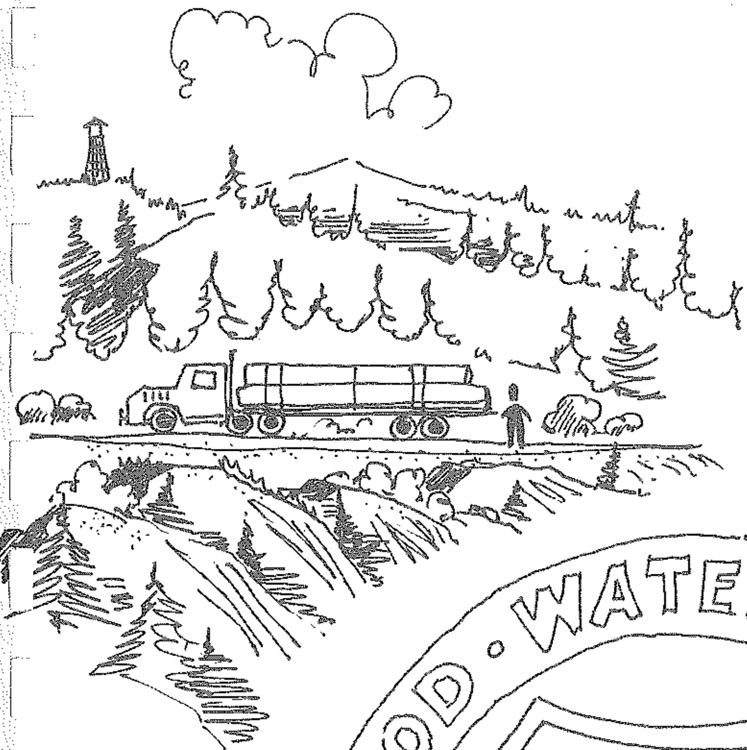
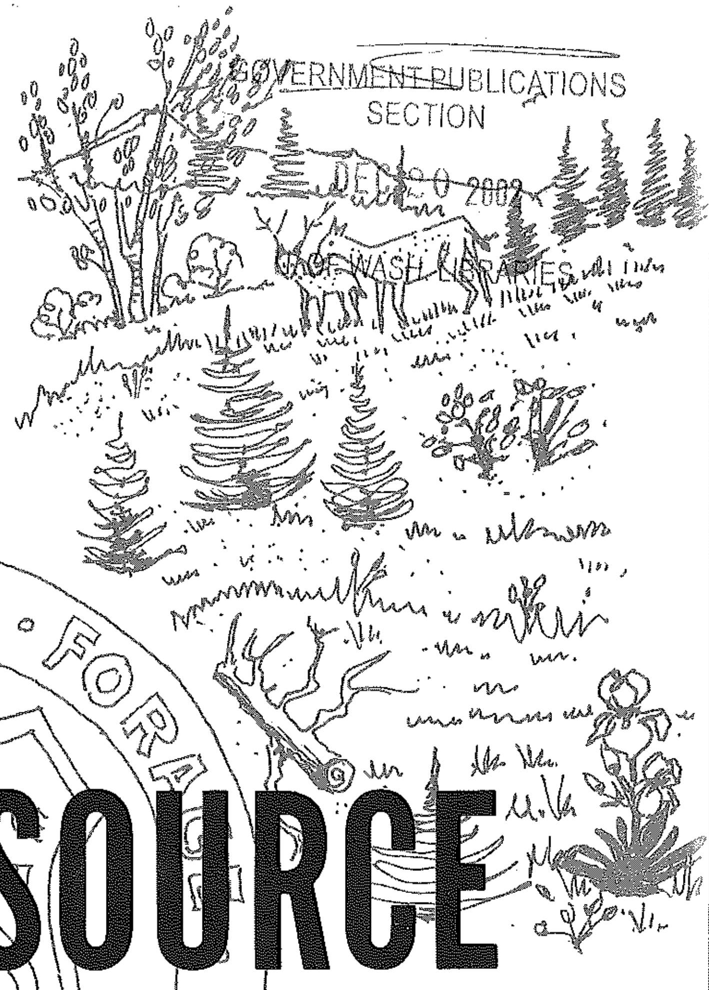
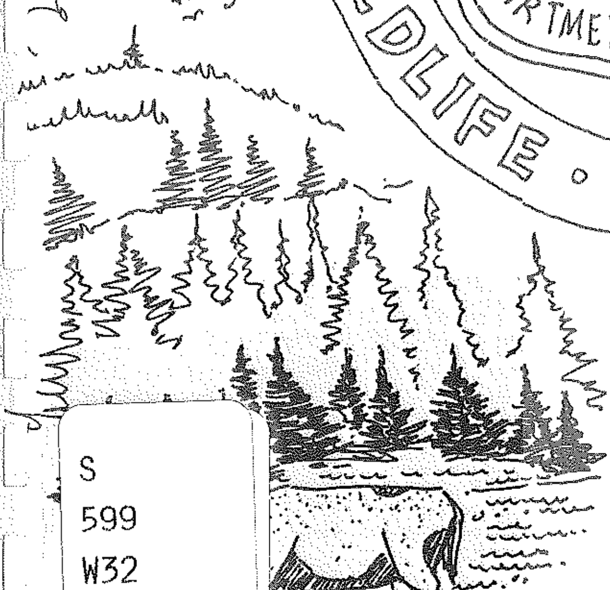




SOIL RESOURCE

OLYMPIC NATIONAL FOREST



OLYMPIC NATIONAL FOREST

SOIL RESOURCE MANAGEMENT SURVEY REPORT

Pacific Northwest Region

1969

Prepared by

Robert V. Snyder, George S. Bush, Jr., and John M. Wade

Soil Scientists

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INTRODUCTION

This Soil Resource Management Survey of the Olympic National Forest was made to provide basic soil and some bedrock information for management interpretations. The survey is part of the Regional soils program developed by the Soil Management Branch of the Division of Watershed Management to assist forest land managers in applying multiple use principles. It is currently planned that all Forests in Region 6 will be surveyed in this manner.

Field mapping was conducted from March through October 1968 by soil scientists Robert V. Snyder and George S. Bush, Jr. Supervision was provided by Loren D. Herman. During the course of the survey, valuable assistance, advice, and cooperation received from Forest personnel was sincerely appreciated.

This report contains information on climate, soils, geology, landform features, and some management interpretations. Under separate cover is an Atlas of soil maps showing location and extent of the various soils, Tables of Management Interpretations, Table of Soil Characteristics of Modal Site, Table of Bedrock Characteristics, and Table of Water Holding Capacities.

LOCATION OF SURVEY AREA

This project covers the entire Olympic National Forest and includes both Forest and other lands within the Forest boundary. The total area mapped was approximately 689,880 acres. Of this, approximately 68,000 acres are private and State-owned lands. Counties within which mapping was done are Clallam, Grays Harbor, Jefferson, and Mason (See Figure 1).

SURVEY OBJECTIVES AND USE

The objective of this Soil Resource Management Survey is to provide soils information in a form useful to the land manager as an aid to multiple use management as directed by Public Law 86-517. This law states that the National Forests are to be administered to achieve and maintain in perpetuity a high level of annual or regular periodic output of the various renewable resources of the National Forests without impairment of the productivity of the land.

All renewable surface resources of the National Forest are dependent upon soil, which is a nonrenewable source. Soil develops at a very slow rate, about one inch every thousand years. This fact necessitates conservation, wise use, and in many instances, preservation of this basic resource in order to produce high-level sustained yields of water, timber, recreation, wildlife, and forage. To accomplish sustained yield of renewable resources, to conserve or preserve the soil resource while making wise use of this resource, it is necessary to have basic soils information and to make sound management interpretations.

The survey was conducted to collect this basic soils information and make management interpretations. The soils have been defined and mapped at an intensity sufficient for broad management interpretations which can be used to develop resource management policies and do sound multiple use planning. Some management interpretations have been made and are included in this report. However, the interpretive potential and value is very flexible and broad, and management interpretations can be made or modified for any use.

The primary use of this report is at the planning level of management. Due to the reconnaissance nature of this survey, there is insufficient detail for use in high-intensity, small-area projects. For this, additional onsite study will be required of various technical specialists, including soil scientists.

At higher management levels the information can be used to establish policy and management directives required to insure the best possible multiple use management. As a few examples, soils information can suggest direction and support policy for allowable cut determinations, logging systems, slash disposal methods, operating season, deferred cutting areas, and land use classification. The soils information can be of great assistance in preparing multiple use plans, tying key timber areas to soils, and in land appraisal and exchange work.

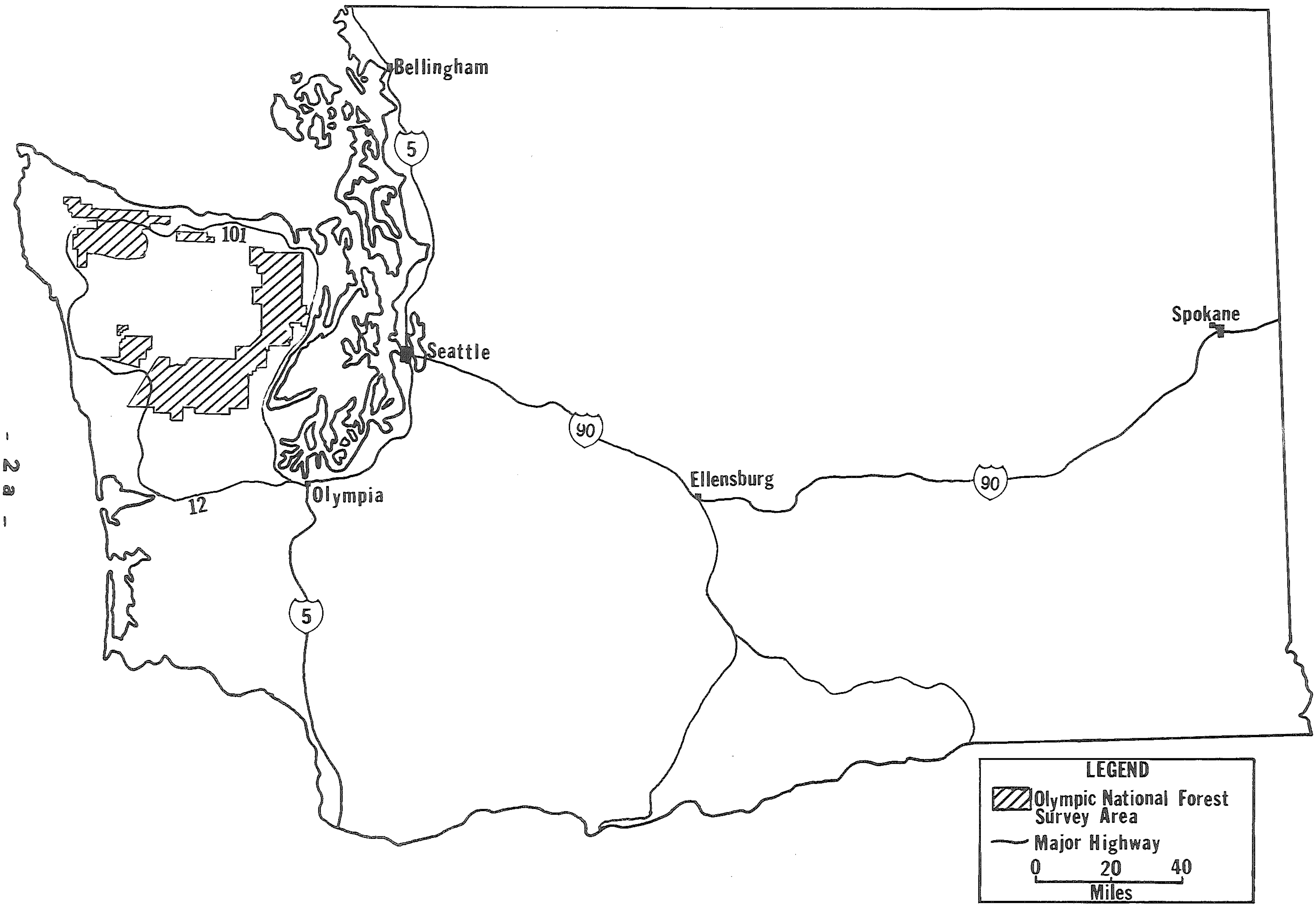
The following is a list of more specific uses of the report. These uses are adaptable and compatible with the survey data and are well within the scope and intensity of the survey:

1. Engineering Testing. By using the soil maps, more efficient testing can be done. The soil maps can be used to determine which soils are most susceptible to certain engineering problems. These problem soils may need more closely spaced testing than soils in which few problems are anticipated.

2. Reservoir Sites. This survey gives much information that can be used to determine problems that may be encountered for a reservoir site. The soil interpretations will better enable the planner to determine the general suitability of a particular site and the soil stability as it affects reservoir uses.

3. Hydrologic Analysis. The information in the report is sufficient to determine a broad hydrologic analysis and water balance on the Forest, and as a basis for comparisons between larger watersheds.

Figure 1 LOCATION MAP



4. Planning Road Locations and Construction Schedules. Certain conditions and problems can be met or avoided based on information such as landscape stability, soil depth, soil drainage and/or bedrock type and competency. Routes may be selected that avoid unstable areas, and construction and maintenance costs may be more accurately estimated. Sources of road rock may also be located through use of soil maps. Soils information is available for assistance in road design of cutbank ratios, road rock thickness, compaction, drainage and restrictions on wet weather construction.

5. Timber Harvest Methods. Additional knowledge of factors such as the potential erodibility and landscape stability will enable selection of timber harvest methods that cause minimum damage to soil and other resources.

6. Timber Harvest Schedules. Timber harvest activities may be scheduled so as to cause minimum soil damage. Many soils are subject to damage, such as compaction, erosion, site deterioration by timber harvest activities when overly wet or excessively dry. Operating schedules can be established for soil which will result in minimum soil damage.

7. Erosion Control. Since there is wide variability in soil texture, depth, structure, permeability, drainage, and topography, wide differences also occur in the ability of the soil to resist erosion. Forest soils are rated as to their potential erosion class. The land manager can use this information to determine which areas will need special erosion protective measures. These will need to be developed on a site-by-site basis.

8. Recreational Developments. Several kinds of information are available in this report to assist in selecting favorable sites for campground development. Among these are soil and landform properties and characteristics, specific ratings of filter drainage field suitability, the relative resistance of soil and vegetation to site deterioration, and indications of special problems which may be encountered.

As a further example of use, the information in the report was used to develop the section on "Water Resource Values, Hydrologic Characteristics, and Management." By using the information in the report, broad management requirements can be similarly developed for other resources.

These are just a few examples of use of this information. There are many other uses. Some are quite simple and apparent; others are not fully understood, and some have not yet been conceived. The real work lies ahead in effectively and fully using this information.

Use is the end product of any study--it determines its success or failure. Very simply, it is successful if it is usable and a failure if not. As stated in the opening sentence of this section, the "objective--is to provide soils information in a form that is useful." Thus, use of this study is the final objective and goal.

The soil maps accompanying this report show the dominant soil and bedrock conditions in each delineation. These are identified by the mapping unit symbol which represents at least 70 percent of any delineated area. The common inclusions associated within a mapping unit are listed in the mapping unit description. Many mapping units are shown as a complex of two primary soil types. Complexes are used when two primary soil types are intermingled to such an extent that separation is either impossible or impractical.

Aerial photographs available to Forest personnel may be used in conjunction with the soil maps. The more accurate and graphic representation of the landscape exhibited by aerial photos gives the user a clearer concept of landforms in relation to management.

SURVEY PROCEDURES

The survey procedures developed to meet the objective consisted of describing mapping units based on soil, bedrock and landform characteristics as they occur naturally on the landscape. Observed and recorded were soil characteristics such as texture, structure, depth, stone content, drainage, permeability, and plasticity; estimated bedrock characteristics such as type, fracture system, hardness, and competency; and landform characteristics such as shape, position, steepness, elevation, and surface drainage pattern. The Geologic Map of Washington[1/] was an aid in determining bedrock types and their location.

The field mapping was done on various scaled aerial photographs using stereoscopic methods. Most photos were approximately 1:70,000 scale, but some of 1:37,000 scale were used. Examination of soils and bedrock exposed in road cutbanks and related landforms in the field was the basis for describing and identifying mapping units. All accessible areas were visited in the field and final delineations were made at that time. Inaccessible areas were delineated and classified through photographic interpretations by relating similar landscape features to known mapping units observed in the field.

1/ Geologic Map of Washington, Washington Department of Conservation, Division of Mines and Geology, Scales 1:500,000, 1961.

<u>CLIMATE</u>

The climate of the Olympic National Forest is primarily influenced by wind direction, ocean surface termperatures, terrain, and intensity of high and low pressure centers over the North Pacific Ocean. These conditions produce a marine climate with heavy winter precipitation and relatively dry summers.

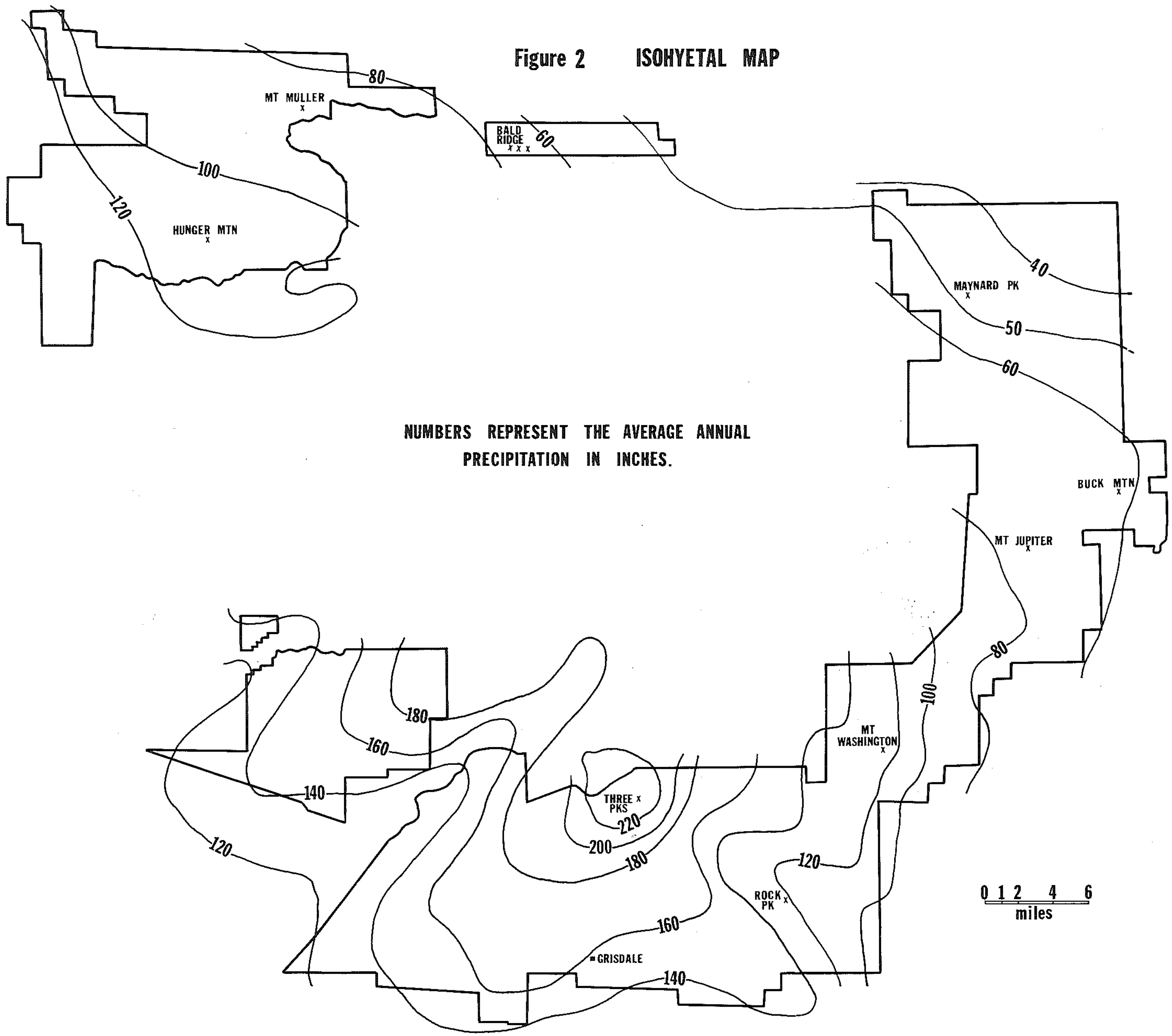
Wide differences in local climatic conditions occur on the Forest. Annual precipitation generally increases from the northeast to the southwest and with increased elevation. The dryest area on the Forest is the lowlands within the northeastern corner of the Quilcene District which receives an average annual precipitation of 35 inches. Extending southwest, the precipitation increases to 70 inches along the mountains bordering the Olympic National Park. The Hoodsport District receives 60 inches in the northeast lowlands and 140 inches along the mountainous southwest boundary. The Soleduck District has a total annual precipitation ranging from 110 inches in the lowlands to 130 inches on the high eastern ridges. The Quinault District north of Quinault Lake ranges from 120 inches of precipitation in the lowlands to 200 inches on the higher eastern ridges. The Shelton District and the southern portion of the Quinault District have an annual precipitation ranging from 120 inches in the areas of lowest elevation to 220 inches in the high northern ridges between the two Districts.[1/]

<u>Winter Conditions.</u> Heaviest precipitation occurs in the fall, reaching a peak in December and then decreasing in the spring. The greatest measured annual rainfall (184 inches) was recorded along the Wynoochee River. The heaviest rainfall during a single storm was 12 inches in 24 hours; 23.5 inches in 48 hours; 28.6 inches in 72 hours, and 35 inches in 4 days, recorded at Quinault Ranger Station, January 21-24, 1935.

Most of the winter precipitation falls as rain in elevations below 2,000 feet, as rain and snow between 2,000 and 4,500 feet, and as snow above 4,500 feet. The winter season snowfall ranges from 10 to 30 inches in the lower valleys, increasing to greater than 250 inches in the higher mountains.

1/ These precipitation figures were taken from a projected Isohyetal Map of Mean Annual Precipitation, 1930 through 1957, State of Washington, U.S. Weather Bureau (Figure 2).

Figure 2 ISOHYETAL MAP



NUMBERS REPRESENT THE AVERAGE ANNUAL PRECIPITATION IN INCHES.

Summer Conditions. During the late spring and summer, the prevailing wind over the Forest is northeasterly, cool, relatively dry and stable. During July and August, two or three weeks may pass with only minor precipitation. In the rain forest areas, the total precipitation for each of the midsummer months can be expected to range from less than ½-inch to more than 6 inches in one out of ten summers. Heavy thunderstorms are unusual; however, there are usually a few days during the summer when some thunderstorm activity occurs.

Afternoon temperatures in the warmest summer months average from approximately 62° near the water to 75° in the lower elevations of the Forest. Night temperatures are near 50°. In the higher elevations afternoon temperatures range from 60° to 75°, while night readings are from 40° to 50°.

The average relative humidity ranges from 90 percent near sunrise to between 50 and 65 percent in the afternoon. During brief periods of dry easterly winds, the relative humidity may drop to between 20 and 30 percent. During the latter half of the summer and early fall, fog banks or low clouds move inland during the night. This usually burns off by mid-day.[2/]

2/ Earl L. Phillips, "Climates of the States, Washington," Climatography of the United States, No. 60-45, U.S. Department of Commerce, Weather Bureau, Revised and Reprinted, April 1965.

TABLE I - Mean Temperature & Precipitation Data

The U.S. Weather Bureau stations in the Olympic Peninsula, with the exception of the Elwha Ranger Station and the Quinault Station, are located outside the Olympic National Forest. They are all low elevation stations and, therefore, do not adequately reflect conditions in the high elevation forest areas. However, they do show the climatic variations in the various quadrants of the National Forest and, therefore, are useful for comparative information.

Forks, Washington — Elevation: 350 feet; Period: 1931-60

Temperature (°F)		Precipitation (inches)
January	38.7	17.49
February	40.3	14.12
March	42.5	12.69
April	46.9	8.33
May	52.1	4.89
June	56.0	3.69
July	59.7	2.50
August	60.0	2.52
September	57.6	5.11
October	51.5	11.70
November	44.1	15.08
December	40.6	19.25
Annual	57.8	117.37

Lake Quinault, Washington — Elevation: 220 feet; Period: 1931-60

Temperature (°F)		Precipitation (inches)
January	39.4	19.95
February	41.1	15.94
March	44.2	14.22
April	49.8	9.18
May	55.3	5.90
June	59.0	4.31
July	63.3	2.60
August	63.3	2.79
September	59.8	6.00
October	52.6	13.27
November	43.9	17.52
December	40.8	22.75
Annual	51.1	134.43

TABLE I (Cont.) Mean Temperature & Precipitation Data

Cushman Dam, Hoodsport, Washington — Elevation: 760 feet; Period: 1931-60

Temperature (^{o}F)		Precipitation (inches)
January	37.1	16.65
February	39.6	12.31
March	42.8	10.41
April	49.0	6.07
May	55.6	3.33
June	59.8	2.44
July	64.7	1.28
August	64.4	1.38
September	60.4	3.74
October	52.6	9.73
November	43.6	14.73
December	39.7	18.18
Annual	50.8	100.25

Quilcene, Washington — Elevation: 123 feet; Period: 1931-60

Temperature (^{o}F)		Precipitation (inches)
January	36.8	8.09
February	39.8	6.51
March	43.5	4.40
April	49.3	3.07
May	55.0	2.52
June	59.2	2.40
July	63.5	.98
August	62.8	1.01
September	58.5	1.49
October	50.9	3.84
November	42.6	7.26
December	39.0	9.41
Annual	50.1	50.98

TABLE I (Cont.) - Mean Temperature & Precipitation Data

Elwha Ranger Station, Washington		Elevation: 345 feet Period: 1943-62
Temperature (°F)		Precipitation (inches)
January	35.2	8.70
February	38.8	7.71
March	41.5	5.73
April	47.0	3.39
May	53.5	1.56
June	57.7	1.22
July	62.5	.66
August	62.0	.96
September	58.5	1.87
October	49.4	5.71
November	41.1	9.37
December	37.8	9.45
Annual	48.8	56.33

WATER RESOURCE VALUES, HYDROLOGIC CHARACTERISTICS, AND MANAGEMENT

The rivers and streams of the Olympic National Forest have a multi-million dollar annual fishery value. According to past records, the Soleduck River alone has an annual value of $450,000.[1/] This is a very conservative figure based on the actual catch of chinook, coho, and steelhead for one year. The Soleduck River is one of 14 major rivers on the Forest with comparable fisheries impact. Other species indigenous to the Forest include pink, chum and king salmon, as well as rainbow and brook trout.

In addition to the fisheries resource, several of the streams on the Forest supply water for domestic and commercial use. These include the cities of Aberdeen and Port Townsend. The rural areas near the town of Dungeness use water from Forest lands for irrigation.

The important fishery and water resources on the Olympic National Forest are being seriously threatened by man's activities. Soil loss, through surface erosion and mass movement resulting from timber harvest and road construction, has adversely affected the sediment and pollution levels of many streams and rivers. The fishery value of the Soleduck River has declined nearly 50 percent during the past 50 years, according to old records. These same records indicate the South Fork Skokomish River has experienced a similar decline, and the Salmon River no longer supports steelhead migrations. These large declines in water resources are suspected to have been proportionately greatest during the past 10 to 15 years when man's activities increased greatly.

The level of watershed management necessary to maintain high water and fishery values is directly related to hydrologic characteristics of soil and bedrock, the pattern and density of the drainage systems, the gradient of the slopes, and rate of peak water runoff. These features are a result of the type of soil and bedrock, and the amount and rate of precipitation. Most of the upland streams on the Olympic National Forest conform to varying intensities of dendritic drainage patterns with parallel patterns occurring locally. Dendritic patterns have developed in areas where the bedrock exhibits uniform weathering characteristics and parallel drainage patterns have developed in areas of sedimentary bedrock that have beds with differential weathering characteristics and are sufficiently continuous to exhibit structural control of the stream channels. As the density of dendritic or parallel drainage channels increases,

1/ Discussion with Carl Anderson, Wildlife Biologist, Forest Service, Olympic National Forest, Olympia, Washington.

the probability of accelerated erosion and subsequent stream sedimentation is also increased when construction of roads, landings, and clearcuts disturbs the natural surface and internal soil stability. Dendritic drainage patterns concentrate the upslope sediment load by channeling the runoff of many small drainages into larger downslope streams and rivers. Therefore, as the density of drainages increases, the level of water resource management needed must also increase.

Parallel drainages are usually associated with deeply weathered saprolitic bedrock and plastic unstable soils. Mass failures of these materials consequent to Forest resource activities increase the amount of soil and rock material available for sedimentation in streams. Steep slopes influence the possible water value loss by increasing stream velocity. The result is an increase in the potential sediment load and an increase in the potential scouring or flushing of stream channels.

Hydrologic characteristics such as base flow, and rate and frequency of peak runoff also influence the level of watershed management necessary to protect water quality. High and frequent peak flows and low base flows result from low soil and/or bedrock water storage capacity and high rainfall. Large volumes of water discharged over a short period of time associated with high peak flows result in greatly increased sedimentation and erosion where timber yarding and road and landing construction have disturbed the natural stability of the area.

The following descriptions of the areas that exhibit four basic drainage situations occurring on the Forest, illustrate the primary relationships that exist between geologic, climatic, hydrologic and soil characteristics of these areas and the relative level of water resource management necessary to maintain their water and fishery values (see Table II).

The Forks Burn area on the Soleduck Ranger District exhibits highly concentrated dendritic stream patterns. This area has high annual precipitation and shallow, highly permeable soils. The sedimentary bedrock is fractured in the upper zone, but impermeable at depth, resulting in a low base flow and very high peak flows. Streams often run low or become dry during the summer due to the low base flow (Figure 3). Susceptibility to stream sedimentation in this area is high due to very steep slopes, weak surface soil structure, and the large volume of surface water runoff that occurs during peak flows. This area requires a high level of water resource management for protection of the water quality and quantity.

The shallow soils over highly fractured basalts that occur throughout the southern half of the Quinault Ranger District, the Shelton

Ranger District, and the nonglaciated portions of the Hoodsport and Quilcene Ranger Districts exhibit dendritic stream patterns which are less dense than those occurring in the Forks Burn. The fractured basalt bedrock allows water to percolate deeply and be slowly yielded to streams as base flow. Peak flows are lower in this area than in the Forks Burn area. Stream sedimentation potential is high in this area due to moderately high surface water runoff and high erosion potential of the weakly structured surface soil. Consequently, this area requires a relatively low level of water resource management for protection of water quantity, but requires a high level of management for protection of water quality.

The Matheny Block of the Quinault Ranger District exhibits moderate to high peak flows and moderate water retention that is yielded as base flow. Soils are moderately fine textured and moderately deep to deep, which results in the high water retention. The sedimentary bedrock is impermeable at depth, and the low water storage capacity of the bedrock combined with a high annual precipitation, results in moderately high peak flows. Streams are dense and have dendritic and parallel patterns. In contrast to the Forks Burn area and the area extending from the southern Quinault Ranger District through nonglaciated portions of the Quilcene Ranger District, this area does not suffer from low water availability. Streamflow is high during the peak flows of the winter and moderate throughout an average summer. However, the susceptibility to sedimentation is high in this area due to the high frequency of deep-seated mass movements in or near drainages. These failures occur primarily in areas where parallel drainage patterns predominate. This area requires a high level of water resource management for protection of water quality.

The deep glacial and colluvial soils that occur in the northern portions of the Quilcene and Soleduck Ranger Districts and in the major valleys and outwash plains throughout the Forest exhibit dendritic stream patterns of low to moderate density. These soils have high water storage capacities which result in maintaining a constant high base flow and low peak flows. These areas require a low to moderate level of water resource management for protection of water quality except where highly erodible stratified sands and silts or very unstable glaciolacustrine deposits predominate, and contribute to a high level of stream sedimentation.

TABLE II

Relative Differences in Some Watershed
Characteristics for the Previously Cited Example Areas

Area	Drainage Pattern	Relative Drainage Density	Base Flow	Peak Flow	Soil Water Storage Capacity	Bedrock Water Storage Capacity	Rate of Runoff	Suscepti-bility to Sedimen-tation	Level of Water Resource Management Requirements
Forks Burn	Den-dritic	Very High	Low	High	Low	Low	Rapid	High	High
Upland Areas of So.Quin-ault, Shelton, Hoodsport & Quilcene R.D.s	Den-dritic	High	* Mod.	* Mod.	Low	Moderate to High	Moderate	High	Moderate
Matheny Block	Paral-lel & Den-dritic	Moderate to High	* Mod.	* Mod. to High	High	Low to Moderate	Slow to Moderate	High	High
Glacia-ted Valleys and Lowlands	Den-dritic	Low to Moderate	High	Low to * Mod.	High	---	Slow to Moderate	Low to Moderate	Low to Moderate

* Mod. indicates Moderate.

Figure 3. Dry riverbed.

This photo, taken in midsummer, illustrates the result of rapid runoff in the Forks Burn area. The soils in the area have very low water storage capacity. Precipitation soon returns to the drainage systems and is lost. Consequently, streams exhibit wide seasonal fluctuations and become low or dry during the summer. Photo is of the North Fork Calawah River, Soleduck Ranger District.

GENERALIZED GEOLOGY OF AREA 1/ & 2/

The bedrock within the survey area consists of Cretaceous marine sedimentary rocks flanked by Eocene marine basaltic lavas interbedded with Eocene to early Miocene marine sedimentary rocks (Figure 4).

Soleduck Formation

The Cretaceous sedimentary rocks known as the Soleduck formation, are the oldest known rocks in the Olympic Mountains. They were formed from sediments deposited in a marine trough-like geosyncline that occupied the present area of the Olympic Peninsula. They occur throughout the Matheny Block of the Quinault Ranger District, and the area south of the Soleduck River. These rocks are profoundly folded and consist of coarse textured, thickly bedded graywacke interbedded with fine textured, thinly bedded mudstone, siltstone and argillite (Figures 7, 8 and 38). Typically, the graywacke is slightly to moderately weathered and relatively hard. The fine textured rocks are soft and highly weathered.

Metchosin-Crescent Formation

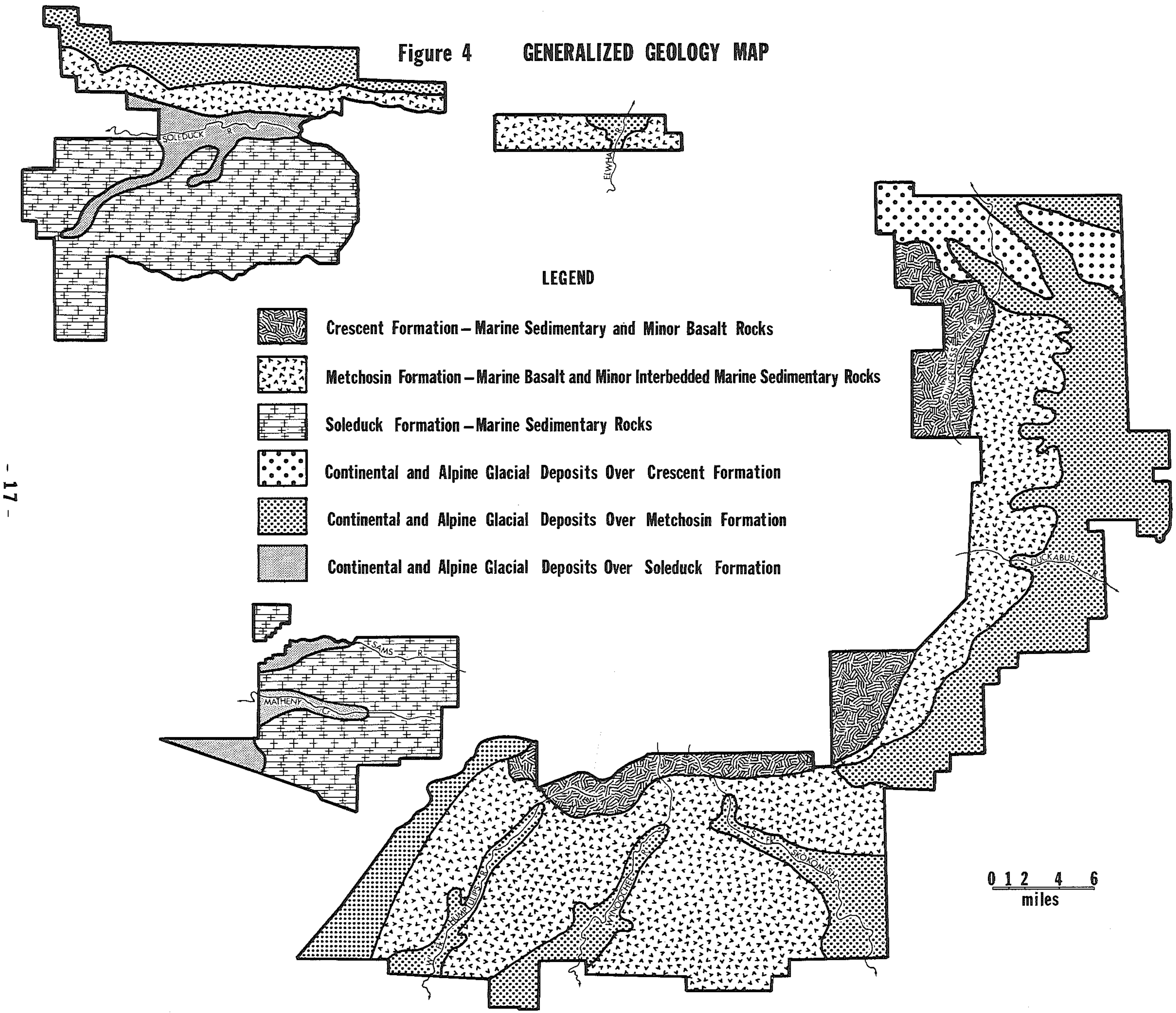
A series of violent upheavals and recessions of these rocks during late Cretaceous and Eocene epochs were accompanied by further sediment deposition and marine volcanic activity. These marine basaltic lavas and sedimentary rocks form a lower and upper sequence. The lower thick sequence, known as the Metchosin formation, is primarily composed of basaltic lavas and breccias, with minor inclusions of interbedded sedimentary rocks (Figure 20). Diminishing volcanic activity and increased sediment deposition during the late Eocene to early Miocene epochs formed the upper sequence known as the Crescent formation. The Metchosin and Crescent rocks occur as the primary bedrock constituents throughout the Shelton, Hoodsport and Quilcene Ranger Districts, as well as the southern block of the Quinault Ranger District and the portion of the Soleduck Ranger District north of the Soleduck River including the Indian Valley Block.

The basaltic lavas and breccias are hard to moderately hard, dark gray to black, coarse to fine textured, highly fractured and strongly chloritized. These rocks are moderately weathered along fracture surfaces and exposed outcrops. The weathering rind varies from one-half inch to several inches thick.

1/ Danner, Wilbert R., Geology of Olympic National Park, Seattle: University of Washington Press: 1955.

2/ Division of Mines and Geology, Geologic Map of Washington, 1961.

Figure 4 GENERALIZED GEOLOGY MAP



The interbedded sedimentary rocks consist of coarse textured, thin to moderately thick beds of graywacke, and fine textured, thinly bedded mudstone, siltstone and argillite. Dark gray, massive to thinly bedded feldspathic, arkosic and basaltic sandstone, and light gray to brown massive conglomerate occur locally in the Soleduck and Quilcene Ranger Districts. Typically, the graywacke, sandstone and conglomerate are slightly to moderately weathered. The fine textured components are moderately to highly weathered.

Glacial Deposits

The landscape of the valleys and lowlands has been extensively altered by ice and water erosion consequent to alpine and continental glaciation that occurred during the Pleistocene epoch. The glacial deposits consist of till, outwash and lacustrine sediments. (Figures 17, 19, 28, 34 and 36). They were derived from alpine glaciation during the Wisconsin or pre-Wisconsin time, and from Vashon drift deposited after alpine glaciation and during early Wisconsin time by a western lobe of the continental ice sheet.

Outwash and till deposits of continental origin occur over the low, undulating hills of the northern Soleduck District, the northern and eastern Quilcene District, and the eastern Hoodsport and Shelton Districts. The outwash is very deep, moderately compact, stratified sands and gravels. The till is shallow to very deep, moderately to strongly compact and nonstratified (Figures 21, 22 and 28).

The remainder of the valley and lowland areas have been influenced by deposition and erosion from alpine glaciation. Deep, stratified, moderately compact silts, sands and gravels have been deposited on the floors on the broad U-shaped valleys and broad outwash plains (Figure 19) with deep moderately compact till on the toeslopes. (Figure 17). Minor remnant lacustrine deposits of periglacial origin occur throughout the glaciated portions of the survey area.

SOILS OF THE AREA

The major soils on the Olympic National Forest may be categorized into three broad groups. Two groups represent contrasting types of steep mountain or "upland soils" while the third group represents the deep valley soils. Each group has broad characteristics which are related to soil development and their position on the landscape. These groups are defined and given a name illustrating this position.

Shallow Ridge and Sideslope Soils

These soils characteristically exhibit little morphological development, are generally shallow, weakly structured, well drained, gravelly medium textured and are derived from basalt or sedimentary bedrock. These soils are related to ridgetop and sideslope positions and are very extensive. Mapping Units 31, 41, 42, 51, 52, 61, 62, 67 and 68 are representative of this group.

Deep Midslope and Toeslope Soils

These soils are characteristically deep. Some are well structured, imperfectly drained and fine textured. They are derived from weathered sedimentary bedrock composed primarily of graywacke, mudstone, siltstone and argillite. These soils are related to midslope and toeslope positions between the ridge crests and valleys. They are found extensively in the Matheny Block of the Quinault District and in portions of the Soleduck District, notably in Goodman Creek, Pistol Creek and the Reade-Hill area. Mapping Units 32 and 33 are representative of the above soils.

Other deep midslope soils are weak to moderately structured, well drained, gravelly and medium to moderately coarse textured. These soils are derived from colluvium and occur locally on steep midslopes and toeslopes throughout much of the Forest. Mapping Units 11, 17 and 19 are representative of these soils.

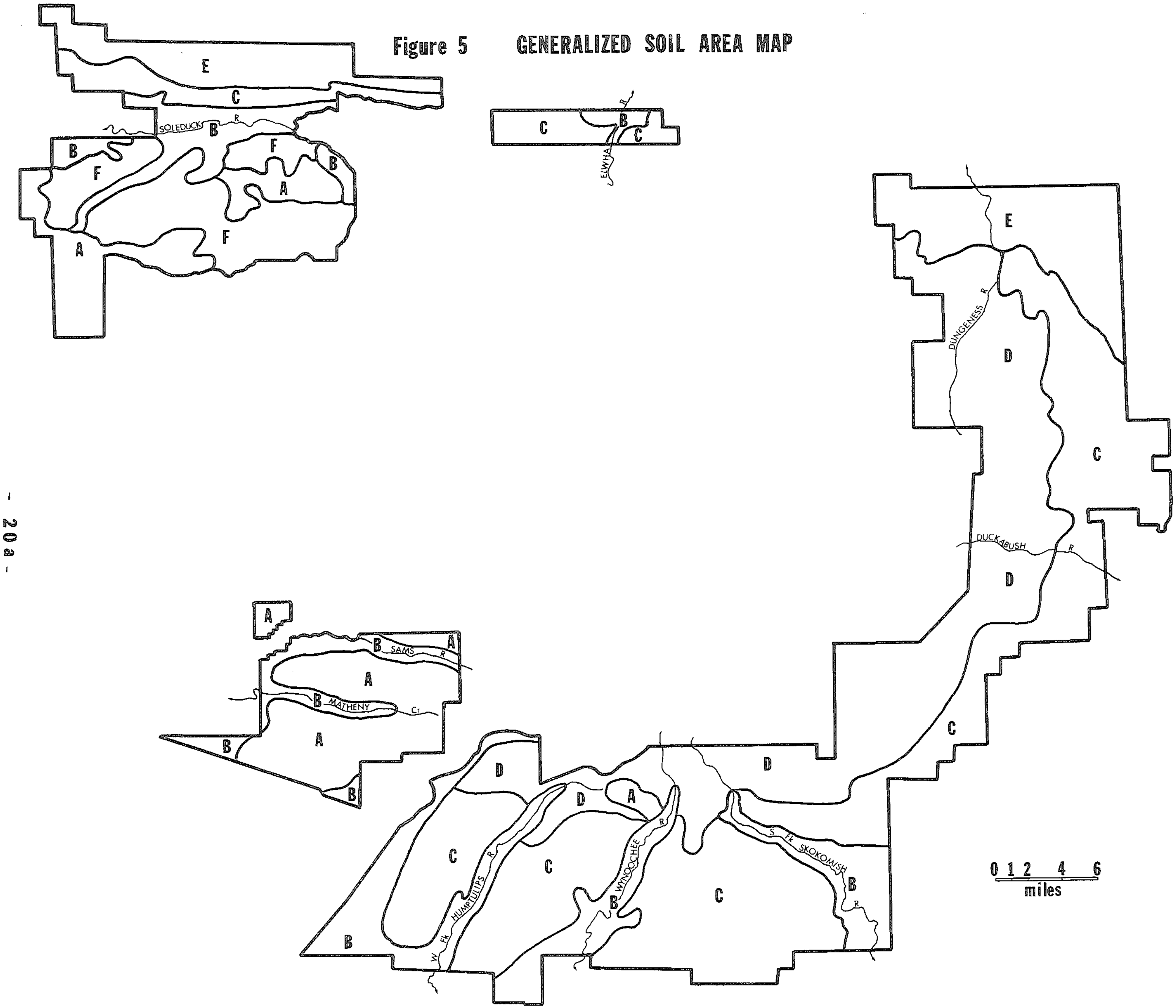
Deep Valley Soils

These soils constitute the glacial soils, from both local and continental glaciation, that occur in all the major valleys throughout the Forest and across the lower lying areas in the north Quilcene and Soleduck Districts. These soils generally have a medium textured, weak to moderately well structured surface soil layer overlying deep till or stratified drift composed of silts, sands, gravels, cobbles and stones. Mapping Units 6, 14, 20, 21, 22 and 23 are representative of this group.

Generalized Soil Areas

The Forest has been divided into six generalized soil areas (Figure 5). These areas were delineated according to broad similarities in soil characteristics and management considerations. Each area has its own bedrock and landform characteristics and the soils occur in repetitive patterns. Soil and bedrock characteristics, major management problems, and soil management recommendations are described for the soils of each area. However, certain kinds of management problems are very widespread and occur in more than one area. The management considerations and recommendations are generally orientated toward attaining the highest level of multiple use management. However, they are broad and apply to the average conditions occurring throughout each area. For more specific information on soil properties and interpretations for each mapping unit, refer to the "Descriptions of Mapping Units" and to the appropriate tables. Management recommendations for detailed projects need onsite evaluations.

Figure 5 GENERALIZED SOIL AREA MAP



SOIL AREA "A"

This area occupies the Matheny Block of the Quinault Ranger District and portions of the southern half of the Soleduck Ranger District.

The bedrock of this area is composed of coarse textured graywacke interbedded with fine textured mudstone, siltstone and argillite. While the graywacke is relatively hard and competent, the fine textured rocks are characteristically soft and highly weathered.

Mapping Units of the Area

The major mapping units of Soil Area "A" are 31, 32, 33 and complexes of these mapping units (Figure 6). Minor mapping units are 10 and 11.

Shallow Ridge and Sideslope Soils

Mapping Unit 31 belongs to this group and consists primarily of shallow, moderate to well structured, well drained, moderately fine textured soils derived from moderately weathered sedimentary bedrock (Figure 7). This mapping unit occurs on nondissected ridges. These ridges are stable but occupy less than 20 percent of Soil Area "A".

Deep Midslope and Toeslope Soils

Mapping Units 32, 33, 10 and 11 belong to this group. Mapping Unit 32 consists primarily of moderately deep, moderate to well structured, well drained, gravelly moderately fine textured soils derived from highly weathered sedimentary bedrock and occurs on steep dissected midslopes (Figure 8). Mapping Unit 33 consists primarily of very deep, moderately well to imperfectly drained, gravelly fine textured soils (Figure 9). Mapping Unit 33 is closely associated with Mapping Unit 32 and occurs on steep midslopes within and adjacent to sideslope drainages. Mapping Units 10 and 11 consist primarily of deep, moderately well structured, well drained, moderately fine textured soils, derived from residuum and colluvium. Mapping Unit 10 occurs on toeslopes of less than 35 percent and Mapping Unit 11 occurs locally throughout the area on sideslopes of greater than 35 percent.

Management Problems of Soil Area "A"

Deep-seated mass movement is the primary management problem and it is associated with the deep midslope and toeslope soils. Mapping Units 32 and 33, which occur on dissected midslopes, are unstable to very unstable, respectively. This instability is caused by the combination of deep plastic soils, highly weathered bedrock, steep slopes and subterraneous water. Deep-seated mass movements frequently occur in the virgin landscape. The frequency of occurrence is greatly increased by road construction. Midslope system roads on the Matheny Block, Quinault District, for instance, are closed by numerous slides each winter (Figure 10). Fill slope and sidecast failures are numerous and deposit large quantities of debris into downslope streams causing extensive damage to other resources. (Figure 11). Damage is caused to streams by increasing sedimentation and pollution levels with a subsequent loss to fisheries. Sidecast material continually ravels and sloughs, thereby inhibiting successful establishment of either grass or trees. Also, damage is often caused to the road prism, resulting in high maintenance costs.

Another problem associated with roads is the high rate of cutbank raveling and sloughing (Figure 13). This often plugs the inside ditch and allows water to run across the road causing erosion to the road prism and fill slope. Of even greater importance is the fact that excessive water may enter the road prism. This reduces the cohesive and frictional strength and contributes to road prism failure. Cutbank raveling and sloughing is highest in this area on Mapping Units 32 and 33.

Recommendations

1. Road construction on Soil Area "A" should be confined to the stable ridgetops in Mapping Unit 31. Roads should be avoided in Mapping Units 32 and 33 as the probability of massive failure occurring, even with the best of engineering techniques, is high due to the instability of soil and bedrock materials.

2. Skyline logging should be used on Mapping Units 32 and 33 in order that damage to other resources be minimized. This system causes minimal soil disturbance from the actual logging operation. More importantly, this system does not need midslope roads, the single greatest cause of massive failures.

Some midslope roads will have to be constructed in order to reach the ridgetop. So that the resulting damage is minimized, the following should be considered:

1. Road location should allow for adverse grade where necessary. This gives the road locator a better opportunity to avoid potentially unstable areas.

2. Full-bench construction should be used on steep sideslopes and across in-curve areas. Sideslope fills associated with partial-bench roads, often fail due to inadequate support and compaction.

3. Fills should be kept free of organic debris. This material prevents adequate compaction and provides channels for water, often contributing to fill collapse.

4. Surplus waste materials should be end hauled to a suitable area rather than sidecast. Sidecasting not only destroys timber and watershed values, but is a major contributor of mass movements. This material is in a loose, noncompacted state, resulting in a very high rate of surface erosion. More important is the fact that this material adds weight to downslope areas, which is greatly increased when the material absorbs water. A natural shear plane exists between sidecast materials and the underlying soils. Slides often occur, uprooting and destroying trees and depositing vast quantities of soil debris in streams.

5. Proper frequency of culverts and adequate installation should be insured so that excessive moisture is removed. Water should not be allowed to run across roads or on fill slopes. Sufficient maintenance should be provided to prevent plugging of culverts.

6. A catch area should be left between the inside ditch and cutslope. This will reduce the plugging of the inside ditch from cutbank raveling and sloughing.

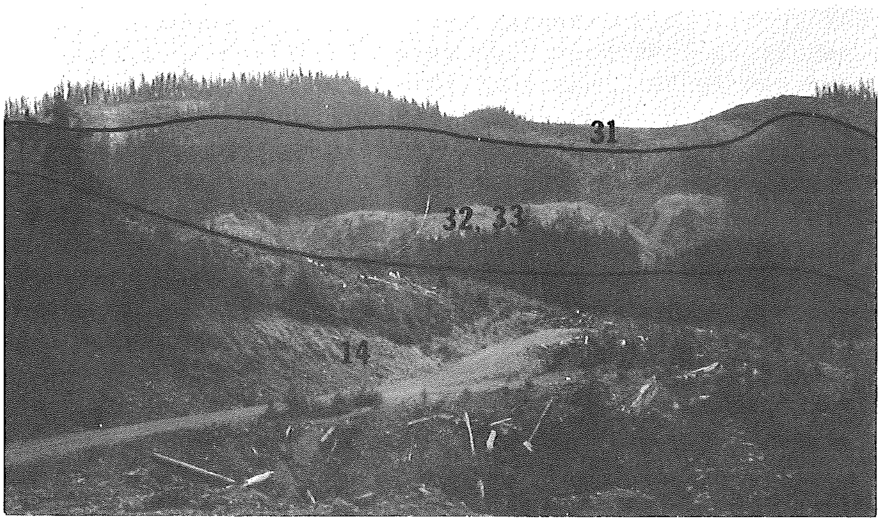


Figure 6 - Topographic Relationships of Mapping Units
31, 32, 33 and 14.

Mapping Unit 31 is stable and occurs on the smooth upper sideslopes and ridges. Mapping Units 32 and 33 are unstable and occur as an association on the dissected sideslopes. Mapping Units 31, 32 and 33 are all derived from sedimentary bedrock. Mapping Unit 14 in the foreground is in Soil Area "B". This mapping unit is derived from stratified glacial drift. View is looking south across Matheny Creek, Quinault Ranger District.

Shallow silt loam and silty clay loam soils of the stable ridge position Mapping Unit 31. Bedrock is relatively unweathered graywacke interbedded with moderately weathered mudstone, siltstone and argillite. Photo taken on Matheny Block, Quinault Ranger District.

Figure 7 - Profile of Soil 31.

Mapping Unit 32 consists of moderately deep to deep silty clay loam soils that occur in midslope positions. Bedrock is moderately weathered graywacke interbedded with highly weathered mudstone, siltstone and argillite. These soils are unstable, with deep-seated massive slides often occurring. Photo taken on Matheny Block, Quinault Ranger District.

Figure 8 - Profile of Soil 32.

Figure 9 - Mapping Unit 33.

Mapping Unit 33 consists primarily of very deep and unstable gravelly sandy clay. Photo taken along Road 2447, Matheny Block, Quinault Ranger District.

Large slide in Mapping Unit 32. This shows the type of failure that can occur on midslope roads in Soil Area "A". Photo taken along Road 2407.1, Matheny Block, Quinault Ranger District.

Figure 10 - Massive Deep-Seated Failure.

Sidecast from road construction and maintenance does extensive damage to resources. Photo taken on Matheny Block, Quinault Ranger District.

Figure 11 - Sidecast Damage.

This culvert outlet is too short. Water spills on the fill slope, causing erosion. An extension or apron is needed to carry water over the fill slope. As a minimal protective measure, rock should be placed below the outlet to absorb energy.

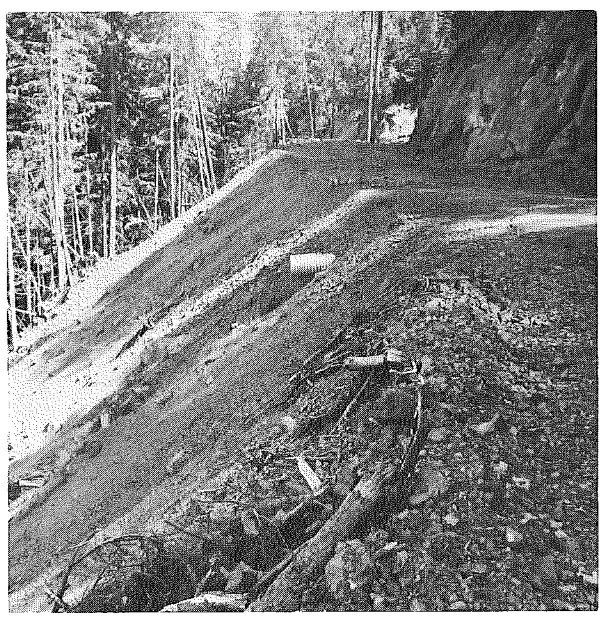
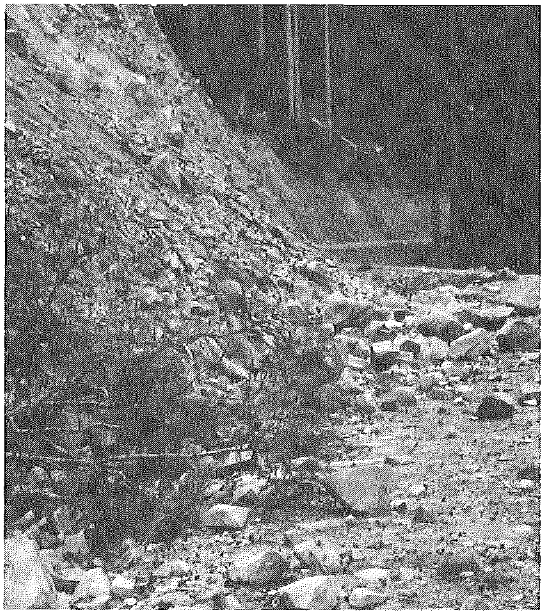


Figure 12 - Short Culvert Installation



Extensive cutbank raveling requires frequent maintenance. This is Mapping Unit 31, but Mapping Units 12, 17, 32, 33, 51, 52, 56, 63 and 64 also exhibit high raveling. Photo taken along Road 246.4, Matheny Block, Quinault Ranger District.

Figure 13 - Cutslope Raveling.

Surface slips are common on the upland soils, especially after logging disturbance. This is Mapping Unit 32 but slips also occur on Mapping Units 11, 31 and 33 in this area. Photo taken along Road 242, Matheny Block, Quinault Ranger District.

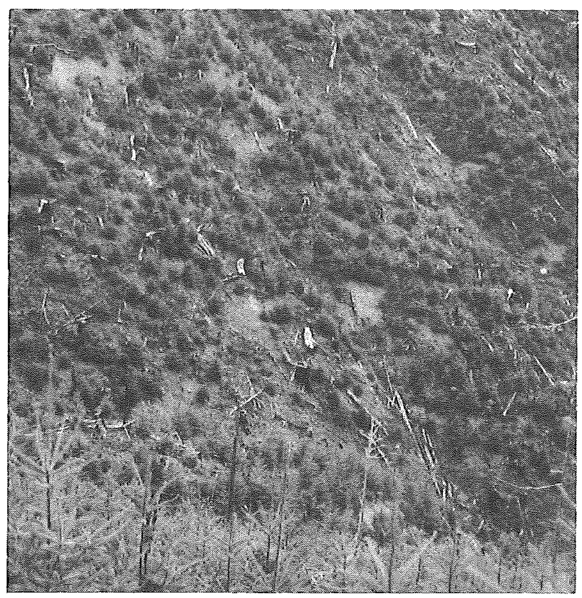


Figure 14 - Surface Slips.

SOIL AREA "B"

This area occupies the valleys of the Soleduck River, Queets River, Matheny Creek, Humptulips River, Wynoochee River, Skokomish River and portions of other valleys throughout the Forest and the outwash plain along the western edge of the Quinault District (Figure 15).

This area contains very deep stratified outwash and glacial till materials that were deposited from alpine valley glaciation.

Mapping Units of the Area

The mapping units in Soil Area "B" all belong to the group of deep valley soils. The major mapping units are 6, 7, 14, 15 and complexes of these mapping units. Mapping Units 6 and 7 consist primarily of 2 to 4 feet of moderately well structured, rapidly permeable, moderately fine textured soils overlying very thick, moderately to slowly permeable, moderately compact, cobbly medium textured glacial till. Mapping Unit 6 occurs on slopes of less than 35 percent, while Mapping Unit 7 occurs on slopes greater than 35 percent. Mapping Units 14 and 15 consist primarily of 2 to 5 feet of moderately well structured, rapidly permeable, medium textured soils overlying very thick, moderately permeable, weakly compact, stratified, very cobbly moderately coarse textured glacial drift. Mapping Unit 14 occurs on slopes of less than 35 percent while Mapping Unit 15 occurs on slopes greater than 35 percent.

Minor mapping units occurring throughout the area are Mapping Units 1, 2, 8, 9 and 13. Mapping Unit 1 consists primarily of very deep fresh sands and gravels occurring along streams. Mapping Unit 2 is the steep raw sides of stream-incised glacial deposits and is very unstable (Figure 16). Mapping Unit 8 consists primarily of very deep soils composed of intermixed layers of medium textured and fine textured materials derived from glaciolacustrine deposits. It occurs on gentle valley bottoms on less than 35 percent slopes. Mapping Unit 9 consists of similar soil materials but occurs on steep dissected slopes adjacent to major streams and is unstable. Mapping Unit 13 consists primarily of thin medium textured soils overlying very deep sand and gravel river wash. This mapping unit occurs on flat flood plain areas adjacent to major streams.

Other minor mapping units that occur locally are Mapping Units 18, 20 and 21. Mapping Unit 18 is similar to Mapping Unit 14 except it is wet for long periods as a result of very poor drainage. It occurs on a portion of the flat outwash plain on the western part of the Quinault District.

Mapping Units 20 and 21 occur primarily on the southeastern part of the Shelton District along the lower Wynoochee Valley and along the Elwha River on the Soleduck District. These mapping units consist primarily of 2 to 4 feet of moderately coarse textured soils overlying very deep, moderately to slowly permeable, weakly compact, gravelly, stratified, moderately coarse and medium textured glacial drift. Mapping Unit 20 occurs on slopes of less than 35 percent. Mapping Unit 21 occurs on slopes greater than 35 percent.

Management Problems

Management problems associated with the major valley soils in this area are related to their texture, drainage, and topographic position. All major mapping units have some degree of restricted drainage because of soil properties and topographic features. Of these, Mapping Unit 6 (Figure 17) has the restriction to drainage, followed by Mapping Unit 7 and Mapping Unit 14. Restricted drainage generally has an adverse effect on management as soils with excessive moisture content are subject to damage from timber harvest, recreation traffic and other activities. These management activities affect the soils by causing muddiness, destroying soil structure and causing compaction. This not only creates damage to the soil, causing possible reduction in productivity, but also increases the erodibility which subsequently increases stream sedimentation, thereby decreasing water quality and fishery values.

Restricted drainage has an effect on recreational developments. Surface soils are wet for longer periods. This causes the soils to become susceptible to muddiness, compaction, and other damage from recreation activities. Also this wetness reduces the desirability as a recreation site. Restricted drainage further affects recreation developments by causing severe limitations for sewer filter field operations.

Restricted drainage affects road construction as it necessitates frequent culvert installations. Proper compaction on fills is difficult to attain and a thick base course is often required.

Relatively few problems are associated with road construction in Soil Area "B" other than those related to restricted drainage. The mapping units are generally stable and are good locations for roads, with the exceptions of Mapping Units 2 and 9 (Figures 16 and 18). A problem that does occur is raveling and sloughing on road cutbanks. Highest occurrence is on Mapping Units 2 and 9, followed by Mapping Units 14, 15, 6 and 7. Raveling and sloughing fills the inside ditch and diverts water across the road and onto the fill slope, causing erosion to both the road prism and fill slope (Figure 19).

Recommendations

1. Road construction and timber harvest activities should be restricted on Mapping Units 6, 7, 8, 9 and 18 during excessively wet periods to avoid damage to soils and other resources.

2. Road construction should be avoided on Mapping Unit 2 and planned with caution on Mapping Unit 9, due to the instability of these mapping units.

3. A catch area should be left between the inside ditch and cutslope. This will reduce the plugging of the inside ditch from cutbank raveling and sloughing.

4. Recreation developments are best suited to the better drained areas of Mapping Unit 14. This mapping unit generally has some limitations imposed by drainage restrictions but the limitations are less than on other mapping units on Soil Area "B". Mapping Unit 13 is frequently satisfactory for limited developments, but does have limitations imposed by a high water table, and due to its position adjacent to streams, it is susceptible to flooding. Mapping Unit 6 has severe restrictions due to wetness and restricted drainage. Mapping Unit 8 has restricted drainage and easily becomes muddy due to wetness and fine textures.

   Campground suitability can be improved on Mapping Unit 6 and on Mapping Unit 14, where it is locally wet, by installing subsurface drains. This will reduce the moisture levels in the surface soils and thereby reduce the susceptibility of soil damage and muddiness. All roads and heavily used trails on Mapping Unit 6 should be graveled. The use of horses and motor scooters should be restricted on unsurfaced areas during the wet season. Trails on all mapping units in Soil Area "B" should be frequently water barred.

5. All mapping units have limitations for filter field use due to restricted drainage. Self-contained sanitary facilities are recommended to avoid water pollution.

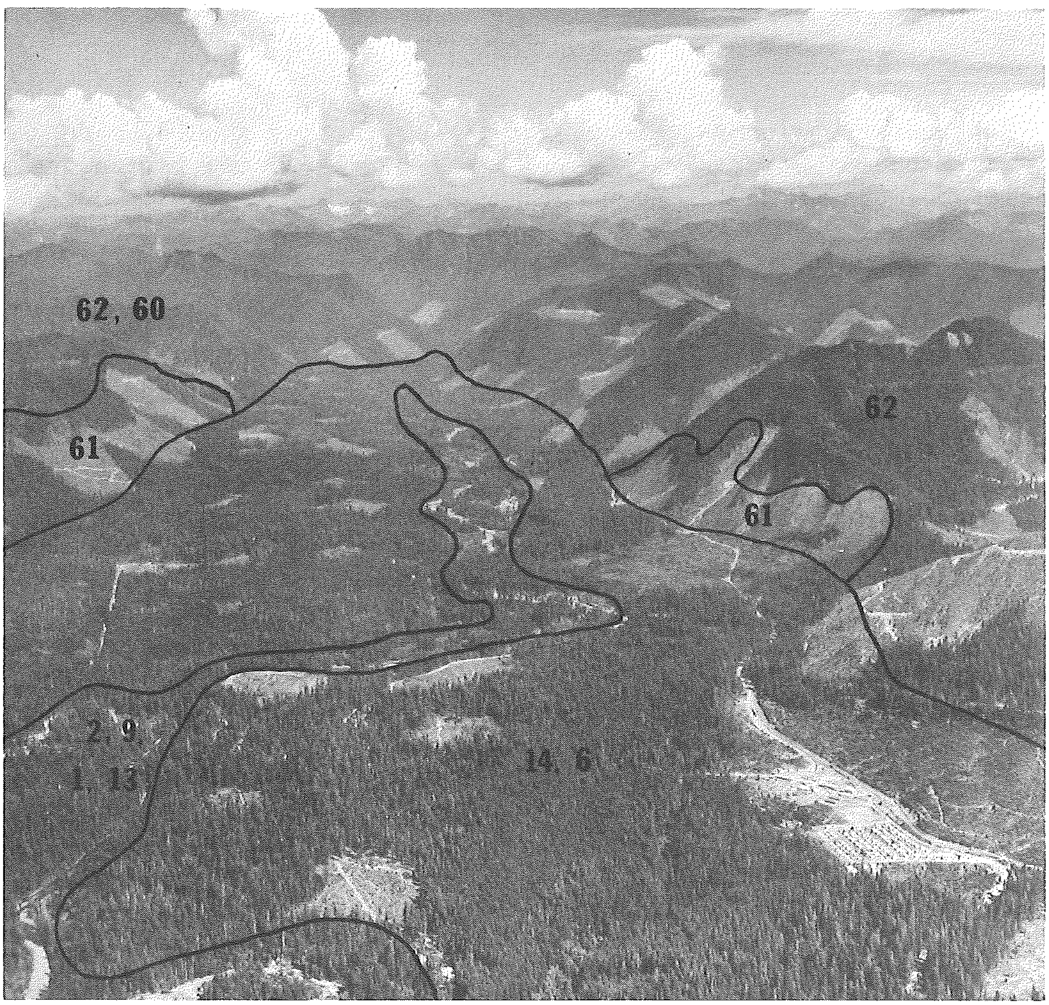


Figure 15 - A View of Soil Areas "B" and "C".

The valley is part of Soil Area "B". Mapping Units 6 and 14 are very deep till and stratified outwash soils. Mapping Unit 1 is fresh sands and gravel. Mapping Unit 13 is recent alluvial soils. Both 1 and 13 occur on the flats adjacent to the river. Mapping Units 2 and 9 are very deep stratified soils occurring along the steep unstable stream-dissected edge.

The mountains are part of Soil Area "C". Mapping Unit 60 is basalt rock outcrop and occurs on ridge crests and some sideslopes. Shallow gravelly loams derived from basalt are mapped 61 on steep, relatively nondissected sideslopes, and 62 on steep, dissected sideslopes. Management problems are high erosion potential and slow regeneration. Mapping Units 61 and 62 are very extensive and occupy about 70 percent of the Shelton District. View is looking up the Wynoochee Valley. Grisdale appears in the lower right corner, Shelton Ranger District.

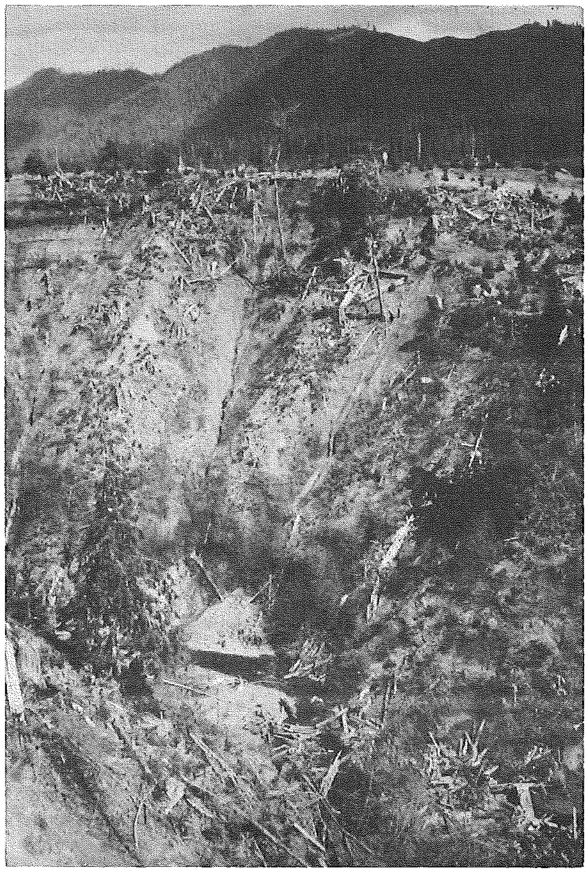


Figure 16.- Landform of Mapping
Unit 2

Mapping Unit 2 is the very steep, unstable raw edge of deeply incised glacial materials. Photo taken along West Fork Humptulips River.

Mapping Unit 6 consists of thin to moderately thick, medium textured soils overlying very thick, moderately compact glacial till. These soils are wet resulting from restricted drainage. Logging and road construction should be restricted during winter to prevent damage to soils and resources. Also these soils have limited campground suitability. Photo taken along Road 242 on Matheny Block, Quinault Ranger District.

Figure 17 - Profile of Soil 6.

The dissected and unstable Mapping Unit 9 shows in the bottom of the picture. Notice the raw soil materials that are actively sliding into the stream (A). A slide scar on Mapping Unit 32 appears on the hillside (B). Photo taken along Sams River, Quinault Ranger District.

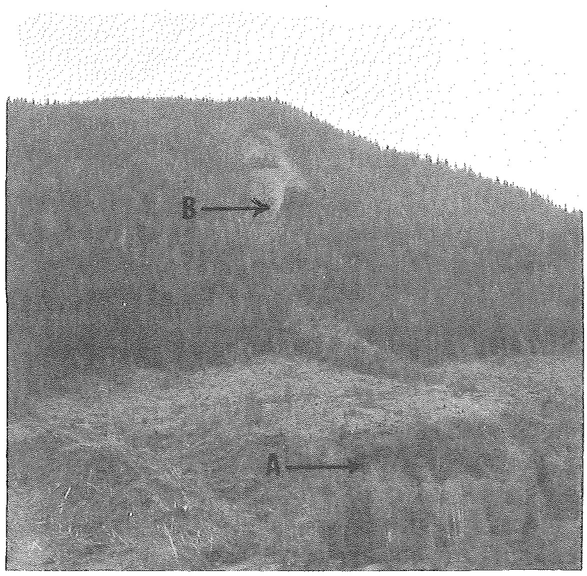
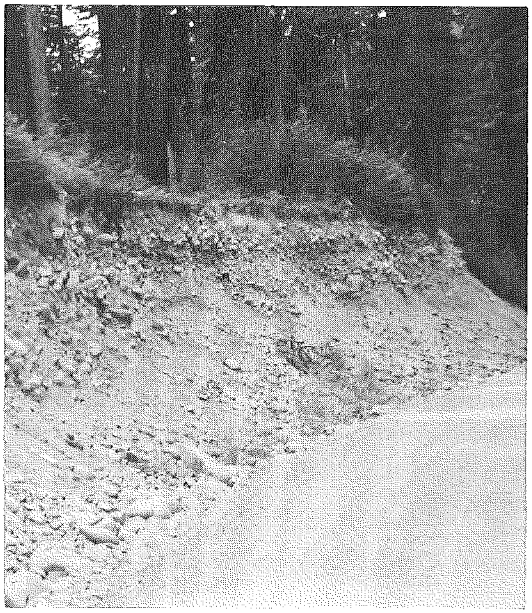


Figure 18 - Landform of Mapping Unit 9.



Mapping Unit 14 has subsoils of stratified outwash and occurs in many of the valleys. These soils are stable. However, cutbanks ravel and occasionally plug the inside ditch and culverts, resulting in water being diverted onto the road causing erosion. Photo taken near Matheny Creek, Quinault Ranger District.

Figure 19 - Profile of Soil 14.

Moderately to highly fractured marine basalt occurs throughout Soil Area "C" and much of Soil Area "D". This bedrock comprises most of the Metchosin Geologic Formation.

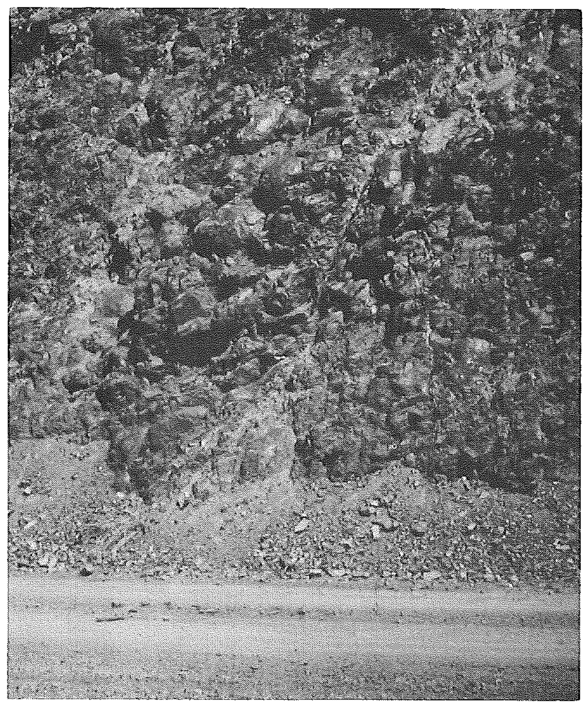


Figure 20 - Basalt Bedrock.

SOIL AREA "C"

This area occupies the steep uplands within the major portions of the Shelton Ranger District and the south block of the Quinault Ranger District; the eastern portion of the Quilcene and Hoodsport Ranger Districts; and the Indian Valley Block and other portions of the Soleduck Ranger District.

The bedrock of this area is composed of dark gray, coarse to fine textured, moderate to highly fractured and strongly chloritized marine basalts (Figure 20), basaltic breccia, and minor inclusions of moderately weathered graywacke and sandstone. The basalts and basaltic breccia are slightly to moderately weathered, and competent to moderately competent. Overlying the basalt and occurring intermittently throughout the eastern portion of the Quilcene and Hoodsport Ranger Districts, is moderately deep to very deep, strongly compact, coarse textured glacial till.

Mapping Units of the Area

The major mapping units of Soil Area "C" are 60, 61, 62, 63, 64, 67, 68, 17, 28, 29 and complexes of these mapping units. The minor mapping units are 12, 19, 20, 21, 27, 73, and 74.

Shallow Ridge and Sideslope Soils

Mapping Units 60, 61, 62, 63, 64, 67, 28 and 29 belong to this group. Mapping Unit 60 is basalt rock outcrop, which generally occurs on higher elevation ridges and sideslopes throughout the area. Mapping Units 61 and 62 consist primarily of shallow, weakly structured, gravelly medium textured colluvial and residual soils derived from basalt and occur on steep sideslopes. These mapping units occupy about 70 percent of the Shelton District and also occur in the Quinault and Soleduck Districts. Mapping Units 63 and 64 consist primarily of shallow to moderately deep, moderately structured, well drained, moderately fine textured soils derived from weathered basalt and minor inclusions of fine textured sedimentary rocks. These mapping units occur on steep slopes in the southern part of the Quinault District.

The following mapping units occur primarily in the Hoodsport and Quilcene Districts: 67, 68, 28 and 29. Mapping Units 67 and 68 consist primarily of shallow, weakly structured, well drained, gravelly medium textured soils derived from basalt and occur on very steep sideslopes. These units are similar to Mapping Units 61 and 62 except for some vegetative differences. Mapping Units 28 and 29 consist primarily of thin, rapidly permeable, gravelly medium textured soils overlying moderately thick, strongly compact, slowly permeable, very gravelly, coarse textured glacial till. Mapping Unit 28 occurs on slopes of less than 35 percent, while Mapping Unit 29 occurs on slopes greater than 35 percent (Figure 21).

Deep Midslope and Toeslope Soils

Mapping Units 17 and 19 belong to this group. Mapping Unit 17 consists primarily of deep, weak to moderately well structured, well drained, gravelly medium textured soils derived from colluvium. This mapping unit occurs on some toeslopes and locally on steep midslopes throughout Soil Area "C". Mapping Unit 19 consists primarily of deep, weakly structured, weakly compact, well drained, very cobbly, moderately coarse textured soils derived from colluvium. This mapping unit occurs locally on steep midslopes and toeslopes in the Hoodsport and Quilcene Districts (Figure 22).

Management Problems of Upland Soils

Management problems in Soil Area "C" are generally associated with the shallow ridge and sideslope soils. These problems are regeneration, surface erosion, and those related to road construction.

Regeneration problems are associated with Mapping Units 61 and 62. Regeneration on lower colluvial toeslopes is generally good but is poor at higher elevations, especially on the rocky south- and west-facing slopes and high ridges where Mapping Units 61 and 62 are in complex with Mapping Unit 60 (Figure 23). This problem is widespread, especially on the Shelton District where these mapping units account for approximately 70 percent of the District.1/

The reasons for the regeneration problems are not clearly known and the nature of this survey did not allow time for detailed study. However, several factors were observed and noted which are believed to be significant. These are: (1) shallow gravelly loam soils which are low in fertility and have low water storage capacity; (2) high summer surface soil temperatures which cause injury to seedlings and also induce a high evapotranspiration rate; (3) accelerated surface erosion is occurring which contributes to low fertility; (4) timber harvest practices have also contributed to the regeneration problems. Large clearcuts have reduced the influence of outside seed sources. Loss of protective organic matter on the soil surface through slash-burning practices has exposed mineral soil and resulted in increased erosion and fertility loss, increased surface soil temperatures, and reduces water storage capacity.

1/ Many of the aerial photos used during the course of this survey were taken in 1953. Clearcuts appearing on these photos were examined in the field. Observations show that although stocking may have occurred, the trees are frequently small and widely spaced.

Another major problem is surface soil erosion. Soils in the uplands occur on very steep slopes, are shallow, and have weak surface structural strength. The soil aggregates are easily dispersed by raindrop impact. These soil and topographic factors and high annual rainfall produce a high rate of surface sheet erosion. Soil pedestaling and the accumulation of soil materials against the uphill side of rocks and organic debris was observed on clearcut areas. This was most evident on Mapping Units 61, 62, 67 and 68. Erosion is especially harmful in areas where these units are mapped in complex with Mapping Unit 60. The soil reservoir on those areas is very limited and any soil loss is highly detrimental.

The third major management problem results from road construction. The primary consideration is not road prism stability on these mapping units as they are relatively stable. Road prism failures are infrequent on Mapping Units 61, 62, 67 and 68, and only moderately frequent on Mapping Units 63, 64 and 17. The important consideration is damage that road construction causes to other resources from sidecasting of surplus waste material (Figures 24, 25, and 26). The midslopes are the highest problem areas. These areas are often highly dissected and very steep. Roads have poor alignment and require full-bench construction, resulting in large quantities of sidecast waste material. This waste material causes extensive damage to other resources as much reaches downslope streams, increasing sedimentation levels and causing damage to fisheries. This sidecast continually ravels and sloughs, thereby inhibiting successful establishment of either grass or trees. On Mapping Units 63, 64, and 17, failures of major proportions often occur in the sidecast waste material which deposits additional large quantities of debris into downslope streams which further increases the damage to the water and fisheries resources.

Road cutbanks frequently ravel and plug the inside ditch. This allows water to run across the road and cause erosion to the road prism and the fill slope. Of the major mapping units, raveling is highest on Mapping Unit 17, as this unit often contains layers of gravel caused by soil creep parallel with the slope (Figure 27).

Recommendations for Upland Soils

1. The possibilities of improving the regeneration on Mapping Units 61, 62 and related complexes is somewhat limited. However, the following should be considered: (a) fertilizer applied at the time of planting may prove helpful (this should first be tried experimentally on a few clearcuts to determine the results); (b) the elimination of slash burning; (c) the use of narrow clearcuts would allow protection from temperature extremes and provide seed source; (d) the most important factor is to maintain balance between timber harvest and regeneration.

2. All steep soils need protection from surface erosion. Generally, the steeper and shallower they are, the more protection they should receive. This protection can be accomplished in part by seeding bare soil areas--skid trail, spur road and landing--by adequately water barring skid trails and spur roads, and by leaving small slash on surface. The most important consideration is to use timber harvest methods that cause minimal damage to the soil surface.

3. Logging debris should be removed rather than broadcast burned.

4. Skyline logging is recommended on the shallow ridge and sideslope soils. This method causes minimal damage to soils and other resources. Most important, it eliminates most midslope roads along with their attendant sidecast waste.

5. Some midslope roads will have to be built regardless of timber harvest method used. To reduce damage to resources, these roads should be of minimum width. They should follow the contours of the topography and allow for adverse grade. All sidecast waste should be end hauled.

6. A catch area should be left between the inside ditch and the cutslope. This will reduce the plugging of the inside ditch as a result of cutbank sloughing and raveling.

Deep Valley Soils

Minor Mapping Units 12, 20, 21, 27, 73 and 74 belong to this group and occur in the Hoodsport and Quilcene Districts. Mapping Unit 12 consists primarily of very deep soils derived from glaciofluvial deposits. These soils are massive to weakly structured, moderately well drained and consist of alternating layers of gravelly medium textures and gravelly moderately coarse textures. This unit occurs in steep and dissected glacial valleys. Mapping Units 20 and 21 consist primarily of 2 to 4 feet of moderately coarse textured soils overlying moderately to slowly permeable, weakly compact, gravelly, stratified, moderately coarse and medium textured glacial drift. These mapping units occur in some low elevation valleys. Mapping Unit 20 occurs on slopes of less than 35 percent. Mapping Unit 21 occurs on slopes greater than 35 percent. Mapping Unit 27 consists primarily of 2 to 6 feet of weakly structured, rapidly permeable, gravelly medium textured soils overlying thick, weakly compact, moderately permeable, very cobbly medium textured subsoils and occurs locally on valley bottoms on slopes of less than 35 percent. Mapping Units 73 and 74 consist primarily of thin, rapidly permeable, gravelly medium textured surface soils overlying very thick, strongly compact, slowly permeable, very gravelly coarse textured subsoils of glacial till. Mapping Unit 73 occurs on some valley bottoms and toeslopes of less than 35 percent. Mapping Unit 74 occurs on some toeslopes and lower sideslopes of greater than 35 percent.

Management Problems of Deep Valley Soils

The deep valley soils are limited in extent in Soil Area "C". Most have few problems except those caused by compact subsoils. This factor implies some limitations to campground development by restricting filter field operation. Also, the compact subsoils on Mapping Unit 74 (Figure 28), along with steep slopes, produce a severe erosion hazard. Water will percolate freely through the surface soils but is restricted by the compact subsoils. Surface soils become saturated and excess water is forced to move laterally. This causes a condition whereby surface soil materials are easily removed.

Mapping Unit 12 does have major problems (Figures 29 and 30). This mapping unit consists of very deep stratified glaciofluvial deposits occurring in steep, dissected and uneven glacial valley bottoms. Down-cutting of the streams has left nearly perpendicular raw edges that are highly subject to failure. The uneven appearance throughout this mapping unit is indicative of past deep-seated failures that can be reactivated by road construction. The potential for failure is highest near the very steep edges adjacent to the streams. The soil material has been undercut locally which further increases the failure potential. Road construction near these edges should be avoided.

This mapping unit also has a high rate of sloughing and raveling on cutbanks and fill slopes. The inside ditch becomes easily plugged. Water is diverted, causing erosion to the road prism and fill slope. The fill slopes continually ravel and slough thereby depositing soil materials into streams. Sedimentation occurs with a loss of water quality and fishery values.

Recommendations for Deep Valley Soils

1. Erosion protection should be provided for soils with steep slopes. This is very important on Mapping Unit 74.
2. Recreation developments should use self-contained sanitary facilities rather than filter fields.
3. Road locations should be selected with caution on Mapping Unit 12 to avoid unstable areas.
4. A catch area should be left between the inside ditch and the cutslope on Mapping Units 12, 20, 21 and 27. This will reduce the plugging of the inside ditch as a result of cutbank sloughing and raveling. This is especially important on Mapping Unit 12.

Mapping Unit 29 consists of a thin gravelly loam surface soil overlying moderately thick, strongly cemented till (A). Underlying bedrock is basalt (B). This mapping unit is very stable but has a high erosion hazard. Photo taken along highway north of Mt. Walker turnoff, Quilcene Ranger District.

Figure 21 - Profile of Soil 29.

Mapping Unit 19 consists of very deep, very cobbly moderately coarse textured soils. These soils are weakly compact. Raveling, low fertility, and compaction makes grass establishment on cutbanks difficult. Photo taken along Road 295, Quilcene Ranger District.

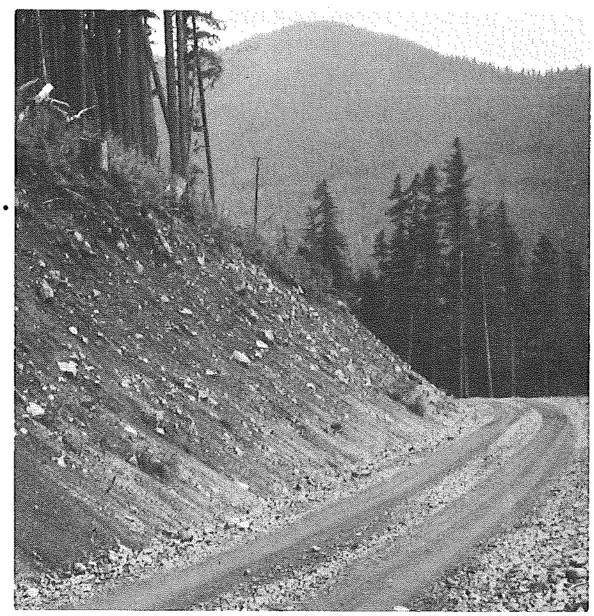


Figure 22 - Profile of Soil 19.

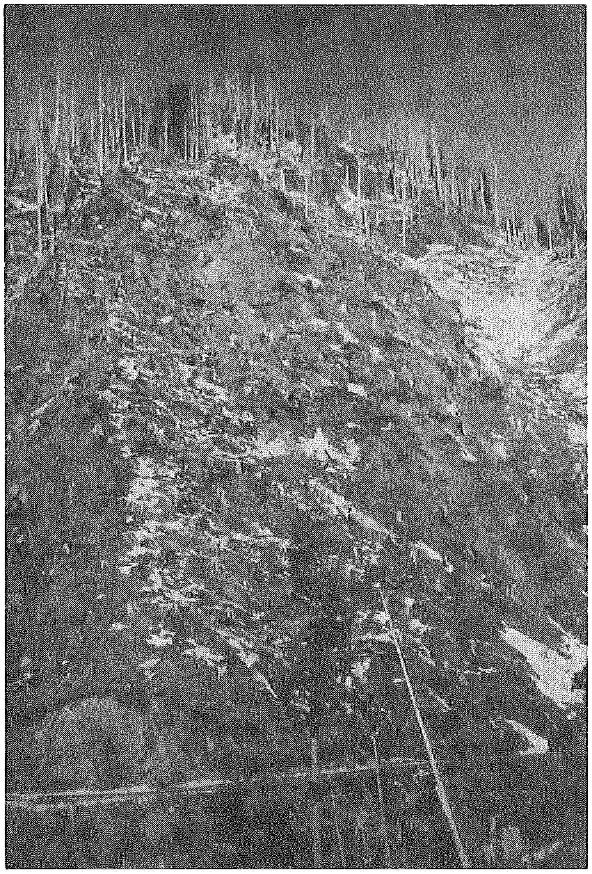
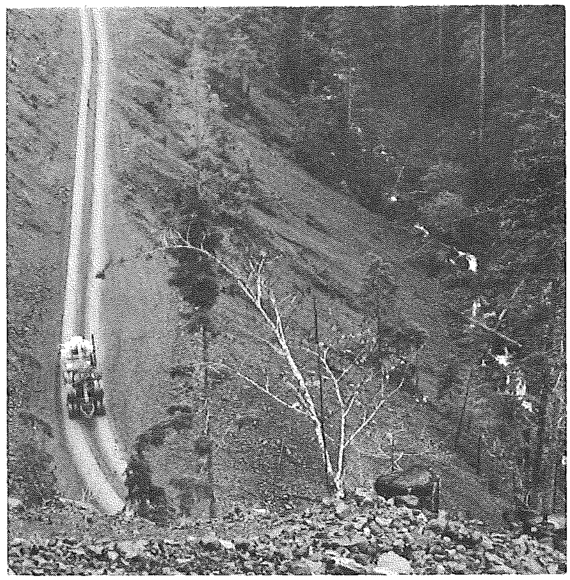


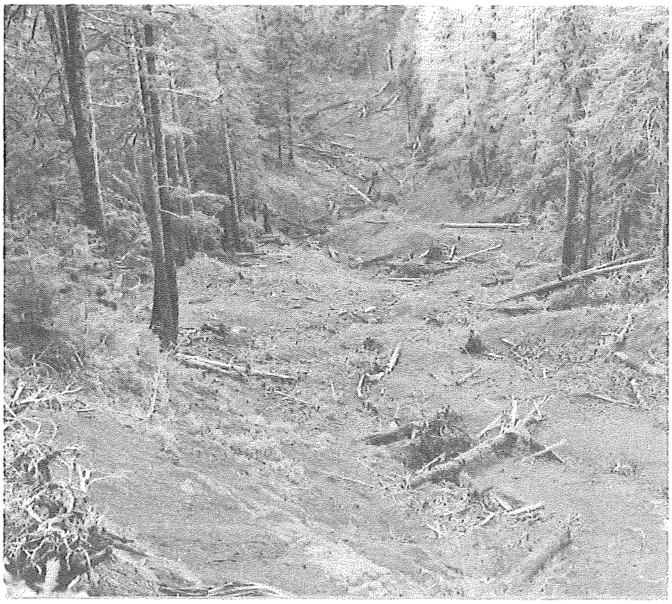
Figure 23 - Erosion and Regeneration Problems on Mapping Unit 620.

Mapping Unit 620 is a complex of Mapping Units 62 and 60. Mapping Unit 62 is shallow gravelly loam soils derived from basalt, and Mapping Unit 60 is basalt rock outcrop. Mapping Unit 620 occurs on steep dissected sideslopes and ridges. Mapping Unit 610 is similar except the slopes are relatively nondissected. Management problems on Mapping Units 61, 62, 610, 620, 601 and 602 are severe sheet erosion and slow regeneration. These problems are greatest on the mapping units with extensive rock outcrop. The clearcut unit pictured was harvested in 1952 and planted in 1957. Practically no regeneration or other vegetation is evident at the present time. Much of the clearcut has exposed mineral soil that is actively being removed by sheet erosion. This is an extreme example but much of the area has similar problems, especially on the ridges and sideslopes that contain a high percentage of rock outcrop. Photo taken from Road 124, Shelton Ranger District.



Figures 24 and 25 - Sidecast Waste Damage.

Notice the erosion occurring on the photo at left. On the photo at right, much of the initial waste reached the stream. Subsequent erosion and raveling on both photos causes continued stream sedimentation and inhibits successful establishment of either grass or trees.



This damage caused by sidecast waste could have been prevented by end hauling.

Figure 26 - Sidecast Waste Damage

This is an example of a mapping unit complex. Two mapping units occur in association and are mapped together. Mapping Unit 62 is shallow gravelly loam derived from basalt bedrock appearing in the background (A). Mapping Unit 17 is very deep gravelly loam derived from colluvium appearing in the foreground (B). Notice the raveling on Mapping Unit 17.

Figure 27 - Mapping Unit 627 (complex of Mapping Units 62 and 17).

Mapping Unit 74 consists of thin gravelly loams overlying very thick, strongly cemented till. This mapping unit is stable but has a high erosion hazard. Photo taken along Road 2621, Hoodsport Ranger District.

Figure 28 - Profile of Soil 74.

The dissected, unstable landform near the center of the picture is characteristic of Mapping Unit 12 (A). This landform is contrastingly different from that of the stable Mapping Unit 29 above (B). Photo taken along Little Quilcene River, Quilcene Ranger District.

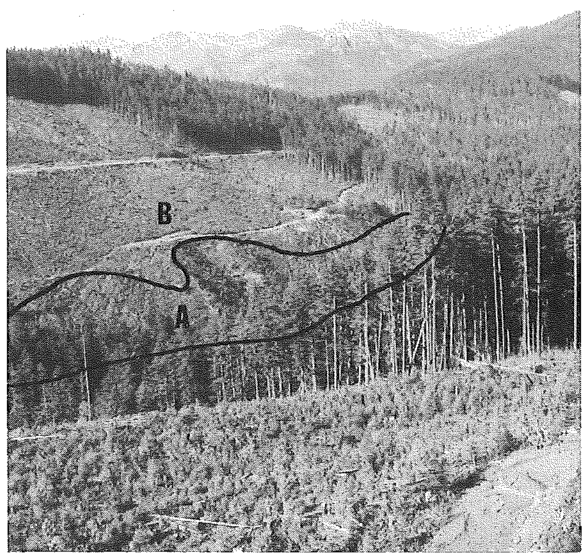


Figure 29 - Landforms of Mapping Units 12 and 29.

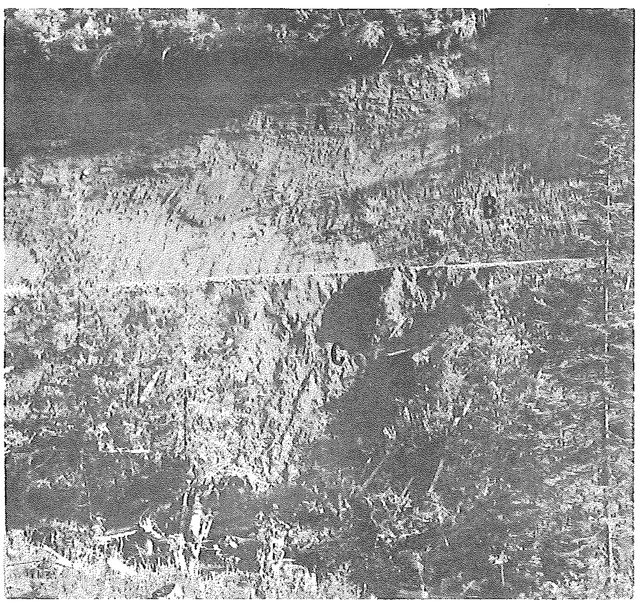


Figure 30 - Profile of Soil 12.

Mapping Unit 12 consists of many stratified layers (A) of gravelly sand, gravel and gravelly silt loam. This mapping unit is moderately stable to unstable. Raveling of cutbanks limits grass establishment and plugs inside ditches. Grass only grows in areas of soil accumulation (B). Stream at bottom is undercutting fill slope and causing failure (C). Other causes of road failure may be incorporated organic matter and inadequate compaction. Photo taken along Road 2751 at Townsend Creek Crossing, Quilcene Ranger District.

SOIL AREA "D"

This area occupies the northern Shelton Ranger District, a portion of the Quinault Ranger District, and western portions of the Quilcene and Hoodsport Ranger Districts. The landscape is typified by steep and rocky high-elevation alpine ridges and valleys (Figure 31).

The bedrock of this area is composed of graywacke, brittle black argillite, red limy argillite, mudstone and altered basalt. The graywacke and basalt are generally competent while the argillites and mudstone are moderately competent.

Mapping Units of the Area

The major mapping units of this area are 40 and 60, and complexes of 40 and 60 with 41, 42, 67 and 68. Minor mapping units are 16 and 17.

Shallow Ridge and Sideslope Soils

Mapping Units 40, 41, 42, 60, 67 and 68 belong to this group. Mapping Unit 40 consists primarily of sedimentary rock outcrop and occurs on high ridges and barren sideslopes. Mapping Units 41 and 42 consist primarily of shallow, weakly structured, well drained, medium textured soils derived from sedimentary rock. These mapping units occur on steep sideslopes. Mapping Unit 60 is basalt rock outcrop and occurs on high elevation ridges and barren sideslopes. Mapping Units 67 and 68 consist primarily of shallow, weakly structured, well drained, gravelly medium textured soils derived from basalt. These mapping units occur on steep sideslopes.

Deep Midslope and Toeslope Soils

Mapping Units 16 and 17 belong to this group and consist primarily of deep, moderately well structured, well drained, gravelly medium textured soils.

Mapping Unit 16 occurs on toeslopes of less than 35 percent. Mapping Unit 17 occurs on steep midslopes and toeslopes of greater than 35 percent.

Management Problems of Soil Area "D"

Severe surface erosion, bedrock failures and stream sedimentation from sidecast road waste are the primary management problems associated with the soils and bedrock of the steep ridge and sideslope mapping units in this area.

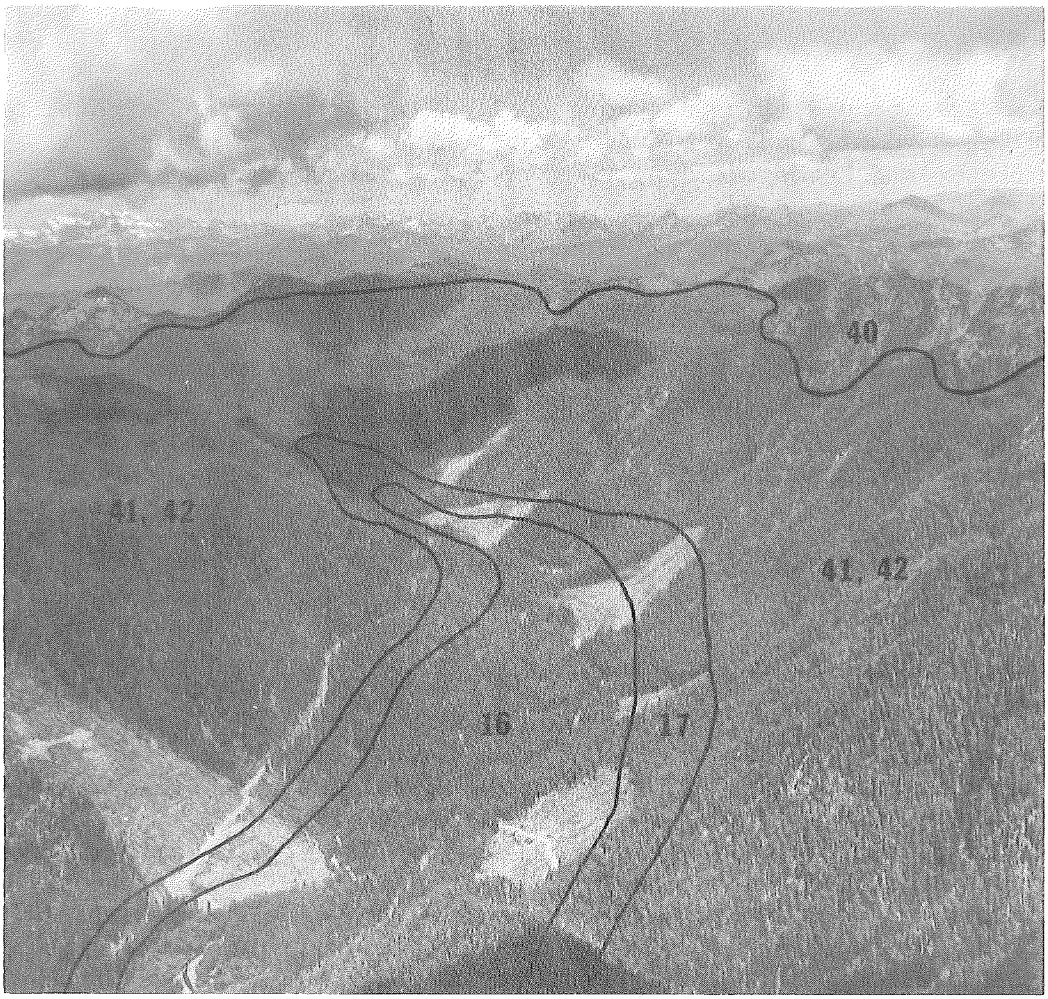


Figure 31 - A View of Soil Area "D".

The foreground is more heavily timbered than is the majority of Soil Area "D". The steep rocky landscape at the top of the picture is more typical of the area.

In the portion of Soil Area "D" shown by this picture, the mapping units are as follows: Mapping Unit 40 is sedimentary rock outcrop. Mapping Unit 41 is shallow gravelly loam soils derived from sedimentary bedrock. This mapping unit occurs on steep, relatively nondissected sideslopes. Mapping unit 42 is similar but occurs on dissected sideslopes. Management problems include severe surface erosion potential, bedrock failures and slow regeneration. Very deep gravelly loam soils derived from colluvium and glacial materials occur in the valley. These soils are mapped (16) on slopes less than 35 percent and (17) on slopes greater than 35 percent. View is looking up the West Branch of the Wynoochee River, Shelton Ranger District.

The high surface erosion potential results from shallow, weakly structured soils, high precipitation and steep slopes. The fact that the soils are shallow and occur in areas of extensive rock outcrop indicates that soil formation is not maintaining pace with natural geologic erosion. This rate of erosion is greatly increased whenever the surface soils are exposed to raindrop impact. Surface soils become exposed as a result of timber harvest activities such as slash burning, log skidding, and road construction. The effects of erosion on the soil resource is especially severe on Mapping Units 401, 402, 607 and 608 as the soils are shallow and extremely limited in fertility and rooting depth. Any loss seriously depletes the soil reservoir.

Another major problem is the tremendous damage caused to the landscape and to various resources from road construction activities. The extreme steepness of this area necessitates sidecasting of waste material. Much of this sidecast reaches streams hundreds of feet below the road. This causes stream sedimentation and results in a reduction in water quality and a loss to fisheries. Also this sidecast continues to ravel and prevents the establishment of either grass or trees.

On Mapping Units 40, 41 and 42 there is an additional problem of bedrock failures. The bedrock on these units is sedimentary and is less stable than is the basalt bedrock of Mapping Units 60, 67 and 68. There exists a moderate probability of failures occurring that not only further increases the damage to resources, but also may damage the road and cause high maintenance costs.

Slash burning is another serious problem in Area "D". It is detrimental to the soil in several respects. Burning reduces the already low fertility of the soil by volitalizing many of the nutrients and rendering many others vulnerable to leaching. Burning also destroys the surface duff and litter layers exposing the soil surface to highly accelerated erosion.

Soil Area "D" is primarily alpine and upper forest. The timber productivity is low and the probability of damage to the shallow, fragile soils is very high. Therefore, the values of this area are primarily those associated with recreation, watershed and aesthetics. Road construction and timber harvest produce large unsightly scars that detract from the scenic beauty of the area. The timber available for harvest is of low quality and quantity. The land manager must weigh the present and future importance and feasibility of timber removal against the preservation of aesthetic and other resource values.

Recommendations

1. Optimum management for recreation, watershed and aesthetic values should be the primary consideration on Mapping Units 40, 401, 402, 60, 607 and 608. Minimal physical disturbance of the soil and vegetation is an absolute requirement for maintaining the soil resource in this area.

2. Eliminate timber harvest in alpine and upper forest areas. This may require adjustments in multiple use plans and allowable cut. This area is indicated by Mapping Units 40, 401, 402, 60, 607, and 608. When it is considered necessary to harvest timber in Area "D", certain precautions and harvesting procedures should be employed so that the goal of minimum soil and site disturbance is realized:

    a. In areas where timber is harvested, strong precautions should be taken to insure protection from surface erosion. This can be accomplished in part by grass seeding bare soil areas, skid trails, spur roads and landing; adequately water barring skid trails and spur roads; and most important, using timber harvest practices that do not destroy the surface duff layer.

    b. The use of skyline logging is strongly recommended. This practice causes minimal damage to soils and other resources.

    c. When roads must be built on steep sideslopes, they should be minimum width and waste material should be end hauled rather than sidecast.

    d. Logging debris should be removed rather than broadcast burned.

SOIL AREA "E"

This area occupies the northern portions of the Quilcene and Hoodsport Ranger Districts.

Bedrock is composed of dark gray massive to thinly bedded feldspathic, arkosic and basaltic sandstone, siltstone, massive conglomerate and moderately to highly fractured marine basalt (Figures 32 and 33). Overlying this bedrock is deep, moderately compact glacial till on the lower hills and across rolling drift plains and deep glaciolacustrine deposits in the major river drainages.

Mapping Units of the Area

Major Mapping Units are 55, 56, 22, 23, 24 and 25. Minor mapping units are 6, 7 and 11.

Shallow Ridge and Sideslope Soils

Mapping Units 55 and 56 belong to this group. These mapping units consist primarily of shallow to moderately deep, weak to moderately structured, well drained, medium textured soils overlying sedimentary bedrock. They occur on steep sideslopes and ridges at higher elevations.

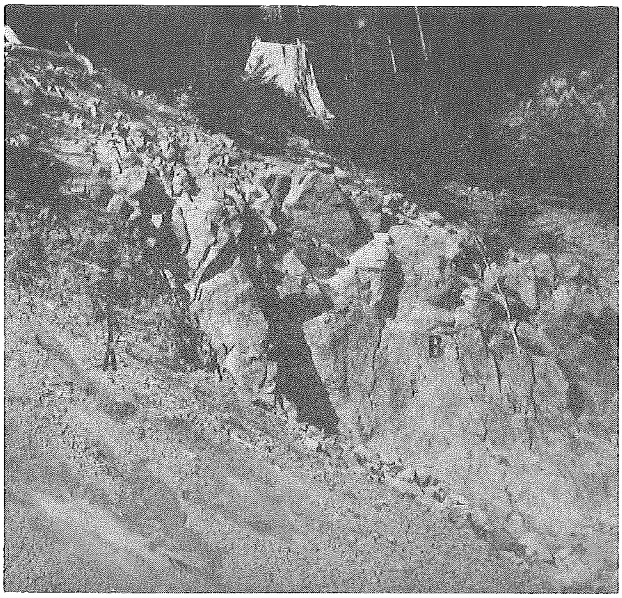
Management Problems on Shallow Ridge and Sideslope Soils

Management problems associated with Mapping Units 55 and 56 are surface erosion and those caused by road construction.

The soils of these mapping units have a high surface erosion potential when mineral soil is exposed. The soil aggregates are easily dispersed by raindrop impact. Individual soil particles are then easily removed, causing a depletion of the soil reservoir and an increase in stream sedimentation.

Another problem results from damage caused to resources from road construction and maintenance. Sidecast waste material causes extensive damage to other resources. Much of this sidecast material reaches downslope streams, increasing sedimentation levels and causing damage to fisheries.

A third problem is cutbank raveling, especially on Mapping Unit 56 (Figure 32). This ravel material often plugs the inside ditch. Water is diverted across the road causing erosion to the road prism and fill slope.



Mapping Unit 56 consists of shallow to moderately deep loams and silt loams derived from glacial deposits and residuum. Bedrock is thinly bedded siltstone (A) and graywacke (B). Notice the raveling from the siltstone. Photo taken along Road 3031, Soleduck Ranger District.

Figure 32 - Profile of Soil 56.

Massive conglomerate occurs locally throughout Soil Area "E". This rock is hard and competent. Blasting is required for excavation. Photo taken on Quilcene Ranger District.

Figure 33 - Conglomerate Bedrock.

Recommendations for Shallow Ridge and Sideslope Soils

1. These soils need protection from surface erosion. This can be accomplished in part by grass seeding bare soil areas, skid trails, spur roads and landings; by adequately water barring of skid trails and spur roads, and by using timber harvest practices that do not destroy the surface duff layer.

2. Logging debris should be piled and burned rather than broadcast-burned. The piling operation should employ methods that cause minimal soil disturbance. Burning slash in this manner minimizes fertility loss and soil erosion.

3. Roads should be full-benched and of minimum width. Surplus waste should be end hauled.

4. A catch area should be left between the inside ditch and the cut-slope, especially on Mapping Unit 56. This will reduce the plugging of the inside ditch from cutbank raveling and sloughing.

Deep Valley Soils

Major mapping units on lower slopes and valleys are Mapping Units 22, 23, 24 and 25. Mapping Units 22 and 23 consist primarily of thin, weakly structured, rapidly permeable, gravelly moderately coarse textured soils overlying very thick, moderately compact, slowly permeable, moderately coarse textured continental till (Figure 34). Mapping Unit 22 is on slopes of less than 35 percent, and Mapping Unit 23 is on slopes greater than 35 percent. Mapping Units 22 and 23 occur across the northern part of the Quilcene District and locally in the northeast part of the Soleduck District. Mapping Units 24 and 25 consist primarily of thin, well structured, rapidly permeable, medium to moderately fine textured surface soils overlying very thick, moderately compact, slowly permeable subsoils derived from glaciolacustrine deposits. Mapping Unit 24 occurs on steep uneven slopes within several of the major drainages. These primarily include the Dungeness, Graywolf and Pysht Rivers, and locally along Deep Creek.

Minor mapping units in the valleys are 6, 7 and 11. Mapping Units 6 and 7 both contain 2 to 4 feet of moderately well structured, rapidly permeable, moderately fine textured soils overlying very thick, moderately slowly permeable, moderately compact, cobbly, medium textured glacial till. Mapping Unit 6 occurs on slopes of less than 35 percent while Mapping Unit 7 occurs on toeslopes greater than 35 percent. Mapping Unit 11 consists primarily of deep, moderately well structured, well drained, moderately fine textured soils derived from residuum and colluvium and occurs on some toeslopes of greater than 35 percent.

Management Problems of Deep Valley Soils

The primary management problems associated with soils in this area are instability, low fertility, restricted drainage, high windfall hazard and alder competition.

The soils of Mapping Unit 24 are very unstable. Steep uneven slopes, in combination with fine textured soils and subterraneous water, are conducive to a frequent occurrence of deep-seated failures. Slumps are occurring in the virgin landscape. This rate of occurrence is greatly accelerated by road construction (Figure 36). Cutbank and fill failures occur, which not only cause damage to the road and increase maintenance costs, but more importantly, cause high damage to various natural resources. One form of damage is the stream sedimentation that causes water pollution and a loss to fisheries. The highly erodible fine textured soil particles that predominate in these soils remain in suspension for long periods of time. Therefore, streams and rivers that drain areas occupied by these mapping units are highly susceptible to sedimentation.

Another problem is low fertility on Mapping Units 22 and 23. It is suspected that nitrogen and perhaps other nutrients are seriously deficient. The nature of this survey did not permit detailed study to determine the reason for this. However, several factors indicate low fertility: (1) the growth rate of Douglas-fir is lower than would be expected considering the elevation and precipitation received (site class for these mapping units is generally not higher than IV); (2) moderately coarse textured soils in the rooting zone have limited capacity to store nutrients; (3) the soils are derived from continental glacial till composed of acidic rock types. These rocks are inherently low in soil nutrients.

Another problem in the area is frequent windfall occurrence on Mapping Units 22, 23, 24 and 25 (Figure 35). This is attributed to the shallow rooting depth which is usually restricted to the surface 2 feet due to compact subsoils.

A problem that occurs in the valleys of the northern Soleduck District is high alder competition in Mapping Units 6, 7 and 11. These areas have a strong tendency to revegetate to alder following timber removal.

A major problem associated with Mapping Units 24 and 25 is damage caused by timber harvest, recreation traffic, road construction and other activities when these soils are wet. These soils have restricted drainage and are fine textured. Due to restricted drainage, the surface soils remain wet for long periods. Management activities affect the soils by causing muddiness, destroying soil structure and causing compaction (Figure 37). This not only causes damage to the soil but also increases the erodibility which subsequently increases stream sedimentation, thereby decreasing water quality and fishery values.

Restricted drainage also implies limitations for recreation area development. Mapping Unit 22 is better suited due to moderately coarse textured surface soils, but the compact, slowly permeable subsoils restrict filter field development. Mapping Units 24, 25 and 6 not only have restricted drainage but also become very muddy. On these mapping units both soil and vegetation are subject to damage from recreation traffic.

Recommendations for Deep Valley Soils

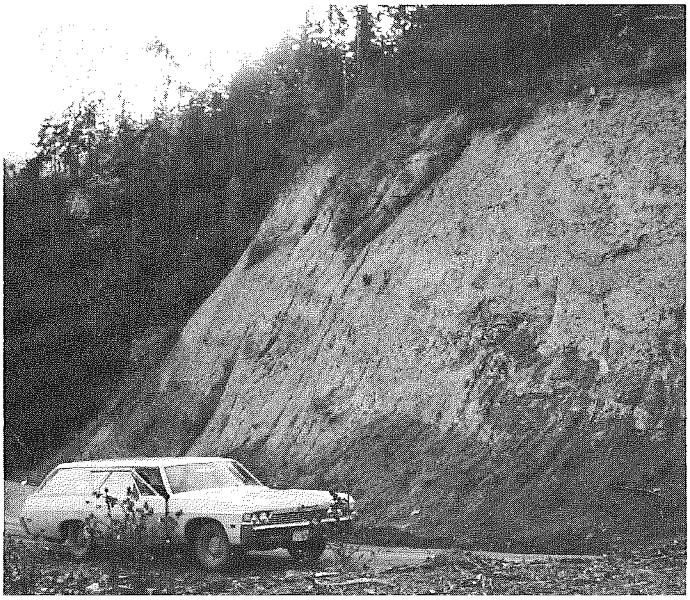
1. Nitrogen fertilizer applied at the time of planting should improve the regeneration growth rate on Mapping Units 22 and 23. This should be tried experimentally on a few clearcuts with different site conditions to determine the results.

2. Timber harvest and other activities should be suspended during wet periods on Mapping Units 24 and 25 to minimize damage to soils and other resources.

3. Road construction should be avoided on Mapping Unit 24 due to high instability. Roads increase the rate of failure. The result is damage to the road and high damage to other resources.

4. Skyline logging should be used on Mapping Unit 24 when feasible. This method causes minimal damage to soils and other resources. Its primary advantage is that it reduces the number of roads required.

5. Campground development is best suited to Mapping Unit 22 although compacted subsoils limit filter field use. Self-contained sanitary facilities should be used.



Mapping Unit 22 consists of thin gravelly sandy loams or gravelly loams overlying very thick, moderately compact, continental till. Soil Unit 23 is similar with the exception of landform. This cutbank is relatively stable, but has a moderately high potential for sloughing and surface erosion. Photo taken along Road 2927, Quilcene Ranger District.

Figure 34 - Profile of Soil 22.

Shallow rooting depth, resulting from compact subsoils, causes high windfall on Soil Units 22, 23 and 24. Photo taken along Road 2824, Quilcene Ranger District.

Figure 35 - Windfall.

Mapping Unit 24 consists of very deep silty and sandy clays derived from glaciolacustrine deposits. These soils are unstable and exhibit a high rate of cutbank failure. These soils are extensive along the Dungeness and Graywolf Rivers, Quilcene Ranger District, and occur in Deep Creek and the Pysht River, Soleduck Ranger District. Photo taken along the Dungeness River.

Figure 36 - Cutbank Failure on Mapping Unit 24.

This picture illustrates the muddy conditions that prevail on Mapping Units 24 and 25 when road construction or timber harvest activities are conducted during wet periods. Such activities should be suspended during wet periods as considerable damage is caused to the soils and other resources. Also, these soils are poorly suited for campground development. Photo taken along the Dungeness River.

Figure 37 - Road Muddiness on Mapping Unit.

SOIL AREA "F"

This area occupies the central portion of the Soleduck Ranger District.

The bedrock consists of massive to poorly bedded, moderately weathered graywacke and sandstone, and highly weathered, thinly bedded mudstone, slate, and siltstone (Figure 38). These rocks are moderately competent to incompetent.

Mapping Units of the Area

The major mapping units of Soil Area "F" are 51 and 52. These mapping units occupy approximately 70 percent of the area. Minor mapping units are 32, 33 and 11.

Shallow Ridge and Sideslope Soils

Mapping Units 51 and 52 belong to this group and consist primarily of shallow, weakly structured, gravelly medium textured residual and colluvial soils derived from sedimentary bedrock. Mapping Unit 51 occurs on smooth ridges and steep, slightly dissected to nondissected sideslopes. Mapping Unit 52 occurs on steep, very highly dissected sideslopes.

Deep Midslope and Toeslope Soils

Mapping Units 32, 33 and 11 belong to this group. Mapping Unit 32 consists primarily of moderately deep, moderately to well structured, well drained, gravelly moderately fine textured soils derived from highly weathered sedimentary bedrock and occurs locally in the eastern portion of Soil Area "F" on steep, dissected midslopes. Mapping Unit 33 consists of very deep, moderately well to imperfectly drained, gravelly fine textured soils. Mapping Unit 33 is closely associated with Mapping Unit 32 and occurs locally in the eastern portion of Soil Area "F" within and adjacent to sideslope drainages. Mapping Unit 11 consists primarily of deep to very deep, moderately to well structured, well drained, moderately fine textured soils derived from moderately weathered bedrock and occurs locally in the eastern, southern and western portions of Soil Area "F" on toeslopes of greater than 35 percent.

Management Problems of Soil Area "F"

The primary management problems in the shallow ridge and sideslope soils of Soil Area "F" are accelerated surface soil erosion, debris slides of soil and bedrock materials, and damage to soils and other resources resulting from road construction. Where deep midslope soils occur (Mapping Units 32 and 33), the primary management problem is deep-seated massive failures.1/ No major management problems are associated with Mapping Unit 11.

Surface soil erosion is severe on the shallow soils of Mapping Units 51 and 52 due to their weak structural strength and steep topographical position. Slash burning and past fires have accelerated the erosion process by destroying the surface duff and exposing the soil to raindrop impact and surface runoff. The Forks Burn is an extreme example, but extensive soil loss through erosion that has taken place illustrates what can happen on forested areas should they be subjected to similar treatment (Figure 39).

Surface soil slips and debris slides occurring on the Forks Burn area have also occurred at an accelerated rate due to harvest techniques following the fire. The structurally weak, highly fractured bedrock of this area is naturally prone to this type of failure. Therefore, the best of management practices are needed to avoid serious erosion and mass movement problems.

Another major management problem is the damage to other resources that is caused by road construction. Sidecast waste material causes extensive damage (Figures 40 and 41). Much of this sidecast material reaches major streams due to the extreme density of sideslope tributaries. This results in high stream sediment loads and pollution levels which cause considerable damage to fisheries and water quality. Failures of major proportions often occur in the sidecast waste material which deposits additional large quantities of debris into downslope streams and further increases the damage to the water and fishery resources. The midslopes are the highest problem areas. These areas are steep, highly dissected and have the most potential waste material. Due to the extreme dissection and steepness of the topography, roads must be full-benched and, typically, have poor alignment.

Raveling and sloughing of road cutbanks is severe. This is due to the highly fractured bedrock and necessarily high, steep cutslopes. The inside ditch is often plugged by this material. This allows water to run across road surfaces, causing erosion to the road prism and fill slope.

1/ For more information on management problems and recommendations associated with these deep plastic soils, refer to Soil Area "A".

Recommendations

1. The soils of Mapping Units 51 and 52 need protection from surface erosion. This can be accomplished in part by grass seeding bare soil areas, skid trails, spur roads and landings; adequately water barring skid trails and spur roads, and diversion of surface water by proper use of culverts and culvert downspouts. Most importantly, timber harvest methods such as skyline logging should be used so that logs are not dragged over the soil surface.

2. Skyline logging, when feasible, is also a very desirable method as it eliminates most sideslope road construction. Roads should be avoided on the steep dissected sideslopes due to the high occurrence of debris slides, cutbank raveling, and damage caused to other resources from sidecast waste.

3. Logging debris should be removed rather than broadcast burned.

Some sideslope roads will need to be constructed regardless of the timber harvest method used. In order to minimize damage to other resources, the following should be considered:

1. Road location should allow for adverse grade where necessary. This gives the road locator a better opportunity to avoid potentially unstable areas.

2. Full-bench and minimum-width construction should be used on steep sideslopes and across in-curve areas. Sideslope fills associated with partial-bench roads often fail due to inadequate support and compaction.

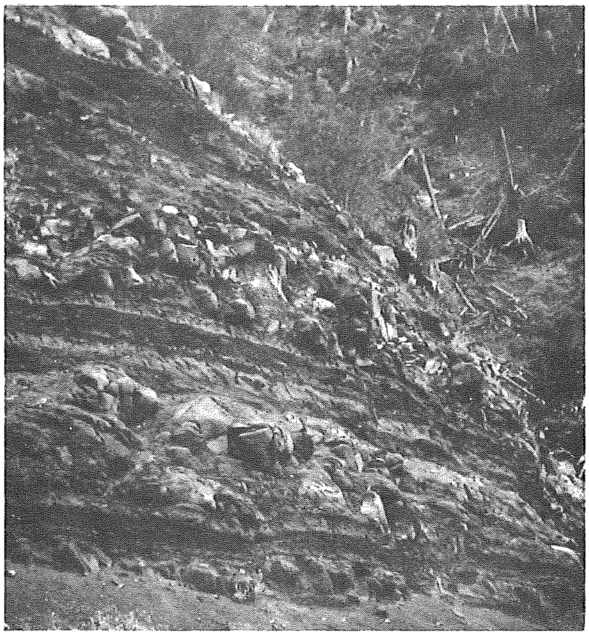
3. Fills should be kept free of organic debris. This material prevents adequate compaction and provides channels for water, often contributing to fill collapse.

4. Surplus waste materials and road maintenance waste should be end hauled to a suitable area rather than sidecast. Sidecasting not only destroys timber and watershed values, but is a major contributor of mass movements. This material is in a loose, noncompacted state, resulting in a very high rate of surface erosion. More important is the fact that this material adds weight to downslope areas, which is greatly increased when the material absorbs water. A natural shear plane exists between sidecast materials and the underlying soil. Slides often occur, uprooting and destroying trees and depositing vast quantities of soil debris in streams.

5. Proper frequency of culverts and adequate installation should be insured so that excessive moisture is removed. Water should not be allowed to run across roads or on fill slopes. Sufficient maintenance should be provided to prevent plugging of culverts.

6. A catch area should be left between the inside ditch and the cutslope. This will reduce the plugging of the ditch as a result of severe cutbank raveling and sloughing.

7. Terracing and seeding of fill slopes, when feasible, helps to stabilize excessive raveling.



Graywacke and sandstone interbedded with mudstone, slate and siltstone. Photo taken along Road 301 on Soleduck Ranger District.

Figure 38 - Bedrock of Soil Area "F".

Surface slips and debris slides are a frequent occurrence on Mapping Unit 52 subsequent to disturbance. This photo is of the Forks Burn. The soil damage was initially caused by fire but was significantly increased by road construction and salvage logging. The Forks Burn is an extreme example but it illustrates what could happen on timbered areas in Mapping Unit 52 should they be subjected to similar treatment. Photo taken along Road 301 on Soleduck Ranger District.

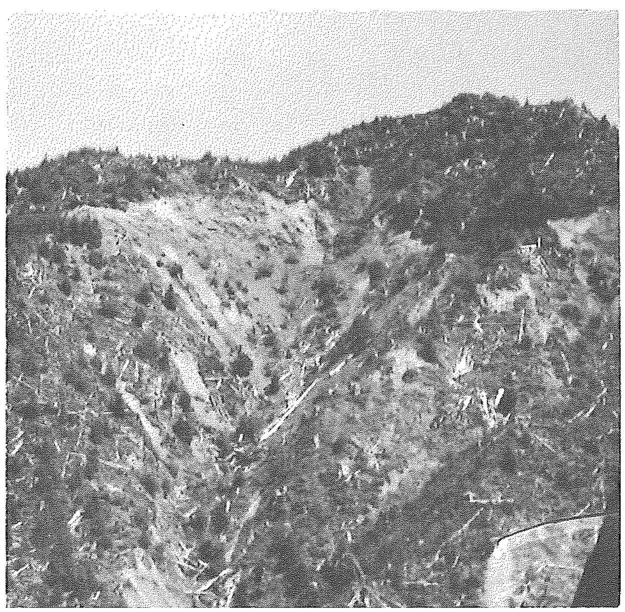
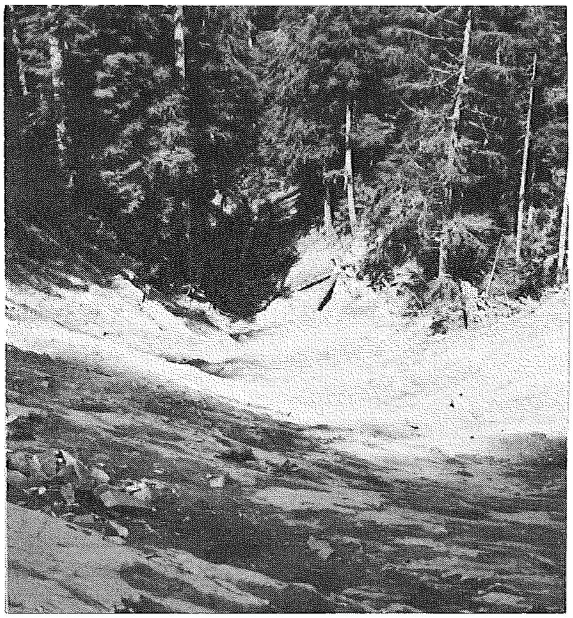
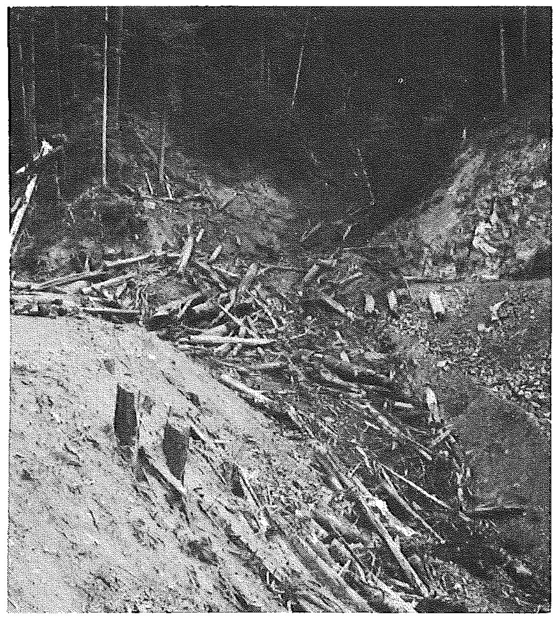


Figure 39 - Erosion and Debris Slides on Mapping Unit 52.

Figures 40 and 41 - Sidecast Waste Damage.

Surplus waste material was sidecast in the picture at left. This triggered a slide downstream that caused the debris dam shown in the picture at right. End hauling of the surplus waste would have prevented this damage.

APPENDIX I

DEFINITIONS AND DESCRIPTIONS OF MAPPING UNITS

This section contains the identifying descriptions of numbers and symbols found on the soil maps. The numbers identify mapping units. The symbols represent land features which are too small to delineate but are important in land management. The symbols used in this survey are listed below:

✓	Rock outcrop
T	Talus
X	Unstable area
	Wet spot and small marshes
	Slump or slide scarp
	Slump
M	Modal site location
S	Sample location
	Avalanche track or debris slide track

Mapping units 1/ are shown on the soil maps as numbers. Mapping units contain a dominant soil which accounts for at least 70 percent of the soil delineation.

The dominant soil of the mapping unit is described in the mapping unit description and identified by the same number as used for the mapping unit. Within the mapping unit other soils occur. Those most commonly associated with the dominant soil of the mapping unit are included in the descriptions as inclusions. These inclusions of other soils account for no more than 30 percent of the mapping unit.

1/ Mapping units contain a dominant taxonomic unit with inclusions of other taxonomic units.

Most of the mapping units are described in detail and have a general profile sketch to depict the dominant soil, ranges of soil layer thicknesses and total depth, and the bedrock type. These soils have a definable range of characteristics that can be represented by a soil profile description. The dominant soils of Mapping Units 1, 2, 3, 4 and 5 are limited in extent or quite variable in composition and have not been described in detail. Mapping Units 40, 50 and 60 are composed of rock outcrop and also have not been described in detail. These eight mapping units are described by a short narrative.

The management interpretations presented in the Atlas apply only to the dominant soil in each mapping unit. The interpretations for most inclusions within any mapping unit are listed on the interpretative tables according to the appropriate soil number. The Tables of Some Mapping Unit Characteristics, Features and Qualities, and Table of Bedrock Characteristics of Mapping Units are also numbered according to the dominant soil in the mapping unit. However, each entry in these tables applies to the entire mapping unit consisting of the dominant soil and all inclusions.

Many symbols shown on the maps have three digits and are called "Complexes." Complexes are mapping units used in areas where two defined mapping units are present in an arrangement too complex to separate. The following legend indicates the mapping unit components of the complex and the percentage of each component. For identification and management interpretations for areas that have been mapped with complexes, refer to the descriptions and interpretative information given for the individual mapping units. For example, Mapping Unit 323 is composed of approximately 70 percent Mapping Unit 32 and 30 percent Mapping Unit 33. Refer to each mapping unit description for the soil, bedrock, and landform characteristics, and to the Tables for the interpretative information.

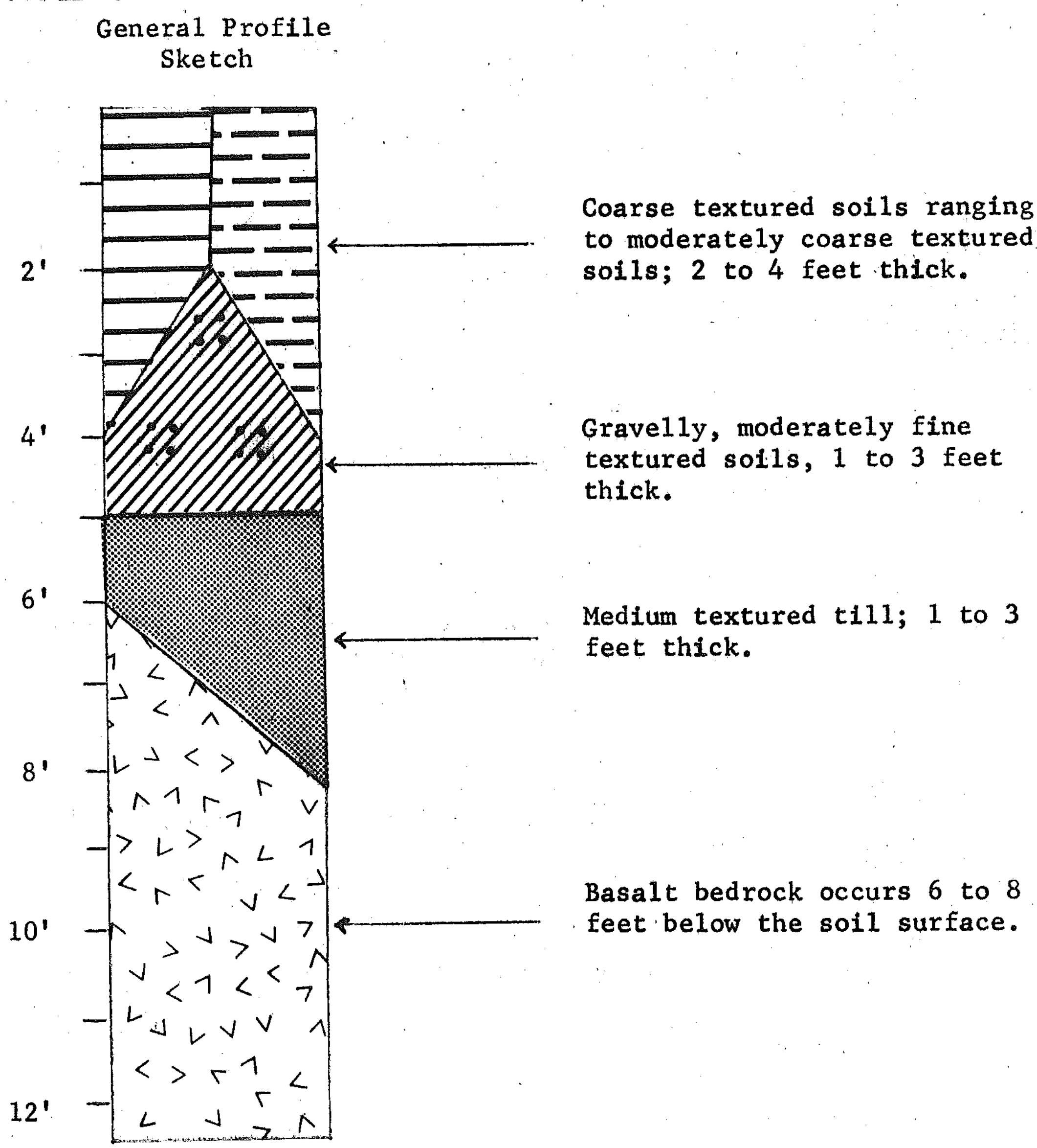
LEGEND OF COMPLEXES

Mapping Unit Number	Mapping Unit Components
067	60 percent Unit 6 and 40 percent Unit 57
071	60 percent Unit 7 and 40 percent Unit 61
072	60 percent Unit 7 and 40 percent Unit 62
077	50 percent Unit 7 and 50 percent Unit 17
131	60 percent Unit 13 and 40 percent Unit 1
146	60 percent Unit 14 and 40 percent Unit 6
152	50 percent Unit 15 and 50 percent Unit 2
171	60 percent Unit 17 and 40 percent Unit 61
197	50 percent Unit 19 and 50 percent Unit 67
198	50 percent Unit 19 and 50 percent Unit 68
311	70 percent Unit 31 and 30 percent Unit 11
312	60 percent Unit 31 and 40 percent Unit 32
317	60 percent Unit 31 and 40 percent Unit 17
321	70 percent Unit 32 and 30 percent Unit 11
323	70 percent Unit 32 and 30 percent Unit 33
402	60 percent Unit 40 and 40 percent Unit 42
410	60 percent Unit 41 and 40 percent Unit 40
417	60 percent Unit 41 and 40 percent Unit 17
420	60 percent Unit 42 and 40 percent Unit 40
423	70 percent Unit 42 and 30 percent Unit 33
429	60 percent Unit 42 and 40 percent Unit 19
521	60 percent Unit 52 and 40 percent Unit 11
550	60 percent Unit 55 and 40 percent Unit 50
553	60 percent Unit 55 and 40 percent Unit 23
560	60 percent Unit 56 and 40 percent Unit 50
572	60 percent Unit 57 and 40 percent Unit 22
576	60 percent Unit 57 and 40 percent Unit 6
602	60 percent Unit 60 and 40 percent Unit 62
607	60 percent Unit 60 and 40 percent Unit 67
608	60 percent Unit 60 and 40 percent Unit 68
610	60 percent Unit 61 and 40 percent Unit 60
617	60 percent Unit 61 and 40 percent Unit 17
620	60 percent Unit 62 and 40 percent Unit 60
627	60 percent Unit 62 and 40 percent Unit 17
670	60 percent Unit 67 and 40 percent Unit 60
673	50 percent Unit 67 and 50 percent Unit 23
679	50 percent Unit 67 and 50 percent Unit 29
680	60 percent Unit 68 and 40 percent Unit 60
689	50 percent Unit 68 and 50 percent Unit 29

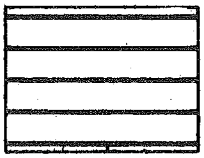
LEGEND FOR GENERAL PROFILE SKETCH

A general profile sketch is a schematic representation of the soil and bedrock materials of mapping units. It depicts the ranges of soil texture, rock fragment content, thickness, depth to bedrock and kind of bedrock. The sketch does not show such factors as soil structure, compaction or permeability. The patterns used are shown and defined on the Legend for General Profile Sketch.

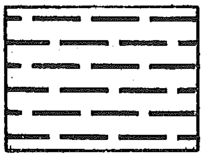
The following example illustrates how a general profile sketch is used.



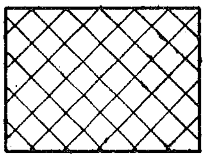
SOIL MATERIALS



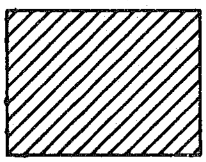
Coarse Textured Soils: Sands, Loamy Sands



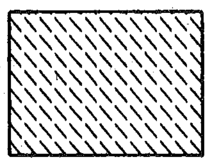
Moderately Coarse Textured Soils: Sandy Loam, Fine Sandy Loam



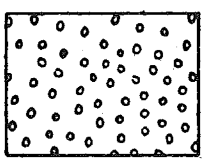
Medium Textured Soils: Very Fine Sandy Loam, Loam, Silt Loam, Silt



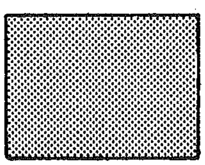
Moderately Fine Textured Soils: Clay Loam, Sandy Clay Loam, Silty Clay Loam



Fine Textured Soils: Sandy Clay, Silty Clay, Clay

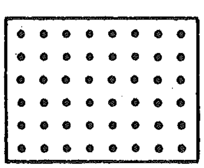


Coarse to Moderately Coarse Textured Till: Loamy Sand, Sandy Loam, Fine Sandy Loam

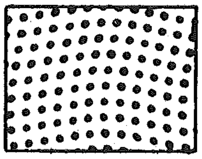


Medium Textured Till: Very Fine Sandy Loam, Silt Loam

TEXTURAL MODIFIERS

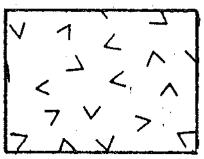


Gravel

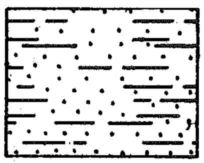


Cobbles

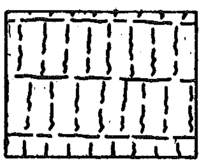
BEDROCK MATERIALS



Basalt Bedrock



Thinly Bedded Sediments: Graywacke, Sandstone, Siltstone, Shale, Argillite, etc.



Massive Thick Bedded Sediments: Conglomerates, Sandstones, Graywacke

MAPPING UNIT DESCRIPTIONS [1/]

Mapping Unit 1 - Fresh sands and gravels. This mapping unit consists of fresh sands and gravels occurring along streams. It is barren of vegetation and is frequently flooded. The most common inclusion is Soil 13.

Mapping Unit 2 - Eroded glacial drift. This mapping unit consists of very steep eroded edges of glacial drift that occur along deeply-incised streams in major glacial valleys. It is often highly dissected and contains numerous slides. The most common inclusions are Soils 9 and 15.

Mapping Unit 3 - Landslide debris. This mapping unit consists of unstable landslide debris occurring on slopes greater than 35 percent. It is highly variable in composition, ranges from nonplastic to plastic, and includes rock, till and/or soil materials of various textures and proportions. Inclusions are unknown.

Mapping Unit 4 - Marshlands. This mapping unit consists of depressional areas that are seasonably ponded. The soils are slowly permeable, imperfectly to poorly drained, and normally support sedges, rushes, grasses, tag alder and willow. The most common inclusion is Soil 18.

Mapping Unit 5 - Glacial plucked land. This mapping unit consists of very shallow, very gravelly loams and very gravelly silt loams overlying boulders and stones. Many boulders are visible at the surface. This mapping unit occurs in high elevation, steep cirque headwalls and sideslopes. Vegetation isusually scrub alder, willow, vine maple, devils club and associated species. The most common inclusions are Soils 40, 41, 42, 60, 67 and 68.

1/ Mapping Units 1 through 5 and 40, 50 and 60 are miscellaneous units and were not described in detail.

MAPPING UNIT 6

Mapping Unit 6 consists of Soil 6 and inclusions of other soils. The most common inclusions are Soils 14, 13 and 10.

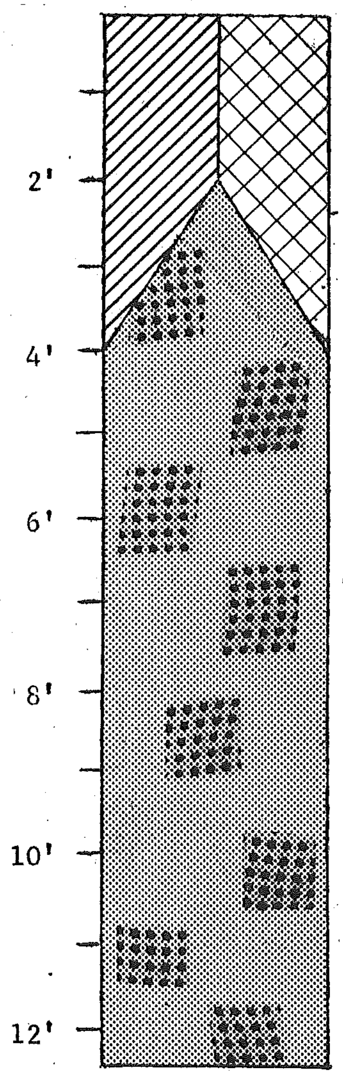
Mapping Unit 6 is similar to Mapping Unit 7 with the exception of landform and inclusions.

Soil 6 is a very deep nonplastic to slightly plastic soil derived from glacial till. Surface soils are generally thin to moderately thick silt loams. Subsoils are generally very thick, moderately compact, cobbly silt loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 6 occurs in glacially modified valley bottoms and gentle toe-slopes of less than 35 percent. This soil ranges in elevation from 100 to 1000 feet and supports Site Class III and IV Douglas-fir along with cedar, hemlock and true fir. This soil is moderately well to imperfectly drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 6



Range of Profile Characteristics of Soil 6

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Reddish brown to brown silty clay loam ranging to loam; moderate to strong fine subangular blocky structure; 15 to 30 percent rounded gravel, cobbles and stones by volume; slightly sticky to sticky; nonplastic to slightly plastic, pH ranges from 5.0 to 6.0. 24 to 48" thick.

Subsoil Layer - Yellowish brown to brown cobbly to very cobbly silt loam ranging to cobbly to very cobbly fine sandy loam; massive; moderately compact; 35 to 60 percent rounded gravel, cobbles, and stones by volume; nonsticky to slightly sticky; non-plastic to slightly plastic; pH ranges from 5.5 to 6.0. 96 to greater than 120 inches thick.

MAPPING UNIT 7

Mapping Unit 7 consists of Soil 7 and inclusions of other soils. The most common inclusions are Soils 61, 31 and 17.

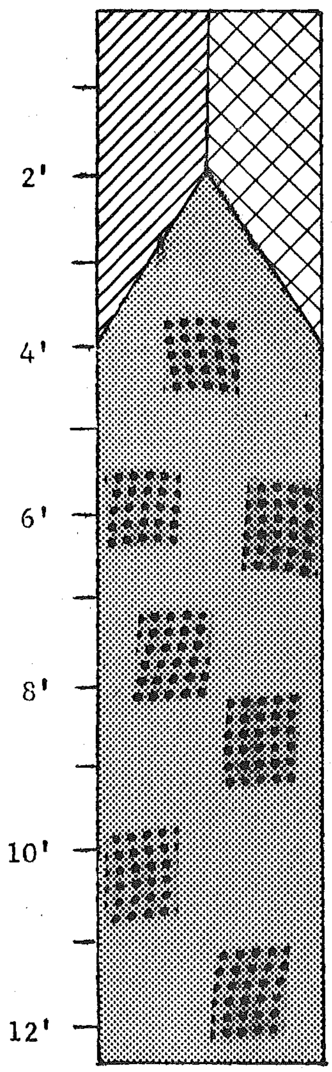
Mapping Unit 7 is similar to Mapping Unit 6 with exception of landform and inclusions.

Soil 7 is a very deep nonplastic to slightly plastic soil derived from glacial till. Surface soils are generally thin to moderately thick silt loams. Subsoils are generally very thick, moderately compact, cobbly silt loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 7 occurs on glacially modified toe slopes and lower sideslopes of greater than 35 percent. This soil ranges in elevation from 200 to 2000 feet and supports Site Class III and IV Douglas-fir along with cedar, hemlock and true fir. This soil is moderately well to imperfectly drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 7



Range of Profile Characteristics of Soil 7

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Reddish brown to brown silty clay loam ranging to loam; moderate to strong fine subangular blocky structure; 15 to 30 percent rounded gravel, cobbles and stones by volume; slightly sticky to sticky; nonplastic to slightly plastic, pH ranges from 5.0 to 6.0. 24 to 48" thick.

Subsoil Layer - Yellowish brown to brown cobbly to very cobbly silt loam ranging to cobbly to very cobbly fine sandy loam; massive; moderately compact; 35 to 60 percent rounded gravel, cobbles, and stones by volume; nonsticky to slightly sticky; nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 96 to greater than 120 inches thick.

MAPPING UNIT 8

Mapping Unit 8 consists of Soil 8 and inclusions of other soils. The most common inclusions are Soils 6, 9 and 14.

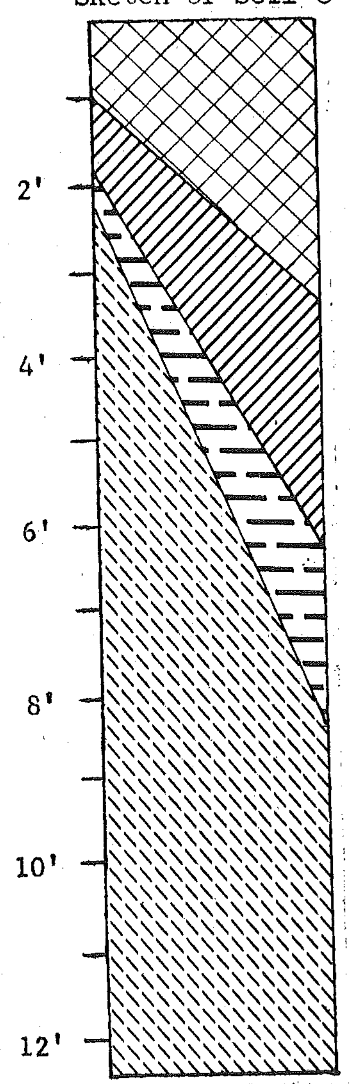
Mapping Unit 8 is similar to Mapping Unit 25 with the exception of Site Class and subsoil variability.

Soil 8 is a very deep plastic soil derived from glacio-lacustrine deposits. Surface soils are generally thin silt loams. Subsoils are very thick and consist of stratified layers of clay loam, fine sandy loam and silty clay.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 8 occurs in glacially modified valley bottoms of less than 35 percent slope. This soil ranges in elevation from 100 to 1500 feet and supports Site Class II and III Douglas-fir along with cedar and hemlock. Permeability is rapid in the surface soils and moderate to slow in the subsoils. This soil is moderately well to imperfectly drained.

General Profile Sketch of Soil 8



Range of Profile Characteristics of Soil 8

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Brown to dark brown silt loam ranging to silty clay loam; moderate to strong, fine, subangular blocky structure; 5 to 20 percent rounded gravels by volume; sticky, slightly plastic; pH ranges from 5.0 to 5.5. 12 to 40 inches thick.

Subsoil Layers - Dark gray brown to olive gray, stratified layers of clay loam, fine sandy loam and silty clay; massive; 5 to 20 percent rounded gravel by volume; nonsticky to very sticky; nonplastic to plastic; pH ranges from 5.5 to 6.0. 109 to greater than 134 inches thick.

MAPPING UNIT 9

Mapping Unit 9 consists of Soil 9 and inclusions of other soils. The most common inclusions are Soils 15, 7, 8 and 2.

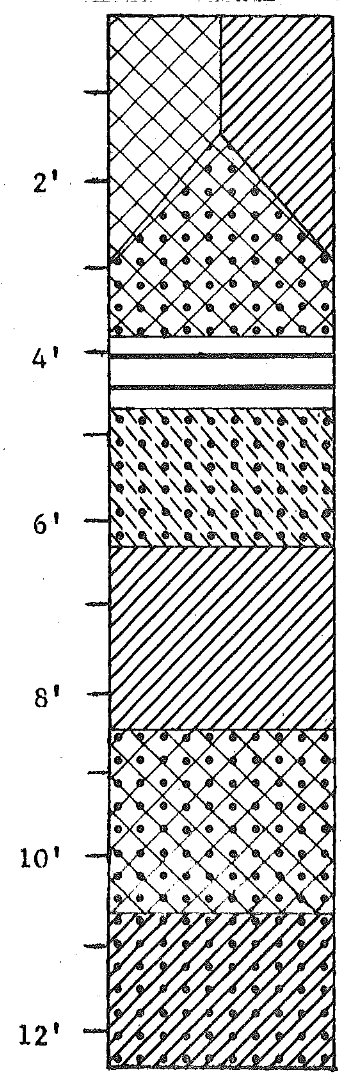
Mapping Unit 9 is similar to Mapping Unit 12 with the exception of vegetation, Site Class, textures and inclusions.

Soil 9 is a very deep slightly plastic to very plastic soil derived from glacio-fluvial deposits. Surface soils are generally thin silty clay loams. Subsoils are generally very thick, slightly to moderately compact, and consist of alternating sublayers of sands, silts, clays and silty clay loams. Sublayers may range from nongravelly to very gravelly.

Bedrock is basalt or sedimentary and occurs 12 or more feet beneath the soil surface.

Typically Soil 9 occurs in glacially modified, dissected and uneven valley toe slopes of greater than 35 percent. Slides are common along stream incised edges. This soil ranges in elevation from 100 to 1500 feet and supports Site Class II and III Douglas-fir along with cedar and hemlock. Permeability is rapid in the surface soils and moderate to slow in the subsoils. This soil is moderately well to imperfectly drained.

General Profile Sketch of Soil 9



Range of Profile Characteristics of Soil 9

Litter - Needles, leaves, twigs and decomposing organic matter. 0 to 3 inches thick.

Surface Layer - Dark brown to dark gray silt loam ranging to silty clay loam; moderate fine subangular blocky structure; 15 to 30 percent rounded gravels and cobbles by volume; slightly sticky to sticky; slightly plastic to plastic; pH ranges from 4.5 to 5.5. 20 to 35 inches thick.

Subsoil Layers - Dark yellowish brown to dark gray, stratified sublayers of sands, silts, clays and silty clay loams ranging from nongravelly to very gravelly; massive; slightly to moderately compact; 25 to 70 percent rounded gravel and cobbles; nonsticky to very sticky; nonplastic to very plastic; pH ranges from 5.5 to 6.0. 109 to greater than 124 inches thick.

MAPPING UNIT 10

Mapping Unit 10 consists of Soil 10 and inclusions of other soils. The most common inclusions are Soils 6, 11 and 14.

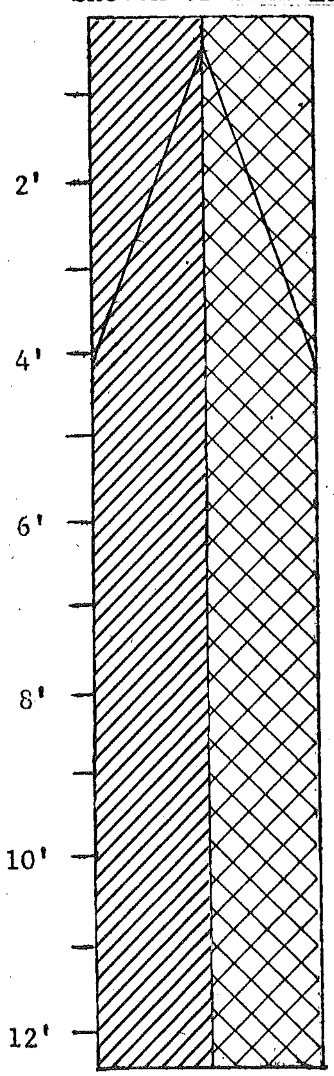
Mapping Unit 10 is similar to Mapping Unit 11 with the exception of landform and inclusions.

Soil 10 is a very deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin to moderately thick silt loams. Subsoils are generally very thick silty clay loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 10 occurs on toeslopes of less than 35 percent. This soil ranges in elevation from 100 to 2000 feet and supports Site Class II and III Douglas-fir along with hemlock and true fir. Subsoils are weakly compacted in areas that have been glacially influenced. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 10



Range of Profile Characteristics of Soil 10

Litter -	Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.
Surface Layer -	Brown to dark yellowish brown silt loam ranging to silty clay loam; moderate to strong medium subangular blocky structure; 5 to 35 percent subangular gravel and cobbles by volume; slightly sticky to sticky; slightly plastic to plastic; pH ranges from 4.5 to 5.5. 5 to 50 inches thick.
Subsoil Layer -	Yellowish brown to brown silt loam ranging to clay loam; massive; 15 to 35 percent subangular gravel and cobbles by volume; noncompacted to weakly compact; slightly sticky to sticky; slightly plastic to plastic; pH ranges from 5.0 to 6.0. 94 to greater than 132 inches thick.

MAPPING UNIT 11

Mapping Unit 11 consists of Soil 11 and inclusions of other soils. The most common inclusions are Soils 63, 64, 32, 31, 51, 52 and 10.

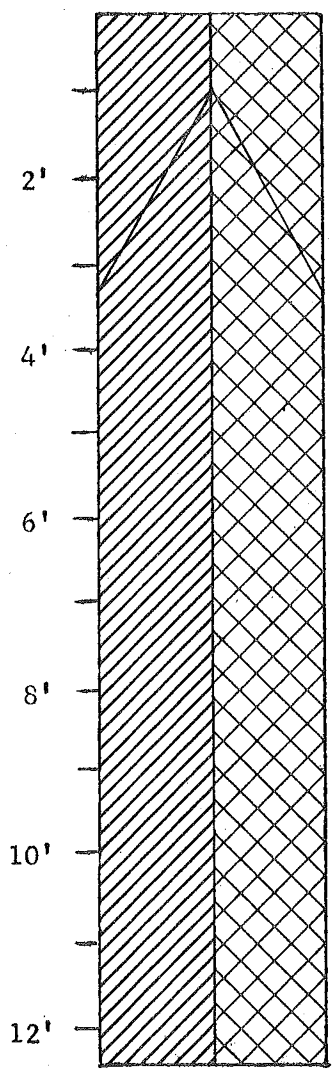
Mapping Unit 11 is similar to Mapping Unit 10 with the exception of landform and inclusions.

Soil 11 is a very deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin to moderately thick silt loams. Subsoils are generally thick to very thick silty clay loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 11 occurs on sideslopes and toeslopes of greater than 35 percent. This soil ranges in elevation from 100 to 2000 feet and supports Site Class II and III Douglas-fir along with hemlock and true fir. Subsoils are weakly compacted in areas that have been glacially influenced. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 11



Range of Profile Characteristics of Soil 11

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Brown to dark yellowish brown silt loam ranging to silty clay loam; moderate to strong fine subangular blocky structure; 10 to 30 percent subangular gravel and cobbles by volume; slightly sticky to sticky; slightly plastic to plastic; pH ranges from 4.5 to 5.5. 12 to 40 inches thick.

Subsoil Layer - Yellowish brown to brown silt loam ranging to clay loam; massive; 20 to 35 percent subangular gravel and cobbles by volume; noncompact to weakly compact; slightly sticky to sticky, slightly plastic to plastic; pH ranges from 5.0 to 6.0. 90 to greater than 120 inches thick.

MAPPING UNIT 12

Mapping Unit 12 consists of Soil 12 and inclusions of other soils. The most common inclusions are Soils 24, 19 and 74.

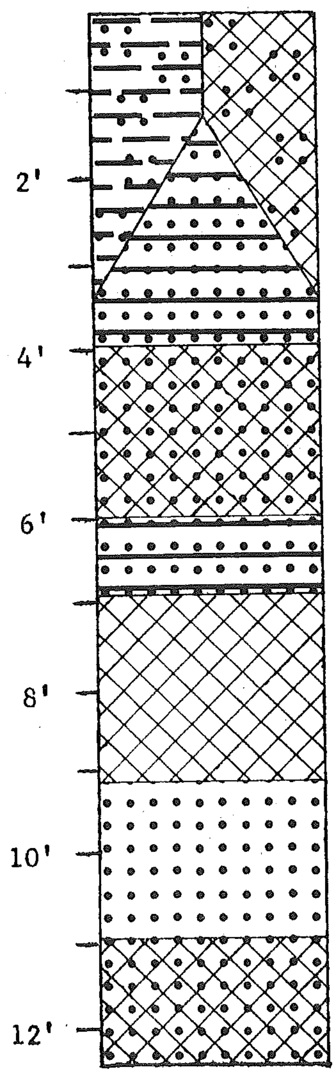
Mapping Unit 12 is similar to Mapping Unit 9 with the exceptions of texture, Site Class, vegetation and inclusions.

Soil 12 is a very deep nonplastic to slightly plastic soil derived from glacio-fluvial deposits. Surface soils are generally thin to moderately thick gravelly loam. Subsoils are generally very thick gravelly sands, gravel, and gravelly silt loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 12 occurs on steep and eroded drainages in glacial valleys. This soil ranges in elevation from 1000 to 3500 feet and supports Site Class IV and V Douglas-fir along with hemlock, true fir and cedar. This soil is well to moderately well drained. Permeability is rapid in the surface soils and moderate to slow in the subsoils.

General Profile Sketch of Soil 12



Range of Profile Characteristics of Soil 12

Litter - Needles, leaves, twigs and decomposing organic matter. 0 to 2 inches thick.

Surface Layer - Brown to dark brown gravelly sandy loam ranging to gravelly silt loam; weak, fine, subangular blocky structure ranging to massive; 35 to 50 percent rounded gravel by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 15 to 40 inches thick.

Subsoil Layers - Dark yellowish brown to gray brown, stratified sublayers of gravelly sand, gravel and gravelly silt loam; massive; 10 to as high as 100 percent rounded gravel and cobbles in some sublayers; weakly to moderately compact; nonsticky to sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 100 to greater than 130 inches thick.

MAPPING UNIT 13

Mapping Unit 13 consists of Soil 13 and inclusions of other soils. The most common inclusions are Soils 1, 6 and 14.

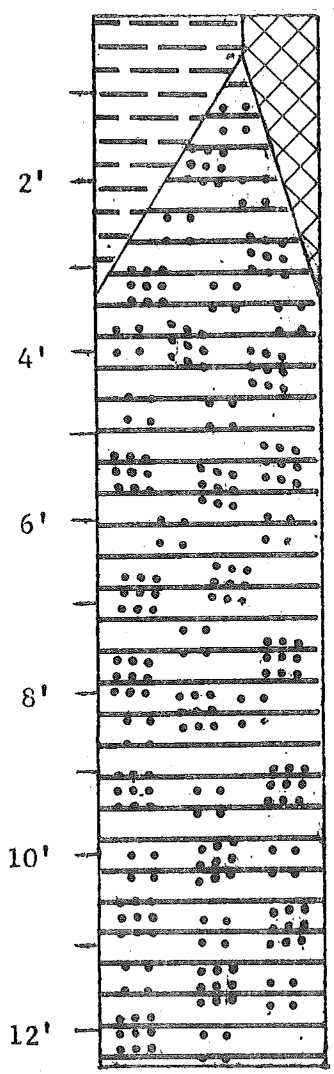
Mapping Unit 13 is similar to Mapping Unit 1 with exception of surface texture, vegetation and inclusions.

Soil 13 is a very deep nonplastic to slightly plastic soil derived from alluvium. Surface soils are generally thin to moderately thick fine sandy loams or silt loams. Subsoils are generally very thick sands, gravel and cobbles.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 13 occurs on river flood plains. This soil ranges in elevation from 100 to 1500 feet and supports bigleaf maple, alder, cedar, and Site Class III Douglas-fir. Permeability is rapid in the surface soils and very rapid in the subsoils. Drainage is moderate to imperfect due to high water table.

General Profile Sketch of Soil 13



Range of Profile Characteristics of Soil 13

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Very dark gray to brown fine sandy loam or silt loam; single grain ranging to weak subangular blocky structure, 5 to 25 percent rounded gravel by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 6 to 40 inches thick.

Subsoil Layer - Very dark gray mixed sands, rounded gravel and cobbles; single grain, nonsticky, nonplastic. 100 to greater than 144 inches thick.

MAPPING UNIT 14

Mapping Unit 14 consists of Soil 14 and inclusions of other soils. The most common inclusions are Soils 6, 10, 16, 15 and 18.

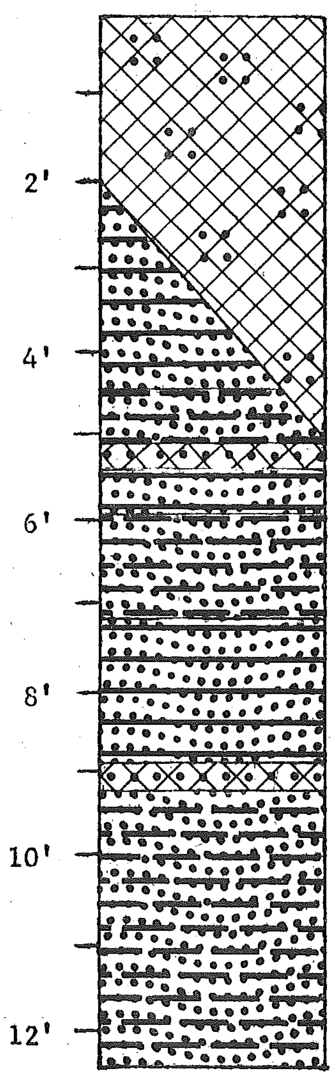
Mapping Unit 14 is similar to Mapping Unit 15 with the exception of landform and inclusions, and to Mapping Unit 18 with exception of drainage and inclusions.

Soil 14 is a very deep nonplastic to slightly plastic soil derived from glacial drift. Surface soils are generally thin to moderately thick gravelly silt loams. Subsoils are generally very thick, weakly to moderately compact, very cobbly loamy sand. Coarse fragments are partially stratified.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 14 occurs on outwash plains in large glacial valleys on slopes of less than 35 percent. This soil ranges in elevation from 100 to 1200 feet and supports Site Class II and III Douglas-fir along with hemlock and cedar. Drainage varies from well to moderately well. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 14



Range of Profile Characteristics of Soil 14

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Brown to dark reddish brown gravelly to very gravelly silt loam ranging to gravelly to very gravelly loam; moderate to strong medium subangular blocky structure in the surface foot grading to weak below; 35 to 65 percent rounded gravel, cobbles and stones by volume; slightly sticky to sticky; nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 24 to 60 inches thick.

Subsoil Layer - Dark grayish brown to brown, very cobbly loamy sand ranging to very cobbly fine sandy loam with lenses of gravelly silt loam; single grain, 65 to 80 percent, partially stratified, rounded gravel, cobbles and stones by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 84 to greater than 120 inches thick.

MAPPING UNIT 15

Mapping Unit 15 consists of Soil 15 and inclusions of other soils. The most common inclusions are Soils 7 and 17.

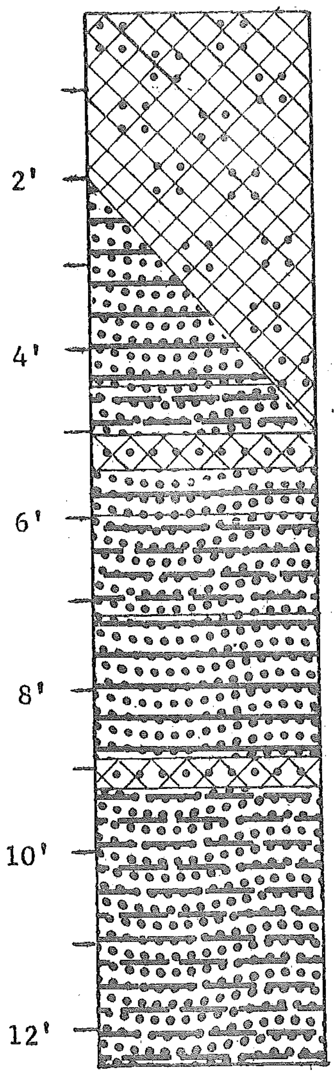
Mapping Unit 15 is similar to Mapping Unit 14 with exception of landform and inclusions.

Soil 15 is a very deep nonplastic to slightly plastic soil derived from glacial drift. Surface soils are generally thin to moderately thick gravelly silt loams. Subsoils are generally very thick, weakly to moderately compact, very cobbly loamy sands. Coarse fragments are partially stratified.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 15 occurs on outwash plains and in large glacial valleys on slopes greater than 35 percent. Slopes are often steep and dissected. This soil ranges in elevation from 100 to 1200 feet and supports Site Class II and III Douglas-fir along with hemlock and cedar. Drainage varies from well to moderately well. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 15



Range of Profile Characteristics of Soil 15

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Brown to dark reddish brown gravelly to very gravelly silt loam ranging to gravelly to very gravelly loam; moderate to strong fine subangular blocky structure in the surface foot grading to weak below; 35 to 65 percent rounded gravel, cobbles and stones by volume; slightly sticky to sticky; nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 24 to 60 inches thick.

Subsoil Layer - Dark grayish brown to brown, very cobbly loamy sand ranging to very cobbly fine sandy loam with lenses of gravelly silt loam; single grain; 65 to 80 percent, partially stratified, rounded gravel, cobbles and stones by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 84 to greater than 120 inches thick.

MAPPING UNIT 16

Mapping Unit 16 consists of Soil 16 and inclusions of other soils. The most common inclusions are Soils 6, 11, 14 and 17.

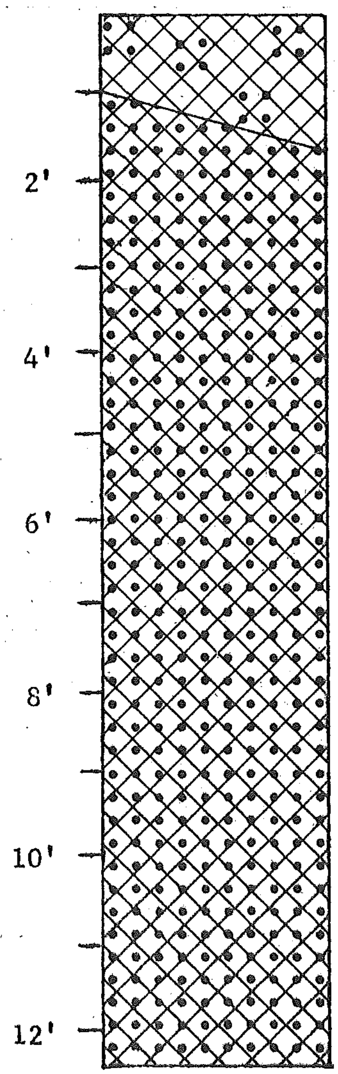
Mapping Unit 16 is similar to Mapping Unit 17 with the exception of landform and inclusions.

Soil 16 is a very deep nonplastic to slightly plastic soil derived from residuum and colluvium. Surface soils are generally thin gravelly loams. Subsoils are generally very thick very gravelly loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 16 occurs in small cirque basins and in valleys on slopes of less than 35 percent. This soil ranges in elevation from 200 to 4000 feet and supports Site Class III and IV Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 16



Range of Profile Characteristics of Soil 16

Litter -	Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.
Surface Layer -	Reddish brown to brown gravelly loam ranging to gravelly silt loam; moderate to weak fine subangular blocky structure; 30 to 45 percent subangular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 12 to 20 inches thick.
Subsoil Layer -	Dark yellowish brown to brown very gravelly loam ranging to very gravelly silt loam; massive; 50 to 70 percent subangular gravel, cobbles and stones by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 124 to greater than 132 inches thick.

MAPPING UNIT 17

Mapping Unit 17 consists of Soil 17 and inclusions of other soils. The most common inclusions are Soils 61, 62, 41, 42, 7 and 16.

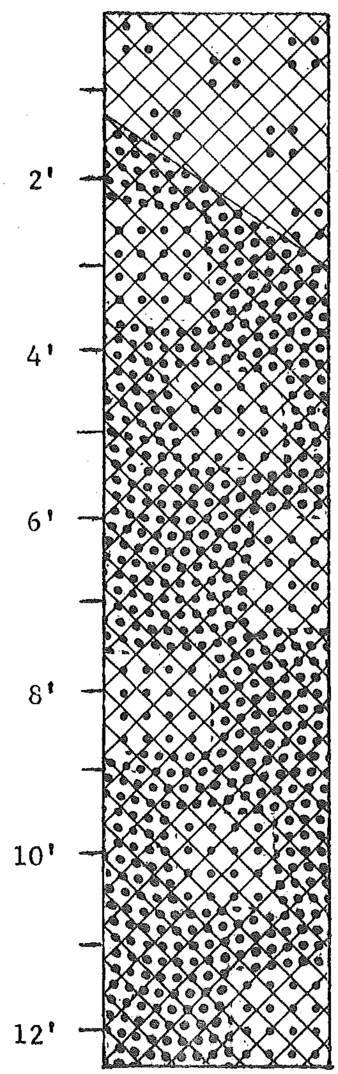
Mapping Unit 17 is similar to Mapping Unit 16 with the exception of landform and inclusions.

Soil 17 is a very deep nonplastic to slightly plastic soil derived from colluvium. Surface soils are generally thin very gravelly loams. Subsoils are generally very thick very gravelly and cobbly loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 17 occurs on sideslopes and toeslopes greater than 35 percent. This soil ranges in elevation from 200 to 4000 feet and supports Site Class III, IV and V Douglas-fir along with hemlock and true fir. Rock fragments may be mixed throughout profile or may be stratified parallel with the slope by colluviation. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 17



Range of Profile Characteristics of Soil 17

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Dark reddish brown very gravelly loam ranging to very gravelly silt loam; weak to moderate fine subangular blocky structure; 35 to 65 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 6.0. 15 to 36 inches thick.

Subsoil Layer - Dark reddish brown to brown very gravelly and cobbly loam dominates but range includes very gravelly sandy loam and very gravelly silt loam; soil and rock materials may be uniformly distributed throughout or may be stratified into many thin sublayers by colluviation; massive; 65 to 85 percent angular gravel, cobbles and stones; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 84 to greater than 105 inches thick.

MAPPING UNIT 18

Mapping Unit 18 consists of Soil 18 and inclusions of other soils. The most common inclusions are Soils 14 and 6.

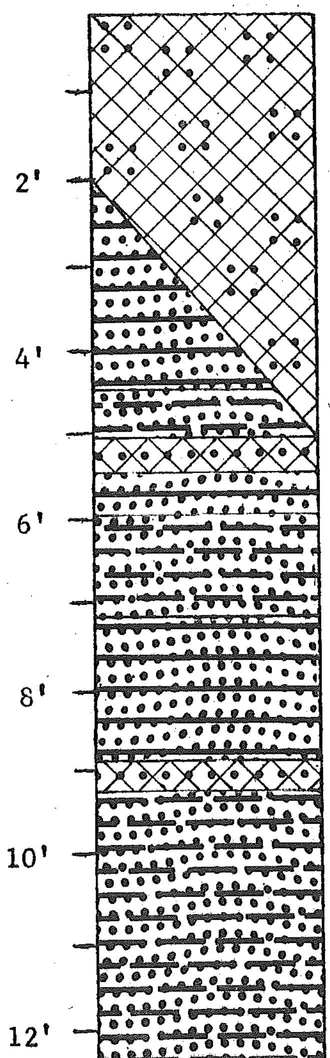
Mapping Unit 18 is similar to Mapping Unit 14 with exception of drainage and inclusions.

Soil 18 is a very deep nonplastic to slightly plastic soil derived from glacial drift. Surface soils are generally thin to moderately thick gravelly silt loams. Subsoils are generally very thick, weakly to moderately compact, very cobbly loamy sand. Coarse fragments are partially stratified.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 18 occurs on outwash plains in large glacial valleys on slopes of less than 35 percent. This soil ranges in elevation from 100 to 1200 feet and supports Site Class II and III Douglas-fir along with hemlock and cedar. This soil is imperfectly to poorly drained. Permeability is moderate in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 18



Range of Profile Characteristics of Soil 18

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Brown to dark reddish brown gravelly to very gravelly silt loam ranging to gravelly to very gravelly loam; moderate to strong medium subangular blocky structure in the surface foot grading to weak below; 35 to 65 percent rounded gravel, cobbles and stones by volume; slightly sticky to sticky; nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 24 to 60 inches thick.

Subsoil Layer - Dark grayish brown to brown, very cobbly loamy sand ranging to very cobbly fine sandy loam with lenses of gravelly silt loam; single grain, 65 to 80 percent, partially stratified, rounded gravel, cobbles and stones by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic to flightly plastic; pH ranges from 5.5 to 6.0. 84 to greater than 120 inches thick.

MAPPING UNIT 19

Mapping Unit 19 consists of Soil 19 and inclusions of other soils. The most common inclusions are Soils 42, 41, 62, 61 and 17.

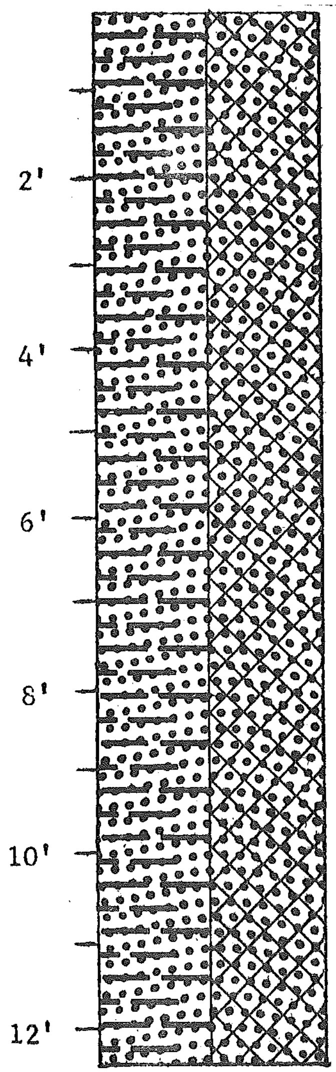
Mapping Unit 19 is similar to Mapping Unit 17 with the exception of compaction and inclusions.

Soil 19 is a very deep nonplastic soil derived from colluvium. Surface soils are generally thin to moderately thick very cobbly loams. Subsoils are generally very thick, weakly to moderately compact, very cobbly sandy loams.

Bedrock is basalt or sedimentary and generally occurs 12 feet or more beneath the soil surface.

Typically Soil 19 occurs on steep glacial valley walls and toeslopes greater than 35 percent. This soil ranges in elevation from 800 to 4000 feet and supports Site Class IV and V Douglas-fir along with hemlock, true fir and cedar. This soil is generally well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 19



Range of Profile Characteristics of Soil 19

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Reddish brown to brown very cobbly loam ranging to very cobbly sandy loam; weak very fine subangular blocky structure ranging to massive; 50 to 70 percent subangular cobbles and gravel by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 20 to 50 inches thick.

Subsoil Layer - Brown to dark yellowish brown very cobbly loam ranging to very cobbly sandy loam; single grain; 50 to 80 percent gravel, cobbles and stones by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic; pH ranges from 5.5 to 6.0. 95 to greater than 125 inches thick.

MAPPING UNIT 20

Mapping Unit 20 consists of Soil 20 and inclusions of other soils. The most common inclusions are Soils 14, 18, 73, 6 and 21.

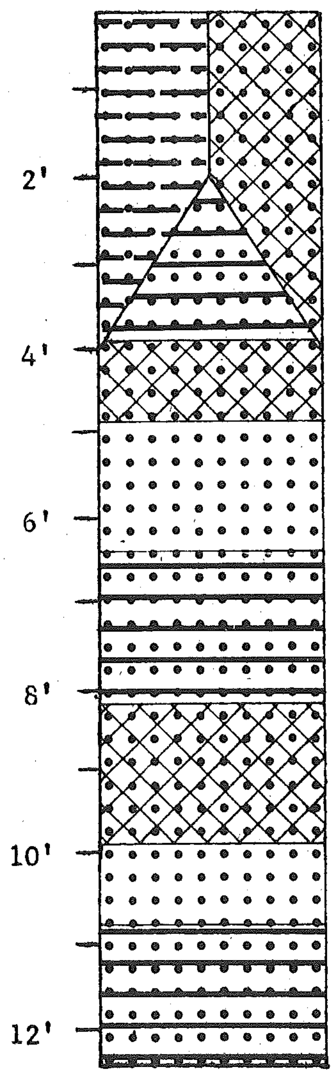
Mapping Unit 20 is similar to Mapping Unit 21 with exception of landform and inclusions.

Soil 20 is a very deep nonplastic soil derived from glacial drift. Surface soils are generally thin to moderately thick gravelly sandy loams. Subsoils are generally thick, weakly to moderately compact, stratified sands, gravel, very gravelly sandy loams and very gravelly silt loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 20 occurs on broad outwash plains of less than 35 percent slope. This soil ranges in elevation from 50 to 1500 feet and supports Site Class IV and V Douglas-fir along with hemlock and cedar. This soil is well drained on areas of higher relief and imperfectly drained in depressions. Permeability is rapid in the surface soils and moderate to slow in the subsoils.

General Profile Sketch of Soil 20



Range of Profile Characteristics of Soil 20

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Reddish brown to dark yellowish brown gravelly to very gravelly sandy loam ranging to gravelly loam; weak very fine subangular blocky structure; 35 to 60 percent subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.5 to 6.0. 24 to 48 inches thick.

Subsoil Layers - This portion of the profile consists of many stratified sublayers of sand, gravel, very gravelly sandy loam and very gravelly silt loam. Colors range from gray to dark yellowish brown; sublayers contain 65 to 100 percent rounded gravel and cobbles by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 96 to greater than 120 inches thick.

MAPPING UNIT 21

Mapping Unit 21 consists of Soil 21 and inclusions of other soils. The most common inclusions are Soils 15 and 20.

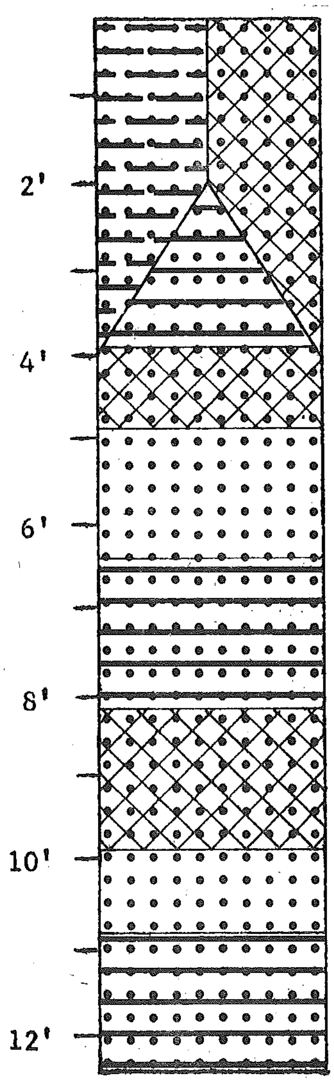
Mapping Unit 21 is similar to Mapping Unit 20 with the exception of landform and inclusions.

Soil 21 is a very deep nonplastic to slightly plastic soil derived from glacial drift. Surface soils are generally thin to moderately thick gravelly sandy loams. Subsoils are thick, weakly to moderately compact, stratified sands, gravel, very gravelly sandy loams and very gravelly silt loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 21 occurs on slopes of greater than 35 percent within or adjacent to outwash plains. This soil ranges in elevation from 100 to 1500 feet and supports Site Class IV and V Douglas-fir along with hemlock. This soil is well to moderately well drained. Permeability is rapid in the surface soils and moderate to slow in the subsoils.

General Profile Sketch of Soil 21



Range of Profile Characteristics of Soil 21

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Reddish brown to dark yellowish brown gravelly to very gravelly sandy loam ranging to gravelly to very gravelly loam; weak medium subangular blocky structure; 35 to 60 percent subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.5 to 6.0. 24 to 48 inches thick.

Subsoil Layers - This portion of the profile consists of many stratified sublayers of sand, gravel, very gravelly sandy loam and very gravelly silt loam. Colors range from gray to dark yellowish brown; sublayers contain 65 to 100 percent rounded gravel and cobbles by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 96 to greater than 120 inches thick.

MAPPING UNIT 22

Mapping Unit 22 consists of Soil 22 and inclusions of other soils. The most common inclusions are Soils 20, 23, 25 and 27.

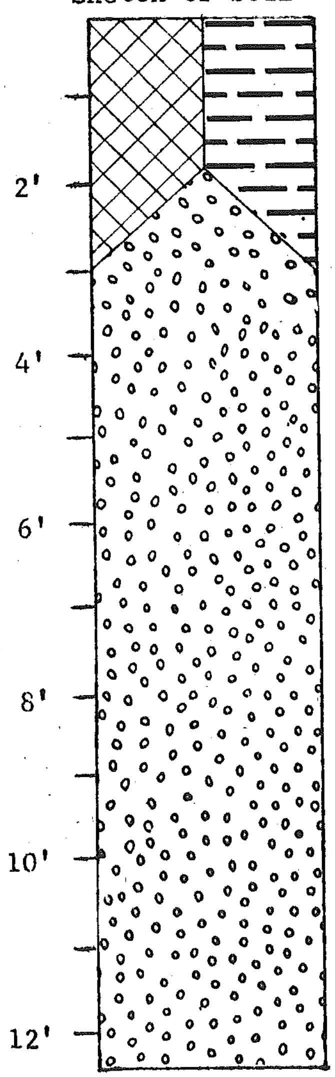
Mapping Unit 22 is similar to Mapping Unit 23 with the exception of landform and inclusions.

Soil 22 is a very deep nonplastic to slightly plastic soil derived from glacial till. Surface soils are generally thin sandy loams. Subsoils are generally very thick, moderately compact, gravelly sandy loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 22 occurs on gently rolling glacial modified foothills of less than 35 percent slope. This soil ranges in elevation from 100 to 3200 feet and supports Site Class IV and V Douglas-fir and cedar. This soil is moderately well drained. Permeability is rapid in the surface soils and moderate to slow in the subsoils.

General Profile Sketch of Soil 22



Range of Profile Characteristics of Soil 22

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Gray brown to yellowish brown sandy loam ranging to loam; weak fine subangular blocky structure ranging to single grain; 15 to 30 percent rounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 4.5 to 5.5. 22 to 36 inches thick.

Subsoil Layer - Dark grayish brown to brown gravelly loam ranging to gravelly sandy loam; massive; 35 to 50 percent rounded gravel and cobbles by volume; moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 100 to greater than 125 inches thick.

MAPPING UNIT 23

Mapping Unit 23 consists of Soil 23 and inclusions of other soils. The most common inclusions are Soils 21, 22, 24, 55 and 56.

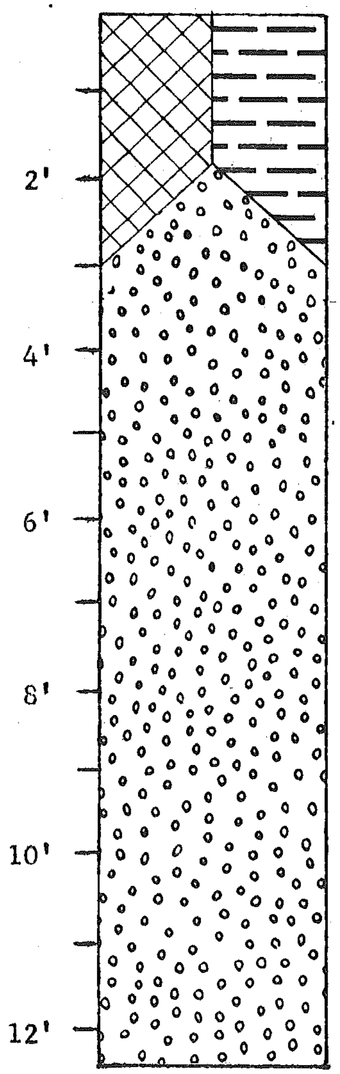
Mapping Unit 23 is similar to Mapping Unit 22 with the exception of landform and inclusions.

Soil 23 is a very deep nonplastic to slightly plastic soil derived from glacial till. Surface soils are generally thin sandy loams. Subsoils are generally very thick, moderately compact, gravelly sandy loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 23 occurs on rolling foothills and glacially modified sideslopes on greater than 35 percent slopes. This soil ranges in elevation from 100 to 3200 feet and supports Site Class IV and V Douglas-fir along with cedar. This soil is moderately well drained. Permeability is rapid in the surface soils and moderate to slow in the subsoils.

General Profile Sketch of Soil 23



Range of Profile Characteristics of Soil 23

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Gray brown to yellowish brown sandy loam ranging to loam; weak fine subangular blocky structure ranging to single grain; 15 to 30 percent rounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 4.5 to 5.5. 22 to 36 inches thick.

Subsoil Layer - Dark grayish brown to brown gravelly loam ranging to gravelly sandy loam; massive; 35 to 50 percent rounded gravel and cobbles by volume; moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 100 to greater than 125 inches thick.

MAPPING UNIT 24

Mapping Unit 24 consists of Soil 24 and inclusions of other soils. The most common inclusions are Soils 25, 23 and 12.

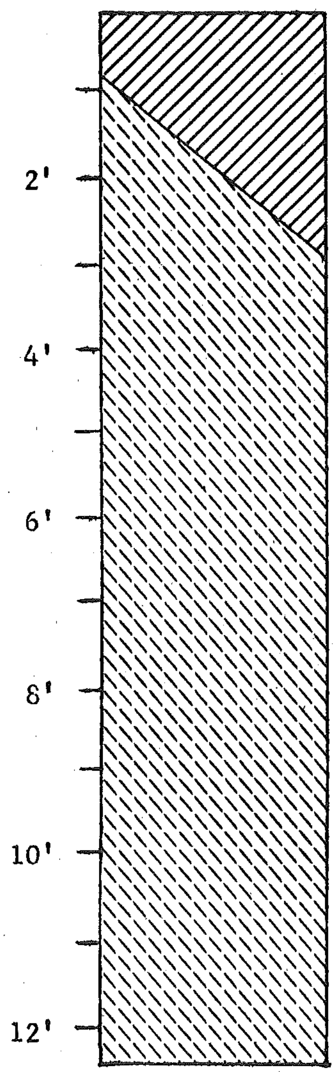
Mapping Unit 24 is similar to Mapping Unit 25 with exception of landform and inclusions.

Soil 24 is a very deep plastic to very plastic soil derived from glacio-lacustrine deposits. Surface soils are generally thin, noncompact to weakly compact, silty clay loams. Subsoils are generally thick to very thick, weakly to moderately compact, silty clays.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 24 occurs on uneven toeslopes and in drainages with slopes greater than 35 percent. This soil ranges in elevation from 500 to 3500 feet and supports Site Class III and IV Douglas-fir along with hemlock, cedar and alder. This soil is moderately well to imperfectly drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 24



Range of Profile Characteristics of Soil 24

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Dark brown to dark yellowish brown silty clay loams ranging to clay loams; moderate to strong, fine and medium blocky structure ranging to subangular; 5 to 20 percent rounded gravel; noncompact to weakly compact; slightly sticky to sticky, slightly plastic to plastic; pH ranges from 5.5 to 6.0. 10 to 35 inches thick.

Subsoil Layer - Dark yellowish brown to bluish gray silty clay ranging to sandy clay and clay; massive; weakly to moderately compact; 5 to 25 percent gravel and cobbles by volume; sticky to very sticky, plastic to very plastic; pH ranges from 5.5 to 6.0. 110 to greater than 135 inches thick.

MAPPING UNIT 25

Mapping Unit 25 consists of Soil 25 and inclusions of other soils. The most common inclusions are Soils 22, 24 and 73.

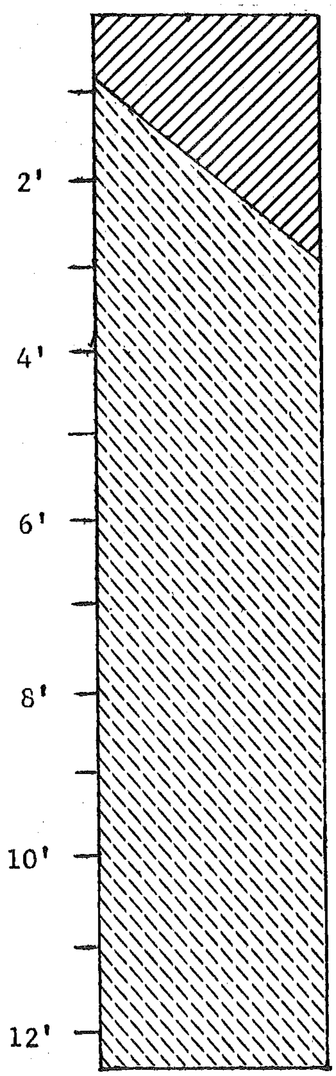
Mapping Unit 25 is similar to Mapping Unit 24 with exception of landform and inclusions, and to Mapping Unit 8 with the exception of Site Class, texture and inclusions.

Soil 25 is a very deep plastic to very plastic soil derived from glacio-lacustrine deposits. Surface soils are generally thin, noncompact to weakly compact, silty clay loams. Subsoils are generally thick to very thick, weakly to moderately compact, silty clays.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 25 occurs in depressions and on areas adjacent to drainages on slopes of less than 35 percent. This soil ranges in elevation from 500 to 3000 feet and supports Site Class III and IV Douglas-fir along with hemlock, cedar and alder. This soil is moderately well to imperfectly drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 25



Range of Profile Characteristics of Soil 25

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Dark brown to dark yellowish brown silty clay loams ranging to clay loams; moderate to strong medium blocky structure ranging to subangular; 5 to 20 percent rounded gravel; noncompact to weakly compact; slightly sticky to sticky, slightly plastic to plastic; pH ranges from 5.5 to 6.0. 10 to 35 inches thick.

Subsoil Layer - Dark yellowish brown to bluish gray silty clay ranging to sandy clay and clay; massive; weakly to moderately compact; 5 to 25 percent gravel and cobbles by volume; sticky to very sticky, plastic to very plastic; pH ranges from 5.5 to 6.0. 110 to greater than 135 inches thick.

MAPPING UNIT 27

Mapping Unit 27 consists of Soil 27 and inclusions of other soils. The most common inclusions are Soils 28, 73 and 16.

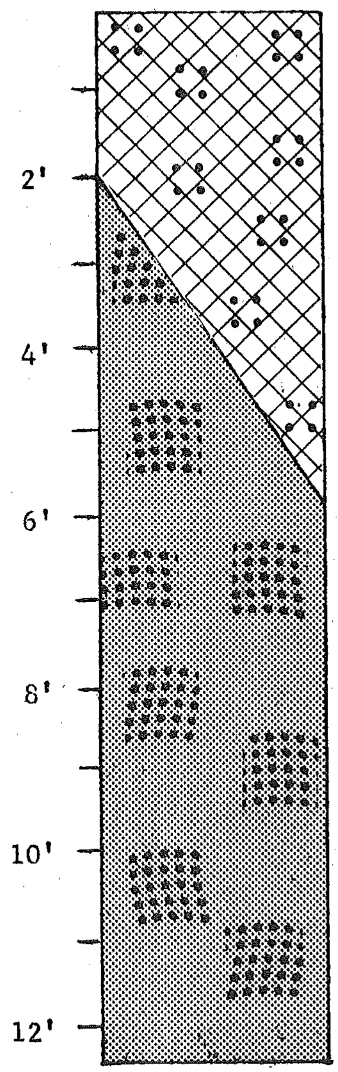
Mapping Unit 27 is similar to Mapping Unit 16 with the exception of compaction and inclusions.

Soil 27 is a very deep nonplastic to slightly plastic soil derived from glacial till and colluvium. Surface soils are generally thin to moderately thick gravelly loams. Subsoils are generally thick, weakly to moderately compact, very cobbly loams.

Bedrock is basalt or sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 27 occurs on glacially modified valley bottoms and toeslopes of less than 35 percent. This soil ranges in elevation from 800 to 3800 feet and supports Site Class III, IV and V Douglas-fir along with hemlock, cedar and true fir. This soil is well to moderately well drained. Permeability is rapid in the surface soils and moderate to slow in the subsoils.

General Profile Sketch of Soil 27



Range of Profile Characteristics of Soil 27

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Dark reddish brown to brown gravelly loams; weak very fine subangular blocky structure ranging to massive; 30 to 45 percent subrounded gravel, cobbles and stones by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 6.0. 24 to 70 inches thick.

Subsoil Layer - Reddish brown to dark yellowish brown very cobbly loam; massive; 50 to 65 percent subrounded gravel, cobbles and stones by volume; weakly to moderately compact; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 74 to greater than 120 inches thick.

MAPPING UNIT 28

Mapping Unit 28 consists of Soil 28 and inclusions of other soils. The most common inclusions are Soils 73, 67, 68 and 29.

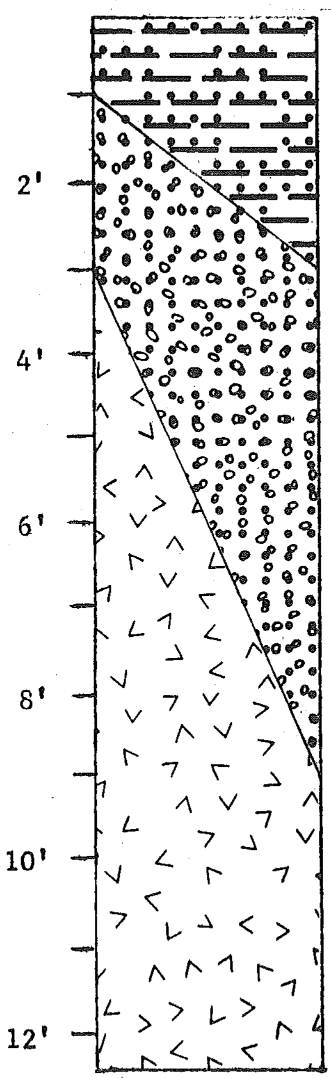
Mapping Unit 28 is similar to Mapping Unit 29 with the exception of landform and inclusions.

Soil 28 is a moderately deep to deep nonplastic soil derived from glacial till. Surface soils are generally thin gravelly sandy loams. Subsoils are generally thin to moderately thick, strongly cemented, very gravelly sandy loams.

Bedrock is basalt and occurs 3 to 9 feet beneath the soil surface.

Typically Soil 28 occurs in valley bottoms and gentle toeslopes of less than 35 percent. This soil ranges in elevation from 500 to 3800 feet and supports Site Class IV and V Douglas-fir along with hemlock. This soil is moderately well drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 28



Range of Profile Characteristics of Soil 28

Litter - Needles, leaves, twigs and decomposed organic matter. 1 to 3 inches thick.

Surface Layer - Reddish brown to dark brown gravelly to very gravelly sandy loam ranging to gravelly to very gravelly loam; weak very fine subangular blocky structure; 35 to 65 percent subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 12 to 36 inches thick.

Subsoil Layer - Light olive brown to brown very gravelly sandy loam ranging to very gravelly loamy sand; massive; strongly cemented; 45 to 75 percent subrounded gravel and cobbles by volume; nonsticky, nonplastic; pH ranges from 5.5 to 6.0. 24 to 72 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 29

Mapping Unit 29 consists of Soil 29 and inclusions of other soils. The most common inclusions are Soils 74, 67, 68 and 28.

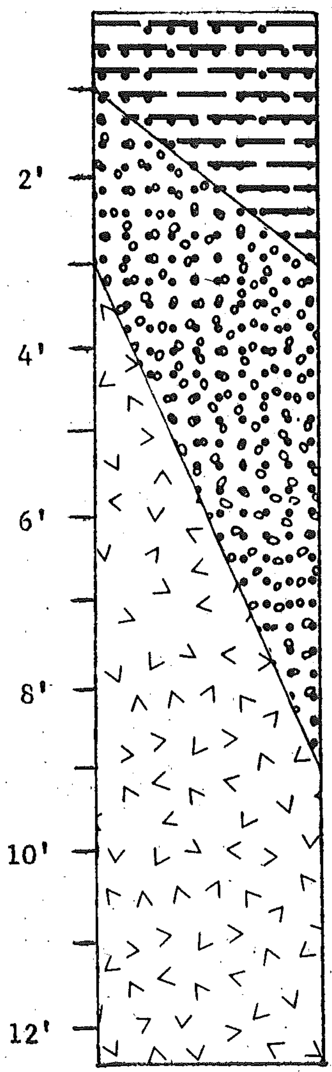
Mapping Unit 29 is similar to Mapping Unit 28 with the exception of landform and inclusions.

Soil 29 is a moderately deep nonplastic soil derived from glacial till. Surface soils are generally thin gravelly sandy loams. Subsoils are generally thin to moderately thick, strongly cemented, very gravelly sandy loams.

Bedrock is a basalt and occurs 3 to 9 feet beneath the soil surface.

Typically Soil 29 occurs on steep sideslopes of greater than 35 percent. This soil ranges in elevation from 500 to 4000 feet and supports Site Class IV and V Douglas-fir and hemlock. This soil is well drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 29



Range of Profile Characteristics of Soil 29

Litter - Needles, leaves, twigs and decomposed organic matter. 1 to 3 inches thick.

Surface Layer - Reddish brown to dark brown gravelly to very gravelly sandy loam ranging to gravelly to very gravelly loam; weak fine subangular blocky structure; 35 to 65 percent subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 12 to 36 inches thick.

Subsoil Layer - Light olive brown to brown very gravelly sandy loam ranging to very gravelly loamy sand; massive; strongly cemented; 45 to 75 percent gravel and cobbles by volume; nonsticky, nonplastic; pH ranges from 5.5 to 6.0. 24 to 72 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 31

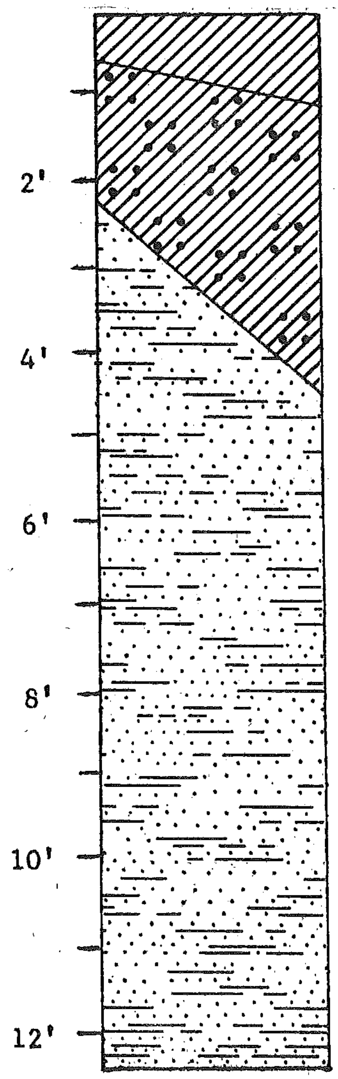
Mapping Unit 31 consists of Soil 31 and inclusions of other soils. The most common inclusions are Soils 11 and 32.

Soil 31 is a shallow to moderately deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin silty clay loams. Subsoils are generally thin gravelly silty clay loams.

Bedrock is sedimentary and is competent graywacke and sandstone interbedded with moderately competent argillite, mudstone and siltstone.

Typically Soil 31 occurs on ridges and upper sideslopes. This soil ranges in elevation from 800 to 3500 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid to moderate.

General Profile Sketch of Soil 31



Range of Profile Characteristics of Soil 31

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Surface Layer - Dark brown to dark yellowish brown silty clay loam ranging to silt loam; moderate to strong fine subangular blocky structure; 20 to 35 percent angular gravel and cobbles by volume; slightly sticky to sticky; slightly plastic to plastic; pH ranges from 4.0 to 5.0. 7 to 14 inches thick.

Subsoil Layer - Brown to yellowish brown gravelly silty clay loam ranging to gravelly clay loam; weak fine subangular blocky structure grading to massive; 40 to 55 percent angular gravel and cobbles by volume; sticky, plastic; pH ranges from 5.0 to 5.5. 20 to 40 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 32

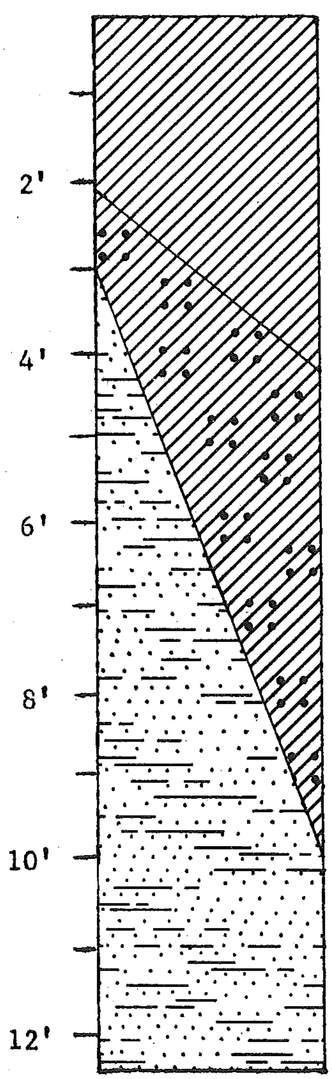
Mapping Unit 32 consists of Soil 32 and inclusions of other soils. The most common inclusions are Soils 11, 31 and 33.

Soil 32 is a moderately deep to deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin to moderately thick silty clay loams. Subsoils are generally thin to thick gravelly clay loams.

Bedrock is moderately competent graywacke interbedded with incompetent mudstone, argillite and siltstone.

Typically Soil 32 occurs on steep midslope positions below major ridge systems. This soil ranges in elevation from 500 to 3500 feet and supports Site Class III and IV Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid to moderate.

General Profile Sketch of Soil 32



Range of Profile Characteristics of Soil 32

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Dark reddish brown to dark brown silty clay loam ranging to clay loam; moderate to strong medium subangular blocky structure; 10 to 35 percent angular gravel and cobbles by volume; slightly sticky to sticky, slightly plastic; pH ranges from 4.5 to 5.0. 25 to 50 inches thick.

Subsoil Layer - Pale brown to strong brown gravelly to very gravelly silty clay loam ranging to gravelly to very gravelly clay loam; weak fine subangular blocky structure ranging to massive; 40 to 60 percent angular gravel, cobbles and stones by volume; sticky to very sticky, plastic; pH ranges from 5.5 to 6.0. 36 to 70 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 33

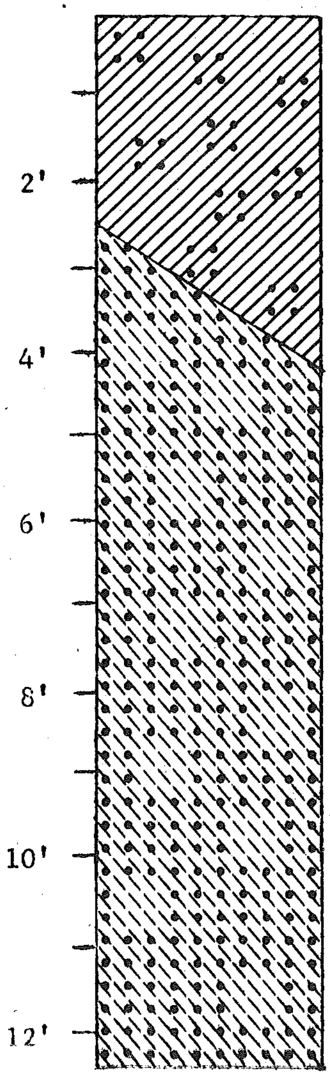
Mapping Unit 33 consists of Soil 33 and inclusions of other soils. The most common inclusions are Soils 31, 32 and 11.

Soil 33 is a very deep plastic to very plastic soil derived from residuum and colluvium. Surface soils are generally thin to moderately thick gravelly silty clay loams. Subsoils are generally thick to very thick gravelly sandy clays.

Bedrock is sedimentary and occurs 12 feet or more beneath the soil surface.

Typically Soil 33 occurs in steep midslope drainage positions below major ridge systems. This soil ranges in elevation from 400 to 3500 feet and supports Site Class III and IV Douglas-fir along with hemlock and cedar. This soil is moderately well to imperfectly drained. Permeability is moderate in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 33



Range of Profile Characteristics of Soil 33

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Dark brown to dark yellowish brown gravelly silty clay loam ranging to gravelly clay loam; moderate to strong medium subangular blocky structure; 30 to 45 percent angular gravel, and cobbles by volume; sticky to very sticky; plastic; pH ranges from 5.0 to 5.5. 30 to 50 inches thick.

Subsoil Layer - Dark gray to dark blueish gray gravelly to very gravelly sandy clay; massive; 45 to 75 percent angular gravel, cobbles and stones by volume; sticky to very sticky, plastic to very plastic; pH ranges from 5.0 to 6.0. 94 to greater than 114 inches thick.

MAPPING UNIT 40

Mapping Unit 40 consists of sedimentary rock outcrop and inclusions of soils. The most common inclusions are Soils 41, 42 and undefined shallow alpine meadow soils. On highest elevations, inclusions of perpetual snow and ice may also occur.

The sedimentary rock outcrop is composed of hard black argillite and red limy argillite associated with mudstone, graywacke and basalt.

Typically, this mapping unit occurs on crests and sideslopes of high elevation mountain systems. Vegetation is generally limited to scattered areas of grasses, sedges and small shrubs.

MAPPING UNIT 41

Mapping Unit 41 consists of Soil 41 and inclusions of other soils. The most common inclusions are Soils 42, 43, 40, 17 and 19.

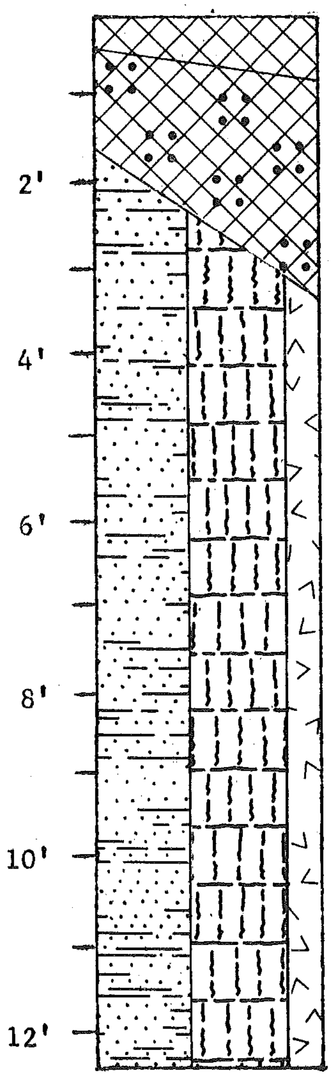
Mapping Unit 41 is similar to Mapping Units 42 and 43 with exception of landform and inclusions.

Soil 41 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. Surface soils are generally thin loams. Subsoils are generally thin gravelly loams.

Bedrock is hard black argillite and red limy argillite with associated manganese ore, graywacky, siltstone and basalt.

Typically Soil 41 occurs on smooth, steep sideslopes and ridge tops. This soil ranges in elevation from 700 to 4300 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 41



Range of Profile Characteristics of Soil 41

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Dark reddish brown to brown loam ranging to silt loam; weak fine subangular blocky structure; 20 to 35 percent angular gravel and cobbles by volume; nonsticky to slightly sticky; nonplastic to slightly plastic; pH ranges from 4.5 to 5.5. 5 to 10 inches thick.

Subsoil Layer - Dark reddish brown to dark brown gravelly loam ranging to gravelly silt loam; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel, cobbles and stones by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 15 to 30 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 42

Mapping Unit 42 consists of Soil 42 and inclusions of other soils. The most common inclusions are Soils 41, 43, 40, 17 and 19.

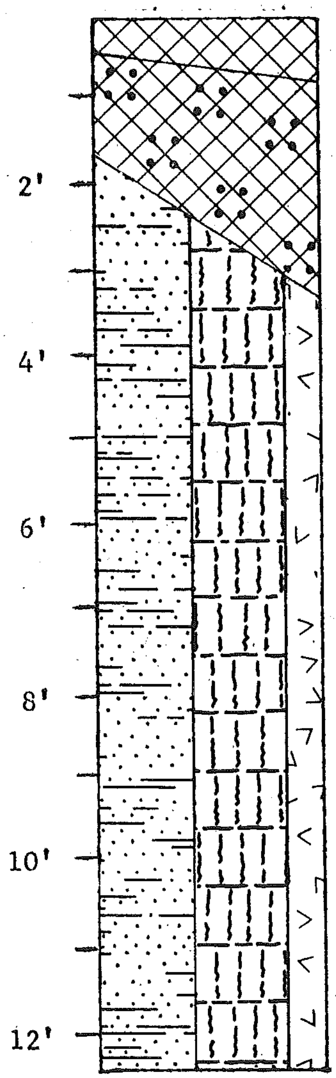
Mapping Unit 42 is similar to Mapping Units 41 and 43 with exception of landform and inclusions.

Soil 42 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. Surface soils are generally thin loams. Subsoils are thin gravelly loams.

Bedrock is hard black argillite and red limy argillite with associated manganese ore, graywacky, siltstone and basalt.

Typically Soil 42 occurs on steep dissected sideslopes and headlands. This soil ranges in elevation from 700 to 4300 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 42



Range of Profile Characteristics of Soil 42

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Surface Layer - Dark reddish brown to brown loam ranging to silt loam; weak very fine subangular blocky structure; 20 to 35 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 4.5 to 5.5. 5 to 10 inches thick.

Subsoil Layer - Dark reddish brown to dark brown gravelly loam ranging to gravelly silt loam; weak very fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel, cobbles and stones by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 15 to 30 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 43

Mapping Unit 43 consists of Soil 43 and inclusions of other soils. The most common inclusions are Soils 16, 41, 42 and 40.

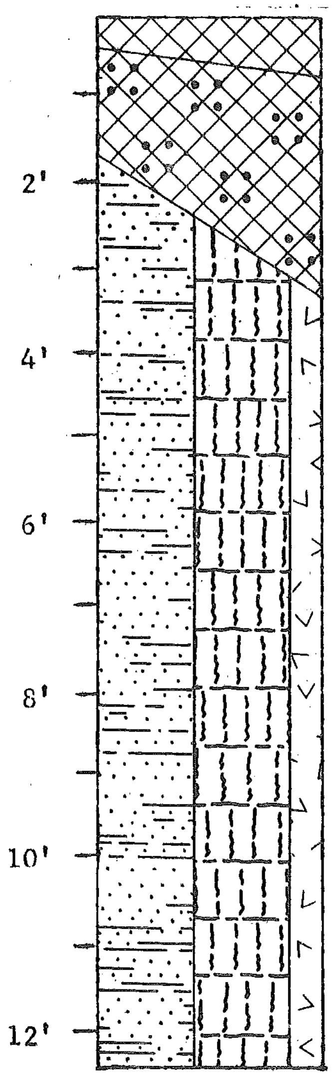
Mapping Unit 43 is similar to Mapping Units 41 and 42 with the exception of landform and inclusions.

Soil 43 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. Surface soils are generally thin loams. Subsoils are generally thin gravelly loams.

Bedrock is hard black argillite and red limy argillite with associated manganese ore, graywacky, siltstone and basalt.

Typically Soil 43 occurs on bench land and sideslopes of less than 35 percent. This soil ranges in elevation from 700 to 4300 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 43



Range of Profile Characteristics of Soil 43

Litter -	Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.
Surface Layer -	Dark reddish brown to brown loam ranging to silt loam; weak very fine subangular blocky structure; 20 to 35 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 4.5 to 5.5. 5 to 10 inches thick.
Subsoil Layer -	Dark reddish brown to dark brown gravelly loam ranging to gravelly silt loam; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel, cobbles and stones by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 15 to 30 inches thick.
Bedrock -	Sedimentary bedrock.

MAPPING UNIT 50

Mapping Unit 50 consists of sedimentary rock outcrop and inclusions of soils. The most common inclusions are Soils 51, 52, 55, 56 and undefined shallow alpine meadow soils. On highest elevations, inclusions of perpetual snow and ice may also occur.

The sedimentary rock outcrop is composed of poorly bedded graywacke and conglomerate and thinly bedded slate, mudstone, siltstone and some arkosic sandstone.

This mapping unit occurs on ridge crests and sideslopes. Vegetation is generally limited to scattered areas of grasses, sedges and small shrubs.

MAPPING UNIT 51

Mapping Unit 51 consists of Soil 51 and inclusions of other soils. The most common inclusions are Soils 52, 50 and 17.

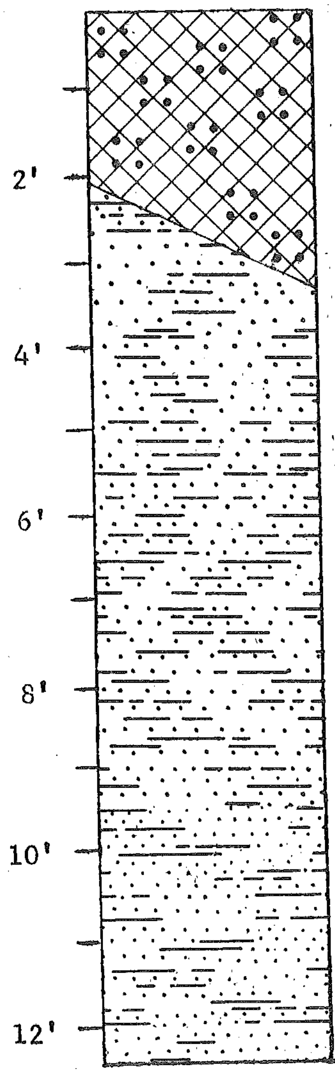
Mapping Unit 51 is similar to Mapping Unit 52 with the exception of landform and inclusions.

Soil 51 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. These soils are generally gravelly loams.

Bedrock is marine sediments composed of moderately fractured graywacke and sandstone, interbedded with highly fractured mudstone, siltstone, and slate.

Typically Soil 51 occurs on steep smooth to somewhat dissected sideslopes and ridgetops. This soil ranges in elevation from 800 to 3800 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 51



Range of Profile Characteristics of Soil 51

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Soil Layer - Dark brown to dark yellowish brown gravelly loams ranging to gravelly silt loams; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 25 to 36 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 52

Mapping Unit 52 consists of Soil 52 and inclusions of other soils. The most common inclusions are Soils 51, 50, 17, 11 and 32.

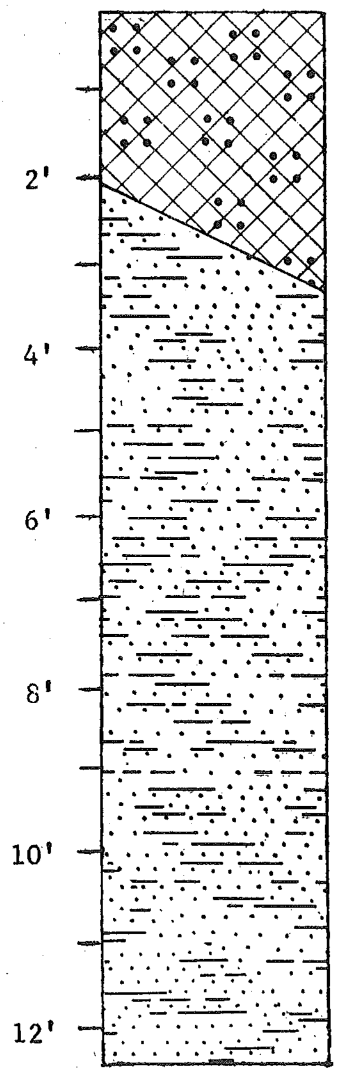
Mapping Unit 52 is similar to Mapping Unit 51 with the exception of landform and inclusions.

Soil 52 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. These soils are generally gravelly loams.

Bedrock is marine sediments composed of moderately fractured graywacke and sandstone, interbedded with highly fractured mudstone, siltstone, and slate.

Typically Soil 52 occurs on very steep, highly dissected sideslopes and ridgetops. This soil ranges in elevation from 800 to 3800 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile
Sketch of Soil 52



Range of Profile Characteristics
of Soil 52

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Soil Layer - Dark brown to dark yellowish brown gravelly loams ranging to gravelly silt loams; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 25 to 36 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 55

Mapping Unit 55 consists of Soil 55 and inclusions of other soils. The most common inclusions are Soils 56, 50, 17 and 7.

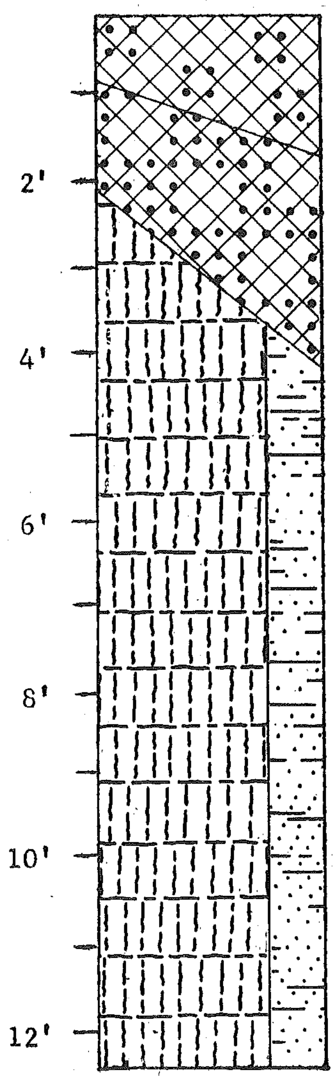
Mapping Unit 55 is similar to Mapping Unit 56 with exception of landform and inclusions.

Soil 55 is a shallow to moderately deep nonplastic to slightly plastic soil derived from glacial till or residuum. Surface soils are generally thin gravelly silt loams. Subsoils are generally thin gravelly silt loams.

Bedrock is marine sediments and is dominated by thickly bedded sandstone, graywacke and conglomerate with lesser amounts of thinly bedded sandstones, siltstones and shales.

Typically Soil 55 occurs on steep smooth sideslopes in areas that have been overridden by continental glaciation. This soil ranges in elevation from 500 to 4000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile
Sketch of Soil 55



Range of Profile Characteristics
of Soil 55

Litter - **Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.**

Surface Layer - **Dark brown to dark yellowish brown gravelly silt loam ranging to gravelly loam; moderate to weak fine subangular blocky structure; 35 to 50 percent angular or subrounded gravel and cobbles by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 10 to 20 inches thick.**

Subsoil Layer - **Brown to dark yellowish brown gravelly to very gravelly silt loams ranging to gravelly to very gravelly loams; weak fine subangular blocky structure grading to massive; 35 to 65 percent angular or subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 15 to 30 inches thick.**

Bedrock - **Sedimentary bedrock.**

MAPPING UNIT 56

Mapping Unit 56 consists of Soil 56 and inclusions of other soils. The most common inclusions are Soils 55, 50 and 17.

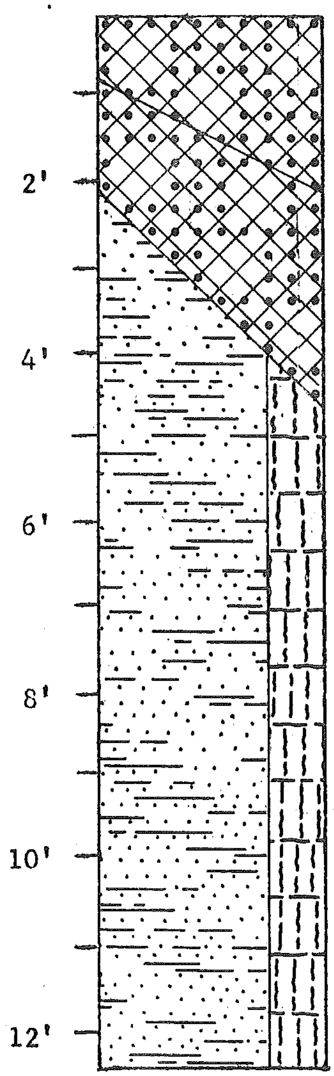
Mapping Unit 56 is similar to Mapping Unit 55 with exception of landform and inclusions.

Soil 56 is a shallow to moderately deep nonplastic to slightly plastic soil derived from glacial till or residuum. Surface soils are generally thin gravelly silt loams. Subsoils are generally thin gravelly silt loams.

Bedrock is marine sediments and is dominated by thinly bedded sandstones, siltstones and shales with lesser amounts of thickly bedded sandstone, graywacke and conglomerate.

Typically Soil 56 occurs on steep, very dissected sideslopes in areas that have been overridden by continental glaciation. This soil ranges in elevation from 500 to 4000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 56



Range of Profile Characteristics of Soil 56

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Dark brown to dark yellowish brown gravelly to very gravelly silt loam ranging to very gravelly loam; weak to moderate fine subangular blocky structure; 35 to 65 percent angular or subrounded gravel and cobbles by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 10 to 25 inches thick.

Subsoil Layer - Brown to dark yellowish brown gravelly to very gravelly silt loams ranging to gravelly to very gravelly loams; massive; 35 to 80 percent angular or subrounded gravel and cobbles by volume; slightly sticky to sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 15 to 30 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 57

Mapping Unit 57 consists of Soil 57 and inclusions of other soils. The most common inclusions are Soils 22, 50 and 55.

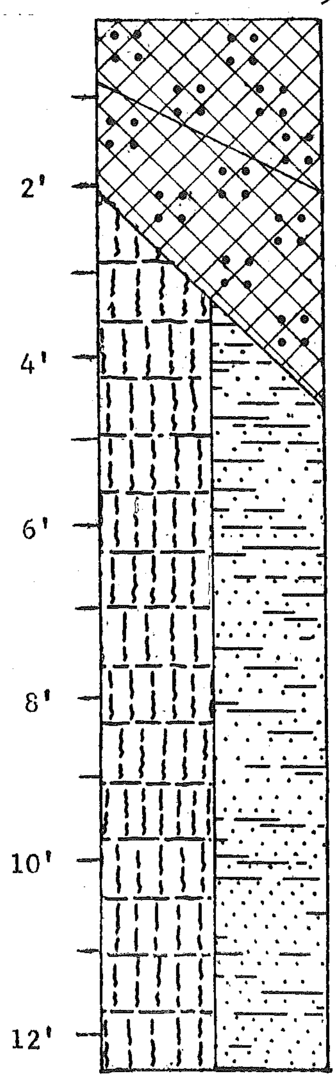
Mapping Unit 57 is similar to Mapping Unit 55 with exception of landform and inclusions.

Soil 57 is a shallow to moderately deep nonplastic to slightly plastic soil derived from glacial till or residuum. Surface soils are generally thin gravelly silt loams. Subsoils are generally thin gravelly silt loams.

Bedrock is marine sediments of conglomerate and bedded sandstone, siltstone and shale.

Typically Soil 57 occurs on gentle smooth sideslopes of less than 35 percent slope. This soil ranges in elevation from 500 to 4000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile
Sketch of Soil 57



Range of Profile Characteristics
of Soil 57

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 3 inches thick.

Surface Layer - Dark brown to dark yellowish brown gravelly silt loams ranging to gravelly loams; moderate to weak fine subangular blocky structure; 30 to 45 percent angular or subrounded gravel and cobbles by volume; nonsticky to slightly sticky; nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 10 to 25 inches thick.

Subsoil Layer - Brown to dark yellowish brown gravelly silt loams ranging to gravelly loams; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular or subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 15 to 30 inches thick.

Bedrock - Sedimentary bedrock.

MAPPING UNIT 60

Mapping Unit 60 consists of moderately to highly fractured and strongly chloritized main basalt rock outcrop and inclusions of soils. The most common inclusions are Soils 61, 62, 67 and 68.

This mapping unit occurs on ridge crests and sideslopes. Vegetation is generally limited to scattered areas of grasses, sedges and small shrubs.

MAPPING UNIT 61

Mapping Unit 61 consists of Soil 61 and inclusions of other soils. The most common inclusions are Soils 17, 62 and 60.

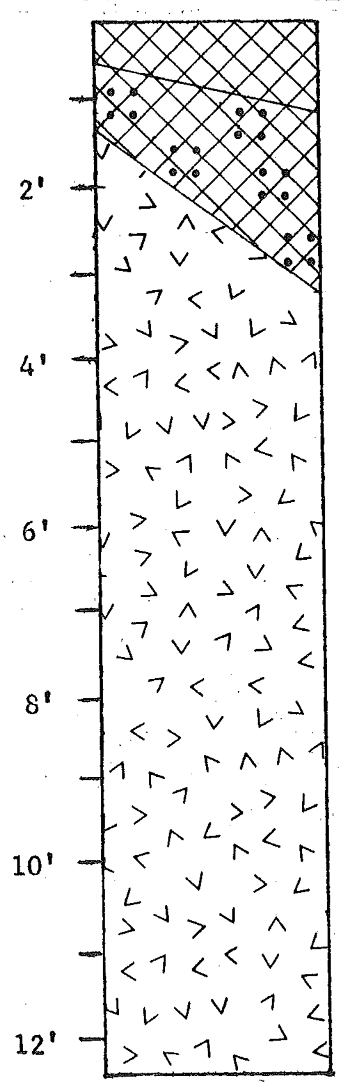
Mapping Unit 61 is similar to Mapping Unit 67 with the exception of landform and inclusions, and to Mapping Unit 67 with the exception of understory composition and inclusions.

Soil 61 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. Surface soils are generally thin loams. Subsoils are generally thin gravelly loams.

Bedrock is competent moderately fractured and highly chloritized marine basalt with minor inclusions of sedimentary rock.

Typically Soil 61 occurs on steep smooth to slightly dissected ridges and sideslopes. This soil ranges in elevation from 300 to 3000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 61



Range of Profile Characteristics of Soil 61

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Surface Layer - Dark reddish brown to dark brown loam ranging to silt loam; weak fine subangular blocky structure; 15 to 30 percent angular gravel and cobbles by volume; nonsticky to slightly sticky; nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 6 to 14 inches thick.

Subsoil Layer - Reddish brown to brown gravelly loam ranging to gravelly silt loam; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel and cobbles by volume; nonsticky to slightly sticky; nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 10 to 22 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 62

Mapping Unit 62 consists of Soil 62 and inclusions of other soils. The most common inclusions are Soils 17, 61 and 60.

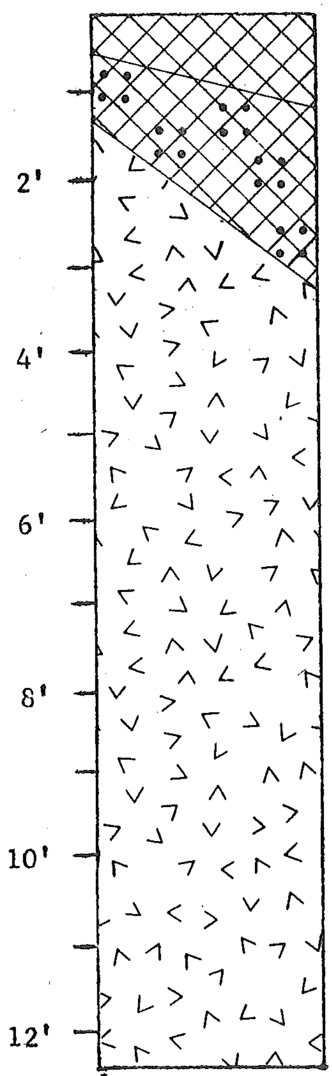
Mapping Unit 62 is similar to Mapping Unit 61 with exception of landform and inclusions, and to Mapping Unit 68 with the exception of understory composition and inclusions.

Soil 62 is a shallow nonplastic to slightly plastic soil derived from residuum and colluvium. Surface soils are generally thin loams. Subsoils are generally thin gravelly loams.

Bedrock is competent moderately fractured and highly chloritized marine basalt with minor inclusions of sedimentary rock.

Typically Soil 62 occurs on steep very dissected sideslopes. This soil ranges in elevation from 300 to 3000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 62



Range of Profile Characteristics of Soil 62

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Surface Layer - Dark reddish brown to dark brown loam ranging to silt loam; weak fine subangular blocky structure; 15 to 35 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 6 to 14 inches thick.

Subsoil Layer - Reddish brown to brown gravelly loam ranging to gravelly silt loam; weak fine subangular blocky structure ranging to massive; 35 to 50 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic to slightly plastic; pH ranges from 5.5 to 6.0. 10 to 22 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 63

Mapping Unit 63 consists of Soil 63 and inclusions of other soils. The most common inclusions are Soils 11, 17, 62 and 64.

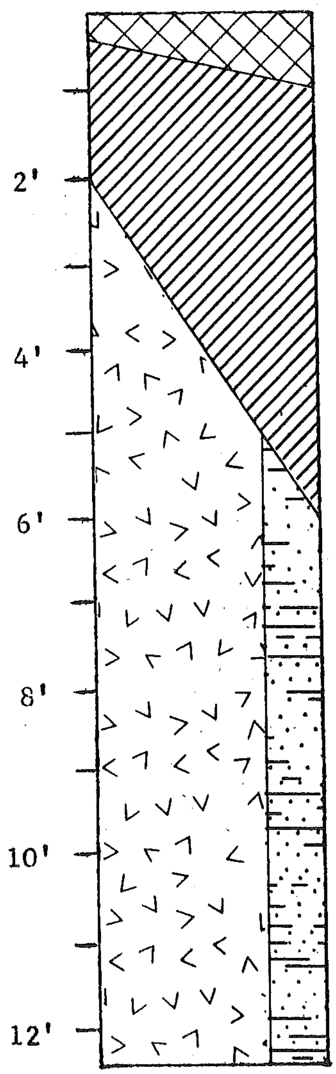
Mapping Unit 63 is similar to Mapping Unit 64 with exception of landform and inclusions.

Soil 63 is a shallow to moderately deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin silt loams. Subsoils are generally thin to moderately thick silty clay loams.

Bedrock is highly fractured, highly chloritized marine basalt with some inclusions of sedimentary rock.

Typically Soil 63 occurs on steep dissected sideslopes. This soil ranges in elevation from 800 to 2500 feet and supports Site Class IV Douglas-fir along with hemlock and cedar. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 63



Range of Profile Characteristics of Soil 63

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Yellowish red to dark brown loam ranging to silt loam; weak to moderate fine subangular blocky structure; 5 to 25 percent angular gravel and cobbles by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 4.5 to 5.5. 4 to 12 inches thick.

Subsoil Layer - Yellowish red to strong brown silty clay loam ranging to clay loam; moderate fine subangular blocky structure ranging to massive; 10 to 35 percent angular gravel and cobbles by volume; sticky, slightly plastic to plastic; pH ranges from 5.5 to 6.0. 20 to 60 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 64

Mapping Unit 64 consists of Soil 64 and inclusions of other soils. The most common inclusions are Soils 11, 17, 61 and 63.

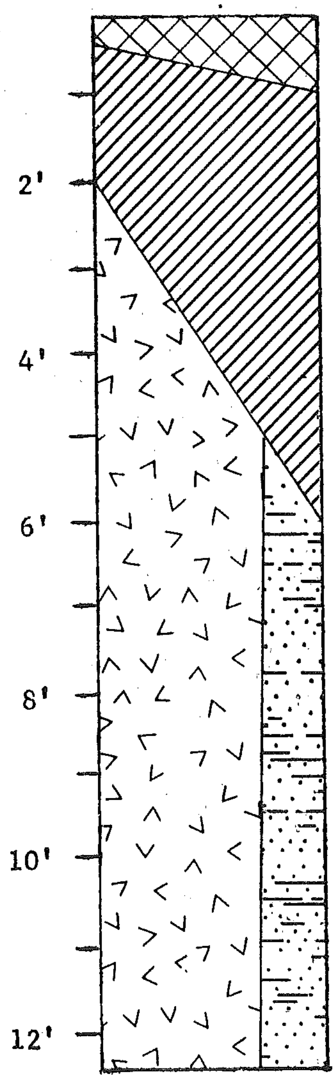
Mapping Unit 64 is similar to Mapping Unit 63 with exception of landform and inclusions.

Soil 64 is a shallow to moderately deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin silt loams. Subsoils are generally thin to moderately thick silty clay loams.

Bedrock is highly fractured, highly chloritized marine basalt with some inclusions of sedimentary rock.

Typically Soil 64 occurs on smooth ridgetops and steep smooth sideslopes. This soil ranges in elevation from 800 to 2500 feet and supports Site Class IV Douglas-fir along with hemlock and cedar. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile Sketch of Soil 64



Range of Profile Characteristics of Soil 64

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Yellowish red to dark brown loam ranging to silt loam; weak to moderate fine subangular blocky structure; 5 to 25 percent angular gravel and cobbles by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 4.5 to 5.5. 4 to 12 inches thick.

Subsoil Layer - Yellowish red to strong brown silty clay loam ranging to clay loam; moderate fine subangular blocky structure ranging to massive; 10 to 35 percent angular gravel and cobbles by volume; sticky, slightly plastic to plastic; pH ranges from 5.5 to 6.0. 20 to 60 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 65

Mapping Unit 65 consists of Soil 65 and inclusions of other soils. The most common inclusions are Soils 63, 64 and 11.

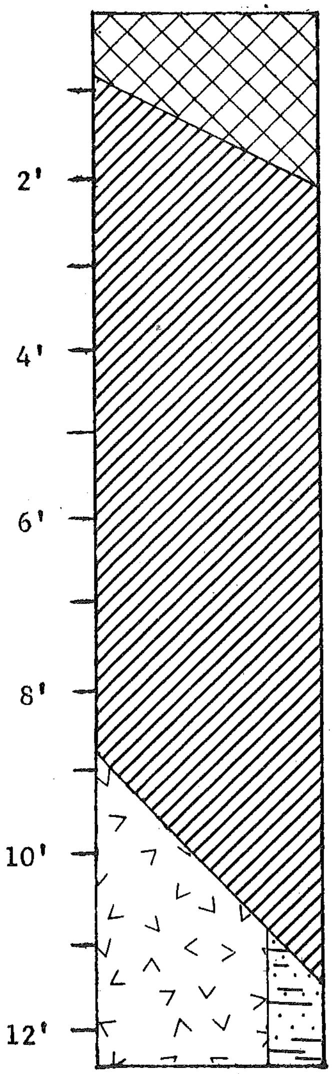
Mapping Unit 65 is similar to Mapping Unit 10 with the exception of depth to bedrock and inclusions.

Soil 65 is a deep to very deep slightly plastic to plastic soil derived from residuum and colluvium. Surface soils are generally thin silt loams. Subsoils are generally thick silty clay loams.

Bedrock is weathered and highly fractured basalt with some inclusions of fine textured marine sediments and breccias.

Typically Soil 65 occurs on gentle to moderately steep sideslopes ranging from 20 to 50 percent slopes. This soil ranges in elevation from 500 to 1200 feet and supports Site Class III and IV Douglas-fir along with hemlock and cedar. This soil is well drained. Permeability is rapid in the surface soils and moderate in the subsoils.

General Profile
Sketch of Soil 65



Range of Profile Characteristics
of Soil 65

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 4 inches thick.

Surface Layer - Reddish brown to yellowish red loam ranging to silt loam; weak to moderate fine subangular blocky structure; 5 to 30 percent angular gravel and cobbles by volume; slightly sticky, nonplastic to slightly plastic; pH ranges from 5.0 to 5.5. 10 to 25 inches thick.

Subsoil Layer - Yellowish red to strong brown silty clay loam ranging to clay loam; moderate fine subangular blocky structure ranging to massive; 20 to 35 percent angular gravel and cobbles by volume; sticky, slightly plastic to plastic; pH ranges from 5.5 to 6.0. 95 to 112 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 67

Mapping Unit 67 consists of Soil 67 and inclusions of other soils. The most common inclusions are Soils 68, 19, 29 and 60.

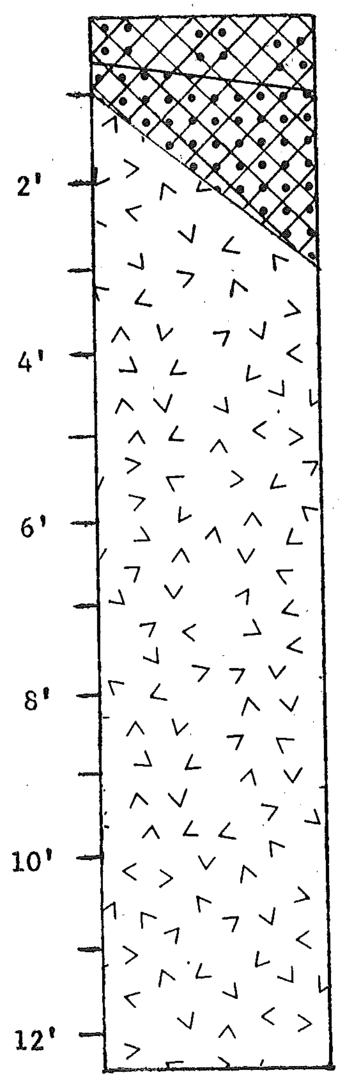
Mapping Unit 67 is similar to Mapping Unit 68 with the exception of landform and inclusions, and to Mapping Unit 61 with the exception of vegetation differences and inclusions.

Soil 67 is a shallow nonplastic soil derived from residuum and colluvium. Surface soils are generally thin gravelly loams. Subsoils are generally thin very gravelly loams.

Bedrock is competent moderately fractured and highly chloritized marine basalt.

Typically Soil 67 occurs on steep smooth to slightly dissected ridges and side-slopes. This soil ranges in elevation from 300 to 3000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 67



Range of Profile Characteristics of Soil 67

Litter - Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.

Surface Layer - Brown to dark brown gravelly loam ranging to gravelly sandy loam; weak fine subangular blocky structure; 35 to 50 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 7 to 12 inches thick.

Subsoil Layer - Brown to strong brown very gravelly loam ranging to very gravelly sandy loam; massive; 50 to 75 percent gravel and cobbles by volume; nonsticky, nonplastic; pH ranges from 5.5 to 6.0. 5 to 24 inches thick.

Bedrock - Basalt bedrock.

MAPPING UNIT 68

Mapping Unit 68 consists of Soil 68 and inclusions of other soils. The most common inclusions are Soils 67, 19, 29 and 60.

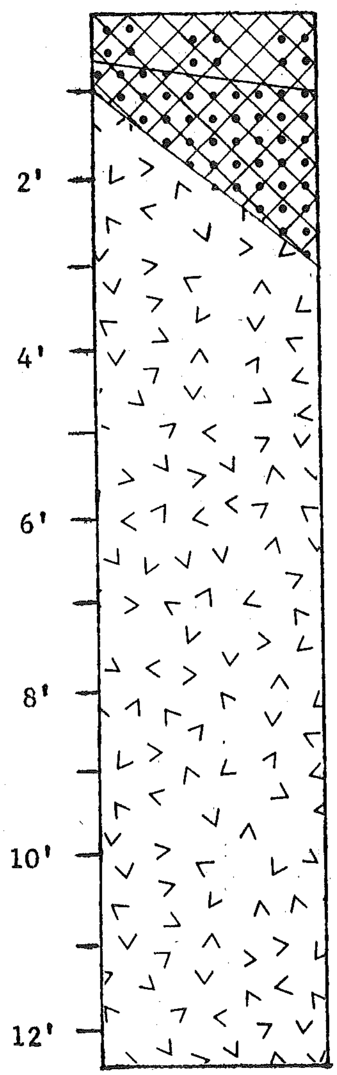
Mapping Unit 68 is similar to Mapping Unit 67 with exception of landform and inclusions, and to Mapping Unit 62 with the exception of vegetation differences and inclusions.

Soil 68 is a shallow nonplastic soil derived from residuum and colluvium. Surface soils are generally thin gravelly loams. Subsoils are generally thin very gravelly loams.

Bedrock is competent moderately fractured and highly chloritized marine basalt.

Typically Soil 68 occurs on steep very dissected sideslopes. This soil ranges in elevation from 300 to 3000 feet and supports Site Class IV and V Douglas-fir along with hemlock and true fir. This soil is well drained. Permeability is rapid.

General Profile Sketch of Soil 68



Range of Profile Characteristics of Soil 68

Litter -	Needles, leaves, twigs and decomposing organic matter. 1 to 2 inches thick.
Surface Layer -	Brown to dark brown gravelly loam ranging to gravelly sandy loam; weak fine subangular blocky structure; 35 to 50 percent angular gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 7 to 12 inches thick.
Subsoil Layer -	Brown to strong brown very gravelly loam ranging to very gravelly sandy loam; massive; 50 to 75 percent gravel and cobbles by volume; nonsticky, nonplastic; pH ranges from 5.5 to 6.0. 5 to 34 inches thick.
Bedrock -	Basalt bedrock.

MAPPING UNIT 73

Mapping Unit 73 consists of Soil 73 and inclusions of other soils. The most common inclusions are Soils 20, 18, 28 and 74.

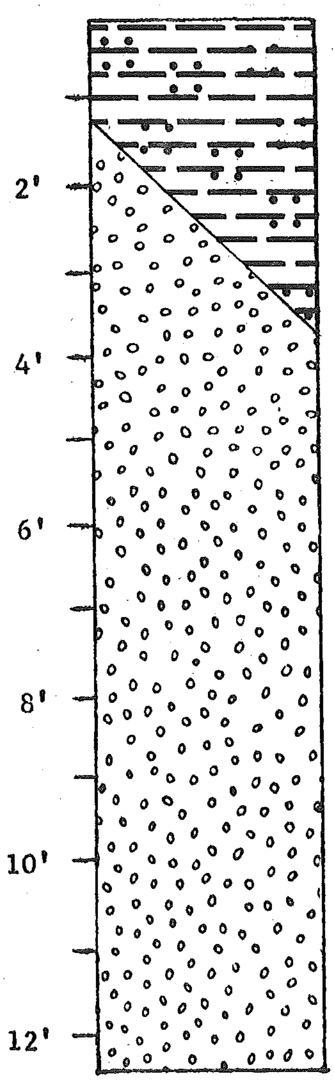
Mapping Unit 73 is similar to Mapping Unit 74 with the exception of landform and inclusions.

Soil 73 is a very deep nonplastic soil derived from glacial till. Surface soils are generally thin to moderately thick gravelly loams. Subsoils are generally thick to very thick, strongly cemented, very gravelly loamy sands.

Bedrock is basalt and occurs 12 feet or more beneath the soil surface.

Typically Soil 73 occurs on glacial terraces and gentle toeslopes of less than 35 percent. This soil ranges in elevation from 700 to 1200 feet and supports Site Class IV and V Douglas-fir along with hemlock and cedar. This soil is well drained in areas of relief and moderately to imperfectly drained in depressions. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile Sketch of Soil 73



Range of Profile Characteristics of Soil 73

Litter - **Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.**

Surface Layer - **Dark reddish brown to dark brown gravelly sandy loam ranging to gravelly loam; weak fine subangular blocky structure; 35 to 50 percent subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 15 to 45 inches thick.**

Subsoil Layer - **Light olive brown to brown very gravelly loamy sand ranging to very gravelly sandy loam; massive; strongly cemented; 50 to 70 percent subrounded gravel and cobbles by volume; nonsticky, nonplastic; pH ranges from 5.0 to 5.5. 99 to greater than 129 inches thick.**

MAPPING UNIT 74

Mapping Unit 74 consists of Soil 74 and inclusions of other soils. The most common inclusions are Soils 29, 67, 68 and 73.

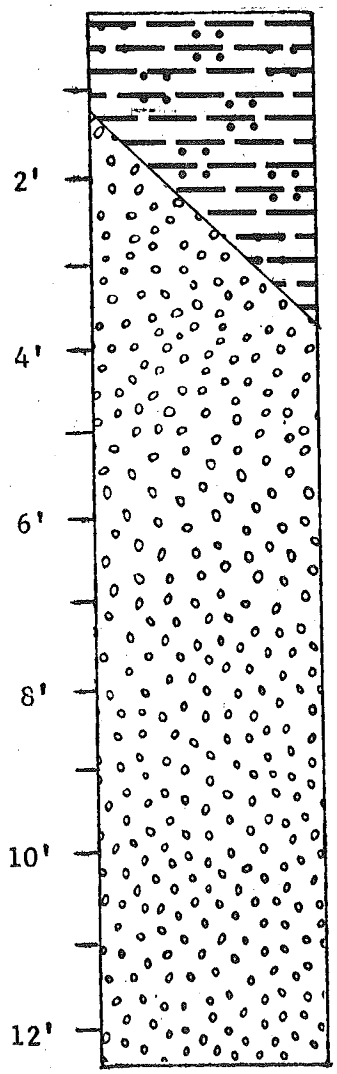
Mapping Unit 74 is similar to Mapping Unit 73 with exception of landform and inclusions.

Soil 74 is a very deep nonplastic soil derived from glacial till. Surface soils are generally thin gravelly sandy loams. Subsoils are generally thick to very thick, strongly cemented, very gravelly loamy sand.

Bedrock is basalt and occurs 12 feet or more beneath the soil surface.

Typically Soil 74 occurs on steep smooth to somewhat dissected sideslopes. This soil ranges in elevation from 700 to 2500 feet and supports Site Class IV and V Douglas-fir along with hemlock. This soil is well to moderately well drained. Permeability is rapid in the surface soils and slow in the subsoils.

General Profile
Sketch of Soil 74



Range of Profile Characteristics
of Soil 74

Litter - Needles, leaves, twigs and decomposing organic matter. 2 to 3 inches thick.

Surface Layer - Dark reddish brown to dark brown gravelly sandy loam ranging to gravelly loam; weak fine subangular blocky structure; 25 to 50 percent subrounded gravel and cobbles by volume; nonsticky to slightly sticky, nonplastic; pH ranges from 5.0 to 5.5. 25 to 45 inches thick.

Subsoil Layer - Light olive brown to brown very gravelly loamy sand ranging to very gravelly sandy loam; massive; strongly cemented; 45 to 70 percent gravel and cobbles by volume; nonsticky, nonplastic; pH ranges from 5.0 to 5.5. 99 to greater than 119 inches thick.

APPENDIX II

TERMS AND DEFINITIONS OF MAPPING UNIT CRITERIA 1/

The following is a list of terms and definitions used in Soil Resource Management Surveys. These terms and definitions are used in compiling information for the Table of Soil Characteristics of Modal Sites; Table of Some Mapping Unit Characteristics, Features and Qualities; Table of Bedrock Characteristics of Mapping Units; and the Mapping Unit Descriptions.

SOIL CHARACTERISTICS

These terms are found in the Table of Soil Characteristics of Modal Sites. They describe morphological properties of the soil.

Soil - Any and all loose, unconsolidated, weathered material on the earth's surface resting on solid, consolidated, unweathered bedrock, regardless of origin, mode of formation, or type of weathering or deposition. Generally includes any material that may be manipulated by hand tools or heavy equipment without the need of blasting except soft unweathered bedrock. In soil horizon designation, soil materials included "A", "B", and "C" horizons.

Depth of Soil to Bedrock - Distance from soil surface to consolidated, unweathered bedrock. Depth is in feet.

Shallow - less than 3 feet.

Moderately Deep - 3 to 6 feet.

Deep - 6 to 12 feet.

Very Deep - greater than 12 feet.

Depth to Restrictive Layer in the Soil - Distance from soil surface to a layer in the soil that is highly restrictive to drainage, water transmission or root growth. Usually this is a discontinuity or stratification layer, but it may be bedrock. If it is bedrock, depth must be the same as recorded under depth to bedrock. A restrictive layer is generally not a genetic soil horizon, except in old soils that have developed claypan, hardpan, or cemented horizons. Depth is in feet.

Litter - Total depth in inches of decomposed and undecomposed organic matter.

1/ Unless otherwise noted, the following definitions were developed for use in Soil Resource Management Surveys, R-6.

Soil Layer - Each soil layer is a homogeneous layer of soil material. Soil layers are described when soil characteristics change significantly and have definite effects on management. Layers are usually at least 12 inches thick, unless material is very contrasting. Each layer may result from stratification or soil formation processes.

Soil Layer Thickness - Thickness of each soil layer in inches.

Soil Layer Thickness Classes - Thickness is in feet.

Thin - less than 3 feet.

Moderately thick - 3 to 6 feet.

Thick - 6 to 10 feet.

Very thick - greater than 10 feet.

Color - Stated in narrative Munsel notations for each soil layer. Colors are taken of moist crushed soil. Mottling is noted, if present, especially in subsoil layers.

Texture - Relative proportions of sand (2.0 mm. - .05 mm.), silt (.05 mm. - .002 mm.), and clay (less than .002 mm.). Standard USDA textural classes are used for each soil layer.

Textural Classes*- These classes apply when general textural terms are used for the profile sketch in the mapping unit descriptions.

Coarse-textured soils - Sands, loamy sands.

Moderately coarse-textured soils - Sandy loam, fine sandy loam.

Medium-textured soils - Very fine sandy loam, loam, silt loam, silt.

Moderately fine-textured soils - Clay loam, sandy clay loam, silty clay loam.

Fine-textured soils - Sandy clay, silty clay, clay.

Rock Fragment Quantity, Size, and Shape* - Percent by volume occupied by consolidated fragments larger than sand size (larger 2 mm.)

Size Classes - gravel, 2 mm. - 3 inches; cobbles, 3 inches to 10 inches; stones, greater than 10 inches.

Shape Classes - round, thin, flat, subangular, subround, angular, blocky, etc.

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*Standard USDA Handbook 18 definitions.

Rock Fragment Classes - Used as an adjective to textural classes. Includes gravel, cobble and stone sizes.

0	- 35%	- not noted.
35	- 50%	- gravelly, cobbly or stony.
50	- 80%	- very gravelly, very cobbly or very stony.
80%+		- extremely gravelly, extremely cobbly or extremely stony.

Soil Structure* - Includes grade, size and type of structure for each soil layer. If no structure exists, then the soil is massive or single-grained. Concretions or shot are recorded, if present. Applies to aggregate structural units (aggregates and peds).

Grade - Degree of aggregation and expression of the differential between cohesion within aggregates and adhesion between aggregates.

Weak - Indistinct peds, barely observable in place.

Moderate - Distinct peds, moderately durable and evident.

Strong - Distinct peds in place, durable.

Size - Refers to size of aggregates according to five size classes.

Very fine - less than 5 mm.

Fine - 5 mm. to 10 mm.

Medium - 10 mm. to 20 mm.

Coarse - 20 mm. to 50 mm.

Very coarse - greater than 50 mm.

Type - Refers to relative shape of individual aggregates. There are four primary basic shapes.

Platy - Soil particles arranged around a plane, generally horizontal.

Prism-like - Soil particles arranged around a vertical line and bounded by relatively flat surface (Prismatic, Columnar).

Block-like - Soil particles arranged around a point and bounded by flat or rounded surfaces (Angular Blocky, Subangular Blocky).

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*Standard USDA Handbook 18 Definitions.

Type - (continued)

Spheroidal - Soil particles arranged around a point and bounded by curved or very irregular surfaces (Granular, Crumb).

Structureless - No observable aggregation or no definite orderly arrangement of natural lines of weakness.

Massive - The soil material is coherent.

Single Grain - The soil material is incoherent.

Cementation* - Includes degree of cementation and the agent of cementation (Ca, Fe, Al, Si). Cementation is generally caused by a chemical process.

Degree of Cementation

Weak - Soil aggregates can be easily broken by hand, and usually nonrestrictive to water and roots. Example - fragipan.

Strong - Soil aggregates are difficult to break by hand or hand tools and resist movement and penetration of water and roots. Water may be perched or ponded for short periods. Aggregates can be penetrated by hand tools.

Indurated - Soil aggregates are insoluble in water and cannot be broken by hand tools. Aggregates are totally restrictive to water and roots, and usually require ripping or blasting.

Compaction - Relative increase in bulk density which is caused by natural pedogenic processes.

Degree of Compaction

Weak - Soil aggregates are easily broken by hand and are usually nonrestrictive to water and roots.

Moderate - Soil aggregates are difficult to break by hand and resist movement and penetration of water and roots. Water may be perched or ponded for short periods of time.

Strong - Soil aggregates cannot be broken by hand. The soil exhibits nearly total restriction to water and root penetration, and usually requires ripping or blasting.

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* Standard USDA Handbook 18 definitions.

Permeability - Water or air movement in and through the soil material. The classes are based on soil texture, rock fragment content, porosity and bulk density.

Class

Very Slow - Very little if any water transmission. Generally fine-textured soils - clay. Less than .05 inch/hr.

Slow - Little water transmission. Generally moderately fine-textured soils - clay loams and silty clay loams. .05 inch/hr. to 1 inch/hr.

Moderate - Good water transmission. Generally medium-textured soils - loams, silt loams. 1 inch/hr. to 5 inches/hr.

Rapid - Water transmission too great for optimum growth. Generally moderately - coarse-textured soils - sandy loams, gravelly loams. 5 inches/hr. to 10 inches/hr.

Very Rapid - Excessive water transmission; soil never becomes saturated. Very porous soils. Generally coarse-textured soils - sands and gravels. Greater than 10 inches/hr.

Consistence* - Degree of cohesion and adhesion as indicated by the resistance of the soil aggregate to deformation or rupture under various moisture conditions.

Dry

Loose - Noncoherent.

Soft - Easily crushes to powder or single grain.

Slightly Hard - Easily broken between thumb and forefinger.

Hard - Can be broken in the hands without difficulty but difficult to break between thumb and forefinger.

Very Hard - Can be broken in hands without difficulty.

Extremely Hard - Cannot be broken in hands.

Moist

Loose - Noncoherent.

Very Friable - Crushes under gentle pressure.

Friable - Crushes easily under gentle to moderate pressure between thumb and forefinger.

* Standard USDA Handbook 18 definitions.

Firm - Crushes under moderate pressure between thumb and forefinger.

Very Firm - Crushes under strong pressure, barely crushable between thumb and forefinger.

Extremely Firm - Crushes under very strong pressure, cannot be crushed between thumb and forefinger.

Wet

Stickiness is measured by pressing wet soil between fingers.

Nonsticky - Practically no adherence when pressure is released.

Slightly sticky - After pressure, soil adheres to both thumb and finger but comes off one rather cleanly. Does not appreciably stretch.

Sticky - After pressure, soil adheres to both thumb and finger and tends to stretch somewhat before pulling apart from either digit.

Very sticky - After pressure, soil adheres strongly to both digits and is markedly stretched when they are separated.

Plasticity is measured by rolling wet soil and observing wire.

Nonplastic - No wire is formable.

Slightly Plastic - Wire forms, but soil mass easily deformed.

Plastic - Wire forms, moderate pressure required to deform soil mass.

Very Plastic - Wire forms, much pressure required to deform soil mass.

Soil pH - Intensity of soil acidity or alkalinity expressed on a scale from 1 to 14.

	pH		
Extremely Acid	Below 4.5	Slightly Alkaline	7.4 - 8.4
Strongly Acid	4.6 - 5.5	Strongly Alkaline	8.5 - 9.0
Slightly Acid	5.6 - 6.4	Very Strongly Alkaline	Above 9.0
Neutral	6.5 - 7.3		

Classification - Estimated 7th approximation classification at family level.

MAPPING UNIT CHARACTERISTICS, FEATURES AND QUALITIES

These terms are found in the Table of Some Mapping Unit Characteristics, Features and Qualities. They describe properties of the mapping unit that result from soil characteristics, bedrock characteristics, topography and site.

Infiltration Rate - Rate of entry of water into soil surface. The rate is dependent upon the type of surface soil texture, rock fragment content, structure, porosity, bulk density and organic matter content.

Infiltration Rate Classes

Slow - Water stands on surface for long periods. Soils are fine textured, poorly aggregated and puddle easily.

Moderate - Water enters soil at commensurated rates of normal rainfall or water application. Water may pond for short periods (a few days) following very intensive rainfall. Soils are medium textured and well aggregated.

Rapid - Water rarely ponds, enters soil surface very rapidly. Soils are coarse textured, porous, loose and usually single grained.

Drainage Class [2]- The rapidity and extent of removal of water from the soil. Based on soil permeability, infiltration, internal drainage and topographic position.

Poorly Drained - Water table at or near the surface a considerable part of the time. Soils of this class usually occupy level or depressed sites and are frequently ponded. Water removed so slowly that soil remains wet almost all the time.

Imperfectly Drained - Water removed so slowly that the soil remains wet for significant periods, but not all the time.

Moderately Well Drained - Soils remain wet for a period somewhat longer (up to one month) than the wet season; may be due in part to a slowly permeable layer, high water table or lateral seepage.

Well Drained - Water is removed from soil readily and these soils are saturated only during the wet season for short periods.

Excessively Drained - Water is removed from soil rapidly and these soils are rarely ever saturated. Commonly, these soils are coarse textured or shallow, stony and/or occur on steep slopes.

2/ Very poorly drained and somewhat excessively drained classes are not used.

Surface Drainage Intensity and Pattern - Number of drainage miles per square mile and dominant drainage pattern.

Intensity Classes

Few - 0 to 1 drainage miles per square mile.

Common - 1 to 3 drainage miles per square mile.

Many - 3 to 5 drainage miles per square mile.

Abundant - greater than 5 drainage miles per square mile.

Patterns

Dendritic - Drainages branch in random directions.

Parallel - Drainages are relatively parallel.

Productivity - Combined evaluation of measured and observed production of timber and forage types. Site classes are to be used for timber types and range condition ratings for range types.

Site Class - Class limits correspond to height (site index) of Douglas-fir at 100 years.

Class I - greater than 185 S.I.

Class II - 185 S.I. to 155 S.I.

Class III- 155 S.I. to 125 S.I.

Class IV - 125 S.I. to 95 S.I.

Class V - less than 95 S.I.

Fertility - Estimated inherent soil fertility and availability of plant nutrients. This rating is derived by correlating measured productivity with soil factors such as texture, pH, color and organic matter content.

High - These soils generally have medium to fine texture, dark surface colors; are slightly acid to slightly alkaline and have abundant incorporated organic matter. Nutrient quantities are adequate and readily available. Productivity is high as evidenced by timber site classes of I and II.

Moderate - These soils generally have one or more soil factors that limit nutrient quantity and/or availability. Productivity is moderate as evidenced by timber site classes of low II to high IV.

Low - These soils generally have several factors that are limiting. They may be coarse textured, strongly acid or strongly alkaline, and lacking in sufficient organic matter. Nutrient quantity and/or availability is seriously limiting. Productivity is low as evidenced by timber site class IV and V.

Percent Vegetative Cover - Evaluation of total vegetative cover, and the cover of three distinct levels of vegetation above the soil surface. Overstory consists of the timber stand canopy. Understory consists of woody shrubs, and timber regeneration. Ground cover consists of ferns, grasses, sedges, and mosses.

Total Ground Cover - Estimated percent of total vegetative cover with overstory, understory and ground cover combined. Maximum of 100%.

Vegetative Cover by Each Level - Estimated percent vegetative cover according to species composition, with overstory, understory, and ground cover estimated separately. Maximum of 100% for each level.

Root Distribution* - Includes root size, abundance and depth to zone of rooting.

Size

Very Fine - 0.075 mm.

Fine - 1 to 2 mm.

Medium - 2 to 5 mm.

Coarse - Over 5 mm.

Abundance

Very Few - Less than 1/unit.[3/]

Few - 1 to 3/unit.

Plentiful - 4 to 14/unit.

Abundant - More than 14.

3/ Unit is a square inch for fine to very fine. A square yard for medium and coarse roots.

Depth

Recorded depth in inches of zone of rooting. Distance is measured from soil surface to depth of majority of roots.

* Standard USDA Handbook 18 definitions.

Landform - Refers to the shape and configuration of a specific, identifiable part of the landscape common to the mapping unit.

Slope - Range of slope of mapping unit.

Aspect- Direction of slope exposure.

Elevation - Altitude above mean sea level expressed in feet.

Origin of Soil Material - Type of material soil is forming in or from. Example: Colluvium, Alluvium, Till, Residuum, Pumice, Loess. This term is found in the mapping unit descriptions.

BEDROCK CHARACTERISTICS

These terms are found in the Table of Bedrock Characteristics of Mapping Units.

Bedrock - Consolidated, competent rock which upon weathering produces loose or unconsolidated soil material. In terminology of soil horizon designation, bedrock is designated at the "R" layer. Bedrock material usually required ripping and/or blasting. Includes soft materials that are unweathered such as some sedimentary rock which can be bladed. (Example: Sandstone).

Composition - Bedrock components and percentage. (Example: Sandstone (20), Conglomerates (70), Mudstone (10).

Color - Color is in narrative terms for fresh unweathered surfaces.

Hardness - Relative rating based on ease of breaking rock with geology hammer.

Hard - Rock cannot be broken or only with great difficulty.

Moderately hard - Rock can readily be broken with hammer but not by hand.

Soft - Rock can be broken by hand.

Degree of Fracturing - Based on the number of frequency of fractures and joints in a rock unit.

Highly fractured -Entire rock unit is completely dissected by fractures and joints less than 1 foot apart.

Moderately fractured - Fractures divide rock unit into units or blocks generally from 1 foot to 5 feet apart.

Slightly fractured - Only occasional fractures noted.

Massive - No fractures or very few fractures noted.

Fracture System - Pattern which the rock fractures follow. Example: horizontal, platy, vertical, blocky, random, etc.

Fracture Surface - Indicates the characteristics of the fracture surface and void space within fractures.

Regular - Smooth, distinct, sharp, clean-fracture surfaces.

Irregular - Rough, irregular, fragmented fracture surfaces.

Competency - Relative inherent strength of rock as it occurs on the landscape. Based on degree of weathering; fracturing, hardness, stability and failures observed.

Competent - No failures within rock unit observed. Rocks of the unit are stable and have strong resistance to mass movement.

Moderately Competent - Some failures are noted. Rocks of the unit are moderately stable and have some resistance to mass movement.

Incompetent - Failures are common to rock unit. Rocks of the unit are soft, deeply weathered and have high potential for mass movement.

APPENDIX III

DEFINITIONS OF MANAGEMENT INTERPRETATIONS

This appendix contains the definitions for the Tables of Management Interpretations found in the Atlas. Definitions apply to Erosion and Some Hydrologic Interpretations, Recreation, Timber Management and Engineering.

EROSION AND SOME HYDROLOGIC INTERPRETATIONS

Erosion and some hydrologic interpretations include erosion and water management interpretations. Interpretations for erosion include the two major kinds of erosion--surface and mass movement. Surface erosion pertains only to surface soil loss by runoff and overland flow. Mass movement pertains to all types of soil and bedrock movement which occur below the soil surface such as landslips, slumps, slides, rockfall, and land flow.

Surface Erosion Potential

This rating is based on expected losses of surface soil when all vegetative cover, including litter, is removed. Evaluations of climate, slope gradient and length, soil characteristics, hydrologic characteristics of the soil and bedrock materials of each mapping unit are considered in making ratings.

Very slight - Practically no loss of surface soil materials is expected.

Slight - Little loss of soil materials are expected. Some minor sheet and rill erosion may occur.

Moderate - Some loss of surface soil materials can be expected. Rill erosion and some small gullies or sheet erosion may be occurring. Sheet erosion can be determined by some soil pedestals and observable accumulation of soil materials along the upslope edge of rocks and debris. At this level of erosion there is a possible fertility loss.

Severe - Considerable loss of surface soil materials can be expected. Rill erosion, numerous small gullies or evidence that considerable loss from sheet erosion may occur. Sheet erosion is indicated by frequent occurrence of soil pedestals and considerable accumulation of soil materials along the upslope edge of rocks and debris. This is accompanied by a probable fertility loss.

Very Severe - Large loss of surface soil material can be expected in the form of many large gullies and/or numerous small gullies or large loss from sheet erosion. Sheet erosion loss is exhibited by numerous examples of soil pedestals and extensive accumulation of soil materials along the upslope edge of rocks and debris. This is accompanied by a fertility loss.

Natural Stability

This rating is based on the relative stability of the mapping units as they occur in the natural state. This includes any movement or loss other than surface erosion, by slumps, slides and all kinds of deep-seated failures. This rating applies throughout Region 6.

I. Very Stable - No evidence of failure.

II. Stable - Occasional failures are observed.

III. Moderately Stable - Several failures are observed.

IV. Unstable - Many failures are observed.

V. Very Unstable - Entire area shows evidence of recent and past failures.

Nature of Mass Movement

This is an estimation of the kind and/or size of mass movement observed.

Expected Mass Movement as a Result of Man's Activities

This rating indicates the expected mass movement resulting from man's activities as compared to stability under natural conditions. Ratings are based on soil and bedrock characteristics, slopes, revegetation potential, and effects of timber removal, road construction and fire.

Unchanged - The expected mass movement is relatively unchanged from that of the natural state.

Increased - The expected mass movement is greater than that of the natural state.

Greatly Increased - The expected mass movement is much greater than that of the natural state.

Subsoil Erosion Potential

This interpretation indicates the potential for subsoil erosion by water for each unit. It includes erosion which takes place after the surface soil has been removed (about 1-foot depth) such as in skid trails and firebreaks. Factors considered in making ratings are texture and structure of subsoil materials, slope, permeability, compaction, climate, and landform.

Low - Factors are such that little or no erosion may occur. Very little evidence of erosion.

Moderate - Considerable erosion occurring such as rills and small gullies. Factors indicate considerable erosion is likely to occur.

High - Factors indicate severe erosion may occur.

Recommendations for Controlling Subsoil Erosion

In this column recommendations are given, when applicable, for controlling subsoil erosion.

Water Yield Potential

This interpretation is an indication of the rate and amount of water yield expected from each unit. It is based on factors such as soil characteristics, bedrock characteristics, infiltration rates, permeability, slope, climate, vegetation, and drainage patterns.

Low - Soils have a high soil and/or ground water storage capacity. Rate of water yield is slow and primarily contributes to base flow. Little water contributes to peak flow except when soils are saturated.

Moderate - Soils have a moderate soil and/or ground water storage capacity. Rate of water yield is moderate. Water contributes to both peak flow and base flow.

High - Soils have a low soil and/or ground water storage capacity. Rate of water yield is high. Most of the water contributes to peak flow with little or no water contributing to base flow.

Hydrologic Group

This interpretation is a grouping of soils into four classes, indicating the general infiltration and water movement ability of the soil and bedrock materials. This method of ratings has been developed by the Soil Conservation Service. The four groups are the standard SCS groupings and definitions.

Group A - Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well to excessively drained sands and/or gravel. These soils have a high rate of water transmission and would result in a low runoff potential.

Group B - Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C - Soils having slow infiltration rates when thoroughly wetted, consisting chiefly of (1) soils with a layer that impedes the downward movement of water or, (2) soils with moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.

Group D - Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) clay soils with high swelling potential, (2) soils with a high permanent water table, (3) soils with claypan or clay layer at or near the surface, and (4) shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

Expected Sediment Size

This interpretation indicates the expected sediment size reaching the streams resulting from erosion of each unit. This interpretation is a statement of the two dominate separates expected (gravel, sand, silt or clay) from each soil unit. The ratings are presented in two columns. The first column indicates the separates expected from the surface soils, and the second indicates the separates expected from the subsoils.

RECREATION

Interpretations for recreation pertain primarily to recreation development. They are based on soil and bedrock properties, drainage, landform and vegetation. Factors such as aesthetics and accessibility are not considered when making these ratings. The following interpretations are some most generally needed for planning recreation developments.

Soil Suitability for Recreation Area Development

This rating is based on soil and bedrock characteristics and topographic features of each unit as related to recreation development. Factors important to this interpretation are soil depth, texture, structure, permeability, drainage, topography, and susceptibility to flooding.

Unsuited - This rating indicates that soils and/or topography are of a nature which would prohibit recreation development without extensive modification. Soil Unit 18, for example, is rated unsuited due to the presence of a water table at or near the surface much of the year. Major subsurface drainage would be required to make this soil unit suitable.

Low - These soil units have major limitations to recreation development but limited development is feasible.

Moderate - This rating indicates that the soil unit is generally suitable for recreation development but has minor limitations.

High - These soils are particularly well suited for recreation development. Generally, they have no limitations.

Soil Limitations for Recreation Development

This indicates the major limitations to recreation development.

Treatment Required to Increase Suitability

This indicates, when applicable, the treatment necessary to increase the suitability for recreation development.

Soil and Site Damage Susceptibility

This interpretation applies to recreational areas after development. Each soil unit that is suitable or can be made suitable for campground development is rated for its susceptibility to damage of soil and/or site by normal recreation use. Site includes vegetation as well as soil conditions. Factors used in determining ratings include erosion potential, soil compactibility, and vegetative growth potential.

Low - These soils resist compaction and have low erosion potential. The native vegetation is hardy and not readily destroyed. These soils will withstand and hold up well under continual use.

Moderate - These soils are not readily compacted or eroded and vegetative types are somewhat hardy. In general, these soils and site can sustain continual use but require some rehabilitation.

High - These soils are fragile and easily damaged and have vegetation that is not hardy, easily damaged and generally herbaceous. Under normal use, the vegetation will very likely be destroyed, the soil compacted and/or eroded to such a degree that period nonuse and major rehabilitation will be required.

Susceptibility to Dustiness

This interpretation pertains only to the soil units suitable, or those that can be made suitable, for recreation development and applies primarily to unsurfaced roads within recreation areas.

Low - Factors indicate dust will not be a problem.

Moderate - Under normal conditions dust will not be a problem but under heavy use and droughty conditions dust very likely will be a problem.

High - Factors indicate dust will be a problem. Dust abatement measures are necessary under normal conditions and use.

Susceptibility to Muddiness

This interpretation pertains only to the soil units suitable, or those that can be made suitable, for recreation development. This interpretation rates each soil unit as to its susceptibility to becoming muddy. The rating is limited to the surface soil under normal conditions. Factors include soil characteristics, climate and drainage.

Low - Muddiness is not likely to be a problem. Factors indicate soils are not susceptible to muddiness.

Moderate - Soils become muddy at times for short periods occasionally causing problems. Road rock is usually necessary.

High - Soils are very likely to become muddy and stay muddy for long periods. Road rock is necessary. Campground closure may be necessary during wet periods.

Trail Suitability

This interpretation indicates the suitability of each soil unit for trails. Factors include soil and bedrock characteristics, drainage, climate, and slope.

Poor - These soils have properties which severely limit their use for trails. Extensive treatment measures are required.

Moderate - These soils have some limitations for trail development. Certain treatment measures may be required.

Well - These soils have no limitations for trail development.

Limitations for Trails

This indicates the limitations to trails.

Considerations for Trail Improvements

This indicates some treatment measures to be considered in improving suitability for trails.

Suitability for Sewage Filter Field

This interpretation evaluates the soil as to its suitability as a sewage filter field. Ratings are based on soil depth, texture, permeability, drainage and slope. Only those soil units suitable for recreation development are rated. Onsite investigation is recommended before design or installation of filter system.

Poor - These soils have properties which make them poorly suited as sewage filter fields. Sewage filter disposal in these soils would be ineffective and create major problems.

Moderate - These soils have properties which limit their use as sewage filter field. They require a large filter area for adequate drainage which limits the capacity of the campground.

Well - These soils are well suited to sewage filter use and offer only minor limitations, if any.

Soil Limitation to Sewage Filter Field Use

This indicates the major limitations to sewage filter field use.

TIMBER MANAGEMENT

Interpretations for timber management are of two types. One type includes some interpretations that directly affect timber management, such as "windthrow hazard" and "potential for regeneration." The other type indicates the effect on soils and other resources from timber harvest activities.

Windthrow Hazard

This interpretation indicates the general susceptibility to windthrow for each mapping unit. Windthrow hazard ratings are based on such factors as texture, soil depth, water table, and effective rooting depth, and are considered individually or in combination.

Low - Factors indicate windthrow is not likely. The effective rooting depth is generally greater than 36 inches.

Moderate - Factors indicate some susceptibility to windthrow, but major problems are not likely. The effective rooting depth is generally between 18 and 36 inches.

High - Factors indicate that windthrow hazard is high. The effective rooting depth is generally less than 18 inches.

Susceptibility to Brush Revegetation

This indicates the susceptibility of mapping units to revegetate naturally by brush following clearcut timber harvest. These ratings are based on soil characteristics, field observation, slope, aspect, climate, and elevation.

Low - Indicates brush revegetation is insignificant.

Moderate - Indicates that some brush revegetation will occur.

High - Indicates brush revegetation is severe.

Potential for Regeneration

This interpretation indicates the potential for each mapping unit to regeneration. Factors included in this interpretation are soil characteristics, climate, aspect, elevation, frost potential, summer drought conditions, brush competition, wildlife competition, and tree species. It is assumed in making these ratings that standard Forest Service procedures of regeneration will be followed.

Low - This rating indicates potential for regeneration is very low. Probability of success is very limited. Major problems of regeneration can be expected and reseeding or replanting may have to be made throughout the area. Regeneration usually takes several years to be successful.

Moderate - This indicates some problems of regeneration will occur. Usually regeneration is spotty. Some reseeding or replanting is usually necessary.

High -This rating indicates regeneration has a high probability of success. Few problems should be encountered in regeneration of these units.

Limits to Regeneration

This indicates the major limitations to regeneration.

Recommended Tree Planting Species

This column lists the tree species that the soil, climate, and topographic factors indicate would be best suited for planting.

Susceptibility to Soil and Other Resource Damage by Timber Harvest Operation

This interpretation indicates the susceptibility of soils and other resources to incur damage during timber harvest. This includes timber removal, spur roads, slash burning, landings and other activities related to timber harvest operations. Damage is caused to soils by creating soil disturbance which may destroy soil structure, cause compaction and increase erosion. This may affect other resources through loss of timber production, lower water quality and yield, and loss of fisheries. Factors involved in making these ratings are wetness of the soil, soil texture, percentage of coarse fragments, slope and drainage.

Low - This rating indicates that soils and other resources are likely to incur minor damage.

Moderate - This rating indicates that soils and other resources are likely to incur moderate damage.

High - This rating indicates that soils and other resources are likely to incur major damage.

Type of Damage Expected During and Subsequent to Timber Harvest Operations

This indicates the type of soil or other resource damage expected.

Considerations for Management Practices

This column provides some considerations for management practices which best protect the soil and water resource. These considerations, which are directed toward the highest level of multiple-use management, provide additional information that may apply to a particular mapping unit.

Considered are such factors as seasonal operation, fertilization, harvest methods, restrictions to road construction and road construction season, slash disposal and yarding.

ENGINEERING

Interpretations for engineering includes characteristics for roads, foundations, bedrock, and some miscellaneous interpretations. These are presented in two tables. One table, "Characteristics Pertinent to Roads and Airfields," is a standard engineering table for road construction based on the Unitied Soil Classification System. The other table, "General Engineering Interpretations," gives other engineering interpretations which will be useful to engineers and other resource managers. These interpretations are explained and defined in this section.

Unified Classification

Each soil unit is classified as to its Unified Classification. Most soils will be classified into one class. Those soils with significant layers of different soil materials will have a classification for each layer designated. The classification will be made for some representative soils by laboratory testing. Those soils not tested will be classified by comparing their properties to those tested.

Generally, the following interpretations and ratings are based on the entire soil unit including soil, bedrock and landform. Some interpretations are based only on the soil material or bedrock material. These are stated in the description for each interpretation. The interpretations pertaining to roads are based on standard Forest Service regulations and construction methods presently used.

Suitability for Use as Topsoil Source

This rating evaluates each soil unit to its suitability for use as topsoil. It does not specify any particular use of the topsoil. Ratings are based on soil characteristics.

Suited - Soil texture ranges from sandy loam to clay loam and gravel content is less than 30 percent.

Unsuited - This rating indicates the soils do not satisfy the requirements specified under "Suited." However, soils rated "Unsuited" may still satisfy a particular requirement. See the table of soil characteristics for soil texture, thickness and gravel content.

Suitability of Soil as Sand and/or Gravel Source

This interpretation indicates the suitability of each soil as a possible source of sand and/or gravel. It does not indicate the kind or quality of sand or gravel or refer to any specific use of the sand and/or gravel.

Suited - This rating indicates that sand and/or gravel is present and the following conditions are satisfied: There is a layer present which is composed of 80 percent, by volume, of sand and/or gravel. This layer is at least 4 feet thick and has no more than a 5-foot overburden.

Unsuited - This rating indicates that sand and/or gravel is generally not present in amounts which satisfy the requirements under "suited." However, soils rated "unsuited" may still satisfy a particular requirement. See the table of soil characteristics for soil depth and gravel content.

Suitability of Soil as a Possible Clay Source

This rating indicates the suitability of each soil unit as a possible source for clay. It does not indicate the kind or quality of clay or refer to any specific use of the clay.

Suited - This rating indicates that the soil unit is a possible source of clay. Soils with this rating have the following: Texture ranges from clay loam to clay. Gravel content is less than 30 percent.

Unsuited - Soils with this rating generally are not possible sources for clay.

Suitability of Bedrock for Road Rock

This interpretation indicates the general stability of rock when used as road rock for base course or wearing surface. These ratings are based on rock hardness, density, and susceptibility to weathering and breakdown. Soils are not rated when depth to bedrock is greater than 12 feet.

Unsuited - Rock is soft and breaks down rapidly under logging traffic.

Poor - Rock is only moderately hard and breaks down easily under logging traffic, usually in one or two years' time.

Fair - Rock is hard and dense but tends to break down under logging traffic after about two to four years' use.

Good - Rock is hard, dense and resists breakdown under logging traffic.

Limitations of Bedrock for Road Rock

This column indicates the major limitation of the bedrock when used for road rock.

Estimate of Road Rock Thickness

This interpretation refers to estimated amount of road rock (base course and wearing surface) generally needed on heavy-vehicle, all-weather-use roads constructed on each soil unit. Factors involved in making this interpretation include texture and plasticity of soil, depth of bedrock, drainage, and kind of subgrade the road generally will have -- common material or bedrock. Ratings are based on uncompacted fills.

Very Thin - Generally less than 10 inches.

Thin - Approximately 10 to 22 inches.

Thick - Approximately 22 to 36 inches.

Very thick - Generally over 36 inches.

Considerations for Road Location and Construction

This column indicates the major considerations for road location and construction through each soil unit. The rating evaluates the impact of road construction on other resources and/or road construction problems likely to be encountered.

Method of Excavation

This interpretation refers to excavation methods most commonly required for each soil unit. This includes soil, bedrock and cemented and/or compacted layers in the soil. Methods are blading, ripping, and/or blasting.

Subsoil Erosion Potential

This interpretation indicates the potential for subsoil erosion of each soil unit. Subsoil refers to that material from approximately the 5-foot depth extending to bedrock. It primarily includes erosion which takes place along road ditches and on cutslopes. Rating is of soil material only and does not apply when cutbank or ditch is in bedrock. Factors considered in making ratings are texture and structure of subsoil materials, permeability, compaction, and climate.

Low - Factors indicate that little or no subsoil erosion is likely to occur.

Moderate - Factors indicate that the subsoils have moderate erosion potential.

High - Factors indicate that the subsoils are likely to erode severely.

Susceptibility to Cutbank Sloughing and Raveling

This rating evaluates each unit for its susceptibility to sloughing or raveling after excavation. Ratings are based on cutbanks at least 10 feet high. Factors include soil and bedrock characteristics, backslope ratio, frost action, climate and potential for revegetation.

<u>Low</u> - Sloughing and/or raveling is a minor problem requiring occasional road maintenance.

<u>Moderate</u> - Sloughing and/or raveling causes some damage. Annual road maintenance is usually adequate.

<u>High</u> - Sloughing and raveling occur at a rate that often plug culverts and fill inside ditches. Frequent road maintenance with heavy equipment such as front-end loader, is required.

Estimated Cutslope Ratio

This interpretation estimates the cutslope ratio which generally will result in the most stable cutbank condition. Ratings made are for cutbanks at least 10 feet high and pertain to both soil and bedrock material.

<u>Steep</u> - Cutbank ratio from vertical to ¼:1.

<u>Moderate</u> - Cutbank ratio from about ¼:1 to 1½:1.

<u>Flat</u> - Cutbank ratio flatter than 1½:1.

Probability of Cutbank Failures

This interpretation indicates the probability of failures in cutbanks following road construction or excavation for buildings. Failures are considered to be at least 10 cubic yards of material in volume. Ratings are based on cutbanks of at least 10 feet in height and refer to more than a 50 percent chance for failures. These ratings are the same as in the Mantle Stability Surveys.

I <u>Very Stable</u> - Practically no probability chance of cutbank failures.

II <u>Stable</u> - Probability of no more than 3 failures per mile of road cutbanks.

III <u>Moderately Stable</u> - Probability of 4 to 8 failures per mile of road cutbank.

IV Unstable - Probability of 9 to 15 failures per mile of road cutbank.

V Very unstable - Probability of more than 15 failures per mile of road cutbanks.

Considerations for Cutbank Stability Problems

This rating gives recommendations, when applicable, to increase stability of cutbanks or reduce damage from raveling and sloughing.

Failure and Erosion on Road Waste and Fills

This interpretation rates the soil units as to the susceptibility of failure and erosion occurring on fill and sidecast waste material and related damage to resources. Failures are defined as a loss or partial loss of road fill or sidecast material on the fill slope. Erosion is a loss of surface soil material from fill or sidecast. Considered are initial and subsequent failures caused by construction, erosion and additional sidecast during maintenance. Failures result in damage to various resources. Stream sedimentation levels are increased, resulting in an adverse effect on both water quality and fisheries. Timber growth potential is affected as fill slope areas no longer contribute to production. Occasionally the failures do damage to the road itself. The ratings are based on current road construction practices and procedures and on type of soil materials, natural drainage of the site, landform, slope of the fill, and field observation.

Low - Failure and erosion on road waste and fills is sufficiently low to result in only minor damage to resource values.

Moderate - Failures and erosion on road waste and fills occur with sufficient frequency to cause moderate damage to resource values.

High - Failures and erosion on road waste and fills occur at a rate and magnitude sufficient to cause major damage to resource values.

Suitability of Cutbanks to Seeding

This interpretation indicates the probable success of cutbank seeding. Factors considered in making ratings are soil characteristics, elevation, slope, climate, snowpack, and frost hazard. Ratings are based on current methods and practices of seeding, grass species, fertilizer application and time of seeding.

Poor - Probability of success is low. Seeding generally is not successful and requires 3 or more reseedings and special treatments.

Fair - Success is likely on about 50 percent of area treated. Requires one or two follow-up treatments. Seeding is usually spotty, some areas become easily established while others fail completely.

Good - Probability of high success. Seeding usually becomes well established within two years. Little follow-up seeding necessary.

Limitation to Cutbank Seeding

This indicates the major limitations to success of cutbank seeding.

Recommendations for Cutbank Seeding

This indicates special treatment to be given, when applicable, to increase the chance of success of cutbank seeding.

Suitability of Fill Slopes to Seeding

This interpretation indicates the probable success of fill slope seeding. Factors considered in making ratings are soil characteristics, elevation, slope, climate, snowpack, and frost hazard. Ratings are based on current methods and practices of seeding, grass species, fertilizer application and time of seeding.

Poor - Probability of success is low. Seeding generally is not successful and requires 3 or more reseeding and special treatments.

Fair - Success is likely on about 50 percent of area treated. Requires one or two follow-up treatments. Seeding is usually spotty; some areas become easily established while others fail completely.

Good - Probability of high success. Seeding usually becomes well established within two years. Little follow-up seeding necessary.

Limitations to Fill Slope Seeding

This indicates the major limitations to success of fill slope seeding.

Recommendations for Fill Slope Seeding

This indicates special treatment to be given, when applicable, to increase the chance of success of fill slope seeding. A statement indicates the necessary requirements other than normal fill slope seeding practices carried on by the Forest.

APPENDIX IV

ENGINEERING LABORATORY TEST DATA

This Appendix contains standard engineering test data for some representative soils. Mechanical analysis was done by Robert G. Nesbitt, Materials Engineering Technician, Olympic National Forest. Hydrometer analysis and comments were provided by James C. Schwarzhoff, Supervisory Materials Engineer, Regional Office.

Report of Laboratory Test Results

Soil No. 6

Location: $NE\frac{1}{4}$, $NW\frac{1}{4}$, Sec. 33, T22N, R8W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 27 Plasticity Index: N.P.	1 1/2	95
pH (by Photovolt pH meter): 4.6	1	92
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	88
Hydrometer Analysis: Silty Sand	1/2	81
This material should have poor drainage characteristics	No. 4	61
and can be expected to be only fair highway subgrade. The	10	51
soil may be frost susceptible and exhibit some expansive	40	35
and compressive characteristics. The sand is fairly acid	80	26
and can be expected to corrode reactive metals which are	200	19.7
uncoated.		

Soil No. 6

Location: $NE\frac{1}{4}$, $NW\frac{1}{4}$, Sec. 33, T22N, R8W, W.M.	Mechanical Analysis	
Depth: 12-13' Unified Classification: GM-u	Sieve Size	% Passing
Liquid Limit: 50 Plasticity Index: 7	2	100
pH (by Photovolt pH meter): 5.7	1 1/2	95
Minimum Electrical Resistivity, Ohms per cc: 15,400	1	91
Hydrometer Analysis: Silty Gravel	3/4	86
This material should have poor drainage characteristics,	1/2	77
but can be expected to be good highway subgrade material.	No. 4	50
This gravel may have slight to medium frost susceptibility.	10	35
The soil should not exhibit expansive or compressive	40	21
characteristics.	80	17
	200	13.8

Soil No. 10

Location: $NE\frac{1}{4}$, $NW\frac{1}{4}$, Sec. 7, T28N, R11W, W.M.	Mechanical Analysis	
Depth: 7-8' Unified Classification: ML	Sieve Size	% Passing
Liquid Limit: 45 Plasticity Index: 13	1 1/2	98
pH (by Photovolt pH meter): 4.9	1	97
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	97
Hydrometer Analysis: Sandy Silt	1/2	96
This material will have poor drainage characteristics	No. 4	93
and will make only fair highway subgrade. The silt may be	10	92
highly frost susceptible and may exhibit expansive and	40	89
compressive characteristics. The soil is fairly acid and	80	84
can be expected to corrode reactive metals which are not	200	72.3
coated.		

Report of Laboratory Test Results

Soil No. 14

Location: SE¼, NW¼, Sec. 36, T22N, R10W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-d	Sieve Size	% Passing
Liquid Limit: 24 Plasticity Index: N.P.	2	100
pH (by Photovolt pH meter): 4.4	1 1/2	93
Minimum Electrical Resistivity, Ohms per cc: 29,800+	1	89
Hydrometer Analysis: Silty Sand	3/4	86
This material should have good drainage characteristics	1/2	81
and can be expected to be at the least fair highway sub-	No. 4	71
grade material. This sand may be slightly frost susceptible,	10	64
but it should not exhibit expansive or compressive charac-	40	44
teristics. The soil is fairly acid and can be expected to	80	34
corrode buried metal which is not coated.	200	26.2

Soil No. 14

Location: SE¼, NW¼, Sec. 36, T22N, R10W, W.M.	Mechanical Analysis	
Depth: 10-11' Unified Classification: GW	Sieve Size	% Passing
Liquid Limit: Plasticity Index: N.P.	1 1/2	85
pH (by Photovolt pH meter): 5.0	1	76
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	68
Hydrometer Analysis: Well-graded Gravel	1/2	56
This material will have excellent drainage characteris-	No. 4	36
tics and will make excellent highway subgrade. The gravel	10	25
will not be frost susceptible nor will it exhibit expansive	40	10
or compressive characteristics. It has a relatively low	80	6
pH and may corrode reactive metals which are uncoated.	200	4.3

Soil No. 16

Location: NW¼, NW¼, Sec. 23, T22N, R6W, W.M.	Mechanical Analysis	
Depth: 10-11' Unified Classification: GP-GM	Sieve Size	% Passing
Liquid Limit: Plasticity Index: N.P.	1 1/2	97
pH (by Photovolt pH meter): 5.5	1	83
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	75
Hydrometer Analysis: Sandy Gravel	1/2	64
This material will have good drainage characteristics	No. 4	38
and should make excellent highway subgrade. The gravel	10	25
may be slightly frost susceptible, but should not exhibit	40	13
expansive or compressive characteristics.	80	10
	200	7.6

Report of Laboratory Test Results

Soil No. 21

Location: SE$\frac{1}{4}$,SW$\frac{1}{4}$, Sec. 13, T22N, R5W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: GW-GM	Sieve Size	% Passing
Liquid Limit: Plasticity Index: N.P.	1 1/2	93
pH (by Photovolt pH meter): 5.4	1	87
Minimum Electrical Resistivity, Ohms per cc: 26,500	3/4	83
Hydrometer Analysis: Sandy Gravel	1/2	74
This material will have good drainage characteristics	No. 4	50
and should make excellent highway subgrade. The gravel	10	35
should not be frost susceptible nor will it exhibit ex-	40	16
pansive or compressive characteristics.	80	9
	200	6.1

Soil No. 21

Location: SE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 13, T22N, R5W, W.M.	Mechanical Analysis	
Depth: 12-13' Unified Classification: SP	Sieve Size	% Passing
Liquid Limit: Plasticity Index: N.P.	2	100
pH (by Photovolt pH meter): 5.3	1 1/2	98
Minimum Electrical Resistivity, Ohms per cc: 29,800+	1	96
Hydrometer Analysis: Sand	3/4	93
This material should have excellent drainage charac-	1/2	85
teristics, and can be expected to be at least fair high-	No. 4	55
way subgrade material. The sand should not be frost sus-	10	41
ceptible nor should it exhibit any expansive or compres-	40	21
sive characteristics.	80	9
	200	3.0

Soil No. 22

Location: SE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 26, T29N, R4W, W.M.	Mechanical Analysis	
Depth: 1-2' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 49 Plasticity Index: N.P.	1 1/2	100
pH (by Photovolt pH meter): 5.2	1	99
Minimum Electrical Resistivity, Ohms per cc: 13,700	3/4	98.7
Hydrometer Analysis: Silty Sand	1/2	97
This material should have poor drainage characteris-	No. 4	87
tics, and can be expected to be fair highway subgrade	10	81
material. The soil may be frost susceptible and exhibit	40	69
some expansive and compressive characteristics.	80	56
	200	42.2

Report of Labratory Test Results

Soil No. 22

	Mechanical Analysis	
Location: $SE\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 26, T29N, R4W, W.M.	Sieve Size	% Passing
Depth: 6-7' Unified Classification: SC-SM	1 1/2	98
Liquid Limit: 16 Plasticity Index: 4	1	97
pH (by Photovolt pH meter): 6.8	3/4	96
Minimum Electrical Resistivity, Ohms per cc: 6,000	1/2	93
Hydrometer Analysis: Clayey Silty Sand	No. 4	85
This material will have poor drainage characteristics and will make only fair subgrade material. This soil will probably be frost susceptible and may exhibit expansive and compressive characteristics.	10	80
	40	68
	80	59
	200	40.2

Soil No. 24

	Mechanical Analysis	
Location: $SW\frac{1}{4}$, $NW\frac{1}{4}$, Sec. 31, T29N, R3W, W.M.	Sieve Size	% Passing
Depth: 2-3' Unified Classification: SM-u	1 1/2	98
Liquid Limit: 31 Plasticity Index: 7	1	96
pH (by Photovolt pH meter): 5.3	3/4	95
Minimum Electrical Resistivity, Ohms per cc: 9,100	1/2	90
Hydrometer Analysis: Silty Sand	No. 4	78
This material should have poor drainage characteristics, and have only fair value as a high way subgrade. The soil may be frost susceptible and exhibit some expansive and compressive characteristics. The soil is fairly acid and contains some soluable salts; therefore it will probably corrode reactive metals which are not coated.	10	69
	40	58
	80	48
	200	37.2

Soil No. 24

	Mechanical Analysis	
Location: $SW\frac{1}{4}$, $NW\frac{1}{4}$, Sec. 31, T29N, R3W, W.M.	Sieve Size	% Passing
Depth: 8-9' Unified Classification: CL	1	99
Liquid Limit: 31 Plasticity Index: 10	3/4	98
pH (by Photovolt pH meter): 7.1	1/2	97
Minimum Electrical Resistivity, Ohms per cc: 3,300	No. 4	96
Hydrometer Analysis: Silty Clay	10	94
This material should have very poor drainage characteristics, and will make only fair subgrade. The soil will be frost susceptible and will exhibit some expansive and compressive characteristics.	40	92
	80	86
	200	78.5

Report of Laboratory Test Results

Soil No. 28

Location: SW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 34, T27N, R2W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: GP-GM	Sieve Size	% Passing
Liquid Limit: Plasticity Index: N.P.	2	100
pH (by Photovolt pH meter): 5.7	1 1/2	93
Minimum Electrical Resistivity, Ohms per cc: 23,700	1	85
Hydrometer Analysis: Sandy Gravel	3/4	80
This material will have good drainage characteristics	1/2	74
and should make excellent highway subgrade. The gravel	No. 4	48
may be slightly frost susceptible, but should not exhibit	10	30
expansive or compressive characteristics.	40	16
	80	13
	200	10.1

Soil No. 28

Location: SW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 34, T27N, R2W, W.M.	Mechanical Analysis	
Depth: 10-11' Unified Classification: GP	Sieve Size	% Passing
Liquid Limit: Plasticity Index: N.P.	2	96
pH (by Photovolt pH meter):	1 1/2	90
Minimum Electrical Resistivity, Ohms per cc:	1	83
Hydrometer Analysis:	3/4	75
	1/2	50
	No. 4	9
	10	6
	40	3.3
	80	2.7
	200	2.1

Soil No. 31

Location: SW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 7, T24N, R10W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 43 Plasticity Index: 3	2	100
pH (by Photovolt pH meter): 4.0	1 1/2	99
Minimum Electrical Resistivity, Ohms per cc: 26,400	1	96
Hydrometer Analysis: Silty Sand	3/4	94
This material should have poor drainage characteristics,	1/2	92.2
and have only fair value as a highway subgrade. The sand	No. 4	92
may be frost susceptible and exhibit some expansive and	10	91
compressive characteristics. The soil is fairly acid and	40	88
does have some soluable salts, therefore, uncoated metal	80	80
buried in this soil can be expected to corrode rapidly.	200	34.5

Report of Laboratory Test Results

Soil No. 32

Location: NW$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 8, T24N, R10W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 43 Plasticity Index: 11	1 1/2	92
pH (by Photovolt pH meter): 4.4	1	87
Minimum Electrical Resistivity, Ohms per cc: 25,400	3/4	83
Hydrometer Analysis: Silty Sand	1/2	79
This material should have poor drainage characteristics	No. 4	68
and have only fair value as a highway subgrade. The soil	10	66
may be frost susceptible and exhibit some expansive charac-	40	58
teristics. The sand is fairly acid and may corrode reac-	80	47
tive metals which are not coated.	200	32.7

Soil No. 33

Location: SE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 7, T24N, R10W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 31 Plasticity Index: N.P.	1 1/2	96
pH (by Photovolt pH meter): 4.5	1	93
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	90
Hydrometer Analysis: Silty Sand	1/2	86
This material should have poor drainage characteristics,	No. 4	80
and have only fair value as a highway subgrade. The soil	10	77
may be frost susceptible and exhibit some expansive and	40	65
compressive characteristics. The soil is fairly acid and	80	50
may corrode reactive metals which are not coated.	200	33.7

Soil No. 33

Location: SE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 7, T24N, R10W, W.M.	Mechanical Analysis	
Depth: 20-21' Unified Classification: SC-SM	Sieve Size	% Passing
Liquid Limit: 24 Plasticity Index: 6	1 1/2	99
pH (by Photovolt pH meter): 6.4	1	94
Minimum Electrical Resistivity, Ohms per cc: 3,900	3/4	91
Hydrometer Analysis: Clayey Silty Sand	1/2	87
This material will have poor drainage characteristics.	No. 4	69
It may be frost susceptible and will be of fair value as a	10	59
highway subgrade.	40	42
	80	35
	200	28.7

Report of Laboratory Test Results

Soil No. 33

Location: $SE\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 9, T24N, R10W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: GM-u	Sieve Size	% Passing
Liquid Limit: 36 Plasticity Index: N.P.	1 1/2	91
pH (by Photovolt pH meter): 4.8	1	85
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	81
Hydrometer Analysis: Silty Gravel	1/2	74
This material should make good highway subgrade, and be	No. 4	55
only slightly frost susceptible. It will probably have	10	49
poor drainage characteristics, but should not be expansive	40	37
or compressive. The gravel is fairly acid and can be	80	27
expected to corrode reactive metals which are not coated.	200	16.9

Soil No. 33

Location: $SE\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 9, T24N, R10W, W.M.	Mechanical Analysis	
Depth: 15-16' Unified Classification: SC	Sieve Size	% Passing
Liquid Limit: 23 Plasticity Index: 8	1 1/2	99
pH (by Photovolt pH meter): 6.1	1	98
Minimum Electrical Resistivity, Ohms per cc: 1,100	3/4	95
Hydrometer Analysis: Clayey Sand	1/2	90
This material should have poor drainage characteristics,	No. 4	70
and have only fair value as a highway subgrade. The soil	10	62
may be frost susceptible and exhibit some expansive and	40	49
compressive characteristics.	80	42
	200	35.6

Soil No. 42

Location: $SW\frac{1}{4}$, $NW\frac{1}{4}$, Sec. 11, T23N, R7W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: GM-u	Sieve Size	% Passing
Liquid Limit: 34 Plasticity Index: N.P.	1 1/2	92
pH (by Photovolt pH meter): 4.7	1	86
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	82
Hydrometer Analysis: Silty Gravel	1/2	76
This material will have poor drainage characteristics,	No. 4	45
and may be frost susceptible. It should not be expansive	10	36
or compressive and should make good highway subgrade. The	40	27
gravel is fairly acid and may corrode reactive metals	80	21
which are not coated.	200	16.0

Report of Laboratory Test Results

Soil No. 52

Location: $NE\frac{1}{4}$, $SW\frac{1}{4}$, Sec. 30, T29N, R12W, W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 29 Plasticity Index: N.P.	1 1/2	92
pH (by Photovolt pH meter):	1	89
Minimum Electrical Resistivity, Ohms per cc:	3/4	86
Hydrometer Analysis: Silty Sand	1/2	82
This material should have poor drainage characteristics,	No. 4	80
and can be expected to be fair highway subgrade. The soil	10	76
may be frost susceptible and exhibit some expansive and	40	66
compressive characteristics. The sand is fairly acid and	80	49
can be expected to corrode reactive metals which are not	200	31.4
coated.		

Soil No. 62

Location: $NW\frac{1}{4}$, $SE\frac{1}{4}$, Sec. 16, T22N, R9W,,W.M.	Mechanical Analysis	
Depth: 2-3' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 30 Plasticity Index: N.P.	1 1/2	100
pH (by Photovolt pH meter): 4.7	1	99.8
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	99
Hydrometer Analysis: Silty Sand	1/2	97
This material should have poor drainage characteristics,	No. 4	78
and have only fair value as a highway subgrade. The soil	10	65
may be frost susceptible and exhibit some expansive and	40	46
compressive characteristics. The sand is fairly acid and	80	39
may corrode reactive metals which are not coated.	200	30.7

Soil No. 63

Location: $NE\frac{1}{4}$, $NE\frac{1}{4}$, Sec. 16, T22N, R9W, W.M.	Mechanical Analysis	
Depth: 4-5' Unified Classification: SM-u	Sieve Size	% Passing
Liquid Limit: 65 Plasticity Index: 5	1 1/2	100
pH (by Photovolt pH meter): 4.5	1	99
Minimum Electrical Resistivity, Ohms per cc: 29,800+	3/4	96
Hydrometer Analysis: Silty Sand	1/2	90
This material should have poor drainage characteristics,	No. 4	68
and can be expected to be fair highway subgrade material.	10	55
The soil may be frost susceptible and exhibit some expan-	40	36
sive and compressive characteristics. The sand is fairly	80	28
acid and can be expected to corrode reactive metals which	200	22.2
are not coated.		

APPENDIX V

GLOSSARY

Alluvium - Fine material such as sand, silt, or clay that has been deposited on land by streams.

Argillite - An extremely hard, fine-grained, gray to black sedimentary rock composed primarily of clay minerals. It is distinguished from shale and slate by its lack of cleavage planes parallel to stratification. It typically breaks up into small pencil-like fragments.

Arkosic Sandstone - Sandstone that is low in quartz and high in clay-bearing minerals.

Basalt - A dark gray to black, dense, fine-grained extrusive igneous rock.

Basaltic Breccia - A highly fractured marine basalt with inclusions of angular fragments of other previously formed rocks.

Base Flow - Sustained or fair weather runoff. It is composed of groundwater runoff and delayed subsurface runoff.

Bedrock - The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Block Glide - A deep-seated, slow moving failure marked by lateral separation with but little vertical displacement. Generally occurs in plastic materials.

Clay - A soil separate less than .002 millimeters in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Colluvium - Soil material or rock fragments moved downslope by gravitational force in the form of soil creep, slides, and local wash.

Compaction - The packing together of soil particles by forces exerted at the soil surface resulting in increased soil density.

Complex - An association in which two soil units or a soil unit and a miscellaneous landtype are so intricately mixed that it is not practical to show them separately at the scale of mapping used.

Conglomerate - A highly resistant sedimentary rock, consisting of firmly cemented sand and gravel.

Debris Slide - A rapidly moving slide composed of soil, bedrock, or both.

Erosion - The wearing away of the land surface by running water, wind, ice or gravitational creep. Accelerated erosion may result from the activities of man or animals.

Feldspathic Sandstones - Sandstone that is high in quartz and low in clay-producing minerals.

Geomorphology - The study of landforms as they relate to geologic composition and history.

Glacial Drift - The debris deposited by glaciers or by streams directly associated with them.

Glacial Soils - Soils derived from materials transported or influenced by glaciers.

Glaciated Valley - U-shaped valley formerly occupied by a glacier.

Glaciolacustrine Deposits - Soil materials transported by glaciers and deposited by glacial meltwater in glacial lakes, ranging from fine sand and small gravel near the lakeshores to fine silts and clay in the lake bottom.

Graywacke - A loose and general term for sandstone containing significant quantities of clay materials.

Hummocky - Hilly, uneven landscape resulting from deep-seated soil movement usually of a rotational nature.

Inclusion - Soil type found within a mapping unit that is not extensive enough to be mapped separately or as part of a complex.

Landform - Structural configuration of the topography as a result of past and present geological activity.

Mapping Unit - Any delineated area shown on a soil map that is identified by a number. A mapping unit may be a soil unit, a miscellaneous landtype, or a complex.

Massive - Soil structure or bedrock condition in which there is no observable aggregation or no definite orderly arrangement of natural lines of weakness.

Mass Movement - All movement of soil and bedrock materials occurring below the soil surface such as landslips, landflows, rock slides, slumps, etc.

Mass Wasting - Wearing away of the landscape through the process of mass movement. Geologic erosion.

Miscellaneous Landtype - A mapping unit for areas of land that have little or no natural soil or have properties that are too variable and unpredictable for classification.

Mudstone - Soft, fine-grained gray to black sedimentary rock composed primarily of clay minerals. It lacks cleavage planes parallel to stratification and typically breaks into small block-like fragments.

Outwash - Glacial material swept out, sorted and deposited by water that originated from the melting of glacial ice.

Peak Flow (Peak Runoff) - The greatest water discharge for any single runoff period.

Plastic Soil - A soil capable of being molded or deformed continuously and permanently, by relatively moderate pressure, into various shapes.

Residuum - Soil material formed by rock weathering in place.

Runoff - That part of the precipitation which appears in surface streams of either perennial or intermittent form.

Sand - A soil separate between .05 and 2.0 millimeters in diameter.

Sandstone - A hard rock composed primarily of cemented sand-size grains.

Sedimentary Rock - Rock formed by deposition of soil and rock particles by water, ice or wind that later solidifies through cementation, ionic exchange or compression.

Shale - Fine-grained rock, softer than slate, consisting of clay minerals and silt, which characteristically splits readily along closely spaced planes, parallel or nearly parallel to stratification.

Sheet Erosion - Uniform removal of surface soil by water flowing overland or by wind.

Silt - A soil separate consisting of particles between 0.002 and 0.05 millimeters in diameter.

Siltstone - A sedimentary rock consisting primarily of silt-size particles.

Slate - Rock formed by the metamorphism of shale. Slate is very fine-grained and exceptionally well foliated. Because of its excellent foliation, it splits into thin sheets parallel to stratification.

Slump - A deep-seated, slow moving rotational failure occurring in plastic materials resulting in vertical and lateral displacement.

Soil - Any and all loose, incoherent, unconsolidated, weathered material on the earth's surface resting on solid, consolidated, unweathered bedrock, no matter how formed, or origin, or method of weathering or deposition. Generally includes any material that may be moved or broken by hand tools or heavy equipment without the need of blasting except soft, unweathered bedrock. In soil horizon designation, soil materials included "A", "B", and "C" horizons.

Soil Creep - Slow mass movement of soil material downslope primarily under the influence of gravity, but facilitated by saturation with water and/or by alternating freezing and thawing.

Soil Unit - Taxonomic description of a portion of the landscape sufficiently uniform in soil, bedrock and landform that it can be clearly defined and easily recognized wherever it occurs.

Spot Symbols - Symbols used on soil maps to represent a landscape factor too small to delineate.

Surface Slips - Rapid movement downslope of the surface few feet of soil on steep slopes.

Till - Glacial materials deposited directly by ice with little or no transportation by water. It is generally an unconsolidated, unstratified compact mixture of clay, silt, sand, gravel and boulders.

Toeslope - Portions of a slope that is transitioned between the valley floor and the upper slope.

Topography - The relief features or surface configuration of an area.

U-shaped Valley - Descriptive phrase of the cross profile of a valley which has been carved out by glacial movement.

V-shaped Valley - A descriptive phrase of the cross profile of a valley which has been cut by stream action.