REPORT
PRELIMINARY FOUNDATION INVESTIGATION
PROPOSED NANAKULI PD-H
LUALUALEI, OAHU,
STATE OF HAWAII

for

KEYSTONE INVESTMENT COMPANY

WILLIAM S. TSAO
Planner

ANBE, ARUGA & ISHIZU ARCHITECTS, INC.
Architects

ROY L. GARDNER & ASSOCIATES, INC.
Consulting Engineers

May 2, 1972
Project No. 175-001-01

MAURSETH, HOWE, LOCKWOOD & ASSOCIATES
Consulting Foundation Engineers & Geologists
Honolulu, Hawaii
May 2, 1972
Job No. 175-001-01

Keystone Investment Company
% Roy L. Gardner & Associates, Inc.
Arctic Building, Penthouse
Seattle, Washington 98104

Attention: Mr. Roy Gardner

Gentlemen:

The attached report represents the data, conclusions and recommendations of a preliminary investigation of the soil and foundation conditions at the site of the proposed Nanakuli PD - H to be located in Lualualei, Oahu, State of Hawaii.

The scope of services provided in this investigation was planned in a discussion with Mr. Roy Gardner. During the course of this investigation, details of our findings were discussed with Mr. William Sowers and Mr. Takashi Anbe.

Based on the findings of this investigation it is believed that the majority of the site can be developed for the intended use with structures founded on shallow, spread foundations. However, one section adjacent to the existing concrete lined drainage channel will require special consideration because of the deep deposit of soft silts. It is believed that this area can be developed for structures of one or two stories in height provided that sufficient time is allowed for settlement of newly placed fill.

This investigation was made in accordance with generally accepted engineering procedures and included such field and laboratory tests.
considered necessary in the circumstances. In the opinion of the under-
signed, the accompanying report has been substantiated by mathematical
data in conformity with generally accepted engineering principles and
presents fairly the design information requested by your organization.

Should there be any questions concerning this report, please do not
hesitate to contact us.

Very truly yours,

MAURSETH, HOWE, LOCKWOOD
& ASSOCIATES

Richard A. Martin

RAM/rk

cc: William S. Tsao & Company (1)
    Anbe, Aruga & Ishizu Architects, Inc. (1)
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INTRODUCTION

This investigation was made for the purpose of obtaining preliminary information on the subsurface soils on which to base recommendations on the foundation design for the proposed Nanakuli PD - H Project. The location of the site, relative to the existing streets and landmarks, is shown on the Vicinity Map, Plate 1, attached to this report.

SCOPE OF WORK

The scope of services provided was outlined in a proposal dated January 20, 1972. Basically, the information provided is as follows:

1. General subsurface conditions of the site.
2. The physical characteristics of the soils and rock encountered.
3. Recommended allowable bearing pressures and recommended foundation depths for shallow footings.
4. Estimated settlements of foundations and fills subjected to the design pressures.
5. Opinions on possible construction problems.

PLANNED DEVELOPMENT

It is presently planned to develop the 53 acre site for low income, multi-family housing units. In this early planning stage, the development consists of approximately 534 units.
SITE CONDITIONS

Surface

The site was once an old quarry that had been abandoned a number of years ago. Steep slopes surround the north and east property lines, and range in height to a maximum of approximately 50 feet. Cemented coral sandstone and a conglomerate of sand and gravel were exposed in these slopes. The surface is covered with numerous humps which appear to be boulders or hard cemented lumps which were wasted in the quarry operation. The majority of the site is covered by the coral limestone and sandstone.

Geology

The general Lualualei - Nanakuli area, in the coastal regions, was once a part of the ocean floor. Ledge coral was developed in the lower regions of the Lualualei Valley when the ocean level stood at a higher elevation. Underlying the ledge coral is the basalt of the Waianae Range.

Subsurface

The subsurface conditions at the site were explored to collect foundation engineering data by drilling seven borings to depths ranging from 12 to 65 feet. The location of these borings is presented on the Plot Plan, Plate 2. Detailed logs of the borings are presented in Appendix A, Field Investigation and Laboratory Testing.
In general, the majority of the site is underlain with coral limestone and sandstone. A layer of stiff clayey silt was encountered in Boring No. 2 at a depth of 10 feet, with the remainder of rock and soil in Borings No. 1 through 4 being of a coral deposit or growth.

The exception of this condition was encountered in Borings No. 5 through No. 7. As shown on the shaded area of the Plot Plan, Plate 2, and on the Log of Boring No. 5, Plate 7, a soft organic silt was encountered between 6 and 57 feet below the existing grade. It is anticipated that this area was created when the Ulehawa Stream cut a deep channel through the valley when the ocean level was at an elevation of approximately 60 feet below the present sea level. In later geologic time, the ocean level rose to approximately 25 feet above the existing sea level. During this period, it is anticipated that the steep valley was filled with this soft, dark grey, clayey silt with shells and organic matter. Below the soft deposit, a medium dense to dense silty gravel was encountered at 57 feet, and weathered basalt at a depth of 63 feet.

Water was encountered in all borings, with the exception of Boring No. 1. The depth to water in each boring is presented on the Log of Borings, Plates 3 through 9.

CONCLUSIONS AND RECOMMENDATIONS

General

Based upon the findings and observations, it is concluded that the majority of the site can be developed for multi-family housing units using
shallow foundations placed on the natural soil or coral limestone, or on a compacted fill. In the area where the soft underlying material was encountered, it is believed that this area could be utilized for the construction of one or two story housing units provided that the permanent fill and a surcharge fill is allowed to induce settlement prior to building construction.

Site Preparation and Grading

It is recommended that the site be prepared in accordance with the "Specification for Controlled Earthwork", Appendix B. It is anticipated that large boulders would be exposed when the "humps" are excavated in the mass grading. These boulders may be used in planting areas or parks, provided that the boulders are not clustered and the matrix surrounding them is well compacted. If there are no areas where substantial non-structural fill is to be placed, these boulders should be wasted from the site.

Although none were encountered or observed on the site, voids in the cemented coral have been encountered in the Nanakuli - Waianae area. Should they be encountered during construction, the openings should be ripped by a dozer, all loose or deleterious material removed, and back-filled in accordance with the suggested grading specifications. This action is recommended to reduce differential settlement between the cemented coral and the loosely filled voids.
Foundations

Where foundations rest on the cemented coral limestone, an allowable bearing pressure of 5,000 pounds per cubic foot is recommended. Where footings are resting on a compacted granular fill, specifically the on-site corals, an allowable bearing pressure of 3,000 pounds per square foot is recommended. All soft soils encountered should be removed in accordance with the "Specification for Controlled Earthwork", Appendix B.

For structures located in the area of soft underlying soils, it is recommended that the permanent fill be placed with an allowance for the anticipated settlement, and a surcharge or overload fill be placed to induce settlement. It is recommended that the total amount of new fill plus surcharge fill not exceed eight feet in height. Preliminary estimates indicate that a fill higher than eight feet would create lateral movement of the soft underlying soils, and possible damage to the existing concrete lined stream channel. The areal settlement of the soft deposit caused by the fill placement should be recorded by level readings on settlement markers established in the fill. Elevation readings on these markers should be at regular intervals to evaluate the settlement rate and to determine when settlement has been reduced to tolerable limits. An example of the estimated settlement pattern for six feet of fill within the area of Boring No. 5 is presented on Plate A.

After settlement has ceased, the overload or surcharge fill can be
removed and building construction started within one month after removal. This time lag is necessary for the area to stabilize after removal of the surcharge based on settlement records of areas having similar conditions. It is recommended that the buildings be one or two stories in height and either all on the fill or all on the firm soil. It is believed that, even though settlement records indicate consolidation of the soft underlying soil has ceased, the long term or secondary settlement could create differential settlement of a structure that is half on good firm, natural soil and partly on the area where the soft underlying materials were encountered. It is recommended that an allowable bearing capacity of 2,000 pounds be used in the area near the channel.

The bearing values presented in this report are net bearing values. The weight of the concrete foundations may be ignored in determining the column loads. The bearing value may be increased by 33 percent for momentary loads due to wind or earthquake. If any foundation is eccentrically loaded, the maximum edge pressure should not exceed the bearing pressure for permanent or for momentary loads.

Settlement of footings under the recommended design pressures founded where the underlying soils consist of the coral limestone is not expected to exceed 1/2 inch. Differential settlement between footings or various portions of the structures due to load concentrations, should be negligible.
Settlement of foundations under the recommended design pressures in areas where soft soils exist are not expected to exceed one inch. Differential settlement between footings or various portions of the structures due to load concentrations, should not exceed 1/2 inch.

Lateral loads, such as wind or seismic forces, may be resisted by the passive pressure against the footings. For design purposes, such resistance for the existing soils and any subsequent compacted fill, may be assumed to be equal to an equivalent fluid pressure of 350 pounds per cubic foot. Lateral forces may also be resisted by the friction between the floor slabs and the base course, and may be assumed to be 0.4 times the dead load.

Slopes

It appears that the existing cut slopes are stable in their present condition. Fill slopes of 2 to 1 (horizontal to vertical), or flatter are recommended to a maximum height of 10 feet. New cut slopes, provided that they are excavated in the coral limestone, may be constructed on a slope ratio of 1 to 1, no higher than 10 feet. All other cut slopes should be 2 to 1 (horizontal to vertical). Buildings or structures should not be placed closer than five feet from the face of the slope or a distance equal to the slope height, whichever is greater.

Pavements

For roads and parking lots to be used for cars or light trucks, a
section using two inches of asphaltic concrete over a six inch base course is recommended. The subgrade to a depth of six inches should be compacted to at least 95 percent of the maximum dry density as determined by the ASTM D - 1557 Method of Compaction. Where soft or loose soils exist, special consideration should be made in the design of the pavement sections or the preparation of the subgrade.

INSPECTION

During the process of construction, so as to achieve the desired results, it is recommended that the Soils Engineer be present to inspect the following operations:

1. Site Preparation
2. Placement of Fill and Backfill
3. Observation of Settlement Records
4. Inspection of Footing Excavations

REMARKS

This report is preliminary in nature, and additional probings should be made when the plans of the intended development are available. Areas between and beyond borings are assumed to be consistent with those sampled and tested. While no major changes in strata depths or thicknesses are anticipated, it should be realized that the depths to the various soil and/or rock layers will vary over the site as indicated by the findings.
This report has been compiled for the exclusive use of Keystone Investment Company. It shall not be transferred to a third party or to another project without consent and/or thorough review by this facility.

Should the project be delayed beyond the period of one year from the date of this report, the report shall be reviewed to consider possible changed conditions.

Samples obtained in this investigation will deteriorate with time and will become unsuitable for further laboratory testing within three months from the date of this report. Unless otherwise advised, the samples will be discarded at that time.

- o 0 o -

The following are included and complete this report:

Plate A - Time versus Settlement Curve

Plate 1 - Vicinity Map

Plate 2 - Plot Plan

Appendix A - Field Investigation and Laboratory Testing

Appendix B - Specification For Controlled Earthwork
Anticipated settlement near Boring No. 5 under a six foot permanent fill.

Last 1" requires two years.
APPENDIX A

FIELD INVESTIGATION AND
LABORATORY TESTING
APPENDIX A

FIELD INVESTIGATION AND LABORATORY TESTING

Field Investigation

Seven borings were drilled to depths ranging from 12 to 65 feet below grade. The borings were drilled with truck-mounted, helical auger drilling equipment, using a 4 inch diameter bit. The locations of these borings are shown on the Plot Plan, Plate 2. Detailed logs of the soils and rock encountered are presented on Plates 3 through 9.

Undisturbed samples were obtained by driving a sampling tube into the underlying soils and rock at various intervals below the surface by means of a heavy driving weight dropping on sampler rods. The sampling tube consists of a steel barrel, 2.50 inches inside diameter, with an interior lining of one inch long, thin brass rings. The sampling tube is driven approximately 18 inches into the soil and a section of the central portion of the sample is taken to the laboratory in a closely fitted, waterproof container in order to retain the field moisture until completion of the tests. The driving energy required to drive the sampler one foot into the undisturbed soil, as noted on the Log of Borings in Blows per Foot, is approximately equivalent to the Standard Penetration Test.

Laboratory Testing

Samples were selected for laboratory testing following a review of the field investigation. Tests performed included unit weight and moisture content, direct shear tests, and load-consolidation tests.
The in-place moisture content and density test of samples obtained was made to correlate between similar samples. One or more one inch long sections of the sample are cut, trimmed, weighed, oven dried, and reweighed. From these measurements, the unit weight of the solids in pounds per cubic foot and the percent of moisture are calculated. The test results are presented on the Log of Borings.

To determine the strength characteristics of the soils encountered, directed shear tests were performed. Each sample is sheared under a normal load approximately equivalent to the expected overburden. By varying the normal load on a particular sample, the internal angle of friction and cohesion may be determined. The test results are presented on the Log of Borings.

Two representative samples of the subsurface soils were tested to determine their consolidation characteristics. A one inch ring of soil is placed in the consolidation apparatus, and loads are applied in increments to the face of the specimen. Deformation or changes in thickness of the specimen are recorded at selected time intervals. Water is introduced to the sample, to prevent drying, through porous disks placed against the top and bottom faces of the specimen. From this data, settlements and time rate of consolidation are determined. The test results are presented on Plate 10.
## LOG OF BORING NO 1

**DATE DRILLED** March 27, 1972  
**EQUIPMENT USED** Truck Mounted Auger, 4" Ø  
**ELEV OF SURFACE** 21.0′

### DESCRIPTION OF SOILS

<table>
<thead>
<tr>
<th>DEPTH (FT)</th>
<th>CONFINING PRESSURE (kips/sq ft)</th>
<th>SHEAR STRENGTH (kips/sq ft)</th>
<th>DRY DENSITY (lb per cu ft)</th>
<th>PERCENT MOISTURE</th>
<th>BLOWS PER FOOT</th>
<th>CLASSIFICATION</th>
<th>COLOR</th>
<th>MOISTURE</th>
<th>CONSISTENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
<td>6.5</td>
<td>25/4&quot;</td>
<td>11/3&quot;</td>
<td>5</td>
<td>CORAL LIMESTONE</td>
<td>pale</td>
<td>moist</td>
<td>hard</td>
</tr>
<tr>
<td>0</td>
<td>70</td>
<td>38.7</td>
<td>14/6&quot;</td>
<td>(GM)</td>
<td>10</td>
<td>GRAVEL, silty, some clay</td>
<td>light</td>
<td>brown</td>
<td>dense</td>
</tr>
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</table>

End of Boring @ 15.0′  
No Water Encountered

*Reference Elevation from Topo Map by Tryck, Nyman & Hayes, Inc. Undated*
# Log of Boring No 2

**Date Drilled:** March 27, 1972  
**Equipment Used:** Truck Mounted Auger, 4" Ø  
**Elev of Surface:** 10.0'

## Description of Soils

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<tr>
<th>Class</th>
<th>Color</th>
<th>Moisture</th>
<th>Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral Limestone</td>
<td>Pale</td>
<td>Moist</td>
<td>Hard</td>
</tr>
<tr>
<td>Lenses of gravel</td>
<td>Grey</td>
<td>Wet</td>
<td></td>
</tr>
<tr>
<td>Gravel, silty, sandy (GM)</td>
<td>Light brown</td>
<td>Dense</td>
<td></td>
</tr>
<tr>
<td>Silty, clayey (MH)</td>
<td>Red</td>
<td>Stiff</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**End of Boring @ 15.0'**  
**Water Encountered @ 6.8'**

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**Keystone Investment**  
**Maurseth Howe Lockwood & Assoc.**
**LOG OF BORING NO 3**

**DATE DRILLED**  March 27, 1972  
**EQUIPMENT USED**  Truck Mounted Auger, 4" Ø  
**ELEV OF SURFACE**  9.0'

<table>
<thead>
<tr>
<th>CONFINING PRESSURE</th>
<th>SHEAR STRENGTH</th>
<th>DRY DENSITY</th>
<th>PERCENT MOISTURE</th>
<th>BLOWS PER FOOT</th>
<th>SAMPLE DEPTH IN FEET</th>
<th>CLASSIFICATION</th>
<th>COLOR</th>
<th>MOISTURE</th>
<th>CONSISTENCY</th>
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<tr>
<td>74</td>
<td>29.2</td>
<td>16</td>
<td>15/1&quot;</td>
<td></td>
<td></td>
<td>CORAL LIMESTONE</td>
<td>pale grey</td>
<td>moist</td>
<td>hard</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lenses of dense coral gravel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>31.8</td>
<td>21</td>
<td>10'</td>
<td></td>
<td></td>
<td>End of Boring @ 15.0'</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Water Encountered @ 6.3'</td>
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**KEYSTONE INVESTMENT**  
**MAURSETH HOWE LOCKWOOD & ASSOC.**  
**PLATE NO**  5  
**FILE NO**  175-001-01
**LOG OF BORING NO 4**

**DATE DRILLED** March 27, 28, 1972

**EQUIPMENT USED** Truck Mounted Auger, 4" Ø

**ELEV OF SURFACE** 18.0'

<table>
<thead>
<tr>
<th>CONFINING PRESSURE kips/sq.ft</th>
<th>SHEAR STRENGTH kips/sq.in</th>
<th>DRY DENSITY lbs per cu ft</th>
<th>PERCENT MOISTURE</th>
<th>BLOWS PER FOOT</th>
<th>SAMPLE DEPTH IN FEET</th>
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<th>MOISTURE</th>
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<tbody>
<tr>
<td>88</td>
<td>30.1</td>
<td>9</td>
<td>5</td>
<td>17/1&quot;</td>
<td>CORAL LIMESTONE</td>
<td>pale grey</td>
<td>moist</td>
<td>hard</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>20.0</td>
<td>14</td>
<td>10</td>
<td>20/0&quot;</td>
<td>thin silt lenses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>8.7</td>
<td>14</td>
<td>15</td>
<td>15/6&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>wet</td>
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</table>

**End of Boring @ 30.0'**

**Water Encountered @ 19.0'**

**KEYSTONE INVESTMENT**

**MAURSETH HOWE LOCKWOOD & ASSOC.**
**LOG OF BORING NO 5**

**DATE DRILLED** March 28, 29, 1972

**EQUIPMENT USED** Truck Mounted Auger, 4" Ø

**ELEV OF SURFACE** 5.0'

### DESCRIPTION OF SOILS

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<tr>
<th>CONFINING PRESSURE</th>
<th>SHEAR STRENGTH</th>
<th>DRY DENSITY</th>
<th>PERCENT MOISTURE</th>
<th>BLOWS PER FOOT</th>
<th>SAMPLE DEPTH IN FEET</th>
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<th>MOISTURE</th>
<th>CONSISTENCY</th>
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<tr>
<td>0.7</td>
<td>0.5</td>
<td>73</td>
<td>49.7</td>
<td>5</td>
<td>5</td>
<td>SILT, clayey, with shells and organic matter (OL)</td>
<td>dark grey</td>
<td>firm</td>
<td>firm</td>
</tr>
<tr>
<td>1.0</td>
<td>0.1</td>
<td>67</td>
<td>45.3</td>
<td>1</td>
<td>10</td>
<td>SILT, clayey</td>
<td>brown wet</td>
<td>firm</td>
<td>firm</td>
</tr>
<tr>
<td>1.5</td>
<td>0.2</td>
<td>62</td>
<td>66.1</td>
<td>2</td>
<td>15</td>
<td>sandier with depth</td>
<td>dark grey</td>
<td>soft</td>
<td>soft</td>
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<table>
<thead>
<tr>
<th>CONFINING PRESSURE</th>
<th>SHELTER</th>
<th>DRY DENSITY</th>
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<th>SAMPLE</th>
<th>ELEV OF SURFACE</th>
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<td>66.6</td>
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<td>0.4</td>
<td>66</td>
<td>56.5</td>
<td>2</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>25/2&quot;</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**CLASSIFICATION**

- **SILT**, clayey, sandy, with shells and organic matter (OL)
- **GRAVEL**, silty (GM)
- BASALT, weathered

**COLOR**

- dark grey
- grey

**MOISTURE**

- sat

**CONSISTENCY**

- very soft
- soft
- mod to dense
- hard

**END OF BORING**

- End of Boring @ 65.2'
- Water Encountered @ 2.8'

---

**KEYSTONE INVESTMENT PLATE No7 (cont)**

**MAURSETH HOWE LOCKWOOD & ASSOC.**

**FILE NO 175-001-01**
LOG OF BORING NO 6

DATE DRILLED March 30, 1972
EQUIPMENT USED Truck Mounted Auger, 4" Ø
ELEV OF SURFACE 9.0'

<table>
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<th>DEPTH IN FEET</th>
<th>CONFINING PRESSURE lbs/sq ft</th>
<th>SHEAR STRENGTH, lbs/sq ft</th>
<th>DRY DENSITY lbs per cu ft</th>
<th>BLOWS PER FOOT</th>
<th>PERCENT MOISTURE</th>
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<th>COLOR</th>
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<tbody>
<tr>
<td>0</td>
<td>80</td>
<td>41.0</td>
<td>5</td>
<td></td>
<td></td>
<td>FILL, SILT, clayey (MH)</td>
<td>brown</td>
<td>moist</td>
<td>firm</td>
</tr>
<tr>
<td>1</td>
<td>84</td>
<td>40.0</td>
<td>6</td>
<td>5</td>
<td></td>
<td>SAND, silty with gravel (SM)</td>
<td>light brown</td>
<td>mod dense</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>74</td>
<td>48.7</td>
<td>4</td>
<td></td>
<td></td>
<td>SILT, clayey (MH)</td>
<td>brown</td>
<td></td>
<td>firm</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>SiLT, clayey, with shells &amp; organic matter (OL)</td>
<td>dark grey</td>
<td>soft</td>
<td></td>
</tr>
</tbody>
</table>

End of Boring @ 12.5'
Water Encountered @ 7.8'

KEYSTONE INVESTMENT
MAURSETH HOWE LOCKWOOD & ASSOC.

PLATE NO 8
FILE NO 175-001-0
# LOG OF BORING NO 7

**DATE DRILLED:** March 30, 1972  
**EQUIPMENT USED:** Truck Mounted Auger 4" Ø  
**ELEV OF SURFACE:** 10.0'

## DESCRIPTION OF SOILS

<table>
<thead>
<tr>
<th>CONFINING PRESSURE</th>
<th>SHEAR STRENGTH</th>
<th>DRY DENSITY</th>
<th>PERCENT MOISTURE</th>
<th>BLOWS PER FOOT</th>
<th>SAMPLE DEPTH IN FEET</th>
<th>CLASSIFICATION</th>
<th>COLOR</th>
<th>MOISTURE</th>
<th>CONSISTENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>19.2</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td>FILL SAND, silty, gravelly boulder, increase in silt (SM)</td>
<td>light brown</td>
<td>moist</td>
<td>dense</td>
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<tr>
<td>82</td>
<td>33.7</td>
<td>12</td>
<td></td>
<td></td>
<td>5</td>
<td>SILT, clayey (MH)</td>
<td>brown</td>
<td>firm</td>
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<td>89</td>
<td>14.9</td>
<td>15</td>
<td></td>
<td></td>
<td>10</td>
<td>SAND, silty, with shells (SM)</td>
<td>pale grey</td>
<td>wet</td>
<td>dense</td>
</tr>
<tr>
<td>15/1&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CORAL SANDSTONE</td>
<td></td>
<td></td>
<td>hard</td>
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<tr>
<td>15/4&quot;</td>
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<td></td>
<td>20</td>
<td>End of Boring @ 14.0' Water Encountered @ 9.5'</td>
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</tr>
</tbody>
</table>
CONSOLIDATION TEST DATA

PRESSURE IN KIPS PER SQUARE FOOT

○ Boring No. 5, Sample No. 9, @ 45.9'

□ Boring No. 5, Sample No. 4, @ 10.8'

KEYSTONE INVESTMENT COMPANY

MAURSETH HOWE LOCKWOOD & ASSOC.

PLATE NO 10

FILE NO 175-001-01
APPENDIX B

SPECIFICATION FOR CONTROLLED EARTHWORK
APPENDIX B
NANAKULI PDH
SPECIFICATION FOR CONTROLLED EARTHWORK

General

The designation "controlled earthwork" is applied to cuts and fills constructed and inspected by a Soils Engineer (a registered Civil Engineer), who shall approve all fill materials, methods of placing and compacting, perform field density tests and inspection during grading. Written approval shall be issued upon completion of cuts and fills. No deviation from these specifications shall be made except upon the written approval of the Soils Engineer or other public agencies having jurisdiction.

Clearing and Grubbing

All timber, logs, trees, brush, roots, grass, buried rubbish, decayed matter, or other deleterious material within the areas effected by the grading, shall be removed or otherwise disposed of in a satisfactory manner. Areas upon which fill is to be placed shall be uniformly scarified to a depth of at least six (6) inches until free of large clods, brought to the proper moisture content and compacted until the density meets the requirements as hereinafter specified. All loose material shall be first removed, brought to the proper moisture content, and recompacted in controlled layers as hereafter specified. Loose material to be considered on this project includes the piles of fill found on the site and the soil presently occupying the cavities.
Fill Material

When the material to be used as fill contains large rocks or hard, cemented lumps that cannot be broken readily, such material shall be placed in open, non-structural fill areas or removed from the site. If placed in open areas, the boulders shall be well distributed throughout the fill and surrounded by sufficient fine soil so as to fill the interstices, and produce a dense fill without voids.

Where the fill supports structures, no rocks over three (3) inches in greatest diameter shall be used in the upper one (1) foot of the fill. All large boulders, which cannot be broken down to a maximum diameter of six (6) inches, shall be removed or stockpiled for use other than as an engineered fill. Jetting will not be permitted. All material to be used as fill shall be approved for the purpose by the Soils Engineer. The existing soils on the site, with the exception of the oversized boulders, are considered suitable for this purpose. Expansive soil can be mixed with non-expansive material in deeper fill areas, provided approval is obtained from the Soils Engineer. No soils shall be imported to the site without prior approval by the Soils Engineer.

Compaction Requirements

All fill shall be placed in uniform layers not to exceed eight (8) inches in loose thickness. Each layer shall be thoroughly compacted completely to the edge before the next layer is laid thereon. Compaction shall be
obtained with the use of conventional equipment designed for the purpose.
The incidental compaction achieved by the passage of hauling units over
the fill shall not be considered adequate.

Each layer of soil shall be brought to a moisture content sufficiently
close to "optimum moisture" to permit the required degree of compaction,
the "optimum moisture" being determined by ASTM D - 1557. If
the soils' moisture content is too low or too high, it shall be adjusted by
suitable means before placing. Compaction of each layer of fill including
slopes, berms, etc., shall be continued until the density as determined by
field tests reaches a value of at least 90 percent of the maximum indicated
by the aforementioned methods. In lieu of compacting the slopes, the
embankment may be overfilled and then cut back to adequately compacted
material.

In all cases where the ground slope is steeper than five (5) horizontal
to one (1) vertical, the existing ground shall be benced as the fill thereon
is brought up in layers. However, existing ground slopes flatter than
five (5) to one (1) shall be benced also, if the Soils Engineer considers
such to be necessary.

Cuts

All cuts shall be made to the lines and grades shown on the project
plans. All cuts shall be inspected and approved by the Soils Engineer.
Where conditions encountered require, he shall direct the necessary modifications to be made.

**Drainage**

Care shall be exercised during rough grading so that areas involved will drain properly. Water shall be prevented from running over slopes by temporary berms.

**Field Testing**

The Soils Engineer shall be notified at least two days prior to the start of grading. A pre-grading conference should be held between the parties involved so as to discuss methods of operations, site problems and scheduling. Field density tests shall be made by the Soils Engineer, subject to the approval of all public agencies having jurisdiction. When tests or inspection indicates that the density or uniformity of any portion of the fill is inadequate, that particular portion shall be removed or reworked until the required density has been satisfactorily obtained.

**Supervision**

At all times, the Contractor shall have a responsible field superintendent on the project in full charge of the work with authority to make decisions. He shall cooperate fully with the Soils Engineer in carrying out the work. Any instructions given to him by the Soils Engineer or his duly appointed representative shall be considered to have been given to the Contractor personally.
Rainy Weather

No fill shall be placed, spread or rolled during unfavorable weather. When the work is interrupted by rain, operations shall not be resumed until field tests by the Soils Engineer indicate that conditions will permit satisfactory results.