EXPLORATORY BORING REPORT
LILIHA STREET REHABILITATION
NORTH KING STREET TO SCHOOL STREET
HONOLULU, HAWAII
PROJECT NO.: 7413A-01-04M

for

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION

HIRATA & ASSOCIATES, INC.
W.O. 12-5333
December 12, 2012

Hirata & Associates
Geotechnical Engineering
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December 12, 2012
W.O. 12-5333

Mr. Herbert Chu
State of Hawaii
Dept. of Transportation - Highways Division
Materials Testing and Research Branch
98-334 Ponohaha Loop
Aiea, Hawaii 96701

Dear Mr. Chu:

Re: Exploratory Boring Report
Liliha Street Rehabilitation
North King Street to School Street
Honolulu, Hawaii
Project No.: 7413A-01-04M

This letter report presents the results of our exploratory borings drilled along Liliha Street for the subject project. Our drilling services were performed in general conformance with the scope presented in our proposal dated February 23, 2012. Foundation design recommendations for the proposed concrete rail extension at the Liliha Street Bridge are presented in a separate foundation investigation report, dated December 12, 2012.

EXPLORATORY BORINGS

Five exploratory borings were drilled along Liliha Street, at selected locations between North King Street and School Street, to depths ranging from about 1.5 to 3.5 feet with a B40-L22 truck-mounted drill rig. The approximate location of the exploratory borings are shown on the attached Boring Location Plans, Plates 2.1 through 2.3.

Prior to drilling into the subgrade soils, core samples of the AC pavement were obtained from all borings with a concrete coring machine with a 5.75-inch I.D. core. In addition, a core sample of concrete, at C1, was obtained from a bus pad. Several attempts to obtain a core sample of concrete from C2 were terminated due to reinforcing steel encountered during coring operations. The thickness of the concrete bus pad at C2 was determined by augering immediately adjacent to the concrete pad. The drilled hole indicated a concrete thickness of about 13 inches at C2. Photographs of pavement cores are presented on Plates 4.1 through 4.3.

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. The soils encountered are logged on Plates 3.1 through 3.5.

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 Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004. The accuracy of the boring locations shown on Plates 2.1 through 2.3 and the boring elevations shown on Plates 3.1 through 3.5 are therefore approximate, in accordance with the field methods used.

LABORATORY TESTING

Classification - Soil classification was verified in the laboratory in accordance with the Unified Soil Classification System. Laboratory classification was determined by visual examination. The final classifications are shown at the appropriate locations on the Boring Logs, Plates 3.1 through 3.5.

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 3.1 through 3.5.

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 letter report was prepared specifically for the State of Hawaii, Department of Transportation - Highways Division and their consultants. The boring logs presented in this letter report are presented for information only.

The services performed for this project were performed in a manner consistent with that level of care, skill, and competence ordinarily exercised by members of the profession in good standing, currently practicing under similar conditions in the same locality. We will not be responsible for the interpretation by others of the information developed. No warranty is made regarding the services performed, either express or implied.

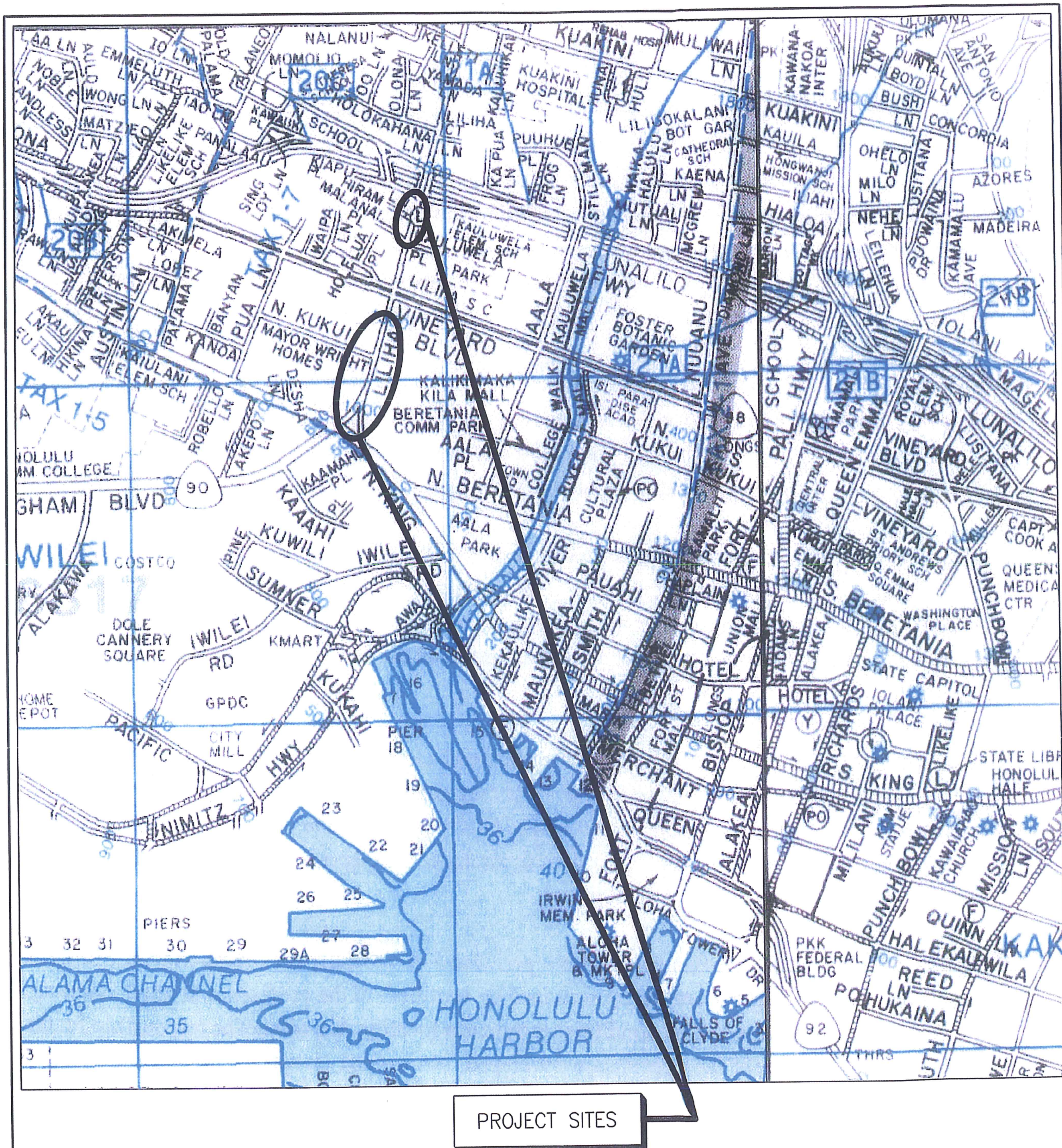
Respectfully submitted,

HIRATA & ASSOCIATES, INC.

Nathan Tanaka

Nathan K. Tanaka, P.E.

Enc: Location Map .... Plate 1
Boring Location Plans .... Plates 2.1 through 2.3
Boring Logs .... Plates 3.1 through 3.5
Pavement Cores .... Plates 4.1 through 4.3



Reference: Bryan's Sectional Maps, 2010 Edition
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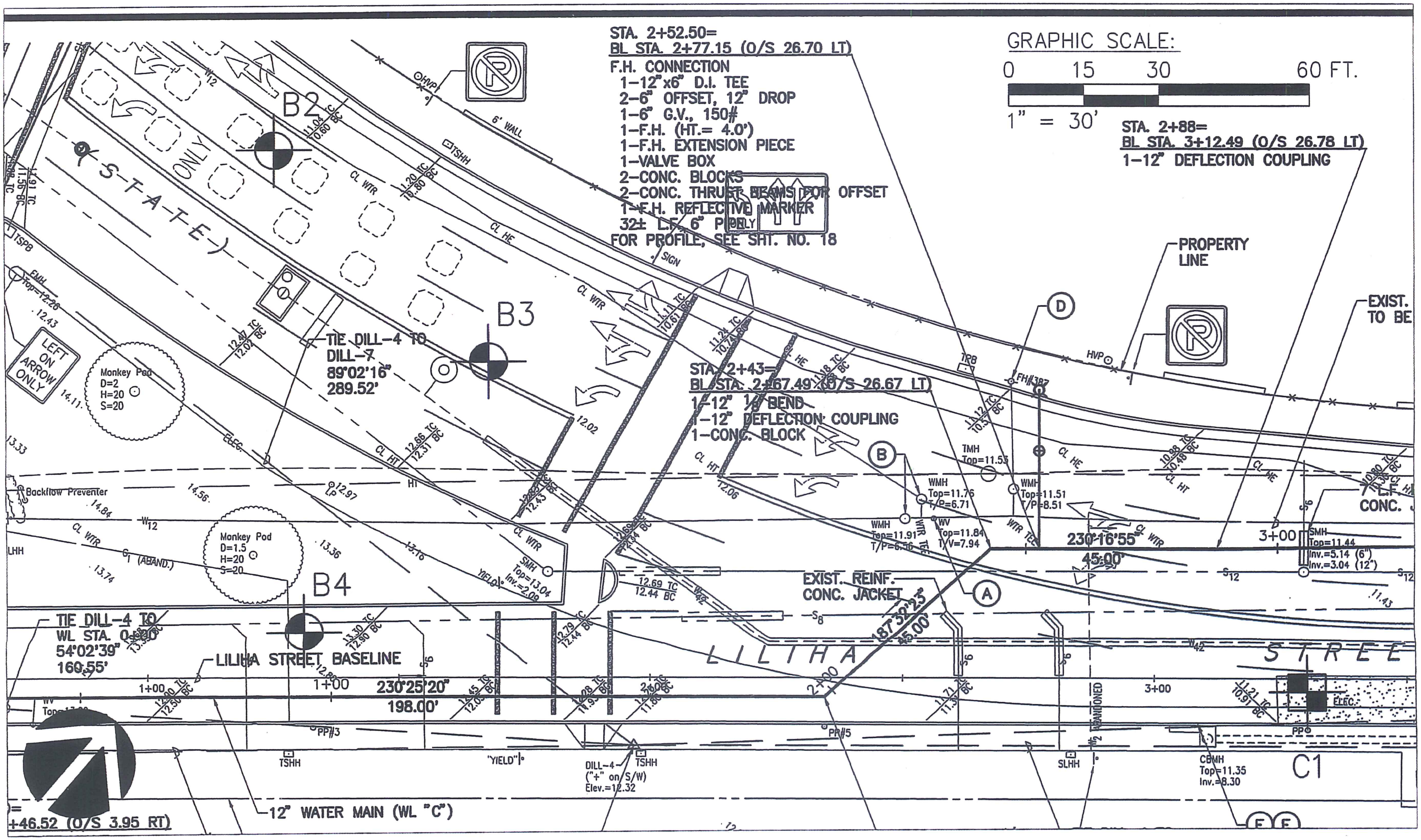
W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	LOCATION MAP Plate 1



LEGEND:

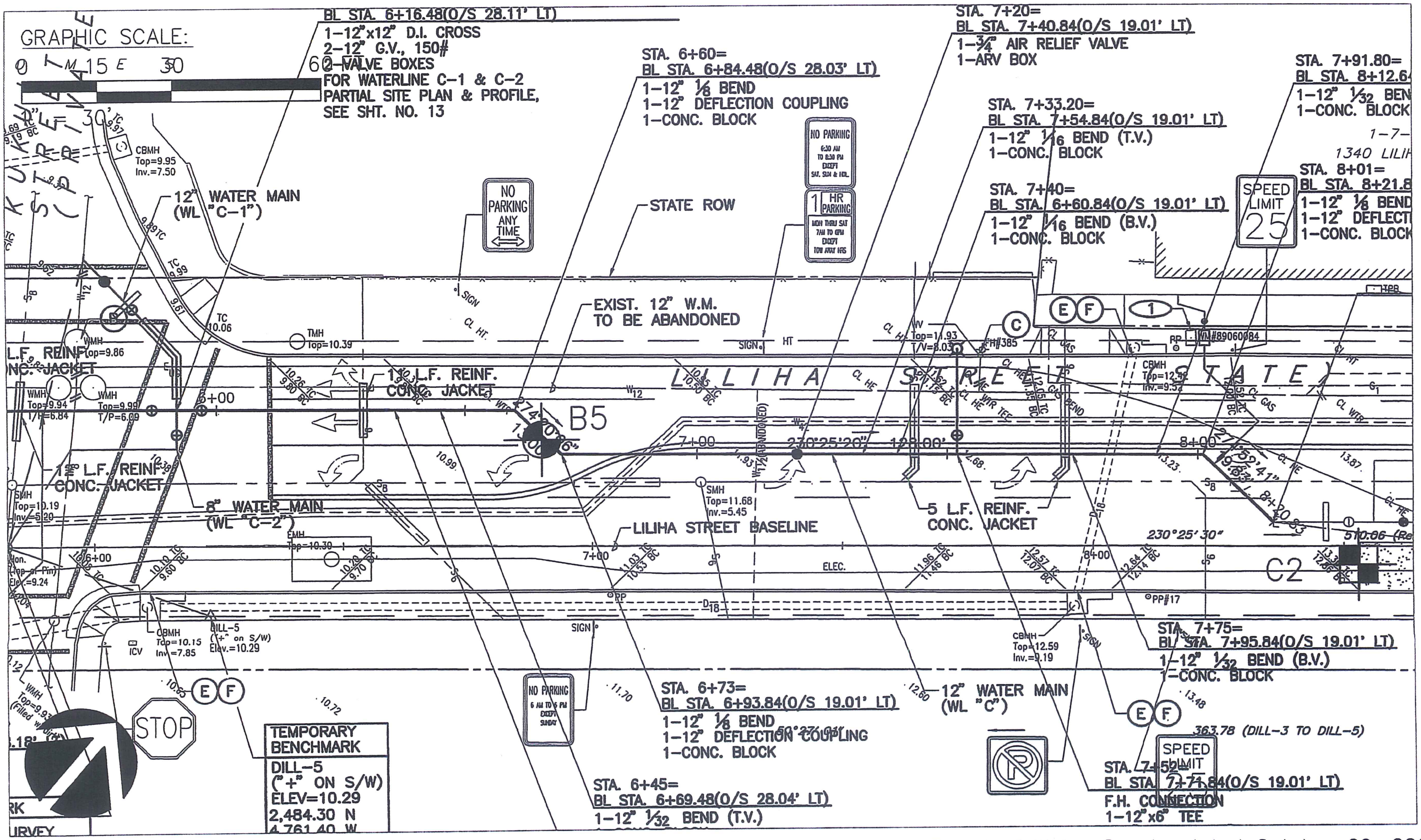
Reference: Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004.

Approximate location of borings

Approximate location of pavement core

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	BORING LOCATION PLAN

Plate 2.1



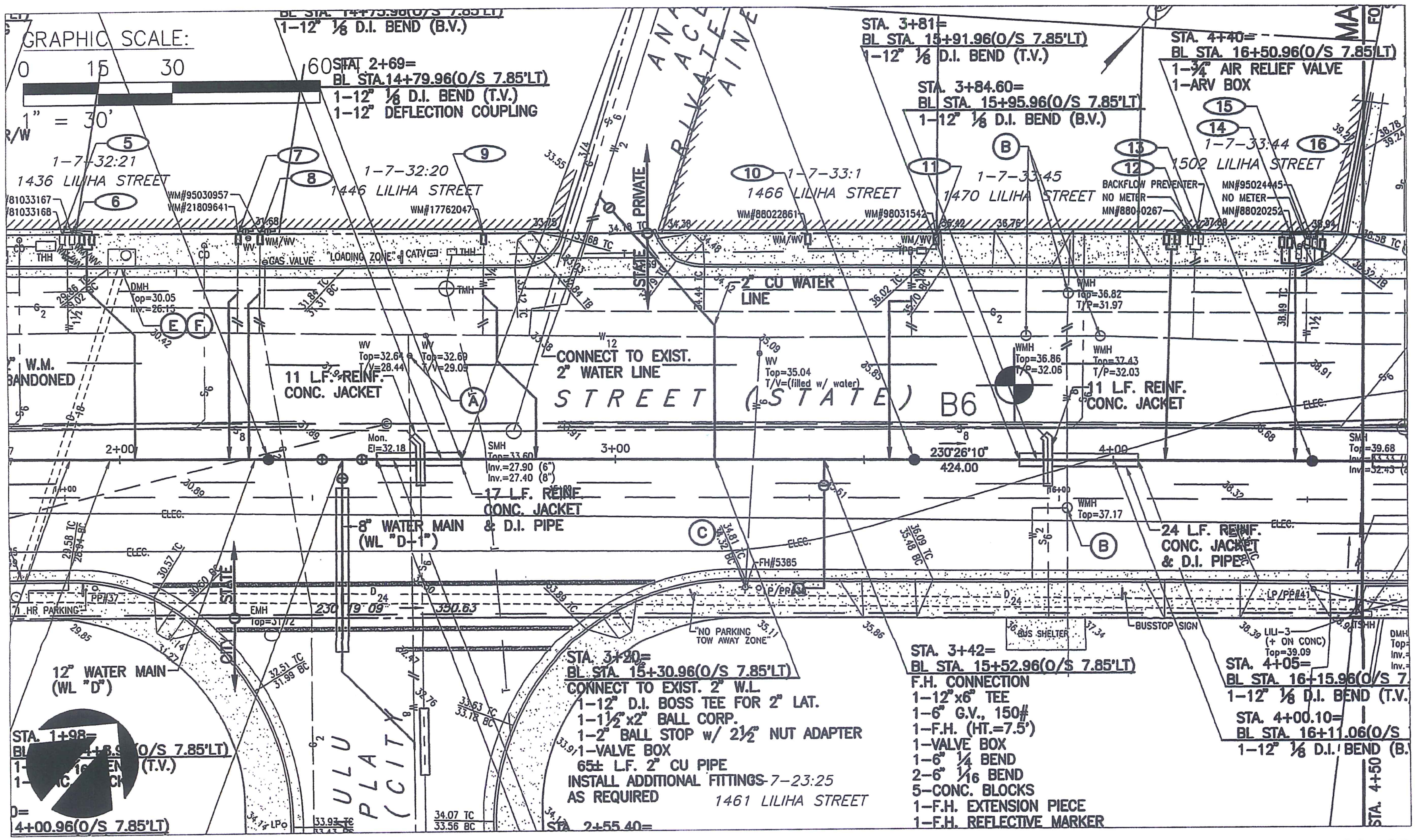
LEGEND:

Approximate location of boring

Approximate location of pavement core

Reference: Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004.

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	BORING LOCATION PLAN Plate 2.2



LEGEND:

Approximate location of boring

Reference: Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004.

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	BORING LOCATION PLAN

Plate 2.3

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 12-5333

BORING NO. B2 DRIVING WT. 140 lb. START DATE 6/5/12

SURFACE ELEV. 11±* DROP 30 in. END DATE 6/5/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0			10/No Penetration			Clayey SILT (ML) – Brown, moist, stiff, with sand and gravel. (Fill) Covered by 6.5 inches of AC over 2 inches of gray basaltic gravel base material.
			10/No Penetration			
			23	71	27	
						CINDER (SP) – Dark gray, moist, medium dense.
						End boring at 3.5 feet.
5						
10						Neither groundwater nor seepage water encountered.
15						
20						
25						* Elevations based on Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004.
30						

Plate 3.1

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 12-5333

BORING NO. B3 DRIVING WT. 140 lb. START DATE 6/5/12
SURFACE ELEV. 12± DROP 30 in. END DATE 6/5/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0			10/No Penetration			Silty GRAVEL (GM) - Brown, moist, dense, with sand. (Fill) Covered by 8 inches of AC over 2 inches of gray basaltic gravel base material.
			30	76	19	
						End boring at 3.5 feet.
5						
10						Neither groundwater nor seepage water encountered.
15						
20						
25						
30						

Plate 3.2

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 12-5333

BORING NO. B4 | DRIVING WT. 140 lb. | START DATE 6/5/12

SURFACE ELEV. 13± | DROP 30 in. | END DATE 6/5/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Silty GRAVEL (GM) – Grayish brown, moist, dense, with sand. (Fill) Covered by 6 inches of AC over 2 inches of gray basaltic gravel base material. Loose at 2 feet.
		☐	44	106	11	
		☐	7	82	15	
						Silty SAND (SM) – Tan, moist, loose, with coralline gravel.
5						End boring at 3.5 feet.
10						Neither groundwater nor seepage water encountered.
15						
20						
25						
30						

Plate 3.3

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 12-5333

BORING NO. B5 DRIVING WT. 140 lb. START DATE 6/5/12
SURFACE ELEV. 11± DROP 30 in. END DATE 6/5/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0			50/5"	123	4	Silty SAND (SM) – Gray, dry, with gravel. (Fill) Covered by 7 inches of AC over 2 inches of gray basaltic gravel base material. Concrete encountered at 1.5 feet.
						End boring at 1.5 feet.
5						
10						Neither groundwater nor seepage water encountered.
15						
20						
25						
30						

Plate 3.4

HIRATA & ASSOCIATES, INC.

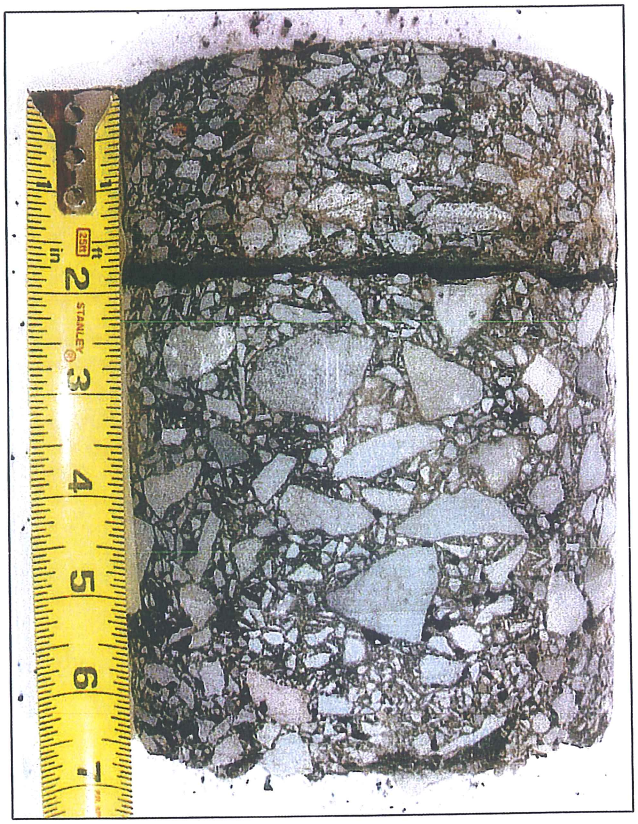
BORING LOG

W.O. 12-5333

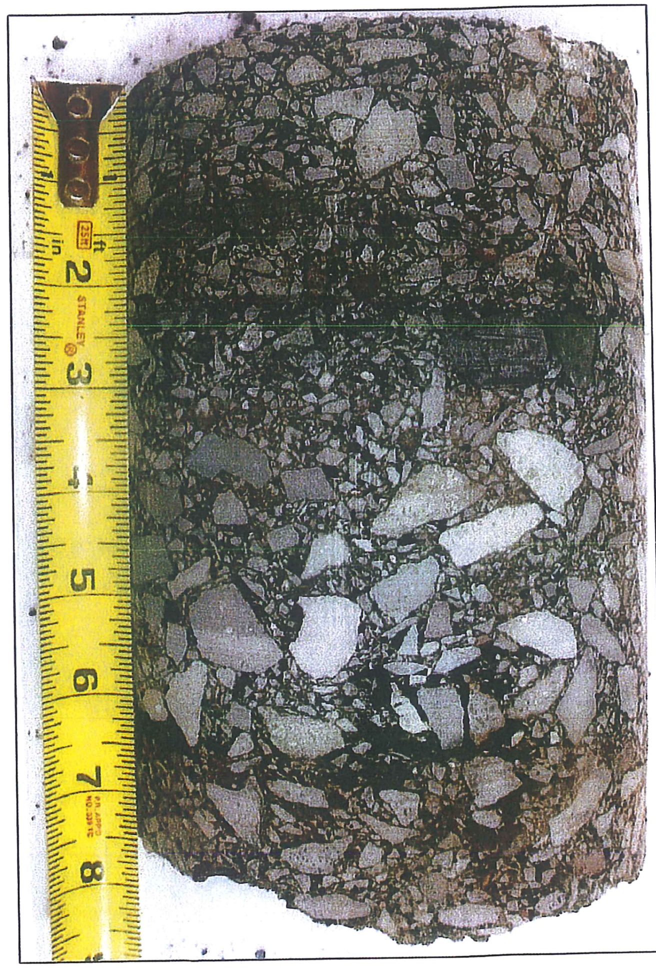
BORING NO. B6 DRIVING WT. 140 lb. START DATE 6/5/12
SURFACE ELEV. 37± DROP 30 in. END DATE 6/5/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0			50/5"	115	7	Silty GRAVEL (GM) – Gray, slightly moist, dense, with sand. (Fill) Covered by 10.5 inches of AC over 1 inch of gray basaltic gravel base material. Concrete encountered at 1.8 feet.
						End boring at 1.8 feet.
5						
10						Neither groundwater nor seepage water encountered.
15						
20						
25						
30						

Plate 3.5



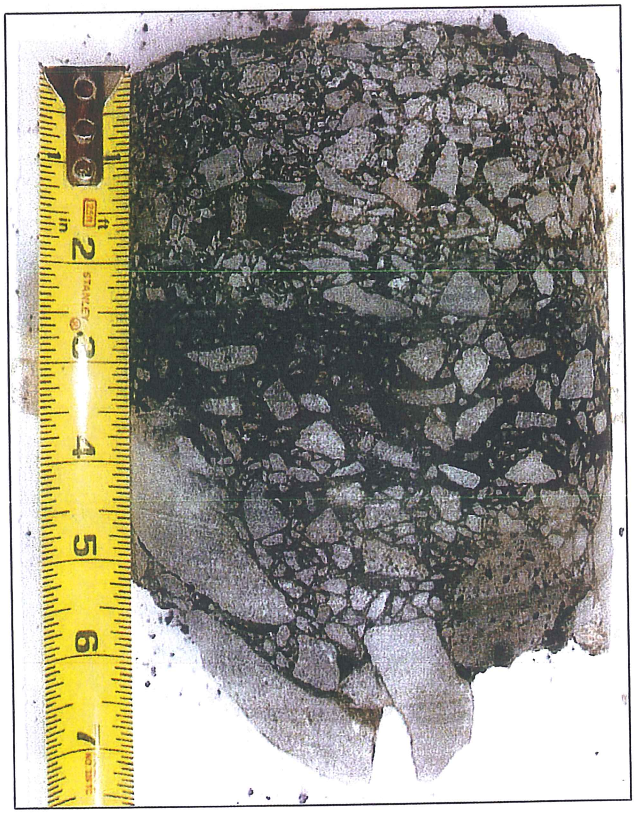
Boring B2



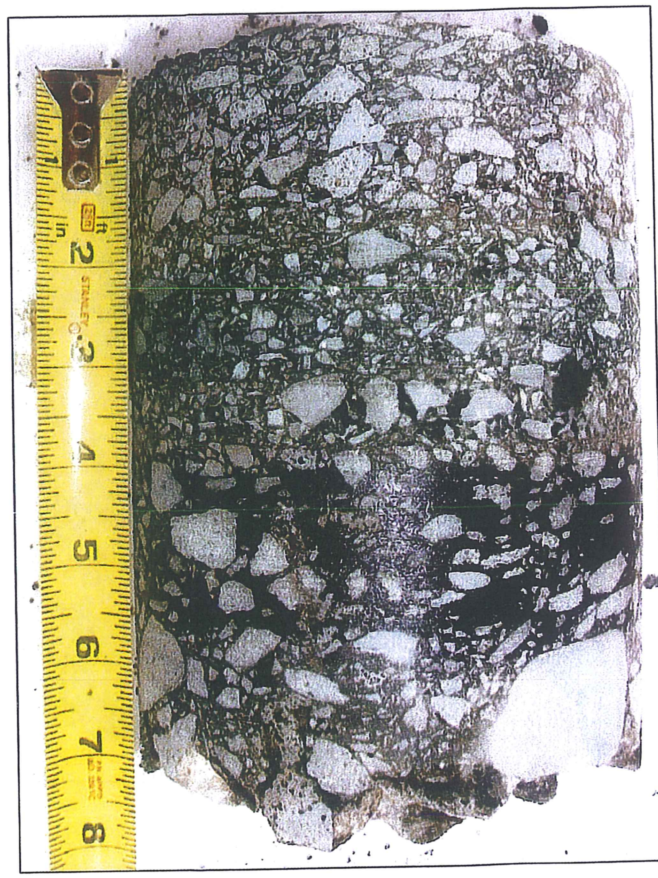
Boring B3

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	PAVEMENT CORES

Plate 4.1



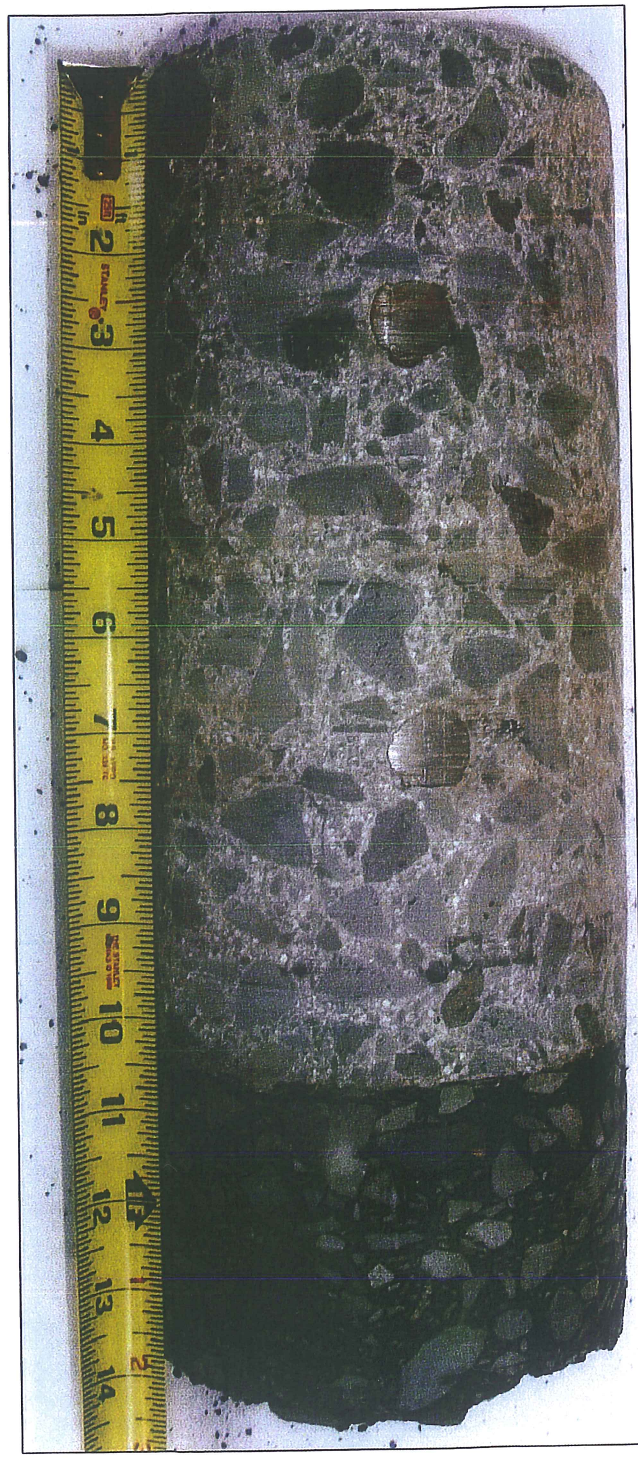
Boring B4



Boring B5

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	PAVEMENT CORES Plate 4.2

Boring B6



Concrete Core C1

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	PAVEMENT CORES

Plate 4.3

FOUNDATION INVESTIGATION
LILIHA STREET REHABILITATION
NORTH KING STREET TO SCHOOL STREET
HONOLULU, HAWAII
PROJECT NO.: 7413A-01-04M

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December 12, 2012
W.O. 12-5333

Mr. Herbert Chu
State of Hawaii
Dept. of Transportation - Highways Division
Materials Testing and Research Branch
98-334 Ponohaha Loop
Aiea, Hawaii 96701

Dear Mr. Chu:

Our report, "Foundation Investigation, Liliha Street Rehabilitation, North King Street to School Street, Honolulu, Hawaii, Project No.: 7413A-01-04M," dated December 12, 2012, our Work Order 12-5333 is enclosed. This investigation was conducted in general conformance with the scope of services presented in our proposal dated February 23, 2012.

Our exploratory boring encountered brown clayey silt in a medium stiff condition, extending from below the AC pavement to a depth of about 4 feet. The clayey silt was underlain by mottled grayish brown silty clay in a firm to medium stiff condition. Underlying the silty clay about 12 feet was a layer of mottled dark grayish brown completely weathered basalt. Hard, gray, moderately weathered basalt was encountered at a depth of about 15 feet, extending to the maximum depth drilled. Seepage water was encountered in the boring at a depth of about 5 feet.

Drilled shaft foundations extending through the surface clayey soils and embedded in the underlying hard basalt may be used for support of the proposed concrete rail extension. Vertical load bearing capacity as well as uplift capacity may be derived from frictional resistance between the drilled shaft and hard basalt. However, we believe that the required drilled shaft lengths will be controlled by the design lateral load and overturning moment.

Additional geotechnical recommendations for the design of the guard rail are included in this report, as well as more detailed explanations of our recommendations.

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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FOUNDATION INVESTIGATION
LILIHA STREET REHABILITATION
NORTH KING STREET TO SCHOOL STREET
HONOLULU, HAWAII
PROJECT NO.: 7413A-01-04M

INTRODUCTION

This report presents the results of our foundation investigation performed for the proposed concrete rail extension on the Liliha Street Bridge, in Honolulu, Hawaii. Our scope of services for this study included the following:

- A visual reconnaissance of the site 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 one exploratory boring to a depth of approximately 45.5 feet. A description of our field investigation is summarized on Plates A1.1 and A1.2. The approximate exploratory boring location is shown on the enclosed Boring Location Plan, Plate A2.2, and the soils encountered in the boring are described on the Boring Logs, Plates A4.1 and A4.2.

- Obtaining a core sample of the AC pavement from the boring. The approximate exploratory boring location is shown on the enclosed Boring Location Plan, Plate A2.2, and a photograph of the pavement core is presented on Plate A5.1.

- Laboratory testing of selected soil samples. Testing procedures are presented in the Description of Laboratory Testing, Plates B1.1 and B1.2. Test results are presented in the Description of Laboratory Testing, and on the Boring Logs (Plates A4.1 and A4.2), Consolidation Test report (Plate B2.1), and Direct Shear Test reports (Plates B3.1 and B3.2).

- Engineering analyses of the field and laboratory data.

- Preparation of this report presenting geotechnical recommendations for design of the bridge rail extension foundations, including seismic considerations, resistance to lateral pressures, and site grading.

PROJECT CONSIDERATIONS

Information regarding the proposed project was provided by personnel from your office.

The proposed project will consist of extending the concrete rail from the northwest corner of the Liliha Street Bridge, about 20 to 25 feet along North School Street. The proposed concrete rail will be situated at the top of a slope which extends down to the H-1 Lunalilo Freeway. Vertical loads for the concrete rail are expected to be light, however, the concrete rails will be designed for vehicle impact loads. As a result, we understand that drilled shafts will be used for support of the proposed concrete rail extension.

Finish grades will generally match the existing, and we expect that only minor site grading will be required for the project.

SITE CONDITIONS

Liliha Street Bridge extends over the H-1 Lunalilo Freeway, in Honolulu, Hawaii, between the intersections of Liliha Street with North School Street and Kiapu Place (or Liliha Access Road). The proposed concrete rail will extend from the northwest corner of the bridge, along the southwest side of North School Street.

The concrete rail will parallel the top of a slope which extends down to the H-1 Lunalilo Freeway. The slope is lightly vegetated, approximately 20 feet in height, and slopes at gradients of about 1.5H:1V. A chainlink fence extends along the top of the slope. Also, a drain inlet is located on the southwest side North School Street, about 15 to 20 feet from Liliha Street.

Drainage along North School Street generally flows in a southeasterly direction. Total relief along the top of slope is approximately 1 foot, with ground elevations ranging from about +49 to +50.

SOIL CONDITIONS

Our boring extended through about 9 inches of AC over approximately 2 inches of base material. Underlying the pavement section was brown clayey silt in a medium stiff condition, extending to a depth of about 4 feet. The clayey silt was underlain by mottled grayish brown silty clay in a firm to medium stiff condition, extending to a depth of about 12 feet.

Although laboratory testing on the near surface clayey silt indicated a low expansion potential when at its in-situ moisture content, our past experience in the project area indicates that the clayey soils are usually moderately to highly expansive. The Soil Survey, prepared by the U.S. Soil Conservation Service, also describes the clay soils in the project area as having a high expansion potential.

The clayey soils were underlain by mottled dark grayish brown completely weathered basalt. The weathered basalt was in a dense condition, and transitioned to gray, moderately weathered basalt at a depth of about 15 feet. The moderately weathered basalt was in a hard condition, and extended to the maximum depth drilled.

Seepage water was encountered in the boring at a depth of about 5 feet.

CONCLUSIONS AND RECOMMENDATIONS

The proposed concrete rail will be designed for vehicle impact loads, and as a result, drilled shafts will be used for support of the proposed concrete rail extension. Due to the light vertical axial load of the proposed concrete rail, the required length of the drilled shaft will be controlled by the design lateral load and overturning moment.

The proposed concrete rail will be situated at the top of a slope, approximately 20 feet in height with gradients of about 1.5H:1V. We recommend that drilled shafts extend through the near surface clayey soils, and be embedded into the underlying hard basalt encountered approximately 15 below the top of slope.

Foundations

Drilled shaft foundations may be used to support the proposed concrete rail extension. Vertical load bearing capacity as well as uplift capacity may be derived from frictional resistance between the drilled shaft and the surrounding hard basalt. The near surface clayey soils overlying the hard basalt should not be considered in computing the load capacity due to friction. The following soil parameters may be used for design of the drilled shaft foundations. The Strength Limit State presented assumes that a static load test will not be performed.

(Hard Basalt)	Strength Limit State	Extreme Event Limit State
Adhesion (Compression)	3,300 psf	6,000 psf
Adhesion (Uplift)	2,400 psf	6,000 psf

Passive earth pressure, presented in the *Lateral Design* section of this report, may be used to evaluate the lateral capacity of drilled shafts.

The bottom of all drilled shaft excavations should be cleaned of loose material prior to placement of reinforcing steel and concrete.

The required drilled shaft diameter and length should be determined by the structural engineer. However, for constructability purposes, we recommend a minimum shaft diameter of 24 inches. In addition, we recommend a minimum 3 feet embedment into hard basalt.

Due to the seepage water encountered in our boring, temporary, non-corrugated steel casing may be necessary to prevent excessive sloughing. The use of permanent casing will not be allowed.

Dewatering of the shaft excavation will not be required for the placement of concrete. However, concrete placed below the level of water should be tremied through a pipe discharging below the surface of fresh concrete. Water displaced by the tremied concrete will need to be contained by the contractor during construction of the foundations.

Seismic Design

Based on the borings drilled as part of this study and our knowledge of the deep soil conditions in the area, the subsurface soils can be characterized as a very dense soil and soft rock profile. Therefore, based on the 2006 International Building Code, Site Class C is recommended for this site.

Lateral Design

Based on a 3-foot embedment into hard basalt, 24-inch diameter drilled shafts may be designed for the following ultimate lateral load capacities and maximum bending moments based on free head conditions. No safety factor was applied to the ultimate capacities and moments. Shear force and bending moment diagrams are presented on Plates C1 and C2.

Free Head Condition		
Shaft Head Deflection	Lateral Load Capacity	Maximum Bending Moment
0.25 inches	5.5 kips	1,020 in-kips
0.50 inches	9.5 kips	1,790 in-kips
1 inch	14.5 kips	2,650 in-kips
2 inches	17.0 kips	3,090 in-kips

Resistance to lateral loading may also be provided by passive earth pressure acting on the embedded portions of drilled shafts in hard basalt.

Passive earth pressure for hard basalt may be computed as an equivalent fluid having a density of 500 pounds per square foot per foot of depth with a maximum earth pressure of 5,000 pounds per square foot. Due to the relatively steep slope gradients, passive earth pressure in the overlying clayey soils should be neglected.

For active earth pressure considerations, equivalent fluid pressures of 45 and 25 pounds per cubic foot may be used for freestanding conditions for the near surface clayey soils and basalt, respectively. To prevent buildup of hydrostatic pressures, weepholes or subdrains should be included in the design of all retaining structures.

Foundation Settlement

Although structural loads were not available at the time of this report, excessive settlement is not anticipated for drilled shaft foundations embedded into the hard basalt stratum.

Site Grading

Site Preparation - The project site should be cleared of all vegetation, including large tree roots, and other deleterious material. In areas requiring fill placement, 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.

Structural Excavations - Based on our exploratory borings, we believe that excavations into the near surface soils can generally be accomplished using conventional excavating equipment.

Shallow temporary cuts into the near surface soils should be stable at slope gradients of 1H:1V or flatter. However, it should be the Contractor's responsibility to conform to all OSHA safety standards for excavations.

Onsite Fill Material - Due to its moderate to high expansion potential, the onsite clayey material will not be acceptable for reuse in compacted fills and backfills.

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 8 and 20 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 15 percent, when tested in accordance with ASTM D 1883.

Compaction - Structural fill and backfill 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.

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 foundation 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 all drilled shaft construction, including the drilling and concrete placement operations, (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 the State of Hawaii, Department of Transportation - Highways Division and their consultants for design of the proposed concrete rail extension on Liliha Street 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 boring, 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 judgement. 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 standing, 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 express or implied.

Respectfully submitted,

HIRATA & ASSOCIATES, INC.

Nathan K. Tanaka, Project Engineer

Rick Yoshida, Project Manager

RICK I.K. YOSHIDA
LICENSED PROFESSIONAL ENGINEER
No. 11118-C
HAWAII, U.S.A.

This work was prepared by me or under my supervision
Expiration Date of License: April 30, 2014

APPENDIX A

FIELD INVESTIGATION

DESCRIPTION OF FIELD INVESTIGATION

GENERAL

The site was explored on June 6 and 7, 2012, by performing a visual reconnaissance of the site and drilling one test boring to a depth of about 45.5 feet with a Mobile B80 truck-mounted drill rig.

A core sample of the AC pavement was obtained from the boring, using a concrete coring machine with a core barrel having an inside diameter of 5.75 inches. A photograph of the pavement core is presented on Plate A5.1.

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. The Unified Soil Classification and Rock Weathering Classification Systems are shown on Plates A3.2 and A3.3, respectively. The soils encountered are logged on Plates A4.1 and A4.2.

The boring was located in the field by measuring/taping offsets from existing site features shown on the plans. The surface elevation at boring location was estimated based on the Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004. The accuracy of the boring location shown on Plate A2.2 and the boring elevation shown on Plates A4.1 and A4.2 are therefore approximate, in accordance with the field methods used.

SOIL SAMPLING

Representative soil samples, as well as rock core samples, were recovered from the boring 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.

ROCK SAMPLING

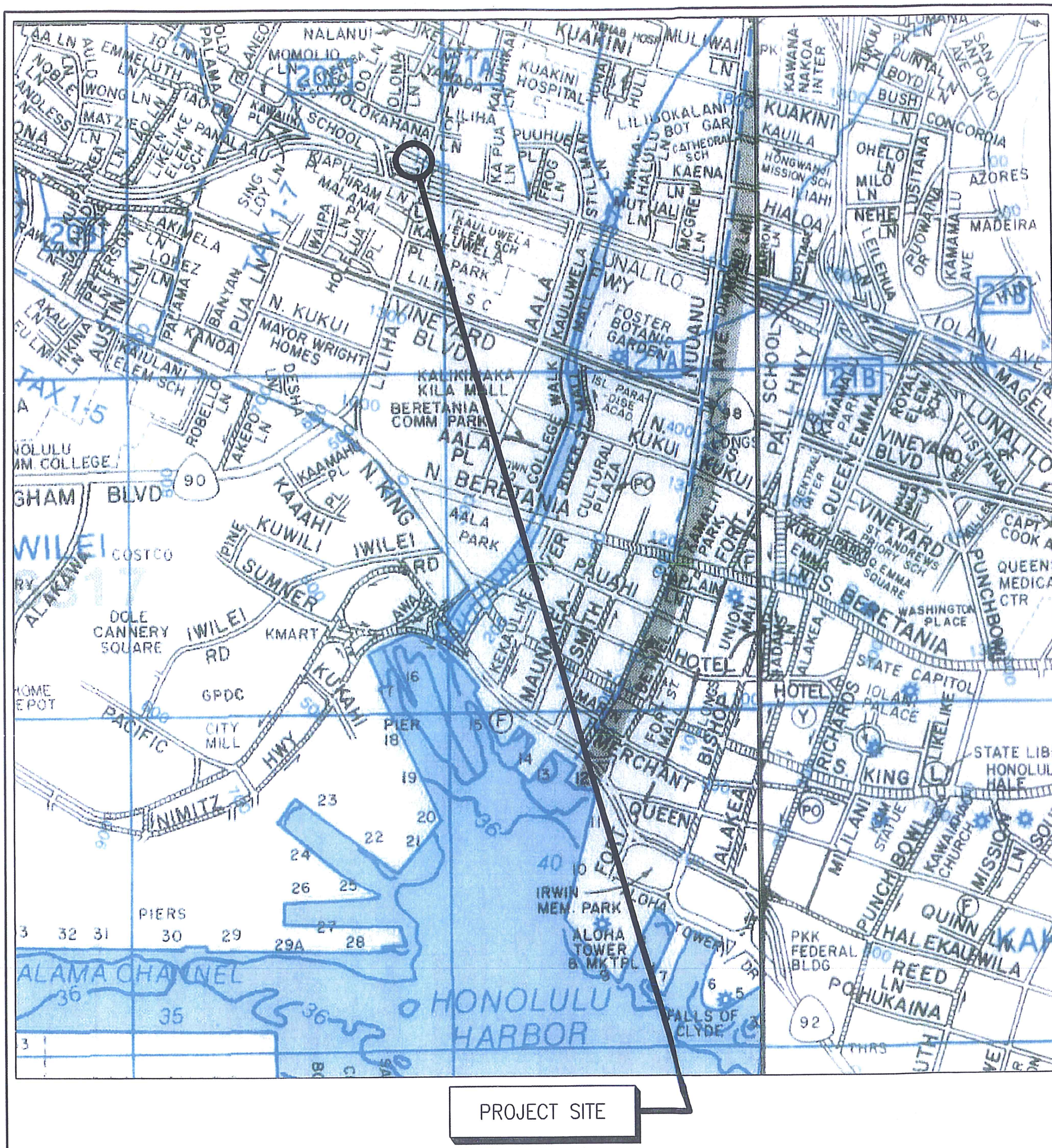
Core samples of rock were obtained by drilling with an NX core barrel having an inside diameter of 2.1 inches. Recovery percentages for each core run are shown on the enclosed Boring Logs.

The rock quality designation (RQD) for the core runs are also shown on the Boring Logs. This is a modified core recovery percentage which takes into account the number of fractures observed in the core samples. Only pieces of core 4 inches in length or longer, as measured along the centerline, were included in the determination of this modified core recovery percentage. Fractures caused by drilling or handling were ignored.

The following is a general correlation between RQD percentages and rock quality.

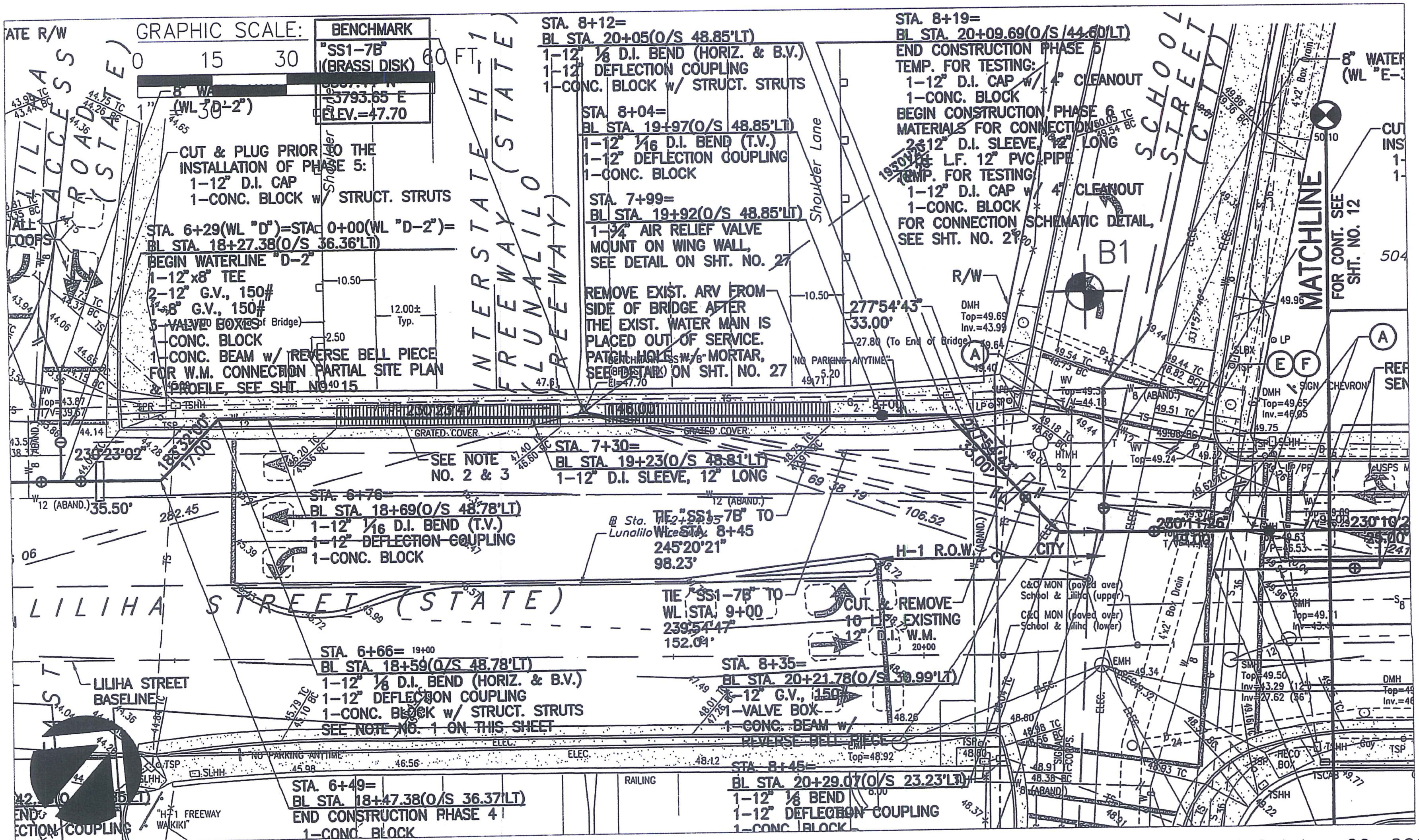
RQD (%)	Description of Rock Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Reference: Tunnel Engineering Handbook, Second Edition, edited by J.O. Bickel, T.R. Kuesel, and E.H. King, 1996.



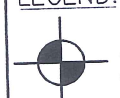
Reference: Bryan's Sectional Maps, 2010 Edition
(Copyright J.R. Clere, used with permission)

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	LOCATION MAP Plate A2.1



Reference: Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004.

LEGEND:


Approximate location of boring

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	BORING LOCATION PLAN

Plate A2.2

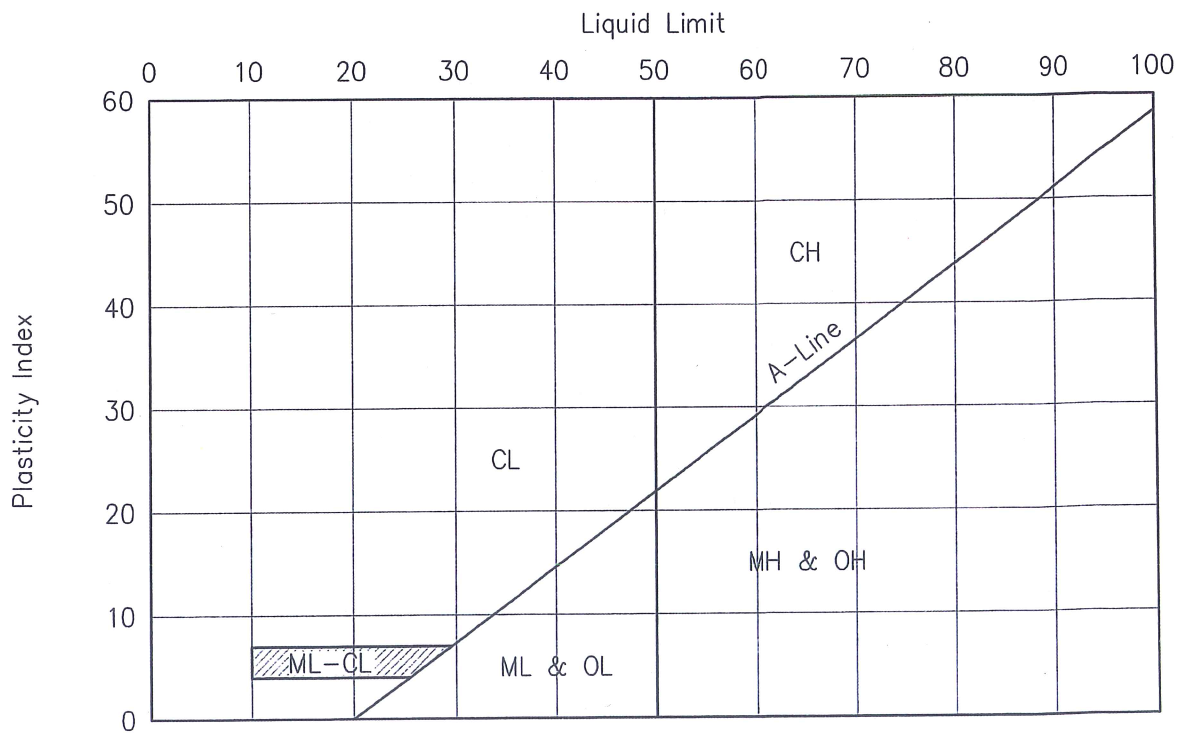
MAJOR DIVISIONS			GROUP SYMBOLS		TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of the material is LARGER than No. 200 sieve size.)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size.)	CLEAN GRAVELS (Little or no fines.)		GW	Well graded gravels, gravel-sand mixtures, little 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. 12-5333	Liliha Street Rehabilitation
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. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	UNIFIED SOIL CLASSIFICATION SYSTEM Plate A3.2

Grade	Symbol	Description
Fresh	F	No visible signs of decomposition or discoloration. Rings under hammer impact.
Slightly Weathered	WS	Slight discoloration inwards from open fractures, otherwise similar to F.
Moderately Weathered	WM	Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock but cores cannot be broken by hand or scraped by knife. Texture preserved.
Highly Weathered	WH	Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with knife. Core stones present in rock mass. Texture becoming indistinct but fabric preserved.
Completely Weathered	WC	Minerals decomposed to soil but fabric and structure preserved (Saprolite). Specimens easily crumbled or penetrated.
Residual Soil	RS	Advanced state of decomposition resulting in plastic soils. Rock fabric and structure completely destroyed. Large volume change.

Reference: Soils Mechanics, NAVFAC DM-7.1, Department of the Navy, Naval Facilities Engineering Command, September, 1986.

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	ROCK WEATHERING CLASSIFICATION SYSTEM Plate A3.3

HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 12-5333

BORING NO. B1 | DRIVING WT. 140 lb. | START DATE 6/6/12

SURFACE ELEV. 49±* | DROP 30 in. | END DATE 6/7/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0			20 25	76 77	35 37	Clayey SILT (MH) – Brown, moist, medium stiff. Covered by 9.5 inches of AC over 2 inches of gray basaltic gravel base material.
5 10			9 21	64 67	56 55	Silty CLAY (CH) – Mottled grayish brown, moist, firm to medium stiff. Seepage water encountered at 5 feet.
			76/11"	73	49	WEATHERED BASALT (WC) – Mottled dark grayish brown, moist, dense, completely weathered.
15 20 25 30						BASALT (WM) – Gray, hard, moderately weathered. Begin NX coring at 15.5 feet. 100% Recovery from 15.5 to 20.5 feet. RQD = 100% 98% Recovery from 20.5 to 25.5 feet. RQD = 92% 100% Recovery from 25.5 to 30.5 feet. RQD = 15% With highly weathered seams from 26 feet.

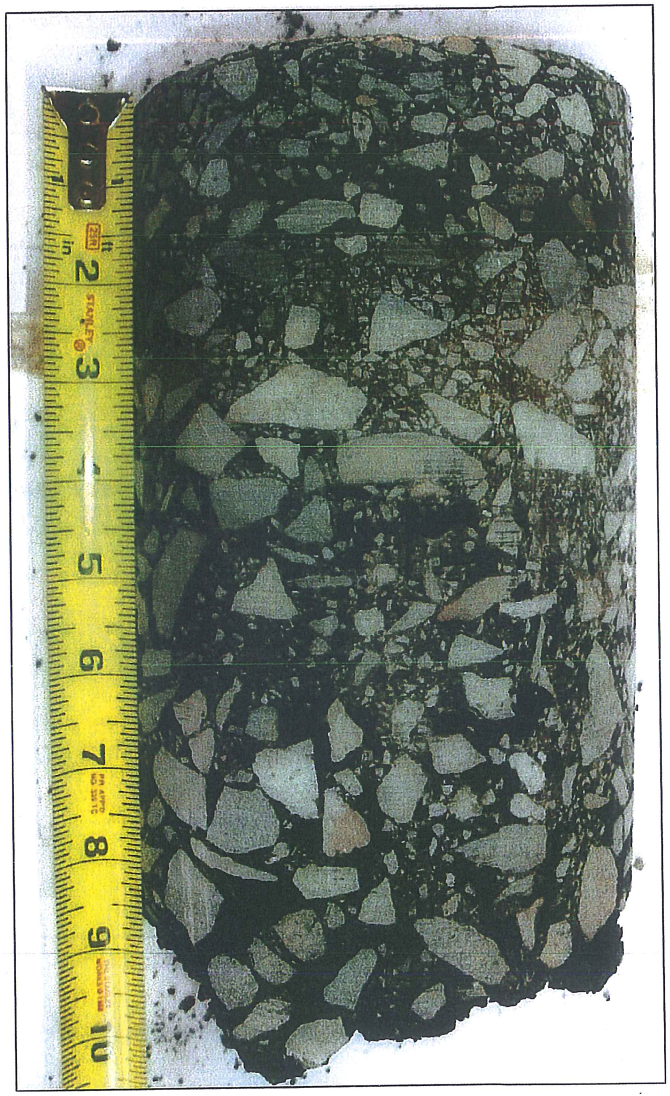
HIRATA & ASSOCIATES, INC.

BORING LOG

W.O. 12-5333

BORING NO. B1 (continued) DRIVING WT. 140 lb. START DATE 6/6/12
SURFACE ELEV. 49± DROP 30 in. END DATE 6/7/12

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
30						100% Recovery from 30.5 to 35.5 feet. RQD = 38%
35						100% Recovery from 35.5 to 40.5 feet. RQD = 78%
40						100% Recovery from 40.5 to 45.5 feet. RQD = 87%
45						End boring at 45.5 feet.
50						
55						Groundwater not encountered. * Elevations based on Plan & Profile prepared by City and County of Honolulu, Board of Water Supply, dated October 29, 2004.
60						



Boring B1

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	PAVEMENT CORE Plate A5.1

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. The final classifications are shown at the appropriate locations on the Boring Logs, Plates A4.1 and A4.2.

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 and A4.2.

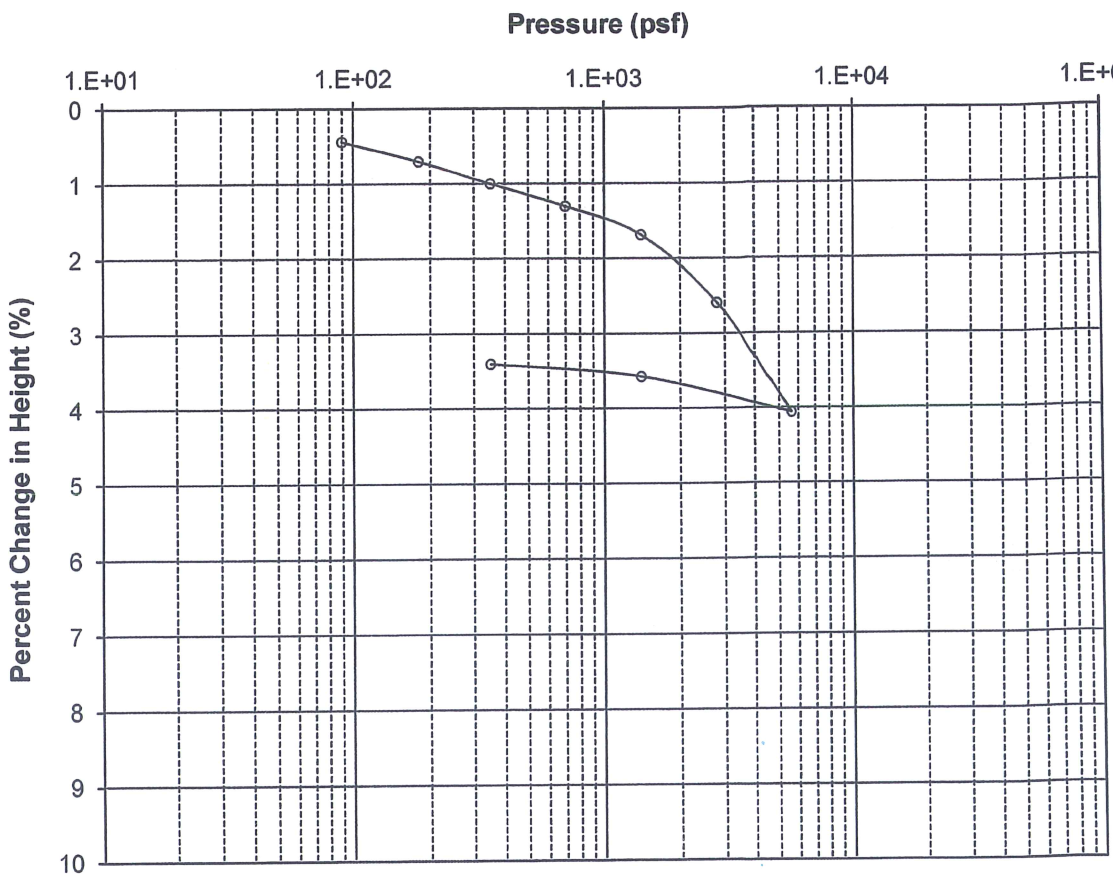
CONSOLIDATION

A selected representative sample was tested for its consolidation characteristics. The test sample was 2.42 inches in diameter and 1 inch high. Porous stones were placed in contact with the top and bottom of the test sample 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 Report, Plate B2.1.

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 and B3.2.

Consolidation Test Results



Sample Description

Boring No.: B1 Depth (ft): 4

Soil Description: Mottled grayish brown silty clay

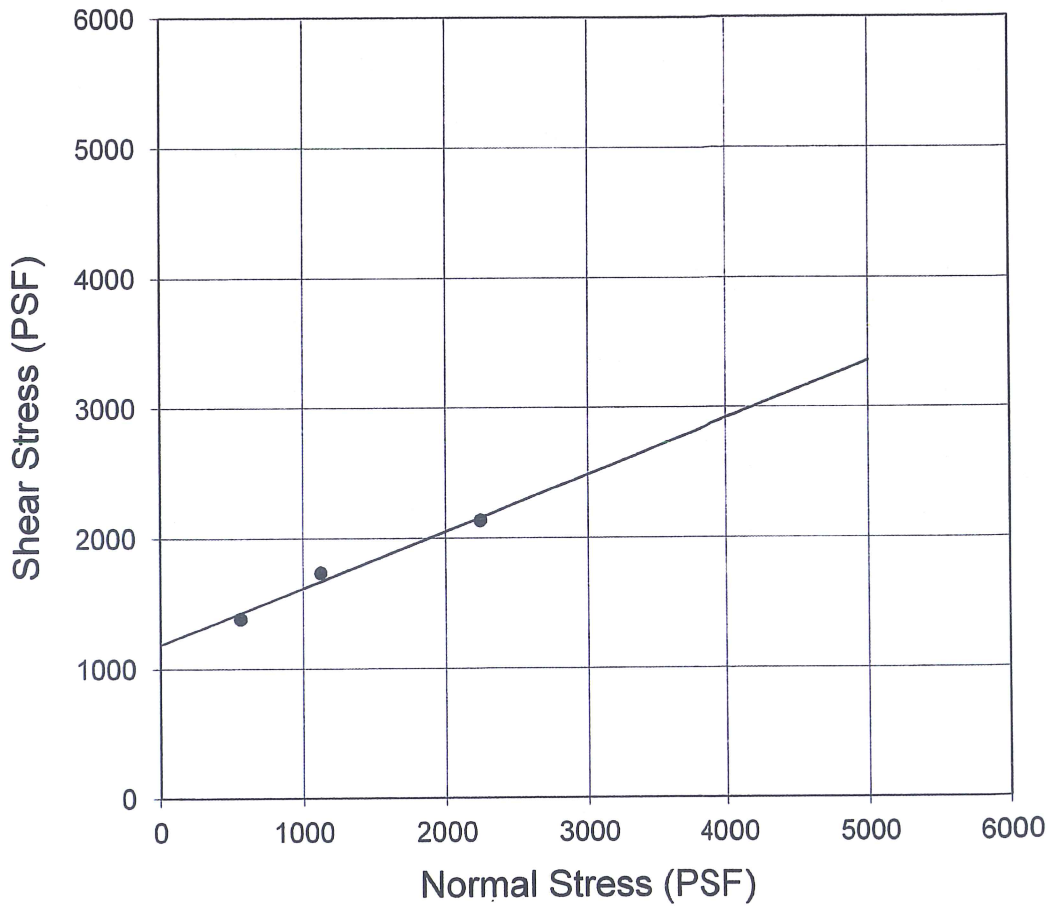
	Moisture Content (%)	Dry Density (pcf)
Initial	56.0	64.3
Final	51.7	66.5

Remark: 6/18/12

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	CONSOLIDATION TEST

Plate B2.1

Direct Shear Test Results



<u>Sample Description</u>

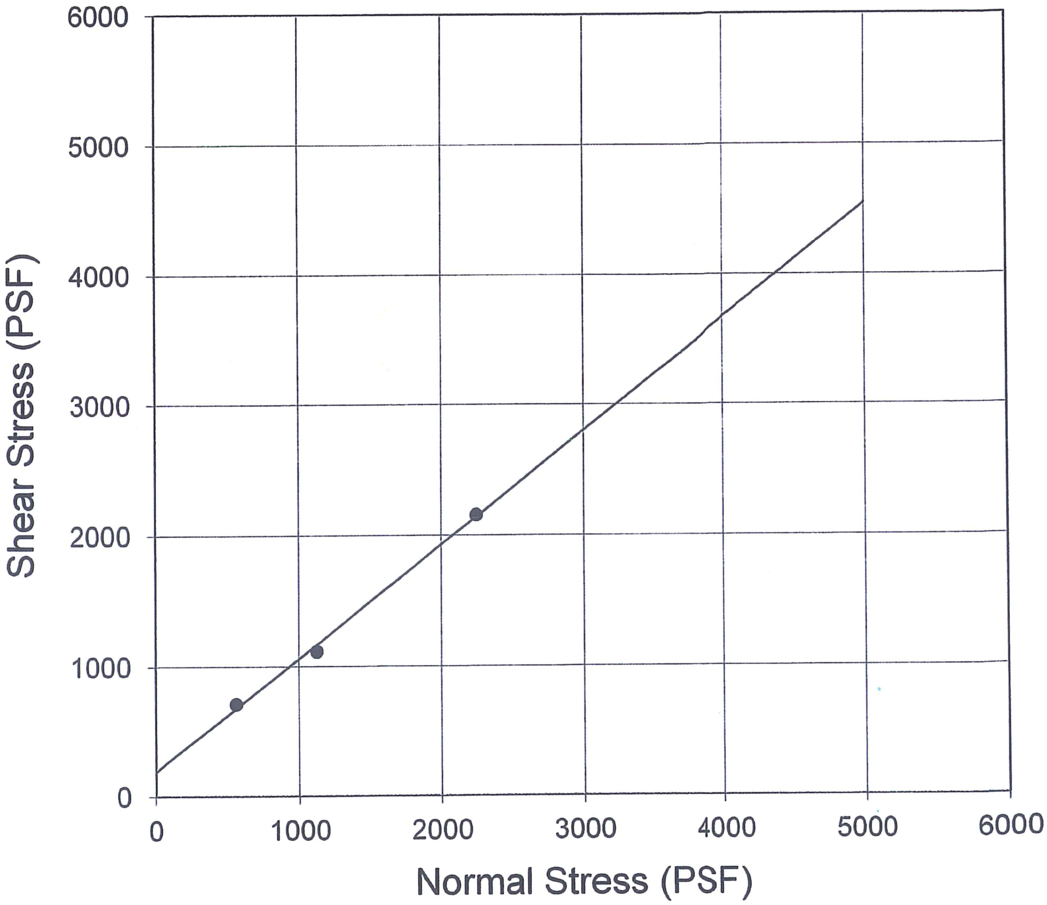
Boring No.: B1 Depth (ft): 4
Soil Description: Mottled grayish brown silty clay
Strength Intercept (C): 1185.7 PSF (Peak Strength)
Friction Angle (ϕ): 23.5 DEG (Peak Strength)

Remark: 6/18/12

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	DIRECT SHEAR TEST

Plate B3.1

Direct Shear Test Results



Sample Description

Boring No.: B1 Depth (ft): 13

Soil Description: Mottled dark grayish brown completely weathered basalt

Strength Intercept (C): 190.9 PSF (Peak Strength)

Friction Angle (ϕ): 41.1 DEG (Peak Strength)

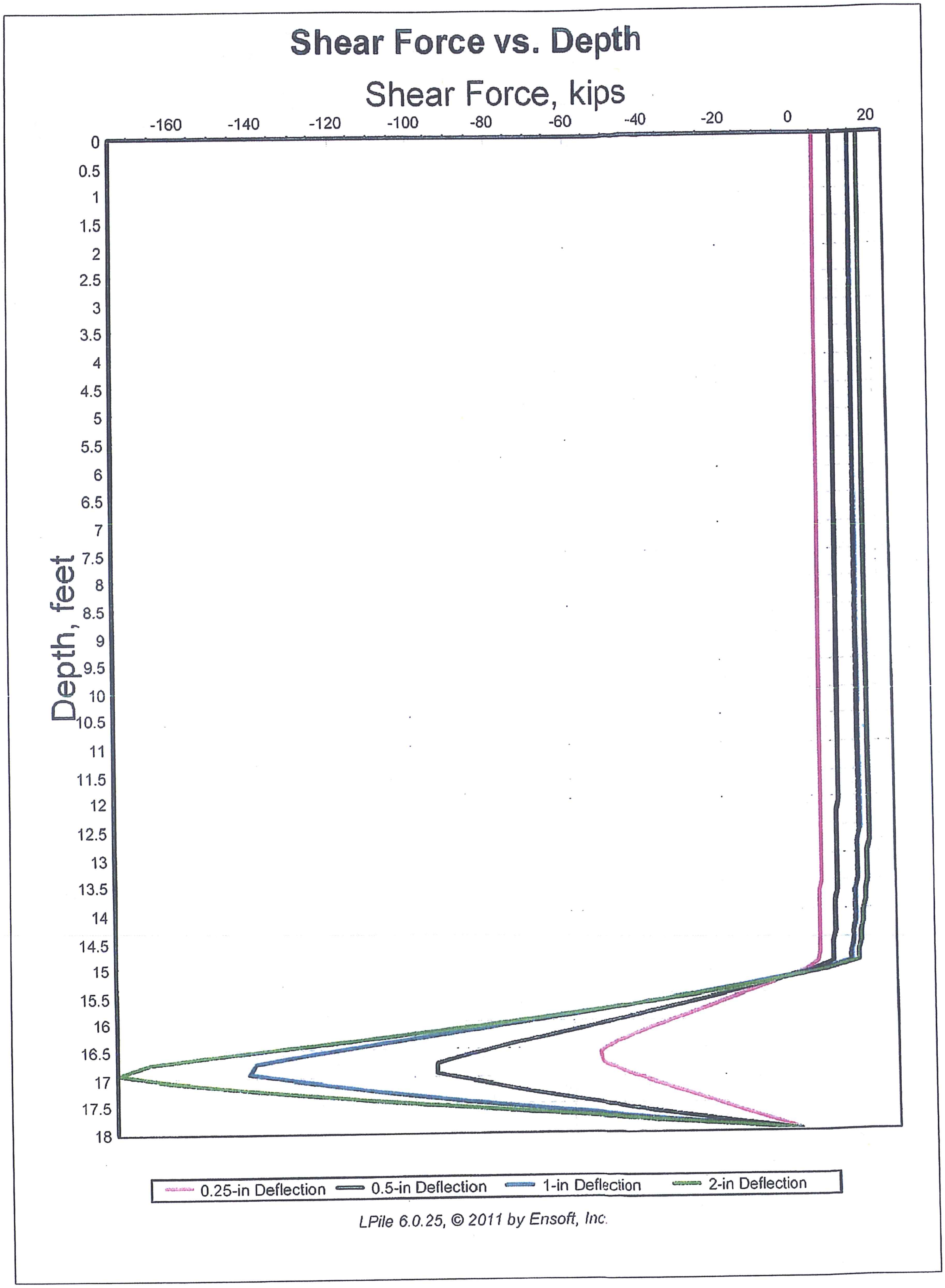
Remark: 6/18/12

W.O. 12-5333	Liliha Street Rehabilitation
Hirata & Associates, Inc.	DIRECT SHEAR TEST

Plate B3.2

APPENDIX C

LATERAL LOAD ANALYSIS



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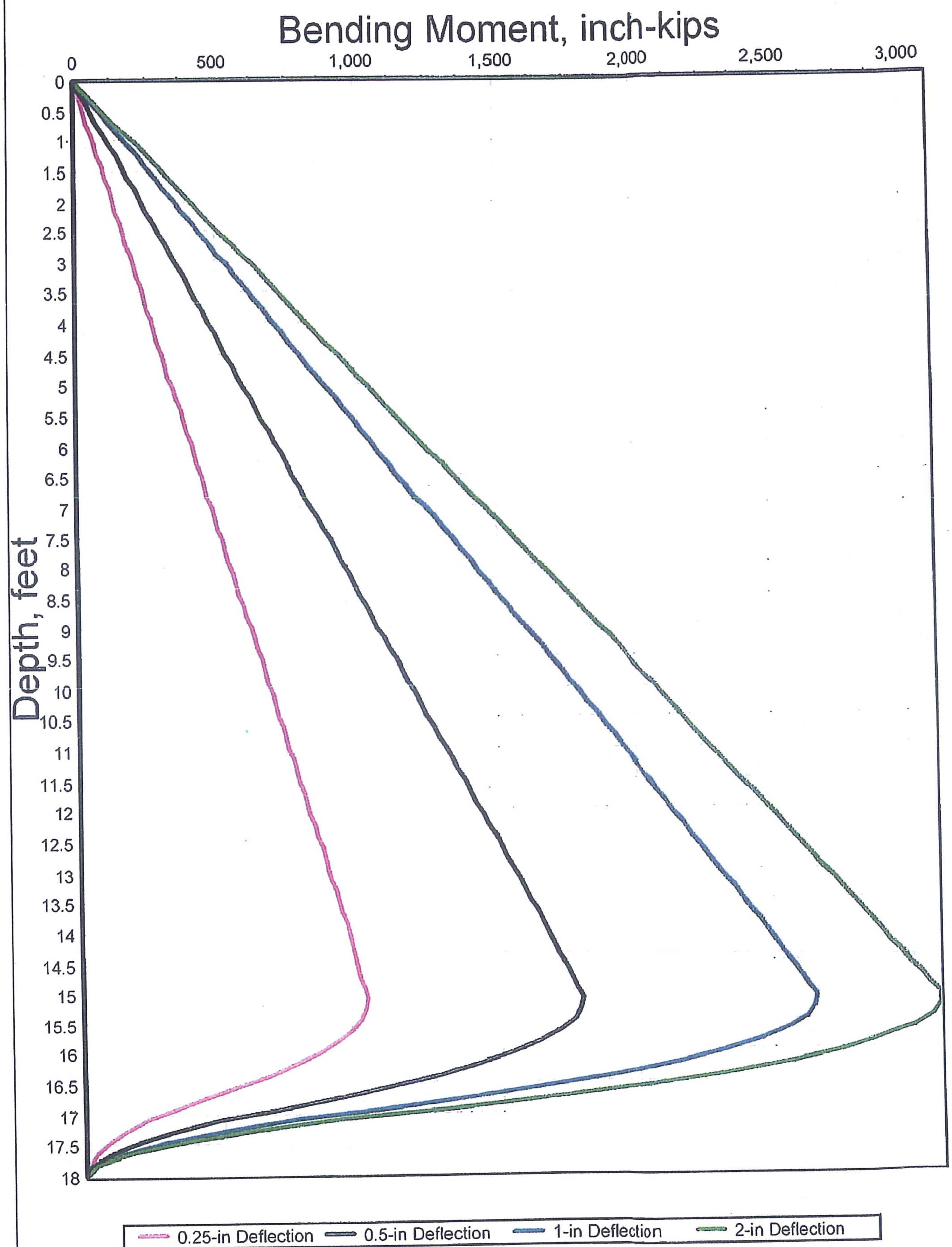
Hirata & Associates, Inc.	SHEAR FORCE DIAGRAM

Plate C1

Bending Moment vs. Depth



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Hirata & Associates, Inc.	BENDING MOMENT DIAGRAM Plate C2