A DESCRIPTION OF AQUIFER UNITS IN WESTERN OREGON

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[Plates are in pocket]

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FACTORS FOR CONVERTING INCH-POUND UNITS TO METRIC UNITS

For readers who prefer SI (International System of Units) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

To convert from	To	Multiply by
	Length	
inch (in.)	millimeter (mm)	25.4
foot (ft)	meter (m)	0.3048
mile (mi)	kilometer (km)	1.609
	Area	
square foot (ft^2)	square meter (m^2)	0.0929
acre	square meter (m^2)	4,047
	square hectometer (hm^2)	0.4047
square mile (mi^2)	square kilometer (km^2)	2.590
	Volume	
cubic foot (ft^3)	cubic meter (m^3)	0.02832
gallon (gal)	liter (L)	3.785
million gallons (Mgal)	cubic meter (m^3)	3,785
	Specific combinations	
foot per day (ft/d)	meter per day (m/d)	0.3048
foot squared per day (ft^2/d)	meter squared per day (m^2/d)	0.929
gallon per minute (gal/min)	liter per second (L/s)	0.06309
gallon per minute per foot (gal/min)/ft	liter per second per meter (L/s)/m	0.2070
million gallons per day (mgal/d)	cubic meter per day (m^3/d)	3,785
	cubic meter per second (m^3/s)	0.04381
	Temperature	
degree Fahrenheit (°F)	degree Celsius (°C)	([1])

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[1] Temp °C = (temp °F-32)/1.8.

GLOSSARY

Aquifer.--A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield or be capable of yielding usable quantities of water to wells and springs.

Drawdown.--The lowering of the water level in an aquifer during pumping. The difference in altitude between the static water level and the pumping level.

Ground water, confined.--Ground water that is under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

Ground water, perched.--Perched ground water is separated from an underlying body of ground water by an unsaturated zone. Perched ground water is held up by a low permeability bed.

Ground water, unconfined.--Water in an aquifer that has a water table.

Head, static.--The height above a standard datum of the surface of a column of water that can be supported by the static pressure at a given point. The terms "head" and "water level" are used interchangeably in this report. The water level in a well represents the composite head in the water-bearing materials open to the well bore.

Hydraulic conductivity.--The hydraulic conductivity of a medium is the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydrogeologic map.--A map that illustrates geologic formations or groups of formations with reference to their hydraulic properties.

Injection well.--A well into which a fluid is pumped or drained (such as wells used to increase the yield of other wells in an area or to dispose of fluids in the subsurface environment).

National Geodetic Vertical Datum of 1929 (NGVD of 1929).--A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level.

Permeability.--The permeability of a rock or soil is a measure of its ability to transmit fluid, such as water, under a hydraulic gradient. Quantitatively referred to as hydraulic conductivity.

Porosity.--The porosity of a rock or sediment is its property of containing interstices or voids and may be expressed quantitatively as the ratio of the volume of the interstices to the total volume.

Saturated thickness.--The thickness of the saturated part of a geologic formation or group of formations.

Specific capacity.--The rate of discharge of water from a well divided by the drawdown of the water level in the well. If the specific capacity is constant except for the variation with time, it is roughly proportional to the transmissivity of the aquifer.

Storage coefficient.--The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Transmissivity.--The rate at which water of prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths.

Water table.--That surface in a ground-water body at which the water pressure is atmospheric. It is defined by the levels at which water stands in wells that peneterate the water body just far enough to hold standing water.

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ABSTRACT

Seven aquifer units were delineated for western Oregon by grouping aquifers according to hydraulic and geologic similarities. The bedrock aquifer units in the Klamath Mountains, Coast Range, and Western Cascade Range all have hydraulic conductivities generally less than 2 feet per day and generally yield less than 10 gallons per minute to wells. The Columbia River Basalt Group aquifer unit, which is present along the Columbia River and in the northern Willamette Valley, also has a low hydraulic conductivity of about 5 feet per day; however, the basalt does contain permeable interflow zones and scoriaceous flow tops that transmit water laterally. Well yields from the Columbia River Basalt Group are generally less than 100 gallons per minute.

The most important aquifer unit in western Oregon is the Tertiary-Quaternary sedimentary deposits that occur in lowlands throughout the area and provide water for irrigation, industry, public supplies, and domestic and stock uses. Hydraulic conductivity of the most recent alluvium in the aquifer unit is generally 200 to 600 feet per day in the Willamette Valley, and well yields exceeding 2,000 gallons per minute have been reported.

At shallow depths, the seven aquifer units generally contain water with low concentrations of dissolved solids. In the Tertiary rocks of the Coast Range, analyses of water from deep wells indicate that water with more than 10,000 milligrams per liter dissolved solids is probably widespread at depths greater than 2,000 feet.

INTRODUCTION

Objectives and Scope

Under the authority of the Safe Drinking Water Act, the U.S. Environmental Protection Agency (EPA) is responsible for development and implementation of an Underground Injection Control (UIC) Program to protect the Nation's ground-water supply from contaminants injected into the subsurface. The U.S. Environmental Protection Agency (1975) regulations state that any aquifer containing water with fewer than 10,000 mg/L (milligrams per liter) of dissolved solids is to be protected. One of EPA's objectives in the UIC Program is to be able to estimate the size of the area around a proposed injection well that could be affected by increased pressures as a result of injection. EPA refers to the area as the "area of review" and defines it as "*** that area the radius of which is the lateral distance from an injection well pattern in which pressure changes resulting from the injection operation may cause the migration of the injection and (or) formation fluid into an underground source of drinking water" (U.S. Environmental Protection Agency, 1979).

In Oregon, the U.S. Geological Survey was asked by the EPA to supply hydrogeologic information that will aid in the evaluation of proposals for underground injection. This report deals with aquifers in Oregon west of the Cascade Range crest. The three primary objectives of the project were to (1) delineate and describe the major aquifers, (2) describe the quality of water in those aquifers and identify geologic formations containing water with dissolved-solids concentrations exceeding 10,000 mg/L, and (3) evaluate methods by which the area of review may be estimated for proposed injection wells in western Oregon.

During compilation of information for objectives 1 and 2, it became apparent that detailed hydrogeologic data for western Oregon's aquifers are inadequate for making reliable estimates of the area of review at any locality without first obtaining more site-specific data. However, rough preliminary calculations can be made to determine the order of magnitude of the size of the area of review using data tabulated in this report in conjunction with mathematical equations for predicting pressure buildup presented in an EPA publication "Radius of Pressure Influence of Injection Wells," by Warner and others (1979). These rough calculations can be improved using data obtained by test drilling and aquifer testing at the proposed injection site. For a detailed discussion of underground injection, the reader is referred to "An Introduction to the Technology of Subsurface Wastewater Injection," by Warner and Lehr (1977).

This report is intended as a general guide for the EPA or other agencies involved in evaluation of proposals to inject waste into the subsurface in western Oregon. It is not intended for use as a sole source of information in evaluating specific sites for underground injection. Detailed information would need to be collected and analyzed on a site-by-site basis to perform such evaluations.

Method of Study and Available Information

Most of the information in this report is compiled from published reports of the U.S. Geological Survey, Oregon Water Resources Department, and Oregon Department of Geology and Mineral Industries (see Selected References, p. 20-25). Additional data were obtained from western Oregon water well reports and lithologic and geophysical logs of more than 60 exploratory oil and gas wells.

Geologic contacts shown on plate 1 and other plates in this report are primarily from the "Geologic Map of Oregon West of the 121st Meridian" (Wells and Peck, 1961). In some areas where more recent studies have been made, contacts from Wells and Peck (1961) were modified slightly. Generally, outcrops with an areal extent less than 1 mi^2 were not included in the plates. An important source of geologic background information is the publication "Geology of Oregon" (Baldwin, 1976).

Description of the Area and its Climate

Oregon is divided into western and eastern Oregon by the Cascade Range that trends north-south through the State. Approximately one-third of the State lies west of the crest of the range. The Cascade Range is an orographic barrier for eastward-moving oceanic weather systems and is a major drainage divide. Western Oregon has a mild climate and is rather humid with an average annual precipitation that ranges from about 30 in. in lowlands to more than 150 in. in the Cascade Range. Most precipitation occurs in fall and winter.

Western Oregon is about 30,000 mi^2 in area and for this study is subdivided into four physiographic divisions: Klamath Mountains, Coast Range, Cascade Range, and Willamette Valley (fig. 1). Each division has a distinct geologic and hydrologic setting. Topographically high areas generally receive the most precipitation and, therefore, water available for recharge to the aquifers is greatest in those areas. The Klamath Mountains occupy most of southwestern Oregon and extend southward into northern California. They are rugged, have 2,000 to 5,000 ft of relief and, locally, receive more than 120 in. of precipitation annually (fig. 2).

The Coast Range parallels the Oregon coast and extends from the Columbia River on the north to the latitude of Coos Bay, Oreg. on the south where it merges with the Klamath Mountains. The altitude of the crest of the Coast Range averages about 1,500 ft with peaks as high as 4,000 ft. Local areas of the Coast Range receive more than 200 in. of precipitation each year.

The Cascade Range includes some of Oregon's highest peaks. The crest of the range averages about 5,000 ft in altitude and a few peaks along the crest rise to more than 10,000 ft. Some of the highest peaks receive more than 150 in. of precipitation annually, most of which falls as snow in the winter. Because of differences in underlying geologic formations, the Cascades are subdivided into two sections, the Western Cascades and the High Cascades. The Western Cascades form the western foothills of the range and are more deeply eroded and lower in altitude than the High Cascades, which are composed of geologically younger volcanic deposits (Peck and others, 1964).

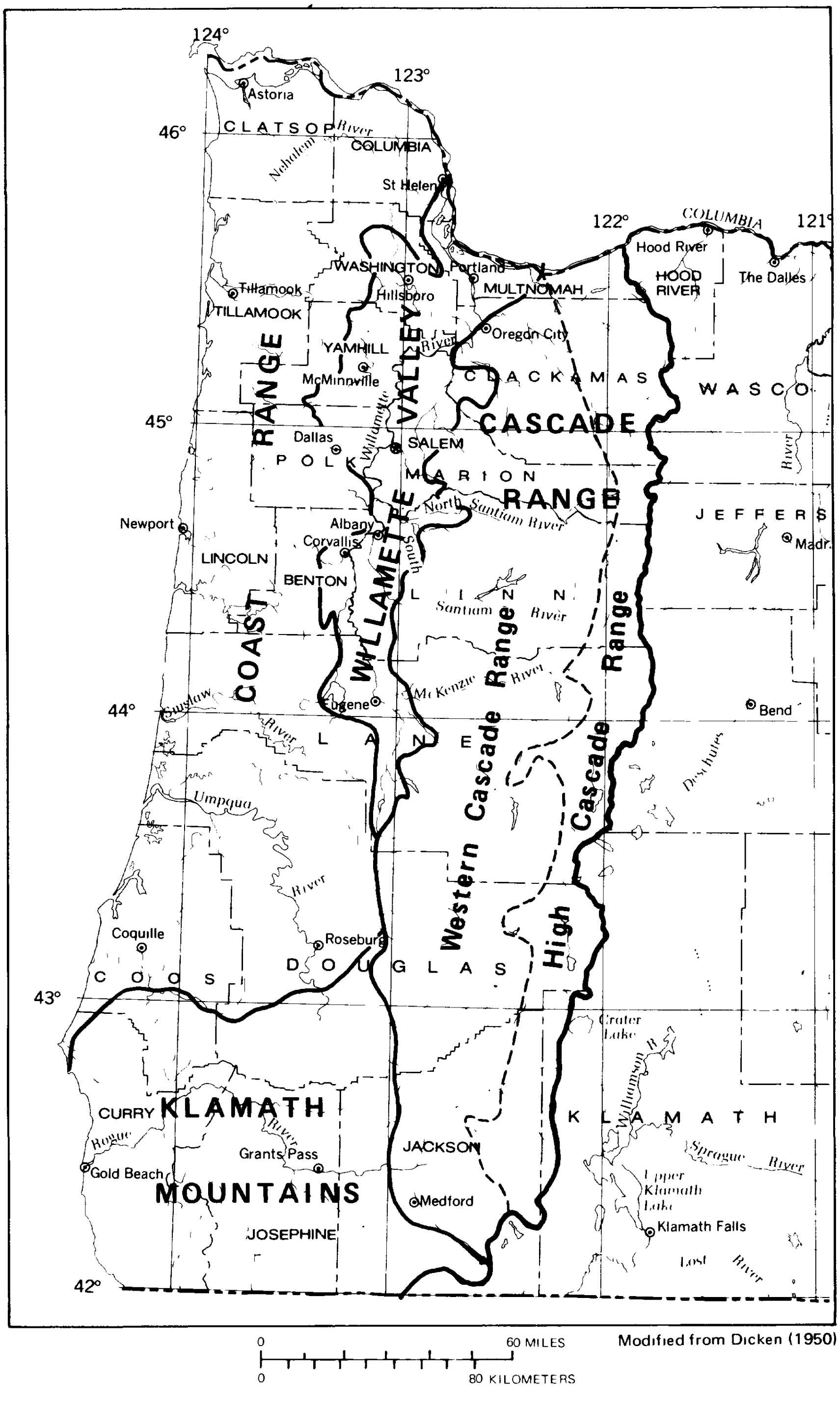
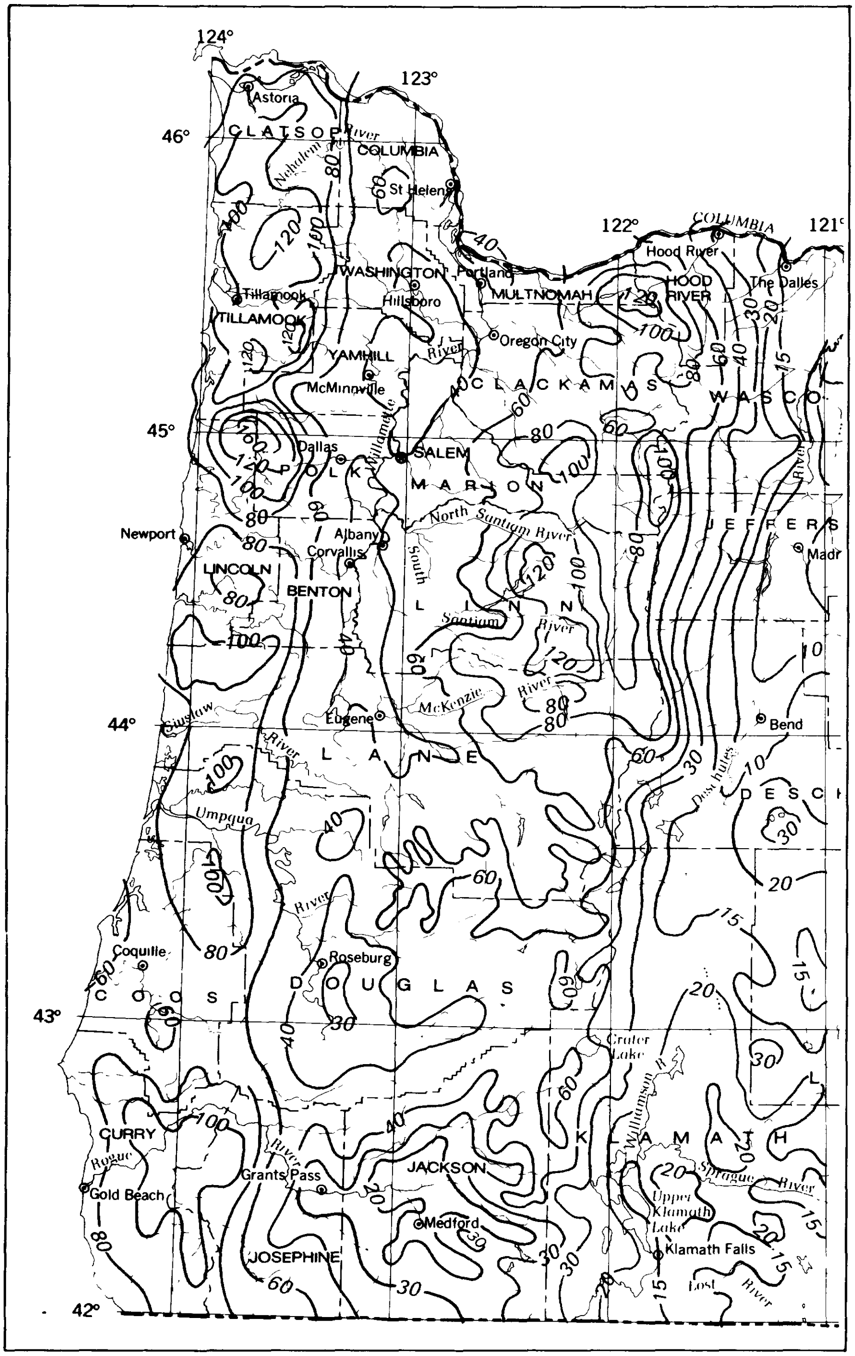


FIGURE 1. Western Oregon and its physiographic divisions.



From: U.S. Geological Survey (1969)

FIGURE 2. – Average annual precipitation in Western Oregon, in inches.

The Willamette Valley is the major lowland of the region. It lies between the Coast and Cascade Ranges and extends from the Columbia River on the north to Cottage Grove, Oreg., on the south. Oregon's three largest cities, Portland, Salem, and Eugene, are in the valley where two-thirds of the State's population resides. The average annual precipitation is about 40 in. in the Willamette Valley.

Seven principal surface-water basins occur in western Oregon (fig. 3 and pl. 1). Rivers in the Willamette and Sandy Basins drain into the Columbia River. Rivers in the North, Mid, and South Coast Basins and the Umpqua and Rogue Basins drain directly into the Pacific Ocean.

MAJOR AQUIFER UNITS OF WESTERN OREGON

General

Almost without exception, all geologic formations or rock types in western Oregon currently yield or are capable of yielding small quantities of potable water suitable for domestic use. Therefore, all formations in western Oregon are considered to be existing or potential aquifers. At shallow depths, these aquifers generally contain water with low concentrations of dissolved solids (less than 1,000 mg/L); however, some aquifers contain saline water with high concentrations of dissolved solids (more than 1,000 mg/L) at depth.

For this study, the aquifers of western Oregon are grouped into seven aquifer units according to hydraulic properties and geology. The areal distribution of these aquifer units is shown on the hydrogeologic map (pl. 1), and each unit is briefly described in table 1.

The generalized geologic structure and stratigraphic relationships of the aquifer units are shown in a series of six west-east geologic sections (pl. 1). This orientation was selected because the regional strike of the geologic formations in western Oregon is north-south. Where possible, the sections were drawn through the sites of deeper water, oil, gas, and geothermal wells. The wells are designated by symbols that indicate their location according to the rectangular system of land division (see p. 26 for explanation of the well-numbering system).

The bedrock formations in the Klamath Mountains (aquifer unit VII), Coast Range (aquifer unit V), and Western Cascade Range (aquifer unit III) have similar water-bearing characteristics and all are poorly permeable. Granitic intrusive rocks in the Klamath Mountains have, in some areas, weathered to saprolite (aquifer unit VI) and have high permeability relative to surrounding bedrock formations. The Columbia River Basalt Group (aquifer unit IV), which crops out in northwestern Oregon, has an overall low permeability. However, the basalt contains interflow zones that transmit water readily. Locally, it is an important aquifer.

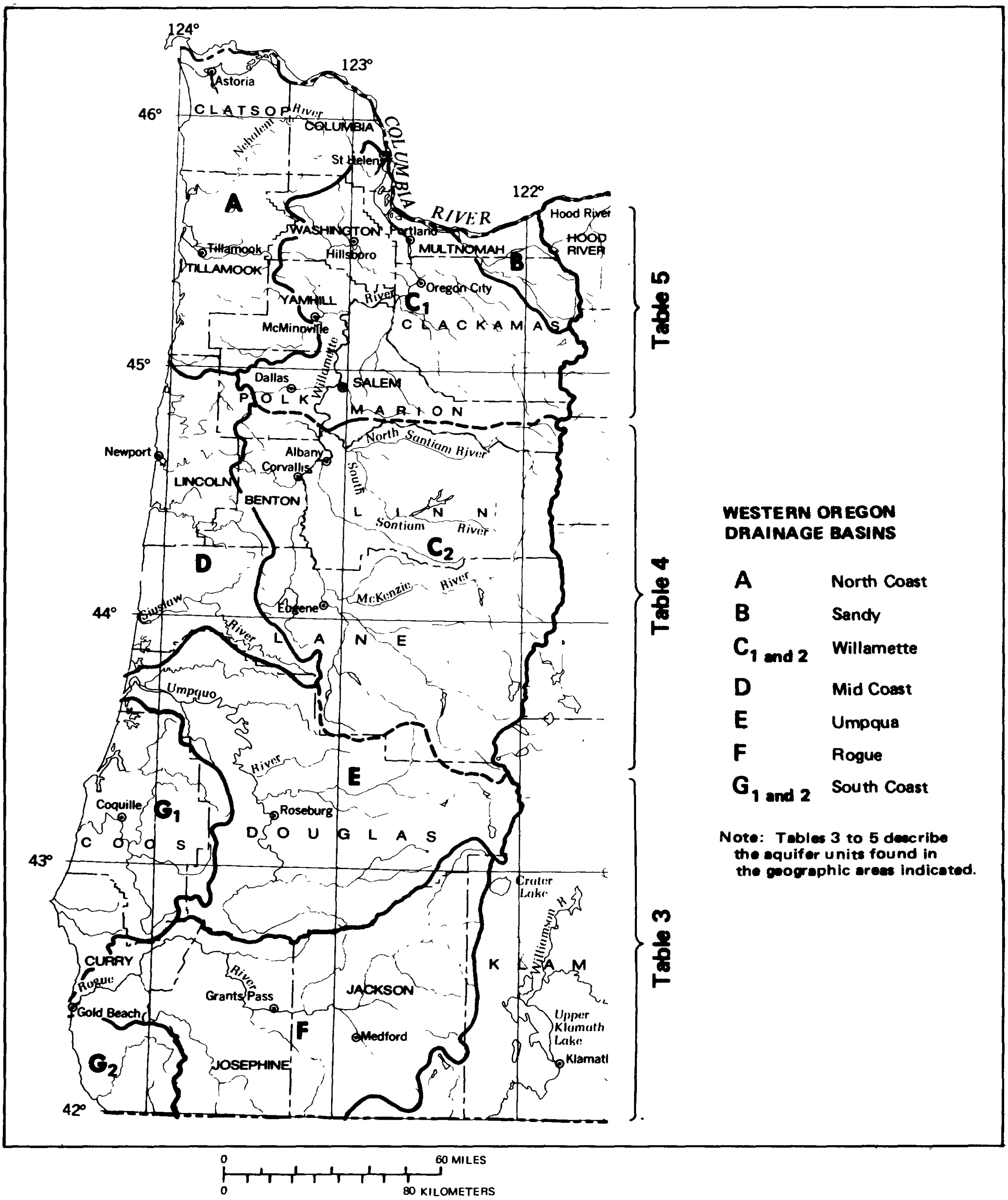


FIGURE 3. – Drainage basins in western Oregon.

Table 1.--Aquifer units of western Oregon

Aquifer unit	Lithologic description	Exposure	Water-bearing characteristics
Tertiary-Quaternary sedimentary deposits (I)	Sand, gravel, and silt, unconsolidated to consolidated; some weathered basalt and pyroclastic rocks are also included.	Alluvium occurs along streams and rivers, most extensively in the Willamette Valley. Beach and dune sand occur along the Pacific coast, and volcanic rocks are localized around source vents near Portland.	Permeability generally high; however, less permeable fine material is commonly interlayered with good aquifers. Wells yield more than 2,000 gal/min in some areas, but average less than 300 gal/min. Most productive aquifer unit in western Oregon.
Tertiary-Quaternary volcanic rocks of the High Cascade Range (II)	Andesite and basalt, flow and pyroclastic rocks.	Form the crest of the Cascade Range	Largely unknown. Available data indicate variable permeability. Well yields range from a few gallons per minute to 300 gal/min. Springs issuing from the unit are commonly large.
Tertiary volcanic rocks of the Western Cascade Range (III)	Andesite, basalt, and dacite; older rocks are dominantly volcaniclastic and younger rocks are almost entirely flow material.	Form the western slope of the Cascade Range.	Permeability is generally low; however, fracturing may form localized permeable zones. Well yields may reach 100 gal/min, but average less than 20 gal/min.
Columbia River Basalt Group (IV)	Basalt; distinctive columnar jointing and fractured interflow zones.	Crops out along the western and eastern edges of the northern Willamette Valley and along the Columbia River as far west as the Pacific Ocean. Forms structural basins beneath the northern Willamette Valley.	Overall permeability low, but interflow zones and scoriaceous flow tops are relatively permeable. Dense, poorly permeable flow centers may limit recharge. Yields may exceed 1,000 gal/min, but are typically less than 100 gal/min.
Tertiary rocks of the Coast Range (V)	Sandstone, siltstone, and mudstone, commonly tuffaceous; intrusive rocks.	Marine sedimentary rocks form most of the Coast Range. Marine volcanic rocks are abundant in the northern part of the range. Intrusive rocks form some of the highest peaks in the Coast Range.	Permeability low. Well yields are generally less than 10 gal/min.
Granitic saprolite of the Klamath Mountains (VI)	Saprolite derived from granite intrusive rocks; degree of weathering variable.	Saprolite occurs most extensively near Grants Pass, Oreg., and Evans Creek in the Klamath Mountains. Extent of weathering variable. Granitic rocks crop out as irregular masses throughout the Klamath Mountains.	Permeability is high relative to surrounding geologic units. The quantity of water available is dependent on the extent of weathering and fracturing. Wells may yield as much as 50 gal/min.
Paleozoic-Mesozoic bedrock of the Klamath Mountains (VII)	Sandstone, siltstone, graywacke, conglomerate, and shale with some andesitic flows, agglomerate, and tuff. Metasedimentary and metavolcanic rocks are common.	Underlie entire Klamath Mountain area, with the exception of the saprolite mentioned above.	Permeability is low. Well yields are typically less than 10 gal/min.

The water-bearing characteristics of the volcanic rocks of the High Cascade Range (aquifer unit II) probably are highly variable, but the unit may have a good potential as an aquifer. The most productive aquifer unit in western Oregon is the Tertiary-Quaternary sedimentary deposits (aquifer unit I) that occur throughout the area, but most extensively in the Willamette Valley.

Saline water occurs at depth in the Tertiary marine rocks of the Coast Range (aquifer unit V), where dissolved-solids concentrations are commonly more than 10,000 mg/L. Analyses of water from deep wells in each of the other bedrock units are too sparse to determine whether saline water is present everywhere at depth. Table 2 summarizes the types of water use and statistics on water quality for the seven aquifer units.

Paleozoic-Mesozoic Bedrock and Granitic Saprolite of the Klamath Mountains

Bedrock formations in the Klamath Mountains are Paleozoic and Mesozoic in age and include several formations and rock types. The formations are sedimentary and volcanic rocks that have been subjected to tectonic deformation and regional metamorphism. These rocks strike northeast, dip steeply to the southeast, and are cut by northeast striking thrust faults (fig. 4). Outcrop patterns of separate formations consist of narrow concentric northeast-trending arcuate strips. In places, narrow slivers of peridotite and dunite altered to serpentinite occur between formations and emphasize this outcrop pattern; in some places, they occur along thrust faults. Generally, the formations in the eastern part of the Klamath Mountains are older, more deformed, and more highly metamorphosed than those cropping out in the western part. During Mesozoic deformation, granitic magma intruded these units, and some of the intrusives underlie areas several tens of square miles in extent. In some areas, these granitic intrusive rocks are deeply weathered.

The Paleozoic-Mesozoic rocks cropping out in the Klamath Mountains area are subdivided into two aquifer units in this report: the Paleozoic-Mesozoic bedrock aquifer unit (VII) and the granitic saprolite aquifer unit (VI). Each of the formations in the Paleozoic-Mesozoic bedrock aquifer is composed of rocks of low permeability; however, they are capable of yielding small quantities of water to domestic wells. The hydraulic conductivity of the aquifer probably ranges from 0.1 to 10 ft/d. Permeability of these rocks is due chiefly to fracture porosity which probably decreases with increased depth in the subsurface. The maximum thickness of these rocks seems to be at least 30,000 ft.

Table 2.--Water use and quality for aquifer units in western Oregon

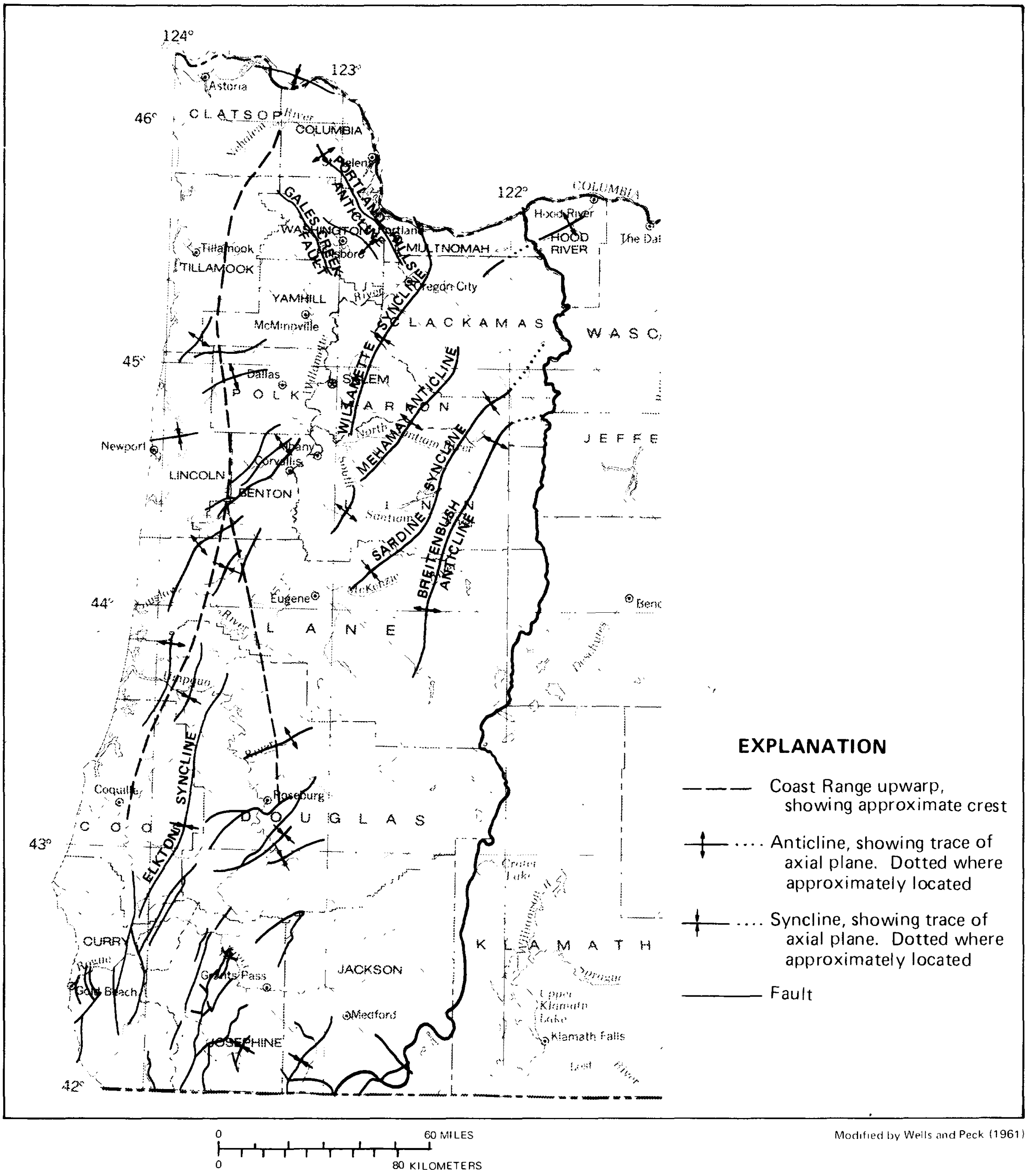
				Ground-water use		Ground-water quality			
						Dissolved solids[2]			
Period	Epoch	Aquifer unit and map symbol	Locations of large withdrawals[1]	Types of use	General remarks on water use	Number of samples	Range	Median	General quality of water
Tertiary to Quaternary	Pliocene to Holocene	Tertiary-Quaternary sedimentary deposits (I)	Willamette Valley, Portland area North and central coast In valleys throughout western Oregon	Irrigation Industrial Public Domestic and stock	Most heavily pumped and most important aquifer unit in western Oregon. Irrigation, industrial, and public use are generally restricted to the Willamette Valley. Coastal dunes near Coos Bay provide public water supply. Alluvium in other valleys commonly provides domestic and stock water supplies.	293	24-3,940	165	Good. Mineralized water from underlying units may degrade water quality locally; local contamination from wastes possible.
Tertiary to Quaternary	Pliocene(?) to Holocene	Tertiary-Quaternary volcanic rocks of the High Cascade Range (II)	Near major transportation corridors Logging communities	Public Domestic and stock	Development is limited because of remote location, small population, and highly variable aquifer-unit permeabilities.	--	--	--	Good. A few mineralized springs are associated with faults.
Tertiary	Eocene to Miocene	Tertiary volcanic rocks of the western Cascade Range (III)	Rural areas along eastern Willamette Valley Medford area	Domestic and stock	Development is limited because of remote location, small population, and low aquifer-unit permeability.	30	70-9,950	196	Good. High arsenic concentrations occur in older formations of unit in the Cottage Grove area; water quality at depth generally unknown.
Tertiary	Miocene	Columbia River Basalt Group (IV)	Cooper and Bull Mountains (Tualatin Valley) Salem Heights Portland metropolitan area Chehalem Mountains Eola-Amity Hills Molalla-Salem Slope	Public Domestic and stock Irrigation	Water-level declines have been reported in the Cooper-Bull Mountain area in Washington County and in the Salem Heights area. These areas were declared "Critical Ground-Water Areas" by the State. Decreased pumpage has resulted in recovery of water levels.	84	51-18,500	178	Good. Mineralized water from underlying units may degrade water quality locally.
Cretaceous to Tertiary	Late Cretaceous to Pliocene	Tertiary rocks of the Coast Range (V)[3]	In valleys throughout the Coast Range Western part of the Willamette Valley	Domestic and stock	Provides important domestic and stock water supplies to many rurel residences and farms.	283	57-69,800	321	Good to poor. Water drawn from a depth greater than 500 ft generally has a high total dissolved-solids concentration.

See footnotes at end of table.

Table 2.--Water use and quality for aquifer units in western Oregon--Continued

			Ground-water use			Ground-water quality			
						Dissolved solids[2]			
Period	Epoch	Aquifer unit and map symbol	Locations of large withdrawals[1]	Types of use	General remarks on water use	Number of samples	Range	Median	General quality of water
Jurassic	Late Jurassic(?)	Granitic saprolite of the Klamath Mountains (VI)	Grants Pass area Evans Creek just north of the city of Rogue River	Domestic and stock	An important source of water in some parts of southwestern Oregon.	91	108-6,730	250	Good.
Pennsylvanian to Cretaceous	Early Pennsylvanian(?) to Early Cretaceous	Paleozoic-Mesozoic bedrock of the Klamath Mountains (VII)	In valleys throughout the Coast Range	Domestic and stock	Provides important domestic and stock water supplies to many rural residences and farms.				Good. Some isolated occurrences of mineralized water from wells and springs; water quality at depth generally unknown.

[1] In order of decreasing quantity withdrawn.
[2] In milligrams per liter.
[3] Includes small exposure of Cretaceous rocks in southwestern Oregon.



Modified by Wells and Peck (1961)

FIGURE 4. – Major geologic structures in western Oregon.

The granitic saprolite aquifer consists of weathered material derived from underlying granitic intrusive rocks. Throughout the Klamath Mountains, granitic rocks crop out as irregular masses. The saprolite, which is not present in all areas underlain by granitic rocks, exceeds a thickness of 100 ft in places, but its distribution and thickness are irregular and poorly known. The granitic rocks, the source of saprolite, have hydraulic properties similar to those of the enclosing Paleozoic-Mesozoic bedrock aquifer. Estimated hydraulic conductivity of the saprolite ranges from 5 to 20 ft/d, whereas the hydraulic conductivity of the unweathered granitic rock is probably less than 5 ft/d. In places, the saprolite may be capable of yielding 10 to 50 gal/min or more to wells.

The quality of water in the two aquifer units of the Klamath Mountains is generally good within a few hundred feet of the land surface. Dissolved-solids concentrations are typically less than 250 mg/L; however, there are some shallow occurrences of saline water in the Paleozoic-Mesozoic bedrock aquifer unit (VII). Plate 2 shows the dissolved-solids concentrations of waters from about a hundred wells completed in these aquifer units. Published reports are the primary sources of these analyses. Water-quality data from wells in the Rogue River basin (which drains a large part of the Klamath Mountains) suggest that high concentrations of dissolved solids may be more widespread in aquifer units VI and VII than previously realized. Because no deep oil, gas, or geothermal exploratory wells exist in the Klamath Mountains, little is known about ground-water quality at depth in the region.

Tertiary Rocks of the Coast Range

The Coast Range is composed of marine rocks of both volcanic and sedimentary origin, and intrusive rocks. The oldest formation is the Siletz River Volcanics which contains abundant pillow basalt, locally interbedded with tuffaceous marine sediments. This formation crops out in the central Coast Range. The most abundant and extensive formations in the range are the Tertiary marine sedimentary rocks, which have a total thickness of more than 15,000 ft in some areas. Snavely and Wagner (1980) have constructed an isopach map of the Tertiary sedimentary rocks of western Oregon and Washington and the adjacent continental margin. Several formations compose these marine sedimentary rocks that were derived from volcanic terrain and include tuffaceous sandstone, shale, and mudstone.

Eastward, some of the Tertiary marine formations interfinger with or underlie the terrestrial sediments and volcanic rocks of the Cascade Range. A few outcrops of marine sedimentary rocks occur on the eastern edge of the Willamette Valley. Mafic igneous dikes, sills, and stocks intrude the older volcanic and sedimentary rocks, and generally underlie the higher peaks of the Coast Range. Structurally, the Coast Range is a northward-trending anticlinorium in which the formations are gently folded (fig. 4).

Geologic formations in the Coast Range contain rocks of low permeability. In this report, they are considered to be a single interconnected aquifer unit -- the Tertiary rocks of the Coast Range (V). Eocene terrestrial sedimentary rocks and Late Cretaceous marine sedimentary rocks that underlie the Medford-Ashland, Oreg., area are also included in this aquifer unit. The outcrop of Cretaceous rocks is limited to about 10 mi^2.

Throughout its extent, the aquifer unit yields small quantities of water to wells, generally sufficient for domestic or stock use. Evaluation of specific-capacity data from several hundred wells completed in several different formations in the Coast Range foothills west of Independence, Oreg., indicates that there are no significant differences in hydraulic characteristics among these formations (Gonthier, 1982). Hydraulic conductivity estimates range from 0.01 to 10 ft/d.

Available information suggests that the Tertiary marine sedimentary rocks (aquifer unit V) contain the poorest quality water in western Oregon; however, it should be noted that the unit generally provides good-quality water for domestic use throughout the area from wells commonly less than 200 ft deep. Chemical analyses of water from both shallow and deep wells in the marine sedimentary rocks of the Coast Range indicate that dissolved-solids concentrations are more than 1,000 mg/L at several locations (pl. 3). The median dissolved-solids concentration of well water is more than 300 mg/L and the maximum reported concentration is nearly 70,000 mg/L (table 2). Chemical analyses of spring water indicate dissolved-solids concentrations from 100 to 14,000 mg/L; however, most are less than 250 mg/L.

Tertiary marine sedimentary formations have been the targets for several exploratory oil and gas wells drilled to depths of as much as 12,000 ft. Data from these wells suggest that at the well sites the depth to water containing 10,000 mg/L or more of dissolved solids is about 2,000 ft. Although evidence is not conclusive, water with high concentrations of dissolved solids may be shallowest in ground-water discharge areas adjacent to and beneath principal streams (Gonthier, 1982). Water-quality data from water wells in the same Tertiary marine sedimentary rocks beneath the Willamette Valley suggest that water containing more than 10,000 mg/L dissolved solids may occur at depths of only a few hundred feet in some places.

Columbia River Basalt Group

The Columbia River Basalt Group of Miocene age is present in the northern one-third of western Oregon. The basaltic lava in this formation was erupted from vents in northeastern Oregon and eastern Washington and flowed westward down valleys of the ancestral Columbia River drainage into western Oregon. The Columbia River Basalt Group underlies the Columbia River Plateau, an area of more than 50,000 mi^2 in eastern Washington, northern Oregon, and western Idaho, and is a major regional aquifer system in that area.

In western Oregon, the basalt crops out discontinuously in the following areas: in the Columbia River Gorge; along the Columbia River as far west as Astoria; on the northern Oregon coast; in hills bordering the Tualatin Valley; in the Eola-Amity Hills; in the Salem Heights; in the Molalla-Salem Slope area; and in the upper drainages of the Bull Run and Clackamas Rivers. The basalt dips beneath younger formations in the Willamette Valley north and east of Salem, the Tualatin Valley, the Portland area, and the northern Oregon Cascades. Where the basalt crops out in the hills, it is deeply weathered and eroded, and its thickness may vary markedly in short distances. The maximum known thickness of the basalt in western Oregon is about 1,500 ft; however, where it is deeply buried beneath younger geologic formations (pl. 1), little is known about its thickness or continuity.

The Columbia River Basalt Group in western Oregon is designated as aquifer unit (IV) in this study. This aquifer unit is productive compared to the formations that directly underlie it. The overall permeability of the basalt is poor; however, water is transmitted through joints in flows and through porous interflow zones, parallel with flow layers. Well yields may exceed 1,000 gal/min in the deeper wells that penetrate several interflow zones. In the 1960's, water-level declines were observed in the basalt aquifer in western Oregon in the Salem Heights area near Salem and at Cooper and Bull Mountains in Washington County. These declines were attributed to local heavy pumping of the aquifer which has limited storage space and recharge rates. Water levels in these areas have since stabilized or partly recovered because of reduced ground-water withdrawal rates. Where it is exposed in uplands, the Columbia River Basalt Group is widely used by individual homeowners for domestic water supply and by small water districts for public supplies. The hydraulic conductivity of the aquifer unit probably ranges from 0.1 to 30 ft/d.

Water in the basalt generally contains less than 250 mg/L of dissolved solids (pl. 4). Available chemical analyses of spring water from the Columbia River Basalt Group generally indicate dissolved-solids concentrations less than 100 mg/L. Hart and Newcomb (1965, p. 54) indicated that in some places saline water, possibly from underlying marine formations, migrates upward into or through the deeply buried basalt.

Tertiary Volcanic Rocks of the Western Cascade Range

The Western Cascade Range is underlain by a sequence of Tertiary volcanic rocks, the oldest of which are predominantly pyroclastic and the youngest of which are almost entirely of andesitic and basaltic lava flows. The total thickness of the sequence varies, but it is as much as 10,000 ft in places. In the northern part of the area, these rocks generally overlie the Columbia River Basalt Group in outcrop and are gently folded into a series of broad, open, northeast-trending en echelon folds. These folds include the Mehama and Breitenbush anticlines and the Sardine syncline adjacent to the Willamette Valley (fig. 4). In the south, these rocks dip 5° to 35° eastward beneath the volcanic rocks of the High Cascades.

In this report, Tertiary volcanic rocks of the Western Cascades are aquifer unit III. Because this unit crops out in sparsely populated rugged terrain, few hydraulic data are available; however, rocks in this unit generally have low permeabilities and wells yield only small quantities of water suitable for domestic supply. Estimated hydraulic conductivities range from 0.1 to 10 ft/d. Ground-water-quality data for this unit are sparse, but the available data indicate that dissolved solids are generally less than 200 mg/L (pl. 4). The chemical quality of water at depth is generally unknown.

Tertiary-Quaternary Volcanic Rocks of the High Cascade Range

The High Cascade Range has a broad, irregular plateau-like surface and is underlain by a thick accumulation of Tertiary-Quaternary volcanic rocks. These rocks overlie older Tertiary volcanic rocks of the Western Cascade (aquifer unit III) and consist chiefly of andesite or basalt with smaller amounts of pyroclastic deposits. Exposed flow rocks typically are fresh, undeformed, and generally less than a few tens of square miles in extent. Andesite and basalt are commonly interlayered with unconsolidated glacial deposits, fluvial deposits, ash, and agglomerate; and combined lithology may be strongly heterogeneous. Stratovolcanoes, intracanyon lava flows, cinder cones, lava domes, and a variety of other volcanic landforms are common in the High Cascade Range.

In this report, Tertiary-Quaternary volcanic rocks of the High Cascades are aquifer unit II. Local lithologic variability of these rocks results in large local variation in their permeability and in their capacity to transmit water. Few wells have been developed in this aquifer and little is known about its hydrogeology. Wells have been drilled only along major highway corridors that cross the Cascade Range. Many springs issue from these rocks, especially on the east side of the crest of the range, which is outside the area of this investigation. In some parts of the Crater Lake area and elsewhere along the range, the depth to the saturated zone probably exceeds 1,000 ft. The chemical quality of the water in these rocks is generally good; however, few data are available. Because of the scarcity of well-water analyses, a dissolved-solids map is not included in this report.

Most of the thermal springs in western Oregon occur in the Cascade Range, commonly near the contact of the High Cascade Range and the older Western Cascade Range. Dissolved-solids concentrations range from about 75 to nearly 4,000 mg/L and temperatures have been reported as high as 92°C (Mariner and others, 1980, p. 6).

Tertiary-Quaternary Sedimentary Deposits

The most important aquifer unit in western Oregon, in terms of its capacity to transmit water and its present or potential use, is the Tertiary-Quaternary sedimentary deposits (1). These deposits are found in most lowlands in western Oregon, in valleys of principal streams, and along the coastal beach and dune areas. The most extensive deposits form the floor of the Willamette Valley. The most permeable aquifer beds are unconsolidated and semiconsolidated gravel or sand, or mixed sand and gravel. In most areas, these materials are interlayered with less permeable silt or clay.

The Willamette Valley is a structural and erosional depression between the Coast and Cascade Ranges. In the part of the valley north and northeast of Salem, the sediments lie directly on the folded, faulted, and partly eroded surface of the Columbia River Basalt Group. Plate 5 shows the locations of three structural basins in the basalt beneath the Portland area, the Tualatin Valley, and the French Prairie area just northeast of Salem. In the McMinnville-Dallas-Monmouth area, the Tertiary-Quaternary sedimentary deposits lie directly on bedrock formations of the Coast Range.

The sediments in the southern Willamette Valley, south of Salem, are underlain by undifferentiated bedrock formations of the Coast and Cascade Ranges. The bedrock surface, shown on plate 5, forms a broad, shallow basin in contrast to the deeper basins to the north and is probably both a structural and an erosional feature. In some places the contact between the bedrock and the overlying sediments is not easily identifiable in drillers' well logs; therefore, the depth to the bedrock is uncertain.

Clastic sediments, chiefly alluvial or lacustrine in origin, fill the structural basins in the Willamette Valley. In the basin beneath the Portland area, the sediments are more than 1,000 ft thick and the basal part is predominantly mudstone; the upper part contains interlayered coarse and fine sediments. Recently, systematic drilling and aquifer testing has enabled the city of Portland Bureau of Water Works to approximately define four separate sand and gravel aquifers in the upper 600 ft or so of the Portland basin-fill sediments. The project area covers about 10 mi^2 and is adjacent to the Columbia River east of the Portland International Airport. Each aquifer is separated by fine-grained confining or semiconfining layers. Hydraulic conductivities in these aquifers range from 0.1 to 400 ft/d and coefficients of storage have a magnitude of 10 to 10 . Little is known about the extent and continuity of the individual aquifers and confining layers outside the project area.

In the Portland-Oregon City area, basaltic lava locally intruded the sediments and also was extruded from local vents onto basin sediments. The basalt is included with the Tertiary-Quaternary sedimentary-deposit aquifer (aquifer unit 1) in this area because it is present chiefly in upland exposures where it is unsaturated, contains perched water, or is in local flow systems overlying the regional flow system in the sediments. Although no detailed supporting evidence is available, the intrusive vents are probably small and do not significantly disrupt the hydraulic continuity of the enclosing sediments.

Throughout the Tualatin Basin, the older clastic sedimentary deposits are generally fine grained. Well-sorted sand beds occur at widely separated vertical intervals, but gravel beds are few. Basal sediments beneath the French Prairie area are fine-grained, but the central part contains some sand and gravel. Throughout much of the Willamette Valley south of Oregon City, the uppermost unit of the valley fill is a layer of lacustrine silt and very fine sand that reaches a thickness of 130 ft in places. This deposit is generally not present on the flood plains of the major streams nor on the valley floor above an altitude of about 500 ft. Generally, sediments beneath the west side of the valley are finer grained than those on the east side.

Alluvial aquifers in western Oregon include chiefly stream-valley alluvium. They generally have hydraulic conductivities of between 20 and 600 ft/d. The flood plains of the streams draining the Cascade Range, especially the flood plains of the McKenzie, South Santiam, North Santiam, and Willamette Rivers, are underlain by highly permeable unconfined sand-and-gravel aquifers. The alluvium ranges in thickness from 0 to 50 ft and is generally in good hydraulic connection with overlying streams.

Principal stream valleys elsewhere in western Oregon contain unconsolidated to semiconsolidated alluvium that is generally less permeable than the Willamette Valley alluvium. Alluvial deposits in other stream valleys are generally poorly sorted and commonly contain a large proportion of silt and clay. Where saturated thickness is greatest, wells yield moderate quantities of water ranging from 20 to 100 gal/min. Outside the Willamette Valley area, alluvium is rarely more than 150 ft thick.

Beach-sand and dune-sand deposits along the Oregon coast are included in the Tertiary-Quaternary sedimentary-deposit aquifer. The most extensive deposits on the coast are between Coos Bay and Heceta Head and from Seaside to Astoria. The maximum saturated thickness of these deposits is about 200 ft. In the sand dune area north of Coos Bay and North Bend, several wells yield more than 300 gal/min. Hydraulic conductivity ranges from about 30 to 90 ft/d, and the magnitude of storage coefficient is between 10 and 10 .

Water in the Tertiary-Quaternary sedimentary-deposit aquifer is generally good (pl. 6). The median dissolved-solids concentration for water from this unit is 165 mg/L. The aquifer is used throughout western Oregon for domestic and stock supplies; however, in the Willamette Valley it is also used for irrigation, industrial and public supplies. In some areas along the coast, freshwater from the dunes is used for public supplies. Any aquifer unit within the tidal zone or within a few hundred feet of the coastal shoreline or estuaries may contain saltwater or could be subject to induced saltwater intrusion if ground-water levels are lowered.

Plate 7 is a generalized water-level-contour map of the Tertiary-Quaternary sedimentary-deposit aquifer in western Oregon and was compiled from published reports, unpublished work maps, and drillers' logs. Water-level data are generally from wells completed in the upper 100 ft of the saturated zone in that aquifer unit. The general direction of ground-water flow and flow paths in the aquifers can be approximately determined from plate 7; however, caution should be exercised in its use because of the small scale of the map. The saturated-thickness map for the Tertiary-Quaternary sedimentary deposits (pl. 8), is compiled from the structure contour map (pl. 5) and the water-level-contour map (pl. 7). In the Willamette Valley, where the saturated thickness is large, the aquifer unit may consist of several aquifers and fine-grained confining beds that are interlayered (as was the case for the Portland project). Much exploratory drilling and aquifer testing would be required in most places to define the extent and thickness of each of the major water-bearing zones within the individual structural basins.

Because of a lack of data, similar maps have not been prepared for other aquifer units; however, some general comments are in order. The water table in most of western Oregon probably conforms to the land-surface topography, but occurs at a greater depth below ridges and peaks than below valleys. In the deeply dissected Klamath Mountains, Coast Range, and Western Cascade Range, ground-water-flow systems probably conform to overlying surface-water basins, except in ephemeral stream basins near ridge tops or summits. Local geologic conditions that cause increased anisotropy in the subsurface may cause local variations in the overall flow pattern.

The pattern of ground-water flow beneath the youthful topography of the High Cascade Range probably is much more complex than it is elsewhere in western Oregon. The High Cascades receive large quantities of precipitation, a large percentage of which infiltrates into the subsurface and percolates downward along complex flow paths and ultimately toward discharge areas in valleys. Base-flow variability in headwater streams of the Rogue River system in the Crater Lake area clearly indicates that streams there both gain and lose water to the subsurface and that ground-water-flow systems differ considerably in their configuration from those of overlying surface-water basins. Similar conditions probably exist in other areas of the High Cascade Range.

DESCRIPTIVE AQUIFER-UNIT INFORMATION BY GEOGRAPHIC AREA

Descriptive geologic and hydrogeologic information for western Oregon's seven aquifer units has been grouped by geographic area and may be found in tables 3 to 5 (at end of report). Table 3 describes the aquifer units in the Rogue, Umpqua, and South Coast river basins in southwestern Oregon; table 4 describes the aquifer units in the Mid Coast and southern Willamette River basins in the central part of western Oregon; and table 5 describes the aquifer units in the North Coast and northern Willamette River basins in northwestern Oregon. The boundaries of these three geographic regions are shown in figure 3.

A geographic grouping by surface-water basins allows an accurate description of the aquifer units because lithology, hydrology, and formation nomenclature vary for some of the aquifer units throughout their extent in western Oregon. In most areas, the surface-water basins correspond to ground-water-flow system boundaries. The grouping is also compatible with the U.S. Geological Survey-Oregon Water Resources Department cooperative long-range plan for evaluation of ground-water resources in each of 18 major surface-water basins in Oregon.

Tables 3 to 5 list the major geologic formations or subunits in each aquifer unit, general lithologic character and areal extent of the formations, overall structural setting of each of the aquifer units, and information on hydrogeology of the aquifer units. The estimated recharge and hydraulic properties are based on available data and emprirical judgment by the author and coworkers. Information is separated into specific subunits where practical. Hydraulic conductivity values listed for the Tertiary-Quaternary sedimentary deposits (aquifer unit I) are representative of the permeable aquifer layers only, not of the confining or semiconfining beds in the different subunits. Hydraulic conductivities listed for the Columbia River Basalt Group are representative of the aquifer unit as a whole; however, as previously mentioned, the most permeable material occurs in the interflow zones. For other major aquifer units, the listed hydraulic conductivity may be considered a representative value for the entire aquifer unit. Most of the hydraulic data compiled in this report were largely obtained from relatively shallow wells and may not be representative of similar rocks covered by 1,000 ft or more of overburden, due to the general decrease in permeability with increasing overburden pressure. Hydraulic conductivity values for deeply buried formations should generally be smaller than for similar shallow rocks.

To use tables 3 to 5 in an injection-well evaluation, a proposed site for underground-waste injection should first be located on plate 1; then the tables and plates may be referred to for more detailed geologic and hydrogeologic information about the area and site. Additional site-specific data will need to be gathered to evaluate properly injection practices at all proposed sites in western Oregon. The data will have to be obtained primarily from exploratory wells that penetrate the proposed injection zone.

SELECTED REFERENCES

Allen, J. E., and Baldwin, E. M., 1944, Geology and coal resources of the Coos Bay quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 27, 160 p.

Baldwin, E. M., 1945, Eocene stratigraphy of southwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 83, 40 p.

________1976, Geology of Oregon: Dubuque, Iowa, Kendall/Hunt Publishing Co., 147 p.

Baldwin, E. M., and Beaulieu, J. D., 1973, Geology and mineral resources of Coos County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 80, 40 p.

Beaulieu, J. D., 1977, Land use geology of central Jackson County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 94, 87 p.

Brown, S. G., 1963, Problems of utilizing ground water in the west-side business district of Portland, Oregon: U.S. Geological Survey Water-Supply Paper 1619-0, p. 01-042.

Brown, S. G., and Newcomb, R. C., 1963, Ground-water resources of the coastal sand-dune area north of Coos Bay, Oregon: U.S. Geological Survey Water-Supply Paper 1619-D, p. D1-D32.

Dicken, S. N., 1950, Oregon geography (Ist ed.): Ann Arbor, Mich., Edwards Bros., Inc., 104 p.

Dott, R. H., Jr., 1971, Geology of the southwestern Oregon coast west of the 124th meridian: Oregon Department of Geology and Mineral Industries Bulletin 69, 63 p.

Feth, J. H., and others, 1965, Preliminary map of the conterminous United States showing depth to and quality of shallowest ground water containing more than 1,000 parts per million dissolved solids: U.S. Geological Survey Hydrologic Investigations Atlas HA-199, scale 1:3,168,000, 2 sheets.

Foxworthy, B. L., 1970, Hydrologic conditions and artificial recharge through a well in the Salem Heights area of Salem, Oregon: U.S. Geological Survey Water-Supply Paper 1594-F, p. FI-F56.

Frank, F. J., 1970, Ground-water resources of the Clatsop Plains sand-dune area, Clatsop County, Oregon: U.S. Geological Survey Water-Supply Paper 1899-A, p. A1-A41.

________1973, Ground water in the Eugene-Springfield area, southern Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 2018, 65 p.

________1974, Ground water in the Corvallis-Albany area, central Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 2032, 48 p.

________1976, Ground water in the Harrisburg-Halsey area, southern Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 2040, 45 p.

________1979, Ground water in the Myrtle Creek-Glendale area, Douglas County, Oregon: U.S. Geological Survey Water-Resources Investigations 79-8, scale 1:62,500, 2 sheets.

Frank, F. J., and Laenen, Antonius, 1977, Water resources of Lincoln County coastal area, Oregon: U.S. Geological Survey Water-Resources Investigations 76-90, 63 p.

Frank, F. J., and Collins, C. A., 1978, Ground water in the Newberg area, northern Willamette Valley, Oregon: Oregon Water Resources Department Ground Water Report 27, 77 p.

Goldblatt, E. L., Van Denburgh, A. S., and Marsland, R. A., 1963, The unusual and widespread occurrence of arsenic in well waters of Lane County, Oregon: Lane County Health Department, Oregon, Eugene, 24 p.

Gonthier, J. B., 1982, Ground-water resources of the Dallas-Monmouth area, Polk, Benton, and Marion Counties, Oregon: Oregon Water Resources Department Ground Water Report 28 (in press).

Griffin, W. C., Watkins, F. A., Jr., and Swenson, H.A., 1956, Water resources of the Portland, Oregon, and Vancouver, Washington, area: U.S. Geological Survey Circular 372, 45 p.

Hampton, E. R., 1963, Ground water in the coastal dune area near Florence, Oregon: U.S. Geological Survey Water-Supply Paper 1539-K, 36 p.

________1972, Geology and ground water of the Molalla-Salem Slope area, northern Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 1997, 83 p.

Hart, D. H., and Newcomb, R. C., 1965, Geology and ground water of the Tualatin Valley, Oregon: U.S. Geological Survey Water-Supply Paper 1697, 172 p.

Helm, D. C., and Leonard, A. R., 1977, Ground-water resources of the lower Santiam River basin, middle Willamette Valley, Oregon: Oregon Water Resources Department Ground Water Report 25, 75 p.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Hogenson, G. M., and Foxworthy, B. L., 1965, Ground water in the East Portland area, Oregon: U.S. Geological Survey Water-Supply Paper 1793, 78 p.

Hotz, P. E., 1969, Relationships between the Dothan and Rogue Formations, southwestern Oregon, <u>in</u> Geological Survey Research 1969: U.S. Geological Survey Professional Paper 650-D, p. D131-D137.

INTERCOMP Resource Development and Engineering, Inc., 1976, A model for calculating effects of liquid waste disposal in deep saline aquifers: U.S. Geological Survey Water-Resources Investigations 76-61, 249 p.; available only from U.S. Department of Commerce, National Technical Information Service, Springfield, Va. 22151 as report PB-256 902/AS.

Irwin, W. P., 1960, Geological reconnaissance of the northern Coast Ranges and Klamath Mountains, California, with a summary of the mineral resources: California Division of Mines Bulletin 179, 80 p.

________1977, Review of Paleozoic rocks of the Klamath Mountains, <u>in</u> Stewart, J. H., Stevens, C. H., and Fritsche, A. E., (eds.), Paleozoic paleogeography of the United States: Pacific Coast Paleogeography Symposium 1, Pacific Section, Society of Economic Paleontologists and Mineralogists Symposium, p. 441-454.

Irwin, W. P., and Dennis, M. D., 1978, Geologic structure section across the southern Klamath Mountains, Coast Ranges, and seaward to Point Delgada, California: Geological Society of America Map and Chart Series MC-28D.

Leonard, A. R., and Collins, C. A., 1982, Ground water in the northern part of Clackamas County, Oregon: Oregon Water Resources Department Ground Water Report 29 (in press).

Lohman, S. W., 1972, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.

Lohman, S. W., and others, 1972, Definitions of selected ground-water terms--Revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.

Mariner, R. H., Swanson, J. R., Oriss, G. J., Presser, T. S., and Evans, W. C., 1980, Chemical and isotopic data for water from thermal springs and wells of Oregon: U.S. Geological Survey Openr-File Report 80-737, 50 p.

McWilliams, R. G., 1980, Eocene correlations in western Oregon-Washington: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 42, no. 9, September 1980.

Molenaar, Dee, Grimstad, Peder, and Walters, K. L., 1980, Principal aquifers and well yields in Washington: U.S. Geological Survey Geohydrologic Monograph 5, scale 1:1,000,000, 1 sheet.

Mundorff, M. J., 1964, Geology and ground-water conditions of Clark County, Washington, with a description of a major alluvial aquifer along the Columbia River: U.S. Geological Survey Water-Supply Paper 1600, 268 p.

Newcomb, R. C., 1972, Quality of the ground water in basalt of the Columbia River Group, Washington, Oregon, and Idaho: U.S. Geological Survey Water-Supply Paper 1999-N, 71 p.

Oregon State Water Resources Board, 1969, Oregon's long-range requirements for water: Salem, Oreg., Oregon State Water Resources Board, 395 p.

Pacific Northwest River Basins Commission, 1970, Columbia North Pacific Region comprehensive framework study of water and related lands, in v. 2 of Water Resources: Pacific Northwest River Basins Commission, app. V, v. 2, p. 545-1022.

Peck, D. L., Griggs, A. B., Schlicker, H. G., Wells, F. G., and Dole, H. M., 1964, Geology of the central and northern parts of the Western Cascade Range in Oregon: U.S. Geological Survey Professional Paper 449, 26 p.

Perttu, R. K., and Benson, G. T., 1980, Deposition and deformation of the Eocene Umpqua Group, Sutherlin area, southwestern Oregon: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 42, no. 8, August 1980.

Phillips, K. N., Newcomb, R. C., Swenson, H. A., and Laird, L. B., 1965, Water for Oregon: U.S. Geological Survey Water-Supply Paper 1649, 150 p.

Piper, A. M., 1942, Ground-water resources of the Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 890, 194 p.

________1969, Disposal of liquid wastes by injection underground--Neither myth nor millenium: U.S. Geological Survey Circular 631, 15 p.

Price, Don, 1967a, Geology and water resources in the French Prairie area, northern Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 1833, 98 p.

________1967b, Ground water in the Eola-Amity Hills area, northern Willamette Valley, Oregon: U.S. Geological Survey Water-Supply Paper 1847, 66 p.

Price, Don, Hart, D. H., and Foxworthy, B. L., 1965, Artificial recharge in Oregon and Washington: U.S. Geological Survey Water-Supply Paper 1594-C, 65 p.

Price, W. E., and Baker, C. H., 1974, Catalog of aquifer names and geologic unit codes used by the Water Resources Division: U.S. Geological Survey, 306 p.

Ramp, Len, 1972, Geology and mineral resources of Douglas County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 75, 105 p.

________1979, Geology and mineral resources of Josephine County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 100, 45 p.

Riccio, J. F. (ed.), 1979, Geothermal resource assessment of Mount Hood: Oregon Department of Geology and Mineral Industries Open-File Report 0-79-8, 273 p.

Robinove, C. J., Langford, R. H., and Brookhart, J. W., 1958, Saline water resources of North Dakota: U.S. Geological Survey Water-Supply Paper 1428, 72 p.

Robison, J. H., 1968, Estimated existing and potential ground-water storage in major drainage basins in Oregon: U.S. Geological Survey open-file report, 13 p.

________1971, Availability and quality of ground water in the Medford area, Jackson County, Oregon: U.S. Geological Survey Hydrologic Investigations Atlas HA-392, scale 1:62,500, 2 sheets.

________1972, Availability and quality of ground water in the Ashland quadrangle, Jackson County, Oregon: U.S. Geological Survey Hydrologic Investigations Atlas HA-421, scale 1:62,500, 2 sheets.

________1973a, Availability of ground water in the Grants Pass area, Josephine County, Oregon: U.S. Geological Survey Hydrologic Investigations Atlas HA-480, scale 1:62,500, 2 sheets.

________1973b, Hydrology of the dunes area north of Coos Bay, Oregon: U.S. Geological Survey open-file report, 62 p.

________1974, Availability and quality of ground water in the Sutherlin area, Douglas County, Oregon: U.S. Geological Survey Water-Resources Investigations 32-74, scale 1:62,500, 2 sheets.

Robison, J. H., and Collins, C. A., 1977, Availability and quality of ground water in the Drain-Yoncalla area, Douglas County, Oregon: U.S. Geological Survey Water-Resources Investigations 76-105, scale 1:62,500, 2 sheets.

________1978, Availability and quality of ground water in the Winston area, Douglas County, Oregon: U.S. Geological Survey Water-Resources Investigations 77-28, scale 1:62,500, 2 sheets.

Schlicker, H. G., and Deacon, R. J., 1967, Engineering geology of the Tualatin Valley region, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 60, 103 p.

Schlicker, H. G., Deacon, R. J., Beaulieu, J. D., and Olcott, G. W., 1972, Environmental geology of the coastal region of Tillamook and Clatsop Counties, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 74, 164 p.

Snavely, P. D., Jr., and Wagner, H. C., 1964, Geologic sketch of northwestern Oregon: U.S. Geological Survey Bulletin 1181-M, p. M1-M17.

________1980, Generalized isopach map of Tertiary sedimentary rocks, western Oregon and Washington, and adjacent Continental Margin: U.S. Geological Survey Open-File Report 80-889, 3 p.

Swanson, D. A., Wright, T. L., Hooper, P. R., and Bentley, R. D., 1979, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.

Sweet, H. R., Wells, C. E., and Maxwell, J., 1980, Surface impoundment assessment for the State of Oregon--Report to the Environmental Protection Agency: Kelso, Wash., Sweet, Edwards, and Associates, 47 p.

Theis, C. V., Brown, R. H., and Meyer, R. R., 1963, Estimating the transmissibility of aquifers from the specific capacity in wells, _in_ Bentall, Ray, compiler, Methods of determining permeability, transmissibility, and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, p. I331-I340.

Trimble, D. E., 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geological Survey Bulletin 1119, 119 p.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, December 24, 1975, v. 40, no. 248, p. 59566-59573.

________1979, Water programs; State underground injection control programs: Federal Register, v. 44, no. 78, April 20, 1979, p. 23738-23766.

________1980, Water programs; Consolidated permit regulations and technical criteria and standards; State underground injection control programs: Federal Register, v. 45, no. 123, June 24, 1980; p. 42472-42512.

U.S. Geological Survey, 1969, Water resources and development, water resources, sec. 2 _of_ Mineral and water resources of Oregon: 90th Congress, 2d sess., U.S. Senate Committee on Interior and Insular Affairs print, p. 325-369.

________1976, Hydrologic unit map--1974, State of Oregon: Reston, Va., U.S. Geological Survey, scale 1:500,000, 1 sheet.

________1979, Chemical analyses of thermal springs and wells in Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-79-3.

Vokes, H. E., Snavely, P. D., Jr., and Myers, D. A., 1951, Geology of the southern and southwestern border area of the Willamette Valley, Oregon: U.S. Geological Survey Oil and Gas Investigations Map OM-110, scale 1:62,500.

Warner, D. L., Koederitz, L. F., Simon, A. D., and Yow, M. G., 1979, Radius of pressure influence of injection wells: U.S. Environmental Protection Agency Environmental Protection Technology Series, EPA-600/2-79-170, August 1979, 204 p.

Warner, D. L., and Lehr, J. H., 1977, An introduction to the technology of subsurface wastewater injection: U.S. Environmental Protection Agency Environmental Protection Technology Series, EPA-600/2-77-240, December 1977, 345 p.

Warren, W. C., Norbisrath, Hans, and Grivetti, R. M., 1945, Geology of northwestern Oregon west of Willamette River and north of latitude 45°15': U.S. Geological Survey Oil and Gas Investigations Map OM-42.

Wells, F. G., 1956, Geology of the Medford quadrangle, Oregon-California: U.S. Geological Survey Geologic Quadrangle Map GQ-89.

Wells, F. G., and Peck, D. L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-325.

Willamette Basin Task Force, 1969, Willamette Basin comprehensive study of water and related land resources, Appendix B, Hydrology: Pacific Northwest River Basins Commission Report, 163 p.

Williams, Howel, 1942, The geology of Crater Lake National Park, Oregon: Carnegie Institute of Washington Publication 540, 162 p.

Willis, R. F., 1977, A report on the ground-water exploratory program for the Department of Public Utilities City of Portland, Oregon: A report submitted to the Portland City Council by the Bureau of Water Works, 287 p.

________1978, Ground-water development program for the city of Portland, Oregon, Pilot well study: City of Portland Bureau of Water Works.

Young, R. A., 1959, Ground-water resources of the Rogue River basin, Oregon: U.S. Geological Survey open-file report, 158 p.

EXPLANATION OF WELL-NUMBERING SYSTEM

In this report, wells used in the geologic sections are designated by symbols that indicate their locations. Two different well-numbering systems have been used in Oregon since ground-water studies began, and the newest system was adopted in 1972. Both numbering systems are used in this report.

In both systems, the symbol or well number indicates the location of the well or test hole by township, range, section, and its position within the section. A graphic illustration of the systems is shown in figure 5. The first numeral and letter of the symbol indicate the township and its direction north or south from the Willamette Base Line; the second, the range and its direction west or east of the Willamette Meridian; and the third, the section in which the well is located and the location of the well within the section.

The two well-numbering systems have different lettering systems to locate a well within a section. The newest lettering system uses a series of three lowercase letters (fig. 5). The first letter indicates the quarter section (160 acres), the second, the quarter-quarter section (40 acres), and a third, the quarter-quarter-quarter section (10 acres). For example, well 1N/2E-27dcc is in SW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 27, T.1 N., R.2 E. The numbering system used before 1972 has a single capital letter to indicate the location of a well within a section (fig. 5). The letter indicates the quarter-quarter section (40 acres) in which the well is located. For example, in the old well-numbering system, the well above would be identified as 1N/2E-27Q. In both numbering systems, where two or more wells are in the same subdivision of a section (that is, 10, 40, or 160 acres), serial numbers are added after the letters (for example, dcc1 or Q1). Some of the wells used in the geologic sections have abbreviated numbers because their exact location within the section is not known.

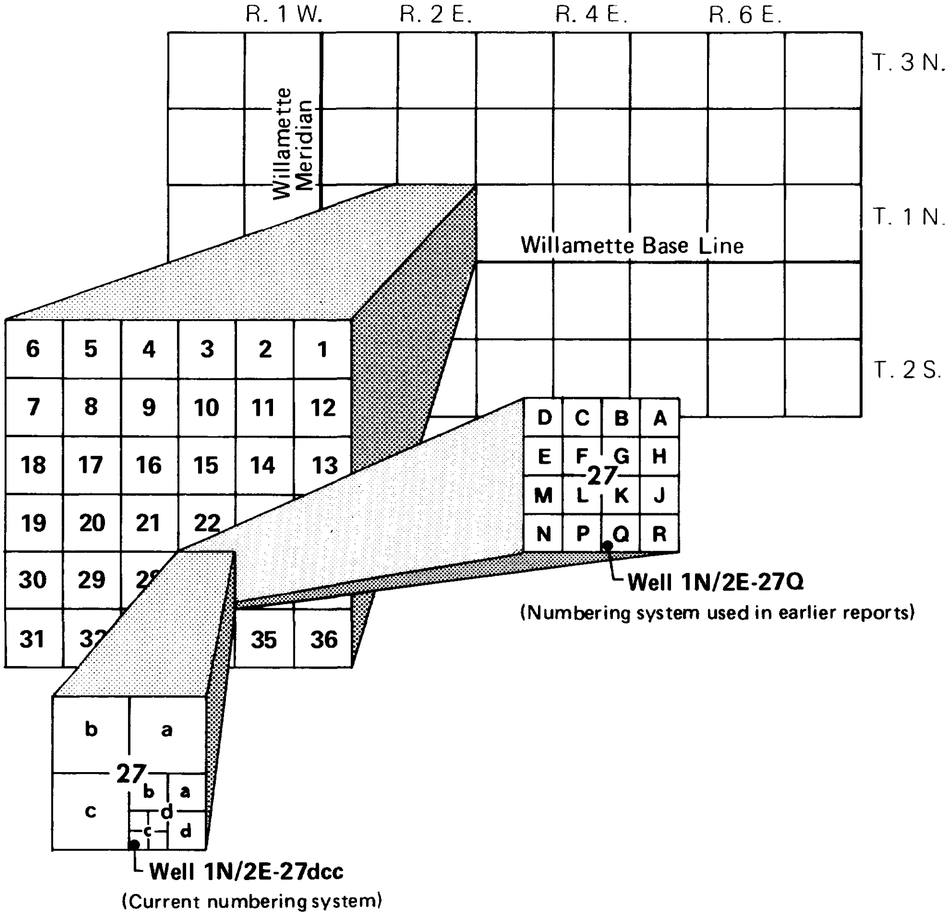


FIGURE 5. – Well-numbering system.

TABULATED HYDROGEOLOGIC INFORMATION

Table 3.--Aquifer units of southwestern Oregon,

Period	Epoch	Aquifer unit and map symbol	Formations included in aquifer unit	Thickness range (feet)	Lithologic description and areal distribution	Structural setting	Hydrogeology
Quaternary	Pleistocene(?) to Holocene	Tertiary-Quaternary sedimentary deposits (I)	Alluvium Dune and beach sand Marine terrace deposits Nonmarine terrace deposits	0-150	Sand, gravel, and silt, well to poorly sorted, unconsolidated to semiconsolidated. Alluvium is typically semiconsolidated sand, gravel, and silt that occurs along the Rogue, Coquille, Coos, and Umpqua Rivers and their tributaries; thickest accumulations occur in the Bear Creek valley near Medford, on the Rogue River from Gold Hill to the Grants Pass area, along the main stem of the Applegate River and its tributaries, along the Illinois River in the Cave Junction-Bridgeview area and at Deer Creek, and on the Umpqua River near Myrtle Creek and Riddle. Dune and beach sand occur along the coast from Reedsport to Cape Blanco; small deposits occur farther south. Marine terrace deposits are semiconsolidated sand that crops out along the coast south of North Bend.	Flat-lying	Permeability and recharge are high relative to all other aquifer units in southwestern Oregon. Water table is generally within 25 ft of land surface. Saturated thickness and extent of alluvium along minor tributary streams is typically small. Hydraulic connection with overlying streams is generally good. Well yields in the alluvium are as high as 200 gal/min, but are typically less than 50 gal/min. Dune and beach sand are a productive aquifer between Coos Bay and Reedsport, where well yields of more than 250 gal/min have been reported. Marine and nonmarine terrace deposits are typically above the water table.
Tertiary to Quaternary	Pliocene(?) to Holocene	Tertiary-Quaternary volcanic rocks of the High Cascade Range (II)	Pyroclastic rocks Andesite and basalt	0->3,000	Andesite and basalt; pyroclastic rocks and flow material. Pyroclastic rocks , which include pumice and ash erupted from Mount Mazama, crop out near Crater Lake and in the Rogue River valley above Big Butte Creek. Several small cinder cones occur along the Cascade Range crest. Most of the High Cascade Range consists of andesitic and basaltic flow material in the form of composite volcanic cones and intracanyon flows.	Deposited on surface with high relief. Locally faulted.	Permeability and recharge may be high locally, especially where pyroclastic deposits are present. The water table may be more than 1,000 ft deep beneath topographically high areas, but is much shallower beneath major valleys; perched water is common. Ground- and surface-water drainage basins do not always coincide. A well near Prospect, completed in basalt that underlies beds of pumice and ash, has been reported to yield more than 300 gal/min. Well yields in the area generally are much smaller. Springs occur in several locations; the city of Medford obtains its water supply (about 26 Mgal/d) from springs issuing from an intracanyon basalt flow near Butte Falls.
Tertiary	Eocene to Miocene	Tertiary volcanic rocks of the Western Cascade Range (III)	Heppsia Andesite "Little Butte Volcanic Series" Roxy Formation Wasaon Formation Colestin Formation	0-15,000	Andesite, dacite, and basalt; flow material, tuff, flow breccia, conglomerate, and agglomerate. The Heppeie Andesite is predominantly flow rocks with lesser amounts of flow breccia, tuff breccia, tuff, and conglomerate; isolated outcrops occur along the western boundary of the High Cascade Range volcanic rocks. The "Little Butte Volcanic Series" is mostly andesitic and dacitic tuff and forms most of the Western Cascade Range in southwestern Oregon. The Colestin Formation is predominantly andesitic tuff and crops out in stream valleys northeast of Medford and also just north of Glide, which is on the North Umpqua River. The outcrop of the Western Cascade Range volcanic rocks narrows to the south to a width of less than 10 mi southeast of Ashland.	Dips east to northeast 5° to 35°. Locally forms open folds and faults.	Permeability and recharge are generally low. The water table may be a few hundred feet below the land surface beneath topographic highs, but is shallow beneath major valleys. Yields of wells completed in these rocks are generally less than 20 gal/min.
Cretaceous to Tertiary	Late Cretaceous to Oligocene	Tertiary rocks of the Coast Range (V)	Bastendorff Shale Coaledo Formation Spencer Formation Tyee Formation Umpqua Formation Nonmarine sediments Hornbrook Formation	0-10,000	Micaceous, tuffaceous, and basaltic sandstone, claystone, and shale; pillow basalt and basaltic breccia. The Bastendorff Shale and the Coaledo, Spencer, Tyee, and Umpqua Formations are predominantly marine sedimentary rocks. The Tyee and Umpqua Formations form most of the southern Coast Range. The base of the Umpqua Formation contains abundant pillow basalt. Nonmarine sediments and the Hornbrook Formation are predominantly sandstone and crop out in Bear Creek valley.	Forms the north-trending Coast Range upwarp and broad open folds. Locally faulted.	Because the rocks are well indurated, they typically have low permeability. Recharge is small. Water table is generally less than 100 ft below land surface. Well yields are generally less than 20 gal/min.
Jurassic	Late Jurassic(?)	Granitic saprolite of the Klamath Mountains (VI)	Granitic saprolite	0-150	Saprolite derived from diorite, granite, and granodiorite. The intrusive rocks, from which the saprolite is derived, occur as irregular masses throughout the Klamath Mountains; however, the extent and thickness of saprolite are irregular and unmapped.	None	Permeability and recharge are high relative to bedrock units. The quantity of water in the unit depends on the saturated thickness of the saprolite. Depth to the water table is generally less than 100 ft. Wells may yield as much as 50 gal/min. Unweathered granitic intrusive rocks have low permeability.
Pennsylvanian to Cretaceous	Early Pennsylvanian(?) to Early Cretaceous	Paleozoic-Mesozoic bedrock of the Klamath Mountains (VII)	Myrtle Group Duys Creek Formation Riddle Formation Dothan Formation Peridotite, dunite, and gabbro Galice Formation Rogue Formation Applegate Group Schist near Condrey Mountain	0->30,000	Sandstone, siltstone, graywacke, conglomerate, and shale, with some andesitic flows, agglomerate, and tuff; metasedimentary and metavolcanic rocks; large masses of peridotite and dunite altered to serpentinite; gabbroic intrusives; and schist. All rocks are Mesozoic in age, with the exception of the schist near Condrey Mountain which is Pennsylvanian-Permian(?) in age. The Myrtle Group is predominantly unmetamorphosed marine sediments that crop out most extensively just inland from Cape Blanco and in the vicinity of Myrtle Creek and Riddle on the South Umpqua River. Peridotite and dunite generally occur as tabular bodies along thrust faults and gabbroic intrusive rocks occur as isolated masses. The Dothan, Galice, and Rogue Formations and the Applegate Group include sedimentary and volcanic rocks which in some cases have been metamorphosed. The schist near Condrey Mountain crops out on the California border south of Squaw Creek, a tributary of the Applegate River.	Complexly folded and faulted. Rocks dip steeply to the east. Imbricate thrust faults are common.	Permeability and recharge are generally small. Sedimentary rocks yield only small quantities of water to wells because of closure of pore space by compaction and cementation. Volcanic and metamorphic rocks have low permeability because of their crystalline character. Water table is generally less than 100 ft below the land surface, but may be deeper beneath topographically high areas. Well yields in all rocks are typically less than 10 gal/min.

South Coastal, Umpqua, and Rogue River basins

Characteristics of aquifer units									
				Hydraulic properties					
Estimated annual recharge (inches)	Hydrogeologic boundaries	Type of porosity	Conditions of occurrence	Subunit	Estimated specific capacity [(gal/min)/ft]		Estimated hydraulic conductivity (ft/d)		Source of data
					Range	Median	Range	Median	
Alluvium: 5-15 Dune and beach sand: 20-40	Top: Water table Lateral: Wedges out to bedrock Bottom: Bedrock	Intergranular	Unconfined Semiconfined	Alluvium: Dune sand:	0.1-10 15-35	1 25	5-150 30-90	20 60	Oral communication (J.B. Gonthiar, USGS, 1981), and Robison (1973b).
10-30	Top: Water table Lateral: Flows wedge out to the west Bottom: Less-permeable rocks of the Western Cascades	Fracture Intergranular Tabular	Unconfined Confined	Pyroclastic rocks overlying basalt:	0.05-8	[1]2	10-100	[1]75	Oral communication (J.B. Gonthier, USGS, 1981).
1-8	Top: Water table Lateral: Interfingers with marine rocks and butts against Paleozoic-Mesozoic rocks to the west Bottom: Unknown	Fracture Intergranular	Unconfined Confined	Flow and pyroclastic rocks:	0.1-2	0.5	0.1-10	1	Oral communication (J.B. Gonthier, USGS, 1981).
1-8	Top: Water table Lateral: Interfingers with Western Cascade volcanic rocks to tbe east. Bottom: Unknown	Fracture Intergranular	Unconfined Confined	Marine and non-marine sediments:	0.01-2	0.2	0.01-10	0.8	Oral communication (J.B. Gonthier, USGS, 1981), Robison and Collins (1977, 1978), Robison (1974), Frank (1970), and oral communication (C.A. Collins, USGS, 1981).
5-15	Top: Water table Lateral: Wedges out to bedrock Bottom: Bedrock	Intergranular Fracture	Unconfined	Entire unit:	0.1-1.5	0.4	5-20	10	Oral communication (J.B. Gonthier, USGS, 1981), and Robison (1973a).
<5	Top: Water table Lateral: Butts against Western Cascade rocks to the east Bottom: Unknown	Fractura	Unconfined Confined	All subunits:	0.01-1	0.3	0.1-10	2	Oral communication (J.B. Gonthier, USGS, 1981).

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[1] Values ere not representative of tbe High Cascade Range as a whole.

Table 4.--Aquifer units of west-central Oregon,

Period	Epoch	Aquifer unit and map symbol	Formations included in aquifer unit	Thickness range (feet)	Lithologic description and areal distribution	Structural setting	Hydrogeology
Tertiary to Quaternary	Pliocene(?) to Holocene	Tertiary-Quaternary sedimentary deposits (I)	Younger alluvium Dune and beach sand Older alluvium Terrace deposits	0-300	Sand, gravel, and silt, unconsolidated to semiconsolidated. Younger alluvium is largely coarse gravel and sand. It underlies the channels and flood plains of the Willamette River and its tributaries and rivers draining the Coast Range into the Pacific Ocean. Dunes occur in localized areas on the coast near Florence, Waldport, and Newport, and beach sand occurs along the entire coast. Older alluvium is sand and gravel interspersed with mixtures of sand, silt, and clay. It covers the main valley floor of the Willamette Valley and also occurs along the Siletz River. The older alluvium is generally finer than the younger alluvium, but contains large proportions of sand and gravel on the east side of the Willamette Valley and becomes progressively finer to the west. Terrace deposits are generally poorly sorted gravel, sand, and clay and are deeply weathered. They generally occur along the margin of the Willamette Valley, above the altitude of the main valley floor.	Flat-lying	Younger alluvium and coastal dune deposits have high permeability. Older alluvium is moderately permeable and generally thicker than younger alluvium. Recharge is high except where fine-grained material occurs at the surface. Hydraulic connection between streams and shallow deposits is generally good. The water table is typically less than 25 ft below the land surface. Terrace deposits are commonly above the water table. Well yields of more than 700 gal/min have been reported for the younger alluvium, but yields for the aquifer unit as a whole probably range from 50 to 100 gal/min.
Tertiary to Quaternary	Pliocene(?) to Holocene	Tertiary-Quaternary volcanic rocks of the High Cascade Range (II)	Pyroclastic rocks Andesite and basalt	0->3,000	Andesite and basalt; pyroclastic rocks and lava-flow material. Pyroclastic rocks occur as pumice flows and small cinder cones. Andesite and basalt lava flows form most of the High Cascade Range and occur as composite volcanic cones and intracanyon flows.	Deposited on surface with high relief. Undeformed.	Permeability and recharge may be large locally, depending on lithology. Water table is probably several hundred feet deep beneath topographically high areas, and less beneath major valleys. Springs are common and may contribute to the high base flow of streams draining the High Cascade Range. Ground- and surface-water drainage basins may not coincide. Well characteristics are largely unknown.
Tertiary	Eocene to Miocene	Tertiary volcanic rocks of the Western Cascade Range (III)	Sardine Formation "Little Butte Volcanic Series" Fisher Formation	0-15,000	Andesite, basalt, and dacite; lava flows, pyroclastic rocks, tuffaceous sandstone and siltstone, mudflow breccia, and conglomerate. The Sardine Formation is predominantly andesite and basalt flow rocks and underlies most of the Western Cascade Range. The "Little Butte Volcanic Series" consists of andesitic and dacitic tuff that outcrops along the eastern edge of the southern Willamette Valley and in the core of the anticlines in the foothills of the Cascade Range. The Fisher Formation outcrops west and south of Eugene and is predominantly andesitic and dacitic tuffaceous sandstone and siltstone.	Forms broad open folds with fold axes that trend northeast. Largest structures include the Mehama and Breitenbush anticlines and the Sardine syncline. Faulted locally.	Permeability is generally low; however, jointed volcanic flows, welded tuffs and breccias, and the coarse sedimentary rocks can serve as aquifers. Recharge is low to moderate depending on the lithology of rocks at the surface. The water table is generally more than 50 ft below the land surface. Well yields of more than 100 gal/min have been reported, but are generally less than 20 gal/min.
Tertiary	Eocene to Miocene	Tertiary rocks of the Coast Range (V)	Nye Mudstone Yaquina Formation Eugene Formation Yachats Basalt Spencer Formation Nestucca Formation Tyee Formation Umpqua Formation Siletz River Volcanics	0->10,000	Micaceous, tuffaceous, and arkosic sandstone, siltstone, and mudstone; basalt flows and pillow basalt flows with interbedded siltstone, tuff, and breccia. Marine sediments form most of the Coast Range, probably underlie a large part of the southern Willamette Valley, and crop out along the eastern edge of the Willamette Valley (Eugene Formation). The Yachats Basalt consists of basalt flows and outcrops along the coast between Heceta Head and Yachats. The Siletz River Volcanics are primarily pillow basalt flows and crop out in a northeast-trending zone west of the Philomath-Corvallis area.	Marine sediments are gently folded and form a northward-trending anticlinorium. The Siletz River Volcanics form a northeast-trending anticlinal structure and are bounded by northeast-trending faults. Localized faulting occurs throughout the Coast Range.	Permeability and recharge are low. Water table is generally less than 50 ft below the land surface in lowland areas, but is greater in topographically high areas. Surface- and ground-water basins coincide. Well yields generally range from 5 to 10 gal/min.

Mid Coastal and Southern Willamette River basins

Characteristics of aquifer units									
				Hydraulic properties					
					Estimated specific capacity [(gal/min)/ft]		Estimated hydraulic conductivity (ft/d)		
Estimated annual recharge (inches)	Hydrogeologic boundaries	Type of porosity	Conditions of occurrence	Subunit	Range	Median	Range	Median	Source of data
Alluvium: 5-15	Top: Water table	Intergranular	Unconfined and seasonally confined	Younger alluvium:	5-500	75	200-6,000	600	Helm and Leonard (1977), and Frank (1973, 1974, 1976).
Dune and beach sand: 20-40	Lateral: Wedges out to bedrock			Dune sand:	5-35	25	35-80	60	Hampton (1963), and Robison (1973b).
	Bottom: Bedrock			Older alluvium:	0.5-100	5	10-100	25	Helm and Leonard (1977), and Frank (1973, 1974, 1976).
10-30	Top: Water table Lateral: Flows wedge out to the west Bottom: Less permeable rocks of the Western Cascades	Fracture Intergranular Tabular	Unconfined Confined	--	--	--	--	--	--
5-10	Top: Water table Lateral: Interfinger with marine rocks to the west Bottom: Unknown	Fracture Intergranular Tabular	Unconfined Confined	Flow and pyroclastic rocks:	0.1-1.5	1	0.1-10	1	Helm and Leonard (1977), and Frank (1976).
2-8	Top: Water table Lateral: Interfingers with Western Cascade volcanic rocks to the east. Bottom: Unknown	Intergranular Fracture	Unconfined Confined	Marine sediments:	0.01-3	0.4	0.01-10	0.8	Helm and Leonard (1977), and Frank (1973, 1974, 1976).

Table 5.--Aquifer units of northwestern Oregon,

Period	Epoch	Aquifer unit and map symbol	Formations included in aquifer unit	Thickness range (feet)	Lithologic description and areal distribution	Structural setting	Hydrogeology
Tertiary to Quaternary	Pliocene to Holocene	Tertiary-Quaternary sedimentary deposits (I)	Younger alluvium Dune and beach sand Older alluvium Terrace deposits Boring Lava Troutdale Formation Sandy River Mudstone	0-1,500	Gravel, sand, silt, and clay, unconsolidated to consolidated; basalt flows, tuff, and cinders. Younger alluvium consists of unconsolidated to semiconsolidated gravel, sand, and silt that underlie flood plains and river channels. Dune sand is most extensive in the Clatsop Plains area west of Astoria; beach sand occurs along the entire coast. Older alluvium and terrace deposits consist of semiconsolidated silt, sand, and gravel that form the main floors of the Willamette and Tualatin Valleys, and several smaller valleys. The Boring Lava is composed of weathered basalt and pyroclastic rocks that are exposed in buttes at source vents in the Portland area. The Troutdale Formation consists of conglomerate or well-sorted sandstone with claystone and siltstone interbeds; it occurs beneath the northern Willamette Valley, the Tualatin Valley, and along the Columbia River. The Sandy River Mudstone overlies the Columbia River Basalt Group beneath the northern Willamette Valley and the Tualatin Valley; it is exposed most extensively in bluffs along the Sandy and Clackamas Rivers.	Horizontal to gently folded.	Permeability and recharge are variable due to variability of surface soils; coarse-grained permeable aquifers are commonly interlayered with finer grained, less permeable confining and semiconfining beds. Water table is generally within 50 ft of the land surface, except in areas where local relief is large. Good hydraulic connection exists between shallowest deposits and streams, but this connection becomes poorer with depth. Well yields of more than 2,000 gal/min have been reported, but are generally less than 300 gal/min. The Boring Lava may be unsaturated where it caps topographic highs and occurs above the regional ground-water flow system. The Sandy River Mudstone is predominantly a low-permeability unit.
Tertiary to Quaternary	Pliocene(?) to Holocene	Tertiary-Quaternary volcanic rocks of the High Cascade Range (II)	Pyroclastic rocks Andesite and basalt	0->3,000	Andesite and some basalt; pyroclastic rocks and lava flows. Forms most of the High Cascade Range and occurs as composite volcanoes, intracanyon flows, domes, fissure flows, and cinder cones.	Deposited on surface with high relief. Locally faulted.	Permeability and recharge may be large locally. Main zone of saturation is probably a few hundred feet below the land surface in most areas and deeper in topographically high areas. Surface-water and underlying ground-water drainage basins may not coincide, especially in highest topographic areas. Although very few wells have been completed in the unit, reported yields are as much as 100 gal/min, but are generally less than 20 gal/min.
Tertiary	Oligocene(?) to Pliocene	Tertiary volcanic rocks of the Western Cascade Range (III)	Sardine Formation "Little Butte Volcanic Series"	0-10,000	Andesite and basalt; flow material, breccia, and pyroclastic rocks. The Sardine Formation underlies much of the Western Cascade Range and consists of andesitic lava flows, mudflows, breccia, and tuff. Its outcrop in the northern Willamette Basin extends from the Bull Run River on the north to the Santiam River on the south, and the outcrop increases in width southward. The "Little Butte Volcanic Series" is primarily basaltic and andesitic tuff, breccia, and agglomerate. Its outcrop is limited to the upper Clackamas River drainage, a small exposure southwest of Molalla, and the upper Molalla River drainage.	Forms open northeast-trending folds in the Western Cascades. Locally faulted.	Permeability is generally low to moderate. Water table may be several hundred feet below the land surface in topographically high areas, but is shallow in major valleys. Surface- and ground-water drainage basins probably coincide in most areas. Well yields may reach 100 gal/min, but are typically less than 20 gal/min.
Tertiary	Miocene	Columbia River Basalt Group (IV)	Columbia River Basalt Group	0-1,500	Basalt. Consists of several individual flows ranging in thickness from 10 to 100 ft. In some places the basalt is weathered to a depth of 200 ft. It is exposed in the Western Cascade Range in the upper drainages of the Clackamas and Sandy Rivers, it crops out along the Columbia River from the core of the Cascades to Astoria, and it is exposed in the northern Willamette Valley in hills bordering three structural basins--Portland, Tualatin, and French Prairie Basins. The French Prairie Basin lies between Canby on the north and Salem on the south.	Forms broad and also tight folds in the northern Willamette Basin. Locally faulted.	Overall permeability is low; however, interflow zones and scoriaceous flow tops may readily transmit water. Ground-water storage is limited. Dense impermeable flow centers may limit vertical flow and recharge. The water table is generally more than 300 ft below the land surface in upland areas. Well yields may exceed 1,000 gal/min, but typically are less than 100 gal/min. Water-level declines may occur because of heavy pumping.
Tertiary	Eocene to Miocene	Tertiary rocks of the Coast Range (V)	Astoria Formation Intrusive rocks Scappoose Formation Pittsburg Bluff Formation Keasey Formation Goble Volcanics Cowlitz and Nestucca Formations Yamhill Formation Tillamook Volcanics Tyee Formation	0->15,000	Sandstone, siltstone, shale, mudstone, and conglomerate; sills and dikes of gabbro, diorite, diabase, and basalt; basaltic flow material, breccia, and intercalated tuffaceous siltstone. Marine sedimentary rocks of the northern Coast Range include the Astoria, Scappoose, Pittsburg Bluff, Keasey, Cowlitz, and Nestucca, Yamhill, and Tyee Formations which predominantly consist of tuffaceous siltstone, sandstone, and conglomerate. Intrusive rocks form most of the prominent peaks in the range. The Goble Volcanics are primarily basalt and breccia; they crop out near Goble, Oreg., on the Columbia River. The Tillamook Volcanics are a thick accumulation of pillow basalt, basalt flow material, and tuffaceous sediments that correlate with the Goble Volcanics, the Nestucca Formation, and the Siletz River Volcanics to the south. The Tillamook Volcanics form the core of the northern Coast Range.	The major structure is the north-trending Coast Range upwarp. Dips are generally less than 10°. Local faulting present.	Permeability and recharge are generally low. The water table may be more than 200 ft below the land surface in topographically high areas, but is typically less than 50 ft below the surface in lowlands. Ground-water basins closely conform in size and shape with overlying surface-water drainage basins. Well yields are typically less than 20 gal/min, but may reach 200 gal/min.

North Coastal and northern Willamette River basins

Characteristics of aquifer units									
				Hydraulic properties					
Estimated annual recharge (inches)	Hydrogeologic boundaries	Type of porosity	Conditions of occurrence	Subunit	Estimated specific capacity [(gal/min)/ft] Range	Estimated specific capacity [(gal/min)/ft] Median	Estimated hydraulic conductivity (ft/d) Range	Estimated hydraulic conductivity (ft/d) Median	Source of data
Alluvium: 5-15 Dune and beach sand: 20-40	Top: Water table Lateral: Wedge out to bedrock Bottom: Sandy River Mudstone	Intergranular	Unconfined Confined	Younger alluvium: Dune sand: Troutdale Formation:	5-500 5-35 1-300	100 25 10	20-4,000 30-90 0.1-400	200 60 30	Price (1967a). Robison (1973b), and Frank (1970). Hogenson and Foxworthy (1965), and Willis (1977, 1978).
10-30	Top: Water table Lateral: Flows wedge out to west Bottom: Less-permeable rocks of the Western Cascades	Intergranular Fracture	Unconfined Confined	--	--	--	--	--	--
5-10	Top: Water table Lateral: Interfingers with Coast Range rocks to the west Bottom: Unknown	Intergranular Fracture Tabular	Unconfined Confined	Flow and pyroclastic rocks:	0.1-4	1	0.1-10	1	Oral communication (J.B. Gonthier, USGS, 1981), Helm and Leonard (1977), and Frank (1976).
5-10	Top: Water table Lateral: Wedges to zero due to erosion or nondeposition Bottom: Tertiary marine rocks (unit V) or volcanic rocks of the Western Cascades (unit III)	Tabular Fracture	Confined	All subunits:	0.01-100	3	0.1-30	5	Hart and Newcomb (1965), Price (1967b), and Foxworthy (1970).
2-8	Top: Water table or Columbia River Basalt Group (unit IV) Lateral: Interfingers with volcanic rocks of the Western Cascades Bottom: Unknown	Intergranular Fracture	Unconfined Confined	Marine sediments:	0.01-5	0.8	0.01-10	0.8	Hampton (1972), Price (1967b), and Gonthier (1982).