Ground Water in the Harrisburg-Halsey Area, Southern Willamette Valley, Oregon

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CONVERSION FACTORS

Factors for converting English units to metric units are shown to four significant figures. However, in the text the metric equivalents are shown only to the number of significant figures consistent with the value for the English units.

English	*Multiply by*	*Metric*
Acres	4,047	m^2 (square meters)
acre-ft (acre-feet)	1,233	m^3 (cubic meters)
	.001233	hm^3 (cubic hectometers)
ft (feet)	.3048	m (meters)
gal (gallons)	3.785	l (liters)
gal/min (gallons per minute)	.0631	l/s (liters per second)
in. (inches)	25.40	mm (millimeters)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)
specific capacity, (gal/min)/ft (gallons per minute per foot)	.2070	(l/s)/m (liters per second per meter)
transmissivity, ft^2/d (square feet per day)	.0929	m^2/d (square meters per day)

GROUND WATER IN THE HARRISBURG-HALSEY AREA, SOUTHERN WILLAMETTE VALLEY, OREGON

By F. J. Frank

ABSTRACT

The Harrisburg-Halsey area lies between the Cascade and Coast Ranges in the southern Willamette Valley in northwestern Oregon. The area consists of approximately 350 square miles (910 km^2) and includes a part of the lower foothills of the Coast and Cascade Ranges. Volcanic and marine sedimentary units exposed in the foothills range in age from Eocene to Miocene. The volcanic rocks are primarily of dacitic and andesitic composition and yield only small quantities of water that are generally adequate only for domestic and stock use. The alluvial deposits (sand and gravel) of the valley plain contain the more productive aquifers in the area and yield most of the water that is pumped from wells in the area.

Aquifers in the area are recharged principally by direct infiltration of precipitation. Most of the precipitation, which averages about 40 in. (1,020 mm) per year occurs during late autumn and winter.

During 1974 the seasonal decline of water levels from winter to late summer averaged about 10 ft (3 m) for the alluvial deposits. The seasonal change of storage for 1974 was estimated to be about 170,000 acre-ft (210 hm^3). Of this volume, about 14,300 acre-ft (17.6 hm^3) was pumped from wells; the rest, about 156,000 acre-ft (190 hm^3), was discharged naturally by seepage and spring flow to streams and by evapotranspiration. The difference between pumpage and natural discharge indicates that a large quantity of additional water is available for development. The storage capacity of the alluvial aquifers is estimated to be about 800,000 acre-ft (1,000 hm^3) in the zone 10–100 ft (3–30 m) below land surface.

Ground water from the alluvial deposits is chemically suitable for irrigation and other uses, as is most of the water obtained from perched-water bodies in the older sedimentary and volcanic rocks. However, the mineral concentration of water from the older sedimentary rocks, particularly from deeper producing zones beneath the valley plain, is greater than that of water from the alluvial deposits. Locally, some of the water from the older rocks is too saline for general use. Water samples from domestic wells were analyzed for fecal coliform bacteria. Although these analyses did not indicate ground-water pollution, further study would be required to establish that none exists in the area.

INTRODUCTION

In the future, increased water supplies will be needed in the Willamette River alluvial valley in the vicinity of Harrisburg and Halsey for maximum beneficial use of irrigable land. Also, economic growth in and around the towns will require increasing suburban, public, and industrial water supplies.

The purpose of this report is to present sufficient geologic and hydrologic data to aid in future development of ground-water supplies. Work during this investigation included (1) delineating the extent, thickness, and water-bearing characteristics of the principal geologic units; (2) determining the sources, occurrence, availability, and movement of ground water; and (3) estimating the quantity of ground water used and the quantity available for development from the alluvial aquifers.

The ground-water resources of the area were described in a general way in a report on ground-water resources of the Willamette Valley by Piper (1942). Also, basic ground-water data and a brief description of ground-water conditions and availability were given in a report by Frank and Johnson (1975). Related ground-water studies have been made in adjacent areas by Frank (1973, 1974). Records of ground-water levels for a number of wells in the study area have been collected over a period of years by the Oregon Water Resources Department (formerly the Oregon State Engineer). Some of those records have been published in the State Engineer's ground-water report series (Sceva and DeBow, 1965, 1966; Bartholomew and DeBow, 1970; Bartholomew and others, 1973).

This investigation is part of a continuing cooperative program between the Oregon Water Resources Department and the U.S. Geological Survey to evaluate the ground-water resources of Oregon. Many of the data for this investigation were supplied by well owners, operators, and drillers. The helpful cooperation of these people and of the well owners who permitted access to their wells to collect ground-water data is gratefully acknowledged.

GEOGRAPHY

The Harrisburg-Halsey area covers about 350 square miles (910 km^2) in the southern Willamette Valley, Oreg. The location and boundaries of the study area are shown in figure 1.

The principal centers of population are Harrisburg, Halsey, Monroe, and Brownsville. The principal industry in the area is agriculture; grass and legume seeds are the major crops. Other important agricultural crops are grains and vegetables. Other industries of importance are related to forest products, ranging from lumber production to the manufacture of wood and paper products.

CLIMATE

The area has a temperate climate, characterized by wet winters and generally dry summers. Topography, nearness to the Pacific

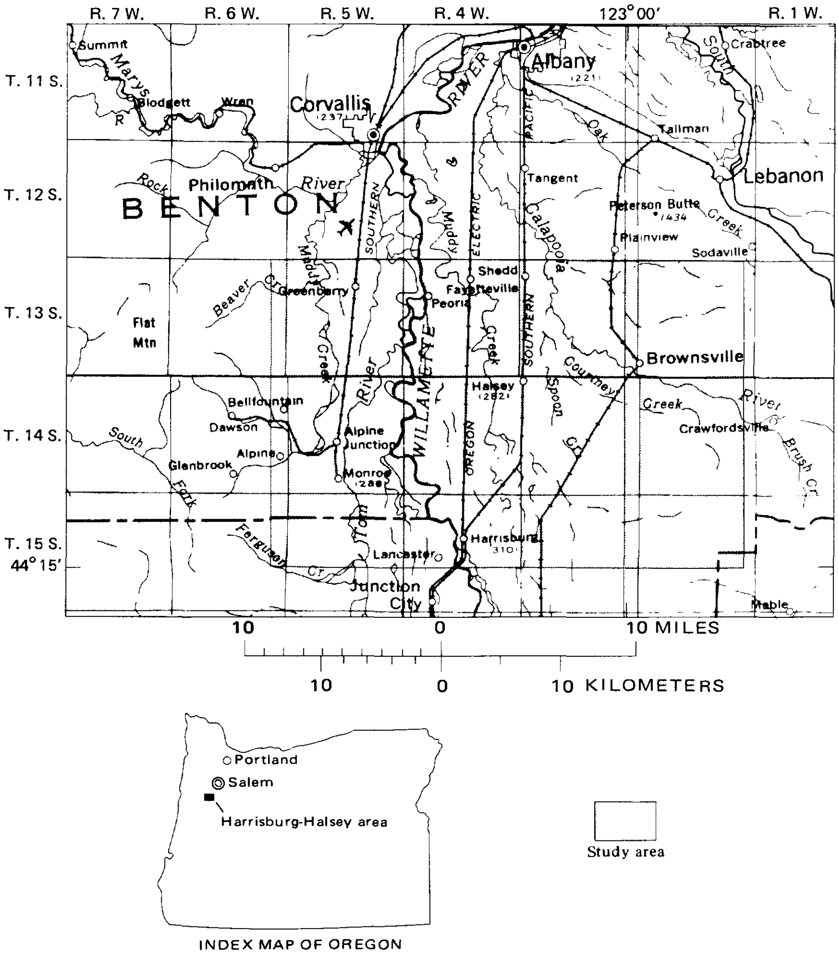

FIGURE 1.—Location and general features of the Harrisburg-Halsey area.

Ocean, and exposure to middle-latitude westerly winds are the principal climatic controls. Since 1887, climatological data have been collected at Albany, immediately north of the project area. These records are believed to be representative of the project area. Figure 2 shows annual precipitation for 1931–74 at Albany. The annual precipitation for that period ranged from 18.91 in. (480 mm) in 1941 to 57.44 in. (1,460 mm) in 1937.

The average annual precipitation in the area is about 40 in. (1,020 mm); most of the precipitation occurs as rain. The wettest months of the year are November through January, during which time about 45 percent of the average annual precipitation occurs. In

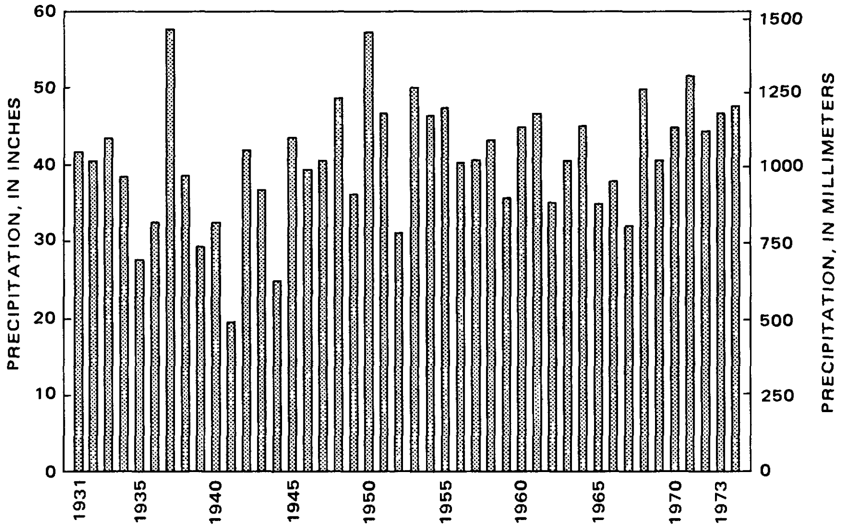

FIGURE 2.—Annual precipitation at Albany, 1931–74.

July and August, normal precipitation is less than half an inch (13 mm), and occasionally in midsummer no rain falls for periods of 30–60 days. Figure 3 shows minimum, mean, and maximum monthly precipitation for 1931–74.

According to National Weather Service records, the average annual temperature at the Albany station is 53°F (11.5°C [Celsius]). January, generally the coldest month, has an average temperature of 39°F (4°C). July, usually the warmest month, has an average temperature of 67°F (19.5°C). The average frost-free growing season is 215 days.

TOPOGRAPHY AND DRAINAGE

The area is part of a broad alluvial plain which lies between the Cascade and Coast Ranges in the southern part of the Willamette Valley. The lowland part of the area is an alluviated plain with irregular bottomlands along the streams, which are 5–30 ft (1.5–9 m) below valley-plain terraces. The valley-plain and associated terraces are practically all level or gently rolling and have altitudes from 200 to 300 ft (60–90 m).

The western margin consists of isolated hills and ridges of the Coast Range which rise to altitudes of 300 to about 1,500 ft (90–460 m). To the east, a series of low extensions of the Cascade Range, at altitudes of 300–1,200 ft (90–370 m), rise above the valley floor; these

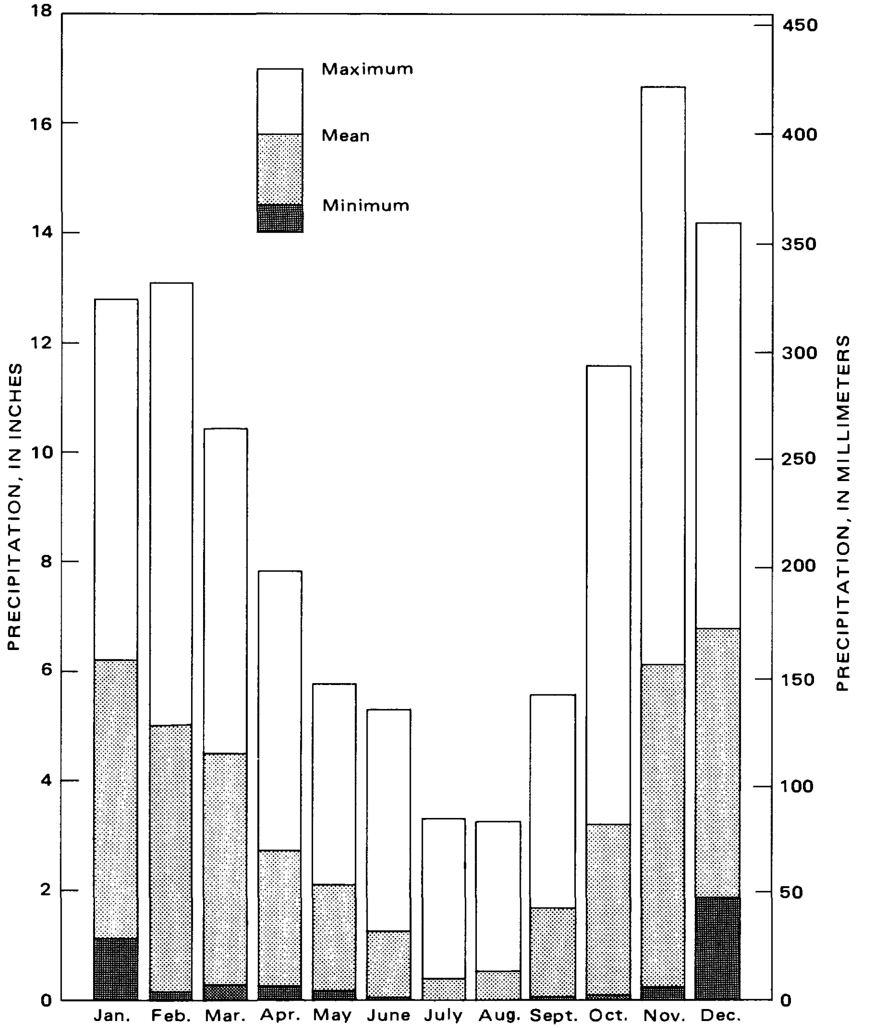

FIGURE 3.—Monthly precipitation at Albany, 1931–74.

extensions form an irregular foothill belt along the uplands on the eastern margin of the area.

The area is drained primarily by the Willamette, Long Tom, and Calapooia Rivers. The Willamette River, which is the master stream, enters the area from the south and flows generally northward east of the Coast Range foothills. The Long Tom River enters the area from the south in the western part of the area and drains into the Willamette River about 2½ mi (4 km) southwest of Peoria. The Calapooia River drains much of the eastern part of the area and flows into the

Willamette River north of the project area at Albany, Oreg.

Two of the principal streams in the area are both named Muddy Creek—one in Benton County west of the Willamette River and the other in Linn County east of the Willamette River. In this report they are referred to as Muddy Creek (west) and Muddy Creek (east). Muddy Creek (west) drains much of the west side of the area and is tributary to the Marys River about 14 mi (22 km) north of the project area. Muddy Creek (east) flows between the Willamette and Calapooia Rivers and is tributary to the east channel of the Willamette River about 12 mi (19 km) north of the project area.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

The geologic formations exposed in the area are those common to the Eugene-Springfield (Frank, 1973) and Corvallis-Albany (Frank, 1974) areas. Areal distribution of the rock units compiled from Beaulieu, Hughes, and Mathiot (1974); Peck, Griggs, Schlicker, Wells, and Dole (1964); and Piper (1942) is shown on plate 1. Plate 1 also shows the thickness of alluvial deposits, based on data from drillers' logs of water wells and information obtained from test holes bored with a truck-mounted auger.

The geologic units in the area consist of unconsolidated deposits and consolidated rocks. The consolidated rocks in the upland parts of the area yield small quantities of water to wells, but such rocks at depth beneath the valley fill generally have low porosities and therefore do not readily transmit water to wells. The unconsolidated alluvial deposits of Pleistocene and Holocene age make up the valley fill. These alluvial deposits form the principal aquifers and yield most of the water that is pumped from wells in the area. The lithology and water-bearing properties of the principal geologic units are described in greater detail in the following pages. A summary of the geologic formations exposed in the area and their water-bearing properties is given in table 1.

In general discussion of the yields of wells, the following rating, in gallons per minute, is used in this report.

Description	*Yield (gal/min)*
Small	5–20
Moderate	20–100
Large	>100

CONSOLIDATED ROCKS

The principal older and generally consolidated rocks in the area consist of the marine Tyee, Spencer, and Eugene Formations and

TABLE 1.—*Principal rock units and their general hydrologic properties*

System	Series		Geologic unit	Approximate thickness (ft)	Lithology	Occurrence	General hydrologic properties
QUATERNARY	Holocene	Unconsolidated deposits	Younger alluvium	35 (avg.)	Largely coarse gravel, ranging in size from small pebbles to cobbles as much as 6 inches in diameter. Pebbles are generally well rounded and are mainly of basaltic and andesitic composition. Contains some sandy zones and a small proportion of silt.	Forms the present flood plain of the Willamette River.	In most places, yields large quantities of water to wells. Yields water copiously to shallow wells, especially where pumping induces recharge from the river.
QUATERNARY	Pleistocene and Holocene	Unconsolidated deposits	Older alluvium	20–200	Sand and gravel interspersed with mixtures of sand, silt, and clay. Forms lenticular bodies of gravel and sand that appear to be interconnected, allowing free movement of ground water. Deposit tends to be of finer materials than the younger alluvium. Upper part consists of about 5–20 feet of the Pleistocene Willamette Silt.	Forms and lies beneath the main valley plain. Includes younger alluvial deposits along tributary streams.	Yields moderate to large quantities of water to wells in the valley plain.
QUATERNARY	Pleistocene and Holocene	Unconsolidated deposits	Terrace deposits	10–100	Poorly sorted gravel, sand, and clay unit; deeply weathered, particularly in upper part.	Occur as dissected benches which rest on bedrock shelves that are higher than the valley plain. Deposits are found in the vicinity of Oak Ridge Cemetery and on bedrock terraces along the west side of project area.	Has limited areal extent and is unimportant as an aquifer. Where present, generally yields small quantities of water to wells.

TABLE 1.—*Principal rock units and their general hydrologic properties*—Continued

System and Series			Geologic unit	Approximate thickness (ft)	Lithology	Occurrence	General hydrologic properties
TERTIARY	Oligocene and Miocene	Consolidated deposits	Little Butte Volcanic Series	10,000	Consists of a sequence of dacitic to andesitic pyroclastic rocks and dense, dark basaltic flows, with some scoriaceous material. Along the foothills of the eastern part of the area, marine sandstone is interbedded with the volcanic rocks.	Comprises the upland and foothill parts of the east side of area.	Yields small quantities of water to wells. Water from most wells usually adequate for domestic and stock use. Much of the water is obtained from saturated zones perched above the regional water table. A few of the wells constructed in the interbedded marine sandstone yield moderate to large supplies of water. Locally yields water of poor quality.
	Oligocene		Eugene Formation	1,500	Marine-deposited sediments of tuffaceous sandstone, siltstone, and shale.	Exposed in foothills in east side of area and underlies the valley plain.	Generally yields only small quantities of water to wells. Locally may contain water of poor quality.
			Tuffaceous sandstone	500	Consists of medium- to coarse-grained tuffaceous sandstone.	Forms Oliver and Winkle Buttes near the town of Monroe in the western part of the area.	Yields small quantities of water to wells.

TERTIARY	Eocene	Consolidated deposits	Spencer Formation	4,500	Upper part of formation is of fine- to medium-grained arkosic and micaceous sandstone. Lower part consists of basaltic arkosic sandstone. Usually contains a few thin beds of sand and shaley siltstone and, locally, has a few thin lenses of tuffaceous materials. Sediments are of marine origin.	Forms part of the foothills and uplands on west side of area.	Generally yields small quantities of water to wells. Water from wells drilled into this unit beneath the valley plain may be of poor chemical quality.
			Tyee Formation	5,000	A marine sequence of tuffaceous sandstone, siltstone, and shale. In fresh exposures, the sandstone is firmly compacted and gray to blue in color. In places, includes well-indurated conglomerate beds which contain subangular basaltic pebbles.	Forms part of the uplands and foothills west of Monroe.	Generally yields small quantities of water to wells. Water may be of poor chemical quality locally. Some water is obtained from small saturated zones perched above the regional water table.

tuffaceous sandstone; and the Little Butte Volcanic Series which is exposed along the eastern margin of the area. Interbedded with the lower and middle parts of the Little Butte Volcanic Series are beds of marine sandstone equivalent to the Eugene Formation. The Little Butte Volcanic Series (as mapped by Beaulieu and others, 1974) includes (1) Oligocene and Miocene andesitic breccia and tuff and associated basaltic accumulations and (2) Oligocene interbeds of marine sandstone equivalent to the Eugene Formation.

The marine sedimentary rocks of the Tyee, Spencer, and Eugene Formations and the tuffaceous sandstone are generally fine-grained sandstone, siltstone, and shale, which have mostly low permeabilities. Those units generally yield only small quantities of water to wells. In the upland and foothills parts of the area, where these formations mostly occur, wells produce small to moderate quantities of good-quality water adequate for domestic use. In places beneath the valley plain, wells in these formations may produce poor-quality water. (See section on "Chemical Quality of the Ground Water.")

UNCONSOLIDATED DEPOSITS

The unconsolidated deposits consist of isolated terrace deposits, older alluvium which underlies the valley plain, and the younger alluvium which is coextensive with the present flood plain of the Willamette River.

The terrace deposits are dissected deposits of gravel, silt, clay, and sand, which generally rest on a bedrock shelf at some elevation above the valley plain. Where the deposits are sufficiently thick to hold and store water, they yield small to moderate quantities of water to wells.

The older alluvium, together with the younger alluvium, forms the principal aquifer in the area. Included in the older alluvium is the Willamette Silt, as mapped by Beaulieu (Beaulieu and others, 1974), and thin, younger alluvial deposits of fine sand and silt along the minor streams. Below a thickness of 5–20 ft (1.5–6 m) of Willamette Silt, the alluvium is composed of interconnected lenses of coarse sand and gravel derived from volcanic rocks and interspersed with fine sand and silt. Below a depth of about 50 ft (15 m), the coarser alluvial deposits grade into and interfinger with lenses of sand, silt, clay, and pebbles.

The younger alluvium contains materials that in most places yield large quantities of water to wells. These deposits are composed of cobbles, coarse gravel, sand, and a small proportion of silt, and they have an average thickness of about 35 ft (11 m). In a few places (probably less than 10 percent of the total outcrop area), the deposits contain so many fine particles interspersed with the sand and gravel that water is yielded slowly to wells. Although not extensive, these fine-grained deposits may locally impede the infiltration of water from the river. Such infiltration is necessary for some of the wells to sustain large withdrawals.

GROUND WATER

Precipitation, falling as rain or snow, is the principal source of ground water in the area. Part of the precipitation evaporates, part is transpired to the atmosphere by vegetation, some runs off as surface flow, and some infiltrates into the ground to replenish soil moisture. Part of the water that infiltrates percolates to the zone of saturation where it recharges the ground-water system. The water in a saturated zone moves by force of gravity downgradient to points of discharge, such as springs, seeps along stream channels, or wells. Rock materials that yield usable quantities of water to wells and springs are called aquifers.

The upper surface of a zone of saturation is the water table, and the water in a zone of saturation is ground water. The water table is regionwide, but other water tables of minor extent (perched-water tables) may occur where ground water collects above poorly permeable materials that are above the main water table. Perched-water bodies in the Harrisburg-Halsey area generally yield only small quantities of water to wells because the rate of recharge and volume of water in storage are normally small.

OCCURRENCE AND AVAILABILITY

CONSOLIDATED ROCKS

In parts of the area where the consolidated rocks are the principal aquifers, ground water occurs under perched, confined, and unconfined conditions. Most of the wells that penetrate the consolidated rocks draw water from aquifers perched above the regional water table. A few of these wells produce water from the main zone of saturation or from confined water bodies. Table 2 gives the depths, yields, and specific capacities (ratio of yield of well in gallons per minute to drawdown, in feet, while pumping at a stated yield) of wells that tap consolidated rock aquifers.

MARINE DEPOSITS

The Tyee, Spencer, and Eugene Formations and the tuffaceous sandstone compose the marine deposits in the project area. These formations are similar in occurrence and water-bearing properties and will be discussed together here. These rocks generally yield small quantities of water to wells which are a source of stock and domestic

TABLE 2.—*Yields and specific capacities of representative wells in the consolidated rocks*

Township and range	Number of wells	Geologic unit	Depth		Yield		Specific capacity	
			Range (ft)	Average (ft)	Range gal/min	Average gal/min	Range [(gal/min)/ft]	Average [(gal/min)/ft]
13S/2W	11	Little Butte Volcanic Series	90–485	204	3–30	15	0.03–0.50	0.19
13S/3W	5	do	131–500	308	1–39	15	.01– 45	.15
14S/2W	8	do	64–315	152	2–60	13	.02– .75	.17
14S/3W	[1]8	do	40–202	114	3–28	14	.04–5.0	.88
13S/5W	8	Spencer Formation	123–410	194	1–28	9	.01–4.0	.50
14S/5W	10	do	114–525	243	2–30	8	.01– .38	.10
15S/5W	6	do	80–500	250	2–20	9	.02– .16	.06
14S–15S/5W	7	Tyee Formation	90–397	159	1–30	11	.01– .30	.10
14S–15S/6W	5	do	40–365	170	1–28	10	.01–1.40	.30

[1]One well reported to yield 250 gal/min with 70 ft of drawdown.

water in a large part of the uplands and foothills in the western part of the area. Most wells drilled into these deposits in the uplands and foothills produce 2 to about 10 gal/min (0.13 to about 0.60 l/s) (table 2).

In the upland parts on the west side of the area, much of the water from these rocks is obtained from small saturated zones perched above the regional water table. Perched water occurs at various elevations and, in places, small springs are outlets for perched water. Some of the springs emanating from the Tyee and Spencer Formations flow 5–10 gal/min (0.30–0.60 l/s) throughout the year and are being utilized as water supplies for stock and domestic uses. Water from these perched zones is usually of good quality. However, some of the wells drilled into these rocks (particularly the Eugene Formation) beneath the valley plain produce poor-quality water because entrapped saltwater has not been displaced by circulating ground water. An example of such a well is 13S/5W–24acc; though it has a reported yield of 800 gal/min (50 l/s), it was abandoned because it yielded water of poor quality (tables 8, 9).

LITTLE BUTTE VOLCANIC SERIES

The Little Butte Volcanic Series yields water supplies for an increasing number of people living in the uplands and foothills near Brownsville. Generally, water is obtainable from the Little Butte Volcanic Series in volumes sufficient for most domestic uses. Because these rocks make up much of the uplands in the eastern part of the area, many of the wells drilled into them penetrate isolated groundwater bodies perched above the regional water table. Perched water occurs at several elevations; in places, small springs are outlets for this water, but most of the springs cease to flow during the dry summer months. Wells that produce water from the Little Butte have a considerable range in depth and yield (table 2).

TABLE 3.—*Yields and specific capacities of representative wells in the unconsolidated deposits*

Township and range	Number of wells	Geologic unit	Depth: Range (ft)	Depth: Average (ft)	Yield: Range (gal/min)	Yield: Average (gal/min)	Specific capacity: Range [(gal/min)/ft]	Specific capacity: Average [(gal/min)/ft]
13S/3W	14	Older alluvium	40–138	85	20–190	80	1–97	6
13S/4W	21	do	40–125	55	10–310	35	.5–12	4
13S/5W	9	do	32–68	42	15–50	35	.5–14	4
14S/2W	7	do	39–120	75	5–125	38	.15–12	3
14S/3W	9	do	30–125	70	18–230	77	.3–12	6
14S/4W	19	do	35–128	57	10–650	72	1.–16	8
14S/5W	7	do	30–70	44	28–100	43	.5–12	4
15S/3W	7	do	31–100	62	20–75	50	.5–20	7
15S/4W	10	do	35–110	47	5–300	40	.6–38	8
15S/5W	5	do	30–71	45	24–65	37	1.2–6	3
13S/5W	12	Younger alluvium	25–41	32	45–500	170	3–70	28
14S/5W	20	do	25–50	32	30–700	240	4–350	50
15S/4W	18	do	21–40	29	20–450	245	20–200	52
15S/5W	6	do	26–50	32	30–450	230	10–65	36

Most of the water obtained from the Little Butte Volcanic Series comes from wells constructed in the part of the formation that is interbedded with marine deposits. (See pl. 1.) A few of the wells at the base of the foothills have been drilled into fairly permeable lenses of sandstone interbedded with claystone; such a well, 14S/3W-13cdc2, has been reported to yield 250 gal/min (16 l/s) (tables 8,9). However, some of the wells drilled into these interbedded marine deposits produced inadequate volumes of water for domestic use and have been abandoned.

UNCONSOLIDATED DEPOSITS

Unconsolidated deposits of older and younger alluvium underlie the valley plain. They are the more productive aquifers in the Harrisburg-Halsey area and are considered to be the only ones from which large-scale development of ground water is feasible. Table 3 gives depths, yields, and specific capacities of wells that tap unconsolidated deposits.

Nearly all the alluvial deposits are below the level of the water table. Most of the ground water in the alluvium is unconfined; however, at a few places ground water in these deposits is confined seasonally. Many of the fine-sand strata lie between clay and silt layers in the alluvium and contain water under a small confining pressure. In late winter and early spring, pressure builds to a point where water rises above land surface in some wells. However, during much of the year these wells do not flow, and water levels in the wells are typical of a water-table system.

OLDER ALLUVIUM

Yields of wells that penetrate the older alluvium depend on the thickness and character of the materials that make up the deposits. The older alluvium was deposited over an eroded bedrock surface and, as shown on plate 1 and in logs of wells in table 8, the thickness and lithology of these deposits vary considerably within a small area.

Plate 1 shows (1) the surficial geology of the area; (2) the thickness of alluvial deposits penetrated by wells and test holes in the area; (3) depth of wells and test holes; and (4) the chemical diagrams and specific conductivities of well water chemically analyzed and, if available, field specific conductivities.

The older alluvium attains its greatest thickness in that part of the area near and north of Harrisburg. At Harrisburg, the alluvium, as shown by logs of wells 15S/4W–16aac and 15S/4W–16adc (table 8), has a thickness of more than 300 ft (90 m). In this part of the area, as shown by Frank (1973), the older alluvium fills a fairly deep trough which extends south through Junction City, Oreg., in the Eugene-Springfield area. North of Harrisburg, the older alluvium thins rapidly to about 60 ft (18 m), as shown on plate 1 and by logs of wells 13S/4W–17bac and abandoned oil-test well 13S/4W–27dba (tables 8, 9).

In that part of the area west of the Willamette River and between the foothills and the river, the older alluvium rarely exceeds 60 ft (18 m) and has an average thickness of about 45 ft (14 m).

East of Harrisburg, in T. 15 S., R. 3 W., the older alluvium becomes thinner toward the foothills. (See pl. 1.)

As indicated by the chemical diagrams and values for specific conductance (pl. 1), wells that penetrate the entire thickness of alluvium and tap the upper part of the buried bedrock units tend to produce water high in dissolved solids. To the north of T. 15 S., R. 3 W., through Ts. 14 S. and 13 S., the alluvium is thinner, ranging from a maximum of 60–90 ft (18–27 m) near the west edge of R. 3 W. to 0 at the contact with the Little Butte Volcanic Series at the east edge of R. 3 W. Near the town of Halsey, water of poor chemical quality is found below depths of about 60–70 ft (18–21 m) (pl. 1 and tables 7, 9). The logs of wells 13S/3W–32ccc1 and 13S/3W–32ccc2 (table 8) indicate that the wells penetrate mostly alluvial materials. However, in this and other parts of the area, connate water may percolate upward into the valley alluvium from underlying marine rocks, causing the ground water to be highly mineralized and of poor quality. Water from well 13S/3W–32ccc2 has a dissolved-solids concentration of 3,4000 mg/l (tables 7, 9).

East of the Calapooia River in T. 13 S., R. 3 W., because of the many bedrock outliers and the nearness to the foothills, alluvial materials in many places are thin and probably do not exceed a thickness of 40 ft (12 m). Well 13S/3W–28cab, one of the better wells in this part of the area, was reported to pump about 165 gal/min (10 l/s) (table 9).

Because of the thinness of the alluvium and its poorer permeability toward the foothills, most wells drilled in Ts. 13 S., 14 S., and 15 S., R. 3 W., can be expected to yield no more than 100 gal/min (6 l/s).

In parts of the Harrisburg-Halsey area, some of the alluvial deposits contain fine-grained sediments, and some wells pump troublesome amounts of sand. Well 14S/4W–21dac pumps some sand but is capable of yielding 650 gal/min (40 l/s) (table 9). Well 14S/3W–16ccb in the eastern part of the area pumps some sand, and well 14S/4W–9baa2 in the valley plain is not being used because of excessive pumping of sand (table 9). Refinements in present well construction by the use of fabricated well screens and (or) a gravel pack around the screen or perforated parts of the casing would solve sand problems and increase the yields of wells in these alluvial aquifers. Well-construction methods are described in a report on another part of the Willamette Valley (Hampton, 1972, p. 61–63), in a publication by Edward E. Johnson, Inc. (1972), and in many other publications.

YOUNGER ALLUVIUM

The wells of highest yield in the area are in the shallow gravel and sand aquifers that make up the younger alluvium of the present flood plain of the Willamette River. Yields of wells in these deposits have been reported to range from about 30 to 700 gal/min (2–44 l/s), and most of the irrigation wells yield several hundred gallons per minute. Some wells have been reported to yield as much as 600–700 gal/min (38–44 l/s) (wells 14S/5W–35aad and 14S/5W–12ddb, tables 8, 9). The specific capacity of wells in the younger alluvium ranged from about 3 to as much as 350 gal/min per foot of drawdown (0.6–70 l/s/m) (table 3).

The underlying surface is irregular and, consequently, the thickness of the younger alluvium varies from place to place. The thickness ranges from about 20 to 40 ft (6–12 m) and averages about 30 ft (9 m). The younger alluvial deposits generally overlie the older alluvial materials, but in some places the deposits may lie directly on consolidated Tertiary rocks.

MOVEMENT OF GROUND WATER

Ground water moves from areas of recharge to areas of discharge. The rate at which ground water is replenished is controlled by the amount and intensity of precipitation, the infiltration capacity of the soil, and the permeability and porosity of the underlying materials. Ground water in the study area is discharged into local surface-water bodies, and ground-water movement is toward those outlets.

The shape and slope of the water table is shown on plate 1 by contours connecting points on the water table that have the same altitudes. Water-level contours show the configuration of the water surface, just as topographic contours show the shape of the land surface. In general, the direction of movement of ground water is at right angles to the contours. In the Harrisburg-Halsey area, the general movement of ground water is from the outer margin of the valley plain toward the Willamette River and in a general downstream direction.

In places along the Willamette River and the larger tributary streams, the water table forms broad, shallow troughs, the bottoms of which meet the water surface of the stream. Conversely, in other places the water table rises into a number of minor ridges where relatively impermeable material is not far below the surface of the land. This condition is shown by the contours near Oliver Butte, near the center of T. 14 S., R. 5 W. Sandstone is exposed there or is at fairly shallow depths below the surface in the vicinity of the ridges. The configurations of the ridges and troughs change because of water-table fluctuations and may be partly or largely obliterated during the rainy season as water is added to the ground-water body.

Widely spaced contours on the map indicate a gentle slope of the water-table surface, probably because of greater transmissivity of the aquifers. The most widely spaced intervals occur in unconsolidated alluvial deposits that are highly permeable and afford large yields of water to wells. Conversely, the more closely spaced contours indicate less permeability or a thinner section of saturated material. Closely spaced contours appear in the western and eastern parts of the area where permeabilities and yields of wells are low.

RECHARGE

The aquifers in the Harrisburg-Halsey area are recharged mostly during late autumn and winter, the seasons of greatest precipitation (fig. 3). The first autumn rains restore the soil moisture, but little water percolates to the ground-water bodies. When the soil becomes saturated (generally by November), nearly all the precipitation that is not lost by overland runoff or evapotranspiration saturates permeable rock materials and begins to infiltrate to the ground-water reservoir.

The unconsolidated alluvial deposits that underlie the valley plain are recharged directly by precipitation, and the reservoir is filled to capacity by January or February. As the reservoir fills, the hydraulic gradient on parts of the water table temporarily steepens and water moves toward the nearest surface drainage. Discharge may increase until it equals the rate of recharge and then the water table will rise no higher. If the rate of recharge exceeds the rate of discharge, the water table may rise to the land surface, creating a waterlogged condition locally. If this occurs, precipitation may collect on the flatter parts of the valley plain during late winter.

When the water table is low, the alluvial aquifers in some places receive some recharge from streams in the flood-plain areas of the Willamette River. (See section on "Relationship of the Alluvial Aquifers to the Willamette River.") Other sources of recharge to the alluvial aquifers are (1) undetermined volumes of water that enter from upstream underflow of the Willamette River and other streams and (2) infiltration from irrigation water and fluid-waste disposal.

Where they are near or form the land surface, the consolidated volcanic and sedimentary rocks that make up the foothill and upland parts of the area are recharged directly by precipitation. They are also recharged indirectly by water percolating downward through soils and overlying unconsolidated deposits. Because these rocks are less permeable, a large volume of precipitation runs off the foothills and uplands.

DISCHARGE

Ground water is discharged naturally from aquifers in the area through seeps, springs, and evapotranspiration, and artificially through wells. In the valley plain, ground water is discharged from the unconsolidated deposits mainly by seeps and springs adjacent to or in stream channels, by evapotranspiration in areas where the water table is near the surface, and by pumping from wells. During the dry summer months, the rate of ground-water discharge exceeds the rate of recharge and the upper part of the ground-water reservoir becomes dewatered. Discharge through springs and seeps helps to sustain the flow of the Willamette River and other streams. An indication of the magnitude of natural discharge from the alluvial deposits may be obtained by determination of the numerical difference between estimated pumpage and change of storage in the summer of 1974. This difference indicates that a net of about 156,000 acre-ft (190 hm^3) per year may be discharged naturally from the alluvial deposits.

Discharge from the consolidated rocks of the upland and foothill parts of the area is mainly by evapotranspiration, by discharge from springs and seeps that issue from shallow perched-water bodies, and by pumping from wells. The springs and seeps supply base flow to streams draining this area.

RELATIONSHIP OF THE ALLUVIAL AQUIFERS TO THE WILLAMETTE RIVER

As discussed in the previous sections, "Movement of Ground Water" and "Recharge," ground water moves both from the edges of the valley plain toward the Willamette River and downstream, contributing to streamflow. However, along certain reaches of the Willamette River at certain times of the year, the river contributes water to the younger alluvial aquifers. The movement of water from one environment to another illustrates that water in the younger alluvial aquifers and water in the river are not separate entities; they are connected and interdependent parts of the water system.

Interrelationships of the Willamette River and ground water in the alluvial deposits are illustrated in figure 4. This figure, consisting of a series of hydrographs showing records of water levels compared to records of river stage, shows the general relationships between precipitation, river stage, and water levels of wells in the younger and older alluvium. Reading downward, the first hydrograph in figure 4 represents the stage of Willamette River at Harrisburg (gaging station 14–1660 at the south end of the project). Succeeding hydrographs are for wells at progressively greater distances from the river. Well 14S/5W–23dbc is in younger alluvial materials about 1 mi (1.6 km) west of the river, well 14S/4W–35daa is in older alluvial materials about 4 mi (6 km) east of the river, and well 14S/3W–17cdb is in older alluvium about 7 mi (11 km) east of the river. Because of the geographic location of the wells in relation to the stream gage, figure 4 cannot be used to depict the numerical relation of ground-water levels to stream stage.

During the dry summers, river stage and water levels in the alluvial aquifers are low. From late August through October of 1973 and 1974, some water was released from upstream reservoir storage. Consequently, both the river stage and water levels in the younger alluvium rose, as illustrated by the hydrograph of well 14S/5W–23dbc (fig. 4). This rise is in contrast to water levels farther away from the river in the older alluvial aquifers, as illustrated by the hydrographs of wells 14S/4W–35daa and 14S/3W–17cdb. The hydrographs of water levels in these wells continued to drop until November when increased precipitation caused a general rise of water levels and river stage throughout the area.

From figure 4, it is apparent that (1) hydrographs of wells in the older and less permeable alluvium are not directly affected by the river stage, and (2) water-level fluctuations of wells in the younger alluvium show a direct relationship to river stage, particularly during the dry summer months when younger alluvial materials hydraulically connected with the river gain water from the river.

TRANSMISSIVITY COEFFICIENTS

Transmissivity and storage coefficient express certain water-bearing properties of the alluvial aquifers. Transmissivity is a

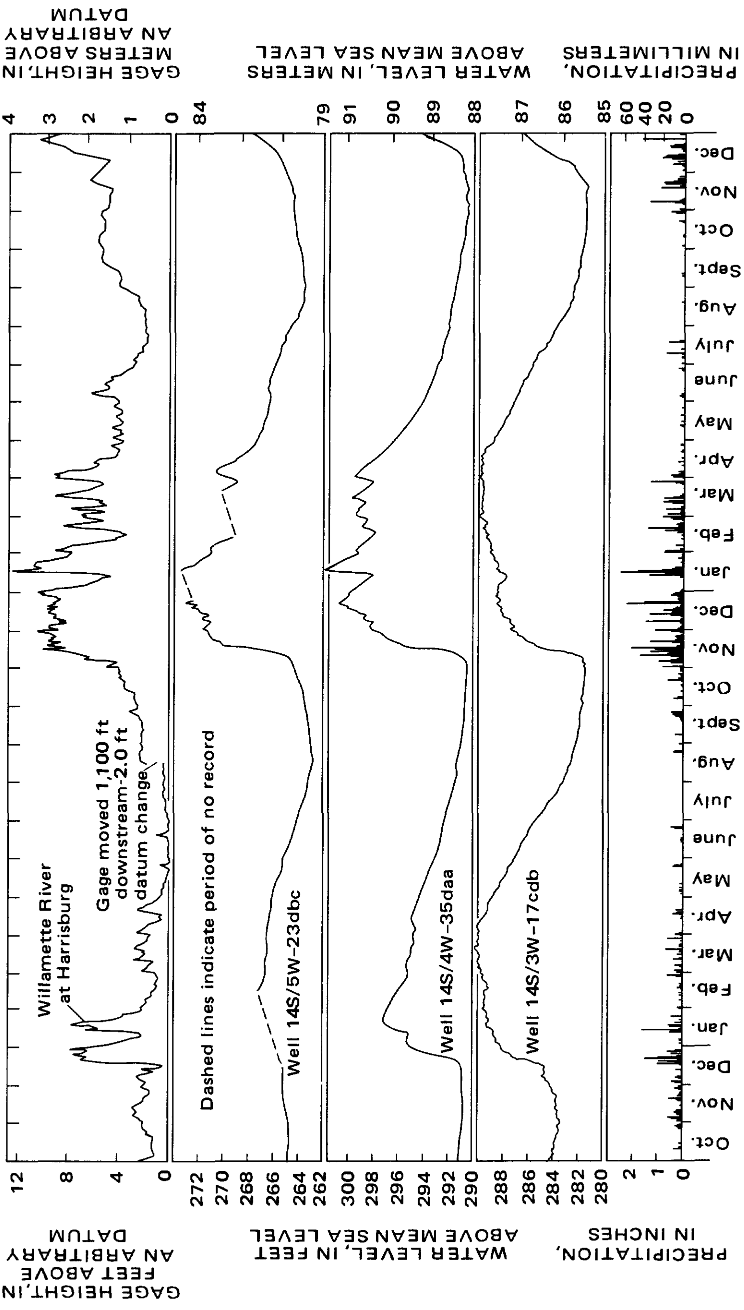

FIGURE 4.—Stage of the Willamette River at Harrisburg, water levels of wells in the younger and older alluvium, and daily precipitation at Albany.

measure of the ability of an aquifer to transmit water and is dependent on the permeability and saturated thickness of the aquifer and the properties of the contained liquid. The storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. Under unconfined or water-table conditions, the storage coefficient is about equal to the specific yield.

Transmissivity may be estimated from specific capacities of wells (Theis and others, 1963, p. 331–340). The specific capacity of a well is determined by dividing its yield (in gallons per minute) by the drawdown (in feet) at the end of the pumping period. Properly designed wells in deposits with high transmissivities have higher specific capacities than do wells in aquifers with low transmissivities.

To determine transmissivity, two pumping tests, 10 hours and 12 hours in duration, were made during this study. Transmissivity values also were estimated from specific capacities obtained from eight commercial pumping tests. No coefficients of storage were calculated. Transmissivities determined from pumping tests and from specific-capacity data are included in table 4. Methods used for analyzing the pumping tests were summarized by Lohman (1972).

WATER-LEVEL FLUCTUATIONS AND GROUND-WATER STORAGE

Water levels in wells indicate the height of the water table and fluctuate largely in response to change in ground-water storage caused by pumping, natural discharge, and recharge. Ground water in storage is water that fills the openings in rocks in the zone of saturation. Because some water will be retained in the aquifers by capillary, molecular, and other forces, not all the ground water stored in the pores of the saturated material is available for use.

TABLE 4.—*Results of aquifer tests on representative wells*

Well No.	Aquifer[1]	Date of pumping test	Length of test (hr)	Pumping rate (gal/min)	Drawdown (ft)	Specific capacity ([gal/min]/ft)	Transmissivity [2] (ft²/d)	
							Based on specific capacity	Based on nonequilibrium formula
13S/3W-18bbc2	Qoal	12- 4-70	3	310	63	4.9	1,300	----
13S/3W-28cab	Qoal	4-25-61	4	165	70	2.4	600	----
13S/5W-35abc	Qyal	5-13-70	1	400	10	40	11,000	----
14S/3W-5baa	Qoal	7-14-57	10	400	70	5.7	1,500	----
14S/3W-7ddc	Qoal	9-13-73	10	75	27.19	2.8	700	600
14S/4W-1dab2	Qoal	8- 8-69	8	200	66	3.0	800	----
14S/4W-6cdc	Qyal	8- 7-57	30	300	18	16.7	4,400	----
14S/4W-21dac	Qoal	9-11-73	12	650	40.39	16.1	4,300	4,900
15S/4W-16adc	Qoal	8- 6-66	27	300	120	2.5	700	----
15S/4W-17aad	Qyal	7- -58	6	300	4	75	20,000	----

[1]Qoal, older alluvium; Qyal, younger alluvium.
[2]The rate at which water is transmitted through a unit width (1 ft) of the aquifer under a hydraulic gradient of 1, expressed as ft²/d⁻¹ (ft²/day = cubic feet per day per foot of gradient).

FLUCTUATIONS OF WATER LEVELS

Changes in water levels in wells reflect changes in the volume of ground water in storage. Ground-water levels in wells in the area are generally at their lowest in September and October. The water table rises when the volume of recharge exceeds the volume of discharge and declines when discharge exceeds recharge. Water levels in wells start to rise as precipitation and infiltration increase, starting about November; they continue at a high level during the rainy winter months; and they decline as rainfall diminishes and as pumping, evaporation, and transpiration increase during spring and summer. The representative hydrographs of wells (fig. 5) show the seasonal aspects of water-level fluctuations.

In general, ground-water levels in the unconsolidated alluvial deposits fluctuate about 10–12 ft (3–4 m) during the year. The hydrographs in figure 6 generally show no net changes in water levels of wells from 1962–1974. The recovery of water levels each winter to approximately the same level indicates that there was no overdraft in the area during the period of measurement. Comparison of water-level data for 1962–74 with those of Piper (1942) indicates that seasonal and long-term fluctuations of water levels in the alluvial deposits have been in the same range for more than 30 years.

STORAGE VOLUME OF ALLUVIAL DEPOSITS

The volume of ground water stored in selected depth intervals was determined for the aquifers beneath the valley plain by the following equation: Volume stored (acre-feet) (cubic hectometers) = area (acres) (square kilometers) × thickness of interval (feet) (meters) × specific yield.

Specific yield is defined as the ratio of the volume of water that will drain by gravity from a saturated rock to the total volume of rock, expressed as a percentage.

The specific yield was estimated for the younger and older alluvial deposits that constitute the two major aquifers of the valley plain. To estimate these values, specific yields were assigned to five lithologic types in representative wells. (See table 5.) These values were adapted with slight modification from the figure used in estimating the ground-water storage volume of similar deposits, as compiled by Johnson (1967).

Average specific yield, based on total thickness of lithologic units reported in drillers' logs, was computed for each township and parts thereof underlain by the alluvial aquifers, as shown on plate 1. The average specific yield of the younger alluvial deposits was estimated for the depth interval of 10–30 ft (3–9 m). The specific yield of the

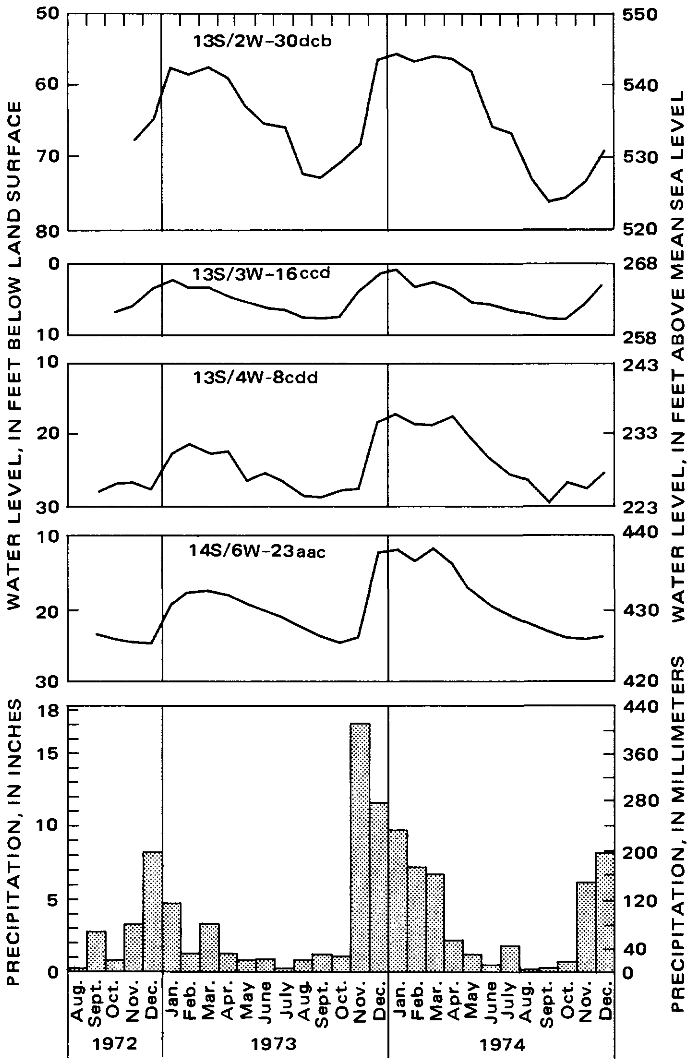

FIGURE 5.—Relation between monthly precipitation at Albany and changes in water levels in selected wells, 1972–74.

older alluvial deposits was estimated for three selected depth intervals: (1) 10–50 ft (3–15 m), (2) 50–80 ft (15–24 m), and (3) 50–100 ft (15–30 m). The volume of saturated rocks in each depth zone was then multiplied by the computed average specific yield to obtain the volume of recoverable ground water in each township. The computed values for specific yield and storage capacities are listed in table 6.

No storage estimates were made for alluvial areas where the older

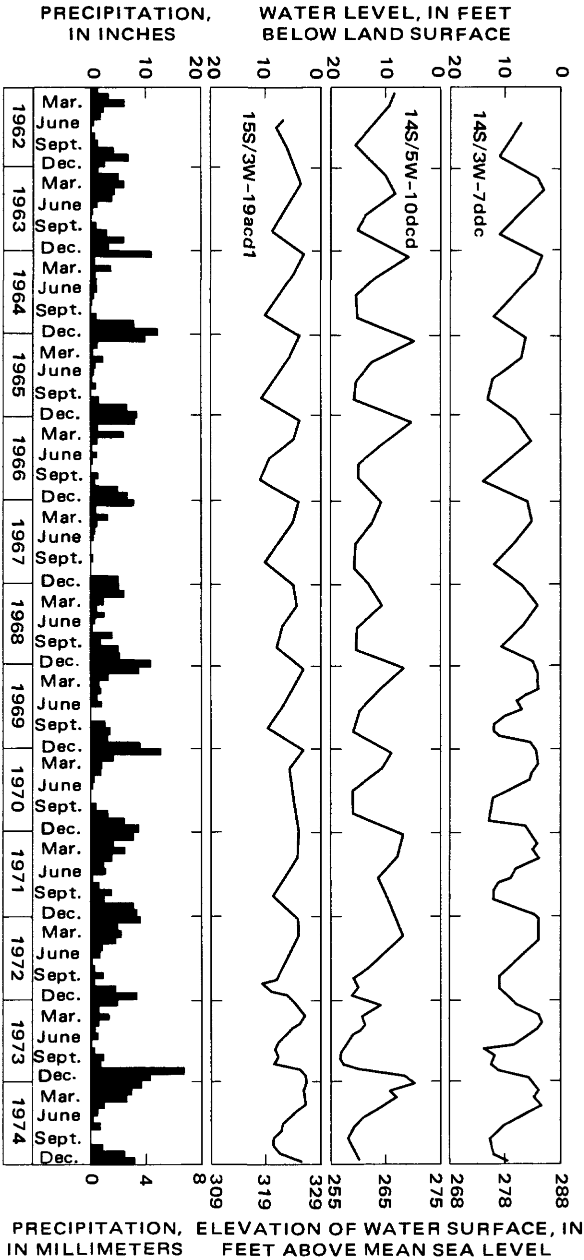

FIGURE 6.—Relation between monthly precipitation at Albany and changes in water levels in selected wells, 1962–74.

TABLE 5.—*Specific yields of materials described in drillers' logs*

Lithologic type	Specific yield (percent)
Gravel, sand and gravel, and related coarse gravelly deposits	25
Sand, medium- to coarse-grained, loose	25
Sand, fine; tight sand; sand lenses; sand with clay lenses	15
Clay and gravel; gravel with clay binder; conglomerate; cemented gravel; clay with gravel lenses	10
Clay, silt, and related fine-grained deposits	3

alluvial sediments were of limited thickness (less than 50 ft, or 15 m). These areas are immediately adjacent to the uplands in the eastern and western parts of the area.

SEASONAL CHANGE OF STORAGE

The seasonal change of storage is the volume of water that drains from saturated rock materials when the water table declines yearly from its high point in winter to its low point in late summer. (See figs. 5 and 6.) A quantitative figure for change of ground water in storage was calculated by applying the appropriate specific-yield value to the change in saturated volume of the deposits. The saturated volume was obtained by multiplying the average water-level change by the area.

During 1974 the seasonal decline of water levels from winter to late summer averaged about 10 ft (3 m) for the alluvial deposits. With a calculated specific yield of about 19 percent and an area of about 30,000 acres (120 km^2) of younger alluvial deposits, the seasonal change in storage in these deposits was about 55,000 acre-ft (70 hm^3). Similarly, with a specific yield of 13 percent and an area of 90,000 acres (360 km^2), the seasonal change in storage for the older alluvial deposits was about 115,000 acre-ft (140 hm^3). Total change of storage in the alluvial deposits was about 170,000 acre-ft (210 hm^3).

CHEMICAL QUALITY OF THE GROUND WATER

Because water is a solvent for practically all minerals, all ground water contains many chemical elements in solution. In the small concentrations in which they occur, most of these dissolved solids are harmless and include many substances that are necessary for proper nutrition of plants and animals. Some of these dissolved solids can be harmful if concentrations are only slightly higher than needed.

Areal variations in dissolved-solids content, and consequently chemical quality of the ground water, relate generally to the geologic environment. This is demonstrated by the chemical diagrams and other data presented on plate 1. As shown in the plate, chemical

TABLE 6.—*Computed values for specific yield and storage volume*

Material	Depth zones (ft)	Specific yield: Average	Specific yield: Range	Area (acres)	Storage volume (acre-ft)
Younger alluvium.	10–30	19	17 percent (T.15S., Rs. 4 and 5 W.) to 20 percent (T.14S, Rs. 4 and 5 W.)	30,000	110,000
Older alluvium.	10–50	13	11 percent (T.13S., R. 5W.) to 18 percent (T.15S., R.4W.)	90,000	470,000
	50–80	12	11 percent (T.14 S., R. 3 W.) to 14 percent (T.13 S., R.4W.)	30,000	110,000
	50–100	9	8 percent (T.14 S., R. 4 W.) to 9 percent (T.15 S., R.4 W.)	25,000	110,000
			Total (rounded)		800,000

character of the ground water in the area varies considerably from place to place. It will be noted from the plate that most of the ground water from the alluvial deposits beneath the present flood plain of the Willamette River and the valley plain contains relatively small concentrations of dissolved minerals. Conversely, wells that tap the underlying marine deposits, as shown by the chemical diagrams of wells 13S/5W–23dac, 14S/5W–23bcbl, and 15S/3W–9cba, are high in dissolved minerals, particularly sodium, calcium, and chloride.

Analyses of 36 ground-water samples from the area are given in table 7, and important features of the chemical quality of the ground water are summarized in the following paragraphs.

EXPLANATION OF DATA

Dissolved solids refers to the substances dissolved in water. In this report, concentrations of dissolved-mineral constituents are reported in milligrams per liter. One mg/l (milligram per liter) is a weight of 1 milligram of the particular constituent dissolved in 1 liter of water. At the low concentrations of water in this area, milligrams per liter values are numerically equivalent to parts per million, the unit used for reporting water-quality data in some reports.

Specific conductance is a measure of the ability of water to conduct electrical current and is expressed in micromhos per centimeter at 25°C. Specific conductance of water is roughly proportional to the concentration of dissolved solids it contains. Numerically, the dissolved-solids concentration in milligrams per liter is commonly 55 to 75 percent of the specific conductance, in micromhos per centimeter at 25°C. The specific-conductance values given on plate 1 and in table

TABLE 7.—*Chemical analyses of water*

[Analyses by the U.S. Geological

Location No.	Water-bearing material	Date of collection	Milligrams per liter: Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)
13S/2W-5dda	Volcanic rocks	-71	-	0.45	--	--	-	--	--	122	0
13S/2W-6cdb	Sandstone	12- 5-73	32	.02	0	40	9.0	68	1.4	303	0
13S/2W-17cdd	do	12- 5-73	38	.08	.10	59	9.6	150	1.1	137	0
13S/2W-30dcb	Volcanic rocks	12- 5-73	43	.20	23	27	6 9	44	2.3	183	0
13S/3W-4bdd	Sandstone	12- 4-73	35	.78	.52	41	20	74	1.5	233	0
13S/3W-17dda	Sand and gravel	12- 4-73	36	.88	1.90	30	14	12	.8	190	0
13S/3W-27aad	Volcanic rocks	12- 4-73	40	.04	.008	14	1	30	.6	110	0
13S/3W-32ccc2[1]	Sand and gravel	6- -58	54	5.8	0	470	47	350	20	150	0
13S/4W-10bca	do	12- 4-73	59	0	1.50	32	14	15	1.2	201	0
13S/4W-17bac	Sand and gravel	12- 4-73	40	1.60	.72	120	36	97	2.5	173	0
13S/5W-7dad	do	12- 6-73	38	4.7	.89	29	12	30	2.8	186	0
13S/5W-13dbc	do	12- 5-73	50	.04	.008	18	10	8.0	1.1	108	0
13S/5W-23dac	Sand and clay	12- 3-73	45	.87	.16	170	10	100	1.5	140	0
14S/2W-8bba	Sand and gravel	12- 5-73	34	.04	0	13	4.5	8.1	.6	74	0
14S/2W-10dbd1	do	12- 5-73	34	.10	.017	15	3.2	31	1.1	138	0
14S/2W-31aca	Volcanic rocks	12- 5-73	42	.04	.008	11	1.1	61	.7	163	0
14S/3W-2dba	Sand and gravel	12- 4-73	34	.16	.23	39	8.4	35	1.1	118	0
14S/3W-4abb	do	12- 4-73	33	.02	.23	42	8.6	40	1.3	132	0
14S/3W-7ddc	do	9-13-73	32	.04	.37	150	28	89	2.4	235	0
14S/3W-13cbd	Volcanic rocks	12- 5-73	70	.25	.67	75	30	13	1.6	125	0
14S/3W-13cdc2	Sandstone	12- 5-73	44	.59	.33	46	11	62	3.3	149	0
14S/4W-1aab2[1]	Sand and gravel	3- -61	53	.29	--	85	13	62	3.7	170	0
14S/4W-9baa1	do	12- 4-73	55	.02	.01	19	13	14	1.0	113	0
14S/4W-21dac	do	9-11-73	38	.23	.08	32	19	39	2.1	200	0
14S/4W-23bac	do	12- 4-73	59	.04	0	39	23	28	1.2	127	0
14S/5W-23bcb1	Sandstone	12- 3-73	23	1.00	.083	250	9.1	160	.9	105	0
14S/5W-31cab	do	12- 6-73	14	.11	0	9.8	3.5	110	1 3	293	0
14S/6W-25baa	do	12- 6-73	28	.04	0	4.3	.9	5.1	1.0	27	0
15S/3W-2bbb	do	12- 5-73	14	.23	.14	150	4.7	360	2.6	64	0
15S/3W-6bdd	Sandy clay and gravel	12- 4-73	39	.13	.033	16	5.7	9.5	1.0	77	0
15S/3W-9cba	Sandstone	12- 4-73	37	.17	.12	220	97	150	4.6	195	0
15S/4W-8bbb	Sand and gravel	12- 6-73	39	.04	.025	34	16	8.9	1.6	72	0
15S/4W-13bab1	do	12- 4-73	53	.01	.008	19	12	22	1.3	136	0
15S/4W-16aac[1]	do	7- -65	23	4.7	04	42	6.4	43	1.2	94	0
15S/5W-9bdd	Sandstone	12- 3-73	25	.02	0	54	12	21	1.3	243	0
15S/5W-11dbb2	Sand and gravel	12- 6-73	38	.04	.033	31	15	13	1.8	128	0

[1]Analysis by Charlton Laboratories, Portland, Oreg.

9 can be used to estimate the dissolved-solids content of water from the wells cited.

Hardness of water is caused principally by dissolved calcium and magnesium and is expressed in milligrams per liter as calcium carbonate. In this report, the following numerical ranges and terms are used to classify hardness of water:

in the Harrisburg-Halsey area
Survey unless otherwise noted]

Milligrams per liter—Continued														
Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrite + nitrate (as N)	Phosphate, ortho as P	Boron (B)	Arsenic (As)	Dissolved solids, calculated from determined constituents	Hardness (Ca, Mg)	Noncarbonate hardness	Sodium-adsorption-ratio (SAR)	Specific conductance (micromhos/cm at 25°C)	pH	Temperature °C	Temperature °F
----	3.1	----	----	----	----	----	170	83	----	----	----	--	---	----
9.6	19	0.2	0.04	0.04	0.06	0	330	140	0	2.5	526	7.5	8.5	47
8.5	280	.1	1.2	.05	.10	.005	620	190	75	4.8	1,160	7.2	8.5	47
4.5	31	.1	.03	.17	.10	.004	250	96	0	2.0	380	7.7	8.0	46
1.5	110	.1	.00	.07	.05	.001	400	180	0	2.4	720	7.7	9.0	48
4.6	5.3	.2	.01	.07	.003	.005	200	130	0	.5	304	7.4	9.0	48
12	3.4	.2	.00	.07	.10	.005	160	39	0	2.1	199	8.0	8.5	47
2.6	1,400	.0	.07	----	----	----	3,400	1,400	----	4.5	----	7.0	10.5	51
3.2	6.0	.3	.00	.20	.01	.002	230	140	0	.6	309	7.3	8.0	46
1.6	360	.1	.00	.06	.07	0	740	450	310	2.0	1,470	7.6	8.0	46
6.1	19	.6	.03	.15	.04	.01	240	120	0	1.2	366	7.2	9.0	48
9.5	3.7	.0	.48	.09	.007	0	160	86	0	.4	206	6.9	9.0	48
1.8	400	.1	.00	.28	.09	0	800	470	350	2.0	1,520	7.3	----	---
2.8	1.0	.1	.05	.04	.003	0	100	51	0	.5	127	7.7	9.5	49
2.9	3.4	.1	00	.06	.005	.001	160	51	0	1.9	225	8.0	8.5	47
26	6.9	.2	.00	.08	.20	0	230	32	0	4.7	327	8.3	9.0	48
.4	79	.1	.02	.27	.040	.001	260	130	35	1.3	452	7.7	----	---
1.8	85	.1	.00	.27	.06	.004	280	140	32	1.5	478	7.9	9.5	49
1.8	360	.1	1.1	.12	0	0	780	490	300	1.8	1,520	7.4	12.0	54
230	4.4	.1	.08	.10	.005	0	490	310	210	.3	645	6.8	5.5	42
150	14	.1	.00	.07	.10	0	400	160	38	2.1	585	7.7	9.5	49
6.5	160	--	----	--	--	-	590	270	---	--	--	--	--	--
14	9.6	.4	3.1	.11	.02	.003	200	100	8	.6	265	7.5	8.0	46
2.8	57	.2	.06	.17	.02	.002	290	160	0	1.4	475	7.7	11.0	52
10	94	.2	.10	.12	0	.003	320	190	88	.9	544	7.2	8.0	46
8.5	630	.1	.03	.03	.40	0	1,100	660	580	2.7	2,220	7.3	7.0	45
4.1	26	.1	.00	.04	.40	0	310	39	0	7.7	521	7.5	--	--
4.1	1.6	.0	.00	.03	.01	0	60	14	0	.6	52	6.9	6.5	44
30	790	.6	.02	.01	1.50	.005	1,400	390	340	7.9	2,690	7.1	7 0	45
4.7	7.3	.1	.64	.15	.007	.002	120	63	0	.5	156	7.7	8.5	47
.7	790	.2	.00	.02	.01	.001	1,400	950	790	2.1	2,730	7 4	8.0	46
37	7.5	.1	15	.05	.02	.003	250	150	92	.3	357	7.0	9.0	48
1.8	24	.4	.28	16	.008	.004	200	97	0	1.0	292	7.7	---	--
1.6	78	.0	---	----	---	---	420	130	----	--	--	---	---	--
26	5.9	.2	00	.03	.07	.001	260	180	0	.7	422	7.5	--	
13	24	.7	4.7	.08	.03	.005	220	140	34	.5	340	6.8	10.0	50

Hardness range (mg/l as $CaCO_3$)	*Description*
0–60	Soft
61–120	Moderately hard
121–180	Hard
> 180	Very hard

The observed hardness values for ground water in the

Harrisburg-Halsey area ranged from 14 (soft) to 1,400 (very hard) mg/l. Of the 36 analyses given in table 7, only 6 showed hardness values in the soft-water range, whereas 23 were either hard or very hard.

SUITABILITY FOR USE

Except for highly mineralized water derived from the marine rocks at places below the valley plain, the ground water is of generally good chemical quality for most uses (table 7 and pl. 1).

The concentrations of certain constituents in water determine the suitability of the water for various uses. In excessive amounts, sodium, chloride, sulfate, and other constituents may impart a disagreeable taste to the water and may affect its usefulness for domestic purposes. Excessive iron or manganese (more than 0.3 mg/1) causes staining of plumbing fixtures and laundry and may give a peculiar taste to the water. Amounts of chloride in excess of about 250 mg/l and dissolved solids in excess of 1,000 mg/1 may give a salty taste to the water. Hardness, caused largely by calcium and magnesium, affects the amount of soap used for laundry and causes scale in hot-water pipes and industrial boilers. Most of the water analyzed is hard or very hard (hardness exceeding 121 mg/1). Samples of water that are very hard contain other constituents (such as iron and chloride) in amounts that are undesirable for domestic use (wells 14S/5W–23bcbl and 13S/4W–17bac, table 7).

Water containing nitrate (as N) in excess of 10 mg/l or arsenic in excess of 0.05 mg/l is unsuitable for drinking. Only one sample, from well 15S/4W–8bbb, had excessive nitrate. Although several samples contained minute quantities of dissolved arsenic, all were well below the recommended limit (table 7).

Suitability of water for drinking and public use can be evaluated on the basis of the recommended limits of the Environmental Protection Agency (1972).

During this study, water samples from 31 domestic wells were analyzed for fecal coliform bacteria. Although these organisms are not necessarily harmful in themselves, their presence indicates pollution from fecal wastes. The membrane-filter technique was used to test the water for fecal coliform bacteria. None was detected in any of the water samples. Although these spot tests did not indicate ground-water pollution, further study would be required to validate the presence or absence of ground-water pollution in the area.

Analyses of water from the alluvial deposits indicate that the water has a low SAR (sodium-adsorption-ratio) and is suitable for irrigation. The SAR indicates the effect that an irrigation water will have on soil-drainage characteristics. Water with a high SAR value lowers the permeability of soils and eventually causes clogging; after the soil is clogged, it is unsuitable for cultivation. An SAR of about 4 is the limit for crops that are sensitive to the effects of soil clogging (Federal Water Pollution Control Adm., 1968, p. 115–117). SAR values are presented with the analytical data in table 7.

In small concentrations, boron is essential for plant growth; however, a slightly larger concentration may be harmful to many plants. Boron-sensitive plants may be affected by water containing more than 0.33 mg/l of boron, and water containing boron concentrations exceeding 3.75 mg/l may be unsuitable for even the most tolerant plants. The water from well 15S/3W–2bbb has a boron concentration high enough to be harmful to certain plants, but water from wells 14S/5W–23bcbl and –31cab might have a slight effect on sensitive plants.

USE OF GROUND WATER

Ground water in the area is used for irrigation, public, domestic, and industrial supplies. As used in this report, irrigation supplies include water used for irrigation of crops and pastures; domestic supplies include water from private wells used for household requirements, watering stock, and irrigation of lawns and small gardens; public supplies include water used for school and recreation facilities in addition to that distributed by municipal agencies; and industrial supplies include water used in dairy operations and lumber-related industries.

Most of the ground water is obtained from the alluvial deposits; total pumpage from this source during 1974 was 14,300 acre-ft ($18\ hm^3$). The volumes of water withdrawn from the alluvial deposits are shown in the following table.

Type of supply	*Estimated 1974 withdrawals (acre-feet)*
Irrigation	13,000
Domestic	750
Industrial	250
Public	300
Total	14,300

In addition to the above, about 300 acre-ft ($0.37\ hm^3$) of ground water was pumped from the consolidated rocks in 1974, mainly for domestic uses.

IRRIGATION

Most of the ground water used for irrigation is pumped from wells in the younger alluvium. By determining the number of acres and types of crops irrigated with well water, it was estimated that approximately 13,000 acre-ft (16 hm^3) of ground water was pumped for irrigation during 1974.

In past years, more ground water was pumped in the main valley plain for irrigation than was being pumped in 1974. In the late 1940's, much of the economy changed from dairies, pastures, and haylands to the production of various grasses and other grains that require no irrigation. Many of the wells that were formerly used to irrigate pastures and hay crops are unused, and much of the ground-water potential of the older alluvium remains unused or undeveloped.

DOMESTIC

Many of the wells in the area, particularly in the rural areas, are used for domestic supplies, and most of these wells also supply water for livestock and for irrigation of lawns and gardens. The volume of ground water used for domestic supplies was estimated on the basis of population and a per capita use of 75 gallons per day (284 liters per day) for all uses. Estimated ground-water use for domestic purposes totals 750 acre-ft (0.92 hm^3) from unconsolidated deposits and 300 acre-ft (0.37 hm^3) from consolidated rock sources.

INDUSTRIAL

At present (1974) the major industries in the area use surface water, and only small quantities of ground water are used for industrial purposes. Industries that utilize ground water include small wood-product plants and dairies. It is estimated that about 250 acre-ft (0.30 hm^3) was pumped by these industries in 1974.

PUBLIC SUPPLY

Two of the incorporated towns, Harrisburg and Halsey, obtain municipal water supplies from wells tapping the older alluvium. Two other incorporated municipalities in the area are Brownsville and Monroe. Brownsville obtains its municipal water supply from surface-water sources. Monroe obtains its supplies from an infiltration gallery emplaced in younger alluvial materials near the Long Tom River. Monroe also obtains auxiliary supplies from two springs. Ground water used for public supplies is estimated to be 300 acre-ft (0.37 hm^3).

POTENTIAL FOR DEVELOPMENT OF GROUND WATER FROM THE ALLUVIAL DEPOSITS

In a previous section, "Seasonal Change of Storage," the seasonal change in the volume of ground-water storage for the alluvial deposits was estimated to be about 170,000 acre-ft (210 hm^3). On the basis of 1974 data, this total is much larger than the estimated total pumpage of 14,300 acre-ft (18 hm^3). The difference of about 156,000 acre-ft (190 hm^3) between the volume of estimated seasonal change and that part of the change attributed to pumpage provides a conservative indication of the annual volume of unused ground water discharged from the aquifer.

The total change in storage of 170,000 acre-ft (210 hm^3) represents the net recharge by the infiltration of precipitation that is necessary to replenish the aquifer each year and is equal to about 17 in. (430 mm) of the average annual precipitation of 40 in. (1,020 mm). Because the volume of water pumped for all uses is only about 14,300 acre-ft (18 hm^3), or the equivalent of about 2 in. (50 mm) of the net recharge, additional ground water could be withdrawn for irrigation and other uses by salvaging part of the natural discharge. If all the natural discharge could be salvaged, it would amount to about 156,000 acre-ft (190 hm^3) of water throughout the valley plain. The salvage of additional ground water would be at the expense of streamflow; however, streamflow data published in the annual reports of the Geological Survey indicate that this volume is only slightly more than 1 percent of the mean annual discharge of the Willamette River at Harrisburg and slightly less than 1 percent at Albany. Any lowering of the water table by pumping may bring the benefits of diverting late winter and early spring runoff to ground-water recharge and prevent waterlogging in parts of the area. On the other hand, it could cause additional upward movement of poor-quality water from the bedrock.

Most of the additional ground water needed for future irrigation and other uses probably will be developed in the central part of the valley plain, near and north of Harrisburg, where the older alluvial deposits (as shown on pl. 1 and table 6) are thickest and have the greatest transmissivity and storage capacity. Because of the presence of bedrock outliers and nearness to the foothills, alluvial materials in the eastern and western parts of the area lack the necessary thickness in many places to store and transmit large quantities of water. However, much additional water can be developed from the alluvial deposits in those parts of the area for domestic and irrigation purposes, but wells drilled there can be expected to yield less than wells drilled in the central valley-plain area.

Major problems affecting the development of ground water in the area are (1) the uneven distribution of the more permeable rocks throughout the foothill and upland parts of the area, (2) the considerable variation in water-bearing characteristics of the alluvial deposits over short distances, (3) the locally poor chemical quality of water from the bedrock of marine origin, (4) the possibility of connate water percolating upward from these underlying rocks into the alluvium, and (5) the undesirable effects on the efficiency and life of wells from pumping sand in parts of the valley plain.

SUMMARY AND CONCLUSIONS

The principal conclusions resulting from this study are:

1. Ground water is generally available for domestic use throughout the Harrisburg-Halsey area; however, the volumes of water that can be developed from the consolidated sedimentary and volcanic rocks that make up the upland parts of the area are generally small and vary considerably from place to place. The unconsolidated alluvial deposits that underlie the valley plain contain the more productive aquifers in the area and yield most of the water that is pumped from wells.
2. The unconsolidated alluvial materials were deposited over an irregular bedrock surface, and the thickness and lithology of these deposits vary considerably within small areas. The older alluvial deposits tend to be fine grained at depths exceeding 50 ft (15 m) but locally contain permeable sand and fine gravel capable of yielding 600–700 gal/min (38–44 l/s) of good-quality water to wells. However, many of the wells pump objectionable amounts of sand. Refinements in present well construction by use of fabricated well screens and (or) a gravel pack around the screen or perforated parts of the casing would virtually eliminate sand, prolong the life of pumping equipment, and increase the yields of wells in these alluvial aquifers.
3. Precipitation (about 40 in., or 1,020 mm per year) is the principal source of recharge to the aquifers in the area. The alluvial deposits that underlie the valley plain are recharged directly by precipitation, and about 17 in. (430 mm) is required to refill the reservoir to capacity by January or February.
4. Ground water moves from the edges of the valley plain toward the Willamette River and in a downstream direction, contributing generally to streamflow. However, along certain reaches of the Willamette River at various times of the year, the river contributes water to the younger alluvial aquifers, as shown by water levels of the younger alluvial deposits and stream-stage fluctuations of the Willamette River.
5. Ground-water levels in the unconsolidated alluvial deposits fluctuate about 10–12 ft (3–4 m) during the year. Available data indicate that seasonal fluctuations have been in the same range for more than 30 years, and there have been no lasting changes in water levels during that period.

6. The seasonal change of storage for the alluvial deposits is estimated to be about 170,000 acre-ft (210 hm^3) of water, which is more than nine times the 1974 pumpage of 14,300 acre-ft (18 hm^3). By salvaging part of this natural discharge, a sizable quantity of ground water could be withdrawn for irrigation or other uses.
7. Storage capacity of the alluvial aquifers in the area is estimated to be about 800,000 acre-ft (1,000 hm^3) between the depths of 10 and 100 ft (3 and 30 m).
8. Chemical quality of water from the alluvial deposits is generally satisfactory for most uses, as is most of the water obtained from perched-water bodies in the older sedimentary and volcanic rocks. Water from the alluvial deposits is hard but has a low sodium-adsorption-ratio and is suitable for irrigation. Water from the older marine sedimentary rocks beneath the valley plains is more highly mineralized and has greater concentrations of sodium, calcium, and chloride than does most other ground water in the area. Locally, some of the water from the older rocks is too saline for most uses.
9. No fecal coliform bacteria were detected in any of the 31 water samples analyzed from domestic wells.

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BASIC DATA

WELL-NUMBERING SYSTEM

Designations of wells discussed in this report are based on the official system for rectangular subdivision of public lands. The 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 this method of well numbering is shown in figure 7. The first numeral indicates the township; the second, the range; and the third, the section in which the well is located. The letters following the section number locate the well within the section. The first letter denotes the quarter section (160 acres, or 0.65 km^2); the second, the quarter-quarter section (40 acres, or 0.16 km^2); and the third, the quarter-quarter-quarter section (10 acres, or 0.04 km^2). For example, well 15S/5W-16dab is in NW¼NE¼SE¼ sec. 16, T. 15 S., R. 5 W. Where two or more wells are in the same 10-acre (0.04 km^2) subdivision, serial numbers are added after the third letter.

BASIC GROUND-WATER DATA

Data summarized in table 8 contain lithologic logs of representative wells drilled in the study area. Nearly all the logs were obtained from drillers' reports submitted to the Oregon State Engineer. The reports were edited for consistency of terminology and for conformance with the stratigraphic units described in the text, but otherwise they are unchanged.

Data summarized in table 9 are representative of ground-water data collected in the study area during this investigation. Well records shown in table 9 were obtained from reports compiled by well drillers and from well owners and operators.

The locations of wells listed in the tables are shown on plate 1. Most of the data collected in the area have been published by the Oregon State Engineer (Frank and Johnson, 1975). Additional unpublished ground-water data, including well reports and ground-water level records, are on file in the offices of the Oregon State Engineer, Salem, Oreg., and the U.S. Geological Survey, Portland, Oreg.

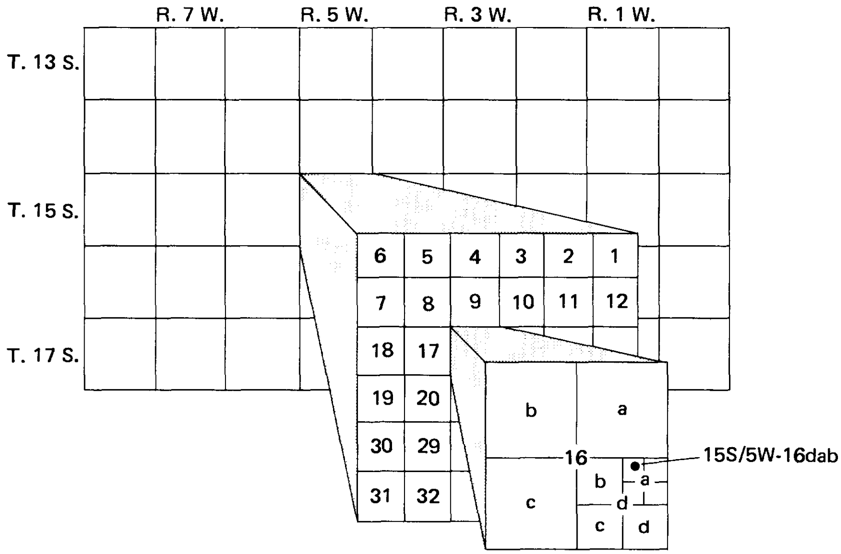

FIGURE 7.—Well-numbering system.

TABLE 8.—*Drillers' logs of representative wells*

13S/2W–30dcb

[Larry Kauffman. Altitude 600± ft. Drilled by Schoen Electric & Pump. 1970. Casing: 6-in. diam to 74 ft. unperforated]

Materials	Thickness (ft)	Depth (ft)
Clay and boulders	12	12
Little Butte Volcanic Series:		
Basalt and gravel, loose	21	33
Clay and gravel	5	38
Basalt, fractured	14	52
Claystone, blue	5	57
Claystone, gray and brown	13	70
Sandstone, blue	42	112
Sandstone, gray	14	126
Sandstone, blue, hard	21	147
Rock, brown, hard	6	153
Basalt, blue	36	189
Basalt, fractured, with white quartz	21	210
Sandstone, brown, with clay streaks	5	215
Sandstone, blue-gray	32	247
Claystone, brown	39	286
Claystone, blue	16	302
Sandstone and "streaky" claystone	15	317
Sandstone, blue-gray	18	335
Basalt, gray	10	345

13S/3W–32ccc1

[Central Linn School Dist. Altitude 280 ft. Drilled by William N. Slate, 1958. Casing: 8-in. diam to 64 ft. perforated 30–34 ft]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Clay, brown	13	13
Clay and gravel, brown	17	30
Gravel and sand	2	32
Gravel, brown, cemented	9	41
Gravel, cemented	19	60
Gravel and black sand	2	62
Gravel, black, cemented	1	63

13S/3W–32ccc2

[Central Linn School Dist. Altitude 282 ft. Drilled by William M. Slate, 1957. Casing. 8-in. diam to 118 ft, perforated 59–63 ft, 110–116 ft]

Materials	Thickness (ft)	Depth (ft)
Soil	1	1
Older alluvium:		
Clay, brown	12	13
Clay, brown, and gravel	23	36
Gravel and sand, brown	1	37
Gravel, brown, cemented	12	49
Gravel, black, cemented	11	60
Sand and gravel, black	2	62
Gravel, cemented, black	9	71
Eugene(?) Formation:		
Clay, blue	39	110
Sand, black, and small gravel	6	116
Clay, blue	5	121

TABLE 8.—*Drillers' logs of representative wells*—Continued

13S/4W-17bac

[W E Horton. Altitude 256 ft Drilled by Ray Gellatly & Ron Witham Well Drilling, 1965 Casing: 6-in diam to 58 ft; perforated 53–58 ft]

Materials	Thickness (ft)	Depth (ft)
Soil	2	2
Older alluvium:		
Clay, gray	15	17
Gravel, fine, and clay	6	23
Clay, dark-gray	7	30
Gravel, coarse	6	36
Clay, blue	9	45
Clay, light-gray, and gravel	13	58
Eugene(?) Formation:		
Clay, gray, hard	2	60

13S/4W-27dba

[Gulf Oil Corp. of California (T J. Porter #1). Altitude 266 ft. Drilled by owner, 1964. Casing 9–5/8-in diam to 486 ft, 13–3/8-in. diam to 526 ft) cemented to surface]

Materials	Thickness (ft)	Depth (ft)
Log not available	50	50
Older alluvium:		
Gravel, weathered, mostly volcanic pebbles	30	80
Eugene(?) Formation:		
Siltstone, with sand and streaks of clay	60	140
Sand, with ½-in.-diam rounded pebbles; streaks of claystone and siltstone	30	170
Siltstone, with streaks of pebbly sand	120	290
Siltstone and medium-gray clay, with streaks of fine-grained sandstone	255	545
Sand, with sandstone and siltstone	1,269	1,814
Spencer(?) Formation:		
Sandstone, siltstone, and shale, assorted (lithologic log not available)	5,286	7,100
Siletz River(?) Volcanics:		
Volcanics (lithologic log not available)	1,370	8,470

13S/5W-23dac

[Gale Miller Drilled by L. W. Mutschler Well Drilling, 1972. Casing: 6-in. diam to 48 ft, perforated 45–47 ft]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Soil, with gravel	1	1
Clay, yellow, and gravel	18	19
Gravel, small to medium	9	28
Gravel, medium	5	33
Sand, fine, and gravel	3	36
Sand, fine	11	47
Clay, blue	4	51

TABLE 8.—*Drillers' logs of representative wells*—Continued

13S/5W–24acc

[Mrs. John Graham. Altitude 242 ft. Drilled by Pitcher Pump & Well Drilling Co. , 1968. Casing: 12-in. diam to 182 ft. perforated 18–95 ft. 130–150 ft. 170–180 ft]

Materials	Thickness (ft)	Depth (ft)
Younger alluvium:		
Sand and gravel	16	16
Sand, brown, and gravel, with clay	11	27
Gravel and clay, blue	8	35
Eugene(?) Formation:		
Sand, blue, with clay	59	94
Clay, greenish-gray, with sand	37	131
Clay, blue-gray, with sand	13	144
Clay, greenish-gray, with sand	10	154
Sand, blue, with clay	16	170
Clay, tight	16	200
Sandstone, water-bearing	22	222

14S/3W–4bbb

[Phillips Petroleum Co. Altitude 286 ft. Drilled by Valley Well Drillers. 1967. Casing: 6-in. diam to 60 ft. perforated 52–58 ft]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Clay, blue	4	4
Clay, yellow	4	8
Clay, gray	6	14
Clay and gravel	10	24
Sand, brown, and gravel and clay	14	38
Sand and gravel	5	43
Clay, blue	17	60
Eugene(?) Formation:		
Sandstone, blue-black, and gravel particles	33	93
Clay, red and black	3	96

14S/3W–7ddc

[H. H. Kirk. Altitude 288 ft. Drilled by C. A. Schaefer, 1953. Casing: 8-in diam to 35 ft, perforated 35–40 ft, 55–60 ft, 80–98 ft, 98–110 ft]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Clay, brown	12	12
Conglomerate, sand, clay, and small rocks	18	30
Rock, water-bearing	6	36
Conglomerate	12	48
Gravel	2	50
Conglomerate and clay	11	61
Clay, blue	17	78
Gravel	2	80
Clay	15	95
Sand and gravel	14	109
Eugene(?) Formation:		
Sand and clay	14	123

TABLE 8.—*Drillers' logs of representative wells*—Continued

14S/3W-13cdc2

[Wynes Poultry Farms, Inc. Altitude 500 ft. Drilled by Schoen Electric & Pump, 1970. Casing: 10-in. diam to 23 ft; unperforated]

Materials	Thickness (ft)	Depth (ft)
Little Butte Volcanic Series		
Loam, brown	3	3
Clay, yellow	11	14
Clay, blue	4	18
Rock, blue	132	150
Claystone, gray	30	180
Claystone, blue, with streaks of coal	20	200

14S/5W-12ddb

[Virgil Haener. Altitude 270 ft. Drilled by Ace Drilling Co., 1963. Casing: 12-in. diam to 25 ft; perforated 21-24 ft]

Materials	Thickness (ft)	Depth (ft)
Soil and clay	4	4
Younger alluvium:		
Clay, sandy	4	8
Sand, fine, with some clay	4	12
Gravel and sand	4	16
Gravel, clean	9	25

14S/5W-35aad

[Mr. Rhea. Altitude 282 ft. Drilled by R. E. White, 1967. Casing: 6-in. diam to 22½ ft; perforated 18-22½ ft]

Materials	Thickness (ft)	Depth (ft)
Soil	12	12
Younger alluvium:		
Clay, blue	2	14
Sand and gravel	8	22½

15S/3W-6bdd

[Roger Neuschwander. Altitude 308 ft. Drilled by Schoen Electric & Pump, 1970. Casing: 10-in. diam to 100 ft; perforated 23-86 ft, 89-98 ft]

Materials	Thickness (ft)	Depth (ft)
Soil	2	2
Older alluvium:		
Clay, brown	6	8
Gravel	17	25
Sand	3	28
Gravel	17	45
Eugene(?) Formation:		
Clay, green, sandy	55	100

15S/3W-9cba

[Texaco, Inc. Altitude 320 ft. Drilled by H. F. Flannery, 1968. Casing: 6-in. diam to 50 ft; unperforated]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Loam, black	26	26
Sand and gravel	14	40
Eugene(?) Formation:		
Clay, blue	46	86
Sandstone, blue	7	93
Sand, water-bearing	4	97
Clay, yellow	24	121
Sand, water-bearing	14	140

TABLE 8.—*Drillers' logs of representative wells*—Continued

15S/4W–16aac

[City of Harrisburg. Altitude 310 ft. Drilled by Christensen Drilling & Irrigation, 1965. Casing 12-in. diam to 155 ft, 8-in. diam 140–305 ft; screened at unrecorded depth]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Soil	9	9
Sand and gravel	35	44
Clay, brown	21	65
Clay, blue	5	70
Sand	24	94
Clay, blue	26	120
Sand and gravel	18	138
Clay, blue	60	198
Sand, black	10	208
Clay, blue	39	247
Sand and gravel	53	300
Eugene(?) Formation:		
Clay, blue	5	305

15S/4W–16adc

[City of Harrisburg. Altitude 311 ft. Drilled by W. W. Drilling & Pump Service, 1966. Casing: 12-in. diam to 350 ft; perforated 100–130 ft, 335–340 ft]

Materials	Thickness (ft)	Depth (ft)
Older alluvium:		
Clay, gray-white	10	10
Clay, gray	4	14
Clay, brown, and pea gravel	33	47
Clay, blue	18	65
Clay, brown, soft, and very fine sand, water-bearing	13	78
Clay, blue, soft	37	115
Sand, black, and gravel, water-bearing	10	125
Clay, blue	10	135
Clay, gray-green	15	150
Clay, blue	28	178
Sand, black, very fine; some water	12	190
Clay, blue, very sticky	60	250
Sand, very fine, and blue clay and lots of wood; some water	25	275
Clay, dark-gray, and fine sand	15	290
Clay, blue, very sticky	45	335
Sand, black, coarse, with small gravel	2	337
Eugene(?) Formation:		
Clay, blue	63	400

15S/5W–9bdc

[Bill Dixon. Altitude 440 ft. Drilled by Casey Jones Well Drilling Co., Inc., 1970. Casing: 6-in. diam to 45 ft; unperforated]

Materials	Thickness (ft)	Depth (ft)
Soil	2	2
Spencer Formation:		
Clay, yellow	26	28
Shale, blue	13	41
Sandstone, blue	176	217
Basalt, black	19	236
Sandstone, blue	264	500

TABLE 9.—*Records of*

Well number: See p. **36** for description of well-numbering system.
Type of well: Dr, drilled; Dv, driven.
Finish: B, open bottom (not perforated or screened); Sc, screened, P, perforated.
Altitude: Altitude of land surface at well, in feet above mean sea level, interpolated from topographic maps.
Water level: Depths to water given in feet and decimals were measured by the Geological Survey; those in whole feet were reported by others or estimated.
Specific conductance of water: Field determination, in micromhos at 25°C.

Well No.	Owner	Type of well	Year completed	Depth of well (ft)	Diameter of well (in.)	Depth of casing (ft)	Finish	Water-bearing	
								Depth to top (ft)	Thickness (ft)
	T. 13 S., R. 2 W.								
18bdc	Pat Strawn	Dr	1971	317	6	54	B	----	----
30dcb	Larry Kauffman	Dr	1970	345	6	74	B	----	----
	T. 13 S., R. 3 W.								
16ccd	Floyd Smith	Dr	1950	33	5	33	B	----	----
18bbc1	J. W. Pugh	Dr	1959	120	8	115	P, 25–35,	25	10
							40–45,	40	5
							60–70,	60	10
							80–100	80	20
28cab	H. Knuths estate	Dr	1961	122	8	112	P, 9–62	14	34
32ccc1	Central Linn School Dist.	Dr	1958	63	8	64	P, 30–34	30	30
32ccc2	do	Dr	1957	121	8	118	P, 59–63,	59	4
							110–116	110	6
	T. 13 S., R. 4 W.								
8cdd	C. Grieg	Dr	1967	60	6	51	P, 42–49	40	9
17bac	W. E. Horton	Dr	1965	60	6	58	P, 53–58	30	6
								45	13
27dba	Gulf Oil Corp. of Calif. (T. J. Porter 1)	Dr	1964	8,470	13–3/8	526	Cemented to surface	----	----
					9–5/8	426			
	T. 13 S., R. 5 W.								
7aac	Inavale School	Dr	1956	130	12	32	P, 18–31	20	6
					6	54			
13adb	Neil Vanderburg	Dr	1969	35	8	34	P, 20–34	12	35+
23dac	Gale Miller	Dr	1972	51	6	48	P, 45–47	33	14
24acc	Mrs. John Graham	Dr	1968	222	12	182	P, 18–95,	18	67
							130–150,	130	20
							170–180	170	10
	T. 14 S., R. 2 W.								
4cbc1	O. T Chamberlain	Dr	1969	85	6	70	B	----	----
10bdc	J. I. McCord	Dr	1965	64	8	64	P, 55–64	52	12
	T. 14 S., R. 3 W.								
4bbb	Phillips Petroleum Co.	Dr	1967	91	6	60	P, 52–58	52	5
7ddc	H. H. Kirk	Dr	1953	123	8	110	P, 35–40,	35	5
							55–60,	50	11
							80–98,	95	14
							98–110	98	12
13cdc2	Wynes Poultry Farms, Inc.	Dr	1970	200	10	23	B	----	----
16ccb	Paul Quimby	Dr	1950	50	10	50	----	----	----

representative wells

Type of pump: C, centrifugal; S, submergible; P, piston; T, turbine; N, none.
Well performance: Yield in gallons per minute, and drawdown in feet below nondischarging water level, reported by owner, operator, driller, or pump company.
Use: D, domestic; PS, public supply; I, industrial; Ir, irrigation; N, none.
Remarks: Ca, chemical analysis of water in table 7; H, hydrograph in figure 9 or 10; L, driller's log of well in table 8; P, B, or At, pumped, bailed, or air tested, for the indicated number of hours, when drawdown was measured. Remarks on adequacy, dependability, and general quality are reported by owners, tenants, drillers, or others.

zone(s)		Water level				Well performance			
Character of material	Altitude (ft)	Feet below datum	Date	Specific conductance of water	Type of pump and hp	Yield (gal/min)	Drawdown (ft)	Use	Remarks
				T. 13 S., R. 2 W.—Continued					
----	950	148.62	10- 2-73	440	S, 1	10	180	D	At 1 hr. Well can easily be pumped dry during summer.
Volcanic rocks	600	70.90	10- 3-73	380	S, 1½	25	265	D	At 2 hr, L, Ca, H.
				T. 13 S., R. 3 W.—Continued					
Gravel and sand	270	6.37	7-20-72	----	N	----	----	----	H.
Gravel and clay	266	15.42	10- 1-73	----	N	150	110	N	P 3 hr. Formerly used for irrigation.
Gravel and sand									
do									
Gravel and clay									
Gravel and sand	277	8.02	10- 9-73	----	T, 7½	165	70	Ir	P 4 hr.
do	280	18	9- 6-58	2,300	T, 10	155	20	Ir	P 6½ hr, L. Water tastes salty.
do	282	18.92	10-10-73	----	N	200	92	N	P 5 hr, L, Ca. Water is of poor quality.
Sand and gravel									
				T. 13 S., R. 4 W.—Continued					
Sand and gravel	258	24.60	7-11-72	250	S, 3/4	30	20	D	B 2 hr, H.
Gravel	256	29	7- 3-65	1,470	S	30	10	D	B 2 hr, L, Ca. Water has bad odor and taste.
Gravel and clay									
----	266	----	----	----	----	----	----	----	Abandoned oil well; plugged to 4,737 ft. L.
				T. 13 S., R. 5 W.—Continued					
Sand and gravel	255	8.88	11-14-73	650	S, ½	----	----	D	Yields inadequate supply of water.
do	244	15.47	10-15-73	330	C, 7½	250	13	Ir	B 1 hr.
do	250	14.04	10-11-73	1,520	C, ½	40	15	D	B 1 hr, L, C.
Sand, gravel, and clay	242	3.5	7-15-68	----	N	800	27	N	P 1 hr, L. Water reported to be saline.
Sand and clay									
Clay									
				T. 14 S., R. 2 W.—Continued					
----	368	6.12	10- 2-73	----	N	15	40	N	B 1 hr. Water is of poor quality.
Gravel	396	8.94	do	----	S, 5	88	24	Ir	B 1 hr.
				T. 14 S., R. 3 W.—Continued					
Sand and gravel	286	11.20	7-27-72	580	S, 1	50	20	D	B 2 hr, L.
do	288	12.27	10- 4-73	1,520	T, 10	75	27	Ir	P 10 hr, L, Ca, H. Federal observation well.
do									
do									
do									
----	500	30	12-23-70	560	S, 10	250	70	I	At 2 hr, L, Ca. Main well for large poultry farm.
----	300	11.40	10- 4-73	----	S, 2	100	----	N	Formerly used for irrigation. Pumps some sand.

TABLE 9.—*Records of*

Well No.	Owner	Type of well	Year completed	Depth of well (ft)	Diameter of well (in.)	Depth of casing (ft)	Finish	Water-bearing	
								Depth to top (ft)	Thickness (ft)
T. 14 S., R. 4 W.									
1dab2	City of Halsey	Dr	1969	200	12	199	P, 40–70,	42	27
							85–95	85	10
6cdc	George Van Leeuwen	Dr	1957	40	10	39	P, 31–39	31	8
9baa2	Emery Heading	Dr	1966	151	8	116	P, 101–114	20	14
								101	13
21dac	Harry Scheffel	Dr	1955	109	10	----	P, 50–100	----	----
T. 14 S., R. 5 W.									
12ddb	Virgil Haener	Dr	1963	25	12	25	P, 21–24	12	13
22dac	Newman Haffner	Dr	1969	28	8	28	P, 20–28	14	14
32dac	Charles Kreitman	Dr	1957	35	6	13	B	----	----
35aad	Mr. Rhea	Dr	1967	22½	6	22½	P, 18–22½	14	8
T. 15 S., R. 3 W.									
6bdd	Roger Neuschwander	Dr	1970	100	10	100	P, 23–86,	28	17
							89–98	89	10
9cba	Texaco, Inc	Dr	1968	140	6	50	B	93	4
19acdl	E. B. Grimes	Dr	1959	98	10	69	P, 21–29,	21	8
							34–65	34	21
T. 15 S., R. 4 W.									
7acc	Glen Lee	Dv	1965	21	4	21	P, 18–21	16	5
16aac	City of Harrisburg	Dr	1965	305	12	0–155	Sc	----	----
					8	140–305			
16adc	do	Dr	1966	400	12	350	P, 110–130,	115	10
							336–340	335	2
T. 15 S., R. 5 W.									
9bdc	Bill Dixon	Dr	1970	500	6	45	B	----	----
16dab	F. E. Peterson	Dr	----	108	8	20	B	----	----

representative wells—Continued.

zone(s)			Water level			Well performance			
Character of material	Altitude (ft)	Feet below datum	Date	Specific conductance of water	Type of pump and hp	Yield (gal/min)	Drawdown (ft)	Use	Remarks
			T. 14 S., R. 4 W.—Continued						
Sand, clay, gravel	280	14	8-28-69	1,150	T, 7	200	66	PS	P 8 hr. One of two wells used for city water supply.
Sand, gravel, and clay									
Gravel	262	10.94	10- 3-73	----	C, 25	300	18	Ir	P 30 hr.
do	277	17	4-28-66	----	N	70	45	N	P. Well abandoned; pumped too much sand.
Sand and clay									
Sand and gravel	288	11.81	10- 2-73	----	T, 20	650	40	Ir	P 12 hr, Ca. Formerly used to irrigate 20 acres of pasture. Pumps some sand.
			T. 14 S., R. 5 W.—Continued						
Sand and gravel	270	12.49	10- 4-73	----	C, 15	600	3	Ir	P 2 hr, L. Used to irrigate 40 acres.
do	265	10.23	do	310	C, 20	200	15	Ir	B 1 hr.
----	360	32.00	10- 5-73	----	C, 1	21	22	D	Do.
Sand and gravel	282	9.26	10- 3-73	----	N	700	2	N	P 1 hr, L.
			T. 15 S., R. 3 W.—Continued						
Gravel	308	6.25	10- 3-72	----	8	45	85	Ir	P 4 hr, L, Ca.
Sandy clay									
Sand	320	8	5- 2-68	2,730	S	20	----	----	At 1 hr, Ca, L.
Sand and gravel	327	8.37	10- 3-73	----	T, 7½	95	32	Ir	P 4 hr, H.
do									
			T. 15 S., R. 4 W.—Continued						
Sand and gravel	295	15.78	8-18-72	320	C, 1	200	6	D	P 2 hr.
do	310	26	7-31-72	420	T, 40	----	----	PS	L, Ca.
do	311	22	8- 5-66	500	S, 7½	300	120	PS	P 27 hr, L.
do									
			T. 15 S., R. 5 W.—Continued						
Sandstone	440	98.39	10- 1-73	690	S	2	420	D	At 1 hr, L.
----	335	----	----	----	C, 1	----	----	D	

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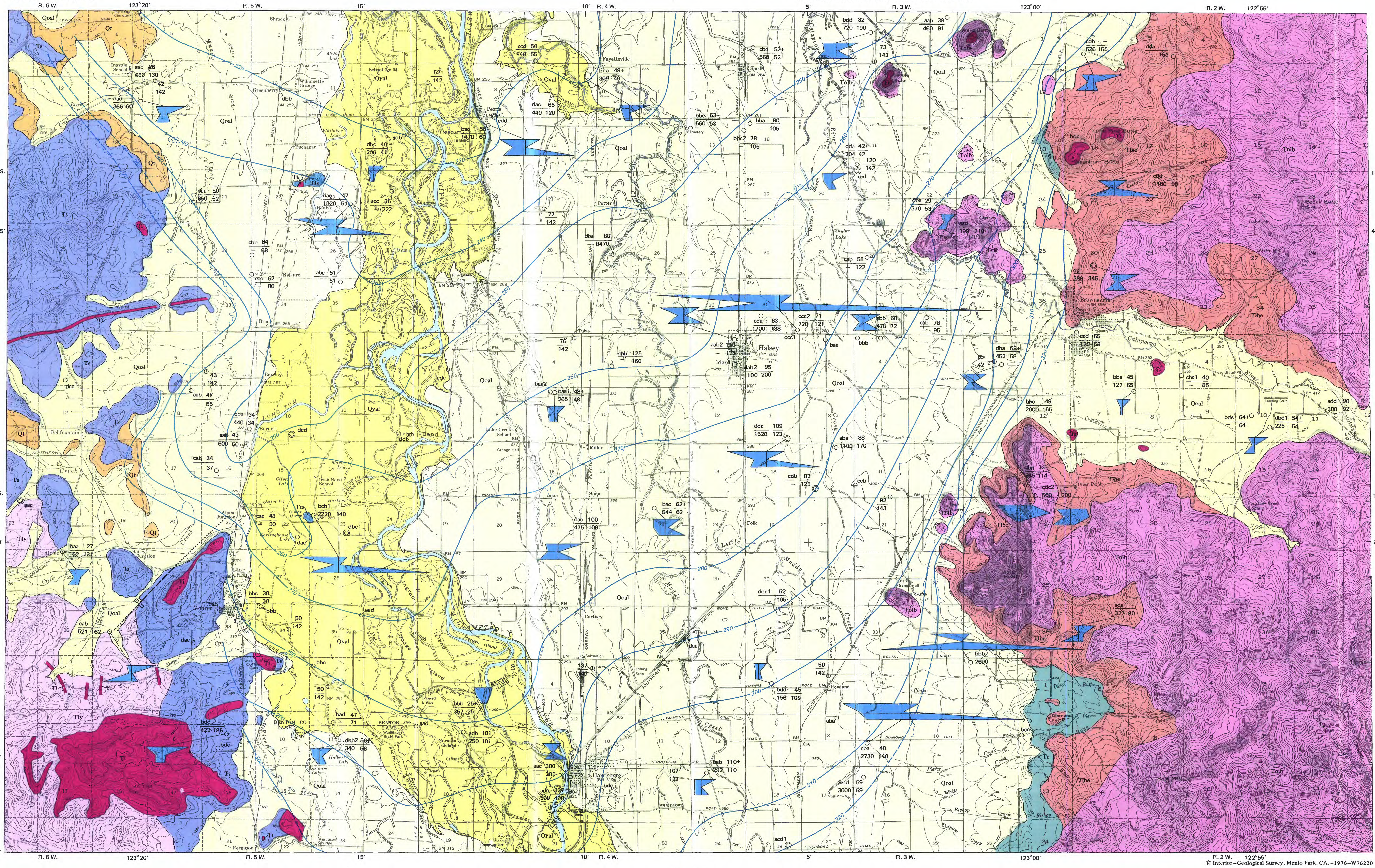
Prepared in cooperation with the
OREGON WATER RESOURCES DEPARTMENT



CORRELATION OF MAP UNITS

UNCONSOLIDATED DEPOSITS

Qyal	Holocene	QUATERNARY
Qoal, Qt	Holocene and Pleistocene	QUATERNARY

CONSOLIDATED ROCKS

Tolb, Tlbe	Lower Miocene and Oligocene	TERTIARY
Te, Tts	Oligocene	TERTIARY
Ts, Tty	Eocene	TERTIARY
Ti	Oligocene(?)	TERTIARY

DESCRIPTION OF MAP UNITS

UNCONSOLIDATED DEPOSITS

Qyal YOUNGER ALLUVIUM – Assorted coarse gravel and sand. Yields moderate to large quantities of water to wells

Qoal OLDER ALLUVIUM – Largely sand and gravel, with mixtures of sand, silt, and clay. Is somewhat finer and less assorted than the younger alluvium. Tends to be of finer materials below depths of 50 feet. Generally yields moderate to large quantities of water to properly constructed wells. Includes some terrace deposits, some younger alluvial deposits along minor streams, and Willamette Silt, as mapped by Beaulieu, 1974

Qt TERRACE DEPOSITS – Poorly sorted gravel, sand, and clay, weathered in upper part. Yield small quantities of water to wells

CONSOLIDATED ROCKS

Ti INTRUSIVE ROCKS – Dikes and sills of gabbro and basalt. Yield little water to wells

Tolb LITTLE BUTTE VOLCANIC SERIES – Dacitic to andesitic pyroclastic rocks and dense basalt flows. Yields small quantities of water to wells

Tlbe Part of the unit (Tlbe) is interbedded with marine sandstone equivalent to the Eugene Formation (Te). Locally yields moderate to large quantities of water to wells. In places contains water of poor quality

Te EUGENE FORMATION – Marine-deposited coarse- to fine-grained sandstone with intercalated shale. Yields water slowly to wells. Locally contains water of poor quality

Tts TUFFACEOUS SANDSTONE – Moderately thick-bedded medium- to coarse-grained tuffaceous sandstone. Yields water slowly to wells

Ts SPENCER FORMATION – A series of marine-deposited arkosic and micaceous sandstone beds. Locally contains tuffaceous materials and thin beds of siltstone. Yields water slowly to wells

Tty TYEE FORMATION – Marine-deposited tuffaceous sandstone, siltstone, and shale. Yields water slowly to wells

Contact – Dashed where approximately located

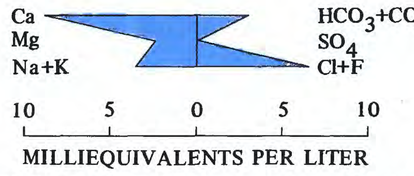
U/D Fault – Dashed where approximately located; dotted where concealed; U, upthrown side; D, downthrown side

300 Water-level contour – Shows altitude of water level, in feet, September 1973; dashed where approximately located. Contour interval 10 feet. (Datum is mean sea level)

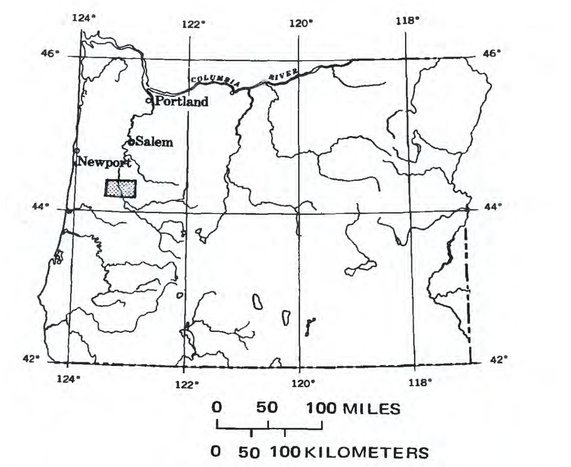
Test hole

Observation well

bdd 32 / 720 190 – Well and location; Approximate thickness of alluvium; Depth of well; Specific conductivity (micromhos at 25°C)



Chemical diagram showing concentrations of major ions



INDEX MAP OF OREGON SHOWING AREA OF THIS REPORT

Base from U.S. Geological Survey topographic quadrangles: Brownsville, 1950; Halsey, 1957; and Monroe, 1957

APPROXIMATE MEAN DECLINATION, 1976

SCALE 1:62 500

CONTOUR INTERVALS 10, 40, AND 50 FEET
DATUM IS MEAN SEA LEVEL

☆ Interior—Geological Survey, Menlo Park, CA.—1976—W76220

Geology from Beaulieu, 1974; Peck, Griggs, Schlicker, Wells, and Dole (1964); Vokes, Myers, and Hoover (1954); and Piper (1942)

GEOHYDROLOGIC MAP OF THE HARRISBURG-HALSEY AREA, OREGON