SECTION 2. SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Maui is the second largest of the Hawaiian Islands and encompasses approximately 728 square miles of land area. The Island of Maui was built by two major volcanoes, the older West Maui, Puu Kului (Tertiary Epoch) and the more recent East Maui, Haleakala (Pleistocene Epoch). A broad low elevation plain, the Isthmus of Maui, was formed by the coalescence of the lava flows emitted from Haleakala. The Isthmus of Maui is a narrow, gently sloping plain between the West Maui and East Maui volcanoes.

Volcanic activity began on the two mountains in the Pleistocene Era and generally ended by the Holocene time. During the evolution of the Island of Maui during the Pleistocene Era, the island experienced episodes of partial submergence and emergence related to the last significant Ice Age sea level fluctuations. During the Pleistocene Era of significantly lower sea levels, the Island of Maui was once connected as a single landmass with the Islands of Molokai, Lanai, and Kahoolawe.

Deeply eroded valleys spreading outward concentrically from the central higher elevations incise the West Maui Mountains. The West Maui Mountains generally consist of inclined layers of basaltic lava flows that consist of the Wailuku, Honolua, and Lahaina Volcanic Series progressing from oldest to youngest in age. A relatively long period of erosion and sediment deposition occurred following the Honolua Volcanic Series during which time thick sequences of sedimentary conglomerate were deposited along the base of the mountains. The lavas of the younger Lahaina Volcanic Series erupted on top of and interstratified with the sedimentary deposits.

The East Maui Volcano, generally consisting of layered basaltic lava flows of the Honomanu, Kula, and Hana Volcanic Series, progressing from oldest to youngest, makes up the eastern half of the Island of Maui. Haleakala Mountain is considered to be dormant with the last eruption taking place on the southerly side of the mountain around 1790.

The project site is on the southwestern flank of the East Maui Volcano. The bulk of the Haleakala Shield Volcano was built by thinly bedded basaltic lava flows of the

Honomanu Volcanic Series and hard, thickly bedded flows of andesitic composition during the Pleistocene Epoch.

2.2 Site Description

The general location of the project site is along Kekaulike Avenue (Interstate Route 377) at MP 8.2 in the Kula area on the Island of Maui, Hawaii, as shown on the Project Location Map, Plate 1. The project limits generally extend about 150 feet along Kekaulike Avenue and include stream repairs consisting of grouted rubble paving extending about 70 and 100 feet from the centerline of the roadway on the upstream and downstream sides, respectively.

Kekaulike Avenue consists of a two-way road with one lane per each direction in the northbound and southbound directions, as shown on the Site Plan, Plate 2. After the heavy rainstorm event, a portion of the shoulder lane on the makai side of the roadway (southbound lane) was eroded by the slope. We observed large boulders were partially exposed on the damaged embankment slope.

The project site generally slopes down in the southbound direction at about 2 to 7 percent slope. The pavement surface generally ranges between approximately +3,405 and +3,415 feet Mean Sea Level (MSL), whereas the bottom stream elevations extend as deep as Elevations +3,365 and +3,385 feet MSL on the downstream and upstream sides, respectively. Based on the upstream slopes and intact portions of the downstream slopes, it appears the embankment was constructed at about a 1.25 horizontal to 1 vertical (1.25H:1V) slope. It should be noted that the erosion left a scarred slope face as steep as up to about 0.5H:1V and which was marginally stable since the heavy rainstorm event without external forces (i.e., seismic, flooding, traffic surcharging, etc.).

2.3 Subsurface Conditions

We explored the subsurface conditions at the project site by drilling and sampling two borings, designated as Boring Nos. 1 and 2, extending to a depth of about 50 feet below the existing ground surface. The boring locations are shown on the Site Plan, Plate 2.

Based on the information obtained from our field exploration, the project site generally is underlain by embankment fills placed over weathered basalt rock, including residual/saprolite soils and hard basalt formation at greater depths. The project site is generally covered with asphaltic concrete pavement about 5 to 6 inches thick. Beneath the pavement section, the borings encountered fills consisting of medium dense to loose silty sand and medium stiff sandy silt extending to depths of about 5 and 16 feet below the existing ground surface at Boring Nos. 2 and 1, respectively. Cobbles and boulders were encountered in Boring No. 1 at about 7 feet below the existing ground surface.

Underlying the embankment fill, our borings encountered residual and/or saprolite soils extending to depths of about 16 and 24 feet below the existing ground surface at Boring Nos. 2 and 1, respectively. The residual and/or saprolite soils generally consisted of very stiff sandy silt and medium dense to dense sands and gravel with varying silt content. Beneath the residual/saprolite soils, our borings encountered weathered basalt formation with generally increasing hardness with depth extending to the maximum depth explored of about 50 feet below the existing ground surface. It should be noted that Boring No. 2 encountered a void at approximately 26 feet below the existing ground surface and clinker consisting of loose silty sand from about 30 to 40 feet below the existing ground surface.

We did not encounter groundwater in the drilled borings at the time of our field exploration. It should be noted that groundwater levels are subject to change due to rainfall, time of year, seasonal precipitation, surface water runoff, and other factors.

Detailed descriptions of the materials encountered in the borings are presented on the Logs of Borings in Appendix A. We performed laboratory tests on selected soil samples and rock cores obtained during our field exploration, and the test results are presented in Appendix B. It should be noted that portions of the laboratory testing are still in progress. Completion of the laboratory testing will be updated in the amended report when all results of the laboratory testing are available.

2.4 Seismic Design Considerations

We envision that seismic design considerations will need to be addressed in general accordance with Table 3.10.3.1-1 of AASHTO LRFD (2020 Edition). The following sections provide discussions on the seismicity of the Island of Maui and the soil profile for seismic design at the site.

2.4.1 Earthquake and Seismicity

In general, earthquakes throughout the world are caused by shifts in the tectonic plates. In contrast, earthquake activity in Hawaii is linked primarily to volcanic activity; therefore, earthquake activity in Hawaii generally occurs before or during volcanic eruptions. In addition, earthquakes may result from the underground movement of magma that comes close to the surface but does not erupt. The Island of Hawaii experiences thousands of earthquakes each year, but most are so small that they can only be detected by sensitive instruments. However, some of the earthquakes are strong enough to be felt, and a few cause minor to moderate damage.

In general, earthquakes associated with volcanic activity are most common on the Island of Hawaii. Earthquakes that are directly associated with the movement of magma are concentrated beneath the active Kilauea and Mauna Loa Volcanoes on the Island of Hawaii. Because the majority of earthquakes in Hawaii (over 90 percent) are related to volcanic activity, the risk of seismic activity and degree of ground shaking diminishes with increased distance from the Island of Hawaii. The Island of Hawaii has experienced numerous earthquakes greater than Magnitude 5 (M5+); however, earthquakes are not confined only to the Island of Hawaii.

To a lesser degree, the Island of Maui has experienced several earthquakes greater than Magnitude 5. Therefore, moderate to strong earthquakes have occurred in the County of Maui. Due to the relatively short period of documented earthquake monitoring in the State of Hawaii, information pertaining to earthquakes on the Island of Maui may not be complete. However, the following are two examples of reported earthquakes within the County of Maui. A Magnitude 6.8 earthquake occurred on the Island of Maui in 1938, and the Lanai Earthquake of 1871 was estimated at Magnitude 7 or greater. Based on these two reported earthquakes, the Island of Maui may be considered seismically active.

2.4.2 Liquefaction Potential

Soil liquefaction is a condition where saturated cohesionless soils located near the ground surface undergo a substantial loss of strength due to the build-up of excess pore water pressures resulting from cyclic stress applications induced by earthquakes. In this process, when the loose saturated sand deposit is subjected to vibration (such as during an earthquake), the soil tends to densify and decrease in volume causing an increase in pore water pressure. If drainage is unable to occur rapidly enough to dissipate the build-up of pore water pressure, the effective stress (internal strength) of the soil is reduced. Under sustained vibrations, the pore water pressure build-up could equal the overburden pressure, essentially reducing the soil shear strength to zero and causing it to behave as a viscous fluid. During liquefaction, the soil acquires sufficient mobility to permit both horizontal and vertical movements, and if not confined, will result in significant deformations.

Soils most susceptible to liquefaction are loose, uniformly graded, fine-grained sands and loose silts with little cohesion. The major factors affecting the liquefaction characteristics of a soil deposit are as follows:

FACTORS	LIQUEFACTION SUSCEPTIBILITY
Grain Size Distribution	Fine and uniform sands and silts are more susceptible to liquefaction than coarse or well-graded sands.
Initial Relative Density	Loose sands and silts are most susceptible to liquefaction. Liquefaction potential is inversely proportional to relative density.
Magnitude and Duration of Vibration	Liquefaction potential is directly proportional to the magnitude and duration of the earthquake.

Based on the subsurface conditions encountered in our field exploration, the geology in the area, and our engineering analyses, the potential for soil liquefaction at the project site is non-existent due to the presence of stiff/dense soils and the absence of groundwater table within the depths explored. Therefore, the potential for liquefaction is not a design consideration at this project site.

2.4.3 Soil Profile Type for Seismic Design

Our field exploration generally encountered relatively stiff/dense soils overlying weathered basalt formation with localized zones of loose silty sand extending to the maximum depth explored of approximately 50 feet below the existing ground surface. Based on the subsurface materials encountered at the project site and the geologic setting of the area, we anticipate the project site may be classified from a seismic analysis standpoint as a "Very Dense Soil and Soft Rock Profile." Based on Site Class C, the following seismic design parameters were estimated and may be used for the seismic analysis of this project based on AASHTO LRFD 2020 and the design criteria prepared by HDOT Highway Divisions.

SEISMIC DESIGN PARAMETERS AASHTO 2020 LRFD BRIDGE DESIGN SPECIFICATIONS 1,000-YEAR RETURN PERIOD (~7% PROBABILITY OF EXCEEDANCE IN 75 YEARS)	
Parameter	**Value**
Peak Bedrock Acceleration, PBA (Site Class B)	0.258g
Spectral Response Acceleration, S_S	0.587g
Spectral Response Acceleration, S_1	0.172g
Site Class	"C"
Site Coefficient, F_{PGA}	1.142
Site Coefficient, F_a	1.165
Site Coefficient, F_v	1.628
Design Peak Ground Acceleration, PGA (Site Class C) or A_s	0.295g
Design Spectral Response Acceleration, S_{DS}	0.684g
Design Spectral Response Acceleration, S_{D1}	0.279g

END OF SITE CHARACTERIZATION