Land Use

GEOLOGY

of

Central Jackson County, Oregon

1977

LAND USE GEOLOGY

OF

CENTRAL JACKSON COUNTY, OREGON

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LAND USE GEOLOGY OF CENTRAL JACKSON COUNTY, OREGON

INTRODUCTION

Purpose

Effective land use planning and land management require on adequate data base with regard to the potential uses and limitations of the land. The purpose of this study is to provide practical information on specified geologic hazards and engineering geology conditions of central Jackson County.

The need for comprehensive, systematic, and reliable information of this sort has gained wide recognition by State officials, County officials, planners, private citizens, and resource specialists and is articulated in Goal 7 of the Land Conservation and Development Commission. Legal trends in recent years have been toward placing increasing emphasis on comprehensive plans in land use decisions in Oregon (Fasano; Baker v. Milwaukee; Green v. Hayward). The nationwide trend is also toward the placing of greater responsibilities on permit-granting agencies.

Acknowledgments

The author greatly appreciates the cooperation and help given by many individuals and organizations in the preparation of this report. The investigation was funded in parts by grants from the Land Conservation and Development Commission to Jackson County and also o grant from Jackson County. The grants were implemented on o matching basis by the Oregon Deportment of Geology and Mineral Industries. Special thanks ore extended to Robert Britzemon, Jackson County Planning Director, and Curtis D. Weaver, Senior Planner.

The Jackson County Planning Department, the U. S. Geological Survey (Portland office), the U. S. Soil Conservation Service, and the Oregon Water Resources Department supplied valuable information in their respective areas.

Staff members of the Oregon Deportment of Geology and Mineral Industries assisting in the project included Steven R. Renaud, Charles A. Schumacher, Wendy John, and Rose Reed, cartographers; Beverly F. Vogt, geologist-editor; Ainslie Bricker, editor; and Ruth E. Pavlot, typist.

How to Use

General

Proper land management and land use planning addresses the characteristics of the land. In addition to County and city planners, the category of land use planners and managers to some degree also includes developers; policy formulators on the notionol, state, and local level; land holders; architects; engineers; and natural resource specialists.

This bulletin provides planners in Jackson County with o synthesis of present thinking on geologic hazards and engineering geologic conditions in the study area. The material is reconnaissance in nature, however, subject to refinement based on additional investigations. The mops, like all mops, represent average conditions as they actually occur on the ground; and on-site examination generally is require' for specific evaluations.

The bulletin is organized and cross referenced to facilitate easy reference and use as a tool in decision making. The maps and tables interrelate the various hazards and geologic units. The text is divided into sections on specific hazards or topics and is structured around the formats of the map legends. The net result is a logical progression of facts with a potential for a wide variety of uses on various levels of inquiry from general to specific (Figure 1).

Site evaluations

In general, the maps, tables, and text are used to assess the use potentials and use limitations of the land. These are matched with the specific site requirements of the proposed development and the surrounding area to determine if the development and the site are compatible. An appreciation of the limitations of map detail is a key prerequisite to correct site-specific decisions, and on-site investigations are generally required for site evaluations. Although the text and tables are designed to guide and facilitate site evaluations, consultation of other sources of information is also recommended.

Land use capability analyses

Data provided in this bulletin and on the maps can either be used directly to develop land use capability maps or indirectly to develop such maps by using various sequences of overlays. Techniques such as these are appropriate preliminary exercises in the preparation of comprehensive plans or in their revision or refinement. To be valid, however, such maps should meet three specifications:
   (1) The maps should be prepared for individual types of development or for closely related types of development.
   (2) Capability categories described in the map legend should be realistic and meaningful in terms of field observations and informed professional judgment.
   (3) Scale must be properly appreciated, and provisions should be made for exceptions based on more detailed information.

Extrapolation of data

On the County and city level, specialists commonly possess a wealth of detailed information on specific sites in their respective fields of expertise but do not readily have at their disposal a mechanism for projecting their observations into other areas. Thus, an individual may have detailed site-specific information on septic-tank failures, aggregate resources, or landslides but may not have adequate means of anticipating similar problems elsewhere. In this bulletin, geologic units, slopes, and hazards are interrelated in the text and maps to provide the specialist with the tools he needs to extrapolate his observations into new areas for which no detailed historic information is available.

Policy formulation

When used in conjunction with a realistic set of goals, this bulletin can be invaluable in formulating land use policies on the local and regional level. Such policies should represent a coordinated effort on the part of government agencies of various levels, consider all significant hazards, and make provisions for local conditions as revealed by more detailed study or on-site investigation. Although policies should be designed in the best interests of society to protect the safety and well-being of the public, they should not be based on overreactions arising from inadequate or inappropriately applied information regarding geologic hazards.

Map Scale and Detail

Obtaining data of an appropriate level of detail for a particular planning task is often the most significant informational concern of the planner. Inventories are generally conducted for a variety of purposes and are available on several levels of detail. Confusion may result if the degree of generalization

1. DEFINE TASKS	Examples include evaluating proposed developments, developing or revising comprehensive plans or zoning ordinances, evaluating requests for variances, advising residents or developers, and developing goals or guidelines.
2. LOCATE SITE OR AREA	Locate the site visually on the appropriate geologic map and geologic hazards map.
3. IDENTIFY GEOLOGIC HAZARDS OR HAZARDOUS ENGINEERING CONDITIONS	Use the geologic map and text to determine the engineering properties of the underlying geologic unit or units. Use the geologic hazards map and text to determine geologic hazards.

ACQUIRE ADDITIONAL INFORMATION

For site-specific work or for construction of additional maps on a significantly larger scale, consultation or additional field work by qualified staff may be needed to establish accurate boundaries.

4. ASSESS THE SITE	Define the physical capabilities and liabilities of the land. The text is organized and cross-referenced to facilitate this type of use. Consult cited references or appropriate agencies where necessary.
5. EVALUATE THE PROJECT	Compare the physical capabilities and liabilities of the land with the physical requirements of the proposed use. Consider possible engineering and land management solutions and their impact on surrounding areas.
6. PLAN	In arriving at a final decision consider local and regional goals, political and economic factors, citizens' input, and other appropriate data.

Figure 1. Suggested use of this bulletin in land use decision making.

of a planning tool generated on a statewide, countywide, or citywide basis is not distinguished from the degree of specificity needed for local implementation. Maps made for o general purpose ore generally not fully adequate for other uses involving more precise levels of inquiry such as site-specific decision making or the construction of large-scale zoning maps.

Where gaps in information exist, arbitrarily adjusting the scale of the map does not generate the additional mop detail required by the new use. Increased detail requires additional investigation (see Site evaluations and Land use capability analyses). The needed information con be obtained by consultation, additional studies, on-site investigation, or in-house revision based on additional information. The text of this report is primarily intended to supplement the mops and to serve local jurisdictions in generating more detailed mops and information for specified local use.

In summary, completion of regional inventories is a necessary prerequisite of local implementation, but these inventories ore not substitutes for site-specific information. As comprehensive plans ore elevated to a more distinguished and fundamental role in local planning (Fasano, Baker v. Milwaukee; Green v. Hayward), more care must be given to their formulation. To preserve the option of making justified zoning variances based on additional future information, the planner must carefully phrase land use restrictions as they ore presented in the comprehensive plan.
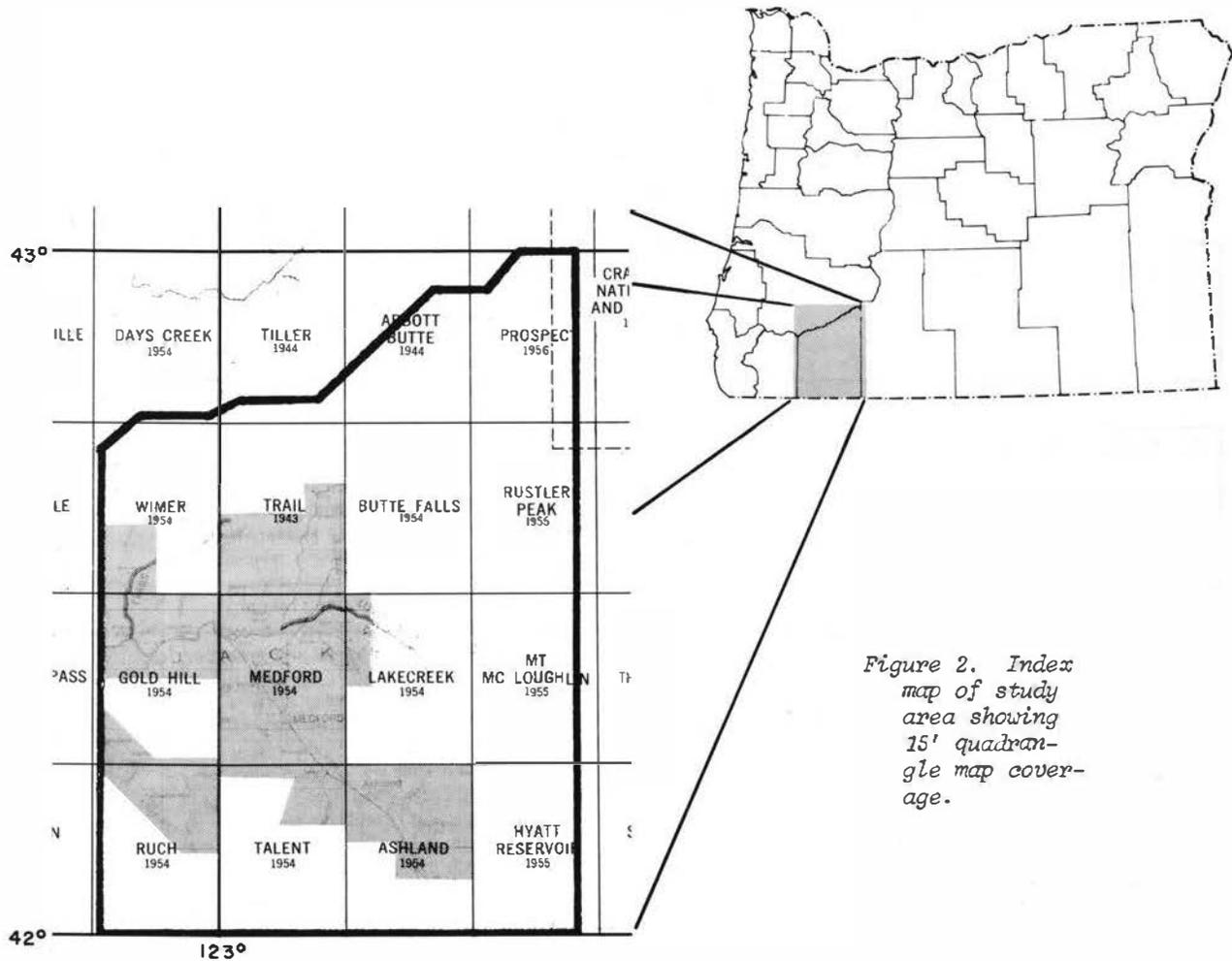
Figure 2. Index map of study area showing 15' quadrangle map coverage.

GEOGRAPHY

Location and Extent

The study area encompasses the central parts of Jackson County (Figure 2). It is bounded by political boundaries or, in some cases, by arbitrary boundaries selected on the basis of topography, County needs for information, and desire for economies in the mapping and publication processes.

Parts of eight topographic quadrangle maps are included. Total areal extent is approximately 750 square miles. Access is provided by Highway I-5 in the Bear Creek and Rogue River valleys and by State, County, local, and private roads in more remote areas.

Climate

Winters are mild, and summers are dry in the study area. Rainfall is least in the valley areas, averaging 20 inches annually, and is greatest to the northeast in the Cascades, where an average annual rainfall of 46 inches per year is recorded at Trail. Average rainfall is greatest at higher elevations but generally is less than 30 inches. Summer rainfall is less than 2 inches in the valleys. Climatic data is summarized in Table 1.

Table 1. Climatic data, Jackson County, Oregon

	Trail	Medford	Ashland
Mean annual precipitation (inches)	47	20	20
Mean January temperature (°F)	37.5	35.4	37.5
Mean July temperature (°F)	67.7	72.1	69.1
Mean maximum temperature (°F)	65	67	65
Mean minimum temperature (°F)	37	41.2	39.8
Maximum temperature (°F)	108	115	106
Minimum temperature (°F)	-1	-3	-1

Topography

The Klamath Mountains of western Jackson County, the Cascade Range of eastern Jackson County, and the Bear Creek valley of central Jackson County are the major physiographic provinces. The Rogue River cuts through each of the provinces as it passes through the study area.

The Klamath Mountains province and parts of the Cascade Range are underlain by hard bed rock with o variety of jointing and bedding characteristics. Slopes are generally steep; and hazards include steep-slope failure, torrential flooding, slope erosion, and highly variable cutbank stability. Slopes are gentle to moderate in areas of large-scale faulting or prolonged weathering and degradation, or where there is softer parent rock such as shale or tuff. Eorthflow and slump are common locally.

The Bear Creek valley, Rogue River valley, and tributary valleys are underlain by o variety of flat-lying, soft to very soft, surficial geologic units. Hazards include ponding, high ground water, flooding, and stream-bank erosion. In youthful parts of volleys, flat terrace forms are developed by erosion of underlying bed rock rather than by deposition of alluvial units. Terrace forms, therefore, ore not always indicators of terrace units, as shown on the geologic mops.

The engineering properties of geologic units ore major factors in the development of landforms and in the distribution of geologic hazards. Accordingly, proper definition and identification of rock units are essential to meaningful land use geology assessments. Engineering properties, regolith, and geologic hazards for each geologic unit ore summarized in Table 3.

Population and Land Use

The population of Jackson County (Table 2) is expanding at o rote more rapid than that for Oregon as o whole, portly because of a greater-than-average rate of immigration. Historically, land use has been related in large part to landforms and the location of major transportation lines. Greatest growth in recent years has occurred along Highway I-5 in the Bear Creek valley.

Table 2. Population of major communities of central Jackson County, Oregon

City	1950	1960	1970	1985	2000*	
					Minimum	Maximum
Ashland	7,739	9,119	12,342	16,719	20,000	30,000
Butte Falls	372	384	358	406	300	700
Central Point	1,667	2,289	4,004	5,605	10,000	16,000
Gold Hill	619	608	603	670	1,000	3,000
Rogue River	590	520	841	1,019	3,000	7,900
Jacksonville	1,193	1,172	1,611	2,124	3,000	6,000
Medford	17,305	24,425	28,454	38,470	50,000	70,000
Phoenix	746	769	1,287	1,740	3,000	5,500
Eagle Point	607	752	1,241	1,858	4,000	7,000
Talent	739	868	1,389	2,235	3,500	6,500
Jackson County	58,510	73,962	94,533	124,513	151,500	238,000

* Figures supplied by Jackson County Deportment of Planning and Development

Physical restraints to development within the valley are not easily delineated or mitigated. For example, high ground water and ponding are governed by a complex set of factors and ore not associated with easily mapped terrain factors. Land use patterns are, in places, in conflict with land limitations. With continued growth, local problems become regional concerns requiring broad-based cooperative treatment.

Dominant land uses in the mountainous areas ore forestry, recreation, and scattered residential development. Potential for a rejuvenated mining industry is recognized for some upland areas. In the future, scattered homes and support facilities for logging and possibly mining will place increasing burdens on the delicate upland terrain and will require careful management.

Future urbanization and associated economic expansion into trade, education, and services will lead to increased development pressures on the land surrounding present communities and in areas of new growth. Proper management of the land resource will assure most beneficial use of the land and mitigation of existing and future potential hazards.

GEOLOGIC UNITS

General

This technical discussion of geologic units is provided to (1) document and rationalize the information on the geologic maps, (2) aid in geologic hazard interpretation, (3) systematically relate the geologic units to the other sections of the bulletin, and (4) update concepts on the geology of the study area.

The geologic units are distinguished primarily by rock type and, to a lesser extent, by other physical properties, distribution, topographic setting, and age. Generally, each geologic unit possesses a unique association of engineering properties.

A total of 17 geologic units is recognized (Figure 3): 4 surficial, 6 volcanic and sedimentary, 3 metamorphic, and 4 intrusive rock units. Ages range from approximately 200 million years to the present.

Bedrock structure is briefly discussed to (1) document interpreted distribution of rock units, (2) enable proper interpretation of mineral distributions, (3) enable proper interpretation of earthquake potential, and (4) allow more accurate interpretation of mass-movement distribution and potential.

Surficial Geologic Units

In the study area, surficial geologic units are unconsolidated, relatively thin, stream deposits that overlie bed rock. Major landforms are flood plains, terraces, and alluvial fans. The elevation of the major valleys is determined by the elevation of the narrows immediately downstream from Roy Gold (Gold Ray). This is the local base level below which valleys and other upstream erosive features do not develop. Accordingly, development of the Bear Creek valley has been dominated by widening rather than deepening.

Quaternary alluvium (Qal)

Quaternary alluvium consists of sand, silt, clay, and gravel in the flood plains and channels of major streams and is equivalent to part of the Quaternary alluvium of Wells (1956). Because of limitations of map scale, some Quaternary alluvium is included in Quaternary older alluvium (Qoo).

Composition of the alluvium varies with source area and stream size. Along the Rogue and Applegate Rivers, gravel and sand predominate. Alluvium found in streams draining the foothills of the Cascades is characteristically dominated by gravel and clay. Deposits along smaller streams crossing flat valleys are generally rich in silt and clay and locally high in organic material. Downcutting by streams has locally exposed erosion-resistant, cemented gravel horizons that are interpreted to be carbonate-cemented layers of older alluvial units produced by soil-forming processes. Quaternary alluvium varies from 20 feet in thickness along major streams to less than a foot along minor streams. Bed rock is locally exposed in major stream channels.

Quaternary alluvium is overlain by little or no soil and is subject to stream flooding, stream-bank erosion, and channel change along major channels. Ephemeral stream channels and depressions are subject to high ground water and ponding. Ground-water potential in the gravels of the Rogue River is good. Placer gold has been recovered from many alluvial channels. The unit is locally a potential source of aggregate.

Quaternary older alluvium (Qoo)

The Quaternary older alluvium, which consists of a variety of alluvial units that generally lie above levels of present flooding (Figure 4) and below the higher terraces, is equivalent to part of the

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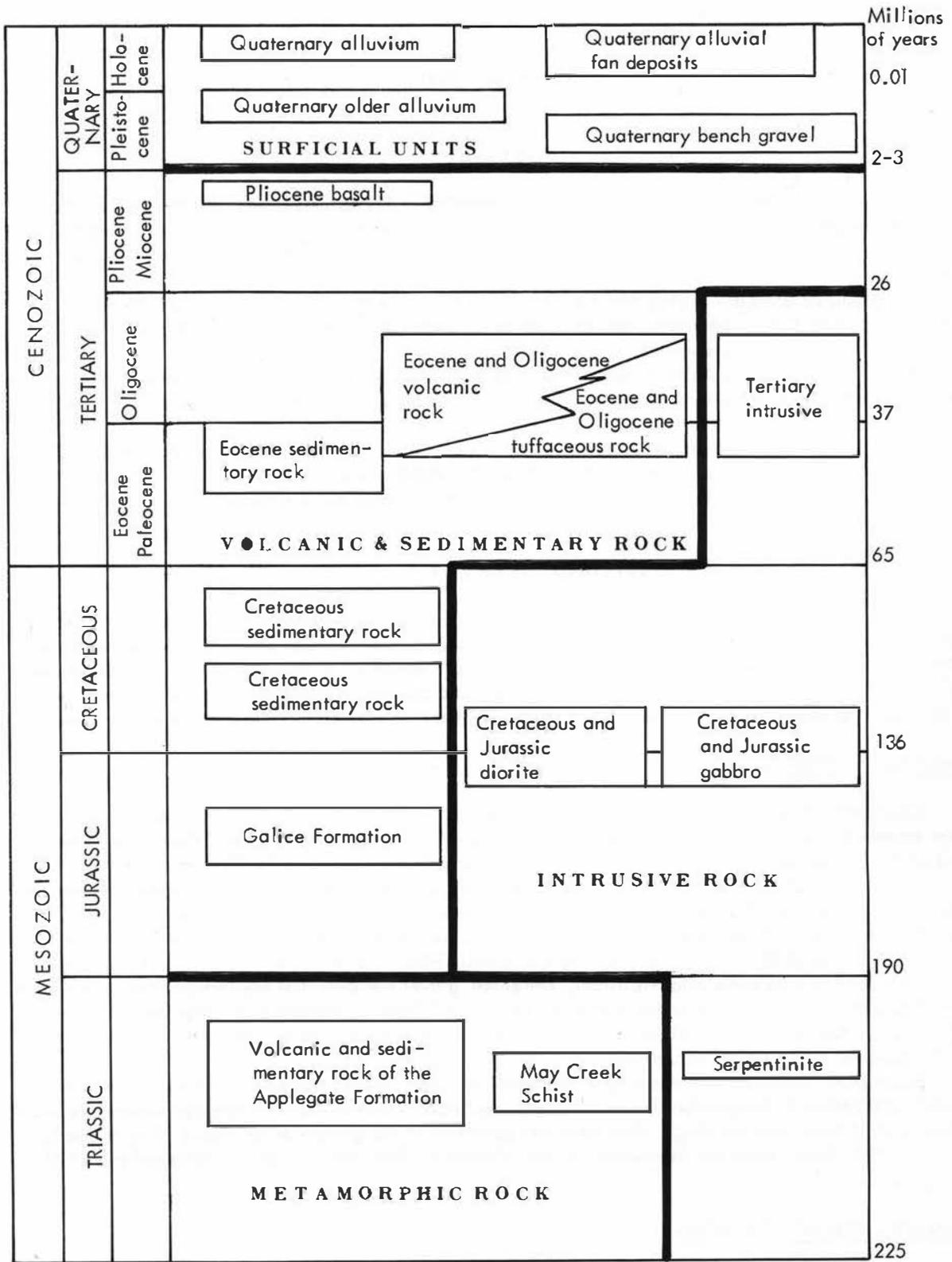
Figure 3. Time distribution of geologic units.

Figure 4.   Quaternary older alluvium (Qoa) along Anderson Creek.

Quaternary alluvium of Wells (1956). Because of scale limitations, this unit includes Quaternary alluvium in some places. The unit does not include flat bedrock surfaces contiguous with depositional terrace land-forms. Major areas include the west Bear Creek valley, the Sams Valley area, and Evans and Pleasant Valleys. Thicknesses range up to 60 feet.

The Quaternary older alluvium consists of sand, silt, and clay in varying proportions throughout the west Bear Creek valley area. Layers of each of the materials are complexly interrelated, and engineering properties vary accordingly. Patterns of ground-water flow are extremely complex. Around the edges of the major valleys the Quaternary older alluvium includes alluvial-fan material and base-slope colluvium.

The Quaternary older alluvium of Sams Valley, Evans Valley, and Pleasant Valley is a product of stream deposition and deep bedrock weathering. The contact with bed rock is commonly gradational, and much of the material is residual rather than depositional. A large residual component is also present in much of the Quaternary older alluvium of the smaller mountain valleys.

Soils overlying the Quaternary older alluvium consist of silty clay loam and silty clay and are the product of weathering and flood deposition. Clay-rich pans of low permeability are developed in the sub-surface. As a result of low permeabilities, flat topographic expression, and gentle depressions, the unit is subject to extensive ponding and high ground water throughout much of the Bear Creek valley. Precise definition of the distribution of high ground-water hazard areas is difficult because of urbanization and agricultural practices. Stream flooding is a hazard where the unit is transitional with Quaternary alluvium (Qol).

Quaternary bench gravel (Qbg)

The Quaternary bench gravel consists of up to 70 feet of river- and stream-deposited silt, sand, clay, and gravel and forms the higher terraces of the study area including the Agate Desert and numerous smaller terrace forms along the Rogue River. The unit includes the Quaternary bench gravel of Wells (1956). It was probably deposited during a Pleistocene glacial period when heavier precipitation in the

study area caused greater erosion in the hills and increased deposition in the valleys. Subsequent erosion during nonglacial periods has reduced the unit to its present distribution.

The unit is characterized by semiconsolidated deposits of cross-bedded gravels and sand with inter-beds of dark-gray to blue-gray sand, silt, and clay. The gravels are commonly set in a matrix of clay-rich material. These gravels were derived locally from tuffaceous rocks of the Cascades foothills and were deposited under torrential conditions.

Infiltration rates at the surface are generally very low because of the high clay content of the parent material. The flat landforms have contributed to the prolonged weathering. Shallow subsurface flow of ground water and associated dissolution of mineral matter through chemical weathering may have contributed to the characteristic patterned ground of the unit. However, the patterned ground (Figure 5) was prob-ably inherited from vastly different soil-forming environments in the Pleistocene. The polygonal to rounded mounds average 100 feet in diameter and are bounded by lower channels laden with residual boulders and gravel. On sloping ground the polygons are elongate (see Soils) and are transitional with dendritic ephem-eral streams. In a superficial analysis, Wells (1956) interpreted the residual boulders as the products of Rogue River deposition.

The bench gravels are subject to high ground water and ponding. Septic-tank capacity of the soils is generally low, especially on flat surfaces. Ground-water potential of sandy and gravelly interbeds is generally good. The unit is a potential source of aggregate.

Quaternary alluvial fan deposits (Qof)

This unit consists of fan-shaped deposits of poorly sorted sand, silt, and gravel at the mouths of torrential-flood channels, where they spill onto other surficial units. Major fans are developed in the Phoenix-Ashland area, and smaller fans are present east of Central Point and near Applegate. The Quater-nary alluvial-fan deposits are transitional with other terrace units and with unmapped base-slope colluvium.

Engineering properties are highly variable; and hazards include torrential flooding, stream-bank erosion, and deposition. Depths to bed rock are variable.

Volcanic and Sedimentary Geologic Units

In the study area, volcanic and sedimentary geologic units, which include a variety of consolidated rock units that underlie surficial units where present, are to some extent folded and faulted and do not display metamorphic features. In addition, the volcanic and sedimentary geologic units do not include intrusive igneous rocks. The various volcanic and sedimentary rocks of the study area have a wide range of engineering properties and associated hazards.

Pliocene basalt (Tpb)

The basaltic peaks of Upper Table Rock, Lower Table Rock, and two peaks immediately to the west are composed of Pliocene basalt (Figure 6) which is equivalent to the pre-Mazama basalt of Wells (1956). The Pliocene basalt consists of two or more basalt flows which presumably filled the ancient valley of the Rogue River to a depth as great as 125 feet. With subsequent erosion of softer rocks in the surrounding area, flow remnants now form topographic highs known as inverted topography.

The basalt, which is a grayish-block dense rock with phenocrysts of feldspar and pyroxene, is broken by vertical joints and short irregular subhorizontal joints of varying spacings. Much of the material overlying the basalt is stream deposited (Paeth, 1967). Although the basalt is an excellent source of quarry rock, the process of quarrying it conflicts with the aesthetic resources of the area. Talus rubble on the slopes below the actual flows have been mined on a very limited basis for quarry rock.

Eocene and Oligocene volcanic rock (Teov)

This unit consists of most of the volcanic rocks of the Cascade Range in the study area (Figure 7) and is equivalent in part to the Roxy Formation of Wells (1956) and the agglomerate and older basalt flows
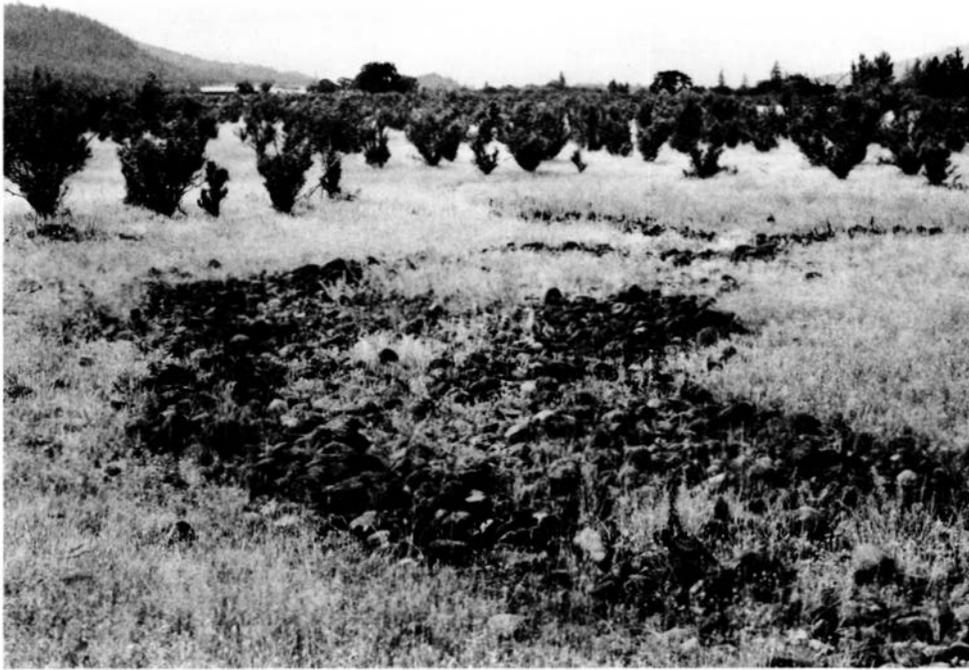
Figure 5.   Patterned ground overlying Quaternary bench gravel (Qbg).
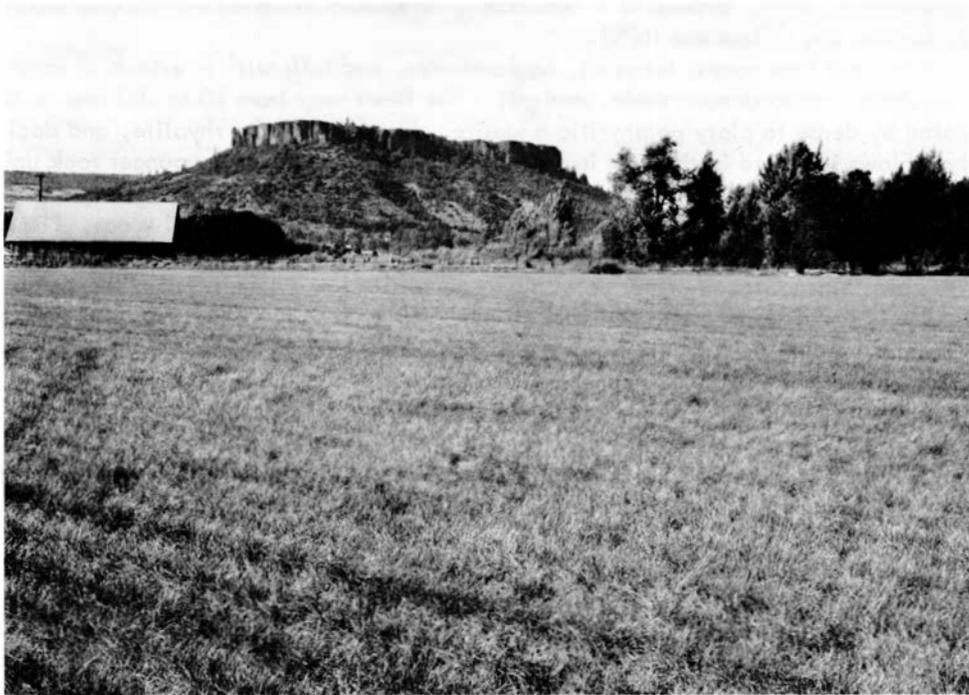
*Figure 6.   Pliocene basalt (Tpb) overlying moderately steep slopes of
     Eocene sedimentary rock (Tes) with Quaternary older alluvium (Qoa)
     in the foreground.*

*Figure 7.   Southern Bear Creek valley: Eocene and Oligocene volcanic rock
(Teov) in the distance; Eocene sedimentary rock (Tes) capped with
Tertiary intrusive rock (Ti) in the middle foreground.*

of Wilkinson ond others (1941). Exposures of dominantly tuffaceous material ore mopped separately as
Teot (Tertiary, Eocene and Oligocene tuffs).

Rocks include hard flow rocks, breccias, agglomerates, and tuffs with interbeds of sandstone,
bedded volcanic shale, carbonaceous shale, ond grit. The flows vary from 10 to 100 feet in thickness
and ore dominated by dense to platy porphyritic andesite. Flows of basalt, rhyolite, and dacite ore
present locally. Flows included in the unit in the Trail area may belong to a younger rock unit.

Engineering properties of the various rock types vary considerably. The flow rocks ore character-
istically hard and stable with moss movement restricted to shallow depths in local areas. The agglomerates
and other fragmental volcanics are characterized by bouldery soils and rockfall. Soils over the flow rocks
ond agglomerates are thin. Ground-water potential is generally low. Localities of discharge produce
marshy areas at the bases of slopes north of Eagle Point.

The sedimentary rocks and tuffs are generally high in clay content and prone to extensive moss
movement and expansion-contraction phenomena. Most landslides in the Eocene and Oligocene volcanic
rocks occur in connection with faults or interbeds of tuffaceous material. Distinction between flow rock
and tuffaceous rock requires on-site examination.

Oligocene leaf prints have been recovered from the unit east of Medford (Roxy Formation of Wells,
1956). The unit is interbedded with Eocene sandstone near Emigrant Creek.

Eocene and Oligocene tuffaceous rock (Teot)

Eocene and Oligocene tuffaceous rock consists of the larger exposures of tuffs and tuffaceous sedi-
mentary rocks within the volcanic rocks of the Cascade Range foothills in the study area and is equiva-
lent in part to the Colestin Formation (Tc) of Wells (1956). In the study area the tuffaceous rocks may
not be stratigraphically equivalent to the type Colestin Formation south of the study area (Monty Elliot,
oral communication, 1977).

The unit, which is exposed in the foothills of the Cascades in the Antelope Creek drainage and in
the Eagle Point area, is interbedded with the lower parts of the Eocene and Oligocene volcanic rock unit
(Teov).

The unit (Teot) is equivalent to the unmapped sedimentary rocks and tuffs (Teov) and consists of vari-colored tuff and sedimentary rocks derived from volcanic rocks. It contains minor interbedded flow rock.

The rock is soft to moderately hard, rich in cloy, and impermeable, especially where weathered. Hazards include moss movement, stream-bonk erosion, very low cutbank stobility, and severe expansion and contraction of overlying soils. Potential use for embankments and rood bose is very slight. Londfill potential is good.

A lote Eocene to Oligocene age is assigned to the unit on the basis of stratigraphic position above Eocene sedimentary rocks and below Eocene and Oligocene volcanic rocks.

Eocene sedimentary rock (Tes)

This unit consists of fluvial to deltaic sandstone and siltstone of probable Eocene age in the east Bear Creek valley and in Soms Valley. It is equivalent to port of the Umpqua Formation of Wells (1956), the Umpqua Formation of Wilkinson and others (1941), and the Payne Cliffs Formation of McKnight (1971). It is apparently not stratigraphically equivalent to the Umpqua Formation of Diller (1898) in the Roseburg quadrangle because of the older age of the true Umpqua Formation (early and middle Eocene) os established in that oreo.

The Eocene sedimentary rock consists of ridge-forming sandstone (Figure 8) and minor conglomerate and siltstone of fluvial origin in the south, grading northward into finer grained sandstone ond shale with rare conglomerate in the Soms Valley area. McKnight (1971) interprets deposition by north-flowing streams. Carbonaceous beds and traces of cool ore geographically widespread, especially in the Roxy Ann Butte oreo. The rocks consist, in port, of tuffaceous moteriol derived from contemporaneous volcanic activity. Scattered interbeds of flow rock and tuff ore exposed near Emigrant Creek.
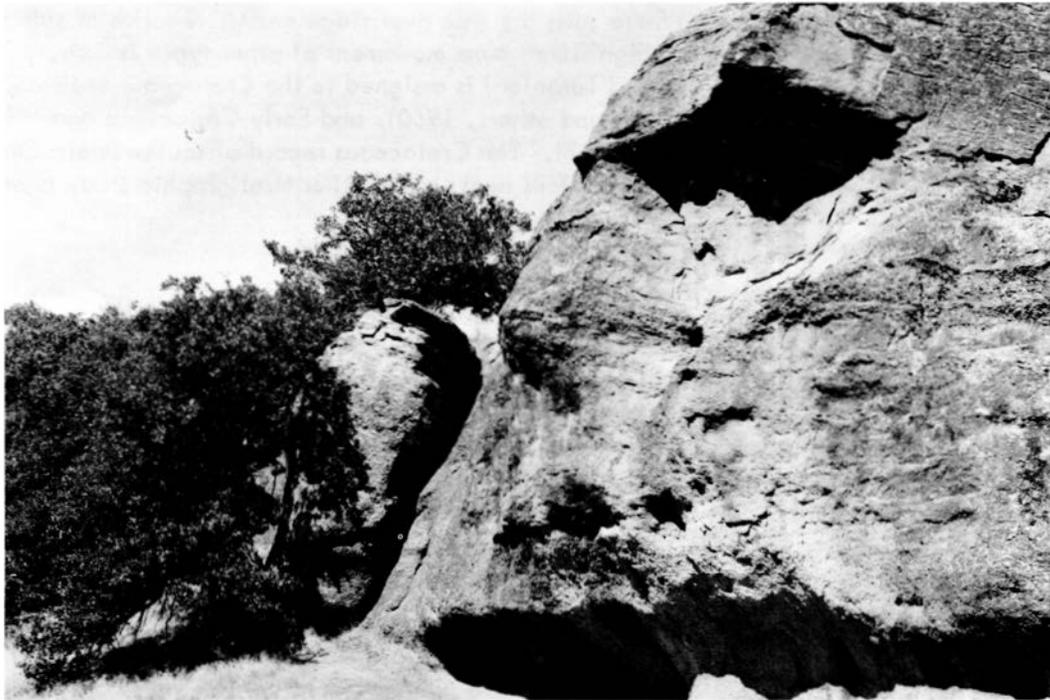
Figure 8. Resistant cliffs of Eocene sedimentary rock (Tes) in southeast Bear Creek valley.

Regolith and soil thicknesses are generally thin on steep slopes. On flat surfaces the regolith varies from thick, deeply-weathered sandstone in Sams Valley to very thin, immature soil over hard, massive bed rock in the southern Bear Creek valley. East and northeast of Medford, prolonged weathering of the tuffaceous sandstones and shales on flat valley surfaces has produced highly expansive, dark, clay-rich soils.

Infiltration rates are generally low. Subsurface flow is largely restricted to the base of the soil or regolith over unweathered bed rock. If this subsurface flow is located at shallow depths, it must be considered in construction (see High Ground Water and Ponding).

The unit is believed to be late Eocene in age, based on leaf fossils recovered from it in the southern Bear Creek valley (McKnight, 1971). In addition, the upper parts of the unit are interbedded with the Eocene and Oligocene volcanic rocks (Teov).

Cretaceous sedimentary rock (Ks)

Sedimentary rocks of Cretaceous age include fault-bounded patches in the hills west of Bear Creek valley, buried strata beneath the western part of Bear Creek valley, and an isolated fault-bounded exposure in the Graves Creek area northwest of Wimer. Cretaceous sedimentary rock (Ks) of this report is equivalent to the Hornbrook Formation of Wells (1956), part of the Umpqua Formation of Wells (1956), and the Hornbrook Formation of McKnight (1971). The unit is possibly equivalent to the Hornbrook and Hilt Formations of Elliot (1971), south of the mapped area.

In the Bear Creek valley, the unit consists of hard conglomerate and sandstone overlain by mudstone with thick sandstone interbeds. At Graves Creek, the unit consists of thin basal conglomerate overlain by gray sandstone. In the Ashland area, the sandstone and mudstone are mapped separately by McKnight (1971).

Infiltration rates are generally low, but ground-water potential is good at certain horizons along the west side of the Bear Creek valley and possibly along major faults. Weathering has produced a thick, clay-rich, lateritic soil over large areas. Where soils are thin over ridge crests, regolith of side slopes is commonly thick, indicating active creep. Significant mass movement of other types is rare.

A Middle Cretaceous age (Cenomanian and Turonian) is assigned to the Cretaceous sedimentary rock unit in the Bear Creek valley area (Popenoe and others, 1960), and Early Cretaceous age (Albian) is assigned in the Graves Creek area (Peterson, 1967). The Cretaceous record of southwestern Oregon consists of numerous, partially preserved units of various ages; and further stratigraphic study is needed.

Galice Formation (Jg)

The Galice Formation consists of slates, shales, and associated sedimentary rocks of Jurassic age that are younger than the metamorphic rocks and older than the Nevadan intrusive rocks. It is equivalent to the Galice Formation of Wilkinson and others (1941) and limited in distribution to remote parts of the Wimer quadrangle.

Rock types include distinctly bedded slate and dark-gray to black shale with subordinate sandstone and conglomerate in thin beds that measure up to a foot or less in thickness. Infiltration rates are low, and ground-water potential is negligible. Major hazards include severe erosion potential, steep-slope failure, and low cutbank stability, especially in areas of unfavorable dips or jointing.

A Late Jurassic age is assigned to the unit on the basis of information from other localities in the Riddle quadrangle (Diller and Kay, 1924).

Metamorphic Geologic Units

Metamorphic rocks are derived from pre-existing rocks by temperature or pressure extremes beneath the zone of weathering. Metamorphic rocks generally have different mineralogic and structural characteristics than those of their parent rocks. In the study area the metamorphic rocks, which are generally very hard and jointed, break into angular chips and slabs. Some of the metamorphic rocks are strongly foliate; that is, they possess closely spaced parallel planes of structural weakness that are the result of metamorphism.
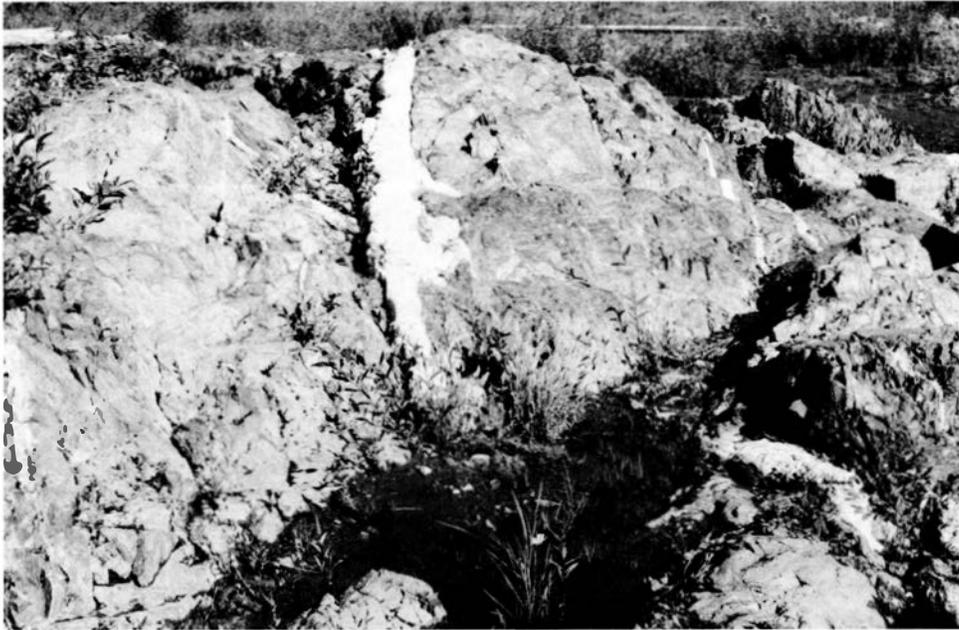
Figure 9. Metamorphosed volcanic rock of the Applegate Formation (Rav) along the Applegate River.

Volcanic rocks of the Applegate Formation (Rav)

The volcanic rocks of the Applegate Formation ore equivalent to port of the Applegate Formation of Wells (1956) and to the metovolconics of Wells and others (1940). They ore exposed in the Applegate drainage (Figure 9), in the mountains southwest of the Bear Creek volley, and in the lower Evans Creek area. The volcanic rocks dip steeply to the southeast in the Applegate River area and steeply to the northwest in the Ashland area.

Rocks mopped as Rov include altered lavas, flow breccias, pyroclastics, minor tuffaceous sedimentary rocks, chert, argillite, and limestone. Unlike their unmetomorphosed equivalents, however, these rocks ore generally hard and display fairly uniform engineering properties. In the north the rocks apparently grade into the May Creek Schist (Rmc) with increasing metamorphism.

Regalith and soil are thin along ridge crests and side slopes but generally thick at the bases of slopes because of slope–wash deposition, creep, and weathering. Hazards include torrential–flood potential; steep-slope failure, especially in the upper reaches of streams; and severe erosion. Infiltration rates ore low, and ground–water potential is minimal. Metallic minerals hove been recovered from the unit near diorite intrusions.

Sedimentary rocks of the Applegate Formation (Ras)

The sedimentary rocks of the Applegate Formation ore equivalent to part of the Applegate Formation of Wells (1956) and to the metasedimentary rocks of Wells and others (1940). Their distribution is similar to that of the volcanic rocks of the Applegate Formation.

Rock types include altered tuffaceous sedimentary rock; block, fine–grained, platy argillite; gray chert; and limestone or marble. The sedimentary interbeds typically form thin northeasterly trending bands within the Applegate Formation. Because of scale limitations, minor amounts of volcanic rock ore also included in the unit.

Unlike unmetamorphosed equivalent rocks, these rocks ore generally hard, with fairly uniform

engineering properties. Unlike the metavolcanic rocks discussed above, however, these rocks display variable engineering properties after being weathered. On gentle slopes, the argillite weathers to a thick, clay-rich regolith with low cutbank stability. The chert weathers to a regolith of fine chips. When fresh, the sedimentary rocks form steep slopes with moderate to severe erosion potential. Mass movement is restricted to steep-slope failures.

Ground-water potential is low. Limestone and silica have been mined locally.

May Creek Schist (Ĵmc)

The May Creek Schist is a medium-grade metamorphic equivalent of other rock units including the volcanic and sedimentary rocks of the Applegate Formation and possibly the Galice Formation (Kays, 1970). It is equivalent to the May Creek Schist of Wilkinson and others (1941) and is exposed west of Sams Valley and east of Evans Valley. Similar rocks are exposed west of Mount Ashland, out of the study area (Wells, 1956). Because the distribution of the May Creek Schist is apparently controlled by the distribution of large dioritic intrusions, the unit may represent local contact metamorphism surrounding the intrusive bodies during their emplacement in Late Jurassic (Nevadan) times (Kays, 1970).

Major rock types include mica slate, mica schist, and metamorphosed mafic volcanic rocks. The rock, which is typically very hard, is platy to strongly foliate, jointed, and fractured. Major hazards include severe erosion potential and steep-slope failure. Cutbank stability is moderate to low as a function of local jointing and fractures. Regolith thickness is low on crests and side slopes but locally thick at the bases of slopes in areas of colluvial accumulation. Ground-water potential is low. Potential for use as aggregate is low because of foliation and the presence of mica, which readily weathers to clay.

Intrusive Geologic Units

Intrusive rocks are rocks that are emplaced as a unit into pre-existing rocks and then exposed at the earth's surface by erosion. Most intrusive rocks are igneous and are characterized by massive (homogenous, non-planar) textures. Intrusive rocks of nonigneous origin (e.g. serpentinite) generally possess planar fabric. The specific manner of emplacement of intrusive rocks strongly influences their engineering properties.

Diorite and granodiorite (KJd)

These crystalline rocks are composed of medium to coarse grains of feldspar and hornblende or pyroxene. In addition, granodiorite contains grains of quartz that are generally equigranular and inter-locking. Generally, there is no siliceous glass.

Diorite and granodiorite are exposed in large bodies along the Applegate River, at the Ashland pluton, and in Evans Valley. The rock bodies are probably much more extensive in the subsurface. Rocks of the Ashland pluton are primarily quartz diorite, but rock types vary from diorite to granite. Available radiometric age dates reveal a Late Jurassic age of 146 to 147 million years (Lanphere and others, 1968).

The diorite and granodiorite are hard in areas of youthful topography as in the Ashland pluton and the steeper sloping areas of Evans Valley. Steep-slope mass movement is favored by jointing patterns, colluvial pockets, and the silty to sandy texture of the soil. Erosion potential is severe. Cutbank stability is extremely variable as a function of jointing patterns. Potential for quarry rock is limited in many places by the steep slopes, low cutbank stability, and depth of weathering along joints. Crushing characteristics are poor to good (see Mineral Resources).

The diorite and granodiorite in gently sloping areas of older topography at Missouri Flat and in much of the Evans Valley is deeply weathered and of poor quality for use as quarry rock. Infiltration rates are high, however, and ground-water potential is very good. Although much of the metallic mineral wealth of the study area is closely related to intrusion of the diorite and granodiorite, the location of metallic minerals is not restricted to regions adjacent to mapped outcrops of the unit because its distribution is far greater at depth.

Gabbro (KJgb)

Gabbro is a dark-colored igneous rock composed primarily of calcic plagioclase feldspar and pyroxene. It is exposed at Gold Hill and apparently grades into the neighboring granodiorite. The gabbro is deeply weathered to a rusty-red soil and regolith; weathering penetrates to considerable depths along major joints. The gabbro is the site of the Gold Hill pocket, a gold lode of considerable production in the past. Ground-water potential is very low.

Use of the rock for concrete aggregate is limited by steep slopes, thick regolith, the local presence of sulphides, and coatings of iron stain along joints in the zone of weathering.

Serpentinite (sp)

Serpentinite is a rock consisting primarily of serpentine minerals, which are similar to clay minerals in structure and have high concentrations of iron and magnesium. Serpentinite of this study is equivalent to the serpentine of Wells (1956) and Wells and others (1940).

Serpentinite intrusions probably have many origins including (1) the alteration and deformation of ultramafic rock (high in iron and magnesium and low in silica) and (2) the intrusion of serpentinite into the earth's crust on the sea floor. Technically, serpentinite is not an igneous rock, and the intrusion is accomplished largely by shearing and deformation rather than by fluid injection. Serpentinite shears readily under tectonic stresses and commonly is remobilized along faults during mountain building. The serpentinite of the study area is generally associated with faults and is strongly sheared, which greatly influences its engineering properties.

Serpentinite is characterized by highly variable engineering properties and a high potential for deep mass movement. Weathering advances along shear planes to produce bouldery, clay-rich soils. Fertility is generally low, and vegetation is sparse. Infiltration rates are low, and ground-water potential is minimal. Serpentinite is not suitable for quarry rock or fill. Finely dispersed chromite of noneconomic value is associated with the olivine that is present in the serpentinite.

Tertiary intrusive rock (Ti)

Tertiary intrusive rocks are igneous rocks which were emplaced at depth during periods of Eocene, Oligocene, and, possibly, later volcanism. The rocks form sills, stocks, and dikes that are exposed as knobs and ridge crests in the eastern parts of the Bear Creek valley and in the Eagle Point area. Rock types are generally coarse grained and include diorite and gabbro. Farther to the east, out of the study area, intrusions of basalt are more common (Wells, 1956).

The intrusive rocks are fresh to deeply weathered, with a variety of engineering properties. Cut-bank stability is variable, depending upon regolith thickness and jointing patterns. Potential for use as quarry rock is limited locally by slopes, thickness of regolith, jointing, and aesthetics. Generally speaking, no siliceous glass is present in the intrusive rocks.

Bedrock Structure

Bedrock structure refers to the general disposition and spatial relationships of the bedrock units. A knowledge of structure is valuable in extrapolating geologic information; and in the study area, a preliminary review of the structure indicates that (1) mineralization is commonly associated with faults and possibly with fault zones; (2) deep bedrock slides are controlled primarily by faults; (3) because no Quaternary units are cut by faults, no active faulting occurs at the surface; and (4) steep-slope landslides in distinctly bedded units are controlled largely by the geometry of major folds. Each of these conclusions is based on reconnaissance information, subject to refinement with more detailed study.

Regional setting

In southwestern Oregon six major associations of rock units are recognized by Irwin (1966), and

each are bounded by major structures or major unconformities. In Jackson County the western Paleozoic and Triassic section is made up of the Applegate Formation (Ɍas, Ɍav), May Creek Schist (Ɍmc), and diorite and granodiorite (KJd) (Figure 10). Cenozoic rocks are represented by Eocene and Oligocene volcanic rocks and tuffaceous rocks (Teat, Teov), and the western Jurassic section is represented by the Galice Formation. Each association of rock represents a major tectonic or depositional episode and, in general terms, is represented by a unique association of rock types, engineering properties, and mineral potential.

EXPLANATION

Upper Cretaceous
shelf deposits

Western Jurassic plate

Cenozoic rocks

Western Paleozoic
and Triassic plate

Uppermost Jurassic and
Lower Cretaceous shelf
deposits.

Uppermost Jurassic
and Cretaceous plate

Contact

Thrust fault
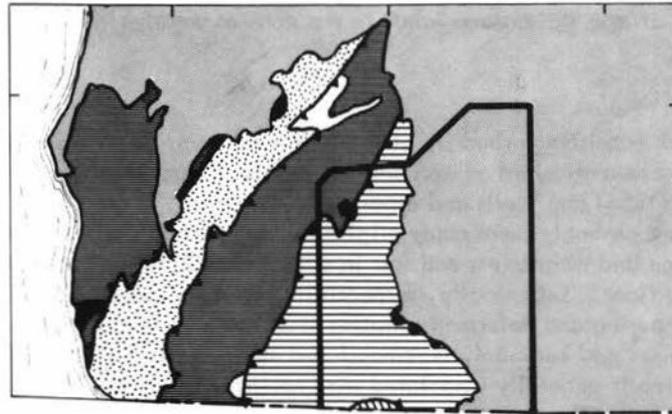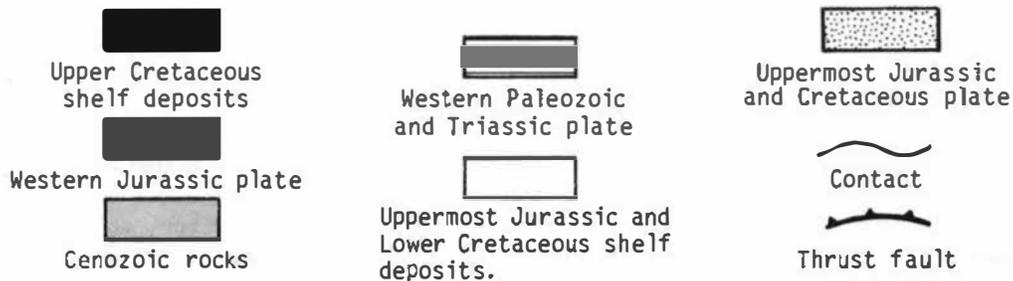
Figure 10.   Regional geology of southwestern Oregon (after Irwin, 1966). Jackson County outlined in black.

Local structure

Major faults are indicated on the geologic maps accompanying this text. Major features include the Bear Creek valley, Sams Valley, and regional structures of the Applegate Formation (Ɍas, Ɍav) and the volcanics of the Cascade Range. Significant relationships of major structures to hazards and engineering properties of rock units are discussed elsewhere.

Major uplift during a long period of geologic time has produced the mountains west of the Bear Creek valley. Detailed stratigraphic analysis indicates that uplift began in the Cretaceous, and eastward tilting of Cretaceous strata indicates that it continued into the Tertiary (Elliot, 1971). Since the Late Cretaceous, the dominant structural style has been one of hinged vertical movement along a narrow zone very close to the present eastern boundary of the Klamath Mountains (Elliot, 1971). Vertical uplift south of the Ashland fault marks the southern boundary of the Bear Creek valley. At present there is no field evidence to suggest that the surface faults are still active.

A major zone of northeasterly trending vertical faults along the west edge of Sams Valley separates late Eocene sedimentary rock in the valley from the May Creek Schist to the west. Faulting probably occurred in the Oligocene or Miocene because the ancestral Rogue River was established near its present location as early as the Pliocene (see Pliocene basalt). Displacement of units along the fault exceeds several thousand feet.

Bedding within the Applegate Formation parallels the regional structure. Many of the contacts between interbeds are possible bedding-plane faults. The unit dips steeply to the southeast in the Applegate drainage and steeply to the northwest in the east Bear Creek valley area, strongly suggesting a large downwarp. Large north-trending faults are inferred in the Sams Valley area near the Cretaceous and Jurassic diorite and granodiorite unit (KJd).

The Eocene and Oligocene volcanic rocks (Teov) and tuffaceous rocks (Teot) are characterized by numerous small joints and faults, many of which probably are related to volcanic activity. Prominent structures of older rock units generally do not appear to deform the volcanic units, except possibly in the southern Bear Creek valley area. Volcanic deposition is extremely complex, and interpretation of structure on a regional basis requires intensive investigation beyond the scope of this report.

ENGINEERING PROPERTIES OF GEOLOGIC UNITS

General

Table 3 relates 17 rock units in the study area to 10 physical properties, five regolith properties, three drainage properties, and 12 hazards. Rock units in this investigation are defined primarily on the basis of rock type. Consequently, each unit is characterized by a fairly distinct association of engineering properties. Table 3 is a tool for relating the geologic maps to specific parts of the text and is a guide in the efficient use of this bulletin.

Physical Properties

Hardness

Hardness of a rock refers to the resistance to crushing, abrasion, or deformation under stress. It is a basic factor in quarry-rock potential, foundation strength, and excavation difficulty of a rock unit. Hardness is determined by the composition, cementation, and weathering of a rock and the manner in which constituent grains are geometrically arranged or interlocked.

Intrusive, metamorphic, and volcanic rocks of the study area are generally very hard, although there is some variation on the basis of specific rock type. The abrasion resistance of granite and granodiorite is less than that of other intrusives because the grains are not as well interlocked in their arrangement. The result is a generally lower potential for use as crushed rock. Serpentinite hardness is highly variable with degree of shearing. Sedimentary rocks vary from fairly hard to soft; surficial rocks are generally soft, with the exception of horizons of bench gravel which are cemented with calcium carbonate.

Physical and chemical weathering reduce the hardness of a rock and are concentrated along zones of weakness including joints, faults, fractures, and bedding planes. On flat terrain, weathered material and soil may be readily removed by slope erosion from rocks with low infiltration rates. Consequently, areas of low slope are commonly not areas of deep weathering and reduced bedrock hardness. In preliminary determinations of bedrock hardness, consideration should be given, first, to rock type; second, to depth of weathering; and third, to slope.

Joint development

Joints are surfaces of active or potential fracture or parting in rocks (Figure 11). Joints differ from faults in that they are not surfaces of actual displacement; they differ from bedding planes in that they are not primarily the result of deposition and contrasting rock types. From an engineering standpoint, joints are surfaces of weakness within a rock. Joints influence foundation strength, cutbank stability, excavation difficulty, infiltration rates, weathering, and slide potential.

Joints are formed by cooling stresses in igneous rocks, pressure stresses in metamorphic rocks, and the effects of rock decay in weathering. Metamorphic rocks in the study area are characterized by irregular and angular jointing of varying densities. Joint patterns in metavolcanic rocks are generally coarser than those in metasedimentary rocks. Foliation (finely spaced parallel joints) is developed in the May Creek Schist; broken rock from this unit is generally planar and is not suited to use for large embankments or fill.

Igneous intrusive rocks are characterized by blocky jointing on all scales. Quarry-rock potential is generally good but varies with location. Serpentinite is generally highly sheared, with numerous irregular weak surfaces. Jointing patterns of volcanic rocks vary from moderately spaced blocky joints in fresh basalt to irregularly spaced joints in breccias and agglomerates. Crushing characteristics of breccias and agglomerates are considerably lower in quality than those of basalt flows.

Table 3. Engineering properties of geologic units, central Jackson County, Oregon

General rating

- ● Relatively high or great
- ◒ Moderate
- ○ Relatively low or small
- ◑ Variable
- • Not applicable

			Physical properties										Regolith					Drainage			Local hazards											
			Hardness	Joint development	Bedding distinctness	Foundation strength	Excavation difficulty	Cut-slope stability	Slope intensity	Infiltration rates	Landfill potential	Septic tank capacity of soils	Thickness on steep slopes	Thickness on gentle slopes	Clay content	Silt content	Expansion-contraction	Overland flow	Shallow subsurface flow	Deep subsurface flow	Deep bedrock slides	Earthflow and slump topography	Steep-slope mass movement	Potential future mass movement	1964 flood	1861 flood	Flood prone	Slope-erosion potential	Historic channel change	Stream-bank erosion	Torrential-flood terrain	High ground-water hazard
Surficial geologic units	Quaternary alluvium	Qol	○	•	◒	◑	○	○	◑	○	●	○	•	●	◑	◑	◑	●	○	●	•	•	•	•	○	●	●	●	○	◑	◑	◑	●
	Quaternary alluvial fan deposits	Qof	○	•	◒	◒	○	○	○	●	○	◑	•	●	◑	◒	◒	◒	○	●	•	•	•	•	○	◒	○	○	◑	•	○	●	○
	Quaternary older alluvium	Qoa	○	•	◒	◒	○	◑	○	○	○	◑	•	●	◑	◑	◑	◒	○	●	•	•	•	•	○	○	○	○	○	•	○	○	●
	Quaternary bench gravel	Qbg	○	•	◒	◒	○	◒	○	○	○	◑	•	●	◑	◑	●	◒	◒	●	•	•	•	•	○	○	○	○	○	•	○	●	●
Volcanic and sedimentary rock	Pliocene basalt	Tpb	●	●	•	●	●	●	◑	◑	◑	◑	○	◒	●	◒	◑	◑	●	◒	○	◑	◑	○	•	•	○	•	•	○	◒
	Eocene and Oligocene volcanic rock	Teov	◑	◑	◑	●	◑	◑	◑	◑	◒	◑	○	◒	◑	○	○	◒	◒	◑	◑	◒	◑	◑	•	•	•	◑	•	◑	◒	○
	Eocene and Oligocene tuffaceous rock	Teot	◒	○	◒	◑	◒	◑	◒	◑	●	○	○	◒	●	◒	●	◒	◒	○	◒	●	◒	●	•	•	•	◒	•	◑	◒	◒
	Eocene sedimentary rock	Tes	◒	○	●	●	●	●	◑	◑	◒	◑	○	◑	◑	○	◑	◑	◒	◑	◑	◒	○	◑	•	•	•	◑	•	○	◑	◑
	Cretaceous sedimentary rock	Ks	◒	○	◒	●	◑	◑	◒	○	◒	◒	○	◒	◑	◒	◒	○	◑	◒	○	○	○	•	•	•	◒	•	◑	○	○
	Golice Formation	Jg	◒	○	●	●	●	◑	◒	○	○	○	◑	○	○	◑	○	◒	◑	○	○	○	●	●	•	•	•	●	•	○	◒	○
Metamorphic rock	Applegate Formation	Ɍav	●	◑	○	●	●	●	●	○	◑	○	◑	◑	◒	◒	○	◑	●	○	○	●	◒	•	•	•	●	•	○	●	○
	Applegate Formation	Ɍas	◒	◑	○	◒	●	◑	●	○	○	○	◑	◑	◑	○	○	◑	●	○	○	●	●	•	•	•	●	•	○	●	○
	May Creek Schist	Ɍmc	●	•	●	●	●	◑	◑	○	○	○	◑	◑	◑	○	○	◑	●	◑	◑	○	●	◒	•	•	•	●	•	○	●	○
Intrusive rock	Diorite and granodiorite	KJd	●	◑	•	●	●	◑	◑	●	○	◑	◑	●	○	●	○	◑	◑	◑	◑	○	●	●	•	•	•	●	•	◑	●	○
	Gabbro	KJgb	●	◑	•	●	●	◑	◒	○	◒	○	◒	◒	◒	◒	○	◒	◒	○	○	◒	◒	•	•	•	◒	•	•	○	○
	Serpentinite	sp	◑	◑	•	◑	◑	◑	◒	○	◑	○	○	◒	◒	◒	◒	◑	◑	○	●	●	○	●	•	•	•	◑	•	•	○	○
	Tertiary intrusive rock	Ti	●	◑	•	●	●	◑	◑	○	○	◑	○	○	◑	○	◒	◒	○	○	○	◒	◒	•	•	•	○	•	•	○	○

Jointing of bedded sedimentary rocks is generally perpendicular to the bedding planes. Joints ore widely spaced in the sedimentary rocks of the study area; consequently, infiltration rates of surface water ore low for gently dipping strata. Surficial geologic units are not consolidated and ore therefore not jointed.

Jointing is o critical property of rock in terms of several hazards and engineering practices. Although general observations ore mode here, specific determinations must be mode on o site-by-site basis. For example, jointing properties of o specific quarry rock may be determined by blasting tests and core sampling as well as by routine field examination.

Bedding distinctness

Bedding refers to the arrangement of sedimentary rocks in beds or layers. Distinctness refers to the degree of difference in rock type and resistance to erosion between adjacent bedded layers. Where bedding distinctness is great, various layers of rock generally hove significontly different engineering properties. In the Eocene sandstone (Tes), layers of hard sandstone olternote with layers of softer siltstone or shale, producing o sharp distinction between beds (Figure 12). In the Cretaceous sandstone (Ks), rock types ore equally variable, but bedding is less distinct because of subtle variations in the environment of deposition and other factors such as thickness of individual beds. Different layers of rock in the Galice Formation (Jg) are composed primarily of mudstone, and bedding distinctness is generally not o concern. However, porting or jointing between adjacent shole interbeds is well developed, and o high rating of bedding distinctness is warranted from on engineering standpoint.

Where distinct interbeds ore tilted steeply toward a cut or steep slope, the surface between any two beds is often o plane of weakness. The contact between two beds with vastly different permeabilities may also be a locus of ground-water accumulation and flow. Thus, steeply dipping distinct interbeds often define surfaces of slope failure and are o major factor in low cutbank stability.

Foundation strength

Foundation strength is the capacity of o rock to support structures. It is determined largely by rock hardness, weathering, jointing, and bedding. An additional concern is variation of rock type beneath the surface. Foundation strength is studied by o variety of tests and is generally rigorously investigated prior to major construction. Construction techniques for dealing with low foundation strength include innovative foundation designs, drainage control, prelooding, use of piling, and actual avoidance of critical areas.

Foundation strength of igneous, metamorphic, volcanic, and sedimentary rocks in the study area is moderate to high in unweathered areas. It is generally adequate for most types of construction. On steep slopes, mass-movement potential is a closely related hazard that also warrants attention.

Foundation strength of terrace surficial deposits (Qoa, Qof, Qbg) is generally good, but the precise nature of subsurface material should also be determined. Differential settling may occur over uncompacted clay, saturated silt, and organic cloys and silts. Alluvium in small low-gradient channels on terraces is commonly rich in cloy and organic material and generally has low foundation strength. Cloy-rich soils (see Expansion-contraction) hove low foundation strengths.

Excavation difficulty

The difficulty with which rock material is excavated is determined by rock hardness, jointing, bedding, and weathering. Rock of considerable hardness con be excavated with relative ease if planes of weakness effectively separate it into small manageable pieces. Excavation difficulty is significant in planning for all underground facilities including basements, utility lines, sewer lines, and road construction.

Igneous intrusive rocks of the study area generally require blasting for lorge excavations and quarry operations except in areas of deep weathering. These, determined by on-site investigation, generally underlie gently sloping terrain in volleys. In contrast, regolith over intrusive rocks on ridge crests is generally thin. Volcanic and metamorphic rock units also require blasting for lorge excavations. Heavy equipment may be adequate for minor excavations and for excavations in the weathered zone.

Figure 11.   Blocky, moderately spaced joints in granodiorite (KJd).

*Figure 12.   Distinct bedding in Eocene sedimentary rock (Tes) of southern
       Bear Creek valley.   Note thin soil.*

   Tuffaceous rocks (Teot and part of Teov) can generally be excavated with heavy equipment. Difficulty in excavation of sedimentary rock units (Tes and Ks) is variable, depending on depth of weathering and rock type. Shales and siltstone are more easily excavated than cemented sandstone. Eocene sedimentary rock is deeply weathered in Sams Valley but is essentially unweathered over large, gently sloping areas east and south of Medford. Surficial deposits are easily excavated, with the possible exception of local horizons of calcite-cemented sand and gravel in the subsurface of the Quaternary bench gravel.

Cutbank stability

   Cutbank stability is resistance to failure or sliding in artificial cuts. Removal of material from the cut provides a site for possible sliding if shear stresses of the reformed slope exceed shear resistance. Cutbank stability in bed rock is determined largely by surfaces of least strength including joints, faults, distinct bedding planes, clay horizons, and avenues of ground-water flow.
   Cutbank stability in intrusive geologic units of the study area is governed largely by joints in deep cuts and by the contact between regolith and bed rock in shallow cuts. South of Ashland large slides in dioritic terrain (KJd) onto Highway I-5 are caused by unfavorable jointing patterns. In the Ashland watershed, shallow debris flows are generally caused by water in the soil and the removal of colluvial material in road cuts. Shear planes and high clay content contribute to the low cutbank stability of serpentinite (sp).
   In volcanic and sedimentary rocks, cutbank stability is adversely affected by jointing in volcanic rocks and by undercutting or ground-water flow where contrasting rock types are interlayered. In distinctly bedded sedimentary rocks (Tes, Ks, Jg), beds dipping steeply into cuts reduce cutbank stability. Joints and unfavorably dipping schistosity adversely affect cutbank stability in metamorphic rocks (Ɍav, Ɍas, Ɍmc).
   Factors influencing cutbank stability in unconsolidated material include ground water, cohesion, density of material, height of cut, and angle of cut. Specific stability assessments are the task of the civil or soils engineer. Thick unconsolidated material in the study area includes surficial geologic units (Qal, Qoa, Qbg, Qaf), deeply weathered bed rock, and base slope colluvium (see Regolith-Thickness on steep slopes). Clay-rich soils developed locally on flat valley landforms over mudstone of the Eocene sedimentary rock (Tes), argillites of the Applegate Formation (Ɍas), and Eocene tuffaceous rock (Teot) are particularly prone to cutbank failure. Surfaces of failure are typically gently dipping; and affected areas are generally large, relative to the height of the cut.

Slope intensity

   Slope intensity or the steepness of slope is generally measured in percentage of slope or degree of rise. The percentage of slope is determined by dividing the vertical change in elevation by horizontal distance and multiplying by 100. If, for example, elevation increases by 10 feet over a horizontal distance of 10 feet, slope intensity is 100 percent. Slope intensity derived from maps is an average of variable local slopes because of the large contour intervals and the small map scale compared to the size of typical sites under investigation.
   Steep slopes generally occur over hard bed rock in areas of youthful topography. Rock types include the metamorphic, intrusive, and volcanic rocks of the study area. Deep weathering along joints, faults, and other zones of weakness produces gentler slopes locally. The evolution of large-scale erosive landforms such as river valleys produces flat slopes over hard bed rock by processes other than local rock weathering. Parts of the gently sloping Bear Creek valley are underlain by hard bed rock.
   Surficial deposits are characterized by gently sloping to flat terrain. Landscape evolution is also a consideration in slope interpretation. For example, although the Pliocene basalt is hard, it forms flat terrain because it flowed into an ancient river channel and cooled with a flat surface.
   Slope intensity is the most critical factor in determining soil-erosion potential and a major factor in the determination of the distribution and nature of mass movement, runoff, and torrential flooding.

Infiltration rate

Infiltration rate is defined here as the general rate at which surface water percolates into geologic units. The concept is qualitative, and statements are based on professional judgment rather than actual measurements. Infiltration rates, which are determined by rock permeability, joints, fractures, and orientation of bedding, are significant in terms of landfill potential, drainage, ground-water potential, and steep-slope mass movement.

Because infiltration rates in metamorphic, volcanic, and sedimentary rocks are generally low, ground-water potential is also low in these rock units. Deeply weathered granodiorite (KJd) is finely fractured, however, and is characterized by moderate infiltration rates and high ground-water potential. In areas of steeply sloping terrain over fresh granodiorite, bedrock infiltration rates are lower than in the overlying silty colluvium; and ground-water flow is restricted to the interface between the bed rock and colluvium. Jointed flow rock in the Eocene and Oligocene volcanic rock (Teov) may have moderate ground-water potential locally. Serpentinite is essentially impermeable. Schistose metamorphic rocks (ℝmc) display moderate to low ground-water potential locally. In areas of faulting, ground-water potential may be moderate to good, regardless of rock type.

Infiltration rates of river alluvium (Qal) and fan deposits (Qaf) are high, and ground-water potential of Quaternary alluvium (Qal) is very good. Water percolates slowly into the bench gravels (Qbg) and Quaternary older alluvium (Qoa) because of clay horizons at shallow depths.

Landfill potential

Landfill potential is the capacity of a rock unit to be used successfully as a site for the sanitary disposal of solid waste. Ideal landfill sites are characterized by gentle slopes, low infiltration rates, low ground-water table, ease of excavation, and isolation from overland flow. Much of the Eocene and Oligocene tuffaceous rock (Teot) meets these specifications.

Major sedimentary rock units of the study area (Tes, Ks) meet these specifications in places, but high permeabilities are possible locally. Excavation difficulty is variable. Major problems associated with intrusive geologic units include high excavation difficulty, steep slopes, and infiltration along joints. The use of quarry sites for landfill sites eliminates excavation difficulty as a consideration but requires careful analysis in terms of overland flow, leachate production, and adequate covering. Soils in granitic and dioritic terrain are characteristically silty and permeable.

Eocene and Oligocene volcanic rocks (Teov) are highly variable in terms of all major landfill-potential factors. Some serpentinite may be suited for landfill use on gentle slopes, but these rocks are geographically isolated from demand centers. Surficial geologic units are generally favorable except in terms of flood potential and high ground-water potential. In some parts of the world, solid waste disposal in landfill mounds has been successfully accomplished. Solid waste disposal is a highly technical discipline, and seemingly unfavorable sites can commonly be used with success through proper design and engineering practice.

Septic-tank capacity of soils

The potential of soils to be used for septic-tank disposal of waste is determined by soil texture, soil thickness, and drainage. Because soil formation is determined, not only by parent material (bed rock), but also by time, slope, climate, and organic activity, there are no clear-cut relationships between bed rock and septic-tank capacity of soils. Therefore, there is no substitute for on-site testing to determine septic-tank capacity. However, an understanding of geology assists in the identification of potential problems that might otherwise be overlooked.

Unfavorable permeabilities are common in clay pans of older alluvial units (Qoa, Qbg), residual soils of flat bed rock in old valleys (Tes), silty and sandy soils over diorite and granodiorite exposures in youthful terrain (KJd), and clay-rich soils over weathered tuffs (Teot). Soil is commonly too thin in steep terrain over hard bed rock and in many gently sloping valley areas. Slope is not an automatic indicator of adequate regolith thickness; but steep slopes are generally inappropriate for septic tanks because of installation difficulties and the high potential for downslope surfacing of effluent and for slope failure.

High ground water and ponding ore concerns in the alluvial units, especially in gentle depressions on flat terrain. In addition, shallow bed rock in much of the Bear Creek volley and Soms Valley restricts subsurface flow to shallow depths along the interface between regolith and bed rock. Excessive lateral migration of effluent introduces the threat of potential hazards to surrounding areas.

Regolith

Regolith, which is unconsolidated rock material at the earth's surface, includes surficial geologic units, landslide debris, weathered bed rock, and soil. It has engineering properties different from those of the underlying bed rock. Specific kinds of regolith (surficial geologic units, landslide deposits, soils) ore discussed in greater detail elsewhere in the text.

Thickness on steep slopes

On steep slopes the thickness of the regolith influences the depth of subsurface ground-water flow, stability of the slope, and cutbank stability. Thickness is determined by rock type, weathering rates, erosion rates, and amounts of colluvial or stream deposition.

Regolith is generally thin on steep side slopes, and bedrock exposures ore common. In steeply sloping diorite terrain, colluvial thicknesses greater than 2 feet ore generally associated with high debris-avalanche potential. Accumulation of slope-wash material, torrential-flood debris, and creep material at the bose of slopes contributes to the relatively thick regolith at the bases of many steep slopes (Figure 13). In addition, the accumulation of ground water at the bases of slopes results in more effective chemical weathering of bed rock which in turn produces more regolith.

Figure 13. Thick silty and sandy regolith in deeply weathered granodio-
rite (KJd) near Ashland.

Small linear drainageways on steep slopes are the sites of ground-water accumulation and shallow downslope migration of ground water. Accelerated chemical weathering and creep contribute to the relatively thick regolith in the drainageways. From a geologic time perspective, debris avalanches and debris flows in the drainageways eventually scour the loose material from the slope to produce ephemeral stream channels. Activities of man may influence the rate at which this occurs.

Thickness on gentle slopes

Regalith thickness on gentle slopes influences excavation difficulty, foundation strength, cutbank stability, and landfill potential. Thickness is determined by rock type, weathering rates, erosion rates, and age of the land surface.

Where surficial deposits cover bed rock, the regolith thickness is equivalent to the thickness of the alluvial unit, which is readily determined by using well-log data and field observations. This thickness varies from 70 feet in parts of the northeastern Bear Creek valley to a few feet in the upper parts of valleys.

Regolith thickness overlying bed rock in older valley areas is determined by the depth of weathering. In Evans Valley, Sams Valley, and northwestern Bear Creek valley, weathered bed rock is present at depths of 10 feet or more. In the younger parts of valleys such as southern Bear Creek valley, regalith thickness over bed rock may be quite thin, even in gently sloping areas. Generally, regolith is thin on ridge crests and thick on side slopes, indicating active creep and erosion.

Clay content

In soils terminology, clays are defined as extremely fine particles (0.002 mm or less) or particles with colloidal properties in water. Most clays are also characterized by submicroscopic sheet-like structures. Engineering properties of clay include low permeability, water retention, and low shear strength when wet.

Regolith with high clay content is characterized by low foundation strength, low excavation difficulty when wet, low cutbank stability, low infiltration rates, and low septic-tank potential. Potential for use as embankments or road base is also very low. Associated hazards include ponding on flat surfaces and mass movement on gently to moderately sloping terrain. Where subject to erosion, the clay contributes to high and lasting turbidity in streams.

Clay content of regalith is determined by the texture and compositon of the parent material, the soil-forming processes, and the age of the weathered surface. In flood-prone areas, overbank deposition also contributes to the clay content of soil.

Geologic units with fine-grained components and clay-rich regolith on old weathering surfaces include parts of the Applegate Formation (Ras), shale interbeds of sedimentary rock units (Tes, Ks), and tuffaceous volcanic rock (Teat, part of Teov). The high clay content of part of the Quaternary bench gravel (Qbg) is the product of deep weathering and parent material derived from fine-grained volcanic rocks in the adjacent Cascade Range. Clay in Quaternary older alluvium (Qoa) is the product of overbank deposition and weathering. Clay in Quaternary alluvium (Qal) is the product of quiet-water deposition. On steep slopes over metamorphic and intrusive units, clay content of the regolith is greatest near the base of the slope, where ground-water accumulation is greatest.

Silt content

Particles that are coarser than clay and finer than sand are termed "silt". Silt size limits recognized in the United States are 0.002 mm to 0.05 mm. Silt does not possess the sheet-like structure or colloidal properties of clay. It is relatively common in most soils. Regolith with high silt content is characterized by higher permeability and better drainage, cutbank stability, and septic-tank potential than regolith that is rich in clay. The cohesive strength is low, however; and associated hazards include severe erosion potential and liquefaction potential.

Silt content of regolith is determined by the texture and composition of the parent material, soil-forming processes, and the youthfulness of the weathering surface. Soils over hard bed rock on steeply sloping terrain commonly have relatively large components of silt. Soils developed over granular, quartz-

rich bed rock such as granodiorite (KJd) are particularly silty and sandy and are characterized by severe erosion potential and high potential for steep-slope failure (debris flow, debris avalanche) during the wet season.

Expansion-contraction

Expandable soil is soil which contains clay, expands to a significant degree when wet, and shrinks when dry. Final identification of significantly expandable soil is the task of the qualified specialist. Preliminary field identification may be made, however, on the basis of certain criteria: when dry, expandable soils are as hard as rock and have deep open cracks and a popcorn surface (a swollen, highly porous, mud-cracked mantle); when wet, these soils are sticky and weak. Vegetation on expandable soils is generally sparse.

Montmorillonite is the name of the family of expandable clays responsible for most expansion in soils. Chemical attraction of water to the sheet structure of montmorillonite pushes the individual sheets farther apart, allowing the incorporation of large amounts of water into the crystal structure and leading to increased soil volume and greatly decreased soil strength.

Montmorillonite is formed by the weathering of volcanic ash. Formation and preservation in the soil profile is favored by low precipitation and presence of andesitic or basaltic parent material. Valley regions of the study area that are underlain by Eocene and Oligocene tuffaceous rock (Teot) or its transported derivatives (Tes, possibly Qbg) meet these specifications and are characterized by expandable soils. Extreme seasonal variations in soil-water content accentuate the expansion-contraction hazard.

Expandable soils damage roads and foundations, especially those which are underdesigned and those which have lightly loaded foundations. Mitigation may include avoidance of critical areas, specialized design, and careful drainage control.

Drainage

Drainage, the mechanism by which water is removed from an area by flow, includes overland flow, shallow subsurface flow (through the regolith), and deep subsurface flow (through bed rock). It is distinguished from soil drainage, which is the rate at which water percolates through a soil. This distinction is critical in understanding the ground-water and ponding problems of the study area.

Overland flow

Overland flow is caused by steep slopes and impermeable bed rock, soil, or surficial deposits. On sloping terrain, the relative significance of overland flow is generally reflected in the drainage density (number of channels per unit area). In the study area, overland flow is most pronounced in steeply sloping terrain of metavolcanics ($\bar{J}$av), metasediments ($\bar{J}$as), and granodiorite (KJd).

Overland flow is not as pronounced in terrain underlain by sedimentary and fractured volcanic rocks because slopes are gentler and infiltration rates are greater. On surficial units, slopes are very gentle and infiltration rates are very low because of the development of a clay-rich horizon in the soil profile. Although the soils are described as moderately well-drained, winter ponding of rain water is common because of impermeable soil horizons, low slope gradients and topographic depressions, and high ground water.

Overland flow in sloping areas is a concern in erosion control, road design, fill placement and stability, and torrential-flood potential. Ponding and high ground water influence land potential for septic-tank and landfill uses (see High Ground Water and Ponding).

Shallow subsurface flow

Shallow subsurface flow is predominant where permeable thin regolith overlies impermeable bed rock. Because regolith thickness and bedrock infiltration rates often cannot be linked directly to type of bedrock slope, recognition of critical areas requires field reconnaissance.

In steeply sloping terrain over hard bed rock, the development of stream channels is preceded by the development of small linear drainageways characterized by relatively thick colluvium and shallow subsurface flow. Soil water percolates through the colluvium and downslope along the contact between the colluvium and the impermeable bed rock. Channels of this type are particularly common in the granodioritic (KJd) and metamorphic (Ɍav, Ɍas) terrain of the study area.

In gently sloping terrain in the east Bear Creek valley and central and northern Sams Valley, soil water percolates to the contact of the regolith with the less permeable bed rock (Tes) where it is restricted in its downslope flow. Lack of overland flow in these areas does not diminish the need for proper drainage control in construction.

Shallow subsurface flow also is associated with the interface of older alluvium (Qoa) over bed rock (Tes) in Sams Valley, the bases of slopes of impermeable bed rock (Teov) where soil water draining the slope comes to the surface at the base of the slope, and on terrace units (Qbg) where flow is restricted to zones above clay pans and other soil horizons of low permeability.

Subsurface flow affects all developments which penetrate to the level of flow. Clear definition and treatment of the problem requires a monitoring program, site investigations, and feasibility studies for proposed solutions.

Deep subsurface flow

Deep subsurface flow is the movement of water through bed rock or through parts of surficial geologic units below the regolith. Flow is either vertical through the overlying geologic units or horizontal from water sources to the side. Deep subsurface flow is equivalent to ground water and is discussed in greater detail under the section entitled Mineral Resources - Ground Water.

Where vertical infiltration of surface water to depth is significant, the importance of overland flow and shallow subsurface flow is diminished. Such areas are also zones of aquifer recharge and are generally not suitable for large-scale waste disposal. Percolation of surface water to depth is favored by permeable geologic units (Qal, part of Ks), jointing (Tpb, part of Teov), schistosity (parts of Ɍmc), or the presence of shearing or faulting.

Soils

Purpose

The study of soils and the application of soils data, which together constitute a separate discipline, are not directly the concern of basic geology investigations. Soils, however, are closely related to the bedrock geology, surficial geologic processes, and geologic hazards of Jackson County. The purpose of this soils discussion is to relate soils to general geologic information and concepts developed elsewhere in the text and thereby (1) promote refinement of soils concepts, (2) assist future soils mapping, (3) supplement standard soils data in site evaluations, (4) make information on the origin of geologic units more useful to the soils scientist, and (5) present concepts on soils and soils-forming processes from a geologic perspective.

General

In this study, unconsolidated mineral formed in place by weathering and found at the earth's surface is termed "soil". This definition is less restrictive than that employed by many agronomists, who limit use of the name "soil" to material capable of supporting plant growth. Our definition is more restrictive than the concept of soil (regolith of this report) used by soils engineers, because it does not include surficial geologic units. It is consistent with most of the methods of sampling (limited to the upper 5 or 6 feet) employed by the U. S. Soil Conservation Service; and it emphasizes the unique characteristics of the weathered zone.

Weathering processes at the earth's surface include chemical breakdown of minerals, chemical reconstitution to form new minerals (clays), physical disintegration, and leaching. During the initial

stages of soil development, the composition of the parent material is a dominant factor in determining soil type. Climate determines the kinds and rates of chemical reactions and also the nature and distribution of vegetative cover. Slope intensity influences drainage and mass movement, and slope orientation partly determines the balance of soil-forming processes within a given area. As time passes, climate becomes increasingly more important in determining soil development.

Horizons of differing composition and texture are developed within a typical soil because physical and chemical conditions vary with depth. The surface horizon (A horizon) is the zone of most intense organic activity, leaching, and downward percolation of fine-grained material. Commonly, iron, carbonates, and clay are removed and deposited in the next lower, or B, horizon, which is characterized by relatively high concentrations of silicated clay materials, iron, or other materials. At greater depths the underlying C horizon consists of partially weathered and decomposed bed rock. At even greater depths is fresh bed rock or surficial geologic units.

Systems of soils classification

The National Cooperative Soils Survey of the U. S. Department of Agriculture adopted the Seventh Approximation System of Soils Classification in 1965. In it, soils of the nation are grouped hierarchically on the basis of regional climate, physical setting, uniformity and types of horizons, nature of gradation between horizons, and broad textural and compositional features related to plant-growth potential, parent material, genetic horizons, and surface texture. Field recognition of soils textures is summarized on Figure 14. All soils mapping is conducted using the system of classification adopted by the U. S. Department of Agriculture. Because it is based on grain-size distribution, it lends itself well to regional mapping.

Two other major types of soils classification are the Unified Soils Classification System (Table 4), used by the U. S. Army Corps of Engineers and the U. S. Bureau of Reclamation, and the AASHO (American Association of State Highway Officials) System (Table 5), used in highway construction. The Unified Soils Classification System places emphasis on the engineering properties of soil, including plasticity index (a measure of water content at which soil behaves as a plastic), liquid limit (a measure of the water content at which the soil behaves as a liquid), and organic content. The AASHO System is used to classify soils according to those properties that affect use in highway construction and maintenance.

The particle-size boundaries recognized by the three systems of soil classification are compared in Table 6.

Distribution

Variations in the five soil-forming factors (parent material, climate, topography, vegetation, and time) produce the many variations of soil type present in Jackson County. The influence of parent material is greatest in young soils and is briefly reviewed in the preceding discussions of individual geologic units and their engineering properties. The engineering properties of soils and the associated rock units are summarized on Table 7. The data are derived from laboratory testing of samples taken from the weathered zone. The data are more limited in scope than the general engineering properties of the geologic units and regolith summarized on Table 3.

The intensity and orientation of slope are generally the most important topographic influences on soil development. Soils are least mature on steep slopes. On north-facing slopes, near the bases of slopes, and in gentle gullies, the influence of ground water on chemical weathering is relatively great; and soil development is generally more advanced. In contrast, soils on the middle and upper parts of south-facing slopes are generally less well developed. Vegetation patterns commonly reflect these differences.

In areas of flat terrain, slope erosion and mass wasting are minimal; and the age of the weathering surface is often the dominant factor in determing soil type. In the Bear Creek valley, the amount of clay in the soils correlates in a general way with the age of the weathering surface.

Most Quaternary alluvium (Qal) does not have soil because the unit is a surficial geologic deposit that is too young to have undergone appreciable weathering.

Soils developing above the Quaternary older alluvium (Qoa) are apparently the youngest soils with clay-rich weathering horizons. These are primarily the Medford soils, equivalent, at least in part, to the Tou Velle weathering surface of Parsons and Herriman (1976). Radiocarbon dating of wood recovered from

Figure 14. Guide for the textural classification of soils.
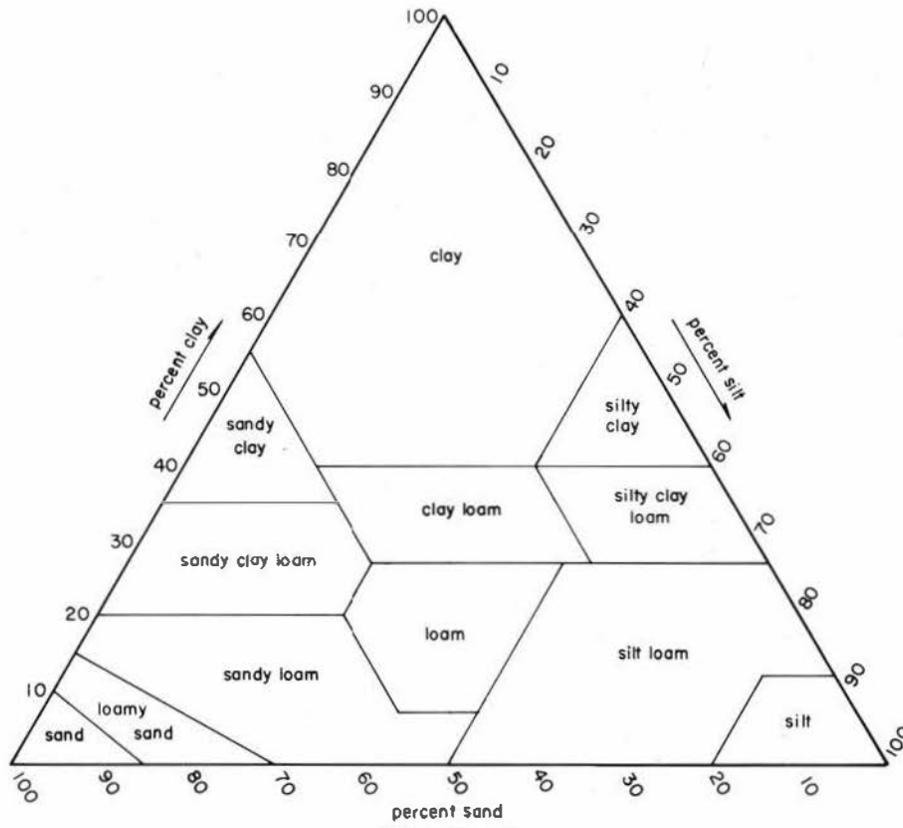
Texture	Dry feel	Moist feel	Moist shine	½"–1" wide, 1/8" thick moist plosticity (ribbon)	Moist 2"+ long plasticity (wire) 1/8"
Sand	Individual groins seen and felt	Individual grains seen and felt	None	Will not ribban	Will not wire
Sandy loom	Individual groins appear dirty	Individual grains appear dirty	None	Will not ribbon	Will not wire
Loom	Gritty, floury feel	Gritty, smooth slick	Faint dull	Very weak ribbon, broken appearance	Very weak wire in broken segments
Silt loam	Soft ond floury	Smooth slick w/ some stickiness	Dull	Ribbon broken appearance	Weak wire easily broken
Clay loom	Slightly hard, little grittiness	Smooth slightly sticky w/same grittiness	Prom-inent dull	Ribbon barely sustains weight	Wire sustains weight
Silty cloy loom	Moderately hard, no grittiness	Smooth sticky, feel some plasticity	Faint	Ribbon sustains weight & careful handling	Wire sustains weight & withstands gentle shaking
Silty cloy	Hard, no grittiness	Smooth, sticky plastic, faint fin-gerprints visible	Shine	Ribbon withstands considerable move-ment & deformation	Wire withstands considerable shok-ing ond rolling
Clay	Very hard, no grittiness	Smooth very sticky – plastic fingerprints	Bright	Long thin ribbon	Wire withstands shaking, rolling, bending, 1/16"

Table 4. Unified Soil Classification System

Major divisions			Group symbols	Typical names	Laboratory classification criteria	
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent........ GW, GP, SW, SP; More than 12 per cent...... GM, GC, SM, SC; 5 to 12 per cent.......... Borderline cases requiring dual symbols**	$C_u = \dfrac{D_{60}}{D_{10}}$ greater than 4; $C_c = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		Gravels with fines (Appreciable amount of fines)	GM* d / u	Silty gravels, gravel-sand-silt mixtures		Atterburg limits below "A" line or P.I. less than 4 ← Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterburg limits above "A" line with P.I. greater than 7
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \dfrac{D_{60}}{D_{10}}$ greater than 6; $C_c = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM* d / u	Silty sands, sand-silt mixtures		Atterburg limits below "A" line or P.I. less than 4 ← Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures		Atterburg limits above "A" line with P.I. greater than 7
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	Highly organic soils		Pt	Peat and other highly organic soils		

Plasticity Chart

Plasticity index (y-axis, 0 to 60) vs Liquid limit (x-axis, 0 to 100). "A" line. Regions labeled: CH, OH and MH, CL, CL-ML, ML and OL.

*Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterburg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.
**Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

Table 5. American Association of State Highway Officials (AASHO) Soils Classification

General classification			Group symbols	Grain size (sieve)	Atterburg limits for fraction passing No. 40		
					Liquid limit	Plasticity index*	
Granular materials — Less than 35% is smaller than No. 200 sieve	Stone fragments gravel and sand	A-1	A-1-a	50% max. posses No. 10 / 30% max. posses No. 40 / 15% max. posses No. 200		Less than 6	Good to excellent subgrade
			A-1-6	50% max. passes No. 40 / 25% max. passes No. 200			
	Fine sand	A-3	A-3	50% min. passes No. 40 / 10% max. passes No. 200		N.P.	
	Silty or clayey, gravel and sand	A-2	A-2-4	35% max. passes No. 200	Less than 40	Less than 10	
			A-2-5		Greater than 40	Less than 10	
			A-2-6		Less than 40	Greater than 10	
			A-2-7		Greater than 40	Greater than 10	
Silt-clay materials — More than 35% is smaller than No. 200 sieve	Silty soils	A-4	A-4	Greater than 35% posses No. 200	Less than 40	Less than 10	Poor to fair subgrade
		A-5	A-5		Greater than 40	Less than 10	
	Clayey soils	A-6	A-6		Less than 40	Greater than 10	
		A-7	A-7-5 and A-7-6		Greater than 40	Greater than 10	

*The difference between liquid limit and plastic limit; the range of water content through which the soil behaves plasticly.

Table 6. Comparison of three systems of particle-size classification

American Association of State Highway Officials – soil classification	Colloids	Cloy		Silt		Fine sand		Coarse sand			Fine gravel	Medium gravel	Coarse gravel	Boulders
U.S. Department of Agriculture – soil classification	Clay			Silt	Very fine sand	Fine sand	Medium sand	Coarse sand	Very coarse sand		Fine gravel	Coarse gravel		Cobbles
Unified soil classification U.S. Army Corps of Engineers Bureau of Reclamation, Dept. of Interior	Fines (silt or clay)					Fine sand		Medium sand			Coarse sand	Fine gravel	Coarse gravel	Cobbles

Sieve sizes – U.S. standard: 270, 200, 140, 60, 40, 20, 10, 4, 1½", ¾", 3"

Particle size – millimeters: .001, .002, .003, .004, .006, .008, .01, .02, .03, .04, .06, .08, .1, .2, .3, .4, .6, .8, 1.0, 2.0, 3.0, 4.0, 6.0, 8.0, 10, 20, 30, 40, 60, 80

one locality in the underlying Quaternary older alluvium (Qoa) indicates an age of 2,355 years (Parsons and Herriman, 1976). The age of the unit probably varies considerably but can be regarded as Holocene.

Soils overlying the next-older terrace form, represented in part by Quaternary bench gravel (Qbg), are of two types. On equidimensional patterned ground (ground characterized by well-defined surficial patterns) (Figure 5), Parsons and Herriman (1976) recognize the first type, the Roxy Ann surface, characterized by an impermeable duripan at shallow depths. The soils are not penetrated by roots and are not suitable for septic-tank use.

The second major type of soil, occurring on very gentle slopes characterized by patterned ground elongate with the slopes, is called the Kirtland surface by Parsons and Herriman (1976). The clay horizons, which they believe postdate the duripan of the Roxy Ann surface, are more permeable. The Kirtland surface soils support pine trees and are locally suited to septic-tank use.

Bordering the Bear Creek valley are a series of flat weathering surfaces underlain by bedrock geologi units rather than surficial geologic units. Along the eastern part of the valley, the major rock units are Eocene sedimentary rock (Tes), Eocene tuffaceous rock (Teot), Eocene volcanic rock (Teov), and related intrusive rock (Ti). Major units along the west are Cretaceous sedimentary rock (Ks) and parts of the Applegate Formation (Ŗas).

Ages of these older weathering surfaces are variable but are generally greater than the surfaces over surficial geologic units in the central and northern parts of the valley. The dominant texture is clay.

Deep clay-rich soil is also present above flat-lying Eocene sedimentary rock in the Sams Creek valley. In the Evans Creek Valley, deep soils overlie flat-lying terrace deposits and granodiorite (KJd).

Table 7. Bedrock and soil associations of central Jackson County, Oregon

	Rock unit	USDA classification (Figure 14)	Unified figure	AASHO figure	Perm. in./hr.	Liquid limit	Plasticity index	Shrink-swell*	Corrosivity* Steel	Corrosivity* Con-crete
Surficial geologic units	Quaternary alluvium (flood plain)	Newberg—sandy loam and silt loam	SM ML	A2 A4	0.6–6.0	30–35 to NP	10–NP	L	L	M
		Comas—gravelly sandy loam	GM SM GP GW	A1 A2	2.0–20+	NP	NP	L	L	M
		Evans—loam	ML	A4	0.6–2.0	NP	NP	L	L	L
	Quaternary older alluvium (center of large valleys)	Medford—silty clay loam	CL ML	A6 A7	0.6–2.0	30–50	10–25	M	M,H	L
		Cove—silty clay loam and clay	CL CH	A6 A7	0.6–0.06	30–50	11–50	M,H	H	M,L
	(sides of large valleys)	Central Point—gravelly and sandy loam	SM SC	A2 A4	2.0–6.0	15–25	0–5	L	L	H
		Kubli—loam to clay	ML CL	A4 A7	0.6–2.0	25–50	0–40	L,M,H	L	L
	(small valleys)	Heppsie—clay loam over gravelly clay	CL CH GC	A7 A6	0.06–0.6	40–65	20–40	H	H	L
		Carney—clay	CH	A7 A6	0.06–0.2	60–75	35–45	H	H	L
		Witzel-cobbly silt to clay loam	GC	A6	0.2–0.6	35–40	15–20	L	M	M
	Quaternary bench gravel (flat to gentle slopes)	Agate—loam and clay with pans, gravel	CL ML	A1 A4	0.06–0.6	25–35 to NP	5–10 to NP	M,L	M,L	M,L
		Winlo—gravelly loam and gravelly sand	GW GM	A1 A4	0.06–0.6	25–35 to NP	5–10 to NP	M,L	M,L	M,L
			GL GW GM	A1 A7	0.06–0.6	40–55 to NP	20–30 to NP	H,M,L	H,L	L
Volcanic and sedimentary rock geologic units	Cretaceous sedimentary rock, Eocene sedimentary rock, Eocene tuffaceous rock (flat to gentle slopes)	Coker—clay	CH	A7	0.06	60–75	35–45	H	H	L
	Eocene sedimentary, volcanic and tuffaceous rock, (moderate slopes)	Medco—loam to clay	ML SM CH	A4 A7	0.6–0.2	30–80	5–50	M,H	M,H	L
		Vilot—cobbly loam to clay loam	ML GM GC	A2 A6	0.6–2.0	30–40	5–20	L,M	L,M	H
	(moderate to steep slopes)	Carney—clay	CH	A7 A6	0.06–0.2	60–75	35–45	H	H	L
		Witzel—cobbly silt and clay loam	GC	A6	0.2–0.6	35–40	15–20	L	M	M
		Broder—clay loam and loam	ML	A4	0.6–2.0	30–40	5–10	M	M	L
	Eocene volcanic rock (moderate slopes)	Bybee—clay loam to clay	CL CH	A6 A7	0.06–0.2	25–80	10–50	M,H	M,H	M,H
		Totouche—gravelly loam to clay loam to clay	ML CL CG	A4 A7	0.2–2.0	25–55	5–35	M,H	L,H	L,M
	Diorite; sedimentary and volcanic rock of the Applegate Formation (gentle base slopes)	Monzonita—loam clay	ML CL	A4 A7	0.2–0.6	25–45	5–25	M,H	L,H	L,M
		Ruch—silt loam and clay loam	CL ML	A4 A6	0.2–2.0	25–40	5–20	L,M	L,M	M
		Holland—loam to clay loam	SM SC	A4	0.2–2.0	NP–35	NP–10	L,M	L,M	L,M

	Rock unit	USDA classification (Figure 14)	Unified figure	AASHO figure	Perm. in./hr.	Liquid limit	Plasticity index	Shrink swell*	Corrosivity* Steel	Corrosivity* Con-crete
Intrusive and metamorphic rock units	Diorite and Moy Creek Schist (steep slopes)	Siskiyou—coarse sandy loam and loamy sand	SM	Al A4	2.0–6.0	NP	NP	L	L	M,H
		Josephine—gravelly loam and clay loam	ML GM CL	A7 A6	0.2–2.0	35–45	10–20	M	L,M	M
		Beekmon—gravelly loam	ML GM GC	Al A4	0.6–2.0	25–35	5–10	L	L	L
		Colestin—gravelly loam and clay loam	ML GM CL	A4 A6	0.6–2.0	25–35	0–15	L	L	L
	Moy Creek Schist; sedimentary and volcanic rock of the Applegate Formation (variable)	Vonnoy—silt loam and clay loam	ML CL	A4 A7	0.6–6.0	35–45	5–25	L,M	L	L,M
		Voorhies—gravelly loam and clay loam	GMGC	A2 A6	0.6–2.0	25–40	5–20	M	L,M	L
		Beekmon—gravelly loam	ML GM GC	Al A4	0.6–2.0	25–35	5–10	L	L	L

* L = low
M = medium or moderate
H = high

MINERAL RESOURCES

General

The mineral resources of central Jackson County ore grouped into four major headings: aggregate, metallic minerals, ground water, and energy sources. As consumption continues, the need for the recognition and proper management of the resource bose of the County will continue to grow. Only with adequate information con realistic, equitable, and efficient planning for future needs be conducted. The following discussion is general and does not toke the place of detailed commodity investigations, should the need for such studies arise in the future.

Aggregate

General

The demand for aggregate is determined by population, rates of population growth, land use potterns and policy, construction practices, large-scale construction projects, and other factors. Traditionolly, however, demand has been correlated solely with population. Thus, annual per capita consumption of sand and grovel for Jackson County has been identifled as 10.2 tons (Schlicker and Deacon, 1970); and per capita consumption of sand, grovel, and quarry rock for Josephine County has been identified os 19 tons (Schlicker, Schmuck, and Pescador, 1975).

Accurate projections for the study oreo ore not presently possible in view of (1) incomplete consumption figures supplied by industry, (2) changing trends in population growth and land use, and (3) inadequate definition of the precise factors ;hot control consumption in the study orea. A tentative per capita consumption of sand, grovel, and quarry rock of 15 to 20 tons con be assumed; but this amount may vary significantly.

Construction materials, like other mineral resources, con be mined only where they occur naturally. Other limitations on production include hauling distances, weathering, thickness of overburden, and associated hazardous conditions such os flooding or moss movement. Further limitations ore placed by the necessary specifications of the intended use.

Conflict with other resources provides additional constraints on the construction-material industry. The preservation of fish spawning grounds commonly removes economic deposits from production. Aesthetic considerations include noise, dust, and increased turbidity.

Sources

Sources for sand and grovel include the surficial geologic units and ore indicated on the geologic mops and on Table 8. Specific locations and pit data ore provided by Schlicker and Deacon (1970). Lorge active quarry operations ore generally near major lines of transportation, and the potential of each mopped geologic unit for use as quarry rock is summarized on Table 8.

Good quarry stone is generally angular, hard, and well suited for use in paved and unpaved roods. Stone with coarse jointing is suitable for use in riverbank protection as riprop; it is not well suited for use os aggregate in concrete because of the harshness of the surfaces. Geologic units with high potential for material suitable for paving include fresh volcanic bed rock and ports of the metomorphic units. Where alteration or weathering hove produced considerable cloy content in rocks, the potential for their use in paving is diminished (Figure 15).

Most bedrock units in the study area hove potential for use in properly engineered fills and embankments. Cloy-rich material of the Eocene to Oligocene tuffaceous rock and planar pieces characteristic of the medium-grade schists (Rmc) generally hove low potential for use in fills. Granite and granodiorite (KJd) ore particularly well suited for use in fills because of the joint occurrence of angular silt and sand particles with the moderately high clay content of the weathered zone.

*Figure 15.   Rubbly Eocene and Oligocene volcanic rock (Teov) near Browns-
boro.*

High-quality sand and gravel for use in cement aggregate is available in Quaternary alluvium and younger terrace units. Generally, mining of the terrace units may conflict with potential for agricultural or residential use. Deposits of older terraces also have weathered coatings in places. The clay content and deep weathering of the Quaternary bench gravels (Qbg) generally necessitate scrubbing and washing before use as aggregate, and the unit is generally undesirable as a source of high quality aggregate at the present time.

Recommendations

County goals with respect to aggregate sources should include the setting aside of sufficient volumes to meet future needs and the minimizing of adverse impacts through adherence to adequate reclamation plans and performance standards. To be effective, the effort must be long range. Recommendations provided here are restricted primarily to constructive suggestions arising from a geologic perspective.

Schlicker and Deacon (1970) state that stream-channel gravel is generally not suitable for profitable extraction because of the small size and thinness of the deposits, uncertain future replenishment, potential impacts on spawning areas, and the availability of other sources. This recommendation is not absolute, however; and, where necessary, removal of channel gravel for aggregate purposes can be a valuable part of an overall resource-management program.

Periodic removal of point bars and channel bars can meet the multiple objectives of channel protection (see Stream Erosion and Deposition), flood control (see Stream Flooding), and resource development in unstable reaches of stream channels. Project design considerations should include proper location of excavations, adequate design and construction of berms (see Stream Erosion and Deposition), and adherence to performance standards.

Excavation of gravel from terrace units (Qoa, Qbg) is generally restricted by high agricultural and residential potential of the land, flood potential, and high ground water. These limitations are not totally

Table 8. Aggregate potential of geologic units, central Jackson County, Oregon

	Geologic unit and rock types	General engineering properties	Specific engineering considerations	Potential uses
Surficial geologic units	Quaternary alluvium (Qal): gravel, sand, silt	Easily excavated. Thin in narrower valleys; over-burden generally a few feet thick. Hazards include flooding, high ground water, severe stream-bank erosion, and channel change.	Gravel of high quality because of stream sorting. Abrasion resistance and weathering resistance very good.	Good for all types of aggregate use. Use may conflict with other stream-resource values; management should consider stream dynamics and low use potential of pits as landfills.
	Quaternary alluvial fan deposits (Qof): gravel, sand, silt	Easily excavated. Overburden generally thin. Hazards include local flooding and high ground water.	Deposits poorly sorted; gravel is mixed with fines.	Suitable for use as fill. Variable potential of pits for use as landfills.
	Quaternary older alluvium (Qoo): gravel, sand, silt, clay	Easily excavated. 20 feet or more thick with several feet of overburden. Hazards include flooding, high ground water, and severe channel change in floodways.	Gravel originally of high quality because of stream sorting. Good abrasion resistance; weathering coatings locally.	Prime agricultural land and residential development. Restrict mining. Pits have low potential for use as landfills because of high ground water. High potential along Applegate River.
	Quaternary bench gravel (Qbg): gravel, sand, silt, clay	Easily excavated except where cemented locally. Estimated thickness 75 feet over large areas.	Weathering coatings on gravel locally. Clay matrix locally. Moderate to good abrasion resistance. Moderate weathering resistance.	Requires washing and scrubbing; generally not preferred by industry. Not suitable for concrete aggregate. Variable landfill potential.
Intrusive geologic units	Diorite and granodiorite (KJd)	Requires blasting where fresh. Deeply weathered on rounded hills. Coarse jointing. Steep-slope mass-movement potential.	Difficult to crush. Dacite reacts with mortar, also harsh surfaces. Good abrasion resistance.	Suitable for embankments and sub-base; weathered material good for fill.
	Gabbro (KJgb)	Requires blasting. Variable joints. Deeply weathered.	Difficult to crush. Moderate abrasion resistance.	Suitable for fill, embankments, and road base and surface locally.
	Serpentinite (sp)	Rippable to needs blasting. Closely spaced shear planes. Deep mass movement out of area.		
	Tertiary intrusive rock (Ti)	Variable hardness, jointing, and regolith as function of bedrock type and setting.	Highly variable. Andesite and dacite dikes react with mortar.	Suitable for fill and embankments and road base and sub-base.

	Geologic unit and rock types	General engineering properties	Specific engineering considerations	Potential uses
Volcanic and sedimentary geologic units	Pliocene basalt (Tpb): basalt	Medium to wide jointing. Fresh and very hard. Overburden of old alluvium.	Good abrasion resistance. Good weathering resistance.	Suitable for most uses. Esthetic values conflict with use potential. Selective talus removal.
	Eocene and Oligocene volcanic rock (Teov): breccias, agglomerate, andesite flows; also sediments	Volcanics with variable hardness and jointing; require blasting. Variable regolith, but generally thin. Sedimentary interbeds and steep slopes hinder use.	Abrasion and weathering resistance good to poor. Andesite reacts with mortar.	Volcanic rocks suitable for embankments, road base and sub-base road surface.
	Eocene and Oligocene tuffaceous rock (Teot): tuffs, sedimentary rocks	Easily excavated. Thick regolith and weathered zone. Mass movement.	Very low abrasion resistance and weathering resistance. Very low crushing strength.	Not suitable for use as aggregate. Pits have good landfill potential.
	Eocene sedimentary rocks (Tes): sandstone, shale	Requires blasting for deep cuts. Deeply weathered on flat terrain. Variable hazard potential.	Low abrasion resistance. Low weathering resistance. Tuffaceous components weather easily to clay.	Not suitable for use as aggregate except for fill. Moderate landfill potential.
	Cretaceous sedimentary rock (Ks): sandstone, mudstone	Generally rippable. Thick regolith. Minimal hazards.	Very low abrasion and weathering resistance.	Not suitable for use as aggregate. Good landfill potential.
	Galice Formation (Jg): siltstone	Moderately difficult excavation. Variable cutbank stability.	Low abrasion resistance and weathering resistance.	Not suitable for use as aggregate except fill locally.
Metamorphic geologic units	Applegate Formation (Ŗov): various metavolcanics	Requires blasting for excavation. Variable jointing, but generally close. Variable overburden.	Abrasion resistance moderate to good. Appreciable clay in fines of crushed rock.	Suitable for paving, road base, backfill, riprap, and embankments; not suitable as concrete aggregate.
	Applegate Formation (Ŗos): altered sedimentary rock, argillite, chert, limestone	Moderately hard with variable jointing.	High clay component. Cherts reactive with mortar. Low abrasion resistance.	Used for forest roads where other materials not available. Suitable for some fill and embankments.
	Moy Creek Schist (Ŗmc): metavolcanics, schist, phyllite, slate	Requires blasting. Planar texture and structure. Variable overburden and mass-movement potential.	Low abrasion and weathering resistance locally. High clay or mica component.	Generally not suitable for aggregate. Planar shapes not stable in fills and embankments. Metavolcanics good locally.

restrictive, however, and selective removal of gravel from acceptable areas is recommended for consideration, provided the removal is part of a well-coordinated sequential land use program. For example, turning excavated areas into urban lakes will enhance surrounding land values and provide potential sites for water recreation. In addition, the lakes which can be designed to accept urban winter runoff con be drained in the summer to reduce the high summer water table in irrigated areas. The drained water con be o source of supply for additional irrigation in neighboring areas.

Management of urban lakes is discussed by Rickert and Spieker (1971) and Britton and others (1975). Pits near major streams must be properly located and designed to prevent their being reclaimed by the river channel during lorge floods (see Stream Erosion and Deposition).

The location of quarry sites in bed rock is limited by geologic hazards and the type and quality of the bed rock, weathering, and overburden. Factors such as these vary considerably over short distances. Policies to control the location and expansion of quarries for aesthetic or other purposes must be flexible, and it is probably not possible for all new quarry activities to be located out of sight of the general public. A good reclamation plan is a viable alternative.

To facilitate early agreement between all parties affected by future aggregate operations in a given area, the county should hove a variety of basic data sources on hand, as suggested by Weaver (1976). These should include resource mops, site-performance criteria, zoning mops, ownership mops, operating standards, procedures for conditional-use permits, and procedures for assuring citizen and industry input to county planning decisions.

Metallic and Nonmetallic

General

Metallic and nonmetallic mineral materials which con be extracted profitably under present economic conditions with present technology are considered resources. Deposits may include proved reserves, where the evaluation is based on sampling, tests, and detailed geologic evaluation; probable reserves, where analysis is less systematic and less nearly complete; and possible reserves, where the presence of minable deposits is suggested on the basis of incomplete evidence.

Most metallic and nonmetallic occurrences in the study area ore indicated by a history of piecemeal production and prospects under o variety of economic and technological conditions. Systematic analysis is generally locking, and deposits ore best characterized as possible reserves. Mine and prospect localities ore shown on the geologic maps. In formulating general land use policy, the mineral-resource potential is on important element which warrants consideration equal to that of other factors, if maximum benefits ore to be derived from the land. This section is intended as a general planning tool and not as on exhaustive treatment of the mineral potential.

Reserves

Estimates of the relative potential for future discoveries of the various mineral commodities of Jackson County ore based primarily on post production and a knowledge of the pertinent geology, as summarized on Table 9. Projections of actual future development ore based on a consideration of (1) the potential for future discoveries, (2) the size of the deposits and the cost of production, (3) competition, and (4) cost and transportation distonce. The general assessments given here ore based on incomplete data.

Minerals having a low probability of future development include molybdenum, nickel, platinum, mercury, manganese, and cobalt. Major factors in these determinations include outside competition and the poor record of discovery. Higher priced commodities such as platinum and molybdenum hove relatively higher potential for development if they are ever discovered in sufficient quantities. With the possible exception of the Shamrock sulfide deposit, the most promising nickel deposits in southwestern Oregon now appear to be located outside Jackson County.

Minerals with moderate potential for future development based on post production include cloy, chromite, copper, lead, zinc, and tungsten. Generally, however, known deposits ore not large enough to compete with outside sources.

Commodities with possibly very high potential for future development include gold, silver, coal, oil, and uranium. Oil is characterized by a low potential for discovery but would be exploited if it were ever discovered. Gold and silver have a history of ongoing mining and probably are still present in minable quantities and grades. Coal potential has not been regionally assessed, but the presence of coal and the growing need for energy sources suggests possible future activity. Commercial quantities of uranium have not been discovered in Jackson County. The bedrock geology, ground-water conditions, and sediment source areas of the Eocene bedrock units in the northern Bear Creek valley and Sams Valley are consistent, however, with the development of economic uranium deposits in other areas of the United States.

The development potential of each mineral commodity varies through time with the various factors enumerated above. Of particular significance is the absence of systematic and regional assessments for each commodity. As more sophisticated information is developed in the future, new deposits and new areas of high potential may be identified for many of the commodities. This new information will be the basis of revisions and refinements of the assessments given here.

Recommendations

The broad-based potential for mineral development in the study area warrants responsible consideration in the planning process. An inventory of mining operations coupled with a commodity-by-commodity regional geologic evaluation is needed. The regional assessments should be based in part on geochemical and geophysical investigations, when available.

Zoning decisions based on inadequate information should not arbitrarily hinder mineral exploration and development. Thus, land use zones in mineralized areas should specifically allow for mining, either as part of the zone description or as a conditional use, if this is the intent of the governing body. Units and areas of mineral potential are summarized on Table 9 and the geologic maps, respectively. Absence of specific mention of mining in zoning ordinances can conceivably result in adverse court decisions that are counter to the actual intentions of the governing body.

Citizen input to planning should include adequate notification and participation of industry on issues related to mining. In addition, in-house review of environmental impact statements should include a consideration of mining potential.

Ground Water

General

Ground water is water that fills the open spaces in rocks and soil beneath the land surface. The zone of saturation is called the water table; the top of the water table conforms in a general way to the land surface but is generally at greater depths beneath hills than beneath valleys and depressions. Perched water tables that are situated above the regional water table are localized zones of saturation resting upon impermeable material. Perched ground water and areas of ground-water discharge commonly impact man's activities and constitute localized geologic hazards (see High Ground Water and Ponding).

Porosity is the percentage of open spaces, such as pore spaces between grains, fractures, and joints, per unit volume. The size, number, and arrangement of these open spaces is dependent on the specific rock type, presence or absence of alteration or cementation, and deformation.

Permeability, the potential for transmission of water, is dependent on porosity, the size of the pore spaces, and the degree of interconnection between pore spaces. The coefficient of permeability is the rate of flow (gallons per day) through a square foot of cross section under a hydraulic gradient of 100 percent at a temperature of 60°F. Specific capacity is a more accurate measure of the capacity of a well to produce water over a prolonged period of time and is determined by dividing well production (gallons per minute) by the drawdown (drop in water table) under specified conditions. Materials such as sand, which has a relatively high porosity and permeability, have a high specific capacity. In contrast, jointed or layered bed rock may locally have high transmitting potential but low specific capacity. Clay has high porosity, low transmitting potential, and low specific capacity.

Table 9. Metallic and nonmetallic mineral resources of central Jackson County, Oregon

Mineral	Geologic occurrence	Production history	Estimated relative potential for future discoveries
Cloy	Weathered Tertiary pyroclastic rock (Teat), flood-plain deposits, deeply weathered Cretaceous sedimentary rock (Ks).	Local production in Teat and Ks; favorable tests in other places.	Probable under favorable market conditions.
Chromium	As massive bodies and os finely disseminated ore in serpentinite and related rocks (sp).	Occurrences of very low tenor ores ore noted; no current production.	Very low; potential is somewhat greater in the upper Applegate drainage south of the study area.
Cool	Deltaic Eocene sedimentary rock (Tes and lower Teov) in eastern Bear Creek volley.	Historic small-scale production; quality improves to northeast.	Future small volume discoveries likely. No regional assessment available.
Cobalt	With other vein minerals in granitic terrain.	None.	None.
Copper	As sulfides in fissures, veins, and stringers in granitic terrain (KJd).	Several mines and numerous prospects.	Relatively good in view of active history; potential for profitable mining probably low.
Geothermal energy	Mineral hot springs along major bedrock structures in southern Bear Creek volley.	Heolth resorts and commercial use of CO_2.	Uncertain.
Gold and silver	As placers in terraces and streams, as veins in shear zones and faults, and also as Cretaceous placers (Ks). Lodes restricted to pre-Cretaceous.	Approximately 30 placer and dredge and 75 lode operations.	Good; historically many operations were good producers regardless of depth (lode). Bedrock deposits restricted to pre-Cretaceous rocks and often clustered along faults; placers depleted.
Lead	Veins and shear zones near and in granodiorite.	Prospects ond small-scale production.	Moderate, based on number of historic occurrences; economic potential low.
Manganese	As rhodonite veins along fractures and bedding planes in pre-Cretaceous rocks (Ɽas, Ɽov) and as cavity-filling oxides in Teov.	Numerous prospects, but no significant production.	Low.
Mercury	Tertiary breccios and tuffs; also in fault and shear zones in metasediments (Ɽos).	Numerous prospects; small-scale historic production in metasediments.	Possible, with low probability that discoveries will be economically significant.
Molybdenum	Veins in granitic rock (KJd).	Prospects; no production.	Low.
Nickel	Prospect in pre-Cretaceous.	None.	Low.
Oil	If present, limited to Cretaceous and Eocene marine sedimentary rocks (Tes, Ks).	No shows and no production; geology generally not favorable in terms of structure, thickness, or reservoirs.	Very low.

Table 9. Metallic and nonmetallic mineral resources of central Jackson County, Oregon (continued)

Mineral	Geologic occurrence	Production history	Estimated relative potential for future discoveries
Platinum	As fine disseminations in ultramafic rock, including some serpentinite.	Prospect.	Very low; measured bedrock concentrations in southwestern Oregon ore considerably below marginal quality.
Tungsten	Reconstituted limy sedimentary rock in Ras or as inclusions in KJd.	Numerous prospects with small-scale production locally.	Moderate; potential for competitive production uncertain.
Uranium	Known to occur in deltaic sandstone interbedded with shale with appropriate ground-water conditions and source areas.	No prospects; no production.	Possible in Soms Valley and Bear Creek valley.
Zinc	In veins and breccias of Teat.	Prospects; small production.	Moderate, but low volume.

In areas where the geologic materials are both porous and permeable and the hydraulic gradient is sufficient to generate flow, the ground water is in constant motion. Precipitation that is absorbed into the soil percolates to the water table and flows down the gradient to o point of discharge. This type of ground-water system con produce low-temperature water with fairly constant chemical characteristics and is generally o highly desirable resource. Because of local and regional variations in geologic conditions, ground-water quality and availability vary considerably in the study area.

Geologic units

Water-well records ore on file at the State W ater Resources Department in Solem and at the U. S. Geological Survey office in Portland. Published reports include Young (1959) and Robison (1971,1972). Emphasis in this investigation is placed on the relation of ground water to geology. Data from producing water wells that are representative of many of the major geologic units are summarized in Table 10.

Several thousand domestic wells are meeting the needs of single-family dwellings in the rural areas of Jackson County. Very few wells produce greater than 50 gallons per minute on a sustained basis. For this reason, large demands such as irrigation are generally supplied by surface-water storage in the mountainous areas. Big Butte Springs, out of the study area, supplies drinking water to Medford. Absence of lorge producing aquifers throughout the study area is reflected in the low bose flow of local streams.

Surficial geologic units: Surficial geologic units include Quaternary alluvium (Qol), Quaternary older alluvium (Qoa), Quaternary alluvial-fan deposits (Qof), and Quaternary bench gravels (Qbg). Wells in these units commonly penetrate to bed rock, and production potential of surficial units is commonly difficult to interpret. Yields are generally limited to 20 gallons per minute or less. Specific capacities are low to moderate. Larger flows are possible for specially designed wells in thick alluvium along major streams. Shallow wells which tap perched aquifers may be threatened by pollution from surface sources. Ground water recovered from Quaternary alluvium is generally hard.

Metamorphic rock units: Very few reliable well logs are available for the metamorphic units (May Creek Schist (Rmc), Applegate Formation (Ros, Rov)). Ground water accumulates in recoverable quantities at shallow depths along fractures, joints, faults, and planes of schistosity. Production potential is generally low, and typical yields ore 5 gallons per minute or less. Greater yields ore possible along shear zones and other favorable structures.

Water produced from the Applegate Formation is generally hard in terms of either sodium bicarbonate or calcium bicarbonate. No consistent pattern of occurrence of these constituents has been identified. Water produced from the metamorphic units is also commonly high in boron and fluoride. Boron present in sufficient concentration to be toxic to plants has been reported in chemical analyses of some wells (Robison, 1971).

Volcanic rocks: Ground-water storage in volcanic rocks is restricted to fracture zones, jointed flows, and permeable interbeds. Wells in the Eocene and Oligocene tuffaceous rock unit (Teat) ore commonly productive because of the presence of permeable interbeds or jointed flow rock beneath the surface. Yields of 10 gallons per minute are possible under good conditions, and some wells ore artesian (the static water level is above the level of the producing aquifer). Small quantities of water also occur in perched aquifers. Ground water from the volcanic units is generally hard in terms of calcium bicarbonate or sodium bicarbonate and also contains boron and fluoride.

Sedimentary rocks: Sedimentary rocks yield variable quantities of water at moderate depths in low-lying areas. Typical yields are 5 to 15 gallons per minute on a sustained-yield basis. High yields reported in some well logs generally correlate with excessive drowdowns. Yields ore particularly good in areas of regional shearing in northwest Soms Volley and possibly around Ashland where sedimentary units dip gently to the east and recharge areas ore exposed at the surface. Aquifers include fault zones, permeable interbeds, and, possibly, bedding planes.

The chemical quality of water derived from sedimentary rocks in the study area is generally good, with significant variations. Boron contents ore high in the southeast Soms Valley area and between

Table 10. Representative water wells for central Jackson County, Oregon

Unit	Location	Owner	Year	Depth (ft)	Water depth (ft)	Yield (gpm)	Drawdown (ft)
Quaternary alluvium (Qal)	NW¼ sec. 15, T. 34 S., R. 1 W.	N. Chapman	1974	82	4/25/74 12 static 37 aquifer	25	70/1 hr.
Quaternary older alluvium (Qoa)	Sec. 29, T. 36 S., R. 2 W.	F. Hilton	1973	40	–	30	20/1 hr.
	NE¼ sec. 22, T. 37 S., R. 2 W.	R. Gustofson	1973	322	7/11/73 24 static 178 aquifer	3.5	298/1 hr.
	NE¼NE¼ sec. 27, T. 37 S., R. 2 W.	D. Wooten	1975	134	2/26/75 8 static 65 aquifer	5	Total/1 hr.
Quaternary bench gravel (Qbg)	SW¼NE¼ sec. 16, T. 36 S., R. 1 W.	J. Bone	1972	115	10/26/72 18 static 67 aquifer	25	92/1 hr.
	NW¼ sec. 22, T. 36 S., R. 1 W.	F. Poole	1974	92	6/25/74 15 static 72 aquifer	10	77/1 hr.
	Sec. 25, T. 36 S., R. 2 W.	K. Winn	1973	45	8/15/73 16 static 42 aquifer	35	29/1 hr.
Eocene and Oligocene tuffaceous rock (Teot)	Sec. 21, T. 35 S., R. 1 W.	H. Phillips	1968	145 (basalt)	3/22/68 74 static 135 aquifer	27	34/1.5 hrs.
	SE¼ sec. 30, T. 36 S., R. 1 E.	H. Shubin	1973	122	1973 23 static 117 aquifer	16	99/1 hr.
Eocene sedimentary rock (Tes)	SW¼ sec. 22, T. 34 S., R. 2 W.	J. Geneja	1974	162	6/26/72 64 static 90 aquifer	14	98/1 hr.
	SE¼SE¼ sec. 27, T. 34 S., R. 2 W.	J. Lancaster	1970	140	5/13/70 20	120	113/1.5 hrs
	Sec. 29, T. 34 S., R. 2 W.	D. Veabrycit	1968	83	6/3/68 30	60	53/2 hrs.
	SE¼NE¼ sec. 32, T. 34 S., R. 2 W.	C. Lemack	1974	117	1974 6 static 44 aquifer	7	100/1 hr.
	NW¼ sec. 15, T. 35 S., R. 2 W.	V. Hartlerader	1974	240	5/17/74 196	21	--
	SE¼NE¼ sec. 16, T. 37 S., R. 1 W.	E. Fordyce	1968	438	5/17/68 200 static	25	238/3 hrs.

Table 10. Representative water wells for central Jackson County, Oregon (continued)

Unit	Location	Owner	Year	Depth (ft)	Water depth (ft)	Yield (gpm)	Drawdown (ft)
Cretaceous sedimentary rock (Ks)	NW¼SW¼ sec. 2, T. 37 S., R. 2 W.	P. Mang	1968	110	2/28/68 31 static 36 aquifer 55 aquifer 89 aquifer 96 aquifer	0.5	14(?)/1 hr.
	SW¼ sec. 18, T. 38 S., R. 1 W.	W. Gaines	1974	202	6/20/74 1 static 32 aquifer	7	201/1 hr.
	NE¼NE¼ sec. 15, T. 38 S., R. 2 W.	D. McLaughlin	1975	301	9/ 8/75 16 static 55 aquifer 264 aquifer 286 aquifer	54	80/2 hrs.
Volcanic rock of Applegate Fm. (₮ₐv)	Sec. 16, T. 38 S., R. 1 W.	Phoenix (city)	1967	200	7/31/67 18 static 144 aquifer	51	150/1.5 hrs.
May Creek Schist (₮mc)	Sec. 20, T. 34 S., R. 2 W.	A. Allen	1969	300	5/5/69 60	2	240
Cretaceous and Jurassic diorite (KJd)	SE¼NE¼ sec. 17, T. 37 S., R. 2 W.	B. Cochran	1975	246	9/ 8/75 40 static 126 aquifer	6	105/1 hr.
	Sec. 8, T. 35 S., R. 4 W.	T. Rolth	1976	83	5/21/76 9 static 6 aquifer	40	60/1 hr.
	Sec. 10, T. 35 S., R. 4 W.	A. Shiller	1972	105	6/21/72 22 static 94 aquifer	25	64/1 hr.

Jacksonville and Medford, and quantities toxic to certain types of plants are reported in some wells (Robison, 1971). High amounts of sodium chloride occur north of Medford. Nonmarine sedimentary rocks are high in calcium bicarbonate, and sedimentary rocks of the Sam's Valley area ore generally high in sodium carbonate. Minor quantities of lithium are reported at Lithia Springs, 3 miles east of Ashland.

Water from numerous wells near Ashland are high in various mineral constituents and carbon dioxide (Winchell, 1914; Robison, 1972). Water temperatures of 95°F are reported from a well at Jackson Hot Springs, 1 mile north of Ashland (Robison, 1972). Warm-water wells are also reported near Emigrant Creek (T. 39 S., R. 2 E., well #7 N 13) by Young (1959). These geothermal manifestations are associated with major bedrock structures and may possibly indicate an energy resource.

Intrusive rocks: Weathered diorite and granodiorite produce ground water from the weathered zone and from joints or faults in fresh bed rock in amounts sufficient for domestic purposes. Potential for production is generally good in areas of gentle topography but is low in areas of steep terrain. The ground-water potential of other intrusive rocks including serpentinite and metagabbro is probably very low.

Recommendations

Pollution and natural mineral content are two factors that affect water quality in Jackson County. Shallow wells should be designed so that surface pollutants do not enter the aquifers. Water from particularly deep wells should be chemically treated prior to use. Wells of intermediate depths are generally the most likely to produce good quality water.

Many well logs that are presently available are inadequate for accurate resource evaluation. Precision and consistency in production testing, rock identification, and identification and description of aquifers should be encouraged.

For planning purposes, typical water wells should be regarded as sources of supply for rural domestic use. Sources of ground water suitable for urban needs are found only out of the study area or in the thick gravel alluvium along the Rogue River. In the Bear Creek valley, groundwater may be a potential alternative source of irrigation water. Specialized recovery techniques may include regional draining of areas with high ground water or redistribution of ground water which naturally fills large excavations such as aggregate pits.

GEOLOGIC HAZARDS

General

Orderly development which insures public health, safety, and welfare is difficult and complex. The complexity is greatly reduced when planners understand the natural characteristics of the land, the processes that shape it, and geologic hazards that threaten it and rationally use that knowledge in the guidance of growth. Geologic hazards of concern to the planner include mass movement, slope erosion, stream flooding, stream erosion and deposition, and earthquake potential. Each hazard is characterized by unique distribution, causes, and ranges of impacts. In this report, recommendations for treatment or mitigation of geologic hazards are flexible to allow for variations in physical, social, political, and economic settings. The distribution of geologic hazards based on reconnaissance investigations is indicated on the accompanying geologic hazards maps.

Mass Movement

General

Mass movement is the movement of rock or soil material downslope in response to gravity. Table 3 summarizes several kinds of mass movement in the study area, including deep bedrock slumps and slides, earthflow, steep-slope mass movement (debris flow, debris avalanche), creep, and potential mass movement. The parts of this study dealing with mass movement are reconnaissance and provide a valuable tool for planning as regional guides and guides to on-site evaluation. They are not substitutes for on-site investigations, however.

Causes

Mass movement occurs on slopes where the downslope component of gravity exceeds shear resistance. In areas of sliding, potential sliding, low cutbank stability, or hazardous slopes, the activities of man should be controlled to assure that the downslope component of gravity is minimized and that shear resistance is maximized.

Downslope gravity component: The weight of the regolith column is increased by the placement of fill for road construction or other purposes, saturation during winter rains, and artificial obstruction of surface and shallow subsurface runoff by improperly designed roads, poorly located dwellings, and other developments.

Models of slope failure presuppose that the weight of the regolith column is perpendicular to the earth's surface. Where nearby blasting or seismicity is a factor, a horizontal component of acceleration is introduced along with the vertical gravity component. The resulting inclined direction of acceleration has the same effect from an engineering standpoint as does steepening of the slope. Also to be considered is the disaggregation and consequent loss of strength caused by blasting of regolith.

Shear resistance: The buoying up of soil particles under saturated conditions reduces internal friction and shear resistance. When soil water is increased to the point of saturation by rainfall, drainage interference, or blocking of springs, shear resistance decreases and potential for sliding increases. Under conditions of heavy rain, infiltration may exceed the rate of shallow subsurface drainage so that the liquid limit of the soil is actually exceeded (Campbell, 1975). Debris flows in colluvial pockets over impermeable bed rock may result.

Cohesion, the bonding attraction of soil particles, varies with soil type and water content. Silts (see Table 3) have low cohesion when dry, moderate cohesion when wet, and no cohesion when saturated. Clay-rich soils (see Table 3) can generally accommodate large quantities of water before reaching their liquid limit. Loss of cohesion produces slow-moving landslides or expanding soils.

Root support by trees is now recognized as a primary agent of stability in colluvial areas on steeply sloping terrain. Root support declines rapidly after logging, and many slides in logged areas are attributed to the loss of root support through root decay. In wooded areas it is doubtful, however, that increased soil moisture associated with logging has a measurable impact on slope stability.

Distribution

Table 11 lists the prevalent types of mass movement in the study area; provides a general definition and description of each type of mass movement; and summarizes the distribution of each in terms of slope, landform, bed rock, structure, and associated ground-water features.

Interpretation of mass movement on the geologic hazards maps is based upon extensive field reconnaissance, topographic analysis, consideration of slide mechanics, and aerial photographic analysis (scale 1:20,000 with a 3X magnifier). More refined delineation costs more and requires more detailed field work, larger scale photographs, and larger map scale. Locally, remote sensing, geophysics, and monitoring can be appropriately utilized in highly critical areas.

The planner must be concerned both with existing landslides and with future slides in new areas. Cutbank failures resulting from improperly engineered cuts can generally be avoided by adhering to the provisions of the Uniform Building Code. Critical features such as jointing, bedding, clay content, and subsurface flow, however, present special problems. These factors and cutbank stability are discussed in the section entitled Engineering Properties of Geologic Units.

Another category of future slides encompasses slides that will be initiated by natural or artificial means other than cuts, including overloading, changes of drainage, and removal of vegetation. Table 12 summarizes geologic units in the study area as they relate to engineering properties related to sliding, types of future slides, and activities of man which may contribute to sliding. Interpretation of slide potential is based primarily on slide causes that were discussed earlier. For additional detail, the reader is referred to the discussions of each of the engineering properties (see Engineering Properties of Geologic Units).

The distribution of present mass-movement features is presented in the geologic hazards maps. Additional mapping of areas of future mass movement can be accomplished on a regional basis using overlays of slope, critical topographic features, and rock type (see Table 11). More detailed maps of local extent can be generated by plotting in detail engineering features that contribute to sliding in each of the geologic rock units (see Table 12).

Impacts

Impacts of mass movement vary with the types of mass movement under consideration. Deep bedrock failures are either active or inactive and have associated with them irregular ground-water and drainage conditions, highly variable foundation strengths and cutbank stabilities, and secondary slides in eroding areas.

Earthflow and slump topography are associated with poor drainage, shallow subsurface flow of ground water, and the possibility of ongoing movement which can destroy man-made structures such as roads, homes and other buildings. In addition, active earthflows leading into streams adversely affect water quality.

Debris flows and debris avalanches generally occur in uninhabited areas and therefore pose greatest threats to water quality and the forestry resource. Logging roads are particularly subject to damage. Another impact is topsoil loss which in extreme instances also reduces the water-retention capabilities of regolith, thereby contributing to local areas of increased storm runoff.

Rockfall and rockslide are minor hazards in most of the study area but pose threats to hikers and motorists in the more steeply sloping terrain. Rolling rocks in areas of high relief occasionally travel considerable distances beyond the bases of slopes from which they were derived.

Table 11. Mass movement in central Jackson County, Oregon

Type			Description	Distribution
Deep bedrock slide			Downward movement of rock or regolith along a curved basal shear plane; accompanied by backward rotation of the slide block. Characterized by pronounced headscarp overlooking irregular, more gently sloping terrain.	Moderately steep to steep slopes in youthful valleys of moderately large to large streams. Common in faulted terrain, jointed terrain, and areas of interbedding of distinctly differing rock types. Favored by deep percolation of ground water.
Earthflow and slump topography			Downslope movement of regolith along numerous shear planes in a manner analogous to highly viscous flow; generally accompanied by rotational failure upslope. Characterized by irregular topography, sag ponds, and irregularities of soil distribution and drainage. Commonly too small to be detected with aerial photography.	Moderately steep to steep slopes in areas of low surface runoff and significant chemical weathering. Most common also along faults, joints, and bedrock contacts; also common in heads of gullies or in areas of natural or artificial undercutting of regolith. Units include sp, Teot, Teov, and Tes.
Steep- slope failure		Debris flow and debris avalanche	Rapid flow or sliding of regolith down steep slopes along bedrock surfaces approximately parallel to the slope. Characterized by linear deposits of unvegetated colluvium in steep drainageways.	Steep to very steep slopes where regolith overlies impermeable bed rock and where shallow subsurface flow is significant, as in steep linear drainageways. Favored by silty soils prone to liquefaction when saturated and by removal of vegetation and consequent loss of root support. Units include KJd and metamorphic rock.
		Rockfall and rockslide	Falling and rolling rock at the base of cliffs. Characterized by unvegetated talus or scattered boulders on slopes beneath cliffs of jointed or faulted hard bed rock.	Very steep slopes with exposures of jointed or faulted bed rock, particularly breccia, agglomerate, and flow interbeds in Teov; also parts of Ŗmc and other metamorphic units.

Table 12. Slide potential of geologic units

General rating
- ● Relatively high or great
- ◐ Variable
- ⊖ Moderate
- ○ Relatively low or small

Group	Unit	Shallow subsurface flow	Deep subsurface flow	Joint development	Bedding distinctness	Slope intensity	Regolith on steep slopes	Regolith on gentle slopes	Regolith clay	Regolith silt	Types of slides and activities which promote sliding
Surficial geologic units	Quaternary alluvium Qal	○	●	—	⊖	○	—	●	◐	◐	No present slides; future failures restricted to cutbank failure in deep cuts and areas of unfavorable ground–water conditions or incompetent interbeds.
	Quaternary alluvial fan deposits Qof	○	●	—	⊖	○	—	●	◐	◐	
	Quaternary older alluvium Qoo	⊖	●	—	⊖	○	—	●	◐	◐	
	Quaternary bench gravel Qbg	●	●	—	⊖	○	—	●	●	◐	
Volcanic and sedimentary rock	Pliocene basalt Tpb	●	⊖	●	—	◐	○	⊖	●	⊖	Future slides highly variable including deep bedrock failure along faults; earthflow and slump over fine-grained sediments; and rockfall and rockslide in flow rock, breccias, and agglomerates. Cutbank failures in deeply weathered terrain on gentle slopes. Other failures the result of improper cuts or poor drainage control.
	Eocene and Oligocene volcanic rock Teov	⊖	◐	◐	◐	◐	○	◐	◐	○	
	Eocene and Oligocene tuffaceous rock Teot	●	○	○	⊖	⊖	○	⊖	●	○	
	Eocene sedimentary rock Tes	⊖	○	○	●	◐	○	◐	◐	○	
	Cretaceous sedimentary rock Ks	○	⊖	○	⊖	⊖	○	⊖	◐	○	
	Galice Formation Jg	◐	○	○	●	⊖	⊖	○	◐	◐	
Metamorphic rock	Applegate Formation Ȓav	●	○	◐	○	●	◐	◐	⊖	⊖	Future failures primarily steep-slope failure including debris flow and debris avalanche as a result of improper cuts, drainage obstructions, etc. Earthflow and slump in Ȓmc result from stream undercutting in youthful terrain.
	Applegate Formation Ȓas	●	○	◐	○	●	◐	◐	◐	⊖	
	May Creek Schist Ȓmc	●	◐	●	○	●	◐	◐	⊖	⊖	
Intrusive rock	Diorite and granodiorite KJd	◐	◐	◐	—	●	◐	●	○	●	Future slides primarily debris flows and debris avalanches on steeply sloping KJd in areas of saturation, thick regolith, and removal of vegetation. Other failures include earthflow in poor cuts in sp or KJgb.
	Gabbro KJgb	⊖	○	◐	—	⊖	⊖	◐	⊖	⊖	
	Serpentinite sp	◐	○	◐	—	⊖	○	○	⊖	⊖	
	Tertiary intrusive rock Ti	⊖	○	◐	—	◐	○	○	◐	◐	

Areas of special concern

With changing land use and multiple land uses of specific parcels of land, areas of special concern are occasionally identified. Presently, the Ashland watershed is such an area, in view of its multiple uses as forestry resource and municipal watershed and its high potential for mass movement and slope erosion. Land-management decisions in areas of special concern require systematic analysis of data and ongoing data collection. Consideration of the Ashland watershed illustrates the procedures that can be followed and the types of data that should be collected. This discussion is technical and is intended in part for use by the resource specialist.

Figure 16 shows the steps that can be followed in land management analysis of critical mass-movement potential. In Step 1, geologic units and hazards are identified. For the Ashland watershed, the unit is granodiorite (KJd) and the hazards are steep-slope failure, erosion, and torrential-flood potential. For the purpose of this discussion, mass movement is identified as the general hazard which is being analyzed. In Step 2, specific types of mass movement that are identified are debris flow and debris avalanche.

In Step 3, mappable terrain factors are identified. For the Ashland watershed, they may include steep slopes, bedrock jointing, depth of weathering, locations of shallow subsurface flow, high silt content of the regolith and soil, locations upslope from the outer bends of meanders, areas below saddles in ridges, and location of thick colluvium in drainageways or on north-facing slopes. Other considerations may include irregularities of vegetation patterns, concavities in slopes, and other soil-water features. Monitoring and detailed mapping may be required to adequately delineate some of these features. Presently, ground-water relationships are being monitored in the Neil Creek basin by the U. S. Forest Service for the purpose of aiding the analysis of the Ashland watershed. The professional judgment of qualified specialists is generally required for proper treatment of many pertinent mappable terrain factors.

Overlays are prepared in Step 4. Care must be taken to assure that information on overlays is accurately related to site conditions as they occur on the ground. For example, slopes interpreted from small-scale maps are generally less intense than many slopes observed on the ground because of the averaging effects of map scale and contour spacing. Selection of slope categories must first define slopes with fundamental significance to stability and then relate slopes properly in the field to slopes as they are interpreted from topographic maps. In this report, local slope variations are given for each slope category.

In Step 5, categories of mass-movement susceptibility are defined and plotted on a composite map. Land use decisions based on the limitations of present-day technology are then made either for the entire area of critical concern or for specified areas within the total area of concern. If logging is judged acceptable in certain parts of the Ashland watershed, sophisticated land-management techniques such as helicopter logging, selective logging, conservative road design, and strategic design and placement of culverts will undoubtedly be required.

Recommendations

Reliance on human memory to define slide hazards completely is not adequate. Memory is incomplete and often inaccurate and makes no allowance for changing stability with changing land use. Furthermore, it does not provide the sophistication required to address all pertinent factors of potential mass movement.

The grading provisions of the Uniform Building Code should be adhered to in all cuts and fills. On steep slopes, areas of mass-movement potential, or areas of past mass movement, more detailed and rigorous treatment is generally required. Some of these areas are identified on the geology and geologic hazards maps of this report. Others that require more detailed mapping are identified in Tables 11 and 12. Specific analytical techniques allow resolution beyond the scope of this report (Figure 16).

Treatment of slide-prone areas varies with the nature of the mass movement and the nature of the land use. In general terms, the treatment must effectively address the specific causes of the failure (see Mass Movement - Causes, Table 11).

STEPS:

1.
┌───┐
│ DETERMINE GEOLOGIC UNITS AND   │
│ GENERAL GEOLOGIC HAZARDS: │
│   using geologic mops   │
│   using geologic hazards mops   │
└───┘

2.
┌───┐
│ DETERMINE SPECIFIC TYPES OF MASS   │
│ MOVEMENT: │
│   using geologic hazard mop legends   │
│   using Table 11   │
│   using other available literature   │
└───┘

3.
┌───┐
│ RELATE SPECIFIC TYPES OF MASS MOVE-   │
│ MENT TO MAPPABLE TERRAIN FACTORS: │
│   including bedrock engineering choroc-   │
│   teristics (Tobles 3 and 12)   │
│   including regolith engineering charac-   │
│   teristics (Tables 3 and 12)   │
│   including topographic factors, ground-   │
│   water data, and vegetation   │
└───┘

4.
┌───┐
│ PREPARE OVERLAYS FOR SELECTED TERRAIN   │
│ FACTORS: │
│   including factors such as slope, topo-   │
│   graphic setting, vegetation, ground- │
│   water, regolith thickness, and bed- │
│   rock engineering factors   │
└───┘

5.
┌───┐
│ EVALUATE MASS-MOVEMENT POTENTIAL   │
│ AND RELATE TO AVAILABLE TECHNOLOGY   │
│ AND DESIRED LAND USE: │
│   using the overlays to identify and define│
│   specific categories of susceptibility│
│   determining if avoiloble technology con │
│   accommodate the hazard within the   │
│   context of the desired land use   │
└───┘

Figure 16. *Land-management analysis in areas of critical mass-movement terrain.*

Slope Erosion

General

Slope erosion is the removal of soil or weathered bed rock which occurs as a result of sheet wash (no conspicuous channels), rill erosion (numerous small rivulets), or gully erosion (larger, more nearly permanent channels). It does not include erosion by larger channels between slopes, stream-bank erosion, or mass movement, although these are sometimes considered together in regional analyses of soil loss. Dominant factors controlling slope erosion are land use, land cover, slope, soil type, and rainfall intensity.

Soil erosion is extremely sensitive to slope gradient and moderately sensitive to slope length. The slope-intensity factor in the study area is greatest in the mountainous areas in the west and along steep valley sides in the east. It is least in the flat bottomlands.

Soil erodibility varies greatly with land use and soil cover. Sediment-yield rates, where they have been measured, provide a good general guide to slope erosion but should not be confused with actual soil loss (Wischmeier, 1976). Sediment-yield studies do not measure foot-slope deposition and other local forms of deposition which capture much of the eroded material before it ever reaches the stream being monitored. Actual soil loss is always greater than measured sediment yield.

In California, Knott (1973) demonstrated that the conversion of woodland to intensive agriculture and construction increased sediment yields by 65 to 85 times. Yorke and Davis (1971) record a 90-fold increase in sedimentation during conversion of postureland to townhouses in a small watershed in Maryland. In the H. J. Andrews Experimental Forest, uncontrolled clear-cut logging increased rates of sedimentation 67 times. Anderson (1971) reports similar results in a similar study in California. Langbein and Schumm (1958) determined that in areas with greater than 40 inches of annual effective precipitation, the sediment-yield rate under natural vegetation was approximately 200 cubic meters per kilometer per year (about 1,500 tons per square mile). In areas with lower rainfall, the sediment yield is greater because of decreased protective cover offered by natural vegetation. These figures apply to land in the natural state; erosion in agricultural or construction areas is much higher.

Soil erosion is also a function of permeability, structure, grain size, and organic content of the soil. In the study area, many of the soils are composed primarily of silt and fine-grained sand, which are both easily eroded. On some of the steeper slopes, very shallow depths to bed rock increase soil erosion because of decreased infiltration and increased runoff.

Methods of study

Many of the diverse factors controlling soil erosion are brought together in the Universal Soil Loss Equation developed by the U. S. Department of Agriculture (1972).

$$A = (R) (K) (LS) (C) (P)$$

"A" refers to the annual soil loss in tons per acre; "R" is the rainfall intensity factor; "K" is a measure of soil erodibility; "LS" is a slope-intensity factor which considers slope gradient and slope length; "C" is the land-cover and land use factor; and "P" is a factor of conservation practices. Until very recently, empirical data used in deriving the equation was based entirely on studies of flat to gently sloping agricultural land. Land use figures are now extended to consider nonagricultural uses.

Figures for steeper slopes are extrapolated beyond the range of empirical data and are used only for speculative estimates. In practice, mass-movement processes are a greater concern on more steeply sloping terrain. The Universal Soil Loss Equation is appropriate for estimating soil losses for particular parcels of land, however, giving good results within broad limits for gently sloping terrain (Williams and Berndt, 1972).

Additional techniques for estimating slope-erosion potential on a regional basis are also available. In a manner similar to the analysis of mass-movement terrain in Figure 16, a series of pertinent overlays can be developed for a region; and a series of erosion-potential provinces can be defined. These can be related to existing erosion data and monitor information to produce relative measures of erosion or actual semiquantitative estimates of erosion. The identification of erosion-potential provinces also allows the

projection of erosion data from one locality to other areas of similar nature. The erosion-province method of analysis is appropriate for regional assessments of erosion potential and sedimentation potential in gently to moderately sloping terrain.

Impacts

Severe slope erosion removes valuable topsoil and may form gullies, damage landscapes, and hinder revegetation. When allowed to continue to extreme conditions, it may result in more rapid storm runoff.

Soil material that is carried to streams may adversely impact stream biology and cause greater flooding by raising the stream bed. Although increased turbidity is also an adverse impact of slope erosion, it is largely the result of moss movement and stream-bank erosion.

Areas of special concern

Areas of steep slopes, erodible soils, or poor ground cover are generally places of special concern with respect to slope erosion. In the study oreo, these localities include mountainous areas and disrupted regions in which construction has occurred and natural vegetation has been removed. Of particular concern are the clay-rich soils of the Cascade Ronge, which contribute to stream turbidity, and the silty-loam soils of the steeply sloping gronodioritic terrain (KJd), which contribute to stream turbidity and stream deposition. The Ashland Creek watershed is on oreo of special concern.

Areas of special concern may be analyzed in o manner similar to that for critical moss-movement terrain (Figure 16). Specific areas are identified by using the geologic and geologic hazards maps. By using the text and Table 3, mappable terrain factors are selected and overlays are prepared. Supplemental field work, literature, and monitoring may be required. The slope-erosion hazard is then analyzed in light of desired land use, available technology, and land-management techniques.

Recommendations

Proper assessment of slope erosion requires systematic and balanced analysis. Impacts of mass movement and stream-bank erosion are commonly far greater than impacts of slope erosion, especially in steeply sloping terrain. For example, of the 150,000 cubic yards of clay and boulders removed from Reeder Reservoir after the 1974 flood, over half was caused by stream-channel erosion; most of the remoinder was the result of rood construction (Wilson and Hicks, 1975). Natural slope erosion was actually a minor factor. A fundamental recommendation in erosion interpretation, therefore, is to consider all means by which sediment may be introduced into streams. Do not assume that slope erosion is the only process.

Various governmental agencies are involved with soil-erosion investigations and treatment. The U. S. Forest Service conducts hydrologic studies and investigotes sedimentation and erosion resulting from forest practices on Federal lands. The Oregon State University Department of Forestry investigates erosion, sedimentation, and streamflow related to various forest practices. The State Deportment of Forestry regulates forest uses through implementation of the Forest Practices Act of 1971.

Slope erosion can be minimized by proper planning and management. Roads in uplands should be located on benches, ridge tops, and gentle slopes rather than on steep hillsides or in narrow canyon bottoms. Vegetation removal and soil disturbances should be kept to o minimum and perhaps avoided during the rainy season. Where new land uses will measurably affect infiltration rates, adequate provisions should be made to handle runoff. Other techniques to minimize erosion and deposition include the use of buffer strips and settling ponds along drainages and the application of protective ground cover such os mulch, asphalt spray, plastic sheets, sod, or jute matting in critical erosion areas and cuts. Logged or devegetated areas should be replanted where reseeding has been unsuccessful.

High Ground Water and Ponding

General

A water table situated high enough to have an adverse effect on selected human activities is termed high ground water. It is recognized on the basis of well-log data and surficial and soil features such as marshy ground, the presence of reeds or marsh grass, extremely flat topography or depressions, high organic content of soil, and black to blue-gray mottling of the soil at shallow depths. Ponding is the local accumulation of runoff in areas of low slopes, topographic restrictions, and low permeability of the underlying soil or bed rock. It is recognized by the same features that characterize high ground water.

High ground water was recognized as a problem in the Bear Creek valley in the beginning days of development; in fact, the old stage coach roads originally avoided the valley bottom for that reason. In the late 1950's, declines in pear yields were traced to rising ground water. Subsequently, the spread of the high ground-water problem has coincided to some extent with the spread of irrigation practices.

Causes

High ground water and ponding in the study area are the product of numerous processes and factors, few of which are closely related or can be related to mappable terrain factors. The kinds of water that contribute to the high ground-water and ponding problem include (1) winter rain water, which is fairly uniform in distribution; (2) ground-water flow and soil-water flow, which require detailed analysis for mapping; (3) irrigation, the impact of which is felt only in the summer time and which varies with management practice; (4) stream flooding, which produces bank overflow and accumulation in low-lying areas; and (5) surfacing of ground water on flat terrain at the bases of certain slopes.

Bedrock factors contributing to the high ground-water and ponding problem include the variable rock material of the terrace units and its distribution into layers and other units. Thus, the complex geologic history of the valley, including fan formation, stream meandering and braiding, and climatic cycles of erosion and deposition, is to be considered in the analysis of ground-water problems. Different soils and soil horizons also influence the migration of ground water. Restrictive layers are fine-grained flood deposits at the surface, tillage pans in areas of inappropriate traffic, and clay-rich B horizons or cemented horizons in areas of mature soils and deep weathering. Determination of the distribution of each of these factors requires detailed field inspection.

Ponding is also controlled by the speed at which runoff moves over the land relative to the rate at which it accumulates on the surface. Accordingly, flat or nearly flat terrain is the site of most ponding. Small elevation changes of a few feet or less can often contribute to ponding over large areas where runoff is restricted. Detailed terrain analyses addressing this factor require use of map scales and contour intervals with far greater resolution than those of this study. Subtle terrain changes introduced by development must also be considered.

Distribution

The high ground-water and ponding phenomena of the study area are the results of a variety of loosely related factors which generally vary significantly over short distances. Meaningful mapping on a reconnaissance basis is difficult and beyond the scope of this study. Generally, high ground water and ponding are restricted to areas underlain by Quaternary older alluvium (Qoa), Quaternary bench gravels (Qbg), and flat-lying terrain over impermeable bed rock.

Detailed on-site study is required for reliable assessments in many instances, and highly technical regional research is required for delineation in larger areas. New techniques in remote sensing of soil moisture have yielded semiquantitative results on the basis of soil darkness, soil temperature, and soil microwave emissivity. Success has been limited, however, either to areas of accurate soils mapping or bare ground devoid of vegetation.

Delineation of the high ground-water and ponding hazards should not be based on insufficient criteria. For example, many valley soils of the study area are described as well-drained to moderately

well-drained in recognition of soil color and restriction of the mottling to the B horizon. The dry climate for much of the year, however, accounts in large part for these features. In terms of high ground water, overriding considerations should also include clay pans in the soil, the nature of the parent material, the flat terrain, winter rain, and runoff patterns. Likewise, measured rates of ground-water percolation are significant only when viewed in terms of the rates at which water is introduced into the subsurface or conveyed over the surface of the ground.

The Central Point area is characterized by granitic and metamorphic parent material and deep residual soils on flat terrain. Compact soil horizons and clay-rich soil horizons contribute to high fluctuating water tables over large areas. Near the hills, valley areas are generally wet at shallow depths; and numerous springs occur. In the Medford and Phoenix areas, sandstone bed rock is present at shallow depths. Source material for stream sediments consists primarily of fine-grained metamorphic rock in the surrounding hills. The high fluctuating water table is strongly influenced by the distribution of impermeable bed rock in the subsurface, the distribution of wet alluvial fans and channels, and the distribution of clay-rich soil horizons and clay-rich overbank flood deposits.

Farther south in the Wagner Creek area, the terrain is characterized by alluvial fans and residual soils over Cretaceous sedimentary rock. High ground water is controlled largely by the location of stream channels and fans along the mountain front and by shallow depths to impermeable bed rock. High ground water in the Ashland area is controlled largely by the distribution of wet alluvial channels and fans.

North and east of Medford, tuffaceous Eocene sedimentary rock (Tes) is deeply weathered over large flat areas to produce thick, clay-rich residual soils of low permeability. High ground water is a particular concern in gentle depressions. In sloping areas, ground-water flow is largely restricted to the weathered zone between soil and bed rock. Percolation of ground water through soils over the Quaternary bench gravels is extremely slow and apparently limited largely to lateral flow toward patterned channels (see Quaternary bench gravel). Along the base of the Cascade Range southeast of Medford, seeps and small wet areas are developed at the bases of slopes.

Northern Sams Valley consists of gently dissected Eocene sedimentary rock, and southern Sams Valley consists of a flat bedrock surface overlain by deposits of clay-rich older alluvium (Qoa). High ground water results from (1) the high clay content of flood deposits and soil horizons in the older alluvium, (2) the delivery of large amounts of runoff into southern Sams Valley along poorly defined stream channels, (3) the shallow depth to impermeable bed rock over large areas, and (4) gentle gradients and numerous depressions. High ground water and ponding on flat terrace forms north of Eagle Point are caused by shallow depths to impermeable bed rock and surfacing of ground water at the bases of mountain slopes.

Impacts

High ground water or ponding can cause (1) flooding of basements, underpasses, and other subsurface facilities; (2) flotation or damage to buoyant structures such as pipelines, tanks, swimming pools, and basements; (3) differential settling of buildings; and (4) complications in installation of underground facilities. Included is the danger of caving during excavation. Also, in the late 1950's, decreases in pear yields were traced to a rise of the saturated zone into the root zone of the pear trees.

Other problems include shrink-swell damage, liquefaction during earthquakes, and threats to water quality in areas of waste disposal. Hepatitis may occur in areas where agricultural runoff or septic-tank effluent pollutes surface or near-surface water that later flows into domestic ground-water wells.

Recommendations

Mitigation of high ground water and ponding hazards includes restrictions on development, limits on general construction practices, and the actual treatment of causes of the hazards. Where hazards are regional, as in Jackson County, mitigation should be systematically planned and coordinated to assure efficiency and avoid conflicts.

In areas of low slope, engineering investigations for large-scale construction should include an assessment of the ponding and high ground-water hazards. Emphasis should be placed on the highest level of occurrence during the wet season rather than lower levels representative of the dry season. Underground storage tanks and swimming pools should be kept filled in areas of high ground water. Adequate safety

measures against caving should be followed in all excavations. Reclamation plans for excavations such as gravel pits should consider the potential for flooding.

Future damage can be reduced through use of realistic zoning ordinances and building codes. Such regulations should make allowances for workable engineering solutions to specific problems. In regions of particularly severe hazard, seasonal construction may be necessary. Sump pumps and drain tiles are often used to handle severe leaking in basements in regions of high infiltration or high ground water. Where problems are less severe, sealants may be applied to either the interior or the exterior of the foundation walls.

Effective treatment of the causes of high ground water or ponding must address the specific causes present at a specific site. Surface-water accumulation can be minimized by (1) maintaining drainage ditches, (2) draining flat areas, (3) intercepting runoff above wet areas, (4) properly draining artificially surfaced areas such as parking lots, (5) eliminating obstructions to surface water flow, and (6) placing structures on elevated fill.

In areas of shallow bed rock, well-log data should be used to assess the magnitude of the hazard prior to construction. Drain tiles are effective in the collection or redirection of ground water. In agricultural areas, harvesting practices should be keyed to the capability of the soil to accommodate traffic and to withstand compaction.

In areas of ground-water discharge, properly designed drains and culverts are recommended. Placing fill in areas of ground-water discharge is not recommended. Ground water recovered by drains in these areas can be used ideally for irrigation purposes in neighboring areas. Winter ponding caused by bank overflow of minor streams can be minimized by appropriate maintenance and design of channels.

Careful positive management is needed to reduce the contribution of excess irrigation water to ground-water levels in the summer. With increasing irrigation and development in recent years, the problem and its possible solutions are becoming regional, rather than local, in scope.

The volume and distribution of irrigation water applied to the ground should be keyed to actual needs and should be managed with a consideration of the high ground-water hazard, the capability of the soil and regolith to accept water, and the pattern of movement of water in the subsurface. Canal leakage should be minimized; and waste channels in high ground-water areas should be installed, where practical. Ground water recovered from given sites by channels or drains can be used to irrigate neighboring areas as a means of reducing total water input into the system. Artificial lakes can possibly be used as reservoirs in a total ground-water management program (see Mineral Resources - Aggregate).

Stream Flooding

General

As discharge of a stream increases, corresponding increases occur in width (caused by stream-bank erosion), depth (resulting from channel scour and rise of water level), and stream velocity. Thus, at any given point on a stream, the velocity increases with increasing discharge. In addition, for most streams the mean velocity increases in the downstream direction. This surprising pattern (Leopold, 1953) occurs because increasing depth and decreasing channel roughness and turbulence more than compensate for decreasing slope downstream.

Where rising water in streams spills over established channels into surrounding lowlands, various categories of flood area are recognized, including flood plain (inundated by larger floods), the floodway (channels that convey fast-moving waters), and floodway fringe (flood plain not in the floodway).

The U. S. Army Corps of Engineers, U. S. Soil Conservation Service, and U. S. Geological Survey delineate areas subject to flooding with a variety of computer models. The programs are used to produce flood maps for a variety of desired frequencies. An intermediate regional flood (also referred to as the 100-year flood) is the flood having a 1 percent probability of occurring in any given year.

In the absence of statistical models, maps showing past flooding are assembled using flood records, high water marks, interviews, newspaper accounts, and aerial and surface photographs. Such data are the basis for the floods of 1861 and 1964 indicated for the study area (see geologic hazards maps). Statistical analysis shows that the 1861 flood is roughly equivalent to the intermediate regional flood and that the 1964 flood is roughly equivalent to the 50-year (2 percent) flood.

For areas in which there is little or no recorded data, flood-prone areas were deduced from topography, landforms, soils, vegetation patterns, and other natural features. Some of the techniques available for reconnaissance or preliminary on-site evaluations are described by Reckendorf (1973). Interpretations are particularly difficult where Quaternary alluvium is transitional into terrace deposits.

Reaches of streams having little or no flood plain are the sites of an additional type of flooding characterized by catastrophic streamflow, erosion, and deposition. For lack of a better term, they are called torrential floods. They are most common in steep-gradient canyons in hard bed rock and impose constraints on road fill and bridge construction (see Stream Erosion and Deposition).

Reaches of streams that pass through valley bottomland and have very low gradients can cause extensive lowland flooding and ponding (see High Ground Water and Ponding).

Causes

Flooding is caused by large increases in discharge or by natural or man-caused modifications of the channel. Review of the Manning Equation of stream discharge provides a systematic basis for reviewing the causes of stream flooding and for qualitatively predicting the impacts of various possible channel modifications:

$$Q = (1.486/n)\ (A)\ (R)^{2/3}\ (S)^{1/2}$$

where "Q" is discharge (cfs), "n" is the channel roughness, "A" is the cross-sectional area of the channel, "R" is the hydraulic radius ("A" divided by the wetted perimeter), and "S" is the slope (gradient) of the stream. Flooding is caused by increasing "Q" or by holding "Q" constant and modifying factors on the right side of the equation to generate compensating increases in depth.

Natural flooding in the study area is caused by heavy orographic rainfall, rapid snowmelt, low infiltration rates, steep slopes, and steep gradients. Most floods on local streams crest shortly after peak precipitation; floods on the Rogue River show greater delay. An additional potential cause of flooding is the impoundment and sudden release of waters behind landslide dams.

Land use can influence local flooding by altering surface-water residence times and infiltration rates. Urbanization greatly increases peak flow and total runoff (Seaborn, 1969; Knott, 1973). In logging areas, road construction decreases regional infiltration and intercepts shallow subsurface flow to produce increases in peak flow (Harr and others, 1975). A variety of modeling procedures are available for predicting runoff in areas of changing land use and should be incorporated into storm-sewer design.

The impact of logging on stream flooding varies with type of tree, soil, and climate but appears to be minimal in most instances. In the Alsea drainage (Harris, 1973) and the H. J. Andrews Experimental Forest (Rothacker, 1970a), no increase of peak flows with logging is noted. Very little investigation of changes of channel geometry and the manner of flood-water conveyance through lowlands outside logged watersheds has been conducted.

A beneficial impact of logging in many areas is increased summer streamflow when the need is greatest. Removal of conifers under ideal conditions of soil thickness and climate reduced summer evapotranspiration by approximately 18 inches in the H. J. Andrews Experimental Forest (Rothacker, 1970a). As a result, summer streamflow after logging increased. In regions like the study area, with drier climate, thinner soils, and less uniform original conifer cover, the beneficial impact of logging is less dramatic. In the Ochoco Mountains, for example, evapotranspiration was reduced by 2 inches, resulting in slightly increased stream flow (Berndt and Swank, 1970).

If discharge "Q" is held constant, flooding may be caused by modifications of the cross-sectional area "A" or slope "S". Thus, artificial fill, other artificial obstructions (roads, bridges, structures), gravel and silt deposits, and natural channel obstructions such as log jams may contribute to flood potential. The Flood Insurance Act of 1968, administered by the U. S. Department of Housing and Urban Development, and Goal 7 of the Land Conservation and Development Commission regulate obstructions in the floodway. Placing of fill in channels is regulated by the U. S. Army Corps of Engineers and the State Land Board.

Slope "S" is influenced by aggradation (see Stream Erosion and Deposition) and channel modifications. If slope is decreased, cross-sectional area (and therefore depth) must be increased accordingly to accommodate a given discharge.

Impacts of channel modifications for the purposes of flood control, aggregate removal, or erosion control depend on specific conditions ot a given site. Thus, channel restrictions in ports of o stream may aggravate flooding, whereas constrictions elsewhere may hove no significant impact on flooding. Like-wise, channel modifications may be justified to minimize flooding or stream-bonk erosion elsewhere (see Minerol Resources – Aggregate).

Distribution

Areas flooded in 1861 and 1964 and areas of potential flooding are indicated on the geologic hazards mops. More accurate flood delineation for ports of the Rogue River is provided by U. S. Army Corps of Engineers (1965). Detailed flood delineation requires detailed topographic mopping and additional doto from interviews, inventorying of high-water marks, and other sources. Profile elevations for various flood frequencies along the main stem of the Rogue and Applegate Rivers ore available from the U. S. Geological Survey but hove not been developed into o detailed flood mop (Harris, 1970).

Stream flooding is restricted primarily to the Quaternary alluvium but also occurs locally on Quater-nary older alluvium (Qoa) where (1) the unit is transitional with Quaternary alluvium, (2) mop scale pre-cluded separate mopping of the Quaternary alluvium, and (3) small streams passing over Quaternary older alluvium overflow their banks. In the latter case, the extent of lowland flooding is not indicated because of paucity of data, absence of mappable terrain factors related to flooding, and the strong influence of cultural development on the extent of flooding.

Greatly decreased infiltrotion rates and modified runoff patterns contribute to ponding hazards in urban areas. Storm sewers must be designed to accommodate these changes and must be suitable for pipe capacities, rainfall distributions and probabilities, projected land use, and projected population.

Table 13 summarizes discharge, gage height, ond frequency of occurrence for floods at selected localities on major drainages. Gage height does not increase consistently with discharge because of channel and drainage variations, such os erosion, deposition, channel relocations, dam construction, ond changing land use, through time. Accordingly, a given discharge at different times may produce different flooding conditions at a given locality. In addition to statistical treatment, flood assessments require judgment based upon local experience and on-site examination.

Impacts

Flooding destroys structures by current action, siltation, and water damage. It inflicts losses on agricultural land by scouring topsoil, eroding stream banks, silting croplands, and killing livestock. It threatens people by isolating dwellings, damaging property, disrupting transportation, and polluting or disrupting water supplies. F lood impacts reviewed here are taken primarily from the Medford Moil Tribune, with the exception of the review of the 1974 flood, which is derived largely from information in the Ashland Doily Tidings.

No meaningful records are readily available to determine the impact of the flood of 1861. The oreal distribution of the flood was determined by the U. S. Army Corps of Engineers (1965) on the basis of surveys and interviews. During the flood of 1890, approximately 50 county bridges were washed out; and many homes around the Medford railroad depot were threatened.

The late February 1927 flood was caused by heavy rains and rapid snow melt. In the Rogue River gorge, houses were swept away, water overtopped the Gold Ray (Ray Gold) bridge, and the east approach to the Gold Hill Highway was inundated with 6 feet of water. In Medford, parts of Riverside, Cottage, and Main Streets were flooded with 2 feet of water. Numerous businesses and basements were flooded, especially in the lower east side of town. The Jackson-Medford Highway was buckled for a distance of 150 yards olong Jackson Creek.

Heavy rains caused the flood of 1955, which inundated 16 houses at Rogue River, 20 houses ot Gold Hill, and numerous houses in the Shady Cove area. The closure of several bridges was necessitated by the flood.

Major impacts of the flood of December 1962 were restricted to the smaller streams of the study area. At Eagle Point, numerous homes along B and C Streets paralleling Little Butte Creek were inundated. Coleman Creek overflowed its banks and flowed down Fourth Street in Phoenix because of a c logged culvert;

Table 13.　Flood discharge and frequency data,
Rogue River, Applegate River, and Bear Creek
(statistical and historic floods)

Stream	Area (miles^2)	Years of record	Discharge (cfs)	Date	Gage	Recurrence frequency (approx.)
Rogue River						
Dodge Bridge	1,215	1938-70	45,000			10
			75,000	12/22/55	12.9	40
			80,000			50
			87,600	12/22/64	12.8	60
			95,000			100
Gold Ray	2,053	1905-70	70,000			10
			110,000	2/21/27	24.8	40
			110,000	12/22/55	23.1	40
			115,000			50
			131,000	12/22/64	23.4	70
			140,000			100
				1890	27.5	
				1861	32.0	
Applegate River						
Copper	223	1938-70	20,300	12/21/55	23.5	*
			29,000	12/22/64	26.0	
Applegate	483	1938-70	25,000			10
			45,700	12/22/64	19.6	40
			47,600	12/21/55	18.0	45
				1927	18.7	
			50,000			50
			70,000			100
Bear Creek						
Medford	289	1915-70	8,300	2/20/27	11.4	*
			9,400	12/22/55	7.5	
			14,500	12/ 2/62	8.0	
			12,300	12/22/64	8.7	

*　Frequency analyses not available

Note:　Figures are not adjusted to consider dams completed since 1970.

at Central Point, water flowed over Hopkins Road. In Medford, Central and Riverside Avenues and the Medford Shopping Center were partly flooded.

The flood of 1964 was caused by 9 inches of rain in 5 days at lower elevations and by rapid melting of deep snow packs at higher elevations in the Cascades. Discharge at Prospect was 150 percent of that of a 50-year flood (Waanenan and others, 1971). Turbidity at Grants Pass was 5,000 ppm. More than 200 homes, cabins, and trailers were washed away at Shady Cove (Figure 17) and at Trail. Residences were flooded along the Applegate River, and the Brownsboro tavern (Figure 18) was flooded with 3 feet of water. River levels at Gold Ray (Ray Gold) were 12 feet above flood stage (Figure 19). Low-lying areas in Ashland, Medford (Figure 20), and along the Rogue River (Figures 21, 22) were flooded.

The flood of 1974 was caused by heavy rains and rapid snow melt in the western Klamath Mountains. The major impact was at Ashland, where torrential streamflows washed out the main water-supply pipeline and disrupted the community water supply for 6 days. Parts of Lithia Park, Bluebird Park, the Ashland Plaza, and a trailer court located at the intersection of Jackson Road and Highway 99 were flooded. Road washouts and slides were widespread in the uplands (see Stream Erosion). Along the Applegate River, residences on lower terraces were flooded, bridges were washed out, and stream banks were eroded.

Recommendations

It is estimated that if all physically practical storage sites in the Rogue River drainage were developed, then flood damage of the adjusted discharge of historic floods since 1890 would be negligible (Water Resources Board, 1959). This projection, however, which assumes optimum reservoir operation and ideal weather forecasting, ignores unfavorable cost-benefit ratios. More local flood management with emphasis on land use regulation is required.

Bank overflow along smaller streams can be minimized by properly maintaining channels, redesigning critical reaches, constructing levees, and adequately providing for the passage of flood water in all developments, especially raised roads. Subdivision and building regulations should address flood distributions, flood-proofing techniques, preservation of drainageways, accommodation of modified runoff, and floor elevations.

Assistance in developing flood-plain management plans is provided by the Oregon Water Resources Department, and broad policies are formulated by the Land Conservation and Development Commission. The U. S. Soil Conservation Service administers the Watershed Protection and Flood Protection Act of 1954 and provides technical assistance for channel protection and other flood-related projects.

Declaration of a flooded area as a disaster area by the governor allows the release of funds for the restoration of public facilities, riverbank repair, and low interest loans to individuals and small businesses. Assistance of this type is coordinated by the Office of Emergency Preparedness, the State Emergency Service Center, and local officials.

Emergency preparedness includes flood forecasting and flood warnings by the National Weather Service River Forecast Center in Portland. Flood fighting by local personnel is commonly supplemented by the U. S. Army Corps of Engineers and coordinated by the State Emergency Operations Center. The Flood Insurance Act of 1968, administered by the U. S. Department of Housing and Urban Development with the assistance of the Oregon Water Resources Department, provides flood insurance to individuals and businesses in regulated developments.

Stream Erosion and Deposition

General

Much planning and designing of channel modifications emphasizes the water aspects of the total stream system. Equally important, but often neglected, are sediment load and a variety of transient stream parameters including width, depth, channel roughness, and channel layout. Changes in any one of these factors leads to changes in one or more of the others.

Larger particles in stream beds, including boulders, pebbles, and coarse sand grains which are moved by rolling, sliding, and bouncing, constitute the bed load of the stream. The capacity of a stream

Figure 17. *Rogue River at Shady Cove during 1964 flood (Photo courtesy Medford Mail Tribune).*

Figure 18. *Brownsboro after 1964 flood (Photo courtesy Medford Mail Tribune).*

Figure 19. Gold Ray (Ray Gold) bridge during 1964 flood (Photo courtesy Medford Mail Tribune).

Figure 20. Bear Creek in Medford during 1964 flood (Photo courtesy Medford Mail Tribune).

Figure 21.   Alder Park Estates downstream from Gold Ray (Ray Gold) along the Rogue River during 1964 flood (Photo courtesy Medford Mail Tribune).

Figure 22.   Rogue River near the community of Rogue River during 1964 flood (Photo courtesy Medford Mail Tribune).

to transport bed load is determined by the geometry of the channel, the volume of the discharge, and velocity. Smaller particles, including fine sand, silt, and clay, are generally transported in suspension. The volume of suspended load is controlled primarily by runoff and slope erosion. This aspect of sediment transport is particularly significant in terms of water-quality management. Medium-grained sand can be carried in suspension under extreme conditions of velocity and turbulence.

Distribution

Torrential-flood channels: Torrential-flood channels are most prevalent in the steeply sloping, mountainous terrain of the eastern Klamath Mountains province, where slopes are characteristically steep and infiltration rates are low (see geologic hazards maps). Areas of recent torrential flooding are easily recognized on the basis of scoured, unvegetated creek bottoms and coarse, poorly sorted stream-bed deposits. Where vegetation has reclaimed the channel, recognition is based upon indirect features including steep side slopes, steep gradients, impermeable bed rock, narrow stream channels, and the absence of a flood plain. Torrential-flood channels pass downstream into topographically more mature channels with flood plains.

Because torrential-flood channels are generally cut in bed rock, they are unable to adjust to rapid changes in discharge by channel modification. Instead, depth and velocity increase sharply during times of high flow. Consequently, torrential floods are highly erosive and commonly destroy artificial obstructions in the channel such as bridge abutments and road fill. Where torrential-flood channels spill into flat terrain, rubble and debris fans may quickly bury roads or clog culverts.

Concentrations of suspended sediment during torrential floods are commonly high. Although torrential-stream channels may transport flowing mud and debris rather than water under extreme conditions of slope erosion and rainfall (Beverage and Culbertson, 1969), no mudflow deposits were observed in Quaternary alluvial-fan deposits in this reconnaissance investigation.

Lowland-flood channels: Gentler gradients, broader valleys, and the greater capacity to modify channel geometry in response to rapidly fluctuating discharge are characteristics which distinguish flood-plain stream channels from torrential-flood channels. Short-term variations in depth and velocity are less extreme in these channels; but long-term changes in width, depth, and layout are more variable in response to slope, discharge, and bed load. The processes which cause stream meandering (flow along a curved sinuous channel) and stream braiding (flow along several channels) in flood plains are subjects of considerable research but are still not completely understood.

Erosion in flood plains is restricted primarily to the channels, the outer bends of meanders, and cutoff channels which develop during times of flooding. Stream deposition includes the deposition of silt and clay from relatively slow-moving overbank flood waters, as well as the formation of bars in channels (Figure 23), on the inner bends of meanders, and behind obstructions such as snags. Stream erosion and stream deposition operate in harmony to modify the stream channel. Sediment supplied by stream-bank erosion is deposited as bars farther downstream which, in turn, redirect streamflow against riverbanks to cause additional stream-bank erosion.

Stream reaches with the most noticeable channel changes in recent years in the study area are the Rogue River in the Dodge bridge area, the Rogue River near Bybee bridge, and the Applegate River downstream from Applegate. Flood plains in these areas are characterized by broad valleys of Quaternary alluvium, reductions in gradient compared to reaches immediately upstream, numerous meander scars, and historic channel changes as shown in aerial photographs. Areas of critical local concern in the study area include parts of Bear Creek and other streams as indicated on the geologic hazards maps.

Deterministic projections of future trends of meander development in the study area are not possible. Much remains to be learned about the development of meanders in general, and data on the study area is limited. Instead, assessments of future channel changes must involve a short time frame and must be based on our limited knowledge of past channel changes.

Figure 23. Stream-bank erosion on left with characteristic bar formation on right.

Five consistent patterns of channel change ore identified for the Rogue and Applegate Rivers in the study area:

1. Areas of greatest potential for channel migration ore characterized by historic channel changes, Quaternary alluvium, and active stream-bonk erosion or meander scars.
2. Highly sinuous reaches of rivers ore the most likely sites for the development of cutoffs during lorge floods.
3. The development of a major cutoff during o given flood is usually preceded by the development of a floodwoy channel during preceding floods.
4. Stream channels downstream from newly developed cutoffs ore subject to increased stream-bonk erosion and accelerated meandering.
5. Straight reaches and gently curving reaches of streams ore generally sites of progressive meandering along unstable ports of the Rogue and Applegate Rivers.

Recommendations

Rood fills along torrential-stream channels should be discouraged, cribbed, or adequately sized to resist erosion in critical areas (Figures 24, 25, and 26). Channel crossings in side hills should include adequately designed and maintained culverts or bridging. Proper land management con greatly reduce the magnitude of slope erosion and con minimize the potential for hazardous deposition. Where residential construction is anticipated, controls should be placed on development near torrential-flood channels and bridge abutments. Channel crossings should be designed to ovoid impeding streamflow.

Major erosional and depositional processes along lowland streams ore floodwoy erosion, meander development, and bar formation (Figures 27, 28, and 29). Floodwoys which convey flood waters across meander loops ore potential sites of erosion and channel changes during lorge floods. Excavations in these areas modify streamflow and increase the potential for erosion. Grovel operations in them must be protected by berms which ore high enough to redirect flood waters and capable of withstanding erosion. Otherwise, the pits may be reclaimed by the river channel.

Figure 24.   Stream-bank erosion caused by 1964 flood (Photo courtesy _Medford_ _Mail_ _Tribune_).

Figure 25.   Road washed out by 1964 flood (Photo courtesy _Medford_ _Mail_ _Tribune_).

Figure 26.   Mountain road washed out by 1964 flood; large culverts were not adequate in terms of potential stream flow (Photo courtesy Medford Mail Tribune).

Figure 27.   Damage caused by 1964 flood to north approach of Bybee bridge (Photo courtesy Medford Mail Tribune).

Figure 28.   Damage to residence along Butte Creek in Lake Creek district during 1964 flood (Photo courtesy *Medford* *Mail* *Tribune*).

Figure 29.   Erosion and deposition caused by 1964 flood in Lake Creek district (Photo courtesy *Medford* *Mail* *Tribune*).

Stream-bank erosion along meanders must be considered in development. Mitigation includes place-ment of riprap, avoidance of the area, or innovative channel maintenance. Removal of gravel from river-wash bars on inner bends of meanders is a means of reducing rates of channel migration and should be considered in formulating gravel-resource policies.

In assessing stream-bank erosion, channel changes upstream must be considered. Generally, when channels have been straightened upstream by truncation of meanders, rates of stream-bank erosion down-stream are accelerated and specific locations are modified.

Gravel bars develop in channels, on the inner bends of meanders, at the mouths of some streams, and near snags or log jams. In areas of unstable channels, the seasonal removal of gravel as it accumulates can be an effective means of reducing stream-bank erosion in the immediate area. Berms constructed around the site for water-quality purposes should be designed to avoid channel obstruction during flooding.

Channel problems arising from structural flood-control measures can be minimized by innovative design. For example, composite channels can be constructed by placing levees away from the stream channel while the natural channel is left untouched. The composite channel is then able to accommodate a range of discharges including low flows in the natural channel and flood flows within the banks of the levee. The hazard of greatly increased deposition which plagues many redesigned channels during low flow is eliminated or greatly reduced.

Erosion along straightened channels can be reduced by the construction of numerous small dams which incrementally lower the grade of the stream. When natural armoring of a channel is disturbed, it must generally be restored or replaced to avoid erosion. Levee designs must include a consideration of increased erosion potential where the channel is constricted.

Earthquakes

General

The shaking of the earth's surface which accompanies the release of energy along an active fault is called an earthquake. The specific location of the displacement within the earth is called the focus; the geographic location above the focus on the earth's surface is called the epicenter. The crustal struc-ture and tectonic behavior of Oregon is very complex, and the historic record is short. Knowledge of future earthquake activity is understandably incomplete.

Intensity and magnitude are measures of the energy released by an earthquake. On the modified Mercalli intensity scale, observations of the effects of the quake on the earth's surface serve as indicators of its relative severity. Determinations made in this way are subject to inaccuracies because of the dis-tance from the epicenter, the nature of the underlying rocks and regolith, and the subjectivity of the viewer. The Mercalli scale is imprecise, for these reasons, if limited observations are available. It is widely used, however, because it is universally applicable and requires no equipment. Reliance on numerous observations eliminates inconsistent and inaccurate data.

The Richter scale is based on records from seismometers rooted in bed rock. It gives a more direct measure of energy released in an earthquake and is less subject to errors arising from local variations in geology. Instead of indicating intensity with Roman numerals as on the Mercalli scale (I–XII), the Richter scale indicates magnitude with decimal numbers (see Table 14). Each digit represents a 10-fold increase in the amplitude of the seismic waves and an approximate 31-fold increase in the actual amount of energy released by the earthquake. Thus, an earthquake of magnitude 5.5 is 31 times greater than an earthquake of 4.5. The scale ranges from less than 1 for small quakes to slightly less than 9 for the largest quakes.

To convert observations stated as intensity on the Mercalli scale to magnitude on the Richter scale, several equations based on observations from around the world or various parts of the world are available. General equivalence is indicated in Table 14.

Earthquake potential

The potential for future earthquakes in a given area such as the study area can be assessed on the basis of the historic seismic record, calculations based on the dimensions of active faults on the surface,

Table 14. Scale of earthquake intensities and magnitudes

Mercalli Intensity	Description of effects	Equiv. Richter magnitude
I	Not felt except by a very few under especially favorable circumstances.	
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.	3.5
		to
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.	4.2
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building; standing motor cars rock noticeably.	4.3
		to
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. A few instances of cracked plaster; unstable objects overturned. Some disturbance of trees, poles, and other tall objects noticed. Pendulum clocks may stop.	4.8
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.	4.9-5.4
VII	Everyone runs outdoors. Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.	5.5-6.1
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.	6.2
		to
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	6.9
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.	7.0-7.3
XI	Few if any (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.	7.4-8.1
XII	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.	Max. recorded 8.9

* Adapted from Holmes (1965) and U.S. Geological Survey (1974)

and calculations based on knowledge of rock strength. For the study area, no information is available on rock strength; and no active faults are exposed at the surface (see Structure). Accordingly, estimates of future seismicity are based almost entirely on the historic record, which is very short (Table 15) and possibly misleading.

Impacts

The greatest historic earthquakes in the study area were Mercalli intensity IV. Future quakes of at least this intensity can be expected. In addition, larger quakes can also be expected in view of the short duration of the historic record. The Uniform Building Code indicates a potential for quakes of Mercalli intensity V or VI for the study area.

Evernden and others (1973) show that, in the historic record, maximum intensities are generally limited to areas of firm or unstable ground as opposed to areas of solid bed rock. Accordingly, intensities as high as VI in the study area can be expected to be restricted to areas of poor ground conditions such as thick saturated alluvium (Qal, in part) or slide-prone terrain. In earthquakes of Mercalli intensity VI, damage to wood-frame structures is 0.2 percent of total structure cost. Damage ratios of nonwood frame structures is 1 percent of total structure cost (Page and others, 1975).

On the basis of limited data and without the aid of detailed local analyses, Algermissen and Perkins (1976) show that quake-induced rock accelerations in the study area will be less than 4 percent of the acceleration of gravity for any given 50-year interval. This estimate does not address the issue of maximum probable earthquakes, and it is based on too limited data in the lower magnitude ranges. It does, however, provide a reasonable estimate of the accelerations to be expected from most earthquakes.

Recommendations

Adoption of the relevant provisions of the Uniform Building Code is recommended. These include sections 2313 (wall anchorage), 2314 (general design and construction of structures), 3704 (anchorage of chimneys), and 1807k (anchorage of mechanical and electrical equipment in high-rise structures). Future revisions may include reassessment of seismic potential based upon more nearly complete data and refinement of building and design specifications based upon more nearly complete assessment and evaluation of ground conditions. Presently, the Uniform Building Code does not address ground response or resonance phenomena between structures and the regolith upon which they are built.

Table 15. Earthquakes felt in Jackson County, Oregon

Date	Location	Mercalli intensity	Comments
1873 Nov. 22	Off northern California coast	–	Chimney damage at Jacksonville
1891 Nov. 9	Ashland	IV	A light shock
1906 Apr. 3	Ashland	IV	
1906 Apr. 13	Ashland	–	
1906 Apr. 23	Ferndale, California	VII (est.)	Felt with intensity VI at Grants Pass where furniture moved and windows cracked
1913 Mar. 15	Medford	III	
1931 Aug. 17	Talent	V	Lamp shaken from ceiling, man thrown from chair; felt at Phoenix and Ashland
1931 Sept. 4	Central Point	II	A slight tremor
1941 July 7	Medford	II	Felt by fire lookouts
1949 Apr. 3	Grants Pass	III	

Information from Couch and Baker (1958)
Byerly (1952)
Eppley (1965)

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GLOSSARY

This is a listing of geologic terms that are not specifically defined in the appropriate parts of the text.

agglomerate – an assemblage of coarse, angular material (usually volcanic) that is bound or fused together.

alluvium – unconsolidated clay, silt, sand, or gravel deposited by a stream or other body of running water during relatively recent geologic time.

andesite – a dark-colored, fine-grained extrusive igneous rock with a chemical composition that is intermediate between basalt and granite. The name "andesite" is derived from the Andes Mountains in South America. Andesite contains such minerals as plagioclase feldspar, biotite, hornblende, pyroxene, and quartz.

aquifer – a body of rock that conducts enough ground water to yield economically significant quantities of ground water to wells and springs.

argillite – a rock derived from siltstone, claystone, or shale that has undergone a higher degree of hardening than those rocks.

basalt – dark- to medium-dark igneous rock that is rich in iron and magnesium. This rock, which is generally extrusive, contains calcic plagioclase and clinopyroxene in a fine-grained groundmass and may contain olivine and hypersthene. Apatite and magnetite are common accessory minerals.

base level – the level below which a stream cannot erode its bed.

base-slope colluvium – colluvium found at the base of slopes.

bedrock geologic unit – solid rock that underlies soil or unconsolidated, superficial material.

braiding – the process of successive branching and rejoining of stream channels, producing islands and bars that split the channel into a network of smaller interconnected channels.

breccia – (sedimentary) coarse-grained clastic rock composed of large, angular, broken rock fragments that are cemented together; (volcanic) rock consisting of large, angular blocks indicative of violent eruption or flowage while cooling.

carbonaceous – rock or sediment that contains organic matter.

carbonate – a sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates (CO_3) of calcium, magnesium, or iron.

chert – an extremely dense and hard rock made of cryptocrystalline quartz (silica).

clast – an individual particle in a sedimentary deposit; a pebble in conglomerate, for example.

clay – very fine-grained granular material or clay minerals; specific grain size varies with system of classification. See Table 6.

cohesion – the property of similar mineral grains that enables them to stick together; the soil quality of sticking together.

colloid – fine-grained material (smaller than the size of clay) in suspension; any such material that can be easily suspended in liquid.

colluvium – earth material transported by mass movement rather than by running water.

cryptocrystalline – texture of a rock having crystals that are too small to be seen with a microscope.

cutbank stability – capacity to stand in cut slopes without sliding.

dacite – a fine-grained extrusive rock with the same general composition as andesite but with less calcic feldspar.

delta – the low, nearly flat, alluvial tract of land deposited at or near the mouth of a river, forming a triangular or fan-shaped plain of considerable area crossed by many distributaries of the main river. Most deltas are partly under water and partly above the water level.

deltaic – pertaining to or characterized by a delta.

dendritic – characterized by a branching pattern.

dike – a tabular intrusive body of igneous rock that cuts across other bedrock structures.

drawdown – the lowering of the water table caused by pumping.

duripan – a horizon in soil that is characterized by silica cementation.

ephemeral stream – a stream that flows only after precipitation has occurred in the immediate area or upstream and whose channel is always above the water table.

epicenter – geographic locality on the earth's surface above the focus of an earthquake.

equigranular – a rock texture characterized by crystals of the same (or nearly the same) size.

expandable soil – soil which expands when wet and contracts when dry because it contains clay whose crystal lattice is expandable according to the amount of water it takes on. This soil is often characterized by a "popcorn" surface.

fabric – the sum of all the structural and textural features of a rock.

feldspar – an abundant rock-forming silicate mineral of the general formula: $MAl\,(Al,Si)_3O_8$, where $M = K$, Na, Ca, Ba, Rb, Sr, and Fe. Feldspars are generally light colored and are the most widespread of any mineral.

fluvial – pertaining to a river or rivers.

foliate – having a planar arrangement of mineral grains or other textural features; of significance in interpreting metamorphism.

geologic hazard – a geologic process that threatens the safety, welfare, or activities of man.

grit – coarse-grained sandstone composed of angular particles.

ground water – water in the zone of saturation beneath the earth's surface; applies to soil water or to water in bed rock, depending on local conditions.

hornblende – the most common member of the amphibole group of minerals; contains varying amounts of Ca, Na, Mg, Fe, Al, Ti, Si, O, and water. It is black, dark green, or brown in color and is found in both igneous and metamorphic rocks.

igneous – rock solidified from molten or partially molten material or magma.

infiltration rate – rate at which ground can absorb rain or melting snow under specified conditions.

interbed – a bed, typically thin, of one kind of rock material occurring between or alternating with beds of another kind.

intrusion – the process of emplacement of molten rock in pre-existing rock; the rock mass so formed within the surrounding rock.

joint – fracture in rock along which little or no movement has occurred.

landform – any physical form or feature of the earth's surface having a characteristic shape and formed by natural processes.

laterite – highly weathered, red subsoil, rich in oxides of iron and aluminum and deficient in primary silicates.

leachate – a solution obtained by leaching.

leaching – the removal of soluble constituents from soil, rocks, or orebodies by the natural action of percolating water.

liquid limit – water content beyond which soil behaves as a liquid.

lithology – the physical character of a rock.

loam – a rich, permeable soil composed of relatively equal proportions of clay, silt, and sand particles, and usually containing organic matter (humus).

mass movement – downslope movement of soil or rock in response to gravity.

massive – a term used to describe sedimentary rock with very thick beds or with bedding that is obscured.

matrix – the fine-grained material filling the spaces between larger grains or particles in a sedimentary or igneous rock.

meander – one of a series of somewhat regular and sinuous curves, bends, turns, or windings in the course of a stream.

metamorphism – mineralogic and structural adjustment of rock to conditions of temperature and pressure more extreme than those in the zone of weathering and different from conditions under which the rock was formed.

orographic – the precipitation that occurs when moisture-laden air encounters a high barrier such as a mountain and is forced to rise over it.

pan – a hard, cement-like layer, crust, or horizon within or just beneath the surface soil, usually impeding the movement of water and air and the growth of plant roots.

patterned ground - ground whose surface is covered with a regular pattern of polygonal to rounded mounds that are bounded by lower channels laden with residual boulders and gravel.

perched water table - the upper surface of a zone of saturation in the ground, situated above the regional water table and separated by impermeable rock or soil.

permeability - a measure of the ease of fluid flow through rock or soil. The coefficient of permeability is the rate of flow (gallons per day) through a square foot of cross section under a hydraulic gradient of 100 percent at 60°F.

petrography - the description and systematic classification of rocks.

phenocryst - relatively large and conspicuous crystal in a finer grained igneous rock.

planar - lying in a plane or in planes; usually implying more or less parallel planes.

platy - a structure caused by contraction of igneous rocks while cooling, occurring as a series of fractures parallel to the cooling surface. Igneous rocks with platy structure appear to be cracked into plates or tabular sheets, which may give the rock a stratified appearance, especially after much weathering has occurred.

pluton - a body of igneous rock that has formed beneath the surface of the earth by consolidation from magma.

porosity - the ratio, expressed as a percentage of the volume of pore space in a rock or soil to the total volume of the rock or soil; a measure of the water-holding capacity of rock or soil.

porphyritic - texture of an igneous rock in which large crystals (phenocrysts) occur in a finer grained groundmass.

pyroclastic - clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic vent.

pyroxene - a group of dark, rock-forming silicate minerals with the general formula: $ABSi_2O_6$, where A - Ca, Na, Mg, or Fe^{+2}, and B = Mg, Fe^{+3}, or Al.

regolith - zone of weathered rock and soil above bed rock.

rhyolite - extrusive igneous rock, generally porphyritic, with flow texture and phenocrysts of quartz and alkali feldspar.

rockfall - the free falling or sudden movement of a detached segment of bed rock of any size from a cliff or other steep slope; the fastest moving landslide. See Table 11.

sand - granular material of sand size; specific grain size varies with system of classification. See Table 6.

schist - strongly foliate crystalline rock formed from metamorphism under conditions of differential stress.

schistosity - strong foliation resulting from parallel planar orientation of mineral grains.

seismicity - the relative degree of earthquake activity of a given area.

shale - a fine-grained sedimentary rock formed by the consolidation of clay, silt, or mud, and characterized by thin layers and the tendency to break parallel to the bedding planes.

shear plane - surface of sliding in many forms of mass movement.

sill - a tabular igneous intrusion that parallels the planar structure of the surrounding rock.

silt - granular material of silt size; specific grain size varies with system of classification. See Table 6.

slope erosion - removal of soil from a slope by sheet wash, rill wash, or gullying.

soil - as used here, refers to unconsolidated mineral matter formed in place by weathering and character-
       ized by various soil horizons.

soil horizon - a layer of soil distinct from other layers on the basis of physical properties and chemical
       composition.

soil profile - a vertical section of a soil that displays all its horizons and its parent material.

specific capacity - a measure of the potential of a well to deliver water; incorporates a consideration of
       both production and drawdown.

stock - an igneous intrusion that is less than 40 sq mi in surface exposure.

structure - the spatial arrangement and deformation of rock units in a given area; includes consideration
       of faulting and folding.

surficial geologic unit - as used here, refers to a mappable body of unconsolidated earth material formed
       by depositional processes and forming a relatively thin layer over bedrock units.

talus - rock fragments of any size or shape (usually coarse and angular) derived from and lying at the
       base of a cliff or a very steep, rocky slope. Also the accumulated heap or mass of such loose
       broken rock.

terrace - an elevated, relatively flat erosional and depositional surface, generally above the level of
       on-going depositional processes.

topographic - representing the topography of a region.

topography - general configuration of land surface or any part of the earth's surface, including its relief
       and position of natural and man-made features.

torrential flood - flood characterized by rapidly moving water in a channel with no flood plain, as in a
       mountain ravine.

tuff - rock composed primarily of small, explosively erupted volcanic particles.
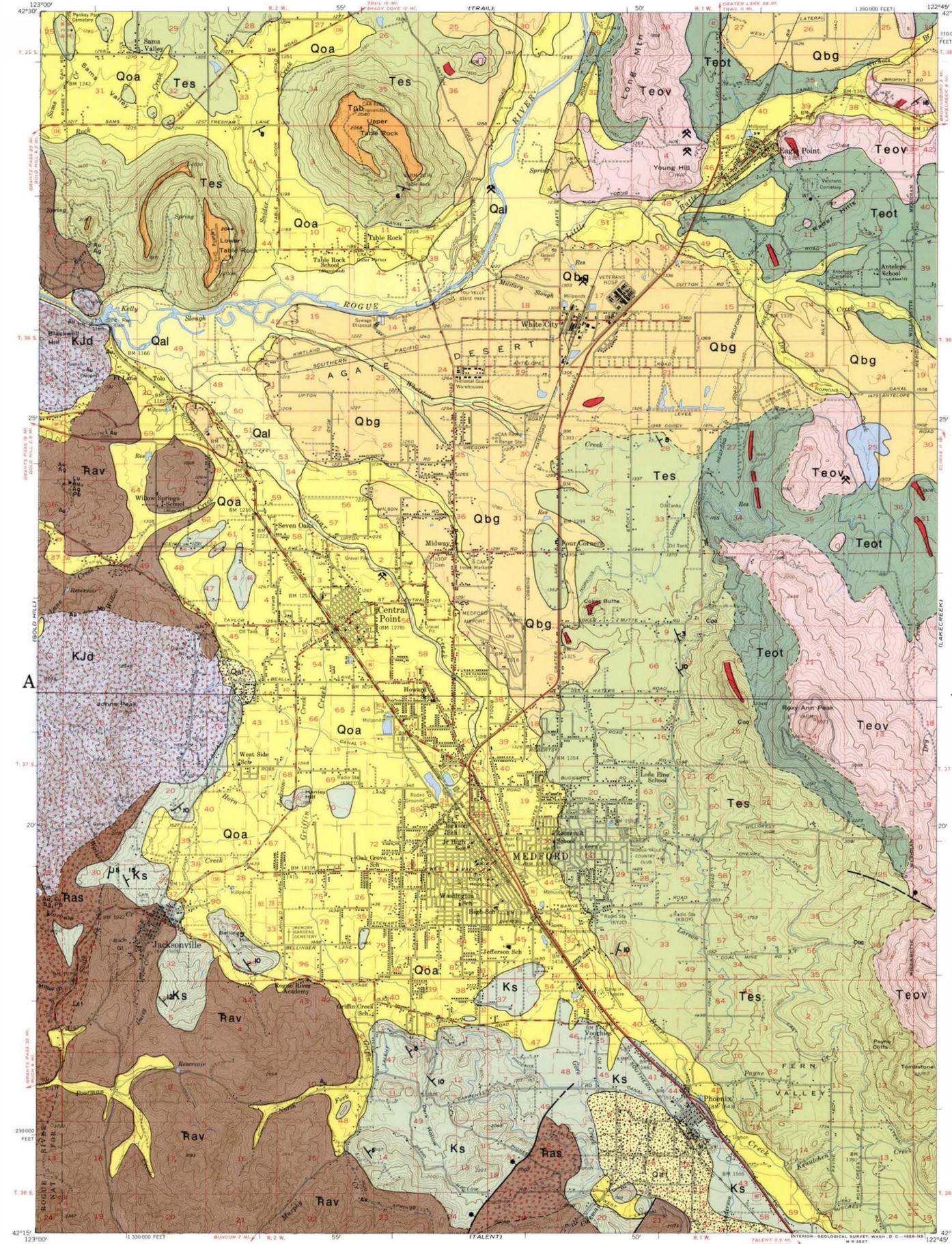
unconsolidated - a loosely arranged, uncemented sediment that generally can be disaggregated by hand.

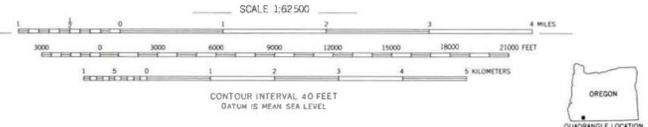water table - the upper limit or surface of the ground water.

weathering - the destructive processes whereby earthy and rocky materials, upon exposure to atmospheric
       agents at or near the earth's surface, are changed in character (color, texture, composition, firm-
       ness, or form), with little or no transport of the loosened or altered material.

GEOLOGIC MAP
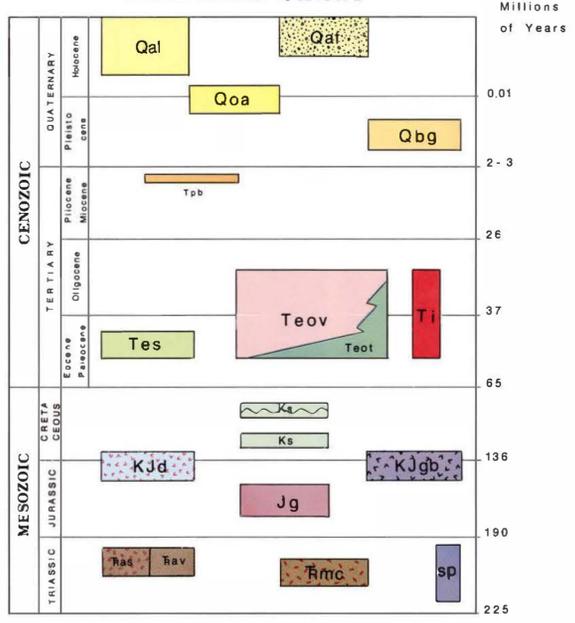## of the
MEDFORD QUADRANGLE
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

TIME ROCK CHART

Millions of Years

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation)

SURFICIAL GEOLOGIC UNITS

Stream deposits

Qal — Quaternary alluvium: Unconsolidated gravel, sand, silt, and clay in stream beds and flood plains of major streams; equivalent to part of Qaf of Wells and others (1956); not shown where smaller streams owing to limitations of scale; subject to stream flooding; immature soils.

Qaf — Quaternary alluvial fan deposits: Unconsolidated gravel, sand, and silt occurring as fan deposits adjacent to Qoa at the mouths of some torrential flood channels; subject locally to torrential flooding, bank overflow, erosion, and deposition.

Qoa — Quaternary older alluvium: Unconsolidated gravel, sand, silt, and clay on terraces generally above flood plains of major streams; also alluvial terraces of upland streams; equivalent in part to Qof of Wells and others (1956); includes several intermediate terrace levels of varying ages; subject to local flooding, ponding and high ground water; restrictive soil layers.

Qbg — Quaternary bench gravels: Semi-consolidated gravel, sand, clay, and silt forming high level terrace in Bear Creek Valley and along Rogue River; upper horizons rich in clay; includes Qbg of Wells and others (1956); generally characterized by distinctive "patterned" ground of low interconnected rocky channels; restrictive soil layers; subject to poor drainage, ponding, and high ground water.

BEDROCK GEOLOGIC UNITS

Volcanic and sedimentary rocks

Tpb — Pliocene basalt: Equivalent to pre-Mazama basalt of Wells and others (1956); grayish-black, dense, fresh basalt; several flows with total thickness of 125 feet; caps Upper and Lower Table Rocks; vertical columnar joints and irregular joints; interpreted as intercanyon flow rock of ancient Rogue River valley now preserved as inverted topography.

Teov — Eocene and Oligocene volcanic rock: Equivalent to Roxy Formation of Wells and others (1956) and agglomerate and older basalt (flows of Wilkinson and others (1941); andesitic flows, breccias, agglomerates, and tuffs with interbedded sandstone and shale; rhyolitic and dacitic flows locally; flow thickness 10-100 feet; flow rocks hard and stable; tuffs and sedimentary rock slide-prone in places; Oligocene leaf prints; similar rocks interbedded with Tes near Emigrant Creek Reservoir; soils highly variable.

Teot — Eocene and Oligocene tuffaceous rocks: Equivalent to part of Tc of Wells and others (1956); varicolored tuffs and sedimentary rocks derived from volcanic rocks, minor interbedded flow rock; soft to moderately hard; low infiltration rates; slide-prone over large areas; possibly not correlative with type Tc south of map area; similar rocks interbedded with Tes near Emigrant Creek Reservoir; clay-rich soils.

Tes — Eocene sedimentary rock: Equivalent to part of Tu of Wells and others (1956) and to Teu of Wilkinson and others (1941); river-deposited hard sandstone, shale, and conglomerate with local coal seams in south; shallow marine sandstone and siltstone in north; tuffaceous debris throughout; regolith variable; distinctly bedded; slides rare; low infiltration rates; volcanic rock interbeds and late Eocene leaves in south; impermeable soil horizons on terrace forms.

Ks — Cretaceous sedimentary rock: Equivalent to Kh and part of Tu of Wells and others (1956); hard conglomerate and sandstone overlain by mudstone and minor sandstone near Ashland; sandstone at Graves Creek; depth of weathering variable with slope and rock type; moderate ground-water potential locally; Early Cretaceous (Albian) at Graves Creek; middle Cretaceous (Cenomanian and Turonian) near Ashland.

Jg — Galice Formation: Dark gray to black shale with minor thin bedded sandstone and granule conglomerate; moderate to high foundation strength; low groundwater potential; silty clay loam soils of variable thickness; thick base slope colluvium; hazards include slope erosion and local mass movement.

Metamorphic rocks

Rav / Ras — Applegate Formation: Rav — Equivalent to metavolcanics of Wells and others (1940); altered lava flows, flow breccia, and pyroclastic rocks with minor tuffaceous sedimentary rocks; grades into Rmeschist; steep terrain, very low permeability; thin soil with exception of base slope colluvium; mineralization in places near intrusive rock Ras — Equivalent to metasedimentary rocks of Wells and others (1940); altered tuffaceous sedimentary rock, argillite, chert, and limestone; minor volcanic rocks locally; variable engineering properties; thick regolith and high slide potential where deeply weathered.

Rmc — May Creek Schist: Medium grade metamorphic rocks derived from Rav, Ras and possibly Jg; includes mafic metavolcanic rock, mica schist, phyllite, and slate; weakly to strongly foliated; hard, impermeable, thin regolith with exception of thick base slope colluvium; potential for steep slope failure; product of multiple metamorphism culminating in proximate granitic plutonism (Kays, 1970).

Intrusive rocks

KJd — Diorite and granodiorite: Light gray medium-grained intrusive rock of intermediate composition; sandy and silty loam soils of variable thickness; thick regolith in places; very high erosion potential and steep-slope failure potential; moderate ground-water potential in moderately to gently sloping valley areas; excellent quarry rock where fresh.

KJgb — Gabbro: Gray-green, coarse-grained intrusive rock consisting of augite and plagioclase; deeply weathered with brown to rusty red soil; moderately high erosion potential; low ground-water potential; geologic relation to diorite unclear.

sp — Serpentinite: Rocks consisting of minerals of the serpentine group and locally including olivine and pyroxene; complex Triassic origin and remobilized along later faults to present positions; brownish to reddish loam and clay soils; scant vegetation; slide prone.

Ti — Tertiary intrusive rock: Sills, stocks, and dikes of diorite, gabbro and basalt north and east of Bear Creek, and basaltic dikes east of the mapped area; quarry rock potential variable; depth of weathering variable.
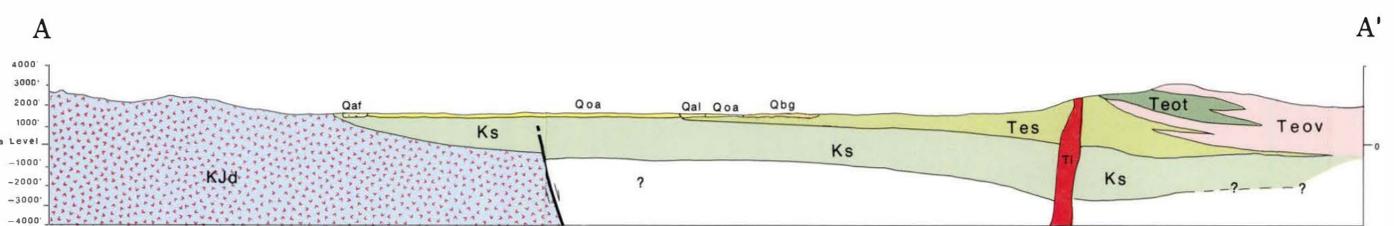
Mineral Mines and Prospects

Ag	Silver	Hg	Mercury	Mo	Molybdenum
Au	Gold	Mg	Magnesium	Pb	Lead
Cu	Copper	Mn	Manganese	W	Tungsten
				Zn	Zinc

GEOLOGIC SYMBOLS

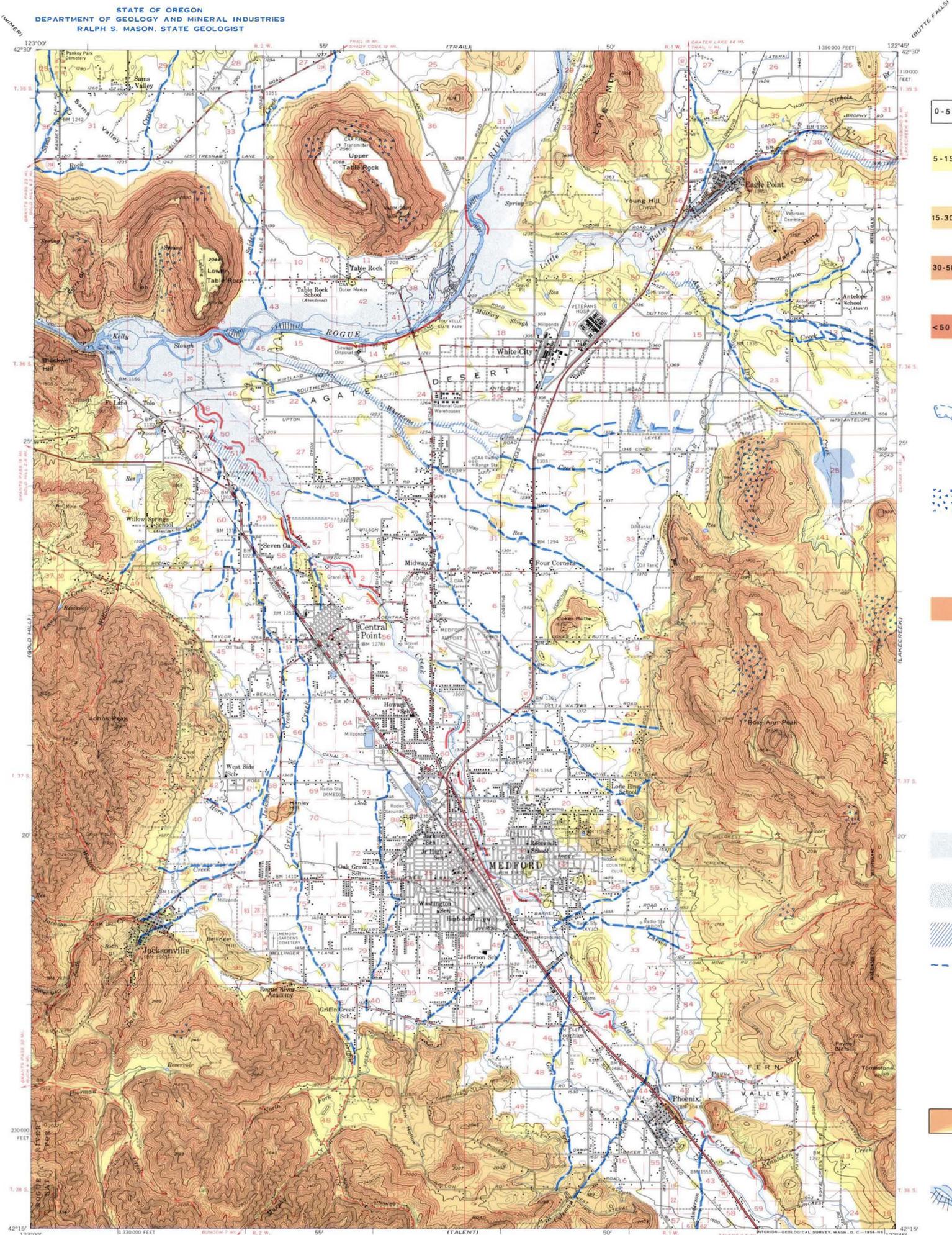**Contacts**
Definite contact
Approximate contact

Faults
Definite fault
Approximate fault
Inferred fault
Concealed fault
Normal fault (ball and bar on downthrown side)

Folds
Definite anticline
Definite syncline
Approximate anticline
Approximate syncline
Inferred anticline
Inferred syncline
Concealed anticline
Concealed syncline

Bedding
Strike and dip of bed
Strike of vertical bed
Horizontal bed

Spring

Geologic Cross Sections

A — A'

Base Map from USGS 15' series (Topographic)
Control by USGS and USC&GS

Topography from aerial photography by multiplex methods
Revised by planetable surveys 1954. Aerial photographs taken 1951

Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon coordinate system, south zone
Red tint indicates areas in which only landmark buildings are shown
Dashed land lines indicate approximate locations

SCALE 1:62500

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
Heavy-duty   Light-duty
Medium-duty   Unimproved dirt
U.S. Route   State Route

QUADRANGLE LOCATION

OREGON

GEOLOGIC HAZARD MAP
of the
MEDFORD QUADRANGLE
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation.)

Average (Regional) Slope

Interpreted from maps with scale 1:62,500

0 - 5 % Local slopes 0-10%; landforms include flood plains, terraces, pediments and ridge crests; hazards include ponding, high ground water, flooding, and stream bank erosion; land-use potential good in areas of minimal hazard.

5 - 15 % Local slopes 0-50%; landforms include gentle slopes and ridge crests surrounding larger valleys; hazards include moderate erosion potential and local mass movement; land-use potential good to fair, primarily devoted to agriculture and low density residential.

15-30% Local slopes 10-50%; landforms include moderately steep hills and valleys; hazards include moderate slope-erosion potential and local to large scale mass movement; land-use potential variable.

30-50% Greater than 50% slope locally; landforms include valleys and mountains; hazards include severe erosion potential, earth-flow, slump, and minor steep slope failure; land-use potential generally limited to very sparse development and well-managed forestry.

< 50 % 50% to vertical locally; landforms include steep canyons, cliffs and mountains; local hazards include rockfall, rockslide, debris avalanche, and severe erosion potential; land-use generally restricted to well-managed forestry and open space.

GEOLOGIC HAZARDS

Mass Movement

Deep bedrock slides: Large areas of deep failure involving bed rock in addition to soil and regolith; active and inactive; recognized by large scale topographic irregularities and displacement of bedrock units; distribution in study area generally determined by faults; possible hazards may include continued sliding, variable foundation strength, variable cutbank stability, poor drainage, and others; potential for development generally low.

Earthflow and slump topography (areas less than 10-20 acres not shown; see Slope): Moderately sloping terrain with irregularities of slope, drainage, or soil distribution; recent movement shown by tension cracks, bowed trees, and others; most widespread in Teot and Teov units, and deeply weathered bed rock; most common in areas of streambank erosion or active headward erosion of streams; possible hazards include continued movements, low cutbank stability, poor drainage, and others; development possible locally, but generally may reactivate or accelerate sliding.

Steep-slope mass movement: General areas subject to localized rock fall, rockslide, debris avalanche, and debris flow; most widespread in steeply sloping KJd, Trmc, Trav, and Tras; specific occurrences controlled by faults, joints, soil water, vegetative cover and land use; mitigation may include structural solutions, drainage control, and appropriate land-use and forest management practices.

Potential future mass movement: Places of highest potential for future mass movement through improper or changing land use include:
Deep bedrock slides — areas of regional faulting or interbedded rocks of differing engineering properties.
Earthflow and slump topography — tuffaceous interbeds of Teot and Teov; also deeply weathered bed rock.
Steep slope failure — steeply sloping KJd, Trmc, Trav, and Tras especially in areas of soil water accumulation, joints, or faults.
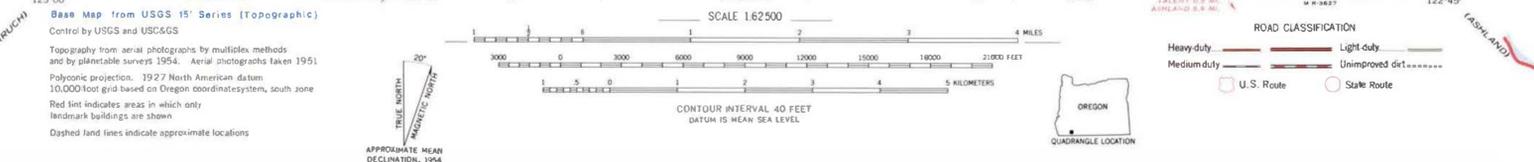*Delineation requires detailed mapping on larger scale than that of this study.*

Flooding

Flood of 1964: Distribution of flood of December, 1964 as determined by U.S. Army Corps of Engineers (1965) using limited observations and gage height data; approximates a 50-year or 2% flood.

Flood of 1861: Distribution of flood of 1861 as determined by U.S. Army Corps of Engineers (1965) using limited observations; approximates a 100-year or 1% flood.

Flood-prone areas: Areas subject to flood hazard of 50- to 100-year frequency near Tolo and Brownsboro, and streams subject to bank overflow (distribution of adjacent lowland ponding not indicated); based on reconnaissance observations and landform analysis.

High ground water and ponding: Accumulation of water in the shallow subsurface or on the surface as a result of flat topography, poor drainage, bank overflow, rain water ponding, irrigation, or other natural or man-induced causes; most widespread on flat Qoa and Qbg; features include distinctive soils and vegetation, depressions, and others; Delineation requires detailed factor mapping on a larger scale than that of this study.

Erosion

Slope erosion: Loss of soil by moving water on slopes; favored by sandy or silty soils (especially over KJd), lack of consolidation, slope gradient, slope length, and absence of vegetation or other protective cover; removes valuable topsoil and causes deposition downslope; may cause siltation of streams, municipal water supplies etc.; wide variety of engineering and land management techniques for control.

Channel change: Areas of relocated stream channel by natural means since preparation of base maps (1954); common between Dodge Bridge and Raygold on Rogue River and downstream from Applegate on Applegate River; indicates areas of unstable channel and high velocity floodways.

Critical stream-bank erosion (not including torrential flood channels): Undercutting and caving of river and stream banks by stream action; restricted primarily to outer bends of meanders on larger streams; characterized by steep slopes, deep water near shore, and actively growing bars on inner bend; mitigation may include riprap, channel modification, bar removal, and land-use restrictions depending on local hydraulics, desired land use, and erosion rates.
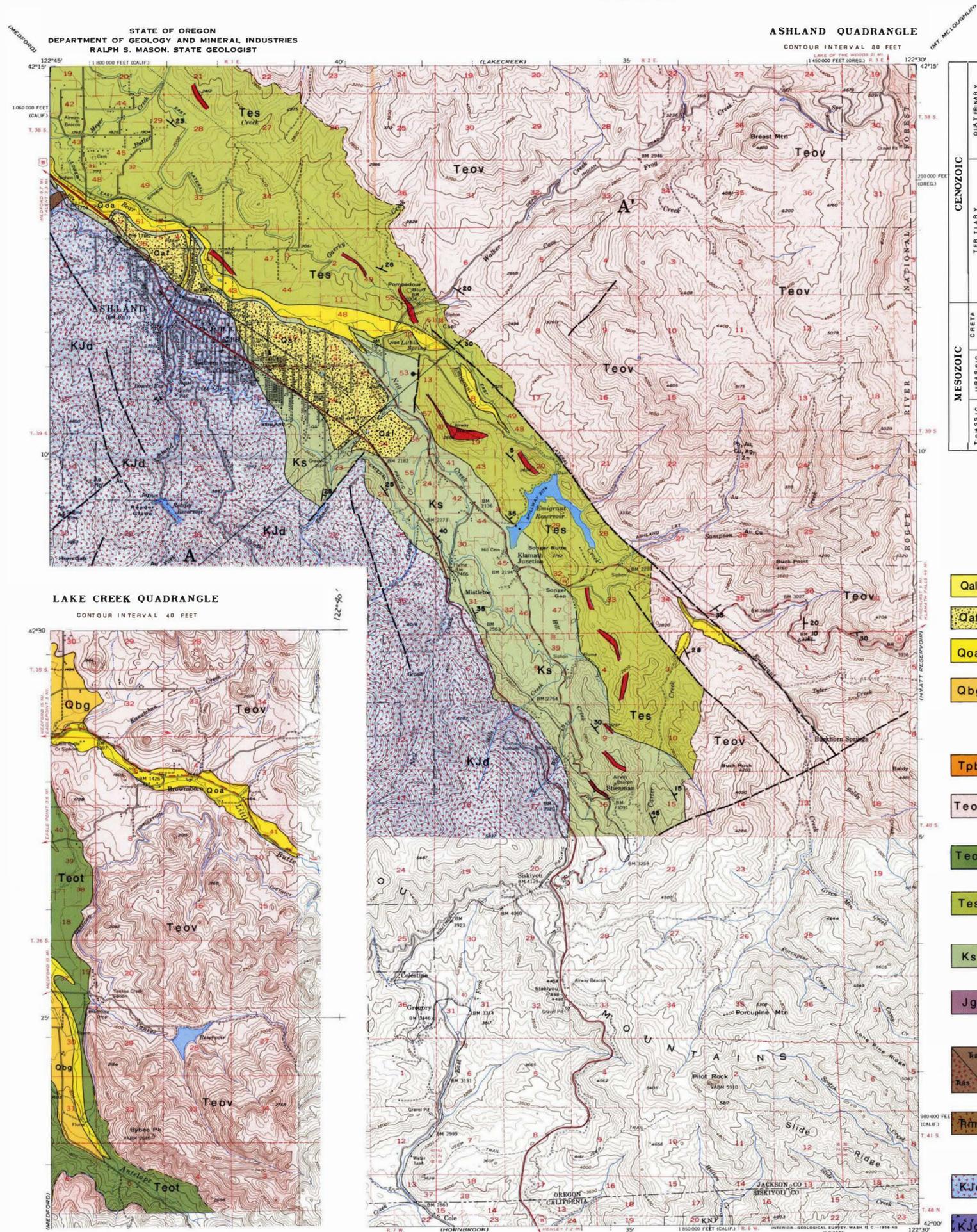
Torrential flooding: Areas of high probability for floods characterized by rapidly flowing water with high channel and stream bank erosion potential in narrow canyons with little or no flood plain; generally restricted to high gradient streams flowing through steep terrain of high relief; channel deposits generally coarse and poorly sorted.

Base Map from USGS 15' Series (Topographic)
Control by USGS and USC&GS

Topography from aerial photographs by multiplex methods and by plane table surveys 1954. Aerial photographs taken 1951

Polyconic projection. 1927 North American datum
10,000 foot grid based on Oregon coordinate system, south zone
Red tint indicates areas in which only landmark buildings are shown
Dashed land lines indicate approximate locations

SCALE 1:62500

ROAD CLASSIFICATION
Heavy-duty _____ Light-duty _____
Medium-duty _____ Unimproved dirt =======
□ U.S. Route ○ State Route

CONTOUR INTERVAL 40 FEET
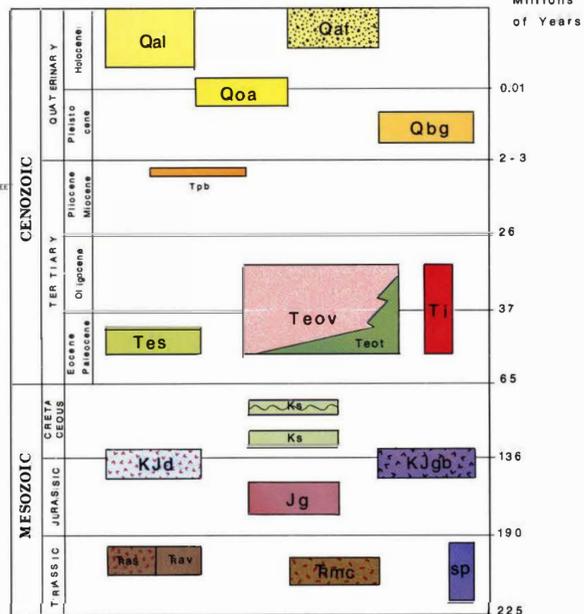DATUM IS MEAN SEA LEVEL

OREGON
QUADRANGLE LOCATION

GEOLOGIC HAZARDS by J. D. Beaulieu, 1977
SLOPE INTERPRETATION by C. A. Schumacher, 1977
CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
EDITED by C. A. Schumacher, 1977

Prepared and Published by the Cartographic Section of the Department of Geology and Mineral Industries
Ralph S. Mason, State Geologist; C. A. Schumacher, Chief Cartographer

GEOLOGIC MAP
of the
parts of ASHLAND & LAKE CREEK QUADRANGLES
OREGON

Plate 10

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

ASHLAND QUADRANGLE
CONTOUR INTERVAL 80 FEET

LAKE CREEK QUADRANGLE
CONTOUR INTERVAL 40 FEET

Base Map from USGS 15' series (Topographic)

Control by USGS and USC&GS
Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951. Field check 1954
Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon coordinate system, south zone
Dashed land lines indicate approximate locations

SCALE: 1: 62,500

ROAD CLASSIFICATION
Heavy-duty ——— Light-duty ———
Medium-duty ——— Unimproved dirt ———
U.S. Route   State Route

APPROXIMATE MEAN DECLINATION 1954

OREGON QUADRANGLE LOCATION

Geologic Cross Sections

A — Qaf — KJd — Ks — Tes — Teov — A'
4000'
3000'
2000'
1000'
Sea Level
-1000'
-2000'
-3000'

TIME ROCK CHART

Millions of Years

CENOZOIC — QUATERNARY — Holocene — Qal, Qaf
Pleisto — Qoa, Qbg — 0.01
Pliocene — Miocene — Tpb — 2 - 3
TERTIARY — Oligocene — Ti — 26
Eocene — Paleocene — Teov, Teot, Tes — 37 — 65
MESOZOIC — CRETACEOUS — Ku, Ks, KJd, KJgb — 136
JURASSIC — Jg — 190
TRIASSIC — Ras, Rav, Rmc, sp — 225

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation)

SURFICIAL GEOLOGIC UNITS

Stream deposits

Qal Quaternary alluvium: Unconsolidated gravel, sand, silt, and clay in stream beds and flood plains of major streams; equivalent to part of Qal of Wells and others (1956); not shown along smaller streams owing to limitations of scale; subject to stream flooding; immature soils.

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BEDROCK GEOLOGIC UNITS

Volcanic and sedimentary rocks

Tpb Pliocene basalt: Equivalent to pre-Mazama basalt of Wells and others (1956); grayish-black, dense, fresh basalt; several flows with total thickness of 125 feet; caps Upper and Lower Table Rocks; vertical columnar joints and irregular joints; interpreted as intercanyon flow rock of ancient Rogue River valley now preserved as inverted topography.

Teov Eocene and Oligocene volcanic rock: Equivalent to Roxy Formation of Wells and others (1956) and agglomerate and older basalt flows of Wilkinson and others (1941); andesitic flows, breccias, agglomerates, and tuffs with interbedded sandstone and shale; rhyolitic and dacitic flows locally; flow thickness 10-100 feet; flow rocks hard and stable; tuffs and sedimentary rock slide-prone in places; Oligocene leaf prints; similar rocks interbedded with Tes near Emigrant Creek Reservoir; soils highly variable.

Teot Eocene and Oligocene tuffaceous rocks: Equivalent to part of Te of Wells and others (1956); varicolored tuffs and sedimentary rocks derived from volcanic rocks, minor interbedded flow rock; soft to moderately hard; low infiltration rates; slide-prone over large areas; possibly not correlative with type Te south of map area; similar rocks interbedded with Tes near Emigrant Creek Reservoir; clay-rich soils.

Tes Eocene sedimentary rock: Equivalent to part of Tu of Wells and others (1956) and to Teu of Wilkinson and others (1941); river-deposited hard sandstone, shale, and conglomerate with local coal seams in south; shallow marine sandstone and siltstone in north; tuffaceous debris throughout; regolith variable; distinctly bedded; slides rare; low infiltration rates; volcanic rock interbeds and late Eocene leaves in south; impermeable soil horizons on terrace forms.

Ks Cretaceous sedimentary rock: Equivalent to Kh and part of Tu of Wells and others (1956); hard conglomerate and sandstone overlain by mudstone and minor sandstone near Ashland; sandstone at Graves Creek; depth of weathering variable with slope and rock type; moderate ground-water potential locally; Early Cretaceous (Albian) at Graves Creek; middle Cretaceous (Cenomanian and Turonian) near Ashland.

Jg Galice Formation: Dark gray to black shale with minor thin-bedded sandstone and granule conglomerate; moderate to high foundation strength; low ground-water potential; silty clay loam soils of variable thickness; thick base slope colluvium; hazards include slope erosion and local mass movement.

Metamorphic rocks

Rav / Ras Applegate Formation: Rav — Equivalent to metavolcanics of Wells and others (1940); altered lava flows, flow breccias, and pyroclastic rocks with minor tuffaceous sedimentary rocks; grades into Ras; hard, steep terrain; very low permeability; thin soil with exception of base slope colluvium; mineralization in places near intrusive rock. Ras — Equivalent to metasedimentary rocks of Wells and others (1940); altered tuffaceous sedimentary rock, argillite, chert, and limestone; minor volcanic rocks locally; variable engineering properties; high slide potential where deeply weathered.

Rmc May Creek Schist: Medium grade metamorphic rocks derived from Rav, Ras and possibly Jg; includes mafic metavolcanic rock, mica schist, phyllite, and slate; weakly to strongly foliated; hard, impermeable, thin regolith with exception of thick base slope colluvium; potential for steep-slope failure; product of multiple metamorphism culminating in proximate granitic plutonism (Kays, 1970).

Intrusive rocks

KJd Diorite and granodiorite: Light gray medium-grained intrusive rock of intermediate composition; sandy and silty loam soils of variable thickness; thick regolith in places; very high erosion potential and steep-slope failure potential; moderate ground-water potential in moderately to gently sloping valley areas; excellent quarry rock where fresh.

KJgb Gabbro: Gray-green, coarse-grained intrusive rock consisting of augite and plagioclase; deeply weathered with brown to rusty red soil; moderately high erosion potential; low ground-water potential; geologic relation to diorite unclear.

sp Serpentinite: Rocks consisting of minerals of the serpentine group and including pyroxene; complex Triassic origin and remobilized along later faults to present positions; brownish to reddish loam and clay soils; scant vegetation; slide-prone.

Ti Tertiary intrusive rock: Sills, stocks, and dikes of diorite, gabbro and basalt north and east of Bear Creek, and basaltic dikes east of the mapped area; quarry rock potential variable; depth of weathering variable.
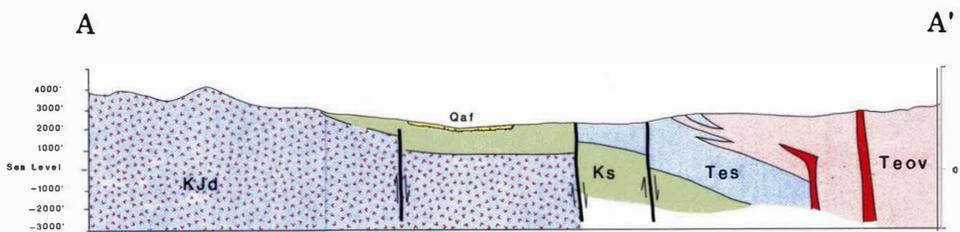
Mineral Mines and Prospects

Ag Silver	Hg Mercury	Mo Molybdenum
Au Gold	Mg Magnesium	Pb Lead
Cu Copper	Mn Manganese	W Tungsten
		Zn Zinc

GEOLOGIC SYMBOLS

Contacts
— Definite contact
---- Approximate contact

Faults
— Definite fault
—— Approximate fault
--- Inferred fault
····· Concealed fault
—↓—↑— Normal fault (ball and bar on downthrown side)

Folds
Definite anticline
Definite syncline
Approximate anticline
Approximate syncline
Inferred anticline
Inferred syncline
Concealed anticline
Concealed syncline

Bedding
Strike and dip of bed
Strike of vertical bed
Horizontal bed
Spring

Bedrock Geology for the Ashland Quadrangle modified after Wells and others, 1956 and McKnight, 1973, by John D. Beaulieu, 1977
Surficial Geology by John D. Beaulieu, 1977

Bedrock Geology for the Lakecreek Quadrangle modified after Wells and others, 1956 by John D. Beaulieu, 1977
Surficial Geology by John D. Beaulieu, 1977

Prepared and Published by the Cartographic Section
of the Department of Geology and Mineral Industries
Ralph S. Mason, State Geologist; C. A. Schumacher, Chief Cartographer

CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
EDITED by C. A. Schumacher, 1977

GEOLOGIC HAZARD MAP
of the
parts of ASHLAND & LAKE CREEK QUADRANGLES
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

ASHLAND QUADRANGLE
CONTOUR INTERVAL 80 FEET

LAKE CREEK QUADRANGLE
CONTOUR INTERVAL 40 FEET

Base Map from USGS 15' Series (Topographic)

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951. Field check 1954.
Polyconic projection. 1927 North American datum
10,000 foot grid based on Oregon coordinate system, south zone
Dashed land lines indicate approximate locations

APPROXIMATE MEAN DECLINATION, 1954

GEOLOGIC HAZARDS by J. D. Beaulieu, 1977
SLOPE INTERPRETATION by C. A. Schumacher, 1977
CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
EDITED by C. A. Schumacher, 1977

SCALE: 1: 62,500

ROAD CLASSIFICATION
Heavy-duty _____   Light-duty _____
Medium-duty _____   Unimproved dirt _____
U.S. Route   State Route

OREGON
QUADRANGLE LOCATION

Prepared and Published by the Cartographic Section
of the Department of Geology and Mineral Industries
Ralph S. Mason, State Geologist; C. A. Schumacher, Chief Cartographer

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation.)

Average (Regional) Slope

Interpreted from maps with scale 1:62,500

0 - 5 % Local slopes 0-10%; landforms include flood plains, terraces, pediments and ridge crests; hazards include ponding, high ground water, flooding, and stream bank erosion; land-use potential good in areas of minimal hazard.

5 - 15% Local slopes 0-50%; landforms include gentle slopes and ridge crests surrounding larger valleys; hazards include moderate erosion potential and local mass movement; land-use potential good to fair, primarily devoted to agriculture and low density residential.

15-30% Local slopes 10-50%; landforms include moderately steep hills and valleys; hazards include moderate slope-erosion potential and local to large scale mass movement; land-use potential variable.

30-50% Greater than 50% slope locally; landforms include valleys and mountains; hazards include severe erosion potential, earthflow, slump, and minor steep slope failure; land-use potential generally limited to very sparse development and well-managed forestry.

< 50 % 50% to vertical locally; landforms include steep canyons, cliffs and mountains; local hazards include rockfall, rockslide, debris avalanche, and severe erosion potential; land-use generally restricted to well-managed forestry and open space.

GEOLOGIC HAZARDS

Mass Movement

Deep bedrock slides: Large areas of deep failure involving bed rock in addition to soil and regolith; active and inactive; recognized by large scale topographic irregularities and displacement of bedrock units; distribution in study area generally determined by faults; possible hazards may include continued sliding, variable foundation strength, variable cutbank stability, poor drainage, and others; potential for development generally low.

Earthflow and slump topography (areas less than 10-20 acres not shown; see Slope): Moderately sloping terrain with irregularities of slope, drainage, or soil distribution; recent movement shown by tension cracks, bowed trees, and others; most widespread in Teot and Teov units, and deeply weathered bed rock; most common in areas of streambank erosion or active headward erosion of streams; possible hazards include continued movements, low cutbank stability, poor drainage, and others; development possible locally, but generally may reactivate or accelerate sliding.

Steep-slope mass movement: General areas subject to localized rock fall, rockslide, debris avalanche, and debris flow; most widespread in steeply sloping KJd, Trmc, Trav and Trat; specific occurrences controlled by faults, joints, soil water, soil thickness, vegetative cover and land use; mitigation may include structural solutions, drainage control, and appropriate land-use and forest management practices.

Potential future mass movement: Places of highest potential for future mass movement through improper or changing land use include:
Deep bedrock slides — areas of regional faulting or interbedded rocks of differing engineering properties.
Earthflow and slump topography — tuffaceous interbeds of Teot and Teov; also deeply weathered bed rock.
Steep slope failure — steeply sloping KJd, Trmc, Trav, and Trat especially in areas of soil water accumulation, joints, or faults.
Delineation requires detailed mapping on larger scale than that of this study.

Flooding

Flood of 1964: Distribution of flood of December, 1964 as determined by U.S. Army Corps of Engineers (1965) using limited observations and gage height data; approximates a 50-year or 2% flood.

Flood of 1861: Distribution of flood of 1861 as determined by U.S. Army Corps of Engineers (1965) using limited observations; approximates a 100-year or 1% flood.

Flood-prone areas: Areas subject to flood hazard of 50- to 100-year frequency near Tolo and Brownsboro, and streams subject to bank overflow (distribution of adjacent lowland ponding not indicated); based on reconnaissance observations and landform analysis.

High ground water and ponding: Accumulation of water in the shallow subsurface or on the surface as a result of flat topography, poor drainage, bank overflow, rain water ponding, irrigation, or other natural or man-induced causes; most widespread on flat Qoa and Qbg; features include distinctive soils and vegetation, depressions, and others; Delineation requires detailed factor mapping on a larger scale than that of this study.
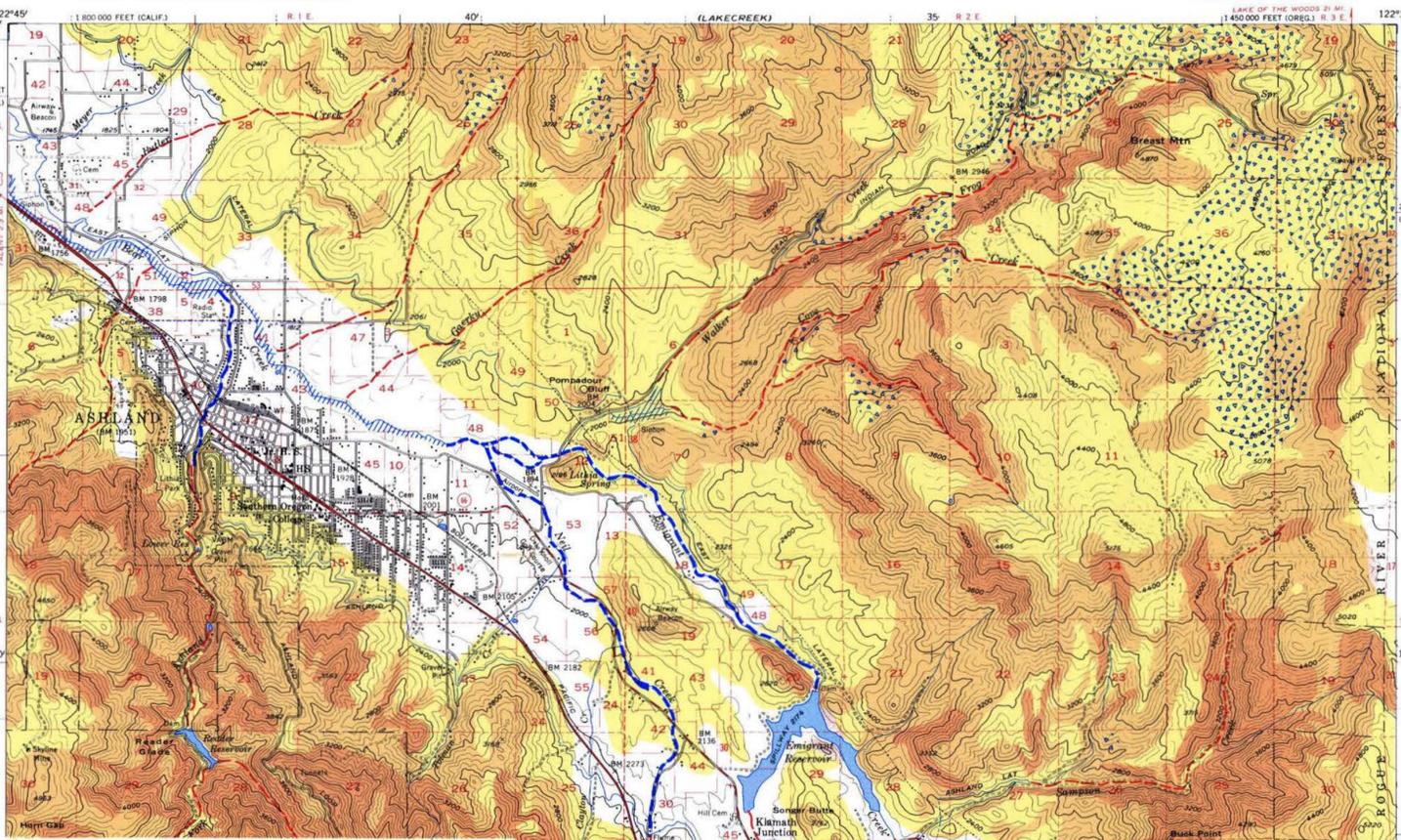
Erosion

Slope erosion: Loss of soil by moving water on slopes; favored by sandy or silty soils (especially over KJd), lack of consolidation, slope gradient, slope length, and absence of vegetation or other protective cover; removes valuable topsoil and causes deposition downslope; may cause siltation of streams, municipal water supplies etc.; wide variety of engineering and land management techniques for control.

Channel change: Areas of relocated stream channel by natural means since preparation of base maps (1954); common between Dodge Bridge and Raygold on Rogue River and downstream from Applegate on Applegate River; indicates areas of unstable channel and high velocity floodways.
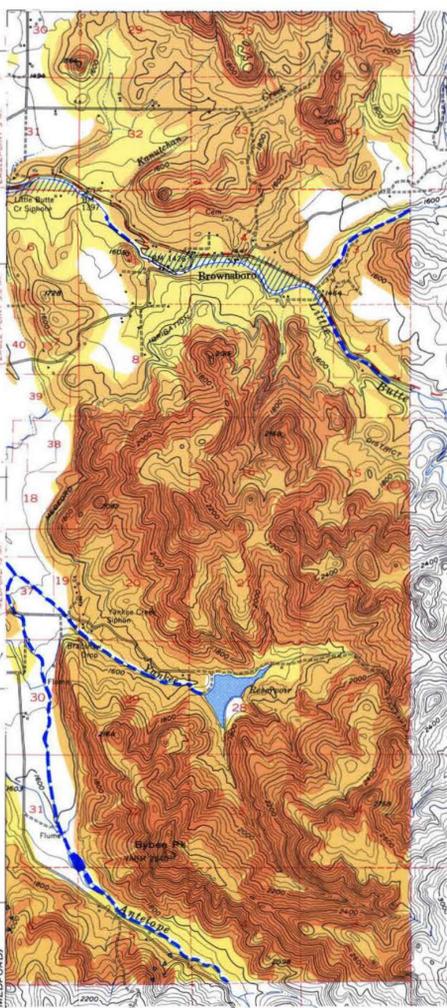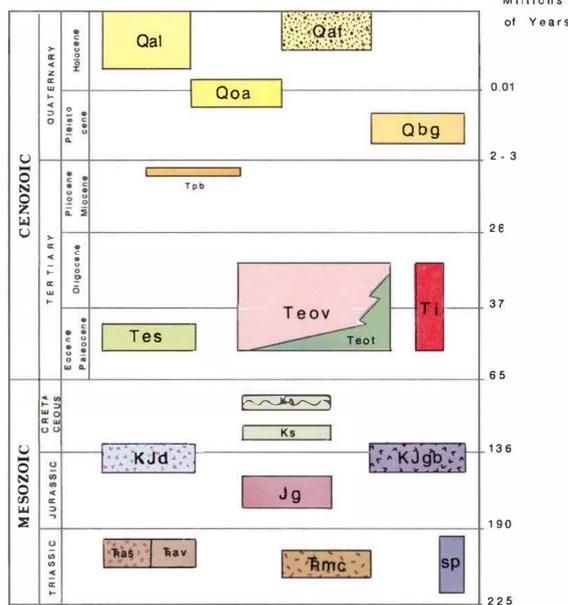
Critical stream-bank erosion (not including torrential flood channels): Undercutting and caving of river and stream banks by stream action; restricted primarily to outer bends of meanders on larger streams; characterized by steep slopes, deep water near shore, and actively growing bars on inner bend; mitigation may include riprap, channel modification, bar removal, and land-use restrictions depending on local hydraulics, desired land use, and erosion rates.

Torrential flooding: Areas of high probability for floods characterized by rapidly flowing water with high channel and stream bank erosion potential in narrow canyons with little or no flood plain; generally restricted to high gradient streams flowing through steep terrain of high relief; channel deposits generally coarse and poorly sorted.

GEOLOGIC MAP
of the
GOLD HILL QUADRANGLE (in part)
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

TIME ROCK CHART

Millions of Years

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation)

SURFICIAL GEOLOGIC UNITS

Stream deposits

Qal Quaternary alluvium: Unconsolidated gravel, sand, silt, and clay in stream beds and flood plains of major streams; equivalent to part of Qaf of Wells and others (1956); not shown along smaller streams owing to limitations of scale; subject to stream flooding; immature soils.

Qaf Quaternary alluvial fan deposits: Unconsolidated gravel, sand, and silt occurring as fan deposits adjacent to Qoa at the mouths of some torrential flood channels; subject to torrential flooding, bank overflow, erosion, and deposition.

Qoa Quaternary older alluvium: Unconsolidated gravel, sand, silt, and clay on terraces generally above flood plains of major streams; also alluvial terraces of upland streams; equivalent in part to Qof of Wells and others (1956); includes several intermediate terrace levels of varying ages; subject to local flooding, ponding and high ground water; restrictive soil layers.

Qbg Quaternary bench gravels: Semi-consolidated gravel, sand, clay, and silt forming high level terrace in Bear Creek Valley and along Rogue River; upper horizons rich in clay; includes Qbg of Wells and others (1956); generally characterized by distinctive 'patterned' ground of low interconnected rocky channels; restrictive soil layers; subject to poor drainage, ponding, and high ground water.

BEDROCK GEOLOGIC UNITS

Volcanic and sedimentary rocks

Tpb Pliocene basalt: Equivalent to pre-Mazama basalt of Wells and others (1956); grayish-black, dense, fresh basalt; several flows with total thickness of 125 feet; caps Upper and Lower Table blocks; vertical columnar joints and irregular joints; interpreted as intracanyon flow rock of ancient Rogue River valley now preserved as inverted topography.

Teov Eocene and Oligocene volcanic rock: Equivalent to Roxy Formation of Wells and others (1956) and agglomerate and older basalt flows of Wilkinson and others (1941); andesitic flows, breccia, agglomerates, and tuffs with interbedded sandstone and shale; rhyolitic and dacitic flows locally, flow thickness 10-100 feet; flow rocks hard and stable; tuffs and sedimentary rock slide prone in places; Oligocene leaf prints; similar rocks interbedded with Tes near Emigrant Creek Reservoir; soils highly variable.

Teot Eocene and Oligocene tuffaceous rocks: Equivalent to part of Tc of Wells and others (1956); varicolored tuffs and sedimentary rocks derived from volcanic rocks, minor interbedded flow rock soft to moderately hard; low infiltration rates; slide-prone over large areas; possibly not correlative with type Tc south of map area; similar rocks interbedded with Tes near Emigrant Creek Reservoir; clay rich soils.

Tes Eocene sedimentary rock: Equivalent to part of Tu of Wells and others (1956) and to Teu of Wilkinson and others (1941); river deposited hard sandstone, shale, and conglomerate with local coalseams in south; shallow marine sandstone and siltstone in north; tuffaceous debris throughout; regolith variable; distinctly bedded; slides rare; low infiltration rates; volcanic rock interbeds and tale Eocene leaves in south; impermeable soil horizons on terrace forms.

Ks Cretaceous sedimentary rock: Equivalent to Kh and part of Tu of Wells and others (1956); hard conglomerate and sandstone overlain by mudstone and minor sandstone near Ashland; sandstone at Graves Creek; depth of weathering variable with slope and rock type; moderate ground-water potential locally; Early Cretaceous (Albian) at Graves Creek; middle Cretaceous (Cenomanian and Turonian) near Ashland.

Jg Galice Formation: Dark gray to black shale with minor thin bedded sandstone and granule conglomerate; moderate to high foundation strength; low ground-water potential; silty clay loam soils of variable thickness; thick base slope colluvium; hazards include slope erosion and local mass movement.

Metamorphic rocks

Rav / Ras Applegate Formation: Rav — Equivalent to metavolcanics of Wells and others (1940); altered lava flows, flow breccias, and pyroclastic rocks with minor tuffaceous sedimentary rocks; grades into Rmc; hard, steep terrain, very low permeability; thin soil with exception of base slope colluvium; mineralization in places near intrusive rock. Ras — Equivalent to metasedimentary rocks of Wells and others (1940); altered tuffaceous sedimentary rock, argillite, chert, and limestone; minor volcanic rocks locally; variable engineering properties; thick regolith and high slide potential where deeply weathered.

Rmc May Creek Schist: Medium-grade metamorphic rocks derived from Rav, Ras and possibly Jg; includes mafic metavolcanic rock, mica schist, phyllite, and slate; weakly to strongly foliated; hard, impermeable, thin regolith with exception of thick base slope colluvium; potential for steep-slope failure; product of multiple metamorphism culminating in proximate granitic plutonism (Kays, 1970).

Intrusive rocks

KJd Diorite and granodiorite: Light gray medium grained intrusive rock of intermediate composition; sandy and silty loam soils of variable thickness; thick regolith in places; very high erosion potential and steep-slope failure potential; moderate ground-water potential in moderately to gently sloping valley areas; excellent quarry rock where fresh.

KJgb Gabbro: Gray-green, coarse-grained intrusive rock consisting of augite and plagioclase; deeply weathered with brown to, rusty red soil; moderately high erosion potential; low ground water potential; geologic relation to diorite unclear.

sp Serpentinite: Rocks consisting of minerals of the serpentine group and locally including olivine and pyroxene; complex Triassic origin and remobilized along later faults to present positions; brownish to reddish loam and clay soils; scant vegetation; slide prone.

Ti Tertiary intrusive rock: Sills, stocks, and dikes of diorite, gabbro and basalt north and east of Bear Creek, and basaltic dikes east of the mapped area; quarry rock potential variable; depth of weathering variable.
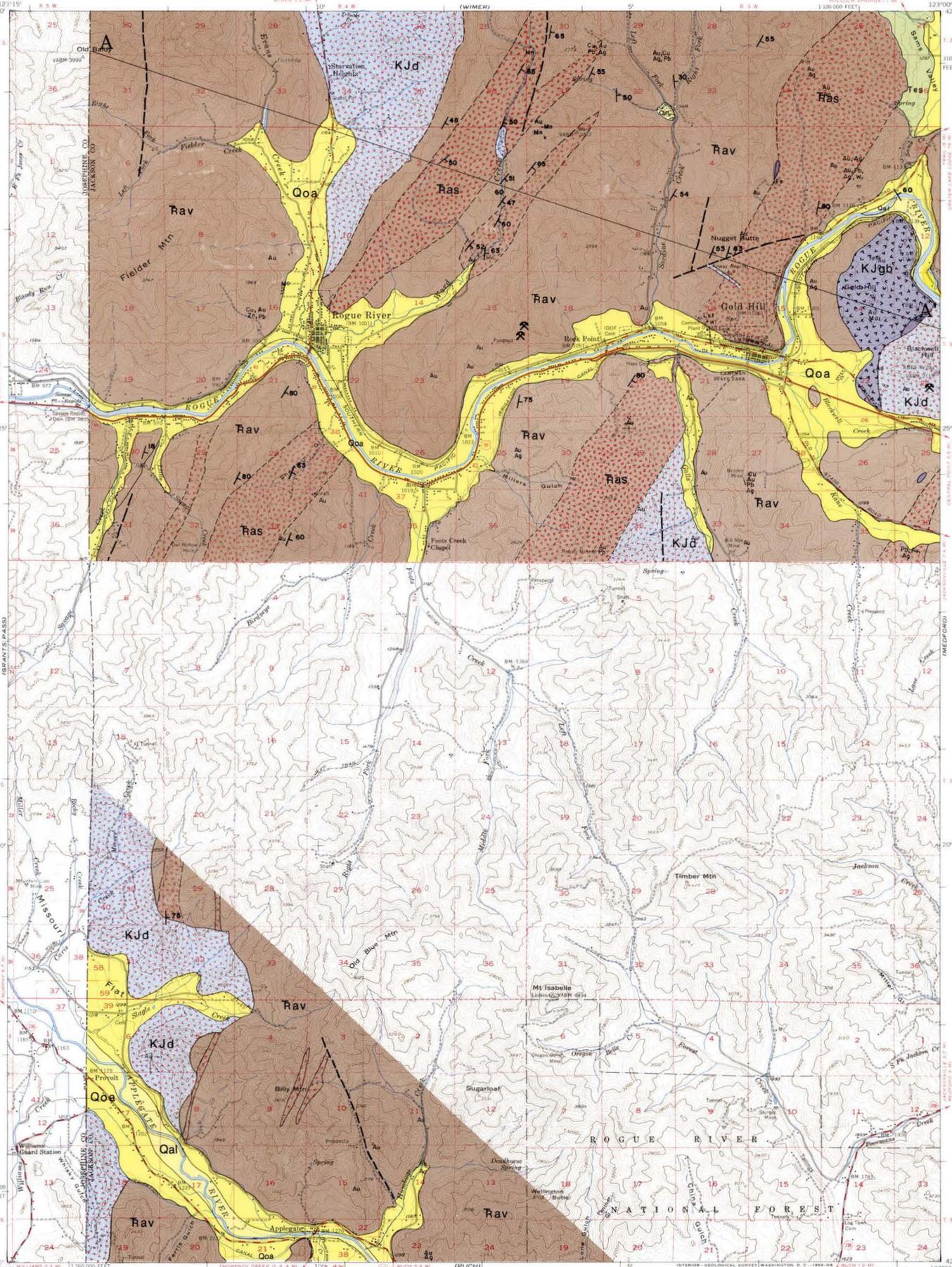
Mineral Mines and Prospects

Ag	Silver	Hg	Mercury	Mo	Molybdenum		
Au	Gold	Mg	Magnesium	Pb	Lead		
Cu	Copper	Mn	Manganese	W	Tungsten		
				Zn	Zinc		

GEOLOGIC SYMBOLS

Contacts
— Definite contact
— — Approximate contact

Faults
— — Definite fault
— — Approximate fault
— — Inferred fault
.... Concealed fault
Normal fault (ball and bar on downthrown side)

Folds
Definite anticline
Definite syncline
Approximate anticline
Approximate syncline
Inferred anticline
Inferred syncline
Concealed anticline
Concealed syncline

Bedding
Strike and dip of bed
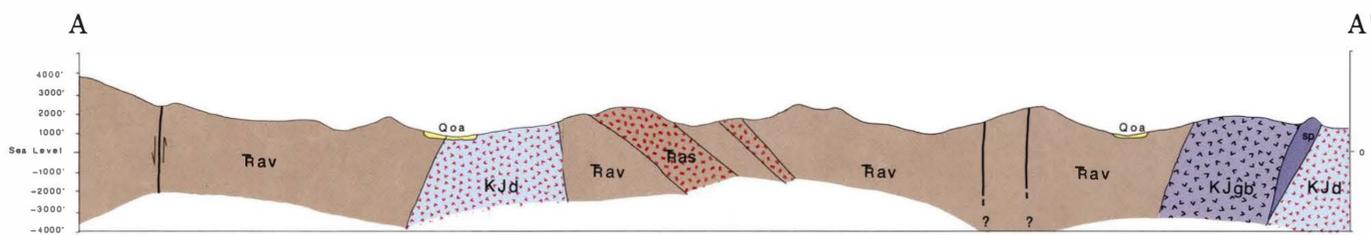Strike of vertical bed
Horizontal bed
Spring

Base Map from USGS 15' series (Topographic)

Control by USGS, USC&GS, and State of Oregon

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951-52. Field check 1954

Polyconic projection. 1927 North American datum
10,000 foot grid based on Oregon coordinate system, south zone
Dashed land lines indicate approximate locations

SCALE 1: 62500

ROAD CLASSIFICATION
Heavy-duty ——— Light-duty
Medium-duty ——— Unimproved dirt ....
U.S. Route   State Route

CONTOUR INTERVAL 80 FEET
DASHED LINES REPRESENT 40 FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION
OREGON

APPROXIMATE MEAN DECLINATION, 1954

Geologic Cross Sections

A — A'

4000
3000
2000
1000
Sea Level
-1000
-2000
-3000
-4000

GEOLOGIC HAZARD MAP
of the
GOLD HILL QUADRANGLE (in part)
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation.)

Average (Regional) Slope

Interpreted from maps with scale 1:62,500

0 - 5 % Local slopes 0-10%; landforms include flood plains, terraces, pediments and ridge crests; hazards include ponding, high ground water, flooding, and stream bank erosion; land-use potential good in areas of minimal hazard.

5 - 15 % Local slopes 0-50%; landforms include gentle slopes and ridge crests surrounding larger valleys; hazards include moderate erosion potential and local mass movement; land-use potential good to fair, primarily devoted to agriculture and low density residential.

15 - 30% Local slopes 10-50%; landforms include moderately steep hills and valleys; hazards include moderate slope-erosion potential and local to large scale mass movement; land-use potential variable.

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GEOLOGIC HAZARDS

Mass Movement

Deep bedrock slides: Large areas of deep failure involving bed rock in addition to soil and regolith; active and inactive; recognized by large scale topographic irregularities and displacement of bedrock units; distribution in study area generally determined by faults; possible hazards may include continued sliding, variable foundation strength, variable cutbank stability, poor drainage, and others; potential for development generally low.

Earthflow and slump topography (areas less than 10-20 acres not shown; see Slope): Moderately sloping terrain with irregularities of slope, drainage, or soil distribution; recent movement shown by tension cracks, bowed trees, and others; most widespread in Teot and Teov units, and deeply weathered bed rock; most common in areas of streambank erosion or active headward erosion of streams; possible hazards include continued movements, low cutbank stability, poor drainage, and others; development possible locally, but generally may reactivate or accelerate sliding.

Steep-slope mass movement: General areas subject to localized rock fall, rockslide, debris avalanche, and debris flow; most widespread in steeply sloping KJd, Tⁱmc, Tᵢav, and Tᵢas; specific occurrences controlled by faults, joints, soil water, soil thickness, vegetative cover and land use; mitigation may include structural solutions, drainage control, and appropriate land-use and forest management practices.

Potential future mass movement: Places of highest potential for future mass movement through improper or changing land use include:
Deep bedrock slides — areas of regional faulting or interbedded rocks of differing engineering properties.
Earthflow and slump topography — tuffaceous interbeds of Teot and Teov; also deeply weathered bed rock.
Steep slope failure — steeply sloping KJd, Tⁱmc, Tᵢav, and Tᵢas especially in areas of soil water accumulation, joints, or faults.
Delineation requires detailed mapping on larger scale than that of this study.

Flooding

Flood of 1964: Distribution of flood of December, 1964 as determined by U.S. Army Corps of Engineers (1965) using limited observations and gage height data; approximates a 50-year or 2% flood.

Flood of 1861: Distribution of flood of 1861 as determined by U.S. Army Corps of Engineers (1965) using limited observations; approximates a 100-year or 1% flood.

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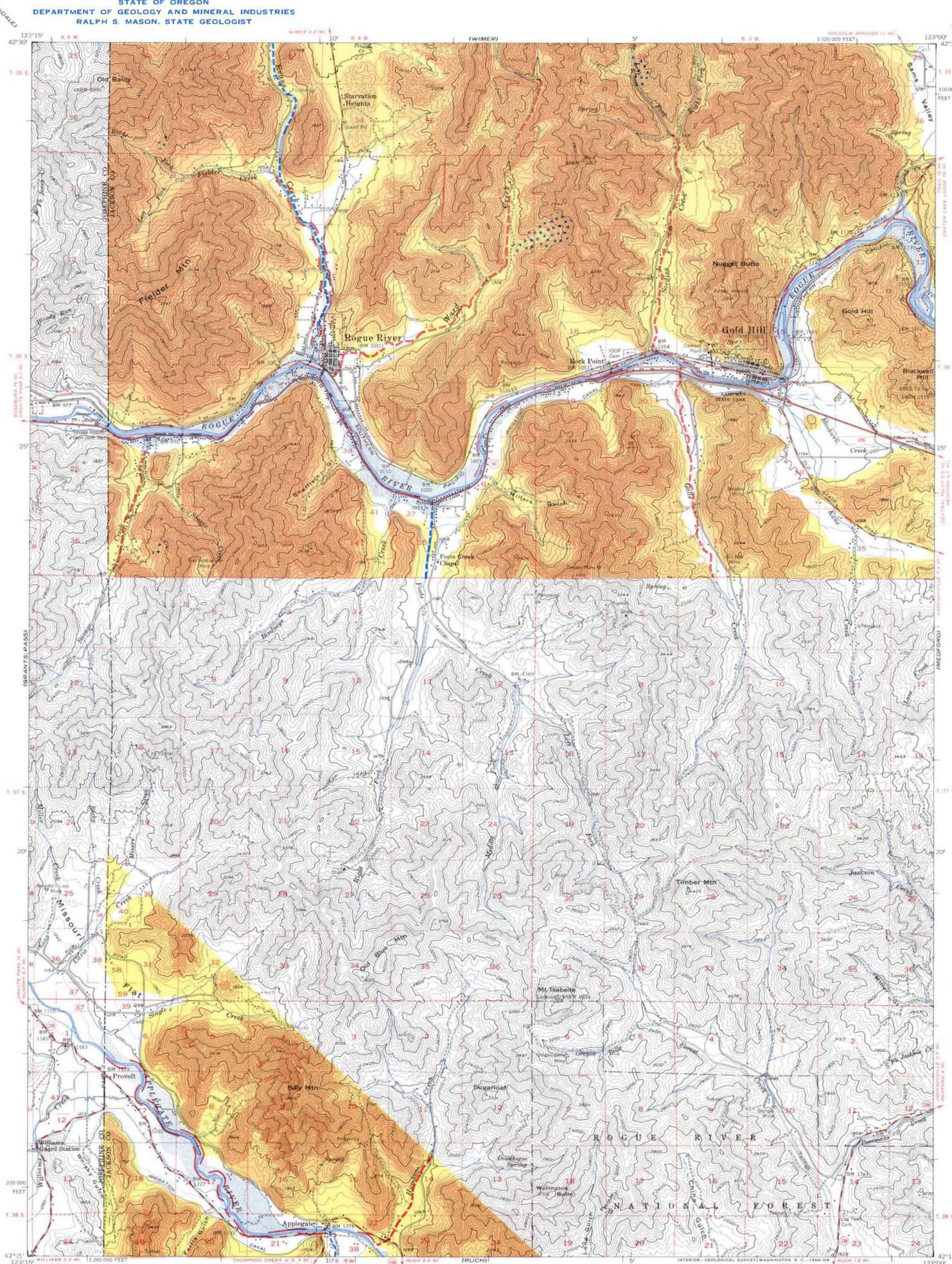
Erosion

Slope erosion: Loss of soil by moving water on slopes; favored by sandy or silty soils (especially over KJd), lack of consolidation, slope gradient, slope length, and absence of vegetation or other protective cover; removes valuable topsoil and causes deposition downslope; may cause siltation of streams, municipal water supplies etc.; wide variety of engineering and land management techniques for control.

Channel change: Areas of relocated stream channel by natural means since preparation of base maps (1954); common between Dodge Bridge and Raygold on Rogue River and downstream from Applegate on Applegate River; indicates areas of unstable channel and high velocity floodways.

Critical stream-bank erosion (not including torrential flood channels): Undercutting and caving of river and stream banks by stream action; restricted primarily to outer bends of meanders on larger streams; characterized by steep slopes, deep water near shore, and actively growing bars on inner bend; mitigation may include riprap, channel modification, bar removal, and land-use restrictions depending on local hydraulics, desired land use, and erosion rates.

Torrential flooding: Areas of high probability for floods characterized by rapidly flowing water with high channel and stream bank erosion potential in narrow canyons with little or no flood plain; generally restricted to high gradient streams flowing through steep terrain of high relief; channel deposits generally coarse and poorly sorted.

Base Map from USGS 15' Series (Topographic)
Control by USGS, US&GS, and State of Oregon

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951-52. Field check 1954
Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon coordinate system, south zone
Dashed land lines indicate approximate locations

SCALE: 1: 62500

CONTOUR INTERVAL 80 FEET
DASHED LINES REPRESENT 40-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty ———
Medium-duty ——— Unimproved dirt ======
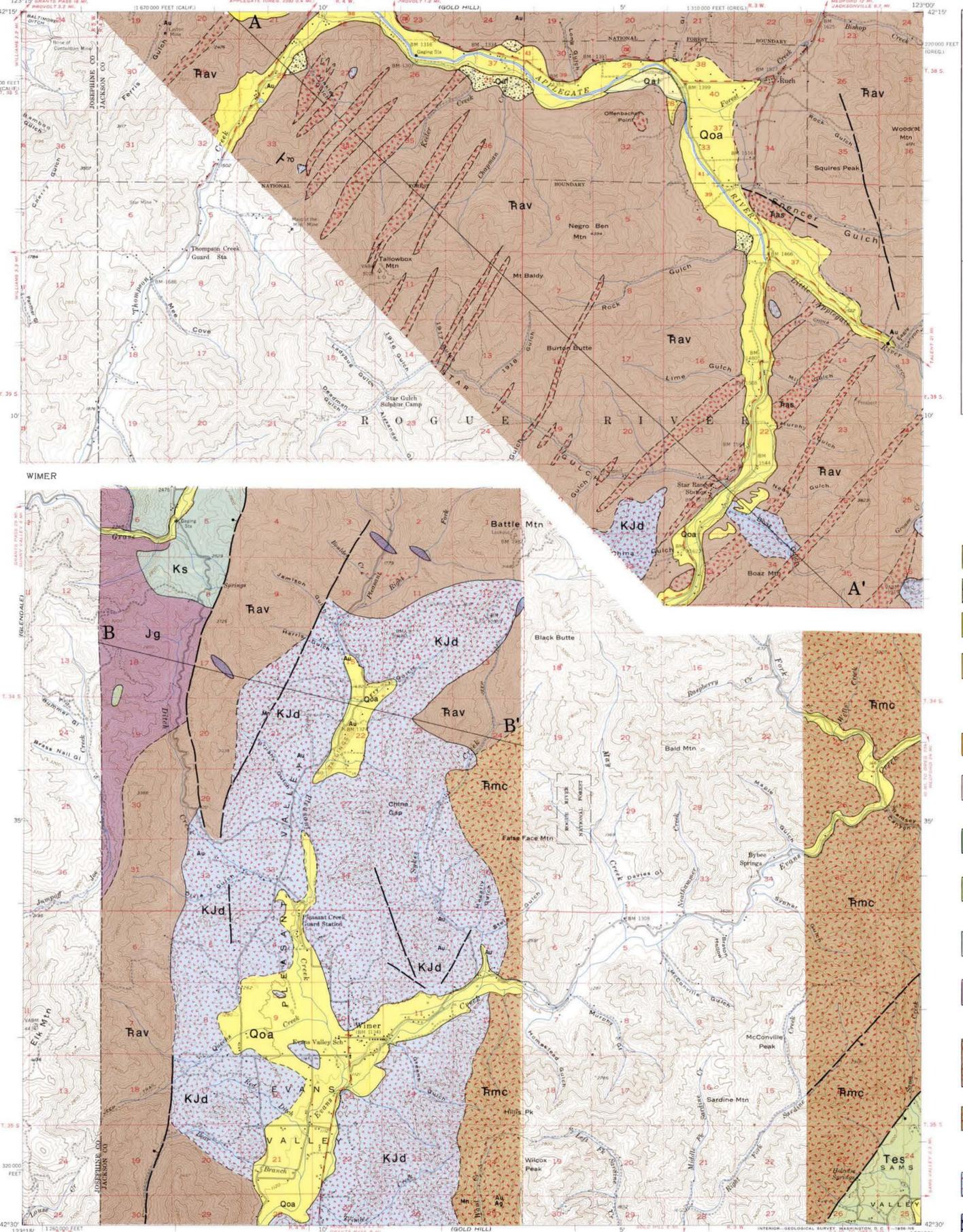□ U.S. Route ○ State Route

GEOLOGIC HAZARDS by J. D. Beaulieu, 1977
SLOPE INTERPRETATION by C. A. Schumacher, 1977
CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
EDITED by C. A. Schumacher, 1977

Prepared and Published by the Cartographic Section
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Ralph S. Mason, State Geologist; C. A. Schumacher, Chief Cartographer

GEOLOGIC MAP
of the
parts of RUCH & WIMER QUADRANGLES
OREGON

STATE OF OREGON
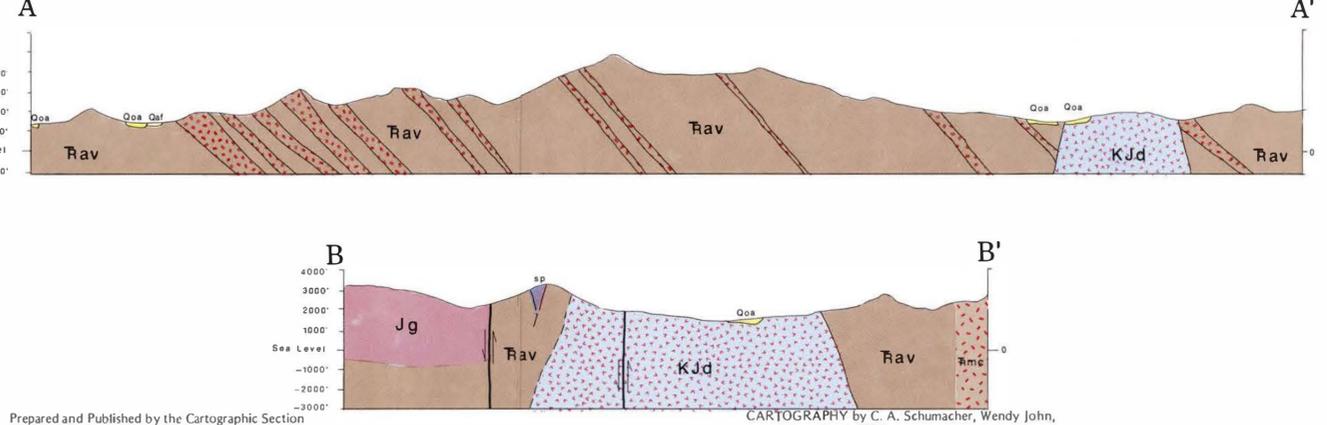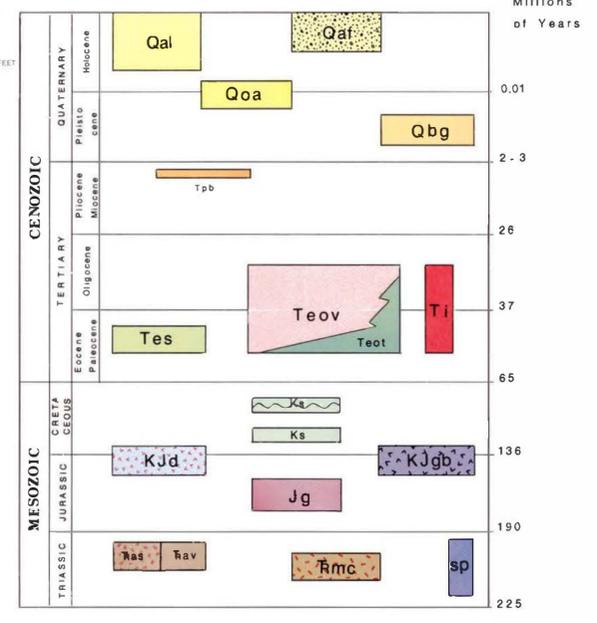DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

TIME ROCK CHART

Millions of Years

Era	Period	Epoch	Units
CENOZOIC	Quaternary	Holocene	Qal, Qaf
		Pleistocene	Qoa, Qbg
	Tertiary	Pliocene	Tpb — 2-3
		Miocene	
		Oligocene	Teov, Ti — 37
		Eocene / Paleocene	Tes, Teot — 65
MESOZOIC	Cretaceous		Ksc, Ks, KJd, KJgb — 136
	Jurassic		Jg — 190
	Triassic		Ras, Rav, Rmc, sp — 225

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation)

SURFICIAL GEOLOGIC UNITS

Stream deposits

Qal — Quaternary alluvium: Unconsolidated gravel, sand, silt, and clay in stream beds and flood plains of major streams; equivalent to part of Qal of Wells and others (1956); not shown along smaller streams owing to limitations of scale; subject to stream flooding; immature soils.

Qaf — Quaternary alluvial fan deposits: Unconsolidated gravel, sand, and silt occurring as fan deposits adjacent to Qoa at the mouths of some torrential flood channels; subject locally to torrential flooding, bank overflow, erosion, and deposition.

Qoa — Quaternary older alluvium: Unconsolidated gravel, sand, silt, and clay on terraces generally above flood plains of major streams; also alluvial terraces of upland streams; equivalent in part to Qof of Wells and others (1956); includes several intermediate terrace levels of varying ages; subject to local flooding, ponding and high ground water; restrictive soil layers.

Qbg — Quaternary bench gravels: Semi-consolidated gravel, sand, clay, and silt forming high level terrace in Bear Creek Valley and along Rogue River; upper horizons rich in clay; includes Qbt of Wells and others (1956); generally characterized by distinctive "patterned" ground of low interconnected rocky channels; restrictive soil layers; subject to poor drainage, ponding, and high ground water.

BEDROCK GEOLOGIC UNITS

Volcanic and sedimentary rocks

Tpb — Pliocene basalt: Equivalent to pre-Mazama basalt of Wells and others (1956); grayish-black, dense, fresh basalt: several flows with total thickness of 125 feet; caps Upper and Lower Table Rocks; vertical columnar joints and irregular joints; interpreted as intercanyon flow rock of ancient Rogue River valley now preserved as inverted topography.

Teov — Eocene and Oligocene volcanic rock: Equivalent to Roxy Formation of Wells and others (1956) and agglomerate and older basalt flows of Wilkinson and others (1941); andesitic flows, breccias, agglomerate, and tuffs with interbedded sandstone and shale; rhyolitic and dacitic flows locally; flow thickness 10-100 feet; flow rocks hard and stable; tuffs and sedimentary rock slide-prone in places; Oligocene leaf prints; similar rocks interbedded with Tes near Emigrant Creek Reservoir; soils highly variable.

Teot — Eocene and Oligocene tuffaceous rocks: Equivalent to part of Te of Wells and others (1956); sericitized tuffs and sedimentary rocks derived from volcanic rocks, minor interbedded flow rock; soft to moderately hard; low infiltration rates; slide-prone over large areas; possibly not correlative with type Te south of map area; similar rocks interbedded with Tes near Emigrant Creek Reservoir; clay-rich soils.

Tes — Eocene sedimentary rock: Equivalent to part of Tu of Wells and others (1956) and to Teu of Wilkinson and others (1941); river-deposited hard sandstone, shale, and conglomerate with local coal seams in south; shallow marine sandstone and siltstone in north; tuffaceous debris throughout; regolith variable; distinctly bedded; slides rare; low infiltration rates; volcanic rock interbeds and late Eocene leaves in south; impermeable soil horizons on terrace forms.

Ks — Cretaceous sedimentary rock: Equivalent to Kh and part of Tu of Wells and others (1956); hard conglomerate and sandstone overlain by mudstone and minor sandstone near Ashland; sandstone at Graves Creek; depth of weathering variable with slope and rock type; moderate ground-water potential locally; Early Cretaceous (Albian) at Graves Creek; middle Cretaceous (Cenomanian and Turonian) near Ashland.

Jg — Galice Formation: Dark gray to black shale with minor thin-bedded siltstone and granule conglomerate; moderate to high foundation strength, low ground-water potential; silty clay loam soils of variable thickness; thick base slope colluvium; hazards include slope erosion and local mass movement.

Metamorphic rocks

Rav / Ras — Applegate Formation: Rav — Equivalent to metavolcanics of Wells and others (1940); altered lava flows, flow breccia, and pyroclastic rocks with minor tuffaceous sedimentary rocks; grades into Rmc; hard, steep terrain, very low permeability, thin soil with exception of base slope colluvium; mineralization in places near intrusive rock. Ras — Equivalent to metasedimentary rocks of Wells and others (1940); altered tuffaceous sedimentary rock, argillite, chert, and limestone; minor volcanic rocks locally; variable engineering properties; thick regolith and high slide potential where deeply weathered.

Rmc — May Creek Schist: Medium grade metamorphic rocks derived from Rav, Ras and possibly Jg; includes mafic metavolcanic rock, mica schist, phyllite, and slate; weakly to strongly foliated; hard, impermeable, thin regolith with exception of thick base slope colluvium; potential for steep-slope failure; product of multiple metamorphism culminating in proximate granitic plutonism (Kays, 1970).

Intrusive rocks

KJd — Diorite and granodiorite: Light gray medium-grained intrusive rock of intermediate composition; sandy and silty loam soils of variable thickness; thick regolith in places; very high erosion potential and steep-slope failure potential; moderate ground-water potential in moderately to gently sloping valley areas; excellent quarry rock where fresh.

KJgb — Gabbro: Gray-green, coarse-grained intrusive rock consisting of augite and plagioclase; deeply weathered with brown to rusty red soil; moderately high erosion potential; low ground-water potential; geologic relation to diorite unclear.

sp — Serpentinite: Rocks consisting of minerals of the serpentine group and including olivine and pyroxene; complex Triassic origin and remobilized along later faults to present positions; brownish to reddish loam and clay soils; scant vegetation; slide prone.

Ti — Tertiary intrusive rock: Sills, stocks, and dikes of diorite, gabbro and basalt north and east of Bear Creek; basaltic dikes east of the mapped area; quarry rock potential variable; depth of weathering variable.

Mineral Mines and Prospects

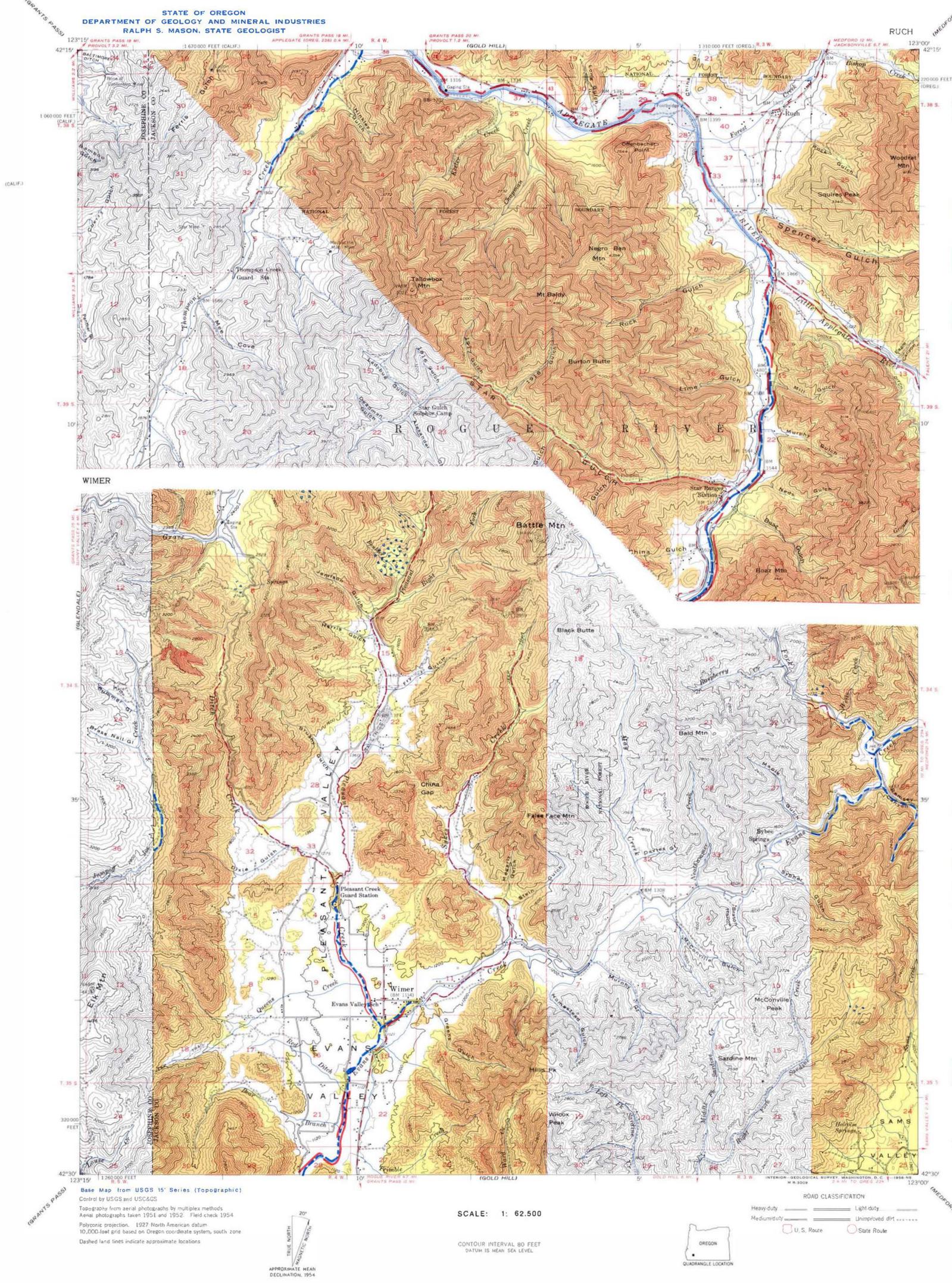|					
Ag	Silver	Hg	Mercury	Mo	Molybdenum
Au	Gold	Mg	Magnesium	Pb	Lead
Cu	Copper	Mn	Manganese	W	Tungsten
				Zn	Zinc

GEOLOGIC SYMBOLS

Contacts
Definite contact
Approximate contact

Faults
Definite fault
Approximate fault
Inferred fault
Concealed fault
Normal fault (ball and bar on downthrown side)

Folds
Definite anticline
Definite syncline
Approximate anticline
Approximate syncline
Inferred anticline
Inferred syncline
Concealed anticline
Concealed syncline

Bedding
Strike and dip of bed
Strike of vertical bed
Horizontal bed

Spring

Base Map from USGS 15' series (Topographic)
Control by USGS and USC&GS
Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951 and 1952. Field check 1954
Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon coordinate system, south zone
Dashed land lines indicate approximate sections

SCALE: 1: 62,500

ROAD CLASSIFICATION
Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U.S. Route — State Route

CONTOUR INTERVAL 80 FEET
DATUM IS MEAN SEA LEVEL

Geologic Cross Sections

A — A'

B — B'

GEOLOGIC HAZARD MAP
of the
parts of RUCH & WIMER QUADRANGLES
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation.)

Average (Regional) Slope

Interpreted from maps with scale 1:62,500

0 - 5 % — Local slopes 0-10%; landforms include flood plains, terraces, pediments and ridge crests; hazards include ponding, high ground water, flooding, and stream bank erosion; land-use potential good in areas of minimal hazard.

5 - 15 % — Local slopes 0-50%; landforms include gentle slopes and ridge crests surrounding larger valleys; hazards include moderate erosion potential and local mass movement; land-use potential good to fair, primarily devoted to agriculture and low density residential.

15-30% — Local slopes 10-50%; landforms include moderately steep hills and valleys; hazards include moderate slope-erosion potential and local to large scale mass movement; land-use potential variable.

30-50% — Greater than 50% slope locally; landforms include valleys and mountains; hazards include severe erosion potential, earth-flow, slump, and minor steep slope failure; land-use potential generally limited to very sparse development and well-managed forestry.

< 50 % — 50% to vertical locally; landforms include steep canyons, cliffs and mountains; local hazards include rockfall, rockslide, debris avalanche, and severe erosion potential; land-use generally restricted to well-managed forestry and open space.

GEOLOGIC HAZARDS

Mass Movement

Deep bedrock slides: Large areas of deep failure involving bed rock in addition to soil and regolith; active and inactive; recognized by large scale topograhic irregularities and displacement of bedrock units; distribution in study area generally determined by faults; possible hazards may include continued sliding, variable foundation strength, variable cutbank stability, poor drainage, and others; potential for development generally low.

Earthflow and slump topography (areas less than 10-20 acres not shown; see Slope): Moderately sloping terrain with irregularities of slope, drainage, or soil distribution; recent movement shown by tension cracks, bowed trees, and others; most widespread in Teot and Teov units, and deeply weathered bed rock; most common in areas of streambank erosion or active headward erosion of streams; possible hazards include continued movements, low cutbank stability, poor drainage, and others; development possible locally, but generally may reactivate or accelerate sliding.

Steep-slope mass movement: General areas subject to localized rock fall, rockslide, debris avalanche, and debris flow; most widespread in steeply sloping KJd, Tpmc, Tpav and Tpai; specific occurrences controlled by faults, joints, soil water, soil thickness, vegetative cover and land use; mitigation may include structural solutions, drainage control, and appropriate land-use and forest management practices.

Potential future mass movement: Places of highest potential for future mass movement through improper or changing land use include:
Deep bedrock slides — areas of regional faulting or interbedded rocks of differing engineering properties.
Earthflow and slump topography — tuffaceous interbeds of Teot and Teov; also deeply weathered bed rock.
Steep slope failure — steeply sloping KJd, Tpmc, Tpav, and Tpai especially in areas of soil water accumulation, joints, or faults.
Delineation requires detailed mapping on larger scale than that of this study.

Flooding

Flood of 1964: Distribution of flood of December, 1964 as determined by U.S. Army Corps of Engineers (1965) using limited observations and gage height data; approximates a 50-year or 2% flood.

Flood of 1861: Distribution of flood of 1861 as determined by U.S. Army Corps of Engineers (1965) using limited observations; approximates a 100-year or 1% flood.

Flood-prone areas: Areas subject to flood hazard of 50- to 100-year frequency near Tolo and Brownsboro, and streams subject to bank overflow (distribution of adjacent lowland ponding not indicated); based on reconnaissance observations and landform analysis.

High ground water and ponding: Accumulation of water in the shallow subsurface or on the surface as a result of flat topography, poor drainage, bank overflow, rain water ponding, irrigation, or other natural or man-induced causes; most widespread on flat Qoa and Qhg; features include distinctive soils and vegetation, depressions, and others; Delineation requires detailed factor mapping on a larger scale than that of this study.

Erosion

Slope erosion: Loss of soil by moving water on slopes; favored by sandy or silty soils (especially over KJd), lack of consolidation, slope gradient, slope length, and absence of vegetation or other protective cover; removes valuable topsoil and causes deposition downslope; may cause siltation of streams, municipal water supplies etc.; wide variety of engineering and land management techniques for control.

Channel change: Areas of relocated stream channel by natural means since preparation of base maps (1954); common between Dodge Bridge and Raygold on Rogue River and downstream from Applegate on Applegate River; indicates areas of unstable channel and high velocity floodways.

Critical stream-bank erosion (not including torrential flood channels): Undercutting and caving of river and stream banks by stream action; restricted primarily to outer bends of meanders on larger streams; characterized by steep slopes, deep water near shore, and actively growing bars on inner bend; mitigation may include riprap, channel modification, bar removal, and land-use restrictions depending on local hydraulics, desired land use, and erosion rates.

Torrential flooding: Areas of high probability for floods characterized by rapidly flowing water with high channel and stream bank erosion potential in narrow canyons with little or no flood plain; generally restricted to high gradient streams flowing through steep terrain of high relief; channel deposits generally coarse and poorly sorted.

Base Map from USGS 15' Series (Topographic)

Control by USGS and USC&GS
Topography from aerial photographs by multiplex methods
Aerial photographs taken 1951 and 1952. Field check 1954
Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon coordinate system, south zone
Dashed land lines indicate approximate locations

SCALE: 1: 62,500

CONTOUR INTERVAL 80 FEET
DATUM IS MEAN SEA LEVEL

APPROXIMATE MEAN DECLINATION, 1954

ROAD CLASSIFICATION

Heavy-duty _____ Light-duty _____
Medium-duty _____ Unimproved dirt _____
U.S. Route   State Route

QUADRANGLE LOCATION

GEOLOGIC HAZARDS by J. D. Beaulieu, 1977
SLOPE INTERPRETATION by C. A. Schumacher, 1977
CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
EDITED by C. A. Schumacher, 1977

Prepared and Published by the Cartographic Section of the Department of Geology and Mineral Industries
Ralph S. Mason, State Geologist; C. A. Schumacher, Chief Cartographer

GEOLOGIC MAP
of
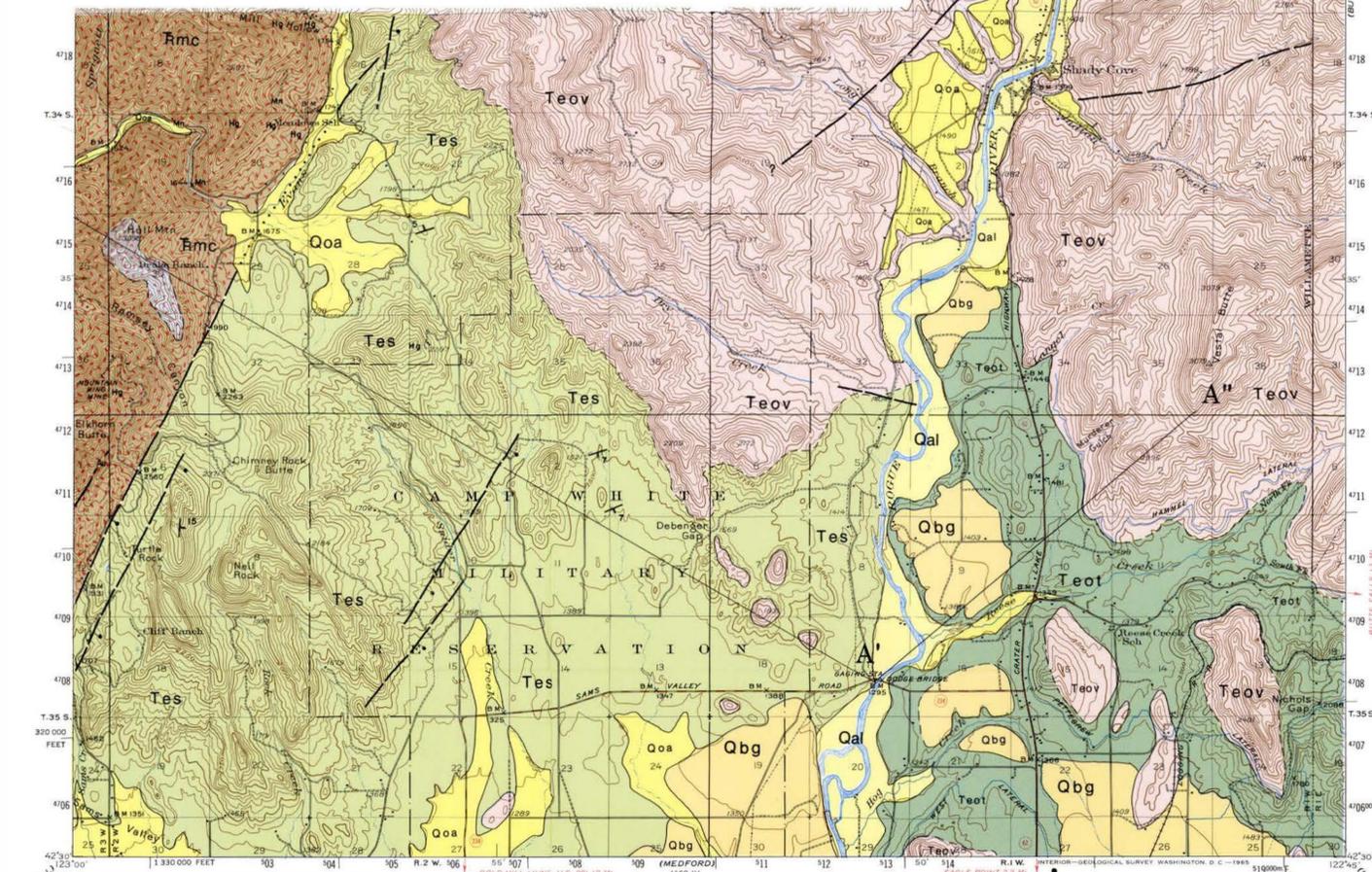## parts of TRAIL & TALENT QUADRANGLES
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST
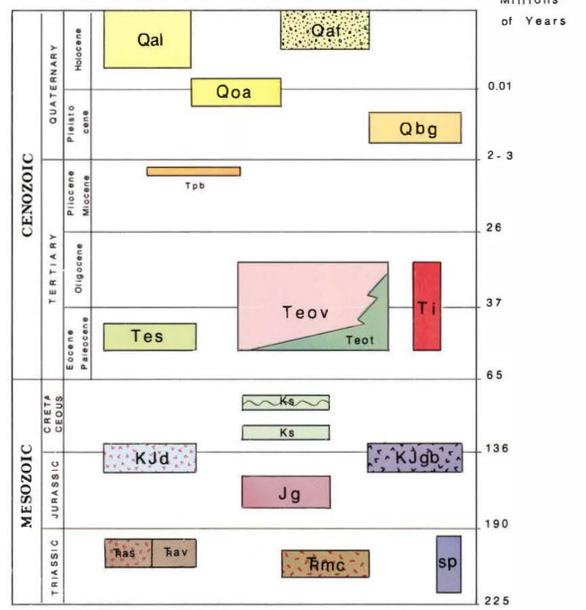
TALENT QUADRANGLE
CONTOUR INTERVAL 80 FEET
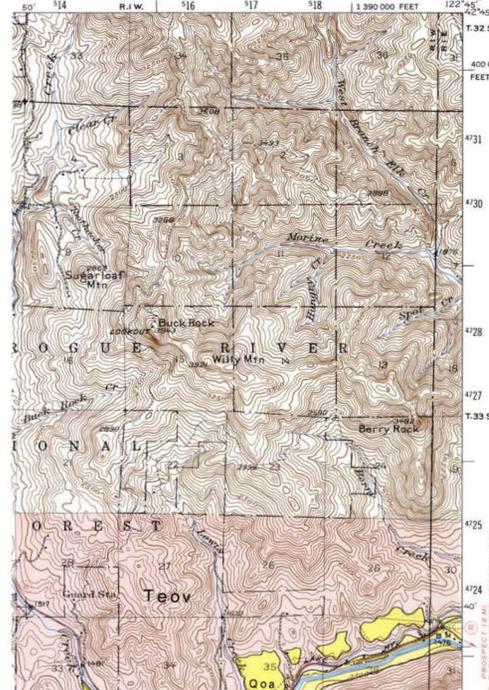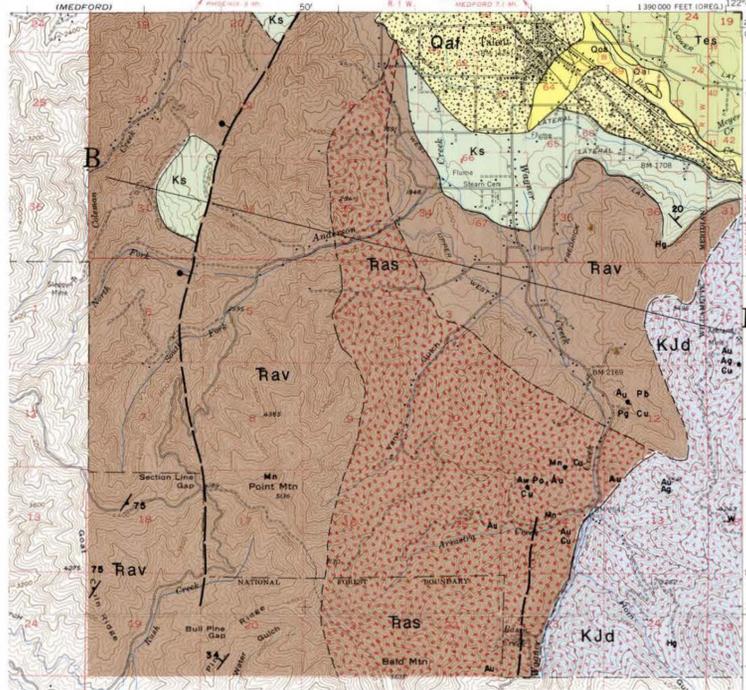
Bedrock Geology modified after Wells and others, 1956, and McKnight, 1973, by
John D. Beaulieu, 1977
Surficial Geology by John D. Beaulieu, 1977

TRAIL QUADRANGLE
CONTOUR INTERVAL 50 FEET

TIME ROCK CHART

Millions of Years

0.01
2 - 3
26
37
65
136
190
225

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation)

SURFICIAL GEOLOGIC UNITS

Stream deposits

Qal — Quaternary alluvium: Unconsolidated gravel, sand, silt, and clay in stream beds and flood plains of major streams; equivalent to part of Qal of Wells and others (1956); not shown along smaller streams owing to limitations of scale; subject to stream flooding; immature soils.

Qaf — Quaternary alluvial fan deposits: Unconsolidated gravel, sand, and silt occurring as fan deposits adjacent to Qoa at the mouths of some torrential flood channels; subject locally to torrential flooding, bank overflow, erosion, and deposition.

Qoa — Quaternary older alluvium: Unconsolidated gravel, sand, silt, and clay on terraces generally above flood plains of major streams; also alluvial terraces of upland streams; equivalent in part to Qal of Wells and others (1956); includes several intermediate terrace levels of varying ages; subject to local flooding, ponding and high ground water; restrictive soil forms.

Qbg — Quaternary bench gravels: Semi-consolidated gravel, sand, clay, and silt forming high level terrace in Bear Creek Valley and along Rogue River; upper horizons rich in clay; includes Qtg of Wells and along Bear Creek (1956); generally characterized by distinctive 'patterned' ground of low interconnected rocky channels; restrictive soil layers; subject to poor drainage, ponding and high ground water.

BEDROCK GEOLOGIC UNITS

Volcanic and sedimentary rocks

Tpb — Pliocene basalt: Equivalent to pre-Mazama basalt of Wells and others (1956); grayish-black, dense, fresh basalt; several flows with total thickness of 125 feet; caps Upper and Lower Table Rocks; vertical columnar joints and irregular joints; interpreted as intercanyon flow rock of ancient Rogue River valley now preserved as inverted topography.

Teov — Eocene and Oligocene volcanic rock: Equivalent to Roxy Formation of Wells and others (1956) and agglomerate and older basalt flows of Wilkinson and others (1941); andesitic flows, breccias, agglomerates, and tuffs with interbedded sandstone and shale; rhyolitic and dacitic flows locally; flow thickness 10-100 feet; flow rocks hard and stable; tuffs and sedimentary rock slide-prone in places; Oligocene leaf prints; similar rocks interbedded with Tes near Emigrant Creek Reservoir; soils highly variable.

Teot — Eocene and Oligocene tuffaceous rocks: Equivalent to part of Tc of Wells and others (1956); varicolored tuffs and sedimentary rocks derived from volcanic rocks, minor interbedded flow rock; soft to moderately hard; low infiltration rates; slide-prone over large areas; possibly not correlative with type Tc south of map area; similar rocks interbedded with Tes near Emigrant Creek Reservoir; clay-rich soils.

Tes — Eocene sedimentary rock: Equivalent to part of Tu of Wells and others (1956) and to Teu of Wilkinson and others (1941); river-deposited hard sandstone, shale, and conglomerate with local coal seams in south; shallow marine sandstone and siltstone in north; tuffaceous debris throughout; regolith variable; distinctly bedded; slides rare; low infiltration rates; volcanic rock interbeds and late Eocene leaves in south; impermeable soil horizons on terrace forms.

Ks — Cretaceous sedimentary rock: Equivalent to Kh and part of Tu of Wells and others (1956); hard conglomerate and sandstone overlain by mudstone and minor sandstone near Ashland; sandstone at Graves Creek; depth of weathering variable with slope and rock type; moderate ground-water potential locally; Early Cretaceous (Albian) at Graves Creek; middle Cretaceous (Cenomanian and Turonian) near Ashland.

Jg — Galice Formation: Dark gray to black shale with minor thin-bedded sandstone and graule conglomerate; moderate to high foundation strength, low ground-water potential; silty clay loam soils of variable thickness; thick base slope colluvium; hazards include slope erosion and local mass movement.

Metamorphic rocks

Rav / Ras — Applegate Formation: Rav — Equivalent to metavolcanics of Wells and others (1940); altered lava flows, flow breccias, and pyroclastic rocks with minor tuffaceous sedimentary rocks; grades into Rmc; hard, steep terrain, very low permeability, thin soil with exception of base slope colluvium; mineralization in places near intrusive rock. Ras — Equivalent to metasedimentary rocks of Wells and others (1940); altered tuffaceous sedimentary rock, argillite, chert, and limestone; minor volcanic rocks locally; variable engineering properties; thick regolith and high slide potential where deeply weathered.

Rmc — May Creek Schist: Medium-grade metamorphic rocks derived from Rav, Ras and possibly Jg; includes mafic metavolcanic rock, mica schist, phyllite, and slate; weakly to strongly foliated; hard, impermeable, thin regolith with exception of thick base slope colluvium; potential for steep-slope failure; product of multiple metamorphism culminating in prominent granitic plutonism (Kays, 1970).

Intrusive rocks

KJd — Diorite and granodiorite: Light gray medium-grained intrusive rock of intermediate composition; sandy and silty loam soils of variable thickness; thick regolith in places; very high erosion potential and steep-slope failure potential; moderate ground-water potential in moderately to gently sloping valley areas; excellent quarry rock where fresh.

KJgb — Gabbro: Gray-green, coarse-grained intrusive rock consisting of mafic and plagioclase; deeply weathered with brown to rusty red soil; moderately high erosion potential; low ground-water potential; geologic relation to diorite unclear.

sp — Serpentinite: Rocks consisting of minerals of the serpentine group and locally including olivine and pyroxene; complex Triassic origin and remobilized along later faults to present positions; brownish to reddish loam and clay soils; scant vegetation; slide prone.

Ti — Tertiary intrusive rock: Sills, stocks, and dikes of diorite, gabbro and basalt north and east of Bear Creek, and basaltic dikes east of the mapped area; quarry rock potential variable; depth of weathering variable.

Mineral Mines and Prospects

Ag	Silver	Hg	Mercury	Mo	Molybdenum
Au	Gold	Mg	Magnesium	Pb	Lead
Cu	Copper	Mn	Manganese	W	Tungsten
				Zn	Zinc

GEOLOGIC SYMBOLS

Contacts
Definite contact
Approximate contact

Faults
Definite fault
Approximate fault
Inferred fault
Concealed fault
Normal fault (ball and bar on downthrown side)

Folds
Definite anticline
Definite syncline
Approximate anticline
Approximate syncline
Inferred anticline
Inferred syncline
Concealed anticline
Concealed syncline

Bedding
Strike and dip of bed
Strike of vertical bed
Horizontal bed
Spring

Geologic Cross Sections

A — A' — A''

B — B'

Base Map from USGS 15' series (Topographic)

ROAD CLASSIFICATION
Heavy-duty   Light-duty
Medium-duty   Unimproved dirt
State Route

SCALE 1:62500

Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon (South)
rectangular coordinate system
1000-meter Universal Transverse Mercator grid ticks,
zone 10, shown in blue

Prepared and Published by the Cartographic Section
of the Department of Geology and Mineral Industries
Ralph S. Mason, State Geologist; C. A. Schumacher, Chief Cartographer

CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
EDITED by C. A. Schumacher, 1977

Bedrock Geology modified after Wilkinson and others, 1941, by John D. Beaulieu, 1977
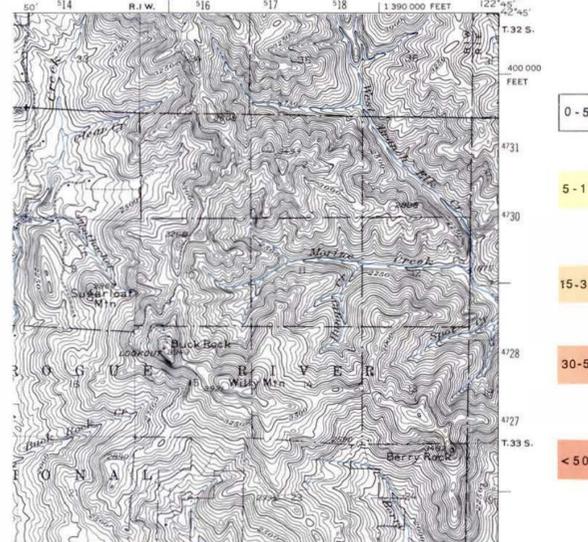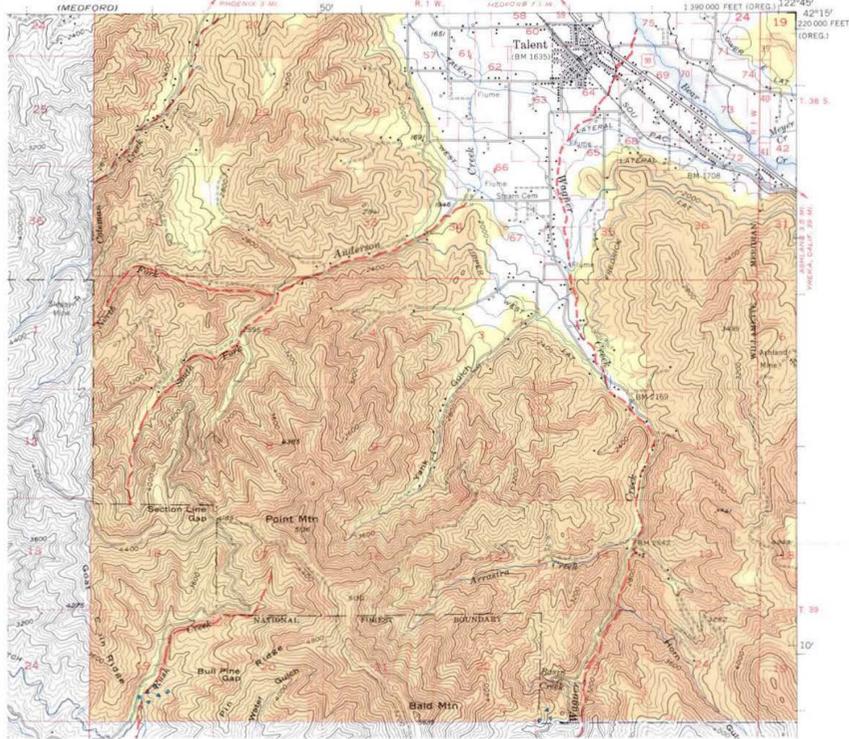Surficial Geology by John D. Beaulieu, 1977

GEOLOGIC HAZARD MAP
of the
parts of TRAIL & TALENT QUADRANGLES
OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
RALPH S. MASON, STATE GEOLOGIST

TALENT QUADRANGLE
CONTOUR INTERVAL 80 FEET

TRAIL QUADRANGLE
CONTOUR INTERVAL 50 FEET

Base Map from USGS 15' Series (Topographic)

ROAD CLASSIFICATION

Heavy-duty _____   Light-duty _____
Medium duty _____   Unimproved dirt ....
○ State Route

SCALE 1:62500

Polyconic projection. 1927 North American datum
10,000-foot grid based on Oregon (South)
rectangular coordinate system
1000-meter Universal Transverse Mercator grid ticks,
zone 10, shown in blue

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1945

EXPLANATION

(Boundaries are approximate; statements are general; specific evaluations require on-site investigation.)

Average (Regional) Slope
Interpreted from maps with scale 1:62,500

0 - 5 % — Local slopes 0-10%; landforms include flood plains, terraces, pediments and ridge crests; hazards include ponding, high ground water, flooding, and stream bank erosion; land-use potential good in areas of minimal hazard.

5 - 15 % — Local slopes 0-50%; landforms include gentle slopes and ridge crests surrounding larger valleys; hazards include moderate erosion potential and local mass movement; land-use potential good to fair, primarily devoted to agriculture and low density residential.

15-30% — Local slopes 10-50%; landforms include moderately steep hills and valleys; hazards include moderate slope-erosion potential and local to large scale mass movement; land-use potential variable.

30-50% — Greater than 50% slope locally; landforms include valleys and mountains; hazards include severe erosion potential, earthflow, slump, and minor steep slope failure; land-use potential generally limited to very sparse development and well-managed forestry.

< 50 % — 50% to vertical locally; landforms include steep canyons, cliffs and mountains; local hazards include rockfall, rockslide, debris avalanche, and severe erosion potential; land-use generally restricted to well-managed forestry and open space.

GEOLOGIC HAZARDS

Mass Movement

Deep bedrock slides: Large areas of deep failure involving bed rock in addition to soil and regolith; active and inactive; recognized by large scale topographic irregularities and displacement of bedrock units; distribution in study area generally determined by faults; possible hazards may include continued sliding, variable foundation strength, variable cutbank stability, poor drainage, and others; potential for development generally low.

Earthflow and slump topography (areas less than 10-20 acres not shown; see Slope): Moderately sloping terrain with irregularities of slope, drainage, or soil distribution; recent movement shown by tension cracks, bowed trees, and others; most widespread in Teot and Teov units, and deeply weathered bed rock; most common in areas of streambank erosion or active headward erosion of streams; possible hazards include continued movements, low cutbank stability, poor drainage, and others; development possible locally, but generally may reactivate or accelerate sliding.

Steep-slope mass movement: General areas subject to localized rock fall, rockslide, debris avalanche, and debris flow; most widespread in steeply sloping KJd, Tmc, Tav and Tas; specific occurrences controlled by faults, joints, soil water, soil thickness, vegetative cover and land use; mitigation may include structural solutions, drainage control, and appropriate land-use and forest management practices.

Potential future mass movement: Places of highest potential for future mass movement through improper or changing land use include:
Deep bedrock slides — areas of regional faulting or interbedded rocks of differing engineering properties.
Earthflow and slump topography — tuffaceous interbeds of Teot and Teov; also deeply weathered bed rock.
Steep slope failure — steeply sloping KJd, Tmc, Tav, and Tas especially in areas of soil water accumulation, joints, or faults.
Delineation requires detailed mapping on larger scale than that of this study.

Flooding

Flood of 1964: Distribution of flood of December, 1964 as determined by U.S. Army Corps of Engineers (1965) using limited observations and gage height data; approximates a 50-year or 2% flood.

Flood of 1861: Distribution of flood of 1861 as determined by U.S. Army Corps of Engineers (1965) using limited observations; approximates a 100-year or 1% flood.

Flood-prone areas: Areas subject to flood hazard of 50- to 100-year frequency near Tolo and Brownsboro, and streams subject to bank overflow (distribution of adjacent lowland ponding not indicated); based on reconnaissance observations and landform analysis.

High ground water and ponding: Accumulation of water in the shallow subsurface or on the surface as a result of flat topography, poor drainage, bank overflow, rain water ponding, irrigation, or other natural or man-induced causes; most widespread on flat Qoa and Qbg; features include distinctive soils and vegetation, depressions, and others; Delineation requires detailed factor mapping on a larger scale than that of this study.
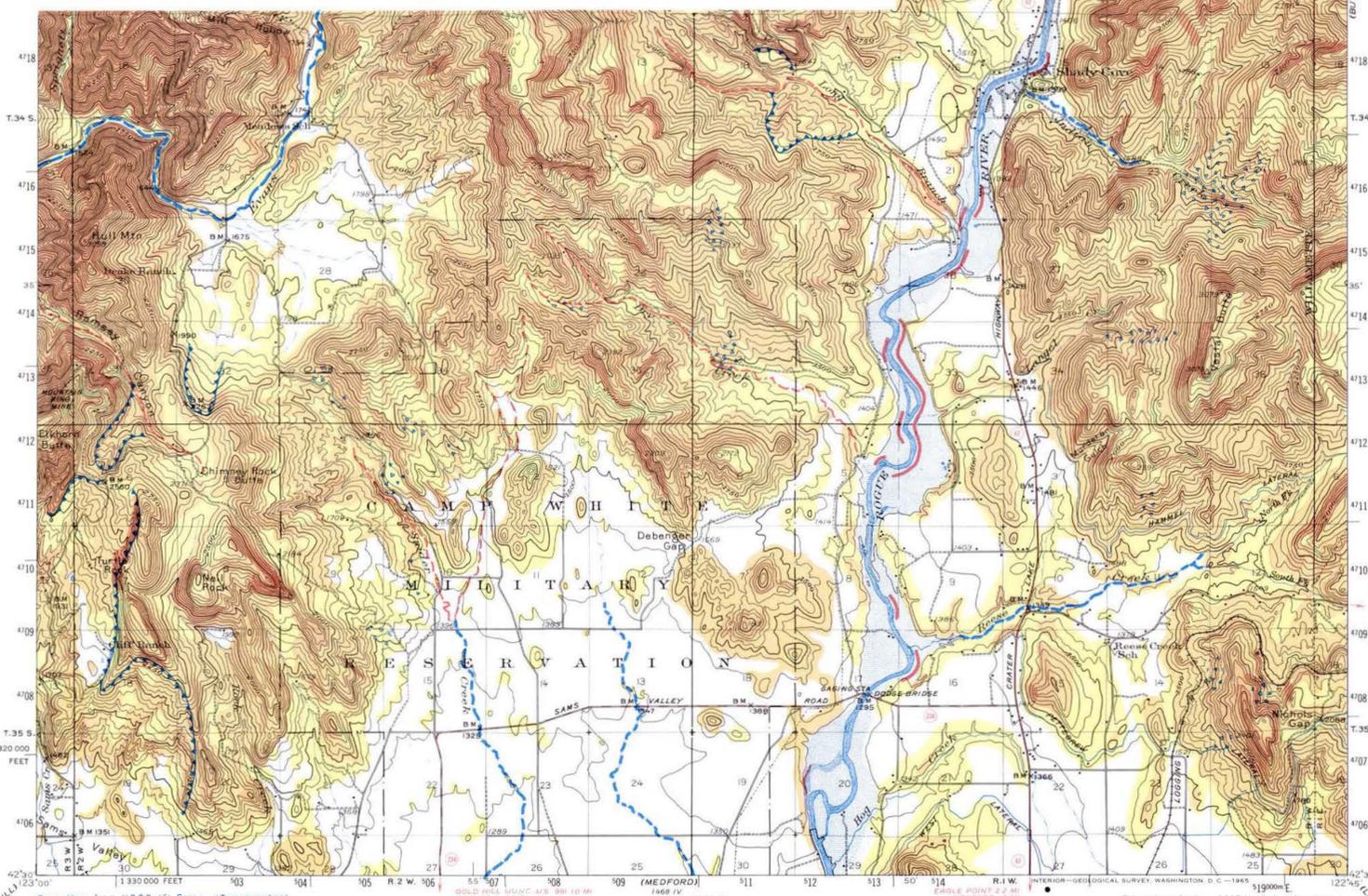
Erosion

Slope erosion: Loss of soil by moving water on slopes; favored by sandy or silty soils (especially over KJd), lack of consolidation, slope gradient, slope length, and absence of vegetation or other protective cover; removes valuable topsoil and causes deposition downslope; may cause siltation of streams, municipal water supplies etc.; wide variety of engineering and land management techniques for control.

Channel change: Areas of relocated stream channel by natural means since preparation of base maps (1954); common between Dodge Bridge and Raygold on Rogue River and downstream from Applegate on Applegate River; indicates areas of unstable channel and high velocity floodways.

Critical stream-bank erosion (not including torrential flood channels): Undercutting and caving of river and stream banks by stream action; restricted primarily to outer bends of meanders on larger streams; characterized by steep slopes, deep water near shore, and actively growing bars on inner bend; mitigation may include riprap, channel modification, bar removal, and land-use restrictions depending on local hydraulics, desired land use, and erosion rates.

Torrential flooding: Areas of high probability for floods characterized by rapidly flowing water with high channel and stream bank erosion potential in narrow canyons with little or no flood plain; generally restricted to high gradient streams flowing through steep terrain of high relief; channel deposits generally coarse and poorly sorted.
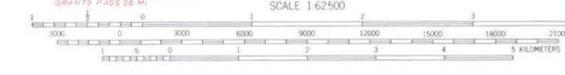
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CARTOGRAPHY by C. A. Schumacher, Wendy John, and Rose Reed, 1977
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