SOILS INVESTIGATION
MANOA STREAM IMPROVEMENTS
AT WOODLAWN DRIVE BRIDGE
HONOLULU, HAWAII

for

R.M. TOWILL CORPORATION

HIRATA & ASSOCIATES, INC.
W.O. 09-4867
May 6, 2016

Hirata & Associates

Geotechnical
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May 6, 2016
W.O. 09-4867

Ms. Stacy Armstrong
R.M. Towill Corporation
2024 North King Street, Suite 200
Honolulu, Hawaii 96819

Dear Ms. Armstrong:

Our report, "Soils Investigation, Manoa Stream Improvements at Woodlawn Drive Bridge, Honolulu, Hawaii," dated May 6, 2016, our Work Order 09-4867 is enclosed. This investigation was conducted in general conformance with the scope of services presented in our proposal dated June 18, 2007.

The surface soils were classified as stiff to medium stiff, dark brown to grayish brown clayey silt, extending to depths ranging from about 7.5 to 12.5 feet. Firm conditions were encountered at deeper sections of the stratum in borings B1 and B4. Underlying the clayey silt were dense to medium dense granular soils consisting of mottled brown silty gravel and dark brown to grayish brown silty sand, extending to the maximum depths drilled. A loose section of silty sand was encountered between depths of about 7.5 to 14 feet in the proposed drop structure area. Cobbles and boulders were encountered within the granular soils. Groundwater was encountered at depths ranging from about 8 to 13 feet below existing grade.

Due to its loose and wet condition, workability of the subgrade may be difficult during construction. As a result, we recommend that 12 inches of gravel fill, such as #3 Coarse or equivalent, be placed to provide a working base during construction. The proposed grouted rip-rap drop structure may be placed directly on the 12-inch gravel fill layer.

Grouted rip-rap placed in stream beds and along banks below groundwater may also be placed directly on the 12-inch gravel fill layer. Grouted rip-rap placed above groundwater on stream banks should be underlain by a minimum 6 inches of imported granular fill to provided a zone of high permeability and prevent buildup of hydrostatic pressures. Weepholes and/or subdrains should be included in the design of grouted rip-rap.

Additional geotechnical recommendations for the design of the grouted rip-rap drop structure and grouted rip-rap, and site grading are presented in this report.

We appreciate this opportunity to be of service. Should you have any questions concerning this report, please feel free to call on us.

Very truly yours,

HIRATA & ASSOCIATES, INC.

Paul S. Morimoto

Paul S. Morimoto President

PSM:NKT

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SOILS INVESTIGATION
MANOA STREAM IMPROVEMENTS
AT WOODLAWN DRIVE BRIDGE
HONOLULU, HAWAII

INTRODUCTION

This report presents the results of our soils investigation performed for the proposed stream improvements of Manoa Stream at Woodlawn Drive Bridge in Honolulu, Hawaii. Our scope of services for this study included the following:

- A visual reconnaissance of the site and its vicinity to observe existing conditions which may affect the project. The general location of the project site is shown on the enclosed Location Map, Plate A2.1.

- A review of available in-house soils information pertinent to the site and the proposed project.

- Drilling and sampling five exploratory borings to depths ranging from approximately 19 to 20.5 feet. A description of our field investigation is summarized on Plates A1.1 and A1.2. The approximate exploratory boring locations are shown on the enclosed Boring Location Plan, Plate A2.2, and the soils encountered in the borings are described on the Boring Logs, Plates A4.1 through A4.5.

- Laboratory testing of selected soil samples. Testing procedures are presented in the Description of Laboratory Testing, Plates B1.1 through B1.3. Test results are presented in the Description of Laboratory Testing, and on the Unified Soil Classification System Chart (Plate A3.2), Boring Logs (Plates A4.1 through A4.5), Consolidation Test reports (Plates B2.1 and B2.2), Direct Shear Test reports (Plates B3.1 through B3.5), Modified Proctor Test report (Plate B4.1), and Gradation Test reports (Plates B5.1 and B5.2).

- Engineering analyses of the field and laboratory data.

- Preparation of this report presenting geotechnical recommendations for the design of grouted rip-rap drop structure, grouted rip-rap, and site grading.

PROJECT CONSIDERATIONS

Information regarding the project was provided by personnel from your office, and personnel from the Department of Land & Natural Resources.

The project consists of improvements to Manoa Stream near Woodlawn Drive Bridge. Stream improvements initially considered at the bridge consisted of a grouted rip-rap drop structure, a concrete drop structure, or concrete chute with supporting wing walls. We understand that the final design will consist of a 1-foot grouted rip-rap drop structure situated approximately 40 lineal feet upstream of the bridge.

To prevent the potential of scour, the drop structure will include a 10-foot deep key backfilled with grouted rip-rap. Articulated concrete blocks will also be placed upstream of the drop structure to prevent the potential of scour. The existing stream bed in the proposed drop structure area is lined with grouted rip-rap which will need to be removed prior to construction of the drop structure.

In addition, the upstream and downstream approaches of the bridge stream bed will be graded to a relatively flat gradient. New grouted rip-rap will replace sloping portions of existing grouted rip-rap along the stream bed and banks, extending approximately 40 lineal feet upstream and downstream of the bridge.

The initial project scope also included improvements consisting of grouted rip-rap on the stream bed and about 2 to 3 feet of the adjacent banks, extending approximately 300 lineal feet downstream of the bridge. Consideration was also given to overexcavating as much as 4 feet into the stream bed to create a downhill grade of about 0.5 percent from Woodlawn Bridge and daylighting in the existing stream bed approximately 950 lineal feet downstream of the bridge. Additional alternatives that were considered included grading the existing stream banks to gradients of 2H:1V, protecting the stream banks with grouted rip-rap, and widening the bottom of stream bed to approximately 20 feet in width.

Based on discussions with personnel from the Department of Land & Natural Resources, the scope of this project does not include improvements or stabilization of existing stream banks, and that the primary scope is for the maintenance of the stream to remove the built-up sediment on the stream bed. As a result, improvements will not be made to the existing conditions of the stream banks, and improvements to relatively steep areas of the existing stream banks will be considered in a future project. Therefore, the design will consist of overexcavating as much as 3 to 4 feet into the stream bed to remove sediment and restore the stream bed, extending approximately 400 lineal feet downstream of the bridge. The channel banks resulting from the overexcavations will be graded to gradients of 2H:1V. The existing stream banks above the overexcavations will not be graded, and the bottom of stream bed will not be widened. Grouted rip-rap will not be utilized to protect the stream bed, newly excavated channel banks, or existing stream banks.

SITE CONDITIONS

The proposed stream improvements are limited to that portion of Manoa Stream near Woodlawn Drive Bridge, which is located along Woodlawn Drive, southwest of its intersection with Lowrey Avenue, in Honolulu, Hawaii. Manoa Stream generally flows in a southeasterly direction. Woodlawn Drive Bridge is bordered on the north by the Manoa Innovation Center, on the east by a townhouse complex, on the south by US Pacific Basin Agricultural Research Center, and on the west by Manoa Market Place.

CRM revetments, approximately 12 feet in height, were observed along the upstream and downstream banks, extending from Woodlawn Drive Bridge in both directions for about 40 feet. The stream bed along the CRM revetments is lined with grouted rip-rap and is covered with soil and debris. Light to moderate vegetation was observed along the CRM revetments and in the stream bed. The depth of water at the time of our fieldwork appeared to be relatively shallow.

Observations of the stream banks situated downstream beyond the CRM revetments were limited to approximately 300 feet downstream. The stream banks are generally covered with light to moderate vegetation with trees. Boulders were observed along the stream banks. The stream banks generally range from about 8 to 14 feet in height, with gradients of about 2H:1V and steeper gradients in isolated, eroded areas.

SOIL CONDITIONS

Boring B5 was drilled through approximately 2 inches of asphaltic concrete over 4 inches of base material.

Underlying the pavement section in boring B5, and at ground surface in the remaining borings, was dark brown to grayish brown clayey silt with sand and gravel. Cobbles and boulders were encountered within the clayey silt stratum in boring B5. The clayey silt was generally in a stiff to medium stiff condition, extending to depths ranging from about 7.5 to 12.5 feet. Borings B1 and B4 encountered firm conditions from depths of about 5 and 9 feet, respectively. Boring B2 encountered a 2.5-foot layer of silty gravel at a depth of about 2.5 feet. Laboratory testing on the clayey silt indicated a low expansion potential when at its in-situ moisture content, and a high expansion potential when air-dried. The Soil Survey, prepared by the US Soil Conservation Service, describes the soil in the project area as having a moderate expansion potential.

Underlying the clayey silt were granular soils consisting of mottled brown silty gravel with sand and dark brown to grayish brown silty sand with gravel, extending to the maximum depths drilled. The silty gravel and silty sand were generally in a dense to medium dense condition, with a loose section of silty sand in boring B1 between depths of about 7.5 to 14 feet. Cobbles and boulders were encountered in boring B3.

Groundwater was encountered at depths ranging from about 8 to 13 feet below existing grade.

CONCLUSIONS AND RECOMMENDATIONS

Based on our exploratory borings, we anticipate that structural excavations will expose loose to medium dense silty sand below groundwater. As a result of the relatively loose and wet condition of the subgrade, it is our opinion that workability of the subgrade may be difficult during construction. Therefore, we recommend that 12 inches of gravel, such as #3 Coarse or equivalent, be placed on the silty sand subgrade to provide a working base during construction. Geotextile filter fabric should be placed below the 12-inch gravel fill working base to prevent the silty sand subgrade from migrating into the gravel fill working base. The grouted rip-rap drop structure and grouted rip-rap placed below existing groundwater encountered during construction may be placed directly on the 12-inch gravel fill working base.

Grouted rip-rap placed immediately upstream and downstream of the bridge along stream banks situated above existing groundwater encountered during construction should be underlain by a minimum 6 inches of imported well-graded granular fill.

Overexcavation of the onsite soils will be required for placement of the gravel fill working base for below groundwater conditions and the imported well-graded granular fill for above groundwater conditions.

Backfill placed below existing groundwater encountered during construction should consist of clean gravel, such as #3B Fine. Backfill placed above existing groundwater encountered during construction may consist of either onsite silty gravel, silty sand, or imported fill. Geotextile filter fabric should be placed between the clean gravel and the fill placed above it.

Grouted Rip-Rap Drop Structure and Grouted Rip-Rap

The grouted rip-rap drop structure and grouted rip-rap placed immediately upstream and downstream of the bridge in stream beds and along banks situated below existing groundwater encountered during construction may be placed directly on a 12-inch gravel fill working base, such as #3 Coarse or equivalent. Geotextile filter fabric should be placed below the 12-inch gravel fill working base.

Overexcavation of the onsite soils will be required for placement of the 12-inch gravel fill working base.

The 12-inch gravel fill working base should be placed in horizontal lifts restricted to 14 inches in loose thickness, and densified or tamped to an unyielding condition.

Grouted rip-rap placed above existing groundwater encountered during construction on stream banks should be well-drained to prevent buildup of hydrostatic pressures. As a result, we recommend that the grouted rip-rap situated above existing groundwater encountered during construction be underlain by a minimum 6 inches of imported well-graded granular fill. Portions of cobbles and boulders extending into the granular fill section should be removed and backfilled with either onsite silty gravel, silty sand, or imported fill. In addition, weepholes and/or subdrains should be included in the design of the grouted rip-rap.

Prior to the placement of the well-graded granular fill, the subgrade should be cleared of all vegetation, including large tree roots, and thoroughly tamped. All deposits of loose and eroded material should be removed down to firm, undisturbed soil. Soft and loose soils indicated by pumping conditions should be removed down to competent material and replaced with either onsite silty gravel, silty sand, or imported fill. All cobbles and boulders encountered near the edges of the grouted rip-rap structure should be removed.

The onsite clayey silt should not be allowed to dry significantly prior to placement of the well-graded granular fill. It may be necessary for the contractor to occasionally add water to the site to maintain the natural moisture content.

The grouted rip-rap should be a minimum 12 inches in thickness, with the median rock size not exceeding two-thirds the blanket thickness. The largest rock used in the rip-rap should not exceed the blanket thickness.

To prevent undermining and outflanking of the grouted rip-rap at the top of the slope, the head of the grouted rip-rap should extend horizontally into the slope and be embedded a minimum of two times the blanket thickness.

Removal of Stream Sediment

We understand that as much as 3 to 4 feet of cuts into the stream bed are planned for the removal of built-up sediment. Permanent cut slopes into the stream banks should be stable at gradients of 2H:1V or flatter.

Site Grading

Site Preparation - The project site should be cleared of all vegetation, including large tree roots, boulders, existing grouted rip-rap, and other deleterious material. In areas requiring fill placement above existing groundwater encountered during construction, the exposed subgrade should be scarified to a minimum depth of 6 inches, moisture conditioned to about 2 percent above optimum moisture content, and compacted to between 90 and 95 percent compaction as determined by ASTM D 1557.

The onsite clayey silt should not be allowed to dry significantly prior to placement of the granular fill. It may be necessary for the contractor to occasionally add water to the site to maintain the natural moisture content.

In areas requiring fill placement below existing groundwater encountered during construction, we anticipate that compaction of the subgrade prior to fill placement may be difficult in areas due to wet onsite soils. As an alternative to scarifying and recompacting the subgrade, the onsite soils may be overexcavated to a minimum depth of 12 inches and replaced with clean gravel such as #3 Coarse. The intent of this recommendation is to provide a firm working base during construction.

If encountered, underlying soft and loose soils indicated by pumping conditions should be removed down to competent material and replaced with either onsite silty gravel, silty sand, or imported fill compacted in lifts to the recommended minimum standard as indicated in the *Compaction* section below.

Portions of cobbles and boulders extending into the granular fill section below the grouted rip-rap should be removed. The overexcavations created by removal of the cobbles and boulders should be backfilled with either onsite silty gravel, silty sand, or imported fill compacted in lifts to the recommended minimum standard as indicated in the *Compaction* section below.

Structural Excavations - Based on our exploratory borings, we believe that excavations into the onsite soils can generally be accomplished using conventional excavating equipment. The removal of boulders in confined excavations may require the use of hydraulic equipment.

Temporary cuts into the onsite soils should be stable at slope gradients of 1H:1V or flatter. However, due to the cohesionless nature of the silty gravel and silty sand, considerable sloughing should be expected. It should be the Contractor's responsibility to conform to all OSHA safety standards for excavations.

Based on the relatively high groundwater level, dewatering may be necessary during construction. The Contractor's dewatering plan should address the potential effects of dewatering on adjacent structures and infrastructure, and the monitoring effort that will be implemented to detect ground movement or settlement of existing structures and infrastructure.

Slope Gradients - The following permanent slope gradients may be used for design purposes:

Slope Type	Gradient
Grouted rip-rap slopes	2H:1V or flatter
Permanent cut and fill slopes	2H:1V or flatter

Permanent cut and fill slopes should be planted as soon as practical upon completion of grading to reduce the effects of erosion and weathering.

Onsite Fill Material – The surface clayey silt will not be acceptable for reuse in structural fills and backfills due to its moderate to high expansion potential. The underlying silty gravel and silty sand will be acceptable for reuse in compacted fills and backfills above existing groundwater encountered during construction, except in the imported granular fill section recommended below the grouted rip-rap placed above existing groundwater encountered during construction. All rock fragments larger than 3 inches in maximum dimension should be removed from the onsite silty gravel and silty sand prior to reuse.

Imported Fill Material - Imported structural fill should be well-graded, non-expansive granular material. Specifications for imported granular structural fill should indicate a maximum particle size of 3 inches, and state that between 5 and 15 percent of soil by weight shall pass the #200 sieve. In addition, the plasticity index (P.I.) of that portion of the soil passing the #40 sieve shall not be greater than 10. Imported structural fill should have a CBR expansion value no greater than 1.0 percent and a minimum CBR value of 12 percent, when tested in accordance with ASTM D 1883.

Clean gravel, such as #3B fine, should be used as backfill material placed below existing groundwater encountered during construction.

Coarse clean gravel, such as #3 coarse or equivalent, may be used as a working base in the 12-inch gravel section below the grouted rip-rap and as an alternative to scarification and recompaction of subgrade in fill areas below groundwater encountered during construction.

Compaction - Granular fill, such as silty gravel, silty sand, and imported fill, should be placed in horizontal lifts restricted to 8 inches in loose thickness and compacted to a minimum 95 percent compaction as determined by ASTM D 1557.

The 12-inch gravel fill working base should be placed in horizontal lifts restricted to 14 inches in loose thickness, and densified or tamped to an unyielding condition.

Fill placed in areas which slope steeper than 5H:1V should be continually benched as the fill is brought up in lifts. Fill placed on slopes should be keyed and benched into the existing slope to provide stability for the new fill against sliding. Filling the slope with sliver fills should be avoided.

ADDITIONAL SERVICES

We recommend that we perform a general review of the final design plans and specifications. This will allow us to verify that the grouted rip-rap design and earthwork recommendations have been properly interpreted and implemented in the design plans and construction specifications.

For continuity, we recommend that we be retained during construction to (1) observe grading operations and subgrade preparation prior to placement of the gravel fill working base and grouted rip-rap, (2) review and/or perform laboratory testing on import borrow to determine its acceptability for use in compacted fills, (3) observe structural fill placement and perform compaction testing, and (4) provide geotechnical consultation as required.

Our services during construction will allow us to verify that our recommendations are properly interpreted and included in construction, and if necessary, to make modifications to those recommendations, thereby reducing construction delays in the event subsurface conditions differ from those anticipated.

LIMITATIONS

The boring logs indicate the approximate subsurface soil conditions encountered only at those times and locations where our borings were made, and may not represent conditions at other times and locations.

This report was prepared specifically for R.M. Towill Corporation and their sub-consultants for design of the proposed stream improvements of Manoa Stream at Woodlawn Drive Bridge in Honolulu, Hawaii. The boring logs, laboratory test results, and recommendations presented in this report are for design purposes only, and are not intended for use in developing cost estimates by the contractor.

During construction, should subsurface conditions differ from those encountered in our borings, we should be advised immediately in order to re-evaluate our recommendations, and to revise or verify them in writing before proceeding with construction.

Our recommendations and conclusions are based upon the site materials observed, the preliminary design information made available, the data obtained from our site exploration, our engineering analyses, and our experience and engineering judgment. The conclusions and recommendations in this report are professional opinions which we have strived to develop in a manner consistent with that level of care, skill, and competence ordinarily exercised by members of the profession in good standing1, currently practicing under similar conditions in the same locality. We will be responsible for those recommendations and conclusions, but will not be responsible for the interpretation by others of the information developed. No warranty is made regarding the services performed, either expressed or implied.

Respectfully submitted,

HIRATA & ASSOCIATES, INC.

Nathan K. Tanaka, Project Engineer

Rick Yoshida, Project Manager

NATHAN K. TANAKA
LICENSED PROFESSIONAL ENGINEER
No. 15005-C
HAWAII, U.S.A.

This work was prepared by me or under my supervision.
Expiration Date of License:
April 30, 2018

APPENDIX A

FIELD INVESTIGATION

DESCRIPTION OF FIELD INVESTIGATION

GENERAL

The site was explored on December 7 and 8, 2010, by performing a visual reconnaissance of the site and drilling five test borings to depths ranging from about 19 to 20.5 feet with a Mobile B40-L22 truck-mounted drill rig.

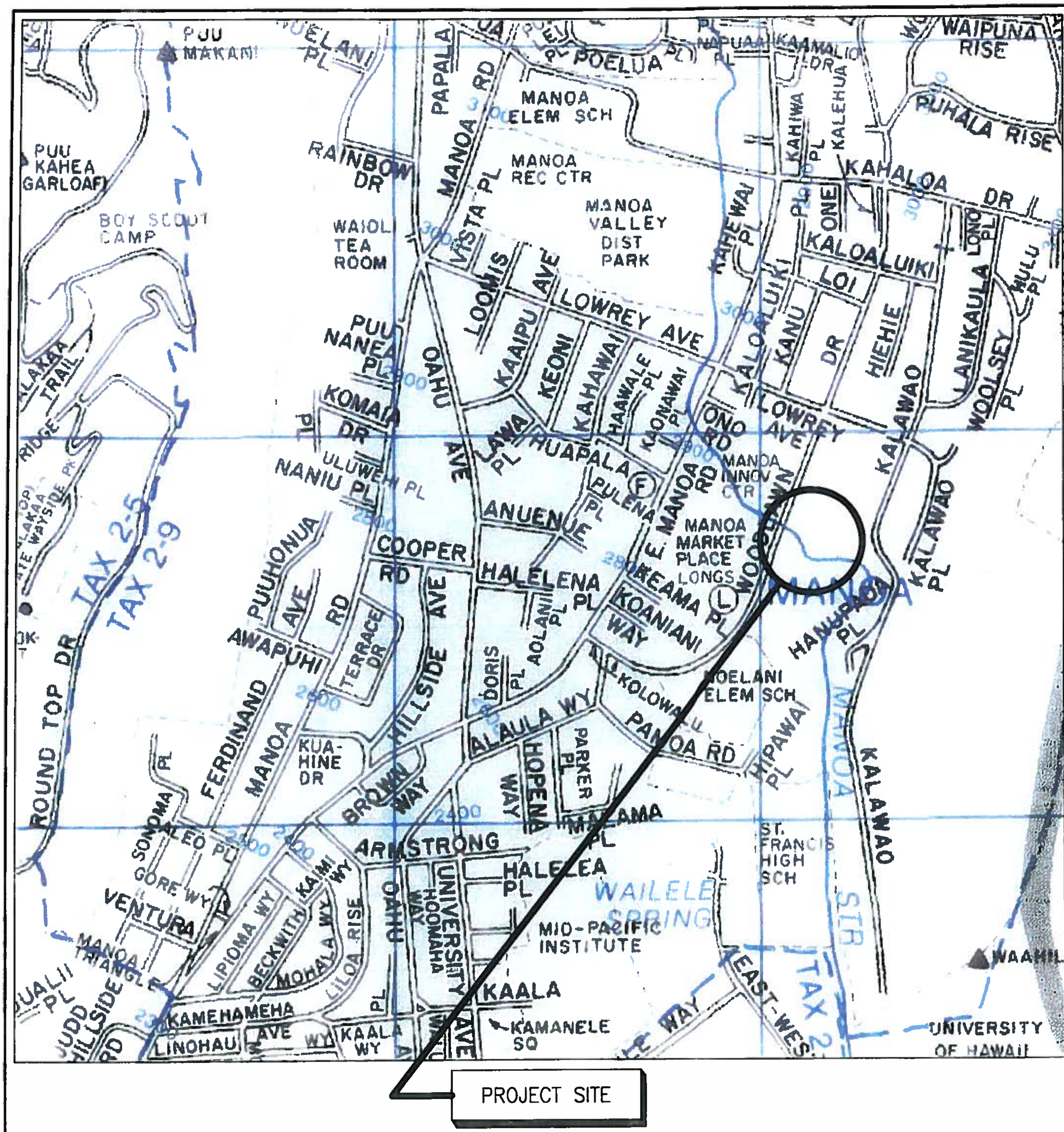
During drilling operations, the soils were continuously logged by our field engineer and classified by visual examination in accordance with the Unified Soil Classification System. The boring logs indicate the depths at which the soils or their characteristics change, although the change could actually be gradual. If the change occurred between sample locations, the depth was interpreted based on field observations. Classifications and sampling intervals are shown on the boring logs. A Boring Log Legend is presented on Plate A3.1, while the Unified Soil Classification System is shown on Plate A3.2. The soils encountered are logged on Plates A4.1 through A4.5.

Borings were located in the field by measuring/taping offsets from existing site features shown on the plans. Surface elevations at boring locations were estimated based on the Topographic Survey prepared by R.M. Towill Corporation dated January, 2008. The accuracy of the boring locations shown on Plate A2.2 and the boring elevations shown on Plates A4.1 through A4.5 are therefore approximate, in accordance with the field methods used.

SOIL SAMPLING

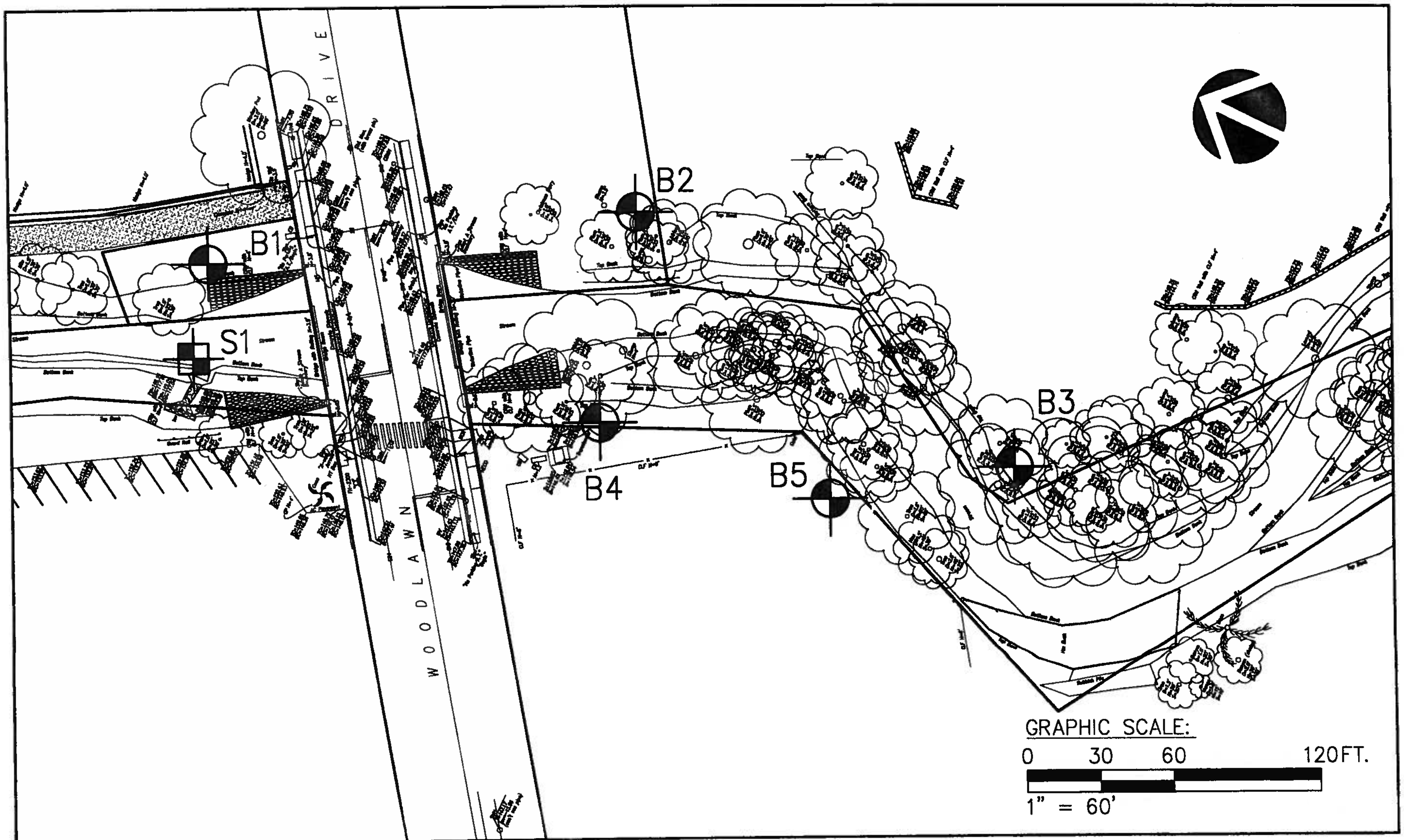
Representative and bulk soil samples were recovered from the borings for selected laboratory testing and analyses. Representative samples were recovered by driving a 3-inch O.D. split tube sampler a total of 18 inches with a 140-pound hammer dropped from a height of 30 inches. The number of blows required to drive the sampler the final 12 inches are recorded at the appropriate depths on the boring logs, unless noted otherwise. A bulk soil sample was recovered from near boring B3 between depths of about 6 to 18 inches below ground surface. The location of boring B3 is shown on Plate A2.2.

In addition, a bulk sample, S1, was recovered from the stream bed upstream of Woodlawn Bridge between depths of about 0 to 1 foot below grade for sieve analysis testing to provide near surface soils information for scour analysis.



Reference: Bryan's Sectional Maps, 2008 Edition
(Copyright J.R. Clere, used with permission)

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	LOCATION MAP Plate A2.1



LEGEND:

- Approximate location of borings
- Approximate location of bulk sample

Reference: Topographic Survey prepared by R.M. Towill Corporation dated January, 2008.

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	BORING LOCATION PLAN Plate A2.2

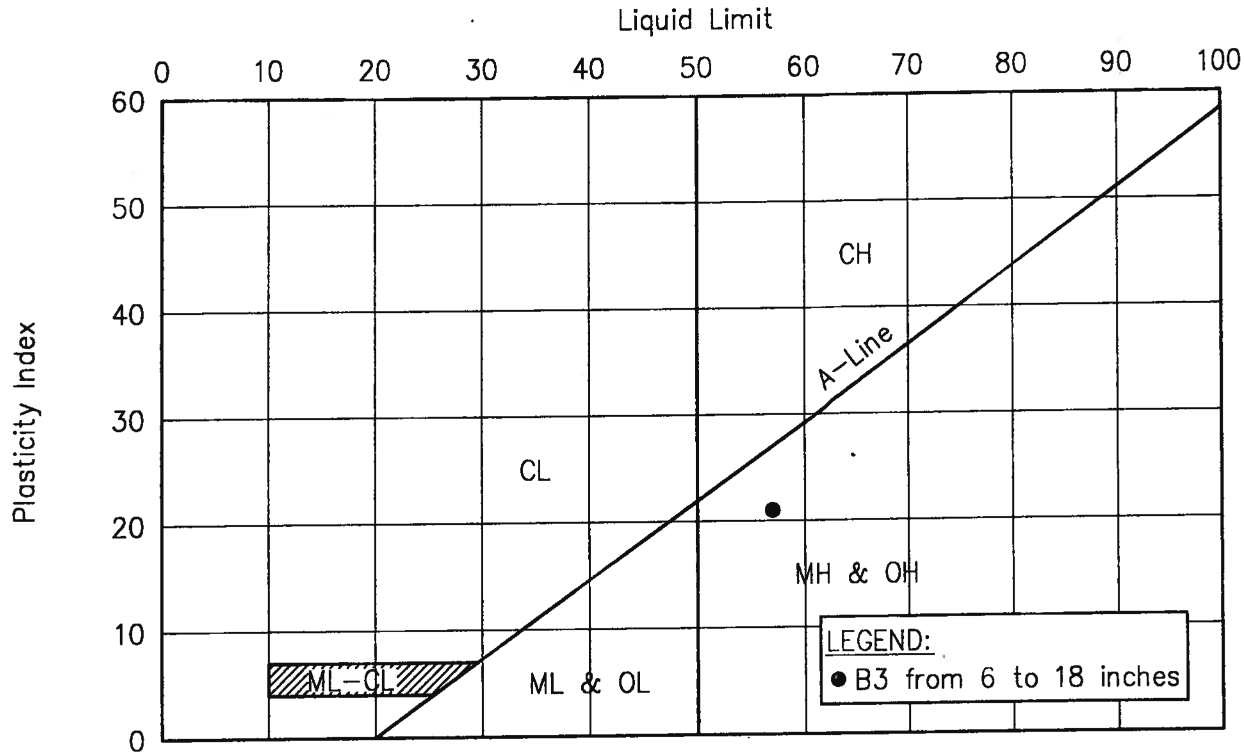
MAJOR DIVISIONS			GROUP SYMBOLS		TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of the material is LARGER than No. 200 sieve size.)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size.)	CLEAN GRAVELS (Little or no fines.)		GW	Well graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GRAVELS WITH FINES (Appreciable amt. of fines.)		GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction is SMALLER than the No. 4 sieve size.)	CLEAN SANDS (Little or no fines.)		SW	Well graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES (Appreciable amt. of fines.)		SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS (More than 50% of the material is SMALLER than No. 200 sieve size.)	SILTS AND CLAYS (Liquid limit LESS than 50.)			ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
				OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (Liquid limit GREATER than 50.)			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				PT	Peat and other highly organic soils.
					FRESH TO MODERATELY WEATHERED BASALT
					VOLCANIC TUFF / HIGHLY TO COMPLETELY WEATHERED BASALT
					CORAL

SAMPLE DEFINITION		
2" O.D. Standard Split Spoon Sampler	Shelby Tube	RQD Rock Quality Designation
3" O.D. Split Tube Sampler	NX / 4" Coring	Water Level

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	BORING LOG LEGEND

Plate A3.1

PLASTICITY CHART



GRADATION CHART

COMPONENT DEFINITIONS BY GRADATION	
COMPONENT	SIZE RANGE
Boulders	Above 12 in.
Cobbles	3 in. to 12 in.
Gravel	3 in. to No. 4 (4.76 mm)
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 (4.76 mm)
Sand	No. 4 (4.76 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.76 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and clay	Smaller than No. 200 (0.074 mm)

W.O. 09-4867	**Manoa Stream Improvements at Woodlawn Drive Bridge**
Hirata & Associates, Inc.	UNIFIED SOIL CLASSIFICATION SYSTEM Plate A3.2

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 09-4867

BORING NO. B1 | DRIVING WT. 140 lb. | START DATE 12/7/09
SURFACE ELEV. 148±* | DROP 30 in. | END DATE 12/7/09

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Clayey SILT (MH) – Brown, moist, medium stiff, with sand and gravel.
		☐	26	91	28	
		☐	19	96	25	
5		☐	7	84	23	Grayish brown in color, firm from 5 feet.
						Silty SAND (SM) – Brown, moist, loose, with gravel.
▽						Groundwater encountered at 8.5 feet on 12/7/09 at 2:15 pm.
10		☐	5	47	107	
		☐	14	96	27	Silty GRAVEL (GM) – Brown, medium dense, with sand.
15						
20		☐	15	80	40	
						End boring at 20.5 feet.
25						
30						

* Elevations based on Topographic Survey prepared by R.M. Towill Corporation dated January, 2008.

Plate A4.1

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 09-4867

BORING NO. B2 DRIVING WT. 140 lb. START DATE 12/8/09

SURFACE ELEV. 147± DROP 30 in. END DATE 12/8/09

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Clayey SILT (MH) – Grayish brown, moist, stiff, with sand.
			31	102	9	Silty gravel from 2.5 to 4 feet.
			35	83	33	
5						
			38	88	22	Silty GRAVEL (GM) – Mottled brown, moist, dense, with sand.
10						Groundwater encountered at 10 feet on 12/8/09 at 11:00 am.
			19	96	29	Gray in color, medium dense from 13 feet.
15						
			18	60	74	
20						End boring at 19.5 feet.
25						
30						

Plate A4.2

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 09-4867

BORING NO. B3 — DRIVING WT. 140 lb. — START DATE 12/8/09

SURFACE ELEV. 144± — DROP 30 in. — END DATE 12/8/09

DEPTH	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0				Clayey SILT (MH) – Grayish brown, moist, stiff, with sand.
	48	87	31	
	47	90	27	
5	21	78	40	Medium stiff from 5 feet.
				Groundwater encountered at 8 feet on 12/8/09 at 10:47 am.
	15	89	32	
10				Silty GRAVEL (GM) – Mottled brown, medium dense, with sand, cobbles, and boulders.
	10/No Penetration			
15				
	10/No Penetration			
20				End boring at 19 feet.
25				
30				

Plate A4.3

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 09-4867

BORING NO. B4 | DRIVING WT. 140 lb. | START DATE 12/7/09
SURFACE ELEV. 148± | DROP 30 in. | END DATE 12/7/09

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Clayey SILT (MH) – Brown, moist, stiff, with sand and gravel.
			10/No Penetration			
			46	72	28	
5			32	75	31	Grayish brown in color, decrease in gravel content from 5 feet.
			8	66	49	Firm at 9 feet.
10						Silty SAND (SM) – Dark brown, moist, medium dense, with gravel.
						Groundwater encountered at 13 feet on 12/7/09 at 12:15 pm.
15			11	83	37	
			29	69	62	
20						End boring at 20.5 feet.
25						
30						

Plate A4.4

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 09-4867

BORING NO. B5 DRIVING WT. 140 lb. START DATE 12/7/09
SURFACE ELEV. 148± DROP 30 in. END DATE 12/7/09

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Clayey SILT (MH) – Dark brown, moist, medium stiff, with gravel and cobbles. Covered by 2 inches of AC over 4 inches of base material.
		☐	25	52	30	
		☐	14	77	25	Grayish brown in color, with sand from 4.5 feet.
5						
						Boulder from 6 to 8 feet.
		☐	16	71	41	
10						
▽						
		☐	31	111	19	Silty SAND (SM) – Grayish brown, dense, with gravel. Groundwater encountered at 12.5 feet on 12/7/09 at 9:50 am.
15						
		☐	19/9" 10/No Penetration	95	32	Cobble at 19 feet.
20						End boring at 19.5 feet.
25						
30						

Plate A4.5

APPENDIX B

LABORATORY TESTING

DESCRIPTION OF LABORATORY TESTING

CLASSIFICATION

Field classification was verified in the laboratory in accordance with the Unified Soil Classification System. Laboratory classification was determined by visual examination, sieve analysis tests, and Atterberg Limit tests. Sieve analysis and Atterberg Limit tests were performed in general accordance with ASTM D 422 and ASTM D 4318, respectively. Results of Atterberg Limit tests are plotted on Plate A3.2. The final classifications are shown at the appropriate locations on the Boring Logs, Plates A4.1 through A4.5.

MOISTURE-DENSITY

Representative samples were tested for field moisture content and dry unit weight. The dry unit weight was determined in pounds per cubic foot while the moisture content was determined as a percentage of dry weight. Samples were obtained using a 3-inch O.D. split tube sampler. Test results are shown at the appropriate depths on the Boring Logs, Plates A4.1 through A4.5.

CONSOLIDATION

Selected representative samples were tested for their consolidation characteristics. Test samples were 2.42 inches in diameter and 1 inch high. Porous stones were placed in contact with the top and bottom of test samples to permit addition and release of pore fluid. Loads were then applied in several increments in a geometric progression, and the resulting deformations recorded at selected time intervals. Test results are plotted on the Consolidation Test Reports, Plates B2.1 and B2.2.

SHEAR TESTS

Shear tests were performed in the Direct Shear Machine which is of the strain control type. Each sample was sheared under varying confining loads in order to determine the Coulomb shear strength parameters, cohesion and angle of internal friction. Test results are presented on Plates B3.1 through B3.5.

SWELL TESTS

Swell tests were performed on representative and air-dried soil samples by placing a 90 psf surcharge load on one-inch high specimens. The samples were inundated with water, and total expansion recorded after a period of at least 24 hours. An air-dried sample was allowed to dry overnight prior to testing. Test results were recorded as a percentage of original height. Test results are summarized in the following table:

Sample	Sample Type	Recorded Expansion	Moisture Content Prior to Test
B3 at 1 foot	Representative	0.2%	31%
B3 at 1 foot	Representative, air-dried	9.7%	21%

PROCTOR TEST

A Modified Proctor test was performed in general accordance with ASTM D 1557 on a bulk sample obtained from near boring B3 between depths of about 6 to 18 inches below grade. The test is used to determine the optimum moisture content at which the soil compacts to 100 percent density. Results are shown on Plate B4.1.

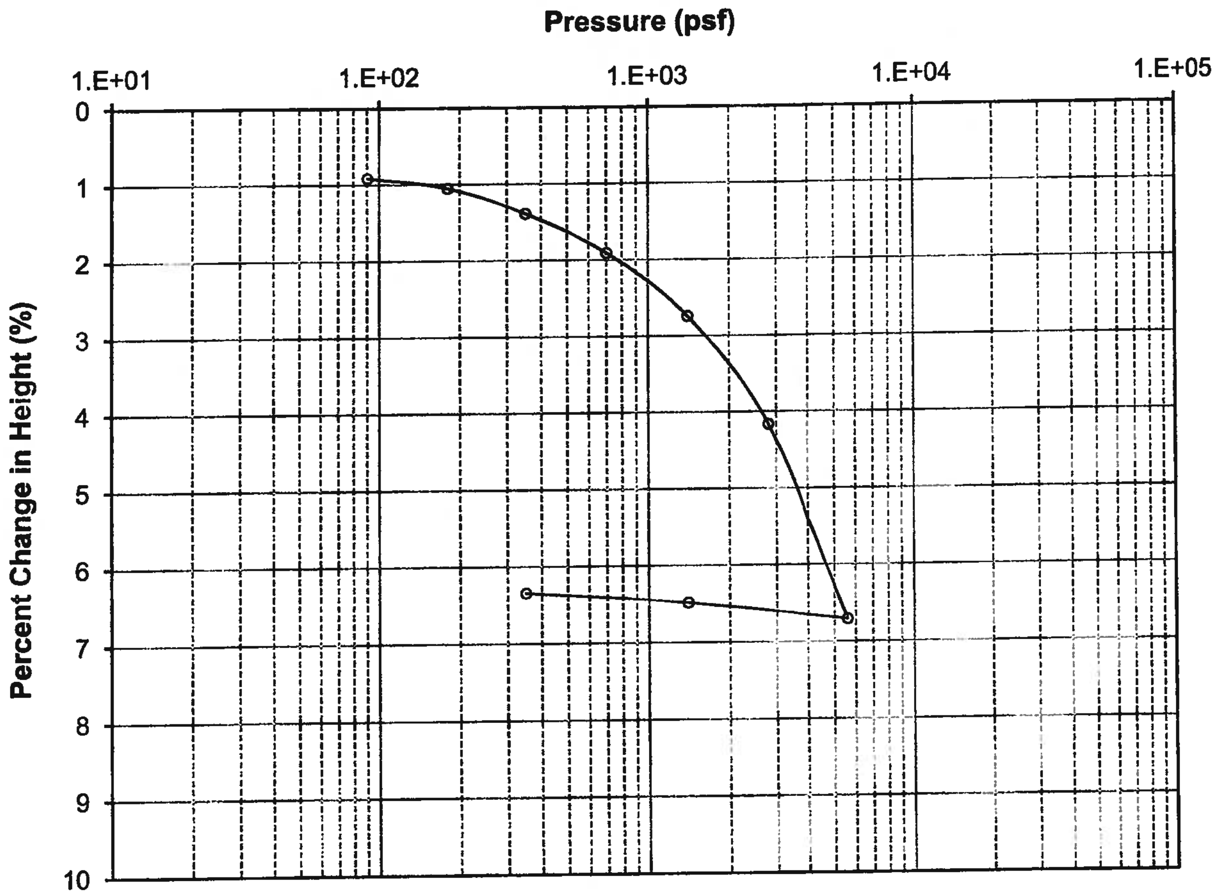
GRADATION ANALYSES

Sieve and hydrometer analysis tests were conducted in general accordance with ASTM D 422 on representative samples obtained from borings B3 and B4 between depths of about 13 to 19 feet and bulk sample S1 between depths of about 0 to 1 foot below grade. The test is used to determine the grain size distribution. Test results are presented on Plates B5.1 and 5.2.

EXPANSION INDEX TEST

An expansion index test was performed in general accordance with ASTM D 4829. A surcharge load of 144 psf was placed on a 1-inch high by 4-inch diameter specimen which was molded to about 50 percent saturation. The sample was inundated with water, and total expansion recorded after volumetric equilibrium was reached. An expansion index test performed on a bulk soil sample obtained from ground surface near boring B3 resulted in an expansion index of 40, corresponding to a low expansion potential.

Consolidation Test Results



Sample Description

Boring No.: B4 Depth (ft): 9

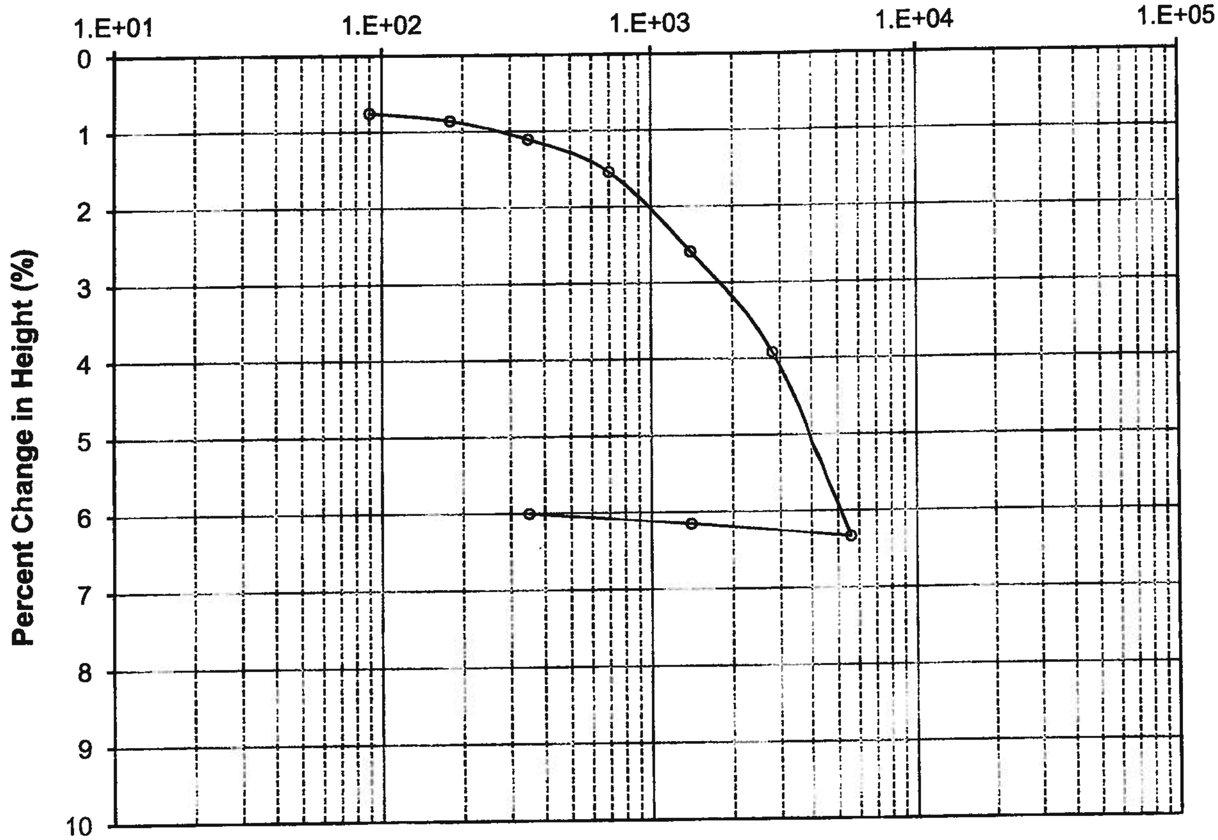
Soil Description: Grayish brown clayey silt

	Moisture Content (%)	Dry Density (pcf)
Initial	48.6	66.0
Final	45.5	70.5

Remark: 12/16/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	CONSOLIDATION TEST Plate B2.1

Consolidation Test Results



Sample Description

Boring No.: B4 Depth (ft): 14

Soil Description: Dark brown silty sand

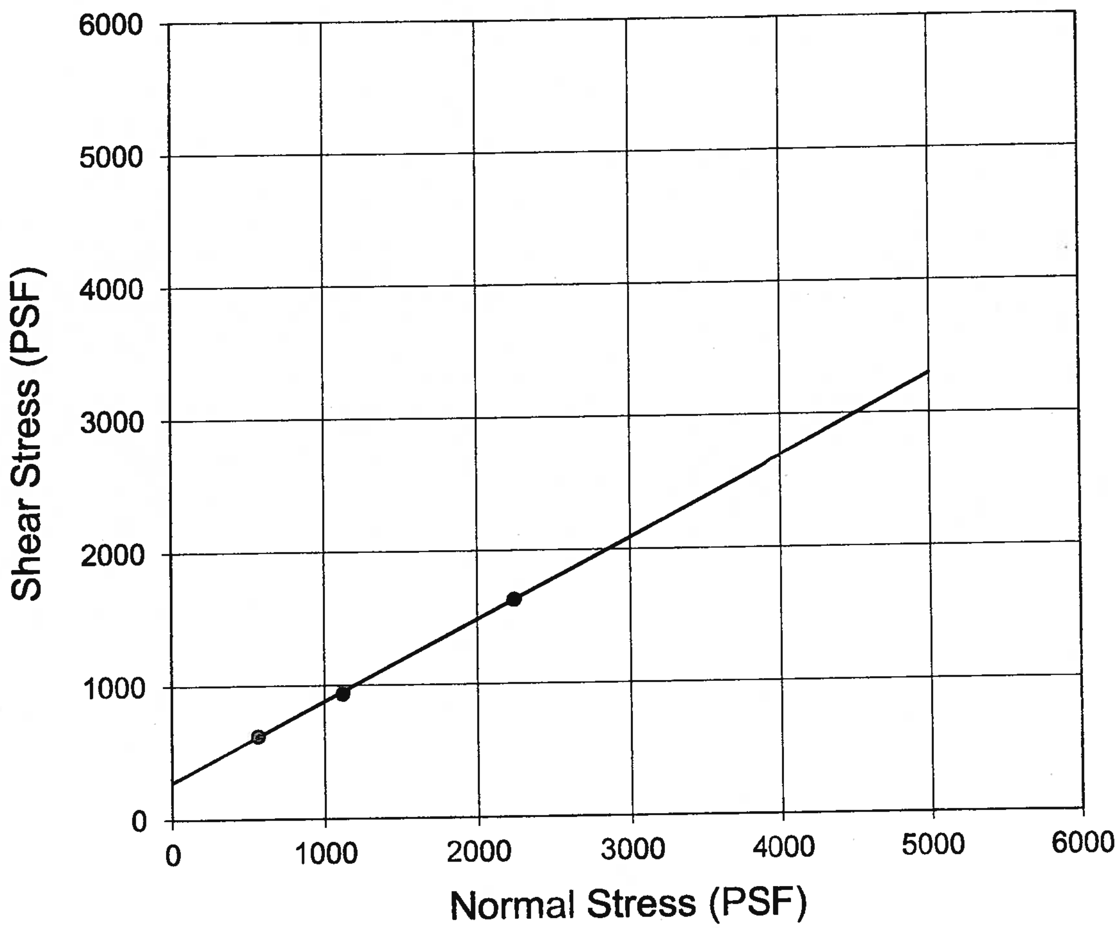
	Moisture Content (%)	Dry Density (pcf)
Initial	37.1	82.7
Final	31.0	88.0

Remark: 12/16/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	CONSOLIDATION TEST

Plate B2.2

Direct Shear Test Results



Sample Description

Boring No.: B1 Depth (ft): 9

Soil Description: Brown silty sand

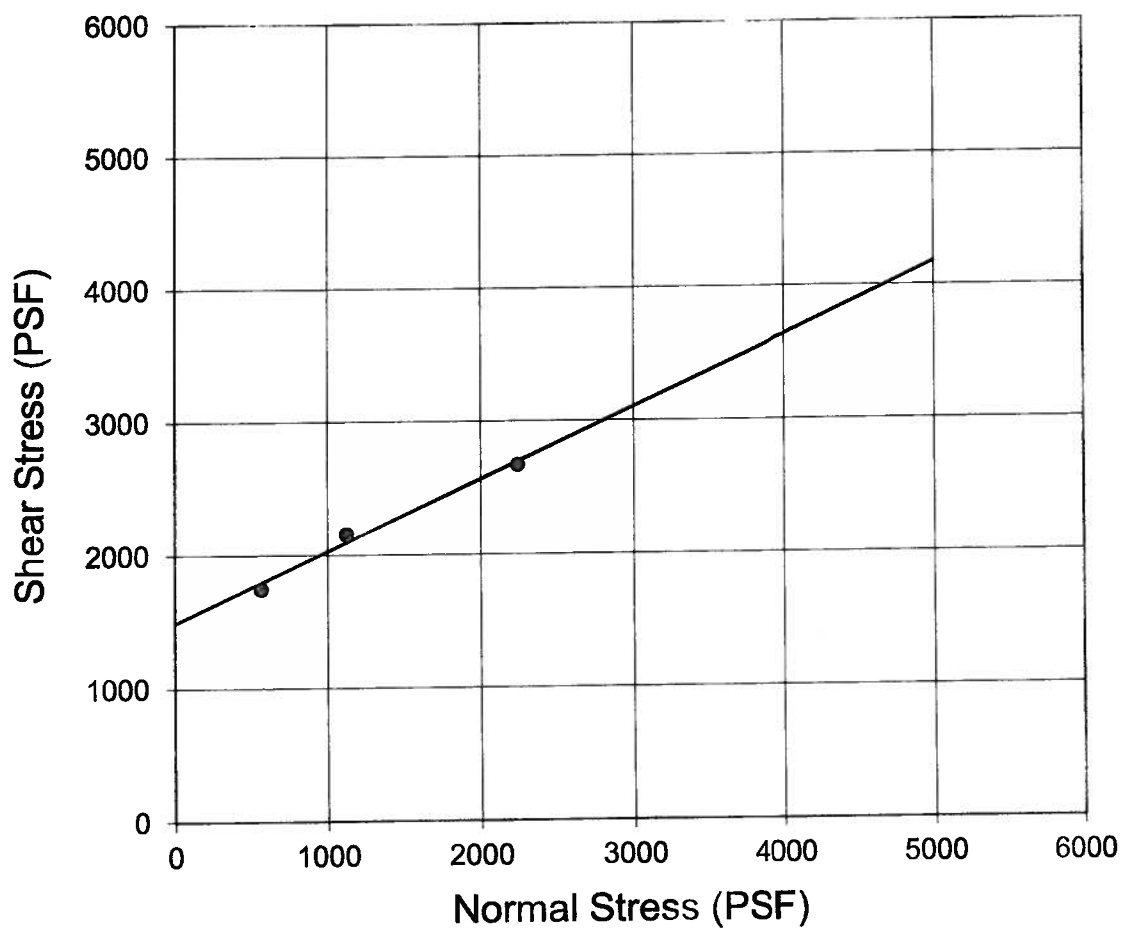
Strength Intercept (C): 276.7 PSF (Peak Strength)

Friction Angle (ϕ): 31.1 DEG (Peak Strength)

Remark: 12/16/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	DIRECT SHEAR TEST Plate B3.1

Direct Shear Test Results



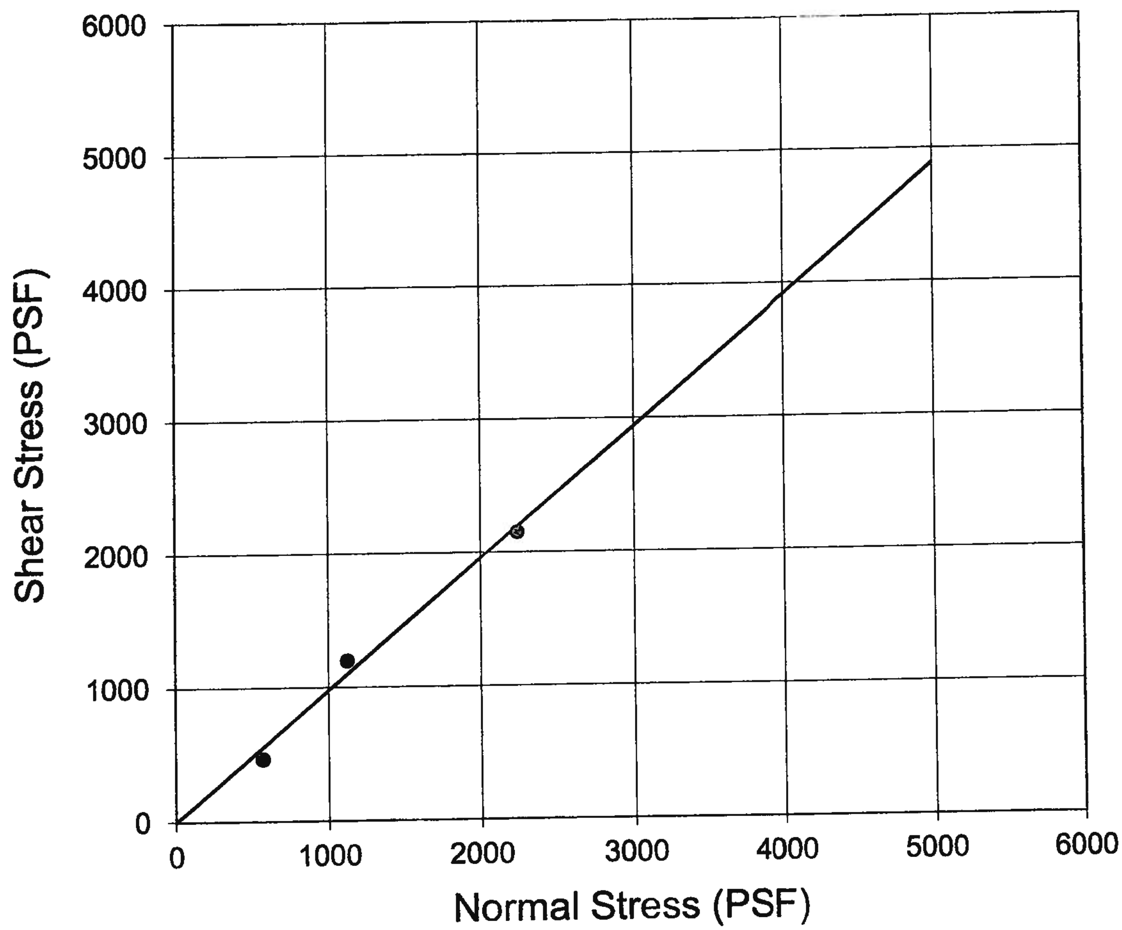
Sample Description

Boring No.: B3 Depth (ft): 5
Soil Description: Grayish brown clayey silt
Strength Intercept (C): 1490.3 PSF (Peak Strength)
Friction Angle (ϕ): 28.2 DEG (Peak Strength)

Remark: 12/15/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	DIRECT SHEAR TEST Plate B3.2

Direct Shear Test Results



Sample Description

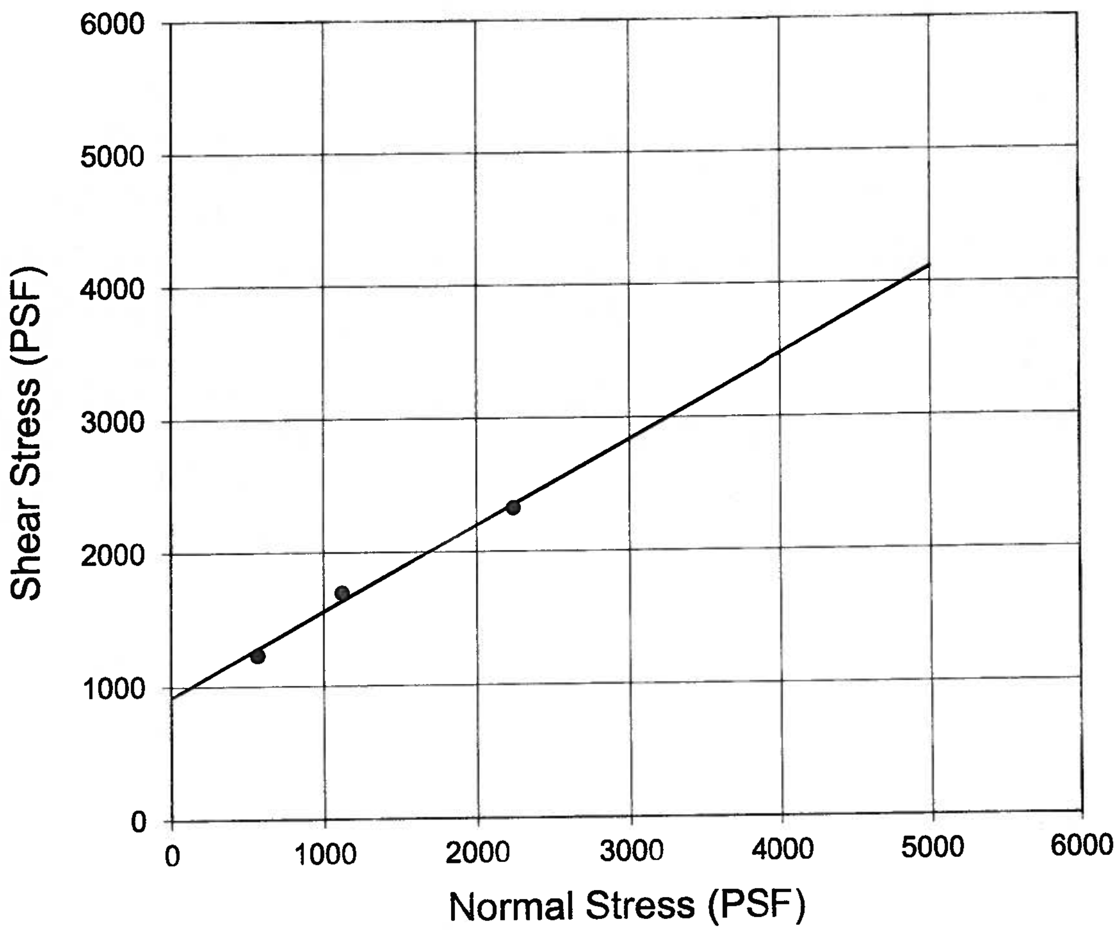
Boring No.: B3		Depth (ft): 9	
Soil Description:	Grayish brown clayey silt		
Strength Intercept (C):		0.0 PSF	(Peak Strength)
Friction Angle (ϕ):		44.3 DEG	(Peak Strength)

Remark: 12/16/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	DIRECT SHEAR TEST

Plate B3.3

Direct Shear Test Results



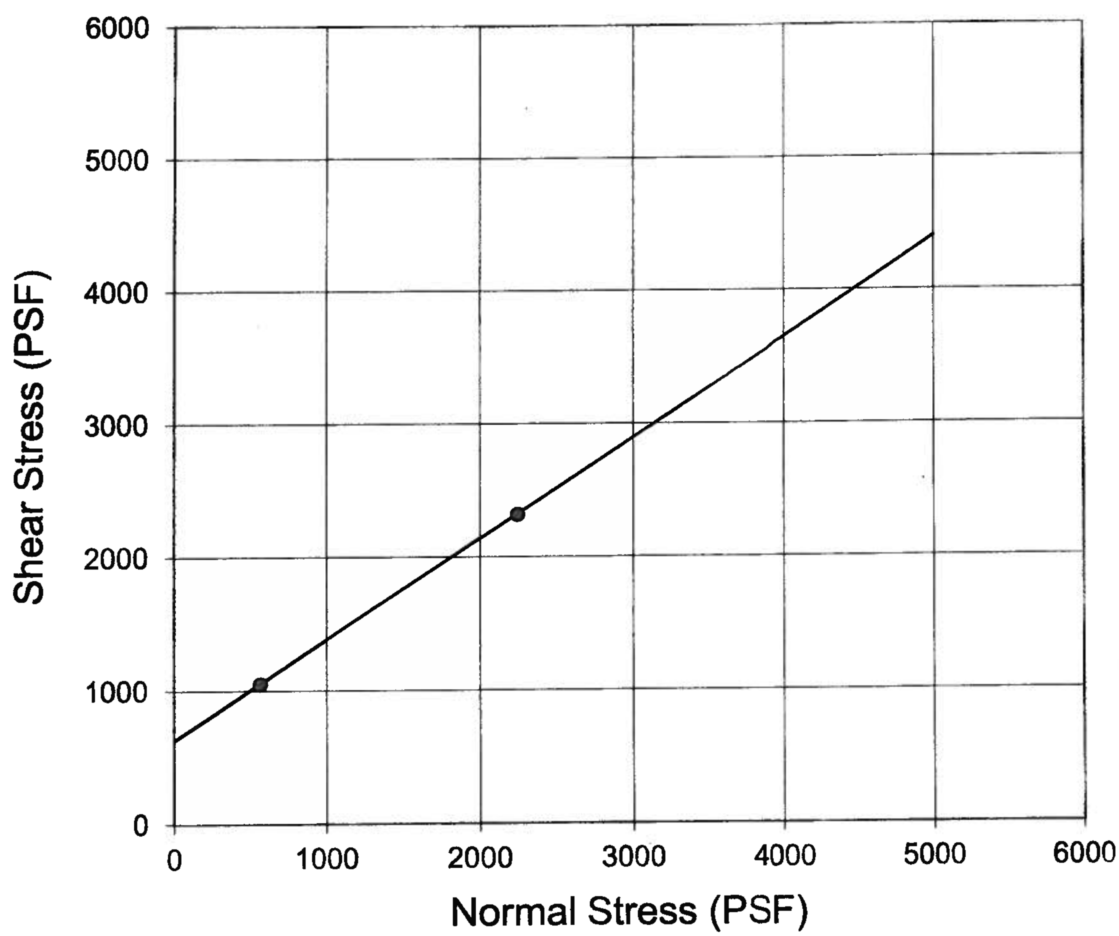
Sample Description

Boring No.: B5 Depth (ft): 8
Soil Description: Grayish brown clayey silt
Strength Intercept (C): 919.2 PSF (Peak Strength)
Friction Angle (ϕ): 32.6 DEG (Peak Strength)

Remark: 12/16/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	DIRECT SHEAR TEST Plate B3.4

Direct Shear Test Results

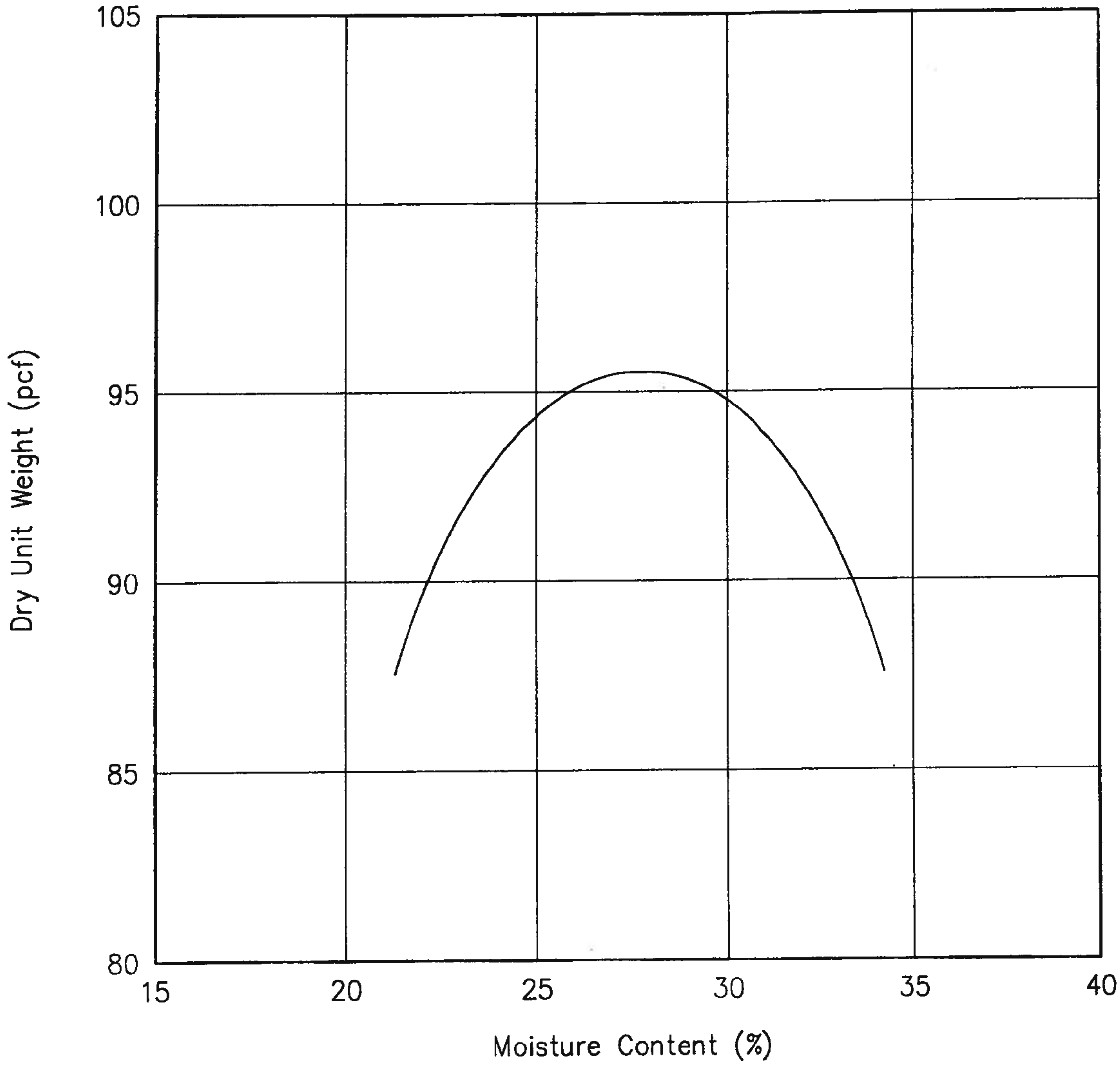


<u>Sample Description</u>

Boring No.: B5		Depth (ft): 13	
Soil Description:	Grayish brown silty sand		
Strength Intercept (C):		630.4 PSF	(Peak Strength)
Friction Angle (ϕ):		37.0 DEG	(Peak Strength)

Remark: 12/16/09

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	DIRECT SHEAR TEST Plate B3.5



Soil Data

Location: Near boring B3 from 6 to 18 inches

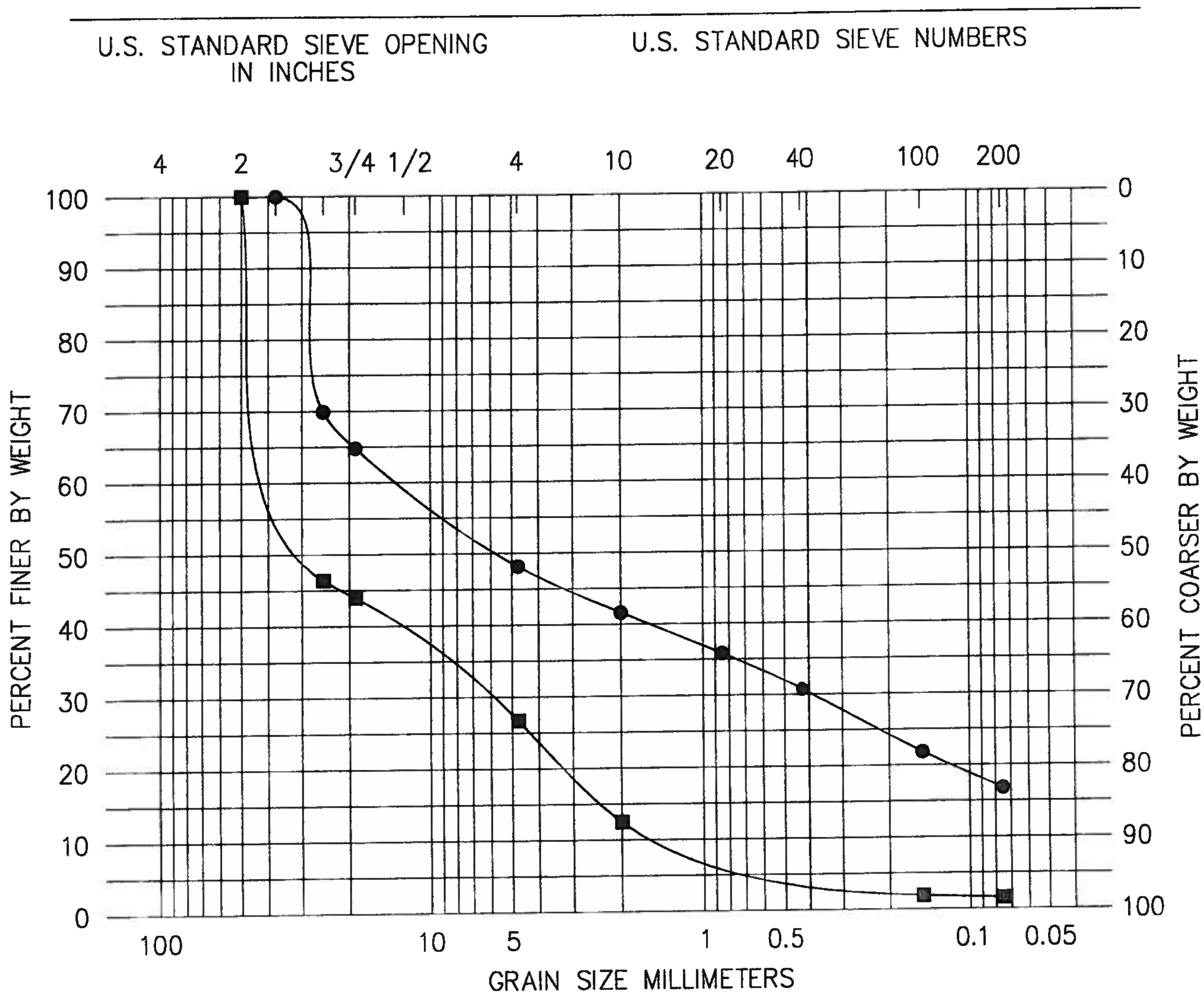
Description: Grayish brown clayey silt

Test Results

Maximum Dry Density: 96 pcf

Optimum Moisture Content: 28%

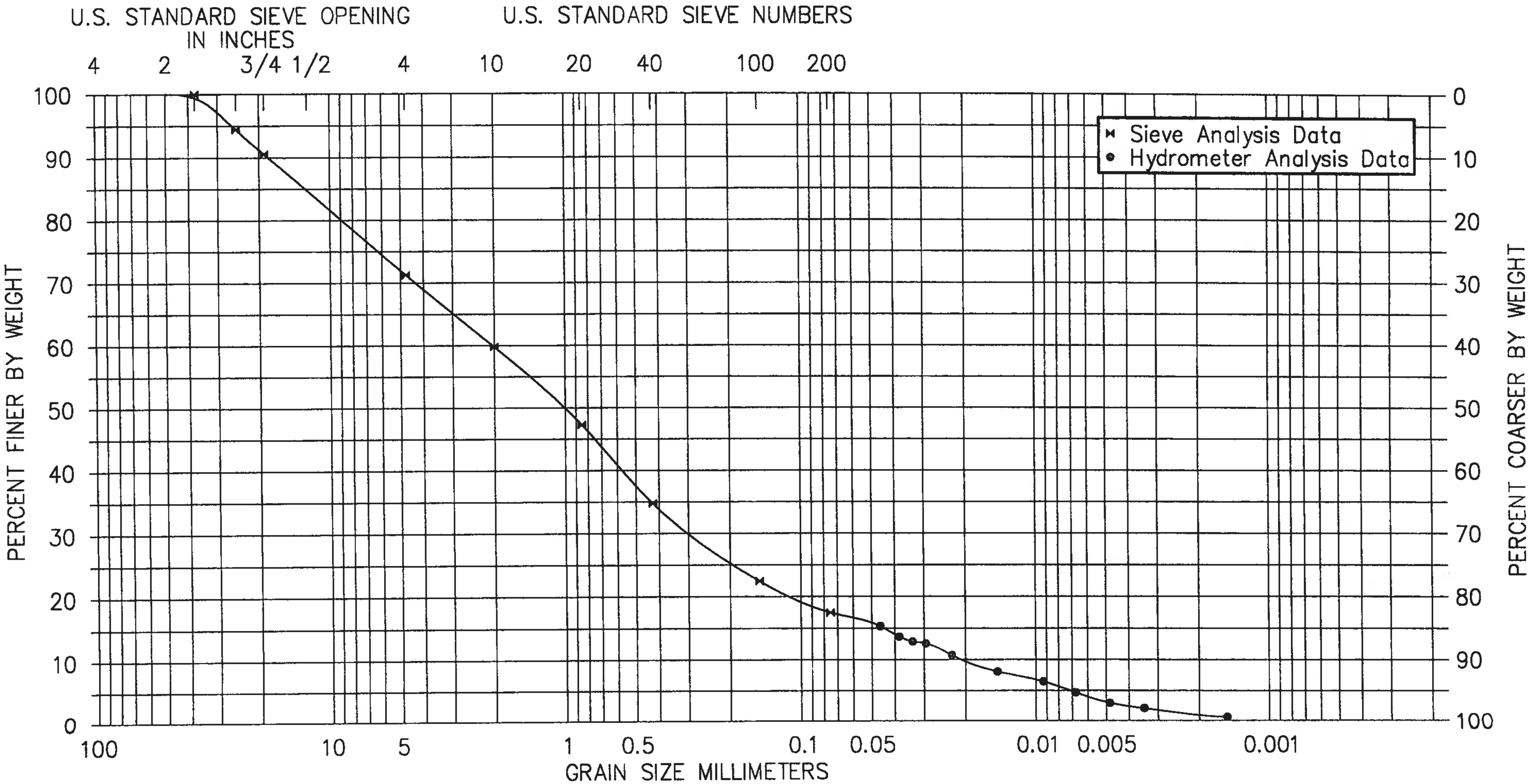
W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	MODIFIED PROCTOR CURVE



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

■ Sample #1	Location:	Bulk Sample S1 from 0 to 1 foot
	Description:	Gray sandy gravel
● Sample #2	Location:	Boring B2 at 13 and 18 feet
	Description:	Gray silty gravel

W.O. 09-4867	**Manoa Stream Improvements at Woodlawn Drive Bridge**
Hirata & Associates, Inc.	GRADATION CURVE Plate B5.1



COBBLES	GRAVEL		SAND			SILT	CLAY	COLLOIDS
	Coarse	Fine	Coarse	Medium	Fine			

Location:	Boring B4 at 14 and 19 feet
Description:	Dark brown silty sand

W.O. 09-4867	Manoa Stream Improvements at Woodlawn Drive Bridge
Hirata & Associates, Inc.	GRADATION CURVE Plate B5.2

Assumed specific gravity = 2.75