LANDSLIDE HAZARD MITIGATION STUDY
Tutuila Island, American Samoa

Prepared in Accordance with the Cooperative Agreement
Between the Soil Conservation Service and American Samoa
Coastal Management Program (ASCMIP) / Economic Development
Planning Office (EDPO). Partial Funding provided by the
National Oceanic and Atmospheric Administration's (NOAA),
Office of Ocean and Coastal Resource Management (OCRM)
through ASCMIP/EDPO, American Samoa Government

October 30, 1990

By

Donald F. White, District Conservationist
Soil Conservation Service
U.S. Department of Agriculture
Pago Pago, American Samoa

and

Charles E. Stearns, Engineering Geologist
Soil Conservation Service
U.S. Department of Agriculture
West National Technical Center
Portland, Oregon
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>I. Introduction</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Background</td>
<td>1</td>
</tr>
<tr>
<td>B. Methods of Study</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II. Causes of Slides</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Literature Search</td>
<td>4</td>
</tr>
<tr>
<td>B. Aerial Photography Review</td>
<td>5</td>
</tr>
<tr>
<td>C. USGS Open-File Report on 1979 Landslides</td>
<td>7</td>
</tr>
<tr>
<td>D. Post-Study Slides</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IV. Existing Slides</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Field Study and Suggested Treatment of Existing Landslides</td>
<td>9</td>
</tr>
<tr>
<td>B. Geology</td>
<td>12</td>
</tr>
<tr>
<td>C. Soil</td>
<td>13</td>
</tr>
<tr>
<td>D. Slopes</td>
<td>15</td>
</tr>
<tr>
<td>E. Vegetation</td>
<td>16</td>
</tr>
<tr>
<td>F. Water</td>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V. Predictability- Landslide Hazard Zone Maps</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI. Mitigation</td>
<td>23</td>
</tr>
<tr>
<td>A. Engineering</td>
<td>24</td>
</tr>
<tr>
<td>B. Retaining Walls</td>
<td>25</td>
</tr>
<tr>
<td>C. Drainage on Building Pads</td>
<td>26</td>
</tr>
<tr>
<td>D. Drainage on Hillslopes Above Cut Slopes</td>
<td>27</td>
</tr>
<tr>
<td>E. Revegetating Slopes</td>
<td>28</td>
</tr>
<tr>
<td>F. Pole Houses</td>
<td>29</td>
</tr>
<tr>
<td>G. Setbacks</td>
<td>30</td>
</tr>
<tr>
<td>H. Access Road Drainage</td>
<td>31</td>
</tr>
<tr>
<td>I. Treatment for Vertical Rock faces</td>
<td>32</td>
</tr>
<tr>
<td>J. cribbing</td>
<td>33</td>
</tr>
<tr>
<td>K. Early Warning System and Public Education</td>
<td>34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VII. Grading Ordinances</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Uniform Building Code</td>
<td>36</td>
</tr>
<tr>
<td>B. Oahu Ordinance</td>
<td>37</td>
</tr>
<tr>
<td>C. Portland Ordinance</td>
<td>38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VIII. Summary</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>IX. Recommendations</td>
<td>39</td>
</tr>
<tr>
<td>Bibliography</td>
<td>43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Appendices</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oahu Ordinance</td>
<td>44</td>
</tr>
<tr>
<td>2. Literature Review</td>
<td>49</td>
</tr>
<tr>
<td>3. Portland Grading Ordinance</td>
<td>51</td>
</tr>
<tr>
<td>4. Uniform Building Code, Chapter 70</td>
<td>61</td>
</tr>
<tr>
<td>5. Retaining Wall</td>
<td>67</td>
</tr>
<tr>
<td>6. Grading Standard Diagram</td>
<td>68</td>
</tr>
<tr>
<td>7. Typical Finish Grading</td>
<td>69</td>
</tr>
<tr>
<td>8. Pole Houses</td>
<td>70</td>
</tr>
<tr>
<td>9. Setbacks</td>
<td>72</td>
</tr>
<tr>
<td>10. Waterbars</td>
<td>73</td>
</tr>
<tr>
<td>11. Crib Retaining Walls</td>
<td>74</td>
</tr>
</tbody>
</table>
I-A. BACKGROUND

Landslides are a recurring problem on Tutuila and other islands of American Samoa. A school building was destroyed by a slide in Nua in 1985. Luckily school was not in session at the time. Four people were killed in Se'e'ta'a by the landslides that occurred during the 1979 storms. Recurring landslides block the Aua-Afono Road almost every year. Numerous landslides occur during hurricanes such as Hurricane Ofa in 1990. Fortunately no lives were lost during Hurricane Ofa in American Samoa. But these three recent episodes of sliding in 1979, 1985, and 1990 show the seriousness of the landslide problem on Tutuila.

Nearly all the 21 slides at 12 separate sites examined during this study were small. Most were caused by construction of pads for homes or access roads to the pads. The problems associated with the house pads were failure of the cut slope and/or failure of the resulting fill. For roads, it was failure of the cut slope itself.

The Soil Conservation Service (SCS), an agency of the U.S. Department of Agriculture, was asked by the American Samoa Coastal Management Program (ASCM) of the Economic Development Planning Office (EDPO) to conduct a Landslide Hazard Mitigation Study for Tutuila Island. A memorandum of Understanding (MOU) was signed between SCS and ASCM/EDPO outlining the job to be done.

Partial funding for this study was provided by the National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management (OCRM) through the American Samoa Coastal Management Program (ASCM) / Economic Development Planning Office (EDPO), American Samoa Government. SCS provided the remaining funds as part of their continuing national program of soil and water conservation.

This report documents the results of the Landslide Hazard Mitigation Study. The methodology used by SCS was to gather first-hand information about the nature of the landslides occurring on Tutuila. Then present this information on maps to show the degree of landslide hazard expected for various areas. These maps can be used for development planning to reduce the hazard to life and property resulting from landslides.
I-B. METHODS OF STUDY

The following steps were followed in completing this study:

1. A literature search was done to find relevant information on landslides. The following topics were researched:
   A. Causes of landslides in general.
   B. Resource data on American Samoa.
   C. Landslide problems in American Samoa and on other Pacific islands.
   D. Mitigation measures suitable for American Samoa.
   E. Grading ordinances for slide-prone areas.

2. Members of the American Samoa Conservation Steering Committee located landslides they were aware of on a topographic map of Tutuila.

3. Aerial photos were reviewed to see if additional older slides could be located.

4. Existing slides were plotted on clear mylar and overlain on ASCMP Atlas (1982) maps of geology, soils, slope zones, and vegetation. Correlations between existing slides and these sources were noted.

5. A field study of existing slides was conducted. Soils, geology, slopes, and vegetation were verified at each site.

6. Based on the above information, a slide hazard rating was developed for the rest of Tutuila and a landslide hazard zone map was compiled. Delineations of low, medium, and high slide hazard were determined by merging delineations from the soils and slope maps. This process is outlined in more detail in Sections IV and V.

7. Data from an unpublished U. S. Geological Survey (USGS) report was also used (Buchanan-Banks, 1981). Buchanan-Banks studied landslides that occurred on Tutuila during exceptionally heavy rains in 1979. The slides she located were plotted on the slide hazard maps. This data and her report were used as a check on the study's conclusions and ratings. Her information supported these conclusions very well.

8. Draft landslide hazard maps were sent to SCS' Cartographic Center in Fort Worth, Texas for compilation, color separation, and printing.
II. CAUSES OF SLIDES

The cause of most landslides is often complex. But basically, landslides occur when the shear stress on a soil or rock mass exceeds its shear strength. Basically, this means that material will slide when the forces pushing or pulling it downslope exceed the forces holding it in place.

There are several practical implications of this general concept. Water added to a potential slide area makes it more likely to slide because it increases the weight of the material. Added water also reduces the strength of the soil mass. See Section IV-F for more information on the relationship between water and landslides on Tutuila.

The shear stress on soil or rock material is directly proportional to the sine of the slope angle. This means that similar material is more likely to slide on steeper slopes. This relationship was very evident during the field portion of our study, as outlined in Section IV-D. A high percentage of slides occurred on slopes greater than 60° (33 degrees).
III-A. LITERATURE SEARCH

Harry Sato, State Soil Scientist for SCS, Hawaii (retired) conducted a literature search for this study at Hamilton Library at University of Hawaii. There were no literature citations for landslides for other Pacific Basin islands. This may indicate that landslides are not a major problem in the region.

There are, however, some significant sliding problems on Oahu in Hawaii, which have been described by the media there. These problems are discussed in sections IV-C and VII-B. A sample ordinance from Oahu which regulates development on slide-prone land is included as Appendix 1.

There were also a number of more general references on slides that Sato located. These may be useful in future slide work done here. A summary of these references is included as Appendix 2.

An additional search was done for literature on landslides and possible mitigation measures at the SCS West National Technical Center in Portland, Oregon. Many of these references were used in writing this report and are cited in the Bibliography. The most pertinent reference was Jane Buchanan-Banks' (1981) study on the 1979 landslides on Tutuila. It is summarized in Section III-C. All references cited in this report are available on request at the SCS office in Pago Pago.
III-B. AERIAL PHOTOGRAPHY REVIEW

Aerial photos from 1971 and 1984 flights were reviewed. The possibility of locating additional existing or old slides was explored.

The 1971 photo coverage was obtained from the SCS Cartographic Center in Fort Worth, Texas. Only partial coverage of first generation photos was available for Tutuila. Complete coverage of less distinct second generation photos with soil survey lines superimposed was also available. These maps were at a scale of 1:15,940 (1 in.=1320 ft.). It was difficult to distinguish slides from clearings on these photos at this scale. The typical slides we saw on Tutuila are too small to locate on such small-scale photos. A typical 50 ft. X 50 ft. slide would be only about 1/32 in. on a side at this scale.

The 1984 aerial photo coverage was at a scale of 1:2400 (1 in.=200 ft.). But the quality of both the original photos and blueprint copies was poor. Clouds obscured some areas completely. There was no photo image at all in a few areas. Some photos were so dark it was impossible to distinguish any landscape features. No stereo coverage was available for this flight. It was not possible to distinguish slides from cleared agricultural areas or rock outcrops for this flight.

Besides the above photography, older aerial photo coverage for American Samoa is also available from the US Geological Survey (USGS). The following coverage is available:

<table>
<thead>
<tr>
<th>DATE</th>
<th>SCALE (RATIO)</th>
<th>SCALE (IN./FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/8/54</td>
<td>1:18,800</td>
<td>1 IN.= 1557 FT.</td>
</tr>
<tr>
<td>9/17/61</td>
<td>1:24,000</td>
<td>1 IN.= 2000 FT.</td>
</tr>
<tr>
<td>1/17/63</td>
<td>1:3888</td>
<td>1 IN.= 324 FT.</td>
</tr>
<tr>
<td>1/11/63</td>
<td>1:21,127</td>
<td>1 IN.= 1761 FT.</td>
</tr>
<tr>
<td>3/3/66</td>
<td>1:20,000</td>
<td>1 IN.= 1667 FT.</td>
</tr>
</tbody>
</table>

Information on obtaining these flights is available from:
U.S. Geological Survey
National Cartographic Information Center
507 National Center
Reston, VA 22092
(703) 660-6045

These older aerial photos could be very useful in establishing historical baseline data such as the original margins of the lagoons or the location of old storage tanks in the Pago Harbor area. It would be difficult to use them for locating additional historical slides because of the small scale of all the flights except the 1/17/63 flight. In addition, it is very difficult to locate old slides in the field because of the extensive vegetative regrowth in the intervening years.
After examining two complete sets of aerial photos of Tutuila photo by photo, it became apparent that slides are relatively uncommon in undisturbed areas. Undisturbed areas are generally heavily vegetated with dense forest and apparently stable. The number of cleared areas, a few of which could also be past slides, increase greatly near the villages. The same pattern was readily apparent during the field reconnaissance of the island.

In slide-prone areas of northern California and southwestern Oregon, there are extensive slides even in undisturbed areas. There are even more, of course, in disturbed areas. But on Tutuila, the soils seem to be fairly stable when undisturbed, particularly considering the steepness of the natural slopes. Slides in undisturbed areas are uncommon except under heavy rains such as occurred in 1979 and during Hurricane Ofa in 1990. All of the slides observed during the course of this study in 1989 were directly traceable to disturbance.
III-C. USGS OPEN-FILE REPORT ON 1979 LANDSLIDES

Jane Buchanan-Banks of the US Geological Survey (USGS) examined about 70 landslides that occurred on Western Tutuila on October 26, 1979. She plotted 60 of these on a map accompanying the report. They have been plotted on the Landslide Hazard maps with a "*" symbol. Her study is documented in an unpublished open file report (Buchanan-Banks, 1981). She concluded that the slides occurred due to a combination of the following factors:

1. Steep slopes
2. Heavy rainfall
3. Deeply weathered rock
4. Downslope dip of most of the bedding planes

Though the slides were confined to the western end of Tutuila, she did not think they were due to landscape features there but to the heavy rain received in that area. She found no record that earthquakes contributed to the slides. She also felt that human activities, such as construction, sometimes unwittingly contributed to landslides.

She recommended several courses of action to get a better understanding of the landslide problem. It is heartening to see how many of these items have been completed in the intervening decade. Among her recommendations were the following:

1. Document the areas of landsliding. She did this for the 1979 slides and it was done for the more recent slides during this study. Future slides should continue to be so documented to add to our knowledge and to test our conclusions.

2. Identify the relationship between slope stability and vegetation. This item was completed during this study.

3. Identify the most geologically unstable areas. This was one of the main objectives of this study.

4. Produce a map showing degree of slope. This was one of the maps produced for the ASCMP Atlas in 1982.

5. Evaluate the types of weathered material underlying the slopes. This was done during the SCS soil survey completed in 1984.

Items 4 and 5 were critical tools in completing this study. This study reinforces Buchanan-Banks' earlier conclusions as well as carrying out many of her recommendations for future work.
III-D. POST-STUDY SLIDES - HURRICANE OFA

The fieldwork for this study was completed in December, 1989 and January, 1990. A copy of the draft report was turned in to ASCEP/EDPO on February 1, 1990. Immediately thereafter on February 2-4, Hurricane Ofa struck Tutuila. Winds up to 145 miles per hour lashed the island. About 13.5 inches of rain fell during the hurricane and an additional 6.5 inches in the four days that followed it. An additional ten landslides that occurred during this period were located.

Unlike the slides we observed in this study, many of these slides were in areas that were largely inaccessible and unused by man. Most occurred along the central ridgeline on Tutuila on extremely steep slopes. Most seem to have been caused by the heavy rains. The strong winds which blew over many large trees all over the island probably also contributed. Many of these slides were probably triggered by trees which toppled and carried soil with them as they fell downslope.

Because these slides occurred after the landslide hazard maps were completed, they are a useful check on the map's validity. Of the ten slides that occurred during this period, all occurred in areas designated as high hazard. These slides are shown on the landslide hazard zone maps by a "*".

IV-A. FIELD STUDY AND SUGGESTED TREATMENT OF EXISTING LANDSLIDES

For this study, 21 existing landslides were examined at 12 sites on Tutuila. These were located on a topographic map by members of the interagency American Samoa Conservation Steering Committee from their knowledge of the island. These existing slides are plotted on the landslide hazard zone map. A brief description of each slide is given in Table 1 below. The slides are numbered. Numbers on Table 1 correspond to those on the map.

Generally, most existing slides on Tutuila are quite small. The exception is the large block slide on the road between Poloa and Fagali'i. This block slide was 275 feet wide when observed (12-15-89) and extended down the slope 200 to 300 feet. A small farm is directly above the road. The farm is on a bench that appears to be the head or top of the block slide. The area was examined for cracks and other evidence of recent activity and none was found. Since there is a house at the head of the slide, the area is heavily used. Evidence of slide movement may have been erased. Residents have not noticed any cracks in their house.

There is direct evidence of new movement on the road, however. Fresh cracks in the asphalt cross the road. The road is also down-dropped about 3-5 inches, showing that the slide is moving. A culvert designed to drain water from a roadside ditch is blocked, causing water to flow over the road. The blocked culvert also allows water to pond on the slide. The ponding water complicates an already hazardous situation by increasing the amount of water seeping into the slide. Instead water should be diverted away from this slide. This slide is #11 on Table 1 and the map.

Hurricane Ofa struck Tutuila in February, 1990 after the field portion of this study was completed. The road on this slide dropped an additional 4-6 inches in the aftermath of Ofa.

The majority of the slides on Tutuila are much smaller than this block slide. Many are less than 50 feet wide by 50 feet long. Most are associated with the construction of house pads and roads.

Two slides (#1 & #2) at Lau'ili'itua'i and Alega are rockfalls associated with construction of the main road. Suggested mitigation measures for slides such as these, using screens or concrete guardrails is included in Sec. VI-I.

A group of eight slides was studied on the road from Aua to Afono. These slides are shown on the landslide hazard zone map as #3. All these slides are in roadcuts and are associated with construction of the road. Many of the cuts
<table>
<thead>
<tr>
<th>SLIDE</th>
<th>LOCATION</th>
<th>SOIL SURVEY MAP UNIT</th>
<th>SOIL</th>
<th>GEOLOGY</th>
<th>FIELD SLOPE</th>
<th>SLOPE MAP</th>
<th>CAUSE OF SLIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aumii</td>
<td>4</td>
<td>Rock outcrop &amp; Lithic Haploxerolls</td>
<td>Ppe</td>
<td>90%</td>
<td>60-80%</td>
<td>Road</td>
</tr>
<tr>
<td>2</td>
<td>Avaio</td>
<td>4</td>
<td>Lithic Haploxerolls</td>
<td>Ppe</td>
<td>96%</td>
<td>&gt;80%</td>
<td>Road</td>
</tr>
<tr>
<td>3-1</td>
<td>Aua/Afono</td>
<td>2,4,74</td>
<td>Aua</td>
<td>Ra,Ppe</td>
<td>84%</td>
<td>8-20%</td>
<td>Road</td>
</tr>
<tr>
<td>3-2</td>
<td></td>
<td>4</td>
<td>Lithic Haploxerolls</td>
<td>Ppe</td>
<td>80%</td>
<td>60-80%</td>
<td>Road</td>
</tr>
<tr>
<td>3-3</td>
<td></td>
<td>4</td>
<td>Rock outcrop &amp; Lithic Haploxerolls</td>
<td>Ppe</td>
<td>65%</td>
<td>60-80%</td>
<td>Road</td>
</tr>
<tr>
<td>3-4</td>
<td></td>
<td>4</td>
<td>Lithic Haploxerolls</td>
<td>Ppe</td>
<td>102%</td>
<td>60-80%</td>
<td>Road</td>
</tr>
<tr>
<td>3-5</td>
<td></td>
<td>4</td>
<td>Lithic Haploxerolls</td>
<td>Ppe</td>
<td>99%</td>
<td>60-80%</td>
<td>Road</td>
</tr>
<tr>
<td>3-6</td>
<td></td>
<td>4</td>
<td>Lithic Haploxerolls</td>
<td>Ppe</td>
<td>56%</td>
<td>20-40%</td>
<td>Road</td>
</tr>
<tr>
<td>3-7</td>
<td></td>
<td>4</td>
<td>Aua</td>
<td>Ra</td>
<td>60%</td>
<td>20-40%</td>
<td>Road</td>
</tr>
<tr>
<td>3-8</td>
<td></td>
<td>2</td>
<td>Aua</td>
<td>Ra</td>
<td>60%</td>
<td>20-40%</td>
<td>Road</td>
</tr>
<tr>
<td>4</td>
<td>Aua</td>
<td>2,4</td>
<td>could not locate</td>
<td>Ra,Ppe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Utulei</td>
<td>4</td>
<td>Fagassa</td>
<td>Ppi,Ppt</td>
<td>81%</td>
<td>60-80%</td>
<td>Road</td>
</tr>
<tr>
<td>5-1</td>
<td></td>
<td>4</td>
<td>Fagassa</td>
<td>Ppi,Ppt</td>
<td>76%</td>
<td>60-80%</td>
<td>Pad</td>
</tr>
<tr>
<td>5-2</td>
<td></td>
<td>4</td>
<td>Fagassa</td>
<td>Ppi,Ppt</td>
<td>58%</td>
<td>60-80%</td>
<td>Pad</td>
</tr>
<tr>
<td>5-3</td>
<td></td>
<td>4</td>
<td>Fagassa</td>
<td>Ppi,Ppt</td>
<td>78%</td>
<td>&gt;80%</td>
<td>Pad</td>
</tr>
<tr>
<td>6</td>
<td>Fatumafuti</td>
<td>4</td>
<td>Lithic Haploxerolls</td>
<td>Ppi(pan)</td>
<td>64%</td>
<td>60-80%</td>
<td>Water Leak</td>
</tr>
<tr>
<td>7</td>
<td>Nuu'uli</td>
<td>4</td>
<td>Fagassa</td>
<td>Po,Ra</td>
<td>71%</td>
<td>60-80%</td>
<td>Stream</td>
</tr>
<tr>
<td>8</td>
<td>Nua</td>
<td>4,34</td>
<td>Inaccessible</td>
<td>Po,Ra(ash)</td>
<td></td>
<td>&gt;80%</td>
<td>Road, Water</td>
</tr>
<tr>
<td>9</td>
<td>Se'etaga</td>
<td>4,34</td>
<td>Fagassa</td>
<td>Po(ash,tuff)</td>
<td>62%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Ananave</td>
<td>4</td>
<td>Fagassa</td>
<td>Po(basalt, tuff)</td>
<td>57%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Poloa</td>
<td>4</td>
<td>Fagassa, Aua</td>
<td>Ppi,Ra(ash,tuff)</td>
<td>70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Nuu'uli</td>
<td>2,4</td>
<td>Fagassa, Aua</td>
<td>Ppi,Ra(ash,tuff)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
are nearly vertical. Regular maintenance is needed to keep the road clear. Vegetation does a good job of stabilizing and reducing erosion from roadcuts in soil material. Revegetating such roadcuts would reduce the need for other maintenance. Landslides in roadcuts that are essentially rockfaces cannot readily be revegetated, but they can be treated with the measures outlined in VI-I.

A series of three related slides was examined in Utulei. They were associated with a recent excavation for house pads and access roads to them. These slides are grouped as #5 on the slide hazard map.

Landslide #7 is located below a water tank 1 mile west of Nu‘uuli. It appears to have been caused by a leaking pipe leading downslope from the tank. According to the landowner, the tank is no longer in service.
IV-B. GEOLOGY

The geology maps and soil maps available for the island of Tutuila are somewhat generalized. The rugged terrain and heavy vegetative cover dictate that fine map delineations can not be made here. The geologic material in which the slides occurred was generally either talus or ash (listed as vitric tuff in several of the geologic map units).

Talus material on Tutuila consists of loose soil and rock fragments that accumulated at the base of steep slopes and reached there by falling, rolling, or sliding. It probably is at its angle of repose. Considering its mode of formation, it is inherently unstable. Unfortunately, on the geology maps it is grouped together with beach sand, which is unlikely to slide. Beach sand and talus are grouped in map unit 8a.

Areas of ash and vitric tuff are also grouped together in two main formations:

1. Taputapu Volcanics
   - Po- Olivine basalts, cinder cones, dikes and vitric tuff beds (looks like ash in field)

2. Pago Volcanic Series
   - Ppe- Extra Caldera volcanics
   - Ppi- Intra Caldera volcanics-andesite and basalt flows
   - Ppt- Lithic Tuff Member (looks like ash in field).

Because the slide-prone geologic materials are included with other units, the geologic map was not a useful slide predictor. Fortunately, talus areas are well delineated on the soil maps as Aaa very stony clay loam (Soil Map Units 1 & 2). A disproportionate number of slides occur in unit 2. While this unit comprises only about 5% of Tutuila, 5 of the 21 slides (23.8%) occurred in areas of unit 2. There are no slides in unit 1, which is less steep than unit 2.

It was not possible to separately delineate the ash areas since they are grouped into broader units of several different rock types on both the geology and soil maps.
Most of the landslides on Tutuila are associated with two soil map units, as described in the Soil Survey of American Samoa (Nakamura, 1984). The two units are listed below:

- Map unit 2: Aua very stony silty clay loam, 30-60% slopes

- Map unit 4: Fagasa family-Lithic Hapludolls-Rock Outcrop Association, very steep (70-110% slopes)

Aua soils are more than 60" deep, are clayey, and contain more than 35% cobbles and stones. They formed on talus slopes where soil and rock have accumulated by gravity at the base of mountain slopes. Because of this mode of formation, they are inherently unstable as discussed previously in Section IV-B.

Fagasa family soils are 20-60" deep to the underlying volcanic rock. These soils are clayey and contain less than 35% loose stones and other rock fragments. Soils of this unit slide because of relatively low strength. These soils are very slippery when wet, an indication of their low cohesion and comparative lack of strength.

The landslide problems on Oahu in Hawaii have been associated with clayey soils with montmorillonitic mineralogy. These are soils that shrink when they are dry and swell when wet. Such soils are notoriously unstable and slide-prone in northern California and southwestern Oregon and many other locations around the world. These soils are generally classified as CH in the Unified Soil Classification System and have poor shear strength.

American Samoa also has large areas of clayey soils like Fagasa and Ofu on steep mountain slopes, but they have halloysitic mineralogy. Halloysitic soils are generally more stable and less slide-prone than montmorillonitic soils. Clayey soils on Tutuila are classified as MH in the Unified System. Their shear strength is poor to fair. The soil characteristics of Tutuila's mountain soils alone do not make them strongly slide-prone. That's why relatively few slides occur on undisturbed sites under normal weather conditions. But the combination of very steep slopes, removal of vegetation and/or supporting toe slopes, and excessive wetness cause even these soils to fail.

Lithic Hapludolls soils are generally similar to Fagasa soils except that they are less than 20" deep to the underlying bedrock. Rock outcrops are simply areas where the solid volcanic rock that forms the mountains of Tutuila is exposed at the surface. Areas of Lithic Hapludolls and Rock Outcrop are less prone to slide than areas of Fagasa soil on the same slope. They slide on very steep slopes when the joints between rocks weaken the rock mass. A rock mass is more
prone to slide when the joints (including bedding planes) are oriented downslope. Just like soils, rock will fail when the resisting forces are less than the driving forces. Nearly vertical rock faces such as those for slides 1 and 2, and many of the small slides at site 5 fail when vertical cracks in the rock become deep and continuous. The small amount of soil of the Lithic Haplustolls does not greatly alter the tendency of the underlying rock to slide. It is essentially carried along when the rock mass fails. There seems to be little difference in the slide tendencies of Lithic Haplustolls and Rock Outcrop areas.

Based on field observations and extrapolations to similar soils, the slide hazard was estimated for each soil on Tutuila. Data on the ASCMP Atlas slope group and soil maps was merged to arrive at the slide hazard map for Tutuila. The estimated slide hazard for the soils on Tutuila are listed in Table 2 below:

<table>
<thead>
<tr>
<th>SOIL</th>
<th>SLOPE</th>
<th>LANDSLIDE HAZARD RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aua</td>
<td>0-8%</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>8-20%</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;20%</td>
<td>high</td>
</tr>
<tr>
<td>Fagasa</td>
<td>20-60%</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;60%</td>
<td>high</td>
</tr>
<tr>
<td>Iliili</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Leatu</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Lithic Hapludolls</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>&lt;40%</td>
<td></td>
<td>moderate</td>
</tr>
<tr>
<td>40-60%</td>
<td></td>
<td>high</td>
</tr>
<tr>
<td>&gt;80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ngedebus</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Ngedebus Variant</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Ngurungor Variant</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Ofu</td>
<td>20-60%</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;60%</td>
<td>high</td>
</tr>
<tr>
<td>Oloaga</td>
<td>&lt;40%</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>40-80%</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;80%</td>
<td>high</td>
</tr>
<tr>
<td>Pavaii</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Papatua</td>
<td>&lt;40%</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>40-80%</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;80%</td>
<td>high</td>
</tr>
<tr>
<td>Rock Outcrop</td>
<td>&lt;40%</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>40-80%</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>&gt;80%</td>
<td>high</td>
</tr>
<tr>
<td>Sogi</td>
<td>&lt;40%</td>
<td>low</td>
</tr>
<tr>
<td></td>
<td>40-80%</td>
<td>moderate</td>
</tr>
<tr>
<td>Tafuna</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Troporthenit</td>
<td></td>
<td>low</td>
</tr>
</tbody>
</table>
IV-D. SLOPES

As noted in Section II, the shear stress on a soil mass increases as the slope angle increases. Therefore, similar material is increasingly likely to slide as the slope steepens. This relationship was evident in the results of our study.

The slope angle was determined at each of the existing slides. The determinations were based on the estimated land surface prior to the slide because this is the important parameter for predicting future slides. All of the slides we examined had slopes greater than 55% (29 degrees). These onsite determinations are listed as "Field Slopes" in Table 1 in Section IV-A.

All of the slide sites were plotted on the ASCMP Atlas slope zone maps. Of the slides examined, 86% (14/21) plotted in the 60-80% or >80% slope zones. Buchanan-Banks' 1979 slides were also plotted on these slope zone maps. She plotted 60 slides on a map in her report. Of the slides she observed 50% (34/60) occurred on slopes greater than 45% (22 degrees). In addition, 63% (38/60) were on slopes greater than 50% (31 degrees). These slope zone maps obviously have considerable predictive value for landslides.
IV-E. VEGETATION

There is a strong correlation between vegetation and the occurrence of slides on Tutuila. This correlation is evident in both aerial photo review and field reconnaissance of the island as outlined in IV-B above. Slides are strongly concentrated in those areas where the native vegetation has been disturbed.

In the Atlas of American Samoa (1982), Whistler designates two categories of disturbed vegetation, "managed land" and "disturbed forest". He defines managed land as "land that is actively or passively being used by the Samoans, so that it is not able to return to its native state." Disturbed forest is land that was once cleared but is slowly returning to native vegetation and is at the secondary forest stage.

All 12 of the slide sites examined this year occurred in areas mapped by Whistler as managed land. Of the slides examined by Buchanan-Banks in 1979 68% (41/60) occurred in areas of managed land. An additional 15% (9/60) occurred in disturbed forest areas. So 83% of the slides one examined occurred on sites where the native vegetation had been disturbed.

Vegetation was also identified at each of the slide sites visited. This is the vegetation around the slide area, not on the slide since the slide itself is disturbed. Common English names are used where known. Otherwise scientific names are used. Vegetation at each slide are shown in Table 3 below.
<table>
<thead>
<tr>
<th>SLIDE</th>
<th>DOMINANT VEGETATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>bananas, wild fig, honolulu rose, elephant grass, wedelia, Scaevola taccada.</td>
</tr>
<tr>
<td>2</td>
<td>wild fig, wild nutmeg, Samoan mahogany, Hibiscus sp.</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3-1</td>
<td>mile-a-minute, guest tree, wild fig, beach bean, Macaranga harveyana.</td>
</tr>
<tr>
<td>3-2</td>
<td>beach bean, fern, elephant grass, Rhus titensis.</td>
</tr>
<tr>
<td>3-3</td>
<td>elephant grass, Hibiscus sp., Rhus titensis, Macaranga harveyana.</td>
</tr>
<tr>
<td>3-4</td>
<td>mile-a-minute, fern, elephant grass, Rhus titensis, Macaranga harveyana.</td>
</tr>
<tr>
<td>3-5</td>
<td>guest tree, elephant grass, Dyoxylum sp., Rhus titensis.</td>
</tr>
<tr>
<td>3-6</td>
<td>wild nutmeg, elephant grass, dracaena, Hibiscus sp., Dyoxylum sp.</td>
</tr>
<tr>
<td>3-7</td>
<td>mile-a-minute, elephant grass, tree fern, Hibiscus sp., Leucaena sp.</td>
</tr>
<tr>
<td>3-8</td>
<td>dadap, guava, elephant grass, ylang ylang, Macaranga harveyana.</td>
</tr>
<tr>
<td>4</td>
<td>guest tree, mile-a-minute, fern, tree fern, Hibiscus sp.</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5-1</td>
<td>mango, cassava, mile-a-minute, ylang ylang, blue ratstail, Zingiber zerumbet.</td>
</tr>
<tr>
<td>5-2</td>
<td>beach bean, breadfruit, fern, Macaranga harveyana.</td>
</tr>
<tr>
<td>5-3</td>
<td>beach bean, mile-a-minute, coconut, Macaranga harveyana, Hibiscus sp.</td>
</tr>
<tr>
<td>6</td>
<td>mile-a-minute, beach bean, elephant grass, blue ratstail, Baringtonia asiatica, Hibiscus sp.</td>
</tr>
<tr>
<td>7</td>
<td>banana, breadfruit, coconut, fern, beach bean, elephant grass.</td>
</tr>
<tr>
<td>8</td>
<td>mango, coconut, elephant grass, Macaranga harveyana, Hibiscus sp.</td>
</tr>
<tr>
<td>9</td>
<td>mile-a-minute, tree fern, ylang ylang, Rhus titensis, fern, wild nutmeg, guest tree, Hibiscus sp.</td>
</tr>
<tr>
<td>10</td>
<td>coconut, elephant grass, beach bean, dracaena, Hibiscus sp.</td>
</tr>
<tr>
<td>11</td>
<td>banana, dadap, beach bean, sensitive weed, tropic lalo, stargrass, nutgrass, Hibiscus sp.</td>
</tr>
<tr>
<td>12</td>
<td>none</td>
</tr>
</tbody>
</table>
the common species at many of the areas around the slides were zile-a-minute and elephant grass which are among the first species to colonize cleared sites. Planted species such as banana, mango, coconut, hibiscus, etc. were also present around many of the slide areas. The preponderance of such vegetation confirms that many of the these sites fit Whistler's definition of "managed land" or "disturbed forest".

Landslides on Tutuila are often directly related to man's activities. Because slides here are concentrated near villages, they constitute a significant threat to life. Since landslides are relatively uncommon in undisturbed areas, it is imperative that future excavations are planned and performed as carefully as possible. Since human activities are causing many of the landslides, there is an opportunity to prevent future slides and save lives.
IV-F. WATER

As noted in Section II, water is a great contributor to landslides because it increases the weight of the soil mass and reduces its strength. Each inch of rainfall which infiltrates a one-acre slope adds about 110 tons to its weight.

Landslides commonly occur on Tutuila during periods of heavy prolonged rainfall. According to Stearns (1944), hundreds of landslides occur when hurricanes hit Tutuila. The severe slides on Western Tutuila in October, 1979 were directly attributable to the heavy rainfall on that end of the island (Buchanan-banks, 1981). Stream gauges in the slide area showed peak flows higher than historic levels and much higher than streams in central and eastern Tutuila. At least 10 large slides occurred during Hurricane Ofa in 1990. About 13.5 inches of rain fell on Tutuila during Ofa and an additional 6.5 inches in the 4 days after it.

Because of this relationship between heavy rains and slides, a landslide watch could be a useful mitigation measure for high slide hazard areas when rains are prolonged and heavy. This idea is discussed more fully in Section VI-K.

In addition to rainfall, springs or concentrated flows of water were common features at many of the existing slides examined. The leaky water tank at slide #7 and blocked culvert at slide #11 were described in Section IV-A. In addition, springs were noted at 5 of the 21 slides examined: 5-3, 8-1, 8-4, 8-6, and 12. In addition, slides 6, 8, 9, 10, and 11 were all in concave or drainage areas that received more runoff water from upslope areas.

Clearly, water is a major contributor to landslides in American Samoa. One of the fundamentals of treating existing landslides or preventing future landslides is to keep excess water off the site as much as possible. This has implications for slide-prone areas which are already built up and appear to be stable. If additional homes and accompanying septic systems are placed in such an area, they could cause it to slide.

People should not build their homes on or immediately below existing landslides because they often will slide again. But new homes are currently being built on or below past slides on Tutuila. New construction has taken place in the areas of slides 3, 6, and 10. If building takes place on old slides or springs are discovered during excavation of steep sites, provision should be made to dewater the site. Such measures do not guarantee that the area will not slide, but they do increase the margin of safety for the occupants. We strongly
recommend that people not build homes on or below past landslides.
V. PREDICTABILITY- LANDSLIDE HAZARD ZONE MAPS

Slopes that have many of the same characteristics as slopes that have failed can be assumed to pose future stability problems. These areas can be depicted on slope stability or landslide hazard maps. These maps are an inventory of those factors related to landslide susceptibility. They delineate parts of the landscape that are most likely to slide at some time in the future. These maps say nothing about when such problems will occur (Roth, 1983).

Landslide hazard maps can be used as a planning tool to indicate locations where more detailed engineering plans and investigations are critically needed. Expensive engineering efforts can then be avoided in lower hazard areas (Roth, 1983). For example, Portland, Oregon requires that a registered civil engineer certify that a building plan is safe before building is allowed in hazardous areas. City engineers review this certification and accompanying documentation prior to granting a grading permit. Portland's grading ordinance is included as Appendix 3. Some localities have even chosen to prohibit development on unstable sites. The city of Los Angeles, for example, prohibits new development on slopes greater than 50%.

Natural resource data in the ASCMP Atlas (Clark, et al., 1982) was thoroughly reviewed. By plotting past slides on these ASCMP maps, a strong correlation was found between landslides and certain classes of soils, geology, slope, and vegetation. Using this correlation, a landslide hazard zone map was produced for Tutuila. Three classes of slope stability were differentiated, those with a low, medium, and high hazard for future landslides. On the final color-coded maps, these colors are used:

- high: red
- medium: gold
- low: green

These maps do not predict where landslides will occur, only where they are most likely to occur. Landslides may occur in any area, even those with a low hazard rating, due to unique local site conditions or poor excavation practices. But future slides will occur dominantly in those areas with a high landslide hazard and less frequently in those with a moderate slide hazard rating. These are the areas which have similar characteristics to the areas that slid in the past.

The existing landslides observed during this study are also plotted on the slide hazard map. They are shown by the same numbers in Table 1 in Section IV-A. These numbers are circled on the maps. Of these 12 slide sites, 11 (92%) fell within areas delineated as having a high slide hazard. One (8%) fell in a medium hazard area and none occurred in areas shown as having a low hazard.
Later, a copy of Buchanan-Banks’ study on the 1979 slides was received. The 60 slides that she located were plotted on the slide hazard maps. Of these 60 slides, 42 (70%) are in areas designated as high hazard and 18 (30%) are in those shown as medium hazard. None are in areas with a low slide hazard rating. This data provides strong support for the conclusions of this report.

Additional slides occurred during Hurricane Ofa in February, 1990 after the landslide hazard maps were completed. Because they post-dated the maps development, they also serve as a useful check on their validity. Ten slides that occurred during this period were located and all of them occurred in areas designated as high hazard.

Delineations on the Atlas slope zone maps were very detailed. It was not possible to carry over all of this detail to the landslide hazard zone maps. Areas smaller than about 3 acres (about a 1/4" square) could not be shown legibly on the map and are included with surrounding delineations which are generally one class higher or lower. No matter how fine slope delineations are made at any scale, there will always be some areas which are flatter or steeper than most of the area and cannot be shown legibly on a map. Indeed, some small delineations had to be removed from the slope zone maps themselves to improve their legibility. In addition, the topographic contours on which these maps were based also omit some cartographic detail (Clark, et. al., 1982). But for the large majority of sites, both the slope zone and landslide hazard zone maps will accurately depict site characteristics.

The landslide hazard zone maps are suitable for planning purposes, but because of the above factors do not eliminate the need for onsite investigations. Slopes and the resultant landslide hazard rating can be readily verified at any site using the soil survey, the soil slide hazard ratings outlined in Section IV-C, and a clinometer. For example, if a potential building site is located on Pagasa soil and the dominant slope is 45%, then the landslide hazard for that particular site is medium.

Clinometers are quick and easy to use. They are commercially available at about $60 each. Information on ordering them has already been provided to ASCRP. SCS can provide training in their use.
VI. MITIGATION

Mitigation measures for landslides are many and varied; expensive or cheap, complex or simple. Measures discussed below are those most applicable to conditions in American Samoa. These measures are generally inexpensive and can be installed by landowners or local contractors. This list is only meant to be a start for the Territory:

A. Engineering
   B. Retaining walls
   C. Drainage on building pads
   D. Drainage on hill slopes
   E. Revegetating slopes
   F. Foe houses
   G. Setbacks
   H. Access road drainage
   I. Treatment for vertical rock faces
   J. Cribbing
   K. Early warning system and public education
VI-A. ENGINEERING

Engineering is a broad term meaning to study and analyze a building site in an engineering sense. Some cities require an engineering report for critical areas before approval for hillside grading is given. Enough data is collected to calculate factors of safety and to make an estimate of cut and fill slope stability. For example, soil compaction and moisture control is standard engineering practice for design of fills. In American Samoa, grading is generally completed without such engineering input.

Considering the environmental damage and hazard to life resulting from non-engineered sites, the American Samoan Government (ASG) should consider hiring a registered civil engineer to assist landowners in developing safe site plans for hazardous areas. Alternatively, they may want to require that a private registered civil engineer develop a plan for sites in high slide hazard zones and certify that the excavation and building site will be safe. An ASG civil engineer could then review the adequacy of such plans and recommend approval or disapproval of permit applications based on them.
VI-8. RETAINING WALLS

Retaining walls can be used as a buttress at the base of a cut slope to support the toe. In this way the slope can be prevented from failing (sliding). The retaining wall replaces the toe of the slope that was cut away in making the pad. The retaining wall can also be used as a catchment for material that slides, falls or rolls off the cut slope.

As the slope becomes stable with the help of the retaining wall and material that fills in behind it, it can be used for landscaping. The bench created by the wall can be planted with flowers or other plants to soften the appearance of the wall.

A standard drawing for a retaining wall is included as Appendix 5. It is critically important to provide drainage for the area behind a retaining wall. The weight of the water that can build up behind undrained retaining walls greatly increases their risk of failure.
VI-C. DRAINAGE ON BUILDING PADS

Building pads and fills should be sloped to drain freely. Pads need to be sloped 1 to 2% to prevent ponding of water. Water should be collected and drained to a stable outlet. Flowing water should be directed away from fill slopes since they are loose and easily eroded. Excessive water on a fill slope can also saturate it and cause it to slide.

Diversion can be constructed to collect runoff from the pad. Diversions are simply shallow, wide ditches dug with a slight downhill grade. They can be dug above slopes to intercept runoff. Hillsides ditches can be constructed across cut and fill slopes to control runoff from the slopes themselves. Runoff should then be directed into a pipe or ditch armored with concrete, rock, or grouted rock and carried to the base of the slope. It should eventually be directed into a stream, onto a paved road or to some other protected outlet that will not erode when water flows into it. Examples of home drainage plans are shown in Appendices 6 and 7.
VI-D. DRAINAGE ON HILLSLOPES ABOVE CUT SLOPES

Ideally, natural slopes above a cut should have diversions or runoff collectors to keep runoff off the newly cut slopes. Many building sites in American Samoa are too steep for such diversions above the site to be feasible. But they may be a helpful alternative on selected sites that are less steep.
VI-E. REVEGETATING SLOPES

Vegetation has 4 main benefits: it uses up water in the soil, it provides erosion control, rocks add to stability, and it enhances the appearance of a site. Efforts are currently being made by SCS to locate convenient, economical, and readily available sources of vegetative materials that are adapted to American Samoa.

There are a number of erosion control plant species, both local and imported, which have done well in local trials. Flowering ornamental ground covers which are well adapted to local conditions include Wedelia, Disoecia, and Portulaca. Low-growing spreading grasses which do well in American Samoa include pangolagrass, Puerto Rican Stargrass, and Tropic Lalo. All of these species must be hand planted. Cuttings are collected from existing plantings and individually planted. Available stocks of these species are still quite small, but additional plantings are continually being planted. All of these plant materials are available free to the public or local government agencies.

The Soil Conservation Service is trying additional erosion control species which can be grown from seed. They are relatively cheap and available from commercial sources. oats, dallisgrass, and Bermudagrass have been successful in local trials. SCS will make planting recommendations for revegetating sites to landowners, contractors, and government agencies based on these continuing local trials.
VI-F. POLE HOUSES

Instead of developing a flat pad for the entire house, builders can use partial pads. Part of the house is supported by poles, anchored by footings, and part on the partial pad. The partial pad is on the uphill side and the poles are on the downhill side. This is the "Pole House" concept developed in Hawaii in response to slope stability problems there. By constructing a smaller pad and resulting fill slope, typical cut and fill problems are reduced. Much less land is disturbed and the need for retaining walls is eliminated.

Cut and fill problems are magnified in American Samoa because many sites are on steep hillsides and extensive earthmoving is needed to form even a relatively small house pad. Some of the FEMA homes built on hillsides in the wake of Hurricane Ofa used a concept similar to this. Information on Hawaiian pole houses is included as Appendix 8. No recommendation of any construction firm is implied by the use of the term "Pole Houses"
VI-G. SETBACKS

Setbacks are used for safety, stability and to prevent damage to adjacent properties. They are also used to provide access for slope maintenance and drainage. Setback limits or requirements are usually shown in grading ordinances. Examples of minimum setbacks from Portland's ordinance are shown in Appendix 9. Additional discussion about setbacks is included in Chapter 70, "Excavation and Grading" in the 1988 edition of the Uniform Building Code (UBC) reproduced as Appendix 4. Many localities establish setbacks different than the UBC to suit their particular needs.
VI-H. ACCESS ROAD DRAINAGE

Some of the methods available to treat drainage on access roads in American Samoa are outsloping, insloping, and water bars.

Outsloping:
Outsloping is an easy, inexpensive way to handle surface drainage for access roads. Outsloping reduces the risk of landslides by dispersing runoff evenly over the road edge instead of letting it concentrate in particular areas. Because runoff is not allowed to concentrate, outsloping also reduces rutting caused by soil erosion. Outsloping is normally done during construction. Instead of constructing the road level, it is built with a slight tilt toward the downhill side of the slope.

Outsloping access roads is effective only where roadbed grades are not excessive. The amount of the sidefall should be about 1/4-1/2 inch/foot where the roadbed grade is 4% or less. The sidefall should be increased about 20% for each 1% increase in roadbed grade up to 8%. When the roadbed grade is greater than 8%, outsloping alone is not adequate.

Insloping:
Another method for handling drainage on steep unpaved roads in American Samoa is the use of a system of water bars and rocklined ditches on insloped roads. A ditch is constructed on the inside edge of the road next to the cutbank. It intercepts runoff water from the hill above the road as well as subsurface flow. The road is built with 1 or 2% tilt toward the cutbank, so the ditch also channels water from the road itself. It must be rock-lined to protect it from scouring by concentrated flows of water. Rocks can usually be gathered from the excavated site. If not, it may be necessary to line the ditch with concrete. Relief culverts carrying water under the road and pipes or other protected methods of moving this water down the hillside may also be necessary on long road grades. Otherwise the ditch capacity may be exceeded and the road damaged.

Water Bars
Water bars built at regular spacings across the roadbed prevent runoff from concentrating on the roadbed. Water bars are simply a shallow dip and bump dug across the road at a slight downhill angle toward an insloped ditch. Appendix 10 is a standard drawing of a waterbar. The spacing between waterbars depends on the steepness of the roadbed and the rainfall. A very general guideline is to divide 1000 ft. by the % slope. For example, on a road grade with a 10% slope, waterbars should be constructed at about 100 foot intervals. Waterbars and other parts of such a system must be maintained to continue to function properly.
VI-1. TREATMENT FOR VERTICAL ROCK FACES

There are many near-vertical cuts in rock around the island. Loose boulders falling or rolling onto the road or homes below are a significant safety hazard. They have resulted in fatalities in other locales and could here too. A particularly dangerous time is during heavy rains when boulders loosened by previous storms are washed off rocky areas. There are two measures which could be used to reduce the danger of rockfalls here: screening and concrete guardrails. Both use locally available materials.

Screening:
Screening is used in cases where faces are vertical and it is not practical to cut the slope back. Chain-link fence material is anchored at the top of the cut and loosely draped over the rock face. It is anchored in a few places on the rock face as well. Rolling rocks are directed safely to the ground by the screen. Screening has been successfully used for years on a major interstate highway (I-5) in the state of Washington.

Concrete Guardrails:
Another method, which is probably easier to install, is to use concrete guardrails near the base of the rock face. They act as a fence to catch rocks after they fall from the cliff face. Such guardrails are already in use on the main island road at numerous curves. This method does not prevent rocks from falling, but the guardrails do reduce the number that roll onto the road or houses below. To be effective, the loose material at the base of the cliff should be cleared away so the concrete guardrails can be securely placed and provide adequate space for the falling rocks.
VI-J. CRIBBING

Cribbing can be used as a retaining wall or bulkhead below a slope. Cribbing can be constructed of concrete, wood, metal, or logs. They fit together much like a child’s “Lincoln Log” toys or like a “Log House”. Once in place, backfill is placed in the space between the crib and natural ground. Backfill must be self-draining and resistant to erosion through the crib members. Cribbing works much like a retaining wall and should be analyzed by an engineer to make sure it will be stable against expected loads. Appendix II shows an example of cribbing.
VI-K. EARLY WARNING SYSTEM AND PUBLIC EDUCATION

A public information campaign and an early warning system triggered by rainfall are additional mitigation measures ASG could put into effect. Total rainfall exceeding a given amount for 2 or more days would trigger public service announcements on radio and TV, warning people to be on the alert for landslides. They should be warned to avoid as much as possible the base of steep mountain slopes, particularly in recently excavated areas. The public should also be told to be wary of sharp reductions in streamflow during heavy storms. A sharp drop in flow may mean a slide has occurred upstream and temporarily blocked the stream. When the stream breaks through this temporary dam, a debris flow may follow. Debris flows have been extremely dangerous here in the past as shown by those at Se’etega in 1979 and several in Nua in the 1980’s. Four people were killed in the Se’etaga debris flow.
VII. GRADING ORDINANCES

Grading ordinances can be developed and used to require that excavating or filling in hazardous areas is regulated in a systematic way. Regulations are made, application fees are set, and enforcement is authorized. Grading ordinances are used by many cities and counties in Hawaii and the U.S. mainland to regulate the environmental damages associated with excavation.

Ordinances are often the most economical and most effective means available to a local government (Kockelman, 1986). Through ordinances, a government can prohibit, restrict, or regulate development in hazardous areas. If development is to be allowed in such areas, the density of that development can be regulated or mitigation measures required.
VII-A. UNIFORM BUILDING CODE

Chapter 70 of the Uniform Building Code (UBC), 1988 edition sets forth example rules and regulations to control excavation, grading and earthwork. The title of this chapter is "Excavating and Grading". The Code could be used as a model and modified to meet the needs of American Samoa. American Samoa already uses an earlier edition of the UBC to regulate some building practices. The UBC has recommended specifications for setbacks, cuts, fills, erosion control, and even permit fees. Copies of the 1988 edition of the UBC may be ordered from the International Conference of Building Officials, 5360 South Workman Mill Road, Whittier, CA 90601. Chapter 70 is reproduced in this report as Appendix 4.
VII-B. OAHU ORDINANCE

Because of recent problems with landslides, the city and county of Honolulu has developed a temporary ordinance (Appendix 1) regulating urban development within certain hillside areas. They have designated a critical hillside area called the Oahu Hillsides Interim Development control Area. In this area, no further development will be permitted during a two-year period while studies are conducted, mitigation measures identified, and regulatory controls developed. The only new construction allowed during this period must be certified safe by two independent civil engineers.
VII-C. PORTLAND ORDINANCE

Also included is a grading ordinance (Appendix 3) from Portland, Oregon, where much development takes place on sloping land. Portland includes areas of slide-prone land and has enforced hillside development ordinances for many years.

To comply with Portland's Grading Ordinance, plans for proposed construction in high hazard areas (as determined by the Director) may require reports by up to three outside experts: a civil engineer, a geotechnical(soils) engineer and an engineering geologist. City engineers then review the plans, reports, and supporting documentation before grading permits are issued. During construction, the site is checked to see that work is being done in conformity with the ordinance and with the recommendations in the site plans and engineering reports.
VIII. SUMMARY

This report documents the study made by SCS to mitigate the landslide problems on Tutuila Island. Principles and concepts used in this report should also apply to the Manu'a islands. By plotting the 31 slides (at 12 sites) located during this study and the 60 slides recorded by the U.S. Geological Survey in 1979, conclusions about the causes of 81 slides could be drawn. After completion of the draft report, Hurricane Ofa struck Tutuila and triggered an additional ten slides. All occurred in areas previously identified as having a high landslide hazard, supporting the conclusions in this report.

In compiling this report and accompanying maps extensive use was made of the maps in the ASCMP Atlas of American Samoa. Strong correlations were found between landslides and certain soils, geology, slopes, and vegetation. Slides were concentrated in areas of Fagatogo and Aua soils, ash and talus geology, slopes greater than 60°, and where the natural vegetation had been disturbed. Concentrations of water from springs, runoff, or man’s activities were often contributing factors to many slides. In making the landslide hazard zone maps, data was merged from the maps noted above to delineate areas of low, medium, and high landslide hazard.

Landslide mitigation measures are suggested for American Samoan conditions. They are for the most part simple, inexpensive, and use materials that can be readily obtained or are already available in American Samoa. Also included are sample grading ordinances from several sources that regulate development on slide-prone sites. These sample ordinances can serve as models should the American Samoan Government decide to develop or amend its own. Finally, recommendations are included for future action to follow up on the results of this study. Recommendations follow on the next page.
IX. RECOMMENDATIONS

Introduction:
Included in this report are brief explanations and, in some cases, drawings of 11 mitigation measures. Also included is a sample grading ordinance from Portland, Oregon. This city has much sloping land within its city limits. A development moratorium ordinance from Oahu is appended. Chapter 70 on Excavation and Grading from the Uniform Building Code (1988 edition) is also appended.

From the information in this report, the American Samoan Government can develop its own ordinances or regulatory policies for slide-prone land. It is certainly possible to improve upon and refine the information in this report and accompanying maps. After all, that is the nature of all scientific inquiry. But it is believed the information provided here is sufficient upon which to base land use planning decisions. Large amounts of money can be spent "studying a problem to death" to avoid making difficult land use choices. Such money might better be spent assisting landowners with the difficult and often expensive technical problems associated with building on steep, slide-prone land.

Recommended Actions:
We have the following recommended courses of action for ASG to take.

1. Adopt either the UBC (1988 edition) guidelines on grading, setbacks etc. or a grading ordinance similar to that of Portland, Oregon.

2. As an interim strategy to item 1 above, adopt Oahu's concept of a moratorium on building in high landslide hazard areas for a specified period (e.g. 2 years). During the moratorium, develop ordinances for American Samoa.

3. For those areas with a high landslide hazard, place the burden of proof for stability on the property owner. The following are two alternative methods:

   A. Require that a registered private civil engineer certify that a proposed development in a high slide hazard area will be stable and safe. An ASG agency, probably either the Department of Public Works (DPW) or ASCMF, would have review and approval authority on such plans. A civil engineer in one of these agencies would then approve or disapprove permit applications based on these plans.

   B. DPW or ASCMF could employ their own registered civil
engineer to work directly with landowners in developing safe, acceptable site plans. If hiring an engineer is not possible, they could contract this service to local private civil engineers. Reasonable fees could be charged to help defray part of the cost of providing such an engineering service. Land use permits would not be granted to sites with a high slide hazard until such a plan was produced and certified safe by the civil engineer.

4. Have an engineer develop more standard drawings for mitigation measures most applicable to American Samoa. The emphasis should be on economical practices using locally available materials. Engineering assistance to tailor these standard measures to specific sites should also be provided.

5. Conduct a public education campaign to alert the public to the following potential hazards of building on steep slopes:
   A. Areas most prone to sliding.
   B. Availability of landslide hazard zone maps.
   C. Contribution of excavation and removal of supporting toeslopes to potentially fatal landslides.
   D. The increased slide hazard created by excess water (springs, septic tanks, blocked culverts, leaky pipes, concentrated runoff, etc.) on steep sites.
   E. Need for engineering assistance for houses built on land with a high slide hazard. It should be emphasized that these efforts are needed to reduce future danger to the residents.
   F. Danger of building on old slides.
   G. Warning signs of debris flows (see Section VI-K).
   H. Areas to avoid during heavy rains.
   I. Dangers associated with stripping land of its stabilizing cover of vegetation.

6. Implement a formal early warning system for landslide hazards based on given amounts of heavy continuous rainfall (see Section VI-K). Such a system could ultimately save lives by alerting people to be watchful during periods of impending landslide danger.

7. Considering past landslide disasters in the Nuu-Se'etaga area, special efforts should be made there in both the public education and the early warning system outlined in items 5 and 6 above.

8. As future landslides occur, they should be plotted on the landslide hazard zone maps. This will serve as a continuing check on the conclusions of this study. If possible, they should also be field checked as was done for this study. This will add to everyone's knowledge of the factors that contribute to landslides on Tutuila. Based on
such knowledge, it may be possible to further refine the landslide hazard zone maps in future years. SCS is willing to work with ASCEMP on future such efforts.

9. Ban building on or immediately below old landslides unless a civil engineer certifies that the slide is stable. This is very difficult to guarantee, and most engineers would be reluctant to make such a certification without considerable remedial work on the site.
BIBLIOGRAPHY


ORDINANCE NO. _______ BILL NO. ________  127 ______ (1989)

APPENDIX 1

A BILL FOR AN ORDNANCE REGULATING, FOR AN INTERIM PERIOD, URBAN DEVELOPMENT WITHIN OAHU HILLSIDES IN THE CITY AND COUNTY OF HONOLULU.

BE IT ORDAINED by the People of the City and County of Honolulu:

SECTION 1. Findings and Purpose.

Numerous hillside areas in the City and County of Honolulu have experienced slope instability and soil movement problems. At the same time, the pressure to build on hillsides and steeper slope areas has increased because of the City’s growing population, rising land values, and the shortage of buildable sites, especially near existing urban areas. Although many areas have experienced problems, some areas of the City have suffered extensive property damage resulting from landslides and debris flows. The most severe and significant incidents in recent years have occurred in the Manoa, Palolo, Aina Haina, Moanalua Valley and Kuliouou areas.

Because of the cumulative effects of the 1987-1988 New Year floods, leaking underground water and wastewater lines, natural subsidence of back-filled areas, and many other natural and man-made causes, an inordinate movement of soil and land under hillside residences within Manoa Valley, Waipo Valley, Kualoa Valley, Hahalome Valley, Kuliouou Valley and Moanalua Valley, has taken place, which is beginning to make homes within these valleys unsafe for habitation and is destroying public utilities and roadways. Some identifiable areas within East Manoa Valley, Waipo Valley, Kuliouou Valley and Moanalua Valley have experienced, or are presently experiencing: (1) uprooted home foundations, garages, and driveways; (2) broken underground water mains and seepage of groundwater; (3) collapsing streets and sidewalks; (4) fractured dwelling unit structures; and (5) other serious problems. These hazards pose a clear and present danger to the safety and well-being of residents that has necessitated emergency actions by the City and County.

Other Oahu hillside areas, such as Lanikai, have also been subject to severe flooding in recent years, which flooding has endangered persons living in and property located within these areas. Inadequate drainage infrastructure has been one of the major factors contributing to this flooding.
The Council by Resolution 88-472, CD-1, adopted December 1, 1988, authorized the City to enter into an intergovernmental agreement with the United States Geological Survey to conduct studies of landslides and debris flows within certain portions of the Honolulu area. These studies of East Honolulu hillsides are ongoing and results are expected to be available in 1992.

By Resolution 89-138, CD-1, adopted April 26, 1989, the Council requested that the City Administration conduct a comprehensive study of soil movement problem areas on Oahu, with the assistance of appropriate State and Federal agencies. Costs for this study are to be estimated by the City Administration for future budget action.

These studies will provide the basis for regulating future hillside development on Oahu. They will also help to identify corrective measures that can be undertaken to reduce or minimize the impact of landslides and debris flows.

The Council finds that in order to reduce the potential hazards for future developments and to protect existing Oahu hillside communities, new procedures and standards to regulate development on designated hillside need to be developed. The Council further finds that certain research is needed to provide adequate data to define the appropriate procedures and standards and to determine the pertinent areas of application.

The Council finds that time is needed for the planning process to evaluate the problems of hillside construction on Oahu, identify effective mitigating measures, and determine what permanent regulatory controls are necessary and reasonable. Interim development controls are needed during this period in order to: (1) allow public participation and debate on these issues; (2) prevent development activity that may frustrate the planning process; and (3) avoid the wasting of development rights for projects inconsistent with the ultimate conclusions of the planning effort.

The City Council, therefore, finds that the public health and safety require that Interim Development Controls be adopted prohibiting urban development within certain Oahu Hillsides for a temporary period of time until permanent controls can be adopted. The Council deems the adoption of this ordinance under its general police and home rule powers to be in the best interest of the community and its health, safety, morals, and general welfare.

There is hereby established an Oahu Hillsides Interim Development Control Area which is designated and appropriately marked on the Interim Development Control Map attached hereto, marked as Exhibit "A" and by reference made a part hereof.

SECTION 3. Applicability.

A. From the effective date of this ordinance until the enactment of an ordinance explicitly superseding this ordinance, or two (2) years from the effective date of this ordinance, whichever occurs first, no building or grading permits shall be accepted, and no building or grading permits shall be issued within the area designated as the Oahu Hillsides Interim Development Control Area on the Interim Development Control Map, except as specifically stated herein.

B. Section 3.A shall not apply to the issuance of building or grading permits in the event the builder or developer submits two independent civil engineering studies, conducted by two independent licensed engineers, and conducted within five (5) years of the date of application for a building or grading permit, concluding or demonstrating that the proposed construction or grading will not pose a threat to nearby property or residents. In the event that the civil engineering studies propose non-identical mitigative actions in order to allow the proposed project to be built, the study, or the portion(s) of the study or studies that are more restrictive to the proposed building or grading activities shall be followed.

C. Section 3.A shall not apply to the issuance of building or grading permits in the following instances, provided the application otherwise qualifies under all other applicable laws, rules, and regulations:

1. To perform work permitted under Section 18-3.1, Revised Ordinances of Honolulu 1978, as amended, to make an existing building or structure conform to or comply with applicable laws or rules and regulations.
2. To perform maintenance and repair to an existing structure or building;

3. To permit improvements to an existing structure or building;

4. To permit the City and County of Honolulu or its designee to make improvements to the drainage system within the subject Interim Development Control Area; or

5. To make improvements within the Interim Development Control Area that are determined by the City Department of Public Works, Building Department and Department of Land Utilization to be necessary for the public health and safety.

D. Nothing contained in this ordinance shall be deemed to affect:

1. Any building or grading permit which has been lawfully issued and is in effect on the effective date of this ordinance; or

2. The granting, issuance and/or approval of building or grading permits within an area not designated on the Interim Development Control Map.

SECTION 4. Penalties.

Any person, firm, entity, or corporation constructing, erecting, enlarging, or altering structurally, any building, roadway or structure, or performing grading work or subdividing land in violation of the provisions of this ordinance shall be subject to the penalties and enforcement procedures set forth in Section 8.60 of the Land Use Ordinance of the City and County of Honolulu (Section 21-8.60, Revised Ordinances of Honolulu 1978, as amended).

SECTION 5. Severability.

The invalidity of any word, section, clause, paragraph, sentence, part or portion of this ordinance shall not affect the validity of any other part of this ordinance which can be given effect without such invalid part or parts.
SECTION 6. Effective Date.

This ordinance shall take effect upon its approval.

INTRODUCED BY:  

DATE OF INTRODUCTION:  
September 5, 1989  
Honolulu, Hawaii

APPROVED AS TO FORM AND LEGALITY:  

Deputy Corporation Counsel  
APPROVED this ___ day of  
________________, 1989.  

Councillmembers

FRANK F. FASI, Mayor  
City and County of Honolulu
LITERATURE REVIEW

1. HAML HAW N 0E599.H6  p38
   The Hind iuka landslide and similar movement.

2. HAML HAW N 0E599.H6  P 4
   Report on causes and remedial measure, Waloomau

3. HAML GOVD I 19.16  no. 697
   Landslides of Rio de Janeiro and Serra.

4. HAML 0E599.U6  M 48
   When the ground falls; planning and engineering

5. HAML 0E599.US 167  1967
   Landslides and attendant probles: a report to

6. HAML TA766.A6  1982
   Application of walls to landslide control problems.

7. HAML OLO599.m 133  1988
   Proceeding of Indonesian-Japan Symposium

8. HAML 0E599.C9  2363
   Landslides and their control.

9. HAML GOVD UNESCO L239
   Landslide hazard zonation: a review of princip

10. HAML f TA718.T34
    Slope stability in urban development: a handbook

11. HAML DE1.G315 NO. 236
    Landslide processes of the eastern US

12. HAML 0E599.N5  1985
    Reducing losses from landsliding in the US-periodicals.
13. HAML GUVD FAC C 765/2 NO. 13/4
   FAO Watershed Field Manual

14. HAML TA710.1413
   Landslides and Their Stabilization

15. HAML GE 599.A2 65
   Landslides and Related Phenomenon: A Study of Mass Move

16. HAML TA 710.C573
   Landslides in Clays

17. HAML GE599.A2 C74 1986
   Landslides: Causes, Consequences, and

18. HAML TA 710.S419 1985
   Hillslope Stability and Land Use

19. HAML GE599.A2 C4
   Landslide Investigation Techniques

20. HAML GE599.H56 S45 1975
    Seminar on Landslides and Erosion Problems
PORTLAND GRADING ORDINANCE

APPENDIX 3

BUILDING REGULATIONS

24.70.080 Fills.
24.70.090 Setbacks.
24.70.100 Drainage and Terracing.
24.70.110 Erosion Control.
24.70.120 Grading Inspection.
24.70.130 Completion of work.

24.70.010 General. The provisions of this Chapter shall regulate grading on private property and construction in geologically hazardous areas.

24.70.020 Permits. Permits for grading are required and shall be issued in accordance with Section 24.10.070 except that no permit shall be required for the following:

(1) Grading in an area, where in the opinion of the Director, there is no danger apparent to or adverse drainage effect on private/public property and inspection of the work is not necessary.

(2) An excavation below finished grade for basements and footings of a building, retaining wall, or other structure authorized by a valid building permit. This shall not exempt any fill made with the material from such excavation nor exempt any excavation having an unsupported height greater than 5 feet after the completion of such structure.

(3) Cemetery graves.

(4) Refuse disposal sites controlled by other regulations.

(5) Excavations for wells or tunnels or utilities.

(6) Mining, quarrying, excavating, processing, stockpiling of rock, sand, gravel, aggregate, or clay where established and provided for by law provides such operations do not affect the lateral support or increase the stresses in or pressure upon any adjacent or contiguous property.

(7) Explorerly excavations under the direction of soil (geotechnical) engineer or engineering geologists.

(b) which does not create a cut slope greater than 5 feet in height and
steeper than 1-1/2 horizontal to 1 vertical.
(9) A fill less than 1 foot in depth, and placed on natural terrain with a slope
flatter than 3 horizontal to 1 vertical, or
less than 3 feet in depth, not intended to
support structures, which does not exceed
50 cubic yards on any one lot and does not
obstruct a drainage course.

24.70.030 Hazards.
(a) Whenever the Director
determines that any existing excavation or
embankment or fill on private property has
become a hazard to life and limb, or
endangers property, or adversely affects
drainage or the safety, use or stability of a
public way or drainage channel, the owner
of the property upon which the excavation
or fill is located, or other person or agent in
control of said property, upon receipt of
notice in writing from the Director shall
within the period specified therein repair or
eliminate such excavation or embankment
so as to eliminate the hazard and be in
conformity with the requirements of this
Title.
(b) Because of the apparent risks
to life, limb, and property, or the potential
adverse effects on drainage or the safe use
or stability of private or public property,
the Director may designate construction of
a potential hazard and require that plans
and specifications and engineering reports
be prepared in compliance with this
Chapter. The construction may include
excavation, grading, or other construction
where the stability of the ground, surface
erosion, or other factor is a consideration
with respect to public safety and property
damage.

24.70.040 Special Definitions. The
definitions contained in this Section relate
to excavation and grading work only as
outlined in this Chapter.
Approval shall mean a written
engineering or geological opinion concerning
the progress and completion of the work.
As graded is the surface conditions
exposed on completion of grading.
Bedrock is in-place solid rock.
Bench is a relatively level step
evacuated into earth material on which fill
is to be placed.
Borrow is earth material acquired from
an off-site location for use in grading on a
site.
Civil engineer shall mean a professional
engineer registered in the State to practice
in the field of civil works.
Civil engineering shall mean the
application of the knowledge of the forces
of nature, principles of mechanics, and the
properties of materials to the evaluation,
design, and construction of civil works for
the beneficial uses of mankind.
Compaction is the densification of a fill
by mechanical means.
Earth material is any rock, natural soil
or fill and/or any combination thereof.
Engineering geologist shall mean a
geologist experienced and knowledgeable in
engineering geology and registered as an
engineering geologist in the State of Oregon.
Engineering geology shall mean the
application of geologic knowledge and
principles in the investigation and
evaluation of naturally occurring rock and
soil for use in the design of civil works.
Erosion is the wearing away of the
ground surface as a result of the movement
of wind, water, and/or ice.
Excavation is the mechanical removal
of earth material.
Fill is a deposit of earth material
placed by artificial means.
Geological hazard shall mean a
potential or apparent risk to persons or
property because of geological or soil
instability either existing at the time of
construction or which would result from
construction.
Grade shall mean the vertical location
of the ground surface.
Existing grade is the grade prior to
grading.
Rough grade is the stage at which the
grade approximately conforms to the
approved plan.
Finish grade is the final grade of the
site which conforms to the approved plan.
Grading is any excavating or filling or
combination thereof.
Key is a designed compacted fill placed
in a trench excavated in earth material beneath the toe of a proposed fill slope.
Site is any lot or parcel of land or contiguous combination thereof, under the same ownership, where grading is performed or permitted.
Slope is an inclined ground surface the inclination of which is expressed as a ratio of horizontal distance to vertical distance.
Soil is naturally occurring surficial deposits overlying bedrock.
Soil (Geotechnical) engineer shall mean a civil engineer competent by education, training, and experience in the practice of soil engineering.
Soil (Geotechnical) engineering shall mean the application of the principles of soil mechanics in the investigation, evaluation, and design of civil works involving the use of earth materials and the inspection and testing of the construction thereof.
Terrace is a relatively level step constructed in the face of a graded slope surface for drainage and maintenance purposes.

24.70.050 Information on Plans and Specifications. Plans and specifications shall be submitted in accordance with Section 24.10.070 and in addition shall comply with the following:
(a) Plans shall be drawn to scale upon substantial paper or cloth and shall be of sufficient clarity to indicate the nature and extent of the work proposed and show in detail that they will conform to the provisions of this Title and all relevant laws, ordinances, rules, and regulations. The first sheet of each set of plans shall give the location of the work and the name and address of the owner and the person by whom they were prepared.
The plans shall include the following information:
(1) General vicinity of the proposed site.
(2) Property limits and accurate contours of existing ground and details of terrain and area drainage for the site and surrounding area.
(3) Limiting dimensions, elevations, or finish contours to be achieved by the grading and the proposed drainage channels and related construction.
(4) Detailed plans of all surface and subsurface drainage devices, walls, cribbing, dams, and other protective devices to be constructed with or as a part of the proposed work together with a map showing the drainage area and the estimated runoff of the area served by any drains.
(5) Location of any buildings or structures on the property where the work is to be performed and the location of any buildings or structures on land of adjacent owners which are within 15 feet of the property or which may be affected by the proposed grading operations.
(6) Specifications shall contain information covering construction and material requirements.
(7) Civil engineering report. The civil engineering report, when required by the Director, shall include hydrological calculations of runoff and the existing or required safe storm drainage capacity outlet of channels both on site and off site, and in 100 year flood elevations for any adjacent watercourse. The report shall include recommendations for stormwater control and disposal.
(8) Soil (Geotechnical) engineering report. The soil engineering report, when required by the Director, shall include data regarding the nature, distribution, and strength of existing soils, design criteria, and conclusions and recommendations applicable to the proposed development. The report shall include recommendation for subdrainage, and for groundwater control and disposal.
Recommendations included in the report and approved by the Director shall be incorporated in the plans and specifications. For single family residences, a surface reconnaissance and stability questionnaire may be substitutes for a formal soils report at the discretion of the Director.
(9) Engineering geology report. The engineering geology report, when required by the Director, shall include an adequate description of the geology of the
site, and conclusions and recommendations regarding the effect of geologic conditions on the proposed development and site(s) to be developed.

Recommendations included in the report and approved by the Director shall be incorporated in the grading plans and specifications.

(b) Issuance. Section 24.10.070 is applicable to grading permits. The Director may require that grading operations and project designs be modified if delays occur which incur weather generated problems not considered at the time the permit was issued.

24.70.060 Bonds. The Director may require bonds in such form and amounts as may be deemed necessary to assure that the work, if not completed in accordance with the approved plans and specifications, will be corrected to eliminate hazardous conditions.

In lieu of a surety bond the applicant may file a cash bond or instrument of credit with the Director in an amount equal to that which would be required in the surety bond.

24.70.070 Cuts.
(a) General. Unless otherwise recommended in the approved soil engineering and/or engineering geology reports, cuts shall conform to the provisions of this Section.

(b) Slope. The slope of cut surfaces shall be no steeper than is safe for the intended use. Cut slopes shall be no steeper than 2 horizontal to 1 vertical.

(c) Drainage and terracing. Drainage and terracing shall be provided as required by Section 24.70.100.

24.70.080 Fills.
(a) General. Unless otherwise recommended in the approved soil engineering report these provisions may be waived for minor fills not intended to support structures. Such fills shall be subject to review at the discretion of the Director.

(b) Ground preparation. The ground surface shall be prepared to receive fill by removing vegetation, noncomplying fill, top-soil, and other unsuitable materials scarringly to provide a bond with the new fill, and where slopes are steeper than 3 to 1, and the height greater than 3 feet, by benching into competent material or sound bedrock as determined by the soils engineer. The bench under the toe of a fill on a slope steeper than 3 to 1 shall be at least 10 feet wide. The area beyond the toe of fill shall be sloped for sheet overflow or a paved drain shall be provided. Where fill is to be placed over a cut the bench under the toe of a fill shall be at least 16 feet wide but the cut must be made before placing fill and approved by the soils engineer and engineering geologist as a suitable foundation for fill. Unsuitable soil is soil which in the opinion of the Director or the civil engineer or the soils engineer or the engineering geologist is not competent to support either soil or fill, to support structures or to satisfactorily perform the other functions for which the soil is intended.

(c) Fill material. Only permitted material free from tree stumps, detrimental amounts of organic matter, trash, garbage, sod, peat, and similar materials shall be used. Rocks larger than 6 inches in greatest dimension shall not be used unless the method of placement is properly devised, continuously inspected, and approved by the Director.

The following shall also apply:
1. Rock sizes greater than 6 inches in maximum dimension shall be 10 feet or more below grade, measured vertically.
2. Rocks shall be placed so as to assure filling all voids with fine. Topsoil may be used in the top 1/2-inch surface layer to aid in planting and landscaping.

(d) Compaction of fill. All fills shall be compacted to a minimum relative dry density of 90 percent as determined by UBC Standard No. 70-1. Field density verification shall be determined in
accompany with UBC Standard No. 70-2 or equivalent and must be submitted for any fill 12 inches or more in depth where such fill may support the foundation for a structure. A higher relative dry density, or additional compaction tests, or both, may be required at any time by the Director.

(e) Fill slope. The slope of fill surfaces shall be no steeper than is safe for the intended use. Fill slopes shall be no steeper than 2 horizontal to 1 vertical.

(f) Drainage and terracing. Drainage and terracing shall be provided and the area above fill slopes and the surfaces of terraces shall be graded and paved as required by Section 24,70.100.

24,70.090 Setbacks.
(a) General. The setbacks and other restrictions specified by this Section are minimal and may be increased by the Director, or by the recommendation of the civil engineer, soils engineer, or engineering geologist, if necessary for safety and stability or to prevent damage of adjacent properties from deposition or erosion or to provide access for slope maintenance and drainage. Retaining walls may be used to reduce the required setbacks when approved by the Director.

(b) Setbacks from property lines. The tops of cuts and toes of fill slopes shall be set back from the outer boundaries of the permit area, including slope right areas and easements, in accordance with Figure No. 2 and Table No. 24,70-C at the end of this Chapter.

(c) Design standards for setbacks. Setbacks between graded slopes (cut or fill) and structures shall be provided in accordance with Figure No. 3 and Table No. 24,70-C at the end of this Chapter.

24,70.100 Drainage and Terracing.
(a) General. Unless otherwise indicated on the approved grading plan, drainage facilities and terracing shall conform to the provisions of this Section.

(b) Terrace. Terraces at least 5 feet in width shall be established at not more than 30-foot vertical intervals on all cut or fill slopes to control surface drainage and debris except that where only one terrace is required, it shall be at mid-height. For cut or fill slopes greater than 60 feet and up to 120 feet in vertical height one terrace at approximately mid-height shall be 12 feet in width. Terrace widths and spacing for cut and fill slopes greater than 120 feet in height shall be designed by the civil engineer and approved by the Director. Suitable access shall be provided to permit proper cleaning and maintenance.

Swales or ditches on terraces shall have a minimum gradient of 3 percent and must be paved with reinforced concrete not less than 3 inches in thickness or an approved equal paving. They shall have a minimum depth at the deepest point of 1 foot and a minimum paved width of 3 feet. A single run of swale or ditch shall not collect runoff from a tributary area exceeding 13,950 square feet (projected) without discharging into a downspout.

(c) Subsurface drainage. Cut and fill slopes shall be provided with subdrainage as necessary for stability. Adequate culverts shall be laid under all fills placed in natural watercourses and along the flow line of any tributary branches in such a manner that the hydraulic characteristics of the stream are not adversely altered. In addition, subdrainage shall be installed if active or potential springs or seeps are covered by the fill. All culverts/subdrainage shall be installed after the suitable subgrade preparation. Design details of culverts/subdrainage shall be shown on each plan and be subject to the approval of the Director and of other government/private agencies as may be required.

A subdrain system shall be provided for embedded foundation retaining walls and floor slabs where ground water or seepage has a potential to affect the performance of the structure. The plans shall indicate

(1) subdrainage details with appropriate specifications,
(2) location of footing subdrain/discharge lines and,
(3) method of disposal.

In lieu of above, walls/floors may be waterproofed and designed to resist...
(d) Disposal. All drainage facilities shall be designed to carry waters to the nearest practicable drainage way approved by the Director and/or other appropriate jurisdiction as a safe place to deposit such waters. Erosion of ground in the area of discharge shall be prevented by installation of non-eroding downdrains or other devices.

Building pads shall have a drainage gradient of 2 percent toward approved drainage facilities, unless waived by the Director.

Exception: The gradient from the building pad may be 1 percent if all of the following conditions exist throughout the permit area:

A. No proposed fills are greater than 10 feet in maximum depth.
B. No proposed finish cut of fill slope faces have a vertical line in excess of 10 feet.
C. No existing slope faces, which have a slope face steeper than 10 horizontal to 1 vertical, have a vertical height in excess of 10 feet.

(e) Interceptor drains. Paved interceptor drains shall be installed along the top of all cut slopes where the tributary drainage area and/or the slopes towards the cut and has a drainage path greater than 40 feet measured horizontally. Interceptor drains shall be paved with a minimum of 3 inches of concrete or gunite and reinforced. They shall have a minimum depth of 12 inches and a minimum paved width of 30 inches measured horizontally across the drain. The slope of the drain shall be approved by the Director.

24.70.110 Erosion Control.
(a) Slopes. The faces of cut and fill slopes shall be prepared and maintained to control against erosion. This control may consist of effective planting. The protection for the slopes shall be installed as soon as practicable and prior to calling for final approval. Where cut slopes are not subject to erosion due to the resistant character of the materials, such protection may be omitted.

(b) Other devices. Where necessary, check dams, cribbing, riprap, or other devices or methods shall be employed to control erosion and provide safety.

24.70.120 Grading Inspection.
(a) General. All grading operations for which a permit is required shall be subject to inspection by the Director. When required by the Director, special inspection of grading operations and special testing shall be performed in accordance with the provisions of Section 24.70.120 (c).

(b) Grading designation. All grading in excess of 3,000 cubic yards shall be performed in accordance with the approved grading plan prepared by a civil engineer and shall be designated as "engineered grading." Grading involving less than 3,000 cubic yards may also be designated as "engineered grading" by the Director if the grading will

(1) support a building or structure of a permanent nature;
(2) support other engineering works such as, but not limited to, tanks, towers, machinery, retaining walls, and paving;
(3) be deemed a potential hazard under Section 24.70.030. The permittee with the approval of the Director may also choose to have the grading performed as "engineered grading." Otherwise, the grading shall be designated as "regular grading."

(c) Engineered grading requirements. For engineered grading, it shall be the responsibility of the civil engineer who prepares the approved grading plan to incorporate all recommendations from the soil engineering and engineering geology reports into the grading plan. He shall also be responsible for the professional inspection and approval of the grading within his area of technical specialty. This responsibility shall include, but need not be limited to, inspection and approval as to the establishment of line, grade, and drainage of the development area. The civil engineer shall act as the coordinating agent in the event that need arises for liaison between the other professionals, the contractor, and the Director. The civil engineer shall also
be responsible for the preparation of revised plans and the submission of as-graded grading plans upon completion of the work. The grading contractor shall submit in a form prescribed by the Director a statement of compliance to said as-graded plan.

Soil engineering and engineering geology reports shall be required as specified in Section 24.70.030. During grading all necessary reports, compaction data, and soil engineering and engineering geology recommendations shall be submitted to the civil engineer and the Director by the soil engineer and the engineering geologist.

The soil engineer’s area of responsibility shall include, but need not be limited to, the professional inspection and approval concerning the preparation of ground to receive fill, testing for required compaction, stability of all finish slopes, and the design of buttress fills, where required, incorporating data supplied by the engineering geologist.

The engineering geologist’s area of responsibility shall include, but need not be limited to, professional inspection and approval of the adequacy of natural ground for receiving fills and the stability of cut slopes with respect to geological matters, and the need for subdrains or other ground water drainage devices. He shall report his findings to the soil engineer and the civil engineer for engineering analysis.

The Director shall inspect the project at the various stages of work requiring approval and at more frequent intervals necessary to determine that adequate control is being exercised by the professional consultants.

(c) Regular grading requirements. The Director may require inspection and testing by an approved testing agency.

(d) The testing agency’s responsibility shall include, but need not be limited to, approval concerning the inspection of cleared areas and benches to receive fill, and the compaction of fills.

When the Director has cause to believe that geological factors may be involved the grading operation will be required to conform to “engineered grading” requirements.

(e) Notification of noncompliance. If, in the course of fulfilling their responsibility under this Chapter, the civil engineer, the soil engineer, the engineering geologist, or the testing agency finds that the work is not being done in conformity with this Chapter or the approved grading plans, the discrepancies shall be reported immediately in writing to the person in charge of the grading work and to the Director. Recommendations for corrective measures, if necessary, shall be submitted.

(f) Transfer of responsibility for approval. If the civil engineer, the soil engineer, the engineering geologist, or the testing agency of record are changed during the course of the work, the work shall be stopped until the replacement has agreed to accept the responsibility within the area of their technical competence for approval upon completion of the work.

24.70.130 Completion of Work.

(a) Final reports. Upon completion of the rough grading work and that final completion of the work the Director may require the following reports and drawings and supplements thereto:

(1) An as-graded grading plan prepared by the civil engineer including original ground surface elevations, as-graded ground surface elevations, lot drainage patterns, and locations and elevations of all surface and sub-surface drainage facilities. He shall provide approval that the work was done in accordance with the final approved grading plan.

(2) A Soil Grading Report prepared by the soil engineer including locations and elevations of field density tests, summaries of field and laboratory tests and other substantiating data and comments on any changes made during grading and their effect on the recommendations made in the soil engineering investigation report. He shall provide approval as to the adequacy of the site for the intended use.

(3) A Geological Grading Report prepared by the engineering geologist including a final description of the geology of the site including any new information.
di'osed during the grading and the effect or value on recommendations incorporated in the approved grading plan. He shall provide approval as to the adequacy of the site for the intended use as affected by geological factors.

(b) Notification of completion. The permittee or his agent shall notify the Director when the grading operation is ready for final inspection. Final approval shall not be given until all work including installation of all drainage facilities and their protective devices and all erosion control measures have been completed in accordance with the final approved grading plan and the required reports have been submitted.

Chapter 24.75
UNIFORM BUILDING ADDRESS SYSTEM
(Added by Ord. No. 161984, effective July 1, 1989.)

§ 24.75.010 Uniform System.
§ 24.75.020 Size and Location of Building Numbers.
§ 24.75.030 Administration.
§ 24.75.040 Owner Responsibility.
§ 24.75.050 Alteration of Building Number - Improper Number.
§ 24.75.060 Building Defined.
§ 24.75.070 Enforcement.

24.75.010 Uniform System. A. There is established a uniform system of numbering all buildings in separate ownership or occupancy in the City dividing the City into five general districts. In establishing the system Williams Avenue and the center line of the Willamette River southerly from Glisan Street shall constitute the north and south base line from which the numbers on all buildings running easterly and westerly from said streets shall be extended each way, upon the basis of one corner for each ten feet of property frontage, wherever possible, starting at the base line with the number 1 continuing with consecutive hundreds at each intersection, wherever possible; provided, however, that streets running easterly and westerly in that district south of Jefferson Street and lying between Front Avenue and the Willamette River shall have the prefix "D" placed before the assigned number, said numbers starting at Front Avenue with the number 1 and continuing with consecutive hundreds at each intersection, where possible. All even numbers shall be placed upon buildings on the southerly side of streets, avenues, alleys and highways, and all odd numbers shall be placed upon buildings on the northerly side of streets, avenues, alleys and highways. Burnside Street shall constitute the east and west base line from which the numbers on all streets running north and south from said streets shall be extended each way, upon the basis of one number for each 10 feet of property frontage, wherever possible, starting at the base line with number 1 and continuing with consecutive hundreds at each intersection, wherever possible. All even numbers shall be placed upon buildings on the easterly side of streets, avenues, alleys, and highways, and all odd numbers upon buildings on the westerly side of said streets, avenues, alleys, and highways.

Free standing buildings on private streets which are separately owned or occupied shall be separately numbered so as to most closely conform to this system.

Each portion of a building which is separately owned or occupied and has a separate entrance from the outside shall have a separate number assigned to it.

B. Suffixes to Building Numbers. Where building address requirements exceed numbers available within the numbering system, the Director may use the suffix "A", "B", "C", etc. as may be required to provide the numbering required by this Chapter.

24.75.020 Size and Location of Building Numbers. All numbers placed in accordance with this Chapter shall be permanently affixed to a permanent structure and of sufficient size and so placed as to be distinctly legible from the public way providing primary access to the
building. All numbers shall be posted as nearly as possible in a uniform place and positioned on the front of each building near the front entrance. Where outside illumination is provided, the numbers shall be placed so as to be illuminated by the outside light. In instances where building mounted numbers are not distinctively visible numbers shall be permanently affixed to a permanent structure at the primary entrance way to such property. If, in the judgment of the Director, the numbering, sequence, legibility, size or location does not meet the requirements as set forth above, the property owner or agent thereof shall be notified and within 30 days shall make such changes as required in the notification.

24.75.030 Administration. The Director shall assign address numbers, keep records of address assignments, and exercise such other powers as are necessary to carry out the provisions of this Chapter.

24.75.040 Owner Responsibility. Whenever any new building is erected, modified, or occupied in a manner requiring an address assignment, the owner or owner’s agent shall procure the correct address number or numbers designated by the Director and pay required fees.

The owner or agent shall prior to occupancy or within 30 days of assignment, whichever occurs later, place the assigned address number(s) upon the building or in a manner and location as provided in this Chapter.

24.75.050 Alteration of Building Number - Improper Number. It is unlawful for any person to cause or knowingly permit a building number to be displayed which is different than that assigned pursuant to this Chapter. It is unlawful for any person to own or have possession of a building which does not display the number assigned pursuant to this Chapter in the manner provided by this Chapter.
Chapter 70
EXCAVATION AND GRADING

Purpose
Sec. 7001. The purpose of this appendix is to safeguard life, limb, property and the public welfare by regulating grading on private property.

Scope
Sec. 7002. This appendix sets forth rules and regulations to control excavation, grading and earthwork construction, including fills and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

Permits Required
Sec. 7003. No person shall do any grading without first having obtained a grading permit from the building official except for the following:

1. Grading in an isolated, self-contained area if there is no danger apparent to private or public property.
2. An excavation below finished grade for basements and footings of a building, retaining wall or other structure authorized by a valid building permit. This shall not exempt any fill made with the material from such excavation nor exempt any excavation having an unsupported height greater than 5 feet after the completion of such structure.
3. Cemetery graves.
4. Refuse disposal sites controlled by other regulations.
5. Excavations for wells or tunnels or utilities.
6. Mining, quarrying, excavating, processing, stockpiling of rock, sand, gravel, aggregate or clay where established and provided for by law, provided such operations do not affect the lateral support or increase the stresses on or pressure upon any adjacent or contiguous property.
7. Exploratory excavations under the direction of a registered engineer or engineering geologists.
8. An excavation which (a) is less than 2 feet in depth, or (b) which does not create a slope greater than 5 feet in height and steeper than one and one-half horizontal to one vertical.
9. A fill less than 1 foot in depth and placed on natural terrain with a slope flatter than five horizontal to one vertical, or less than 3 feet in depth, not intended to support structures, which does not exceed 50 cubic yards on any one lot and does not obstruct a drainage course.

Hazard
Sec. 7004. Whenever the building official determines that any existing excavation or enhancement or fill on private property has become a hazard to life and limb, or endangers property, or adversely affects the safety, use or stability of a public way or drainage channel, the owner of the property upon which the excavation or fill is located, or other person or agent in control of said property,
5. Location of any buildings or structures on the property where the work is to be performed shall be consistent with the location of any buildings or structures on land of adjacent owners which are within 15 feet of the property or which may be affected by the proposed grading operations.

Specifications shall contain information covering construction and material requirements.

(c) Subsurface Engineering Report. The soils engineering report required by Subsection (e) shall include data regarding the manner, distribution and strength of existing soils, conclusions and recommendations for grading procedures and design criteria for corrective measures, including support fills, when necessary, and opinions and recommendations covering adequacy of sites to be developed by the proposed grading, including the stability of slopes.

Recommendations included in the report and approved by the building official shall be incorporated in the grading plans or specifications.

(2) Engineering Geology Report. The engineering geology report required by Subsection (e) shall include an adequate description of the geology of the site, conclusions and recommendations regarding the effect of geologic conditions on the proposed development, and opinions and recommendations covering adequacy of sites to be developed by the proposed grading.

Recommendations included in the report and approved by the building official shall be incorporated in the grading plans or specifications.

(g) Bases. The provisions of Section 303 are applicable to grading permits. The building official may require that grading operations and project designs be modified if delays occur which incur weather-generated problems not considered at the time the permit was issued.

Grading Fees

Sec. 7007. (a) General. Fees shall be assessed in accordance with the provisions of this section or shall be as set forth in the fee schedule adopted by the jurisdiction.

(b) Plan Review Fees. When a plan or other data are required to be submitted, a plan review fee shall be paid at the time of submitting plans and specifications for review. Said plan review fee shall be as set forth in Table No. 70-A. Separate plan review fees shall apply to retaining walls or major drainage structures as required elsewhere in this code. For excavation and fill on the same site, the fee shall be based on the volume of excavation or fill, whichever is greater.

(c) Grading Permit Fees. A fee for each grading permit shall be paid to the building official as set forth in Table No. 70-B. Separate permits and fees shall apply to retaining walls or major drainage structures as required elsewhere in this code. There shall be no separate charge for standard terrace drains and similar facilities.

TABLE NO. 70-A—GRADING PLAN REVIEW FEES

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Fee</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 cubic yards or less</td>
<td>$10.00</td>
<td>No fee for 51 to 100 cubic yards</td>
</tr>
<tr>
<td>101 to 1000 cubic yards</td>
<td>$15.00</td>
<td>101 to 100 cubic yards $22.50</td>
</tr>
<tr>
<td>1001 to 50,000 cubic yards</td>
<td>$30.00</td>
<td>101 to 1000 cubic yards $22.50</td>
</tr>
<tr>
<td>10,001 to 100,000 cubic yards</td>
<td>$50.00</td>
<td>1001 to 50,000 cubic yards $30.00</td>
</tr>
<tr>
<td>Additional 10,000 cubic yards or fraction thereof</td>
<td>$50.00</td>
<td>10,001 to 100,000 cubic yards, plus $50.00 for each additional 10,000 cubic yards or fraction thereof</td>
</tr>
<tr>
<td>Additional 10,000 cubic yards or fraction thereof</td>
<td>$50.00</td>
<td>10,001 to 100,000 cubic yards, plus $50.00 for each additional 10,000 cubic yards or fraction thereof</td>
</tr>
</tbody>
</table>

TABLE NO. 70-B—GRADING PERMIT FEES

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Fee</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 cubic yards or less</td>
<td>$15.00</td>
<td>No fee for 51 to 100 cubic yards</td>
</tr>
<tr>
<td>101 to 1000 cubic yards</td>
<td>$22.50</td>
<td>101 to 1000 cubic yards $22.50</td>
</tr>
<tr>
<td>1001 to 10,000 cubic yards</td>
<td>$50.00</td>
<td>1001 to 10,000 cubic yards $117.00</td>
</tr>
<tr>
<td>10,001 to 100,000 cubic yards</td>
<td>$150.00</td>
<td>10,001 to 100,000 cubic yards, plus $150.00 for each additional 10,000 cubic yards or fraction thereof</td>
</tr>
<tr>
<td>10,001 to 100,000 cubic yards</td>
<td>$195.00</td>
<td>10,001 to 100,000 cubic yards, plus $195.00 for each additional 10,000 cubic yards or fraction thereof</td>
</tr>
<tr>
<td>100,001 cubic yards or more</td>
<td>$220.50</td>
<td>100,001 cubic yards or more, plus $220.50 for each additional 10,000 cubic yards or fraction thereof</td>
</tr>
<tr>
<td>Additional 10,000 cubic yards or fraction thereof</td>
<td>$220.50</td>
<td>100,001 cubic yards or more, plus $220.50 for each additional 10,000 cubic yards or fraction thereof</td>
</tr>
</tbody>
</table>

Other Inspections and Fees

1. Inspections outside of normal business hours | $30.00 per hour | (minimum charge—two-hour)
2. Reinspection fees assessed shall be inspections of Section 303(g) | $30.00 per hour |
3. Additional inspections upon specific request | No fee | (minimum charge—one-half hour)
APPENDIX

Bonds
Sec. 7008. The building official may require bonds in such form and amounts as may be deemed necessary to ensure that the work, if not completed in accordance with the approved plans and specifications, will be corrected to eliminate hazardous conditions.

In lieu of a surety bond the applicant may file a cash bond or instrument of credit with the building official in an amount equal to that which would be required in the surety bond.

Cuts
Sec. 7009. (a) General. Unless otherwise recommended in the approved soils engineering or engineering geology report, cuts shall conform to the provisions of this section.

In the absence of an approved soils engineering report, these provisions may be waived for cases not intended to support structures.

(b) Slope. The slope of cut surfaces shall be no steeper than is safe for the intended use and shall be no steeper than 2 horizontal to 1 vertical unless the owner furnishes a soils engineering or an engineering geology report, or both, stating that the site has been investigated and giving an opinion that a cut at a steeper slope will be stable and not create a hazard to public or private property.

(c) Drainage and Terracing. Drainage and terracing shall be provided as required by Section 7012.

Fill
Sec. 7018. (a) General. Unless otherwise recommended in the approved soils engineering report, fills shall conform to the provisions of this section.

In the absence of an approved soils engineering report these provisions may be waived for minor fills not intended to support structures.

(b) Fill Location. Fill slopes shall not be constructed on natural slopes steeper than two to one.

(c) Preparation of Ground. The ground surface shall be prepared to receive fill by removing vegetation, noncomplying fill, topsoil and other unsuitable materials scarring to provide a bond with the new fill and, where slopes are steeper than five to one and the height is greater than 5 feet, by benching into sound bedrock or other competent material as determined by the soils engineer.

The bench under the toe of a fill on a slope steeper than five to one shall be at least 10 feet wide. The area beyond the toe of fill shall be sloped for sheet overflow or a paved drain shall be provided. When fill is to be placed over a cut, the bench under drainage of fill shall be at least 10 feet wide for the cut shall be made before placing the fill and acceptance by the soils engineer or engineering geologist or both as a suitable foundation for fill.

(d) Fill Material. Detrital amounts of organic material shall not be permitted in fills. Except as permitted by the building official, no rock or similar

1988 EDITION

irradiable material with a maximum dimension greater than 12 inches shall be buried or placed in fills.

EXCEPTION: The building official may permit placement of larger rock when the soils engineer properly devises a method of placement, continuously inspects the placement and approves the fill stability. The following conditions shall also apply:

A. Prior to issuance of the grading permit, potential rock disposal areas shall be delineated on the grading plan.

B. Rock sizes greater than 12 inches in maximum dimension shall be 10 feet or more below grade, measured vertically.

C. Rock shall be placed so as to ensure filling of all voids with fines.

(c) Compaction. All fills shall be compacted to a minimum of 90 percent of maximum density as determined by U.S. C. Standard No. 70-1. In-place density shall be determined in accordance with U.S. C. Standard No. 70-2, 70-3, 70-4 or 70-5.

(f) Slope. The slope of fill surfaces shall be no steeper than is safe for the intended use. Fill slopes shall be no steeper than two horizontal to one vertical.

(g) Drainage and Terracing. Drainage and terracing shall be provided and the area above fill slopes and the surfaces of terraces shall be graded and paved as required by Section 7012.

Setbacks
Sec. 7011. (a) General. Cut and fill slopes shall be set back from site boundaries in accordance with this section. Setback dimensions shall be horizontal distances measured perpendicular to the site boundary. Setback dimensions shall be shown in Figure No. 70-1.

(b) Top of Cut Slope. The top of cut slopes shall be made not nearer than a site boundary line than one fifth of the vertical height of cut with a minimum of 2 feet and a maximum of 10 feet. The setback may need to be increased for any required interceptor drains.

(c) Toe of Fill Slope. The toe of fill slope shall be made not nearer to the site boundary line than one half the height of the slope with a minimum of 2 feet and a maximum of 20 feet. Where a fill slope is to be located near the site boundary and the adjacent off-site property is developed, special precautions shall be incorporated in the work as the building official deems necessary to protect the adjoining property from erosion as a result of such grading. These precautions may include but are not limited to:

1. Additional setbacks.
2. Provisions for retaining or slough walls.
3. Mechanical or chemical treatment of the fill slope surface to minimize erosion.

(d) Modification of Slope Location. The building official may approve alternate setbacks. The building official may require an investigation and recommendation by a qualified engineer or engineering geologist to demonstrate that the intent of this section has been satisfied.
APPENDIX

UNIFORM BUILDING CODE

Drainage and Terracing
Sec. 7012. (a) General. Unless otherwise indicated on the approved grading plan, drainage facilities and terracing shall conform to the provisions of this section for cut or fill slopes steeper than 3 horizontal to 1 vertical.

(b) Terraces. Terraces at least 6 feet in width shall be established at not more than 30-foot vertical intervals on all cut or fill slopes to control surface drainage and debris except that where only one terrace is required, it shall be at midheight. For cut or fill slopes greater than 50 feet in vertical height, one terrace at approximately midheight shall be 13 feet in width. Terraces widths and spacing for cut and fill slopes greater than 120 feet in height shall be designed by the civil engineer and approved by the building official. Suitable access shall be provided to permit proper cleaning and maintenance.

Swales or ditches on terraces shall have a minimum gradient of 5 percent and must be paved with reinforced concrete not less than 3 inches in thickness or an approved equal paving. They shall have a minimum depth at the deepest point of 1 foot and a minimum paved width of 5 feet.

A single run of swale or ditch shall not collect runoff from a tributary area exceeding 13,500 square feet (projected) without discharging into a down drain.

(c) Subsurface Drainage. Cut and fill slopes shall be provided with subsurface drainage as necessary for stability.

(d) Disposal. All drainage facilities shall be designed to carry waters to the nearest practicable drainage way approved by the building official and/or other appropriate jurisdiction as a safe place to deposit such waters. Erosion of ground in the area of discharge shall be prevented by installation of nonerosive silt fences or other devices.

Building pads shall have a drainage gradient of 2 percent toward approved drainage facilities, unless waived by the building official.

EXCEPTION: The gradient from the building pad may be 1 percent if all of the following conditions exist throughout the perimeter area:
A. No proposed fills are greater than 10 feet in maximum depth.
B. No proposed cut or fill slope faces have a vertical height in excess of 10 feet.
C. No existing slope faces, which have a slope face steeper than 10 horizontally to 1 vertically, have a vertical height in excess of 10 feet.

(e) Interceptor Drains. Paved interceptor drains shall be installed along the top of all cut slopes where the tributary drainage area above slopes towards the cut and has a drainage path greater than 40 feet measured horizontally. Interceptor drains shall be paved with a minimum of 3 inches of concrete or gravel and reinforced. They shall have a minimum depth of 12 inches and a minimum paved width of 30 inches measured horizontally across the drain. The slope of drain shall be approved by the building official.

Erosion Control
Sec. 7013. (a) Slopes. The faces of cut and fill slopes shall be prepared and maintained to control against erosion. This control may consist of effective planting. The protection for the slopes shall be installed as soon as practicable and prior to calling for final approval. Where cut slopes are not subject to erosion due to the erosion-resistant character of the materials, such protection may be omitted.

(b) Other Devices. Where necessary, check dams, cribbing, riprap or other devices or methods shall be employed to control erosion and provide safety.

Grading Inspection
Sec. 7014. (a) General. All grading operations for which a permit is required shall be subject to inspection by the building official. Where required by the building official, special inspection of grading operations and special testing shall be performed in accordance with the provisions of Section 106 and Subsection 7016.

(b) Grading Designation. All grading in excess of 5000 cubic yards shall be performed in accordance with the approved grading plan prepared by a civil engineer, and shall be designated as "engineered grading." Grading involving less than 5000 cubic yards shall be designated "regular grading" unless the permitter, with the approval of the building official, chooses to have the grading performed as "engineered grading."

(c) Engineered Grading Requirements. For engineered grading, it shall be the responsibility of the civil engineer who prepares the approved grading plan to incorporate all recommendations from the soils engineering and engineering geology reports into the grading plan. He also shall be responsible for securing the professional inspection and approval of the grading within his area of technical specialty. This responsibility shall include, but need not be limited to, inspection and approval as to the establishment of line, grade and drainage of the development area. The civil engineer shall act as the coordinating agent in the event the need arises for liaison between the other professionals, the contractor and the building official. The civil engineer also shall be responsible for the preparation of revised plans and the submission of as-graded grading plans upon completion of the work. The grading contractor shall submit in a form prescribed by the building official a statement of compliance to said as-built plan.

Soils engineering and engineering geology reports shall be required as specified in Section 7006. During grading all necessary reports, compaction data and soil engineering and engineering geology recommendations shall be submitted to the civil engineer and the building official by the soils engineer and the engineering geologist.

The soils engineer's area of responsibility shall include, but need not be limited to, the professional inspection and approval concerning the preparation of ground for receiving fills, testing for required compaction, stability of all fill slopes and the design of buttress fills, where required, incorporating data supplied by the engineering geologist.

The engineering geologist's area of responsibility shall include, but need not be limited to, professional inspection and approval of the adequacy of natural ground for receiving fills and the stability of cut slopes with respect to geological matters and the need for subsurface or other groundwater drainage devices. He shall report his findings to the soils engineer and the civil engineer for engineering analysis.
APPENDIX

UNIFORM BUILDING CODE

The building official shall inspect the project at the various stages of the work requiring approval to determine that adequate control is being exercised by the professional consultants.

(d) Regular Grading Requirements. The building official may require inspection and testing by an approved testing agency.

The testing agency's responsibility shall include, but need not be limited to, approval concerning the inspection of cleared areas and benches to receive fill, and the compaction of fills.

When the building official has cause to believe that geologic factors may be involved the grading operation will be required to conform to "engineered grading" requirements.

(e) Notification of Noncompliance. If, in the course of fulfilling his responsibility under this chapter, the civil engineer, the soils engineer, the engineering geologist or the testing agency finds that the work is not being done in conformance with this chapter or the approved grading plans, the discrepancies shall be reported immediately in writing to the person in charge of the grading work and to the building official. Recommendations for corrective measures, if necessary, shall be submitted.

(f) Transfer of Responsibility for Approval. If the civil engineer, the soils engineer, the engineering geologist or the testing agency of record is changed during the course of the work, the work shall be stopped until the replacement has agreed to accept the responsibility within the area of his technical competence for approval upon completion of the work.

Completion of Work
Sec. 7015. (a) Final Reports. Upon completion of the rough grading work and at the final completion of the work the building official may require the following reports and drawings and supplement thereto:

1. An as-graded grading plan prepared by the civil engineer including original ground surface elevations, as-graded ground surface elevations, lot drainage patterns and locations and elevations of all surface and subsurface drainage facilities. He shall state that to the best of his knowledge the work was done in accordance with the final approved grading plan.

2. A soils-grading report prepared by the soils engineer, including locations and elevations of field density tests, summaries of field and laboratory tests and other substantiating data and comments on any changes made during grading and their effect on the recommendations made in the soils engineering investigation report. He shall render a finding as to the adequacy of the site for the intended use.

3. A geologic grading report prepared by the engineering geologist, including a final description of the geology of the site and any new information disclosed during the grading and the effect of same on recommendations incorporated in the approved grading plan. He shall render a finding as to the adequacy of the site for the intended use as affected by geologic factors.

(b) Notification of Completion. The permittee or his agent shall notify the building official when the grading operation is ready for final inspection. Final approval shall not be given until all work, including installation of all drainage facilities and their protective devices, and all erosion-control measures have been completed in accordance with the final approved grading plan and the required reports have been submitted.
Typical Retaining Wall Cross-Section

Note: Detailed design specifications should be site-specific and require engineering assistance.
1. Elev. A to be rough graded at a slope of 2% higher than outlet Elev. B. Finish grading must provide positive drainage to street.

2. A sedge swale, a catch basin and pipe, or other similar drainage device is required when a portion of the building extends within 5 feet of the property line.

POLE HOUSES

... this architect's rendering of a "stepped-down" Kyoto farmhouse model tells the whole story of our approach to house construction, and illustrates our capacity for custom-designing a house to meet both your wants and the needs of your particular building site ...

THE POLE HOUSE PHILOSOPHY

We believe that a house should look like a house; that it should have a great sense of shelter, a great sense of nature and that it should be relevant to its environment.

The character of POLE HOUSES evolves from the study of, and respect for, the architecture indigenous to Polynesia, feudal Japan, rural California and the Great American West. All of this is expressed in the bold use of heavy timber, projecting beams, broad roof lines, overhanging eaves, extensive use of woods left in their natural state, broad verandas, and finally the incorporation of the surrounding landscape, the air and the sky in the total design.

"Because they harmonize so well with Hawai'i's environment, land and climate, Pole Houses have been hailed as the first truly 'ecological' modern homes to be introduced to the tropics."

— California Builder and Engineering Magazine

Visit us at our office, or send $5.00 for our complete Pole Houses of Hawai'i brochure to:

POLE HOUSES
OF HAWAII
745 Fort St., 702,
Honolulu, Hawaii 96813
Ph: 521-3442

Best Single Family Dwelling, Parade of Homes 1976
Best Bathroom, Parade of Homes 1976
Award of Merit, National Association of Home Builders 1975
Best of Show in Price Category, Parade of Homes 1975
Nasco Award — American Institute of Architects 1974
Best Use of Wood in Price Category, Parade of Homes 1972, 1973
Best Use of Wood, Parade of Homes 1972, 1975
Best of Show, Parade of Homes 1972, 1973
The Engineering

These homes have been engineered like a great or a great building. From the solid reinforced concrete footings to which the poles are bolted and forever secured, the ceiling, ventilation system, is a sound and fully integrated framework.

The framework is made up of very large beams and poles, which are notched and bolted together to form a rigid structural frame; one that is designed specifically to withstand the ravages of time and circumstance.

Island Design

HAWAII IS UNIQUE, like no other place in the world. We insist that our homes reflect that essential fact. Design is therefore - another significant element - which sets Pole Houses well apart from ordinary homes built in Hawaii.

While our designs are very much reflective of current life styles, you won't have to look close to sense a link with the past - a tie with our cultural and ethnic past and present.

OUR LIFE here differs considerably from that on the Mainland, or elsewhere. We design around this kind of life. We build to take advantage of our great outdoors, Big old fashioned verandas encircle our homes.

T Quality Woods

...HOUSES use the finest woods. A great variety, each with an express purpose, and each grooved or textured with a very specific objective in mind.

Every Pole House is constructed with vertical structural poles of Ponderosa Pine, 12 to 14 inches in diameter. Each pole is notched and interlocked with huge rough sawn beams of Douglas Fir, and bolted to form an integrated and structurally sound framework.

Those Magnificent Poles

- The poles are of considerable significance. View any of our houses and see what great and practical purposes they serve. They are the vertical columns upon which the entire house rests; an essential element in a solid, integrated structural system.

A Flexible System

- One of the interesting aspects of these houses is that the walls do not act as supporting members, provides great flexibility for future alterations. Walls can be moved, room sizes and the veranda configuration can be changed as the size of lifestyle of the family warrants.

Level or Hillside

There is considerable flexibility in placement of the house on most any terrain. Expensive excavation and retaining walls are unnecessary. This flexibility simplifies the foundation conditions and leaves the ground relatively undisturbed. In general, the poles greatly minimize the difficulty and expense normally associated with hillside construction.

The Total Environment House

POLE HOUSES are unique in that they provide man and nature with an opportunity to live in mutual respect. They adapt to the land, they use the air, relying on natural forces for cooling, they properly protect against the destructive effects of the sun, and are designed to provide maximum enjoyment of nature's forces and pleasures.

Our Goal

As designers and builders, we feel a special responsibility to provide houses which reflect our highest aspirations. If the structures we design and build signify houses which are intelligent, inspiring and fulfilling and if they help to elevate the quality of our lives then they will have achieved their purpose.

The Amazing Cooling System

Warmer Air Rises

Hawaiian trade winds give us our remarkable cooling system. We could wish for none finer. Through its use we have eliminated the need, even the desirability for costly mechanical air conditioning.

Cool Air

By providing a vent, at or near the peak of the ceiling, in conjunction with controlled opening throughout the house, we have made practical use of the 'venturi' principle. This provides a means for the escape of warmer air.

As the warmer air rises and becomes hotter than the outside air it is actually lifted out of the house through these vent openings. This in turn pulls in the cooler, fresher air through the openings at veranda level.

Fresh Air

Smoke and cooking odors are drawn up and out, noiselessly. The system works effortlessly. It is not drafty, and makes for a cool house on the warmest days. The openings, of course, can be closed conveniently when unnecessary.

This system has been in use by Polynesian and African cultures for centuries, and for a very good reason. It is a practical system and an obvious solution for conditioning the air naturally.
Figure 2 (24.70, Portland Ordinance)
From 1988 UBC, Fig. 70-1, p. 881
(For use with table below)

Figure 3 (24.70, Portland Ordinance)
From 1988 UBC, Fig. 29-1, p. 605

Table 24.70-C (Portland Ordinance)
Required Setbacks from Permit Area Boundary
(In Feet)

<table>
<thead>
<tr>
<th>H</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5-30</td>
<td>H/2</td>
<td>H/3</td>
</tr>
<tr>
<td>Over 30</td>
<td>15</td>
<td>6</td>
</tr>
</tbody>
</table>
WATERBARS

6 UP TO 2 FEET IN HEIGHT
FALLS TO 0 INCHES
& A VS. FEET