Ground-Water Reconnaissance in the Burnt River Valley Area, Oregon

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GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1839-I

Prepared in cooperation with the U.S. Bureau of Reclamation and the Oregon State Engineer

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By DON PRICE

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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GROUND-WATER RECONNAISSANCE IN THE BURNT RIVER VALLEY AREA, OREGON

By Don Price

ABSTRACT

The Burnt River valley area in southern Baker and northern Malheur Counties, Oreg., is underlain by rocks that range in age from pre-Tertiary to Quaternary. The pre-Tertiary rocks, which underlie more than half the map area, are chiefly argillites, schists, limestones, and intrusive igneous rocks; the Tertiary rocks consist chiefly of fluviolacustrine deposits (mostly tuffaceous clay and silt) and felsic to mafic volcanic tuffs, flows, breccias, and agglomerates. The Quaternary rocks are Recent stream-valley alluvium and Pleistocene and Recent terrace deposits (mostly sand and gravel).

The pre-Tertiary rocks and most of the Tertiary rocks that underlie the map area have relatively low permeability and yield water slowly to wells and springs. Potentially productive aquifers occur in the Quaternary alluvium in the Burnt River and Willow Creek valleys, in the fluviolacustrine deposits, and in basaltic lava flows that extend beneath the valley floors.

The fluviolacustrine deposits that underlie the irrigated valley segments are the most likely to be penetrated by prospective irrigation wells; these deposits extend to depths of more than 1,000 feet in the Burnt River valley and to more than 680 feet in Willow Creek valley. They yield only small to moderate quantities of water, generally less than 50 gallons per minute, to wells, but they contain gravel lenses locally which could yield moderate to large quantities of water to properly constructed wells. Basaltic rocks that are intercalated with and extend beneath the fluviolacustrine deposits near Huntington and in Willow Creek valley yield moderate to large quantities of water (as much as 1,000 gallons per minute) to wells; however, those rocks are of limited extent in the study area and in most places appear to lie above the regional water table.

The ground water is chemically suitable for irrigation of most crops that can be grown under the climatic conditions of the area. However, samples collected from two wells that tap the fluviolacustrine deposits, one near Durkee and the other near Bridgeport, were classified as having very high sodium and a high salinity hazard; those samples also contained concentrations of boron that could be toxic to some plants.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

The purpose of this investigation was to determine the availability of ground water for irrigation in the Burnt River valley, because additional water is needed to supplement existing surface-water supplies. The investigation was made in cooperation with the U.S. Bureau of Reclamation and the office of the Oregon State Engineer.

Most of the work for this investigation was done during the fall of 1963. Fieldwork consisted of reconnaissance geologic mapping and collection of basic hydrologic data. Ground-water samples were collected from several wells and analyzed for concentrations of boron and other mineral constituents which might affect the suitability of water for irrigation. A report on this subject by Price (1964), "Ground-Water Reconnaissance in the Burnt River Valley, Baker County, Oregon," compiled for the Bureau of Reclamation, was released to the open file in September 1964.

This report includes most of the information in the earlier open-file report, as well as additional geologic and hydrologic data; it also covers a larger area. The geologic map in this report was adapted from a report of the Oregon Department of Geology and Mineral Industries (Wagner, 1958) and is more generalized than the geologic map in the earlier report. Compilation of the present report was under the supervision of E. R. Hampton, acting district geologist in charge of ground-water investigations in Oregon.

LOCATION AND EXTENT OF THE AREA

The area of investigation includes the Burnt River valley and part of Willow Creek valley in southern Baker County and northern Malheur County in east-central Oregon. The map area lies between lat 44°20′ and 44°42′ N. and long 117°10′ and 118°20′ W. (fig. 1) and covers approximately 1,300 square miles.

The principal areas of interest were four broad segments of the Burnt River valley where supplemental irrigation water is most likely to be needed. Those segments, which have a total area of about 25 square miles, are centered about the communities of Unity, Hereford, Bridgeport, and Durkee (pl. 1).

PREVIOUS INVESTIGATIONS

Geologic investigations of areas adjacent to or encompassing the Burnt River valley area include a study of the gold-belt region of the Blue Mountains by Lindgren (1901), a study of the geology and mineral resources of the Baker quadrangle by Gilluly (1937), and a study of the geology of the Sumpter quadrangle by Pardee, Hewett, Rosenkranz, Katz, and Calkins (1941). Wagner (1958) compiled a general geologic map of northeastern Oregon. The segment of Wagner's map that covers the Burnt River valley area was used to compile the geologic map for this report.

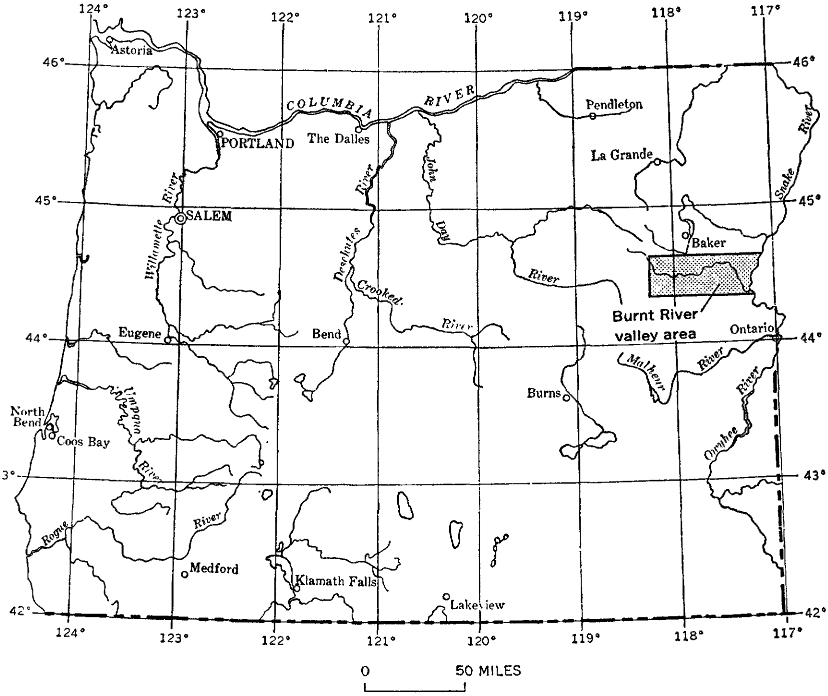

FIGURE 1.—Location of the area of investigation.

Prior to the present investigation, only cursory observations were made of the ground-water resources in the Burnt River valley area. Newcomb (1960) prepared a summary of ground-water subareas of the Snake River basin in Oregon south of the Wallowa Mountains. That summary included a brief description of the geology and ground-water conditions of the Burnt River valley. A study of the ground-water resources of Cow Valley, which adjoins the Burnt River valley area on the south, was made by Brown and Newcomb (1962). Some of the water-bearing rock units that underlie Cow Valley also underlie parts of the Burnt River valley area.

ACKNOWLEDGMENTS

The writer extends thanks to the officials of the Oregon State Department of Geology and Mineral Industries, who provided access to unpublished geologic data held by that office. Some of the well records were furnished by officials of the Union Pacific Railroad Co. and by individuals living in the area. The helpful cooperation of all is gratefully acknowledged.

WELL-NUMBERING SYSTEM

In this report wells and stream-sampling points are designated by symbols that indicate their locations according to the official rectangular subdivision of public lands. In the symbol for well 12/37–28E1, for example, the numbers preceding the hyphen indicate the township and range (T. 12 S., R. 37 E.) south and east of the Willamette base line and meridian. The number following the hyphen indicates the section (sec. 28), and the letter (E) indicates the 40-acre subdivision of that section according to figure 2. The final digit is the serial number of the well within that 40-acre tract. Thus, well 12/37–28E1 is in the SW¼NW¼ sec. 28, T. 12 S., R. 37 E., and was the first well in that tract to be listed. It is identified on the map (pl. 1) by that part of its number which follows the hyphen. A similar numbering system is used for stream-sampling sites except that the final digit is omitted.

GEOGRAPHY

CLIMATE

The Burnt River valley area is in a semiarid region where summers are generally warm and dry and winters are cool and moist. The warmest and driest months are July and August. The coldest and wettest periods usually occur from November to February, but there is a secondary wet period in May and June. Figure 3 shows the average monthly temperature and precipitation at Unity (alt 4,031 ft), which is near the upper end of the Burnt River valley, and at Huntington (alt 2,110 ft), which is at the lower end of the valley.

Annual precipitation is rather uniformly distributed throughout the study area but varies considerably in amount from year to year. During the period 1937–64 the annual precipitation recorded at Unity ranged from 5.92 inches (1954) to 16.04 inches (1940) and averaged 10.64 inches. (See fig. 4.) During the same period of record the annual precipitation recorded at Huntington ranged from 5.38 inches (1949) to 18.90 inches (1940) and averaged 11.38 inches. Generally, precipitation in the area increases with altitude. The lower average annual precipitation at Unity, which is nearly 2,000 feet higher than

Huntington, is probably caused by the rain shadow of the high Greenhorn Mountains, which lie due west of Unity. These mountains intercept much of the moisture from eastward-moving storms.

The length of the growing season varies considerably between the upper and lower parts of the Burnt River valley. The average number of days between the last spring and the first fall minimum temperature of 32°F (recorded in 1950–64) was only 33 days at Unity as compared with 166 days at Huntington. At Unity, it is not uncommon to have less than 10 days elapse between the last spring and the first fall minimum temperature of 32°F. The following table shows the average number of days between the last spring and the first fall minimum temperatures of 24°, 28°, and 32°F at Huntington and Unity for the period 1950–64. (See bottom of p. I 7.)

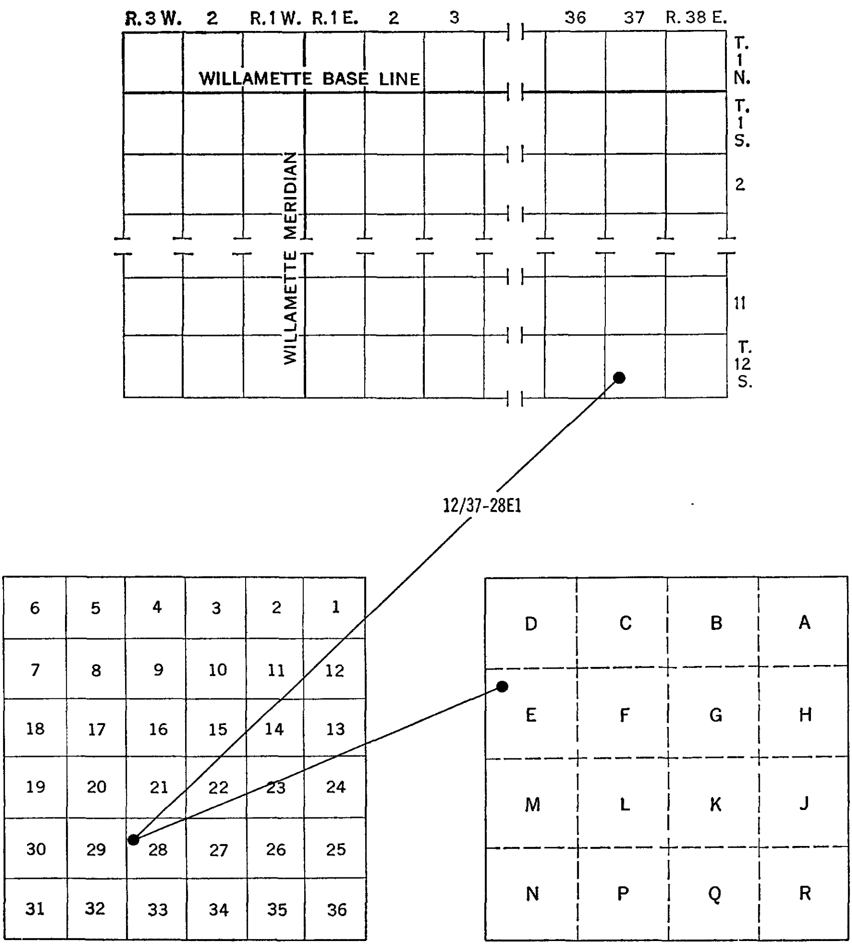

FIGURE 2.—Well-numbering system.

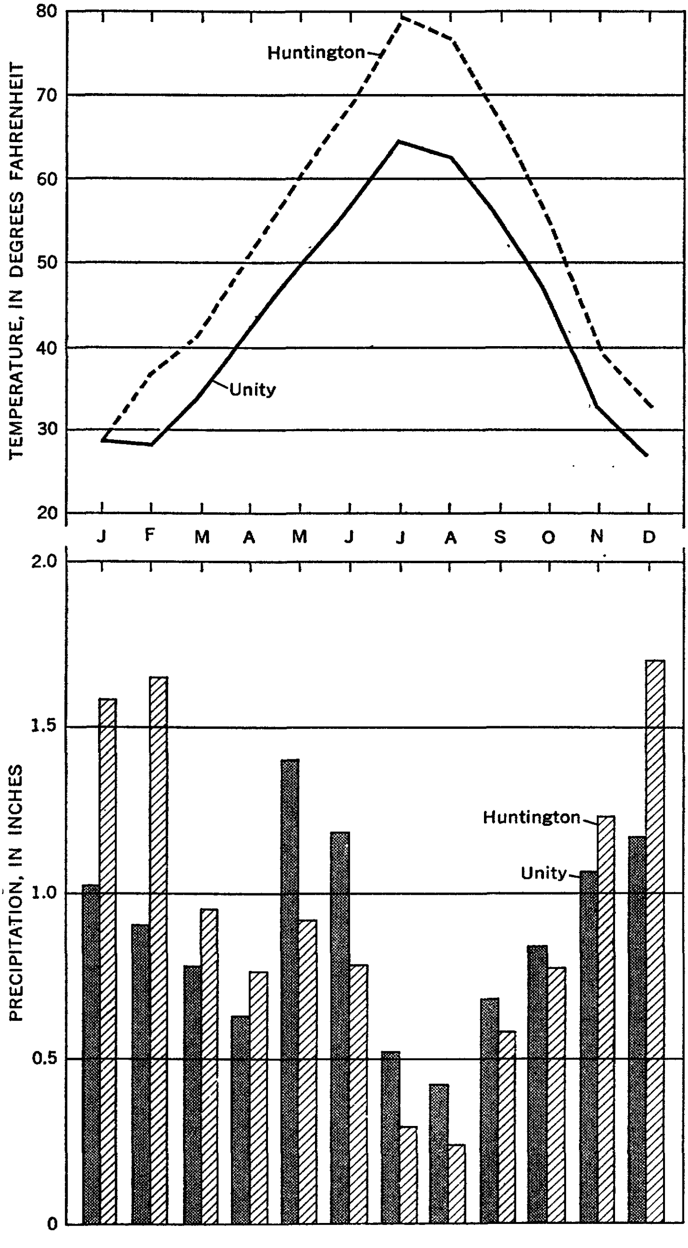

FIGURE 3.—Average monthly precipitation and temperature at Unity and Huntington, 1937–64. (Data from U.S. Weather Bureau.)

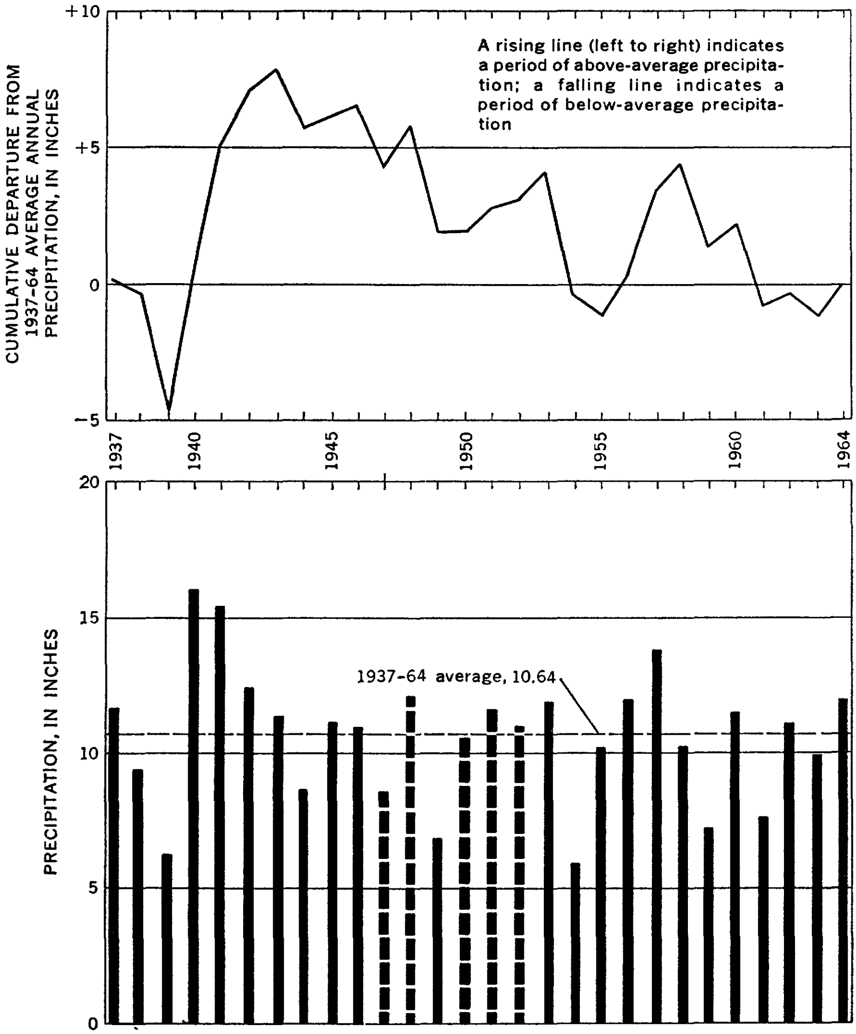

Figure 4.—Annual precipitation and cumulative departure from the average precipitation at Unity, 1937–64. Dashed bars indicate total precipitation interpolated from records of nearby precipitation stations. (Data from U.S. Weather Bureau.)

Average number of days between the last spring and the first fall minimum temperatures of 24°, 28°, and 32° F at Huntington and Unity (1950–64)

	Average number of days between dates		
	24°F or below	28°F or below	32°F or below
At Huntington	221	192	166
At Unity	136	92	33

TOPOGRAPHY AND DRAINAGE

The area of this report has moderate to high relief. Along most of its 64-mile course, the Burnt River occupies a narrow canyon, a few hundred feet wide, bounded by steep walls that rise more than a thousand feet above the alluvial plain. In the vicinities of Unity, Hereford, Bridgeport, and Durkee, the canyon broadens to valley segments, 1 to 3 miles wide, bounded by low terraces and rolling hills that merge with more rugged terrain a short distance from the valley floor.

The total relief in the study area exceeds 5,700 feet. The highest point on the drainage divide of the Burnt River is about 7,900 feet above mean sea level, but the average altitude is near 6,000 feet. The altitude of the Burnt River valley floor near Hereford is about 3,200 feet; near Durkee, 2,750 feet; and near Huntington, about 2,100 feet.

Most of the area is drained by the Burnt River, although part is drained by Willow Creek and part by the Powder River. The Burnt River, including the tributaries which head outside the study area, drains about 1,100 square miles. The larger tributaries of the river downstream from Unity Reservoir are Camp, Alder, and Dixie Creeks.

Streamflow measurements are made on the Burnt River by the U.S. Geological Survey about half a mile downstream from Unity Reservoir (Hereford gaging station), near Bridgeport, and at Huntington; past measurements were made at Durkee. Records of the river's discharge are published in the Geological Survey water-supply paper series entitled "Surface-Water Supply of the United States, Part 13, Snake River Basin." These records show that the average annual runoff of the Burnt River at the Hereford gaging station was about 58,350 acre-feet during the period 1928–64. Prior to completion of Unity Reservoir in 1938, the highest monthly runoff of the river at the Hereford gaging station was about 34,000 acre-feet; since 1938, however, owing to the annual refilling of Unity Reservoir, the highest monthly runoff has been about 20,000 acre-feet. Figure 5 shows the monthly runoff of Burnt River at the Hereford and Huntington gaging stations for water year 1932 and the average monthly runoff at those stations during water years 1957–59 and 1963–64. (Water years 1932, 1957–59, and 1963–64 were the only water years in which simultaneous streamflow measurements were made at the Hereford and Huntington gaging stations.) As figure 5 shows, the monthly runoff at Huntington was negligible in August, September, and October 1932 prior to completion of Unity Reservoir, but the average monthly runoff for those same months was 4,000–4,900 acre-feet during water years 1957–59 and 1963–64 after completion of Unity Reservoir. A significant increase in late-summer runoff at the Hereford station following completion of Unity Reservoir is also shown in figure 5.

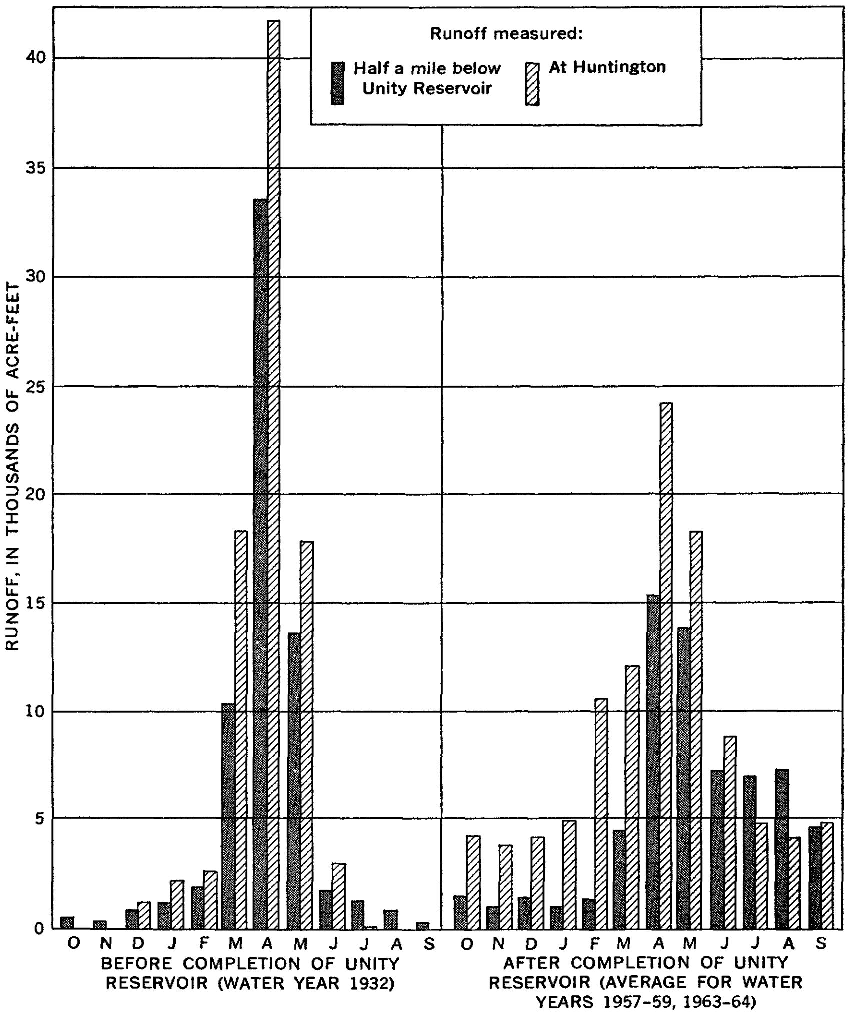

FIGURE 5.—Monthly runoff of the Burnt River before and after Unity Reservoir was completed in 1938.

The principal reason for the greater late-summer flow of the Burnt River at Hereford and Huntington during the later water years is regulation of flow of the river at Unity Reservoir. However, the increased late-summer flow at Huntington, which is downstream from the main irrigated segments of the valley, is caused partly by irrigation return and more ground-water seepage into the river. The greater amount of ground-water and irrigation-return inflow is indicated by a general increase of dissolved mineral constituents in the river water in a downstream direction (table 3). For example, on

September 25 and 26, 1963, the specific conductance (a rough index of the total dissolved-solids concentration) of the river water was 374 micromhos near Unity Reservoir as compared with 477 near Bridgeport and 483 near Durkee. On September 17, 1959, the specific conductance near Huntington was 677 micromhos. Because the water samples were collected during the irrigation season, some of the increased mineral content was probably due to rather highly mineralized irrigation return flow.

CULTURE AND INDUSTRY

The Burnt River valley area is utilized mainly for grazing and raising of food for livestock. Population is sparse, although there are several small community centers, including Huntington, Unity, Hereford, Bridgeport, and Durkee. Huntington (population of 660 in 1964) is the largest town in the area and also the main railroad station between Baker, Oreg., and Weiser, Idaho. Baker, which is about 25 miles northwest of Durkee on U.S. Highway 30, is the principal commercial center for the study area. Lumber milling at Unity and cement manufacturing at Lime are the main industries. The area is easily accessible by U.S. Highways 26 and 30 and by Oregon State Highway 7, all of which are paved; other roads are only graded.

GEOLOGIC SETTING

The rocks exposed in the Burnt River valley area range in age from pre-Tertiary to Recent; they consist chiefly of variably metamorphosed sedimentary and igneous rocks; intrusive igneous rocks of granitic composition; lava flows, tuffs, and breccias of felsic to mafic composition; and fluviolacustrine deposits derived largely from volcanic rocks. For this report the rocks have been grouped into five major geologic units (after Wagner, 1948): (a) pre-Tertiary rocks, undifferentiated, (b) rhyolite, andesite, and related volcanic rocks (Tertiary), (c) fluviolacustrine deposits (Tertiary), (d) basalt and balsaltic andesite (Tertiary and Quaternary(?)), and (e) Quaternary alluvium. These rock units and their water-bearing properties are described briefly in plate 1.

GROUND WATER

GENERAL FEATURES OF OCCURRENCE

Ground water completely fills the voids in the rock materials in which it occurs. All the rocks in the Burnt River valley area are completely saturated with water below a certain depth. The depth to the top of this main zone of saturation, the regional water table, ranges from a few feet along the alluvial plains of some streams to several hundred feet along the higher divides. There are, however, local discontinuous bodies of ground water perched above the regional water table, as shown by springs that issue from the rocks along canyon walls high above the stream-valley floors.

Ground water in the Burnt River valley area discharges naturally through seeps and springs and by evapotranspiration; most of the natural discharge takes place along larger streams and their flood plains, where the water table is at a shallow depth and vegetation is most abundant. Some ground water is pumped from wells for domestic, stock, and irrigation supplies; however, the amount pumped is small compared with the amount that is discharged naturally.

The ground water is replenished chiefly by deep percolation of precipitation that falls within the map area and by underflow of ground water from without the area. There is also some recharge to aquifers beneath the alluvial plains of the Burnt River and Willow Creek by percolation of water from irrigated land and leaky canals.

It was beyond the scope of this investigation to determine the amount of water discharged from and recharged to the ground-water reservoirs in the Burnt River valley area each year. Measurements of ground-water levels indicate that discharge exceeds natural recharge during the summer and fall, whereas recharge exceeds discharge during winter and spring. (See hydrograph of well 14/39–21F1 in fig. 6.) In areas of heavy irrigation, however, this condition may be reversed; that is, recharge from irrigated land exceeds discharge and causes ground-water levels to rise in late summer.

GROUND-WATER POTENTIAL OF SELECTED ROCK UNITS

Because none of the wells for which records were available are known to tap the pre-Tertiary rocks or the rhyolite and related rocks of Tertiary age, little information is available regarding the water-bearing properties of those geologic units. However, the rocks appear to have low permeability and to yield water slowly to springs. The basalt and basaltic andesite, the fluviolacustrine deposits, and the Quatenary alluvium appear to be the most favorable rocks from which to develop ground-water supplies; the ground-water potential of those rock units is described below.

BASALT AND BASALTIC ANDESITE

Basalt of the Columbia River Group generally yields moderate to large quantities of water to wells in Baker Valley and nearby valleys in northeastern Oregon (Ducret and Anderson, 1965; Hampton and Brown, 1964; Hogenson, 1964). These rocks are well exposed west of Unity Reservoir and also underlie a large area in the north-central and northeastern parts of the map area. However, the basalt appears to be too limited in extent in the Burnt River valley to constitute a major aquifer for irrigation. Basaltic rocks (probably of the Columbia River Group) underlie fluviolacustrine deposits in Willow Creek valley and are intercalated with the fluviolacustrine deposits near Huntington; these rocks have been penetrated by a number of irrigation and public-supply wells (table 1) of moderate to high yield. (See table 2 for drillers' logs.) Well 14/39–21F1 reportedly yielded 700 gpm (gallons per minute) with 140 feet of drawdown, and well 14/45–18M1 reportedly yielded about 75 gpm with about 60 feet of drawdown.

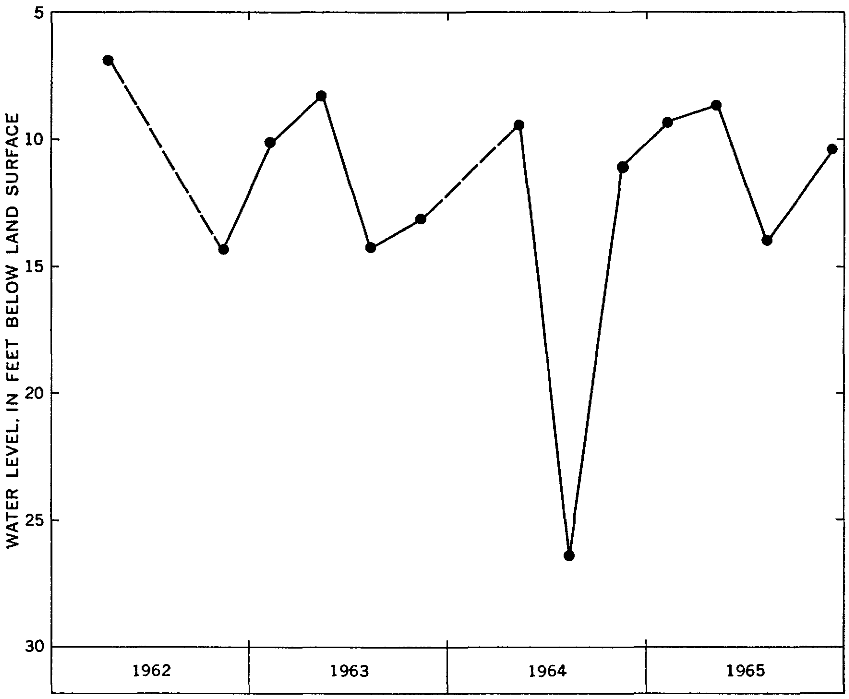

FIGURE 6.—Hydrograph of well 14/39–21F1.

A hydrograph of well 14/39–21F1 is given in figure 6. It shows that there has been a slight decline in ground-water levels in Willow Creek valley near Ironside during the period 1962–66. This indicates that, even though the aquifers tapped by well 14/39–21F1 are moderately to highly permeable, recharge to them may not be sufficient to support withdrawals from more than the few (about five) existing large-yield irrigation wells near Ironside. For example, withdrawals from 14 wells that tap similar rocks in Cow Valley increased from 2,020 acre-feet in 1951 to 6,820 acre-feet in 1959, a condition causing a decline in the water level of more than 16 feet in some wells (Brown and Newcomb, 1962).

FLUVIOLACUSTRINE DEPOSITS

The fluviolacustrine deposits underlie much of the Burnt River and Willow Creek valleys (pl. 1). Wells drilled in the alluvial plain of the Burnt River in the vicinities of Unity, Hereford, Bridgeport, Durkee, and Huntington and in the alluvial plain of Willow Creek near Ironside and upstream from Willow Creek Reservoir 3 would probably penetrate the fluviolacustrine deposits at depth. These deposits consist chiefly of fine-grained sedimentary material which is not likely to yield large volumes of water to wells. However, the fluviolacustrine deposits contain some relatively permeable sand and gravel lenses locally that could yield moderate quantities of water to wells.

Several wells in the study area tap the fluviolacustrine deposits (table 1). Although most of the wells yield only a few gallons per minute, well 11/43–28D1 near Durkee reportedly yields 65 gpm with about 162 feet of drawdown, and wells 12/37–9M1 and –16F1 near Unity reportedly yielded 40 gpm by bailing with 20 feet of drawdown and 30 gpm with 11 feet of drawdown, respectively. Also, part of the 700 gpm produced from well 14/39–21F1 is obtained from the fluviolacustrine deposits.

The ground water in the fluviolacustrine deposits is generally chemically suitable for most uses; however, analyses of water samples collected from several wells indicated the water to be of questionable quality for irrigation because of excessive boron or other dissolved minerals (p. I 15).

QUATERNARY ALLUVIUM

The Quaternary alluvium consists of the silt, sand, and gravel that underlie the flood plains of the Burnt River, Willow Creek, and their larger tributaries. The map unit also includes the terrace deposits near these streams that are composed of sand, gravel, and boulders (pl. 1). Saturated alluvium underlies about 15 square miles in the Burnt River valley; this alluvium yields small to moderate quantities of water to wells and springs.

Well 11/43–18J1 (table 1), north of Durkee, is believed to be fairly representative of most wells that tap the alluvium of the Burnt River and Alder Creek. That well reportedly yields 15 gpm and supplies sufficient water for domestic and stock use and irrigation of nursery stock. Well 11/43–28P1 (table 1) taps alluvium of the Burnt River south of Durkee. On completion, that well reportedly was pumped at 30 gpm with 5 feet of drawdown.

Recharge to the alluvium results from percolation of precipitation and irrigation water. Because the recharge from irrigated land continues into late summer and early autumn when natural recharge is at a minimum, wells that tap the alluvium in the irrigated parts of the area are likely to have longer sustained yields during late summer. The water from those wells is likely to contain larger concentrations of dissolved mineral constituents than does water from wells that tap aquifers recharged only from precipitation, because the recharge water from irrigation is more mineralized.

CHEMICAL QUALITY OF THE WATER

Samples of water from 7 wells and 8 points along the Burnt River were collected and analyzed for mineral content. Samples were collected 2 or more times at 3 of the 8 points along the Burnt River, making 20 samples in all (table 3).

The few ground-water analyses in table 3 are not intended to represent the chemical quality of all ground water in the Burnt River valley area. They do, however, indicate that there is a wide variation in the chemical quality of the ground water. Similarly, the Burnt River water analyses are not intended to be entirely representative of river water, but those analyses show that the quality of the river water varies considerably depending on the sampling site and the season of the year.

The analyses of samples from four wells indicate that the water is of suitable chemical quality for irrigation and most other uses. Analyses of samples from two wells (11/43–28D1 and 12/40–26P1) indicate that the water may be undesirable for irrigation owing to relatively high concentrations of boron and sodium; a sample from another well (12/38–27A1) contained 205 ppm (parts per million) of nitrate, which is far in excess of the 45 ppm recommended by the U.S. Public Health Service (1962) as the maximum allowable concentration of nitrate in drinking water.

The analyses of samples of Burnt River water show a seasonal variation in chemical quality in the river system that is related to high and low flow and to a general increase in dissolved-mineral concentration in a downstream direction. All the samples of river water were of generally good chemical quality for irrigation and other uses.

Comparison of the analyses of ground and surface water shows that, as is usual, the ground water generally has greater concentrations of dissolved minerals than the surface water. For example, the specific conductance ranged from 433 to 1,590 micromhos and averaged about

884 micromhos in the ground-water samples, whereas the specific conductance of the surface-water samples ranged from 89 to 677 micromhos and averaged about 536 micromhos.

SUITABILITY OF WATER FOR IRRIGATION

The characteristics most important in determining suitability of water for irrigation are the total concentration of soluble salts, the relative proportion of sodium to the principal cations in the water, and the concentration of boron or other elements that may be toxic to plants.

Large amounts of dissolved solids (soluble salts) in irrigation water can have some harmful effects on crops and soil. The concentration of soluble salts in water is indicated by the electrical conductivity (specific conductance), which is usually expressed in micromhos at 25°C (table 3). By measuring the specific conductance of the water, one can obtain an indication of the water's salinity hazard. If the specific conductance of the irrigation water is high, the salinity hazard may be high.

The sodium (alkali) hazard of water used for irrigation is determined by the proportion of sodium to calcium and magnesium. If the proportion of sodium is high, the alkali hazard is high; if the proportion of calcium and magnesium is high, the alkali 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 classification of water with respect to SAR is based primarily on the effects of exchangeable sodium on the physical conditions of the soil.

Figure 7 shows the classification of irrigation water on the basis of specific conductance and SAR. This diagram classifies irrigation water into 16 categories, ranging from low salinity (C1) and low sodium (S1) to high salinity (C4) and high sodium (S4). Water in the C1–S1 category can be used on practically all soils with little possibility of harmful effects on the soils or crops; water in the C4–S4 category is not suitable for any type of crop or soil except under special conditions.

Eleven of the analyses in table 3 are plotted on figure 7 to illustrate the suitability of the water for irrigation. As figure 7 shows, four samples of Burnt River water and three samples of ground water fell in the C2–S1 category, which indicates that those waters have a medium-salinity hazard and a low-sodium hazard. Two of the ground-water samples are in the C3–S1 category, which indicates that they have a high-salinity hazard but a low-sodium hazard. The other two ground-water samples (from wells 11/40–28D1 and 12/40–26P1) have a high-salinity hazard and a very high sodium hazard.

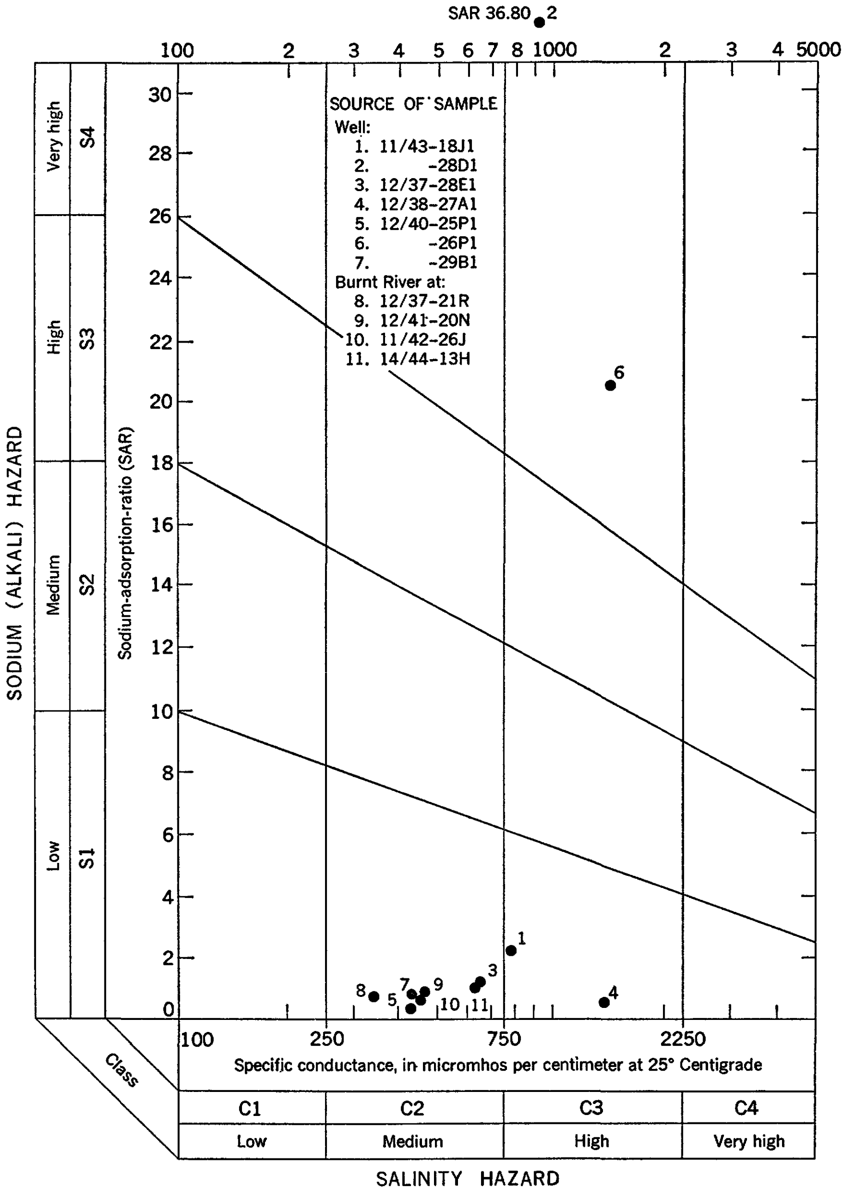

FIGURE 7.—Classification of irrigation water. (Adapted from U.S. Salinity Laboratory Staff, 1954, p. 80.)

Because the salinity and sodium hazards of some of the water analyzed were high, careful chemical analyses should be made of water from other wells that tap the same rocks before considering use of the water for irrigation.

Plants are rated as sensitive, semitolerant, or tolerant, according to their ability to withstand boron concentrations (Wilcox, 1948). Irrigation water containing boron is classified in five categories (from excellent to unsuitable) for each of these classes of plants. Water having concentrations of boron of less than 0.33 ppm is regarded as excellent for virtually all plants, whereas water containing more than 3.75 ppm of boron is regarded as unsuitable for even the most boron-tolerant plants.

Of the 10 water samples analyzed for boron (table 3), 7 had concentrations of boron ranging from 0.00 to 0.14 ppm and are, therefore, excellent for irrigation. Two of the samples, as mentioned earlier, had concentrations of boron (3.6 and 2.3 ppm) which could be toxic to even some of the more boron-tolerant plants.

SUMMARY AND CONCLUSIONS

Most of the area is underlain and bounded by rocks of generally low permeability that yield water slowly to wells and springs. Fluviolacustrine deposits underlie the irrigated valley segments to depths of more than 1,000 feet and are the geologic unit most likely to be penetrated by prospective irrigation wells; those deposits consist chiefly of clay and silt of low permeability but contain some sand and gravel lenses locally which could yield moderate quantities of water to properly constructed wells. The fluviolacustrine deposits are intercalated with and underlain by moderately to highly permeable basaltic rocks. Wells that tap the basaltic rocks in the Burnt River valley near Huntington and in Willow Creek valley near Ironside produce moderate to large quantities (as much as 1,000 gpm) of water. However, the basalt is limited in extent and appears to extend above the regional water table in other parts of the map area.

The chemical quality of the water in the Burnt River valley seems to be generally good, but the presence of potentially toxic amounts of boron in two of the well-water samples, along with the high SAR value in those samples, indicate that water from wells should be checked for chemical quality before application to crops, especially if the wells tap deep aquifers in the fluviolacustrine deposits.

The low permeability of many of the rocks in the Burnt River valley area suggests that most aquifers would yield water too slowly to sustain large continuous drafts for irrigation. Furthermore, the high boron, salinity, and sodium hazards of some of the ground water sampled indicate that, locally, the water may not be chemically suitable for irrigation. However, additional drilling may show that some of the fluviolacustrine deposits and volcanic rocks will locally yield moderate to large supplies of good-quality water to wells, as has been the case in parts of Willow Creek valley.

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TABLES 1–3

TABLE 1.—*Records of representative wells*

Well number: See p. I 4 for explanation of well-numbering system.
Type of well: Dg, dug; Dr, drilled.
Altitude: Altitude of land surface at well, in feet above mean sea level, interpolated from topographic maps.
Water level: Measured depth of water given in feet and decimal fractions; those in whole feet reported by the well owner or driller. F, flowing well with unknown static water level.
Type of pump: C, centrifugal; Cy, cylinder; J, jet; N, none; S, submersible; T, turbine.
Well performance: Yield, in gallons per minute; drawdown, in feet, below nondischarging water level reported by owner, operator, or driller. Bailed yields indicated by a "b."

Well	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Water-bearing zone	
								Depth to top (feet)	Thickness (feet)
11/43-18J1	D. S. Kirby	Dg	------	30±	48	30	------	------	------
19K1	Cynthia A. Moore.	Dr	1958	41	6	39	Perforated at unreported depth.	------	------
28D1	Union Pacific Railroad Co.	Dr	1921	1,082	12-6	941.4	Open bottom	921 973	42 10
12/36-24B1	John Rice	Dr	1955	212	12	------	------	------	------
12/37-28E1	Oregon State Highway Dept.	Dr	1959	300	6	60	Open bottom	220 280	12 2
12/38-27A1	Hereford Community Church.	Dr	1959	81	6	81	do	74	7
12/40-25P1	Harry Elliott	Dr	1930±	98	6	------	do	------	------
26P1	Virgil Elliott	Dr	1914	165	8	------	------	------	------
29B1	J. R. Mitchell	Dr	1952	80	6	------	Open bottom	------	------
36N1	J. A. Andersen	Dr	1958±	300	12	300	Casing perforated at unknown depth.	------	------
12/41-31C1	Wendt Bros	Dr	1900±	145	6	145(?)	do	145	------
12/44-6E1	Hite Bros	Dr	1961	101	6	64	Casing perforated 60-64 ft.	61	40
13/37-9M1	Ellingson Lumber Co.	Dr	1960	285	6	167	Casing perforated 35-167 ft.	130 257	80 3
16F1	U.S. Forest Service (Whitman Natl. Forest, Unity Annex).	Dr	1964	458	8	70	Casing perforated 21-31 ft, 37-40 ft, and 50-60 ft.	27	7
17G1	Unity School Dist. 30J.	Dr	------	330	------	------	------	------	------
13/43-33G1	U.S. Bur. of Land Management.	Dr	1963	355	6	308.5	Casing perforated 285-305 ft.	302	5

in the Burnt River valley area, Oregon

Use: D, domestic; Ir, irrigation; N, none; PS, public supply; R, formerly supplied water for steam locomotives.
Remarks: Ca, chemical analysis of water in table 3; L, driller's log of well in table 2; temp, temperature of water, in degrees Fahrenheit. Remarks on adequacy and dependability of supply, general quality of water, and materials penetrated are reported by owners, operators, drillers, or others.

Water-bearing zone—Continued	Altitude (feet)	Water level		Type of pump and horsepower	Well performance		Use	Remarks
Character of material		Feet below datum	Date		Yield (gpm)	Drawdown (feet)		
------	2,720	18.40	9-24-63	C	15	------	D	Temp 60, Ca.
Sand and gravel	2,800	22	2-10-58	------	30b	5	D	L.
Quartz sand; Quartz sand and gravel.	2,650	F	1921	T, 10	65	162+	R, D	Currently supplies several homes; temp on completion of well 96; 1Ca, L.
"Blue shale"	3,950	8-10	1955	N	5-10	------	N	Well origina ly planned for irrigation; reportedly penetrated only "blue shale" to 212 ft and was abandoned owing to insufficient yield.
Shale and sand	3,900	220	1959	------	150(?)	200(?)	D	Well supplies water for camping and picnic area; temp 58, Ca, L.
Clay and gravel; some sand.	3,660	48.83	4-10-59	J, ½	22b	5	D	Temp 54, Ca, L.
------	3,550	5	1962	J, ¾	------	------	D	Ca.
Gray clay	3,550	------	------	Cy	------	------	D	Water from well reportedly contains some gas; temp 54, Ca.
------	3,600	22.00	9-25-63	S	------	------	D	Water reportedly contains soft, chalky-white sediment that coats fixtures; temp 53, Ca.
Shale and volcanic wash.	3,600	------	------	N	------	------	N	Well originally planned for irrigation; reportedly penetrated shale and "volcanic wash" to 300 ft; abandoned owing to insufficient yield.
"Granite" rock	3,440	10-15	1963	N	10	------	N	Pumps dry when equipped with gasoline-driven motor.
Black and light-green rock.	3,040	4.36	9-24-63	N	18b	80	N	Well planned for limited irrigation of small plot; temp 50, L.
Clay and gravel	3,950	9	4-20-60	------	40b	22	D	L.
Gravel	3,950	20	11-21-64	S, 3	30	11	D	L.
------	------	17.04 16.76	5-7-64 11-19-64	T, 15	------	------	D	Formerly used for irrigation.
Clay and gravel	4,260	266	7-28-64	J, 3	3	35	S	Temp 56, L.

TABLE 1.—*Records of representative wells*

Well	Owner	Type of well	Year completed	Depth of well (feet)	Diameter of well (inches)	Depth of casing (feet)	Finish	Water-bearing zone	
								Depth to top (feet)	Thickness (feet)
13/44-27A1	Union Pacific Railroad Co.	Dr	------	184	8-6	171	Open bottom	167	17
14/39-21F1	Ralph Duncan	Dr	1961	734	12	161	Casing perforated 20-160 ft.	18 510 582	22 2 152
14/44-13H1	do	Dr	1907	391	10-8	228			
13H2	do	Dr	1920	240	12-10	61			
14/45-18M1	City of Huntington.	Dr	1932	583	10-8	523	Casing perforated 325-523 ft.	460 523	45 30
18N1	do	Dr	1944	870±	8-4	-------	Open bottom		

TABLE 2.—*Drillers' logs of wells in the Burnt River valley area, Oregon*

11/43-19K1

[Cynthia A. Moore. Alt 2,800 ft. Drilled by O.C. Tandy Well Drilling, 1958. Casing: 6-in. diam to 39 ft; perforated at unreported depth]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Topsoil	2	2	Clay, gray	7	23
Sand and gravel	3	5	Gravel, fine	11	34
Rocks, large	2	7	Sand, coarse, and gravel	5	39
Gravel, fine, and clay	9	16			

11/43-28D1

[Union Pacific Railroad Co. Alt 2,650 ft. Drilled by G. E. Scott, 1921. Casing: 12-in. diam, 0-193.4 ft; 10-in. diam, 0-621.6 ft; and 8-in. diam, 576.6-941.4 ft; unperforated]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Clay and boulders	25	25	Clay, sandy, blue, water-bearing; well began to flow at a rate of 1 gpm	23	900
Soapstone	10	35	Clay, dense, blue	31	931
Clay, dense, blue	165	200	Sand, "quartz"	42	973
Clay, dense, brown	45	245	Sand and gravel, "quartz"; artesian flow measured to 20 gpm	10	983
Clay, dense, blue	285	530	Granite or syenite, "secondary," hard to medium-hard	48	1,031
Rock; yields some water	8	538	Rock, hard, mineral-bearing; contains considerable pyrite	5	1,036
Clay, dense, blue	70	608	Granite or syenite, "secondary," hard to medium-hard	27	1,063
Clay, dense, white; yields some water	8	616	Clay, dense, blue	19	1,082
Clay, dense, blue	79	695			
Clay, dense, brown	5	700			
Clay, dense, blue	72	772			
Rock, "lava"	3	775			
Clay, dense, blue	3	778			
Clay, sandy, grayish	56	834			
Clay, dense, blue; water level 40 ft below land surface	43	877			

in the Burnt River valley area, Oregon—Continued

Water-bearing zone—Continued: Character of material	Altitude (feet)	Water level: Feet below datum	Water level: Date	Type of pump and horsepower	Well performance: Yield (gpm)	Well performance: Drawdown (feet)	Use	Remarks
Sandstone and coarse sand.	2,530	2	----------	N	30	41	R	Formerly equipped with a turbine pump having a capacity of 120 gpm; capped and abandoned; L.
Gravel; do; Rock	3,730	6.86	4-17-62	S, 40(?)	700	140	Ir	Hydrograph in fig. 7; L.
----------	1,920	----------	----------	----------	----------	----------	R	Owner's well 1 at Huntington; formerly equipped with a turbine pump having a capacity of 165 gpm; reportedly capped and abandoned.
----------	1,920	----------	----------	----------	----------	----------	R	Owner's well 2; formerly equipped with a turbine pump having a capacity of 200 gpm.
Red rock; "Lime rock"	2,115	465	May 1944.	T, 50	75±	60+	PS	Temp 76; soap hardness of water 40–45 parts per million, L.
----------	2,150	----------	----------	----------	----------	----------	----------	Test well; no yield reported.

TABLE 2.—*Drillers' logs of wells in the Burnt River valley area, Oregon*—Con.

12/37-28E1

[Oregon State Highway Dept. Alt 3,900 ft. Drilled by Holloway Drilling Co., 1959. Casing: 6-in. diam to 60 ft; unperforated]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Topsoil	3	3	Shale, blue	30	220
Hardpan	3	6	Shale, sandy; yields some water	12	232
Gravel and sand, dry	16	22	Shale, blue	40	272
Clay, sandy	30	52	Shale, black	8	280
Shale, blue	98	150	Sand, water-bearing	2	282
Shale, brown	20	170	Shale, blue	18	300
Shale, white	20	190			

12/38-27A1

[Hereford Community Church. Alt 3,660 ft. Drilled by R. W. Davis, 1959. Casing: 6-in. diam to 81 ft; unperforated]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Topsoil	5	5	Clay and dark-brown gravel	7	57
Clay, light-brown	15	20	Hardpan	1	58
Clay, yellow; sand and gravel	5	25	Sand, brown; yields some water	3	61
Clay, light-brown; some gravel	12	37	Clay, packed, hard, and water-bearing gravel	7	68
Clay, hard, brown, and gravel	2	39	Clay and gravel	6	74
Sand, gravel, and tan clay	11	50	Clay, soft; gravel and sand	7	81

TABLE 2.—*Drillers' logs of wells in the Burnt River valley area, Oregon*—Con.

12/44-6E1

[Hite Bros. Alt 3,040 ft. Drilled by O. C. Tandy, 1961. Casing: 6-in. diam to 64 ft; perforated 60–64 ft]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Topsoil	4	4	Rock, solid, light-green	17	78
Clay, blue-black	38	42	Rock, solid, black	23	101
Clay, yellow	19	61			

13/37-9M1

[Ellingson Lumber Co. Alt 3,950 ft. Drilled by R. W. Davis, 1960. Casing: 6-in. diam to 167 ft; perforated 135–167 ft]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Soil, dark-brown	5	5	Clay, blue and brown, with gravel; yields some water	80	210
Clay, blue; some gravel	15	20	Clay, brown, with lots of gravel	35	245
Clay, light-brown; gravel	15	35	Clay, green, and gravel; water-bearing	15	260
Clay, light-brown, and coarser gravel	15	50	Rock, gray; interbedded with gray and greenish-tan clay	25	285
Clay, blue, and greenish sand	40	90			
Clay, crumbly, blue	30	120			
Clay, grayish, and gravel	10	130			

13/37-16F1

[U.S. Forest Service (Whitman Natl. Forest, Unity Annex). Alt 3,950 ft. Drilled by Holloway Drilling Co., 1964. Casing: 8-in. diam to 70 ft; perforated 21–31 ft, 37–40 ft, and 50–60 ft]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Soil, sandy	3	3	Clay, hard	15	54
Gravel, cemented	9	12	Clay, sandy	3	57
Clay, gravel-embedded	9	21	Clay, blue	96	153
Gravel, medium, water-bearing	7	28	Clay, blue, very hard	7	160
Clay, blue	11	39	Clay, blue	298	458

13/43-33G1

[U.S. Bureau of Land Management. Alt 4,260 ft. Drilled by Rich Knoblock, 1963. Casing: 6-in. diam to 308.5 ft; perforated 285–305 ft]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Clay and large boulders	20	20	Clay, pale-green; "cinders," and fine gravel, water-bearing	5	307
Lava, gray	94	114	Clay, dark-green, dense	18	325
Cinders and large basalt boulders	37	151	Soapstone, white, soft	4	329
Volcanic ash	4	155	Clay, dark-green, dense, alternating with rock layers	26	355
Lava, porous	28	183			
Clay, "medium-textured"	119	302			

TABLE 2.—*Drillers' logs of wells in the Burnt River valley area, Oregon*—Con.

13/44-27A1

[Union Pacific Railroad Co. Alt 2,530 ft. Drilled by A. A. Durand. Casing: 8-in. diam from land surface to 43 ft below; 6-in. diam from 1½ ft above land surface to 171 ft below; unperforated]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Topsoil and clay	14	14	Rock, red; quartz abundant	15	127
Gravel; some clay	9	23	Sand, fine, brown	5	132
Limestone, white	29	52	Rock, broken	4	136
Shale, hard	3	55	Quartz, hard, white	5	141
Basalt, hard, red	10	65	Rock, broken; quartz	21	162
Shale, broken; streaks of clay	9	74	Rock, hard, and quartz	5	167
Clay and shale, with quartz	13	87	Sand, coarse	6	173
Shale, hard, red	16	103	Sand, cemented, and rock	11	184
Rock, hard, red; some quartz	9	112			

14/39-21F1

[Ralph Duncan. Alt 3,730 ft. Drilled by Holloway Drilling Co., 1961. Casing: 12-in. diam to 161 ft; perforated 20–160 ft]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Topsoil and clay	8	8	Clay, gray, hard	70	582
Clay	10	18	Rock, black	28	610
Gravel, water-bearing	22	40	Rock, black, caving	2	612
Clay, green, crumbly	23	63	Rock, "granitic"	9	621
Clay, green	77	140	Clay, blue	27	648
Gravel	5	145	Rock, black, hard	32	680
Clay, green	301	446	Rock, red	18	698
Clay, black, "oily"	52	498	Rock, black, hard	16	714
Soapstone, blue	12	510	Rock, broken, with crevice	16	730
Gravel, pea-sized	2	512	Rock, black, broken	4	734

14/45-18M1

[City of Huntington. Alt 2,115 ft. Drilled by A. A. Durand, 1932. Casing: 10-in. diam 0–264 ft and 8-in. diam at unknown depth to 523 ft; perforated 325–523 ft]

Materials	Thickness (feet)	Depth (feet)	Materials	Thickness (feet)	Depth (feet)
Soil	15	15	Boulders	20	400
Gravel	7	22	Mud, blue	5	405
Clay and gravel	18	40	Basalt	15	420
Shale and soapstone	45	85	Rock, black	38	458
Shale and blue mud	115	200	Clay, sticky	2	460
Boulders	10	210	Rock, red	45	505
Clay, blue	54	264	Shale, crumbly	18	523
Shale	41	305	Limerock	30	553
Basalt, hard	17	322	Basalt, gray	12	565
Shale, green	58	380	Rock, black	18	583

TABLE 3.—*Chemical analyses of water in the Burnt River valley area, Oregon*

[Well or stream-sampling number: see page I 4 for explanation of numbering system. Dissolved solids: residue on evaporation at 180° C. Laboratory: BR, U.S. Bur. of Reclamation; GS, U.S. Geol. Survey]

Well or stream-sampling No.	Source	Date of collection	Temperature (°F)	Parts per million															Sodium-adsorption-ratio (SAR)	Residual sodium carbonate (milliequivalents per liter)	Specific conductance (micromhos at 25° C)	pH	Laboratory
				Silica (SiO_2)	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	Hardness: As $CaCO_3$	Hardness: As noncarbonate					
Ground water																							
	Water-bearing zone in feet																						
11/43-18J1	30±	9-24-63	60	----	67	19	80	18	410	0	88	7.1	----	6.2	0.56	----	243	0	2.2	1.86	774	7.3	BR
28D1	877-900, 973-983	do	68	----	.8	1.0	212	1.6	372	82	12	12	----	.0	3.60	----	6	0	36.8	8.72	871	9.4	BR
12/37-28E1	220-232, 280-282	9-25-63	57	----	44	24	49	21	225	0	135	19	----	4.3	.00	----	209	26	1.5	0.00	683	7.0	BR
12/38-27A1	74-81	do	54	----	109	109	38	7.8	626	0	91	49	----	205	.00	----	720	2.07	.6	.00	1,400	7.6	BR
12/40-25P1	----	do	54	----	72	5.1	14	5.5	212	0	59	2.8	----	.0	.06	----	200	26	.4	.00	436	7.5	BR
26P1	----	do	54	----	18	6.7	397	15	1,150	0	1.4	24	----	.0	2.3	----	72	0	20.3	17.38	1,590	7.8	BR
29B1	----	do	53	----	21	8.5	23	4.7	95	0	50	9.9	----	.0	.00	----	86	9	1.1	.00	433	7.2	BR

Surface water

	Burnt River, in downstream order																						
11/36-3G	North Fork near Whitney.	4- 6-60	50	28	8.0	3.9	3.6	1.1	52	0	2.2	0.0	0.1	0.3	------	86	36	0	0.3	0.13	89	7.4	GS
13/37-6B	South Fork 2 miles above Unity Reservoir.	6-27-57	----	----	32	10	23	5.5	164	2	------	------	----	------	------	-----	121	0	.9	.33	327	8.3	
12/37-32C	South Fork 1 mile above Unity Reservoir.	4- 6-60	54	33	11	4.1	6.3	2.6	65	0	6.2	.0	.1	.3	------	103	44	0	.4	.18	119	7.5	GS
21R	Main stem ½ mile below Unity Reservoir.	6-27-57	----	----	19	6.7	11	2.6	88	4	------	------	----	------	------	-----	75	0	.5	.07	194	8.6	GS
	do	9- 2-60	63	36	23	9.0	16	4.0	112	0	33	2.0	.3	1.0	------	191	94	2	.7	.00	255	7.5	GS
	do	9-25-63	60	----	32	13	23	5.1	152	0	62	2.1	----	.0	.04	-----	135	10	.9	.00	347	7.9	BR
12/41-20N	Main stem near Bridgeport.	do	60	----	46	18	34	7.4	242	0	64	3.5	----	.0	.00	-----	188	------	1.1	.20	477	8.2	BR
11/42-26J	Main stem above Durkee.	9-24-63	64	----	50	17	36	8.6	198	27	63	2.8	----	.0	.14	-----	196	------	1.1	.24	483	8.8	BR
11/43-29J	Main stem at Durkee	4- 6-60	61	32	28	8.1	16	3.6	125	0	31	2.2	.3	1.3	------	188	103	0	.7	.00	274	7.6	GS
	do	9-29-60	65	43	55	20	39	8.0	263	7	74	4.8	.4	.3	------	386	218	0	1.1	.17	558	8.4	GS
14/44-13H	Main stem at Huntington.	7-25-58	----	42	60	17	38	7.0	251	0	87	4.5	.4	1.1	------	384	220	14	1.2	.00	548	8.0	GS
	do	9-17-59	65	42	75	16	50	8.9	282	14	110	6.0	.5	.5	------	471	252	0	1.4	.04	677	8.5	GS
	do	4- 6-60	59	32	32	7.8	16	3.8	131	0	34	2.0	.3	1.6	------	200	112	4	.7	.00	289	7.6	GS