1.0 INTRODUCTION

Masa Fujioka & Associates (MFA) are pleased to submit this geotechnical data report for the subject project, Kalanianaʻole Highway Resurfacing – Vicinity of Poalima Street to Huli Street, Milepost 3.3 to Milepost 5.64, Waimānalo, Oʻahu Hawaiʻi. The general location of the site is depicted on *Figure 1, Project Location Map*.

1.1 PROJECT CONSIDERATIONS

Kalanianaʻole Highway is an existing two-lane highway. We understand that the project will consist of the following for Kalanianaʻole Highway, from the vicinity of Poalima Street to Huli Street (Waimānalo Beach Park), Milepost 3.3 to Milepost 5.64 in the town of Waimānalo, Oʻahu Hawaiʻi:

- Typical Resurfacing Project - pavement reconstruction, AC pavement for existing travel ways and shoulders only
- No driveway/street realignment at Poalima Street/Shopping Center
- No intersection improvements per the Environmental Assessment
- No resurfacing of existing sidewalks
- No new utilities
- No street lighting improvements
- No drainage improvements
- Inaole Bridge Improvements not included; however, resurfacing through this area

MFA conducted a field investigation and collected samples for delivery to the State of Hawaii Department of Transportation (HDOT) – Highways Division Laboratory (HWY-L). We understand that HWY-L will conduct all laboratory testing and will provide the pavement design. MFA's scope consists of the following:

1. Identify and locate pavement reconstruction areas.
2. Provide sample locations, sample cores, and boring logs to HDOT.
3. Review pavement recommendations/report
4. Review of 60%, 90% and Final Plans and Specifications
5. Attend Comment Disposition Meetings (CDMs) and Over-the-Shoulder Reviews (OSRs), as needed
6. Attend pre-bid meeting and respond to questions during bidding.

2.0 SCOPE OF WORK

Based on the foregoing, the following scope of work was proposed and performed or is anticipated:

1. **Data Review, Site Reconnaissance, Project Coordination, Traffic Permit, One Call**

   MFA reviewed available soils and geologic information for the project site and general area.

   MFA conducted a geotechnical/geological reconnaissance of the project corridor to observe the geology and likely soil conditions along the alignment, and to review site and pavement conditions.

   Our reconnaissance included a detailed review of site conditions and an evaluation of the performance of existing road surfaces with respect to soils conditions. We mapped conditions of note. The reconnaissance included a detailed review of the condition and crack patterns of the existing pavements.

   Based on the site reconnaissance, MFA selected the twenty (20) locations for coring and sampling along the project corridor. A subcontracted traffic control specialist prepared a Traffic Control Plan. MFA used the Traffic Control Plan to obtain an HDOT Permit to Perform Work Upon State Highways.

   Prior to drilling, MFA marked the boring locations (or offsets) in the field and completed the Hawaii One Call process for utility clearance.

2. **Site Investigation**

   At each of the 20 core sites, an asphaltic concrete pavement (ACP) core was collected with a six-inch (6") diameter core barrel. Pavement thicknesses were measured. A Modified California sample of the basecourse (where existing) was collected from directly under the ACP. A Modified California sample of the material beneath the basecourse was also collected.

   Additionally, our office elected to collect macrocore samples at 15 of the coring locations although this was not in our proposed scope. Macrocore sampling was conducted in order to provide supplementary information on pavement sections and underlying soils.

Following sampling, the boreholes were backfilled with cuttings / slough from the sample supplemented with basalt chip gravel, and the surface repaired with quick-setting concrete. Boreholes were backfilled and repaired immediately upon completion of drilling and sampling.

During the field investigation, traffic control including signs, cones, flaggers, and a special duty officer (when available) was provided in accordance with the HDOT Permit requirements. Work was conducted during the allowed hours for lane closures between 8:30 am to 3:00 pm.

No survey was included in our scope. Approximate coring locations were mapped based on distances to existing features.

Coring and sampling were conducted by a subcontracted driller, GeoTek Hawaii, Inc. under the supervision of an MFA Project Geologist who logged the borings and collected samples for HDOT laboratory review and testing.

3. Data Report

MFA reviewed the data obtained during our investigation and prepared this data report summarizing our findings.

4. Consultation during Design

We would review the pavement recommendations report if requested. A review can only be accomplished if all relevant data are provided to us, including laboratory test data, falling weight deflectometer data to correlate with pavement data, and design traffic count.

We would review 60%, 90%, and final plans and specifications, if requested.

We would attend meetings as requested, including Comment Disposition Meetings (CDMs) and Over-the-Shoulder Reviews (OSRs), and pre-bid meetings.

We would respond to questions during bidding, as applicable.

3.0 SITE CONDITIONS

3.1 PROJECT LOCATION

The project is located in Waimānalo along approximately 2.34 miles of Kalaniana‘ole Highway in the eastern portion of O‘ahu, Hawai‘i. The highway runs in a northwest-southeast direction and is bound to the south and southwest by the Ko‘olau mountain range and by the coastline of Waimānalo Bay to the east and northeast (*Figure 1*).

3.2 GEOLOGIC SETTING

3.2.1 Regional Geology

The Hawaiian Archipelago is a 1600 miles long group of islands, reefs, and shoals running northwest–southeast in the Pacific Ocean. The major islands, in the southeast part of the archipelago, "are basaltic volcanic domes in various stages of dissection."[1] The islands have complex geologic histories that generally include four stages of volcanism, water and wind erosion, sea level change, catastrophic landslides and accompanying tsunami, and subsidence of the crust due to the loads of the volcanoes. The older volcanoes are experiencing rebound of the crust as they erode and the load gets lighter.

The four stages of eruption of an idealized Hawaiian volcano are: preshield, shield, postshield, and rejuvenated. They are distinguished by lava composition, eruptive rate and style, and stage of development. The rejuvenated stage occurs after up to a few million years of volcanic quiescence.

3.2.2 General Geology of O‘ahu

The Island of O‘ahu was formed by two shield volcanoes, the older Wai‘anae and younger Ko‘olau. The lavas of the Ko‘olau Volcano banked against the Wai‘anae Volcano, creating the Schofield Plateau in the center of the island. Each volcano has been truncated by massive submarine slides – the Wai‘anae Slump to the southwest, the Ka‘ena Slump to the northwest, and the Nu‘uanu Slide to the northeast[2].

[1] Stearns, Harold T. 1966. *Geology of the State of Hawaii*. Palo Alto: Pacific Books.
[2] Eakins, Barry W., Joel E. Robinson, Toshiya Kanamatsu, Jiro Naka, John R. Smith, Eiichi Takahashi, and David A. Clague. 2003. *Hawaii's Volcanoes Revealed* (map with accompanying text). United States Geological Survey (USGS), United States Department of the Interior. Prepared in Cooperation with the Japan Marine Science and

The Waiʻanae Volcanics date from about 4.0 million years ago (Ma) to about 2.9 Ma. The oldest Koʻolau basalts are dated to about 3 Ma, and the youngest of the shield-building stage to somewhere between about 1.8 to about 2.1 Ma. After a long period of quiet during which deep canyons were cut into the Koʻolau shield, volcanic activity resumed on the southeastern end of the Koʻolau Range, consisting of the sporadically scattered lava flows and vent deposits of the Honolulu Volcanics. The Honolulu Volcanics range in age from 0.8 to "somewhat younger than" 0.1 Ma. These rejuvenated-stage volcanics include the iconic Diamond Head crater, Punchbowl, Koko Head, and cones on Mokapu peninsula in Kāneʻohe.[3]

The island's geologic history includes a deep (>1200 feet), gradual submergence of Oʻahu in possibly Early Pleistocene time (resulting from deformation of the Earth's crust caused by the island's load on it) and oscillations of sea level (attributable to advances and recessions of the polar ice caps) in Middle and Late Pleistocene time.[4]

The submergence of the island was not uniform and was sometimes interrupted, resulting in unconformities. When sea level rose, coral reefs grew offshore; as sea level fell, the reefs emerged. Emerged reefs are subject to weathering, erosion, and infill of voids with sediments. They may also be submerged again as a result of sea level rise, and new reefs may grow atop the fossil reefs. Coralline deposits and sea shells break down to form calcareous sands.

3.2.3 Mapped Geology

The project site is mapped on the *Geologic Map of the State of Hawaii*[5] in three mapping units: *Older dune deposits*, Geologic symbol *Qdo*, consisting of well sorted calcareous sand; *Alluvium*, Geologic symbol *Qa*, consisting of sand and gravel; and *Younger dune deposits*, Geologic symbol *Qdy*, consisting of sand dunes of well sorted calcareous sand. Geologic symbols are presented on *Figure 2, Project Geologic Map*. The corresponding geologic units are respectively: *Pd*, *Ra*, and *Rd*. The units are an older nomenclature than the map symbols and were

Technology Center, University of Hawaii School of Ocean and Earth Science and Technology, and the Monterey Bay Aquarium Research Institute.

[3] Macdonald, G. A., A.T. Abbott, & F.L. Peterson. 1983. *Volcanoes in the Sea: The Geology of Hawaii* (2nd Ed.). Honolulu: University of Hawaii Press.

[4] Stearns, H.T and K.N. Vaksvik. 1935. *Geology and Ground-water Resources of the Island of Oahu, Hawaii*. [Bulletin 1.] Hawaii Division of Hydrography. Published in Cooperation with the Geological Survey, United States Department of the Interior. pp. 178-179.

[5] Sherrod, D.R., Sinton, J.M., Watkins, S.E., and Brunt, K.M. 2007. *Geologic Map of the State of Hawaiʻi*. Open-File Report 2007-1089. United States Geological Survey.

formalized in the seminal geologic mapping of the Hawaii Division of Hydrography; however, the symbols were later adopted to meet national standards. Standard error of the mapping is 100 m (±50 m).

3.3 MAPPED SOILS

A soils map of the project area is provided by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), based on mapping in 1972 by the USDA Soil Conservation Service (SCS), predecessor to the NRCS, in cooperation with the University of Hawaii (UH) Agricultural Experiment Station. Various soils are mapped at the project site and are listed below:

Coral Outcrop (CR). NCRS indicates that erodibility is: potentially highly erodible land.[6]

Eva Silty Clay Loam, moderately shallow, 0-2 percent slopes (EmA). These soils developed in alluvium derived from igneous rock. NCRS indicates that runoff is very slow, and erodibility is: not highly erodible land.[7]

Haleiwa Silty Clay, 0-2 percent slopes (HeA). These soils developed in alluvium derived from igneous rock. NCRS indicates that runoff is very slow, and erodibility is: not highly erodible land.[8]

Jaucas Sand, 0-15 percent slopes (JaC). These soils developed in wind- and water-deposited sand from coral and seashells. NCRS indicates that runoff is very slow to slow, and erodibility is: potentially highly erodible land.[9]

Kaloko Clay, noncancerous variant (*Kfb*). These soils developed in alluvium derived from igneous rock; the alluvium has been deposited over marly lagoon deposits. NCRS indicates that runoff is slow to very slow, and erodibility is: not highly erodible land.[10]

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[6] United States Department of Agriculture Soil Conservation Service [in cooperation with The University of Hawaii Agricultural Experiment Station]. 1972. *Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*. Washington, DC: U.S. Government Printing Office. P. 29.
[7] Ibid., p. 30.
[8] Ibid., p. 33.
[9] Ibid., p. 48.
[10] Ibid., p. 58.

Kawaihapai Clay Loam, 0-2 percent slopes (KIA). These soils developed in alluvium derived from igneous rock. NCRS indicates that runoff is slow, and erodibility is: not highly erodible land.[11]

Mokuleia Loam, percent slopes not defined (MS). These soils developed in recent alluvium deposited over coral sand. NCRS indicates that erodibility is: not highly erodible land.[12]

Pohakupu Silty Clay, 0 to 8 percent slopes (*PkB*). These soils formed in old alluvium derived from igneous material. NCRS indicates that runoff is generally slow, and erodibility is: potentially highly erodible land.[13]

The mapped soils fall into three of the ten soil orders: inceptisols, mollisols, and entisols (*Juacas Series* only). These are typically younger soils and are not characterized by high shrink-swell potential.[14]

A soils map is provided as *Figure 3*.

3.4 SITE GEOMORPHOLOGY

The town of Waimānalo is situated at the base of the eastern side of the Koʻolau mountain range. The general topography of the project site and surrounding area is gently sloping down from west to east toward the ocean. The elevation of the project ranges from approximately 5 to 35 feet above average mean sea level. A contour map is provided as *Figure 4*. A branch of Kahawai Stream run perpendicular under the project roadway; the branch of the stream was observed during the site reconnaissance and is shown on *Figures 2* and *4*.

[11] Ibid., p. 64.
[12] Ibid., p. 96.
[13] Ibid., p. 113.
[14] Ibid. pp. 203-219.

4.0 SITE RECONNAISSANCE

An MFA Project Geologist conducted a geotechnical/geological reconnaissance to observe site conditions and evaluate the performance of the existing road surfaces with respect to soils conditions.

Several pavement failures, pavement cracking, pavement depressions, potholes, and failing paving overlays were noted during the reconnaissance.

The majority of pavement distress was noted to be concentrated between Poalima Street and Aloiloi Street. Better pavement conditions were observed between Aloiloi Street and Huli Street with only minor pavement cracking noted.

Clusters of pavement depressions, cracking, and moderate to intense failures were most notable towards Waimānalo town center, and adjacent to the Waimānalo Polo Field between Bellows Air Force Base and Aloiloi Street.

Pavement distress, cracking, depressions, and potholes were generally noted to be along the shoulder and near the outer edges of the lanes, with fewer areas of pavement distress noted towards the highway centerline. Areas of pavement distress are mapped on *Figures 5* through *13*, and written descriptions of each distressed area are presented in *Appendix A*.

5.0 CORING INVESTIGATION AND SAMPLING

Eighteen of the core locations were in areas of pavement distress. Two cores were collected from areas where the pavement appeared to be performing well, for comparison purposes. The proposed coring locations were provided to the HDOT Highways Division for review.

Following approval of coring locations by HDOT, a subcontracted traffic control specialist, Safety Systems and Signs Hawaii, Inc. prepared a Traffic Control Plan. MFA used the Traffic Control Plan to obtain an HDOT Permit to Perform Work Upon State Highways. A Weekly Lane Closure form was also submitted upon request by HDOT Highways Division. We marked boring locations or offsets and completed Hawaii One Call, as required by State law.

MFA's geotechnical investigation was conducted on January 14, 15, 16, and 22, 2019. Twenty (20) AC pavement cores and accompanying Modified California samples were drilled by GeoTek Hawaii, Inc. ("GeoTek") utilizing a mobile 6620 Geoprobe® truck-mounted drill rig. The Modified California sampler was lined with six inch (6 in.) long metal sleeves and driven 18 inches.

A Modified California sample of the basecourse (where existing) was collected directly under the ACP and a sample of the material beneath the basecourse was also collected. Depending on the thickness of the basecourse, this resulted in either one or two Modified California samples at each location. In addition to coring and Modified California sampling, MFA collected macrocore samples at 15 of the coring locations. Macrocore sampling was conducted in order to provide supplementary information for evaluation of the pavement sections and subgrade (as they frequently penetrated deeper than the Modified California Samples), and to aid in logging the borings. An MFA Geologist logged the borings and recovered the samples. Approximate boring locations are shown on *Figure 5* (entire alignment), and in more detail on *Figures 6* through *13*.

AC coring was conducted with a 6" diamond blade concrete coring bit. Intact cores could only be retrieved from a few of the locations due to the pavement distress: The majority of core samples were highly fractured and in pieces when retrieved from the core bit. Care was taken to retrieve the AC pavement in a manner that would be representative of the AC column, i.e. preserving original pavement and overlays. The majority of pavement cores were wrapped in shrink wrap with the top (pavement surface) marked. Four of the core samples were intensely fractured and could not be collected in a representative column. Observations for layering of intensely fractured cores were made from the hole in the roadway after cores samples were retrieved.

For the 20 Modified California samples (C1 through C20), the depth of sampling was dependent on the subsurface profile at each location: The depth varied between 1 and 5 feet. Sampling was conducted with a 3-inch OD/2.5-inch ID Modified California sampler with 140-pound automatic drop hammer with a 30-inch drop. Each sample consisted of three 6" sleeves. In typical split-spoon sampling, the top 6 inches are discarded as slough; however, because it was important to collect as much of the pavement section as possible, we preserved all three sleeves except those with no recovery. Samples were immediately capped to preserve in-situ moisture content, and were labeled as follows: core ID; sample number; and label of A, B, C, or D. “A” indicates pavement core. “B” through “D” indicate the three sleeves of a Modified California sample: “B” indicates the top sleeve, “C” the middle sleeve, and “D” the bottom sleeve. For example, sample C1-A is the pavement core from core C1. Sample C2-2D is the bottom sleeve from the second modified California sample collected from core C2. In cases in which the top sleeve of a sample had no recovery, the recovered sample consists of sleeves “C” and “D” only, with no sleeve “B”.

A piece of PVC pipe with tracer string but no wires was recovered in the bottom sleeve of sample C5-2 (i.e. C5-2D). No soil was recovered in sleeves C5-2B or C5-2C. HDOT and other agencies (Board of Water Supply, Hawaiian Electric Company and City and County of Honolulu Department of Transportation Services) were contacted but the owner of the pipe could not be determined. The pipe was assumed abandoned and the boring backfilled.

Macrocore samples were collected to the side of each coring location. Sampling was conducted with a 2.5-inch OD/2-inch ID macrocore sampler. Samples were retrieved and were preserved in plastic semi-transparent macrocore tubes. The depth of macrocore sampling ranged between 30 inches and 54 inches. Macrocores were not opened in the event that HDOT would like to review them. They will be stored in MFA's soils laboratory until 30 days after the date of this report, after which they will be discarded if not requested by HDOT.

All the AC pavement cores, Modified California samples, and macrocores were collected within the limits of the project roadway.

No survey was included in our scope. Approximate boring locations were plotted on this report's figures by measuring distance and azimuths from identifiable physical locations. Therefore, mapped boring locations are approximate.

Logs of subsurface conditions encountered within the boreholes are presented in *Figure 18, Logs of Borings*. Soils were classified in the field in accordance with the Unified Soil Classification System, *Exhibit 1*; classifications were not confirmed with laboratory testing. A boring log legend is presented as *Exhibit 2*. AC pavement cores and Modified California soil samples were recovered for delivery to HDOT Highways Division for testing in their soils laboratory.

5.1.1 Findings

The AC pavement in the cores along the project roadway vary in thickness between 4 to 10 inches and are at different stages of degradation. Core samples consisted of up to four layers, suggesting three overlays atop the original pavement.

The majority of Modified California and macrocore samples encountered a layer of grey basalt gravel immediately below the AC; this layer is interpreted as basecourse. The grey basalt gravel was absent from samples C3, C12, and C15 through C19. In the other borings, the basecourse thickness varied from 2 to 12 inches.

Samples collected below the basecourse generally match the mapped geology and are likely native soils. Below the grey basalt gravel layer (where encountered), the soils varied in classification and are as follows:

Tan to tannish or brown coral SAND (USCS - SW or SP)

Coral GRAVEL with coral sand and or silt (USCS - GW or GP)

Brown to dark brown SILT with or without sand (USCS - ML)

The majority of samples were collected with the bottom-most portion consisting of tan coral sand that is fine to medium grained and poorly graded.

6.0 LIMITATIONS

We have prepared this geotechnical data report for the use of the HDOT, in accordance with generally accepted soils and foundation engineering practices. No other warranty, expressed or implied, is made as to the professional information included in this report.

The subsurface conditions assumed in preparing this report require confirmation by close monitoring during construction. The nature and extent of variations in subsurface conditions may not become evident until construction.

This report may not contain sufficient information for the purposes of other parties or for other uses.

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