FOUNDATION INVESTIGATION
PROPOSED PLANT QUARANTINE STATION
HONOLULU, OAHU, HAWAII
FOR
STATE OF HAWAII
2-1-60-8
3927 GP
July 25, 1969

Wilson, Okamoto & Associates, Inc.
1150 South King Street
Suite 800
Honolulu, Hawaii 96814

Attention: Mr. Alvin Zane

Gentlemen:

Six copies of our report, "Foundation Investigation, Proposed Plant Quarantine Station, Honolulu, Oahu, Hawaii, for the State of Hawaii," are herewith submitted.

The scope of our work was defined in discussions with Mr. Alvin Zane. Mr. Zane provided us with a Plot Plan of the proposed construction and copies of boring logs from the nearby irradiation building. The results of our investigation were discussed with Mr. Zane prior to submitting our formal recommendations.

The proposed building can be supported on shallow spread footings. However, relatively large settlement would be anticipated unless the area is surcharged prior to construction.

If you have any questions regarding this report, please contact us for clarification.

Yours very truly,

DAMES & MOORE

JRS RJW jms
FOUNDATION INVESTIGATION
PROPOSED PLANT QUARANTINE STATION
HONOLULU, OAHU, HAWAII
FOR
STATE OF HAWAII

INTRODUCTION

Presented in this report are the results of our foundation investigation for the proposed structure to be located at the Plant and Animal Quarantine Station off of Ilalo Street. The geographical location of the site is shown on Plate 1, Map of Area. The location of the proposed structure is shown relative to the intersection of Ilalo Street and Coral Street on Plate 2, Plot Plan.

We understand that the site is to be developed for a new plant quarantine station. The site is approximately 250 by 300 feet in plan dimensions. The existing kennels and other small structures will be removed from the site. The proposed building will be a one-story structure and will impose relatively light loads. Parking areas and related facilities will be constructed in conjunction with the proposed building. Final grades will be generally higher than the existing ground surface to facilitate drainage.

The purpose of our investigation was to explore and
define the subsurface conditions and to develop foundation
design recommendations. Specifically, this report discusses
our opinions and recommendations on the following:

1) Subsurface conditions at the proposed site;
2) Earthwork recommendations;
3) Most appropriate type of foundation to fit the
   subsurface conditions;
4) Bearing pressures and estimated settlements;
5) Foundation and earthwork construction problems
   which might occur and methods of overcoming these
   problems;
6) Pavement design.

The investigation was performed by drilling three
test borings at the locations shown on the Plot Plan. The
borings range in depth from approximately 27 feet to 65 feet.
The results of our field exploration were supplemented with
information retained in our files from other projects in the
general area.

Detailed descriptions of the field exploration and
laboratory testing are presented in the Appendix of this re-
port.

**SITE CONDITIONS**

Two rows of closely spaced kennels presently occupy
the site of the proposed building. Several groups of large
- 3 -

trees exist in the structural area. A recently constructed fill for the existing irradiation building extends slightly into the northern side of the proposed building area at about elevation 6 feet. The rest of the proposed building area is flat at about elevation 4 feet.

The upper 7 to 10 feet of soil is an older coral sand and gravel fill. The fill is loose to moderately dense. Except for a lens of black sand encountered at depth in Boring 2, the natural soils underlying the fill are coral sands and silts mixed intermittently with coral gravel. The area was originally a marshland, and these natural soils vary laterally and horizontally from moderately dense to very loose and compressible. The loose soils are underlain by cemented sand and gravel rock at depths on the order of 60 feet.

The ground water table is very near to sea level. Surface drainage in the flat terrain is presently facilitated by pumping runoff water from concrete catch basins.

DISCUSSIONS AND RECOMMENDATIONS

GENERAL

Settlement is of primary concern because the subsurface soils are heterogeneous with considerable thicknesses of compressible material. The proposed building can be satisfactorily supported on shallow footings provided certain precautions are taken to minimize the settlement problem. No
major construction problems are anticipated.

EARTHWORK

The site should be graded to drain during construction in order to avoid muddy conditions in the flat terrain.

Judging from estimated existing surface elevations, a maximum of 5 feet of new fill will be placed over the old surface fill to raise the site grades to the planned elevations of 7½ feet in the parking area and approximately 9 feet in the building area. Because the existing surface fill or crust is of miscellaneous materials with extensive tree roots in some areas, we recommend the entire site be proof-rolled after existing structures have been removed and the trees have been grubbed from the area. The proof-rolling should be done with a pneumatic roller weighing at least 40 tons. All soft materials that yield under the roller should be excavated and replaced with clean granular fill. The existing surface should then be scarified to a depth of 8 inches and recompacted before any new fill is placed. The new fill should be placed in layers 6 to 8 inches thick and compacted to 90 percent of the maximum density*.

*All maximum densities in this report refer to the maximum dry density as determined by the modified AASHO (T-180).
FOUNDATION CONSTRUCTION

We believe that by utilizing a surcharge program, as described below, the proposed building can be satisfactorily supported on shallow spread footings. Column and wall footings should be designed for a maximum allowable bearing pressure of 1200 pounds per square foot. The wall footings should have a minimum width of 18 inches. The bottoms of the footings should be at least 18 inches below the surrounding grade.

We recommend that the total load exerted on the floor slab be limited to 500 pounds per square foot. The floor should be constructed of concrete with reinforcement at both the top and the bottom of the slab. We recommend that the slab be at least 6 inches thick with rigid connections to the foundation. A four-inch thick layer of granular material should be placed between the slab and the general fill to serve as a moisture break.

Utility lines should be constructed with flexible joints where they enter the building.

ESTIMATED SETTLEMENTS AND RECOMMENDED SURCHARGE PROGRAM

Because of the compressible subsoils under the existing surface fill, excessive settlements would occur under the structure if the building were constructed immediately after the site is raised to final grade. Based on an analysis of
field and laboratory data, we estimate that as much as 15 inches of settlement could occur. For this reason, we recommend that the structural area be brought to grade and surcharged for a period of time prior to construction. By surcharging the area according to the recommendations in the following paragraphs, we estimate that the total settlement can be reduced to 2 or 3 inches. Differential settlements can be expected to be less than one inch.

Based on the anticipated structural loads, we recommend that the minimum height of the surcharge should be four feet above the final grade. The full height of the surcharge should extend five feet outside the perimeter of the building area including that portion of the dock that is directly connected to the floor slab. The extended surcharged area is recommended to prevent downdrag on the building and the loading dock by differential settlement between the structural area and the parking area. The surcharge should not be closer than 20 feet from the existing irradiation building. The recommended surcharge area is delineated on the Plot Plan.

The fill that will be used to raise the grade in the parking lot can be utilized temporarily as surcharge material in the building area. We estimate this fill will be sufficient to provide approximately two feet of surcharge. The surcharge can probably be raised an additional two feet if existing fill
is borrowed from the vicinity of the planned parking lot immediately northeast of the proposed building. The borrow area should be scraped to a level surface to facilitate the construction of homogeneous fill when the material is returned to the parking area.

Our experience in this area indicates that approximately 90 percent of the total settlement can be expected to occur within one to three months after the loads are applied. We recommend that settlement gages be installed in the surcharge fill to provide accurate indication of the rate and amount of settlement. These gages should extend through the surcharge to the original ground surface. A qualified soils engineer should design the observation program and interpret the results.

The weight of the new fill placed in the parking area will produce settlement of any existing utility lines. In addition, the surcharge and structural loads imposed on the general area may cause slight settlement under the existing irradiation building. It should be pointed out that additional settlement could occur under the proposed new structure if future fill construction is undertaken in adjacent areas.

PAVING

It is assumed that traffic over the paved parking facilities and driveways will be moderate with occasional heavy
truckloads. Provided the pavements are constructed over compacted fill as described under earthwork, it is considered that a 6-inch select base course under a 2-inch asphalt layer will support the moderate traffic loads with minimal maintenance. Paving should be delayed as long as possible to allow the new fill to settle.

- o0o -

The following Plates and Appendix are attached and complete this report:

<table>
<thead>
<tr>
<th>Plate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate 1</td>
<td>Map of Area</td>
</tr>
<tr>
<td>Plate 2</td>
<td>Plot Plan</td>
</tr>
<tr>
<td>Appendix</td>
<td>Field Exploration and Laboratory Testing</td>
</tr>
</tbody>
</table>

Respectfully submitted,

DAMES & MOORE

JRS RJW jms
APPENDIX

FIELD EXPLORATION AND LABORATORY TESTING

FIELD EXPLORATION

Three borings were drilled at the locations shown on the Plot Plan to explore the subsurface conditions at the site. Boring 3 was drilled slightly outside the building perimeter because existing structures prevented access to the planned locations at the south end of the structural area. The drilling was accomplished with truck-mounted rotary drilling equipment. The borings were logged by one of our engineers at the site. Representative samples were extracted from the borings for classification and laboratory testing. The samples were obtained using a Dames & Moore Type U sampler illustrated on Exhibit A-1. Descriptions of the subsurface materials encountered are presented graphically on the Log of Borings, Plates A-1A through A-1C of this appendix. The materials encountered at the site were classified in accordance with the Unified Soil Classification System shown on Plate A-2.

LABORATORY TESTING

Direct shear tests were performed on selected samples to determine the strength characteristics of the subsurface materials at the site. The method of performing this strength test is described on Exhibit A-2. The results of the strength tests are listed below.
A consolidation test was performed on a sample of compressible material from Boring 2 to determine settlement characteristics. The method of performing this test is described in Exhibit A-3. A plotted curve representing the consolidation test data is presented on Plate A-3, Consolidation Test Data.

Moisture and density determinations were made on most samples to correlate vertical and horizontal variations in engineering characteristics of the subsoils. The results of these tests are presented on the Log of Borings.
The following Exhibits and Plates are attached and complete this Appendix:

Exhibit A-1 - Soil Sampler Type U
Exhibit A-2 - Method of Performing Direct Shear and Friction Tests
Exhibit A-3 - Method of Performing Consolidation Tests
Plate A-1A - Log of Borings, Boring 1
Plate A-1B - Log of Borings, Boring 2
Plate A-1C - Log of Borings, Boring 3
Plate A-2 - Unified Soil Classification System
Plate A-3 - Consolidation Test Data
SOIL SAMPLER TYPE U
FOR SOILS DIFFICULT TO RETAIN IN SAMPLER

EXHIBIT A-1

NOTE:
"HEAD EXTENSION" CAN BE INTRODUCED BETWEEN "HEAD" AND "SPLIT BARREL"

SPLIT BARREL
(TO FACILITATE REMOVAL OF CORE SAMPLE)

ALTERNATE ATTACHMENTS

DAMES & MOORE
EXHIBIT A-2

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DIRECT SHEAR TESTS ARE PERFORMED TO DETERMINE THE SHEARING STRENGTHS OF SOILS. FRICTION TESTS ARE PERFORMED TO DETERMINE THE FRICTIONAL Resistances BETWEEN SOILS AND Various OTHER MATERIALS SUCH AS WOOD, STEEL, OR CONCRETE. THE TESTS ARE PERFORMED IN THE LABORATORY TO SIMULATE ANTICIPATED FIELD CONDITIONS.

EACH SAMPLE IS TESTED WITHIN THREE BRASS RINGS, TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

DIRECT SHEAR TESTS

A THREE-INCH LENGTH OF THE SAMPLE IS TESTED IN DIRECT DOUBLE SHEAR. A CONSTANT PRESSURE, APPROPRIATE TO THE CONDITIONS OF THE PROBLEM FOR WHICH THE TEST IS BEING PERFORMED, IS APPLIED NORMAL TO THE ENDS OF THE SAMPLE THROUGH POROUS STONES. A SHEARING FAILURE OF THE SAMPLE IS CAUSED BY MOVING THE CENTER RING IN A DIRECTION PERPENDICULAR TO THE AXIS OF THE SAMPLE. TRANSVERSE MOVEMENT OF THE OUTER RINGS IS PREVENTED.

THE SHEARING FAILURE MAY BE ACCOMPLISHED BY APPLYING TO THE CENTER RING EITHER A CONSTANT RATE OF LOAD, A CONSTANT RATE OF DEFLECTION, OR INCREMENTS OF LOAD OR DEFLECTION. IN EACH CASE, THE SHEARING LOAD AND THE DEFLECTIONS IN BOTH THE AXIAL AND TRANSVERSE DIRECTIONS ARE RECORDED AND PLOTTED. THE SHEARING STRENGTH OF THE SOIL IS DETERMINED FROM THE RESULTING LOAD-DEFLECTION CURVES.

FRICTION TESTS

IN ORDER TO DETERMINE THE FRICTIONAL RESISTANCE BETWEEN SOIL AND THE SURFACES OF VARIOUS MATERIALS, THE CENTER RING OF SOIL IN THE DIRECT SHEAR TEST IS REPLACED BY A DISK OF THE MATERIAL TO BE TESTED. THE TEST IS THEN PERFORMED IN THE SAME MANNER AS THE DIRECT SHEAR TEST BY FORCING THE DISK OF MATERIAL FROM THE SOIL SURFACES.
METHOD OF PERFORMING CONSOLIDATION TESTS

CONSOLIDATION TESTS ARE PERFORMED TO EVALUATE THE VOLUME CHANGES OF SOILS SUBJECT TO INCREASED LOADS. TIME-CONSOLIDATION AND PRESSURE-CONSOLIDATION CURVES MAY BE PLOTTED FROM THE DATA OBTAINED IN THE TESTS. ENGINEERING ANALYSES BASED ON THESE CURVES PERMIT ESTIMATES TO BE MADE OF THE PROBABLE MAGNITUDE AND RATE OF SETTLEMENT OF THE TESTED SOILS UNDER APPLIED LOADS.

EACH SAMPLE IS TESTED WITHIN BRASS RINGS TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

IN TESTING, THE SAMPLE IS RIGIDLY CONFINED LATERALLY BY THE BRASS RING. AXIAL LOADS ARE TRANSMITTED TO THE ENDS OF THE SAMPLE BY POROUS DISKS. THE DISKS ALLOW DRAINAGE OF THE LOADED SAMPLE. THE AXIAL COMPRESSION OR EXPANSION OF THE SAMPLE IS MEASURED BY A MICROMETER DIAL INDICATOR AT APPROPRIATE TIME INTERVALS AFTER EACH LOAD INCREMENT IS APPLIED. EACH LOAD IS ORDINARILY TWICE THE PRECEDING LOAD. THE INCREMENTS ARE SELECTED TO OBTAIN CONSOLIDATION DATA REPRESENTING THE FIELD LOADING CONDITIONS FOR WHICH THE TEST IS BEING PERFORMED, EACH LOAD INCREMENT IS ALLOWED TO ACT OVER AN INTERVAL OF TIME DEPENDENT ON THE TYPE AND EXTENT OF THE SOIL IN THE FIELD.
<table>
<thead>
<tr>
<th>Moisture Content in %</th>
<th>Dry Density in Pcf</th>
<th>Blows/Ft. on Sampler</th>
<th>Type of Sample and/or Core and % Recovery</th>
<th>Depth in Feet</th>
<th>Graph Symbol</th>
<th>Letter Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>84</td>
<td>16</td>
<td></td>
<td></td>
<td>ML</td>
<td>SW</td>
<td>Brown Coral Sandy Silt - Fill</td>
</tr>
<tr>
<td>30</td>
<td>91</td>
<td>2</td>
<td></td>
<td></td>
<td>SW</td>
<td>SP</td>
<td>Light Brown Coral Sand with some Coral Gravel - Fill (Medium Dense)</td>
</tr>
<tr>
<td>43</td>
<td>74</td>
<td>3</td>
<td></td>
<td></td>
<td>SP</td>
<td>GP</td>
<td>Gray Fine Coral Sand with Occasional Coral Fragments - Fill (Loose)</td>
</tr>
<tr>
<td>29</td>
<td>88</td>
<td>18</td>
<td></td>
<td></td>
<td>GP</td>
<td>SM</td>
<td>Gray Coral Gravel with some Coral Sand - Fill (Dense)</td>
</tr>
<tr>
<td>39</td>
<td>73</td>
<td>43</td>
<td></td>
<td></td>
<td>SM</td>
<td></td>
<td>Gray Silty Coral Sand with some Coral Gravel (Loose)</td>
</tr>
<tr>
<td>29</td>
<td>88</td>
<td>18</td>
<td></td>
<td></td>
<td>SM</td>
<td></td>
<td>Gray Silty Coral Sand (Loose)</td>
</tr>
</tbody>
</table>

Boring completed at 27 1/2 feet on 6-25-69

Log of Boring

Notes:

- Depth at which undisturbed sample was taken
- Depth at which disturbed sample was taken
- Depth at which sample was lost during extraction
- Depth and length of core run

Driving Energy = 300 lb weight dropping 30 inches
<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Symbol</th>
<th>Type of Core and Sample</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1</td>
<td>PM</td>
<td>Brown silt and coral gravel - fill (loose)</td>
</tr>
<tr>
<td>18</td>
<td>33</td>
<td>SM</td>
<td>Light brown fine to coarse coral sand with some coral gravel - fill (loose)</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
<td>SP</td>
<td>Water level at 0 feet on 6-25-69</td>
</tr>
<tr>
<td>29</td>
<td>1</td>
<td>SM</td>
<td>Gray-brown fine coral sand - fill (loose to moderately dense)</td>
</tr>
<tr>
<td>37</td>
<td>1</td>
<td>SP</td>
<td>Gray large coral fragments and partially cemented sand - fill (moderately dense)</td>
</tr>
<tr>
<td>39</td>
<td>3</td>
<td>GP</td>
<td>Gray sandy silt with some coral fragments (very loose)</td>
</tr>
<tr>
<td>51</td>
<td>3</td>
<td>SM</td>
<td>Gray silty coral sand (very loose)</td>
</tr>
<tr>
<td>52</td>
<td>3</td>
<td>SP</td>
<td>Grading with some shells and coral fragments</td>
</tr>
<tr>
<td>55</td>
<td>3</td>
<td>SP</td>
<td>Gray fine sand with occasional shells (loose)</td>
</tr>
<tr>
<td>44</td>
<td>11</td>
<td>SM</td>
<td>Black fine to coarse partially cemented sand with shell fragments and pockets of silt (loose)</td>
</tr>
<tr>
<td>88</td>
<td>5</td>
<td>ML</td>
<td>Black sandy silt (soft)</td>
</tr>
<tr>
<td>70</td>
<td>32</td>
<td>ML</td>
<td>Grading to stiff</td>
</tr>
<tr>
<td>15</td>
<td>26</td>
<td>SP</td>
<td>Grading dark brown</td>
</tr>
<tr>
<td>100</td>
<td>3</td>
<td>SP</td>
<td>Black medium to coarse sand (moderately dense)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Light brown cemented coral sand and gravel (hard)</td>
</tr>
</tbody>
</table>

Notes:
- D = Depth at which undisturbed sample was taken
- J = Depth at which disturbed sample was taken
- O = Depth at which sample was lost
- D = Driving energy = 300-lb weight dropping 30 inches
- P = Sampler pushed into the soil (piston sampler)
BORING 3  ESTIMATED SURFACE ELEV. 4 FEET (MSL)

Blows/ft on Sampler
Dry Density in PCF
Moisture Content in %
Type of Core and Percent Recovery

<table>
<thead>
<tr>
<th>Samples</th>
<th>Depth in Feet</th>
<th>Symbol</th>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>89</td>
<td>28</td>
<td>ML</td>
<td>BROWN SANDY SILT - FILL</td>
</tr>
<tr>
<td>41</td>
<td>84</td>
<td>23</td>
<td>SM</td>
<td>BROWN CORAL SAND WITH CORAL FRAGMENTS AND SOME SILT - FILL (MODERATELY DENSE)</td>
</tr>
<tr>
<td>43</td>
<td>73</td>
<td>1</td>
<td>GPM</td>
<td>GRAY FINE CORAL SAND WITH LENSES OF LARGE CORAL FRAGMENTS - FILL (LOOSE TO MODERATELY DENSE)</td>
</tr>
<tr>
<td>37</td>
<td>84</td>
<td>2</td>
<td>GM</td>
<td>WATER LEVEL AT 4 FEET ON 6-25-69</td>
</tr>
<tr>
<td>36</td>
<td>73</td>
<td>2</td>
<td></td>
<td>GRAY SANDY SILT (VERY LOOSE)</td>
</tr>
<tr>
<td>39</td>
<td>81</td>
<td>3</td>
<td></td>
<td>GRAY CORAL GRAVEL SAND SILT MIXTURE (LOOSE)</td>
</tr>
</tbody>
</table>

Grading with less gravel

Boring completed at 32½ feet on 6-24-69

Notes:

- Depth at which undisturbed sample was taken.
- Depth at which disturbed sample was taken.
- Depth at which sample was lost.
- Depth and length of coring run.
- Driving Energy = 300-lb weight dropping 30 inches.
- P = Sampler pushed into the soil.
# Soil Classification Chart

**Major Divisions**

<table>
<thead>
<tr>
<th>Coarse Grained Soils</th>
<th>Fine Grained Soils</th>
<th>Highly Organic Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gravel and Gravelly Soils</strong></td>
<td><strong>Silts and Clays</strong></td>
<td><strong>Peat, Humus, Swamp Soils</strong></td>
</tr>
<tr>
<td>MORE THAN 50% OF COARSE FRACTION IN SIEVE 88</td>
<td>MORE THAN 85% OF COARSE FRACTION IN SIEVE 14</td>
<td>NO SIEVE 200 PASS</td>
</tr>
<tr>
<td><strong>WELL- GRADED</strong></td>
<td><strong>LIQUID LIMIT LESS THAN 50</strong></td>
<td><strong>HIGHLY ORGANIC</strong></td>
</tr>
<tr>
<td>GRAVELS, GRAVELY SANDS, SAND MIXTURES, LITTLE OR NO FINES</td>
<td>SILT CLAYS, SANDY CLAYS, CLAY CLAYS, SPECIAL SOILS</td>
<td>WITH HIGH ORGANIC CONTENT</td>
</tr>
<tr>
<td>CLEAN GRAVELS, LITTLE OR NO FINES</td>
<td>CLEAN SANDS, LITTLE OR NO FINES</td>
<td>CLEAN SANDS, SANDY CLAYS, CLAY CLAYS</td>
</tr>
<tr>
<td>CLEAN SANDS, LITTLE OR NO FINES</td>
<td>SANDS WITH FEW FINES, LITTLE OR NO FINES</td>
<td>CLAY INFILTRATION HUGO</td>
</tr>
<tr>
<td>SANDY SOILS</td>
<td>CLAY INFILTRATION HUGO</td>
<td></td>
</tr>
</tbody>
</table>

**Letter Symbols**

<table>
<thead>
<tr>
<th>GRADE</th>
<th>SYMBOL</th>
<th>TYPICAL DESCRIPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GW</strong></td>
<td>GRAVELS</td>
<td>WELL- GRADED, GRAVELS, GRAVELY SANDS, SAND MIXTURES, LITTLE OR NO FINES</td>
</tr>
<tr>
<td><strong>GP</strong></td>
<td>GRAVELY SANDS</td>
<td>GRAVELY SANDS, SANDY SANDS, CLAY CLAYS, SPECIAL SOILS</td>
</tr>
<tr>
<td><strong>GM</strong></td>
<td>GRAVELY MUDS</td>
<td>GRAVELY MUDS, GRAVELY CLAY CLAYS</td>
</tr>
<tr>
<td><strong>SC</strong></td>
<td>SILT CLAYS</td>
<td>CLAY INFILTRATION HUGO</td>
</tr>
<tr>
<td><strong>SW</strong></td>
<td>SEDIMENTARY</td>
<td>SEDIMENTARY</td>
</tr>
</tbody>
</table>

**Descriptive Definitions**

- **Clean Gravels:** Coarse materials, little or no fines
- **Clean Sands:** Sand mixtures, little or no fines
- **Sandy Soils:** Sands, sandy sands, clay clays
- **Organic Soils:** Peat, humus, swamp soils
- **Highly Organic Soils:** With high organic content

**Notes:**

1. Dual symbols are used to denote overlaps in classifications.
2. Definitions are provided for cohesive soils and cohesionless soils.
3. Descriptions include the relative compaction of cohesive soils and the relative shearing strength of cohesionless soils.

## Gradation Chart

- **Material Size:** particle size
- **Particle Size:** material size
- **Lower Limit:** lower limit of the particle size
- **Upper Limit:** upper limit of the particle size

<table>
<thead>
<tr>
<th>Material Size</th>
<th>Particle Size</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>FINE</td>
<td>0.074</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>MEDIUM</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>COARSE</td>
<td>0.02</td>
<td>0.001</td>
</tr>
<tr>
<td>Gravel</td>
<td>FINE</td>
<td>0.074</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>MEDIUM</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>COARSE</td>
<td>0.02</td>
<td>0.001</td>
</tr>
<tr>
<td>Clays</td>
<td></td>
<td>0.01</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

**Unified Soil Classification System**

- **PARTICULAR EMBRACE:** Scientists and engineers
- **DESCRIPTION:** Classification of soils
- **DEFINITIONS:** Universal soil classification system
- **SAMPLING:** Samples entered on the first log on which the data appear.