

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

GEOLOGIC DESCRIPTION  
OF  
SELECTED STRONG-MOTION ACCELEROGRAPH SITES

PART IV

by B. L. Silverstein

OPEN FILE REPORT  
No. 80-473

The report is preliminary and has not  
been edited or reviewed for conformity with  
Geological Survey standards and nomenclature.

Prepared on behalf of the  
National Science Foundation  
Grant CA-114

## Preface

This is one in a series of reports that summarizes geologic and engineering data for selected strong-motion ascelrograph stations in the western hemisphere.

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## Introduction

This report is intended to serve as a convenient compilation of geologic and engineering data for those who interpret strong-motion accelerograph records. The data are taken from unpublished information on file with the Seismic Engineering Branch and published reports such as Duke and Leeds, 1962; Woodward Lundgrun Assoc., 1963; and Shannon and Wilson and Agbabian Assoc., 1976.

If data are available from more than one source, the information given is the most complete or up-to-date. The date of the coring is included when available. The first page, of the two page summary for each site contains a brief narrative of local or site geology, a location map, plus the station name, number and coordinates as taken from Open-File Report No. 77-374. Where the first page is used to describe more than one site, coordinates are listed on the bottom of the second page.

The second page contains a graphic representation of the geology, and where available, density (wet or dry indicated if known) and P- and S-wave data. The lithologic symbols are taken from Figure 1.

The log, in most cases, is taken from actual core samples at the site. Indication is given when the log is not directly at the site or the geologic information is taken from sources other than cores, e.g. geologic cross section.

The code on the bottom of the second page is a geologic summary for use in a computer data bank. The reader is referred to Appendix II and Open-File Report No. 79-289 for further information.

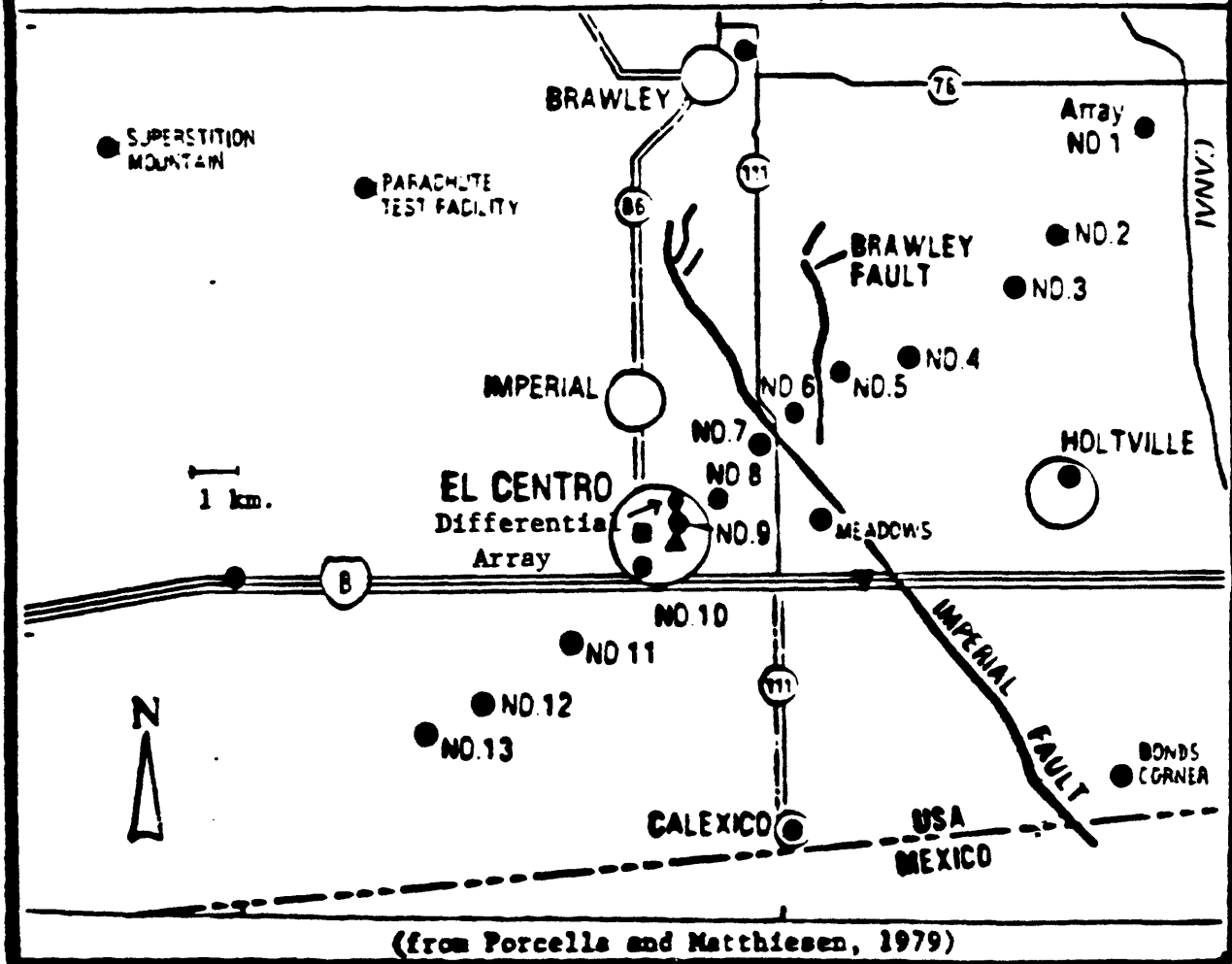
The term "generalized" indicates that a geologic core was not the source of information and that the rock's actual sequence, thickness, and depth are not known.

Station No. 502B Station El Centro; Sta 7 Imperial Valley College

Coordinates 32.83° N. 115.50° W




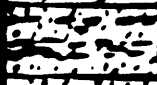







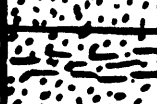


### SITE DESCRIPTION

This site is located on Quaternary alluvium and Tertiary sedimentary rocks of the Imperial Valley in southern California. The maximum depth of these deposits is believed to be about 6 km.. (Biehler and others, 1964)






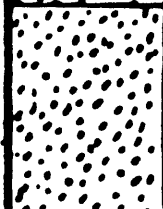
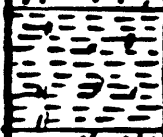

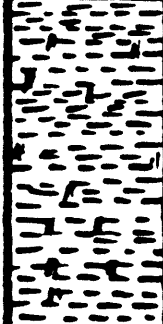

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Site 4/79 Station No. 5028 Station El Centro: Sta. 7, Imperial Valley Col.

| <u>Depth</u><br><u>meters</u> | <u>P-Wave</u><br><u>m/sec</u> | <u>S-Wave</u><br><u>m/sec</u> | <u>Density</u><br><u>g/cm<sup>3</sup></u> | <u>LOG</u>  | <u>Site Geology</u>                           |
|-------------------------------|-------------------------------|-------------------------------|---|---|---|
|                               |                               |                               |   |    | Sand with clay stringers                      |
|                               |                               |                               |   |    | Sand with clay stringers & fine gravel        |
| -20                           |                               |                               |   |    | Sand  |
|                               |                               |                               |   |    | Sand and clay                                 |
| -40                           |                               |                               |   |    | Sand with clay stringers                      |
|                               |                               |                               |   |    | Sand and clay                                 |
| -60                           |                               |                               |   |    | Sand and clay                                 |
|                               |                               |                               |   |    | Sand and clay                                 |
| -80                           |                               |                               |   |   | Clay and sand                                 |
|                               |                               |                               |   |  | Sand and clay                                 |
| -100                          |                               |                               |   |  | Sand and clay                                 |
|                               |                               |                               |   |  | Sand with clay stringers                      |
| -120                          |                               |                               |   |  | Sand and clay                                 |
|                               |                               |                               |   |  | Clay with stringers of sand                   |
| -140                          |                               |                               |   |   |   |
|                               |                               |                               |   |   | 4/25/58                                       |
| -160                          |                               |                               |   |   | Well located approx. 6.4 km northwest of site |

Hansen, W.R., and others, 1973

ADY:ADD

| Depth<br>meters | P-Value<br>m/1000 | S-Value | Density<br>g/cm <sup>3</sup> | LOG   | Site Geology   |
|-----------------|-------------------|---------|------------------------------|---|--|
|                 |                   | 122     | 1.54                         |    | Silty clay with occ. lenses of silty fine sand.                    |
|                 |                   |         | 1.51                         |   |  |
|                 |                   | 175     | 1.57                         |    | Alternating layers of silty clay, silty fine sand, and sandy silt. |
| 10              |                   |         | 1.51                         |   |  |
|                 |                   | 213     | 1.49                         |   |  |
|                 |                   |         | 1.51                         |    | Silty fine sand with occ. lenses of silty clay.                    |
| 20              |                   |         | 1.36                         |   |  |
|                 |                   | 251     | 1.51                         |    | Silty fine sand with occ. lenses of silty clay.                    |
| 30              |                   |         | 1.57                         |   |  |
|                 |                   |         | 1.55                         |    | Silty clay with occ. layers of sandy, clayey silt.                 |
| 40              |                   |         | 1.52                         |   |  |
|                 |                   |         | 1.52                         |    | Silty fine sand  |
| 50              |                   | 305     | 1.62                         |   |  |
|                 |                   |         | 1.47                         |   | Silty clay   |
| 60              |                   |         | (DRY)                        |   |  |
| 70              |                   |         |                              |  | Silty fine sand  |
|                 |                   |         |                              |   | 4/75   |
|                 | See page 2        |         |                              |   |  |

Shannon & Wilson & Agabian, 1976

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 10/79 Station No. 412 Station El Centro: Sta. 10, Comm. Hospital

| <u>Depth</u><br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>LOG</u> | <u>Site Geology</u> |
|------------------------|------------------------|------------------------|-------------------------------------|------------|---------------------|
|------------------------|------------------------|------------------------|-------------------------------------|------------|---------------------|

|            |  |  |  |  |                              |
|------------|--|--|--|--|------------------------------|
|            |  |  |  |  | Top soil                     |
| 1          |  |  |  |  | Clay                         |
| 2          |  |  |  |  |                              |
| 3          |  |  |  |  |                              |
| 4          |  |  |  |  |                              |
| 5          |  |  |  |  | Sandy clay                   |
| 6          |  |  |  |  | 1962                         |
| See page 2 |  |  |  |  |                              |
|            |  |  |  |  | Hansen, W.R., & others, 1973 |

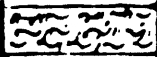

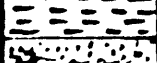

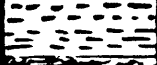
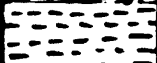
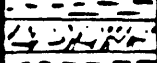

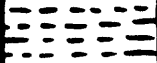
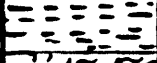
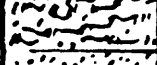
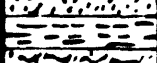
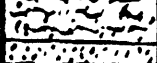
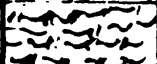
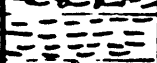
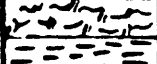
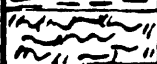
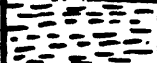


Coordinates 32.78 N 115.57 W

ALV:AL6:AL



GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 10/79 Station No. 5165 Station E C Differential Array Dogwood Rd.

| <u>Depth</u><br><u>meters</u> | <u>P-Wave</u><br><u>m/sec</u> | <u>S-Wave</u><br><u>m/sec</u> | <u>Density</u><br><u>g/cm<sup>3</sup></u> | <u>Log</u>  | <u>Site Geology</u>                                     |
|-------------------------------|-------------------------------|-------------------------------|---|---|---|
|                               |                               |                               |   |    | Silty clay loam   |
|                               |                               |                               |   |    | Clay  |
|                               |                               |                               |   |    | Laminations of fine sand, sandy loam, & silty clay loam |
|                               |                               |                               |   |    | Clay  |
|                               |                               |                               |   |    | Lens of silty clay loam                                 |
| 10                            |                               |                               |   |    | Clay  |
|                               |                               |                               |   |    | Laminations of sandy loam and silty clay loam           |
|                               |                               |                               |   |    | Clay  |
|                               |                               |                               |   |    | Silty clay loam   |
| 20                            |                               |                               |   |    | Sand  |
|                               |                               |                               |   |    | Clay  |
|                               |                               |                               |   |    | Silty clay loam & sandy loam                            |
|                               |                               |                               |   |   | Sand  |
|                               |                               |                               |   |  | Silty loam  |
|                               |                               |                               |   |  | Clay  |
|                               |                               |                               |   |  | Silty clay loam   |
| 30                            |                               |                               |   |  | Clay  |
|                               |                               |                               |   |  | Laminations of silty clay loam, and silty loam          |
|                               |                               |                               |   |  | Clay  |
|                               |                               |                               |   |  | Sand  |
|                               |                               |                               |   |   | 1946<br>500 m northeast of site                         |
|                               |                               |                               |   |   | See page 2  |

Hansen, W.R., and others, 1973

Coordinates 32.80 N 115.54 W

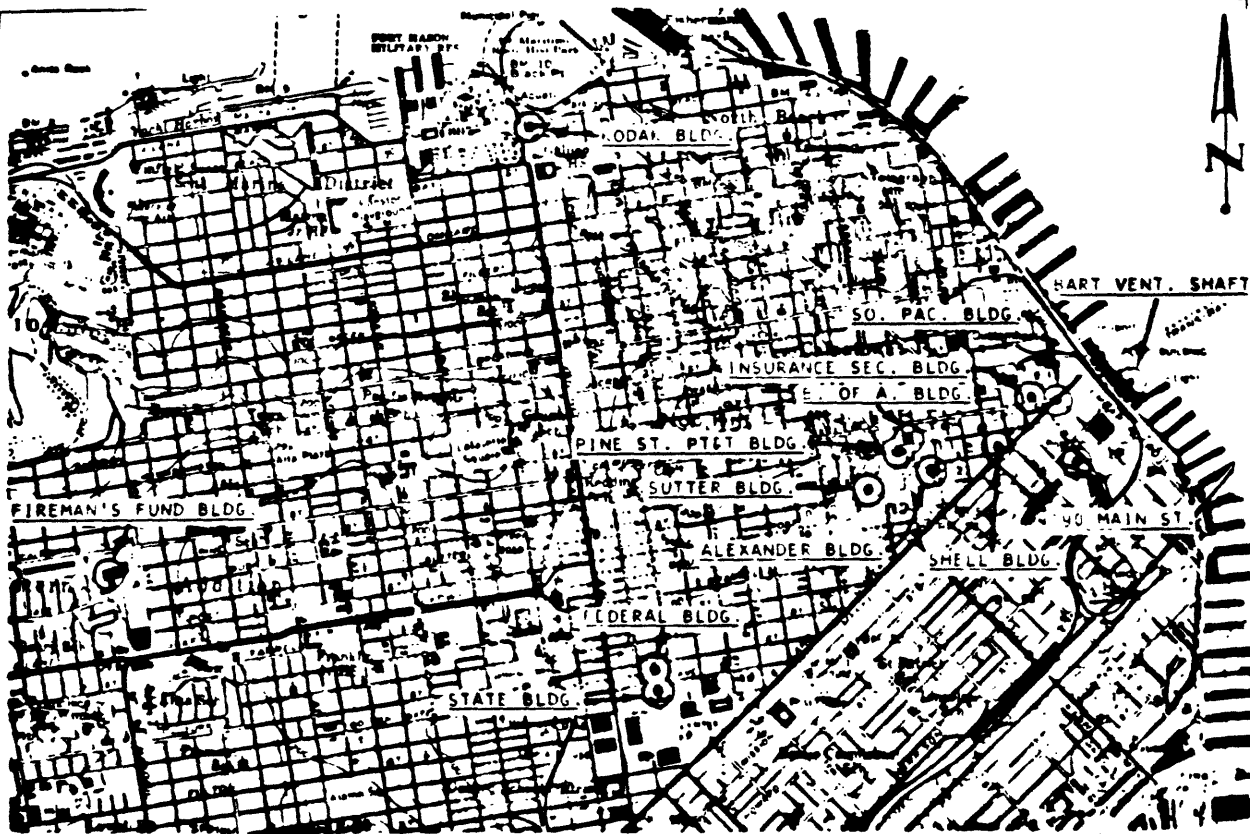
ALV:AL35:AL

Station No. 1068 Station San Francisco, Bank of America, 555 California

Coordinates 37.79 N, 122.40 W

### SITE DESCRIPTION

The geology of the San Francisco North quadrangle consists of two distinct rock types: 1) the Jurassic to Cretaceous Franciscan assemblage, which is about 80% graywacke sandstone, 10% shale and siltstone, and the remaining 10% consisting of mafic volcanics, radiolarian chert, conglomerate, limestone and glaucophane schist and 2) Quaternary eolian and alluvial deposits. (Schlocker, 1974)



LOCATION AND TOPOGRAPHY  
SAN FRANCISCO NORTHEAST SITES

GEOLOGIC SUMMARY OF STRONG-MOTION SITES




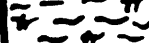

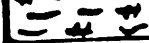



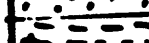
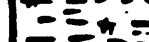
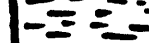


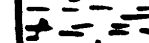



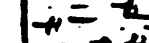


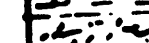

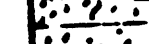
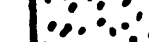

Date 1/80 Station No. 1068 Station San Francisco B of A 555 California

| <u>Depth</u><br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>LOG</u> | <u>Site Geology</u>  |
|------------------------|------------------------|------------------------|-------------------------------------|------------|--|
|                        |                        |                        | 1.91                                |            | Clayey sand — Sandy clay                                   |
|                        |                        |                        | 1.76                                |            | Clayey sand  |
|                        |                        |                        | 1.78                                |            | Sand with silt and clay                                    |
|                        |                        |                        | 1.81                                |            |  |
|                        |                        |                        | 1.96                                |            |  |
| 10                     |                        |                        | 1.78                                |            |  |
|                        |                        |                        | 1.78                                |            | Sand   |
|                        |                        |                        | 1.72                                |            |  |
|                        |                        |                        | 1.70                                |            |  |
| 20                     |                        |                        | 1.96                                |            | Silty sand with rock fragments                             |
|                        |                        |                        | 1.75                                |            | Sand with clay and silt                                    |
|                        |                        |                        | 1.62                                |            | Sand with clay, silt and gravel lenses                     |
|                        |                        |                        | 1.60                                |            |  |
|                        |                        |                        | 1.68                                |            |  |
|                        |                        |                        | 1.67                                |            |  |
| 30                     |                        |                        | 1.84                                |            | Clay with rock fragments grading to highly fractured shale |
|                        |                        |                        | 1.91                                |            |  |
|                        |                        |                        | 1.99                                |            | Gouge of highly fractured shale                            |
|                        |                        |                        | (Dry)                               |            | Sandstone-fractured  |
| 40                     |                        |                        |                                     |            | Shale-highly fractured                                     |
|                        |                        |                        |                                     |            | Silty sandstone-fractured                                  |
|                        |                        |                        |                                     |            | Shale-highly fractured                                     |
|                        |                        |                        |                                     |            | Silty sandstone-fractured                                  |
|                        |                        |                        |                                     |            | 12/17/64   |
|                        |                        |                        |                                     |            | Hansen, W.R., & others, 1973                               |

ALV:AL33:SHF+SSF46

**GEOLOGIC SUMMARY OF STRONG-MOTION SITES**

Date 1/80 Station No. 1136 Station San Francisco BART Vent Shaft

| Depth<br>meters | P-Wave<br>m/sec | S-Wave<br>m/sec | Density<br>g/cm <sup>3</sup> | Log   | Site Geology                    |
|-----------------|-----------------|-----------------|------------------------------|---|---------------------------------|
|                 |                 |                 | 0.63                         |    | Silty clay                      |
|                 |                 |                 | 0.91                         |    | Sand                            |
|                 |                 |                 | 1.17                         |    | Silty clay                      |
|                 |                 |                 | 1.06                         |    | Sand with shell fragments       |
|                 |                 |                 | 1.06                         |    | Silty clay with shell fragments |
|                 |                 |                 | 1.41                         |    | Sand                            |
|                 |                 |                 | 1.41                         |    | Silty clay                      |
| 10              |                 |                 | 1.60                         |    | Sand                            |
|                 |                 |                 | 1.04                         |    |                                 |
|                 |                 |                 | 1.15                         |    |                                 |
|                 |                 |                 | 1.04                         |    |                                 |
|                 |                 |                 | 1.09                         |    |                                 |
|                 |                 |                 | 1.14                         |    |                                 |
|                 |                 |                 | 1.25                         |    |                                 |
|                 |                 |                 | 1.25                         |    | Silty clay                      |
| 20              |                 |                 | 1.22                         |    |                                 |
|                 |                 |                 | 1.31                         |    |                                 |
|                 |                 |                 | 1.03                         |    |                                 |
|                 |                 |                 | 1.14                         |   |                                 |
|                 |                 |                 | 1.14                         |  | Silty to clayey sand            |
| 30              |                 |                 | 1.64                         |  | Sand and gravel                 |
|                 |                 |                 | 1.23                         |  |                                 |
|                 |                 |                 | 1.19                         |  |                                 |
|                 |                 |                 | 1.30                         |  | Silty clay                      |
| 40              |                 |                 | 1.51                         |  |                                 |
|                 |                 |                 | 1.38                         |  |                                 |
|                 |                 |                 | (Dry)                        |   |                                 |

See page 7

8/28/70

Hansen, W.R., & others, 1973

Coordinates 37.80 N 122.39 W

ALV:AL43:AL

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 1/80 Station No. 1071 Station San Francisco <sup>\*</sup>Beth. Pac Bldg. 100 Calif.

| <u>Depth</u><br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>LOG</u> | <u>Site Geology</u>   |
|------------------------|------------------------|------------------------|-------------------------------------|------------|---|
|                        |                        |                        |                                     |            | Sand and gravel with concrete & brick rubble and wood debris. |
| 10                     |                        |                        |                                     |            | Silty clay with seashell fragments                            |
| 20                     |                        |                        |                                     |            | Sandy loam  |
|                        |                        |                        |                                     |            | Clay  |
| 30                     |                        |                        |                                     |            | Sandy clay  |
|                        |                        |                        |                                     |            | 3/3/57  |
| 40                     |                        |                        |                                     |            | *same as Insurance Sec. Bldg..                                |
|                        |                        |                        |                                     |            | See page 7  |

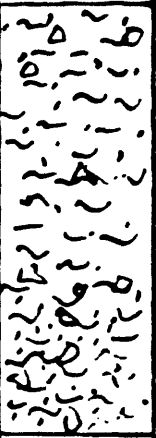
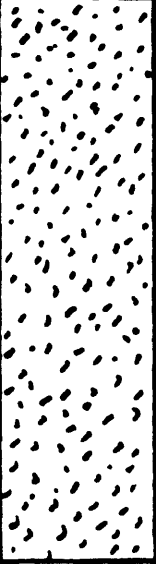


Hansen, W.R., & others, 1973

Coordinates 37.79 N 122.40 W

ALV:AL30

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 1/80 Station No. 1118 Station San Francisco, Eastman Kodak, 3250 Van Ness

| <u>Depth</u><br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>Log</u>  | <u>Site Geology</u>                                  |
|------------------------|------------------------|------------------------|-------------------------------------|---|--|
|                        |                        |                        |                                     |    | Loose fill and rubble material,<br>firmer with depth |
| 10                     |                        |                        |                                     |   | Sand with trace of clay                              |
| 20                     |                        |                        |                                     |  | Clay with rock and decomposed<br>rock                |
| 30                     |                        |                        |                                     |  | Franciscan shale and sandstone<br>with clay          |
| 40                     |                        |                        |                                     |   | Jan., 1957   |
|                        |                        |                        |                                     |   | See page 7   |
|                        |                        |                        |                                     |   | Hansen, W.R., & others, 1973                         |

Coordinates 37.81 N 122.42 W

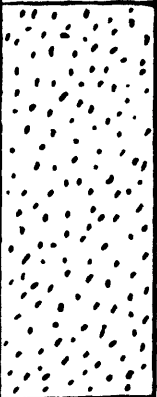
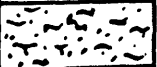
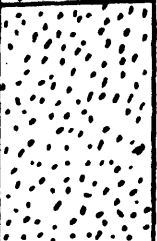


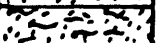

ALV:AL32:SH+SS33:SH+SS

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 12/79

Station No. 1073

Station S.F. Federal Bldg. 450 Golden Gate

| <u>Depth</u><br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>Log</u>  | <u>Site Geology</u>          |
|------------------------|------------------------|------------------------|-------------------------------------|---|------------------------------|
|                        |                        |                        |                                     |    | Sand                         |
| 10                     |                        |                        |                                     |    | Silty Sand                   |
|                        |                        |                        |                                     |    | Sand                         |
| 20                     |                        |                        |                                     |    | Lense of clayey sand         |
|                        |                        |                        |                                     |   |                              |
| 30                     |                        |                        |                                     |  | Silty sand                   |
|                        |                        |                        |                                     |  | Sand                         |
| 40                     |                        |                        |                                     |   | 8/4/58                       |
|                        |                        |                        |                                     |   | See page 7                   |
|                        |                        |                        |                                     |   | Hansen, W.R., & others, 1973 |

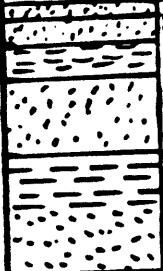
Coordinates 37.78 N 122.42 W

ALV:AL38:AL

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 1/80 Station No. 1127 Station San Francisco Firemans Fund 3333 Calif.

| <u>Depth</u><br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>Log</u> | <u>Site Geology</u> |
|------------------------|------------------------|------------------------|-------------------------------------|------------|---------------------|
|------------------------|------------------------|------------------------|-------------------------------------|------------|---------------------|

|    |  |  |  |   |   |
|----|--|--|--|---|---|
|    |  |  |  |  | Sand<br>Sandy loam<br>Clay loam<br>Sandy loam with sandstone frag.<br><br>Shale and sandstone (fractured) |
| 5  |  |  |  |   |   |
| 10 |  |  |  |   | 4/26/54   |
|    |  |  |  |   | See page 7  |
|    |  |  |  |   | Hansen, W.R., & others, 1973  |

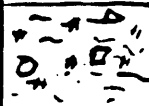
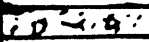

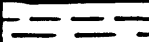
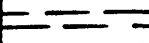

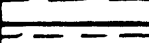


Coordinates 37.79 N 122.45 W

ALV:AL4:SHF+SSF7



GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 1/80 Station No. 1168 Station San Francisco Pac. T&T 555 Pine

| <u>Depth</u><br><u>meters</u> | <u>P-Wave</u><br><u>m/sec</u> | <u>S-Wave</u><br><u>m/sec</u> | <u>Density</u><br><u>g/cm<sup>3</sup></u> | <u>Log</u>  | <u>Site Geology</u>                       |
|-------------------------------|-------------------------------|-------------------------------|---|---|---|
|                               |                               |                               | 1.75                                      |  | Silty clay with bricks & rock frags.      |
|                               |                               |                               | 1.78                                      |  | Sand with some clay, bricks & rock frags. |
|                               |                               |                               | 1.80                                      |  | Sand with some clay, bricks & rock frags. |
|                               |                               |                               | 2.00                                      |  | Clay                                      |
|                               |                               |                               | 2.12                                      |  |   |
|                               |                               |                               | 2.20                                      |  |   |
|                               |                               |                               | 2.07                                      |  | Shale - weathered and altered             |
| 10                            |                               |                               | 2.28                                      |  | Shale and sandstone                       |
|                               |                               |                               |   |  | Sandstone                                 |
|                               |                               |                               |   |   | 12/9/57                                   |

See page 7


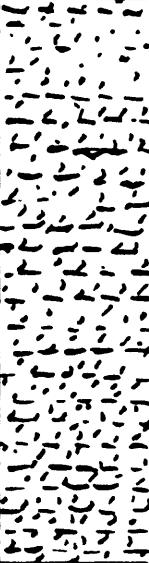


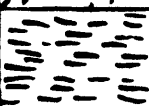
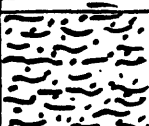
Hansen, W.R., & others, 1973

Coordinates 37.79 N 122.40 W

ALV:AL5:SH+SS13

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 1/80 Station No. 1115 Station San Francisco Shell Building

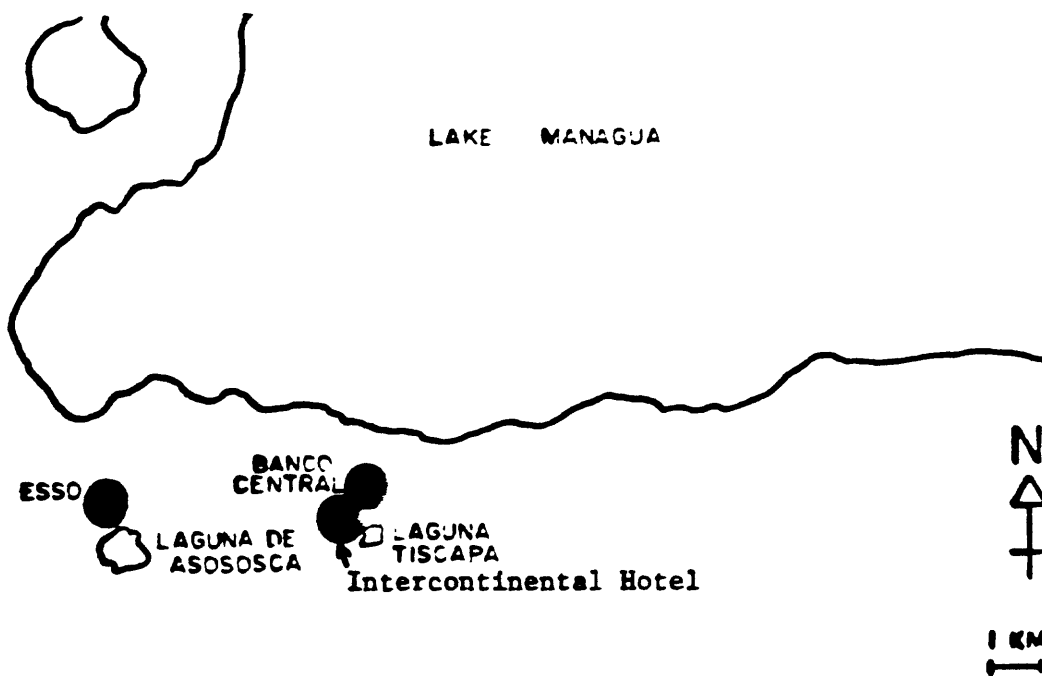
| Depth<br>meters | <u>P-Wave</u><br>m/sec | <u>S-Wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>Log</u>  | <u>Site Geology</u>          |
|-----------------|------------------------|------------------------|-------------------------------------|---|------------------------------|
|                 |                        |                        |                                     |    | Sand                         |
| 10              |                        |                        |                                     |   | Sandy clay                   |
| 20              |                        |                        |                                     |  | Sand                         |
| 30              |                        |                        |                                     |  | Sandy clay                   |
|                 |                        |                        |                                     |  | Clay                         |
| 40              |                        |                        |                                     |  | Sandy clay                   |
|                 |                        |                        |                                     |   | June, 1929                   |
|                 |                        |                        |                                     |   | See page 7                   |
|                 |                        |                        |                                     |   | Hansen, W.R., & others, 1973 |

Coordinates 37.79 N 122.40 W

Station No. 3500 Station Managua, Banco Central (NICARAGUA)





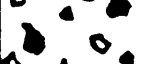


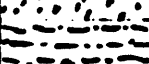

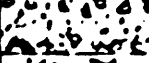
Coordinates 12.15 N, 86.27 W

Managua is located on several thousand feet of deposits consisting of thick units formed by volcanic ash-laden mud flows and thinner stream-deposited beds. This alluvium is interspersed with layers of volcanic ash, cinder, and pumice. (Valera, 1973)



(EERI Reconnaissance Report, 1973)

Date 9/79 Station No. 3500 Station Managua, Banco Central (Nicaragua)

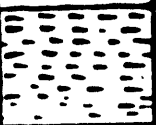
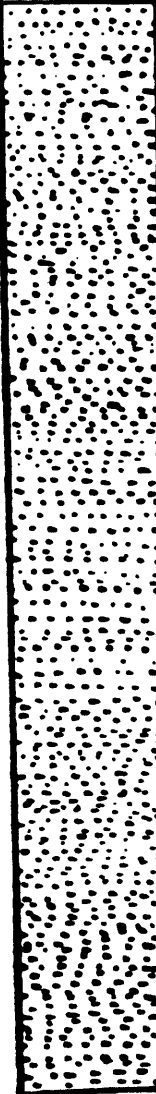
| Depth<br>meters | P-Wave<br>m/sec | S-Wave<br>m/sec | Density<br>g/cm <sup>3</sup> | Log   | Site Geology   |
|-----------------|-----------------|-----------------|------------------------------|---|--|
|                 |                 |                 |                              |  | Sand (coarse, dense and partially cemented)                                    |
|                 |                 |                 | 1.70                         |  | Volcanic tuff agglomerate  |
|                 |                 |                 | 1.50                         |  |  |
|                 |                 |                 | 1.52<br>(wet)                |  | Sand (coarse and dense)  |
|                 |                 |                 |                              |  |  |
|                 |                 |                 |                              |  | Silt (cemented)  |
|                 |                 |                 |                              |  | Pumice   |
|                 |                 |                 |                              |  | Clayey silty sand (very dense)   |
| 10              |                 |                 |                              |  | Silty sand (dense)   |
|                 |                 |                 |                              |  | Alternating layers of calcareous conglomerate and dense cemented gravelly sand |
|                 |                 |                 |                              |   | June. 1962   |
|                 |                 |                 |                              |   | Valera, 1973   |

ALV:AL+CP

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 9/79 Station No. 3507 Station Name, Intercontinental Hotel

Depth meters      P-wave m/sec      S-wave m/sec      Density g/cm<sup>3</sup>      Log      Site Geology


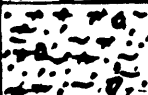
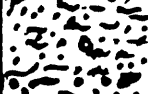


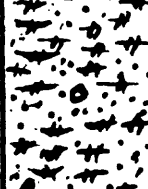
| <u>Depth</u><br>meters | <u>P-wave</u><br>m/sec | <u>S-wave</u><br>m/sec | <u>Density</u><br>g/cm <sup>3</sup> | <u>Log</u>   | <u>Site Geology</u>  |
|------------------------|------------------------|------------------------|-------------------------------------|--|----------------------|
|                        |                        |                        |                                     |   | Clay                 |
|                        |                        |                        |                                     |  | Stratified sandstone |
| 20                     |                        |                        |                                     |  |                      |
| See page 16            |                        |                        |                                     |  |                      |
|                        |                        |                        |                                     |  | Valera, 1973         |

Coordinates 12.14 N 86.27 W

ALV:AL2:8820

GEOLOGIC SUMMARY OF STRONG-MOTION SITES

Date 9/79 Station No. 3501 Station Managua, ESSO Refinery (Nicaragua)

| Depth<br>meters | P-Wave<br>m/sec | S-Wave<br>m/sec | Density<br>g/cm <sup>3</sup> | Log  | Site Geology   |
|-----------------|-----------------|-----------------|------------------------------|--|--|
|                 |                 |                 |                              |   | Sandy silt   |
|                 |                 |                 |                              |   | Silty sand with gravel                                     |
|                 |                 |                 |                              |   | Silt with gravel   |
| 10              |                 |                 |                              |   | Sandy silt with layers of silty sand and occasional gravel |
|                 |                 |                 |                              |   | Silty sand with some gravel                                |
| 20              |                 |                 |                              |  | Fine to coarse sand with gravel                            |
|                 | See page 16     |                 |                              |  |  |
|                 |                 |                 |                              |  | Valera, 1973   |

Coordinates 12.14 N 86.32 W

ALV: AL25:AL

## References

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- Porcella, R. L., and Matthiesen, R. B.; 1979, Preliminary Summary of the U.S. Geological Survey Strong-Motion Records from the October 15, 1979 Imperial Valley Earthquake; U.S. Geological Survey Open-File Report 79-1654.
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- Seismic Engineering Branch; 1976, Western Hemisphere Strong-Motion Accelerograph Station List, 1976; U.S.G.S. Open-File Report No. 77-374.
- Shannon and Wilson, Inc. and Agbabian Assoc.; 1976, Geotechnical and Strong-Motion Earthquake Data from U.S. Accelerograph Stations; Nureg-0029, Vol. I.
- Vatera, J. E.; 1973, Soil Conditions and Local Soil Effects During the Managua Earthquake of December 23, 1972; Earthquake Engineering Research Institute Conference Proceedings, Vol. I.

TABLE 1

ALPHABETIZED GEOLOGIC CODE

| <u>ROCK TYPES</u>           | <u>CLASS CODE</u>         |
|-----------------------------|---------------------------|
| AC Coarse Alluvium          | ALV Alluvium              |
| AF Artificial Fill          | IGN Igneous Rock          |
| AG Agglomerate              | MET Metamorphic Rock      |
| AL Alluvium                 | MIX Mixture of Rock Types |
| AM Amphibolite              | SED Sedimentary Rock      |
| AN Andesite                 |                           |
| BA Basalt                   |                           |
| BR Breccia                  |                           |
| CG Conglomerate             |                           |
| CH Chert                    |                           |
| CI Combination Igneous      |                           |
| CM Combination Metamorphics |                           |
| CR Combination Rock Types   |                           |
| CS Combination Sedimentary  |                           |
| CY Claystone                |                           |
| DI Diorite                  |                           |
| DK Dikes or Sills           |                           |
| DO Dolomite                 |                           |
| FR Franciscan Rocks         |                           |
| GB Gabbro                   |                           |
| GD Granodiorite             |                           |
| GN Gneiss                   |                           |
| GO Gouge                    |                           |
| GR Granite                  |                           |
| GS Greenstone               |                           |
| HF Hornsfe1                 |                           |
| LF Lava Flows               |                           |
| LS Limestone                |                           |
| MR Marble                   |                           |
| MS Mudstone                 |                           |
| MZ Monzonite                |                           |
| OB Obsidian                 |                           |
| PH Phyllite                 |                           |
| PU Pumice                   |                           |
| QM Quartz Monzonite         |                           |
| QZ Quartzite                |                           |
| RY Rhyolite                 |                           |
| SC Schist                   |                           |
| SH Shale                    |                           |
| SI Siltstone                |                           |
| SL Slate                    |                           |
| SP Serpentinite             |                           |
| SS Sandstone                |                           |
| SY Syenite                  |                           |
| TF Tuff                     |                           |
| VA Volcanic Ash             |                           |

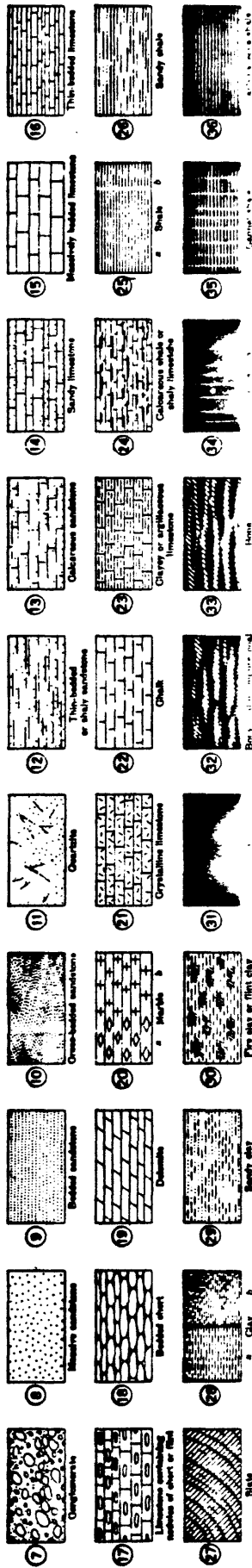
| <u>EXPLANATORY SYMBOLS</u> |                                |
|----------------------------|--------------------------------|
| C                          | Cemented                       |
| D                          | Deep                           |
| F                          | Fractured, Sheared, or Jointed |
| I                          | Interbedded                    |
| K                          | x1000 (multiplier)             |
| L                          | Layered or Stratified          |
| M                          | Massive                        |
| P                          | Permafrost                     |
| S                          | Semiconsolidated               |
| U                          | Unconsolidated                 |
| V                          | Veneer                         |
| W                          | Weathered or Friable           |
| X                          | Crystalline Basement           |
| :                          | Overlying                      |
| +                          | And                            |
| .                          | Decimal                        |



**SURFICIAL**



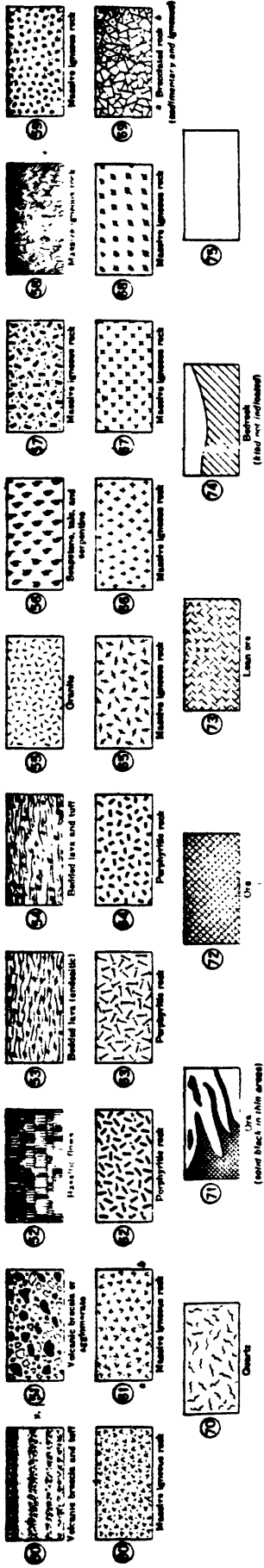
**SEDIMENTARY**



**METAMORPHIC**



**IGNEOUS AND VEIN MATTER**



LITHOLOGIC SYMBOLS USED IN STRUCTURE AND COLUMNAR SECTIONS TO REPRESENT DIFFERENT KINDS OF ROCK

Appendix A

Combined Index of Parts I - IV

| <u>Station No</u> | <u>State</u> | <u>Instrument Site</u>                | <u>Part</u> | <u>Page</u> |
|-------------------|--------------|---------------------------------------|-------------|-------------|
| 2305              | Arizona      | Phoenix V.A. Hospital                 | I           | 3           |
| 1001              | California   | APEEL Array Sta. 1                    | III         | 6           |
| 1002/1194         | "            | " " " 2A                              | III         | 8           |
| 1003              | "            | " " " 6                               | III         | 10          |
| 1161              | "            | " " " 9                               | III         | 12          |
| 1007              | "            | " " " 10                              | III         | 14          |
| 1180              | "            | " " " 1E                              | III         | 16          |
| 1121              | "            | " " " 2E                              | III         | 18          |
| 1219              | "            | " " " 3E                              | III         | 20          |
| 1008              | "            | Bishop                                | II          | 3           |
| 1120              | "            | Buena Vista Pumping Plant             | II          | 5           |
| 1013-16           | "            | Cholame-Shandon Stations              | II          | 7           |
| 5028              | "            | El Centro Sta. 7                      | IV          | 2           |
| 5117              | "            | El Centro Sta. 9                      | IV          | 4           |
| 5412              | "            | El Centro Sta. 10                     | IV          | 5           |
| 5165              | "            | El Centro, Differential Array         | IV          | 6           |
| 1023              | "            | Ferndale, Old City Hall               | I           | 7           |
| 1024              | "            | Foster City, Audubon School           | III         | 24          |
| 1188              | "            | Fremont, 3909 Stevenson               | III         | 26          |
| 1229              | "            | Fresno V.A. Hospital                  | II          | 12          |
| 1028              | "            | Hollister City Hall                   | III         | 28          |
| 638               | "            | Los Angeles V. A. Hospital, Brentwood | I           | 9           |
| 1222              | "            | Menlo Park, 1330 University Drive     | II          | 14          |

|           |          |                                    |     |    |
|-----------|----------|------------------------------------|-----|----|
| 1215      | "        | Mt. Diablo Summit Building         | II  | 16 |
| 1046      | "        | Newville, Flood Farm               | II  | 18 |
| 1140      | "        | Oroville Dam                       | I   | 11 |
| 1051      | "        | Oroville, Seismograph Station      | I   | 13 |
| 1191/1212 | "        | Palo Alto Sq. Nos. 1 and 2         | III | 28 |
| 1054      | "        | Pine Flat Dam                      | II  | 20 |
| 639       | "        | San Diego V.A. Hospital            | II  | 22 |
| 1068      | "        | San Francisco, B of A              | IV  | 7  |
| 1136      | "        | San Francisco, BART Vent Shaft     | IV  | 9  |
| 1071      | "        | San Francisco, Beth. Pac. Bldg.    | IV  | 10 |
| 1118      | "        | San Francisco, Eastman Kodak       | IV  | 11 |
| 1073      | "        | San Francisco, Federal Bldg.       | IV  | 12 |
| 1127      | "        | San Francisco, Firemen's Fund      | IV  | 13 |
| 1117      | "        | San Francisco, Golden Gate Park    | I   | 15 |
| 1168      | "        | San Francisco, Pac. T & T          | IV  | 14 |
| 1228      | "        | San Francisco, Randall Museum      | I   | 17 |
| 1115      | "        | San Francisco, Shell Bldg.         | IV  | 15 |
| 1225      | "        | San Francisco, V.A. Hospital       | I   | 19 |
| 1098      | "        | Terminus Dam                       | II  | 24 |
| 2201      | Montana  | Butte, Metallurgy Building         | I   | 21 |
| 2008      | Nevada   | Reno, V.A. Hospital                | I   | 23 |
| 2605      | New York | Albany, V.A. Hospital              | I   | 25 |
| 2206      | Utah     | Flaming Gorge, Seismograph Station | I   | 27 |
| 2203      | "        | Logan, Admin. Bldg., USU           | I   | 29 |
| 2210      | "        | Salt Lake City, V.A. Hospital      | I   | 31 |

|      |                    |                                  |    |    |
|------|--------------------|----------------------------------|----|----|
| 2130 | Washington         | American Lake V.A. Hospital      | II | 26 |
| 2101 | "                  | Olympia, Highway Test Laboratory | I  | 33 |
| 2102 | "                  | Seattle Federal Building         | II | 29 |
| 2106 | "                  | Seattle, Pier 20                 | I  | 35 |
| 2124 | "                  | Walla Walla, V.A. Hospital       | II | 31 |
| 3500 | Managua, Nicaragua | Banco Central                    | IV | 16 |
| 3501 | "                  | Esso Refinery                    | IV | 18 |
| 3507 | "                  | Intercontinental Hotel           | IV | 19 |

## APPENDIX B

### Explanation of Geologic Code

The symbols and their meanings are listed in Table 1. The code's first characters (class code) describe the surface materials without regard to depth. Specific site lithology is indicated after the first three letter class code by groups of two letter abbreviations (rock types) which may have a third letter (explanatory symbol) that describes a physical characteristic, e.g. SH is shale and SHF is fractured, sheared, or jointed shales.

A number after the rock type is the depth to the base of the unit, e.g. AL914 means alluvium to a depth of 914 meters. Except for the first colon after the three letter code, which serves as a separator, the colon indicates "overlying", e.g. AL914:CS1067 means alluvium to 914 meters overlying a combination of sedimentary rocks that extend to a depth of 1067 meters. The letter K after a number is 1000 times multiplier, e.g. 4K means 4000 meters. A lack of number means the depth of the material is not known. A standard geological abbreviation is not used.