GEOTECHNICAL ENGINEERING REPORT
HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MILEPOST 28 TO MILEPOST 42)
ISLAND OF HAWAII

OCTOBER 10, 2003

Prepared for

OKAHARA AND ASSOCIATES, INC.

and

FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS
HIGHWAYS DIVISION

W.O. 3411-20

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THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

SIGNATURE

4-30-04
EXPIRATION DATE
OF THE LICENSE

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GEOLABS, INC.
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October 10, 2003
W.O. 3411-20

Mr. Donald Okahara
Okahara & Associates, Inc.
200 Kohola Street
Hilo, HI 96720

Dear **Mr. Okahara:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Report, Hawaii State Route 200 (Saddle Road), PTA-1 Alignment (Milepost 28 to Milepost 42), Island of Hawaii" prepared in support of the design of the project.

Our work was performed in general accordance with the scope of work outlined in Task Order No. DTFH68-00-T-00008, Statement of Work document dated May 26, 2001 (modified by the memorandum of Mr. Barry D. Siel dated June 12, 2001), and our revised fee proposal dated June 22, 2001.

Detailed discussion and specific recommendations for the design of the project 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:TK:mg

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

Based on the results of our field exploration program, it appears that the majority of the proposed Saddle Road PTA-1 alignment is predominantly underlain by weakly cemented, poorly graded sands and moderately cemented conglomerate materials that overlie the underlying a'a basalt rock formation. Volcanic ash and pahoehoe basalt rock formations are exposed at the ground surface near the eastern terminus of the roadway alignment. In general, we believe that a large portion of the excavated materials may be used as a source of fill materials for embankment construction, provided that the materials are properly processed and placed in accordance with the recommendations presented in the "Site Grading" section of this report.

The near-surface volcanic ash soils, if used as a source of fill materials, should be blended with the cinder sands, alluvial sands, and/or basalt rock fragments to provide a relatively well-graded material prior to placement as fills for the construction of embankments. Because the volcanic ash soils may be potentially thixotropic in nature (when wet), significant strength may be temporarily lost when remolded and/or disturbed. Furthermore, the volcanic ash soils are highly susceptible to wind and/or surface water erosion. Therefore, appropriate soil erosion protection, dust control provisions, and earthwork construction procedures should be observed and implemented during the earthwork operations when volcanic ash soils are involved. If it is necessary to utilize the pure volcanic ash soils as fill materials, the contractor should be made aware that additional time and effort likely will be involved with the fill placement operations. In general, we believe that cut slopes exposing the volcanic ash deposits should be designed with a slope ratio of 3H:1V or flatter.

The excavated cinder sand and alluvial sand materials encountered in our exploration may be used as a source of fill materials or blended with volcanic ash soils and basalt rock fragments to provide a relatively well-graded fill material. Based on our experience, the cinder sands and alluvial sands may experience a volume decrease of about 10 to 20 percent when excavated, processed, and used as fill material. In general, cut slopes exposing cinder sand and alluvial sand deposits may be designed with a slope ratio of 2H:1V or flatter. However, it should be noted that the cinder sands and alluvial sands are highly susceptible to erosion (by wind and/or surface water runoff) and should be adequately protected from erosion by appropriate means.

In general, cut materials generated from excavations into the surface conglomerate and underlying basalt formation may be used as a source of fill and

backfill materials. However, fill materials within the upper 2 feet from the finished subgrades should be screened of over-sized materials and processed to provide a relatively well-graded material to prevent the occurrence of voids in the compacted mass. Over-sized rock fragments (greater than 6 inches in maximum dimension) may be utilized in the fills deeper than 2 feet below the finished subgrades or they may be broken down to smaller-sized materials (meeting the maximum particle size requirements) and incorporated into the upper fill materials. Placement of boulders (rock fragments larger than 24 inches in dimension) in fills should be in accordance with the procedures recommended in the "Boulder Disposal" subsection of this report.

Based on our experience, clinker materials may experience a substantial volume decrease of about 20 to 30 percent when excavated, processed, and used as fill materials. On the other hand, dense basalt formation may experience an increase in volume of about 5 to 10 percent when excavated, processed, and used as fill materials. Cut slopes exposing clinker materials and dense basalt may be designed with a slope ratio of 1.5H:1V and 0.5H:1V or flatter, respectively. Embankment fills constructed of well-graded basaltic gravel, cobbles and boulders may be designed with a slope ratio of 2H:1V or flatter.

Due to the potential for presence of cavities, soft, loose and/or wet soils at the site, we recommend that contingencies be included in the cost estimates for over-excavation of these areas and structural fill placement to account for variations in the over-excavation and backfill quantities.

It should be noted that the on-site soils exist in a relatively dry state and will require a substantial amount of water and water trucks for transport of the water needed during construction to achieve the specified moisture content of the soils for earthwork construction (subgrade preparation and controlled fill placement). For preliminary estimating purposes, we believe that approximately 44 to 62 gallons of water (with an average of about 50 gallons) would be needed to attain the specified moisture contents of the soils for each cubic yard of earthwork (subgrade preparation and controlled fill placement) at the project site. In addition, a significant amount of water also would be needed for dust control and other earthwork related activities during construction.

Our field percolation testing at selected locations indicated that the in-situ materials along the roadway alignment exhibit relatively low permeability for the basalt rock formation to a relatively high percolation rate for the sandy soils. Provisions should be made in the contract documents to extend the drywells deeper for the disposal of storm water runoff, if needed, in order to achieve the design disposal capacity.

Detailed discussion of these items and our geotechnical recommendations for design of the project are presented in the following sections of this report.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1.0 - GENERAL

1.1 Introduction

This report presents the results of the geotechnical engineering exploration performed for the PTA-1 alignment of the new Saddle Road (State Route 200) project located in the vicinity of the Pohakuloa Training Area (PTA) in the District of Hamakua on the Island of Hawaii. More specifically, the project is located approximately between Milepost 28 and Milepost 42 of the existing Hawaii State Route 200 (Saddle Road). The general location and the vicinity of the project limits are shown on the Project Location Map, Plate 1.

This report summarizes the findings and presents our geotechnical engineering recommendations resulting from our literature research, site reconnaissance, field exploration, laboratory testing, and engineering analyses performed for the proposed Saddle Road PTA-1 Alignment project. These findings and geotechnical engineering recommendations are intended to support the design of the project and include information for the planning, design, and project cost estimation purposes only. The findings and recommendations presented herein are subject to the limitations noted at the end of this report.

1.2 Background Information

The existing Saddle Road was initially constructed in 1942 by the United States Department of the Army to provide access to the Pohakuloa Army Base on the Island of Hawaii. The road was released by the United States and turned over to the Territory of Hawaii in 1945. The Territory of Hawaii maintained the road until 1957 and then transferred the maintenance responsibility to the County of Hawaii. In 1965, Saddle Road was included in the State Highway System established by the State of Hawaii. However, we understand that the County of Hawaii has continued to provide maintenance work for Saddle Road up to this date.

Saddle Road is the only paved arterial roadway serving the U.S. Department of the Army's Pohakuloa Training Area (PTA) and the astronomy complexes located atop

Mauna Kea Volcano. Saddle Road also has become an important cross-island link between Hilo (center of the county government) on the east side of the island, Waimea toward the north, and Kailua-Kona and the developing resort areas located on the west side of the Island of Hawaii. Until recent reconstruction efforts by the County of Hawaii, the route has received only minimal upgrading since it was first constructed. Between 1988 and 1992, the County of Hawaii widened and repaved 14 miles of the existing alignment from Hilo westerly. However, geometric deficiencies (i.e., substandard horizontal and vertical curvature) still exist. We understand that the existing Saddle Road alignment remains inadequate in terms of currently acceptable roadway design standards.

As a result, it was proposed to improve the existing Saddle Road into a two-lane highway with enough capacity to handle both current and projected traffic volumes up to Year 2025. The proposed Saddle Road project will extend approximately from State Route (SR) 190, the Mamalahoa Highway (western terminus), to about Milepost 6, (the intersection of Saddle Road with the proposed Puainako Street Extension) near the Town of Hilo (eastern terminus). The approximate length of the existing route is about 48.5 miles.

Due to the large areal extent of the corridors and length of the roadway alignment, a preliminary site reconnaissance and background information research to identify potential geologic hazards and/or geotechnical constraints that may affect the planning and preliminary design of the proposed roadway alignment was undertaken by our office. The findings and preliminary geotechnical engineering recommendations in support of the Environmental Impact Statement documents are presented in our report entitled "Preliminary Geotechnical/Materials Report, Proposed Saddle Road Project, Mamalahoa Highway to Hilo, Island of Hawaii" dated July 24, 1996.

Subsequently, a preliminary geotechnical engineering exploration was conducted in support of the 30% Preliminary Design Phase of the project. The preliminary geotechnical field exploration under Task Order No. DTFH68-99-T-00005 generally consisted of site reconnaissance and the performance of seismic refraction geophysical

surveys along the new roadway alignment. In general, a seismic refraction survey is a geophysical subsurface exploration method that involves the application of energy to the ground surface at a source location and the subsequent measurement of the rate of energy transmission in the form of elastic compression waves passing through the subsurface soil and rock materials.

In addition, a limited subsurface exploration consisting of borehole drilling was conducted to supplement the information obtained using the seismic refraction exploration method described previously. The subsurface exploration was conducted to evaluate the general types and depths of the soil and rock materials encountered along the proposed roadway alignment. The boring information was also used to evaluate the correlation of subsurface materials with the seismic refraction wave velocities obtained from the geophysical surveys. The results of our preliminary geotechnical engineering exploration are presented in our report entitled "Preliminary Geotechnical Engineering Exploration, Hawaii State Route 200 (Saddle Road), PTA-1 Alignment (Milepost 28 to Milepost 42), Island of Hawaii" dated January 3, 2001.

1.3 Project Considerations

The work contained in this task order (Task Order No. DTFH68-00-T-00008) for the Saddle Road project addresses only the portion of roadway alignment within the approximate limits of the Pohakuloa Training Area (PTA). This portion of the realigned Saddle Road is located approximately between Milepost 28 and Milepost 42 and is designated as the PTA-1 Alignment as shown on the Saddle Road Alignment Plan, Plate 2.

In general, we envision that the proposed Saddle Road PTA-1 Alignment project will include about 13.14 miles of realigned new roadway along with some segments of existing roadway widening. Based on the information provided, the new roadway will have two 12-foot wide lanes with an 8-foot wide shoulder on the side of each travel direction. Design of the new roadway pavement structure should be referred to the Pavement Justification Report for this project, which was prepared by our office and transmitted under separate cover.

Based on the plan and profile drawings provided for the proposed PTA-1 roadway alignment, we anticipate that the majority of the cuts and fills will be on the order of about 5 to 10 feet thick. However, some major cuts on the order of about 20 to 25 feet deep are anticipated at some isolated locations. In addition, some substantial fills up to about 30 to 40 feet thick may be needed in areas where the proposed highway traverses gullies and broad basins. At the time this report was prepared, it was anticipated that retaining structures would not be required for grade separation because the right-of-way may be acquired to accommodate the cut and/or fill slopes without the need for retaining structures.

Based on the preliminary geotechnical engineering exploration, we recommended that the subsurface exploration for the design phase of the project consist of approximately 28 additional borings ranging in depths from about 20 to 50 feet below the existing ground surface. Due to budget constraints, a memorandum prepared by Mr. Barry D. Siel, Geotechnical Engineer with the Federal Highway Administration, modified the scope of the field exploration to consist of eight additional borings (in-lieu of the 28 borings recommended). The following table provides a list of the eight additional borings recommended by the Geotechnical Engineer with the Federal Highway Administration for this portion of the project. An additional boring (Boring No. 109) was subsequently included to evaluate the subsurface conditions and drainage characteristics at the Pohakuloa Training Area.

ADDITIONAL BORINGS				
Boring No.	**Station No.**	**Earthwork and/or Structure**	**Approximate Depth** (feet)	**Access Conditions**
101	102+25	24 Feet of Cut	39.5	Long Trail
102	114+60	Arch Culvert, 30 Feet of Fill	25	Long Trail with Special Portable Equipment
103	138+40	Arch Culvert	25	Long Trail
104	500+30	20 Feet of Cut	40	Helicopter
105	510+00	24 Feet of Fill	18	Helicopter
106	539+00	18 Feet of Cut	32	Helicopter

ADDITIONAL BORINGS				
Boring No.	**Station No.**	**Earthwork and/or Structure**	**Approximate Depth** (feet)	**Access Conditions**
107	578+00	14 Feet of Fill	32	Minor Leveling
108	608+00	10 Feet of Fill	26	Minor Leveling
109	317+40	Drainage	26.5	Minor Leveling

1.4 Purpose and Scope

The purpose of our geotechnical engineering exploration was to obtain an overview of the surface and subsurface conditions along the proposed new roadway alignment through literature research, site reconnaissance, and field exploration. The subsurface information obtained was utilized to develop an idealized soil/rock data set for the formulation of geotechnical engineering recommendations pertaining to the design of earthwork, structures, and pavements for the proposed Saddle Road PTA-1 Alignment project.

As indicated previously, pavement design recommendations are contained in the Pavement Justification Report prepared for this project transmitted under separate cover. In general, our work on the project was performed in general accordance with Task Order No. DTFH68-00-T-00008, Statement of Work document dated May 26, 2001 (modified by the memorandum of Mr. Barry D. Siel dated June 12, 2001), and our revised fee proposal dated June 22, 2001. The scope of our work included the following tasks and work efforts:

1.4.1 Task 1 – Research and Review of Available Information

Review of the available in-house soils and boring data in the vicinity of the project site retrieved from the preliminary geotechnical engineering exploration. The review also included information obtained from aerial photographs, the United States Geological Service, the Natural Resource Conservation Service, the United States Department of Agriculture Soil Conservation Service, and other available topographic maps and information from State and County sources.

1.4.2 Task 2 – Field Exploration

The field exploration consisted of two categories of work: 1) Site Reconnaissance, and 2) Drilling Exploration. A site reconnaissance of the proposed PTA-1 alignment was conducted during the preliminary geotechnical engineering exploration phase of the project. Therefore, a limited reconnaissance was conducted by our project geologist during the current field exploration to review the site conditions and to collect bulk samples at some of the culvert locations for corrosion testing.

In addition, a reduced drilling exploration consisting of nine additional test borings was conducted to supplement the geophysical data and limited borings performed during the preliminary geotechnical engineering exploration at the site. The additional test borings ranged in depths from about 18 to 40 feet below the existing ground surface, for a total of about 264 lineal feet of subsurface exploration. Field permeability tests were conducted in four of the drilled borings to evaluate the infiltration characteristics of the in-situ soils/rock for the formulation of preliminary recommendations pertaining to the design of the surface water runoff disposal systems.

1.4.3 Task 3 – Laboratory Testing

Laboratory tests were conducted on selected soil samples obtained during the field exploration. The tests were performed to evaluate the on-site soils with respect to the proposed earthwork, drainage structure, and pavement design. The tests performed included Moisture Content, Unit Weight, Atterberg Limits, Grain Size Distribution, Specific Gravity, Direct Shear, R-Value, California Bearing Ratio (CBR), and modified Proctor tests. Unconfined compression tests were performed on selected rock core samples obtained to evaluate the hardness and strength characteristics of the in-situ basalt rock formation. In addition, corrosion tests, including pH, minimum resistivity, chlorides, and sulfates, were conducted on the in-situ soils at some of the culvert locations for the evaluation of corrosion and design of the culverts.

1.4.4 Task 4 – Data Analyses and Design Recommendations

Analyses of the field and laboratory data for the formulation of preliminary geotechnical engineering recommendations for the Intermediate Design Phase (50% Design) and the Plan-In-Hand Design Phase (70% Design) pertaining to earthwork, structures, and pavement design. This task also included attendance of meetings and field reviews with the design team by a project manager from our firm.

1.4.5 Task 5 – Preparation of Geotechnical Engineering Report

Preparation of this report summarizing our work on the project and presenting the findings and recommendations pertaining to the proposed project. In addition, a pavement justification report presenting the pavement design recommendations was prepared and transmitted under separate cover. This task also included quality assurance of our work and client/design team consultation by a principal engineer from our firm.

Detailed descriptions of our field exploration methodology including the Logs of Borings and Seismic Refraction Profiles are presented in Appendix A and Appendix B, respectively, of this report. Laboratory tests were performed on selected soil and rock samples, and the test results are presented in Appendix C. Field permeability tests were conducted in selected borings, and the test results are presented in Appendix D.

END OF GENERAL

SECTION 2.0 - SITE CHARACTERIZATION

2.1 Regional Geology

The Hawaiian Archipelago consists of an elongated island chain comprising the eight major islands of the State of Hawaii and hundreds of small islets and atolls extending for more than 1,000 miles to the northwest of the Hawaiian Island of Niihau. The age of the islands in the Hawaiian Archipelago increases, progressing from the southeast toward the northwest direction.

The Hawaiian Archipelago is believed to have formed as a result of plate tectonic movement working in combination with a relatively deep, stationary focal point of volcanic heat and magma (lava) generation. The Pacific Plate, containing the upper earth's crust underlying the Central Pacific Ocean, continues to slowly move in a northwesterly direction while the nearly stationary "hot spot" of magma generation continues to produce eruptive emissions beneath the plate. As a result, a continuous chain of volcanic islands formed and has slowly moved off in the northwesterly direction, carried away from the active center of volcanism by plate movement. The Island of Hawaii is presently located adjacent to the deep-seated "hot spot" region. The most distant volcanic island remnants located far to the northwest of Hawaii have been reduced to submerged seamounts as a result of a long history of land erosion and subsidence.

The Island of Hawaii, the largest in the Hawaiian Archipelago, covers an area of approximately 4,030 square miles. The island was formed by the coalescence of five primary shield volcanoes. These are Kohala, which is long extinct; Mauna Kea, which has had some activity during recent geologic time; Hualalai, which last erupted in 1801; and Mauna Loa and Kilauea, both of which are considered to be active. Due to the coalescence of the primary volcano flanks, the oldest lower flanks have been overlapped and buried deeply by more recent volcanic eruption of lava; thus, the evolution of the broad dome shape of the Island of Hawaii that is visible today.

As an illustration of volcanic activity on the Island of Hawaii, over the past 150 years or so, Mauna Loa Volcano has averaged a caldera eruption approximately

every several years. Kilauea Volcano continues an ongoing active eruption cycle, which has spanned continuously since about 1983. Therefore, the southern and eastern portions of the Island of Hawaii remain volcanically active whereas toward the north, volcanism appears to be in its waning stages.

A sixth volcano, Loihi, which is presently an active submarine volcano, lies offshore of the southeast coastline of the Island of Hawaii and may emerge some hundreds of thousands of years in the future. Due to the presence of ongoing volcanic activity at Mauna Loa, Kilauea, and Loihi, the Island of Hawaii is located in a zone of active seismic influence. The Island of Hawaii experiences frequent light to moderate earthquakes associated with the movement of underground magma and shifting of the earth's crust under the weight of the growing island formation. Occasional large earthquakes are usually less frequent based on recorded historic occurrence and may involve geologic fault rupture and lateral offset.

2.2 Local Site Geology

The proposed Saddle Road PTA-1 alignment is located in the vicinity of the Department of Army's Pohakuloa Training Area (PTA) in the District of Hamakua on the Island of Hawaii. The PTA is located on the western side of the Humuula Saddle, which forms the central upland portion of the Island of Hawaii located between the Mauna Kea and Mauna Loa Volcanoes. The Humuula Saddle is a broad relatively flat to gently sloping plateau situated between the Mauna Kea and Mauna Loa Volcanoes. The regional terrain rises from the east (Hilo side) and from the west (Waikoloa side) to crest at the Humuula Saddle, which is located just to the west of the intersection of the existing Saddle Road and the Mauna Kea Observatory access road. The Humuula Saddle formed as a result of the coalescence of lava flows erupted from the Mauna Kea and Mauna Loa Volcanoes.

In general, the proposed Saddle Road PTA-1 alignment traverses the foot of the steeper south and southwest facing slopes comprising the upper mass of Mauna Kea Volcano. The south and southwest facing slopes of Mauna Kea rise abruptly from the surrounding flatter terrain of the Humuula Saddle. Several prominent cinder cone vents

composed of bedded tephra deposits are located within and adjacent to the project site. The circular-shape cinder cones rise above the surrounding terrain and represent the volcanic vents from which the younger age volcanic ash, cinder, and scoriaceous rock (pyroclastic tephra) deposits were emitted. The cinder cone vents are typically oriented along the axes of the rift zones that compose Mauna Kea Volcano.

Most of the geologic materials at the project site are derived from the late-stage eruption and erosion of the alkalic a'a lavas and cinder materials emitted from Mauna Kea Volcano. The cinder materials were observed to range in size from fine through coarse sands and include gravel and cobble size pumice and scoria fragments existing in a semi-consolidated and weakly cemented condition. Based on the available geologic information and our experience, the youngest lava flows comprising the surface flanks of Mauna Kea Volcano consist mainly of a'a type lavas.

The a'a lavas typically consist of rubbly and irregular clinker surfaces consisting of loosely indurated basalt rock fragments with layer thickness on the order of about 3 to 15 feet. Below the rubbly surface, very dense and often massive basalt rock termed "blue rock" may be encountered. The dense rock contains the solid core of the a'a lava flow, which may range to several tens of feet in thickness.

Most of the project site has accumulated a ground surface veneer of geologic materials that represent both pyroclastic air-fall deposits, such as volcanic ash and cinder sand emitted from the late-stage eruption of cinder cones, and alluvial materials derived from glaciation and erosion of the upper slopes of Mauna Kea Volcano. The surface veneer of pyroclastic and sedimentary materials generally overlies hard basalt rock. The mantling effect of the surface deposits has created a subdued surface topographic character, which masks the usually observed irregular and undulating topography of a'a lava flows. As a result, the depth from the ground surface to the top of the buried hard basalt rock surfaces varies considerably within relatively short distances.

The flatter terrain, located at the foot of the Mauna Kea mountain slopes in the vicinity of the PTA, is underlain by surface alluvial and fluvial sediments that appear to have been consolidated to form weakly to moderately cemented conglomerate materials, which may be classified as sedimentary rock. The weakly to moderately cemented sediments consist of well-graded sands with embedded gravel, cobble, and boulder clasts that exhibit a rounded shape, which is characteristic of fluvial materials that have been eroded and transported by the work of flowing water.

Previous studies by H.T. Stearns have characterized the deposits as "fan-glomerate" owing to the apparent deposition as alluvial fan features. It is believed that the cemented character of the conglomerate deposits is due to the rapid fluid transportation and quick deposition of the materials from extreme runoff events and associated debris flows. The large-scale runoff events are hypothesized to have occurred when volcanic eruptions rapidly melted portions of the historic Pleistocene age glacial icecap atop Mauna Kea Volcano. The melted water sent torrents of heated debris flows containing rock and sediment down the mountain flanks and gullies to flood the gentle slopes in the vicinity of the Humuula Saddle.

The alluvial fan deposits appear to be thicker at the mouths of the larger gullies carved into the southwestern facing slopes of Mauna Kea Volcano. Two of the more prominent gullies are the Pohakuloa and Waikahalulu Gulches, which are located northerly of the eastern portion of the project site. There are a number of smaller, unnamed gullies along the southwestern facing slopes that are believed to have contributed to the deposition of the alluvial materials located at the foot of the mountain. The alluvial fans may have coalesced to produce the gently sloping, uniform topographic character of the region. Based on our observations, the consolidated sandy materials grade to very coarse conglomerate, consisting of rounded fluvial cobbles and boulders cemented in a matrix of sand and gravel as the mouths of the larger gullies are approached.

Based on our reconnaissance of the ground surface, the near surface exposure of conglomerate materials indicates that the relative boulder content (by volume) may

vary from less than about 5 percent to greater than about 40 percent. In general, the boulders observed at the ground surface appear to range up to about 2 to 3 feet in diameter. It should be noted that larger boulders and blocks of hard rock greater than about 4 to 6 feet in diameter may be encountered buried within the conglomerate deposits.

2.3 General Site Conditions

As mentioned previously, the project site is located on the upland plateau located along the foot of the steeper southwest facing slopes of Mauna Kea Volcano. The summit of Mauna Kea Volcano has an elevation of about +13,784 feet Mean Sea Level (MSL). The neighboring Mauna Loa Volcano, located approximately 25 miles toward the south has a summit elevation of about +13,680 feet MSL. The elevations of the project site ranges from about +5,530 feet MSL at the western terminus of the alignment to about +6,760 feet MSL at the eastern terminus.

The length of the proposed new Saddle Road PTA-1 alignment is approximately 13.14 miles and generally traverses the northern limits of the PTA and portions of the existing power transmission easement. Most of the project site exists as undeveloped land that has been used for army training maneuvers. Despite the remote location of the project site, numerous existing jeep trails traverse the proposed Saddle Road PTA-1 alignment. Some observed disturbance to the native ground conditions along the proposed alignment include localized areas of ground surface grading (flattening and clearance of vegetation) for the construction and maintenance of access trails, and mining of cinder cone and granular alluvial materials.

The project site is generally sparsely to moderately vegetated with flora consisting of grasses, small shrubs, and scattered trees depending on the time of the year. In general, the vegetation coverage gradually increases toward the easterly direction along the proposed road alignment. The middle-eastern half of the proposed alignment traverses some older a'a lava flows where a thicker growth of larger trees was observed. The far-eastern portion of the proposed road alignment traverses land presently occupied by Parker Ranch for cattle grazing. These ranch land areas are

vegetated with short grass and widely scattered pockets of trees. The eastern end of the proposed alignment traverses barren ground surfaces generally devoid of vegetation. The terrain is covered by a relatively young pahoehoe lava flow that emanated from the distant slopes of Mauna Loa Volcano.

The project site is located southerly of the summit of Mauna Kea Volcano and at elevations on the order of about +6,000 feet MSL. The southern flank of Mauna Kea Volcano, including the area of the PTA, resides in a rain shadow created by the blocking effect of the mountain on the moisture bearing northeasterly trade-wind flow. Therefore, rainfall on the southern and southwestern (leeward) flanks of Mauna Kea is generally lower. The zones of greater rainfall generally are located below about +3,000 feet MSL on the northern through eastern flank of Mauna Kea Volcano. Due to the higher elevation of the project site (cooler temperatures and lower humidity) and location on the south facing mountain slopes, annual rainfall is generally less than about 30 inches. The typical rainfall occurs in the afternoon as infrequent light misting showers as clouds and fog form and migrate up toward the Humuula Saddle from the eastern and occasionally the western slopes. Heavier rainfall may be anticipated during storm weather conditions and shifts in the prevailing wind direction.

The average daytime temperatures (in Fahrenheit) range between the low 60s and 70s with abrupt changes occurring with the formation of afternoon clouds and fog. Night-time temperatures average in the upper 40s and 50s under generally clear sky conditions. The low cloud and fog conditions may occur periodically; however, the frequency of occurrence is generally lower than at lower elevations of Saddle Road, which are located toward the east and west of the project site. The overall climate may be characterized as dry, cool, and breezy with relatively low precipitation, low humidity, and a high evaporation rate.

2.4 Geologic Materials

Considering the significant length of the project site, the various geologic deposits encountered along the surface of the proposed roadway alignment are relatively uniform and may be grouped into six generalized types of geologic materials.

The generalized types of geologic materials encountered along the proposed roadway alignment include the following:

GEOLOGIC MATERIAL	DESCRIPTION
Type No. 1	Weakly Cemented, Poorly Graded Sandy Deposits, Loose to Medium Dense Relative Density (Sandy Pyroclastic Cinder and Alluvium)
Type No. 2	Weakly Cemented, Poorly Graded Silt and Sand Mixed with some Basalt Clinker and Scattered Surface Rock Outcroppings, Loose to Medium Dense Relative Density with some Embedded Hard Rock (Silty/Sandy Cinder and Alluvium with some Basalt Rock)
Type No. 3	Moderately Cemented, Well-Graded Sand and Gravel with Cobbles and Boulders, Medium Dense to Very Dense Relative Density (Conglomerate)
Type No. 4	Weakly Cemented, Poorly Graded Pyroclastic, Scoria and Pumice Gravel with Some Cobbles, Medium Dense Relative Density (Gravelly Cinder and Tephra)
Type No. 5	Exposed Basalt Rock Lava Flow, Hard Rock (Exposed Basalt Rock Formation)
Type No. 6	Weakly Cemented, Silty Volcanic Ash with Sand, Stiff to Medium Dense Relative Density (Silty Volcanic Ash)

Based on our field exploration, the most dominant surface materials encountered along the proposed roadway alignment consist of the sandy deposits, which are classified as Geologic Material Type Nos. 1 and 2. These materials are encountered at the ground surface along most of the length of the project site, except easterly of about STA. 555+00 where more silty volcanic ash soils and barren lava rock is encountered at the ground surface. The sands consist of brown and gray colored, poorly graded, fine

to medium-grained sands with some silt (characteristic of a pyroclastic origin) and varying amounts of embedded gravel and/or cobbles and boulders. Based on our field exploration, the sands appear to be weakly to moderately cemented and are medium dense to dense with seismic refraction P-wave (compression wave) velocities of about 950 to 1,500 feet per second.

Some of the sandy deposits, especially those located in the vicinity of the cinder cone vents and on the sloping terrain of the Mauna Kea Volcano mountain flank, may be of pyroclastic origin and exist in their original depositional environment. The sandy deposits (Geologic Material Type No. 2) were observed to contain some basalt clinker and scattered surface outcropping of hard basalt rock material. The rocky character of the Type No. 2 deposits indicate that the potential exists for encountering hard basalt rock and clinker material at relatively shallow depths in the subsurface beneath the surface mantle of sandy soil.

Another dominant geologic deposit encountered along the proposed roadway alignment is Geologic Material Type No. 3, which is referred to as conglomerate. The conglomerate materials are concentrated in the vicinity of the mouths of the larger gulches located along the plateau at the foot of the mountain slopes. The deposits may be recognized on aerial photographs and topographic maps by their uniform fan-shaped topography spreading outward and away from the mouths of the gulch.

Based on our field exploration, the conglomerate material appears to be moderately cemented and consists of rounded cobbles, boulders, and gravel cemented by a silty and sandy matrix. The field exploration data indicate that the materials are generally medium dense to very dense with probable seismic P-wave velocities on the order of about 1,100 to 4,000 feet per second. The higher velocities are believed to occur where a greater percentage of rocky materials including larger boulders and stronger cementation compose the conglomerate. The conglomerate may be observed to be cropping out in the shallow gullies located on the plateau and in the side walls of the deeper gullies located on the lower Mauna Kea Volcano mountain flank northerly of the project site. In addition, ground underlain by conglomerate may be recognized in

the field by the presence of smooth rounded boulders scattered on the ground surface. As mentioned previously, it is believed that the conglomerate deposits originated by the erosion and transportation of upslope materials by glacial melt water and runoff.

Geologic Material Type No. 4 consists of pyroclastic air-fall deposits associated with cinder cone vents that are composed of a variety of tephra materials ranging from fine cinder sand to coarse pumice and scoria gravel and cobbles. The deposits may be encountered on the steep slopes composing the cinder cones and on the surrounding terrain located in the vicinity of the cinder cones. The materials appear to be weakly to moderately cemented and medium dense in relative density. The exposed surfaces may be brown in color and loose in relative density due to environmental exposure to weathering processes, which act to break down the grain cementation.

Based on our field exploration, the seismic P-wave velocities of the pyroclastic sand deposits appear to average about 1,100 feet per second. Also included with the pyroclastic deposits are layers of soft to stiff volcanic ash, which generally consist of light brown colored, low plasticity, fine sandy silts and silty sands. The volcanic ash may typically cap the thicker pyroclastic deposits or may be interbedded within the clinker surface layer of the underlying a'a lava rock.

A'a basalt rock is widespread across the project site and generally exists buried in the subsurface beneath the surface cover of pyroclastic deposits, the alluvial sands, and the conglomerate deposits. Segments of the proposed roadway alignment may encounter buried a'a basalt rock located in relatively close proximity to the ground surface. Shallower depth basalt rock may be anticipated where in-situ jagged, brown colored rock outcroppings are observed protruding among a "matrix" of fine-grained alluvial and pyroclastic sediments. As mentioned previously, the a'a basalt rock encountered at the project site typically consists of an undulating, thick, rubbly clinker surface ranging from about 3 feet to greater than 10 feet in thickness overlying very dense, massive basalt rock.

The surface sandy cinder and alluvial soils usually mantle the top of the buried a'a lava flow; therefore, the ground surface expression of the buried a'a lava flow may resemble a relatively smooth sandy surface with some scattered clinker fragments or basalt rock protruding. Because of the buried undulating rocky terrain, the top of the basalt rock may be encountered at variable depths in the subsurface corresponding to the buried topographic mounds and depressions that are typical of a'a lava flows.

Geologic Material Type No. 5 consists of exposed hard basalt rock at the ground surface that generally is devoid of soil cover. Surface exposure of pahoehoe basalt rock consisting of relatively flat to very gently undulating terrain was encountered near continuously between about STA. 631+00 and about STA. 694+00. Periodic areas of hard a'a basalt rock outcropping were encountered between about STA. 550+00 and about STA. 631+00 as shown on the Site Plans, Plates 4.10 and 4.11. Other widely scattered and localized surface outcroppings of hard basalt rock were encountered along the alignment between about STA. 482+00 and about STA. 545+00. The localized hard rock outcroppings were generally encompassed by sandy cinder soils (Geologic Material Type No. 2) and were typically exposed as knoll and ridge topography.

The pahoehoe basalt rock encountered at the far-eastern end of the proposed roadway alignment forms a broad, relatively flat, black colored surface generally devoid of vegetation. The pahoehoe rock was erupted from Mauna Loa Volcano in 1935 and ponded against the pre-existing lava flows of Mauna Kea Volcano. The ground surface is typified by relatively smooth, low relief hummocks separated by open fractures that penetrate several feet into the surface of the lava flow. Some scattered pockets of loose, rocky rubble mounds are interspersed across the flow surface. Based on our field exploration, the pahoehoe lava flow ranges in thickness between about 3 and 15 feet and is underlain by reddish brown colored clinker materials representing the top of an older buried a'a lava flow. The seismic P-wave velocities in the pahoehoe rock appear to be on the order of about 4,300 feet per second. The underlying clinker appears to have a seismic P-wave velocity of about 2,000 feet per second.

Based on our field exploration, the basalt rock encountered by the field exploration ranges from medium hard and highly fractured to very hard and massive. The seismic P-wave velocities appear to range from about 2,000 to 3,000 feet per second for medium hard clinker and from about 3,000 to 10,000 feet per second for hard to very hard basalt rock. It should be noted that some open fractures, voids, and small diameter lava tubes were encountered in the borings drilled at the project site.

Geologic Material Type No. 6 consists of silty volcanic ash soils, which are encountered sporadically along the proposed roadway alignment. The silty volcanic ash soils are generally composed of stiff, light brown to brown colored, silty fine sand. In general, these soil materials are most commonly encountered in the vicinity of cinder cone vents, on the adjacent slopes of Mauna Kea Volcano, and at the far-eastern portion of the project. Secondarily, some of the silty volcanic ash materials were observed mixed with the sandy soils composing the flatter plateau areas. Localized deposits of wind-blown volcanic ash also may be encountered in protected locations that are favorable for aeolian deposition. Once disturbed by vehicle traffic or excavation, the dry ash soils exhibit a very light and powdery character that is highly susceptible to erosion.

2.5 Existing Site Conditions

A site reconnaissance was conducted prior to the commencement of the field exploration program in an effort to map the surface deposits and select possible locations for the seismic refraction survey and drilling exploration. A set of preliminary topographic maps and profiles were provided by Okahara & Associates, Inc. for our use to reference the location of the proposed roadway alignment and features noted in the field. The reconnaissance was accomplished by driving along the existing jeep trails that intersect the proposed roadway alignment and by hiking in the less accessible portions of the alignment. At the time of our site reconnaissance, the centerline and boundary stakes were available for our use in referencing the location of the proposed roadway alignment. Descriptions of the surface and exposed subsurface materials encountered and other pertinent features observed during our site reconnaissance are presented in the following subsections.

2.5.1 STA. 0+00 to STA. 33+80

The proposed alignment traverses low relief topography, which is gently inclined toward the east. The ground surface appears to be composed of dry, weakly cemented, medium dense silty sands with some gravel and cobbles. The upper 1 foot depth is weathered and loose. Some low hills with basalt rock outcroppings were observed in the vicinity of STA. 29+00 to STA. 33+00 on the left side of the alignment. The vegetation consists of nearly complete ground coverage consisting of small shrubs.

Subsurface data (B-1 and SR-1) indicate that the alluvial soils located on the plateau area may extend to depths of about 10 to 20 feet below the ground surface where hard basalt rock may be encountered. Other shallower depth rock formation may be anticipated where the alignment traverses closer to the base of the Mauna Kea Volcano mountain flank.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 1 and some localized Geologic Material Type No. 2. The approximate mapped location of the materials is shown on the Site Plan, Plate 4.1

2.5.2 STA. 33+80 to STA. 52+50

The proposed alignment traverses low relief topography, which is gently inclined toward the east with the exception of a moderately inclined hill associated with the lower, western flank of the cinder cone. The near-surface soils consist of dry silty fine sand that is believed to represent pyroclastic ash and cinder deposited in a weakly cemented condition. A significant gully showing good profile exposure of the buried spatter lava formation exists near the northern boundary of the alignment at about STA. 36+00. Vegetation generally consists of grasses and scattered small shrubs.

Subsurface data (B-2 and SR-2) indicate that medium dense sandy pyroclastic soils overlie a layer of medium hard, porous, spatter lava and clinker material. The

seismic refraction data indicate that hard basalt rock may exist at depths of about 30 to 40 feet below the ground surface adjacent to the cinder cone. Visual evidence of basalt rock located at the ground surface was not observed.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 1. The approximate mapped location of the materials is shown on the Site Plan, Plate 4.1.

2.5.3 STA. 52+50 to STA. 116+00

The proposed alignment continues to climb the Mauna Kea Volcano mountain flank around the north side of a group of three prominent cinder cones. A large cut is planned between about STA. 93+00 and STA. 109+00. The alignment then traverses back down the mountain flank to merge with the plateau area. The relief is moderate as the alignment crosses some incised gullies and broad sloping ridge and bowl topographic features. The near-surface soils consist of dry, brown colored, silty sand with basalt rock fragments. Scattered outcroppings of basalt rock and clinker produce a slightly irregular ground surface. The clinker outcroppings protrude through the surrounding flattened ground surface composed of weakly cemented sandy soil. The occurrence of the rock outcroppings indicates that basalt rock may be encountered locally in the shallow subsurface.

Subsurface data (B-3, B-101, B-102, and SR-3 through SR-8) indicate that the general stratigraphy for this segment may consist of about 5 to 15 feet of medium dense, cemented sand over medium hard to very hard a'a basalt rock.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 2. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.1 and 4.2.

2.5.4 STA. 116+00 to STA. 204+00

The proposed alignment traverses generally flatter, low relief terrain located on the plateau that is inclined gently toward the east. Some broad, gently sloping topographic rises are traversed centered at about STA. 169+00 and STA. 196+00.

Some partially exposed basalt rock outcroppings were observed at the ground surface in the vicinity of about STA. 126+00 to STA. 129+00. In addition, an area of scattered surface basalt rock outcroppings was observed located toward the south (right side) of the proposed alignment in the vicinity of about STA. 142+00 to STA. 154+00 indicating that shallower rock conditions may exist in the vicinity. As the proposed road alignment traverses closer to the foot of the mountain slopes (about STA. 185+00 and onward), the surface soils were observed to contain a greater percentage of rock fragments generally consisting of clinker and cobbles. Vegetation along this segment consists of a growth of mostly low shrubs and some grasses.

Subsurface data (B-4, B-5, B-103, and SR-9 through SR-13) indicate that the general stratigraphy for this segment may consist of about 20 to 30 feet of medium dense, cemented sand with some rock fragments and cobbles overlying hard basalt rock. In the vicinity of about STA. 152+00, the basalt rock surface may exist at somewhat shallower depths of about 10 to 20 feet below the ground surface.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 1 and some localized Geologic Material Type No. 2. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.2 through 4.4.

2.5.5 STA. 204+00 to STA. 215+00

The proposed road alignment traverses some moderately rugged, steeper terrain that crosses an area of surface basalt rock outcroppings exhibiting positive relief above the surrounding ground surface. Based on our observations, the a'a basalt rock may exist at the ground surface and buried in the shallow subsurface at depths of less than about 10 feet below the ground surface. The vegetation consists of low shrubs and grasses.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 2 with some Geologic

Material Type No. 5. The approximate mapped location of the materials is shown on the Site Plan, Plate 4.4.

2.5.6 STA. 215+00 to STA. 241+00

The proposed road alignment traverses low relief terrain, which is gently inclined toward the east. The ground surface is covered with weakly cemented dry sandy and gravelly alluvial soils, which contain rounded basalt cobbles and some boulders. A good exposure of these conglomerate materials was observed in the small gully crossing the alignment at about STA. 223+60. A series of man-made bermed features of approximately 10 to 15 feet in height exist along the alignment. The bermed features consist of generally loosely placed sand and rock fragments with some cobbles and boulders that appear to be representative of the surrounding native soils.

Subsurface data (SR-14 and SR-15) indicate that the cemented sandy and rocky soils may extend to depths greater than 20 feet below the existing ground surface. The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 3. The approximate mapped location of the materials is shown on the Site Plan, Plate 4.4.

2.5.7 STA. 241+00 to STA. 304+00

The proposed road alignment traverses terrain of generally low relief that is gently to moderately inclined toward the east. Several more bermed features were observed along this segment of the alignment. In addition, a well-defined drainage gully is traversed at about STA. 281+75. The gully provides good exposure of the cemented coarse alluvial materials (conglomerate) that generally consist of well-graded gravel, cobbles, and boulders with sand. This segment of the roadway alignment traverses the surface of a broad and topographically well-defined alluvial fan that emanates from the large gulch located northerly of about STA. 283+00.

Based on our observations, it appears that the boulder content of the conglomerate is greater throughout this segment of the alignment. Boulders of generally 2 to

3 feet in size were observed at the ground surface and in the vicinity of an existing borrow pit located northerly of about STA. 272+00. The borrow pit offers an approximately 10-foot thick exposure of the conglomerate materials.

Subsurface data (B-6 and B-7 and SR-16 through SR-19) indicate that the cemented alluvial materials are coarser and more strongly cemented than the alluvial deposits previously encountered along the proposed alignment. Due to the greater quantity of embedded cobble and boulder materials and the stronger cementation, the seismic P-wave velocities are generally greater (2,800 to 4,000 feet per second), attaining velocities similar to basalt rock materials. Based on the subsurface data, basalt rock formation may be encountered at depths of greater than about 20 feet below the ground surface.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 3. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.5 and 4.6.

2.5.8 STA. 304+00 to STA. 312+00

The proposed roadway alignment traverses the lower northern flank of a cinder cone (Puu Pohakuloa). The original shape of the cinder cone appears to have been altered by some cinder mining activity. A gully and dry streambed exists bounding the cinder cone toward the north. A significant accumulation of loose surface boulders was observed at about STA. 307+50 in the vicinity of an existing streambed.

Based on our observations, the materials encountered by the proposed alignment may include loose to cemented fluvial and alluvial deposits associated with the streambed, surface sandy and rocky materials (conglomerate) composing the slopes not associated with the cinder cone, and weakly cemented, porous cinder cone materials consisting of gravel and cobbles.

Subsurface data (B-8 and SR-20) indicate that the subsurface conditions along this segment vary with respect to location. The materials composing the cinder cone

are medium dense and weakly cemented cinder gravel and cobbles. The materials covering the adjacent slopes and lower elevations include loose to medium dense, sandy and rocky fluvial and alluvial materials overlying hard basalt rock formation. Based on our observations and data from Boring No. 8, the hard basalt rock may be encountered buried in the subsurface at depths of about 15 to 30 feet below the ground surface. Very hard and massive basalt rock formation was observed exposed in the stream channel bottom located northerly of the proposed alignment.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type Nos. 3 and 4. The approximate mapped location of the materials is shown on the Site Plan, Plate 4.6.

2.5.9 STA. 312+00 to STA. 481+50

The proposed alignment traverses low relief, gently sloping ground, which is inclined toward the east. The alignment crosses multiple small and medium size dry streambeds showing exposure of the semi-consolidated sandy and rocky alluvial and conglomerate materials comprising the shallow subsurface. The alignment also crosses the existing Saddle Road at the location just westerly of the existing Mauna Kea State Park. Multiple jeep trails intersect the proposed alignment located easterly of Mauna Kea State Park. The existing power line easement and associated access trail parallels the proposed alignment toward the north between about STA. 406+00 and STA. 476+00.

Based on our observations, the boulder content of the near-surface conglomerate appears to be relatively higher between about STA. 312+00 and STA. 360+00 and between about STA. 448+00 and 481+50. However, boulders larger than about 2 to 3 feet in size were not observed at the ground surface. Some scattered, rounded alluvial boulders ranging up to about 4 feet in diameter were observed along the alignment segment from about STA. 444+00 to about STA. 481+50. In addition, some widely scattered pockets of low relief basalt rock outcroppings were observed between about STA. 415+00 to about STA. 448+00. The basalt rock

outcroppings may be indicative of in-situ basalt rock formation existing at shallow depths in the subsurface.

Subsurface data (B-9 through B-11, B-109, and SR-21 through SR-31) indicate that the proposed alignment may be underlain by about 5 to 10 feet of weakly cemented sandy alluvium and conglomerate overlying more consolidated alluvial deposits. In general, hard basalt rock may be encountered at depths of about 20 to 30 feet below the ground surface. Boring No. 10 (B-10) and SR-28 through SR-30 indicate that hard basalt rock may be encountered at shallower depths of about 5 to 10 feet below the ground surface at their respective locations corresponding to between about STA. 415+00 and about STA. 475+00.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 3, followed by Geologic Material Type No. 1 and finally Geologic Material Type No. 2 in relative order of occurrence. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.6 through 4.9.

2.5.10 STA. 481+50 to STA. 545+50

The proposed alignment traverses some irregular ground surfaces of moderate to high relief consisting of rocky knolls and hilly terrain separated by flatter low relief ground surfaces. Basalt rock outcrops and surface deposits of large boulders (up to 6 feet in diameter) are frequently encountered, especially at the crests of hills located along the alignment. This segment of the proposed alignment appears to contain the most extensive quantity of basalt rock composing the surface and shallow subsurface of the alignment encountered thus far. The hard basalt rock appears to be mantled by a surface layer of cinder sand mixed with clinker and basaltic boulders.

The vegetation is generally thicker and consists of tall grass, shrubs and some groves of larger trees. Due to the localized growth of some larger trees, the normally sandy surface soils were observed to contain a component of dark brown,

silty organic matter, especially where the groves of mature tree growth were observed. The ground surface elevations continue to increase toward the east.

Subsurface data (B-104, B-105, B-106, and SR-32 through SR-35) indicate that the proposed alignment may be underlain by hard basalt rock covered with a mantle of sandy soil with some clinker and loose boulders. Based on the field exploration, the depth to the hard basalt rock generally may be on the order of about 5 to 10 feet. Based on our observations, some hard basalt rock and clinker (Geologic Material Type No. 5) was encountered at the ground surface protruding from the surrounding sandy soils.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 2 with some Geologic Material Type No. 5. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.9 and 4.10. The majority of this segment of the alignment was mapped as Geologic Material Type No. 2 due to the predominance of the sandy soil cover overlying basalt rock formation. Significant surface outcropping of hard basalt rock was mapped as Geologic Material Type No. 5.

2.5.11 STA. 545+50 to STA. 582+00

The proposed alignment traverses terrain of generally low relief that begins to gradually fall in elevation toward the east. The alignment traverses between a series of cinder cone vents; therefore, it appears that the surface ash and cinder soils may be thicker because of the proximity to the cinder cone vents. Some elongated lobes of basalt rock protrude from the surrounding soils and transect the alignment at about STA. 550+00 and STA. 555+50. Other irregular surface outcroppings of hard basalt rock were observed between about STA. 564+00 and STA. 566+00 and between about STA. 571+50 through STA. 576+00. The basalt rock in this area is an anomalous feature with respect to the generally flattened soil covered ground surfaces of this segment. Based on our observations, the surface soils appear to grade with greater silt and very fine sand components that resemble finer-grained volcanic ash deposits.

Subsurface data (B-12, B-107, and SR-36) indicate that the proposed alignment may be underlain by volcanic ash and cinder overlying hard basalt rock. The basalt rock was encountered at a depth of about 11 feet below the ground surface at Boring No. 12 (B-12), which contrasts with the previously mentioned basalt rock outcrops that exist at the ground surface located toward the southeast. Boring No. 107 (B-107) encountered a hard basalt rock layer sandwiched between volcanic ash and cinders at a depth of about 10 to 20 feet below the ground surface. Therefore, it appears that basalt rock may be encountered at variable depths mixed with volcanic ash layers. Furthermore, the data obtained at SR-36 indicates that the basalt rock may be buried at depths of about 30 feet below the flatter, ash covered ground surfaces. The refraction survey at SR-37 was performed along the crest of a basalt rock outcropping to evaluate the relative hardness of the exposed basalt rock material.

The primary geologic materials encountered at the surface along this segment of the alignment include Geologic Material Type No. 6 with some Geologic Material Type Nos. 1 and 5. The approximate mapped location of the materials is shown on the Site Plan, Plate 4.10.

2.5.12 STA. 582+00 to STA. 631+00

The proposed alignment traverses terrain of low to moderate relief with locally high relief that falls in elevation toward the south. The ground surface consists of scattered high relief mounds and lobes of hard basalt rock outcropping at the ground surface. The basalt rock outcroppings represent a'a lava flow surfaces; therefore, the exposed surfaces are irregular and jagged and consist of hard boulders and tabular shaped rock fragments. The ground surface between the rock outcrops is generally flat and composed of light brown sandy and silty volcanic ash supporting a growth of grass turf. The volcanic ash soil moistures were observed to be damp to moist, which is in contrast to the dry soil conditions encountered throughout most of the alignment toward the west.

Subsurface data (B-13, B-14, B-108, and SR-38 and SR-39) indicate that the proposed alignment traverses areas of hard basalt rock exposed at the ground surface and areas of medium stiff volcanic ash and clinker overlying hard to very hard basalt rock buried in the subsurface. The test borings drilled adjacent to the existing surface rock outcroppings indicate that the surface volcanic ash soil deposits may range from about 3 to 8 feet thick. Below the surface volcanic ash, basalt clinker mixed with some ash was encountered extending to depths of about 15 to 18 feet below the existing ground surface. Very hard basalt rock was encountered below the significant thickness of clinker materials encountered.

Based on the field exploration, it is anticipated that the depth to basalt rock may vary considerably over very short distances as evidenced by the occurrence of deeper basalt rock located adjacent to surface outcropping of hard basalt rock. The primary geologic materials encountered at the surface along this segment of the alignment include Geologic Material Type Nos. 2, 5 and 6. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.10 and 4.11.

2.5.13 STA. 631+00 to STA. 694+00

The proposed alignment traverses a young pahoehoe lava flow (1935), which is relatively flat with low surface relief. The pahoehoe flow surface has many open fractures and crevices created by the cooling and contraction of the molten lava. The lava flow also contains localized pits and depressions up to about 8 feet in depth, which are exposed at the ground surface. It is anticipated that some voids and smaller lava tubes may be encountered in the upper 10 feet of the pahoehoe lava flow. The pahoehoe lava from Mauna Loa Volcano flowed and ponded in a topographic low created by an older a'a lava flow. Some of the older, reddish brown colored a'a lava flow is visible beneath thinner portions of the overlying pahoehoe lava. The alignment intersects with the existing Saddle Road near the termination of the eastern project limits.

Subsurface data (B-15 and SR-40 and SR41) indicate that the hard pahoehoe lava overlies a rubbly a'a lava flow and that the thickness of the pahoehoe lava flow may

range from about 5 to 15 feet thick. Due to the lower P-wave velocity of the underlying a'a lava flow (velocity inversion), layer profile computations could not be performed using seismic refraction in this area.

The primary geologic materials encountered at the ground surface along this segment of the alignment include Geologic Material Type No. 5. The approximate mapped location of the materials is shown on the Site Plans, Plates 4.11 and 4.12.

2.6 Subsurface Conditions

Our preliminary field exploration program for the proposed Saddle Road PTA-1 Alignment project consisted of drilling and sampling 15 borings, designated as Boring Nos. 1 through 15, extending to depths of about 16.5 to 50 feet below the existing ground surface. The borings were located at truck accessible locations along the proposed new roadway alignment. In addition, forty-one (41) seismic refraction surveys, designated as SR-1 through SR-41, were performed at selected locations along the proposed roadway alignment. The non-intrusive geophysical surveys were conducted to supplement the subsurface data obtained from the limited test borings. Seven bulk samples, designated as Bulk-1 through Bulk-7, of the near-surface soils were obtained at selected locations along the proposed roadway alignment.

Our current field exploration program consisted of drilling and sampling of nine additional borings, designated as Boring Nos. 101 through 109, extending to depths of about 18 to 40 feet below the existing ground surface. The borings were located at selected locations along the new roadway alignment where the existing ground surface will require special work efforts to allow for access for drilling equipment. Twelve additional bulk samples, designated as Bulk-101 through Bulk-112, were obtained of the near-surface soils and at the drainage structure locations along the proposed roadway alignment for the subject project. The approximate locations of the drilled borings and near-surface bulk samples from the previous and current field explorations are shown on the General Site Plan, Plate 3. Detailed locations of the drilled borings, seismic refraction surveys, and near-surface bulk samples are shown on the Site Plans,

Plates 4.1 through 4.12 and are summarized on Tables A-1.1, A-1.2, and B-1 (contained in Appendix A and Appendix B) of this report.

Based on the results of our field explorations, the majority of the proposed Saddle Road PTA-1 alignment is underlain by pyroclastic, alluvial soil and sedimentary rock (conglomerate) materials that blanket the underlying a'a basalt rock. The thickness of the surface soils and conglomerate deposit generally ranges from on the order of about 5 feet to greater than about 30 feet depending on location. In general, the sandy pyroclastic and alluvial materials appear to be medium dense and weakly consolidated (cemented). The conglomerate appears to be medium dense to dense and moderately consolidated (cemented).

Basalt rock formation composing the ground surface was also encountered, predominantly at the eastern half of the project site. The basalt rock formation encountered in the borings ranges from hard to very hard with frequent layers of massive, fine-grained "blue rock" materials. In general, the basalt rock encountered at the project site has a surface clinker layer of medium hardness mixed with cinder and ash, which becomes hard to very hard with generally fewer fractures and voids with increased depth below the ground surface. In addition, it should be noted that some small lava tubes were encountered in the borings drilled along the proposed roadway alignment.

Groundwater was not encountered in the borings drilled at the time of our field exploration. It should be noted that groundwater levels within the project limits may be influenced by seasonal precipitation and weather conditions, spring discharges, and other factors.

Detailed descriptions of the drilling and sampling methodology are presented in Appendix A of this report. Descriptions and graphic representations of the materials encountered in the borings drilled are provided on the Logs of Borings, Plates A-1 through A-24. In addition, detailed descriptions of the seismic refraction survey methodology are presented in Appendix B. Graphic representations of the subsurface

profiles generated from our analyses of the seismic refraction field data are presented on the Seismic Refraction Profiles, Plates B-1 through B-39. Laboratory tests were performed on selected soil and rock samples, and the results are presented in Appendix C. Field permeability tests were performed in selected borings drilled, and the test results are presented in Appendix D of this report.

END OF SITE CHARACTERIZATION

SECTION 3.0 - DISCUSSION AND RECOMMENDATIONS

Based on the plan and profile drawings provided for the proposed roadway alignment, we anticipate that the majority of the cuts and fills will be on the order of about 5 to 10 feet thick. However, some major cuts on the order of about 20 to 25 feet deep are anticipated at some isolated locations along the alignment. In addition, some substantial fills up to about 30 to 40 feet thick may be needed in areas where the proposed roadway traverses gullies and broad basins.

Based on the results of our field exploration program, it appears that the majority of the proposed Saddle Road PTA-1 alignment is predominantly underlain by weakly cemented, poorly graded sands and moderately cemented conglomerate materials that blanket the underlying a'a basalt rock. Volcanic ash and pahoehoe basalt rock formation are exposed at the ground surface in localized areas and near the eastern terminus of the roadway alignment. In general, we believe that a large portion of the excavated materials may be re-used as a source of fill materials for embankment construction provided that the materials are properly processed and placed in accordance with the recommendations presented in the "Site Grading" section of this report.

As mentioned previously, some near-surface volcanic ash soils were encountered along the eastern portion of the alignment. It should be noted that the volcanic ash soils may be potentially thixotropic in nature, especially the volcanic ash soils with higher moisture contents (greater than 100 percent moisture content). Thixotropic volcanic ash soils may lose significant strength temporarily when remolded and/or disturbed. Therefore, the near-surface volcanic ash soils, if used as a source of fill materials, should be blended with the cinder sands, alluvial sands, and/or basalt rock fragments to provide a relatively well-graded material prior to placement as fills.

In addition, appropriate soil erosion protection, dust control provisions, and earthwork construction procedures should be observed and implemented during the earthwork operations when volcanic ash soils are involved. If it is necessary to utilize

pure volcanic ash soils as fill materials, the contractor should be made aware that additional time and effort may be involved with the fill placement operations. In general, we believe that cut slopes exposing volcanic ash deposits should be designed with a slope ratio of three horizontal to one vertical (3H:1V) or flatter.

The excavated cinder sands and alluvial sands (including gravel and cobbles) also may be used as a source of fill materials or blended with volcanic ash soils and basalt rock fragments to provide a relatively well-graded fill material. Based on our experience, cinder sands and alluvial sands may experience a volume decrease of about 10 to 20 percent when excavated, processed, and used as fill material for embankment construction. In general, cut slopes exposing cinder sand and alluvial sand deposits may be designed with a slope ratio of 2H:1V or flatter. However, it should be noted that the cinder sands and alluvial sands are highly susceptible to erosion (wind and surface water runoff) and should be adequately protected from erosion by appropriate means.

Cut materials generated from excavations into the surface conglomerate and underlying basalt formation also may be used as a source of fill and backfill materials. However, the fill materials within the upper 2 feet from the finished subgrades should be screened of over-sized materials and processed to provide a relatively well-graded material to prevent the occurrence of voids in the compacted mass. Over-sized rock fragments (greater than 6 inches in maximum dimension) may be disposed of in the deeper fills or may be broken down to smaller-sized materials and incorporated into the fill material. Placement of boulders (rock fragments larger than 12 inches in dimension) in fills should be in accordance with the procedures recommended in the "Boulder Disposal" subsection of this report.

Based on experience, clinkers may experience a volume decrease of about 20 to 30 percent when excavated, processed, and used as fill materials. On the other hand, dense basalt may experience an increase in volume of about 5 to 10 percent when excavated, processed, and used as fill materials. Cut slopes exposing clinker materials and dense basalt may be designed with a slope ratio of 1.5H:1V and 0.5H:1V or flatter,

respectively. Embankments constructed of fill materials composed of basalt gravel, cobbles and boulders may be designed with a slope ratio of 2H:1V or flatter.

Due to the potential for presence of cavities, unsuitable materials, soft, loose, and/or wet soils, we recommend that contingencies be included in the cost estimates for over-excavation and structural fill placement to account for variations in the over-excavation and backfill quantities.

Based on our field observations and laboratory test results, the in-situ sandy soils exist in a relatively dry condition of about 10 to 20 percent below the optimum moisture content. Therefore, in order to prepare the on-site sandy soils from their existing moisture content to near the optimum moisture content for site preparation and grading, a significant amount of water will be needed at the site to facilitate the site grading work. Based on our estimates, we believe that approximately 44 to 62 gallons of water (with an average of about 50 gallons) would be needed for each cubic yard of controlled fill for the grading operations. Therefore, an adequate water supply and number of water trucks should be available at the site to moisture-condition the on-site soils to the specified moisture contents to prepare the subgrades and work the on-site soils as controlled fills. Detailed discussion of these items and our geotechnical recommendations for design of the project are presented in the following sections of this report.

3.1 Site Grading

Based on the plan and profile drawings provided for the proposed roadway alignment, we anticipate that the majority of the cuts and fills will be on the order of about 5 to 10 feet thick. However, some major cuts on the order of about 20 to 25 feet deep are anticipated at some isolated locations along the alignment. In addition, some substantial fills up to about 30 to 40 feet thick may be needed in areas where the proposed roadway traverses gullies and broad basins.

We understand that the majority of the fill materials will be generated from the planned excavations along the proposed alignment. Based on the geologic conditions

along the proposed alignment, we anticipate that the excavated materials would range from volcanic ash soils and cinder sands and gravel to weakly cemented cobbly basalt rock and hard basalt rock formation. In general, we believe that a large portion of the excavated materials may be re-used as a source of fill materials for embankment construction provided that the materials are properly processed and placed in accordance with the recommendations presented in the following subsections of this report. Items of earthwork that are addressed in the subsequent subsections include the following:

1. Site Preparation
2. Fills and Backfills
3. Boulder Disposal
4. Earthwork Quantities
5. Fill Placement and Compaction Requirements
6. Excavation
7. Cut Slopes
8. Fill Slopes
9. Subdrainage

3.1.1 Site Preparation

At the on-set of earthwork, areas within the contract grading limits should be thoroughly cleared and grubbed. Vegetation, debris, deleterious material, and other unsuitable materials should be removed and disposed of properly off-site to reduce the potential for contamination of the excavated materials. Volcanic ash soils encountered in cut areas may be stockpiled and re-used as a source of general fill material provided that the recommendations presented in the "Fill Placement and Compaction Requirements" subsection are diligently implemented during earthwork construction.

Soft and yielding areas encountered during clearing and grubbing below areas designated to receive fill should be over-excavated to expose firm natural materials, and the resulting excavation should be backfilled with well-compacted fill. The excavated soft soils should be properly disposed of off-site or in a designated area. Areas with soft and/or yielding subgrade soils are likely in areas where the

proposed roadway traverses gullies and broad basins because soft and compressible soils may be encountered in these areas.

The volcanic ash soils encountered in our field exploration along the proposed alignment, especially near the eastern terminus, has relatively low moisture contents and exists in a friable state as compared to the Pahala Ash found in other locations on the Island of Hawaii. The volcanic ash soil, when wetted, has relatively low strength characteristics and is highly susceptible to erosion in a dry state. In addition, if the in-situ moisture contents are high enough, they become thixotropic, i.e., they lose strength temporarily when remolded and/or disturbed. Therefore, appropriate soil erosion protection, dust control provisions, and construction procedures should be observed and implemented during the earthwork operations when volcanic ash soils are involved.

Based on our field exploration and site reconnaissance, the approximate extents of the volcanic ash deposits generally extend from about STA. 556+00 to about STA. 630+00 of the roadway alignment. The thickness of the surface ash soils inferred from our field exploration is shown in the following table. It should be noted that the approximate limits of the volcanic ash deposits presented in the table is based on information obtained from site reconnaissance, seismic refraction surveys, and limited borings drilled along the proposed alignment. Therefore, other areas containing volcanic ash deposits outside the limits presented in the table also may be encountered during the earthwork operations.

PROBABLE THICKNESS OF VOLCANIC ASH DEPOSITS FROM STA. 556+00 TO STA. 630+00		
Station Number	**Probable Volcanic Ash Thickness** (feet)	**Reference** (Boring No. or Seismic Refraction Line No.)
558+00	5 to 10	SR-36
578+00	10	B-107
597+25	3 to 4	B-13
597+70	1 to 5	SR-38
608+00	2 to 3	B-108
620+50	5 to 8	SR-39
620+95	2 to 8	B-14

In areas where volcanic ash soils are exposed at the ground surface and areas designated to receive fill, the subgrades should be moisture-conditioned to about the optimum moisture content and compacted to at least 90 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 Test Designation D 1557 (AASHTO T-180). Optimum moisture is the water content corresponding to the maximum dry density.

Due to the sensitive nature of the volcanic ash soils, use of the vibratory action of the compactor should be carefully controlled to avoid disturbing the volcanic ash soils. In addition, moisture-conditioning of the volcanic ash soils should be carefully controlled to avoid over-wetting of the soils. It should be noted that the volcanic ash soils are generally sensitive to moisture contents and may be difficult to achieve the specified compaction. Therefore, additional compaction effort with proper moisture control likely will be necessary to meet the specified compaction criteria.

If the subgrade soils are pumping during subgrade preparation, the subgrade should be proof-rolled to a firm condition and a woven geotextile fabric, such as

Mirafi 500X or equivalent, should be placed on the subgrade prior to placement of fill materials. In addition, where shrinkage cracks are noted after compaction of the subgrade, we recommend that the soil be thoroughly moistened to close the cracks, or the subgrade should be moisture-conditioned and recompacted. Saturation and subsequent yielding of the exposed subgrade due to inclement weather and poor drainage may require over-excavation of the soft areas and replacement with well-compacted fill.

In areas where the subgrade exposes cinder, alluvial sand, clinker, or basalt rock formation, the subgrade should be scarified to a depth of about 12 inches, where possible, and proof-rolled with a minimum 20-ton vibratory drum roller (or a Caterpillar D-10 bulldozer) or similar heavy equipment for a minimum of eight passes. The vibratory drum roller should be operated at a speed of about 200 to 300 feet per minute. If the proof-rolling operations detect near-surface cavities or loose zones in the subsurface, the area should be ripped open, cleaned of debris, and then backfilled with compacted fill materials. The proof-rolling operation also should be performed at the finished subgrades in cut areas.

Due to the potential for presence of cavities (lava tubes, blisters, pockets, etc.) and soft and/or wet soils, we recommend that contingencies be included in the cost estimates for the project for over-excavation and structural fill placement to account for variations in the over-excavation and backfill quantities.

3.1.2 Fills and Backfills

Based on the subsurface conditions anticipated along the proposed alignment, we believe that the excavated materials, consisting of volcanic ash, cinder sands, alluvial sands, conglomerate materials and basalt rocks, may be re-used as a source of fill materials for embankment construction. In general, we recommend that the near-surface volcanic ash soils, if used as a source of fill materials, be

blended with cinder sands, alluvial sands, and/or basalt rock fragments to provide a relatively well-graded material prior to placement as fills. The blending serves to increase the workability of the volcanic ash soils and reduces the potential for significant erosion of the exposed fill materials.

We wish to point out that some of the highly sensitive volcanic ash soils may need to be wasted by disposing of them off-site. If it is necessary to utilize pure ash soils as fill material, the contractor should be made aware that additional time and effort may be involved with the fill placement operations. It should be noted that relatively pure ash soils are potentially thixotropic (when wet) and may lose substantial shear strength when remolded. In addition, it should be noted that moisture conditioning and compaction of pure ash soils may be very difficult to control in the field.

The excavated cinder sands and alluvial sands may be used as a source of fill material or blended with volcanic ash soil and basalt rock fragments to provide a relatively well-graded fill material. Cut materials generated from excavations into the conglomerate materials and underlying basalt formation may be used as a source of fill and backfill materials provided that they processed to provide a relatively well-graded material meeting the requirements of the intended use of the material.

In general, we recommend that the fill areas of the project be capped with a minimum 2-foot thick layer of structural fill material to serve as a choking layer over the larger-sized general fill materials. Structural fill materials should consist of well-graded granular materials less than 6 inches in maximum dimension with sufficient fines to prevent the occurrence of voids in the compacted mass. Consideration also should be given to limiting the maximum particle size (maximum particle size of 6 inches) of the fill materials placed within utility line corridors (if known) to facilitate future excavations for utility line trenches.

Fill and backfill materials below the minimum 2-foot thick structural fill layer may consist of general fill materials. General fill and backfill materials should consist of well-graded granular materials, the majority of which are less than 12 inches in size with an absolute maximum dimension of 24 inches. The excavated on-site materials, if less than 24 inches in maximum dimension, may be used as a source of general fill or backfill materials (other than for trench backfill), provided that they are processed to meet the above gradation requirements. If the excavated materials do not contain sufficient fines to produce a well-graded material, off-site borrow or on-site rock crushing of larger rock fragments or boulders should be considered to provide the required gradation and particle sizes to develop a well-graded material.

Over-sized rock fragments may be disposed of off-site, used in deeper fills, or broken down to smaller-sized materials and incorporated into the fill material. The excavated on-site materials consisting of boulders less than 5 feet in diameter (but larger than 24 inches in largest dimension) may be used as rock fill provided that the top of the rock fill layer is placed at least 4 feet below the finished subgrades. In general, placement of boulders in fills should be in accordance with the procedures recommended in the "Boulder Disposal" subsection.

Due to the large extent of earthwork for this project, consideration should be given to mobilizing a crusher to the site to aid in reducing the size of large size boulders and excavated rock fragments. It is possible that portions of the dense basalt rock could yield material with characteristics suitable to allow its use as aggregate for construction purposes, such as aggregate subbase materials, if properly crushed and processed. A typical sketch of the recommended grading detail is shown on Plate 5 for reference.

3.1.3 Boulder Disposal

Over-sized materials, such as boulders, i.e., rock fragments larger than 24 inches in maximum size but less than 5 feet in largest dimension, encountered during site grading, may be used in rock fills provided that the following recommendations are followed:

1. Boulders less than 5 feet in largest dimension (but greater than 24 inches in largest dimension) may be utilized as rock fills provided that the top of the boulder is placed at least 4 feet below the finished subgrades. Boulders or portions of boulders should not encroach within 4 feet of the finished subgrade elevation. Boulders larger than 5 feet in maximum dimension should not be used as rock fill unless reduced in size.

2. Boulders greater than 24 inches in largest dimension should not be exposed at the face of the fill slope. Boulder placement should be setback a lateral distance of at least 6 feet measured from the edge of the fill slope face.

3. If underground utilities are planned (and known), care should be exercised to avoid placement of boulders in the proposed utility line alignment and within the depths of the proposed utility lines to reduce the potential for encountering the boulders during excavation for the utility line trenches.

3.1.4 Earthwork Quantities

Based on experience on the Island of Hawaii, it is anticipated that the soil and rock materials encountered along the proposed alignment will experience a volume change when excavated, processed and used as fill materials. In general, the net change will depend upon whether the material is loose clinker or sandy soil deposits versus dense basalt, the average particle size of the desired fill material, and the amount of void space in the fill.

Based on experience on projects with similar materials, the following guidelines may be used in the rough estimation of earthwork quantities when excavating the type of materials and processed to fill materials for the subject project. The values presented below do not include wastage resulting from hauling, etc.

ESTIMATED VOLUME CHANGE IN EARTHWORK QUANTITY	
Geologic Material Type	**Volume Change** (percent in volume)
Type No. 1: Sandy Pyroclastic Cinder and Alluvium	10% to 20% Decrease
Type No. 2: Silty/Sandy Cinder and Alluvium with some Basalt Rock	10% to 30% Decrease
Type No. 3: Conglomerate	5% to 10% Increase
Type No. 4: Gravelly Cinder and Tephra	20% to 30% Decrease
Type No. 5: Exposed Basalt Rock Formation (Pahoehoe)	5% to 10% Increase
Type No. 5: Exposed Basalt Rock Formation (A'a Clinker)	20% to 30% Decrease
Type No. 6: Silty Volcanic Ash	Highly Variable

It should be noted that the volume change for volcanic ash soils is very difficult to estimate because it depends on the in-situ moisture content. If the in-situ moisture content is low, the material may experience a slight increase in volume when wetted. Conversely, if the in-situ moisture content of the material is on the wet side, the material may experience a significant decrease in volume when dried.

Based on our field exploration and experience with similar materials, we believe that the following table may be used in the rough estimation of earthwork quantities when excavating the type of materials and processed to fill materials for the design of the project. We wish to emphasize that the shrinkage and bulking factors provided herein are best guess estimates only based on our experience. We recommend that contractors proposing to bid on this project be encouraged to

examine the site conditions and the boring data to make their own interpretation based on their own local experience working on similar materials on the Island of Hawaii.

ANTICIPATED VOLUME CHANGE IN CUT AREAS					
Start Station	**End Station**	**Maximum Cut** (feet)	**Anticipated Subsurface Conditions**	**Volume Change** (percent in volume)	**Reference**
0+00	26+00	2	6 Feet Alluvial Sand	10% to 20% Decrease	B-1
31+80	32+70	6	Sandy Soils with Clinker	10% to 30% Decrease	-
34+00	40+75	15	8 Feet Cemented Sand Over	5% to 10% Increase	B-2 SR-2
			Loose/Medium Hard Spatter Lava	20% to 30% Decrease	
57+80	64+80	9	5 Feet Cinder Sand Over	10% to 20% Decrease	SR-3
			20 Feet Clinker	20% to 30% Decrease	
70+70	74+60	10	Sandy Soils with Clinker	10% to 30% Decrease	-
83+10	86+00	11	2 to 10 Feet of Cinder	10% to 30% Decrease	SR-5
92+70	109+50	20	8 to 15 Feet Cemented Sand Over Hard Basalt Rock	5% to 10% Increase	B-3, B-101, SR-6, and SR-7
126+00	133+00	6	10 to 20 Feet Cemented Sand	5% to 10% Increase	SR-9
162+90	173+10	8	20 to 30 Feet Cemented Sand Over Hard Basalt Rock	5% to 10% Increase	B-4, SR-11
192+50	198+80	4	Cemented Alluvial Sand	5% to 10% Increase	B-5, SR-13
205+60	209+70	10	Sandy Soils with Clinker	10% to 30% Decrease	-

ANTICIPATED VOLUME CHANGE IN CUT AREAS					
Start Station	**End Station**	**Maximum Cut** (feet)	**Anticipated Subsurface Conditions**	**Volume Change** (percent in volume)	**Reference**
213+50	216+90	2	Sandy Soils	5% to 10% Increase	-
221+20	222+60	6	8 to 18 Feet Cemented Sand	5% to 10% Increase	SR-14
227+00	230+90	4	6 to 12 Feet Cemented Sand	5% to 10% Increase	SR-15
242+00	249+00	10	20 Feet Cemented Sand	5% to 10% Increase	B-6
281+70	291+00	8	20 Feet Cemented Sand	5% to 10% Increase	SR-19
308+20	311+05	15	20 Feet Cemented Alluvium Over Medium Dense Cinder	5% to 10% Increase	B-8, SR-20
319+30	326+10	5	10 Feet Cinder/Alluvial Sand	10% to 20% Decrease	B-109, SR-21
345+50	350+50	4	9 Feet Cemented Sand	5% to 10% Increase	B-9, SR-23
360+00	368+60	5	10 Feet Cemented Sand	5% to 10% Increase	SR-24
400+60	408+50	3	10 Feet of Sand Over Conglomerate	5% to 10% Increase	SR-27
456+00	464+30	3	10 Feet Cemented Sand Over Hard Basalt rock	5% to 10% Increase	SR-30
482+00	487+80	5	10 Feet Sandy Soils with Clinker	10% to 30% Decrease	SR-31
492+70	508+50	40	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	5% to 10% Increase	SR-32
513+60	516+50	13	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	5% to 10% Increase	SR-33

ANTICIPATED VOLUME CHANGE IN CUT AREAS					
Start Station	**End Station**	**Maximum Cut** (feet)	**Anticipated Subsurface Conditions**	**Volume Change** (percent in volume)	**Reference**
532+20	542+80	22	7 Feet Cinder Over	10% to 20% Decrease	B-106
			8 Feet Hard Basalt Over	5% to 10% Increase	
			Clinker	20% to 30% Decrease	
548+50	551+20	10	Cemented Sand	5% to 10% Increase	-
555+20	556+50	7	10 Feet Ash and Cinder Over	10% to 20% Decrease	SR-36
			Basalt Rock	5% to 10% Increase	
581+70	584+60	7	Silty and Sandy Ash Soils with Clinker	20% to 30% Decrease	-
586+20	602+00	21	8 Feet Ash Over Medium Dense Clinker	20% to 30% Decrease	B-13, SR-38
603+00	606+70	5	2 Feet Ash Over Cinder	10% to 20% Decrease	B-108
609+60	610+50	4	2 Feet Ash Over Cinder	10% to 20% Decrease	B-108
621+00	629+90	9	2 Feet Ash Over Clinker	20% to 30% Decrease	B-14, SR-39
633+50	647+00	5	Dense Basalt Rock	5% to 10% Increase	B-15, SR-40
673+00	681+00	4	Dense Basalt Rock	5% to 10% Increase	B-15, SR-40

3.1.5 Fill Placement and Compaction Requirements

Structural fill materials, consisting of granular fill materials with a maximum particle size of 6 inches, should be placed in level lifts not exceeding 12 inches in loose thickness, moisture-conditioned to above the optimum moisture, and compacted to at least 95 percent relative compaction. General fills and backfills should be placed in level lifts not exceeding 12 inches in loose thickness or the largest dimension of the majority of the materials, moisture-conditioned to above the optimum moisture content, and compacted to a minimum of 90 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 Test Designation D 1557. Optimum moisture is the water content (percentage by weight) corresponding to the maximum dry density.

Compaction of fill materials should be accomplished using sheepsfoot rollers, vibratory rollers, or other types of acceptable compaction equipment. Volcanic ash soils should not be used as fills within the upper 2 feet below the finished subgrade elevations. In addition, water tamping, jetting or ponding should not be allowed to compact the on-site volcanic ash soils.

Due to the dry and sometimes windy site conditions, moisture conditioning of fill materials will be a critical aspect during fill placement, especially when volcanic ash soils are involved. In some areas, the in-situ soils appear to be very dry relative to the optimum moisture content. Therefore, water trucks should be made available in sufficient numbers to provide adequate water for moisture conditioning during compaction. State and Federal governments have enacted stringent regulations pertaining to the release of dust from construction sites. Therefore, it is also advisable to institute a dust control program during grading operations to reduce the amount of airborne dust due to the nature of the on-site soils.

As mentioned previously, the on-site soils exist in a relatively dry condition of about 10 to 20 percent below the optimum moisture content. Therefore, in order to prepare the on-site soils from their existing moisture content to near the optimum moisture content for site preparation and grading, a large amount of water will be needed at the site to facilitate the site grading work. Based on our estimates, we believe that approximately 44 to 62 gallons of water (with an average of about 50 gallons) would be needed for each cubic yard of controlled fill for the grading operations. Therefore, an adequate water supply and number of water trucks should be available at the site to moisture-condition the on-site soils to the specified moisture contents to prepare the subgrades and work the on-site soils as controlled fills.

"Rock" fills should be placed in lifts not exceeding the maximum dimension of the majority of the rocks or 5 feet, whichever is less. Placement should be by haul-trucks traversing previously placed lifts and placing at the edge of the currently placed lift. Spreading of the "rock" fill should be performed using a large bulldozer to facilitate "seating" of the rocks. The rock fill should be watered heavily during placement by water trucks traversing the front of the current rock lift face and spraying water continuously during placement.

Compaction equipment (such as a Caterpillar D-9 bulldozer or similar heavy compaction equipment) providing suitable energy to achieve the required compaction should be utilized to place rock fills. The number of passes (usually six to eight passes) to be made to achieve proper compaction should be determined at the on-set of site grading by the performance of a trial compaction test and/or by plate bearing tests. Subsequent layers of rock fill above the previously placed rock fill should provide a choking layer of smaller-sized boulder materials to fill in the voids between the boulders of the preceding rock fill layer.

Conventional compaction testing (field density testing) generally is not practicable in fills composed of rocks, boulders, and/or cobbles. Instead, a testing program to evaluate the number of passes by a compactor needed to achieve the desired level of compaction should be conducted at the start of the grading phase of the project under the observation of a representative from Geolabs. Based on this testing program, the number of passes may then be used as the field criterion for adequate compaction. For preliminary estimating purposes, compaction may be accomplished by using a large vibratory drum roller having a static weight of at least 20 tons traveling at a speed of about 200 to 300 feet per minute. The roller should pass over the fill surface at least eight times for structural fill and six times for general fill. For general fill (with larger particle sizes), a Caterpillar D-9 bulldozer or similar size equipment may be used in-lieu of the vibratory drum roller.

3.1.6 Excavation

Our field reconnaissance and exploration program disclosed that the majority of the proposed alignment generally is underlain by pyroclastic materials and alluvial soils on the order of about 5 to 30 feet thick. In general, the sandy pyroclastic and alluvial materials appear to be medium dense and weakly consolidated. We believe that excavations into these materials generally may be achieved by conventional heavy excavation equipment, such as Caterpillar D-9 bulldozer or similar heavy construction equipment.

Based on our field exploration, medium hard to hard basalt rock formation may be anticipated below the pyroclastic and alluvial soil materials and at the existing ground surface near the eastern terminus of the roadway alignment. Based on the grading concept and our field exploration, the following planned excavations will likely encounter hard rock excavation. It should be noted that the assumed rock profile is based on information obtained from site reconnaissance, seismic refraction surveys, and limited borings drilled along the proposed alignment. Therefore, other areas of excavation not designated in the table below also may encounter hard rock excavation.

POTENTIAL SIGNIFICANT HARD ROCK EXCAVATION AREAS				
Start Station	**End Station**	**Maximum Cut** (feet)	**Anticipated Subsurface Conditions**	**Reference**
93+00	109+00	20	8 to 15 Feet Cemented Sand Over Hard Basalt Rock	B-3, B-101, SR-6 & SR-7
493+00	505+00	20	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	B-104, SR-31 & SR-32
532+50	539+50	15	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	B-12, B-106, SR-34 & SR-35

It is anticipated that the basalt rock formation may be excavated with normal heavy excavation equipment, such as ripping with large bulldozers, where the rock is near the existing ground surface. However, excavations into the deeper formations may require the use of hoerams, chipping, or blasting. The method and equipment to be used for excavation should be determined by the contractor, subject to practical limits and safety considerations.

The above discussions regarding the rippability of the surface materials are based on our experience on the Island of Hawaii and the field exploration program performed at the subject site. We recommend that contractors proposing to bid on this project be encouraged to examine the site conditions and the boring data to make their own interpretation.

3.1.7 Cut Slopes

Based on the subsurface conditions anticipated along the proposed alignment, we believe that the planned cut slopes may consist of materials ranging from volcanic ash and cinder sands to a'a and pahoehoe lava flows. In general, the a'a lava would consist of clinker materials with occasional layers of dense basalt; therefore, cut slopes exposing a'a lava should be designed in general accordance with the recommendations presented for "clinker" materials. On the other hand, pahoehoe lava flows generally consist of dense basalt with occasional clinker layers and,

therefore, should be designed in general accordance with the recommendations presented for "dense basalt" materials. The following cut slope inclinations may be used for the design of the planned cut slopes along the proposed alignment.

GENERAL CUT SLOPE DESIGN RATIO	
Type of Material	**Cut Slope Ratio**
Volcanic Ash	3H:1V or Flatter
Cinder Sands and Alluvial Sands	2H:1V or Flatter
Conglomerate	2H:1V or Flatter
Clinker	1.5H:1V or Flatter
Dense Basalt	0.5H:1V or Flatter

As mentioned previously, some major cuts on the order of about 20 to 25 feet deep are anticipated at some isolated locations along the proposed roadway alignment. Based on our field exploration, we believe that the following preliminary cut slope design recommendations may be used at these major cut areas.

RECOMMENDED CUT SLOPE INCLINATIONS AT MAJOR CUT AREAS				
Start Station	**End Station**	**Maximum Cut** (feet)	**Anticipated Subsurface Conditions**	**Design Cut Slope Ratio**
34+00	40+50	15	8 Feet Cemented Sand Over Loose/Medium Hard Spatter Lava	2H:1V
57+70	61+30	10	5 Feet of Cinder/Ash Over Clinker	2H:1V
70+60	74+50	10	10 Feet of Cinder/Ash Over Basalt Rock	2H:1V
93+00	109+00	20	8 to 15 Feet Cemented Sand Over Hard Basalt Rock	2H:1V
163+00	173+00	10	20 to 30 Feet Cemented Sand Over Hard Basalt Rock	2H:1V

RECOMMENDED CUT SLOPE INCLINATIONS AT MAJOR CUT AREAS				
Start Station	**End Station**	**Maximum Cut** (feet)	**Anticipated Subsurface Conditions**	**Design Cut Slope Ratio**
205+60	209+70	10	10 Feet Cemented Sand Over Clinker	2H:1V
242+00	249+00	10	20 Feet Cemented Sand	2H:1V
281+70	291+00	10	20 Feet Cemented Sand	2H:1V
308+30	311+05	15	20 Feet Cemented Alluvium Over Medium Dense Cinder	2H:1V
492+70	508+50	40	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	2H:1V Top 10 feet 1H:1V Below
513+60	516+50	13	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	2H:1V Top 10 Feet 1H:1V Below
532+20	542+80	22	5 to 10 Feet Cemented Sand Over Hard Basalt Rock	2H:1V Top 10 Feet 1H:1V Below
548+50	551+20	10	Cemented Sand	2H:1V
586+20	602+00	21	8 Feet Ash Over Medium Dense Clinker	3H:1V Top 10 Feet 1.5H:1V Below

Large cavities that may be exposed on the cut slope face should be backfilled and/or grouted, if necessary. In the event that over-cutting occurs (especially in basalt formation), consideration should be given to leaving the slope as-is rather than attempting to backfill the slope to the design grade with sliver fills. If backfilling of an over-cut slope is necessary, keying and benching requirements should be implemented. Alternatively, cut slopes may be buttressed with fill slopes constructed of well-compacted fills. However, the slope will need to be designed as a fill slope.

For cut slopes steeper than 3H:1V with vertical heights greater than 25 feet, we recommend that a minimum 8-foot wide bench be provided at the mid-point of the slope or at every 25-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 rock formation. We also recommend that V-ditches (or earth berms) be provided at the top and bottom of the slopes. In addition, we also recommend the placement of geotextile fabrics on the slope to reduce the potential for significant erosion of the exposed slopes. We recommend that cut slopes exposing volcanic ash soils, cinder sands (highly susceptible to erosion), and alluvial sands be immediately protected by appropriate slope planting or other means to reduce the potential for significant erosion of the exposed soils.

3.1.8 Fill Slopes

Permanent fill embankments constructed of general fills and rock fills may be designed with a slope inclination of 2H:1V or flatter. Fills that are to be placed on slopes with inclinations steeper than 5H:1V should be keyed and benched into the existing slope to provide stability of the new fill against sliding. 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. In addition, boulders greater than 24 inches in largest dimension should not be exposed at the face of the fill slope. Water should be diverted away from the top of slopes, and slope planting should be provided as soon as possible to reduce the potential for significant erosion of the finished slopes. A typical sketch of keying and benching is shown on Plate 6 of this report.

For fill slopes with a vertical height greater than 15 feet, we recommend that a key be provided at the toe of the fill slope to provide additional stability of the new fill embankment against sliding. The key should be embedded at least 2 feet below the lowest adjacent grade and should have a minimum base width of 10 feet. A typical sketch of the key is shown on Plate 6.

In addition, we recommend that a minimum 8-foot wide bench be provided at the mid-point of fill slopes greater than 25 feet (or at every 25-foot height interval) to reduce the potential for significant erosion due to surface water runoff. We also recommend that V-ditches (or earth berms) be provided at the top of the slopes and geotextile fabrics be placed on the slope faces to reduce the potential for significant erosion of the exposed soils.

3.1.9 Subdrainage

Seepage conditions may be present at localized areas along the proposed roadway alignment, especially toward the eastern portion of the roadway alignment. Therefore, we recommend that provisions be incorporated into the construction documents to provide for subdrains in the following areas.

1. At all springs and seepage areas
2. Where fill abuts natural uphill slopes
3. On the uphill side of keyways
4. In other areas of the site where seepage is observed during or after grading or as recommended by the Engineer during construction

At stream crossings and other spring/seepage areas where drainage structures, such as pipe culverts, are planned, we believe that a subdrain system for subterranean seepage would not be necessary. We believe that the bedding material underneath the drainage structures may serve as a subdrain system in these areas.

Where needed, subdrains should consist of perforated pipes with perforations placed down and should be at least 4 inches diameter. Subdrains should be surrounded and underlain by at least 6 inches of drainage material, such as AASHTO M43, Size No. 67 gravel (ASTM C 33, No. 67 gradation) or equivalent. A non-woven filter fabric, such as Mirafi 180N or equivalent, should wrap around the drainage material. In general, subdrain trenches should be at least 12 inches wide,

at least 2 feet deep, and should be capped with compacted fill. A sketch of the Typical Trench Subdrain Detail is presented on Plate 7. Subdrains should be positioned along the upside of the selected keyway excavations and should discharge into storm drain structures, where possible, or other outlet structures.

3.2 Erosion Control

Implementation of an adequate erosion control program would be crucial to the satisfactory performance of the planned cut slopes and fill embankments against potential failure or raveling. In general, erosion of the existing slopes, planned cut slopes, or new fill embankments are caused by surface water runoff. General guidelines, such as establishment of vegetation and provision of drainage swales and earth berms, have been provided and discussed under the "Cut Slopes" and "Fill Slopes" subsections of this report. In areas where the establishment of vegetation at the slope face is difficult and may require a long period of time, other temporary erosion control methods or applications, such as flexible geosynthetic matting, should be considered as part of the erosion control program. Flexible geosynthetic matting provides a flexible ground armor that resists erosion while allowing natural vegetation to establish. Its primary and secondary functions include the following:

1. Temporary Erosion Control
2. Mulching
3. Permanent Erosion Control
4. Reduced Surface Water Runoff Velocities

3.2.1 Temporary Erosion Control

The flexibility, weight, web structure, and porosity features of the flexible geosynthetic matting make it particularly effective in temporary erosion control. It conforms easily to the ground surface and remains firmly in-place as a stable ground armor. The mat shields the soil surface from the erosive forces of wind and rain and prevents soil, seed, and fertilizer from washing away. Finally, it provides a rough surface to retain sediment deposits during surface water runoff.

3.2.2 Mulching

The high porosity web structure of the flexible geosynthetic matting acts as a non-deteriorating mulch. It holds soil, seed, and fertilizer in place and retains sediment runoff as a medium for root growth. It also retains moisture and heat necessary for germination and allows uninhabited growth of grass and other vegetation.

3.2.3 Permanent Erosion Control

Once vegetation growth is established, the flexible geosynthetic matting continues to provide permanent erosion control as it becomes embedded in the new stem and root system. It protects new vegetation from washout and reinforces and anchors the vegetation in-place as a cohesive unit.

3.2.4 Reduced Surface Water Runoff Velocities

Re-vegetated slopes and ditches reinforced with the matting reduce water runoff flow velocities, which is an important advantage that cannot be achieved with concrete lining or other rigid lining systems. It reduces runoff flow volume and concentrations and reduces the need for energy dissipation at the ditch outlet or slope base. It also promotes water percolation and groundwater recharge.

3.3 New Culvert Structures

We envision that retaining walls for the new culvert structures, such as headwall structures, box culverts, etc., may be required for the proposed roadway project. In general, we believe that the following general guidelines may be used for design of these retaining walls for the new culvert structures.

3.3.1 Foundations

In general, we anticipate that a shallow foundation system will be utilized for support of the planned retaining walls for the culvert structures for the project. In general, the new retaining structures would probably be supported on

shallow foundations, such as continuous footings and/or mat foundations. In areas where marginal subsurface soil conditions are encountered at the bottom of footing elevations, consideration may be given to improving the bearing capacity of the subsoil with the use of structural geogrids, foundation stabilization layer, and/or other ground improvement applications.

In general, we recommend that an 8-inch thick layer of granular bedding, consisting of AASHTO M43 Size No. 67 gravel (ASTM C 33, No. 67 gradation material), be provided between the bottom of the box culvert and retaining wall foundations and the underlying subgrade materials to provide for uniform bearing support. Where loose sands and/or unsuitable materials are encountered at the subgrade level, a foundation stabilization layer should be provided below the 8-inch bedding layer for uniform support. The foundation stabilization layer may consist of either 18 inches of bedding material wrapped in a non-woven filter fabric, such as Mirafi 180N or equivalent, or compacted structural fill materials. Based on our site reconnaissance and field exploration, the anticipated foundation stabilization layer requirements are further discussed and presented in the "Box and Pipe Culverts" subsection of this report.

Based on the field exploration results and the foundation stabilization layer requirements recommended above, we believe that the following values may be used to evaluate the bearing support, sliding resistance, and passive pressure resistance of the planned structures based on Load and Resistance Factor Design (LRFD) methods.

DESIGN PARAMETERS FOR RETAINING STRUCTURE FOUNDATIONS			
	Extreme Event Limit State	**Strength Limit State**	**Service Limit State**
Bearing Pressure	20,000 psf	9,000 psf	3,000 psf
Coefficient of Sliding Friction	0.46	0.37	N/A
Passive Resistance	450 pcf	225 pcf	N/A

3.3.2 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 structures, 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	35	50
	Vertical	None	None
Maximum 2H:1V Sloping Backfill	Horizontal	50	65
	Vertical	25	32

The values provided above assume that granular materials (structural fill) will be used to backfill behind the box culvert and headwall retaining structures. In addition, the backfill immediately behind the box culvert and headwall retaining structures (within 3 feet of the backside 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 structures will be compacted to between 90 and 95 percent relative compaction. Over-compaction of the retaining structure backfill should be avoided.

In general, an active condition may be used for gravity retaining walls and structure walls that are free to deflect by as much as 0.5 percent of the wall height. If the tops of the walls are not free to deflect beyond this degree, or are restrained, the walls should be designed for the at-rest condition. 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 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 30 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 structures that are restrained, a rectangular distribution equal to 45 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.

For the headwalls, the typical drainage system may consist of a sack of permeable material placed at each of the weephole locations. The sack of permeable material should consist of about 1 to 2 cubic foot of AASHTO M43 Size No. 67 gravel (ASTM C 33, No. 67 gradation material) wrapped with non-woven filter fabric (Mirafi 180N or equivalent). The weepholes should consist of a minimum 2-inch diameter PVC pipe. In addition, the weepholes should be spaced not more than 6 feet apart.

Backfill immediately behind the permeable drainage material should consist of select granular fill material with a maximum particle size of 3 inches. Unless covered by concrete slabs, the upper 12 inches of backfill should consist of relatively impervious material (well-graded soils) to reduce the potential for significant water infiltration behind the walls.

3.3.3 Box and Pipe Culverts

Based on the information provided, we understand that approximately 57 pipe and box culverts are planned at the drainageways along the proposed roadway project. General information pertaining to the subgrade preparation of these culvert structures are summarized in the following table.

FOUNDATION STABILIZATION FOR CULVERT STRUCTURES

Culvert Number	Station Number	Drainage Structure	Approximate Depth of Cover (feet)	Anticipated Subgrade Conditions	Special Subgrade Preparation
1	11+20	1 - 30" Circular Culvert	6	Med. Dense Sand with Gravel	Provide 18" Stabilization Layer
2	33+10	2 – 6' x 4' Box Culverts	3	Med. Dense Sand with Gravel	N.A.
3	57+40	1 - 48" Circular Culvert	15	Med. Dense Sand with Clinker	N.A.
4	75+30	1 - 36" Circular Culvert	12	Med. Dense Sand with Clinker	N.A.
5	81+47	1 – 36" Circular Culvert	6	Med. Dense Sand with Clinker	N.A.
6	86+76	1 – 36" Circular Culvert	8	Med. Dense Sand with Clinker	N.A.
7	114+51	1 – 42" Circular Culvert	27	Loose Silty Sand	Provide 18" Stabilization Layer

FOUNDATION STABILIZATION FOR CULVERT STRUCTURES					
Culvert Number	**Station Number**	**Drainage Structure**	**Approximate Depth of Cover** (feet)	**Anticipated Subgrade Conditions**	**Special Subgrade Preparation**
8	123+67	1 – 48" Circular Culvert	4	Med. Dense Silty Sand	N.A.
9	138+40	1 – 36" Circular Culvert	5	Med. Dense Silty Sand	N.A.
10	141+51	1 – 24" Circular Culvert	6	Loose Silty Sand	Provide 18" Stabilization Layer
11	148+41	1 – 24" Circular Culvert	6	Loose Silty Sand	Provide 18" Stabilization Layer
12	151+54	1 – 6' x 4' Box Culvert	4	Loose Silty Sand	Provide 18" Stabilization Layer
13	162+00	1 – 30" Circular Culvert	3	Loose Silty Sand	Provide 18" Stabilization Layer
14	175+38	2 – 30" Circular Culverts	2	Loose Silty Sand	Provide 18" Stabilization Layer
15	180+02	1 – 36" Circular Culvert	5	Loose Silty Sand	Provide 18" Stabilization Layer
16	187+50	1 – 24" Circular Culvert	3	Med. Dense Silty Sand	N.A.
17	201+51	3 – 8' x 4' Box Culverts	5	Loose Sand w/ Silt	Provide 18" Stabilization Layer
18	210+36	1 – 24" Circular Culvert	5	Med. Dense Sand with Clinker	N.A.
19	223+84	1 – 10' X 4' Box Culvert	4	Med. Dense Sand with Gravel	N.A.
20	234+47	1 – 48" Circular Culvert	5	Med. Dense Sand with Gravel	N.A.
21	249+89	1 – 30"Circular Culvert	4	Med. Dense Sand with Gravel	N.A.

FOUNDATION STABILIZATION FOR CULVERT STRUCTURES					
Culvert Number	**Station Number**	**Drainage Structure**	**Approximate Depth of Cover** (feet)	**Anticipated Subgrade Conditions**	**Special Subgrade Preparation**
22	257+50	1 – 30" Circular Culvert	5	Loose Sand with Silt	Provide 18" Stabilization Layer
23	264+98	2 – 42" Circular Culverts	4	Loose Sand with Silt	Provide 18" Stabilization Layer
24	274+79	1 – 42" Circular Culvert	10	Med. Dense Sand with Gravel	N.A.
25	281+60	2 – 8' x 4' Box Culverts	6	Loose Sand with Silt	Provide 18" Stabilization Layer
26	293+18	1 – 54" Circular Culvert	4	Med. Dense Sand with Gravel	N.A.
27	304+16	1 – 7' x 4' Box Culvert	3	Loose Sand with Silt	Provide 18" Stabilization Layer
28	328+71	1 – 7' x 4' Box Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
29	334+29	1 – 24" Circular Culvert	5	Med. Dense Sand with Gravel	N.A.
30	335+88	1 – 24" Circular Culvert	3	Loose Sand with Silt	Provide 18" Stabilization Layer
31	342+51	1 – 36"Circular Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
32	343+17	1 – 36" Circular Culvert	3	Loose Sand with Silt	Provide 18" Stabilization Layer
33	351+98	2 – 10' x 4' Box Culverts	3	Loose Sand with Silt	Provide 18" Stabilization Layer
34	372+82	1 – 24" Circular Culvert	5	Loose Sand with Silt	Provide 18" Stabilization Layer

FOUNDATION STABILIZATION FOR CULVERT STRUCTURES					
Culvert Number	**Station Number**	**Drainage Structure**	**Approximate Depth of Cover** (feet)	**Anticipated Subgrade Conditions**	**Special Subgrade Preparation**
35	379+89	1 – 48" Circular Culvert	6	Med. Dense Sand with Gravel	N.A.
36	383+38	1 – 48" Circular Culvert	6	Med. Dense Sand with Gravel	N.A.
37	395+99	1 – 7' x 3' Box Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
38	397+80	1 – 30" Circular Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
39	422+75	3 – 30" Circular Culverts	5	Loose Sand with Silt	Provide 18" Stabilization Layer
40	437+11	1 – 24" Circular Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
41	444+50	2 – 12'x 5' Box Culverts	3	Loose Sand with Silt	Provide 18" Stabilization Layer
42	448+64	1 – 34" Circular Culvert	3	Med. Dense Sand and Gravel	N.A.
43	464+69	1 – 24" Circular Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
44	472+50	1 – 30" Circular Culvert	3	Loose Sand with Silt	Provide 18" Stabilization Layer
45	473+63	1 – 30" Circular Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
46	474+87	2 – 30" Circular Culvert	4	Loose Sand with Silt	Provide 18" Stabilization Layer
47	480+14	1 – 30" CircularCulvert	6	Med. Dense Sand and Gravel	N.A.

FOUNDATION STABILIZATION FOR CULVERT STRUCTURES					
Culvert Number	**Station Number**	**Drainage Structure**	**Approximate Depth of Cover** (feet)	**Anticipated Subgrade Conditions**	**Special Subgrade Preparation**
48	488+99	1 – 30" Circular Culvert	5	Loose Sand with Silt	Provide 18" Stabilization Layer
49	509+49	1 – 24" Circular Culvert	5	Loose Sand with Silt	Provide 18" Stabilization Layer
50	518+94	1 – 42" Circular Culvert	5	Loose Sand with Silt	Provide 18" Stabilization Layer
51	530+12	1 – 48" Circular Culvert	7	Loose Sand with Silt	Provide 18" Stabilization Layer
52	547+40	1 – 30" Circular Culvert	8	Loose Sand with Silt	Provide 18" Stabilization Layer
53	553+60	1 – 24" Circular Culvert	8	Loose Sand with Silt	Provide 18" Stabilization Layer
54	579+00	1 – 30" Circular Culvert	11	Loose Sand with Silt	Provide 18" Stabilization Layer
55	581+23	1 – 24" Circular Culvert	8	Loose Sand with Silt	Provide 18" Stabilization Layer
56	585+60	1 – 36" Circular Culvert	8	Loose Sand with Silt	Provide 18" Stabilization Layer
57	612+29	1 – 30" Circular Culvert	9	Loose Sand with Silt	Provide 18" Stabilization Layer
Note: N.A. = Not Anticipated					

In general, we recommend that granular bedding consisting of 6 inches of AASHTO M43 Size No. 67 gravel (ASTM C 33, No. 67 gradation material) be provided below the pipe culverts. The thickness of the granular bedding layer should be increased to 8 inches below the box culvert structures and headwall structures as recommended in the "Foundations" subsection (Subsection 3.3.1) of this report. If

soft and/or loose soils are encountered at the proposed culvert locations, a foundation stabilization layer consisting of an additional 18 inches of bedding material wrapped in a non-woven filter fabric, such as Mirafi 180N or equivalent, should be provided below the bedding layer for uniform support.

Based on our site reconnaissance and field exploration, the anticipated culvert locations requiring the foundation stabilization layer are also shown in the above table for preliminary planning and cost estimation purposes. It should be noted the actual exposed subsurface soil conditions at the proposed culvert locations may differ from those shown in the above table. Therefore, the subgrade preparation for foundation stabilization recommendations presented in the above table should be confirmed in the field during the project construction.

Free-draining granular materials, such as AASHTO M43 Size No. 67 gravel (ASTM C 33, No. 67 gradation material) also should be used for the initial trench backfill up to about 12 inches above the pipe culverts to provide adequate support around the pipes. It is critical that free-draining materials be used 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 trench backfill could result in settlement of the backfill and damage to the pipes. The use of pure sand or S4C sand as backfill materials around the pipes should be prohibited due to the potential for migration or loss of fines during heavy rains, which may result in potential ground settlement and pavement distress.

The upper portion of the trench backfill from the level 12 inches above the pipes to the top of the subgrade or finished grade may consist of on-site materials generally less than 6 inches in maximum size (structural fill material). The backfill material should be moisture-conditioned to above the optimum moisture, placed in maximum 8-inch level loose lifts and mechanically compacted to not less than 90 percent relative compaction. Where trenches are below pavement areas, the upper 3 feet of the trench backfill below the pavement grade should be compacted to at least 95 percent relative compaction.

3.4 Surface Water Runoff Disposal System

Four in-situ constant head and one falling head permeability tests were conducted to evaluate the infiltration characteristics of the subsurface soils to provide data for design of the facilities to be used for disposal of storm water runoff. The field permeability tests were conducted in Boring Nos. 103, 107, 108, and 109 extending to depths of about 22.6 to 31 feet below the existing ground surface.

Test procedures for the in-situ constant head and falling head permeability tests are generally described in Appendix D of this report. Based on the permeability tests conducted, the calculated permeability of the tested subsurface soils is on the order of about 4.0×10^{-1} to 8.0×10^{-3} feet per minute for Boring Nos. 103, 107, and 108. However, a relatively low permeability of about 4.0×10^{-6} feet per minute was obtained in Boring No. 109. The results of our permeability tests are presented on Plates D-1 through D-5 in Appendix D.

It should be noted that the permeability value of the subsurface soils appears to be very poor for disposal of storm water runoff in the area of Boring No. 109. Therefore, we recommend that provisions be included in the contract documents to extend the drywells deeper for disposal of storm water runoff, if needed, in order to achieve the design disposal capacity.

3.5 Corrosion Protection

Laboratory corrosion tests, including pH, minimum resistivity, chlorides, and sulfates, were performed to evaluate the corrosivity of the near-surface soils at some of the planned drainage structure locations along the roadway alignment. Results of the corrosion tests are presented on Plate C-1 in Appendix C. We recommend that substructures (especially metallic substructures) be properly designed for protection against potential corrosion, where appropriate. A corrosion engineer should be consulted for detailed recommendations on corrosion protection.

3.6 Pavement Design

We anticipate that either asphaltic concrete and/or Portland Cement Concrete pavements will be used on the proposed Saddle Road PTA-1 Alignment project. Design of the new roadway pavement structures should be based on the Pavement Justification Report for this project prepared by our office and transmitted under separate cover.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4.0 - LIMITATIONS

The analyses and recommendations submitted in this report are based, in part, upon information obtained from literature research, site reconnaissance, seismic refraction surveys, test borings, bulk samples, and laboratory test data. Variations of conditions between and beyond the field data points 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 presented in this report.

The locations of the field data points are approximate, having been estimated by taping from reference points and visible features shown on the Plan and Profile Drawings dated September 2000 and July 20, 2001 provided by Okahara & Associates, Inc. Elevations of the field data points were interpolated between the spot elevations and contour lines shown on the same plans. The locations and elevations of the field data points should be considered accurate only to the degree implied by the methods used.

The stratification breaks shown on graphic representations of the borings and seismic refraction surveys depict the approximate boundaries between soil/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 of this report. These data have been reviewed and interpretations made in the formulation of this report. However, it must be noted that fluctuation may occur due to variation in rainfall, tides, temperature, and other factors.

This report has been prepared for the exclusive use of Okahara & Associates, Inc. and their client, the Federal Highway Administration, Central Federal Lands, Highways Division, for specific application to the Saddle Road PTA-1 Alignment project 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 design engineers in the planning and design of this project. Therefore, this report may not contain sufficient data, or the proper information, to serve as the basis for preparation of construction cost estimates or contract bidding. A contractor wishing to bid on this project should retain a competent geotechnical engineer to assist in the interpretation of this report and/or in the performance of site-specific exploration for bid estimating purposes.

The owner/client should be aware that unanticipated subsurface conditions are commonly encountered. Unforeseen subsurface conditions such as perched groundwater, soft deposits, hard layers, or cavities, 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.

END OF LIMITATIONS

CLOSURE

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

Plate 1	-	Project Location Map
Plate 2	-	Saddle Road Alignment Plan
Plate 3	-	General Site Plan
Plates 4.1 thru 4.12	-	Site Plans
Plate 5	-	Typical Grading Detail
Plate 6	-	Typical Keying and Benching Detail
Plate 7	-	Typical Trench Subdrain Detail
Appendix A	-	Field Exploration
Tables A-1.1 and A-1.2	-	Approximate Boring Locations
Plate A	-	Boring Log Legend
Plates A-1 thru A-24	-	Logs of Borings
Appendix B	-	Geophysical Survey
Table B-1	-	Approximate Seismic Refraction Survey Locations
Plates B-1 thru B-39	-	Seismic Refraction Profiles

Appendix C	-	Laboratory Testing
Plates C-1 thru C-45	-	Laboratory Test Data
Appendix D	-	Field Permeability Testing
Plates D-1 thru D-5	-	Field Permeability Test Data

-o0o0o0o0o0o0o0o0o-

Respectfully submitted,

GEOLABS, INC.

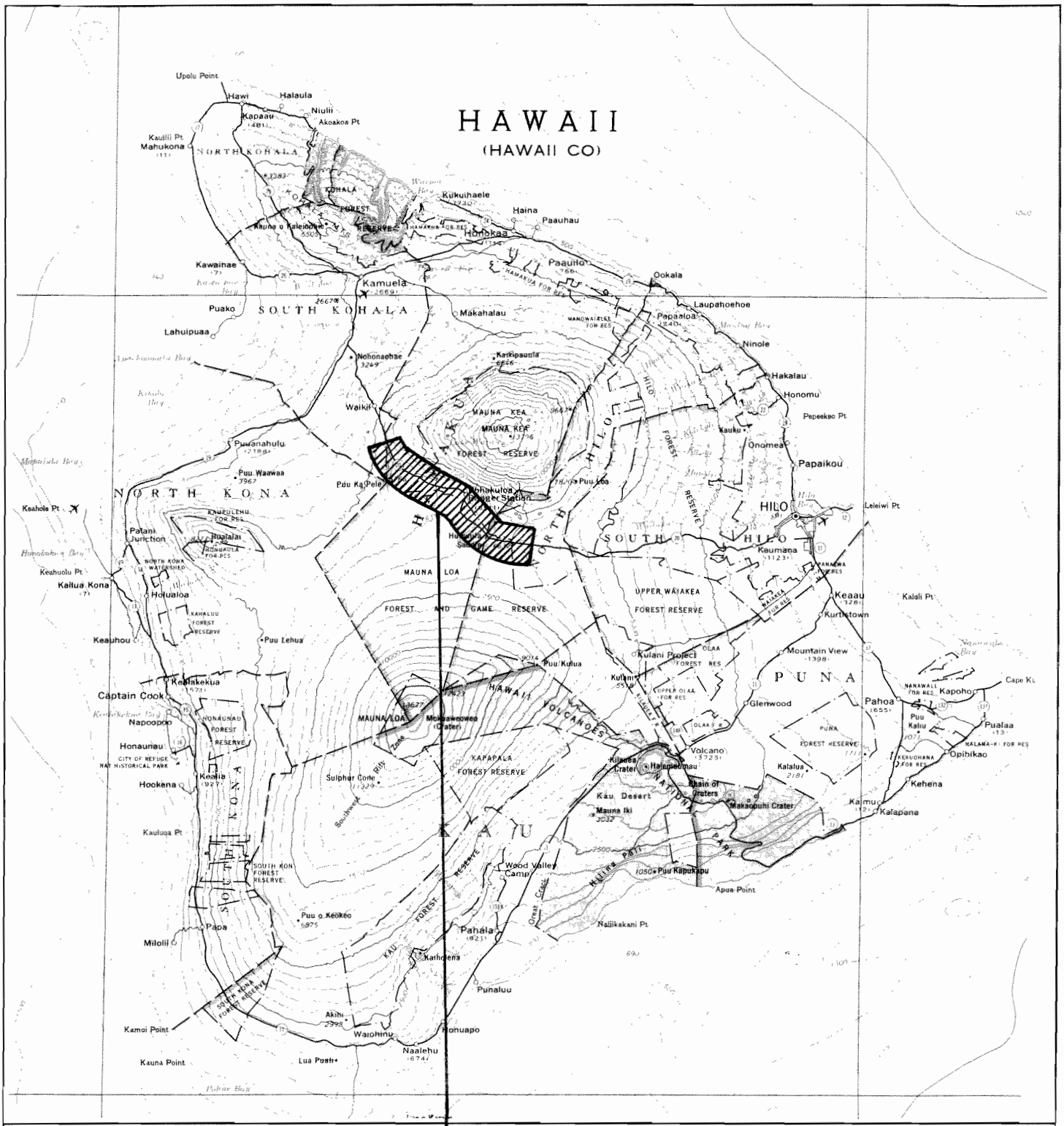
By _____
Teddy S.T. Kwok, P.E.
Senior Project Engineer

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

RML:TK:mg

(u:\03reports\3411-20.tk2 – p76)

PLATES



GENERAL PROJECT LOCATION »

PROJECT LOCATION MAP

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

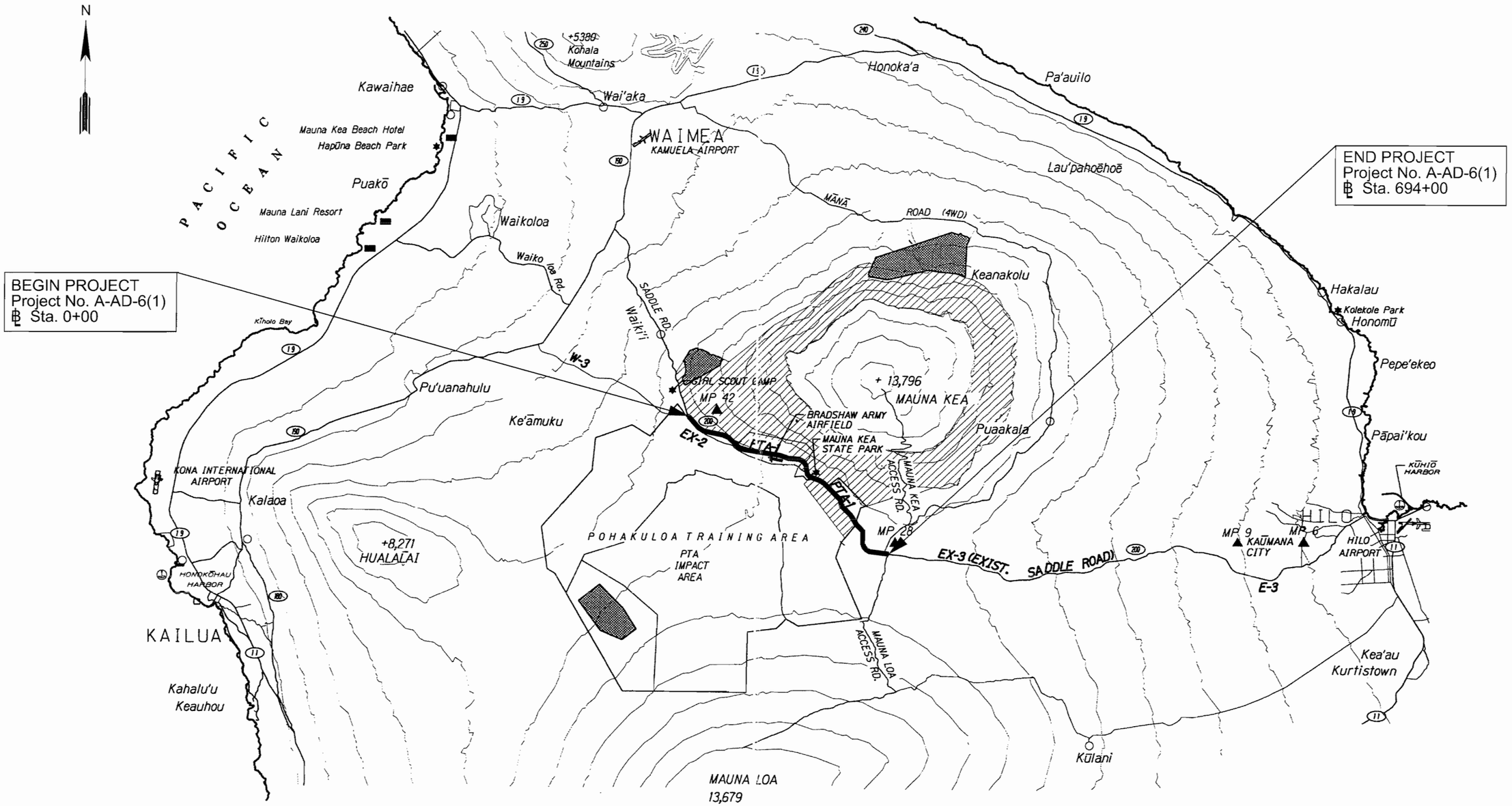
N

REFERENCE: U.S.G.S. QUADRANGLE MAP; STATE OF HAWAII (1972).

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
SEPTEMBER 2003	JJP	1
SCALE	W.O.	
NO SCALE	3411-20	

File: 3411-20PLM.dwg Thu, October 09, 2003 - 3:14:16pm



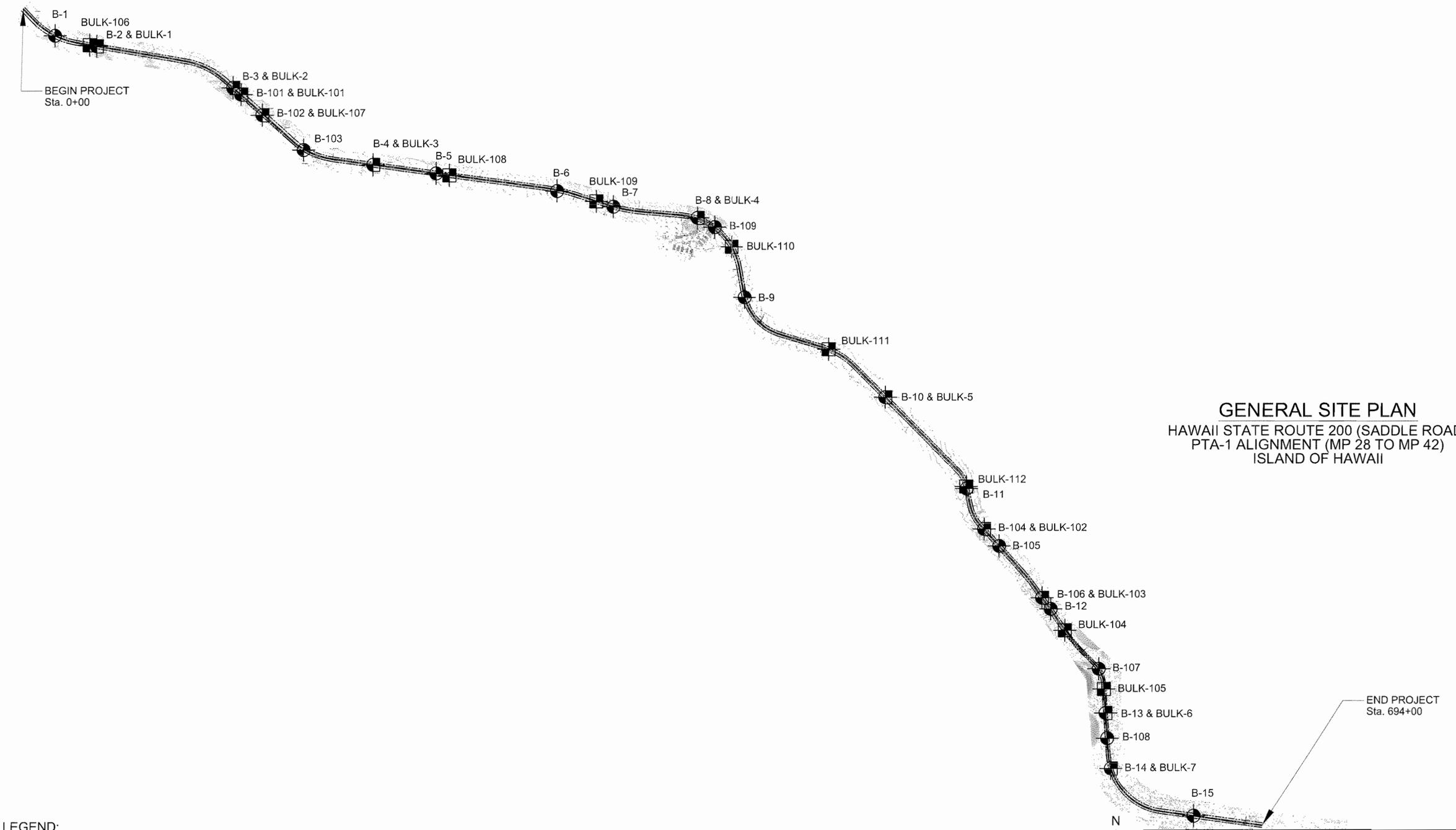
SADDLE ROAD ALIGNMENT PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
MARCH 2002	KHN	2
SCALE	W.O.	
NO SCALE	3411-20(A)	

REFERENCE: OVERALL SITE PLAN PREPARED BY OKAHARA & ASSOCIATES INC. DATED OCTOBER, 2000.



GENERAL SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

LEGEND:

APPROXIMATE BORING LOCATION

APPROXIMATE BULK SAMPLE LOCATION

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.

0 2000 4000 8000 12000 FT.

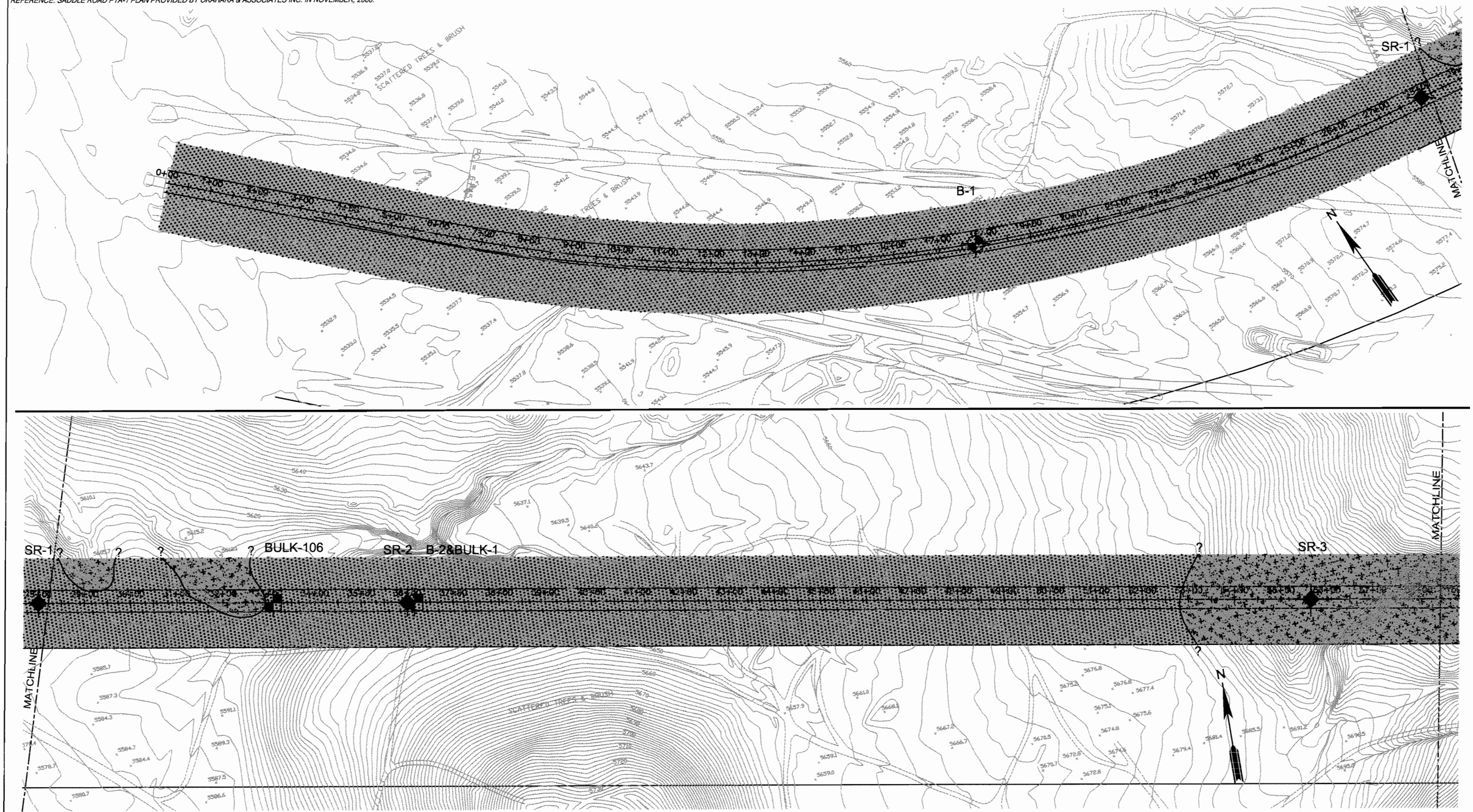
GRAPHIC SCALE

GEOLABS, INC.

Geotechnical Engineering

DATE	DRAWN BY	PLATE
MARCH 2002	KHN	3
SCALE	W.O.	
1" = 4000'	3411-20(A)	

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
- MATERIAL TYPE NO. 2 (SILTY/SANDY CINDER & ALLUVIUM W/ SOME BASALT ROCK)
- MATERIAL TYPE NO. 3 (CONGLOMERATE)
- MATERIAL TYPE NO. 4 (GRAVELLY CINDER & TEPHRA)
- MATERIAL TYPE NO. 5 (EXPOSED BASALT ROCK FORMATION)
- MATERIAL TYPE NO. 6 (SILTY VOLCANIC ASH)
- ?—? APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

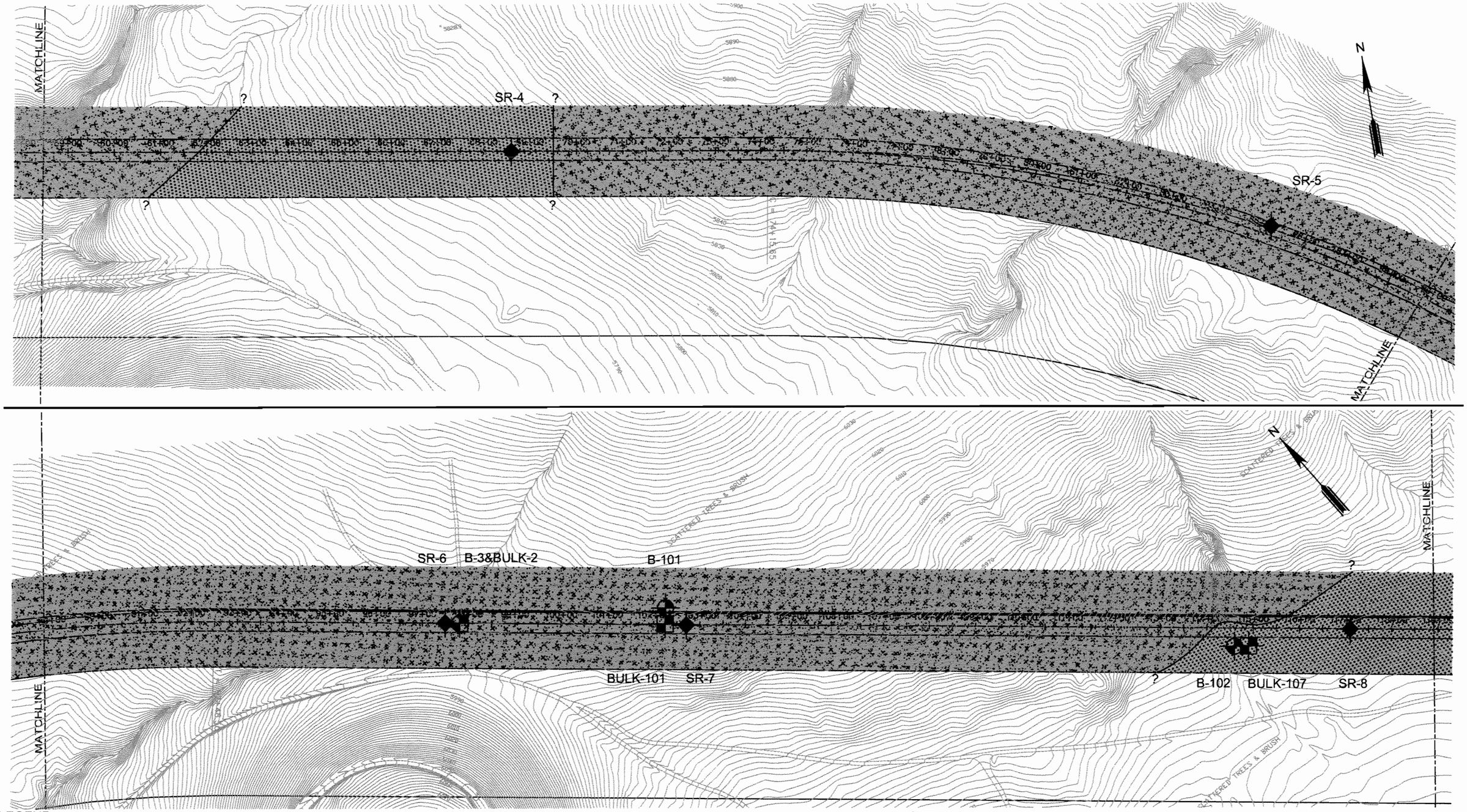
0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.1
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 8:41am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
- MATERIAL TYPE NO. 2 (SILTY/SANDY CINDER & ALLUVIUM W/ SOME BASALT ROCK)
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- MATERIAL TYPE NO. 5 (EXPOSED BASALT ROCK FORMATION)
- MATERIAL TYPE NO. 6 (SILTY VOLCANIC ASH)
- ?—? APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

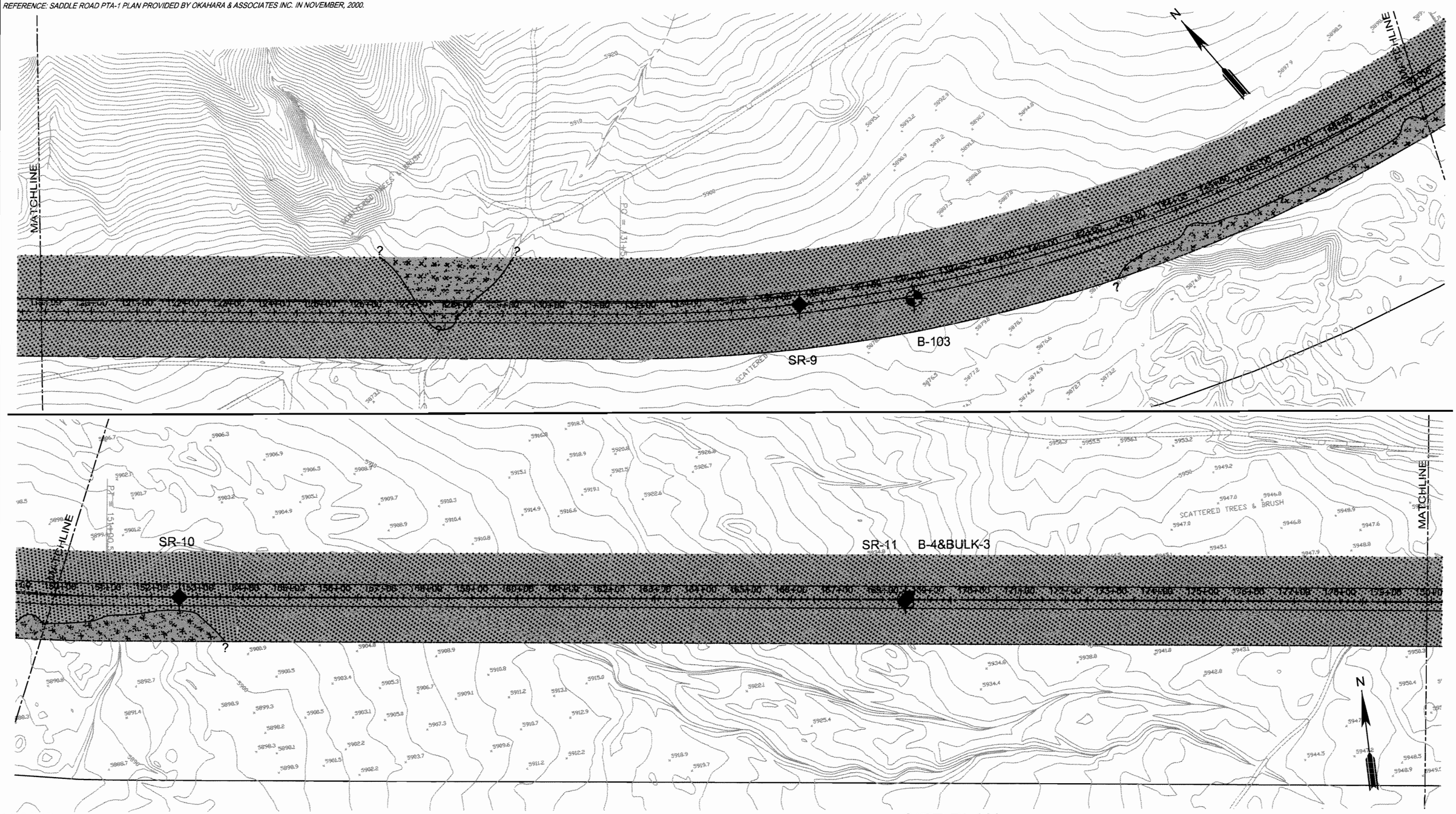
0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.2
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 8:43am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
- MATERIAL TYPE NO. 2 (SILTY/SANDY CINDER & ALLUVIUM W/ SOME BASALT ROCK)
- MATERIAL TYPE NO. 3 (CONGLOMERATE)
- MATERIAL TYPE NO. 4 (GRAVELLY CINDER & TEPHRA)
- MATERIAL TYPE NO. 5 (EXPOSED BASALT ROCK FORMATION)
- MATERIAL TYPE NO. 6 (SILTY VOLCANIC ASH)
- ? APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

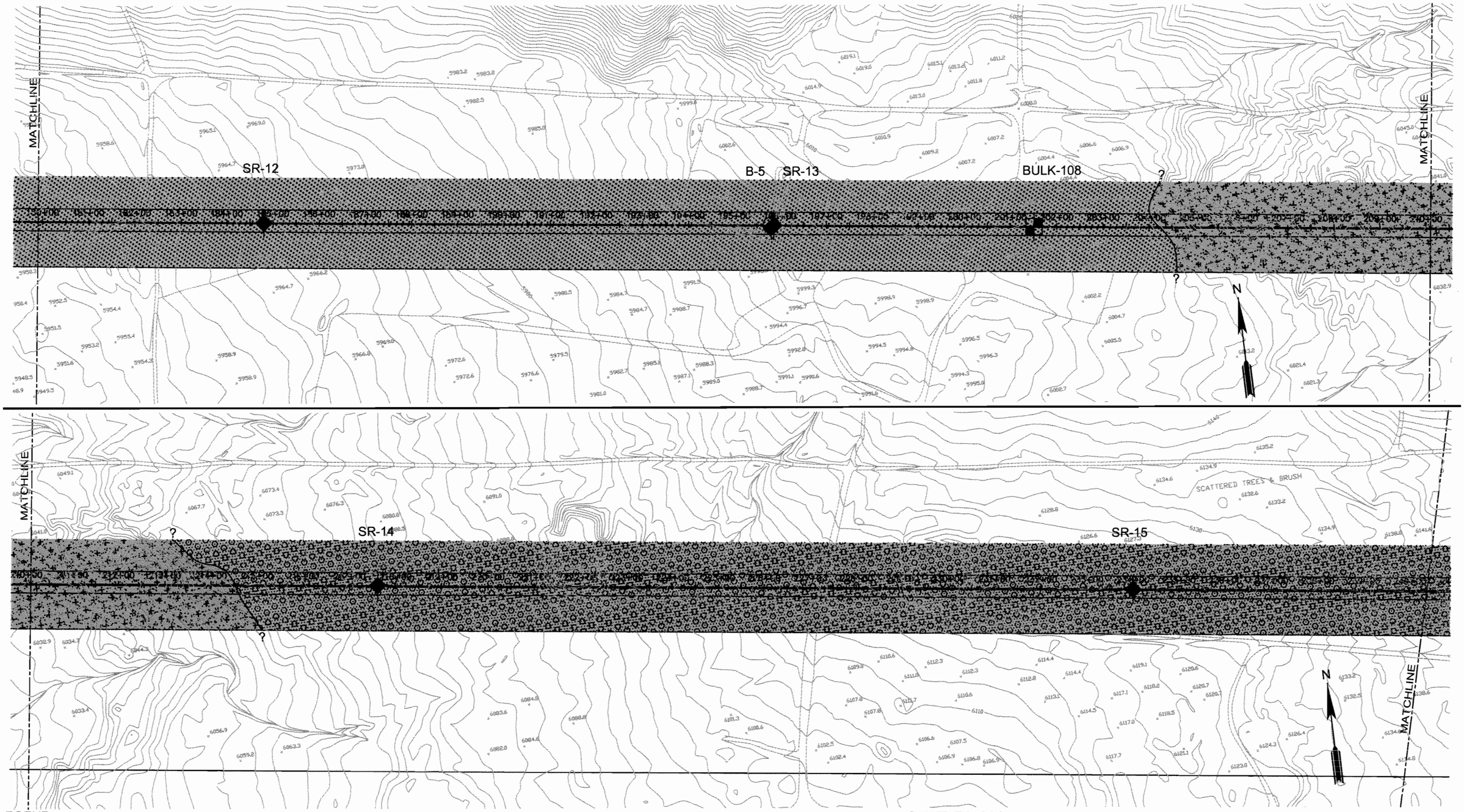
0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.3
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 8:49am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
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SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

0 100 200 400 600 FT.

GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
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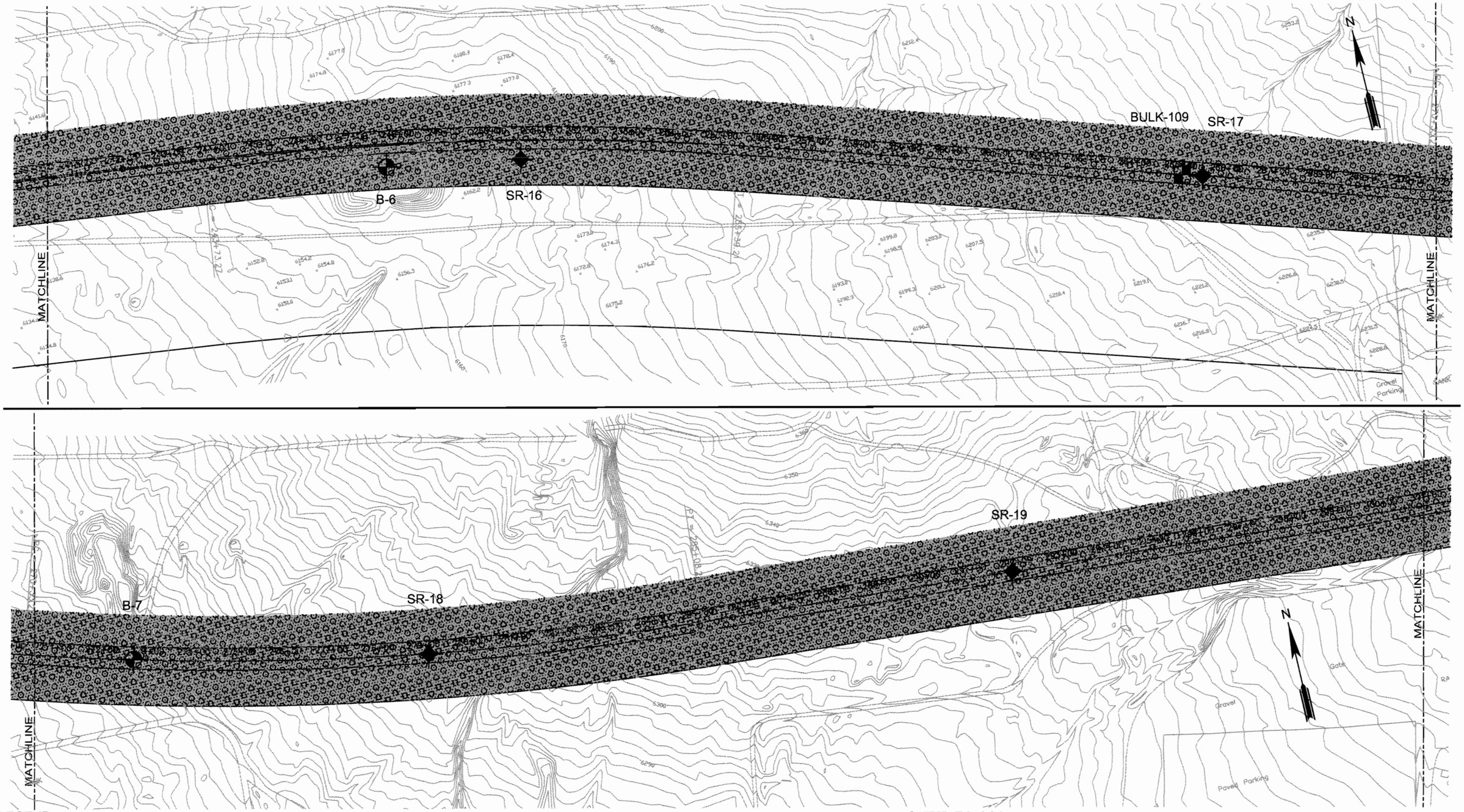

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- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
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SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
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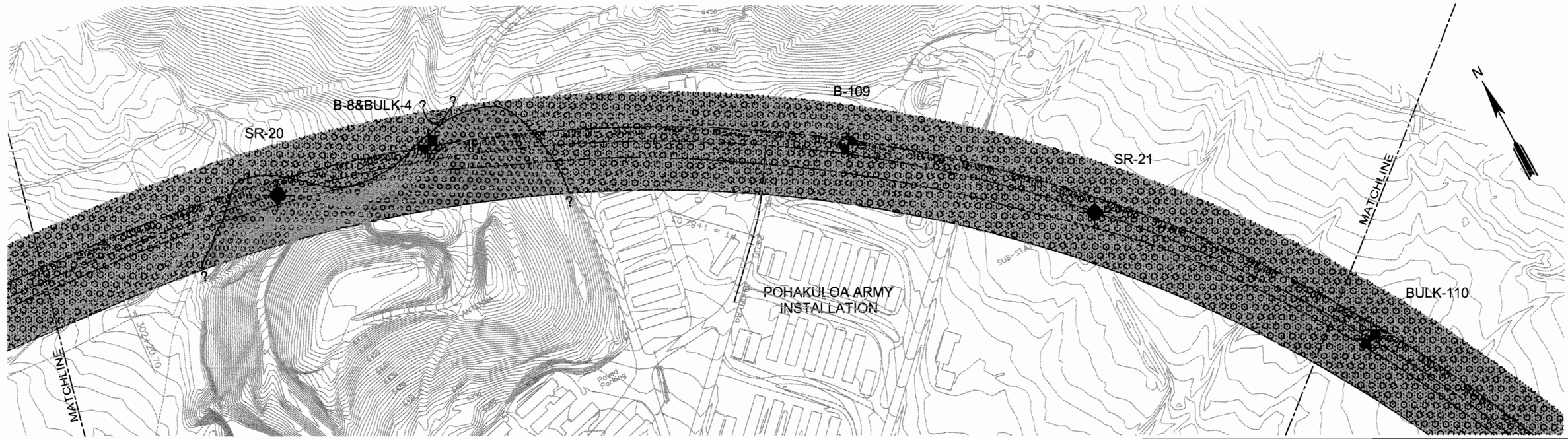

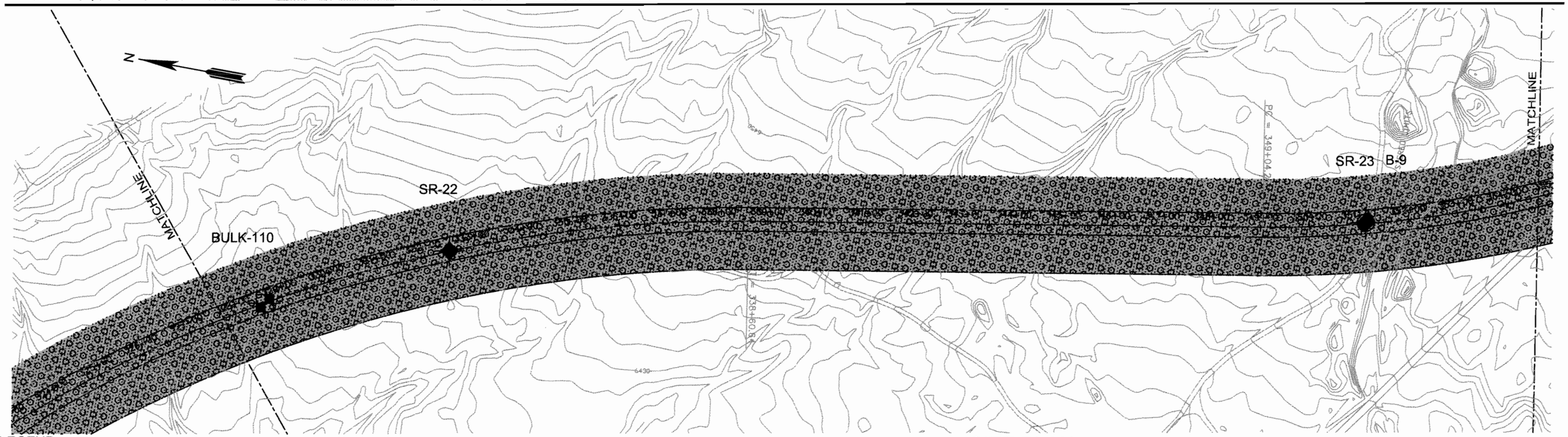

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SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
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File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 9:09am

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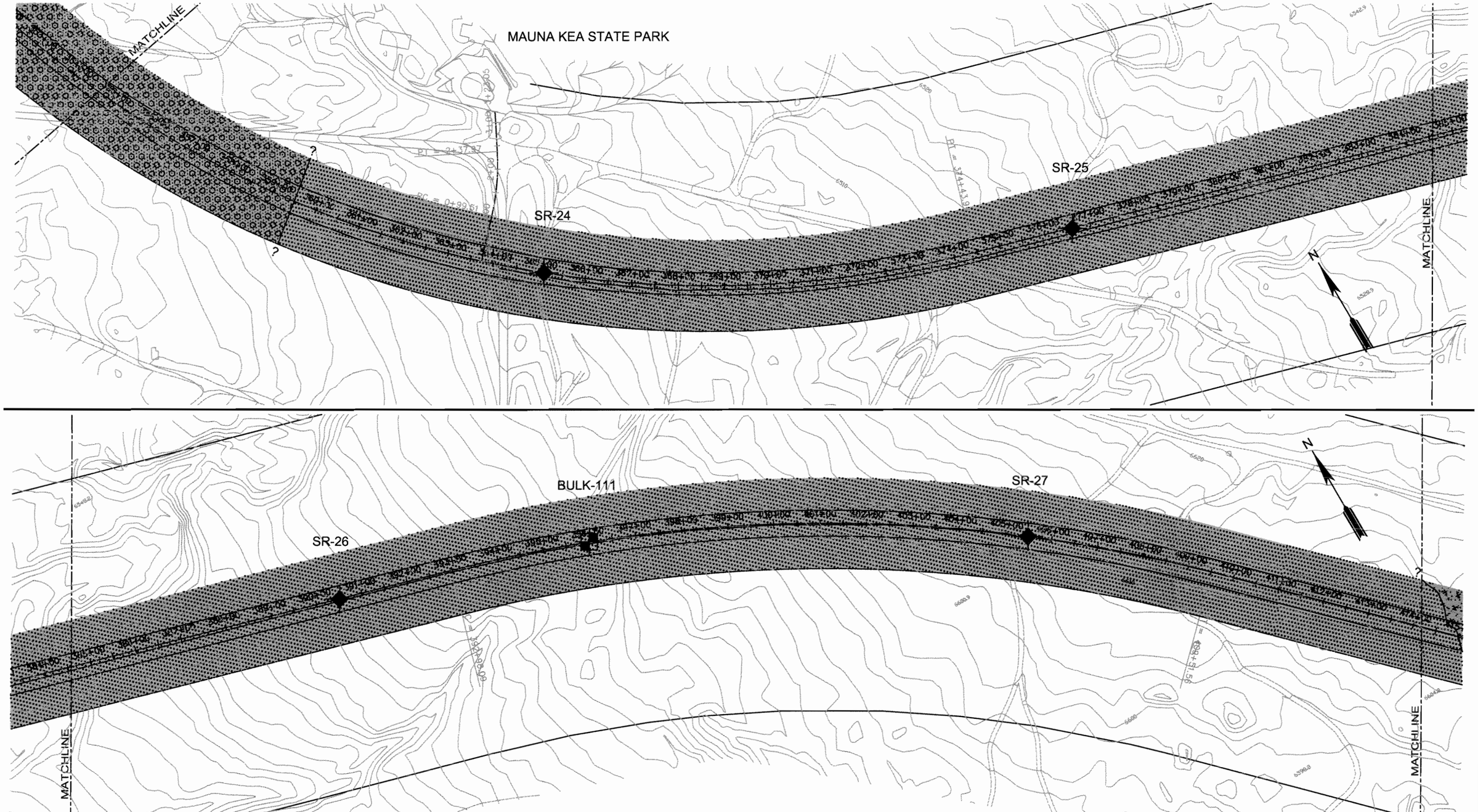

LEGEND:

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SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
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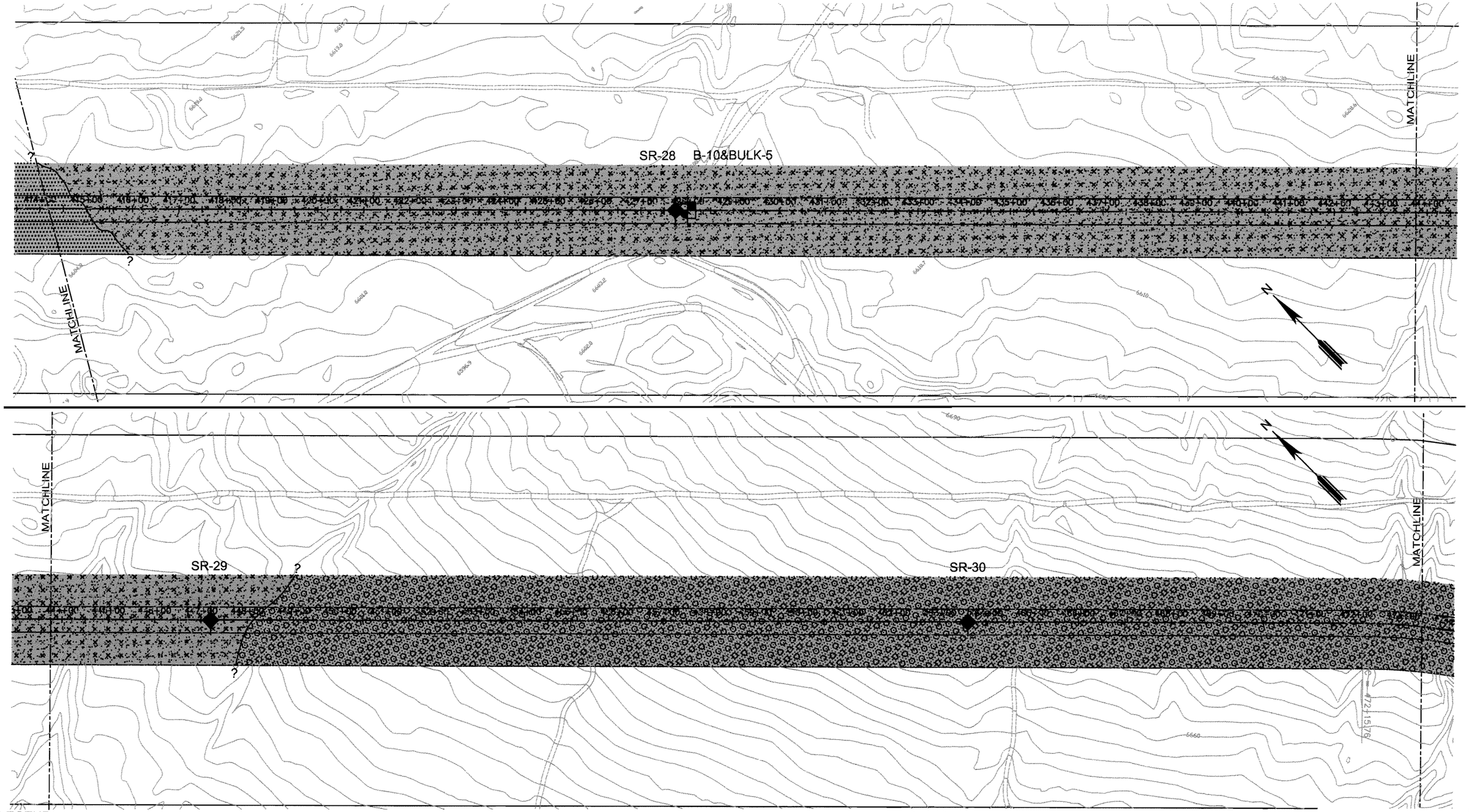
REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

- APPROXIMATE BORING LOCATION
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SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
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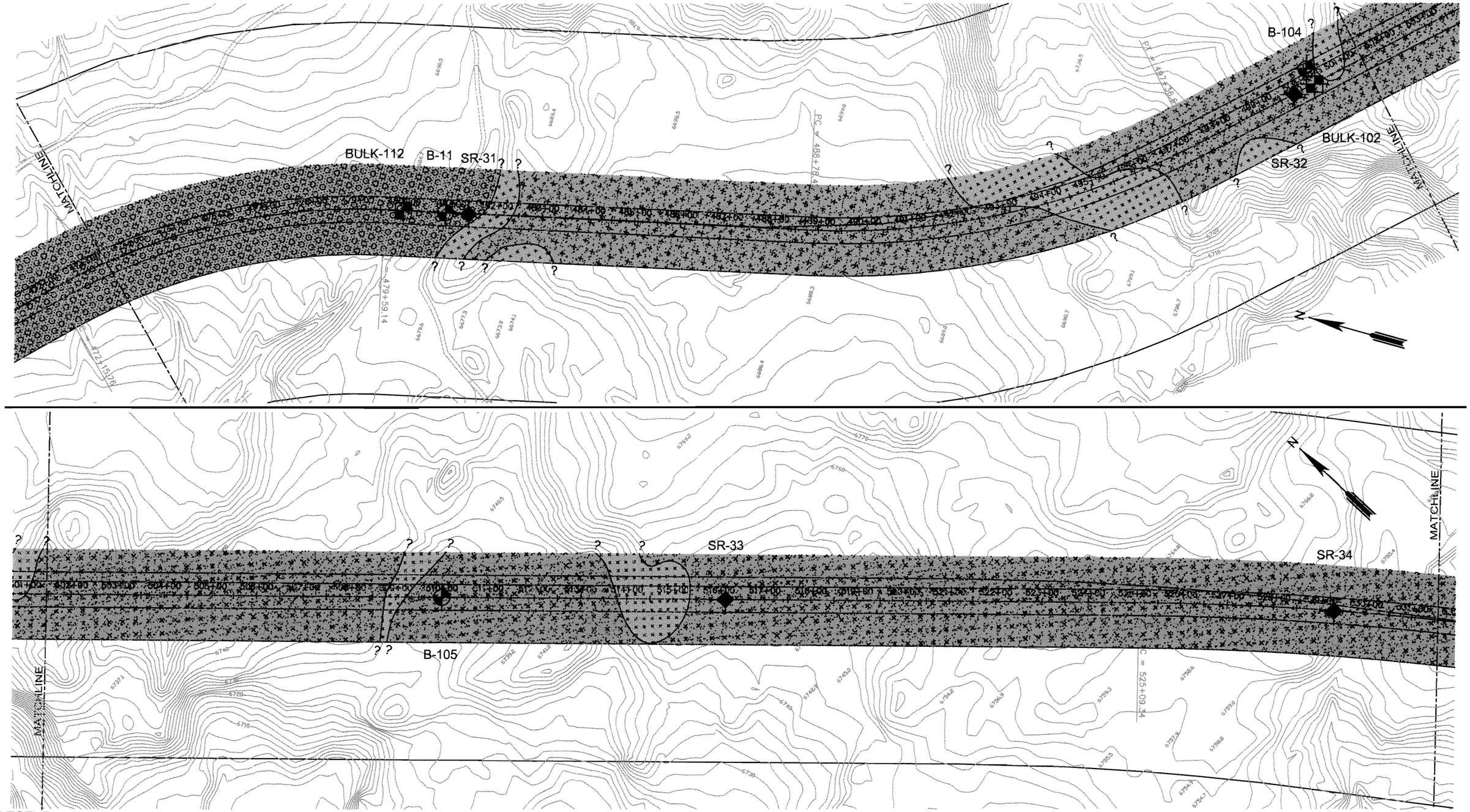
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 9:18am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

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- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
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- MATERIAL TYPE NO. 6 (SILTY VOLCANIC ASH)
- APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

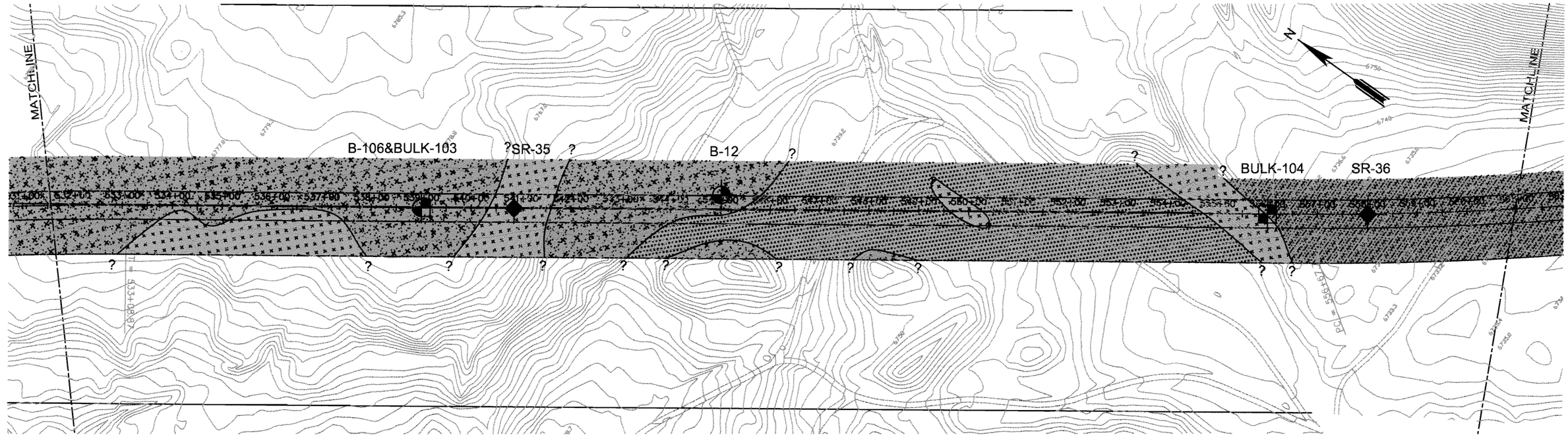
0 100 200 400 600 FT.
GRAPHIC SCALE

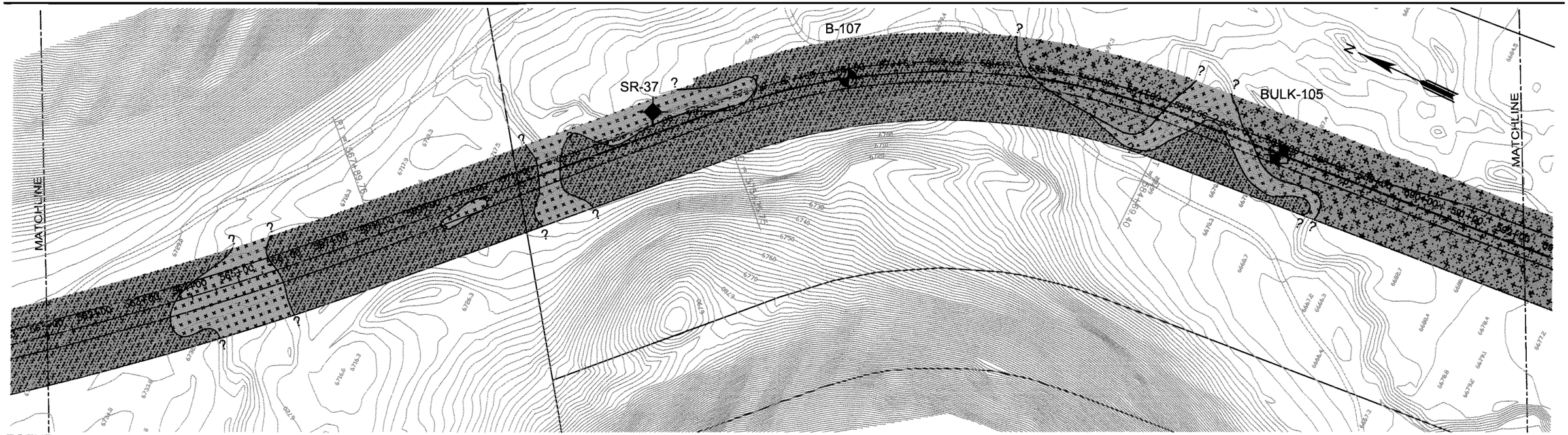
GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.9
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 9:23am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.





LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
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- ? APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

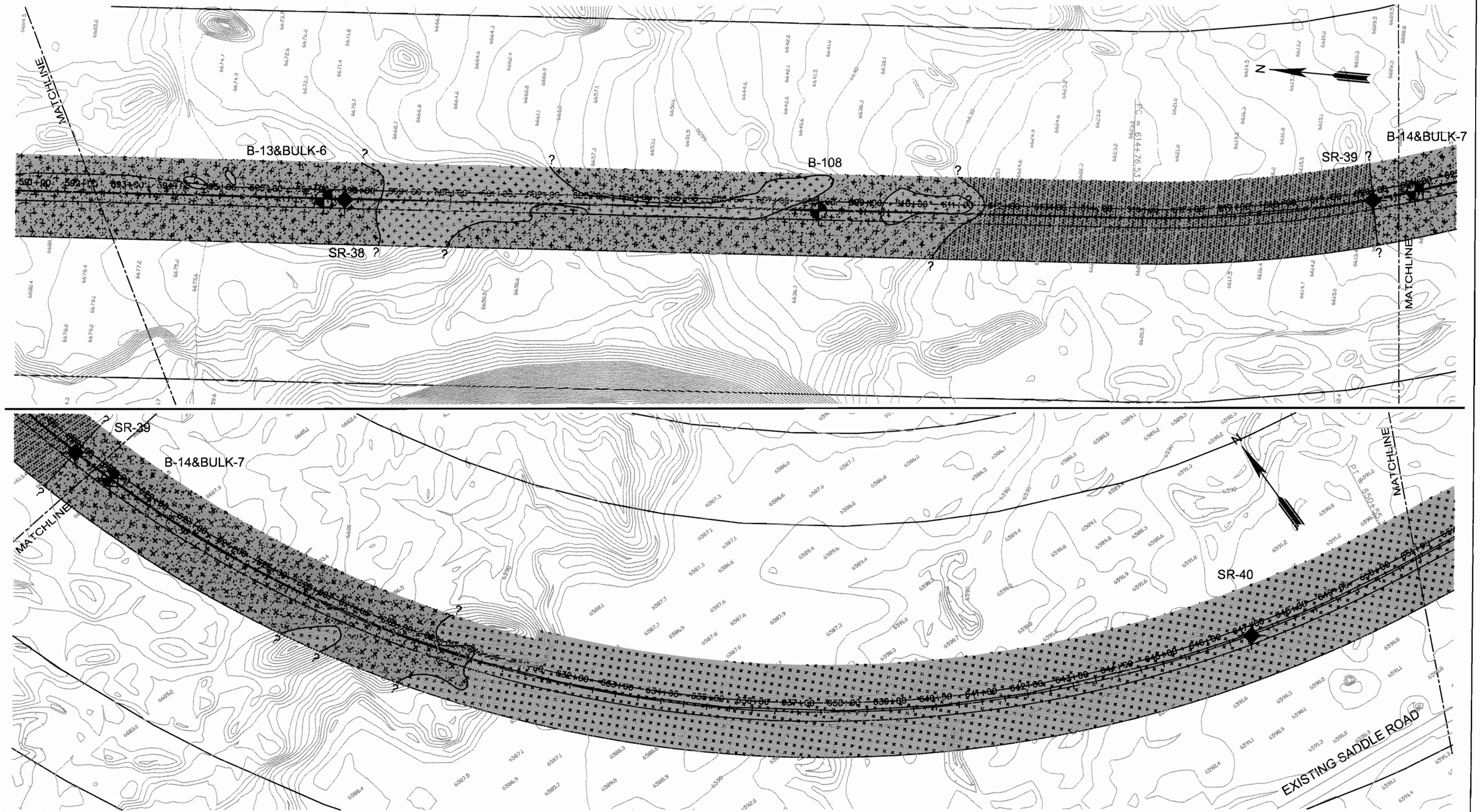
0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.10
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 9:22am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
- MATERIAL TYPE NO. 2 (SILTY/SANDY CINDER & ALLUVIUM W/ SOME BASALT ROCK)
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- MATERIAL TYPE NO. 5 (EXPOSED BASALT ROCK FORMATION)
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- ? APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

0 100 200 400 600 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.11
SCALE 1" = 200'	W.O. 3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 9:26am

REFERENCE: SADDLE ROAD PTA-1 PLAN PROVIDED BY OKAHARA & ASSOCIATES INC. IN NOVEMBER, 2000.

LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION
- APPROXIMATE SEISMIC REFRACTION SURVEY LOCATION
- MATERIAL TYPE NO. 1 (SANDY PYROCLASTIC CINDER & ALLUVIUM)
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- MATERIAL TYPE NO. 6 (SILTY VOLCANIC ASH)
- APPROXIMATE BOUNDARY BETWEEN SURFACE SOIL/ROCK MATERIALS

SITE PLAN

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

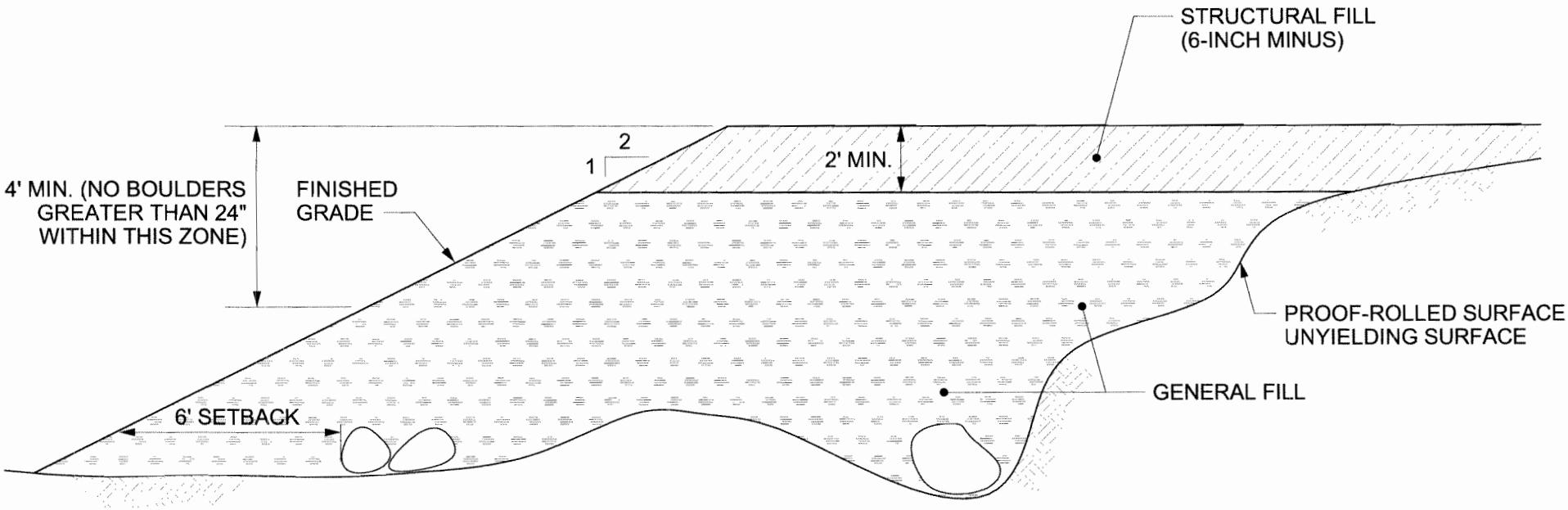
0 100 200 400 600 FT.

GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
OCTOBER 2002	KHN	4.12
SCALE	W.O.	
1" = 200'	3411-10&20	

File: 3411-10&20SitePlansRubbish.dwg Mar 10, 2005 - 9:28am



LEGEND:

- STRUCTURAL FILL
- GENERAL FILL

TYPICAL GRADING DETAIL

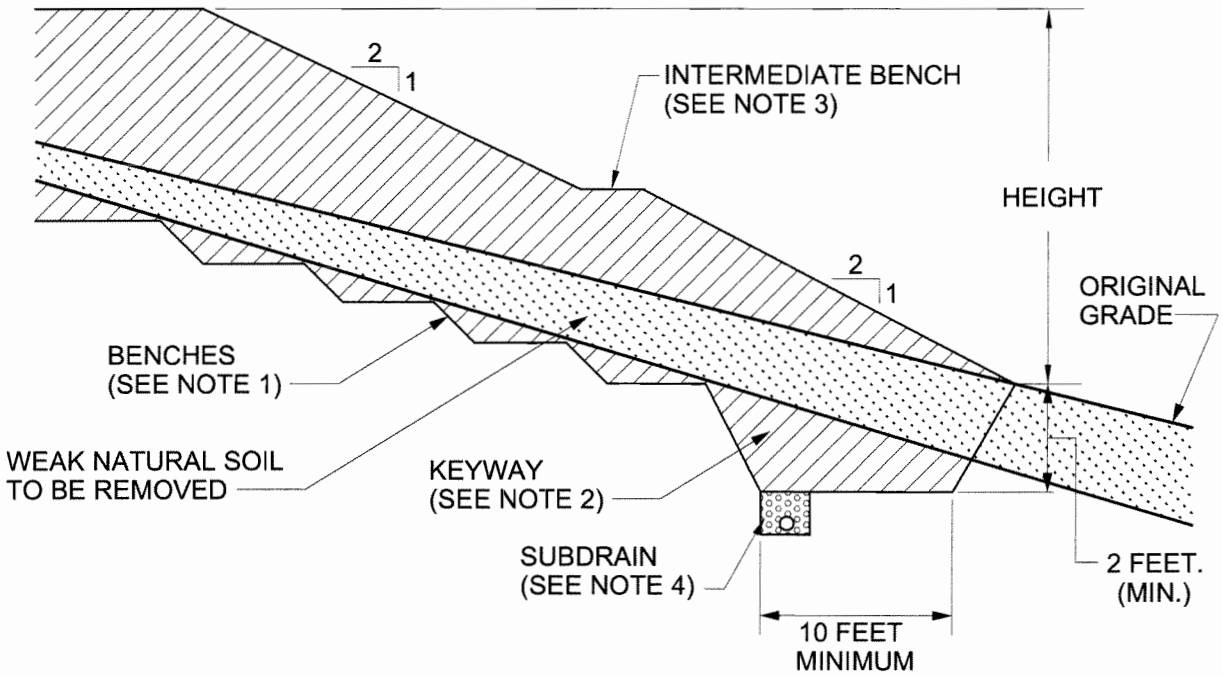
HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

NOTES:

BOULDERS (GREATER THAN 24") MAY BE DISPOSED OF IN GENERAL FILLS PROVIDED THAT THEY ARE SPREAD OUT AND PROPERLY SEATED. BOULDERS (GREATER THAN 24") SHOULD NOT ENCROACH INTO A ZONE OF 6 FEET FROM THE FINISHED GRADE AT THE SLOPE FACE AND WITHIN 4 FEET OF THE FINISHED SUBGRADE.

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
MARCH 2002	JJP	5
SCALE	W.O.	
NO SCALE	3411-20	



NOTES:

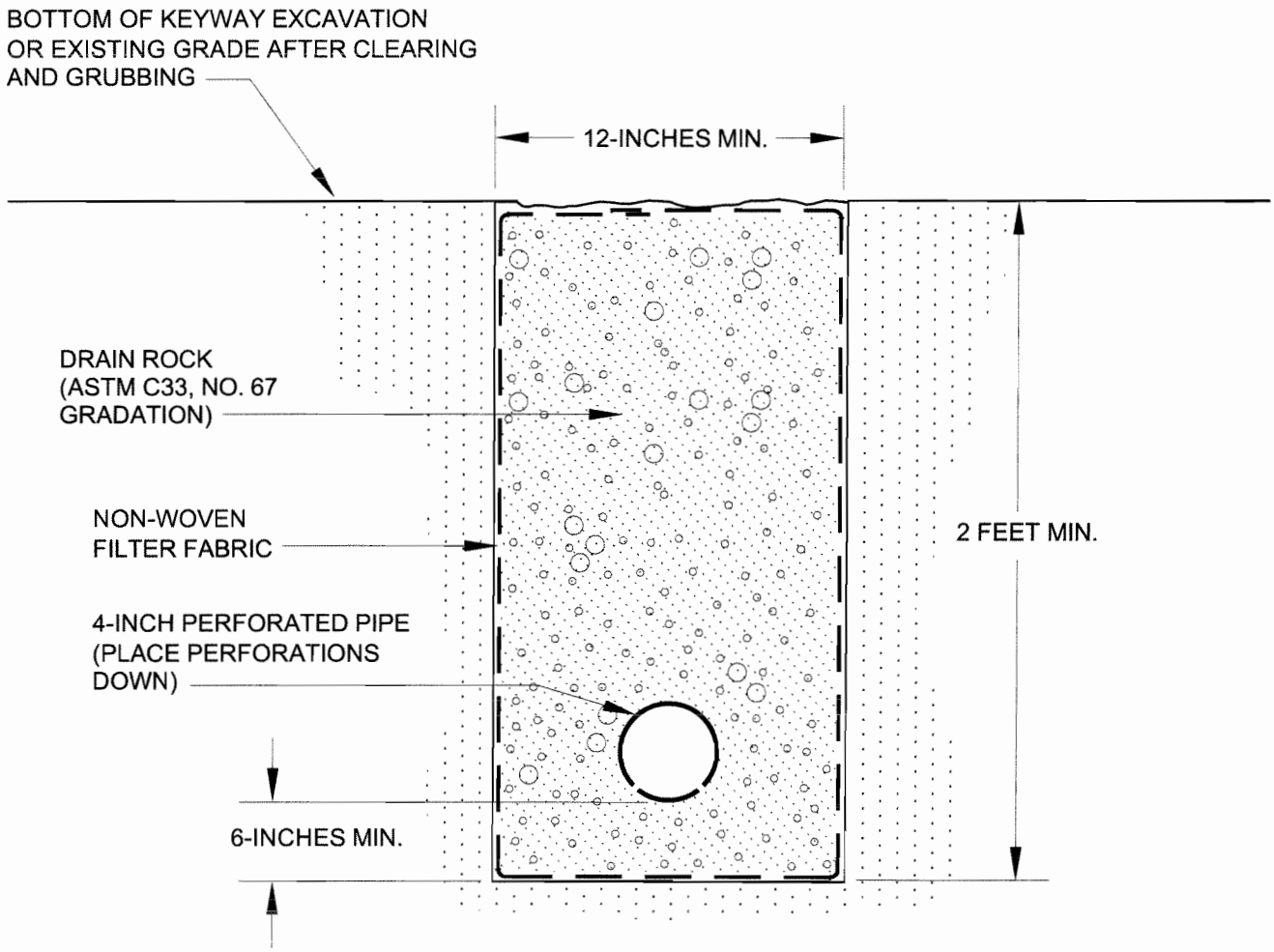
1. WHERE NATURAL GRADE IS STEEPER THAN 5H:1V, BENCH INTO STIFF/DENSE SOIL AS RECOMMENDED BY GEOTECHNICAL ENGINEER.
2. KEYWAY SHOULD EXTEND AT LEAST 2 FEET INTO STIFF/DENSE SOIL AS RECOMMENDED BY THE GEOTECHNICAL ENGINEER. KEYWAY WIDTH SHOULD BE A MINIMUM OF 10 FEET.
3. INTERMEDIATE BENCHES SHOULD BE SPACED EVERY 25 VERTICAL FEET.
4. SUBDRAIN SHOULD DISCHARGE VIA A CLOSED PIPE TO STORM DRAIN OR SUITABLE NATURAL DRAINAGE. SEE PLATE 7 FOR SUBDRAIN DETAIL.
5. TO REDUCE POTENTIAL FOR SIGNIFICANT EROSION, SLOPE PROTECTION SHOULD BE ESTABLISHED AS SOON AS FILL SLOPE IS COMPLETED.

TYPICAL KEYING AND BENCHING DETAIL

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
MARCH 2002	JJP	6
SCALE	W.O.	
NO SCALE	3411-20	



PERFORATED PIPE SUBDRAIN

TYPICAL TRENCH SUBDRAIN DETAIL

HAWAII STATE ROUTE 200 (SADDLE ROAD)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

GEOLABS, INC. *Geotechnical Engineering*		
DATE MARCH 2002	DRAWN BY JJP	PLATE
SCALE NO SCALE	W.O. 3411-20	7

APPENDIX A

Field Exploration

APPENDIX A

Field Exploration

The subsurface conditions along the proposed Saddle Road PTA-1 Alignment project were explored by drilling and sampling 24 borings (designated as Boring Nos. 1 through 15 and Boring Nos. 101 through 109). The borings extended to depths ranging from about 16.5 to 50 feet below the existing ground surface. Nineteen bulk samples, designated as Bulk-1 through Bulk-7 and Bulk-101 through Bulk-112, were obtained of the near-surface soils to evaluate the pavement support characteristics and the quality of the materials for use as embankment fills. Seven of the bulk samples, Bulk-106 through Bulk-112, were obtained at the proposed culvert locations to evaluate the corrosivity of the near-surface soils for the design of the culverts.

The approximate locations of the test borings drilled and bulk samples collected are summarized on Tables A-1.1 and A-1.2 and are shown on the General Site Plan, Plate 3. The approximate locations of the test borings and near-surface bulk samples also are shown on the Site Plans, Plates 4.1 through 4.12. The borings were drilled using both truck-mounted and skid-mounted drilling equipment equipped with continuous flight augers and coring tools, as appropriate.

The materials encountered in the borings were classified by visual and textural examination in the field by our project/staff geologist, who monitored the drilling operations on a near-continuous basis. These classifications were further reviewed visually and by testing in the laboratory. Soils were classified in general conformance with the Unified Soil Classification System as shown on Plate A. Graphic representations of the materials encountered are provided on the Logs of Borings, Plates A-1 through A-24.

Relatively "undisturbed" soil samples were obtained from the borings drilled in general accordance with ASTM Test Designation 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 Test Designation 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.

Pocket penetrometer tests were performed on selected cohesive soil samples in the field. The pocket penetrometer test provides an indication of the unconfined compressive strength of the soil sample. Results of the pocket penetrometer tests are summarized on the Logs of Borings at the appropriate sample depths.

Core samples of the rock formations encountered at the site were obtained using diamond core drilling techniques in general accordance with ASTM Standard Practice D 2113, Diamond Core Drilling for Site Investigation. Core drilling is a rotary drilling method that uses a hollow bit to cut into the rock formation. The material left in the hollow core of the bit is mechanically recovered for examination and classification.

Recovery (REC) is used as a subjective guide to the interpretation of the relative quality of rock masses. Recovery is defined as the actual length of material recovered from a coring attempt versus the length of the core attempt. For example, if 4 feet of material is recovered from a 5-foot core run, the recovery would be 80 percent and would be shown on the Logs of Borings as REC = 80%.

The Rock Quality Designation (RQD) is also a subjective guide to the relative quality of rock masses. RQD is defined as the percentage of the core run that is sound material in excess of 4 inches in length without any discontinuities, discounting any drilling-induced fractures or breaks. If 2.5 feet of sound material is recovered from a 5-foot core run, the RQD would be 50 percent and would be shown on the Logs of Borings as RQD = 50%. Generally, the following is used to describe the relative quality of the rock, based on the "Practical Handbook of Physical Properties of Rocks and Minerals."

Rock Quality	**RQD** (%)
Very Poor	0 – 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 – 100

The rippability of a rock mass is a function of the relative hardness of the rock, its relative quality, brittleness, and fissile characteristics. A dense rock formation with a high RQD value would be very difficult to rip and would probably require more arduous methods of excavation.

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Approximate Boring Locations
Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

Boring No.	Station No.	Offset from Centerline (feet)	Surface Elevations (feet MSL)
B-1	17+80	CL	+5,554
B-2	36+15	CL	+5,633
B-3	97+80	CL	+5,989
B-4	168+50	CL	+5,937
B-5	196+30	CL	+6,003
B-6	247+70	50 Right	+6,168
B-7	272+70	CL	+6,259
B-8	309+75	30 Left	+6,426
B-9	351+15	CL	+6,461
B-10	428+00	CL	+6,606
B-11	480+90	CL	+6,682
B-12	545+00	30 Left	+6,744
B-13	597+25	CL	+6,682
B-14	620+95	CL	+6,610
B-15	664+75	CL	+6,591
B-101	102+25	35 Left	+6,005
B-102	114+60	41 Right	+5,882
B-103	138+40	26 Right	+5,882
B-104	500+30	35 Left	+6,757
B-105	510+00	CL	+6,732
B-106	539+00	CL	+6,778
B-107	578+00	CL	+6,681
B-108	608+00	CL	+6,645
B-109	317+40	20 Left	+6,400

Notes: MSL - Mean Sea Level
CL - Centerline
5 Right - Boring is offset 5 feet to the right of the centerline.
4 Left - Boring is offset 4 feet to the left of the centerline.

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Approximate Bulk Sample Locations
Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

Bulk Sample No.	Station No.	Offset from Centerline (feet)	Surface Elevations (feet MSL)
BULK-1	36+00	CL	+5,633
BULK-2	97+80	CL	+5,989
BULK-3	168+50	CL	+5,937
BULK-4	309+75	30 Left	+6,426
BULK-5	428+00	CL	+6,606
BULK-6	597+25	CL	+6,682
BULK-7	620+95	CL	+6,610
BULK-101	102+25	CL	+6,000
BULK-102	500+30	CL	+6,756
BULK-103	539+00	CL	+6,777
BULK-104	556+00	CL	+6,743
BULK-105	587+00	CL	+6,688
BULK-106	33+10	CL	+5,600
BULK-107	114+90	40 Right	+5,882
BULK-108	201+51	CL	+6,001
BULK-109	265+05	CL	+6,232
BULK-110	328+62	CL	+6,419
BULK-111	396+00	CL	+6,581
BULK-112	480+00	CL	+6,682

Notes: MSL - Mean Sea Level
CL - Centerline
5 Right - Boring is offset 5 feet to the right of the centerline.
4 Left - Boring is offset 4 feet to the left of the centerline.

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GEOLABS, INC.

Geotechnical Engineering

Boring 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
- SHELBY TUBE SAMPLE
- 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

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 1

Approximate Ground Surface Elevation" "(feet MSL): 5554 *

Sta.17+80

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
								SM	Brown and gray **SILTY SAND,** loose, dry (alluvium)
	8	66			20				
								SP	Brown and gray **SAND** with some silt and basaltic gravel/cobbles, medium dense, dry (alluvium)
	2	104			35				
	3	97			19		5		
									Dense **COBBLES**
								GW	Light brown and gray **SANDY BASALTIC GRAVEL,** dense, dry (cinder and a'a clinker)
	7				68/.5' Ref.		10		
									Gray vugular **BASALT,** medium hard (a'a clinker)
			100	100					Gray vugular **BASALT**, slightly to moderately fractured, unweathered, hard (a'a basalt rock)
			100	100			15		
									grades to non-vesicular, very hard
							20		Boring terminated at 20 feet
							25		
							30		
							35		

* Elevations estimated from Plan and Profile drawings provided by Okahara and Associates Inc. on November 2000.

Date Started:	August 1, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 1, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 1
Total Depth:	20 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 2

Approximate Ground Surface Elevation" "(feet MSL): 5633 *

Sta.36+15

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
	15	56			29					SM	Brown and gray **SILTY SAND,** loose to medium dense, dry (alluvium)
					55		5			SP	Light brown and gray fine **SAND,** medium dense, dry (cemented cinder)
	1				10		10				Brownish gray strongly vesicular, porous **BASALT**, slightly weathered, loose, dry (scoriaceous/spatter lava)
	1				12		15				grades to red and brown, loose to medium dense
	1				7		20				
	1				11		25				
	1				17		30				
							35				Boring terminated at 31.5 feet

Date Started:	August 1, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 1, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 2
Total Depth:	31.5 feet	Drilling Method: 8" Hollow-Stem Auger	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 3

Approximate Ground Surface Elevation" "(feet MSL): 5989 *

Sta.97+80

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
	7	63			35			SP	Brown and gray **SAND** with basaltic gravel and cobbles, medium dense, dry (cinder)
	9	71			84		5	SP-SM	Brown, white and gray poorly graded **SAND** with silt, dense, dry (cemented cinder)
	3				21		10	SP	Black **SAND,** medium dense, dry (cemented cinder)
								ML	Light brown **SANDY SILT,** stiff, dry (volcanic ash)
									Gray **BASALT**, closely fractured, slightly weathered, medium hard (a'a clinker)
			100	100	15/.0' Ref.		15		Gray vugular **BASALT**, slightly fractured, unweathered, hard to very hard (a'a basalt rock)
			53	27					**VOID**
			60	50			20		Brownish gray strongly vesicular **BASALT**, closely fractured, slightly weathered, medium hard (clinker)
							25		Gray vugular **BASALT**, slightly fractured, unweathered, very hard (a'a basalt rock)
			90	67					**VOID**
							30		Gray vugular **BASALT**, slightly fractured, slightly weathered, very hard (a'a basalt rock)
			40	20					Brownish gray vesicular **BASALT**, closely to severely fractured with voids, slightly weathered, medium hard (clinker)
							35		

Date Started:	August 2, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 2, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	50 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 3.1
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 3

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
			100	100							Brownish gray vesicular **BASALT**, closely fractured, slightly weathered, medium hard to hard (a'a basalt rock)
											VOID at 34 feet
											Gray vesicular **BASALT**, slightly fractured, slightly weathered, very hard (a'a basalt rock)
							40				grades to medium hard to hard
			43	20							Brownish gray **BASALT**, severely fractured, slightly weathered, medium hard (clinker)
							45				Brownish gray vesicular **BASALT**, closely fractured, slightly weathered, medium hard to hard (a'a basalt rock)
			76	17							
							50				Boring terminated at 50 feet
							55				
							60				
							65				
							70				

Date Started:	August 2, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 2, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 3.2
Total Depth:	50 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 4

Approximate Ground Surface Elevation" "(feet MSL): 5937 *

Sta.168+50

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
										SM	Dark brown **SILTY SAND,** loose, dry (alluvium)
	6	75			15					SP-SM	Brown and gray fine **SAND** with some silt and gravel, loose to medium dense, dry (alluvium)
	5				14		5			SP	Brown and gray fine **SAND** with some silt, medium dense, dry (weakly cemented cinder)
	4	90			42		10				Dense **COBBLES**
	6				20		15			SP	Brown and gray fine **SAND** with some silt, medium dense, dry (ash and cinder)
											Dense **COBBLES**
	6				31		20				
											Gray **BASALT**, medium hard (a'a clinker)
			86	56			25				Gray vugular **BASALT**, moderately vertically fractured, slightly weathered, hard to very hard (a'a basalt rock)
			64	17							**VOID**
							30				Brownish gray vesicular **BASALT**, closely fractured, slightly weathered, medium hard to hard (clinker) **VOID** at 29 feet Boring terminated at 30 feet
							35				

Date Started:	August 2, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 3, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	30 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 4
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 5

Approximate Ground Surface Elevation" "(feet MSL): 6003 *

Sta.196+30

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
	3	97			35			GW-GM	Brown and gray well-graded **BASALTIC GRAVEL** with silt, medium dense, dry (alluvium)
									grades to dense
	3				50		5		
			27						**BOULDER**
								SM	Brown and gray **SILTY SAND,** medium dense, dry (cemented alluvium)
	5				16		10		
			14						Dense **COBBLES**
								SP	Brown and gray **SAND** with some gravel and cobbles, medium dense, dry (cemented alluvium)
	3				18		15		
			0						
	3				19		20		
			7						
	4				48		25		Brown and gray **COBBLES** with sand and gravel, dense, dry (cemented alluvium)
			11						
	2				27		30		
									Boring terminated at 31.5 feet
							35		

Date Started:	August 3, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 3, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 5
Total Depth:	31.5 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 6

Approximate Ground Surface Elevation" "(feet MSL): 6168 *

Sta.247+70

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
	4				52			GW	Brown and gray **SANDY GRAVEL** with some silt and cobbles, dense, dry (cemented alluvium)
	8	76			22		5	SP	Brown and gray fine **SAND** with some silt, loose to medium dense, dry (cemented alluvium)
									Dense **COBBLES** grades to medium dense
	5				18		10		
	9	73			50		15	SM	Brown **SILTY SAND,** medium dense, dry (cemented alluvium)
									Dense **COBBLES**
	11				8		20	ML	Tan and white **SILT** with some sand and traces of gravel, soft, dry (volcanic ash)
									Gray **BASALT,** medium hard (clinker)
			100	67	15/.0' Ref.		25		Gray vugular **BASALT**, moderately to slightly fractured, slightly weathered, hard (a'a basalt rock)
			100	85					grades to slightly vesicular, very hard
							30		Boring terminated at 30 feet
							35		

Date Started:	August 3, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 3, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	30 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 6
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 7

Approximate Ground Surface Elevation" "(feet MSL): 6259 *

Sta.272+70

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
	3	104			54					SP-SM	Brown and gray poorly graded **SAND** with silt and gravel, medium dense, dry (cemented alluvium)
	2				29						
	2	104			85		5				
			20								Gray and brown **COBBLES** with sand and gravel, dense to very dense, dry (cemented alluvial conglomerate)
							10				
			5		20/.0' Ref.						
							15				
			28		20/.0' Ref.						
	4				65		20				
											Boring terminated at 21.5 feet
							25				
							30				
							35				

Date Started:	August 4, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 4, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 7
Total Depth:	21.5 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 8

Approximate Ground Surface Elevation" "(feet MSL): 6426 *

Sta.309+75

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
	13	67			79					SP-SM	Brown and gray poorly graded **SAND** with silt and gravel, dense, dry (cemented alluvium)
	7				46		5				
	6	86			113		10			SP	Black **CINDER SAND,** dense, damp (cemented cinder)
	8				36		15				Black scoriaceous **GRAVEL AND COBBLES,** medium dense, damp
	12				34		20				
	13	63			64		25				
	9				55		30			SP	Black **SAND,** dense, damp (cemented cinder)
			100	96			35				Gray slightly vugular **BASALT**, slightly fractured, unweathered, very hard (a'a basalt rock)

Date Started:	August 7, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 8, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	45 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 8.1
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 8

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
			100	63							
							40				Brownish gray strongly vesicular **BASALT**, moderately fractured, slightly to moderately weathered, medium hard to hard (pahoehoe basalt rock)
			100	90							
							45				Boring terminated at 45 feet
							50				
							55				
							60				
							65				
							70				

Date Started:	August 7, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 8, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 8.2
Total Depth:	45 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 9

Approximate Ground Surface Elevation" "(feet MSL): 6461 *

Sta.351+15

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
	4	95			49					SM	Brown and gray **SILTY SAND** with some gravel, medium dense to dense, dry (cemented alluvium)
	2				24						
	2				36		5				
	3	109			20		10			SW	Light gray **GRAVELLY SAND,** loose to medium dense, dry (alluvium)
	3				116		15			GW	Gray **SANDY GRAVEL,** dense to very dense, dry (cemented alluvium)
	2				26		20			SP	Gray and brown **SAND,** medium dense, dry (alluvium)
											Boring terminated at 21.5 feet
							25				
							30				
							35				

Date Started:	August 8, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 8, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 9
Total Depth:	21.5 feet	Drilling Method: 8" Hollow-Stem Auger	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 10

Approximate Ground Surface Elevation" "(feet MSL): 6606 *

Sta.428+00

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
	8	73			44			GM	Light brown **SILTY GRAVEL** with sand, medium dense, dry (volcanic ash and a'a clinker)
									grades to dense
	6				72				
			67	50	20/.0' Ref.		5		Gray vugular **BASALT**, slightly to moderately fractured, slightly weathered, hard to very hard (a'a basalt rock)
			100	80					
							10		grades to slightly fractured
			100	100					grades to massive, very hard
							15		
									Boring terminated at 16.5 feet
							20		
							25		
							30		
							35		

Date Started:	August 9, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 9, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	16.5 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 10
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 11

Approximate Ground Surface Elevation" "(feet MSL): 6682 *

Sta.480+90

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
	6	77			31/.7' Ref.					GW	Brown and gray **SANDY GRAVEL** with a few cobbles/boulders, medium dense, dry (alluvium) **BOULDER**
	8				45					SP-SM	Brown and gray poorly graded **SAND** with some silt and gravel, medium dense, dry
	7				94		5			SP	Brown, red and gray **SAND** with some gravel, dense to very dense, dry (cemented cinder)
	4				19		10			SP	Dark gray cemented **SAND,** medium dense, dry to damp (cinder)
	81					2	15				grades to loose
					44		20				Gray **BASALT**, medium dense to dense (a'a clinker)
							25				Boring terminated at 21.5 feet
							30				
							35				

Date Started:	August 9, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 9, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 11
Total Depth:	21.5 feet	Drilling Method: 8" Hollow-Stem Auger	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 12

Approximate Ground Surface Elevation" "(feet MSL): 6744 *

Sta.545+00

Laboratory			Field				Depth (feet)	Sample	Graphic	USCS	Description
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)					
										SM	Light brown and gray **SILTY SAND** with basaltic gravel, loose, dry to damp (alluvium)
	10	51			11						
											Black and red scoriaceous **BASALT**, loose (volcanic cinder)
	19				8						
	19	39			12		5				
	13				6/.5' +18/.3' Ref.		10				
			100	100							Gray vugular **BASALT**, slightly fractured, slightly weathered, hard (a'a basalt rock)
			100	100			15				
											grade to massive, unweathered, very hard
							20				Boring terminated at 20 feet
							25				
							30				
							35				

Date Started:	August 10, 2000	Water Level: ▽	Not Encountered	Plate
Date Completed:	August 10, 2000			
Logged By:	S. Carr	Drill Rig:	MOBILE B-53	
Total Depth:	20 feet	Drilling Method:	8" Hollow-Stem Auger & HQ Coring	A - 12
Work Order:	3411-20(A)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 13

Approximate Ground Surface Elevation" "(feet MSL): 6682 *

Sta.597+25

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
	7	66			6	<0.1				ML	Light brown **CLAYEY SILT** with a little fine sand, soft, dry (volcanic ash)
	7	87			30					GM	Brownish gray **SILTY BASALTIC GRAVEL** with sand, loose to medium dense, dry (ash and a'a clinker)
	6				14		5				
	5	92			55		10				Gray **BASALT**, severely fractured, slightly weathered, medium hard (a'a clinker)
	4		100	0	50/.4' Ref.		15				Brownish gray weakly vugular **BASALT**, closely fractured, slightly weathered, hard (a'a clinker)
			100	90							Gray slightly vesicular **BASALT**, massive, slightly weathered, very hard (a'a basalt rock)
			100	100			20				
			100	100			25				
			100	83			30				
							35				

Date Started:	July 27, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	July 27, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	35 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 13.1
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 13

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description

(Continued from previous plate)

Gray vesicular **BASALT**, closely fractured, slightly weathered, hard (clinker)

Boring terminated at 35 feet

40

45

50

55

60

65

70

Date Started:	July 27, 2000	Water Level: ▽ Not Encountered		Plate
Date Completed:	July 27, 2000			
Logged By:	S. Carr	Drill Rig:	MOBILE B-53	
Total Depth:	35 feet	Drilling Method:	8" Hollow-Stem Auger & HQ Coring	A - 13.2
Work Order:	3411-20(A)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 14

Approximate Ground Surface Elevation" "(feet MSL): 6610 *

Sta.620+95

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
LL=94 PI=22	10	43			23			MH	Light brown **CLAYEY SILT,** soft, dry (volcanic ash)
	6				26		5	GM-MH	Gray **BASALT AND LIGHT BROWN CLAYEY SILT,** medium dense, stiff, dry (a'a basalt and volcanic ash)
	9	87			28		10		Gray and brown vesicular **BASALT** with a little silt, medium dense, damp (a'a clinker)
	5				20		15		
			55						
			100	65					
							20		Brown and gray vesicular **BASALT**, slightly fractured, slightly weathered, hard (a'a basalt rock)
			100	100					Gray massive **BASALT**, slightly fractured, unweathered, very hard (a'a basalt rock)
							25		Boring terminated at 25 feet
							30		
							35		

Date Started:	July 28, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	July 28, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	
Total Depth:	25 feet	Drilling Method: 8" Hollow-Stem Auger & HQ Coring	A - 14
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 15

Approximate Ground Surface Elevation" "(feet MSL): 6591 *

Sta.664+75

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	
			100	83							Gray vesicular **BASALT**, slightly to moderately fractured, unweathered, hard (pahoehoe basalt rock)
			100	75			5				
			100	100							grades to slightly fractured, hard to very hard
			70	40			10				
							15				Reddish brown vugular **BASALT**, closely to severely fractured, slightly weathered, medium hard (a'a clinker)
											Boring terminated at 16 feet
							20				
							25				
							30				
							35				

Date Started:	August 10, 2000	Water Level: ▽ Not Encountered	Plate
Date Completed:	August 10, 2000		
Logged By:	S. Carr	Drill Rig: MOBILE B-53	A - 15
Total Depth:	16 feet	Drilling Method: HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 101

Approximate Ground Surface Elevation" "(feet MSL): 6005 *

Sta.102+25

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
										SM	Light brown fine **SILTY SAND,** loose, dry
	14	76			34					SP-SM	Dark orangish brown poorly graded **SAND** with silt and some roots/rootlets, medium dense, damp
	7				20/.5' +30/.3' Ref.		5				grades with some basaltic gravel and cobbles, dense
			28	0							Gray with brown mottling vesicular **BASALT** in a silty sand matrix, medium dense, dry to damp (clinker)
			53	38			10				
			60	57			15				Gray vesicular **BASALT**, slightly fractured, moderately to slightly weathered, hard (pahoehoe basalt rock) **VOID**
			37	17			20				Gray vesicular **BASALT** with sand, loose, dry (clinker)
			40	38	15/.0' Ref.		25				Gray vesicular to dense **BASALT**, massive, slightly weathered, very hard (pahoehoe basalt rock) **VOID**
			90	68			30				Gray with reddish brown mottling vesicular **BASALT,** medium dense, dry (clinker)
							35				Gray vesicular **BASALT**, slightly to moderately fractured, slightly to moderately weathered, hard (pahoehoe basalt rock) **VOID**

Date Started:	December 18, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 18, 2001		
Logged By:	Y. Chiba	Drill Rig: CME-55D	
Total Depth:	39.5 feet	Drilling Method: 4" Auger & 4" Casing/NQ	A - 16.1
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 101

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
			82	50							grades to moderately fractured
							40				Boring terminated at 39.5 feet
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	December 18, 2001	Water Level: ▽	Not Encountered	Plate
Date Completed:	December 18, 2001			
Logged By:	Y. Chiba	Drill Rig:	CME-55D	
Total Depth:	39.5 feet	Drilling Method:	4" Auger & 4" Casing/NQ	A - 16.2
Work Order:	3411-20(A)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 102

Approximate Ground Surface Elevation" "(feet MSL): 5882 *

Sta.114+60

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
								SM	Brown fine **SILTY SAND,** loose, dry (recent alluvium)
	9	79			42/.5' +20/.3' Ref.			SP-SM	Dark brown poorly graded **SAND** with silt and gravel, medium dense, damp (alluvium)
									grades with basaltic cobbles and boulders
			95	45	15/.0' Ref.		5		Gray dense **BASALT**, moderately to slightly fractured, moderately weathered, very hard (pahoehoe basalt rock)
			88	50			10		grades to vesicular
			100	67			15		Brownish gray vesicular **BASALT**, moderately weathered, medium dense (clinker)
									Gray dense **BASALT**, slightly fractured, slightly weathered, very hard (pahoehoe basalt rock)
			100	60			20		Gray vesicular **BASALT**, closely fractured, moderately weathered, hard
									Gray dense **BASALT**, massive to slightly fractured, unweathered, very hard
							25		grades to vesicular, closely to severely fractured, moderately to highly weathered, medium hard
									Boring terminated at 25 feet
							30		
							35		

Date Started:	December 19, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 19, 2001		
Logged By:	Y. Chiba	Drill Rig: CME-55D	
Total Depth:	25 feet	Drilling Method: 4" Auger & NQ Coring	A - 17
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 103

Approximate Ground Surface Elevation" "(feet MSL): 5882 *

Sta.138+40

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
	19	64			11			SM	Dark brown fine **SILTY SAND,** medium dense, damp (recent alluvium)
								SP	Light brown **SAND** with gravel and silt, medium dense, dry
	4	93			20		5		
								SM	Light brownish tan very fine **SAND,** medium dense, dry
	7				12		10		
			67 28				15		grades to dark brown with vesicular to dense basaltic cobbles and boulders (old alluvium)
	4				31		20		
			95	76					Gray dense **BASALT**, slightly fractured, slightly weathered, very hard (pahoehoe basalt rock)
							25		Boring terminated at 25 feet
							30		
							35		

Date Started:	December 19, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 19, 2001		
Logged By:	Y. Chiba	Drill Rig: CME-55D	A - 18
Total Depth:	25 feet	Drilling Method: 4" Auger & 4" Casing/NQ	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 104

Approximate Ground Surface Elevation" "(feet MSL): 6757 *

Sta.500+30

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
								SM	Dark brown **SILTY SAND** with some gravel, medium dense, dry
								GP	Tannish brown poorly graded **GRAVEL** with sand, medium dense, dry
	9	87			38/.5' +45/.3' Ref.				
	1				9		5	SW	Tannish brown **GRAVELLY SAND** in a silty matrix, medium dense, dry
			76	59					Gray dense **BASALT**, moderately fractured, slightly to moderately weathered, very hard (pahoehoe basalt rock)
							10		
			98	94					
									grades to slightly fractured, unweathered
							15		
			100	100					
			63	47					grades to vesicular
							20		Gray with light reddish brown mottling **SANDY BASALT**, moderately weathered, loose (a'a clinker)
			58	23					
							25		Gray dense **BASALT**, moderately fractured, slightly weathered, very hard (pahoehoe basalt rock)
			68	38					
							30		Light reddish brown with gray mottling **BASALT**, moderately weathered, loose (a'a clinker)
			55	0					
							35		

Date Started:	December 13, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 14, 2001		
Logged By:	Y. Chiba	Drill Rig: DIEDRICH D-25	
Total Depth:	40 feet	Drilling Method: 4" Auger & HQ/NQ	A - 19.1
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

BORING_LOG_WITH_STA_3411-20.GPJ GEOLABS.GDT 10/24/02

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 104

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
			57	0							Gray with grayish red mottling vesicular **BASALT,** loose (clinker)
					20/.0' Ref.		40				Boring terminated at 40 feet
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	December 13, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 14, 2001		
Logged By:	Y. Chiba	Drill Rig: DIEDRICH D-25	A - 19.2
Total Depth:	40 feet	Drilling Method: 4" Auger & HQ/NQ	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 105

Approximate Ground Surface Elevation" "(feet MSL): 6732 *

Sta.510+00

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
										GP-GM	Grayish brown poorly graded **GRAVEL** with silt and sand, loose, dry (residual soil)
					19						grades to dark reddish brown
	19	63									grades to brown with some gravel and cobbles
							5			SP	Reddish brown poorly graded **CINDER SAND** with some gravel and cobbles, loose, moist
	2				22						
			67	30	15/.0' Ref.		10				Gray dense **BASALT** in a sandy matrix, medium dense, dry (clinker)
			58	12							Gray dense **BASALT**, moderately fractured, slightly weathered, very hard (pahoehoe basalt rock)
											grades to scoriaceous
			73	67			15				
											Boring terminated at 18 feet
							20				
							25				
							30				
							35				

Date Started:	December 17, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 17, 2001		
Logged By:	Y. Chiba	Drill Rig: DIEDRICH D-25	A - 20
Total Depth:	18 feet	Drilling Method: 4" Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 106

Approximate Ground Surface Elevation" "(feet MSL): 6778 *

Sta.539+00

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	
										SM	Dark brown **SILTY SAND** with some a'a basalt, cobbles and boulders, medium dense, dry
										ML	Dark brown **SANDY SILT** with some clay, cobbles and boulders, medium dense, dry
					39					GW	Dark brown with orange mottling well-graded **GRAVEL** with sand, medium dense, moist grades with cobbles and boulders
					32		5				
			98	98							Light gray to dense **BASALT**, slightly fractured, slightly to moderately weathered, very hard (pahoehoe basalt rock)
							10				
			78	73							
							15				Gray with brown mottling **BASALT**, moderately weathered, loose (a'a clinker)
			43	0							
							20				Gray dense to vugular **BASALT**, closely fractured, slightly to moderately weathered, hard
			95	38	10/.0' Ref.						
							25				grades to dense, massive, unweathered, very hard
			100	100							
							30				
											Boring terminated at 32 feet
							35				

Date Started:	December 12, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 12, 2001		
Logged By:	Y. Chiba	Drill Rig: DIEDRICH D-25	A - 21
Total Depth:	32 feet	Drilling Method: 4" Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 107

Approximate Ground Surface Elevation" "(feet MSL): 6681 *

Sta.578+00

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
										MH	Dark brown **CLAYEY SILT,** medium stiff, moist (residual soil)
					12					SM	Dark brown with red mottling fine **SILTY SAND,** medium dense, damp
	63	45									
										MH	Whitish tan **CLAYEY SILT** with very fine sand, soft, dry
	23				10		5				
										SM	Yellowish tan very fine **SILTY SAND,** medium dense, dry (weathered ash)
			100	100	10/.0'		10				Gray vesicular **BASALT**, slightly fractured, slightly weathered, very hard (pahoehoe basalt rock)
			95	95	Ref.						
											VOID grades to dense to vesicular, slightly to moderately fractured
			100	90			15				
							20				
			17							SP	Dark reddish brown moderately cemented poorly graded coarse **SAND,** medium dense, dry to damp (cinder)
							25				
	37				22						
			31								grades with brownish tan mottling silt
							30				
	66				6						grades to black poorly graded coarse sand, loose
											Boring terminated at 32 feet
							35				

Date Started:	December 20, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 20, 2001		
Logged By:	Y. Chiba	Drill Rig: CME-55D	A - 22
Total Depth:	32 feet	Drilling Method: 4" Auger & 4" Casing/HQ	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 108

Approximate Ground Surface Elevation" "(feet MSL): 6645 *

Sta.608+00

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
	85	37			7			ML	Dark blackish brown very fine **SANDY SILT** with roots/rootlets, soft, moist (residual soil)
								SM	Dark brown fine **SILTY SAND,** loose, moist
	11				24		5	GW	Dark orangish brown well graded **GRAVEL** with sand, medium dense, moist (cinder)
	1				12		10	GW	Dark brown with gray mottling **SANDY GRAVEL** with some cobbles, medium dense, moist
	8				31		15	SW	Dark brown **GRAVELLY SAND** with some cobbles, medium dense, moist (cinder)
			67	67					Gray dense **BASALT**, slightly fractured, slightly weathered, very hard (pahoehoe basalt rock)
			97	97			20		**VOID**
							25		
									Boring terminated at 26 feet
							30		
							35		

Date Started:	December 20, 2001	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 20, 2001		
Logged By:	Y. Chiba	Drill Rig: CME-55D	A - 23
Total Depth:	26 feet	Drilling Method: 4" Auger & HQ Coring	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42) ISLAND OF HAWAII	Log of Boring 109

Approximate Ground Surface Elevation" "(feet MSL): 6402 *

Sta.317+40

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
					37					SP-SM	Dark brown poorly graded **SAND** with silt and gravel, medium dense, dry (fill/residual soil)
	4	80									
					34		5				
	7	80									
					23		10			SM	Tannish brown **SILTY SAND,** medium dense, dry
	15	95									
			67		15/.0' Ref.		15				Gray dense **BASALT** in a silty sand matrix, dense (boulder/colluvium)
			5				20			GW-GM	Gray well-graded **GRAVEL** with silt and sand, medium dense
	11				54		25				
											Boring terminated at 26.9 feet
							30				
							35				

Date Started:	December 22, 2002	Water Level: ▽ Not Encountered	Plate
Date Completed:	December 22, 2002		
Logged By:	Y. Chiba	Drill Rig: CME-55D	A - 24
Total Depth:	26.9 feet	Drilling Method: 4" Auger	
Work Order:	3411-20(A)	Driving Energy: 140 lb. wt., 30 in. drop	

BORING_LOG_WITH_STA_3411-20.GPJ GEOLABS.GDT 10/24/02

APPENDIX B

Geophysical Survey

APPENDIX B

Geophysical Survey

The subsurface conditions along the Saddle Road PTA-1 alignment also were explored by the performance of 41 seismic refraction survey lines from June 19 through July 14, 2000. The approximate locations of the seismic refraction surveys are summarized on Table B-1 and are shown on the Site Plans, Plates 4.1 through 4.12.

Refraction seismography is based on the transmission of elastic energy (compression) waves through geologic materials. The seismic refraction surveys were conducted using a 12-channel signal enhancement seismograph with a 12-pound sledge hammer as a seismic energy source. Generally, the denser or more consolidated a material is, the faster the transmission of the compression waves (P-waves). These waves are refracted at interfaces between materials with contrasting densities. The refracted waves are received by geophones on the surface and recorded by the operator.

The recorded data is input into a desktop computer for processing, which involves the interpretive selection of the arrival times of the refracted waves. After the interpretive selection of arrival times, the technique permits mathematical calculations that yield approximate depths or thickness of materials below the survey lines and provide their approximate compression wave (P-wave) velocities. The velocities are averaged along the travel path of the compression waves. The calculated velocities may be empirically related to the excavation characteristics of the materials. The following legend explains the terms shown on the Seismic Refraction Profiles presented on Plates B-1 through B-39. Due to the lower P-wave velocity of the underlying a'a lava flow (velocity inversion), layer profile computations could not be performed using seismic refraction at the locations of SR-40 and SR-41.

Velocity = Compression wave velocity in feet per second
Dip = Dip of the top of the layer in degrees
Depth = Depth below ground surface in feet

The typical estimated seismic velocities for the various materials underlying the site are classified as follows. A contractor wishing to bid on this project should retain a qualified professional to assist in the interpretation of these geophysical survey results.

Material Type	Seismic (P-wave) Velocity (feet per second)
Sand	950 to 1,500
Conglomerate	1,100 to 4,000
Clinker	2,000 to 3,000
Dense Basalt	3,000 to 10,000

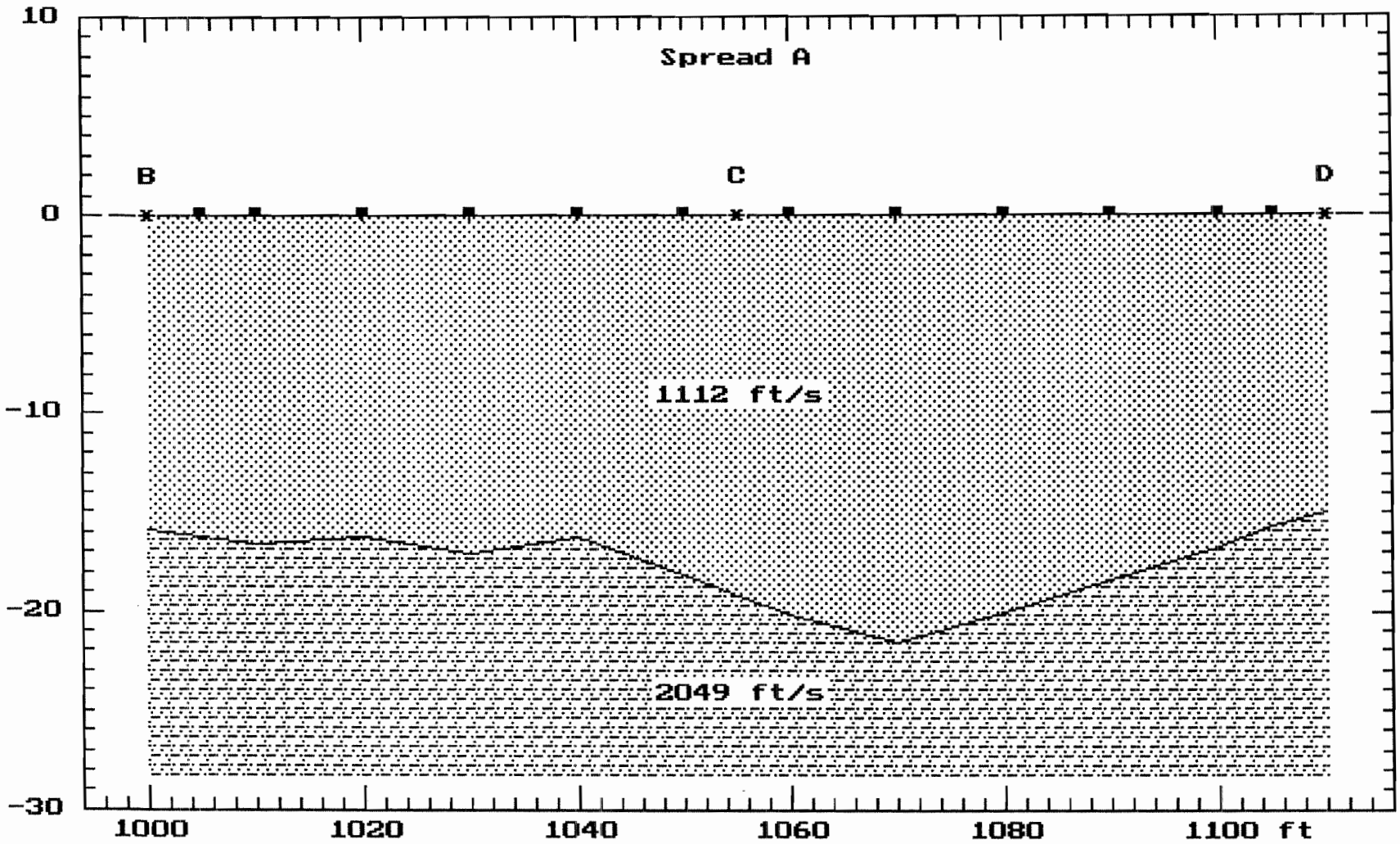
(u:\03reports\3411-20.tk2-p78)

Approximate Seismic Refraction Survey Locations
Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

Seismic Survey No.	Station No.	Offset from Centerline (feet)	Surface Elevations (feet MSL)
SR-1	28+00	CL	+5,581
SR-2	36+00	CL	+5,633
SR-3	55+65	CL	+5,719
SR-4	68+60	CL	+5,813
SR-5	85+20	50 Left	+5,941
SR-6	97+50	CL	+5,987
SR-7	102+70	CL	+5,999
SR-8	117+10	CL	+5,885
SR-9	135+50	CL	+5,884
SR-10	152+60	CL	+5,899
SR-11	168+50	CL	+5,937
SR-12	184+80	CL	+5,967
SR-13	195+85	CL	+6,002
SR-14	217+60	CL	+6,078
SR-15	234+00	CL	+6,124
SR-16	250+70	40 Right	+6,169
SR-17	265+50	CL	+6,233
SR-18	279+10	CL	+6,296
SR-19	291+90	CL	+6,323
SR-20	305+85	CL	+6,398
SR-21	322+50	CL	+6,418
SR-22	332+50	CL	+6,427
SR-23	351+15	CL	+6,461
SR-24	365+10	CL	+6,491
SR-25	376+60	CL	+6,522
SR-26	390+50	CL	+6,564
SR-27	405+50	CL	+6,609
SR-28	427+74	CL	+6,607
SR-29	447+20	CL	+6,629
SR-30	463+60	CL	+6,669
SR-31	481+40	CL	+6,683
SR-32	499+80	CL	+6,751
SR-33	516+15	CL	+6,750
SR-34	529+30	CL	+6,758
SR-35	540+85	CL	+6,749
SR-36	558+00	CL	+6,735
SR-37	574+00	45 Left	+6,703
SR-38	597+70	CL	+6,682
SR-39	620+50	CL	+6,611
SR-40	647+00	CL	+6,591
SR-41	666+00	CL	+6,590

(u:\3411-10(A).tk1 - bulk sample locations.xls)

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 1



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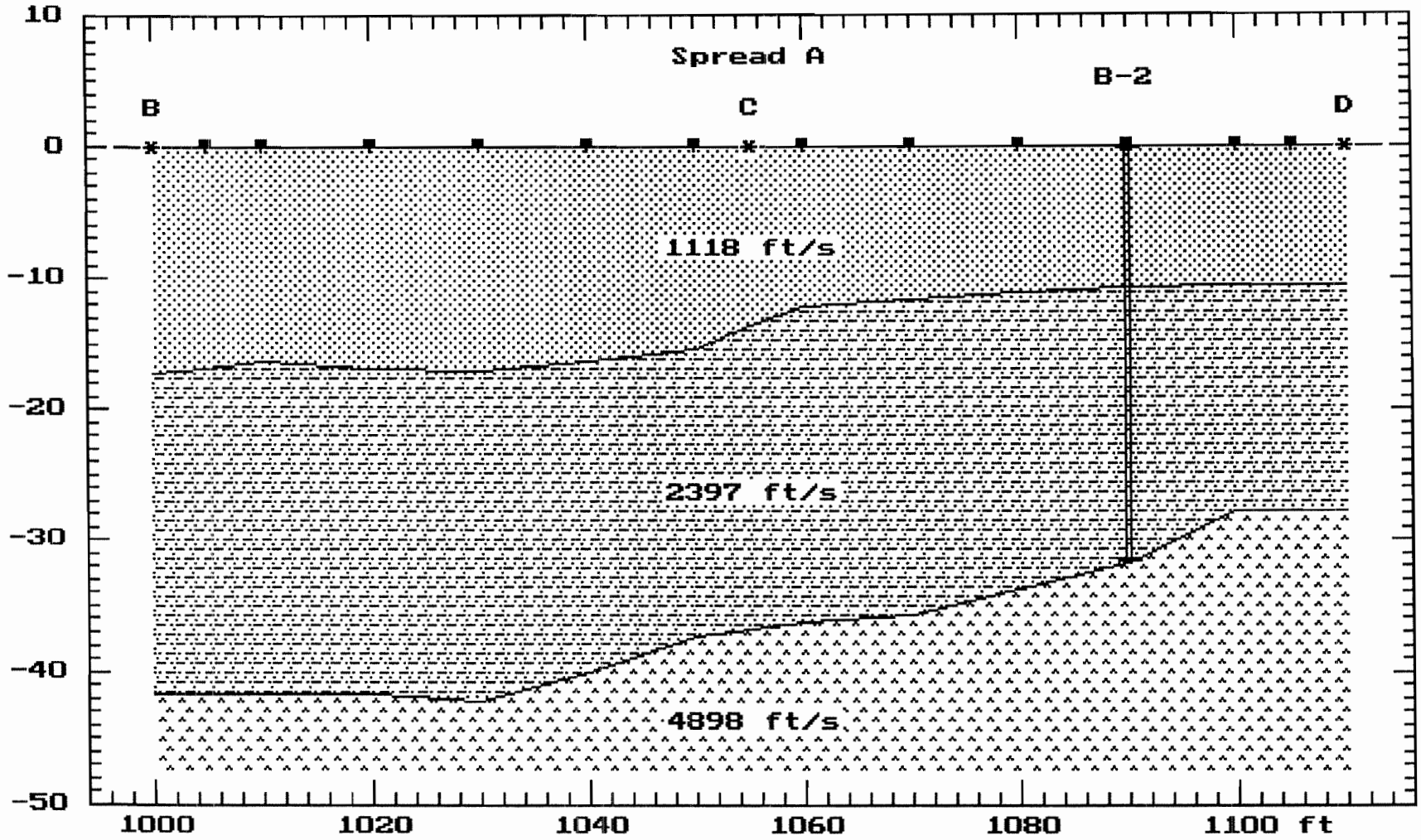
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
	Honolulu, HI August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 2



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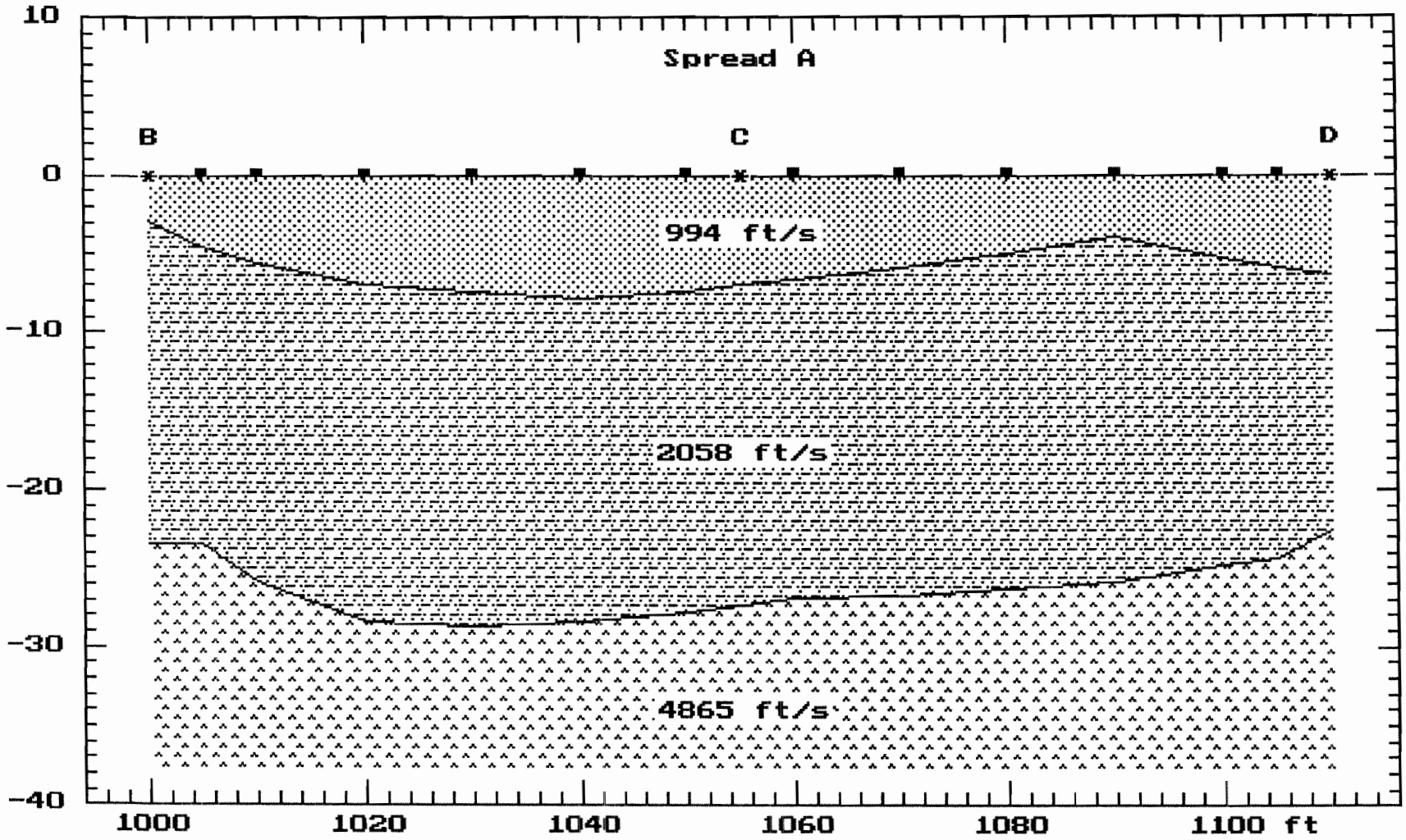
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 3



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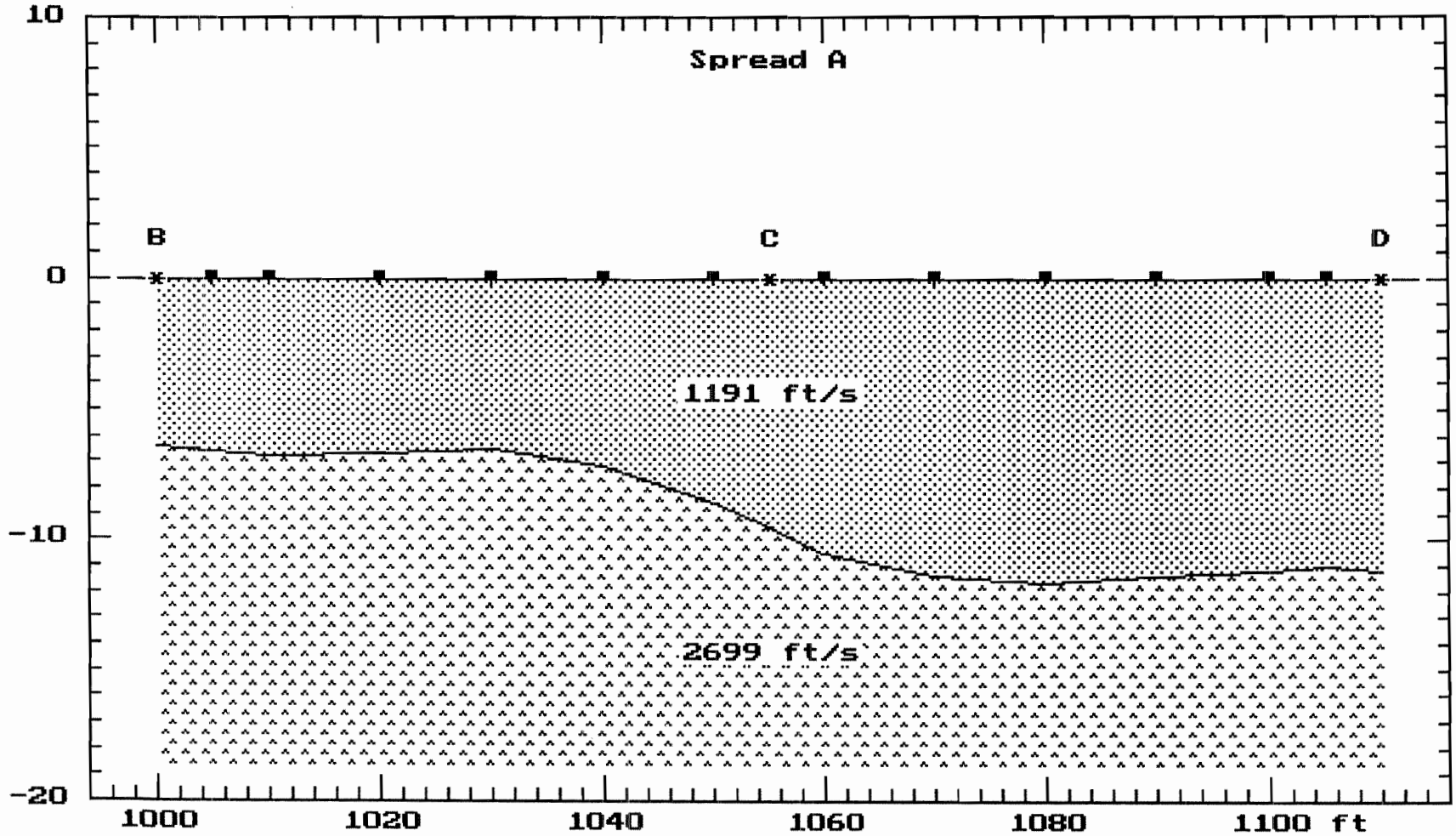
SADDLE ROAD PTA-1 ALIGNMENT: LINE NO. 4



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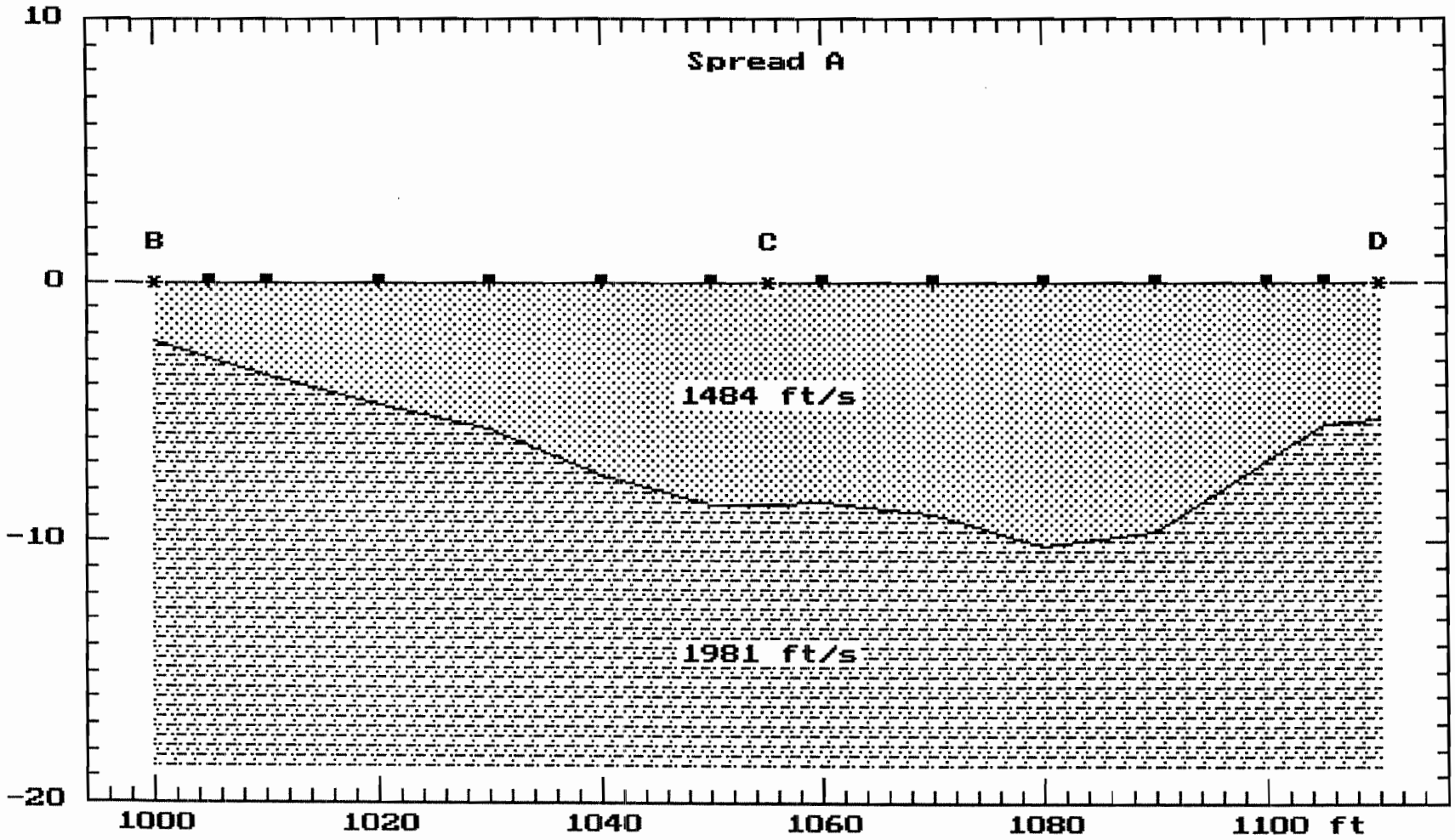

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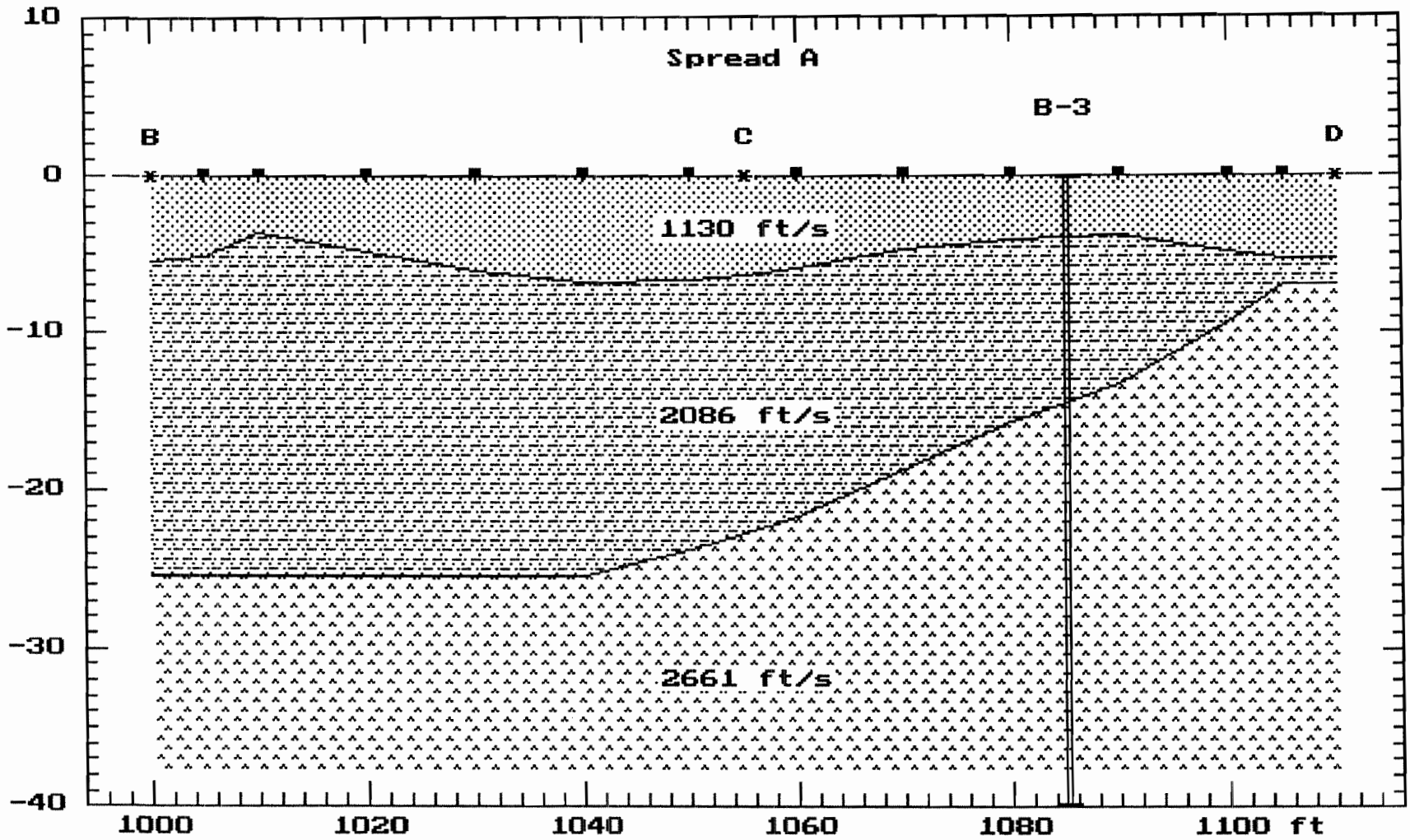
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 6



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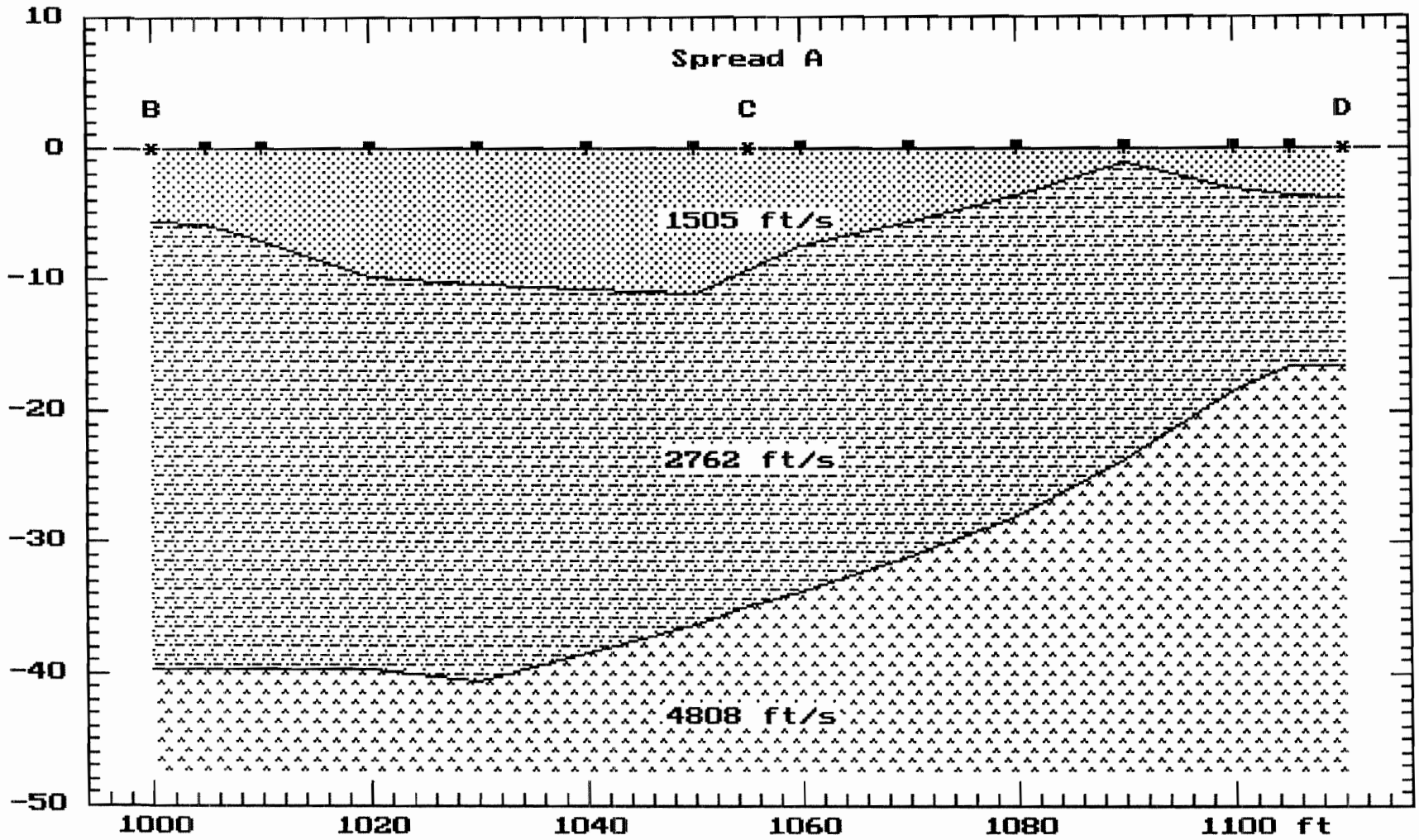

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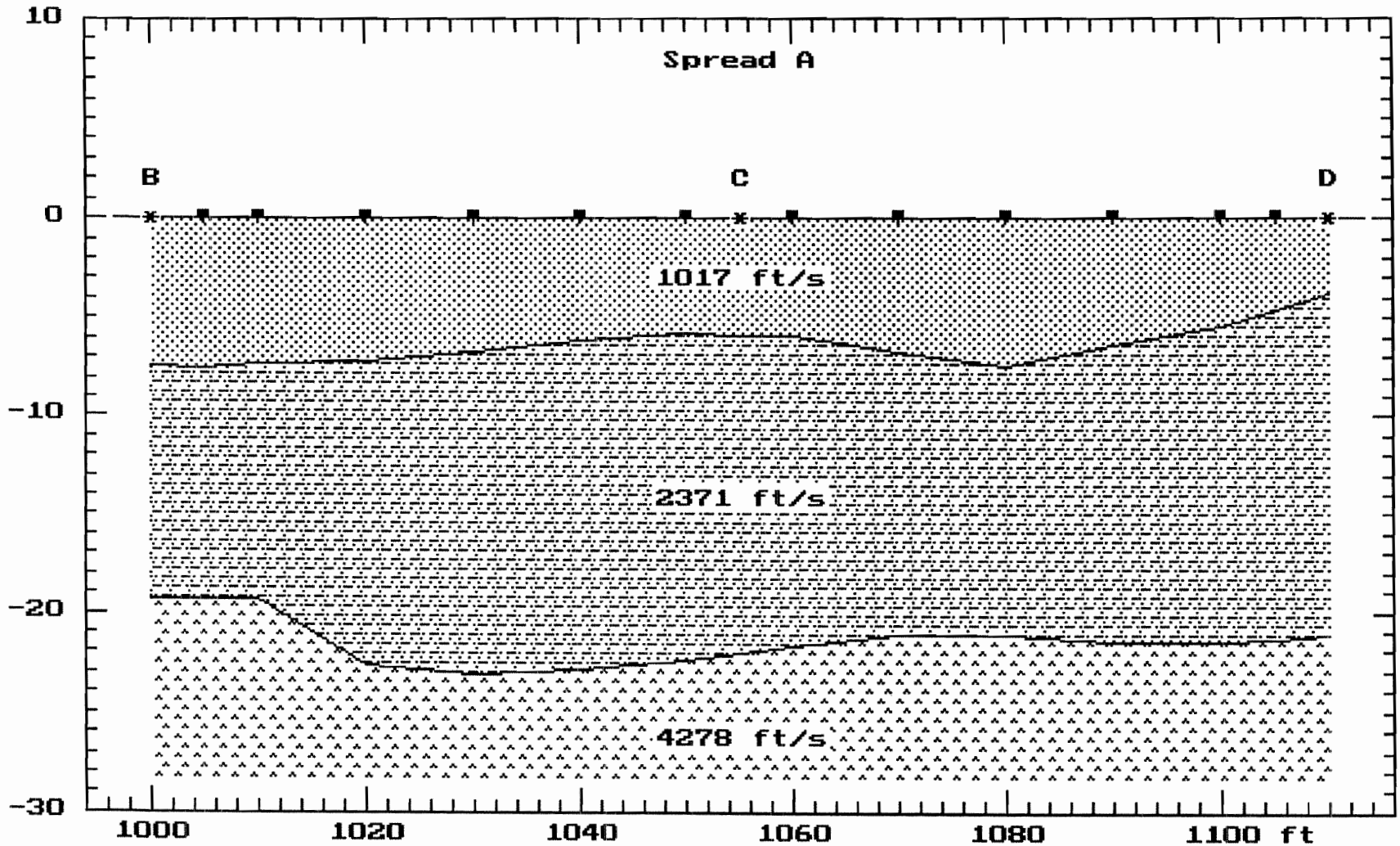

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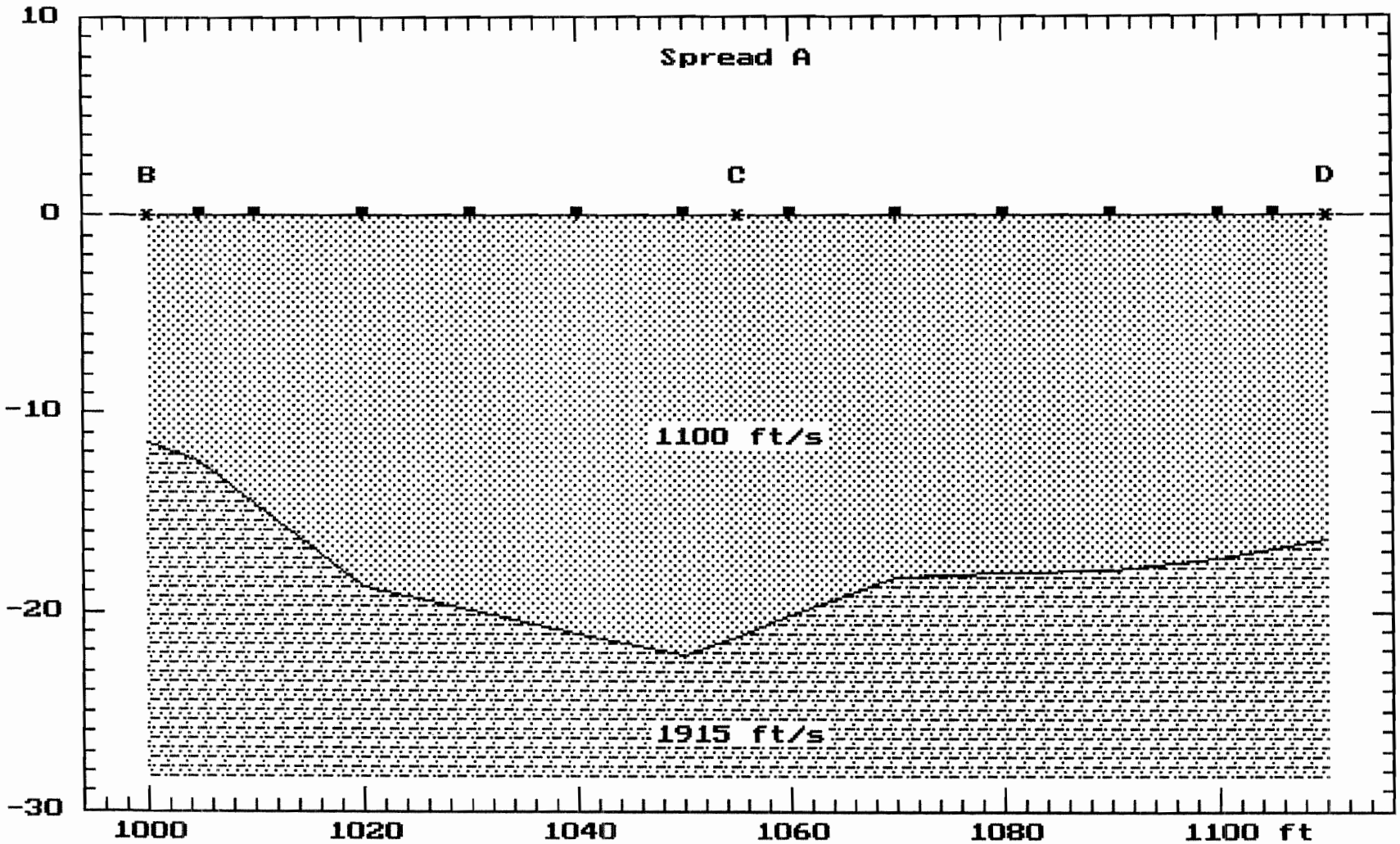

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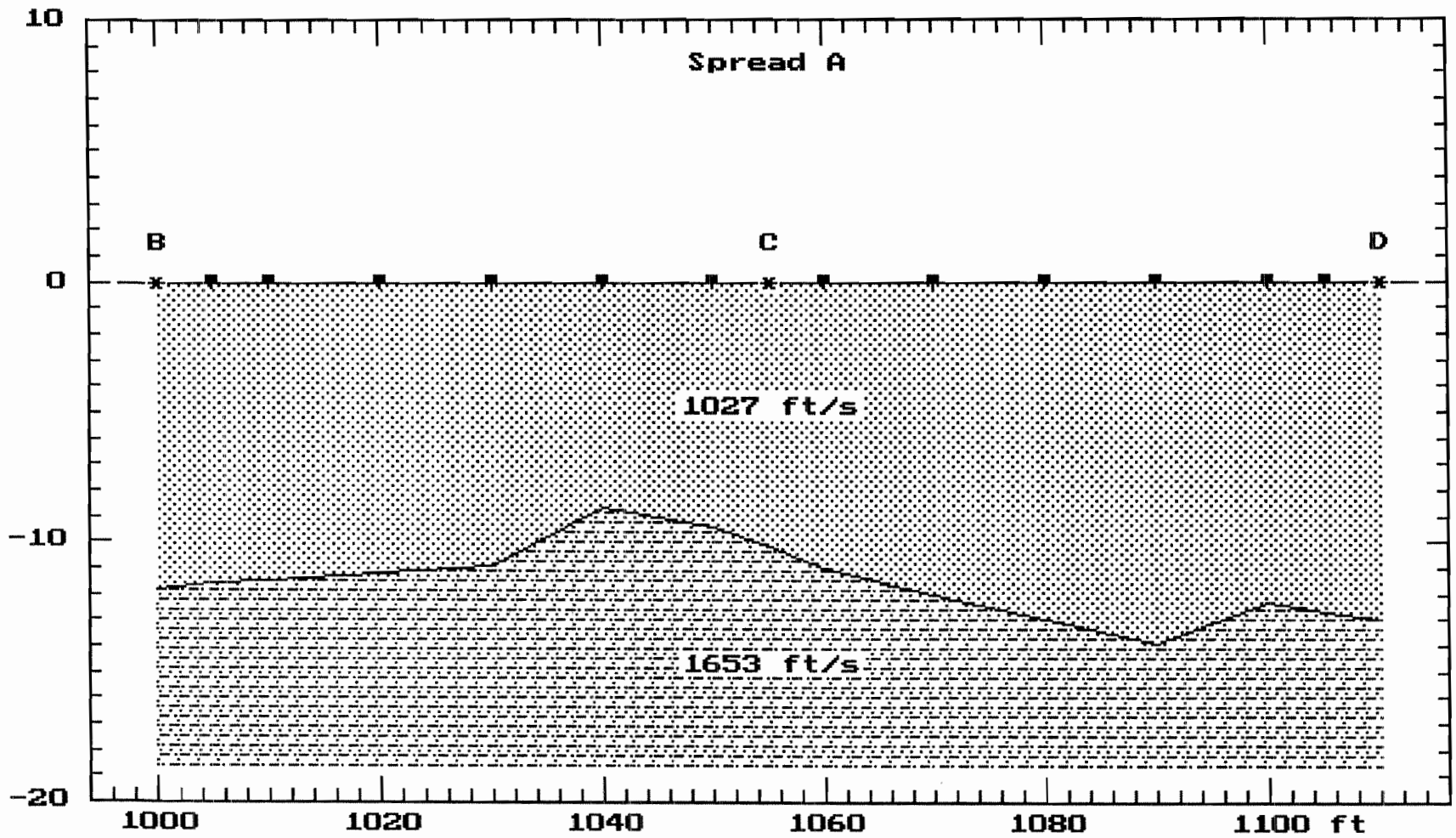

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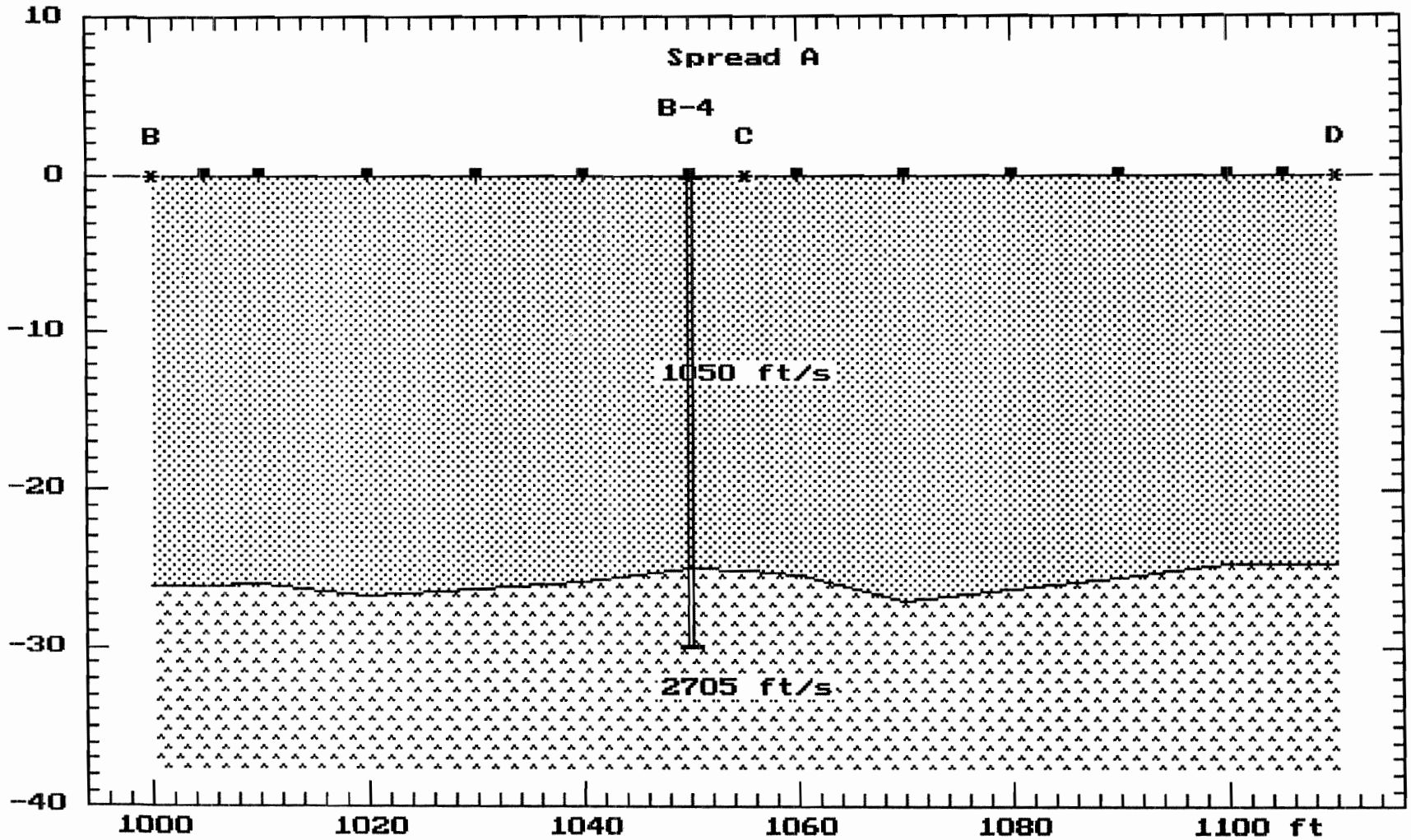

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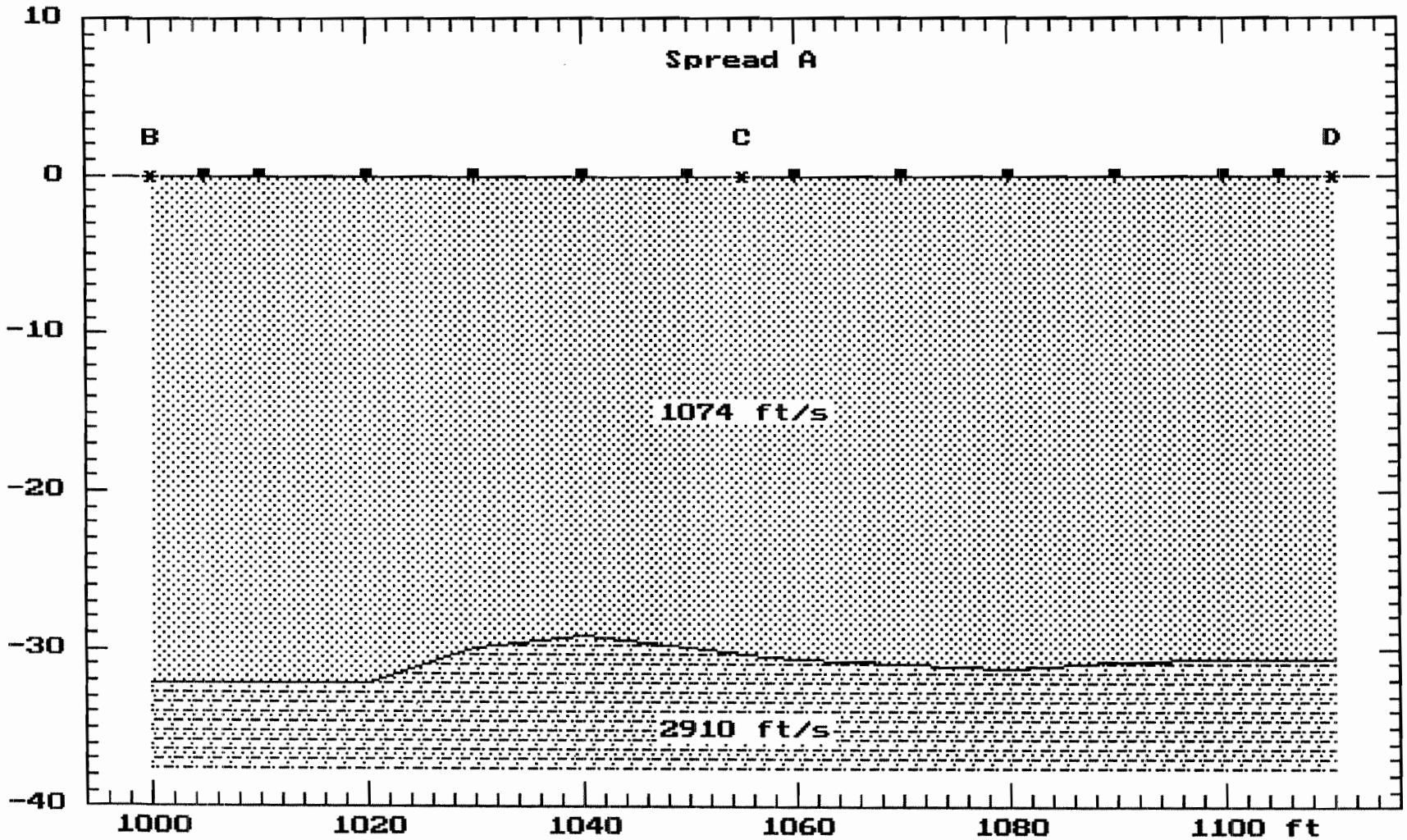

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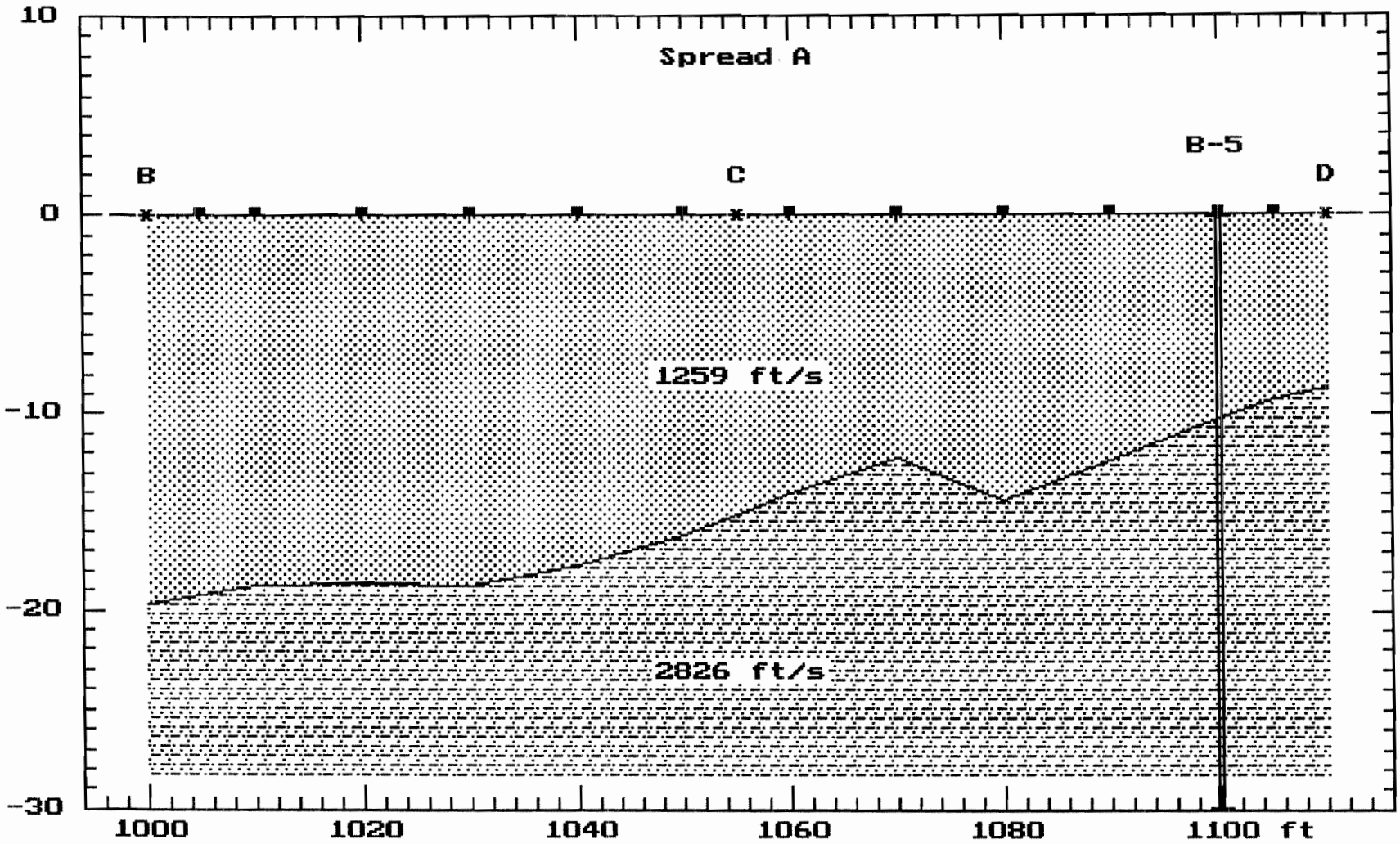

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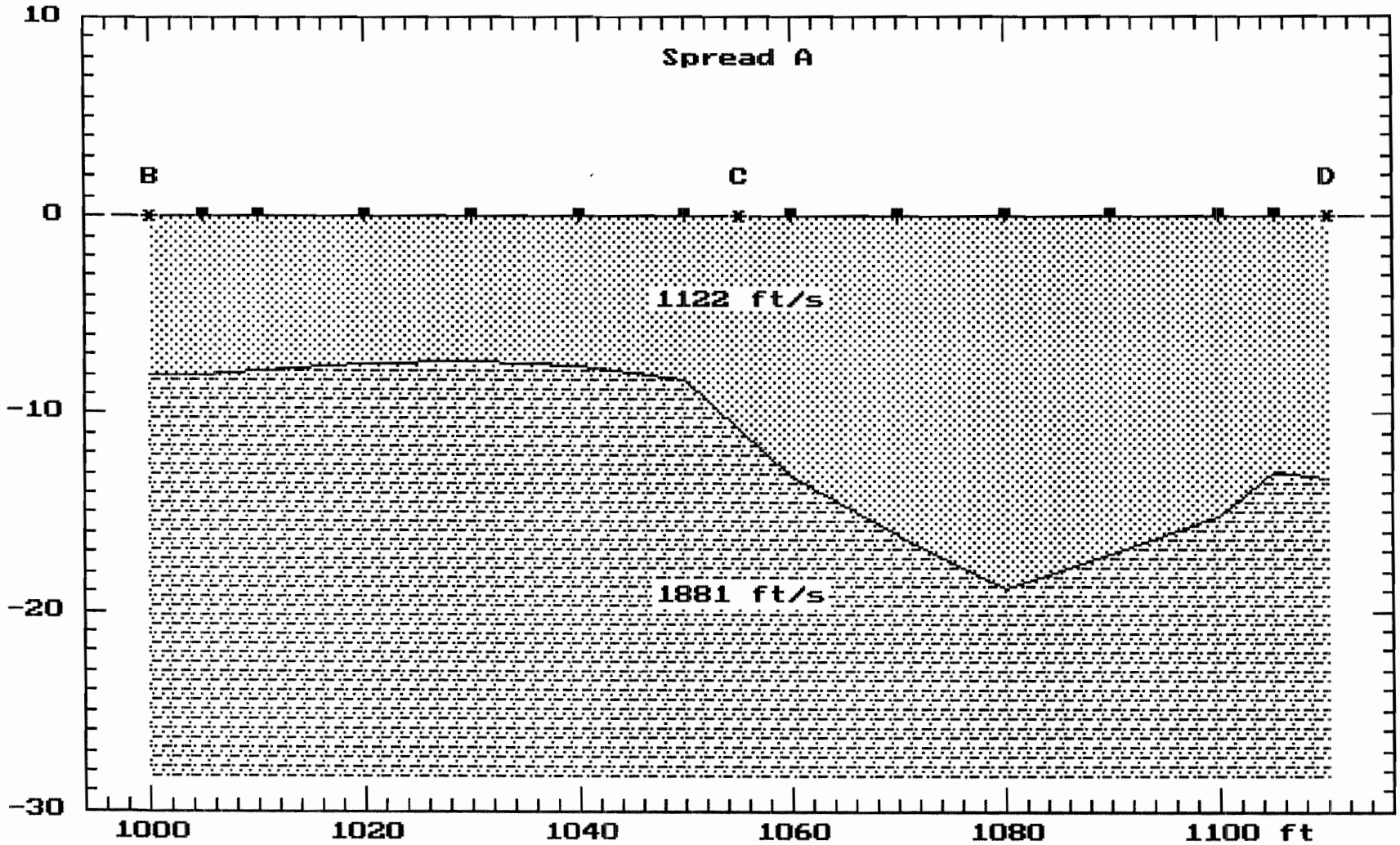

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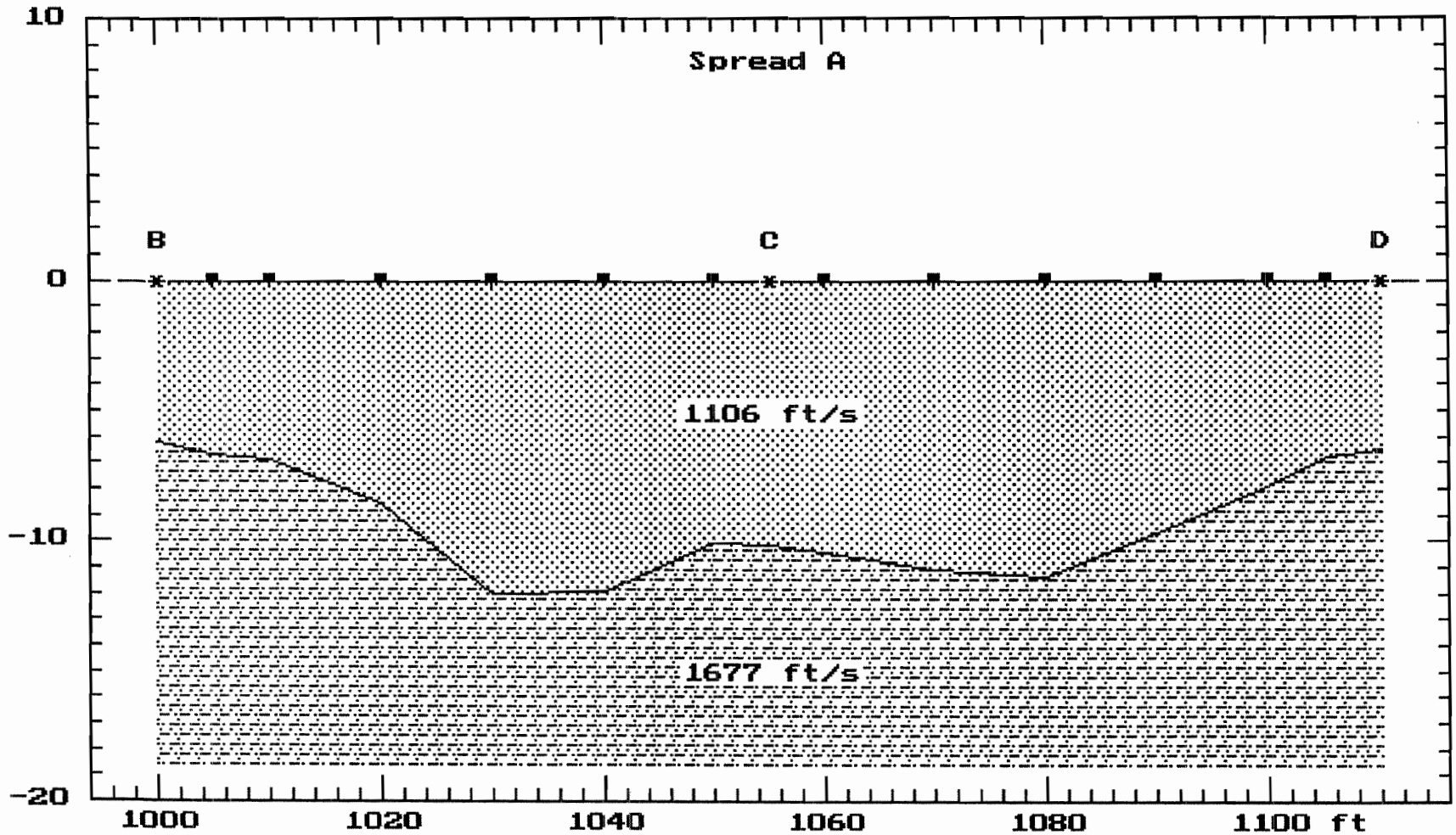
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 15



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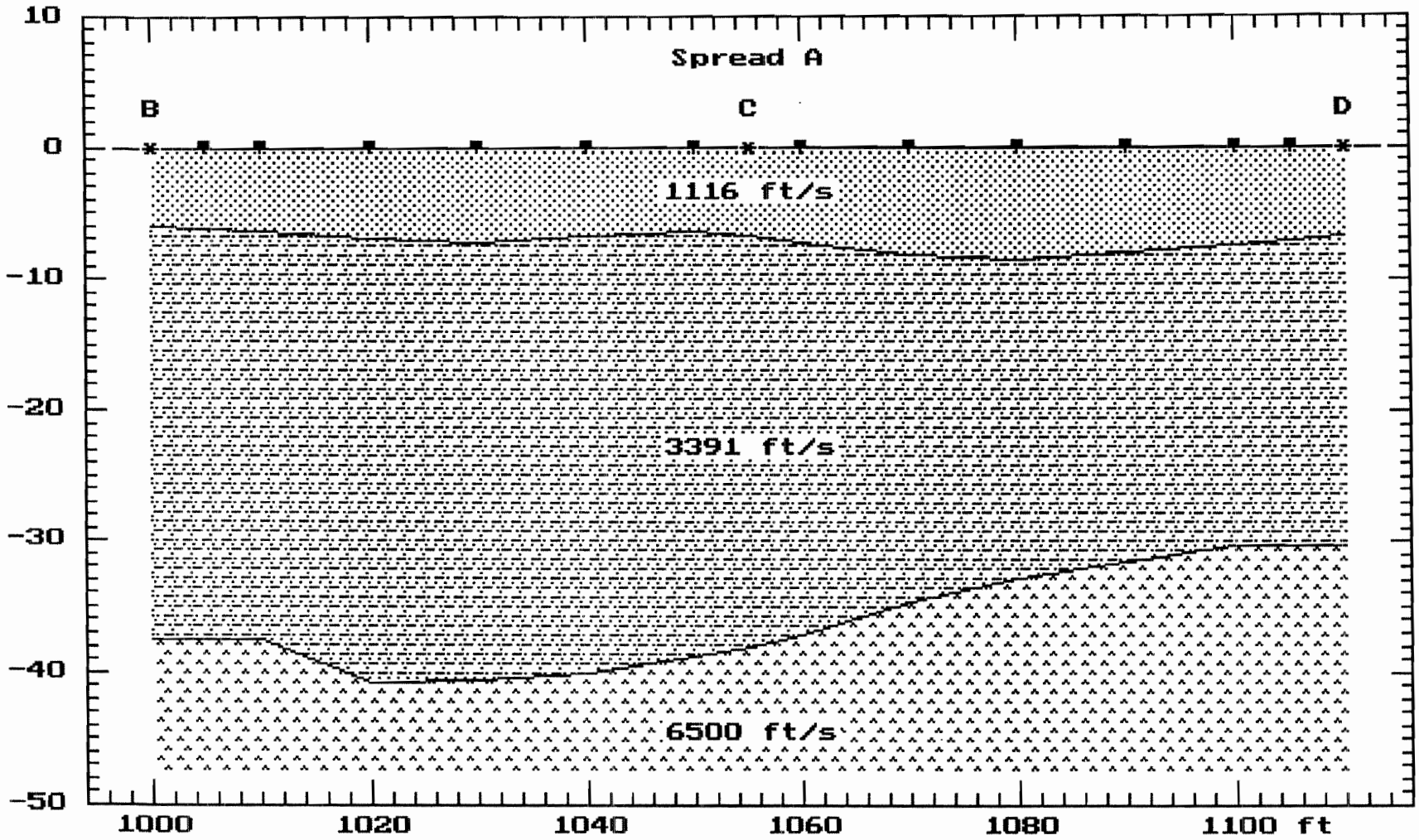

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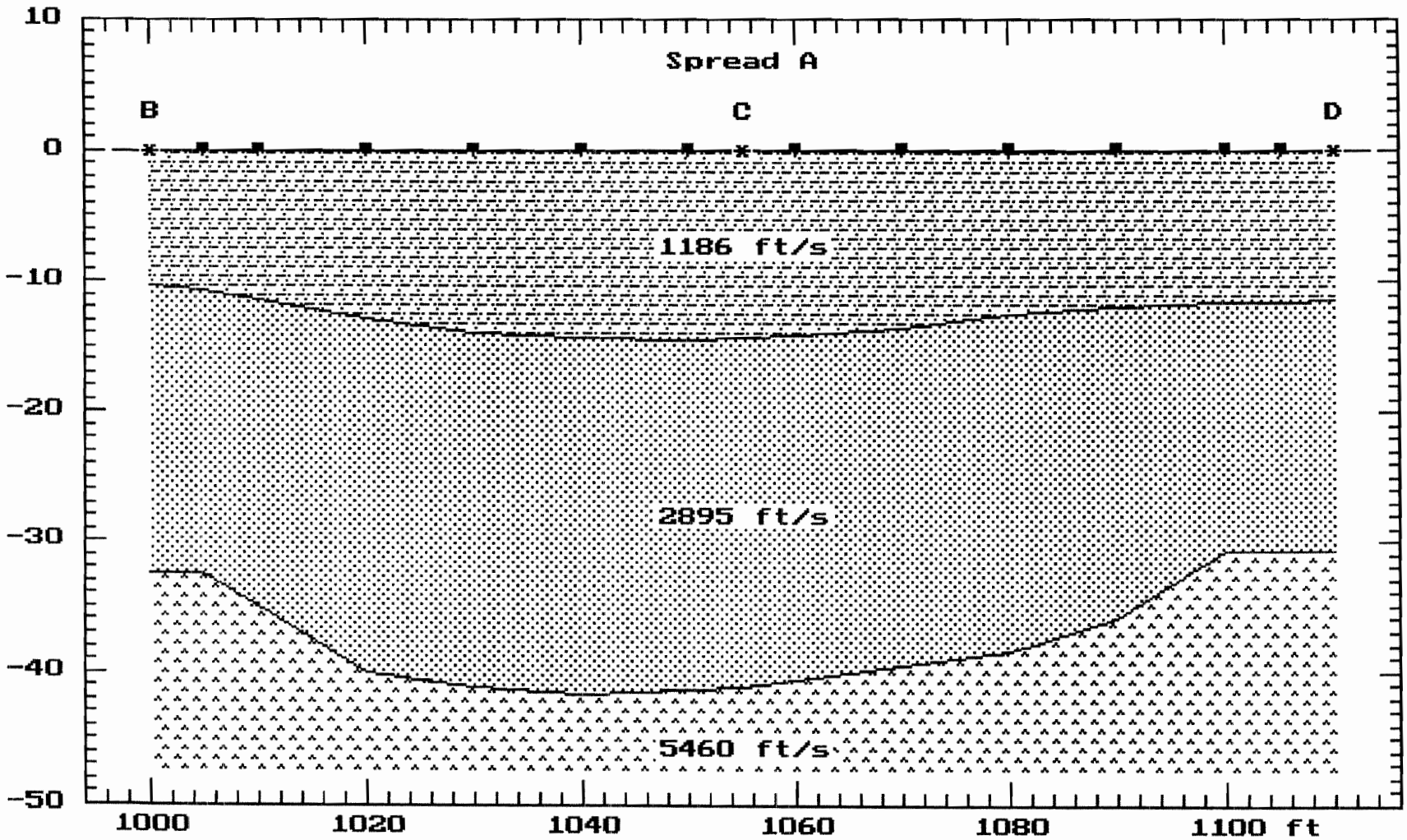

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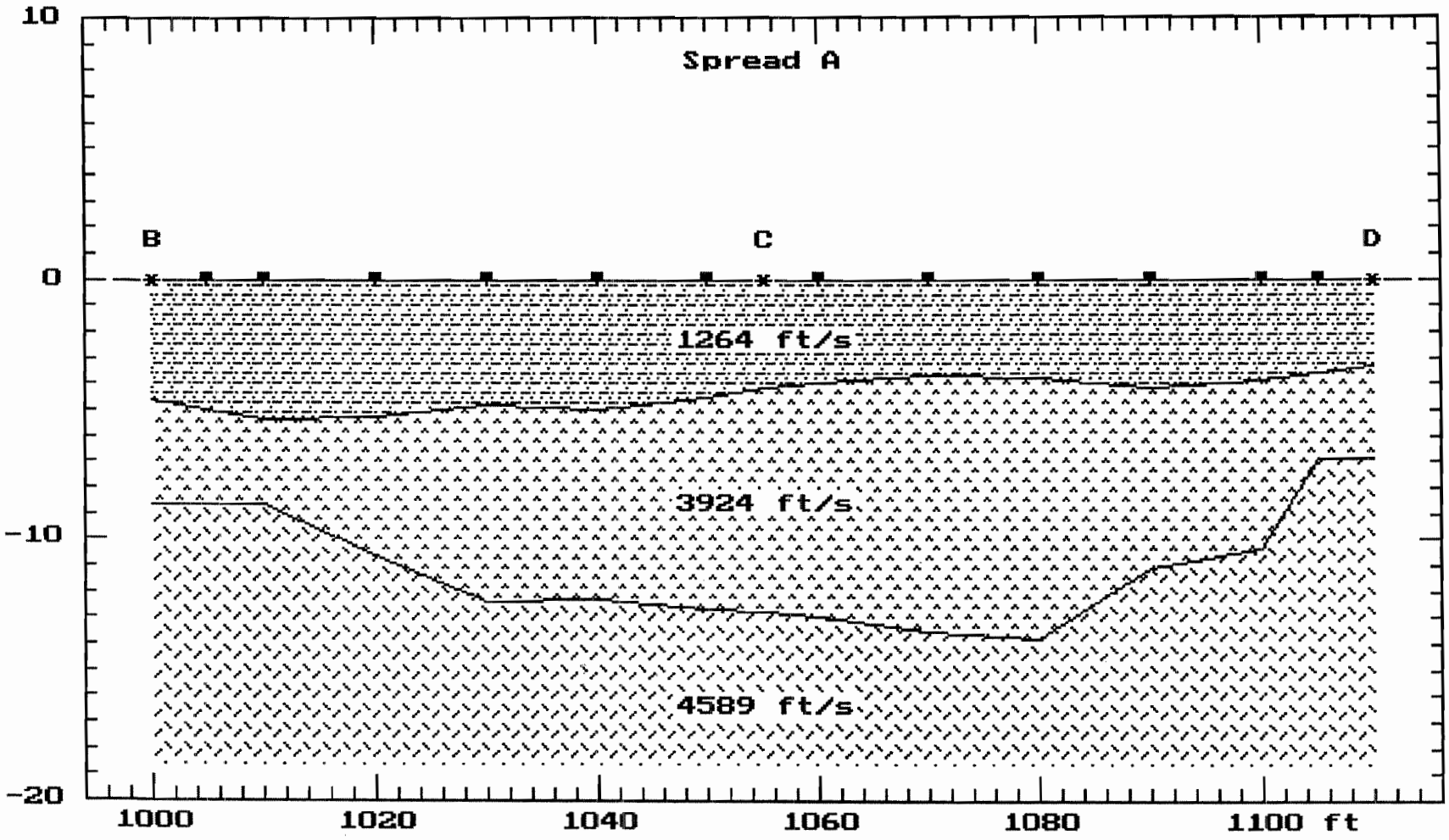
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 18



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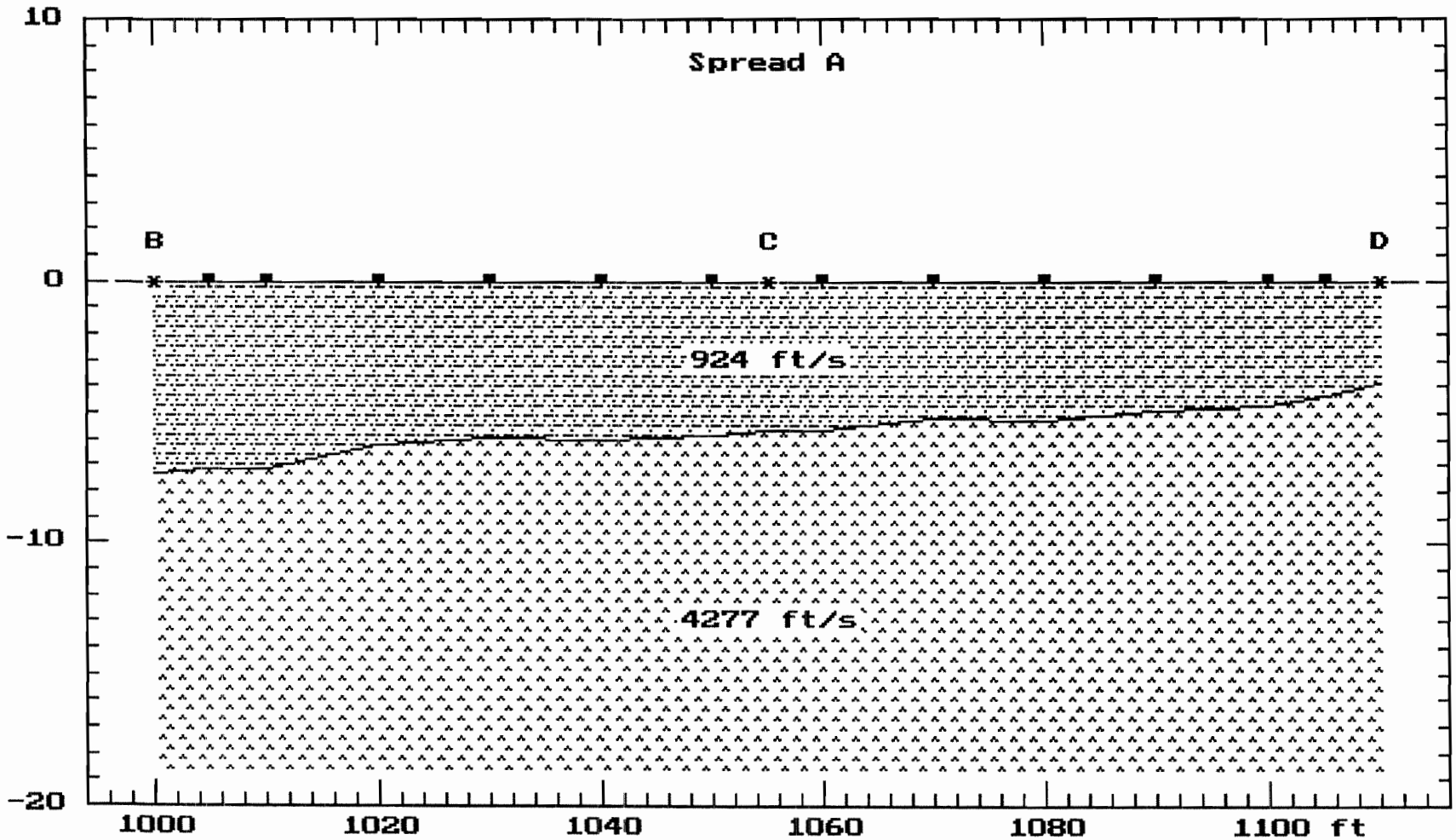
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 19



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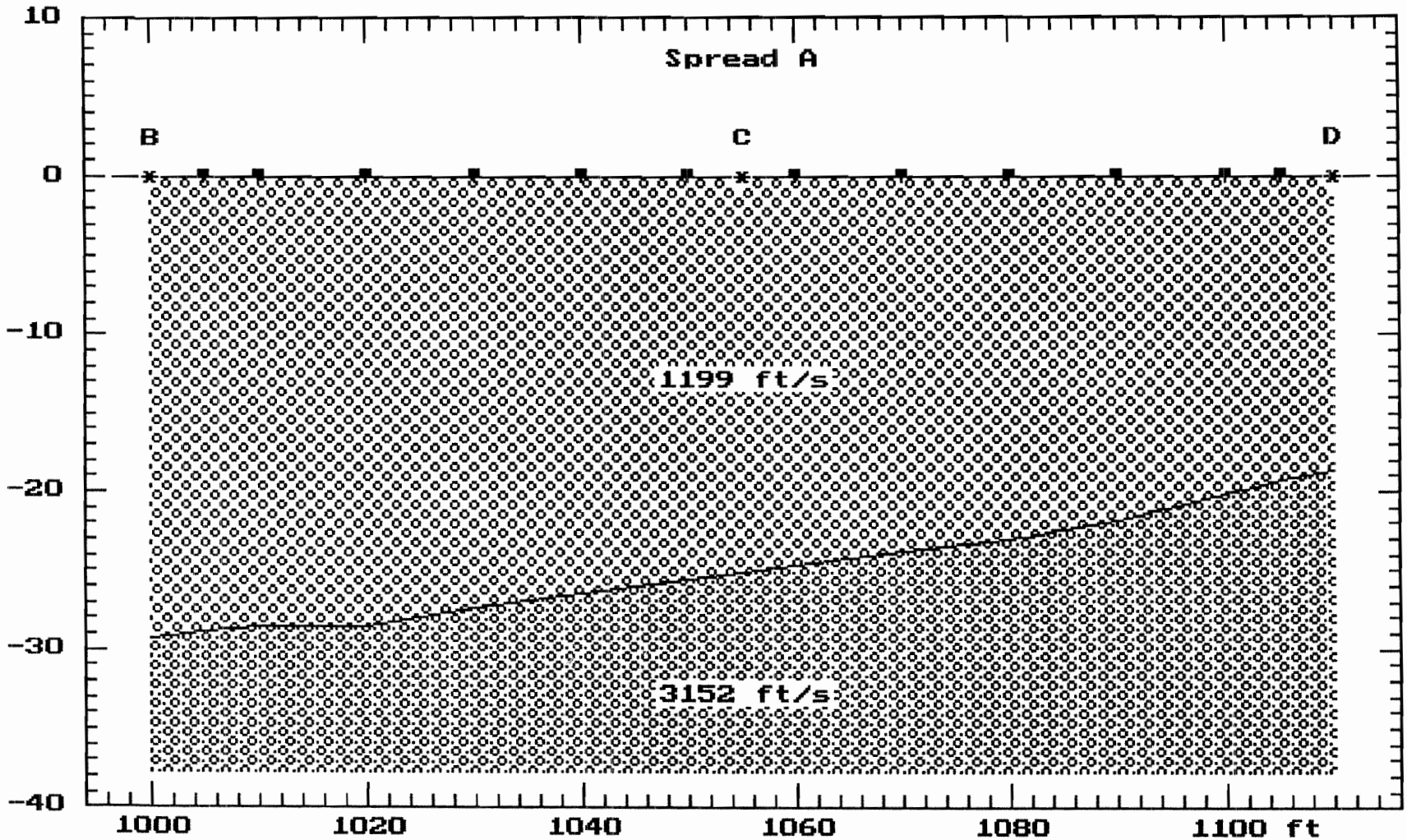

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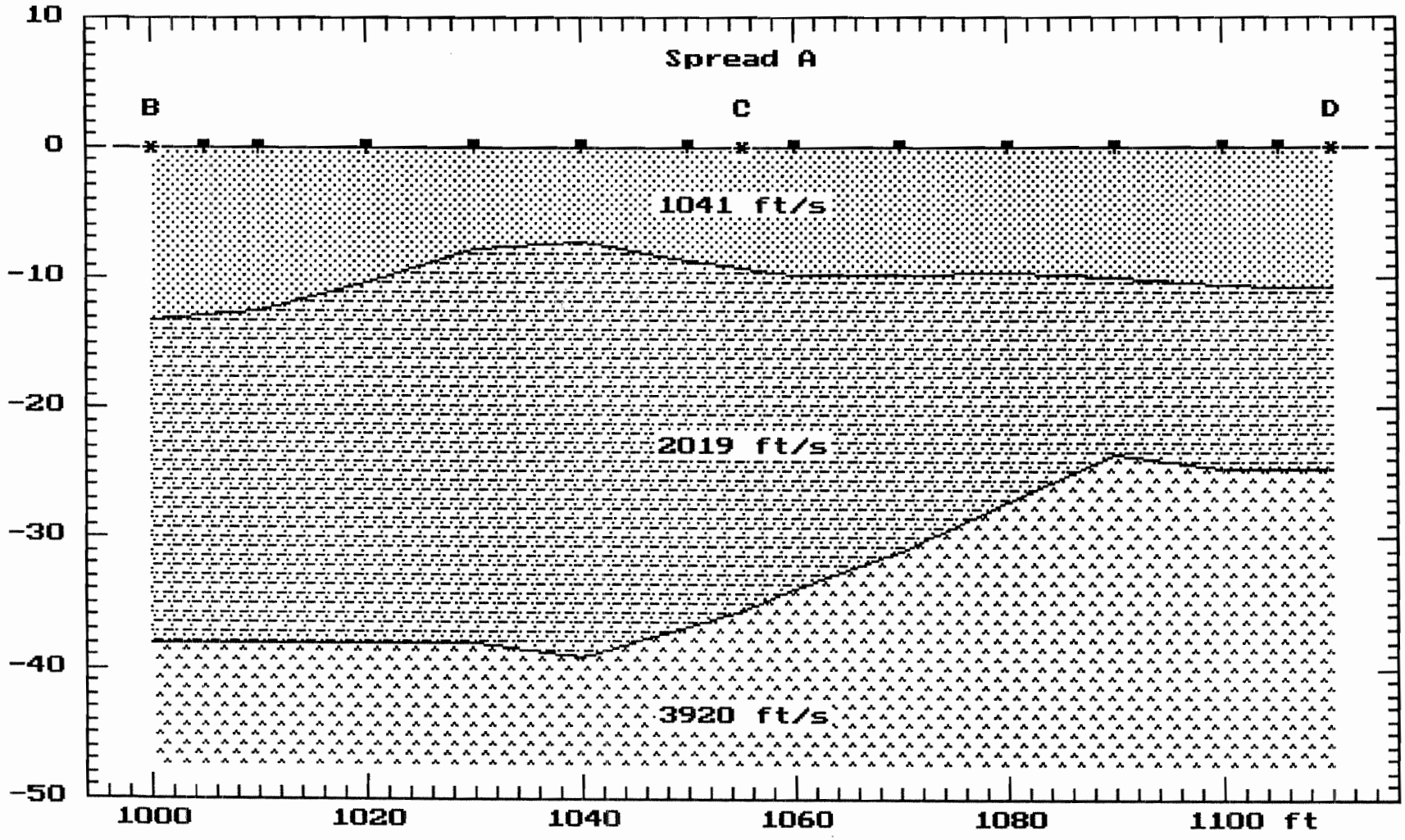

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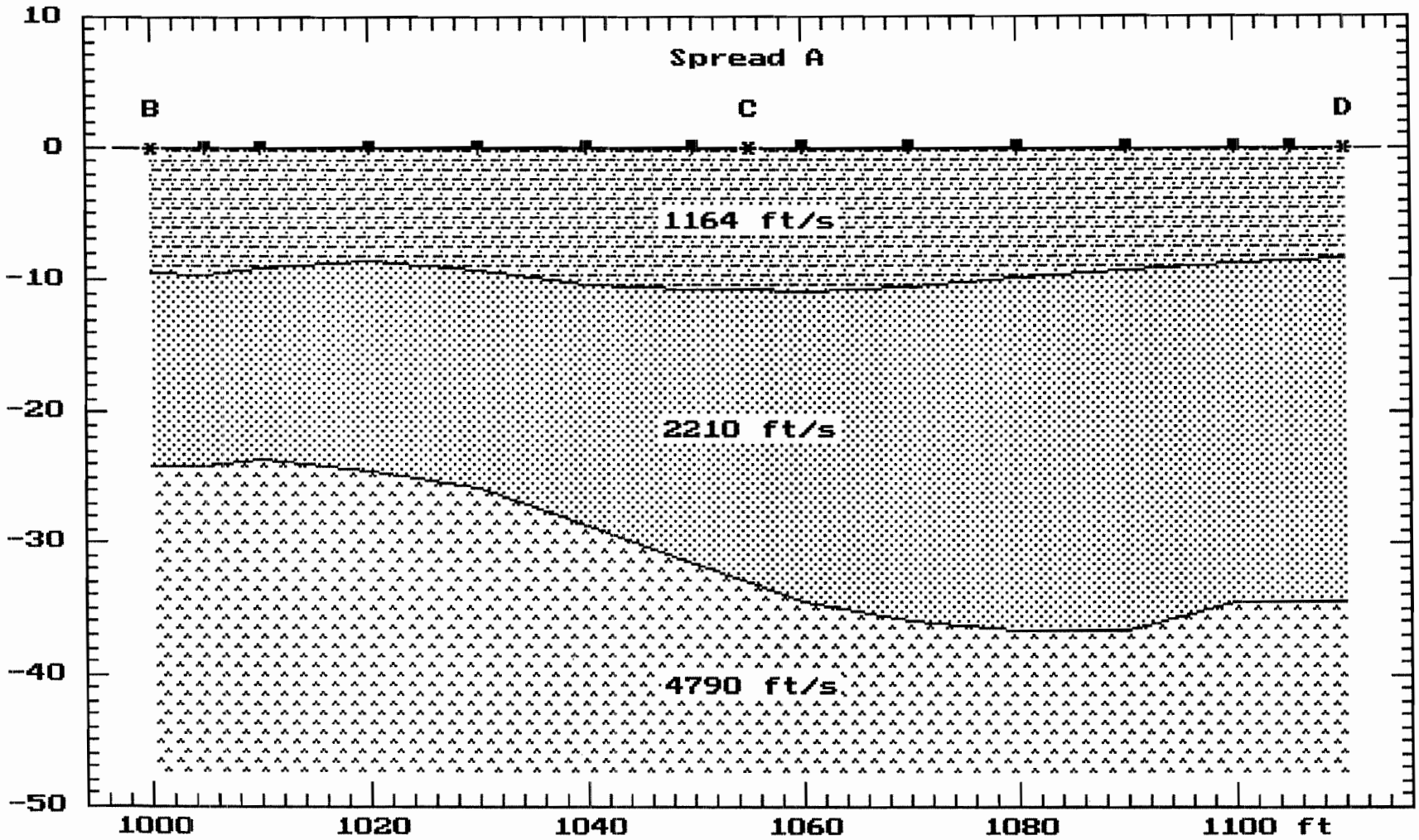
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 22



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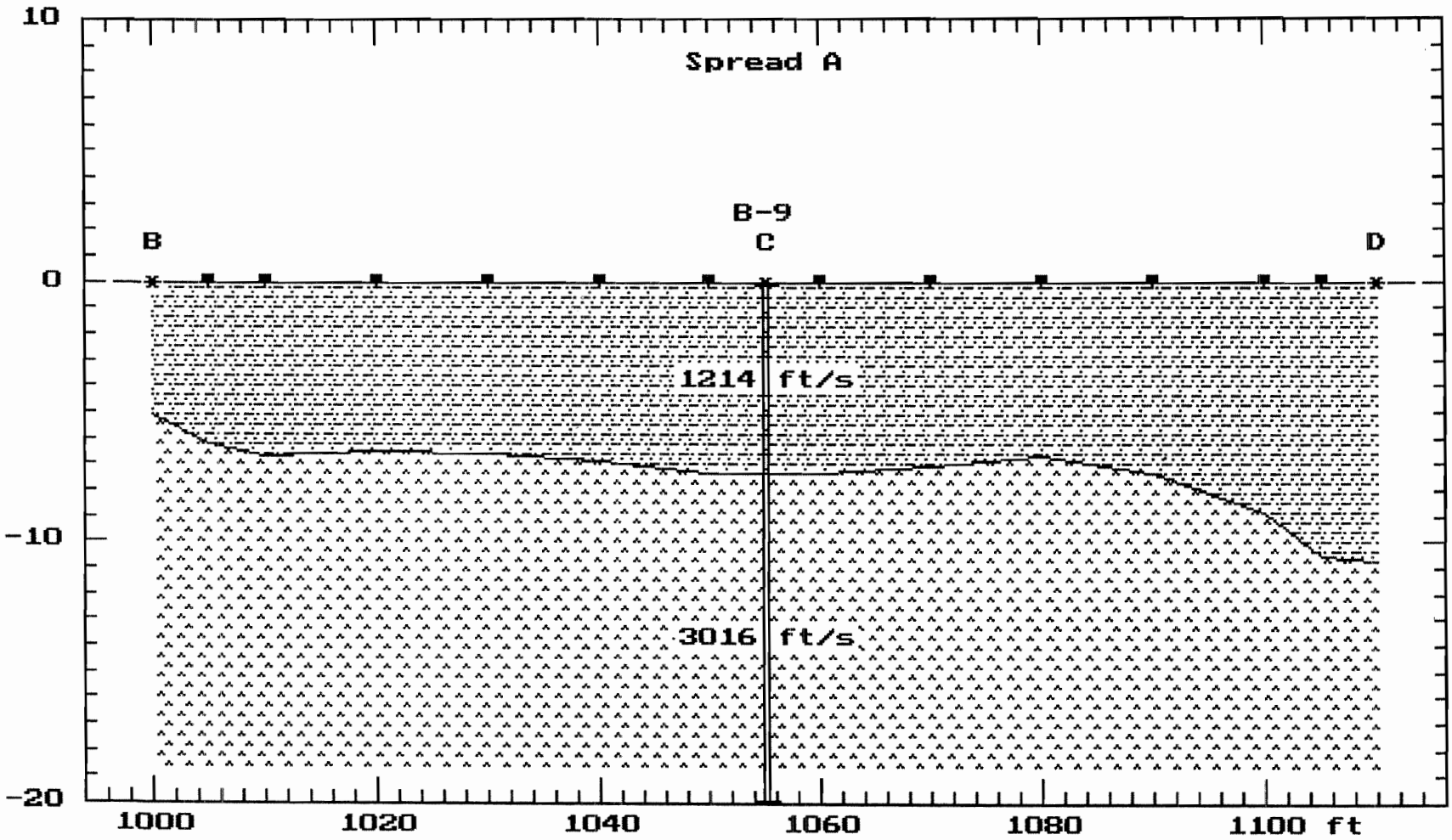
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 23



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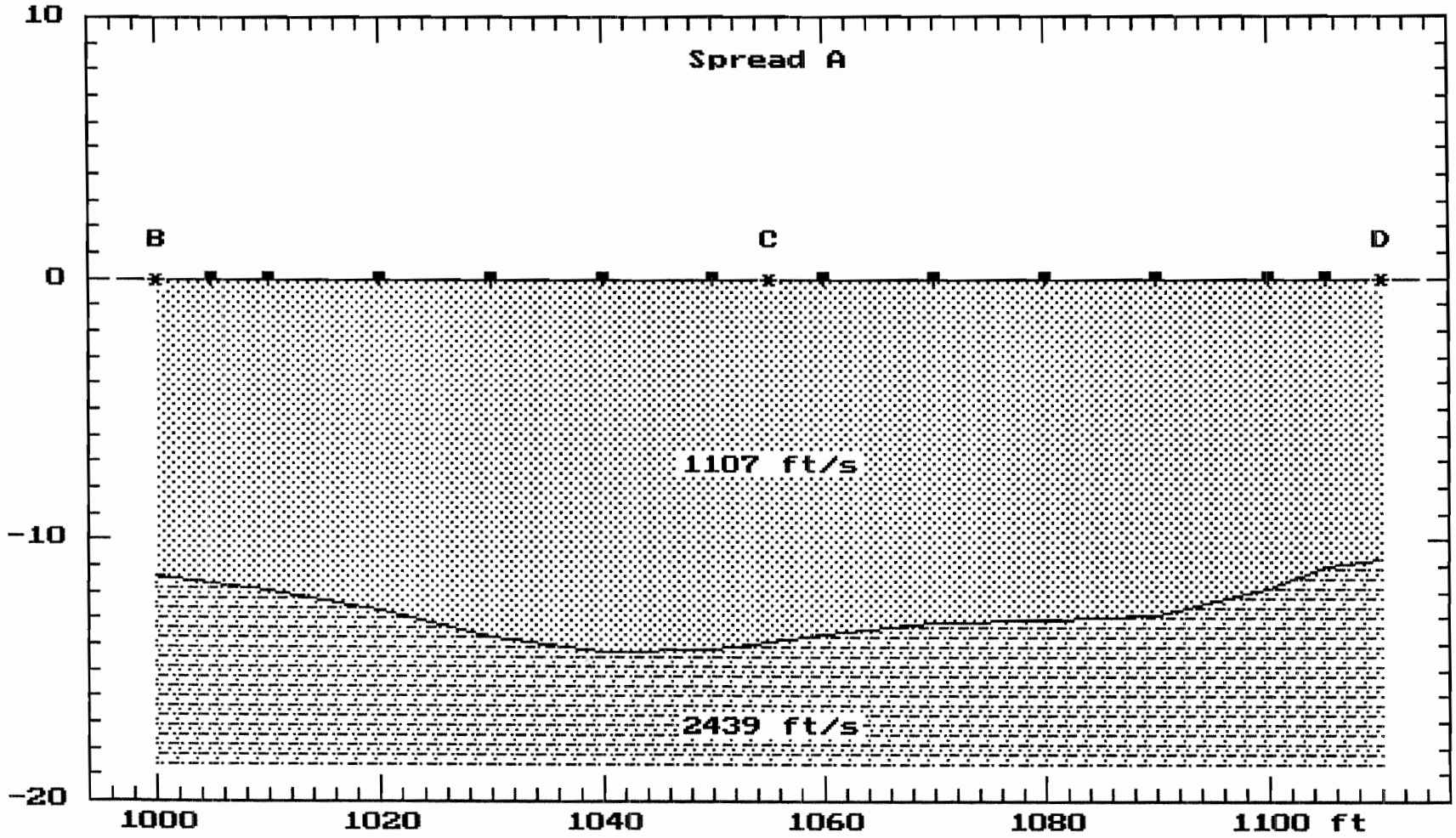
	Honolulu, HI August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 24



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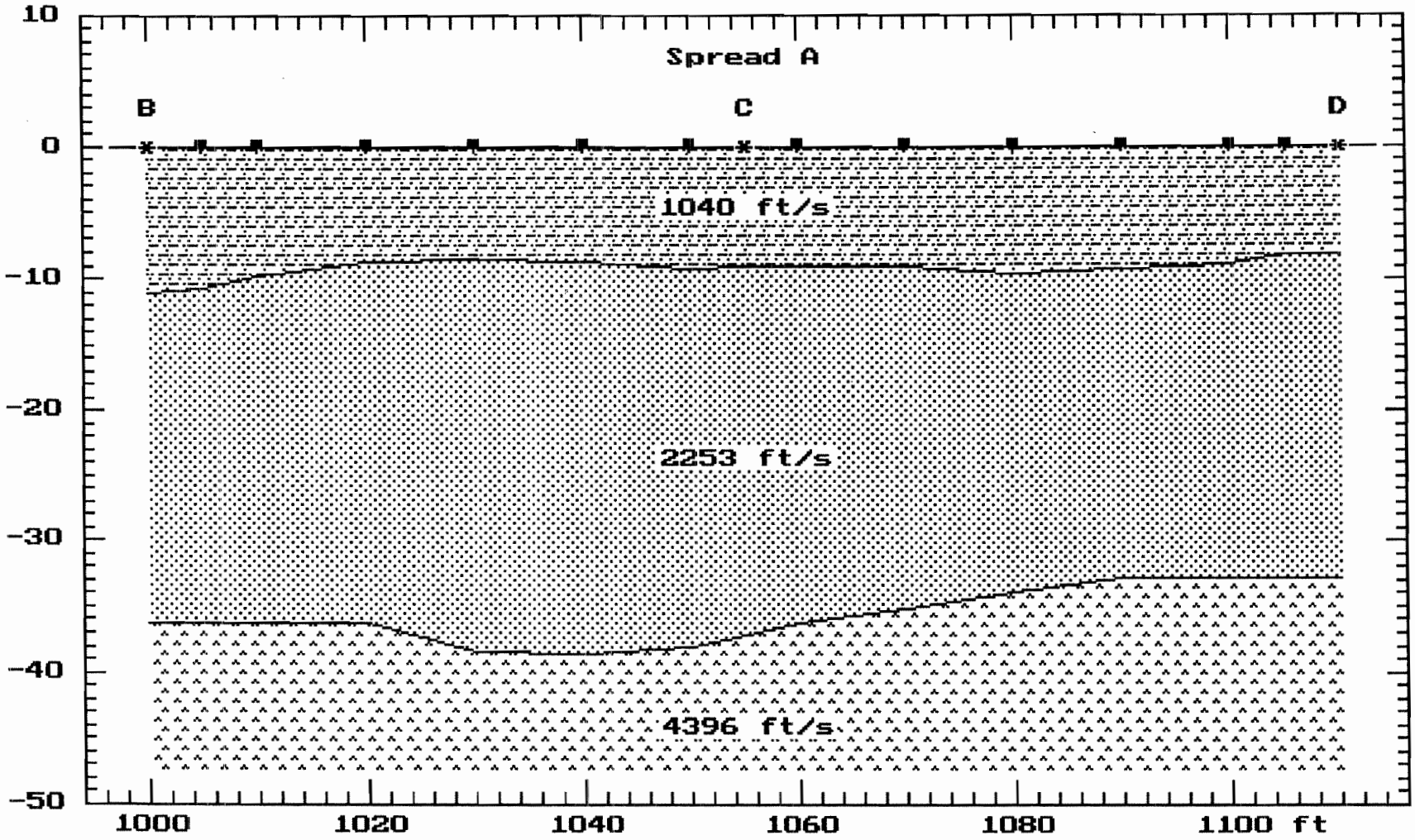
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 25



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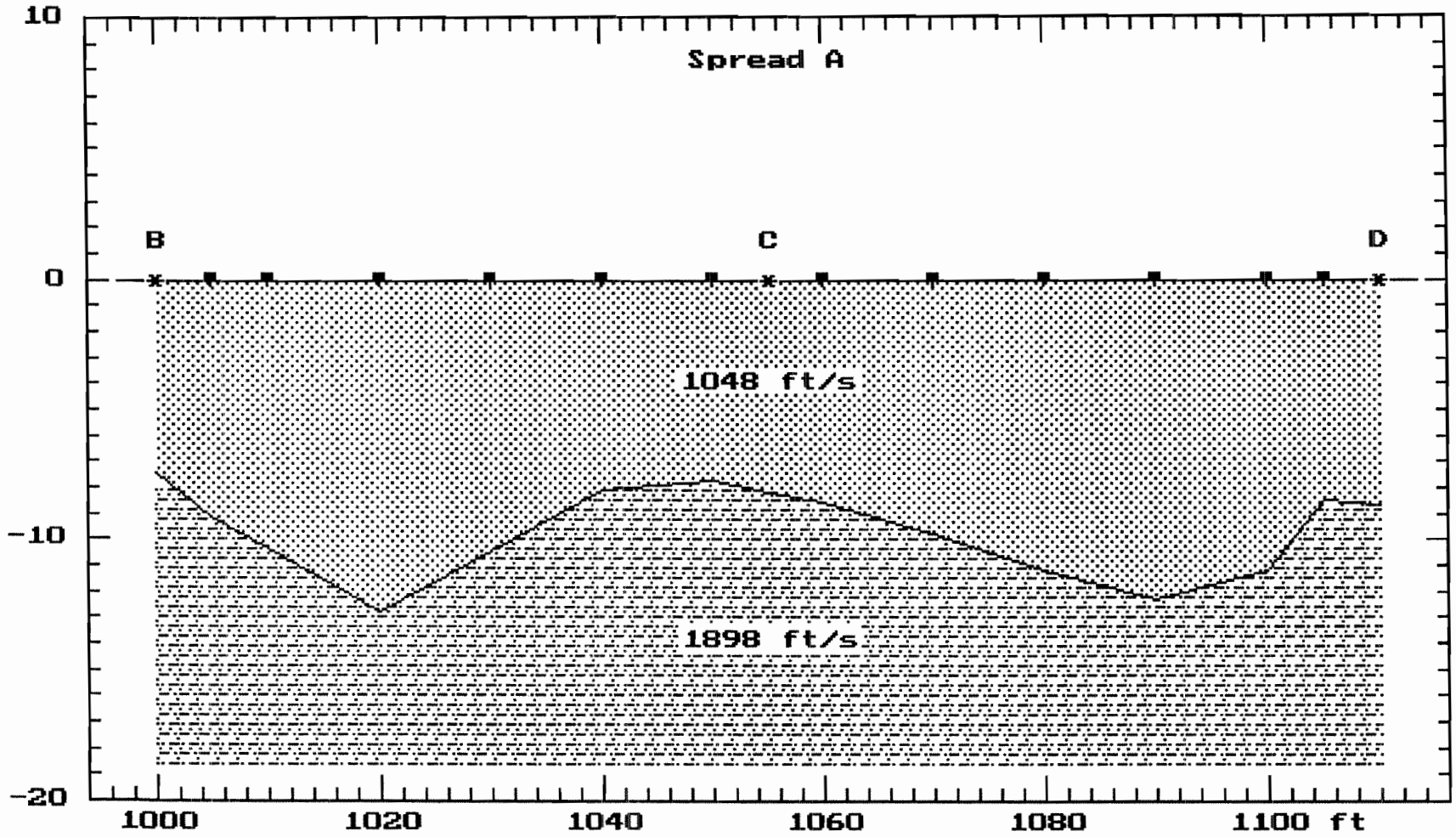
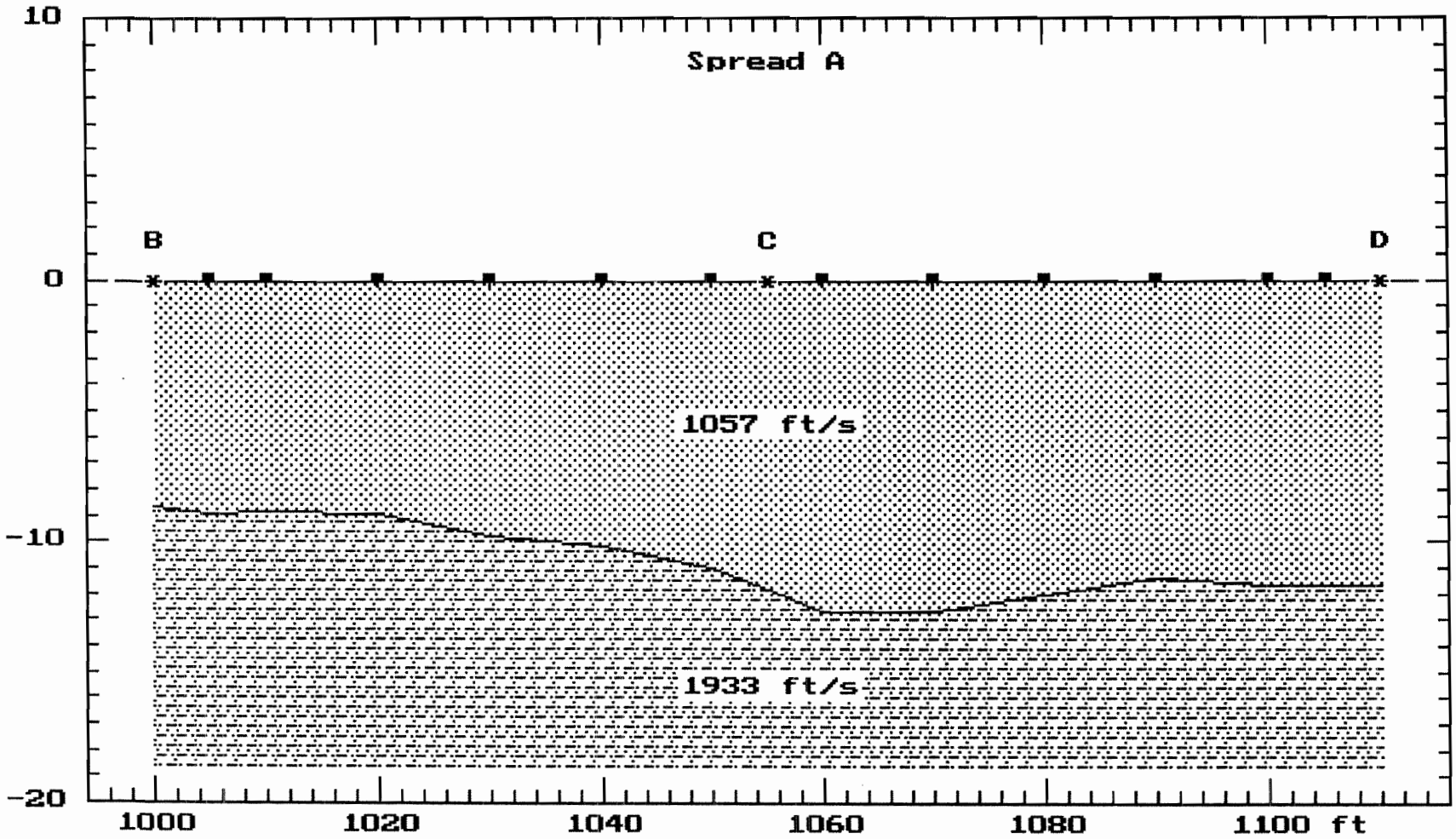
	Honolulu, HI August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTIONLINE NO. 26



Prepared for	Prepared by
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
	Honolulu, HI August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 27



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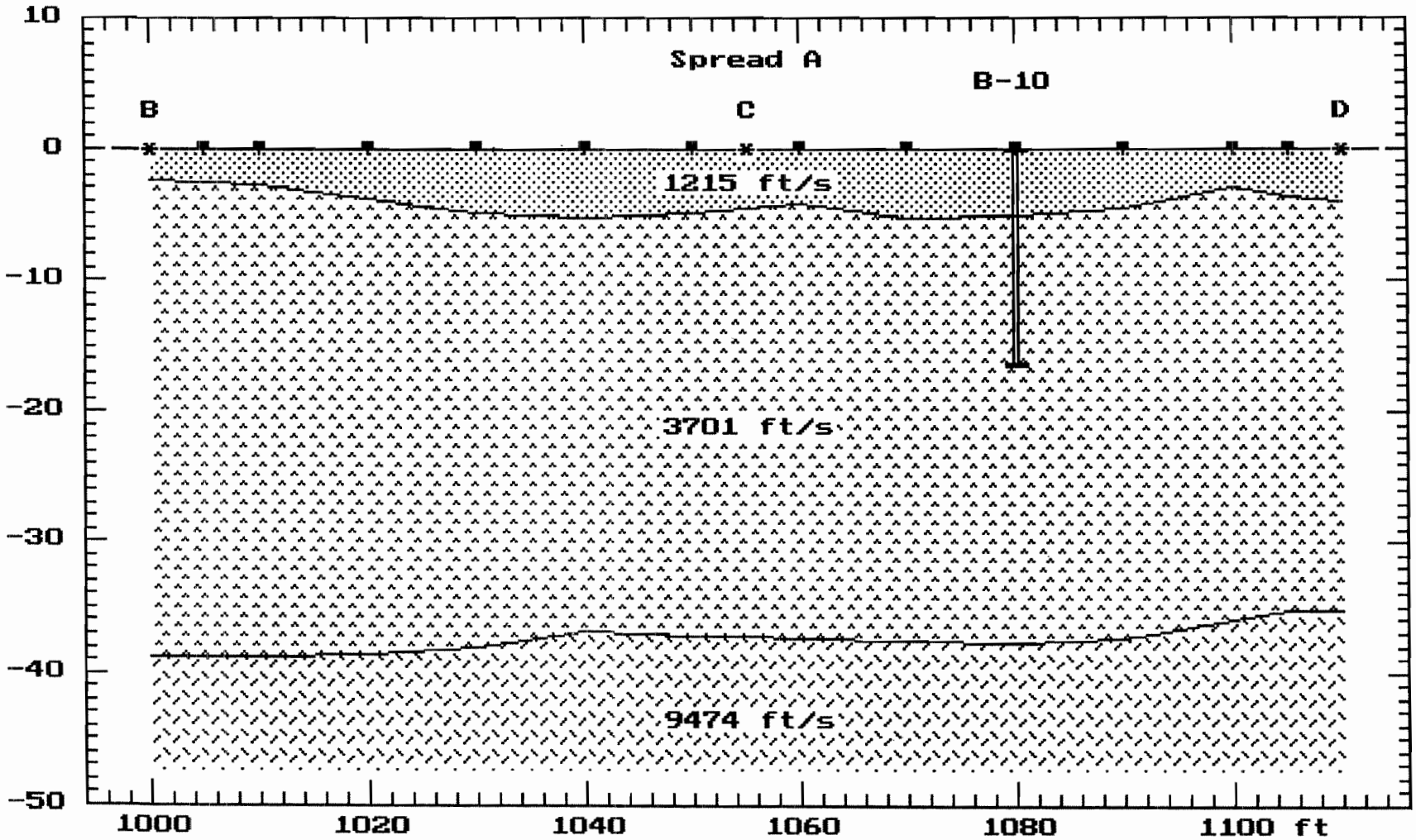
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 28



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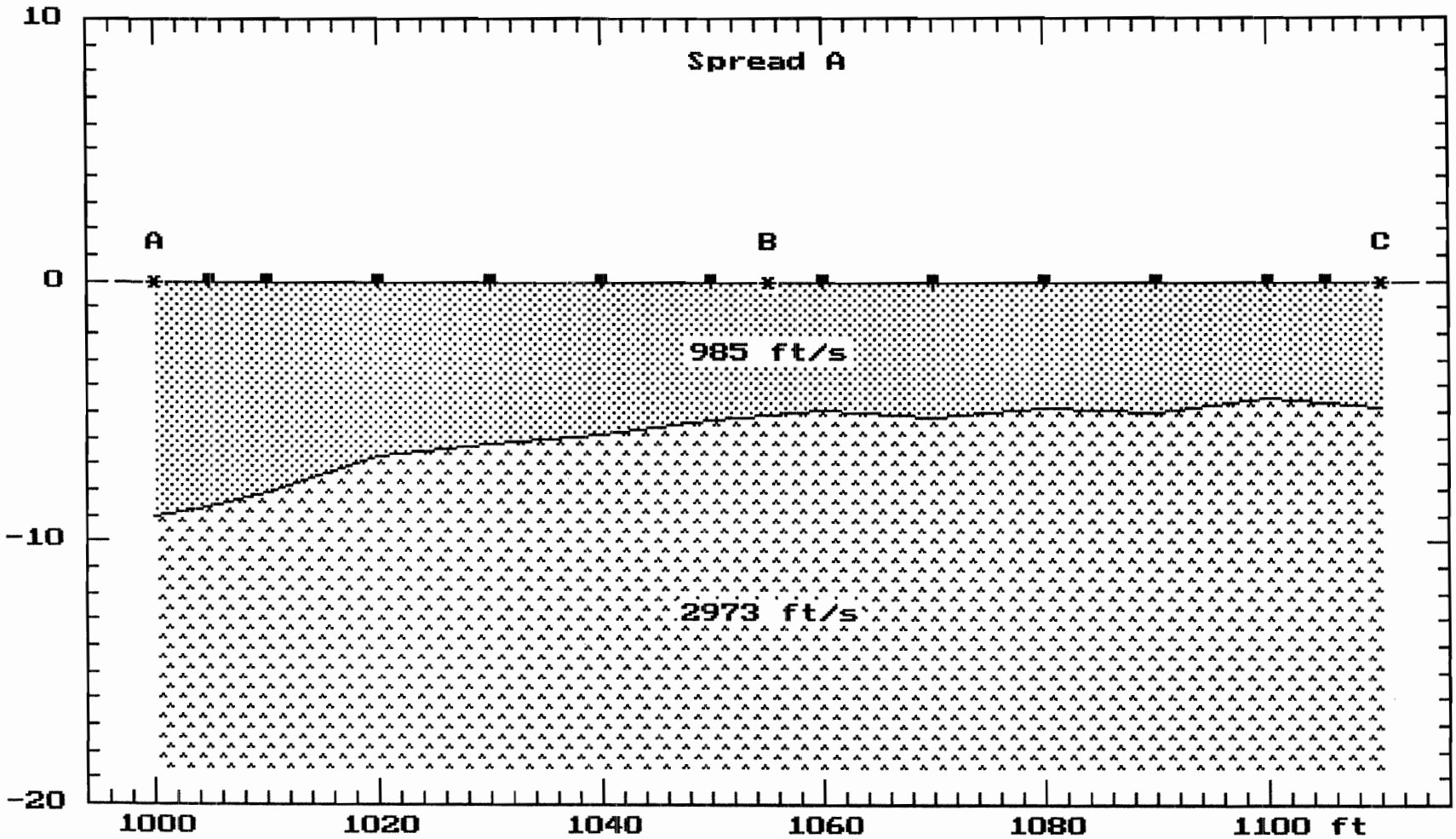
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 29



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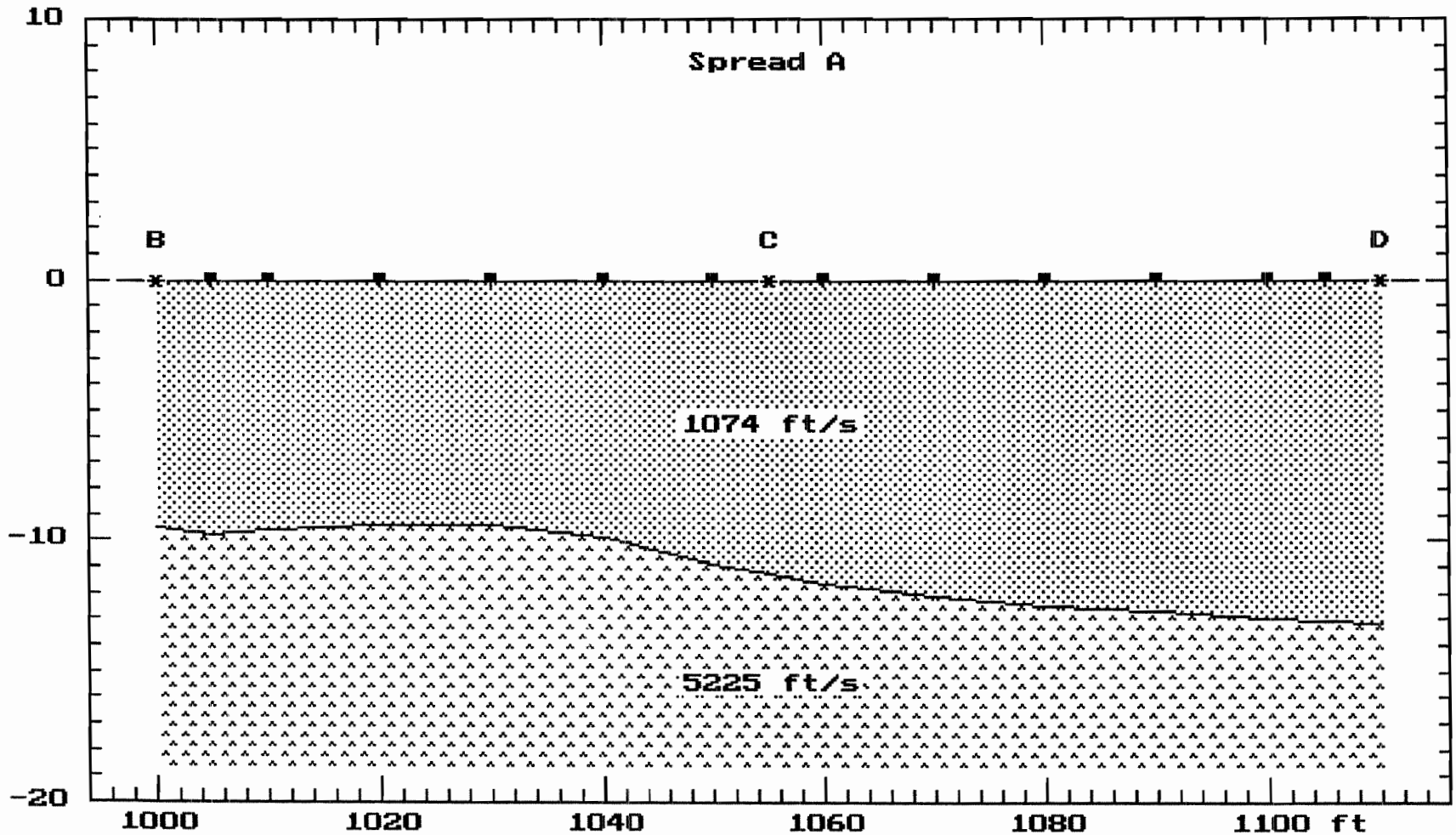
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 30



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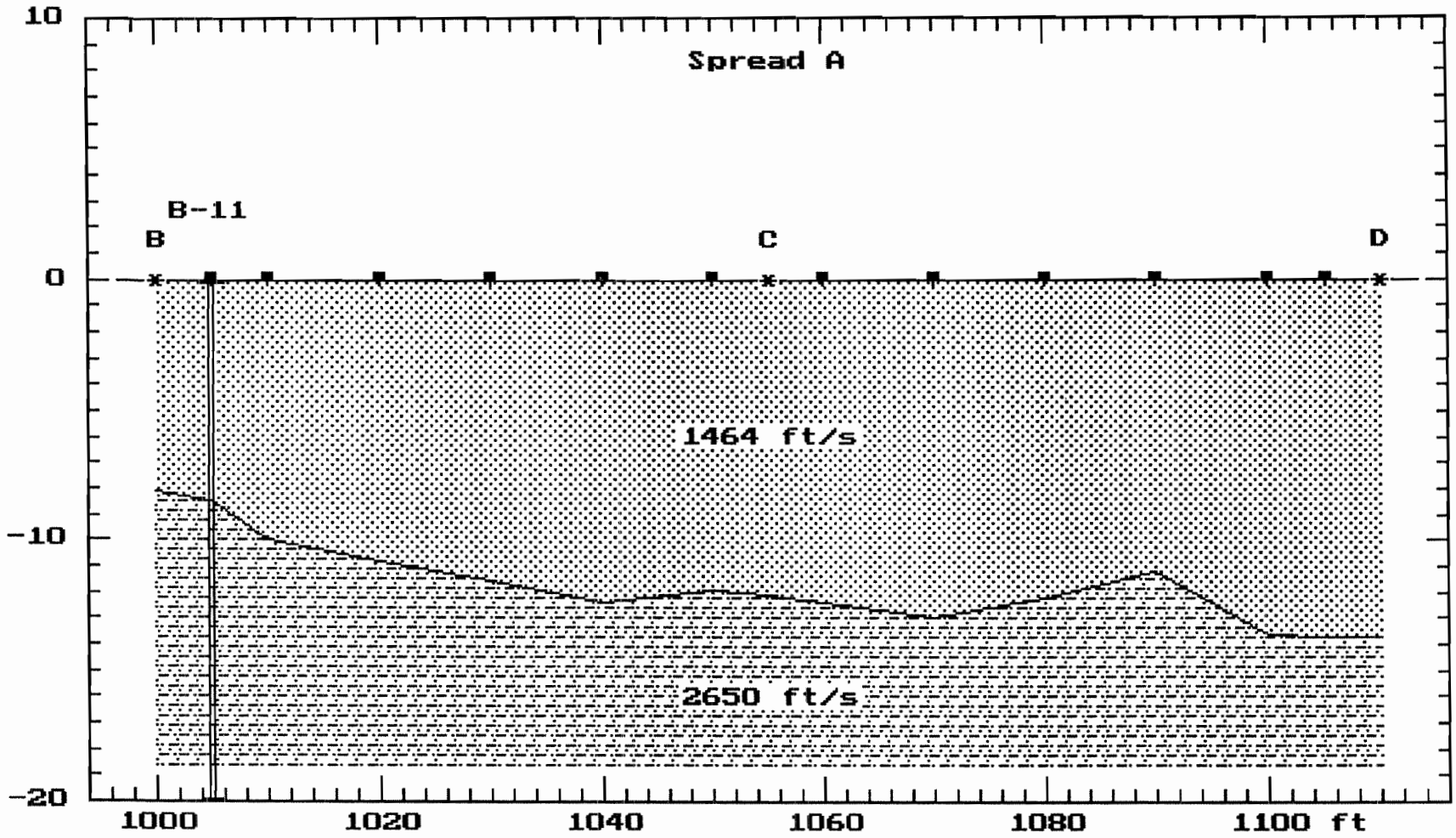
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 31



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SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
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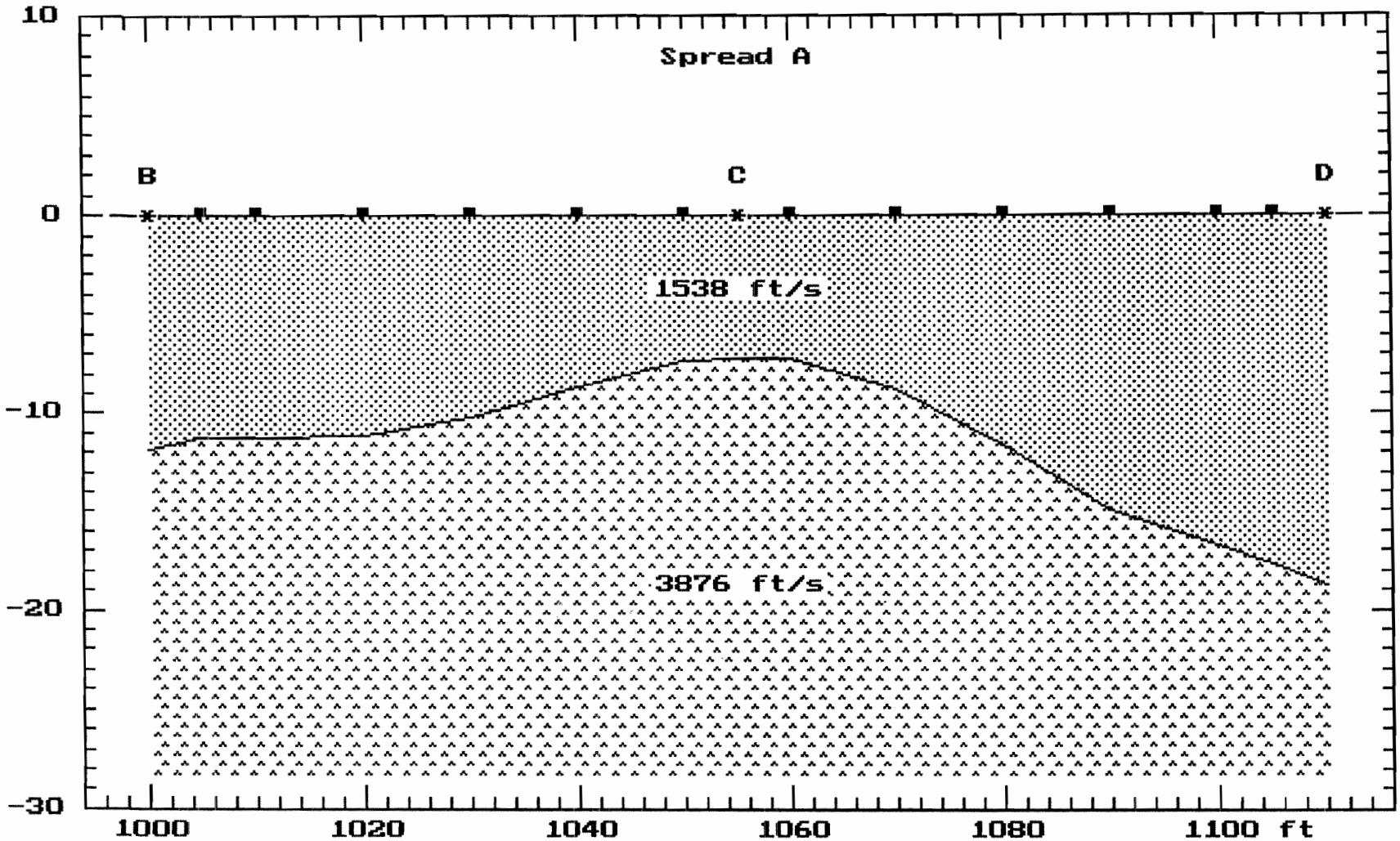
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 32



Prepared for	Prepared by
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
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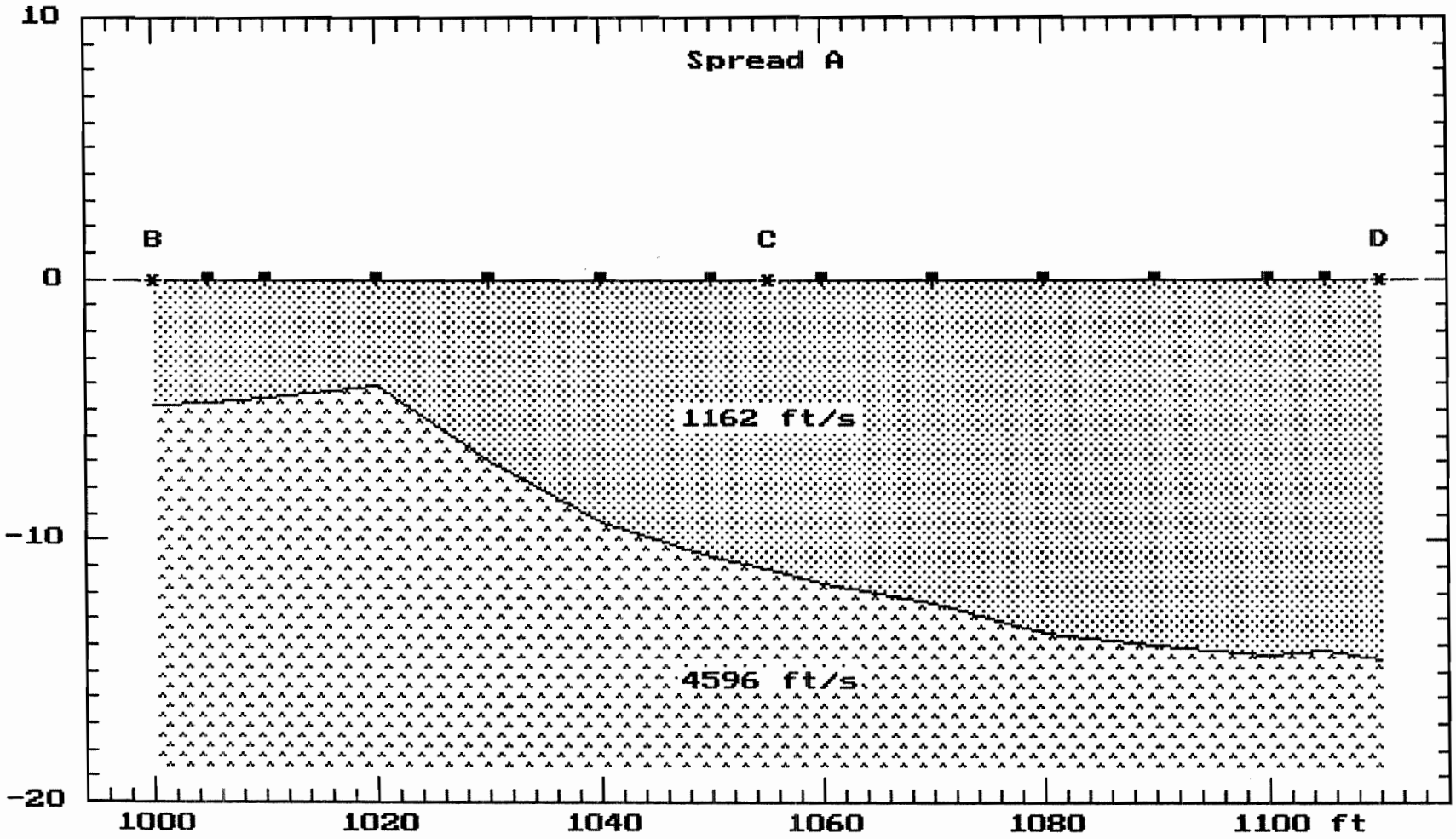
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 33



Prepared for	Prepared by
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
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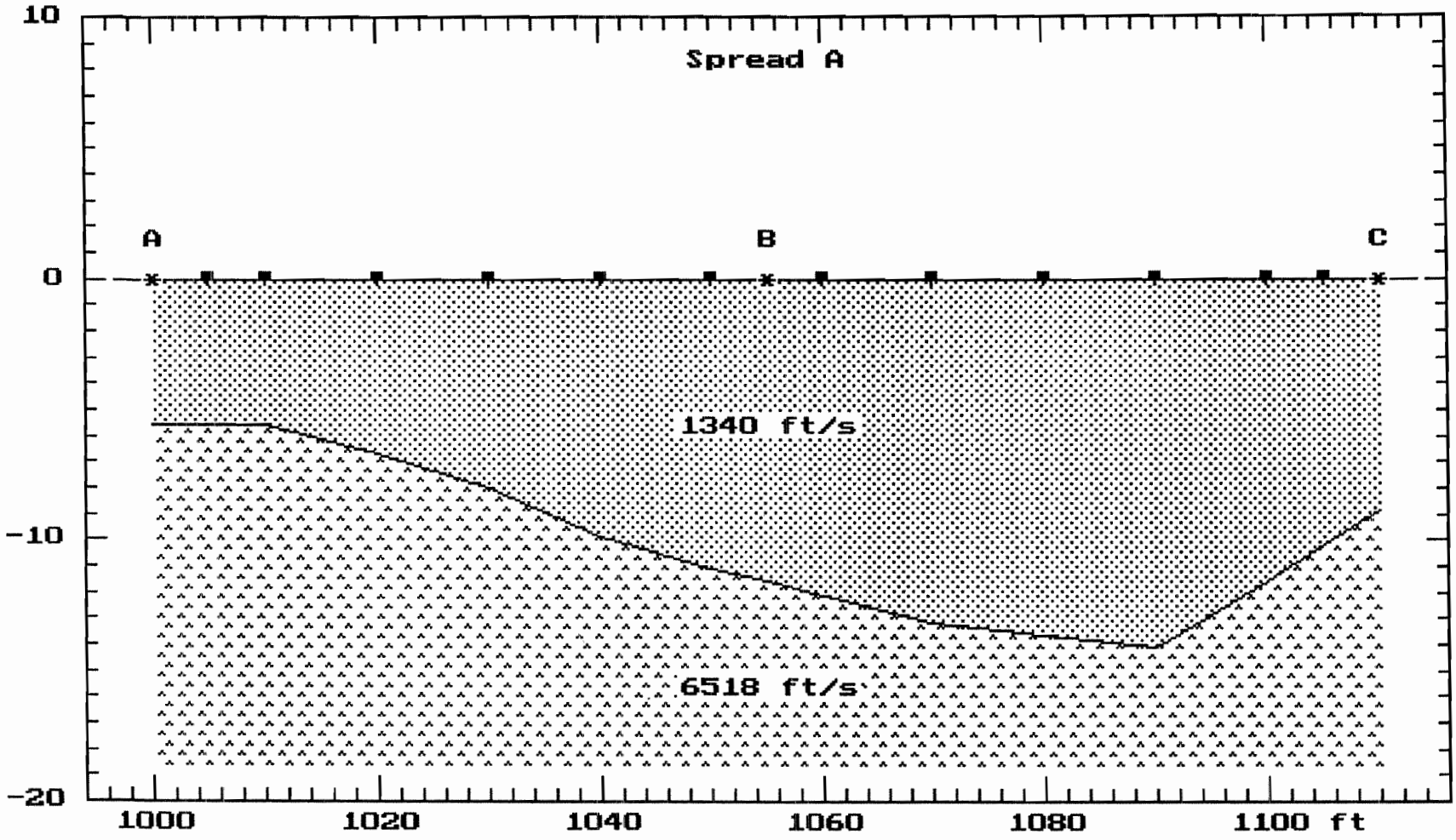
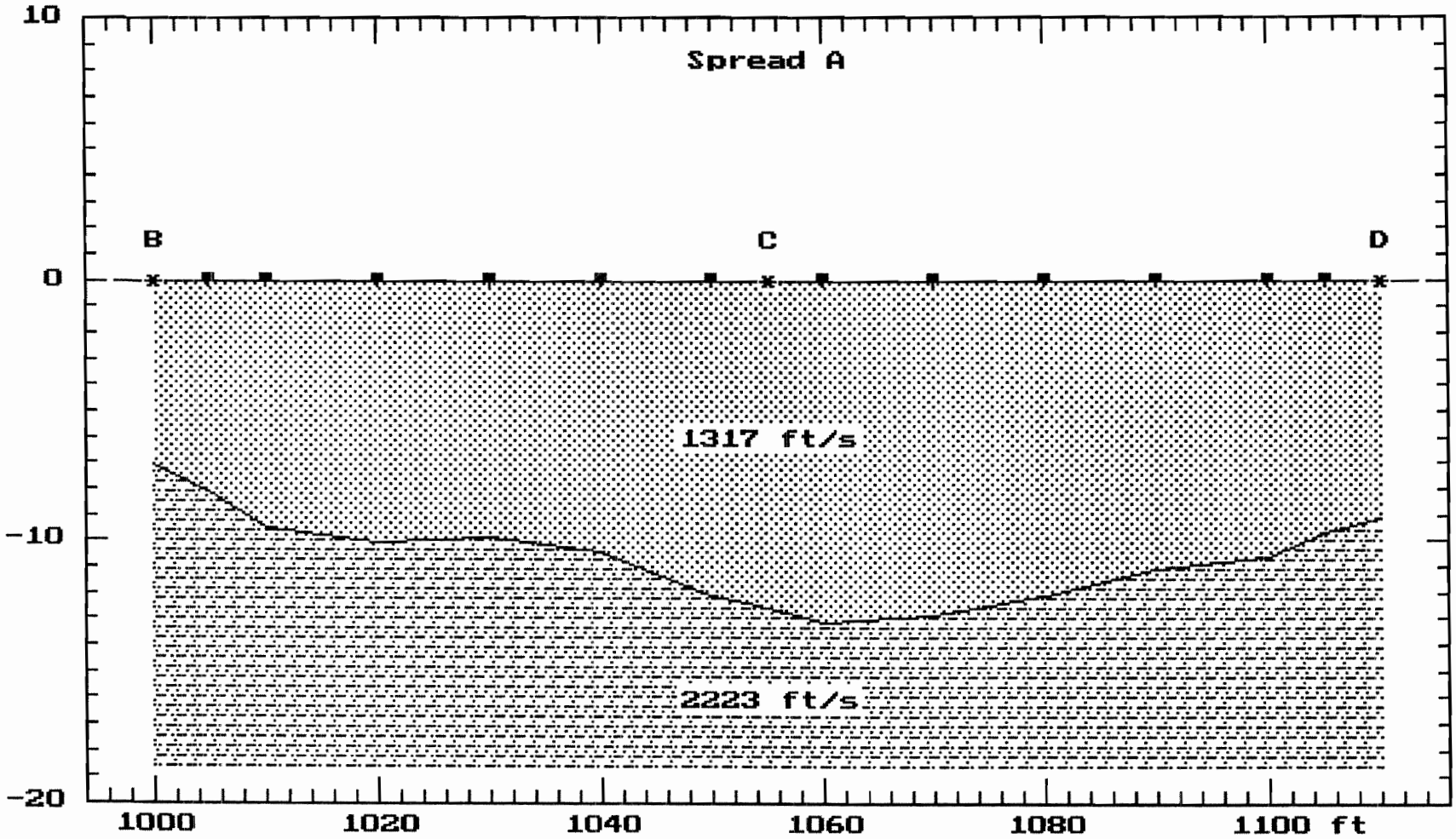
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 34



Prepared for	Prepared by
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
	Honolulu, HI August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 35



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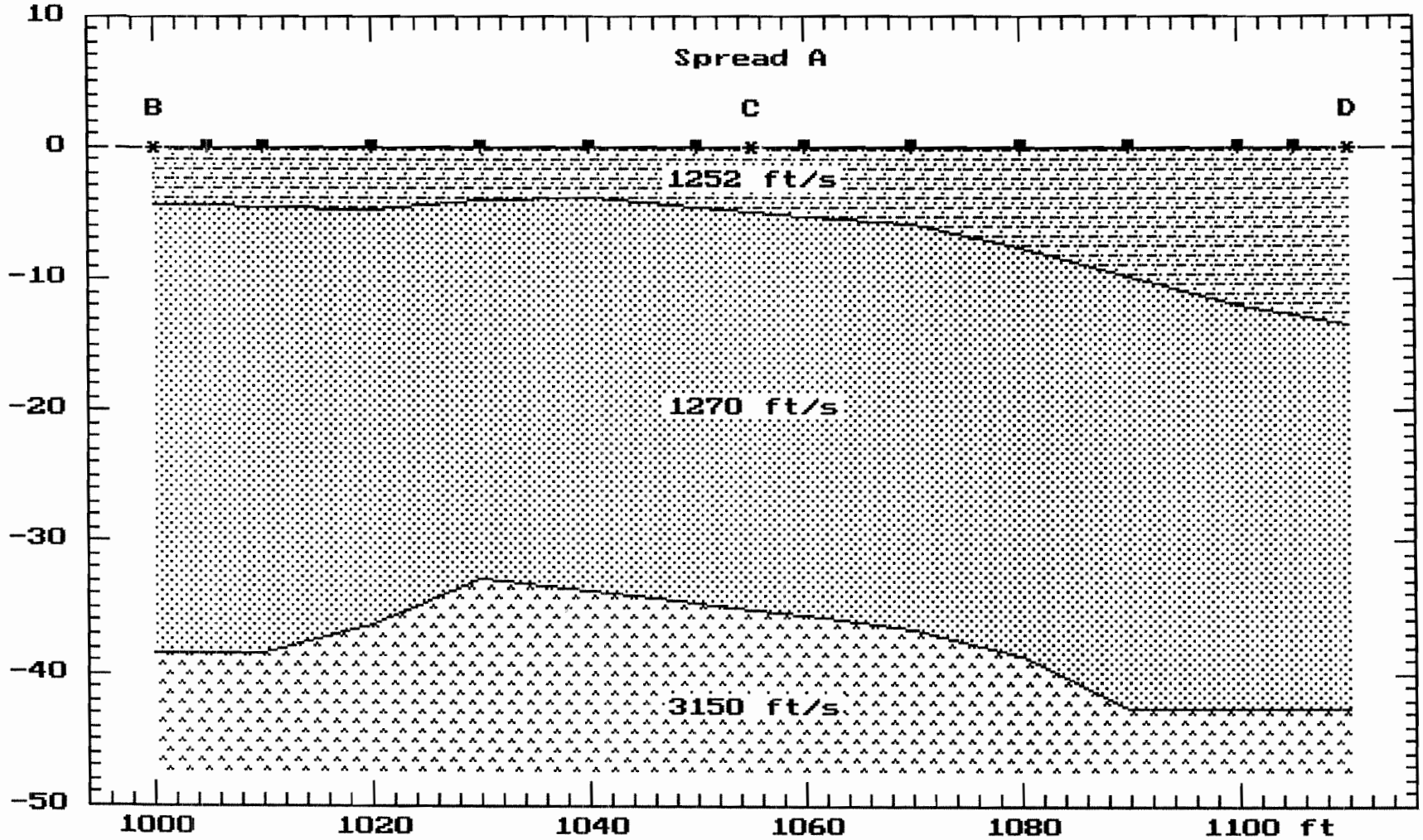
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
	Honolulu, HI August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 36



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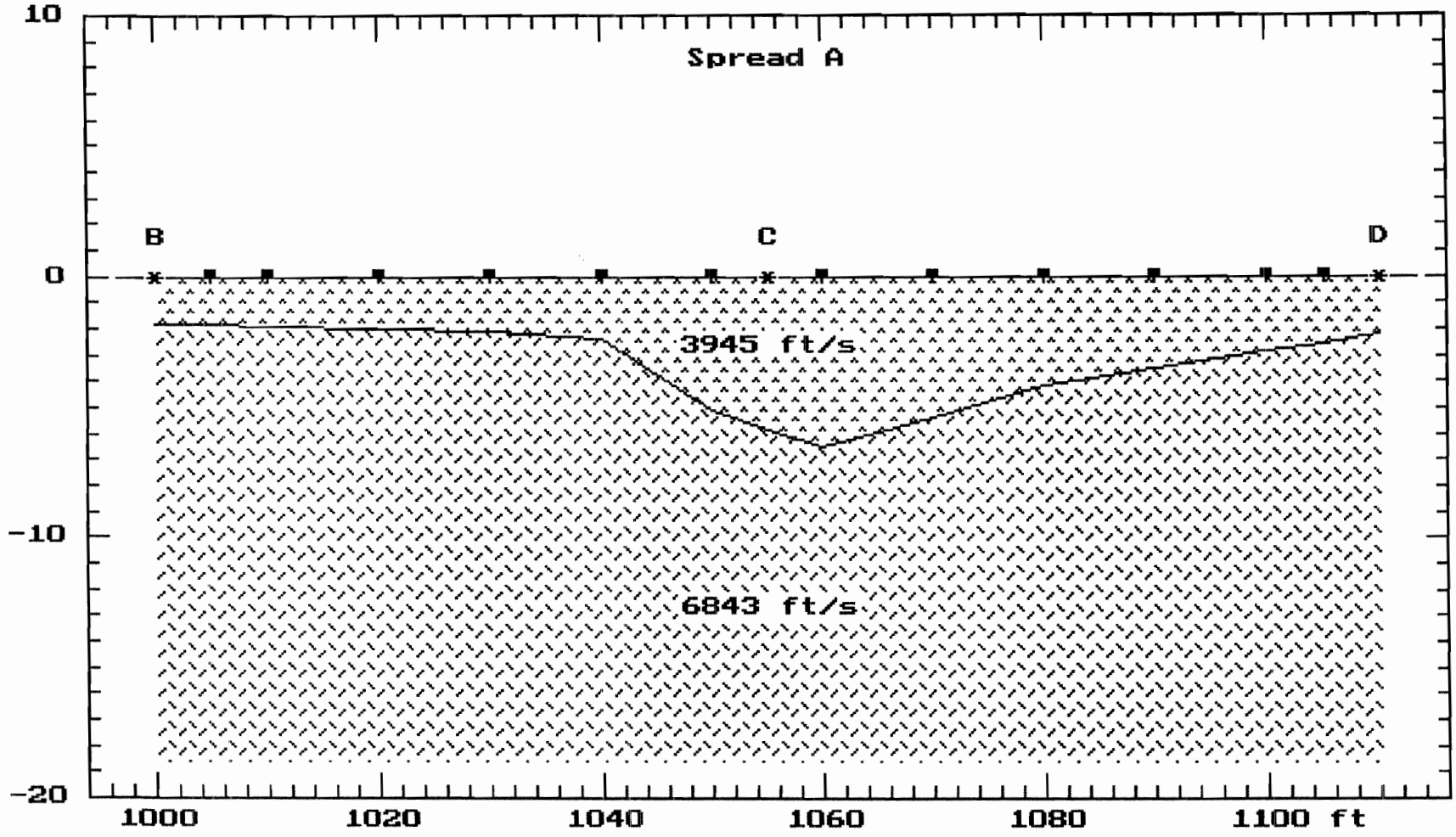
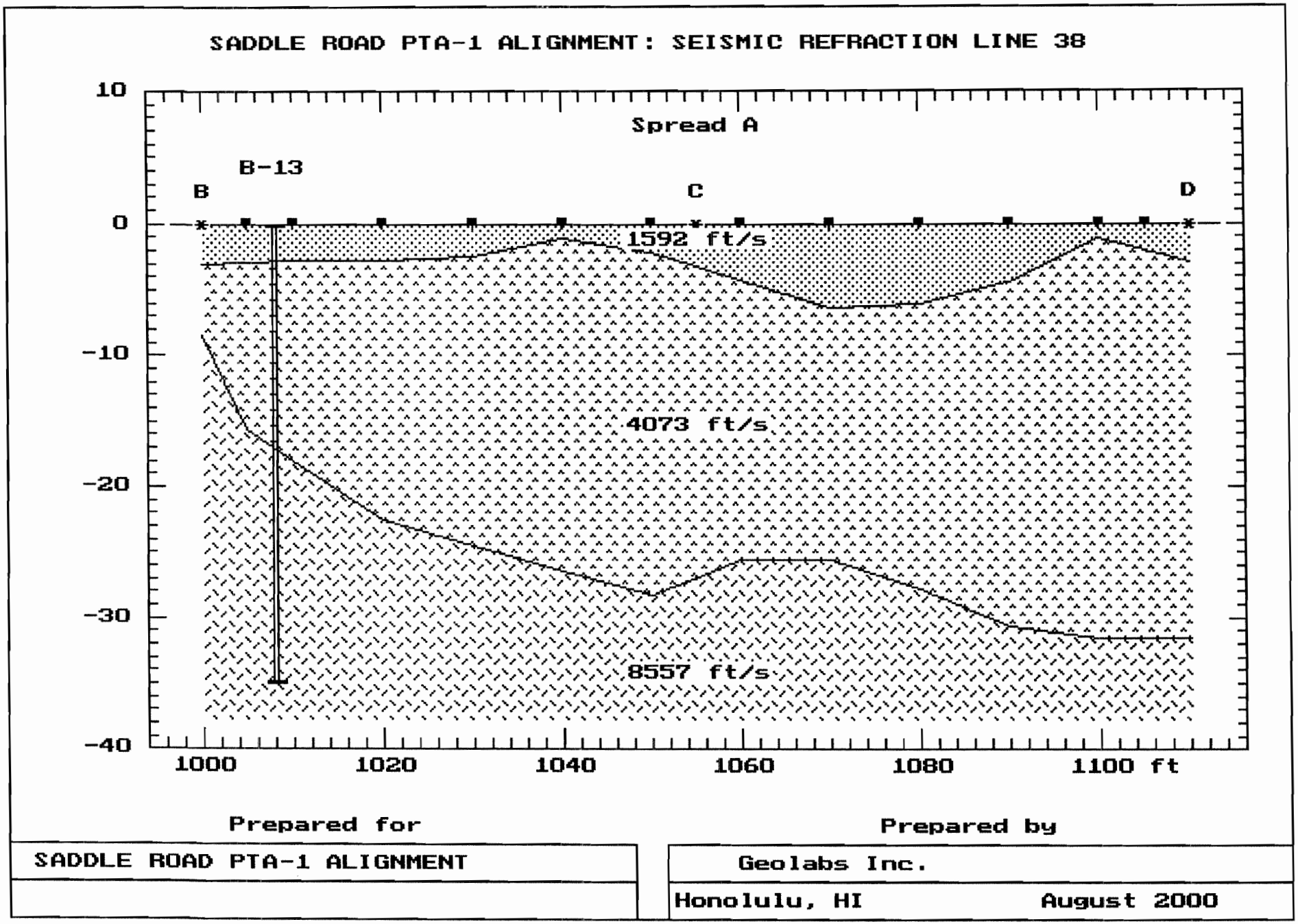
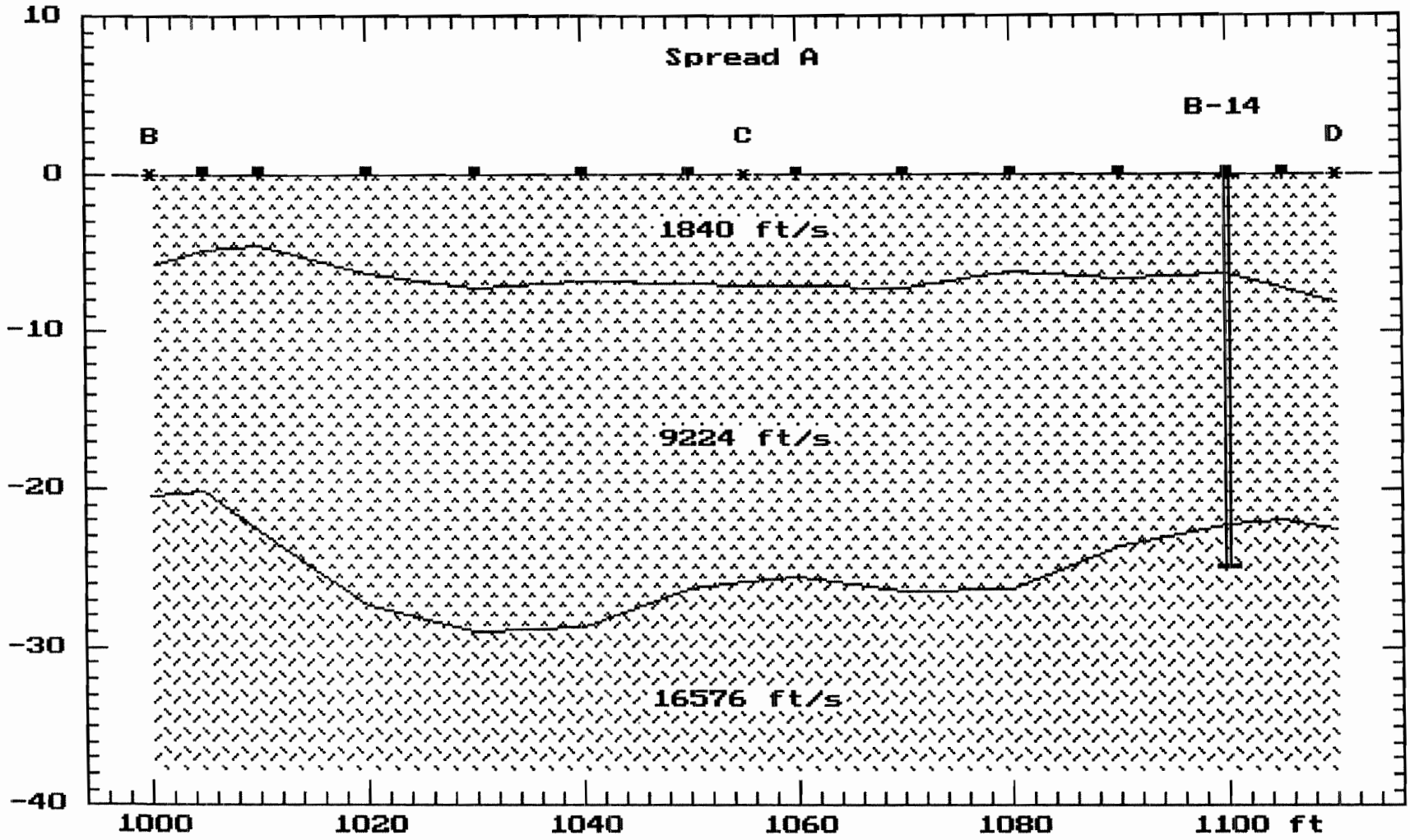
SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 37



Prepared for	Prepared by
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
	Honolulu, HI August 2000


SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE 38
Spread A
B-13
B
C
D
1592 ft/s
4073 ft/s
8557 ft/s
10
0
-10
-20
-30
-40
1000
1020
1040
1060
1080
1100 ft
Prepared for
SADDLE ROAD PTA-1 ALIGNMENT
Prepared by
Geolabs Inc.
Honolulu, HI
August 2000

SADDLE ROAD PTA-1 ALIGNMENT: SEISMIC REFRACTION LINE NO. 39



Prepared for	Prepared by
SADDLE ROAD PTA-1 ALIGNMENT	Geolabs Inc.
	Honolulu, HI August 2000

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 results of these tests are presented on the Logs of Borings at the appropriate sample depths.

Seven sets of Corrosion Tests, including pH (SW 9045B), Minimum Resistivity (EPA 120.1), Chloride Content (EPA 325.2), and Sulfate Content (EPA 375.2), were performed by Oceanic Analytical Laboratory, Inc. on selected soil samples obtained from some of the planned drainage structure locations during our field exploration. The results of these tests are summarized on Plate C-1.

Two Specific Gravity tests (ASTM D 854) were performed on selected soil samples to evaluate the specific gravity of the soils. The test results are summarized on Plate C-2.

One Atterberg Limits test (ASTM D 4318) was performed on a selected soil sample to evaluate the liquid and plastic limits. The test results are summarized on the Logs of Borings at the appropriate sample depth. Graphic presentation of the test results is provided on Plate C-3.

Thirty-seven Sieve Analysis tests (ASTM C 117 & C 136), including three Hydrometer tests (ASTM D 422), were performed on selected soil samples to evaluate the gradation characteristics of the soils and to aid in soil classification. Graphic presentations of the grain size distribution are provided on Plates C-4 through C-11.

Four Direct Shear tests (ASTM D 3080) were performed on selected samples to evaluate the shear strength characteristics of the materials tested. Results of the direct shear tests are presented on Plates C-12 through C-15.

One Consolidation test with time rates (ASTM D 2435) was performed on a sample of the potentially compressible soils to evaluate the compressibility characteristics of the materials encountered. Results of the consolidation test are presented on Plate C-16.

Ten unconfined compression tests (ASTM D 2938) were performed on selected rock cores to evaluate the unconfined compressive strength of the rock formation encountered. Results of the unconfined compression tests are presented on Plate C-17.

Twelve laboratory California Bearing Ratio Tests (ASTM D 1883) were performed on bulk samples of the near-surface soils to evaluate the pavement support characteristics of the soils and the quality of the materials for use as embankment fills. The test results are presented on Plates C-18 through C-29.

Nine Modified Proctor compaction tests (ASTM D 1557) were performed on bulk samples of the near-surface soils to evaluate the dry density and moisture content relationships. The test results are presented on Plates C-30 through C-38.

Seven laboratory Resistance (R) Value Tests (AASHTO T 190-93) were performed on selected bulk samples of the near-surface soils to evaluate the pavement support characteristics of the soils. The test results are presented on Plates C-39 through C-45.

(u:\03reports\3411-20.tk2-pg.80)

SUMMARY OF SOIL ANALYSIS

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

Location	Station No.	pH Value	Minimum Resistivity (ohm-cm)	Chloride Content (mg/kg)	Sulfate Content (mg/kg)
BULK-106	33+10	7.08	1,700	45.9	ND
BULK-107	114+90	6.77	4,200	ND	ND
BULK-108	201+51	6.91	4,030	15.6	ND
BULK-109	265+05	6.93	7,350	ND	ND
BULK-110	328+62	7.29	6,800	ND	ND
BULK-111	396+00	7.00	17,200	ND	ND
BULK-112	480+00	6.80	6,250	ND	ND

TEST METHODS

pH Value	SW 9045B
Minimum Resistivity	EPA 120.1
Chloride Content	EPA 325.2
Sulfate Content	EPA 375.2

ND: Not Detected within Reporting Limits

(u:\03reports\3411-20.tk2-pg.82)

SUMMARY OF SPECIFIC GRAVITY

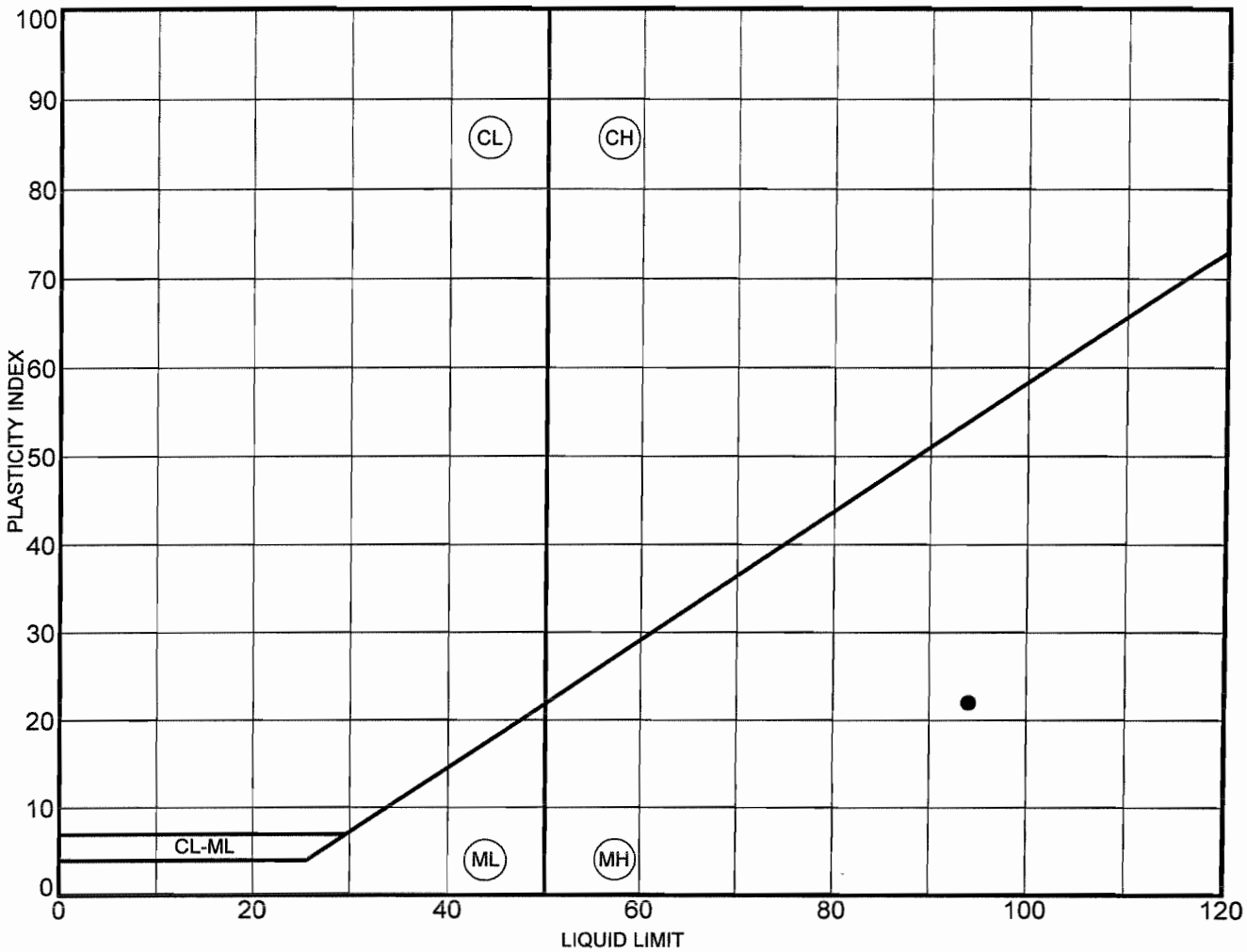
Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

Sample No.	Location	Specific Gravity
BULK-108	Sta. 201+51	2.68
BULK-112	Sta. 480+14	2.64

TEST METHOD

ASTM D 854 - Specific Gravity

(u:\03reports\3411-20.tk2-pg.83)



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-14	1.0 - 2.5	94	72	22	Light brown CLAYEY SILT (MH)

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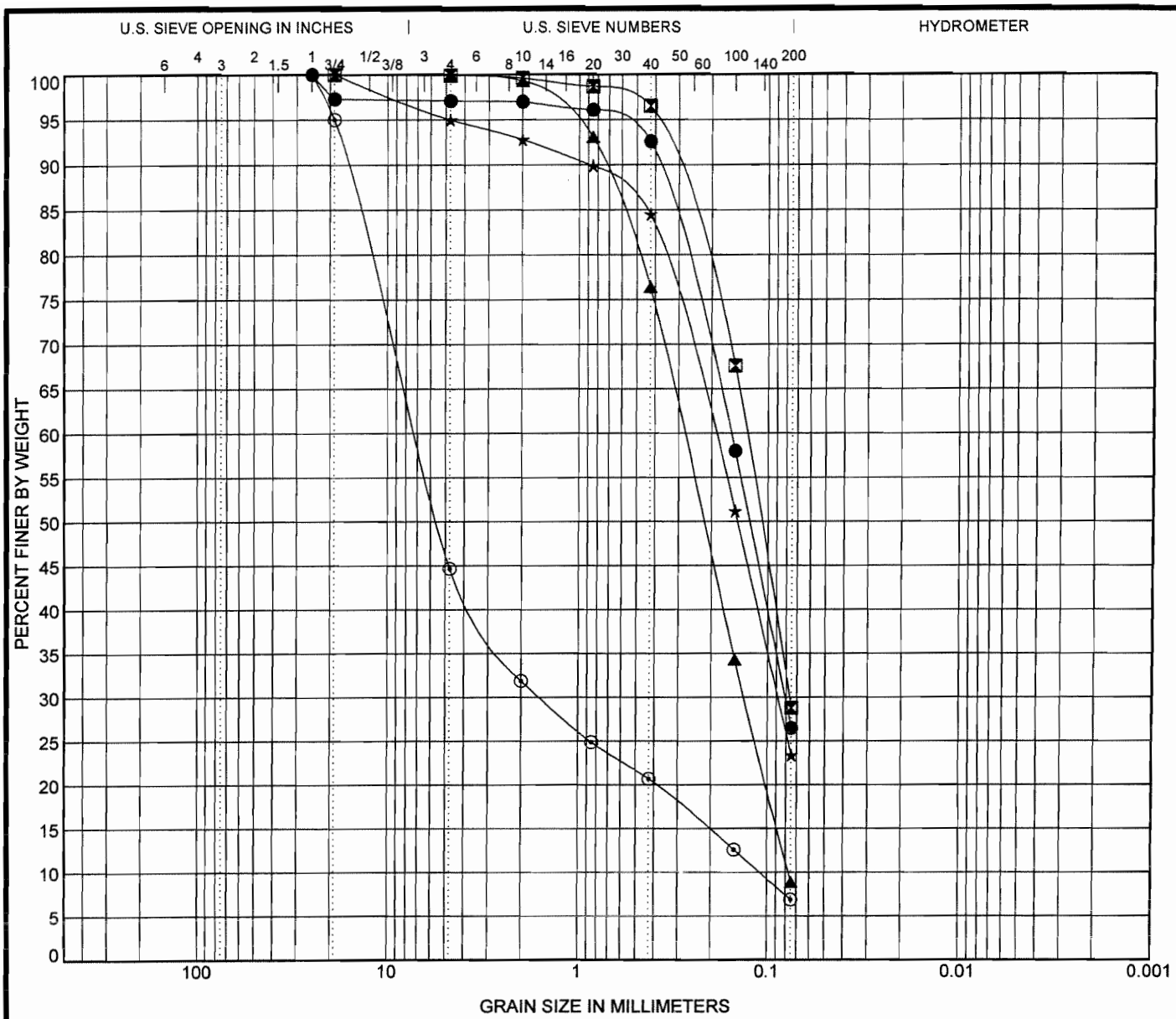
ATTERBERG LIMITS TEST RESULTS - ASTM D 4318

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 3

G ATTERBERG 3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-1	1.0 - 2.5	Brown and gray SILTY SAND (SM)					
⊠	B-2	1.0 - 2.5	Brown and gray SILTY SAND (SM)					
▲	B-3	5.0 - 6.5	Brown, white & gray poorly gr. SAND (SP-SM) w/ silt				0.8	3.7
★	B-4	1.0 - 2.5	Dark brown SILTY SAND (SM)					
⊙	B-5	1.0 - 2.5	Brown & gray well-gr. GRAVEL (GW-GM) w/ silt				3.2	66.2

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-1	1.0 - 2.5	25	0.159	0.081		2.9	70.6	26.5
⊠	B-2	1.0 - 2.5	19	0.131	0.077		0.1	71.1	28.8
▲	B-3	5.0 - 6.5	4.75	0.283	0.133	0.077	0.0	91.1	8.9
★	B-4	1.0 - 2.5	19	0.198	0.088		5.0	71.6	23.4
⊙	B-5	1.0 - 2.5	25	7.241	1.585	0.109	55.3	37.8	6.9

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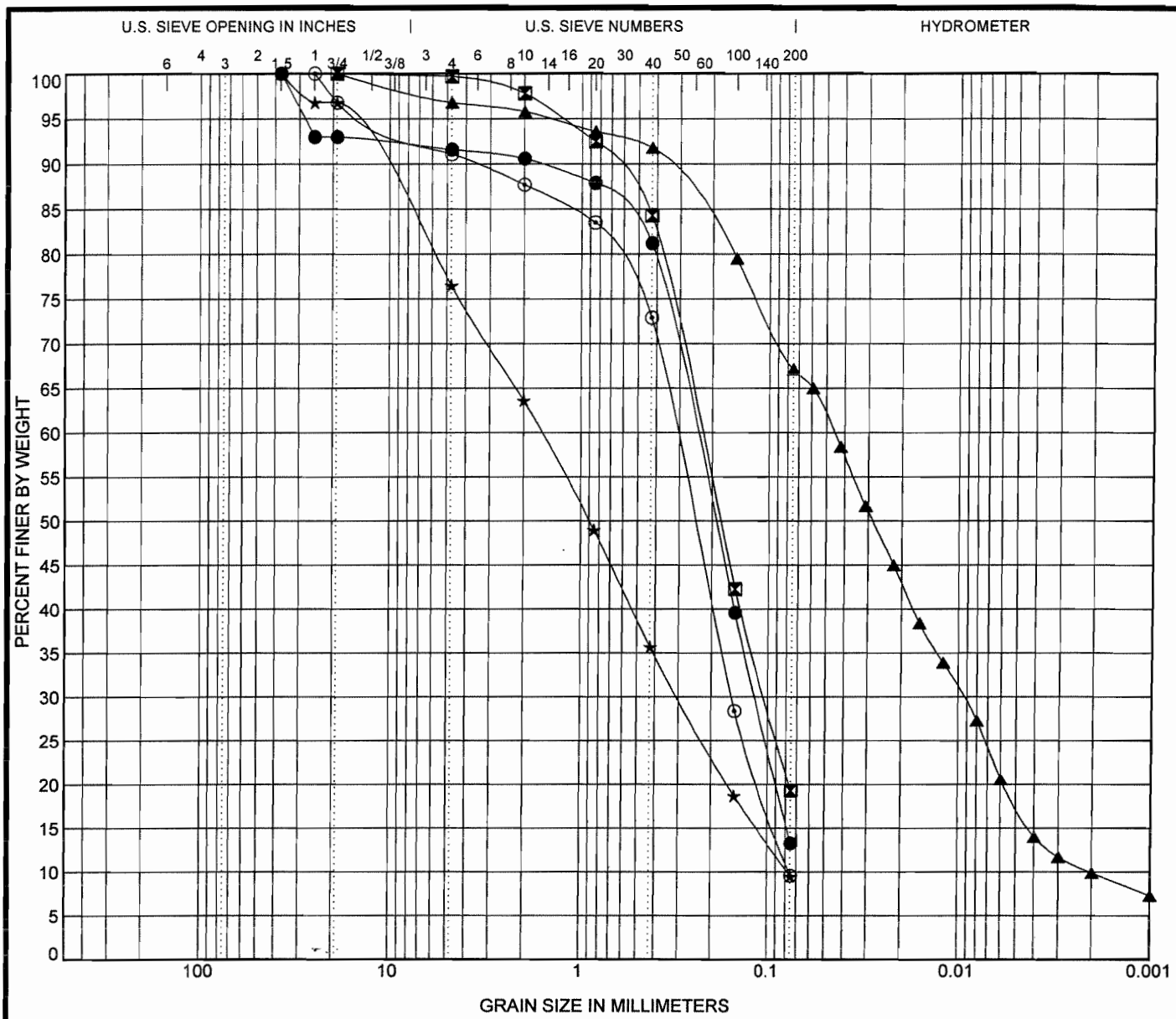
GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 4

G_GRAIN_SIZE_3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-5	10.5 - 12.0	Brown and gray SILTY SAND (SM)					
⊠	B-6	15.0 - 16.5	brown SILTY SAND (SM)					
▲	B-6	20.0 - 21.5	Tan & white SILT (ML) w/ some sand & traces of gravel				1.0	22.3
★	B-7	1.0 - 2.5	Brown & gray poorly-gr. SAND (SP-SM) w/ silt & gravel				0.7	20.8
⊙	B-8	1.0 - 2.5	Brown & gray poorly- gr. SAND (SP-SM) w/ silt & gravel				1.0	4.1

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-5	10.5 - 12.0	37.5	0.25	0.116		8.4	78.3	13.3
⊠	B-6	15.0 - 16.5	19	0.233	0.104		0.3	80.4	19.3
▲	B-6	20.0 - 21.5	19	0.046	0.009	0.002	3.2	29.7	67.1
★	B-7	1.0 - 2.5	37.5	1.62	0.3	0.078	23.5	67.0	9.5
⊙	B-8	1.0 - 2.5	25	0.314	0.156	0.076	8.9	81.5	9.6

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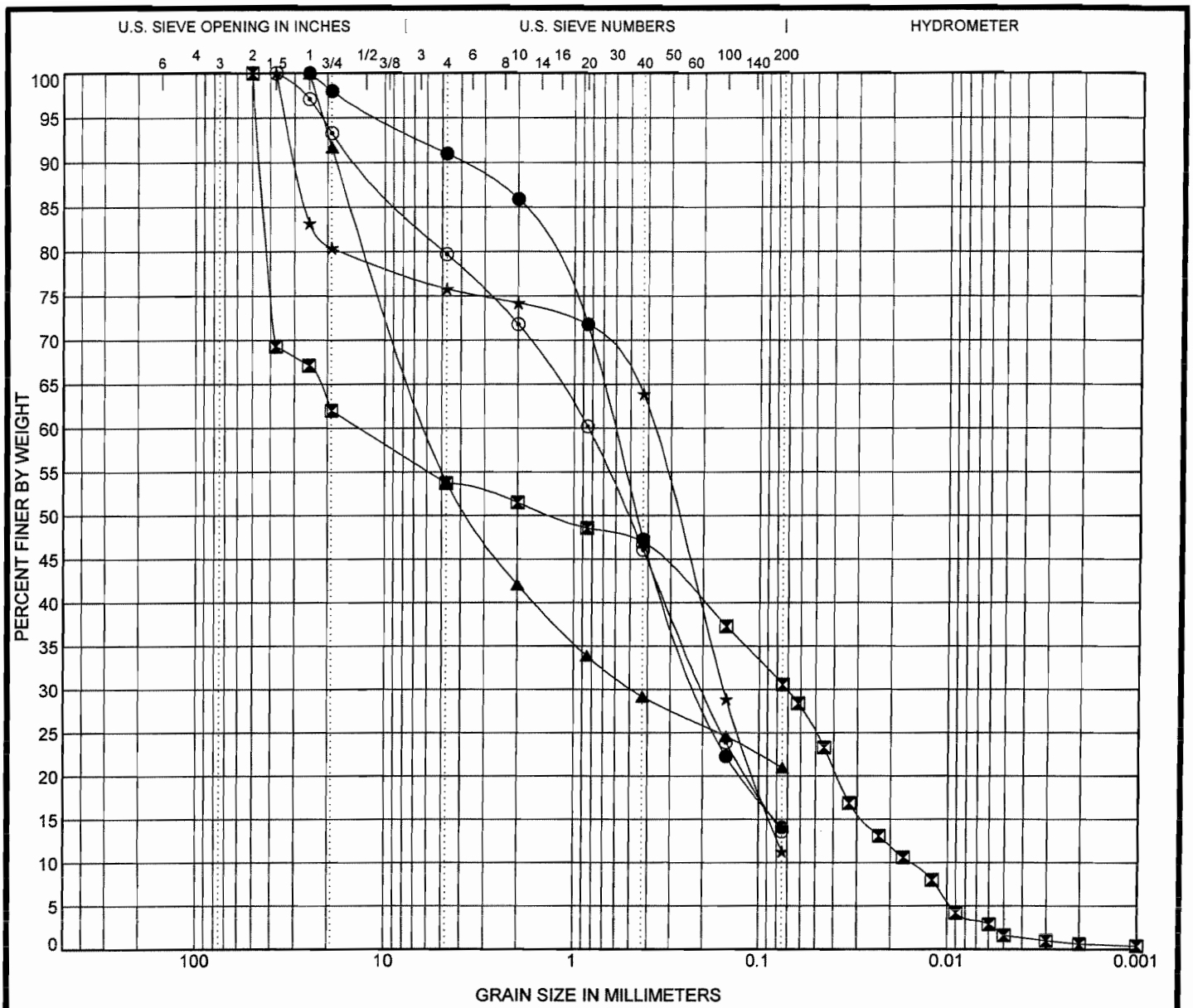
GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 5

G GRAIN SIZE 3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-9	1.0 - 2.5	Brown and gray SILTY SAND (SM) with some gravel					
⊠	B-10	1.0 - 2.5	Light brown SILTY GRAVEL (GM) with sand				0.0	867.2
▲	B-10	3.0 - 4.5	Light brown SILTY BASALTIC GRAVEL (GM) with sand					
★	B-11	3.0 - 4.5	Brown & gray poorly-gr. SAND (SP-SM) w/ silt & gravel				0.9	5.3
⊙	B-12	1.0 - 2.5	Light brown & gray SILTY SAND (SM) w/ basaltic gravel					

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-9	1.0 - 2.5	25	0.609	0.207		9.0	76.9	14.1
⊠	B-10	1.0 - 2.5	50	13.604	0.071	0.016	46.3	23.1	30.6
▲	B-10	3.0 - 4.5	25	5.941	0.478		46.1	32.9	21.0
★	B-11	3.0 - 4.5	37.5	0.378	0.155		24.2	64.5	11.3
⊙	B-12	1.0 - 2.5	37.5	0.842	0.2		20.3	66.1	13.6

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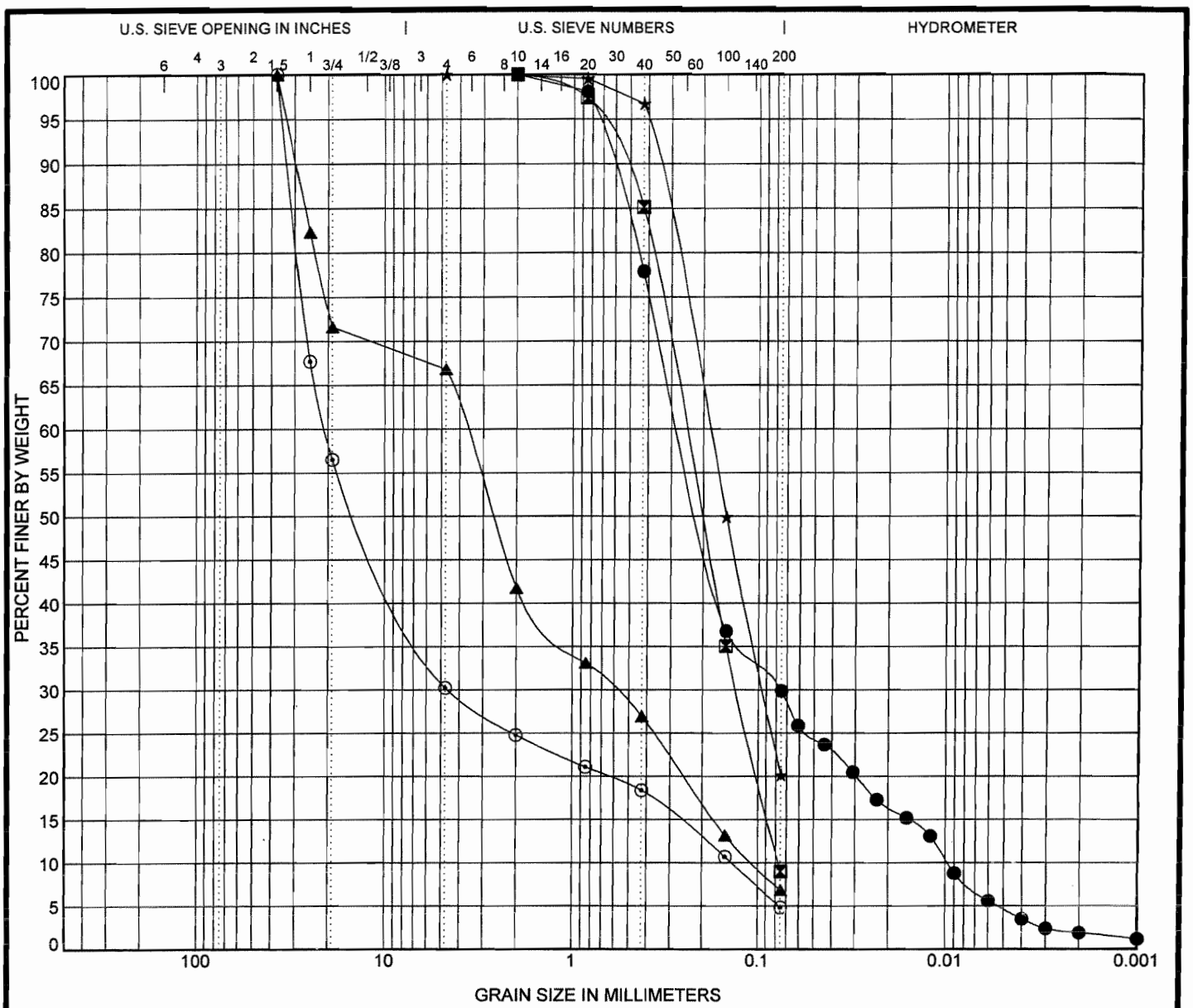
GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 6

G_GRAIN_SIZE_3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-13	3.0 - 4.5	Brownish gray SILTY BASALTIC GRAVEL (GM) w/ sand				2.2	27.7
⊠	B-101	1.5 - 2.0	Brown poorly graded SAND with silt (SP-SM)				0.9	3.3
▲	B-102	1.3 - 1.8	Brown poorly graded SAND with silt and gravel (SP-SM)				0.9	35.4
★	B-103	1.5 - 2.0	Dark brown SILTY SAND (SM)					
⊙	B-104	1.8 - 3.3	Tannish brown poorly graded GRAVEL with sand (GP)				7.3	149.9

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-13	3.0 - 4.5	2	0.27	0.076	0.01	0.0	70.1	29.9
⊠	B-101	1.5 - 2.0	2	0.252	0.131	0.077	0.0	91.0	9.0
▲	B-102	1.3 - 1.8	37.5	3.754	0.599	0.106	33.2	60.0	6.8
★	B-103	1.5 - 2.0	4.75	0.188	0.094		0.0	79.8	20.2
⊙	B-104	1.8 - 3.3	37.5	20.694	4.565	0.138	69.7	25.4	4.8

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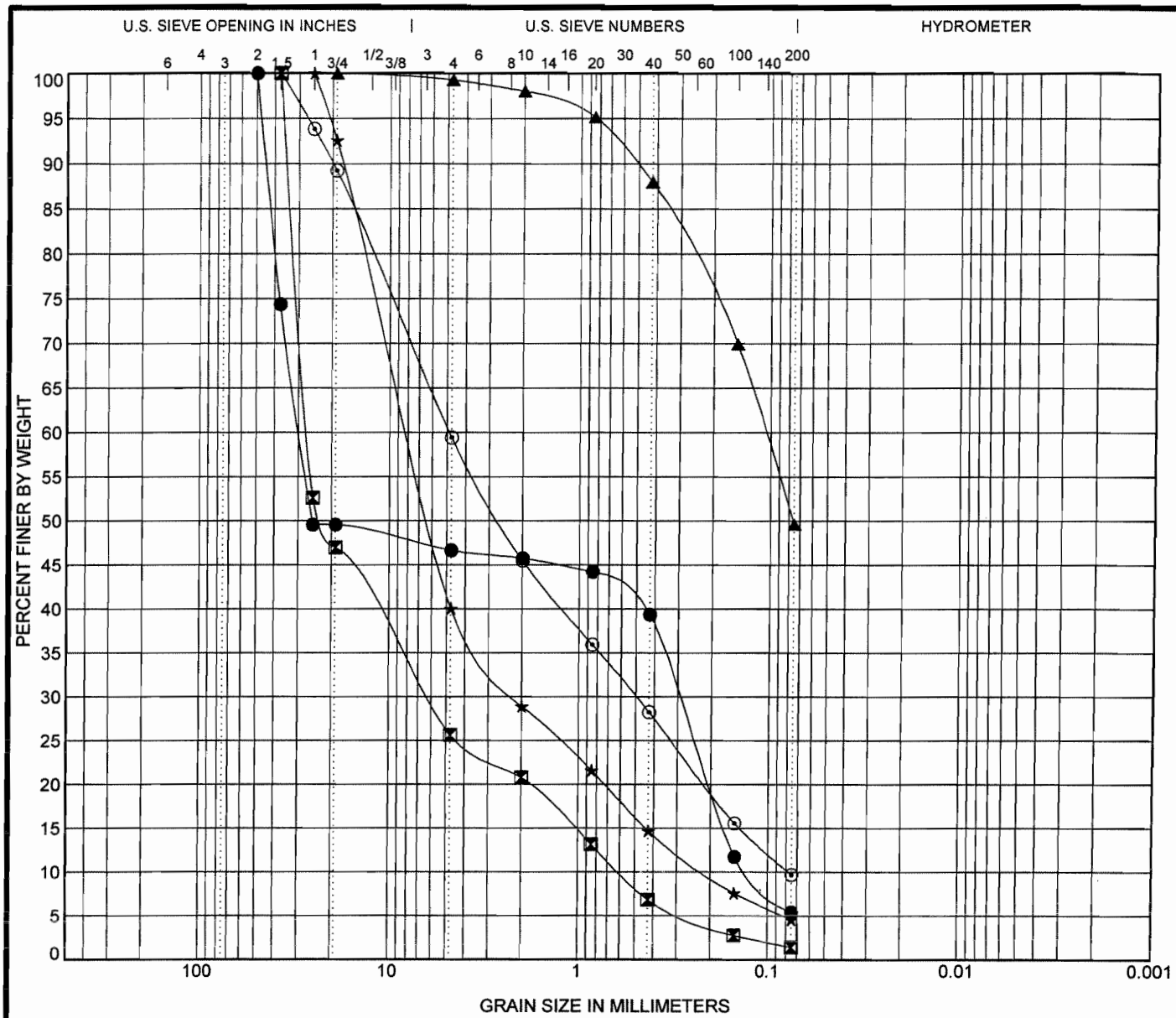
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 7

G GRAIN SIZE 3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-105	2.0 - 2.5	Dark br. poorly gr. GRAVEL w/ SILT & SAND (GP-GM)				0.0	239.7
⊠	B-106	2.0 - 3.5	Dark brown well-graded Gravel with SAND (GW)				2.5	44.3
▲	B-107	2.0 - 2.5	Dark brown Silty SAND (SM)					
★	B-108	5.0 - 6.5	Dark brown well graded GRAVEL with sand (GW)				2.8	37.7
⊙	B-109	2.0 - 2.5	Brown poorly graded SAND with silt and gravel (SP-SM)				0.7	63.0

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-105	2.0 - 2.5	50	29.641	0.298	0.124	53.3	41.2	5.4
⊠	B-106	2.0 - 3.5	37.5	26.628	6.302	0.601	74.4	24.2	1.4
▲	B-107	2.0 - 2.5	19	0.107			0.7	49.6	49.6
★	B-108	5.0 - 6.5	25	8.04	2.176	0.213	59.9	35.5	4.6
⊙	B-109	2.0 - 2.5	37.5	4.881	0.497	0.078	40.6	49.7	9.7

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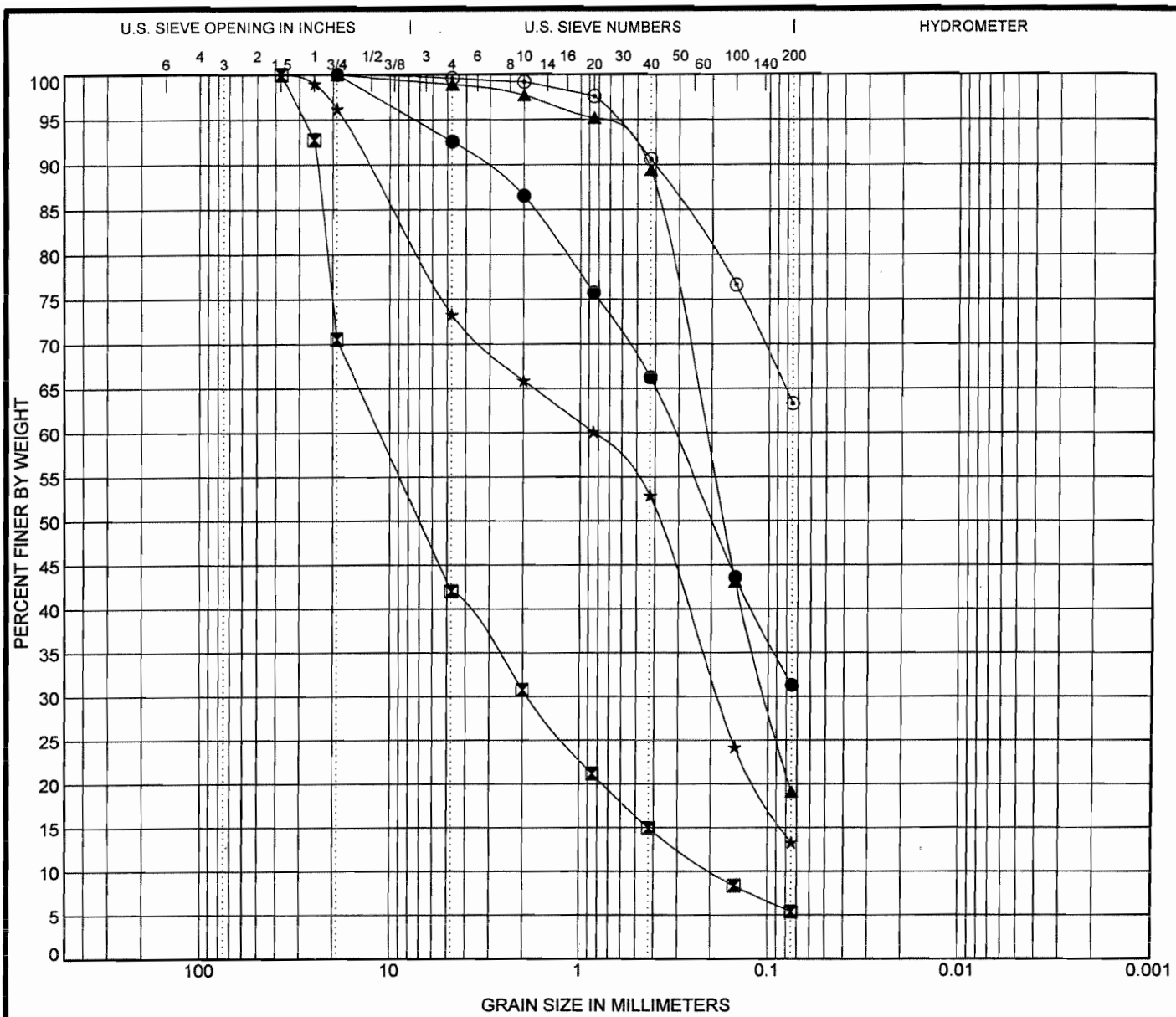
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 8

G GRAIN SIZE 3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-109	11.0 - 11.5	Tannish brown SILTY SAND (SM)					
⊠	B-109	25.0 - 26.5	Gray well graded GRAVEL with silt and sand (GW-GM)				1.6	58.6
▲	Bulk-3	Surface	Light brown SILTY SAND (SM)					
★	Bulk-4	Surface	Grayish brown SILTY SAND with gravel					
⊙	Bulk-5	Surface	Tannish brown SILT with sand					

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-109	11.0 - 11.5	19	0.319			7.4	61.3	31.3
⊠	B-109	25.0 - 26.5	37.5	11.387	1.869	0.194	58.0	36.6	5.4
▲	Bulk-3	Surface	19	0.219	0.103		1.1	79.8	19.1
★	Bulk-4	Surface	37.5	0.842	0.185		26.7	60.0	13.3
⊙	Bulk-5	Surface	19				0.4	36.3	63.3

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

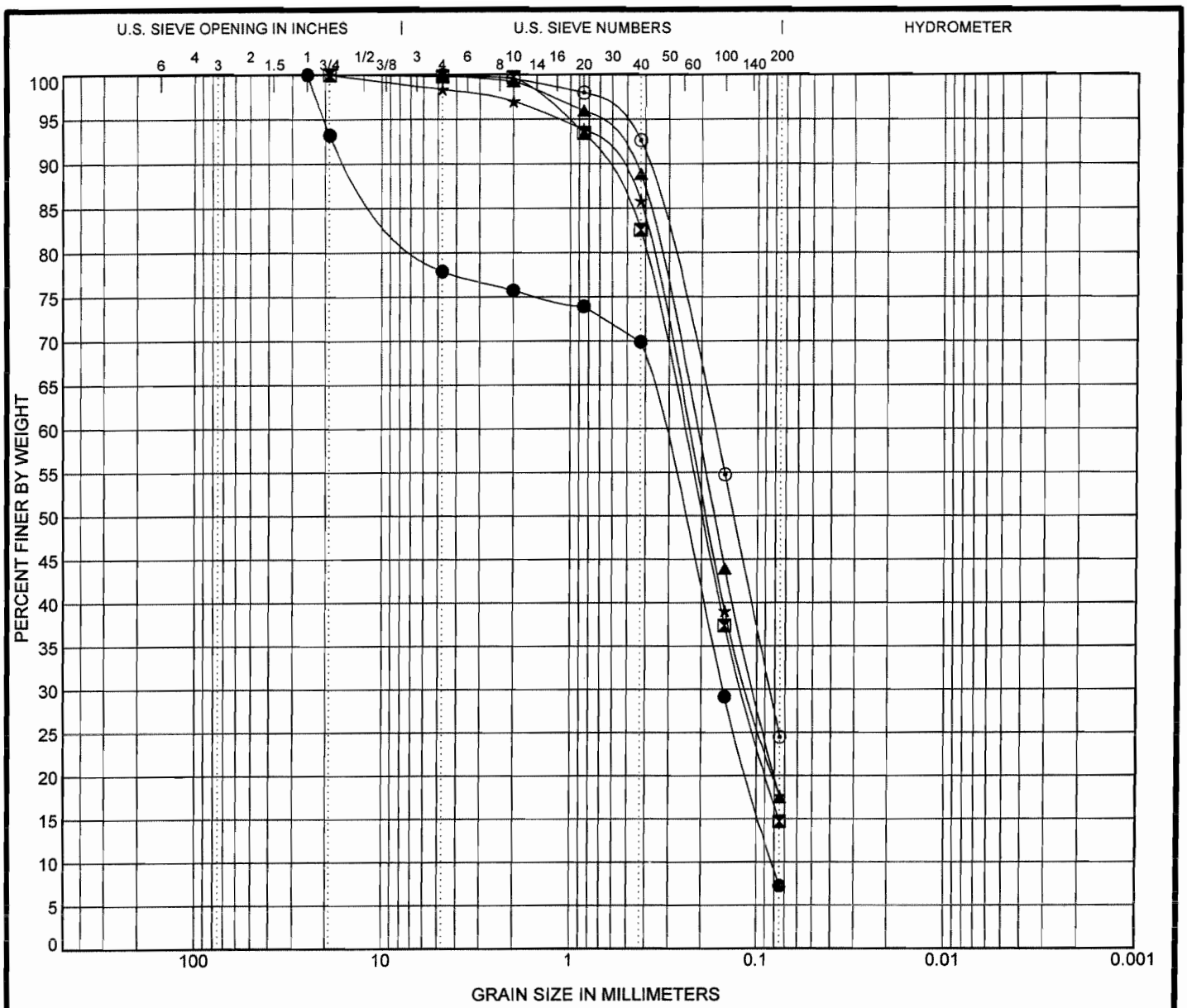
W.O. 3411-20(A)

GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 9

G GRAIN SIZE 3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	Bulk-106	0.0 - 1.0	Brown poorly graded SAND with silt and gravel (SP-SM)				0.9	4.0
⊠	Bulk-107	0.0 - 1.0	Brown SILTY SAND (SM)					
▲	Bulk-108	0.0 - 1.0	Brown SILTY SAND with some roots (SM)					
★	Bulk-109	0.0 - 1.0	Brown SILTY SAND with some roots (SM)					
⊙	Bulk-110	0.0 - 1.0	Dark brown Silty SAND (SM)					

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	Bulk-106	0.0 - 1.0	25	0.33	0.153	0.082	22.1	70.6	7.3
⊠	Bulk-107	0.0 - 1.0	19	0.253	0.12		0.2	85.1	14.7
▲	Bulk-108	0.0 - 1.0	4.75	0.218	0.104		0.0	82.5	17.5
★	Bulk-109	0.0 - 1.0	19	0.239	0.112		1.6	80.7	17.7
⊙	Bulk-110	0.0 - 1.0	4.75	0.173	0.085		0.0	75.5	24.5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

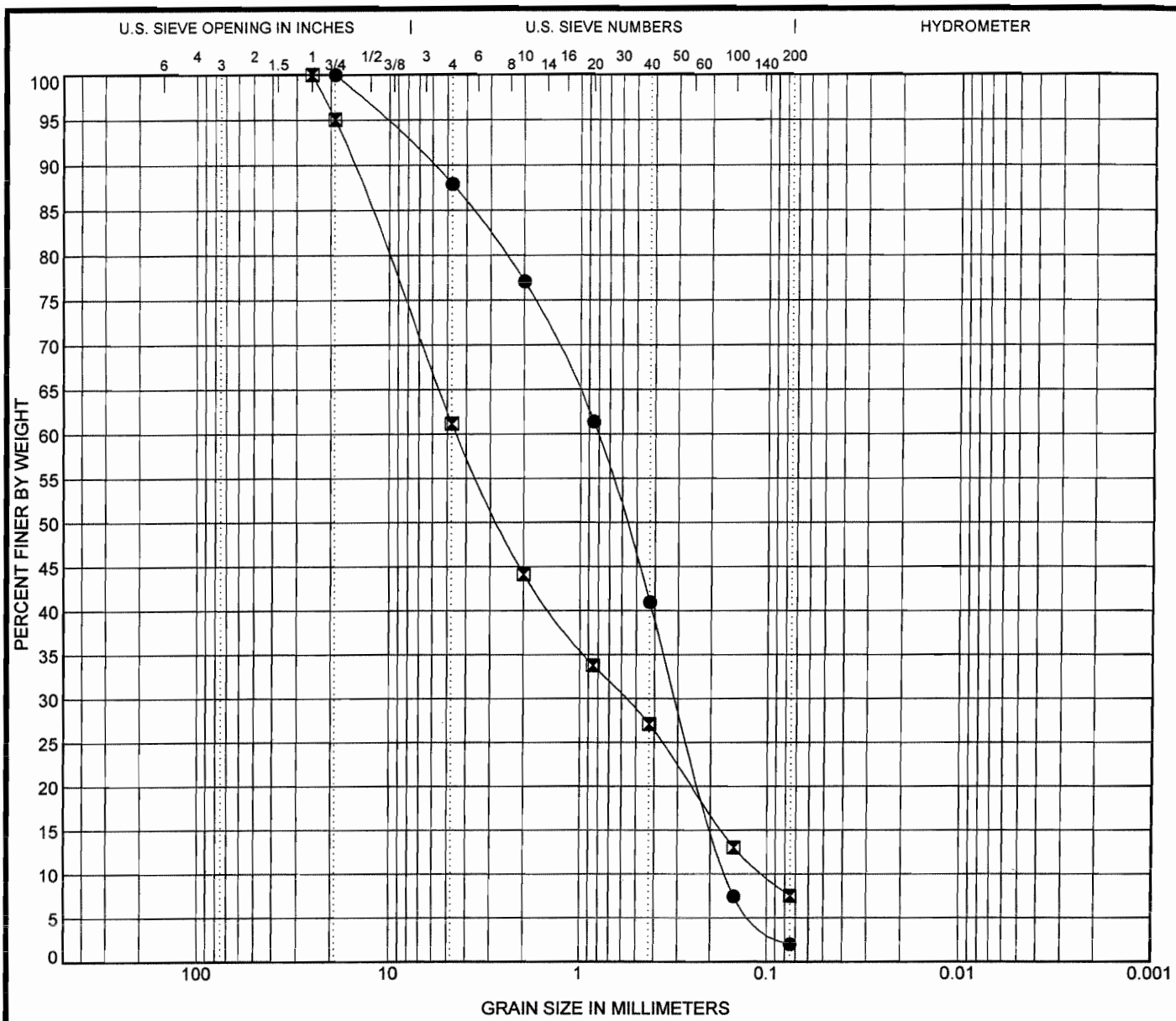
W.O. 3411-20(A)

GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 10

G_GRAIN_SIZE_3411-20.GPJ GEOLABS.GDT 10/25/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	Bulk-111	0.0 - 1.0	Dark brown poorly graded SAND (SP)				0.7	5.0
⊠	Bulk-112	0.0 - 1.0	Dark brown poorly gr. SAND w/ silt & gravel (SP-SM)				0.7	43.8

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	Bulk-111	0.0 - 1.0	19	0.811	0.302	0.162	12.1	85.9	2.0
⊠	Bulk-112	0.0 - 1.0	25	4.477	0.573	0.102	38.8	53.6	7.5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

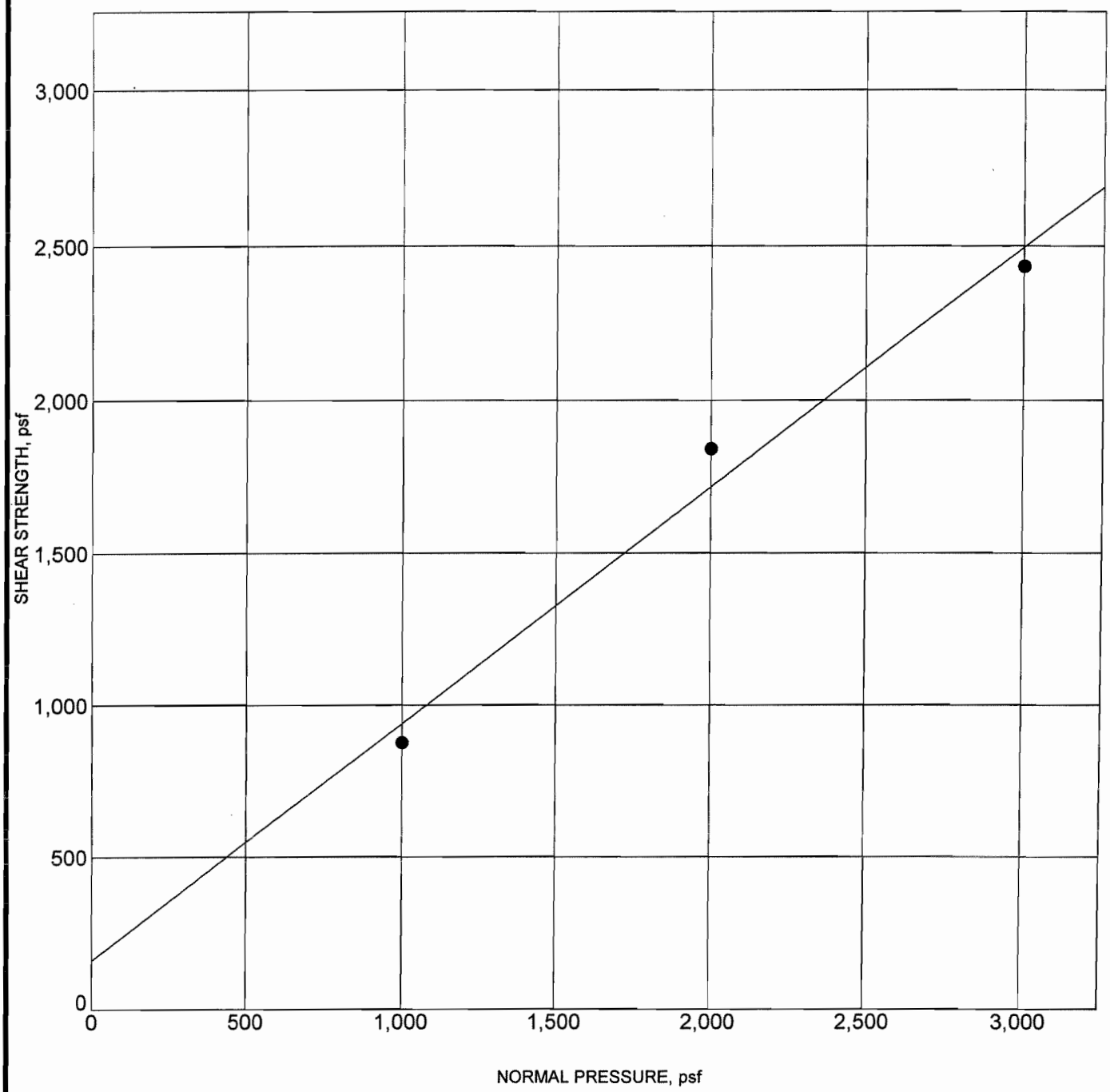
W.O. 3411-20(A)

GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 11

G GRAIN SIZE 3411-20.GPJ GEOLABS.GDT 10/25/02

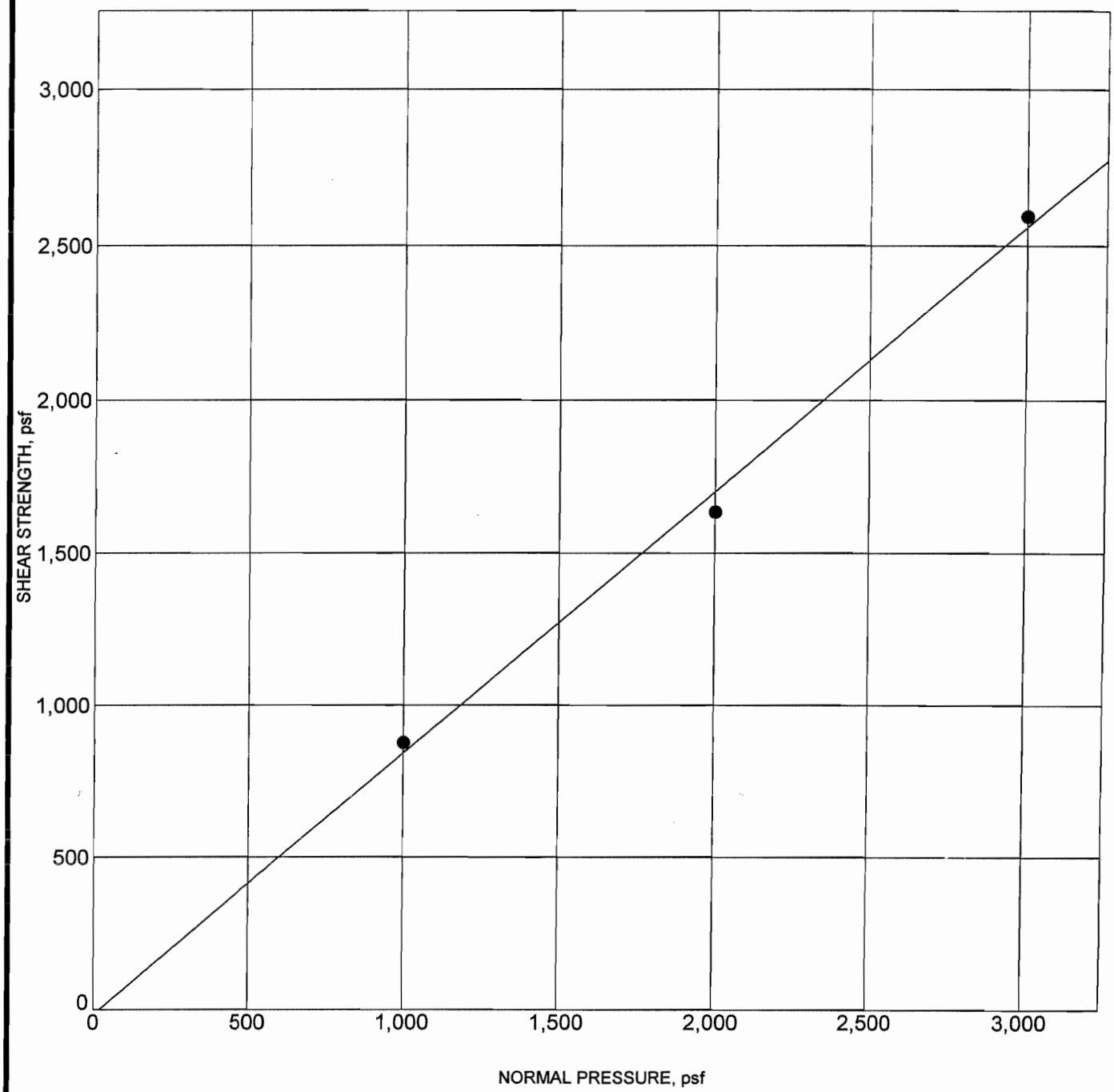


Friction angle (degrees):	**38**
cohesion (psf):	**161**

Sample: B-2
Depth: 5.0 - 6.5 feet
Description: Light brown and gray fine SAND

GEOLABS, INC. GEOTECHNICAL ENGINEERING	**DIRECT SHEAR TEST - ASTM D 3080**	
	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42)	Plate C - 12
W.O. 3411-20(A)	ISLAND OF HAWAII	

G_DIRECT_SHEAR_3411-20.GPJ GEOLABS.GDT 10/25/02

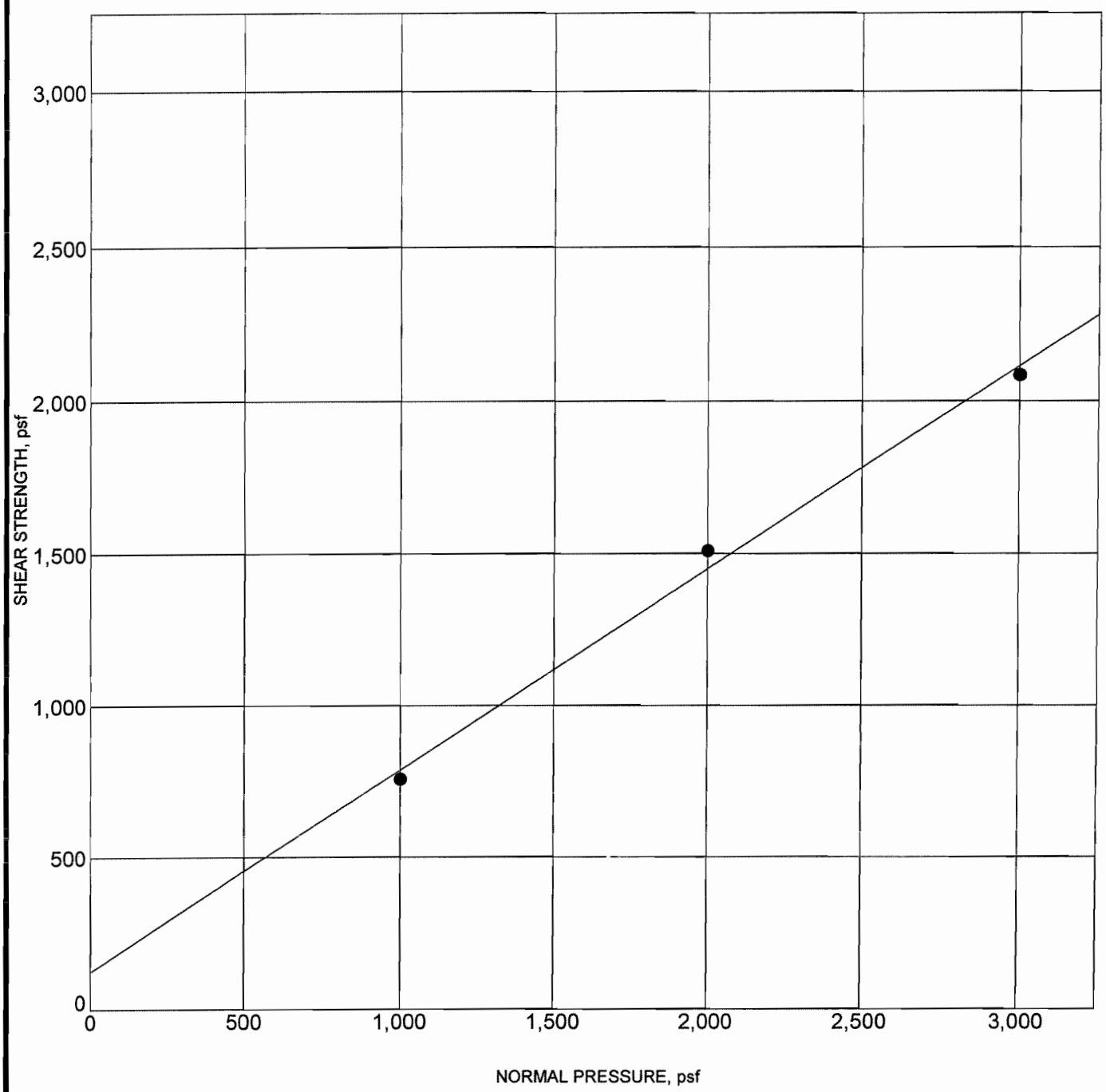


Friction angle (degrees):	**41**
cohesion (psf):	**0**

Sample: B-4
Depth: 10.0 - 11.5 feet
Description: Brown and gray fine SAND with some silt

G_DIRECT_SHEAR_3411-20.GPJ GEOLABS.GDT 10/25/02

GEOLABS, INC. GEOTECHNICAL ENGINEERING	**DIRECT SHEAR TEST - ASTM D 3080**	
	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42)	Plate C - 13
W.O. 3411-20(A)	ISLAND OF HAWAII	



Friction angle (degrees):	**34**
cohesion (psf):	**124**

Sample: B-6
Depth: 5.0 - 6.5 feet
Description: Brown and gray fine SAND with some silt

G_DIRECT SHEAR 3411-20.GPJ GEOLABS.GDT 10/25/02

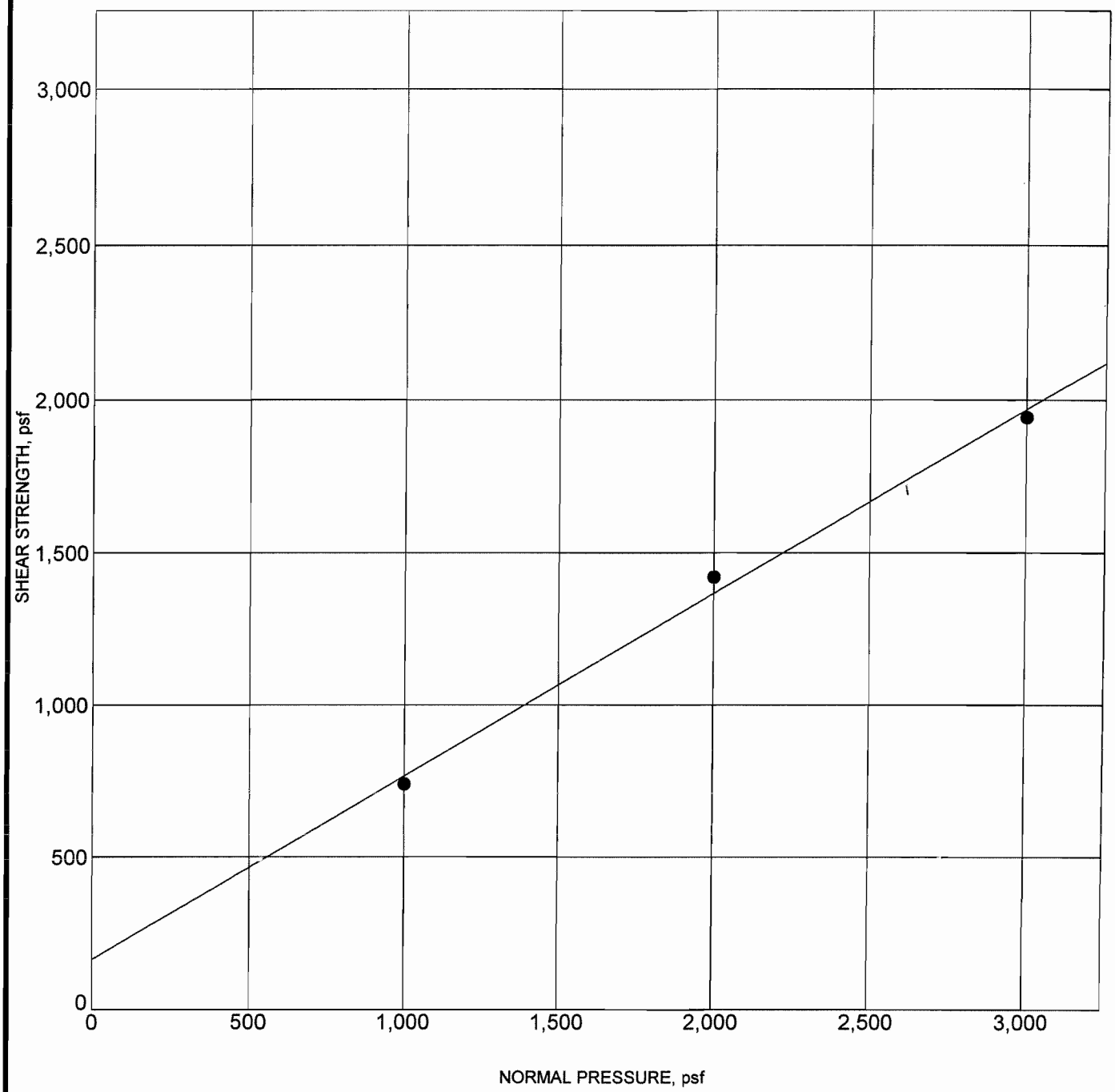
GEOLABS, INC.
GEOTECHNICAL ENGINEERING

W.O. 3411-20(A)

DIRECT SHEAR TEST - ASTM D 3080

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 14

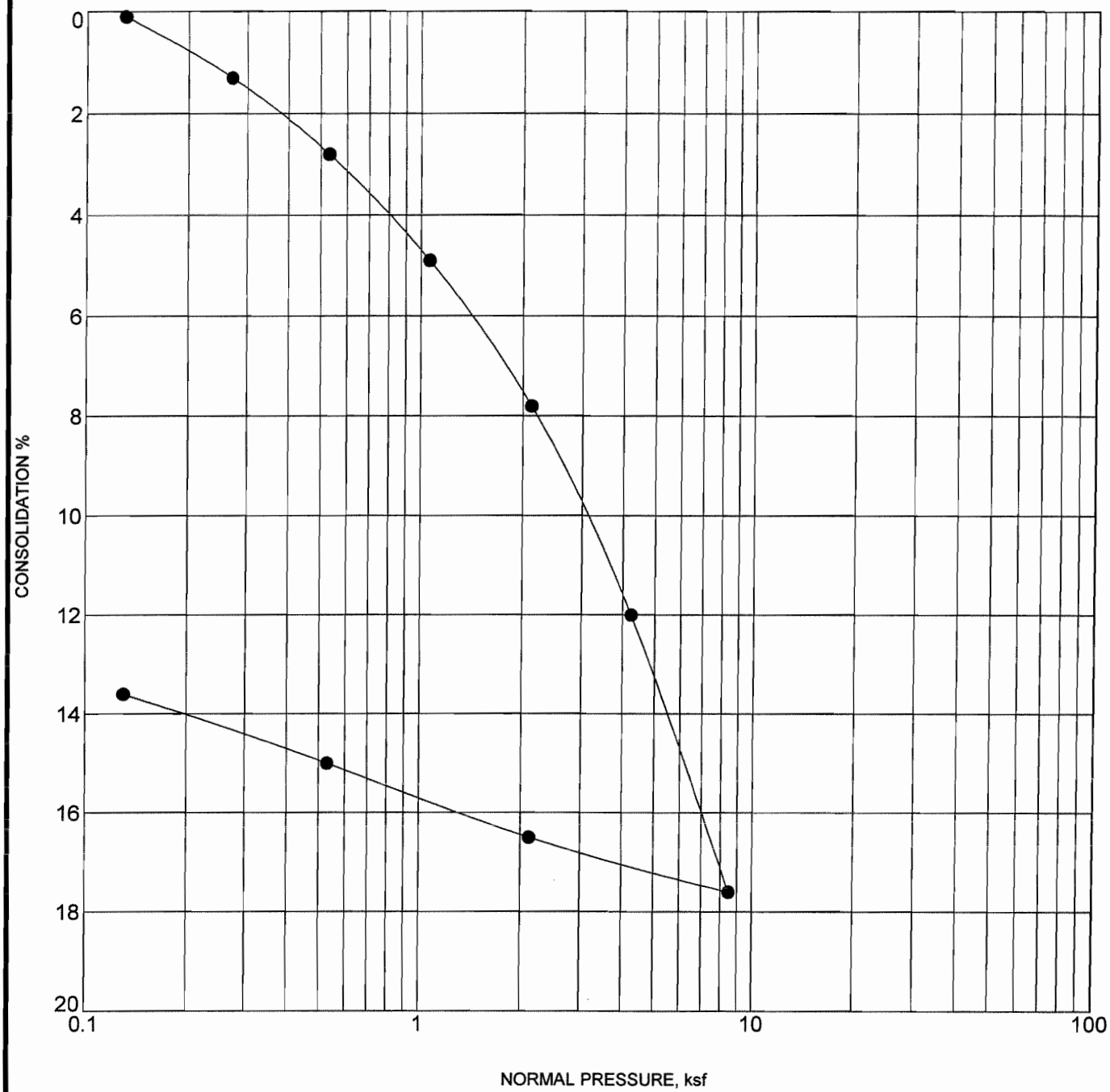


Friction angle (degrees):	**31**
cohesion (psf):	**165**

Sample: B-8
Depth: 10.0 - 11.5 feet
Description: Black CINDER SAND

G_DIRECT_SHEAR_3411-20.GPJ GEOLABS.GDT 10/25/02

GEOLABS, INC. GEOTECHNICAL ENGINEERING	**DIRECT SHEAR TEST - ASTM D 3080**	
	HAWAII STATE ROUTE 200 (SADDLE RD.) PTA-1 ALIGNMENT (MP 28 TO MP 42)	Plate C - 15
W.O. 3411-20(A)	ISLAND OF HAWAII	



	Initial	Final
water content, %:	195.9	104.5
dry density, pcf:	36.6	42.4

Sample: B-108
Depth: 1.0 - 2.0 feet
Description: Dark blackish brown very fine SANDY SILT

G CONSOL 3411-20.GPJ GEOLABS.GDT 10/25/02

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

W.O. 3411-20(A)

CONSOLIDATION TEST - ASTM D 2435

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 16

UNCONFINED COMPRESSION TEST

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

Location Boring No.	Sample Depth (feet)	Total Unit Weight (pcf)	Unconfined Compressive Strength (psi)
B-101	19.0 – 19.5	130	1,670
B-101	39.0 – 39.5	147	5,710
B-102	23.5 – 24.0	165	6,140
B-104	15.0 – 15.5	172	5,290
B-105	17.0 – 17.5	155	4,990
B-106	27.0 – 27.5	168	5,070
B-107	10.5 – 11.0	147	2,360
B-107	19.3 – 19.8	163	4,010
B-108	25.5 – 26.0	165	7,410
B-109	17.0 – 17.5	176	8,480

TEST METHOD

ASTM D 2938 – Unconfined Compression Test for Rock Cores

NOTES

pcf - pounds per cubic foot
psi - pounds per square inch

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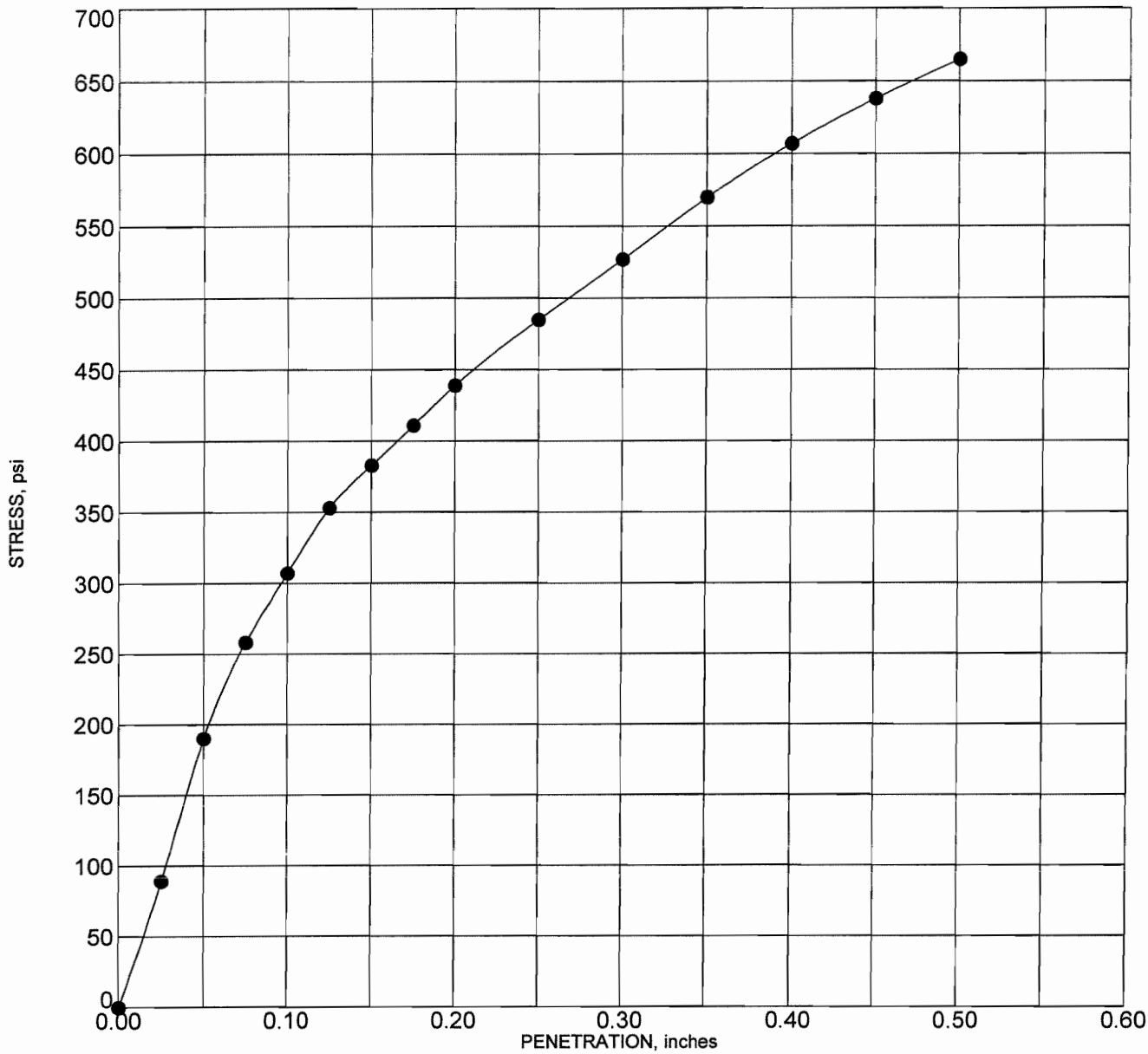


Corr. CBR @ 0.1"	31.0
Swell (%)	0.20

Sample: Bulk-1
Depth: Suface
Description: Brown SILTY SAND

Molding Dry Density (pcf)	86.5	Hammer Wt. (lbs)	10
Molding Moisture (%)	25.7	Hammer Drop (inches)	18
Days Soaked	2	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

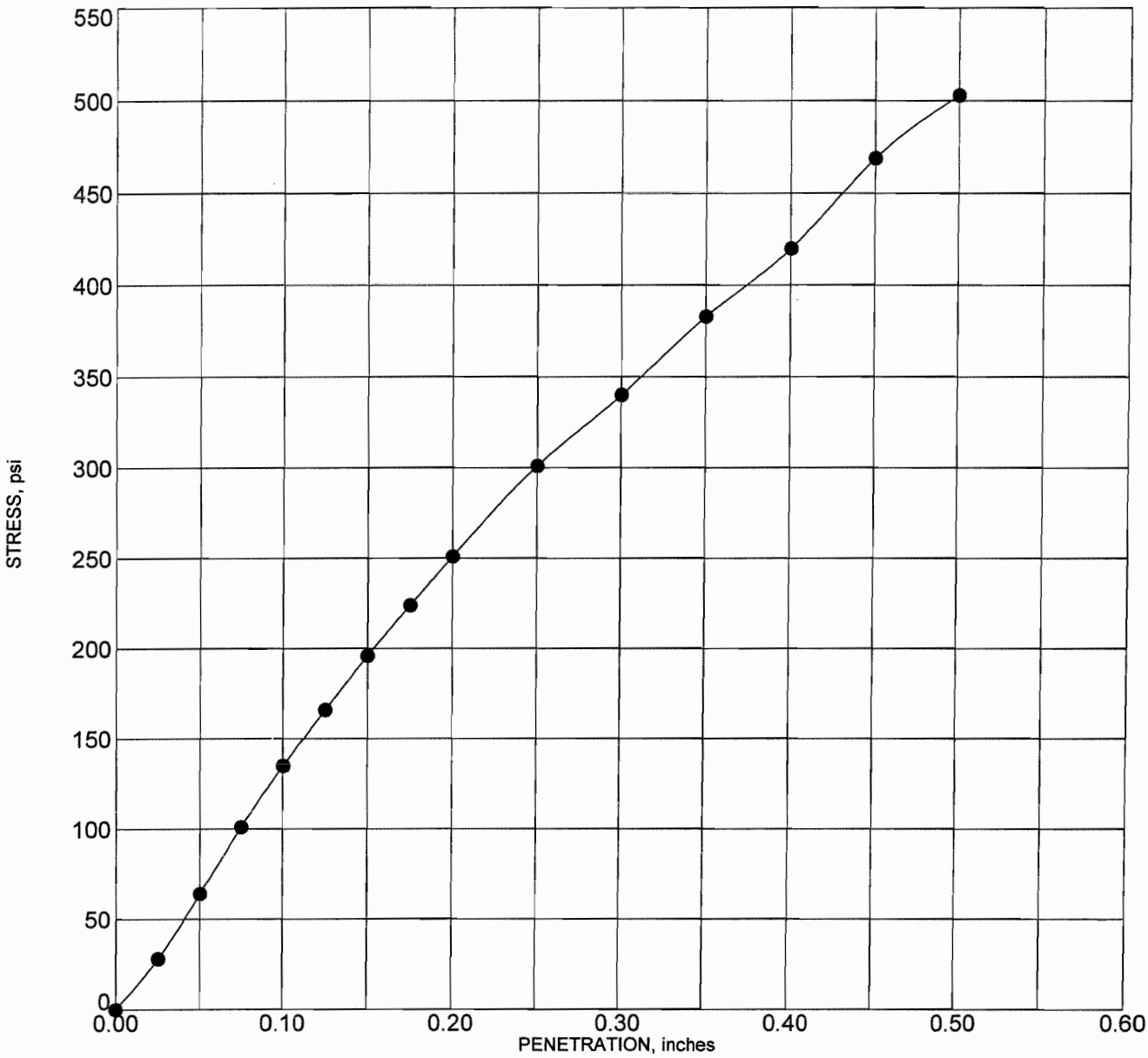
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 18

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	13.5
Swell (%)	0.00

Sample: Bulk-2
Depth: Surface
Description: Brown SILTY SAND

Molding Dry Density (pcf)	89.2	Hammer Wt. (lbs)	10
Molding Moisture (%)	23.9	Hammer Drop (inches)	18
Days Soaked	2	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

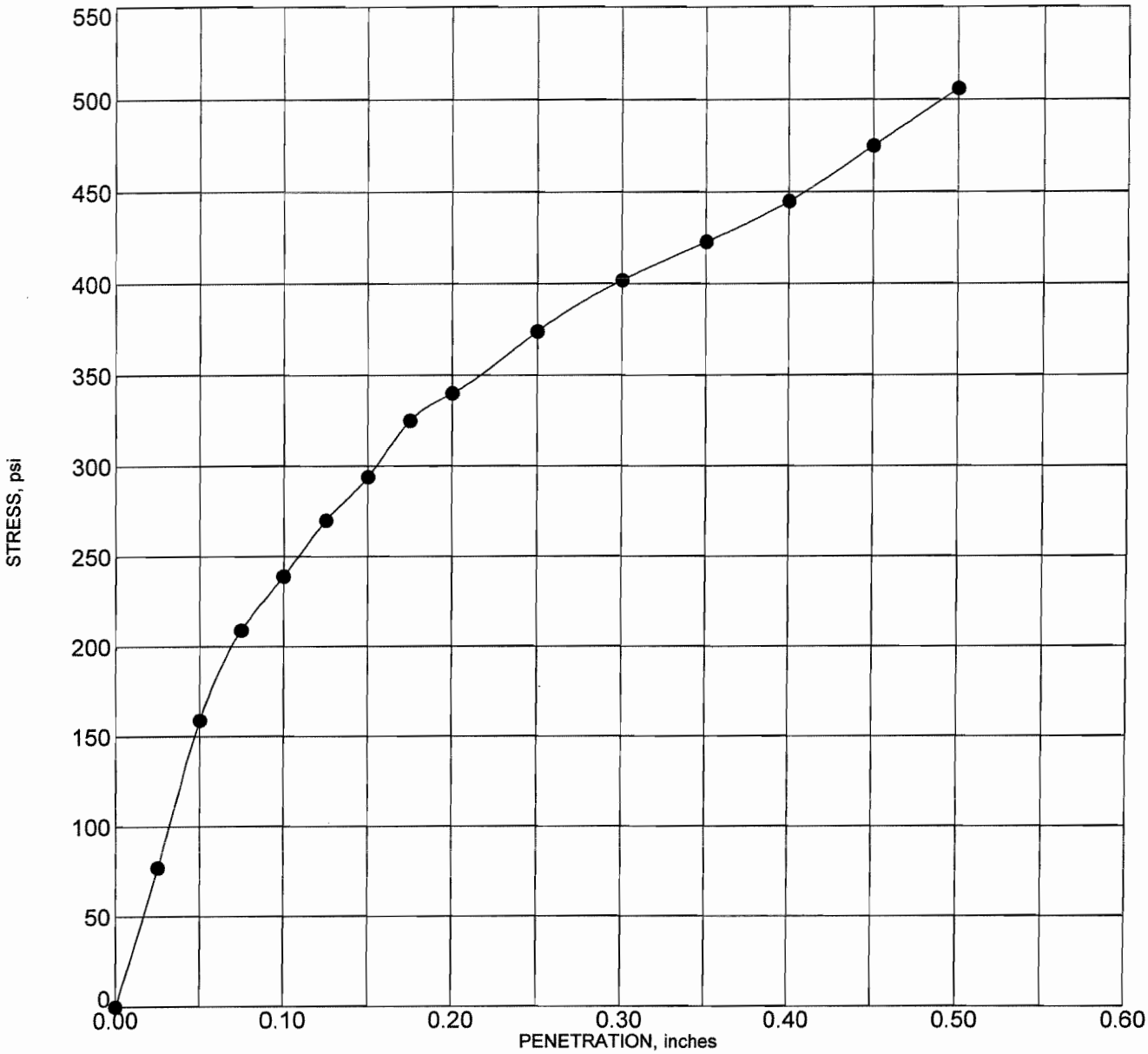
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 19

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	23.9
Swell (%)	0.13

Sample: Bulk-3
Depth: Surface
Description: Light brown SILTY SAND

Molding Dry Density (pcf)	90.5	Hammer Wt. (lbs)	10
Molding Moisture (%)	16.5	Hammer Drop (inches)	18
Days Soaked	3	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

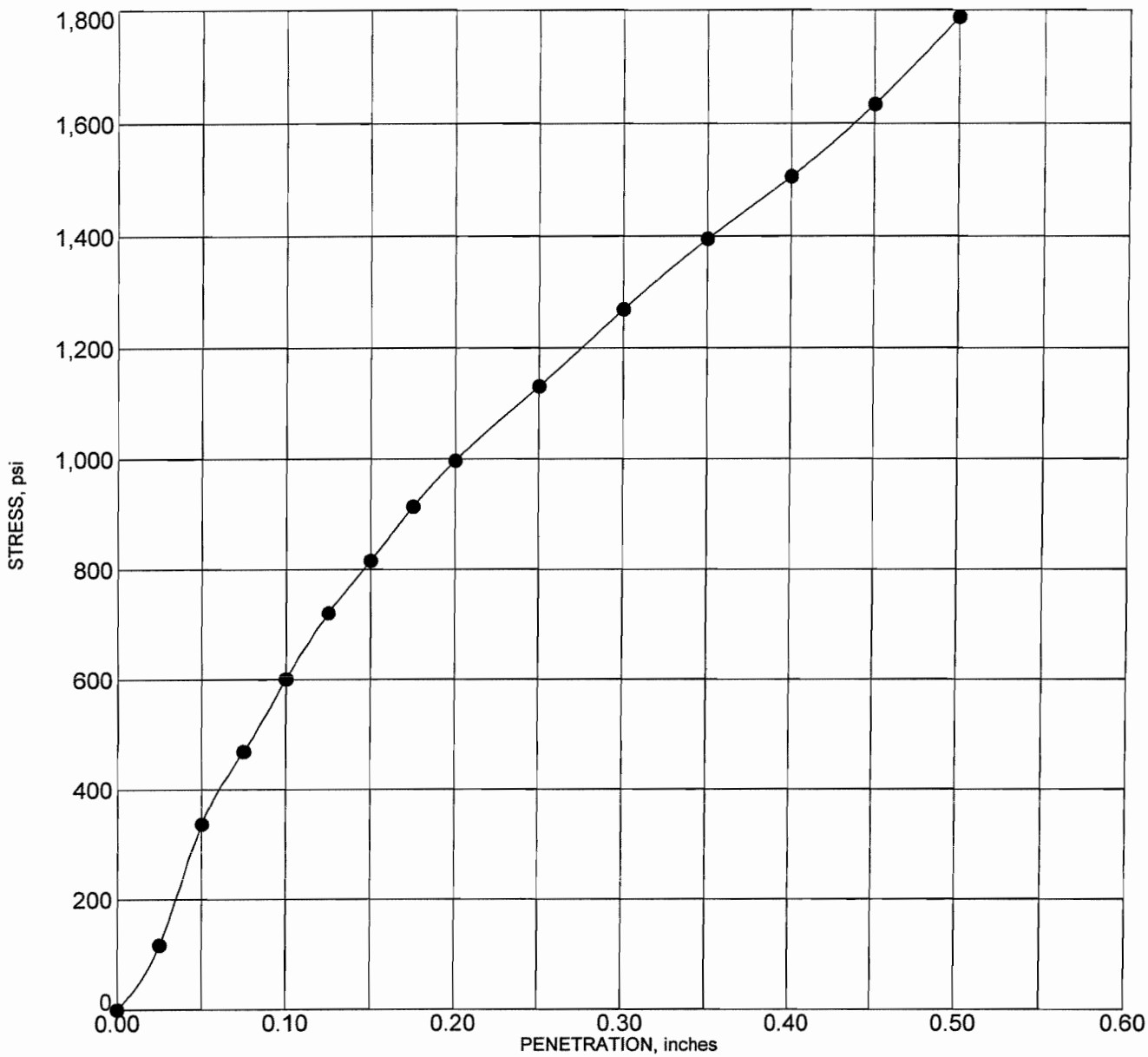
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 20

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	65.5
Swell (%)	0.00

Sample: Bulk-4
Depth: Surface
Description: Grayish brown SILTY SAND with gravel

Molding Dry Density (pcf)	105.2	Hammer Wt. (lbs)	10
Molding Moisture (%)	18.9	Hammer Drop (inches)	18
Days Soaked	2	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

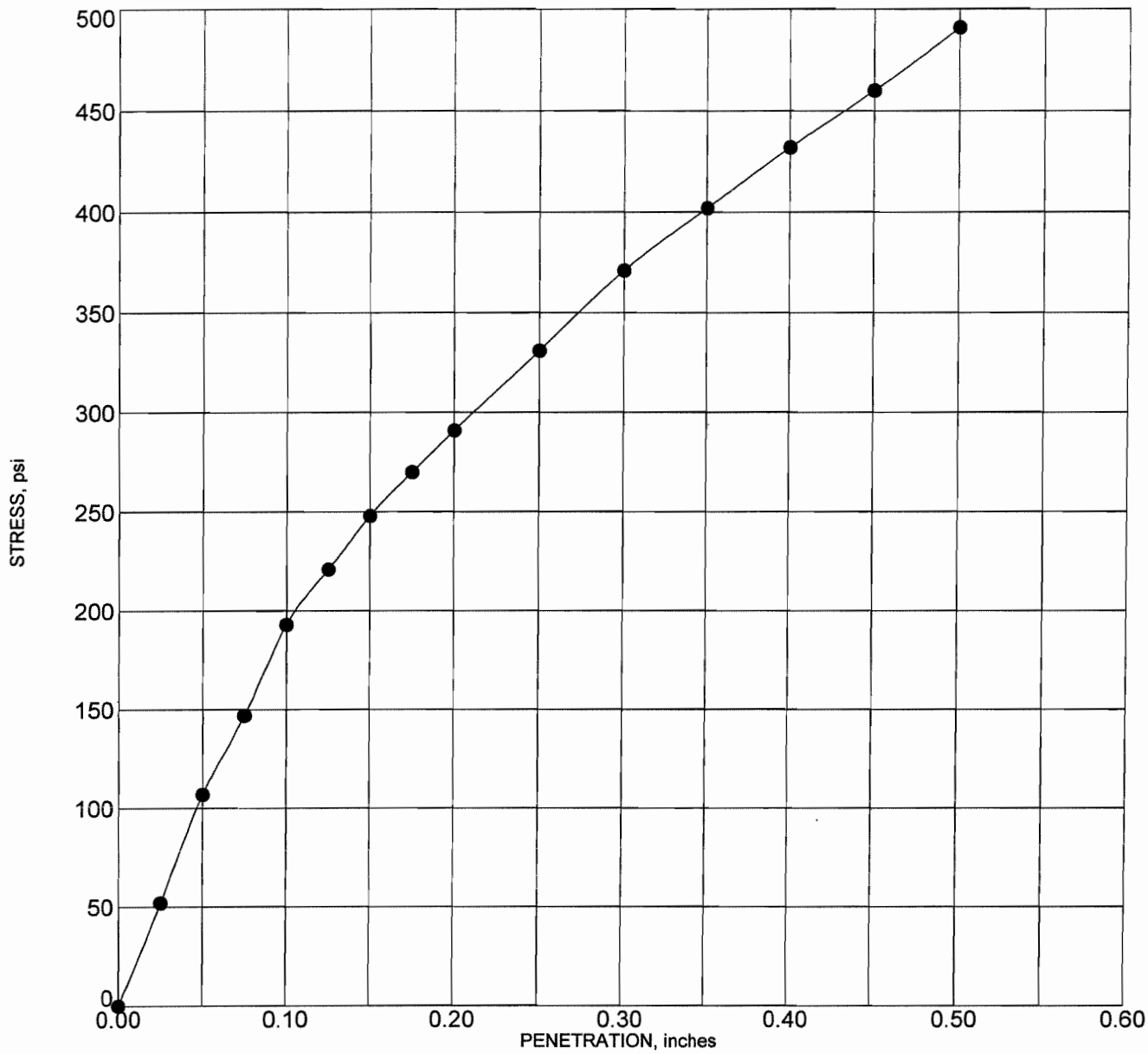
GEOLABS, INC.
GEOTECHNICAL ENGINEERING

W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 21



Corr. CBR @ 0.1"	21.0
Swell (%)	1.03

Sample: Bulk-5
Depth: Surface
Description: Tannish brown SILT with sand

Molding Dry Density (pcf)	87.8	Hammer Wt. (lbs)	10
Molding Moisture (%)	29.6	Hammer Drop (inches)	18
Days Soaked	3	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

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GEOTECHNICAL ENGINEERING

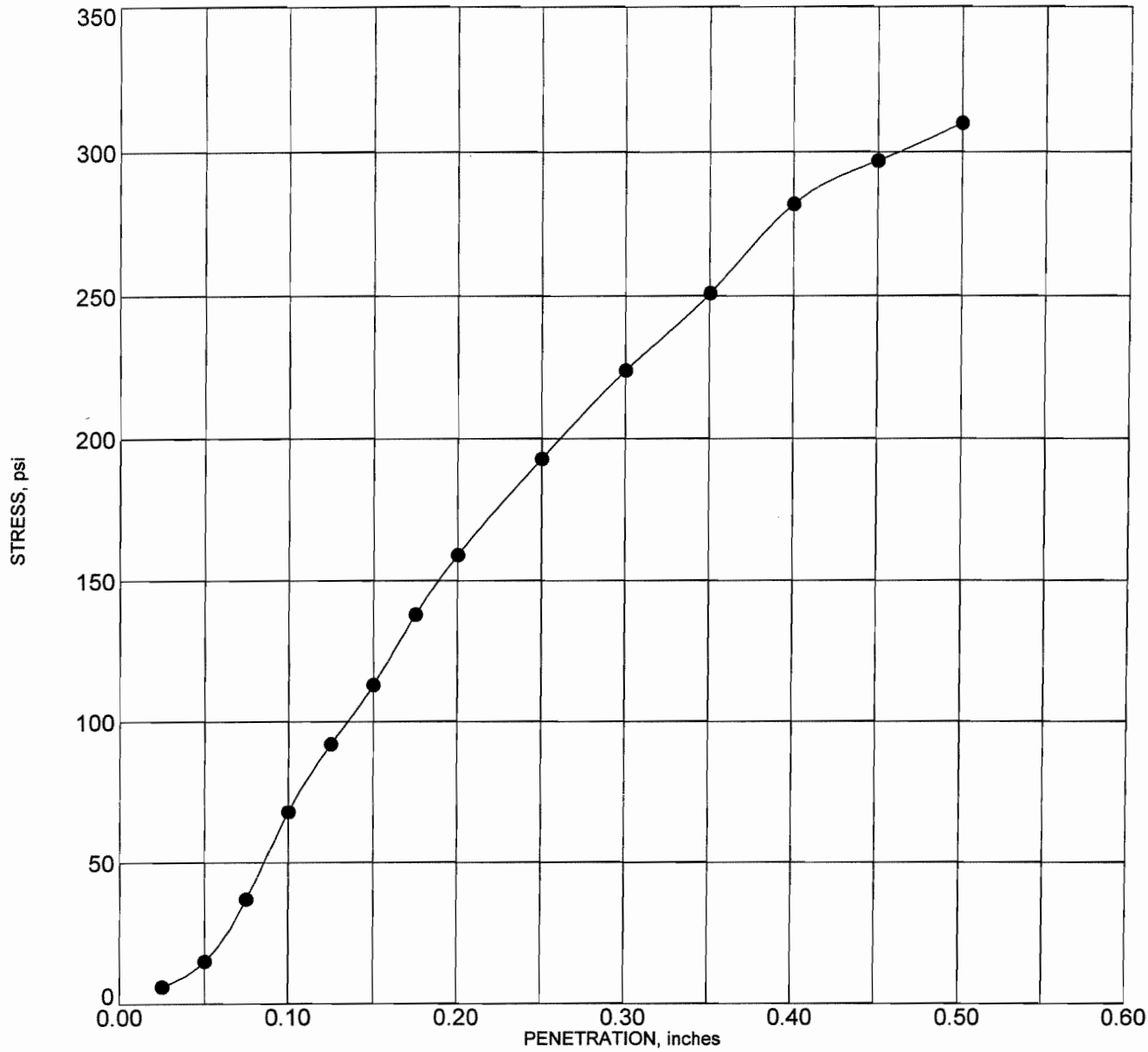
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 22

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	11.0
Swell (%)	1.50

Sample: Bulk-6
Depth: Surface
Description: Tannish brown SILT with gravel

Molding Dry Density (pcf)	75.5	Hammer Wt. (lbs)	10
Molding Moisture (%)	32.4	Hammer Drop (inches)	18
Days Soaked	3	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

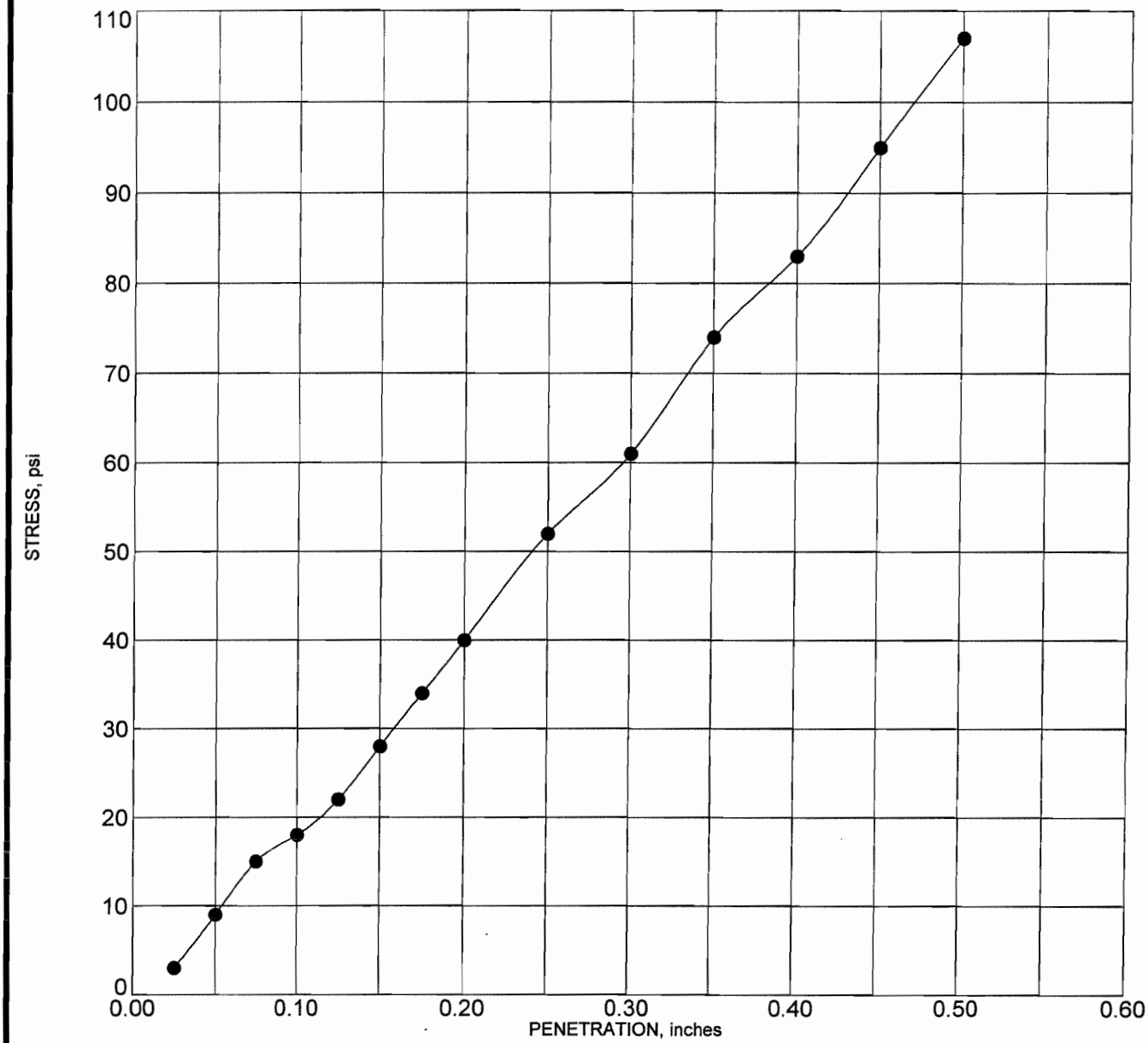
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 23

G CBR 3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	2.2
Swell (%)	1.40

Sample: Bulk-7
Depth: Surface
Description: Light brown SILT with sand

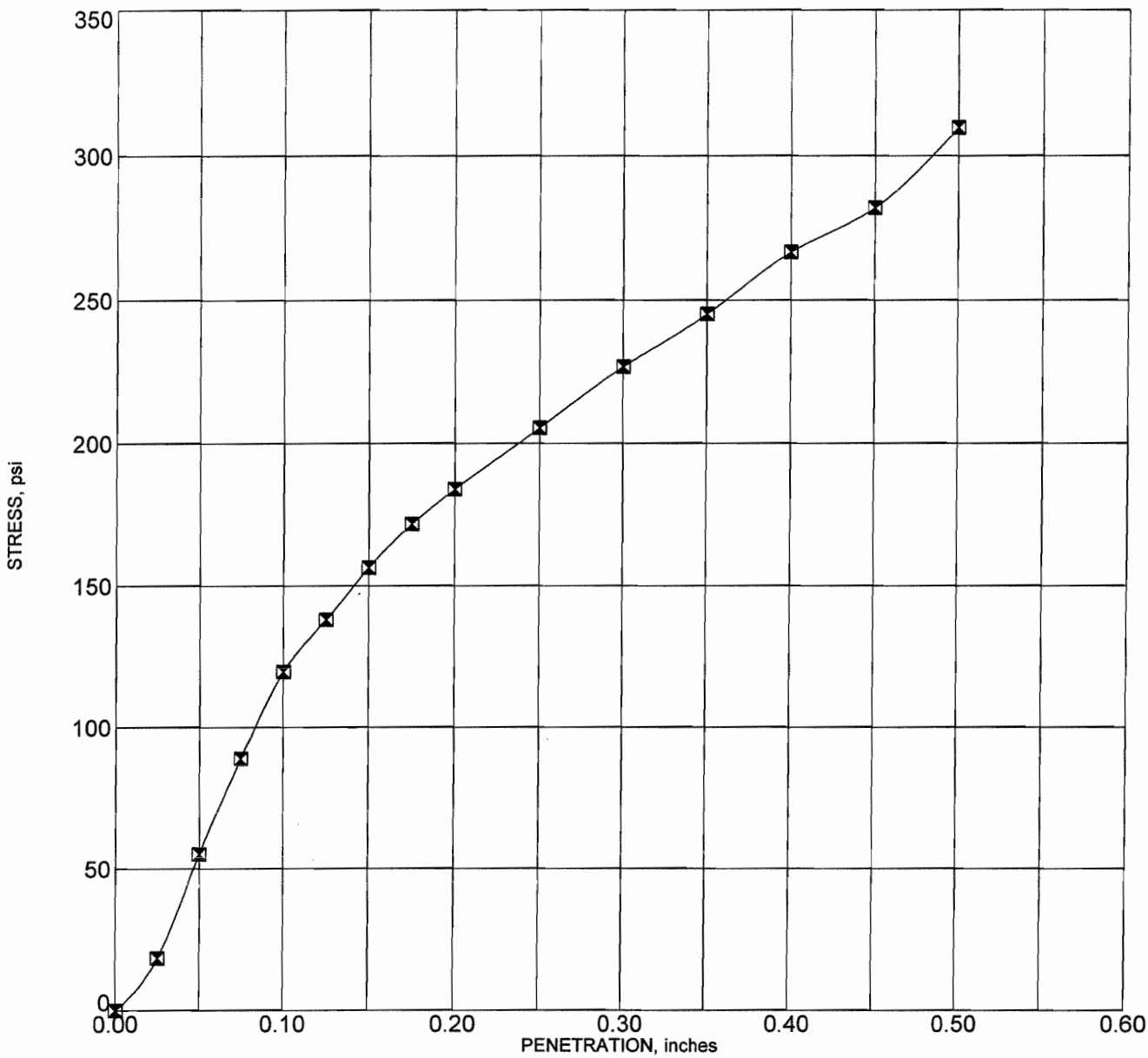
Molding Dry Density (pcf)	52.0	Hammer Wt. (lbs)	10
Molding Moisture (%)	64.0	Hammer Drop (inches)	18
Days Soaked	3	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883
HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 24

G_CBR 3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	14.0
Swell (%)	0.30

Sample: Bulk-101
Depth: 0.3 - 1.0 feet
Description: Dark tannish brown SAND with some silt

Molding Dry Density (pcf)	81.5	Hammer Wt. (lbs)	10
Molding Moisture (%)	27.8	Hammer Drop (inches)	18
Days Soaked	2	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
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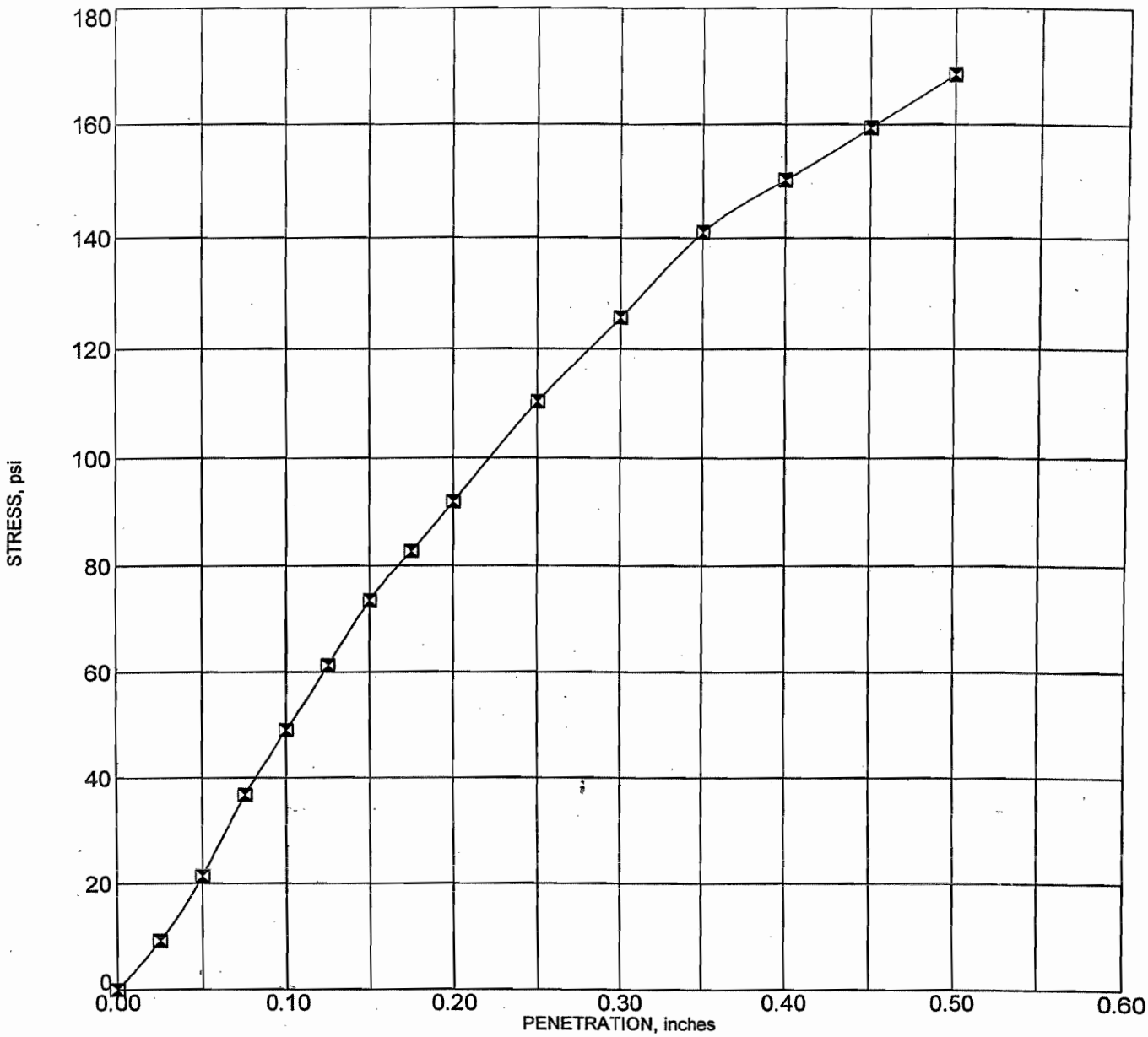
CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 25

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	5.4
Swell (%)	1.60

Sample: Bulk-102
Depth: 0.3 - 1.0 feet
Description: Dark tannish brown SANDY SILT

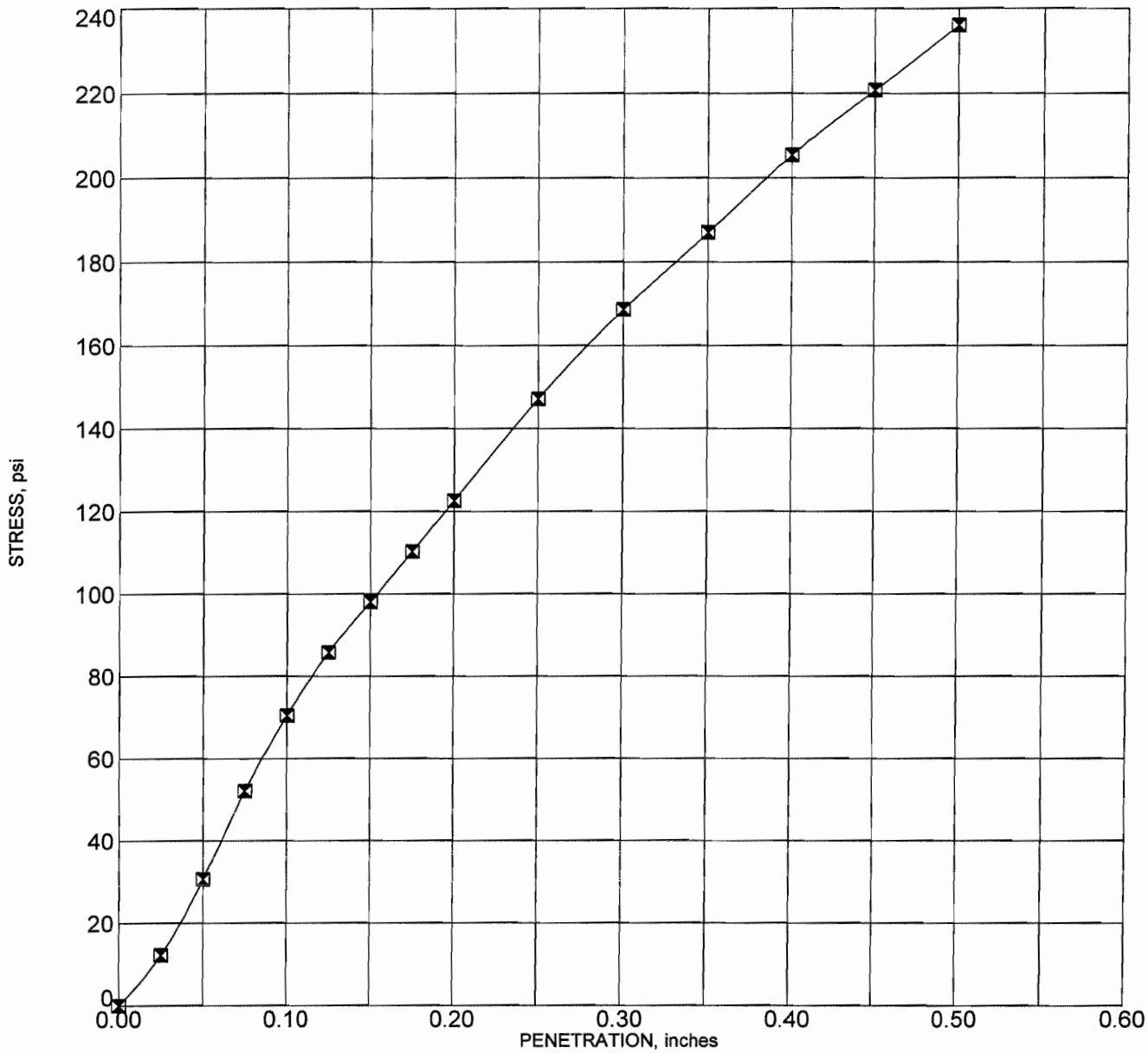
Molding Dry Density (pcf)	71.1	Hammer Wt. (lbs)	10
Molding Moisture (%)	28.8	Hammer Drop (inches)	18
Days Soaked	5	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883
HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 26

G CBR 3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	8.0
Swell (%)	1.20

Sample: Bulk-103
Depth: 0.3 - 1.0 feet
Description: Tannish brown SANDY SILT with some volcanic gravel

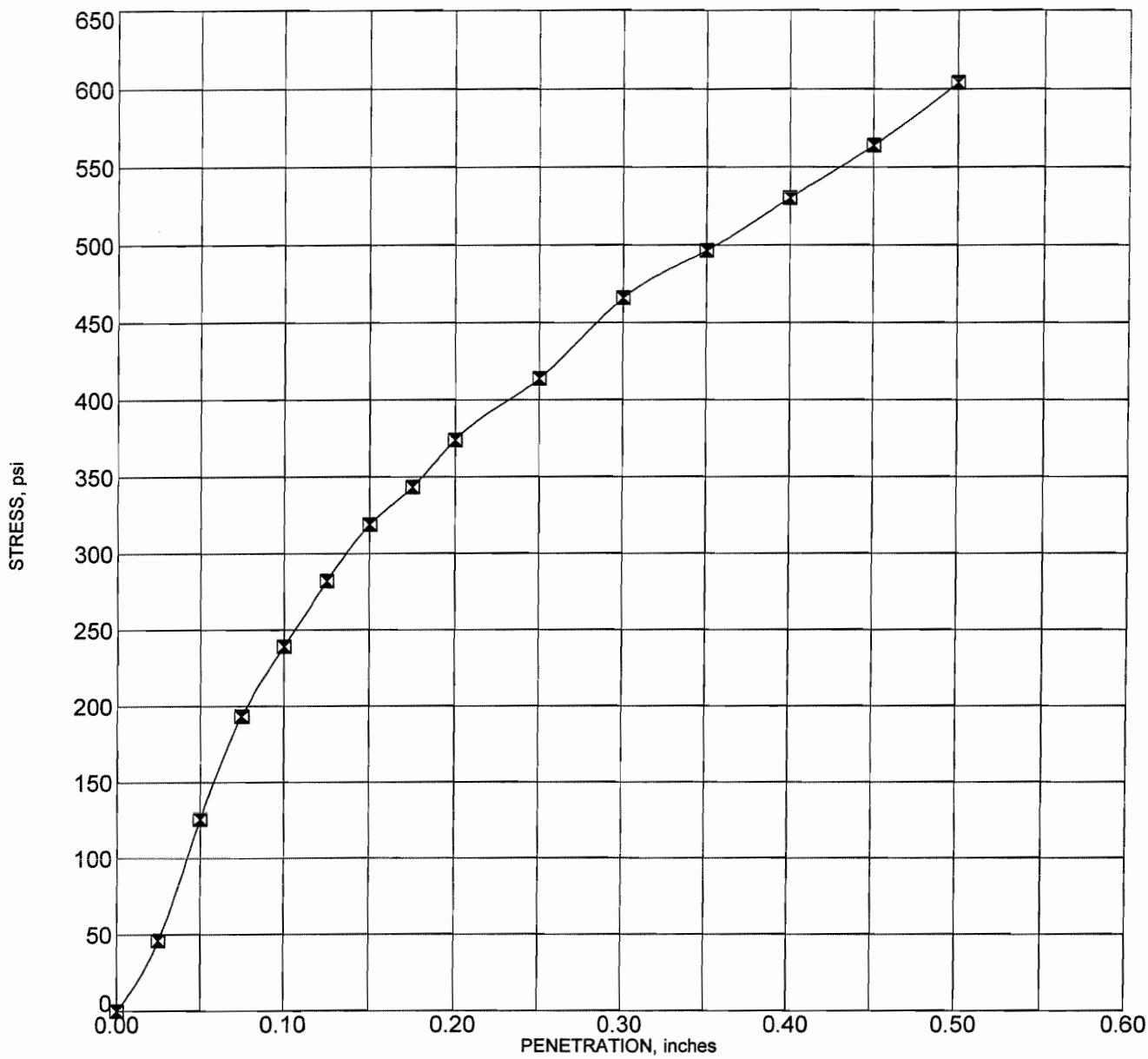
Molding Dry Density (pcf)	69.8	Hammer Wt. (lbs)	10
Molding Moisture (%)	40.9	Hammer Drop (inches)	18
Days Soaked	3	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883
HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 27

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	28.9
Swell (%)	0.20

Sample: Bulk-104
Depth: 0.3 - 1.0 feet
Description: Tannish brown SILTY SAND

Molding Dry Density (pcf)	80.6	Hammer Wt. (lbs)	10
Molding Moisture (%)	31.8	Hammer Drop (inches)	18
Days Soaked	2	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

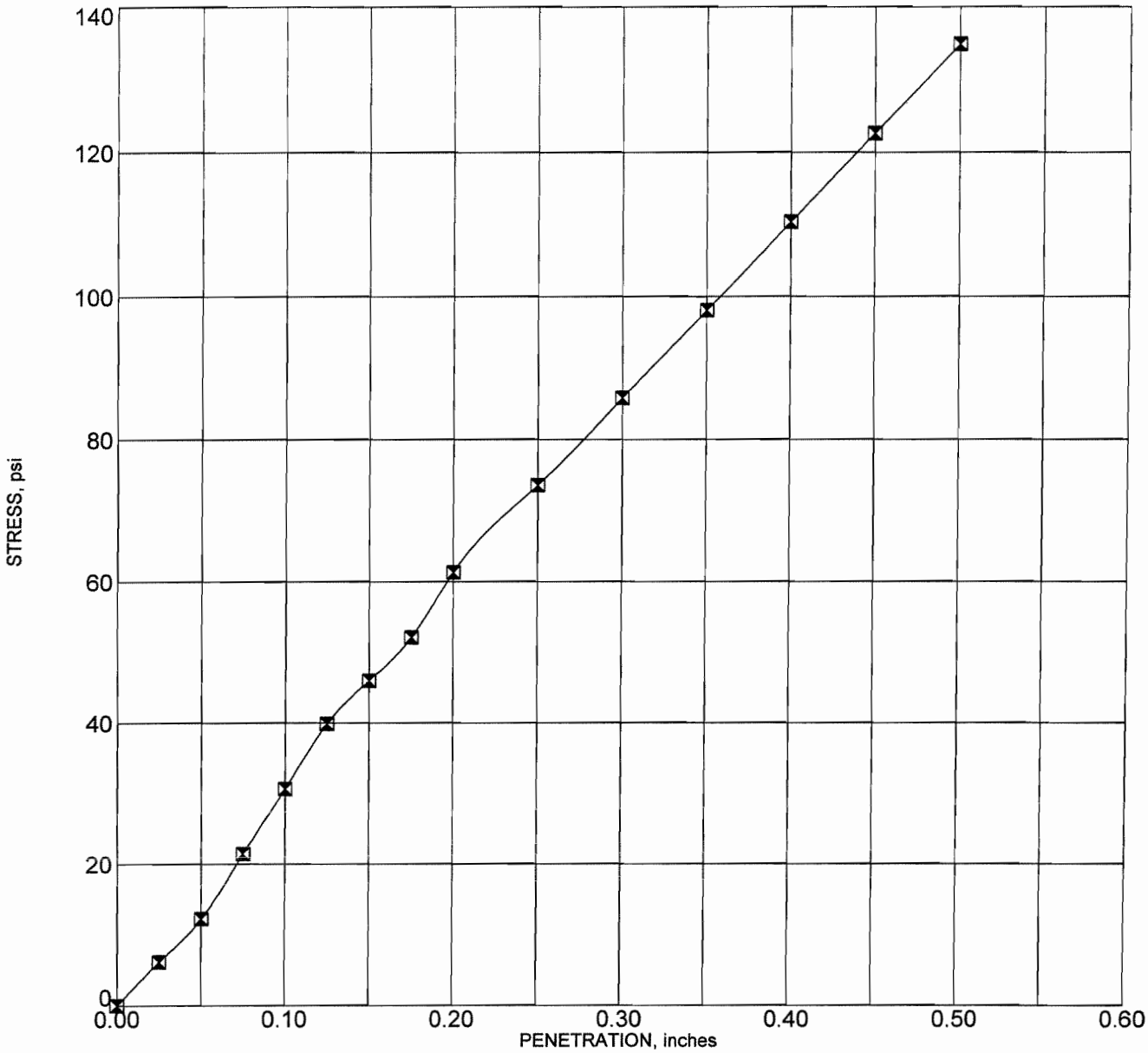
W.O. 3411-20(A)

CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 28

G_CBR 3411-20.GPJ GEOLABS.GDT 10/25/02



Corr. CBR @ 0.1"	3.7
Swell (%)	2.40

Sample: Bulk-105
Depth: 0.3 - 1.0 feet
Description: Dark tannish brown CLAYEY SILT

Molding Dry Density (pcf)	49.7	Hammer Wt. (lbs)	10
Molding Moisture (%)	61.8	Hammer Drop (inches)	18
Days Soaked	2	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

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W.O. 3411-20(A)

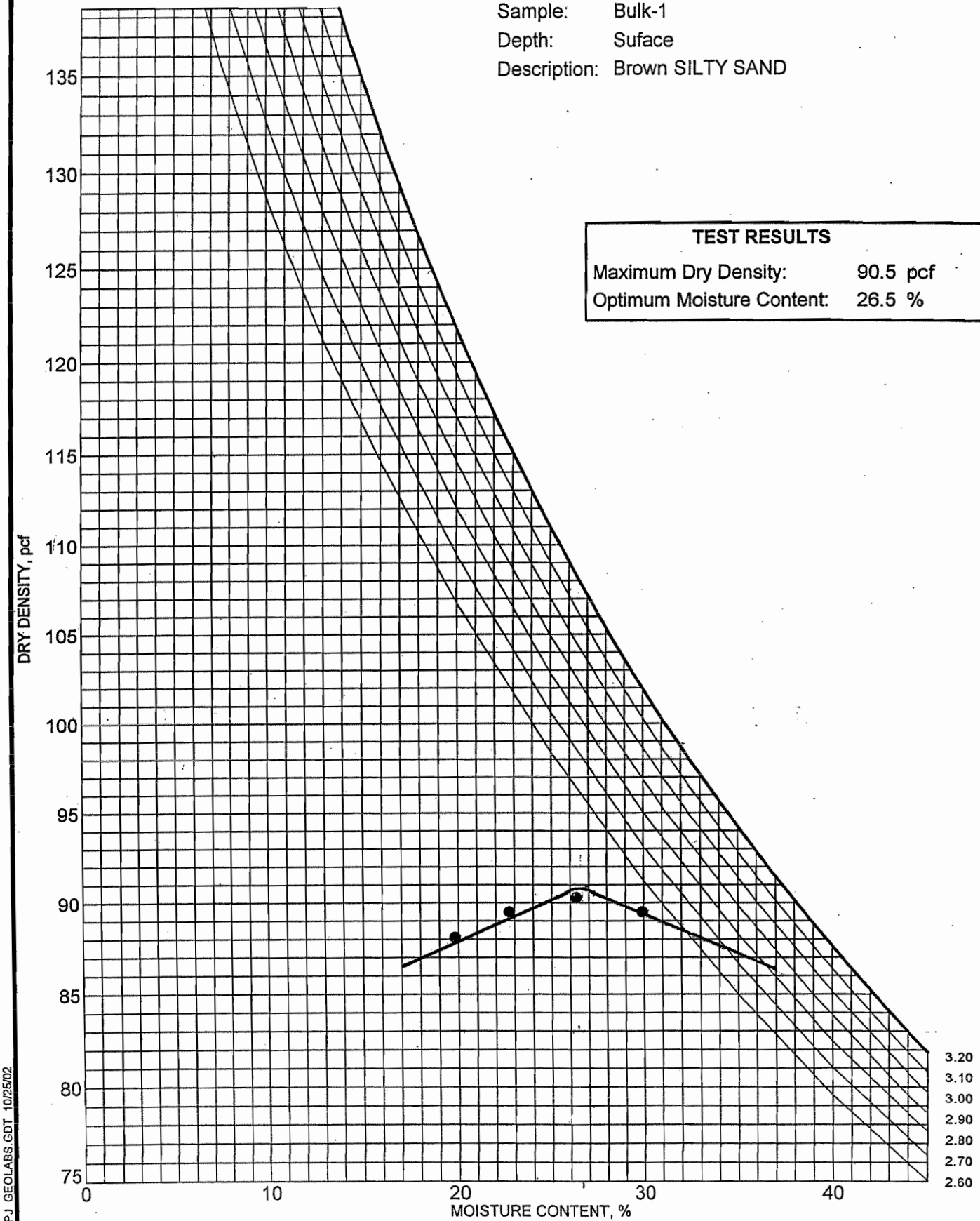
CALIFORNIA BEARING RATIO - ASTM D 1883

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 29

G_CBR_3411-20.GPJ GEOLABS.GDT 10/25/02

Sample: Bulk-1
Depth: Suface
Description: Brown SILTY SAND



TEST RESULTS

Maximum Dry Density:	90.5 pcf
Optimum Moisture Content:	26.5 %

G COMPACTION 3411-20.GPJ GEOLABS.GDT 10/25/02

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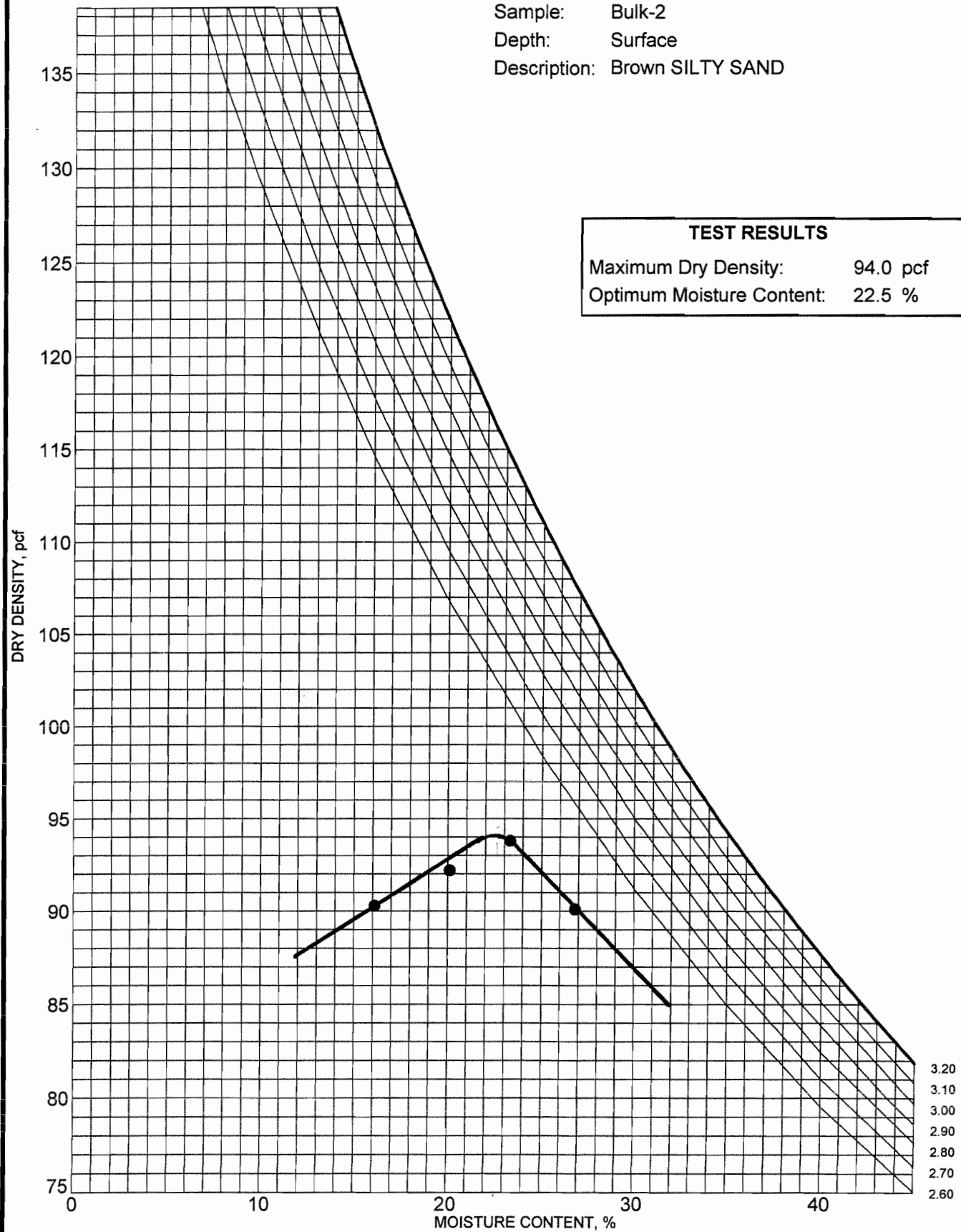
W.O. 3411-20(A)

MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 30

Sample: Bulk-2
Depth: Surface
Description: Brown SILTY SAND



TEST RESULTS

Maximum Dry Density:	94.0 pcf
Optimum Moisture Content:	22.5 %

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W.O. 3411-20(A)

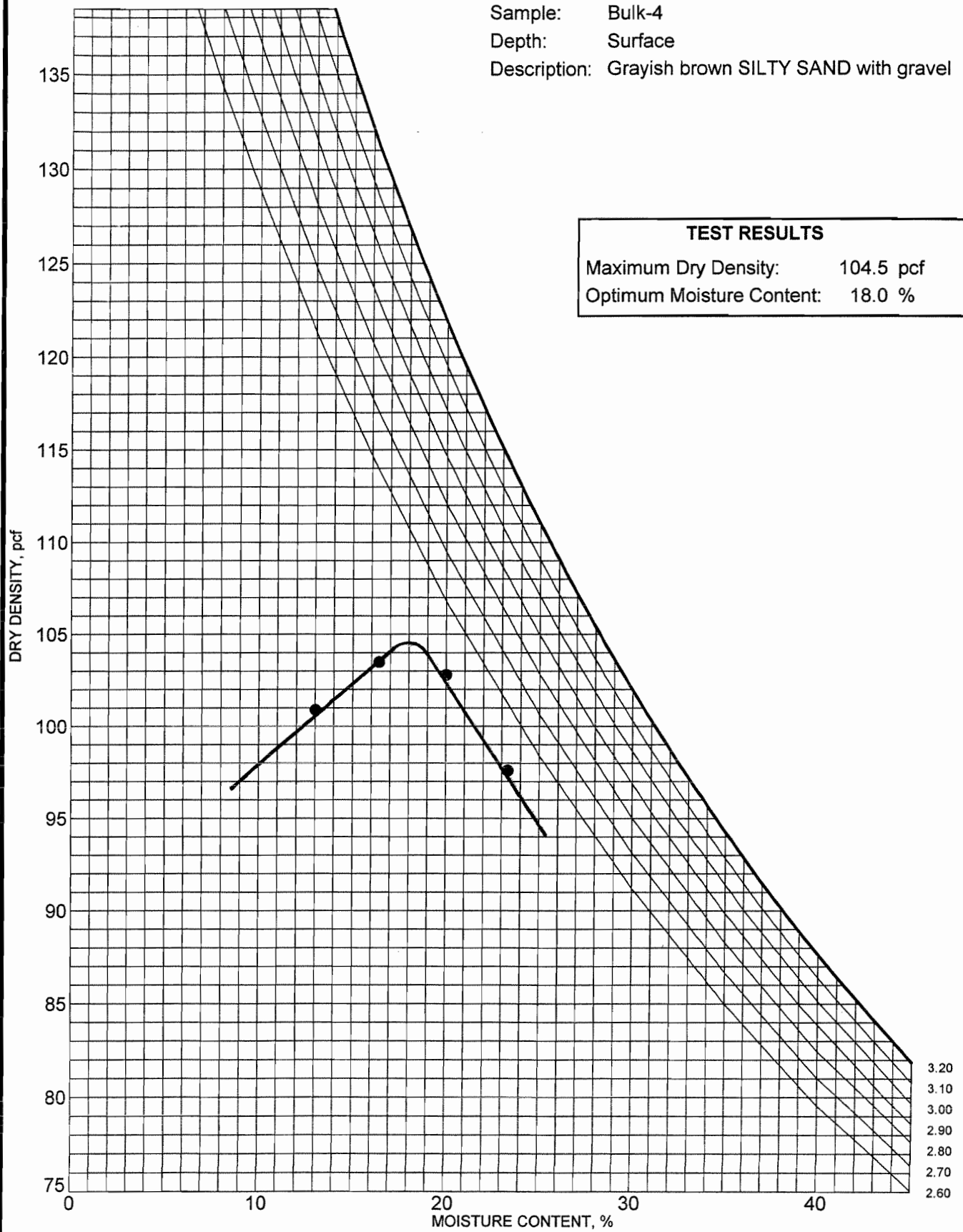
MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 31

G COMPACTION 3411-20.GPJ GEOLABS.GDT 10/25/02

Sample: Bulk-4
Depth: Surface
Description: Grayish brown SILTY SAND with gravel



TEST RESULTS

Maximum Dry Density:	104.5 pcf
Optimum Moisture Content:	18.0 %

G_COMPACTION 3411-20.GPJ GEOLABS.GDT 10/25/02

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

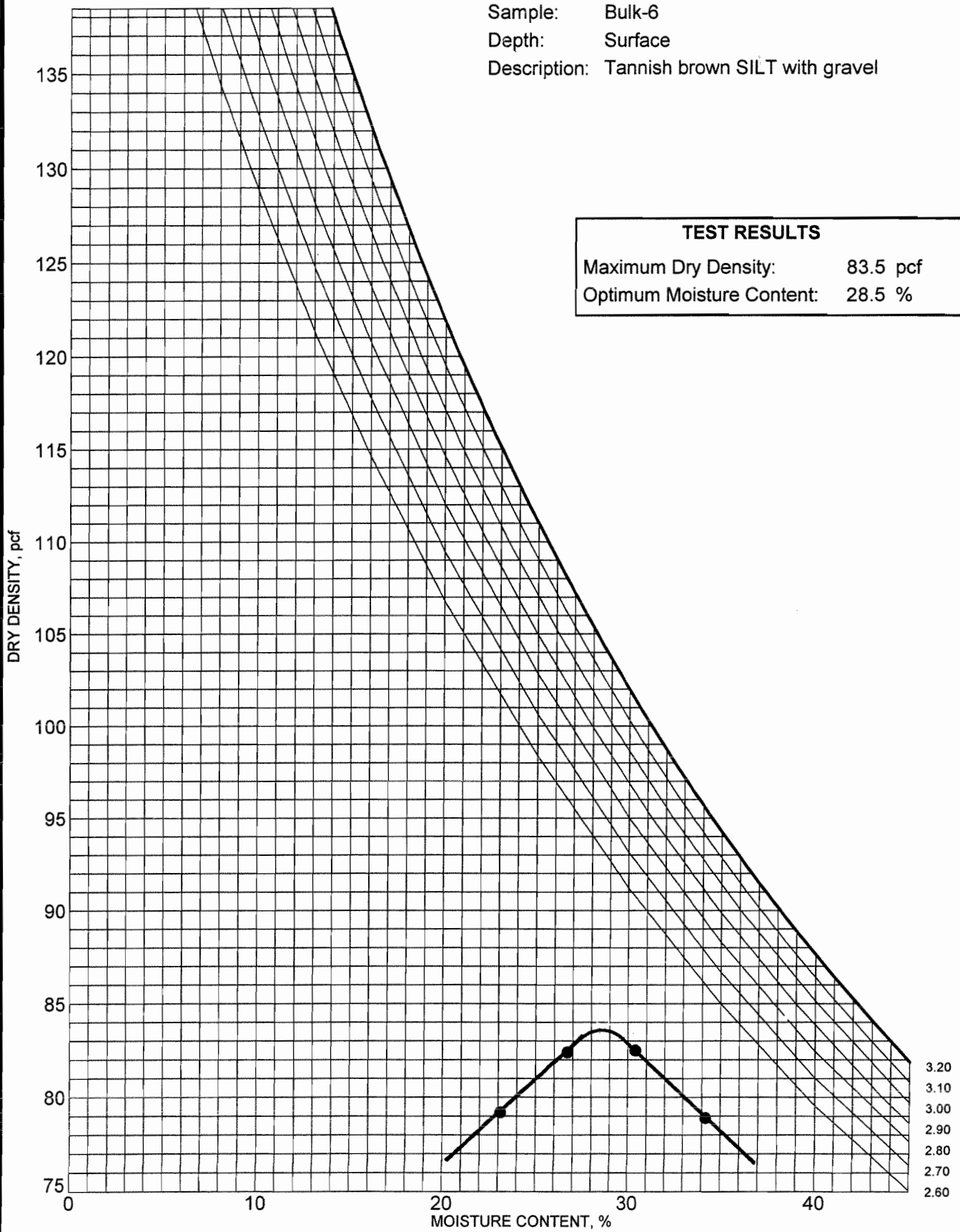
W.O. 3411-20(A)

MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 32

Sample: Bulk-6
Depth: Surface
Description: Tannish brown SILT with gravel



TEST RESULTS

Maximum Dry Density:	83.5 pcf
Optimum Moisture Content:	28.5 %

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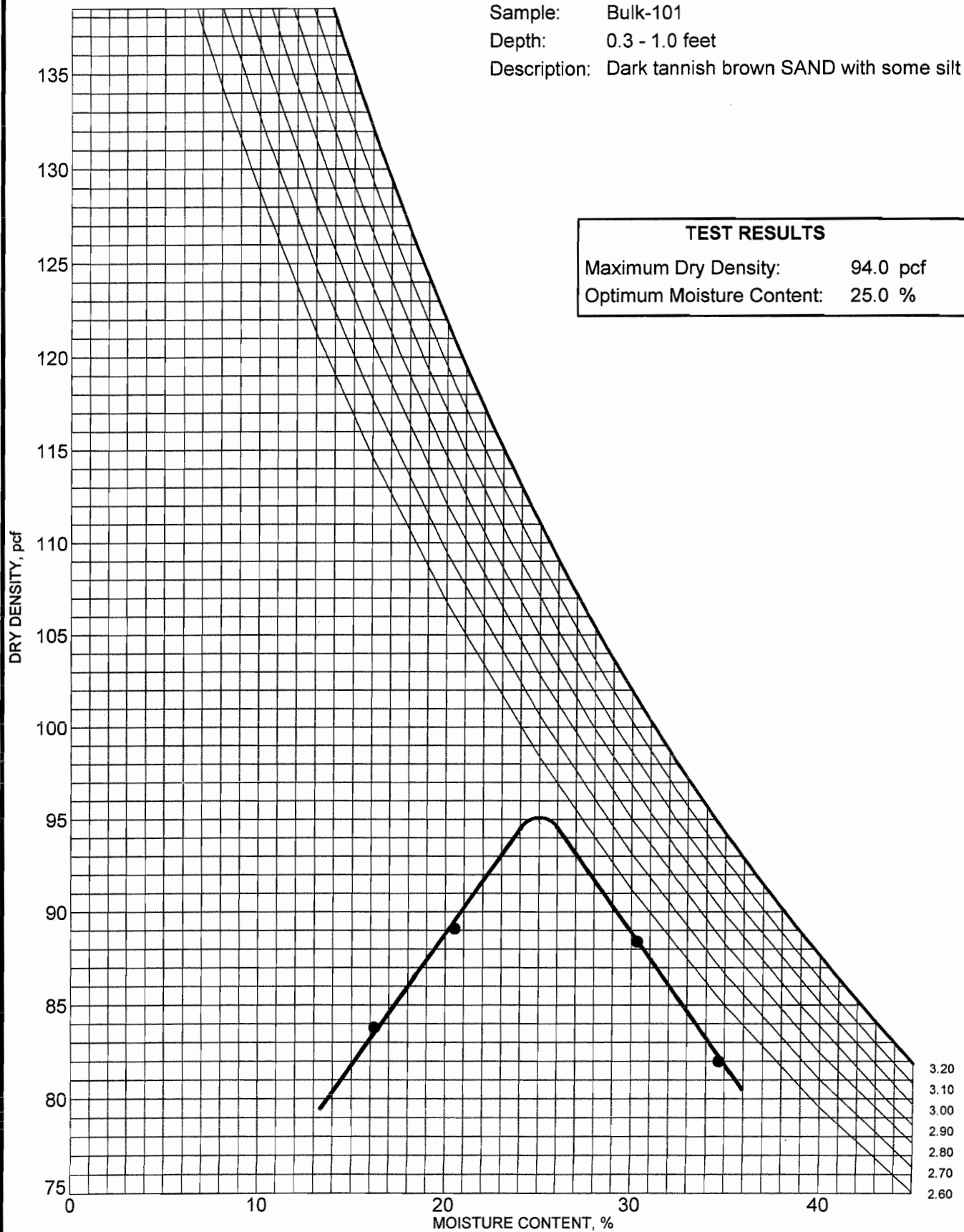
MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 33

G_COMPACTION 3411-20.GPJ GEOLABS.GDT 10/25/02

Sample: Bulk-101
Depth: 0.3 - 1.0 feet
Description: Dark tannish brown SAND with some silt



TEST RESULTS

Maximum Dry Density:	94.0 pcf
Optimum Moisture Content:	25.0 %

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GEOTECHNICAL ENGINEERING

W.O. 3411-20(A)

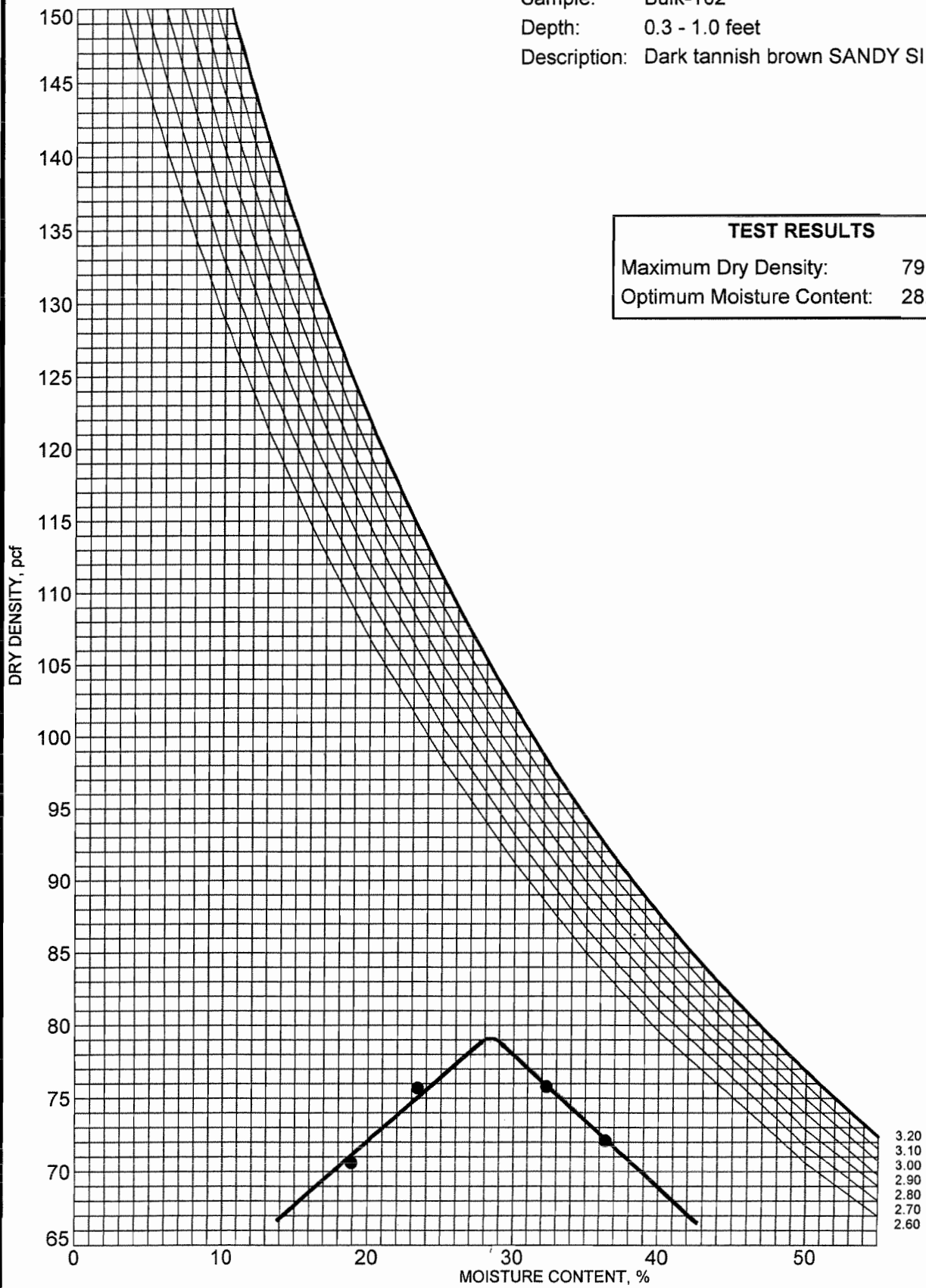
MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 34

G COMPACTION 3411-20.GPJ GEOLABS.GDT 10/25/02

Sample: Bulk-102
Depth: 0.3 - 1.0 feet
Description: Dark tannish brown SANDY SILT



TEST RESULTS

Maximum Dry Density:	79.0 pcf
Optimum Moisture Content:	28.5 %

G_COMPACTION65 3411-20.GPJ GEOLABS.GDT 10/25/02

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W.O. 3411-20(A)

MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

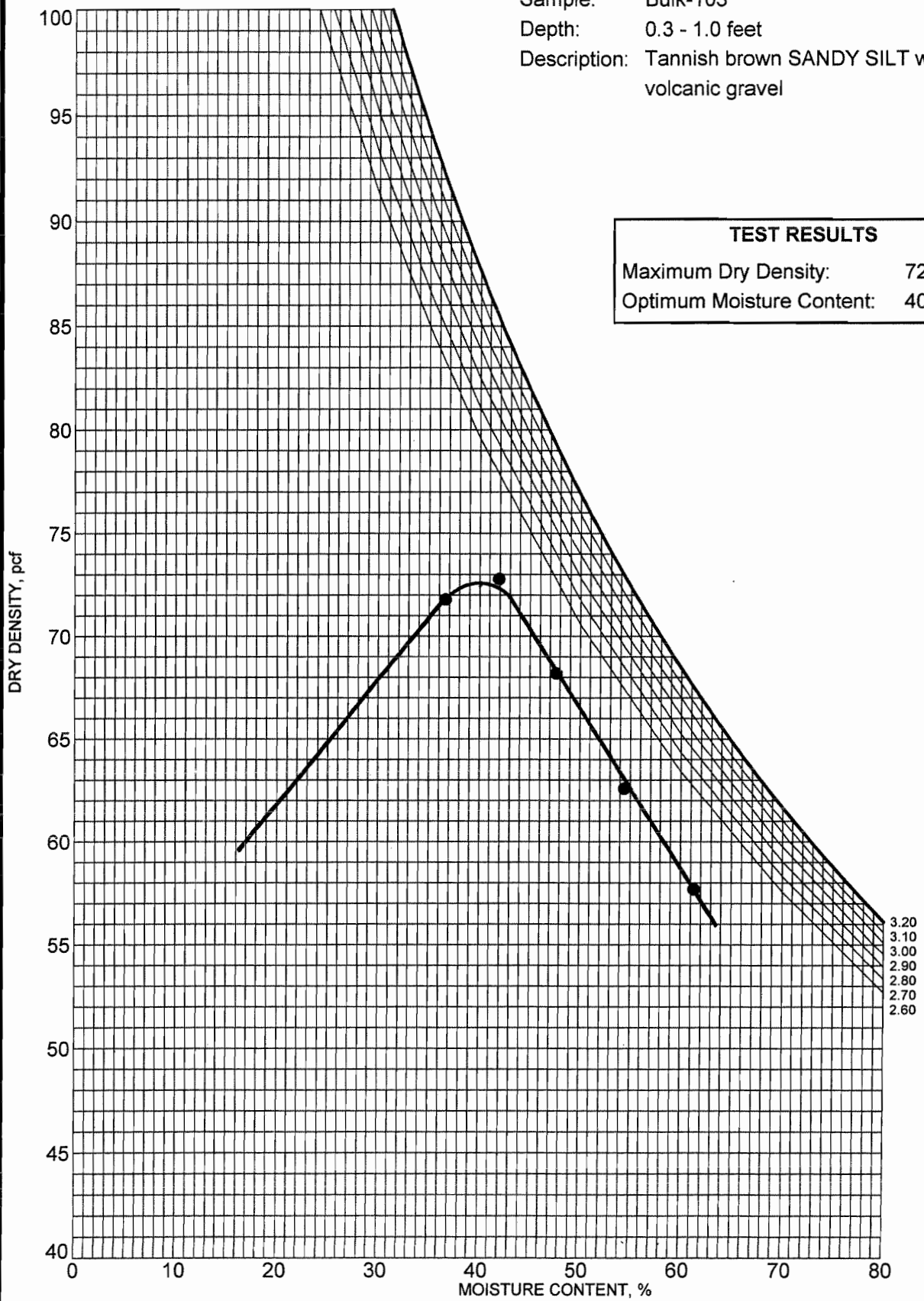
HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 35

Sample: Bulk-103
Depth: 0.3 - 1.0 feet
Description: Tannish brown SANDY SILT with some volcanic gravel

TEST RESULTS

Maximum Dry Density:	72.5 pcf
Optimum Moisture Content:	40.0 %



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W.O. 3411-20(A)

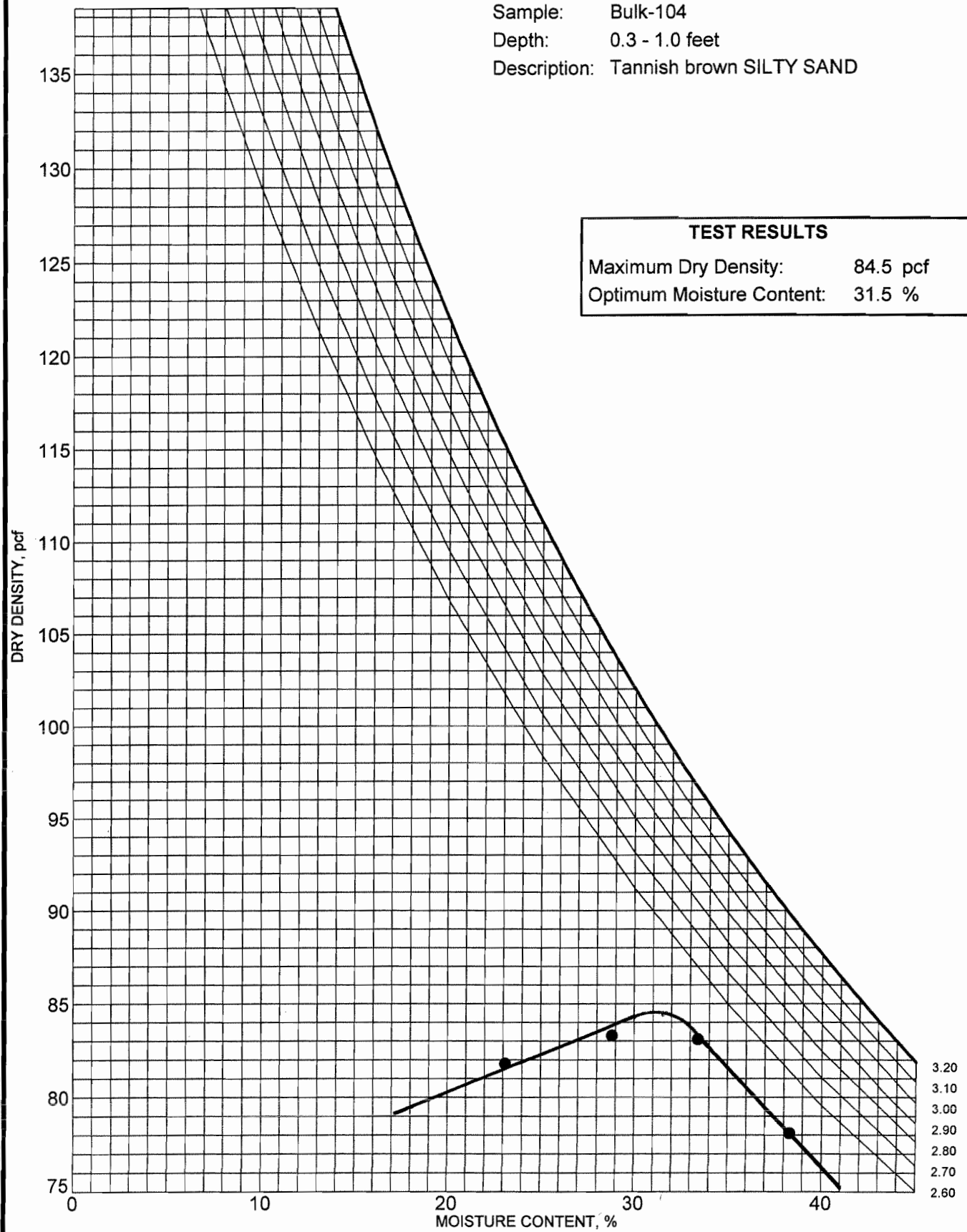
MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 36

G:\COMPACTION\65 3411-20.GPJ GEOLABS.GDT 10/25/02

Sample: Bulk-104
Depth: 0.3 - 1.0 feet
Description: Tannish brown SILTY SAND



TEST RESULTS

Maximum Dry Density:	84.5 pcf
Optimum Moisture Content:	31.5 %

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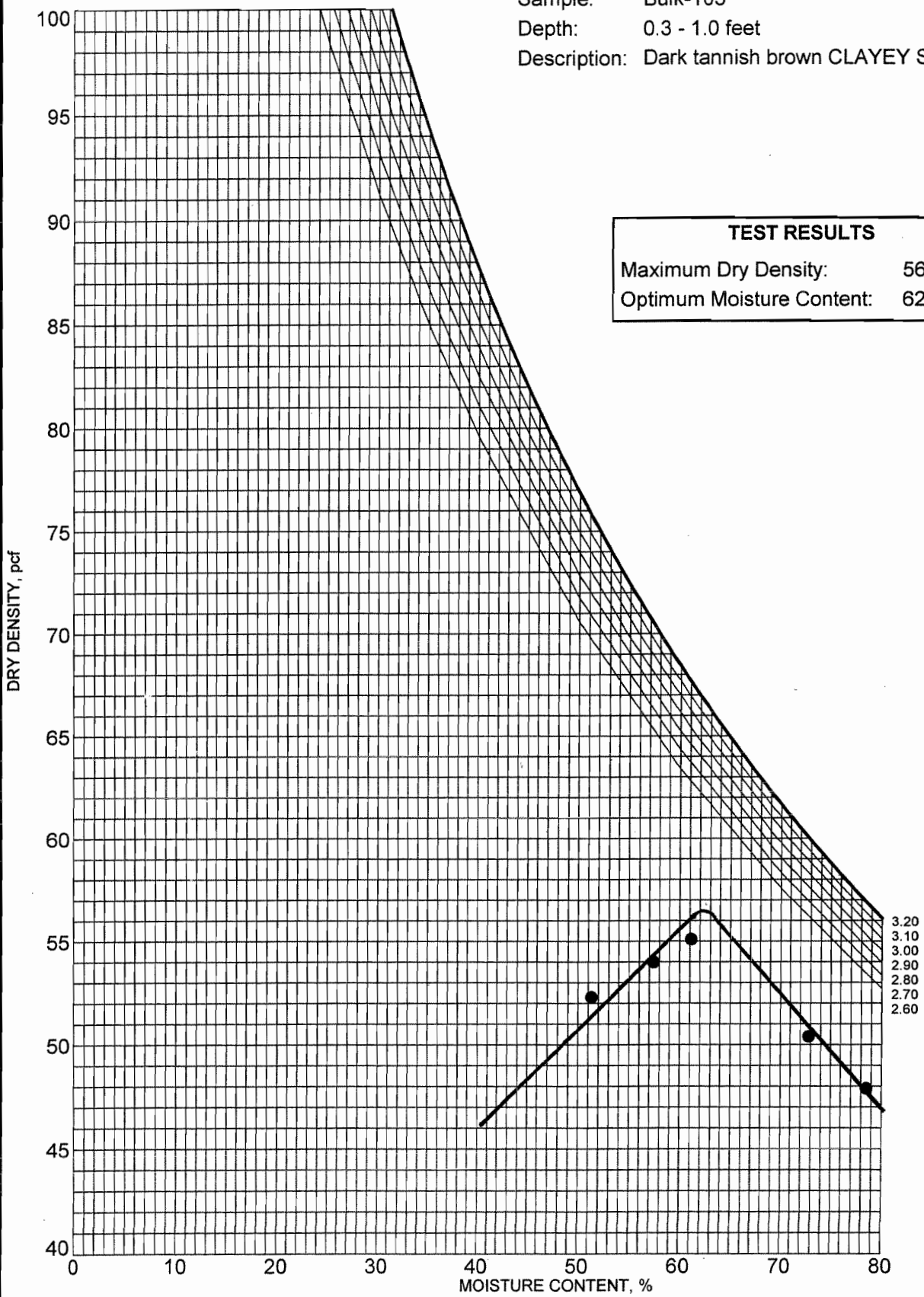
MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 37

G COMPACTION 3411-20.GPJ GEOLABS.GDT 10/25/02

Sample: Bulk-105
Depth: 0.3 - 1.0 feet
Description: Dark tannish brown CLAYEY SILT



TEST RESULTS

Maximum Dry Density:	56.5 pcf
Optimum Moisture Content:	62.5 %

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W.O. 3411-20(A)

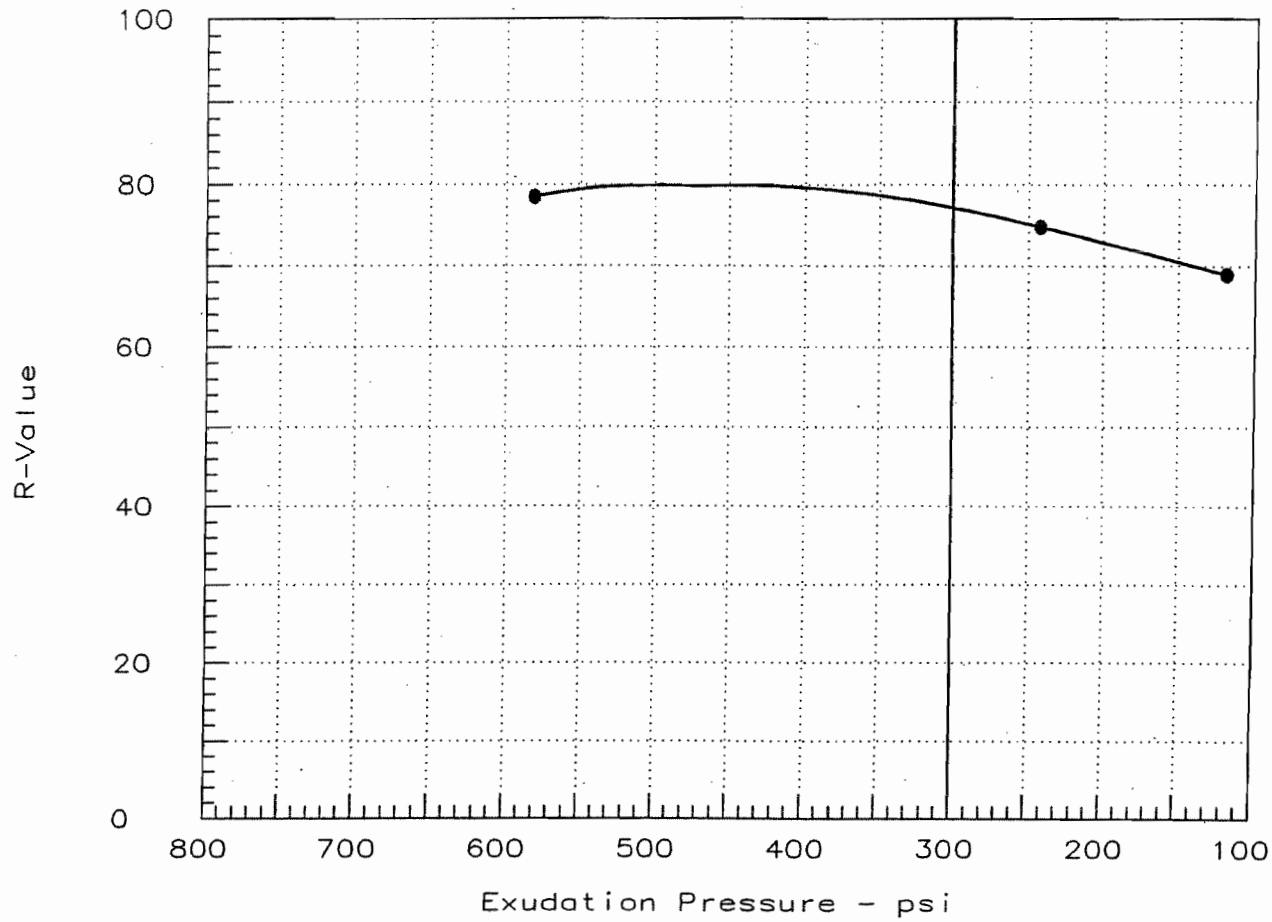
MOISTURE-DENSITY RELATIONSHIP - ASTM D 1557 A

HAWAII STATE ROUTE 200 (SADDLE RD.)
PTA-1 ALIGNMENT (MP 28 TO MP 42)
ISLAND OF HAWAII

Plate
C - 38

G_COMPACTION65 3411-20.GPJ GEOLABS.GDT 10/25/02

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	350	94.5	22.2	0.00	22	2.59	581	77	78
2	350	93.1	24.2	0.00	31	2.52	119	69	69
3	350	93.9	23.2	0.00	28	2.54	242	75	75

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 77	Dark brn sandy silt

Project No.:
Project: Saddle Road PTA Alignment
Location: Bulk E BULK-3

Date: 10/20/2000

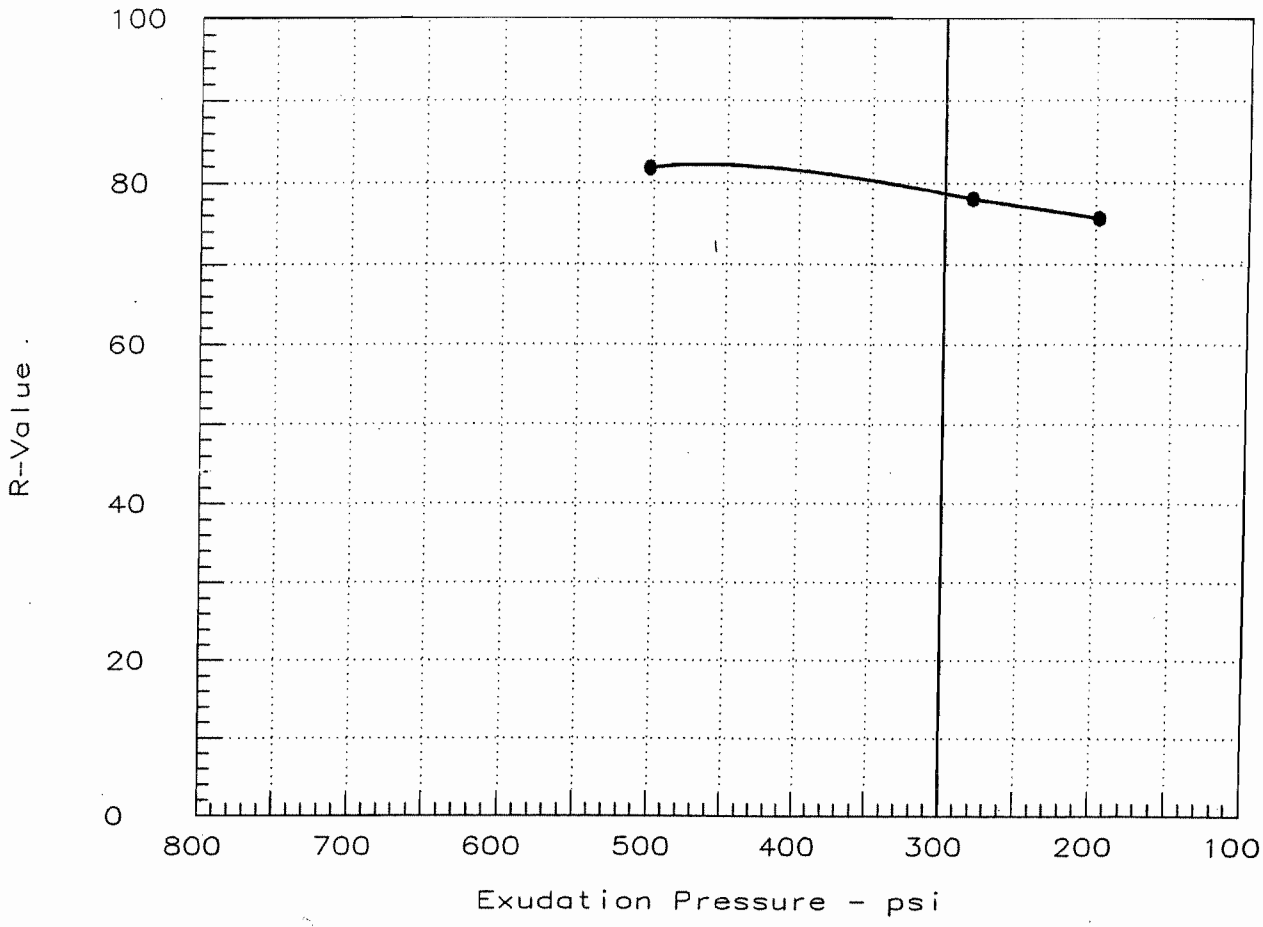
Tested by: YUN
Checked by: LKL
Remarks:
STL Job #7653
STL Lab #S5954-2

R-VALUE TEST REPORT

SIGNET TESTING LABS, INC.

Fig. No. 2

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	350	100.3	19.6	0.00	19	2.54	502	82	82
2	350	99.5	20.3	0.00	22	2.53	282	78	78
3	350	99.1	21.1	0.00	25	2.52	197	76	76

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 79	Reddish rocky silt

Project No.:
Project: Saddle Road PTA Alignment
Location: Bulk F BULK-4

Date: 10/20/2000

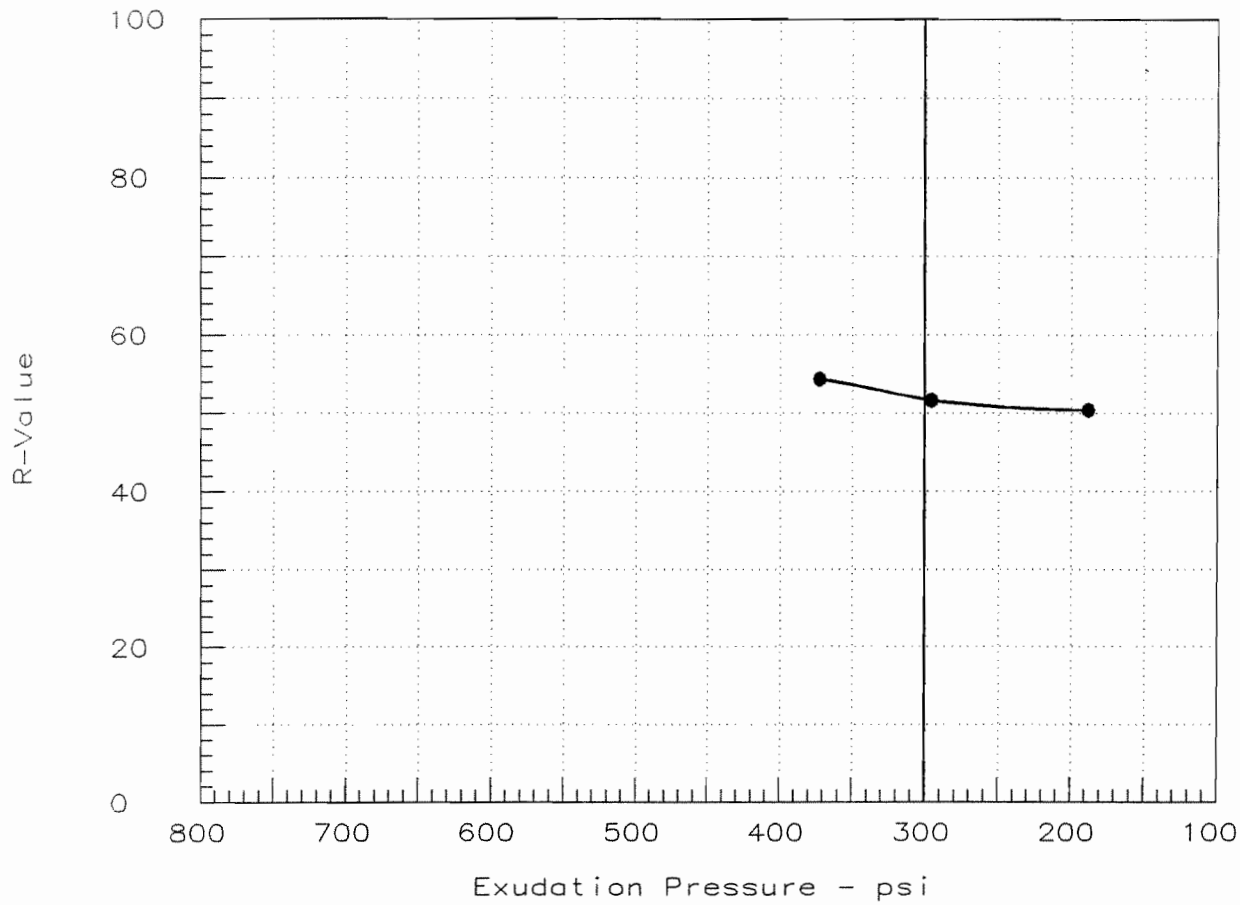
Tested by: YUN
Checked by: LKL
Remarks:
STL Job #7653
STL Lab #S5954-3

R-VALUE TEST REPORT

SIGNET TESTING LABS, INC.

Fig. No. 3

R-VALUE TEST REPORT

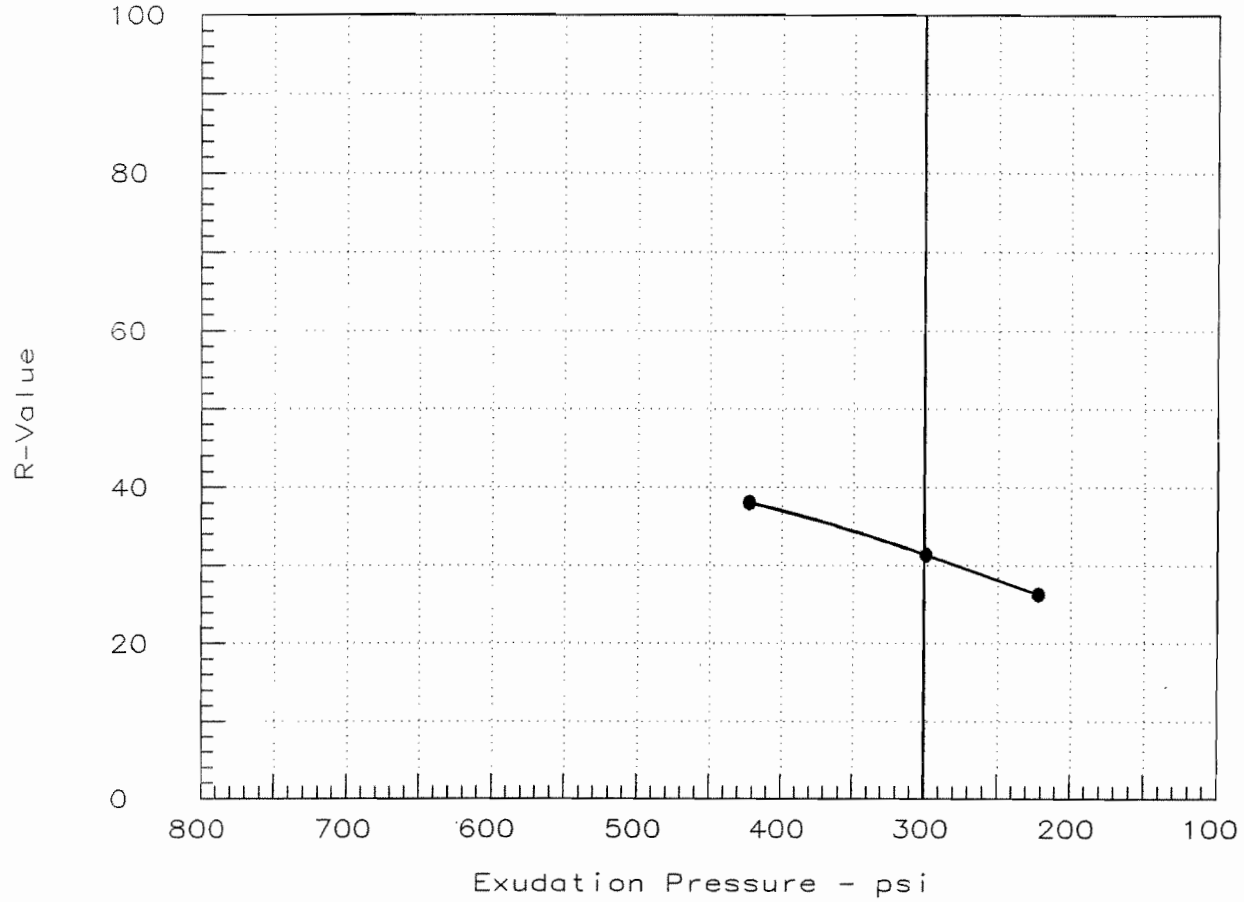


Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	150	73.8	36.0	0.12	36	2.50	372	54	54
2	100	73.3	38.3	0.24	40	2.53	188	50	50
3	125	74.6	37.1	0.18	38	2.51	296	52	52

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 52	Dark red brown silty sand
Project No.: 0007653 Project: 3411-20 Location: Saddle Road, BULK-101 Date: 1/8/2002	Tested by: GR Checked by: BR Remarks: STL Lab #S9933-6
R-VALUE TEST REPORT SIGNET TESTING LABS, INC.	Fig. No. 6

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	150	61.7	41.2	1.15	50	2.53	423	38	38
2	125	59.2	43.5	0.70	62	2.52	299	31	31
3	0	115.6	117.8	0.48	74	2.51	222	26	26

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 31	Dark brown silty sand with organics

Project No.: 0007653
Project: 3411-20
Location: Saddle Road, **BULK-102**

Date: 1/8/2002

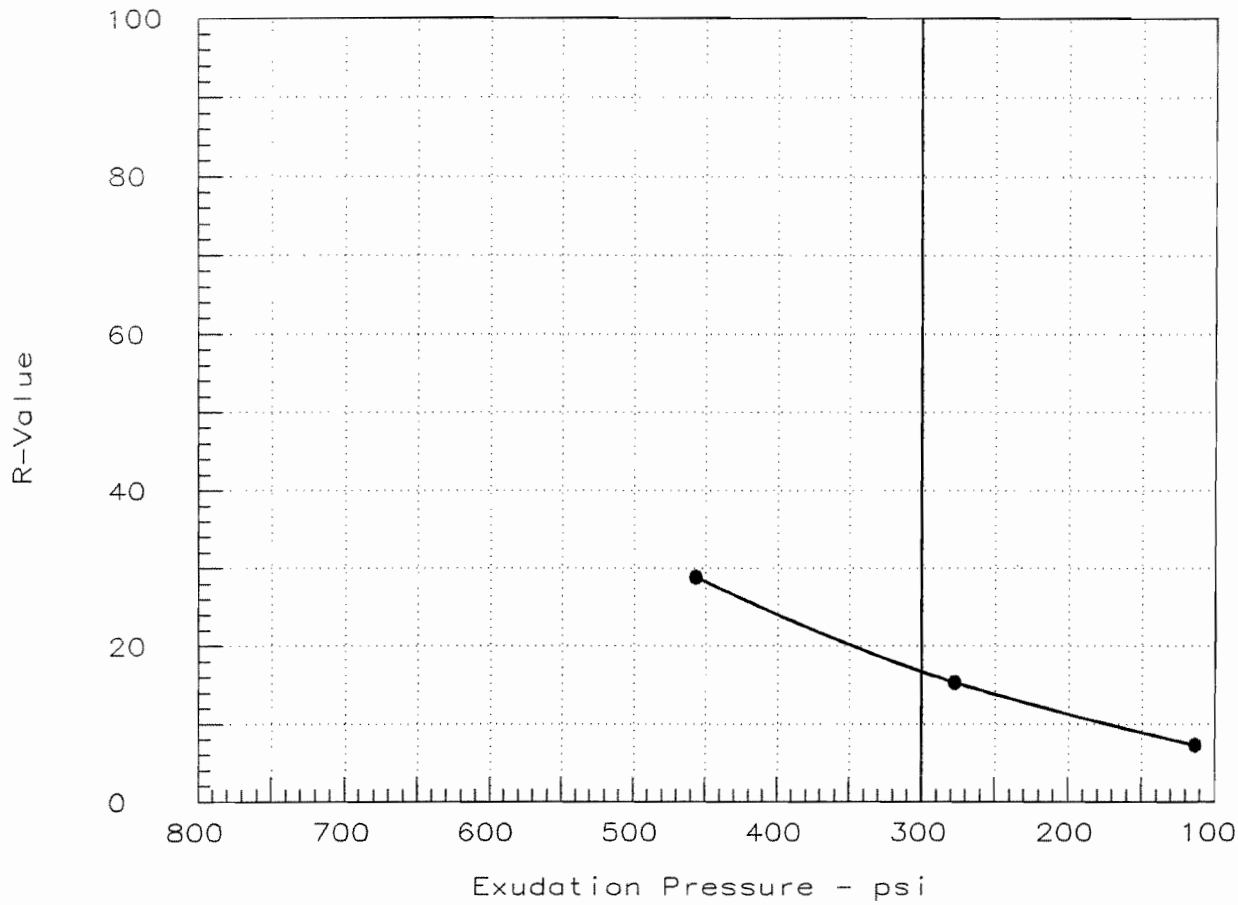
Tested by: GR
Checked by: BR
Remarks:
STL Lab #S9933-4

R-VALUE TEST REPORT

SIGNET TESTING LABS, INC.

Fig. No. 4

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	20	48.8	81.3	0.00	130	2.50	114	7	7
2	40	51.3	74.5	0.21	101	2.53	278	15	15
3	75	54.8	66.0	0.36	66	2.51	457	29	29

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 17	Dark red brown silty sand

Project No.: 0007653
Project: 3411-20
Location: Saddle Road, **BULK-103**

Date: 1/8/2002

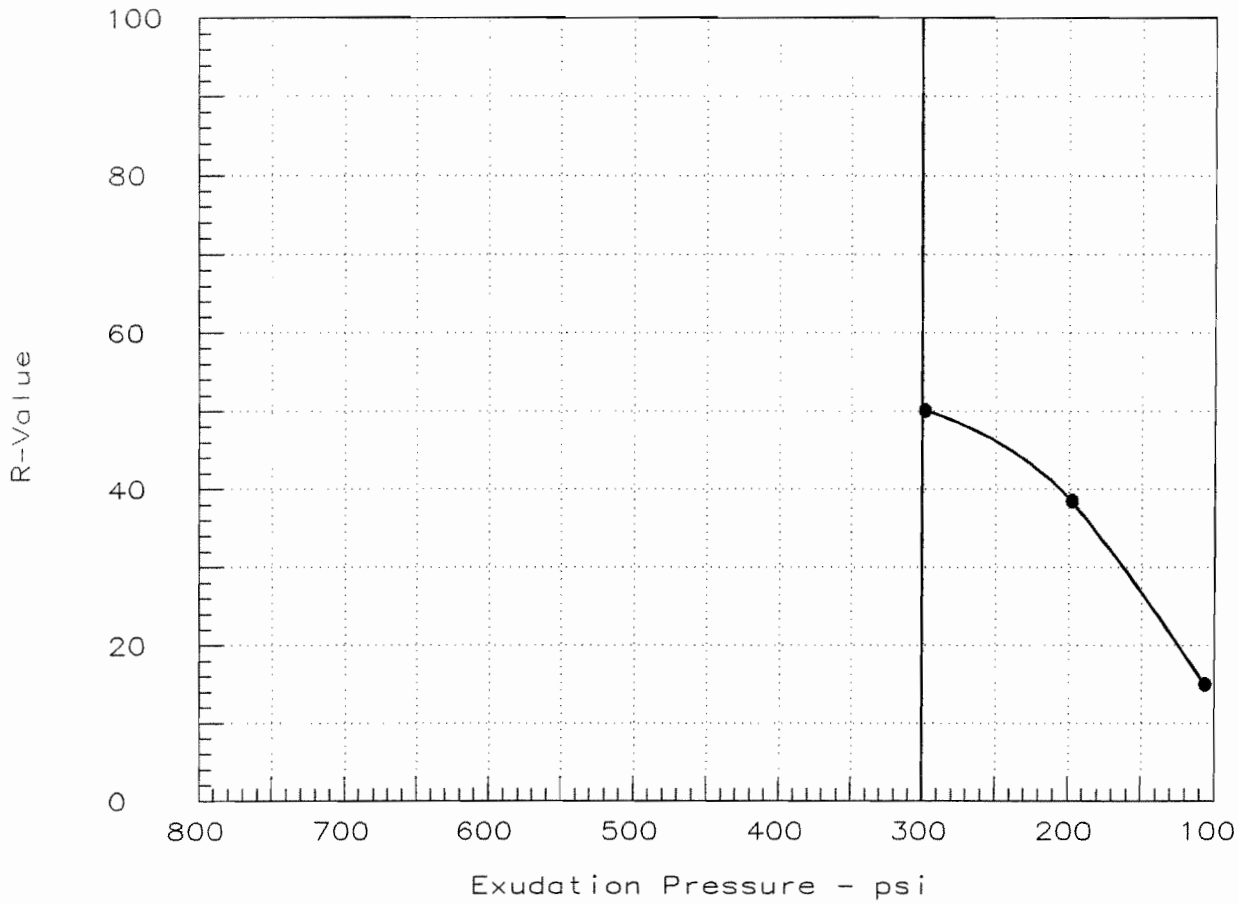
Tested by: GR
Checked by: BR
Remarks:
STL Lab #S9933-8

R-VALUE TEST REPORT

SIGNET TESTING LABS, INC.

Fig. No. 8

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	75	63.4	52.8	0.06	102	2.53	107	15	15
2	100	65.5	47.2	0.55	54	2.51	197	38	38
3	125	67.9	41.7	0.97	40	2.52	298	50	50

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 50	Dark brown silty sand with organics

Project No.: 0007653
Project: 3411-20
Location: Saddle Road, BULK-104

Date: 1/8/2002

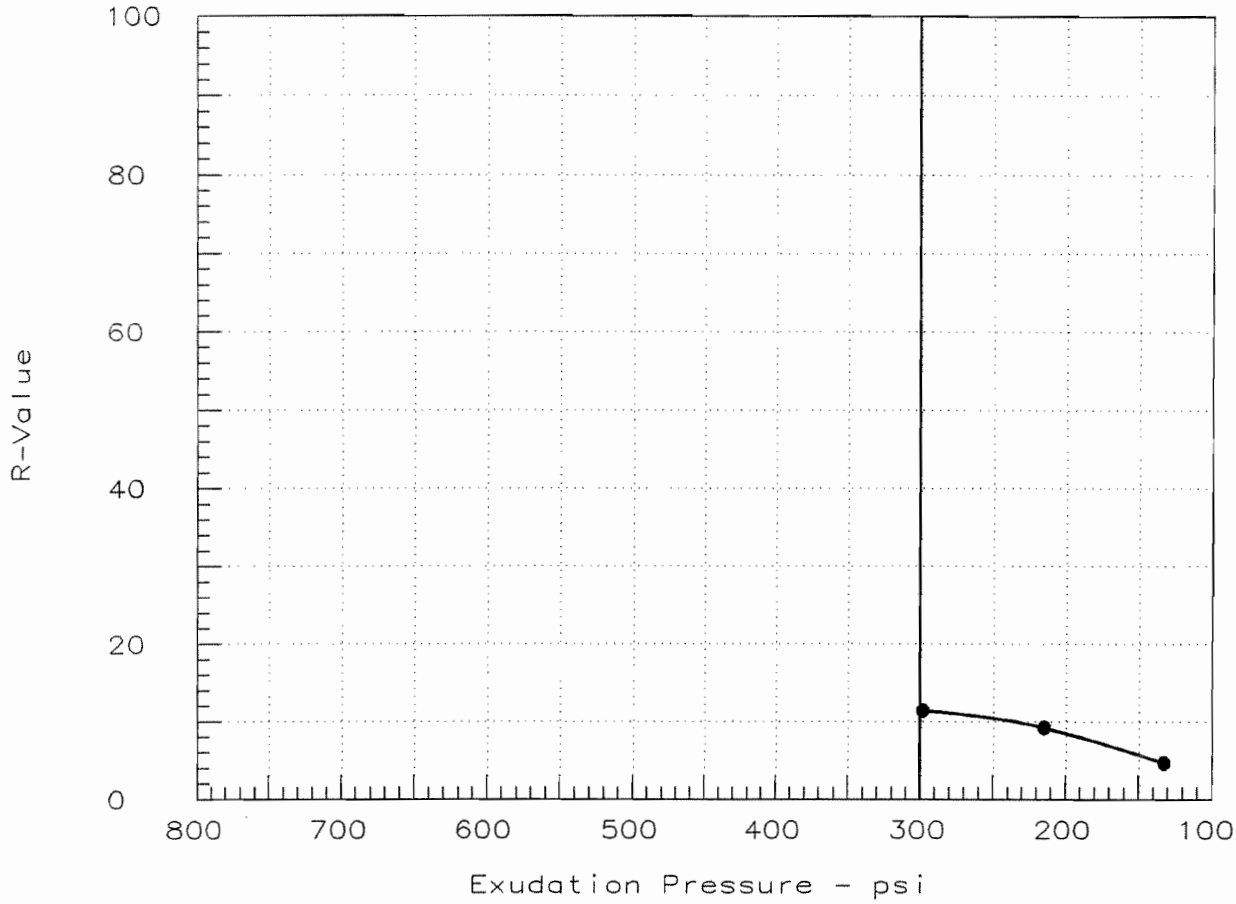
Tested by: GR
Checked by: BR
Remarks:
STL Lab #S9933-5

R-VALUE TEST REPORT

SIGNET TESTING LABS, INC.

Fig. No. 5

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - Cal Test 301

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	30	41.5	91.7	0.00	140	2.53	133	5	5
2	50	41.7	88.3	0.48	126	2.51	215	9	9
3	75	42.7	84.8	0.91	118	2.52	298	11	11

TEST RESULTS	MATERIAL DESCRIPTION
R-Value @ 300 psi exudation pressure = 11	Dark brown silty sand with organics

Project No.: 0007653
Project: 3411-20
Location: Saddle Road **BULK-105**

Date: 1/8/2002

Tested by: GR
Checked by: BR
Remarks:
STL Lab #S9933-1

R-VALUE TEST REPORT

SIGNET TESTING LABS, INC.

Fig. No. 1

APPENDIX D

Field Permeability Testing

APPENDIX D

Field Permeability Testing

The permeability of the in-situ soils were evaluated by performing four constant head and one falling head tests in selected borings (Boring Nos. 103, 107, 108, and 109) at depths ranging from approximately 22.6 to 31 feet below the existing ground surface.

The constant head tests were performed by pumping relatively clean water into the boreholes until the water surface has stabilized and remained at equilibrium for a sufficient period of time. The water height and the rate of pumping were then measured to provide data upon which to base calculation of the subsurface soil permeability.

During the falling head testing, the boreholes were carefully filled with relatively clean water to the top of the boreholes. The time intervals and water drops were then recorded to provide data upon which to base calculation of the permeability values of the subsoils. The test results of the field permeability tests are presented on Plates D-1 through D-5.

(u:\03reports\3411-20.tk2 – p75)

PERMEABILITY TEST NO. 1

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

TEST LOCATION:	B-103
DATE OF TEST:	December 21, 2001
TYPE OF TEST:	Constant Head Method
DEPTH OF HOLE:	22.6 feet
CASING DEPTH:	17 feet
DIAMETER OF OPEN HOLE:	4.5 inches
DIAMETER OF CASED HOLE:	3.5 inches
DEPTH TO GROUNDWATER:	22.6 feet (Assumed)

Note: Groundwater was not encountered within the depth of boring

Elapsed Time (min.)	Depth to Water (feet)	Flow Rate (gal/min)
3	19.82	85

Calculated Permeability = 4.1×10^{-1} feet/min.

(u:\03reports\3411-20.tk2-pg.85)

PERMEABILITY TEST NO. 2

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

TEST LOCATION:	B-103
DATE OF TEST:	December 21, 2001
TYPE OF TEST:	Constant Head Method
DEPTH OF HOLE:	24.7 feet
CASING DEPTH:	22 feet
DIAMETER OF OPEN HOLE:	4.5 inches
DIAMETER OF CASED HOLE:	3.5 inches
DEPTH TO GROUNDWATER:	24.7 feet (Assumed)

Note: Groundwater was not encountered within the depth of boring

Elapsed Time (min.)	Depth to Water (feet)	Flow Rate (gal/min)
3	10	27

Calculated Permeability = 3.8×10^{-2} feet/min.

(u:\03reports\3411-20.tk2-pg.86)

PERMEABILITY TEST NO. 3

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

TEST LOCATION:	B-107
DATE OF TEST:	December 20, 2001
TYPE OF TEST:	Constant Head Method
DEPTH OF HOLE:	31 feet
CASING DEPTH:	9 feet
DIAMETER OF OPEN HOLE:	4.5 inches
DIAMETER OF CASED HOLE:	3.5 inches
DEPTH TO GROUNDWATER:	31 feet (Assumed)

Note: Groundwater was not encountered within the depth of boring

Elapsed Time (min.)	Depth to Water (feet)	Flow Rate (gal/min)
13	7.1	42

Calculated Permeability = 8.0×10^{-3} feet/min.

(u:\03reports\3411-20.tk2-pg.87)

PERMEABILITY TEST NO. 4

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 to Milepost 42)
Island of Hawaii

TEST LOCATION:	B-108
DATE OF TEST:	December 20, 2001
TYPE OF TEST:	Constant Head Method
DEPTH OF HOLE:	25.85 feet
CASING DEPTH:	0 feet
DIAMETER OF OPEN HOLE:	4.5 inches
DIAMETER OF CASED HOLE:	3.5 inches
DEPTH TO GROUNDWATER:	25.85 feet (Assumed)

Note: Groundwater was not encountered within the depth of boring

Elapsed Time (min.)	Depth to Water (feet)	Flow Rate (gal/min)
5	18.1	85

Calculated Permeability = 4.4×10^{-2} feet/min.

(u:\03reports\3411-20.tk2-pg.88)

PERMEABILITY TEST NO. 5

Hawaii State Route 200 (Saddle Road)
PTA-1 Alignment (Milepost 28 To Milepost 42)
Island of Hawaii

TEST LOCATION:	B-109
DATE OF TEST:	January 22, 2002
TYPE OF TEST:	Falling Head Method
DEPTH OF HOLE:	24.0 feet
CASING DEPTH:	22 feet
DIAMETER OF OPEN HOLE:	4.5 inches
DIAMETER OF CASED HOLE:	3.5 inches
DEPTH TO GROUNDWATER:	24.7 feet (Assumed)

Note: Groundwater was not encountered within the depth of boring

Elapsed Time (min.)	Depth to Water (ft.)
0	10.42
100	13.64
960	21.63

Calculated Permeability = 4.0×10^{-6} feet/min.

(u:\03reports\3411-20.tk2-pg.83)