WATER RESOURCES DEPARTMENT GROUND WATER REPORT NO. 28

STATE OF OREGON

WILLIAM H. YOUNG
DIRECTOR

GROUNDWATER RESOURCES OF THE DALLAS—MONMOUTH AREA, POLK, BENTON, AND MARION COUNTIES, OREGON

BY

JOSEPH B. GONTHIER
U.S. GEOLOGICAL SURVEY

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[Plates are in pocket]

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FACTORS FOR CONVERTING INCH-POUND UNITS TO METRIC UNITS

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

To convert from	To	Multiply by
	Length	
inch (in.)	millimeter (mm)	25.4
foot (ft)	meter (m)	0.3048
mile (mi)	kilometer (km)	1.609
	Area	
acre	square meter (m^2)	4,047
	square hectometer (hm^2)	0.4047
square mile (mi^2)	square kilometer (km^2)	2.590
	Volume	
acre-foot (acre-ft)	cubic meter (m^3)	1,233
	cubic hectometer (hm^3)	0.001233
cubic foot (ft^3)	cubic meter (m^3)	0.02832
gallon (gal)	liter (L)	3.785
million gallons (Mgal)	cubic meter (m^3)	3,785
	Specific combinations	
cubic foot per second (ft^3/s)	cubic meter per second (m^3/s)	0.02832
foot per day (ft/d)	meter per day (m/d)	0.3048
foot squared per day (ft^2/d)	meter squared per day (m^2/d)	0.0929
gallon per minute (gal/min)	liter per second (L/s)	0.06309
gallon per minute per foot (gal/min)/ft	liter per second per meter (L/s)/m	0.2070
million gallons per day (Mgal/d)	cubic meter per day (m^3/d)	3,785
	cubic meter per second (m^3/s)	0.04381
	Temperature	
degree Fahrenheit (°F)	degree Celsius (°C)	([1])

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[1] Temp °C = (temp °F-32)/1.8.

DEFINITIONS OF TERMS

Aquifer.--A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells or springs.

Confined ground water.--Ground water that is under pressure significantly greater than atmospheric. In a well that taps a confined ground-water body, the static water level is above the top of the aquifer.

Drawdown.--The lowering of the ground-water level caused by well discharge. It is the difference, expressed in feet or meters, between the static water level and the pumping or flowing water level in a well.

Evapotranspiration.--Water transferred to the atmosphere by evaporation from water surfaces and moist soil and by plant transpiration.

Hydraulic conductivity.--The volume of water that will move in a unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Hydraulic conductivity has replaced the term "field coefficient of permeability."

Hydraulic gradient.--The change in static head per unit of distance in a given direction. The direction generally is understood to be that of the maximum rate of decrease in head.

Perched ground water.--Ground water separated from an underlying body of ground water by an unsaturated zone.

Potentiometric surface.--A surface that represents the static head. In an aquifer it is defined by the levels at which water stands in tightly cased wells. The water table is a special kind of potentiometric surface. The static head (water level) in a well represents the average nonpumping water level of the water-bearing materials open to the well bore.

Specific capacity.--The rate of discharge of water from a well divided by the drawdown of water level within the well.

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

Transmissivity.--The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to the average hydraulic conductivity times the saturated thickness of the aquifer.

Unconfined ground water.--Ground water in an aquifer that has a water table.

Water table.--The water surface in an unconfined water body, at which the pressure is atmospheric.

GROUND-WATER RESOURCES OF THE DALLAS-MONMOUTH AREA, POLK, BENTON, AND MARION COUNTIES, OREGON

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By Joseph B. Gonthier

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ABSTRACT

The Dallas-Monmouth area is in the west-central Willamette Valley of western Oregon. It comprises a total of about 400 square miles in Polk, Benton, and Marion Counties.

Tertiary consolidated rocks underlie the entire area. These rocks include marine sandstone, siltstone, shale, tuff, basalt, and gabbro. In the lowlands, the consolidated rocks are overlain by unconsolidated deposits of clay, silt, sand, and gravel which reach a maximum thickness of about 125 feet locally.

The consolidated rocks generally are poor water-bearing formations and yield only small quantities of ground water to wells. From 1956 to 1976, about 6 percent of all wells completed in basalt and 14 percent of those completed in marine sedimentary rocks were reported to be "dry holes." The median yield of wells completed in the consolidated rocks was less than 10 gallons per minute, and the maximum reported yield was 200 gallons per minute.

Shallow ground water in the consolidated rocks is generally of good quality, but with increasing depth in these rocks the water contains increasing concentrations of dissolved minerals. It is estimated that about 5 percent of all the wells completed in the consolidated rocks yield poor-quality water.

The best water-bearing units are sand-and-gravel beds in the unconsolidated deposits. Near Independence, the sand-and-gravel beds are hydraulically continuous and exceed a saturated thickness of 10 feet over an area covering several tens of square miles chiefly within the Willamette River flood plain. Properly constructed wells in these deposits can generally obtain yields of 100 to 500 gallons per minute, and large quantities of additional ground water can be developed from this source.

Outside the above area, sand-and-gravel beds generally are less than 10 feet thick, lenticular in shape, local in extent, and generally yield less than 30 gallons per minute to wells. Sand-and-gravel beds probably are absent in the Baskett Slough drainage basin, in the E. E. Wilson Wildlife Management area, and in the Luckiamute and Little Luckiamute River valleys upstream from the U.S. Highway 99W bridge.

INTRODUCTION

Water supplies for a large part of the growing population of the Dallas-Monmouth area in the west-central Willamette Valley are obtained from ground-water sources. In most of the area, these sources yield only small quantities of water to wells, and the use of the water commonly is limited by its poor chemical quality. Moderate-to-large quantities of good water can be obtained from sand-and-gravel aquifers adjacent to and beneath the Willamette River flood plain along the east margin of the study area. Water from this source is widely used for irrigation, municipal, and industrial supplies. With good management, large quantities of additional water can be developed from the sand-and-gravel aquifers.

Purpose and Scope

This study is part of a cooperative program between the U.S. Geological Survey and the Oregon Water Resources Department. The purpose of the study is to describe (1) the hydrogeology of the area, (2) the availability of ground water, (3) the pattern of ground-water movement, (4) the quantity of ground-water withdrawals and use, (5) the quality of ground water, and (6) the ground-water problems, and to suggest solutions where possible.

To accomplish these objectives, approximately 500 wells were field located and inventoried, water samples from selected wells were analyzed, and all available hydrologic and well data were evaluated.

Acknowledgments

Appreciation is expressed for the cooperation of citizens, well owners, and drillers in the area who provided access to wells and data for the study. Public officials, consultants, and municipal and private water company personnel also provided data, assistance, and invaluable discussions of the hydrology of the area.

Previous Studies

Ground-water resources of the area were described briefly in a report by Piper (1942), and parts of the area are included in reports by Price (1967), Foxworthy (1970), and Frank (1974). A ground-water study by Helm and Leonard (1977) covered the lower Santiam River basin which borders part of this study area on the east side of the Willamette River. The geology, ground-water resources, and ground-water quality of the Kings Valley area are covered in a report by Penoyer and Niem (1975). Geologic mapping of the area was completed by Baldwin (1964); Vokes, Myers, and Hoover (1954); and Mundorff (1939).

Location and Geography

The Dallas-Monmouth area (fig. 1) occupies a total of about 400 mi^2 in west-central Willamette Valley in western Oregon. About 305 mi^2 are in Polk County, 90 mi^2 in Benton County, and 5 mi^2 in Marion County. It is bounded on the north by the 45° parallel of latitude and on the west by the 123°30' meridian of longitude. The south boundary is the line separating Tps. 10 and 11 S. in Benton County. The east boundary is the Willamette River, except near Independence and north of Eola.

The area is drained by the Willamette River and its tributaries. All the principal tributaries have headwaters in the Coast Range. From north to south, the principal tributaries are Rickreall Creek, Ash Creek, and the Luckiamute and Little Luckiamute Rivers.

The topography is varied; the eastern half consists of lowland plains separated by rolling hills, and the western half contains rugged forested mountains cut by valleys of the principal streams. The lowest point is on the Willamette River near Eola, at an altitude of about 125 ft; the highest is on Rickreall Ridge in sec. 25, T. 7 S., R. 7 W., near the northwest border, at an altitude of 2,749 ft.

The flood plain of the Willamette River is bounded by a low terrace that ranges from 15 to 40 ft above the flood plain. This terrace marks the east edge of a second broad lowland that covers large areas of the lower valleys of Rickreall and Ash Creeks and the Luckiamute and Little Luckiamute Rivers.

Annual precipitation increases with increasing altitude of the land surface; it is less than 40 in. in the lowland adjacent to the Willamette River and 120 in. or more in the Coast Range foothills in the western part of the area (fig. 2). The graphs (fig. 3) show the range and the monthly distribution of precipitation and temperature at Dallas, Oreg., which is at an altitude of 325 ft. Precipitation is seasonal. The summer is warm and dry, and the late fall and winter are cool and moist. On the average, more than 75 percent of the precipitation occurs during the 5-month period from November through March.

Well- and Spring-Numbering System

Wells and springs are assigned a number based on their location according to the rectangular system for subdivision of public lands (fig. 4). In successive order, the numerals represent the township, range, and section. Thus, well 10S/4W-16bbc is in township 10 south, range 4 west, section 16. The letters following the section number show the location within the section, the first letter designating the quarter section (160 acres), the second letter the quarter-quarter section (40 acres), and the third letter the quarter-quarter-quarter section (10 acres). Well 10S/4W-16bbc is in the SW¼ of the NW¼ of the NW¼ of section 16. Where two or more wells are in the same 10-acre subdivision, serial numbers are added after the third letter. For a spring, a lower case (s) is appended to the number as described.

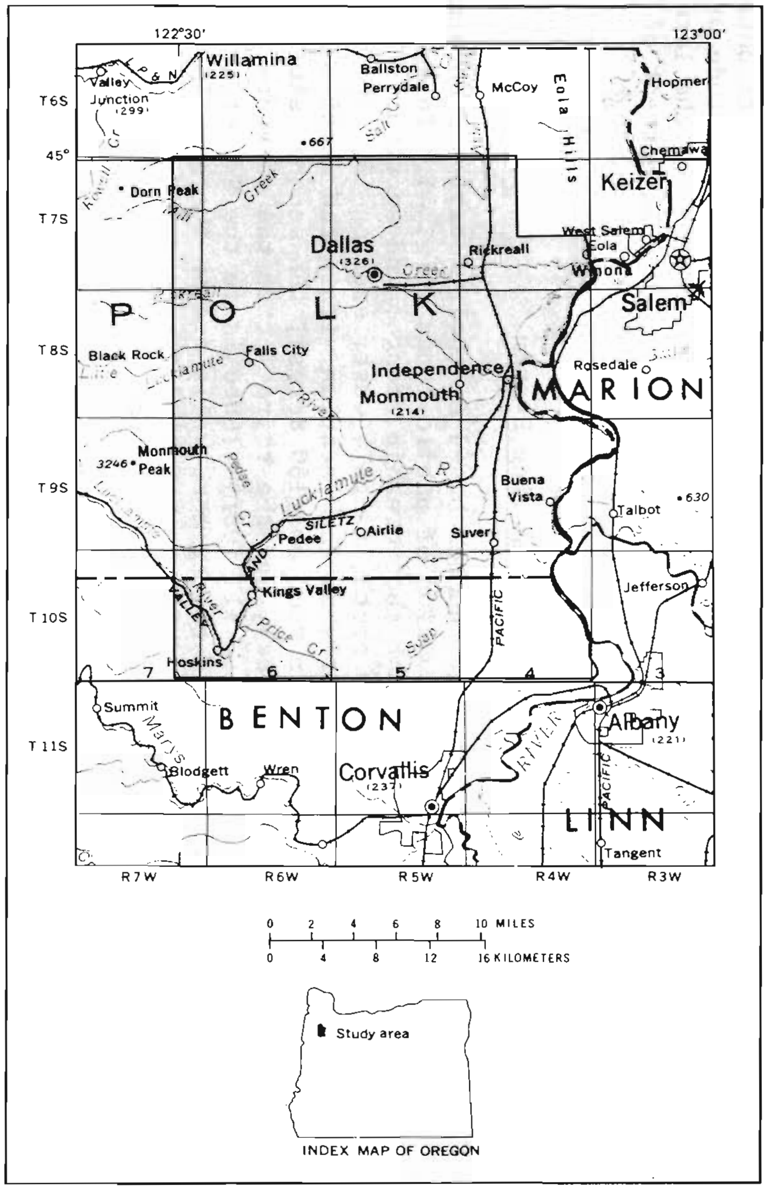

Figure 1. – Location of the Dallas-Monmouth study area.

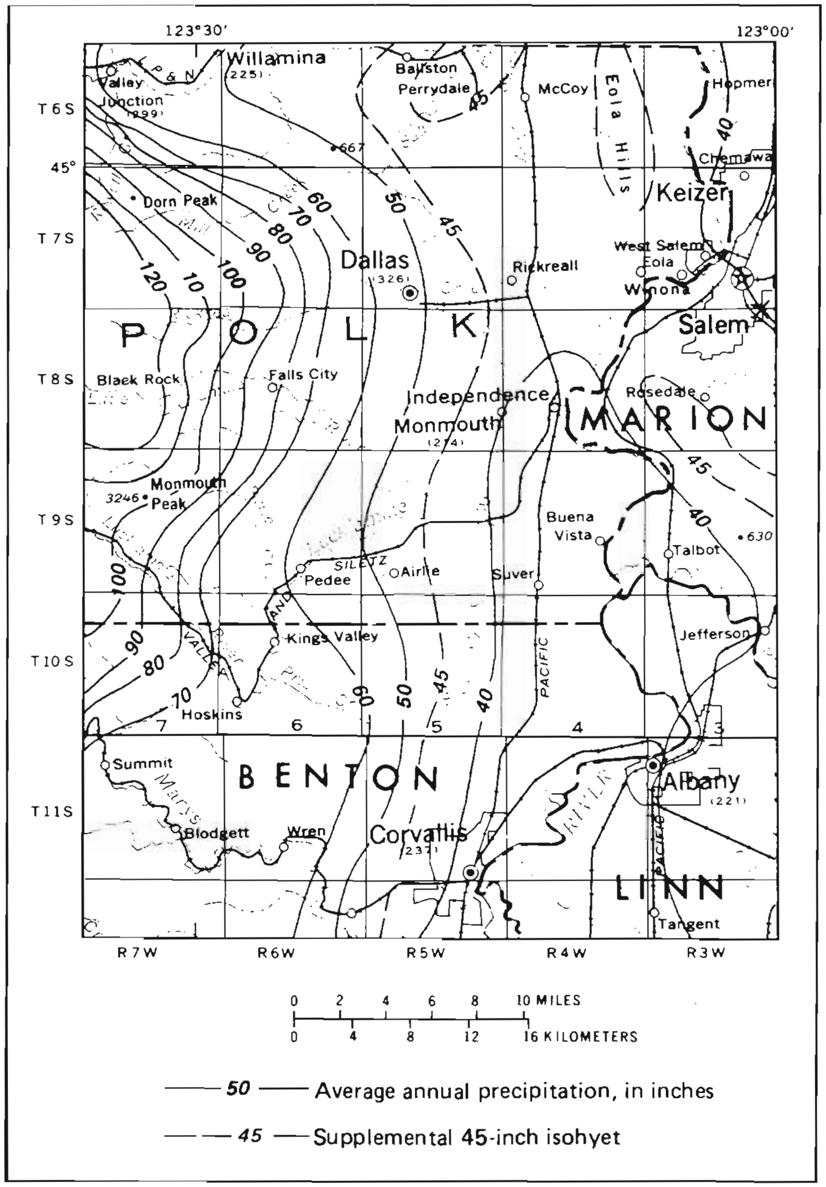

Figure 2. – Annual precipitation, Dallas-Monmouth study area.

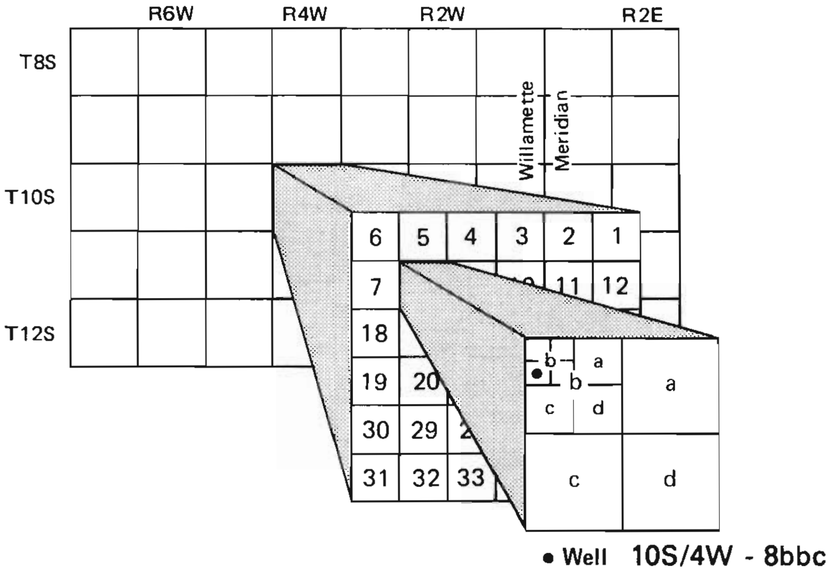

Figure 4.—Well- and spring-numbering system

GEOLOGY

In the Dallas-Monmouth area, the geologic units include consolidated rocks consisting of basalt, marine siltstone, sandstone, shale, and tuff, and unconsolidated deposits consisting of clay, silt, sand, and gravel. The surface distribution of the geologic formations is shown in the hydrogeologic map (pl. 1). Table 1 summarizes the stratigraphy and hydrogeology of the area.

GROUND WATER

Occurrence, Recharge, Movement, and Discharge

Ground water occurs in the interconnected openings in rock units under unconfined, confined, or perched conditions. (See definition of terms, p.vi In the consolidated rocks, the most important types of openings are fractures and joint openings formed as the result of folding, faulting, weathering, or cooling of the rocks. The occurrence of fractures and joints in the consolidated rocks is unpredictable because they are irregularly distributed. Fractures and joints commonly are more abundant, and the openings along them are larger in size near the land surface than at depth.

The openings in the unconsolidated deposits consist of pores between the individual rock particles. The most productive water-bearing materials in the Dallas-Monmouth area are beds of saturated sand and gravel in the unconsolidated deposits. The pores in these deposits store a considerable volume of ground water that is easily tapped and withdrawn by wells.

Table 1.--Summary of stratigraphy and hydrogeology of the Dallas-Monmouth area

System	Series	Geologic unit	Lithology	Estimated thickness range (ft)	Location and extent	Well characteristics					Aquifer hydraulic properties		Estimated annual recharge range (in.)
						Mean			Median				
						Depth (ft)	Static water-level depth (ft)	Yield (gal/min)	Yield (gal/min)	Specific capacity [(gal/min)/ft]	Hydraulic conductivity median (ft/d)	Coefficient of storage range	
Unconsolidated Quaternary rocks	Holocene and Pleistocene	Younger alluvium	Silt and very fine sand 5 to 50 feet thick overlying well-sorted sand and gravel 10 to 45 feet thick	0-55	Willamette River flood plain	45	19	100	--	40	170	0.2	8-15
		Older alluvium	Silt and clay 0 to 45 feet thick overlying poorly sorted sand and gravel interbedded with clay and silt	0-85	Underlies terraces above Willamette River flood plain and valleys of principal tributaries to the Willamette River	70	19	30	15	.59	19	.001-0.2	2-5
		Terrace deposits	Poorly sorted, deeply weathered sand and gravel, silt, clay, and cobbles	0-125	Crops out in two principal areas--near Dallas and near Adair Village								
Consolidated Tertiary rocks	Miocene	Columbia River Basalt Group	Basalt lava flows	0-150	Caps two hills in northeastern part of area	--	--	--	--	--	--	--	--
	Oligocene	Tertiary intrusive rocks	Gabbro and diorite dikes and sills	0-500	In foothills in western one-third of area	--	--	--	--	--	--	--	--
	Eocene	Tertiary rocks, undifferentiated	Tuffaceous sandstone and shale and volcanic ash	500-1,000	Exposed in northeastern part of area; may underlie unconsolidated deposits on east side of area								
		Spencer Formation	Sandy, micaceous marine siltstone	0-2,000	Crops out in east half of area and underlies younger formations in same area								
		Yamhill Formation	Thin-bedded marine sandstone and siltstone	0-3,000	Crops out in west-central and northwest foothills; slopes eastward and underlies younger formations in northeastern part of area	186	39	10	5.4	.10	.3	.00001-0.001	2-5
		Tyee Formation	Micaceous, arkosic marine sandstone and sandy siltstone	0-1,500	Crops out on west-central and southwest foothills; probably underlies younger formations in southeastern part of area								
		Siletz River Volcanics Kings Valley Siltstone Member	Tuffaceous marine siltstone, shaly siltstone, and tuff	0-3,000	Crops out in Kings Valley in southwestern part of area								
			Basalt flows, breccia, pillow lava, and tuffaceous sedimentary rocks	?-10,000	Crops out in northwestern and south-central parts of the area; may underlie entire area at great depths	192	44	13	7	.11	.2	.00001-0.001	

Ground water is recharged directly or indirectly by precipitation that falls in the surface drainage basin of the study area. Precipitation infiltrates directly into the subsurface wherever unsaturated permeable deposits are at the land surface. The water then percolates downward under the influence of gravity in the unsaturated zone until it reaches the zone of saturation and becomes ground water.

Recharge from precipitation varies widely and depends on factors such as precipitation rate and duration, soil permeability, soil moisture, surface slope, and vegetative cover. In general, the lower the permeability of the surface deposits the lower will be the rate of ground-water recharge.

All the consolidated rocks in the Dallas-Monmouth area are low-permeability formations; consequently, the recharge to these units is estimated to be small. Although reliable recharge data are not available, it is conservatively estimated that the annual ground-water recharge to the consolidated rocks ranges between 2 and 5 in. A similar range of recharge is estimated for the older alluvium because the upper several feet of that unit also consist of low-permeability silt or clay.

Recharge to the younger alluvium is estimated to range between 8 and 15 in. annually. This high recharge rate occurs because (1) the surface deposits are thin and relatively permeable, and (2) precipitation runoff collects in numerous surface depressions from which it percolates downward into underlying sand and gravel.

Recharge also occurs indirectly by movement of ground water between adjacent geologic formations. This probably occurs, for example, beneath the Willamette River flood plain, where small quantities of water move upward from the deeper consolidated sedimentary rocks into the younger alluvium.

Under certain hydrologic conditions, ground-water recharge also occurs along streams or lakes. Surface water will percolate into adjacent formations when the stream or lake levels are higher than the local ground-water level. This condition occurs naturally in most areas during sudden storms or snowmelt periods when stream stages rise more rapidly than local ground-water levels. Surface water can also be induced into the ground artificially by lowering ground-water levels in the formations adjacent to the streams or lakes. Induced infiltration of surface water is a particularly important factor in development of ground water from the younger alluvium.

Lateral movement of ground water toward a discharge area begins when recharge reaches the zone of saturation. Movement occurs if the pore spaces are interconnected and if a hydraulic gradient is present. Movement of unconfined ground water generally is from topographically high areas toward low areas, where water is discharged to surface-water bodies or to the atmosphere by evapotranspiration. In most areas, the approximate direction of ground-water flow can be estimated from topographic maps, as it generally follows the topographic slope. Unconfined ground water is present at greater depths beneath hills than in valleys. The top of the saturated zone is the water table and is indicated by water levels in wells. Water levels and other well data are included in tables of well records and drillers' logs (tables 7 and 8) at the end of this report.

Potentiometric contours for sand and gravel in the east-central part of the Dallas-Monmouth area are shown on plate 1. The sand-and-gravel aquifer in that area is the most productive in the project area. Arrows crossing some of the potentiometric contours denote the approximate direction of ground-water flow in the aquifer, toward the east into the Willamette River. The contours indicate that the gradient is much flatter for the sand-and-gravel aquifer beneath the Willamette River flood plain than it is for the sand and gravel immediately west of the flood plain. The steeper gradient suggests that the sand-and-gravel aquifer in that area is less permeable than sand and gravel beneath the flood plain.

Potentiometric contours are not shown for the remainder of the project area because water-level data are too sparse and because the formations elsewhere yield only small to moderate supplies of ground water.

Natural discharge of ground water is by seepage to surface-water bodies, by springflow, and by evapotranspiration in areas where ground water is shallow. Artificial discharge of ground water is chiefly by wells, by tile subdrains, and by water-table irrigation ponds. In dry weather, ground-water discharge sustains the flow of many perennial streams. The quantity of ground-water discharge to streams depends on several conditions, including formation permeability and thickness, the hydraulic gradient, the area of the ground-water basin, and many other factors.

Fluctuations of Water Levels

Fluctuations of ground-water levels reflect changes in the volume of ground water in storage caused by changes in the rate of ground-water recharge and discharge. Changes in the rate of recharge and discharge are due to natural causes such as drought or precipitation and to artificial causes such as pumping of ground water.

During the past several years, personnel of the Oregon Water Resources Department have made water-level measurements in 12 observation wells in the Dallas-Monmouth area. In general, the data indicate that changes in ground-water storage are seasonal and that ground-water recharge is in balance with ground-water discharge.

Annual fluctuations of ground-water levels range from 5 to 15 ft. Hydrographs for six representative observation wells (fig. 5) show the fluctuations of ground-water levels during 1962 to 1977. Water levels in the wells rose each year during the rainy winter season and declined during the summer and fall. The annual high and low water levels differ each year by only a small amount, indicating that recharge and discharge are in balance at the well sites.

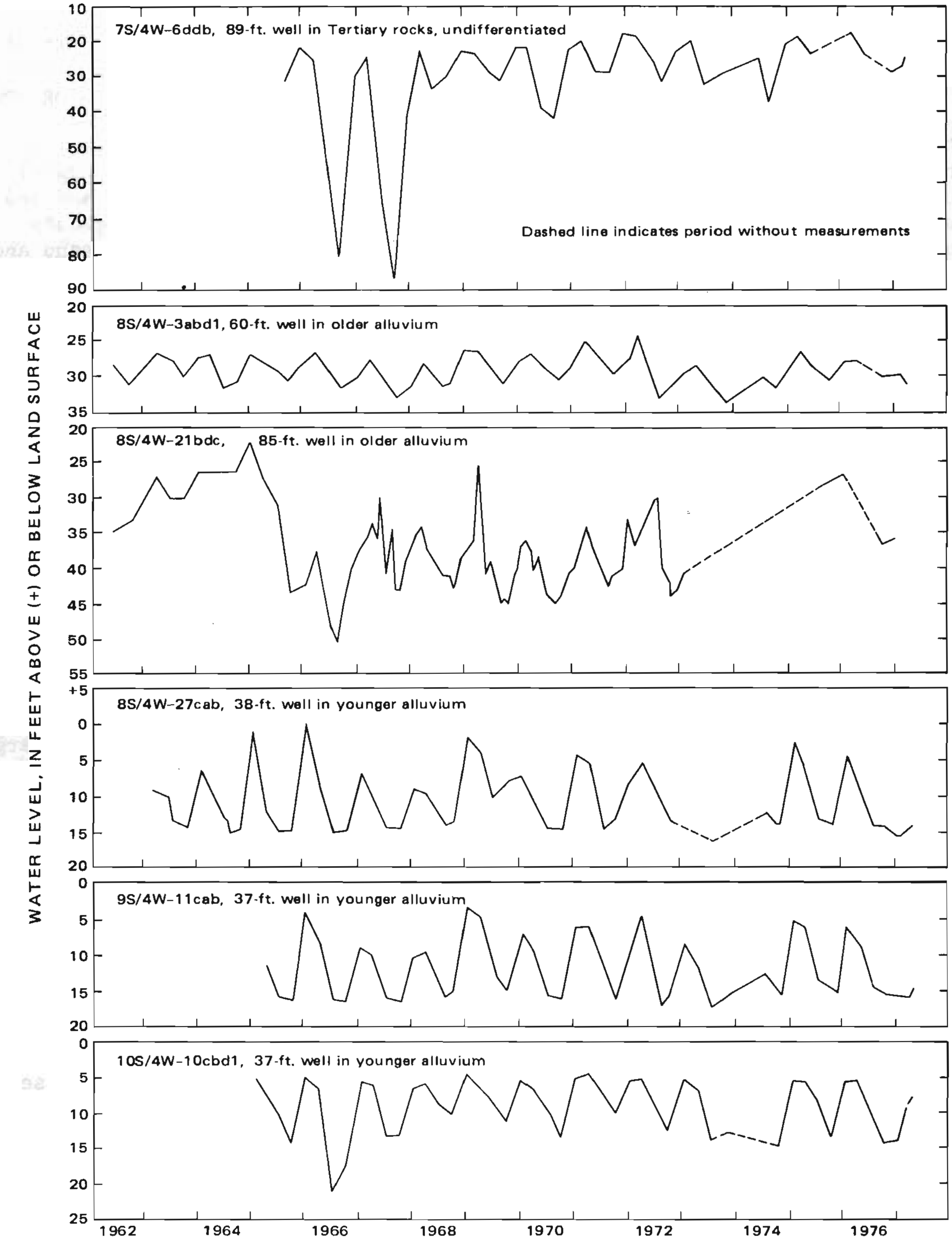

Figure 5. – Hydrographs of water levels in selected wells.

Possible changing conditions at well 8S/4W-21bdc are illustrated by the hydrograph in figure 5. This well, an 85-foot industrial-supply well tapping sand and gravel in older alluvium, had a sharp water-level decline in 1965 and lower water levels thereafter. The most probable causes for the 1965 decline are (1) an increase in pumping rate of the well beginning in 1965 and (2) a decrease in the aquifer recharge rate. To differentiate between these causes would require daily pumpage and water-level data on the well. The well is within a few feet of a log and fire-protection pond and is used to replenish water seeping or evaporating from the pond and for boiler feed water.

Availability

Consolidated Rocks

The consolidated rocks are a source of water supply for domestic use throughout the Dallas-Monmouth area. These rocks generally yield only small quantities of water to wells, however, and "dry holes" were reported for about 14 percent of the drilling attempts in the sedimentary rocks and in 6 percent of the attempts in basalt. Well yields of as much as 200 gal/min have been reported, but the probability of obtaining such a large quantity of good-quality water from any of the consolidated-rock formations is small. In addition, the risk of obtaining poor-quality water at depth in these rocks is fairly high.

Despite the small well yields, the consolidated rocks will continue to be used for water supplies because no other source is available in many areas. Yields of wells may fluctuate annually because of seasonal variations in recharge, water levels, and water use. An estimated 5 percent of the wells in the consolidated rocks in the area have required deepening to obtain dependable domestic supplies. Typical wells completed in consolidated rocks are 6 in. in diameter. They are cased and grouted with cement to a depth of at least 18 ft. Below 18 ft the well is generally uncased except where caving formations are penetrated.

About 130 of approximately 1,500 wells drilled in the Dallas-Monmouth area since 1956 have been completed in basalt of the Siletz River Volcanics. The reported yield of the basalt wells ranged from 0 to 80 gal/min (gallons per minute); the median yield was 7 gal/min. About 6 percent of the wells were reported to be dry holes; 11 percent were reported to yield 1 gal/min or less. Reported depths of the basalt wells ranged from 26 to 580 ft and averaged 192 ft. Reported depths to the static or nonpumping water levels in these wells ranged from 1 ft above the land surface to 266 ft below it and averaged 44 ft.

The average well depth and the average depth to the static water level in the area are greatest in wells completed in the basalt of the Siletz River Volcanics.

About 75 percent of the Dallas-Monmouth area is underlain by Eocene marine sedimentary rocks and by the undifferentiated Tertiary rocks, a sequence of several sedimentary formations that have similar water-bearing and water-yielding characteristics. These formations include the Kings Valley Siltstone

Member of the Siletz River Volcanics; the Tyee, Yamhill, and Spencer Formations; and the undifferentiated Tertiary rocks. About 875 wells, or 60 percent of the wells for which data are available, have been drilled in these formations, mainly for domestic water supplies. About 14 percent of these wells reportedly were dry holes. Yields ranged from 0 to 200 gal/min. The average yield was 10 gal/min and the median was 5.4 gal/min. The distribution of yields of the 875 wells is listed in table 2.

Table 2.--Yield-frequency data for the consolidated sedimentary rock wells

Reported yield (gal/min)	Percentage of wells with yield equal to or less than indicated values
0	14
1	19
2	28
3	34
4	40
5	48
6	53
7	57
8	61
9	66
10	71
11	75
20	90
50	99

Wells tapping these formations ranged in depth from 24 to 614 ft and averaged 186 ft. A 614-ft well (7S/4W-5daa) produced saline water and was backfilled to a depth of 248 ft to seal it off.

Evaluation of well and aquifer data for the consolidated rocks in the Dallas-Monmouth area indicates that the hydraulic properties of the Tertiary sedimentary formations do not differ appreciably, because the lithologies of the formations are similar. The principal occurrence of water in each formation apparently is in the interconnected fracture-and-joint openings that are distributed irregularly but are most abundant at shallow depths.

In most areas, wells capable of yielding adequate supplies of ground water for household use have been drilled in the consolidated rocks, but in many places two or more wells were drilled before an adequate supply was obtained. In most of these cases, the successful well was completed within 100 ft of the dry hole.

Unsuccessful wells in the consolidated rocks are reported more frequently on hill or hillside well sites than in lowland well sites where the consolidated rocks are commonly overlain by saturated unconsolidated deposits. At a given well site, the best water-bearing beds in the consolidated rocks will generally be the coarsest beds penetrated by the well below the water table; for example, sandstone will generally be more productive than siltstone, which, in turn, will be more productive than claystone or shale.

The performance of wells provides a general indication of aquifer transmissivity and hydraulic conductivity. In the Dallas-Monmouth area, reported specific capacities of many wells are available in the well-completion reports submitted by drillers to the Oregon Water Resources Department. Although the specific-capacity values (table 7) are based generally on 1 to 2 hours of pumping, and well efficiency is not known, the data permit some gross estimates of relative aquifer capabilities. Thus, the specific-capacity values indicate that the hydraulic conductivity of the basalt and Tertiary marine rocks is very low, similar to silt-clay mixtures. Hydraulic conductivity of the older alluvium is low to moderate; and for the younger alluvium it is moderate to good, about 10 times that of the older alluvium.

A separate evaluation was made to judge if the hydraulic conductivity of the Tertiary marine rocks differs with topography. For that evaluation, selected well data were separated into two topographic groups: (1) hillside or hilltop sites, and (2) lowland valley sites. The results indicated that the median hydraulic conductivity of the aquifer in the lowland is slightly greater than that in the hillside-hilltop areas, but the difference is too small to be of significance.

Although the hydraulic conductivity of the consolidated rocks is small compared to that of the aquifers in the younger alluvium, the large total saturated thickness of the consolidated rocks makes the total transmissivity of these units large. Therefore, at almost any locality, it should be possible to obtain a few hundred gallons per minute from wells 1,500 to 2,000 ft deep in these rocks. Such wells would probably yield poor-quality, highly mineralized water, however.

Table 3 is a summary of some well statistics for the Dallas-Monmouth area. The table shows, by township and range, data on the number of wells, well depth, and static-water-level depth.

Unconsolidated Deposits

The principal aquifers in the unconsolidated deposits are saturated sand or gravel in terrace deposits, older alluvium, and younger alluvium. Small quantities of water are obtained from finer grained materials, but they are not significant aquifers. Sand-and-gravel layers in the terrace deposits and in older alluvium generally are local in extent and less than 10 ft thick. Near Independence, however, sand-and-gravel layers in the older alluvium range from 10 to 45 ft in thickness over an area of several square miles.

Table 3.--Summary of data for wells drilled in the Dallas-Monmouth area

[F, flowing well]

	Number of drilled wells									Well depth (feet)								Static water-level depth (feet)							
Township and range	Total	Principal water-bearing units1/					Dry	Section with highest well density		Range	Mean	Mean by principal water-bearing units1/				Section with greatest mean well depth		Range	Mean	Mean by principal water-bearing units1/				Section with greatest mean water-level depth	
		Tsv	T		Qoal	Qyal																			
			Units present	No. of wells				Section number	No. of wells			Tsv2/	T	Qoal2/	Qyal	Section number	Mean depth (feet)			Tsv2/	T	Qoal2/	Qyal	Section number	Mean depth (feet)
T.7 S., R.4 W.3/	104	0	Ts,Tu	68	25	11	5	26	16	27-362	100	--	119	70	51	7	160	4-85	26	--	29	39	28	26	40
T.7 S., R.5 W.	243	14	Ty,Ts, Tu	184	44	0	16	19	23	28-554	126	160	137	69	--	19	209	0-266	32	72	33	14	--	7	92
T.7 S., R.6 W.	56	20	Ty	36	0	0	5	11, 26	11	45-402	147	163	138	--	--	36	164	5-170	36	46	30	--	--	12	58
T.8 S., R.4 W.3/	166	0	Ts,Tu	27	98	24	2	9	22	26-240	61	--	98	57	46	6	108	6-40	20	--	18	25	17	28	29
T.8 S., R.5 W.	238	2	Ty,Ts	182	32	0	26	8	16	15-411	109	--	118	68	--	11, 15	203	F-276	31	--	34	16	--	22	60
T.8 S., R.6 W.	112	29	Ty	79	2	0	9	1	9	34-575	146	179	136	--	--	1	203	F-216	44	65	36	--	--	12	62
T.9 S., R.4 W.3/	197	0	Ts	59	47	73	7	14	17	25-560	93	--	157	47	47	35	252	F-114	23	--	29	21	20	8	49
T.9 S., R.5 W.	35	0	Ty,Ts	33	2	0	4	5	12	40-580	124	--	126	--	--	2	354	0-70	22	--	21	--	--	12	26
T.9 S., R.6 W.	32	2	Tt,Ty	28	2	0	0	34	6	45-330	94	--	93	--	--	15	148	8-45	25	--	24	--	--	34	25
T.10 S., R.4 W.3/	185	19	Tt,Ts	84	54	27	6	30	36	25-500	116	240	94	76	36	25	149	F-261	22	20	31	15	17	31	44
T.10 S., R.5 W.	65	41	Tsvk, Tt	15	7	0	4	34	17	25-405	138	151	127	84	--	36	188	F-115	25	27	22	13	--	36	46
T.10 S., R.6 W.	56	3	Tsvk, Tt	52	1	0	4	30	7	26-410	150	113	152	--	--	27	247	F-65	26	24	26	--	--	22	38

1/ Water-bearing units: Tsv, chiefly wells completed in basalt in Siletz River Volcanics, but may also include a few wells completed in Tertiary intrusive rocks.
T, includes all wells completed in consolidated Tertiary sedimentary rocks; (Tsvk), Kings Valley Siltstone of Siletz River Volcanics; (Tt), Tyee Formation; (Ty), Yamhill Formation; (Gs), Spencer Formation; (Tu), Tertiary rocks, undifferentiated.
Qoal, chiefly wells completed in older alluvium, but includes a few wells completed in terrace deposits.
Qyal, includes only wells completed in younger alluvium.

2/ Mean values not determined where township had less than three wells.

3/ Includes only the sections within the study area.

Typical wells completed in unconsolidated deposits are 6 to 20 in. in diameter and cased with steel the entire depth. The casing is generally perforated opposite the most productive sand or gravel beds, which allows water in but keeps most of the formation particles out of the well. A few large-capacity wells in unconsolidated deposits are completed with wire screen instead of a perforated casing. The screen generally has more open area per unit of length, and the openings are sized to allow only the smallest particles to enter the well. A properly constructed screened well generally operates more efficiently than a perforated-casing well, but the initial cost of the screened well generally is greater.

Wells capable of pumping more than about 50 gal/min for irrigation, public, or industrial supplies range between 6 and 20 in. in diameter.

Terrace deposits and older alluvium.--Sand and gravel in the terrace deposits and in the older alluvium generally yield a few to more than 50 gal/min to properly constructed wells. Most wells in these units, however, yield less than 30 gal/min. Near Independence, many wells in the older alluvium yield more than 100 gal/min because the sand and gravel in the older alluvium is thickest and most extensive in that area.

The older alluvium apparently contains no sand and gravel in the Salt Creek and Baskett Slough drainage basins north of Rickreall Creek, in the Thielsen area south of Rickreall Creek, nor in the area beneath the E. E. Wilson Game Management Area near Adair Village. The general absence of wells and lithologic information for the valleys of the Luckiamute and Little Luckiamute Rivers upstream from the Highway 99W bridge in sec. 18, T. 9 S., R. 5 W., strongly suggests that few sand and gravel beds are present in these areas either.

Data are available for about 315 wells completed in terrace deposits and in older alluvium in the Dallas-Monmouth area. Only a few of these wells are in terrace deposits, however. The yields of these wells ranged from 0 to 1,000 gal/min and averaged 29 gal/min. Static water levels ranged from a few feet above to 55 ft below the land surface, and the average static water-level depth was 19 ft. The average well depth was 69 ft.

Younger alluvium.--Sand-and-gravel beds in the younger alluvium are the most productive aquifers in the Dallas-Monmouth area. These beds underlie the entire Willamette River flood plain and extend both upstream and downstream beyond the boundaries of the study area. The sand-and-gravel aquifer is in good hydraulic connection with the Willamette River; therefore, wells completed in the younger alluvium within several hundred feet of the river could be capable of inducing recharge from the river during pumping. Estimated recharge to the younger alluvium from direct infiltration of precipitation ranges from 8 to 15 in. annually. Occasional flooding of the flood plain ensures that the sand-and-gravel aquifer in the younger alluvium is periodically recharged. Large additional ground-water supplies can be developed from the younger alluvium; but, because of its relatively small total saturated thickness and limited extent, development of the younger alluvium should be carefully planned.

Data are available for about 160 wells completed in the younger alluvium. The reported yields of these wells ranged from 0 to 1,700 gal/min and averaged 160 gal/min. The average well depth was 45 ft. Static water levels ranged from 3 to 45 ft and averaged 19 ft. Properly constructed wells completed in sand and gravel in the younger alluvium can generally obtain 100 to 500 gal/min.

In the east-central part of the project area, near Independence, sand-and-gravel beds in younger alluvium are continuous with and hydraulically connected with sand-and-gravel beds in the adjacent older alluvium. When pumping stresses are applied, the two units respond as a single continuous aquifer. The discussion that follows concerns the availability of ground water from this source.

Map A of plate 2, compiled from drillers' logs of wells and from geologic-map data, shows contours on the bottom of the sand-and-gravel aquifer. Potentiometric-surface contours for the sand-and-gravel aquifer in the Independence area are shown on plate 1. Because the potentiometric surface of the sand-and-gravel aquifer was compiled from water-level data collected in October 1976, during a period when ground-water levels were low, the surface is one that approximates a low for the aquifer. The altitude of the potentiometric surface probably ranges from 5 to 10 ft higher each winter and spring.

Map B of plate 2 is a saturated-thickness map of the sand-and-gravel unit in the Independence area. It was compiled from the potentiometric-surface map on plate 1, the contour map of the bottom of the aquifer (map A of pl. 2), drillers' logs of wells, and the geologic map. Map B of plate 2 approximately defines the minimum saturated thickness of the sand-and-gravel aquifer. In many places, the saturated thickness will be greater in winter and spring when ground-water levels are much higher. The sand-and-gravel part of the older alluvium is overlain by 15 to 45 ft of clay and silt, whereas in the younger alluvium it is overlain by 5 to 30 ft of silt, very fine sand, and fine sand that averages less than 15 ft in thickness.

Ground water in the sand and gravel near Independence occurs chiefly under unconfined conditions, but locally beneath the older alluvium the sand and gravel may respond as a confined aquifer when pumped for periods of less than a few weeks. The entire aquifer will probably respond as an unconfined aquifer, however, when pumped for periods of more than a few weeks. A value of about 0.2 probably is suitable for use as a storage coefficient of the sand-and-gravel aquifer. More reliable estimates of the storage coefficient could be obtained from aquifer tests.

No saturated-thickness map or potentiometric-surface map has been prepared for the younger alluvium along the Willamette River south of Buena Vista, because lithologic data for that area were sparse. Irrigation wells completed in the younger alluvium in that area, however, generally are less than 37 ft deep, and they yield 75 to more than 300 gal/min.

The reported yields of wells in the sand-and-gravel aquifer in the east-central part of the project area near Independence are as high as 1,700 gal/min, but most wells yield less than 500 gal/min. The highest reported yield was obtained from well 8S/4W-2cac1, a 45-foot irrigation well in younger alluvium. The maximum yield reported for a well in the older alluvium was 1,000 gal/min from well 9S/4W-3ccc, a 97-foot irrigation well that obtains most of its yield from sand and gravel between the depths of 30 and 61 ft.

Specific-capacity values for wells completed in the sand and gravel near Independence range from near 0 to as much as 500 (gal/min)/ft of drawdown. All reported values greater than 100 (gal/min)/ft of drawdown are for wells tapping sand and gravel in the younger alluvium. The highest specific capacity is for well 8S/4W-35bdc, a 36-foot irrigation well. The specific capacity of wells in sand and gravel in the older alluvium ranges from near 0 to 25 (gal/min)/ft; however, most have specific capacities of less than 15 (gal/min)/ft.

Reduced pumping capacity due to interference will occur if wells in the sand and gravel are spaced too closely. Problems of reduced pumping capacity may become more common and more serious during extended droughts. Interference problems can be minimized through proper well spacing and well location.

Drawdown due to well interference or to reduced well efficiency has diminished the capacity of the individual wells in the city of Monmouth well field. Wells 8S/4W-28cdb, -28cdc1, -28cdc2, and -28cdc3 (pl. 1) are separated by a distance of about 200 ft. They each tap sand and gravel in the older alluvium. Use of well 8S/4W-28cdc1 has been discontinued because its capacity is significantly decreased and it is no longer economical to operate.

The quantity of ground water that can be developed from the sand and gravel near Independence without widespread decline of water levels is determined by the amount of recharge that the sand and gravel receives. The most important sources of recharge to the sand and gravel are direct infiltration of precipitation and infiltration of streamflow. Less important sources are underflow from adjacent formations and infiltration of excess irrigation water. The natural annual recharge to younger alluvium from infiltration of precipitation was conservatively estimated to range between 8 and 15 in. It probably averages about 12 in., or more than 200 Mgal/mi^2. Without extensive aquifer tests and mathematical model studies, it is not practicable to estimate the recharge that could be induced from the Willamette River. The amount probably is several times greater than the amount of recharge to the aquifer from precipitation and depends on the hydraulic connection between the river and the sand and gravel.

suggests that because of its shallow depth and high permeability, the younger alluvium may be more susceptible to contamination or degradation of water quality than are other aquifers in the study area.

Water in the unconsolidated deposits ranges from soft to very hard. The median concentrations are 92 mg/L in water from the older alluvium and 91 mg/L in water from the younger alluvium.

Interchange of ground water between the consolidated rocks and the overlying unconsolidated deposits occurs in most areas where the two types of material are in contact. The interchange may be due to the natural flow pattern or may be induced artificially by pumping. Each of the analyses of water from wells 7S/4W-32aab and 8S/4W-19bdb in the older alluvium and from wells 8S/4W-36cbd and 9S/4W-10bad1 in the younger alluvium shows evidence of the ground-water interchange. Water from the first three wells contains a high sodium concentration, which is more characteristic of water from the consolidated rocks.

Well 9S/4W-10bad1, a public supply well, was sampled on two dates--the first time on April 28, 1969, when the well reportedly was pumping 970 gal/min, and the second time on September 30, 1976, when it was pumping 200 gal/min. Chloride was 102 mg/L in the first water sample and 4.3 mg/L in the second sample. These data suggest that at the higher pumping rate a larger percentage of water pumped was being induced upward from the underlying consolidated rocks.

Downward flow of shallow freshwater into the consolidated rocks probably took place at well 10S/7W-12dcc, an 88-foot well completed in the Tyee Formation and located about 100 ft from the Luckiamute River. Two visits were made to the site, the first on July 20, 1976, and the second on September 15, 1976, when a water sample was collected for analysis. On the July 20 visit, the well had been pumping for several weeks for lawn irrigation, whereas on the September 15 visit, the well had been unused for at least a few weeks. The specific conductance of the water was 1,500 micromhos/cm on July 20 and 5,660 micromhos/cm on September 15. The lower specific conductance on the first visit probably was due to dilution by shallow freshwater induced to flow downward by pumping. The higher value probably was determined after the natural ground-water flow pattern was reestablished at the site.

Water Withdrawals and Use

Ground-water withdrawal for all types of use in 1975 in the Dallas-Monmouth area was estimated to be 9,500 acre-ft, of which irrigation pumpage accounted for the greater part (table 6).

By 1975, water rights totaling about 45 ft^3/s for irrigation of about 4,600 acres from ground-water sources had been applied for in the Dallas-Monmouth area. All but about 150 acres was in Tps. 7, 8, 9, and 10 S., R. 4 W., and most of the acreage was in the younger alluvium in the Willamette River flood plain.

Table 6.--Estimated ground-water withdrawals by use, in the Dallas-Monmouth area

Use	Source and quantity				Combined total	
	Consolidated rocks		Unconsolidated deposits			
	Mgal/d	Acre-ft	Mgal/d	Acre-ft	Mgal/d	Acre-ft
Irrigation	--	--	6.4	7170	6.4	7170
Public supply	0	15	1.1	1230	1.1	1245
Domestic and stock	0.5	560	0.2	224	0.7	784
Industrial	--	--	0.3	336	0.3	336
Total	0.5	575	8.0	8960	8.5	9535

On the basis of field observation and discussions with irrigators, during any one year a maximum of about two-thirds of the ground-water irrigation water rights are in use. The length of the irrigation season is about 120 days, or from mid-May to mid-September on the average, depending on the type of crop, summer precipitation, and soil-moisture conditions. The maximum daily withdrawal for irrigation, on the basis of the above estimates, is about 29 Mgal/d for the 120-day irrigation period. Most of this water is withdrawn from younger alluvium.

In 1975, an average of 1.1 Mgal/d of ground water was withdrawn for public-supply purposes. Nearly all this amount was pumped from the unconsolidated deposits. The Pacific Power & Light Co. pumped an average of 0.72 Mgal/d to supply the city of Independence; the remainder was withdrawn by the city of Monmouth, Luckiamute Water Cooperative, Rickreall Water Association, and the Fir View Water District.

Two of the five wells that supply the city of Independence are in a well field in younger alluvium in the SW¼ of the NE¼ of sec. 28 in T. 8 S., R. 4 W., within 150 ft of each other, and generally are used only during the summer peak demand period. The other three wells are within 250 ft of one another in the NE¼ of the SW¼ of sec. 28. Detailed information about the construction and depth of each well is not available; consequently, the wells are not listed in table 7 nor shown on plate 1.

The city of Monmouth obtains most of its water supply from surface-water sources and from small springs in the Teal Creek area south of Falls City. The city also obtains a supplemental supply for the summertime peak demand period from wells 8S/4W-28cdb, -28cdc1, -28cdc2, and -28cdc3 in older alluvium. In 1975, the wells pumped an average of 0.11 Mgal/d. The combined yield from both sources is sometimes inadequate to meet peak demands, and water conservation is occasionally required in summer.

The Luckiamute Water Cooperative system serves a small population living in a large rural area in the Luckiamute and Little Luckiamute River drainage basins in the central part of the study area. Two wells in younger alluvium (9S/4W-10bad1 and -10bad2) supply water to a system that extends from the supply wells westward for more than 16 mi. The system has about 80 mi of pipelines, and the 1975 pumpage averaged 0.13 Mgal/d.

The Rickreall Water Association, also, is a rural water-supply system that services a small population scattered over a large area generally north of Rickreall Creek and extending west almost to Dallas and into the Salt Creek area. Two wells in older alluvium (7S/4W-34ddc and -35cbc) supply water to the system; in 1975, they pumped an average of 0.04 Mgal/d.

The Fir View Water District is in a development in the NW¼ of sec. 23, T. 10 S., R. 4 W. The source of water supply is two wells in the Spencer Formation at the development.

Many homes in the Oak Grove area in the southeastern part of the study area are served by ground water from a well field in younger alluvium just east of the study area (Frank, 1974). In 1975, about 0.26 Mgal/d was pumped by that system, but not all the water was used within the study area.

A small area in the Salt Creek basin in the northwestern part of the study area is served by the Perrydale Water Cooperative. The system is supplied by a well in alluvium near the Willamette River several miles north of West Salem outside the study area. The volume of water supplied to residents living in the study area is small.

The city of Dallas obtains its water supply from a reservoir on Rickreall Creek west of Dallas. Falls City obtains its supply from springs and from surface-water sources on Teal Creek south of Falls City. Adair Village and a few rural customers nearby are served by surface water withdrawn from the Willamette River south of the study area. Their supply was originally developed by the U.S. Army to serve troops training at Camp Adair during World War II.

Ground-water withdrawals for domestic and stock use in rural areas were estimated to be 0.7 Mgal/d. The withdrawal rate is based on an estimated rural population of 6,800 persons not served by public water supplies. Seventy-five percent, or 0.5 Mgal/d, is estimated to be from wells in consolidated rocks and the remainder, or 0.2 Mgal/d, from unconsolidated deposits.

Problems and Solutions

The major ground-water-related problems in the Dallas-Monmouth area are low well yield and poor-quality ground water. These problems commonly occur together in individual wells, and they occur most frequently in wells drilled into the consolidated rocks. The problems occur because the consolidated rocks consist chiefly of low-permeability formations that generally contain water having increasing concentrations of dissolved minerals with depth below the land surface. Commonly, several wells are drilled into the consolidated rocks before an adequate domestic freshwater supply is obtained. Unsuccessful wells generally are backfilled and abandoned. Records indicate that as many as five unsuccessful wells have been drilled on a given property. Other solutions have been to develop water supplies from nearby springs, obtain water from neighbors, collect water in cisterns, connect into existing public water supplies, or to form a new public water-supply system utilizing a distant but dependable source of supply.

Excessive pumping of sand is a significant problem associated chiefly with wells completed in sand and gravel. The sand enters the well through casing perforations and causes excessive wear of pumping equipment, clogging of pipes, and sometimes results in the destruction of the well through the collapse of the unsupported casing. The problem is caused by high turbulence around the well bore due to excessive ground-water velocities. It can be controlled by reducing the pumping rate of an affected well; it is prevented through good well design, operation, and maintenance.

Excessive declines of ground-water levels resulting from heavy pumping of wells is a potential problem in the Dallas-Monmouth area. These declines could become a significant problem in the area's most productive sand and gravel because sand and gravel will continue to supply much of the area's increasing water needs. The problem will occur if pumping wells are spaced too closely and if they extract water at rates that exceed the sand and gravel local hydraulic capacity. Future development of the sand and gravel therefore should be planned with care so as to minimize the adverse effects.

Ground-water pollution is not a major or widespread problem in the Dallas-Monmouth area, but local occurrences have been reported. Pollution of ground water will occur if facilities for the disposal of wastes or for application of other degrading substances are poorly designed, operated, and maintained for the type of soil conditions existing at a disposal site or if the potential pollutants are handled carelessly. The risk of pollution is higher in sand and gravel in the younger alluvium because of their high porosity and permeability and shallow depth. These soil characteristics may allow a potential pollutant to reach the water table and to move downgradient toward a discharge area more quickly than in other water-bearing formations in the area.

Locally, ground water from sand-and-gravel aquifers contains concentrations of iron and (or) manganese that may be excessive for some types of uses. Prediction of the occurrence of excessive concentrations of iron or manganese is not feasible with the data presently available.

SUMMARY AND CONCLUSIONS

Ground water is the principal source of water for most of the rural population of the Dallas-Monmouth area. Water-bearing formations include consolidated rocks consisting of basalt, marine siltstone, sandstone, shale, and tuff and unconsolidated deposits consisting of clay, silt, sand, and gravel. Consolidated rocks are exposed in about 70 percent of the area, and they are chiefly low-permeability formations that yield less than 10 gal/min to wells. Commonly these rocks yield quantities of water that are inadequate even for household use. Ground water in the consolidated rocks is of suitable quality for most uses in most localities; however, the water contains concentrations of dissolved minerals that increase with depth in the rocks. Locally, wells may intercept water that contains excessive concentrations of dissolved minerals and is too saline for most uses. The depth at which saline water occurs is highly variable, and determination of that depth in each locality was beyond the scope of this study.

Movement of unconfined ground water in the project area is from topographically high areas toward lowlands where the water may be discharged as springs, as seepage to surface-water bodies, or as evapotranspiration to the atmosphere. The depth to unconfined ground water generally is greater beneath hills and hillsides than beneath lowlands. The potentiometric-surface contour map for the sand and gravel in the east-central part of the Dallas-Monmouth area (pl. 1) indicates a general eastward flow of ground water toward the Willamette River. Potentiometric-surface contours were not prepared for other parts of the project area because water-level data are inadequate and because the formations elsewhere yield only small to moderate supplies of ground water.

The best water-bearing materials in the study area are beds of sand and gravel in the unconsolidated deposits. The thickest, most extensive, and most productive sand and gravel deposits are in the younger alluvium underlying the flood plain of the Willamette River. The largest yielding wells completed in sand and gravel in the younger alluvium generally yield 100-500 gal/min. In the east-central part of the Dallas-Monmouth area, sand-and-gravel beds in the younger alluvium are continuous and are hydraulically connected with sand and gravel in adjacent older alluvium. When either unit is heavily pumped, the two units respond as a single aquifer. Although large quantities of ground water are being withdrawn from this aquifer, additional large quantities can be developed if adequate well spacing is maintained. Outside the Willamette River flood plain and the east-central area, sand and gravel beds in older alluvium or in terrace deposits are too thin and too small in extent to support wells of large yield.

The quality of water in the unconsolidated deposits is adequate for most uses; however, it may contain excessive concentrations of iron or manganese in some localities.

About 9,500 acre-ft of ground water was withdrawn from all sources in the Dallas-Monmouth area in 1975. Of this total, about 7,200 acre-ft was pumped from sand and gravel in unconsolidated deposits for irrigation. Most ground water for irrigation was pumped from wells completed in younger alluvium. About 1,200 acre-ft was pumped from unconsolidated deposits for public-supply use, and the remainder, or about 1,100 acre-ft, was for domestic, stock, and industrial uses.

Principal ground-water-related problems are low well yield, poor-quality ground water, and sand pumping by wells. Low well yield and poor-quality ground water occur most frequently in wells tapping the low-permeability consolidated rocks. Because the consolidated rocks are the only source of ground water in much of the area, these problems will continue to persist as long as people are attracted to build in the area's rural setting. Sand pumping by wells is a common problem, occurring most frequently in large-capacity wells completed in the unconsolidated deposits. The sand causes excessive wear of pumping equipment, clogging of irrigation systems, and caving around pumping wells.

Potential ground-water problems include pollution and excessive water-level decline. Excessive water-level declines result from spacing pumping wells too closely for the local hydraulic conditions or simply from heavy pumping. Excessive declines could be a problem, especially in the productive sand-and-gravel deposits in younger and older alluvium where the water table is shallow and the water-bearing sand and gravel are highly permeable. Particular caution is needed in these areas in the use and disposal of potential pollutants.