FEWELL GEOTECHNICAL ENGINEERING, LTD.

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SUBSURFACE INVESTIGATION REPORT

MAKUU 844' 1.0 M.G. RESERVOIR
MAKUU OFFSITE WATER SYSTEM, PHASE 2
PAHOA, HAWAII, HAWAII

for

AKINAKA & ASSOCIATES, LTD.

by

FEWELL GEOTECHNICAL ENGINEERING, LTD.

NOVEMBER 2, 2004

Important Information About Your
Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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Telephone: 301/565-2733 Facsimile: 301/589-2017
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File 2460.01
November 2, 2004

Akinaka & Associates, Ltd.
3049 Ualena Street, Suite 500
Honolulu, Hawaii 96819-1947

Attention: Mr. Sheldon Yamasato
President

Subject: **Subsurface Investigation Report**
Makuu 844' 1.0 M.G. Reservoir
Makuu Offsite Water System, Phase 2
Pahoa, Hawaii, Hawaii

We have completed a subsurface investigation for the proposed Makuu 844' 1.0 M.G. Reservoir of the Makuu Offsite Water System, Phase 2, project in Pahoa, Hawaii, Hawaii. This report summarizes our findings and conclusions and presents geotechnical recommendations for the design and construction of the proposed water tank. This work was completed in general accordance with our June 6, 2003 Proposal and your September 16, 2004 Notice to Proceed.

Project Description – The site of the proposed Makuu 844' 1.0 M.G. Reservoir is at the end of a rough-graded access road extending about 1 mile southwest of the end of Kauakai Place in Pahoa. The general area is shown on the attached Project Location Map, Figure 1.

The site is in an undeveloped area, which was recently cleared to provide access. The existing ground surface within the new reservoir site is slightly undulating with existing ground surface elevations varying from about Elev. 831 on the southern edge of the reservoir pad, down to about Elev. 827 on its northwestern edge.

The preliminary plans indicate that the tank will be a 100-foot diameter, 1.0 million gallon (M.G.) concrete tank constructed with a finish floor level at Elev. 824. Additional improvements will include a well pump, small control building, an asphalt-paved access road for maintenance, and a 12-inch diameter water line extending from the new reservoir to the existing 605' 0.5M.G. Reservoir.

We understand that the tank's column and wall loads are not anticipated to exceed 50 kips and 2 kips per foot, respectively. Based on the tank capacities and planned diameters, we have assumed that the tank will hold up to about 20 feet of water, resulting in a tank floor load of about 1,250 pounds per square foot (p.s.f.).

The preliminary plans indicate that site grading will consist of cuts of between 3 and 7 feet in depth throughout the reservoir pad to attain the finish floor level. Graded slopes are planned to support the grades differences resulting from the pad grading.

Subsurface Investigation – Three test borings were drilled on September 27 and 28, 2004, at the approximate locations shown on the attached Site and Boring Location Plan, Figure 2. The borings were extended to depths of between 9.0 and 24.5 feet below the existing ground surface with a Mobile B-34 truck-mounted drilling rig advancing 4-inch diameter continuous flight augers and NX coring equipment. A percolation hole was drilled to a depth of 4 feet below the existing ground surface and its location is also shown in Figure 2. The materials encountered in the test borings and percolation hole are shown in the Boring and Percolation Hole Logs, Figures 3 through 6. A Boring Log Legend is included as Figure 7.

Due to the rocky nature of the materials encountered throughout the depths of the borings and percolation hole, laboratory testing was not appropriate.

Percolation Testing – A falling head percolation test was performed in the percolation hole on September 29, 2004. The test consisted of filling the percolation hole with water and measuring the drop in water level at various time intervals. The percolation test indicated a slow percolation rate of over 34 minutes per inch (m.p.i.). The percolation test results are presented in the attached Figure 8.

General Subsurface Conditions - The subsurface investigation indicates that the reservoir site is underlain by intact basalt, which is exposed at the ground surface throughout most of the site. The basalt extends to the bottom of all of the borings at depths of 9.0 to 25.5 feet below the existing ground surface. Discontinuous thin surface layers of loose gravel- and cobble-sized rock fragments with varying amounts of clayey silt ash were observed in random areas of the site. These surface layers appear to be less than 12 inches in thickness.

The near-surface basalt is moderately to slightly weathered, highly vesicular basalt, which is medium hard. The deeper basalt generally grades to slightly weathered to fresh and hard. Most of the basalt is occasionally broken to massive with thin layers of broken rock. Rock Quality Designations (RQD's) ranged from 0 to 100 percent, though generally above 70 percent.

Groundwater was not encountered in any of the borings during this investigation.

Discussion - We believe that the site can be adequately developed to support the proposed water tank provided the recommendations of this report are followed. The subsurface investigation has revealed that the site is overlain by a thin, discontinuous layer of surface ash and clinker over massive basalt, which should provide excellent support for the proposed tank and related site improvements.

The main geotechnical concerns associated with the proposed construction are the excavation characteristics of the basalt. Based on the proposed finish floor level at Elev. 824, it appears that cuts of between 3 and 7 feet will be necessary to attain the finish pad grade for the tank. The pad grading should remove the thin layer of surface ash and clinker and extend into the massive basalt. The use of heavy rock excavating equipment, such as large ripper-equipped dozers and trackhoe-mounted hoerams, should be anticipated to facilitate the removal of the rock within the tank pad and for the trench excavations for the water lines associated with the tank.

Although no voids or cavities were indicated in the borings of this investigation, voids are commonly found in the rock formations similar to those at the site. The foundation excavations should be probed with a small-diameter air track drilling rig to evaluate the possible presence of voids beneath the foundations. Any voids encountered should be filled with lean concrete, prior to the construction of the tank foundations.

Recommendations

Site Preparation - Prior to the start of the actual grading operations, the site should be cleared and grubbed to remove the surface vegetation, organics, and other deleterious materials. This material would be unsuitable for use as fill, and should be wasted off site. The clearing and grubbing should be done in accordance with Section 201 of the 1994 State of Hawaii Standard Specifications for Road, Bridge, and Public Works Construction (Standard Specifications).

Site Grading - After the site preparation has been completed, the grading operations may begin to generate the planned finished grades. The use of heavy rock excavating equipment, such as large ripper-equipped dozers and trackhoe-mounted hoerams, should be anticipated to facilitate the removal of the hard massive basalt, which was encountered at depths of less than 1 foot in the test borings and is exposed at the ground surface throughout most of the general site area.

After the site grading has attained the finish subgrade levels, the tank pad should be proof-rolled to determine if any loose clinker pockets, soft spots, or large voids in the underlying rock exist. The proof-rolling should consist of at least 6 passes of a D-9 dozer, or equivalent, and should extend at least 5 feet laterally beyond the perimeter of the tank and its foundations. Any pockets of ash or loose clinker encountered during the proof-rolling operations should be removed down to the underlying basalt, and the resulting depression backfilled in accordance with these recommendations. Where cavities or voids within the rock are encountered, they should be filled with low-strength concrete. Should larger, i.e., greater than 2 feet in depth, voids or cavities be encountered, FGE, Ltd. should be notified for additional recommendations.

The excavated surface ash and clinker may be re-used as fill and backfill provided all vegetation, deleterious materials, and soil clods and rock particles greater than 3 inches in diameter are removed and they are placed and compacted in accordance with these recommendations. The excavations within the basalt will likely generate mainly large cobble- and boulder-sized rock fragments, which are unsuitable for use in thin fills or as utility trench backfill, without significant crushing.

Due to the relatively insignificant amounts of the surface soils and the oversized materials anticipated to be generated from the rock excavations, the use of imported fill should be anticipated to complete the site grading and for utility trench backfill. Imported fill should consist of low expansion granular soil, free of organics, rocks and clods greater than 3 inches in diameter. It should possess a Plasticity Index of less than 10 and no more than 1.5 percent swell when tested in accordance with ASTM D1883.

Fill and backfill should be placed in relatively level lifts no greater than 8 inches in loose thickness, moisture conditioned to within 3 percent of its optimum moisture content, and uniformly compacted to at least 95 percent relative compaction.

Cut slopes within the basalt should be sloped no steeper than 1 Horizontal to 1 Vertical (1H:1V) for slope heights of up to 5 feet. Slopes exceeding this height are not anticipated at this time and should be individually evaluated, should they occur.

Foundations – We believe that the proposed tank may be adequately supported on a foundation system consisting of individual spread foundations and either a continuous ring footing or thickened-edge slab foundation founded on the intact basalt. The control building should be supported on similar shallow foundation systems bearing on intact basalt.

Foundations bearing upon the basalt may be designed for an allowable bearing pressure of 8,000 p.s.f. This value may be increased by one-third for short term transient loadings. Individual spread foundations should have a minimum base width of 18 inches. Continuous strip footings and thickened-edge foundations should have a minimum width of 12 inches. Foundations should be embedded at least 6 inches into the basalt.

The foundations should bear entirely on the massive basalt. Should both soil and rock be encountered in the footing excavations, the foundation embedment should be increased such that the entire foundation is bearing upon basalt.

The bottom of the foundation excavations for the new reservoir should be probed to a depth equal to one footing width, or to a minimum depth of 8 feet below the bottom of foundation level, to detect the possible presence of voids beneath the foundations. At least one probe should be drilled near the center of each individual spread foundation, and one probe drilled every 10 feet along the tank's perimeter foundation. Any voids detected during the probing operations should be filled with lean concrete.

The bottom of all footing excavations should be cleaned out of all loose material, prior to the placement of reinforcing steel and concrete. Steel reinforcement of the foundations should be provided in accordance with the recommendations of the Project Structural Engineer

Total and differential settlements exceeding 1/4 inch are not anticipated for foundations designed and constructed in accordance with these recommendations and the assumed loading conditions indicated previously in this report. Should the actual tank loads exceed these assumed loads, FGE, Ltd. should be notified so that additional recommendations can be provided, if necessary.

Concrete Slabs-on-Grade - Concrete slabs-on-grade may be used for the tank floor provided the grading recommendations of this report are followed. This will assure that the slab subgrade consists of intact basalt, or granular fill, which has been uniformly compacted to at least 95 percent relative compaction.

The concrete slab should be underlain by at least 6 inches of Aggregate for Untreated Base (UTB). The UTB should conform to Section 703.06 of the Standard Specifications and should be compacted to at least 95 percent relative compaction as determined by ASTM D 1557. Where intact basalt is encountered at the subgrade level beneath the tank floor slab, it should be over-excavated sufficiently to allow placement of the base course material.

Steel reinforcement of the concrete slabs should be provided in accordance with the recommendations of the Project Structural Engineer.

Utilities - Utilities should be installed and backfilled in accordance with the Grading Recommendations of this report and the specific requirements of each particular utility. Utility backfills should be placed and compacted utilizing the appropriate mechanical compactors around and above the pipes. Jetting or ponding of the backfill as a method to achieve compaction should not be allowed.

Utilities may be founded in properly compacted fill or the intact basalt. Where soft spots are encountered at the bottom of utility excavations, they should be removed down to the properly compacted fill or intact basalt and the resulting depression backfilled in accordance with the Grading Recommendations. Where boulders or intact basalt are encountered at the utility invert level, they should be overexcavated sufficiently to allow the placement of the appropriate thickness of bedding indicated in the Standard Specifications. At least 6 inches of pipe cushion should be placed beneath the pipes founded in basalt.

The use of rock excavating equipment should be anticipated to facilitate the removal of intact rock encountered in the utility trenches.

Quality Control - The site preparation and site grading should be observed by FGE, Ltd. to verify that the anticipated subsurface materials are encountered during construction and that the earthwork operations are being performed in accordance with the recommendations of this report. Intermittent field density tests should be taken to determine whether the specified levels of compaction for the fills and backfills are consistently obtained. Samples of the proposed fill materials should be submitted to FGE, Ltd. no less than 7 working days prior to their intended jobsite delivery to allow adequate time for testing, evaluation, and approval.

Foundation excavations, and the foundation probing operations, should be observed by FGE, Ltd. prior to the placement of reinforcing steel to determine whether the anticipated bearing materials have been encountered. The recommendations contained herein are contingent on adequate monitoring of the geotechnical phases of the construction by FGE, Ltd.

Limitations - This report has been prepared for the exclusive use of **Akinaka & Associates, Ltd.** for the proposed **Makuu 844' 1.0 M.G. Reservoir** of the Makuu Offsite Water System, Phase 2, project in Pahoa, Hawaii, Hawaii. In the performance of our work and the completion 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, expressed or implied, is made.

The analysis, conclusions, and recommendations of this report are based in part upon the data obtained in the test borings and 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, FGE, Ltd. should be notified so that additional 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 are modified or verified in writing.

The site investigation for this report 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, Ltd. 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 any environmental evaluations or assessments. Silence in the report regarding any environmental aspects of the site does not indicate the absence of potential environmental problems.

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 boring locations were staked in the field based on measurements from reference stakes established in the field by the Project Surveyors. The ground surface elevations of the borings were estimated based on the available topographic plans. The locations and elevations of the borings should be considered accurate only to the degree implied by the methods used.

Groundwater was not encountered in any of the borings at the time of this investigation. However it should be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperatures and other factors not present at the time the measurements were made.

FGE, Ltd. 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 specifications. If FGE, Ltd. is not accorded the privilege of making this recommended review, it can assume no responsibility for misinterpretation of the recommendations.

FGE, Ltd. 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 in this report are contingent on adequate construction monitoring of the geotechnical phases of construction by FGE, Ltd.

We appreciate the opportunity to be of service to you and look forward to continuing our work with you on this and future projects. Should you have any questions regarding this report, or any aspects of the services which we provide, please do not hesitate to contact us.

Respectfully submitted,

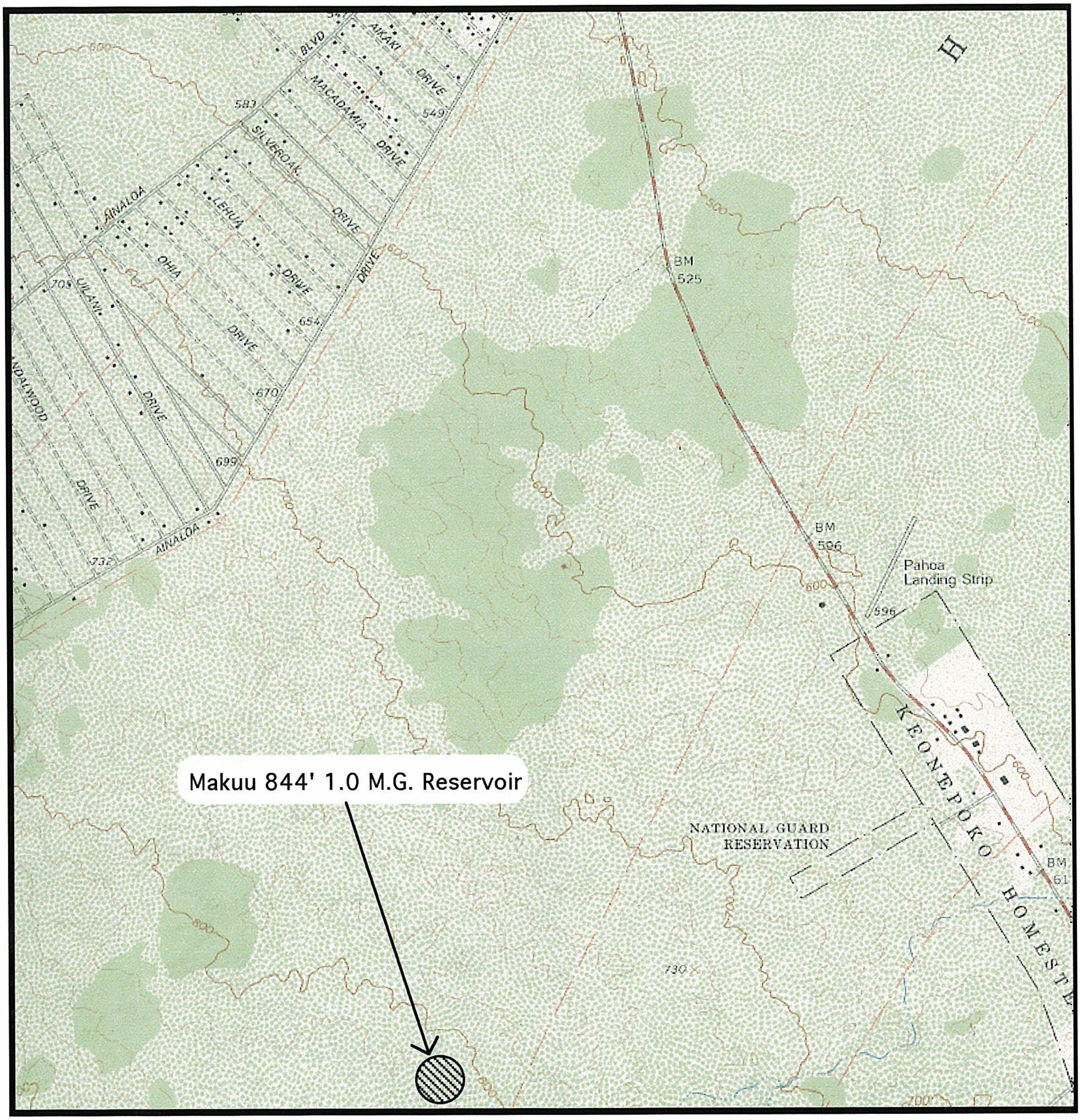
FEWELL GEOTECHNICAL ENGINEERING, LTD.

By Timothy J. Cavanaugh, P.E.

TIMOTHY J. CAVANAUGH
LICENSED PROFESSIONAL ENGINEER
No. 6619-C
HAWAII, U.S.A.

tjc:ajs:fse

Attachments



LEGEND:

PROJECT LOCATION

SCALE: 1: 24000

GENERAL AREA:

PAHOA, HAWAII, HAWAII

REFERENCE:

PAHOA NORTH QUADRANGLE
U.S.G.S. TOPOGRAPIC MAP

F.G.E. Ltd.

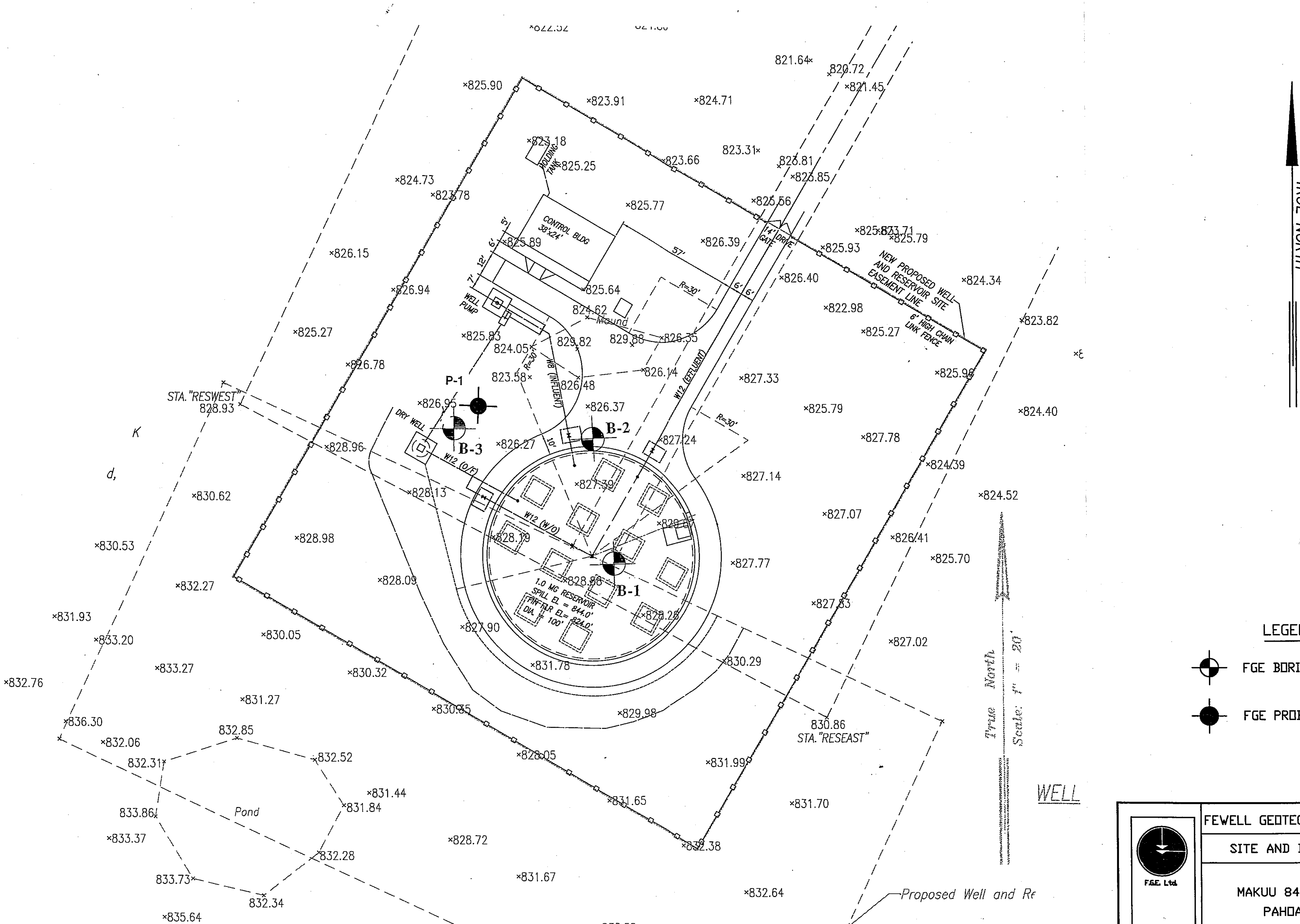
PROJECT LOCATION MAP

Makuu 844' 1.0 M.G. Reservoir
Pahoa, Hawaii, Hawaii

File: 2460.01

November 2004

Figure 1



LEGEND

- FGE BORING LOCATION
- FGE PROBE LOCATION

F.G.E. Ltd. 96-1416 VAIHONA PLACE PEARL CITY HAWAII 96782-1973	FEWELL GEOTECHNICAL ENGINEERING, LTD.
	SITE AND BORING LOCATION PLAN
	MAKUU 844' 1.0 M.G. RESERVOIR PAHOA, HAWAII, HAWAII
	FILE: 2460.01 NOVEMBER 2004
	FIGURE 2

REFERENCE: PLAN PROVIDED BY: AKINAKA & ASSOCIATES, LTD. (7/28/04)

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

Boring: 1
Project: Makuu 844' 1.0M.G. Reservoir Phase 2
Location: Pahoa, Hawaii, Hawaii
Surface Elevation: 828' ±
Depth to Water: None Encountered
Date Completed: 9-28-04

File: 2460.01
Project Engineer: TJC
Field Engineer: TJC
Drafted by: CPD
Date of Drawing: November 2004

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
			90%REC 53%RQD	NX CORE		Gray Slightly Weathered Highly Vesicular BASALT (WS), medium hard, occasionally broken to massive
					5	
			100%REC 70%RQD	NX CORE		At 7.0', grades to hard, broken
					10	
			100%REC 86%RQD	NX CORE		At 11.0', grades to massive
						Gray Fresh Slightly Vesicular BASALT (F), hard, broken At 14.5', grades to occasionally broken
					15	
			100%REC 58%RQD	NX CORE		Gray Slightly Weathered to Fresh Highly Vesicular BASALT (WS-F), medium hard to hard, broken to occasionally broken
					20	
			100%REC 93%RQD	NX CORE		At 20.5', grades to hard, massive
					25	Reddish Gray Slightly Weathered Highly Vesicular BASALT (WS), medium hard, occasionally broken
						BOH @ 25.5'
					30	
					35	

Figure 3

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

Boring:	2	**File:**	2460.01
Project:	Makuu 844' 1.0M.G. Reservoir Phase 2		
Location:	Pahoa, Hawaii, Hawaii	**Project Engineer:**	TJC
Surface Elevation:	828' ±	**Field Engineer:**	TJC
Depth to Water:	None Encountered	**Drafted by:**	CPD
Date Completed:	9-28-04	**Date of Drawing:**	November 2004

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
						Gray Moderately to Slightly Weathered Highly Vesicular BASALT (WM-WS), medium hard, occasionally broken
			75%REC 0%RQD	NX CORE	5	At 4.5', grades to Reddish Gray, broken
			100%REC 93%RQD	NX CORE		Gray Fresh Highly Vesicular BASALT (F), hard, massive
					10	
			100%REC 55%RQD	NX CORE		Reddish Gray Moderately Weathered Highly Vesicular BASALT (WM), medium hard, to hard
						Gray Slightly Weathered Highly Vesicular BASALT (WS), hard, massive
					15	
			100%REC 100%RQD	NX CORE		
					20	
			100%REC 98%RQD	NX CORE		
					25	**BOH @ 24.5'**
					30	
					35	

Figure 4

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

Boring: 3
Project: Makuu 844' 1.0M.G. Reservoir Phase 2
Location: Pahoa, Hawaii, Hawaii
Surface Elevation: 827' ±
Depth to Water: None Encountered
Date Completed: 9-28-04

File: 2460.01

Project Engineer: TJC
Field Engineer: TJC
Drafted by: CPD
Date of Drawing: November 2004

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
			41 sec. 52 sec. 112 sec. 105 sec. 54 sec. 38 sec. 128 sec. 201 sec. 235 sec.		0–9	Gray Slightly Weathered Highly Vesicular BASALT (WS), medium hard At 7.0', grades to hard
					10	**BOH @ 9.0'**
					15	
					20	
					25	
					30	
					35	

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

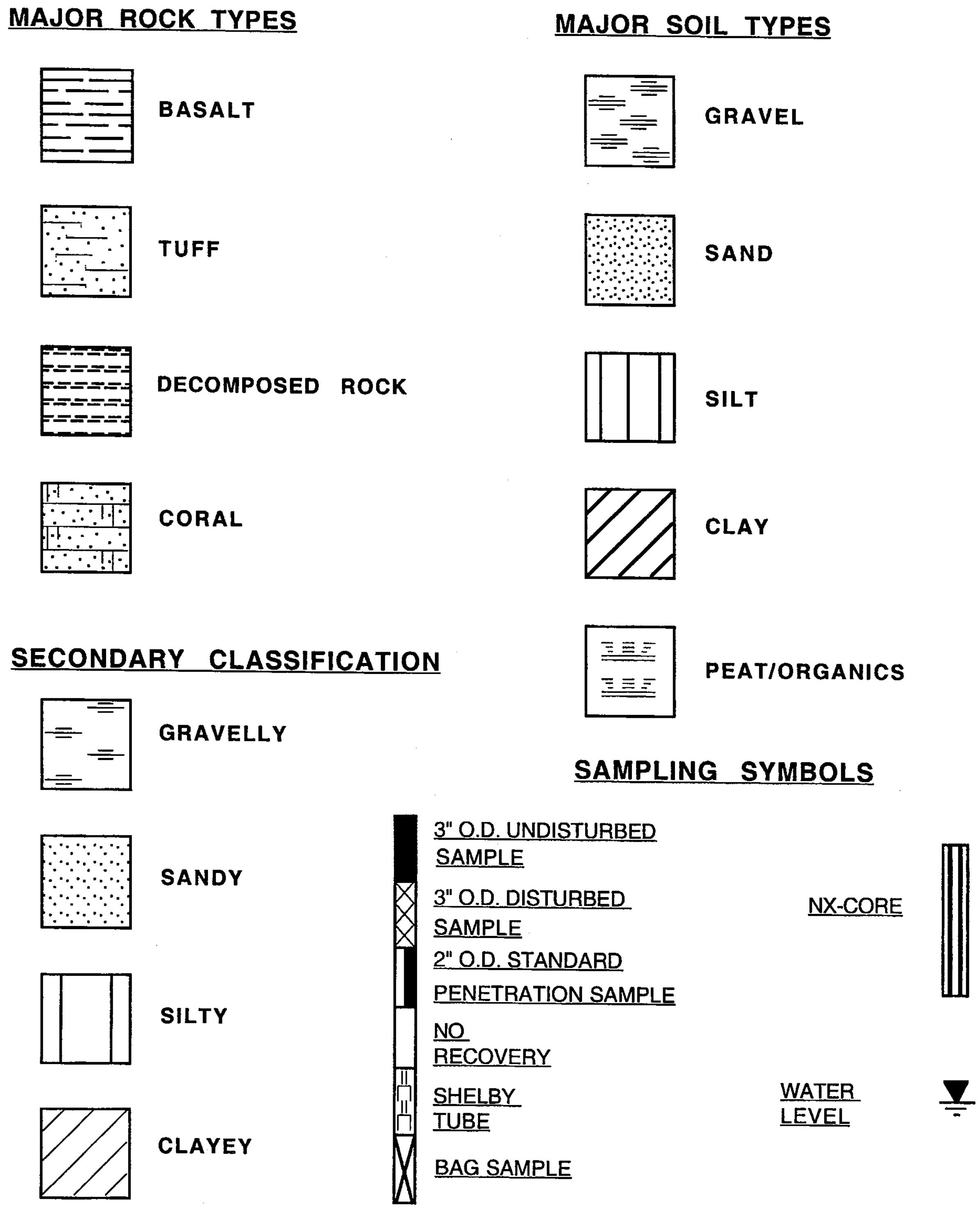
Probe: P-1
Project: Makuu 844' 1.0M.G. Reservoir Phase 2
Location: Pahoa, Hawaii, Hawaii
Surface Elevation: 827' ±
Depth to Water: None Encountered
Date Completed: 9-28-04

File: 2460.01

Project Engineer: TJC
Field Engineer: TJC
Drafted by: CPD
Date of Drawing: November 2004

LAB TEST RESULTS	MOIST CONT. %	DRY DEN. PCF	BLOWS PER FT.	SAMPLE	DEPTH	CLASSIFICATION
			42 sec.			Gray Slightly Weathered Highly Vesicular BASALT (WS), medium hard
			53 sec.			
			36 sec.			
			104 sec.			
						BOH @ 4.0'
					5	
					10	
					15	

Figure 6



F.G.E. Ltd.

TEST PIT LOG LEGEND

Makuu 844' 1.0 M.G. Reservoir
Pahoa, Hawaii, Hawaii

File: 2460.01

November 2004

Figure 7

Site Evaluation/Percolation Test

Percolation Test: P-1
Date/Time: September 29, 2004
Test Performed By: Fewell Geotechnical Engineering, Ltd.
Project: Makuu 844' 1.0 M.G. Reservoir
Owner: State of Hawaii Department of Hawaiian Home Lands
Tax Map Key: (3) 1-5-08:3 and (3) 1-5-119:51

Elevation: 827± feet
Depth to Groundwater Table: None Encountered
Depth to Bedrock (if observed): 0 feet
Diameter of Hole: 4 inches
Depth to Bottom of Hole: 4 feet below grade

Depth Below Grade	Soil Profile
0 to 4 feet	Gray Moderately Weathered Highly Vesicular Basalt

Percolation Readings

Time 12 inches of water to seep away: > 150 minutes (first trial)
Time 12 inches of water to seep away: ______ minutes (second trial)

Time Interval (minutes)	Drop in Inches	Time Interval (minutes)	Drop in Inches
30	1.25		
30	1.13		
30	0.94		
30	0.88		
30	0.88		
30	0.88		

Average Percolation Rate (time/final water level drop): 34.3 min/inch