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SUBSURFACE INVESTIGATION REPORT

KAKAINA SUBDIVISION
WAIMANALO, OAHU, HAWAII

for

AKINAKA & ASSOCIATES, LTD.

by

FEWELL GEOTECHNICAL ENGINEERING, LTD.

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By______________________________
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SUBSURFACE INVESTIGATION REPORT

Kakaina Subdivision

Waimanalo, Oahu, Hawaii

INTRODUCTION

A subsurface investigation has been completed for the proposed site of the Kakaina Subdivision in Waimanalo, Oahu, Hawaii. This report summarizes our findings and conclusions and presents geotechnical recommendations for the design and construction of the subdivision and its related infrastructure improvements. This work was completed in general accordance with our May 31, 2006 Proposal and your March 2007 verbal authorization to proceed.

PURPOSE AND SCOPE

The subsurface investigation was undertaken to assist Akinaka & Associates, Ltd. (AAL) with the geotechnical aspects of the design and construction of the subdivision and its related site improvements. Our work included drilling a total of 7 test borings, performing laboratory tests on the recovered samples to determine their general soil characteristics, evaluating the subsurface conditions as they impact the planned construction, and presenting our findings in this report.

The drilling work originally was planned with borings drilled to depths of 20 feet below the existing ground surface. However, 3 of the borings were extended to a depth of 30 feet due to unanticipated conditions found in the borings, and additional laboratory testing was completed to better evaluate the conditions encountered.

The subsurface exploration, including the Boring Location Plan and the Boring Logs are summarized in Appendix A. The laboratory test results are presented on the logs where appropriate, and selected results are graphically illustrated in Appendix B. The limitations of this investigation and report are presented in Appendix C.

PROJECT CONSIDERATIONS

The preliminary information provided by AAL indicates that an 8-acre parcel in Waimanalo will be developed to support a residential subdivision by the Department of Hawaiian Home Lands (DHHL). The parcel is on the southern side of an existing residential subdivision, which is accessed by Poalimu Street. The remainder of the site is bordered by Kakaina Street on its southern side, Mekia Street on its western end, and Hihimanu Street on its eastern end. The general area of the site is shown on the Project Location Map, Figure 1, in Appendix A.

The site consists of 4 separate but contiguous parcels, which are designated as Parcels 91, 92, 10 and 81. Together, they form a long narrow site, which is irregularly shaped due to the different sizes of the lots, which extend into its northern side. The site is generally oriented in the east-west direction along its longitudinal axis, and is about 1,100 to 1,300 feet long by between 200 and 400 feet wide.

At the time of the subsurface exploration, the site was vacant and much of it had been cleared of vegetation. Piles of cleared materials were stockpiled in scattered areas of the site. The site is relatively level, with a slight slope down toward the east and north. Ground surface elevations range from about Elev. 42 at the southwestern corner of the site down to about Elev. 32 at the northeastern corner of the site. Much of the northern edge of the site is between Elev. 32 and Elev. 36.

A portion of the channelized Kahawai Stream passes about 45 feet to the west of the western end of the subdivision and the proposed re-alignment of the western end of Mekia Street. The stream generally passes beneath Mekia Street and Kakaina Street via a culvert, but a portion of the culvert is open to the ground surface about 20 feet west of the right-of-way for Mekia Street. The opening to the culvert is about 50 feet long by up to

25 feet wide and is lined with CRM. The bottom of the culvert appears to be about 10 feet below the adjacent ground surface in this area.

The June 7, 2007 Preliminary Grading Plan provided by AAL indicates that the parcel will be developed by DHHL to support a 50-lot residential subdivision accessed from Poalimu Street, Kakaina Street and Hihimanu Street. The lots will be served by approximately 1,340 feet of interior streets with a right-of-way of 44 feet. We understand that the streets will be asphalt concrete paved and will include standard concrete curbs, gutters and sidewalks.

The plans indicate that typical residential improvements will be included in the subdivision construction, such as underground utility lines for electrical/telephone, sewer, water and drainage. No dwelling information is available at this time. We have assumed that the residential dwellings will be 1- to 2-story, wood- or steel-framed structures using concrete slabs-on-grades, with carports. Maximum column and wall loads of 50 kips and 2 kips per foot of wall have been assumed for the dwellings.

The preliminary grading plan indicates the subdivision will generally be graded with cuts of 1 to 2 feet in depth and fills of less than 4 feet in thickness. An excavation of about 8 feet deep will be necessary for a detention basin planned for the southeastern corner of the site, adjacent to the intersection of Kakaina and Hihimanu Streets. In general, it appears that most of the fills will be placed along the site perimeters, while most of the site excavations are planned for the central portions of the site. Graded slopes are planned to support the grade differences.

SUBSURFACE INVESTIGATION

A total of 7 test borings were drilled during the period of April 18 through 24, 2007 at the approximate locations shown on the Site and Boring Location Plan, Figure 2, in Appendix A. The borings were extended to depths of 20 to 30 feet below the existing ground surface with a truck-mounted Simco 2400SK drilling rig advancing 4-inch diameter continuous flight augers.

Relatively undisturbed samples of the subsurface soils were obtained at selected depths using a 3.0-inch O.D. split-spoon sampler driven by a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler the final 12 inches into the underlying soil mass was recorded and is shown on the Boring Logs, Figure 3 through 9, in Appendix A. A Boring Log Legend is included as Figure 10.

Two bulk samples, designated as Bag A and Bag B, were obtained along the approximate alignment of the interior subdivision streets to determine the pavement support characteristics of the predominant near-surface soils. Their approximate locations are shown on Figure 2 in Appendix A.

LABORATORY TESTING

Laboratory tests were performed on selected samples of the subsurface soils to determine their pertinent engineering characteristics, including in-situ moisture content, density, shear strength, consolidation, and swell under their in-situ moisture conditions. Bags A and B were tested in general accordance with ASTM D1883 to determine their California Bearing Ratio (CBR) and swell when compacted for the support of pavements. Atterberg Limits and gradation tests were performed on visually representative samples to aid in the classification of the soils.

The results of the laboratory tests are shown on the Boring Logs, where appropriate. Additional test results are graphically exhibited as Figures 11 through 23 in Appendix B. Table I at the end of Appendix B summarizes the results of the tests completed on the undisturbed subsurface samples, while Table II presents the CBR test results.

GENERAL SUBSURFACE CONDITIONS

The test borings have revealed that the site of the Kakaina Subdivision is generally underlain by a surface mantle of fill, over natural alluvial (water-deposited) soils, which extend to the bottom of the borings at depths of 20 to 30 feet below the existing ground surface. The alluvial materials generally consist of highly plastic clays with occasional layers of clayey sand and gravel found at depths of 18 to 20 feet.

The fill varied from ½ to 4 feet in thickness at the boring locations and is generally 2½ to 3 feet thick in most of the borings. The existing fills exhibit consistencies ranging from stiff to hard and relatively low in-situ densities of 68 to 76 pounds per cubic foot (p.c.f.). These densities correspond to about 76 to 85 percent relative compaction, based on Laboratory Compaction Test ASTM D1557 performed on Bags A and B. The fill appears uncompacted based on the current compaction standard of 90 percent relative compaction.

Both the surface fills and most of the natural alluvium generally consist of highly plastic fat clays and silty clays, which are designated as CH under the Unified Soil Classification (USC) system. The alluvial clays and the fill exhibit moderate to high shrink-swell characteristics with swells of up to 7.9 percent under their relatively wet in-situ moisture conditions and up to 11.5 percent when compacted at their optimum moisture contents.

Most of the undisturbed samples exhibit moisture contents of 10 to 18 percent over their estimated optimum moisture contents but still showed significant swells of 3.5 to 7.9 percent at these high moisture contents. Laboratory tests indicate that a load in excess of 2,000 pounds per square foot (p.s.f.) would be necessary to reduce the swelling of the soils to less than 3 percent when compacted near their optimum moisture content.

The natural alluvial soils below the surface fills exhibit low to moderate in-situ densities, relatively high in-situ moisture contents, and low shear strengths, with friction angles of 3 to 12 degrees and cohesion of 640 to 1,050 p.s.f. when saturated. They generally exhibit consistencies of very stiff to hard, although the consistencies generally appear to decrease with increasing depth.

Occasional layers of medium stiff alluvial clays and loose to very loose alluvial clayey sands and gravel were found starting at depths of 17 to 20 feet below the existing ground surface. Three borings, which were extended through these layers, indicate that they are generally 5 to 6 feet in thickness. Consolidation tests indicate that the alluvial clays, including those which showed the lower consistencies, are pre-consolidated, likely due to prior desiccation and shrinkage, and should not significantly consolidate under the relatively light anticipated loads and fills of the subdivision.

Groundwater was encountered in all of the test borings at depths of 13.1 to 16.9 feet below the existing ground surface. Based on the estimated elevations of the test borings from the topographic plan provided by AAL, the depths of the groundwater in the borings correspond to between about Elev. 17 and Elev. 28.

DISCUSSION

The subsurface investigation has revealed that the site of the Kakaina Subdivision is generally underlain by about 2½ to 3 feet of uncompacted and expansive clay fill over relatively competent, albeit expansive natural alluvial clays. The presence of the uncompacted fill and the moderately to highly expansive clays will necessitate special considerations in the design and construction of the subdivision and its appurtenances, and will likely result in higher than normal costs.

The most significant geotechnical concerns regarding the development of the site are the uncompacted fills found throughout the site and the moderately to highly expansive characteristics of both the fill and the natural clays. The existing uncompacted fills will not provide adequate support for the new construction and should be removed and replaced with fill compacted in accordance with the recommendations of this report prior to additional construction.

The moderate to high shrink-swell characteristics of both the existing fills and the natural clays introduce significant risks into the construction. These risks can be reduced but not entirely eliminated without the complete removal and replacement of the expansive soils beneath the site. This is not economically feasible due to the depth of the expansive soils and the difficulties in obtaining large quantities of low-expansion soils to replace the expansive clay.

Methods to reduce the risks of potential problems with the expansive soils on the new construction include selective grading to partially remove and replace the expansive soils during the site grading, or the use of special foundations and slabs to reduce the effects of the expansive soils on the construction. Both of these methods will necessitate higher than normal costs for the construction and more than the typical observation and testing during construction.

The costs associated with each alternative depend on the availability and costs associated with the various materials necessary for each. The actual method selected will depend on the preferences of the developer and the comparative costs of each alternative to the project. Each of these alternatives is described separately below:

Special Structure Design - The site could be graded with the expansive soils using typical grading procedures, which would result in earthwork costs similar to those incurred with low-expansion soils. However, provisions must be included in the design of the structures to minimize the effects of the expansive soils on the structures, which results in significantly higher structure costs.

Since the resulting graded lots would consist of expansive soils capable of significantly lifting the dwellings, this method entails designing the dwellings with a deepened foundation system and a structure floor slab over the expansive soils such that vertical movements of the soils will have little impact on the dwellings. The foundations must be extended a sufficient depth into the expansive clays such that vertical movements of the near-surface clays resulting from seasonal moisture changes are resisted by the friction on the deeper parts of the foundations.

We believe that deep pier foundations, such as drilled piers or helical piers, are the most suitable to limit vertical movements to the structures due to seasonal moisture changes to the expansive clays. Our analysis indicates that 12-inch diameter drilled piers extending to a depth of 12 feet into the expansive soils should provide sufficient vertical resistance to the uplift pressures of the near surface soils and should provide an allowable vertical capacity of 20 kips. The drilled piers should provide a lateral resistance of 2 kips with a deflection of less that ¼ inch at the ground surface.

The structural concrete slabs-on-grades over the piers must be designed with a sufficient clear space between the bottom of the slabs and the soil subgrades to allow for some vertical movements of the expansive soils without heaving of the slabs. Special forms will be necessary to construct the slabs and their grade beams. Styrofoam forms are manufactured for different swelling heights and different swelling pressures for expansive clays. For the characteristics for the expansive clays found at this site, we believe that 4-inch high forms, which crush when pressures exceed 250 p.s.f. should be sufficient. A Dynavoid 40142 Slab Cushion, or its equivalent, should provide these characteristics.

Utilities must be designed to accommodate differential movements between themselves and the dwellings and other similar "fixed" structures. The utilities must be fitted with flexible couplings, or other similar devices, at the points of transition between the expansive soils and the structures to allow for abrupt differential movements at these locations. Additionally, gutter downspouts, landscaping and other items, which involve water, must be designed such that water cannot access the area within 5 feet of the dwellings or their related attachments.

Exterior items such as sidewalks would still be subjected to potential vertical movements of the soils, but are typically not considered "critical" structures. Hence, they are designed to allow for some movement provided cracking is controlled to minimize the potential for hazardous conditions arising from abrupt differential movements. Sidewalks for the dwellings should be designed such that they are founded over at least 6 inches of non-expansive select borrow material with a thickened edge extending at least 3 inches below the bottom of the select borrow layer.

The poor pavement support characteristics of the expansive soils will require a special design under the pavement design criteria of the City and County of Honolulu, and relatively thick pavements. Based on our CBR test results, pavements over the expansive soils should consist of 2 inches of Asphalt Concrete Paving (ACP), over 4 inches of Asphalt Concrete Base Course (ACB), over 12 to 18 inches of Aggregate Base Course, placed over the expansive soil subgrades.

Additionally, due to the expansion of the soils exceeding 3 percent, 6 inches of Select Borrow subbase must be placed beneath the street sidewalks, curbs and gutters under the design requirements of the City and County of Honolulu. Drainage provisions should be included in the design to minimize the accumulation of water within the pavement subgrades, which can result in heave to the sidewalks, curbs and gutters.

<u>Selective Grading or Partial Removal and Replacement</u> - Selective grading to partially remove the expansive soils and replace them with a low-expansion fill is typically used to reduce the risks of the expansive soils lifting the concrete slabs-on-grades and lightly

loaded foundations of the dwellings. Although the weight of the replacement soil would not be sufficient to completely restrict the swelling of the expansive clays below, the mat of low-expansion fill beneath the structure generally acts to reduce the moisture content changes to the underlying clays and tends to reduce abrupt differential movements to the dwelling resulting from expansion of the clays.

A relatively impermeable low-expansion fill is preferable over a pervious material since pervious materials, such as granular materials, can allow significant moisture to seep into the subsurface and promote swelling of the underlying expansive clays. Where a pervious material must be used, subdrains should be provided to reduce the potential of water accumulating within the granular material and infiltrating the expansive clays below.

Provided a relatively impermeable low-expansion fill is used to replace the expansive soils, we believe that a 3-foot thick layer of low-expansion soils beneath the dwellings should be sufficient to limit differential movements of the structures to within tolerable levels of less than ½ inch. Although there is still some risk of "hot spots" where soil expansion will occur, the thickness of the mat should minimize the abrupt differential vertical movements to the structures.

This method would necessitate removing a sufficient thickness of the expansive soils in each lot such that the finish lot subgrades below the concrete slabs-on-grades, including the lot driveways and dwelling sidewalks, are underlain by at least 3 feet of low-expansion, impervious fills, as measured from the bottom of the slabs. Since there is little low-expansion soil at the site, and the on-site soils are visually nearly identical, it is anticipated that the low-expansion impermeable fills will have to be imported.

Once the lots have been "capped" with the low-expansion impermeable fills, the dwelling construction could proceed using relatively typical building construction designs and methods. Judicious raising of the site through the site grading can result in reduced undercutting costs for the removal of the expansive clays.

Removal and replacement of the expansive soils within the roadways would also result in significantly reduced pavement sections for the roads under the design criteria of the City and County of Honolulu for residential streets. We believe that provided the subgrades beneath the streets consist of at least 2 feet of low-expansion impermeable soils, the pavements for the streets can be reduced to the minimum pavement requirement of 2 inches of ACP, over 3 inches of ACB, over 6 inches of Aggregate Base Course, placed on the compacted subgrade. No Select Borrow subbase would be necessary beneath the sidewalks, curbs and gutters for the streets.

It should be realized that any future structures added to the lots by the future lot owners, which are founded below the existing ground surface could be affected by the expansive soils below the low-expansion fills. The buyers of the lots and dwellings should be advised of the soil conditions at their lots and also that any improvements or additions to their lots and dwellings should be completed through consultation with their own geotechnical engineers.

The remainder of this report provides detailed recommendations for selectively grading the entire site, including the road right-of-ways, using partial removal of the on-site clays and their replacement with a low-expansion, impermeable imported fill. Fewell Geotechnical Engineering, Ltd. (FGE) should be notified should it be more desirable to use a special structure design, or other methods, to mitigate the effects of the on-site expansive clays so that additional detailed recommendations can be provided for the selected method.

RECOMMENDATIONS

General

1. We believe that the site for the Kakaina Subdivision can be satisfactorily developed to support the planned subdivision and its improvements provided the recommendations of this report are closely followed. The presence of uncompacted fills over the site and moderately to highly expansive clays throughout the site will necessitate special design and construction considerations.

2. The problems associated with the uncompacted fills and the on-site expansive clays can be reduced by removing the uncompacted fills and sufficient thicknesses of the expansive clays such that the concrete slabs-on-grades and other similarly lightly loaded structures and foundations are underlain by a layer of well-compacted low-expansion, relatively impermeable fill.

3. Groundwater was found in all of the borings drilled throughout the site during this investigation at depths of 13.1 feet to 16.9 feet, or between about Elev. 17 and Elev. 28. At these levels, groundwater is not anticipated to affect most of the construction. However, provisions should be included for dewatering where utility excavations or other similar deep site excavations approach the above-indicated groundwater levels.

Site Preparation

4. Prior to the start of the actual grading operations, the site should be cleared and grubbed in accordance with Section 10 of the Standard Specifications for Public Works Construction of the City and County of Honolulu (Standard Specifications).

   a. All vegetation, boulders, rubbish and other deleterious materials should be removed and wasted off-site. Stockpiles of cleared and grubbed materials were observed at the site during this investigation. Should any these remain, they should be removed and wasted off-site.

b. The depth of the grubbing operations can best be determined in the field, but it is likely that 2 to 4 inches should suffice. Deeper grubbing should be anticipated where trees or large shrubs exist.

c. The organically contaminated grubbed materials are not suitable for use as fill and should be removed from the site. They may be stockpiled for future use as topsoil provided they meet the requirements of the Project Landscape Architect.

5. Where the existing ground to receive fill slopes in excess of 5 Horizontal and 1 Vertical (5H:1V), the ground surface should be benched with a series of horizontal terraces prior to the placement of the fill. The benches should extend through any loose materials into the very stiff to hard natural ground or properly compacted fills.

Grading

6. Once the site has been cleared and grubbed, site grading may commence to generate the planned finish grades. The graded building pads of the lots should extend at least 5 feet beyond the perimeter of the structures and their related structural attachments. Where this criteria cannot be met, deeper than normal foundations will be necessary.

7. The existing uncompacted fills over the site will not provide adequate support for the new construction and should be removed throughout the area of the new construction and down to the very stiff to hard natural alluvial clays prior to additional grading. Sediments and other loose materials found in ditches or swales on the site should similarly be removed.

a. The actual depth and lateral extent of the removal of these materials must be determined in the field during construction. The boring information indicates that the uncompacted fills extend to depths ranging from ½ to 4 feet below the existing ground surface and generally down to depths of 2½ to 3 feet.

b. The excavated material may be re-used as fill in the grading provided it meets the material recommendations for fill and is selectively placed, moisture-conditioned, and compacted as recommended herein.

8. Care must be taken by the contractor to minimize the potential for undermining the existing structures along the property lines of the site during the excavation to remove the uncompacted fills. Temporary underpinning of these existing structures should be anticipated to allow the removal of the uncompacted fills and their replacement with compacted fill.

9. Once the uncompacted fills have been removed the then-exposed ground surface in the areas to receive fill or new construction should be proof-rolled to detect any soft spots or remaining uncompacted fills. The proof-rolling should consist of no less than 5 passes with a Caterpillar 825B compactor, or its equivalent, weighing at least 40,000 pounds.

10. Soft spots or any remaining uncompacted fills should be removed down to very stiff to hard natural ground and the resulting depression backfilled in accordance with the recommendations herein.

11. The expansive on-site clays should then be removed a sufficient depth beneath the proposed concrete slabs-on-grades and pavements such that the slabs and pavements are underlain by low-expansion imported fill.

a. The expansive soils should be removed throughout the areas of the lots, roadways and other areas designated for new construction, except for areas designated for landscaping.

b. The depth of the undercutting and removal of the expansive soils should extend a sufficient depth below the concrete slabs-on-grades to allow the placement of at least 3 feet of low-expansion imported fill beneath the slabs, as measured from the bottom of the concrete slab.

c. The depth of the undercutting should extend a sufficient depth below the pavement sections (as measured from the bottom of the Aggregate Base Course layer) to allow the placement of at least 2 feet of low-expansion imported fills beneath these items.

12. Once the expansive soils have been removed, the then-existing expansive clay subgrade to receive fill or new construction should be scarified, moisture-conditioned to at least 3 percent above its optimum moisture content, and uniformly compacted to at least 90 percent relative compaction as determined by Laboratory Compaction Test ASTM D1557.

13. The expansive clay subgrades should be kept moist and not be allowed to dry excessively during the intervening period between its compaction and subsequent placement of additional fill or new construction. Where significant drying occurs, such that shrinkage cracks exceeding 1/8 inch, the subgrade should be scarified, moisture-conditioned and compacted as recommended above.

14. The excavated expansive soils may be used as fill in the site grading provided they are used below the above-recommended thicknesses of low-expansion imported fill, and they are placed, moisture-conditioned and compacted as recommended herein.

15. Fill placed within 3 feet of the bottom of the concrete slabs-on-grades and within 2 feet of the foundations and pavement sections should consist of a low-expansion, relatively impervious imported material.

16. Low-expansion imported fill should be free of organics, rocks or soil clods larger than 2 inches in maximum dimension and meet the following additional requirements.

a. The low-expansion imported fill should exhibit a Liquid Limit of less than 60 and a PI of less than 20.

b. The low-expansion imported fill should exhibit a CBR in excess of 10 and a swell of no more than 2½ percent when tested in accordance with Laboratory CBR Test ASTM 1883 under a 51-pound per square foot surcharge and 96 hours of soaking.

c. When compacted to 90 percent relative compaction, the low-expansion imported fill should also exhibit a permeability, *k*, of less than 1×10^{-4} cm/sec when tested in accordance with ASTM D5084.

17. Fill and backfill should be placed in horizontal lifts of no more than 8 inches in loose thickness, moisture-conditioned as indicated below and uniformly compacted to at least 90 percent relative compaction as determined by ASTM D1557. Fill placed within 2 feet of the pavement subgrades should be compacted to at least 95 percent relative compaction.

a. The on-site expansive clays should be moisture-conditioned to at least 3 percent above their optimum moisture contents.

b. Imported low-expansion fill should be moisture-conditioned to within 3 percent of its optimum moisture content.

18. Should excessive drying of the low-expansion soil subgrades occur during the intervening period between the construction of the lots and the dwelling construction, the subgrade should be scarified for a depth of at least 8-inches, moisture-conditioned and re-compacted as recommended above.

19. Cut and fill slopes should be limited to no steeper than 2H:1V for heights of up to 10 feet. Slopes exceeding this height are not anticipated on this project and should be individually evaluated should they occur.

Utilities

20. The installation of the utilities should be in accordance with Section 11 of the Standard Specifications and the appropriate section of the Standard Specifications pertaining to each utility.

21. Backfills for the utilities should be selectively placed, moisture-conditioned and compacted in accordance with the Grading Recommendations above, using the appropriate mechanical compactors around and above the pipes. Flooding, jetting and/or ponding with water are not acceptable methods of compaction.

22. The utilities may be founded in compacted fills or the natural expansive soils. Where the utilities are founded within 3 feet of the finish grades, flexible couplings should be provided where they pass between the natural expansive soils and the low-expansion fills, or where they connect to a structure from the expansive soils.

23. Utilities should be designed such that they are not within the supportive prism of soil beneath the foundations of the dwellings or structures. This is delineated by an imaginary line extending down from the outside edges of the foundations at a slope of 1½H:1V. FGE should be notified should this occur such that it can be evaluated and additional recommendations provided.

24. The utility excavations and other deep site excavations should be shored and braced in accordance with the HIOSH and other applicable governmental regulations to safeguard the workers in the trench. The design of the shoring and bracing system should be the responsibility of the contractor.

25. Groundwater was encountered at depths corresponding to between Elev. 17 and Elev. 28 during this investigation. Dewatering should be anticipated for utility

excavations or other deep excavations approaching these levels. The design of the dewatering system should be the responsibility of the contractor.

Foundations

26. Provided the Grading Recommendations are followed, we believe that the dwellings may be satisfactorily supported by a shallow foundation system. This will assure that the concrete slabs for the dwellings are underlain by at least 3 feet of low-expansion fill and the foundations are underlain by at least 2 feet of low-expansion fill.

27. We believe that the dwellings can be adequately supported on individual spread foundations, thickened edge continuous perimeter footings, or a combination of these types. Although other foundation systems are available, we believe the above foundations should perform satisfactorily and should prove the most economical.

28. Foundations should maintain a minimum base width of at least 12 inches and should be founded at least 12 inches below the lowest adjacent compacted subgrade on level ground. Foundations on slopes or within 5 feet of the top of slopes, should be embedded a sufficient depth such that there is at least 5 feet of horizontal set-back from the lower outside edge of the footing to the compacted slope face.

29. The bottom of the foundation excavations should be cleaned of loose materials, moisture-conditioned to within 3 percent of their optimum moisture content, and uniformly compacted to at least 90 percent relative compaction as determined by ASTM D1557 prior to the placement of the reinforcing steel and concrete. Any soft spots encountered should be removed and the resulting depression backfilled with low-expansion impermeable fill in accordance with the Grading Recommendations.

30. The foundations should bear on the imported low-expansion impermeable fill where they may be designed for an allowable bearing pressure of 3,000 p.s.f. This value may be increased by 1/3 for short-term transient loads.

31. Steel reinforcement of the foundations should be provided as recommended by the Project Structural Engineer. Total and differential vertical movements exceeding ½ inch are not anticipated provided the Grading Recommendations have been followed and the loads do not exceed 50 kips and 2 kips per foot for the columns and walls, respectively. FGE should be notified for additional recommendations should the actual loads exceed those assumed above.

Concrete Slabs-on-Grades

32. Concrete slabs-on-grades may be used provided the Grading Recommendations are followed. This will assure that the slabs are underlain by at least 3 feet of low-expansion impermeable fill which has been uniformly compacted to at least 90 percent relative compaction, and has not been allowed to dry excessively prior to the construction of the slabs.

33. The on-site soils and recommended imported fills are susceptible to the capillary rise of moisture. The concrete slabs-on-grade should be underlain by at least 4 inches of lightly compacted slab cushion material consisting of ASTM C-33 No. 67 aggregate (3B Fine) to act as a capillary break beneath the slabs. A vapor barrier, if desirable, should be placed between the slab and the slab cushion.

34. Where the concrete slabs will support vehicular traffic, such as in driveways, carports or garages, the slab cushion should be replaced with either 6 inches of Select Borrow subbase or 4 inches of Aggregate Base Course. The Select Borrow and Aggregate Base Course should conform to Sections 30 and 31, respectively, of the

Standard Specifications and should be compacted to at least 95 percent relative compaction.

35. Steel reinforcement of the concrete slabs should be provided as recommended by the Project Structural Engineer. Differential movements between the concrete slabs and foundations exceeding ¼ inch are not anticipated provided the Grading Recommendations have been followed.

Pavements

36. Provided the Grading Recommendations are followed, the subgrades beneath the interior residential streets should consist of at least 2 feet of low-expansion, imported impermeable fill with a CBR in excess of 10 and a CBR swell of less than 2.5 percent.

37. For these conditions we believe that a minimum pavement section consisting of 2 inches of Asphalt Concrete Paving (ACP), over 3 inches of Asphalt Concrete Base Course (ACB), over 6 inches of untreated Aggregate Base Course, placed on the compacted subgrade will be necessary for the interior streets under the pavement design criteria of the City and County of Honolulu.

38. Weepholes should be provided at the catch basins along the roads to minimize the build up of water in the pavements. A 1-cubic foot prism of filter gravel, or ASTM C-33 No. 67 aggregate wrapped in a geotextile filter fabric, should be placed in front of the weepholes to facilitate drainage. Care must be taken during construction to ensure that the weepholes and their filter materials are hydraulically connected to the base course layers of the pavements of the roads.

39. For the extension of Mekia Street on the western end of the site, it is anticipated that the excavation for the road prism will likely encounter subgrade soils which will be

similar to the expansive clays of Bag A, with a CBR of 4 and a swell of 5 percent.

a. For this section of Mekia Street, we believe that a pavement section consisting of 2 inches of ACP, over 4 inches of ACB, over 12 inches of Aggregate Base Course, placed on the compacted subgrade will be required.

b. Due to the anticipated expansion of the subgrade soils exceeding 3 percent, at least 6 inches of Select Borrow Subbase should be provided beneath the sidewalks, curbs and gutters for this section of Mekia Street.

c. A longitudinal subdrain should be provided beneath the concrete curb and gutter to minimize the potential for the accumulation of water within the pavement subgrade. The subdrain should be hydraulically connected to the Aggregate Base Course layer of the pavement and the Select Borrow layer under the sidewalks.

40. The composition, placement and compaction of the Select Borrow subbase and Aggregate Base Course should be in accordance with Sections 30 and 31, respectively, of the Standard Specifications.

41. The subgrade should be shaped to drain and compacted to at least 95 percent relative compaction as determined by ASTM D1557 for a minimum depth of 6 inches in accordance with Section 29 of the Standard Specifications.

42. The above pavement recommendations are given for preliminary design and cost-estimating purposes. The actual pavements constructed will be dependent on the CBR and swell values of the soils found at the pavement subgrade levels during construction.

Quality Control

43. The site preparation and site grading, including the proof-rolling operations should be observed by FGE to determine whether the anticipated materials are encountered.

44. Intermittent field density tests should be taken on the fills and backfills to determine whether the specified levels of compaction are consistently obtained.

45. Samples of the proposed fill materials should be submitted to FGE no less than 7 working days prior to their intended job-site delivery to allow adequate time for testing, evaluation, and approval.

46. Foundation excavation should be observed by FGE to determine whether the anticipated bearing materials are encountered. The recommendations provided herein are contingent on adequate construction observations and testing of the geotechnical aspects of the construction by FGE.

47. Due to the presence of uncompacted fill and expansive soils at the site, more than the normal earthwork observation and testing will be necessary. The construction budget for the project should be adjusted to accommodate these costs.

Miscellaneous

48. Adequate drainage should be included in the design of the project to direct water away from the slopes and to preclude the ponding of water adjacent to or beneath the dwellings, pavement and structures.

49. The graded slopes should be grassed or mulched as soon as practical after grading to minimize the erosion.

Limitations

50. This report has been completed for the exclusive use of **Akinaka & Associates, Ltd.** for the site of the **Kakaina Subdivision** in Waimanalo, Oahu, Hawaii. The limitation of this investigation and report are presented in Appendix C.

APPENDIX A

Subsurface Exploration Summary

Project Designation: Kakaina Subdivision **File:** 2760.01

Location: Waimanalo, Oahu, Hawaii

Project Location Map: Figure 1

Boring Location Plan: Figure 2

Drilling Contractor: Hawaii Test Borings, Inc.

Drilling Equipment: Simco 2400SK

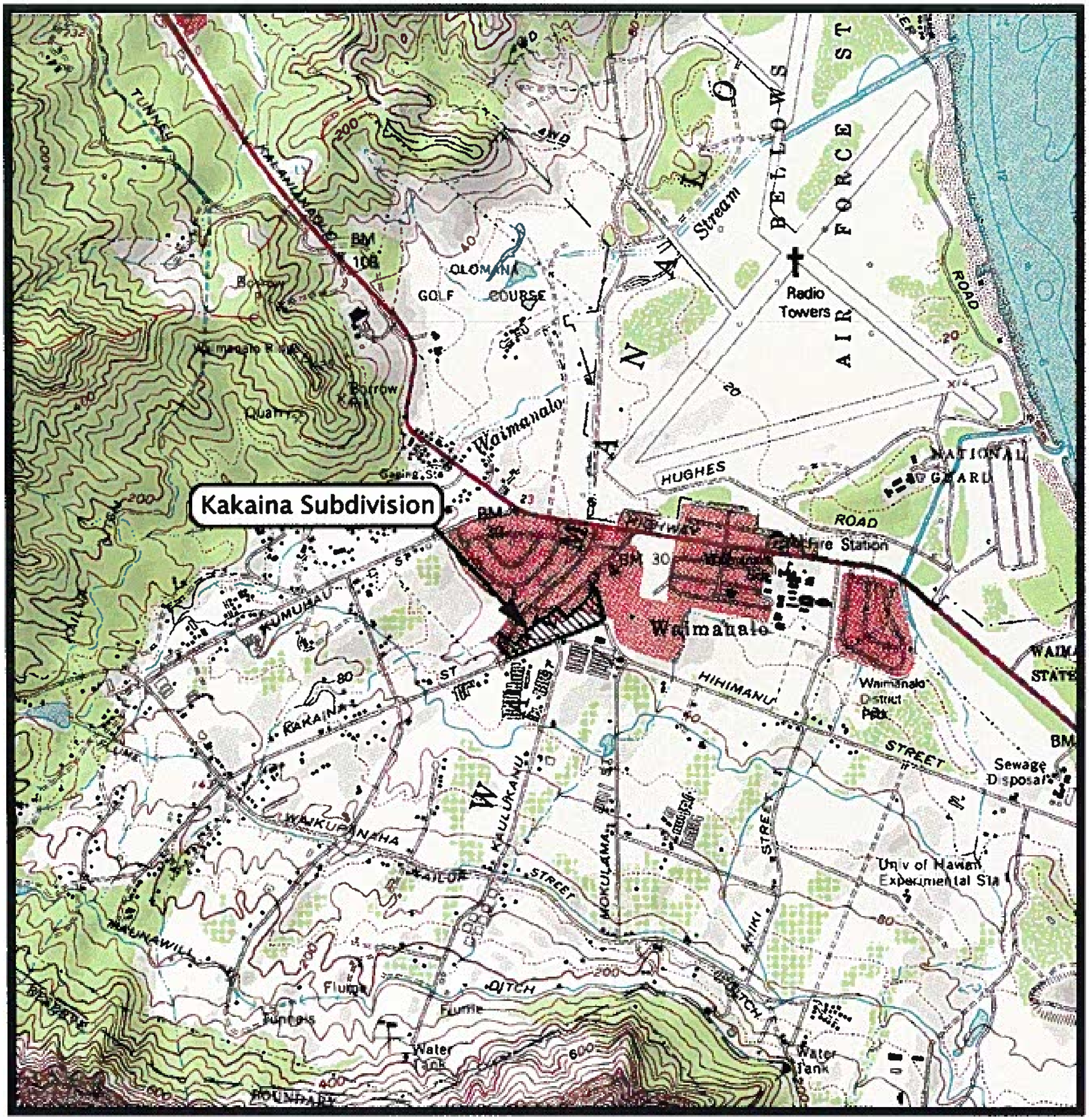
Drilling Method:
/x/ 4-inch Auger // Wash
// 5-inch Auger // HQ Core

Boring Summary

Boring	Depth	Number of Samples	Depth to Water Table	Elev. of Water Table	Boring Log Figure No.
1	30.0'	8	13.6'	Elev. 28±	3
2	20.0'	6	16.9'	Elev. 25±	4
3	30.0'	8	13.1'	Elev. 21±	5
4	20.0'	6	14.1'	Elev. 23±	6
5	30.0'	8	14.5'	Elev. 20±	7
6	20.0'	6	14.6'	Elev. 17±	8
7	20.0'	6	14.3'	Elev. 20±	9
Total	170.0'	48			

Date Started: 4-18-07 **Date Completed:** 4-24-07

Boring Log Legend: Figure 10



LEGEND:

▨ PROJECT LOCATION

SCALE: 1:24000

GENERAL AREA:

WAIMANALO, OAHU, HAWAII

REFERENCE:

WAIMANALO QUADRANGLE
U.S.G.S. TOPOGRAPHIC MAP

F.G.E. Ltd.

PROJECT LOCATION MAP

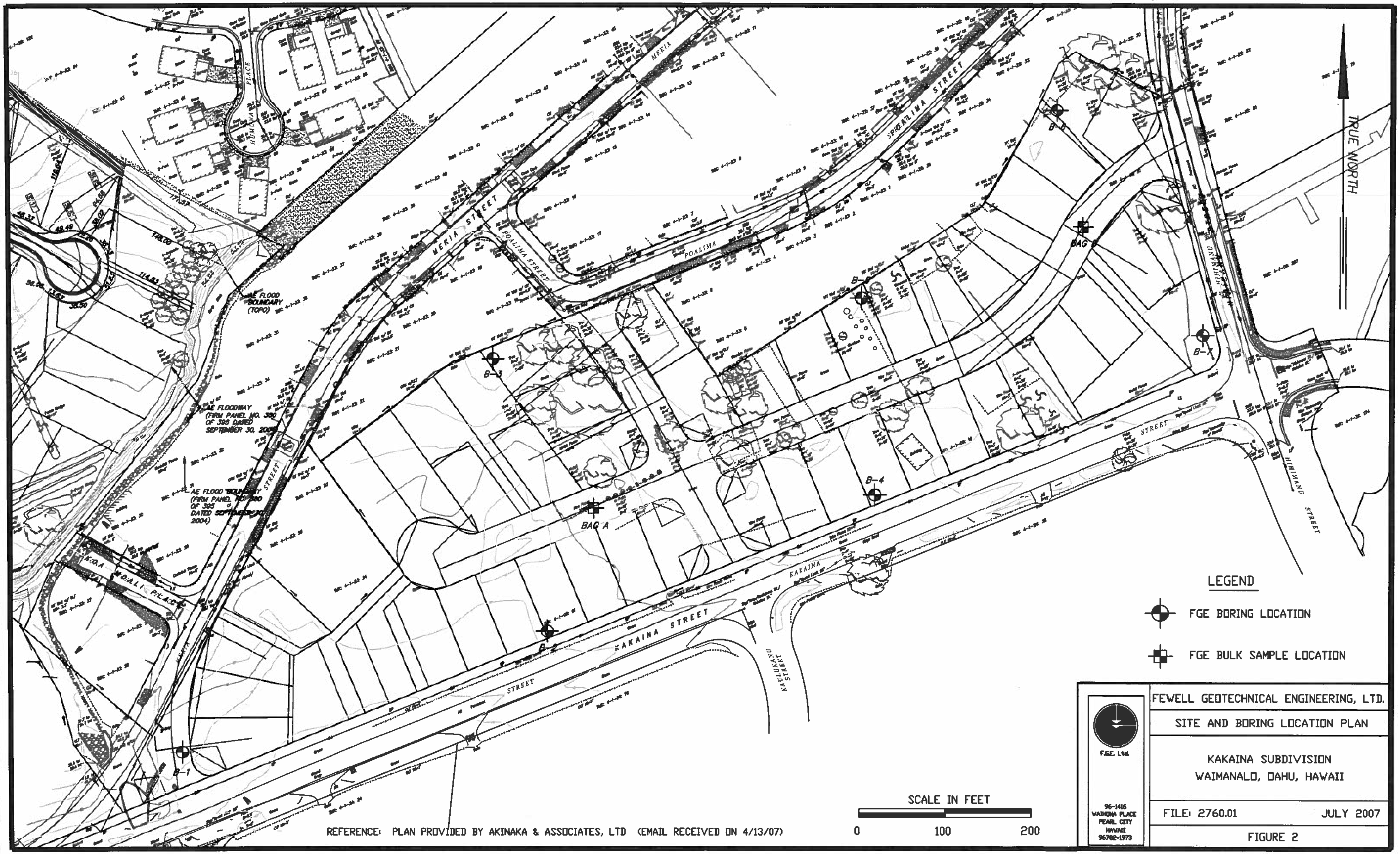
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 1



REFERENCE: PLAN PROVIDED BY AKINAKA & ASSOCIATES, LTD (EMAIL RECEIVED ON 4/13/07)

FEWELL GEOTECHNICAL ENGINEERING, LTD.

SITE AND BORING LOCATION PLAN

KAKAINA SUBDIVISION
WAIMANALO, OAHU, HAWAII

FILE: 2760.01 JULY 2007

FIGURE 2

F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 1
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 42' ±
Depth to Water: 13.6'
Date Completed: 4-24-07

File: 2760.01
Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
						Dark Brown Silty CLAY (CH) with some gravel, very stiff to hard, moist **(FILL)**
			28	1		
7.9%Swell SI=0.51 Torv.>5,000psf Direct Shear: C=800psf Ø=4.0°	41	79	35	2		Gray/Brown Multi-Colored Silty CLAY (CH), hard, moist
					5	
3.7%Swell SI=0.21 Torv.>5,000psf	43	78	33	3		
						At 7', grades with trace of sand
LL=110,PI=73 Torv.=4,500psf	45	73	32	4		
					10	
						▼
Torv.=4,800psf	45	74	31	5		
					15	
						(ALLUVIUM)
Torv.=2,000psf	57	67	13	6		Gray CLAY (CH), stiff, saturated **(ALLUVIUM)**
					20	
						Brown Multi-Colored Sandy CLAY (CH) with trace Gravel, medium stiff, saturated
Torv.=720psf Gradation: 0%Gravel 34%Sand 66%Silt/Clay	62	64	11	7		
					25	**(ALLUVIUM)**
						Gray CLAY (CH), very stiff, saturated
Torv.=2,950psf	54	69	26	8		
					30	**(ALLUVIUM)**
						BOH @ 30.0'
					35	

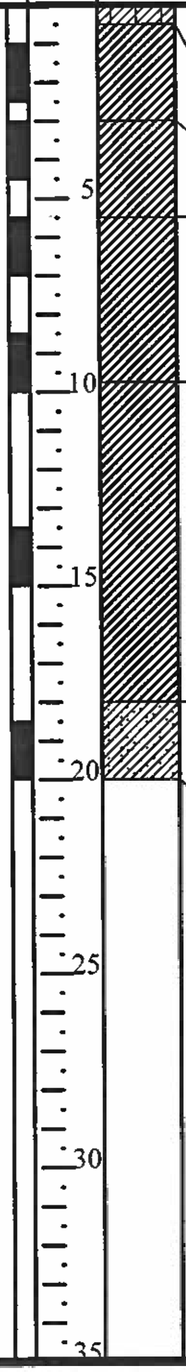
Figure 3

F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 2
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 42' ±
Depth to Water: 16.9'
Date Completed: 4-19-07

File: 2760.01
Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE
			29	1
LL=105,PI=66 Torv.=4,950psf 1.5%Swell SI=0.40	46	75	49	2
Torv.=4,000psf	40	76	67	3
Torv.>5,000psf	40	79	27	4
Torv.=4,100psf	47	74	37	5
Gradation: 0%Gravel 56%Sand 44%Silt/Clay	66	62	14	6



CLASSIFICATION

Dark Brown Clayey SILT (MH) with fine Sand, very stiff, damp **(FILL)**

Dark Brown Silty CLAY (CH) with some fine Sand, hard, moist **(FILL)**

Dark Brown Silty CLAY (CH) with some fine Sand, hard, moist **(ALLUVIUM)**

Brown Multi-Colored Silty CLAY (CH) with highly weathered Gravel and trace fine Sand, hard, moist **(ALLUVIUM)**

Gray/Brown Silty CLAY (CH), hard, wet

▼

(ALLUVIUM)

Brown Multi-Colored Clayey SAND (SC), loose, saturated **(ALLUVIUM)**

BOH @ 20.0'

Figure 4

F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 3
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 34' ±
Depth to Water: 13.1'
Date Completed: 4-24-07

File: 2760.01
Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
Torv.=4,200psf	42	76	32	1		Brown Clayey SILT (MH) with trace fine Sand, hard, damp **(FILL)**
LL=62%,PI=26			23	2		Light Brown Clayey SILT (MH) with weathered Gravel and Sand, hard, damp **(ALLUVIUM)**
Torv.=2,500psf Direct Shear: C=640psf Ø=11°	52	69	19	3	5	Gray CLAY (CH), very stiff, moist **(ALLUVIUM)**
6.8%Swell SI=0.77 Torv.=3,850psf	52	70	23	4	10	Gray/Brown Multi-Colored Silty CLAY (CH), very stiff to hard, moist
						▼
Torv.=2,800psf	55	70	27	5	15	
Torv.=2,200psf	54	64	19	6	20	**(ALLUVIUM)**
Torv.=860psf	59	67	10	7		Brown Silty CLAY (CH) with seams of loose weathered Gravel trace Sand, medium stiff, saturated **(ALLUVIUM)**
					25	Gray Silty CLAY (CH) with trace Sand, very stiff, moist
Torv.=2,450psf	58	66	20	8	30	**(ALLUVIUM)**
						BOH @ 30.0'
					35	

Figure 5

F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 4
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 37' ±
Depth to Water: 14.1'
Date Completed: 4-19-07

File: 2760.01

Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
			16	1		Brown Sandy SILT (MH) with trace Asphalt Concrete fragments, stiff, damp **(FILL)**
Torv.=2,900psf	49	72	20	2		Brown Silty CLAY (CH) with trace roots and Sand, very stiff, moist **(ALLUVIUM)**
Torv.=4,100psf 5.9%Swell SI=0.38	49	69	22	3	5	Gray Silty CLAY (CH), very stiff to hard, wet At 5.5', grades to Brown
Torv.=4,900psf LL=138,PI=100	60	64	23	4	10	
Torv.=2,700psf	62	63	15	5	15	▼
						(ALLUVIUM)
	67	62	11	6	20	Brown Clayey weathered GRAVEL (GC) with coarse Sand, loose, saturated **(ALLUVIUM)**
						BOH @ 20.0'

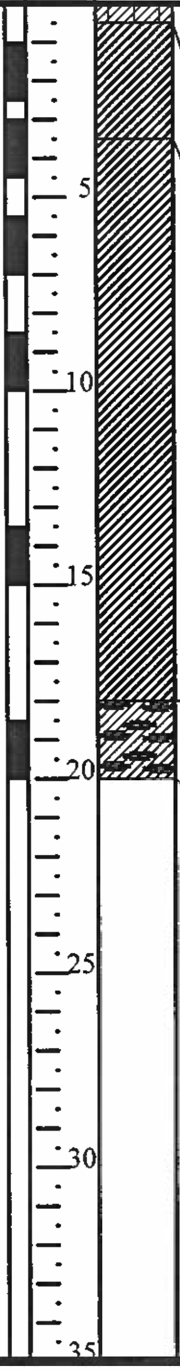


Figure 6

F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 5
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 34' ±
Depth to Water: 14.5'
Date Completed: 4-24-07

File: 2760.01
Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE
Torv.=2,550psf 3.5%Swell SI=0.39	48	68	11	1
Torv.=2,650psf LL=111,PI=78	48	72	18	2
			18	3
Direct Shear: C=1,050psf Ø=12° 3.0%Swell SI=0.48	61	62	17	4
Torv.=3,250psf	52	73	28	5
Torv.=1,950psf	64	63	12	6
Torv.=1,500psf Gradation: 0%Gravel 25%Sand 75%Silt/Clay	61	66	14	7
Torv.=1,700psf	65	61	14	8

SAMPLE **DEPTH**

CLASSIFICATION

Brown Silty CLAY (CH) with trace of decayed organics, stiff to very stiff, moist **(FILL)**

Gray Multi-Colored Silty CLAY (CH), very stiff, moist

▼

(ALLUVIUM)

Brown Multi-Colored Silty CLAY (CH) with weathered Gravel and trace Sand, stiff to very stiff, saturated **(ALLUVIUM)**

Multi-Colored Sandy CLAY (CH), stiff, saturated **(ALLUVIUM)**

Gray CLAY (CH), stiff, saturated **(ALLUVIUM)**

BOH @ 30.0'

Figure 7

F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 6
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 32' ±
Depth to Water: 14.6'
Date Completed: 4-18-07

File: 2760.01
Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST. CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
LL=91,PI=64 Torv.=1,850psf			12	1		Brown Silty CLAY (CH), stiff, damp **(FILL)**
0.9%Swell SI=0.25 Torv.>5,000psf	52	69	10	2	5	Brown Multi-Colored Silty CLAY (CH), hard, wet **(ALLUVIUM)**
Torv.=3,750psf			36	3		
Direct Shear: C=960psf Ø=3° 7.3%Swell SI=0.77	58	66	19	4	10	Gray CLAY (CH), very stiff, wet **(ALLUVIUM)**
Torv.=2,860psf	50	72	18	5	15	▼Brown/Gray Silty CLAY (CH), very stiff, wet **(ALLUVIUM)**
						Multi-Colored Sandy CLAY (CH), stiff, saturated **(ALLUVIUM)**
Gradation: 0%Gravel 35%Sand 65%Silt/Clay	76		7	6	20	
						BOH @ 20.0'
					25	
					30	
					35	

Figure 8

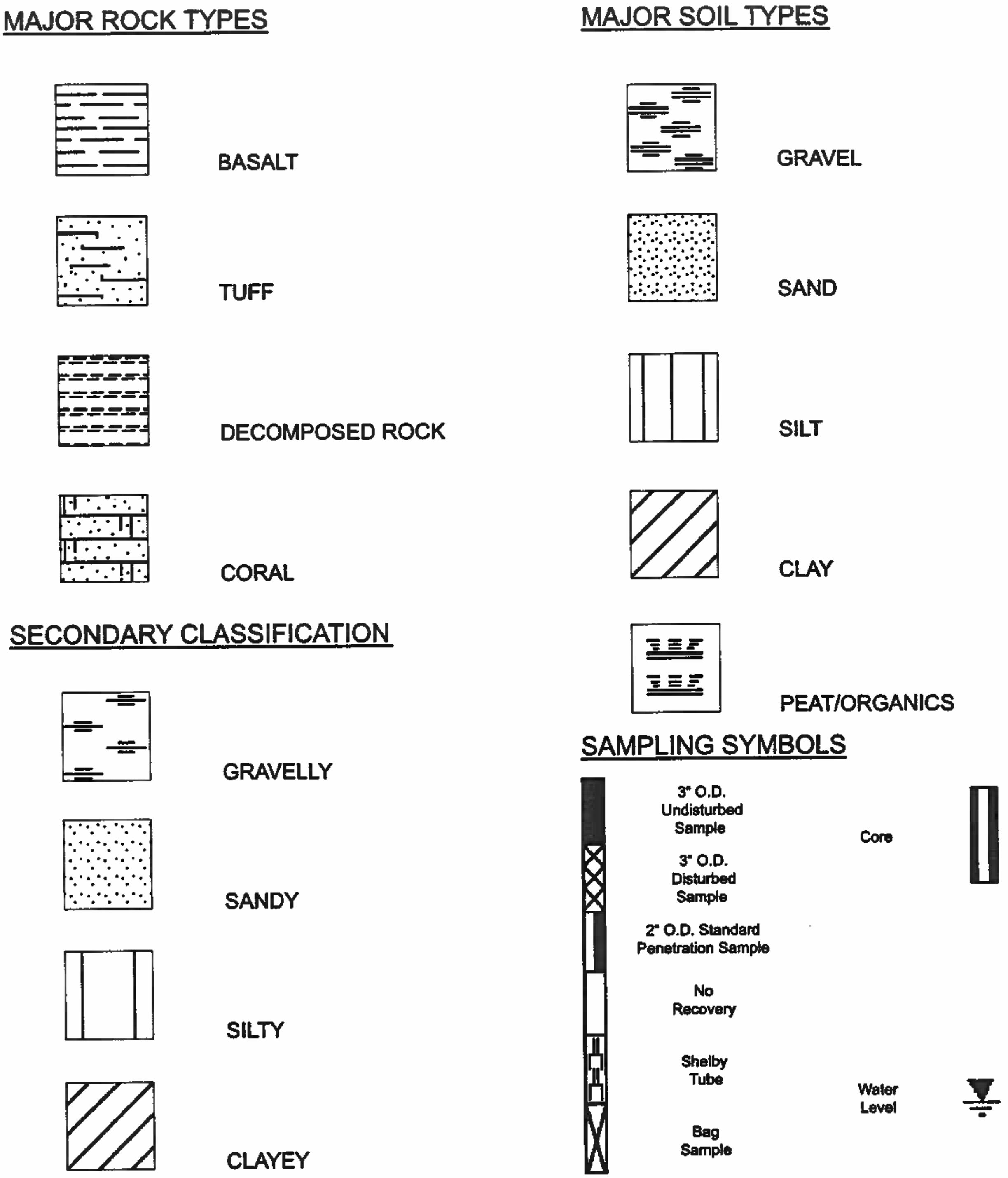
F.G.E. Ltd.
96-1416 Waihona Place
Pearl City, Hawaii

Boring: 7
Project: Kakaina Subdivision
Location: Waimanalo, Oahu, Hawaii
Surface Elevation: 33' ±
Depth to Water: 14.3'
Date Completed: 4-19-07

File: 2760.01

Project Engineer: AS
Field Engineer: MA
Drafted by: MA/SW
Date of Drawing: July 2007

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
Gradation: 12%Gravel 50%Sand 38%Silt/Clay	18		42/6"	1		Brown Silty SAND (SM) with some Asphalt Concrete fragments, medium dense to dense, damp **(FILL)**
			28	2		Brown Multi-Colored Silty CLAY (CH), hard, wet
					5	
LL=117,PI=83 1.3%Swell SI=0.12	38	85	49	3		
Torv.=5,000psf	44	75	26	4		
					10	
						(ALLUVIUM)
Torv.=4,750psf	55	67	23	5		▼Gray CLAY (CH) with trace yellowish brown Silt, hard, wet
					15	
						(ALLUVIUM)
						Brown Sandy CLAY (CH), medium stiff to stiff, wet **(ALLUVIUM)**
Torv.=840psf	60	66	9	6		
					20	Brown/Gray Silty CLAY (CH) with Sand, very stiff, wet
						BOH @ 20.0'
					25	
					30	
					35	



F.G.E. Ltd.

BORING LOG LEGEND

Kakaina Subdivision
Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 10

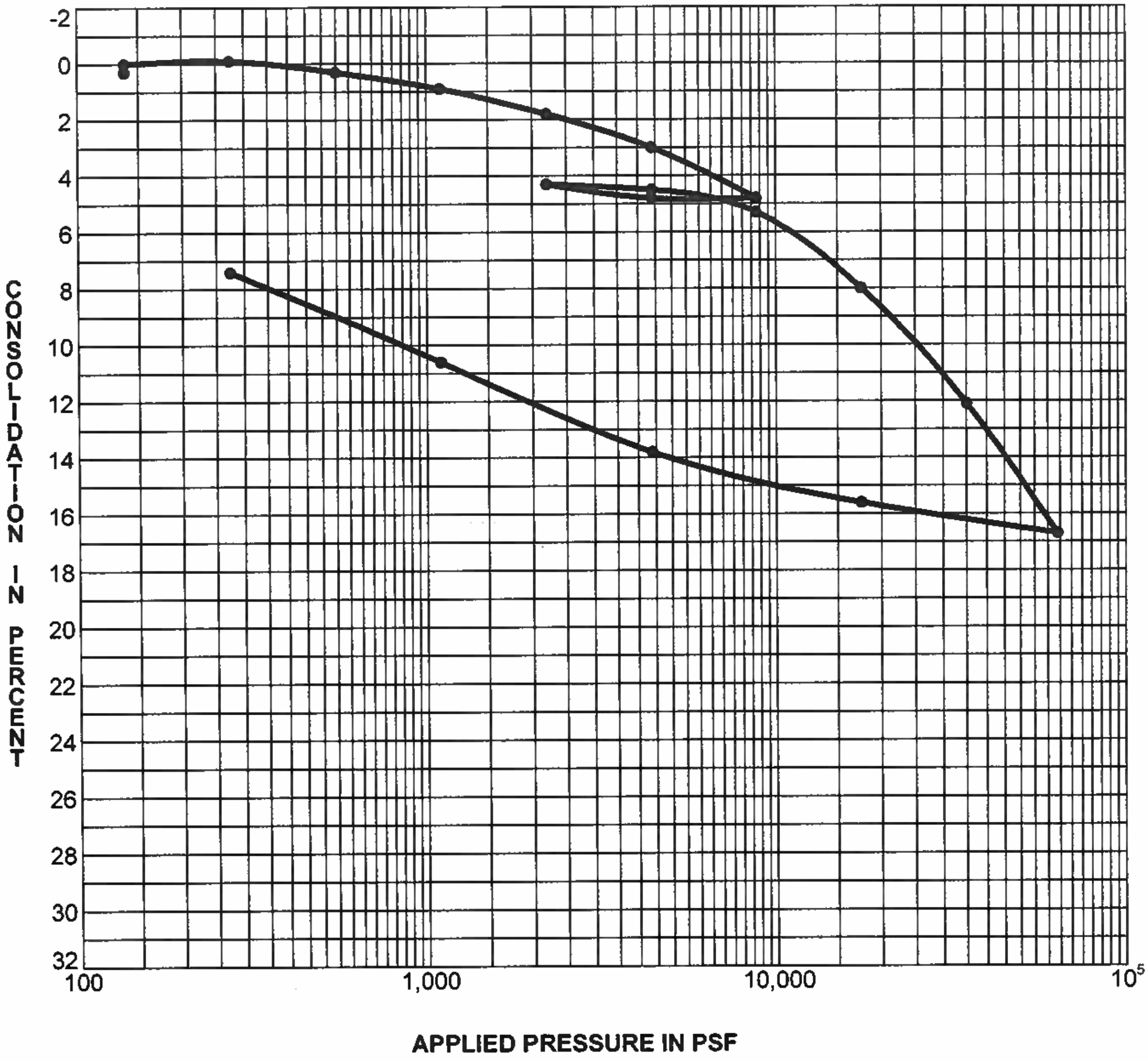
APPENDIX B

Laboratory Testing Summary

Project Designation: Kakaina Subdivision **File:** 2760.01

Location: Waimanalo, Oahu, Hawaii

	Sample No.	Figure Designation
Consolidation Curves:	1-6	11
	5-2	12
	6-2	13
	7-6	14
California Bearing Ratio:	Bag A	15
	Bag B	16
Gradation:	1-7	17
	2-6	18
	5-7	19
	6-6	20
	7-1	21
Plasticity Charts:	1-4	22
	2-2	22
	3-2	22
	4-4	22
	5-2	22
	6-1	22
	7-3	22
	Bag A	23
	Bag B	23
Summary of Laboratory Test Results		Table I
Summary of Laboratory CBR Test Results		Table II



Sample Identification	Depth (feet)	Classification	LL	PI
1 - 6	18.5	Gray CLAY (CH)		

F.G.E. Ltd.

CONSOLIDATION CURVE

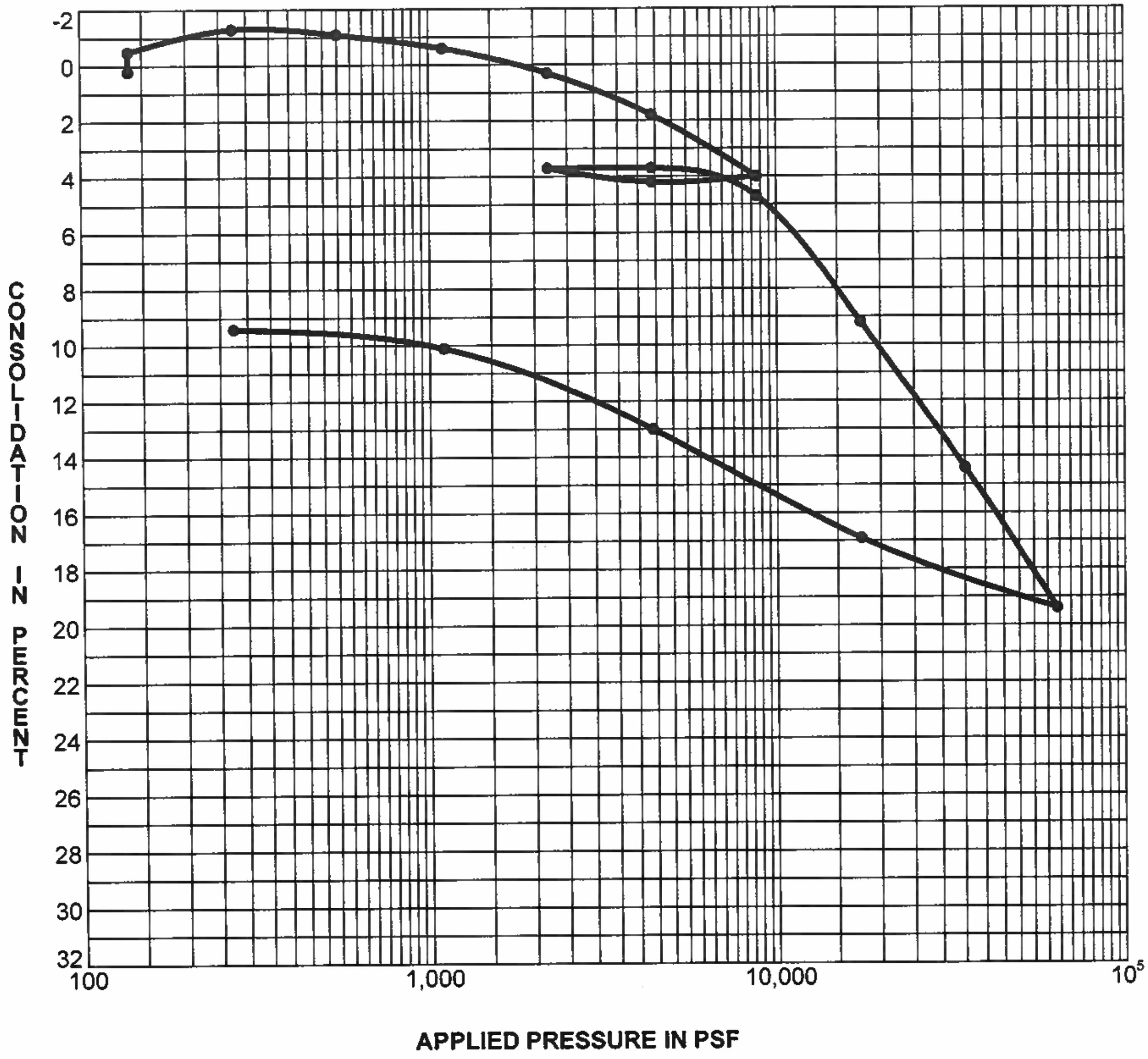
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 11



Sample Identification	Depth (feet)	Classification	LL	PI
5 - 2	3.0	Gray Multi-Colored Silty CLAY (CH)	111	78

F.G.E. Ltd.

CONSOLIDATION CURVE

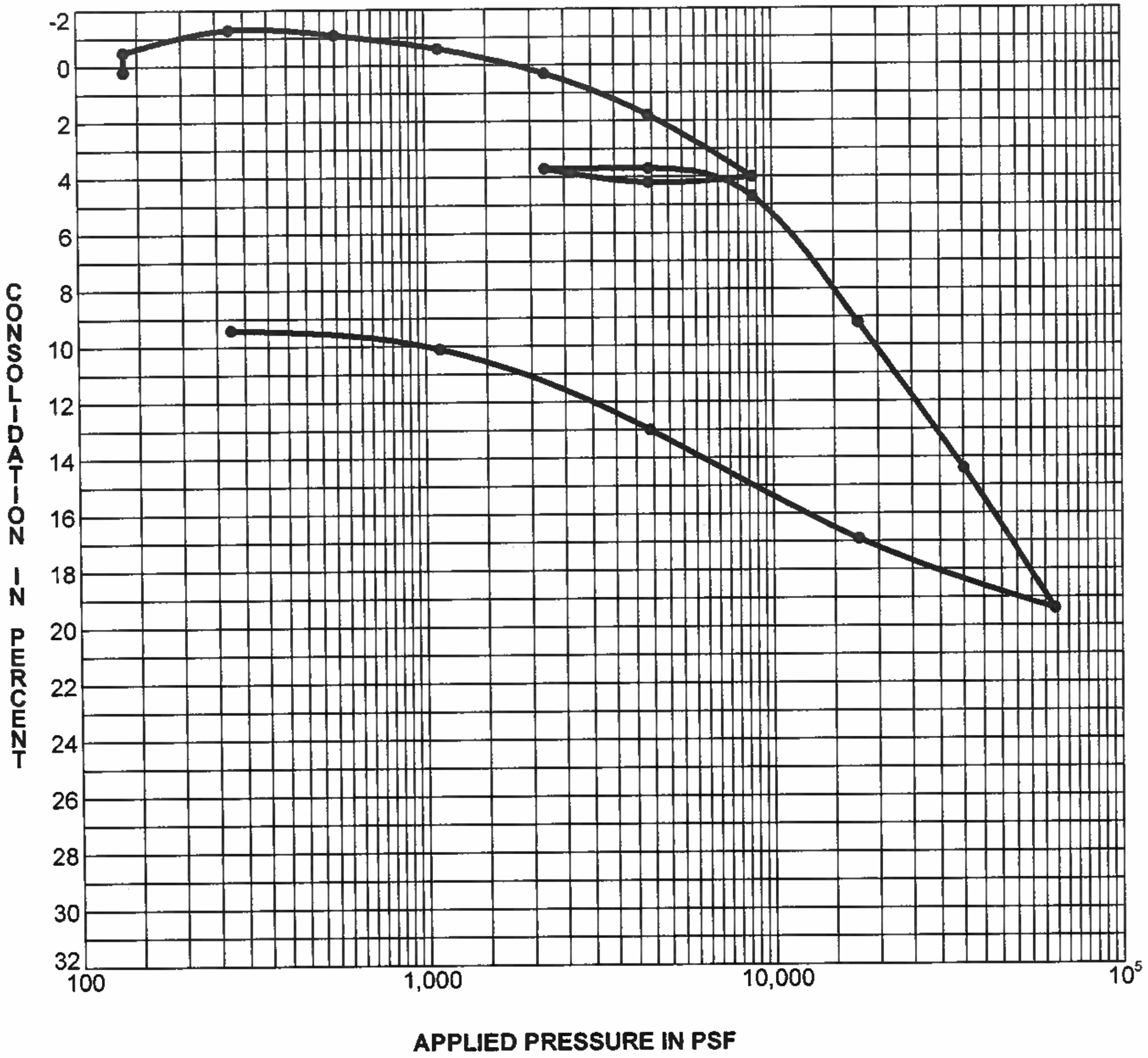
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 12



Sample Identification	Depth (feet)	Classification	LL	PI
6 - 2	3.0	Brown Multi-Colored Silty CLAY (CH)		

F.G.E. Ltd.

CONSOLIDATION CURVE

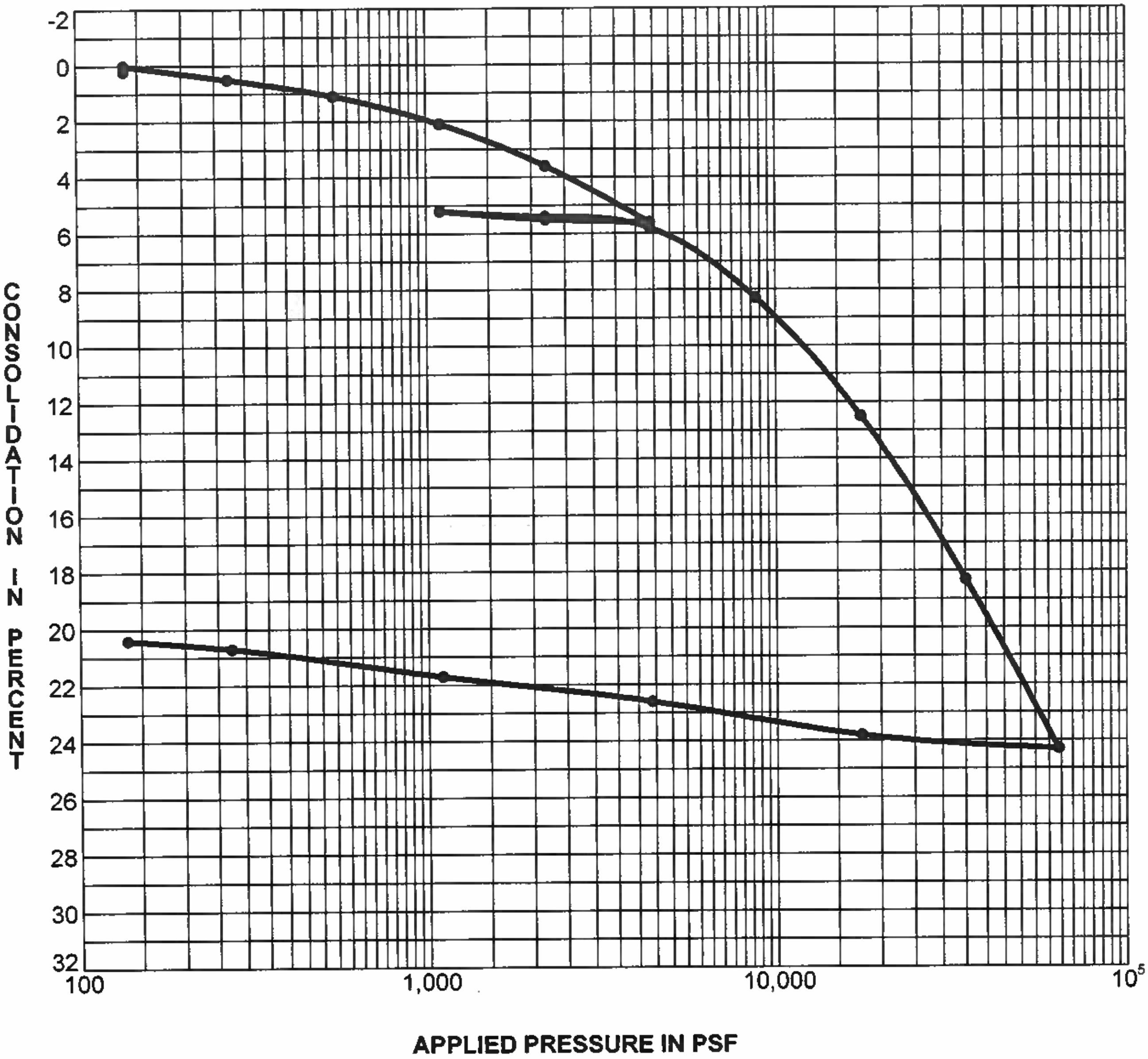
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 13



Sample Identification	Depth (feet)	Classification	LL	PI
7 - 6	18.5	Brown Sandy CLAY (CH)		

F.G.E. Ltd.

CONSOLIDATION CURVE

Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 14

Sample Identification	Classification	CBR	% Comp.	Max Den.	Opt. % MC	% Swell	LL	PI
● BAG A	Brown CLAY (CH)	4.0	99	89.0	32.0	5.0	70	36

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CALIFORNIA BEARING RATIO

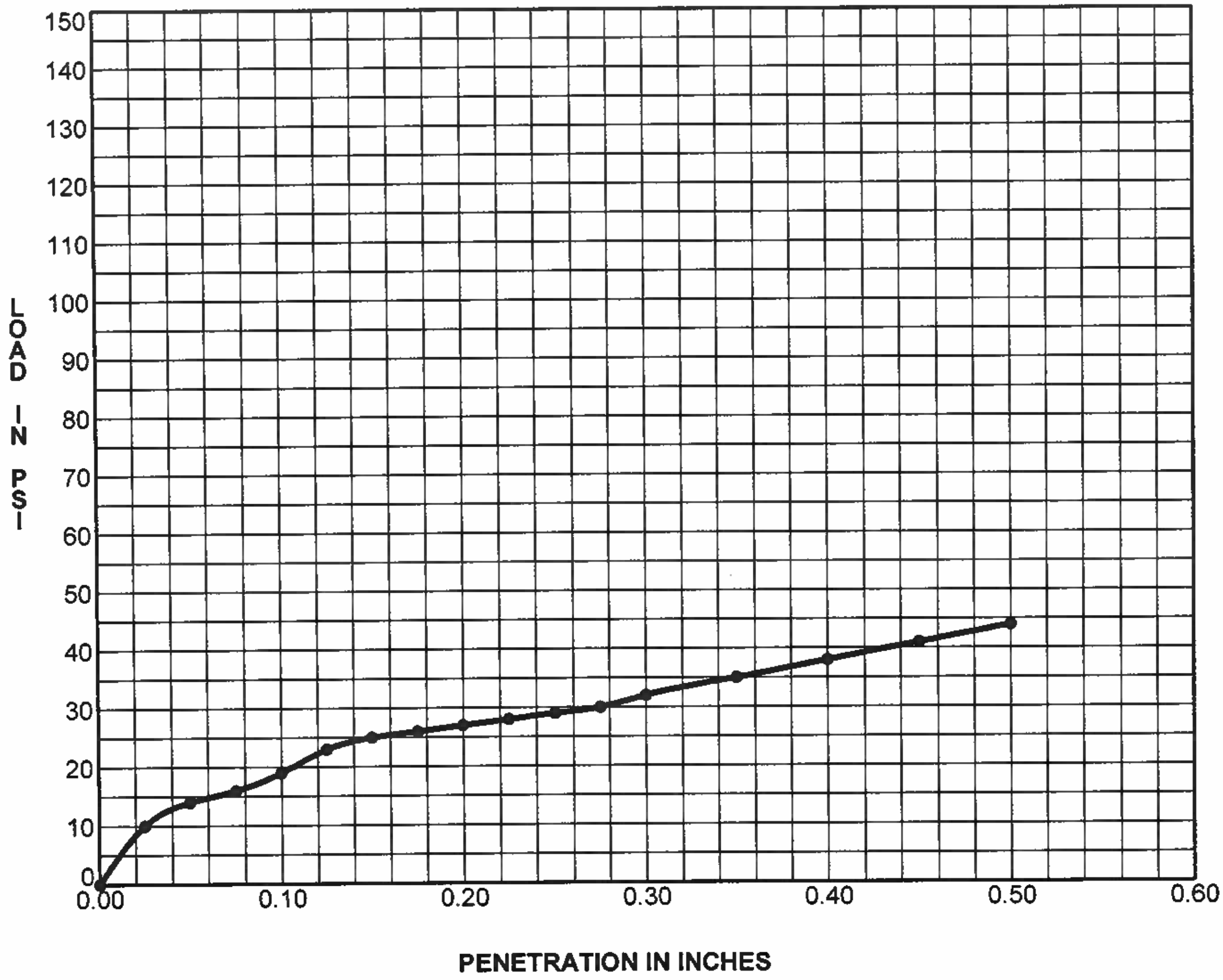
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 15



Sample Identification		Classification	CBR	% Comp.	Max Den.	Opt. % MC	% Swell	LL	PI
●	BAG B	Brown CLAY (CH) with Sand	2.0	97	91.0	28.0	11.5	83	51

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CALIFORNIA BEARING RATIO

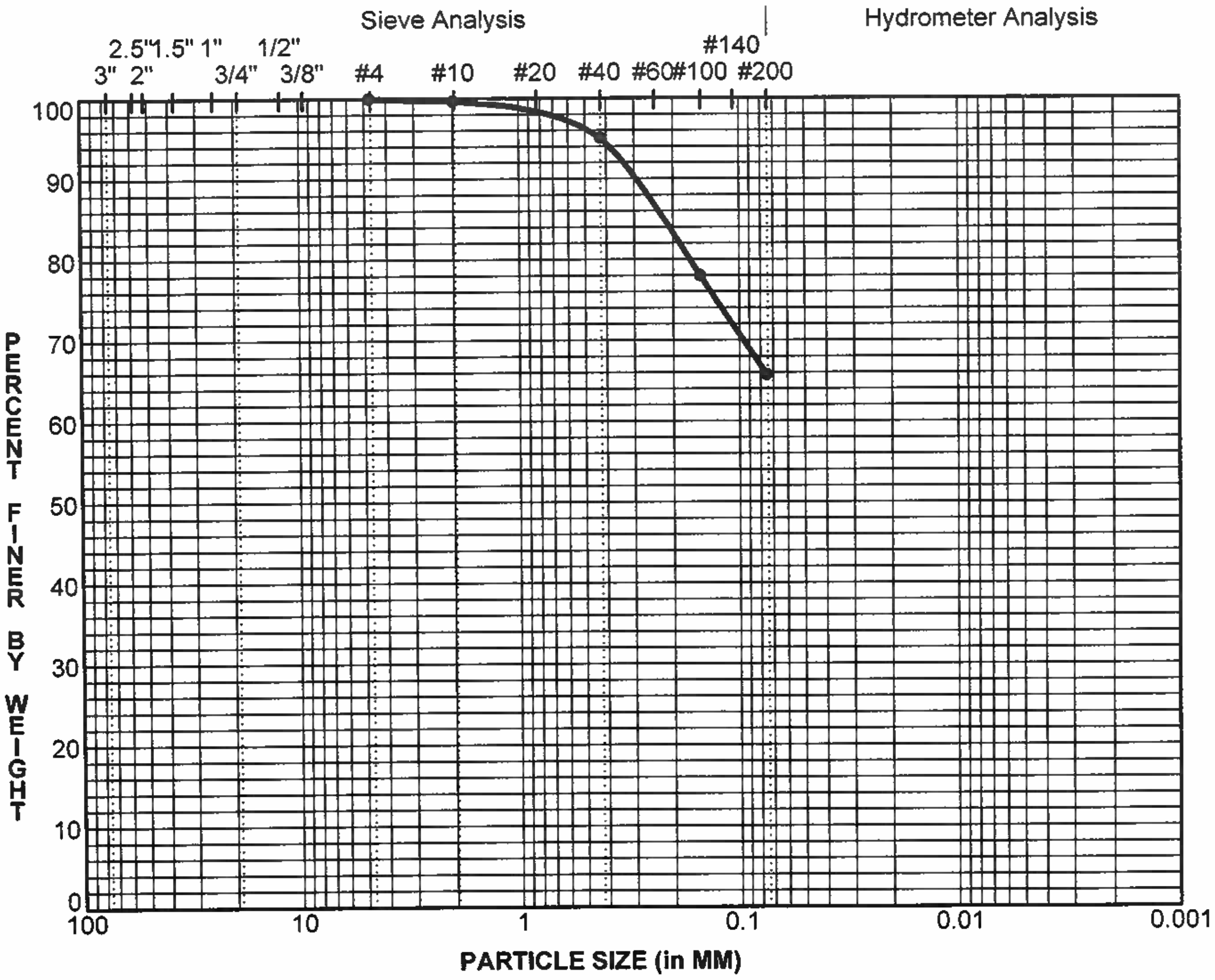
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 16



Gravel		Sand			Silt and Clay
coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	1 - 7	23.5	Brown Multi-Colored Brown Sandy CLAY (CH)	62					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt & Clay
●	1 - 7	23.5	4.8				0	34	66

F.G.E. Ltd.

GRAIN SIZE DISTRIBUTION

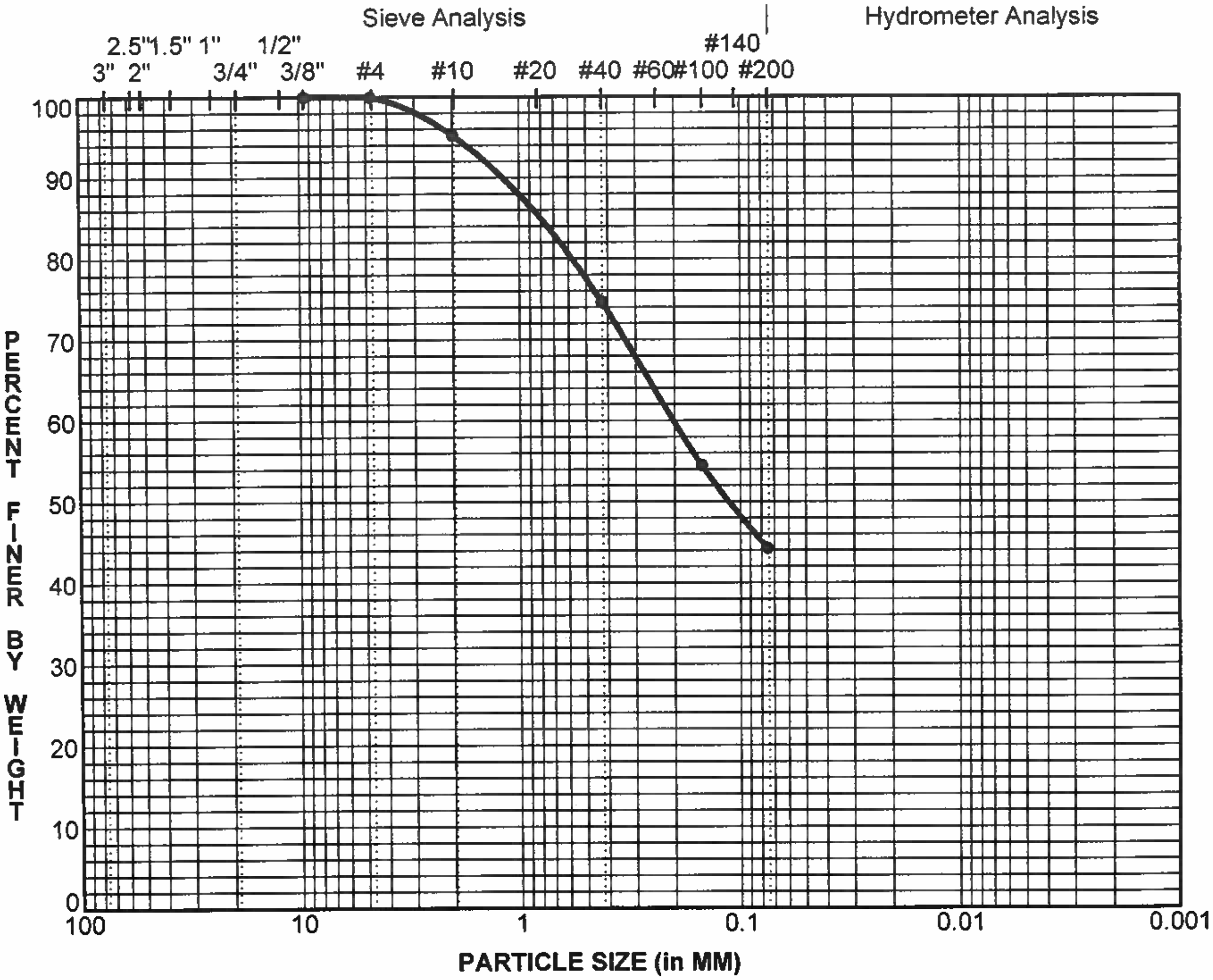
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 17



Gravel		Sand			Silt and Clay
coarse	fine	coarse	medium	fine	

Sample ID	Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● 2 - 6	18.5	Brown Multi-Colored Clayey SAND (SC)	66					

Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt & Clay
● 2 - 6	18.5	9.5	0.2			0	56	44

F.G.E. Ltd.

GRAIN SIZE DISTRIBUTION

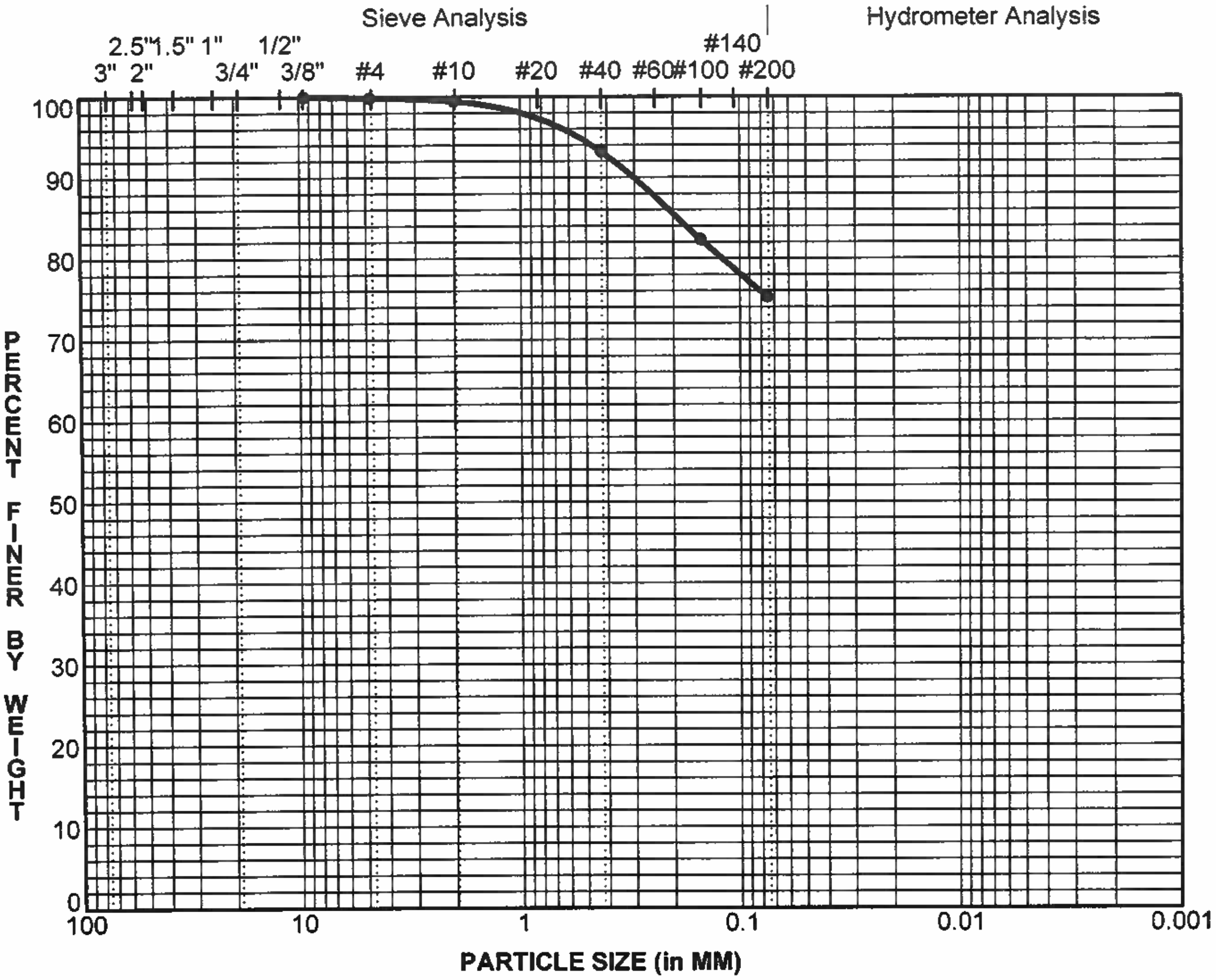
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 18



Gravel		Sand			Silt and Clay
coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	5 - 7	23.5	Multi-Colored CLAY (CH) with Sand	61					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt & Clay
●	5 - 7	23.5	9.5				0	25	75

F.G.E. Ltd.

GRAIN SIZE DISTRIBUTION

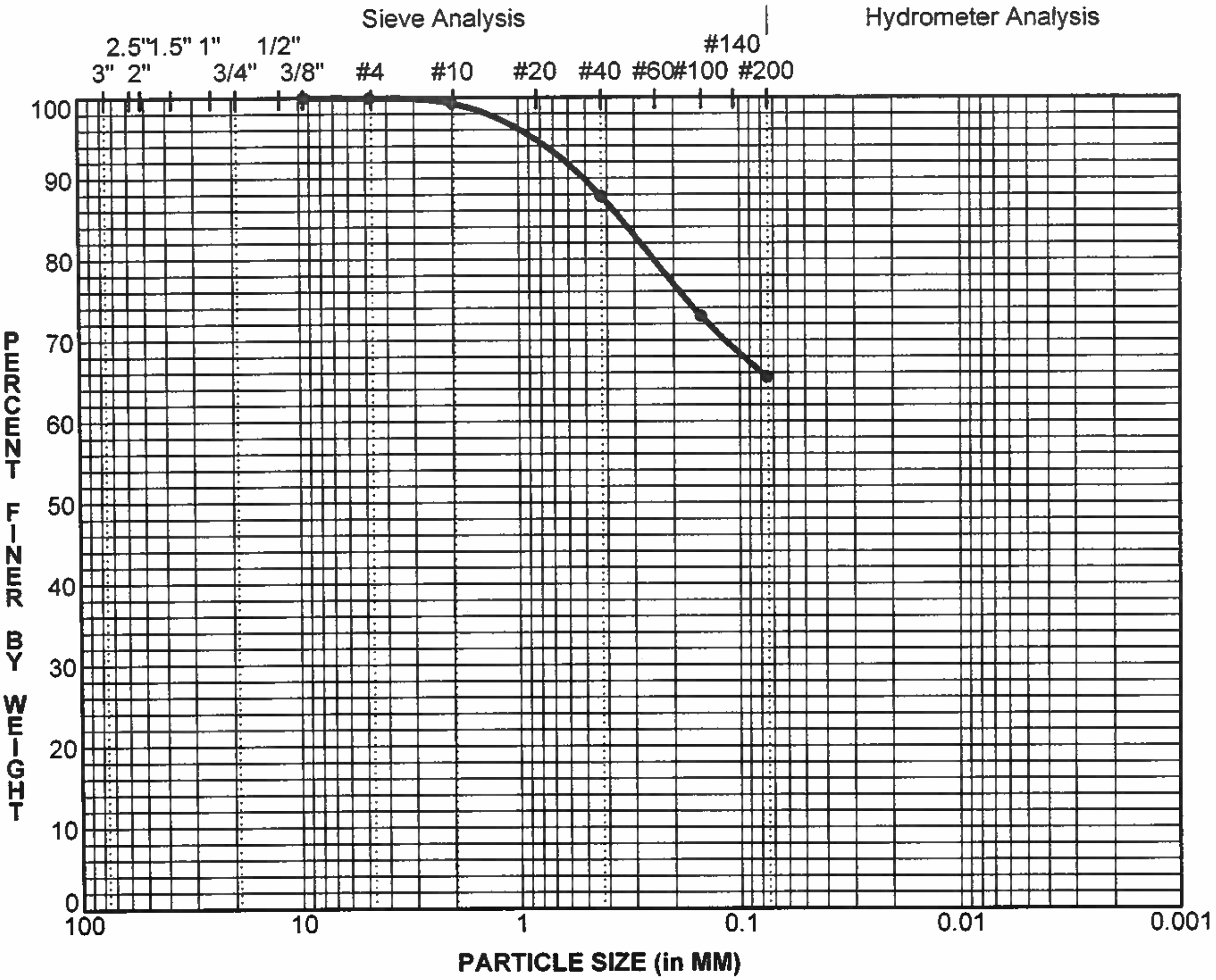
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 19



Gravel		Sand			Silt and Clay
coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	6 - 6	18.5	Multi-Color Brown Sandy CLAY (CH)	76					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt & Clay
●	6 - 6	18.5	9.5				0	35	65

F.G.E. Ltd.

GRAIN SIZE DISTRIBUTION

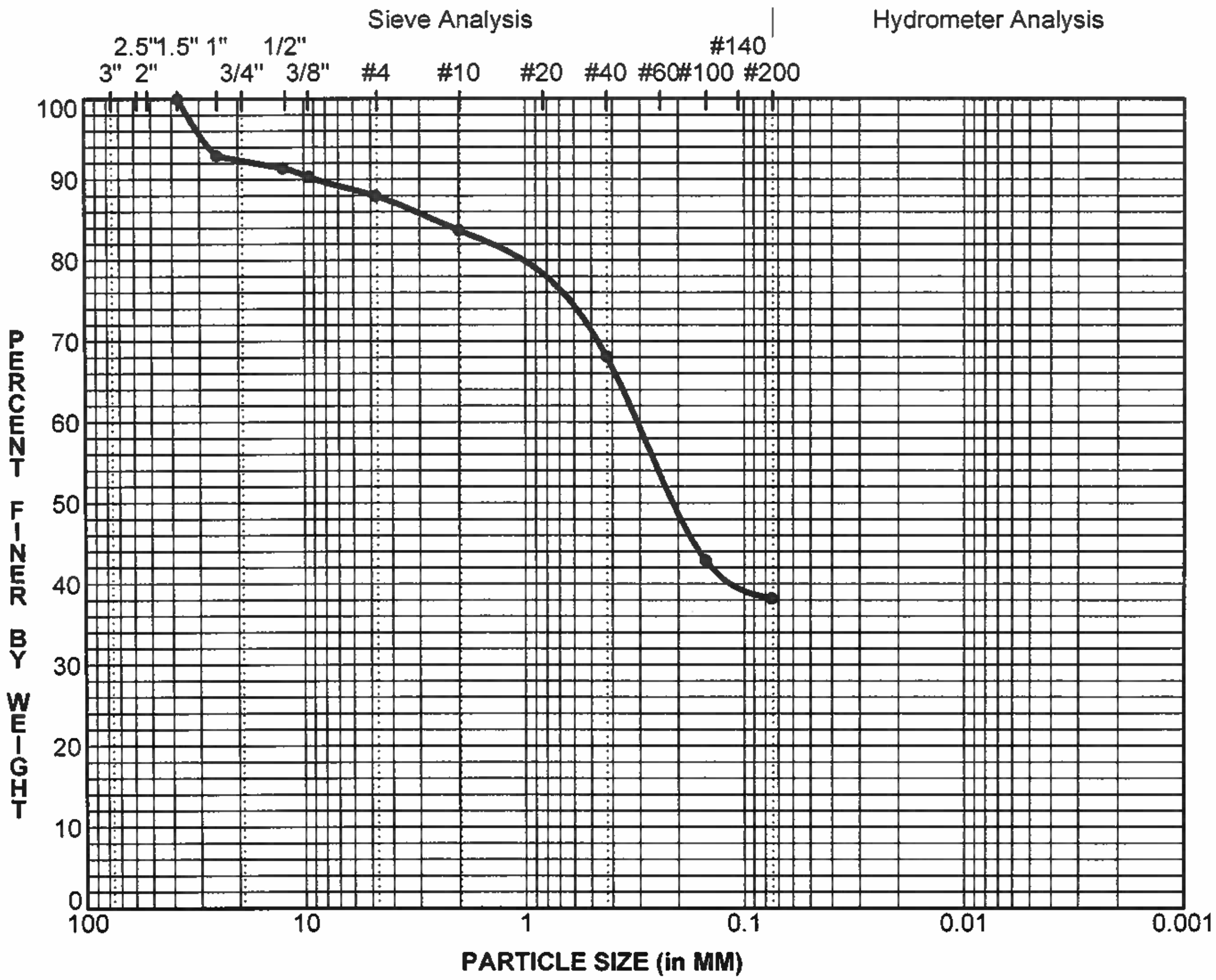
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 20



Gravel		Sand			Silt and Clay
coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	7 - 1	1.0	Brown Silty SAND (SM) with Gravel	18					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt & Clay
●	7 - 1	1.0	37.5	0.3			12	50	38

F.G.E. Ltd.

GRAIN SIZE DISTRIBUTION

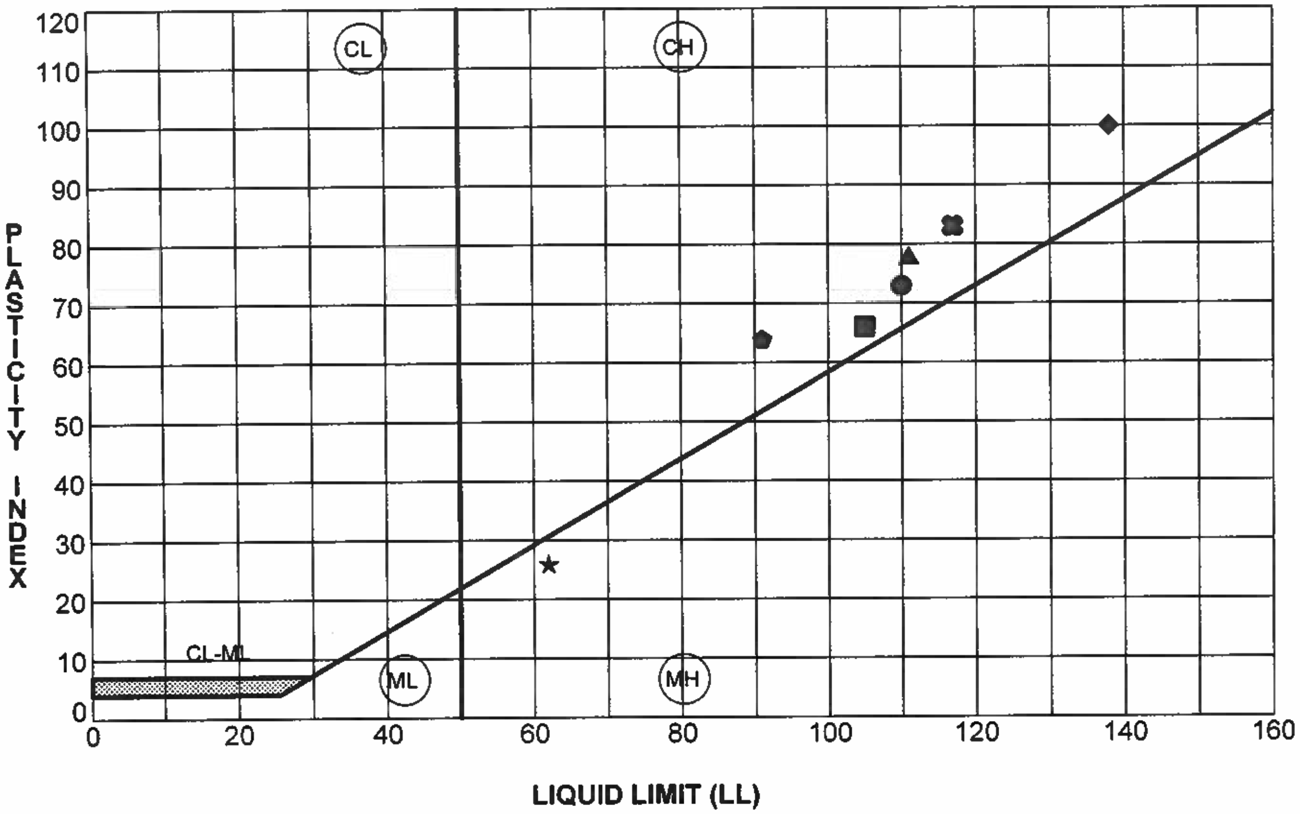
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 21



Sample ID	Depth (ft)	LL	PL	PI	Classification
● 1 - 4	8.5	110	37	73	Gray/Brown Multi-Colored Silty CLAY (CH)
■ 2 - 2	3.0	105	39	66	Dark Brown Silty CLAY (CH)
★ 3 - 2	3.0	62	36	26	Light Brown Clayey SILT (MH)
◆ 4 - 4	8.5	138	38	100	Gray/Yellowish Brown Silty CLAY (CH)
▲ 5 - 2	3.0	111	33	78	Gray Multi-Colored Silty CLAY (CH)
⬟ 6 - 1	1.0	91	27	64	Brown Silty CLAY (CH)
✖ 7 - 3	5.5	117	34	83	Brown Multi-Colored Silty CLAY (CH)

F.G.E. Ltd.

PLASTICITY INDEX CHART

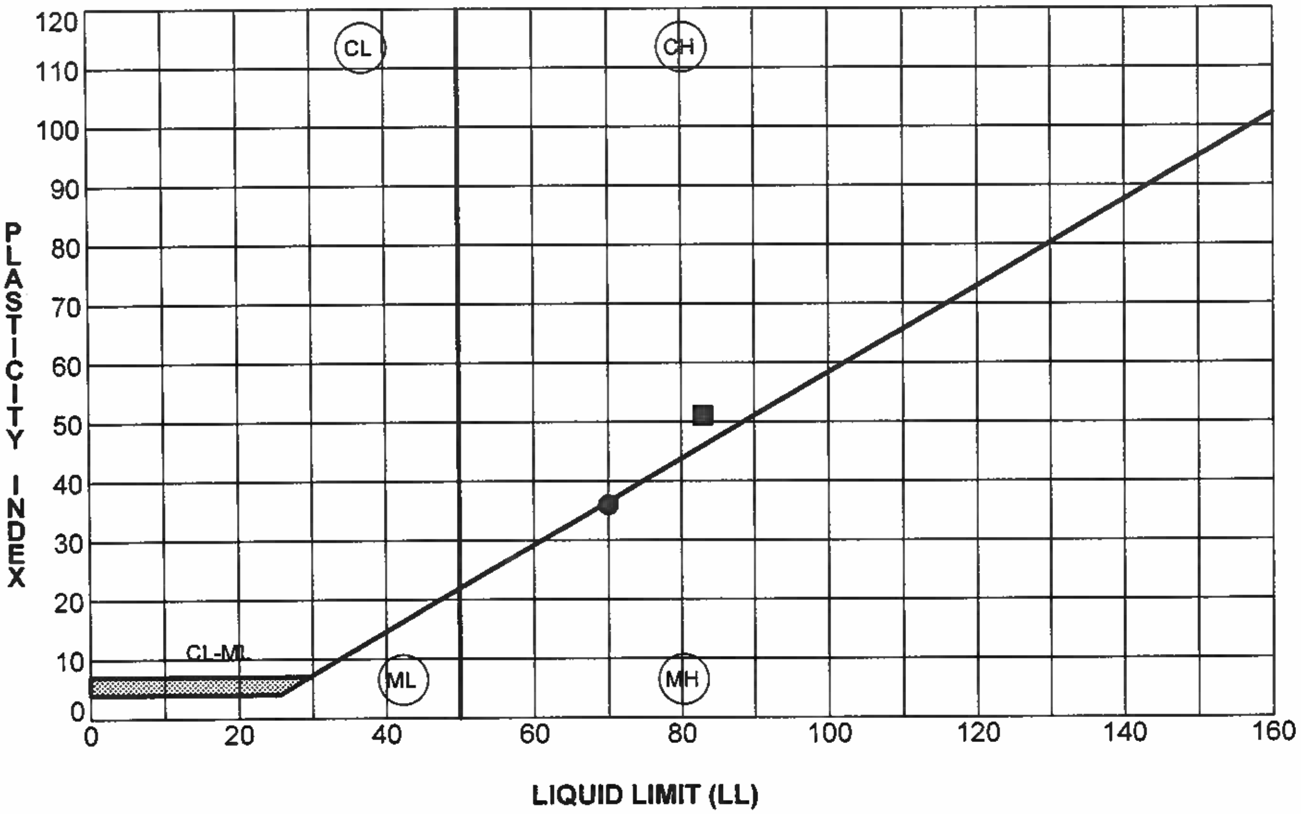
Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 22



	Sample ID	Depth (ft)	LL	PL	PI	Classification
●	BAG A	0.0	70	34	36	Brown CLAY (CH)
■	BAG B	0.0	83	32	51	Brown CLAY (CH) with Sand

F.G.E. Ltd.

PLASTICITY INDEX CHART

Kakaina Subdivision

Waimanalo, Oahu, Hawaii

File: 2760.01

July 2007

Figure 23

TABLE I

Summary of Laboratory Test Results

Sample No.	Depth (ft)	Moisture Contents (%)	Dry Density (pcf)	Direct Shear C (psf)	Direct Shear Ø (Degrees)	Liquid Limit	Plasticity Index	Gradation Gravel (%)	Gradation Sand (%)	Gradation Silt/Clay (%)	Torv. (psf)	% Swell (Surch.)	Swell Index
1-2	3.0	41	79									7.9 (100)	0.51
1-3	5.5	43	78	800	4°						>5,000	3.7 (100)	0.21
1-4	8.5	45	73			110	73				>5,000		
1-5	13.5	45	74								4,800		
1-6	18.5	57	67								2,000		
1-7	23.5	62	64					0	34	66	720		
1-8	28.5	54	69								2,950		
2-2	3.0	46	76			105	66				4,950	1.5 (100)	0.40
2-3	5.5	40	76								4,000		
2-4	8.5	40	79								>5,000		
2-5	13.5	47	74								4,100		
2-6	18.5	66	62					0	56	44			
3-1	1.0	42	76								4,200		
3-2	3.0					62	26						
3-3	5.5	52	69	640	11°						2,500	6.8 (100)	0.77
3-4	8.5	52	70								3,850		
3-5	13.5	55	70								2,800		
3-6	18.5	54	64								2,200		
3-7	23.5	59	67								860		
3-8	28.5	58	66								2,450		

TABLE I (Continued)

Summary of Laboratory Test Results

Sample No.	Depth (ft)	Moisture Contents (%)	Dry Density (pcf)	Direct Shear		Liquid Limit	Plasticity Index	Gradation			Torv. (psf)	% Swell (Surch.)	Swell Index
				C (psf)	Ø (Degrees)			Gravel (%)	Sand (%)	Silt/Clay (%)			
4-2	3.0	49	72								2,900		
4-3	5.5	50	72								4,100	5.9 (100)	0.38
4-4	8.5	60	64			138	100				4,900		
4-5	13.5	62	63								2,700		
4-6	18.5	67	62										
5-1	1.0	51	68								2,550	3.5 (100)	0.39
5-2	3.0	48	72			111	78				2,650		
5-4	8.5	62	63	1,050	12°							3.0 (100)	0.48
5-5	13.5	52	73								3,250		
5-6	18.5	64	63								1,950		
5-7	23.5	61	66					0	25	75	1,500		
5-8	28.5	65	61								1,700		
6-1	1.0					91	64						
6-2	3.0	52	69								1,850	0.9 (100)	0.25
6-3	5.5	---	---								>5,000		
6-4	8.5	58	66	960	3°						3,750	7.3 (100)	0.77
6-5	13.5	50	72								2,800		
6-6	18.5							0	35	65			
7-1	1.0							12	50	38			
7-3	5.5	38	85			117	83					1.3 (100)	0.12

TABLE I (Continued)

Summary of Laboratory Test Results

				Direct Shear				Gradation					
Sample No.	Depth (ft)	Moisture Contents (%)	Dry Density (pcf)	C (psf)	Ø (Degrees)	Liquid Limit	Plasticity Index	Gravel (%)	Sand (%)	Silt/Clay (%)	Torv. (psf)	% Swell (Surch.)	Swell Index
7-4	8.5	44	75								5,000		
7-5	13.5	55	67								4,750		
7-6	18.5	60	66								840		

TABLE II

Summary of Laboratory CBR Test Results

Sample No.	Depth in feet	In-Situ Moisture Cont.(%)	Max. Dry Density (pcf)	Opt. Moist. Cont.(%)	Liquid Limit	Plasticity Index	USC	Comp. Moist. (%)	Relative Compaction (%)	CBR	CBR Swell (%)
Bag A	0-1.0	35	89	32	78	44	CH	32	99	4.0	5.0
Bag B	0-1.0	33	91	28	83	51	CH	28	97	1.9	11.5

APPENDIX C

Limitations

This report has been prepared for the exclusive use of **Akinaka & Associates, Ltd.** for the site of the **Kakaina Subdivision** in Waimanalo, Oahu, Hawaii. In the performance of the investigation and the preparation of this report, we have strived to perform our services in a manner consistent with that level of care and skill ordinarily exercised by members of the geotechnical profession practicing under similar conditions in Hawaii. No other warranty, either expressed or implied, is made.

The analysis, conclusions, and recommendations submitted in this report are based in part upon the data obtained in the test borings and upon the assumption that the soil conditions do not deviate from those observed. If any variations or undesirable conditions are encountered during construction, or if the proposed construction will differ from that planned at the present time, Fewell Geotechnical Engineering, Ltd. (FGE) should be notified so that supplemental recommendations can be given. The conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report modified or verified in writing.

Unanticipated soil conditions are commonly encountered and cannot be fully determined by soil samples, test borings, or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Some contingency funds are recommended to accommodate such potential extra costs.

The site investigation may not have disclosed the presence of underground structures, such as cesspools, drywells, storage tanks, etc. that may be present at the site. Should these items be encountered during construction, FGE should be notified to provide recommendations for their disposition. The cost for these services was not included within the fee for this investigation.

The scope of work for this investigation was limited to conventional geotechnical services and did not include botanical, environmental or archeological assessments or evaluations. Silence in the report regarding any archeological, environmental or botanical aspects of the site does not indicate the absence of potential botanical environmental or archeological problems.

The boring locations were staked out in the field using tape measurements from the visible physical features shown on the April 13, 2007 Preliminary Plan provided by AAL. Ground surface elevations were estimated from the Preliminary Plan. The locations and elevations of the borings should be considered accurate only to the degree implied by the methods used.

Groundwater or seepage was encountered in all of the borings at the dates and times indicated on the Boring Logs. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall and other factors not present at the time the measurements were made.

FGE should be provided the opportunity for general review of the final design drawings and specifications to verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design and specification. If FGE is not accorded the privilege of making this recommended review, it can assume no responsibility for misinterpretations of the recommendations.

FGE should also be retained to provide periodic soil engineering services during construction. This is to observe compliance of the design concepts, specifications, and recommendations and to allow design changes in the event the subsurface conditions differ from that anticipated prior to construction. The recommendations contained herein are contingent upon adequate construction monitoring of the geotechnical phases of the construction by FGE.