Geotechnical Engineering Report

Līhu'e-Kōloa Forest Reserve Queensland Crossing

Wailua, Kaua'i, Hawai'i

Prepared for

KAI Hawaii, Inc.

April 2022

0203306-000 (3140-026-001)

HARTCROWSER

A division of Haley & Aldrich

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Līhu'e-Kōloa Forest Reserve Queensland Crossing

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1.0 INTRODUCTION

This report provides Hart Crowser's geotechnical engineering evaluation and recommendations for the construction of the low-water crossing (LWC) on the Wailua River North Fork to replace the 50-year-old concrete LWC that was significantly damaged during the historic April 2018 flooding events on the island of Kauaʻi. The crossing project is located within the Līhu'e-Kōloa Forest Reserve (Reserve) in Wailua, Kauaʻi. The Reserve owner and land manager is the Hawaiʻi Department of Land and Natural Resources (DLNR). The general location of the site is shown on Figures 1 and 2.

A field evaluation was conducted on January 11, 2019, and a preliminary damage and site assessment report was issued (Hart Crowser 2019). A follow-up field visit was conducted on July 7, 2020, after additional flooding in March 2020. It was apparent the condition of the site had degraded since the January 2019 visit.

2.0 LOW-WATER CROSSING PROPOSED DESIGN

An updated design (60 percent) was provided by KAI Hawai'i (KAI) to Hart Crowser on March 7, 2022. The 60 percent conceptual design proposes to replace the damaged LWC with a new LWC consisting of 3-foot by 4-foot reinforced concrete box culverts (RCBs) spanning the stream and structurally tied together through a reinforced concrete slab poured on top of the culverts. 5-foot wide concrete aprons will secure the RCBs on the upstream and downstream sides. The concrete aprons are designed with thickened leading edges that extend 3 feet into the streambed stratum to resist overturning and sliding. Debris catchers will be installed at the upstream side of the crossing structure to minimize clogging. Wingwalls will constructed on the upstream and downstream and structurally tie into the LWC abutment (on each side of the stream). The RCBs, reinforced concrete aprons, wingwalls, and retaining walls will be supported on shallow foundations.

Based on review of topographic surveys done by Esaki Surveying and Mapping (Esaki) between May and June 2021, we anticipate that most of the construction excavation in the stream will not exceed 5 feet in depth from the current ground surface for placement and/or casting of the RCBs. During our field investigation in June 2021, we noted that the scoured area on the south bank has been backfilled with gravel and cobbles, and the cobbles were placed within the streambed, between the damaged portions of the LWC, to temporarily bridge the stream.

No prior geotechnical investigation at the Queensland Crossing location has been performed. Hart Crowser provided a proposal to KAI to perform a field investigation at the Queensland site, a geotechnical evaluation, and provide geotechnical recommendations to support the design and anchoring of the new structure. The contents of this report summarize our findings from our field investigation and analyses and provide recommendations.

Attachments included in this report are:

- Appendix A: Field Explorations
- Appendix B: Laboratory Testing

3.0 SCOPE OF SERVICES

Our Scope of Services included:

- Conduct a preliminary site reconnaissance
- Review existing available subsurface soil and groundwater information, including reports, geologic maps, and other information pertinent to the site
- Subcontract drilling of one geotechnical boring to approximately 20 feet below ground surface (bgs)
- Perform a dynamic cone penetrometer (DCP) test on either side of the stream above the ordinary high-water mark (OHWM) to a depth of 5 feet bgs or when penetration is less than 1/8 inch per 10 blows
- Excavate one hand auger and collect bulk samples of soil for lab testing
- Conduct laboratory testing, including moisture content, particle size distribution, and plasticity, on representative soil samples obtained from the boring and hand auger
- Perform engineering analyses to develop micropile and foundation recommendations
- Prepare this geotechnical report summarizing our findings and providing recommendations

4.0 SITE CONDITIONS

The Reserve is a remote area maintained by DLNR for multiple uses such as hiking, fishing, horseback riding, and other recreational activities. Access into the Reserve is via Highway 580 (Kuamo'o Road) up to the Keāhua Arboretum. From there, the Wailua Forest Management Road provides access through the rest of the Reserve.

The Queensland LWC is located about 0.4 miles southwest of the Keāhua Arboretum. It crosses the north fork of the Wailua River.

4.1 Geology and Soil Maps

The site geology is mapped by the U.S. Geological Survey (USGS) Open-File Report 2007-1089; *Geologic Map of the State of Hawai'i* (Sherrod et al. 2007). Two main geologic units are mapped within the project area: Older Alluvium (Pleistocene and Pliocene), Geologic Symbol (QTao), overlaying the Kōloa Volcanics Lava flows, Geologic Symbol (QTkol).

The Older Alluvium (QTao) is described as "consolidated sand and gravel, some of it sufficiently lithified to warrant the designation 'conglomerate.' This unit's sand and gravel are described as chiefly well rounded and moderately sorted, but include minor, poorly sorted colluvial deposits. The unit forms terrace deposits and thick valley fills now being incised by modern drainages" (Sherrod et al. 2007). The Kōloa Volcanics Lava flows are described as rock type consisting of lava flows that are described as "ʻAʻā and lesser pāhoehoe" (Sherrod et al. 2007).

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has mapped near-surface soils in the vicinity of the project (Foote et al. 1972), and this information is also available on their online portal (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

Soil types at the site were mapped as Kolokolo clay loam (Kw) in stream areas, Hanalei silty clay (HnA), and Rough Broken Land (rRR) adjacent and upslope of the site. However, the Kolokolo clay loam (Kw) and Rough Broken Land (rRR) are the likely soil units to be encountered in the immediate area of the crossing.

Based on the soil survey information, the Kolokolo clay loam is described as forming along streams on toeslope and rise locations and is derived from alluvium. In a typical profile, it is composed of low-plasticity clay loam to a depth of 19 inches bgs, then transitions to low-plasticity loam up to 28 inches bgs, and then a high-plasticity silty clay loam to at least 60 inches bgs (Foote et al., 1972). The Kolokolo clay loam has a moderately high to high hydraulic conductivity of approximately 0.20 to 1.98 inches per hour and is described as well drained with negligible runoff (USDA 2020).

The Rough Broken Land (rRR) is described as forming in gulches on a backslope or mountain flank and is derived from alluvium and colluvium. It is composed primarily of silty clay to a depth of 30 inches bgs, over bedrock. The rough broken land has a low to moderately low hydraulic conductivity of approximately 0 to 0.06 inches per hour and is described as well drained with very high runoff (USDA 2020).

4.2 Seismicity

4.2.1 Regional Seismicity

Earthquake (seismic) activity in Hawaiʻi is related primarily to volcanic activity. Such activity generally occurs before or during volcanic eruptions, although earthquakes may also result from the underground movement of magma that comes close to the surface but does not erupt. Since volcanic activity is largely limited to Hawaiʻi Island, earthquakes associated with volcanic activity most affect Hawaiʻi Island. The risk of seismic activity and degree of ground shaking diminishes with increased distance from Hawaiʻi Island (DLNR 2004); however, earthquakes are not confined only to the Island of Hawaiʻi.

The Islands of Hawaiʻi and Maui have had recorded earthquakes greater than Magnitude 5 (M5+), and the effects of earthquakes occurring on the Islands of Hawaiʻi and Maui may be felt on the Island of Kauaʻi. It is important to note that in the last 150 years of recorded earthquake history, earthquakes greater than Magnitude 6 have not occurred on the Island of Kauaʻi, but it is possible the project site may be subjected to seismic activity. We have provided seismic design parameters in *Section 4.3 Seismic Design Parameters*; however, the risk level of the LWC is low and it is highly unlikely that seismic considerations will govern the design.

4.2.2 Seismic Hazards

Based on the location, subsurface soil conditions, groundwater level, and site topography, the risks at the site for fault rupture, liquefaction, lateral spread, and flow failure are very low.

4.3 Seismic Design Parameters

Seismic design is assumed to be governed by the Hawai'i State Building Code (adopted November 2018) which amends the 2012 International Building Code (IBC). The parameters provided in Table 1, below, are appropriate for 2012 IBC code-level seismic design.

The soil site class is based on the soil characteristics and a weighted average of the blow counts observed to a depth of 100 feet bgs. Since our boring was drilled to less than 100 feet bgs, we assumed a constant bedrock material, similar to what has been found at the nearby Keāhua Bridge. Based on the soil characteristics, the seismic designation is Site Class C.

Table 1 provides seismic design parameters for the site latitude and longitude and the site class. The parameters were obtained from the ASCE 7 Hazard Tool web application (https://asce7hazardtool.online/).

Table 1 – 2012 IBC Seismic Design Parameters

Parameter	Value
Latitude	22.070495
Longitude	–159.419388
Site Class	C
Spectral Response Acceleration, S_s	0.212 g
Spectral Response Acceleration, S_1	0.059 g
Site Coefficient, F_a	1.2
Site Coefficient, F_v	1.7
Spectral Response Acceleration (Short Period), S_{DS}	0.17 g
Spectral Response Acceleration (1-Second Period), S_{D1}	0.067 g
PGA	0.1 g
PGA_M	0.12 g
F_{PGA}	1.2 g

4.4 Subsurface Conditions

Figure 1 is an overall vicinity map. Figure 2 shows the exploration locations at the Queensland site as well as nearby borings that were used in the evaluation and report development. The geotechnical field investigation was performed in June 2021. Figure 3 is a topographic map of the specific crossing which shows the drilled boring location we completed. Appendix A summarizes our exploration methods and presents our exploration logs. Results of soil laboratory testing are provided in Appendix B and references where appropriate on the exploration logs.

4.4.1 Field Investigation

A geotechnical boring (B-3) with Standard Penetration Test (SPT) sampling and rock coring was drilled on the north bank of the Queensland Crossing to a depth of approximately 19.8 feet bgs. The boring was advanced using a track-mounted drill rig subcontracted with GeoTek Hawaii, Inc. The drill rig did not have access to the south side of the stream. A hand auger exploration (HA-1a/1b) was attempted on the south bank; but, due to shallow refusal on boulders, did not yield useful information. Dynamic cone penetrometer (DCP) tests were attempted on the stream banks, but no penetration was achieved due to the presence of gravels and cobbles.

The following sections provide general descriptions of the soil conditions encountered from the ground surface downwards. The soils are referred to as “Engineering Soil Unit” (ESU) within this report.

4.4.2 Elastic Silt (ESU 1)

In B-3 from the ground surface to 4 feet bgs, the elastic silt was a very stiff, brown, elastic silt (MH) with a few fine to coarse gravel. The observed soil conditions appear generally consistent with the “Kolokolo” alluvium soil unit, as identified by the soil survey.

4.4.3 Silty Sand with Gravel (ESU 2)

The elastic silt transitioned into a very loose to very dense, wet, brown silty sand with gravel, cobbles, and boulders from about 4 feet bgs to the bottom of the borehole at 19.8 feet bgs. Atterberg limit testing on representative soil samples indicated that the fine-grained soil within this soil unit has low plasticity.

Due to the presences of cobbles and boulders, we performed coring from approximately 12 feet to 19 feet bgs. Sample recovery was very low due to the granular and saturated soil conditions. A final SPT was performed from 19 feet bgs to 19.8 feet bgs (bottom of the hole). The observed soil conditions are consistent with the “Older Alluvium” geologic unit (QTao) described in *Section 4.1 Geology and Soil Maps.*

4.4.4 Engineering Soil Units (ESUs)

Representative $(N1)_{60}$ value ranges for each soil unit were developed using the SPT blow count data from B-3. The SPT blow count data were corrected for overburden stress and used to estimate representative friction angles for granular materials using the average of published correlations and our experience and engineering judgement.

Table 2 summarizes the results of our interpretation and estimate of appropriate engineering properties of various ESUs adopted for developing our geotechnical engineering design recommendations.

Table 2 – Summary of ESU and Engineering Properties

ESU	Soil Description	Design Total Unit Weight (pcf[a])	Design Friction Angle, φ' (degree)	Design Cohesion, c' (psf[b])
1	Elastic Silt	115	27	300[c]
2	Sand with gravel, cobbles, boulders	125	34	0

Notes:
a. pcf = pounds per cubic foot
b. psf = pounds per square foot
c. Hirata & Associates, Inc. (May 2014)

A Hirata & Associates, Inc. geotechnical investigation report dated May 22, 2014, was provided to us. The report outlines a foundation investigation for the near-by Keahua Bridge. The report includes boring information and laboratory testing results for soil samples collected at the Keahua Bridge site. We have reviewed the boring and laboratory analysis provided in the 2014 Hirata & Associates report and believe that the soil properties presented are generally consistent with our interpretation and estimate of appropriate engineering properties presented in Table 2 above.

4.4.5 Groundwater

Groundwater was encountered during the field investigation at approximately 4 feet bgs [elevation 535 feet Mean Sea Level (MSL)]. Because of the high groundwater recharge in the area, seasonal and other short-term variations are small, relative to the high heads that characterize the aquifer (USGS 1998). USGS states "groundwater saturates the entire volcanic shield nearly to the surface. Streams incising the Kōloa Volcanics drain the upper part of the aquifer and keep water levels just below the ground surface in most places."

5.0 CONCLUSIONS

Based on our explorations, testing, and analyses, we have formulated recommendations in this report for use in the design and construction of the Queensland LWC. We provide the following summary of our conclusions:

- During our site visit after the spring 2020 storms, it was apparent that scour continues to occur at the site and conditions have worsened with each storm event. It is possible that site conditions will be different if a long period of time or heavy rains occur since the date of our field investigation, and we recommend that we perform a site visit and update the recommendations prior to construction.

- Laboratory tests performed on the native soils indicate that the silty sand with gravel (ESU 2) underlying the elastic silt (ESU 1) is not susceptible to significant shrink-swell behavior. The current design indicates that the bottom elevation of the LWC along either approach roadway of the crossing will be within ESU 2. The concrete aprons securing the RCBs within the stream crossing will extend to 3 feet within the streambed material. It is likely that the streambed material does not consist of ESU 1 and we do not anticipate that uplift swell force will need to be considered in the design.

- Construction in the stream will require diversion/control of the stream flow. Water control efforts and construction will require permits to work in the stream.

- If the construction is not started and completed within the dry season, then it is possible that a more robust and costly system may be needed for diversion/control (e.g., cofferdam, sheet pile wall, etc.).

6.0 DESIGN RECOMMENDATIONS

This section presents our conclusions and recommendations for the geotechnical aspects of design and construction on the project site. We have developed our recommendations based on our current understanding of the project and the subsurface conditions encountered in our explorations at the time of drilling. If during construction, the nature of the soil conditions is different than we have assumed, we should be notified so we can change or confirm our recommendations.

It is our understanding that the RCBs will be precast sections. The downstream and upstream aprons are currently designed as 6-inch-thick slabs with thickened edges embedded about 3 feet into the adjacent ground surface. The project will be designed in accordance with the ICC International Building Code (IBC), 2012 Edition as amended by the Hawai'i State Building Code (adopted November 2018).

6.1 Retaining Walls

6.1.1 Retaining Wall Foundation

The wingwall foundations will be shallow (strip) footings. The wall footing subgrade excavation should be prepared in accordance with *Section 7.3.1 RCB and Footing Subgrade Preparation* and extend **a minimum of 18 inches below the lowest anticipated scour depth**. Scour depth should be determined by the project hydrologist.

6.1.1.1 Allowable Bearing Pressures

We recommend a maximum allowable net bearing pressure of 2,500 psf for shallow foundations bearing directly on dense structural fill or dense older alluvium. The allowable soil bearing pressure may be increased by up to one-third for short-duration loads, such as wind or seismic forces.

6.1.1.2 Shallow Foundation Spring Constants

Modeling foundation behavior under loading conditions may require a modulus of subgrade reaction (vertical spring constant) applicable to the soils on which the foundations bear. Depending on the elevation of the foundation elements, the underlying soil may vary in its density and consistency. Loading type, such as static or dynamic loading, has a dramatic effect on the stiffness of the springs. Determining the subgrade modulus value to be used depends on:

- The structural and geotechnical engineer's experience designing similar foundations in similar soil conditions;

- The quantity, magnitude, and area of the foundation under various loads; and

- Back-checking settlement and pressures predicted from structural modeling with geotechnical settlement estimates for given foundation geometries.

For modeling of rectangular and strip footings under static loading conditions, we recommend using a modulus of vertical subgrade reaction (K_{V1}) of 80 pounds per cubic inch (pci) for dense native soil and dense structural fill. This value assumes groundwater will be at the base of the footing. Note that K_{v1} is based on a 1-foot by 1-foot vertically loaded plate and obtained from standard charts. Subgrade moduli tend to decrease with increasing area of a foundation element. For this reason, the unit modulus will need to be reduced based on the actual dimensions of the foundation modeled.

For a square footing of size B, supported on the ESU 2 unit identified at the site, the modulus of subgrade reaction (K_V) should be calculated using the following equation (NAVFAC 1986):

$K_v = K_{V1}\,(B+1)^2/(4B^2)$ for footings for $B \leq 20$ feet

$K_v = K_{V1}\,(B+1)^2/(2B^2)$ for footings for $B \geq 40$ feet

Where: B = foundation width in feet. Interpolate for intermediate values of B.

K_{v1} = vertical subgrade reaction modulus for a 1-foot square plate

For a rectangular footing of dimension B x mB, where m is ≥ 1, K_V may be modified to obtain the modulus of subgrade reaction (K_{VR}) as:

$K_{VR} = K_V[(m+0.5)/(1.5m)]$

We recommend that Hart Crowser review the calculated bearing pressures and settlement results from the structural engineer's foundation design. Should the geotechnical and structural estimates of settlement differ substantially, we will recommend modifications to the preliminary modulus values presented above.

6.1.1.3 Lateral Resistance

Shallow foundation resistance to lateral loads is resisted by passive earth pressure on the side(s) of the foundations and/or frictional resistance along the base of the foundation. For passive resistance to lateral loads, we recommend applying passive equivalent fluid pressure of 130 pcf and sliding resistance (coefficient of friction) of 0.27 for foundations cast directly on ESU 2 or dense structural fill. The passive earth pressure and friction components may be combined, provided that the passive component does not exceed two-thirds of the total. The equivalent fluid pressure should be applied using triangular pressure distribution, ignoring the passive resistance 2 feet below the adjacent ground surface. A factor of safety of 1.5 has been applied to these values.

6.1.2 Lateral Earth Pressure Design Parameters

"Unrestrained" walls that retain new engineered fill should be designed to resist **active** earth pressure of 35 pcf (above the groundwater table) and 18 pcf plus the weight of water (below the groundwater table) acting as an equivalent fluid weight. Unrestrained walls are defined as those where the top of the wall is allowed to move at least 0.1 percent of the wall height. If settlement-sensitive structures exist within the potential zone of deformation, or where the wall system is too stiff to allow sufficient lateral movement to develop an active condition, **at-rest** earth pressures of 55 pcf (above the groundwater table) and 28 pcf plus the weight of water (below the groundwater table) acting as an equivalent fluid weight should be used for design. Based on the 60% design plan sheets, there will be no settlement-sensitive structures near the retaining wall, so KAI may use the active earth pressure value (adjusted for groundwater table conditions).

The earth pressures were estimated based on the assumption of level backfill and drainage provided behind the wall to prevent the build-up of hydrostatic pressure and shrinkage/swelling phenomena. If level backfill is not planned or drainage is not provided, then our office should be contacted to revise the design recommendation. A superimposed seismic lateral force should be calculated based on a dynamic force of 0.9H psf, where H is the height of the wall in feet, and the resultant is applied at 0.5H from the base of the wall footings.

Walls retaining sections of roadways or parking areas should be designed using a uniform vertical live load surcharge of 250 psf over the road surface. The live load surcharge is applied as a uniform lateral earth pressure of 100 psf on the back of the wall. The passive earth pressure resistance and sliding friction recommendations are noted in *Section 6.1.1.3 Lateral Resistance.*

If other surcharges (e.g., stockpiles, sloped backfill) are located within a horizontal distance from the back of a wall equal to twice the height of the wall, then additional pressures may need to be accounted for in the wall design. Our office should be contacted for appropriate wall surcharges based on the actual magnitude and configuration of the applied loads.

6.1.3 Drainage and Backfill

The retaining wall design parameters have been provided assuming that back-of-wall drains will be installed to prevent buildup of hydrostatic pressures behind all walls. If a drainage system is not installed, then our office should be contacted to revise the design recommendation.

Drainage should consist of a minimum 12-inch-wide zone of drain rock, extending from the base of the wall to within 6 inches of finished grade, and placed against the back of all retaining walls. Perforated collector pipes should be embedded at the base of the drain rock. The drain rock should meet the requirements provided in *Section 7.2 Structural Fill and Backfill* of this report.

The perforated collector pipes should discharge at an appropriate location away from the base of the wall. The drain rock section should be separated from general wall backfill with a geotextile separation fabric meeting the specifications of Hawaii Standard Specifications for Road and Bridge Construction (HSS) *Section 716.02 Geotextiles for Permeable Separator Applications,* and the separation geotextile should be installed in accordance with HSS *Section 313 Permeable Separator*.

General wall backfill and drain rock backfill materials should meet the requirements of *Section 7.2 Structural Fill and Backfill* and should be compacted to meet the requirements of *Section 7.3 Fill Placement and Compaction*.

7.0 EARTHWORK AND CONSTRUCTION RECOMMENDATIONS

Earthwork should be conducted in accordance with the 1986 Standard Specifications (SS) for Public Works Construction for the four counties in the State of Hawai'i (Counties 1986). Specific earthwork recommendations are provided in the following sections.

7.1 Excavation and Dewatering

7.1.1 Open Cuts

All excavations should be made in accordance with the State of Hawaiʻi Occupational Safety and Health (HIOSH) and Occupational Safety and Health Administration (OSHA) guidelines, which require temporary sloping or shoring for excavations greater than 4 feet deep. The site soils overlying the medium dense to dense sand (older alluvium) would be considered Type C soil based on the OSHA soil type classification system. Generally, the regulations allow a temporary cut slope of 1.5H:1V for Type C Soils.

The stability and safety of cut slopes depend on a number of factors, including:

- Type and density of the soil and/or rock;
- Presence and amount of seepage;
- Depth of cut;
- Proximity and magnitude of the cut to surcharge loads, such as stockpiled material, traffic loads, or structures;
- Duration of the open excavation; and
- Care and methods used by the contractor.

Because of the variables involved, slope angles required for stability in temporary cut areas can only be estimated before construction. Appropriate temporary slope inclinations will ultimately depend on the soil and groundwater seepage conditions exposed in the cuts at the time of construction. It is the responsibility of the contractor to ensure all excavations are properly sloped or braced for worker protection, in accordance with HIOSH and OSHA guidelines. If shoring is required, then shoring design is the responsibility of the contractor and should be designed by a professional engineer registered in the State of Hawaiʻi. Further, the shoring design engineer should be provided with a copy of this report.

While this report describes certain approaches to excavation and shoring, the contractor is responsible for selecting and designing the specific methods, monitoring the excavations for safety, and providing shoring required to protect personnel and adjacent structural elements.

If the excavations are left open for extended periods of time, then caving of the sidewalls may occur. The presence of caved material will limit the ability to properly backfill and compact the excavations.

7.1.2 Dewatering and Surface Runoff

We strongly recommend construction occur in the dry season (April through October). Groundwater will likely be encountered within anticipated depths of excavations, and surface water (i.e., the stream) will need to be diverted away from the construction. Depending on the stream flow, this may be accomplished using sandbags, supersacks, portadam, etc. Pumping from sumps located within the excavation may be effective in removing water resulting from seepage; but they may need to be spaced closely to be effective. It is important to note that these measures will not prevent or reduce the greater risk of unsupported trench wall caving and sloughing caused by seepage. If groundwater is present at the base of excavations and unsuitable subgrade conditions exist, we recommend placing stabilization material at the base of the excavation as a working platform. Stabilization material should be placed to a minimum thickness of 12-inches and should meet the criteria discussed in *Section 7.2 Structural Fill and Backfill*.

During construction, the contractor should be responsible for keeping excavations free of water. The project specifications should affirm that the contractor is responsible for temporary drainage, and control of surface water and groundwater as necessary.

7.2 Structural Fill and Backfill

Structural fill should be considered to include any fill that is placed beneath structures, foundations, slabs, pavements, and other areas intended to support structural elements or within their influence zone. A variety of material may be used as structural fill at the site. However, all structural fill should be free of debris, clay balls, roots, organic matter, man-made contaminants, particles with greatest dimension exceeding 4 inches, and other deleterious materials, and should meet the appropriate specification provided in the SS (Counties 1986).

Fill and backfill materials should be placed and compacted in lifts with maximum uncompacted thicknesses and relative densities as recommended in *Section 7.3 Fill Placement and Compaction* of this report.

7.2.1 Native Soils

The near-surface, on-site soils are elastic silt (ESU 1) and would require additional efforts to separate the stockpile, moisture conditioning, and/or possibly blend the near-surface soils with non-expansive granular import soil prior to being used as structural fill. Therefore, it is unlikely that the elastic silt will be suitable for use as structural fill without these additional measures, but it may be suitable for reuse in landscaping at the site.

The underlying soil (ESU 2) is coarse-grained (granular) and may be suitable for re-use if the percent of fines in the soil (material passing the U.S. No. 200 mesh sieve) is less than 5 percent.

7.2.2 Imported Select Structural Fill

Imported granular material used as structural fill should be pit or quarry run rock, crushed rock, crushed gravel, and sand or coral and should meet the specifications of No. 10 or better material provided in SS *Section 15 - Crushed Rock* (Counties 1986).

7.3 Fill Placement and Compaction

Structural fill should be placed and compacted in accordance with SS *Sections 11* and *13* (Counties 1986) and the following guidelines.

- Place fill and backfill on a prepared subgrade that consists of firm, inorganic native soils or approved structural fill.
- Place fill or backfill in uniform horizontal lifts with a thickness appropriate for the material type and compaction equipment. Table 3 provides general guidance for uncompacted lift thicknesses.

Table 3 – Guidelines for Uncompacted Lift Thickness

Compaction Equipment	Fine-Grained Soil	Granular and Crushed Rock Maximum Particle Size ≤ 1½ inch	Crushed Rock Maximum Particle Size > 1½ inch
Jumping Jack	4 – 6	4 – 8	Not Recommended
Rubber-Tire Equipment	6 – 8	10 – 12	6 – 8
Light Roller	8 – 10	10 – 12	8 – 10
Heavy Roller	10 – 12	12 – 18	12 – 16
Hoe Pack Equipment	12 – 16	18 – 24	12 – 16

Note: The above table is based on our experience and is intended to serve as a guideline. The information provided in this table should not be included in the project specifications.

- Do not place fill and backfill until the required tests and evaluation of the underlying materials have been made and the appropriate approvals have been obtained.
- Limit the maximum particle size within the fill to two-thirds of the loose lift thickness.
- In general, we recommend controlling the moisture content of the fill to within 2 percent of the optimum moisture content based on laboratory modified Proctor tests (ASTM D1557). The optimum moisture content corresponds to the maximum attainable modified Proctor dry density.
- During structural fill placement and compaction, a sufficient number of in-place density tests should be completed by Haley & Aldrich or their representative to verify that the specified degree of compaction is being achieved.
- Compact fill soils to the percentages of maximum dry density as shown in Table 4 unless an alternative compaction method (such as T-probe) is used as noted in *Section 8.0 Foundation Review and Construction Observations*.

Table 4 – Fill Compaction Criteria

Fill Type	Percent of Maximum Dry Density Determined in Accordance with ASTM D1557		
	0 – 2 Feet Below Subgrade	>2 Feet Below Subgrade	Pipe Bedding and Pipe Zone
General Structural Fill (fine-grained materials)	92	92	-----
General Structural Fill (granular materials)	95	92	-----
Aggregate Base	95	95	-----
Trench Backfill	95	92	90
Nonstructural Trench Backfill	88	88	-----
Nonstructural Zones	88	88	90

Note: Structural fill with more than 30 percent retained on the 3/4-inch sieve should be compacted to a well-keyed dense state within 3 percent of optimum moisture content. Compaction should be verified by qualified personnel through performance testing, such as a proof roll or other practical means.

7.3.1 RCB and Footing Subgrade Preparation

Based on the 60 percent design drawings, the bottom elevation of the RCBs will be at about elevation 533.5 feet MSL. At this elevation, the soil may be loose and not suitable for structure placement.

Wherever loose, compressible, or disturbed conditions are encountered at the bottom of structure elevation then all unsuitable soils should be removed. We recommend up to 2 feet of over-excavation of unsuitable materials and replacement with granular compacted fill to create a dense and unyielding surface. This depth will vary depending on the conditions at time of construction. If water infiltrates and pools in the excavation, the water and any disturbed or sloughed soil should be removed before placing the reinforcing steel. We recommend Hart Crowser observe all excavations before placement of structural fill to assess whether bearing surfaces have been adequately prepared and the soil conditions are consistent with those observed during our explorations.

8.0 FOUNDATION REVIEW AND CONSTRUCTION OBSERVATIONS

KAI Hawaii should allow Hart Crowser to review any foundation plans to confirm that our foundation recommendations have been adequately incorporated. Satisfactory foundation and earthwork performance depend to a large degree on quality of construction. Sufficient monitoring of the contractor’s activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. We recommend retaining Hart Crowser to monitor construction at the site to confirm that subsurface conditions are consistent with the site explorations and that the intent of project plans and specifications related to earthwork and foundation construction is being met. We recommend Hart Crowser observe structural subgrades for the LWC, wingwalls, and retaining walls, and placement/compaction of fill.

There are no heavy loads and only occasional passenger vehicle loads anticipated for the LWC. Due to the restrictions around shipping nuclear materials, it would be costly to procure a nuclear gauge to test compaction for these low-risk structures, especially if the work activity occurs either sporadically, for a short duration (less than five working days), or for low volumes of fill. It may be more cost-effective and efficient to check backfill compaction by having a qualified Haley & Aldrich staff member perform full-time observations during placement and compaction, and then use a T-probe to check the penetration depth into the compacted fill, and/or use loaded equipment to proof roll the subgrade.

9.0 LIMITATIONS

We have prepared this report for the exclusive use of KAI Hawaii and in accordance with our approved scope of services. Our report is intended to provide our opinion of geotechnical parameters for design and construction of the proposed project based on exploration locations that are believed to be representative of site conditions. However, subsurface conditions can vary significantly, and our conclusions should not be construed as a warranty or guarantee of subsurface conditions or future site performance.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty, express or implied, should be understood.

Any electronic form, facsimile, or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by Hart Crowser and will serve as the official document of record.

10.0 REFERENCES

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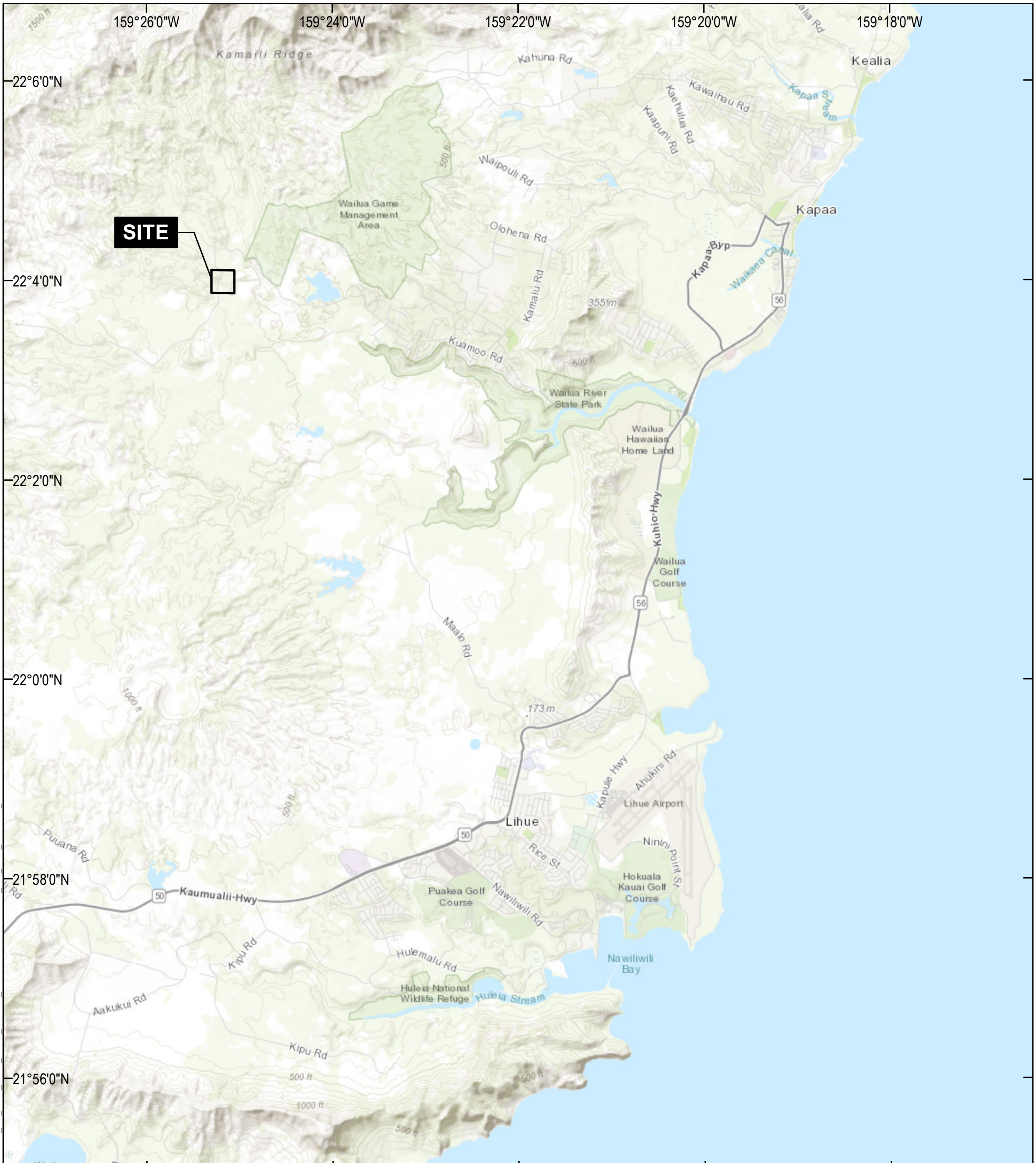
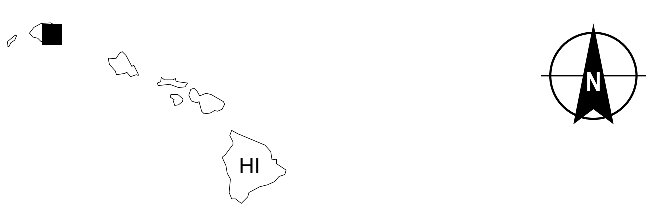




MAP SOURCE: ESRI
SITE COORDINATES: 22°3'56"N, 159°25'14"W

HARTCROWSER
A division of Haley & Aldrich

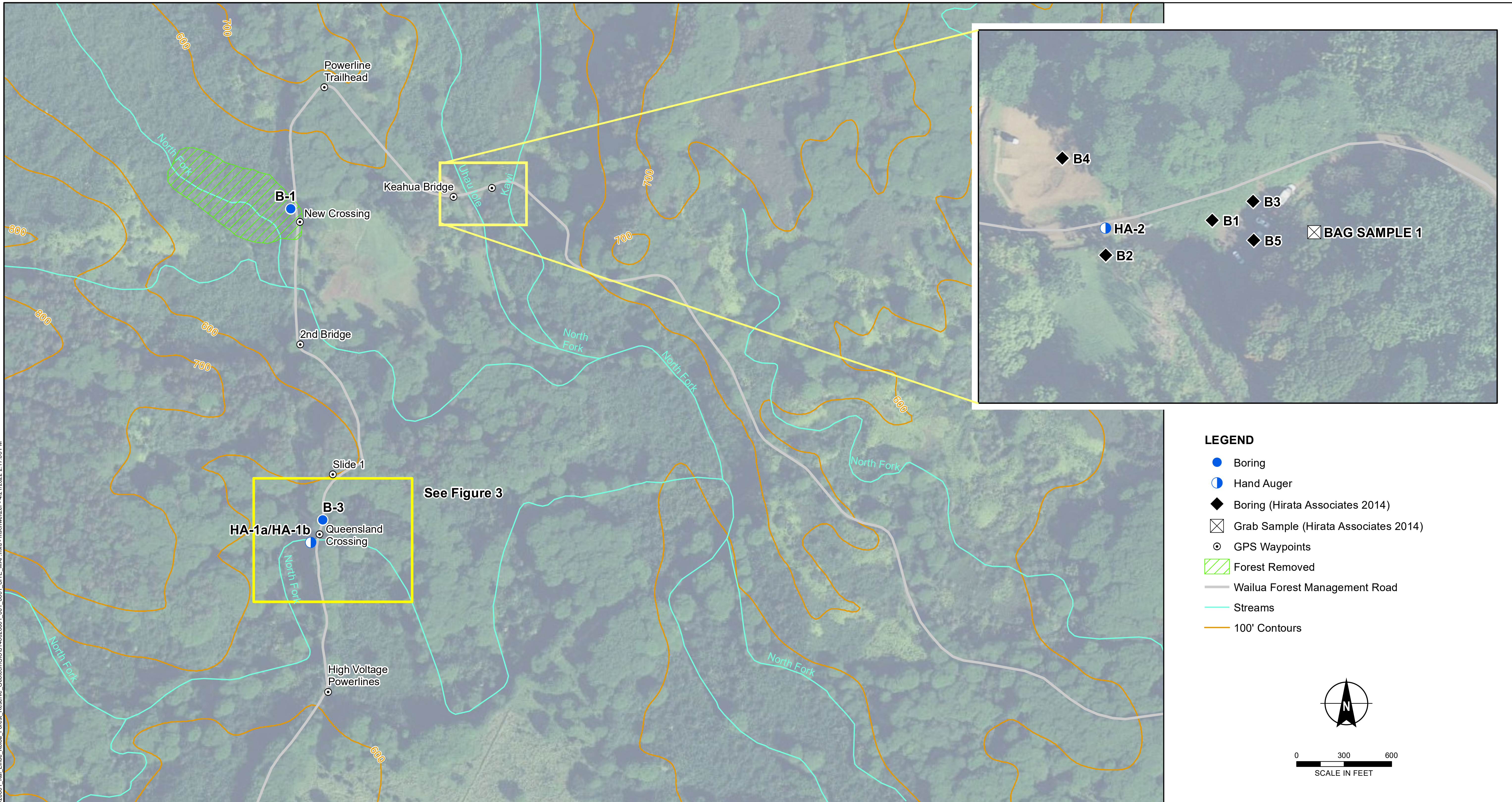
LIHUE-KOLOA FOREST RESERVE
QUEENSLAND CROSSING
WAILUA, KAUA'I, HAWAII

VICINITY MAP

APPROXIMATE SCALE: 1 IN = 8000 FT
APRIL 2022

FIGURE 1

GIS: \\haleyaldrich.com\share\pdx_data\Notebooks\3140026001_Kai_Lihue_Koloa_Forest_Reserve_Geotech\GIS\3140026001_001_0002_VICINITY_MAP.mxd - mschweitzer - 3/15/2022 9:59:13 PM



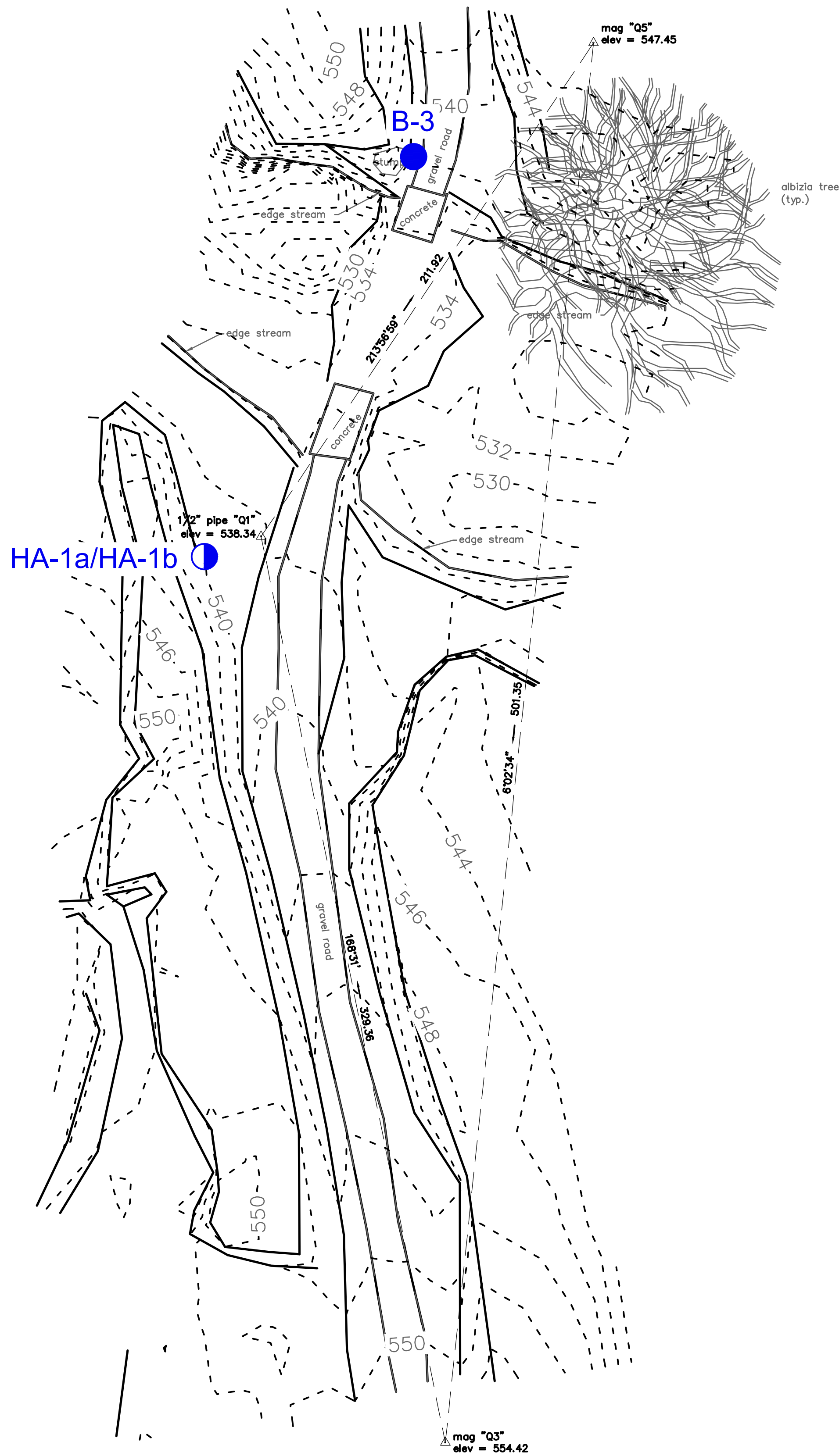
HARTCROWSER
A division of Haley & Aldrich

LIHUE-KOLOA FOREST RESERVE
QUEENSLAND CROSSING
WAILUA, KAUA'I, HAWAII

SITE MAP

APRIL 2022

FIGURE 2



LEGEND

B-3 ●	BORING
HA-1a ◑	HAND AUGER

NOTES

1. SURVEY PREPARED BY ESAKI SURVEYING AND MAPPING, DATED MAY 11, 2021.

N

0 60 120

SCALE IN FEET

HARTCROWSER
A division of Haley & Aldrich

LIHUE-KOLOA FOREST RESERVE
QUEENSLAND CROSSING
WAILUA, KAUA'I, HAWAII

SITE AND EXPLORATION PLAN
QUEENSLAND CROSSING

APRIL 2022

FIGURE 3

Saved by: MSCHWEITZER Printed: 4/21/2022 1:56 PM Sheet: QUEENSLAND
\\HALEYALDRICH.COM\SHARE\PDX DATA\NOTEBOOKS\3140026001 KAI LIHUE KOLOA FOREST RESERVE GEOTECH\CAD\3140026001 001 0001 SITE EXPL PLAN.DWG

APPENDIX A
Field Explorations

APPENDIX A

Field Explorations

This appendix documents the processes Hart Crowser used to determine the nature (and quality) of the soil and bedrock underlying the project site addressed by this report. The discussion includes information on the following subjects:

- Explorations and Their Locations
- Hollow-Stem Auger and PQ Core Borings
- Standard Penetration Test (SPT) Procedures

Explorations and Their Locations

Subsurface explorations for this project included one mechanically drilled boring and one hand auger boring. The exploration logs in this appendix show our interpretation of the explorations, sampling, and testing data. The logs indicate the depths where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure A-1 *Key to Exploration Logs*. This key also provides a legend explaining the symbols and abbreviations used in the exploration logs.

Hollow-Stem Auger and PQ Core Borings

Boring B-3 was drilled from June 16 to 17, 2021, using a 4.5-inch-diameter hollow-stem auger and a 3.35-inch PQ core barrel (when basalt rock was encountered) advanced with a track-mounted drill rig subcontracted by Hart Crowser. The drilling was continuously observed by a geologic staff member from Hart Crowser and detailed field logs of the borings were prepared. Approximate locations of the borings are noted on figures attached to the report.

Standard Penetration Test (SPT) Procedures (ASTM D 1586)

Using an SPT sampler, we obtained soil samples in 2.5-foot and 5-foot sampling intervals. The SPT test is an approximate measure of soil density and consistency. To be useful, the results must be used with engineering judgment in conjunction with other tests. The SPT employs a standard 2-inch outside-diameter split-spoon sampler to obtain disturbed samples. Using a 140-pound manual hammer, free-falling 30 inches, the sampler is driven into the soil for 18 inches. The number of blows required to drive the sampler the last 12 inches only is the Standard Penetration Resistance. This resistance (also referred to as blow count or N-value), measures the relative density of granular soils and the consistency of cohesive soils. The N-values are plotted on the boring logs at their respective sample depths.

Soil samples are recovered from the split-barrel samplers, field classified, and placed into watertight bags. They are then taken to a subcontracted soils laboratory for further testing.

Hand-Auger Boring

One hand augured boring designated HA-1a/1b was advanced on June 15, 2021 by a geologist from Hart Crowser. Detailed field logs were prepared of each hand auger. A disturbed ("grab") samples was collected from drill spoils during hand auger explorations, was field classified, and placed into a watertight bag for moisture content testing.

Sample Description

Identification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. ASTM D 2488 visual-manual identification methods were used as a guide. Where laboratory testing confirmed visual-manual identifications, then ASTM D 2487 was used to classify the soils.

Relative Density/Consistency

Soil density/consistency in borings is related primarily to the standard penetration resistance (N). Soil density/consistency in test pits and probes is estimated based on visual observation and is presented parenthetically on the logs.

SAND or GRAVEL Relative Density	N (Blows/Foot)	SILT or CLAY Consistency	N (Blows/Foot)
Very loose	0 to 4	Very soft	0 to 1
Loose	5 to 10	Soft	2 to 4
Medium dense	11 to 30	Medium stiff	5 to 8
Dense	31 to 50	Stiff	9 to 15
Very dense	>50	Very stiff	16 to 30
		Hard	>30

Moisture

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

USCS Soil Classification Chart (ASTM D 2487)

Major Divisions			Symbols Graph	Symbols USCS	Typical Descriptions
Coarse Grained Soils More than 50% of Material Retained on No. 200 Sieve	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravels *(<5% fines)*		GW	Well-Graded Gravel; Well-Graded Gravel with Sand
				GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Gravels *(5-12% fines)*		GW-GM	Well-Graded Gravel with Silt; Well-Graded Gravel with Silt and Sand
				GW-GC	Well-Graded Gravel with Clay; Well-Graded Gravel with Clay and Sand
				GP-GM	Poorly Graded Gravel with Silt; Poorly Graded Gravel with Silt and Sand
				GP-GC	Poorly Graded Gravel with Clay; Poorly Graded Gravel with Clay and Sand
		Gravels with Fines *(>12% fines)*		GM	Silty Gravel; Silty Gravel with Sand
				GC	Clayey Gravel; Clayey Gravel with Sand
	Sand and Sandy Soils More than 50% of Coarse Fraction Passing No. 4 Sieve	Sands with few Fines *(<5% fines)*		SW	Well-Graded Sand; Well-Graded Sand with Gravel
				SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Sands *(5-12% fines)*		SW-SM	Well-Graded Sand with Silt Well-Graded Sand with Silt and Gravel
				SW-SC	Well-Graded Sand with Clay; Well-Graded Sand with Clay and Gravel
				SP-SM	Poorly Graded Sand with Silt; Poorly Graded Sand with Silt and Gravel
				SP-SC	Poorly Graded Sand with Clay; Poorly Graded Sand with Clay and Gravel
		Sands with Fines *(>12% fines)*		SM	Silty Sand; Silty Sand with Gravel
				SC	Clayey Sand; Clayey Sand with Gravel
Fine Grained Soils More than 50% of Material Passing No. 200 Sieve	Silts			ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
				MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
	Silty Clay *(based on Atterberg Limits)*			CL-ML	Silty Clay; Silty Clay with Sand or Gravel; Gravelly or Sandy Silty Clay
	Clays			CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
				CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
	Organics			OL/OH	Organic Soil; Organic Soil with Sand or Gravel; Sandy or Gravelly Organic Soil
Highly Organic *(>50% organic material)*				PT	Peat - Decomposing Vegetation - Fibrous to Amorphous Texture

Minor Constituents

	Estimated Percentage
Sand, Gravel	
Trace	<5
Few	5 - 15
Cobbles, Boulders	
Trace	<5
Few	5 - 10
Little	15 - 25
Some	30 - 45

Soil Test Symbols

%F	Percent Passing No. 200 Sieve
AL	Atterberg Limits (%)

Liquid Limit (LL)
Water Content (WC)
Plastic Limit (PL)

CA	Chemical Analysis
CAUC	Consolidated Anisotropic Undrained Compression
CAUE	Consolidated Anisotropic Undrained Extension
CBR	California Bearing Ratio
CIDC	Consolidated Drained Isotropic Triaxial Compression
CIUC	Consolidated Isotropic Undrained Compression
CK0DC	Consolidated Drained k0 Triaxial Compression
CK0DSS	Consolidated k0 Undrained Direct Simple Shear
CK0UC	Consolidated k0 Undrained Compression
CK0UE	Consolidated k0 Undrained Extension
CRSCN	Constant Rate of Strain Consolidation
DS	Direct Shear
DSS	Direct Simple Shear
DT	In Situ Density
GS	Grain Size Classification
HYD	Hydrometer
ILCN	Incremental Load Consolidation
K0CN	k0 Consolidation
kc	Constant Head Permeability
kf	Falling Head Permeability
MD	Moisture Density Relationship
OC	Organic Content
OT	Tests by Others
P	Pressuremeter
PID	Photoionization Detector Reading
PP	Pocket Penetrometer
SG	Specific Gravity
TRS	Torsional Ring Shear
TV	Torvane
UC	Unconfined Compression
UUC	Unconsolidated Undrained Triaxial Compression
VS	Vane Shear
WC	Water Content (%)

Groundwater Indicators

Groundwater Level on Date or At Time of Drilling (ATD)

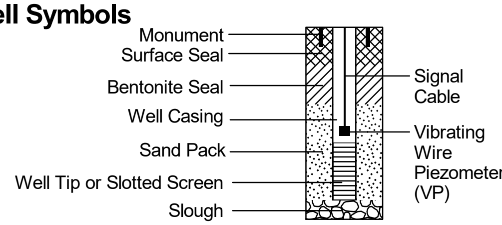
Groundwater Level on Date Measured in Piezometer

Groundwater Seepage (Test Pits)

Sample Symbols

- 1.5" I.D. Split Spoon
- Rock Core Run
- Grab
- 3.0" I.D. Split Spoon
- Sonic Core
- Cuttings
- Modified California Sampler
- Thin-walled Sampler
- Push Probe

Well Symbols



HARTCROWSER
A division of Haley & Aldrich

Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Key to Exploration Logs

Figure **A-1**
Sheet **1 of 1**

Date Started: 06/17/2021 Date Completed: 06/17/2021
Logged by: S. Ueno Checked by:
Location: Lat: 22.071352 Long: -159.421178 (WGS 84)
Ground Surface Elevation: 544.00 feet (Mean Sea Level)
Comments: New Crossing

Drilling Contractor/Crew: GeoTek Hawaii, Inc. / Chad and Chris
Drilling Method: Hollow Stem Auger
Rig Model/Type: GeoProbe® 6620DT / Track-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140 Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 4.5 inches Well Casing Diameter: NA
Total Depth: 15.5 feet Depth to Groundwater: 7.25 feet

Elevation (feet)	Depth (feet)	Blow Count	Recovery	Length (inches)	Number / Tests	Material Description	Water Level	PL / WC (%) / LL; Fines Content (%); SPT N Value
544	0					ELASTIC SILT (MH), few cobbles, trace fine sand, soft, moist, brown, trace organics.		
						grades to trace fine sand, no cobbles		
		0 / 1 / 1	18in.	18	S-1 / AL, WC			SPT N = 2; WC = 72.6
540	5	0 / 0 / 12	18in.	18	S-2 / WC	grades to trace sand, trace gravel, stiff, no organics, gold-gray mottling		SPT N = 12; WC = 82.3
						grades to wet, few gravel		
						grades to few cobbles	ATD	
		6 / 6 / 10	4in.	18	S-3	SILTY SAND WITH GRAVEL (SM), medium dense, wet, brown, fine to coarse sand, fine gravel, possible cobbles.		SPT N = 16
535	10	12 / 7 / 12	12in.	18	S-4 / WC			SPT N = 19
						grades to cobbles		
		50	6in.	6	S-5			SPT N = 50/6"
530		16 / 18 / 15	16in.	18	S-6 / AL, GS, WC			SPT N = 33; Fines = 77
	15					grades to dense and trace sand		

Bottom of Borehole at 15.5 feet.

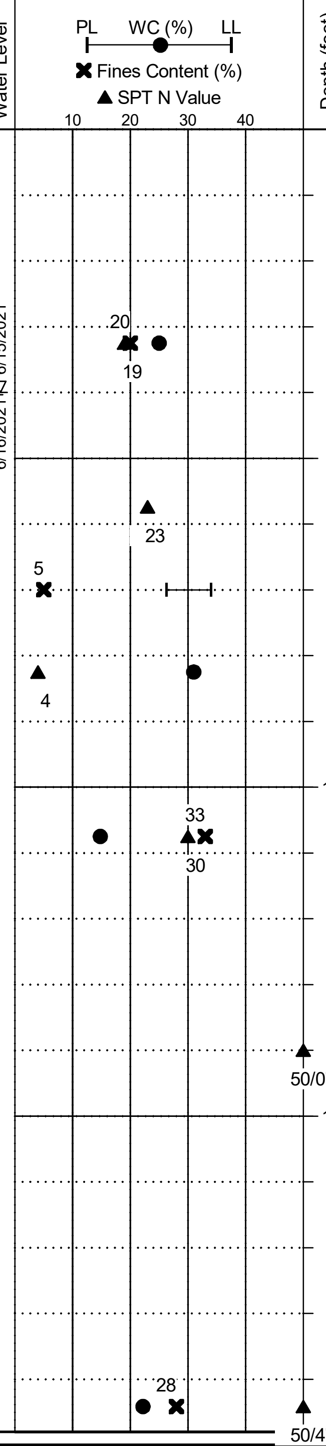
General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

Date Started: 06/15/2021
Date Completed: 06/16/2021
Logged by: S. Ueno
Checked by:
Location: Lat: 22.065945 Long: -159.420568 (WGS 84)
Ground Surface Elevation: 539.00 feet (Mean Sea Level)
Comments: Queensland Crossing

Drilling Contractor/Crew: GeoTek Hawaii, Inc. / Chad and Chris
Drilling Method: Hollow Stem Auger/Wireline Coring
Rig Model/Type: GeoProbe® 6620DT / Track-mounted drill rig
Hammer Type: Auto-hammer
Hammer Weight (pounds): 140
Hammer Drop Height (inches): 30
Measured Hammer Efficiency (%): Not Available
Hole Diameter: 4.5 inches
Well Casing Diameter: NA
Total Depth: 19.8 feet
Depth to Groundwater: 4 feet

Elevation (feet)	Depth (feet)	Blow Count	Recovery (RQD)	Length (inches)	Number / Tests	Material Description
	0					ELASTIC SILT (MH), few gravel, very stiff, moist, brown, coarse to fine gravel.
		3, 7, 12	18in.	18	S-1 GS, WC	
535						SILTY SAND WITH GRAVEL (SM), medium dense, wet, brown.
	5	28, 14, 9	12in.	18	S-2 Bulk 2 AL, GS	
		3, 1, 3	9in.	18	S-3 WC	grades to very loose, fine to coarse sand
530						grades to few cobbles
	10	16, 14, 16	15in.	18	S-4 GS, WC	grades to medium dense
			10in.(17%)	30	S-6	
525		50	0in.	0	S-5	grades to very dense, less gravel
						grades to boulders
	15					
			17in.(0%)	54	S-7	
520		7, 50	9in.	10	S-8 GS, WC	grades to red-brown mottling

Water Level: 6/16/2021 ∇ 6/15/2021



Bottom of Borehole at 19.8 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HARTCROWSER
A division of Haley & Aldrich

Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Boring Log
B-3

Figure **A-3**
Sheet **1 of 1**

Date Started: 06/15/2021	Date Completed: 06/15/2021	Contractor/Crew: Hart Crowser	
Logged by: S. Ueno	Checked by:	Rig Model/Type: Hand Auger	
Location: Lat: 22.065553 Long: -159.420788 (WGS 84)		Hole Diameter: 2.25 inches	Well Casing Diameter: NA
Ground Surface Elevation: 539.00 feet (Mean Sea Level)		Total Depth: 0.7 feet	Depth to Groundwater: Not Identified
Comments: Queensland Crossing			

Elevation (feet)	Depth (feet)	Sample Data: Type	Length (inches)	Number / Tests	Graphic Log	Material Description	WC (10 / 20 / 30 / 40)	Depth (feet)
	0			S-1 / WC		SILTY SAND WITH GRAVEL (SM), (soft), moist, brown, fine gravel, trace organics.	~19	0
						Refusal at 0.7 feet.		
535								
	5							5
530								
	10							10
525								
	15							15
520								

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HARTCROWSER
A division of Haley & Aldrich

Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Hand-Auger Log
HA-1a

Figure **A-4**
Sheet **1 of 1**

HC PUSH PROBE - \\HALEYALDRICH.COM\SHARE\PDX_DATA\GEOMATICS\GINT\HC_LIBRARY.GLB - 21/4/22 14:34 - \\HALEYALDRICH.COM\SHARE\PDX_DATA\NOTEBOOKS\3140026001_KAI_LIHUE_KOLOA_FOREST_RESERVE_GEOTECH\FIELD DATA\PERM_GINT FILES\3140026001_EXPLORATIONS.GPJ - mschweitzer

Date Started: 06/15/2021	Date Completed: 06/15/2021	Contractor/Crew: Hart Crowser	
Logged by: S. Ueno	Checked by:	Rig Model/Type: Hand Auger	
Location: Lat: 22.065553 Long: -159.420788 (WGS 84)		Hole Diameter: 2.25 inches	Well Casing Diameter: NA
Ground Surface Elevation: 539.00 feet (Mean Sea Level)		Total Depth: 0.5 feet	Depth to Groundwater: Not Identified
Comments: Queensland Crossing			

Elevation (feet)	Depth (feet)	Sample Data: Type	Sample Data: Length (inches)	Sample Data: Number / Tests	Graphic Log	Material Description	Depth (feet)
	0			S-2		SILTY SAND WITH GRAVEL (SM), (soft), moist, brown, fine gravel, trace organics.	0
						Refusal at 0.5 feet.	
535							
	5						5
530							
	10						10
525							
	15						15
520							

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HC PUSH PROBE - \\HALEYALDRICH.COM\SHARE\PDX_DATA\GEOMATICS\GINT\HC_LIBRARY.GLB - 21/4/22 14:34 - \\HALEYALDRICH.COM\SHARE\PDX_DATA\NOTEBOOKS\3140026001_KAI_LIHUE_KOLOA_FOREST_RESERVE_GEOTECH\FIELD DATA\PERM_GINT FILES\3140026001_EXPLORATIONS.GPJ - mschweitzer

Date Started: 06/17/2021	Date Completed: 06/17/2021	Contractor/Crew: Hart Crowser	
Logged by: S. Ueno	Checked by:	Rig Model/Type: Hand Auger	
Location: Lat: 22.071589 Long: -159.418002 (WGS 84)		Hole Diameter: 12 inches	Well Casing Diameter: NA
Ground Surface Elevation: 523.00 feet (Mean Sea Level)		Total Depth: 2.4 feet	Depth to Groundwater: Not Identified
Comments: Keahua Bridge			

Elevation (feet)	Depth (feet)	Type	Length (inches)	Number / Tests	Graphic Log	Material Description	PL — WC — LL; ✖ Fines Content (%) (10, 20, 30, 40)	Depth (feet)
	0			S-1 AL, GS, WC		SILTY SAND WITH GRAVEL (SM), few cobbles, (soft), moist, brown, fine sand, fine gravel, trace organics.		0
						SILTY SAND WITH GRAVEL (SM), few cobbles, (medium stiff), moist, brown, fine sand, fine gravel.	16	
						grades to few sand, some cobbles		
						Refusal at 2.4 feet. Refusal on boulders		
520								
	5							5
515								
	10							10
510								
	15							15
505								

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

APPENDIX B
Laboratory Testing

APPENDIX B

Laboratory Testing

A geotechnical laboratory testing program was performed for this study by Hart Crowser to evaluate the basic index and geotechnical engineering properties of the site soil. Testing was completed by a subcontracted company Masa Fujioka & Associates (MFA) of Aiea, Hawai'i. The tests performed and the procedures followed are outlined below.

Soil Classification

Soil samples from the explorations were visually classified in the field and classifications were verified in a controlled laboratory environment. Field and laboratory observations include density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by laboratory tests, such as water content determinations, plasticity indices, and grain size analyses. Classifications were made in general accordance with the Unified Soils Classification System (USCS) and ASTM Test Method D 2487.

Water Content Determinations

Water contents were determined for samples recovered in the explorations in general accordance with ASTM Test Method D 2216. The results of these tests are plotted at the respective sample depth on the exploration logs included in Appendix A and are also presented on Figure B-1 in this appendix.

Atterberg Limits

Atterberg limits (liquid limit, plastic limit, and plasticity index) of fine-grained soil samples were obtained in general accordance with ASTM Test Method D 4318. The results of the Atterberg limits tests completed on the samples from the explorations are presented on the exploration logs included in Appendix A and on Figure B-2 in this appendix.

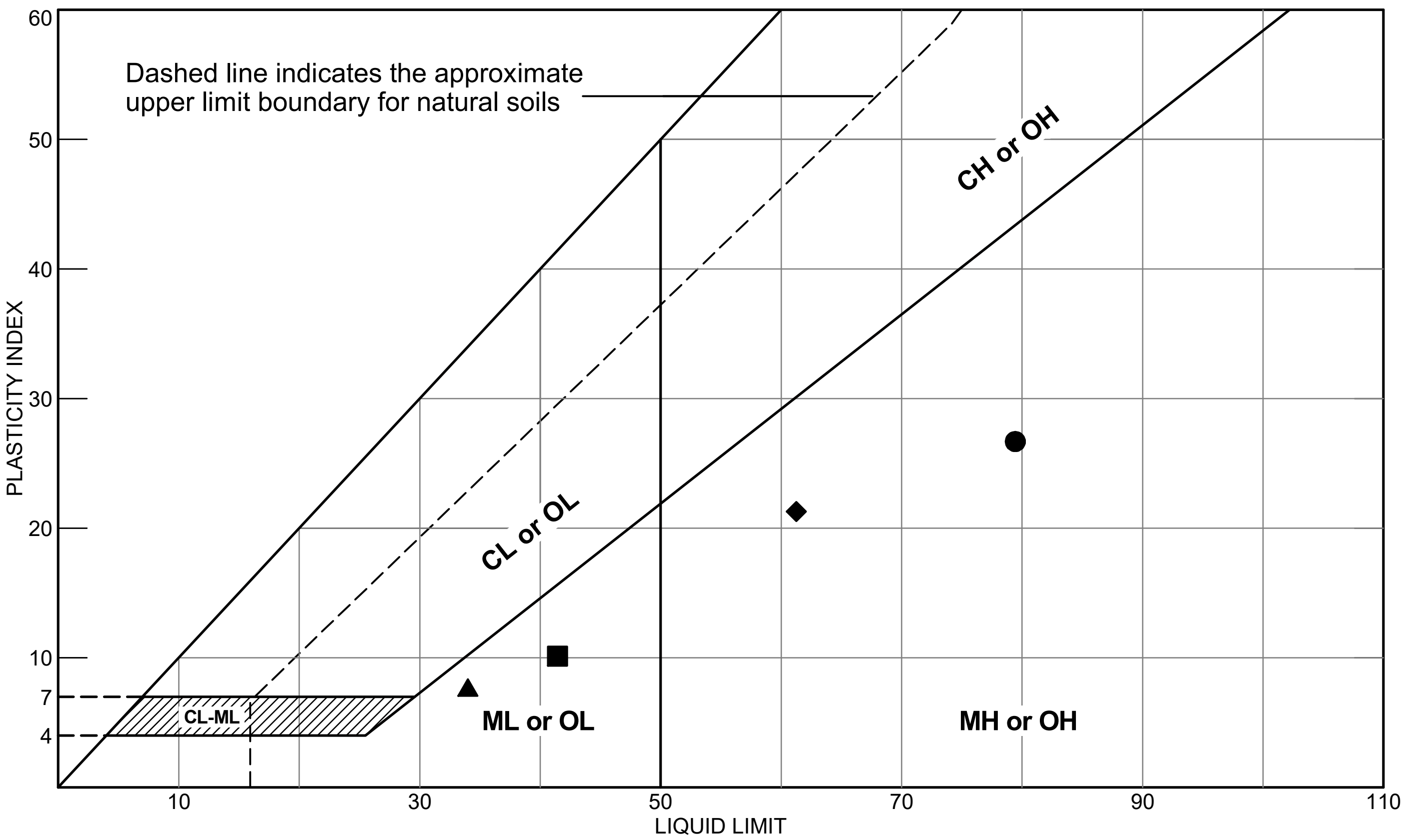
Grain Size Distribution and Wash No. 200 Analyses

Grain size distribution analyses were conducted to determine the quantitative distribution of particle sizes in different soil samples. The tests were performed in general accordance with ASTM Test Methods D 1140 and D 6913. The results of the grain size tests completed on samples from the explorations are presented on the exploration logs included in Appendix A and on Figure B-3 in this appendix.

Maximum Dry Density and California Bearing Ratio (CBR) Analyses

Maximum dry density determinations and California Bearing Ratio (CBR) tests were completed on select soil samples. In addition to obtaining CBR values, the analysis was used to determine expansive potential for the selected soil samples. The tests were conducted in general accordance with ASTM Test Methods C 1557 and D 1883. The test results are shown on the attached laboratory data from Masa Fujioka & Associates (MFA) at the end of this appendix.

Exploration	Sample ID	Depth	Water Content (%)	Dry Density (pcf)	Fines (%)	Sand (%)	Gravel (%)	Liquid Limit	Plastic Limit	Plasticity Index	Organic Content (%)	Pocket Pen (tsf)	Torvane (tsf)	
B-1	S-1	2.5	72.6					79	53	26				
B-1	S-2	5.0	82.3											
B-1	S-4	10.0	29.2											
B-1	S-6	14.0	22.9		77			41	31	10				
B-3	S-1	2.5	25.0		20									
B-3	Bulk 2	5.0			5	53	37	34	26	8				
B-3	S-3	7.5	31.0											
B-3	S-4	10.0	14.8		33	37	30							
B-3	S-8	19.0	22.2		28	38	34							
HA-1a	S-1	0.0	19.0											
HA-2	S-1	0.0	31.5		16	42	35	61	40	21				



Location and Description			LL	PL	PI	-#200	MC%	USCS
● **Source:** B-1	**Sample No.:** S-1	**Depth:** 2.5 to 4.0	79	53	26	NT	73	MH
ELASTIC SILT								
■ **Source:** B-1	**Sample No.:** S-6	**Depth:** 14.0 to 15.5	41	31	10	77	23	SM
SILTY SAND WITH GRAVEL								
▲ **Source:** B-3	**Sample No.:** Bulk 2	**Depth:** 5.0 to 9.0	34	26	8	5	NT	SP-SC
POORLY GRADED SAND WITH CLAY AND GRAVEL								
◆ **Source:** HA-2	**Sample No.:** S-1	**Depth:** 0.0 to 2.4	61	40	21	16	32	SM
SILTY SAND WITH GRAVEL								

Remarks:

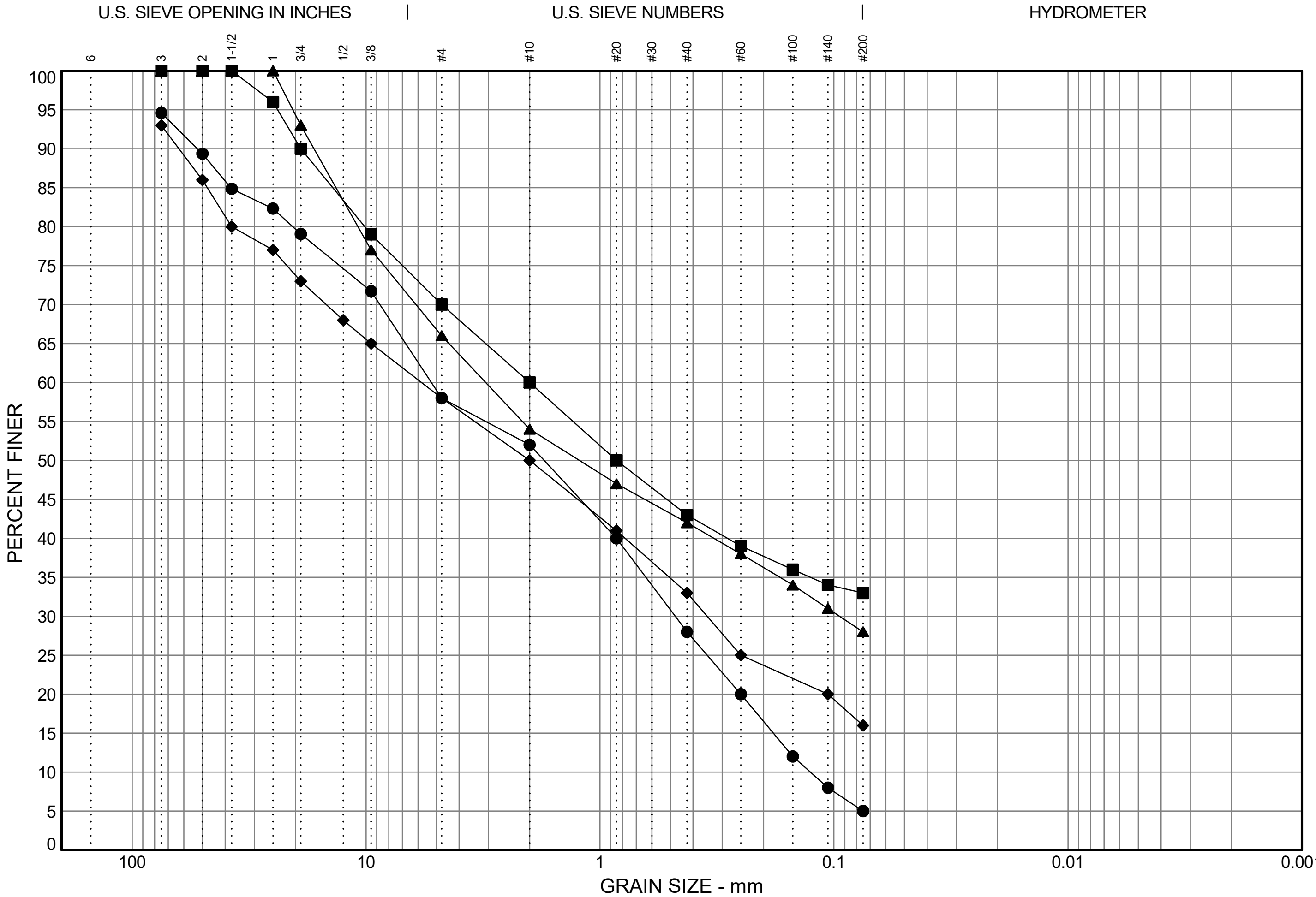
●
■
▲
◆

HARTCROWSER A division of Haley & Aldrich

Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Liquid Limit, Plastic Limit, and Plasticity Index

Figure **B-2**
Sheet **1 of 1**



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Location and Description	% Cobbles	% Gravel	% Sand	% Silt	% Clay	MC%	USCS
●	**Source:** B-3 **Sample No.:** Bulk 2 **Depth:** 5.0 to 9.0 POORLY GRADED SAND WITH CLAY AND GRAVEL		36.6	53.0	5.0		NT	SP-SC
■	**Source:** B-3 **Sample No.:** S-4 **Depth:** 10.0 to 11.5 SILTY SAND WITH GRAVEL	0.0	30.0	37.0	33.0		15	SM
▲	**Source:** B-3 **Sample No.:** S-8 **Depth:** 19.0 to 19.8 SILTY SAND WITH GRAVEL	0.0	34.0	38.0	28.0		22	SM
◆	**Source:** HA-2 **Sample No.:** S-1 **Depth:** 0.0 to 2.4 SILTY SAND WITH GRAVEL		35.0	42.0	16.0		32	SM

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	34	8	37.832	5.256	1.734	0.477	0.182	0.126	0.34	41.68
■			13.865	2.000	0.850					
▲			13.435	3.082	1.227	0.094				
◆	61	21	47.659	5.790	2.000	0.348				

Remarks:

●
■
▲
◆

HARTCROWSER
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Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Particle-Size Analysis

Figure **B-3**
Sheet **1 of 1**

Exploration	Sample ID	Depth	Water Content (%)	Dry Density (pcf)	Fines (%)	Sand (%)	Gravel (%)	Liquid Limit	Plastic Limit	Plasticity Index	Organic Content (%)	Pocket Pen (tsf)	Torvane (tsf)	
B-1	S-1	2.5	72.6					79	53	26				
B-1	S-2	5.0	82.3											
B-1	S-4	10.0	29.2											
B-1	S-6	14.0	22.9		77			41	31	10				
B-3	S-1	2.5	25.0		20									
B-3	Bulk 2	5.0			5	53	37	34	26	8				
B-3	S-3	7.5	31.0											
B-3	S-4	10.0	14.8		33	37	30							
B-3	S-8	19.0	22.2		28	38	34							
HA-1a	S-1	0.0	19.0											
HA-2	S-1	0.0	31.5		16	42	35	61	40	21				

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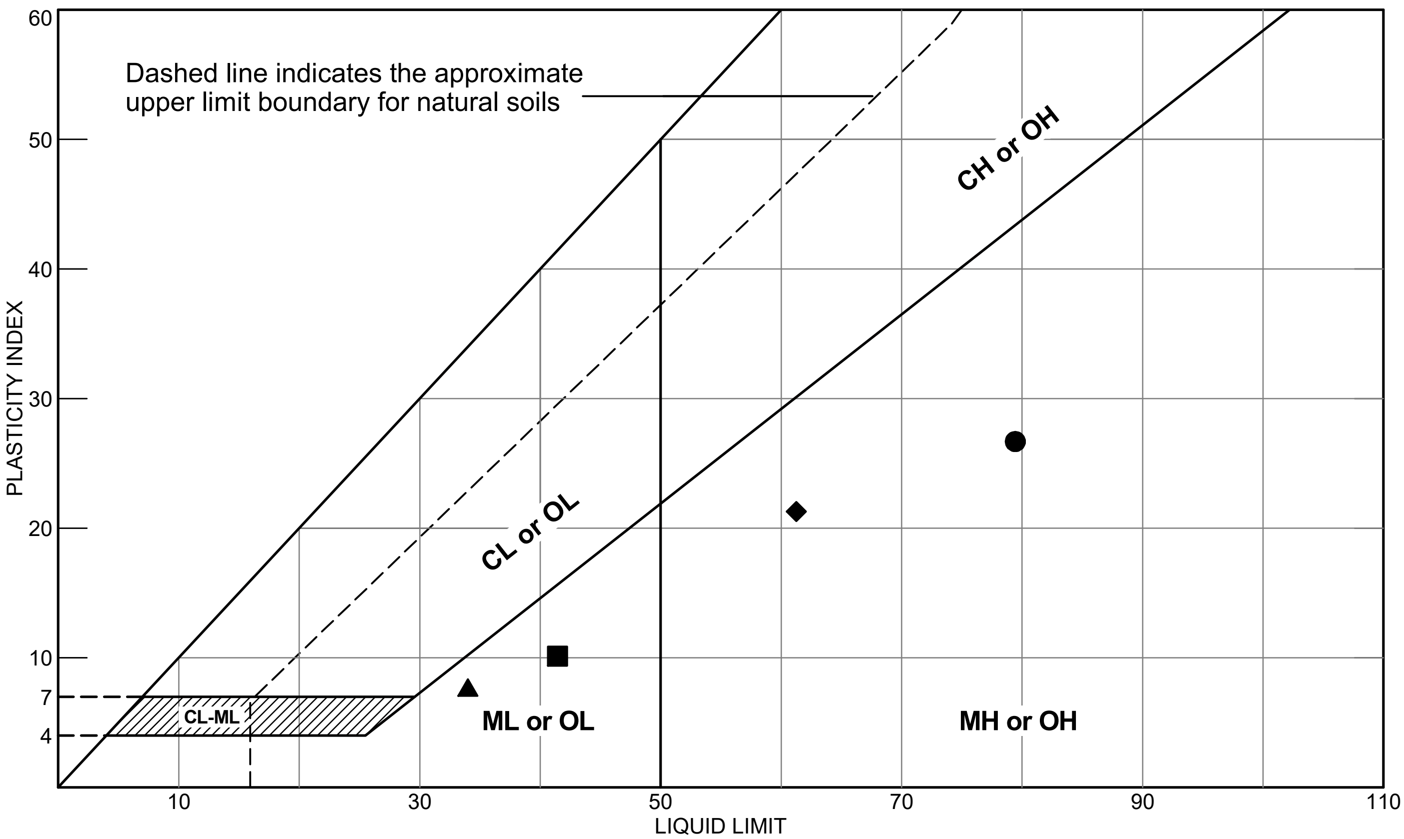
Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Summary of Laboratory Results

Figure **B-1**
Sheet **1 of 1**



Location and Description			LL	PL	PI	-#200	MC%	USCS
● **Source:** B-1 ELASTIC SILT	**Sample No.:** S-1	**Depth:** 2.5 to 4.0	79	53	26	NT	73	MH
■ **Source:** B-1 SILTY SAND WITH GRAVEL	**Sample No.:** S-6	**Depth:** 14.0 to 15.5	41	31	10	77	23	SM
▲ **Source:** B-3 POORLY GRADED SAND WITH CLAY AND GRAVEL	**Sample No.:** Bulk 2	**Depth:** 5.0 to 9.0	34	26	8	5	NT	SP-SC
◆ **Source:** HA-2 SILTY SAND WITH GRAVEL	**Sample No.:** S-1	**Depth:** 0.0 to 2.4	61	40	21	16	32	SM

Remarks:

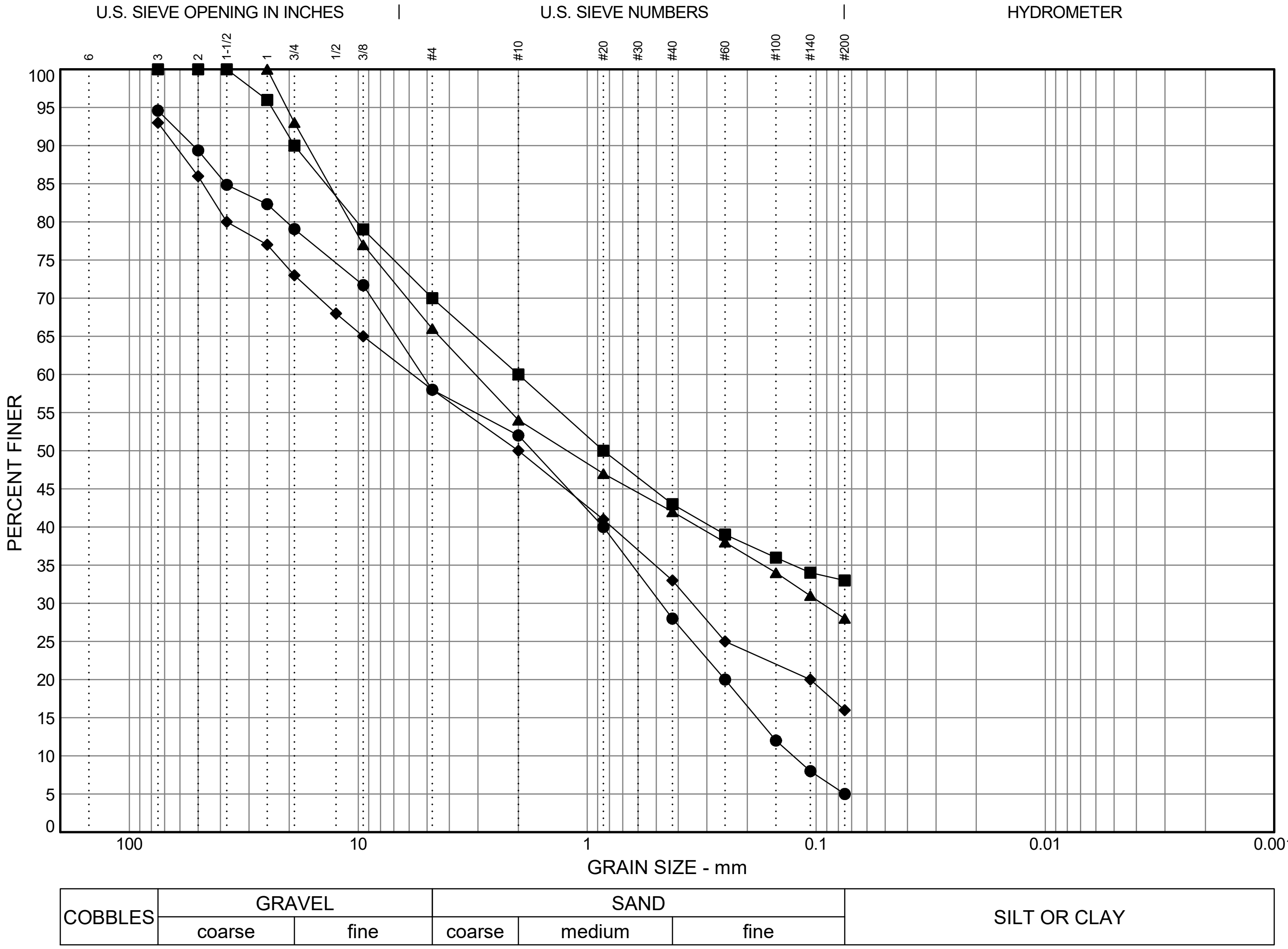
- ●
- ■
- ▲
- ◆

HARTCROWSER
A division of Haley & Aldrich

Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Liquid Limit, Plastic Limit, and Plasticity Index

Figure **B-2**
Sheet **1 of 1**



Location and Description	% Cobbles	% Gravel	% Sand	% Silt / % Clay	MC%	USCS
● **Source:** B-3 **Sample No.:** Bulk 2 **Depth:** 5.0 to 9.0 POORLY GRADED SAND WITH CLAY AND GRAVEL		36.6	53.0	5.0	NT	SP-SC
■ **Source:** B-3 **Sample No.:** S-4 **Depth:** 10.0 to 11.5 SILTY SAND WITH GRAVEL	0.0	30.0	37.0	33.0	15	SM
▲ **Source:** B-3 **Sample No.:** S-8 **Depth:** 19.0 to 19.8 SILTY SAND WITH GRAVEL	0.0	34.0	38.0	28.0	22	SM
◆ **Source:** HA-2 **Sample No.:** S-1 **Depth:** 0.0 to 2.4 SILTY SAND WITH GRAVEL		35.0	42.0	16.0	32	SM

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	34	8	37.832	5.256	1.734	0.477	0.182	0.126	0.34	41.68
■			13.865	2.000	0.850					
▲			13.435	3.082	1.227	0.094				
◆	61	21	47.659	5.790	2.000	0.348				

Remarks:

●
■
▲
◆

HARTCROWSER
A division of Haley & Aldrich

Project: Kai Lihue Koloa Forest Reserve
Location: Lihue, Kauai, Hawaii
Project No.: 0203306-000

Particle-Size Analysis

Figure **B-3**
Sheet **1 of 1**

MASA FUJIOKA
& ASSOCIATES

LETTER OF TRANSMITTAL

TO: Hart Crowser	RE: Soil Laboratory Results
ATTENTION: Shyun Ueno	
JOB NUMBER: 669-008	
DATE: 07/06/2021	

We are sending you _X_ Attached ____ Under Separate cover via ____________ the following items:

____ Report(s) ____ Prints ____ Samples ____ Plans ____ Specifications

____ Copy of letter ____ Change order ____ Other/Amended: ____________

COPIES	DATE	NO.	DESCRIPTION
1	07/06/2021	1	Soil laboratory results

THESE ARE TRANSMITTED as checked below:

____ For approval	____ Approval as submitted	____ Resubmit	____ copies for approval
____ For your use	____ Reviewed as noted	____ Submit	____ copies for distribution
_X_ As requested	____ Returned for corrections	____ Return	____ corrected prints
____ For review and comment	____ Other: ____________		
____ For bids due ____________		____ Prints returned after loan to us	

REMARKS:

COPY TO JoDee Taylor

SIGNED:

NAME AND TITLE: Ryan T. Ishikawa P.E. Managing Principal

If enclosures are not as noted, kindly notify us at once

ENVIRONMENTAL • GEOTECHNICAL • HYDROGEOLOGICAL CONSULTANTS

98-021 KAMEHAMEHA HIGHWAY, SUITE 337 • AIEA, HAWAII 96701-4908
PHONE: (808) 484-5366 • FAX: (808) 484-0007

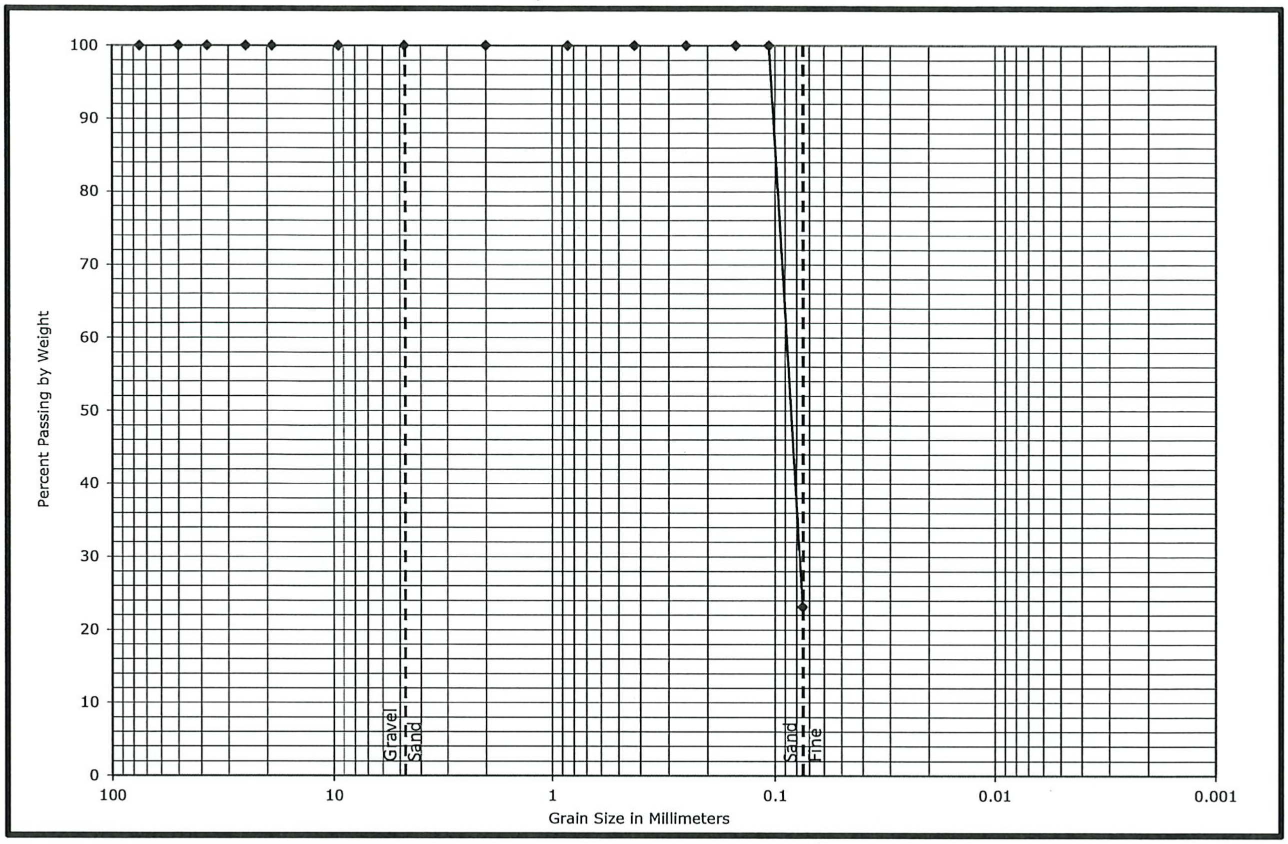
Grain Size Analysis

Project: Lihue-Koloa Forest Reserve
MFA Job No.: 669-008
Client: Hart Crowser, Inc.
Location: Kauai, HI

Date Received: 6/21/2021
Test Start Date: 6/21/2021
Test End Date: 7/6/2021
Date Reported: 7/6/2021

ASTM: D1140
Wash: Method A
Soil Class: N/A
USCS: N/A

Figure: N/A
Sample: B-1, S-6
Depth: 14.0 - 15.5'



Sieve ID	Mass Ret. Individual (g)	Mass Ret. Cumulative (g)	% Retained Cum	Percent Passing
3	0.0	0.0	0	100
2	0.0	0.0	0	100
1 1/2	0.0	0.0	0	100
1	0.0	0.0	0	100
3/4	0.0	0.0	0	100
3/8	0.0	0.0	0	100
#4	0.0	0.0	0	100
#10	0.0	0.0	0	100
#20	0.0	0.0	0	100
#40	0.0	0.0	0	100
#60	0.0	0.0	0	100
#100	0.0	0.0	0	100
#140	0.0	0.0	0	100
#200	189.7	57.1	77	23
Pan	-----	-----	-----	-----
Passing No. 200 Wash	-----	-----	-----	-----
Total	246.8	-----	-----	-----

MASA FUJIOKA & ASSOCIATES

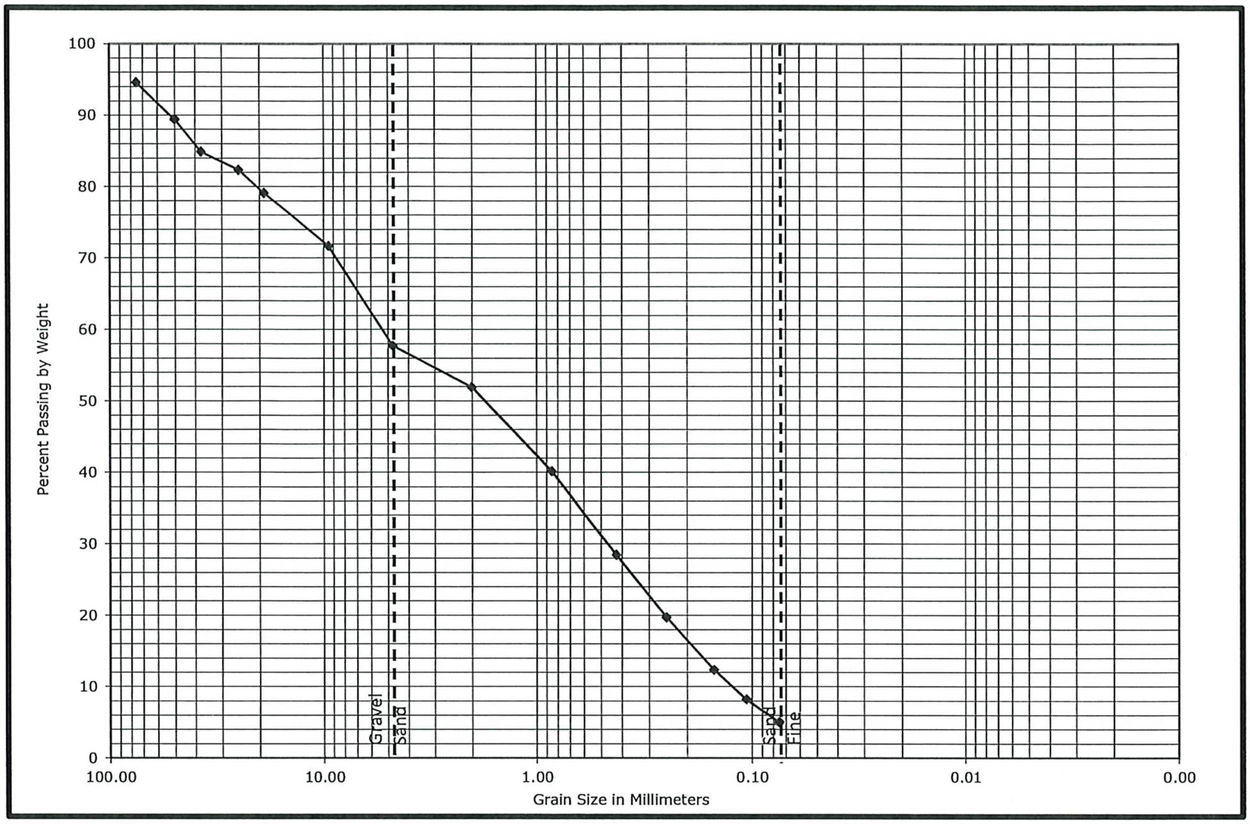
Grain Size Analysis

Project: Lihue-Koloa Forest Reserve
MFA Job No.: 669-008
Client: Hart Crowser, Inc.
Location: Kauai, HI

Date Received: 6/21/2021
Test Start Date: 6/21/2021
Test End Date: 7/6/2021
Date Reported: 7/6/2021

ASTM: D6913/D1140
Wash: Method A
Soil Class: Poorly graded sand w/ gravel
USCS: SP

Figure: N/A
Sample: B-3, Bulk 2
Depth: 5.0 - 9.0'

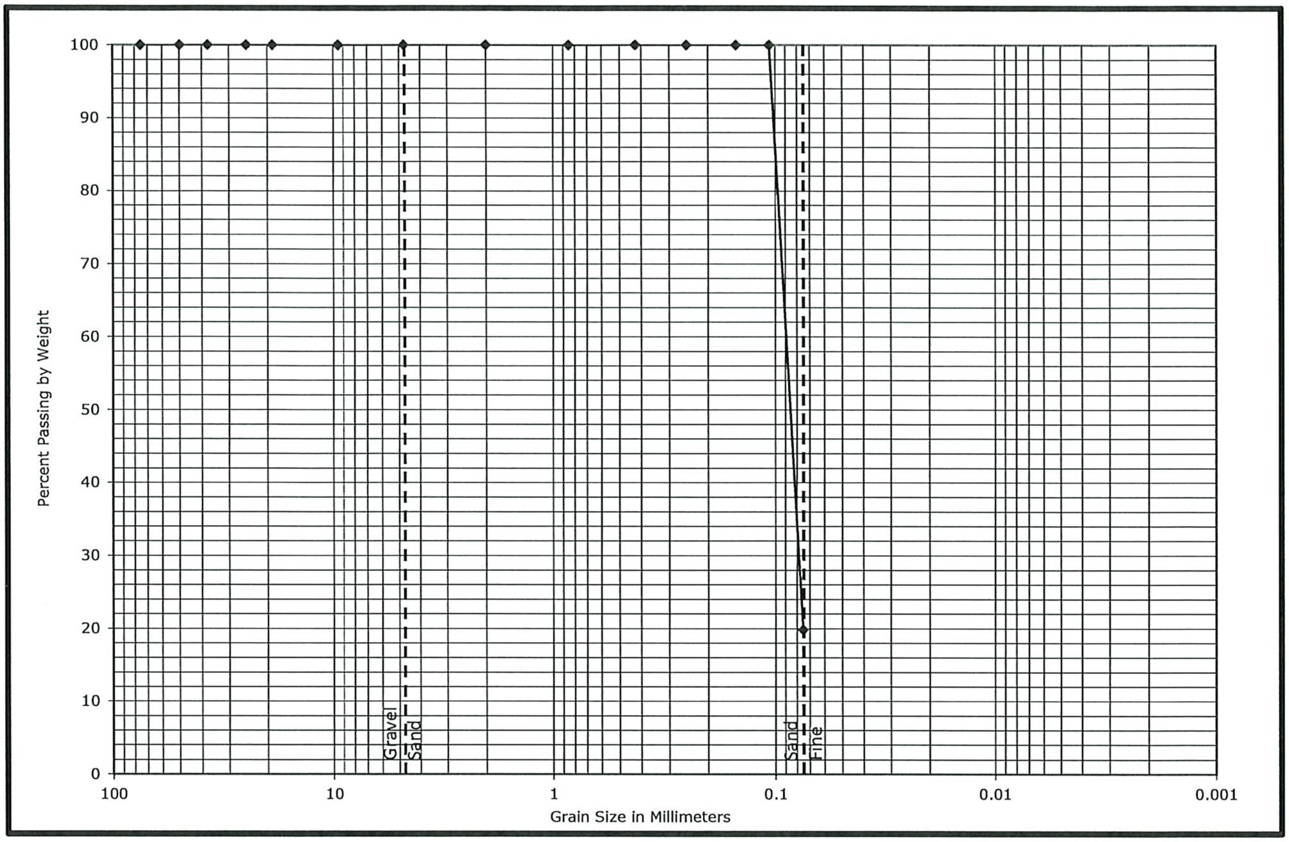


Sieve ID	Mass Ret. Individual (g)	Mass Ret. Cumulative (g)	% Retained Cum	Percent Passing
3	939.8	939.8	5	95
2	905.9	1845.7	11	89
1 1/2	783.1	2628.8	15	85
1	440.9	3069.7	18	82
3/4	566.8	3636.5	21	79
3/8	1276.6	4913.1	28	72
#4	2434.1	7347.2	42	58
#10	999.6	8346.8	48	52
#20	2045.4	10392.2	60	40
#40	2036.2	12428.4	72	28
#60	1517.9	13946.2	80	20
#100	1277.2	15223.4	88	12
#140	721.9	15945.3	92	8
#200	555.3	16500.7	> 95	< 5
Pan	148.1	16648.7	----	----
Passing No. 200 Wash	716.8	----	----	----
Total	17365.6	----	----	----

MASA FUJIOKA
& ASSOCIATES

Grain Size Analysis

Project:	Lihue-Koloa Forest Reserve	Date Received:	6/21/2021	ASTM:	D1140	Figure:	N/A
MFA Job No.:	669-008	Test Start Date:	6/21/2021	Wash:	Method A	Sample:	B-3, S-1
Client:	Hart Crowser, Inc.	Test End Date:	7/6/2021	Soil Class:	N/A	Depth:	2.5 - 4.0'
Location:	Kauai, HI	Date Reported:	7/6/2021	USCS:	N/A		

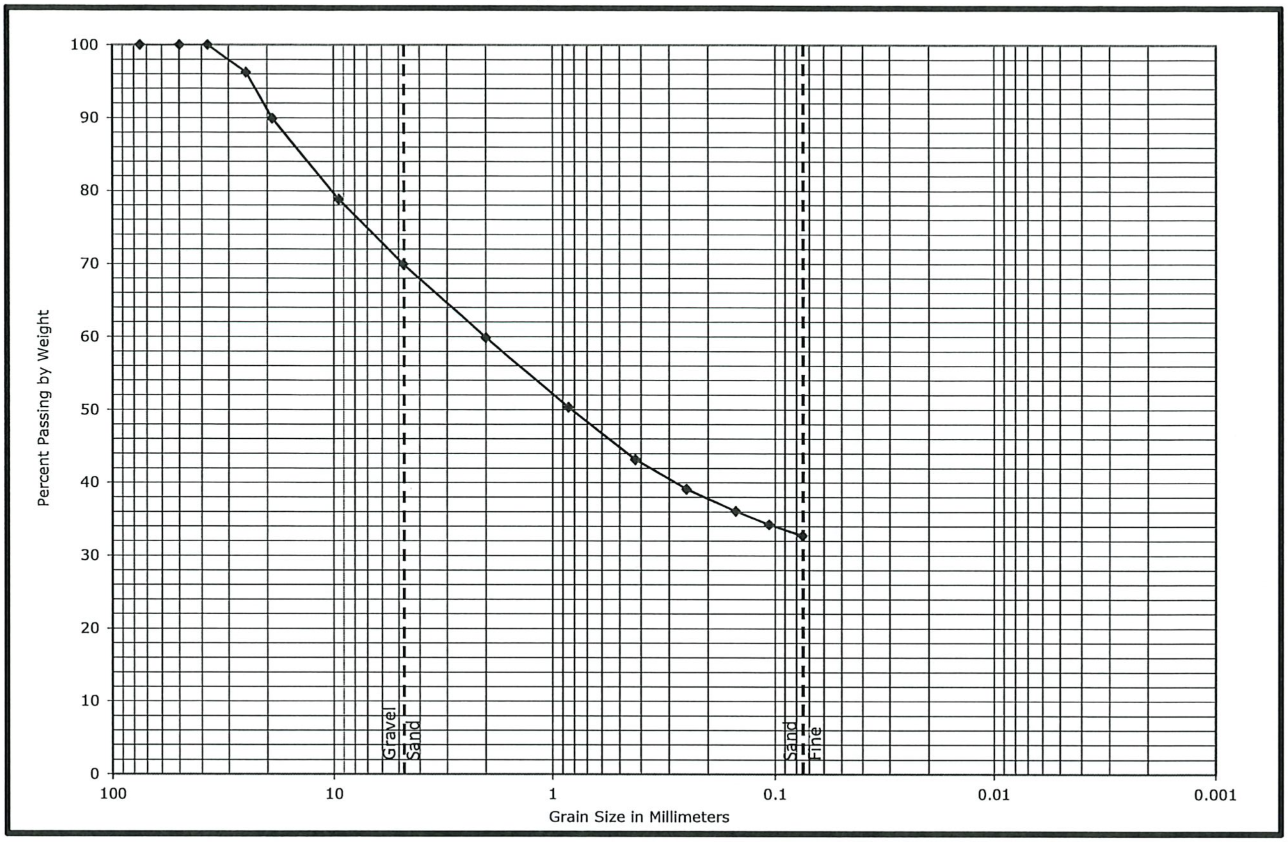


Sieve ID	Mass Ret. Individual (g)	Mass Ret. Cumulative (g)	% Retained Cum	Percent Passing
3	0.0	0.0	0	100
2	0.0	0.0	0	100
1 1/2	0.0	0.0	0	100
1	0.0	0.0	0	100
3/4	0.0	0.0	0	100
3/8	0.0	0.0	0	100
#4	0.0	0.0	0	100
#10	0.0	0.0	0	100
#20	0.0	0.0	0	100
#40	0.0	0.0	0	100
#60	0.0	0.0	0	100
#100	0.0	0.0	0	100
#140	0.0	0.0	0	100
#200	575.6	142.1	80	20
Pan	-----	-----	-----	-----
Passing No. 200 Wash	-----	-----	-----	-----
Total	717.7	-----	-----	-----

MASA FUJIOKA & ASSOCIATES

Grain Size Analysis

Project: Lihue-Koloa Forest Reserve | Date Received: 6/21/2021 | ASTM: D6913/D1140 | Figure: N/A
MFA Job No.: 669-008 | Test Start Date: 6/21/2021 | Wash: Method A | Sample: B-3, S-4
Client: Hart Crowser, Inc. | Test End Date: 7/6/2021 | Soil Class: N/A | Depth: 9.8 - 11.3'
Location: Kauai, HI | Date Reported: 7/6/2021 | USCS: N/A

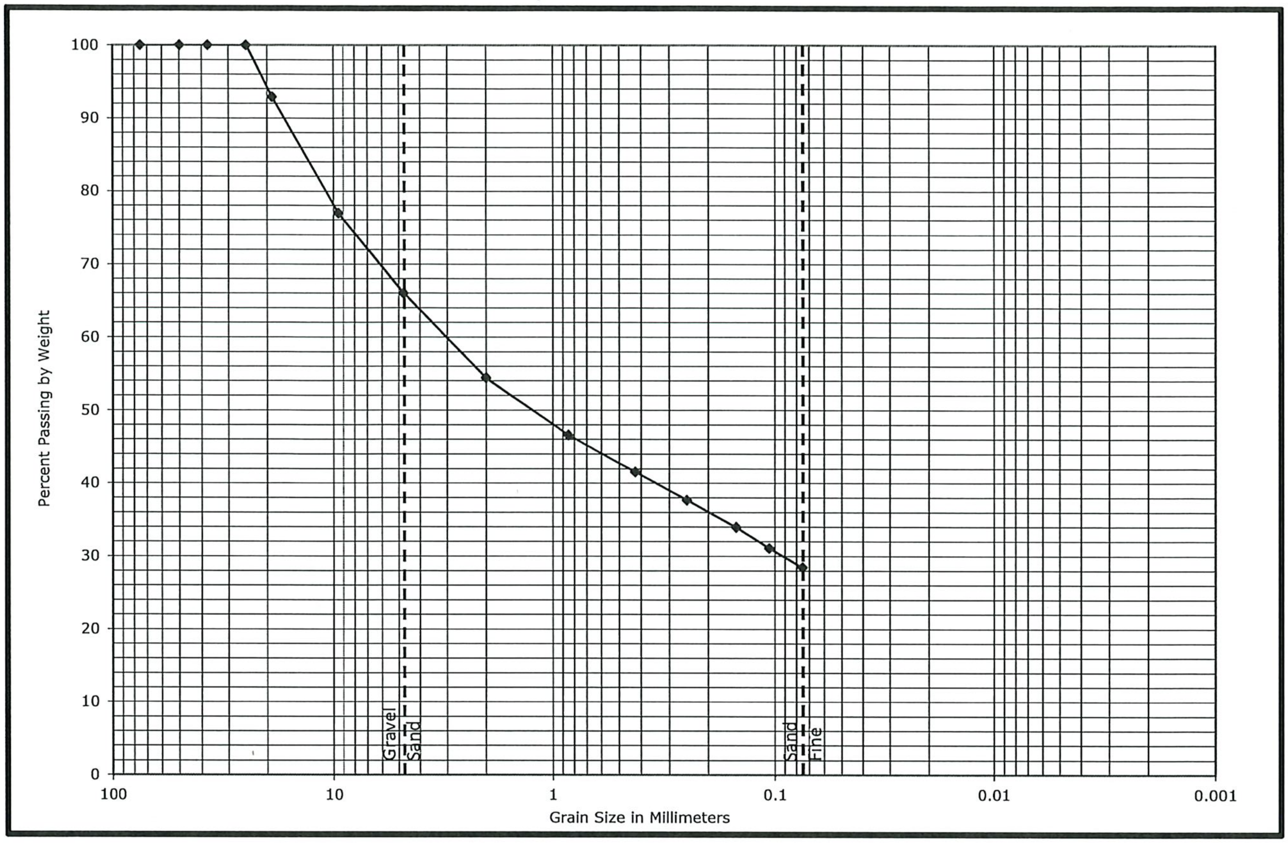


Sieve ID	Mass Ret. Individual (g)	Mass Ret. Cumulative (g)	% Retained Cum	Percent Passing
3	0.0	0.0	0	100
2	0.0	0.0	0	100
1 1/2	0.0	0.0	0	100
1	37.6	37.6	4	96
3/4	63.1	100.7	10	90
3/8	110.6	211.3	21	79
#4	89.2	300.5	30	70
#10	100.0	400.5	40	60
#20	95.6	496.1	50	50
#40	71.7	567.8	57	43
#60	40.2	608.0	61	39
#100	30.0	638.0	64	36
#140	18.5	656.5	66	34
#200	15.4	671.9	67	33
Pan	4.9	676.8	-----	-----
Passing No. 200 Wash	321.9	-----	-----	-----
Total	998.7	-----	-----	-----

MASA FUJIOKA & ASSOCIATES

Grain Size Analysis

Project:	Lihue-Koloa Forest Reserve	**Date Received:**	6/21/2021	**ASTM:**	D6913/D1140	**Figure:**	N/A
MFA Job No.:	669-008	**Test Start Date:**	6/21/2021	**Wash:**	Method A	**Sample:**	B-3, S-8
Client:	Hart Crowser, Inc.	**Test End Date:**	7/6/2021	**Soil Class:**	N/A	**Depth:**	19.0 - 19.9'
Location:	Kauai, HI	**Date Reported:**	7/6/2021	**USCS:**	N/A		

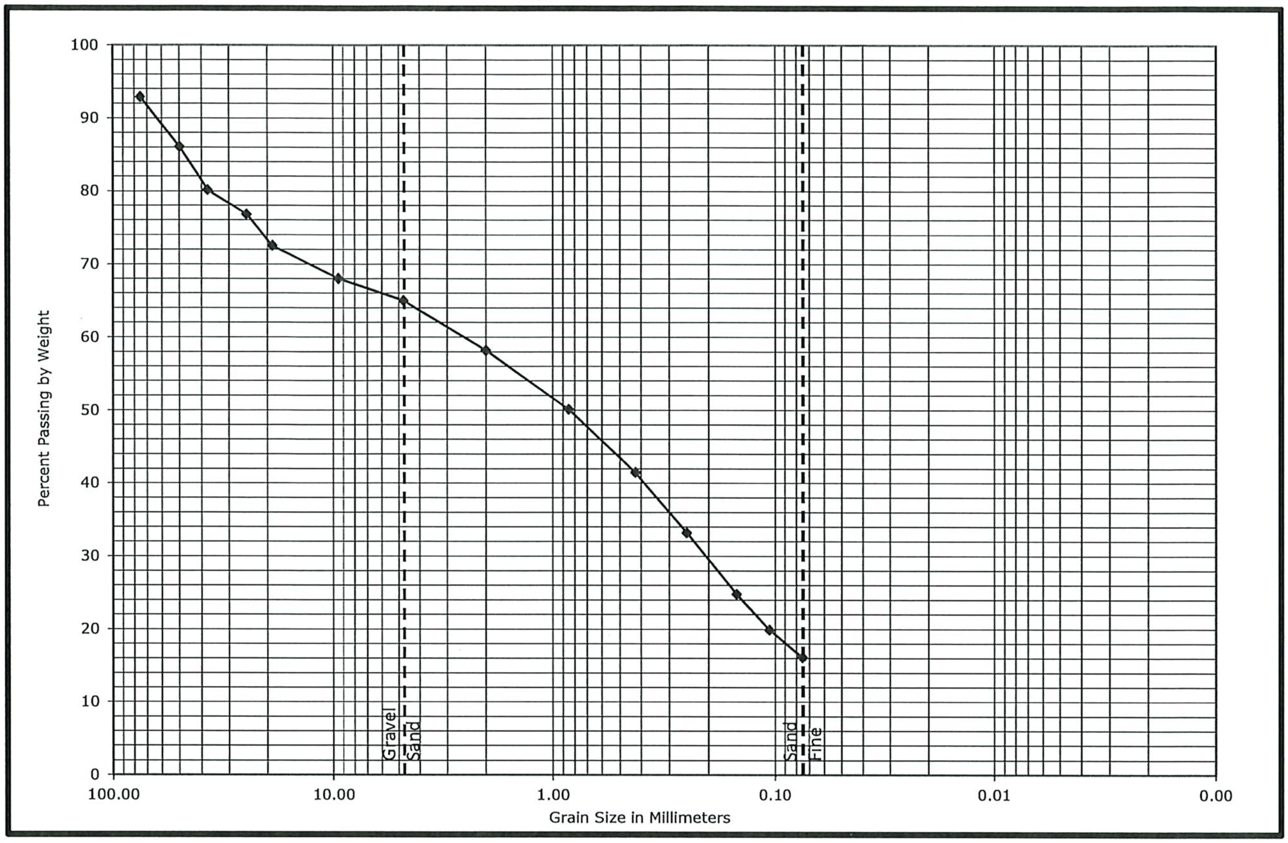


Sieve ID	Mass Ret. Individual (g)	Mass Ret. Cumulative (g)	% Retained Cum	Percent Passing
3	0.0	0.0	0	100
2	0.0	0.0	0	100
1 1/2	0.0	0.0	0	100
1	0.0	0.0	0	100
3/4	22.9	22.9	7	93
3/8	51.4	74.3	23	77
#4	35.3	109.6	34	66
#10	37.4	147.0	46	54
#20	25.3	172.3	53	47
#40	16.2	188.5	58	42
#60	12.5	201.0	62	38
#100	12.0	213.0	66	34
#140	9.2	222.2	69	31
#200	8.5	230.7	72	28
Pan	1.8	232.5	-----	-----
Passing No. 200 Wash	90.0	-----	-----	-----
Total	322.5	-----	-----	-----

MASA FUJIOKA & ASSOCIATES

Grain Size Analysis

Project:	Lihue-Koloa Forest Reserve	Date Received:	6/21/2021	ASTM:	D6913/D1140	Figure:	N/A
MFA Job No.:	669-008	Test Start Date:	6/21/2021	Wash:	Method A	Sample:	HA-2, S-1
Client:	Hart Crowser, Inc.	Test End Date:	7/6/2021	Soil Class:	Silty sand w/ gravel	Depth:	0.0 - 2.5'
Location:	Kauai, HI	Date Reported:	7/6/2021	USCS:	SM		



Sieve ID	Mass Ret. Individual (g)	Mass Ret. Cumulative (g)	% Retained Cum	Percent Passing
3	939.8	939.8	7	93
2	905.9	1845.7	14	86
1 1/2	783.1	2628.8	20	80
1	440.9	3069.7	23	77
3/4	566.8	3636.5	27	73
3/8	595.0	4231.5	32	68
#4	401.5	4633.1	35	65
#10	902.0	5535.1	42	58
#20	1070.8	6605.8	50	50
#40	1146.4	7752.2	59	41
#60	1094.0	8846.3	67	33
#100	1111.5	9957.8	75	25
#140	645.9	10603.7	80	20
#200	506.3	11110.0	84	16
Pan	104.7	11214.7	-----	-----
Passing No. 200 Wash	2025.3	-----	-----	-----
Total	13240.1	-----	-----	-----

MASA FUJIOKA
& ASSOCIATES

ATTERBERG LIMITS

PROJECT:	Lihue-Koloa Forest Reserve	Figure:	N/A
JOB NO:	669-008	Air Dried:	Before
SAMPLE NO:	B-1, S-2	Preparation:	Dry
LOCATION:	Kauai, HI	Date Received:	6/21/2021
DEPTH:	5.0 - 6.5'	Test Start Date:	6/21/2021
DESCRIPTION OF SOIL:	MH	Test End Date:	7/6/2021
CLIENT:	Hart Crowser, Inc.	Date Reported:	7/6/2021

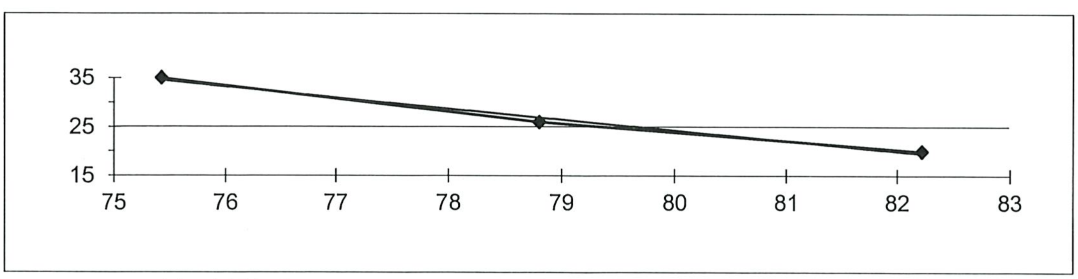
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	N/A	N/A
WT WET SOIL +TARE (g)	21.87	21.94
WT. DRY SOIL + TARE (g)	19.68	19.72
WT. MOISTURE TIN	15.49	15.55
WT. WATER (g)	2.19	2.22
WT. DRY SOIL (g)	4.19	4.17
MOISTURE CONTENT (%)	52.27	53.24

Plastic Limit = 53 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	N/A	N/A	N/A
WT WET SOIL +TARE (g)	8.92	9.54	9.14
WT. DRY SOIL + TARE (g)	5.85	6.12	5.81
Wt. Tare (g)	1.78	1.78	1.76
wT. WATER (g)	3.07	3.42	3.33
WT. DRY SOIL (g)	4.07	4.34	4.05
MOISTURE CONTENT (%)	75.43	78.80	82.22
No. of Blows	35	26	20
	35-25	30-20	25-15



Liquid Limit = 80 % at N = 25 blows
Plasticity Index = 27 %

MASA FUJIOKA & ASSOCIATES

ATTERBERG LIMITS

PROJECT:	Lihue-Koloa Forest Reserve	Figure:	N/A
JOB NO:	669-008	Air Dried:	Before
SAMPLE NO:	B-1, S-6	Preparation:	Dry
LOCATION:	Kauai, HI	Date Received:	6/21/2021
DEPTH:	14.0 - 15.5'	Test Start Date:	6/21/2021
DESCRIPTION OF SOIL:	ML	Test End Date:	7/6/2021
CLIENT:	Hart Crowser, Inc.	Date Reported:	7/6/2021

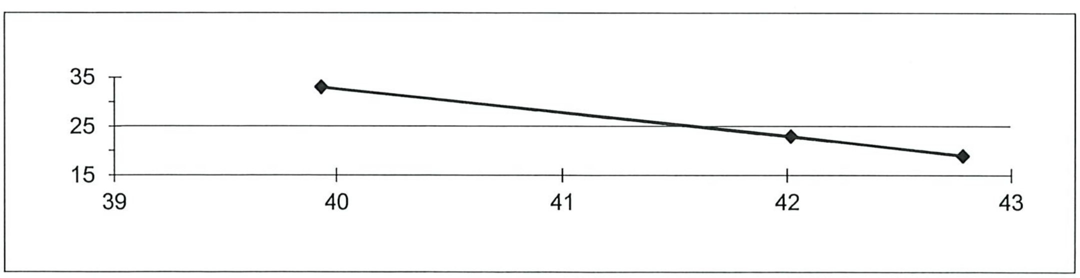
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	N/A	N/A
WT WET SOIL +TARE (g)	22.68	22.13
WT. DRY SOIL + TARE (g)	21.05	20.54
WT. MOISTURE TIN	15.84	15.47
WT. WATER (g)	1.63	1.59
WT. DRY SOIL (g)	5.21	5.07
MOISTURE CONTENT (%)	31.29	31.36

Plastic Limit = 31 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	N/A	N/A	N/A
WT WET SOIL +TARE (g)	13.80	10.23	10.51
WT. DRY SOIL + TARE (g)	10.37	7.73	7.90
Wt. Tare (g)	1.78	1.78	1.80
wT. WATER (g)	3.43	2.50	2.61
WT. DRY SOIL (g)	8.59	5.95	6.10
MOISTURE CONTENT (%)	39.93	42.02	42.79
No. of Blows	33	23	19
	35-25	30-20	25-15



Liquid Limit = 42 % at N = 25 blows
Plasticity Index = 11 %

MASA FUJIOKA & ASSOCIATES

ATTERBERG LIMITS

PROJECT:	Lihue-Koloa Forest Reserve	Figure:	N/A
JOB NO:	669-008	Air Dried:	Before
SAMPLE NO:	B-3, Bulk 2	Preparation:	Dry
LOCATION:	Kauai, HI	Date Received:	6/21/2021
DEPTH:	5.0 - 9.0'	Test Start Date:	6/21/2021
DESCRIPTION OF SOIL:	ML	Test End Date:	7/6/2021
CLIENT:	Hart Crowser, Inc.	Date Reported:	7/6/2021

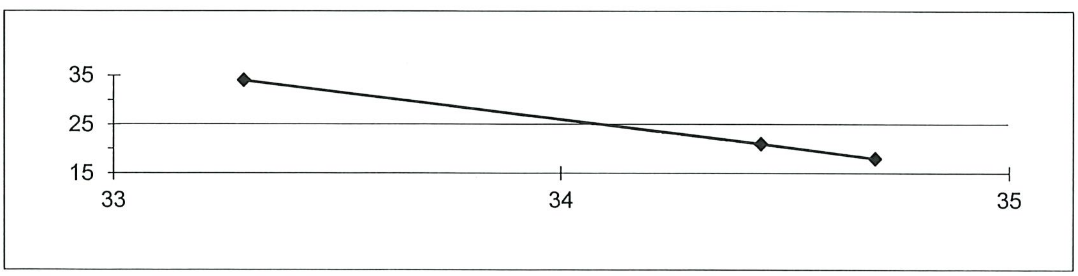
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	N/A	N/A
WT WET SOIL +TARE (g)	23.38	23.16
WT. DRY SOIL + TARE (g)	21.82	21.60
WT. MOISTURE TIN	15.90	15.65
WT. WATER (g)	1.56	1.56
WT. DRY SOIL (g)	5.92	5.95
MOISTURE CONTENT (%)	26.35	26.22

Plastic Limit = 26 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	N/A	N/A	N/A
WT WET SOIL +TARE (g)	13.50	12.64	11.28
WT. DRY SOIL + TARE (g)	10.57	9.85	8.83
Wt. Tare (g)	1.77	1.75	1.77
wT. WATER (g)	2.93	2.79	2.45
WT. DRY SOIL (g)	8.80	8.10	7.06
MOISTURE CONTENT (%)	33.30	34.44	34.70
No. of Blows	34	21	18
	35-25	30-20	25-15



Liquid Limit = 34 % at N = 25 blows

Plasticity Index = 8 %

MASA FUJIOKA & ASSOCIATES

ATTERBERG LIMITS

PROJECT:	Lihue-Koloa Forest Reserve	Figure:	N/A
JOB NO:	669-008	Air Dried:	Before
SAMPLE NO:	HA-2, S-1	Preparation:	Dry
LOCATION:	Kauai, HI	Date Received:	6/21/2021
DEPTH:	0.0 - 2.5'	Test Start Date:	6/21/2021
DESCRIPTION OF SOIL:	MH	Test End Date:	7/6/2021
CLIENT:	Hart Crowser, Inc.	Date Reported:	7/6/2021

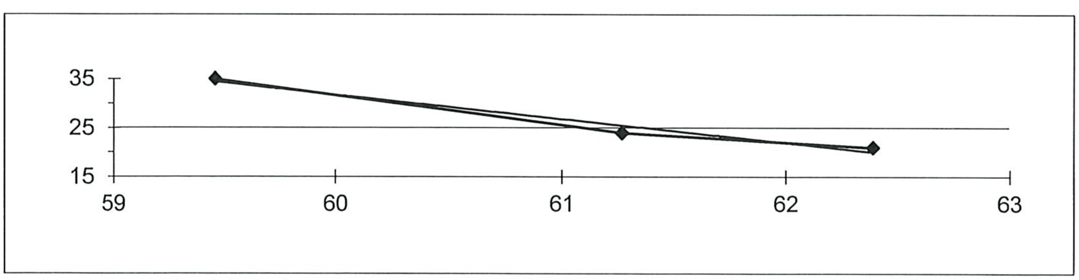
PLASTIC LIMIT DETERMINATION

SAMPLE OR TRIAL NO.	1	2
MOISTURE TIN NO.	N/A	N/A
WT WET SOIL +TARE (g)	22.93	22.25
WT. DRY SOIL + TARE (g)	20.89	20.35
WT. MOISTURE TIN	15.83	15.56
WT. WATER (g)	2.04	1.9
WT. DRY SOIL (g)	5.06	4.79
MOISTURE CONTENT (%)	40.32	39.67

Plastic Limit = 40 %

LIQUID LIMIT

SAMPLE OR TRIAL NO.	1	2	3
MOISTURE TIN NO.	N/A	N/A	N/A
WT WET SOIL +TARE (g)	10.03	9.14	9.38
WT. DRY SOIL + TARE (g)	6.95	6.34	6.46
Wt. Tare (g)	1.77	1.77	1.78
wT. WATER (g)	3.08	2.80	2.92
WT. DRY SOIL (g)	5.18	4.57	4.68
MOISTURE CONTENT (%)	59.46	61.27	62.39
No. of Blows	35	24	21
	35-25	30-20	25-15



Liquid Limit = 61 % at N = 25 blows
Plasticity Index = 21 %

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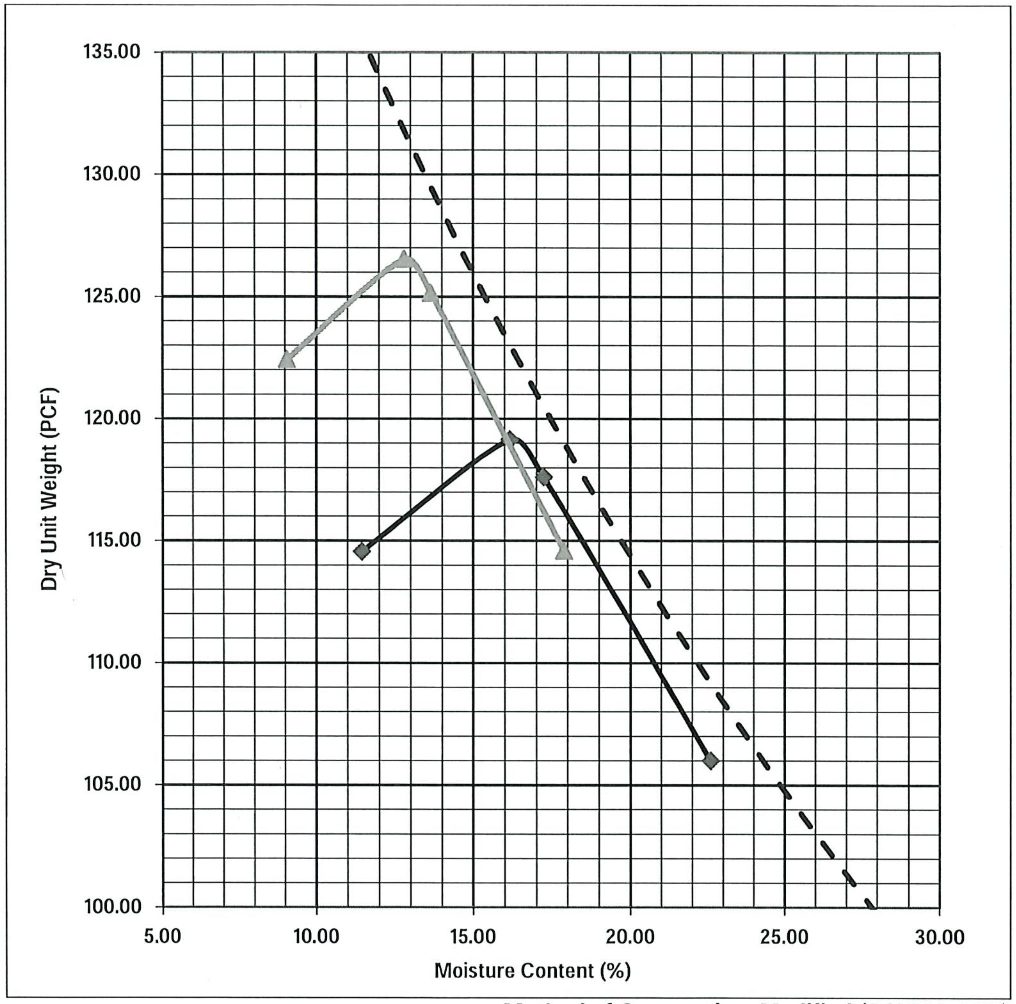
Modified Proctor Compaction Test

Project:	Lihue-Koloa Forest Reserve	Figure:	N/A
Location:	Kauai, HI	ASTM/Method:	ASTM D1557/C
Soil:	Poorly-graded sand w/ gravel	Preparation Method:	Dry
Sample:	B-3, Bulk 2	Rammer:	Manual
Depth:	5.0 - 9.0'	Date Received:	6/21/2021
Job No.:	669-008	Date Tested:	6/21/2021
Client:	Hart Crowser, Inc.	Date Tested:	7/1/2021
		Date Reported:	7/6/2021



Method of Compaction: Modified (ASTM D1557)

Test Results:

Optimum Moisture Content	16.2 %
Maximum Dry Density	119.2 PCF
Corrected Max Dry Density	126.5 PCF
Corrected Opt Moist Content	12.9 %
Initial Moisture Content	27.4 %

Sieve	%
Retained 3/4	20.9%
Passing 3/4	79.1%

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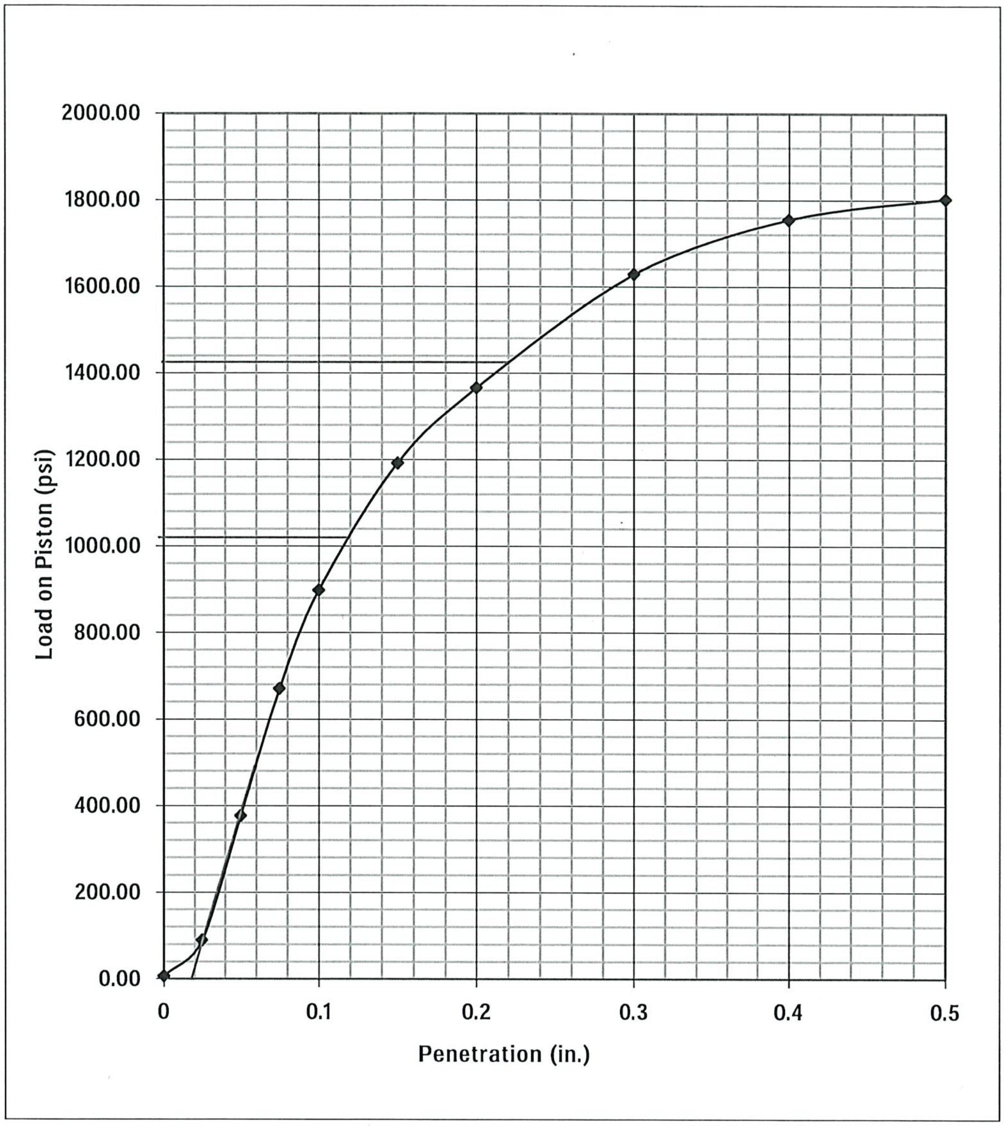
Project: Lihue-Koloa Forest Reserve
Job No.: 669-008
Location: Kauai, HI
Soil: Poorly-graded sand w/ gravel
Sample: B-3, Bulk 2   Depth: 5.0 - 9.0'

Method: ASTM D1557
Surcharge: 10 lbs
Condition of Sample: Soaked

Figure: N/A



CBR at 0.1:	103.1 %
at 0.2:	95.4 %
Linear expansion:	0.73 %
Dry unit weight before soak:	120.0 PCF
Dry unit weight after soak:	117.7 PCF
H2O before soak:	13.9 %
H2O after soak:	20.0 %

CBR 1883 Test Result

Date Received:	6/21/2021
Test Start Date:	6/21/2021
Test End Date:	7/6/2021
Date Reported:	7/6/2021

MASA FUJIOKA
& ASSOCIATES

Project: Lihue-Koloa Reserve
Location: Kauai, HI
Job No.: 669-008

Date Received: 6/21/2021
Date Tested: 7/1/2021
Date Reported: 7/6/2021

Figure: N/A

MASA FUJIOKA & ASSOCIATES

MOISTURE CONTENT DETERMINATION

Boring No.	B-1		B-1		B-1		B-1		B-3		B-3		B-3		B-3	
Sample No.	S-1		S-2		S-4		S-6		S-1		Bulk 2		S-3		S-4	
Depth (ft)	2.5 - 4.0'		5.0 - 6.5'		10.0 - 11.5'		14.0 - 15.5'		2.5 - 4.0'		5.0 - 9.0'		7.5 - 9.0'		9.8 - 11.3'	
Trial No.	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
MC Can No.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wt wet soil+tare(g)	401.3	401.3	442.7	442.7	557.4	557.4	488.8	488.8	1084.3	1084.3	564.1	564.1	536.9	536.9	1119.2	1119.2
Wt dry siol+tare(g)	311.4	311.4	327.2	327.2	473.5	473.5	432.3	432.3	905.1	905.1	482.5	482.5	454.3	454.3	998.7	998.7
Wt water(g)	89.9	89.9	115.5	115.5	83.9	83.9	56.5	56.5	179.2	179.2	81.6	81.6	82.6	82.6	120.5	120.5
Wt tare(g)	187.60	187.60	186.90	186.90	185.80	185.80	185.50	185.50	187.40	187.40	185.00	185.00	187.60	187.60	186.90	186.90
Wt dry soil(g)	123.8	123.8	140.3	140.3	287.7	287.7	246.8	246.8	717.7	717.7	297.5	297.5	266.7	266.7	811.8	811.8
Moisture Content%	72.6	72.6	82.3	82.3	29.2	29.2	22.9	22.9	25.0	25.0	27.4	27.4	31.0	31.0	14.8	14.8
Avg. MC%	72.6		82.3		29.2		22.9		25.0		27.4		31.0		14.8	

MOISTURE CONTENT DETERMINATION

Boring No.	B-3		HA-1a		HA-2	
Sample No.	S-8		S-1		S-1	
Depth (ft)	19.0 - 19.9'		0.0 - 0.7'		0.0 - 2.4'	
Trial No.	1	2	1	2	1	2
MC Can No.	N/A	N/A	N/A	N/A	N/A	N/A
Wt wet soil+tare(g)	579.1	579.1	761.6	761.6	610.5	610.5
Wt dry siol+tare(g)	507.4	507.4	670.0	670.0	509.2	509.2
Wt water(g)	71.7	71.7	91.6	91.6	101.3	101.3
Wt tare(g)	184.90	184.90	187.80	187.80	187.40	187.40
Wt dry soil(g)	322.5	322.5	482.2	482.2	321.8	321.8
Moisture Content%	22.2	22.2	19.0	19.0	31.5	31.5
Avg. MC%	22.2		19.0		31.5	