GEOTECHNICAL ENGINEERING EXPLORATION
ENERGY LABORATORY
HAWAII PREPATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

JUNE 27, 2008

Prepared for

PA'AHANA ENTERPRISES, LLC

W.O. 5915-10

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Prepared for

PA'AHANA ENTERPRISES, LLC

ROBIN M. LIM
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HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

SIGNATURE

4-30-10
EXPIRATION DATE
OF THE LICENSE

GEOLABS, INC.
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GEOLABS, INC.
Geotechnical Engineering and Drilling Services

June 27, 2008
W.O. 5915-10

Mr. Ken Melrose
Pa'ahana Enterprises, LLC
P.O. Box 109
Kealakekua, HI 96750

Dear **Mr. Melrose:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Exploration, Energy Laboratory, Hawaii Preparatory Academy, Waimea, Island of Hawaii" prepared in support of the design of the proposed facility.

Our work was performed in general accordance with the scope of services outlined in our fee proposal dated April 7, 2008.

Please note that the soil samples recovered during our field exploration (remaining after testing) will be stored for a period of two months from the date of this report. The samples will be discarded after that date unless arrangements are made for a longer sample storage period. Please contact our office for alternative sample storage requirements, if appropriate.

Detailed discussion and specific design recommendations are contained in the body of this report. If there is any point that is not clear, please contact our office.

Very truly yours,

GEOLABS, INC.

Robin M. Lim, P.E.
Vice President

RML:ST:as

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Hawaii • California

GEOTECHNICAL ENGINEERING EXPLORATION

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W.O. 5915-10 JUNE 27, 2008

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

Our borings generally encountered fill materials consisting of stiff sandy and clayey silts extending down to about 3.5 to 9.5 feet below the ground surface. In some areas, significant amounts of tree stumps, branches and other organic materials were encountered in the fill layer. Fill materials, where encountered, generally were underlain by volcanic ash materials consisting of very stiff to hard sandy and clayey silts. In some areas, the volcanic ash graded with varying amounts of gravel and cobbles. Basalt formation was encountered at depths ranging from about 3 to 23 feet below the ground surface. Basalt formation was generally moderately weathered and relatively hard. We did not encounter groundwater in the borings at the time of our field exploration.

As mentioned previously, fill materials containing significant amounts of organic materials (unsuitable materials) were encountered at the project site. In general, these deleterious materials should be removed, and the resulting excavation should be backfilled with compacted fill. The approximate areas where unsuitable materials were encountered are shown on the Site Plan, Plate 2. We envision the removal of the unsuitable materials would need to extend down to a depth of about 10 feet below the ground surface in some areas. A Geolabs representative should determine the extent of unsuitable material removal in the field during earthwork construction.

It should be noted that the fill materials and volcanic ash deposits encountered in the borings drilled do not possess as high natural moisture contents as the typical volcanic ash deposits. As a result, the volcanic ash deposits at the site appear to be more workable as compacted fills when compared to the volcanic ash found in other localities. Therefore, we believe the excavated on-site materials may be re-used as a source of fill materials provided the materials are less than 6 inches in largest dimension and are free of organics and/or other deleterious materials.

Based on the subsurface conditions encountered at the project site and anticipated grading activities (after removal of the unsuitable materials), we recommend using shallow spread and/or continuous strip footings to support the new structures planned. Foundations may be designed using an allowable bearing pressure of up to 3,000 psf for footings bearing on either the recompacted on-site materials or compacted fill. The text of this report should be referred to for detailed discussion and specific design recommendations.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1.0 - GENERAL

1.1 Introduction

This report presents the results of our geotechnical engineering exploration performed for the Energy Laboratory project within the Hawaii Preparatory Academy (HPA) in the District of South Kohala on the Island of Hawaii. The project location and general vicinity are shown on the Project Location Map, Plate 1. This report summarizes the findings from our field exploration and presents our geotechnical recommendations for the design of the Energy Laboratory project only.

The recommendations provided herein are intended for the design of site grading, building foundations, slabs-on-grade, retaining structures, underground utilities, and pavements only. The findings and recommendations presented herein are subject to the limitations noted at the end of this report.

1.2 Project Considerations

The Hawaii Preparatory Academy (HPA) is in the Waimea area within the District of South Kohala on the Island of Hawaii. It is desired to construct new school facilities at the existing HPA campus. As part of the new school facility, we understand an energy laboratory is planned at the mauka portion of the campus.

Based on the moderately sloping condition of the existing ground surface, the new building will be constructed in a partial basement condition. We understand that the new building will have finished floor elevations ranging from about +2,559 to +2,564 feet Mean Sea Level (MSL). The basement level will have a finished floor elevation of about +2,547 feet MSL.

Associated infrastructure, such as roadways and underground utilities will be installed as part of the project. Based on the preliminary grading plans provided, we understand that site grading may consist of cuts and fills of up to about 15 feet to achieve the design grades.

1.3 Purpose and Scope

The purpose of our field exploration was to obtain an overview of the surface and subsurface conditions to develop a soil and/or rock data set to formulate geotechnical recommendations for the design of site grading, foundations, slabs-on-grade, retaining structures, underground utilities, and pavements for the project. In order to accomplish this, we conducted an exploration program consisting of the following tasks and efforts:

1. Mobilization and demobilization of a backhoe and an operator to the project site and back.

2. Excavation of seven test pits at the project site to depths of about 5 to 14 feet to evaluate the thickness and characteristics of the near-surface fill materials and volcanic ash layer.

3. Mobilization and demobilization of a truck-mounted drill rig and two operators to the project site and back.

4. Drilling and sampling of four borings to depths of about 20 to 24.5 feet below the ground surface.

5. Performance of one percolation test to evaluate the subsurface permeability characteristics for the individual wastewater system design.

6. Coordination of the field exploration and logging of the borings and test pits by our engineer/geologist.

7. Laboratory testing of selected samples obtained during the field exploration as an aid in classifying the materials and evaluating their engineering properties.

8. Analyses of the field and laboratory data to formulate geotechnical recommendations for the design of site grading, foundations, slabs-on-grades, retaining structures, underground utilities, and pavements for the project.

9. Preparation of this report summarizing our work on the project and presenting our findings and recommendations.

10. Coordination of our overall work on the project by our project engineer.

11. Quality assurance of our work and client/design team consultation by our principal engineer.

12. Miscellaneous work efforts such as drafting, word processing, and clerical support.

Detailed descriptions of our field exploration methodology and the Logs of Borings are presented in Appendix A. The Logs of Test Pits are presented in Appendix B. Results of the laboratory tests performed on selected samples obtained during our field exploration are presented in Appendix C. Results of the percolation test performed in a selected boring from our field exploration are presented in Appendix D.

END OF GENERAL

SECTION 2.0 - SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Hawaii is the largest island in the Hawaiian Archipelago and covers an area of approximately 4,000 square miles. The island was formed by the activity of the following five shield volcanoes: Kohala (long extinct), Mauna Kea (activity during recent geologic time), Hualalai (last erupted in 1801 - 1803), and Mauna Loa and Kilauea (both still active).

The HPA campus is situated in a saddle between the Kohala and Mauna Kea Shield Volcanoes, where Mauna Kea lava flows banked against the older Kohala rocks. Based on available geologic information and geomorphological interpretation, the campus site is located on Mauna Kea rocks near the surface contact with Kohala Shield Volcano.

Following the cessation of volcanic activity in Kohala and Mauna Kea, activity from the other shields resulted in widespread aerial fall of ash over much of the island. This ash has weathered rapidly into a fine silty soil, which is typified by low in-situ densities and high field moisture contents. In some locales, when the field moisture content is sufficiently high, the ash soil exhibits thixotropic properties, i.e., the soil temporarily loses strength when remolded and regains its strength after internal pore pressures dissipate. In more arid areas, the ash soil exists in a dry friable state even though field moisture contents can approach 100 percent of the dry unit weight. Our exploration indicates that the campus site is underlain by a surface mantle of this drier volcanic ash soil, which transitions to basalt formation and clinker with increasing depth.

The lava formation at the site appears to be of a'a and pahoehoe basalt type flows, which spread and ponded as they flowed toward the ocean. A'a lava typically is characterized by a porous, rough, and irregular flow surface resembling a jagged accumulation of rock fragments including cobbles and boulders. Typically, a denser and more layered lava rock material is contained within the lava flow core. Pahoehoe lava is characterized by a smooth, rope-like or billowy surface and an internal structure of

vesicular (porous) rock. Cavities are commonly encountered in pahoehoe lavas. Cavities form when the lavas are still in a molten state and represent both lava tubes (intra-flow cavities) and blisters and pockets (inter-flow cavities). Lava tubes form when molten lava drains from the cooling flow leaving a hollow tube-like structure, which may extend for a large longitudinal distance along the flow. Blisters and pockets (inter-flow cavities) are generally smaller in horizontal extent.

2.2 Existing Site Conditions

The HPA campus is in the Waimea area within the District of South Kohala on the Island of Hawaii. The Energy Laboratory facility is on the mauka portion of the HPA campus. The Energy Laboratory facility site is shown on the Site Plan, Plate 2.

Based on the topographic survey map provided, the existing grades at the majority of the project site generally vary from about +2,530 to +2,570 feet MSL. The project site generally slopes down from north to south, with several localized mounds and depressions. The majority of the project site is generally in original ground conditions with dense wild grasses and other vegetation. We understand a portion of the project site has been filled with debris and organic materials generated from the previous development of the HPA campus. In addition, some access trails crossing the project site were observed at the time of our field exploration.

2.3 Subsurface Conditions

Our field exploration consisted of drilling and sampling four borings, designated as Boring Nos. 1 through 4, extending to depths of about 20 to 24.5 feet below the existing ground surface. In addition, we excavated seven test pits, designated as Test Pit Nos. 1 through 7, extending to depths of about 5 to 14.5 feet below the existing ground surface. The approximate boring and test pit locations are shown on the Site Plan, Plate 2.

Based on the borings drilled, the project site generally is underlain by fill materials and volcanic ash deposits overlying basalt formation and a'a clinker at greater depths. The fill materials encountered generally consisted of stiff sandy and clayey silts extending down to about 3.5 to 9.5 feet below the ground surface. As mentioned

previously, some areas of the site were previously filled with debris and organic materials. Some of the test pits and borings encountered significant amount of tree stumps, branches and other organic materials in the fill layer. The approximate areas where significant amounts of organic materials were encountered are shown on the Site Plan, Plate 2. It should be noted the fill materials (unsuitable materials) were not encountered in some of the borings drilled.

Fill materials, where encountered, generally were underlain by volcanic ash materials consisting of very stiff to hard sandy and clayey silts. In some areas, the volcanic ash graded with varying amounts of gravel and cobbles. Basalt formation was encountered at depths ranging from about 3 to 23 feet below the ground surface. The basalt formation generally was moderately weathered and relatively hard. Although we did not encounter cavities and/or voids in the basalt formation at the project site, cavities and/or voids are commonly present in the basaltic lava flows in the vicinity. Therefore, there is a potential for encountering cavities and/or voids in the basalt formations at the site during construction.

We did not encounter groundwater in the borings at the time of our field exploration. However, groundwater levels may change due to seasonal precipitation, surface water runoff, and other factors. Detailed descriptions of the materials encountered from our field exploration are presented on the Logs of Borings in Appendix A. Detailed descriptions of the materials encountered in the test pits excavated are presented on the Logs of Test Pits (Appendix B). Results of the laboratory test performed on selected samples obtained during our field exploration are presented in Appendix C.

2.4 Earthquakes and Seismicity

In general, earthquakes that occur throughout the world are caused by shifts in the tectonic plates. In contrast, earthquake activity in Hawaii is primarily linked to volcanic activity, therefore, earthquake activity in Hawaii generally occurs before or during volcanic eruptions. In addition, earthquakes may result from the underground movement of magma that comes close to the surface but does not erupt. The Island of

Hawaii experiences thousands of earthquakes each year, but most are so small that only sensitive instruments can detect them. However, some of the earthquakes are strong enough to be felt, and a few cause minor to moderate damage.

In general, earthquakes associated with volcanic activity are most common on the Island of Hawaii. Earthquakes that are directly associated with the movement of magma are concentrated beneath the active Kilauea and Mauna Loa Volcanoes on the Island of Hawaii. Because the majority of the earthquakes in Hawaii (over 90 percent) are related to volcanic activity, the risk of seismic activity and degree of ground shaking diminishes with increased distance from the active volcanoes in the southern portion of the Island of Hawaii.

The Island of Hawaii has experienced numerous earthquakes greater than Magnitude 6 (M6+). Based on information obtained from the United States Geological Survey (USGS) Bulletin 2006, the following is a list of some destructive earthquakes that occurred on the Island of Hawaii since 1868.

DATE	LOCATION	MAGNITUDE
March 28, 1868	South Hawaii	7.0
April 2, 1868	South Hawaii	7.9
October 5, 1929	Hualalai	6.5
August 21, 1951	Kona	6.9
April 26, 1973	North Hilo	6.2
November 29, 1975	Kalapana	7.2
November 16, 1983	Kaoiki	6.7
June 25, 1989	Kalapana	6.2
October 15, 2006	Kiholo Bay/Hawi	6.7/6.0

Several significant earthquakes have occurred on the Island of Hawaii in the past 100 years including earthquakes with Magnitudes of 6.7 and 6.0 in 2006. Therefore, it may be concluded that the Waimea area of the Island of Hawaii could experience moderate to severe earthquakes and associated ground shaking, depending on the earthquake origin.

2.5 Seismic Design Considerations

The Island of Hawaii is within Seismic Zone 4 and has an effective peak ground acceleration of 0.40g in general accordance with the requirements of the 1997 Uniform Building Code (UBC). Based on the subsurface materials encountered at the project site and the geologic setting of the area, the project site may be classified from a seismic analysis standpoint as a Very Dense Soil and Soft Rock Profile corresponding to a Soil Profile Type S_C. Based on our review of the available geologic information, the project site does not appear to be located in the immediate proximity of mapped geologic fault structures. Therefore, the near-source factors (N_a and N_v) for this project may be assumed to be 1.0.

END OF SITE CHARACTERIZATION

SECTION 3.0 - DISCUSSION AND RECOMMENDATIONS

Our borings generally encountered fill materials consisting of stiff sandy and clayey silts extending down to about 3.5 to 9.5 feet below the ground surface. In some areas, significant amounts of tree stumps, branches and other organic materials were encountered in the fill layer. Fill materials, where encountered, generally were underlain by volcanic ash materials consisting of very stiff to hard sandy and clayey silts. In some areas, the volcanic ash graded with varying amounts of gravel and cobbles. Basalt formation was encountered at depths ranging from about 3 to 23 feet below the ground surface. The basalt formation generally was moderately weathered and relatively hard. We did not encounter groundwater in the borings at the time of our field exploration.

As mentioned previously, fill materials containing significant amounts of organic materials (unsuitable materials) were encountered in some areas. In general, these deleterious materials should be removed, and the resulting excavation should be backfilled with compacted fill. The approximate areas where significant amounts of organic materials (unsuitable materials) were encountered are shown on the Site Plan, Plate 2. We envision the removal of the unsuitable materials would need to extend down to a depth of about 10 feet below the ground surface in some areas. A Geolabs representative should determine the extent of unsuitable material removal in the field during earthwork construction.

The fill materials and volcanic ash deposits encountered in the borings drilled do not possess as high natural moisture contents as the typical volcanic ash deposits encountered elsewhere on the island. As a result, the volcanic ash deposits at the site appear to be more workable as compacted fills when compared to the volcanic ash found in other localities. Therefore, we believe the excavated on-site materials may be re-used as a source of fill materials provided the materials are less than 6 inches in largest dimension and are free of organics and/or other deleterious materials.

Based on the subsurface conditions encountered at the project site and anticipated grading activities (after removal of the unsuitable materials), we recommend

using shallow spread and/or continuous strip footings to support the new structures planned. As an alternative, foundation support for the new structures may consist of thickened-edge slab footings. Detailed discussion of these items and our geotechnical recommendations for the project design are presented in the following sections.

3.1 Site Grading

Based on the preliminary grading plan provided, we understand that site grading may consist of cuts and fills of up to about 15 feet or less to achieve the design grades. The following grading items are addressed in the succeeding subsections:

- Site Preparation
- Fills and Backfills
- Fill Placement and Compaction Requirements
- Excavation
- Cut and Fill Slopes

3.1.1 Site Preparation

At the on-set of earthwork, areas within the contract grading limits should be cleared and grubbed thoroughly. Vegetation, debris, deleterious materials, and other unsuitable materials should be removed and disposed properly off-site to reduce the potential for contamination of the excavated materials to be used as embankment fill materials.

As mentioned previously, fill materials containing significant amounts of organic materials were encountered in some areas. In general, these unsuitable materials should be removed, and the resulting excavation should be backfilled with compacted fill. The approximate areas where significant amounts of organic materials (unsuitable materials) were encountered are shown on the Site Plan, Plate 2. Based on the borings drilled, removal of the unsuitable materials would need to extend down to a depth of about 10 feet below the ground surface in some areas.

Because the vertical and lateral extents of the unsuitable material removal are variable, we recommend a Geolabs representative be present during earthwork

construction to assist in evaluating the extents of the unsuitable material removal. Considering the variable nature of this work item, we recommend obtaining additive and deductive unit prices for removal of the unsuitable materials followed by backfilling with compacted fill to account for variations in the over-excavation and backfill quantities.

After clearing and grubbing and removal of the unsuitable materials, finished subgrades in cuts and areas to receive fills should be scarified to a minimum depth of 8 inches, where possible, moisture-conditioned to above the optimum moisture, and compacted to at least 90 percent relative compaction. The compaction requirement for subgrades under roadways and other paved areas should be increased to at least 95 percent relative compaction. Where scarification of the subgrades is not practical, such as areas with exposed basalt formation, the subgrade materials should be proof-rolled with a minimum 20-ton vibratory drum roller for a minimum of eight passes to help detect and collapse near-surface cavities and/or voids. The vibratory drum roller should be operated at a speed of about 300 feet per minute.

The scarification and proof-rolling operations should be performed in the presence of a Geolabs representative. Yielding areas, loose areas, or cavities disclosed during clearing and proof-rolling operations should be over-excavated and backfilled with compacted fill materials.

3.1.2 Fills and Backfills

As indicated previously, the fill materials and volcanic ash deposits encountered in the borings drilled do not possess as high natural moisture contents as the typical volcanic ash deposits. As a result, the volcanic ash deposits at the site appear to be more workable as compacted fills when compared to the volcanic ash found in other localities. Therefore, we believe the excavated on-site materials may be re-used as a source of fill materials provided that the materials are less than 6 inches in largest dimension and are free of organics and/or other deleterious materials.

Imported fill materials (where required) should consist of non-expansive select granular fill materials, such as crushed basalt. The material should be well graded from coarse to fine with particles no larger than 6 inches in largest dimension. The material also should contain less than 30 percent particles passing the No. 200 sieve. In addition, a Geolabs representative should observe and/or test the imported materials a minimum of 7 days prior to being transported to the project site for the intended use.

3.1.3 Fill Placement and Compaction Requirements

Fill materials should be placed in level lifts not exceeding 8 inches in loose thickness, moisture-conditioned to above the optimum moisture content, and compacted to at least 90 percent relative compaction. The compaction requirement for the finished subgrades under pavements should be increased to a minimum of 95 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same soil established in accordance with ASTM D 1557. Optimum moisture is the water content (percentage by weight) corresponding to the maximum dry density. Compaction should be accomplished by sheepsfoot rollers, vibratory rollers, or other types of acceptable compaction equipment.

It should be noted that the on-site materials consisting primarily of silty volcanic ash soils may cause some difficulties in achieving the specified compaction requirements, especially when the specified requirements are a minimum of 95 percent relative compaction. Where the specified compaction requirement is difficult to achieve, the silty volcanic ash soils may be blended with more granular soils or over-excavated and replaced with select granular fill to achieve the specified compaction requirement at no additional cost to the owner.

3.1.4 Excavation

Based on our field exploration, the project site is underlain by fills and volcanic ash materials overlying basalt formation at greater depths. We anticipate the near-surface fills, volcanic ash, and highly fractured basalt formation may be

excavated readily with normal heavy excavation equipment, such as excavators, and ripped with large bulldozers. However, some of the deeper excavations into the dense pahoehoe lava likely will require the use of hoerams or chipping.

The above discussions regarding the rippability of the surface materials are based on our visual observation of the existing basalt formation and field data from the borings. Contractors should be encouraged to examine the site conditions and the subsurface data to make their own reasonable and prudent interpretation.

3.1.5 Cut and Fill Slopes

In general, we envision most of the cut slopes would expose the existing fills and volcanic ash. In general, we believe the cut slopes planned at the site may be designed with a slope inclination of two horizontal to one vertical (2H:1V) or flatter. Where dense basalt formations are exposed at the cut slope faces, the cut slopes may be steepened to 1H:1V or flatter. Where the steeper cut slope inclination is used, a Geolabs representative should observe and map the cut slopes during construction to evaluate whether the exposed cut slope materials are consistent with our assumptions appropriate for the steeper cut slopes.

In general, permanent fill slopes may be designed with a slope inclination of 2H:1V or flatter. In addition, fills placed on slopes steeper than 5H:1V should be benched. A keyway should be provided for fill slopes greater than 10 feet in vertical height placed on existing ground steeper than 5H:1V. A typical keying and benching detail is shown on the Slope Detail, Plate 3.

The filling operations should start at the lowest point and continue up in level horizontal compacted layers in accordance with the above fill placement recommendations. Fill slopes should be constructed by overfilling and cutting back to the design slope ratio to obtain a well-compacted slope face. The fill slope face should be finished to a relatively smooth and well-compacted surface. In addition, slope planting or other means of slope protection should be provided as soon as possible to reduce the potential for significant erosion of the finished slopes. It

should be noted that the volcanic ash deposits are highly susceptible to water and/or wind erosion.

For cut and fill slopes steeper than 3H:1V with vertical heights greater than 30 feet, we recommend providing a minimum 8-foot wide bench at the mid-point of the slope or at every 30-foot height interval to reduce the potential for significant erosion due to surface water runoff. The 8-foot wide benches may be omitted for cut slopes in dense basalt formation. Where slope benches are provided (especially for fill slopes), concrete-lined swales should be provided on the benches to collect and divert surface water from the slopes to appropriate discharge outlets. In addition, construction of interceptor ditches and the use of geotextile fabrics over the fill slope face should be considered to reduce the potential for significant erosion, thus enhancing the long-term stability of the fill slopes.

3.2 Foundations

Based on the subsurface conditions encountered at the project site and anticipated grading activities, we recommend using shallow spread and/or continuous strip footings to support the new structures planned. As an alternative, foundation support for the new structures may consist of thickened-edge slab footings. Foundation subgrades should be scarified to a minimum depth of 8 inches, where possible, moisture-conditioned to above the optimum moisture, and compacted to a minimum of 90 percent relative compaction. If the subgrade exposes rocky material where scarification is not practical, the rocky subgrade should be proof-rolled with a drum roller or similar construction equipment a minimum of eight passes to help detect and collapse near surface cavities.

An allowable bearing pressure of up to 3,000 pounds per square foot (psf) may be used to design the footings bearing on either the recompacted on-site materials or compacted fill. This bearing value is for dead-plus-live loads and may be increased by 50 percent for transient loads, such as those caused by wind or seismic forces.

In general, footings should be embedded a minimum of 24 inches below the lowest adjacent grade. Footings constructed near the tops of slopes or on slopes should

be embedded deep enough such that the horizontal distance measured from the outside edge (at the base of the footing) to the face of the slope is no less than 6 feet.

In addition, foundations next to other foundations, utility trenches, easements or other retaining walls should be embedded below a 45-degree imaginary plane extending upward from the bottom edge of the structure or utility trench, or the footings should be extended to a depth as deep as the inverts of the utility lines. This requirement is necessary to avoid surcharging adjacent below-grade structures with additional structural loads and to reduce the potential for appreciable foundation settlement.

Soft and/or loose materials that may be encountered at the bottom of footing excavations should be over-excavated until dense materials are exposed in the footing excavations. The over-excavation should be backfilled with select granular fill materials, moisture-conditioned to above the optimum moisture content, and compacted to a minimum of 90 percent relative compaction. Alternatively, the bottom of the footing may extend down to bear directly on the underlying competent material.

If the foundations are designed and constructed in strict accordance with our recommendations, we estimate the total foundation settlements to be less than 1 inch. Differential settlements between adjacent footings supported on similar materials may be on the order of about 0.5 inch or less.

Lateral loads acting on the structure may be resisted by the friction developed between the bottom of the foundation and the bearing soil and by passive earth pressure acting against the near-vertical faces of the foundation system. A coefficient of friction of 0.35 may be used for footings bearing on the recompacted on-site materials or compacted fill. Resistance due to passive earth pressure may be estimated using an equivalent fluid pressure of 300 pounds per square foot per foot of depth (pcf) assuming that the soils around the footings are well compacted. The passive resistance in the upper 12 inches of the soil should be neglected unless covered by pavements or slabs.

A Geolabs representative should observe the footing excavations prior to the placement of reinforcing steel and concrete to confirm the foundation bearing conditions and the required embedment depths.

3.3 Slabs-On-Grade

We anticipate concrete slabs-on-grade will be used for the floors of the new building structures. Due to the presence of volcanic ash at the building subgrade elevation, we recommend properly preparing the silty subgrade soils under the concrete slabs-on-grades and keeping the subgrades moist until covered by cushion fill and slab concrete. In addition, we recommend that the concrete slabs-on-grades be a minimum of 5 inches thick and reinforced with No. 4 reinforcing bars spaced at 12 inches on-center in both directions due to the low strength characteristics of the on-site soils.

For the interior building slabs (not subject to vehicular traffic), we recommend providing a minimum 4-inch thick layer of cushion fill below the slabs for uniform support. The cushion fill should consist of open-graded gravel (ASTM C 33, No. 67 gradation) and also would serve as a capillary moisture break. Where slabs are subject to vehicular traffic or sustained vibrations, a minimum of 6 inches of compacted aggregate subbase course should be provided below the slabs in lieu of the 4-inch thick cushion fill layer. The aggregate subbase course layer should be moisture-conditioned to above the optimum moisture content and compacted to a minimum of 95 percent relative compaction.

To reduce the potential for excessive moisture infiltration and subsequent damage to floor coverings, an impervious moisture barrier is recommended on top of the gravel cushion layer. Flexible floor coverings should be considered above the floor slab because they can better mask minor slab cracking.

In addition, we envision exterior concrete walkways and exterior flatwork likely will be required. In general, we recommend providing a minimum 4-inch thick cushion layer of compacted aggregate subbase below the exterior concrete slab. The aggregate subbase should be moisture-conditioned and compacted to at least 90 percent relative compaction. To reduce the potential for substantial shrinkage cracks

in the slabs, crack control joints should be provided at intervals equal to the width of the walkways (or slabs) with expansion joints at right-angle intersections.

3.4 Retaining Structures

We understand that retaining structures, such as basement walls and/or site retaining walls, may be required for the project. Therefore, the following general guidelines are provided and may be used for the design of retaining structures.

3.4.1 Retaining Structure Foundations

In general, we believe that retaining structure foundations may be designed in accordance with the recommendations and parameters presented in the "Foundations" section herein. However, the retaining structure footings should have a minimum width of 18 inches. For sloping ground conditions, the footing should extend deeper to obtain a minimum 6-foot setback distance measured horizontally from the outside edge of the footing to the face of the slope. Wall footings oriented parallel to the direction of the slope should be constructed in stepped footings. In addition, a Geolabs representative should observe the footing excavations during construction to confirm the exposed conditions.

3.4.2 Static Lateral Earth Pressures

In general, retaining structures should be designed to resist the lateral earth pressures due to the adjacent soils and surcharge effects. The recommended lateral earth pressures for design of retaining walls, expressed in equivalent fluid pressures of pounds per square foot per foot of depth (pcf), are presented in the following table.

LATERAL EARTH PRESSURES FOR DESIGN OF RETAINING STRUCTURES			
Backfill Condition	**Earth Pressure Component**	**Active** (pcf)	**At-Rest** (pcf)
Level Backfill	Horizontal	40	60
	Vertical	None	None
Maximum 3H:1V Sloping Backfill	Horizontal	46	65
	Vertical	15	22

In general, an active condition may be used for gravity retaining walls and retaining structures that are free to deflect laterally by as much as 0.5 percent of the wall height. If the tops of the structures are not free to deflect beyond this degree, or are restrained, the retaining structures should be designed for the at-rest condition.

The values provided above assume that the excavated on-site soils may be used to backfill behind the wall. In addition, the backfill behind the retaining walls (within about 3 feet of the back of the wall) should be limited to a maximum particle size of 3 inches to facilitate compaction of the backfill using smaller-sized equipment. It is assumed that the backfill behind retaining walls will be compacted to between 90 and 95 percent relative compaction. Over-compaction of the retaining structure backfill should be avoided. These lateral earth pressures do not include hydrostatic pressures that might be caused by groundwater trapped behind the walls.

Surcharge stresses due to areal surcharges, line loads, and point loads within a horizontal distance equal to the depth of the retaining structure should be considered in the design. For uniform surcharge stresses imposed on the loaded side of the structure, a rectangular distribution with uniform pressure equal to 33 percent of the vertical surcharge pressure acting on the entire height of the structure, which is free to deflect (cantilever), may be used in design. For retaining structures that are restrained, a rectangular distribution equal to

50 percent of the vertical surcharge pressure acting over the entire height of the structure may be used for design. Additional analyses during design may be needed to evaluate the surcharge effects of point loads and line loads.

3.4.3 Dynamic Lateral Earth Forces

Because the project site is on the seismically active Island of Hawaii (Seismic Zone 4), forces due to dynamic lateral earth pressures should be considered in the design of retaining structures. The force due to dynamic lateral earth pressures associated with seismic loading (a_{max}=0.40g) may be estimated using $16H^2$ pounds per foot of wall length for level backfill conditions where H is the height of the wall in feet. For a sloping backfill condition (up to 3H:1V), a dynamic lateral force of $28H^2$ pounds per lineal foot of wall (H in feet) may be used in design. The dynamic lateral earth force generally would act at the mid-height of the wall.

It should be noted that the dynamic lateral earth forces provided assume that the wall will be allowed to move laterally by up to about 2 to 4 inches in the event of an earthquake. If this amount of lateral movement is not acceptable, the retaining wall should be designed with higher dynamic lateral forces for a semi-restrained wall condition. For a semi-restrained wall condition, dynamic lateral forces due to seismic loading may be estimated using $28H^2$ pounds per lineal foot of wall for level backfill conditions. The force due to dynamic lateral earth pressures generally would act at the mid-height of the wall.

The force due to dynamic lateral earth pressures presented is in addition to the static lateral earth pressures. An appropriately reduced factor of safety may be used when dynamic lateral earth pressures are accounted for in the design of the retaining structure.

It should be noted that due to relatively high dynamic lateral forces, sloping backfill behind the retaining structures should be limited to an inclination of 3H:1V or less. The sloping backfill inclination of 3H:1V should extend a horizontal distance of at least two times the wall height. The sloping backfill may be

steepened to a maximum slope inclination of 2H:1V behind this horizontal setback distance.

3.4.4 Drainage

In general, retaining structures should be well drained to reduce the potential for excessive build-up of hydrostatic pressures. A typical drainage system would consist of a 12-inch wide zone of permeable material, such as open-graded gravel (ASTM C 33, No. 67 gradation), placed directly around a perforated pipe (perforations down) at the base of the retaining wall. The perforated pipe should discharge to an appropriate outlet or weepholes.

As an alternative, a prefabricated drainage product, such as MiraDrain or EnkaDrain, may be used instead of the permeable drainage material. The prefabricated drainage product also should be connected to a perforated pipe at the base of the retaining wall. Unless covered by concrete or asphaltic concrete, the upper 12 inches of backfill should consist of relatively impervious or less pervious materials, such as well-graded soils, to reduce the potential for significant water infiltration behind the walls.

3.5 Percolation Testing

One field percolation test was performed to aid in the design of an individual wastewater system for the project. The field percolation test was performed in general accordance with the State of Hawaii, Department of Health's Administrative Rules, Chapter 11-62-31.2, "Wastewater Systems" and Chapter 10 of the Ten State's Standards to evaluate the permeability of the subsurface soils for disposal of wastewater effluent.

The percolation test was performed in a 4.5-inch diameter borehole drilled to a depth of about 5 feet below the existing ground surface at the time of the test. Approximately 1 inch of gravel was then placed at the bottom of the borehole to protect the bottom of the hole from scouring and sediments. During testing, the hole was carefully filled with water to a depth of about 6 inches above the gravel and refilled as necessary. The time intervals and water drops were recorded to provide data upon

which the calculation of the percolation rate was based. The percolation test results are presented on Plate D-1 of Appendix D.

Based on the percolation test conducted, the percolation rate near the proposed leaching field location is on the order of approximately 30 minutes per inch. In accordance with the "Manual of Septic-Tank Practice" prepared by the U.S. Department of Health, Education, and Welfare, the proposed leach field location with the percolation rate obtained at the site would be suitable for siting of the absorption system at the project site.

3.6 Underground Utility Lines

We envision that new underground utility lines will be required as part of the project. Generally, we anticipate most of the utility line trenches will be excavated in the compacted fill and/or on-site fills and volcanic ash materials encountered at the site.

In general, granular bedding consisting of 6 inches of open-graded gravel (ASTM C 33, No. 67 gradation) should be provided below the pipes for uniform bearing support. Free-draining granular materials, such as open-graded gravel (ASTM C 33, No. 67 gradation), should be used for the initial trench backfill up to about 12 inches above the pipes. It is critical to use this free-draining material to reduce the potential for formation of voids below the haunches of pipes and to provide adequate support for the sides of the pipes. Improper backfill material around the pipes and improper placement of the backfill could result in backfill settlement and pipe damage.

As an alternative, the granular bedding and the initial trench backfill (up to about 12 inches above the top of the pipes) may consist of 1-inch minus, well-graded granular materials (aggregate base course). Where the 1-inch minus, well-graded granular materials are used, the granular bedding and the initial trench backfill should be moisture-conditioned and compacted to no less than 90 percent relative compaction.

The upper portion of the trench backfill from the level 12 inches above the pipes to the top of the subgrade or finished grade should consist of well-graded granular materials less than 6 inches in maximum particle size. The backfill should be

moisture-conditioned to above the optimum moisture, placed in about 8-inch loose lifts, and mechanically compacted to at least 90 percent relative compaction. Where trenches are located in paved areas, the upper 3 feet of the trench backfill below the pavement grade should be compacted to not less than 95 percent relative compaction.

3.7 Pavement Design

We envision that entry roadways and parking areas will be constructed for the new energy laboratory. In general, we anticipate the vehicle loading for the new pavements would consist of primarily passenger vehicles and light trucks with some heavy trucks. Therefore, we assumed generally light to medium traffic loading conditions for pavement design purposes. In addition, we assumed the pavement subgrade soils will be similar to the recompacted on-site volcanic ash materials with a laboratory CBR value of 2 or greater. On this basis, we recommend using the following preliminary pavement design section for this project.

Flexible Pavement

2.0-Inch Asphaltic Concrete
6.0-Inch Aggregate Base Course (95 Percent Relative Compaction)
12.0-Inch Aggregate Subbase Course (95 Percent Relative Compaction)
20.0-Inch Total Pavement Thickness on a Moist Compacted Subgrade

The subgrade soils under the pavement areas should be scarified to a minimum depth of 8 inches, where possible, moisture-conditioned to above the optimum moisture, and compacted to at least 95 percent relative compaction. Where scarification of the subgrades is not practical, subgrade soils should be proof-rolled with a minimum 15-ton vibratory drum roller for a minimum of eight passes. CBR tests and/or field observations should be performed on the actual subgrade soils during construction to confirm that the above design section is adequate. The aggregate base and subbase courses should consist of crushed basaltic aggregates moisture-conditioned and compacted to a minimum of 95 percent relative compaction.

In general, paved areas should be sloped, and drainage gradients should be maintained to carry surface water off the pavements. Surface water ponding should not be allowed on-site during or after construction. Where concrete curbs are used to

isolate landscaping in or adjacent to the pavement areas, we recommend extending the curbs a minimum of 2 inches into the subgrade soil to reduce the potential for migration of excessive landscape water into the pavement section.

3.8 Drainage

The finished grades outside the buildings and other structures should be sloped to shed water away from the foundations and slabs and to reduce the potential for ponding. In addition, it is advised to install gutter systems around the buildings and to divert discharge away from the foundation and slab areas. Excessive landscape watering near the foundations and slabs also should be avoided. Planters next to foundations should be avoided or have concrete bottoms and drains to reduce the potential for excessive water infiltration into the subsurface, especially subsurface conditions consisting of fill materials.

The foundation excavations should be backfilled properly against the walls or slab edges immediately after setting of the concrete to reduce the potential for appreciable water infiltration into the subsurface. In addition, drainage swales should be provided as soon as possible and should be maintained to drain surface water runoff away from the foundations and slabs.

3.9 Design Review

Preliminary and final drawings and specifications for the proposed project should be forwarded to Geolabs for review and written comments prior to bid solicitation. This review is necessary to evaluate conformance of the plans and specifications with the intent of the geotechnical recommendations provided herein. If this review is not made, Geolabs cannot be responsible for misinterpretation of our recommendations.

3.10 Construction Monitoring

Geolabs should be retained to provide geotechnical services during construction of the project. The critical items of construction monitoring that require "Special Inspection" include observation of the site preparation including removal of the organic materials, subgrade preparation, fill placement and compaction, and foundation construction. A Geolabs representative also should monitor the other aspects of the

earthwork construction to observe compliance with the intent of the design concepts, specifications, or recommendations and to expedite suggestions for design changes that may be required in the event that subsurface conditions differ from those anticipated at the time this report was prepared. The recommendations provided herein are contingent upon such observations.

If the actual exposed subsurface conditions encountered during construction are different from those assumed or considered in this report, then appropriate design modifications should be made.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4.0 - LIMITATIONS

The analyses and recommendations submitted herein are based, in part, upon information obtained from the borings, test pits and bulk samples. Variations of the subsurface conditions between and beyond the borings, test pits, and bulk samples may occur, and the nature and extent of these variations may not become evident until construction is underway. If variations then appear evident, it will be necessary to re-evaluate the recommendations provided herein.

The boring and test pit locations indicated herein are approximate, having been taped from surveyed stakes at the project site. Elevations of the borings and test pits were based on interpolation between the spot elevations and contour lines shown on the plans provided by Belt Collins Hawaii, Ltd. on May 6, 2008. The physical locations and elevations of the borings and test pits should be considered accurate only to the degree implied by the methods used.

The stratification lines shown on the graphic representations of the borings depict the approximate boundaries between soil and/or rock types and, as such, may denote a gradual transition. Water level data from the borings were measured at the times shown on the graphic representations and/or presented in the text herein. These data have been reviewed and interpretations made in the formulation of this report. We did not encounter groundwater in the borings drilled; however, it must be noted that fluctuation may occur due to variation in rainfall, temperature, and other factors.

This report has been prepared for the exclusive use of Pa'ahana Enterprises, LLC and their design consultants for specific application to the design of the Energy Laboratory facility within the Hawaii Preparatory Academy in the District of South Kohala on the Island of Hawaii in accordance with generally accepted geotechnical engineering principles and practices. No warranty is expressed or implied.

This report has been prepared solely for the purpose of assisting the engineers and architects in the design of the proposed project. Therefore, this report may not contain sufficient data, or the proper information, to serve as a basis for construction

cost estimates. A contractor wishing to bid on this project is urged to retain a competent geotechnical engineer to assist in the interpretation of this report and/or to perform additional site-specific exploration for bid estimating purposes.

The owner/client should be aware that unanticipated soil and/or rock conditions are commonly encountered. Unforeseen subsurface conditions, such as soft deposits, hard layers, cavities, or perched groundwater, may occur in localized areas and may require additional probing or corrections in the field (which may result in construction delays) to attain a properly constructed project. Therefore, a sufficient contingency fund is recommended to accommodate these possible extra costs.

This geotechnical engineering exploration conducted at the project site was not intended to investigate the potential for presence of hazardous materials existing at the site. It should be noted that the equipment, techniques, and personnel used to conduct a geo-environmental exploration differ substantially from those applied in geotechnical engineering.

END OF LIMITATIONS

CLOSURE

The following plates and appendices are attached and complete this report:

Plate 1	-	Project Location Map
Plate 2	-	Site Plan
Plate 3	-	Slope Detail
Appendix A	-	Field Exploration
Plate A	-	Log Legend
Plates A-1 thru A-4	-	Logs of Borings
Appendix B	-	Test Pit Exploration
Plates B-1 thru B-3	-	Logs of Test Pits
Appendix C	-	Laboratory Testing
Plates C-1 thru C-5	-	Laboratory Test Results
Appendix D	-	Percolation Testing
Plate D-1	-	Percolation Test Data

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Respectfully submitted,

GEOLABS, INC.

By _____
Satoshi Tanaka, P.E.
Senior Project Engineer

By _____
Robin M. Lim, P.E.
Vice President

RML:ST:as

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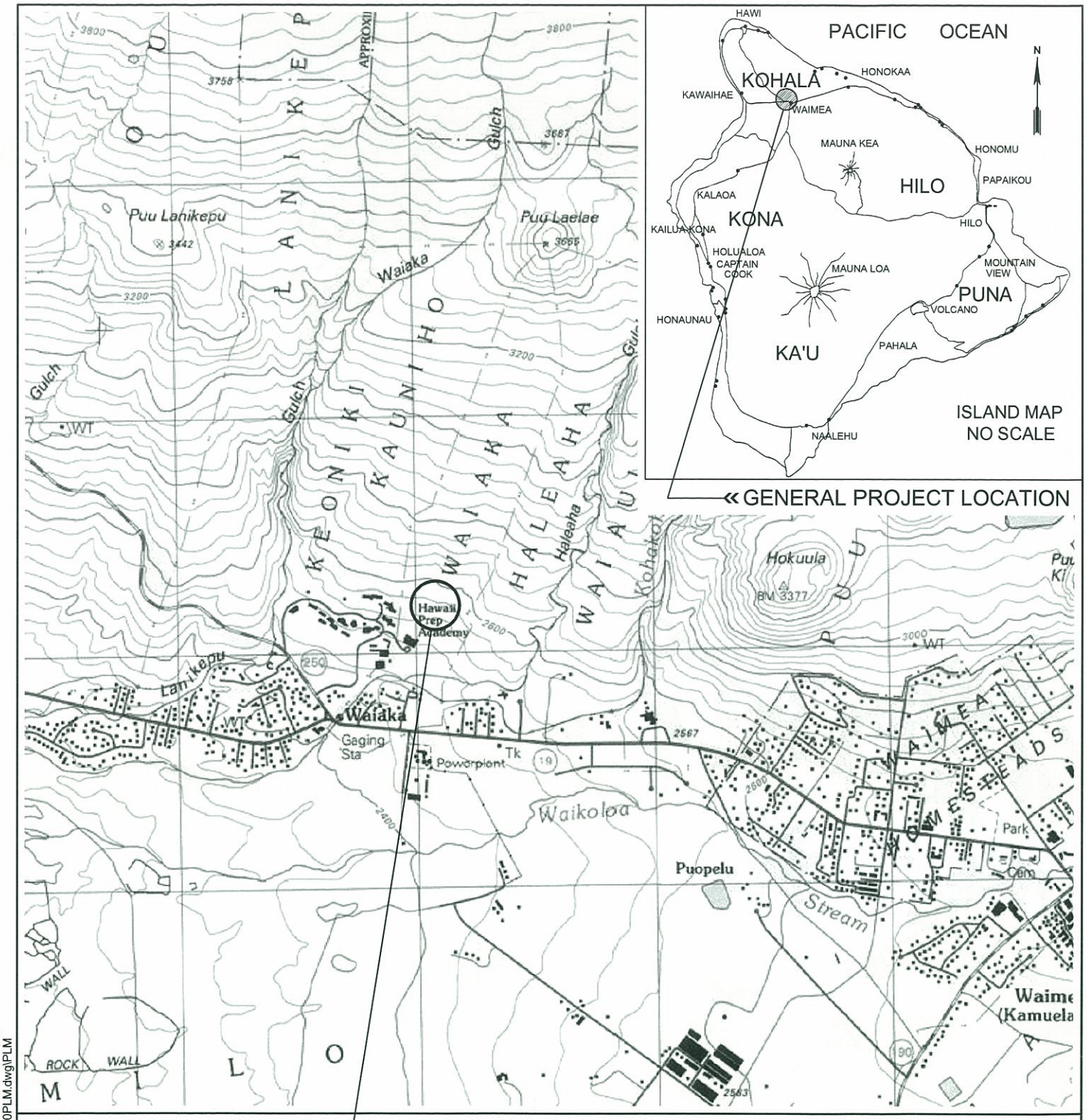
PLATES



PROJECT LOCATION MAP

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

2000 1000 0 2000 FT.

GRAPHIC SCALE

N

REFERENCE: MAP CREATED WITH TOPO!® ©2001 NATIONAL GEOGRAPHIC (WWW.NATIONALGEOGRAPHIC.COM/TOPO).

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Geotechnical Engineering

DATE	DRAWN BY	PLATE
MAY 2008	JRP	1
SCALE	W.O.	
1" = 2,000'	5915-10	

User: JJP File Created: May 05, 2008 File Last Updated: June 23, 2008 2:35:31pm
File: T:\Drafting-9904\Working\5915-10EnergyLaboratory\5915-10PLM.dwg\PLM

APPROXIMATE AREA POTENTIALLY CONTAINING UNSUITABLE MATERIALS

TP-1
TP-2
TP-3
TP-4
TP-5
TP-6
TP-7
B-1
B-2
B-3
B-4
P-1
BULK-1

SITE PLAN

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE TEST PIT LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE PERCOLATION TEST LOCATION

N

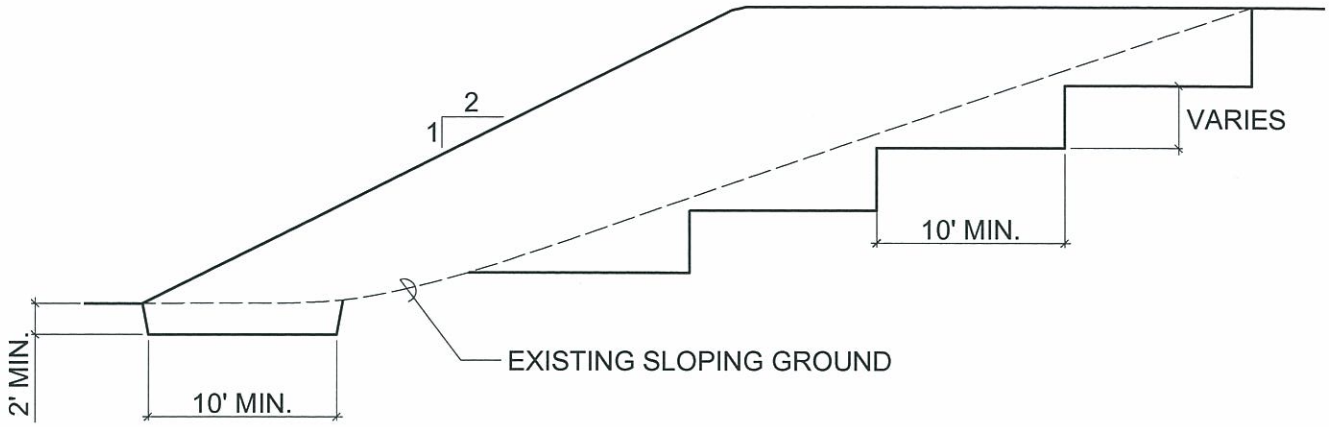
0 20 40 80 120 FT.
GRAPHIC SCALE

REFERENCE: SITE GRADING AND DRAINAGE PLAN TRANSMITTED BY BELT COLLINS HAWAII LTD. ON JULY 2, 2008.

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JULY 2008	JRP	2
SCALE 1" = 40'	W.O. 5915-10	

CAD User: JJP File Last Updated: July 09, 2008 8:46:27am Plot Date: July 09, 2008 - 9:34:33am
File: T:\Drafting-9904\Working\5915-10HawaiiPrepAcademyEnergyLaboratory\5915-10SitePlan.dwg\SitePlan



TYPICAL KEYING AND BENCHING FOR FILLS ON SLOPES STEEPER THAN 5H:IV

SLOPE DETAIL

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
MAY 2008	JRP	3
SCALE	W.O.	
NTS	5915-10	

User: JJP File Created: December 28, 2001 File Last Updated: May 05, 2008 12:59:39pm
File: T:\Drafting-9904\Working\5915-10EnergyLaboratory\5915-10SlopeDetail.dwg\SlopeDetail

APPENDIX A

Field Exploration

APPENDIX A

Field Exploration

We explored the subsurface conditions by drilling and sampling four borings, designated as Boring Nos. 1 through 4, extending to depths of about 20 to 24.5 feet below the existing ground surface. We drilled the borings using a truck-mounted drill rig equipped with continuous flight augers. The approximate boring locations are shown on the Site Plan, Plate 2.

Our geologist classified the materials encountered in the borings by visual and textural examination in the field and monitored the drilling operations on a near-continuous basis. Soils were classified in general conformance with the Unified Soil Classification System, as shown on Plate A. Graphic representations of the materials encountered are presented on the Logs of Borings, Plates A-1 through A-4.

Relatively "undisturbed" soil samples were obtained from the borings drilled in general accordance with ASTM D 3550, Ring-Lined Barrel Sampling of Soils, by driving a 3-inch OD Modified California sampler with a 140-pound hammer falling 30 inches. In addition, some samples were obtained from the borings drilled in general accordance with ASTM D 1586, Penetration Test and Split-Barrel Sampling of Soils, by driving a 2-inch OD standard penetration sampler using the same hammer and drop. The blow counts needed to drive the sampler the second and third 6 inches of an 18-inch drive are shown as the "Penetration Resistance" on the Logs of Borings at the appropriate sample depths.

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Log Legend

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS MORE THAN 50% OF MATERIAL RETAINED ON NO. 200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES MORE THAN 12% FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS 50% OR MORE OF COARSE FRACTION PASSING THROUGH NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES MORE THAN 12% FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS 50% OR MORE OF MATERIAL PASSING THROUGH NO. 200 SIEVE	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 50 OR MORE	MH	INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

LEGEND

- (2-INCH) O.D. STANDARD PENETRATION TEST
- (3-INCH) O.D. MODIFIED CALIFORNIA SAMPLE
- S SHELBY TUBE SAMPLE
- G GRAB SAMPLE
- CORE SAMPLE

LL	LIQUID LIMIT
PI	PLASTICITY INDEX
TV	TORVANE SHEAR (tsf)
PEN	POCKET PENETROMETER (tsf)
UC	UNCONFINED COMPRESSION (psi)
▽	WATER LEVEL OBSERVED IN BORING

Plate

A

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HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

Log of Boring

1

Approximate Ground Surface Elevation (feet MSL): 2561 *

Laboratory			Field								Description
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	
										MH	Brown **CLAYEY SILT** with organic matter, very stiff, damp (fill)
LL=67 PI=22	29	64			27	2.0					
											COBBLE
	33				12	>4.5	5			MH	Brown **CLAYEY SILT** with traces of sand, hard, damp (volcanic ash with some cinder)
	39	69			26	>4.5	10				
											grades to weathered tuff
	29				50/4" Ref.		15				Grayish brown **VOLCANIC TUFF**, closely fractured, highly weathered, soft to medium hard (cemented volcanic ash and cinder)
											Brownish gray **BASALT**, moderately fractured, slightly weathered, hard to very hard
					25/0" Ref.		20				
					20/0" Ref.		25				Boring terminated at 24.5 feet
							30				* Elevations estimated from Site Grading And Drainage Plan transmitted by Belt Collins Hawaii Ltd. on July 2, 2008.

Date Started:	April 22, 2008	Water Level: ▽	Not Encountered
Date Completed:	April 22, 2008		
Logged By:	S. Latronic	Drill Rig:	MOBILE B-53
Total Depth:	24.5 feet	Drilling Method:	4" Auger
Work Order:	5915-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 1

GEOLABS, INC.

Geotechnical Engineering

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

Log of Boring

2

Approximate Ground Surface Elevation (feet MSL): 2559 *

Laboratory			Field								Description
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	
										MH	Brown **CLAYEY SILT** with sand, gravel, and some organic matter, soft to medium stiff, damp (fill)
LL=64 PI=18	32	51			6						
	36				4		5				
										MH	Brown **CLAYEY SILT** with some sand, hard, damp (volcanic ash with traces of cinder)
	37	78			52	>4.5	10				
											grades to very stiff
	41				13	2.0	15				
											grades to interbedded with medium dense cinder
	30				59	>4.5	20				grades with some gravel (basaltic)
											Brownish gray **BASALT**, moderately fractured, slightly weathered, hard to very hard
					25/0" Ref.		25				Boring terminated at 24.5 feet
							30				

Date Started:	April 22, 2008	Water Level: ▽	Not Encountered
Date Completed:	April 22, 2008		
Logged By:	S. Latronic	Drill Rig:	MOBILE B-53
Total Depth:	24.5 feet	Drilling Method:	4" Auger
Work Order:	5915-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 2

BORING LOG 5915-10.GPJ GEOLABS.GDT 7/3/08

GEOLABS, INC. Geotechnical Engineering	ENERGY LABORATORY HAWAII PREPARATORY ACADEMY WAIMEA, ISLAND OF HAWAII	Log of Boring 3

Approximate Ground Surface Elevation (feet MSL): 2540 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	53	47			19					SP-SM	Brown **GRAVELLY SAND** with silt and traces of organic matter, stiff, damp (fill)
	45				57						Brownish gray **BASALT**, closely fractured, highly weathered, medium hard
	16				50/5" Ref.		5				Gray vugular **BASALT** with some clinker, moderately fractured, slightly weathered, hard
	24				20/1" Ref.		10				grades to very hard at 11.5 feet
					20/0"		15				Gray vugular **BASALT**, slightly fractured, slightly weathered, very hard
	8				50/1" Ref.		20				Boring terminated at 20.1 feet
							25				
							30				

Date Started:	April 22, 2008	Water Level: ▽	Not Encountered
Date Completed:	April 22, 2008		
Logged By:	S. Latronic	Drill Rig:	MOBILE B-53
Total Depth:	20.1 feet	Drilling Method:	4" Auger
Work Order:	5915-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 3

BORING LOG 5915-10.GPJ GEOLABS.GDT 7/9/08

GEOLABS, INC. Geotechnical Engineering	ENERGY LABORATORY HAWAII PREPARATORY ACADEMY WAIMEA, ISLAND OF HAWAII	Log of Boring 4

Approximate Ground Surface Elevation (feet MSL): 2545 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								MH	Brown **CLAYEY SILT**, very stiff to hard, damp (volcanic ash)
LL=69 PI=27	42				31	>4.5			
	42				13	3.5			
	34	69			21/6" +50/4" Ref.		5		
									Brownish gray vugular **BASALT**, moderately fractured, slightly to moderately weathered, medium hard to hard
	20				25/1" Ref.		10		
									grades to very hard
									Gray vugular **BASALT**, slightly fractured, slightly weathered, very hard
	21				50/1" Ref.		15		
					25/0" Ref.		20		Boring terminated at 20 feet
							25		
							30		

Date Started:	April 22, 2008	Water Level: ▽	Not Encountered
Date Completed:	April 22, 2008		
Logged By:	S. Latronic	Drill Rig:	MOBILE B-53
Total Depth:	20 feet	Drilling Method:	4" Auger
Work Order:	5915-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 4

APPENDIX B

Test Pit Exploration

APPENDIX B

Test Pit Exploration

We explored the subsurface conditions at the project site by also excavating seven test pits, designated at TP-1 through TP-7, extending to depths of approximately 5 to 14.5 feet below the existing ground surface using a backhoe excavator. The approximate test pit locations are shown on the Site Plan, Plate 2.

The materials encountered in the test pits were classified by visual and textural examination in the field by our geologist, who monitored the excavation operations and observed the sidewalls of the test pit excavation. Soil materials were classified in general conformance with the Unified Soil Classification System as shown on Plate A. Descriptions of the materials encountered in the test pits are presented on the Logs of Test Pits, Plates B-1 through B-3.

(h:\5900 Series\5915-10.st1 – p37)

LOGS OF TEST PITS

Energy Laboratory
Hawaii Preparatory Academy
Waimea, Island of Hawaii

Test Pit No.	Depth Below Surface (feet)	Description
TP-1 Approximate Elevation +2,564 ft MSL	0 - 4.0	Brown **CLAYEY SILT** (MH) with sand and some organic matter, stiff, damp (fill)
	4.0 - 8.5	Brown **CLAYEY SILT** (MH) with sand, very stiff, damp (volcanic ash)
	8.5 - 11.5	Grayish brown **SANDY GRAVEL** (GP) with cobbles, medium dense, damp (clinker)
		Test pit terminated at 11.5 feet on April 21, 2008
		Groundwater was not encountered
TP-2 Approximate Elevation +2,569 ft MSL	0 - 5.0	Brown **CLAYEY SILT** (MH) with sand and organic matter, stiff, damp (fill)
	5.0 - 9.0	Grades with numerous tree stumps and branches
	9.0 - 11.0	Brown **CLAYEY SILT** (MH) with sand, very stiff, damp (volcanic ash)
	11.0 - 13.0	Grayish brown **COBBLES AND BOULDERS** with gravel and sands, dense, damp (clinker)
		Test pit terminated at 13.0 feet on April 21, 2008
		Groundwater was not encountered

Logs of Test Pits (Continued)

Test Pit No.	Depth Below Surface (feet)	Description
TP-3 Approximate Elevation +2,569 ft MSL	0 - 3.0	Brown **CLAYEY SILT** (MH) with organic matter, stiff, damp (fill)
	3.0 - 9.5	Grades with numerous tree stumps and branches
	9.5 - 14.5	Brown **CLAYEY SILT** (MH) with sand, very stiff, damp (volcanic ash)
		Test pit terminated at 14.5 feet on April 21, 2008
		Groundwater was not encountered
TP-4 Approximate Elevation +2,565 ft MSL	0 - 5.0	Brown **CLAYEY SILT** (MH) with organic matter and cobbles, stiff, damp (fill)
	5.0 - 8.0	Grades with numerous tree stumps and branches
	8.0 - 9.0	Brown **CLAYEY SILT** (MH) with sand, very stiff, damp (volcanic ash)
	9.0 - 10.5	Brownish gray **COBBLES AND GRAVEL** with sand and silt, dense, damp (clinker)
		Test pit terminated at 10.5 feet on April 21, 2008
		Groundwater was not encountered
TP-5 Approximate Elevation +2,562 ft MSL	0 - 5.0	Brown **CLAYEY SILT** (MH) with organic matter, stiff, damp (fill)
	5.0 - 6.0	Brown **CLAYEY SILT** (MH) with sand, very stiff, damp (volcanic ash)
		Test pit terminated at 6.0 feet on April 21, 2008
		Groundwater was not encountered

Logs of Test Pits (Continued)

Test Pit No.	Depth Below Surface (feet)	Description
TP-6 Approximate Elevation +2,552 ft MSL	0 - 4.0	Brown **CLAYEY SILT** (MH) with trace rootlets, stiff, damp (fill)
	4.0 - 5.0	Brown **CLAYEY SILT** (MH) with sand, very stiff, damp (volcanic ash)
		Test pit terminated at 5.0 feet on April 21, 2008
		Groundwater was not encountered
TP-7 Approximate Elevation +2,548 ft MSL	0 - 3.5	Brown **CLAYEY SILT** (MH) with trace rootlets, stiff, damp (fill)
	3.5 - 6.5	Brown **CLAYEY SILT** (MH), very stiff, damp (volcanic ash)
		Test pit terminated at 6.5 feet on April 21, 2008
		Groundwater was not encountered

APPENDIX C

Laboratory Testing

APPENDIX C

Laboratory Testing

Moisture Content (ASTM D 2216) and Unit Weight (ASTM D 2937) determinations were performed on selected samples as an aid in the classification and evaluation of soil properties. The test results are presented on the Logs of Borings at the appropriate sample depths.

Three Atterberg Limits tests (ASTM D 4318) were performed on selected soil samples to evaluate the liquid and plastic limits. The test results are summarized on the Logs of Borings at the appropriate sample depths. Graphic presentations of the test results are provided on Plate C-1.

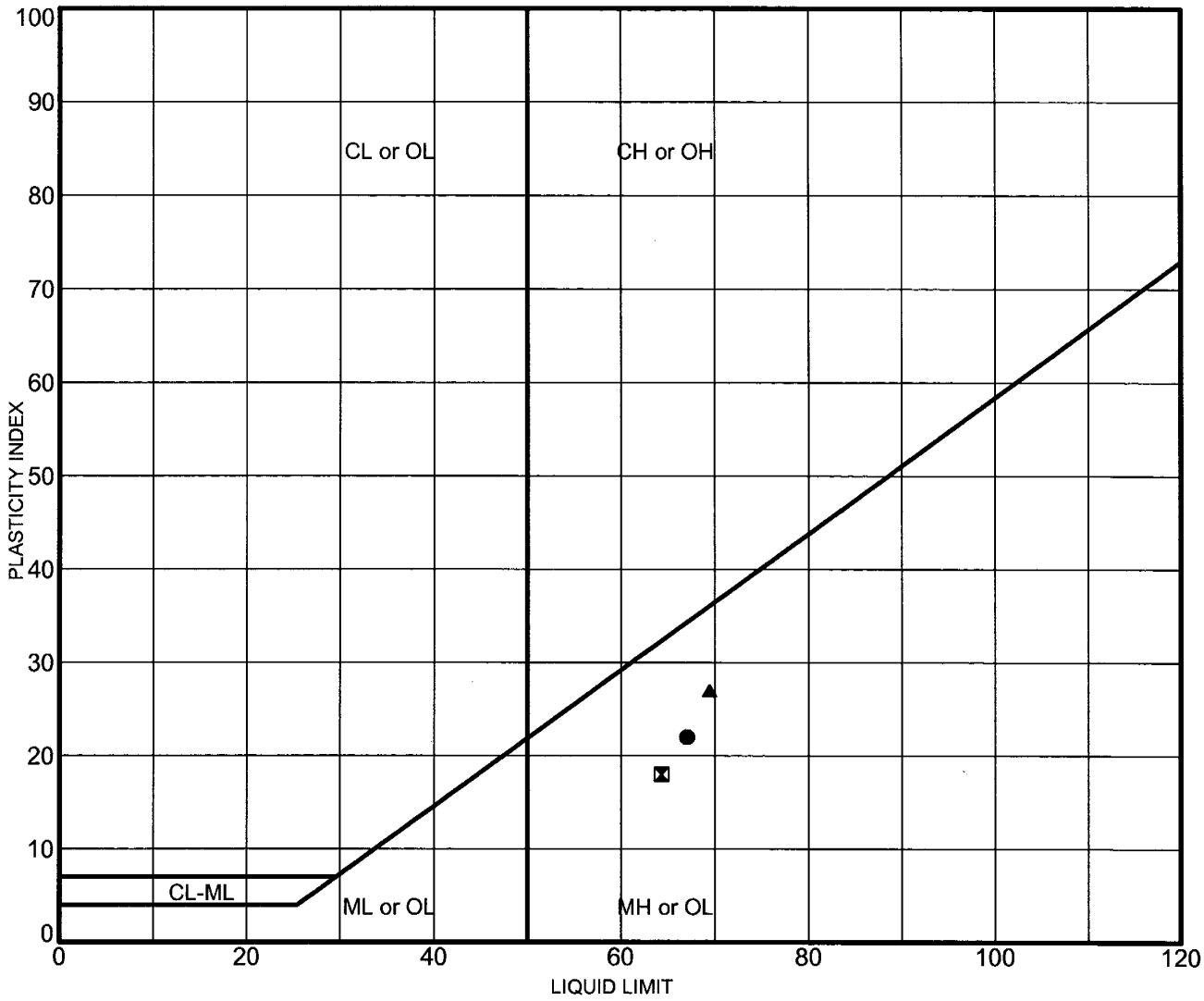
One Sieve Analysis test (ASTM C 136 & D 1140) was performed on a selected soil sample to evaluate the gradation characteristics of the soils and to aid in soil classification. Graphic presentation of the grain size distribution is presented on Plate C-2.

One Direct Shear test (ASTM D 3080) was performed on a selected sample to evaluate the shear strength characteristics. The direct shear test results are presented on Plate C-3.

One laboratory California Bearing Ratio test (ASTM D 1883) was performed on a bulk sample of the near-surface soils to evaluate the pavement support characteristics. The sample was remolded to near the optimum moisture content and saturated. The test results are presented on Plate C-4.

One Modified Proctor compaction test (ASTM D 1557A) was performed on a bulk sample of the near-surface soils to evaluate the dry density and moisture content relationships. The test results are presented on Plate C-5.

(h:\5900 Series\5915-10.st1 – p41)



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-1	1.0-2.5	67	45	22	Brown clayey silt (MH)
⊠	B-2	1.0-2.5	64	46	18	Brown clayey silt (MH) with sand
▲	B-4	1.0-2.5	69	42	27	Brown clayey silt (MH)

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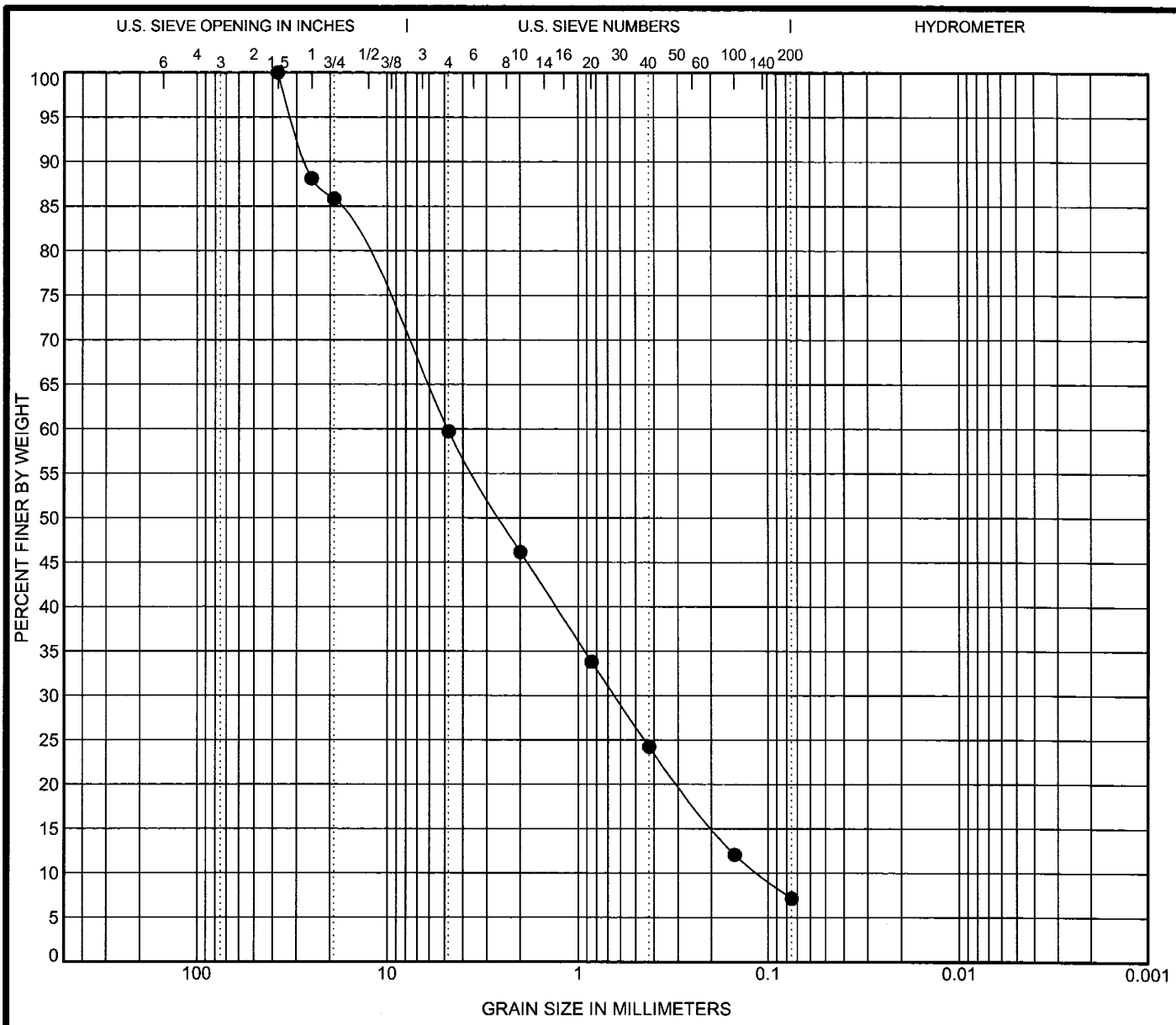
ATTERBERG LIMITS TEST RESULTS - ASTM D 4318

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

Plate
C - 1

G ATTERBERG 5915-10.GPJ GEOLABS.GDT 7/9/08



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-3	2.5-4.0	Brown gravelly sand (SP-SM) with silt				0.8	43.0

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-3	2.5-4.0	37.5	4.819	0.645	0.112	40.3	52.6	7.1

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GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

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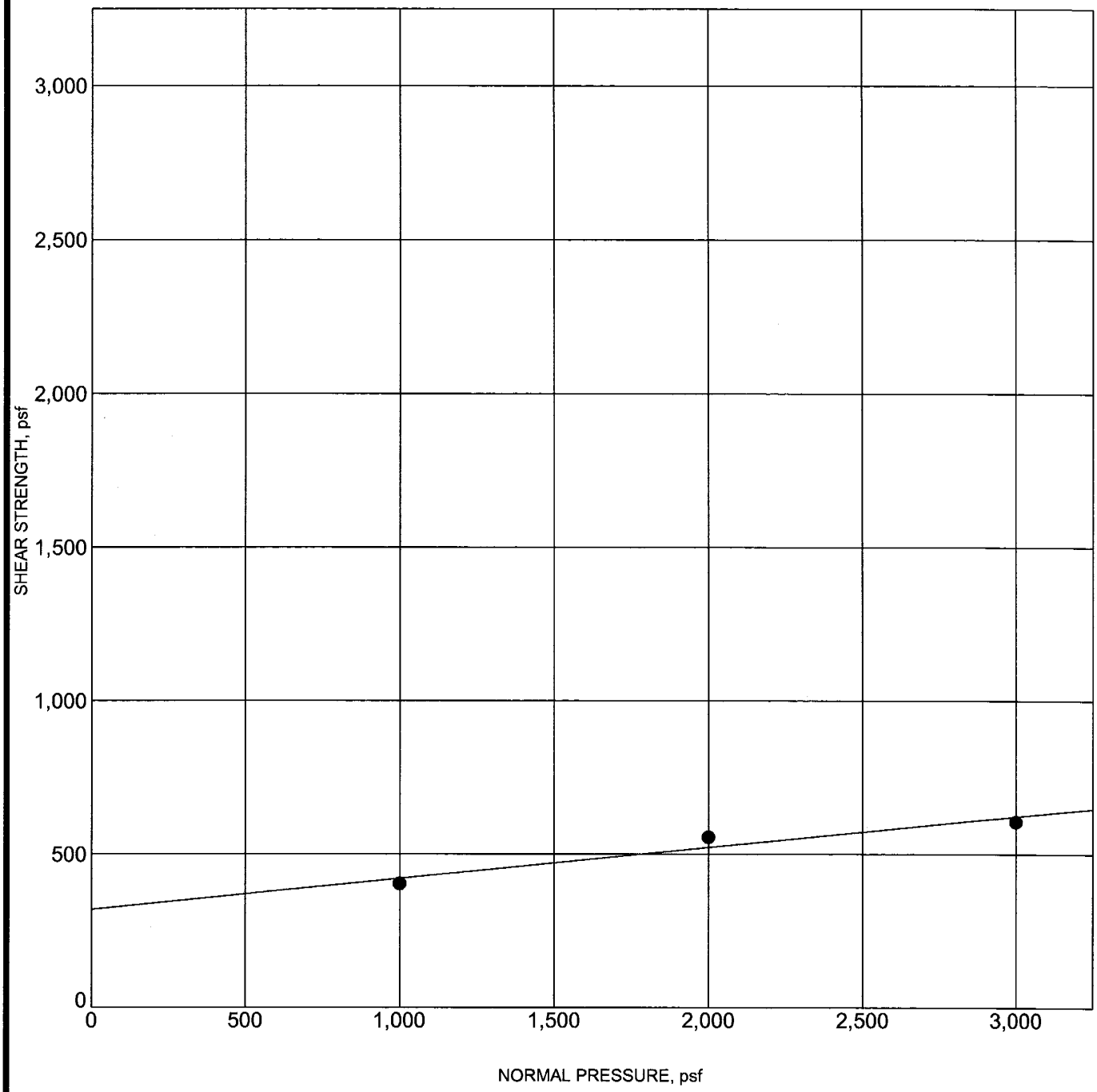
WAIMEA, ISLAND OF HAWAII

Plate
C - 2

G GRAIN SIZE 5915-10.GPJ GEOLABS.GDT 7/9/08



Friction angle (degrees):	**6**
cohesion (psf):	**320**

Sample: B-1
Depth: 1.0 - 2.5 feet
Description: Brown clayey silt (MH)

G DIRECT SHEAR 5915-10.GPJ GEOLABS.GDT 7/9/08

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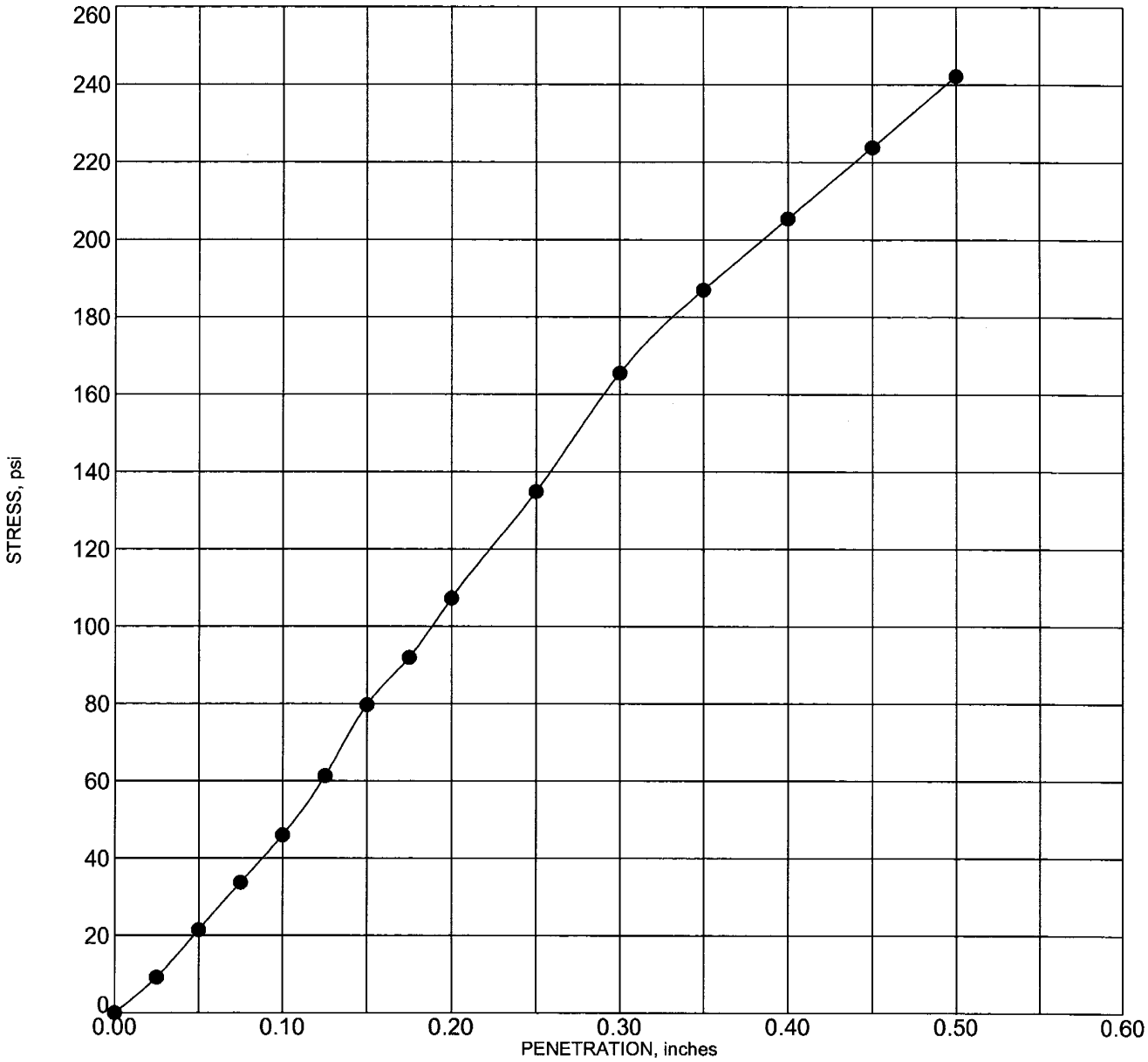
DIRECT SHEAR TEST - ASTM D 3080

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

Plate
C - 3



Corr. CBR @ 0.1"	2.2
Swell (%)	0.96

Sample: Bulk-1
Depth: Surface
Description: Brown clayey silt

Molding Dry Density (pcf)	73.9	Hammer Wt. (lbs)	10
Molding Moisture (%)	42.7	Hammer Drop (inches)	18
Days Soaked	5	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

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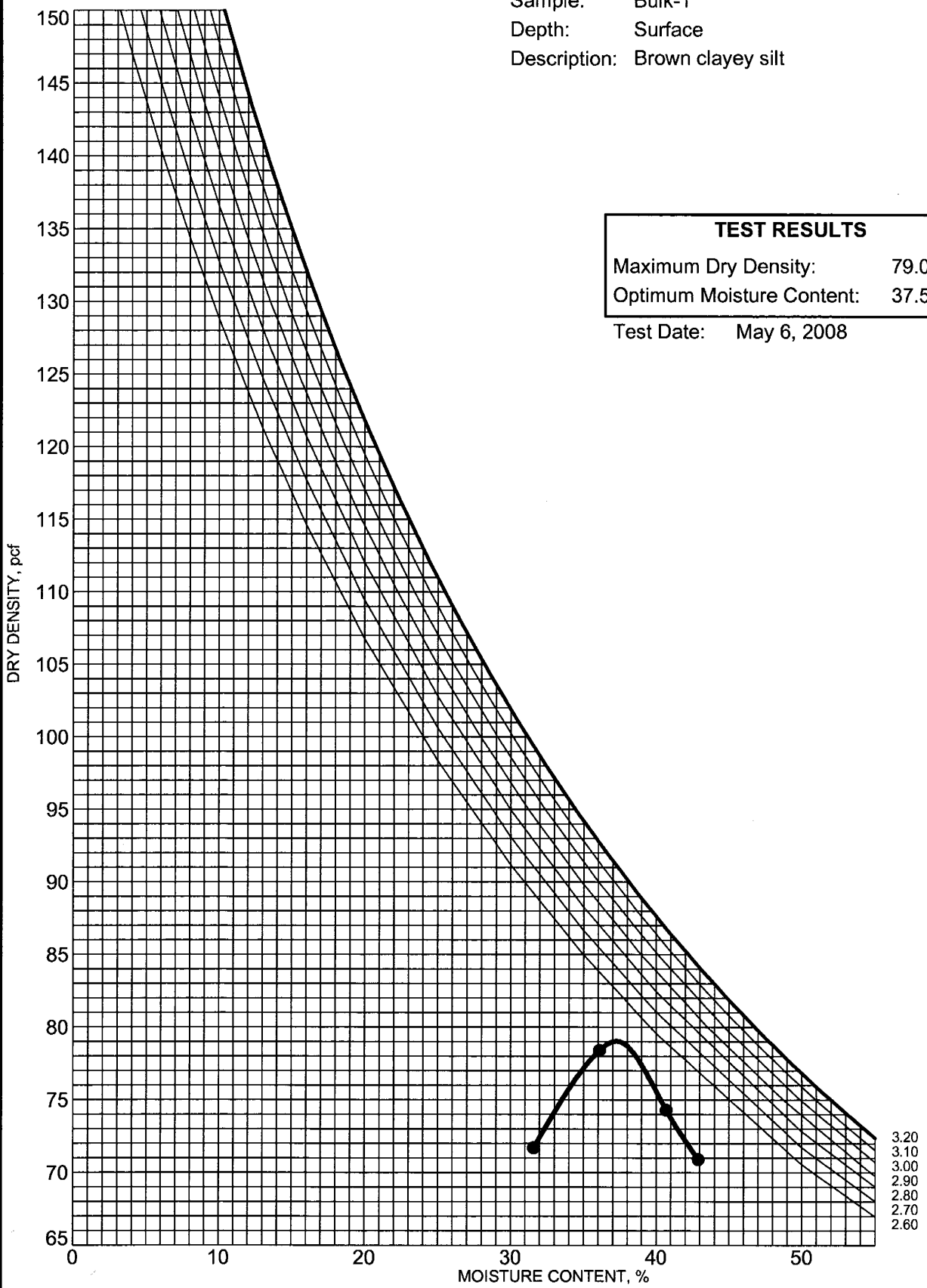
CALIFORNIA BEARING RATIO - ASTM D 1883

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

Plate
C - 4

Sample: Bulk-1
Depth: Surface
Description: Brown clayey silt



TEST RESULTS

Maximum Dry Density:	79.0 pcf
Optimum Moisture Content:	37.5 %

Test Date: May 6, 2008

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W.O. 5915-10

MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

ENERGY LABORATORY
HAWAII PREPARATORY ACADEMY
WAIMEA, ISLAND OF HAWAII

Plate
C - 5

G COMPACTION65 5915-10.GPJ GEOLABS.GDT 7/9/08

APPENDIX D

Percolation Testing

APPENDIX D

Percolation Testing

As part of our field exploration program, we conducted one percolation test in a selected boring in general accordance with the State of Hawaii, Department of Health's Administrative Rules, Chapter 11-62-31.2, "Wastewater Systems" and Chapter 10 of the Ten State's Standards. In general, the boring drilled had a diameter of about 4.5 inches and extended to a depth of about 5 feet below the ground level at the time of the test. The percolation test results are presented on Plate D-1.

(h:\5900series\5915-10.st1-pg.41)

SITE EVALUATION/PERCOLATION TEST

Date/Time: April 22, 2008 / 10:25 AM P-1

Test performed by: Steve Latronic

Owner: Hawaii Preparatory Academy

Tax Map Key: T.M.K.: 6-5-01: 09

Elevation: +2,549 ft MSL
Depth to Groundwater Table: N/A ft below grade
Depth to Bedrock (if observed): N/A ft below grade

Diameter of Hole: 4.5 in
Depth to Hole Bottom: 5 ft below grade

Soil Profile

Depth below grade	(color, texture, other)
0 – 5'	Brown CLAYEY SILT (MH) w/ sand and gravel

PERCOLATION READINGS

Time 12 in of water to seep away: >400 min (first trial reading)
Time 12 in of water to seep away: >400 min (second trial reading)

Check one:
_____For percolation tests in sandy soils, record time intervals and water drops at least every 10 minutes for at least 1 hour.

X For percolation tests in non-sandy soils, presoak the test hole for at least 4 hours. Record time intervals and water drops at least every 10 minutes for 1 hour; or if the time for the first 6 inches to seep away is greater than 30 minutes, record time intervals and water drops at least every 30 minutes for 4 hours or until 2 successive drops do not vary by more than 1/16 inch.

Time Interval (min)	Drop in Inches	Time Interval (min)	Drop in Inches
30	2.0		
30	1.0		
30	2.0		
30	1.0		
30	2.0		
30	1.0		
30	2.0		
30	1.0		

Percolation Rate (time/final water level drop): 30 min/in

As the engineer responsible for gathering and providing site information and percolation test results, I attest to the fact that the above site information is accurate and that the site evaluation was conducted in accordance with the provisions of Chapter 11-62, "Wastewater Systems" and the results were acceptable.

ROBIN M. LIM
LICENSED PROFESSIONAL ENGINEER
No. 8436-C
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE — EXPIRATION DATE OF THE LICENSE 4-30-10

Revised 5/92