

STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES  
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GEOLOGIC RESTRAINTS TO DEVELOPMENT  
IN SELECTED AREAS OF MARION COUNTY, OREGON

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In cooperation with  
Marion County  
Board of County Commissioners  
Salem, Oregon

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**Maps for O-77-04**

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**Maps exist only as mylars and overlays**

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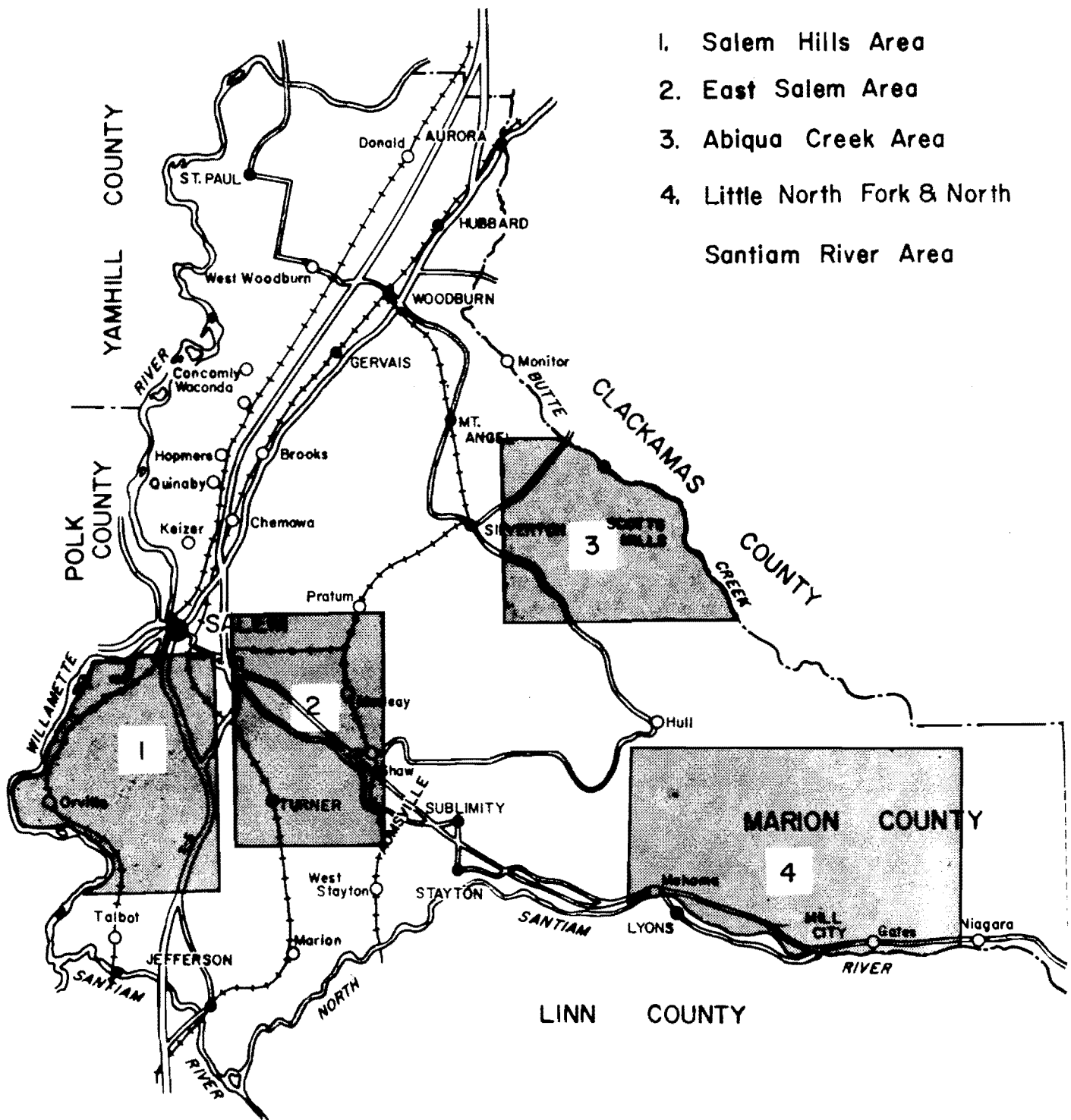
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# GEOLOGIC RESTRAINTS TO DEVELOPMENTS IN SELECTED AREAS OF MARION COUNTY, OREGON

## INTRODUCTION

### Purpose and Scope of Report

Urban expansion and recreational, commercial, and industrial developments in Marion County have subjected the land to an ever-increasing intensity of use. Most areas have one or more hazardous conditions which must be considered if the development is to be successful. Frequently, hazardous conditions not recognized by persons using the land will result in financial loss and possible physical harm.

Engineering, architecture, and urban and regional planning have long been recognized as essential elements to be considered by builders, subdividers, developers, and building officials in the selection and preparation of construction sites. Until recent years, economic evaluation for proposed development was based solely upon these three principal fields of professional expertise. Master plan concepts for most cities have been developed on the general basis of flat land terrain with little consideration for topographic relief and problems related to drainage, erosion control, and slope stability. Geological and soil engineering problems which are an integral part of every site, especially those located in hillside or hazardous terrain, have seldom been considered except in recent years. The importance of these two highly specialized

fields of expertise and the need to involve the engineering geologist and soils engineer in preliminary planning stages for development projects are now recognized as the result of spectacular failures of a number of man's finest structures.

The purpose of this investigation is to provide information on the existing and potential geologic problems that should be of prime concern in land use planning and land development in four areas of Marion County. The report and accompanying maps are designed for use by governmental agencies, developers, engineers, and private citizens.

It should be emphasized that the study is general in scope. It delineates areas where hazardous geologic conditions may exist, but it is not sufficiently detailed for individual site evaluations; many areas too small to have been mentioned in the report or shown on the maps are potentially unsafe. Development of a particular site should proceed only after a careful, detailed evaluation is made of its geologic and engineering characteristics.

#### Responsibility of Government Regarding Geologic Hazards

County governments through their planning and building departments are responsible for the issuance of building permits. They require that certain construction standards and design criteria be followed. In recent years, some planning departments have taken on the increasingly larger function of providing information on the characteristics of the land.



In processing applications for subdivisions and other land use developments, physical characteristics of the site are usually reviewed. With a geologic or hazards map and supporting information on soils and geology, the permit-granting agency can advise developers and builders of conditions which must be evaluated.

Many California counties now retain geologists for staff consultants to review development plans and make on-site inspections. Certain counties have instituted ordinances that require developers to hire geotechnical engineers and geologists to make site studies. For new developments, this procedure has helped avoid damages from landslides, erosion, and water.

It has been determined through the California courts that the issuance of construction permits by a governmental agency for land development implies that no dangerous or seriously damaging conditions will occur as a result of such construction or in relation to the presence of the development. The permit-granting agency thus may be held responsible for damages incurred because of lack of knowledge of, or concern about, the geologic hazards.

In a court case between Sheffet and Los Angeles County (Los Angeles Superior Court Case No. 32487), the court ruled that the County was responsible and must pay damages caused by water and mud flowing from a 12-lot subdivision above the plaintiff's property. In its decision, the District Court of appeals declared: "...where a public entity approved

plans for a subdivision including a drainage system, and there is damage to an adjacent property as a result of those improvements, the public entity, not the subdivider, is liable. The fact that the work is performed by the contractor, subdivider, or private owner does not necessarily exonerate the public agency if (they) follow the plans and specifications furnished or approved by the public agency.

"When the work thus planned, specified, or authorized results in injury to adjacent property, the liability is upon the public agency under its obligation to compensate for the damage resulting from the exercise of its governmental power."

The Sheffet decision was upheld by Superior Court Judge William Fox of Pasadena, California. In addition, the County's petition for a rehearing was refused by the State Supreme Court. Refusal by the Supreme Court to rehear the case established a judicial precedent.

Since the Sheffet decision places the responsibility on the permit-granting agency, that agency is now faced with the necessity of obtaining adequate information on hazardous conditions for the protection of both the local government and the unwary public who tend to minimize or ignore these hazards until the casualty occurs.

Construction by County Public Works Departments can also result in liability. The Los Angeles Superior Court (Case No. 684595) ruled that road building by Los Angeles County had triggered further damaging landslides in the Palos Verdes Hills and that the County must pay damages

of approximately \$6 million. Since that time, additional lawsuits have cost the county at least another 12 million dollars.

#### Source of Data

This report contains geology published by the U.S.G.S. and the Oregon State Department of Geology and Mineral Industries; flood reports and maps by the U.S. Army Corps of Engineers, the U.S. Department of Agriculture, Soils Conservation Service; and information developed during this study.

#### Use of Report

Although the material in this report may seem to be detailed, it does not relate to specific properties or development sites. Therefore, the report should be used only as a guide to point out to the developer most of the problems which are or may be present in the area of a proposed development.

Five tables have been prepared to help determine the significance of the hazards in each of the four areas. The tables are interrelated and should be used in conjunction with each other to alert the planner of the impact of certain combinations of land uses with geologic hazards. The tables also make reference to the requirement of consultants regarding investigations and reports.

They will also serve as a guide to the planner and developer regarding the geologic hazard and its significance to the intended use of the property.

Table 1 lists the major hazards which are likely to be found in each of the four study areas. Table 2 indicates the significance of each hazard to a specific land use. Table 3 indicates the restrictions to land use of each of the geomorphic landforms present. Table 4 gives the county requirement and response to development with each of the major hazards present. Table 5 relates the county response to each construction item or type of land use. The tables, text, and maps should each be consulted before making a land-use decision. A suggested procedure would be as follows:

1. Outline the property on the base map.
2. Overlay each hazard map and note the areas on the property affected by the hazards.
3. Check the tables to determine if other hazards might be present. Note on the topographic base the landforms present.
4. Consult Table 3 and note hazards likely with the landforms present.
5. Use Table 2 to determine the potential for problems with the type of development and the geologic hazards.
6. Go to Tables 4 and 5 to determine the need for studies and reports by the developer for each hazard and construction item in the proposed development.

Table 1. Potential Hazards vs. Area.

[illegible]

High Potential ●  
Moderate Potential ◐  
Slight Potential ○

Table 2. Land Use vs. Geologic Hazard.

Geologic Hazard	Land Use	High Density Housing	Low Density Housing	Heavy Foundation Loads	Roads and Streets	Drainfield Disposal	Landfill	Basements	Underground Fuel Storage	Underground Utilities										
Landslide	●	●	●	●	●	●	●	●	●	●										
Steep Slope	●	●	●	●	●	●	○	○	○											
Rock Fall	●	●	NA	●	NA	NA	NA	NA	NA											
Flooding	●	●	○	●	●	●	●	●	●											
High Water Table	●	●	○	●	●	○	●	●	○											
Ponding	●	●	○	○	●	●	●	●	○											
Weak Foundation Soil	●	●	●	●	●	●	●	●	●											
Heavy Clay Soil	●	●	●	●	●	●	○	○	○											
Erosion	●	○	○	●	○	●	NA	○	○											
Near Surface Bedrock	●	●	○	○	●	○	●	●	●											
Pollution	●	●	NA	NA	●	●	NA	○	○											
Eventual Slope Failure	●	○	●	●	●	●	○	NA	○											

High Potential for Problems



Moderate Potential for Problems



Low Potential for Problems



Not Applicable

NA

Table 3. Land Use vs. Geology and Landform.

Geology and Landform	Land Use	Housing Development	Landfill and Road Embankment	Cut Slopes	Water Well Supply	Septic Tank Use	Water Distribution-Sewer Systems	Agriculture and Open Space	Intense Development	Minor Development									
<b>Landslide Potential</b>																			
Active Landslide	●	●	●	●	●	●	●	●	●	●									
Inactive Landslide	●	●	●	●	●	●	●	●	●	●									
Potential Slope Failure	●	●	●	●	●	●	●	●	●	●									
Steep Topography	●	●	●	●	●	●	●	●	●	●									
<b>Flood Potential</b>																			
Floodplain	●	●	●	●	●	●	●	●	●	●									
Lower Terrace	●	●	●	●	●	●	●	●	●	●									
High Terrace	●	●	●	●	●	●	●	●	●	●									
Small Stream Valleys	●	●	●	●	●	●	●	●	●	●									
<b>Engineering Properties</b>																			
Near Surface Bedrock	●	●	●	●	●	●	●	●	●	●									
Near Surface Water Table	●	●	●	●	●	●	●	●	●	●									
Impermeable Clay	●	●	●	●	●	●	●	●	●	●									
Compressible Soil	●	●	●	●	●	●	●	●	●	●									

Not Recommended ●

Restricted Use ●

Normal Use ○

Table 4. County Response to Geologic Hazard.

	County Requirement	Review of Geology	Review of Hazards Data	Analyze Development Plans	Preliminary Geology Inspection	Detailed Geology Report	Engineering Design-Grading Program	Geologist & Engineer Surveillance	Review Completed Project			
Hillside Property												
Steep Slope												
Landslide	●	●	●	●	●	●	●	●	●			
Potential Slide	●	●	●	●	●	●	●	●	●			
Soil Creep	●	●	●	●	●	●	●	●	●			
Rock Fall	●	●	●	●	●	●	●	●	●			
Water Problems												
Flooding	●	●	●	●	●	○	●	○	●			
Ponding	●	●	●	●	●	○	●	○	●			
High Water Table	●	●	●	●	●	○	●	○	●			
Pollution	●	●	●	●	●	○	●	○	●			
Geology												
Near Surface Bedrock	●	●	●	●	●	●	○	●	●			
Compressible Soils	●	●	●	●	●	●	●	●	●			
Clay Soils	●	●	●	●	●	●	●	●	●			
Shrink and Swell	●	●	●	●	●	○	●	○	●			
Erosion	●	●	●	●	●	●	●	●	●			

Required ●

Can Be Required ○

Not Necessary ○



Table 5. County Response to Development and Construction Item.

Construction Item	County Response	Inspect Proposal	Review Hazard Data	Review Geology	Preliminary Geology	Preliminary Geology Report	Detailed Engineering Report	Grading Geology Report	Final Program	Geologist-Engineer Design	Review Completed Project		
Development													
High Density Urban	●	●	●	●	●	●	●	●	●	●			
Low Density Rural	●	●	●	●	●	○	○	●	○	●			
Utilities													
Water Supply System	●	●	●	●	●	●	●	●	●	●			
Individual Water Wells	●	●	●	●	●	○	○	○	○	●			
Storm Sewers	●	●	●	●	●	●	●	○	○	●			
Sewerage System	●	●	●	●	●	●	●	●	●	●			
Septic Tanks	●	●	●	●	○	●	○	●	○	○			
Engineering Foundation													
Heavy	●	●	●	●	●	○	○	●	○	○			
Light	●	●	●	●	●	○	○	●	●	●			
Embankments & Excavations													
Large	●	●	●	●	●	●	●	●	●	●			
Small	●	●	●	●	○	○	○	●	○	●			

Required ●  
 May Be Required ●  
 Not Required or Necessary ○

7. Make a list of the hazards, the county requirements, and the county actions. This will include reports and studies furnished by the developer and reviews and inspections by the county.

Areas of possible geologic hazard require that a geologic report be prepared by a professional engineering geologist. The preliminary geologic report should indicate one of several conditions: 1. that no special geologic problems exist, 2. that geologic conditions exist that can be corrected, and 3. that the geologic hazard is extensive, attempt to correct the hazard is uneconomical, and any development on the property would most likely fail. For conditions 1 and 3 additional geologic studies do not appear warranted. For item 2 detailed geologic and engineering studies and reports are necessary if the property is to be developed. In addition the geologist and soils engineer should be available during construction to make periodic inspections and to provide assistance whenever unexpected conditions occur.

In conjunction with this report, the County should develop a grading program or require that Chapter 70 of the Uniform Building Code (see appendix) is followed.

It should be emphasized that this report in most cases, does not negate development in problem areas; it does point out that problems exist and strongly suggests that they be considered by the developer and planner and that the assistance of engineers and geologists be acquired when necessary.

## GEOLOGIC HAZARDS

Geologic processes or geologic conditions which constitute a threat to any activities of man are geologic hazards. These include erosion, deposition, mass wasting (landslide), flooding, high water table, and soil and bedrock instability. Each of the major hazards implies some sort of restraint to development.

### Steep Slope

#### Definition

Steep slope refers to slopes which can present restraints to certain types of land use (see Table 1 and others as needed). The degree of slope causing a hazard varies relative to the type of development and geological conditions present (Tables 2 and 4).

A proposed development on hillside property should be thoroughly analyzed to determine its effect on slope stability (Table 4). It should not only be analyzed for the conditions existing, but for the conditions which will be created by the development.

If the analysis indicates that special precautions are necessary, geologic and engineering studies should be prepared in sufficient detail to prevent unnecessary failures caused by geologic hazard or improper design (Table 2).

Water supply may become scarce as steep and landslide ground becomes fully developed and the demand for water increases. Ground-water channels are disrupted in landslides, and the presence of good water is erratic and unpredictable. The installation of public water systems are not feasible in areas of creep or periodic slope movement. Developments which require public water and sewer should be located where water distribution systems can be reasonably maintained.

#### Impact

Sloping ground may present problems to development relative to the use of septic tanks and dry well sumps. Septic tank drainage overflow can cause pollution of streams creating a health hazard. Depending upon the density of houses, up to 50% of the ground surface can be covered by building, driveways, sidewalks, and streets. Runoff from these impermeable surfaces is transferred, in part, to the open ground. Watering of lawns and gardens also contributes moisture to the ground. The size and placement of cuts and embankments along streets and driveways can cause oversteepening and overloading of critical slopes. Embankments may also act as dams by restricting the flow of surface water or shallow subsurface water. These factors contribute water to the ground and may eventually lead to a disastrous landslide on ground that may have had no previous history of landslide or slope instability. For this reason,

the impact that a development may have in the future should be given as much considerations as is given to present conditions.

### Landslides

A downslope movement of earth materials in response to gravity is termed a landslide, or mass wasting. A slope which has not failed by landslide but which could fail through natural geologic processes or man-made operations is called an unstable slope or potential landslide. Landslide, or mass wasting, is a normal process of slope development and therefore is widespread.

Active landslides are easily recognized, but ancient landslide surfaces, areas of slow creep, and otherwise unstable slopes may be hard to recognize.

### Identification

Landslides are recognized by a number of features some of which are readily apparent, some recognizable to the trained eye, and others discerned only after detailed study.

The ground surface immediately following a slide usually has an arcuate shaped headscarp, secondary parallel breaks, and a jumble of material at the toe. The surface may have a series of back tilted blocks and associated sag ponds. Trees are tipped or lie on the ground, and drainage is disrupted.

After several years the headscarp becomes rounded, many cracks cave in and become filled, and ponds may be drained by cutting of outlets. The crowns of trees which were tilted grow vertically, but the lower trunks are bowed. Ancient slides more than several hundred years old still show some irregular hummocks, but all trees which have grown since the slide are straight and vertical and show no indications of previous sliding. Springs are common in many slide areas, some of which have provided reliable water sources for single family rural development.

When a landslide occurs on developed property containing housing, streets, and other structures, the expenditure of money to treat the slide can be greater than on undeveloped property, providing the damage to property has been slight to moderate and the cost of repair and correction is justified. If destruction was nearly complete, slide correction may not be prudent.

Stable landslide areas and steep slopes may be used for light development only after adequate study and design. Intense development should not be allowed in these areas because of the likelihood of making the slope unstable. Water supply for other than light development would be inadequate, and water would have to be piped in. Any minor slope movement could damage the water mains, introduce excessive water to the slopes, and a minor slide could develop into a major disaster.

## Types of Landslides

Landslides in the Marion County area are primarily those classed as mudflow, slump, soil creep, and rock fall.

The type of landslide that is likely to occur in any one site will depend to a great extent on the geology and topography.

### Mudflow

Mudflows are a common type of steep slope failure on construction projects. They occur in moisture-sensitive soils which become over-saturated and undergo liquefaction. The soil mass begins to move due to weight and loss of strength, and the subsequent decrease of pore space caused by the shifting of the silt and sand grains produces excess water which buoys the mass down even gentle slopes.

Mudflows move downslope in any available channel. As they reach the toe of the slope, they fan out, leaving a characteristic interlobed deposit. Once these slides have attained their velocity, they can travel hundreds of feet on a horizontal surface. These deposits can vary in size, but only the largest ones will show up on a topographic map.

### Slump

Slumps (also called rotational slides) develop major spoon-shaped slip planes in homogeneous materials. The slip plane at the top or heel of the slide is usually vertical. The radius of the curve increases toward the toe of the slide, which causes the sliding mass to develop a series of

parallel subsidiary slide blocks. Each block tilts or rotates backward as the sliding mass moves downslope. Where the arc of the slide plane intersects the surface, the sliding material rides out over the original ground surface in a jumbled heap which eventually resists further movement. On the surface of this type of slide, trees and fence posts tilt uphill.

### Soil Creep

Soil creep is a slope failure in which no slip surface develops. It most frequently occurs in deeply weathered surface materials and colluvium. Because the surface moves a greater distance downslope than the subsoil, trees and fence posts tip or are displaced downhill. The rate of movement may be imperceptible, as little as only one foot in ten years, but structures will suffer damage within a short period of time. Cracks form in the soil which introduce more water into the ground, and other types of landslides can develop from creep.

Because soil creep often goes unrecognized on natural ground, development may inadvertently be allowed to take place. Foundation cracks and uneven settlement of less than one inch in a year may at first be construed to be normal foundation settlement. Continued widening of cracks and settlement over a several-year period is evidence that the problems are more serious, and the effects of soil creep will probably continue.

Recognition of areas of creep prior to development is the most prudent method of avoiding damage from soil creep.



### Rockfall

Rockfall occurs on very steep exposed bedrock surfaces when material becomes dislodged and tumbles, slides, or falls downward to the bottom of the slope or where undercutting produces an overhand which fails abruptly with little warning. Small rockfalls characteristically occur in combination with steep bedding plane slides.

### Impact

All types of active landslides can damage or destroy most man-made structures including industrial and commercial buildings, homes, and linear developments such as roads, highways, pipelines, and communication cables. For large projects, such as dams and nuclear power plants, engineering solutions may be possible. Where movement is restricted to a few tens of feet in depth, landslide potential may even be removed by grading; however, where slides are particularly deep, this solution is not possible.

Active slides can be generated by acts of man which alter the balance of nature. Excavations, cuts, fills, and drainage modifications may decrease the stability of an area and initiate sliding. Water introduced into the subsurface by irrigation, drain field disposal, septic tank drainage, and improper handling of runoff from street and parking lots may also initiate slides.

An area of landslide may not become stable for many years after movement, and the ground may move periodically in response to wet seasons. Such land is unsuited for any development use until all movement has ceased.

A proposed development on hillside property should be thoroughly analyzed to determine its effect on slope stability. It should be analyzed not only for the conditions existing, but for the conditions which will be created by the development.

If the analysis indicates that special precautions are necessary, a geologic and engineering study in sufficient detail is necessary to determine the problems and assure adequate engineering design for the development.

Because large structures and regional developments are normally restricted to gently sloping regions, they are generally not threatened by rockfall. Rockfall, however, is a threat to highways, railroads, pipelines, and other developments in steeper areas and can be a threat to the safety of hikers, motorists, loggers, and miners.

Treatment of a landslide begins with the elimination of the major causes. On natural undeveloped slopes the causes of landsliding are most likely oversteepening by erosion and excessive moisture. The action by the slide reduces the slope angle except at and above the head scarp. Restoration of the ground may include smoothing the ground surface, filling and compacting all cracks, constructing surface drainage which will route water in water tight ditches around the slide area, and

installation of horizontal drains to drain the subsurface. After the area has been stabilized, a properly engineered development can be allowed.

#### Recommendations for all Categories of Unstable Slope and Landslide

It is imperative that all landslides, potential landslides, and unstable slopes be identified in an area where proposed development or construction is to take place (Tables 1 through 5).

The danger of rockfall can be minimized through proper engineering of all projects in areas of rockfall potential. Excavating, blasting, and placing of fills should be conducted only after the potential for rockfall has been accommodated. Along highways and railroads the use of multiple benches, screens, and earth ridges can reduce the impact of rockfall. Warning signs should be placed in all regions of rockfall potential in parks and recreation areas.

Large, obviously active landslides will in almost every instance cost more to stabilize than the property is worth afterwards. Such areas should be left undeveloped. If the original cause of the landslide is still in effect, such as erosion of the toe of the slide by stream action, future sliding will probably occur.

Old landslides which still exhibit features such as bent trees and water-filled sag ponds should be viewed with suspicion. Many such areas may be moving intermittently and very slowly. Movement of only a few inches per year will cause continual and extensive damage to structures.

Excessive maintenance costs can, in time, force abandonment. Housing developments located on this type of landslide may increase the rate of movement of the slide by adding moisture to the ground and by creating unsupported excavations.

In contrast to old landslides, ancient landslides are those having no historical movement. They exhibit a subdued rolling topography, sag ponds are drained, large trees stand straight (if present), and the surface slopes less than in adjacent areas. Generally speaking, no development should be allowed in areas of active sliding. If an ancient slide area can be identified as being stable and distinguished from an "old landslide" which may still have movement, certain uses can be permitted depending upon its degree of stability.

For urbanizing areas threatened by mantle creep and associated landslides, the National Flood Insurance Act as appended in 1969 should be applied. The U.S. Department of Housing and Urban Development oversees this Act. Engineering studies should be required of all large structures and regional developments where mass wasting is a potential hazard. Building and zoning regulations should incorporate the grading standards of the Uniform Building Code, and the density and nature of developments should be keyed to slide potential.

#### High Ground Water Table

A high ground water table refers to a condition in which the water table is at or near the surface for at least part of the year. A high water

table can cause numerous problems to land development and construction. Hydrostatic pressure can force empty fuel tanks out of the ground and fracture and buckle basement walls and floors. It can cause excavations to cave in from pore pressure and the weight of saturated soil, and septic tanks can overflow and pollute local streams.

Differential settlement of structures and problems of maintenance of underground utilities are also common with a fluctuating high water table.. During periods of high precipitation, the water table often surfaces, ponding low-lying areas. These low areas generally have immature drainage networks and drain slowly. Any fills or developments under these conditions must be carefully designed so as not to block drainage ways even though they carry water for only one or two months a year. Blockage by construction will increase ponding, slow the rate of drainage, and cause greater flooding.

Developments in regions of high water table should be restricted to land use that is either compatible with the characteristics of the land or that can be engineered to provide an adequate level of safety (Table 1).

### Soft Compressible Soils

Several categories of soil settle unevenly under light to moderate foundation loads. The most critical of these is peat. Peat contains a large percentage of organic matter, mostly fibers, and is spongy and lightweight. It is usually water saturated and under load will frequently

consolidate to less than 50 percent of its original volume. Peat occurs at the surface in swampy areas where the water table is rising slowly enough to allow the vegetation to remain and grow without being completely or continually submerged. These conditions prevail along the Willamette River floodplain in abandoned channels of old oxbows. They also occur in old stream channels which have been filled with sediment. The prime example is the Labish area.

Certain clay structures in soils allow abundant water to be contained. Under heavy loads the water migrates to areas of less pressure, and excessive settlement takes place.

### Impact

Construction on compressible soils can result in differential settling of a wide variety of structures including the foundations of large buildings, homes, roads, railroads, airport runways, and pipelines.

### Recommendations

Proper geological and geotechnical engineering investigations should precede all construction in regions of possible highly compressible soils. Engineering solutions may include excavation and backfilling with more suitable material, preloading, or the use of spread footings or piling, depending upon the nature of the structure being considered and the degree of hazard.

## Flood Hazard

Marion County is situated near the center of the Willamette River Basin. Major tributaries of Willamette River within the county include the Santiam River, Mill Creek, Beaver Creek, Battle Creek, and Pudding River. This report covers: (1) Willamette River adjacent to the South Salem Hills, (2) North Santiam River between Mill City and Stayton, (3) Mill Creek in the vicinity of Aumsville to Salem, Oregon, Abiqua Creek, and Pudding River.

Commercial, industrial, residential, and agricultural developments on the flood plain have been flooded in the past and are within reach of probable future floods.

The Greatest Historic Flood of the Willamette River at Salem, Oregon, occurred in December 1861. Basinwide, this flood probably was of the same magnitude as the December 1964 flood under natural conditions, but larger than any other previous flood. Data for making comparisons of the 1861 flood with others are lacking on most tributaries (see Table 6).

Flood of 1964. Without seven flood control projects that were operating during the flood of 1964, the stage of the Willamette River at Salem would have been almost equal to that of the 1861 flood (45.3 feet compared to 47.0 feet).

Floods in the Willamette Basin are so widespread that whenever they occur on the main stream they also occur on the tributaries. A significant

Table 6. Ten Greatest Known Observed Floods in Order of Magnitude  
Willamette River at Salem, Oregon 1861-1964

Order No.	Date of crest	Gage Height		Peak <sup>1</sup> discharge c.f. s.
		Stage feet	Elevation feet	
1	December 4, 1861	47.0	153.1	500,000
2	February 5, 1890	45.1	151.2	448,000
3	January 16, 1881	44.3	150.4	428,000
4	January 8, 1923	38.3	144.4	348,000
5	January 15, 1901	39.5	145.6	329,000
6	February 6, 1907	39.3	145.4	325,000
7	November 25, 1909	38.5	144.6	315,000
8	December 23, 1964	37.78	143.9	308,000
9	January 2, 1943	38.6	144.7	291,000
10	January 27, 1903	36.6	142.7	283,000

<sup>1</sup> Variation in relationship between the discharges and elevations is the result of changes in the channel which have taken place over the years.



Table 7. Ten Greatest Known Observed Floods in Order of Magnitude  
North Santiam River at Mehama, Oregon 1907-1964

Order No.	Date of crest	Gage Heights		Peak <sup>1</sup> discharge c. f. s.
		Stage feet	Elevation feet	
1	December 28, 1945	15.37	617.9	76,600
2	November 20, 1921	17.5	620.0	62,900
3	January 6, 1923	17.5	620.0	62,900
4	January 7, 1948	13.50	616.0	60,200
5	December 22, 1964	13.55	616.0	58,400
6	November 23, 1942	13.56	616.1	56,700
7	March 31, 1931	16.0	618.5	54,000
8	December 15, 1946	12.60	615.1	52,400
9	February 5, 1907	15.0	617.5	50,900
10	January, 1943	12.69	615.2	49,500

<sup>1</sup> Variation in relationship between the discharges and elevations is the result of changes in the channel which have taken place over the years.

Ave. of 1 flood/year 1906-1966

flood occurs on Mill Creek about every three years. The stream floods out of its banks almost annually, however. The North Santiam River has a significant flood about every six years but has averaged a flood per year since 1906.

It must be noted that (1) larger floods may occur; (2) major floods of an infrequent probability may occur in two or more consecutive years; and (3) more than one major flood may occur in any one year.

Furthermore, the flood plain is subject to constant change due to the ever-changing topographic pattern of the land caused by highway, road, and street construction; modifications of the drainage pattern; and the development and construction of new industrial locations and subdivisions. Consequently, it is not possible to predict the exact limits of inundation during future floods.

Standard Project Flood is defined as the largest flood that can be expected from the most severe combination of meteorological conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations. It is approximately equivalent to a 500-year flood. Studies are now underway by the Army Corps of Engineers to develop a uniform technique for deriving Standard Project Floods, on the basis of the latest available information, for any location in the basin. Standard Project Floods should be considered in any development in the flood plain.

Flood mapping by the Army Corps of Engineers on the Willamette River and Mill Creek delineated three categories of flooding. They included a 5% chance of flooding or a 20-year flood, a 2% chance or a 50-year flood, and a 1% chance or a 100-year flood. (Note frequency of floods page 28 ). In some areas the locations of the various categories of floods are nearly identical, while in others the flood outlines are widely spaced. The latter is primarily due to the gentle slope of the ground between the minimum and maximum elevations of the several floods.

Flood mapping along Mill Creek southeast of Salem includes the 20-year, 50-year, and 100-year floods. All three appear to occupy the same general ground south of the intersection of I-5 and State Highway 22. The area north to State Street lies almost exclusively in the 100-year flood outline.

Flood areas of the small tributary streams and adjacent areas mapped as flood-prone are based on U.S. D. A. Soils Conservation Commission mapping of flood-prone soils. Although most of these soil types are subject to flooding, parts of some may not be inasmuch as the mapping appears to have been extended to elevations above the normal flood height. It is suggested that for rural density development a site located on flood prone soil be examined to determine if that part of the soil is above the actual flood elevation.

Main Flood Season for streams in Marion and Polk Counties begins in October and extends through April with the majority of the larger floods

occurring in December and January. Most of the larger floods have resulted from general heavy rains augmented by snowmelt at a time when the soil was near saturation from prior rains.

Duration of Floods is several days and stream stages rise from streambed to extreme flood peaks over a period of 1 or more days. Due, in part, to similar flood magnitudes, the duration of flooding and the rate of rise of the December 1964 flood would be similar to that of a 100-year flood. Floods of this magnitude have a maximum rate of rise on the streams investigated from about 0.1 to 0.7 foot per hour, and they remain out of bank from 3 to 8 days on the tributaries and up to 10 days on Willamette River.

In 1972, of forty-eight presidentially declared disasters, forty-six were for flooding. Of all uninsured disaster losses in the United States, 90 percent are due to flooding.

Trends indicate that without adequate control of flood prone areas, flood damages will continue to increase.

#### Flood Plain Use and Development Standards

To assure that flood plain regulations are effective, minimum standards or guidelines should be established for flood plain use and development.

Although larger floods can occur, it is recommended that flood plain regulations be based upon a 1 percent or 100-year flood, which is

defined as a flood having a 1 percent chance of occurrence in any single year unless specific reasons exist for using a greater or lesser flood. Flood plains should be analyzed as two separate areas: the floodway, and the floodway fringe, which is the flood prone area outside of the floodway but within the selected flood limits. The type and extent of regulations needed will vary between the two areas.

### Recommendations

#### The floodway

Because certain intensive development in the floodway will aggravate the flood situation, the floodway should, wherever possible, be maintained as open space for uses such as agriculture generally excluding structures; recreation for parks, golf courses, public hunting, fishing, or scenic areas; and similar open space uses.

#### The floodway fringe

Inasmuch as development in this area will not aggravate the flood problem appreciably, regulations need not prohibit structural development but should control floor elevations or require flood proofing to an elevation above that of a 100-year flood. Storage or processing of noxious or floatable materials should be carefully controlled in this area. Any water supply or sewerage system facilities developed in this area should be designed and constructed so as not to be contaminated or become a source of contamination during flood situations.

The potential for future damages will not necessarily be reduced with the construction of new dams or other flood control projects such as levees and channel improvements. More and more people are moving into the flood plains, and it is unlikely that it will be possible to build flood control works adequate to protect all of the areas which may be developed for residential, commercial, and industrial use.

The best approach to preventing increase in future flood damages which can be initiated by the communities or counties entails the use of reasonable preventive measures which "keep man away from water" by allowing developments on the flood plain to be constructed only in predetermined areas where the risks are reasonable. For example, the more flood susceptible areas near streams could be reserved for the development of parks and other open-type facilities least subject to flood damages.

#### Flood Forecasting

In Oregon, the U. S. Department of Commerce's National Weather Service (NWS) River Forecast Centers in Portland and Medford are responsible for stream flood forecasting. This is accomplished by using data from a network of automatic and manual streamflow and precipitation measuring stations throughout the state. The Weather Service should be urged to provide 24-hour rather than 8-hour surveillance.

#### Flood Warning

When meteorological, hydrological, or other conditions indicate that

a flood is imminent, the River Forecast Center transmits a warning to the State Executive Department's Division of Emergency Services. The Division forwards this warning to city and county officials through its communication systems, including the National Warning System (NAWAS).

#### Flood Insurance

The National Flood Insurance Act of 1968 was enacted by Title XIII of the Housing and Urban Development (HUD) Act of 1968 (PL 90-448) and has two major purposes: (1) to offer insurance at subsidized rates to present flood plain occupants and (2) to discourage future unwise development of flood plains.

In order to qualify for this coverage, an appropriate unit of government must have enacted adequate flood plain regulations. Marion County and the city of Salem have qualified for this coverage.

## STUDY AREAS

Four areas in Marion County were selected for special study; each containing between 60 and 100 square miles. They were selected because they were receiving development pressure for housing, and much of the land appeared to have significant geological hazards.

The four areas are:

- I. the South Salem Hills area
- II. the East Salem - Aumsville area
- III. the Abiqua Creek area and
- IV. the North Santiam and Little North Fork, Santiam River area.

The report includes a topographic base map for each area at a scale of 1/24,000 and overlays showing the areas of major hazards.

Geologic maps of the first two listed areas are available in the Water and Sewer Study prepared in 1972 and have not yet been reproduced for this report. Geologic maps have been prepared for areas III and IV.

The use of the text, tables, and maps should follow an appropriate sequence to determine the feasibility of a proposed development and to assure that it has been properly considered. Suggestions as to how to use the report are found on page 5 .

### South Salem Hills Area

#### Topography

This region has moderate relief and is bounded on the west by the



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Willamette River. The land slopes rapidly from about 150 feet elevation at the river to just over 900 feet in about a mile to the east. The topography is highly irregular as a result of landslides.

### Geology

The oldest rocks in the area are the Oligocene marine beds called the Eugene Formation. They are composed of tuffaceous sandstone, siltstone, and clay. The rocks are highly fossiliferous and contain abundant weathered clam and snail shells.

The Columbia River Basalt overlies the Eugene Formation and occupies the upper elevations of the hills and the rolling upland surface towards the east. Large chunks of basalt have been carried down the west slope by landslides. The basalt ranges from 200 to about 600 feet thick and dips eastward. The upper surface has been deeply weathered and where erosion has not removed it, the soil contains valuable deposits of bauxite formed by laterization of the basalt.

### Hazards

The major hazards in this area are landslide, steep slope, and near surface bedrock. Proposed developments in areas of landslide and steep slope will require a preliminary geologic report. If the preliminary geology report indicates that development may be possible, a follow-up engineering report is justified. Should this report favor construction,

a detailed geologic study and engineering design will be necessary.

The design should include a grading program and upon completion of the project, the work should be thoroughly reviewed.

Other hazards are considered moderate in that special design can adequately cope with the problems. These are high water table, impermeable clay soils, weak foundation soil, erosion, scarce groundwater supply, and pollution problems. Flooding is a problem along some creeks and in the Willamette River floodplain.

#### East Salem-Aumsville Area

##### Topography

The Willamette Valley east of Salem is an upper terrace area moderately dissected by small streams. The sediments lap up on Columbia River lavas which extend from the valley elevation of about 200 feet to a maximum of 700 feet in a series of scattered small hills. The flattish upper surface of the basalt is cut in places by steep sided narrow canyons several hundred feet deep.

Glacial outwash southeast of Turner slopes about 50 feet per mile and is poorly drained.

##### Geology

No geologic map was prepared for this area because it is contained in the appendix of the 1972 Water and Sewer study. The geology is rather

simple. The Waldo Hills area is mostly Columbia River Basalt with some areas of deeply weathered laterite whereas in other areas fresh basalt occurs very near the surface.

The lavas range up to 500 to 600 feet thick but a few windows have exposed small areas of the underlying Eugene Formation.

Silty alluvium covers the Salem-Howell Prairie area east of Salem and glacial outwash of gravelly sandy soil is present south and east of Turner. Thick gravel is present through the Turner gap along Mill Creek to the Salem area.

#### Hazards

The major problems in this area are flooding and high water table. Impermeable and weak foundation soils are widespread and will require consideration in development and engineering design. Near surface basalt bedrock covers much of the Waldo Hills area north of Turner. For areas of flooding or other hazards consult the overlay maps for this area.

#### Abiqua Creek Area

#### Topography

The Abiqua Creek area includes part of the eastern edge of the Willamette Valley, the Abiqua Creek valley and narrow floodplain, and the adjacent uplands. The uplands have been dissected by deep steep-sided

canyons. Along Abiqua Creek in the eastern part of the area large landslides have produced an irregular topography containing numerous sag ponds and small lakes. Elevations range from 300 feet to almost 2000 feet.

### Geology

The geologic map indicates units beginning with the Oligocene Eugene Formation to the recent Valley Alluvium. The Eugene marine sedimentary rocks previously described are exposed east of Silverton and along upper Abiqua Creek. They are overlain by the Columbia River basalt. The basalt about 500 feet thick is widespread throughout the Silverton Hills. The basalt is usually fresh, and in some areas it is covered by only a few inches of soil.

The Sardine Formation, composed of pumice and platy basalt flows, overlies the Columbia River basalt in a small area in the southeastern part of the map.

### Hazards

Several large landslide areas should be avoided if at all possible, and areas of steep slope should be cautiously considered for development. Near surface bedrock is common in the area, and its effect on excavation and septic and storm water drainage should be considered. Groundwater is generally scarce, and wells frequently produce only enough for household use.

## North Santiam and Little North Fork, Santiam River Area

### Topography

The area is mostly steeply sloping mountainous ground with bedrock cropping out on the surface and less steep slopes with thin soil and rock mixed and covered with timber. Lesser areas are the narrow flat valley of the Little North Fork and the wider North Santiam River. The Santiam River Valley contains a thin soil cover overlying coarse gravel and bedrock. The relief ranges from about 600 to 4000 feet.

### Geology

The oldest rocks in the area are the Oligocene-Miocene Little Butte Volcanic Series. They occupy the valley sides of both the North Santiam and the Little North Fork Rivers from the valley floors up to about 2000 feet elevation. They have a total thickness of more than 5000 feet. They are composed of interbedded lavas, tuffs, and volcanic agglomerates. The tuffs are unstable and have been responsible for many landslides.

### Columbia River Basalt

The basalt is exposed in one small outcrop two miles west of Mehama, Oregon and partly along the contact between the Little Butte and Sardine Formations. It has been previously discussed in sections where it is prominently exposed.

### Sardine Formation

The Sardine Formation of late Miocene age to early Pliocene is widespread above about 1500 to 2000 feet elevation. It is composed primarily of lavas, breccias, and tuffs. Several thick massive andesite tuff flows are present in the upper Little North Fork Area. Blasting produces blocks weighing up to 40 tons or more.

### Hazards

Hazards are primarily landslides, steep slope, and near surface bedrock. The slides are produced by failure of the weak tuffs and agglomerates of the Little Butte volcanics along the steep canyon slopes. Other hazards are difficult excavation of blocky rock, impermeable near surface bedrock, and floods in the streams floodplains.

### Selected Bibliography

- Hampton, E. R., 1972, Geology and Ground Water of the Mollalla-Salem Slope Area, Northern Willamette Valley, Oregon: U.S. Geol. Survey Water-Supply Paper 1997.
- Peck, D. L., Griggs, A. B., Schlicker, H. G., Wells, F. G., and Dole, H. M., 1964, Geology of the Central and Northern Parts of the Western Cascade Range in Oregon: U.S. Geol. Survey Prof. Paper 449.
- Schlicker, H. G. and Deacon, R. J., 1969, Preliminary Engineering, Geology Studies of Marion County, Oregon In A Comprehensive Water, Sewerage, and Resource Development Plan, Marion County, Oregon: Mid Willamette Valley Council of Governments, Clark and Groff Eng., Oregon Dept. Geol. and Mineral Industries.
- Beaulieu, J. D., 1974, Geologic Hazards Inventory of the Oregon Coastal Zone, Miscellaneous Paper 17, Oregon Dept. of Geol. and Mineral Industries.
- U.S. Army, Corps of Engineers, Portland District, 1968, Flood Plain Information, Willamette River and Tributaries in Marion and Polk Counties, Oregon, Vol. I and II.

## APPENDIX A

### Title XIII-National Flood Insurance

#### Short Title

Sec. 1301. This title may be cited as the "National Flood Insurance Act of 1968."

#### Findings and Declaration of Purpose

Sec. 1302. (a) The Congress finds that (1) from time to time flood disasters have created personal hardships and economic distress which have required unforeseen disaster relief measures and have placed an increasing burden on the Nation's resources; (2) despite the installation of preventive and protective works and the adoption of other public programs designed to reduce losses caused by flood damage, these methods have not been sufficient to protect adequately against growing exposure to future flood losses; (3) as a matter of national policy, a reasonable method of sharing the risk of flood losses is through a program of flood insurance which can complement and encourage preventive and protective measures; and (4) if such a program is initiated and carried out gradually, it can be expanded as knowledge is gained and experience is appraised, thus eventually making flood insurance coverage available on reasonable terms and conditions to persons who have need for such protection.



(b) The Congress also finds that (1) many factors have made it uneconomic for the private insurance industry alone to make flood insurance available to those in need of such protection on reasonable terms and conditions; but (2) a program of flood insurance with large-scale participation of the Federal Government and carried out to the maximum extent practicable by the private insurance industry is feasible and can be initiated.

(c) The Congress further finds that (1) a program of flood insurance can promote the public interest by providing appropriate protection against the perils of flood losses and encouraging sound land use by minimizing exposure of property to flood losses; and (2) the objectives of a flood insurance program should be integrally related to a unified national program for flood plain management and, to this end, it is the sense of Congress that within two years following the effective date of this title the President should transmit to the Congress for its consideration any further proposals necessary for such a unified program, including proposals for the allocation of costs among beneficiaries of flood protection.

(d) It is therefore the purpose of this title to (1) authorize a flood insurance program by means of which flood insurance, over a period of time, can be made available on a nationwide basis through the cooperative efforts of the Federal Government and the private insurance industry, and (2) provide flexibility in the program so that such flood insurance may be based on workable methods of pooling risks, minimizing costs,

and distributing burdens equitably among those who will be protected by flood insurance and the general public.

(e) It is the further purpose of this title to (1) encourage State and local governments to make appropriate land use adjustments to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses, (2) guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards, (3) encourage lending and credit institutions, as a matter of national policy, to assist in furthering the objectives of the flood insurance program, (4) assure that any Federal assistance provided under the program will be related closely to all flood-related programs and activities of the Federal Government and (5) authorize continuing studies of flood hazards in order to provide for a constant reappraisal of the flood insurance program and its effect on land use requirements.

(f) The Congress also finds that (1) the damage and loss which results from mudslides is related in cause and similar in effect to that which results directly from storms, deluges, overflowing waters, and other forms of flooding, and (2) the problems involved in providing protection against this damage and loss, and the possibilities for making such protection available through a Federal or federally sponsored program, are similar to those which exist in connection with efforts to provide protection against damage and loss caused by such other forms of flooding. It is therefore the further purpose of this title to make available, by means

of the methods, procedures, and instrumentalities which are otherwise established or available under this title for purposes of the flood insurance program, protection against damage and loss resulting from mudslides that are caused by accumulations of water on or under the ground.

## APPENDIX B

### L.C.D.C. Goal #7

#### Areas Subject to Natural Disasters and Hazards

GOAL: To protect life and property from natural disasters and hazards.

Developments subject to damage or that could result in loss of life shall not be planned nor located in known areas of natural disasters and hazards without appropriate safeguards. Plans shall be based on an inventory of known areas of natural disaster and hazard.

Areas of Natural Disaster and Hazards -- are areas that are subject to natural events that are known to result in death or endanger the works of man, such as stream flooding, ocean flooding, ground water, erosion and deposition, landslides, earthquakes, weak foundation soils and other hazards unique to local or regional areas.

#### GUIDELINES:

##### A. Planning:

1. Areas subject to natural hazards should be evaluated as to the degree of hazard present. Proposed developments should be keyed to the degree of hazard and to the limitations on use imposed by such hazard in the planning areas.
2. In planning for flood plain areas, uses that will not require protection through dams, dikes and levies should be preferred

over uses that will require such protection.

3. Low density and open space uses that are least subject to loss of life or property damage such as open storage, forestry, agriculture and recreation should be preferred in floodplains, especially the floodway portion. The floodway portion should be given special attention to avoid development that is likely to cause an impediment to the flow of floodwaters.
4. Plans taking into account known areas of natural disasters and hazards should consider as major determinant, the carrying capacity of the air, land and water resources of the planning area. The land conservation and development actions provided for by such plans should not exceed the carrying capacity of such resources.
5. Planning for known areas of natural disasters and hazards should include an evaluation of the beneficial impact on natural resources and the environment from letting such events naturally reoccur.

B. Implementation:

1. Cities and counties not already eligible should qualify for inclusion in the National Flood Insurance Program, provided under the National Flood Insurance Act of 1968 (Public Law 90-448). The Act requires that development in flood-prone areas be appropriate to the probability of flood damage,

and the danger to human life. The Flood Disaster Protection Act of 1973 (P.L. 93-234) and other pertinent federal and state programs should be considered. The United States Department of Housing and Urban Development should identify all flood and mud slide prone cities and counties in Oregon, and priority should be given to the completion of flood rate maps for such areas.

2. When locating developments in areas of known natural hazards, the density or intensity of the development should be limited by the degree of the natural hazard.
3. When regulatory programs and engineering projects are being considered, the impacts of each should be considered.
4. Natural hazards that could result from new developments, such as runoff from paving projects and soil slippage due to weak foundation soils, should be considered, evaluated and provided for.

## APPENDIX C

### Grading Code

1976 EDITION

7001-7004—APPENDIX

#### Chapter 70

#### EXCAVATION AND GRADING

##### Purpose

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

##### Scope

Sec. 7002. This Chapter 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 in or pressure upon any adjacent or contiguous property.
7. Exploratory excavations under the direction of soil engineers or engineering geologists.
8. An excavation which (a) is less than 2 feet in depth, or (b) which does not create a cut 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.

##### Hazards

Sec. 7004. Whenever the Building Official 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 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 agency in control of said property, upon receipt of notice in writing from the Building Official shall within the period specified therein repair and eliminate such excavation or embankment so as to eliminate the hazard and be in conformance with the requirements of this Code.

### Definitions

Sec. 7005. For the purposes of this Chapter the definitions hereunder shall be construed as specified in this Section.

**APPROVAL** shall mean a written engineering or geological opinion concerning the progress and completion of the work.

**AS-GRADED** is the surface conditions existing on completion of grading.

**BEDROCK** is in-place solid rock.

**BENCH** is a relatively level step excavated 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 this 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.

**ENGINEERING GEOLOGY** shall mean the application of geological knowledge and principles in the investigation and evaluation of natural 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.

**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 bed rock.

**SOIL ENGINEER** shall mean a civil engineer experienced and knowledgeable in the practice of soil engineering.

**SOIL 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.

#### **Grading Permit Requirements**

**Sec. 7006. (a) Permits Required.** Except as exempted in Section 7003 of this Code, no person shall do any grading without first obtaining a grading permit from the Building Official. A separate permit shall be required for each site, and may cover both excavations and fills.

**(b) Application.** The provisions of Section 301 (b) are applicable to grading and in addition the application shall state the estimated quantities of work involved.

**(c) Plans and Specifications.** When required by the Building Official, each applicant for a grading permit shall be accompanied by two sets of plans and specifications, and supporting data consisting of a soil engineering report and engineering geology report. The plans and specifications shall be prepared and signed by a civil engineer when required by the Building Official.

**(d) Information on Plans and in Specifications.** 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 Code 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.
3. Limiting dimensions, elevations or finish contours to be achieved by the grading, and 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 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 or 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.

(e) **Soil Engineering Report.** The soil engineering report required by subsection (c) shall include data regarding the nature, distribution and strength of existing soils, conclusions and recommendations for grading procedures and design criteria for corrective measures when necessary, 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.

(f) **Engineering Geology Report.** The engineering geology report required by subsection (c) 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 the 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) **Issuance.** The provisions of Section 302 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.

#### **Fees**

**Sec. 7007. (a) Plan-checking Fee.** For excavation and fill on the same site, the fee shall be based on the volume of the excavation or fill, whichever is greater. Before accepting a set of plans and specifications for checking, the Building Official shall collect a plan-checking fee. Separate permits and fees shall apply to retaining walls or major drainage structures as indicated elsewhere in this Code. There shall be no separate charge for standard terrace drains and similar facilities. The amount of the plan-checking fee for grading plans shall be as set forth in Table No. 70-A.

The plan-checking fee for a grading permit authorizing additional work to that under a valid permit shall be the difference between such fee paid for the original permit and the fee shown for the entire project.

(b) **Grading Permit Fees.** A fee for each grading permit shall be paid to the Building Official as set forth in Table No. 70-B.

TABLE NO. 70-A—PLAN-CHECKING FEES

50 cubic yards or less .....	No Fee
51 to 100 cubic yards .....	\$10.00
101 to 1000 cubic yards .....	15.00
1001 to 10,000 cubic yards .....	20.00
10,001 to 100,000 cubic yards — \$20.00 for the first 10,000 cubic yards plus \$10.00 for each additional 10,000 cubic yards or fraction thereof.	
100,001 to 200,000 cubic yards — \$110.00 for the first 100,000 cubic yards plus \$6.00 for each additional 10,000 cubic yards or fraction thereof.	
200,001 cubic yards or more — \$170.00 for the first 200,000 cubic yards, plus \$3.00 for each additional 10,000 cubic yards or fraction thereof.	

TABLE NO. 70-B—GRADING PERMIT FEES

50 cubic yards or less .....	\$10.00
51 to 100 cubic yards .....	15.00
101 to 1000 cubic yards — \$15.00 for the first 100 cubic yards, plus \$7.00 for each additional 100 cubic yards or fraction thereof.	
1001 to 10,000 cubic yards — \$78.00 for the first 1000 cubic yards, plus \$6.00 for each additional 1000 cubic yards or fraction thereof.	
10,001 to 100,000 cubic yards — \$132.00 for the first 10,000 cubic yards, plus \$27.00 for each additional 10,000 cubic yards or fraction thereof.	
100,001 cubic yards or more — \$375.00 for the first 100,000 cubic yards, plus \$15.00 for each additional 10,000 cubic yards or fraction thereof.	

The fee for a grading permit authorizing additional work to that under a valid permit shall be the difference between the fee paid for the original permit and the fee shown for the entire project.

#### Bonds

**Sec. 7008. Bonds.** The Building Official 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 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 soil engineering and/or engineering geology report 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 two horizontal to one vertical.

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

**Fills**

**Sec. 7010. (a) General.** Unless otherwise recommended in the approved soil engineering report fills shall conform to the provisions of this Section.

In the absence of an approved soil 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, top-soil and other unsuitable materials scarifying to provide a bond with the new fill, and where slopes are steeper than five to one, and the height is greater than five 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. Where fill is to be placed over a cut, the bench under the toe of fill shall be at least 10 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 Building Official or the civil engineer or the soils engineer or the geologist is not competent to support other soil or fill, to support structures or to satisfactorily perform the other functions for which the soil is intended.

(d) **Fill Material.** Detrimental amounts of organic material shall not be permitted in fills. Except as permitted by the Building Official, no rock or similar irreducible 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 its 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. Rocks shall be placed so as to assure filling of all voids with fines.

(e) **Compaction.** All fills shall be compacted to a minimum of 90 percent of maximum density as determined by U.B.C. Standard No. 70-1. Field density shall be determined in accordance with U.B.C. Standard No. 70-2 or equivalent as approved by the Building Official.

(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.** The setbacks and other restrictions specified by this Section are minimum and may be increased by the Building Official or by the recommendation of a 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 Building Official.

(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. 1 and Table No. 70-C.

(c) **Design Standards for Setbacks.** Setbacks between graded slopes (cut or fill) and structures shall be provided in accordance with Figure No. 2 and Table No. 70-C.

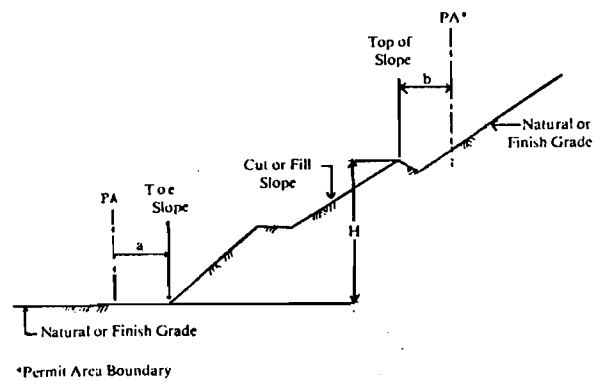


FIGURE 1

TABLE NO. 70-C  
REQUIRED SETBACKS FROM PERMIT AREA BOUNDARY  
(IN FEET)

H	SETBACKS	
	a	b'
Under 5	0	1
5 - 30	H/2	H/5
Over 30	15	6

'Additional width may be required for interceptor drain.

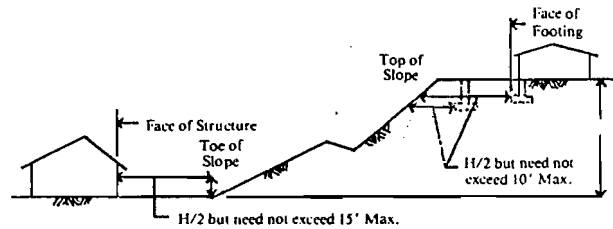


FIGURE 2

#### Drainage and Terracing

Sec. 7012. (a) **General.** Unless otherwise indicated on the approved grading plan, drainage facilities and terracing shall conform to the provision of this Section.

(b) **Terrace.** 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 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 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 non-erosive downdrains 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 one 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 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 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 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. When required by the Building Official, special inspection of grading operations and special testing shall be performed in accordance with the provisions of Section 305 and subsection 7014 (c).

(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 permittee, with the approval of the Building Official chooses to have the grading performed as "engineered grading."

(c) **Engineered Grading Requirements.** For engineered grading, it be the responsibility of the civil engineer who prepares the approved grading plan to incorporate all recommendations from the soil engineer 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 the need arises for liaison between the other professionals, the contractor, and the Building Official. The civil engineer shall also be responsible for the preparation of revised plans and the submission of as-graded grading plans upon completion of work. The grading contractor shall submit in a form prescribed by the Building Official a statement of compliance to said as-built plan.

Soil engineering and engineering geology reports shall be required as specified in Section 7006. During grading all necessary reports, construction data and soil engineering and engineering geology recommendations shall be submitted to the civil engineer and the Building Official by the civil 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 fills, testing for required compactness and 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 groundwater drainage devices. He shall report his findings to the soil engineer and the civil engineer for engineering analysis.

The Building Official shall inspect the project at the various stages of the work requiring approval and at any more frequent intervals necessary 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 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 conformance with this Chapter or the approved grading plans,



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 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.

#### **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 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 Geologic Grading Report prepared by the engineering geologist including a final description of the geology of the site including any new information disclosed during the grading and the effect of same 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 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.