STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION

ADDENDUM NO. 3

FOR

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS VICINITY OF LANIAKEA BEACH (MP 3.06 TO MP 3.54)

PROJECT NO. 83B-01-09

DISTRICT OF WAIALUA

ISLAND OF OAHU

September 19, 2023

This Addendum shall make the following amendments to the Bid Documents:

A. SPECIAL PROVISIONS

1. Delete the Table of Contents in its entirety dated r9/1/23 and replace with the attached Table of Contents in its entirety dated r9/19/23.

2. Delete the Section 622 in its entirety dated 10/01/17 and replace with the attached Section 622 in its entirety dated r9/19/23.

3. Add and make part of the specifications the attached Section 623 dated r9/19/23.

B. PROPOSAL

1. Replace Proposal Schedule in its entirety dated r09/01/23 with the attached Proposal Schedule in its entirety dated r09/19/23.

C. PLANS

1. Replace Plan Sheet No. 31 with the attached Plan Sheet No. Addendum 31.

2. Replace Plan Sheet No. 45 with the attached Plan Sheet No. Addendum 45.

3. Replace Plan Sheet No. 46 with the attached Plan Sheet No. Addendum 46.

4. Replace Plan Sheet No. 47 with the attached Plan Sheet No. Addendum 47.

5. Replace Plan Sheet No. 48 with the attached Plan Sheet No. Addendum 48.

6. Replace Plan Sheet No. 89 with the attached Plan Sheet No. Addendum 89.

7. Replace Plan Sheet No. 94 with the attached Plan Sheet No. Addendum 94.

8. Replace Plan Sheet No. 96 with the attached Plan Sheet No. Addendum 96.

9. Replace Plan Sheet No. 97 with the attached Plan Sheet No. Addendum 97.

10. Replace Plan Sheet No. 98 with the attached Plan Sheet No. Addendum 98.

11. Replace Plan Sheet No. 99 with the attached Plan Sheet No. Addendum 99.

12. Replace Plan Sheet No. 100 with the attached Plan Sheet No. Addendum 100.

13. Replace Plan Sheet No. 101 with the attached Plan Sheet No. Addendum 101.

14. Replace Plan Sheet No. 102 with the attached Plan Sheet No. Addendum 102.

15. Replace Plan Sheet No. 103 with the attached Plan Sheet No. Addendum 103.

16. Replace Plan Sheet No. 104 with the attached Plan Sheet No. Addendum 104.

17. Replace Plan Sheet No. 107 with the attached Plan Sheet No. Addendum 107.

18. Replace Plan Sheet No. 108 with the attached Plan Sheet No. Addendum 108.

19. Replace Plan Sheet No. 112 with the attached Plan Sheet No. Addendum 112.

20. Replace Plan Sheet No. 113 with the attached Plan Sheet No. Addendum 113.

21. Replace Plan Sheet No. 114 with the attached Plan Sheet No. Addendum 114.

22. Replace Plan Sheet No. 115 with the attached Plan Sheet No. Addendum 115.

23. Replace Plan Sheet No. 117 with the attached Plan Sheet No. Addendum 117.

24. Replace Plan Sheet No. 118 with the attached Plan Sheet No. Addendum 118.

25. Replace Plan Sheet No. 121 with the attached Plan Sheet No. Addendum 121.

26. Replace Plan Sheet No. 123 with the attached Plan Sheet No. Addendum 123.

27. Replace Plan Sheet No. 124 with the attached Plan Sheet No. Addendum 124.

28. Replace Plan Sheet No. 126 with the attached Plan Sheet No. Addendum 126.

29. Replace Plan Sheet No. 131 with the attached Plan Sheet No. Addendum 131.

30. Replace Plan Sheet No. 132 with the attached Plan Sheet No. Addendum 132.

31. Replace Plan Sheet No. 138 with the attached Plan Sheet No. Addendum 138.

32. Replace Plan Sheet No. 139 with the attached Plan Sheet No. Addendum 139.

33. Replace Plan Sheet No. 140 with the attached Plan Sheet No. Addendum 140.

34. Replace Plan Sheet No. 141 with the attached Plan Sheet No. Addendum 141.

35. Replace Plan Sheet No. 142 with the attached Plan Sheet No. Addendum 142.

36. Replace Plan Sheet No. 143 with the attached Plan Sheet No. Addendum 143

37. Replace Plan Sheet No. 145 with the attached Plan Sheet No. Addendum 145.

38. Replace Plan Sheet No. 146 with the attached Plan Sheet No. Addendum 146.

39. Replace Plan Sheet No. 147 with the attached Plan Sheet No. Addendum 147.

40. Replace Plan Sheet No. 148 with the attached Plan Sheet No. Addendum 148.

41. Replace Plan Sheet No. 152 with the attached Plan Sheet No. Addendum 152.

42. Replace Plan Sheet No. 157 with the attached Plan Sheet No. Addendum 157.

43. Replace Plan Sheet No. 177 with the attached Plan Sheet No. Addendum 177.

44. Replace Plan Sheet No. 178 with the attached Plan Sheet No. Addendum 178.

45. Replace Plan Sheet No. 180 with the attached Plan Sheet No. Addendum 180.

46. Add and make part of the Plans the attached Plan Sheet No. Addendum 180S-1.

47. Add and make part of the Plans the attached Plan Sheet No. Addendum 180S-2.

48. Replace Plan Sheet No. 180 with the attached Plan Sheet No. Addendum 181.

49. Add and make part of the Plans the attached Plan Sheet No. Addendum 182S-1.

50. Replace Plan Sheet No. 184 with the attached Plan Sheet No. Addendum 184.

51. Replace Plan Sheet No. 189 with the attached Plan Sheet No. Addendum 189.

The following is provided for information.

D. RESPONSES TO REQUESTS FOR INFORMATION/QUESTIONS (RFIs/Questions)

1. Attached Responses to Requests for Information/Questions (RFIs/Questions) is provided for information.

E. GEOTECHNICAL REPORT

1. Geotechnical Engineering Exploration, Kamehameha Highway Drainage and Safety Improvements, Vicinity of MP 3.06 to MP 3.54 is provided for information.

Please acknowledge receipt of this Addendum No. 3 by recording the date of its receipt in the space provided on Page P-4 of the Proposal.

ROBIN K. SHISHIDO
Deputy Director of Transportation for Highways

TABLE OF CONTENTS

DIVISION 400 - PAVEMENTS

DIVISION 500 - STRUCTURES

DIVISION 600 - INCIDENTAL CONSTRUCTION

DIVISION 700 - MATERIALS

END OF TABLE OF CONTENTS

Amend **Section 622 - Roadway Lighting System** to read as follows:

"SECTION 622 - ROADWAY LIGHTING SYSTEM

622.01 Description. This work includes furnishing and installing a roadway lighting system in accordance to the contract.

This work includes furnishing and installing metal lamp posts with brackets, luminaires, breakaway transformer bases, electrical conductors and conduits, fittings, concrete bases, pullboxes, equipment enclosures, meter sockets, electrical apparatus, and other materials necessary for operating and controlling the roadway lighting system according to the contract.

Furnish and install the incidental parts necessary to complete the roadway lighting system as though the contract showed such parts.

Electrical equipment shall conform to the NEMA Standards. Material and workmanship shall conform to the latest requirements of the "National Electrical Code," herein referred as the Code; General Order Nos. 6 and 10, of the Hawaii Public Utilities Commission; the standards of the ASTM; the ANSI; Local Joint Pole Agreement; local power company rules; and local ordinances that may apply.

622.02 Materials. Materials shall conform to the following:

Structural Concrete	601
Concrete Pull Box	712.06(B)
Conduits	712.27
Light Poles	761.01
Luminaire Mast Arm	761.02
Luminaires for Roadway Lighting	761.03
Cables and Wires for Roadway Lighting System	761.04
Disconnect and Protective Devices	761.05
Outdoor Wireless Control System	761.07
Dark Green Enamel Paint	708.03

Concrete shall conform to Section 601 - Structural Concrete and shall be Class B.

Stainless steel anchor bolts and steel plate covers shall be structural steel conforming to ASTM A 325 and A 36 respectively.

Materials will be subject to inspection. Failure of the Engineer to note faulty material or workmanship during construction will not relieve the responsibility of the Contractor for removing or replacing such materials and redoing the work at no cost to the State.

622.03 Construction Requirements.

(A) Equipment List and Drawings. Within 10 days following the award of the contract, the Contractor shall submit to the Engineer for acceptance 6 copies of a list of materials and equipment that the Contractor will incorporate in the work. The list shall include the name of the manufacturer, size and catalog number of the unit, detailed scale drawings and wiring diagrams of special equipment, and proposed deviations from the contract. If required, submit for acceptance samples of the material that the Contractor will use at no cost to the State.

Upon completion of the work, submit an ‘As Built’ plan showing in detail construction changes.

(B) Excavation and Backfill. Excavation and backfill shall conform to Section 204 - Excavation and Backfill for Miscellaneous Facilities.

Excavate carefully to prevent damage to pavements, sidewalks, and other improvements.

(C) Installation.

(1) Foundations. Concrete for foundations of metal lamp posts shall be Class B.

Locations of metal lamp posts shown in the contract are approximate only. The Engineer will decide the exact location in the field.

Forms shall be true to the lines and grades as accepted. Forms shall be rigid and securely braced in place. Place the conduit ends and anchor bolts in proper position, placed in proper height, and held in place by a template until the concrete sets. Cure the concrete for not less than 72 hours.

(2) Metal Lamp Standards. Install each metal lamp standard on a concrete foundation. Set the shaft precisely vertical by adjusting the two nuts on each anchor bolt, while the bracket shall be perpendicular to the roadway centerline.

After the lamp standard is in its proper position, place the grout under the base plate shown in the contract. Form the exposed portions to present a neat appearance.

Grout includes one part by volume of Portland cement and three parts of beach sand.

Install metal lamp standards with breakaway design features at the locations shown in the contract. Install the standards with breakaway design features according to the manufacturer's recommendations and shown in the contract.

(3) Mast Arms. Install each mast arm on the metal pole shown in the contract. The mast arms shall be in a plane perpendicular to the roadway centerline.

(4) Luminaires. Install the roadway lighting luminaires on lamp posts and mast arms with the vertical axis perpendicular to the roadway and longitudinal axis parallel to the roadway centerline.

(5) Circuits. Encase the cables installed underground or in concrete rigid barrier type guard rail in conduits or other accepted encasement.

Before installing the wires and cables in conduits, pull a wire brush, swab and mandrel through each conduit for the removal of extraneous matter and verification of the absence of obstructions and debris from the conduit system.

Pull the cables directly from their cores or reels into the conduits. Do not pull off and lay the cable on the ground before installation. Make the pulls in one direction only. Lubricants used shall be as recommended by the cable manufacturer or accepted by the Engineer.

Do not leave wires or cables under tension nor tight against bushings or fittings. Remove damaged ends resulting from the use of pulling grips soon after pulling the cable. Maintain the cable end seals. Do not pull open-ended cables through the conduits.

Cables shall be continuous from pulling point to pulling point. The Engineer will not permit splices from pulling point to pulling point. Make splices, taps and terminations with pressure-indented connectors or lugs as appropriate or specified in the contract.

When requiring splicing, join the conductors by a ‘western union’ type splice or by using an accepted connector. Use the connectors for splicing conductors, No. 8 AWG or larger. Solder the "western union" type splice by the pouring or dipping method. Cable splices and termination shall be according to the cable manufacturer's recommendation. Submit the cable manufacturer's splicing instruction sheets for acceptance.

Trim the conductor insulation to a conical shape. Roughen the conductor insulation before applying splice insulation. Splice insulation includes layers of thermoplastic electrical insulating tape not over 0.007 inches thick conforming to Federal Specification MIL-7798. Apply the splice insulation a thickness equal to and well lapped over the original insulation. Leave at least 2 feet of slack for each conductor at each splice.

(6) Bonding and Grounding. Secure the metallic cable sheaths, conduits and lamp posts mechanically and electrically to form a continuous system. Ground them effectively as specified in the Code and in the contract.

(7) Pullboxes. Install pullboxes at the locations shown in the contract.

(8) Conduits. Lay the polyvinyl chloride (PVC) conduits carefully in trenches prepared to receive the conduits. Conduits under roadway areas and driveways shall be PVC, Schedule 80 or shown in the contract.

Lay the conduit that will be encased in concrete to the required lines and grades. Support the conduit rigidly in place by masonry material, manufactured conduit spacers, or other accepted means. Wire the conduit so that the Contractor will not dislodge the conduit during the placing and tamping of the concrete. The thickness of the concrete around the conduits shall be shown in the contract. Use only hand shovels in compacting the concrete. Cure the concrete jackets for at least 36 hours before permitting vehicular traffic.

Install rigid PVC conduit according to Article 354 of the Code PVC conduit connections shall be of the solvent-weld type. Make solvent-weld joints according to the conduit manufacturer's recommendations and as accepted by the Engineer. The Engineer will permit pre-assembling sections of conduit.

Make directional changes in non-metallic conduit runs such as bends and changes to clear obstructions with curved segments using accepted deflection couplings or with short lengths of straight ducts and couplings. The deflection angle between two adjacent lengths of duct shall not exceed 6° and the bends shall not have a radius of less than 12 times the nominal size of the conduit unless using factory-made ells.

Thread the fittings for connecting non-metallic conduits to rigid metal conduits on the side that will be connected to the metal conduit. Metal conduits entering pullboxes shall end in insulating grounding bushings. Non-metallic conduits shall end in end bells.

Cap or plug and mark the ends of conduits shown or specified. Provide each conduit run with a No. 10 gage flexible zinc-coated pull wire or 1/8 inch polyolefin line extending uninterrupted through handholes for the entire length of run. Double an additional 2 feet of wire or polyolefin line back into the conduit at both ends of the run.

Ends of conduit runs shall extend at least 24 inches past the face of curb or edge of pavement, unless the ends end in pullboxes. Locate the ends accurately by special markers, markings on curbs or as specified by the Engineer.

Keep the interior of conduits clean during the construction. Plug the ends of conduits to keep the ends clear during and after construction. Install the conduits to drain toward a pullbox. The Contractor may consider a single run to drain toward both ends.

(D) Painting. Furnish the metal poles and mast arms in natural finish. The metal poles and mast arms require no painting.

(E) Electric Service. During relocation, reconstruction or other improvements of existing roadway lighting facilities, keep the existing roadway lighting system operational in its entirety during hours of darkness. Schedule the work accordingly and provide a temporary lighting system if necessary, to keep the project area illuminated during the hours of darkness.

(F) Field Test. Before acceptance of the work, make the following tests on lighting circuits, in the presence of the Engineer.

(1) Test for continuity of each circuit.

(2) Test for grounds in each circuit.

(3) A megger test on each circuit between the circuit and round. The insulation resistance shall not be less than the values specified in Table 622-I when measured with an instrument having a voltage rating of 500 volts.

TABLE 622-I - INSULATION RESISTANCE

Cable or Circuit	Minimum Resistance (ohms)
No.14 - No.12 wire	1,000,000
25 to 50 amperes	250,000
51 to 100 amperes	100,000
101 to 200 amperes	50,000
201 to 400 amperes	25,000
401 to 800 amperes	12,000
over 800 amperes	5,000

(4) A functional test to show that each part of the system functions according to the contract.

Correct the faults in the material or the installation revealed by these tests at no cost to the State. Repeat the tests until no fault appears.

(G) Salvaging Electrical Equipment. The contract directs the Contractor to Section 202 - Removal of Structures and Obstructions, regarding existing highway facilities. When shown in the contract or specified by the Engineer, remove and salvage the existing electrical equipment including luminaires, standards, mast arms, ballasts, transformers, service equipment, and pullboxes, otherwise the existing electrical equipment shall become the property of the Contractor and the Contractor shall remove and dispose of the existing electrical equipment at no cost to the State.

Underground conduits, conductors and foundations not reused in the work shall become the property of the Contractor. Remove them from the highway right-of-way at no cost to the State.

When removing a foundation on outside the roadbed area, completely remove the foundation. Backfill the resulting hole with material equivalent to the surrounding material.

622.04 Method of Measurement. The lighting system will be paid on a lump sum basis. Measurement for payment will not apply for the lighting system. The HECO Costs and HDOT Light Grid Consultant Costs will be paid on a force account basis. The engineer will measure HECO Costs and HDOT Light Grid Consultant Costs on a force account basis in accordance with Subsection 109.06 - Force Account Provisions and Compensation and as ordered by the Engineer.

622.05 Basis of Payment. The Engineer will pay for the accepted lighting system on a contract lump sum basis. The Engineer will pay for the HECO Costs and HDOT Light Grid Consultant Costs on a force account basis. Payment will be full compensation for the work prescribed in this section and the contract documents.

The Engineer will pay for the following pay item when included in the proposal schedule:

Pay Item	**Pay Unit**
Roadway Lighting System	Lump Sum
HECO Costs	Force Account
HDOT Light Grid Consultant Costs	Force Account

Hauling and stockpiling of salvaged materials and equipment off the right-of-way to the locations specified by the Engineer shall be incidental to the contract work.

END OF SECTION 622

Make this section a part of the Standard Specifications:

"SECTION 623 - COMMUNICATION SYSTEMS"

623.01 Description. This work shall consist of furnishing all labor, materials and equipment to install in place and in operating condition underground structures required for the facilities of the Department of Transportation, herein referred to as DOT. Such works shall be performed and tested at the indicated locations in accordance with the requirements herein specified and the indicated details, or as ordered by the Engineer, and includes but is not limited to the following:

(A) Complete underground duct system including excavation, backfilling, concrete work, conduits, handholes to be used by the DOT for their cables and equipment. Work shall also include securing the approval of the DOT inspector.

(B) Coordinate work and arrange for periodic inspections by DOT and Engineer.

(C) Pass test mandrel through all conduits, and make corrections as directed by the inspector or Engineer.

(D) Provide all communication conduits with 3 cell fabric innerduct.

(E) Immediately report and pay for damages to existing equipment.

(F) Obtain and pay for electrical permits, arrange for periodic inspection by local authorities and deliver certificate of final inspection to Engineer.

(G) Contractor shall check and test the installation for completeness and functional operation as described by the drawings and specified herein. Final test shall be in the presence of Engineer and DOT inspector. Contractor shall arrange and pay for all testing costs.

Incidental parts which are not shown on the plans or specified herein and which are necessary to complete the underground duct systems shall be furnished and installed by the Contractor as though such parts were shown on the plans, or specified herein or in the special provisions.

Applicable rules, standards and specifications of following associations shall apply to materials and workmanship:

American National Standards Institute (ANSI)

Edison Electric Institute (EEI)
National Board of Fire Underwriters (NBFU)
National Electrical Manufacturer's Association (NEMA)
National Fire Protection Association (NFPA)
Underwriters' Laboratories, Inc. (UL)

623.02 Materials. Materials shall meet the requirements specified in the following subsections of Division 700 - Materials.

(A) Ducts and Conduits. Ducts and Conduits shall conform to the requirements of Section 712.27 - Conduits. Ducts and conduits required shall be new and provided by the Contractor in accordance with the construction drawings and specifications.

(1) Polyvinyl Chloride (PVC) Schedule 40 type ducts shall be provided for the electrical and communication duct systems. The fittings shall be of the same material as the conduit and duct.

(B) Innerduct. 3-cell fabric innerducts shall be installed in communication conduits. Innerducts shall be pre-lubricated for lower friction during cable installation and have pre-installed pull tapes.

(C) Concrete. Concrete shall conform to the requirements of Section 601 - Structural Concrete, except that for concrete jackets and concrete caps, the maximum size of coarse aggregate shall be 3/4 inch in lieu of the one-inch to No. 4 specified and the slump shall be 6-inch minimum and 7-inch maximum. Concrete for handholes and pullboxes shall be Class A. Concrete for jacketing conduits and ducts shall be Class B except that the cement content shall be 5.6 sacks per cubic yard.

(D) Non-Metallic Expansion Fitting. Non-Metallic Expansion Fittings shall be installed per the details on drawings.

(E) Non-Metallic Expansion Deflection Fitting. Non-Metallic Expansion Deflection Fittings shall be installed per the details on drawings.

(F) Inspection. Materials will be subject to inspection at any time. Failure of the Engineer to note faulty material or workmanship during construction will not relieve the Contractor of his responsibility for removing or replacing such materials and dredging the work at his expense.

623.03 Construction Requirements.

(A) General.

(1) The Contractor shall in performing required installation of conduit, exercise due care to avoid disturbing existing facilities. The Contractor shall remove and dispose of all demolished or excess material from the job site.

(2) Upon completion of the work, the Contractor shall submit an 'As Built' or corrected plan showing in detail thereon all construction changes.

(3) Before bidding, the Contractor shall visit the project site, carefully review each section of the Specification and all Drawings of this Contract.

The Contractor shall report any error, conflicts or omissions to the Engineer at least one week before submission of bids for interpretation or clarification. If errors or omissions are not reported, the Contractor shall provide necessary work at no cost to the State of Hawaii to properly complete intent of Specification and Plans.

(B) Installation of Conduits and Duct Banks. All joints shall be watertight.

(C) Existing Utilities. Existing utilities are shown on the drawings in approximate locations for the convenience of the Contractor. It is not the intention of plans to imply that all existing utilities are drawn and located, and the fact that any utility is not shown on the drawings shall not relieve the Contractor of his responsibility under this Section. It shall be the Contractor's responsibility to ascertain the location of all existing utilities which may be subject to damages by construction under this Contract. The Contractor shall:

(1) Support and protect all HECO, CATV and/or HTCO utilities during construction,

(2) Notify HECO, CATV and/or HTCO immediately of any damage to its system caused by construction under this Contract, and

(3) Reconstruct, at his expense, damaged portions of the utility system in accordance with the requirements and specifications of HECO, CATV and/or HTCO.

(4) The Contractor shall be responsible for and shall pay for all damages to existing utilities of all types.

(D) HECO Facilities. The Contractor shall provide HECO with 24-hour access to all existing HECO facilities. The Contractor shall be responsible for any delays in utility company work due to his failure to provide access to utility company facilities. All existing HECO facilities shall remain in place until proposed permanent facilities are completed and energized. Any cost for temporary relocations arising during construction shall be borne by the Contractor.

Electrical equipment or conductors, whether electrically energized or not, shall remain in place at all time during construction. Handling and moving of electrical equipment or conductors, when required by the Engineer, shall be done by HECO. Work by the Contractor in areas with energized electrical equipment or conductors shall be performed with extreme caution to prevent accidents and to avoid disturbing or damaging this equipment or conductors or any temporary supports or protective guards that are constructed. Unless otherwise permitted by HECO, all work by the Contractor in areas with energized equipment of conductors shall be performed in the presence of a HECO inspector and/or standby man. The Contractor shall have the sole responsibility for maintaining safe and efficient working conditions and procedures in these areas.

Any existing or new HECO facilities including equipment or conductors damaged by the Contractor during construction shall be replaced by HECO at the Contractor's expense.

The Contractor shall give HECO two weeks advance notice for any work to be done by HECO on its facilities.

(E) Excavation and Backfill. All excavation and backfill for electric, telephone and cable television underground structures and trenches shall conform to the requirements of Section 204 - Excavation and Backfill for Miscellaneous Facilities, modified as follows:

(1) Excavation.

(a) The width of trenches for concrete encased ducts shall be not less than the width of the encasement nor more than that required to properly and safely execute the work.

(b) Ducts encased in concrete jackets which are bedded in disturbed (fill) ground shall be installed in the following manner: Embankments shall be built up and thoroughly compacted to the elevation which is three feet above the top-of-jacket elevation, or to the required elevation shown on the plans, whichever is less than five times the width of the jacket. This work shall conform to the requirements of Section 203 - Excavation and Embankment. The trench to accommodate the jacket shall then be excavated through the constructed embankment.

(c) Trenches shall be excavated at least 50 feet ahead of duct placement so that any obstruction to the duct line can be avoided through gradual alignment. The profile grade may be adjusted by the Engineer to increase or decrease the excavation depth (up to 3 feet) as a result of unforeseen obstruction at no additional cost.

(d) Excavation for each handhole, plus 50 feet of trenching for all ducts connected to those structures shall be completed, and the locations and depths of the handholes shall be verified and approved by the DOT inspector prior to construction or installation of the structures. All cuts in excess of depths required shall be filled with concrete, beach sand, or Type A backfill. The lateral limit for handholes shall be the vertical surfaces two feet outside the neat lines of the structures.

(e) The bottom of the trench excavation shall be flat and smooth. All trenches shall be approved by the Engineer and the DOT inspector before any ducts or conduits are placed or any structures and foundations are constructed.

(f) The trenches shall be widened at handholes to permit proper entry of the ducts and conduits.

(g) The Contractor shall provide all sheathing and bracing to support the sides of the excavated trench. Provision and removal of these items are incidental to the trenching work.

(h) Saw cutting work shall be considered incidental to the trenching work.

(2) Backfill.

(a) No backfilling shall be done until the duct and conduit installations, and the handhole placements have been verified to be correct, and approved by the DOT inspector.

(b) Material for use as trench backfill for direct buried conduit above select backfill shall be non-expansive and shall conform to Section 204 – Excavation and Backfill for Miscellaneous Facilities and requirements stated below. Backfilling and compaction shall be as specified in Section 204 - Excavation and Backfill for Miscellaneous Facilities. Backfill material shall be beach sand, earth or earth and gravel mixture. If earth and gravel, mixture must pass 1/2 inch mesh screen and contain no more than 20 percent of rock particles by volume.

(c) Backfilling shall be to finished grades indicated on accompanying drawings, and/or matching existing conditions. Backfill material shall be placed in maximum of 8" layers in loose thickness before compacting. Backfill shall be thoroughly compacted with hand or mechanical tampers to 95% of the ASTM D1557 maximum dry density. In no case shall tamping be accomplished by using the wheels or tracks of a vehicle.

(F) Installation of Conduits and Duct Banks. All joints shall be watertight and all ducts shall be installed to drain towards pull points unless otherwise shown on the plans.

(1) Plastic Duct Joints.

(a) Field cutting of plastic ducts shall be performed by the Contractor and only with the use of a miter box. Burrs shall be removed by filing before the joint is made. All foreign matter shall be wiped off the sockets of the fittings and the edges of the duct with a clean cloth.

(b) Cement for plastic duct joints shall be obtained from the duct manufacturer. Thinning of the cement will not be permitted. A liberal and uniform coat of cement shall be applied with a natural bristle brush to the inside of the coupling and to the outside of the duct end. Immediately thereafter, the duct shall be slipped into the socket of the fitting with a half-twisted, and the excess cement shall be wiped off.

(c) Allow the joined members to cure for at least five minutes before disturbing or applying stress to the joint. After this initial cure, care must be exercised in handling to prevent twisting or pulling the joint. In damp weather, this interval shall be increased to allow for slower evaporation of the solvent.

(d) Another fitting or section of conduit may be added to the opposite end within 2 or 3 minutes if care is exercised in handling so that strain is not placed on the previous assembly.

(e) Any joint included in a section of conduit to be bent in the trench shall be assembled above ground and allowed to lie undisturbed for at least two hours before installation. In cases where a plastic connection is made with the union under stress due to misalignment or other factors, the union shall be staked out to relieve stress on the joint until the conduit is backfilled or encased.

(2) Plastic Duct Installation.

(a) The Contractor shall provide spacers to maintain proper separation between ducts. The bottom duct spacers shall be placed on the prepared trench bottom, the first tier of ducts placed in the grooves of the spacers, and couplings attached to the duct ends. Spacers shall be 15 inches or more away from any coupling or joint. Successive lengths of ducts shall then be placed and connected to the preceding lengths as specified above. The second tier of duct spacers shall then be placed over the ducts previously placed and followed by installation of couplings. The operation shall be repeated for each successive tier until the top tier is set in place after which the top spacers are placed.

(b) When conduit is assembled above the ground, the spacer shall be supported in a vertical position by use of a No. 4 rebar and smooth black steel wire, No. 14 gage.

(c) Duct alignment shall be as straight as feasible. Such directional changes as are required shall be made by using field made bends or with segments using angle couplings or deflection couplings, except where otherwise indicated. The deflection angle between two adjacent lengths of duct shall not exceed five degrees, unless otherwise indicated.

Horizontal bends for conduits/ducts shall be constructed with 25-foot minimum radius curves unless indicated otherwise or approved by the DOT inspector. Vertical bends for conduits/ducts shall be constructed with 20-foot minimum radius curves unless indicated otherwise or approved by the DOT inspector.

Spacers shall not be located at the centers of a long radius bend. On pre-fabricated bends, the spacer shall be located in the tangent, free of the coupling. On trench formed bend, the spacer shall be located midway between the tangent and center of the bend.

(d) Precaution shall be taken to prevent damage in plastic duct lines from thermal expansion and contraction. All ducts shall be cool when placed in trenches and when the concrete jacket is being poured.

(e) Ducts ending in handholes shall be terminated with junior end bells. End bells, terminators or ducts shall be flush to inside wall surfaces; duct extension into boxes is not acceptable.

The terminated ends of the conduit in an underground structure shall be free of support for a distance of at least 10 feet from the structure. The conduit shall be aligned and supported inside the structure with proper spacing and shall be cut to length after the concrete envelope has cured.

(f) The ends of the conduit shall be sealed with a plastic cap, plug, or approved substitute at the end of each day`s work, when work on duct installation has to be interrupted, where ducts may be submerged in water, and in stub outs.

(3) **Detectable Warning Tape.** The Contractor shall provide a detectable warning tape for the entire duct line run. The tape shall have a minimum thickness of 4 thousandths of an inch (mils), with a solid aluminum core or aluminum backing for detection with metal detector. Tape shall be 6 inches wide, red in color for electrical power lines, and imprinted with “CAUTION BURIED COMMUNICATIONS LINE BELOW” in black lettering.

(4) **Duct Couplings and Bells.** The Contractor shall apply a thin coat of sealing compound on ducts and conduits at couplings and bells.

(5) **Conduit Stub-out.** Conduits stubbed for future connections shall be plugged and marked.

(6) **Anchoring.** The Contractor shall securely anchor duct banks prior to pouring concrete encasement to prevent ducts from floating.

(G) **Mandrel Testing.** The Contractor shall test the completed ducts by passing a test mandrel through the length of each duct of each duct run. The mandrel shall be a bullet shaped, blunt tipped type, unless indicated otherwise, about 6 inches long with a diameter 1/2 inch less than the inside diameter of the ducts through the length of each duct run. Scars in the mandrel deeper than 1/32 inch, other than that caused by normal abrasion between the duct line and bottom of mandrel shall be considered an indication of the presence of burrs and/or obstructions in the duct run. The Contractor shall remove such burrs and/or obstructions, after which the test mandrel will be passed through again. All tests shall be conducted in the presence of the Engineer and respective DOT inspector, and shall be repeated until the results obtained are satisfactory to the Engineer and to the DOT inspector.

(H) **Concrete.** The Contractor shall notify the DOT inspector a minimum of 72 hours prior to placement of any concrete.

(1) Securely anchor duct banks prior to pouring concrete encasement to prevent ducts from floating.

(2) When pouring concrete, prevent heavy masses of concrete from falling directly on ducts. If unavoidable, protect ducts with plank.

(3) Direct flow of concrete down sides of duct bank to bottom, allowing concrete to rise between ducts, filling all open spaces uniformly.

(4) To insure against voids in concrete, work a long, flat splicing bar or spatula liberally and carefully up and down the vertical rows of ducts. Mechanical vibrators shall be used for stacked duct banks of three ducts or higher.

(5) Cure concrete for a minimum of 72 hours before permitting traffic and/or backfilling.

(6) Convey concrete from mixer to forms rapidly to prevent segregation. Free drop shall be limited to five feet, unless authorized by inspector.

(7) Placing.

- **(a)** Clean and remove all debris from inside forms and trenches before placing concrete.

- **(b)** Place concrete only on clean damp surfaces, free from water.

- **(c)** Place concrete in forms, in horizontal layers not exceeding 18" thickness.

- **(d)** Place concrete to avoid segregation of materials and displacement of ducts, inserts and reinforcing.

- **(e)** Vibrate structural concrete thoroughly during and immediately after placing to insure dense watertight concrete.

(8) Forming.

- **(a)** Forms shall be of good sound lumber with sufficient strength and conforming to shapes and dimensions indicated on drawings.

- **(b)** Forms shall be treated with non-staining form oil immediately before each use.

(9) Patching. Patch all voids, pour joints and holes before concrete is thoroughly dry. Use mortar of same proportions as original concrete.

(10) Curing. Curing of concrete shall be accomplished by impervious membrane method with liquid membrane compound. Apply two or more coats to obtain a total of one gallon for each 150 square feet of concrete surface.

(I) Handholes and Pullboxes.

(1) Boxes shall be installed approximately where shown. The exact location of each box shall be determined after careful consideration has been given to the location of other utilities, grades, and pavement. Boxes shall be of the type noted on the Drawings and shall be constructed in accordance with the applicable details and standard drawings as indicated.

(2) Pullboxes shall be installed on a minimum of 3" #3 crushed rock.

(3) Ducts ending in handholes shall be terminated with junior end bells. End bells, terminators or ducts shall be flush to inside wall surfaces; duct extension into boxes is not acceptable. Verify complement and arrangement of ducts entering each handhole and location of duct entrance with the DOT inspector prior to fabrication of the respective handhole.

(4) State boxes shall be provided with a tamper proof cover.

(J) Restoration of Existing Streets and Other Improvements.

(1) Street, sidewalks, curbs, gutters, traffic detection loops, and other improvements of the State, private owners, or those of the City and County which are maintained by the State, which are damaged by rearrangements to the electric, cable television or telephone system, shall be restored by the Contractor to their original condition. Existing concrete pavement, sidewalks, curbs, gutters, concrete facilities, etc. disturbed by the Contractor shall be removed and reconstructed at the pavement, sidewalks, curbs, gutters, concrete facilities, etc. scorelines or joints. Spot repairing of the concrete pavement sidewalks, curbs, gutters, concrete facilities, etc. must not be allowed. Materials and workmanship shall conform to the applicable sections in these specifications.

(2) Repairing of existing City streets and other improvements not maintained by the State and where such work is called for on the plans, inside and outside of the right-of-way, publicly or privately owned, which are damaged by the Contractor's operations shall be restored to their original condition, or better, at his expense. Materials and workmanship shall conform to the "STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, SEPTEMBER 1986, AS AMENDED", of the Department of Public Works, County of Kauai, City and County of Honolulu, County of Maui, and County of Hawaii, of the State of Hawaii. Copies of the Standard Specifications are on file and may be inspected at the Division of Purchasing during regular business hours of the City.

(3) All disturbed unpaved surfaces shall be backfilled and graded to match the surrounding areas, and sodded areas shall be replanted with the same type of grass. Fences and other improvements shall be restored to their original condition.

623.04 Method of Measurement.

(A) The Engineer will measure the non-metallic expansion fitting, non-metallic expansion deflection fitting, and 2' x 4' telecommunications handhole per each in accordance with the contract documents.

(B) The Engineer will measure the 2"C PVC schedule 40, 2" 3 cell fabric innerduct, and trench and backfill per linear foot in accordance with the contract documents.

(C) The Engineer will measure concrete per cubic yard in accordance with the contract documents.

(D) The engineer will measure cleanup and mobilization on a lump sum basis.

623.05 Basis of Payment.

The Engineer will pay for the 2"C PVC Schedule 40 at the contract unit price per linear foot complete in place. The price includes full compensation for furnishing, installing, and furnishing equipment, tools, labor, materials and other incidentals necessary to complete the work.

The Engineer will pay for saw cutting; trenching; excavating and backfilling, including asphalt concrete pavement, aggregate base course and aggregate subbase course for trench repair; concrete curb and/or gutter, concrete sidewalk repair and striping restoration; and furnishing equipment, tools, labor, materials and other incidentals necessary to complete the work.

The Engineer will pay for the 2” 3 cell fabric innerduct at the contract unit price per linear foot complete in place. The price includes full compensation for furnishing, installing, and furnishing equipment, tools, labor, materials and other incidentals necessary to complete the work.

The Engineer will pay for non-metallic expansion fittings at the contract unit price per each complete in place. The price includes full compensation for furnishing and installing the fitting, and furnishing equipment, tools, labor, materials, and other incidentals necessary to complete the work.

The Engineer will pay for non-metallic expansion deflection fittings at the contract unit price per each complete in place. The price includes full compensation for furnishing and installing the fitting, and furnishing equipment, tools, labor, materials, and other incidentals necessary to complete the work.

The Engineer will pay for 2’ x 4’ telecommunications handholes at the contract unit price per each complete in place. The price includes full compensation for furnishing and installing the handhole, and furnishing equipment, tools, labor, materials, and other incidentals necessary to complete the work.

The Engineer will pay for the concrete at the contract price per cubic yard.

The Engineer will pay for the cleanup and mobilization on a lump sum basis.

The Engineer will consider full compensation for additional materials and labor not shown in the contract that are necessary to complete the installation of the various systems incidental to the various contract items. The Engineer will not allow additional compensation.

The Engineer will pay for the following pay items when included in the proposal schedule:

Pay Item	**Pay Unit**
Trench and Backfill	Lin. Ft
Concrete for Duct	Cub. Yd
2” C PVC Schedule 40	Lin. Ft

2” 3 Cell Fabric Innerduct	Each
Lin. Ft Non-Metallic Expansion Fitting	Each
Non-Metallic Expansion Deflection Fitting	Each
2’ x 4’ Telecommunications Handhole	Each
Cleanup	Lump Sum
Mobilization	Lump Sum

END OF SECTION 623

PROPOSAL SCHEDULE					
ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
201.1000	Clearing and Grubbing	17,910	SY	$________	$________
202.0100	Removal of Existing Traffic Sign and Post	35	Each	$________	$________
202.0200	Removal of Existing Signs	56	Each	$________	$________
202.0300	Removal of Existing Headwall	1	Each	$________	$________
202.0500	Removal of Existing Pavement and Driveways	5,985	SY	$________	$________
202.0600	Removal of Existing Pavement Striping, Markers and Crosswalks	LS	LS	LS	$________
202.0700	Removal of Existing Fence	745	LF	$________	$________
202.0900	Removal of Existing Barriers, Barrels and Sand	LS	LS	LS	$________
202.2000	Removal of Existing CRM Walls	LS	LS	LS	$________
203.1000	Roadway Excavation	980	CY	$________	$________
203.2000	Imported Borrow	11,420	CY	$________	$________
204.1000	Trench Excavation for Water Systems	LS	LS	LS	$________
204.2000	Trench Backfill for Water Systems	LS	LS	LS	$________
205.1000	Structure Excavation for Abutments, Pier and Wingwalls	825	CY	$________	$________

PROPOSAL SCHEDULE					
ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
205.2000	Structure Backfill for Abutments and Wingwalls	140	CY	$__________	$___________
205.3000	Structure Excavation for Cutoff Wall	90	CY	$__________	$__________
205.4000	Structure Excavation Dumped Riprap and Cushion Layer	60	CY	$__________	$__________
205.5000	CLSM Backfill for Abutments and Wingwalls	1,220	CY	$__________	$__________
206.1000	Excavation for 24-inch Drainline	80	CY	$__________	$__________
207.1000	Ditch and Channel Excavation	170	CY	$__________	$__________
209.1000	Installation, Maintenance, Monitoring and Removal of BMP for Construction Activities including in-water inspections	LS	LS	LS	$__________
209.2000	Installation, Maintenance, Monitoring and Removal of BMP for Hydrotesting Activities	LS	LS	LS	$__________
209.3000	Installation, Maintenance, Monitoring and Removal of BMP for Dewatering Activities	LS	LS	LS	$__________
209.4000	Additional Water Pollution, Dust and Erosion Control	FA	FA	FA	$25,000.00
212.1000	Archaeological Monitoring	FA	FA	FA	$100,000.00
219.1000	Determination and Characterization of Fill Material	LS	LS	LS	$__________
219.2000	Testing for Lead Based Paint	FA	FA	FA	$250,000.00

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
301.1000	Hot Mix Asphalt Base Course	2,735	Ton	$_________	$_________
304.1000	Aggregate Base	1,920	CY	$_________	$_________
313.1000	Permeable Separator	12,995	SY	$_________	$_________
401.1000	PMA Pavement, Mix No. IV	1,420	Ton	$_________	$_________
415.1000	Cold Planing	LS	LS	LS	$_________
417.1000	Geogrid	10,850	SY	$_________	$_________
417.1010	Additional Geogrid	FA	FA	FA	$10,000.00
503.1000	Concrete for Abutment Walls	LS	LS	LS	$_________
503.1010	Concrete for Drill Shaft Cap Beams, Pier Wall and Pier Cap Beam	LS	LS	LS	$_________
503.1020	Concrete for Concrete Topping, Edge Beams, Pier Diaphragm, and End Beams	LS	LS	LS	$_________
503.1030	Concrete Approach Slabs and Sleeper Slabs	LS	LS	LS	$_________
503.1040	Concrete for Wingwalls and Drilled Shaft Caps	LS	LS	LS	$_________
503.1050	Concrete for Keywalls	LS	LS	LS	$_________
503.1060	Concrete for Mud Slabs	LS	LS	LS	$_________

PROPOSAL SCHEDULE					
ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
503.2000	Concrete for Cutoff Wall	LS	LS	LS	$_________
503.3000	Concrete for Water System	LS	LS	LS	$_________
503.4000	Blanket Grinding and Mechanical Grooving	LS	LS	LS	$_________
504.1000	Prestressed Concrete Planks	16	Each	$_________	$_________
507.1000	Bridge Concrete Railing	220	LF	$_________	$_________
507.1010	Concrete End Post Railing	4	Each	$_________	$_________
511.0100	Furnishing Drilled Shaft Drilling Equipment	LS	LS	LS	$_________
511.0200	Obstructions	40	Hours	$_________	$_________
511.0300	Load Test (36-inch Diameter)	1	Each	$_________	$_________
511.0400	Drilled Shaft for Abutments and Pier (36-inch Diameter)	600	LF	$_________	$_________
511.0410	Drilled Shaft for Wingwalls (36-inch Diameter)	200	LF	$_________	$_________
511.0500	Unclassified Shaft Excavation (36-inch Diameter)	800	LF	$ ________	$_________
511.0600	Trial Shaft (36-inch Diameter)	70	LF	$_________	$_________
511.0700	Coring for Integrity Testing for Acceptable Drilled Shafts	220	LF	$_________	$_________

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
602.1000	Reinforcing Steel for Abutment Walls	LS	LS	LS	$_________
602.1010	Reinforcing Steel for Drilled Shaft Cap Beam, Pier Wall, and Pier Cap Beam	LS	LS	LS	$_________
602.1020	Reinforcing Steel for Concrete Topping, Edge Beams, Pier Diaphragm and End Beams	LS	LS	LS	$_________
602.1030	Reinforcing Steel for Approach Slabs and Sleeper Slabs	LS	LS	LS	$_________
602.1040	Reinforcing Steel for Wingwalls and Drilled Shaft Caps	LS	LS	LS	$_________
602.1050	Reinforcing Steel for Keywalls	LS	LS	LS	$_________
602.2000	Reinforcing Steel for Cutoff Wall	LS	LS	LS	$_________
603.1000	Bed Course Material for Culvert	15	CY	$_________	$_________
603.2000	24-inch Reinforced Concrete Pipe, Class III	75	LF	$_________	$_________
603.3000	Clean Existing Culverts	FA	FA	FA	$5,000.00
604.1000	Type 61614P Grated Drop Inlet, 4 feet to 5 feet	1	Each	$_________	$_________
604.1010	Type A Storm Drain Manhole, 6 feet to 7 feet	1	Each	$_________	$_________
606.1000	Guardrail Type 3 Thrie Beam	100	LF	$_________	$_________
606.2000	Guardrail Type 3 (31” W-Beam with Standard 8” Offset Block)	1,660	LF	$_________	$_________

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
606.3000	Terminal Section (MSKT-SP-MGS or Approved Equal)	6	Each	$________	$________
607.1000	4-Feet Chain Link Fence	1058	LF	$________	$________
607.1010	4-Feet Wooden Fence	577	LF	$________	$________
607.1020	4-Feet High Tensile Hinge Joint Fence	401	LF	$________	$________
607.1030	4-Feet Chain Link fence w/ Geotextile Fabric	931	LF	$________	$________
607.1040	4-Feet Bollard	14	Each	$________	$________
607.1050	4-feet High Tensile Hinge Joint Fence w/ Geotextile Fabric	996	LF	$________	$________
607.1060	Cattle Gate, 20' Span	2	Each	$________	$________
610.1000	4-inch Reinforced Concrete Driveway	LS	LS	LS	$________
612.1000	Grouted Rubble Paving	25	CY	$________	$________
613.1000	Centerline and Reference Survey Monuments	3	Each	$________	$________
615.1000	12-Inch Bicycle Friendly Milled Edgeline Rumble Strip, Shoulder	600	LF	$________	$________
615.2000	12-Inch Continuous Milled Strip	1,200	LF	$________	$________
617.0100	Imported Planting Soil, 4" Layer	1,545	CY	$________	$________

PROPOSAL SCHEDULE					
ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
617.0200	Imported Compost, 2" Layer	124,900	SF	$_________	$_________
619.0100	True Kou Tree (Cordia subcordata, 25 Gal.)	LS	LS	LS	$_________
619.0200	Beach Heliotrope Tree (Heliotropium foertherianum, 25 Gal.)	LS	LS	LS	$_________
619.0300	Milo Tree (Thespesia popuinea, 25 Gal.)	LS	LS	LS	$_________
619.0400	Beach Naupaka Shrub (Scaevola taccada, 1 Gal. 30" O.C. Tri. Spacing)	LS	LS	LS	$_________
619.0500	Akia (Wikstroemia uva-ursi, 1 Gal., 24" O.C. Tri. Spacing)	LS	LS	LS	$_________
619.0600	Nanea (Vigna marina, 6" Pot 12" O.C. Tri. Spacing)	LS	LS	LS	$_________
619.0700	Pohinahina (Vitex rotundifolia, 4" Pots, 24" O.C. Tri. Spacing)	LS	LS	LS	$_________
619.0800	Wood Mulch, 2" Layer	LS	LS	LS	$_________
619.0900	Plastic Root Control Barrier, 36" Depth	LS	LS	LS	$_________
621.0100	Inventory of Invasive Species before Construction	LS	LS	LS	$_________
621.0200	Invasive Species Removal Plan	FA	FA	FA	$5,000.00
621.0300	Removal of Plants and Animals Established before Physical Construction or Site Work, Post-removal Monitoring	FA	FA	FA	$30,000.00

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
621.0400	Monitoring of Invasive Species Before and After Construction	LS	LS	LS	$_________
621.0500	Post-Construction Inventory Prior to Returning the Site to the State	LS	LS	LS	$_________
622.1000	Roadway Lighting System	LS	LS	LS	$_________
622.2000	HECO Costs	FA	FA	FA	$_________
622.3000	HDOT Light Grid Consultant Costs	FA	FA	FA	$2,100.00
623.1000	Communication System	LS	LS	LS	$_________
624.1000	Fire Hydrant Water System A	LS	LS	LS	$_________
624.2000	Fire Hydrant Water System B	LS	LS	LS	$_________
624.3000	Fire Hydrant Water System C	LS	LS	LS	$_________
624.4000	Temporary 12-inch Water System	LS	LS	LS	$_________
624.5000	Adjusting Water Meter Frame and Cover	6	Each	$_________	$_________
626.1000	Adjusting Water Manhole Frame and Cover	6	Each	$_________	$_________
626.2000	Adjusting Water Standard Valve Box	9	Each	$_________	$_________
627.1000	Cathodic Protection System	LS	LS	LS	$_________

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
629.1000	White, 6-inch Pavement Striping (Tape, Type I, or Thermoplastic)	4,395	LF	$__________	$__________
629.1010	Yellow, Double 4-Inch Pavement Striping (Tape, Type I, or Thermoplastic)	6,010	LF	$__________	$__________
629.1020	White, 12-Inch Pavement Striping (Tape, Type III, or Thermoplastic)	25	LF	$__________	$__________
629.1030	Yellow, 12-inch Pavement Striping (Tape, Type III, or Thermoplastic)	495	LF	$__________	$__________
629.2000	Type C Pavement Marker	107	Each	$__________	$__________
629.2010	Type D Pavement Marker	60	Each	$__________	$__________
629.2020	Type H Pavement Marker	90	Each	$__________	$__________
629.2030	Type F Pavement Marker	3	Each	$__________	$__________
631.1000	Regulatory Sign and Post (10 Square Feet or Less)	5	Each	$__________	$__________
631.1010	Relocation of Existing Sign Installed on New Post	3	Each	$__________	$__________
631.1020	Relocation of Existing Sign	6	Each	$__________	$__________
632.1000	Type II Object Marker	10	Each	$__________	$__________
632.1010	Type III Object Marker	4	Each	$__________	$__________
632.1020	Flexible Delineator Post and Reflectors	17	Each	$__________	$__________

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
636.1000	Additional E-Construction Programs, Additional License or Additional Equipment	FA	FA	FA	$10,000.00
638.1000	Curb, Type 2D	123	LF	$__________	$__________
640.1000	Concrete Spillway No. 1	1	Each	$__________	$__________
640.1010	Concrete Spillway No. 2	1	Each	$__________	$__________
641.0100	Hydro-Mulch Seeding	LS	LS	LS	$__________
641.0200	Additional Hydro-Mulch Seeding Applications	FA	FA	FA	$15,000.00
642.1000	Maintenance of Existing Landscape	FA	FA	FA	$30,000.00
645.1000	Traffic Control	LS	LS	LS	$__________
645.2000	Additional Police Officers, Additional Traffic Control Devices, and Advertisement	FA	FA	FA	$50,000.00
648.1000	Field Posted Drawings	LS	LS	LS	$__________
652.1000	Grass Pavers	19,235	SF	$__________	$__________
655.0100	Dumped Riprap	600	CY	$__________	$__________
655.0200	Dumped Riprap Cushion Layer	55	CY	$__________	$__________
671.1000	Protection of Endangered Species	FA	FA	FA	$25,000.00

PROPOSAL SCHEDULE

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
694.1000	Public Education Materials or Services	FA	FA	FA	$20,000.00
695.1000	Just-In-Time Training	LS	LS	LS	$__________
696.1000	Maintenance of Trailer	FA	FA	FA	$60,000.00
696.2000	Field Office Trailer (Not to Exceed $32,000.00)	LS	LS	LS	$__________
699.1000	Mobilization (Not to Exceed 6 Percent of the Sum of All Items Excluding Bid Price of This Item)	LS	LS	LS	$__________

Total Amount for Comparison of Bids $ __________

NOTE: Bidders must complete all unit prices and amounts. Failure to do so may be grounds for rejection of bid.

Kamehameha Highway Drainage and Safety Improvemenents
Vicinity of Laniakea Beach
Project No. 83B-01-09
Addendum 3 **Date: 9/19/2023**

RFI #	Description	Response
1	Is there an anticipated timeframe that BWS will review/sign the plans? A critical activity of the project's schedule will involve relocating the water line.	Signed sheets included in Addendum 2 issued on September 1, 2023
2	Will HDOT consider extending the bid date 2 weeks, due to the high level of detail in estimating this work?	Postponement of Bid Opening included in Addendum 1, issued on August 23, 2023
3	Was wondering if the State will be issuing any Addendums/Amendments for this bid? And if so, will it still be bidding on Aug 24th? Please let us know as it would be greatly appreciated!	Addendums will be issued. Addendum No. 1 was issued on August 23, 2024. Addendum No. 2 was issued on September 1, 2023. Bidding opening will be postponed until September 28.
4	1.BI 313.1000 Permeable Separator quantity appears significantly lower than what is required for the roadway. Please advise.	Quantities for Permeable Separator revised in Addendum No. 2
5	a.Geogrid quantity appears significantly lower than what is required for the roadway. Please advise. b.Geogrid specifications, 417.02 says to "Furnish biaxial geogrid…..", while 417.05 (2) says 70% of the contract bid price upon completion of furnishing and placing of the triaxial geogrid.;" Please confirm biaxial geogrid is required. c.Geogrid specifications, 417.03 (C) para.2 says "The surface of the grid shall be rolled with a rubber-coated drum roller, or pneumatic-tired roller, with enough passes to active the adhesive." This does not appear to be applicable to the prescribed use of the geogrid. Please advise.	a. Quantities of geogrid revised in Addendum No. 2, b. use triaxial geogrid, c. Revise to "The surface of the grid shall be rolled with a rubber-coated drum roller or pneumatic tired roller."

Kamehameha Highway Drainage and Safety Improvemenents
Vicinity of Laniakea Beach
Project No. 83B-01-09
Addendum 3 **Date: 9/19/2023**

RFI #	Description	Response
6	a.Please provide Addendumitional information for Geofabric/Geogrid placement within the cross section. Specification 652.03 (D)(3) says "geogrid shall be installed directly on top of the prepared aggregate bedding layer". This appears to contradict manufacturer recommendations for subgrade stabilization with Geogrid and Geofabric. Detail on Sheet Please advise. b.Please confirm that the same Geofabric/Geogrid specified for the full thickness roadway will be used for the Grass Paver section.	a. Pavement justification report indicates to install 3" AC over 6" ACB over 6" ABC on a layer of reinforcing geogrid., b. geogrid will be used for the grass pavers. See revised quantities and details in Addendum No. 2.
7	5.Spec 652.05 Payment says that "The Engineer will pay for bedding material in accordance with and under Section 304 – Aggregate Base Course." In Bid Item 304.1000 Aggregate Base, quantity seems significantly lower than what is required for the roadway plus the grass pavers. Please advise.	Quantities of Aggregate Base Course revised. See Addendum No. 2.
8	6.On Alignment Plans, Sheet 31 (AL-02), Station callouts (6 each) to the east of the new bridge appear incorrect, labeled Sta.156+... instead of Sta.155+... Please advise.	Callouts should read 155+... See revised sheet attached
9	1.Please clarify what size range of rock is required for 655.0100 Dumped Riprap. Note 1 on Sheet 50(C-17) says "Class 4 Stone". Spec 655.02 says 1/3 length/width ratio and 155 pounds per cubic foot minimum unit weight.	D50 15-inch rock
10	2.Note 1 on Sheet 19(B-03) says that the geotechnical engineering report is on file at the office of the Engineer for review by the Contractor. What is the procedure for viewing this document? Is this available electronically?	Geotechincal included in Addendum No. 3

Kamehameha Highway Drainage and Safety Improvemenents
Vicinity of Laniakea Beach
Project No. 83B-01-09
Addendum 3 **Date: 9/19/2023**

RFI #	Description	Response
11	3.Per the General Notes and HECo notes, the Contractor is responsible for all design reviews, inspection, and work performed by Johnson Controls and HECO. Since it is difficult to quantify these costs, please consider creating a Force Account Pay Item to Addendumress 3rd party fees.	HECo Costs will be revised under Addendum No. 3 Cost estimate to be shown as Force Account Pay Item.
12	4.HECO note 22 - Joint Pole Removal states, "The Last Joint Pole Occupant off the Poles Shall Remove the Poles." Please specify if the Contractor will be responsible for any Joint Pole removal or disposal. If so, which poles? (references below)	No HECo utility poles are being removed under this project.
13	5.607.1000 4-Feet Chain Link Fence. a.Please confirm bid quantity vs. what is shown on plan. Is this bid item intended to include the 4' High Chain Link Fence along the top of the new bridge wing walls shown on Sheet 38(C-5)? b.Please confirm that the permanent 4-Feet High Chain Link Fence along the Right of Way begins at Line K, Sta.155+74.21. c.The permanent 4-Feet High Chain Link Fence along the Right of Way ends at Line K, Sta.169+41.88. There appears to be a gap between the end of the new fence and the existing fence. Is the intent to tie-in to the existing fence and close the gap?	a. Bid item to include CLF along bridge Wing Wall. Quantitiy revised in Addendum 2., b. High Tensile Hinge Joint Fence continues to Sta. 157+48.08. See revised plan sheet in Addendum No. 2., c. Field investigation did not find a HDOT fence along existing ROW at Sta. 169+41.88. 4-feet CLF does not connect to any fence.
14	6.607.1020 4-Feet High Tensile Hinge Joint Fence a.Please confirm quantity vs. what is shown on plan. b.The permanent 4-Feet High Tensile Hinge Joint Fence begins at Line K, Sta.153+66. It is not clear where this type of fence ends, but it appears to end at Line K, Sta.155+74.21. Please advise.	a. quantity of High Tensile Hinge Joint Fence revised. See Addendum 2., b. Hinge Joint fence ends at Sta. 157+48.08. See revised plan sht. In Addendum No. 2.

Kamehameha Highway Drainage and Safety Improvemenents
Vicinity of Laniakea Beach
Project No. 83B-01-09
Addendum 3 **Date: 9/19/2023**

RFI #	Description	Response
15	7.607.1030 4-Feet Temporary Construction Fence a.Please confirm quantity vs. what is shown on plan. b.Is this bid item intended to include both the 48" High Tensile Hinged Joint Fencing with Geotextile Fabric and 48" Chain Link Fencing w/ Geotextile Fabric, both shown on Sheet 24(TF-1)?	a. Quantity and bid items revised in Addendum No. 2., b. Temp and permanent Hinge Joint fence and CLF separated into different bid items. See revised Propsal Schedule Addendum No. 2.
16	a. On Sheet 69(SS-04) the rumble strips are represented by dashed lines while on Sheet 70(SS-05) an arrowhead points to empty space between road striping and edge of pavement. b. Please revise Sheet 70(SS-05) to include rumble strips required and confirm total bid item quantity for this work.	a. Disregard callout on SS-05. Rumble strips are not allowed adjacent to residences, b. Quantites of rumble strip are correct.
17	2.Legend on Sheet 37(C-4) refers to Standard Plan D-06, and the standard indicates that typical pavement thickness under this standard is 6" for residential driveways not 4", as indicated by description for Bid item 610.1000 "4-Inch Reinforced Concrete Driveways". Please confirm what thickness of pavement is required.	Follow Standard Plan D-06, use 6" thickness
18	Sheet E0.1 says to coordinate with Johnson Controls and to pay for any charges for installation of the nodes for the highway lights (See attached). My understanding is Johnson Controls has a contract with the State to connect the new nodes to the node system. On previous bids this has been the case and there was no costs for this work. Please confirm and change the note regarding covering costs from Johnson Controls. If this not the case and we are required to pay for Johnson Controls costs please provide a contact number for the person we need to talk to that is in charge of this work as we have been unable to get in contact with the correct person at Johnson Controls to get a quote and the people at Johnson Controls that we talk to do not seem to know who is taking care of this.	HECo Costs will be revised under Addendum No. 3. Cost estimate to be shown as Force Account Pay Item. Note to be revised to read HDOT Lighting Grid Consultant.

Kamehameha Highway Drainage and Safety Improvemenents
Vicinity of Laniakea Beach
Project No. 83B-01-09
Addendum 3 **Date: 9/19/2023**

RFI #	Description	Response
19	Per Addendum 2 RFI question 21. The question referenced standard guardrail details on sheet 63 showing 8" blockouts. But the answer provided appears to say that only the first 4 post at the concrete end post are 8" blockouts and ALL other post using the standard W6x8.5 post will use 12' blockouts. Please confirm this as the details on sheet 63-64, and plan sheet 37-40 all state standard 8" blockout for the standard W-beam guardrail. If not, then show us where the transion from 12" blockouts at the concrete end post will transition to the 8" blockouts in the W-beam run as the details are not clear.	The portion of the guardrail system shown on sheet S10.3 is limited to the 12 posts closest to the bridge." Beyond the 12th post, the detail on sheet C-30 with the 8" blockout shall be used. On sheet S10.3, there is a callout for "balance, see civil plans.
20	1.Quantities for Bid Items 203.1000 Roadway Excavation and 203.2000 Place Import do not appear to include cut/fill to subgrade of pavement sections. Please verify.	Correct, volumes shown on plans are from existing grade to finish grade.
21	2.Traffic Control Phases 2A and 3 indicate locations for public parking for public access to the beach. Please clarify intended locations for public parking for Phases 1, 2B, and 2C.	The existing parking on the mauka side of the existing highway is to remain available for public use during these phases of construction to the maximum extent possible.

GEOTECHNICAL ENGINEERING EXPLORATION

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS

VICINITY OF MP 3.06 TO MP 3.54

WAIALUA, OAHU, HAWAII

W.O. 7651-00(A)   NOVEMBER 30, 2022

Prepared for

WSP USA

GEOLABS, INC.

Geotechnical Engineering and Drilling Services

GEOTECHNICAL ENGINEERING EXPLORATION

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS

VICINITY OF MP 3.06 TO MP 3.54

WAIALUA, OAHU, HAWAII

W.O. 7651-00(A)   NOVEMBER 30, 2022

Prepared for

WSP USA

GERALD Y. SEKI
No. 5635-C

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

SIGNATURE

4-30-24
EXPIRATION DATE
OF THE LICENSE

GEOLABS, INC.
Geotechnical Engineering and Drilling Services
94-429 Koaki Street, Suite 200 • Waipahu, HI 96797

Hawaii • California

GEOLABS, INC.

Geotechnical Engineering and Drilling Services

November 30, 2022
W.O. 7651-00(A)

Mr. Dexter Eji
WSP USA
American Savings Bank Tower
1001 Bishop Street, Suite 2400
Honolulu, HI 96813

Dear **Mr. Eji:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Exploration, Kamehameha Highway Drainage and Safety Improvements, Vicinity of MP 3.06 to MP 3.54, Waialua, Oahu, Hawaii," prepared for the design of the project.

Our work was performed in general accordance with our revised fee proposal dated October 12, 2021.

Please note that the soil samples and rock cores recovered during our field exploration (remaining after testing) will be stored for a period of two months from the date of this report. The samples will be discarded after that date unless arrangements are made for a longer sample storage period. Please contact our office for alternative sample storage requirements, if appropriate.

Detailed discussion and specific design recommendations are contained in the body of this report. If there is any point that is not clear, please contact our office.

Very truly yours,

GEOLABS, INC.

Gerald Y. Seki, P.E.
Vice President

GS:HC:sh

GEOTECHNICAL ENGINEERING EXPLORATION
KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

W.O. 7651-00(A) NOVEMBER 30, 2022

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KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS
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W.O. 7651-00(A) NOVEMBER 30, 2022

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Our field exploration at the project site generally encountered a thin surface fill and/or alluvial soils layer about 0.5 to 4 feet thick underlain by beach deposit, alluvium, clinker materials, and basalt rock formation extending to the maximum depth explored of about 71.5 feet below the existing ground surface. The surface fill layer consisted of about 7 and 8 inches of asphaltic concrete in paved areas and about 0.5 to 3 feet of medium dense to dense silty sand and sandy gravel. The surface alluvial soil layer, about 0.5 to 1 foot thick, consisted of medium dense silty sand. Beach deposit consisting of loose to medium dense poorly graded sand was encountered at depths of about 0.5 to 18 feet below the existing ground surface. Beach deposit was not encountered in the borings drilled along approximately the northern half of the project site. Below the beach deposit, alluvium about 9 feet thick, consisting of soft to hard silty clay and clayey silt with cobbles and boulders, was encountered and underlain by interbedded layers of basalt formation and clinker materials to the maximum depth explored of about 71.5 feet below the existing ground surface. Basalt formation encountered ranged from hard to very hard and moderately to slightly weathered. Clinker materials encountered generally consisted of medium dense to very dense silty/sandy gravel and silty sand.

We encountered groundwater in the drilled borings at depths of about 9.9 to 12.3 feet below the existing ground surface at the time of our field exploration. The groundwater levels measured generally correspond to about Elevations +0.7 to +2.2 feet MSL, respectively. Due to the proximity of the project site to the Pacific Ocean, groundwater levels can fluctuate depending on tidal fluctuations, storm surge conditions, seasonal precipitation, groundwater withdrawal and/or injection, and other factors.

Based on the information provided, we understand that the relatively heavy structural load demands will require supporting the new bridge on a deep foundation system, such as cast-in-place concrete drilled shafts. The drilled shaft foundations would derive support primarily from adhesion between the drilled shaft and the hard to very hard basalt formation and medium dense to very dense clinker materials encountered in our borings drilled. Based on the structural load demands provided for our engineering analyses, drilled shafts with diameter of 3 feet and embedment lengths of 52 feet (Abutment #1), 48 feet (Abutment No. 2), and 54 feet (Center Pier) may be used for design of the new bridge crossing Lauhulu Stream. The recommended drilled shafts lengths are referenced to the design shaft cutoff elevations at +3 feet MSL.

We understand that retaining walls may be used for the wingwalls of the new bridge structure and other retaining walls for grade separation. It is our understanding that Wingwall

No. 1 will be designed as a cantilever wall off the bridge abutment structure and Wingwall Nos. 2 to 4 will be supported by additional drilled shaft foundations. Structural load demands for these additional drilled shafts were not available at the time of this report preparation. Additional analysis and recommendations for the drilled shaft lengths will be provided when structural load demands become available.

Design of retaining walls (not structurally connected to the bridge structure) may be supported by a shallow footing foundation bearing on the recompacted on-site soils. In the event that soft soils are encountered at the footing subgrade elevations, the exposed soft soils within the limits of the footing foundations should be removed and replaced with compacted fills.

Based on the information provided, we understand that site grading consisting of both cut and fill are required for the proposed project. In general, we anticipate the excavations during site grading operations likely will encounter a surface fill/alluvial soil layer and beach deposits. The excavated materials may be used as a source of general fill and backfill materials provided that the materials are processed to meet the gradation requirements discussed herein. Cut and fill slopes should be designed with a maximum inclination of 2H:1V or flatter.

The text of this report should be referred to for detailed discussion and specific design recommendations.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1. GENERAL

This report presents the results of our geotechnical engineering exploration performed for the *Kamehameha Highway Drainage and Safety Improvements, Vicinity of MP 3.06 to MP 3.54* project located in Waialua on the Island of Oahu, Hawaii. The project location and general vicinity are shown on the Project Location Map, Plate 1.

This report summarizes the findings and geotechnical recommendations resulting from our field exploration, laboratory testing, and engineering analyses for the project. These findings and geotechnical recommendations are intended for the design of bridge foundations, retaining structures, site grading, and underground utilities. The findings and recommendations presented herein are subject to the limitations noted at the end of this report.

1.1 Project Considerations

It is proposed to realign Kamehameha Highway in the mauka direction near the vicinity of Laniakea Beach due to safety concerns. The new roadway will be about 2,140 linear feet in length with a new bridge structure crossing Lauhulu Stream. It is our understanding that the new bridge will have two spans consisting of precast concrete planks supported on two abutments and one center pier. The total span length of the new bridge is about 102.5 feet, and the width is about 36.3 feet. The structural load demands provided for Strength I Limit State axial loads on top of each drilled shaft are 675 kips and 750 kips for the abutments and center pier, respectively.

1.2 Purpose and Scope

The purpose of our field exploration was to obtain an overview of the subsurface conditions to develop a soil/rock data set to formulate geotechnical engineering recommendations for the design of the proposed drainage and safety improvements project. The work was performed in general accordance with our revised fee proposal dated October 12, 2021. The scope of work for this exploration included the following tasks and work efforts:

1. Research and review of available in-house soils boring data and other information for the project.
2. Application for State excavation and street usage permits.
3. Mobilization/demobilization of trail clearing equipment and operator to and from the project site.
4. Mechanized equipment and operator rental for performing the trail clearing.
5. Coordination of boring stakeout and utility clearances by our engineer/geologist.
6. Provision of traffic control and safety devices during our field exploration.
7. Mobilization/demobilization of drilling equipment, water truck, and two operators to and from the project site.
8. Drilling and sampling of eight boreholes extending to depths of about 5.1 to 71.5 feet below the existing ground surface. In addition, bulk soil samples were collected for R-Value testing.
9. Coordination of the field exploration, including logging of the boreholes by our field engineer/geologist.
10. Laboratory testing of selected samples obtained during the field exploration as an aid in classifying the materials and evaluating their engineering properties.
11. Analyses of the field and laboratory data to formulate geotechnical recommendations for the proposed roadway realignment project.
12. Preparation of this report summarizing our work on the project and presenting our findings and recommendations.
13. Preparation of a pavement justification report, under separate cover, for the project.
14. Coordination of our overall work on the project by our project engineer.
15. Quality assurance of our work, and client/design team consultation by our principal engineer.
16. Miscellaneous work efforts, such as drafting, word processing, and clerical support.

Detailed descriptions of our field exploration methodology and the Logs of Borings are presented in Appendix A. Results of the laboratory tests performed on selected soil samples are presented in Appendix B. Photographs of the core samples retrieved are presented in Appendix C.

END OF GENERAL

SECTION 2. SITE CHARACTERIZATION

Of interest to our geotechnical analysis are the subsurface materials encountered at the project site, the engineering properties of the materials encountered, and the variability of the subsurface conditions across the project site. Therefore, the following subsections provide a description of the geologic setting of the project site, the surface and subsurface conditions encountered at the site, and a discussion of the items needed for seismic design, such as seismicity, soil liquefaction, and the soil profile characteristics for seismic analysis.

2.1 Regional Geology

The Island of Oahu was built by the extrusion of basaltic lava from two shield volcanoes, Waianae and Koolau. The older volcano, Waianae, is estimated to be middle to late Pliocene in age, and younger shield, Koolau Volcano, is estimated to be late Pliocene to early Pleistocene in age. After a long period of volcanic inactivity, during which time erosion incised deep valleys into the Koolau shield, volcanic activity returned with a series of lava flows followed by cinder and tuff cone formations. These series are referred to as the Honolulu Volcanic Series. The project site is located at the southwestern flank of the Koolau Mountain Range.

During the Pleistocene Epoch (Ice Age), sea levels fluctuated in response to the cycles of continental glaciation. As the glaciers grew and advanced, less water was available to fill the oceanic basins such that sea levels fell below the present stands of the sea. When the glaciers melted and receded, an excess of water became available such that the sea levels rose to elevations above the present sea level.

The higher sea level stands caused the formation of deltas and fans of accumulated terrigenous sediments in the heads of old bays, accumulated reef deposits at correspondingly higher elevations, and lagoonal/marine sediments in the quiet waters protected by fringing reefs. The lower sea stands caused streams to carve valleys in the sediments and reef deposits. Subaerial exposure of the sediments and calcareous materials caused consolidation of the soft deltaic materials and lagoonal deposits and induration of the calcareous reef materials.

The project site lies on the North Shore Coastal Plain and the pediment of the northwestern end of the Koolau Mountain Range. The project area is straddling areas generally classified from a geological standpoint as “Qbd” for Quaternary Beach Deposits and ‘Qa’ for Quaternary Alluvium (Sinton, et.al.) deposited since the Pleistocene Epoch. Experience in the vicinity of the project site indicates that the project site is underlain by fill, beach deposits, alluvial deposits, and basalt rock formation.

2.2 Existing Site Conditions

The project site encompasses approximately 2,140 lineal feet of new roadway and a new bridge of about 102.5 feet long to be constructed on the mauka side of Kamehameha Highway in vicinity of Laniakea Beach in the North Shore neighborhood area of Waialua on the Island of Oahu, Hawaii. The busy Laniakea Beach is located on makai side of Kamehameha Highway within short walking distance and there are numerous vehicle parking on the mauka side of the highway.

The intermittent Lauhulu Stream crosses under Kamehameha Highway within the project limits. The streambed is mainly bare sand and is about 8 feet below Kamehameha Highway. It is our understanding that the upper reaches of Lauhulu Stream are generally dry except when heavy rains occur resulting in stream water flowing to the beach.

Based on the topographic survey map provided, the elevation of the existing ground surface within the project limits ranges from about +8 to +22 feet Mean Sea Level (MSL). The roadway elevation along the existing Kamehameha Highway ranges from about +16 to +21 feet MSL.

2.3 Subsurface Conditions

We explored the subsurface conditions at the project site by drilling and sampling eight borings, designated as Boring Nos. 1 through 8, extending to depths of about 5.1 to 71.5 feet below the existing ground surface. In addition, three bulk samples of the near-surface soils, designated as Bulk-1 through Bulk-3, were obtained to evaluate the pavement support characteristics of the near-surface soils. The approximate boring and bulk sample locations are shown on the Site Plan, Plate 2.

In general, our borings encountered a thin surface fill and/or alluvium about 0.5 to 4 feet thick underlain by beach deposit to depths of 11 to 19.5 feet. Below the beach deposit, alluvium, clinker and basalt rock formation were encountered, extending to the maximum depth explored of about 71.5 feet below the existing ground surface. The beach deposit was not encountered in three of the drilled borings. The surface fill layer consisted of about 7 and 8 inches of asphaltic concrete (AC) in paved areas and about 0.5 to 3 feet of medium dense to dense silty sand and sandy gravel and boulders. Beach deposit consisted of loose to medium dense poorly graded sand. The alluvium consisted of medium dense silty sand, stiff to hard silty clay and clayey silt with cobbles and boulders. Basalt formation encountered ranged from hard to very hard and moderately to slightly weathered. The clinker generally consisted of medium dense to very dense silty/sandy gravel and silty sand. An idealized subsurface cross-section across the proposed bridge is shown on the Generalized Geologic Cross-Section A-A', Plate 3.

We encountered groundwater in the drilled borings at depths of about 9.9 to 12.3 feet below the existing ground surface at the time of our field exploration. The groundwater levels measured generally correspond to about Elevations +0.7 to +2.2 feet MSL, respectively. Due to the proximity of the project site to the Pacific Ocean, groundwater levels can fluctuate depending on tidal fluctuations, storm surge conditions, seasonal precipitation, groundwater withdrawal and/or injection, and other factors.

Detailed descriptions of the materials encountered from our field exploration are presented on the Logs of Borings, Plates A-1 through A-8, in Appendix A. Results of the laboratory tests performed on selected samples obtained from our field exploration are presented in Appendix B. Photographs of the core samples retrieved from our field exploration are presented in Appendix C.

2.4 Seismic Design Considerations

Based on the LRFD Bridge Design Specifications, 9th Edition (2020), the project site may be subject to seismic activity, and seismic design considerations will need to be addressed. The following subsections provide discussions on the seismicity and the potential for liquefaction at the project site.

2.4.1 Earthquakes and Seismicity

In general, earthquakes that occur 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 only sensitive instruments can detect them. 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 the earthquakes in Hawaii (over 90 percent) are related to volcanic activity, the risk of high 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. The effects of earthquakes occurring on the Islands of Hawaii and Maui may be felt on the Island of Oahu. For example, several small landslides occurred on the Island of Oahu as a result of the Maui Earthquake of 1938 (M6.8). In addition, some houses on the Island of Oahu were reportedly damaged as a result of the Lanai Earthquake of 1871 (M7+).

Due to the relatively short period of documented earthquake monitoring in the State of Hawaii, information pertaining to earthquakes that were felt on the Island of Oahu may not be complete. In general, we are not aware of reported earthquakes greater than Magnitude 6 occurring on the Island of Oahu over the last 150 years of recorded history. Based on available information, we understand an earthquake of about Magnitude 5.6 occurred on June 28, 1948 in the vicinity of the Island of Oahu, possibly along the hypothesized and controversial Diamond Head Fault feature.

The Diamond Head Fault feature is believed to extend northeasterly away from the southeastern tip of the Island of Oahu. The Diamond Head Fault feature may be related to the widely documented Molokai Fracture Zone located on the sea floor in the vicinity of the Hawaiian Islands. Despite only the moderate tremor intensity, the resulting damage was reportedly widespread and included broken windows, ruptured masonry building walls, and a broken underground water main. In addition, some areas on the Island of Oahu, including the Tantalus, Iwilei, and Tripler areas, reported more intense ground shaking, severe enough to have cracked reinforced concrete.

2.4.2 Liquefaction Potential

Based on the AASHTO LRFD Bridge Design Specifications Ninth Edition, 2020, the project site may be subjected to seismic activity, and the potential for soil liquefaction at the project site will need to be evaluated.

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 a mobility sufficient 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, the phenomenon of soil liquefaction is not a design consideration for this project site. The risk for potential liquefaction is low based on the subsurface conditions encountered.

2.4.3 Soil Profile Type for Seismic Design

Based on the subsurface materials encountered at the project site, we believe the project site may be classified from a seismic analysis standpoint as being a “Stiff Soil” site corresponding to a Site Class D soil profile type based on AASHTO 2020 LRFD Bridge Design Specifications, 9th Edition.

Based on the AASHTO 2020 LRFD Bridge Design Specifications, the bridge structure will need to be designed based on an earthquake return period of 1,000 years. Based on a 1,000-year return period and the anticipated Site Class D, the following seismic design parameters were estimated and may be used for the seismic analysis of the bridge structure planned for the project.

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)	0.160g
Spectral Response Acceleration (Site Class B), S_S	0.363g
Spectral Response Acceleration (Site Class B), S_1	0.099g
Site Class	"D"
Site Coefficient, F_{pga}	1.48
Site Coefficient, F_a	1.51
Site Coefficient, F_v	2.40
Design Peak Ground Acceleration, PGA (Site Class D) or A_s	0.236g
Design Spectral Response Acceleration, S_{DS}	0.547g
Design Spectral Response Acceleration, S_{D1}	0.238g
Seismic Design Category	"B"

END OF SITE CHARACTERIZATION

SECTION 3. DISCUSSION AND RECOMMENDATIONS

Our field exploration at the project site generally encountered a thin surface fill and/or alluvial soils layer about 0.5 to 4 feet thick underlain by beach deposit, alluvium, clinker materials, and basalt rock formation extending to the maximum depth explored of about 71.5 feet below the existing ground surface. The surface fill layer consisted of about 7 and 8 inches of asphaltic concrete in paved areas and about 0.5 to 3 feet of medium dense to dense silty sand and sandy gravel. The surface alluvial soil layer, about 0.5 to 1 foot thick, consisted of medium dense silty sand. Beach deposit consisting of loose to medium dense poorly graded sand was encountered at depths of about 0.5 to 18 feet below the existing ground surface. Beach deposit was not encountered in the borings drilled along approximately the northern half of the project site. Below the beach deposit, alluvium about 9 feet thick, consisting of soft to hard silty clay and clayey silt with cobbles and boulders, was encountered and underlain by interbedded layers of basalt formation and clinker materials to the maximum depth explored of about 71.5 feet below the existing ground surface. Basalt formation encountered ranged from hard to very hard and moderately to slightly weathered. Clinker materials encountered generally consisted of medium dense to very dense silty/sandy gravel and silty sand.

We encountered groundwater in the drilled borings at depths of about 9.9 to 12.3 feet below the existing ground surface at the time of our field exploration. The groundwater levels measured generally correspond to about Elevations +0.7 to +2.2 feet MSL, respectively. Due to the proximity of the project site to the Pacific Ocean, groundwater levels can fluctuate depending on tidal fluctuations, storm surge conditions, seasonal precipitation, groundwater withdrawal and/or injection, and other factors.

Based on the information provided, we understand that the relatively heavy structural load demands will require supporting the new bridge on a deep foundation system, such as cast-in-place concrete drilled shafts. The drilled shaft foundations would derive support primarily from adhesion between the drilled shaft and the hard to very hard basalt formation and medium dense to very dense clinker materials encountered in our borings drilled. Based on the anticipated subsurface soil/rock conditions and structural load demands provided, drilled shafts with diameter of 3 feet and embedment lengths varying from 48 to 54 feet are analyzed and recommended for the new bridge foundations. Structural load demands for drilled shafts supporting the proposed wingwalls were not available at the time of this report preparation. Additional analysis and recommendations for these drilled shafts will be provided when structural demands become available.

Retaining walls (not structurally connected to the bridge structure) may be supported on a shallow footing foundation bearing on the recompacted on-site soils. In the event that soft soils are encountered at the footing subgrade elevations, the exposed soft soils within the limits of the footing foundations should be removed and replaced with compacted fills.

Based on the information provided, we understand that site grading consisting of both cut and fill are required for the proposed project. In general, we anticipate the excavations during site grading operations likely will encounter surface fills, alluvial soils and/or beach deposits. The excavated materials may be used as a source of general fill and backfill materials provided that the materials are processed to meet the gradation requirements discussed herein. Cut and fill slopes should be designed with a maximum inclination of three horizontal to one vertical (3H:1V) or flatter.

Detailed discussion of these items and other geotechnical aspects of the project are presented in the following sections.

3.1 Drilled Shaft Foundations

Based on the information provided and the anticipated subsurface conditions, we believe drilled shaft foundations with a nominal diameter of 3 feet may be used to support the abutments and the center pier of the new bridge structure at Lauhulu Stream. The drilled shaft foundations would derive support primarily from adhesion between the drilled shaft and the basalt formation and clinker materials encountered in our borings. It should be noted that scour evaluation and protection should be considered and provided for the drilled shaft foundations.

It is our understanding that drilled shaft foundations will also be used as foundation supports for the proposed wingwalls. Structural demands for these drilled shafts were not available at the time of this report preparation. Additional analysis and recommendations will be provided when the structural demands become available.

Based on our engineering analyses and the above assumptions, we recommend using drilled shafts with the following compressive load capacities for the strength limit state based on Load and Resistance Factor Design (LRFD) methods for design of the new bridge provided in the table below.

SUMMARY OF COMPRESSIVE AXIAL CAPACITIES
FOR INDIVIDUAL DRILLED SHAFTS

Shaft Location	**Shaft Diameter** (feet)	**Shaft Length*** (feet)	**Drilled Shaft Tip Elevation** (feet MSL)	**Compressive Load Capacity Per Drilled Shaft** (kips)	
				Extreme Event Limit State	**Strength Limit State**
Abutment No. 1	3	52	-49	1384	692
Abutment No. 2	3	48	-45	1352	676
Center Pier	3	54	-51	1522	761

*Shaft length is based on design shaft cutoff elevation at +3 feet MSL.

In general, we anticipate that the drilled shafts with a minimum spacing of 4 times the diameter of the shaft measured from center-to-center will be provided. Therefore, the effect of group action was not considered in our axial load analyses. For the strength limit state, a resistance factor of 0.50 has been applied to the extreme event limit state capacities for design of the drilled shaft foundations.

Based on our evaluation of the subsurface conditions and the foundation design parameters, we anticipate the drilled shaft installation will require an experienced drilled shaft subcontractor to install the drilled shaft foundations. Therefore, consideration should be given to requiring pre-qualification of the drilled shaft subcontractor. The succeeding subsections address the design and construction of the drilled shaft foundations:

1. Lateral Load Resistance
2. Foundation Settlements

3. Drilled Shaft Construction Considerations
4. Test Shaft Program
5. Non-Destructive Integrity Testing

3.1.1 Lateral Load Resistance

In general, lateral load resistance for the drilled shaft is a function of the stiffness of the surrounding soil/rock, the stiffness of the shaft, allowable deflection at the top of the shaft, and induced moment in the shaft. To evaluate the lateral load resistance of the new bridge structure, stiffness modeling parameters were estimated based on the subsurface conditions encountered in the drilled borings. The stiffness modeling parameters were obtained using the program LPILE 2019 for Windows, which is a microcomputer adaptation of a finite difference, laterally loaded pile program. The program solves for a deflection and bending moment along a pile under lateral loads as a function of the depth. The analysis was carried out to generate non-linear “p-y” curves to represent soil moduli at various depths.

Due to the relatively close spacing of the drilled shaft foundations, the effect of group action was considered in our lateral load analyses by including an efficiency factor of p-multiplier in the direction of loading. Results of the generated non-linear “p-y” curves are summarized and presented on Plates 4.1 through 4.12.

3.1.2 Foundation Settlements

Settlement of the drilled shaft foundation will result from elastic compression of the shaft and subgrade response of the foundation embedded in the basalt formation and clinker materials. Total settlements of the drilled shafts are estimated to be on the order of about 0.5 inches. Therefore, differential settlements between the drilled shafts may be on the order of about 0.25 inches. We believe a significant portion of the settlement is elastic and should occur as the loads are applied.

3.1.3 Drilled Shaft Construction Considerations

Groundwater was encountered in our borings at a relatively high elevation. Therefore, we believe that the contractor should be prepared to contain the groundwater during drilled shaft construction. In addition, beach sand deposits were encountered in our drilled borings, therefore, temporary casing to prevent caving-ins of the beach sand will be necessary during the drilled shaft construction.

In general, the performance of drilled shafts depends significantly upon the contractor's method of installation and construction procedures. The following conditions would have a significant effect on the effectiveness and cost of the drilled shaft foundations.

The load-bearing capacities of drilled shafts depend, to a significant extent, on the friction between the shaft and the surrounding soils and rock formation. Therefore, proper construction techniques, especially during the drilling operations, are important. The contractor should exercise care in drilling the shaft holes and in placing concrete into the drilled holes.

Based on the anticipated subsurface conditions described above, some of the geotechnical considerations associated with drilled shaft foundations are discussed below.

3.1.3.a Obstructions, Boulders, and Basalt Rock Formation

Where obstructions, boulders, and basalt rock formation are anticipated, some difficult drilling conditions will likely be encountered and should be expected. The drilled shaft subcontractor will need to have the appropriate equipment and tools to drill through these types of natural or man-made obstructions where encountered. The drilled shaft subcontractor will need to demonstrate that the proposed drilling equipment (and coring tools, where appropriate) will be capable of installing the drilled shafts to the recommended depths and dimensions.

It should be noted that cavities and voids may be encountered in the basalt rock formation. Therefore, the actual volume of concrete required to fill the drilled shaft foundation may be appreciably more than the theoretical concrete volume.

3.1.3.b Shallow Groundwater Conditions

Groundwater conditions are anticipated within the depths of the drilled shaft excavations and, therefore, concrete placement by tremie methods will be required during drilled shaft construction. The concrete should be placed in a suitable manner by displacing the water in an upward fashion from the bottom of the drilled hole. A low-shrink concrete mix with high slump (7 to 9 inches slump range) should be used to provide close contact between the drilled shafts and the surrounding soils. The concrete should be placed in a suitable manner to reduce the potential for segregation of the aggregates from the concrete mix.

In addition, the concrete should be placed promptly after drilling (within 24 hours after substantial completion of the holes) to reduce the potential for softening of the sides of the drilled holes. Furthermore, drilling adjacent to a recently constructed shaft (within five shaft diameters of the recently constructed drilled shaft) should not commence until the concrete for the recently constructed drilled shaft has cured for a minimum of 24 hours.

It is imperative for a Geolabs representative to be present during construction to observe the drilling and installation of drilled shafts. Although the drilled shaft designs are primarily based on skin friction, the bottom of the drilled hole should be relatively free of loose materials prior to placement of concrete. Therefore, Geolabs observation of the drilled shaft installation operations is necessary to confirm the assumed subsurface conditions.

3.1.4 Test Shaft Program

A test shaft program is normally required and highly recommended for bridge foundation projects. Considering the diameter and structural load capacities of the drilled shafts, we recommend performing a test shaft program, including the performance of an instrumented load test at the bridge site to fulfill the following objectives:

- To examine the adequacy of the methods and equipment proposed by the contractor to install the high-capacity drilled shafts into the existing subsurface soil deposits.
- To confirm or modify the estimated tip elevations of the drilled shafts.
- To assess the contractor's method of placing and extracting the temporary casing for the drilled shaft.
- To assess the contractor's method of concrete placement.

To achieve these objectives, we recommend that the test shaft program consist of drilling one 3-foot diameter test shaft extending to a depth of about 75 feet below the existing ground surface. The location of the test shaft should be near, but outside of, the planned Abutment No. 2 foundation location. In general, the load test shaft should be structurally reinforced and instrumented with embedment strain gauges for load testing purposes. The embedment strain gauges should be placed starting from an elevation of about 5 feet above and below the load cell and subsequently at the pre-determined intervals, as shown on the Drilled Shaft Load Test Detail, Plate 5.

Due to the high capacities recommended for the drilled shafts, a conventional load test would not be practical and would be costly to conduct. Therefore, we recommend conducting a bi-directional axial load test on the reinforced load test shaft using an expandable base load cell (Osterberg Load Cell). The expandable base load cell will need to be installed within the load test shaft reinforcing cage prior to lowering the cage in place.

The drilled shaft load test should be performed in general accordance with the Quick Load Test Method of ASTM D1143. In general, the load test shaft should be loaded at increments of about 50 to 100 kips and should be held for a minimum of 12 hours at or near failure to evaluate the potential for creep effects. The load test shaft should be loaded to failure to evaluate the ultimate side shear resistance of the shaft. Installation of the expandable base load cell and embedment strain gauges, performance of the bi-directional axial load test, and analyses of the load test data should be performed by a qualified professional experienced in these types of load testing procedures.

Considering the specialized nature of the test shaft program, we recommend that a Geolabs representative be present during the test shaft program to evaluate the contractor's method of drilled shaft installation and to evaluate the subsurface materials encountered. In addition, Geolabs should observe the instrumented load test on the reinforced load test shaft. It should be noted that the drilled shaft design was developed from our analysis using limited field exploration data. Therefore, observation of the drilled shaft installation operations by Geolabs is a vital part of the foundation design to confirm our design assumptions.

3.1.5 Non-Destructive Integrity Testing

Based on the critical nature of the drilled shaft foundations for the new bridge abutments and center pier, we recommend conducting non-destructive integrity testing on the test shaft and production drilled shafts for the project. Crosshole Sonic Logging (CSL) is one of the non-destructive integrity testing methods that has gained widespread use and acceptance for integrity testing of drilled shafts.

Crosshole Sonic Logging techniques are based on the propagation of sound waves through concrete. In general, the actual velocity of sound wave propagation in concrete is dependent on the concrete material properties, geometry of the element and wavelength of the sound waves. When ultrasonic frequencies are generated, Pressure (P) waves and Shear (S) waves travel though the concrete. If anomalies are contained in the concrete, the anomalies will reduce the P-wave travel velocity in the concrete. Anomalies in the drilled shaft concrete may include soil particles, gravel, water, voids, contaminated concrete, and highly segregated constituent particles.

The transit time of an ultrasonic P-wave signal may be measured between an ultrasonic transmitter and receiver in two parallel water-filled access tubes placed into the concrete during construction. The P-wave velocity can be obtained by dividing the measured transit time from the distance between the transmitter and receiver. Therefore, anomalies may be detected (if they exist).

In general, the access tubes should be securely attached to the interior of the reinforcing cage as near to parallel as possible in the drilled shaft. We recommend casting a minimum of four access tubes into the concrete of the 3-foot diameter drilled shafts.

In addition, the access tubes should extend from the bottom of the drilled shaft reinforcing cage to at least 3.5 feet above the top of the shaft. It is imperative that joints required to achieve the full length of the access tubes are watertight. The contractor is responsible for taking extra care to prevent damage to the access tubes during the placement of the reinforcing cage into the drilled hole. The tubes should be filled with potable water as soon as possible after concrete placement, but the water filling of the access tubes should not be later than 4 hours after the concrete placement. Subsequently, the top of the access tubes should be capped with watertight caps.

The Crosshole Sonic Logging (CSL) test of drilled shafts should be conducted after at least seven days of curing time, but no later than 28 days after concrete placement. In addition, the CSL testing of drilled shafts should be performed in general accordance with ASTM D6760. In the event that a drilled shaft is found to have significant anomalies and/or is suspected to be defective based on the CSL testing and/or field observations, the drilled shaft should be cored to evaluate the integrity of the concrete in the drilled shaft. The coring location within the drilled shaft should be determined by our representative, who should be present to observe the installation of the drilled shafts. After completion of the crosshole sonic logging of the drilled shafts, all the access tubes should be filled with grout of the same strength as the drilled shaft concrete.

3.2 Structural Approach Slabs

To reduce the potential for appreciable abrupt differential settlements between the drilled shaft supported bridge structure and the compacted backfills behind the abutment structures, we recommend providing structure approach slabs at the abutment locations. In general, the structure approach slabs should be at least 10 feet long.

The structure approach slabs should be supported on a minimum of 8 inches of aggregate subbase course placed on a prepared subgrade. The subgrade should be scarified to a depth of about 8 inches, moisture-conditioned to above the optimum moisture content, and compacted to no less than 95 percent relative compaction. The aggregate subbase course should also be moisture-conditioned to above the optimum moisture content and compacted to at least 95 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same soil established in accordance with AASHTO T 180 (or ASTM D1557). Optimum moisture is the water content (percentage by dry weight) corresponding to the maximum dry density.

3.3 Retaining Walls

Based on the information provided, we understand that retaining structures, including the abutment wall and wingwalls, should be designed to resist the lateral earth pressures due to the adjacent soils and surcharge effects. Parameters for the design of foundations for the abutment walls supported on drilled shafts have been provided in the "Drilled Shaft Foundations" section herein. Structural load demands for drilled shafts supporting the proposed wingwalls were not available at the time of this report preparation. Additional analysis and recommendations for these drilled shafts will be provided when structural demands become available. Design of retaining walls (not structurally connected to the bridge structure) should be based on the parameters presented in the following subsections.

3.3.1 Retaining Wall Foundations

Based on the subsurface conditions encountered during our field exploration, we believe that conventional retaining walls may be supported by a shallow footing foundation bearing on recompacted on-site soils consisting of loose to medium dense sand and/or stiff silty clay.

Based on our analyses, the following values may be used for the design of the retaining walls bearing on soil material based on LRFD methods.

RETAINING WALL FOUNDATIONS BEARING ON SOIL MATERIAL			
	Extreme Event Limit State	**Strength Limit State**	**Service Limit State**
Bearing Pressure (psf)	9,000	4,050	3,000
Coefficient of Sliding Friction	0.35	0.28	N/A
Passive Pressure Resistance (pcf)	330	165	N/A

The passive earth pressure values in the table above assume that the soils around footings are well compacted. Unless covered by pavements or slabs, the passive pressure resistance in the upper 12 inches of the soils should be neglected.

Soft and/or loose materials encountered at the bottom of footing excavations should be over-excavated until dense materials are exposed in the footing excavation. The over-excavation should be backfilled with select granular fill materials, moisture-conditioned to above the optimum moisture content, and compacted to a minimum of 90 percent relative compaction, or may be backfilled with lean concrete or flowable fill.

The bottom of wall footings should be embedded at a minimum depth of 24 inches below the lowest adjacent finished grade. Wall footings oriented parallel to the direction of the slope should be constructed in stepped footings. Foundations located next to utility trenches or easements should be embedded below a 45-degree imaginary plane extending upward from the bottom edge of the utility trench, or the bottom of footing should be extended to a depth as deep as the inverts of the utility lines. This requirement is necessary to avoid surcharging adjacent below-grade structures with additional structural loads and to reduce the potential for appreciable foundation settlement.

3.3.2 Static Lateral Earth Pressures

Retaining walls should be designed to resist the lateral earth pressures due to the adjacent soils and surcharge effects. The recommended lateral earth pressures for the design of retaining walls, expressed in equivalent fluid pressures of pounds per square foot per foot of depth (pcf), are presented in the following tables. These lateral earth pressures do not include hydrostatic pressures that might be caused by groundwater trapped behind the walls.

LATERAL EARTH PRESSURES			
Backfill Condition	**Earth Pressure Component**	**Active** (pcf)	**At-Rest** (pcf)
Level Backfill	Horizontal	37	55
	Vertical	None	None
Maximum 2H:1V Sloping Backfill	Horizontal	56	73
	Vertical	14	18

The values provided above assume that on-site soils or select granular fill materials will be used to backfill behind the retaining walls. It is assumed that the backfill behind the retaining wall will be compacted to between 90 and 95 percent relative compaction. Over-compaction of the backfill should be avoided.

The at-rest condition should be used for retaining walls where the top of the structure is restrained from movement prior to backfilling of the wall. The active condition should be used only for gravity retaining walls and retaining walls that are free to deflect by as much as 0.5 percent of the wall height.

Surcharge stresses due to areal surcharges, line loads, and point loads within a horizontal distance equal to the depth of the wall should be considered in the design. For uniform surcharge stresses imposed on the loaded side of the wall, a rectangular distribution with a uniform pressure equal to 33 percent of the vertical surcharge pressure acting over the entire height of the wall, which is free to deflect (cantilever), may be used in the design. For walls that are restrained, a rectangular distribution equal to 50 percent of the vertical surcharge pressure acting over the entire height of the wall may be used for design. Additional analyses during design may be needed to evaluate the surcharge effects of point loads and line loads.

3.3.3 Dynamic Lateral Earth Forces

Dynamic lateral earth forces due to seismic loading will need to be considered in the design of the retaining wall structures based on LRFD design methods. An appropriately reduced factor of safety (or resistance factor) may be used when dynamic lateral earth forces are accounted for in the design of retaining wall structures. Dynamic lateral earth forces due to seismic loading (a_{max} = 0.236g) may be estimated by using $4.2H^2$ pounds per linear foot of wall length for level backfill conditions, where H is the height of the wall in feet. It should be noted that the dynamic lateral earth forces provided assume that the wall will be allowed to move laterally by up to about 1 to 2 inches in the event of an earthquake. The resultant force should be assumed to act through the mid-height of the wall. The dynamic lateral earth forces are in addition to the static lateral earth pressures provided above.

If the estimated amount of lateral movement is not attainable or the retaining structure is restrained, the retaining structure should be designed with higher dynamic lateral forces for a restrained condition. For a restrained condition (less than 0.5 inches of lateral movement), dynamic lateral forces due to seismic loading may be estimated using $15.7H^2$ pounds per linear foot of wall (H measured in feet) for level backfill conditions.

3.3.4 Drainage

The retaining walls should be well-drained to reduce the potential for build-up of hydrostatic pressures. A typical drainage system would consist of a 12-inch wide zone of permeable material, such as No. 3B Fine gravel (ASTM C33, No. 67 gradation), placed directly around a perforated pipe (perforations facing down) at the base of the wall discharging to an appropriate outlet or weepholes. As an alternative, a prefabricated drainage product, such as MiraDrain or EnkaDrain, may be used instead of the drainage material. The prefabricated drainage product also should be hydraulically connected to a perforated pipe at the base of the wall.

The backfill from the bottom of the wall to the bottom of the perforated pipe or weep hole should consist of relatively impervious materials to reduce the potential for significant water infiltration into the subsurface. In addition, the upper 12 inches of the retaining structure backfill should consist of relatively impervious materials to reduce the potential for significant water infiltration behind the retaining structure unless covered by concrete slabs at the surface.

3.4 Site Grading

Based on the information provided, we anticipate that cuts of about 5 feet deep and fills up to about 8 feet high may be required for the proposed project. Items of site grading that are addressed in the subsequent subsections include the following:

1. Site Preparation
2. Fills and Backfills
3. Fill Placement and Compaction Requirements
4. Excavation
5. Cut and Fill Slopes

A Geolabs representative should monitor the grading operations to review the site preparation operations to observe whether undesirable materials are encountered during the excavation and scarification process and to confirm whether the exposed soil/rock conditions are similar to those encountered in our field exploration.

3.4.1 Site Preparation

At the onset of earthwork, areas within the contract grading limits should be thoroughly cleared and grubbed. Vegetation, debris, demolished man-made structures, and other unsuitable materials should be removed and disposed of properly off-site to reduce the potential for contamination of the excavated materials designated to be reused as fill and/or backfill. If soft or wet soils are encountered during clearing, over-excavation may be required to remove the soft or wet materials to expose firm and/or dense soils. The resulting over-excavation should be backfilled with compacted fill material.

After clearing and grubbing, the existing ground surface should be scarified to a depth of 8 inches, moisture-conditioned to at least 2 percent above the optimum moisture content, and compacted to a minimum of 90 percent relative compaction. For pavement subgrades, the compaction requirement should be a minimum of 95 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same soil established in accordance with AASHTO T-180 (or ASTM D1557). Optimum moisture is the water content (percentage by dry weight) corresponding to the maximum dry density.

3.4.2 Fills and Backfills

In general, we anticipate the excavations will likely encounter fill, alluvium, beach deposits, cobbles and boulders at relatively shallow depths. The excavated on-site soil may be used as a source of fill material provided that the material meets the following requirements.

In general, the on-site soil encountered during our field exploration should be suitable for use as general fill materials, provided that the maximum particle size is less than 3 inches in largest dimension. The excavated on-site materials may be used as general fill or backfill materials if they are screened of the over-sized materials and/or processed to meet the gradation requirements (less than 3 inches in largest dimension). In addition, fill materials should be free of vegetation and deleterious materials. Excavated soft and wet soils may not be reused as a source of fill and backfill materials.

Imported materials to be used as select granular fill should consist of non-expansive granular material, such as crushed coral or basalt. The select granular fill should be well-graded from coarse to fine with particles no larger than 3 inches in largest dimension. The material should also contain between 10 and 30 percent particles passing the No. 200 sieve. The material should have a laboratory CBR value of 20 or more and should have a maximum swell value of 1 percent or less. Imported fill materials should be tested for conformance with these recommendations prior to delivery to the project site for the intended use.

3.4.3 Fill Placement and Compaction Requirements

Fills and backfills should be moisture-conditioned to at least 2 percent above the optimum moisture content, placed in level lifts not exceeding 8 inches in loose thickness, and compacted to at least 90 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same soil established in accordance with the AASHTO T180 (or ASTM D1557) test procedures. Optimum moisture is the water content (percentage by dry weight) corresponding to the maximum dry density.

Imported fill materials should be moisture-conditioned to above the optimum moisture content, placed in level lifts of about 8 inches in loose thickness, and compacted to a minimum of 90 or 95 percent relative compaction, as appropriate. Aggregate base course and subbase materials should be moisture-conditioned to above the optimum moisture content, placed in level lifts not exceeding 8 inches in loose thickness, and compacted to a minimum of 95 percent relative compaction.

Compaction should be accomplished by sheepsfoot rollers, vibratory rollers, multiple-wheel pneumatic-tired rollers, or other types of acceptable compaction equipment. Where compaction is less than required, additional compactive effort should be applied with adjustment of moisture content as necessary, to obtain the specified compaction.

3.4.4 Excavation

The project site generally is underlain by a thin surface fill/alluvial soil layer over beach deposits, recent alluvium, clinker materials and hard basalt formation. It is anticipated that the fills, alluvial soils, and beach deposits near the ground surface may be readily excavated with normal heavy excavation equipment, such as excavators, and ripped with large bulldozers. However, cobbles and boulders are frequently encountered in fills and alluvial soil deposits and should be expected. Excavations that encounter cobbles and boulders within the on-site soils and deeper excavations extending into the underlying basalt rock formation may require the use of hoerams or chipping.

The above discussions regarding the rippability of the subsurface materials are based on our field and laboratory data from the borings drilled. Contractors should be encouraged to examine the site conditions and the subsurface data to make their own reasonable and prudent interpretation.

3.4.5 Cut and Fill Slopes

Based on the anticipated grading and our field exploration, permanent cut and fill slopes for the drainage and safety improvements project should be designed with an inclination of three horizontal to one vertical (3H:1V) or flatter. Fills that are to be placed on existing ground steeper than 5H:1V should be benched. The filling operation should start at the lowest point and continue up in level horizontal compacted layers in accordance with the above fill placement recommendations. Fill slopes should be constructed by overfilling and cutting back to the design slope ratio to obtain a well-compacted slope face. In addition, slope planting or other means of slope protection should be provided as soon as possible to reduce the potential for significant erosion of the finished slopes.

3.5 Underground Utility Lines

We anticipate that new underground utilities will be installed for the project. We envision that most of the trenches for utilities will be excavated in the near-surface soils encountered in the borings drilled. In general, granular bedding consisting of 6 inches of open-graded gravel (AASHTO M43, No. 67 gradation materials) is recommended below the pipes for uniform support. Free-draining granular materials, such as open-graded gravel (AASHTO M43, No. 67 gradation materials), should also be used for the initial trench backfill up to about 12 inches above the pipes to provide adequate support around the pipes and to reduce the compaction effort of the backfill. It is critical to use free-draining materials around the pipes to reduce the potential for the formation of voids below the haunches of pipes and to provide adequate support for the sides of the pipes, which could result in backfill settlement.

The upper portion of the trench backfill from the level 12 inches above the pipes to the top of the subgrades or finished grade may consist of the on-site soils generally less than 3 inches in maximum particle size. The backfill material should be moisture-conditioned to above the optimum water content, placed in maximum 8-inch level loose lifts, and mechanically compacted to no less than 90 percent relative compaction to reduce the potential for appreciable future ground subsidence. Where trenches are below pavement areas, the compaction requirement for the upper 3 feet of the trench backfill below the pavement grade should be increased to at least 95 percent relative compaction.

3.6 Design Review

Preliminary and final drawings and specifications for the project should be forwarded to Geolabs for review and written comments prior to bid solicitation for construction. This review is necessary to evaluate the conformance of the plans and specifications with the intent of the foundation and earthwork recommendations provided herein. If this review is not made, Geolabs cannot be responsible for the misinterpretation of our recommendations.

3.7 Post-Design Services/Services During Construction

It is highly recommended to retain Geolabs for geotechnical engineering support and continued services during construction. The following are critical items of construction monitoring that require "Special Inspection":

1. Observation of the test drilled shaft installation and testing
2. Observation of the production drilled shaft installation
3. Observation of shallow foundation excavations
4. Observation of the subgrade soil preparation
5. Observation of fill placement and compaction

A Geolabs representative should observe other aspects of the earthwork construction. This is to observe compliance with the intent of the design concepts, specifications, or recommendations and to expedite suggestions for design changes that may be required in the event that subsurface conditions differ from those anticipated at the time this report was prepared. The recommendations provided herein are contingent upon such observations.

If the actual subsurface conditions encountered during construction are different from those assumed or considered in this report, then appropriate modifications to the design should be made.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4. LIMITATIONS

The analyses and recommendations submitted herein are based in part upon information obtained from the field borings and bulk samples. Variations of the subsurface conditions between and beyond the field data points may occur, and the nature and extent of these variations may not become evident until construction is underway. If variations then appear evident, it will be necessary to re-evaluate the recommendations presented herein.

The field boring locations indicated herein are approximate, having been estimated using a handheld GPS device. Elevations of the borings were estimated from contours and spot elevations shown on the Roadway Plan and Profile dated May 2022 transmitted by WSP USA. The field boring locations and elevations should be considered accurate only to the degree implied by the methods used.

The stratification breaks shown on the graphic representations of the borings depict the approximate boundaries between soil types and, as such, may denote a gradual transition. Water level data from the borings were measured at the times shown on the graphic representations and/or presented in the text of this report. This data has been reviewed and interpretations made in the formulation of this report. However, it should be noted that groundwater levels can fluctuate depending on surface water runoff, storm surge conditions, seasonal precipitation, perched groundwater, and other factors.

This report has been prepared for the exclusive use of WSP USA and their client, the State of Hawaii, Department of Transportation – Highways Division for specific application to the design of the *Kamehameha Highway Drainage and Safety Improvements* project in Waialua on the Island of Oahu, Hawaii in accordance with generally accepted geotechnical engineering principles and practices. No warranty is expressed or implied.

This report has been prepared solely for the purpose of assisting the engineers in the preparation of the design documents for the highway improvements project. Therefore, this report may not contain sufficient data, or the proper information, for use to form the basis for the preparation of construction cost estimates or contract bidding. A contractor wishing to bid on this project should retain a competent geotechnical engineer to assist in the interpretation of this report and/or performance of site-specific exploration for bid estimating purposes.

The owner/client should be aware that unanticipated soil conditions are commonly encountered. Unforeseen subsurface conditions, such as perched groundwater, soft deposits, hard layers, or cavities may occur in localized areas and may require additional probing or corrections in the field (which may result in construction delays) to attain a properly constructed project. Therefore, a sufficient contingency fund is recommended to accommodate these possible extra costs.

This geotechnical engineering exploration conducted at the project site was not intended to investigate the potential presence of hazardous materials existing at the project site. It should be noted that the equipment, techniques, and personnel used to conduct a geo-environmental exploration differ substantially from those applied in geotechnical engineering.

END OF LIMITATIONS

CLOSURE

The following plates and appendices are attached and complete this report:

Project Location Map .... Plate 1

Site Plan .... Plate 2

Generalized Geologic Cross-Section A-A’ .... Plate 3

Lateral Load Analysis .... Plates 4.1 thru 4.12

Drilled Shaft Load Test Detail .... Plate 5

Field Exploration .... Appendix A

Laboratory Tests .... Appendix B

Photographs of Core Samples .... Appendix C

-ΩΩΩΩΩΩΩΩΩ-

Respectfully submitted,

GEOLABS, INC.

By Herbert Chu
Herbert Y.F. Chu, P.E.
Associate/Senior Project Engineer

By
Gerald Y. Seki, P.E.
Vice President

GS:HC:sh

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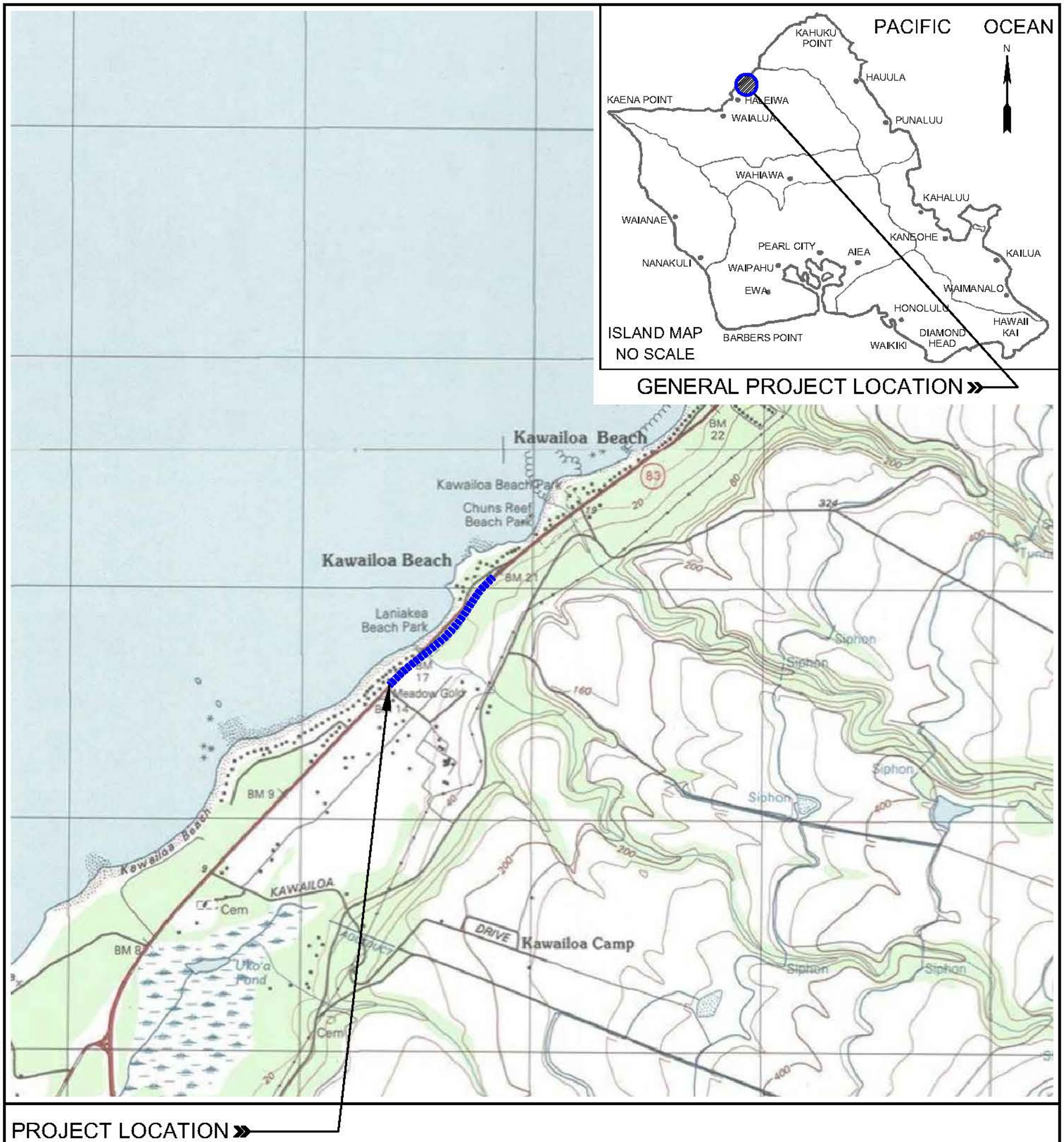
PLATES



2000 1000 0 2000 FT.

GRAPHIC SCALE

N

REFERENCE: MAP CREATED WITH TOPO!® ©2010 NATIONAL GEOGRAPHIC; ©2007 TELE ATLAS, REL. 1/2007.

PROJECT LOCATION MAP

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS VICINITY OF MP 3.06 TO MP 3.54 WAIALUA, OAHU, HAWAII

GEOLABS, INC.

Geotechnical Engineering

DATE JULY 2022	DRAWN BY KHN	PLATE
SCALE 1" = 2,000'	W.O. 7651-00(A)	1

CAD User: KIM File Last Updated: June 30, 2022 8:19:04pm Plot Date: June 30, 2022 - 9:16:13pm
File: T:\Drafting\Working\7651-00(A)_Kam_Hwy_Drainage_and_Safety_Improvements\7651-00(A)PLM.dwg\1
Plotter: DWG To PDF-GEO.pc3 Plotstyle: GEO-No-Dither-RBGC-HEAVY.ctb

SITE PLAN

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

LEGEND:

⌖	APPROXIMATE BORING LOCATION
⊞	APPROXIMATE BULK SAMPLE LOCATION
⊔	GENERALIZED GEOLOGIC CROSS-SECTION

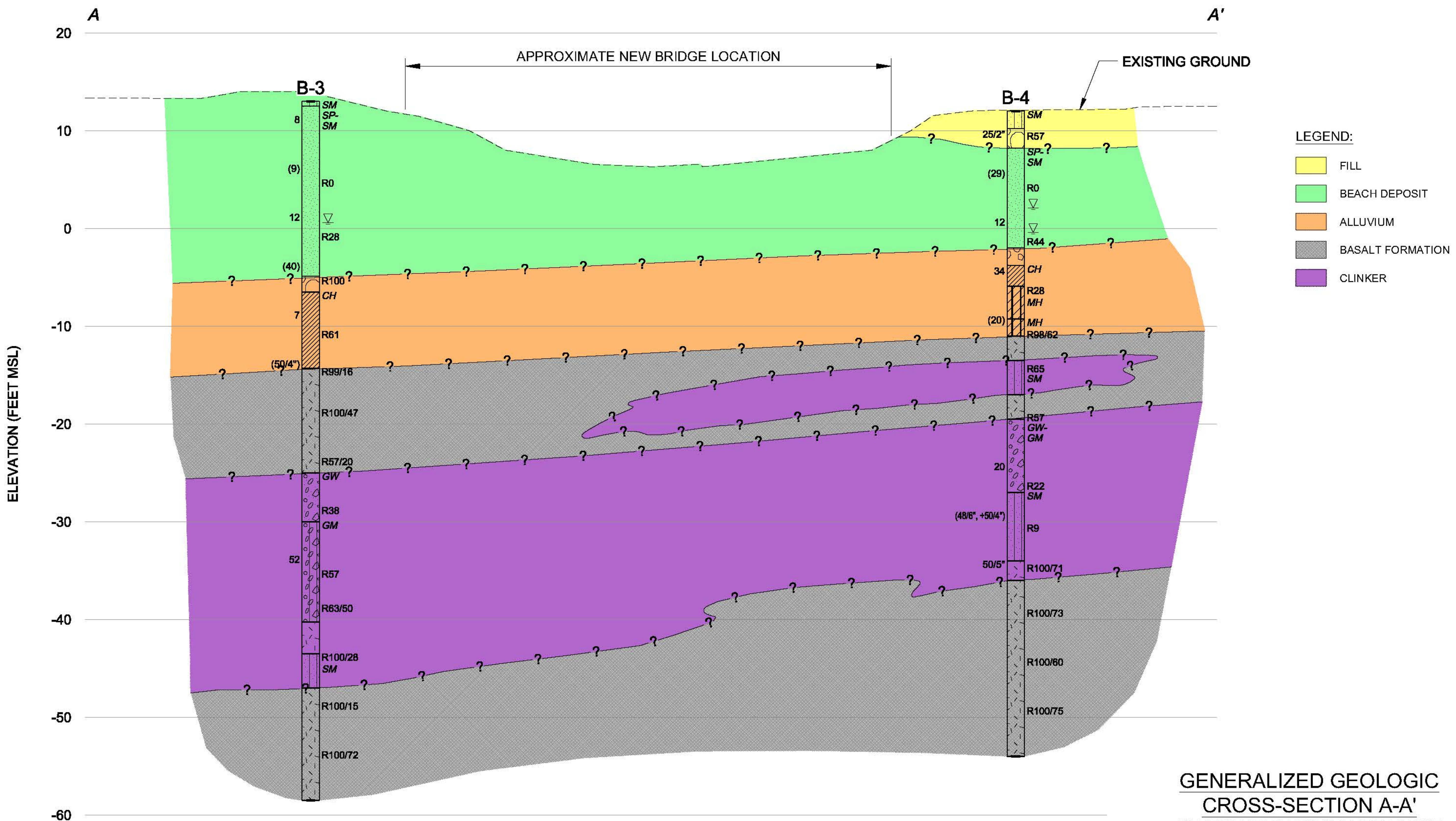
REFERENCE: ROADWAY PLANS DATED MAY 2022
TRANSMITTED BY WSP USA.

0 40 80 160 240 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JULY 2022	KHN / HYC	
SCALE	W.O.	
1" = 80'	7651-00(A)	2

CAD User: HENRY File Last Updated: August 10, 2022 12:55:42pm Plot Date: August 10, 2022 - 1:07:57pm
File: A:\Drafting\Drafting\Working\7651-00(A)_Kam_Hwy_Drainage_and_Safety_Improvements\7651-00(A)SitePlan.dwg\2
Plotter: DWG To PDF-GEO.pc3 Plotstyle: GEO-No-Dither-RBGC-HEAVY.ctb



LEGEND:

∇	WATER TABLE MEASURED IN BORING
20	BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 2-INCH O.D. STANDARD PENETRATION SAMPLER
(20)	BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 3-INCH O.D. MODIFIED CALIFORNIA SAMPLER
R100/50	REC/RQD VALUES IN PERCENT

NOTE: THE CONDITIONS ILLUSTRATED ARE BASED ON OUR BORINGS AND GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

HORIZONTAL	0	10	20	40	60 FT.
VERTICAL	0	5	10	20	30 FT.

GRAPHIC SCALE

GENERALIZED GEOLOGIC CROSS-SECTION A-A'

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
AUGUST 2022	HYC	
SCALE HORIZ: 1" = 20' VERT: 1" = 10'	W.O. 7651-00(A)	3

CAD User: HENRY File Last Updated: August 15, 2022 11:45:21am Plot Date: August 17, 2022 - 11:08:47am
File: A:\Drafting\Drafting\Working\7651-00(A)_Kam_Hwy_Drainage_and_Safety_Improvements\7651-00(A)SubsurfaceProfile.dwg\3
Plotter: DWG To PDF-GEO.pc3 Plotstyle: GEOLABS-Standard-Half.ctb

LATERAL LOAD ANALYSIS - Abutment No. 1 (No Scour)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

1 feet		5 feet		15 feet		20 feet		30 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.000	0.000	0.000
0.054	514.2	0.093	805.5	0.001	72.0	0.014	11520.000	0.286	13740.658
0.104	674.9	0.139	976.7	0.010	144.0	0.019	11712.000	0.315	14381.579
0.153	794.6	0.185	1120.3	0.051	216.0	0.024	11904.000	0.343	14992.953
0.203	893.4	0.231	1246.2	0.160	288.0	0.029	12096.000	0.372	15578.441
0.253	978.8	0.278	1359.7	0.391	360.0	0.034	12288.000	0.400	16141.007
0.302	1055.0	0.324	1463.7	0.811	432.0	0.038	12480.000	0.429	16683.093
0.352	1124.2	0.370	1560.3	1.502	504.0	0.043	12672.000	0.457	17206.736
0.401	1187.9	0.416	1650.8	2.563	576.0	0.048	12864.000	0.486	17713.658
0.451	1247.2	0.462	1736.2	4.106	648.0	0.053	13056.000	0.514	18205.331
0.501	1302.8	0.508	1817.3	6.258	720.0	0.058	13248.000	0.543	18683.022
0.550	1355.2	0.554	1894.7	9.162	792.0	0.062	13440.000	0.571	19147.835
0.600	1405.0	0.600	1968.7	12.976	864.0	0.067	13632.000	0.600	19600.733
0.975	1771.9	0.975	2559.4	17.873	936.0	0.072	13824.000	0.975	25480.953
1.350	2138.7	1.350	3150.0	24.040	1008.0	0.077	14016.000	1.350	31361.173
1.620	2138.7	1.620	3150.0	31.680	1080.0	0.082	14208.000	1.620	31361.173
1.890	2138.7	1.890	3150.0	39.600	1080.0	0.086	14400.000	1.890	31361.173

40 feet		52 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0
0.381	22875.2	0.014	11520.0
0.401	23440.3	0.019	11712.0
0.421	23991.1	0.024	11904.0
0.441	24528.5	0.029	12096.0
0.461	25053.4	0.034	12288.0
0.481	25566.7	0.038	12480.0
0.501	26069.0	0.043	12672.0
0.520	26561.1	0.048	12864.0
0.540	27043.5	0.053	13056.0
0.560	27516.8	0.058	13248.0
0.580	27981.3	0.062	13440.0
0.600	28437.7	0.067	13632.0
0.975	36969.0	0.072	13824.0
1.350	45500.4	0.077	14016.0
1.620	45500.4	0.082	14208.0
1.890	45500.4	0.086	14400.0

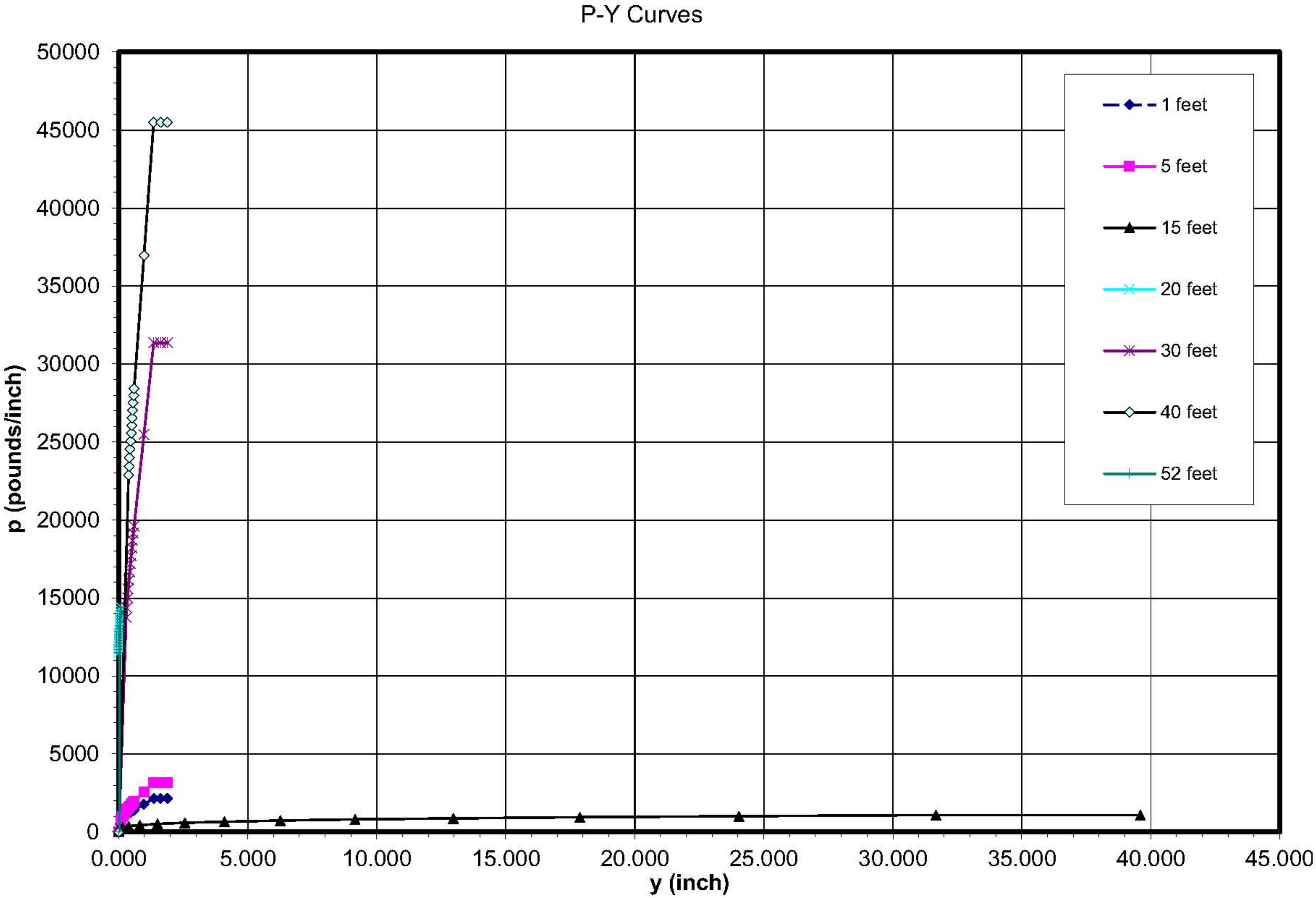
Soil Profile at Abutment No. 1 (B-3)

	Depths*
Beach Deposit (above water)	0 - 2 feet
Beach Deposit (below water)	2 - 10 feet
Alluvium	10 - 18 feet
Basalt Formation	18 - 28 feet
Clinker	28 - 50 feet
Basalt Formation	50 - 62 feet

*Depths below top of drilled shaft at Elevation +3 feet MSL

LATERAL LOAD ANALYSIS - Abutment No. 1 (No Scour)

Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii



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GEOLABS, INC.
Hawaii • California

PLATE 4.2

LATERAL LOAD ANALYSIS - Abutment No. 2 (No Scour)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

3 feet		5 feet		10 feet		15 feet		20 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.000	0.000	0.000
0.062	425.9	0.001	72.0	0.001	72.0	0.014	11520.000	0.127	4435.725
0.111	573.6	0.010	144.0	0.010	144.0	0.019	11712.000	0.170	5099.306
0.160	691.2	0.051	216.0	0.051	216.0	0.024	11904.000	0.213	5680.317
0.208	792.1	0.160	288.0	0.160	288.0	0.029	12096.000	0.256	6203.104
0.257	881.9	0.391	360.0	0.391	360.0	0.034	12288.000	0.299	6682.013
0.306	963.6	0.811	432.0	0.811	432.0	0.038	12480.000	0.342	7126.334
0.355	1039.1	1.502	504.0	1.502	504.0	0.043	12672.000	0.385	7542.491
0.404	1109.7	2.563	576.0	2.563	576.0	0.048	12864.000	0.428	7935.142
0.453	1176.2	4.106	648.0	4.106	648.0	0.053	13056.000	0.471	8307.792
0.502	1239.2	6.258	720.0	6.258	720.0	0.058	13248.000	0.514	8663.155
0.551	1299.3	9.162	792.0	9.162	792.0	0.062	13440.000	0.557	9003.387
0.600	1356.8	12.976	864.0	12.976	864.0	0.067	13632.000	0.600	9330.228
0.975	1788.6	17.873	936.0	17.873	936.0	0.072	13824.000	0.975	12129.296
1.350	2220.3	24.040	1008.0	24.040	1008.0	0.077	14016.000	1.350	14928.364
1.620	2220.3	31.680	1080.0	31.680	1080.0	0.082	14208.000	1.620	14928.364
1.890	2220.3	39.600	1080.0	39.600	1080.0	0.086	14400.000	1.890	14928.364

30 feet		45 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0
0.195	9112.0	0.014	11520.0
0.232	9902.5	0.019	11712.0
0.268	10629.9	0.024	11904.0
0.305	11306.9	0.029	12096.0
0.342	11942.7	0.034	12288.0
0.379	12543.7	0.038	12480.0
0.416	13115.0	0.043	12672.0
0.453	13660.6	0.048	12864.0
0.489	14183.5	0.053	13056.0
0.526	14686.4	0.058	13248.0
0.563	15171.2	0.062	13440.0
0.600	15639.8	0.067	13632.0
0.975	20331.7	0.072	13824.0
1.350	25023.7	0.077	14016.0
1.620	25023.7	0.082	14208.0
1.890	25023.7	0.086	14400.0

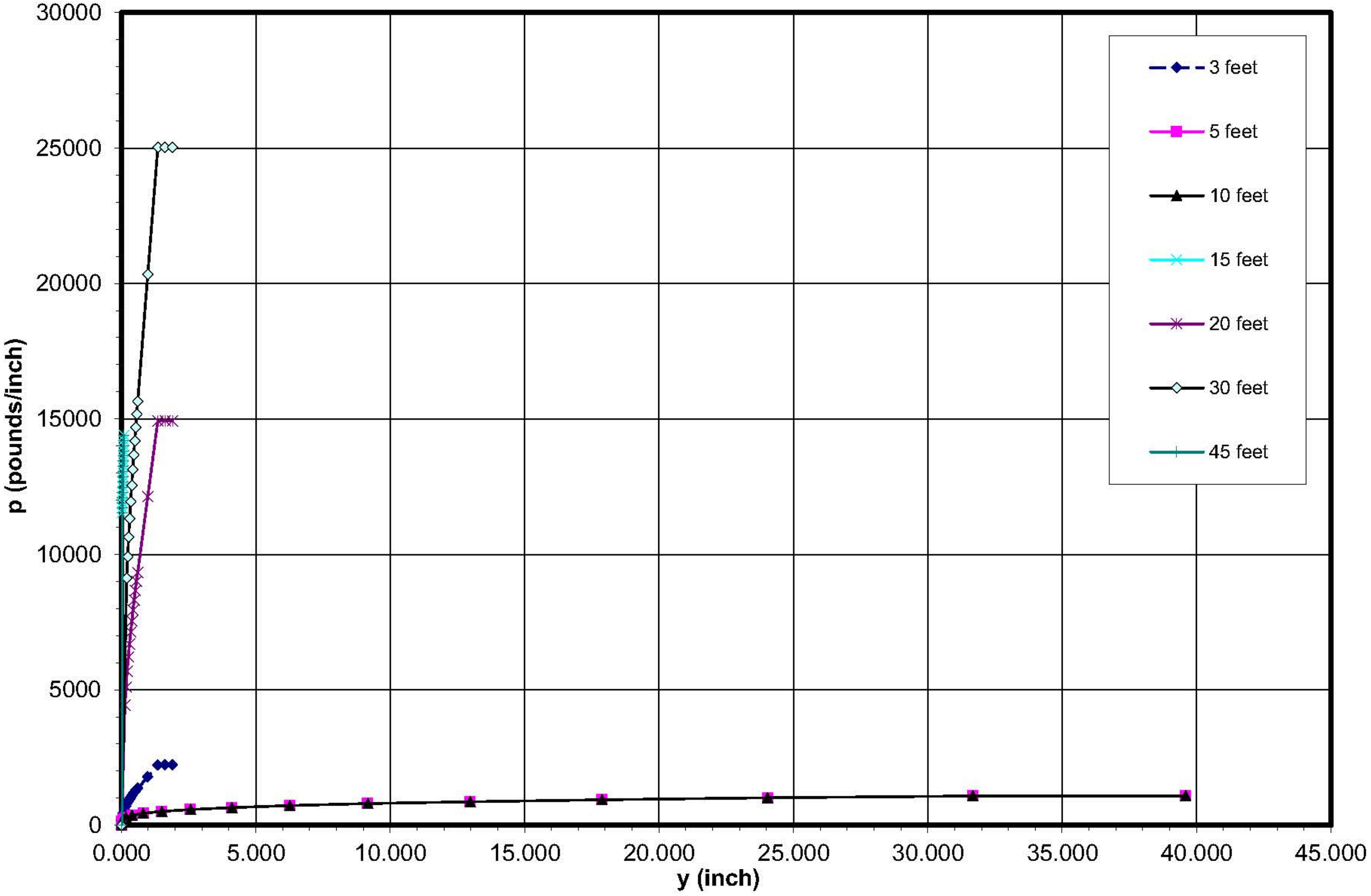
Soil Profile at Abutment No. 2 (B-4)

	Depths*
Beach Deposit (above water)	0 - 1 feet
Beach Deposit (below water)	1 - 5 feet
Alluvium	5 - 14 feet
Basalt Formation	14 - 17 feet
Clinker	17 - 39 feet
Basalt Formation	39 - 56 feet

*Depths below top of drilled shaft at Elevation +3 feet MSL

LATERAL LOAD ANALYSIS - Abutment No. 2 (No Scour)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

P-Y Curves



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GEOLABS, INC.
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PLATE 4.4

LATERAL LOAD ANALYSIS - Center Pier (No Scour)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

1 feet		5 feet		15 feet		19 feet		30 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.000	0.000	0.000
0.068	235.4	0.133	615.1	0.001	69.2	0.014	11520.000	0.148	5851.740
0.116	266.6	0.176	656.4	0.010	138.5	0.019	11712.000	0.189	6583.463
0.165	289.0	0.218	690.7	0.051	207.7	0.024	11904.000	0.230	7236.131
0.213	306.8	0.261	720.2	0.160	277.0	0.029	12096.000	0.271	7830.490
0.262	321.7	0.303	746.3	0.391	346.2	0.034	12288.000	0.312	8379.570
0.310	334.6	0.346	769.7	0.811	415.5	0.038	12480.000	0.353	8892.183
0.358	346.1	0.388	791.0	1.502	484.7	0.043	12672.000	0.394	9374.617
0.407	356.4	0.430	810.5	2.563	554.0	0.048	12864.000	0.436	9831.543
0.455	365.8	0.473	828.7	4.106	623.2	0.053	13056.000	0.477	10266.543
0.503	374.5	0.515	845.6	6.258	692.5	0.058	13248.000	0.518	10682.435
0.552	382.6	0.558	861.6	9.162	761.7	0.062	13440.000	0.559	11081.484
0.600	390.1	0.600	876.6	12.976	831.0	0.067	13632.000	0.600	11465.540
0.975	446.7	0.975	1005.7	17.873	900.2	0.072	13824.000	0.975	14905.202
1.350	503.3	1.350	1134.9	24.040	969.5	0.077	14016.000	1.350	18344.864
1.620	503.3	1.620	1134.9	31.680	1038.7	0.082	14208.000	1.620	18344.864
1.890	503.3	1.890	1134.9	39.600	1038.7	0.086	14400.000	1.890	18344.864

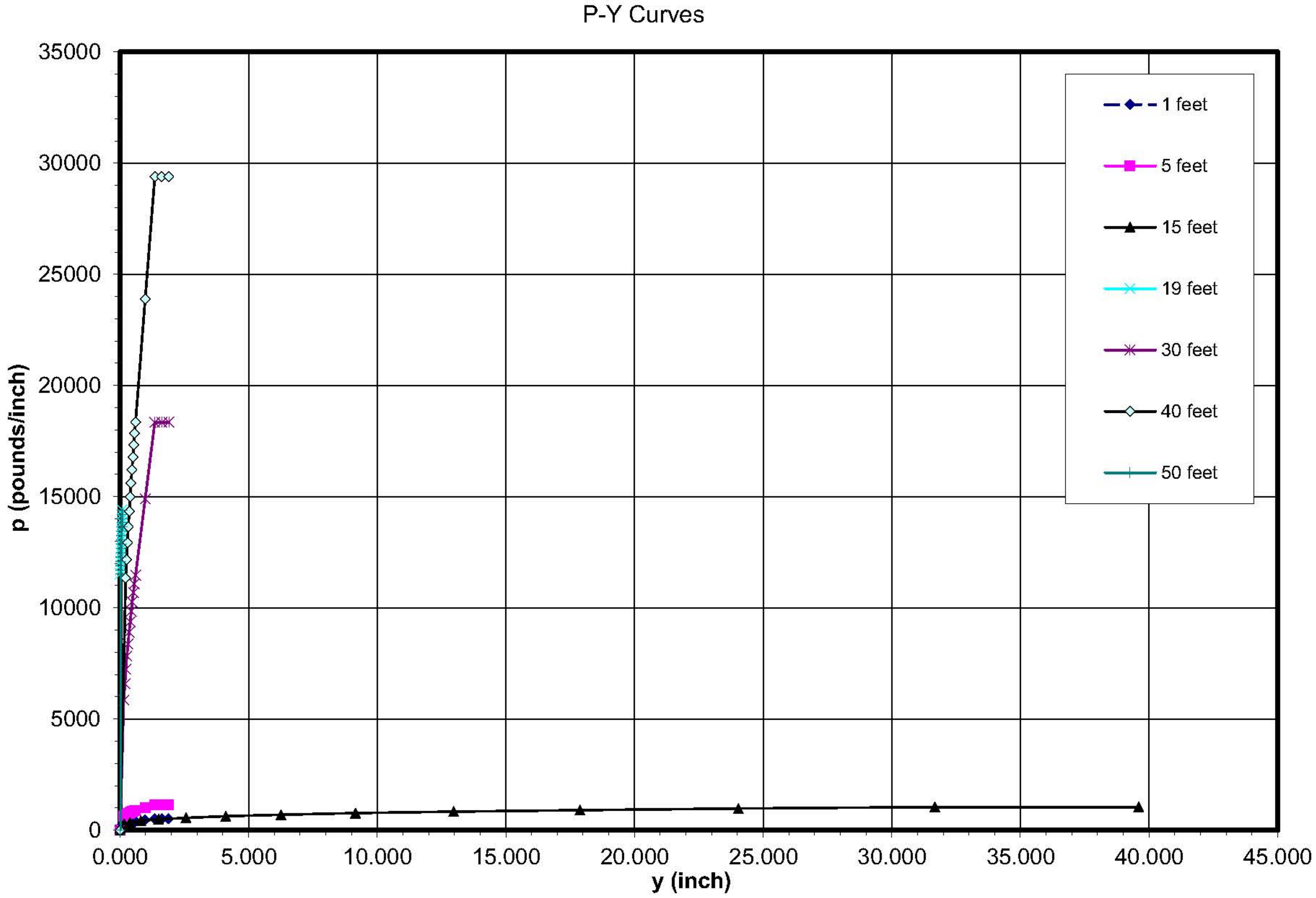
40 feet		50 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0
0.220	11344.7	0.014	11520.0
0.254	12168.2	0.019	11712.0
0.289	12935.3	0.024	11904.0
0.324	13656.0	0.029	12096.0
0.358	14337.7	0.034	12288.0
0.393	14986.0	0.038	12480.0
0.427	15605.2	0.043	12672.0
0.462	16198.9	0.048	12864.0
0.496	16769.9	0.053	13056.0
0.531	17320.6	0.058	13248.0
0.565	17852.9	0.062	13440.0
0.600	18368.6	0.067	13632.0
0.975	23879.2	0.072	13824.0
1.350	29389.8	0.077	14016.0
1.620	29389.8	0.082	14208.0
1.890	29389.8	0.086	14400.0

Soil Profile at Center Pier (B-3 and B-4)

	Depths*
Beach Deposit (above water)	0 - 3 feet
Beach Deposit (below water)	3 - 7 feet
Alluvium	7 - 16 feet
Basalt Formation	16 - 20 feet
Clinker	20 - 45 feet
Basalt Formation	45 - 62 feet

*Depths below top of drilled shaft at Elevation +3 feet MSL

LATERAL LOAD ANALYSIS - Center Pier (No Scour)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii



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GEOLABS, INC.
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PLATE 4.6

LATERAL LOAD ANALYSIS - Abutment No. 1 (Scour to Elev. -2.0 ft)

Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

7 feet		15 feet		20 feet		30 feet		40 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.000	0.000	0.000
0.023	26.9	0.001	37.4	0.014	11520.0	0.123	3678.255	0.188	7876.961
0.076	35.4	0.010	74.7	0.019	11712.0	0.166	4254.157	0.225	8597.122
0.128	40.0	0.051	112.1	0.024	11904.0	0.209	4755.845	0.263	9257.177
0.181	43.3	0.160	149.4	0.029	12096.0	0.253	5205.831	0.300	9869.791
0.233	46.0	0.391	186.8	0.034	12288.0	0.296	5617.157	0.338	10443.737
0.285	48.2	0.811	224.2	0.038	12480.0	0.340	5998.177	0.375	10985.386
0.338	50.1	1.502	261.5	0.043	12672.0	0.383	6354.618	0.413	11499.538
0.390	51.8	2.563	298.9	0.048	12864.0	0.426	6690.610	0.450	11989.913
0.443	53.3	4.106	336.3	0.053	13056.0	0.470	7009.245	0.488	12459.466
0.495	54.8	6.258	373.6	0.058	13248.0	0.513	7312.909	0.525	12910.588
0.548	56.1	9.162	411.0	0.062	13440.0	0.557	7603.490	0.563	13345.245
0.600	57.3	12.976	448.3	0.067	13632.0	0.600	7882.510	0.600	13765.081
0.975	65.6	17.873	485.7	0.072	13824.0	0.975	10247.263	0.975	17894.605
1.350	73.9	24.040	523.1	0.077	14016.0	1.350	12612.016	1.350	22024.130
1.620	73.9	31.680	560.4	0.082	14208.0	1.620	12612.016	1.620	22024.130
1.890	73.9	39.600	560.4	0.086	14400.0	1.890	12612.016	1.890	22024.130

45 feet		52 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0
0.225	10823.1	0.014	11520.0
0.260	11578.9	0.019	11712.0
0.294	12284.7	0.024	11904.0
0.328	12949.1	0.029	12096.0
0.362	13578.4	0.034	12288.0
0.396	14177.6	0.038	12480.0
0.430	14750.6	0.043	12672.0
0.464	15300.4	0.048	12864.0
0.498	15829.6	0.053	13056.0
0.532	16340.3	0.058	13248.0
0.566	16834.2	0.062	13440.0
0.600	17313.0	0.067	13632.0
0.975	22506.8	0.072	13824.0
1.350	27700.7	0.077	14016.0
1.620	27700.7	0.082	14208.0
1.890	27700.7	0.086	14400.0

Soil Profile at Abutment No. 1 (B-3)

	Depths*
Air	0 - 5 feet
Beach Deposit (below water)	5 - 10 feet
Alluvium	10 - 18 feet
Basalt Formation	18 - 28 feet
Clinker	28 - 50 feet
Basalt Formation	50 - 62 feet

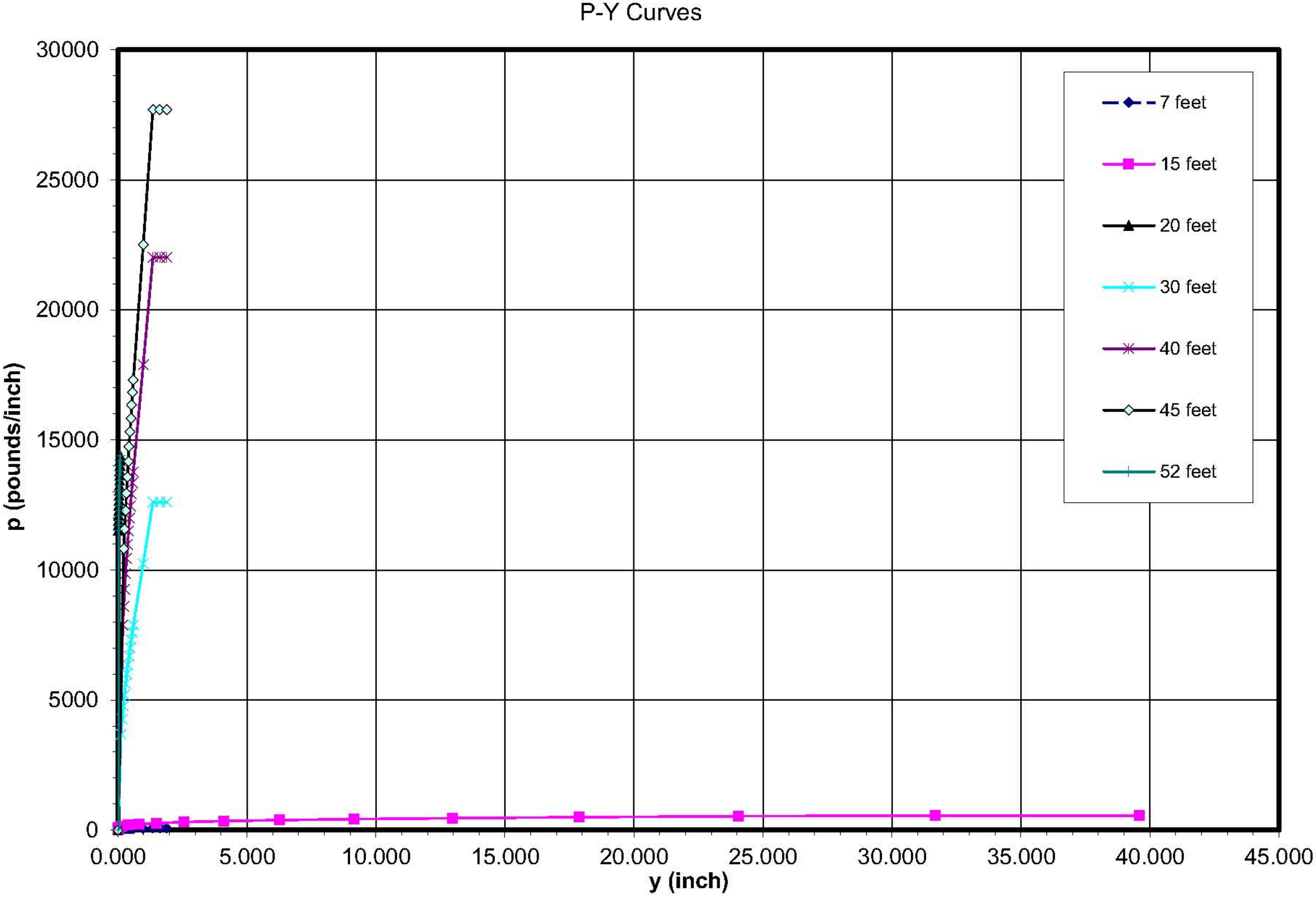
*Depths below top of drilled shaft at Elevation +3 feet MSL

LATERAL LOAD ANALYSIS - Abutment No. 1 (Scour to Elev. -2.0 ft)

Kamehemeha Highway Drainage and Safety Improvements

Vicinity of MP 3.06 to MP 3.54

Waialua, Oahu, Hawaii



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GEOLABS, INC.
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PLATE 4.8

LATERAL LOAD ANALYSIS - Abutment No. 2 (Scour to Elev. -2.0 ft)

Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

6 feet		11 feet		15 feet		20 feet		30 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.000	0.000	0.000
0.001	26.1	0.001	36.6	0.014	11520.0	0.035	634.466	0.075	2256.581
0.010	52.2	0.010	73.3	0.019	11712.0	0.087	976.710	0.123	2856.557
0.051	78.3	0.051	109.9	0.024	11904.0	0.138	1221.293	0.171	3343.522
0.160	104.4	0.160	146.6	0.029	12096.0	0.189	1421.621	0.218	3763.553
0.391	130.5	0.391	183.2	0.034	12288.0	0.241	1595.203	0.266	4138.034
0.811	156.6	0.811	219.8	0.038	12480.0	0.292	1750.386	0.314	4478.957
1.502	182.7	1.502	256.5	0.043	12672.0	0.343	1891.923	0.361	4793.840
2.563	208.9	2.563	293.1	0.048	12864.0	0.395	2022.821	0.409	5087.763
4.106	235.0	4.106	329.8	0.053	13056.0	0.446	2145.127	0.457	5364.347
6.258	261.1	6.258	366.4	0.058	13248.0	0.497	2260.308	0.505	5626.280
9.162	287.2	9.162	403.0	0.062	13440.0	0.549	2369.455	0.552	5875.624
12.976	313.3	12.976	439.7	0.067	13632.0	0.600	2473.408	0.600	6113.998
17.873	339.4	17.873	476.3	0.072	13824.0	0.975	3215.431	0.975	7948.198
24.040	365.5	24.040	513.0	0.077	14016.0	1.350	3957.453	1.350	9782.397
31.680	391.6	31.680	549.6	0.082	14208.0	1.620	3957.453	1.620	9782.397
39.600	391.6	39.600	549.6	0.086	14400.0	1.890	3957.453	1.890	9782.397

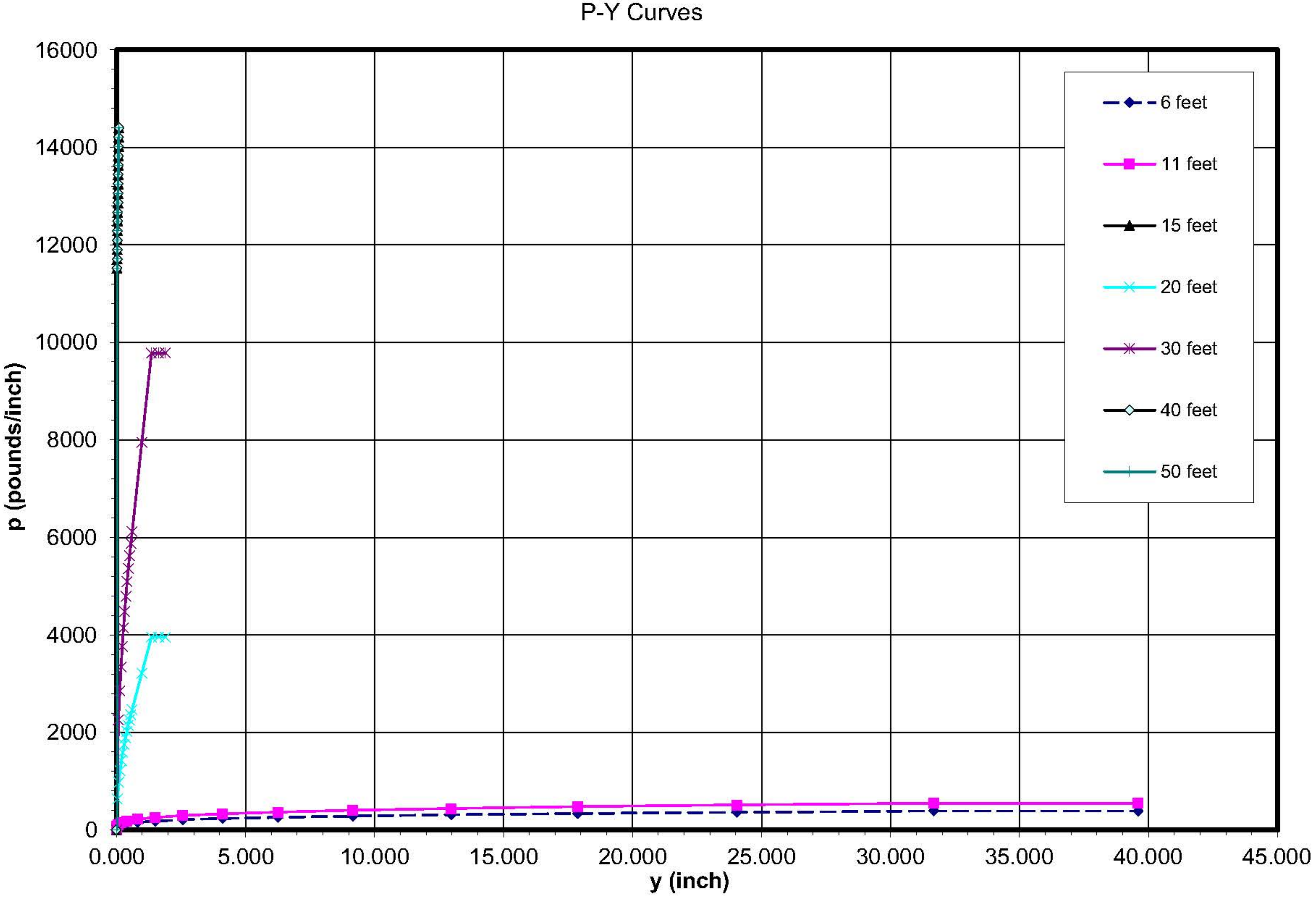
40 feet		50 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0
0.014	11520.0	0.014	11520.0
0.019	11712.0	0.019	11712.0
0.024	11904.0	0.024	11904.0
0.029	12096.0	0.029	12096.0
0.034	12288.0	0.034	12288.0
0.038	12480.0	0.038	12480.0
0.043	12672.0	0.043	12672.0
0.048	12864.0	0.048	12864.0
0.053	13056.0	0.053	13056.0
0.058	13248.0	0.058	13248.0
0.062	13440.0	0.062	13440.0
0.067	13632.0	0.067	13632.0
0.072	13824.0	0.072	13824.0
0.077	14016.0	0.077	14016.0
0.082	14208.0	0.082	14208.0
0.086	14400.0	0.086	14400.0

Soil Profile at Abutment No. 2 (B-4)

	Depths*
Air	0 - 5 feet
Alluvium	5 - 14 feet
Basalt Formation	14 - 17 feet
Clinker	17 - 39 feet
Basalt Formation	39 - 56 feet

*Depths below top of drilled shaft at Elevation +3 feet MSL

LATERAL LOAD ANALYSIS - Abutment No. 2 (Scour to Elev. -2.0 ft)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii



W.O. 7651-00(A)

GEOLABS, INC.
Hawaii • California

PLATE 4.10

LATERAL LOAD ANALYSIS - Center Pier (Scour to Elev. -2.0 ft)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii

6 feet		10 feet		15 feet		18 feet		25 feet	
y	p	y	p	y	p	y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.000	0.000	0.000
0.013	9.7	0.001	30.5	0.001	41.0	0.014	11520.000	0.059	1422.864
0.067	14.7	0.010	61.0	0.010	82.0	0.019	11712.000	0.108	1901.257
0.120	17.1	0.051	91.5	0.051	123.0	0.024	11904.000	0.158	2274.941
0.173	18.9	0.160	122.0	0.160	164.0	0.029	12096.000	0.207	2591.574
0.227	20.2	0.391	152.5	0.391	205.0	0.034	12288.000	0.256	2870.963
0.280	21.4	0.811	183.1	0.811	246.0	0.038	12480.000	0.305	3123.595
0.333	22.3	1.502	213.6	1.502	287.0	0.043	12672.000	0.354	3355.814
0.387	23.2	2.563	244.1	2.563	328.0	0.048	12864.000	0.403	3571.803
0.440	24.0	4.106	274.6	4.106	368.9	0.053	13056.000	0.453	3774.490
0.493	24.7	6.258	305.1	6.258	409.9	0.058	13248.000	0.502	3966.018
0.547	25.4	9.162	335.6	9.162	450.9	0.062	13440.000	0.551	4148.013
0.600	26.0	12.976	366.1	12.976	491.9	0.067	13632.000	0.600	4321.743
0.975	30.3	17.873	396.6	17.873	532.9	0.072	13824.000	0.975	5618.266
1.350	34.5	24.040	427.1	24.040	573.9	0.077	14016.000	1.350	6914.788
1.620	34.5	31.680	457.6	31.680	614.9	0.082	14208.000	1.620	6914.788
1.890	34.5	39.600	457.6	39.600	614.9	0.086	14400.000	1.890	6914.788

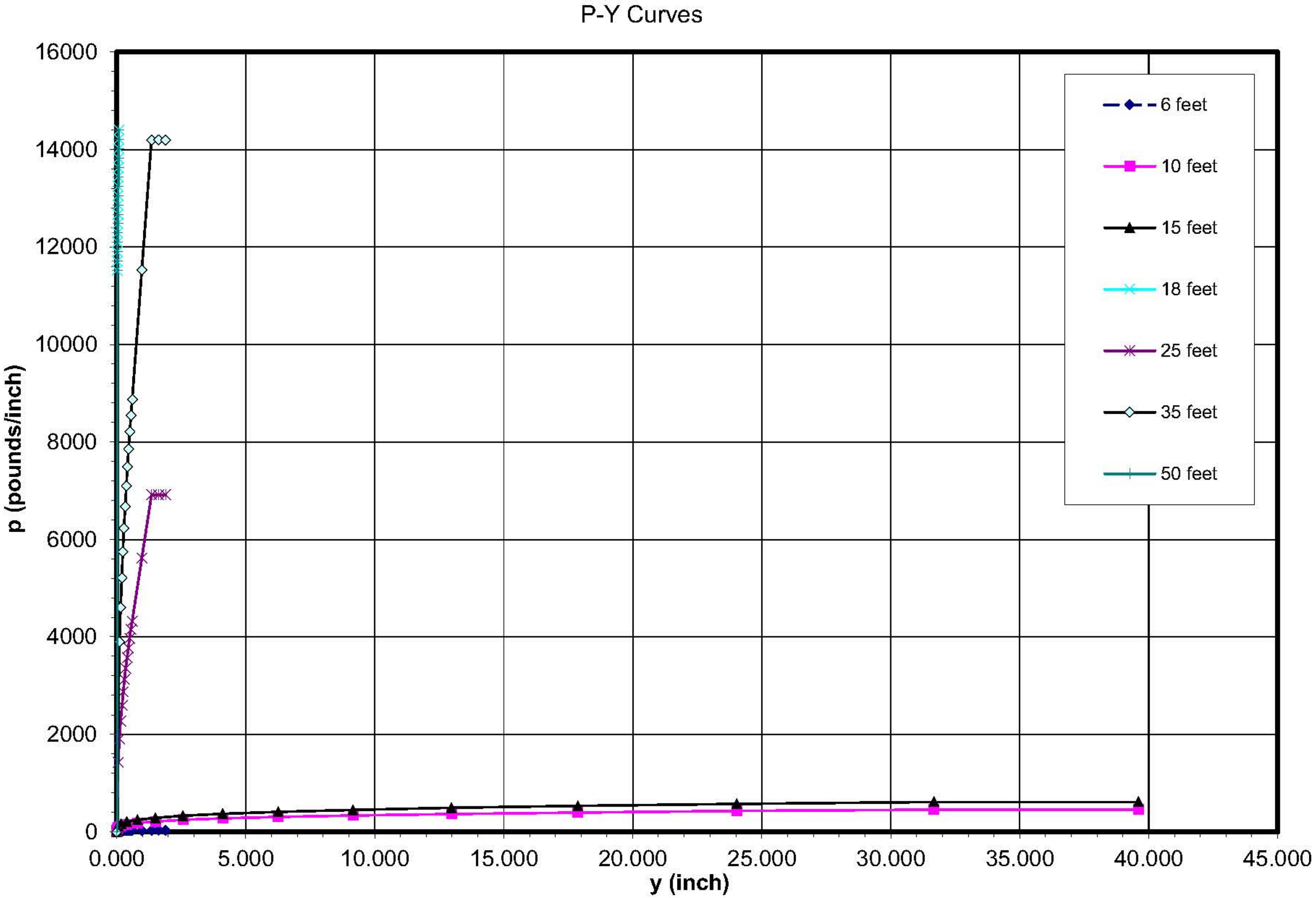
35 feet		50 feet	
y	p	y	p
(inch)	(pounds/inch)	(inch)	(pounds/inch)
0.000	0.0	0.000	0.0
0.108	3900.4	0.014	11520.0
0.153	4603.7	0.019	11712.0
0.198	5206.2	0.024	11904.0
0.242	5741.2	0.029	12096.0
0.287	6227.0	0.034	12288.0
0.332	6674.8	0.038	12480.0
0.377	7092.2	0.043	12672.0
0.421	7484.5	0.048	12864.0
0.466	7855.8	0.053	13056.0
0.511	8208.9	0.058	13248.0
0.555	8546.3	0.062	13440.0
0.600	8869.8	0.067	13632.0
0.975	11530.8	0.072	13824.0
1.350	14191.7	0.077	14016.0
1.620	14191.7	0.082	14208.0
1.890	14191.7	0.086	14400.0

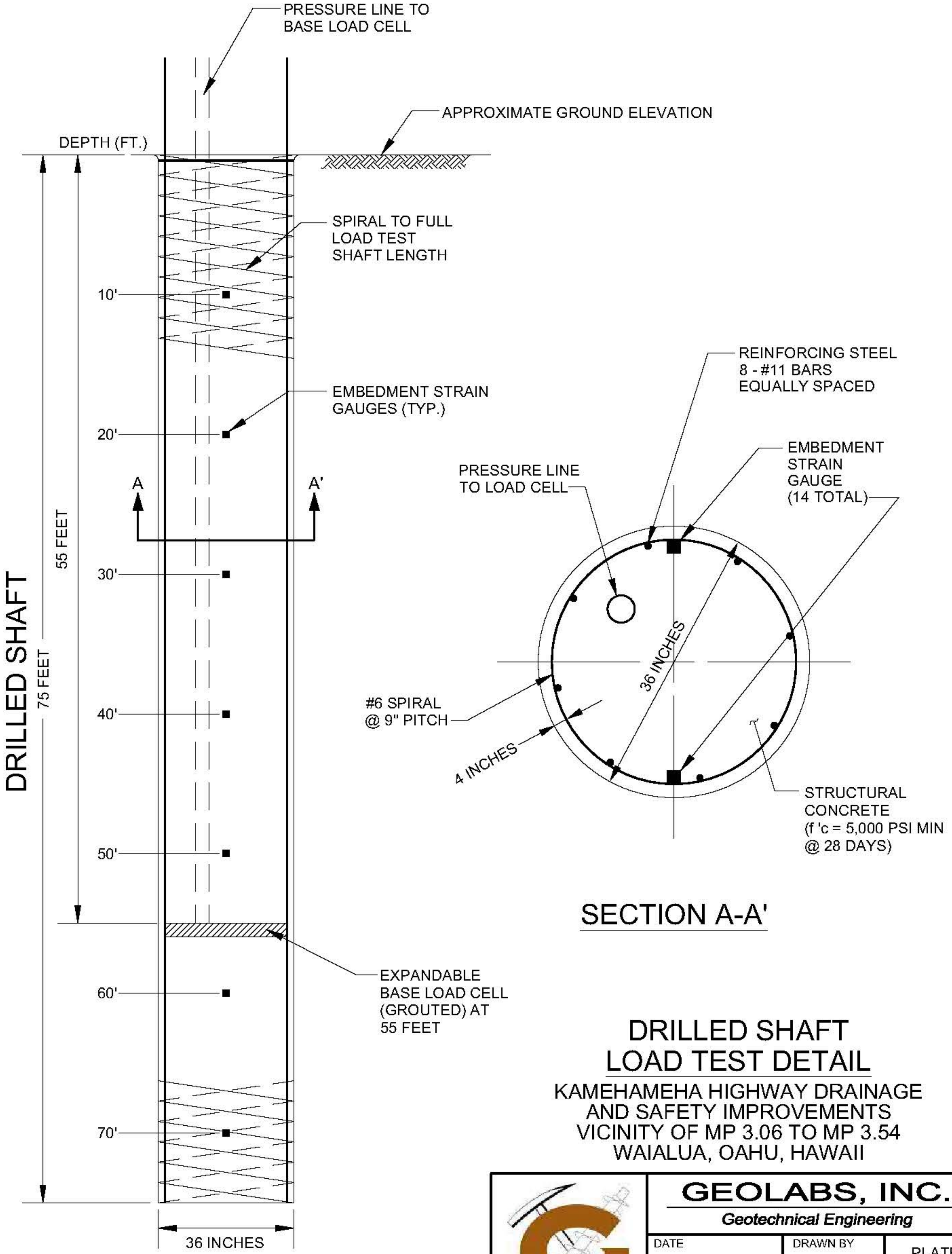
Soil Profile at Center Pier (B-3 and B-4)

	Depths*
Air	0 - 5 feet
Beach Deposit (below water)	5 - 7 feet
Alluvium	7 - 16 feet
Basalt Formation	16 - 20 feet
Clinker	20 - 45 feet
Basalt Formation	45 - 62 feet

*Depths below top of drilled shaft at Elevation +3 feet MSL

LATERAL LOAD ANALYSIS - Center Pier (Scour to Elev. -2.0 ft)
Kamehemeha Highway Drainage and Safety Improvements
Vicinity of MP 3.06 to MP 3.54
Waialua, Oahu, Hawaii





SECTION A-A'

DRILLED SHAFT LOAD TEST DETAIL

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
SEPTEMBER 2022	HYC	
SCALE	W.O.	
NOT TO SCALE	7651-00(A)	5

CAD User: HENRY File Last Updated: September 02, 2022 8:43:55am Plot Date: September 02, 2022 - 8:44:36am
File: A:\Drafting\Working\7651-00(A)_Kam_Hwy_Drainage_and_Safety_Improvements\7651-00(A)DrilledShaftDetail.dwg\5
Plotter: DWG To PDF-GEO.pc3 Plotstyle: GEO-No-Dithering.ctb

APPENDIX A

APPENDIX A

Field Exploration

We explored the subsurface conditions at the project site by drilling and sampling eight borings, designated as Boring Nos. 1 through 8, extending to depths of about 5.1 to 71.5 feet below the existing ground surface. In addition, three bulk samples of the near-surface soils, designated as Bulk-1 through Bulk-3, were obtained to evaluate the pavement support characteristics of the near-surface soils. The approximate boring and bulk sample locations are shown on the Site Plan, Plate 2. The borings were drilled using a truck-mounted drill rig equipped with continuous flight augers and coring tools.

Our geologist classified the materials encountered in the borings by visual and textural examination in the field in general accordance with ASTM D2488, Standard Practice for Description and Identification of Soils, and monitored the drilling operations on a near-continuous (full-time) basis. These classifications were further reviewed visually and by testing in the laboratory. Soils were classified in general accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), as shown on the Soil Log Legend, Plate A-0.1. Deviations made to the soil classification in accordance with ASTM D2487 are described on the Soil Classification Log Key, Plate A-0.2. Graphic representations of the materials encountered are presented on the Logs of Borings, Plates A-1 through A-8.

Relatively “undisturbed” soil samples were obtained in general accordance with ASTM D3550, Ring-Lined Barrel Sampling of Soils, by driving a 3-inch OD Modified California sampler with a 140-pound hammer falling 30 inches. In addition, some samples were obtained from the drilled borings in general accordance with ASTM D1586, Penetration Test and Split-Barrel Sampling of Soils, by driving a 2-inch OD standard penetration sampler using the same hammer and drop. The blow counts needed to drive the sampler the second and third 6 inches of an 18-inch drive are shown as the “Penetration Resistance” on the Logs of Borings at the appropriate sample depths. The penetration resistance shown on the Logs of Borings indicates the number of blows required for the specific sampler type used. The blow counts may need to be factored to obtain the Standard Penetration Test (SPT) blow counts.

Pocket penetrometer tests were performed on selected cohesive soil samples in the field. The pocket penetrometer test provides an indication of the unconfined compressive strength of the sample. Results of the pocket penetrometer tests are summarized on the Logs of Borings at the appropriate sample depths.

Core samples of the rock materials encountered at the project site were obtained by using diamond core drilling techniques in general accordance with ASTM D2113, Diamond Core Drilling for Site Investigation. Core drilling is a rotary drilling method that uses a hollow bit to cut into the rock formation. The rock material left in the hollow core of the bit is mechanically recovered for examination and description. Rock cores were described in general accordance with the Rock Description System, as shown on the

Rock Log Legend, Plate A-0.3. The Rock Description System is based on the publication "Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses" by the International Society for Rock Mechanics (March 1977).

Recovery (REC) may be used as a subjective guide to the interpretation of the relative quality of rock masses, where appropriate. Recovery is defined as the actual length of material recovered from a coring attempt versus the length of the core attempt. For example, if 3.7 feet of material is recovered from a 5.0-foot core run, the recovery would be 74 percent and would be shown on the Logs of Borings as REC = 74%.

The Rock Quality Designation (RQD) is also a subjective guide to the relative quality of rock masses. RQD is defined as the percentage of the core run in rock that is sound material in excess of 4 inches in length without any discontinuities, discounting any drilling, mechanical, and handling induced fractures or breaks. If 2.5 feet of sound material is recovered from a 5.0-foot core run in rock, the RQD would be 50 percent and would be shown on the Logs of Borings as RQD = 50%. Generally, the following is used to describe the relative quality of the rock based on the "Practical Handbook of Physical Properties of Rocks and Minerals" by Robert S. Carmichael (1989).

Rock Quality	**RQD** (%)
Very Poor	0 – 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 – 100

The excavation characteristic of a rock mass is a function of the relative hardness of the rock, its relative quality, brittleness, and fissile characteristics. A dense rock formation with a high RQD value would be very difficult to excavate and probably would require more arduous methods of excavation.

Soil Log Legend

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS		TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS MORE THAN 50% OF MATERIAL RETAINED ON NO. 200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	▨	**GW**	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			▨	**GP**	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES MORE THAN 12% FINES	▨	**GM**	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			▨	**GC**	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS 50% OR MORE OF COARSE FRACTION PASSING THROUGH NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	▨	**SW**	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			▨	**SP**	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES MORE THAN 12% FINES	▨	**SM**	SILTY SANDS, SAND-SILT MIXTURES
			▨	**SC**	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS 50% OR MORE OF MATERIAL PASSING THROUGH NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▨	**ML**	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	**CL**	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▨	**OL**	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT 50 OR MORE	▨	**MH**	INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	**CH**	INORGANIC CLAYS OF HIGH PLASTICITY
			▨	**OH**	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			▨	**PT**	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

LEGEND

◩	(2-INCH) O.D. STANDARD PENETRATION TEST
⧗	(3-INCH) O.D. MODIFIED CALIFORNIA SAMPLE
S	SHELBY TUBE SAMPLE
G	GRAB SAMPLE
▮	CORE SAMPLE
▽	WATER LEVEL OBSERVED IN BORING AT TIME OF DRILLING
▼	WATER LEVEL OBSERVED IN BORING AFTER DRILLING
▼	WATER LEVEL OBSERVED IN BORING OVERNIGHT

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

Plate
A-0.1

GEOLABS, INC.

Geotechnical Engineering

Soil Classification Log Key

(with deviations from ASTM D2488)

GEOLABS, INC. CLASSIFICATION*

GRANULAR SOIL (- #200 <50%)

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

COHESIVE SOIL (- #200 ≥50%)

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

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

RELATIVE DENSITY / CONSISTENCY

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

MOISTURE CONTENT DEFINITIONS

Dry: Absence of moisture, dry to the touch

Moist: Damp but no visible water

Wet: Visible free water

ABBREVIATIONS

WOH: Weight of Hammer

WOR: Weight of Drill Rods

SPT: Standard Penetration Test Split-Spoon Sampler

MCS: Modified California Sampler

PP: Pocket Penetrometer

GRAIN SIZE DEFINITION

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

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

GEOLABS, INC.

Geotechnical Engineering

Rock Log Legend

ROCK DESCRIPTIONS

⁄	**BASALT**	∘	**CONGLOMERATE**
○	**BOULDERS**	▤	**LIMESTONE**
△	**BRECCIA**	⁘	**SANDSTONE**
×	**CLINKER**	×	**SILTSTONE**
○	**COBBLES**	▩	**TUFF**
✲	**CORAL**		**VOID/CAVITY**

ROCK DESCRIPTION SYSTEM

ROCK FRACTURE CHARACTERISTICS

The following terms describe general fracture spacing of a rock:

Massive:	Greater than 24 inches apart
Slightly Fractured:	12 to 24 inches apart
Moderately Fractured:	6 to 12 inches apart
Closely Fractured:	3 to 6 inches apart
Severely Fractured:	Less than 3 inches apart

DEGREE OF WEATHERING

The following terms describe the chemical weathering of a rock:

Unweathered:	Rock shows no sign of discoloration or loss of strength.
Slightly Weathered:	Slight discoloration inwards from open fractures.
Moderately Weathered:	Discoloration throughout and noticeably weakened though not able to break by hand.
Highly Weathered:	Most minerals decomposed with some corestones present in residual soil mass. Can be broken by hand.
Extremely Weathered:	Saprolite. Mineral residue completely decomposed to soil but fabric and structure preserved.

HARDNESS

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

Very Hard:	Specimen breaks with difficulty after several "pinging" hammer blows. Example: Dense, fine grain volcanic rock
Hard:	Specimen breaks with some difficulty after several hammer blows. Example: Vesicular, vugular, coarse-grained rock
Medium Hard:	Specimen can be broked by one hammer blow. Cannot be scraped by knife. SPT may penetrate by ~25 blows per inch with bounce. Example: Porous rock such as clinker, cinder, and coral reef
Soft:	Can be indented by one hammer blow. Can be scraped or peeled by knife. SPT can penetrate by ~100 blows per foot. Example: Weathered rock, chalk-like coral reef
Very Soft:	Crumbles under hammer blow. Can be peeled and carved by knife. Can be indented by finger pressure. Example: Saprolite

GEOLABS, INC.

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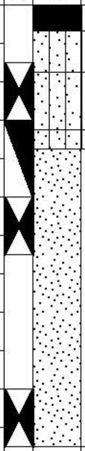
KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring
1

Approximate Ground Surface Elevation (feet): 16 *



Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
									8-inch **ASPHALTIC CONCRETE**
	13	95			40			SM	Brown with some gray **SILTY SAND** with a little gravel (basaltic), medium dense, moist (fill)
	14				9			SM	Light tan with traces of brown **SILTY SAND (CORALLINE)** with some gravel, medium dense, moist (fill)
								SM	Brownish tan fine **SILTY SAND**, medium dense, moist (alluvium)
Sieve - #200 = 1.5%	6	89			11		5	SP	Tan poorly graded **SAND (CORALLINE)** with traces of silt and gravel, loose, moist (beach deposit)
	5	93			8		10		
									Boring terminated at 11.5 feet * Elevations estimated from Roadway Plan and Profile dated May 2022 transmitted by WSP USA.
							15		
							20		
							25		
							30		
							35		

Date Started:	June 13, 2022	Water Level: ▼	Not Encountered
Date Completed:	June 13, 2022		
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Total Depth:	11.5 feet	Drilling Method:	6" Hollow-Stem Auger
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 1

BORING_LOG 7651-00(A).GPJ GEOLABS.GDT 10/13/22

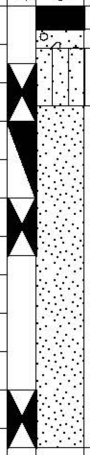
GEOLABS, INC.

Geotechnical Engineering

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring 2

Approximate Ground Surface Elevation (feet): 14 *



Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											7-inch **ASPHALTIC CONCRETE**
										GW	Light tan **SANDY GRAVEL (CORALLINE)** with a little silt, dense, moist (fill)
	12	91			25					SM	Brownish tan fine to medium **SILTY SAND**, medium dense, moist (alluvium)
	7				16					SP	Tan poorly graded **SAND (CORALLINE)**, medium dense, moist (beach deposit)
	5	96			30		5				
	6	99			26		10				
											Boring terminated at 11.5 feet
							15				
							20				
							25				
							30				
							35				

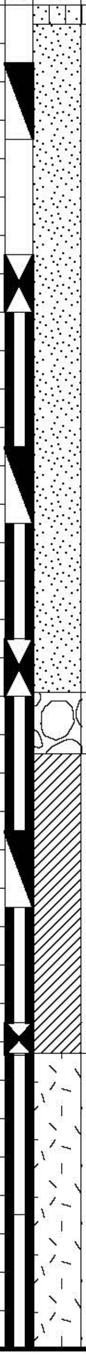
Date Started:	June 13, 2022	Water Level: ▼	Not Encountered
Date Completed:	June 13, 2022		
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Total Depth:	11.5 feet	Drilling Method:	6" Hollow-Stem Auger
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 2

GEOLABS, INC. Geotechnical Engineering	KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS VICINITY OF MP 3.06 TO MP 3.54 WAIALUA, OAHU, HAWAII	Log of Boring 3

Approximate Ground Surface Elevation (feet): 13 *



Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								SM	Brown fine **SILTY SAND**, medium dense, dry to moist (alluvium)
	2				8			SP-SM	Light tan poorly graded fine **SAND (CORALLINE)** with a little silt, loose, dry to moist (beach deposit)
							5		
Direct Shear	23	114			9				grades coarser locally
			0						
							10		
	27				12		▼		grades to medium dense, wet
			28						
							15		
	28	89			40				grades with fine gravel
			100						Gray subrounded **BOULDERS (BASALTIC)**, very dense (alluvium)
							20	CH	Brown **SILTY CLAY** with some sand (basaltic) and a little gravel, medium stiff (alluvium)
LL=53 PI=29	43				7				
			61						
							25		grades with cobbles (basaltic) locally
	47	71			50/4"				
			99	16					Gray with traces of brown vugular **BASALT**, moderately to closely fractured, slightly weathered, hard to very hard (a'a basalt)
							30		
UC= 12820 psi			100	47					
							35		

Date Started:	June 7, 2022	Water Level: ∇	12.4 ft. 06/08/2022 1250 HRS	Plate
Date Completed:	June 8, 2022	▼	12.3 ft. 06/08/2022 1805 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)	A - 3.1
Total Depth:	71.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC.

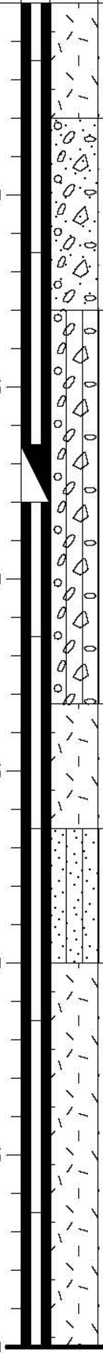
Geotechnical Engineering

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring

3

(Continued from previous plate)



Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
			57	20					
								GW	Gray with some brown subangular **SANDY GRAVEL (BASALTIC)** with some cobbles, dense (clinker)
							40		
			38						
								GM	Brown with some gray **SILTY GRAVEL (BASALTIC)** with some sand, very dense (clinker)
							45		
Sieve - #200 = 13.9%	24				52				
			57						
							50		
									grades with cobbles (basaltic) locally
UC= 8500 psi			63	50					
									Gray vugular **BASALT**, moderately fractured, slightly weathered, hard to very hard (a'a basalt)
							55		
								SM	Reddish brown with some gray **SILTY SAND (BASALTIC)** with some gravel, slightly cemented, dense (clinker)
			100	28					
							60		Gray dense **BASALT**, moderately to closely fractured, unweathered to slightly weathered, very hard (a'a basalt)
			100	15					
							65		
			100	72					
							70		

Date Started:	June 7, 2022
Date Completed:	June 8, 2022
Logged By:	S. Latronic
Total Depth:	71.5 feet
Work Order:	7651-00(A)

Water Level: ▽	12.4 ft. 06/08/2022 1250 HRS
▼	12.3 ft. 06/08/2022 1805 HRS
Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Drilling Method:	4" Solid-Stem Auger & PQ Coring
Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 3.2

GEOLABS, INC. Geotechnical Engineering	KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS VICINITY OF MP 3.06 TO MP 3.54 WAIALUA, OAHU, HAWAII		**Log of Boring** 3

Laboratory			Field								(Continued from previous plate)
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	**Description**
											Boring terminated at 71.5 feet
							75				
							80				
							85				
							90				
							95				
							100				
							105				

Date Started:	June 7, 2022	Water Level: ▽	12.4 ft. 06/08/2022 1250 HRS ▼ 12.3 ft. 06/08/2022 1805 HRS	Plate
Date Completed:	June 8, 2022			
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)	A - 3.3
Total Depth:	71.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 7651-00(A).GPJ GEOLABS.GDT 10/13/22

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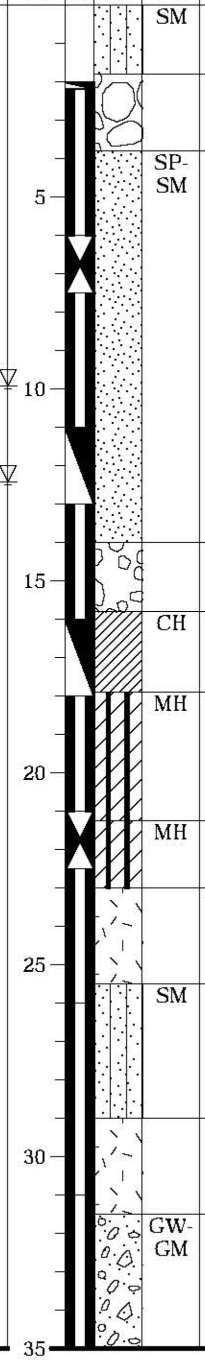
KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring

4

Approximate Ground Surface
Elevation (feet): 12 *

Laboratory			Field			
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)
	7		57		25/2"	
Direct Shear TXUU S_u=2.4 ksf Sieve - #200 = 6.8%	20	105			29	
			0			
	21				12	
			44			
	36				34	
			28			
LL=60 PI=28 TXUU S_u=2.4 ksf UC= 10460 psi	60	66			20	2.0
			98	62		
			65	0		
			57	0		



USCS	Description
SM	Brownish tan with some gray **SILTY SAND (CORALLINE)** with a little cobbles (basaltic), medium dense, moist (fill)
	Gray **BOULDERS (BASALTIC)**, very dense, dry (fill)
SP-SM	Tan poorly graded **SAND (CORALLINE)** with a little silt and traces of gravel, medium dense, moist to wet (beach deposit)
	grades with brown sandy silt pockets locally
	Gray with traces of brown subrounded **GRAVELLY COBBLES (BASALTIC)**, dense (alluvium)
CH	Reddish brown with some gray **SILTY CLAY** with some gravel (basaltic), hard (alluvium)
MH	Brown with grayish brown mottling **CLAYEY SILT** with a little gravel (basaltic), very stiff (alluvium)
MH	Brown with reddish brown mottling **CLAYEY SILT** with some sand and a little gravel (basaltic), stiff (alluvium)
	Gray vugular **BASALT**, slightly fractured, slightly weathered, hard (a'a basalt)
SM	Brown and gray **SILTY SAND (BASALTIC)** with some gravel, medium dense (clinker)
	Brownish gray vugular **BASALT**, severely fractured, moderately weathered, medium hard (a'a basalt)
GW-GM	Brown and gray **SANDY GRAVEL (BASALTIC)** with a little cobbles and traces of silt, medium dense (clinker)

Date Started:	June 9, 2022	Water Level: ⊻	12.4 ft. 06/09/2022 1030 HRS ⊻ 9.9 ft. 06/09/2022 1535 HRS
Date Completed:	June 9, 2022		
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Total Depth:	66 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 4.1

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KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring

4

Laboratory			Field								(Continued from previous plate)
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
										GW-GM	
	31				20						
			22								
										SM	Brown with some gray **SILTY SAND (BASALTIC)** with some gravel and a little cobbles, very dense (clinker)
							40				
	21	114			48/6" +50/4"						
			9								
							45				
	21				50/5"						Reddish brown with some gray cemented **BASALT**, moderately fractured, moderately weathered, hard (welded clinker)
UC= 24070 psi			100	71							
											Gray dense **BASALT**, moderately fractured, slightly weathered, very hard (a'a basalt)
							50				
UC= 13280 psi			100	73							
							55				
			100	60							
							60				
UC= 25730 psi			100	75							
							65				
											Boring terminated at 66 feet
							70				

Date Started:	June 9, 2022	Water Level: ⊻ 12.4 ft. 06/09/2022 1030 HRS ⊻ 9.9 ft. 06/09/2022 1535 HRS	Plate
Date Completed:	June 9, 2022		
Logged By:	S. Latronic	Drill Rig: CME-55D (Energy Transfer Ratio = 77.2%)	A - 4.2
Total Depth:	66 feet	Drilling Method: 4" Solid-Stem Auger & PQ Coring	
Work Order:	7651-00(A)	Driving Energy: 140 lb. wt., 30 in. drop	

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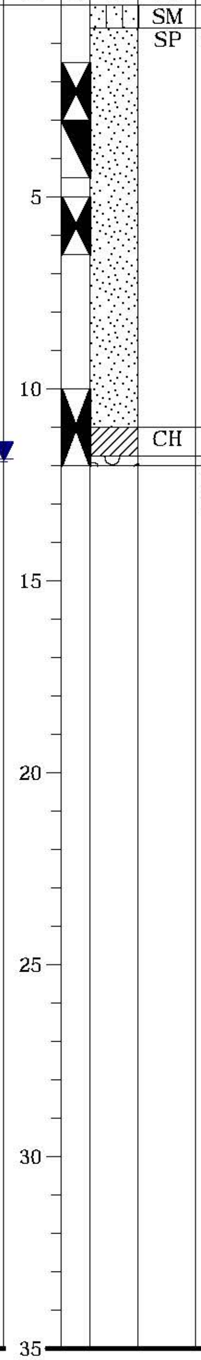
KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring

5

Approximate Ground Surface Elevation (feet): 14 *

Laboratory			Field				
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)
	1	84			17		
	3				11		
	6	82			12		5
	33	78			4		10



USCS	Description
SM	Brownish tan **SILTY SAND**, medium dense, moist (alluvium)
SP	Light tan with some white poorly graded fine to medium **SAND (CORALLINE)**, loose to medium dense, dry to moist (beach deposit)
CH	Brown to reddish brown **SILTY CLAY**, soft to medium stiff, moist (alluvium)
	Brownish gray **GRAVELLY COBBLES (BASALTIC)** with some clayey silt, medium dense, wet (alluvium)
	Boring terminated at 12 feet

Date Started:	June 15, 2022	Water Level: ▼	11.8 ft. 06/15/2022 0905 HRS
Date Completed:	June 15, 2022		
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Total Depth:	12 feet	Drilling Method:	6" Hollow-Stem Auger
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 5

GEOLABS, INC. Geotechnical Engineering	KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS VICINITY OF MP 3.06 TO MP 3.54 WAIALUA, OAHU, HAWAII	Log of Boring 6

Approximate Ground Surface Elevation (feet): 14 *

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
										SM	Brown **SILTY SAND** with traces of clay, medium dense, moist (alluvium)
										CH	Brown **SILTY CLAY** with a little cobbles (basaltic), very stiff to hard, moist (alluvium)
LL=59 PI=29	24	76			32	4.0					
	22				45						
	18				23/6" +25/1"		5				
											grades with boulders (basaltic)
											Boring terminated at 6.1 feet
							10				
							15				
							20				
							25				
							30				
							35				

Date Started:	June 15, 2022	Water Level: ▼	Not Encountered	Plate
Date Completed:	June 15, 2022			
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)	A - 6
Total Depth:	6.1 feet	Drilling Method:	6" Hollow-Stem Auger	
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop	

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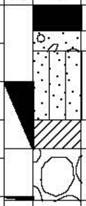
KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring

7

Approximate Ground Surface Elevation (feet): 16 *

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											8-inch **ASPHALTIC CONCRETE**
										GW	Brownish gray **SANDY GRAVEL (BASALTIC)** with some cobbles, very dense, moist (fill)
	13				16					SM	Brown fine to medium **SILTY SAND** with some cobbles (basaltic), medium dense, moist (fill)
										CH	Reddish brown with some gray **SILTY CLAY** with a little gravel (basaltic), very stiff, moist (alluvium)
	6				25/1"		5				Gray **BOULDER (BASALTIC)**, very dense, dry (alluvium)
											Boring terminated at 5.1 feet
							10				
							15				
							20				
							25				
							30				
							35				



Date Started:	June 14, 2022	Water Level: ▼	Not Encountered
Date Completed:	June 14, 2022		
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Total Depth:	5.1 feet	Drilling Method:	4" Solid-Stem Auger
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 7

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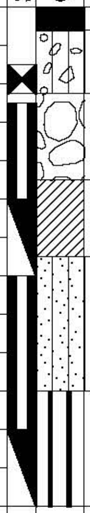
KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Log of Boring

8

Approximate Ground Surface Elevation (feet): 19 *



Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
									7-inch **ASPHALTIC CONCRETE**
	15	88			25/3"			GM	Gray with some brown **SILTY GRAVEL (BASALTIC)** with some cobbles and a little sand, very dense, moist (fill)
			80						Gray **BOULDERS (BASALTIC)**, very dense, dry (alluvium)
	38				17		5	CH	Reddish brown **SILTY CLAY**, very stiff, moist (alluvium)
			63					SM	Brown with some gray **SILTY SAND (BASALTIC)** with some rounded gravel, medium dense, moist (alluvium)
	43				21		10	ML	Brown with gray mottling **CLAYEY SILT** with traces of decomposed gravel, very stiff, moist (alluvium)
									Boring terminated at 13 feet
							15		
							20		
							25		
							30		
							35		

Date Started:	June 14, 2022	Water Level: ▼	Not Encountered
Date Completed:	June 14, 2022		
Logged By:	S. Latronic	Drill Rig:	CME-55D (Energy Transfer Ratio = 77.2%)
Total Depth:	13 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	7651-00(A)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 8

APPENDIX B

APPENDIX B

Laboratory Tests

Moisture Content (ASTM D2216) and Unit Weight (ASTM D2937) determinations were performed on selected samples as an aid in the classification and evaluation of soil properties. The test results are presented on the Logs of Borings at the appropriate sample depths.

Three Atterberg Limits tests (ASTM D4318) were performed on selected soil samples to evaluate the liquid and plastic limits to aid in soil classifications. The test results are summarized on the Logs of Borings at the appropriate sample depths. Graphic presentations of the test results are provided on Plate B-1.

Three Sieve Analysis tests (ASTM D6913) were performed on selected soil samples to evaluate the gradation characteristics of the soils and to aid in soil classification. Graphic presentations of the grain size distributions are provided on Plate B-2.

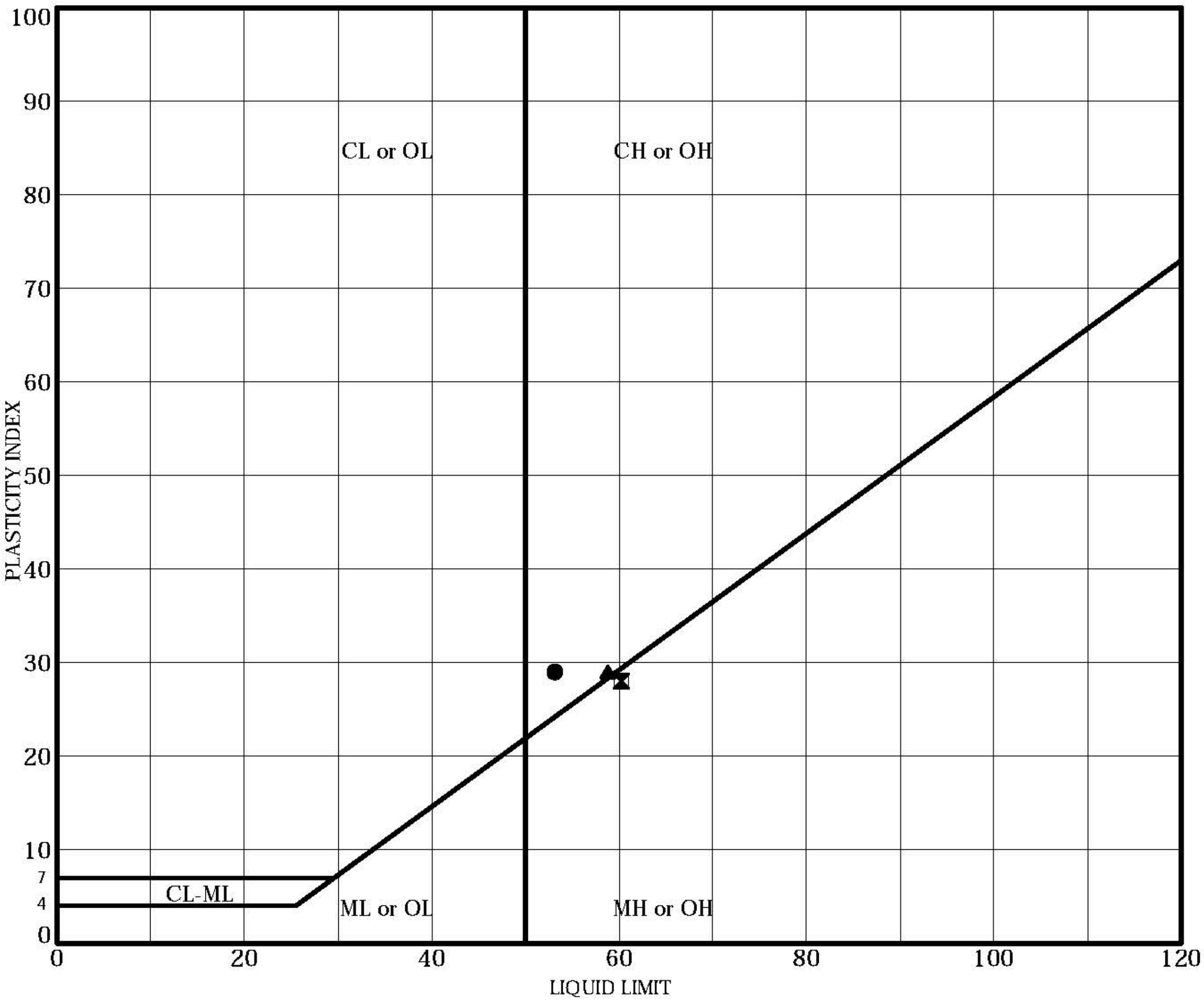
One one-inch Ring Swell test was performed on a remolded sample to evaluate the swelling potential of the near-surface soils. The test results are summarized on Plate B-3.

Six Uniaxial Compressive Strength tests (ASTM D7012) were performed on selected rock cores to evaluate the unconfined compressive strength of the rock materials encountered. Test results are presented on Plate B-4.

Two Unconsolidated Undrained Triaxial Compression tests (ASTM D2850) were performed on selected soil samples to evaluate the undrained shear strength of the in-situ soils. The approximate in-situ effective overburden pressure was used as the applied confining pressure for the relatively “undisturbed” soil sample. The test results and the stress-strain curves are presented on Plates B-5 and B-6.

Two Direct Shear tests (ASTM D3080) were performed on selected samples to evaluate the shear strength characteristics of the material tested. The test results are presented on Plates B-7 and B-8.

Three laboratory Resistance (R) Value tests (ASTM D2844) were performed by Ninyo & Moore on selected bulk samples of the near-surface soils to evaluate the pavement support characteristics of the soils. The test results are presented on Plates B-9 through B-11.



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-3	21.5-23.5	53	24	29	Brown silty clay (CH) w/ some sand & a little gravel
⧗	B-4	21.0-22.5	60	32	28	Brown w/ reddish brown mottling clayey silt (MH) w/ some sand & a little gravel
▲	B-6	1.5-3.0	59	30	29	Brown silty clay (CH) with a little cobbles

NP = NON-PLASTIC

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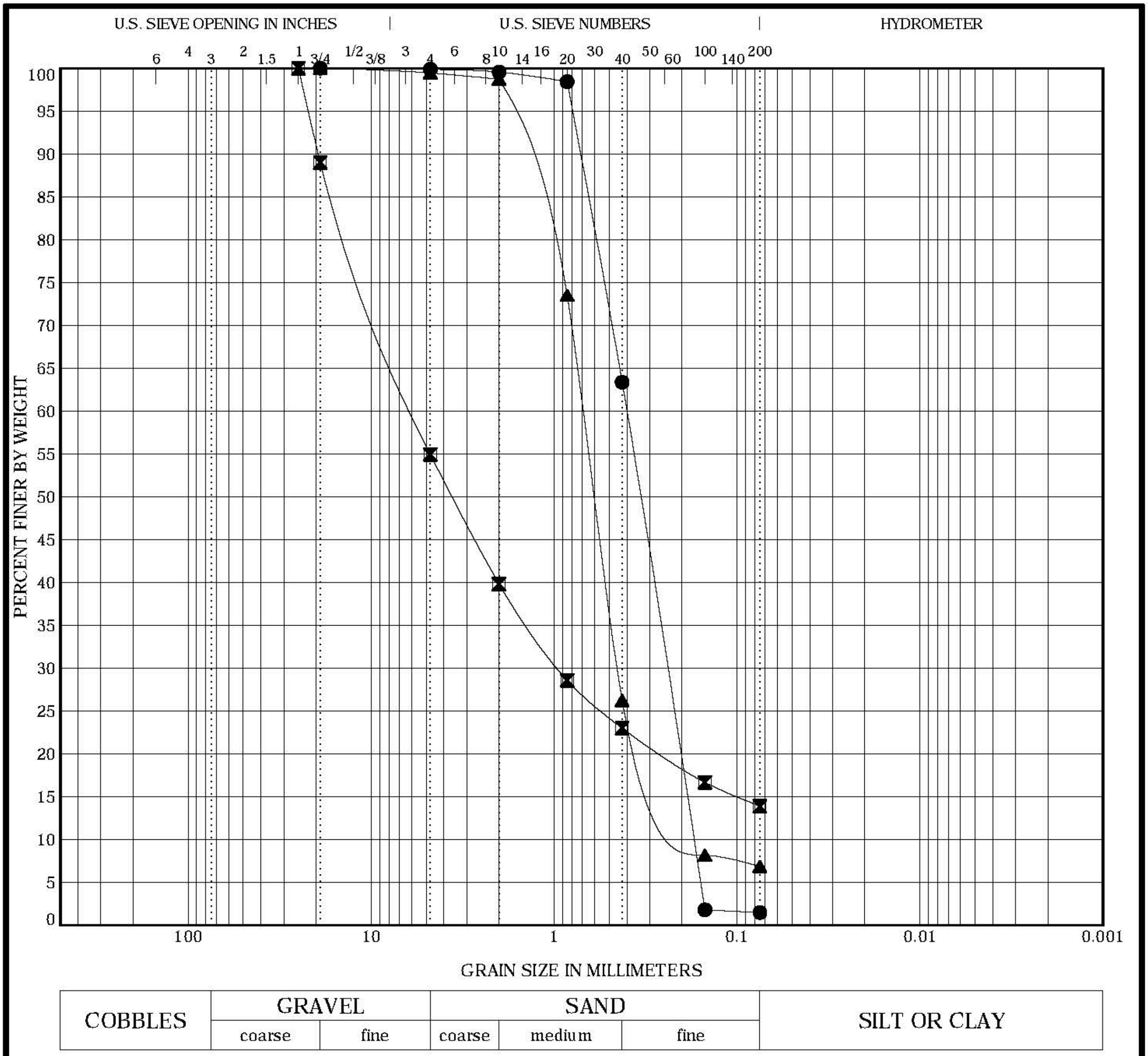
ATTERBERG LIMITS TEST RESULTS - ASTM D4318

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 1

G ATTERBERG PI-100 LL-120 7651-00(A).GPJ GEOLABS.GDT 7/27/22



	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-1	5.0-6.5	Tan poorly graded sand (SP) with traces of silt and gravel				0.8	2.3
⧗	B-3	46.5-48.0	Brown with some gray silty gravel (GM) with some sand					
▲	B-4	6.0-7.5	Tan poorly graded sand (SP-SM) w/ a little silt & traces of gravel				1.7	4.2

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-1	5.0-6.5	19	0.402	0.242	0.172	0.1	98.4	1.5
⧗	B-3	46.5-48.0	25	5.835	0.948		45.1	41.1	13.9
▲	B-4	6.0-7.5	19	0.697	0.449	0.167	0.5	92.6	6.8

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GRAIN SIZE DISTRIBUTION - ASTM D6913

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 2

G_GRAIN_SIZE_MOD 7651-00(A).GPJ GEOLABS.GDT 10/13/22

Location	Depth	Soil Description	Dry Density	Moisture Contents			Ring Swell
				Initial	Air-Dried	Final	
	(feet)		(pcf)	(%)	(%)	(%)	(%)
B-6**	1.5 - 3.0	Brown silty clay (CH) with a little cobbles	87.8	28.5	24.8	39.9	9.3

NOTE: Samples tested were either relatively undisturbed or remolded in 2.4-inch diameter by 1-inch high rings. They were air-dried overnight and then saturated for 24 hours under a surcharge pressure of 55 psf.

* Relatively Undisturbed

** Remolded

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SUMMARY OF RING SWELL TESTS

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 3

Location	Depth	Length	Diameter	Length/ Diameter Ratio	Density	Load	Compressive Strength
	(feet)	(inches)	(inches)		(pcf)	(lbs)	(psi)
B-3	31.5 - 36.5	6.580	3.240	2.03	163.0	105,700	12,820
B-3	51.5 - 56.5	6.570	3.240	2.03	151.7	70,050	8,500
B-4	22.5 - 26	6.620	3.230	2.05	165.1	85,700	10,460
B-4	46.4 - 51	6.630	3.230	2.05	176.4	197,270	24,070
B-4	51 - 56	6.670	3.240	2.06	171.1	109,460	13,280
B-4	61 - 66	6.570	3.240	2.03	175.9	212,120	25,730

ASTM D7012 (METHOD C)

Note: Samples were not prepared in accordance with ASTM D4543. Therefore, results reported may differ from results obtained from a test specimen that meets the requirements of Practice D4543

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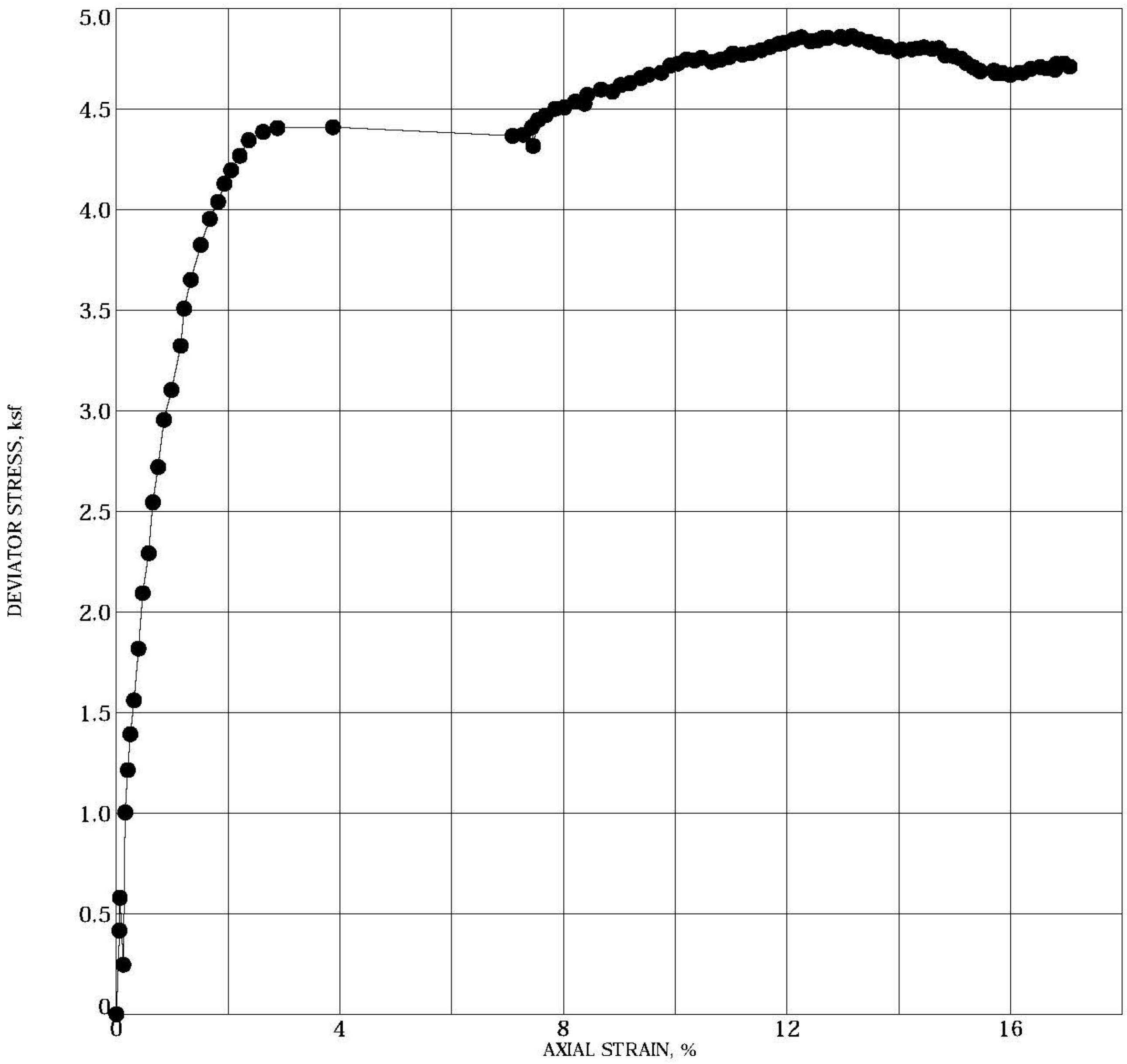
UNIAXIAL COMPRESSIVE STRENGTH TEST

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 4



Max. Deviator Stress (ksf):	4.9
Confining Stress (ksf):	0.6

Location: B-4

Depth: 6.0 - 7.5 feet

Description: Tan poorly graded sand with a little silt and traces of gravel

Test Date: 6/27/2022

Dry Density (pcf)	115.9	Sample Diameter (inches)	2.413
Moisture (%)	15.4	Sample Height (inches)	4.250
Axial Strain at Failure (%)	13.2	Strain Rate (% / minute)	0.42

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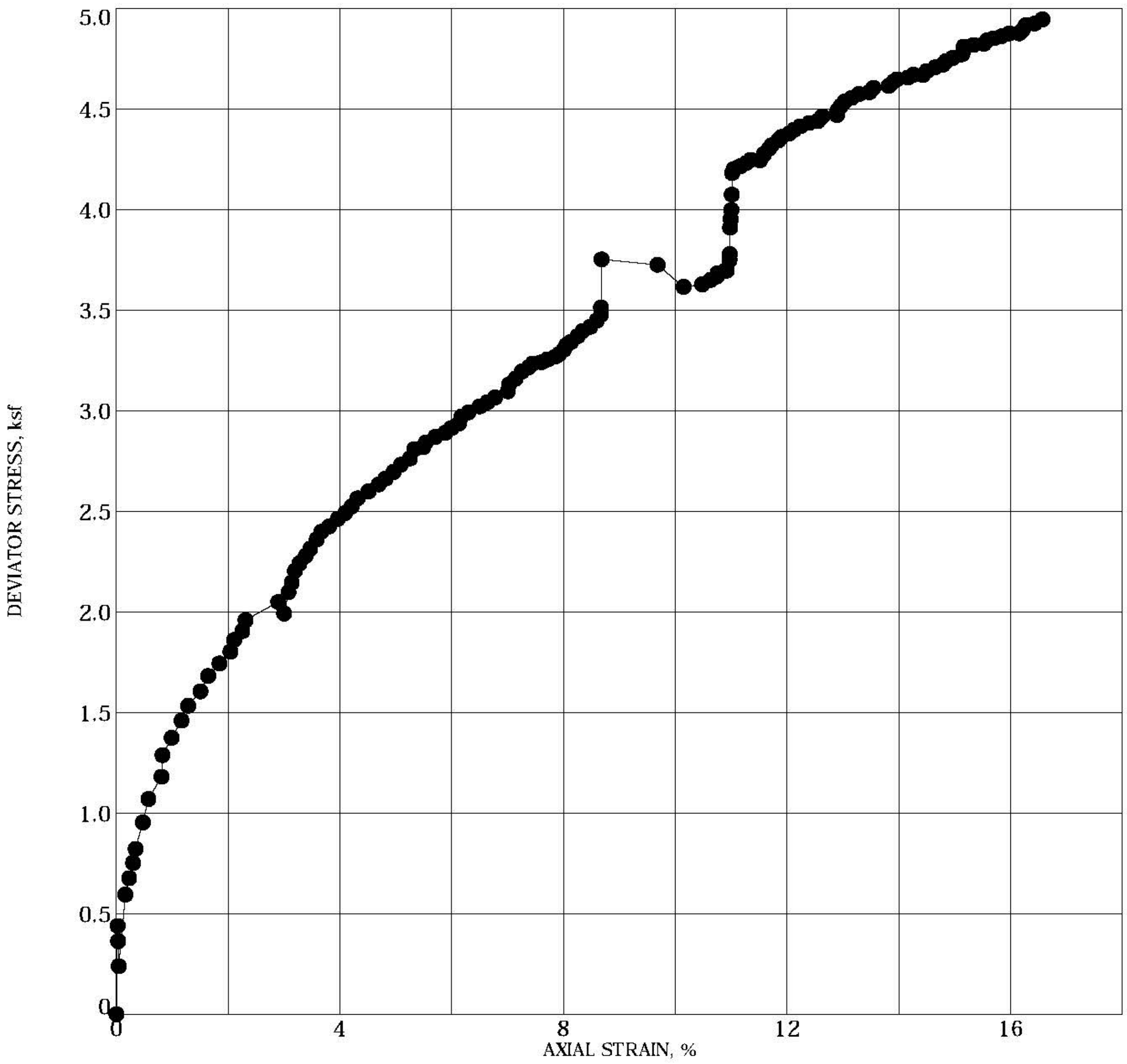
TRIAXIAL UU COMPRESSION TEST - ASTM D2850

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 5



Max. Deviator Stress (ksf):	4.8
Confining Stress (ksf):	1.4

Location: B-4
Depth: 21.0 - 22.5 feet
Description: Brown w/ reddish brown mottling clayey silt (MH) w/ some sand & a little gravel
Test Date: 6/27/2022

Dry Density (pcf)	67.4	Sample Diameter (inches)	2.413
Moisture (%)	59.9	Sample Height (inches)	5.067
Axial Strain at Failure (%)	15.0	Strain Rate (% / minute)	0.34

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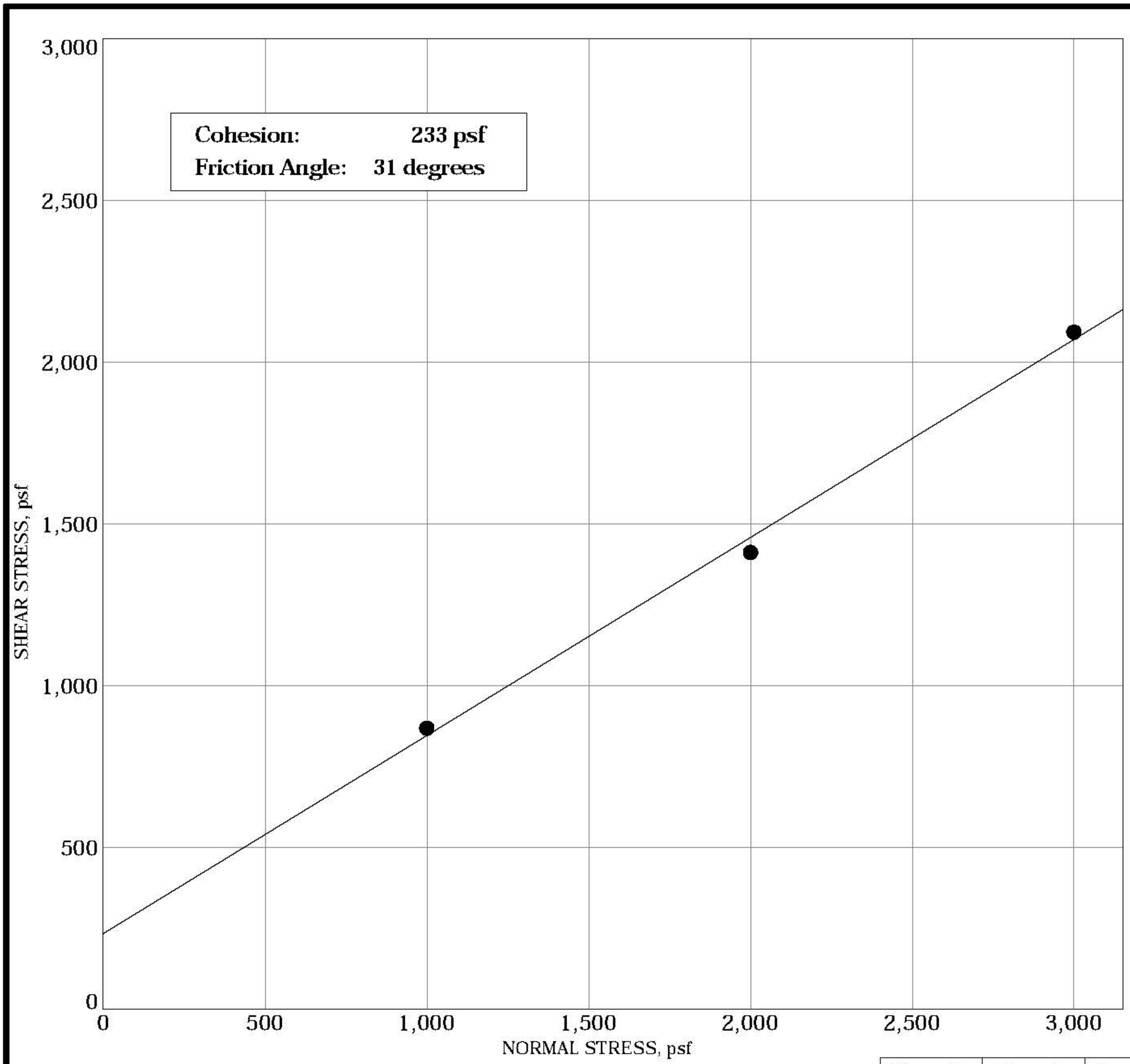
TRIAXIAL UU COMPRESSION TEST - ASTM D2850

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 6



		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	22.3	28.0	27.0
	Dry Density, pcf	76.6	74.9	75.1
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	29.1	28.4	28.9
	Dry Density, pcf	75.7	76.3	76.3
	Height, inches	1.012	0.982	0.984
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0024	0.0022	0.0023
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**868**	**1411**	**2092**
	Shear Displacement, inches	0.43	0.41	0.42

Sample: B-3
Depth: 6.5 - 8.0 feet
Description: Light tan poorly graded fine sand with a little silt

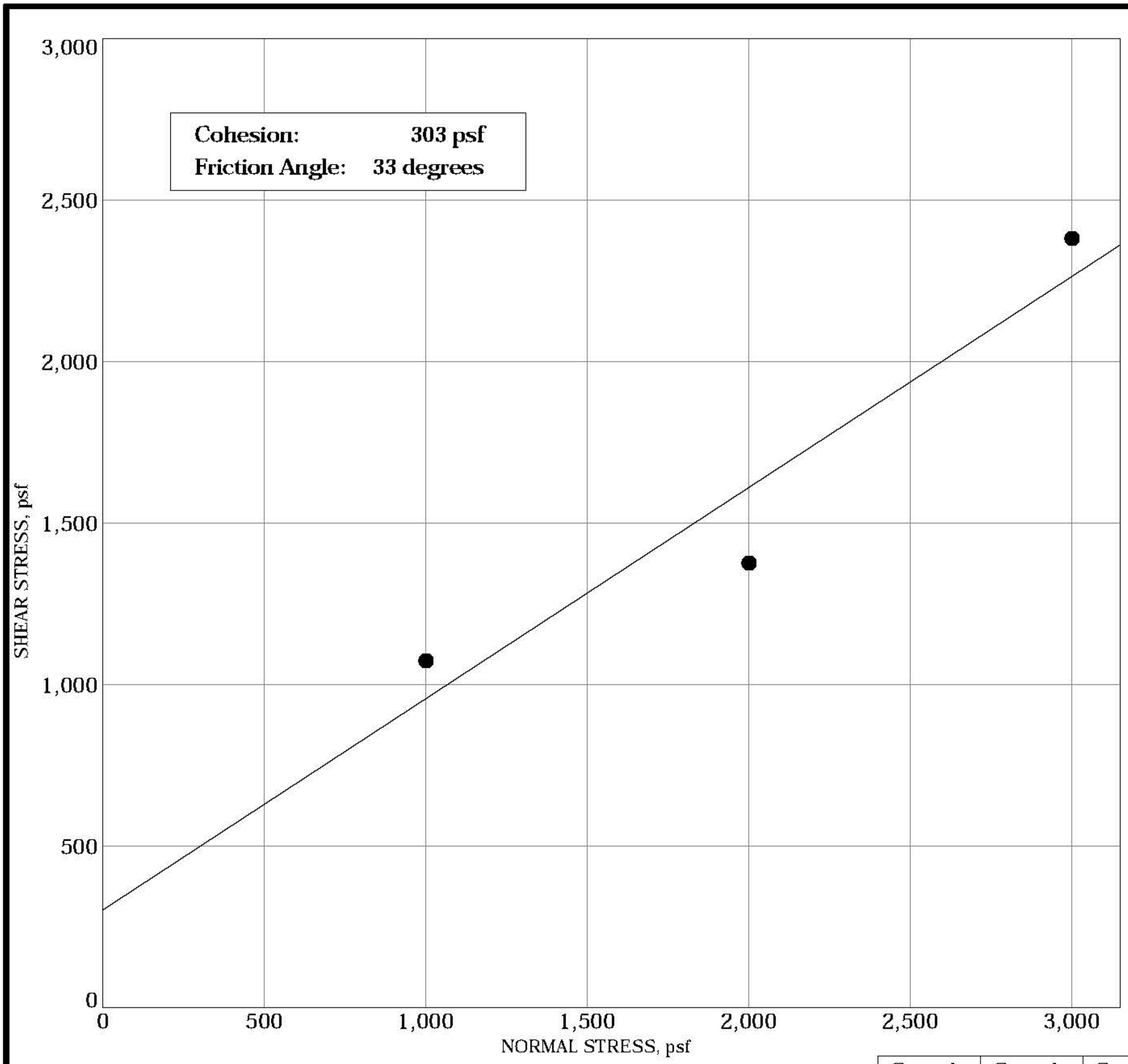
GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 7651-00(A)

DIRECT SHEAR TEST - ASTM D3080

KAMEHAMEHA HIGHWAY DRAINAGE
AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

Plate
B - 7

G_DIRECT_SHEAR 7651-00(A).GPJ GEOLABS.GDT 8/1/22



Cohesion: **303 psf**
Friction Angle: **33 degrees**

		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	20.9	21.2	21.0
	Dry Density, pcf	91.4	87.7	87.7
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	22.1	21.6	21.5
	Dry Density, pcf	90.4	88.8	88.6
	Height, inches	1.011	0.988	0.990
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0025	0.0023	0.0022
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**1073**	**1376**	**2381**
	Shear Displacement, inches	0.43	0.41	0.41

Sample:	B-4
Depth:	6.0 - 7.5 feet
Description:	Tan poorly graded sand with a little silt and traces of gravel

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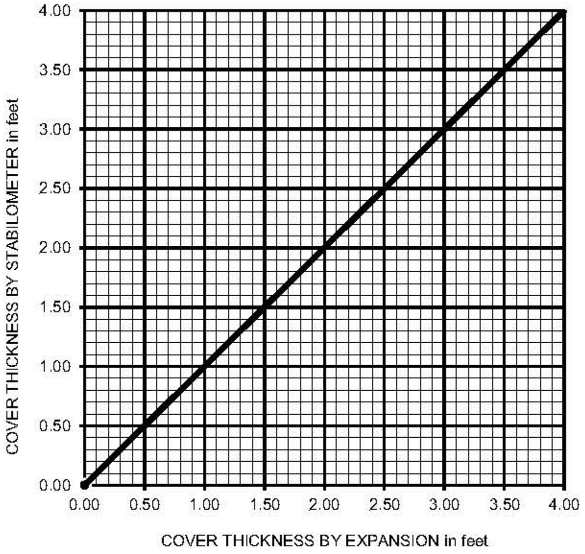
WAIALUA, OAHU, HAWAII

Plate
B - 8

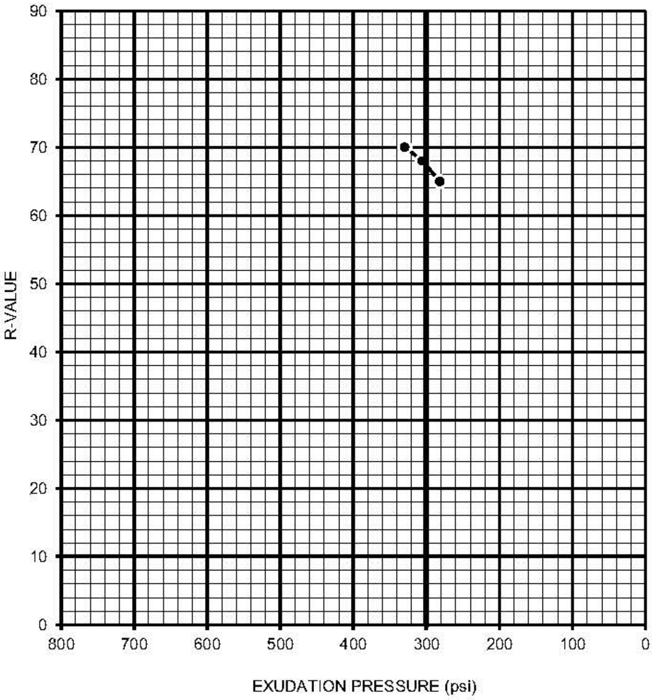
TEST SPECIMEN	a	b	c
MOISTURE AT COMPACTION, %	15.1	15.4	15.8
HEIGHT OF SAMPLE, inches	2.56	2.55	2.52
DRY DENSITY, pcf	104.9	103.6	102.3
COMPACTOR AIR PRESSURE, psi	75	75	75
EXUDATION PRESSURE, psi	330	306	282
EXPANSION, inches x 10exp-4	0	0	0
STABILITY Ph 2,000 lbs (160 psi)	28	30	33
TURNS DISPLACEMENT	5.13	5.16	5.20
R-VALUE UNCORRECTED	70	68	65
R-VALUE CORRECTED	70	68	65

DESIGN CALCULATION DATA	a	b	c
GRAVEL EQUIVALENT NEEDED, ft.	0.00	0.00	0.00
TRAFFIC INDEX	0.0		
STABILOMETER THICKNESS, ft.	#DIV/0!	#DIV/0!	#DIV/0!
EXPANSION PRESSURE THICKNESS, ft.	0.00	0.00	0.00

EXPANSION PRESSURE CHART



EXUDATION PRESSURE CHART



R-VALUE BY EXPANSION: NOT APPLICABLE

R-VALUE BY EXUDATION: 67

Sample Location	Job No.	Description	Equilibrium R-Value
BULK #1 @ B2	7651-00A	SAND	67

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2844/CT 301

153994

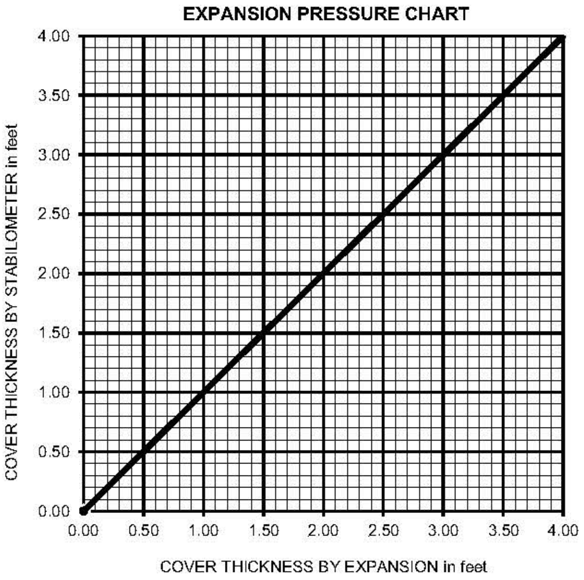
Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

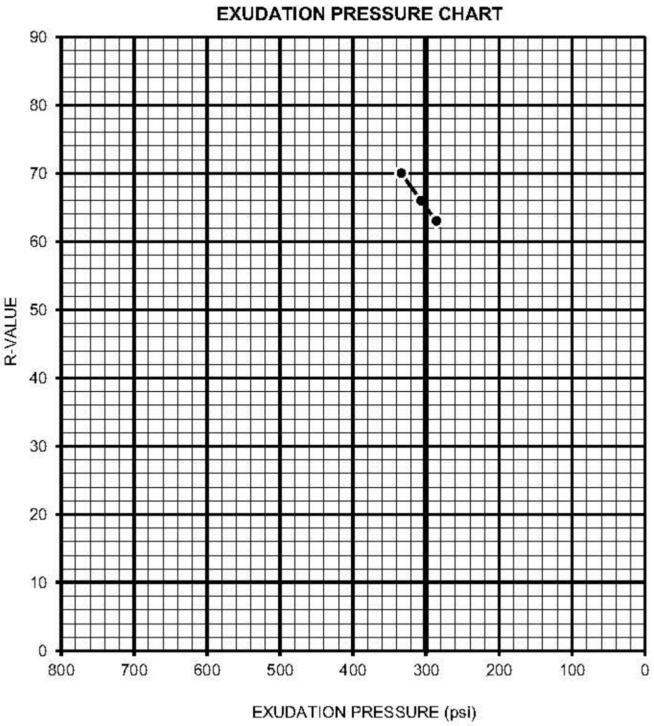
R-VALUE TEST RESULTS

GEOLABS INC.
KAMEHAMEHA HIGHWAY REALIGNMENT
108026001 7/22

TEST SPECIMEN	a	b	c
MOISTURE AT COMPACTION, %	16.2	16.5	16.8
HEIGHT OF SAMPLE, inches	2.44	2.56	2.54
DRY DENSITY, pcf	92.0	90.5	89.7
COMPACTOR AIR PRESSURE, psi	75	75	75
EXUDATION PRESSURE, psi	334	307	286
EXPANSION, inches x 10exp-4	0	0	0
STABILITY Ph 2,000 lbs (160 psi)	28	32	35
TURNS DISPLACEMENT	5.17	5.20	5.22
R-VALUE UNCORRECTED	70	66	63
R-VALUE CORRECTED	70	66	63

DESIGN CALCULATION DATA	a	b	c
GRAVEL EQUIVALENT NEEDED, ft.	0.00	0.00	0.00
TRAFFIC INDEX	0.0		
STABILOMETER THICKNESS, ft.	#DIV/0!	#DIV/0!	#DIV/0!
EXPANSION PRESSURE THICKNESS, ft.	0.00	0.00	0.00





R-VALUE BY EXPANSION: NOT APPLICABLE
R-VALUE BY EXUDATION: 65

Sample Location	Job No.	Description	Equilibrium R-Value
BULK #2 @ B6	7651-00A	SAND	65

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2844/CT 301

153995

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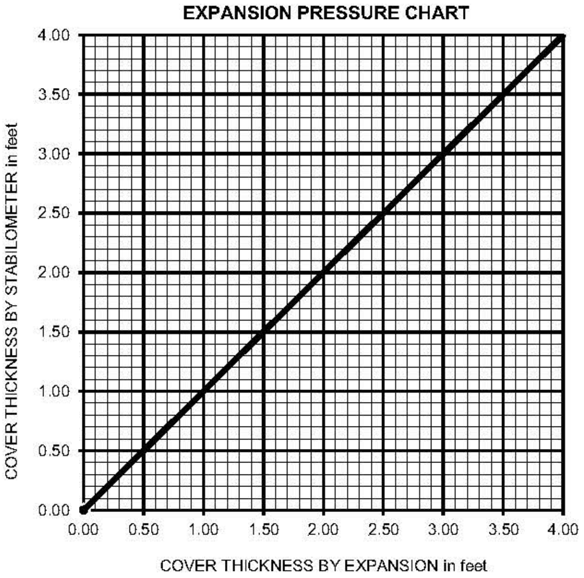
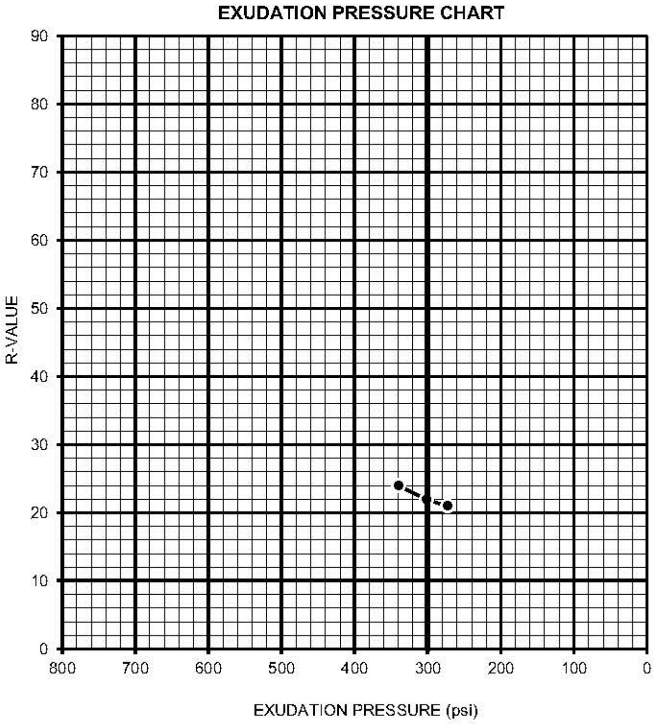
R-VALUE TEST RESULTS

GEOLABS INC.
KAMEHAMEHA HIGHWAY REALIGNMENT
108026001 7/22

TEST SPECIMEN	a	b	c
MOISTURE AT COMPACTION, %	32.1	32.6	33.1
HEIGHT OF SAMPLE, inches	2.44	2.56	2.54
DRY DENSITY, pcf	92.2	91.2	90.8
COMPACTOR AIR PRESSURE, psi	50	50	50
EXUDATION PRESSURE, psi	340	302	273
EXPANSION, inches x 10exp-4	0	0	0
STABILITY Ph 2,000 lbs (160 psi)	99	102	104
TURNS DISPLACEMENT	5.01	5.05	5.12
R-VALUE UNCORRECTED	24	22	21
R-VALUE CORRECTED	24	22	21

DESIGN CALCULATION DATA	a	b	c
GRAVEL EQUIVALENT NEEDED, ft.	0.00	0.00	0.00
TRAFFIC INDEX	0.0		
STABILOMETER THICKNESS, ft.	#DIV/0!	#DIV/0!	#DIV/0!
EXPANSION PRESSURE THICKNESS, ft.	0.00	0.00	0.00





R-VALUE BY EXPANSION: NOT APPLICABLE
R-VALUE BY EXUDATION: 22

Sample Location	Job No.	Description	Equilibrium R-Value
BULK #3 @ B5	7651-00A	Sandy CLAY	22

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153997

R-VALUE TEST RESULTS

GEOLABS INC.
KAMEHAMEHA HIGHWAY REALIGNMENT
108026001 7/22

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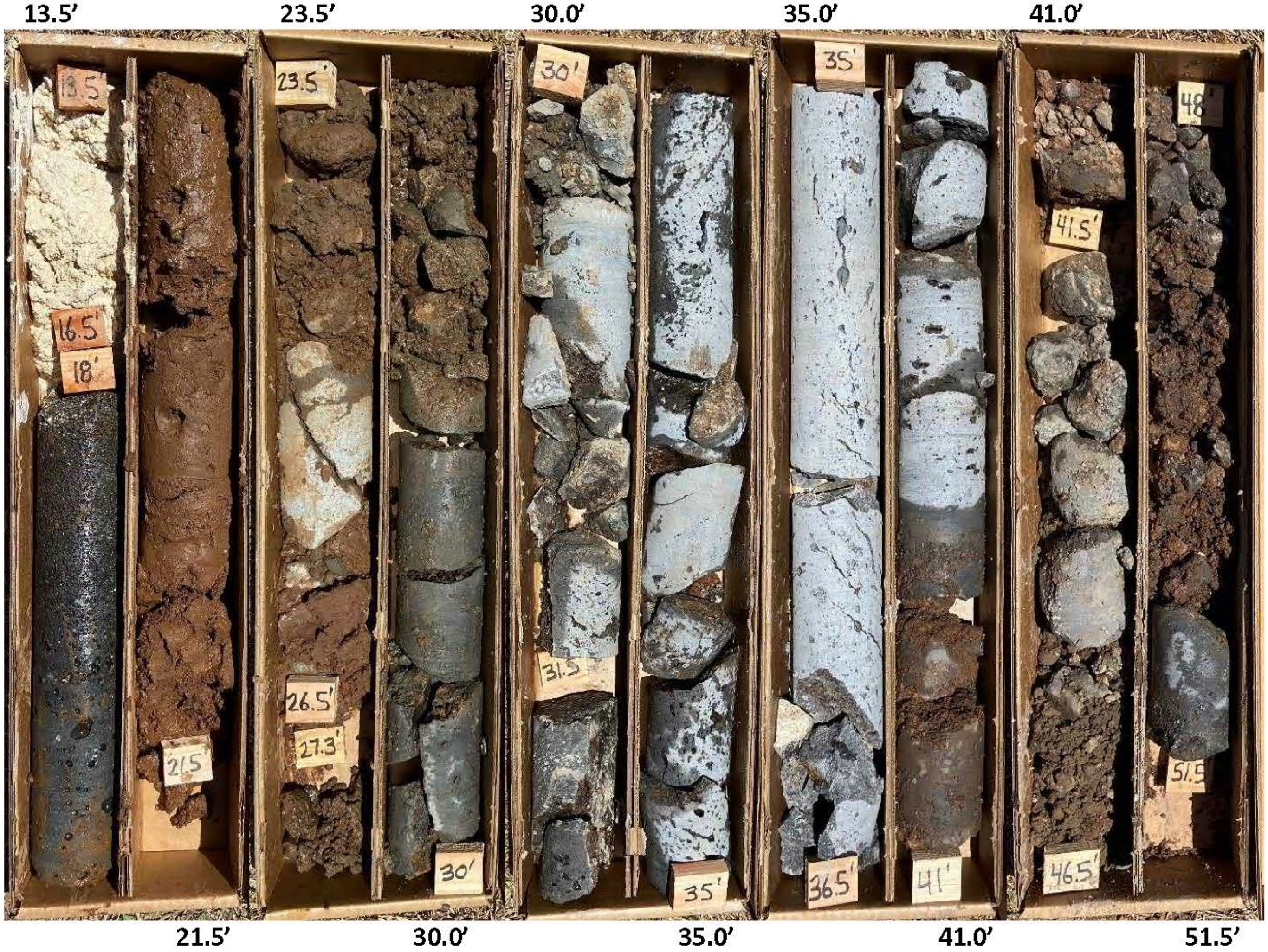
APPENDIX C

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

B-3 13.5' TO 51.5'



KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

B-3 51.5' TO 71.5'

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

B-4 2.2' TO 49.5'

KAMEHAMEHA HIGHWAY DRAINAGE AND SAFETY IMPROVEMENTS
VICINITY OF MP 3.06 TO MP 3.54
WAIALUA, OAHU, HAWAII

B-4 49.5' TO 66.0'

49.5' 53.0' 57.0' 62.0'

53.0' 57.0' 62.0' 66.0'

B-8 2.5' TO 11.0'

2.5'

11.0'