# Geology and Ground Water of the Umatilla River Basin Oregon

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## CONTENTS

# ILLUSTRATIONS

[Plates are in pocket]

## TABLES

# GEOLOGY AND GROUND WATER OF THE UMATILLA RIVER BASIN, OREGON

By G. M. Hogenson

## ABSTRACT

The Umatilla River is a tributary of the Columbia River and drains about 2,700 square miles of the Columbia Plateaus physiographic province in northeastern Oregon. The southern and eastern parts of the basin lie in the upland of the Blue Mountains. The upland, which reaches a general altitude of about 5,000 feet, is separated from the lower land in the northwestern part of the area by the ramplike Blue Mountain slope.

The climate of the Umatilla River basin ranges from mild and semiarid in the Umatilla lowland to cool and temperate in the Blue Mountain upland. Average annual precipitation increases with altitude from about 7 inches at the mouth of the river to about 35 inches in the upland.

The oldest rocks of the Umatilla River basin are pre-Tertiary in age and consist of amphibolite schist and gneiss, which were intruded by a composite igneous body of norite and quartz diorite. This pre-Tertiary material is overlain unconformably by a fairly thick deposit of lavas and continental sediments of Eocene age (Clarno formation). The lavas are of acidic to intermediate composition and the sediments are sandstone, silt, and shale—some of which are highly carbonaceous. The pre-Tertiary rocks and the Clarno formation crop out only in the Blue Mountain upland and the higher parts of the Blue Mountain slope.

The Eocene rocks, in turn, are overlain by the Columbia River basalt of Miocene age. On the basis of extent, thickness, and structural control of the topography, this series of accordantly layered basaltic lava flows is the most important rock unit in the basin.

In places the basalt is overlain by one or more of five types of terrestrial sediments. The oldest of these is fanglomerate containing lenses of sand and silt. The gravel of this fanglomerate is composed of basalt pebbles, cobbles, and boulders. The fanglomerate was deposited during Pliocene time after deformation of the basalt had started.

Below an altitude of 1,150 feet the basalt (and in places the fanglomerate of Pliocene age) is overlain by Pleistocene glacial-lake beds and, below 750 feet, by glaciofluviatile deposits.

All the pre-Pleistocene rock units of the area are mantled in places by a veneer of loess that was derived, in part at least, from the glacial-lake deposits.

Thin ribbons of Recent alluvium border the larger streams. These alluvial deposits are composed mostly of basaltic gravels in the Blue Mountains and of reworked loess in the lowland districts. In some places, small deposits of white volcanic ash occur in the alluvium.

The major topographic features in the area are controlled by the structure of the Columbia River basalt. The basin, as a whole, is a westward-plunging synclinorium bounded on the southeast by the northeastward-trending anticlinal crest of the Blue Mountains and on the northeast by the northwestward-trending crest of the Horse Heaven anticlinal ridge. Lesser structural features include the transverse Rieth anticlinal ridge, which trends northeastward and separates the Pendleton plains on the east from the Umatilla lowland on the west. A low ridge formed by the Service anticline has been mostly removed by erosion, but a vestigial row of buttes trends northward from Service Buttes to Sillusi Butte. The axis of the Agency syncline extends northeastward from the city of Pilot Rock to Athena beneath the topographically low area that served as a depository for part of the fanglomerate of Pliocene age.

The Columbia River basalt is the most productive and widespread aquifer in the Umatilla River basin. The fractured scoriaceous zones at the tops of many of the flows are porous and permeable, but the more compact central and lower parts of most flows are relatively impermeable. The ground water forms tabular bodies confined within these scoriaceous zones. Where the lava beds are tilted, the parts that lie downdip at lower elevations may contain water under artesian pressure. Recharge to these ground-water bodies occurs where the beds are tilted and the upturned edges of the scoriaceous zones are exposed or approach the surface, in slopes and stream valleys, as in the Blue Mountain slope and the west limb of the Rieth anticline. Large quantities of ground water are available in the basalt at places where structural conditions are favorable and recharge is available, as in the lower parts of the Blue Mountain slope and the Agency syncline and in most of the Umatilla lowland. In less favored areas, such as the higher parts of the Blue Mountains and the Rieth and Horse Heaven anticlines, supplies of ground water are commonly developed only in limited quantities from small zones of perched water.

Moderate quantities of ground water are present under water-table conditions in parts of the glaciofluviatile deposits where these deposits are thick enough to provide an adequate storage reservoir. Within these deposits layers of coarse, well-sorted sand transmit water readily. The glaciofluviatile deposits lie in an area of low annual precipitation and probably receive most of their recharge from water spread for irrigation and from streams that cross the deposits.

The gravelly deposits of the Recent alluvium in and near the Blue Mountains transmit water readily. In most places the ground water in this alluvium is in hydraulic continuity with the nearby streams.

Except in a few places, the quality of the ground water in the Umatilla River basin is excellent. In general, the water ranges from soft to moderately hard, has a moderate mineral content, and does not contain significant concentrations of objectionable constituents.

# INTRODUCTION

## PURPOSE AND HISTORY OF THE INVESTIGATION

The study of the geology and ground-water resources of the Umatilla River basin was begun in 1951. A reconnaissance study of the geology of the area, a well inventory, and a survey of water use were made, and a report was compiled that listed and interpreted the data. This report is intended to assist in the wise development and management of the ground water and to aid in the selection of ground-water areas for further, more detailed study.

The project was interrupted by assignment of the author to military duty in 1951, but was resumed in December 1952. Fieldwork for the project was done mainly in the 11 months from December 1952 to November 1953. In March 1957 a preliminary version of the report was released to the open file.

The base map for the project was compiled from standard 30-minute U.S. Geological Survey topographic maps of the Blalock Island, Umatilla, and Pendleton quadrangles, a Forest Service planimetric map of the Pendleton Ranger district of the Umatilla National Forest, and—in the area south of the Willamette base line and west of longitude 118°30′—a planimetric map that was compiled by the author from aerial photographs, Forest Service maps, and field reconnaissance.

Data gathered in cooperation with the State Engineer of Oregon were used freely.

## PREVIOUS WORK IN THE AREA

The Umatilla River basin has received intermittent attention of geologists during the last 30 years or so. In the 1920's J. Harlan Bretz (1920, 1923, 1925, 1927, 1930) presented a series of papers reporting field evidence and advancing a theory to explain the origin of the scablands and glaciofluviatile deposits bordering the Columbia River. Hodge (1931, p. 985–1010) prepared a paper reporting "exceptional morainelike deposits in Oregon" involving the glaciofluviatile deposits. Allison (1933, p. 675–722) prepared a paper advancing a new theory to explain the relation of the scablands farther north to glaciofluviatile deposits of which a part occur in the lower limits of the Umatilla Basin.

In 1937 Thomas Hite compiled a rough reconnaissance geologic map of Umatilla County for the Soil Conservation Service of the Department of Agriculture. In 1949, Hite's map was published by Wagner (1949, p. 4) in a report for the Oregon Department of Geology and Mineral Industries.

In an unpublished report of the latter agency, Allen [1] briefly described the general geologic and ground-water conditions in a 150-square-mile area surrounding the city of Pendleton.

## ACKNOWLEDGMENTS

Dr. Roland W. Brown and Mrs. Jean Hough, paleobotanist and vertebrate paleontologist, respectively, of the U.S. Geological Survey,

[1] Allen, J. E., 1939, Geology and ground water of the Pendleton area, Oregon: Oregon Dept. Geology and Mineral Resources, unpublished rept.

identified fossil plants and animals found in the area, thereby establishing the ages of some of the rock units.

Professors W. D. Wilkinson and William Taubeneck of the Department of Geology of Oregon State College offered much technical assistance and many helpful suggestions.

Local citizens, city and county officials, and people connected with the construction and operation of water wells were cooperative and helpful. Commercial well drillers who contributed well logs and other information include the late Bert Gladney of Pendleton, Oreg.: Harold Yager, A. A. Durand and Son, the firm of Moore and Anderson, and D. K. Smith of Walla Walla, Wash.; A. M. Jannsen of Aloha, Oreg.; R. J. Strasser and Sons of Portland, Oreg.; and A. M. Edwards of Lexington, Oreg. Well information was given by officers of the Walla Walla District, U.S. Army Corps of Engineers, on wells at the McNary dam site and by officers of the Umatilla Ordnance Depot on wells at that installation.

The U.S. Soil Conservation Service at Pendleton furnished aerial photographs and valuable information concerning the soil types and their distribution within the area. U.S. Forest Service officials furnished some of the base maps that were used.

## LOCATION SYMBOLS

Wells and springs in this report are designated by symbols that indicate their location according to the official rectangular survey of the public land. In the well symbol 2N/32–10F1, for example, the part preceding the hyphen indicates respectively the township and range (T. 2 N., R. 32 E.) north and east of the Willamette base line and meridian. Because most of the State lies south of the Willamette base line and east of the Willamete meridian, the letters indicating the directions south and east are omitted, but the letters "W" and "N" are included for wells and springs lying west of the meridian and north of the base line. The first number after the hyphen indicates the section (sec. 10). The letter following it designates a particular 40-acre tract within the section, according to the diagram below (fig. 1), and the final digit is a serial number of this well with respect to the other wells and springs scheduled within that 40-acre tract.

Thus, the example above indicates that the well is located in the SE¼NW¼ of sec. 10, T. 2 N., R. 32 E., and that this well was the first to be inventoried in this 40-acre tract.

In the tables, well and spring numbers are listed in the order of the lettered 40-acre tracts within successive sections of the townships. The townships are listed in the numerical order of the township tiers north of the Williamette base line and then south of the base line; the range numbers increase successively eastward in each township tier.

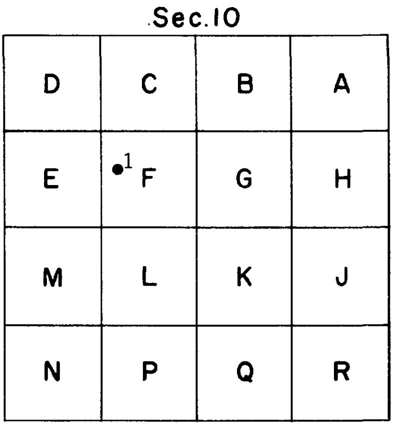



FIGURE 1.—Well-numbering system.

In tables 1 and 2, the location symbols are not given in full for each well. They are arranged by township and range, under appropriate subheads, and each well or spring is designated only by that part of the symbol that indicates section number, 40-acre tract, and serial number.

## GEOGRAPHY

### LOCATION AND DESCRIPTION OF THE AREA

This report is concerned with the part of Umatilla and Morrow Counties in northeastern Oregon that is drained by the Umatilla River and several smaller streams as shown on figure 2. The area is roughly oval and includes about 2,700 square miles.

Among the cities and towns within the area are Pendleton, Hermiston, Umatilla, Pilot Rock, Stanfield, Athena, Echo, Helix, Adams, Meacham, Rieth, and Kamela, listed in order of decreasing size. The city of Pendleton (population 14,304 in 1960), centrally located within the area, is a main railroad, highway, and airline station. The area is well served by roads and highways, although most of the Blue Mountains region is accessible only by forest roads and only in fair weather.

Major industries within the area are agriculture and lumbering. Dominant agricultural products are small grains, peas, and cattle. Sawmills in Pendleton, Pilot Rock, and some smaller places produce lumber from the pine and fir forests of the Blue Mountain upland.

### TOPOGRAPHY AND DRAINAGE

#### GENERAL SUBDIVISIONS

The Umatilla River basin lies entirely within the physiographic province described by Fenneman (1931, p. 225) as the "Columbia Plateau." Two of Fenneman's subdivisions are represented. These

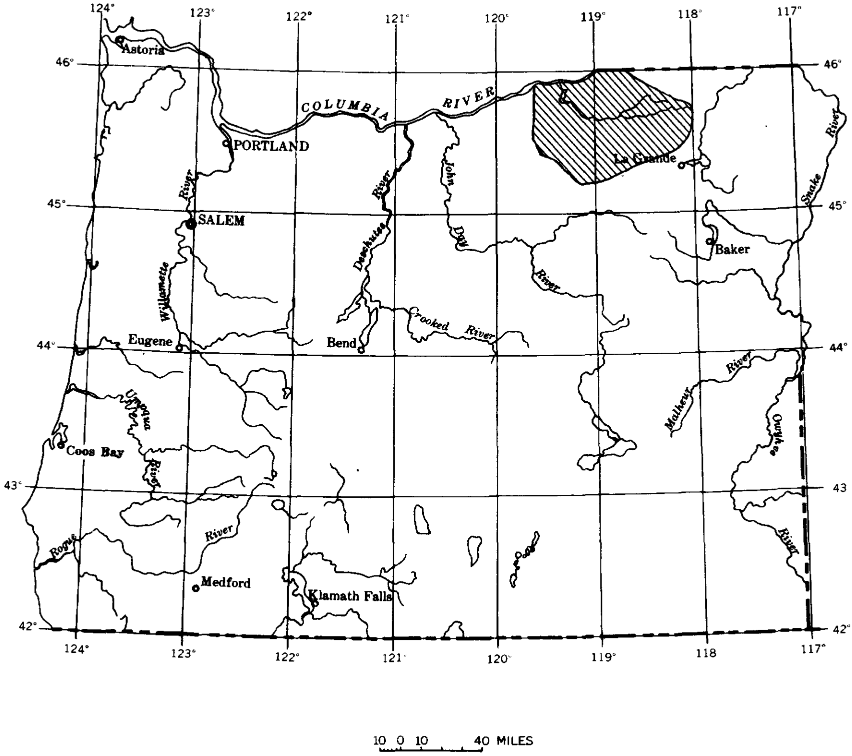



FIGURE 2.—Map of Oregon showing area of this investigation.

are the "Blue Mountain section" and the north central Oregon district of the "Walla Walla section." In this report, two major components of Fenneman's Blue Mountain section are described—the upland plateau of the Blue Mountain section and the ramplike slope descending northwestward from the Blue Mountain upland. This ramp is referred to as the Blue Mountain slope.

### BLUE MOUNTAIN UPLAND

The uplands of the Blue Mountain section have been eroded to youthful and mature stages by consequent streams which have produced many steep-walled canyons. In the more maturely dissected regions, which lie near the edges of the upland area, the canyons are separated by sharp razorbacked ridges and narrow remnants of the older surface on the bedrock lavas. In the less maturely eroded parts, which lie near the summit of the Blue Mountains, the deep narrow canyons are separated by strips of the broad, relatively flat plateau that composes the Blue Mountain upland. The elevation of the Blue Mountain upland ranges from 3,500 feet at Cabbage Hill to more than 5,000 feet at Huckleberry Mountain.

The uplands receive slightly more than 35 inches of precipitation annually and have a large volume of surface runoff. The streams have consequently produced a well-developed drainage system within which both rectangular and dendritic patterns occur. Northeast of Meacham and Kamela the drainage pattern is mainly rectangular and is controlled chiefly by the pattern of fracturing in the bedrock. In the rest of the upland area the pattern is dendritic and the streams flow mainly in the direction of the dip on the slopes of the old surface of the lava bedrock.

Branches of several of the larger streams join in the upland area south of the monocline formed by the northwestward-dipping basalt that underlies the Blue Mountain slope. For example, Squaw Creek, Meacham Creek, Ryan Creek, and the forks of the Umatilla River all join the Umatilla River upstream from the vicinity of Gibbon (pl. 1). Between Bingham Springs and Gibbon the river flows generally parallel to the strike of the basalt. Farther downstream, and west of Gibbon, it flows across the monocline. Similarly, the tributaries of both McKay Creek and upper East Birch Creek merge above the monoclinal slopes that the two streams cross near Pilot Rock.

#### BLUE MOUNTAIN SLOPE

The bedrock surface descends about 2,000 feet from the Blue Mountain upland to the lowland of the north-central Oregon district in a slope that, from a distance, appears as a gently sloping even ramp. In places the slope is maturely dissected. It occupies a northeastward-trending belt that is about 10 miles wide east of Athena. Northwest of Emigrant Hill it narrows to about 3 miles and maintains this width southwestward to Pilot Rock. West of Pilot Rock and Battle Mountain the slope broadens into a much gentler slope that extends about 25 miles southward from the edge of the lowland at Pine City to the summit of the Blue Mountains at Arbuckle Mountain. Views of the slope, the upland, and the lowland plains of the major subareas are shown in figures 3–5, and a map of these areas is shown in figure 6.

#### NORTH-CENTRAL OREGON DISTRICT

The remainder of the Umatilla River basin lies within the north-central Oregon district and consists of a broad topographic and structural trough oriented east to west, lying between the Blue Mountain slope on the south and the relatively low Horse Heaven Hills on the north. This general trough is divided in R. 31 E. by the northeastward-trending crest of Rieth Ridge. In this report the part of the lowland east of Rieth Ridge is called the Pendleton plains and the part west of the ridge is called the Umatilla lowland.

The Pendleton plains form a roughly rectangular area that is bounded on the south and southeast by the Blue Mountain slope, on

FIGURE 3.—View southward across part of the Pendleton plains toward the Blue Mountain slope, which rises in the background. The skyline is formed by part of the Blue Mountain upland, including the ridge known as Emigrant Hill, in left center.

FIGURE 4.—View southward from Emigrant Hill down one of the headwater branches of the North Fork of McKay Creek, showing the stream dissection that is common near the edges of the Blue Mountain upland.

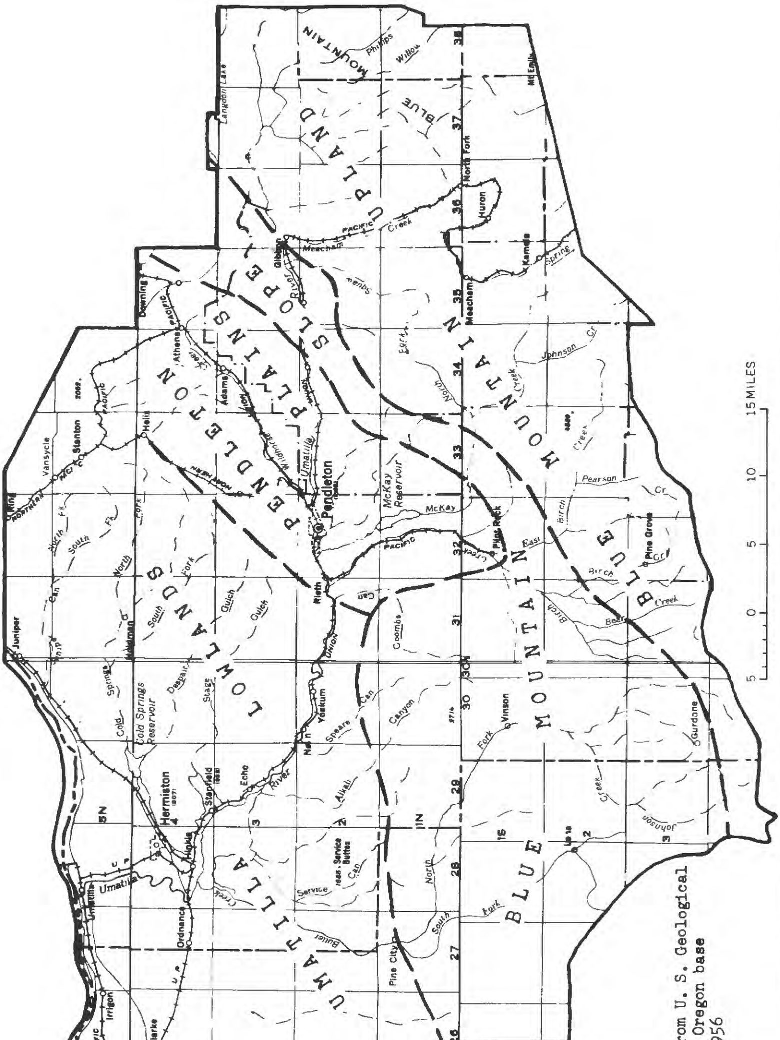
the northeast by the crest of the Horse Heaven Hills, and on the west by the crest of Rieth Ridge. The northeastern part of the Pendleton plains is rolling and loess-covered and slopes gently southwestward from the crest of the Horse Heaven Hills. These hills trend east-southeastward and have a maximum altitude of 2,100 feet just north of Helix. Their gentle southward slope into the Umatilla valley contrasts with a much steeper descent into the Walla Walla

FIGURE 5.—View southward across Birch Creek valley (southern part of Pendleton plains), which follows approximately the axis of the Agency syncline. Part of Blue Mountain slope rises in background. Cattle graze on a half-section of land irrigated by excess well water from lumber and fiber-products plants at Pilot Rock, which is out of view in creek valley at the left center of the photograph.

basin on the north. The southern part of the Pendleton plains area is a slightly dissected piedmont alluvial plain sloping gently northward from the foot of the Blue Mountain slope. All the streams traversing the Pendleton plains are consequent, although the Umatilla River is antecedent in its relation to Rieth Ridge. The Rieth Ridge is a broad arched upland extending north-northeastward from the Blue Mountain slope to the Horse Heaven Hills. The Umatilla River crosscuts the ridge in a sharp canyon just below Pendleton.

The Umatilla lowland makes up the remainder of the area. It is gently rolling, slightly dissected, and rises from an altitude of about 200 feet at the Columbia River near Irrigon southward to the foot of the Blue Mountain slope and eastward to the crests of Rieth Ridge and the Horse Heaven Hills. It may be divided into three areas that have different altitudes and surface characteristics: The water- and wind-scoured area below an altitude of 750 feet; the dissected glacial-lake deposits between altitudes of 750 feet and 1,150 feet; and the loess-covered youthfully dissected and rolling plains above 1,150 feet.

The part of the district lying below 750 feet consists of a stream-channeled, water-scoured area of nearly horizontal basalt layers. In places the basalt is covered by glaciofluviatile deposits that have a maximum thickness of 150 feet. The glaciofluviatile deposits are easily eroded by the wind and their terrace surfaces are dotted by many blowouts. The area is traversed by numerous longitudinal sand




Base from U. S. Geological Survey Oregon base map, 1956

FIGURE 6.—Map of the Umatilla River basin, Oreg., showing major physiographic and ground-water subareas.

dunes oriented generally parallel to the direction of the prevailing wind. The interesting geologic history of this area has been described by Bretz (1930, p. 92–93), Allison (1933, p. 675–722), and others.

The dissected glacial-lake beds, lying between altitudes of 750 feet and 1,150 feet, are so badly eroded by wind and water that only a few remnants of the old lakebed surface remain as long, low terraces at altitudes of 1,000 feet to 1,150 feet in Tps. 3 and 4 N., R. 30 E. The terraces are underlain by thick deposits of rudely stratified lacustrine silt and small quantities of erratic (ice-rafted) sand, gravel, and boulders. In places the silt has been much reworked by wind. The reworked material is similar to the loess that lies at higher altitudes but is slightly coarser grained.

The loess, derived in part from the glacial-lake silt, forms a veneer over most of the pre-Pleistocene rocks that lie above an altitude of 750 feet. South of the Umatilla River the loess is fairly thin, generally not exceeding 10 feet in thickness, and it becomes thinner with increasing distance south. The loess hills have an overall southwest-northeast alinement, indicating that the material was deposited by predominantly southwesterly winds. The loess is as thick as 50 feet in the district around Holdman, Helix, and Adams northeast of the old glacial-lake site.

The Umatilla River is a consequent stream in most of its course across the Pendleton plains and the Umatilla lowland; that is, its general course was determined by preceding geologic and tectonic events. However, where it crosses Rieth Ridge the river seems to be antecedent flowing on rocks that were uplifted after its course was established. It flows through a shallow canyon where it traverses the lowlands east of Pendleton, then crosses Rieth Ridge in a sharp canyon between Pendleton and Echo. The canyon is narrow and steep-walled and reaches a maximum depth of about 750 feet. Two miles north of Echo the river reaches the lowland area covered by the glaciofluviatile deposits. From there to the mouth of Butter Creek, its valley is broad and shallow. West of the mouth of Butter Creek, the Umatilla River turns northward and flows through a shallow, narrow canyon to the Columbia River.

All the tributaries to the Umatilla River are consequent. Ryan Creek, Meacham Creek, Squaw Creek, and several smaller streams drain the Blue Mountain upland and join the Umatilla River in the upland area. Wildhorse Creek drains part of the Blue Mountain slope and the south flank of the Horse Heaven Hills and enters the Umatilla River in the Pendleton plains. McKay and Birch Creeks drain part of the Blue Mountain upland and the Blue Mountain slope and flow into the Umatilla River in the Pendleton plains. Butter

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Creek drains the part of the Blue Mountain slope west of Rieth Ridge and joins the Umatilla River in the Umatilla lowlands.

Hydrographs of the discharge of two of these streams are shown in figures 7 and 8. The graph of the discharge of Butter Creek (figs. 7 and 8) shows the close correlation of the streamflow with the winter period of higher precipitation and with the spring rains and thaw of the accumulated snow in the uplands. The flow of the creek is small from July to October, the streambed being nearly dry during August and September of most years. The graph of the discharge of the Umatilla River (fig. 7) is similar but shows a greater summer flow and a slightly longer period of "rainy season" discharge. This longer period of sustained discharge appears to be due to the different timing of the separate parts of the composite runoff, as well as to the more varied types of topography that affect runoff in the main river.

The ground-water drainage, which largely maintains this late-summer flow in the streams, comes from numerous springs, none of which have a great discharge. Most of the springs of relatively large or moderate discharge enter the Umatilla River because its level is below that of the water table. Evapotranspiration in the summer months greatly reduces the discharge of the myriad upland springs that drain to the tributary creeks.

The total annual runoff ranges from none from the sandy terraces of the lowest parts of the valley to a volume of water equal to a depth of more than 2 feet over the drainage areas of some creek basins in the Blue Mountain upland and Blue Mountain slope (fig. 7).

Nearly all the summer runoff of the Umatilla River is used for irrigation or the public supply of the city of Pendleton. Winter runoff in McKay Creek and Cold Springs Canyon and part of that in the Umatilla River is stored behind dams for release to irrigation projects during the summer.

## CLIMATE

The temperate climate of the Umatilla River basin ranges from mild and semiarid in the Umatilla lowland to cool and more humid in the Blue Mountain upland. In the weather summations given below, all data are taken from records of the U.S. Weather Bureau. The total annual precipitation increases progressively with altitude from about 7 inches at Umatilla to about 35 inches in the higher parts of the Blue Mountains. It falls mostly in the winter months, as may be seen in figure 9. The precipitation falls mostly as rain in the lower parts of the mountains and as rain and snow on the upland. Snow accumulates to a depth of several feet on the Blue Mountain upland during most winters and is not entirely melted in the forested areas until June of most years.

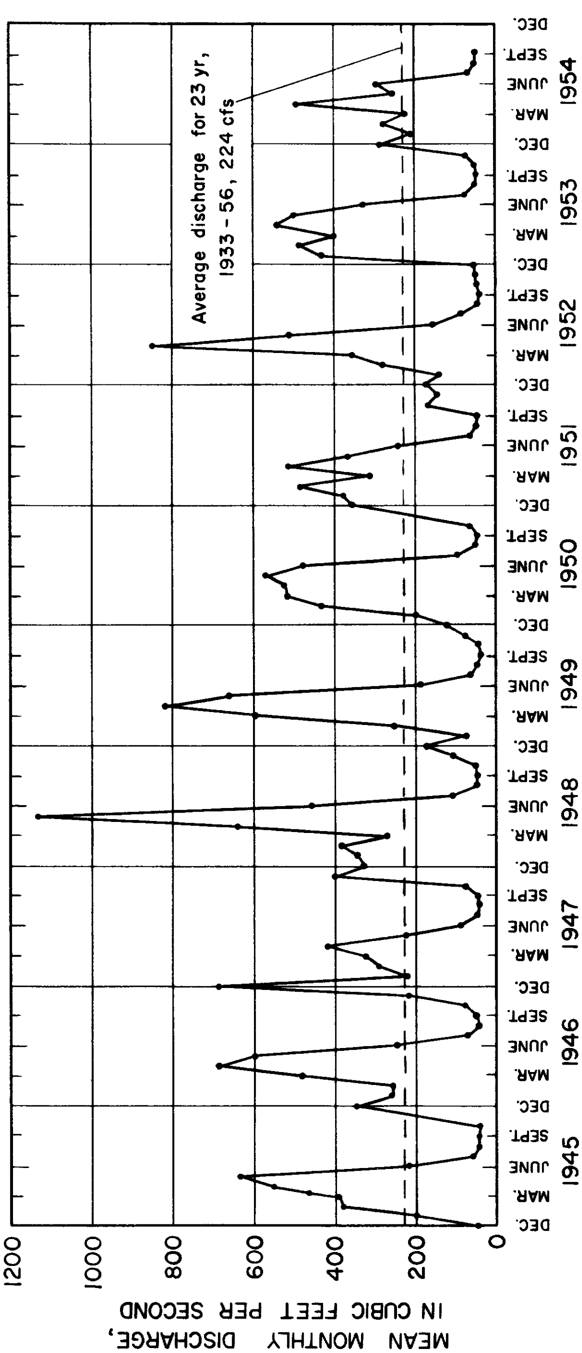


FIGURE 7.—Monthly mean discharge of Umatilla River above Meacham Creek near Gibbon. Drainage area is 125 sq mi. Average annual runoff was 1.79 cfs per sq mi; average depth of runoff from drainage area was 24.24 inches per year for 1933–56.

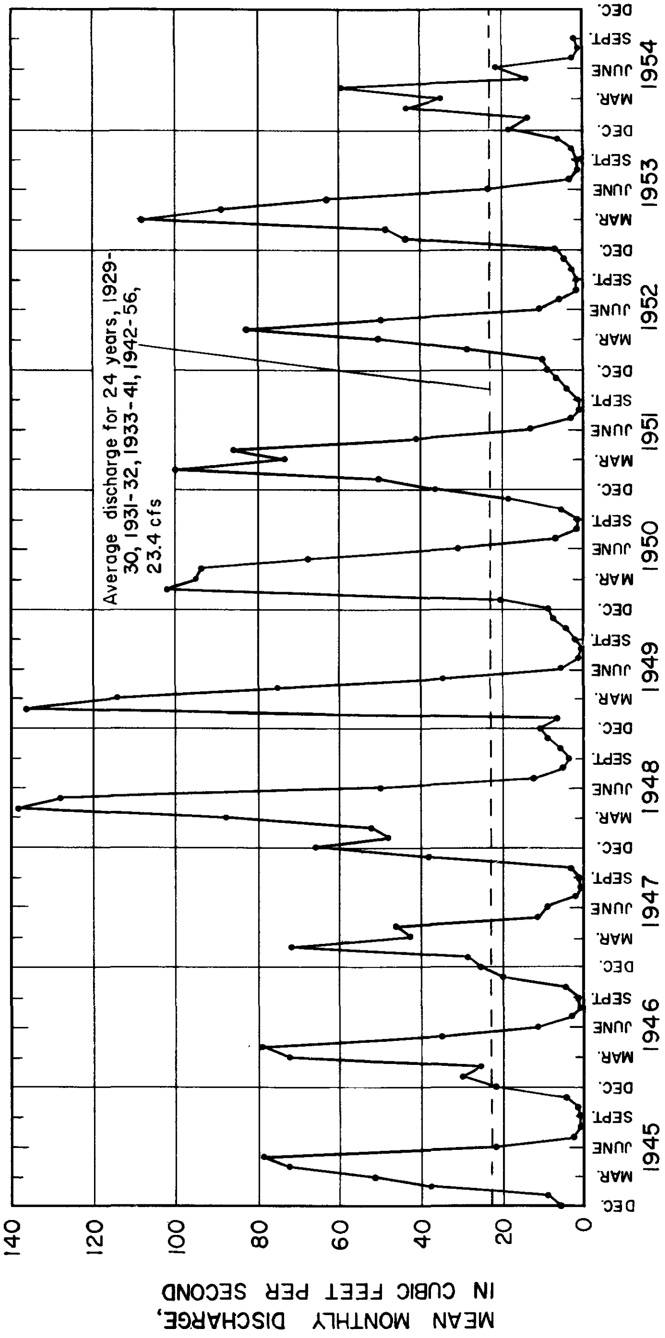


FIGURE 8.—Monthly mean discharge of Butter Creek near Pine City. Drainage area is 291 sq mi. Average annual runoff was 0.08 cfs per sq mi; average depth of runoff from drainage area was 1.10 inches per year for 1929–30, 1931–32, 1933–41, 1942–56. Graph does not include water diverted above the gaging station to irrigate about 600 acres.

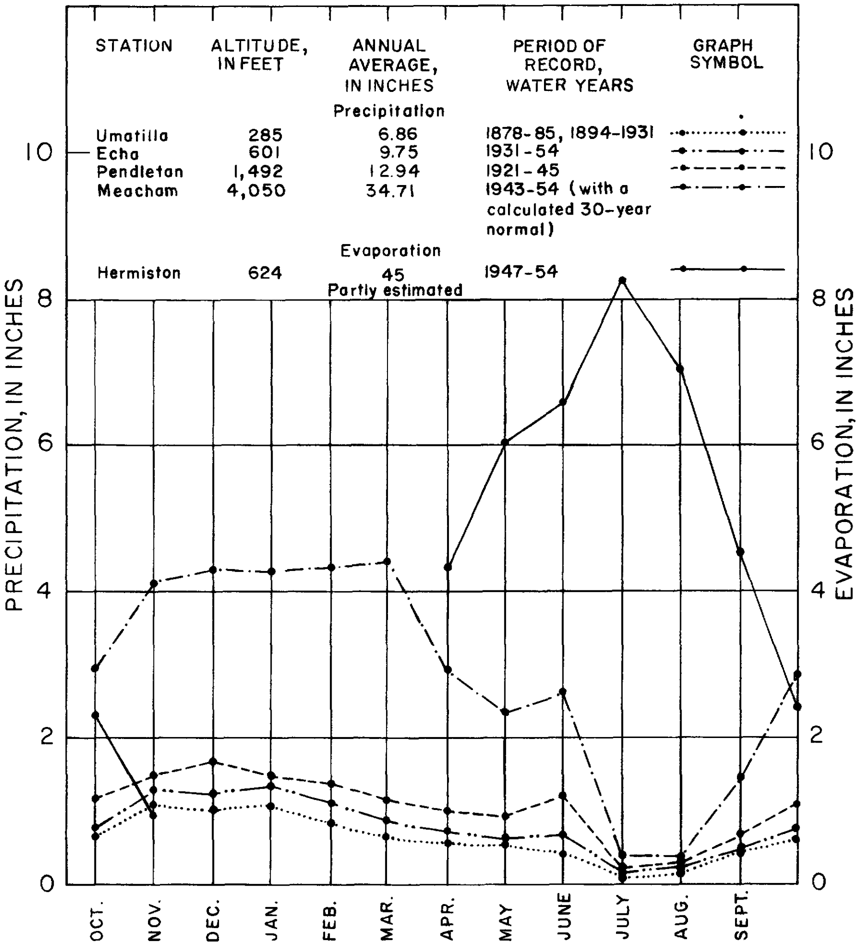


FIGURE 9.—Average monthly precipitation at four stations in the Umatilla River basin, and average monthl evaporation at Hermiston.

The relation of altitude to average annual temperature, length of growing season (in which air circulation also is a factor), and average annual precipitation is shown by the following table:

| Station | Altitude | Average temperature (° F) | | | Average frost-free period (days) | Average annual precipitation (inches) |
|---|---|---|---|---|---|---|
| | | Annual | Highest | Lowest | | |
| Umatilla | 285 | 54.2 | 102 | 0 | 173 | 6.86 |
| Hermiston | 624 | 52.7 | 103 | −5 | 158 | 8.24 |
| Pendleton Airport | 1,492 | 52.7 | 100 | 1 | 184 | 12.94 |
| Pilot Rock | 1,697 | 52.1 | 102 | −3 | 152 | 13.29 |
| Meacham | 4,050 | 46.3 | 92 | −3 | 115 | 34.71 |

For this table the average highest and lowest annual temperatures are based on records for the period 1945–54, and the average annual frost-free period on records for 1948–54. Average annual temperature and precipitation are based on the entire period of record up to 1954 for each station.

The long-term trends in annual precipitation are shown for the Pendleton weather station in figure 10. Plotted as a long-term departure from the average of a base period (water years 1921–45), the curve shows that the precipitation was generally above average during the period 1893–1927, below average from 1928–39, and about average during the most recent period, 1940–58. The cumulative-departure graph is plotted because it shows the relation of ground-water fluctuation to the long-term trends of precipitation.

Records of evaporation measurements, made in a sunken pan 24 inches in depth and 6 feet in diameter, have been kept at Hermiston for the years 1947–54, exclusive of the winter months. Evaporation during the winter months is assumed to be small, not exceeding 4 inches per year. The resulting figures indicate an average annual evaporation from the pan of about 45 inches for the Hermiston area. Average monthly (pan) evaporation figures are indicated on figure 9.

Wind-velocity records were kept at Hermiston for nearly all months of the period 1951–54. They indicate an average wind velocity of 3.45 miles per hour. The windiest month of the average year is May, with an average of 4.8 miles per hour, and the least windy month is November, with an average wind velocity of 1.8 miles per hour. This is not consistent every year; although May has the highest average wind velocity for the 4 years, it does not have the highest in every year. For single months, January had the highest average velocity in 1951, March in 1952 and 1953, and June in 1954.

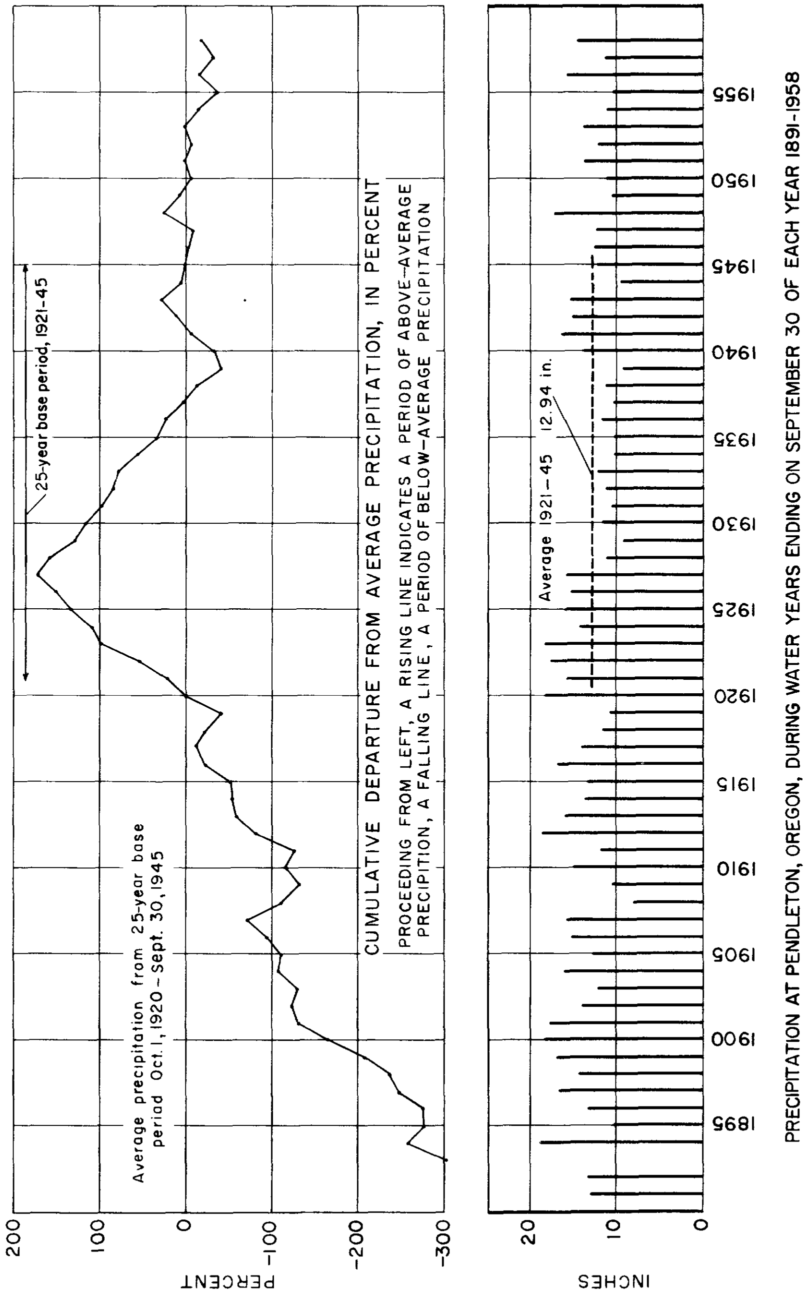


FIGURE 10.—Precipitation and cumulative departure from average at Pendleton, 1891–1958.

# GEOLOGY

## GENERAL CHARACTER AND RELATIONS OF THE ROCK UNITS

The oldest rocks in the Umatilla River basin are pre-Tertiary in age and consist of metamorphic rocks that were intruded by a large composite igneous body of norite and quartz diorite. The pre-Tertiary rocks are overlain unconformably by a fairly thick deposit of Eocene volcanic rocks and terrestrial sediments (Clarno formation) which are of comparable age and somewhat analogous in lithology to the Swauk formation (Smith, 1904, p. 1) of central Washington. The areal extent of the pre-Miocene rocks are shown on plate 1.

The Eocene rocks, in turn, are overlain by the Columbia River basalt of Miocene age. This basalt is the most extensive and thickest rock unit in the area, and it controls the topography over most of the area.

The basalt is overlain by five types of terrestrial sediments. The oldest of these is a fanglomerate composed of silt and basaltic conglomerate. The fanglomerate was deposited during Pliocene time after mild deformation of the Columbia River basalt. It consists of particles of basalt eroded from higher altitudes and deposited as debris upon the basalt at lower elevations.

Below an altitude of 1,150 feet the basalt (and in places the fanglomerate of Pliocene age) is overlain by Pleistocene glacial-lake beds and, below 750 feet, by glaciofluviatile deposits.

All pre-Pleistocene rock units in the area are overlain by a veneer of loess. This wind-deposited silt of Pleistocene age was derived at least partly from the glacial-lake beds previously mentioned.

The youngest materials in the area are the narrow, thin deposits of Recent alluvium, which border the streams. This alluvium is composed mostly of basaltic gravel in the Blue Mountain section and of reworked loess in the lowland districts. In some places small amounts of white volcanic ash occur in the alluvium, forming minor local terraces along the edges of the canyon bottoms and on the adjacent slopes.

Each of the rock units is discussed in more detail below.

### PRE-TERTIARY ROCKS

#### METAMORPHIC COMPLEX

Metamorphic rocks are exposed in the southern part of the area in the Blue Mountain slope. The topography of this region is mature, and in places the deep canyons have been cut through the Columbia River basalt and Clarno formation into the underlying rocks. The metamorphic rocks now are exposed in a total area of almost 15 square miles (pl. 1). These rocks are rather highly metamorphosed and are members of the amphibolite facies (Turner, 1948, p. 61).

The metamorphic rocks consist of a fairly thick series of gneisses and schists intruded by small bodies of granite pegmatite and ultrabasic rocks. A broad zone of migmatite is exposed in Bear Creek canyon near the contact of the metamorphic rocks and an intrusive mass of quartz diorite. In this zone the schist and gneiss are cut by many nearly vertical dikes of rock similar in appearance to the quartz diorite intrusive. These dikes, ranging from a few inches to several feet in thickness, parallel the foliation of the metamorphic rocks.

The schists are of the amphibolite or amphibolite-epidote type. Some of them contain appreciable quantities of calcite.

The gneisses are composed almost entirely of alternating layers of hornblende and plagioclase, generally andesine. Some of them contain minor amounts of calcite and epidote. The hornblende and plagioclase layers are as much as 5 millimeters thick. Where the grain size and plagioclase content decrease the gneiss grades into the schist.

The bodies of granite pagmatite and ultrabasic rocks may be more than a mile from the exposures of the quartz diorite. In the NE¼ sec. 4, T. 3 S., R. 32 E., a mass of hornblendite and one of pegmatite lie within a few feet of each other and are more than 3 miles from the nearest exposure of quartz diorite. The pegmatite contains garnet, tourmaline, and muscovite in a groundmass of potassium feldspar and quartz. The hornblendite is composed almost entirely of hornblende. The hornblendite body lies parallel to the foliation of the hornblende-plagioclase gneiss surrounding it, but the pegmatite body is not oriented with that foliation.

Other pegmatite bodies occur near the center of sec. 33, T. 3 S., R. 30 E., near the center of sec. 8, T. 3 S., R. 32 E., and elsewhere.

#### INTRUSIVE ROCKS

The metamorphic rocks are in contact with a large composite igneous intrusive mass. The intrusive mass is exposed over about 8 square miles in the vicinity of Battle Mountain State Park. It consists of a large body of quartz diorite and a smaller body of norite. (Quartz diorite and norite are igneous rocks similar in appearance to granite, though of darker color.) The norite is nearly surrounded by exposures of the quartz diorite.

The quartz diorite is composed of about 38 percent andesine, 30 percent quartz, 20 percent hornblende, and 4 percent biotite, with traces of sphene, apatite, and iron minerals. Zenoliths of darker quartz diorite are present, and many small dikes cut the rock. These dikes have a maximum width of 3 inches and are composed of light-colored quartz diorite. Most of the contacts between the dikes and the country rock are fairly sharp but in some places they are gradational. At the surface the quartz diorite is badly disintegrated and is readily eroded. It is exposed mainly in steep-walled valleys beneath basalt-capped ridges.

The norite is composed of approximately 63 percent labradorite, 16 percent hypersthene, and 21 percent hornblende, with accessory sphene, apatite, and iron minerals. Some of the hornblende crystals contain small cores of augite.

A small igneous body of quartz diorite is exposed in the Pearson Creek canyon in the NE¼ sec. 9, T. 3 S., R. 33 E. This exposure is less than one-fourth square mile in areal extent. It lies more than 10 miles from the larger quartz diorite body and is richer in quartz than the larger mass. This smaller body is probably a separate intrusive, although possibly it is a part of the larger body.

## TERTIARY ROCKS

### CLARNO FORMATION

Volcanic rocks and terrestrial sedimentary rocks of Eocene age crop out over approximately 18 square miles in T. 4 S., R. 29 E., in the extreme southern part of the Umatilla River basin. Twenty miles northeast of this exposure, scattered outcrops of this same material are present under a total area of approximately 2 square miles in T. 2 S., Rs. 32 and 33 E.

The lower part of the Clarno formation consists of sandstone, micaceous shale, and siltstone. The sandstone makes up the bulk of the material. It is thickly bedded and is composed mostly of quartz, some feldspar, white mica, and rock fragments in various proportions. The cement is predominantly calcium carbonate. The grains of feldspar, mostly andesine, are fairly fresh. The mineral grains are angular to subangular. The shale is made up mostly of clay, very fine grains of quartz, and white mica. Some beds contain much carbonaceous material.

The upper part of the formation contains several light-brown to gray lava flows, in addition to the shale and sandstone previously described. The individual lava flows are of small areal extent, although some are more than 100 feet thick. The lava rock is characterized by phenocrysts of feldspar in a fine-grained nonporous groundmass. Quartz phenocrysts are present in many of the flows.

A sample from a representative lava flow is found to be a dacite porphyry in which phenocrysts of quartz and andesine constitute more than 50 percent of the rock and are set in a dense groundmass. Mica phenocrysts make up about 5 percent of the rock and are partly altered to chlorite and iron oxide.

Another sample from a different flow is porphyritic andesite with phenocrysts of andesine, augite, and hornblende in a dense groundmass. Both samples were highly weathered.

Many of the beds of shale, as mentioned previously, contain large amounts of carbonaceous matter, some altered to lignite or bituminous coal. The coal beds are thin and clayey. Plant fossils from several of these beds were studied by Roland W. Brown of the U.S. Geological Survey. He determined the Eocene age of the beds from his fossil identification (written communication, 1955).

NW¼SW¼ sec. 12, T. 2 S., R. 32 E.

[Fossils from shale bed in the north wall of East Birch Creek canyon]

*Allantodiopsis erosa* (Lesquereux) Knowlton and Maxon
*Lastrea fischeri* Heer
*Equisetum* sp.
*Glyptostrobus dakotensis* Brown
*Sabalites* sp.
*Betula* sp.
*Quercus banksiaefolia* Newberry
Numerous other dicotyledonous leaves

NW¼NE¼ sec. 31, T. 2 S., R. 33 E.

[Fossils from shale beds on west bank of Pearson Creek]

*Aneimia* sp.
*Lastrea fischeri* Heer
*Glyptostrobus dakotensis* Brown
Numerous other dicotyledonous leaves.

NE¼NW¼ sec. 20, T. 4 S., R. 29 E.

[Fossils taken from a shale bed underlying a massive sandstone bed which forms a ridge top]

*Aneimia* sp.
*Glyptostrobus dakotensis* Brown
*Sabalites* sp.
*Quercus banksiaefolia* Newberry
*Magnolia* sp.
*Carpites verrucosus* Lesquereux
Numerous other dicotyledonous leaves.

An outcrop of these rocks in Willow Creek canyon, southwest of the Umatilla River basin, was referred to the Clarno formation by Mendenhall (1909, p. 406–408).

### COLUMBIA RIVER BASALT

The Clarno formation is unconformably overlain by the Columbia River basalt. The basalt is by far the most extensive rock unit in the Umatilla River basin, as it is in the rest of the Columbia Plateau province. In all but a few of the 2,700 square miles within the Umatilla River basin, the basalt either crops out or underlies the surface at relatively shallow depth. According to Newcomb (1959, fig. 1) the basalt underlies about 50,000 square miles of Oregon, Washington, and Idaho to depths, in some places, in excess of 4,000 feet.

The maximum thickness of the basalt in the Umatilla River basin has not been determined but is known to exceed 2,500 feet. In the vicinity of Pendleton, Echo, Umatilla, and Athena, water wells have penetrated more than 1,000 feet of basalt without reaching the bottom. The canyon of the Umatilla River near Gibbon cuts through a total of 2,500 feet of basalt without exposing its base. Only in the southern part of the drainage basin, where the basalt thins over the older rocks, is the bottom of the Columbia River basalt exposed.

The Columbia River basalt is of Miocene age and consists of a thick sequence of basaltic lava flows lying accordantly one above the other. The individual flows range in thickness from about 10 to 100 feet and in lateral extent from less than 1 to more than 10 miles.

The bottom few inches of most flows consists of fine-grained, glassy fractured rock which grades upward into a coarser grained but still nonporous rock. The nonporous rock is separated into polygonal, usually hexagonal, columns by sets of roughly vertical cooling-contraction joints. These columns may be a few inches to several feet in diameter in the bottom half of the flow but become progressively smaller and more perfectly formed in the upper part of most flows. The upper few feet of a flow is commonly finer grained, but vesicular or scoriaceous. Variations of this structure are common, apparently being dependent upon such factors as the chemical composition of the lava, the temperature at which it was extruded, its rate of cooling, and the amount of movement that took place during cooling. Some flows are composed almost entirely of blocky, columnar basalt, whereas others have in their upper parts thick zones of greatly inflated "honeycomb" lava (fig. 11). One flow, at Eagle Rock near Mount Emily,

FIGURE 11.—View of Columbia River basalt exposed by highway cuts and cropping out in ridges of the Blue Mountain slope in the descent to the Pendleton plains (left background). The 10-foot-thick lava flow in the center of the cut tapers out to the right of the photograph. The dashed line indicates the gentle northwestward dip of the outcropping flows on the ridge in the background.

about 15 miles east of Kamela and just beyond the southeast corner of the area shown on plate 1, is slightly less than 100 feet thick and composed mostly of a volcanic breccia, whose larger fragments are basaltic and apparently pyroclastic in origin, resting in a matrix of finer grained lava fragments or welded tuff.

Weathered soil zones are comparatively scarce between the lava flows, although the upper parts of some flows were weathered reddish brown to a depth of a foot or two before burial by the next flow. Apparently, most of the flows were exposed for only a short time before being buried by subsequent flows.

In parts of the basin a few interbeds of tuffaceous lacustrine sedimentary material lie between some of the flows. Apparently these beds were deposited when the lava flows impounded the drainage. Within the Columbia Plateau province, particularly in the Yakima and Pasco Basins in Washington, the largest and most extensive of these interbeds has been referred to the lower part of the Ellensburg formation of Smith (1903, p. 3). That interbed is not known to crop out in the Umatilla River basin, but the same or a similar interbed does occur a few miles farther northwest in the escarpment north of the Columbia River and has been penetrated by water wells in the Umatilla-Echo area. Another sedimentary interbed, of uncertain extent and identity, was reported by well drillers to have been penetrated in wells near Athena.

Only one sedimentary interbed was found cropping out. The outcrop is in sec. 19, T. 2 S., R. 33 E., at the bottom of the east wall of the Pearson Creek canyon. The exposure is about 600 feet long and consists of about 60 feet of tuffaceous, slightly sandy shale. Individual beds range in thickness from a sixteenth of an inch to 3 inches and in composition from fine-grained sandstone to claystone. Numerous poorly preserved leaf fossils are present, and, on the basis of these, the Miocene age of the Columbia River basalt at that place is confirmed. Fossil determinations were made by Roland W. Brown (written communication, 1954) and a list of his findings follows:

*Quercus pseudolyrata* Lesquereux
*Zelkova oregoniana* (Knowlton) Brown
*Cedrela pteraformis* (Berry) Brown

The shale is soft and incompetent. Consequently, huge blocks of the overlying basalt have broken loose and slumped down, resulting in an irregular outcrop pattern and obscuring the shale on its northern and southern ends. The presence of similar slump blocks up the slope to the east indicates that this shale bed extends eastward under the basalt ridge at least a mile from the outcrop. The fact that none of this shale was found on the west side of the canyon indicates that the canyon may follow a fault line along which the west side is dropped.

The basalt overlying the shale dips about 3° NW. and the Clarno formation crops out about a mile farther south in this same canyon. Therefore, this shale deposit is stratigraphically low in the Columbia River basalt of the Blue Mountain slope.

The basalt probably issued quietly and in a highly fluid state from fissures or low shield volcanoes. As single flows are seldom traceable for more than 10 miles, large numbers of fissures must have once existed over most of the basin area, and one would expect the lower lava flows to be cut by many small dikes. However, such dikes are rarely observed. One prominent basalt dike is shown on plate 1 in T. 2 N., R. 37 E. Its trend is arcuate from north to south and concave eastward. Such a trend does not conform to the main regional northwest-southeast faulting and jointing pattern now present in the basalt.

Black Mountain, 2 miles southwest of this dike, has the shape of a shield volcano and may have been a source of some of the basalt.

#### FANGLOMERATE OF PLIOCENE AGE

Two large deposits of fanglomerate of Pliocene age immediately overlie the Columbia River basalt at low altitude. Both units contain subangular to well-rounded particles of basalt ranging in size from grit to boulders. Thick silt and sand lenses are included. The deposits have a low permeability, the interstices having been almost completely filled by silt and clay during deposition.

Though there is a great variety in the size of particles, most range in size from 1-inch pebbles to 3-inch cobbles. Nearly all pebbles, cobbles, and boulders are of basalt derived from the nearby basalt flows that form the highlands. In all the gravel observed, only one cobble was seen that was not composed of basalt. This one was a piece of brown waxy chert, a secondary material that fills joints and fissures at places in the basalt.

The bedding structure of the fanglomerate is crude, nearly horizontal, with some crossbedding of the type common to torrential deposition. In most places the master bedding dips northward at low angles.

One of the larger deposits of fanglomerate gravel underlies the Pendleton plains in the vicinity of McKay Reservoir (pl. 1), and locally is referred to informally as the McKay beds. The other large deposit lies west of Butter Creek and was designated by Hodge (1942, p. 19) as the lower part of the Shutler formation.

The so-called McKay beds are Pliocene fanglomerate deposited in the northeastward-trending trough of the Agency syncline, which lies at the foot of the Blue Mountain slope. The beds underlie about 50 square miles in a roughly triangular area whose apexes are at Pendleton, Pilot Rock, and Blakeley.

The so-called McKay beds are composed of basaltic pebble and cobble conglomerate having silt-filled interstices. There are many siltstone and sandstone lenses; some are several hundred feet long and as much as 40 feet thick, but most of the lenses are smaller. The material has been fairly well indurated by compaction and cementation with carbonate minerals. It is sufficiently consolidated to stand in vertical cliffs for several years.

The structure of the so-called McKay beds is virtually horizontal; however, there is local crossbedding that dips northwestward. The size of the gravel particles ranges from angular boulders, mostly located near the foot of the Blue Mountain slope, to well-rounded grit, pebbles, and cobbles that are common near Pendleton (fig. 12).

**FIGURE 12.—View of Fanglomerate of Pliocene age overlying the Columbia River basalt along a contact marked *A–B*, in a roadcut at the southeast edge of Pendleton. A small pocket of wind-laid volcanic ash (*C*) of Recent age lies in the soil zone on the eroded surface of the fanglomerate.**

The Pliocene age of the so-called McKay beds is estabilshed by their stratigraphic position (overlying the Columbia River basalt of Miocene age and underlying the loess of Quaternary age), and by means of fossils. Vertebrate fossils from a silt lens on the east bank of McKay Reservoir (NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 2, T. 1 N., R. 32 E.) were identified by Jean Hough (written communication, 1954) of the U.S. Geological Survey as follows:

| | *Age* |
|---|---|
| ***Dipoides*** sp | Pliocene |
| ***Castor*** sp | Pliocene to Recent |

The gravel of the lower part of the Shutler formation of Hodge (1942, p. 19) is exposed west of Butter Creek north of the Willamette base line and above the 750-foot contour. In attitude, composition, and structure the gravel is very similar to that of the so-called McKay beds. It was derived from the basalt of the Blue Mountains to the south and was deposited on the nearly horizontal basalt of the Umatilla lowland. The maximum thickness of the gravel is about 100 feet. The gravel is slightly thinner than the so-called McKay beds but is laterally much more extensive. It extends westward beyond the Umatilla River basin.

## QUATERNARY DEPOSITS

### PLEISTOCENE DEPOSITS

Two water-laid sedimentary deposits of Pleistocene age are present in this area. One is a lacustrine sediment deposited in a lake of late glacial age. The other is a glaciofluviatile deposit of sand and gravel.

The glacial-lake sediments lie mostly between altitudes of 750 and 1,150 feet (pl. 1). They consist of poorly stratified silt and sand and local inclusions of gravel and scattered erratic (ice-rafted) sand, pebbles, cobbles, and boulders. The beds are generally less than 80 feet thick and rest upon the basalt and Pliocene fanglomerate. In size the erratics range from sand grains to boulders weighing several tons.

The glaciofluviatile deposits are scattered over the "scabland" area bordering the Columbia River. Their upper limit approximates the 750-foot contour line in most places, although it rises as high as the 1,150-foot contour between Juniper and Cold Springs Canyons just southeast of Wallula Gap. The outwash deposits consist of rather clean sand and fine gravel and some large boulders and local silt lenses. Their thickness is variable but is as much as 200 feet. Locally they may rest upon Pliocene gravel, but in most of the area they rest directly upon the Columbia River basalt. The outwash material is very crudely stratified, with crossbedding of torrential-current type. The material is permeable, and surface drainage has not developed upon much of the area it underlies. Surface water percolates quickly downward into the outwash materials and escapes by subsurface flow. The finer grained parts of this material are readily susceptible to wind erosion, and many small dunes and deflation basins are scattered over the area.

The glacial-lake sediments are believed to be equivalent to the Touchet beds described by Flint (1938, p. 461–523). The Pleistocene material of the whole Columbia basin has been described in some detail by Bretz (1923, p. 617–649; 1925, p. 97–115, 236–239), Allison (1933, p. 675–722), and others.

### PLEISTOCENE AND RECENT DEPOSITS

Besides the glacial-lake and glaciofluviatile deposits, there are one major and two minor deposits of Pleistocene and Recent age. The major deposit is the loessial Palouse formation of Pleistocene age, and the minor ones are volcanic ash and alluvium of Recent age.

The Palouse formation is a widely spread veneer of windblown loessial silt derived in part from the glacial-lake silt previously mentioned. The loess occurs throughout the Umatilla River basin in thicknesses that range from 1 to 2 feet on the summit of parts of the Blue Mountain upland to more than 50 feet in the Horse Heaven Hills upland around Holdman and Helix. Above 750 feet almost all the Pendleton plain and the Umatilla lowland is underlain by several feet of loess. The prevailing wind that deposited this loess was from the southwest, so the loess is thickest and coarsest in grain in the area northeast of the original lakebed deposit. Near Holdman there are several hundred square miles of northeastward-trending dunelike ridges of loess. (See pl. 1.)

In the author's opinion the loess ranges in age from Pleistocene to Recent. However, it is probable that in places the bulk of the eolian erosion and redeposition took place shortly after the drainage of the glacial lake, and subsequently both the loess and the glacial-lake silt were stabilized by a cover of prairie vegetation.

Near the lakebeds the loess consists of sandy silt, but at greater distance it is a fine, powdery soil. As its surface layers are rather permeable and the annual precipitation is low, much of the rainfall and snowmelt percolates into it rather than running off. In many small areas surface drainage has not been established.

A few small patches of volcanic ash occur in talus slopes and beneath terraces along the edges of streams. The ash is white, fine grained, and uniformly textured. It commonly shows some thick stratification, indicating that it has been reworked by water. The beds are mostly less than 4 feet thick and are of too small an extent to be shown on the geologic map. They are generally both underlain and overlain by Recent alluvium, derived mostly from the loess.

The tributary streams of the Umatilla River have steep gradients and flow swiftly through narrow, steep-walled canyons having only very small flood plains. Consequently, the deposits of Recent alluvium are narrow ribbons of river-washed gravel, reworked loess, and volcanic ash at the borders of the streams. As there is a high ratio of silt to gravel-sized particles, the alluvium is not very permeable. In the area covered by glaciofluviatile deposits, the Recent alluvium is largely indistinguishable from the glacial-outwash material.

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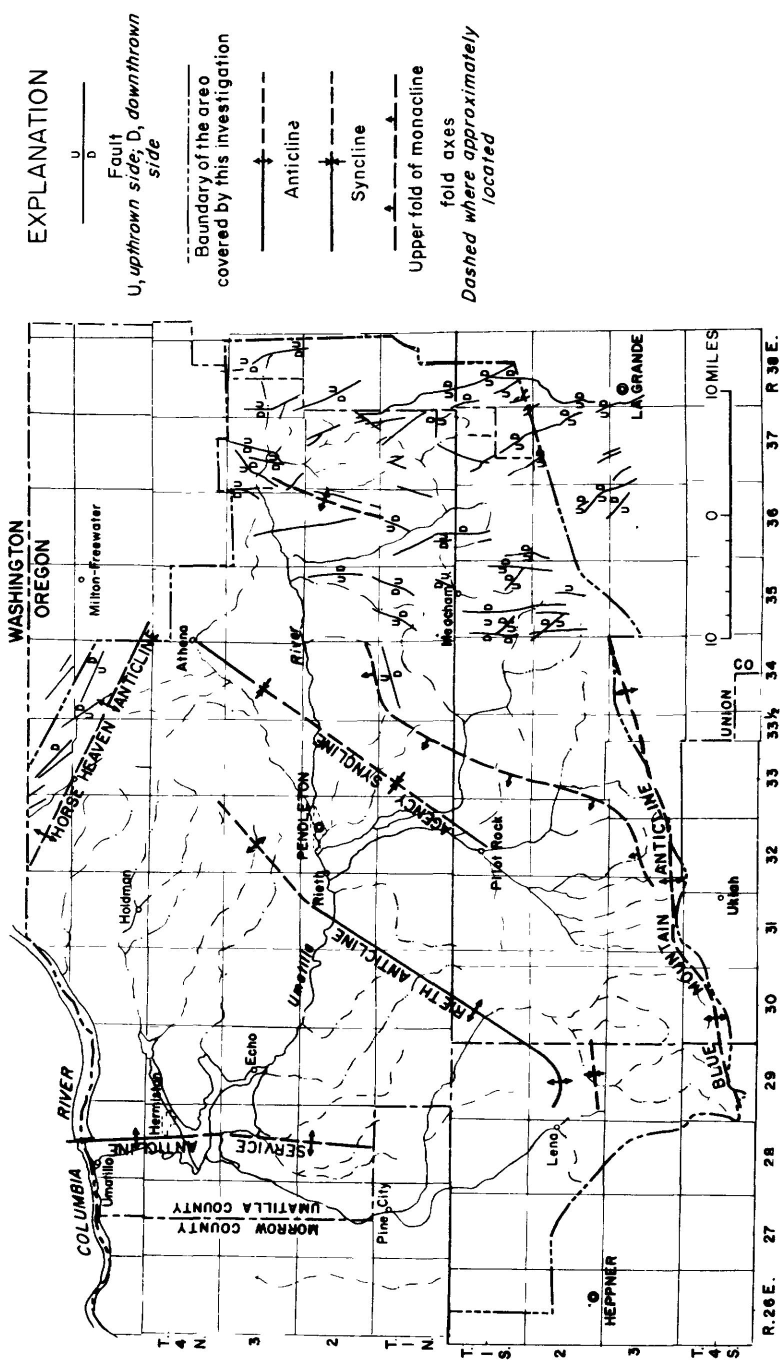


FIGURE 13.—Map of the Umatilla River basin, Oregon, showing the locations of major structural features of the Columbia River basalt.

### STRUCTURE

Structurally, the Umatilla River basin consists of a broad westward-plunging syncline between two anticlines. The large anticline to the south is the northeastward-trending structure that forms the Blue Mountains. Its axis lies close to the southeast edge of the Umatilla River basin. The smaller anticline to the north is the south-southeastward-trending structure that forms the Horse Heaven Hills. The axis of the Horse Heaven anticline merges with the flank of the Blue Mountain anticline just east of Athena. The broad syncline of the Umatilla River basin is crossed by several smaller structures including the Rieth anticline, Agency syncline, and Service anticline. In general, its axis plunges westward from the vicinity of Athena and parallels the course of the Columbia River downstream from Irrigon. The location of the axis of this broad downwarp is indefinite, and is not shown on the geologic map. Each of the smaller structural features will be discussed in more detail in the section on the structure of the Columbia River basalt.

The tectonic structures of the bedrock units of the Umatilla River basin are dominated by those visible in the Columbia River basalt. For this reason, it is convenient to discuss the structural geology in three phases: the structure of the pre-Miocene material, the structure of the Columbia River basalt, and the structure of the post-Miocene material.

Locations of major structural features of the basalt are shown on figure 13, as well as in more detail on plate 1.

#### PRE-MIOCENE ROCKS

The geologic map (pl. 1) shows the pre-Miocene rocks exposed in a narrow belt extending about 30 miles southwestward from East Birch Creek to Arbuckle Mountain. The Clarno formation of Eocene age is exposed at the northeast end of this belt, where it dips northeastward, and at the southwest end, where it dips westward. The intrusive quartz diorite lies in the center of the belt, and the metamorphic rocks occupy areas between the quartz diorite center and the Clarno formation on the flanks. Therefore, the regional structure of the pre-Miocene material seems to be a broad, gentle upwarp whose apex is in the area underlain by the quartz diorite.

#### COLUMBIA RIVER BASALT

The topography of the Umatilla River basin is largely a result of the tectonic structures in the Columbia River basalt. Therefore, in general, the topographic units coincide with structural units in the basalt. The Blue Mountain slope is underlain by the northwest limb of the Blue Mountain anticline, but for the purposes of this report it may be regarded as a monocline dipping northwestward down from the Blue Mountain upland to the relatively horizontal basalt flows of the Umatilla lowlands and the Pendleton plains. (See fig. 11.)

The basalt in most of the area was deformed by folding or warping of the beds and associated fracturing and minor faulting. However, in that part of the Blue Mountain upland east of longitude 118°30′, the basalt was deformed to a considerable extent by movement along faults.

#### BLUE MOUNTAIN UPLAND

The Blue Mountain upland is a nearly horizontal, platformlike crest of a broad anticline. The axis of this anticline is fairly distinct from Arbuckle Mountain eastward to the vicinitcy of Kamela. The basalt on either side of this axis dips gently away at inclinations that are mostly less than 3°.

East of Meacham and Kamela (pl. 1) the anticlinal axis is interrupted by a broad trough trending north-northwestward, produced by gentle warping of the basalt and by movement along faults. The trough is bounded on the northeast by faults along Ryan Creek, Camp Creek, and probably the main branch of Meacham Creek. It is bounded on the southwest by a fractured downwarp, which passes through the towns of Meacham and Kamela.

East of the Meacham Creek trough the Blue Mountain upland is a large upraised block of nearly horizontal basalt flows. Locally there is considerable topographic relief produced by movements along a northwest-southwest fracture pattern.

This part of the upland is bounded on the east by the Mount Emily fault zone. The individual fractures of that fault zone trend slightly west of due north but the zone as a whole has a northward trend, which farther north becomes northwestward. The western block at Mount Emily was upthrown more than 3,000 feet, but the magnitude of that displacement decreases to the north.

#### BLUE MOUNTAIN SLOPE

The basalt layers descend as a long gentle monocline, dipping 1° to 3° from the upland of the Blue Mountains northwestward to the lower lands of the Pendleton plains and the Umatilla lowland. The fairly uniform angle of descent is interrupted by several local steepenings where the dips range from 3° to 30°.

#### NORTHWEST OF THE BLUE MOUNTAIN SLOPE

The basalt flows beneath the Pendleton plains and the Umatilla lowland have a gentle northwestward regional dip. This regional structure is interrupted by several structural features that are of minor magnitude as compared to the Blue Mountain anticline, but which have considerable local importance. These are the Horse

Heaven anticline, Rieth anticline, Agency syncline, and Service anticline. The Horse Heaven anticline continues to the northwest of the Umatilla River basin and becomes a prominent feature in south-central Washington. The anticlines form topographic ridges, which were mentioned by corresponding names in the section on topography and drainage. Each of these structural features is discussed in more detail below.

The axis of the Horse Heaven anticline trends northwestward from near Athena, along the ridge between Vansycle Canyon and Juniper Canyon, and continues beyond Wallula Gap (about 8 miles northeast of the mouth of Juniper Canyon) through which the Columbia River crosses the structure. South of the anticlinal axis the basalt dips less than 1° generally southwestward under the Umatilla Valley. The north limb breaks off abruptly into the Walla Walla Valley over a series of northward-tilted fault blocks, whose echelon-type high-angle faults trend more nearly due south than the axis of the anticline. Dips in this northern limb are generally 2° to 5°.

The axis of the Rieth anticline branches off the northwestward-dipping Blue Mountain slope southwest of Pilot Rock and trends northeastward until it loses its identity west of Helix in the rising slope of the Horse Heaven anticline. Dips on either side of the axis of the Rieth anticline are less than 3°.

The Agency syncline was first named by Allen, in an unpublished report (see p. 3), and the name was formalized by Wagner (1949, p. 8). It lies at the foot of the Blue Mountain slope southeast of Pendleton along the structural sag between the Blue Mountain slope and the Rieth and Horse Heaven anticlines as shown on plate 1. Its axis trends southwestward from Athena to the vicinity of Pilot Rock. This syncline and the Rieth anticline are of special economic importance because of their effect on the position of the water table in the basalt beneath the valley area. The basalt is overlain by the so-called McKay beds of Pliocene fanglomerate in minor sags in the lower part of the Agency syncline.

The axis of the Service anticline trends northward from Service Buttes, northeast of Pine City, to Sillusi Butte, which is in Washington across the Columbia River from Umatilla, Oreg. At one time the anticlinal ridge probably extended between these buttes; but, if so, it has been mostly removed by erosion. Remnants of this former ridge appear at Service Buttes, Emigrant Buttes, Hermiston Butte, Umatilla Butte, and Sillusi Butte. The eastern limb of this anticline dips more steeply than the western limb. At Service Buttes the east limb dips 11° and the west limb only 2°. At Sillusi Butte the east limb immediately adjacent to the axis dips 12°, the west limb only 6°.

The folding of this anticline was sharp and, locally, the basalt flows were closely jointed and faulted.

The origin of the major structures is related to the age of the deformation, and the relative movements of the Blue Mountain section and the lower land to the northwest.

The attitudes of the successive basalt flows in any given section are remarkably concordant. If the deformation was concurrent with the extrusion of the basalt, one would expect appreciable discordance in the attitudes of the successive flows. As this discordance does not exist on a large scale this writer believes that the warping postdates the extrusion of the basalt.

Additional evidence regarding the age of the movement is the position of the fanglomerate or the so-called McKay beds. The fanglomerate lies upon the basalt in the lowland of the Agency syncline and obviously was derived from the basalt at higher levels in the area that is now the Blue Mountains. As these gravels of Pliocene age owe their origin and position to the structure, they therefore must postdate at least part of the movement.

In the Blue Mountain slope, two stages of erosive canyon cutting are evident in some of the stream canyons, such as in the south wall of East Birch Creek at T. 2 S., R. 33 E. This indicates that there must have been at least two stages of deformation.

The deformation that created the Horse Heaven anticline has been dated by other workers from evidence gathered outside the Umatilla River basin. Warren (1941, p. 209–232) has found that the Columbia River was diverted into the Pasco basin, in southern Washington, by the uplift of the Horse Heaven Hills. After entering the Pasco basin the Columbia deposited fluviatile sediments (the Ringold formation) which have been dated as middle to late Pleistocene by Strand and Hough (1952, p. 152–153). Therefore, the age of deformation of the Horse Heaven Hills is middle to late Pleistocene and the cutting of Wallula Gap through the Horse Heaven Hills by the Columbia River has continued from the time of that deformation to the present. The canyon of the Umatilla River through Rieth Ridge shows a degree of erosional maturity similar to that of Wallula Gap, so the deformation that formed the Rieth anticline possibly was contemporaneous with that forming the Horse Heaven anticline.

The nature of the dominant deformation is indicated by a section of basalt about 2,500 feet thick which is exposed in the canyon of the Umatilla River at Gibbon in the Blue Mountains. The remnant of the pre-erosion surface of the basalt at Pendleton lies at an altitude of about 1,300 feet. If the movement consisted of uplifting of the Blue Mountains from the predeformation level of the Pendleton area, the lowermost flows now exposed at Gibbon must have been, therefore, deposited at least 1,000 feet below sea level. These flows do not show any sign of the pillow structure, zeolite mineralization, or interflow marine sediments that one might expect under conditions of submarine extrusion; the basalt was therefore deposited above sea level, and the subsequent deformation consisted, at least in part, of depression of the lowland area.

In summary, the deformation producing the present structure of the basalt consisted of at least two major stages of movement, and the movement started after the extrusion of the basalt in late Miocene or early Pliocene time and continued until middle to late Pleistocene time. Most of the deformation that formed the Horse Heaven anticline, and probably much of that which formed the Blue Mountain anticline, occurred in middle to late Pleistocene time. The difference in altitude between the Blue Mountains and the lower land to the northwest was in part the result of depression of the latter area, although the lesser structures forming the Horse Heaven Hills and Rieth Ridge were uplifted with respect to the lowlands.

### POST-MIOCENE MATERIAL

As previously described, the post-Miocene material consists of Pliocene fanglomerate, Pleistocene glacial-lake beds and glaciofluviatile sediments, and Pleistocene to Recent eolian and alluvial sediments. These materials disconformably and unconformably overlie the Columbia River basalt. Their crude, obscure primary structures are described in the sections on lithology. They have no discernible secondary structure.

## GEOLOGIC HISTORY

Little is known of the pre-Tertiary geologic history of the area beyond the fact that old rocks of igneous and sedimentary origin were intruded and, in part, metamorphosed by the large composite quartz diorite-norite mass.

During the Eocene epoch the area had fairly high relief, abundant rainfall, and a subtropical climate. The old metamorphic and intrusive rocks were eroded and the materials were redeposited as alluvial sands and silts. The Eocene was a time of vulcanism, and several acidic to intermediate lava flows were extruded upon the old land surface. These volcanic rocks dammed the drainage system and created lakes and ponds which served as depositories for micaceous and carbonaceous silt and clay.

The Oligocene epoch apparently was a time of erosion in this area. While tuffs of the John Day formation were being deposited farther south, this area was uplifted and eroded.

This period of erosion was interrupted during the Miocene epoch when fissures opened and flow after flow of very fluid black basaltic lava was extruded upon the surface. These flows first filled the valleys and then spread out over the upland until probably all but the very highest parts of the ancestral Blue Mountains were covered by basaltic lava. Short periods of time separated successive extrusions of the lava. Only rarely was an appreciable soil zone developed on top of one flow before it was covered by the next. At times the drainage was dammed locally by the lava to form lakes in which silt and clay were deposited. By the time the vulcanism ceased near the end of the Miocene or in early Pliocene time, at least 2,500 feet of lava had been deposited upon the northern part of this area.

The Pliocene epoch was a transitional period between the vulcanism of the Miocene and the glaciation of the Pleistocene. The deformation that was later to produce the Blue Mountains had started but probably had not progressed far. After the deformation had begun, the fanglomerates were deposited in the lower land along the face of the growing Blue Mountains.

The deformation of the basalt reached a climax during middle or late Pleistocene time when the Horse Heaven anticlinal ridge was formed, and the ancestral Blue Mountain anticline was uplifted farther. The glacial stages of the Pleistocene are generally regarded as periods of cooler climate than the present. Toward the end of the Pleistocene, continental and valley glaciers existed farther north in Washington and Canada in the Columbia basin. Ice blocks from those glaciers floated down the Columbia River and probably added their mass to the ice from the annual freezeup of the river itself. Many of these iceblocks carried rock and soil from upriver. According to Allison (1933, p. 721), during Wisconsin time these iceblocks, supplemented by ice from the annual freezeup of the river, were obstructed by a landslide and formed an ice jam downstream in the vicinity of The Dalles. This ice jam grew in height and extended upstream, damming the river and causing a lake to form upstream from The Dalles. The waters of this lake rose to a maximum altitude of about 1,150 feet and deposited stratified sand and silt. Scattered pockets of erratic sand, gravel, and boulders mark the locations where rock-laden iceblocks melted and dropped their loads. The lake surface was constantly changing in elevation and failed to remain stationary long enough at any one stage to cut a prominent strand line. The lake level reached its maximum elevation, then began to lower as the ice jam melted and eroded. When the lake surface had lowered to an altitude of about 750 feet, the river reestablished a current through the Umatilla area. The stream stripped the basaltic bedrock of its cover of Pliocene gravel and lacustrine silt and even cut deep channels in the basalt itself, thus forming the channeled scablands on some of the bedrock benches along the Columbia River.

After the ice jam melted and the lake drained, the exposed lacustrine silt was subjected to strong erosion by variable but dominantly southwesterly winds. A veneer of silty loess was deposited by the wind over the entire Umatilla River basin, and thicker deposits of sandy loess were formed northeast of the lakebeds.

The geologic history of the area since the close of the Pleistocene epoch has been largely one of relative crustal stability and stream erosion. There was one brief, though probably intense, fall of white pumiceous volcanic ash. This ash apparently originated with volcanic action in some other area and was borne into the Umatilla basin by the wind. Initially it probably covered the entire area to a depth of several inches, but it was eroded and, in places, concentrated by wind and stream movement. It exists now only as minor terrace deposits in the upland stream valleys and as lenses and scattered inclusions in the loess and the Recent alluvium and colluvium (fig. 12).

## OCCURRENCE OF GROUND WATER

Ground water is the most important economic mineral resource obtained from the rocks in the Umatilla River basin. However, it is not uniformly distributed throughout the area. Because of the topographic and structural conditions, some districts, such as the Umatilla lowland and parts of the Pendleton plains, possess moderate to large supplies of ground water of good quality, whereas other districts, such as the higher parts of the Horse Heaven Hills and the Rieth Ridge, have little ground water within economic reach.

The Columbia River basalt is the most widespread and productive aquifer within the area, although the younger deposits are important aquifers in some places.

### PRE-MIOCENE ROCKS

The older rocks, which underlie the Columbia River basalt, are exposed in the Blue Mountain slope. This is a region of high topographic relief where little arable land exists; consequently, very little ground-water development has been attempted. Surface streams supply most of the irrigation water needed, and springs flowing from the basalt, as well as from the soil zones overlying the consolidated rocks, supply most of the domestic and stock water.

The dioritic rocks originally were compact and had little porosity. However, near the surface they are now badly disintegrated by weathering and have sufficient secondary porosity to yield small amounts of water from zones near present or former erosion surfaces. The norite is relatively fresh and is still firm and compact. Little ground water can be expected from it except for small amounts from joints and other fractures.

The metamorphic rocks have a wider range of textures than the igneous rocks but, where unweathered, are similarly compact and impermeable. A few shallow wells dug into the soil overlying the metamorphic rocks produce water for the domestic use of several ranches in the vicinity of Gurdane.

No wells are known to produce water from the Clarno formation in the Umatilla River basin, although some domestic shallow wells of small yield are dug into the soil and alluvium overlying the Clarno. Potentially the best aquifers in the Clarno formation are the coarser sandstone beds, but microscopic examination shows that even these are rather tightly cemented with calcium carbonate.

## COLUMBIA RIVER BASALT

### WATER-BEARING CHARACTERISTICS

As stated previously, the Columbia River basalt is the most productive and widespread aquifer in the Umatilla River basin. The main permeable zones are (1) tabular bodies comprising the scoriaceous and fractured zones at the tops of some lava flows and (2) bodies of irregular form comprising the joints and other fractures within some of the flows. In places sedimentary beds are present between the flow layers, but most of these consist of silt and clay and do not yield water readily. The fractured and scoriaceous zones at the tops of many of the flows are porous and permeable, but the more compact center parts of most flows are relatively impermeable. Water can, therefore, move with relative ease and rapidity parallel to the flow layers but does not readily pass through the denser parts. Each tabular porous zone is at least partly limited by the denser parts of the flows and, where the layers are tilted, the porous zones farther downdip at lower altitudes may contain water under relatively high artesian pressure. Where the zones are continuous through great horizontal distances, even minor changes in the direction or angle of dip of the basalt flows can produce marked changes in the vertical position of the permeable zones and in the pressure head of the ground water.

The tabular ground-water bodies generally are not continuous. Interruptions of their permeability and even termination of individual water-bearing zones are due to the original rock structures, to stratigraphic irregularities, and to tectonic deformation. Each lava flow lenses out between the overlying and underlying flows. Consequently, its scoriaceous water-bearing zone may be cut off or may merge with that of an adjacent flow. Sharp folding or warping of the beds may have caused flows to slide past each other, thereby grinding up the weaker scoriaceous zone and partly destroying its permeability. Furthermore, faults and other fractures strongly influence the occurrence of ground water. Where much movement has taken place along a fault, the water-bearing zones may be offset and may abut impermeable zones. Also, the fault gouge decomposes into clayey material which may form a barrier, particularly to the horizontal movement of ground water. On the other hand, if the fault movement has failed to seal its broken zone completely, the fracture may be a conduit for the percolation of water vertically across the dense center parts of some flows.

Many of the individual lava flows do not contain permeable zones. In some no such zones were formed, and in others they were eroded away prior to the extrusion of the subsequent flows.

Owing to the discontinuity of the ground-water bodies and imperfect hydraulic connections between water-bearing zones, a general regional "water table" or "piezometric surface" is difficult to discern, especially in the upland areas. Rather, each water-bearing zone may have its own water table or piezometric surface. Thus, it is common for the static water level in a well to rise or decline as successive water-bearing zones are penetrated during well drilling. This situation is noted in table 2 in the logs of wells 1/32–9N1 and –23J1, 2N/31–2B2, 2N/32–9B1 and –10N1, 3N/29–16G1, 3N/34–3C1, 3N/35–19L1, 4N/27–27R1, 4N/28–27J1, and 4N/34–22H1. More accurate and complete drilling logs collected in the future may reflect this situation more extensively.

Most of the recharge to the ground water occurs at places where the lava flows have been warped or deformed over a wide area and the tilted beds reach or approach the surface, where they receive infiltrating water directly, or by transfer from the surficial deposits. Thus, the Blue Mountain slope is the main recharge area for the water in the basalt beneath the Umatilla River basin. Lesser recharge areas probably exist; one in particular where the Umatilla River and smaller streams cross inclined lava strata in the west limb of the Rieth anticline.

The lithologic character of the basalt is remarkably constant throughout the Umatilla River basin, but its water-bearing characteristics are greatly influenced by tectonic structures and vary from place to place. For this reason, it is convenient to discuss the ground water in the basalt by subordinate areas. These areas are analogous to those designated in the sections on structural geology and topography and drainage.

### BLUE MOUNTAIN UPLAND

The uplands of the Blue Mountains are underlain by nearly horizontal basalt flows that, in places, have been deeply entrenched by streams. Because of their horizontal attitude, water does not enter the beds readily and tends to drain out rapidly. Except in the towns of Meacham and Kamela, there is little demand in the upland district for ground water in addition to that obtained from springs and shallow wells tapping the water perched in the soil on top of the basalt.

Locally, irregularities in the dip of the basalt flows and in other structural features cause the ground-water conditions to be favorable for the drilling of wells. The upland community of Meacham is located on a slightly eastward-dipping downwarp and has several drilled wells that are reliable sources of water. One 279-foot drilled well in the basalt (1/35–10C1) flowed 25 gpm (gallons per minute) when first drilled and was test pumped at 314 gpm with a 24-foot drawdown of the water level. Several other drilled wells in the vicinity yield reliable domestic supplies. Only about 5 miles to the south, however, the community of Kamela lies near the crest of the Blue Mountain anticline. Here a 996-foot drilled well in the basalt (1/35–36N1) was abandoned because of low yield and deep water level.

Numerous springs discharge in scattered localities in the upland districts. Most of them are at or just below the rims of the upland plateaus and yield less than 2 gpm. Many of them discharge water from the soil overlying the basalt. A few emerge from fractures or scoria in the second or third lava flow below the rim. Water from one of these minor springs, 2/28–23E1, was analyzed by the Geological Survey (table 3). That spring, owned by W. W. Weaver, discharges from broken basalt in the canyon of an unnamed tributary of the South Fork of Butter Creek (pl. 1).

Only one "hot" spring is known to exist in the area. This is Bingham Spring (3N/37–18H1), whose water has a temperature of 94° F and issues from a fractured zone in the lava in the south wall of the canyon of the Umatilla River. This spring discharges about 80 gpm from 3 openings, 2 that are close to each other and about 50 feet above river level, and another, the smallest, that is about 50 feet farther downstream and about 10 feet above river level. The spring lies just west of the axis of the Blue Mountain anticline.

### BLUE MOUNTAIN SLOPE

As the basalt layers in the Blue Mountain upland lie generally horizontal and water has little opportunity to percolate into them, the annual precipitation is removed largely by evapotranspiration and surface runoff. As the streams flow northward and westward from the highland area and cross the beveled edges of the northwestward-dipping basalt of the Blue Mountain slope, water has an opportunity to enter the scoriaceous interflow zones. From there it percolates generally northwestward under the Pendleton plains and the Umatilla lowland.

Ground water occurs in wells in the Blue Mountain slope under a variety of conditions. In some places water is present in large quantities under considerable pressure. Several strongly flowing artesian wells have been drilled in the canyon of the North Fork of Butter Creek east of Pine City. Well 1N/28–28D1, near the lower end of the monocline forming the Blue Mountain slope, yields 1,300 gpm by free flow from a 12-inch hole in 355 feet of basalt. Well 1/29–3A1, also near the foot of the slope, is a 5½-inch well that penetrates 161 feet of basalt and flows at a rate of 550 gpm. To the south, higher on the slope, several reliable, though less spectacular, wells furnish enough water for stock and domestic uses, and small-scale irrigation.

Numerous small springs and seeps discharge from the south walls of the east-west segments of the canyons cut in the Blue Mountain slope. Most of them yield less than 3 or 4 gpm and many merely create damp spots in the soil. The small springs supply domestic water for most of the ranches of the slope.

#### PENDLETON PLAINS

A principal area of recharge for the basalt of the Pendleton plains is the Blue Mountain slope to the south and east. The ground water moves mainly northwestward through the Agency syncline, where it is under considerable artesian pressure, and part way through the limbs of the Horse Heaven and Rieth anticlines. Along the axis of the syncline and to the east, the water is under sufficient pressure to flow at the surface from artesian wells in a belt that extends from Pilot Rock to Athena. The flowing wells include the municipal wells of those two cities. Almost any well drilled sufficiently deep in this area of confined ground water is likely to yield flowing water.

The artesian head decreases abruptly northwestward from the axis of the syncline, and static water levels in wells become progressively deeper until, at Pendleton, the hydrostatic surface of the deeper water bodies (the regional water table) is about 150 feet below the level of the Umatilla River. Some bodies of perched water at shallower depths have higher hydrostatic levels.

The upper 700 feet of basalt in the Rieth anticline is cut by the canyon of the Umatilla River west of Pendleton. The lava beds along the axis of this anticline plunge slightly to the north, and the water table in that part of the anticline immediately south of the Umatilla River is at about the same altitude as the river. Wells near the axis of the Rieth anticline south of the river commonly find only perched water in the basalt above the levels of the Umatilla River. These perched bodies are discontinuous and are dependent upon local recharge. The annual precipitation in this area is only about 12 inches, and the annual recharge to the perched water bodies is small. Aquifers tapped by wells less than 700 feet deep are relatively unproductive and undependable. If wells located along this anticlinal crest can be drilled to such depth that they penetrate stratigraphic horizons below the level of the Umatilla River, they might reach productive aquifers below the regional water table.

The area north of the Umatilla River was a plain whose uplift in the Rieth and Horse Heaven anticlines has been accentuated by the erosional entrenchment of the Umatilla River in the Pendleton plains and the Rieth anticline. The shallower water-bearing zones discharge where they are cut by the Umatilla River in its canyon through Rieth Ridge to the south and by the Columbia River in Wallula Gap to the northwest. This northward drainage of the shallower ground water is probably facilitated by canyons tributary to the Columbia and Walla Walla Rivers, such as Cold Springs, Juniper, and Vansycle Canyons. The annual precipitation here is about 12 to 14 inches and the topography favors absorption of most of it by the soil and later discharge from the soil by evapotranspiration, so local recharge to the ground water probably is negligible. The consequence of all these factors is that economical ground-water development by means of wells becomes progressively more difficult with increasing distance northwest from the Agency syncline. In the broad upland area between Despain Gulch and the axis of the Horse Heaven anticline, northwest of the axis of the Rieth anticline, wells are deep and have poor yields and high pumping lifts. Only one large producing well (4N/32–2M1) is known on this upland surface. Its yield reportedly is decreasing progressively with water withdrawal.

### UMATILLA LOWLANDS

The basalt flows of the west limb of the Rieth anticline slope gently westward beneath the Umatilla lowlands. The shallower water-bearing zones of the nearly horizontal basalt of the lowlands receive their principal recharge from three sources: Butter Creek and many minor creeks where they cross the northward-dipping basalt of the Blue Mountain slope above Pine City, the Umatilla River where it crosses the westward-dipping basalt of the west limb of the Rieth anticline, and, to a lesser extent, the Columbia River and local intermittent creeks where they cross the southwestward-dipping basalt of the south limb of the Horse Heaven anticline. As the entry points for the water from the Umatilla River and Butter Creek are relatively high, a pressure gradient is established and flowing artesian water is obtained from wells scattered throughout the main part of the Umatilla lowland in the Nolin and Hermiston areas, as well as near Pine City and Echo. In nearly all wells in basalt in this area the water is confined under pressure and rises above the point where it enters the well, even if it does not flow at the surface.

Two structural variations from the even slope of the basalt necessitate caution in locating water wells in the Umatilla lowlands. These two structures are the Service anticline and the inferred Butter Creek fault (pl. 1).

The Service anticline trends diagonally to the northwestward direction of ground-water movement and is a minor barrier to that movement. The anticline is low, sharply warped, and locally faulted. The permeability of the water-bearing zones may have been partly destroyed by the grinding action of the lava beds sliding past each other during the folding, thus reducing the horizontal permeability within the narrow structural flexure. Wells drilled within the structure would tap the zone of lowered permeability and would be generally of low yield; furthermore, it is commonly difficult and expensive to drill wells in rock disturbed by faults. For maximum yield, therefore, new wells should be located at some distance from the anticlinal axis shown on plate 1.

The other structural feature to be considered is a presumed fault just west of and parallel to Butter Creek, north of Pine City and south of the confluence of Butter Creek and the Umatilla River. The existence of this fault is not certain, but its presence is indicated by the low, straight scarp forming the west bank of Butter Creek north of Pine City. This scarp is composed of gravel (Pliocene fanglomerate) and does not have the usual fault features such as slickensides, fault gouge, or fault-line springs. If a fault exists, however, it would impede the northwestward flow of ground water in the basalt from the Butter Creek recharge area. This effect does seem to exist, because wells to the southeast, along Butter Creek, have notably large yields and high water levels, whereas those to the northwest, such as well 2N/27-20J1, have smaller yields and lower water levels. Farther north, in T. 4 N., R. 27 E., the effects of this hypothetical fault seem to be negligible or nonexistent.

## AQUIFER CONSTANTS

The permeability of the basalt in directions both parallel to and normal to the flow layers differs from place to place. The ground water is in a series of superposed tabular zones, each of which differs from the others in permeability and porosity. Consequently, reliable average values for the permeability,[2] transmissibility,[3] and storage [4] coefficients of the basalt would require a large amount of data whose

[2] The coefficient of permeability can be expressed as the number of gallons per day of water at 60° F that will pass through a cross section of 1 square foot of the aquifer under a hydraulic gradient of 1 foot in 1 foot (Brown, 1953). The field coefficient is the same, except that it is measured under prevailing conditions of temperature, etc.

[3] The coefficient of transmissibility is defined as the number of gallons of water that will pass in 1 day through a vertical strip 1 foot wide extending the height of the aquifer under a hydraulic gradient of 1 foot in 1 foot; it is the field coefficient of permeability multiplied by the thickness of the aquifer, in feet.

[4] The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit of surface area of the aquifer per unit change in the component of head normal to that surface.

collection is beyond the scope of this investigation. However, some characteristics have been determined that are of aid in planning wells in basalt. Newcomb (1959, p. 14) has found that the average yield of deep wells, 12 inches or larger in diameter, in the Columbia River basalt is approximately 1 gpm per ft of depth below the static water level. This estimate is based on a study of several hundred wells, each of which penetrated at least 300 feet of basalt below the static water level and was pumped with a drawdown of 50 to 100 feet. In favorable areas, such as that near the Agency syncline, the lower part of the Blue Mountain slope near Pine City, and the lower parts of the Umatilla lowland, this estimate is valid, though for many wells it has proved to be conservative.

Well 1/32–9M1, near the axis of the Agency syncline, extends 649 feet below the basalt surface, and 718 feet below the piezometric surface of the ground water. The well yields 650 gpm, or somewhat less than the yield computed from Newcomb's estimate. Within half a mile of this well, another (1/32–9N1) yielded 1,500 gpm from a depth of 359 feet below the piezometric surface, or about 4 times as much as the estimate. The specific capacity of that well (yield per foot of drawdown) is about 21 gpm per ft. Of the wells in Pendleton, two of the city wells (2N/32–2R1 and 10F1) and the Smith Canning Co. well (2N/32–10M1) greatly exceed the yield based on Newcomb's estimate, whereas the State Hospital well (2N/32–9B1) equals it, and a third city well (2N/32–10N1) falls far short of it. On the other hand, in unfavorable areas such as the crests of the Rieth and Horse Heaven anticlines and in the Blue Mountain uplands where many of the wells tap only perched water, the yield per foot of depth is small. Well 4N/32–2M1, high on the Horse Heaven anticline, penetrates 507 feet of basalt below the piezometric surface and produces only 115 gpm, or about 0.23 gpm per foot of penetration, with a specific capacity of about 0.8 gpm per foot of drawdown. Even that yield reportedly is decreasing with use. This well is the farthest northwest of any well of moderate yield in the Pendleton plains area. All other wells to the north and west either are unsuccessful or yield only small quantities of water suitable for domestic or stock needs, but not for large-scale irrigation. This area of low yields in the anticlinal uplands extends to the west for about 15 miles to the Umatilla lowlands, where wells tapping aquifers in the synclinal area have large yields.

Some of the general hydrologic characteristics of the basalt can be inferred from the drillers' logs in table 2. The vertical footage of basalt drilled below the hydrostatic level and the footage of basalt reported by the driller to be water bearing were both totaled for 52 of the most reliable and complete of these logs. In individual wells, the percentage of total basalt drilled and reported as water bearing ranges from 0.9 percent for well 3N/29–11G2 to 48 percent for well 1N/32–34P1. The total footage of basalt drilled below the hydrostatic level in all 52 wells was 15,675 feet, and 1,840 feet, or 12 percent, was reported to be water bearing. Certain difficulties in recognizing a water-bearing zone during drilling in the basalt may make these percentage figures too low. Few wells have been test pumped at more than one depth during the drilling. Drillers commonly use changes in static water levels, change in drill-mud consistency, and bailing tests as criteria for recognizing water-bearing zones; and, if these changes are not noticeable, a water-bearing zone may not be recorded on the log. For example, in the log of well 4N/34–24J1 in table 2, a total of 54 feet was reported as "water-bearing" material. However, below the first water discovered, at 182–193 feet, another 170 feet of material was reported as "broken" and, therefore, potentially water bearing. If this 170 feet is added to the 54 feet of reported water-bearing material, the percentage of basalt that is water bearing would be raised from 4.8 to 20 for this well. In other wells scoriaceous, broken, creviced, honeycomb, and fractured zones are reported, and, in part, may have been water bearing, but were not detected to be water bearing by the usual drilling criteria. The estimated average percentage of basalt below the piezometric surface that is capable of yielding water probably is somewhere between 20 percent and the 12 percent on the basis of reports of the drillers.

Some of the wells have been test pumped by drillers or pump servicemen. These tests are primarily short-term capacity tests, which are unsuitable for determining coefficients of permeability, transmissibility, and storage. However, some of these tests are adequate to obtain the specific capacities of the individual wells during short-term periods of pumping. The specific capacity of a given well varies with changes in pumping, diameter of the well, and drawdown. Consequently, it cannot be relied upon as a constant quantitative characteristic of the aquifer. However, it is useful for comparing similar wells that yield water from the same aquifer and have the same general order of drawdown. A comparison of the specific capacities of 52 wells throughout the basin, the general structural area in which each well is situated, and the thickness of basalt that was penetrated below the hydrostatic surface in each well is given in the following table, which shows the effects of structural environment on the water-bearing characteristics of the basalt.

The table shows that, of the 13 wells having specific capacities greater than 10, 8 are on the Umatilla lowland and 3 are near the axis of the Agency syncline. All four areas are represented among those wells having specific capacities of less than 1.

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*Relation of specific capacities of 52 wells tapping the Columbia River basalt, thickness of saturated basalt penetrated by the wells, and general location of the wells within the Umatilla River basin, Oregon*

| General location of wells | Number of wells | Range of thickness of saturated basalt penetrated (feet) | Thickness of saturated basalt penetrated (feet) | | Number of wells for which indicated specific capacities were determined | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Range | Average | <1 | 1–10 | 10.1–50 | >50 |
| In the Umatilla lowland | 20 | 65–720 | 360 | 0.2–150 | 3 | 9 | 5 | 3 |
| Near the axis of the Agency syncline | 17 | 120–750 | 380 | 0.2–92 | 4 | 10 | 2 | 1 |
| On the Rieth and Horse Heaven anticlinal ridges | 10 | 65–510 | 210 | 0.2–7 | 5 | 5 | 0 | 0 |
| On the Blue Mountain upland or on the Blue Mountain slope | 5 | 180–360 | 250 | 0.1–200 | 3 | 0 | 2 | 0 |

Fluctuations of water levels in wells tapping the basalt are shown on plate 2.

## SEDIMENTS OVERLYING BASALT

The fanglomerate, the glacial-lake sediments, and loess lie in areas having low annual precipitation. In large part, these deposits cap ridges and terraces and are cut off from surface water of other areas. Therefore, what ground water they contain is derived mostly from local precipitation and is "perched" above the basalt while in transit to deeper formations or to areas of discharge at the surface.

Though the glaciofluviatile deposits and the Recent alluvium lie in a low-precipitation area, unlike the bulk of the fanglomerate they lie mostly at lower altitudes and are recharged partly by percolation from streams and irrigation diversions. The deposits are less than 100 feet thick at most places, and consequently, do not contain thick zones of saturation. The ground water in them is, at places, perched upon the surface of the underlying basalt, above unsaturated zones in the basalt. The temperature of the ground water in these deposits is about the same as the mean annual air temperature.

### FANGLOMERATE OF PLIOCENE AGE

The fanglomerate of Pliocene age consists of a heterogeneous mixture of poorly sorted, rudely stratified gravel, silt, and clay. Silt lenses are common and the interstices in some of the gravel are filled with silt and clay. In places the gravel is rather tightly cemented with calcium carbonate. Clean layers of sand or gravel are rare, and the fanglomerate as a unit is rather impermeable.

The general low permeability, low precipitation, and high altitude above nearby streams make the fanglomerate an inadequate source of ground water. The fanglomerate is dissected completely at places by streams, and whatever ground water is in it is mostly discharged to the streams.

Many ranches and residences, however, rely upon ground water from the fanglomerate, especially the so-called McKay beds, for domestic and stock-water supply. Water is withdrawn from shallow dug or drilled wells, most yielding less than 3 gpm. The water levels in many such wells decline considerably after several successive years of less than average precipitation. The water-level variations in a well tapping ground water in the fanglomerate are shown in plate 2.

### GLACIAL-LAKE SEDIMENTS AND LOESS

The glacial-lake sediments and the loess are considered together as they are both composed of silt with some sand and they have similar hydrologic properties. The lake sediments also contain bodies of sand and gravel, partly of ice-rafted origin, but these do not increase the average permeability of the sediments.

The ground water within the silt is perched or semiperched in thin lenses upon the underlying basalt. Most wells that are dug through the silt and to the basalt contain less than 6 feet of water. Where the silt is underlain by Pliocene fanglomerate, it is generally unsaturated. Because the silt mostly lies high above the streams, it is recharged from local precipitation. Where the silt is thickest the annual precipitation is low and evaporation is high; consequently, there is very little recharge. The record of water-level variations in well 3N/33–18A1, shown in plate 2, indicates that the total winter and spring recharge is insignificant.

In spite of the paucity of recharge, the low permeability of the silt, and the small amount of water available, both the loess and the lake sediments are widely used as sources of small amounts of water for domestic and livestock use. In areas such as Rieth Ridge and the high plains north of Pendleton, where surface sources are limited and water in the basalt is deep or of small quantity, many ranches are partly or entirely dependent upon water from shallow wells in the loess.

### GLACIOFLUVIATILE DEPOSITS

The glaciofluviatile deposits are composed of coarser particles than the loess and lake sediments and are cleaner and better sorted than the fanglomerate. Therefore, they are more permeable and yield more ground water. However, these deposits lie in an area of low annual precipitation and contain appreciable amounts of ground water only in areas where they are recharged by streams or by irrigation. Plate 2 shows that the annual rise in water level in well 4N/29–34R2 after the winter and spring recharge period was less than 0.4 foot in 1953–54.

The area underlain by the glaciofluviatile deposits is divided into an eastern and a western part by the courses of Butter Creek and the lower 10 miles of the Umatilla River.

The eastern part lies about two-thirds below and one-third above the 750-foot topographic contour. Above 750 feet the glaciofluviatile deposits have been reworked by the wind and in places overlie the loess and lake sediments, from which they are distinguishable by their coarser texture. At these higher altitudes, the glaciofluviatile deposits are hydrologically similar to the loess and yield small quantities of water to stock and domestic wells.

Below the 750-foot contour, the eastern part of the area of the glaciofluviatile deposits is rather heavily populated and is traversed by many irrigation ditches. The ground water is semiperched upon the basalt and is recharged largely by the Umatilla River, by seepage of irrigation water, and by discharge from the intermittent streams that drain the higher lands farther east. In this locality the glaciofluviatile sediments range in thickness from less than 10 feet to about 100 feet. The water table lies within a few feet of the surface in the lower areas, such as Fourmile Gap and the other abandoned river channels east of Hermiston and Umatilla Buttes. These are the most heavily populated and irrigated areas. During the spring months and following irrigation seasons, the water sometimes rises to the surface of the ground locally. The ground water has been developed mostly for domestic uses, as the people here rely upon the Umatilla River and the Cold Springs Reservoir for irrigation and stock water.

Most of the western part of the area of the glaciofluviatile deposits is occupied by a U.S. Army installation. Only a few wells in this area develop water in the sedimentary deposits. Those wells are clustered in the southern part of T. 4 N., R. 27 E., and their water levels, 60 to 65 feet below the land surface, coincide roughly with the altitude of the Umatilla River to the east. Fire-protection wells at the Army installation are equipped with casing down into the basalt and therefore do not draw water directly from the overlying glaciofluviatile deposits. However, the drillers' reports indicate that the deposits contain water in that area.

Wells 4N/27-33H1 and J2 are irrigation wells which were tested at 500 and 750 gpm, respectively, reportedly with "no" drawdown. Seemingly the drawdown is too small to be noticed by the owners after pumping each well at 520 gpm for 3 months. If such ground-water conditions extend northward from these wells for several miles, this part of the glaciofluviatile deposits is a potentially important aquifer.

Recharge of this part of the glaciofluviatile deposits comes from infiltration from the Umatilla River and Butter Creek to the east and from intermittent streams flowing across the fanglomerate farther south. Surface drainage is well developed on the Pliocene fanglomerate but disappears entirely on the glaciofluviatile deposits. Probably very little recharge reaches the ground water in the glaciofluviatile deposits directly from the precipitation, as the annual precipitation is only about 8 inches per year, and the evaporation rate is more than 40 inches per year. Ditch or pump diversion of excess floodwater from the Umatilla River or Butter Creek might be used for artificial recharge. This water could be recharged to the glaciofluviatile deposits by basin or ditch infiltration in the sandy depressions near the south border of T. 4 N., R. 27 E.

### ALLUVIUM OF RECENT AGE

As noted previously, the alluvium of Recent age occurs mainly as thin, narrow flood-plain deposits along the larger streams. Where such streams traverse the Blue Mountain slope the alluvium is composed of well-washed, fairly clean though poorly sorted gravel and sand which is porous and permeable.

In the Pendleton plains and in the higher parts of the Umatilla lowland the alluvium consists mostly of reworked material from the loess and fanglomerate. That reworked material contains many beds which are relatively tight and impermeable. Even so, the alluvium there is widely used as a source of ground water for domestic use at the ranches and dwellings bordering the streams.

In the lower parts of the Umatilla lowland, where the streams traverse the area underlain by glaciofluviatile deposits, alluvium of Recent age is commonly lacking. Where it exists, it is nearly indistinguishable from the glaciofluviatile deposits.

Recent alluvium occurs mainly in three large areas. One is a broad flood plain extending upstream for about 7 miles from Pendleton. The alluvium there is composed mostly of gravel but is less than 40 feet thick, and ground water from it is used only for domestic supply at a few dwellings.

The second large area underlain by Recent alluvium is a mile-wide flood plain bordering the lowest 12 miles of Butter Creek. This alluvium also is thin; it is composed almost entirely of reworked loess and is therefore rather impermeable. It contains a few scattered lenses of fairly clean sand, but the ground-water yields are sufficient only for domestic and stock water. Deeper wells are being drilled on some of the ranches to obtain water from the underlying basalt.

The third large deposit of alluvium of Recent age underlies the broad flood plain of the Umatilla River northwest from Echo to the confluence with Butter Creek. The alluvium there is composed mostly of reworked glaciofluviatile material and is fairly coarse and permeable. Its thickness is not known, as no wells are known to penetrate it entirely, but it is presumed to be thin. It is crossed and almost completely surrounded by irrigation ditches and is crossed by the

Umatilla River. The water table is within 6 feet of the surface in most of the area and rises to the surface in many places during the spring months. Drainage is a problem in this area. The ground water in the alluvium is developed only by domestic and stock wells at the ranches. The wells are dug, bored, or driven and are pumped at low rates.

The Thorn Hollow supply of water for Pendleton infiltrates to pipes laid below the water table in the alluvial gravel beneath the Umatilla River flood plain at the following places. The Wenix "spring" is in the N½ sec. 5, T. 2 N., R. 35 E., west of the small settlement of Thorn Hollow and includes South Wenix "spring" which was the first source developed for the system. Simon "spring" in the NE¼ sec. 4, T. 2 N., and Shapplish "spring" in the S½ sec. 34, T. 3 N., were gallery networks added for more capacity as the conduit was extended upstream. The Long Hair line is a fourth source and consists of a single linear infiltration pipe in the NE¼ sec. 35, T. 3 N. It was the last source added to the system.

## QUALITY OF THE GROUND WATER

Except in a few places, the quality of the ground water in the Umatilla River basin is excellent. In general, the water ranges from soft to moderately hard, has a moderate mineral content, and does not contain significant amounts of objectionable constituents.

Samples of water from 17 wells and 2 springs within the area were analyzed by the Geological Survey. Chemical analyses of water samples from 6 other wells were obtained from other sources (table 3). In addition, water samples from 126 wells and springs were tested by field methods for hardness and chloride. In the field determinations a standard soap solution was used to estimate hardness, and silver nitrate solution with potassium chromate indicator solution was used to determine chloride. The results of the field tests of well waters are given in table 1 and those of spring waters in table 4.

### HARDNESS

Hardness of water is caused principally by calcium and magnesium compounds, such as the carbonates, bicarbonates, sulfates, and chlorides of these metals. Hard water deposits scale when the water is heated, affects the use of detergents and dyestuffs, and requires excessive amounts of soap in laundry operations. Water has been classified with respect to hardness by the U.S. Geological Survey (1953, p. 13) according to the following scale:

| *Hardness as* $CaCO_3$ *(ppm)* | *Class* |
|---|---|
| 0–60 | Soft |
| 61–120 | Moderately hard |
| 121–200 | Hard |
| 201 | Very hard |

Hardness of water from 104 springs and wells which draw water from the basalt ranged from 15 to 225 ppm and averaged 77 ppm. Thus, from place to place, the water in the basalt may range from soft to very hard and on the average is moderately hard. Of the 104 samples, 22 were soft, 59 were moderately hard, 21 were hard, and only 2 were very hard.

Determinations of the hardness of water from 97 wells and springs in the basalt can be grouped according to the depths of the water-bearing zones from which the water was obtained. Water from 20 springs—water that probably never had been more than 100 feet below the land surface—had an average hardness of 62 ppm. The average hardness of water from 26 wells drilled less than 200 feet into the basalt was 90 ppm; that for 20 wells between 200 and 300 feet deep was 80 ppm; and that for 31 wells more than 300 feet deep was 74 ppm. This shows that the hardness of the water varies little with depth in the basalt.

Samples of water from the sedimentary deposits overlying the basalt ranged in hardness from a minimum of 40 ppm in the Recent alluvium to a maximum of 195 ppm in the loess. Average hardness values and the number of wells upon which the values were established for each of the sedimentary units are as follows: Pliocene fanglomerate, 5 wells, 93 ppm; loess, 14 wells, 124 ppm; glaciofluviatile deposits, 6 wells, 101 ppm; and Recent alluvium, 9 wells, 97 ppm.

## SALINITY

The chloride content in any of the sampled water is not sufficient to be objectionable for ordinary uses. The highest concentration of chloride was 104 ppm in water from a shallow well in the loess. The upper limit of concentration of chloride in drinking water recommend by the U.S. Public Health Service for use on interstate carriers (1946) is 250 ppm, and a concentration of 300 ppm or more ordinarily is reached before the water tastes noticeably salty.

Water from the loess contains more chloride than that from the other rock units. In samples of water from 14 wells that tap the loess, the chloride content ranged from 10 to 104 ppm and averaged 41 ppm. In the water withdrawn from 104 springs and wells in the basalt, the chloride content ranged from 4 to 99 ppm and averaged 22 ppm. Water from 20 wells in the Pliocene fanglomerate, glaciofluviatile deposits, and Recent alluvium ranged in chloride concentration from 6 to 70 ppm and averaged 21 ppm.

Detailed chemical analyses of water from 21 springs and wells in the area indicate that the sulfate and nitrate concentrations are not excessive. The U.S. Public Health Service suggests a maximum permissible sulfate concentration of 250 ppm for drinking water.

The maximum concentration in ground water in this area was 42 ppm. The National Research Council (Maxcy, 1950, p. 265) recommends a limit of 44 ppm of nitrate in water for domestic use. Nitrate in only one well water (from 4N/33–29K1) exceeded this, the concentration being 57 ppm. The other waters tested had nitrate concentrations ranging from 0.1 ppm to 20 ppm.

## MINOR CONSTITUENTS

### BORON

In small amounts, boron is essential to the growth of practically all plants. In only slightly greater amounts, however, it is detrimental to plant growth. Plants are rated (Wilcox, 1948) as sensitive, semitolerant, and tolerant, according to their ability to withstand boron concentrations. Irrigation waters are rated in five classifications—from "excellent" through "unsuitable"—for each of these classes of plants. Water having a boron concentration of less than 0.33 ppm is regarded as excellent for the sensitive plants, and water containing more than 3.75 ppm of boron is regarded as unsuitable even for the tolerant plants.

Nineteen of the chemical analyses of table 3 list boron concentrations. Of these, 18 show less than 0.33 ppm of boron and are, therefore, "excellent" irrigation water in this respect. One sample (3N/37–18H1), from a hot spring, had an objectionable amount of boron (10 ppm) and is rated "unsuitable" for even the most tolerant of plants.

### FLUORIDE

A concentration of fluoride of about 1.0 ppm in drinking or culinary water is considered beneficial to children's teeth (Dean, 1936, p. 1269–1272). In higher concentrations fluoride may cause a dental defect known as mottled enamel, and accordingly, the Public Health Service specifies a maximum limit of 1.5 ppm in water to be used for drinking and cooking.

Determinations of fluoride were made on water from 22 springs and wells. Concentrations ranged from 0.1 to 1.0 ppm in most of the waters, which would classify them as mildly beneficial to beneficial for children's teeth. In the samples from well 4N/28–11N1 and spring 3N/37–18H1, the fluoride concentrations were 1.7 and 4.0 ppm, respectively. This latter sample is from the same hot spring whose water contained 10 ppm of boron.

### IRON

Water containing more than about 0.3 ppm of iron, or of iron and manganese together, may stain plumbing fixtures, utensils, and laundry. Water samples from one well in the basalt (4N/34–6L1) and from one well in the Pliocene fanglomerate (1N/32–24R1) were found to have concentrations in excess of this amount. Water from one well (3/30–29R2) in the metamorphic rocks had a very high total concentration of iron (47 ppm) but most of the iron apparently precipitated when the water was allowed to stand. In the 20 other samples in which iron was determined, the concentrations were less than 0.3 ppm.

### GASEOUS CONSTITUENTS

Several of the wells and springs discharging water from the basalt have a noticeable odor of hydrogen sulfide ("rotten egg" gas). This condition seems to be normal (especially in newly drilled wells) for water from the basalt of the Pacific Northwest. The gas, in part, may be released by the decomposition of iron sulfides in the lava rock.

Drilling operations in well 1N/30–24E1 disclosed a small amount of combustible gas which ignited with a muffled report when pieces of burning paper were dropped into the well. Well 1N/27–24R1 tapped a fairly strong flow of inflammable gas in the water-bearing zones of the basalt. The gas, which probably was methane, apparently came from an interflow soil or peat zone and probably was formed from the organic matter in that zone.

Gas can be removed easily from water by aeration.

### SUITABILITY FOR IRRIGATION

The U.S. Department of Agriculture (U.S. Salinity Laboratory Staff, 1954) has stated that the characteristics most important in determining the quality of an irrigation water are (1) total concentration of soluble salts, or salinity; (2) relative proportion of sodium to the principal cations as a whole; and (3) concentration of boron (which was discussed previously) or other elements that may be toxic. The concentration of soluble salts in water can be determined approximately by measuring the electrical conductivity of the water. This determination can be made readily and is reasonably accurate for the purpose. Conductivity is usually expressed in micromhos per centimeter at 25° C and is a partial measure of the suitability of water for irrigation use.

The sodium (alkali) hazard involved in the use of water for irrigation is determined by the absolute and relative concentrations of the cations. If the proportion of sodium is high, the alkali hazard is high; if the calcium and magnesium predominate, the hazard is low.

A useful index for designating the sodium hazard is the sodium-adsorption-ratio (SAR), which is related to the adsorption of sodium by the soil. The sodium-adsorption-ratio may be calculated from the following formula, in which all the cations are expressed in equivalents per million:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

The classification of waters with respect to SAR is based primarily on the effect of exchangeable sodium on the physical condition of the soil.

A diagram used for the classification of irrigation waters on the basis of electrical conductivity and the sodium-adsorption-ratio is reproduced as figure 14. This diagram classifies irrigation waters into

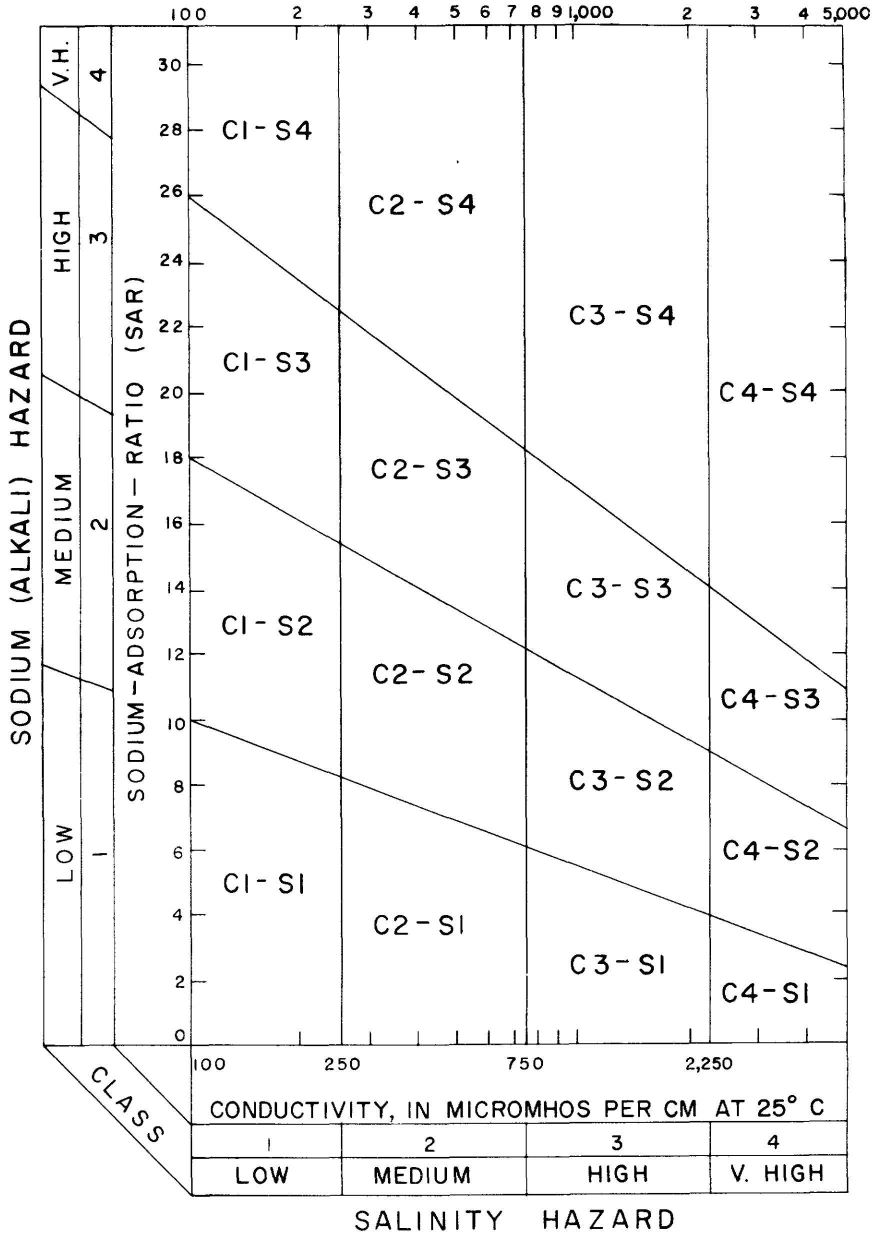


FIGURE 14.—Diagram for the classification of irrigation waters (after U.S. Salinity Laboratory Staff, 1954).

16 types ranging from low salinity (C1) and low sodium (S1) to high salinity (C4) and high sodium (S4). Water classed as C1–S1 can be used on practically all soils with little danger of harmful effects on the soils or crops, whereas a water classified as C4–S4 is not suitable for irrigation of any type of crops or any kind of soil except in very special situations.

Of 19 waters for which major constituents are analyzed, 15 fall into class C2–S1. Water of this class can be used for irrigation if enough water is used to cause a moderate amount of leaching. Plants having moderate salt tolerance can be grown without special practices for salinity control. This type of water can be used on almost all soils with little danger of developing harmful levels of exchangeable sodium.

Two of the waters fell into class C1–S1; this type of water can be used for irrigating most crops on most soils with little likelihood that soil salinity or harmful concentrations of sodium will develop.

One sample (5N/32–31F1) was classed as C2–S2. This water will not create a salinity hazard if a moderate amount of leaching occurs but will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity. It can be used on coarse-textured or organic soils of good permeability.

The remaining sample is from a hot spring (3N/37–18H1) and is classed as C3–S2. This has sodium-hazard characteristics similar to the sample just discussed. With respect to salinity hazard, the water in the C3–S2 class may not be suitable for use on soils having restricted drainage. Even with adequate drainage, if this water is used for irrigation, special management for salinity control may be required and plants having good salt tolerance may need be selected.

## TEMPERATURE

The average temperature of rocks lying at a depth of less than about 100 feet below the ground surface is commonly about the same as the mean annual temperature of the atmosphere at the ground surface. Wells and springs that discharge water from the pre-Miocene rocks tap water bodies in the weathered zones of these rocks. The water table lies within a few feet of the ground surface and the water temperature approximates the mean annual air temperature.

The sedimentary deposits overlying the basalt also are commonly shallow; the depths of wells are generally less than 100 feet and seldom exceed 150 feet. The temperature of the water they contain also is about the same as the mean annual air temperature.

Ground water from the basalt occurs in porous zones, which are tapped by wells ranging in depth from about 100 feet to more than 1,000 feet below the ground surface. Such waters show a distinct, though irregular, increase of water temperature with increasing depth of the water source.

The temperature of the water and other derived information for 26 wells in the basalt are tabulated below:

| Well | Mean depth [1] of aquifer (feet) | Temperature of the water (°F) | Mean annual [2] temperature (°F) | Temperature difference (°F) | Temperature increase (°F per 100 ft of depth) |
|---|---|---|---|---|---|
| 2/27-8P1 | 221 | 56 | 48 | 8 | 3.6 |
| 1/27-18M1 | 126 | 55 | 48 | 7 | 5.6 |
| 1/32-9L1 | 465 | 66 | 52 | 14 | 3.0 |
| 9N1 | 348 | 64 | 52 | 12 | 3.4 |
| 17G1 | 301 | 65 | 52 | 13 | 4.3 |
| 1/32-19Q1 | 160 | 55 | 52 | 3 | 1.9 |
| 23J1 | 750 | 68 | 52 | 16 | 2.1 |
| 1N/28-28D1 | 355 | 64 | 48 | 16 | 4.5 |
| 1N/30-4C1 | ---------- | 65 | 48 | 17 | ---------- |
| N/27-11H1 | 427 | 61 | 48 | 13 | 3.0 |
| 2N/29-30H1 | 59 | 62 | 48 | 14 | 24 |
| 2N/32-10M1 | 421 | 51 | 49 | 2 | .1 |
| 10N1 | 580 | 56 | 49 | 7 | 1.2 |
| 29D1 | 194 | 58 | 49 | 9 | 4.6 |
| 2N/33-21H1 | 450 | 66 | 51 | 15 | 3.3 |
| 3N/29-16G1 | 450 | 65 | 48 | 17 | 3.8 |
| 4N/27-27R1 | 540 | 58 | 50 | 8 | 1.5 |
| 4N/28-10F1 | 157 | 62 | 50 | 12 | 7.6 |
| 10P1 | 438 | 76 | 50 | 26 | 5.9 |
| 11N1 | 699 | 71 | 50 | 21 | 3.0 |
| 4N/31-9P1 | 311 | 61 | 50 | 11 | 3.5 |
| 5N/28-19A1 | 770 | 71 | 50 | 21 | 2.7 |
| 5N/29-13E1 | 272 | 63 | 50 | 13 | 4.8 |
| 5N/32-18C1 | 240 | 61 | 50 | 11 | 4.6 |
| 31F1 | 66 | 58 | 50 | 8 | 12 |
| 5N/33-31A1 | 253 | 58 | 50 | 8 | 3.2 |

[1] Mean depth of aquifer is taken as the depth of a point halfway between the top and bottom of the reported water-bearing zone; for wells in which the water-bearing rock was not reported, it is taken as the depth of a point halfway between the static water level and the bottom of the well.

[2] Mean annual temperature is estimated from the elevation of the well site and the proximity of the site to temperature-recording stations at Echo, Hermiston, McNary, Meacham, Pendleton, Pilot Rock, Ukiah, Umatilla, and Weston. Mean annual temperatures for these stations were computed from weather records for the years 1945–54.

Of the temperatures recorded for the water in wells, the highest was 76° F in well 4N/28–10P1 in the Umatilla lowland, the lowest was 51° F in well 2N/32–10M1 in the Pendleton plains, and the average temperature for all 26 wells was 62.2° F.

For the earth in general, the average rate of increase in temperature below the first 100 feet is 1° to 2° F per hundred feet. The temperature of the first 100 feet of depth is expected to average about the same as the mean annual temperature for that locality. This common assumption apparently is not entirely valid for the Columbia River basalt of the Umatilla River basin, as water from wells 2N/29–30H1 and 5N/32–31F1 show temperatures greater than the mean annual for aquifers whose mean depth is less than 100 feet. For this reason, the thermal gradients in the foregoing table were computed directly from the earth's surface.

Of the 26 wells for which data are complete, only 4 had temperature gradients of less than 2° F per hundred feet. Of these, 2 are in the Pendleton plains area, 1 is in the Umatilla lowlands, and the other one is at the foot of the Blue Mountain slope.

Of the wells that show unusually high thermal gradients, more than 5° F per 100 feet of depth, nearly all are located in areas that contain lines of significant tectonic deformation. Well 1/27–18M1 is on the Blue Mountain slope; 4N/28–10F1 and 10P1 are near the axis of the Service anticline; and 5N/32–31F1 is high on the Horse Heaven anticline. Well 2N/29–30H1 is in a trough between the Service and Rieth anticlines.

Possibly well 2N/29–30H1 may be bridged or obstructed in such a manner that only part of the depth to its water-bearing zone could be measured; thus, an erroneous depth measurement may account for the apparently very high temperature of the water, which may come from much greater depth.

Near Pilot Rock, where the mean annual temperature for the years 1945–54 was 51.8° F, the water temperatures listed are for wells drawing water from different depths. One well (1/32–19Q1) yields water at 55° F from an aquifer whose mean depth is 160 feet, and another (17G1) yields water at a temperature of 65° F from an aquifer whose mean depth is 301 feet. A third well (9L1) yields water at a temperature of 66° F, mainly from an aquifer whose mean depth is 465 feet, and a fourth (23J1) yields water at 68° F from an aquifer whose mean depth is 750 feet. These four wells would indicate a temperature gradient of 1° F per 50 feet of depth to 160 feet, 1° F per 14 feet of depth from 160 to 301 feet, 1° F per 164 feet of depth from 301 feet to 465 feet, 1° F per 142 feet of depth from 465 feet to 750 feet; the overall gradient would be 1° F per 47 feet of depth from the atmospheric temperature to the temperature of the water at 750 feet. If these data were plotted temperature against depth, the result would not be a smooth curve. The roughness of the curve seems to indicate that the ground water from the main producing zone of some wells may be mixed with water from higher or lower water-bearing zones, or that the rock has different temperature zones within it.

The warmest ground water known in the Umatilla River basin issues from Bingham Spring (3N/37–18H1) in the canyon of the Umatilla River near the crest of the Blue Mountain anticline. Hot springs are commonly considered to represent water that has risen along faults or other conduits from deeper strata. Using a temperature gradient of 1° F for each 50 feet of depth and starting from a mean annual temperature of 50° F, the 94° F temperature of the spring would require that its water rise without temperature loss from a depth of some 2,000 feet. However, the nearest recognizable fault is about half a mile downstream from the spring, and the position of the spring near the crest of the anticline makes it difficult to explain the source of sufficient hydraulic head to cause the water to rise in such volume from such a depth. The water possibly could have reached a depth of 2,000 feet in its percolation to the springs if it came from the south and passed under the high mountain mass south of the spring. Fractures along the crest of the anticline may be open, thus creating a greater vertical permeability than is common. If water were traveling in a straight line from the junction of the south fork of the Umatilla River and Thomas Creek (altitude about 3,500 feet) to Bingham Spring (altitude about 2,200 feet) the water would have to descend vertically 1,300 feet in the basalt and would pass under a mountain mass which reaches an altitude about 4,500 feet above sea level, or 2,300 feet above Bingham Spring.

Another possible source of the heat is residual heat in an igneous intrusive mass near the surface. However, this hypothesis is doubted, because only one hot spring is known and because the only other possible indication of the presence of such an igneous mass is the high concentration of boron in the water from this spring. The possibility exists that fault zones may contain abnormally warm rock due to mechanical disruption of the rock during fault movements and may pass such heat on to the circulating ground water.

## USE OF GROUND WATER

### HISTORY OF GROUND-WATER DEVELOPMENT

There have been three major periods of ground-water development in the Umatilla basin. These correspond to periods of general increase in population, agriculture, and industry.

The earliest period of settlement in the area was characterized by little or no ground-water development. Prior to the termination of the Indian wars in 1857, the population was transient and consisted mostly of trappers, traders, small settlements of white stockmen and missionaries, and Indians. Most of the settlements were temporary and several were destroyed or the people were frightened away during the Indian wars. In 1863, gold mining was started in the Powder River valley to the southeast, and several ranches were started in the Umatilla area to raise cattle, sheep, and foodstuffs for the miners. During that time the ranches and settlements were widely scattered and relied mostly on surface or spring water for domestic and stock use and upon surface water for any irrigation.

The change in emphasis from stockraising to grain farming as the dominant industry took place between 1875 and 1900. By the end of that period, most of the Pendleton plains and much of the Umatilla lowlands were under cultivation. Many of the settlements and ranch headquarters were located on the narrow flood plains of the larger streams. The people relied upon surface water for irrigation and stock use and upon shallow dug wells in the Recent alluvium for domestic use. Ranches on the terraces and on the plains between the streams used shallow dug wells in the loess or other sediments overlying the basalt for domestic and stock water and practiced dry farming. The first exploratory wells into the basalt were drilled about the turn of the century. Many of them were shallow and either failed or were only moderately successful.

During the period 1912 to 1920, high wheat prices, stimulated by the First World War, caused many lands previously regarded as submarginal to be brought under cultivation. Many drilled wells were developed during this period of prosperity. The emphasis at that time was on dry farming and the wells were needed only for domestic and stock use. The wells were generally small in diameter—6 inches or less, and in most wells the drilling was discontinued as soon as a small amount of water was obtained. With the decline in grain prices after the First World War, many of the poorer lands, such as those on the Rieth anticline and the Blue Mountain slope, reverted to grazing use and many farmsteads were abandoned as the land was consolidated into larger units. Many of the farmstead wells either fell into disuse or served only to supply water for stock.

A period of minor ground-water development occurred during the drought of the 1930's, when the Government financed the drilling of several low-yield wells for drought relief.

The period of greatest ground-water development was from 1940 to the present (1960). This recent activity has been caused by three factors: First, the general period of prosperity during and after the Second World War made it possible for people to finance ground-water development; second, the local people found that large quantities of ground water are available under some parts of the area; third, many of the ranchers turned their attention to crops other than small grains. Some of those crops require irrigation. The second factor is probably the dominant one, and wells have been, and are now being, drilled for domestic, industrial, and municipal use as well as for irrigation.

## PRESENT USE

At the present time ground water has been developed for rural domestic and stock supply, irrigation, public supply, and industrial use; at one spring it has been developed for recreational use.

### RURAL DOMESTIC AND STOCK SUPPLY

Most of the wells and developed springs in the Umatilla River basin are used for rural domestic and stock supply. In many places water from these wells and springs is used also to irrigate small gardens or yards of generally less than 1 acre. About 600 representative wells of this class were inventoried, and are listed in table 1. Fifty representative springs used for these purposes are listed in table 4.

The population of Umatilla County was 41,703 according to the 1950 census. If from this is subtracted the 19,696 who lived within incorporated towns that have municipal water supplies and the estimated 5,500 who live in the part of the Walla Walla drainage basin that lies within Umatilla County, a rural population of approximately 16,000 is obtained for the Umatilla River basin. Per capita water use for a rural population is commonly about the same as for a small city without industry—about 50 gpd. The rural domestic use of water, all which is withdrawn from wells or springs, therefore, is about 800,000 gpd, or about 900 acre-feet per year. Most of this water is withdrawn from the basalt.

The amount of ground water used for watering stock cannot be accurately determined, but probably is less than 500 acre-feet per year.

### IRRIGATION

Quantities of water used for irrigation were estimated from data for individual wells. Most of the data were obtained from annual reports of the well owners to the State Engineer of Oregon. Where such reports were not made, the total water use was derived from an estimated average use of 3 acre-feet per acre irrigated per year. Where the total acreage was not known, the estimate was based on the reported yield of the well, in gallons per minute, for a 3-month irrigation season.

The estimated total amount of ground water used for irrigation in the Umatilla River basin was 8,100 acre-feet per year in 1956–57. Of this amount, about 6,400 acre-feet was withdrawn from the basalt, and about 1,700 acre-feet from the glaciofluviatile deposits; the amount withdrawn from the fanglomerate and the alluvium and used for irrigation probably was only about 50 acre-feet.

### PUBLIC SUPPLY AND INDUSTRIAL USES

Some of the industries within the area obtain all or part of their water from public-supply sources, whereas others furnish water to public-supply agencies, especially during periods of water shortage. For this reason, public-supply and industrial uses of ground water are grouped in this report.

Water-use figures were obtained from city officials or the State Engineer of Oregon where records were adequate, or were estimated for cities and industries where records are inadquate. The estimates were made by multiplying the population of the city by 50 gallons per day per person for the domestic use, or by comparing reported well yields against the reported hours of pumping by industrial water users.

The estimated total amount of ground water used for industrial and public supply is 7,100 acre-feet per year. Of this, 3,800 acre-feet is withdrawn from wells in the basalt. The city of Pendleton obtains about 3,200 acre-feet per year from infiltration galleries in the Recent alluvium underlying the flood plain south of that part of the Umatilla River which lies in R. 35 E. The combined flow from the infiltration pipes of Pendleton's Thorn Hollow supply is a little over 5 mgd, which is all that the pipeline will carry by gravity to the city reservoirs 15 miles to the west. The deep wells within the city (table 1) have been added for standby supply during periods of maximum use. The city of Stanfield obtains about 30 acre-feet per year from a well in the glaciofluviatile deposits overlying the basalt, and the city of Helix gets about 40 acre-feet per year from a dug well in the loess. The latter well has the highest production rate (about 25 gpm) known for any well in the loess.

### TOTAL WITHDRAWAL

The total withdrawal of ground water for all purposes in the Umatilla River basin was about 16,000 acre-feet per year in 1956–57. Of this, 8,800 acre-feet per year was used for irrigation and seasonal industries and was withdrawn mostly during the summer months. The remainder included usage for domestic and public supply and for nonseasonal industries. The withdrawal of this 7,200 acre-feet of water was distributed fairly evenly over the year, with perhaps a slight increase during the summer months when irrigation of yards and small gardens and a slight rise in population during the harvest season raised the rate of water use.

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# BASIC DATA

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*

Well: See text for description of well-numbering system.
Topography: Ap, alluvial plain, dissected; Fp, flood plain; Rc, former river channel; S, slope to major valley; T, terrace; U, upland; Uv, upland valley of minor stream.
Altitude: Altitudes of land-surface datum at wells, in feet above mean sea level. Approximated from topographic maps and barometer surveys.
Type of well: Dn, driven; Dg, dug; Bd, bored; Dr, drilled.
Ground-water occurrence: C, confined; P, perched; U, unconfined.
Water level: Depths given in feet and decimal fractions measured by the U.S. Geological Survey; those in whole feet reported by owner or driller. For flowing well whose static head is known, a "+" precedes the water level; a flowing well whose static head is not known is indicated by "F." All levels are related to land-surface datum at well.
Type of pump: C, centrifugal; J, jet; N, none; P, piston; T, turbine.
Use of water: D, domestic; In, industrial; Ir, irrigation; N, none; PS public supply; RR, railroad; S, stock.
Remarks: Ca, chemical analysis in table 3; dd, drawdown; gpm, gallons per minute; H, hydrograph included in this report; L, log in table 2; ppm, parts per million by weight; Temp, temperature of water; W, water-level record in table 5. Values listed for hardness and chloride content of the water were determined in the field, without laboratory control.

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | T. 1 N., R. 26 E. | | | | | | | | | |
| 10B1 | W. J. Doherty | Ap | 1,200 | Dr | 150 | 6 | ------- | ------- | ------- | Basalt | C | 56 | 1952 | T | 20 | D, S | Static water level reportedly declined from 10 ft in 1913 to below 56 ft in 1952. Hardness, 90 ppm; chloride, 91 ppm. |
| 10L1 | Julian Rauch | Ap | 1,255 | Dr | 189 | 6 | ------- | ------- | ------- | do | U | 152.3 | 8-25-53 | P | ------- | ------- | W. |
| 12C1 | G. D. Abercrombie. | Ap | 1,165 | Dr | 143 | 6 | 40 | 128 | 12 | do | C | 24 | 1950 | P | 50 | D | Water has slight "sulfur" odor. Hardness, 115 ppm; chloride, 27 ppm. L. |
| 23E1 | J. Stubblefield estate. | Fp | 1,300 | Dr | 58.4 | 6 | ------- | ------- | ------- | Alluvium | U | 9.7 | 8-18-53 | P | ------- | ------- | |
| 24D1 | Howard Kelly | Uv | 1,410 | Dr | 351 | 8 | ------- | 334 | 13 | Basalt | C | 135 | 1952 | T | 50 | D | L. |
| 25G1 | Claude White | U | 1,610 | Dr | 492 | 6 | ------- | ------- | ------- | ------- | ------- | 336 | ------- | T | ------- | D | Hardness, 90 ppm; chloride, 18 ppm. |
| 27F1 | J. Stubblefield estate. | Ap | 1,450 | Dr | 100 | 4 | ------- | ------- | ------- | ------- | ------- | 96.3 | 8-19-53 | P | ------- | D | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 1 N., R. 27 E.** | | | | | | | | | | | | | | | | | |
| 3G1 | E. W. Wattenburger. | Fp | 1,025 | Dr | 97 | 6 | | 25 | 72 | Basalt | C | 20 | | C | | D | Hardness, 90 ppm; chloride, 11 ppm. |
| 3R1 | do | Fp | 1,040 | Dr | 120 | 8 | | 104 | 4 | do | C | 4 | | T | 235 | Ir | Pumped 200 gpm for 1 hr; dd, 55 ft. Supplied 73 acre-ft to 19 acres during 1954. L. |
| 7D1 | Mr. Campbell | Uv | 1,200 | Dr | 290 | 6 | | | | | C | 116.8 | 8-19-53 | P | | | |
| 10H1 | Mr. Kamerrer | Fp | 1,050 | Dr | 110 | 6 | | 90 | | Basalt | C | | | C | | D, S | |
| 16G1 | J. E. Meyers | Fp | 1,250 | Dr | 240 | 6 | | | | do | C | | | J | | D, S | Hardness, 70 ppm; chloride, 22 ppm. |
| 21R1 | James Daly | Fp | 1,385 | Dg | 10.6 | | | | | Alluvium | U | 6.3 | 8-28-53 | J | | D | |
| 24R1 | Antone Vey | Uv | 1,350 | Dr | 777 | 12-8 | 500 | 562 | 145 | Basalt | C | +90 | 5-23-58 | N | | Ir | Flowed 700 gpm with much gas when drilled in 1958. Temp 74° F. |
| 27F1 | John Healy estate. | Uv | 1,400 | Dg | 25 | | | | | Alluvium | U | 22 | | C | | D | |
| **T. 1 N., R. 28 E.** | | | | | | | | | | | | | | | | | |
| 21Q1 | Antone Vey | S | 1,440 | Dr | 270 | 12 | 45 | 225 | 45 | Basalt | C | 30 | | | | | L, W. |
| 28C1 | do | T | 1,400 | Dr | 500 | 12 | 29 | 178 | 21 | do | C | 0.0 | 7-18-53 | | | D, S, Ir | L. |
| 28D1 | do | T | 1,390 | Dr | 365 | 12 | 16 | | | do | C | F | | | | Ir | Flows 1,300 gpm. Water has a "sulfur" odor. Ca, L. |
| 30G1 | do | S | 1,425 | Dr | 150 | 4 | | | | do | C | 30 | | P | | S | Water appears turbid. Hardness, 120 ppm; chloride, 14 ppm. |

T. 1 N., R. 29 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7B1 | Joseph Cunha | Uv | 1,430 | | | | | | | | C | F | | N | | S | May have been constructed in spring outlet. Hardness, 110 ppm; chloride, 26 ppm. |
| 14R1 | Cunningham Sheep Co. | Uv | 2,050 | Dr | 340 | 6½ | | 325 | 15 | Basalt | C | 210 | | P | 8 | S | |

T. 1 N., R. 30 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4C1 | Cunningham Sheep Co. | Uv | 1,760 | Dr | | 6 | | | | Basalt | C | F | | N | | N | Flows 6 gpm. Hardness, 110 ppm; chloride, 18 ppm. Temp 65° F. |
| 14E1 | R. M. Warren | Uv | 2,200 | Dr | 49.2 | | | | | | U | 48.0 | 7-1-53 | P | | D, S | |
| 23P1 | Mark Cargill | Uv | 2,150 | Dg | 22 | 30 | | | | | U | 10.6 | 6-24-53 | | | D, S | |
| 24E1 | T. A. Cross | Uv | 2,220 | Dr | 587 | 12 | | 327 | | Basalt | C | 247.3 | 3-2-54 | N | | | Pumped 30 gpm. L. |
| 27D1 | Leslie Owen | Uv | 2,350 | Dg | 15 | | | | | Loessial soil. | U | 0.0 | 7-9-53 | P | | D | Hardness, 140 ppm; chloride, 48 ppm. |
| 34J1 | G. W. Johnston | U | 2,590 | Dg | 16.0 | | | | | do | U | 8.3 | 6-24-53 | N | | D, S | |

T. 1 N., R. 31 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1P1 | Leroy Beilke | Uv | 1,400 | Dg | 18 | 36 | | | | Alluvium | U | 6 | | | 2 | D | |
| 7B1 | W. C. Warren | U | 2,080 | Dr | 502 | 6 | 20 | | | Basalt | | | | P | | D, S | |
| 8K1 | do | Uv | 1,650 | Dg | 16.4 | 26 | | | | Alluvium | U | 10.3 | 2-17-53 | P | | S | W. |
| 9R1 | M. Hoke | Uv | 1,545 | Dg | 21.4 | 8 | | | | | U | 17.8 | 2-19-53 | | | | |
| 11L1 | do | Uv | 1,445 | Dg | 13.3 | | | | | Alluvium | U | 11.8 | 2-17-53 | | | | |
| 12A1 | O. L. Straughn | U | 1,555 | Dr | 230 | 6 | 15 | | | Basalt | C | 123 | | P | 1 | S | |
| 17E1 | T. A. Cross | Uv | 1,750 | Dr | 327 | 6 | 20 | | | do | C | 160 | 12-8-53 | P | 120 | S | Pumped 120 gpm for 2½ hr; dd, 105 ft. |
| 23L1 | Frank Leeper | Uv | 1,750 | Dr | 200 | 6 | | | | do | | | | P | | D, S | |
| 28C1 | J. S. Robertson | Uv | 1,910 | Dg | 15.7 | 84 | | | | Alluvium | U | 5.1 | 2-25-53 | P | | | |
| 30B1 | T. A. Cross | Uv | 2,050 | Dr | 550 | 6 | | | | Basalt | C | 190 | 7-1-53 | T | 20 | D, S | Pumped 25 gpm for 12 hr; dd, 55 ft. Ca. |
| 34J1 | Fred Rauch | Uv | 2,030 | Dr | 385 | 6 | | | | do | P | 365.0 | 10-27-53 | P | | D, S | Yield inadequate for domestic supply. Hardness, 85 ppm; chloride, 20 ppm. |
| 35J1 | Charles Winget | Uv | 1,830 | Dr | 332 | 6 | | | | do | | 110 | | P | | S | Pumped 15 gpm for 20 min; dd, 190 ft. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **T. 1 N., R. 32 E.** | | | | | | | | | |
| 1D1 | J. R. Hanna | Ap | 1,360 | Dg | 28 | 108 | | | | Fanglomerate | U | 22.7 | 1-21-53 | P | 30 | D, S Ir | Supplies water to 4 acres. Ca, H. |
| 1J1 | Roy Horne | Ap | 1,435 | Dr | 95 | | | | | Gravel | U | 40 | | P | | D | |
| 1M1 | Peter Timm | Ap | 1,395 | Dg | 64 | 120-36 | | 60 | 4 | do | U | 55.3 | 7-16-53 | J | | D, S | Penetrates loess and fanglomerate. |
| 1M2 | do | Ap | 1,410 | Dr | 504 | 8 | 185 | 501 | 3 | Basalt | C | | | T | 80 | Ir | Supplied 45 acre-ft of water to 15 acres during 1956. L. |
| 4R1 | Ed Kangas | S | 1,205 | Bd | 12.5 | 6 | | | | | U | 9.5 | 7-17-53 | C | | D | |
| 6R1 | O. L. Straughn | Uv | 1,485 | Dr | 260 | 6 | | | | Basalt | C | 80 | | P | | S | |
| 9H1 | Jack Sparks | Fp | 1,240 | Dr | | 10 | | | | Alluvium | U | 15 | | | | D, S | Static water level is at level of Birch Creek, 30 ft east. |
| 10G1 | G. A. McKay | Ap | 1,350 | Dr | 389 | 8 | | | | Tuff(?) | C | 190 | | P | | D | |
| 12Q1 | T. C. Holmes | Ap | 1,400 | Dg | 40 | 48 | | | | | U | | | P | | D | Recovers in 24 hr after being pumped dry. |
| 15D1 | William Eldridge. | S | 1,310 | Dr | 284 | 12 | 24 | 24 | | Basalt | C | 12 | | | | D | Pumped 320 gpm for 6 hr; dd, 5 ft. L. |
| 15D2 | Robert Schuening. | S | 1,310 | Dr | 80 | 6 | 23 | 57 | | do | C | 17 | | | 25 | D | About 23 ft of soil, gravel, and boulders overlies porous basalt. |
| | | | | | | | | do | | | | | | | | | |
| 18Q1 | O. L. Straughn | Uv | 1,545 | Dr | 218 | | | 203 | | do | | | | J | 10 | D | |
| 18R1 | do | Uv | 1,540 | Dg, Dr | 110 | | | | | do | | 50 | | P | | D, S | |
| 19M1 | do | Uv | 1,650 | Dr | 40 | 6 | | | | | | 20 | | | 4 | D, S | |
| 20F1 | do | Uv | 1,410 | Dg | 18.3 | 36 | | | | | U | 13.4 | 2-27-53 | P | | | |
| 22B1 | J. L. Eldridge | Fp | 1,345 | Dr | 406 | 10 | 20 | | | Basalt | C | 20 | | T | 500 | Ir | Pumped 400 gpm for 15 min; dd, 52 ft. Supplies 159 acre-ft to 80 acres during 1953. L. |
| 22B2 | John Hummell | S | 1,355 | Dr | 110 | 6 | 4 | 85 | 25 | do | C | 70 | | | | D | Pumped 23 gpm for 8 hrs; dd, 30 ft. Driller reports 10 ft |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | of soil and cemented gravel overlying basalt. |
| 22G1 | J. L. Eldridge | Fp | 1,345 | Dr | 540 | 12 | 30 | | | | C | 9.5 | 7-17-52 | T | 450 | Ir | Supplied 154 acre-ft to 77 acres during 1953. |
| 23J1 | C. S. Holmes | Fp | 1,395 | Dg | 15.8 | 36 | | | | | U | 8.3 | 7-16-52 | P | | D | |
| 24R1 | V. A. Bolt | Ap | 1,420 | Dg | 29.8 | | | | | Gravel | U | 17.9 | 1-21-53 | P | | D,S | Ca, W. |
| 26Q1 | Guy Rockwell | Fp | 1,440 | Dr | 2,000 | 6 | | | | | | | | N | | N | Oil test well; plugged at about 8 ft. |
| 26R1 | J. W. Miller | Fp | 1,430 | Dg | 12 | 60 | | | | | U | 8.2 | 7-16-53 | P | C | D,S | Reported 6 ft of loess overlying basalt. |
| 27P1 | Adolph Weinkes. | Fp | 1,420 | Dr | 134 | | 30 | 117 | 17 | Basalt | C | 16 | 1948 | | 28 | D | L. |
| 28D1 | Edwin Hoeft | Uv | 1,510 | Dr | 583 | 12 | 20 | | | do | C | +2 | 1956 | N | | N | Not in use in 1956. Flows 30 gpm. Pumped 600 gpm; dd, 200 ft. L. Temp 66° F. |
| 29N1 | do | Uv | 1,610 | Dr | 500 | 6 | | | | | | | | T | | D, S | |
| 29P1 | do | Uv | 1,600 | Dr | 110 | 2 | | | | | | | | P | | N | Abandoned because of inadequate yield. |
| 30F1 | Army Korvola | Uv | 1,640 | Dr | 185 | 6 | | | | Basalt | C | | | P | 9 | D | |
| 30L1 | do | Uv | 1,660 | Dr | 358 | 10 | 22 | 225 | | do | C | 94 | 7-15-52 | T | 180 | Ir | Pumped 177-210 gpm for 1¾ hr; dd, 167 ft. |
| 34P1 | Everett Hawkes | S | 1,510 | Dr | 200 | 6 | 52 | 125 | 75 | do | C | 44 | 1948 | | 21 | D | L. |
| 35G1 | Guy Rockwell | Fp | 1,430 | Dg | 33 | 8 | | 20 | 13 | Gravel | U | | | P | | D, S | Entirely in Quaternary alluvium. |
| 35K1 | Tom Ellis | Fp | 1,450 | Dr | 273 | 8 | 193 | | | Gravel or fault breccia (?). | | 36.4 | 7-16-52 | | 30 | N | Originally 350 ft deep. |
| | | | | | | | | | | **T. 1 N., R. 33 E.** | | | | | | | |
| 3G1 | H. A. Thompson | Ap | 1,695 | Dr | 800 | 8 | 74 | | | Basalt | | 161 | | | | | |
| 3R1 | do | Ap | 1,820 | Dr | 121 | 10 | 20 | 16 | 105 | do | C | F | | | | | Flows 2 gp. About 16 ft of loess and fanglomerate overlies basalt. |
| 7F1 | Marvin Cargill | Ap | 1,480 | Dr | 160 | | | | | Fanglomerate. | | | | P | | D | Ca. |
| 9B1 | A. Anderson | Ap | 1,610 | Dg | 19.3 | 18 | | | | do | U, P | 5.2 | 2-21-53 | | | | Not in use in 1953. |
| 10D1 | G. Redhawk | Ap | 1,740 | Dg | 42.4 | 24 | | | | do | U, P | 1.6 | 2-21-53 | P | | | |
| 16R2 | Mr. Patton | Ap | 1,950 | Dg | 36 | | | | | Colluvium | U, P | 3.4 | 2-21-53 | P | | D | Refills in 3 days after being pumped dry. W. |
| 18H1 | Roy Horne | Ap | 1,565 | Dr | 180 | 6 | | | | Fanglomerate (?) | U | 124.9 | 1-21-53 | | | | W. |
| 19R1 | W. H. Caplinger | Ap | 1,715 | Dr | 150 | 12 | | | | Basalt | | 78.8 | 9- 8-54 | | | | Drilling not completed in 1956. W. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s) | | | Ground-water occurrence | Water level | | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Depth to top (feet) | Thickness (feet) | Character of material | | Feet below datum | Date | | | | |
| | | | | | | | | **T. 1 N., R. 34 E.** | | | | | | | | | |
| 16M1 | Frank Leeper | U | 3,450 | Dr | 118 | 6 | 38 | 62 | 3 | Basalt | P | 52 | 5-20-58 | ---- | ---- | D | Basalt overlain by 35 ft of clay and loess. |
| | | | | | | | | 110 | 2 | do | | | | | | | |
| 19G1 | Frieda Tugit | U | 3,450 | Dg | 46.8 | 36 | ---- | ---- | ---- | ---- | U | 16.2 | 10-29-53 | P | ---- | N | |
| | | | | | | | | **T. 1 N., R. 35 E.** | | | | | | | | | |
| 4M1 | H. L. Nielson | S | ---- | Dr | 320 | 8 | 33 | ---- | ---- | Basalt | ---- | 50 | 9-14-57 | ---- | ---- | ---- | Basalt overlain by 32 ft of soil and clay. |
| 28M1 | Gus Moll | S | ---- | Dr | 180 | 6 | ---- | ---- | ---- | ---- | C | 80 | ---- | J | ---- | D, S | |
| 29C1 | Oregon Highway Dept. | S | ---- | Dr | 286 | 6 | ---- | ---- | ---- | ---- | C | 16 | ---- | J | ---- | PS | Supplies water for public park. |
| | | | | | | | | **T. 2 N., R. 26 E.** | | | | | | | | | |
| 2P1 | A. C. Lindsay | Ap | 810 | Dr | 147 | 6 | ---- | ---- | ---- | ---- | ---- | 142.9 | 6-10-53 | ---- | ---- | ---- | |
| 14K1 | do | Ap | 905 | Dr | ---- | 6 | ---- | ---- | ---- | Fanglomerate. | P | 9.1 | 9-23-53 | ---- | ---- | ---- | W. |
| 14K2 | do | Ap | 905 | Dr | 229 | 6 | ---- | ---- | ---- | Basalt | C | 2.1 | 8-14-53 | ---- | ---- | ---- | |
| 19R1 | D. O. Nelson | Ap | 1,010 | Dr | 343 | 8 | 40 | 294 | 49 | do | C | 168 | 1948 | T | 50 | D | Water has a slight "sulfur" odor. |
| 35C1 | W. B. Gottschalk | Ap | 1,045 | Dr | 114 | 6 | ---- | ---- | ---- | ---- | C | 31.7 | 8-18-53 | J | ---- | D, S | Hardness, 160 ppm; chloride, 36 ppm. |
| 35C2 | Fred Rauch | Ap | 1,045 | Dr | 160 | 6 | ---- | ---- | ---- | ---- | C | 70 | ---- | J | 35 | D, S | |
| | | | | | | | | **T. 2 N., R. 27 E.** | | | | | | | | | |
| 1F1 | Ammon Bros | Fp | 785 | Dr | 554 | 15 | 140 | ---- | ---- | Basalt | C | 330 | 3- 1-55 | T | 1,000 | Ir | Pumped 1,000 gpm; dd, 65 ft. Supplied 570 acre-ft to 221 acres. L. |
| 1M1 | C. M. Stanfield | Fp | 780 | Dr | 504 | 8-5½ | 441 | 489 | 15 | do | ---- | 19 | 1935 | P | 20 | D | L. |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2J1 | C. Ammon | Fp | 790 | Dr | 799 | 12 | 77 | | | do | C | F | 1957 | | | Ir | Flows 580 gpm; pumped 1,600 gpm for 2 hr; dd to 90 ft. L. Temp 72° F. |
| 6F1 | Corrigal Ranch | Ap | 1,010 | Dr | 447 | | 300 | 413 | 14 | do | C | 280 | | | | D | Bailed 40 gpm. L. |
| 11H1 | J. S. Williams | Fp | 825 | Dr | 525 | 10 | 185 | 330 | 195 | do | C | F | 4-22-53 | T | 900 | Ir | Supplied 33 acre-ft to 105 acres during 1953. Ca, L. |
| 11R1 | Sloan Thompson. | Fp | 855 | Dr | 270 | 6 | | | | do | C | F | 4-22-53 | J | | D, S | |
| 12D1 | J. S. Williams | Fp | 815 | Dr | 50 | 5 | | | | | | | | C | | D, Ir | Supplies water for 1 acre. Hardness, 135 ppm; chloride, 19 ppm. |
| 14M1 | Mr. McCarty | Fp | 880 | Dr | 280 | 12 | | 192 | 28 | do | C | 45 | 1953 | T | 2,000 | Ir | Supplied about 720 acre-ft to 400 acres during 1953. L. |
| 20J1 | Ed Tucker | Ap | 1,120 | Dr | 370 | 10 | 53 | | | do | C | 250 | 1948 | | | | Pumped 200 gpm. L. |
| 27A1 | D. W. Terry | Fp | 910 | Dr | 370 | 6 | 230 | 230 | 8 | do | | | | J | | D, S | Hardness, 120 ppm; chloride, 15 ppm. L. |
| 27E1 | J. F. Kilkenny | Fp | 950 | Dr | 260 | 6 | | | | do | C | 10 | | C | 150 | D, Ir | Water level reportedly is lowered by pumping of neighbor's well. Hardness, 80 ppm; chloride, 11 ppm. |
| 27E3 | do | Fp | 950 | Dr | 598 | 16 | 29 | | | do | C | 50 | | N | | N | Pumped 780 gpm for 5 hr; dd, 150 ft. To be used for irrigation. L. |
| 28H1 | Ed Tucker | Fp | 950 | Dr | 263 | 12 | 32.5 | 242 | 12 | do | C | 10 | | T | 620 | Ir | Supplied 330 acre-ft to 250 acres during 1953. L, W. |
| 28K1 | L. H. Vanbusker. | Fp | 980 | Dr | 92 | 8 | 18 | | | | C | 20 | | J | 110 | D, Ir | |
| 29N1 | Leland Archer | Ap | 1,160 | Dr | 439 | 10 | | | | | C | 190 | | | | | Bailed 20 gpm. |
| 32G1 | H. G. Campbell | Ap | 1,200 | Dr | 334 | 6 | | | | Basalt | C | 215 | | T | 35 | D, Ir | Supplies water for 2 acres. |
| 34L1 | B. P. Dougherty. | Fp | 1,055 | Dr | 100± | | | | | | | | | C | | D | Hardness, 75 ppm; chloride, 17 ppm. |
| 34N1 | Lou Wattenburgher. | Uv | 1,150 | Dr | 72 | 6 | | | | Basalt | C | F | | | | D | Flows 15 gpm. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 2 N., R. 28 E.** | | | | | | | | | | | | | | | | | |
| 2C1 | F. Correa, Jr. | Ap | 750 | Dg | 18.8 | 36 | | | | | U | 11.9 | 7-16-53 | C | | S | |
| 11R1 | J. L. Hinds | Uv | 930 | Dg | 14.3 | | | | | | U | 11.4 | 7-16-53 | P | | D | |
| 16K1 | Antone Vey | Uv | 1,240 | Dr | 185 | 6 | 52 | 130 | 55 | Basalt | C | 100 | 1948 | P | 14 | S | Hardness, 100 ppm; chloride, 16 ppm. L. |
| 28K1 | Joseph Vais | Uv | 1,100 | Dr | 400 | 8 | | 200 | | do | | | | P | | S | |
| 35F1 | do | Uv | 1,280 | Dr | 200 | 6 | | | | | | | | P | | S | |
| **T. 2 N., R. 29 E.** | | | | | | | | | | | | | | | | | |
| 30H1 | Joseph Cunha | Uv | 1,180 | Dr | 119 | 6 | | | | Basalt | C | F | 7- 8-53 | | | S | Flows about 1 gpm. Hardness, 90 ppm; chloride, 14 ppm. Temp 62°F. |
| **T. 2 N., R. 30 E.** | | | | | | | | | | | | | | | | | |
| 6G1 | C. C. Crowner | Fp | 735 | Dg | 10 | 42 | | | | Gravel | U | 4 | | | | N, Ir | Supplied water to 1 acre during 1950. |
| 6H1 | Cunningham Sheep Co. | T | 730 | Dr | 233 | 8 | | 225 | 8 | Basalt | C | F | 1946 | C | | D, S | Flows 100 gpm. L. |
| 9F1 | Edward DuPuis. | Fp | 780 | Dg | 10 | 24 | | | | Gravel | U | 6 | | P | | D, S | |
| 17K1 | Cunningham Sheep Co. | Uv | 1,080 | Dr | 158 | 8 | | | | Basalt | C | F | 7-14-53 | | | S | |
| 20N1 | do | Uv | 1,275 | Dr | | 6 | | | | do | | | | P | | S | Hardness, 110 ppm; chloride, 20 ppm. |
| 28F1 | do | Uv | 1,440 | Dr | 81 | | | | | do | P | 64.9 | 7-10-53 | P | | D, S | H. |

T. 2 N., R. 31 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2B1 | Leo Gorger | U | 1,545 | Dr | 282 | 6 | | | | Basalt | | | | P | 2 | S | |
| 2B2 | do | U | 1,555 | Dr | 310 | 8 | 25 | 289 | 14 | do | C | 260 | | T | 40 | D | Hardness, 15 ppm; chloride, 28 ppm. L. |
| 4C1 | E. A. Fanshier | U | 1,560 | Dr | 720 | 6 | 12 | | | do | | 600± | | P | | D | Can be pumped dry in 4 hr at 5 gpm. Hardness, 90 ppm; chloride, 13 ppm. |
| 11J1 | Dean Forth | S | 1,100 | Dr | 382 | 6 | 22 | 350 | 32 | do | | | | J | | D, S | |
| 12R1 | Rieth School | S | 1,150 | Dr | 268 | 6 | | | | do | | | | T | | D | Pumped 100 gpm for 1 hr; dd to 250 ft. |
| 15K1 | Brown Bros. Dairy. | Fp | 900 | Dr | 150 | 6 | | | | | C | 8 | | C | | D, S | |
| 15L1 | Union Pacific Railroad. | Fp | 895 | Dr | 161 | | | | | Basalt | C | 3 | 1- -40 | C | 40 | D | L. |
| 31D1 | Ernest French | Uv | 1,930 | Dr | 624 | 6 | | | | | C | 50 | 1947 | P | 6 | S | |
| 36N1 | Mr. Picket | Uv | 1,275 | Dg | 15.9 | 36 | | | | | U, P | 10.6 | 4- 8-53 | P | | D, S | |

T. 2 N., R. 32 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1P1 | S. E. Allen | Fp | 1,120 | Dg | 16 | 48 | | | | Gravel | U | 2 | | | | D, Ir | Supplies water to 3 acres. |
| 1Q1 | E. C. Ralls | Fp | 1,117 | Dg | 8.0 | 48 | | | | | U | 6.5 | 10- 8-45 | C | | D | |
| 2D1 | H. M. Peringer | S | 1,355 | Dr | 600 | | 600 | | | | | | | N | | N | Oil test well; water cased out. L. |
| 2N1 | Pendleton (Emigrant Park well). | T | 1,100 | Dr | 700 | 24 | 186 | | | Basalt | C | 162 | 12- 1-58 | T | | PS | Pumped 2,400 gpm; dd, 85 ft. Temp 60° F. |
| 2R1 | Pendleton (Byers Street well). | T | 1,120 | Dr | 774 | 20 | 147 | 680 | 43 | do | C | 185 | 1948 | T | 1,800 | PS | Pumped 1,155 gpm; dd, 12 ft. Ca, L. |
| 4R1 | Wilbur Jones | S | 1,050 | Dg | 22.4 | 60 | | | | Colluvium. | U | 9.8 | 4-13-53 | C | | D | |
| 4R2 | do | S | 1,060 | Dr | 224 | 8 | | | | Basalt | C | 90 | | N | | N | New well, not in use in 1954. Pumped 220 gpm; dd, 5 ft. Temp 56° F. |
| 7L1 | Union Pacific Railroad (Rieth well 1). | Fp | 1,000 | Dr | 188 | 12 | | | | Basalt | C | 65 | | | | RR | Not in use in 1953. |
| 7N1 | Union Pacific Railroad (Rieth well 2). | Fp | 1,000 | Dr | 287 | 12-10 | 55 | 127 | | do | C | 65 | 7-19-42 | T | 638 | RR | L. |
| 9B1 | Oregon State Hospital. | Fp | 1,040 | Dr | 851 | 20 | 57 | | | do | C | 135 | 1954 | T | | PS | Pumped 810 gpm for 12 hr; dd, 178 ft. L. |
| 10F1 | Pendleton (well 2, or Round-Up Park well). | Fp | 1,054 | Dr | 761 | 16 | 80.5 | | | do | C | 139 | 11-22-48 | T | 2,500 | PS | Pumped 1,670 gpm; dd, 18 ft. Ca, L. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s) | | | Ground-water occurrence | Water level | | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Depth to top (feet) | Thickness (feet) | Character of material | | Feet below datum | Date | | | | |
| | | | | | | | | | | T. 2 N., R. 32 E.—Continued | | | | | | | |
| 10M1 | Smith Canning Co. | Fp | 1,045 | Dr | 665 | 12 | 35 | | | Basalt | C | 178 | | T | 900 | In | L. Temp 51°F. |
| 10N1 | Pendleton (well 3). | S | 1,040 | Dr | 1,008 | 20–16 | 81 | | | do | C | 153 | | T | 585 | PS | Temp 56° F, increases to 64° F after heavy pumping. L. |
| 11B1 | George Byers | Fp | 1,080 | Dr | 387 | 8 | | | | | C | 18 | 7- 9-52 | | 30 | Ir | Supplies water for yard. |
| 11D1 | First National Bank of Oregon. | Fp | 1,060 | Dr | 703 | 10 | | | | Basalt | | | | T | | | Supplies water for air conditioning. L. |
| 13J1 | Fred Peterson | Ap | 1,240 | Dg | 11.9 | 84 | | | | Loessial soil. | U | 4.8 | 6-22-53 | P | | D | Hardness, 160 ppm; chloride, 20 ppm. |
| 16D1 | Charles Ford | Fp | 1,090 | Dr | 280 | | | | | Basalt | | 27 | | J | | D, Ir | Pumped 30 gpm; dd, 113 ft. L. Temp 52° F. |
| 16M1 | Gilbert Struve | Fp | 830 | Dr | 385 | 6 | 75 | | | do | | 120 | 1956 | T | 30 | D | Pumped 30 gpm. L. |
| 16P1 | C. N. Clark | S | 1,160 | Dr | 257 | 6 | 16 | 71 | | do | | 182 | 1950 | T | 8 | D | Owner plans to irrigate 3 acres of pasture. L. |
| 18N1 | W. Enbysk | Fp | 1,050 | Dr | 150 | 6 | | | | do | C | 60 | | J | | D, S | Hardness, 105 ppm; chloride, 15 ppm. |
| 19N1 | Milton Carter | S | 1,090 | Dr | 200 | | | 130 | | do | C | 103 | 1952 | | 20 | D | L. |
| 19P1 | do | Fp | 1,075 | Dr | 229 | 8 | 57 | | | do | C | 60 | | T | 385 | Ir | Supplied 270 acre-ft to 107 acres during 1953. L. |
| 21C1 | Neal Riddle | Fp | 1,090 | Dr | 315 | 8 | | | | do | | 180 | | | | D | Pumped 45 gpm for 3 hr; dd, 70 ft. |
| 23E1 | Glenn Rogers | S | 1,190 | Dr | 225 | | | | | do | C | 200 | 1955 | T | 40 | D | When drilled, pumped for 6 hr at 100 gpm, later decreased to 40 gpm. |
| 28H1 | Henry Lembke | Fp | 1,100 | Dg | 6 | 30 | | | | Gravel | U | 4 | | | | Ir | Supplied 6 acre-ft for 2 acres during 1954; reportedly pumped 28 gpm with slight drawdown after 10 hr. Water level |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | fluctuates with the level of nearby McKay Creek. |
| 29D1 | John Korvola | Fp | 1,075 | Dr | 280 | 10 | 20 | | | Basalt | C | 108 | | | | N | Pumped 525 gpm for 1 hr; dd, 52 ft. Temp 58° F. |
| 29F1 | do | Fp | 1,075 | Dr | 56 | 8 | | 32 | 24 | do | C | 14 | 1950 | J | 200 | D | L. |
| 34G1 | G. R. Patterson | S | 1,200 | Dg | 13 | | | | | | U | 9 | | P | | D, S | |
| 35H1 | John Crow | S | 1,300 | Dr | 244 | 8 | 15 | 70 | | Basalt | C | 40 | | J | | D, S | Ca. |
| | | | | | | | | **T. 2 N., R. 33 E.** | | | | | | | | | |
| 2K1 | Luke Cowapoo | Fp | 1,230 | Dn | | 1¼ | | | | Young alluvium. | U | | | P | | D, S | Hardness, 95 ppm; chloride, 20 ppm. |
| 6N1 | Lester Moens | Fp | 1,145 | Dr | 95 | 6 | 24 | 65 | | Basalt | | 51 | 11-28-56 | N | | D | New well, not in use in 1956. Basalt overlain by 10 ft of sand and gravel. Bailed 30 gpm for half an hour, with slight drawdown. |
| 6N2 | do | Fp | 1,145 | Dr | 95 | 6 | 24 | 65 | | do | | | | N | | D | New well, not in use in 1956. |
| 6N3 | Crispin Bros | Fp | 1,140 | Dr | 500 | 10 | 60 | | | do | P | | | N | | N | Proposed supply for suburban water district. L. |
| 8G1 | William Purchase (well 2). | Fp | 1,135 | Dr | 30 | 10 | 13 | 12 | 18 | do | U | 8 | | | | D | Supplied 10 acre-ft to irrigate 3 acres during 1954. L. |
| 8G2 | H. P. Shafer | Fp | 1,135 | Dr | 200 | 8 | | | | do | C | +21 | | T | 80 | Ir | Supplied 7 acre-ft to 7 acres during 1955. Water level reportedly declines when wells -8G1, -8J1 and -8K1 are pumped. |
| 8J1 | William Purchase (well 1). | T | 1,225 | Dr | 779 | 8 | 95½ | | | do | C | 19 | 1949 | T | 100 | D, S | Originally used for irrigation until its capacity was decreased by interference from well -8K1. L. |
| 8K1 | William Purchase (well 3). | T | 1,225 | Dr | 604 | 12 | 64 | | | do | C | 20 | 1953 | T | 500 | Ir | Pumped about 615 gpm for 6½ hr; dd, 220 ft. Supplied 221 acre-ft to 80 acres during 1955. L. |
| 10E1 | N. H. Laughlin | Fp | 1,210 | Dr | 252 | 6 | | | | | | 22 | | T | 500 | Ir | Supplies water for 1 acre. L. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | T. 2 N., R. 33 E.—Continued | | | | | | | |
| 10E2 | Roy Morris | Fp | 1,210 | Dr | 275 | 6 | 19 | 19 | 73 | Basalt | C | 17 | 1-25-57 | N | | N | Proposed irrigation supply. Pumped 40 gpm for 10 hr; dd, 6 ft. L. |
| 11F1 | Mrs. Joseph Allen estate. | Fp | 1,255 | Dn | 12 | 1½ | | | | Sand and gravel. | U | 9 | | C | | D, S | |
| 13Q1 | Lewis Shipentower. | Ap | 1,570 | Dg | 25.6 | 72 | | | | | U | 8.6 | 8-31-53 | J | | D | |
| 18Q1 | Mr. Matlock | Ap | 1,260 | Dg | 25 | | | | | Loessial soil. | U | 10 | | P | | D | Hardness, 155 ppm; chloride, 16 ppm. |
| 20D1 | M. F. Umbarger | Ap | 1,290 | Dr | 472 | 6 | 8 | | | Basalt | C | 9 | | J | | D, S | Hardness, 110 ppm; chloride, 30 ppm. |
| 21H1 | Richard Curl | Ap | 1,395 | Dr | 900 | 6 | | | | do | C | F | 6-22-53 | | | N | Reported abandoned because of sulfur content of water, although no sulfurous odor was apparent in 1953. Pumped 85 gpm; flows about 1 gpm. Hardness, 20 ppm; chloride, 8 ppm. Temp 66° F. |
| 22P1 | James Thompson. | Ap | 1,435 | Dr | 50 | 6 | | | | Gravel | U | 20 | | J | | D | Hardness, 95 ppm; chloride, 6 ppm. |
| 22P2 | do | Ap | 1,435 | Dg | 34 | | | | | do | U | 12 | | N | | N | In about 1950 water was contaminated by gasoline from nearby underground storage tank. |
| 33N1 | Guy Mueller | Ap | 1,525 | Dr | 310 | 12 | 119 | | | Basalt | C | F | 6-22-53 | T | 550 | Ir | Pumped 456 gpm for 2½ hr; dd, 205 ft; supplies water for 100 acres. Hardness, 80 ppm; chloride, 8 ppm. L. |

**T. 2 N., R. 34 E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3D1 | Layton Mann | S | 1,710 | Dg | 25 | 36 | ------ | ------ | ------ | ------ | U | 20.7 | 8-31-53 | P | ------ | D | |
| 4R1 | Union Pacific Railroad. | T | 1,400 | Dr | 85 | 8 | 40 | 50 | 35 | Basalt | C | 4 | 1941 | P | 30 | D | L. |
| 7P1 | Ester Temple | S | 1,400 | Dg | 13.5 | 48 | ------ | ------ | ------ | ------ | U | 6.2 | 8-31-53 | P | ------ | D | |
| 8C1 | Clinton Case | T | 1,360 | Dg | 10 | 36 | 8 | ------ | ------ | Gravel | U | 7.2 | 8-31-53 | C | ------ | D | |
| 17A1 | Philip Guyer | S | 1,540 | Dg | 11 | 48 | ------ | ------ | ------ | ------ | U | 9.5 | 8-31-53 | P | ------ | D | Goes dry in summer. |
| 17Q1 | R. A. Fowler | S | 1,725 | Dr | 450 | 8 | 24 | { 65<br>405 | 4<br>45 } | Basalt | C | +5 | 9-29-58 | T | ------ | Ir | Pumped 850 gpm; dd, 185 ft. |

**T. 2 N., R. 35 E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4H1 | E. Kidder | S | ------ | Dr | 106 | 8 | 42 | ------ | ------ | Basalt | ------ | 30 | 6-24-57 | ------ | ------ | D | Soil and gravel, 32 ft deep, overlies basalt. |

**T. 3 N., R. 26 E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4N1 | L. W. Cramer | T | 640 | Dr | 358 | 12 | 96 | ------ | ------ | Gravel, sand, and clay. | C | 166 | 1955 | N | ------ | N | Pumped 350 gpm for 4 hr, dd, 98 ft. Proposed irrigation supply. L. Temp 66° F. |
| 10A1 | W. A. Cramer | T | 650 | Dr | 544 | 12 | 64 | 382 | 162 | Basalt | C | 181 | 8-10-56 | ------ | ------ | Ir | Silt and sand overlie basalt. |
| 10N1 | Ernest Cramer | T | 640 | Dr | 666 | 12 | 173 | { 438<br>117 | 228<br>55 | do.<br>Sand and gravel, cemented. | } C | ------ | ------ | ------ | ------ | Ir | Pumped 1,140 gpm; dd, 22 ft. L. Temp 71° F. |
| 14J1 | Willard Jones | T | 640 | Dr | 197 | 8 | ------ | ------ | ------ | Basalt | C | 84 | 1954 | T | 450 | Ir | Supplies water to 40 acres. Pumped 200 gpm for 4 hr; dd, 25 ft. L. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s) | | | Ground-water occurrence | Water level | | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Depth to top (feet) | Thickness (feet) | Character of material | | Feet below datum | Date | | | | |
| **T. 3 N., R. 27 E.** | | | | | | | | | | | | | | | | | |
| 4R1 | Dean Hall | T | 590 | Dr | 185 | 12 | 89 | 111 | | Basalt | U | | | N | | N | Proposed irrigation supply. Pumped 360 gpm for 8 hr; dd, 110 ft. L. |
| 25J1 | George Wallace | Fp | 720 | Dr | 400 | 8 | 216 | | | do | C | 196 | 1935 | P | 20 | S | L. |
| 36A1 | do | Fp | 740 | Dg | 24.5 | | | | | Younger alluvium derived from loess. | U | 14.4 | 4-22-53 | | | S | Ca. |
| 36H1 | Ralph Saylor | Fp | 755 | Dg | 24.2 | | | | | | U | 12.6 | do | C | | D | Hardness, 120 ppm; chloride, 11 ppm. |
| 36P1 | W. L. Green | Fp | 765 | Dr | | 6 | | | | | | | | | | D, S | Hardness, 75 ppm; chloride, 12 ppm. |
| **T. 3 N., R. 28 E.** | | | | | | | | | | | | | | | | | |
| 1A1 | Lee Beckner | Fp | 600 | Dg | 10 | 42 | | | | | U | 4.7 | 9-17-53 | C | | D | |
| 8P1 | Ralph Saylor | Fp | 655 | Dg | 24.8 | | | | | | U | 13.3 | 7-28-53 | | | | |
| 12J1 | Mr. Coppinger | Fp | 590 | Dg | 30 | 2 | | | | Alluvium | U | | | P | | D | |
| 14L1 | John Ubanks | Fp | 630 | Dg | 14 | | | | | do | U | 3 | | C | | D, S | Probably receives recharge from nearby irrigation ditch. Hardness, 120 ppm; chloride, 70 ppm. |
| 19Q1 | G. M. Madison | Fp | 695 | Dg | 26.2 | | | | | | U | 9.6 | 7-28-53 | P | | S | |
| 23D1 | John Ubanks | Fp | 690 | Dg | 17.1 | | | | | Alluvium | U | 7.2 | 7-29-53 | N | | N | |

T. 3 N., R. 29 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5C1 | H. R. Ohlsen | Fp | 605 | Dr | 235 | 6 | | | | Basalt | C | 75 | 1954 | S | 80 | Ir | Supplied 20 acre-ft to 6 acres during 1954. Pumped 80 gpm for half an hour; dd, 50 ft. |
| 8F1 | Frank Correa, Sr. | Fp | 620 | Dn | | 2 | | | | Alluvium | U | | | C | | Ir | |
| 8L1 | J. B. Correa | Fp | 620 | Dn | | 1½ | | | | do | U | | | C | | D | |
| 10P1 | D. R. Long | S | 780 | Dr | 170 | 6 | | | | Basalt | | | | P | | D | |
| 11G1 | Peter Meyers | U | 885 | Dg | 80 | | | 12 | 13 | Gravel | U | 75 | | J | 5 | D | L. |
| 11G2 | Claude Meyers | U | 890 | Dr | 675 | 10 | 106 | 670 | 5 | Basalt | C | +46.2 | | C | | Ir | Flows 665 gpm. Supplies water for 240 acres. L. Temp 72° F. |
| 16C1 | L. L. Fife | Fp | 600 | Dg | 12 | 36 | | | | Alluvium | U | 4 | | C | 150 | Ir | Water level fluctuates with level of Umatilla River. Supplied 29 acre-ft to 14 acres during 1954. Pumped 150 gpm for 8 hr; dd, 4 ft. |
| 16G1 | City of Echo | Fp | 630 | Dr | 490 | 10 | 169 | 442 | 18 | Basalt | C | 95 | 1951 | T | 400 | PS | Supplied about 12 acre-ft in 1,637 hr of operation during water-year 1955. L. Temp 65° F. |
| 16K1 | C. F. Grossmiller. | Fp | 610 | Dg | 36 | | | | | Alluvium | U | 6 | | C | 120 | Ir | Supplies supplemental water for 8 acres; with present pump, pumps dry in 15 min; requires 2 hr to refill. |
| 24J1 | Homer Coppinger. | U | 1,045 | Dr | 285 | 5 | | | | Basalt | | | | P | | D | Hardness, 70 ppm; chloride, 16 ppm. |
| 26K1 | Mary Raines | Fp | 750 | Dr | 6 | 16 | | | | do | | | | J | | D | |
| 32L1 | John Pedro | Uv | 890 | Dr | 183 | 8 | | | | | C | 127.8 | 7-8-53 | P | | S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 3 N., R. 30 E.** | | | | | | | | | | | | | | | | | |
| 1A2 | Brian Branstetter. | Uv | 1,050 | Dg | 135 | | | | | | | 11.6 | 6-13-53 | P | | N | |
| 4D1 | Mr. Coleman | Uv | 850 | Dr | 290 | 5.7 | | | | Basalt (?) | C | 18.0 | 5-13-53 | N | | N | W. |
| 7E1 | Marshall Meyers. | Uv | 840 | Dg | 12 | 30 | | | | | U | 6 | | C | | Ir | Supplies water for 5 acres. |
| 7M1 | do | Uv | 840 | Dg | 20 | | | | | "Soil" | U | 10 | | P | | D | |
| 9M1 | Leon Reese | Uv | 910 | Dr | 141 | 6 | | | | | C | 90 | 11-27-53 | J | 115 | D | Pumped 115 gpm for 1 hr; dd, 20 ft. Hardness, 115 ppm; chloride, 52 ppm. |
| 10K1 | A. H. Rohde | Uv | 980 | Dr | 200 | 6 | | | | | C | 50± | | J | | D | Hardness, 105 ppm; chloride, 62 ppm. |
| 13E1 | Arthur Lorenzen. | Uv | 1,120 | Dr | 500 | | | | | | | | | T | | D, Ir | Hardness, 70 ppm; chloride, 22 ppm. |
| 14M1 | Mr. Whitmore | Uv | 1,045 | Dr | 264 | | | | | | C | 150 | | P | | D | Hardness, 90 ppm; chloride, 41 ppm. |
| 22P1 | Leon Reese | Uv | 1,100 | Dr | 239 | 6 | | | | | C | 176 | 11-30-53 | P | 120 | N | Pumped 120 gpm for 1 hr; dd, 20 ft. |
| 28A1 | Unknown | U | 1,100 | Dg | 24 | | | | | | U | 20 | | P | | D | |
| 30J1 | Clarence Weltzin. | U | 1,050 | Dr | 260 | 6 | | | | Basalt | C | 200 | | P | | D | Hardness, 75 ppm; chloride, 19 ppm. |
| 32M1 | C. A. Moll | U | 1,160 | Dr | 220 | 6 | | | | do | C | 70 | | P | | D | Hardness, 55 ppm; chloride, 14 ppm. |
| **T. 3 N., R. 31 E.** | | | | | | | | | | | | | | | | | |
| 1F1 | Mr. Chadwick | Uv | 1,340 | Dr | 637 | 8 | | 632 | 5 | Basalt | | 300 | | S | 20 | D | |
| 1G1 | C. Jacobsen | Uv | 1,400 | Dg | 24.4 | | | | | | U | 17.0 | 4-16-53 | N | | N | |
| 2A1 | Cris Jacobson | Uv | 1,350 | Dg | 30 | | | | | | U | 22 | | P | | D, S | |
| 7G1 | Leonard Lorenzen. | Uv | 1,070 | Dr | 175 | 6 | | | | | | | | P | | D | Water level reportedly deep. |
| 8Q1 | E. T. French | Uv | 1,140 | Dr | 416 | 6 | 12 | | | Basalt | C | 90 | | P | | D | |
| 11G1 | Andrew Harvey. | Uv | 1,260 | Dr | 641 | 6 | 14 | 640 | | do | C | 340 | | P | 25 | D, S | Water rose to surface from perched aquifer at 89 ft, but was lost |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | when a porous layer was penetrated at 340 ft. Hardness, 55 ppm; chloride, 12 ppm. |
| 22L1 | Herman Lorenzen. | Uv | 1,230 | Dr | 320 | 6 | | | | do | | 300± | | J | 10 | D | Hardness, 80 ppm; chloride, 18 ppm. |
| 26A1 | Mr. Engdahl | Uv | 1,290 | Dr | 400 | 6 | | | | do | | 350 | | P | | D | Hardness, 85 ppm; chloride, 18 ppm. |
| 31C1 | B. E. Isom | U | 1,360 | Dr | 555 | 6 | | | | do | | 400± | | P | 7 | D | Hardness, 100 ppm; chloride, 17 ppm. |
| 33P1 | Ronald Rew | U | 1,540 | Dr | 620 | 6 | | | | do | | Dry | 1953 | | | N | |
| 34C1 | R. H. Sievers | U | 1,440 | Dr | 520 | 6 | 50 | | | do | C | 490 | | P | 6 | D | Hardness, 80 ppm; chloride, 14 ppm. |
| **T. 3 N., R. 32 E.** | | | | | | | | | | | | | | | | | |
| 1B1 | V. Meeks, et al. | U | 1,740 | Dr | 156 | 6 | | | | Basalt | | 115.4 | 2- 9-53 | T | | D | |
| 2B1 | Struve estate | U | 1,650 | Dr | 500 | 6 | | | | do | C | 260 | | P | 10 | D, S | |
| 2C1 | do | U | 1,670 | Dr | 175 | | | | | do | | | | P | 2.5 | | Reported inadequate for domestic supply. |
| 4D1 | James Daniel | U | 1,560 | Dr | 210 | 8 | 18 | 180 | | do | C | 65 | | P | | D | |
| 6D1 | S. Westersund | U | 1,480 | Dr | 600 | 6 | | | | do | | | | P | | D | Hardness, 75 ppm; chloride, 19 ppm. |
| 9A1 | Arthur Lindbergh. | U | 1,695 | Dr | 530 | 6 | 118 | | | do | C | 300± | | P | 30 | D | |
| 10G1 | Herman Mumm | Uv | 1,605 | Dr | 800 | 6 | 10 | | | do | | | | | | D, S | |
| 13P1 | Herman Rosenburg. | U | 1,540 | Dr | 90 | 6 | 90 | | | | C | 50 | | J | | D, S | Reported inadequate; easily pumped dry. |
| 13P2 | do | U | 1,540 | Dr | 120 | 6 | | | | Basalt | C | 63 | | J | | D, S | Do. |
| 14J1 | E. Lindberg, et al. | U | 1,560 | Dg | 61 | 72 | 12 | | | | U | | | | | N | |
| 16F1 | J. H. Hagen | U | 1,450 | Dr | 345 | | | | | | | | | P | | D, S | |
| 16F2 | do | Uv | 1,440 | Dg | 49 | | | 38 | | Basalt | U | | | | 60 | Ir | Supplies water for about 1 acre. |
| 16L1 | Joseph Snyder | Uv | 1,455 | Dr | 550 | 6 | None | | | do | C | 250 | | P | | D, S | |
| 16L2 | do | Uv | 1,445 | Dr | 235 | 6 | None | | | do | | | | P | | D, S | |
| 18B1 | Andrew Harvey | Uv | 1,360 | Dg | 17 | | | | | | U | 8.5 | 4-16-53 | P | | S | |
| 22C1 | George Mumm | U | 1,605 | Dr | 236.7 | 6 | | | | Basalt | C | 145.7 | 2- 2-53 | P | | D, S | |
| 27F1 | Charles Goodyear. | U | 1,495 | Dr | 509 | 6 | | | | do | | | | J | | D, In. | |
| 29D1 | Dr. Miller | U | 1,390 | Dr | 365 | 3 | | | | do | C | 100 | | P | | D | |
| 32P1 | Pendleton airport. | U | 1,490 | Dr | 350 | 6 | | | | do | | | | | | N | Formerly pumped 12 gpm; caved from 825 ft depth. L. |
| 33R1 | Mr. Nelson | Uv | 1,325 | Dr | 420 | | | | | do | | 400 | | P | | D, S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 3 N., R. 33 E.** | | | | | | | | | | | | | | | | | |
| 1N1 | L. Straughn | S | 1,590 | Dg | 29 | | | | | | U | 26.0 | 8-28-53 | J | | D, S | |
| 2Q1 | C. C. Curl | Uv | 1,560 | Dr | 295 | 8 | 30 | | | Basalt | C | 15 | | T | 75 | D, S, Ir | Supplies water for 3 acres. |
| 3H1 | Laura Enbysk | Uv | 1,595 | Dg | 25 | 60 | 14 | | | | U | 13.7 | 9- 1-53 | J | | D, S | |
| 5Q1 | Mr. Schaeffer | U | 1,595 | Dg | | 40 | | | | Loessial soil. | U | | | P | | D, S | Hardness, 195 ppm; chloride, 46 ppm. |
| 6R1 | Barney Anderson. | U | 1,625 | Dg, Dr | 60+ | | | | | | U | | | | | D, S | Deepend to improve dependability of supply. |
| 9Q1 | Jack Shafer | U | 1,575 | Dg | 33 | 60 | | | | | U | 21.5 | 9- 1-53 | P | | D, S | |
| 10B1 | Mrs. Fred Brown. | U | 1,580 | Dg, Dr | 38+ | | | | | | U | 26.2 | 8-28-53 | P | | D, S | Drilled well in bottom of dug well. |
| 11B1 | Everett Rothrock. | U | 1,605 | Dr | 98 | 6 | | | | Basalt | | | | J | | D, S | |
| 14L1 | McCormack Bros. | S | 1,450 | Dr | 96 | 8 | 60 | 32 | 22 | do | C | 20 | 8- -53 | J | 70 | D, S | Well flows as much as 1 gpm during rainy season. L. |
| 17A1 | Ben Cresswell | U | 1,575 | Dr | 111 | 6 | | | | | C | 51 | 6-13-53 | P | 5 | | |
| 17L1 | K. E. Ruppe, et al. | U | 1,515 | Dg | 33 | 52 | | | | | U | 25.2 | 4-14-53 | | | | |
| 18A1 | G. W. Temple | U | 1,545 | Dg | 38.5 | | | | | Loess | P | 19.6 | 1-30-53 | P | | D | H. |
| 22M1 | McCormack Bros. | Fp | 1,260 | Dr | 181 | 6 | | | | | | 12 | | | | S | Yields 15 gpm; dd, 158 ft. |
| 24Q1 | U.S. Dept. Agriculture, Pendleton Experiment Station. | U | 1,490 | Dr | 268 | 6 | | | | | C | 39 | 1- 8-54 | P | 115 | D | Pumped 105 gpm for 3½ hr; dd, 46 ft. |
| 27H1 | Frank Duff | Uv | 1,410 | Dr | 564 | 10 | 25 | 540 | 24 | Basalt | C | 20 | 11-21-53 | | | N | Plugged and abandoned. |
| 27H2 | do | Uv | 1,405 | Dr | 280 | 10 | 15 | | | do | C | 39 | 3- -53 | | 30 | N | New well not in use in 1954. |
| 27M1 | George Moens | U | 1,440 | Dr | 148 | 6 | 60 | | | do | C | 60 | | J | | D | |
| 29Q1 | Ralph Tachella | T | 1,200 | Dr | 200 | 6 | | | | | C | 15.1 | 9- 1-53 | J | | D, S | |
| 31K1 | James Rutten | T | 1,125 | Dr | 300 | 6 | | | | | | | | | | Ir | Supplies water for lawn. |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31Q1 | do | Fp | 1,120 | Dg | 35 | | | | | | | | | P | | Ir | Supplies water for 2 acres of pasture. |
| 31Q2 | do | Fp | 1,120 | Dr | 608 | 12 | 23 | 376 | 19 | Basalt | | 247 | 1956 | | 400 | Ir | New well not in use in 1956. L. Temp 54° F. |
| | | | | | | | | 550 | 58 | do | | | | | | | |
| 33J1 | Roy Duff | U | 1,420 | Dg | 70 | 96 | 10 | 10 | 60 | do | P | 45.6 | 8-27-53 | J | | D, S | |
| 34B1 | Jack Duff | U | 1,460 | Dr | 425 | 6 | 50 | 50 | 350 | do | | | | P | | D, S | Gravel to 50(?) ft. |
| 35G1 | Lee Foster | U | 1,430 | Dr | 600 | 8 | 70 | | | do | P | | | J | 100 | D | Basalt is overlain by 70 ft of gravel. Hardness, 128 ppm. |

**T. 3 N., R. 34 E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1R1 | Mrs. M. E. Pamburn. | Uv | | Dg | 23 | 36 | | | | | U | 19 | | C | | D | Reported inadequate in summer. |
| 2E1 | F. C. Lieuallen | S | 1,620 | Dr | 150 | 6 | | | | Basalt | | | | J | | D, S, Ir | Supplies water for 3 acres of pasture. |
| 3C1 | B. A. Davis | Uv | 1,560 | Dr | 160 | 6 | 25 | 160 | | do | C | 15 | 3- -44 | J | | D | Hardness, 50 ppm; chloride, 16 ppm. L. |
| 3D1 | do | Uv | 1,560 | Dr | 298 | 12 | 60 | 283 | 15 | do | C | 7 | | T | 500 | Ir | Supplies water for 60 acres; supplied 46 acre-ft during 1954. Hardness, 60 ppm; chloride, 12 ppm. L, W. |
| 3L1 | S. J. Lieuallen | S | 1,510 | Dr | 180 | 6 | 55 | | | do | C | 30 | 1948 | J | | D, S | Hardness, 105 ppm; chloride, 22 ppm. L. |
| 4G1 | City of Adams | S | 1,570 | Dr | 163 | 16 | 35 | 93 | 40 | do | C | F | | | 100 | PS | Supplied 17 acre-ft during 1954. L. |
| 6A1 | G. B. Johnson | Uv | 1,550 | Dg | 16 | 48 | | | | | U | 6 | | C | | D | |
| 10D1 | William Coppock. | S | 1,510 | Dr | 190 | 8 | 20 | | | do | C | 30 | | J | | D, S, Ir | Supplies water for 9 acres. |
| 11H1 | L. L. Rogers | Uv | 1,660 | Dr | 340 | 6 | | 65 | | do | C | 30 | | T | 130 | Ir | Supplied 72 acre-ft of water to 26 acres during 1954. L. |
| 11Q1 | John Pierce | S | 1,740 | Dg | 20 | 60 | | | | Loessial soil. | U | 17 | | P | | D | Hardness, 90 ppm; chloride 10 ppm. |
| 14R1 | Mrs. Rondeau | U | 1,775 | Dg | 35 | 72 | | | | | U | 16 | | P | | D, S | |
| 17D1 | B. G. Haynes | S | 1,430 | Dr | 503 | 6 | 27 | 444 | 19 | Basalt | C | 40 | 1950 | J | 13 | D | L. |
| 17M1 | Standard Oil Co. | U | 1,550 | Dr | 386 | 8 | | 338 | 5 | do | C | 61 | 1950 | C | 100 | In | Supplies water for fire protection. L. |
| 18M1 | Robert Rothrock. | S | 1,450 | Dr | 175 | 6 | 30 | | | do | C | 23 | 11- 2-45 | P | 10 | D, S | L. |
| 20E1 | B. G. Haynes | S | 1,480 | Dr | 155 | 8 | 7 | 131 | 13 | do | C | 14 | 8-28-53 | J | 30 | D | Hardness, 80 ppm; chloride, 16 ppm. L. |
| 22Q1 | Irvine Mann | Uv | 1,625 | Dr | 315 | 8 | 63 | | | do | P | 18 | 5- 8-44 | T | 40 | D | L. |
| 25B1 | C. C. Curl | S | 1,800 | Dr | 305 | 8 | 86 | | | do | C | 125 | 1940 | N | | N | Abandoned. Insufficient yield. L. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **T. 3 N., R. 34 E.—Continued** | | | | | | | | | | | | | | | | |
| 25C1 | C. C. Curl | S | 1,800 | Dg | 26.3 | 60 | | | | | U | 15.4 | 8-28-53 | C | | D, S | |
| 32D1 | J. H. Maloney | U | 1,535 | Dr | 159 | 8 | 54 | 110 | 44 | Basalt | C | 47.6 | 8-28-53 | T | 30 | S, Ir | Supplies water for 2 acres. Hardness, 95 ppm; chloride, 18 ppm. L. |
| 33B1 | Mary Lawyer | Uv | 1,630 | Dg | 20.3 | 96 | 8 | | | Loessial soil. | U | 16.0 | 8-28-53 | P | | D | Reported inadequate for domestic supply during dry season. Hardness, 125 ppm; chloride, 16 ppm. |
| 33M1 | Wade Menthorn | Uv | 1,570 | Dr | 190 | 6 | 22 | 151 | 41 | Basalt | C | 22 | | | | D | Yields 28 gpm; dd, 22 ft. |
| 33Q1 | L. L. Rogers | Uv | 1,640 | Dr | 414 | 10 | | | | do | P | 14 | | T | 200 | Ir | Supplied 92 acre-ft to 186 acres during 1954. L. |
| | **T. 3 N. R. 35 E.** | | | | | | | | | | | | | | | | |
| 4D1 | Anna Bell | Uv | | Dg | 16.9 | 48 | | | | | U | 13.2 | 9-3-53 | | | D, S | |
| 7P1 | B. A. Davis | Uv | | Dg | 10 | 36 | | | | | U | 7.8 | 9-3-53 | P | | | |
| 9H1 | do | Uv | | Dr | 298 | 6 | | | | Basalt(?) | U | 282.0 | 9-2-53 | | | | W. |
| 9J1 | E. B. Foster | Uv | | Dr | 481 | 8 | | | | Basalt | C | 51 | | P | | D | Pumps dry. L. |
| 15B1 | Walter Adams | Uv | | Dr | 100 | 8 | 38 | 38 | 62 | do | C | 20 | | T | 80 | Ir | Supplies water for 10 acres. L. |
| 18H1 | Frank Williams | Uv | | Dr | 176 | 6 | | 100 | | do | C | F | | J | | D, S | Pumps dry. L. |
| 19K1 | Harold Barnett | Uv | | Dr | 200 | 6 | 18 | | | | C | 18 | | P | | D | |
| 19L1 | do | Uv | | Dr | 968 | 8 | 22 | | | Basalt | C | 275 | 9-19-53 | T | | D, S | Hardness, 65 ppm; chloride, 12 ppm. L. |
| 20E1 | R. M. Thompson. | Uv | | Dg | 47.5 | 36 | | | | | U | 25.0 | 9-2-53 | | | | |
| 21N1 | Freida Lent | Uv | | Dg | 30 | 10 | | | | | U | 10 | | P | | D | |
| 28K1 | R. Thompson | U | | Dr | 470 | | | | | Basalt | | 310 | 1955 | T | 15 | D | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 3 N., R. 36 E.** | | | | | | | | | | | | | | | | | |
| 17L1 | Unknown | U | | Dg | 19.4 | | | | | | U | 8.8 | | P | | S | |
| 18K1 | A. H. Schwandt | U | | Dg | | | | | | | U | 4.4 | 8-3-53 | | | | |
| 29L1 | Gibbon School Dist. | Fp | | Dg<br>Dr | 28<br>60 | 6 | | 50 | 4 | Basalt | U | | | | | D | L. |
| 31C1 | Union Pacific Railroad. | Fp | | Dr | 80 | 6 | 56 | 71 | 9 | do | | 8 | | | | RR | L. |
| **T. 4 N., R. 26 E.** | | | | | | | | | | | | | | | | | |
| 25E1 | Unknown | T | 580 | Dr | 170 | 6 | | | | Glacio-fluviatile deposits. | P | 50.2 | 6-10-53 | J | | S | W. |
| **T. 4 N., R. 27 E.** | | | | | | | | | | | | | | | | | |
| 5B1 | U.S. Army | T | 545 | Dr | 710 | 16 | | | | Basalt | C | 80 | 1954 | T | 100 | In | Pumped 1,080 gpm; dd, 6 ft. L. |
| 8J1 | U.S. Army (well 3). | T | 625 | Dr | 453 | 15<br>12 | 256 | | | do | C | 138 | 1941 | T | 600 | PS, Ir | L. |
| 18P1 | U.S. Army (well 5). | Rc | 585 | Dr | 618 | 16<br>12 | 560 | | | do | C | 110 | | T | 1,000 | PS, Ir | L. |
| 19C1 | U.S. Army (well 4). | Rc | 585 | Dr | 600 | 16<br>12 | 430 | | | do | C | 110 | | T | 800 | PS | L. |
| 20M1 | Union Pacific Railroad. | Rc | 500 | Dr | 457 | 12 | 175 | 450 | 7 | do | C | 43 | 1945 | T | 316 | RR | Pumped 300 gpm for 3½ hr; dd, 9 ft. L. |
| 22K1 | U.S. Army (well 2). | T | 585 | Dr | 360 | 15<br>12 | 218 | | | do | C | 95 | | | | | L. |
| 22L1 | U.S. Army (well 1). | T | 585 | Dr | 327 | 12 | 150 | | | do | C | 18 | 5-1-53 | T | 1,000 | PS, Ir | Supplied 92 acre-ft of water during 1953. L, Ca. |
| 27R1 | U.S. Army (housing project well). | T | 600 | Dr | 543 | 16<br>12<br>10<br>6 | 146<br>346<br>530<br>97 | 538 | 5 | do | C | 121 | | T | 750 | PS | L. Temp. 58° F. |
| 28E1 | V. R. Fulton | T | 545 | Dr | 102 | 6 | 97 | 97 | 5 | Loose gravel. | U | 64 | | | | D | Reportedly yields 30 gpm; drawdown slight. L. |
| 28E2 | do | T | 550 | Dr | 119 | 12 | | 72 | 8 | "Pea gravel". | U | 64 | | | | | Pumped 820 gpm for 17 hr; drawdown slight. L. |
| 28G1 | S. F. Hoyt | T | 570 | Dr | 126 | 12 | 126 | 73 | | Gravel | U | 73 | 1954 | T | 1,250 | Ir | Supplies water for 150 acres. L. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 4 N., R. 27 E.—Continued** | | | | | | | | | | | | | | | | | |
| 32A1 | R. G. Holzapfel | T | 575 | Dr | 106 | 16 | 100 | | | Glaciofluviatile deposits. | U | 65 | | T | | Ir | Pumped 960 gpm for 7 hrs; drawdown slight. |
| 32G1 | G. B. Holzapfel | T | 590 | Dr | 123 | 12 | | | | do | | 77 | 1954 | T | 450 | Ir | Drilled entirely in glaciofluviatile sand, gravel, and clay. Supplies water for 18 acres. |
| 32J1 | R. G. Holzapfel | T | 595 | Dr | 310 | 12 | | 90 | | Glaciofluviatile deposits and basalt. | | 90 | | T | 600 | Ir | Supplies water for 111 acres. L. Temp 70° F. |
| 33C1 | C. F. Collman | Rc | 560 | Dr | 100 | 16 | | 32 | | do | | 20 | | T | 2,000 | Ir | Basalt is overlain by 32 ft of glaciofluviatile sand and gravel. Pumped 2,300 gpm for 1 hr; dd, 7 ft. Supplied about 15 acre-ft of water for 60 acres during 1955. |
| 33H1 | McDole Bros | Rc | 560 | Dr | 96 | 12 | 96 | 65 | 30 | Glaciofluviatile deposits. | U | 63 | 1950 | T | 520 | Ir | Supplies water for 80 acres. L. Temp 62° F. |
| 33J2 | do | Rc | 560 | Dr | 96 | 12 | 75 | | | do | | 69 | 12-1-54 | T | 520 | Ir | Supplies water for 80 acres; reportedly in operation for 1,440 hr during 1953. L. Temp 62° F. |
| 36D1 | G. W. Redwine | T | 590 | Dr | 812 | 15<br>10 | 122 | 67<br>703 | 23<br>72 | Sand<br>Basalt | U<br>C | 65<br>77.6 | 3-1-58<br>6-9-59 | | | Ir | Sand, gravel, clay to 207 ft; basalt below. Has 10-inch liner from 357 to 394 ft. |
| 36E1 | do | T | 575 | Dr | 194 | 12 | | | | do | U | 55 | 1955 | T | 225 | Ir | Supplied 141 acre-ft to 40 acres during 1954. L. |

T. 4 N., R. 28 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1H1 | A. J. Rathke | Rc | 470 | Dr | 100 | 6 | 100 | -------- | -------- | Sand | U | 55 | 1949 | J | -------- | D | Hardness, 95 ppm; chloride, 14 ppm. |
| 10F1 | City of Hermiston. | Rc | 470 | Dr | 160 | 12 | 64 | 154 | 6 | Basalt | C | 30 | 1937 | T | 175 | N | L. Temp 62° F. |
| 10P1 | do | Rc | 475 | Dr | 500 | -------- | -------- | 375 | -------- | do | C | F | -------- | T | 250 | PS | Supplied 38 acre-ft of water during 1954. Ca. |
| 11N1 | do | Rc | 455 | Dr | 962 | 20 | 92 | -------- | -------- | do | C | 12 | 1954 | T | -------- | PS | Pumped 2,315 gpm for 3 hr; dd, 134 ft. Ca. |
| 11P1 | do | Rc | 500 | Dr | 918 | 18 | 598 | -------- | -------- | do | C | F | -------- | T | 1,200 | PS | Supplied 800 acre-ft of water during 1954. L. |
| 16B1 | A. C. Langenwalter. | T | 500 | Dr | 282 | 8 | -------- | -------- | -------- | do | -------- | 90 | 1953 | T | -------- | D | Pumped 35 gpm for three-quarters of an hour; dd, 120 ft. Temp 70° F. |
| 18D1 | Otto Lubbes | T | 530 | Dr | 57 | 6 | 57 | -------- | -------- | Sand and gravel. | U | -------- | -------- | -------- | -------- | D | |
| 20H1 | E. L. Jackson | S | 490 | Dg | 31 | 16 | 6 | 10 | 21 | Gravel | U | 25 | -------- | C | -------- | D, S | |
| 20N1 | C. O. Porter | S | 510 | Dr | 145 | 8 | 125 | 125 | 20 | Basalt | P | -------- | -------- | N | -------- | Ir | New well not in use in 1956; pumped 40 gpm; dd, 50 ft. L. |
| 21A1 | Cleve Clark | T | 560 | Dr | 65 | 4 | -------- | 52 | 13 | -------- | U | 20 | -------- | J | -------- | D, S | Hardness, 110 ppm; chloride, 12 ppm. |
| 24A1 | Ray Moses | T | 655 | Dr | 427 | 6 | 30 | 402 | 25 | Basalt | C | 15 | -------- | J | -------- | D | L. |
| 24A2 | Frank Ille | T | 655 | Dr | 155 | 8 | 30 | 100 | 55 | Sandy "clay." | C | 16 | -------- | J | -------- | D | Entirely in glaciofluviatile deposits. |
| 24C1 | W. R. Ille | T | 645 | Dr | 105 | 6 | 28 | 100 | 5 | do | C | 18 | -------- | J | -------- | D | |
| 27J1 | Union Pacific Railroad (Hinkle station). | T | 610 | Dr | 553 | 16<br>12 | 547 | 513 | 24 | Basalt | C | 155 | 1950 | T | 1,150 | RR | Pumped 1,200 gpm for 1 hr; dd, 10 ft. L. |
| 28A1 | W. T. Turner | T | 590 | Dr | 200 | 12<br>10 | 120 | 80 | 35 | Gravel | U | 81 | 4-25-58 | T | -------- | Ir | Sand to 20 ft, coarse gravel to 115 ft, and blue clay to 200 ft. Pumped 1,100 gpm; dd, 6 ft. |

T. 4 N., R. 29 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3L1 | Gene Gray | Rc | 610 | Dr | 140 | 6 | -------- | -------- | -------- | -------- | C | 35 | -------- | J | -------- | D, S | |
| 3N1 | do | Rc | 610 | Dr | 754 | 12-10 | 167 | -------- | -------- | Basalt | C | 35 | -------- | -------- | -------- | Ir | Supplies water for 64 acres. Pumped 350 gpm. L. |
| 4C1 | K. H. Williams | Rc | 495 | Dr | 140 | 6 | -------- | -------- | -------- | -------- | C | 2 | -------- | C | -------- | D, S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s) | | | Ground-water occurrence | Water level | | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Depth to top (feet) | Thickness (feet) | Character of material | | Feet below datum | Date | | | | |
| **T. 4 N. R. 29 E.—Continued** | | | | | | | | | | | | | | | | | |
| 5R1 | C. C. Harpster | Rc | 615 | Dr | 770 | 10 | | 140 | 120 | Basalt | C | 66 | 9-18-53 | T | 135 | Ir | Supplied 29 acre-ft to 20 acres during 1955. Hardness, 75 ppm; chloride, 10 ppm. |
| 6L1 | Frank Rodda | Rc | 460 | Dr | 200 | 6 | 100 | | | do | C | 11 | | J | | D, Ir | Sand to 100 ft. Hardness, 50 ppm; chloride, 18 ppm. |
| 8G1 | Hermiston Farms, Inc. | T | 640 | Dr | 170 | 6 | | | | | C | 100 | | J | | D | |
| 9E1 | E. Walchli | T | 635 | Dr | 240 | 6 | 200 | 200 | 40 | Basalt | C | 30 | | P | | D, S | |
| 10A1 | T. Higgenbotham. | T | 630 | Dr | 73.8 | 6 | | | | Glaciofluviatile deposits. | U | 10.6 | 9-18-53 | C | | D | Hardness, 110 ppm; chloride, 42 ppm. |
| 11B1 | Marvin Hurd | Rc | 650 | Bd | 30 | 6 | 20 | 20 | 10 | Gravel and clay. | U | 5.1 | 9-16-53 | C | 6 | D | L. |
| 12B1 | Peter Kosmos | Rc | 640 | Dr | 330 | 6 | | | | | C | 230 | | P | | S | |
| 13C1 | Ray Meyersick | Rc | 625 | Dr | 70 | 4 | | | | | | 12 | | C | | D, S | |
| 13K1 | Edwards Farms, Inc. | Rc | 740 | Dr | 527 | 12 | | | | Basalt | C | 76 | 1954 | T | | Ir | Supplies water for 360 acres; supplied 1,475 acre-ft during 1954. L. |
| 13N1 | do | Rc | 680 | Dr | 425 | 6 | 140 | 410 | 15 | do | C | 55 | | T | 300 | Ir | Reportedly supplied 142 acre-ft to 80 acres during 1954. L. Hardness, 60 ppm; chloride, 54 ppm. |
| 17C1 | Ben Dryer | T | 680 | Dr | 245 | 12 | | 101 | 44 | Glaciofluviatile deposits. | C | 90 | 1955 | T | | Ir | Pumped 1,500 gpm; supplies water for 110 acres. L. |
| 18J1 | I. J. Couch | T | 675 | Dr | 262 | 12 | | | | Basalt | C | 65 | 1954 | | | Ir | New well in 1956; owner plans to irrigate 160 acres. Soil and clay to 225 ft; basalt below. Pumped 1,250 gpm; dd, 83 ft. |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23G1 | Carl Johnson | Rc | 700 | Bd | 26.8 | 6 | | | | Glacio-fluvia-tile deposits. | U | 11.7 | 9-16-53 | J | | D, S | Hardness, 95 ppm; chloride, 64 ppm. |
| 26D1 | Otto Broker | Rc | 650 | Dg | 14 | 36 | | 12 | 2 | do | U | 11.1 | 9-25-53 | C | | D, S | Hardness, 120 ppm; chloride, 8 ppm. |
| 27L1 | R. P. Leslie | Rc | 650 | Dr | 52 | 4 | | | | | | 9.8 | 9-18-53 | C | | D, S | |
| 28Q1 | Vernon Bryant | Rc | 650 | Dg | 18 | 36 | 10 | | | | U | 10.2 | 9-25-53 | P | | N | |
| 29L1 | Del Harmon | T | 700 | Dr | 123 | 6 | | | | Glacio-fluvia-tile deposits. | U | 17.7 | | J | | D | Hardness, 75 ppm; chloride, 6 ppm. |
| 29L2 | W. C. Gifford | T | 725 | Dr | 126 | 6 | 97 | 40 | | | C | 30 | | J | | D, S | |
| 32L1 | City of Stanfield. | Rc | 605 | Dr | 187 | 10-6 | | | | | C | 23 | 1945 | | 125 | PS | |
| 33N1 | C. Boylen | Rc | 660 | Dr | 80 | 6 | | | | | | | | J | | D, S | |
| 34R1 | George Ransier | T | 755 | Dr | 300 | | | | | | | | | T | | D, S | Hardness, 20 ppm; chloride, 33 ppm. |
| 34R2 | do | T | 755 | Dr | 161 | 7 | | | | Glacio-fluvia-tile deposits. | P | 81.1 | 5-22-53 | N | | N | H. |

T. 4 N., R. 30 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8J1 | Pete Kosmos | T | 800 | Dr | 230 | 6 | | | | | | 200 | | P | | D, S | |
| 14F1 | Bob Terney | T | 1,060 | Dr | 365 | 6 | | | | Basalt | C | 175 | | P | | S | |
| 25B1 | Mr. Hocken-smith. | Uv | 945 | Dr | 310 | 6 | | | | do | C | 35 | | P | | D | |
| 26A1 | J. J. Lorenzen | Uv | 925 | Dr | 240 | 6 | | | | | | 100 | | P | | D | Hardness, 40 ppm; chloride, 36 ppm. |
| 32P1 | G. M. Ransier | Uv | 720 | Dr | 65 | 8 | | | | | | 10 | | J | 20 | D, S | Hardness, 90 ppm; chloride, 35 ppm. |
| 33Q1 | Mr. Coleman | Uv | 850 | Dg | 25 | | | | | Loessial soil. | U | 9.4 | 6-13-53 | J | 12 | Ir | Supplies water for lawn. Hardness, 85 ppm; chloride, 49 ppm. |
| 33Q2 | do | Uv | 870 | Dr | 260 | 6 | | | | Basalt | C | 30 | | P | | D, S | Hardness, 90 ppm; chloride, 37 ppm. |
| 35Q1 | Leonard Lorenzen. | Uv | 955 | Dr | 612 | 6 | | 574 | 38 | do | C | 65 | | T | 130 | Ir | Supplied 27.6 acre-ft to 25 acres in 1954. |

T. 4 N., R. 31 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2F1 | Glen Thorne | Uv | 1,185 | Dg | 25 | 48 | | | | | U | 12 | | P | | D, S | |
| 5E1 | Mr. Guerrant | Uv | 1,005 | Dg | 16 | | | 10 | 6 | Basalt | P | 5 | | J | | D, S | |
| 8B1 | M. Kilgore | Uv | 1,070 | Dr | 430 | 6 | 27 | 400 | 30 | | C | | | P | 20 | D | Hardness, 75 ppm; chloride, 27 ppm. |
| 8H1 | do | Uv | 1,090 | Dg | 30 | | | | | | U | 10 | | P | | S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 4 N., R. 31 E.—Continued** | | | | | | | | | | | | | | | | | |
| 9P1 | R. E. Bissinger | Uv | 1,200 | Dr | 342 | 8 | 25 | 280 | 62 | Basalt | C | 160 | 1952 | T | 15 | D, S | Ca, L. |
| 9Q1 | Dewey Purcell | Uv | 1,275 | Dr | 175 | 8 | 12 | 79 | | do | C | 20 | | | 5 | D | L. |
| 14E1 | Mr. Pell | Uv | 1,305 | Dg | 20 | | | | | Soil | U | 14.1 | 4-15-58 | | | D, S | |
| 14L1 | Lee Bissinger | Uv | 1,320 | Dr | 280 | | | | | | | | | T | | D, S | Hardness, 220 ppm; chloride, 99 ppm. |
| 18D1 | Bob Terney | U | 1,230 | Dr | 350 | 6 | | 290 | | Basalt | | 290 | | P | | D | |
| 23H1 | A. H. Schluter | Uv | 1,370 | Dr | 463 | | | 447 | 16 | do | C | 130 | | | 20 | | L. Temp 62° F. |
| 24P1 | R. O. Earnheart | Uv | 1,400 | Dr | 250 | 6 | 16 | 50 | | do | | 175 | | T | | D, S | |
| 29B1 | Unknown | Uv | 1,150 | Dg | 24.6 | 30 | | | | | U | 11.8 | 4-16-53 | P | | N | |
| 29D1 | C. A. Case | Uv | 1,050 | Dr | 270 | 6 | | | | | C | 30 | | P | | D, S | Hardness, 20 ppm; chloride, 48 ppm. |
| 29M1 | Mr. Terney | Uv | 1,025 | Dg | 97 | | 20 | | | | U | Dry | 4-16-53 | J | | D, S | Usually goes dry late in each summer. |
| 29P1 | Henry Nelstrom. | Uv | 1,125 | Dr | 400 | 6 | 19 | | | Basalt | C | 110 | | P | 16 | D | |
| 29P2 | do | Uv | 1,050 | Dg | 33 | | | | | | U | 20 | | P | | S | |
| 30F1 | Glen Simpson | Uv | 970 | Dr | 310 | 6 | 29 | 283 | 22 | Basalt | | 80 | | | | D | Pumped 24 gpm; dd, 3 ft. L. |
| 33K1 | John Holmgren | Uv | 1,125 | Dr | 219 | 6 | 8 | 100 | 119 | do | | 119 | | P | | D, S | Hardness, 105 ppm; chloride, 50 ppm. |
| **T. 4 N., R. 32 E.** | | | | | | | | | | | | | | | | | |
| 1K1 | G. E. Jenske | Uv | 1,740 | Dg | 23.9 | | | | | | U | 22.1 | 4-14-53 | P | | N | |
| 2K1 | Janet Dand | Uv | 1,690 | Dg | 38 | | | | | | U | 29.6 | 4-14-53 | P | | N | |
| 2M1 | L. King | Uv | 1,660 | Dr | 527 | 10 | | | | Basalt | C | 20 | | T | 115 | Ir | W. |
| 3C1 | E. C. Enoch | Uv | 1,600 | Dg | 22 | | | | | | U | 17 | | | | D, S | |
| 3J1 | L. King | Uv | 1,655 | Dr | 168 | 8 | 46 | | | Basalt | C | 32 | 1947 | | 32 | D | L. |
| 12N1 | Janith Dand estate. | Uv | 1,720 | Dr | 72 | 6 | | | | | | 40 | | J | | D, S | |
| 18R1 | W. R. Meiner | Uv | 1,320 | Dr | 200 | 8 | | | | Basalt | C | 20 | | | | D | Yields 10 gpm; dd, 36 ft. L. |
| 24D1 | Mrs. A. Baker | U | 1,670 | Dg | 30 | 60 | 8 | | | | U | 30.0 | 9-15-53 | P | | D, S | |
| 26K1 | Robert Campbell. | U | 1,610 | Dr | 168 | 6 | | | | | | | | T | | D | Pumped 7 gpm for 2 hr; dd, 150 ft. |
| 33A1 | Mr. Lorenzen | U | 1,640 | Dr | 300 | | | | | Basalt | C | 150 | | P | | D, S | |
| 33R1 | do | Uv | 1,590 | Dr | 545 | 6 | | | | do | C | 112.0 | 4-13-53 | N | | N | Pumped 2½ gpm. W. |
| 35J1 | Kenneth Bowman. | U | 1,690 | Dr | 200 | | | | | | | | | P | | D, S | Hardness, 85 ppm; chloride, 20 ppm. |

T. 4 N., R. 33 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1F1 | E. Timmerman | U | 1,860 | Dg | 50.1 | 36 | 12 | | | Loess | U | 40.2 | 4-15-53 | P | | N | |
| 2P1 | City of Helix | U | 1,760 | Dg | 52.5 | | | | | do | U | 30.0 | 7-30-53 | T | 200 | PS | Pumps dry in 3 hr; furnishes city 36,000 gpd. |
| 2P2 | do | U | 1,760 | Dr | 600 | 6 | | | | Basalt | C | 125 | | T | | N | Abandoned because of crooked hole. |
| 5L1 | R. H. Leisinger | U | 1,795 | Dg | 65 | | | | | Loess | U | 50 | | J | | D | Hardness, 200 ppm; chloride, 44 ppm. |
| 6M1 | Isabel Turner | Uv | 1,740 | Dg | 37 | | | | | Loessial soil. | U | 28.6 | 4-14-53 | P | | S | |
| 6R1 | Ernest Koepke | Uv | 1,780 | Dg | 70 | | | | | do | U | 50 | | P | | S | |
| 11R1 | Mrs. Roy Penland. | U | 1,740 | Dg | 50.5 | 48 | 3 | | | Loess | U | 30.5 | 9-15-53 | J | | D | |
| 14J1 | S. E. Brogoitti | U | 1,745 | Dg | 46 | 48 | | | | do | U | 43.7 | 9-15-53 | P | | D, S | |
| 15Q1 | Lester Wilson | U | 1,810 | Dg | 79.5 | 48 | 12 | | | Loessial soil. | U | 66.7 | 9- 4-53 | J | | D, S | |
| 23F1 | W. H. Reeder | U | 1,780 | Dg | 92.5 | 48 | | | | | U | 80.6 | 9- 4-53 | P | | N | |
| 24R1 | George Woodward. | U | 1,720 | Dg | 84.3 | 36 | 15 | | | | U | 70.3 | 9- 4-53 | P | | | |
| 28P1 | John Molstrom | U | 1,920 | Dr | 192 | 6 | 20 | | | | | 50 | 1951 | J | | D, S | |
| 29C1 | Peterson Bros | Uv | 1,710 | Dr | 155 | 6 | 40 | | | Basalt | C | 45 | | P | 20 | D | Reported 40 ft of loess overlies basalt. |
| 29K1 | J. C. Hawkins | U | 1,740 | Dr | 211 | 6 | 60 | | | do | C | 53 | | J | 20 | D | Ca, L. |
| 32N1 | Carl Hudeman | U | 1,670 | Dg | 46.6 | 36 | | | | | U | 40.0 | 4- 4-53 | P | | D, S | |
| 33B1 | Frank Molstrom | U | 1,680 | Dr | 200 | 8 | | | | Basalt | C | 35 | | | | D | Yields 30 gpm; dd, 35 ft. L. |
| 33C1 | F. Hudeman | U | 1,690 | Dg | 50.4 | 60 | | | | | U | 42.4 | 9- 4-53 | P | | D, S | |
| 35Q1 | I. Christopher | U | 1,640 | Dg | 32.5 | 48 | | | | | U | 23.6 | 9- 1-53 | P | | N | |
| 36R1 | John Hales | U | 1,670 | Dg | 37 | 60 | 10 | | | Loess | U | 34.6 | 9- 1-53 | J | | D | Hardness, 85 ppm; chloride, 16 ppm. |
| 36R2 | do | U | 1,630 | Dr | 258 | 6 | 69 | 90 | | Basalt | C | 43 | 1948 | J | 18 | D, S | Hardness, 85 ppm; chloride, 16 ppm. L. |

T. 4 N., R. 34 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E1 | Richard Thompson. | Uv | 1,850 | Dg | 33.4 | 60 | 12 | | | Loess | U | 12.9 | 9- 9-53 | P | | D, S | |
| 6H1 | George Piper | Uv | 1,760 | Dg | 21 | 60 | | 13 | 8 | Gravel underlying loessial soil. | U | 13.1 | 9-10-53 | C | | D | Hardness, 90 ppm; chloride, 40 ppm. |
| 6L1 | R.B. Taylor | U | 1,895 | Dr | 505 | 8 | | 470 | 30 | Basalt | C | 90 | 1952 | T | | D, S | Quickly pumps dry; reportedly yields about 18 gpm. Hardness, 75 ppm; chloride, 12 ppm. Ca, L. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | T. 4 N., R. 34 E.—Continued | | | | | | | | | |
| 10D1 | Joe Cannon | Uv | 1,800 | Dg | 27 | 36 | | | | | U | 16.8 | 9-10-53 | P | | D, S | |
| 12G1 | Unknown | Uv | 1,820 | Dg | 14.1 | 36 | | | | | U | 7.9 | 9-9-53 | P | | D, S | |
| 12L1 | Herbert Whitmore. | Uv | 1,800 | Dr | 800 | 6 | 185 | | | Basalt | C | 120 | | T | 15 | D, S | L. |
| 15G1 | Jay Scott | Uv | 1,760 | Dr | 205 | 8 | | | | do | C | 30 | 1946 | J | 7 | D, S | L. |
| 17A1 | H. M. Hale | Uv | 1,745 | Dg | 20 | 8 | | | | Gravel | U | 12 | | C | | D, S | |
| 18P1 | R. A. Brogoitti | Uv | 1,690 | Dr | 116 | 8 | 26 | 60 | 12 | Basalt | C | 12 | 8- -53 | T | 40 | D, S, Ir | Supplies water for 2 acres. |
| 20N1 | Harold Gerking | U | 1,610 | Dg | 40 | 48 | | | | | U | 22.5 | 9-4-53 | J | | D, S | |
| 22H1 | Dean Dudley | U | 1,720 | Dr | 260 | 6 | 117 | 63<br>210 | 11<br>10 | Gravel and sand.<br>Basalt | P | 200 | 1945 | C | | D, S | Bails dry at 20 gpm. L. |
| 22K1 | Mr. Sampson | U | 1,700 | Dg | 30 | | | | | Loess | U | 27 | | P | | D | Pumps dry in 1 hr. Ca. |
| 24R1 | Rogers Canning Co. (well 3). | Uv | 1,645 | Dr | 1,148 | 24-12 | 102 | {1,025<br>{1,144 | 6<br>4 | Basalt<br>do | }C | F | | T | 550 | In | Supplies water for cannery; flows during winter season; supplied 65 acre-ft during June and July 1954. L. |
| 26H1 | M. F. Sheard | Uv | 1,645 | Dr | 65 | 8 | 32 | | | | | 15 | 10-24-45 | | 40 | D | L. |
| 26J1 | O. L. Straughn | Uv | 1,650 | Dr | 333 | 8 | 28 | 265 | | Basalt | C | 25 | | | 25 | D | |
| 26J2 | Neil McIntyre | Uv | 1,650 | Dr | 200 | 4 | 138 | | | do | C | 34 | 10-16-45 | C | | D | L. |
| 27Q1 | Gillanders and Burroughs. | Uv | 1,590 | Dg | 12.9 | 48 | | | | | U | 9.5 | 4-24-53 | N | | N | |
| 28E1 | Nettie Woodward. | U | 1,675 | Dr | 979 | 8 | | | | Basalt | C | 121 | 1946 | T | 18 | D, S | L. |
| 30R1 | Vina Hales | U | 1,660 | Dg | 57.3 | 60 | 6 | | | | U | 54.3 | 8-29-53 | J | | D | |
| 32M1 | L. L. Rogers (well 1). | Uv | 1,555 | Dr | 842 | 10 | 42.5 | 600 | | Basalt | C | 13 | | T | 120 | Ir | Supplied 60 acre-ft to 46 acres during 1954. L. |
| 32N1 | L. L. Rogers (well 3). | Uv | 1,555 | Dr | 451 | 8 | | | | do | C | 40 | 1953 | T | 80 | Ir | Supplied 6½ acre-ft to 20 acres during 1954. L. |
| 33Q1 | L. L. Rogers (well 2). | Uv | 1,560 | Dr | 414 | 10 | 20 | | | do | | | | T | | Ir | Supplies water for 43 acres. Hardness, 70 ppm; chloride, 16 ppm. L. |
| 34P1 | Wild Horse Grange. | Fp | 1,555 | Dr | 209 | 6 | 23 | 165 | 3 | do | C | 18 | 1947 | T | | | L. |

T. 4 N., R. 35 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8E1 | F. Swaggart | U | ------ | Dg | 23.5 | ------ | ------ | ------ | ------ | ------ | U | 18.9 | 9-3-53 | P | ------ | D, S | |
| 8M1 | J. H. McDougal | U | ------ | Dr | 106 | 8 | 20 | 29 | ------ | Basalt | ------ | ------ | ------ | T | ------ | D | Hardness, 80 ppm; chloride, 8 ppm. L. |
| 18H1 | C. J. Scheard | U | ------ | Dr | 100 | 6 | 60 | 90 | 10 | do | C | 42 | ------ | J | ------ | D, S | |
| 19E1 | Rogers Canning Co. (well 1). | U | ------ | Dr | 1,070 | ------ | ------ | 270 | ------ | do | C | 5 | 4- -41 | T | ------ | In | Supplied 63.6 acre-ft during 1953. L. |
| 19E2 | Rogers Canning Co. | U | | Dr | 1,156 | 12 | ------ | ------ | ------ | do | C | 16 | 1944 | N | ------ | N | L. |
| 19E3 | Athena Mill Co. | U | ------ | Dr | 46 | 12 | 44 | 10 | ------ | Gravel | U | 6 | 7- -56 | ------ | ------ | In | Supplies mill pond; pumped 90 gpm for ½ hr; dd, 40 ft. L. |
| 19L1 | City of Athena (well 1). | Uv | ------ | Dr | 680 | 12 | 82 | ------ | ------ | Basalt | C | F | ------ | T | 75 | PS | Standby well. L. |
| 19L2 | City of Athena | Uv | ------ | Dr | 1,200 | 12 | ------ | ------ | ------ | do | C | 15 | 1948 | T | 500 | PS | Supplies city population of 750; supplied 218 acre-ft during 1953. |
| 29P1 | Henry Koepke | Uv | ------ | Dr | 486 | 8 | ------ | ------ | ------ | do | C | ------ | ------ | T | ------ | D | L. |
| 34M1 | R. V. Wood | U | ------ | Dr | 900 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | P | ------ | D, S | |

T. 5 N., R. 26 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23J1 | Mrs. Carl Hubbert. | T | 280 | Dr | 71 | 6 | 70 | 45 | 26 | Sand | U | 27 | 5-16-58 | J | 5 | D | Sand to 5 ft, sand and gravel to 45 ft. |
| 26E1 | C. E. Early | T | 325 | Dr | 235 | 6 | ------ | ------ | ------ | Basalt | C | F | 1956 | T | ------ | N | Not in use in 1956; to be used for irrigation. |

T. 5 N., R. 27 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19P1 | Irrigon School | T | 280 | Dr | 190 | 6 | ------ | ------ | ------ | Gravel and sand. | U | ------ | ------ | T | ------ | PS | |
| 30C1 | Albert Partlow | T | 300 | Dr | 70 | 6 | ------ | 50 | 19 | do | U | 50 | ------ | ------ | ------ | D | Sand to 3 ft, sand and gravel to 69, and basalt to 70 ft. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 5 N., R. 28 E.** | | | | | | | | | | | | | | | | | |
| 9Q1 | Bonneville Power Administration. | S | 299 | Dr | 115¼ | 8 | 115 | 98 | 13 | Gravel | U | 54 | 1953 | T | 350 | In | Pumped 225 gpm; dd, 13 ft. |
| 10R1 | U.S. Army Corps of Engineers. | S | 370 | Dr | 167 | 12<br>10 | 127<br>167 | 95 | 51 | Glacio-fluviatile deposits. | U | 96 | 1947 | | 224 | N | L. |
| 10R2 | do | S | 370 | Dr | 704 | 16 | 320 | 470 | | Basalt | C | | | T | 2,400 | PS | Has submersible pump. L. |
| 10R3 | do | S | 360 | Dr | 777 | 24 | 300 | | | do | C | 145 | 1952 | T | 1,300 | PS | This well and 10R2 have mutual interference. L. |
| 15N1 | Mr. Ramsey | S | 430 | Dr | 90 | 6 | 16 | | | do | | 50 | | J | | | |
| 16A1 | Ben Shapler | S | 450 | Dr | 385 | 8 | | | | do | | 100 | | T | | PS | Pumped 25 gpm for 30 hr; dd, 20 ft. |
| 16R1 | Power City | S | 430 | Dr | 222 | 16 | | 198 | 24 | do | C | 100 | | T | 18 | PS | Community well; inadequate to supply 15 families. |
| 17G1 | City of Umatilla (auxiliary well). | T | 295 | Dr | 536 | 10–8 | 66 | | | Basalt | C | 70 | 1953 | T | | PS | Flowed until 1944; water level dropped to 32 ft by 1947 and to 70 ft by 1953. |
| 17J1 | City of Umatilla (well 1). | T | 295 | Dr | 133 | 6 | | | | | | | | N | | N | Abandoned; bridged at 12-ft depth. |
| 18H1 | Union Pacific Railroad. | T | 290 | Dr | 192 | | | 170 | 22 | Basalt | | | | | | RR | |
| 19A1 | City of Umatilla (well 3). | S | 540 | Dr | 785 | 16<br>10<br>8<br>6 | 170<br>373<br>535<br>8 | 755 | 30 | do | C | 115 | 11–19–47 | T | 1,000 | PS | L. Temp 71° F. |
| 22D1 | Munson Court | Sc | 450 | Dr | 189 | | | | | Basalt | C | 7.0 | 9–26–53 | P | | D | Pumping dd, 13 ft. Hardness, 100 ppm; chloride, 22 ppm. W. |
| 23M1 | Bill Kik | Rc | 460 | Dr | 160 | 6 | 21 | 87 | 8 | do | C | 68 | 11–1–44 | J | 3 | D | L. |
| 26Q1 | C. P. Baggett | T | 480 | Dr | 54 | 4 | | | | | U | 32 | | J | | D, S | Supplies water for turkey farm. |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27B1 | Charles Tracts Water Co. | T | 465 | Dr | 200 | | | | | | | | | T | | PS | Supplies 20 families; inadequate at times in summer. |
| 34H2 | F. C. Booth | U | 520 | Dr | 161 | 10 | 100 | 150 | 11 | Basalt | C | 85 | | T | 200 | PS | Supplies domestic water for 25 families. Hardness, 110 ppm; chloride, 12 ppm. |
| 34H3 | F. C. Booth | U | 520 | Dr | 162 | 10 | | 120 | | do | C | 85 | | T | 300 | PS | Auxiliary to well —34H2; driller reports 110 ft of sand and clay overlies basalt. |
| 35N1 | Ruby Welch | T | 525 | Dr | 178 | 6 | 168 | 92 | | Glaciofluviatile deposits. | | | | N | | N | About 168 ft of sand and gravel overlies broken basalt. Pumped 125 gpm for 4 hr; dd, 78 ft. To be used for irrigation. |
| | | | | | | | | | T. 5 N., R. 29 E. | | | | | | | | |
| 13E1 | Walso Birchman. | S | 400 | Dr | 505 | | | 76 | | Basalt | C | 39 | 1948 | | | D | Pumped 1,089 gpm; dd, 108 ft. L. Temp. 63° F. |
| 14H1 | William Campbell. | Fp | 380 | Dr | 56.6 | 6 | | | | | | 4.8 | 9-30-53 | | | | |
| 27C1 | Thompson Meat Co. | S | 470 | Dr | 102 | 6 | 6 | 100 | 2 | Basalt | C | 12 | | J | 16 | In | |
| 27Q1 | H. W. Lambert | S | 550 | Dr | 136 | 6 | 11 | 107 | 29 | Soft rock and "clay" (?). | C | 15 | | J | | D, S | Hardness, 85 ppm; chloride, 24 ppm. |
| 28B1 | W. O. Whitsett | S | 460 | Dg | 98 | 22 | 20 | | | | U | 5.8 | 9-29-53 | P | | D | |
| 28R1 | Golda Myrick | S | 465 | Dr | 100 | 6 | | | | | | 15 | | J | | D, S | |
| 29E1 | Gordon Spearman. | S | 455 | Dn, Dr | 43.3 | 4 | 43.3 | 20 | 13 | Sand and gravel. | U | 19.4 | 9-29-53 | C | | D | Entirely in glaciofluviatile deposits. |
| 32N1 | M. A. McPheters. | S | 450 | Dn | 30 | 1½ | 30 | | | Sand | U | 13 | | C | | D | |
| 33R1 | Union Pacific Railroad. | T | 615 | Dr | 298 | 10 | 111 | | | Basalt | C | 58 | | J | 36 | D | L. Temp 62° F. |
| 34C1 | Curtin Walls | S | 545 | Dr | 60 | 6 | 12 | 45 | 5 | "Porous rock". | U | 45 | | P | 2 | D, S | |
| 36H1 | R. L. Brock | S | 650 | Dr | 280 | 6 | | | | | | | | P | | D, S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s) | | | Ground-water occurrence | Water level | | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Depth to top (feet) | Thickness (feet) | Character of material | | Feet below datum | Date | | | | |
| **T. 5 N., R. 30 E.** | | | | | | | | | | | | | | | | | |
| 25F1 | Peter Kosmos | Uv | 850 | Dg | 18 | 36 | | | | Soil | U | 16.7 | 9-28-53 | | | | |
| 25F2 | do | Uv | 850 | Dr | 215 | 6 | 22 | | | Basalt | C | 17 | 10-1-58 | J | | D | Sand and silt to 16 ft, basalt to 215 ft. |
| 25J1 | Dale Tucker | Uv | 860 | Dg | 18 | | | | | Soil | P | 15 | | J | | D | |
| 26L1 | Peter Kosmos | Uv | 850 | Dg | 23.2 | 36 | | | | | U | 21.0 | 9-28-53 | C | | D, S | |
| **T. 5 N., R. 31 E.** | | | | | | | | | | | | | | | | | |
| 1P1 | Peter Kosmos | Uv | 1,150 | Dr | 97 | 6 | 30 | 54 | 43 | Basalt | C | 23 | 1950 | J | 10 | D | L. |
| 12H1 | do | U | 1,325 | Dr | 300 | 6 | | 270 | 30 | do | U | 280 | | P | | | |
| 29C1 | E. C. McCook | Uv | 900 | Dg | 24.5 | | | | | Alluvium | U | 15.6 | 4-14-53 | C | | S | |
| 33D1 | B. D. Grilley | Uv | 970 | Dg | 10.2 | | | | | do | U | 9. | 4-15-53 | P | | | |
| 34F1 | Mr. Holdman | Uv | 1,050 | Dr | 220 | 8 | | | | | | 110 | | P | | D, S | |
| **T. 5 N., R. 32 E.** | | | | | | | | | | | | | | | | | |
| 3P1 | S. Ornlid | Uv | 1,525 | Dg | 41.5 | 36 | | | | | U | 17.4 | 9-11-53 | J | | D, S | |
| 4J1 | Ruth Furnish | Uv | 1,450 | Dg | 16 | 72 | | | | | U | 11.8 | 9-11-53 | P | | | |
| 10A1 | Knutson Bros | Uv | 1,600 | Dg | 31.8 | 60 | | | | | U | 24.4 | 9-11-53 | P | | D, S | |
| 16Q1 | Einer Knutson | Uv | 1,455 | Dg | 15.6 | 96 | | | | Loess, reworked by water. | U | 7.7 | 9-15-53 | P | | D, S | Hardness, 100 ppm; chloride, 98 ppm. |
| 18B1 | Chester Gordon | Uv | 1,475 | Dr | 325 | 6 | 8 | 300 | 25 | Basalt | C | 295 | | P | | D, S | Hardness, 70 ppm; chloride, 20 ppm. |
| 18C1 | C. F. Westersund. | Uv | 1,475 | Dr | 302 | 6 | | | | do | | | | P | 3 | D, S | Hardness, 55 ppm; chloride, 16 ppm. L. Temp 61° F. |
| 21J1 | Walter Egg | Uv | 1,540 | Dg | 22.5 | 72 | | | | Loess | U | 16.6 | 9-15-53 | P | | D, S | |
| 25D1 | L. McRae | Uv | 1,570 | Dg | 23.4 | 36 | | | | do | U | 17.8 | 9-12-53 | D | | S | |
| 25E1 | do | Uv | 1,580 | Dr | 220 | 6 | 14 | | | Basalt | C | 50 | | P | | D | Hardness, 105 ppm; chloride, 34 ppm. |
| 27C1 | Vern Terjeson | Uv | 1,570 | Dg | 25.4 | 60 | | | | Loess | U | 9.2 | 9-12-53 | C | | D, S | Hardness, 75 ppm; chloride, 104 ppm. |
| 30N1 | O. G. Bissinger | Uv | 1,305 | Dg | 21.1 | 60 | | | | | U | 10.0 | 4-15-53 | D | | | |
| 31F1 | E. N. Brown | Uv | 1,400 | Dr | 98 | 6 | 8 | | | Basalt | | 35 | | J | | D, S | Ca. |
| 33N1 | Leonard King | Uv | 1,510 | Dr | 520 | 8 | | | | do | | | | | | | Abandoned because of insufficient yield. |

T. 5 N., R. 33 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6F1 | Roscoe C. Lee | Uv | 1,650 | Dr | 140 | 6 | | | | Basalt | | 120 | 1951 | J | | D, S | |
| 9P1 | G. L. Muller | Uv | 1,650 | Dg | 35.4 | 52 | | | | Loess | U | 15.6 | 9-11-53 | P | | S | |
| 15N1 | R. R. Raymond | Uv | 1,730 | Dg | 14.0 | 48 | | | | do | U | 11.2 | 9-11-53 | J | | D, S | |
| 16G1 | R. Terjeson, et al. | Uv | 1,760 | Dg | 19.3 | 72 | | | | do | U | 14.4 | 9-11-53 | C | | D, S | |
| 16N1 | Mrs. G. B. Terjeson. | U | 1,850 | Dg | 85.6 | 36 | | | | | U | 81.2 | 9-14-53 | J | | D, S | |
| 19P1 | Melvin Winn | Uv | 1,790 | Dr | 120 | 6 | | | | Basalt | | | | P | | D, S | |
| 20N1 | E. W. Muller | U | 1,850 | Dr | 380 | 6 | | | | do | C | 155 | | T | | D, S | |
| 23Q1 | Stewart Place | Uv | 1,930 | Dg | 74.9 | 48 | | | | | U | 35.8 | 9-11-53 | P | | | |
| 25Q1 | W. M. Stimmel | Uv | 1,910 | Dr | 202 | 6 | | | | Basalt | C | 40.6 | 9- 9-53 | P | | D, S | |
| 26C1 | Bill Timmerman. | U | 1,925 | Dg | 47 | 36 | | | | Loess | U | 41.0 | 9-11-53 | P | | D, S | |
| 27N1 | Rees Bros | U | 1,800 | Dr | 300 | 6 | 50 | | | Basalt | C | 100 | | P | | D, S | |
| 31A1 | E. Koepke | Uv | 1,845 | Dr | 394 | 8 | 47 | 117 | | do | C | 92 | 1954 | | | D | Bailed 35 gpm for 30 min, dd 40 ft. L. Temp 58° F. |
| 32D1 | do | Uv | 1,840 | Dg | 76 | | | | | Loess | P | 68.6 | 4-14-53 | P | | D,S | W. |
| 35N1 | Henry Kupers | U | 1,820 | Dg, Dr | 165 | 6 | | | | Basalt | C | 90 | | P | | D, S | Dug to 80 ft; drilled to 165 ft. |

T. 5 N., R. 34 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16R1 | R. M. Thompson. | U | 1,960 | Dr | 228 | 6 | | | | Basalt | C | 148.5 | 9- 9-53 | P | | D, S | W. |
| 20A1 | A. H. McIntyre | U | 2,060 | Dr | 212 | | | | | do | | | | P | | | L. |
| 22L1 | do | U | 1,965 | Dr | 350 | 8 | 25 | | | do | C | 115 | | P | | D, S | |
| | | | | | | 6 | 350 | 200 | 20 | | | | | | | | |
| 27B1 | Frank Sanders | Uv | 1,970 | Dg | 29 | 60 | 10 | 12 | 16 | Soft rock | U | 15.2 | 9- 9-53 | P | | D, S | |
| 28N1 | P. W. Froese | Uv | 1,940 | Dg | 25 | 48 | | | | Loess | U | 19.0 | 9-10-53 | J | | D, S | |
| 30Q1 | R. B. Taylor | Uv | 1,940 | Dr | 195 | 6 | | | | Basalt | C | 45 | | P | | D | |
| 35G1 | E. A. Zerba | Uv | 1,890 | Dg | 27.2 | 36 | | | | Loess | U | 9.3 | 9- 9-53 | P | | D, S | |

T. 6 N., R. 31 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25H1 | A. Peterson | Uv | 1,310 | Dg | 19 | 36 | | | | Loess | U | 17.4 | | C | | D, S | |

T. 6 N., R. 32 E.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21Q1 | Mr. Rogers | U | 1,800 | Dr | 827 | 6 | 80 | 800 | 27 | Basalt | C | 540 | | P | 1.5 | D, S | Entirely in gray, broken basalt. Hardness, 80 ppm; chloride, 10 ppm. |
| 28Q1 | Fred Peterson estate. | U | 1,660 | Dr | 534 | 8 | 80 | | | do | | 434 | | P | | D, S | |
| 30E1 | Arnold Peterson | Uv | 1,350 | Dr | 250 | 6 | | | | do | | 200 | | P | | S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **T. 6 N., R. 33 E.** | | | | | | | | | |
| 31J1 | A. Campbell | Uv | 1,350 | Dr | 130 | 8 | ------ | 100 | 30 | Basalt | C | 60 | ---------- | P | 3 | D, S | Alluvium to 15 ft; basalt below. |
| | | | | | | | | **T. 1 S., R. 26 E.** | | | | | | | | | |
| 1J1 | O. W. Cutsforth. | Uv | ------ | Dr | 70 | 12 | 70 | ------ | ------ | Basalt | C | F | 6-15-57 | ------ | ------ | D, Ir | Alluvium to 27 ft; basalt below. Flowed 700 gpm when drilled in 1957. |
| | | | | | | | | **T. 1 S., R. 27 E.** | | | | | | | | | |
| 18M1 | Samuel Turner | Uv | ------ | Dr | 140 | 6 | 8 | ------ | ------ | Basalt | C | 113 | ---------- | P | 14 | D | Hardness, 115 ppm; chloride, 50 ppm. Temp 55° F. |
| 19N1 | Donald Evans | Uv | ------ | Dr | ------ | 8 | ------ | ------ | ------ | ---------- | C | 11.7 | 8-27-53 | P | ------ | D, Ir | |
| | | | | | | | | **T. 1 S., R. 28 E.** | | | | | | | | | |
| 7G1 | Mr. O'Brien | Fp | ------ | Dg | 19.5 | 36 | ------ | ------ | ------ | Alluvium | U | 10.6 | 10-23-53 | C | ------ | D | |
| 31M1 | Anna Healey | Uv | ------ | Dg | 31.2 | ------ | ------ | ------ | ------ | ---------- | U | 27.7 | 8-27-53 | P | ------ | D | |
| 35B1 | Antone Vey | Uv | ------ | Dr | 323 | 6 | 46 | 240 | 20 | Basalt | C | 21 | 1948 | P | ------ | S | Bailed 28 gpm. L. |
| | | | | | | | | **T. 1 S., R. 29 E.** | | | | | | | | | |
| 1N1 | J. D. Owens | Fp | ------ | Dr | 225 | 8 | 67 | 197 | 28 | Basalt | C | +27.6 | 7-2-58 | ------ | ------ | D | Flowed 100 gpm when drilled in 1958. |
| 3A1 | Lowell Rugg | S | ------ | Dr | 161 | 5½ | 40 | 160 | 1 | do | C | F | ---------- | ------ | ------ | D, Ir | Flows 550 gpm; water has slight sulfur odor; supplies water for 13 acres. Hardness, 90 ppm; chloride, 15 ppm. |
| 14G1 | do | Uv | ------ | Dr | 440 | 6 | ------ | ------ | ------ | do | C | 30 | ---------- | P | ------ | S | |

**T. 1 S., R. 30 E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1K1 | Mrs. Elliot | Uv | | Dr | 595 | 8 | 20 | | | Basalt | C | 40 | | P | | D, S | Water reportedly fluctuates with barometric pressure; sometimes flows. Hardness, 80 ppm; chloride, 22 ppm. |
| 3C1 | John Reeder | U | | Dr | 114 | 6 | | | | do | C | 34 | | P | 10 | D | Hardness, 120 ppm; chloride, 20 ppm. |
| 12F1 | Victor Roumagaux. | Uv | | Dr | 200 | 6 | | | | do | | | | P | | D, S | |
| 12M1 | Nelson Murray | U | | Dr | 670 | 6 | | | | | | 630 | | P | | D, S | Yields 14 gpm, drawdown slight. |
| 17J1 | Wayne Bowman. | S | | Dg | 24 | 36 | | | | | U | 12 | | P | | D, S | |
| 21F1 | Daniel Doherty | T | | Dr | 225 | 10 | | | | Basalt | C | 14.8 | 9-24-53 | | | | Bailed 12 gpm. W. |
| 26G1 | Leroy Bowman | Uv | | Dr | 49 | 6 | | | | do | C | 36.6 | 9-24-53 | | | | |

**T. 1 S., R. 30½ E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1L1 | Thomas Elliot | Uv | | Dr | 390 | 6 | | | | | P | | | | | D, S | |
| 12Q1 | Mrs. Elliot | Uv | | Dr | 130 | 6 | | | | | P | | | | | D, S | Low yield reported. |

**T. 1 S., R. 31 E.**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1L1 | Jack Sacrison | U | 1,940 | Dr | 427 | | | | | Basalt | | 345 | | P | | D | Yields 20 gpm. |
| 2B1 | do | Uv | 1,880 | Dg | 12 | | | | | | U | 9 | | P | | S | |
| 3P1 | M. F. Ellenberger. | U | 2,150 | Dg | 10.1 | 48 | | | | | U | 7.5 | 10-23-53 | P | | | Not used in 1953. |
| 4E1 | P. H. Schmidt | Uv | 2,255 | Dr | 110 | 2 | | | | | | Dry(?) | 2-25-53 | | | | |
| 11D1 | H. A. Main | Uv | 2,045 | Dg | 18 | 100 | 10 | | | "Blue clay below bedrock." | U | 12.2 | 10-25-53 | P | | D, S | |
| 17Q1 | Mr. Whitaker | Uv | | Dr | 800 | | | | | | | | | P | | D, S | |
| 19R1 | T. J. Stanton | Uv | | Dg | 20.2 | 48 | | | | Basaltic alluvium. | U | 12.1 | 8-29-53 | P | | D | |
| 22H1 | Cunningham Sheep Co. | Uv | | Dg | 12.1 | | | | | | U | 11.7 | 8- 5-53 | P | | S | |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s): Depth to top (feet) | Water-bearing zone(s): Thickness (feet) | Water-bearing zone(s): Character of material | Ground-water occurrence | Water level: Feet below datum | Water level: Date | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 1 S., R. 32 E.** | | | | | | | | | | | | | | | | | |
| 3E1 | William Bowers | S | 1,550 | Dr | 345 | 6 | 45 | 267 | 79 | Basalt | C | 66 | 6-23-58 | | | D | Basalt is overlain by 62 ft of fanglomerate. |
| 8J1 | Glen Newquist | S | | Dr | 115 | 8 | 18 | 90 | 13 | do | C | 85 | 1956 | T | | D, Ir | Pumped 75 gpm for 4 hrs dd, 8 ft. L. |
| 9G1 | V. Jacobsen | S | 1,600 | Dr | 150 | 6 | 85 | 92 | 58 | do | C | 150 | | | 20 | D, Ir | Supplies water for 3½ acres. L. |
| 9L1 | Wayne Chapman. | T | 1,590 | Dr | 491 | 12 | 44 | 440 | 40 | do | C | F | 4- 6-53 | | | D, Ir | Flowed 500 gpm when drilled. Ca, L. |
| 9M1 | Oregon Fibre Products Co. | Fp | 1,600 | Dr | 735 | 12 | 47 | 200 | | do | C | 17.2 | 4-30-53 | T | 650 | In | Supplied 225 acre-ft of water during 1954. L. |
| 9N1 | Pilot Rock Lumber Co. | Fp | | Dr | 365 | 10 | 41 | 50 | | do | C | 6 | 9-12-52 | T | 1,500 | In | Supplied 415 acre-ft during water year 1954. Hardness, 97 ppm; chloride, 17 ppm. L. Temp 64° F. |
| 16L1 | William Etter | Fp | | Dr | 265 | 6 | | | | do | C | 15 | | T | 150 | D, S, Ir | Pumped 120 gpm for 1 hr; dd, 101 ft. Supplies irrigation water for 30 acres. L. |
| 17G1 | City of Pilot Rock. | Fp | | Dr | 309 | 12 | 31 | 293 | 16 | Basalt | C | F | | C | | PS | Flowed 1,420 gpm in 1946; supplied about 300 acre-ft during 1955. Ca, L. |
| 17K1 | do | Fp | | Dr | 486 | 12 | 101 | 232 | | do | C | F | 3-5-56 | | | N | New well, not in use in 1956. Flows about 10 gpm; pumped 450 gpm for 1 hr; dd, 192 ft. L. |
| 19B1 | Jack Luck | Fp | | Dr | 82 | 12 | | | | | | | | | 45 | S | |
| 19Q1 | Arnold Hoeft | Fp | | Dr | 165 | 8 | | 154 | 11 | Basalt | C | +23 | | | | D | Flows 35 gpm. Hardness, 120 ppm; chloride, 26 ppm. Temp 55° F. |
| 20A1 | Robert Roy | S | | Dr | 300 | 6 | 89 | 278 | 22 | do | C | 32 | 1951 | J | 30 | D | L. |
| 21M1 | J. A. Porter | S | | Dr | 100 | 6 | | | | do | C | | | J | | D | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23J1 | Hilmer Horn | Uv | 1,990 | Dr | 794 | 10 | 28 | 705 | 89 | do | C | 89.4 | 10-28-53 | T | 130 | Ir | Supplies water for 40 acres; supplied 109 acre-ft during 1952. Ca, L. |
| 28E1 | Levi Eldridge | S | ------- | Dr | 160 | 6 | 23 | ------- | ------- | do | C | F | ---------- | J | 30 | D | Flows 1 gpm. Hardness, 80 ppm; chloride, 22 ppm. L. |
| | | | | | | | | T. 1 S., R. 33 E. | | | | | | | | | |
| 5F1 | Mrs. Georgia Wickert. | Fp | 1,620 | Dg | 12 | 60 | 12 | ------- | ------- | Alluvium | U | 10 | ---------- | P | ------- | D | |
| 6G1 | Jennie Red Hawk | Fp | 1,575 | Dn | 10 | 1½ | ------- | ------- | ------- | do | U | 8 | ---------- | P | ------- | D, S | Hardness, 40 ppm; chloride, 8 ppm. |
| 12H1 | Orin Sampson | Fp | ------- | Dn | 12 | 1½ | ------- | ------- | ------- | do | U | ------- | ---------- | C | ------- | D | Yield reported inadequate for domestic supply. |
| | | | | | | | | T. 1 S., R. 34 E. | | | | | | | | | |
| 18E1 | Lewis Umbager | Fp | ------- | Dn | 10 | 1½ | ------- | ------- | ------- | Alluvium | U | ------- | ---------- | P | ------- | D | Hardness, 40 ppm; chloride, 6 ppm. |
| 19Q1 | Mrs. Forth | Uv | ------- | Dn | ------- | 1½ | ------- | ------- | ------- | do | U | ------- | ---------- | P | ------- | D | Hardness, 60 ppm; chloride, 14 ppm. |
| | | | | | | | | T. 1 S., R. 35 E. | | | | | | | | | |
| 3G1 | Earl Gillander | S | ------- | Dg | 9 | 48 | ------- | ------- | ------- | ---------- | U | 8.6 | 10-29-33 | ------- | ------- | ------- | |
| 3K2 | do | S | ------- | Dr | 383 | 6 | 65 | ------- | ------- | Basalt | ---------- | 26 | 1-29-45 | ------- | 17 | D | L. |
| 3Q1 | Oregon Highway Dept. | S | ------- | Dr | 388 | 8 | ------- | 380 | 4 | do | C | 20 | ---------- | J | 20 | D, In | L. |
| 10C1 | Union Pacific Railroad. | T | ------- | Dr | 279 | 20<br>16 | 12<br>125 | 28 | 75 | do | C | F | 1944 | T | 314 | N | Flows 25 gpm. L. |
| 36N1 | do | U | ------- | Dr | 996 | 20<br>16 | 51<br>141 | ------- | ------- | do | ---------- | 264 | 1946 | N | ------- | N | Not used because of insufficient yield. L. |
| | | | | | | | | T. 2 S., R. 27 E. | | | | | | | | | |
| 5B1 | Don Robinson | Uv | ------- | Dr | 320 | ------- | ------- | ------- | ------- | Basalt | C | F | ---------- | J | 10 | S, Ir | Flows 2 gpm; supplies water for 4 acres. |
| 8P1 | Samuel Turner | Uv | ------- | Dr | 256 | 6 | ------- | ------- | ------- | do | C | 186 | ---------- | P | ------- | S | Hardness, 55 ppm; chloride, 14 ppm. Temp 56°. |

TABLE 1.—*Records of representative wells in the Umatilla River basin, Oregon*—Continued

| Well | Owner or tenant | Topography | Altitude (feet) | Type of well | Depth of well (feet) | Diameter of well (inches) | Depth of casing (feet) | Water-bearing zone(s) | | | Ground-water occurrence | Water level | | Type of pump | Yield (gpm) | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Depth to top (feet) | Thickness (feet) | Character of material | | Feet below datum | Date | | | | |
| **T. 2 S., R. 28 E.** | | | | | | | | | | | | | | | | | |
| 12E1 | W. E. Hughes | Uv | ------- | Dr | 150 | 8 | ------- | 100 | 50 | Basalt | C | 23.8 | 10-23-53 | T | ------- | D, S | Hardness, 70 ppm; chloride 8 ppm. W. |
| **T. 2 S., R. 30 E.** | | | | | | | | | | | | | | | | | |
| 4H1 | Daniel Doherty | Uv | ------- | Dg | 16 | 13 | ------- | ------- | ------- | ------- | U | 9.9 | 10-24-53 | C | ------- | D, S | |
| 9L1 | Joseph Doherty | Uv | ------- | Dr | 117 | 8 | 24 | 110 | 7 | Basalt | C | 7.3 | 10-24-53 | T | ------- | D | Pumped 70 gpm for 2½ hr; dd, 51 ft. |
| 17F1 | do | Uv | ------- | Dg | 9 | 60 | ------- | ------- | ------- | ------- | U | 9.1 | 10-24-53 | C | ------- | S | |
| 28B1 | Mary Pedro | Uv | ------- | Dr | 400 | 10 | ------- | 370 | 30 | Basalt | C | 110 | 10-24-53 | ------- | ------- | ------- | Pumped 265 gpm. |
| **T. 2 S., R. 30½ E.** | | | | | | | | | | | | | | | | | |
| 13J1 | Virgil Rhinhart | U | ------- | Dr | 104 | 6 | ------- | 84 | 20 | Basalt | P | 72 | ------- | P | 2 | D, S | Reported 27 ft of overburden overlies the basalt. Hardness, 65 ppm; chloride, 48 ppm. |
| **T. 2 S., R. 32 E.** | | | | | | | | | | | | | | | | | |
| 10C1 | Marius Jensen | Fp | ------- | Dg | 22 | ------- | ------- | ------- | ------- | Alluvium | U | 19 | ------- | B | ------- | D | |
| 12M1 | Arvine Porter | Fp | ------- | Dg | 20 | ------- | ------- | ------- | ------- | do | U | ------- | ------- | C | ------- | D | |
| 12R1 | do | Fp | ------- | Dn | 15 | ------- | ------- | ------- | ------- | do | U | ------- | ------- | C | ------- | D | |
| **T. 2 S., R. 33 E.** | | | | | | | | | | | | | | | | | |
| 7N1 | Arthur Osdorne | Fp | ------- | Dn | 15 | ------- | ------- | ------- | ------- | ------- | U | ------- | ------- | C | ------- | D | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T. 2 S., R. 35 E.** | | | | | | | | | | | | | | | | | |
| 28A1 | U.S. Forest Service. | U | ------- | Dg | 6.7 | ------- | ------- | ------- | ------- | Alluvium | U | 0.3 | 8- 4-53 | P | ------- | D, S | In marshy upland meadow. |
| **T. 3 S., R. 29 E.** | | | | | | | | | | | | | | | | | |
| 7A1 | Mrs. Ralph Jones. | Uv | ------- | Dr | 150 | 6 | 34.5 | ------- | ------- | Basalt | C | 50 | ------- | J | 20 | S | Bailed 17 gpm for 17 min; dd, 10 ft. L. |
| 9B1 | J. G. Barratt | Uv | ------- | Dr | 208 | 8 | 22 | 160 | 48 | ---do | C | 50 | ------- | T | ------- | D, S | |
| 10C1 | Raymond French. | Uv | ------- | Dr | 150 | 8 | 50 | 135 | 15 | ---do | C | F | ------- | J | ------- | D, S | Flows slightly. Hardness, 65 ppm; chloride, 8 ppm. |
| **T. 3 S., R. 30 E.** | | | | | | | | | | | | | | | | | |
| 1F1 | Joseph Pedro | Uv | ------- | Dr | 149 | 6 | 19 | 149 | ------- | Basalt | C | 20 | ------- | ------- | ------- | D | Pumped 410 gpm. |
| 29R1 | George Egg | Uv | ------- | Dg | 15.2 | 48 | ------- | ------- | ------- | Metamorphic rocks. | U | 5.9 | 10-26-53 | C | ------- | D | Hardness, 80 ppm; chloride, 8 ppm. |
| 29R2 | -----do | Uv | ------- | Dr | 85.0 | 6 | ------- | ------- | ------- | ---do | U | 3.8 | 10-25-53 | P | ------- | D | Ca. |
| 33C1 | Orville Carley | Uv | ------- | Dg | 16.1 | 60 | ------- | ------- | ------- | ------- | U | 5.4 | 10-25-53 | P | ------- | N | |
| **T. 3 S., R. 30½ E.** | | | | | | | | | | | | | | | | | |
| 1B1 | Joseph Pedro | Uv | ------- | Dr | 99 | 6 | ------- | ------- | ------- | Basalt | C | 24.6 | 8-29-53 | N | ------- | N | H. |

TABLE 2.—*Drillers' logs of representative wells*

[Tentative stratigraphic designations by G. M. Hogenson]

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1N/26-12C1. G. D. Abercrombie. Drilled by A. M. Edwards, 1950** | | |
| No records; old drilled well | 100 | 100 |
| Columbia River basalt: | | |
| Basalt | 28 | 128 |
| Basalt, honeycomb | 12 | 140 |
| Basalt | 3 | 143 |
| **1N/26-24D1. Howard Kelly. Drilled by Moore and Anderson, 1952** | | |
| Palouse formation and residual soil, undifferentiated: | | |
| Soil | 1 | 1 |
| Columbia River basalt: | | |
| Basalt, brown | 55 | 56 |
| Basalt, gray, soft | 23 | 79 |
| Basalt, gray, hard | 29 | 108 |
| Basalt, gray, boulders(?) | 42 | 150 |
| Basalt, gray, hard | 21 | 171 |
| Basalt, blue-black, and blue clay | 39 | 210 |
| Basalt, black, hard | 19 | 229 |
| Basalt, black, and soapstone | 6 | 235 |
| Basalt, black, soft | 39 | 274 |
| Basalt, black, hard | 60 | 334 |
| Basalt, brown, water-bearing | 13 | 347 |
| Basalt, black, hard | 4 | 351 |
| **1N/27-3R1. E. W. Wattenburger. Drilled by Ben Dreyer, 1952** | | |
| Quaternary alluvium: | | |
| Soil | 16 | 16 |
| Sand and gravel, water-bearing | 13 | 29 |
| Columbia River basalt: | | |
| Basalt, black, moderately hard | 9 | 38 |
| Basalt, red, soft | 18 | 56 |
| Basalt, black, hard | 48 | 104 |
| Basalt, red, soft, water-bearing | 4 | 108 |
| Basalt, black, hard | 12 | 120 |
| **1N/28-21Q1. Antone Vey. Drilled by H. Yager, 1953** | | |
| Quaternary alluvium: | | |
| Gravel, cemented | 24 | 24 |
| Columbia River basalt: | | |
| Basalt, gray | 6 | 30 |
| Basalt, red | 15 | 45 |
| Basalt, gray | 38 | 83 |
| Basalt, black | 91 | 174 |
| Basalt, gray | 51 | 225 |
| Basalt, black, broken, water-bearing | 45 | 270 |
| **1N/28-28C1. Antone Vey. Drilled by H. Yager, 1953** | | |
| Quaternary alluvium: | | |
| Gravel, cemented | 8 | 8 |
| Silt and clay | 12 | 20 |
| Columbia River basalt: | | |
| Basalt, gray | 9 | 29 |
| Basalt, black | 70 | 99 |
| Basalt, porous, soft, water-bearing; water flowing over casing at 50 gpm | 1 | 100 |
| Basalt, gray, hard | 78 | 178 |
| Basalt, black, hard, water-bearing; flow increased | 21 | 199 |
| Basalt, black, hard | 13 | 212 |
| Basalt, gray, hard | 41 | 253 |
| Basalt, black, medium-hard | 7 | 260 |
| Basalt, gray, hard | 79 | 339 |
| Basalt, gray, soft | 95 | 434 |
| Basalt, gray, hard | 2 | 436 |
| Basalt, brown, medium-hard | 13 | 449 |
| Basalt, gray, hard | 25 | 474 |
| Basalt, brown, medium-hard | 5 | 479 |
| Basalt, gray, hard | 21 | 500 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1N/28-28D1. Antone Vey. Drilled by H. Yager, 1953** | | |
| Quaternary alluvium: | | |
| Gravel, cemented | 10 | 10 |
| Columbia River basalt: | | |
| Basalt, gray, broken | 32 | 42 |
| Basalt, gray, hard | 35 | 77 |
| Basalt, black, hard | 44 | 121 |
| Basalt, gray, hard | 54 | 175 |
| Basalt, gray, medium-hard | 107 | 282 |
| Basalt, black, broken | 30 | 312 |
| Basalt, gray, soft, and "soapstone" | 33 | 345 |
| Basalt, red, soft | 20 | 365 |
| **1N/30-24E1. T. A. Cross. Drilled by Bert Gladney, 1953** | | |
| Columbia River basalt, fault zone: | | |
| Soil and "gravel," gray | 80 | 80 |
| "Gravel" and clay, gray | 10 | 90 |
| Boulders and clay, red | 30 | 120 |
| Gravel and clay, gray | 12 | 132 |
| Basalt, gray | 6 | 138 |
| Clay, gray, and green gravel; basalt fragments coated with green encrustation | 62 | 200 |
| Columbia River basalt: | | |
| Basalt | 5 | 205 |
| Basalt, red | 7 | 212 |
| Basalt, black; a green layer at 235 ft; water-bearing at 327 ft | 172 | 384 |
| Basalt, gray, hard | 203 | 587 |

NOTE.—Well was drilled with 12-inch diameter to 299 ft and 8-inch diameter to bottom; later was reamed to 12-inch diameter to 350-ft depth, with the cuttings filling the hole up to the 440-ft depth. Drilling then stopped.

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1N/32-1M2. Peter Timm. Drilled by Turner, 1955** | | |
| Palouse formation: | | |
| Soil | 2 | 2 |
| Fanglomerate: | | |
| Gravel | 4 | 6 |
| Clay, red | 119 | 125 |
| Gravel, water-bearing, 8 gpm | 10 | 135 |
| Gravel and blue clay | 50 | 185 |
| Columbia River basalt: | | |
| Basalt, black, broken | 110 | 295 |
| Basalt, red | 10 | 305 |
| Basalt, gray | 75 | 380 |
| Clay, blue, and gravel | 10 | 390 |
| Basalt, black | 20 | 410 |
| Basalt, gray | 25 | 435 |
| Basalt, red | 35 | 470 |
| Basalt, black | 31 | 501 |
| Basalt, black, water-bearing | 3 | 504 |
| **1N/32-15D1. William Eldridge. Drilled by Roy French, 1956** | | |
| Quaternary alluvium: | | |
| Soil | 4 | 4 |
| Gravel | 4 | 8 |
| Clay, red, sandy | 16 | 24 |
| Columbia River basalt: | | |
| Rock, red, water-bearing | 46 | 70 |
| Basalt, gray | 20 | 90 |
| Rock, red, water-bearing | 12 | 102 |
| Basalt, black and gray | 71 | 173 |
| Rock, red, water-bearing | 12 | 185 |
| Basalt, black and gray | 51 | 236 |
| Basalt, red and black, with clay seams, water-bearing | 47 | 283 |
| Basalt, gray | 1 | 284 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1N/32-22B1. J. L. Eldridge. Drilled by Bert Gladney** | | |
| Quaternary alluvium: | | |
| Soil | 10 | 10 |
| Sand | 5 | 15 |
| Columbia River basalt: | | |
| Basalt, gray | 32 | 47 |
| Basalt, brown | 99 | 146 |
| Basalt, gray | 11 | 157 |
| Basalt, red and brown | 38 | 195 |
| Basalt, gray | 159 | 354 |
| Basalt, black | 52 | 406 |
| **1N/32-27P1. Adolph Weinkes. Drilled by H. Yager, 1948** | | |
| Quaternary alluvium: | | |
| Clay and gravel | 50 | 50 |
| Columbia River basalt: | | |
| Basalt, black | 30 | 80 |
| Basalt, gray | 37 | 117 |
| Basalt, red, water-bearing | 17 | 134 |
| **1N/32-28D1. Edwin Hoeft. Drilled by D. K. Smith, 1956** | | |
| Palouse formation and Quaternary alluvium, undifferentiated: | | |
| Silt and sand | 12 | 12 |
| Sand and gravel | 2 | 14 |
| Columbia River basalt: | | |
| Basalt, broken, gray and brown | 40 | 54 |
| Basalt, brown and black | 46 | 100 |
| Basalt, brown, broken, water-bearing | 10 | 110 |
| Basalt, brown and gray | 63 | 173 |
| Basalt, reddish brown | 9 | 182 |
| Basalt, black and gray | 158 | 340 |
| Rock, broken, and mud | 10 | 350 |
| Basalt, brown and black | 44 | 394 |
| Basalt, brown, and clay | 11 | 405 |
| Basalt, brown and black | 108 | 513 |
| Basalt, brown, water-bearing | 12 | 525 |
| Basalt, black; well tested at 200 gpm with 200 ft of drawdown | 15 | 540 |
| Basalt, black and gray | 32 | 572 |
| Basalt, red and brown, broken, water-bearing | 3 | 575 |
| Basalt, hard, brown | 8 | 583 |
| **1N/32-34P1. Everett Hawkes. Drilled by H. Yager, 1948** | | |
| Palouse formation: | | |
| Soil | 8 | 8 |
| Columbia River basalt: | | |
| Basalt, brown, broken | 52 | 60 |
| Basalt, red, broken | 15 | 75 |
| Basalt, black, broken | 50 | 125 |
| Basalt, gray, broken, water-bearing | 75 | 200 |

NOTE.—Walls of well sloughing in during entire drilling operation.

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/27-1F1. Ammon Bros. Drilled by Ben Dreyer, 1952** | | |
| Quaternary alluvium: | | |
| Soil | 12 | 12 |
| Gravel | 2 | 14 |
| Clay, yellow | 36 | 50 |
| Rock, shaly | 20 | 70 |
| Clay, yellow | 15 | 85 |
| Clay, red | 35 | 120 |
| Clay, green | 10 | 130 |
| Clay, blue | 40 | 170 |
| Columbia River basalt: | | |
| Basalt, black, moderately hard | 33 | 203 |
| Basalt, black, soft | 18 | 221 |
| Basalt, black, hard | 34 | 255 |
| Basalt, red, soft | 37 | 292 |
| Basalt, blue, hard | 130 | 422 |
| Basalt, black, moderately hard | 27 | 449 |
| Basalt, black, hard | 30 | 479 |
| Basalt, black, soft | 21 | 500 |
| Basalt, black, moderately hard | 54 | 554 |
| **2N/27-1M1. C. M. Stanfield. Drilled by A. A. Durand, 1935** | | |
| Quaternary and older alluvium, undifferentiated: | | |
| Soil | 10 | 10 |
| Gravel, cemented | 12 | 22 |
| Gravel, water-bearing | 3 | 25 |
| Gravel and boulders | 7 | 32 |
| Clay and loose gravel | 17 | 49 |
| Gravel, cemented | 22 | 71 |
| Clay, red | 44 | 115 |
| Clay, blue | 41 | 156 |
| Shale, blue | 34 | 190 |
| Columbia River basalt: | | |
| Basalt | 299 | 489 |
| "Water sand" (scoriaceous basalt?) | 15 | 504 |
| **2N/27-2J1. C. Ammon. Drilled by Ben Dreyer, 1957** | | |
| Quaternary alluvium: | | |
| Soil | 11 | 11 |
| Gravel | 8 | 19 |
| Clay, sandy, yellow | 21 | 40 |
| Clay, red | 12 | 52 |
| Sand | 2 | 54 |
| Clay, red | 16 | 70 |
| Shale, yellow | 36 | 106 |
| Clay, green | 78 | 184 |
| Columbia River basalt: | | |
| Basalt, black, hard and soft | 102 | 286 |
| Basalt, red, soft | 19 | 305 |
| Basalt, black, hard | 127 | 432 |
| "Boulders," gray, hard | 10 | 442 |
| Basalt, black, hard to soft | 118 | 560 |
| "Boulders," black and gray, hard | 188 | 748 |
| Clay, sandy, black | 6 | 754 |
| Basalt, gray, medium-hard | 15 | 769 |
| Clay, sandy, blue | 8 | 777 |
| Basalt, blue, hard to soft | 22 | 799 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/27-6F1. Corrigal Ranch. Drilled by A. M. Edwards, 1938** | | |
| Glacial-lake sediments: | | |
| Top soil and sandy soil | 40 | 40 |
| Fanglomerate: | | |
| Gravel, cemented | 60 | 100 |
| Clay, yellow | 20 | 120 |
| Gravel, cemented | 80 | 200 |
| Clay, red | 10 | 210 |
| Clay, blue | 7 | 217 |
| Gravel, cemented | 67 | 284 |
| Columbia River basalt: | | |
| "Rock," brown, broken and seamy | 4 | 288 |
| "Rock," brown, solid | 62 | 350 |
| Basalt, blue and gray | 63 | 413 |
| Basalt, black, water-bearing | 14 | 427 |
| Basalt, gray, hard | 20 | 447 |
| **2N/27-11H1. J. S. Williams. Drilled by Ben Dreyer, 1952** | | |
| Quaternary alluvium: | | |
| Soil | 12 | 12 |
| Gravel | 10 | 22 |
| Shale, blue | 41 | 63 |
| Columbia River basalt: | | |
| Basalt, blue, medium-hard | 12 | 75 |
| Clay, blue, sandy | 57 | 132 |
| Basalt, blue, medium-hard | 12 | 144 |
| Clay, blue | 6 | 150 |
| Basalt, blue, hard | 12 | 162 |
| Shale(?) | 24 | 186 |
| Basalt, black, medium-hard | 29 | 215 |
| Basalt, red, medium-hard | 27 | 242 |
| Basalt, black, hard | 68 | 310 |
| Basalt, black, medium-hard | 20 | 330 |
| Basalt, black, hard, water-bearing | 41 | 371 |
| Basalt, black, soft | 27 | 398 |
| Basalt, black, hard | 26 | 424 |
| Basalt, black, soft | 101 | 525 |
| **2N/27-14M1. Mr. McCarty. Drilled by Ben Dreyer, 1952** | | |
| Quaternary alluvium: | | |
| Soil | 12 | 12 |
| Soil and gravel | 33 | 45 |
| "Shale rock" | 43 | 88 |
| Columbia River basalt: | | |
| Basalt, blue and black, hard | 104 | 192 |
| Basalt, black, soft, water-bearing | 28 | 220 |
| Basalt, blue, hard | 20 | 240 |
| Basalt, black, soft | 40 | 280 |
| **2N/27-20J1. Ed Tucker. Drilled by Moore and Anderson, 1948** | | |
| Glacial-lake sediments: | | |
| Soil | 10 | 10 |
| Fanglomerate: | | |
| Gravel | 12 | 22 |
| Scab rock (hardpan?) | 13 | 35 |
| Columbia River basalt: | | |
| Basalt, black | 20 | 55 |
| Basalt, brown, with clay seams | 35 | 90 |
| Basalt, black | 14 | 104 |
| Basalt, brown, with clay seams | 23 | 127 |
| Basalt, brown | 7 | 134 |
| Clay | 6 | 140 |
| Basalt, black | 93 | 233 |
| Basalt, brown | 4 | 237 |
| Basalt, black | 17 | 254 |
| Basalt, red, water-bearing | 4 | 258 |
| Basalt, gray | 45 | 303 |
| Basalt, brown, water-bearing | 52 | 355 |
| Clay | 2 | 357 |
| Basalt, gray | 13 | 370 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/27-22A1. D. W. Terry. Drilled by A. M. Edwards** | | |
| Quaternary alluvium: | | |
| Sand with some cobbles | 200 | 200 |
| Clay, yellow | 30 | 230 |
| Columbia River basalt: | | |
| Basalt, porous | 8 | 238 |
| Basalt, blue, medium-hard | 62 | 300 |
| Clay, blue, loose; runs easily; contains some water | 26 | 326 |
| Basalt, hard | 44 | 370 |
| **2N/27-27E3. J. F. Kilkenny. Drilled by Ben Dreyer, 1957** | | |
| Quaternary alluvium: | | |
| Soil | 14 | 14 |
| Gravel | 7 | 21 |
| Clay | 9 | 30 |
| Columbia River basalt: | | |
| Rock, blue, hard | 94 | 124 |
| "Boulders" (broken basalt?) | 4 | 128 |
| "Shale," blue; weathered basalt?; well tested at 500 gpm | 12 | 140 |
| Rock, black, hard | 74 | 214 |
| "Boulders" | 5 | 219 |
| Rock, black, soft | 16 | 235 |
| Rock, gray, hard | 11 | 246 |
| Rock, black, soft | 14 | 260 |
| Rock, gray, hard | 109 | 369 |
| "Shale," black; weathered basalt? | 7 | 376 |
| Rock, black, soft | 14 | 390 |
| Rock, gray and black, hard | 101 | 491 |
| Rock, black, soft | 18 | 509 |
| Rock, gray, hard | 15 | 524 |
| Rock, red, soft; well tested at 780 gpm | 6 | 530 |
| Rock, black, hard | 41 | 571 |
| "Boulders" | 27 | 598 |
| **2N/27-28H1. Ed Tucker. Drilled by Moore and Anderson** | | |
| Quaternary alluvium: | | |
| Soil | 6 | 6 |
| Gravel, cemented | 5 | 11 |
| Gravel | 20 | 31 |
| Columbia River basalt: | | |
| Basalt, gray | 56 | 87 |
| Basalt, blue-black; water-bearing | 17 | 104 |
| Basalt, black, broken | 46 | 150 |
| Basalt, black | 50 | 200 |
| Basalt, gray | 13 | 213 |
| Basalt, gray, hard | 29 | 242 |
| Basalt, black, broken, water-bearing | 12 | 254 |
| Basalt, blue-black | 9 | 263 |
| **2N/28-16K1. Antone Vey. Drilled by H. Yager, 1948** | | |
| Palouse formation and residual soil, undifferentiated: | | |
| Soil | 6 | 6 |
| Columbia River basalt: | | |
| Basalt, brown, decomposed, and clay | 46 | 52 |
| Basalt, broken, brown | 78 | 130 |
| Basalt, broken, brown, water-bearing | 55 | 185 |

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TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/30-6H1. Cunningham Sheep Co. Drilled by A. A. Durand and Son, 1946** | | |
| Dug pit, no record | 8 | 8 |
| Quaternary alluvium: | | |
| Gravel, coarse, and boulders | 7 | 15 |
| Gravel, boulders, and some clay | 9 | 24 |
| Gravel, coarse | 3 | 27 |
| Columbia River basalt: | | |
| Basalt | 6 | 33 |
| Basalt, hard, water-bearing | 40 | 73 |
| Basalt, hard, gray | 11 | 84 |
| Basalt, black | 8 | 92 |
| Basalt, hard, blue | 4 | 96 |
| Basalt, gray | 46 | 142 |
| Basalt, gray, hard, water-bearing | 11 | 153 |
| Basalt | 3 | 156 |
| Basalt, hard | 12 | 168 |
| Basalt, black | 15 | 183 |
| Basalt, firm | 8 | 191 |
| Basalt, hard | 18 | 209 |
| Basalt | 5 | 214 |
| Basalt, hard | 11 | 225 |
| Basalt, porous, brown; flowing water | 8 | 233 |
| **2N/31-2B2. Leo Gorger. Drilled by D. K. Smith** | | |
| Palouse formation: | | |
| Top soil | 2 | 2 |
| Fanglomerate: | | |
| Gravel, cemented | 18 | 20 |
| Columbia River basalt: | | |
| Basalt, broken | 4 | 24 |
| Basalt, gray | 43 | 67 |
| Basalt, brown, broken | 18 | 85 |
| Basalt, brown | 4 | 89 |
| Basalt, gray | 69 | 158 |
| Basalt, black | 33 | 191 |
| Basalt, gray | 11 | 202 |
| Basalt, black, water level standing at 142 ft | 71 | 273 |
| Basalt, gray | 16 | 289 |
| Basalt, brown, water-bearing | 14 | 303 |
| Basalt, gray | 1 | 304 |
| Basalt, black, water level standing at 260 ft | 6 | 310 |
| **2N/31-15L1. Union Pacific Railroad. Drilled by A. A. Durand and Son, 1940** | | |
| Quaternary alluvium: | | |
| Soil and gravel | 10 | 10 |
| Columbia River basalt: | | |
| Basalt, broken | 18 | 28 |
| Basalt, gray, hard | 5 | 33 |
| Basalt, gray | 45 | 78 |
| "Rock," porous, and shale | 21 | 99 |
| Basalt, gray, hard | 56 | 155 |
| "Rock," porous, and "soapstone" | 6 | 161 |
| **2N/32-2D1. H. M. Peringer. Drilled by Bert Gladney** | | |
| Palouse formation: | | |
| Soil | 35 | 35 |
| Columbia River basalt: | | |
| Sand and gravel (broken basalt?) | 10 | 45 |
| Basalt, gray | 95 | 140 |
| Gravel | 15 | 155 |
| Basalt, gray | 19 | 174 |
| Basalt, gray-black | 74 | 248 |
| Basalt, brown, hard | 24 | 272 |
| Basalt, black | 20 | 392 |
| Basalt | 208 | 600 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

**2N/32-2R1. Pendleton (Byers Street well). Drilled by A. A. Durand and Son, 1948**

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| Quaternary alluvium: | | |
| Gravel | 14 | 14 |
| Columbia River basalt: | | |
| Basalt, black, soft | 11 | 25 |
| Basalt, black, hard | 48 | 73 |
| Basalt, soft, and "soapstone" | 12 | 85 |
| Basalt, black, hard | 24 | 109 |
| Basalt, soft and medium-hard | 32 | 141 |
| Basalt, hard | 18 | 159 |
| Basalt, black, soft | 21 | 180 |
| Basalt, black, soft, water-bearing | 11 | 191 |
| Basalt, hard | 5 | 196 |
| Basalt, black, soft | 14 | 210 |
| Basalt, red, soft | 7 | 217 |
| Basalt, black, medium-hard | 48 | 265 |
| Basalt, gray, hard | 62 | 327 |
| Basalt, black, medium-hard | 6 | 333 |
| Basalt, gray | 12 | 345 |
| Basalt, red, soft, broken | 30 | 375 |
| Basalt, gray, hard | 51 | 426 |
| Basalt, black, soft, water-bearing | 24 | 450 |
| Basalt, black, hard | 3 | 453 |
| Basalt, black, soft | 11 | 464 |
| Basalt, gray, hard | 8 | 472 |
| Basalt, black, medium-hard | 54 | 526 |
| Basalt, black, hard | 154 | 680 |
| Basalt, black, medium-hard, water-bearing | 43 | 723 |
| Basalt, gray, hard | 4 | 727 |
| Basalt, black | 24 | 751 |
| Basalt, gray, hard | 22 | 773 |
| Basalt, brown, red, and gray, soft, water-bearing | 11 | 784 |
| Basalt, gray, hard | 17 | 801 |
| Basalt, brown | 5 | 806 |
| Basalt, black | 15 | 821 |
| Basalt, gray, hard | 20 | 841 |
| Basalt, black | 39 | 880 |
| Basalt, gray | 4 | 884 |
| Basalt, black | 12 | 896 |
| Basalt, black, porous, water-bearing | 16 | 912 |
| Basalt, black | 23 | 935 |

NOTE.—Well redrilled in adjacent hole to depth of 774 ft.

**2N/32-7N1. Union Pacific Railroad (Rieth 2). Drilled by A. A. Durand and Son, 1942**

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| Artificial fill (cinders) | 7 | 7 |
| Quaternary alluvium: | | |
| Gravel | 7 | 14 |
| Columbia River basalt: | | |
| Basalt | 4 | 18 |
| Basalt, black | 11 | 29 |
| Basalt, gray, hard | 14 | 43 |
| Basalt, broken; water-bearing but little water | 3 | 46 |
| Basalt, gray, hard | 14 | 60 |
| Basalt, black; contains clay-filled fractures | 15 | 75 |
| Basalt, gray, hard | 10 | 85 |
| Basalt, red; crumbling into hole | 16 | 101 |
| Basalt, brown, hard | 2 | 103 |
| Basalt, black and gray, broken | 24 | 127 |
| Basalt, broken, water-bearing | 11 | 138 |
| Basalt, hard | 43 | 181 |
| Basalt, alternatingly hard and broken | 7 | 188 |
| Basalt, broken | 15 | 203 |
| Basalt, gray, very hard | 7 | 210 |
| Basalt, gray, hard, fractured, water-bearing | 7 | 217 |
| Basalt, brown, fractured | 11 | 228 |
| Basalt, brown, hard | 7 | 235 |
| Basalt, fractured | 26 | 261 |
| Basalt, gray, fractured | 19 | 280 |
| Basalt, fractured, water-bearing | 7 | 287 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/32-9B1. Oregon State Hospital. Drilled by R. J. Strasser, 1953-54** | | |
| Quaternary alluvium: | | |
| Top soil | 4 | 4 |
| Boulders and clay | 5 | 9 |
| Sand and clay | 9 | 18 |
| Gravel and clay | 6 | 24 |
| Columbia River basalt: | | |
| Basalt, brown and gray; water standing at 32 ft | 32 | 56 |
| Basalt, gray | 13 | 69 |
| Basalt, red and gray | 8 | 77 |
| Basalt, gray | 2 | 79 |
| Basalt, gray, broken; water standing at 27 ft | 2 | 81 |
| Basalt, gray | 7 | 88 |
| Basalt, broken, with green clay | 3 | 91 |
| Basalt, gray | 43 | 134 |
| Basalt, gray and red | 35 | 169 |
| Basalt, gray | 59 | 228 |
| Basalt, gray and red | 6 | 234 |
| Clay, brown, sticky | 4 | 238 |
| Basalt, gray | 9 | 247 |
| Basalt, gray, broken | 10 | 257 |
| Basalt, brown, honeycomb | 17 | 274 |
| Basalt, gray | 36 | 310 |
| Basalt, gray, creviced | 3 | 313 |
| Basalt, gray | 24 | 337 |
| Basalt, gray and brown, porous | 13 | 350 |
| Basalt, gray and brown, porous, water-bearing; water standing at 116 ft | 11 | 361 |
| Basalt, gray | 18 | 379 |
| Basalt, gray and red, porous | 28 | 407 |
| Basalt, gray | 6 | 413 |
| Basalt, gray, creviced | 2 | 415 |
| Basalt, gray | 14 | 429 |
| Basalt, gray, water standing at 135 ft | 5 | 434 |
| Basalt, gray | 29 | 463 |
| Basalt, gray, broken | 8 | 471 |
| Basalt, gray | 45 | 516 |
| Basalt, gray, creviced | 3 | 519 |
| Basalt, gray | 34 | 553 |
| Basalt, gray, creviced | 1 | 554 |
| Basalt, gray | 126 | 680 |
| Basalt, brown, porous, water-bearing | 11 | 691 |
| Basalt, gray, water standing at 135 ft | 160 | 851 |
| **2N/32-10F1. Pendleton (Well 2, or Round-Up Park Well). Drilled by A. A. Durand and Son, 1948** | | |
| Quaternary alluvium: | | |
| Gravel and rock | 17 | 17 |
| Columbia River basalt: | | |
| Basalt, black | 53 | 70 |
| Basalt, black, broken | 7 | 77 |
| Basalt, black, hard | 182 | 259 |
| Basalt, black, broken | 57 | 316 |
| Basalt, black | 47 | 363 |
| Basalt, black, broken | 7 | 370 |
| Basalt, black; creviced at 428, 615, 650, and 668 ft | 344 | 714 |
| Basalt, red | 14 | 728 |
| Basalt, black | 33 | 761 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/32-10M1. Smith Canning Co. Drilled by A. A. Durand and Son, 1942** | | |
| Quaternary alluvium: | | |
| Gravel, loose | 23 | 23 |
| Columbia River basalt: | | |
| Basalt, broken | 2 | 25 |
| Basalt | 7 | 32 |
| Gravel, sand, clay (fractured basalt?) | 28 | 60 |
| Basalt, brown, broken | 38 | 98 |
| Basalt, red | 17 | 115 |
| Basalt, brown, decomposed | 10 | 125 |
| Basalt, gray, porous | 5 | 130 |
| Basalt, gray | 4 | 134 |
| Basalt, red | 6 | 140 |
| Conglomerate, gray | 9 | 149 |
| Basalt, gray, soft | 9 | 158 |
| Basalt, gray, solid | 67 | 225 |
| "Volcanic ash," red, muddy | 33 | 258 |
| Basalt, red | 17 | 275 |
| Basalt, brown | 30 | 305 |
| Basalt, red | 15 | 320 |
| Basalt, brown | 42 | 362 |
| Basalt, gray | 23 | 385 |
| Basalt, brown | 17 | 402 |
| Basalt, gray | 27 | 429 |
| Basalt, black | 21 | 450 |
| Basalt, gray | 147 | 597 |
| Basalt, brown | 38 | 635 |
| Basalt, gray | 30 | 665 |
| **2N/32-10N1. Pendleton (well 3). Drilled by A. A. Durand and Son, 1952** | | |
| Quaternary alluvium and Palouse formation: | | |
| Rock, brown, and clay | 4 | 4 |
| Columbia River basalt: | | |
| Basalt, medium-hard, broken, brown and black | 28 | 32 |
| Basalt, broken | 12 | 44 |
| Basalt, broken, yellow; water standing at 20 ft | 6 | 50 |
| Basalt, gray, hard, and broken | 14 | 64 |
| Basalt, brown and red, medium-hard, broken, muddy | 11 | 75 |
| Basalt "shells" (alternating hard and soft layers) and brown mud | 6 | 81 |
| Basalt, brown, broken, medium-hard | 7 | 88 |
| Basalt, gray, hard; water standing at 30 ft | 2 | 90 |
| Basalt, brown and gray, hard, broken | 45 | 135 |
| Basalt, red, broken; with soft mud | 3 | 138 |
| Basalt, brown, medium-hard; with mud | 6 | 144 |
| Basalt, brown and gray, hard | 20 | 164 |
| Basalt, brown and red, broken; some mud | 4 | 168 |
| Basalt, brown and gray, hard | 62 | 230 |
| Basalt, brown, broken, soft; with mud | 24 | 254 |
| Basalt, black and gray, medium-hard | 66 | 320 |
| Basalt, gray and black, hard; water standing at 50 ft | 15 | 335 |
| Basalt, red, medium-hard | 4 | 339 |
| Basalt, black, medium-hard; water standing at 155 ft | 13 | 352 |
| Basalt, red | 2 | 354 |
| Basalt, black | 4 | 358 |
| Basalt, gray, hard | 26 | 384 |
| Basalt, brown, broken, medium-hard | 16 | 400 |
| Basalt, black and gray, medium-hard | 76 | 476 |
| Basalt, brown, broken; with some clay | 7 | 483 |
| Basalt, dark, medium-hard | 102 | 585 |
| Basalt, brown and red, broken, medium-hard and soft | 7 | 592 |
| Basalt, brown, medium-hard | 2 | 594 |
| Basalt, gray, hard | 9 | 603 |
| Basalt, broken; color variable | 12 | 615 |
| Basalt, gray and black, hard and medium-hard | 48 | 663 |
| Basalt, red, soft, broken; with brown clay | 2 | 665 |
| Basalt, brown, broken; with mud | 6 | 671 |
| Basalt, black, medium-hard; static water level at 153 ft | 32 | 703 |
| Basalt, black and brown, broken, medium-hard | 69 | 772 |
| Basalt, black and gray, medium-hard | 225 | 997 |
| Basalt, gray, hard; static water level at 153 ft | 11 | 1,008 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/32-11D1. First National Bank of Oregon. Drilled by A. M. Jannsen, 1940** | | |
| Columbia River basalt: | | |
| "Rock" | 115 | 115 |
| "Lava rock," brown | 30 | 145 |
| "Rock," gray and black | 556 | 701 |
| Sand | 2 | 703 |
| **2N/32-16D1. Charles Ford. Drilled by D. K. Smith** | | |
| Quaternary alluvium: | | |
| Soil | 4 | 4 |
| Hardpan | 12 | 16 |
| Gravel | 2 | 18 |
| Columbia River basalt: | | |
| Rock, broken, cemented | 17 | 35 |
| Rock, broken, brown | 13 | 48 |
| Rock, red | 21 | 69 |
| Basalt, brown, broken | 61 | 130 |
| Basalt, red | 5 | 135 |
| Basalt, brown, broken | 112 | 247 |
| Basalt, black | 33 | 280 |
| **2N/32-16M1. Gilbert Struve. Drilled by Roy French, 1956** | | |
| Quaternary alluvium: | | |
| Soil | 17 | 17 |
| Columbia River basalt: | | |
| "Volcanic ash," red and black; decomposed basalt? | 13 | 30 |
| Rock, red | 18 | 48 |
| Basalt, gray; small amount of water | 62 | 110 |
| Rock, red | 40 | 150 |
| Basalt, gray | 35 | 185 |
| Rock, red; with clay seams; static water level 40 ft below land surface | 115 | 300 |
| Basalt, red and black; water-bearing at 385 ft; static water level dropped to 120 feet | 85 | 385 |
| **2N/32-16P1. C. N. Clark. Drilled by D. K. Smith, 1950** | | |
| Palouse formation: | | |
| Soil | 12 | 12 |
| Hardpan | 2 | 14 |
| Columbia River basalt: | | |
| Basalt, brown, broken | 21 | 35 |
| Basalt, gray | 5 | 40 |
| Basalt, brown | 10 | 50 |
| Basalt, black | 15 | 65 |
| Basalt, brown | 6 | 71 |
| Basalt, red, water-bearing | 1 | 72 |
| Basalt, gray | 66 | 138 |
| Basalt, red | 20 | 158 |
| Basalt, brown | 19 | 177 |
| Basalt, gray | 53 | 230 |
| Basalt, brown and red | 27 | 257 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/32-19N1. Milton Carter. Drilled by D. K. Smith, 1952** | | |
| Palouse formation: | | |
| Soil | 3 | 3 |
| Quaternary alluvium: | | |
| Gravel, cemented | 10 | 13 |
| Columbia River basalt: | | |
| Basalt, broken | 3 | 16 |
| Basalt, gray, hard | 14 | 30 |
| Basalt, gray | 5 | 35 |
| Basalt, gray, hard | 16 | 51 |
| Basalt, brown | 24 | 75 |
| Basalt, brown, broken | 15 | 90 |
| "Mud" | 3 | 93 |
| Basalt, brown | 16 | 109 |
| Basalt, gray | 21 | 130 |
| Basalt, brown, fractured, water-bearing | 5 | 135 |
| Basalt, gray | 29 | 164 |
| Basalt, black, water-bearing | 18 | 182 |
| Basalt, gray | 11 | 193 |
| Basalt, brown | 5 | 198 |
| Basalt, black | 2 | 200 |
| **2N/32-19P1. Milton Carter. Drilled by D. K. Smith, 1951** | | |
| Palouse formation and Quaternary alluvium, undifferentiated: | | |
| Soil | 10 | 10 |
| Columbia River basalt: | | |
| Basalt, broken, cemented | 10 | 20 |
| Basalt, brown | 24 | 44 |
| Basalt, gray | 20 | 64 |
| Basalt, brown, broken | 34 | 98 |
| Basalt, gray | 4 | 102 |
| Basalt, black | 12 | 114 |
| Basalt, grav, hard | 18 | 132 |
| Basalt, black | 3 | 135 |
| Basalt, gray | 2 | 137 |
| Basalt, black | 1 | 138 |
| Basalt, gray | 6 | 144 |
| Basalt, brown, broken | 11 | 155 |
| Basalt, grav | 12 | 167 |
| Basalt, brown, broken | 32 | 199 |
| Basalt, black; static water level at 10 ft | 14 | 213 |
| Basalt, brown, broken; static water level at 60 ft | 16 | 229 |
| **2N/32-29F1. John Korvola. Drilled by Bert Gladney, 1950** | | |
| Quaternary alluvium: | | |
| Soil and gravel | 12 | 12 |
| Columbia River basalt: | | |
| Basalt | 20 | 32 |
| Basalt, red | 24 | 56 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/33-6N3. Crispin Bros. Drilled by Roy French, 1956** | | |
| Quaternary alluvium: | | |
| Soil | 4 | 4 |
| Gravel | 14 | 18 |
| Columbia River basalt: | | |
| Basalt, black | 22 | 40 |
| Sand, black, heaving | 3 | 43 |
| Basalt, gray | 54 | 97 |
| Basalt, red and black (decomposed) | 31 | 128 |
| Basalt, gray | 19 | 147 |
| Basalt, red | 13 | 160 |
| Basalt, black and gray | 80 | 240 |
| Basalt, red and black, decomposed | 40 | 280 |
| Basalt, gray and black | 85 | 365 |
| Basalt, red and black | 15 | 380 |
| Basalt, gray | 85 | 465 |
| Basalt, red, static water level 26 ft | 10 | 475 |
| Basalt, red; during drilling of this section the static water level dropped twice, first to 66 ft, then to 108 ft | 25 | 500 |

NOTE.—After drilling was completed, water level dropped twice, first to 155 ft and then to an unknown depth below 200 ft.

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/33-8G1. William Purchase (well 2). Drilled by D. K. Smith, 1953** | | |
| Quaternary alluvium and fanglomerate, undifferentiated: | | |
| Soil | 5 | 5 |
| Gravel, cemented | 5 | 10 |
| Gravel, loose | 2 | 12 |
| Columbia River basalt: | | |
| Basalt, black, broken, water-bearing | 8 | 20 |
| Basalt, gray, hard, with water-bearing crevices | 6 | 26 |
| Basalt, black; water level standing at 8 ft | 4 | 30 |
| **2N/33-8J1. William Purchase (well 1). Drilled by D. K. Smith, 1949** | | |
| Palouse formation: | | |
| Sandy soil | 6 | 6 |
| Fanglomerate: | | |
| Gravel, cemented | 34 | 40 |
| Clay, sandy | 5 | 45 |
| Gravel, cemented | 45 | 90 |
| Columbia River basalt: | | |
| Basalt, black, broken | 25 | 115 |
| Basalt, black, solid | 90 | 205 |
| Basalt, brown | 15 | 220 |
| Basalt, red | 15 | 235 |
| Basalt, brown | 38 | 273 |
| Basalt, black | 97 | 370 |
| Basalt, gray, with clay seams | 33 | 403 |
| Basalt, brown, porous | 5 | 408 |
| Basalt, gray | 57 | 465 |
| Basalt, red | 7 | 472 |
| Basalt, brown | 13 | 485 |
| Basalt, black | 30 | 515 |
| Basalt, gray | 47 | 562 |
| Basalt, red, green, black, brown | 4 | 566 |
| Basalt, red | 14 | 580 |
| Basalt, red-brown | 5 | 585 |
| Basalt, gray, hard | 12 | 597 |
| Basalt, black | 15 | 612 |
| Basalt, gray, hard | 10 | 622 |
| Basalt, black; static water level at 23 ft | 31 | 653 |
| Basalt, gray | 23 | 676 |
| Basalt, black, porous | 10 | 686 |
| Basalt, gray | 14 | 700 |
| Basalt, black; static water level at 26 ft | 27 | 727 |
| Basalt, black | 52 | 779 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/33-8K1. William Purchase (well 3). Drilled by D. K. Smith, 1953** | | |
| Palouse formation: | | |
| Soil | 15 | 15 |
| Fanglomerate: | | |
| Gravel, cemented | 2 | 17 |
| Gravel, loose | 2 | 19 |
| Gravel, loosely cemented | 6 | 25 |
| Clay, brown | 2 | 27 |
| Gravel, cemented | 3 | 30 |
| Gravel and clay | 11 | 41 |
| Gravel, cemented, and sand | 91 | 132 |
| Columbia River basalt: | | |
| Basalt, red | 16 | 148 |
| Basalt, brown | 17 | 165 |
| Basalt, black | 25 | 190 |
| Basalt, gray | 12 | 202 |
| Basalt, brown, broken | 5 | 207 |
| Basalt, brown | 23 | 230 |
| Basalt, black | 10 | 240 |
| Basalt, dark gray | 15 | 255 |
| Basalt, black | 95 | 350 |
| Clay, dark, sticky | 6 | 356 |
| Basalt, gray, hard, contains shale(?) seams | 38 | 394 |
| Basalt, brown, porous, water-bearing | 16 | 410 |
| Basalt, dark gray | 48 | 458 |
| Basalt, red | 7 | 465 |
| Basalt, brown | 15 | 480 |
| Basalt, gray | 23 | 503 |
| Crevice, muddy; decomposed tuff layer? | 4 | 507 |
| Basalt, gray, hard | 38 | 545 |
| Basalt, brown, water-bearing | 15 | 560 |
| Basalt, gray | 19 | 579 |
| Basalt, brown | 6 | 585 |
| Basalt, red, brown, and black, broken | 5 | 590 |
| Basalt, black | 13 | 603 |
| Basalt, gray | 1 | 604 |
| **2N/33-10E1. N. H. Laughlin** | | |
| Quaternary alluvium: | | |
| Soil | 5 | 5 |
| Gravel and soil | 7 | 12 |
| Gravel, loose, water-bearing | 4 | 16 |
| Sand | 4 | 20 |
| Sand and gravel, cemented | 7 | 27 |
| Columbia River basalt: | | |
| Basalt, broken | 8 | 35 |
| Basalt, solid, black and gray | 194 | 229 |
| Basalt, black, porous, water-bearing | 23 | 252 |
| **2N/33-10E2. Roy Morris. Drilled by owner, 1957** | | |
| Quaternary alluvium: | | |
| Soil | 4 | 4 |
| Gravel, cemented | 15 | 19 |
| Columbia River basalt: | | |
| Basalt, water-bearing | 73 | 92 |
| Basalt, blue | 128 | 220 |
| Clay, green | 39 | 259 |
| Basalt, porous, and clay | 16 | 275 |
| **2N/33-33N1. Guy Mueller. Drilled by Bert Gladney, 1951** | | |
| Palouse formation: | | |
| Soil | 6 | 6 |
| Fanglomerate: | | |
| Gravel and clay | 99 | 105 |
| Columbia River basalt: | | |
| Basalt | 32 | 137 |
| Basalt, gray | 92 | 229 |
| Gravel (broken basalt?) | 2 | 231 |
| Basalt, gray | 4 | 235 |
| Basalt, black | 75 | 310 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **2N/34-4R1. Union Pacific Railroad. Drilled by A. A. Durand and Son, 1941** | | |
| Quaternary alluvium: | | |
| Gravel | 15 | 15 |
| Columbia River basalt: | | |
| Basalt, gray, hard | 35 | 50 |
| Basalt, brown, porous | 35 | 85 |
| **3N/26-4N1. L. W. Cramer. Drilled by owner, 1955** | | |
| Glaciofluviatile deposits: | | |
| Sand and silt | 92 | 92 |
| Clay, tan | 27 | 119 |
| Columbia River basalt and interbedded sediments: | | |
| Basalt, gray | 15 | 134 |
| Clay, tan | 40 | 174 |
| Basalt, gray | 67 | 241 |
| Lower part of Ellensburg formation: | | |
| Gravel, clay, and sand, water-bearing | 2 | 243 |
| Clay, blue | 70 | 313 |
| Sand, yellow, coarse, water-bearing | 30 | 343 |
| Clay and gravel | 7 | 350 |
| Gravel, cemented | 8 | 358 |
| **3N/26-10N1. Ernest Cramer. Drilled by owner, 1958** | | |
| Glaciofluviatile deposits: | | |
| Silt | 6 | 6 |
| Sand, coarse | 49 | 55 |
| Sand and clay | 36 | 91 |
| Clay, brown | 26 | 117 |
| Sand and gravel, cemented, water-bearing | 55 | 172 |
| Columbia River basalt and lower part of Ellensburg(?) formation: | | |
| Rock, gray | 76 | 248 |
| Clay, brown (Lower part of Ellensburg? formation) | 37 | 285 |
| Sandstone, blue (Lower part of Ellensburg? formation) | 45 | 330 |
| Rock, black, brown, gray | 108 | 438 |
| Shale, blue | 13 | 451 |
| Rock, black, green, brown, and gray | 184 | 635 |
| No record; cuttings lost | 11 | 646 |
| Rock, gray and black | 20 | 666 |
| **3N/26-14J1. Willard Jones. Drilled by Troy Griffin, 1954** | | |
| Glaciofluviatile deposits: | | |
| Soil | 80 | 80 |
| Sand | 20 | 100 |
| "Hardpan" | 10 | 110 |
| Clay and gravel | 20 | 130 |
| Columbia River basalt and interbedded sediments: | | |
| Rock, red, rotten | 10 | 140 |
| Clay and gravel | 20 | 160 |
| Rock, porous | 20 | 180 |
| Clay and gravel | 10 | 190 |
| Rock, rotten | 7 | 197 |
| **3N/27-4R1. Dean Hall. Drilled by Ben Dreyer, 1955** | | |
| Glaciofluviatile deposits: | | |
| Soil, sandy | 3 | 3 |
| Gravel, sandy | 22 | 25 |
| Clay, yellow | 5 | 30 |
| Gravel | 4 | 34 |
| Clay, white | 16 | 50 |
| Sand, white | 39 | 89 |
| Columbia River basalt: | | |
| Clay, red | 22 | 111 |
| Rock, black, shaly, water-bearing | 24 | 135 |
| Clay, red | 11 | 146 |
| Rock, black, shaly, water-bearing | 39 | 185 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/27-25J1. George Wallace** | | |
| Alluvium and older gravels, undifferentiated: | | |
| "Earth" | 20 | 20 |
| Clay and gravel | 49 | 69 |
| Clay, sticky, and gravel | 31 | 100 |
| Clay, blue, and gravel | 85 | 185 |
| Columbia River basalt: | | |
| Basalt, black | 40 | 225 |
| Basalt, "blue lava rock" | 18 | 243 |
| Basalt, red and blue | 17 | 260 |
| Basalt, blue | 10 | 270 |
| Basalt, "iron rock" | 48 | 318 |
| Basalt, red | 18 | 336 |
| Basalt, gray | 64 | 400 |
| **3N/29-11G1. Peter Meyers** | | |
| Glacial-lake sediments: | | |
| Silt | 12 | 12 |
| Fanglomerate: | | |
| Gravel | 13 | 25 |
| Sandstone | 55 | 80 |
| **3N/29-11G2. Claude Meyers. Drilled by Roy French, 1954** | | |
| Glacial-lake sediments: | | |
| Soil and gravel, cemented | 52 | 52 |
| Sandstone | 31 | 83 |
| Columbia River basalt: | | |
| Basalt, brown and black | 57 | 140 |
| Basalt, gray; crevices | 58 | 198 |
| Basalt, black and gray, solid | 320 | 518 |
| Basalt, black, with crevices | 37 | 555 |
| Basalt, black and gray, solid | 22 | 577 |
| Basalt, black, soft; red and green streaks | 31 | 608 |
| Basalt, gray | 62 | 670 |
| Basalt, red; changes to green, with increasing depth, water-bearing; water flows at the surface | 5 | 675 |
| **3N/29-16G1. City of Echo. Drilled by A. A. Durand and Son, 1951** | | |
| Quaternary alluvium: | | |
| Soil, brown | 14 | 14 |
| Gravel, water-bearing | 11 | 25 |
| Columbia River basalt: | | |
| Basalt, broken, and gravel | 7 | 32 |
| Basalt, hard | 3 | 35 |
| Basalt, gray, hard; static water level at 10 ft | 50 | 85 |
| Basalt, black, medium-hard | 18 | 103 |
| Basalt, black, broken | 13 | 116 |
| Clay, blue | 2 | 118 |
| Basalt, black, broken | 14 | 132 |
| Basalt, black, medium-hard; broken 137 to 138 | 27 | 159 |
| Basalt, black, medium-hard, broken | 5 | 164 |
| Basalt, black; static water level at 10 ft | 15 | 179 |
| Basalt, black, broken; contains soft clay | 5 | 184 |
| Basalt, gray, hard | 3 | 187 |
| Basalt, gray, medium-hard | 88 | 275 |
| Basalt, black, soft, honeycomb; static water level at 107 ft | 15 | 290 |
| Basalt, black | 70 | 360 |
| Basalt, gray, hard | 2 | 362 |
| Basalt, gray, very hard | 44 | 406 |
| Basalt, gray, firm | 24 | 430 |
| Basalt, black, soft, broken | 5 | 435 |
| Basalt, gray, hard; static water level at 100 ft | 55 | 490 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/32-32P1. Pendleton airport. Drilled by W. E. Ruther, 1934; deepened, 1936** | | |
| Palouse formation and Columbia River basalt, undifferentiated: | | |
| Top soil, clay, gravel and boulders | 80 | 80 |
| Columbia River basalt: | | |
| Basalt, gray, medium-hard | 185 | 265 |
| Basalt, honeycomb, water-bearing | 20 | 285 |
| Basalt, gray, medium-hard; lost all water at 511 ft | 226 | 511 |
| Basalt, red, honeycomb; well "blew and sucked" air from this formation; water bearing at bottom of original hole (573 ft); static water level at 521 ft; yield 12 gpm with little drawdown | 62 | 573 |
| Basalt, blue, hard | 190 | 763 |
| Basalt, blue, honeycomb; static water level, 573 ft | 62 | 825 |
| **3N/33-14L1. McCormack Bros. Drilled by D. K. Smith, 1950** | | |
| Palouse formation: | | |
| Soil | 10 | 10 |
| Columbia River basalt: | | |
| Basalt, brown, broken | 9 | 19 |
| Basalt, brown | 13 | 32 |
| Basalt, brown and red, water-bearing | 22 | 54 |
| Basalt, brown, hard | 13 | 67 |
| Basalt, brown | 13 | 80 |
| Basalt, brown, broken | 9 | 89 |
| Basalt, black; static water level at 7 ft | 7 | 96 |
| **3N/33-31Q2. James Rutten. Drilled by Roy French, 1956** | | |
| Alluvium: | | |
| Sand and soil | 18 | 18 |
| Boulders | 5 | 23 |
| Columbia River basalt: | | |
| Basalt, black | 52 | 75 |
| Basalt, red and black | 32 | 107 |
| Basalt, gray and brown | 185 | 292 |
| Clay, green, sticky | 23 | 315 |
| Basalt, gray | 49 | 364 |
| Clay, red; weathered basalt | 12 | 376 |
| Basalt, red, water-bearing | 19 | 395 |
| Basalt, red and black | 15 | 410 |
| Basalt, gray | 40 | 450 |
| Basalt, red | 25 | 475 |
| Basalt, brown and gray | 75 | 550 |
| Basalt, red and black, water-bearing | 58 | 608 |
| **3N/34-3C1. B. A. Davis. Drilled by A. A. Durand, 1944** | | |
| Palouse formation: | | |
| Soil | 10 | 10 |
| Columbia River basalt: | | |
| "Boulders and hardpan" | 11 | 21 |
| Basalt, gray; static water level at 20 ft | 41 | 62 |
| Basalt, soft; static water level at 15 ft | 10 | 72 |
| Basalt, hard; static water level at 25 ft | 15 | 87 |
| Basalt, soft; static water level at 30 ft | 33 | 120 |
| Basalt, hard | 28 | 148 |
| Basalt; static water level at 15 ft | 12 | 160 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/34-3D1. B. A. Davis. Drilled by D. K. Smith, 1952** | | |
| Palouse formation: | | |
| Soil | 3 | 3 |
| Hardpan | 6 | 9 |
| Columbia River basalt: | | |
| "Rock," broken, cemented | 9 | 18 |
| Basalt, broken | 4 | 22 |
| Basalt, gray, hard | 2 | 24 |
| Basalt, gray, hard; black "fault seam"(?) | 37 | 61 |
| Basalt, gray | 58 | 119 |
| Basalt, black | 2 | 121 |
| Basalt, gray | 4 | 125 |
| Basalt, black, porous | 20 | 145 |
| Basalt, black, broken | 20 | 165 |
| Basalt, gray | 30 | 195 |
| Basalt, black | 35 | 230 |
| Basalt, gray | 18 | 248 |
| Basalt, black, porous | 5 | 253 |
| Basalt, black; broken lowest 15 ft | 45 | 298 |
| **3N/34-3L1. S. J. Lieuallen. Drilled by A. A. Durand and Son, 1948** | | |
| Dug pit | 6 | 6 |
| Columbia River basalt: | | |
| Basalt, brown, loose | 11 | 17 |
| Basalt, brown | 19 | 36 |
| Basalt, blue, hard | 25 | 61 |
| Basalt, blue | 6 | 67 |
| Basalt, blue, hard | 17 | 84 |
| Basalt, blue | 1 | 85 |
| Basalt, blue, hard | 52 | 137 |
| Basalt, blue, medium-hard and hard | 43 | 180 |
| **3N/34-4G1. City of Adams. Drilled by W. E. Ruther, 1938** | | |
| Palouse formation: | | |
| Top soil and sand | 35 | 35 |
| Columbia River basalt: | | |
| Basalt, black, hard | 58 | 93 |
| Basalt, porous, soft, water-bearing | 40 | 133 |
| Basalt, black, hard | 30 | 163 |
| **3N/34-11H1. L. L. Rogers. Drilled by A. A. Durand and Son, 1940** | | |
| Palouse formation: | | |
| Soil | 29 | 29 |
| Columbia River basalt: | | |
| Basalt, black, hard | 6 | 35 |
| Basalt, brown | 10 | 45 |
| Basalt, black and gray, hard | 130 | 175 |
| Basalt, black, soft | 3 | 178 |
| Basalt, black, hard | 109 | 287 |
| Basalt, soft, and clay | 14 | 301 |
| Basalt, hard | 6 | 307 |
| Clay and rock | 2 | 309 |
| Basalt, black, hard | 31 | 340 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/34-17D1. B. G. Haynes. Drilled by D. K. Smith, 1950** | | |
| Palouse formation: | | |
| Soil | 7 | 7 |
| Hardpan, sandy | 7 | 14 |
| Columbia River basalt: | | |
| Basalt, brown | 22 | 36 |
| Basalt, gray | 39 | 75 |
| Basalt, brown | 5 | 80 |
| Basalt, brown with red steaks, water-bearing | 15 | 95 |
| Basalt, brown | 9 | 104 |
| Basalt, black | 26 | 130 |
| Basalt, gray and black | 314 | 444 |
| Basalt, black, porous, water-bearing | 19 | 463 |
| Basalt, brown | 32 | 495 |
| Basalt, gray | 8 | 503 |
| **3N/34-17M1. Standard Oil Co. Drilled by A. A. Durand and Son, 1950** | | |
| Palouse formation: | | |
| Soil | 20 | 20 |
| Fanglomerate: | | |
| Gravel, cemented | 35 | 55 |
| Clay and rock | 3 | 58 |
| Columbia River basalt: | | |
| Basalt, porous, some clay | 12 | 70 |
| Basalt, brown | 10 | 80 |
| Basalt | 25 | 105 |
| Basalt, porous | 20 | 125 |
| Basalt, broken | 12 | 137 |
| Basalt, porous | 48 | 185 |
| Basalt, hard | 4 | 189 |
| Basalt, porous | 16 | 205 |
| Basalt | 15 | 220 |
| Basalt, porous, and clay | 30 | 250 |
| Basalt, broken | 5 | 255 |
| Basalt, porous | 15 | 270 |
| Basalt, broken | 15 | 285 |
| Basalt, hard; static water level at 61 ft | 4 | 289 |
| Basalt | 21 | 310 |
| Basalt, broken | 7 | 317 |
| Basalt, gray | 4 | 321 |
| Basalt, hard; water-bearing at 338 to 343 ft | 24 | 345 |
| Basalt | 15 | 360 |
| Basalt, hard | 26 | 386 |
| **3N/34-18M1. Robert Rothrock. Drilled by A. A. Durand and Son, 1950** | | |
| Palouse formation: | | |
| Soil | 6 | 6 |
| Quaternary alluvium: | | |
| Gravel and clay | 6 | 12 |
| Gravel | 4 | 16 |
| Columbia River basalt: | | |
| Basalt; static water level at 23 ft | 159 | 175 |
| **3N/34-20E1. B. G. Haynes. Drilled by A. A. Durand and Son, 1947** | | |
| Palouse formation: | | |
| Soil | 4 | 4 |
| Columbia River basalt: | | |
| Basalt, brown, soft | 3 | 7 |
| Basalt, blue, hard | 4 | 11 |
| Basalt, brown | 14 | 25 |
| Basalt, blue, medium-hard | 20 | 45 |
| Basalt, brown, and clay | 21 | 66 |
| Basalt, blue, hard | 65 | 131 |
| Basalt, brown, medium-hard, water-bearing | 13 | 144 |
| Basalt, blue, hard | 11 | 155 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/34-22Q1. Irvine Mann. Drilled by A. A. Durand and Son, 1944** | | |
| Palouse formation: | | |
| Soil | 3 | 3 |
| Hardpan | 7 | 10 |
| Fanglomerate(?): | | |
| Gravel | 3 | 13 |
| Columbia River basalt: | | |
| "Shale," red, hard; weathered basalt? | 3 | 16 |
| Basalt, broken | 24 | 40 |
| Basalt, red, soft | 20 | 60 |
| Basalt, blue, hard | 78 | 138 |
| Basalt, broken | 22 | 160 |
| Basalt | 20 | 180 |
| Basalt, soft | 15 | 195 |
| Basalt, hard | 33 | 228 |
| "Shale"(?) | 17 | 245 |
| Basalt; dry crevice at 315 ft | 70 | 315 |

NOTE.—Concrete plug from 310 to 315 ft.

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/34-25B1. C. C. Curl. Drilled by A. A. Durand and Son, 1947** | | |
| Palouse formation: | | |
| Soil | 4 | 4 |
| Fanglomerate(?): | | |
| Gravel and boulders | 13 | 17 |
| Shale | 5 | 22 |
| Columbia River basalt: | | |
| "Rock," soft | 60 | 82 |
| Basalt, black, hard | 13 | 95 |
| Basalt, gray | 12 | 107 |
| Basalt, black | 85 | 192 |
| Basalt, gray | 10 | 202 |
| Basalt, black | 23 | 225 |
| Basalt, gray; static water level at 125 ft | 55 | 280 |
| "Rock," black | 24 | 304 |
| Clay, black | 1 | 305 |
| **3N/34-32D1. J. H. Maloney. Drilled by D. K. Smith** | | |
| Palouse formation: | | |
| Soil | 14 | 14 |
| Fanglomerate(?) or Columbia River basalt: | | |
| "Rock," broken, cemented | 51 | 65 |
| Columbia River basalt: | | |
| Basalt, gray, hard | 22 | 87 |
| Basalt, gray, seamy | 23 | 110 |
| Basalt, brown, broken, water-bearing | 30 | 140 |
| Basalt, red, water-bearing | 14 | 154 |
| Basalt, gray; static water level at 46 ft | 5 | 159 |
| **3N/34-33Q1. L. L. Rogers. Drilled by George Scott, 1951** | | |
| Palouse formation: | | |
| Soil | 11 | 11 |
| Columbia River basalt: | | |
| Basalt, broken | 9 | 20 |
| Basalt, hard | 28 | 48 |
| Basalt, soft | 30 | 78 |
| Basalt, black, firm | 32 | 110 |
| Basalt, reddish | 13 | 123 |
| Basalt, black; crevices | 159 | 282 |
| Basalt, black | 132 | 414 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/35-9J1. E. B. Foster. Drilled by A. A. Durand and Son, 1950** | | |
| Palouse formation: | | |
| Soil | 11 | 11 |
| Columbia River basalt: | | |
| Basalt, blue, broken | 3 | 14 |
| Basalt, blue, hard | 121 | 135 |
| Basalt, gray, hard | 65 | 200 |
| Basalt, gray, broken | 12 | 212 |
| Basalt, blue, hard | 44 | 256 |
| Basalt, broken, and clay | 12 | 268 |
| Basalt, blue, broken, and clay | 11 | 279 |
| Basalt and clay | 6 | 285 |
| Basalt, blue, hard | 17 | 302 |
| Basalt, broken, and clay | 8 | 310 |
| Basalt, blue | 14 | 324 |
| Basalt, blue, hard | 51 | 375 |
| Basalt, black | 9 | 384 |
| Basalt, broken | 11 | 395 |
| Basalt, blue | 54 | 449 |
| Basalt, gray, hard | 9 | 458 |
| Basalt, blue | 7 | 465 |
| Clay, blue, sticky | 5 | 470 |
| Basalt, blue | 11 | 481 |
| **3N/35-15B1. Walter Adams. Drilled by Moore and Anderson** | | |
| Palouse formation and Quaternary alluvium: | | |
| Gravel and "dirt" | 7 | 7 |
| Boulders | 31 | 38 |
| Columbia River basalt: | | |
| "Rock," brown, water-bearing | 62 | 100 |
| **3N/35-18H1. Frank Williams. Drilled by A. A. Durand and Son, 1947** | | |
| Palouse formation: | | |
| Topsoil | 10 | 10 |
| Quaternary alluvium: | | |
| Gravel, cemented | 4 | 14 |
| Columbia River basalt: | | |
| Basalt, hard | 1 | 15 |
| Basalt, black | 83 | 98 |
| Basalt, gray, bailed 5 gpm of water | 2 | 100 |
| Basalt, black, water trickling over top of casing | 34 | 134 |
| Basalt, black, hard | 42 | 176 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **3N/35-19L1. Harold Barnett. Drilled by A. A. Durand and Son, 1946** | | |
| Palouse formation: | | |
| Soil | 7 | 7 |
| Columbia River basalt: | | |
| "Boulders" | 21 | 28 |
| "Boulders," basalt, gray | 12 | 40 |
| Basalt, gray, hard | 2 | 42 |
| Basalt, porous | 26 | 68 |
| Basalt, gray | 8 | 76 |
| Basalt, black, porous | 24 | 100 |
| Basalt, black | 14 | 114 |
| Basalt, gray; static water level at 16 ft | 88 | 202 |
| Basalt, gray, hard | 16 | 218 |
| Basalt, black, porous and creviced; with "soapstone" | 94 | 312 |
| Basalt, black | 113 | 425 |
| Basalt, red, soft | 20 | 445 |
| Basalt, black | 48 | 493 |
| Basalt and clay | 14 | 507 |
| Basalt, decomposed, hard, caving | 11 | 518 |
| Basalt and clay | 20 | 538 |
| Basalt, gray, hard | 18 | 556 |
| Basalt and clay | 6 | 562 |
| Basalt, gray, hard | 11 | 573 |
| Basalt with some clay | 28 | 601 |
| Basalt, hard | 24 | 625 |
| Basalt, decomposed | 15 | 640 |
| Material unreported; water level dropped from 16 to 200 ft | 13 | 653 |
| Basalt | 9 | 662 |
| Basalt, decomposed; static water level at 272 ft | 10 | 672 |
| Basalt, hard | 6 | 678 |
| Basalt, gray | 24 | 702 |
| Basalt and red clay | 28 | 730 |
| Basalt, black | 14 | 744 |
| Basalt, broken | 39 | 783 |
| Basalt, black, hard | 58 | 841 |
| Basalt, brown, soft | 5 | 846 |
| Basalt, porous | 33 | 879 |
| Basalt, black, with "soapstone" | 21 | 900 |
| Basalt, black, hard | 68 | 968 |
| **3N/36-29L1. Gibbon School District. Drilled by Bert Gladney, 1953** | | |
| Dug well, no record | 28 | 28 |
| Columbia River basalt: | | |
| Basalt, hard | 22 | 50 |
| Basalt, soft, water-bearing | 4 | 54 |
| Basalt, broken | 6 | 60 |
| **3N/36-31C1. Union Pacific Railroad. Drilled by A. A. Durand and Son** | | |
| Quaternary alluvium: | | |
| Gravel and boulders | 12 | 12 |
| Gravel, cemented | 12 | 24 |
| Boulders, blue, basaltic | 2 | 26 |
| Columbia River basalt: | | |
| Basalt, platy, caving | 3 | 29 |
| Basalt, gray | 2 | 31 |
| Basalt, black, broken | 22 | 53 |
| Basalt, black, solid, hard | 4 | 57 |
| Basalt, black; crevices | 9 | 66 |
| Basalt, gray, hard | 5 | 71 |
| Basalt, black, "honeycomb," water-bearing | 9 | 80 |

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TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/27-5B1. U.S. Army** | | |
| Glaciofluviatile deposits: | | |
| Gravel, fine | 10 | 10 |
| Sand, fine | 57 | 67 |
| Clay | 20 | 87 |
| Sand | 35 | 122 |
| Clay | 19 | 141 |
| Columbia River basalt: | | |
| Basalt, soft | 557 | 698 |
| Basalt, red, porous | 12 | 710 |
| **4N/27-8J1. U.S. Army (well 3). Drilled by A. A. Durand and Son, 1941** | | |
| Dug pit, no record | 10 | 10 |
| Glaciofluviatile deposits: | | |
| Sand | 73 | 83 |
| "Shale," sandy, brown | 22 | 105 |
| Clay, sandy, yellow | 32 | 137 |
| Clay, gray | 38 | 175 |
| Sand, cemented | 15 | 190 |
| Columbia River basalt and lower part of the Ellensburg formation: | | |
| Basalt, black, hard | 150 | 340 |
| Basalt, black; some green clay | 20 | 360 |
| Clay, green and blue | 5 | 365 |
| "Volcanic ash," black | 15 | 380 |
| Basalt, black, hard | 51 | 431 |
| Basalt, black | 7 | 438 |
| Clay, green | 15 | 453 |
| **4N/27-18P1. U.S. Army (well 5). Drilled by R. J. Strasser** | | |
| Glaciofluviatile deposits: | | |
| Sand and gravel | 100 | 100 |
| Clay | 40 | 140 |
| Columbia River basalt: | | |
| Basalt | 40 | 180 |
| Lower part of the Ellensburg formation: | | |
| Clay | 20 | 200 |
| Columbia River basalt: | | |
| Basalt | 418 | 618 |
| **4N/27-19C1. U.S. Army (well 4). Drilled by R. J. Strasser** | | |
| Glaciofluviatile deposits: | | |
| Sand and gravel | 115 | 115 |
| Columbia River basalt and lower part of the Ellensburg formation: | | |
| Basalt | 190 | 305 |
| Shale | 45 | 350 |
| Basalt | 35 | 385 |
| Clay | 30 | 415 |
| Basalt | 185 | 600 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/27-20M1. Union Pacific Railroad. Drilled by A. M. Jannsen, 1945** | | |
| Glaciofluviatile deposits: | | |
| Sand, black, fine; static water level at 50 ft | 105 | 105 |
| Sand, fine to coarse | 40 | 145 |
| Sand, coarse, and gravel | 25 | 170 |
| Columbia River basalt: | | |
| Basalt, gray; static water level at 40 ft | 5 | 175 |
| Basalt, gray, hard; static water level at 35 ft | 12 | 187 |
| Basalt, gray, broken | 4 | 191 |
| Basalt, gray, hard | 118 | 309 |
| Basalt, some clay | 16 | 325 |
| Lower part of the Ellensburg formation: | | |
| "Lava sediment"; some blue clay | 45 | 370 |
| Columbia River basalt: | | |
| Basalt, gray, broken | 10 | 380 |
| Basalt, broken | 3 | 383 |
| Basalt, dark gray | 5 | 388 |
| Basalt, gray, broken | 59 | 447 |
| Basalt, gray, hard | 3 | 450 |
| Basalt, gray, hard, water-bearing; static water level at 43 ft | 7 | 457 |
| **4N/27-22K1. U.S. Army (well 2). Drilled by A. A. Durand and Son, 1941** | | |
| Dug pit, no record | 12 | 12 |
| Glaciofluviatile deposits: | | |
| Gravel, coarse, some boulders | 31 | 43 |
| Sand and coarse gravel | 23 | 66 |
| Sand | 3 | 69 |
| Sand and coarse gravel | 11 | 80 |
| Sand and small gravel | 15 | 95 |
| Gravel | 54 | 149 |
| Gravel, cemented | 6 | 155 |
| Columbia River basalt: | | |
| "Rock," hard, with clay seams | 42 | 197 |
| Clay and shale | 7 | 204 |
| Basalt, gray, hard | 3 | 207 |
| Basalt, and blue clay | 6 | 213 |
| Basalt, black | 2 | 215 |
| Clay, blue | 1 | 216 |
| Basalt, black, hard | 7 | 223 |
| Basalt, black, very hard | 41 | 264 |
| Basalt, gray | 13 | 277 |
| Basalt, black, creviced | 5 | 282 |
| Basalt, gray, hard | 6 | 288 |
| Basalt, black, hard | 8 | 296 |
| Basalt, black, honeycomb | 20 | 316 |
| Basalt, black | 4 | 320 |
| Basalt, black, honeycomb | 10 | 330 |
| Basalt, black | 5 | 335 |
| Basalt, black, honeycomb | 18 | 353 |
| Basalt, gray, hard | 3 | 356 |
| Basalt, black | 4 | 360 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/27-22L1. U.S. Army (well 1). Drilled by A. A. Durand and Son, 1941** | | |
| Dug pit, no record | 4 | 4 |
| Glaciofluviatile deposits: | | |
| Gravel and sand, loose | 57 | 61 |
| Gravel and boulders | 2 | 63 |
| Gravel | 3 | 66 |
| Gravel and clay | 21 | 87 |
| Gravel, fine | 15 | 102 |
| Gravel and sand | 2 | 104 |
| Gravel, fine, loose, and sand | 45 | 149 |
| "Shale" | 2 | 151 |
| Gravel | 6 | 157 |
| Columbia River basalt: | | |
| Basalt, black | 3 | 160 |
| Gravel, cemented | 20 | 180 |
| Basalt, black | 15 | 195 |
| Basalt and clay | 5 | 200 |
| Basalt | 6 | 206 |
| Basalt, black, hard | 57 | 263 |
| Basalt, gray, hard | 32 | 295 |
| Basalt, black; some clay | 6 | 301 |
| Basalt, gray, hard | 7 | 308 |
| Basalt, black, honeycomb | 10 | 318 |
| Basalt, gray, very hard | 9 | 327 |
| **4N/27-27R1. U.S. Army (housing project well)** | | |
| Glaciofluviatile deposits: | | |
| Sand | 4 | 4 |
| Gravel, loose | 127 | 131 |
| Gravel and clay | 4 | 135 |
| Gravel, small, water-bearing; static water level at 100 ft | 5 | 140 |
| Gravel, loose | 6 | 146 |
| Boulders | 24 | 170 |
| Clay, brown | 32 | 202 |
| "Soapstone" | 6 | 208 |
| Columbia River basalt: | | |
| Basalt, black | 97 | 305 |
| Clay, sticky | 7 | 312 |
| Basalt, black, honeycomb, water-bearing; static water level at 99 ft | 18 | 330 |
| Basalt, black | 27 | 357 |
| Basalt, gray | 4 | 361 |
| Basalt, black | 14 | 375 |
| Basalt, black, soft | 10 | 385 |
| Clay | 6 | 391 |
| Basalt, honeycomb, water-bearing, and blue clay; static water level at 98 ft | 21 | 412 |
| Basalt, black | 21 | 432 |
| Basalt, brown | 2 | 434 |
| Basalt, gray | 57 | 491 |
| Basalt, red, and "shale" | 23 | 514 |
| Basalt, gray | 2 | 516 |
| Basalt, brown | 22 | 538 |
| Basalt, red, porous, water-bearing; static water level at 121 ft | 5 | 543 |
| **4N/27-28E1. V. R. Fulton. Drilled by A. M. Edwards, 1953** | | |
| Glaciofluviatile deposits: | | |
| Soil, sandy | 3 | 3 |
| Gravel, cemented | 18 | 21 |
| Gravel, loose | 12 | 33 |
| Hardpan | 2 | 35 |
| Gravel, loose, with sand layers | 67 | 102 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/27-28E2. V. R. Fulton. Drilled by A. M. Edwards, 1954** | | |
| Glaciofluviatile deposits: | | |
| Soil, sandy, loose | 2 | 2 |
| Gravel, cemented | 3 | 5 |
| Boulders, gravel and sand | 13 | 18 |
| Hardpan | 3 | 21 |
| Boulders | 10 | 31 |
| Clay, yellow | 4 | 35 |
| Gravel | 2 | 37 |
| Clay, blue | 5 | 42 |
| Clay, yellow, sandy | 18 | 60 |
| Sand, coarse, and "pea gravel" | 1 | 61 |
| Clay, blue, and heavy boulders | 3 | 64 |
| Clay, yellow; mixed with gravel | 8 | 72 |
| "Pea gravel," sandy, water-bearing | 8 | 80 |
| Gravel, large and small, mixed | 7 | 87 |
| Gravel, cobble-size, and smaller gravel | 11 | 98 |
| Gravel, pebbles | 3 | 101 |
| Gravel, cobbles | 4 | 105 |
| "Pea gravel" and sand | 4 | 109 |
| "Pea gravel" and cobbles | 10 | 119 |
| **4N/27-28G1. S. F. Hoyt. Drilled by A. M. Edwards, 1954** | | |
| Glaciofluviatile deposits: | | |
| Topsoil | 4 | 4 |
| Gravel, boulders, cemented | 9 | 13 |
| Clay with imbedded cobbles and boulders | 25 | 38 |
| Clay, blue; mixed with gravel and boulders | 6 | 44 |
| Clay, blue and yellow; gravel layers | 25 | 69 |
| Clay, red | 4 | 73 |
| Gravel, coarse; 3 inches and smaller; water-bearing | 8 | 81 |
| "Pea gravel" and sand; some cobbles | 21 | 102 |
| Gravel, coarse | 4 | 106 |
| "Pea gravel," "heaving," water-bearing | 20 | 126 |
| **4N/27-32J1. R. G. Holzapfel** | | |
| Glaciofluviatile deposits: | | |
| Loam, sandy | 6 | 6 |
| Sand | 20 | 26 |
| Gravel | 37 | 63 |
| Gravel with clay binder | 27 | 90 |
| Clay, "burnt," water-bearing | 3 | 93 |
| Clay | 17 | 110 |
| Columbia River basalt: | | |
| Basalt, black | 26 | 136 |
| Basalt, gray | 21 | 157 |
| Lower part of the Ellensburg formation: | | |
| Clay, green, and sand | 30 | 187 |
| Columbia River basalt: | | |
| Basalt, black, water-bearing | 5 | 192 |
| Basalt, black | 103 | 295 |
| Basalt, black, "burnt out" (scoriaceous?) water-bearing | 15 | 310 |
| **4N/27-33H1. McDole Bros. Drilled by L. E. Wallis, 1950** | | |
| Glaciofluviatile deposits: | | |
| Sandy soil | 5 | 5 |
| Sand, black, with a few "rocks" | 31 | 36 |
| Gravel, pea sized, and sand | 29 | 65 |
| Sand, coarse, and pea gravel, water-bearing | 30 | 95 |
| Clay, soft | 1 | 96 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/27-33J2. McDole Bros.** | | |
| Glaciofluviatile deposits: | | |
| Sandy topsoil | 7 | 7 |
| Sand, gray | 26 | 33 |
| Gravel, "egg size," and sand | 32 | 65 |
| Gravel, pea size, and coarse sand | 29 | 94 |
| Older alluvium or Columbia River basalt: | | |
| Clay, broken; "weathered" basalt? | 2 | 96 |
| **4N/27-36E1. G. W. Redwine. Drilled by Bert Gladney, 1952** | | |
| Glaciofluviatile deposits: | | |
| Loam, sandy | 20 | 20 |
| Sand and gravel | 10 | 30 |
| Gravel | 65 | 95 |
| Clay, gray | 10 | 105 |
| Columbia River basalt: | | |
| Rock, gray | 30 | 135 |
| [Lower member of Ellensburg formation:] | | |
| Clay and shale, blue | 59 | 194 |
| **4N/28-10F1. City of Hermiston** | | |
| Glaciofluviatile deposits: | | |
| Soil | 5 | 5 |
| Sand | 29 | 34 |
| Gravel, water-bearing (water cased out) | 10 | 44 |
| Clay, blue | 20 | 64 |
| Columbia River basalt: | | |
| Basalt | 90 | 154 |
| Basalt, water-bearing; water level standing at 30 ft | 6 | 160 |

NOTE.—Casing, 12¼-inch, set to 64 feet. Open 12¼-inch hole below.

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/28-11P1. City of Hermiston. Drilled by A. A. Durand and Son, 1949** | | |
| Glaciofluviatile deposits: | | |
| Soil, sandy | 30 | 30 |
| Mud, blue | 14 | 44 |
| Columbia River basalt: | | |
| Basalt, blue, hard, broken; soft layers | 51 | 95 |
| Basalt, blue, hard; broken layers | 140 | 235 |
| Basalt, broken; gumbo mud | 41 | 276 |
| Basalt; "mixture;" some gumbo and dark sand | 206 | 482 |
| Basalt, gray, hard, broken | 436 | 918 |
| **4N/28-20N1. C. O. Porter. Drilled by W. R. Ille, 1956** | | |
| Glaciofluviatile deposits: | | |
| Sand and gravel | 25 | 25 |
| Silt and sand | 45 | 70 |
| Clay, silt, and gravel | 25 | 95 |
| Clay, blue | 30 | 125 |
| Columbia River basalt: | | |
| Basalt, water-bearing | 20 | 145 |
| **4N/28-24A1. Ray Moses. Drilled by W. R. Ille, 1952** | | |
| Glaciofluviatile deposits: | | |
| Sand and gravel | 30 | 30 |
| Clay | 60 | 90 |
| Columbia River basalt: | | |
| "Rock" | 312 | 402 |
| Basalt, vesicular, water-bearing | 25 | 427 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/28-27J1. Union Pacific Railroad (Hinkle station). Drilled by A. A. Durand and Son, 1950** | | |
| Glaciofluviatile deposits: | | |
| Sand | 31 | 31 |
| Gravel | 21 | 52 |
| Boulders and coarse gravel | 46 | 98 |
| Gravel, coarse | 6 | 104 |
| Gravel and sand | 9 | 113 |
| Gravel | 32 | 145 |
| Gravel, fine | 10 | 155 |
| Columbia River basalt: | | |
| Basalt, blue, medium-hard, and blue clay | 12 | 167 |
| Basalt | 3 | 170 |
| Basalt, blue, broken | 10 | 180 |
| Lower part of the Ellensburg formation: | | |
| Clay or shale, blue | 20 | 200 |
| Clay, gray; some broken basalt | 20 | 220 |
| Clay, green, sticky | 25 | 245 |
| Gravel | 2 | 247 |
| Columbia River basalt: | | |
| Basalt, brown | 3 | 250 |
| Basalt, black | 41 | 291 |
| Basalt, hard | 9 | 300 |
| Basalt | 8 | 308 |
| Basalt, dark | 16 | 324 |
| Basalt, dark, hard | 9 | 333 |
| Basalt, gray, hard; crevice at 352 ft | 27 | 360 |
| Basalt, brown, water-bearing; static water level at 125 ft | 5 | 365 |
| Basalt, brown, broken | 11 | 376 |
| Basalt, black | 11 | 387 |
| Shale, blue | 10 | 397 |
| Basalt | 8 | 405 |
| Basalt, dark | 10 | 415 |
| Basalt, dark, fractured | 3 | 418 |
| Shale, blue; static water level at 132 ft | 5 | 423 |
| Basalt, dark, broken | 12 | 435 |
| Basalt, dark, hard; fractured 458-460 | 29 | 464 |
| Basalt, dark, broken; static water level at 137 ft | 6 | 470 |
| Basalt, dark, hard; static water level at 140 ft | 20 | 490 |
| Basalt, gray, hard; static water level at 160 ft | 23 | 513 |
| Basalt, broken, loose | 4 | 517 |
| Basalt, gray, hard | 19 | 536 |
| Basalt, gray, creviced; static water level at 156 ft | 1 | 537 |
| Basalt, gray, hard | 16 | 553 |
| **4N/29-3N1. Gene Gray. Drilled by Ben Dreyer, 1953** | | |
| Glaciofluviatile deposits: | | |
| Soil, sandy | 20 | 20 |
| Clay, red | 44 | 64 |
| Clay, blue | 13 | 78 |
| Clay, yellow, sandy | 32 | 110 |
| Sand | 17 | 127 |
| Columbia River basalt: | | |
| Basalt, red, soft | 40 | 167 |
| Basalt, blue, hard | 88 | 255 |
| Basalt, black, medium-hard | 39 | 294 |
| Clay, blue | 12 | 306 |
| Basalt, blue, medium-hard | 74 | 380 |
| Basalt, blue, hard | 54 | 434 |
| Basalt, red, soft | 20 | 454 |
| Basalt, black, medium-hard and hard | 300 | 754 |
| **4N/29-11B1. Marvin Hurd. Bored by owner** | | |
| Glaciofluviatile deposits: | | |
| Sand | 6 | 6 |
| Hardpan | 3 | 9 |
| Sand, fine, water-bearing | 11 | 20 |
| Clay and gravel | 10 | 30 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/29-13K1. Edwards Farms, Inc.** | | |
| Glaciofluviatile deposits: | | |
| Soil, sandy | 27 | 27 |
| Gravel | 4 | 31 |
| Clay, red | 45 | 76 |
| Boulders and sand | 35 | 111 |
| Columbia River basalt: | | |
| Basalt, black | 20 | 131 |
| Clay, blue, and sand | 16 | 147 |
| Boulders and sand; broken basalt? | 20 | 167 |
| Basalt, black, soft | 89 | 256 |
| Basalt, red and black | 252 | 508 |
| Basalt, red | 14 | 522 |
| Basalt, black, hard | 5 | 527 |
| **4N/29-13N1. Edwards Farms, Inc. Drilled by Ille Bros., 1954** | | |
| Glaciofluviatile deposits: | | |
| Sand and silt | 30 | 30 |
| Sand and gravel | 32 | 62 |
| Columbia River basalt: | | |
| "Flow breccia" | 16 | 78 |
| Basalt; clay layer | 169 | 247 |
| Basalt, broken | 73 | 320 |
| Interbed; sedimentary? | 27 | 347 |
| Basalt; dense and broken layers | 63 | 410 |
| "Flow breccia" | 15 | 425 |
| **4N/29-17C1. Ben Dreyer. Drilled by owner, 1952** | | |
| Glaciofluviatile deposits: | | |
| Soil | 18 | 18 |
| Clay, red | 83 | 101 |
| Sand and gravel | 44 | 145 |
| Clay, red | 42 | 187 |
| Sand, white | 25 | 212 |
| Clay, white | 8 | 220 |
| Columbia River basalt: | | |
| Basalt, black, soft | 25 | 245 |
| **4N/31-9P1. R. E. Bissinger. Drilled by D. K. Smith, 1952** | | |
| Palouse formation: | | |
| Soil | 12 | 12 |
| Columbia River basalt: | | |
| "Rock," cemented | 18 | 30 |
| Basalt, gray, hard | 6 | 36 |
| Basalt, black | 10 | 46 |
| Basalt, gray, hard | 24 | 70 |
| Basalt, black | 2 | 72 |
| Basalt, red, water-bearing | 10 | 82 |
| Basalt, brown | 13 | 95 |
| Basalt, black, gray and green; in layers | 185 | 280 |
| Basalt, black, hard, water-bearing | 62 | 342 |
| **4N/31-9Q1. Dewey Purcell** | | |
| Dug well, no record | 18 | 18 |
| Columbia River basalt: | | |
| Basalt, broken | 2 | 20 |
| Basalt, gray and brown, hard | 45 | 65 |
| Basalt, black, soft | 10 | 75 |
| Basalt, gray | 4 | 79 |
| Basalt, brown, water-bearing | 6 | 85 |
| Basalt, black and gray | 70 | 155 |
| Basalt, black, water-bearing; static water level at 20 ft | 20 | 175 |

NOTE.—Casing, 8-inch, set to 20 feet, open 8-inch hole to bottom.

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/31-23H1. A. H. Schluter. Drilled by D. K. Smith** | | |
| Palouse formation: | | |
| Soil | 6 | 6 |
| Hardpan | 16 | 22 |
| Columbia River basalt: | | |
| Basalt, brown, broken | 53 | 75 |
| Basalt, black, porous | 5 | 80 |
| Basalt, brown, broken, muddy | 20 | 100 |
| Basalt, black | 22 | 122 |
| Basalt, gray | 22 | 144 |
| Basalt, black, water-bearing | 34 | 178 |
| Basalt, gray | 12 | 190 |
| Basalt, brown | 18 | 208 |
| Basalt, gray, seamy | 12 | 220 |
| Basalt, black, porous, water-bearing | 30 | 250 |
| Basalt, black | 82 | 332 |
| Basalt, gray, creviced (cuttings washed away) | 17 | 349 |
| Basalt, gray, soft streaks | 71 | 420 |
| Basalt, gray, very hard | 5 | 425 |
| Basalt, gray | 22 | 447 |
| Basalt, black, water-bearing | 14 | 461 |
| Basalt, gray, water-bearing | 2 | 463 |
| **4N/31-30F1. Glen Simpson. Drilled by D. K. Smith** | | |
| Palouse formation: | | |
| Soil | 12 | 12 |
| Columbia River basalt: | | |
| Rock, cemented | 14 | 26 |
| Sand, decomposed basalt? | 2 | 28 |
| Basalt, gray and black | 255 | 283 |
| Basalt, black, broken, water-bearing | 22 | 305 |
| Basalt, gray | 5 | 310 |
| **4N/32-3J1. Lester King. Drilled by A. A. Durand and Son, 1947** | | |
| Palouse formation and Quaternary alluvium: | | |
| Soil | 10 | 10 |
| Clay, brown | 12 | 22 |
| Columbia River basalt: | | |
| Basalt, brown | 6 | 28 |
| Basalt, blue, hard | 4 | 32 |
| Basalt, brown | 11 | 43 |
| Basalt, blue, hard | 40 | 83 |
| Basalt, brown, soft | 16 | 99 |
| Basalt, blue and brown layers | 43 | 142 |
| Basalt, brown, medium-hard | 3 | 145 |
| Basalt, brown, very hard | 19 | 164 |
| Basalt, blue, hard, broken | 4 | 168 |
| **4N/32-18R1. W. R. Meiner. Drilled by A. A. Durand and Son, 1948** | | |
| Palouse formation: | | |
| Soil | 6 | 6 |
| Clay | 10 | 16 |
| Columbia River basalt: | | |
| Basalt, broken | 1 | 17 |
| Basalt, blue, hard | 32 | 49 |
| Basalt, blue, broken | 9 | 58 |
| Basalt, blue, hard | 97 | 155 |
| Basalt, blue, broken | 19 | 174 |
| Basalt, blue, hard | 11 | 185 |
| Basalt, gray, broken | 15 | 200 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/33-29K1. J. C. Hawkins. Drilled by W. E. Ruther** | | |
| Palouse formation: | | |
| Soil | 63 | 63 |
| Columbia River basalt: | | |
| "Rock" | 133 | 196 |
| Shale, green | 12 | 211 |
| **4N/33-33B1. Frank Molstrom. Drilled by D. K. Smith, 1954** | | |
| Palouse formation: | | |
| Soil | 2 | 2 |
| Hardpan and "shellrock" | 42 | 44 |
| Columbia River basalt: | | |
| Basalt, brown | 6 | 50 |
| Basalt, gray, hard | 38 | 88 |
| Basalt, red | 7 | 95 |
| Basalt, brown | 38 | 133 |
| Basalt, black, broken | 3 | 136 |
| Basalt, black | 18 | 154 |
| Basalt, black, broken | 31 | 185 |
| Basalt, black, hard | 10 | 195 |
| Basalt, black, soft | 5 | 200 |
| **4N/33-36R2. John Hales. Drilled by D. K. Smith, 1948** | | |
| Palouse formation: | | |
| Soil | 6 | 6 |
| Hardpan | 2 | 8 |
| Clay, brown | 12 | 20 |
| Undesignated: | | |
| Hardpan; decomposed basalt? | 18 | 38 |
| Columbia River basalt: | | |
| Basalt, black | 6 | 44 |
| Clay, sandy, brown; decomposed basalt? | 4 | 48 |
| Basalt, black | 5 | 53 |
| Clay, sandy, brown | 7 | 60 |
| Basalt, black and gray | 30 | 90 |
| Basalt, black, porous, water-bearing; static water level at 40 ft | 8 | 98 |
| Basalt, black | 3 | 101 |
| Basalt, porous, water-bearing | 1 | 102 |
| Basalt, gray | 22 | 124 |
| Basalt, black, porous, water-bearing | 16 | 140 |
| Basalt, black and gray | 75 | 215 |
| Basalt, black, water-bearing | 30 | 245 |
| Basalt, black | 13 | 258 |
| **4N/34-6L1. R. B. Taylor. Drilled by Bert Gladney, 1951** | | |
| Palouse formation: | | |
| Soil | 36 | 36 |
| Columbia River basalt: | | |
| Basalt with a few soft porous zones | 434 | 470 |
| Basalt, porous, water-bearing | 30 | 500 |
| Basalt | 5 | 505 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/34-12L1. Herbert Whitmore. Drilled by D. K. Smith** | | |
| Palouse formation: | | |
| Soil | 18 | 18 |
| Undesignated: | | |
| Gravel and sand, water-bearing | 1 | 19 |
| Columbia River basalt: | | |
| Basalt, brown and black, broken | 84 | 103 |
| Basalt, black | 19 | 122 |
| Clay, yellow | 2 | 124 |
| Basalt, red | 1 | 125 |
| Basalt, brown, broken | 13 | 138 |
| Clay, yellow | 2 | 140 |
| Basalt, brown, broken | 20 | 160 |
| Basalt, black, hard | 7 | 167 |
| Clay, yellow | 15 | 182 |
| Basalt, gray and black | 63 | 245 |
| Basalt, gray, hard | 6 | 251 |
| Basalt, black and gray | 89 | 340 |
| Basalt, gray, hard | 20 | 360 |
| Basalt, black | 20 | 380 |
| Basalt, gray, hard | 47 | 427 |
| Basalt, black | 3 | 430 |
| Basalt, gray, hard | 116 | 546 |
| Basalt, black | 39 | 585 |
| Basalt, gray, hard | 45 | 630 |
| Basalt, black | 10 | 640 |
| Basalt, gray, hard | 50 | 690 |
| Basalt, black | 31 | 721 |
| Basalt, gray, hard | 57 | 778 |
| "Shale," black | 22 | 800 |
| **4N/34-15G1. Jay Scott. Drilled by A. A. Durand and Son, 1946** | | |
| Palouse formation: | | |
| Soil | 15 | 15 |
| Fanglomerate: | | |
| Gravel, cemented | 10 | 25 |
| Columbia River basalt: | | |
| Basalt, hard | 25 | 50 |
| Basalt, blue, hard | 13 | 63 |
| Basalt, black | 82 | 145 |
| Basalt, gray, brown, black and dark layers | 60 | 205 |
| **4N/34-22H1. Dean Dudley. Drilled by A. A. Durand and Son, 1945** | | |
| Palouse formation: | | |
| Soil | 8 | 8 |
| Fanglomerate: | | |
| Clay, sandy | 55 | 63 |
| Gravel and sand, water level at 60 ft | 11 | 74 |
| Gravel, cemented | 6 | 80 |
| Sand, brown, hard | 10 | 90 |
| Gravel, cemented, static water level at 50 ft | 14 | 104 |
| Columbia River basalt: | | |
| "Sand rock," brown, hard (decomposed basalt) | 7 | 111 |
| Basalt, hard, crevice at 112 ft; static water level at 50 ft | 99 | 210 |
| Basalt, soft, static water level at 46 ft | 10 | 220 |
| Undesignated interbeds: | | |
| Clay, blue | 5 | 225 |
| Clay, brown | 10 | 235 |
| Gravel | 2 | 237 |
| Shale, green; static water level at 200 ft | 23 | 260 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

**4N/34-24R1. Rogers Canning Co. (well 3). Drilled by A. A. Durand and Son, 1946**

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| Quaternary alluvium: | | |
| Silt, yellow | 7 | 7 |
| Gravel, water-bearing | 15 | 22 |
| Columbia River basalt: | | |
| Basalt, dark | 2 | 24 |
| Basalt, gray, hard | 7 | 31 |
| Basalt, broken | 7 | 38 |
| Shale, brown | 3 | 41 |
| Basalt, gray | 15 | 56 |
| "Rock," broken, and brown shale | 14 | 70 |
| Basalt; hard and soft layers alternating with gray clay | 5 | 75 |
| Basalt, gray, hard | 5 | 80 |
| Basalt, dark | 45 | 125 |
| "Rock," broken | 9 | 134 |
| Basalt, dark-gray, broken | 8 | 142 |
| Basalt, broken; some blue shale | 40 | 182 |
| Basalt, black, soft, broken, water-bearing | 11 | 193 |
| Basalt, dark | 4 | 197 |
| Basalt, gray, hard | 103 | 300 |
| Basalt, gray | 70 | 370 |
| Shale, blue | 10 | 380 |
| Basalt, dark, medium-hard | 44 | 424 |
| Basalt, gray; upper 17 ft brown | 64 | 488 |
| Shale, brown; decomposed basalt | 12 | 500 |
| Basalt, dark | 70 | 570 |
| Basalt, dark; upper 38 ft broken | 102 | 672 |
| Shale, blue, sticky | 6 | 678 |
| Basalt, dark-gray; water-bearing 700 to 713 ft | 52 | 730 |
| Basalt, black, water-bearing | 6 | 736 |
| Basalt, gray, hard | 4 | 740 |
| Basalt, dark-gray | 26 | 766 |
| Basalt, dark, broken; water-bearing 796–810 ft | 74 | 840 |
| Basalt, alternately dark-gray | 95 | 935 |
| Mud, gray, sticky | 5 | 940 |
| Basalt, gray | 6 | 946 |
| Basalt, brown | 14 | 960 |
| Basalt, red-brown, broken | 47 | 1,007 |
| Basalt, broken, dark | 18 | 1,025 |
| Basalt, broken, dark, water-bearing; artesian water flowing from casing | 6 | 1,031 |
| Basalt, gray | 88 | 1,119 |
| Basalt, black; brown and broken 1,132 to 1,139 ft | 25 | 1,144 |
| Basalt, gray, water-bearing | 4 | 1,148 |

**4N/34-26H1. M. F. Sheard. Drilled by A. A. Durand and Son, 1945**

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| Quaternary alluvium: | | |
| Soil | 13 | 13 |
| Gravel with boulders | 5 | 18 |
| Boulders | 7 | 25 |
| Gravel and clay | 5 | 30 |
| Columbia River basalt: | | |
| Basalt | 30 | 60 |
| Basalt, soft, and sand | 5 | 65 |

**4N/34-26J2. Neil McIntyre. Drilled by A. A. Durand and Son, 1945**

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| Old well, no record | 65 | 65 |
| Columbia River basalt: | | |
| "Shale" (weathered basalt), brown; static water level at 30 ft | 12 | 77 |
| "Shale," blue | 10 | 87 |
| Basalt | 23 | 110 |
| Clay | 18 | 128 |
| Basalt | 7 | 135 |
| Basalt with blue clay (caving from above?) | 31 | 166 |
| Basalt | 18 | 184 |
| Basalt, soft; static water level at 34 ft | 16 | 200 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/34-28E1. Nettie Woodward. Drilled by A. A. Durand and Son, 1940** | | |
| Palouse formation: | | |
| Soil | 7 | 7 |
| Undesignated: | | |
| Dirt, yellow (weathered basalt?) | 49 | 56 |
| Columbia River basalt: | | |
| Basalt, black | 21 | 77 |
| Basalt, blue and black, hard | 58 | 135 |
| Basalt, red, soft, and clay | 18 | 153 |
| Basalt, black | 2 | 155 |
| Basalt, brown, soft, and mud | 10 | 165 |
| Basalt, black and gray, hard | 45 | 210 |
| Basalt, brown, "muddy" | 2 | 212 |
| Basalt, black | 31 | 243 |
| Basalt, blue, very hard | 27 | 270 |
| Basalt, black | 20 | 290 |
| Basalt, gray, hard; crevices | 9 | 299 |
| Basalt, gray, hard | 21 | 320 |
| Clay, blue | 1 | 321 |
| Basalt, gray and black, hard | 65 | 386 |
| Basalt, black, with clay seams | 19 | 405 |
| Basalt, gray and black, hard | 15 | 420 |
| "Rock," hard and soft streaks | 7 | 427 |
| Basalt, blue, very hard | 29 | 456 |
| Basalt, black; some clay | 3 | 459 |
| Basalt, black, hard | 6 | 465 |
| Basalt, gray and black, hard, creviced | 4 | 469 |
| Basalt, gray, very hard | 24 | 493 |
| Basalt, black, with clay streaks | 62 | 555 |
| Basalt, brown and black, medium-hard | 19 | 574 |
| Basalt, gray, hard | 24 | 598 |
| Basalt, black, and clay | 34 | 632 |
| Basalt, blue, hard | 8 | 640 |
| Basalt, black, water-bearing | 3 | 643 |
| Basalt, gray, hard; static water level at 64 ft | 2 | 645 |
| Basalt, blue, black and gray, hard | 155 | 800 |
| Shale, brown, sticky | 10 | 810 |
| Shale, blue, sticky | 12 | 822 |
| Shale, gray, sandy | 20 | 842 |
| Basalt, black | 16 | 858 |
| Basalt, gray, hard | 89 | 947 |
| Basalt, brown, hard | 4 | 951 |
| Basalt, red, hard; static water level at 121 ft | 28 | 979 |
| **4N/34-32M1. L. L. Rogers (well 1). Drilled by George Scott** | | |
| Palouse formation: | | |
| Soil | 11 | 11 |
| Columbia River basalt: | | |
| Basalt, broken | 5 | 16 |
| Basalt, black and gray, hard | 65 | 81 |
| Basalt, reddish brown | 11 | 92 |
| Basalt, black | 18 | 110 |
| Shale (weathered basalt?) | 16 | 126 |
| Basalt, black | 14 | 140 |
| Clay, blue | 5 | 145 |
| Basalt, black and gray | 167 | 312 |
| Basalt, black, caving | 24 | 336 |
| Basalt, black, static water level at 12 ft | 64 | 400 |
| Basalt, black, caving | 16 | 416 |
| Basalt, black | 10 | 426 |
| Basalt, black, water-bearing | 7 | 433 |
| Basalt, black | 91 | 524 |
| Shale, blue | 3 | 527 |
| Basalt, black | 5 | 532 |
| Shale, blue | 3 | 535 |
| Basalt, black, hard; creviced below 600 ft | 116 | 651 |
| Basalt, broken and creviced, caving | 19 | 670 |
| Shale, hard, greenish | 3 | 673 |
| Basalt, black, hard | 54 | 727 |
| Basalt, soft, and clay | 10 | 737 |
| Basalt, broken | 5 | 742 |
| Basalt, hard | 52 | 794 |
| Clay, pasty | 6 | 800 |
| Basalt, black | 42 | 842 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/34-32N1. L. L. Rogers (well 3). Drilled by Ben Dreyer, 1953** | | |
| Palouse formation: | | |
| Soil, sandy | 6 | 6 |
| Columbia River basalt: | | |
| Basalt, black, hard | 30 | 36 |
| Boulders, loose | 33 | 69 |
| Basalt, red, hard | 11 | 80 |
| Boulders and sand | 5 | 85 |
| Basalt, red, soft | 7 | 92 |
| Basalt, black, hard | 158 | 250 |
| Boulders and sand | 6 | 256 |
| Basalt, red, soft, becoming harder with depth | 32 | 288 |
| Basalt, blue, hard | 47 | 335 |
| Boulders and sand | 33 | 368 |
| Basalt, black, hard | 60 | 428 |
| Shale, green | 6 | 434 |
| Boulders and sand | 17 | 451 |
| **4N/34-33Q1. L. L. Rogers (well 2). Drilled by George E. Scott** | | |
| Palouse formation: | | |
| Soil | 11 | 11 |
| Columbia River basalt: | | |
| Basalt, broken | 9 | 20 |
| Basalt, hard | 28 | 48 |
| Basalt, softer | 30 | 78 |
| Basalt, firm | 24 | 102 |
| Basalt, black | 8 | 110 |
| Basalt, red | 13 | 123 |
| Basalt, black | 7 | 130 |
| Basalt, black, water-bearing | 14 | 144 |
| Basalt, black | 16 | 160 |
| Basalt, black, crevices at 161 and 210 ft | 110 | 270 |
| Basalt, black, harder, water-bearing | 20 | 290 |
| Basalt, black, broken top 2 ft | 40 | 330 |
| Basalt, black, water-bearing top 25 ft | 84 | 414 |
| **4N/34-34P1. Wild Horse Grange. Drilled by A. A. Durand and Son, 1947** | | |
| Quaternary alluvium: | | |
| Clay and boulders | 17 | 17 |
| Columbia River basalt: | | |
| Basalt, black | 3 | 20 |
| Basalt, gray | 10 | 30 |
| Basalt, dark, hard | 22 | 52 |
| Basalt, gray | 14 | 66 |
| Basalt, black, hard | 13 | 79 |
| Basalt, dark | 13 | 92 |
| Basalt, gray, soft | 8 | 100 |
| Basalt, black | 12 | 112 |
| "Shale, brown"; decomposed basalt? | 5 | 117 |
| Basalt, dark, hard | 26 | 143 |
| Basalt, gray | 17 | 160 |
| Basalt, black; some hard layers | 5 | 165 |
| Basalt, black, water-bearing | 3 | 168 |
| Basalt, black, hard streaks | 41 | 209 |
| **4N/35-8M1. J. H. McDougal. Drilled by D. K. Smith, 1952** | | |
| Palouse formation: | | |
| Soil, sandy | 14 | 14 |
| Columbia River basalt: | | |
| Basalt, broken | 13 | 27 |
| Basalt, gray | 2 | 29 |
| Basalt, brown, broken, water-bearing | 8 | 37 |
| Basalt, gray, hard | 3 | 40 |
| Basalt, gray and black layers | 50 | 90 |
| Basalt, black, water-bearing | 16 | 106 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/35-19E1. Rogers Canning Co. (well 1). Drilled by A. A. Durand and Son, 1941** | | |
| Palouse formation: | | |
| Soil | 10 | 10 |
| Fanglomerate: | | |
| Clay, gray; some gravel | 5 | 15 |
| Gravel, cemented | 36 | 51 |
| Columbia River basalt: | | |
| Basalt, black | 40 | 91 |
| Basalt, black; some blue clay | 39 | 130 |
| Basalt, black, porous | 15 | 145 |
| Basalt, black, porous; "soapstone" | 11 | 156 |
| Basalt, black | 75 | 231 |
| "Soapstone," blue (clay?) | 4 | 235 |
| Basalt, black | 18 | 253 |
| Basalt, black, porous | 17 | 270 |
| Basalt, black; static water level at 8 ft | 12 | 282 |
| Basalt, gray, hard; static water level at 6 ft | 80 | 362 |
| Basalt, black, porous | 28 | 390 |
| Basalt, gray, hard | 66 | 456 |
| Basalt, black, porous | 2 | 458 |
| Basalt, black, porous, some "soapstone" | 13 | 471 |
| Basalt, black, porous | 59 | 530 |
| Basalt, gray, hard | 46 | 576 |
| Basalt, brown, porous | 45 | 621 |
| Basalt, brown and black | 37 | 658 |
| Basalt, black, hard | 92 | 750 |
| Shale, black; static water level at 8 ft | 23 | 773 |
| Basalt, gray and black; static water level at 6 ft | 91 | 864 |
| Basalt, red | 5 | 869 |
| Clay, blue | 16 | 885 |
| Basalt, black | 12 | 897 |
| Basalt, gray, hard | 95 | 992 |
| Basalt, brown and black | 69 | 1,061 |
| Basalt, gray; caving in bottom | 9 | 1,070 |
| **4N/35-19E2. Rogers Canning Co. Drilled by A. A. Durand and Son** | | |
| Palouse formation: | | |
| Soil | 4 | 4 |
| Fanglomerate(?): | | |
| Gravel | 15 | 19 |
| Gravel, cemented, hard | 3 | 22 |
| Gravel and clay | 4 | 26 |
| Gravel, cemented | 21 | 47 |
| Gravel and red and brown clay | 22 | 69 |
| Boulders | 3 | 72 |
| Gravel and brown clay | 8 | 80 |
| Gravel, cemented | 4 | 84 |
| Gravel and clay; water standing at 35 ft | 2 | 86 |
| Columbia River basalt: | | |
| Basalt, black, hard; water standing at 25 ft | 74 | 160 |
| Basalt, black, porous, and clay | 18 | 178 |
| Basalt, black, hard; at 245 ft depth, water level rose to 18 ft | 127 | 305 |
| Clay, green, sticky | 7 | 312 |
| Basalt, black and gray, hard; at 475 ft depth, the water level rose to 16 ft | 451 | 763 |
| Basalt, soft | 102 | 865 |
| Basalt, gray, hard | 67 | 932 |
| Basalt, medium-hard | 16 | 948 |
| Basalt, brown | 47 | 995 |
| Basalt, red and black | 82 | 1,077 |
| Basalt, red | 79 | 1,156 |
| **4N/35-19E3. Athena Mill Co. Drilled by Ben Dreyer, 1956** | | |
| Palouse formation and Quaternary alluvium, undifferentiated: | | |
| Soil | 10 | 10 |
| Gravel, water-bearing | 6 | 16 |
| Clay | 13 | 29 |
| Gravel, sandy, water-bearing | 7 | 36 |
| Clay | 5 | 41 |
| Columbia River basalt: | | |
| Rock, shaly; decomposed basalt | 3 | 44 |
| Basalt, blue, hard | 2 | 46 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **4N/35-19L1. City of Athena (well 1). Drilled by A. A. Durand and Son, 1935** | | |
| Palouse formation: | | |
| Soil | 25 | 25 |
| Columbia River basalt: | | |
| "Rock," broken | 57 | 82 |
| Basalt, gray, brown 144 to 195 ft | 168 | 250 |
| Conglomerate | 100 | 350 |
| Basalt, black, gray upper 45 ft | 80 | 430 |
| Basalt | 69 | 499 |
| Basalt, black | 81 | 580 |
| "Rock," broken | 70 | 650 |
| Basalt, gray | 30 | 680 |
| **4N/35-29P1. Henry Koepke. Drilled by A. A. Durand and Son, 1940** | | |
| Palouse formation: | | |
| Soil | 16 | 16 |
| Columbia River basalt: | | |
| "Boulders" | 4 | 20 |
| Basalt, hard | 29 | 49 |
| Basalt, medium hard | 7 | 56 |
| Basalt, soft | 74 | 130 |
| Basalt, medium hard | 15 | 145 |
| Basalt, soft | 51 | 196 |
| Basalt, hard, gray | 96 | 292 |
| Basalt, gray | 31 | 323 |
| Basalt, hard | 9 | 332 |
| Basalt, gray and black | 89 | 421 |
| Basalt, gray, hard | 57 | 478 |
| Basalt, black | 8 | 486 |
| **5N/28-10R1. U.S. Army Corps of Engineers. Drilled by A. A. Durand and Son, 1947** | | |
| Glaciofluviatile deposits: | | |
| Sand | 6 | 6 |
| Gravel and small boulders | 6 | 12 |
| Boulders | 18 | 30 |
| Gravel | 5 | 35 |
| Gravel and sand | 33 | 68 |
| Gravel and silt | 12 | 80 |
| Gravel and sand | 8 | 88 |
| Gravel; static water level at 95 ft | 13 | 101 |
| Gravel and boulders | 9 | 110 |
| Gravel | 5 | 115 |
| Gravel and sand | 1 | 116 |
| Sand | 1 | 117 |
| Gravel and coarse sand | 6 | 123 |
| Boulders and fine sand | 2 | 125 |
| Boulders | 3 | 128 |
| Sand, fine | 2 | 130 |
| Boulders | 8 | 138 |
| Boulders and sand | 8 | 146 |
| Columbia River basalt: | | |
| Basalt and shale (clay?) | 8 | 154 |
| Basalt, firm | 6 | 160 |
| Basalt, creviced | 3 | 163 |
| Basalt, hard | 4 | 167 |
| **5N/28-10R2. U.S. Army Corps of Engineers. Drilled by A. A. Durand and Son, 1948** | | |
| Glaciofluviatile deposits: | | |
| Overburden (see strata recorded in log of well-10R1) | 100 | 100 |
| Columbia River basalt: | | |
| Basalt | 130 | 230 |
| Lower part of the Ellensburg formation: | | |
| "Interbed" (clay?) | 40 | 270 |
| Columbia River basalt: | | |
| Basalt | 300 | 570 |
| Basalt, scoriaceous | 10 | 580 |
| Basalt | 80 | 660 |
| "Interbed basalt" | 10 | 670 |
| Basalt | 34 | 704 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **5N/28-10R3. U.S. Army Corps of Engineers. Drilled by R. J. Strasser, 1952** | | |
| Glaciofluviatile deposits: | | |
| Soil and loose sand | 20 | 20 |
| Gravel and boulders, cemented | 15 | 35 |
| Gravel and boulders | 5 | 40 |
| Sand and gravel, cemented | 11 | 51 |
| Sand and gravel, loose | 11 | 62 |
| Gravel, some boulders and clay | 10 | 72 |
| Gravel, cemented, hard | 14 | 86 |
| Gravel | 11 | 97 |
| Gravel, cemented | 3 | 100 |
| Boulders and loose gravel | 7 | 107 |
| Gravel, cemented | 10 | 117 |
| Columbia River basalt: | | |
| Basalt, black and red, broken | 7 | 124 |
| Basalt, flow breccia | 9 | 133 |
| Basalt, gray, hard; creviced at 182 and 194 ft | 116 | 249 |
| Lower part of the Ellensburg formation: | | |
| Shale, green | 24 | 273 |
| Clay, gray | 15 | 288 |
| "Selvage" | 12 | 300 |
| Columbia River basalt: | | |
| Basalt, black, porous | 6 | 306 |
| Basalt, gray | 51 | 357 |
| Basalt, black, hard and soft | 48 | 405 |
| Shale, green | 2 | 407 |
| Basalt, medium-hard | 15 | 422 |
| Basalt, gray and black, hard | 49 | 471 |
| Basalt, brown and black, creviced | 5 | 476 |
| Basalt, gray | 20 | 496 |
| Basalt, porous, caving | 16 | 512 |
| Basalt, gray and black, hard and broken | 17 | 529 |
| Basalt, broken; some clay | 15 | 544 |
| Basalt, gray, hard | 43 | 587 |
| Basalt, red, black, brown, porous | 9 | 596 |
| Basalt, gray | 26 | 622 |
| Basalt, black, porous, broken | 11 | 633 |
| Basalt, gray, medium-hard | 17 | 650 |
| Basalt, black, porous, loose | 20 | 670 |
| Basalt, black and gray | 37 | 707 |
| Basalt, broken, and blue clay | 2 | 709 |
| Basalt, broken, and green "slate," mineralized with iron pyrites, green coating in vesicles | 4½ | 713½ |
| Basalt, black, porous, and green "slate" | 42½ | 756 |
| Basalt, black | 21 | 777 |
| **5N/28-19A1. City of Umatilla (well 3). Drilled by A. M. Jannsen, 1947** | | |
| Glaciofluviatile deposits: | | |
| Clay and topsoil | 17 | 17 |
| Gravel and boulders | 10 | 27 |
| Sand | 11 | 38 |
| Gravel | 132 | 170 |
| Columbia River basalt: | | |
| Basalt | 175 | 345 |
| Lower part of the Ellensburg formation and interbedded basalt: | | |
| Clay, blue | 28 | 373 |
| Basalt, broken | 42 | 415 |
| Basalt | 90 | 505 |
| Clay | 30 | 535 |
| Columbia River basalt: | | |
| Basalt | 215 | 750 |
| Sandy formation (decomposed basalt?) | 5 | 755 |
| Basalt | 30 | 785 |

NOTE.—Casing, 16-inch, set to 170 feet; 10-inch set from 310 to 373 ft; 8-inch set from 361 to 535 ft. Open 8-inch hole from 535 to 785 ft.

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TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **5N/28-23M1. Bill Kik. Drilled by A. A. Durand and Son, 1944** | | |
| Glaciofluviatile deposits: | | |
| Sand | 15 | 15 |
| Columbia River basalt: | | |
| Basalt, broken | 2 | 17 |
| Basalt | 70 | 87 |
| Basalt, water-bearing | 8 | 95 |
| Basalt | 32 | 127 |
| Basalt, alternating hard and soft; thin layers | 33 | 160 |
| **5N/29-13E1. Walso Birchman. Drilled by A. A. Durand and Son, 1948** | | |
| Glaciofluviatile deposits: | | |
| Sand | 15 | 15 |
| Boulders and sand | 5 | 20 |
| Columbia River basalt: | | |
| Basalt, hard | 14 | 34 |
| Basalt, broken | 4 | 38 |
| Basalt, brown, broken | 4 | 42 |
| Basalt, very hard | 34 | 76 |
| Basalt, honeycomb, water-bearing | 14 | 90 |
| Clay and "soapstone" | 4 | 94 |
| Basalt | 91 | 185 |
| Basalt, water-bearing; water level stands at 36 ft | 10 | 195 |
| Basalt | 8 | 203 |
| Basalt, gray, hard | 51 | 254 |
| Basalt, black | 24 | 278 |
| Basalt, gray | 62 | 340 |
| Basalt, black | 20 | 360 |
| Basalt | 130 | 490 |
| Basalt, very hard; water level standing at 39 ft | 15 | 505 |
| **5N/29-33R1. Union Pacific Railroad. Drilled by A. A. Durand and Son, 1952** | | |
| Glaciofluviatile deposits: | | |
| Sand, silty, soft, brown | 9 | 9 |
| Sand and gravel | 6 | 15 |
| Gravel | 3 | 18 |
| Gravel and boulders | 4 | 22 |
| Gravel, cemented | 13 | 35 |
| Gravel, course | 2 | 37 |
| Gravel, fine, gray, loose | 28 | 65 |
| Clay, brown, soft | 9 | 74 |
| Gravel | 4 | 78 |
| Clay, brown | 2 | 80 |
| Gravel | 2 | 82 |
| Columbia River basalt: | | |
| Basalt, black, medium-hard | 26 | 108 |
| Basalt, brown, broken | 3 | 111 |
| Basalt, gray hard | 41 | 152 |
| Basalt, black, medium-hard; some clay | 33 | 185 |
| Basalt, gray, hard, broken | 14 | 199 |
| Basalt, black and gray, hard | 46 | 245 |
| Basalt, gray, hard | 13 | 258 |
| Basalt, fractured; some clay | 16 | 274 |
| Basalt, black; alternating soft and hard layers | 24 | 298 |
| **5N/31-1B1. Pete Kosmos. Drilled by H. Yager, 1950** | | |
| Quaternary alluvium: | | |
| Soil | 25 | 25 |
| Gravel | 1 | 26 |
| Sand and gravel | 14 | 40 |
| Sand | 10 | 50 |
| Sand and boulders | 4 | 54 |
| Columbia River basalt: | | |
| Basalt, brown, water-bearing | 43 | 97 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **5N/32-18C1. C. F. Westersund. Drilled by H. Yager, 1950** | | |
| Old drilled well, no record | 177 | 177 |
| Columbia River basalt: | | |
| Basalt, black | 8 | 185 |
| Basalt, gray | 41 | 226 |
| Basalt, black | 16 | 242 |
| Basalt gray | 60 | 302 |
| **5N/33-31A1. Earnest Koepke. Drilled by A. A. Durand and Son, 1954** | | |
| Palouse formation: | | |
| Soil | 10 | 10 |
| "Hardpan," yellow | 33 | 43 |
| Columbia River basalt: | | |
| Basalt, gray, very hard | 43 | 86 |
| Basalt, black, medium-hard | 21 | 107 |
| Basalt, gray, very hard; water-bearing crevice at 117 ft; water level standing at 75 ft | 10 | 117 |
| Basalt, black, medium-hard | 3 | 120 |
| Basalt, gray, very hard | 40 | 160 |
| Basalt, black and gray, medium-hard to very hard | 71 | 231 |
| Basalt, brown, soft, vesicular | 2 | 233 |
| Basalt, gray, medium-hard; water level at 75 ft | 5 | 238 |
| Basalt, brown, vesicular | 7 | 245 |
| Basalt, black and gray, hard | 80 | 325 |
| Basalt, brown, water-bearing; water level at 75 ft | 5 | 330 |
| Basalt, black and gray | 57 | 387 |
| Basalt, black, medium-hard, water-bearing; water level at 92 ft | 2 | 389 |
| Basalt, black, hard | 5 | 394 |

NOTE.—Well bail-tested when at 330 ft depth; drawdown was 80 ft after 10 minutes bailing at 29 gpm.

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **5N/34-20A1. A. H. McIntyre** | | |
| Palouse formation (and fault gouge?): | | |
| Soil | 147 | 147 |
| Columbia River basalt: | | |
| "Soapstone" | 15 | 162 |
| Basalt | 50 | 212 |
| **1/28-35B1. Antone Vey. Drilled by Harold Yager, 1948** | | |
| Palouse formation: | | |
| Soil | 7 | 7 |
| Columbia River basalt: | | |
| Gravel (broken basalt?) | 55 | 62 |
| Basalt, black | 90 | 152 |
| Basalt, gray | 88 | 240 |
| Basalt, gray, water-bearing | 20 | 260 |
| Basalt, gray | 6 | 266 |
| Basalt, brown | 57 | 323 |
| **1/32-8J1. Glen Newquist. Drilled by Turner and Son, 1956** | | |
| Palouse formation and fanglomerate of Pliocene age, undifferentiated: | | |
| Sand and gravel | 18 | 18 |
| Columbia River basalt: | | |
| Basalt, black | 37 | 55 |
| Basalt, red | 7 | 62 |
| Basalt, gray | 13 | 75 |
| "Soapstone" (weathered basalt) | 2 | 77 |
| Basalt, gray | 13 | 90 |
| Basalt, broken, water-bearing | 13 | 103 |
| Basalt | 12 | 115 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1/32-9G1. V. Jacobsen. Drilled by D. K. Smith** | | |
| Palouse formation: | | |
| Soil | 3 | 3 |
| Fanglomerate: | | |
| Gravel, cemented | 55 | 58 |
| "Rock," brown, broken | 13 | 71 |
| Sand | 1 | 72 |
| Gravel, cemented | 20 | 92 |
| Columbia River basalt: | | |
| Rock, brown, broken, cemented | 40 | 132 |
| Basalt, brown | 18 | 150 |
| **1/32-9L1. Wayne Chapman. Drilled by Bert Gladney, 1953** | | |
| Quarternary alluvium: | | |
| Rock and gravel | 44 | 44 |
| Columbia River basalt: | | |
| Basalt, brown | 71 | 115 |
| Basalt, black | 45 | 160 |
| Basalt, brown and black | 150 | 310 |
| Basalt, brown | 13 | 323 |
| Basalt, gray | 52 | 375 |
| Basalt, gray, very hard | 53 | 428 |
| Basalt, honeycomb | 12 | 440 |
| Basalt, honeycomb, water-bearing | 40 | 480 |
| Basalt, honeycomb, and soapstone | 11 | 491 |
| **1/32-9M1. Oregon Fibre Products Co. Drilled by A. M. Jannsen Drilling Co., 1952** | | |
| Quarternary alluvium: | | |
| Gravel, rubble | 12 | 12 |
| Fanglomerate: | | |
| Gravel, cemented | 5 | 17 |
| Gravel, rocks, rubble | 33 | 50 |
| Gravel, coarse, cemented | 36 | 86 |
| Columbia River basalt: | | |
| Basalt, hard | 14 | 100 |
| Basalt, layered and creviced | 15 | 115 |
| Basalt, gray | 20 | 135 |
| Basalt, soft, decomposed | 6 | 141 |
| Basalt, hard, layered | 31 | 172 |
| Basalt, honeycomb, hard; in layers, some crevices | 14 | 186 |
| Basalt, hard, layered | 29 | 215 |
| Basalt, gray; crevice at 216 feet | 16 | 231 |
| Basalt, black; loose in places | 11 | 242 |
| Basalt, hard, layered | 40 | 282 |
| Basalt, soft, loose | 14 | 296 |
| Basalt, hard, brown | 25 | 321 |
| Basalt, black; hard and soft layers | 34 | 355 |
| Basalt, brown, soft | 27 | 382 |
| Basalt, black | 3 | 385 |
| Basalt, yellowish, creviced, layered | 27 | 412 |
| Basalt, yellowish-brown; some hard layers | 19 | 431 |
| Basalt; contains bad crevice | 3 | 434 |
| Basalt, yellowish | 11 | 445 |
| Basalt | 11 | 456 |
| Basalt, hard, brown | 17 | 473 |
| Basalt, brown, soft; crevice at 482 ft | 16 | 489 |
| Basalt, brown; hard and soft layers | 12 | 501 |
| Basalt, brown, very hard | 41 | 542 |
| Basalt, honeycomb, water-bearing | 15 | 557 |
| Basalt, gray; hard layers | 24 | 581 |
| Basalt, gray; softer | 19 | 600 |
| Basalt, gray, broken | 6 | 606 |
| Basalt, gray; hard and soft layers | 21 | 627 |
| Basalt, gray, "cube rock" | 8 | 635 |
| Basalt, gray; hard layers | 12 | 647 |
| Basalt, gray and black | 48 | 695 |
| Basalt, gray, broken; contains crevices | 19 | 714 |
| Basalt, gray | 5 | 719 |
| Shale(?), gray, caving; sample is basalt cuttings | 11 | 730 |
| Shale(?), hard; sample is basalt cuttings | 5 | 735 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1/32-9N1. Pilot Rock Lumber Co. Drilled by A. M. Jannsen, 1952** | | |
| Quarternary alluvium: | | |
| Gravel, rubble; water-bearing below 25 ft | 27 | 27 |
| Columbia River basalt: | | |
| Basalt, red | 14 | 41 |
| Basalt, black; some water at 50 ft with water level at 30 ft | 21 | 62 |
| Basalt, layered | 38 | 100 |
| Basalt, hard, solid | 15 | 115 |
| Basalt, creviced; water level standing at 17 ft | 2 | 117 |
| Basalt, red | 3 | 120 |
| Basalt, gray, hard | 2 | 122 |
| Basalt, creviced | 1 | 123 |
| Basalt, broken, caving | 3 | 126 |
| Basalt, gray, hard | 21 | 147 |
| Basalt, gray, softer | 39 | 186 |
| Basalt, hard; water-bearing at 209 ft and at 211 ft | 29 | 215 |
| Basalt, layered, hard and soft | 30 | 245 |
| Basalt, black, hard | 53 | 298 |
| Basalt, softer | 3 | 301 |
| Basalt, black, hard | 17 | 318 |
| Basalt, gray | 13 | 331 |
| Basalt, yellow; water-bearing 331 ft to 336 ft | 9 | 340 |
| Basalt, brown, hard; water flowed over top of casing at 356 ft | 23 | 363 |
| Basalt, creviced | 2 | 365 |
| **1/32-16L1. William Etter. Drilled by D. K. Smith** | | |
| Dug well, no record | 31 | 31 |
| Fanglomerate: | | |
| Gravel, cemented | 14 | 45 |
| Columbia River basalt: | | |
| Basalt, brown, broken | 33 | 78 |
| Basalt, gray, hard | 11 | 89 |
| Basalt, brown, broken | 17 | 106 |
| Basalt, brown and red | 19 | 125 |
| Basalt, black | 116 | 241 |
| Basalt, black, broken | 24 | 265 |
| **1/32-17G1. City of Pilot Rock. Drilled by A. M. Edwards, 1945** | | |
| Quaternary alluvium: | | |
| Soil | 10 | 10 |
| Gravel | 4 | 14 |
| Hardpan, very hard | 5 | 19 |
| Hardpan | 8 | 27 |
| Columbia River basalt: | | |
| Basalt, blue, hard | 23 | 50 |
| Basalt, porous, water-bearing; water level at 10 ft | 15 | 65 |
| Basalt, very hard | 70 | 135 |
| Basalt, porous, water-bearing; water level at 4 ft | 23 | 158 |
| Basalt, hard | 19 | 177 |
| Basalt, porous, water-bearing; drill cuttings washed away | 5 | 182 |
| Basalt, hard | 15 | 197 |
| Basalt, soft and hard | 18 | 215 |
| Basalt; contains seams and crevices | 2 | 217 |
| Basalt, moderately hard | 15 | 232 |
| Basalt; contains seams and crevices | 3 | 235 |
| Basalt, porous, soft, water-bearing; water flows over top of casing | 15 | 250 |
| Basalt, moderately hard | 38 | 288 |
| Basalt; crevices and broken rock | 2 | 290 |
| Basalt, fairly hard | 3 | 293 |
| Basalt, porous, water-bearing; water overflowing casing at an extimated 700 gpm | 16 | 309 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1/32-17K1. City of Pilot Rock. Drilled by D. K. Smith, 1956** | | |
| Quaternary alluvium: | | |
| Soil, brown | 4 | 4 |
| Rock, broken, and brown clay | 5 | 9 |
| Gravel, cemented | 6 | 15 |
| Rock, broken; caved during drilling | 2 | 17 |
| Gravel, cemented | 8 | 25 |
| Columbia River basalt: | | |
| Basalt, gray and black, broken | 25 | 50 |
| Basalt, hard, gray, black, and brown | 62 | 112 |
| Basalt, red | 20 | 132 |
| Basalt, brown, broken | 10 | 142 |
| Basalt, black | 90 | 232 |
| Basalt, brown, broken, water-bearing | 3 | 235 |
| Basalt, gray | 37 | 272 |
| Basalt, brown, broken, water-bearing | 27 | 299 |
| Basalt, gray | 48 | 347 |
| Basalt, brown and black | 83 | 430 |
| Basalt, brown, broken, water-bearing | 56 | 486 |
| **1/32-20A1. Robert Roy. Drilled by D. K. Smith, 1951** | | |
| Palouse formation: | | |
| Soil | 5 | 5 |
| Fanglomerate: | | |
| Rocks and boulders | 3 | 8 |
| Gravel, cemented | 42 | 50 |
| Gravel, cemented, water-bearing | 1 | 51 |
| Gravel, cemented | 37 | 88 |
| Columbia River basalt: | | |
| Basalt, gray, hard | 39 | 127 |
| Basalt, black | 118 | 245 |
| Basalt, gray | 15 | 260 |
| Basalt, brown and gray, creviced | 18 | 278 |
| Basalt, black; contains water-bearing seams | 22 | 300 |
| **1/32-23J1. Hilmer Horn. Drilled by A. A. Durand and Son, 1950** | | |
| Palouse formation: | | |
| Soil | 4 | 4 |
| Clay, hardpan | 10 | 14 |
| Columbia River basalt: | | |
| Basalt, blue, broken | 8 | 22 |
| Basalt, blue, very hard | 80 | 102 |
| Basalt, blue, very hard | 2 | 104 |
| Basalt, blue, hard, water-bearing | 28 | 132 |
| Basalt, blue, broken, water-bearing; static water level about 90 ft | 4 | 136 |
| Basalt, blue, hard | 72 | 208 |
| Basalt, blue, broken | 15 | 223 |
| Basalt, blue, hard | 5 | 228 |
| Basalt, blue | 4 | 232 |
| Basalt, broken | 11 | 243 |
| Basalt, blue, medium-hard | 1 | 244 |
| Basalt, blue, hard | 6 | 250 |
| Basalt, gray, hard | 29 | 279 |
| Basalt, gray | 8 | 287 |
| Basalt, gray, very hard | 3 | 290 |
| Basalt, gray | 26 | 316 |
| Basalt, gray and broken, and brown | 24 | 340 |
| Basalt, broken | 48 | 388 |
| Basalt | 10 | 398 |
| Basalt, firm and broken | 17 | 415 |
| Basalt, broken | 15 | 430 |
| Basalt | 15 | 445 |
| Basalt, black | 45 | 490 |
| Basalt, gray, very hard | 2 | 492 |
| Basalt, dark gray, hard | 126 | 618 |
| Basalt, light gray | 4 | 622 |
| Basalt, grav, hard | 5 | 627 |
| Basalt, light gray, hard | 48 | 675 |
| Basalt, dark gray | 7 | 682 |
| Basalt, black; water-bearing at 705 ft; static water level at 68 ft | 33 | 715 |
| Basalt, gray, hard | 26 | 741 |
| Basalt, brown, hard | 7 | 748 |
| Basalt, gray, hard | 46 | 794 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1/32-28E1. Levi Eldridge. Drilled by A. A. Durand and Son, 1949** | | |
| Palouse formation: | | |
| Soil | 2 | 2 |
| Fanglomerate: | | |
| Gravel | 1 | 3 |
| Gravel and boulders | 21 | 24 |
| Columbia River basalt: | | |
| Basalt, blue, broken | 6 | 30 |
| Basalt, blue, hard | 23 | 53 |
| Basalt, blue, broken | 19 | 72 |
| Basalt, blue, hard | 13 | 85 |
| Basalt, blue, broken | 7 | 92 |
| Basalt, blue, hard | 3 | 95 |
| Basalt, blue, broken | 25 | 120 |
| Basalt, brown | 5 | 125 |
| Conglomerate(?) | 20 | 145 |
| Basalt, blue, hard | 15 | 160 |
| **1/35-3K2. Earl Gillander. Drilled by A A. Durand and Son, 1945** | | |
| Palouse formation and Recent deposits, undifferentiated: | | |
| Soil | 3 | 3 |
| Clay and shale(?) | 13 | 16 |
| Clay and cobbles | 4 | 20 |
| Clay, blue, and pea gravel | 12 | 32 |
| Columbia River basalt: | | |
| Basalt, brown and blue, decomposed | 48 | 80 |
| Basalt, brown and gray | 194 | 274 |
| Basalt, red | 32 | 306 |
| Basalt, gray | 25 | 331 |
| Basalt, red and brown | 29 | 360 |
| Basalt, gray | 23 | 383 |
| **1/35-3Q1. Oregon Highway Dept. Drilled by A. A. Durand and Son, 1935** | | |
| Palouse formation and Recent deposits, undifferentiated: | | |
| Soil | 12 | 12 |
| Columbia River basalt: | | |
| Basalt, very hard | 188 | 200 |
| Basalt, honeycomb | 25 | 225 |
| Basalt, very hard | 155 | 380 |
| Basalt, porous | 4 | 384 |
| Basalt, solid | 4 | 388 |
| **1/35-10C1. Union Pacific Railroad. Drilled by A. A. Durand and Son, 1944** | | |
| Residual soil and Palouse formation, undifferentiated: | | |
| Top soil | 3 | 3 |
| Soil and boulders | 10 | 13 |
| Columbia River basalt: | | |
| Basalt, black | 5 | 18 |
| Basalt, black; contains clay seams; water-bearing at 28 ft | 10 | 28 |
| Basalt, black | 16 | 44 |
| Clay, blue | 2 | 46 |
| Lava sand (scoria), water-bearing; water level even with top of casing when well at 60 ft | 14 | 60 |
| Basalt, disintegrated, and clay, water-bearing; flows at rate of 22 gpm | 3 | 63 |
| Lava sand (scoria?); water flow increased to 35 gpm, later decreased to 25 gpm | 12 | 75 |
| Basalt, black, solid | 5 | 80 |
| Basalt, black; contains seams; fractured? | 5 | 85 |
| Basalt, black, solid | 10 | 95 |
| Basalt, black; contains seams; fractured? | 3 | 98 |
| Basalt, black and gray, solid | 18 | 116 |
| Basalt, gray; contains "cinders," and blue clay | 6 | 122 |
| Basalt, black; contains "cinders," and blue clay | 5 | 127 |
| Basalt, black; some "cinders" | 19 | 146 |
| Basalt, black, very hard | 31 | 177 |
| Basalt, black; some blue clay | 12 | 189 |
| Basalt, black; small layer of blue clay at 219 ft | 88 | 277 |
| Basalt, shattered; blue clay | 2 | 279 |

TABLE 2.—*Drillers' logs of representative wells*—Continued

| Materials | Thickness (feet) | Depth (feet) |
|---|---|---|
| **1/35-36N1. Union Pacific Railroad. Drilled by A. A. Durand and Son, 1946** | | |
| Palouse formation and residual soil: | | |
| Clay, brown, and hardpan | 49 | 49 |
| Columbia River basalt: | | |
| Basalt, black, hard | 32 | 81 |
| Basalt, black, soft | 10 | 91 |
| Basalt, black; streaks of black "shale" | 10 | 101 |
| Basalt, black | 12 | 113 |
| Basalt, brown, porous | 32 | 145 |
| Basalt, black and red | 60 | 205 |
| Basalt and clay | 60 | 265 |
| Basalt, red, hard | 150 | 415 |
| Basalt, black and brown, hard | 39 | 454 |
| Basalt, brown, hard and broken | 13 | 467 |
| Basalt, red and brown; clay seams | 41 | 508 |
| Basalt, brown, porous | 23 | 531 |
| Basalt, gray, porous | 5 | 536 |
| Basalt, red; some clay | 15 | 551 |
| Basalt, porous, decomposed | 65 | 616 |
| Basalt, black and gray, hard | 42 | 658 |
| Basalt, gray and blue, with some clay | 18 | 676 |
| Basalt, blue, hard | 17 | 693 |
| Basalt, red | 69 | 762 |
| Basalt, gray, hard | 8 | 770 |
| Basalt, broken; contains red clay | 37 | 807 |
| Basalt, gray | 32 | 839 |
| Basalt, gray and red, porous | 54 | 893 |
| Basalt, red | 11 | 904 |
| Basalt, brown | 9 | 913 |
| Basalt, gray | 83 | 996 |
| **3/29-7A1. Mrs. Ralph Jones. Drilled by Bert Gladney, 1951** | | |
| Quaternary alluvium: | | |
| Soil and small gravel | 12 | 12 |
| Soil, brown, claylike; mixed with rock | 20 | 32 |
| Columbia River basalt: | | |
| Soil, brown, claylike; soft rock? | 15 | 47 |
| Rock, creviced | 7 | 54 |
| Rock, brown, sugary-textured | 24 | 78 |
| Rock, brown, sugary, creviced | 34 | 112 |
| Rock, brown, sugary; includes ash layers | 12 | 124 |
| Rock, brown, sugary | 4 | 128 |
| Rock, soft, brown, sugary; volcanic ash | 20 | 148 |
| Rock, hard, gray | 2 | 150 |

TABLE 3.—*Chemical analyses of water from wells and springs of the Umatilla River basin, Oregon*

[Chemical constituents in parts per million. Analysis by U.S. Geological Survey unless otherwise indicated]

| Well or spring | Date of collection | Temperature (°F) | Silica ($SiO_2$) | Iron (Fe) Total | Iron (Fe) In solution | Manganese (Mn) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_3$) | Boron (B) | Dissolved solids Sum | Dissolved solids Residue at 180° C | Hardness As $CaCO_3$ | Hardness Noncarbonate | Sodium-adsorption-ratio (SAR) | Specific conductance (micromhos at 25° C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1N/28-28D1 | Apr. 28, 1953 | 64 | 70 | 0.2 | ---- | ---- | 15 | 5.7 | 40 | 5.2 | 163 | 0 | 0.6 | 15 | 0.1 | 0.4 | 0.23 | 233 | 225 | 61 | 0 | 2.2 | 285 | 8.1 |
| 1N/31-30B1 | Apr. 27, 1953 | ---- | 66 | .1 | ---- | ---- | 36 | 12 | 22 | 4.4 | 154 | 0 | 26 | 20 | .4 | 9.9 | .00 | 273 | 277 | 139 | 13 | .8 | 378 | 7.8 |
| 1N/32-1D1 | do | 53 | 61 | .0 | ---- | ---- | 18 | 6.8 | 20 | 3.2 | 130 | 0 | 5.6 | 4.5 | .6 | .9 | .00 | 185 | 181 | 73 | 0 | 1.2 | 224 | 7.9 |
| 24R1 | do | 51 | 13 | 2.7 | ---- | ---- | 13 | 5.8 | 17 | 2.8 | 93 | 0 | 8.6 | 8.0 | .3 | .6 | .01 | 115 | 118 | 56 | 0 | .9 | 188 | 7.3 |
| 1N/33-7F1 | do | 56 | 68 | .1 | ---- | ---- | 25 | 12 | 20 | 4.8 | 167 | 0 | 9.5 | 6 | .5 | 1.5 | .02 | 230 | 225 | 112 | 0 | .8 | 296 | 7.7 |
| 2N/27-11H1 | Apr. 28, 1953 | 61 | 66 | .1 | ---- | ---- | 14 | 7.5 | 32 | 9.0 | 161 | 0 | .8 | 9.5 | .6 | .2 | .08 | 219 | 211 | 66 | 0 | 1.7 | 273 | 8.1 |
| 2N/32-2R1 [1] | Jan. 7, 1949 | ---- | 40 | .01 | ---- | ---- | 27 | 7.6 | 31 | | 130 | 0 | 21 | 26 | .3 | ---- | ---- | 217 | ---- | 98 | ---- | ---- | ---- | 7.7 |
| 10F1 [2] | June 13, 1952 | ---- | 49 | .03 | 0.01 | ---- | 32 | 12 | 30 | 5.2 | 220 | ---- | 11 | 7.9 | .2 | 2.9 | .08 | 299 | ---- | 129 | 0 | 1.2 | 385 | 7.8 |
| 35H1 | Mar. 3, 1953 | ---- | 43 | .06 | .06 | 0.00 | 9.2 | 2.8 | 70 | 9.9 | 145 | 9 | 35 | 21 | .7 | .1 | .01 | 272 | ---- | 34 | 0 | 5.2 | 383 | 8.5 |
| 3N/27-36A1 | Apr. 28, 1953 | 52 | 47 | .0 | ---- | ---- | 47 | 16 | 58 | 5.4 | 333 | 0 | 14 | 9.5 | .5 | 11 | .03 | 372 | 376 | 184 | 0 | 1.9 | 571 | 7.4 |
| 3N/32-22C1 | Mar. 3, 1953 | ---- | 49 | ---- | .11 | .00 | 28 | 13 | 43 | 7.6 | 186 | ---- | 31 | 23 | .7 | 3.2 | .05 | 290 | ---- | 123 | 0 | 1.7 | 433 | 8.0 |
| 3N/37-18H1 [3] | Apr. 1, 1954 | 94 | 68 | .20 | .00 | ---- | 14 | 3.5 | 133 | 7.6 | 64 | 9 | .2 | 192 | 4.0 | .2 | 10 | 464 | ---- | 50 | 0 | 8 | 765 | 8.6 |
| 4N/27-22L1 [1] | Apr. 26, 1941 | ---- | ---- | .15 | ---- | ---- | 38 | 11 | ---- | ---- | 148 | ---- | 11 | 11 | ---- | ---- | ---- | ---- | ---- | 140 | ---- | ---- | ---- | 7.7 |
| 4N/28-10P1 [4] | Aug. 3, 1950 | 76 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 14 | .9 | ---- | ---- | ---- | 329 | 66 | ---- | ---- | ---- | 8.4 |
| 11N1 [4] | Aug. 10, 1950 | 71 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 112 | 28 | ---- | 23 | 1.7 | ---- | ---- | ---- | 239 | 15 | ---- | ---- | ---- | 8.4 |
| 4N/31-9P1 | Apr. 27, 1953 | 61 | 52 | .1 | ---- | ---- | 18 | 9.1 | 41 | 8.7 | 173 | 0 | 18 | 7.8 | .6 | 6.3 | .02 | 247 | 248 | 82 | 0 | 2.0 | 346 | 8.0 |
| 4N/33-29K1 | do | 54 | 52 | .0 | ---- | ---- | 65 | 30 | 25 | 2.6 | 236 | 0 | 32 | 45 | .4 | 57 | .01 | 425 | 436 | 286 | 92 | .6 | 656 | 7.9 |
| 4N/34-6L1 [5] | | ---- | 20 | 1.4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 20 | ---- | ---- | ---- | ---- | ---- | 132 | ---- | ---- | ---- | ---- |
| 22K1 | Apr. 28, 1953 | ---- | 49 | .0 | ---- | ---- | 64 | 18 | 56 | 1.0 | 370 | 0 | 8.4 | 13 | .5 | 20 | .01 | 412 | 415 | 234 | 0 | 1.6 | 642 | 7.9 |
| 5N/32-31F1 | Apr. 27, 1953 | 66 | 52 | .0 | ---- | ---- | 2.8 | 2.2 | 106 | 11 | 224 | 0 | 42 | 23 | .6 | .3 | .04 | 350 | 350 | 16 | 0 | 11 | 510 | 8.3 |
| 1/32-9L1 | do | 66 | 71 | .0 | ---- | ---- | 28 | 10 | 22 | 5.5 | 167 | 0 | 13 | 8.5 | .5 | 1.8 | .01 | 243 | 240 | 111 | 0 | .9 | 310 | 7.8 |
| 17G1 [6] | 1946 | 65 | *60 | *.2 | ---- | ---- | ---- | ---- | ---- | ---- | 137 | 5 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | *7.7 |
| 23J1 | Dec. 22, 1954 | 68 | 70 | .0 | ---- | ---- | 22 | 6.3 | 24 | 5.6 | 154 | ---- | 7.9 | 5.0 | .5 | .3 | .02 | 218 | ---- | 81 | 0 | 1.2 | 263 | 7.9 |
| 2/28-23E1 [3] | Apr. 1, 1954 | 58 | 55 | .08 | .02 | ---- | 26 | 5.8 | 22 | 3.9 | 144 | ---- | 7.0 | 6.0 | 1.0 | 4.4 | .05 | 202 | ---- | 89 | 0 | 1.0 | 274 | 8.1 |
| 3/30-29R2 | Mar. 29, 1954 | ---- | 20 | 47 | .0 | ---- | 48 | 8.6 | 22 | 3.1 | 224 | ---- | 15 | 5.5 | .8 | .3 | .06 | 234 | ---- | 155 | 0 | .8 | 395 | 7.9 |

[1] Analysis by Charlton Laboratories, Inc., Portland, Oreg.
[2] Lithium 0.0 ppm.
[3] Spring.
[4] Analysis by Oregon State Board of Health.
[5] Analysis by L. L. Meyers, Laboratory, Oakland, Ohio.
[6] Items marked with an asterisk were determined by Northwest Filter Co., Seattle, Wash. Other items in this analysis were determined by Perolin Co. of New York.

TABLE 4.—*Representative springs in the Umatilla River basin, Oregon*

Topography and altitude: Cb, canyon bottom; Fp, flood plains; S, slope; T, terrace; U, upland; Um, upland meadow; Uv, upland valley. Altitudes of the springs (shown on pl. 1), in feet above sea level, are approximated from topographic maps and barometer surveys.

Use of water: D, domestic; FC, forest camp; N, none; S, stock; Sp, recreational resort; Remarks: Ca, chemical analysis in table 3; ppm, parts per million; T, temperature of water; values listed for hardness and chloride content of the water were determined in the field without laboratory control.

| Spring | Owner or tenant and name of spring | Topography | Altitude (feet) | Water-bearing material | Occurrence | Yield | | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Gallons per minute | Date | | |
| | | | | | **T. 1 N., R. 27 E.** | | | | |
| 28N1 | J. E. Dougherty | Uv | 1,550 | Basalt | Flows from alluvium overyling basalt | 2 | 8-28-53 | S | Small amount of sulfurous gas. T 64°F. |
| | | | | | **T. 1 N., R. 29 E.** | | | | |
| 22E1 | A. J. Vey | Uv | 1,900 | Basalt | Flows from fracture in basalt | 1 | 7- 9-53 | S | Hardness 85 ppm; chloride 25 ppm. T 56°F. |
| | | | | | **T. 1 N., R. 30 E.** | | | | |
| 23C1 | T. A. Cross | Uv | 2,050 | Basaltic alluvium | Seeps from alluvium overlying basalt | | | S | |
| | | | | | **T. 1 N., R. 31 E.** | | | | |
| 11A1 | LeRoy Beilke | Uv | 1,330 | Alluvium, basalt | Flows from several openings in alluvium and basalt bedrock. | 93 | 2-24-53 | S | |
| 11K1 | Mac Hoke | Uv | 1,460 | Basalt | Seeps through soil from perched water zone at edge of valley bottom. | 2 | 2-23-53 | N | |
| 32K1 | Hemphill | Uv | 2,140 | do | Seeps through alluvium in valley bottom. | | | D, S | |
| | | | | | **T. 1 N., R. 32 E.** | | | | |
| 20G1 | Ray Eckles | Uv | 1,460 | Basalt | Flows upward through soil overlying basalt. | 4 | 2-27-53 | D, S | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **T. 1 N., R. 34 E.** | | | | | |
| 32M1 | Herman Rosenburgh | S | 1,950 | Basalt | Flows from fractures in basalt hillside | | | D, S | Hardness, 35 ppm; chloride 4 ppm. |
| | | | | **T. 1 N., R. 35 E.** | | | | | |
| 29B1 | State Highway Department (Emigrant Springs). | S | 3,810 | Basalt | Flows from several openings and seepage areas in soil overlying basalt; most openings yield less than 1 gpm and are several hundred feet apart. | | | N | Once supplied water to emigrant trains, and later to a State park. |
| | | | | **T. 1 N., R. 37 E.** | | | | | |
| 6F1 | U.S. Forest Service | S | | Basalt | Flows from wet area in soil overlying basalt. | 1 | 9-3-53 | S | |
| 6K1 | U.S. Forest Service (Black Mountain). | S | | do | Flows from soil overlying basalt | 2 | do | FC | Hardness, 20 ppm; chloride 4 ppm. T 43°F. |
| 23J1 | U.S. Forest Service (Farley Spring). | U | | do | Seeps from soil overlying basalt | 1− | do | FC | Supplies very little water. |
| 24G1 | U.S. Forest Service (Pole Spring). | U | | do | Flows from soil overlying basalt | 3 | 9-7-53 | FC | T 46°F. |
| 34P1 | U.S. Forest Service (Bear Camp Spring). | S | | do | Seeps from soil overlying basalt | 1− | 9-9-53 | FC | |
| | | | | **T. 2 N., R. 28 E.** | | | | | |
| 9G1 | Antone Vey (Service Spring) | S | 1,000 | Basalt | Flows from fractures in basalt | 3 | 7-16-53 | S | Spring enclosed by concrete box. Water has a slight sulfur odor; hardness, 95 ppm; chloride, 22 ppm. |
| 10E1 | do | S | 1,100 | do | Seeps from area extending 100 yards along face of steep hillside. | 1 | do | S | Hardness, 115 ppm; chloride, 18 ppm; small nodules of carbonate material have been deposited on the end of discharge pipe. |
| 10J1 | do | S | 930 | do | Flows from basaltic rubble and soil overlying basalt. | 1 | do | S | Hardness, 90 ppm; chloride, 16 ppm. |
| 11R2 | J. L. Hinds (Vais Spring) | Uv | 925 | | Flows from soil in valley bottom | 1 | do | S | Hardness, 115 ppm; chloride, 18 ppm. T 60° F. |
| 30D1 | R. C. Lloyd | | 980 | | | 3 | 7-15-53 | S | T 58°F. |

TABLE 4.—*Representative springs in the Umatilla River basin, Oregon*—Continued

| Spring | Owner or tenant and name of spring | Topography | Altitude (feet) | Water-bearing material | Occurrence | Yield: Gallons per minute | Yield: Date | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **T. 2 N., R. 30 E.** | | | | |
| 14N1 | Cunningham Sheep Co. (Lower Mud Spring). | Cb | 1,100 | Basalt | Seeps from loessal alluvium overlying basalt. | 5 | 7- 1-53 | S | Seepage area extends about 150 yards up canyon. |
| 23D1 | Cunningham Sheep Co. (Upper Mud Spring). | S | 1,250 | do | do | 5 | 7- 7-53 | N | Seepage area extends about a quarter of a mile up a gully. |
| | | | | | **T. 2 N., R. 32 E.** | | | | |
| 26N1 | Robert Bowman | Uv | 1,225 | Soil | Seeps from perched water table in soil overlying basalt. | | | D,S | |
| 33L1 | Bigham | Fp | 1,150 | Alluvium | Rises through alluvium | 70 | 4- 8-53 | D, S | |
| | | | | | **T. 2 N., R. 33 E.** | | | | |
| 26J1 | Hobby | S | 1,740 | Basalt | Flows from perched aquifer in basalt | | | D | Water used to irrigate one-quarter acre of lawn. |
| | | | | | **T. 2 N., R. 34 E.** | | | | |
| 18Q1 | Melisse Abrahams | S | 1,600 | | | 4 | 8-31-53 | D | Hardness, 70 ppm; chloride, 6 ppm. |
| 30E1 | St. Andrews School | Uv | 1,900 | Basalt | Flows from fractures in basalt | 30 | 4-30-53 | D | Hardness, 50 ppm; chloride, 6 ppm. |
| | | | | | **T. 2 N., R. 37 E.** | | | | |
| 25E1 | U.S. Forest Service (Ruckel Spring). | Uv | | Basalt | Seeps into reservoir from soil and basalt rubble. | | | FC | Hardness, 45 ppm, chloride 6 ppm. T 49°F. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| T. 2 N., R. 38 E. | | | | | | | | | |
| 5E1 | U.S. Forest Service (Squaw Spring). | Uv | | Basalt | Seeps through soil covering basalt | 1 | 8-22-53 | FC | T 42° F. |
| 7K1 | U.S. Forest Service (Portugese Spring). | Uv | | do | do | 3 | 9- 3-53 | FC | Hardness, 30 ppm; chloride 6 ppm. T 45° F. |
| T. 3 N., R. 29 E. | | | | | | | | | |
| 7C1 | Zina Houser | Fp | 590 | Gravel | Discharges in marshy lowland | 10 | 10- 1-53 | D, S | Yield increases slightly when irrigation ditches are full. |
| 36G1 | L. G. Matheny | S | 760 | Basalt | Flows from perched aquifer in basalt | 5 | do | D, S | |
| T. 3 N., R. 33 E. | | | | | | | | | |
| 21G1 | Hans Pahl | Uv | 1,320 | Basalt | Flows from a series of small openings along bottom of steep canyon. | | | D, S | Hardness, 65 ppm; chloride 52 ppm. |
| T. 3 N., R. 35 E. | | | | | | | | | |
| 3M1 | Bessie Bill & Sons | Uv | | Basalt | | 4 | 9- 2-53 | D, S | Reportedly has greater yield during rainy season. |
| T. 3 N., R. 37 E. | | | | | | | | | |
| 18H1 | Bar M. Ranch (Bingham Spring). | S | | Basalt | Flows from 3 fissures in cliff face; located near fault. | 85 | 12-19-53 | Sp | Water has strong sulfurous odor and taste. T 94° F. Ca. |
| T. 3 N., R. 38 E. | | | | | | | | | |
| 29D1 | U.S. Forest Service (Shamrock Springs). | S | | Basalt | Seeps from soil overlying basalt | 1– | 8-22-53 | FC | Hardness, 20 ppm; chloride, 6 ppm. T 42° F. |

TABLE 4.—*Representative springs in the Umatilla River basin, Oregon*—Continued

| Spring | Owner or tenant and name of spring | Topography | Altitude (feet) | Water-bearing material | Occurrence | Yield: Gallons per minute | Yield: Date | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **T. 4 N., R. 28 E.** | | | | |
| 20A1 | D. C. Keller | Fp | 490 | Gravel overlying basalt. | Flows from one opening at base of terrace scarp. | 2,250 | 8- -60 | D | Supplies 5 homes; may be used to supply fish-rearing ponds. Flow nearly constant. T 58°–59°F. |
| | | | | | **T. 4 N., R. 31 E.** | | | | |
| 12J1 | D. Casteei | Uv | 1,340 | Basalt | Seeps from soil overlying basalt | | | D, S | |
| | | | | | **T. 4 N., R. 34 E.** | | | | |
| 22G1 | Sampson | Uv | 1,680 | Loess | Flows from a confined perched water body in silt overlying basalt. | 35 | 4-24-53 | | |
| | | | | | **T. 5 N., R. 33 E.** | | | | |
| 11R1 | R. R. Raymond | Uv | 1,750 | Basalt | Flows from fracture in basalt | 10 | 9-10-53 | D, S | Hardness, 90 ppm; chloride 44 ppm. |
| | | | | | **T. 1 S., R. 26 E.** | | | | |
| 1E1 | John Graves | Uv | 1,620 | Basalt | Flows through soil overlying basalt | 3 | 8-27-53 | D | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **T. 1 S., R. 27 E.** | | | | | |
| 20B1 | E. C. Dougherty | Uv | | Basalt | Seeps from many openings in thick soil cover over basalt in canyon bottom. | 12 | 8-27-53 | S | |
| 21R1 | do | Uv | | do | Seeps through soil overlying basalt | 3 | do | D | |
| 29B1 | Ferguson | Uv | | Alluvium | Seeps into reservoir from alluvium in bottom of basalt canyon. | | | D | |
| | | | | **T. 1 S., R. 28 E.** | | | | | |
| 20M1 | Joe Kenny | Uv | | Basalt | Flows from soil overlying basalt | | | D, S | |
| | | | | **T. 1 S., R. 30 E.** | | | | | |
| 32F1 | Dan Doherty | Uv | | Soil | Forms small pools in alluvium of canyon bottom; no running water visible. | 1– | 9-24-53 | S | |
| | | | | **T. 1 S., R. 31 E.** | | | | | |
| 31A1 | Krosting | Uv | | Basalt | Seeps from talus in canyon bottom | | | D, S | |
| | | | | **T. 1 S., R. 33 E.** | | | | | |
| 1P1 | Wilfred Minthorn | S | 1,860 | Basalt | Flows from soil covering basalt | 2 | 10- 2-53 | D, S | Reportedly yields more during wet season. Hardness, 50 ppm, chloride, 6 ppm. |
| 19M1 | Grant Horn | Uv | | Alluvium | | 10 | 10-28-53 | D, S | Reportedly yields more during the spring months. |
| 20D1 | R. B. Rugg | S | | Basalt | | | | D | Hardness, 70 ppm; chloride 4 ppm. |
| | | | | **T. 1 S., R. 36 E.** | | | | | |
| 12J1 | U.S. Government (Tie Camp Spring). | U | | Basalt | Seeps through soil covering the basalt | 2 | 9- 9-53 | D, FC | T 45°F. |

TABLE 4.—*Representative springs in the Umatilla River basin, Oregon*—Continued

| Spring | Owner or tenant and name of spring | Topography | Altitude (feet) | Water-bearing material | Occurrence | Yield: Gallons per minute | Yield: Date | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **T. 1 S., R. 37 E.** | | | | |
| 10Q1 | U.S. Forest Service (Yarn Spring). | U | -------- | Basalt | Flows through thin soil overlying basalt. | 2 | 9- 9-53 | FC | T 44°F. |
| 16A1 | U.S. Forest Service (Indian Spring). | S | -------- | do | do | 2 | do | FC | Located in upland meadow. T 42°F. |
| 16N1 | U.S. Forest Service (Allan Spring). | S | -------- | do | do | 1 | do | FC | Water appears milky. T 44°F. |
| | | | | | **T. 1 S., R. 38 E.** | | | | |
| 6D1 | U.S. Forest Service (Pot Spring). | Uv | -------- | Basalt | Flows through thin soil overlying basalt. | 1 | 9-23-53 | FC | T 44°F. |
| | | | | | **T. 2 S., R. 28 E.** | | | | |
| 23E1 | W. W. Weaver | S | -------- | Basalt | Flows from broken basalt | -------- | -------- | D, S | Owner reports that water stains user's teeth. Ca. |
| 24A1 | Zetta Brosnan | S | -------- | do | -------- | -------- | -------- | D | Hardness, 60 ppm; chloride 8 ppm. |
| | | | | | **T. 2 S., R. 29 E.** | | | | |
| 4Q1 | W. H. Wachter | Uv | -------- | Basalt | -------- | 10 | -------- | D, S | |
| | | | | | **T. 2 S., R. 31 E.** | | | | |
| 1D1 | Arthur Nieson | Uv | -------- | Alluvium | Seeps from marshy area in canyon bottom. | 0.5 | 8- 6-53 | D | Hardness, 140 ppm; chloride, 26 ppm. |
| 29B1 | Lilly A. Edwards | Uv | -------- | Basalt | Flows from fractures in basalt | 2 | do | D | Hardness, 105 ppm; chloride, 12 ppm. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| T. 2 S., R. 32 E. | | | | | | | | | |
| 30F1 | Archie S. Warner | S | | Basalt | Flows from fracture in basalt | 0.5 | 8-10-53 | D | Enclosed in 6-ft adit into hillside. |
| T. 2 S., R. 33 E. | | | | | | | | | |
| 7Q1 | Arvine Porter | Uv | | Basalt | | | | D | Hardness, 70 ppm; chloride, 10 ppm. |
| T. 2 S., R. 35 E. | | | | | | | | | |
| 31H1 | U.S. Forest Service (Flat Spring). | Uv | | Basalt | Seeps from soil overlying basalt | 1 | 8- 4-53 | FC, S | Water has milky color. |
| T. 3 S., R. 29 E. | | | | | | | | | |
| 19L1 | Paul Hisler | S | | Basalt | | | | D, S | Enclosed in concrete reservoir. |
| T. 3 S., R. 30 E. | | | | | | | | | |
| 33E1 | Orville Corlley | Uv | | | | | | D, S | Reported to yield little in summer. Hardness, 50 ppm; chloride, 6 ppm. |
| T. 3 S., R. 32 E. | | | | | | | | | |
| 4N1 | Pine Grove School | S | | Gneiss | Flows from crevices in weathered rock | 2 | 8-10-53 | D | Piped to school from concrete spring box. Hardness, 225 ppm; chloride, 5 ppm. T52° F. |
| 26M1 | Charles Carnes | Uv | | Basalt | Seeps from soil overlying basalt | 2 | | D | Spring enclosed by concrete box. |
| 27G1 | Roley (Roley Cabin Spring) | Uv | | do | Flows from broken basalt | 2 | 8-11-53 | D | Water appears milky. |

TABLE 4.—*Representative springs in the Umatilla River basin, Oregon*—Continued

| Spring | Owner or tenant and name of spring | Topography | Altitude (feet) | Water-bearing material | Occurrence | Yield | | Use | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Gallons per minute | Date | | |
| | | | | | **T. 3 S., R. 33 E.** | | | | |
| 12K1 | U.S. Government (McLellan Spring). | Um | | Soil | Seepage in marsh | | | D | Water appears milky. |
| 16J1 | U.S. Forest Service (Klondike Spring). | S | | Soil | Flows from soil overlying basalt | 2 | 8-11-53 | FC | Water appears milky. Hardness 75 ppm, chloride 32 ppm. |
| | | | | | **T. 4 S., R. 29 E.** | | | | |
| 29G1 | U.S. Forest Service (Chicken Spring). | S | | Basalt | Seeps from soil overlying basalt | 3 | 9-24-53 | FC | Enclosed in small reservoir. T 44°F. |
| 29R1 | U.S. Forest Service (Happy Home Spring). | S | | do | do | 1− | do | FC | Enclosed by small wooden box. T 44°F. |
| | | | | | **T. 4 S., R. 30 E.** | | | | |
| 21K1 | U.S. Forest Service (Log Spring). | Uv | | Basalt | Seeps from soil overlying basalt | 1− | 10- 6-53 | FC | Enclosed by small wooden box. T 44°F. |
| | | | | | **T. 4 S., R. 32 E.** | | | | |
| 5C1 | U.S. Forest Service (Cold Spring). | Uv | | Basalt | Seeps from soil overlying basalt | 5 | 8- 5-53 | FC | Hardness 40 ppm, chloride 2 ppm. |

TABLE 5.—*Ground-water levels in observation wells*

[All measurements are in feet below land-surface datum at the well. See plate 2 for hydrographs of five other wells]

**1N/26-10L1. Julian Rauch. Drilled well 189 ft deep and presumably tapping unconfined water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | Dec. 17 | 159.6 | Mar. 1 | 150.67 | Aug. 6 | 150.69 |
| | | | | Mar. 29 | 150.43 | Sept. 9 | 158.74 |
| Aug. 25 | 152.30 | *1954* | | May 11 | 161.4 | Oct. 5 | 156.47 |
| Sept. 23 | 151.80 | | | June 2 | 156.18 | | |
| Oct. 22 | 151.36 | Jan. 21 | 151.12 | July 7 | 150.85 | | |

**1N/28-21Q1. Antone Vey. Drilled well 270 feet deep tapping confined water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | *1954* | | June 2 | 52.62 | *1955* | |
| Sept. 23 | 51.32 | Jan. 21 | 53.77 | July 7 | 51.28 | Apr. 27 | 52.90 |
| Oct. 22 | 58.26 | Mar. 1 | 52.40 | Aug. 6 | [1] 74.84 | June 14 | 52.36 |
| Dec. 17 | 57.78 | Mar. 29 | 51.38 | Sept. 9 | [2] 63.90 | Sept. 9 | 58.90 |
| | | May 11 | 55.39 | Oct. 5 | 60.60 | | |

**1N/31-8K1. W. C. Warren. Dug well 16.4 ft deep tapping unconfined water in alluvium**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | June 15 | 9.49 | Dec. 17 | 9.44 | Mar. 30 | 9.97 |
| Feb. 17 | 8.70 | July 17 | 10.00 | *1954* | | May 11 | 13.72 |
| Apr. 6 | 9.08 | Aug. 25 | 10.04 | | | June 2 | 11.76 |
| Apr. 27 | 9.65 | Sept. 23 | [1] 13.00 | Jan. 21 | 9.72 | | |
| May 23 | 9.56 | Oct. 21 | 9.93 | Mar. 2 | 9.57 | | |

**1N/32-24R1. V. A. Bolt. Dug well 29.8 ft deep tapping unconfined water in gravel**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | June 16 | 13.02 | *1954* | | June 2 | 12.72 |
| Jan. 21 | 16.50 | July 17 | 13.17 | | | July 7 | 13.99 |
| Feb. 19 | 14.19 | Aug. 25 | 15.07 | Jan. 19 | 13.56 | Aug. 6 | 14.68 |
| Apr. 6 | 10.95 | Sept. 23 | 15.27 | Mar. 1 | 7.68 | Sept. 8 | 18.49 |
| Apr. 27 | 12.25 | Oct. 21 | 16.56 | Mar. 29 | 10.39 | Oct. 4 | 18.04 |
| May 22 | 12.60 | Dec. 15 | 14.97 | May 11 | 10.96 | | |

**1N/33-16R2. Patton. Dug well 36 ft deep tapping water in colluvium**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | | | *1954* | | | |
| Feb. 21 | 3.40 | July 17 | [1] 12.74 | Jan. 19 | 4.60 | June 2 | 9.02 |
| Apr. 6 | 4.42 | Aug. 25 | [1] 13.56 | Mar. 1 | 3.81 | July 7 | 16.89 |
| Apr. 27 | 6.14 | Sept. 23 | 5.16 | Mar. 29 | 7.45 | Aug. 6 | 12.22 |
| May 22 | 6.82 | Oct. 21 | 5.01 | May 11 | 8.33 | Oct. 4 | 10.97 |
| June 16 | [1] 7.69 | Dec. 15 | 12.66 | | | | |

**1N/33-18H1. Roy Horne. Drilled well 180 ft deep tapping unconfined water presumably in Pliocene fanglomerate**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | June 16 | 125.06 | *1954* | | | |
| Jan. 21 | 124.90 | July 17 | 124.99 | Mar. 1 | 124.48 | July 7 | 123.82 |
| Feb. 21 | 127.60 | Aug. 25 | 124.60 | Mar. 29 | 133.91 | Aug. 6 | 123.90 |
| Apr. 6 | 125.15 | Sept. 23 | 124.77 | May 11 | 123.92 | Sept. 8 | 123.90 |
| Apr. 27 | 125.02 | Oct. 21 | 124.95 | June 2 | 124.14 | Oct. 4 | 132.30 |
| May 22 | 125.03 | Dec. 15 | 124.70 | | | | |

**1N/33-19R1. W. H. Caplinger. Drilled well 150 ft deep tapping water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | *1954* | | | | *1955* | |
| Sept. 23 | 75.97 | Jan. 19 | 77.80 | July 7 | 78.39 | Jan. 18 | 78.79 |
| Oct. 21 | 78.30 | Mar. 1 | 78.34 | Aug. 6 | 78.63 | Apr. 27 | 79.69 |
| Dec. 15 | 78.12 | Mar. 29 | 78.14 | Sept. 8 | 78.76 | June 14 | 79.43 |
| | | May 11 | 78.14 | Oct. 4 | 78.85 | | |
| | | June 2 | 78.39 | | | | |

See footnotes at end of table.

TABLE 5.—*Ground-water levels in observation wells*—Continued

**2N/26-14K1. A. C. Lindsay. Drilled well, presumably to shallow depth, tapping perched water in Pliocene fanglomerate**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | *1954* | | | | | |
| Sept. 23 | 9.08 | Mar. 1 | 9.68 | May 11 | 9.76 | July 7 | 10.09 |
| Oct. 22 | 9.91 | Mar. 29 | 9.64 | June 2 | 9.76 | Aug. 6 | 10.25 |
| Dec. 17 | 9.86 | | | | | | |

**2N/27-28H1. Ed Tucker. Drilled well 263 ft deep tapping confined water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | *1954* | | *1955* | | *1957* | |
| June 16 | 44 | Jan. 21 | 25 | Apr. 27 | [1] 67 | Sept. 25 | [1] 95 |
| July 21 | 53 | Mar. 1 | 17 | June 14 | 63 | Nov. 16 | 78 |
| Aug. 25 | 57 | Mar. 29 | 14 | Aug. 5 | [1] +100 | | |
| Sept. 23 | 70 | May 11 | 38 | Sept. 19 | [2] 85 | *1958* | |
| Oct. 22 | [1] 73 | June 2 | [1] 60 | Dec. 9 | 66 | July 31 | [1] 90 |
| Dec. 17 | 35 | July 7 | 62 | | | Sept. 18 | [1] +100 |
| | | Sept. 9 | [1] 95 | *1956* | | | |
| | | Oct. 5 | [1] 89 | Apr. 14 | [1] 85 | | |
| | | | | Dec. 1 | 67 | | |

**3N/30-4D1. Coleman. Drilled well 290 ft deep, presumably tapping confined water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | Sept. 23 | 18.94 | Mar. 2 | 18.68 | July 7 | 18.84 |
| May 13 | 18.02 | Oct. 22 | 18.90 | Mar. 31 | 18.63 | Aug. 6 | 18.97 |
| June 16 | 18.27 | Dec. 16 | 18.85 | May 11 | 18.60 | Sept. 8 | 19.03 |
| July 21 | 18.56 | | | June 2 | 18.61 | | |
| Aug. 18 | 18.62 | *1954* | | | | | |
| | | Jan. 20 | 18.83 | | | | |

**3N/31-3D1. B. A. Davis. Drilled well 298 ft deep tapping confined water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | July 8 | [2] 37 | Dec. 10 | 16 | Nov. 16 | 18 |
| Dec. 16 | 11 | Aug. 7 | [2] 48 | | | | |
| | | Sept. 10 | 34 | *1956* | | *1958* | |
| *1954* | | Oct. 5 | 36 | Apr. 14 | 10.5 | Jan. 9 | 12 |
| Jan. 20 | 11 | | | June 16 | [1] 118 | Aug. 1 | [2] 54 |
| Mar. 2 | 10 | *1955* | | Sept. 25 | 44 | | |
| Mar. 30 | 10 | Mar. 24 | 11 | | | *1959* | |
| May 12 | 21 | June 14 | [1] 94.5 | *1957* | | Apr. 8 | 11 |
| June 4 | 25 | Sept. 20 | 60 | May 21 | 11.5 | | |
| | | | | Sept. 26 | 50 | | |

**3N/35-9H1. B. A. Davis. Drilled well 298 ft deep, presumably tapping unconfined water in basalt**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| *1953* | | *1954* | | | | | |
| Sept. 2 | 292.00 | Jan. 20 | 293.60 | May 12 | 295.57 | Aug. 7 | 296.18 |
| Dec. 16 | 293.60 | Mar. 2 | 294.01 | June 4 | 294.70 | Sept. 10 | 296.40 |
| | | Mar. 30 | 294.44 | July 8 | 295.79 | Oct. 5 | 297.36 |

**4N/26-25E1. Unknown. Drilled well 170 ft deep tapping perched water in glaciofluviatile deposits**

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| | | Sept. 23 | 49.94 | Mar. 2 | 49.51 | Aug. 8 | 49.38 |
| *1953* | | Oct. 22 | 49.84 | Mar. 29 | 49.51 | Sept. 8 | 49.42 |
| June 10 | 50.20 | | | May 11 | 49.52 | Oct. 6 | 49.26 |
| July 21 | 50.03 | *1954* | | June 2 | 49.41 | | |
| Aug. 25 | 49.95 | Jan. 1 | 52.70 | July 7 | 49.35 | | |

See footnotes at end of table.

TABLE 5.—*Ground-water levels in observation wells*—Continued

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| **4N/32-2M1. L. King. Drilled well 527 ft deep tapping confined water** | | | | | | | |
| *1953* | | *1954* | | *1955* | | *1957* | |
| June 6 | 21 | Jan. 20 | 24 | Mar. 24 | 23 | Sept. 25 | 40 |
| July 21 | 26 | Mar. 2 | 24 | June 14 | 28 | Nov. 16 | 19.15 |
| Aug. 26 | 11 | Mar. 30 | 23 | Sept. 20 | [1]+144 | | |
| Sept. 23 | [1]106 | May 12 | 55 | Dec. 10 | 24 | *1958* | |
| Oct. 21 | 32 | June 4 | 25 | | | Jan. 9 | 18.45 |
| Dec. 16 | 24 | July 8 | 46 | *1956* | | Apr. 16 | 17.53 |
| | | Aug. 8 | [1]144 | Apr. 14 | | Sept. 19 | 20.69 |
| | | Sept. 10 | 75 | June 16 | 19 | | |
| | | Oct. 5 | [1]128 | | 28 | | |
| **4N/32-33R1. Mr. Lorenzen. Drilled well 545 ft deep tapping confined water in basalt** | | | | | | | |
| *1953* | | | | *1954* | | | |
| Apr. 13 | 116.00 | Aug. 26 | 115.94 | Jan. 20 | 116.35 | June 4 | 116.15 |
| May 22 | 116.20 | Sept. 23 | 116.07 | Mar. 2 | 116.62 | July 8 | 116.19 |
| June 16 | 116.04 | Oct. 21 | 116.58 | Mar. 30 | 116.42 | Aug. 8 | 116.34 |
| July 21 | 116.16 | Dec. 16 | 116.40 | May 12 | 117.42 | | |
| **5N/28-22D1. Munson Court. Drilled well 189 ft deep tapping confined water in basalt** | | | | | | | |
| *1953* | | | | | | | |
| Sept. 26 | 7.02 | Sept. 8 | 8.66 | Dec. 9 | 7.18 | Nov. 16 | 7.58 |
| | | Oct. 5 | 7.34 | | | | |
| *1954* | | Dec. 9 | 7.18 | *1956* | | *1958* | |
| Jan. 21 | 7.11 | | | Apr. 14 | [2]11.68 | Jan. 8 | 8.24 |
| Mar. 2 | 6.77 | *1955* | | June 16 | 10.98 | Apr. 16 | 6.26 |
| Mar. 31 | 6.63 | Jan. 18 | 6.62 | Sept. 25 | 10.29 | July 31 | [1]31.32 |
| May 11 | 6.38 | Apr. 27 | 6.10 | Dec. 1 | 8.26 | Sept. 18 | [1]39.50 |
| June 2 | 8.77 | June 13 | 6.07 | | | | |
| July 7 | [1]14.01 | Aug. 5 | 7.98 | *1957* | | *1959* | |
| Aug. 6 | 5.37 | Sept. 19 | 7.21 | Sept. 25 | 12.78 | Apr. 8 | 9.38 |
| **5N/33-32D1. E. Koepke. Dug well 76 ft deep tapping perched water in loess** | | | | | | | |
| *1953* | | *1953*—Con. | | *1954* | | *1954*—Con. | |
| Apr. 14 | 68.62 | Aug. 26 | 69.38 | Mar. 2 | 69.96 | July 8 | 70.36 |
| May 22 | 69.34 | Sept. 23 | [1]73.78 | Mar. 30 | 69.74 | Aug. 8 | 72.37 |
| June 16 | 69.66 | Oct. 21 | 70.22 | May 12 | [1]73.56 | Sept. 10 | 68.90 |
| July 21 | 69.94 | Dec. 16 | 69.73 | June 4 | 72.92 | Oct. 5 | 69.72 |
| **5N/34-16R1. R. M. Thompson. Drilled well 228 ft deep tapping confined water in basalt** | | | | | | | |
| *1953* | | *1954*—Con. | | *1956* | | *1958* | |
| Sept. 9 | 148.50 | Aug. 8 | 156.78 | Apr. 14 | 151.26 | Jan. 9 | 158.10 |
| Dec. 16 | 149.03 | Sept. 10 | 150.91 | June 16 | 151.92 | Apr. 16 | 148.36 |
| | | Oct. 5 | 154.29 | Sept. 25 | [2]156.70 | Aug. 1 | 148.40 |
| *1954* | | | | Nov. 30 | 162.50 | Sept. 19 | 150.22 |
| Jan. 20 | 155.70 | | | | | | |
| Mar. 2 | 153.78 | *1955* | | *1957* | | *1959* | |
| Mar. 30 | 150.98 | Jan. 19 | 150.80 | May 21 | 156.01 | Apr. 8 | 147.85 |
| May 12 | 159.02 | Mar. 24 | 153.50 | Sept. 26 | [2]156.36 | | |
| June 4 | 156.69 | June 14 | 153.50 | Nov. 16 | 149.70 | | |

See footnotes at end of table.

TABLE 5.—*Ground-water levels in observation wells*—Continued

| Date | Water level | Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|---|---|
| **1/30-21F1. Daniel Doherty. Drilled well 225 ft deep tapping confined water in basalt** | | | | | | | |
| *1953* | | *1954* | | *1954*—Con. | | *1954*—Con. | |
| Sept. 24 | 14.82 | Mar. 1 | 13.26 | June 2 | 14.38 | Oct. 5 | [1] 44.56 |
| Dec. 18 | 13.55 | Mar. 29 | 13.36 | Aug. 6 | [1] 24.29 | | |
| **2/28-12E1. W. E. Hughes. Drilled well 150 ft deep tapping confined water in basalt 100 to 150 ft below land surface** | | | | | | | |
| *1953* | | *1954*—Con. | | *1954*—Con. | | *1955*—Con. | |
| Oct. 23 | 23.85 | Apr. 1 | 23.43 | Oct. 5 | 23.17 | Apr. 27 | 24.85 |
| Dec. 18 | 24.02 | May 10 | 22.02 | | | June 14 | 22.04 |
| | | Aug. 5 | 24.16 | *1955* | | | |
| *1954* | | Sept. 9 | 24.49 | Jan. 18 | 27.70 | | |
| Mar. 1 | 23.67 | | | | | | |

[1] Well being pumped when measured.
[2] Well pumped recently.

[Italic page numbers indicate major references]

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