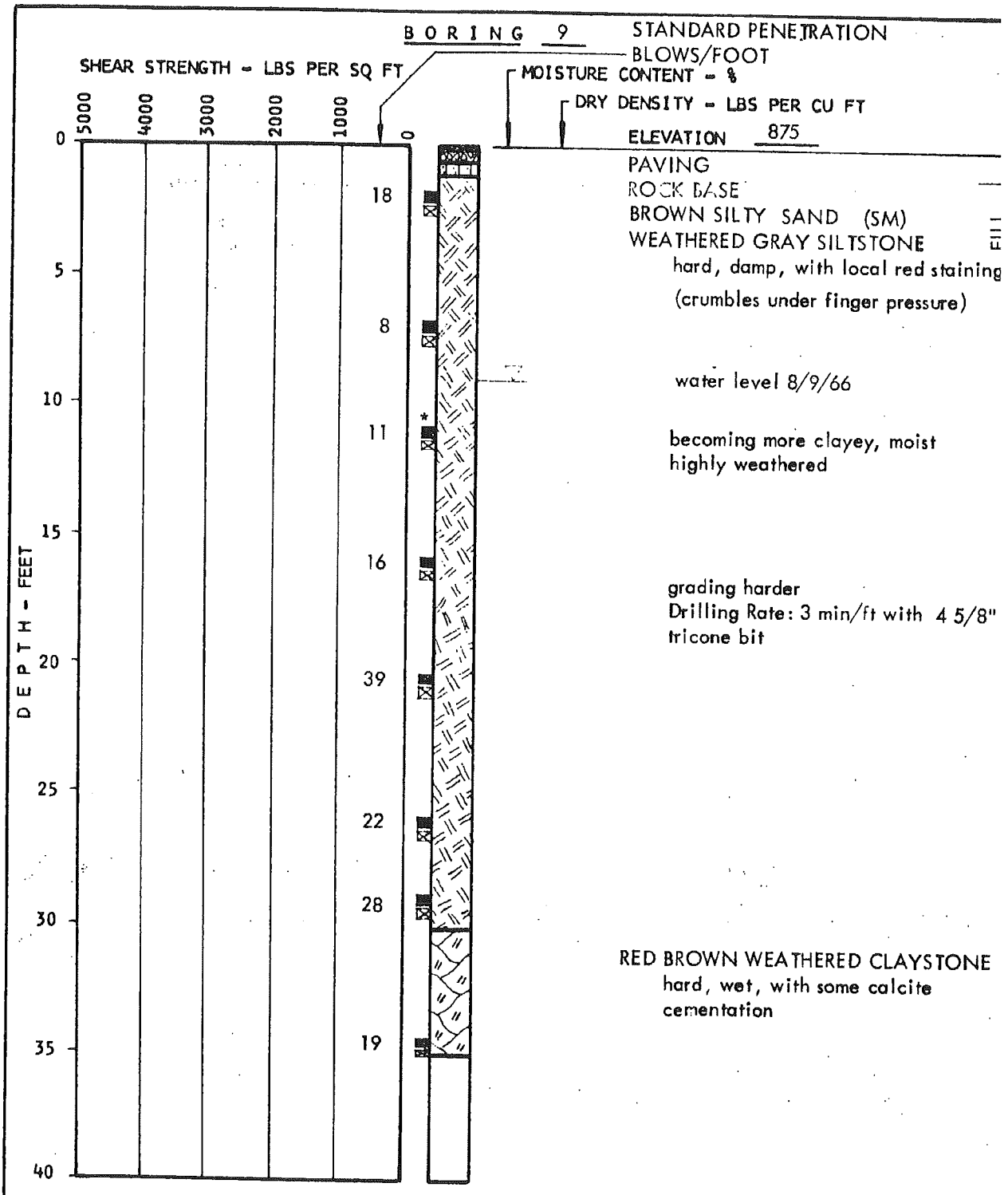
LOG OF BORING

EQUIPMENT 4 5/8" Mayhew Rotary Wash DRILLED 7/15-18/66

PLATE A-9

MUB 13803

JOB Lawrence Rad. Lab. - Omnitron Site NO 2000.37 BY ABC/rr DATE 7/14/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/6/66

PLATE

MUB-13

008_00017

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 8/10/66

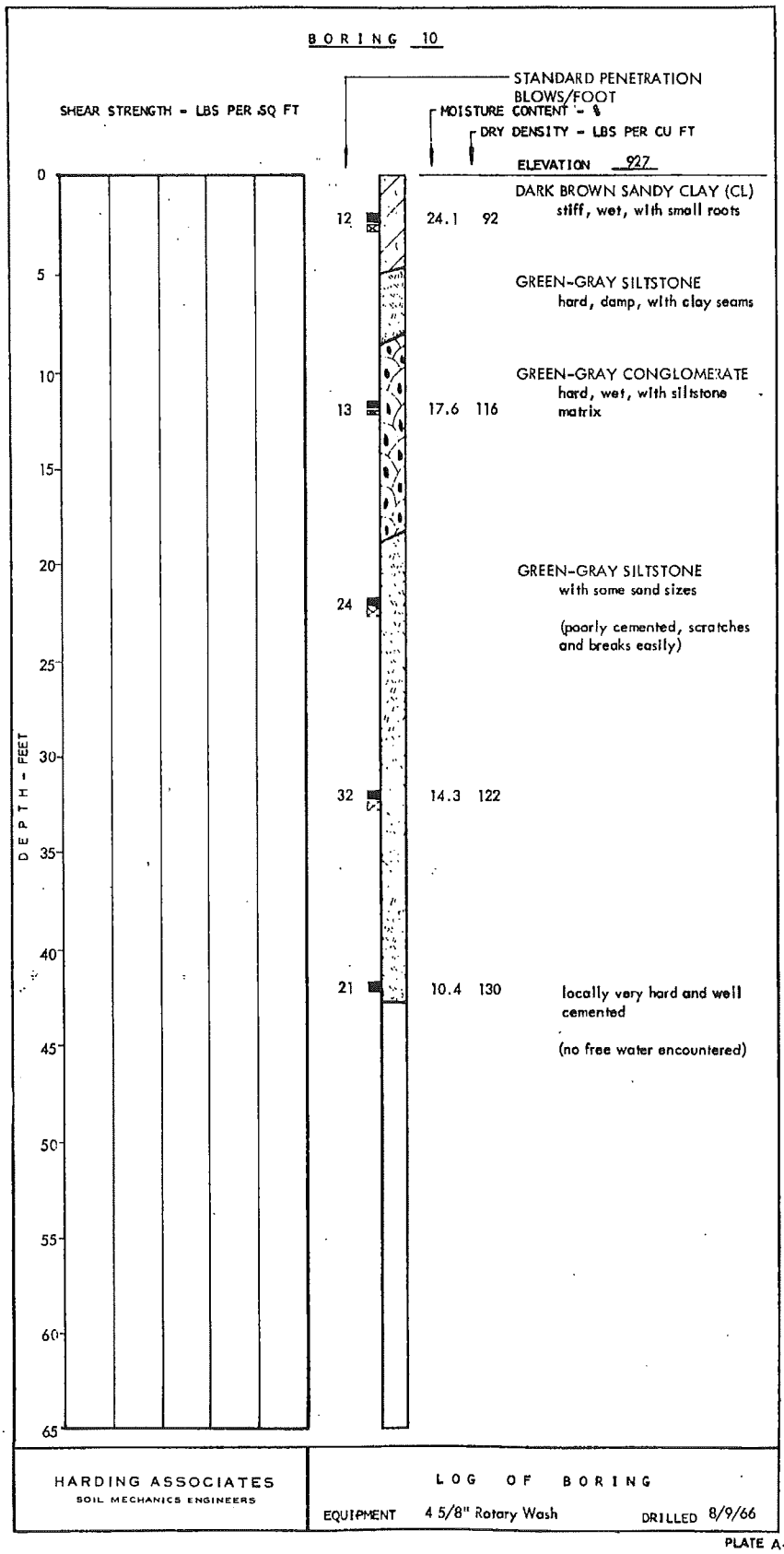
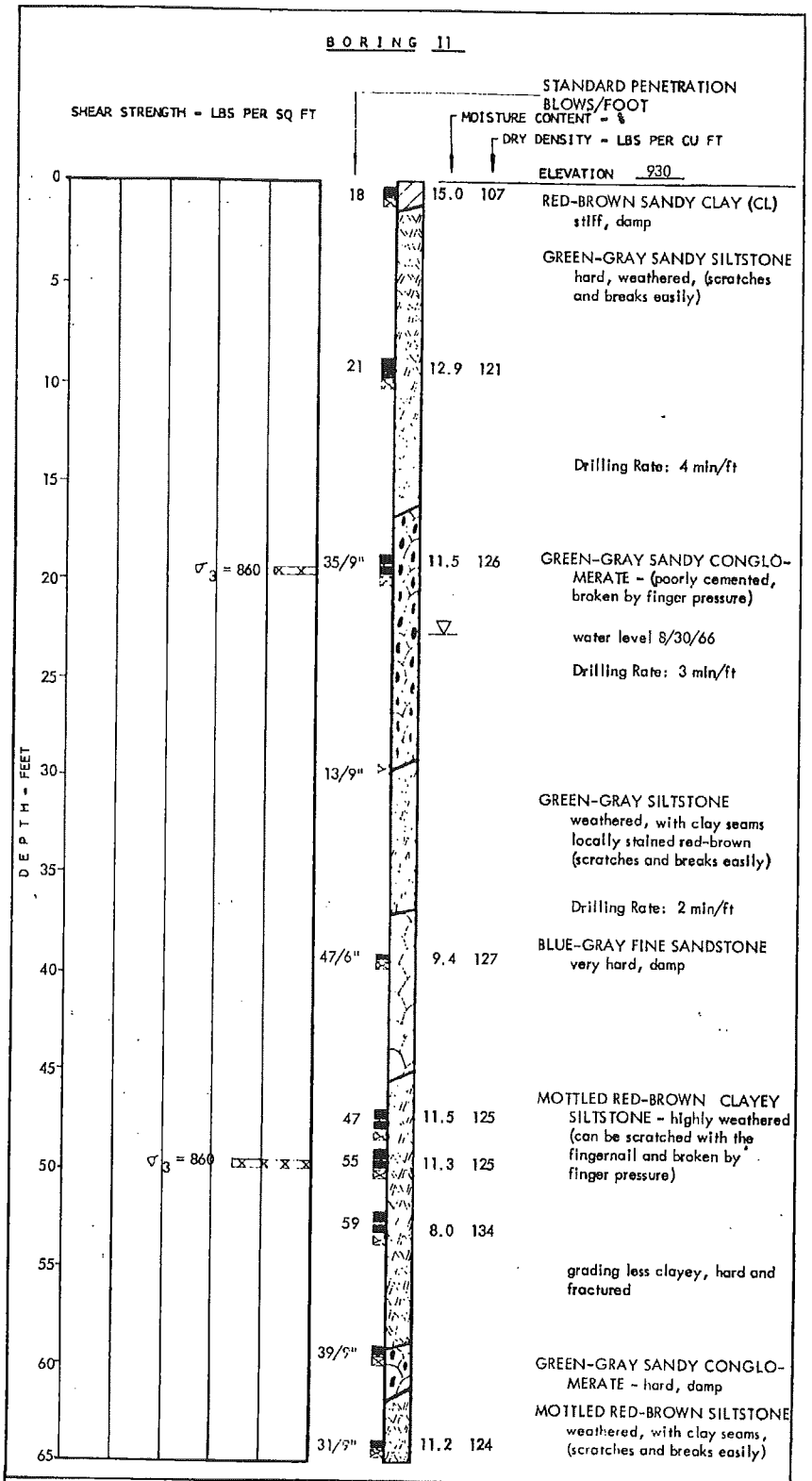


PLATE A-11

MUB-13805

008_00018

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 8/16/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

EQUIPMENT 4 3/4" Rotary Wash DRILLED 8/15/66

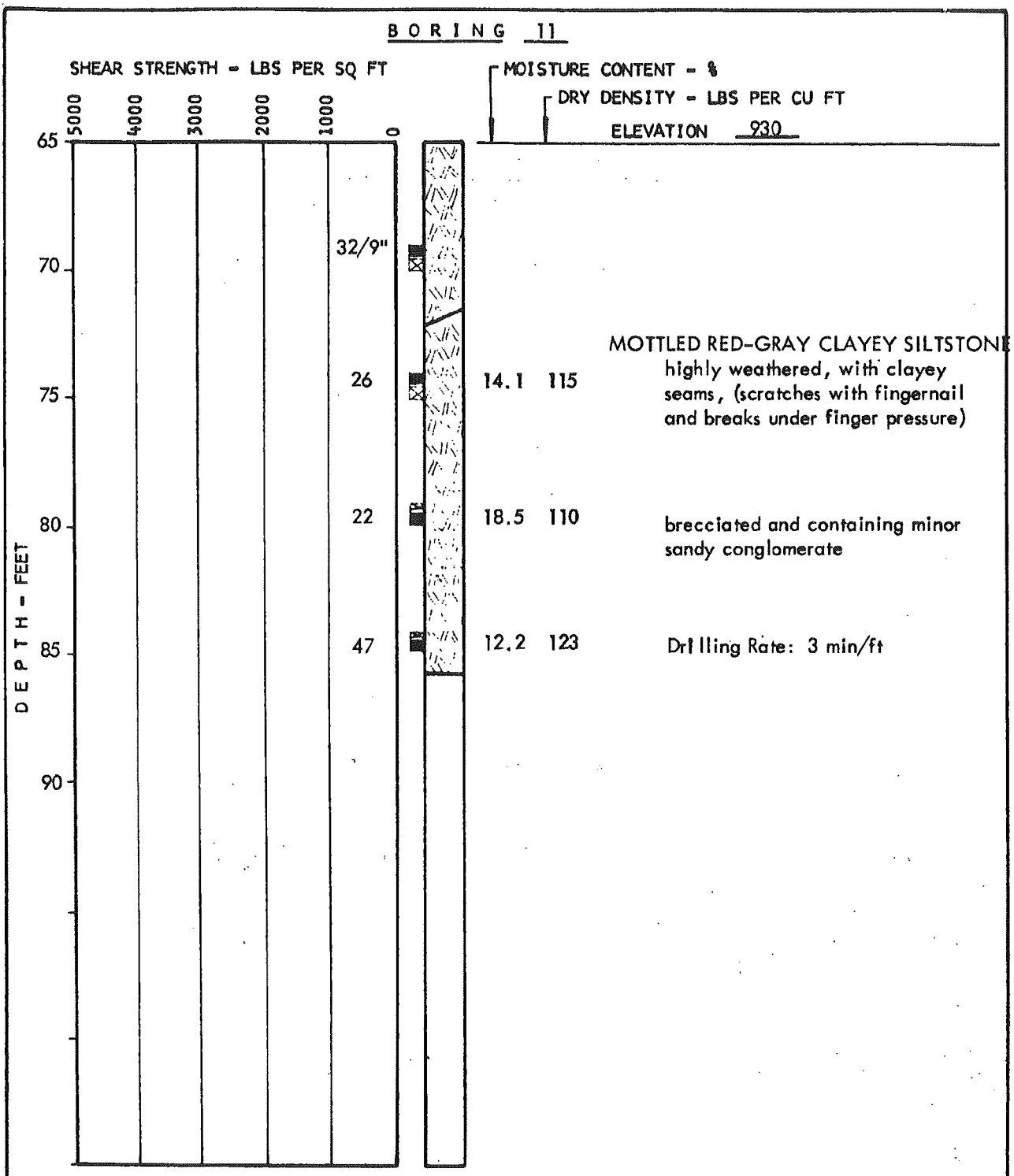
PLATE A-12

MUB-13806

008_00019

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 8/16/66

BORING 11



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

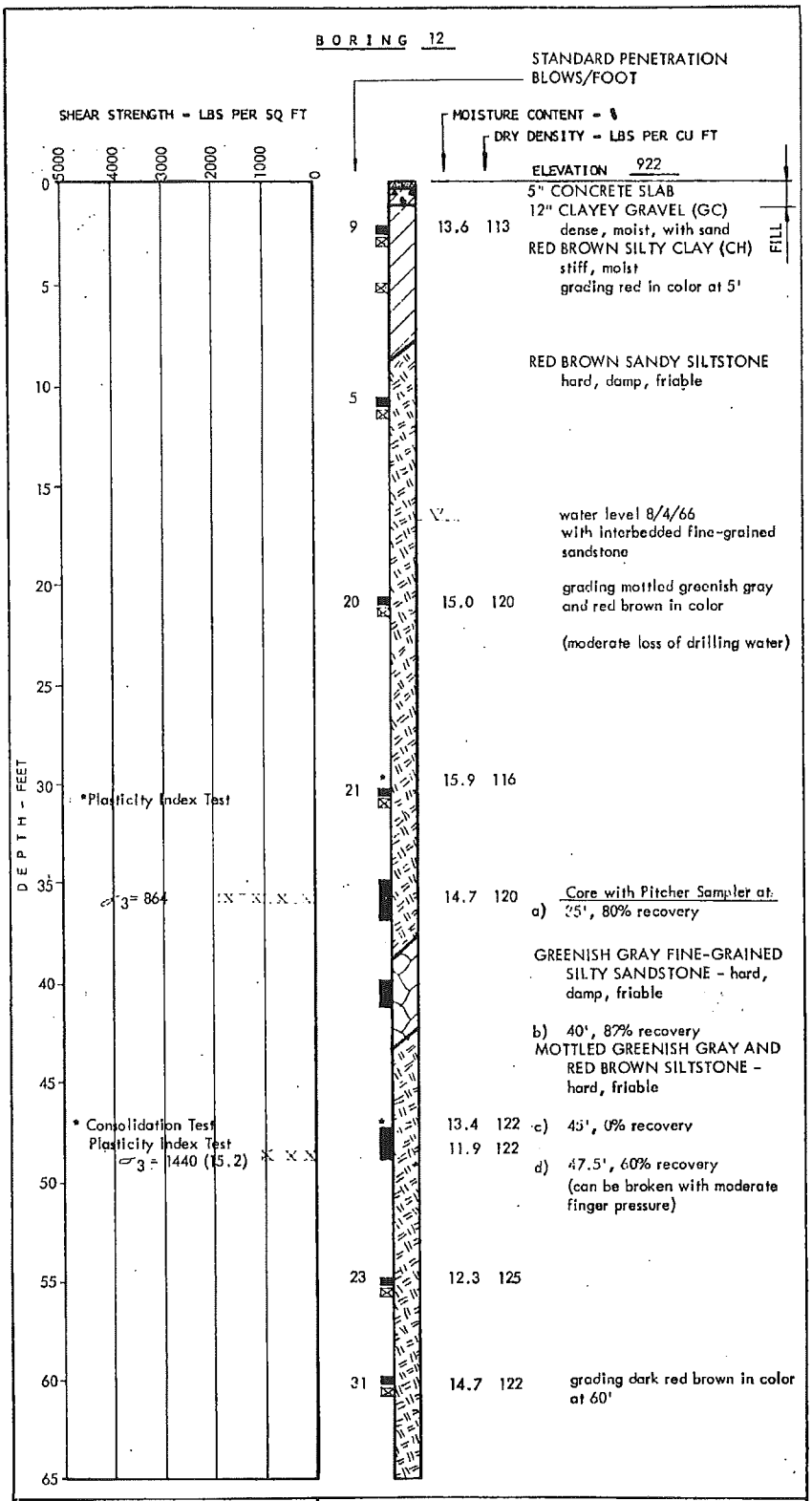
LOG OF BORING

EQUIPMENT 4 3/4" Rotary Wash DRILLED 8/15/66

PLATE A-13

MUB-13807

JOB Lawrence Rad. Lab. - Omnitron Site NO 2000.37 BY ABC/rr DATE 7/15/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

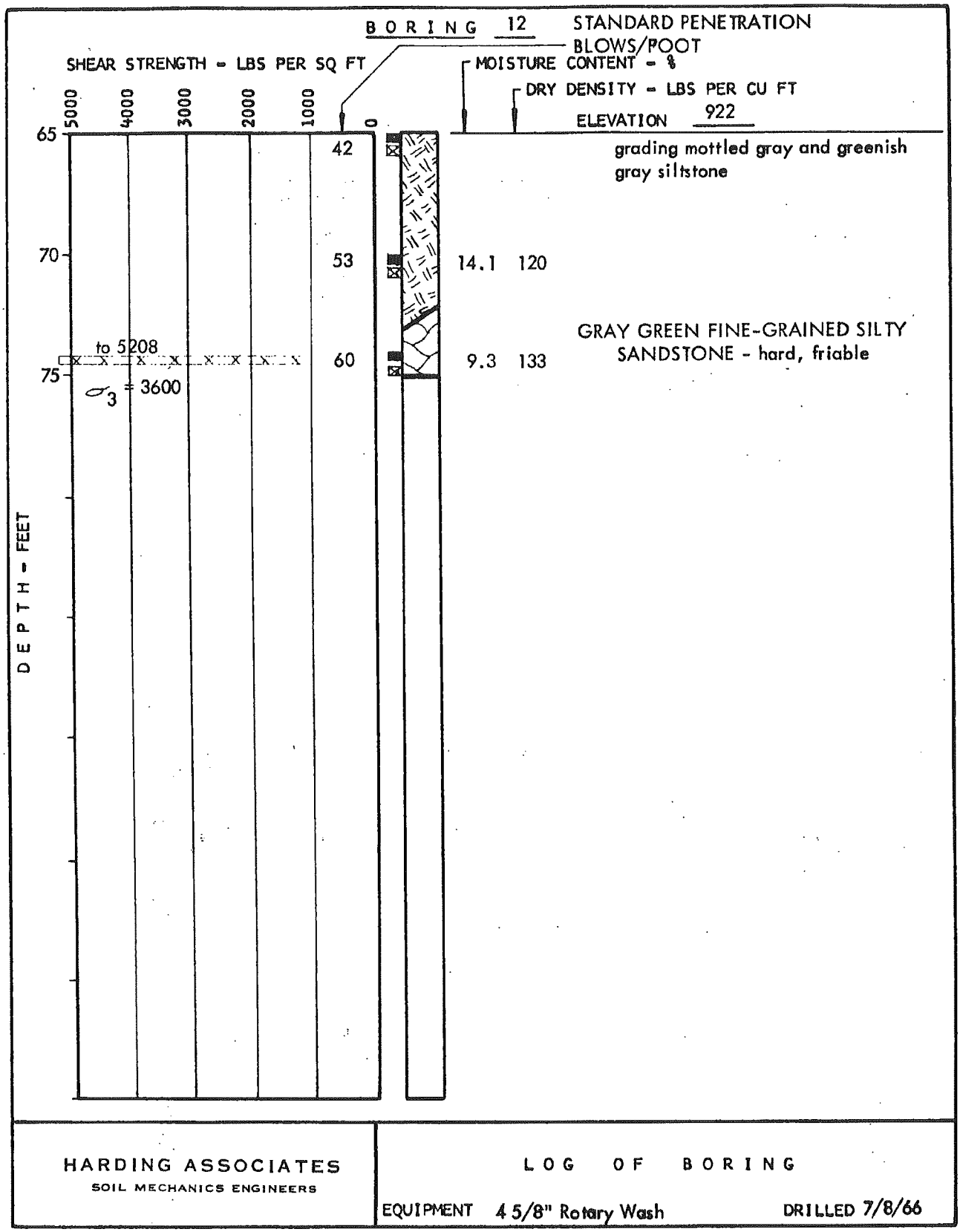
EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/8/66

PLATE A-14

MUB-13808

008_00021

JOB Lawrence Rad. Lab. - Omnitron Site NO 2000.37 BY ABC/rr DATE 7/15/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/8/66

PLATE A-15

MUB-13809

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gkr DATE 7/15/66

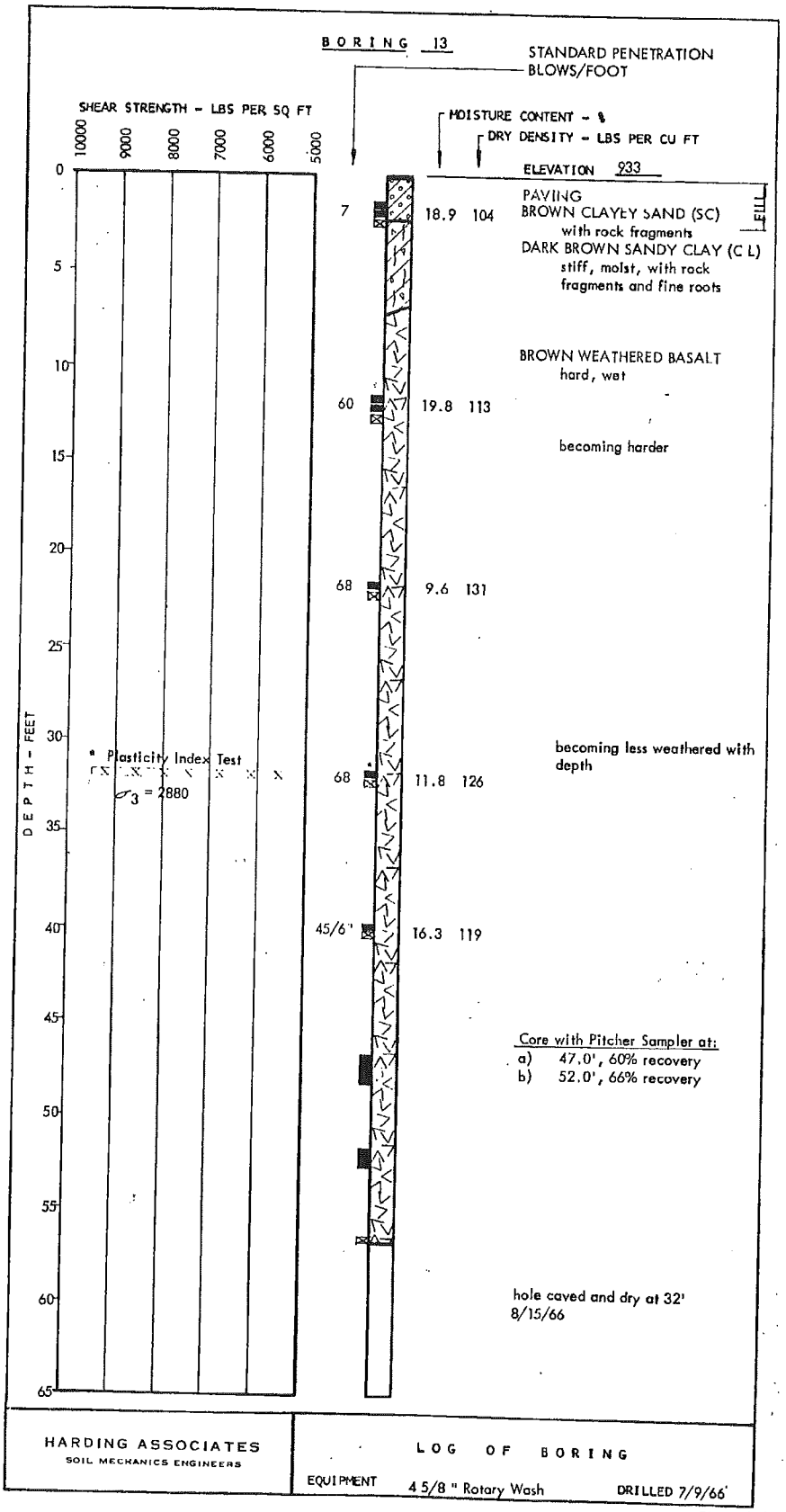


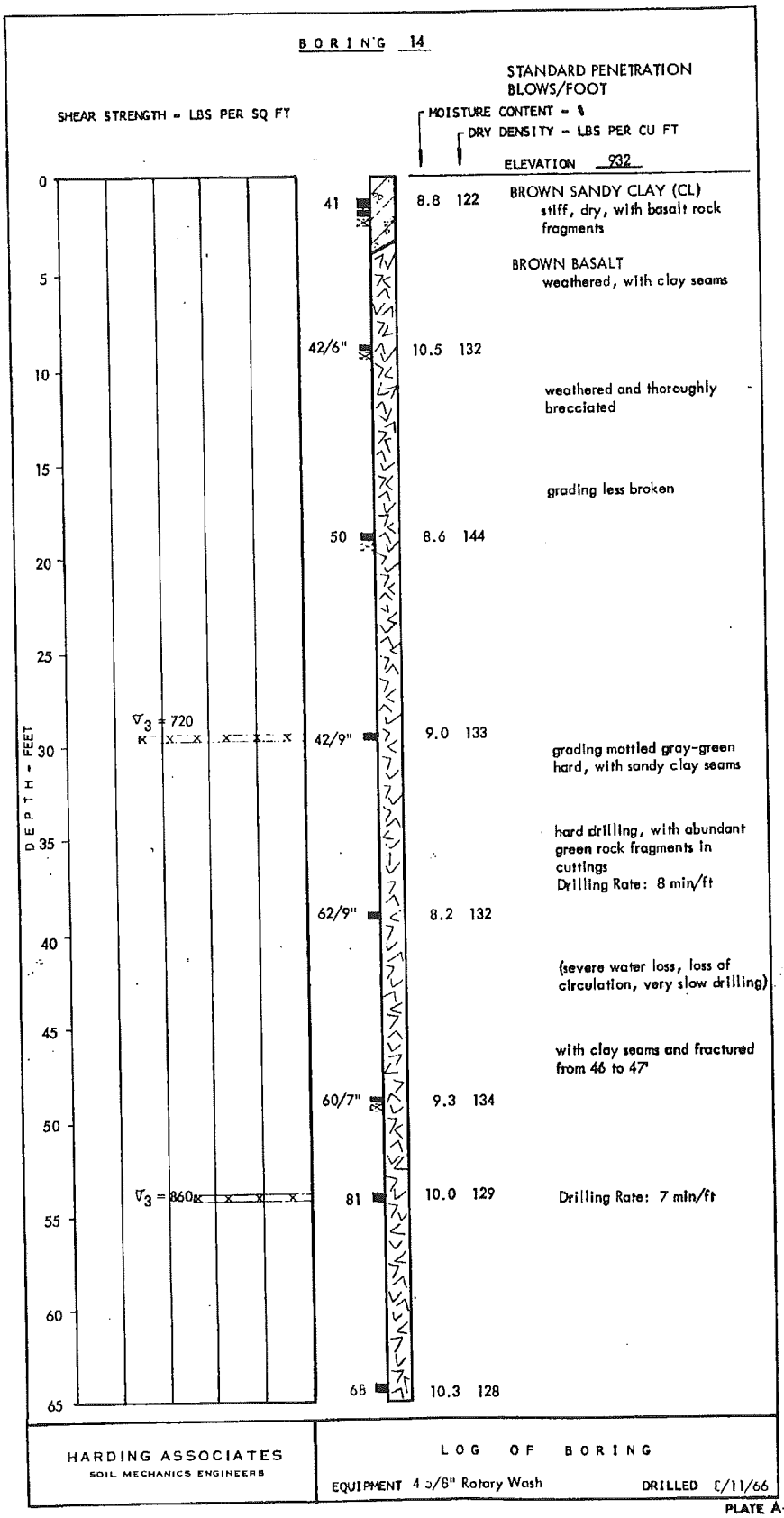
PLATE A-16

MUB-13810

008_00023

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gf DATE 8/12/66

BORING 14



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 8/11/66

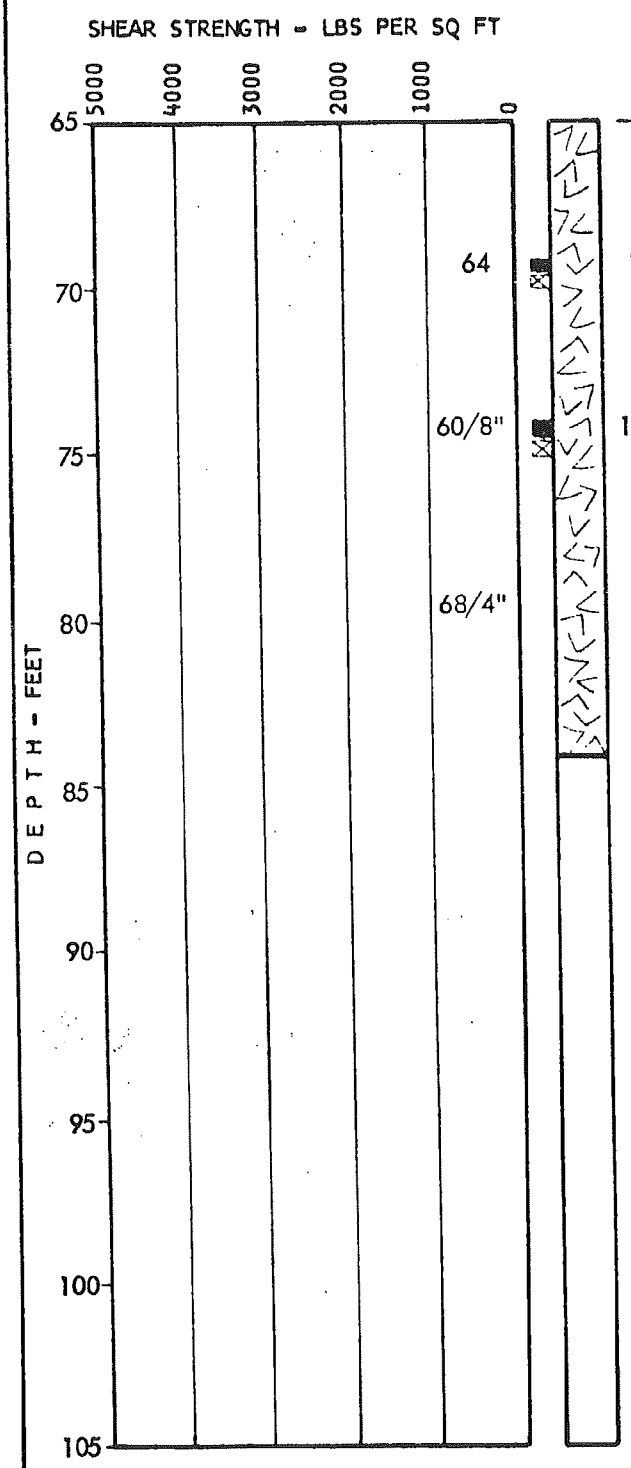
PLATE A-17

MUB-13811

008_00024

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AC/gr DATE 8/12/66

BORING 14



MOISTURE CONTENT - %
DRY DENSITY - LBS PER CU FT
ELEVATION 932

highly fractured with brown sandy clay in seams
Drilling Rate: 3 min/ft

9.8 132

highly fractured and brecciated

10.4 130

Drilling Rate: 7 min/ft

water level below 50' prior to back filling

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

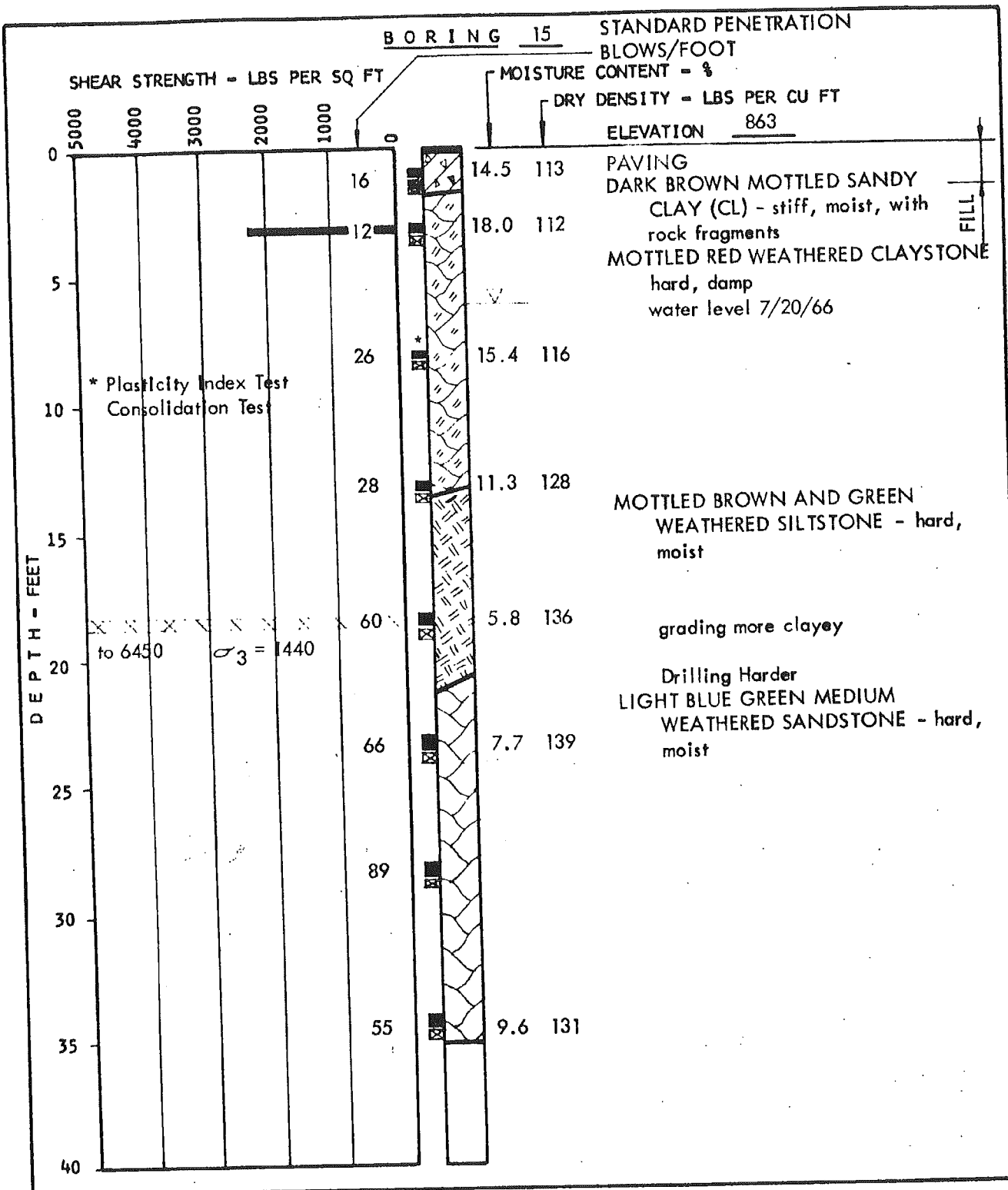
LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 8/11/6

PLAT

MUB-1

JOB Lawrence Rad. Lab. - Omnitron Site NO 2000.37 BY PK, AC/rn DATE 7/14/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

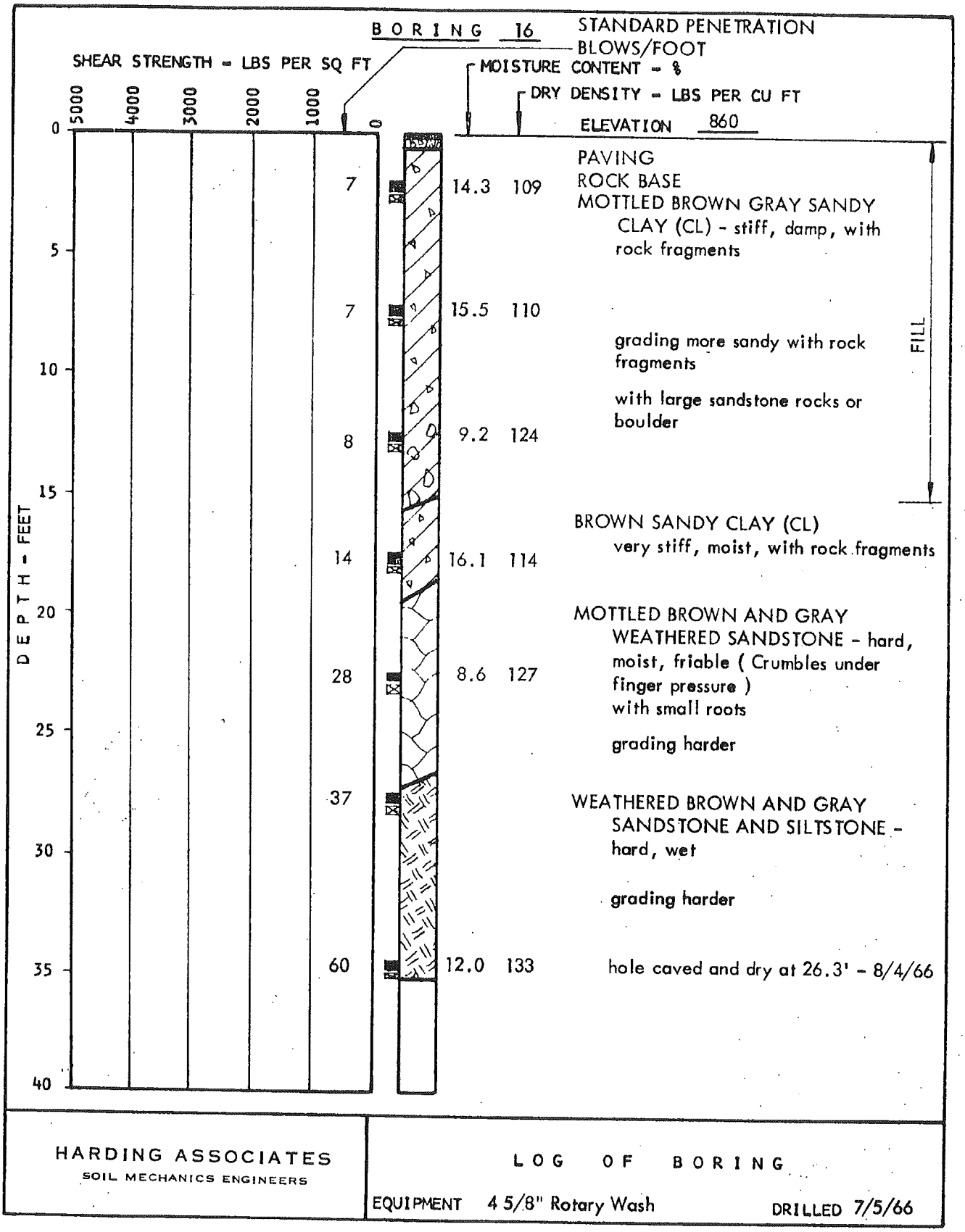
LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/1/66

PLATE A-19

MUB-13813

JOB Lawrence Rad. Lab. - Omnitron Site NO 2000.37 BY ABC/rr DATE 7/14/66



HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

LOG OF BORING

EQUIPMENT 4 5/8" Rotary Wash DRILLED 7/5/66

PLATE A-20

MUB-13814

008_00027

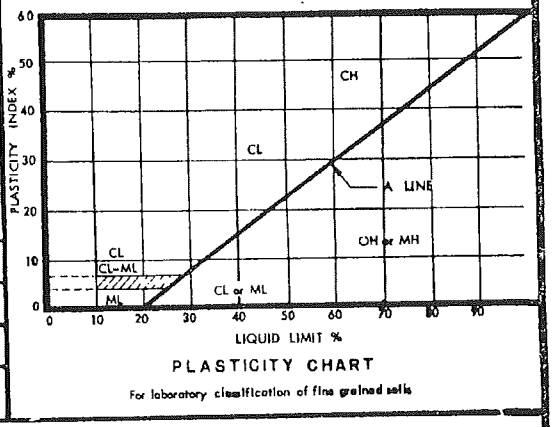
MAJOR DIVISIONS				TYPICAL NAMES	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE**)	GRAVELS (MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE*)	CLEAN GRAVELS (little or no fines)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 & 3
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR GW
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR PI LESS THAN 4
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI GREATER THAN 7
	SANDS (MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE.*)	CLEAN SANDS (Little or no fines)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 & 3
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
		SANDS WITH FINES (Appreciable amount of fines)	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR PI LESS THAN 4
			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES	ATTERBURG LIMITS ABOVE "A" LINE WITH PI GREATER THAN 7
FINE GRAINED SOILS (MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE**)	SILTS AND CLAYS (LIQUID LIMIT LESS THAN 50)		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY	
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
	SILTS AND CLAYS (LIQUID LIMIT GREATER THAN 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	

Determine percentages of gravel and sand from grain size curve
Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows
Less than 5% — GW, GP, SW, SP
More than 12% — GM, GC, SM, SC
5% to 12% — Borderline cases requiring use of dual symbols.

ABOVE "A" LINE WITH PI BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

ABOVE "A" LINE WITH PI BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

*for visual classification, the 1/4 inch size may be used as equivalent to the no. 4 size.
**the no. 200 sieve size is about the smallest particle visible to the naked eye.



PLASTICITY CHART

For laboratory classification of fine grained soils

UNIFIED SOIL CLASSIFICATION SYSTEM

SAMPLE DESIGNATION

- Undisturbed Sample
- Disturbed or Bulk Sample
- Sample attempt with no recovery
- V — Vane Shear Test
- ▽ — Observed Water Level

STRENGTH TEST RESULTS

- * — Vane Shear Test
- Unconfined Compression Test
- 1000 (30.0) — Unconsolidated - Undrained Triaxial Compression Test
- 1000 (30.0) — Consolidated - Undrained Triaxial Compression Test
- 1000 (30.0) — Consolidated - Drained Triaxial Compression Test
- 1000 (30.0) — "Quick" Direct Shear Test
- 1000 (30.0) — Consolidated - Drained Direct Shear Test

Bar Length Represents Shear Strength
Moisture Content of Shear Zone after Test in Percent
Stress Normal to Shear Plane in PSF

* F denotes in-situ field test
L denotes laboratory vane shear test
(R) denotes remolded vane shear strength

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

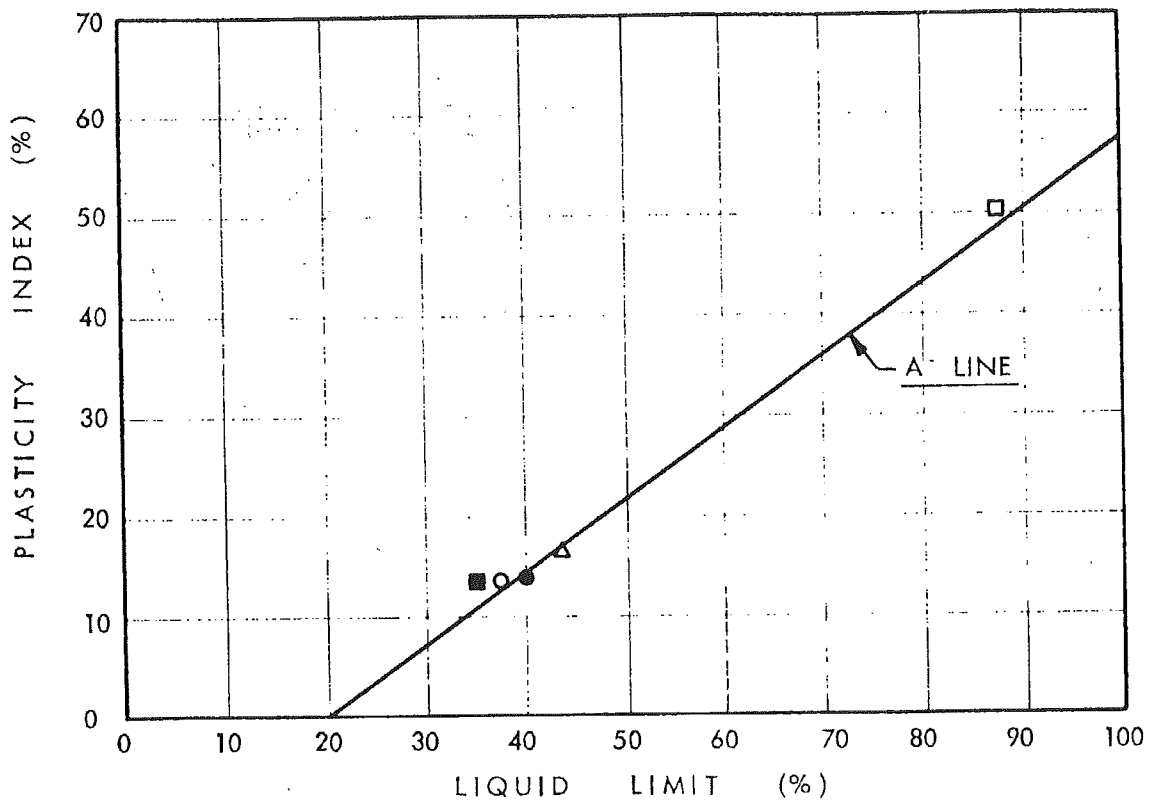
SOIL CLASSIFICATION CHART AND KEY TO TEST DATA

PLATE A-2J

MUB-13815

008_00028

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AJS/gkr DATE 8/19/66



SYMBOL	CLASSIFICATION & SOURCE	LIQUID LIMIT(%)	PLASTIC LIMIT(%)	PLASTICITY INDEX (%)	% PASSING #200 SCREEN
●	BROWN WEATHERED BASALT (CL-ML) Boring 1 at 17.0'	40	27	13	---
o	BROWN SANDY SILTSTONE (CL-ML) Boring 2 at 13.5'	37	24	13	68.3
■	GRAY SILTSTONE (CL-ML) Boring 2 at 25.0'	35	22	13	---
△	RED-BROWN SANDY CLAY (CL-ML) Boring 3 at 12.2'	43	26	17	67.7
□	DARK BROWN CLAY (CH) Boring 5 at 2.0'	87	37	50	---

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

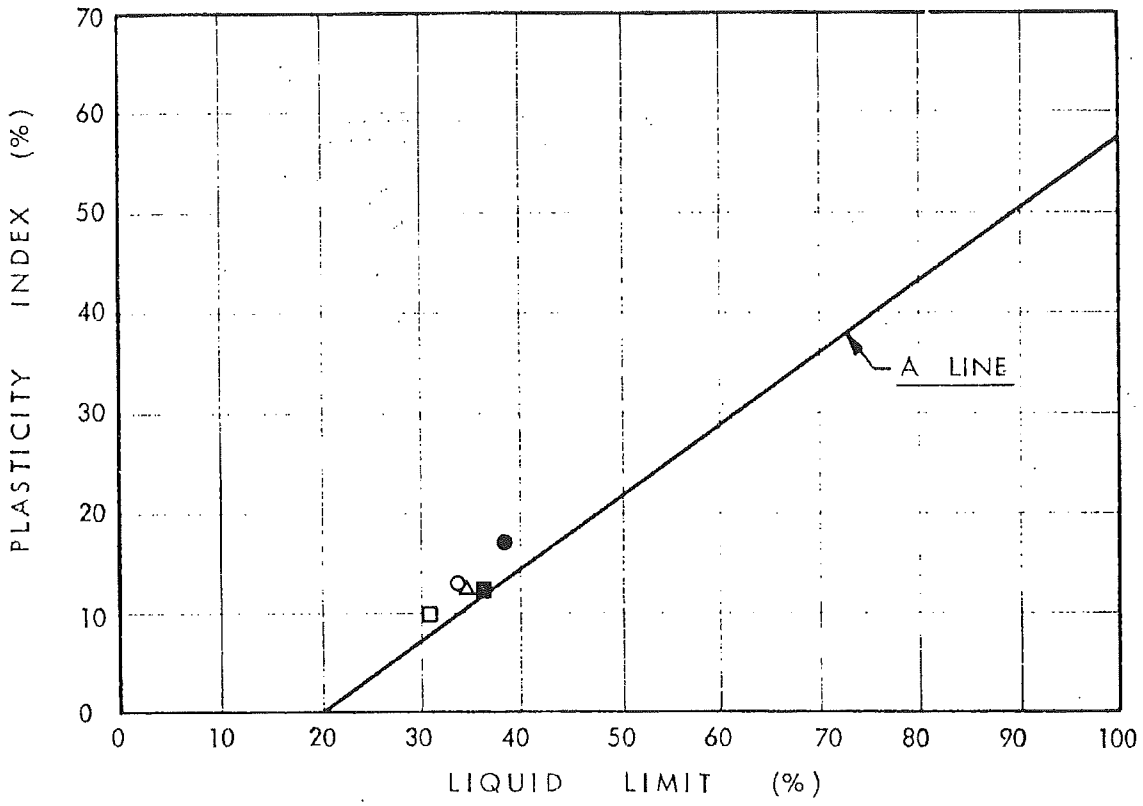
PLASTICITY CHART

PLATE A-36

MUB-13830

008_00043

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AJS/gkr DATE 8/19/66



SYMBOL	CLASSIFICATION & SOURCE	LIQUID LIMIT(%)	PLASTIC LIMIT(%)	PLASTICITY INDEX (%)	% PASSING #200 SCREEN
●	RED-BROWN SILTSTONE (CL-ML) Boring 6 at 34.5'	38	21	17	81.3
○	GRAY-GREEN SILTSTONE (CL-ML) Boring 7 at 37.0'	33	19	14	81.7
■	BROWN SILTY SANDSTONE (CL-ML) Boring 8 at 20.0'	36	23	13	74.2
△	RED-BROWN SILTSTONE (CL-ML) Boring 8 at 30.3'	34	21	13	96.8
□	RED-BROWN SANDY SILTSTONE (CL-ML) Boring 12 at 30.4'	31	21	10	87.1

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

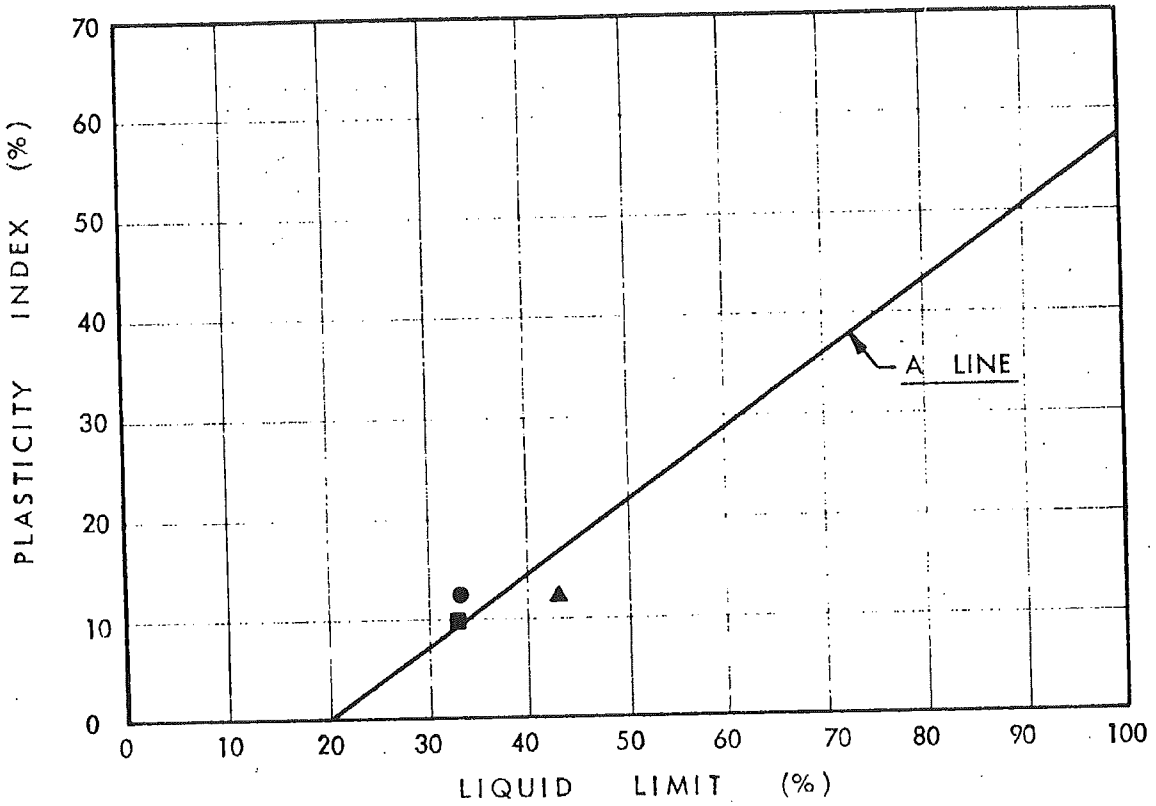
PLASTICITY CHART

PLATE A-37

MUB-13831

008_00044

JOB U.C. Rad. Lab. - Omnitron Site NO 2000.37 BY AJS/gkr DATE 8/19/66



SYMBOL	CLASSIFICATION & SOURCE	LIQUID LIMIT(%)	PLASTIC LIMIT(%)	PLASTICITY INDEX (%)	% PASSING #200 SCREEN
●	GRAY-GREEN SILTSTONE (CL-ML) Boring 12 at 47.6'	33	20	13	96.7
▲	BROWN WEATHERED BASALT (ML) Boring 13 at 31.9'	43	30	13	----
■	RED CLAYSTONE (CL-ML) Boring 15 at 8.8'	33	23	10	98.8

HARDING ASSOCIATES
SOIL MECHANICS ENGINEERS

PLASTICITY CHART

PLATE A-3

269

Harding Lawson Associates

• ENG. FILE COPY

A Report Prepared for

Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, California

FOUNDATION INVESTIGATION
BUILDING 26 ADDITION
LAWRENCE BERKELEY LABORATORY
BERKELEY, CALIFORNIA

HLA Job No. 2000,222.02

by

Beng Hwee Koh
Engineer

Lyle E. Lewis
Geotechnical Engineer

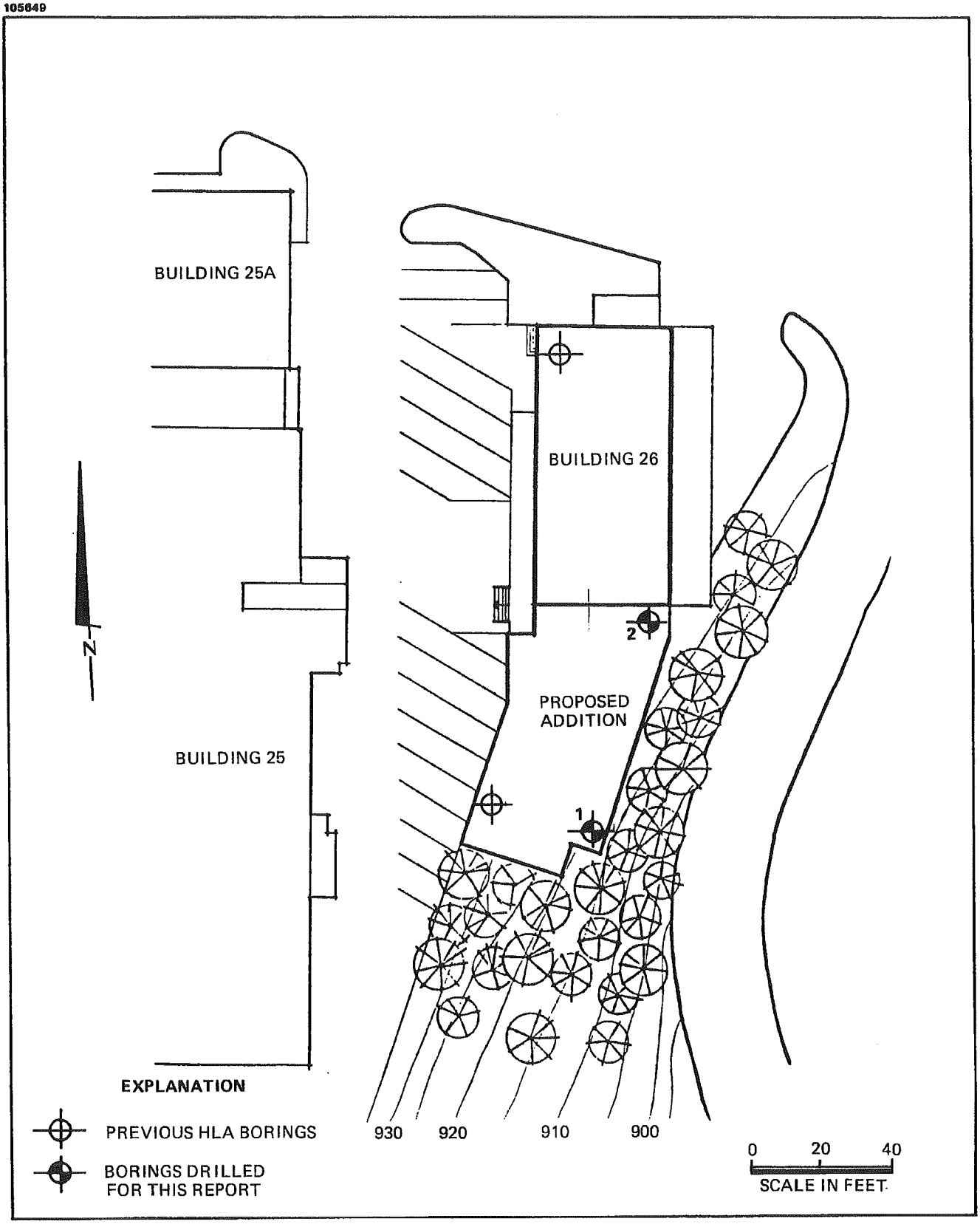
REGISTERED PROFESSIONAL ENGINEER
LYLE E. LEWIS
GE523
Exp. 06/30/89
GEOTECHNICAL
STATE OF CALIFORNIA

Harding Lawson Associates
7655 Redwood Boulevard, P.O. Box 578
Novato, California 94948
415/892-0821

October 31, 1988

UNIVERSITY OF CALIFORNIA
LAWRENCE BERKELEY LABORATORY
NOV 4 19
UNIVERSITY OF CALIFORNIA
LAWRENCE BERKELEY LABORATORY
NOV 4 1988
PLANT ENGINEERING

105649



Harding Lawson Associates
Engineers and Geoscientists

Site Plan
Building 26 Addition
Lawrence Berkeley Laboratory
Berkeley, California

PLATE
1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
CSN	2000,222.02	KBH	10/88		

269_00015

Equipment Minute Man Portable

Elevation ~920' Date 10/1/88

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Core Recov. % /RQD	Drilling Rate (min/ft)	Depth (ft)	Sample
PI=14 LL=37	21					0	
	21					5	
TxUU 3143(1140)	37	14.3	106			10	
	32/4"	8.8				15	
	32/4.5"					20	
						25	
						30	
						35	
						40	

BROWN CLAYEY SILT WITH SAND AND GRAVEL (ML)
stiff, dry — Fill

RED-BROWN CLAY (CL)
stiff, moist — Colluvium

GRAY ANDESITE — Moraga

RED-BROWN CLAYSTONE
weathered, moist — Orinda

bottom of hole at 29.0'
no free water encountered

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

Log of Boring 1
Building 26 Addition
Lawrence Berkeley Laboratory
Berkeley, California

PLATE 2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
CSN	2000,222.02	KBH	10/88		

Equipment Minute Man Portable

Elevation ~923' Date 10/1/88

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Core Recov. %/RQD	Drilling Rate (min/ft)	Depth (ft)	Sample
	18	10.6				0	
	23					5	
	32/4"						
						10	
	40					15	
TxUU 1376(2580)	14	22.9	99			20	
TxUU 4199(3420)	58	18.2	110			25	
						30	
						35	
						40	

BROWN CLAYEY SILT WITH SAND AND GRAVEL (ML)
stiff, dry

RED-BROWN CLAY (CL)
stiff, moist

GRAY ANDESITE

MOTTLED RED-BROWN CLAYSTONE
weathered, moist

RED-BROWN CLAYSTONE
weathered, moist

bottom of hole at 22.5'
no free water encountered

Fill

Colluvium

Moraga

Orinda

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

Log of Boring 2
Building 26 Addition
Lawrence Berkeley Laboratory
Berkeley, California

PLATE 3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
CSN	2000,222.02	KBH	10/88		

6196

MAJOR DIVISIONS					TYPICAL NAMES
COARSE–GRAINED SOILS MORE THAN HALF IS COARSER THAN NO. 200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN No 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW		WELL GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
			GP		POORLY GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM		SILTY GRAVELS, SILTY GRAVELS WITH SAND
			GC		CLAYEY GRAVELS, CLAYEY GRAVELS WITH SAND
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW		WELL GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
			SP		POORLY GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM		SILTY SANDS WITH OR WITHOUT GRAVEL
			SC		CLAYEY SANDS WITH OR WITHOUT GRAVEL
FINE–GRAINED SOILS MORE THAN HALF IS FINER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50% OR LESS		ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTS WITH SANDS AND GRAVELS
			CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, CLAYS WITH SANDS AND GRAVELS, LEAN CLAYS
			OL		ORGANIC SILTS OR CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH		INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS, FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH		ORGANIC SILTS OR CLAYS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS

UNIFIED SOIL CLASSIFICATION – ASTM D2487-85

Perm — Permeability
Consol — Consolidation
LL — Liquid Limit (%)
PI — Plastic Index (%)
G_s — Specific Gravity
MA — Particle Size Analysis
■ — "Undisturbed" Sample
☒ — Bulk or Classification Sample

Shear Strength (psf)	Confining Pressure		
TxUU (FM) or (S)	3200	(2600)	— Unconsolidated Undrained Triaxial Shear (field moisture or saturated)
TxCU (P)	3200	(2600)	— Consolidated Undrained Triaxial Shear (with or without pore pressure measurement)
TxCD	3200	(2600)	— Consolidated Drained Triaxial Shear
SSCU (P)	3200	(2600)	— Simple Shear Consolidated Undrained (with or without pore pressure measurement)
SSCD	3200	(2600)	— Simple Shear Consolidated Drained
DSCD	2700	(2000)	— Consolidated Drained Direct Shear
UC	470		— Unconfined Compression
LVS	700		— Laboratory Vane Shear

KEY TO TEST DATA

Harding Lawson Associates
Engineers and Geoscientists

Soil Classification Chart and Key to Test Data
Building 26 Addition
Lawrence Berkeley Lbaoratory
Berkeley, California

4

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
MAG	2000,222.02	KBH	10/88		

269_00018

I CONSOLIDATION OF SEDIMENTARY ROCKS; usually determined from unweathered samples. Largely dependent on cementation.

U = unconsolidated
P = poorly consolidated
M = moderately consolidated
W = well consolidated

II BEDDING OF SEDIMENTARY ROCKS

Splitting Property	Thickness	Stratification
Massive	Greater than 4.0 ft.	very thick bedded
Blocky	2.0 to 4.0 ft.	thick-bedded
Slabby	0.2 to 2.0 ft.	thin-bedded
Flaggy	0.05 to 0.2 ft.	very thin-bedded
Shaly or platy	0.01 to 0.05 ft.	laminated
Papery	less than 0.01 ft.	thinly laminated

III FRACTURING

Intensity	Size of Pieces in Feet
Very little fractured	Greater than 4.0
Occasionally fractured	1.0 to 4.0
Moderately fractured	0.5 to 1.0
Closely fractured	0.1 to 0.5
Intensely fractured	0.05 to 0.1
Crushed	Less than 0.05

IV HARDNESS

1. **Soft** — Reserved for plastic material alone
2. **Low hardness** — can be gouged deeply or carved easily with a knife blade
3. **Moderately hard** — can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and is readily visible after the powder has been blown away.
4. **Hard** — can be scratched with difficulty; scratch produces little powder and is often faintly visible.
5. **Very hard** — cannot be scratched with knife blade; leaves a metallic streak.

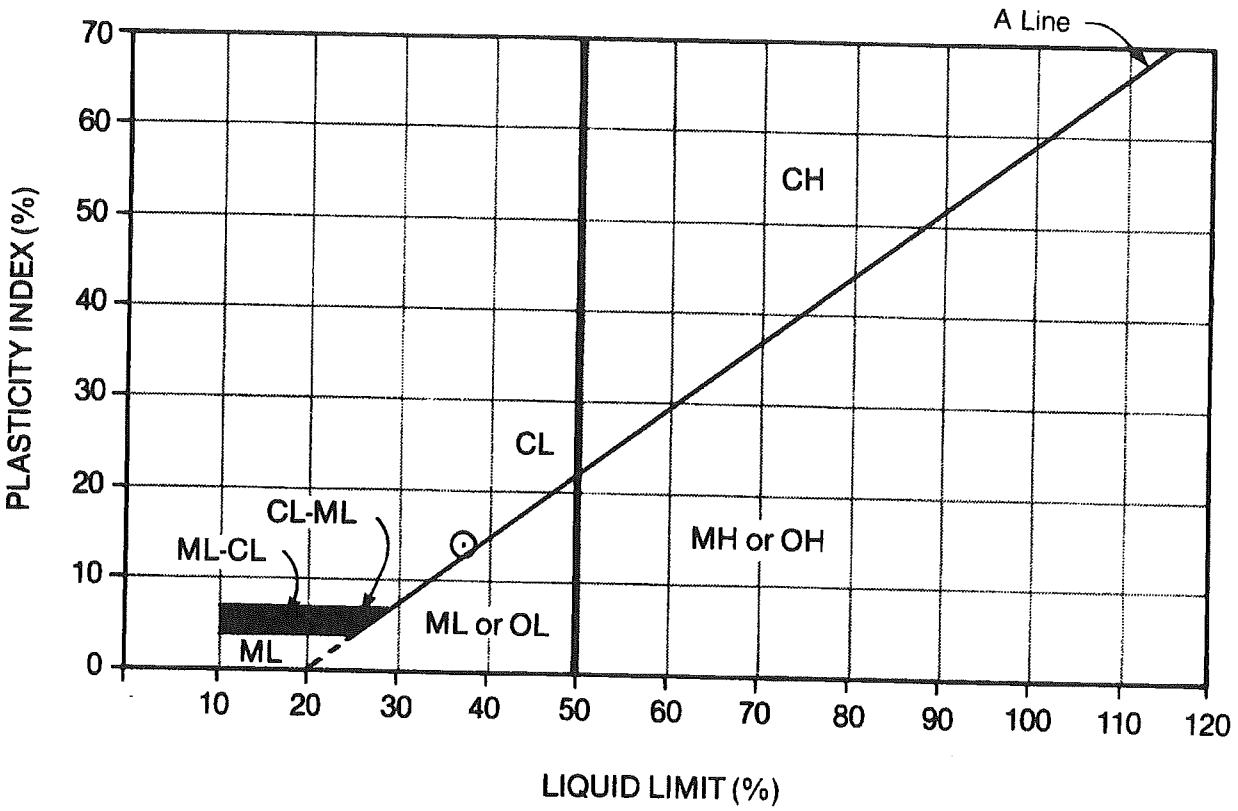
V STRENGTH

1. **Plastic** or very low strength
2. **Friable** — crumbles easily by rubbing with fingers
3. **Weak** — An unfractured specimen of such material will crumble under light hammer blows.
4. **Moderately strong** — Specimen will withstand a few heavy hammer blows before breaking.
5. **Strong** — Specimen will withstand a few heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.
6. **Very strong** — Specimen will resist heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.

VI WEATHERING — The physical and chemical disintigration and decomposition of rocks and minerals by natural processes such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing.

D. **Deep** — Moderate to complete mineral decomposition; extensive disintegration; deep and thorough discoloration; many fractures, all extensively coated or filled with oxides, carbonates and/or clay or silt.
M. **Moderate** — Slight change or partial decomposition of minerals; little disintegration; cementation little to unaffected. Moderate to occasionally intense discoloration. Moderately coated fractures.
L. **Little** — No megascopic decomposition of minerals; little or no effect on normal cementation. Slight and intermittent, or localized discoloration. Few stains on fracture surfaces.
F. **Fresh** — Unaffected by weathering agents. No disintegration or discoloration. Fractures usually less numerous than joints.

Reference: ASTM D 423, 424



Symbol	Source	Classification	Natural M.C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
⊙	Boring 1 at 2.5'	BROWN CLAYEY SILT WITH SAND AND GRAVEL (ML)		37	14	

HLA **Harding Lawson Associates**
Engineers, Geologists & Geophysicists

Plasticity Chart
Building 26 Addition
Lawrence Berkeley Laboratory
Berkeley, California

PLATE **9**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
CSN	2000,222.02	KBH	10/88		

269_00023

APPENDIX C

Logs of Previous Environmental Borings by LBNL

FUGRO WILLIAM LETTIS & ASSOCIATES, INC.

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December 10, 2009

Wayne Magnusen
Alan Kropp & Associates
2140 Shattuck Avenue, Suite 910
Berkeley, CA 94704

RE: DRAFT LBNL Building 25 – Core Review for the General Purpose Laboratory Geotechnical Study

Dear Mr. Magnusen,

This letter presents Fugro William Lettis & Associates, Inc.'s (FWLA) review and evaluation of boring logs and archived soil samples to support Alan Kropp & Associates' (AKA) design-level geotechnical study for the proposed General Purpose Laboratory (GPL) project at the Lawrence Berkeley National Laboratory (LBNL). The scope of this work was developed through multiple conversations with you and is summarized in the AKA proposal submitted to Mr. Richard Stanton dated October 27, 2009.

Proposed GPL site Geology

The proposed GPL site will be located at the site currently occupied by LBNL Building 25 within the "Old Town" area of LBNL, which includes some of the earliest buildings constructed at the LBNL. Although the natural topography in the vicinity of the proposed GPL footprint has been extensively modified by grading, it is apparent that Building 25 is situated atop a roughly north-south trending ridgeline that extends down into Strawberry Canyon (Figure 1). The general area of Building 25 has been graded to an approximately level pad near Elevation +940 feet (LBNL datum); the nose of the ridgeline intersects the floor of Strawberry Canyon at about 500 feet below the level of the building pad.

Regional geologic mapping (Graymer, 2000), recent subsurface investigations, and mapping performed in the general area of Building 25 (WLA, 2009) shows the ridgelines and ridgeline

margins include thin colluvium overlying volcanic rocks of the Moraga Formation and sedimentary rocks of the Orinda Formation (See Figure 2 and Plate 1 from WLA, 2009). In addition, a "mixed unit" comprised of both Moraga and Orinda affinity has been interpreted through geologic borings, trenches, and geologic mapping (Parsons, 2000; WLA, 2009). Trenches excavated as part of a "paleolandslide" study for Building 25 characterizes the inferred Tertiary mixed unit as a series of dark reddish brown silty clays and reddish brown gravels. These deposits may have formed closely in time with the initiation of Moraga volcanism near the alluvial depocenter. These previous observations (detailed in trench logs and photographs) significantly aided the re-interpretation of core from the RCRA report (Table1).

Scope of Work

Our scope of work included a review and evaluation of the existing relevant and archived geologic borings near the proposed GPL foot print. The primary objective of the review was to evaluate: 1) the quality of previous boring logs; 2) identify the depth to bedrock; and 3) provide a general characterization of any overlying soils that may be present near the GPL footprint. To accomplish these tasks we compiled existing borehole logs from previous consulting reports (HLA 1963; 1988), LBNL's RCRA facility Investigation (RFI) report (Parsons, 2000), and compared these logs with FWLA's and AKA's previous boring and trench logs (AKA, 2009; WLA, 2009).

On November 30, 2009, Preston Jordan (LBNL) provided FWLA staff (Mr. Baldwin and Mr. Givler) access to the core library at LBNL. On December 1, 2009 David Baskin (LBNL) provided PDF copies of logs described in the RCRA report that cover the proposed development area of the GPL. After compiling these borehole data, FWLA staff reviewed pertinent samples from the LBNL core library on December 2 and 3, 2009. FWLA staff made hand-written notes to the existing boring logs as a means to evaluate the quality of previous soil and rock descriptions, and to place these original observations in context with the current geologic model of the GPL site vicinity. Edited boring logs are provided as Appendix A.

A list of the RCRA borings located in the general GPL site vicinity is provided in Table 1. In total, FWLA Staff reviewed 29 individual samples from 12 borings drilling between 1992 and 1999 (Table 1). The samples available for review included the tips of brass rings, or where possible

the extruded sample. In some instances, samples appeared to be missing (possibly submitted for environmental testing) or these samples were not readily found by FWLA in the core library. According to LBNL staff, logs for soil borings SB25-95-1 through SB25A-95-1 are not available. However, Preston Jordan (LBNL) provided a table of field notes compiled during the drilling of these soil borings (Table 2).

Results of Core Review

Overall, the quality of the previous boring logs was generally high. Of the samples reviewed, FWLA's observations generally matched the original lithologic descriptions noted on the logs. In most instances, evaluating physical properties (e.g. stiffness and plasticity) is difficult to impossible because the samples are on the order of 10 to 15 years old and thus, the original moisture content is unknown. In a few instances, FWLA staff disagreed with the textural descriptions provided on the original logs (e.g. silty clay vs. clayey silt), but overall these differences were minor. We should note that some key samples were not located in the core library (borings W25-95-26) and thus, we are unable to evaluate the quality of these boring logs. See Table 1 for more details.

The colluvium overlying the Tertiary bedrock units consists primarily of a clayey SILT with coarse-grained sand, and angular clasts of Orinda and Moraga Formations (See boring log MW2593-15; Appendix A).The thickness of colluvium (or the depth to bedrock) across the GPL footprint is variable and ranges from zero to 16 ft thick. The compiled boring information suggests that colluvium is thin (0-2 ft) along the northern margin of the proposed GPL footprint and increases up to 16 ft thick near the southern third of the footprint. The colluvium abruptly thins (0 to 2 ft thick) directly south of the proposed footprint. Borehole and trench suggest that colluvium coincides with an east-trending buried topographic swale that extends east from WLA trench T-1 to boring MW25-95-26 (See Plate 1 of WLA, 2009).

Closing

We appreciate the opportunity to assist AKA in characterizing the subsurface conditions at the proposal GPL site at LBNL. Please feel free to call (925-256-6070), or email (givler@lettis.com or baldwin@lettis.com) if you have any questions or comments about this letter.

Sincerely,

FUGRO William Lettis & Associates, Inc.

Robert W. Givler, C.E.G. #2533

Senior Geologist

John Baldwin, C.E.G. # 2167

Principal Geologist

REFERENCES

Alan Kropp & Associates, 2009, Slide Investigation Building 25 Area Project (LBNL Subcontract No 6881630), unpublished consulting memorandum with 3 pages and 3 figures; no LBNL file number.

Graymer, R.W., 2000, Geologic map and map database of the Oakland metropolitan area, Alameda, Contra Costa, and San Francisco Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2342, U.S. Geological Survey, Menlo Park, CA, scale 1:50,000.

Harding-Lawson Associates (HLA), 1964, "Report: Consultation Regarding Foundations Building 62, Lawrence Radiation Laboratory, Berkeley, California," March 1964, Project No. 2000.170.

Harding-Lawson Associates (HLA), 1988, "Foundation Investigation Building 26 Addition, Lawrence Berkeley Laboratory, Berkeley, California," October 31, 1981; LBNL # 269.

Parsons Engineering Science, Inc., 2000, "draft final RCRA Facility Investigation Report for the Lawrence Berkeley National Laboratory Environmental Restoration Program" Prepared for Lawrence Berkeley National Laboratory, dated September 29, 2000.

William Lettis & Associates, Inc. (WLA), 2009, Paleolandslide Investigation Building 25, Lawrence Berkeley National Laboratory Berkeley California,: unpublished consulting report to Lawrence Berkeley National Laboratory, dated August 31, 2009, 41 p. plus figures, plates, and appendices.

Table 1. List of borings surrouding the proposed GPL Footprint

ERP boring	UC East	UC North	Coordinate Source	Logs Available	WLA GIS ID	Ground Elevation (ft)	Elevation Source	Samples Logged by WLA	Intervals Logged
MW26-92-11	3173.89	160.07	?	Yes	451			Yes	8.5-9.0 ft.
MW25-93-15	3057.62	-46.77	survey	Yes	450	936	survey	Yes	3.1-3.6, 8.0-8.3, 23.5-23.8 ft
MW25-94-12	3021.73	24.6	survey	Yes	424	937.93	survey	Yes	4.0-4.2, 9.0-9.5, 14.0-14.2 ft
MW25A-95-4	3033.97	219.82	survey	Yes		938.67	survey	No	
MW25-95-5	3091.6	-154.47	survey	Yes	428	933.24	survey	Yes	3.0-3.1, 93.5-94.0 ft
MW25A-95-15	2960.59	148.22	survey	Yes	427	932.14	survey	No	
MW25-95-26	3139.2	-54.01	survey	Yes	426	936.17	survey	NA*	Could not find samples
MW25-95-27	3045.68	-327.09	?	Yes				No	Could not find samples
SB25-95-1	3065	-31	approximate tape and compass	NA*		937	contour map interpolation	NA*	
SB25-95-2	3131	106	approximate tape and compass	NA*		941	contour map interpolation	NA*	
SB25-95-3	3145	130	approximate tape and compass	NA*		940	contour map interpolation	NA*	
SB25-95-4	3072	-96	tape and compass	NA*		935	contour map interpolation	NA*	
SB25-95-5	3045	-62	tape and compass	NA*		934	contour map interpolation	NA*	
SB25A-95-1	2963	141	tape and compass	NA*				NA*	
SB25A-96-1	2949	127.86	survey	Yes	423	932.55		NA*	
SB25A-96-2	2986.96	99.96	survey	Yes	424?	937.29		Yes	1.5-2.0 ft only sample
SB25A-96-3	3036	107	tape and compass	Yes	421	939	contour map interpolation	Yes	5.5-6.0, 15.2-15.7 ft
MW25A-98-1	2986.86	99.79	survey	Yes	449			Yes	3.0-4.0, 8.7-9.2, 19.0-19.5 ft.
MW25A-98-3	3027.87	175.76	survey	Yes	433			No	Could not find samples
MW25A-98-6	3091.47	134.29	survey	Yes	448			Yes	4.0-4.5, 10.5-11.0, 40.8-41.3 ft
MW25A-98-7	3001.67	140.51	survey	Yes				Yes	15.6-16.1, 20.3-20.8, 30.6-31.1 ft
MW25-98-10	3087.97	-105.23	survey	Yes	425			Yes	20.2-20.7 ft - only sample
MW25A-99-2	3037.07	137.7	survey	Yes				Yes	5.5-6.0, 10.5-11.0 ft
MW25A-99-5	3062.06	166.42	survey	Yes	434			Yes	5.5-6.0, 7.6-8.1, 13.9-14.4, 23.5-24.0, 33.9-44.4 ft
MW25A-00-5	2965.28	139.64	survey	Yes	422			No	
SB25A-02-1	3080.73	217.66	?	Yes				No	

*NA - Boring logs were not available and samples were not logged or not available.

Table 2. List of Building 25 soil boring data where logs are unavailable.

Boring	Logged by	Field notes?	Date drilled	UC East	UC North	Coordinate Source	Datum	Ground surface elevation	Ground surface elevation comment	Qaf thick.	Depth to Qc top	Elev. of Qc top	Qc thick.	Depth to Moraga material	Elev. of Moraga material top	Moraga material thick.	Depth to Mixed Unit top	Elev. of Mixed Unit top	Mixed Unit thickness	Depth to Orinda material	Elev. of Orinda material top	BOH depth	BOH elev.
SB25-95-1	pdj	yes	21-Apr-95	3065	-31	approximate tape and compass	UC	937	contour map	1	1	936	7	8	929							16	921
SB25-95-2	pdj	yes	21-Apr-95	3131	106	approximate tape and compass	UC	941	contour map	1	1	940	0	1	940							10	931
SB25-95-3	pdj	no	19-Apr-95	3145	130	approximate tape and compass	UC	940	contour map	0	0	940	0	0	940	35	35	905	1	36	904	37	903
SB25-95-4	pdj	no	19-Apr-95	3072	-96	tape and compass	UC	935	contour map	1	1	934	2	3	932							13	922
SB25-95-5	pdj	yes	21-Apr-95	3045	-62	tape and compass	UC	934	contour map	1	1	933	8	9	925							13	921
SB25-95-6	sf	yes	19-Dec-95	3027	-290	tape and compass	UC	862	contour map	1	1	861	7							8	854	13	849
SB25A-95-1	pdj	no	19-Apr-95	2963	141	tape and compass	UC	933	contour map	0	0	933	2							2	931	46	887

*Table provided by P. Jordon via email December 2, 2009.

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW 25-93-15	**935.4 ft**	**Preston Holland**	**11/3-11/93**	**1/2**

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
≈ 60 ft	**Westex**	**8" hollow-stem auger**	**Mobile B61**

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	PID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
CONCRETE						Traffic-grade cover w/locking well cap	
CLAY (CL), dark brown; stiff; includes occasional sandy clay lenses; sand of deeply weathered andesitic breccia; moist (FILL)							
• at 6 ft: grades to black, foul organic odor		5		24			
SANDY CLAY (CH), dark brown; stiff; sand is medium to coarse grained; subrounded to angular; consisting primarily of tuff and andesite, minor basalt; moist		10		31			
VOLCANIC BRECCIA, brown; intensely fractured to crushed; plastic; soft; deeply weathered; includes moderately strong, hard fragments, occasionally basaltic; fracture fill of sandy clay; moist		15		73		Cement grout seal	
• at 20 ft: change to red-brown		20		45/6"			
• at 23 ft: grey, purple, red-brown, and dark brown imbricated zones bounded by slickensides dipping 40° to 45°. Grey and purple layers contain fragments of siltstone.		25		45/4"			
• at 28 ft: grey, friable; low hardness; secondary mineralization in voids		30		45/3"			
• 31-34 ft: orange brown ?bake zone		35		45/1"		2" PVC solid casing Sch. 40, 10' sections, O-ring seals	
AGGLOMERATE BRECCIA, dark grey; intensely to closely fractured; friable to moderately strong; moderately hard to hard; moderately weathered; mostly basaltic; subrounded fine gravel; calcite cement; siliceous veining up to 3/16" thick; moist		40		90/3"			
ANDESITE, brown; crushed to intensely fractured; friable to moderately strong; low hardness to hard; moderately weathered; minor siliceous vein fillings; black phenocrysts; moist		45		45/3"			
		50		45/3"			

LAWRENCE BERKELEY LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 6/14/94	BORING # **MW 25-93-15**

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW 25-93-15	935.4 ft	Preston Holland	11/3-11/93	2/2

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
≈ 60 ft	Westex	8" hollow-stem auger	Mobile B61

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	PID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
ANDESITE, cont.				45/3"		Bentonite pellets seal	
		55					
				45/3"		No. 2/12 sand filter pack	
• wet below 60 ft		60					
				45/4"			
		65				Machine-slotted PVC well screen, slot size 0.010"	
SILTY CLAY (CL), red orange brown and purplish brown, soft to medium stiff; saturated							
SILTY SANDSTONE, blue-grey; closely fractured, plastic; soft; little weathered; saturated				67			
		70					
SILTY CLAYSTONE, red-brown; closely fractured; friable to weak; low hardness; little weathered; wet to saturated				63/6"			
		75				Silt trap	
Total drilled depth = 75.5 ft							
		80					
		85					
		90					
		95					
		100					

LAWRENCE BERKELEY LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 6/14/94	BORING # MW 25-93-15

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW 25-94-12	≈ 938 feet	Preston Holland	10/12-14/94	1/2

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
not encountered	Western Strata Exploration	8" hollow-stem auger	Mobile B-61

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Standard Penetration Resistance (Blows/ft)	ambient PID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
CONCRETE						Traffic-grade cover w/locking well cap	
SILTY CLAY (CH), dark brown; stiff; damp.							
SILTSTONE, dark orange brown, less than closely fractured; friable to weak; little to moderate hardness; moderately to little weathered; minor well rounded coarse sand; damp.		5		41		Cement grout seal	
				51/3"		2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
		10					
SILTY CONGLOMERATE, brown; less than closely fractured; weak; moderately hard; moderately weathered; rounded to well rounded fine to medium gravel includes a high proportion of andesitic and basaltic fragments; numerous purple brown and dark orange, thinly bedded, subhorizontal siltstone layers; damp.		15		47/11		Bentonite pellets seal	
						Collapse	
				40/8"			
BASALT, dark gray; closely to intensely fractured; moderately strong; hard; moderately to little weathered; damp.		20					
		25		33			
ANDESITE, light gray; closely fractured; strong; hard; moderately to little weathered; vesicular; some vesicles are filled with iron oxides; damp.				39/9"			
		30				No. 2/12 sand filter pack	
• at 34 ft: light green gray; crushed; orange brown clay fracture fillings; wet				32/6"		Machine-slotted PVC well screen, slot size 0.010"	
		35					
SANDY SILTSTONE AND CLAYEY SILTSTONE, blue gray and red brown; less than closely fractured; plastic; soft; little weathered; saturated to wet.		40		26			
		45		33		Silt trap	
						Bentonite pellets seal	
		50		43/10"		Bentonite chips seal	
SANDSTONE, cont. on next page							

all samples taken with 2 inch internal diameter split spoon sampler

LAWRENCE BERKELEY LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 1/9/95	BORING # MW 25-94-12

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW 25-94-12	≈ 938 feet	Preston Holland	10/12-14/94	2/2

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
≈ 52.7 feet	Western Strata Exploration	8" hollow-stem auger	Mobile B-61

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	ambient PID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
SILTY SANDSTONE, blue gray; less than closely fractured; friable; little hardness; little weathered; wet.		55		37/11"			
• becoming weak; moderately hard; inclusive of occassional gravelly layers; damp with depth.		60		37		Bentonite chips seal	
		65		56/6"			
SILTSTONE, bluish gray; less than closely fractured; weak; moderately hard; little weathered; moist. • at 72 ft: color changes to red brown; includes minor round, coarse grained sand.		70		35/7"			
Total drilled depth = 74 ft		75		51/9"			
		80					
		85					
		90					
		95					
		100					

LAWRENCE BERKELEY LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 1/9/95	BORING # MW 25-94-12

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW25-95-5		**Steve Flexser/ Preston Holland**	**8/21-24/95**	**1/2**
DEPTH TO GROUNDWATER: **~76.5'**	DRILLING CONTRACTOR: **Western Strata Exploration**	BORING EQUIPMENT: **6.5" air rotary thru 10" HS auger**		DRILL RIG: **B-61**

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Standard Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
ASPHALT GRAVEL (GP) - base rock					0.0	Traffic-grade well cover with locking cap	
ANDESITE, brown and light green, intensely fractured, weak to moderately strong, moderately hard, moderately to deeply weathered, moist, black vug fillings		5		53/9" 39/6"			
• brown, with quartz phenocrysts and veins below 8'		10		56/5"	0.0		
		15		56/5"			
		20		45/6"		Cement grout seal	
• brown-gray with light green zones, moderately strong, hard, moderately weathered, moist to wet below 22'		25		56/6"	0.2		
		30		107/11"		2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
• gray, strong, hard, little weathered, slower drilling below 33.5'		35					
		40		56/0"			
		45			0.0		
		50					

all samples taken with 2 inch internal diameter split spoon sampler

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # **Site Restoration Project**	DATE: **9/14/95**	BORING # **MW25-95-5**

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW25-95-5		Steve Flexser/ Preston Holland	8/21-24/95	2/2

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
~76.5'	Western Strata Exploration	6.5" air rotary thru 10" HS auger	B-61

DESCRIPTION AND CLASSIFICATION							
DESCRIPTION AND REMARKS	SOIL TYPE	DEPTH (FEET)	SAMPLE	Standard Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
• gravel in cuttings and slough at ~53' continue as gray to gray-green andesite, strong, hard, little weathered, with black clay vug fillings, and reddish tint to some phenocrysts		55		28/0"	0.0	Cement grout seal	
		60		28/0"		Bentonite pellets	
		65					
		70				No. 2/12 sand filter pack	
		75		⊠ 8/24			
		80			0.0	Machine-slotted PVC well screen, slot size 0.010"	
		85					
SILTY CLAYSTONE, gray and red-brown, largely crushed, weak to friable, little hardness, little weathered, moist; sheared, with small slickensided surfaces		90					
• with minor subangular gray fine-grained andesite gravel at ~93.5', and fine subhorizontal gray-and-red bedding lamination		95		68/9"		silt trap	
• gray siltstone with fine sand at ~98', damp to moist, with similar lamination				60/8"		slough	
TOTAL DRILLED DEPTH = 98.6 ft		100					

all samples taken with 2 inch internal diameter split spoon sampler

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 9/14/95	BORING # MW25-95-5

BORING #	SURF ELEV:	UC EAST:	UC NORTH:	LOGGED BY:	DATE DRILLED:	PAGE:
MW25-95-26	**936 feet**	**3139 feet**	**-54 feet**	**E. Rosenberg (Parsons) Preston Jordan**	**4/29/96**	**1/2**

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
	Westex	**7" air rotary**	

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
ASPHALT CLAY (CH), black with orange brown laminae and mottles, very stiff, moist, minor medium grained sand.		5 10	36			Locking well cap Cement grout seal	
ANDESITE, light greenish brown, intensely fractured, friable to weak, moderately hard, deeply weathered, vesicular, black phenocrysts or vug fillings.		15 20	30			2" PVC solid casing Sch. 40, 10' sections, O-ring seals	
		25 30	75/6"				
SILTSTONE, reddish brown with dark bluish gray mottles, fracture?, friable to plastic, low hardness to soft, moderately weathered, minor coarse sand of andesite and sandstone.		35 40	50/3"			Bentonite pellets seal No. 2/12 sand filter pack	
SANDSTONE, greenish gray with purplish gray and reddish brown mottling, weak subhorizontal lamination, crushed to intensely fractured, friable to weak, low hardness, moderately to little weathered, wet.		45				Machine-slotted PVC well screen, slot size 0.020"	
SILTSTONE, greenish gray with red brown laminae, crushed, friable to weak, little hardness, little weathered, wet, sheared, minor fine sand.		50	60				

all samples taken with 2 inch internal diameter split spoon sampler

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # **Site Restoration Project**	DATE: **4/29/96**	BORING # **MW25-95-26**

BORING #	SURF ELEV:	UC EAST:	UC NORTH:	LOGGED BY:	DATE DRILLED:	PAGE:
MW25-95-26	936 feet	3139 feet	-54 feet	E. Rosenberg	4/29/96	1/2

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
	Westex	7" air rotary	

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
SILTSTONE continued							
SANDSTONE, bluish gray, intensely fractured, weak to moderately strong, moderately hard, little weathered, wet, minor fine gravel, well cemented.		55		50/1"		Silt trap	
Total Depth = 58 feet		60					
		65					
		70					
		75					
		80					
		85					
		90					
		95					
		100					

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 4/29/96	BORING # MW25-95-26

Form 1.2-1

see air monitoring sheet

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
25-95-26		E. Rosenberg	4/29/96	1/2
DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:	
	Westex	Air Rotary 7'		

DESCRIPTION AND CLASSIFICATION

DESCRIPTION AND REMARKS	SOIL TYPE	DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	PID readings (ppm)	REMARKS	Well Construction
Asphalt 3"							locking well cap at 2 1/4'
silty sand w/ ~~some~~ gravel. red-brown. loose. dry. (FILL)							
(out of hole as) clayey silt and some pieces of rock. silt is brown-red. rock is gray-black, fine-grain, hard.		5					
Rock weathered to clay. reddish-brownish black. very stiff. slightly damp. extremely weathered, no fresh surfaces. clay is slightly plastic.		10	X	15 17 19			
(out of hole as) as above, but no fresh surfaces on fractured rock. rock fragments ~~[illegible]~~ readily crushed		15					grout neat cement w/ < 5% bentonite
(out of hole as) silt yellow-tan. dry. Few rock fragments are readily broken, red-brown on "Fresh" surfaces		20	X	20 12 18			
volcanic rock blackish-greenish-gray on fresh surfaces, some yellow and reddish purple. Extremely fractured and weathered. dry. hard to moderately hard. phenocryst of ~1mm dia		25	O				unslotted sch 40 PVC
volcanic rock as above. ~~[illegible]~~ less weathered, less fractured.		30	X	75 for 6" (2/3 of tube recovered)			
(out of hole as) fractured volcanic rock fragments down to siltly powder, rock is grey-black. powder is greenish-blackish brown		35	O			32 1/2' 36' 38'	3/8" bentonite pellets; #2/12 sand
Volcanic Rock. gray black on fresh surfaces. ~~[illegible]~~ fractured. fine-grain. rock is hard to moderately hard. green-black brown weathering, dry		40	X	50 for 3" (1/2 of one tube recovered)			
(out of hole as) clay + rock. clay is red-brown, damp, plastic. Rock is up to 1/2 cm dia fragments. fine-grain. gray black on fresh surfaces, hard.		45	O				0.02 slotted PVC sch 40
(out of hole ~~[illegible]~~ as above, until collect sample at 48-49 1/2)		50	X				

LAWRENCE BERKELEY LABORATORY

EXPLORATORY BORING LOG

PROJECT #	DATE:	BORING #

X drive distance lab sample O bagged sample out of hole or from shoe.

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW25-95-27		**Preston Holland**	**12/19,20/95**	**1/1**

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
not encountered	**Gregg Drilling**	**6" hollow stem auger, reamed 8.5" hollow stem auger**	**B-61HDX**

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
ASPHALT GRAVEL (GP), base rock						Traffic-grade well cover with locking cap	
SILTY CLAY (CH); dark brown, medium stiff, wet to saturated, minor fine-grained, andesitic gravel (fill). • irregular, horizontal laminae and thin beds of brown and gray siltstone at 5.3 ft • thin bed of orange-red brown silty clay at 10.1 ft		5 10		8 10	0.0 0.0	Cement grout seal 2" PVC solid casing, Sch. 40, O-ring seals	
SANDSTONE; light brown, less than closely fractured, plastic, little hardness, little to moderately weathered, wet, fine-grained, tuffaceous?, contains claystone rip-up clasts. • becoming closely fractured, friable with depth, some fractures have a black coating • occasional beds of red-brown, crushed to intensely fractured claystone • saturated at 23 ft • greenish gray, little weathered below 24 ft		15 20 25		42 20 20	0.0	Bentonite pellets Machine-slotted PVC well screen, slot size 0.010"	
SILTSTONE; bluish gray with occasional reddish brown mottles, intensely fractured, friable, little hardness, little weathered, moist. • red brown with green gray mottles below 31 ft		30 35		34/5" 34	0.0	No. 2/12 sand filter pack silt trap slough	
Total depth = 35.5 feet		40 45 50					

all samples taken with 2 inch internal diameter split spoon sampler

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # **Site Restoration Project**	DATE: **1/9/96**	BORING # **MW25-95-27**

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

SITE:	UC EAST:	UC NORTH:	UC SURF. ELEV:
25-98-10	3089.00	-106.00	935.00'

LOCATION: South of 25

DATE(S) INSTALLED:	BORING DIAMETER:	TOTAL DEPTH:	COMPLETED DEPTH:	REMARKS:
09/11/98 - 09/12/98	5.50in	90.50'	90.30'	Boring drilled to 10 feet with 6.5 inch diameter ODEX system.

DRILLING METHOD: A400 with air rotary percussion hammer

LOGGED BY: PDJ

DRILLING CONTRACTOR: Western Strata Exp

CONSULTING FIRM: LBNL-ERP

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	MP. EL. 934.42	WELL MATERIALS
ASPHALT GRAVEL (GP), base rock (fill). GRAVELLY CLAY (CH), dark brown, stiff, wet, andesitic gravel. ANDESITE, dark brownish gray, crushed, weak to moderately strong, low to moderate hardness, moderately to deeply weathered, wet, black vug fillings.		5 10 15 20 25 30	51 R/4" 37 51 R/3" 27 25 30 51 R/1"		930 920 910		christy box set in concrete cement grout 2" ID, Schedule 40 PVC casing
- grading to gray, intensely to closely fractured, strong, hard, little weathered							

ENVIRONMENTAL RESTORATION PROGRAM

REVIEWED BY:

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25-98-10 3087.97 -105.23 934.70'

South of 25

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY / BLOW COUNT	ELEVATION (ft)	WELL MATERIALS
			51 R/0" 25S		cement grout
		45		890	2" ID, Schedule 40 PVC casing
		50	51 R/0" 25S		
		55		880	medium bentonite chip
		60			
		65		870	1/4" bentonite pellet
					#2/12 sand
		70			0.010" slotted screen
					centralizer
		75		860	

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25-98-10 3087.97 -105.23 934.70'

South of 25

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	WELL MATERIALS
-- water level 79 feet the morning of 9/12/98						#2/12 sand
						centralizer
						0.010" slotted screen
SILTSTONE, red brown, friable, low hardness, little weathered, saturated.		85			850	
						centralizer
SILTY SANDSTONE, blue gray, intensely fractured, friable to weak, low to moderate hardness, little weathered, saturated, fine grained, calcite cemented zones.		90	99	2SS		silt trap
		95			840	
		100				
		105			830	
		110				
					820	

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW25A-95-4		**Preston Holland**	**4/20/95**	**1/1**

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
	Western Strata Exploration	**8" hollow-stem auger**	**B-61**

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	PID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
ASPHALT/ CONCRETE						Traffic-grade well cover with locking cap	
GRAVEL, base rock							
ANDESITE, brownish gray, closely to intensely fractured, weak to moderately strong, moderately hard, moderately weathered, moist, black vug fillings.		5		56/4"			
SILTY PEBBLY SANDSTONE, green gray and redd brown, closely fractured to less than closely fractured, friable, moderate to little hardness, moderately weathered, wet, fine- to medium-grained, rounded to well-rounded gravel.		10		47		Cement grout seal	
					0.0-0.1		
• occasional red brown siltstone layers		15		49		2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
FINE SANDSTONE, bluish gray, less than closely fractured to closely fractured, weak to moderately strong, little to modearte hardness, little weathered, wet to saturated, calcite cementation and veins occur in zones.				54/6"			
• occasional red brown mottling, silty zones.		20					
• harder drilling below 25', more cementation, strong in places.				47		Bentonite pellets seal	
		25			0.0		
				41/10"			
• occasional minor medium sand.		30					
				43		No. 2/12 sand filter pack	
• easy drilling from 34.5-35.5 feet.							
• harder drilling below 35.5 feet.		35					
SANDSTONE, blue gray, intensely to closely fractured, friable to weak, little to moderate hardness, little weathered, saturated, fine to medium grained.				47		Machine-slotted PVC well screen, slot size 0.010"	
		40			0.0		
				43			
		45					
•Claystone laminae sheared in along ~40° dipping planes at 49.5 feet.				38		Silt trap	
Total drilled depth = 48.0 ft		50					

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # **Site Restoration Project**	DATE: **7/17/95**	BORING # **MW25A-95-4**

BORING #	SURFACE ELEVATION:	LOGGED BY:	DATE DRILLED:	PAGE:
MW 25A-95-15		**Steve Flexser**	**8/3, 30/95**	**1/1**
DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR: **Western Strata Exploration**	BORING EQUIPMENT: **8" hollow-stem auger**	DRILL RIG: **B-61**	

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
CONCRETE						Traffic-grade well cover with locking cap	
SILTY CLAY (CL), dark brown, stiff, damp to moist, with blebs of gray-green fine sandy silt (fill?)		5		15			
					0.0	Cement grout seal	
SILTSTONE with fine sand, light gray-green, closely fractured, weak, little hardness, dry to damp?, moderately weathered; with brown subvertical banding		10		16		2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
• becomes red-brown at 15-16', with minor charcoal blebs (dry?)		15		44/11"			
					0.0	Bentonite pellets seal	
SANDSTONE, fine-grained, silty, light gray-green, closely fractured or less, weak, little hardness, little weathered		20		28/6"		No. 2/12 sand filter pack	
SILTSTONE with fine sand, red-brown, closely fractured or less, weak, little hardness, little weathered, dry to damp		25		29			
• subvertical fracture 1-5 mm wide, with coarse calcite filling, at ~25'							
• easier drilling at ~28'		30		28/6"			
• with rounded coarse gray sand and mica flakes at 30'							
• harder drilling at 33'					0.0	Machine-slotted PVC well screen, slot size 0.010"	
• easier drilling at 37.5'; harder below 38.5'		35		47/8"			
					0.0		
• saturated, and easier drilling, below ~40'		40		28/6"			
		45		28/5"		silt trap bentonite chip	
						slough	
TOTAL DRILLED DEPTH = 50.5		50		28/6"			

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # **Site Restoration Project**	DATE: **9/15/95**	BORING # **MW 25A-95-15**

BORING #	SURF ELEV:	UC EAST:	UC NORTH:	LOGGED BY:	DATE DRILLED:	PAGE:
SB25A-96-1	feet	feet	feet	Preston Holland	7/22,31/96	1/1

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
not equlibrated	Gregg	6" hollow-stem auger	0'-20':D-7 Simco 20'-40': B-61

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Standard Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
APHALT CLAY (CH), dark brown, stiff, moist to wet, minor coarse, well rounded to rounded sand, well developed peds.		5		no blow counts provided with the hammer arrangement on this drill rig all samples taken with 2 inch ID split spoon sampler		Bentonite chip	
SILTY SANDSTONE, greenish gray, closely fractured, friable to weak, low to moderate hardness, moderately weathered, moist, fine, occasional strong, hard zones (well cemented). • mottled red brown below 12 ft		10 15				2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
SILTSTONE, red brown and gray mottled, closely to intensely fractured, friable to weak, low to moderate hardness, little weathered, moist, calcite veins.		20					
SILTSTONE AND CLAYSTONE, greenish gray and red brown, crushed, friable to weak, low to moderate hardness, little weathered, wet, fine, occasional red brown mottling and red brown sandy siltstone zones.		25		56			
SANDSTONE, green gray, intensely fractured, friable to weak, low to moderate hardness, little weathered, saturated, fine.		30 35		42/10" 39/10"		Machine-slotted PVC well screen, slot size 0.020"	
SANDY SILTSTONE, blue gray with red brown mottling, closely fractured, friable to weak, low to moderate hardness, little weathered, saturated, calcite veins.		40		37		Silt trap Slough	
Total depth = 41.0 feet		45 50					

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 8/5/96	BORING # SB25A-96-1

BORING #	SURF ELEV:	UC EAST:	UC NORTH:	LOGGED BY:	DATE DRILLED:	PAGE:
SB25A-96-2	**feet**	**feet**	**feet**	**Preston Holland**	**7/31/96**	**1/1**

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
not equilibrated	**Gregg**	**6" hollow-stem auger**	**B-61**

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Standard Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
CONCRETE							
SILTY CLAY (CH), brown, stiff, moist, minor medium to coarse, subround to subangular, deeply weathered, andesitic gravel.				24		Bentonite chip	
SILTY SANDSTONE, greenish gray with brown mottling and subhorizontal layering, closely fractured, friable, low hardness, moderately weathered, moist.		5		45/10"			
SANDY SILTSTONE, greenish gray with red brown mottling and zones, closely fractured or less, friable, low hardness, little to moderately weathered, moist, some zones without sand.		10		37			
		15		39		2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
SANDSTONE, gray, closely fractured, weak, moderately hard, moderately weathered, moist, fine to medium.		20		51/11"			
SILTY SANDSTONE, greenish gray with red brown zones, closely to intensely fractured, weak, moderately hard, little weathered, moist, fine.		25		48			
SANDSTONE, bluish gray, closely fractured, weak, moderately hard, little weathered, moist to wet, calcite veins.		30		42/10"			
• becomes silty, closely to intensely fractured, without calcite veins, with occasional red brown sandy siltstone zones with depth		35		51/10"			
• saturated at 35 ft		40		27		Machine-slotted PVC well screen, slot size 0.020"	
						Silt trap	
Total depth = 44.0 feet		45					
		50					

all samples taken with 2" ID split spoon

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # **Site Restoration Project**	DATE: **8/29/96**	BORING # **SB25A-96-2**

BORING #	SURF ELEV:	UC EAST:	UC NORTH:	LOGGED BY:	DATE DRILLED:	PAGE:
SB25A-96-3	feet	feet	feet	Preston Jordan	8/23/96	1/1

DEPTH TO GROUNDWATER:	DRILLING CONTRACTOR:	BORING EQUIPMENT:	DRILL RIG:
not equilibrated	Clear Heart	4" solid-stem auger	RP-89

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	ambient FID readings (ppm)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE						
open concrete swale to ~1.5 feet below boardwalk							
CONCRETE						Bentonite chip	
TUFFACEOUS SILTSTONE, red orange to orangish red brown, crushed, friable, low hardness, little weathered, dry, minor deeply weathered predominantly andesitic and tuffaceous, fine gravel to medium sand occurs in occasional red brown zones, minor carbon-rich laminae, subhorizontal structure.		5		19			
		10		39			
TUFFACEOUS SILTY SANDSTONE, brown to purplish brown, intensely fractured, friable, low to moderate hardness, little weathered, dry, fine, faint structure (bedding?) dipping ~25°. • brownish purple, medium grained interbeds at 20 ft		15		88		2" PVC solid casing, Sch. 40, 10' sections, O-ring seals	
		20		49			
SANDSTONE, greenish gray, intensely to closely fractured, friable to weak, low to moderate hardness, little weathered, wet, fine, minor silt. • blue gray below 25.2 ft		25		81/11"			
• red brown mottled below 30 ft		30		70/6"			
		35		75/5"		Machine-slotted PVC well screen, slot size 0.010"	
• bluish gray, saturated below 37 ft							
		40		77/5"		Silt trap Slough	
Total depth = 40.4 feet		45					
		50					

all samples taken with 2" ID split spoon

LAWRENCE BERKELEY NATIONAL LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 10/10/96	BORING # SB25A-96-3

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

	25A-98-1	2986.86	99.79	934.70'

LOCATION: West of the north end of 25

DRILLING START/END	BOREHOLE DIAMETER	TOTAL DEPTH	COMPLETED WELL DEPTH	REMARKS
04/23/98 - 04/23/98	8.00in	50.00'	50.00'	This well replaced and deepened temporary well SB25A-96-2. Soil samples shown are from SB25A-96-2.

DRILLING METHOD	LOGGED BY
M-11 with hollow stem auger	PDJ

DRILLING CONTRACTOR	CONSULTING FIRM
Gregg	LBNL-ERP

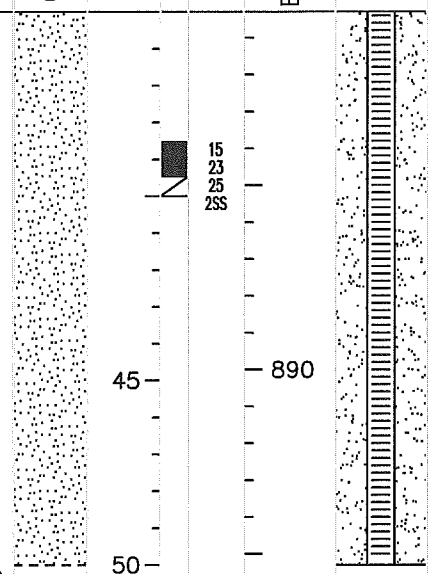
GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY / BLOW COUNT	ELEVATION (ft)	MP.EL. 936.88	WELL MATERIALS
CONCRETE						christy box set in concrete
SILTY CLAY (CH), brown, stiff, moist, minor medium to coarse, subround to subangular, deeply weathered, andesitic gravel.			8 18 24 2SS			
SILTY SANDSTONE, greenish gray with brown mottling and subhorizontal layering, closely fractured, friable, low hardness, moderately weathered, moist.			30 50 R/4" 2SS	930		
SANDY SILTSTONE, greenish gray with red brown mottling and zones, closely fractured or less, friable, low hardness, little to moderately weathered, moist, some zones without sand.		10	15 25 40 2SS			cement grout
		15	12 35 35 2SS	920		2" ID, Schedule 40 PVC casing
SANDSTONE, gray, closely fractured, weak, moderately hard, moderately weathered, moist, fine to medium.			40 50 R/5" 2SS			
SILTY SANDSTONE, greenish gray with red brown zones, closely to intensely fractured, weak, moderately hard, little weathered, moist, fine.		20				
		25	35 50 2SS	910		3/8" bentonite pellets
SANDSTONE, bluish gray, closely fractured, weak, moderately hard, little weathered, moist to wet, calcite veins.		30	25 50 R/4" 2SS			#2/12 sand
- becomes silty, closely to intensely fractured, without calcite veins, with occasional red brown sandy			20 40 50 R/4" 2SS	900		0.010" slotted screen

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

SITE			
25A-98-1	2986.86	99.79	934.70'

LOCATION: West of the north end of 25

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	WELL MATERIALS
siltstone zones with depth – saturated at 35 feet						#2/12 sand
				15 23 25 2SS		0.010" slotted screen
		45			890	
		50				silt trap
		55			880	
		60				
		65			870	
		70				
		75			860	



ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

SITE:	UC EAST:	UC NORTH:	UC SURF. ELEV:
25A-98-3	3027.00	176.00	940.00'

LOCATION: North of the west end of 25A

DATE(S) INSTALLED:	BORING DIAMETER:	TOTAL DEPTH:	COMPLETED DEPTH:
04/30/98 - 04/30/98	8.00in	50.00'	45.00'

DRILLING METHOD: B-61 with hollow stem auger

LOGGED BY: PDJ

DRILLING CONTRACTOR: Gregg

CONSULTING FIRM: LBNL-ERP

REMARKS: This well replaced temporary well SB25A-98-1. Problems were encountered during well construction due to the amount of water and cuttings in the boring. Bentonite chip was used instead of pellets to avoid the risk of bridging.

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	MP. EL. 939.60	WELL MATERIALS
ASPHALT ANDESITE, brown to gray brown, crushed to intensely fractured, moderately strong to strong, hard, moderately weathered, wet, black vug fillings, sandy silt fracture fillings.					940		christy box set in concrete
BASALT, dark gray, intensely fractured to crushed, strong, hard, moderately weathered, wet, flow banded.		5					cement grout
VOLCANICLASTIC SANDSTONE, reddish brown, closely fractured or less, friable, low hardness, little weathered, wet, medium, round, volcaniclastic sand, minor light gray tuff matrix. SILTSTONE, red orange brown with light gray laminae and mottling, crushed, plastic to friable, soft to low hardness, little weathered, wet, laminations dip ~75 degrees.		10			930		
- purplish brown at 12 ft							
GRAVELLY SILTSTONE AND GRAVELLY SANDSTONE, brown and brownish gray, intensely fractured, plastic, soft to low hardness, little weathered, saturated, thinly bedded, beds dip ~30 degrees, gravel consists of cemented siltstone. SILTSTONE, brown, crushed, plastic, low hardness, little weathered, wet to saturated, occasional thin beds of blue gray silty sandstone, occasionally strong, hard, calcite cemented and veined zones, occasional shear		15					2" ID, Schedule 40 PVC casing

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

25A-98-3 3027.87 175.76 940.52'

North of the west end of 25A

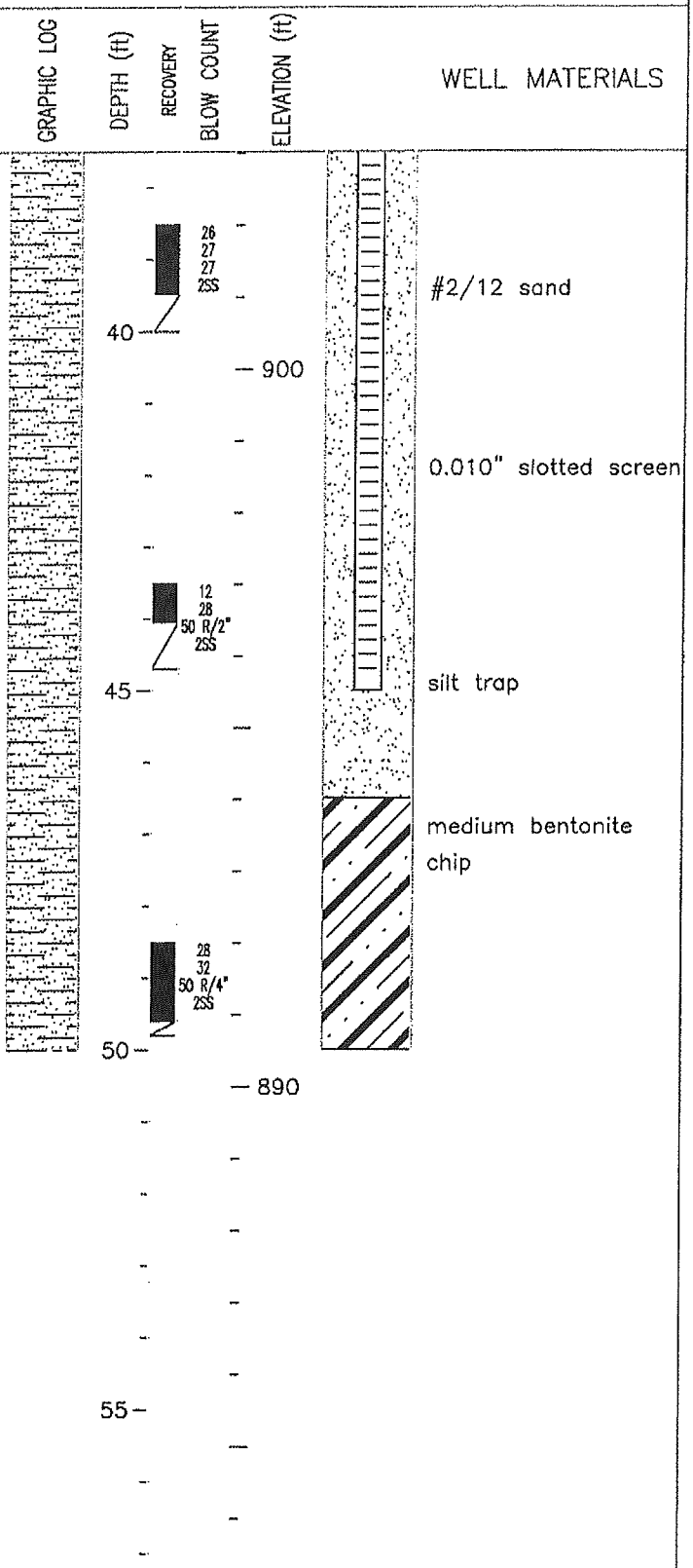
GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	WELL MATERIALS
zones which dip ~40 degrees.						
SILTY SANDSTONE, bluish gray, closely fractured, friable, low hardness, little weathered, saturated, fine grained.		20			920	medium bentonite chip
SANDSTONE, brown, closely fractured or less, soft, plastic, moderately to deeply weathered, saturated, sand medium to coarse grained, subround to round, coarse sand includes lithics, metawacke, medium grained sandstone, and red chert.				50 R/2" 2SS		slough
– includes minor silt and fine gravel with depth, gravel subangular to subround		25				
SILTY SANDSTONE, bluish gray, closely fractured or less, weak, low hardness, little weathered, saturated, fine grained, occasional fine to coarse grained zones, occasional thin bed of brown siltstone.		30		12 27 50 R/5" 2SS	910	#2/12 sand
				50 R/4" 2SS		0.010" slotted screen

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25A-98-3 3027.87 175.76 940.52'

North of the west end of 25A

GEOLOGICAL MATERIAL DESCRIPTION



ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

BERKELEY LAB

	25A–98–6	3091.47	134.29	940.70'

Inside the east end of 25A

DATE(S) DRILLED	BOREHOLE DIAMETER	TOTAL DEPTH	COMPLETED WELL DEPTH	REMARKS
10/01/98 – 10/02/98	6.00in	42.00'	40.80'	Bridging problems due to highly turbid formation water in borehole reduced sand volume in filter pack one quarter from expected volume.

DRILLING METHOD	LOGGED BY
8x8 with solid stem auger	PDJ

DRILLING CONTRACTOR	DRILLING FIRM
Clear Heart	LBNL–ERP

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY / BLOW COUNT	ELEVATION (ft)	MP.EL. 939.90	WELL MATERIALS
CONCRETE GRAVEL (GP), base rock (fill). TUFF BRECCIA, reddish brown with white and green mottles, closely fractured or less, friable, low hardness, little weathered, moist, includes fine to medium gravel of angular gray siltstone and rounded lithics, contains calcite inclusions. – red brown at 9 feet – greenish white and purplish gray at 11 feet ANDESITE, light orange brown, intensely fractured, weak to moderately strong, moderately hard, deeply weathered, moist, black vug fillings. – andesite supported in a dark gray to black sheared clay matrix from 12 to 17 feet – grades to gray brown, closely fractured, friable to weak with depth – wet at 23 feet		5: 12 17 31 2SS; 5 13 29 2SS 10: 9 39 51 R/5" 2SS 15: 9 43 51 R/5" 2SS 20: 12 28 51 R/3" 2SS 25: 12 26 33 2SS 30: 36 51 R/4" 2SS	940 930 920 910		christy box set in concrete cement grout 2" ID, Schedule 40 PVC casing medium bentonite chip #2/12 sand centralizer 0.010" slotted screen centralizer

ENVIRONMENTAL RESTORATION PROGRAM

REVIEWED BY

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

25A-98-6	3091.47	134.29	940.70'

Inside the east end of 25A

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)		WELL MATERIALS
BASALT, black, closely fractured, strong, hard, moderately weathered, saturated.				80 2SS			centralizer
SILTY SANDSTONE AND SILTSTONE, blue gray and red brown, laminated to thin bedded, crushed to intensely fractured, friable, little weathered, saturated, sheared, slickensides dip ~35 degrees, includes minor brown claystone.				12 24 33 2SS	900		silt trap
		45					
		50			890		
		55					
		60			880		
		65					
		70			870		
		75					

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

	25A-98-7	3001.67	140.51	940.10'

Between 25A and 44A

09/01/98 - 09/01/98	6.00in	36.00'	34.00'	Note refusal encountered at original well location (SB25A-98-2) ~6 feet to the south. Refusal occurred at 9 feet in a calcite cemented sandstone.
C&RP-98 with solid stem auger			PDJ	
Gregg	LBNL-ERP			

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	MP.EL. 942.71	WELL MATERIALS
SILTY GRAVEL (GM), reddish brown and gray, medium dense to dense, moist, andesitic gravel. SILTSTONE, reddish brown, crushed, friable to weak, low hardness, little weathered, moist, calcite veined.		0			940		stand pipe
		5					cement grout
SILTY SANDSTONE, gray, intensely fractured, weak, low hardness, moderately weathered, moist. CLAYEY SILTSTONE AND SANDY SILTSTONE, brown and green gray, crushed, plastic, low hardness, little weathered, moist to wet. SANDY SILTSTONE WITH GRAVELLY SANDSTONE, light brownish gray with brown, friable, intensely to closely fractured, low hardness, little to moderately weathered, wet to saturated, fine to medium, subangular gravel, fine sand with minor silt. - GRAVELLY SANDSTONE not present - SANDY SILTSTONE grades to SILTY SANDSTONE with minor SILTSTONE, reddish brown, weak with depth		10	N	13 50 2SS	930		2" ID, Schedule 40 PVC casing
		15	N	20 23 30 2SS			medium bentonite chip
		20	N	40 50 2SS	920		#2/12 sand
							centralizer
		25	N	12 14 25 2SS			0.010" slotted screen
CLAYSTONE WITH SANDY SILTSTONE, red brown with blue gray, crushed, plastic to moderately strong, low to moderate hardness, little weathered, saturated, calcite veined. - hard drilling at 32 feet SANDSTONE, reddish brown, crushed, moderately strong, moderately hard, little weathered, saturated, calcite							centralizer
		30	N	20 40 51 R/5" 2SS	910		
							slip cap slough

ENVIRONMENTAL RESTORATION PROGRAM

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

SITE	UC EAST	UC NORTH	UC SURF. ELEV.
25A-98-7	3001.67	140.51	940.10'

LOCATION: Between 25A and 44A

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)		WELL MATERIALS
cemented. SILTY SANDSTONE, blue gray, closely fractured or less, weak, low to moderate hardness, little weathered, saturated.				50 2SS			
					900		
		45					
		50			890		
		55					
		60			880		
		65					
		70			870		
		75					

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

SITE	NORTHING	EASTING	LOCATION ELEV.
25A-99-2	3037.07	137.70	940.69'

LOCATION: Inside the west end of 25A

DATE(S) DRILLED	BORING DIAMETER	TOTAL DEPTH	COMPLETED DEPTH
05/01/99 - 05/01/99	8.00in	31.50'	30.00'

DRILLING METHOD: M5T with hollow stem auger

LOGGED BY: PDJ

DRILLING CONTRACTOR: Gregg

CONSULTING FIRM: LBNL-ERP

REMARKS: Boring initially drilled with 5 1/2" augers and then reamed with 8" augers. Boring drilled to 30.0 feet only. No blow counts due to use of hydraulic percussion hammer to drive sampler.

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	MP.EL. 940.45	WELL MATERIALS
CONCRETE GRAVEL (GP), base rock (fill). SILTSTONE, orange brown, less than closely fractured, plastic to friable, soft to low hardness, little weathered, moist, bedding dips ~70 degrees, includes purplish brown with siltstone beds with greenish white mottling sandy which contains coarse-grained sand and minor fine-grained gravel of volcanics as well as clasts of tuff, also includes thin beds of brown sandstone.		5	SP		940		christy box set in concrete cement grout
		10	SP		930		2" ID, Schedule 40 PVC casing
- cuttings change at 13 feet SANDSTONE, gray, less than closely fractured, weak to moderately strong, low to moderate hardness, little weathered, wet to saturated, sand medium-grained, angular, and predominantly basaltic, includes beds with fine to medium-grained, predominantly basaltic gravel, also includes red brown mottled, silty, tuffaceous thin beds.		15	SP				3/8" bentonite pellet

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

WELL	EASTING	NORTHING	GROUND ELEV.
25A-99-2	3037.07	137.70	940.69'

LOCATION: Inside the west end of 25A

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	WELL MATERIALS
SILTY SANDSTONE AND SILTSTONE, greenish gray and reddish brown, closely fractured, friable, low hardness, little weathered, saturated, sandstone fine-grained.		20	SP		920	#2/12 sand
– free water in boring at 22 feet SILTY SANDSTONE, blue gray, less than closely fractured, friable, low hardness, little weathered, saturated, fine grained, occasional moderately strong to strong, hard, calcite-cemented zones.		25	SP			0.010" slotted screen
SANDSTONE, dark blue gray, closely fractured, friable to weak, low to moderate hardness, little weathered, saturated, medium grained, minor silt matrix, occasional strong, hard, calcite-cemented zones. SILTSTONE, reddish brown with blue gray mottling, closely fractured, weak, moderately hard, little weathered, saturated.		30	SP		910	silt trap

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

25A-99-5 3062.06 166.42 940.60'

North of 25A

07/19/99 – 07/19/99 8.00in 47.50' 44.00'

B-61 with hollow stem auger PDJ

Gregg LBNL-ERP

GEOLOGICAL MATERIAL DESCRIPTION

GRAVEL (GP), coarse, rounded (fill).
SANDSTONE, brown, less than closely fractured, friable, low hardness, moderately weathered, moist to wet, medium to coarse grained, coarse grains rounded, minor silt.

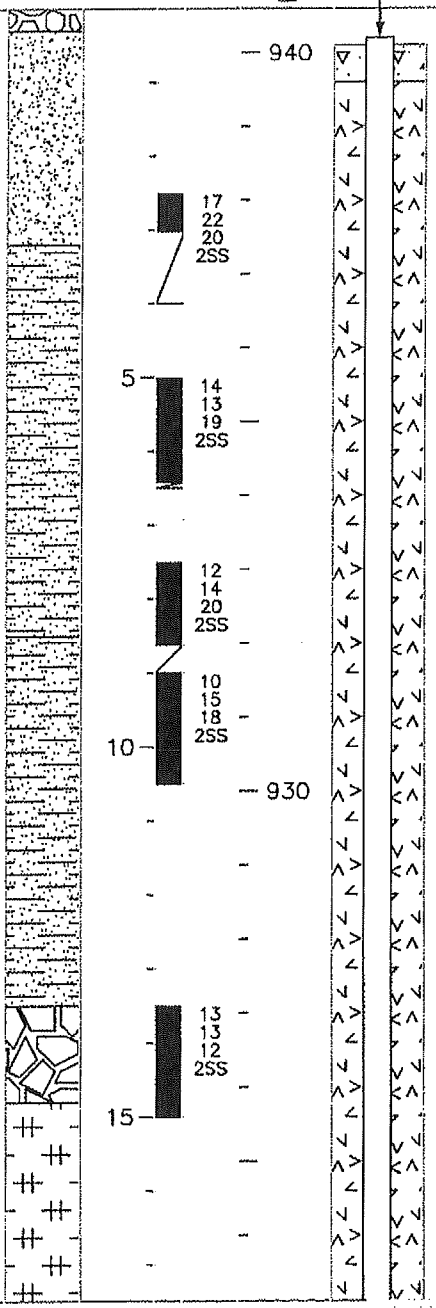
– red brown sheared clay laminae at the contact with green gray below

SILTY SANDSTONE, purple gray and orange brown mottled and bedded, closely fractured, friable, low hardness, little weathered, wet to saturated, fine grained.

TUFFACEOUS SILTY SANDSTONE, light orangish brown, greenish white and light brown mottled and laminated, closely fractured or less, friable, low hardness, moderately weathered, wet to saturated, fine grained, minor silt, red brown sheared clay, laminae dipping ~40 degrees, fine to medium grained.

– grades to greenish white and purplish brown mottled with minor round, fine gravel of brown sandstone, gray shale, and andesite.
– shear zone with red brown silt laminae dipping ~20 degrees at contact

SILTY VOLCANIC BRECCIA, red brown and purple gray mottled, closely fractured or less, friable, low hardness, little weathered, wet to saturated, subangular to subround, fine to coarse grained gravel of volcanics.
ANDESITE, brown, intensely fractured to crushed, friable to moderately strong, low hardness to hard, deeply weathered, wet, red brown vug fillings.



WELL MATERIALS

christy box set in concrete

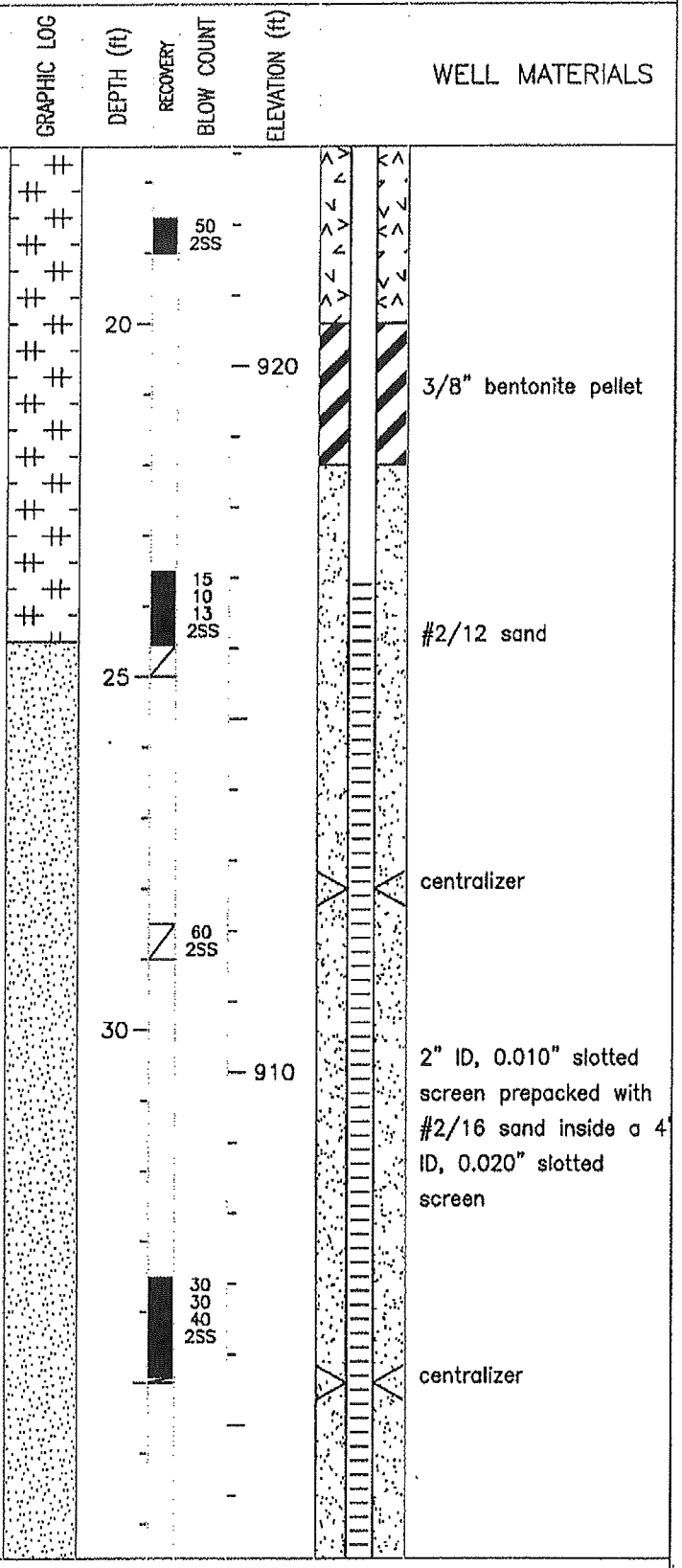
cement grout

2" ID, Schedule 40 PVC casing

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25A-99-5 3062.06 166.42 940.60'

North of 25A

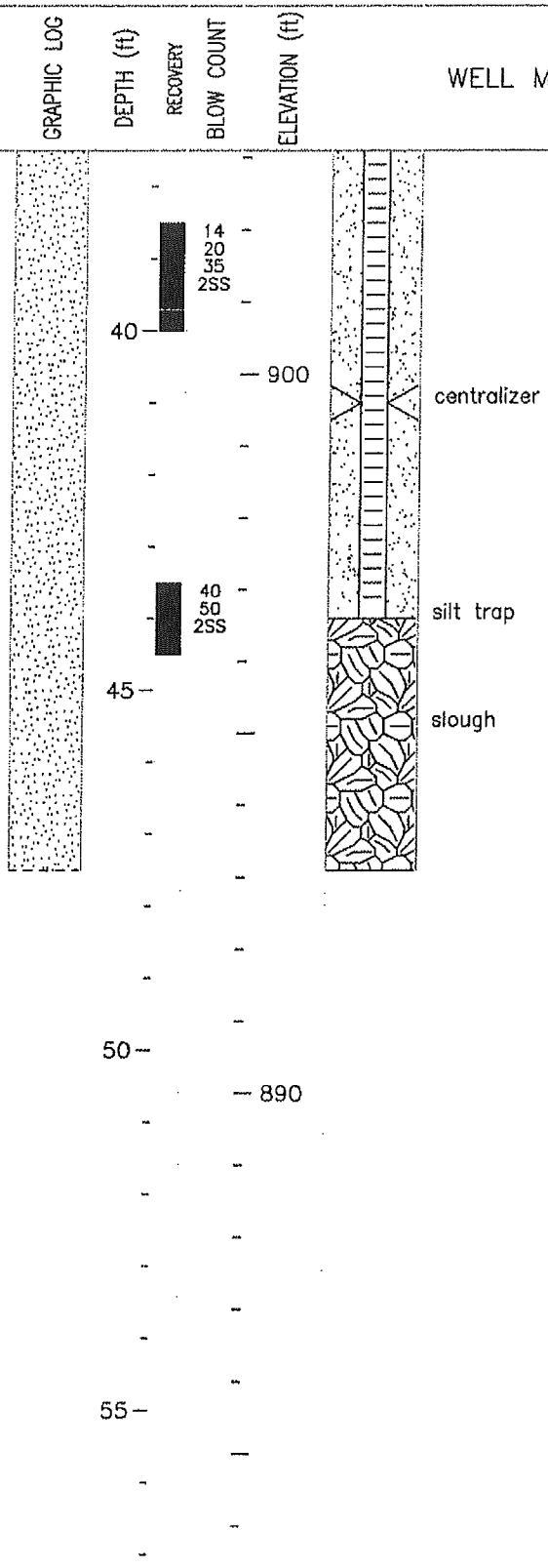


ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25A-99-5 3062.06 166.42 940.60'

North of 25A

GEOLOGICAL MATERIAL DESCRIPTION



WELL MATERIALS

– silty with thin, subhorizontal beds of red brown siltstone at 39 feet

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25A-00-5 2965.28 139.64 933.37'

West of 25A

04/10/00 - 05/17/00 7.63in 85.00' 85.00'

M-11 w/ HS auger, CME 75 w/ air tri-cone PDJ & HP

Gregg & Water Develo LBNL-ERP and Parsons

Well installed in two stages: conductor casing in installed after auger drilling, well installed after air drilling. 2' tail pipe for 2" centralizer (4" unavailable). Geology to 37 foot depth from SB25A-95-1.

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	MP.EL. 933.12	WELL MATERIALS
ASPHALT - contact gradational CLAY (CH), dark brown, medium stiff, wet. SANDSTONE AND SILTSTONE, green brown and brown, crushed to intensely fractured, friable, low hardness, moderately to deeply weathered, moist.		5				christy box set in concrete 8" ID, 1/8" wall steel conductor casing
- some zones becoming moderately strong, moderately hard, calcite cemented in with depth - occasional calcite veins in red brown siltstone		10				grout outside conductor casing
- occasional red brown clayey, plastic zones SANDSTONE, green gray, closely fractured, friable, moderately hard, little weathered, moist.		15 20				2" ID, Schedule 40 PVC casing
SILTSTONE, red brown with some blue gray mottling, intensely fractured, weak, moderate hardness, little weathered, moist. - wet to saturated at 28 feet		25 30				grout inside conductor casing

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

25A-00-5 2965.28 139.64 933.37'

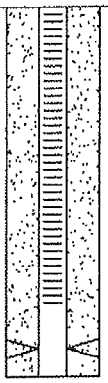
West of 25A

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	WELL MATERIALS
SANDSTONE, blue gray, intensely fractured, friable to weak, low hardness, little weathered, saturated, medium grained. – grades through fine-grained sandstone at contact. SANDY SILTSTONE, bluish gray with red brown mottles, closely to intensely fractured, weak to moderately strong, low to moderate hardness, little weathered, saturated, sand fine-grained. SANDSTONE, blue gray, closely fractured or less, weak, low hardness, little weathered, saturated, medium to coarse grained.		45		10 25 27 41 50	8" ID, 1/8" wall steel conductor casing grout outside conductor casing
SILTY CLAYSTONE, red brown, intensely fractured to crushed, weak, low to moderate hardness, little weathered, saturated, includes occasional zones of blue gray, fine-grained sandstone, minor calcite veining. SANDSTONE, blue gray, less than closely fractured, weak to moderately strong, low to moderate hardness, little weathered, saturated, medium grained. – grades through fine-grained sandstone at contact. SILTSTONE, red brown with occasional blue gray sandy zones, crushed to intensely fractured, weak to moderately strong, low to moderate hardness, little weathered, saturated, minor calcite veining.		50 55		38 50 33 50 21 37 50 30 50 12 16 18 12 16 26	2" ID, Schedule 40 PVC casing grout inside conductor casing slough outside conductor casing
SANDY SILTSTONE, red brown with bluish gray zones, crushed to intensely fractured, friable to weak, low to moderate hardness, little weathered, saturated, sand fine-grained, calcite veining. SANDSTONE, bluish gray to dark bluish gray, weak to moderately strong, moderately hard, little weathered, medium to coarse, subround to round grains, calcite cemented. SANDY SILTSTONE, red brown, friable to weak, low to moderate hardness, little weathered, fine grained sand,		60 65 70 75			medium bentonite chip centralizer #2/12 sand

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

25A-00-5 2965.28 139.64 933.37'

West of 25A

GEOLOGICAL MATERIAL DESCRIPTION	GRAPHIC LOG	DEPTH (ft)	RECOVERY	BLOW COUNT	WELL MATERIALS
calcite veins. – bluish gray below 76 feet – bluish gray and reddish brown, weak, not calcite cemented below 79 feet SANDSTONE, bluish gray to dark bluish gray, weak to moderately strong, moderately hard, little weathered, medium to coarse, subround to round grains, calcite cemented. SANDY SILTSTONE, bluish gray and reddish brown, weak, low to moderate hardness, little weathered, fine grained sand.		75 85 90 95 100 105 110			 2" ID, 0.010" slotted screen prepacked with #2/16 sand inside a 4" ID, 0.020" slotted screen silt trap centralizer

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

BERKELEY LAB

SITE	EASTING	NORTHING	TOP OF CASING ELEV.
SB25A-02-1	3080.79	217.68	941.01'

LOCATION: North of 25A

DATE(S) DRILLED	CASING DIAMETER	TOTAL DEPTH COMPLETED (ft)	TOTAL DEPTH COMPLETED (ft)
06/25/02 - 06/25/02	8.00in	35.00'	32.00'

DRILLING METHOD: M-11 with hollow stem auger

LOGGED BY: HP

DRILLING CONTRACTOR: Gregg

CONSULTANT NAME: Parsons

REMARKS: Geologic log to 8.5 feet interpreted from logs for MW25A-95-4, MW25A-98-3 and MW25A-99-5. Well abandoned on 3/17/05 by overdrilling with 10" OD auger and removing all casing. Backfilled 0'-20', grout; 20'-33', bentonite chip; 33'-33.5', slough.

GEOLOGICAL MATERIAL DESCRIPTION	DEPTH (ft)	RECOVERY	BLOW COUNT	ELEVATION (ft)	WELL MATERIALS
ASPHALT				940	christy box set in concrete
GRAVEL (GP), base rock (fill).					
ANDESITE, brown, intensely fractured to crushed, friable to moderately strong, low hardness to hard, deeply weathered, wet, red brown vug fillings.	5				grout
– purple silt at contact			16 15 24 2SS		
SANDSTONE, gray, closely fractured, friable to weak, low hardness, moderately weathered, moist, fine, minor silt.	10			930	2" ID, Schedule 40 PVC casing
GRAVELLY SANDSTONE, brownish gray, closely fractured, friable, low hardness, moderately weathered, saturated, coarse, gravel fine- to medium-grained.	15				
			29 29 40 2SS		3/8" bentonite pellets
SANDSTONE, bluish gray, closely fractured or less, friable to weak, low to moderate hardness, little weathered, saturated, fine, minor coarse-grained sand.	20			920	#2/16 sand
SILTSTONE, gray intensely fractured, friable to weak, low hardness, little to moderately weathered, saturated.	25				0.010" slotted screen
			20 35 28 2SS		
– grades to include minor clay with depth	30			910	silt trap
SILTSTONE, gray, intensely fractured, friable to weak, low hardness, little weathered, saturated.			7 15 18 2SS		medium bentonite chip

MP.EL. 940.70

ENVIRONMENTAL RESTORATION PROGRAM

REVIEWED BY: PDJ

DRILL RIG: Mobile B-61	SURFACE ELEVATION: ≈ 941 feet	LOGGED BY: Preston Holland
DEPTH TO GROUNDWATER: ≈18 feet	BORING EQUIPMENT: 8.5" hollow-stem auger	DATE DRILLED: 3/9/92

DESCRIPTION AND CLASSIFICATION		DEPTH (FEET)	SAMPLE	Penetration Resistance (Blows/ft)	REMARKS	Well Construction
DESCRIPTION AND REMARKS	SOIL TYPE					
CLAYEY GRAVEL (GC), red-brown					Traffic-grade well cover with locking cap	
CLAYEY GRAVEL (GC), volcaniclastic; mottled green-grey, orange-brown, and purple-black;low to moderate hardness; plastic to moderately strong; subvertical clay seams; moist to WET (deeply weathered ?andesite)		5		56	Cement grout seal	
SANDY CLAYSTONE, green-grey and red-brown; subhorizontally sheared; plastic to weak; soft to low hardness; crushed; deeply to moderately weathered; calcite veinlets; WET		10		29	2" PVC solid casing Sch. 40, 10' sections, O-ring seals	
SANDY SILTSTONE, grey-green; intensely subvertically fractured; moderately weathered; low to moderate hardness; friable to weak; WET		15		62	Bentonite pellets seal	
SILTY SANDSTONE, green-grey; fine to medium grained; intensely to closely fractured; moderately weathered; calcite-cemented; moderately hard; weak to moderately strong; WET to SATURATED • drilling slower 21-25 ft • at 25 ft: red-brown; low to moderate hardness; friable to weak		20 25		71 40/3.5"	No. 1/20 sand filter pack Machine-slotted PVC well screen, slot size 0.010"	
SANDY SILTSTONE, grey-green; moderately fractured; moderately weathered; plastic to weak; low hardness; SATURATED		30		40/2"	Silt trap	
Total Drilled Depth = 31 ft		35 40 45 50				

LAWRENCE BERKELEY LABORATORY	EXPLORATORY BORING LOG		
	PROJECT # Site Restoration Project	DATE: 3/20/92	BORING # 26-92-11