APPENDIX A

APPENDIX A

Field Exploration

We explored the subsurface conditions by drilling and sampling five borings, designated as Boring Nos. 1 through 5, to depths of about 15.5 to 21.5 feet below the existing ground surface at the approximate locations shown on the Site Plans, Plates 2.1 through 2.5. We used a truck-mounted drill rig equipped with solid-stem augers and rotary coring tools.

Our geologists classified the materials encountered in the borings by visual and textural examination in the field in general accordance with ASTM D2488, Standard Practice for Description and Identification of Soils, and monitored the drilling operations on a near-continuous (full-time) basis. These classifications were further reviewed visually and by testing in the laboratory. Soils were classified in general accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), as shown on the Soil Log Legend, Plate A-0.1. Deviations made to the soil classification in accordance with ASTM D2487 are described on the Soil Classification Log Key, Plate A-0.2. Graphic representations of the materials encountered are presented on the Logs of Borings, Plates A-1 through A-5.

Relatively “undisturbed” soil samples were obtained in general accordance with ASTM D3550, 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 drilled borings in general accordance with ASTM D1586, 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. The penetration resistance shown on the Logs of Borings indicates the number of blows required for the specific sampler type used. The blow counts may need to be factored to obtain the Standard Penetration Test (SPT) blow counts.

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 sample. Pocket penetrometer tests results are summarized on the Logs of Borings at the appropriate sample depths.

Core samples of the rock materials encountered at the project sites were obtained by using diamond core drilling techniques in general accordance with ASTM D2113, 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 rock material left in the hollow core of the bit is mechanically recovered for examination and description. Rock cores were described in general accordance with the Rock Description System, as shown on the Rock Log Legend, Plate A-0.3. The Rock Description System is based on the publication

"Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses" by the International Society for Rock Mechanics (March 1977).

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 in rock 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 in rock, 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 excavation characteristic 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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Soil 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
- WATER LEVEL OBSERVED IN BORING AT TIME OF DRILLING
- WATER LEVEL OBSERVED IN BORING AFTER DRILLING
- WATER LEVEL OBSERVED IN BORING OVERNIGHT

- LL LIQUID LIMIT (NP=NON-PLASTIC)
- PI PLASTICITY INDEX (NP=NON-PLASTIC)
- TV TORVANE SHEAR (tsf)
- UC UNCONFINED COMPRESSION OR UNIAXIAL COMPRESSIVE STRENGTH
- TXUU UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION (ksf)

Plate

A-0.1

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Soil Classification Log Key

(with deviations from ASTM D2488)

GEOLABS, INC. CLASSIFICATION*

GRANULAR SOIL (- #200 <50%)

- **PRIMARY** constituents are composed of the largest percent of the soil mass. Primary constituents are capitalized and bold (i.e., **GRAVEL, SAND**)
- **SECONDARY** constituents are composed of a percentage less than the primary constituent. If the soil mass consists of 12 percent or more fines content, a cohesive constituent is used (**SILTY** or **CLAYEY**); otherwise, a granular constituent is used (**GRAVELLY** or **SANDY**) provided that the secondary constituent consists of 20 percent or more of the soil mass. Secondary constituents are capitalized and bold (i.e., **SANDY** GRAVEL, **CLAYEY** SAND) and precede the primary constituent.
- **accessory descriptions** compose of the following:
  with some: >12%
  with a little: 5 - 12%
  with traces of: <5%
  accessory descriptions are lower cased and follow the Primary and Secondary Constituents
  (i.e., SILTY GRAVEL **with a little sand**)

COHESIVE SOIL (- #200 ≥ 50%)

- **PRIMARY** constituents are based on plasticity. Primary constituents are capitalized and bold (i.e., **CLAY, SILT**)
- **SECONDARY** constituents are composed of a percentage less than the primary constituent, but more than 20 percent of the soil mass. Secondary constituents are capitalized and bold (i.e., **SANDY** CLAY, **SILTY** CLAY, **CLAYEY** SILT) and precede the primary constituent.
- **accessory descriptions** compose of the following:
  with some: >12%
  with a little: 5 - 12%
  with traces of: <5%
  accessory descriptions are lower cased and follow the Primary and Secondary Constituents
  (i.e., SILTY CLAY **with some sand**)

EXAMPLE: Soil Containing 60% Gravel, 25% Sand, 15% Fines. Described as: **SILTY GRAVEL** with some sand

RELATIVE DENSITY / CONSISTENCY

Granular Soils			Cohesive Soils			
N-Value (Blows/Foot)		Relative Density	N-Value (Blows/Foot)		PP Readings (tsf)	Consistency
SPT	MCS		SPT	MCS		
0 - 4	0 - 7	Very Loose	0 - 2	0 - 4		Very Soft
4 - 10	7 - 18	Loose	2 - 4	4 - 7	< 0.5	Soft
10 - 30	18 - 55	Medium Dense	4 - 8	7 - 15	0.5 - 1.0	Medium Stiff
30 - 50	55 - 91	Dense	8 - 15	15 - 27	1.0 - 2.0	Stiff
> 50	> 91	Very Dense	15 - 30	27 - 55	2.0 - 4.0	Very Stiff
			> 30	> 55	> 4.0	Hard

MOISTURE CONTENT DEFINITIONS

Dry: Absence of moisture, dry to the touch

Moist: Damp but no visible water

Wet: Visible free water

ABBREVIATIONS

WOH: Weight of Hammer

WOR: Weight of Drill Rods

SPT: Standard Penetration Test Split-Spoon Sampler

MCS: Modified California Sampler

PP: Pocket Penetrometer

GRAIN SIZE DEFINITION

Description	Sieve Number and / or Size
Boulders	> 12 inches (305-mm)
Cobbles	3 to 12 inches (75-mm to 305-mm)
Gravel	3-inch to #4 (75-mm to 4.75-mm)
Coarse Gravel	3-inch to 3/4-inch (75-mm to 19-mm)
Fine Gravel	3/4-inch to #4 (19-mm to 4.75-mm)
Sand	#4 to #200 (4.75-mm to 0.075-mm)
Coarse Sand	#4 to #10 (4.75-mm to 2-mm)
Medium Sand	#10 to #40 (2-mm to 0.425-mm)
Fine Sand	#40 to #200 (0.425-mm to 0.075-mm)

Soil descriptions are based on ASTM D2488-09a, Visual-Manual Procedure, with the above modifications by Geolabs, Inc. to the Unified Soil Classification System (USCS).

Plate

A-0.2

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Rock Log Legend

ROCK DESCRIPTIONS

	**BASALT**		**CONGLOMERATE**
	**BOULDERS**		**LIMESTONE**
	**BRECCIA**		**SANDSTONE**
	**CLINKER**		**SILTSTONE**
	**COBBLES**		**TUFF**
	**CORAL**		**VOID/CAVITY**

ROCK DESCRIPTION SYSTEM

ROCK FRACTURE CHARACTERISTICS

The following terms describe general fracture spacing of a rock:

Massive: Greater than 24 inches apart

Slightly Fractured: 12 to 24 inches apart

Moderately Fractured: 6 to 12 inches apart

Closely Fractured: 3 to 6 inches apart

Severely Fractured: Less than 3 inches apart

DEGREE OF WEATHERING

The following terms describe the chemical weathering of a rock:

Unweathered: Rock shows no sign of discoloration or loss of strength.

Slightly Weathered: Slight discoloration inwards from open fractures.

Moderately Weathered: Discoloration throughout and noticeably weakened though not able to break by hand.

Highly Weathered: Most minerals decomposed with some corestones present in residual soil mass. Can be broken by hand.

Extremely Weathered: Saprolite. Mineral residue completely decomposed to soil but fabric and structure preserved.

HARDNESS

The following terms describe the resistance of a rock to indentation or scratching:

Very Hard: Specimen breaks with difficulty after several "pinging" hammer blows.
Example: Dense, fine grain volcanic rock

Hard: Specimen breaks with some difficulty after several hammer blows.
Example: Vesicular, vugular, coarse-grained rock

Medium Hard: Specimen can be broked by one hammer blow. Cannot be scraped by knife. SPT may penetrate by ~25 blows per inch with bounce.
Example: Porous rock such as clinker, cinder, and coral reef

Soft: Can be indented by one hammer blow. Can be scraped or peeled by knife. SPT can penetrate by ~100 blows per foot.
Example: Weathered rock, chalk-like coral reef

Very Soft: Crumbles under hammer blow. Can be peeled and carved by knife. Can be indented by finger pressure.
Example: Saprolite

Plate

A-0.3

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FREEWAY MANAGEMENT SYSTEM
PHASE 3, UNITS 1 AND 2, IM-0300(152)
INTERSTATE ROUTES H-1 AND H-2 FREEWAYS
DISTRICTS OF HONOLULU AND EWA, OAHU, HAWAII

Log of Boring 1

Laboratory			Field							
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Approximate Ground Surface Elevation (feet): 168 * Description
							0			CH	Reddish brown **SILTY CLAY**, very stiff, moist (residual soil)
Direct Shear	23	69			36	4.5					
LL=71 PI=42	20				18						
											Brownish gray **BOULDERS (BASALTIC)**
Sieve - #200 = 31.6%	35	80			10		5			SM	Reddish brown with gray mottling **SILTY SAND (BASALTIC)** with a little gravel (basaltic), loose, moist (saprolite)
UC= 3710 psi	3		100	100	20/2"		10				Gray **BASALT**, closely to slightly fractured, moderately to slightly weathered, hard to very hard (basalt formation)
UC= 2910 psi			100	80			15				grades to moderately to severely fractured
							20				Boring terminated at 20 feet
							25				
							30				
							35				

Date Started:	September 1, 2020	Water Level: ▼	Not Encountered	Plate
Date Completed:	September 1, 2020			
Logged By:	D. Gremminger	Drill Rig:	CME-45C TRUCK	A - 1
Total Depth:	20 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	6891-30(A)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 6891-30A&B.GPJ GEOLABS.GDT 2/9/21

GEOLABS, INC.

Geotechnical Engineering

FREEWAY MANAGEMENT SYSTEM
PHASE 3, UNITS 1 AND 2, IM-0300(152)
INTERSTATE ROUTES H-1 AND H-2 FREEWAYS
DISTRICTS OF HONOLULU AND EWA, OAHU, HAWAII

Log of Boring

2

Approximate Ground Surface Elevation (feet): 117 *

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
Direct Shear	19	67			38	4.5				ML	Reddish brown **SANDY SILT** with a little gravel (basaltic), very stiff, moist (fill)
	22				26						
Direct Shear	18	66			12		5				grades to medium stiff
										SC	Reddish brown **CLAYEY SAND** with some gravel, loose, moist (fill)
LL=57 PI=29	30				10		10				
	35	79			13	2.0	15			MH	Reddish brown with gray mottling **CLAYEY SILT** with some sand, medium stiff, moist (residual soil)
	39				4		20			MH	Brown **CLAYEY SILT** with some sand, soft, wet (residual soil)
											Boring terminated at 21.5 feet
							25				
							30				
							35				

Date Started:	September 1, 2020	Water Level: ▼ Not Encountered	Plate
Date Completed:	September 1, 2020		
Logged By:	D. Gremminger	Drill Rig: CME-45C TRUCK	A - 2
Total Depth:	21.5 feet	Drilling Method: 4" Solid-Stem Auger	
Work Order:	6891-30(A)	Driving Energy: 140 lb. wt., 30 in. drop	

BORING_LOG 6891-30A&B.GPJ GEOLABS.GDT 2/9/21

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FREEWAY MANAGEMENT SYSTEM
PHASE 3, UNITS 1 AND 2, IM-0300(152)
INTERSTATE ROUTES H-1 AND H-2 FREEWAYS
DISTRICTS OF HONOLULU AND EWA, OAHU, 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
LL=63 PI=41	18	85			50	4.5				CH
	8		100	16	50/4"					
UC= 13160 psi			100	23			5			
UC= 29720 psi			83	0			10			
							15			
							20			
							25			
							30			
							35			

Approximate Ground Surface Elevation (feet): 296 *

Description

Reddish brown **SILTY CLAY** with some gravel (basaltic), very stiff, dry (fill)

Gray **BASALT**, severely to moderately fractured, moderately to slightly weathered, hard to very hard (basalt formation)

Boring terminated at 15.5 feet

Date Started:	September 2, 2020	Water Level: ▼	Not Encountered
Date Completed:	September 2, 2020		
Logged By:	D. Gremminger	Drill Rig:	CME-45C TRUCK
Total Depth:	15.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	6891-30(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 3

BORING_LOG 6891-30A&B.GPJ GEOLABS.GDT 2/9/21

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FREEWAY MANAGEMENT SYSTEM
PHASE 3, UNITS 1 AND 2, IM-0300(152)
INTERSTATE ROUTES H-1 AND H-2 FREEWAYS
DISTRICTS OF HONOLULU AND EWA, OAHU, HAWAII

Log of Boring 4

Laboratory			Field							
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS
TXUU	27	96			41	4.5				GP-GM MH
LL=53 PI=24	26				25					
	25	76			65	4.5	5			
										GM
	17				22		10			
UC= 9790 psi			43							
			70				15			
							20			
					20/0" Ref.					
							25			
							30			
							35			

Approximate Ground Surface Elevation (feet): 195 *

Description

3-inch **ASPHALTIC CONCRETE**

Reddish gray **SANDY GRAVEL (BASALTIC)** with a little silt, dry (fill)

Reddish brown **CLAYEY SILT** with some sand and gravel, very stiff, dry (fill)

grades to hard

Grayish brown **SILTY GRAVEL (BASALTIC)** with some sand and a little clay, medium dense, dry (residual soil)

Brownish gray **COBBLY BOULDERS (BASALTIC)** with some clay seams, very dense, dry (residual soil)

Boring terminated at 20.5 feet

Date Started:	September 2, 2020	Water Level: ▼	Not Encountered
Date Completed:	September 2, 2020		
Logged By:	D. Gremminger	Drill Rig:	CME-45C TRUCK
Total Depth:	20.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	6891-30(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 4

BORING_LOG 6891-30A&B.GPJ GEOLABS.GDT 2/9/21

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FREEWAY MANAGEMENT SYSTEM
PHASE 3, UNITS 1 AND 2, IM-0300(152)
INTERSTATE ROUTES H-1 AND H-2 FREEWAYS
DISTRICTS OF HONOLULU AND EWA, OAHU, HAWAII

Log of Boring

5

Approximate Ground Surface Elevation (feet): 62 *

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
										SM	3-inch **GRASSED SURFACE**
TXUU	15	106			22						Brownish tan **SILTY SAND (CORALLINE)** with some gravel (coralline), medium dense, moist (fill)
Sieve - #200 = 15.3%	9				25						grades with some silty clay
Direct Shear	22	74			36		5				grades with a little cobbles (coralline)
	18				14		10				grades to wet
										GP-GM	Brownish gray **SANDY GRAVEL (BASALTIC)** with a little silt, dense, moist (colluvium)
	16	90			64		15				
	11				34		20			SM	Brownish gray **SILTY SAND (BASALTIC)** with some gravel (basaltic), medium dense, moist (colluvium)
											Boring terminated at 21.5 feet
							25				
							30				
							35				

Date Started:	August 31, 2020	Water Level: ▼	Not Encountered
Date Completed:	August 31, 2020		
Logged By:	D. Gremminger	Drill Rig:	CME-45C TRUCK
Total Depth:	21.5 feet	Drilling Method:	4" Solid-Stem Auger
Work Order:	6891-30(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 5

BORING_LOG 6891-30A&B.GPJ GEOLABS.GDT 2/9/21