

# Ground-Water Resources of the Wind River Indian Reservation Wyoming

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**GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1576-I**

*Prepared as part of the program of  
the Department of the Interior for  
development of the Missouri River basin*



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By LAURENCE J. MCGREEVY, WARREN G. HODSON, and SAMUEL J. RUCKER IV  
WATER SUPPLY OF INDIAN RESERVATIONS

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**UNITED STATES DEPARTMENT OF THE INTERIOR**

**STEWART L. UDALL, *Secretary***

**GEOLOGICAL SURVEY**

**William T. Pecora, *Director***

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WATER SUPPLY OF INDIAN RESERVATIONS

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**GROUND-WATER RESOURCES OF THE WIND RIVER  
INDIAN RESERVATION, WYOMING**

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By LAURENCE J. MCGREEVY, WARREN G. HODSON, and  
SAMUEL J. RUCKER IV

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**ABSTRACT**

The area of this investigation is in the western part of the Wind River Basin and includes parts of the Absaroka, Washakie, Wind River, and Owl Creek Mountains. The purposes of the study were to determine the general hydrologic properties of the rocks in the area and the occurrence and quality of the water in them. Structurally, the area is a downfolded basin surrounded by upfolded mountain ranges. Igneous and metamorphic rocks of Precambrian age are exposed in the mountains; folded sedimentary rocks representing all geologic periods, except the Silurian, crop out along the margins of the basin; and relatively flat-lying Tertiary rocks are at the surface in the central part of the basin. Surficial sand and gravel deposits of Quaternary age occur along streams and underlie numerous terraces throughout the basin.

The potential yield and quality of water from most rocks in the area are poorly known, but estimates are possible, based on local well data and on data concerning similar rocks in nearby areas. Yields of more than 1,000 gpm are possible from the rocks comprising the Bighorn Dolomite (Ordovician), Darby Formation (Devonian), Madison Limestone (Mississippian), and Tensleep Sandstone (Pennsylvanian). Total dissolved solids in the water range from about 300 to 3,000 ppm.

Yields of as much as several hundred gallons per minute are possible from the Nugget Sandstone (Jurassic? and Triassic?). Yields of 20 gpm or more are possible from the Crow Mountain Sandstone (Triassic) and Sundance Formation (Jurassic). Dissolved solids are generally high but are less than 1,000 ppm near outcrops in some locations.

The Cloverly and Morrison (Cretaceous and Jurassic), Mesaverde (Cretaceous) and Lance(?) (Cretaceous) Formations may yield as much as several hundred gallons per minute, but most wells in Cretaceous rocks yield less than 20 gpm. Dissolved solids generally range from 1,000 to 5,000 ppm but may be higher. In some areas, water with less than 1,000 ppm dissolved solids may be available from the Cloverly and Morrison Formations.

Tertiary rocks yield a few to several hundred gallons per minute and dissolved solids generally range from 1,000 to 5,000 ppm. Wells in the Wind River Formation (Eocene) yield about 1-500 gpm of water having dissolved solids of about 200-5,000 ppm.

Yields of a few to several hundred gallons per minute are available from alluvium (Quaternary). Dissolved solids range from about 200 to 5,000 ppm.

Many parts of the Wind River Irrigation Project have become waterlogged. The relation of drainage problems to geology and the character and thickness of rocks in the irrigated areas are partly defined by sections drawn on the basis of test drilling. The drainage-problem areas are classified according to geologic similarities into five general groups: flood plains, terraces, underfit-stream valleys, slopes, and transitional areas.

Drainage can be improved by open drains, buried drains, relief wells, and pumped wells or by pumping from sumps or drains. The methods that will be most successful depend on the local geologic and hydrologic conditions. In several areas, the most effective means of relieving the drainage problem would be to reduce the amount of infiltration of water by lining canals and ditches and by reducing irrigation water applications to the optimum.

Water from underground storage in alluvium could supplement water from surface storage in some areas. A few thousand acre-feet of water per square mile are in storage in some of the alluvium. The use of both surface and underground storage would reduce the need for additional surface-storage facilities and also would alleviate drainage problems in the irrigated areas.

## INTRODUCTION

### LOCATION AND EXTENT OF THE AREA

The area of this investigation consists of about 3,500 square miles in west-central Wyoming and includes most of central and western Fremont County and part of southern Hot Springs County. It is the area within the outer boundary of the Wind River Indian Reservation. The area of the investigation and areas of related ground-water studies are shown in figure 1.

### PURPOSE AND SCOPE OF THE INVESTIGATION

This study was conducted by the U.S. Geological Survey at the request of the U.S. Bureau of Indian Affairs as a part of the program of the Department of the Interior for development of the Missouri River basin.

The purposes of this investigation were to determine the general hydrologic properties of geologic formations in the area and the occurrence and quality of ground water in them. Of particular need were data concerning the availability of water for domestic and stock use and data concerning drainage problems in the Wind River Irrigation Project.

Fieldwork for this investigation was carried on during 1965 and 1966. Records of 387 wells in the area were collected and tabulated; water samples were collected from selected wells for chemical analysis. Specific conductances were determined in the field for some waters. Periodic measurements of selected wells were made to observe water-level fluctuations. Drillers' logs were collected from local drillers, from

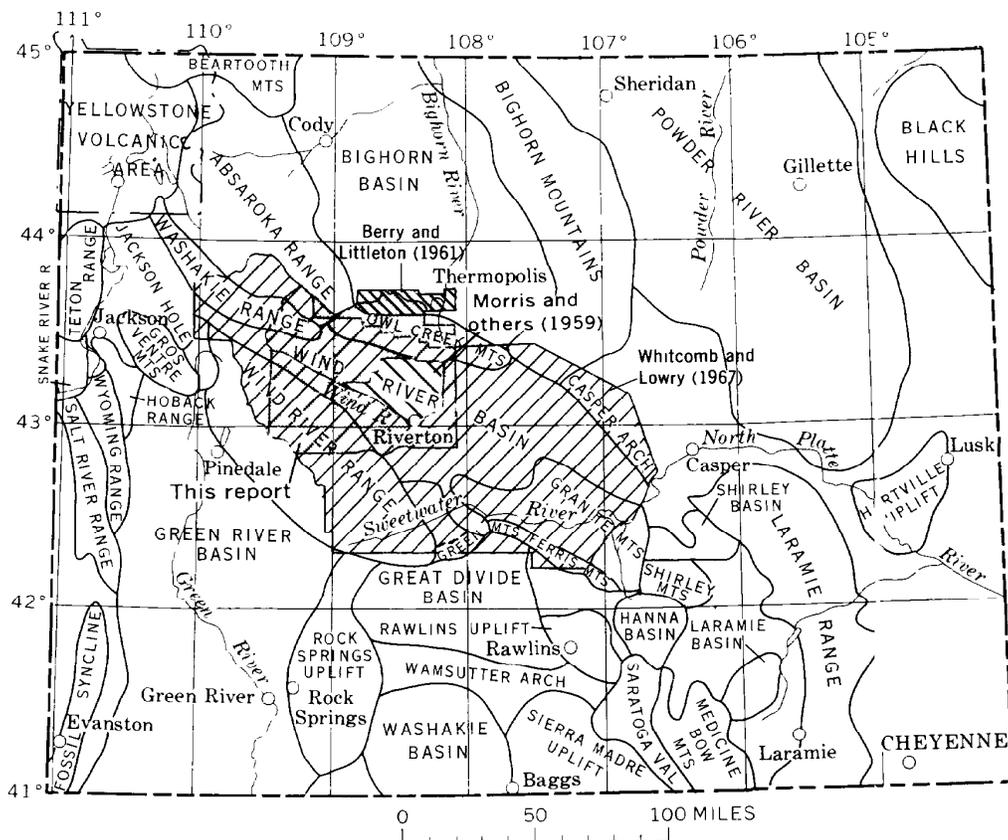


FIGURE 1.—Structural feature map showing the area of this study and areas of related ground-water studies. Adapted from Love (1961).

the Indian Health Center on the Wind River Indian Reservation, and from the files of the Wyoming State Engineer. Additional subsurface information was obtained from several hundred feet of test augering in 1965 and from about 6,000 feet of test drilling contracted in 1966. The general thickness and character of the alluvium and the relation of the deposits to areas of drainage problems were determined by test drilling in the principal valleys, mostly in the irrigated areas. Additional drilling was done in remote areas of the reservation, previously untested for water, to determine the ground-water potential for the stock-grazing industry. Data collected for previous studies (Morris and others, 1959; Berry and Littleton, 1961) were also used in arriving at the conclusions of the report.

A geologic map was compiled at a scale of 1:125,000 from existing geologic maps of the area (pl. 2). The details, purposes, and scales of the existing maps varied considerably and, at the scale of the compilation, all geologic contacts must be considered approximate. Discrepancies in contacts of Quaternary units were minimized by using 7½-minute topographic maps, aerial photographs, and data from test drilling.

### PREVIOUS INVESTIGATIONS

Reports of ground-water studies have been published on the Riverton Irrigation Project (Morris and others, 1959), which includes an area of about 500 square miles between the Wind River and the south flank of the Owl Creek Mountains, and on the Owl Creek area (Berry and Littleton, 1961), which includes an area of about 250 square miles along the north flank of the Owl Creek Mountains. Little additional fieldwork in these areas was done in conjunction with this investigation. A reconnaissance of the ground-water resources of the Wind River Basin was made by Whitcomb and Lowry (1967). The locations of areas of these previous ground-water investigations are shown in figure 1.

Geologic studies pertinent to this study include reports by Keefer and Van Lieu (1966) on Paleozoic formations in the Wind River Basin; by Keefer (1965a) on the Upper Cretaceous, Paleocene, and Eocene rocks of the Wind River Basin; and by Keefer and Troyer (1964) on the geology of the Shotgun Butte area in the north-central part of the Wind River Indian Reservation. The index map on plate 2 shows the locations of areas of these studies and of areas described by other maps and reports that provide the principal sources of geologic data used in this study. References to other pertinent reports are listed at the end of this report.

### ACKNOWLEDGMENTS

The authors are indebted to well owners and drillers who furnished essential information regarding wells and to the many persons who assisted in the collection of information and in the preparation and review of this report. Special thanks are due John T. Myers, of the U.S. Public Health Service, and William L. Benjamin and the late John Jolley, of the U.S. Bureau of Indian Affairs, who gave assistance in obtaining data.

### WELL-NUMBERING SYSTEM

Wells, springs, and test holes referred to in this report are numbered according to their location within the Federal system of land subdivision. Each number shows the location by township, range, section, and location within the section. The uppercase letter that begins the number designates the quadrant of the Wind River Meridian and Base Line system. The quadrants are lettered A, B, C, and D in a counterclockwise direction beginning with A in the northeast quadrant. The first numeral denotes the township; the second numeral, the range; and the third numeral, the section in which the well or test hole is located. The lowercase letters after the section number indicate the loca-

tion within the section as follows: The first letter denotes the quarter section; the second letter, the quarter-quarter section; and the third letter, if used, the quarter-quarter-quarter section (10-acre tract). The subdivisions of the sections are lettered a, b, c, and d in a counter-clockwise direction beginning with "a" in the northeast quarter. If more than one well is listed in the smallest subdivision used, they are differentiated by consecutive numerals (starting with 1) that are added to the well or test-hole number. For example, well D1-2-15abc is in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 15, T. 1 S., R. 2 E. (fig. 2).

### TERMINOLOGY

Many terms and abbreviations that are used in this report may be unfamiliar to the reader, or the terms may be used in other reports in a less restricted or in a slightly different sense than they are used in this report. The following definitions should clarify the intended meanings.

**Aquifer.** A rock formation, bed, or zone that will yield water to wells or springs. If one or more water-bearing units are hydraulically connected, these units may be considered as one aquifer. An aquifer may be *confined* (artesian) or *unconfined* (water table). A *confined aquifer* is overlain by relatively impermeable rock, and the water in a well will rise above the top of the aquifer. In an *unconfined aquifer*, the level to which water will rise in a well is below the top of the aquifer.

**Alluvium.** Deposits that have been transported and deposited by streams. Alluvium, as herein used, is restricted to deposits of Quaternary age that underlie the flood plains and terraces. Alluvium grades into slope wash along the valley sides; deposits that are predominantly stream laid are referred to as alluvium.

**Clastic rock.** A rock composed of fragments of preexisting rock. Most clastic rocks are shale, sandstone, conglomerate, clay, silt, sand, or gravel.

**Coefficient of storage.** The coefficient of storage of an aquifer is defined as the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface (Ferris and others, 1962).

**Colluvial deposits.** Slope wash and material transported principally by gravity.

**Cuesta.** A ridge with one long and gentle slope and one relatively steep slope.

**Dissolved solids.** Minerals in solution in water. As used in this report, it refers to the total concentration of dissolved solids in water.

**gpd.** Abbreviation of *gallons per day*.

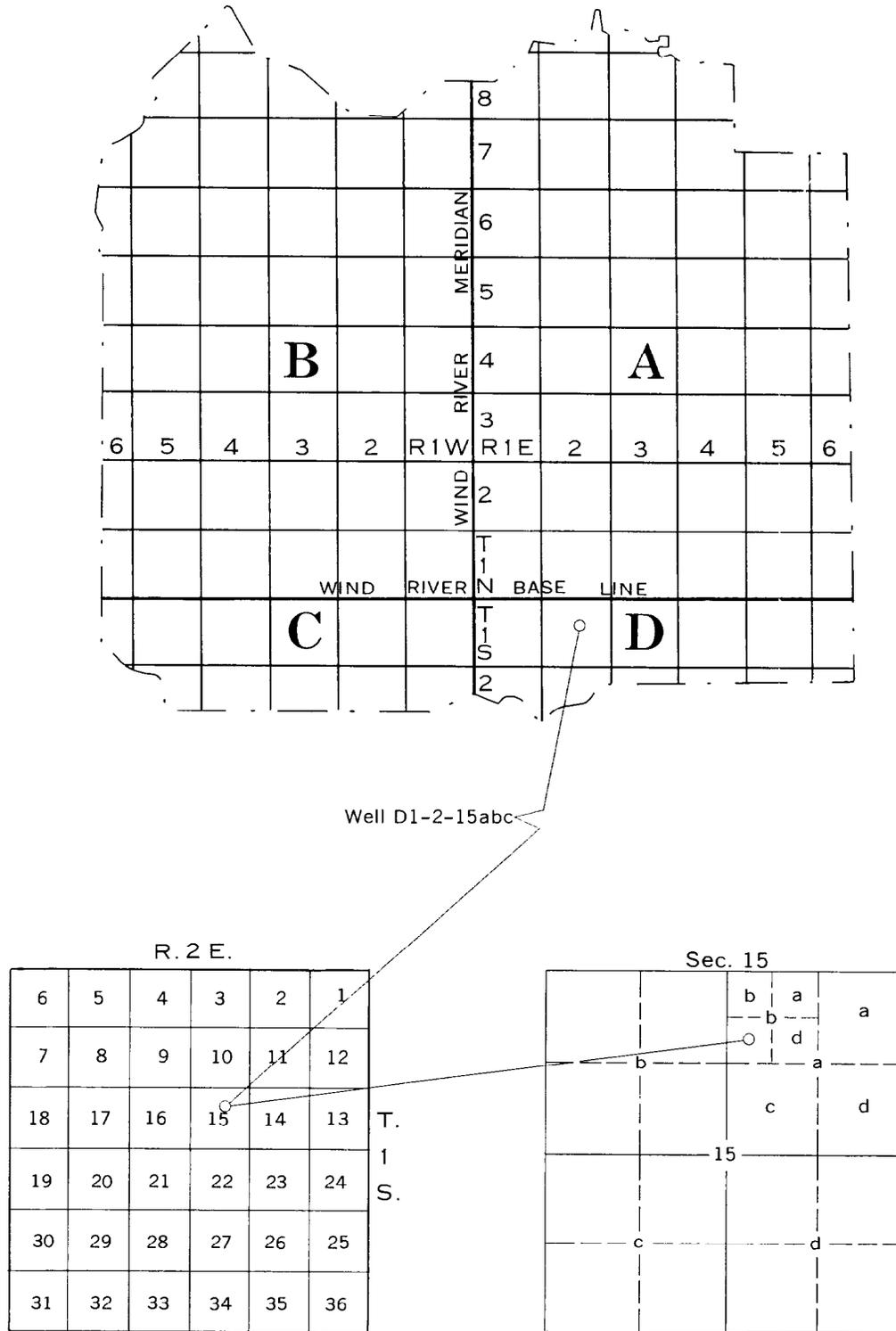


FIGURE 2.—Well-numbering system.

**gpm.** Abbreviation of *gallons per minute*.

**Infiltration.** The flow or seepage of water into rocks or soil through pores or small openings.

**Intermittent stream.** A stream that flows only part of the time.

**ppm.** Abbreviation of *parts per million*; the unit of expression for the concentration of dissolved material in water. One part per million is one unit weight of dissolved material per million unit weights of water.

**Perennial stream.** A stream that flows all the time.

**Permeability.** The capacity of materials to transmit water. The measure of permeability used in this report is the *field coefficient of permeability*, which is defined as the rate of flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 1 foot per foot at the prevailing water temperature (Ferris and others, 1962). It is expressed in gallons per day per square foot (gpd/ft<sup>2</sup>).

**Physiography.** As used in this report, it is restricted to description of landforms, the topographic features.

**Recharge.** The process by which water moves into an aquifer, or the amount of water that moves into an aquifer.

**Specific capacity.** The amount of water discharged from a well per unit of drawdown. It is expressed as gallons per minute per foot of drawdown (gpm/ft).

**Specific conductance.** A measure of the ability of a water to conduct electricity. Specific conductance is expressed in mhos (reciprocal of ohms) per centimeter times 10<sup>6</sup> (micromhos per centimeter) and is adjusted to a standard temperature of 25° C. Specific conductance is related to the amount of dissolved solids in water, but the relation depends on the particular minerals present. The ratio of total dissolved solids (in parts per million) to specific conductance (in micromhos per centimeter at 25° C) ranges from about ½ : 1 to 1 : 1, but is usually nearer ⅔ : 1. Specific conductance is easily measured in the field and provides a quick estimate of the dissolved solids.

**Specific yield.** The ratio of the volume of water that will drain by gravity from a saturated material to the volume of the material. It is expressed as a percentage

$$\left( \frac{\text{volume of water}}{\text{volume of material}} \times 100 \right).$$

**Transmissibility.** The capacity of the full saturated thickness of an aquifer to transmit water. The measure of transmissibility used in this report is the *coefficient of transmissibility*, which is defined as the rate of flow of water, at the prevailing water temperature, in gallons per day, through a vertical strip of the aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 1 foot per foot (Ferris and others, 1962). It is expressed in gallons per day per foot (gpd/ft). The coefficient of transmissibility is equal to

the product of the saturated thickness times the field coefficient of permeability.

**Transpiration.** The process by which water moves from living plants to the atmosphere.

**Underfit stream.** A stream that occupies a valley that was formed by a much larger stream. Dury (1964a, b) discusses underfit streams.

**Water table.** The top of the zone of saturation in an unconfined aquifer.

## GEOGRAPHIC SETTING

### PHYSIOGRAPHY AND DRAINAGE

The Wind River Indian Reservation is in the western part of the Wind River Basin, which is a structural and topographic basin typical of the Rocky Mountain physiographic system. The southwestern boundary of the reservation extends along the crest of the Wind River Mountains; the northern part of the reservation includes parts of the Washakie, Absaroka, and Owl Creek Mountains. The Wind River Basin is a large structural basin that approximately coincides with the topographic basin. Altitudes range from about 4,400 feet at the north end of the Wind River Canyon to more than 13,000 feet on the crest of the Wind River Mountains. In most of the central part of the basin, the altitude is between 4,800 and 6,000 feet. Upturned rocks of Paleozoic and Mesozoic age form distinct cuestas and hogbacks along the mountain fronts, and, in the central part of the basin, nearly horizontal rocks of Tertiary age form generally broad valleys and prominent gravel-capped mesas and buttes. The Wind River valley is relatively deep compared to most other stream valleys in the basin, and high bluffs border the river in many places. Mesas and buttes form drainage divides between the smaller streams.

The Wind River is the master stream in the area, originating in the Absaroka Mountains in the northwest corner of the Wind River Basin. The Wind River flows southeastward parallel to the Wind River Mountains to its confluence with the Little Wind River near Riverton where it turns northward, eventually flowing through the Wind River Canyon into the Bighorn Basin where the river is called the Bighorn River. The larger tributaries to the Wind River head in the Wind River and Absaroka Mountains. The principal tributaries, within the area of this investigation, are Bull Lake Creek, the Little Wind River, and the Popo Agie River in the southern part of the area; Crow Creek in the northwestern part; and Fivemile Creek and Muddy Creek in the central part.

### CLIMATE AND POPULATION

The climate ranges from humid in the Wind River and Owl Creek Mountains to arid in the central part of the area. Mean annual temperature at Riverton for the period of reference, 1931–60, is 43.5° F. Wide ranges in seasonal temperatures are common—winter temperatures commonly dropping far below 0° F, and summer temperatures frequently exceeding 100° F. Mean annual precipitation at Riverton for the period 1931–60 was 8.79 inches. Annual precipitation ranged from 4.85 to 14.74 inches. Mean annual precipitation at Lander, just south of the report area at the edge of the Wind River Mountains, was 13.58 inches. The generalized areal distribution of mean annual precipitation on the reservation has been mapped by the U.S. Bureau of Indian Affairs (1962) and is shown in figure 3.

Much of the population is rural. Riverton, the largest town in the area, has a population of about 6,900. The Wind River Reservation is the home of more than 3,000 Shoshone and Arapahoe Indians.

### OWNERSHIP OF THE LAND

Ownership of the lands of the report area has evolved from historical events discussed in Duntsch (1965), Gerharz (1949), U.S. Bureau of Indian Affairs (1962), and U.S. Bureau of Reclamation (1950). The first non-Indians settled in the Wind River Basin in the early 1860's. Treaties of 1863 and 1868 with the Shoshone Indians established the Wind River Reservation with boundaries nearly identical to the area of this study. In 1877 the Federal Government obtained permission from the Shoshone Tribe to bring a tribe of Northern Arapahoe to the reservation, temporarily, until one for the Arapahoes could be established. The reservation was never established and the Arapahoe and Shoshone Indians now share the Wind River Reservation.

In 1904 the land north of the Wind River and the land southeast of the Popo Agie River, which together consisted of about two-thirds of the reservation, were ceded to the United States. The ceded land was opened to homesteading in 1906, and the townsite of Riverton was established. Part of the ceded land was repurchased by the tribes, and part was restored to tribal ownership by legislation; however, some is still privately owned by non-Indians. Most of the land within the outer boundary of the reservation, except for the Riverton Irrigation Project and Boysen Reservoir withdrawal areas (pl. 3), is owned by the tribes.

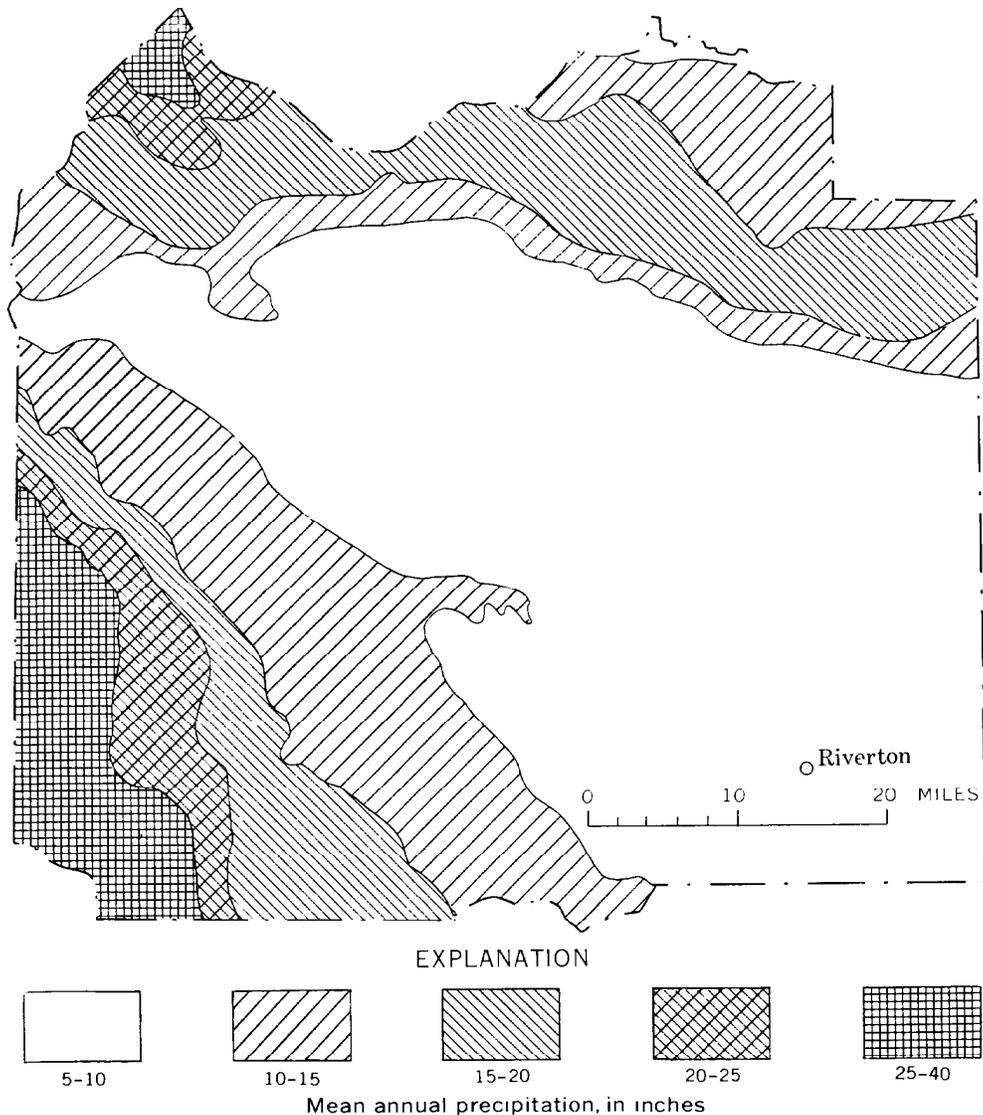


FIGURE 3.—Generalized areal distribution of mean annual precipitation. Adapted from U.S. Bureau of Indian Affairs (1962).

### PRESENT DEVELOPMENT OF GROUND WATER

Development of ground water has been principally for stock watering and for domestic and public supplies. Privately owned wells furnish water to oil fields and a few industries at Riverton. In the Owl Creek valley, irrigation water from streams is supplemented with water from wells, but in the rest of the reservation, irrigation depends entirely on surface supplies.

Most wells are in the area of the Riverton Irrigation Project (pl. 3) and in the areas along the Wind and Little Wind Rivers. Except for test drilling that was done for this study, many remote areas are virtually untested for water. Locations of wells and data concerning the chemical quality of water from the wells are shown on plate 1.

Domestic and public supplies generally utilize ground water, although surface water is used at some localities. Municipally owned wells furnish water to Riverton, Pavillion, Hudson, and Shoshoni. The wells furnishing water to Hudson are south of the reservation boundary (Whitcomb and Lowry, 1967); Shoshoni, 3 miles east of the reservation boundary, is supplied by wells inside the boundary. An infiltration gallery in the bed of the South Fork Little Wind River supplies water to Fort Washakie. Mill Creek School, 3 miles south of Ethete, and the community of Ethete are supplied by separate infiltration galleries in the bed of the Little Wind River near Ethete. Co-operative community wells are being considered to serve homes in the Arapahoe area. In other communities and in rural areas, homes depend on individually owned wells.

## GEOLOGIC SETTING

### STRUCTURE

The structural framework of the area consists of a downfolded basin bounded on the north and southwest by upfolded and faulted mountain ranges. Vertical structural displacement is more than 30,000 feet between the basin and the mountains. Keefer (1965a) gives a detailed account of the structural development of the area during Laramide deformation. Major structures and generalized structure contours are shown on plate 2. Two deep structural troughs are separated by a central anticlinal structure which trends northwestward through the basin approximately parallel to the Wind River Mountains. Major oil fields in the area are on the central anticlinal structure and on a parallel structure of lesser magnitude to the northeast.

Formation of the basin began in Late Cretaceous time and continued into Eocene time. As the basin subsided in relation to the bordering highlands, sediments accumulated in the depression. Along the margins of the basin, the rocks of Paleozoic and Mesozoic age dip basinward at angles ranging from about  $10^{\circ}$  on the flanks of the Wind River Mountains to vertical or overturned along the northern mountains. Rocks of early Eocene age, which occur at the surface in much of the basin, are nearly flat lying in most of the area. Dips measured in the lower Eocene Wind River Formation (pl. 2) indicate that the structure of this formation is extremely subdued, but corresponds to the structure of the underlying rocks. The subdued structure may be partly depositional, but some deformation of the formation has occurred along the margins of the basin and on the central anticlinal structure.

## STRATIGRAPHY

Igneous and metamorphic rocks of Precambrian age comprise the core of the mountain ranges and underlie sedimentary rocks within the basin. Sedimentary rocks have a maximum thickness of more than 40,000 feet and represent all geologic periods except the Silurian. Descriptions of sedimentary units are given in table 1, and the relation of these units to ground water are discussed in the table and in another section. Outcrop areas of the rocks are shown on the geologic map (pl. 2).

## GROUND WATER

### OCCURRENCE

Ground water occurs in rocks in the open spaces between grains, in fractures, or in solution openings. The water is derived from precipitation either directly or from seepage of surface waters. Water moves through the rocks from recharge areas to discharge areas at rates dependent on the gradient and the permeability of the rocks. Principles of occurrence are described in Meinzer (1923a) and in E. E. Johnson, Inc. (1966).

### RECHARGE AND DISCHARGE

Rocks older than the Wind River Formation are recharged primarily in their outcrop areas by streams and by direct infiltration of precipitation; some movement of water between formations probably occurs where the rocks are buried. Most discharge from the rocks is through springs where the rocks have been cut into by streams. Discharge to wells is minor because few wells tap these rocks.

The Wind River Formation crops out, or is thinly covered by alluvium or slope wash, in most of the basin. In their upper reaches, streams crossing the formation generally contribute water to it. In their lower reaches, many of these streams drain parts of the formation. Some water-bearing rocks of the formation are at higher altitudes than nearby streams. Water in these rocks comes from direct infiltration of precipitation or, in some areas, from irrigation.

Hundreds of wells tap the Wind River Formation, but most wells discharge only a small amount of water. Almost 500 million gallons of water per year are withdrawn from the formation by wells in the Riverton well field. Figures are not available for other wells, but the total withdrawal from the formation by wells, including those in the Riverton well field, is estimated at 700–800 million gallons per year.

Alluvium is recharged primarily from streams and irrigation, but some water is derived from direct infiltration of precipitation. Water in alluvium adjacent to the streams moves to or from the streams, de-

TABLE 1.—Generalized section of the geologic units and potential water supply

Era	System	Series	Map unit where stratigraphic units are combined	Stratigraphic unit (approximate thickness, in feet)	Physical character	Potential water supply
CENOZOIC	Quaternary	Pleistocene and Recent	Alluvium of flood plains and related low terraces (0-100±)		Gravel, sand, silt, clay, cobbles and boulders, unconsolidated. Present in stream valleys throughout the area.	Yields range from a few gallons to several hundred gallons per minute. Dissolved solids in the water range from about 200 to 2,000 ppm.
			Slope wash and alluvium (includes some windblown deposits) (0-80±)		Silt, clay, sand, and gravel, unconsolidated. Present in valleys and on moderate slopes in much of the area.	Yields range from zero to as much as several hundred gallons per minute. Dissolved solids range from about 500 to 5,000 ppm.
			Terrace and pediment deposits (0-80±)		Gravel, sand, silt, cobbles, and boulders, unconsolidated. Underlie terraces and pediments throughout the basin and along the margins of the mountains.	In irrigated areas, yields range from a few gallons to several hundred gallons per minute; dissolved solids generally range from about 300 to 2,000 ppm, but may be much higher where drainage is poor. In unirrigated areas, the deposits are largely drained.
			Landslide and steep-slope colluvial deposit		Rubble, blocks, and talus, unconsolidated. Occur in or along the margins of the mountains.	Not considered an aquifer, but may yield water locally to springs. Dissolved solids are probably less than 2,000 ppm.
			Travertine deposits		Spring deposits associated with dissected high terraces west of Bull Lake along the northeast slope of the Wind River Mountains.	Yields of 50 gpm or more may be possible from outwash, but till generally does not yield water. Dissolved solids are probably less than 500 ppm. Many of these rocks are topographically high and are largely drained.
			Glacial deposits		Silt, sand, gravel, cobbles, and boulders; unconsolidated till and outwash. Present on northeast slope of Wind River Mountains.	
			Wiggins Formation (0-1,000±)		Volcanic conglomerate, breccia, and tuff; tuff is pink, light gray, and white; volcanic fragments are generally dark. Present in the extreme northwestern part of the area.	

See footnotes at end of table.

TABLE 1.—Generalized section of the geologic units and potential water supply—Continued

Era	System	Series	Map unit where stratigraphic units are combined	Stratigraphic unit (approximate thickness, in feet) <sup>1</sup>	Physical character <sup>2</sup>	Potential water supply <sup>3</sup>	
CENOZOIC	Tertiary	Pocene	Tepee Trail Formation (0-1,500±)	Unnamed tuff (0-300+)	Tepee Trail Formation: Volcanic conglomeration, breccia, sandstone, shale, and tuff; interbedded; green, olive, and brown. Present in the extreme northwestern part of the area.	Unamed tuff: Tuff, fine- to coarse-grained, volcanic conglomeration, and some limestone; yellow green, green, olive, and gray. Present along the north-central margin of the basin. These rocks are probably contemporaneous in part to the Tepee Trail Formation of the northwestern part of the basin and to the Wagon Bed Formation (Van Houten, 1964) of the southern part of the basin.	Water wells are not known to tap these units. The units are largely drained because of their high topographic position. Where the units contain water, yields of as much as 50 gpm may be possible. Dissolved solids in water from most of these rocks would probably be less than 2,000 ppm.
			Aycross Formation (0-1,000+)	Tuff, claystone, shale, sandstone, and conglomerate; greenish gray to brightly variegated; highly tufaceous; contains abundant volcanic rock fragments. Present in the northwestern part of the area.		Many wells tap this formation. Yields of wells range from about 1 to 500 gpm. Dissolved solids range from about 200 to 5,000 ppm.	
			Wind River Formation (0-5,000±)	Sandstone, conglomerate, siltstone, claystone, and shale; contains a small amount of bentonite, tuff, and limestone; red, gray, green, purple, white, tan, and brown. Present throughout the central part of the area.		Water wells are not known to tap this formation. Yields of as much as 50 gpm may be possible, but some of the rocks will not yield water. Dissolved solids probably range from about 1,000 to 5,000 ppm.	
			Indian Meadows Formation (0-3,000±)	Conglomerate, sandstone, claystone, siltstone, and some algal-ball limestone; variegated red, purple, lavender, tan, gray, green, buff, brown, and white; reddish colors are generally predominant. The formation crops out in			

			<p>the northern part of the area, but is not known in the southern. It underlies the Wind River Formation in most of the central part of the area.</p>	<p>Yields of several hundred gallons per minute may be possible from the complete section of rocks, but most wells tap only a small part of the formation and have yields of less than 10 gpm. Dissolved solids range from about 1,000 to 5,000 ppm.</p>
MESOZOIC	Cretaceous	<p>Fort Union Formation (0-7,000±)</p>	<p>Sandstone, conglomerate, shale, and siltstone, interbedded. Along the north side of the Wind River Basin, the formation has been divided into upper and lower parts. The upper part consists of the Shotgun and Waltman Shale Members. The Shotgun Member (0-2,800± ft) consists of even-bedded, soft siltstone, shale, sandstone, and some conglomerate; colors are gray, olive, buff, brown, tan, red, and purple. Sandstones are mostly fine-grained and porous. To the east, the Shotgun Member interbeds with and overlies the Waltman Shale Member (0-1,000± ft), which consists of dark-brown and black shale with some interbedded sandstone. The lower part is not named. It is predominantly sandstone and conglomerate with lesser amounts of gray and brown shale. Sandstone is fine to coarse grained, thin bedded to massive; conglomerate is lenticular; colors are white, gray, buff, and brown. The formation thins toward the southwest. In the south, the formation is not divided. It consists of interbedded white, gray, tan, and brown sandstone, conglomerate, shale, and siltstone. The formation is not present in the western part of the area.</p>	<p>Yields of as much as several hundred gallons per minute may be possible. Dissolved solids probably range from about 1,000 to 5,000 ppm.</p>
	Upper	<p>Lance(?) Formation (0-1,200)</p>	<p>Sandstone, conglomerate, claystone, and shale. Sandstones are gray, buff, and brown; fine to coarse grained; massive to thin bedded. Conglomerate occurs with the sandstone in thin beds or irregular lenses; it locally contains rounded pebbles and cobbles. Claystone and shale are mostly gray and black with some maroon and purple. Carbonaceous shale and thin coal are present locally. The formation is not present in the southwestern and western parts of the area.</p>	<p>Yields of as much as several hundred gallons per minute may be possible. Dissolved solids probably range from about 1,000 to 5,000 ppm.</p>

See footnotes at end of table.

TABLE 1.—Generalized section of the geologic units and potential water supply—Continued

Era	System	Series	Map unit where stratigraphic units are combined	Stratigraphic unit (approximate thickness, in feet 1)	Physical character 2	Potential water supply 3
Cretaceous	Upper		Map unit where stratigraphic units are combined	Meeteetse Formation (0-1,400)	Sandstone, siltstone, shale, carbonaceous shale, and coal; interbedded; soft; banded gray, black, yellow, buff, and brown. Sandstone is gray and buff, fine to coarse grained, thin bedded to massive, porous; concretions are common. Individual sandstone beds in the upper 300± ft of the formation are as much as 120 ft thick. The formation is not present in the southern or western parts of the area.	Yields of as much as 50 gpm may be available from sandstone beds. Dissolved solids probably range from about 1,000 to 5,000 ppm.
			Mesaverde Formation (0-2,000)	Sandstone, very fine grained to coarse grained, porous, massive, crossbedded, lenticular; and interbedded sandstone, siltstone, shale, carbonaceous shale, and coal; white, gray, brown, and buff colors predominant. Sandstone beds range in thickness from a few feet to a few hundred feet. The formation ranges in thickness from about 1,000 to 2,000 ft except toward the southwest where it was eroded before deposition of the Fort Union Formation.	Yields of as much as several hundred gallons per minute may be possible. Dissolved solids generally range from about 1,000 to more than 5,000 ppm.	
			Cody Shale (2,500-5,000)	Upper part is gray to buff, very fine grained, silty, mostly thinbedded sandstone and siltstone, interbedded with lesser amounts of gray to black shale. Lower part is gray to black shale, partly bentonitic, partly silty and sandy; contains a few thin silty sandstone beds.	Yields of as much as 20 gpm are possible from sandstone beds, but most of the formation is not an aquifer. Dissolved solids generally range from about 1,500 to 5,000 ppm, but are much higher in some oil-field waters.	
			Frontier Formation (600-1,000)	Shale and sandstone, alternating beds, some thin beds of tuff, coal, and bentonite. Sandstone is white, gray, and brown, fine to coarse grained, commonly crossbedded; some beds are porous. Shale is black, partly carbonaceous and bentonitic.	Yields of as much as 50 gpm are available from sandstone beds. Dissolved solids generally range from about 1,000 to 5,000 ppm, but are much higher in some oil-field waters.	

MESOZOIC					
Lower		Mowry and Thermopolis Shales (700-900)	Mowry Shale at top; Black and silver gray siliceous shale; contains thin beds of yellow bentonite and greenish-gray sandstone. Thermopolis Shale at base; Black and brown soft locally sandy shale; includes gray thinbedded sandstone of the Muddy Sandstone Member (0-150 ft).	Yields of as much as 10 gpm may be possible from sandstone beds, but most of the unit is not an aquifer. Dissolved solids will generally be greater than 2,000 ppm.	
?	?	Cloverly and Morrison Formations (350-650)	Upper part is gray, tan, and brown thinbedded fine to coarse grained sandstone interbedded with gray and black siltstone and shale. Middle part is brightly variegated claystone and clean, porous sandstone, locally conglomeratic. Lower part is lenticular white fine- to medium-grained soft sandstone that is interbedded with, and grades laterally, to variegated red, purple, gray, blue, and green claystone.	Yields of as much as several hundred gallons per minute are possible from the complete section of rocks. Dissolved solids range from less than 500 ppm near outcrops to more than 10,000 ppm in some oil-field waters.	
Upper	Jurassic	Sundance Formation (200-400)	Upper glauconitic unit is sandstone, siltstone, shale, and minor amount of interbedded limestone; green and gray. Lower nonglauconitic unit is oolitic limestone, shale, siltstone, and minor amount of sandstone; green and gray, contains red beds near the top except in the northern part of the area.	Yields of 20 gpm or more may be possible. Dissolved solids may be less than 1,000 ppm near outcrops, but are probably higher elsewhere.	
Middle		Gypsum Spring Formation (50-250)	Siltstone and shale, red; green and gray limestone and dolomite; and white gypsum; interbedded, mostly thin bedded; massive gypsum in lower part, locally removed by leaching. The formation thins to the southeast and pinches out southeast of the area.	Not considered an aquifer, but local solution cavities may yield water with dissolved solids of about 3,000 ppm or more.	
?	?	Nugget Sandstone (0-400)	Sandstone, fine to medium grained, massive to thick bedded, locally crossbedded, porous; red, salmon, and gray; contains rounded frosted sand grains; thin red shales in lower part. The formation thins to the east and to the north and is missing along the northern edge of the area.	Yields of as much as several hundred gallons per minute may be possible. Dissolved solids may be less than 1,000 ppm near outcrops, but will be much higher elsewhere and may be more than 20,000 ppm in some oil-field waters.	
		Jurassic, Jurassic(?) and Triassic(?) rocks (400-800)			

See footnotes at end of table.

TABLE 1.—Generalized section of the geologic units and potential water supply—Continued

Era	System	Series	Map unit where stratigraphic units are combined	Stratigraphic unit (approximate thickness, in feet 1)	Physical character 2	Potential water supply
MESOZOIC	Triassic		Triassic rocks (1,000-1,400)	Popo Agie Formation (200-300)	Siltstone, shale, and silty sandstone, red and purple; lenses of purplish-gray limestone-pebble conglomerate; and analcime-bearing red and ochre dolomitic claystone.	Some of the rocks may yield as much as 10 gpm, but most of the formation does not yield water. Dissolved solids will generally range from about 1,500 to 5,000 ppm, but may be less than 1,500 ppm near outcrops.
				Crow Mountain Sandstone (10-90)	Sandstone, fine- to coarse-grained, thick-bedded, cross-bedded in part, porous; generally contains rounded frosted sand grains; red, orange, and gray.	Yields of 20 gpm or more may be possible. Dissolved solids may be less than 1,000 ppm near outcrops, but will be much higher elsewhere and may be more than 10,000 ppm in some oil-field waters.
				Alcova Limestone (0-20)	Limestone, hard, finely crystalline, laminated bedding, gray to pink. Very persistent marker bed generally 5-15 ft thick; missing in extreme northern part of the area.	Not considered an aquifer.
				Red Peak Formation (700-1,000)	Siltstone, shale, and fine grained silty sandstone, interbedded, thin- to thick-bedded; red.	Some of the rocks may yield as much as 10 gpm, but most of the rocks do not yield water. Dissolved solids will generally range from about 1,500 to 5,000 ppm, but may be less than 1,500 ppm near outcrops.
				Dinwoody Formation (50-150)	Siltstone, sandstone, and shale, interbedded; thin bedded, hard, tight, and dolomitic; minor amounts of limestone and dolomite and, locally, gypsum; tan, yellow, gray, green, and red. The formation thins eastward and is 50-100 ft thick throughout most of the area.	
	Permian		Permian rocks (180-310)	Park City Formation and interbedded tongues of the Phosphoria Formation (Sheldon, 1963). Park City Formation: Mudstone, dolomite, and limestone, cherty; minor amount of sandstone; yellow, brown, green, and gray. Phosphoria Formation: Chert and gray, brown, and black phosphatic shale.	Yields of as much as 500 gpm may be possible where artesian pressures are high and solution cavities or fractures are present. In most areas, yields would probably be less than 100 gpm. Dissolved solids range from about 1,000 ppm to more than 10,000 ppm.	

PALEOZOIC					
Carboniferous	Mississippian	Pennsylvanian	Pennsylvanian and Mississippian rocks (500-700)	Mississippian and Devonian rocks (400-1,000)	Devonian
		Tensleep Sandstone (210-400)			
		Amsden Formation (180-400)			
		Darwin Sandstone Member (0-170)			
		Madison Limestone (400-800)			
		Darby Formation (0-250)			

Yields of as much as 1,000 gpm may be available. Dissolved solids range from about 300 to 3,000 ppm.

Yields of 20 gpm or more may be possible from parts of the formation, but most of the rocks would yield little water unless fractured. Dissolved solids will probably be less than 1,500 ppm.

Yields of as much as 1,000 gpm may be available. Dissolved solids range from about 300 to 3,000 ppm.

Sandstone, fine- to coarse-grained, thick-bedded, cross-bedded; mostly porous; buff, white, and gray; contains a few hard quartzitic beds and a few thin beds of chert and dolomite.

Dolomite, shale, siltstone, sandstone, limestone, and chert, interbedded; hematite in some sandstone and shale beds; red, green, brown, gray, and buff.

Sandstone, fine- to medium-grained, thin-bedded to massive, crossbedded, friable, moderately porous; pyritic in part; white, red, gray, and buff. The thickness varies irregularly; locally absent or indistinguishable.

Limestone and dolomite; contains abundant bedded and nodular chert. Upper part is thin-bedded gray and tan limestone, red shale, and limestone breccia (0-100± ft). Middle part is gray and blue limestone with carbonate cemented breccia zone at base (130± ft). Lower part is gray and brown dolomite and dolomitic limestone; intergranular and vuggy porosity common (300± ft).

Dolomite, massive, and interbedded dolomite, limestone, sandstone, siltstone, and shale. Upper part is interbedded clastics and carbonates; green, gray, red, brown, and tan. Lower part is massive; buff, brown, and gray dolomite; generally vuggy and porous; clastic channel fill present locally at base. The formation thins toward the east, and is missing in the eastern part of the area.

See footnotes at end of table.

TABLE 1.—Generalized section of the geologic units and potential water supply—Continued

Era	System	Series	Map unit where stratigraphic units are combined	Stratigraphic unit (approximate thickness, in feet)	Physical character <sup>2</sup>	Potential water supply <sup>3</sup>
PALEOZOIC	Ordovician	Middle and Upper	Orlovician and Cambrian rocks (800-1,600)	Bighorn Dolomite (0-300)	Dolomite, massive, buff; the thin-bedded light-colored Leigh Dolomite Member (0-85 ft) occurs at the top in the northwestern part of the area; Lander Sandstone Member (0-20 ft) occurs locally at the base. The formation thins toward the southeast, and is missing in the southeast corner of the area.	
	Cambrian	Upper		Gallatin Limestone (200-450)	Limestone, thin-bedded to massive; some siltstone and shale; contains many beds of limestone pebble conglomerate; gray, green, brown, and tan.	Yields of as much as 10 gpm may be possible from parts of the section, but most of the rocks would not yield water unless fractured. Dissolved solids will probably be less than 1,500 ppm.
	Cambrian	Middle		Gros Ventre Formation (400-700)	Siltstone and silty shale interbedded with silty fine-grained sandstone. Limestone, and limestone-pebble conglomerate; very glauconitic throughout; green, gray, brown, tan, red, and purple.	
				Flathead Sandstone (120-300)	Sandstone, fine- to coarse-grained; contains thin siltstone and shale partings; conglomerate at base; varies from soft sandstone to quartzite; brown, tan, green, gray, pink, and purple.	Yields of as much as 20 gpm may be possible. Dissolved solids will probably be less than 1,500 ppm.

<p>Yields of as much as 30 gpm may be possible where open fractures or weathered zones occur. Dissolved solids will generally be less than 200 ppm near outcrops. Where the rocks are deeply buried, dissolved solids will be greater.</p>	<p>Metamorphic and igneous rocks.</p>	<p>PreCambrian</p>
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<sup>1</sup> Thickness of Cretaceous and older rocks are of complete sections that do not reflect removal or thinning by post-Fort Union Formation erosion.

<sup>2</sup> Based primarily on works by many authors. Refer to geologic reports listed at the end of this report for more detailed descriptions.

<sup>3</sup> Based on limited local well data, on data concerning quality of oil-field water (Crawford, 1940, 1957; Crawford and Davis, 1962), and on data concerning water in the same of similar lithologic units in nearby areas (Lowry, 1962; Whitcomb and Lowry, 1967; and unpublished chemical analyses).

pending on local conditions, but the general movement is down the valley. Alluvium that lies at levels above the streams derives water from precipitation or, in many areas, from irrigation, and discharges most of the water to springs at terrace scarps. Discharge from the alluvium to existing wells is minor because only a few wells are pumped at high rates.

Evaporation and transpiration return a large portion of the precipitated water to the atmosphere. Evaporation continues from open-water surfaces and from the water table in areas where it is near the land surface. Large amounts of water are transpired by plants during the growing season.

#### WATER LEVELS

Water levels in wells reflect the pressure of water in confined aquifers and show the top of the zone of saturation in unconfined aquifers. Changes in the balance between recharge and discharge cause water-level fluctuations. Discharge of water from an aquifer by pumping alters the natural balance and lowers the water level until a new balance is established. Hydrographs of several types of water-level fluctuations are shown in figure 4.

Confined aquifers in the area are large, and effects of changes in the balance between recharge and discharge on water levels are dampened. Water levels may vary only a few tenths of a foot during a year, but may change several feet over a period of many years in reaction to long-term changes in balance between recharge and discharge (fig. 5). However, water levels may decline several tens of feet in a short period in response to local pumping.

Unconfined aquifers in the area are small, and changes in the balance of recharge and discharge have an immediate and pronounced effect on water levels. Short-term variations in precipitation and daily and seasonal variations in evaporation and transpiration may cause water levels to rise or fall in a short period. Artificial influences, such as irrigation, overcome natural influences and control water levels in many areas (fig. 4).

Data concerning water levels in rocks older than the Wind River Formation are sparse. Except in outcrop areas, water in these rocks is generally confined. Well depths are as much as several thousand feet, but water generally will rise to near the surface and, in some areas, will flow. Specific data are given in table 3 and on plate 1.

The Wind River Formation consists of numerous separate aquifers. At a single location, aquifers at different depths will have very different water levels. Differences in depth to water of as much as 140 feet were measured in adjacent wells, A3-3-21ada1 and -21ada2 (fig. 4), and also in well A1-2-21bbb (table 3), which was cased and completed at two different depths.

Most wells in the Wind River Formation tap confined aquifers. Well depths are as much as 900 feet, and depths of more than 400 feet are common. Water rises far above the producing zones in most wells and, in some areas flows at the surface. Depths to water generally range from the surface to about 200 feet; but there are many exceptions, and depths to water of more than 500 feet have been measured.

In the part of the Wind River Formation tapped by the Riverton well field, water levels have declined in response to pumping. Figure 6 compares 1951 and 1966 water levels in well A1-4-33ddb, which is influenced by pumping of the well field. Pumpage records for 1951 are not available, but annual pumpage in 1966 is estimated to have been about one-third larger than in 1951.

A few shallow wells in the Wind River Formation tap unconfined aquifers. The water-table wells are generally less than 70 feet deep, and depths to water are generally less than 30 feet.

Water in alluvium and other unconsolidated rock of Quaternary age is unconfined. Wells tapping these rocks are generally less than 50 feet deep, and depths to water are generally less than 20 feet.

#### AQUIFER CHARACTERISTICS

Data on aquifer characteristics are available for the Wind River Formation and for the alluvium. The data consists of specific capacities reported by drillers and a few pumping tests. The following discussion relates the data to the thickness of rock that contributes water to a well. Thicknesses of contributing rock were taken from drillers' logs. The data are used to define the range of permeability and specific capacity per foot of contribution. Specific capacity per foot of contribution is the discharge in gallons per minute, per foot of drawdown, per vertical foot of rock that contributes water to a well. It is related to specific capacity in the same way that permeability is related to transmissibility.

Definitions of several terms related to aquifer characteristics are given in the section on terminology. Symbols used in the discussion include:

$m$  = Saturated thickness or thickness of section that contributes water to a well, in feet.

$P$  = Permeability, in gpd/ft<sup>2</sup>.

$Q$  = Discharge, in gpm.

$s$  = Drawdown, in feet.

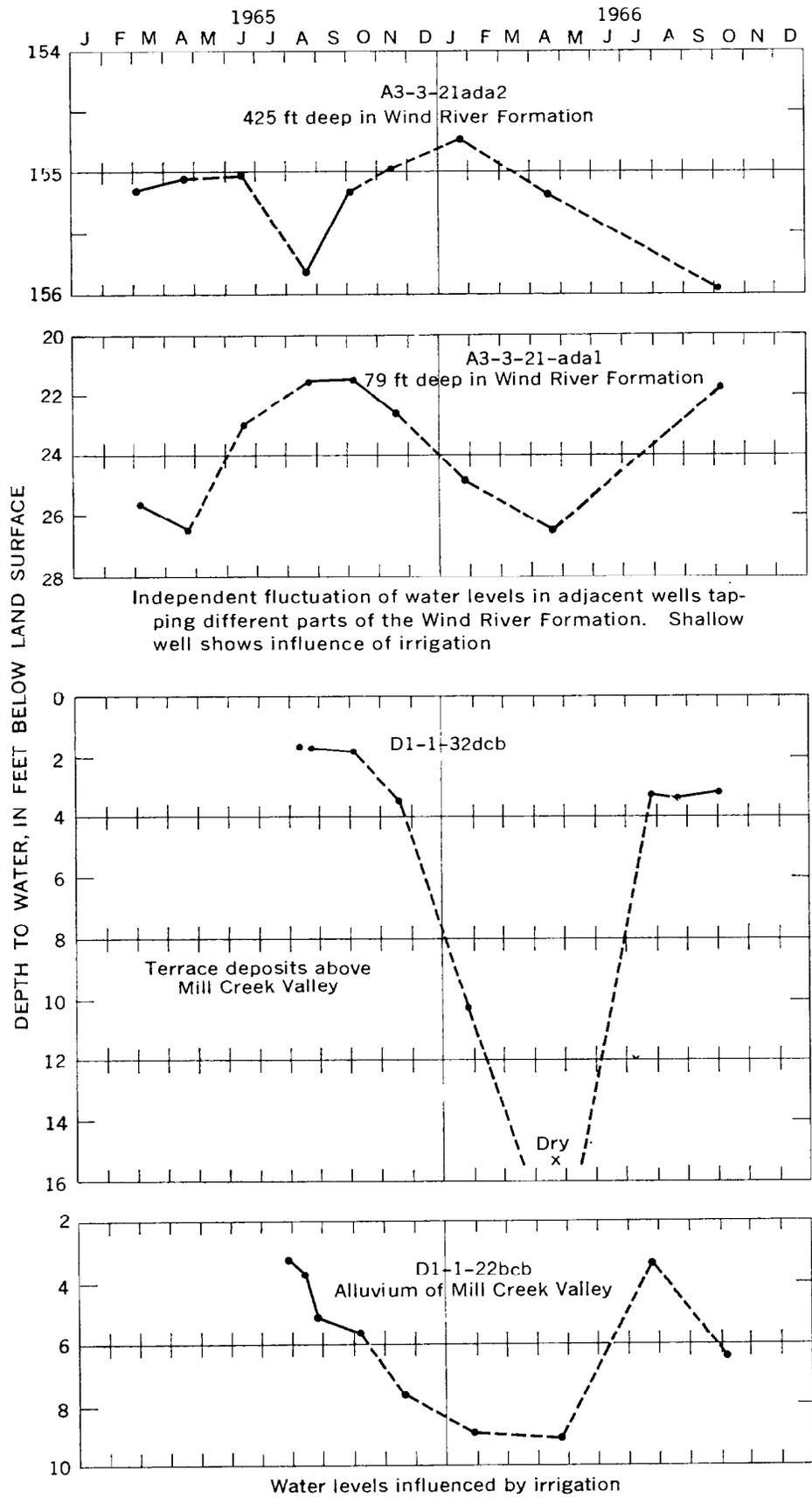
$\Delta s$  = Change in drawdown per log cycle, in feet.

$T$  = Transmissibility, in gpd/ft.

$t$  = Time since pumping began, in minutes.

$t'$  = Time since pumping stopped, in minutes.

WATER SUPPLY OF INDIAN RESERVATIONS



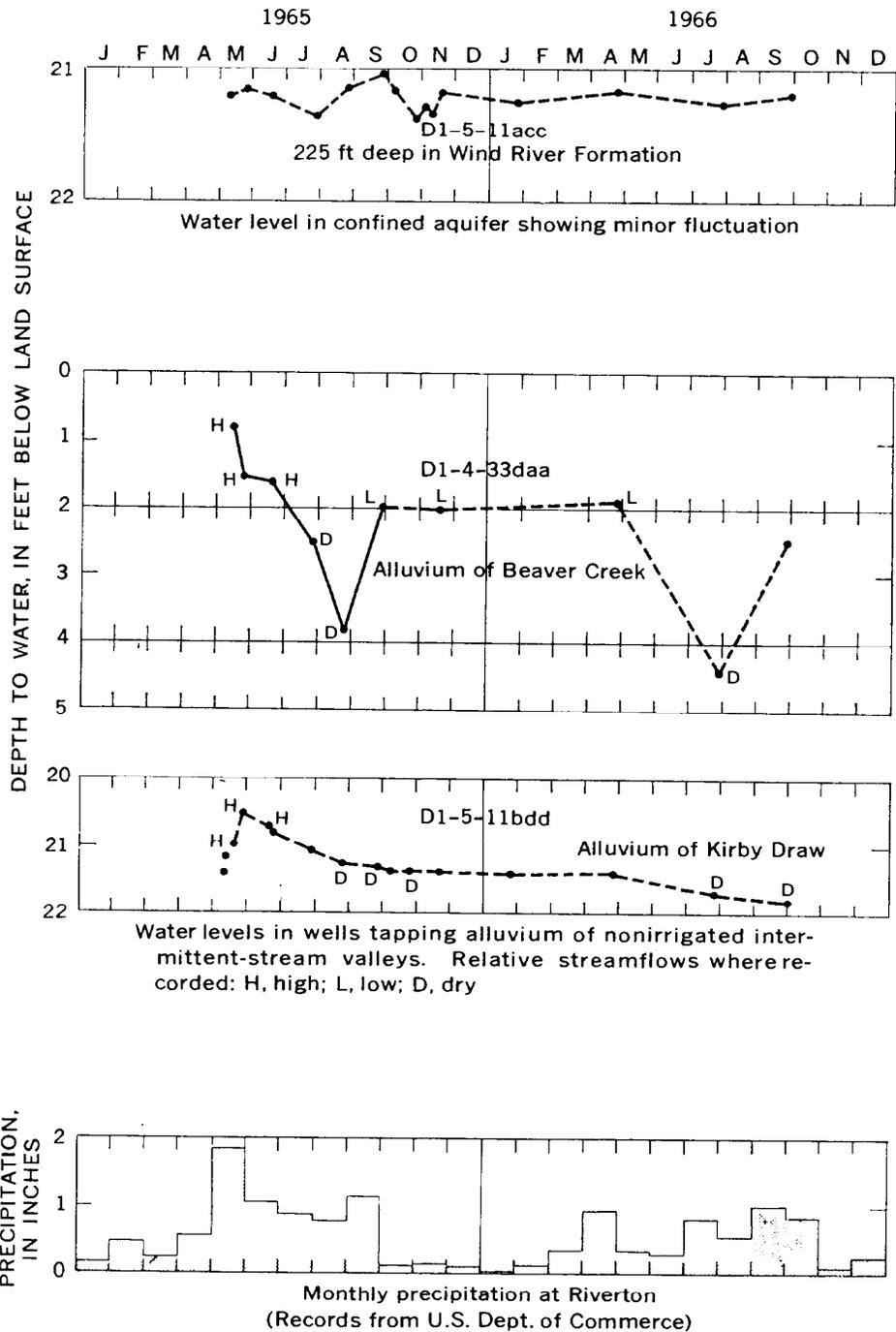


FIGURE 4.—Several types of water-level fluctuations in wells. See figure 5 for longer record of well A3-3-21ada2.

**WIND RIVER FORMATION**

Data from four pumping tests and specific capacity per foot of contribution for 139 wells tapping the Wind River Formation were available for analysis. The data are from wells in the eastern half of the area, but the formation probably has similar characteristics throughout the area.

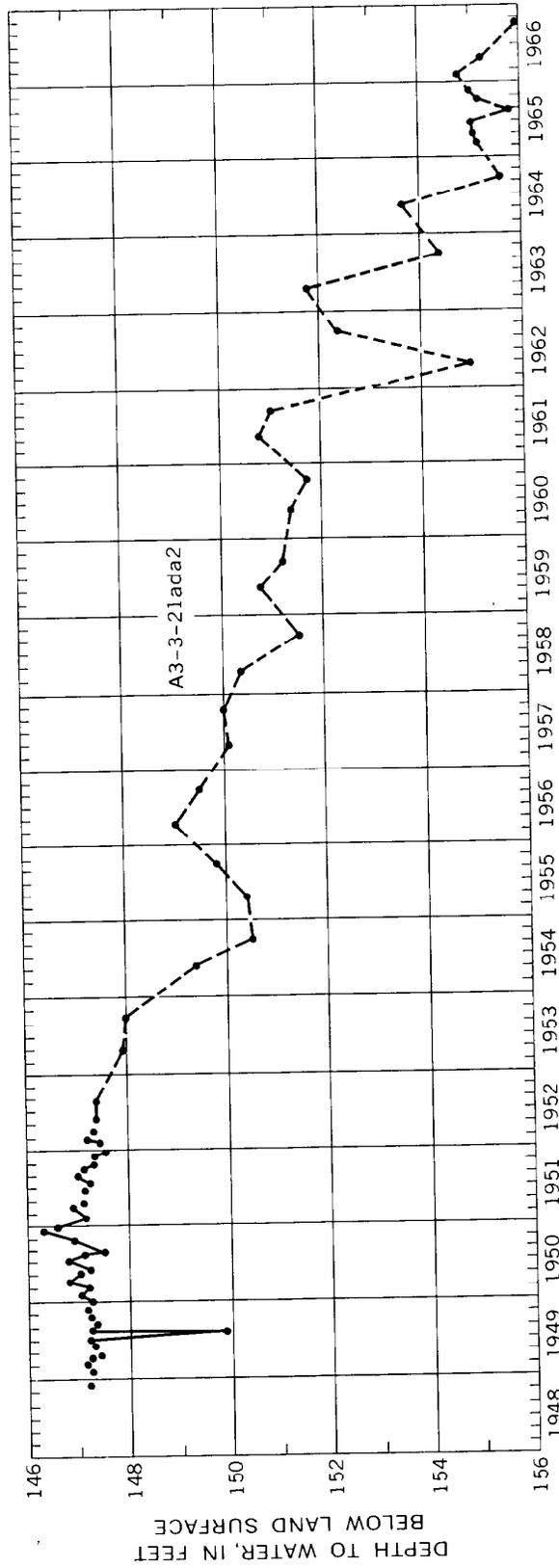


FIGURE 5.—Hydrograph of well A3-3-21ada2.

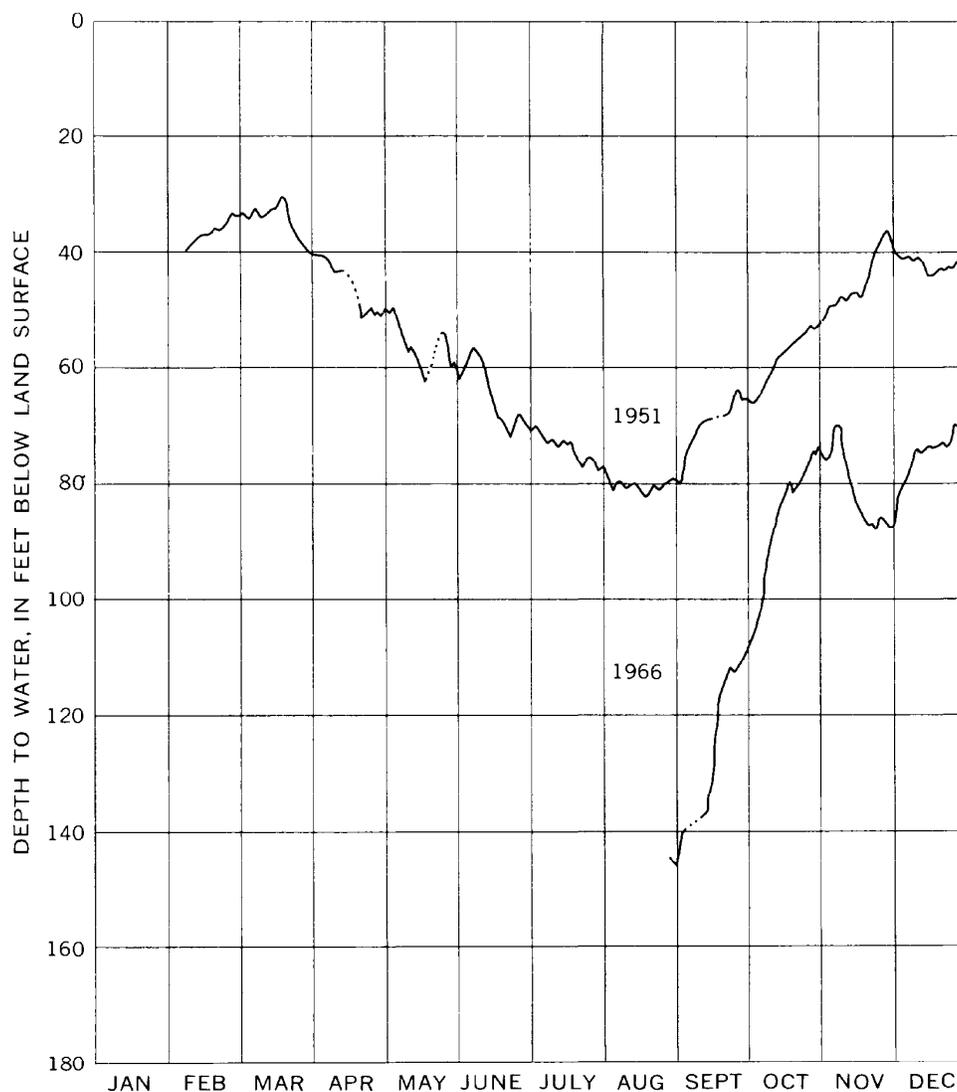


FIGURE 6.—Hydrograph of well A1-4-33ddb comparing the influence of the Riverton well field in 1951 and 1966. Data from recorder charts.

#### PUMPING TESTS

Results of pumping tests (table 2) are expressed as permeability rather than transmissibility, because the Wind River Formation contains numerous separate aquifers and transmissibility of the formation has little meaning. Some water-bearing beds of the formation are hydraulically connected, but others, perhaps most, are only remotely connected; some are completely separated.

Data from pumping tests were analyzed by methods described by Ferris and others (1962) and also in E. E. Johnson, Inc. (1966). Recovery data were used for analyzing the tests; drawdown data were not considered usable, either because of variation in discharge, or because prepumping trends could not be defined. Adjusted residual

drawdown was plotted against  $t/t'$  where the prepumping trend was defined. Where only the drawdown trend was defined, adjusted recovery was plotted against  $t'$ . Both plots theoretically give the same result. Figure 7 is a sketch showing the relation of drawdown, residual drawdown, and recovery. Table 2 gives principal data concerning the tests.

*Well A3-6-15bcb.*—At the time this test was started, water levels were recovering from effects of previous pumping. The trend of the pretest rise in water level was not defined; thus drawdown data could not be adjusted. The drawdown trend was defined, and recovery data were adjusted accordingly. Figure 8 shows the drawdown, the adjustment for the drawdown trend, and the adjusted recovery data.

A step-drawdown test of well A3-6-15bcb was made in November 1951. Discharges ranged from about 7 to 50 gpm. The specific capacity was 1.3 gpm/ft, which is comparable to that from the 1966 test (table 2).

*Well D1-4-4cdd.*—The test of well D1-4-4cdd was conducted by a consultant for the owner, Susquehanna-Western, Inc., and data were obtained from the owner. Drawdown was large compared to any probable influence from the Riverton well field, which is about 1 mile north of the well, and interpretation of the test was probably not affected. This well had been pumped irregularly for several months and was shut down for only 15 hours before the test began. The trend of recovery from previous pumping was not known; thus, drawdown data could not be adjusted. The drawdown trend was known, and recovery data were adjusted accordingly. Figure 9 shows the water levels during drawdown, the adjustment for the drawdown trend, and the adjusted recovery data.

Specific capacity from various pumping data were not consistent. Table 2 gives an approximate specific capacity of 2.3 gpm/ft, which was interpreted from the data.

*Well D1-5-11acc.*—Depth-to-water measurements before this test showed a change of only 0.03 foot in 16 hours; thus, no adjustment was required for the prepumping trend, and residual drawdown was analyzed (fig. 10). Drawdown was very sensitive to minor variations in the pumping rate and could not be analyzed.

*Riverton well field.*—A pumping test of the Riverton well field was conducted for a previous study in March 1951. The test is described in detail by Morris and others (1959). The test indicates a coefficient of transmissibility of about 6,000 to 10,000 gpd/ft and a coefficient of storage of about  $2 \times 10^{-4}$ . The permeability of 180 gpd/ft<sup>2</sup> that was computed in 1951, however, seems too high to be representative of the formation. It was based on a thickness of 55 feet, which was the thick-

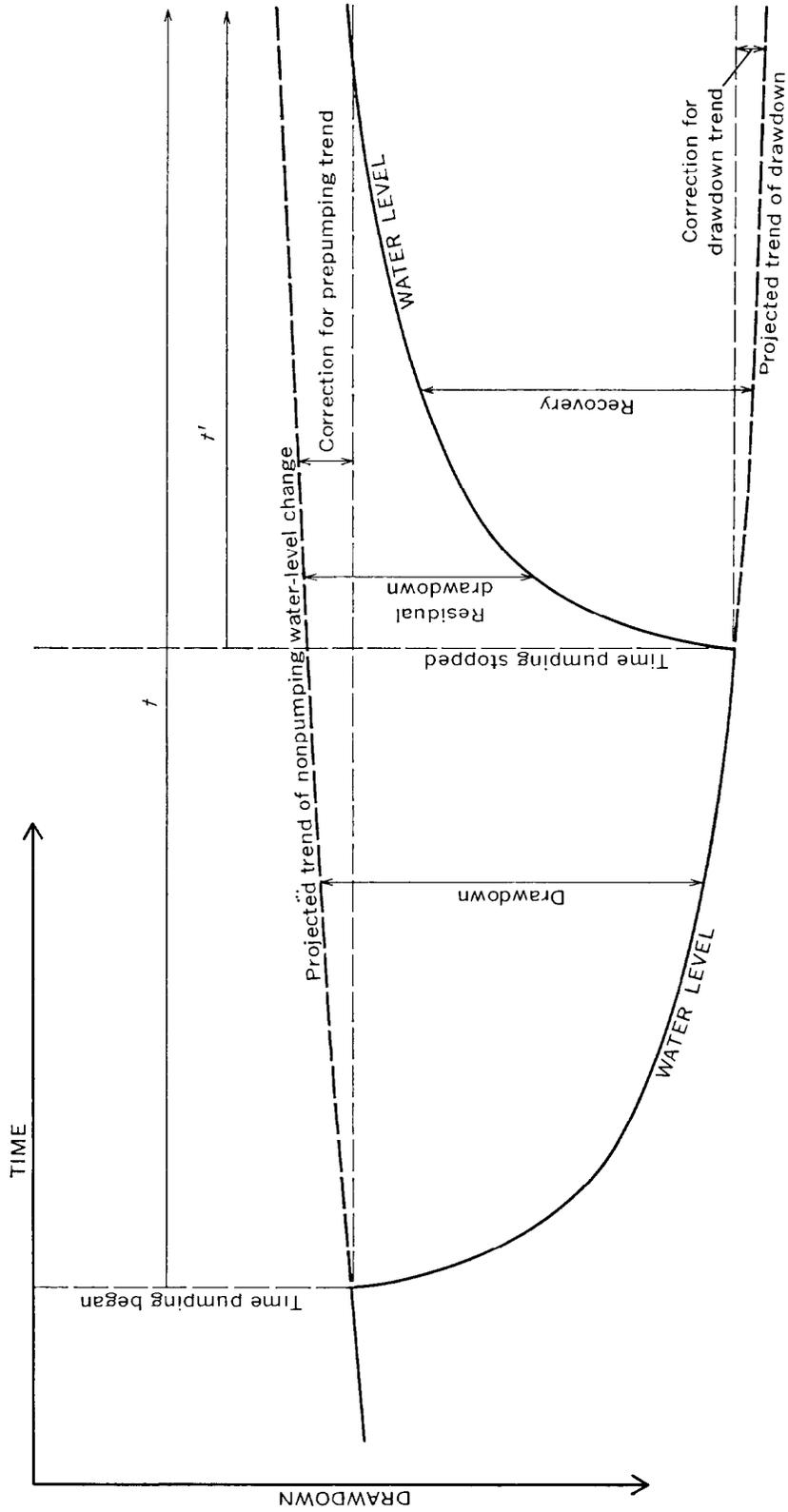


FIGURE 7.—Relation of drawdown, residual drawdown, and recovery.

TABLE 2.—Principal data concerning pumping tests

## Wells in Wind River Formation

Well	Date	Depth of well (feet)	Thickness of sandstone contributing before pumping (feet)	Depth to water before pumping (feet)	Duration of pumping (minutes)	Discharge (gpm)		Specific capacity (gpm/ft)	Specific capacity per foot of contribution (gpm/ft <sup>2</sup> )	Permeability (gpd/ft <sup>2</sup> )
						Range	Average			
A3-6-15hcb	Oct. 28, 1966.....	495	44	66.0	360	160-175	165	1.5	0.034	43
D1-4-4cdd	Sept. 12-17, 1958.	450	63	-----	3,716	540-605	550	1.2.3	.037	45
D1-5-1lace	Nov. 5, 1965.....	225	40	22.32	500	2.6-4.2	3.6	1.5	.038	43

## Wells in alluvium

Well	Date	Depth of well (feet)	Depth to bedrock (feet)	Thickness of saturated sand and gravel (feet)	Depth to water before pumping (feet)	Drawdown before pumping stopped (feet)	Duration of pumping (minutes)	Discharge, average (gpm)	Specific capacity (gpm/ft)	Specific capacity per foot of contribution (gpm/ft <sup>2</sup> )	Estimated yield at two-thirds of maximum drawdown (gpm)
A1-4-31dec	Nov. 6, 1965	9	9	5	3.97	4.5	160	5	1	.2	1.5
B4-4-2cda	Oct. 26, 1966	2 33	44	40	3.80	1.0	120	65	65	1.6	3 1,200
B4-4-22aba	Oct. 26, 1966	2 33	35	23	12.32	2.1	120	42	20	.9	3 200
D1-1-15ccc	Oct. 25, 1966	38	38	25	11.50	1.2	240	40	33	1.3	3 350

<sup>1</sup> Qualified in text.<sup>2</sup> Not cased to bedrock.<sup>3</sup> Based on graph relating drawdown to yield (E. E. Johnson, Inc., 1966, p. 107).

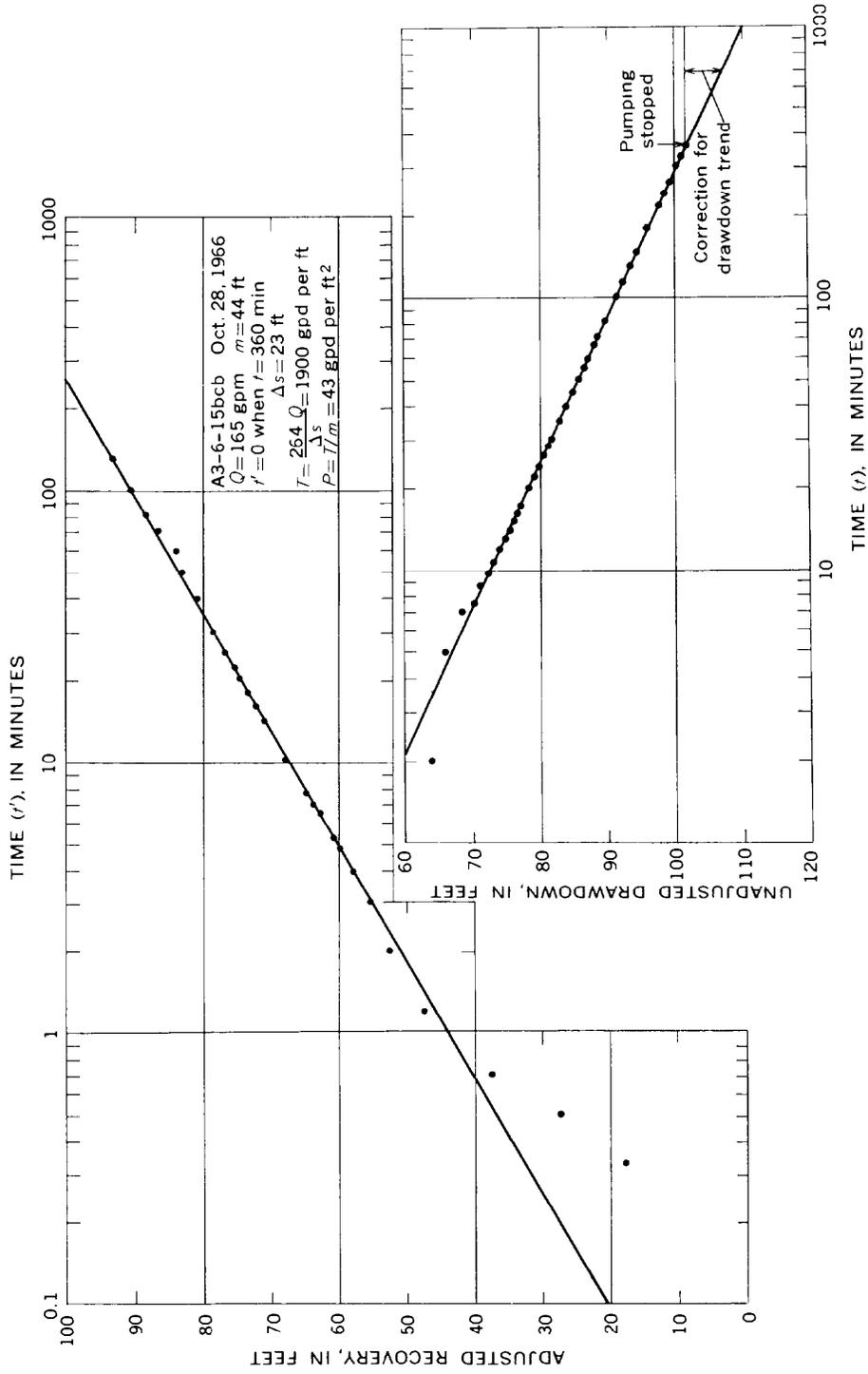


FIGURE 8.—Adjusted recovery of well A3-6-15bcb.

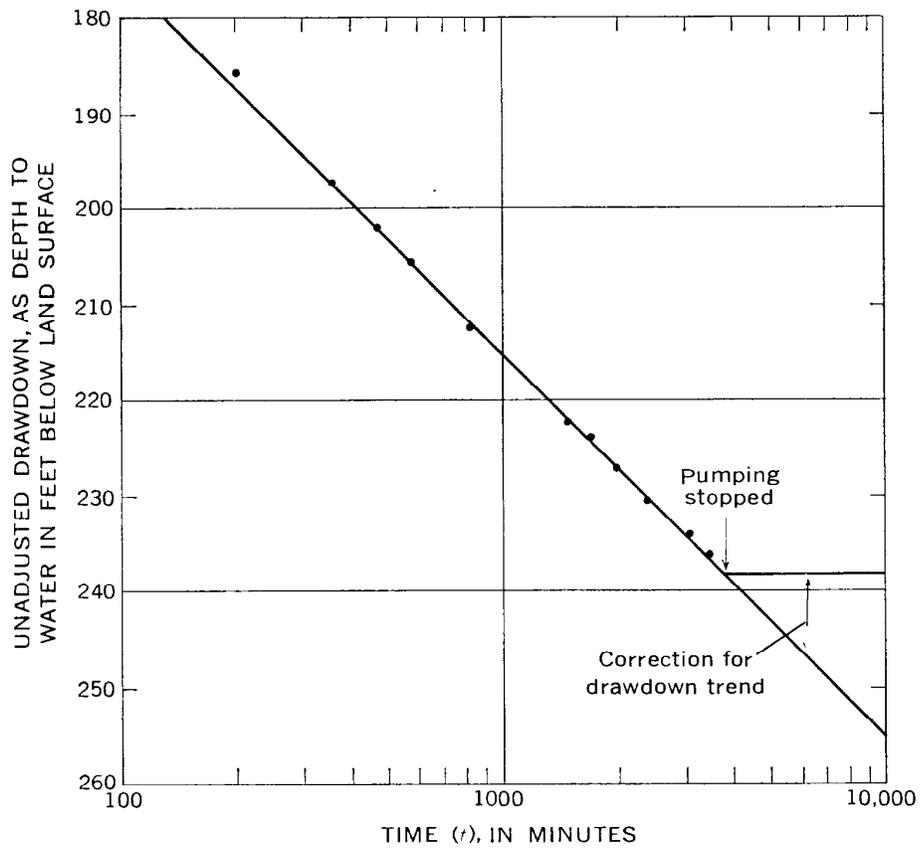
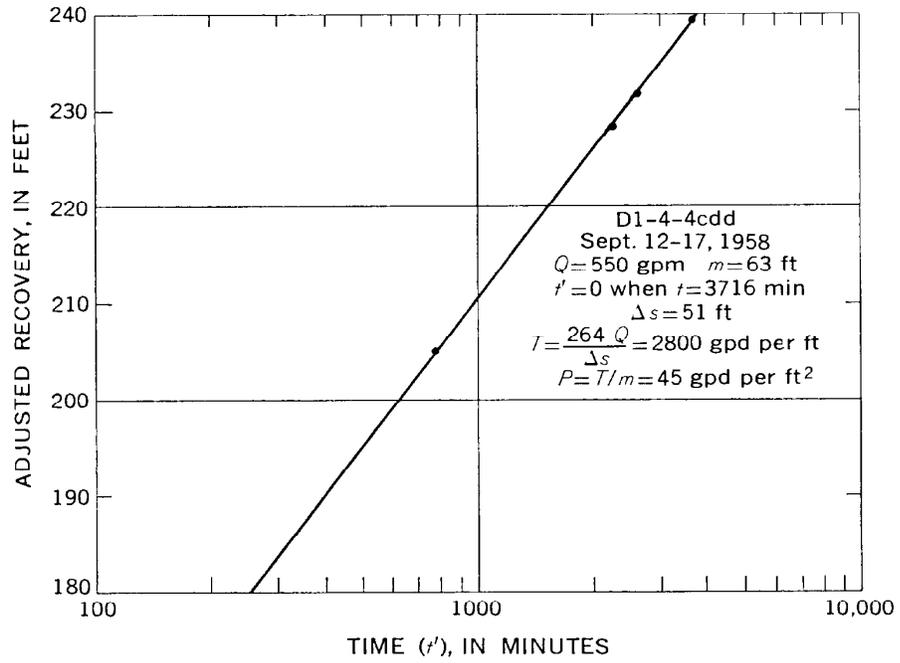


FIGURE 9.—Adjusted recovery of well D1-4cdd.

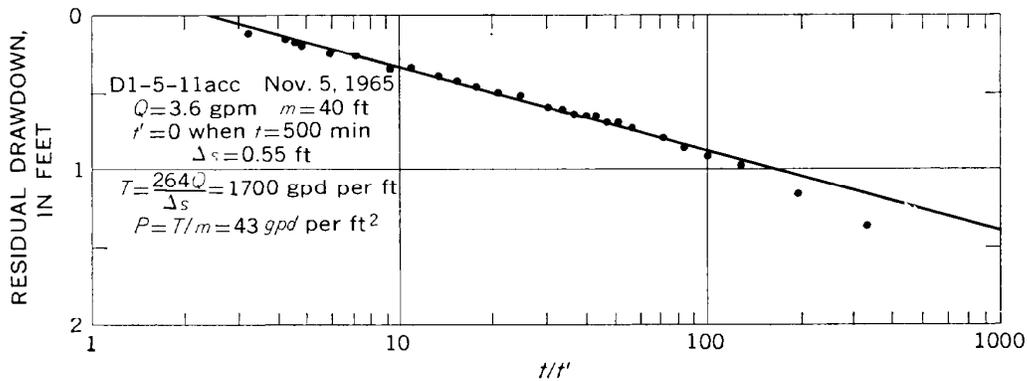


FIGURE 10.—Residual drawdown of well D1-5-11acc.

ness of water-bearing sandstone open to the pumped well of the test. Drillers' logs show that the "water sands" open to the Riverton wells have thicknesses that range from 45 to 148 feet and average about 100 feet per well. Therefore, average permeability based on the average thickness and the transmissibility is between about 60 and 100 gpd/ft<sup>2</sup>.

#### SPECIFIC-CAPACITY DATA

Specific capacity per foot of contributing section for 139 wells in the Wind River Formation is shown in figure 11. Specific capacity and contributing section were obtained primarily from drillers' records or other reported data. Figure 12 shows the distribution of the data.

Estimates of permeability can be made from the specific capacity per foot of contribution of a well. Specific capacity per foot of contribution  $\frac{Q/s}{m}$  and permeability are related in the same way as specific capacity ( $Q/s$ ) and transmissibility. This relation has been described by Theis, Brown, and Meyer (in Bentall, 1963) and by Johnson and others (1966) and can be expressed as:

$$T=K(Q/s), \text{ or}$$

$$P=K\left(\frac{Q/s}{m}\right),$$

where  $K$  combines all factors that affect the relation. Included in  $K$  are factors that depend on aquifer characteristics, on well efficiency, and on rate and duration of pumping. Generally,  $K$  has a value of 1,500–2,100, but it can be outside this range. Values for  $K$  cannot be accurately determined because of the many factors involved, but it can be estimated fairly closely. Even with fairly large errors in  $K$ , the estimates of permeability will be of the correct order of magnitude.

A value of  $K$  that would apply to the data on the Wind River Formation is probably near 1,500. Generally,  $K$  is larger than this for artesian aquifers; but the available data are for very short pumping

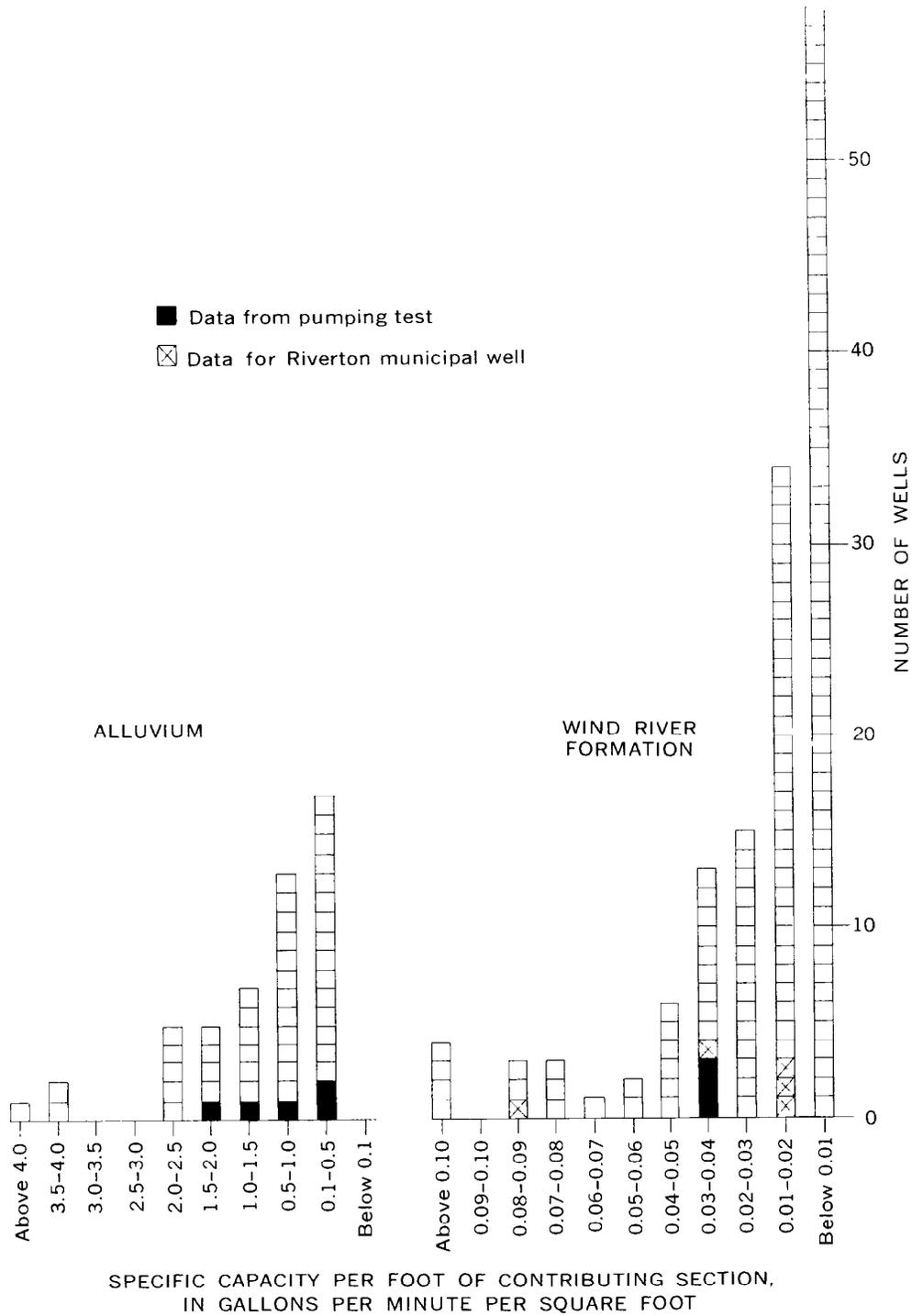


FIGURE 11.—Histograms of specific capacity per foot of contribution for wells in alluvium and in the Wind River Formation.

periods, and the shorter the pumping period, the smaller the value of  $K$ . Most of the data are from drillers' tests of probably 2 hours or less. The relation between specific capacity per foot of contribution and permeability for the tested wells (table 2) indicates a very low  $K$  of

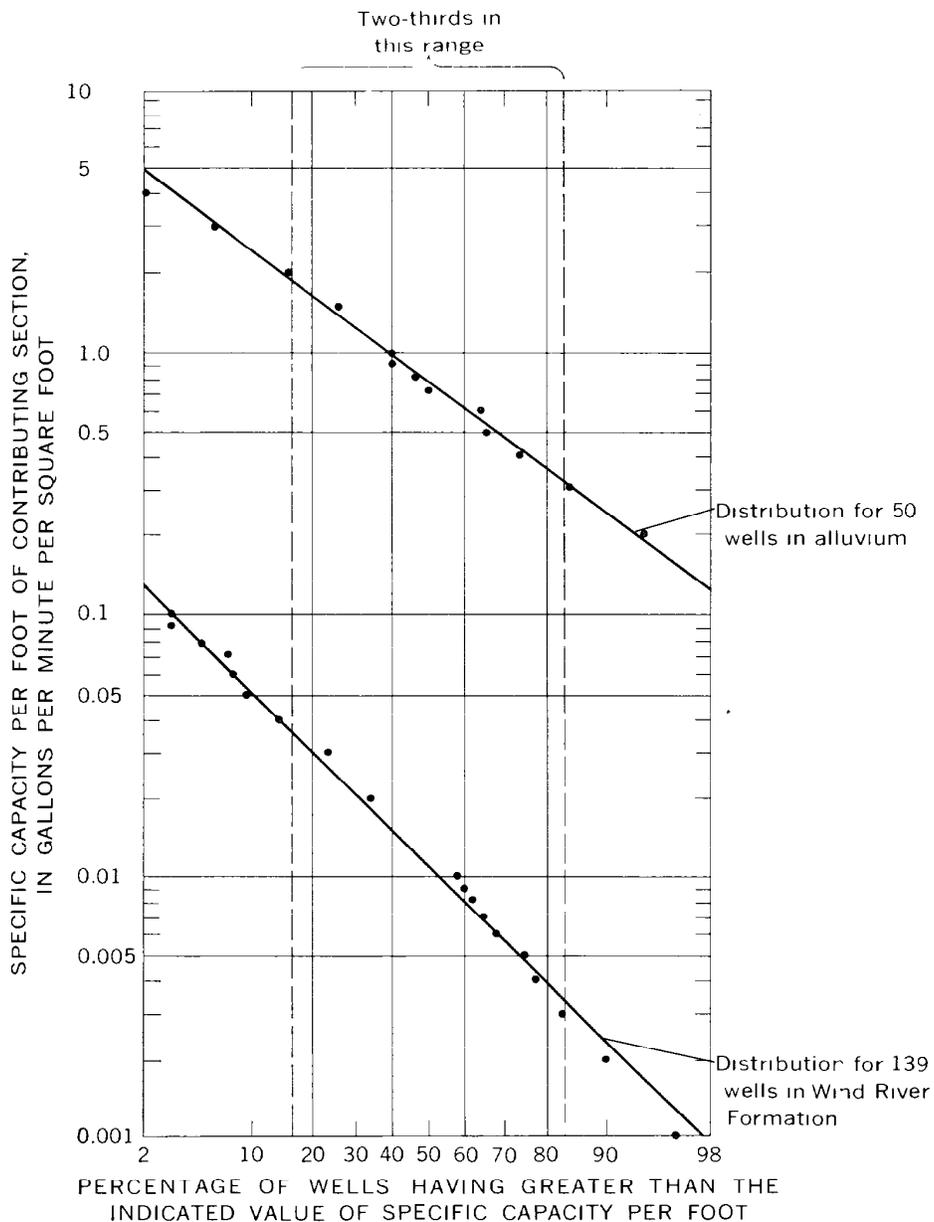


FIGURE 12.—Distribution of specific capacity per foot of contribution for wells in alluvium and in the Wind River Formation.

1,200. A general value of  $K$  of 1,500 is probably adequate for estimating permeabilities from the available data.

The probable range of specific capacity per foot of contribution for water-bearing sandstone of the Wind River Formation is shown in figure 12. This interpretation assumes that the data adequately represent the formation, and that the line drawn through the data plot correctly describes the distribution of the data. The probable range of permeability can be estimated by assuming that the  $K$  value of 1,500 approximately defines the relation between permeability and the spe-

cific capacity per foot of contribution. Figure 12 shows that, neglecting the high and low extremes, the probable range of specific capacity per foot of contributions is about 0.001–0.15 gpm/ft<sup>2</sup>, and the mean is 0.01 gpm/ft<sup>2</sup>. The indicated permeability is about 1 to 220 gpd/ft<sup>2</sup>, and the mean is 15 gpd/ft<sup>2</sup>. Two-thirds of the wells in the formation will have a specific capacity per foot of contribution between 0.003 and 0.04 gpm/ft<sup>2</sup> and an indicated permeability between 4 and 60 gpd/ft<sup>2</sup>.

#### ALLUVIUM

Data from five pumping tests and specific capacity per foot of contribution for 50 wells tapping the alluvium were available for analysis. All the data are from wells in alluvium underlying flood plains or terraces in the valley of the Wind River or in those tributary-stream valleys that drain the Wind River Mountains. The deposits are generally coarse grained and similar in character. They are quite different from the finer grained deposits of valleys in the southeast, such as the valleys of Beaver Creek and Kirby Draw, and in the center of the basin, such as the valleys of Fivemile and Muddy Creeks. No pumping-test nor specific-capacity data are available for wells in the finer grained deposits; consequently, the following discussion concerns only the coarser deposits.

#### PUMPING TESTS

Specific-capacity data were obtained from the pumping tests of the wells in alluvium, and estimates were made of potential yields of the alluvium at the test sites. Principal data concerning the tests are given in table 2.

Four of the wells were pumped at minor rates compared to their potential yields because large-capacity pumps were not available for the tests. To estimate potential yields, the relation of the drawdown to the yield was used. Under water-table conditions that exist in the alluvium, specific capacity cannot be used directly to estimate yields at increased drawdowns because the specific capacity decreases significantly with dewatering of the aquifer. As drawdown increases, specific capacity decreases. A graph showing the general relation between drawdown and yield under water-table conditions is given in E. E. Johnson, Inc. (1966, p. 107). When drawdown at a particular yield is known, the yield at a different drawdown for a similar pumping period can be estimated from the graph. According to the graph, the yield at two-thirds of the maximum drawdown is about 90 percent of the maximum yield; table 2 gives the estimated yield at two-thirds of the maximum drawdown.

*Well A1-1-34bcb.*—The specific capacity determined by the test of well A1-1-34bcb near Ethete was 4 gpm/ft. This well was poorly de-

veloped and was partly plugged with sand. Results of the test were affected by well conditions, are not indicative of the aquifer conditions, and cannot be used to estimate the yield of a properly developed well: Test drilling indicated that the water-bearing deposits were similar to those tapped by the other tested wells. Based on comparison with the other well tests, an estimated yield of about 150–250 gpm at two-thirds of the maximum drawdown may be possible for a properly developed well in the Ethete area.

*Well A1-4-31dec.*—Well A1-4-31dec was pumped at about its maximum discharge, 5 gpm. This well is probably less productive than is possible for the area, but large yields are not possible from wells because of the limited saturated thickness. However, very large sumps or other methods of greatly increasing the effective diameter could produce larger yields.

*Wells B4-4-2cda and B4-4-22aba.*—Wells B4-4-2cda and B4-4-22aba did not penetrate the full thickness of alluvium, but drawdowns were very small and effects of partial penetration were probably negligible.

*Well D1-1-15ccc.*—At well D1-1-15ccc, the sand and gravel is overlain by 13 feet of sandy silt, which is partly saturated. The silt is of relatively low permeability, and, for the short test, it was not considered as part of the contributing thickness.

#### SPECIFIC-CAPACITY DATA

Specific capacity per foot of contributing section for 50 wells in alluvium are shown in figure 11. About 80 percent of the data is taken from drillers' reports of wells in the Little Wind River valley near Fort Washakie. The deposits in the Fort Washakie area are generally similar to those in other valleys draining the Wind River Mountains, and the range of specific capacity per foot of contribution is probably also similar. Figure 12 shows the distribution of the data.

The approximate relation between specific capacity per foot of contribution and permeability has already been discussed relative to the Wind River Formation. It is expressed as:

$$P = K \left( \frac{Q/s}{m} \right).$$

A value of  $K$  that would apply to the data of the alluvium is probably near 1,500, but there are no permeability data available for comparison.

The probable range of specific capacity per foot of contribution for the alluvium is shown in figure 12. This interpretation assumes that the data adequately represent the alluvium and that the line drawn through the data plot correctly describes the distribution of the data.

The probable range of permeability can be estimated by assuming that the  $K$  value of 1,500 approximately defines the relation between permeability and the specific capacity per foot of contribution. Figure 12 shows that, neglecting the high and low extremes, the probable range of specific capacity per foot of contribution is about 0.1–5 gpm/ft<sup>2</sup>, and the mean is 0.8 gpm/ft<sup>2</sup>. The indicated permeability is about 150–7,500 gpd/ft<sup>2</sup>, and the mean is 1,200 gpd/ft<sup>2</sup>. Two-thirds of the wells in the alluvium will have a specific capacity per foot of contribution between 0.3 and 2 gpm/ft<sup>2</sup> and an indicated permeability of 450–3,000 gpd/ft<sup>2</sup>.

## **GEOLOGIC UNITS IN RELATION TO GROUND WATER**

Most water wells in the area derive water from the Wind River Formation and from alluvium. Consequently, most of the data collected in conjunction with this study concerns these deposits. Discussions of other units are based on limited local well data, on data concerning quality of oil-field waters (Crawford, 1940, 1957; Crawford and Davis, 1962), and on data concerning water in nearby areas (Lowry, 1962; Whitcomb and Lowry, 1967; and unpublished chemical analyses). Lithologic descriptions of the rocks are based largely on published works of other authors. The selected references at the end of the report provide references to more detailed descriptions of the geologic formations and their stratigraphic relations. (See table 1 for descriptions of individual formations.)

### **PRECAMBRIAN ROCKS**

Metamorphic and igneous rocks of Precambrian age are exposed in the Wind River Mountains and in scattered outcrops in the Washakie and Owl Creek Mountains. Yields of as much as 30 gpm may be possible where open fractures or weathered zones occur. Dissolved solids in the water will generally be less than 200 ppm near outcrops. Two springs (B7-1-1ead and B7-1-2aab), which probably derive water from Precambrian rocks, have specific conductances of 200 and 140 micromhos (dissolved solids of less than 150 ppm). Dissolved solids will be greater where the rocks are deeply buried.

### **PALEOZOIC ROCKS**

Paleozoic rocks consist predominantly of limestone, dolomite, and sandstone, but include lesser amounts of chert, shale, siltstone, and claystone. The rocks are mostly gray, brown, and buff, but some are green, red, purple, and white. Outcrops are predominantly gray and

buff. Paleozoic rocks range in thickness from about 1,900 to 3,600 feet. The thickness is greatest in the southwest; the rocks thin eastward and, to a lesser degree, northward. Most Paleozoic rocks are massive; steep cliffs and narrow valleys occur in outcrop areas.

Paleozoic rocks crop out along the flanks of the mountains and are deeply buried in most of the basin. The rocks dip steeply along the northeast slope of the Wind River Mountains toward a deep trough paralleling the range. Northeast of this trough, the rocks are relatively near the surface—but do not crop out—in a central anticlinal structure that runs generally parallel to the Wind River Mountains (pl. 2). The rocks are very deeply buried in the north-central part of the Wind River Basin near Boysen Reservoir, and occur in folded and complexly faulted blocks along the south slope of the Washakie and Owl Creek Mountains. The rocks also crop out along the north slope of the Owl Creek Mountains where they dip regionally northward toward the Bighorn Basin.

Many of the Paleozoic rock units are potentially high yielding aquifers. Yields of more than 1,000 gpm are possible from the rocks comprising the Bighorn Dolomite, Darby Formation, Madison Limestone, and Tensleep Sandstone. Wells tapping similar rocks near Tensleep, Wyoming, in the Bighorn Basin, flow as much as 2,500 gpm (Lowry, 1962). Except in cavernous or intensely fractured zones, permeabilities are not high, but large flows are possible because of thick sections of water-bearing rock and because of high pressures. Where pressures are low, as near outcrops, yields may be relatively low except where the rocks are cavernous or intensely fractured.

Water from Paleozoic rocks commonly contains various gases and oil. Dissolved solids in water from most Paleozoic rocks range from about 300 to 3,000 ppm, but Permian rocks yield water having about 1,000 to more than 10,000 ppm dissolved solids.

Economic drilling depths limit the potential development of ground water from Paleozoic rocks to a narrow belt along the northeast flank of the Wind River Mountains, to a somewhat wider belt along the north flank of the Owl Creek Mountains, and to parts of the central anticlinal structure. Depths to the Paleozoic rocks in the basin may be estimated from the generalized structure contours shown on plate 2. The top of the Paleozoic rocks is about 2,000–3,000 feet below the horizon shown by the contours.

## MESOZOIC ROCKS

### LOWER MESOZOIC ROCKS

The lower Mesozoic rocks (Triassic and Jurassic rocks excluding the Morrison Formation) consist of siltstone, shale, and sandstone and

lesser amounts of limestone, dolomite, and gypsum. The rocks are mostly red, salmon, and green, but some are purple, ochre, gray, tan, and yellow. Outcrops are predominantly red and light green. The lower Mesozoic rocks range in thickness from about 1,400 to 2,200 feet. They are thickest in the southwest and thin eastward and northward. The lower Mesozoic rocks are generally less resistant to erosion than Paleozoic rocks; hills and ridges and moderately broad valleys occur in outcrop areas.

The lower Mesozoic rocks crop out along the flanks of the mountains and on some of the structures within the basin. The rocks dip from the flanks of the Wind River Mountains toward the deep trough paralleling the range. Northeast of this trough, the rocks crop out, or are at relatively shallow depths on the central anticlinal structure and on the structures in the Maverick Springs-Circle Ridge area. The rocks are very deeply buried in the north-central part of the Wind River Basin near Boysen Reservoir and occur in folded and complexly faulted blocks along the south slope of the Washakie and Owl Creek Mountains. The rocks also crop out along the north slope of the Owl Creek Mountains where they dip regionally northward toward the Bighorn Basin.

Moderate to high yields of water may be available from some of the lower Mesozoic rocks. Yields of as much as several hundred gallons per minute may be possible from the Nugget Sandstone. Yields of 20 gpm or more are possible from the Sundance Formation and Crow Mountain Sandstone. Yields of as much as 10 gpm may be possible from some of the other lower Mesozoic rocks, but most of these rocks will yield little, if any, water.

Water from the lower Mesozoic rocks generally contains high concentrations of dissolved solids, but, near outcrops in some locations, the dissolved solids are less than 1,000 ppm. Some oil-field waters have dissolved solids of more than 20,000 ppm.

Economic drilling depths limit the potential development of ground water from lower Mesozoic rocks to narrow belts along the flanks of the mountains and to parts of the major anticlinal structures within the basin. Depths to the lower Mesozoic rocks in the basin may be estimated from the generalized structure contours shown on plate 2. The top of this sequence of rocks, the top of the Sundance Formation, is about 350–650 feet below the horizon shown by the contours.

#### UPPER MESOZOIC ROCKS

The upper Mesozoic rocks (Cretaceous rocks and the Morrison Formation) consist of shale and sandstone and lesser amounts of siltstone, claystone, conglomerate, coal, and bentonite. The rocks are mostly

gray, black, and brown, but some are buff, red, purple, and white. Outcrops are predominantly gray and brown. The upper Mesozoic rocks range in thickness from about 4,000 to 12,000 feet. The thickness is greatest in the north-central and east-central parts of the area. The rocks are mostly nonresistant shale and soft sandstone, but some are resistant beds of harder sandstone. Broad shallow valleys separated by numerous hogbacks and cuestas occur in outcrop areas.

The youngest of the upper Mesozoic rocks were removed by erosion in the southwestern half of the area before rocks of Eocene age were deposited. Remaining upper Mesozoic rocks crop out in a thin belt along the flanks of the Wind River Mountains and on the central anticlinal structure. The complete section of upper Mesozoic rocks is exposed on structures in the north-central part of the area; eastward, near Boysen Reservoir, they are deeply buried. Part of the section is exposed at Alkali Butte in the southeast corner of the area. The rocks also crop out along the north slope of the Owl Creek Mountains where they dip regionally northward toward the Bighorn Basin.

Moderate to high yields of water may be available from some of the upper Mesozoic rocks but most yields will be low. Yields of as much as several hundred gallons per minute may be available from the Cloverly and Morrison Formations and from the Mesaverde and Lance(?) Formations. Yields of as much as 50 gpm may be available from sandstone of the Frontier and Meeteetse Formations. Yields of as much as 20 gpm may be possible from sandstone beds in the Mowry and Thermopolis Shales and Cody Shale.

Dissolved solids generally range from about 1,000 to 5,000 ppm, but may be much higher in some oil-field waters. In some areas, water with less than 1,000 ppm dissolved solids may be available from the Cloverly and Morrison Formations.

Economic drilling depths limit the potential development of ground water from upper Mesozoic rocks to the major anticlinal structures within the basin. The generalized structure contours (pl. 2) show the top of the Cloverly Formation, which is about 350–650 feet above the base of the upper Mesozoic rocks.

## CENOZOIC ROCKS

### TERTIARY ROCKS

#### FORT UNION FORMATION

The Fort Union Formation consists of interbedded sandstone, conglomerate, shale, and siltstone. The rocks are gray, olive, buff, brown, and tan; some zones are red and purple. The thickness ranges from 0 to about 7,000 feet. The rocks are thickest in the north-central part of

the Wind River Basin near Boysen Reservoir; they thin toward the southwest.

The Fort Union Formation is not present southwest of the central anticlinal structure but crops out along the northeast side of this structure, on Alkali Butte, and in the Shotgun Butte area. It underlies rocks of Eocene age in the center of the basin.

The few water wells in the area that tap the Fort Union Formation have yields of less than 10 gpm of water having dissolved solids of about 1,000 ppm. These wells tap only a small part of the formation. The potential yield of a well tapping the complete formation could be as much as several hundred gallons per minute. Existing wells, which are near outcrops, provide water that is of better quality than water from most of the formation. Generally, dissolved solids in water from the Fort Union would range from about 1,000 to 5,000 ppm.

#### INDIAN MEADOWS FORMATION

The Indian Meadows Formation or equivalent rocks underlie the Wind River Formation in much of the basin, but are not differentiated in the subsurface. The Indian Meadows consists of conglomerate, sandstone, claystone, siltstone, and some limestone. The rocks are brick red and variegated red, purple, lavender, tan, gray, green, buff, brown, and white; reddish colors are generally predominant. The thickness ranges from 0 to about 3,000 feet. The formation crops out in the northern and northwestern parts of the area but not in the southern part.

The Indian Meadows Formation is a potential aquifer, but no water wells are known to tap it. Yields of as much as 50 gpm may be possible, but some of the rocks will not yield water. Dissolved solids probably range from about 1,000 to 5,000 ppm.

#### WIND RIVER FORMATION

The Wind River Formation consists of sandstone, conglomerate, siltstone, claystone, and shale; some parts of the formation contain small amounts of bentonite, tuff, and limestone. The rocks are partly gray, green, and yellow; partly red, maroon, and brown; and partly varicolored. The thickness ranges from 0 to about 5,000 feet.

A diagrammatic section (fig. 13) shows the approximate relations of the major facies of part of the Wind River Formation in the eastern part of the reservation, east and north of the central anticlinal structure. The diagram and the following discussion are based on interpretation of published descriptions of the formation, on oil-well logs, and on data obtained from test drilling (table 5). This interpretation of the relations is oversimplified and should be regarded as preliminary.

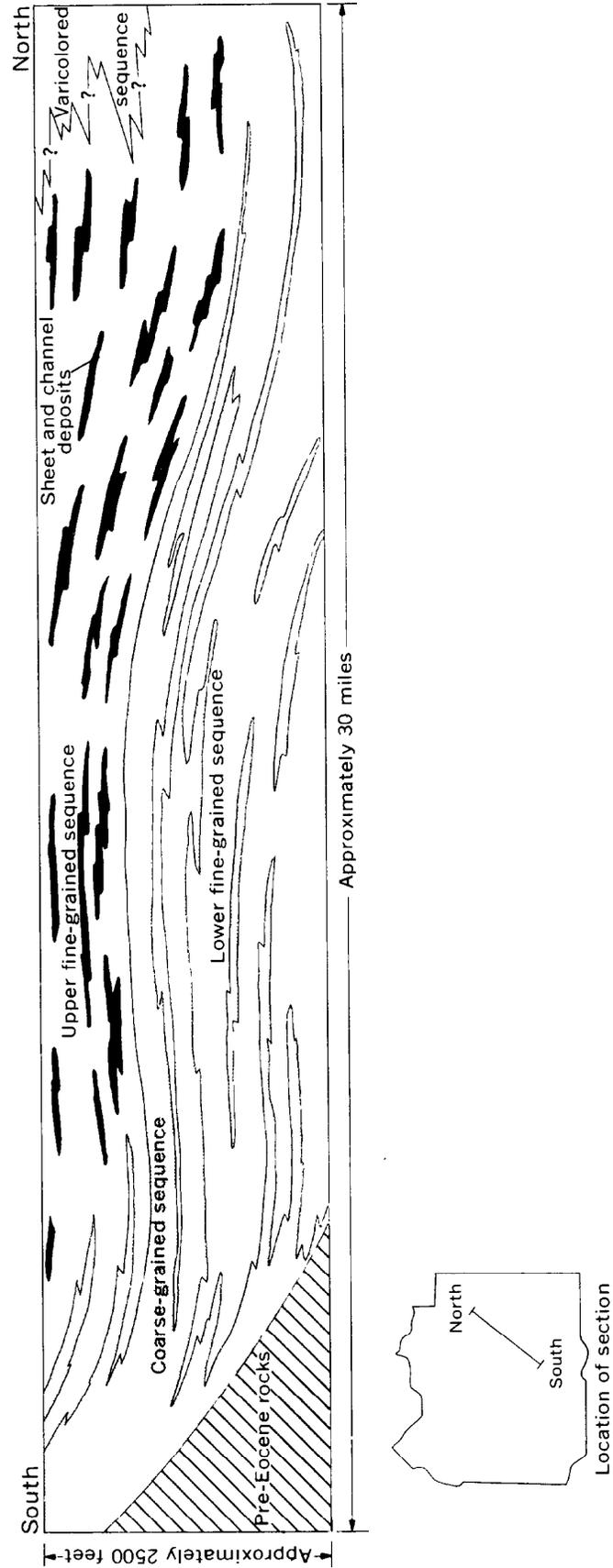


FIGURE 13.—Diagrammatic section showing approximate relations of major facies of part of the Wind River Formation.

Further refinement of the relations would require investigations beyond the scope of this report. Although preliminary, the relations as presented form a reasonable basis for exploration for water in the formation.

The oldest Eocene rocks shown on the diagram are the lower fine-grained sequence of the Wind River Formation, which is probably several thousand feet thick. These rocks are mostly brown, maroon, red, and gray siltstone and shale and some sandstone. Undifferentiated older rocks of the Wind River Formation and rocks of the Indian Meadows Formation underlie the sequence, but are not shown on the diagram (fig. 13). The lower fine-grained sequence is overlain by, and intertongues toward the south with, a coarse-grained sequence.

The main body of the coarse-grained sequence is probably about 1,000 feet thick along the northeast side of the central anticlinal structure, but the sequence thins toward the northeast. The rocks consist of green and gray, largely arkosic sandstone, conglomerate, and siltstone. Many of the coarse-grained sandstone and conglomerate beds are very well sorted, loosely cemented, and very porous. The coarse-grained sequence crops out along the northeast side of the central anticlinal structure and north of Alkali Butte. On the outcrop, most of the rocks have weathered to rusty tan and yellow colors. The coarse-grained sequence intertongues with and underlies an upper fine-grained sequence.

The upper fine-grained sequence is at the surface in most of the eastern part of the reservation. The maximum thickness of the sequence is about 800 feet in most of the area, but it is thicker in the northeast near the structural trough (pl. 2). These rocks are mostly gray and green siltstone, shale, and sandstone, but there are also thin beds of red, maroon, and green siltstone and shale. Toward the north, the red, maroon, and green rocks are thicker and become a large part of the sequence. Numerous sheet and channel deposits of brown siltstone and sandstone occur in the sequence.

The youngest rocks of the Wind River Formation in the eastern part of the reservation are a complex varicolored sequence that occurs along the north margin of the basin. These rocks are grouped together for simplicity because they are poorly known, but they contain several facies and probably exceed 1,000 feet in maximum thickness. The rocks consist of claystone, siltstone, shale, sandstone, conglomerate, and limestone. They are generally colorful; red, green, yellow, maroon, and violet are common. Most of the rocks are composed of Paleozoic and Mesozoic rock fragments. Relations of the varicolored sequence in the northeastern part of the reservation with other rocks of the Wind River Formation are assumed to be as shown in figure 13.

In the western part of the reservation, the rock sequences are similar to those in the eastern part. The basin, however, is narrower in the west, and conglomeratic rocks along the margins of the basin are a larger part of the formation and the basinward finer grained facies, a lesser part. The lower fine-grained sequence is probably represented in the deep part of the structural trough (pl. 2) west and south of the central anticlinal structure. Rocks similar to the coarse-grained sequence are present and crop out in many places along the Wind River valley. Along the margin of the basin to the southwest, the sequence becomes largely conglomeratic. The upper fine-grained sequence is present and intertongues northward with conglomerate and brightly colored finer grained rocks that are similar to the varicolored sequence present in the east. Overlying the upper fine-grained sequence and parts of the varicolored sequence are 200–300 feet of tuffaceous rocks, which consist mostly of buff sandstone and white and pink tuff.

Most wells in the Wind River Formation tap sandstone of the upper fine-grained sequence. Yields are as much as 50 gpm, but most wells have lower yields. The most productive aquifers are in the coarse-grained sequence. Wells tapping these rocks, as in the Riverton well field, yield as much as 500 gpm. Few, if any, wells tap the other rocks of the Wind River Formation.

The Wind River Formation contains water having dissolved solids that generally range from about 200 to 5,000 ppm. Most of the water in the upper fine-grained sequence contains more than 1,500 ppm of dissolved solids. Water with lower concentrations of dissolved solids, however, occurs in some sandstones where recharge water contains low concentrations of dissolved solids and where the water infiltrates through rocks containing small amounts of soluble salts.

Water from many wells tapping the coarse-grained sequence has dissolved solids of 200–1,000 ppm; however, some rocks in this sequence have water containing very high concentrations of dissolved solids. Most wells that yield water containing dissolved solids of less than 1,000 ppm, including the Riverton well field, tap the coarse-grained sequence at altitudes lower than where the sequence is crossed by the Wind and Little Wind Rivers (Kinnear and Johnstown Valleys along the Wind River south of Morton, and about 5 miles west of Arapahoe on the Little Wind River). These are assumed to be principal recharge areas for part of the coarse-grained sequence.

The Wind River Formation has a large potential for continued development. Water of quantity and quality suitable for stock use is available from the formation in almost any area, although well depths of 500 feet or more will be necessary in a few places. Wells yielding several hundred gallons per minute are possible from some aquifers in

the coarse-grained sequence. Water of quality suitable for drinking or other uses requiring low concentrations of dissolved solids is available from some aquifers of the formation. The dissolved solids and specific-conductance data shown on plate 1 indicate the quality of water and the depths at which it is found locally.

#### OTHER TERTIARY ROCKS

Other Tertiary rocks in the area are the Aycross, Tepee Trail, and Wiggins Formations and an unnamed tuff. These rocks consist of conglomerate, breccia, tuff, sandstone, and claystone. Volcanic rock fragments and tuff are predominant. Colors are pink, white, green, olive, brown, yellow green, and gray. The combined thickness ranges from 0 to more than 3,000 feet. The rocks and their equivalents have been removed by erosion from most of the area. The Aycross, Tepee Trail, and Wiggins occur only in the northwest corner of the area. The unnamed tuff is present only along the north margin of the basin near Boysen Reservoir.

The rocks are largely drained because of their high topographic position. Where they contain water, yields of as much as 50 gpm may be possible; but no water wells are known to tap them in the area. Water from most of these rocks would probably contain less than 2,000 ppm of dissolved solids.

#### QUATERNARY ROCKS

A few deposits of travertine occur along the northeast slope of the Wind River Mountains in the western part of the area. They are associated with dissected high terraces and may yield water locally to springs. Landslide and steep-slope colluvial deposits occur along the margins of the mountain ranges. These rocks may also yield water locally to springs. Glacial deposits occur in and along the northeast flank of the Wind River Mountains. They are described in detail by Richmond and Murphy (1965) and by Murphy and Richmond (1965). Some of the glacial deposits will yield water. (See table 1.)

#### TERRACE AND PEDIMENT DEPOSITS

Remnants of many terraces and pediments occur throughout the basin and along the margins of the mountains. Deposits that consist predominantly of gravel, sand, and cobbles underlie these surfaces to depths of as much as about 80 feet, but generally the thickness is less than 30 feet.

These deposits are largely drained except in irrigated areas. Thin saturated zones probably underlie some of the more extensive nonirrigated terraces and would yield a few gallons per minute. This water would probably contain more than 1,500 ppm dissolved solids.

Deposits underlying irrigated terraces will contain water, at least through the irrigation season. The saturated thickness will decrease after irrigation ceases, and some of these deposits may be nearly drained before irrigation resumes. Potential yields range from a few gallons to a few hundred gallons per minute and depend to a large extent on the thickness of saturation. The water will generally contain about 300–2,000 ppm dissolved solids, but the concentration may be much higher in areas of poor drainage. The quality will change seasonally because of the irrigation, and the concentration of dissolved solids will be highest in the spring before irrigation begins.

#### SLOPE WASH AND ALLUVIUM

Deposits mapped as slope wash and alluvium on the geologic map (pl. 2) include slope wash, slope wash and interbedded or underlying alluvium, and alluvium of smaller stream valleys where slope wash and alluvium have not been mapped separately. The thickness of these rocks range from 0 to about 80 feet. Slope wash is generally fine grained and consists predominantly of silt, clay, and sand. Alluvium is both fine and coarse grained.

In the upper reaches of many of the stream valleys, the alluvium has not been mapped separately from slope wash. Yields of a few gallons per minute are available from many of these rocks.

In the Mill Creek valley, alluvium interbeds with and underlies slope wash. The alluvium consists predominantly of sand and gravel, and the slope wash is predominantly sand and silt. Sections of these rocks are shown on plate 3. Yields of a few to several hundred gallons per minute are available. Dissolved solids range from about 500 to 5,000 ppm.

In Kirby Draw and Beaver Creek valley in the southeast, the alluvium is predominantly sand and silt; slope wash and alluvium are very similar and have not been mapped separately. Sections of the alluvium of Kirby Draw are shown in figure 14. A few test holes augered in the Beaver Creek valley penetrated similar deposits. Part of the alluvium is well-sorted sand and very fine gravel that would probably yield as much as 20 gpm. Chemical analyses (table 6) indicate that water having dissolved solids of about 1,500 ppm is available from shallower wells in at least parts of the valleys. Some of the water in the deeper part of the alluvium contains more than 4,000 ppm dissolved solids, as is shown by the analysis of water from well D1-5-11bdd (table 6).

North of the Wind River in the central part of the basin, the rocks consist mostly of fine-grained slope wash and poorly sorted fine- to coarse-grained alluvium that underlies slope wash. These rocks contain water in some places, but mostly they are thin, tight, or drained.

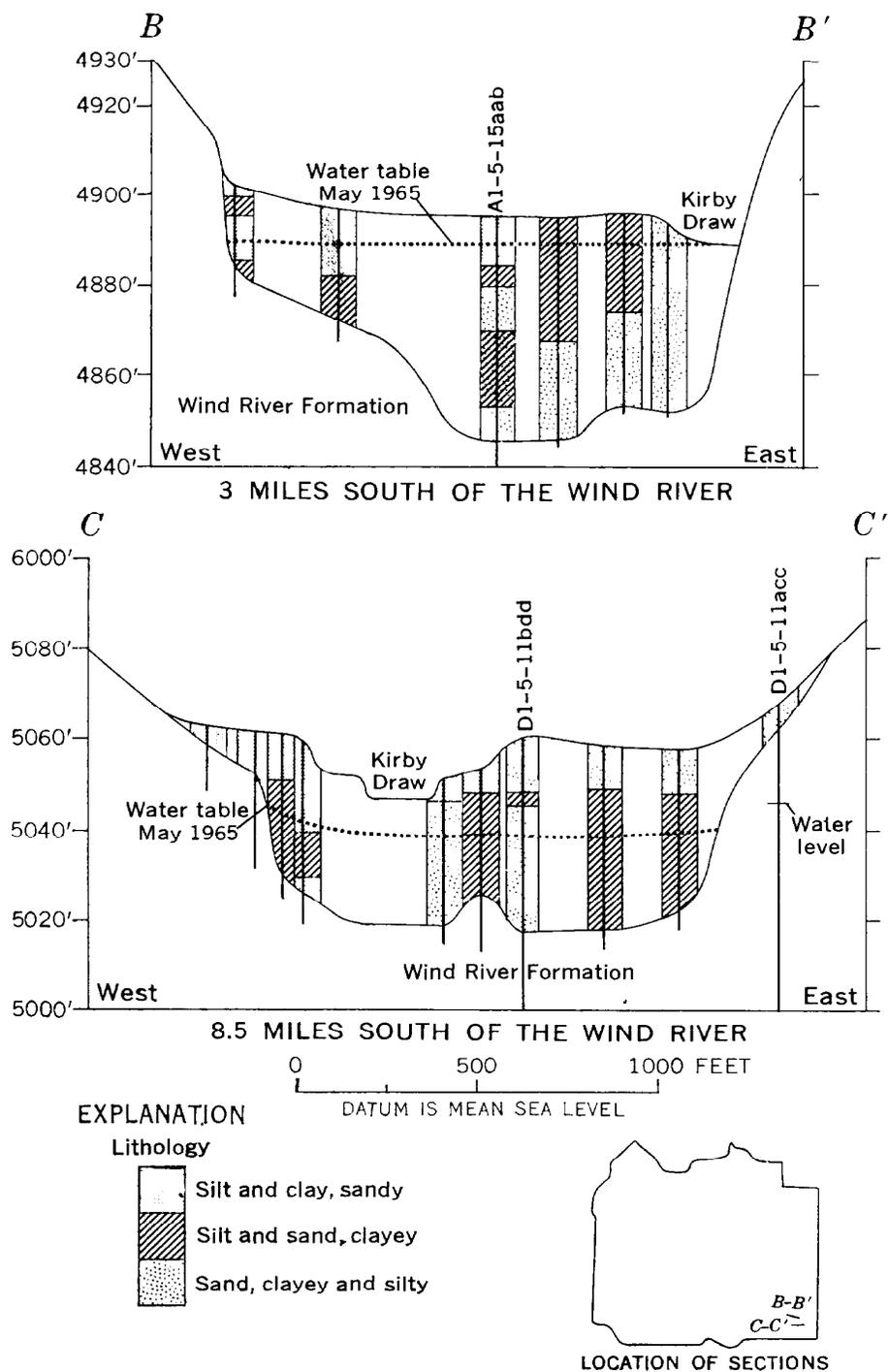


FIGURE 14.—Sections of alluvium in Kirby Draw. Lines of sections are shown on geologic map. Numbered holes are cased wells for which data are given in tables.

Where they will yield water, less than 20 gpm would generally be expected. The water probably contains about 1,000–5,000 ppm dissolved solids.

#### ALLUVIUM OF FLOOD PLAINS AND RELATED LOW TERRACES

Deposits mapped as alluvium of flood plains and related low terraces (pl. 2) are of two general types, coarse grained and relatively fine grained. The thickness ranges from 0 to about 100 feet, but most of the alluvium is less than 40 feet thick.

Alluvium is generally coarse grained in the Wind River valley and in the valleys of those tributaries that flow northeastward from the Wind River Mountains. Representative sections of alluvium in these valleys are shown on plate 3. Crow Creek valley in the northwest and Owl Creek valley along the northern border of the area also have generally coarse-grained alluvium. Gravel, sand, and cobbles are predominant; silt, clay, and boulders are present in lesser amounts. Yields of a few to several hundred gallons per minute are available from these rocks. The water will contain about 200–2,000 ppm dissolved solids.

Alluvium in the valleys of Fivemile, Muddy, and Cottonwood Creeks is relatively fine grained. Sand and silt are predominant; clay, gravel, and cobbles are present in lesser amounts. Yields of a few gallons per minute are available from some of these rocks. The water from most of these rocks probably contains about 1,000–2,000 ppm dissolved solids.

#### CHEMICAL QUALITY OF WATER

Chemical analyses of 146 ground-water samples are given in table 6. In addition to the data in the table, specific conductance and dissolved solids for water from many wells are given on plate 1. Dissolved-solids data from Geological Survey analyses are not shown on plate 1 if data from other sources are available because Geological Survey analyses are given in table 6. Most of the dissolved-solids data on plate 1 are from chemical analyses made by the Wyoming State Department of Agriculture or by the U.S. Bureau of Reclamation. The specific-conductance data on plate 1 were collected in the field during this study.

Chemical analyses of surface waters collected at five sampling stations are given in table 7. Locations of four of the stations are shown on plate 1; the other station is at Dubois about 10 miles west of the reservation. Additional chemical analyses of surface waters of the area have been published in Colby and others (1956) and in the annual series of water-supply papers, "Quality of Surface Waters of the United States."

### WATER-QUALITY CRITERIA

The quality of a water is judged according to the use for which it is needed. Generally, the lower the dissolved solids, the better the water; however, for some uses, the concentration of particular substances in a water may be even more important than the total concentration of dissolved solids. Some general criteria for evaluating water for common uses are discussed below. More detailed information may be obtained from the publications cited in the discussion.

#### DOMESTIC AND MUNICIPAL USE

Chemical-quality standards for potable water used by public carriers and by others subject to Federal quarantine regulations have been established by the U.S. Public Health Service (1962). These standards concern bacteria, radioactivity, and chemical constituents that may be objectionable in a water supply. The following is a partial list of the standards that pertain only to those constituents for which analyses are given in this report:

The following chemical substances should not be present in a water supply in excess of the listed concentrations where \* \* \* other more suitable supplies are or can be made available. (U.S. Public Health Service, 1962)

<i>Substance</i>	<i>Recommended limit (concentration in ppm)</i>
Chloride (Cl) .....	250
Fluoride (F) .....	0.8-1.7
Iron (Fe) .....	.3
Nitrate (NO <sub>3</sub> ) .....	45
Sulfate (SO <sub>4</sub> ) .....	250
Total dissolved solids.....	500

Fluoride limits are based on the average of maximum daily air temperatures in order to relate the limit to total consumption. For example, when the average is 50.0°-53.7° F, the upper limit is 1.7 ppm; when the average is 79.3°-90.5° F, the upper limit is 0.8 ppm.

Iron in water tends to stain porcelain fixtures and laundry and can be tasted. Nitrate in excess of the recommended concentration presents a potential danger if the water is used for infant feeding. Sulfate in concentrations above the recommended limit may have a laxative effect.

Excessive hardness in water is determined for domestic and municipal use and some industrial uses. It is defined as the property that causes soap to form an insoluble curd. It is also a major contributor to the scale that forms in boilers and pipes. Calcium-magnesium hardness values reported in the analyses (tables 6, 7) are approximately equivalent to the total hardness of a water. Calcium and magnesium

cause most of the hardness of natural water; other hardness-causing constituents are generally negligible. Part of the hardness can be removed from water by heating, and an insoluble precipitate or scale is formed. The precipitate is a compound of carbonate, and that part of the hardness that is removed is called carbonate hardness. The remaining hardness is the noncarbonate hardness reported in the analyses. Methods used by the Geological Survey to calculate hardness are given in Rainwater and Thatcher (1960). Adjectival ratings used by the Geological Survey to describe hardness are:

<i>Calcium-magnesium hardness as CaCO<sub>3</sub> (ppm)</i>	<i>Adjectival rating</i>
0-60.....	Soft
61-120.....	Moderately hard
121-180.....	Hard
181+.....	Very hard

### AGRICULTURAL USE

#### STOCK

The tolerance of animals to dissolved solids in water depends on the species, age, and physiological condition of the animal; on the amount of water consumption; and on the quantity and type of salts present in the water. However, standards for most of these factors have not been determined, and general standards based on the total concentration of dissolved solids are used. McKee and Wolf (1963) discuss some of the criteria that have been used. Beath and others (1953) suggest the following classification as a guide for evaluating stock water in Wyoming.

<i>Classification</i>	<i>Dissolved solids (ppm)</i>
Good.....	Under 1,000
Fair (usable).....	1,000-3,000
Poor (usable).....	3,000-5,000
Very poor (questionable).....	5,000-7,000
Not advisable.....	7,000 and over

#### IRRIGATION

Boron, bicarbonate, sodium, and salinity are the principal hazards related to the chemical character of water for irrigation use.

Boron is an essential plant nutrient, but even very low concentrations may be toxic to boron-sensitive crops. Eaton (1935) has classified crops according to their tolerance to boron. For boron-sensitive crops, concentrations of less than about 0.7 ppm have very slight effect; higher concentrations have significant yield depression or may be unusable. For tolerant crops, concentrations of less than 2.0 ppm have very slight effect (Scofield, 1936).

When bicarbonate concentrations are high, calcium and magnesium tend to precipitate as carbonates. The calcium-magnesium concentra-

tion is thereby reduced, and the relative proportion of sodium is increased.

When the sodium concentration in water is high compared with that of calcium and magnesium, sodium replaces calcium and magnesium in the soil and a sodium soil remains. Sodium soils may be improved by adding amendments, such as gypsum, which replenish the calcium or magnesium. An index of the sodium hazard is the sodium-adsorption-ratio (SAR) which expresses the relative activity of sodium ions in the exchange reactions with soil (U.S. Salinity Lab. Staff, 1954).

Salinity (dissolved solids) increases the osmotic pressure in the soil solution, and when salinity is high, plant growth is retarded. Because the salinity of water is closely related to the specific conductance of water, specific conductance may be used as a measure of the salinity hazard of water.

Specific conductance and SAR for water from alluvium are plotted (fig. 15) on a diagram (U.S. Salinity Lab. Staff, 1954) that is used for classification of water for irrigation. Other water may be classified in the same manner by use of this diagram. The water is classified according to salinity and sodium hazards as follows:

#### *Salinity hazard*

##### *Class*

1. Low-salinity water can be used for irrigation of most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.
2. Medium-salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control.
3. High-salinity water cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity may be required and plants with good salt tolerance should be selected.
4. Very high salinity water is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt tolerant crops should be selected.

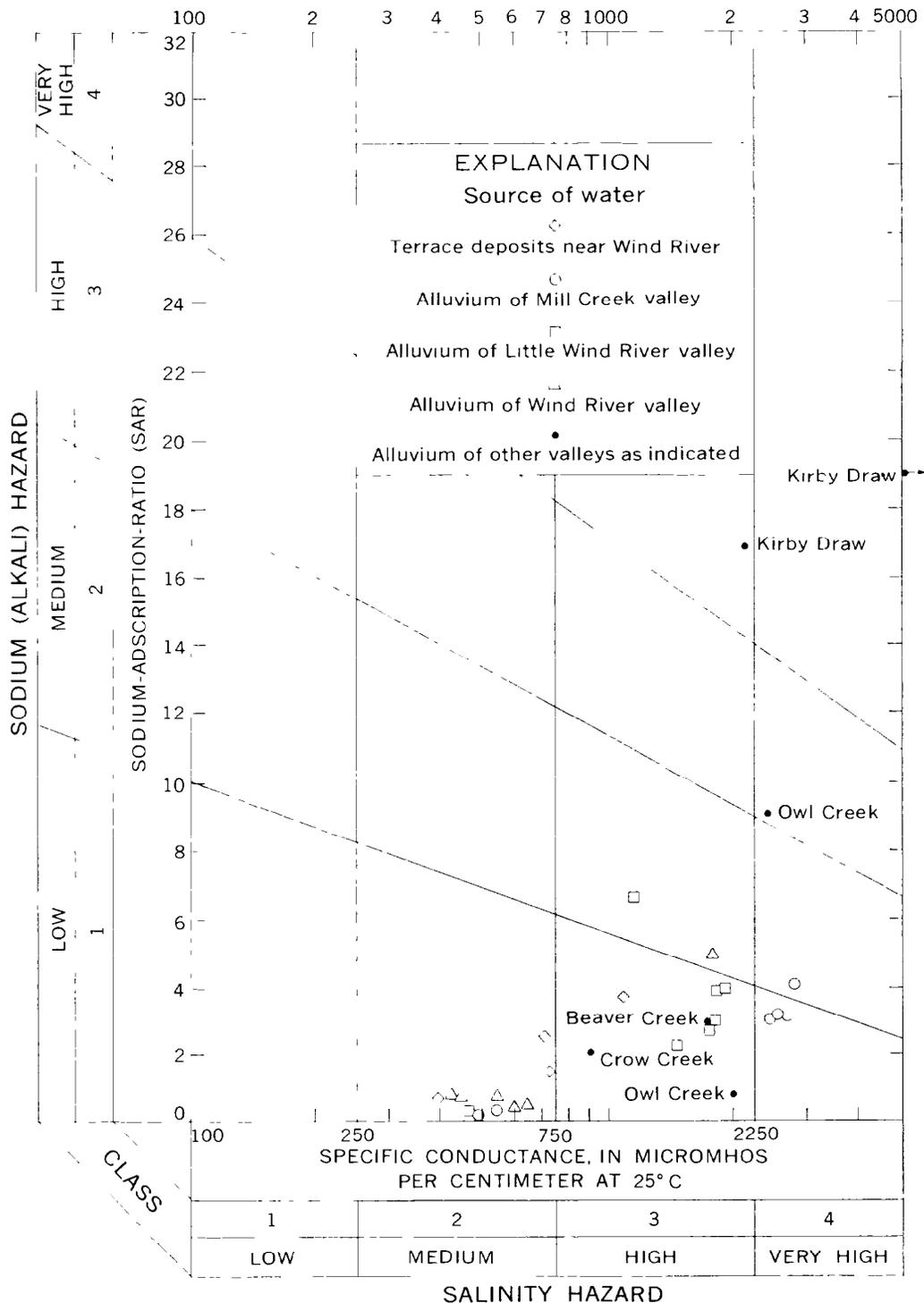


FIGURE 15.—Classification of water from alluvium for irrigation use. Diagram adapted from U.S. Salinity Laboratory Staff, 1954.

*Sodium hazard**Class*

1. Low-sodium water can be used for irrigation on almost all soils with little danger of the development of a sodium problem. Sodium-sensitive crops, however, may accumulate injurious amounts of sodium in the leaves.
2. Medium-sodium water may present a moderate sodium problem in fine-textured (clay) soils unless there is gypsum in the soil. This water can be used on coarse-textured (sandy) or permeable organic soils.
3. High-sodium water may produce troublesome sodium problems in most soils and will require special management, good drainage, high leaching, and additions of organic matter. If there is plenty of gypsum in the soil, a serious problem may not develop for some time. If gypsum is not present, it or some similar material may have to be added.
4. Very high sodium water is generally unsatisfactory for irrigation except at low- or medium-salinity levels where the use of gypsum or some other amendment makes it possible to use such water.

**INDUSTRIAL USE**

Water-quality criteria for industrial use vary widely according to use. Some industries have strict quality requirements. Requirements for cooling and waste disposal are generally lenient, although certain waters may require treatment to prevent corrosion and scale. Criteria for many industrial uses are given in McKee and Wolf (1963, p. 92-106).

**QUALITY OF SURFACE WATER**

The Geological Survey maintains sampling stations near Dubois on the Wind River (about 10 miles west of the reservation), near Riverton on the Wind and Little Wind Rivers, near Arapahoe on the Little Wind River, and near Hudson on the Popo Agie River. Dissolved solids in the Wind River near Dubois range from about 50 to 300 ppm (Colby and others, 1956). The Wind River at Riverton contains a calcium bicarbonate water that is moderately hard to hard; dissolved solids range from about 150 to 350 ppm. Analyses show an appreciable increase in sulfate downstream from Dubois. Much of the water from the Wind River is diverted for irrigation on the Riverton Irrigation Project, but the return flow is discharged into the river by way of Fivemile Creek downstream from the sampling station at Riverton.

Dissolved solids in the Little Wind River near Riverton range from about 300 to 850 ppm; water in the Popo Agie River near Hudson is

probably similar, but water in the Little Wind River above Arapahoe has a high concentration of dissolved solids. Water from these streams is used extensively for irrigation, and much of their flow in downstream reaches during the irrigation season is return flow from irrigation.

Fivemile Creek is used as a drain for the Riverton Irrigation Project. The surplus irrigation water and seepage of ground water from the irrigated land has made the formerly intermittent stream a perennial stream. The water is a sodium sulfate type, very hard, and dissolved solids range from about 1,000 to 4,000 ppm (Colby and others, 1956).

### QUALITY OF GROUND WATER

Most of the geologic formations in the area have few, if any, wells, and little or no data are available concerning the quality of the ground water in them. A relatively large amount of data is available concerning the quality of the water in the Wind River Formation and in some of the alluvium. Chemical-quality data are presented in table 6 and on plate 1. General estimates of the dissolved solids that may be expected in water from the formations are included with the discussion of the geologic units in the text and in table 1.

### DRAINAGE PROBLEMS IN IRRIGATED AREAS

#### HISTORY OF IRRIGATION

Irrigation began in the early 1860's with simple diversions of water from the Popo Agie and Little Wind Rivers. In 1905 the Wind River Irrigation Project was established on lands under supervision of the Bureau of Indian Affairs. The Wyoming No. 2 canal was built near Riverton in 1907 on land ceded by the Indians. About 1914 the Riverton-Le Clair Irrigation District was formed. In 1920 the Bureau of Reclamation began construction of the Riverton Irrigation Project in the Fivemile Creek drainage; the project was expanded in 1951 to include areas in the Muddy Creek drainage. (See locations of projects and irrigated areas on pl. 3.)

Irrigation began about 1880 in the Owl Creek valley. Several unsuccessful attempts have been made to augment and stabilize the supply of water in Owl Creek, but irrigation in the valley remains dependent on uncontrolled runoff supplemented to a small degree by ground water.

More detailed information on the history of irrigation in the Wind River Reservation can be found in Gerharz (1949), U.S. Bureau of Indian Affairs (1962), and U.S. Bureau of Reclamation (1950).

## AREAS OUTSIDE THE WIND RIVER IRRIGATION PROJECT

The discussion of drainage problems is confined to those of the Wind River Irrigation Project, which is under the supervision of the Bureau of Indian Affairs. Other irrigated areas are under the supervision of individuals, private irrigation districts, or the Bureau of Reclamation.

Much detailed work has been done by the Bureau of Reclamation in the study and control of drainage and related problems in the Riverton Irrigation Project. Some work has also been done in the Riverton-Le Clair and Owl Creek Irrigation Districts. Unpublished reports and maps have been prepared by the Bureau of Reclamation. A Geological Survey report on the ground-water resources of the Riverton Irrigation Project (Morris and others, 1959) contains a discussion of drainage problems.

## AREAS IN THE WIND RIVER IRRIGATION PROJECT

### PREVIOUS DRAINAGE STUDIES

The first recorded drainage canal on the Wind River Irrigation Project was constructed about 1918. The first comprehensive drainage plan, presented by Gerharz (1949), included the location and design of proposed drainage facilities. The plan was based on topographic mapping of problem areas and on some subsurface investigation.

A more detailed drainage investigation was conducted from 1960 to 1965 by Missouri River Basin Investigations (U.S. Bur. Indian Affairs, 1965). Drainage-problem areas of the Left Hand unit, the flood plains of the Sub-Agency system near Arapahoe, the underfit-stream valleys of Mill and Trout Creeks, and the area just east of Ray Lake (pl. 3) were intensely studied and drainage facilities were proposed. Holes were augered in a grid pattern approximately every eighth of a mile, and pipes were installed approximately every quarter of a mile to observe water levels. Hole depths were 9–14 feet (lengths of the auger stem), except where coarse deposits limited augering to shallower depths. Maps were constructed showing the depth to gravel based on auger data. Water levels were measured frequently, and maps were prepared showing water-table conditions at various times during both irrigating and nonirrigating seasons for the years 1961 through 1963. The maps show the depth to water and water-table and land-surface contours. In addition to the areas of intensive study, the investigation included a reconnaissance of the other drainage-problem areas in the Wind River Irrigation Project.

Soil studies have been made, and the lands have been mapped and classified. One such study was made for the Branch of Land Operations

as a part of a resource inventory of the reservation (U.S. Bur. Indian Affairs, 1962).

Two reports are now in preparation concerning the Wind River Irrigation Project in general and will include information on drainage. "The Wind River Irrigation Project Completion Report," is in preparation by Missouri River Basin Investigations. The "Report on the Wind Division, Wyoming," is in preparation by the Bureau of Reclamation and will include relations of the Wind River Irrigation Project to other existing or proposed developments in the Wind River Basin.

#### METHODS FOR IMPROVING DRAINAGE

Methods commonly used to improve drainage are discussed in detail in publications on drainage engineering such as that by Luthin (1957). Methods that are, or could be, used in relieving drainage problems in the Wind River Irrigation Project include the reduction of applied water and the use of drains or wells to remove excess water.

Open drains about 8 feet in depth are used to lower water tables; they increase gradients locally and provide channels for water transport. They are also used to intercept the lateral movement of ground water. Shallower drains, less than 4 feet in depth, are in use in some parts of the area, but they have a limited effect on the water table. Buried drains increase gradients, provide channels for water transport, and have the general effect of increasing the permeability of the material in which they are buried.

Relief wells can be used to make drains more effective where deposits of low permeability extend below practical drain depths but overlie more permeable gravel. The relief wells are constructed in the bottom of drains and are drilled into the underlying gravel. They provide a direct hydraulic connection between the drain and the gravel, and water flows from the wells into the drains.

Pumping from wells can lower the water table and drain waterlogged areas where geologic conditions are suitable. Pumping from sumps or from drains can be used effectively to move water from a waterlogged area, and they can be particularly useful where the gradient between the waterlogged area and the ultimate surface drainage is flat and conditions are not favorable for pumping from wells. The water obtained by pumping would be available for irrigation, and the amount of surface water used could be reduced.

Reduction of the amount of water entering an area may be essential in some areas. The lining of canals and ditches and the reduction of irrigation-water applications to an optimum would relieve the load on the drainage system.

### CLASSIFICATION AND EVALUATION OF DRAINAGE-PROBLEM AREAS

The present study is limited chiefly to the relation of drainage problems to geology. Most irrigated lands are unconsolidated slope wash or stream deposits underlying flood plains, terraces, or gentle slopes. Test holes were drilled through these deposits to define their composition and thickness. Sections at nine locations are shown on plate 3. On the basis of the test drilling, the alluvium was divided into coarse-grained alluvium and fine-grained alluvium. The coarse-grained alluvium consists of sand, gravel, cobbles, and boulders and contains very little silt or clay; it generally lies on the bedrock. The fine-grained alluvium grades from a silty soil zone formed on sand and gravel of flood plains and terraces to slope wash of clay, silt, and sand.

Terms used to describe permeability in the discussion of the drainage problems have arbitrarily been given the values: "Low," less than 10 gpd/ft<sup>2</sup>; "moderate," 10–100 gpd/ft<sup>2</sup>; and "high," greater than 100 gpd/ft<sup>2</sup>.

Areas of the Wind River Irrigation Project where drainage problems occur were mapped by the U.S. Bureau of Indian Affairs (1965) and are shown on plate 3. For this report, the drainage-problem areas have been classified according to geologic similarities into five general groups: flood plains, terraces, underfit-stream valleys, slopes, and transitional areas.

#### FLOOD PLAINS

Many of the drainage-problem areas occur on the flood plains and related low terraces in the river valleys. In these areas, highly permeable coarse-grained alluvium underlies fine-grained alluvium of low to high permeability. Downstream land-surface gradients range from about 20 to 50 feet per mile, but gradients across the valleys, toward the rivers, are generally less than 5 feet per mile. The water-table gradient is approximately parallel to that of the land surface; accordingly, most ground-water movement is parallel to the river rather than toward it. Water tables are naturally high, and some of the area was probably waterlogged before addition of irrigation water. The problem is aggravated in some areas where water from terrace deposits discharges into the flood-plain deposits.

#### LEFT-HAND UNIT

As section A–A' and B–B' (pl. 3) show, the land surface of this area is about 5–8 feet above the level of the Wind and Little Wind Rivers. The water table ranges from the land surface to a depth of about 8 feet. The total thickness of the alluvium is 10–15 feet in most

of the area. It consists of highly permeable coarse-grained alluvium overlain by 6 feet, or less, of moderately to highly permeable fine-grained alluvium.

Barriers of low permeability probably contribute to the drainage problems in some areas, but the principal problems are the low gradient and the naturally high water table. Left-Hand Canal and its distribution ditches are unlined and add water to the alluvium. Springs, which are visible along the terrace scarps in several places, are evidence that the irrigated terraces to the south contribute some water.

The alluvium is underlain by siltstone and sandstone of the Wind River Formation. Water in the sandstone in contact with the alluvium is hydraulically connected to the water table in the alluvium. Some deeper sandstones have piezometric heads about the water table, which suggests the possibility that the bedrock could contribute some water to the alluvium. Generally, however, layers of relatively impermeable siltstone separate the deeper sandstones from the alluvium. Water from the bedrock probably has no significant effect on the drainage problems.

Drainage problems would be alleviated by reducing the amount of water entering the area. Steps that would improve drainage include the lining of canals and ditches and the reduction of irrigation-water applications to the optimum. Drains would be effective for intercepting canal losses, but would be only partially effective in lowering the water table because of flat gradients across the valley.

The use of wells to aid drainage does not seem feasible because of the thinness of the alluvium. A pumping test on well A 1-4-31dc showed a maximum yield of about 5 gpm. (See discussion on test under "Aquifer characteristics.") A much larger yield would be necessary to lower the water table significantly. Pumping from sump pits or from drains, however, could produce larger discharges and, if pumped into a lined canal system, the water table could be lowered. Ground water recovered from the area would probably be suitable for irrigation or, if marginal in quality, could be diluted with surface water and used.

#### JOHNSTOWN UNIT

In the problem area shown in section *C-C'* (pl. 3), the land surface is generally about 10 feet above the river level. The water table in the problem area ranges from the land surface to a depth of about 10 feet. The total thickness of the alluvium is about 25-30 feet. About 20 feet of highly permeable coarse-grained alluvium underlie 5-10 feet of fine-grained alluvium, which is mostly of moderate permeability. The other problem area in this unit (pl. 3) is apparently very similar.

The alluvium is underlain by siltstone, sandstone, and conglomerate of the Wind River Formation. Coarse-grained sandstone and conglomerate, which are moderately to highly permeable, are at places directly in contact with the alluvium as at well A1-2-6aaa. In this area, water movement is from the alluvium to the bedrock, as the water table of section *C-C'* (pl. 3) shows.

Drains should be effective in improving drainage. Where practical, the drains should penetrate the coarse-grained alluvium or be hydraulically connected to it with relief wells. The lining of Johnstown canal would be desirable, but section *C-C'* (pl. 3) indicates that a drain along the south edge of the drainage-problem area would intercept much of the canal losses.

Wells could be used as an alternative or supplement to drains. A battery of wells tapping the coarse-grained alluvium should lower the water table effectively and would yield water suitable for irrigation.

#### UPPER WIND UNIT

In the problem area shown in the northern part of section *D-D'* (pl. 3), the land surface ranges from 5 to 50 feet above the river level. Water-level data are sparse, but the water table is known to rise to the land surface in parts of the area during the irrigation season. Water-table fluctuations are probably large in the southern part of the problem area. The total thickness of the alluvium ranges from about 40 to 90 feet. About 40-70 feet of highly permeable coarse-grained alluvium underlie fine-grained alluvium. The fine-grained alluvium ranges in thickness and in character from about 1 foot of highly permeable soil in the northeast to about 30 feet of slope wash and alluvial-fan deposits of low to moderate permeability in the southwest. The other problem areas along the flood plain in the Upper Wind unit (pl. 3) are probably very similar.

Ground-water movement is predominantly down the valley, but water also moves laterally into the valley from the streams, draws, and terraces draining from the southwest. Bedrock should have no significant effect on the drainage problems. Drainage problems result from the abundance of surface water, from the low permeability of the surface deposits in the southwest, and from low land near the river in the northeast.

Drains would be effective in some of the area, and wasteways to divert surface flows would be helpful. Wells could produce irrigation supplies of good quality and help lower the water table. (See discussion of test of well B4-4-2cda under "Aquifer characteristics.") Water from canals and irrigation applications are a significant source of the excess water. If ground water from wells were used for irrigation and

imported water were reduced to a minimum, many drainage problems would be alleviated.

SUB-AGENCY SYSTEM, LITTLE WIND UNIT

In the problem area, shown in sections  $F-F'$  and  $G-G'$  (pl. 3), the land surface is generally about 10 feet above the river level. The water table ranges from the land surface to a depth of about 10 feet, but is less than 5 feet below land surface in most of the area. The total thickness of the alluvium ranges from about 5 to 20 feet. Highly permeable coarse-grained alluvium underlies about 5 feet, or less, of fine-grained alluvium of low to moderate permeability. The other problem area of the flood plain in the Sub-Agency system (pl. 3) is probably very similar.

Ground-water movement is both toward the river and down the valley. Part of the excess ground water in the valley drains from irrigated terraces on the north and part is from local irrigation.

The alluvium is underlain by siltstone and sandstone of the Wind River Formation. Water in the sandstone in contact with the alluvium is hydraulically connected to water in the alluvium. Some deeper sandstones have piezometric heads above the water table. Generally, however, layers of relatively impermeable siltstone separate the deeper sandstones from the alluvium. Water from the bedrock probably has no significant effect on the drainage problems.

Drainage problems would be alleviated by reducing the amount of water entering the area, particularly that water draining from the higher irrigated terraces to the north. Intercept drains along the base of the terrace scarp would be helpful. Flat gradients across the valley, however, would seriously limit the usefulness of drains in most of the area. Other steps that would improve drainage include the lining of canals and ditches and the reduction of irrigation-water applications to the optimum.

The use of wells to aid drainage does not seem feasible because of the thinness of the alluvium in most of the area. Pumping from sump pits or drains, however, would lower the water table and would make drains more effective. Ground water recovered from the area would generally be of poor quality for irrigation, but could be used by diluting with surface water.

COOLIDGE SYSTEM, LITTLE WIND UNIT

In the problem area near Ethete shown in section  $H-H'$  (pl. 3), the land surface is about 15 feet above the river level. The depth to water is less than 5 feet in most of the area. The total thickness of the alluvium ranges from about 15 to 30 feet. About 15-25 feet of highly

permeable coarse-grained alluvium underlie about 5 feet, or less, of fine-grained alluvium of low to moderate permeability.

Ground-water movement is both toward the river and down the valley. The water table rises in the drainage-problem areas in response to applied irrigation water and leakage from ditches. Contribution of water from the bedrock, if any, is probably not significant to the drainage problems. The bedrock is shale and sandy shale of the Cody Shale. Section *H-H'* (pl. 3) arbitrarily shows the base of the coarse-grained alluvium as the contact with the Cody. A zone of clay underlying the coarse-grained alluvium generally could not be distinguished from weathered shale of the Cody.

Drains penetrating the coarse-grained alluvium should be effective. Wells could produce water suitable in quality for irrigation and effectively lower the water table. (See discussion of test of well A1-1-34bcb under "Aquifer characteristics.")

The small drainage-problem areas on the flood plains of the Little Wind River in the eastern part of the Coolidge system (pl. 3) are generally similar to the areas near Ethete. Bedrock is sandstone, siltstone, and shale of the Fort Union or Wind River Formation; bedrock probably has no significant effect on the drainage problems. Water moves laterally into the area from the Mill Creek valley. This water is much higher in dissolved solids than the water upstream in the Little Wind River valley. To be used for irrigation, water pumped from these areas would probably have to be diluted with surface water.

#### TERRACES

Small drainage-problem areas occur on the irrigated terraces. The alluvium underlying the terraces is similar to that underlying the flood plains. Soil zones are older and better developed, but are still moderately permeable. The terrace deposits are higher in relation to streams and are mostly well drained. Drainage problems occur where the water table is at or near the land surface because of abrupt changes in slope, changes in thickness of the alluvium, topographic lows, or local variations in permeability.

#### UPPER WIND UNIT

Sections *D-D'* and *E-E'* (pl. 3) show the general relation of the deposits of Crowheart terrace to the Wind River and its tributaries. The total thickness of the alluvium in the drainage-problem areas ranges from about 30 to 60 feet. About 20-50 feet of highly permeable coarse-grained alluvium underlies about 2-15 feet of permeable fine-grained alluvium.

The water table rises as water is applied to the land for irrigation and declines rapidly after the irrigation season as water drains from the terraces to the streams and the river valley. The terraces are mostly well drained; problem areas are small and scattered. Drains, including intercept drains along the base of slopes, should be effective in most of the areas. Wells could produce water for irrigation and help lower the water table. (See discussion of test of well P4 4-22aba under "Aquifer characteristics.")

The problem area at Burris (pl. 3), on a terrace of Dry Creek, is below the Crowheart terrace. Water draining from the Crowheart terrace probably causes most of the waterlogging. This water could be intercepted by a drain.

#### SUB-AGENCY SYSTEM, LITTLE WIND UNIT

The terrace deposits north of the Little Wind River near Arapahoe range in thickness from about 5 to 30 feet and are mostly 10-20 feet thick. They consist of highly permeable coarse-grained alluvium overlain by fine-grained alluvium of generally moderate permeability.

The water table rises as water is applied for irrigation and declines rapidly after the irrigation season as water drains from the terraces to the Little Wind River valley. Most of the terrace deposits are well drained; problem areas are small and scattered (pl. 3).

Drains penetrating the coarse-grained alluvium should be effective. Because the saturated terrace deposits are generally thin, wells would probably not be very effective in controlling drainage. Pumping into lined ditches, or canals, from sump pits or drains, however, could effectively remove water from the widely scattered drainage-problem areas, and the need for long interconnected drains could be reduced. The water could be used for irrigation if diluted with surface water.

#### RAY SYSTEM, LITTLE WIND UNIT

Two small problem areas south of Mill Creek have conditions similar to those described for terraces in general. The alluvium is similar to that of the Crowheart terrace in the Upper Wind unit. Most of the water is derived from irrigation. The hydrograph of well D1-1-32deb (fig. 4) shows the rise in water table during the irrigation season. Drains or wells should be effective in lowering the water table.

#### UNDERFIT-STREAM VALLEYS

Two large drainage-problem areas are in the lower valleys of Mill and Trout Creeks. In their lower reaches, both Mill and Trout Creeks have stream channels that are small and shallow compared with the size of the valleys they occupy, and they are considered underfit

streams. The fine-grained alluvium in the underfit-stream valleys is generally thicker and contains more slope wash than the fine-grained alluvium underlying the flood plains and terraces previously discussed.

RAY SYSTEM, LITTLE WIND UNIT

The land surface ranges from about the level of the Little Wind River to about 20 feet above the river and from about 10 feet below to 10 feet above the level of Trout Creek. (See section *I-I'*, pl. 3.) The water table ranges from the land surface to a depth of about 10 feet.

The general relations of the alluvial deposits are shown in section *I-I'* (pl. 3). The deposits in the northern part of the valley are very coarse, are largely glacial outwash, and are generally well drained. They merge to the south with generally thinner and finer deposits. In the drainage-problem area near section *I-I'*, about 2-15 feet of moderately to highly permeable coarse-grained alluvium underlie about 5-15 feet of fine-grained alluvium, which is of low to moderate permeability. Upstream from section *I-I'*, several valleys merge, and the pattern of alluvial deposition is probably more complex. Downstream, the valley narrows, and the alluvium thins where the Little Wind River passes through a gap in an anticlinal structure.

The Cody Shale underlies all except the northeastern part of the area. Sandy shale of the Cody may contribute some water, but the effect on drainage problems is probably insignificant. In the northeast, artesian water, including that from Washakie Hot Springs, comes from the bedrock formations and may affect the drainage problems locally.

Dark-gray clay, which includes some shale-pebble gravel and a few permeable zones, underlies the coarse-grained alluvium in some of the southern part of the valley (section *I-I'*, pl. 3). The contact between the clay and the underlying Cody Shale could not be distinguished; thus, the thickness of the clay is unknown, but is probably at least as thick as is indicated on section *I-I'*. A few wells derive water from the permeable zones, but the clay probably acts generally as a barrier to downward drainage.

Ground-water movement is generally down the valley, but there is also movement toward the waterlogged area from the irrigated lands in the north-central part of the valley. North and South Forks Little Wind River act as drains, but the small streams in the southern part of the valley, including Trout Creek, probably contribute water to the waterlogged area.

Deep drains would be effective in most of the area. Where possible, the drains should penetrate the coarse-grained alluvium or be hydraulically connected to it with relief wells. Drains could be used to intercept ground water from the north and to intercept salt-laden ground

water that moves northward from the irrigated slope wash and shale south of the valley. Wells tapping the coarse-grained alluvium could supplement the drain system; but the permeability and thickness vary, and wells would not be effective everywhere. Ground-water quality is generally better in the north and poorer in the south, but even the water of poorer quality could be used for irrigation if diluted with surface water.

#### COOLIDGE SYSTEM, LITTLE WIND UNIT

Both the land surface and the water table range from about the level of Mill Creek to about 60 feet above the creek. (See sections *J-J'* and *K-K'*, pl. 3.) These relations are shown slightly distorted because the sections are not drawn perpendicular to the valley. The water table ranges from the land surface to a depth of about 15 feet.

The total thickness of the alluvium ranges from about 15 to 50 feet. About 5–30 feet of highly permeable coarse-grained alluvium underlie about 5–20 feet of fine-grained alluvium. The fine-grained alluvium is mostly of low to moderate permeability, but contains some sand and gravel of moderate to high permeability.

The underlying bedrock is sandstone and shale of the Frontier Formation and Cody Shale. The sections arbitrarily show the base of the coarse-grained alluvium as the contact with the bedrock. A zone of clay underlying the coarse-grained alluvium generally could not be distinguished from weathered shale, and could not be defined. The bedrock probably contributes a minor amount of water to the alluvium, but does not significantly affect the drainage problems.

Ground-water movement is toward and down the Mill Creek valley. One of the most important aspects of the drainage problem is the need for interception of ground water that moves into the valley from the irrigated higher lands south and southwest of Mill Creek.

Deep drains would not penetrate the coarse-grained alluvium in most places, and relief wells would be necessary to connect hydraulically the drains with the coarse-grained alluvium. Wells might be more effective than drains for much of the needed drainage. Wells could effectively lower the water table and produce water for irrigation. (See discussion of test of well D1-1-15ccc under "Aquifer characteristics.") The quality of water from alluvium northwest of Mill Creek is "poor to bad" for irrigation, but could be used if diluted with surface water. Water pumped from alluvium southeast of Mill Creek would be "fair to good" for irrigation.

#### SLOPES

Several drainage-problem areas in the Ray and Coolidge systems, Little Wind unit, are on gentle slopes above the main valleys (pl. 3). The north ends of sections *J-J'* and *K-K'* (pl. 3) cross two such areas.

A generally thin mantle of slope wash overlies bedrock in these areas. Most of the slope wash is of low permeability, but there are some scattered thin beds of sand and gravel of moderate permeability. Nearly impermeable barriers are scattered irregularly through some of these deposits.

The slope wash is underlain by the Frontier Formation and Cody Shale. The shale, sandy shale, and sandstone of these formations generally act as a barrier to drainage, but, in some places, bedrock may be a source of water. Irrigation water, canal leakage, and possibly artesian flows from the bedrock add water to the slope wash at rates faster than the material can transmit the water. Much of the waterlogged area is above the principal water table, but perched water accumulates during the irrigation season. Much of this perched water evaporates and leaves a concentration of salts in the soil. Drainage would be difficult in most of these areas, but drains that would intercept water below canals or other sources of water would reduce the size of the waterlogged areas.

Slope deposits grade from the slope wash described above to nearly impermeable clay or weathered shale, which cannot be drained adequately and are usually not irrigated. Material underlying the area in the eastern part of the Coolidge system, secs. 17 and 18, T. 1 S., R. 2 E. (pl. 3), is nearly impermeable (U.S. Bur. of Indian Affairs, 1965).

#### TRANSITIONAL AREAS

Several small drainage-problem areas grade from slope wash over bedrock to slope wash over coarse-grained alluvium. Although details of these areas are unknown, conditions are generally similar, in part, to those of both the underfit-stream valleys and the slopes. Drains could be used where underlying coarse-grained alluvium is present, but most of these areas would be difficult to drain.

#### POTENTIAL USE OF UNDERGROUND STORAGE

As yet, underground storage of water for irrigation supplies has not been utilized, except to a very small degree in the Owl Creek valley. A large volume of water is stored in alluvium along the Wind River, Little Wind River, and Mill Creek; lesser volumes are stored in deposits underlying irrigated terraces and in alluvium in some of the smaller stream valleys. The water in these deposits is actually in transient storage, that is, the water is moving through the deposits at a fairly slow rate; but at any particular time the deposits contain a certain amount of water. The underground storage could be utilized by pumping ground water from the alluvium during the irrigation season. Water removed by pumping would eventually be replaced by

infiltration of precipitation, streamflow, and irrigation water. The process would be somewhat analogous to the way water in a surface-storage facility is used and is eventually replenished by streamflow.

The amount of water that is available from storage is the product of the volume of the saturated deposits and the specific yield of the deposits. The volume of the alluvium is known in a few areas that have been test drilled. The specific yield is unknown, but a specific yield of 10 percent is probably conservative for the type of deposits discussed. In the area along the Wind River near Crowheart (north end of section *D-D'*, pl. 3) saturated coarse-grained alluvial deposits are about 40 feet thick and  $1\frac{1}{2}$  miles wide. Using 10 percent as specific yield, about 4,000 acre-feet of water is available from storage for each mile length of the valley. Near Riverton (section *B-B'*, pl. 3), where saturated coarse-grained deposits average about 8 feet in thickness and a little more than 1 mile in width, about 500 acre-feet of water is available from storage per mile length of the valley. Near Ethete (section *H-H'*, pl. 3), where saturated coarse-grained deposits are about 20 feet thick and  $1\frac{1}{2}$  miles wide, about 2,000 acre-feet of water is available from storage per mile length of the valley. In the Mill Creek valley (sections *J-J'* and *K-K'*, pl. 3) the saturated coarse-grained deposits average about 15 feet in thickness, and about 1,000 acre-feet of water are available from storage for each square mile.

These values are intended only to give an estimation of the amount of water available in underground storage. Not all this water would be usable because it would be impractical to pump the deposits dry.

The use of both surface and underground storage of water could reduce the need for additional surface storage in some areas. Careful water management would be required because of the close relation of streamflows to the ground water; heavy pumping could divert entire streamflows. Overall planning would be required to make available the most water at the right time and at the least cost.

Both surface and underground storage are means of storing water, not of producing new supplies. The only increase in total water available would be by reduction of evaporation from open-water surfaces and from the water table in waterlogged areas. If underground storage were used rather than surface storage, the water that would have evaporated from that open surface would be salvaged. Lowering water levels in waterlogged areas by pumping would reduce evaporation from the water table. No estimate has been made of the possible amount of water retained by minimizing evaporation, but it would probably be significant.

## SUMMARY

Most wells in the area derive water from the Wind River Formation and the alluvium; consequently, hydrologic properties of these rocks are better known than those of other rocks. The range of permeability is estimated to be about 1–220 gpd/ft<sup>2</sup> for water-bearing sandstone of the Wind River Formation and about 150–7,500 gpd/ft<sup>2</sup> for the alluvium.

Geologic units having the largest potential for development of ground-water supplies are the Bighorn Dolomite, Madison Limestone, Tensleep Sandstone, Crow Mountain Sandstone, Nugget Sandstone, Sundance Formation, Cloverly and Morrison Formations, Mesaverde Formation, Lance(?) Formation, Fort Union Formation, Wind River Formation, and the alluvium. Descriptions of these and other geologic units in the area are tabulated (table 1) along with estimates of the potential water supply from the rocks and the probable concentration of dissolved solids.

Many parts of the Wind River Irrigation Project have become waterlogged. The drainage-problem areas are classified according to geologic similarities into five general groups: flood plains, terraces, underfit-stream valleys, slopes, and transitional areas. Local geologic and hydrologic conditions indicate the type of drainage facilities that would be successful.

Water from underground storage in alluvium could supplement water from surface storage in some areas. The use of both surface and underground storage would reduce the need for additional surface-storage facilities and also would alleviate drainage problems in the irrigated areas.

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TABLES OF BASIC DATA

TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.

Additional well records have been published in Water-Supply Papers 1375 (Morris and others, 1939) and 1519 (Berry and Littleton, 1961).  
 Well No.: See explanation of well-numbering system in text.  
 Use: C, commercial; H, household (domestic); I, irrigation; N, industrial; P, public supply; S, stock; T, test; U, unused.  
 Finish: O, open end; P, perforated; S, screened; T, sand point; X, open hole.  
 Water level: Reported depths given in feet; measured depths in tens or hundredths; +, indicates artesian head above land surface.  
 Altitude: Altitude above mean sea level; given in feet and tenths where determined by instrument leveling; given in feet where determined from topographic maps.  
 Geologic source (symbols listed alphabetically): J, Ju, Jurassic, Jurassic(?), and Triassic(?) rocks; Kc, Cody Shale; Kf, Frontier Formation; Km, Mesaverde Formation; MDu, Mississippian and Devonian rocks; O-C, Ordovician and Cambrian rocks; Pu, Permian rocks; PMu, Pennsylvanian and Mississippian rocks; Qa, alluvium of flood plains and related low terraces; Qg, glacial deposits; Qsa, slope wash and alluvium; Qt, terrace and pediment deposits; Tf, Fort Union Formation; Tw, Wind River Formation; Twi, Wind River and Indian Meadows Formations; Tu, Triassic.  
 Well tests: Data are reported except as indicated (M, measured). Drawdown determined while pumping at indicated discharge. F, indicates flow, in gallons per minute.  
 Remarks: C, chemical analysis in table 6; K, specific conductance given on hydrologic map (pl. 1), date is that of conductance measurement; LD, log in table 4; LT, log in table 5.

Well	Owner or tenant	Use	Depth of well (feet)	Well construction			Water level		Well tests			Remarks	
				Dis-meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above (+) or below land surface (feet)	Date of measurement	Altitude of land surface (feet)	Geologic source of water	Discharge or flow (gallons per minute)		Draw-down (feet) below non-pumping water level
A1-1-3bbb	Indian tribes	S	579	3	559	.....	532.8	6-22-65	5,665	Tw	1	.....	C, K 8-31-66
27add	H. Lindauer	II	54	4	44	X	.....	.....	5,290	Kc	20	.....	LD
33bbb	St. Michael's Mission	II	712	8	385	X	+	1957	5,355	Kf	40	375	C, LD
34aab	N. Quiver	H	21	4	21	P16-21	6	4-25-61	5,302	Qa	10	.....	K 6-22-66
34lcb	USGS	T	28	4	28	P6-28	5.63	6-28-66	5,328.8	Qa	20M	5M	C, K 6-29-66, LT
35ade	C. Trumbull	H	21	4	21	P11-21	8	4-13-61	5,270	Qa	5	.....	K 6-22-66, LD
35lbb	A. Goggles	H	20	4	20	P10-20	5.73	4-28-65	5,290	Qa	6	.....	.....
35ccb	A. Walker	H	32	4	32	P27-32	19.29	4-28-65	5,310	Qa	.....	.....	LD
36cb	Wind River Agency	U	>300	.....	.....	.....	.....	.....	.....	Kc(?)	4	.....	C
36ccb	R. Rhoads	II	21	4	21	P13-21	5	5-31-61	5,270	Qa	.....	.....	LT
A1-2-6aaa	USGS	T	50	1½	44	P37-44	36.32	6-6-66	5,260.2	Qsa, Tw	.....	.....	.....
6adb	do.	T	161	6	5	X	78.91	6-6-66	5,300.4	Tw	.....	.....	K 6-3-66, LT
21lbb	do.	T	300	½	115	X115-300	205.2	11-3-66	5,303.8	Tw	.....	.....	K 6-27-66, LT, commented at 115 ft.



TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.—Continued

Well	Owner or tenant	Use	Well construction			Water level		Altitude of land surface (feet)	Geologic source of water	Well tests		Remarks
			Depth of well (feet)	Dia- meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above(+) or below land surface (feet)			Date of measure- ment	Discharge or flow (gallons per minute)	
A2-2-32bcb	USGS	T	36	1/2	21	P	1.19	5,232	Qa			LT
32ccb	J. Enos	H	16	2	16	T	10	5,235	Qa		5	K 9-15-65
A2-4-12adb	R. Montgomey	H	210	6	145	X	50	5,065	TW			50
A2-5-11abb	A. Trawcek	II	364	6	334	X	123	4,975	TW			
A2-6-30dcb	Indian tribes	S		5			+	4,775	TW			
30ddd	do.	S		6			+	4,780	TW			
A3-1-9eda	USGS	T	207	4	0	X	106.4	5,622	TW			
24cca	R. Pingetzer	U	560		0		Dry	5,530	TW			
A3-2-3bdb	C. Pincer	II, S	238	6		X	155	5,390	TW		5	75
7cda	Pavillion City	P	500	8	338	X	180	5,465	TW		45	220
7cdb	do.	P	500					5,475	TW			
8ba	R. Henry	S	112	6	75	X	60	5,322	TW		6	30
32cbb	T. Stearns	H	485	5	204	X			TW		25	
A3-3-36ada	C. Mason	H	50	6	25	X	21	5,215	TW		40	19
A3-6-15lcb	Shoshoni City	P	495	6	440	X	17.3	4,772	TW		300	194
15bcc	do.	P	525	10			45.5	4,763	TW			
A4-1-11bbd	USGS	T	185	1	9	X	51.0	5,645	TW		2M	
18dbc	do.	T	272	4	21	X	98.0	5,810	TW		10M	
A4-2-11aab	W. Eykamp	S	28	8	11	X		5,350	TW(?)		20	
12ddd	C. Meigs	S	400	8	56	X	7	5,315	TW		90	
29aab	B. White	H	220	6	168	X	70	5,505	TW		5	37
34add	A. Over	S	100	6	59	X	15	5,415	TW		2	85
A4-3-5deb	E. Darrington	S	325	6	12	X	16	5,360	TW		10	3
8aad	L. Rungle	S	500	6	100	X	87	5,330	TW		1.5	29
9add	R. Mohlman	H	225	6	177	X	105	5,275	TW		2	120
11acd	R. Madsen	H, S	347	6	293	X	78.0	5,153	TW		4	
15aca	L. Harrison	S	310	6	239	X		5,250	TW		3	

Section	Name	Acres	Class	Year	Notes	Value	Year	Notes	Value	Year	Notes
17ced	M. Smith	135	H	6	39 X	95	3-52	5,298	2	15	
20abc	H. Fisher	122	S	6	112	75	1952	5,275	40	25	LD
20bda	W. Neidigh	385	H, S	6	230 P			5,280	20		LD
21bbc	D. Moore	790	S	6	669			5,248			
21dec	A. Trook	329	H, S	6	286	42	7-52	5,220	10	118	
24dac	M. Walters	490	II	6	422 X	145	4-52	5,200	5	255	
35abh	K. Harmon	317	II, S	6	251	60	1952	5,147	1	255	
35adc	F. Newell	315	II, S	6	254	100	2-52	5,155	3	212	LD
36dhh	W. Marlatt	120	H, S	4	120			5,115			C
A4-5-16idd		30	U	6		2.96	11-3-66	4,923			
21daa	Intex Oil Co.	110	S			4.74	9-12-64	4,910			
A5-2-13ac	do.	150	N								
26ac	do.	180	N								
27aba	Arapahoe Ranch	14	U			11.36	9-14-64	5,470			LT, destroyed
A5-3-32bcb	USGS	560	T		0 X		Dry	5,320			
A5-4-21ecd	do.	296	T	1	9 X	130.3	11-3-66	5,095	7M		C, K 11-3-66, LT
A5-5-27oda	Phillips Petroleum	280	N					4,804			
33aba	USGS	190	T	1	9 X	37.6	11-3-66	4,880	2M		C, K 10-26-66, LT
A5-6-21aa	USBR	800	H			+					C
A6-2-32aba	Arapahoe Ranch	95	U	4		7.55	4-28-65	5,715			
A6-4-14bbb	do.	740	U			Dry					
32add	do.	44	S	5		+1	8-17-65	5,430			K 8-17-65
A7-1-19eca	W. Bradford		U	12		+	4-28-65		10M		C, K 4-28-65
30ba	Indian tribes	1,272	S	11	306	+	3-1-61	6,760			
A7-5-22bbc	Arapahoe Ranch	740	S			> 600	3-3-65		5		
B1-1-5ach1	S. Ward	40	U	6	35	6	7-10-63	5,670	5	14	K 6-22-66, LD
5ach2	A. Ward	35	H	6	33	7	7-17-63	5,670	5	13	K 6-22-66
7ddb	Indian tribes		S					5,740			K 9-12-64
29bdb	do.		S					5,850	F1M		K 9-11-64
31add	R. Quiver	90	H	6	90	15	6-3-63	5,640	2	60	K 6-21-66, LD
31eba	D. Clare	22	II	6	23	9	10-16-63	5,705	10	5	K 6-21-66
32dde	B. McAdams	40	II	6	21	9	5-28-63	5,600	10	5	Do.
35eba	Amerada Petroleum	435	U	6	15 X	+		5,480			Plugged
B1-2-25ebb	F. Ethos	25	II	6	24	11	6-22-63	5,812	10	2	K 6-21-66
25dbc	B. Stagner	26	H	6	26	8	9-10-63	5,782	15	7	Do.
26add	S. Peahrona	28	II	6	28	8	6-21-63	5,825	10	4	K 6-21-66, LD
26cbl	E. LeClair	28	H	6	29	4	6-28-63	5,890	15	5	Do.

TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.—Continued

Well	Owner or tenant	Use	Depth of well (feet)	Well construction			Water level			Well tests			Remarks
				Dia-meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above (+) or below land surface (feet)	Date of measurement	Altitude of land surface (feet)	Geologic source of water	Discharge or flow (gallons per minute)	Draw-down (feet below non-pumping water level)	
B1-2-26dda	A. Compton	H	22	6	21	P16-17	6	6-19-63	5,830	Qa	10	3	K6-21-66
35adc	J. Tyler	H	32	6	32	P30-31	12	6-11-63	5,875	Qa	10	3	Do.
35baa	B. Teran	H	34	6	27		4	6-11-63	5,885	Qa	18	8	K6-21-66, LD
36dby	J. Dick	H	36	6	34		11	6-8-63	5,858	Qa	15	5	Do.
B2-1-2dea	Indian tribes	S	608	4	608		301.0	3-8-65	5,895	Tw(?)	7		
18ccc	Pan American	N	4,222	13	3,571	X	496	12-62	6,100	MDL, OCu	173		C
B2-2-2bda	J. Brown	S	474	6			362.0	8-24-65	6,083	Tw(?)			
17bca	N. Ambloh	H	62	6	62	P25-28	20	7-24-63	6,000	Tw(?)	15	12	K6-23-66
21cdc	J. Guinea	H	60	6	60	P35-50	21	7-23-63	5,960	Tw(?)	15	13	Do.
26aca	V. Hankass	H	40	6	40	P24-35	9	7-26-63	5,821	Tw(?)	6	20	K6-22-66, LD
28bca	D. Roberts	H	127	6	128	P116-122	+2	7-19-63	6,000	Tw(?)	10	26	Do.
31cdal	F. Harris, Sr	U	40	6	40	P30-34	20	7-18-63	6,190	Qsa	15	2	K6-23-66
31cda2	F. Harris, Jr	H	39	6	39	P30-34	20	7-18-63	6,195	Qsa	15	1	K6-23-66, LD
B3-1-5ba	British-American Oil.	N	5,306	9	5,175					J Ru			C
5 18dba	H. Hall	H	128	6			50			Tw	100		
B3-2-17abc	L. Curby	U	38						5,670	Qg			
17acb	R. Crowe	C	45	6		O	35.30	9-25-64	5,080	Qg			C, K9-25-64
22ebd	A. Winchester	H, S	225	4	100	X			5,675	Tw			K9-30-65
22adc	A. Morris	H	375	4	350	X	20		5,680	Tw			Do.
23dby1	R. Hoopengartner	H	180	6	120	X			5,625	Tw			Do.
23dby2	do.	S	50	6		P20	41.6	9-30-65	5,620	Qa			Do.
30baa	Midvale Irrig. Dist.	H	10	72			2.39	9-25-64	5,750	Qa			Do.
B3-3-1ddd1	D. Stagner	S	80	6	20		5.12	4-27-65	5,690	Qa(?)			K4-27-65
1ddd2	do.	H	80						5,690	Qa(?)			Do.
4aba	H. White	H	55	7	33		35		5,970	Tw			C, K9-30-65
B4-1-4ebb	USGS	T	166	1	9	X	113.6	11-2-66	6,162	Tw	3M		C, K10-31-66, LT
25daa	J. Barquin	S	487	5			435.5	6-27-66	5,824	Tw			C

B4-2-6add	USGS	T	301	4	0	X	116.8	8-22-66	6,149	TW	-----	K 8-22-66, LT
33daa	do	T	131	4	0	X	44.24	8-22-66	5,776.6	TW	-----	Do.
B4-3-6acb	J. Hankins	H	11	24	10		9.46	4-27-65	5,980	Qa	-----	K 4-27-65
8bbd	C. Henry	H	30	4			10.04	4-27-65	5,918	Qa	-----	C, K 4-27-65
17bbb	C. Snyder	II	90	5			15		5,875	Qa	-----	K 4-27-65
21cda	L. Meade	II	14	1	14	T	9	4-27-65	5,795	Qa	-----	K 4-27-65
29baa	D. Frank	II	22				10		5,863	Qa	-----	K 9-30-65
B4-3-30acb	G. Penmoyer	H	15	4		P	7.61	10-1-65	5,940	Qa	-----	K 10-1-65
31baa	J. Pogue	II	70	6	48	X	25.2	10-1-65	6,070	TW	-----	
32ada	J. Frank	H	36			P			5,955	Qt	-----	
32baa	C. Smith	H	41						6,005	Qt	-----	K 9-30-65
32ded	V. Frank	S	100	8	21	X	40	2-64	6,050	TW	-----	C, K 9-30-65
33cac	H. White	II, S	42	7			20		5,955	Qt	-----	LD
34beb	A. Nipper, Sr	II, S	50	8	45	X	21		5,905	TW	-----	K 9-30-65
34cdd	A. Nipper, Jr.	II, S	40	6	35	X	18		5,895	TW	-----	Cemented at 45 ft.
B4-4-2cda	USGS	T	33	4	32	P 10-32	.88	8-20-66	5,932.0	Qa	-----	K 9-30-65
2dcb	B. O'Neil	II								Qa(?)	-----	C, K 6-16-66, LT
5acd	Jack & Lee's Cafe	C	22	30	22		5	6-5-63	6,180	Qt	-----	C, K 4-28-66
14ceb	Crowheart School	P	400	6	319	X	31.01	11-4-65	6,125	Kf	-----	
16ada	R. Urbigkit	H	130	6	58	X	60		6,170	TW(?)	-----	C, LD
22aba	USGS	T	33	4	33	P 11-33	10.61	6-15-66	6,160.8	Qt	-----	LD
23ade	D. Rice	C	30	48	30		4.15	6-5-63	6,090	Qt	-----	C, K 6-14-66, LT
24che	St. Helen's Church	II	50	8	35	P			6,080	Qt	-----	C, K 4-28-66
25 dac	R. Burnett	II	212	6	58	X			6,010	Kf(?)	-----	
26abb	USGS	T	46	4	0				6,136.0	Qt	-----	LT
B5-3-12dce		U	98	6			84.02	6-25-66	6,316	TW	-----	
31cbd	J. Brown	H	70	5					6,040	TW	-----	K 4-27-65
32dda	USGS	T	91	4	0	X	22.06	8-22-66	6,151.6	TW	-----	K 6-22-66, LT
B5-4-10abc	do	T	92	4	0	X	65.53	8-22-66	6,481.7	TW	-----	Do.
10acd	F. Swallow	II	10	24	10		9.5	4-24-65	6,415	Qa	-----	K 4-24-65
17bdd	USGS	T	317	4	0	X	101.1	8-22-66	6,285	TW	-----	LT
30acd	L. Bradford	H, S	50	8		O	20		6,070	Qa	-----	K 3-4-65
31adc	C. Deshaw	H	12	1	12	T	7.47	3-4-65	6,110	Qa	-----	
31cbb	J. Le Clair	H	100	6	100	S	+		6,230	(?)	-----	
32bbb	H. Stall	II	82	4			12.80	3-4-65	6,070	TW(?)	-----	
32caa	E. Bonatsie	H	65	6					6,190	TW(?)	-----	
34bdc	W. Hiftshew	S	10	36			3.60	9-30-64	5,975	Qa	-----	K 9-30-64
B5-5-10bca	L. Miller	H	Spring						6,195	Qa	-----	K 3-4-65
13bcd	B. Lowe	II	180	7		O	33.02	9-30-64	6,140	TW	-----	K 9-30-64

TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.—Continued

Well	Owner or tenant	Use	Well construction				Water level		Well tests			Remarks
			Depth of well (feet)	Dia-meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above(+) or below(-) land surface (feet)	Date of measurement	Altitude of land surface (feet)	Geologic source of water	Discharge or flow (gallons per minute)	
B5-6-13bbd	Red Lodge Motel	C	25	7	20	P17-20	7.1	9-28-64	6,310	Qa	-----	K 9-28-64
14dad	do	U	980	7	120	X	+	-----	6,440	Pu(?)	-----	C, K 9-30-64
14ddb	do	U	Spring	-----	-----	-----	-----	-----	6,480	Qsa(?)	-----	K 9-28-64
35ada	H. Stall	S	200	5	127	P107-127	27	3-26-64	7,640	Pu(?)	3	C, K 10-1-64, LD
B6-2-22cba	-----	U	Spring	-----	-----	-----	-----	9-17-64	6,690	J Ru	-----	K 9-17-64
26dba	-----	U	-----	-----	-----	-----	-----	-----	6,570	P Mu(?)	-----	-----
B6-3-2yeb	J. Fike	H	138	3	138	-----	19	-----	6,950	Kl(?)	-----	K 4-24-65
21ead	-----	S	-----	8	-----	-----	+	4-24-65	6,580	(?)	-----	Do.
27ebd	-----	S	-----	6	-----	-----	+	4-27-65	6,622	(?)	-----	K 4-27-65
33ecd	USGS	T	96	4	0	X	42.9	10-31-66	6,625	Tw	30M	C, K 10-31-66, LT
36cba	Skelly Oil	U	-----	-----	-----	-----	+	4-28-65	6,460	(?)	F6M	K 4-28-65
B6-4-20add	D. Roberts	II	12	36	12	-----	5	4-24-65	6,840	Qa	-----	K 4-24-65
36edb	USGS	T	212	4	0	X	-----	-----	6,940	Tw	-----	LT, destroyed
B7-1-1ead	Arapahoe Ranch	S	Spring	-----	-----	-----	-----	-----	8,280	(?)	F15M	K 8-23-65
2aab	do	S	Spring	-----	-----	-----	-----	-----	7,930	(?)	-----	K 9-15-64
26edb	Barge School	P	200	6	45	P9-34	20	6-65	6,390	Qsa	6	K 4-28-65
27dad	L. Bollet	II	50	8	40	X	12	4-28-65	6,347	Qsa(?)	-----	K 4-28-65
C1-1-2aad	Indian tribes	C	Spring	-----	-----	-----	-----	-----	5,475	P Mu(?)	F1,230	C
3ccb	L. Chavez	H	26	6	24	P16-19	4	5-21-63	5,550	Qa	20	K 6-22-66
4abd	B. Brown	H	23	6	23	P16-19	10	5-22-63	5,545	Qa	15	K 6-22-66, LD
4adc	V. Herford	II	24	6	24	O	4	5-63	5,563	Qa	15	C, LD
4beb	G. Henan	II	21	6	21	P17-18	6	5-63	5,590	Qa	20	K 6-22-66
4cbb	L. McAdams	II	33	6	33	P	9	5-4-63	5,600	Qa	20	Do.
4ccc	G. Hill	H	42	6	41	X	24.5	5-3-63	5,595	Qa	12	C, K 6-23-66
4cdb	Fort Washakie	P	25	6	21	P	6	7-11-63	5,580	Qa	10	K 6-23-66
4dac	USGS	T	46	1	36	P	5.36	7-25-66	5,560.7	Qa	-----	LT
4dad	G. Twitchell	H	26	6	-----	P17-20	4	5-24-63	5,562	Qa	15	K 6-22-66
54ab	P. Pardia	H	150	6	28	-----	7	4-28-63	5,620	Qa	12	K 6-22-66, LD
5dba	F. Nicol	II	42	6	29	X	14	-----	5,620	Qa	6	C, LD

6ada	C. Soonup	H	58	6	57	P29-32	5	6-3-63	5,660	(?)	10	15	K 6-22-66
6ead	N. Engavo	II	20	6	20	P11-15	8	4-20-63	5,700	Qa	10	4	Do.
6edd	R. Murphy	II	62	6	50	X	5.5		5,695	(?)	5	34	C, LD
6dde	T. Gould	II	23	6	23	P20-23	6	4-22-63	5,675	Qa	10	4	C, K 6-22-66, LD
7dde	M. Tyler	II	43	6	40	P35-40	18	4-5-63	5,720	Qa	10	5	K 6-22-66, LD
7dda	P. Meyers	H	31	6	27	P15-20	8.5	4-8-63	5,690	Qa	12		K 6-23-66
8aab	E. St. Clair	H	66	6	53	X	3		5,612	(?)	20	5	C, LD
8aba	R. Burnett	II	31	6	31	P	10	5-20-63	5,620	Qa	10	2	K 6-22-66
8ada	G. Day	II	20	6	18	P9-12	4		5,610	Qa	10	1	C, LD
8adb	Robert's Mission	II	548	6	452	X	+	1945	5,675	Kf			C, LD
8daa	A. Washakie	II	100	6	43	P10-16	3	4-9-63	5,620	Qa	40	1	K 6-23-66
8dea	J. Pogorev	II	40	6	32	P11-16	11.5	4-6-63	5,635	Qa	25	3	Do.
8dda	M. Lebeau	II	43	6	41	P 8-10	7		5,617	Qa	7	1	C, LD
9aab	I. Clairmont	II	30	4					5,560	Qa			C, K 5-31-66
9abc	F. Chingman	H	36	6	36	P26-29	5	7-2-63	5,560	Qa	10	10	C, K 6-23-66, LD
9aac	W. Cashen	II	40	6	21	P 8-11	5	5-20-63	5,570	Qa	15	3	K 6-23-66
10aed	F. Wise	H	40	6	34	P25-28	9	5-15-63	5,550	Qa	20	7	K 6-22-66, LD
10abd1	M. Moon	II	60	6	60	P33-37	6	5-63	5,550	Qa	20	6	C, LD
10abd2	L. Coulston	H	60	6	53	P19-22	4		5,550	Qa	10	5	LD
10cda	S. Weed	II	48	6	45	P20-23	7	7-1-63	5,542	Qa	15	8	K 6-22-66, LD
16lcb	A. Ute	II	23	6	23	P16-19	11	4-10-63	5,620	Qa	12	1	K 6-23-66, LD
18bab	S. Wagon	II	32	6	32	P23-26	8		5,738	Qa	15	11	C, LD
18bce	T. Robertson	H	33	6	33	P20-24	12	4-13-63	5,770	(?)	10	10	C, K 6-23-66, LD
19bbb	M. Posey	H	21	6	21	P15-20	5.5	4-1-63	5,795	Qa	20	10	K 6-23-66
25ded	D. Hollings	S	10	24	10		1.06	7-20-65	5,555	Qsa	6M	10	K 6-23-66
26ddb	W. Moats	II	81	6			6.61	7-20-65	5,610	Kf			K 7-20-65
26dde	do.	S	15				7.0	7-20-65	5,605	Qsa			Do.
C1-2-iced	W. Hugo	H	37	6	37		20	4-16-63	5,800	Qa	15	1	K 6-22-66, LD
1dba	H. Shoyo	U	56	6	48	X	8	6-6-63	5,762	Kf(?)	5	32	Do.
1dbd	D. Shoyo	II	57	6	55	P21-24	6	6-8-63	5,760	Qa	20	4	Do.
1dca	J. Wagon	II	25	6	25		10	4-18-63	5,735	Qa	12	2	K 6-22-66
1dcd	D. Tillman	II	20	6	20	P12-16	10		5,780	Qa	6	3	C, LD
13ddd	L. Perry	U	70	6	08	P12-15	9	4-3-63	5,805	Qa	7	31	K 6-23-66, LD
24ada	H. Hill	H	41	6	41	P36-40	8.5		5,827	(?)	15	4	C, LD
24dab	C. Pingree	H	90						5,845	(?)			C
24deb	H. Weed	II	40	6	34	X	17.5	3-29-63	5,885	JRu	10	3	K 6-23-66, LD
26ada	J. Lafferty	H	56	6	56	P48-55	32	3-30-63	5,980	Ru	9	2	Do.
C2-1-1ddd	L. Twitchell	H, S	71	5			37.7	7-20 65	5,645	Qt(?)			K 7-20 65

TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.—Continued

Well	Owner or tenant	Use	Depth of well (feet)	Well construction			Water level			Well tests			Remarks	
				Dia- meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above(+) or below land surface (feet)	Date of measur- ment	Altitude of land surface (feet)	Geologic source of water	Discharge or flow (gallons per minute)	Draw- down (feet below non-pumping water level)		
D1-1-1dde	K. Hansen	H	40	6	34	P	5							K 8-16-65
12bc	C. Harris	H, S	29	4	29	P	6.65	8-13-65	5,290	Qsa	6			K 8-13-65, LD
13bbb	F. Nicol	H	15	18	P				5,285	Qsa				K 8-16-65
13ccb	T. Arnaajo	U	33	4	33	P28-33	13.10	8-13-65	5,345.9	Qsa				LD
14aaa	USGS	T	26	1	18	P	4.66	7-25-66	5,289.2	Qsa				LT
14bab	C. O'Neal	H	26	4	26	P21-26	7.95	8-13-65	5,317	Qsa	7			LD
14ddd	E. Arnaajo	II	98	4	98	P15-25	4.29	8-13-65	5,355.6	Qsa	4			LD
15ab1	R. Van Hees	H	45	8			5.60	8-13-65	5,370	Kf(?)				K 8-13-65
15ab2	do	S	45	8			10		5,350	Qsa				Do.
15add	M. Underwood	H	31	4	31	P26-31	14.5	5-10-61	5,340	Qsa	6			K 8-13-65, LD
15ccc	USGS	T	38	4	38	P16-38	5.71	7-25-66	5,377.1	Qsa	40M			1.2M C, LD
16acb	B. Hutchinson	H	80	4	80	P70-80			5,480	Kf				K 8-13-65, LD
16ddd	USGS	T	34	1	34	P16-34	7.58	6-28-66	5,378.5	Qsa				LT
21add	J. Arthur	H	21	4	21	P13-21	7	5-8-61	5,382	Qsa	6			K 8-13-65, LD
21dda	USGS	T	56	1	45	P	12.87	7-25-66	5,409.9	Qsa				LT
22ba1	T. Reed	II	30				12		5,370	Qsa				C, K 8-13-65
22ba2	do	S	11	24			4.18	8-13-65	5,370	Qsa				
22cb	USGS	T	21	1	21	S19-21	3.71	8-13-65	5,377	Qsa				C, K 10-5-65, LT
22ccc	S. Snyder	H	23	4	23	P18-23	4.5		5,379	Qsa	6			LD
22c	G. Hamilton	II, S					+		5,395 (?)					
23ada	USGS	T	41	1	36	P	6.86	7-25-66	5,373.7	Qt				LT
28d1bb	E. Barton	H, S	26				2.34	8-13-65	5,460	Qsa				K 8-13-65
30bda	G. Abeyta	H, S	14	7					5,490	Qsa				Do.
30bda	R. Eichholz	H	1,015	4	295				5,498	Kc				LD
31aaa	W. Lozier	II, S	60	6			29.40	4-27-66	5,497	Kc(?)				K 7-20-65
31dad	M. Clark	H	685						5,533	Qt				Water from upper 50 ft.
31dda	do	II, S	45	5					5,533	Qt				C, K 7-20-65
32acd	C. Deshaw	H, S	45	6	45				5,493	Qsa				Do.

32deb	USGS	T	17	1	17	S15-17	1.66	8-13-65	5,510	Qt		K 10-5-65
D1-2-5dde	J. White Plume	H	47	6		P			5,195	Qa		K 8-16-65
6dec	C. Nirider	II	40	10					5,235	Qsa		Do.
8aad	P. Heil	II	160	6			5.02	8-16-65	5,195	(?)		Do.
8beb	W. Hirasawa	II	35						5,230	Qsa		Do.
9bb1	H. Heil	H	430	4	363	X	110		5,190	Tf		C, K 8-16-65, LD
9bb2	do	S	20	6		P	3.59	8-16-65	5,190	Qa		C, K 8-16-65
9ecd	do	II	25	6			1.51	8-16-65	5,210	Qsa		K 8-16-65
10lcc	F. Collins	H	473	7	407	X	80	10-54	5,157	Tf		C, K 8-16-65, LD, cemented at 407 ft.
11edc	H. Fegler	H	60		60				5,130	(?)		K 8-16-65
14abc	E. Chamberlain	H	230	4					5,130	(?)		Do.
15aaa	H. Fegler	H	50	3		O	10		5,150	(?)		Do.
D1-3-1bba	H. Whitehead	S		8			4.04	6-22-65	5,005	Qa		
2aba	J. Busheyhead	H	60						5,030	Tw		
7dcd	USGS	T	130	4	25	X	73.9	11-3-66	5,175	Tw		C, K 11-3-66, LT
10cca	L. Arthur	H	390	6	99	X	75	10-64	5,135	Tw		C, LD
11add	S. Spoonhunter	H	100			X			5,100	Tw		K 9-14-65
12ebc	S. Duran	II	80	7	51	P	32		5,055	Tw		
12aba	T. Durai	II	55						5,050	Tw		K 9-14-65, LD
12dce	M. Haskins	II	18	1	18	T	7.65	9-20-65	5,030	Qt		K 9-20-65
13aab	H. Decoteau	H	300	4					5,025	Tw		C, K 9-14-65
13acc	J. White Plume	H							5,025	Tw		K 9-14-65
13dad	J. Blackburn	H	80	6	40	X	20	9-11-64	5,010	Tw		C, K 9-14-65, LD
14aaa	M. Eldridge	H	80	8			30		5,058	Tw		K 8-26-65
14abb	V. Bell	II	40	8	19	X	6	7-64	5,085	Tw		LD
14bbd	J. Headley	H	108	6	83	X			5,085	Tw		C, K 6-22-65
15aad1	D. Bath	H	130	6			28.01	8-26-65	5,090	Tw		K 8-26-65
15aad2	do	H, S	450	8			40		5,090	Tw		Do.
15bce	L. Frazier	H	120	6	80		18		5,065	Tw		K 9-28-65
15cca	J. Gallington	H	126	6		X	11		5,065	Tw		K 8-26-65
15dde	C. Hubbard	H, S							5,050	Tw		Do.
1bedd	R. Weber	H	160	6	110	X			5,065	Tw		K 8-26-65, cement- ed at 110 ft.
17aaa	J. Warren	II	85		65	X	24		5,130	Tw		K 8-26-65
17beb	P. Moss	H	150						5,125	Tw		C, K 8-26-65
17ded1	O. Linden	H	70			X	22		5,075	Tw		K 8-26-65
17ded2	do	S	80		25	X			5,080	Tw		Do.
17ddd	H. Warren	H	85		60	X	25		5,075	Tw		

TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.—Continued

Well	Owner or tenant	Use	Depth of well (feet)	Well construction			Water level			Well tests			Remarks
				Dia-meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above(+) or below land surface (feet)	Date of measurement	Altitude of land surface (feet)	Geologic source of water	Discharge or flow (gallons per minute)	Draw-down (feet below non-pumping water level)	
D1-3-18dda	R. Mix	H	12	60	8	X	7.95	8-20-65	5,067	Qa			C, K 8-26-65
21bba	H. Linden	H	95	5	70	X	20		5,065	Tw			K 8-26-65, commented at 70 ft.
23adc	W. Arthur	H	60	6	50		25		4,993	Tw	40		C, K 9-14-65
23bcc	Arapahoe Council	H	120	6	87	X	7		5,005	Tw	16	93	LD
23bdd1	T. Lajunesse	II	42	10					4,997	Tw			K 9-14-65
23bdd2	Arapahoe School	P	250	6	200	X	35		5,025	Tw	25	150	LD
23cha	Wind River Agency	II	550	6			+	5-18-45		Tw			C
24cha	USGS	T	10	1	10 S, T 6-10		5.76	8-13-65	4,980.3	Qa			C, K 10-5-65
24cbb	W. Hanway	H	230	4	175	X	+		4,983	Tw	F4		LD
24cbd	W. Shangreau	H	235	5	200	X	+	6-04	4,978	Tw	15	160	C, LD
24cda	M. Large	II	265	4	190	X	+	9-14-65	4,975	Tw	F3		K 9-14-65, LD
24cdc	do	U	50	6			19.03	9-28-65	4,990	Tw	60		LD
24dcb	A. Jeffery	H	18		18	T			4,975	Qa			K 9-14-65
26ba	Wind River Bar	II	100	8	16	X	46.50	7-16-65	5,030	Tw			
29ccc	USGS	T	210	1	9	X	135.3	9-30-66	5,166.1	Tw			K 6-26-66, LT
34aba	V. Pozun	II	105	5		P, X	15		5,040	Tw			K 7-16-65
34bad	E. Wagner	II	35						5,035	Qsa			
34bed	J. Dudley	H	29	6	29	P 21-29	28	3-65	5,043	Qa			
34bdh	E. Kerr	H	45	6		P	5		5,035	Qa			K 7-16-65
34bdc	J. Dudley	II	41	6		P	23	5-65	5,038	Qsa	10		
D1-4-2bce	KVOW	N	205	6			+		4,910	Tw			
2bca	USGS	T	16	1	16	P	6.36	7-27-66	4,913.7	Qa			LT
2cab	F. Brown	H	65	6	28	X	8.20	9-20-65	4,913.4	Tw		42	K 9-14-65, LD
3dbd	USGS	T	9	1	9	T	2.18	6-18-65	4,920	Qa			K 9-20-65
3deb	D. Brown	II	137	6	67	X	20	8-64	4,925	Tw	5	80	K 9-14-65, LD
4adcl	T. Duran	H	60	7	40	X	12		4,940	Tw			K 9-14-65
4ade2	do	U	18	3	18	T			4,940	Qa			Plugged.

4ced	Susquehanna Western.	N	63	10	63	P	7.46	10-22-58	4,948	TW	100	7	LD
4ced	do	N	450	10	450	P 320-338 385-420 435-438	+	10-58	4,948	TW	350	236	C, LD
4ddd	C. Mayland	II, S	265	6	125	X	+		4,985	TW			LD
5bbb	F. Blake	S	60	6	35	X			4,969	TW	50		LD
7bbb	Griffin Bros.	H, S	390	8	390	P 103-180 367-382	100	11-59	5,075	TW	20	50	LD
7bdd	G. Bartlett	H, S	80						5,072	TW			K 9-14-65
7deb	J. Miller	II	85	6	54	X	12		5,008	TW	5	58	K 9-14-65, LD
8acb	R. Brown	II	70	8			10.37	9-14-65	4,970	TW			K 9-14-65
8dad	Stradley	II	400	6			+		4,955	TW	F1		
8ded	Biddle	II	400				+		4,955	TW	F6		
9aad	C. Westlake	H	267	6	118				4,985	TW	3		LD
9ced	St. Stephens' Mission.	H	180				14	10-58	4,940	TW			
9cdc2	do	H	515	6	515	P	20		4,940	TW	30	140	LD
9cdc3	do	I	57	8	22	P, X	8		4,940	Qa, TW	50	2	LD
10add	do	H	60						4,910	TW			K 10-65
10bba1	H. Blomberg	H, S	274	6	118	X	+14	10-65	4,925	TW	F2		
10bba2	do	S	100	6			6.10	10-22-58	4,925	TW			
11bba	USGS	T	16	1	12	P	7.23	7-27-66	4,913	Qa			LT
11cac	do	T	83	4	0	X	22.4	6-7-66	4,952	TW			LT, destroyed
17acd	G. Griffin	S	20						4,988	Qa			K 10-65
17dba	do	H	280						4,988	TW			Do.
18baa	A. Eagle	H	320	5	213	X	30	10-65	5,003	TW	10	120	K 9-14-65, LD
18bba	R. Littlefield	H	330	6	233	X	35	11-64	5,013	TW	25		C, LD
18bbd	A. Duran	H	60	7	38	X	1	11-60	5,010	TW	20	35	LD
18daa	R. Yellowplume	II	270	7	159	X	+	1957	4,988	TW	F9		K 9-14-65, LD
20cad	USGS	T	102	4	0	X	33.81	5-27-65	4,985	TW			Destroyed
25dc	Atlantic Refrining Co.	N	620	6	604	P			5,264	TW	130		
28ccc	G. Griffin	S	46	5			7.94	9-28-65	5,005	Qsa(?)			K 9-28-65
33daa	USGS	T	22	1	22	T	1.99	9-27-65	5,025	Qsa			C, K 9-28-65, LT
DI-5-11ace	Gilpatrick	N	225	9	217	P	21.20	5-10-65	5,075	TW	3.6M	2.4M	C, K 11-5-65, LD
11bdd	USGS	T	34	1	34	P 32-34	20.52	5-27-65	5,060	Qsa			C, K 10-6-65, LT

Construction.

TABLE 3.—Records of wells and springs, Wind River Indian Reservation, Wyo.—Continued

Well	Owner or tenant	Use	Depth of well (feet)	Well construction			Water level		Altitude of land surface (feet)	Geologic source of water	Well tests		Remarks
				Dia-meter (inches)	Depth of casing (feet)	Finish (depth interval, in feet)	Distance above (+) or below land surface (feet)	Date of measurement			Discharge or flow (gallons per minute)	Draw-down (feet below pumping water level)	
D1-5-12db	Continental Oil	N	800	7	600	P 300-600	-----	5,197	TW	-----	-----	C, K 12-3-65	
13db	do	N	800	7	754	P 304-754 X 754-800	-----	5,190	TW	33	-----		
17dbd	Brinkerhoff	N	612	5	612	P	-----	5,287	TW	15	-----		
D1-6-7bcd	Humble Oil	N	960	7	960	P 284-955	220	5,275	TW	15	137	LD, cemented at 264 ft.	
29dde	Atlantic Refining Co.	N	107	5	107	P	-----	5,332	TW	10	-----		
D2-1-6ddd1	I. Seaniands	U	39	6	-----	-----	1.55	5,580	Qt	-----	-----		
6ddd2	do	H	48	5	-----	-----	2.33	5,580	Qt	-----	-----	K 7-19-65	
7aad	S. Clark	H	11	36	11	-----	4.25	5,583	Qt	-----	-----	Do.	
7daa	M. Meyers	H	350	-----	-----	-----	-----	5,610	Kf	-----	-----	C	
7ddd	E. Meyers	H, S	250	7	230	-----	-----	5,600	Kf	-----	-----	K 7-19-65	
17cdb1	W. Carstens	H	12	-----	-----	-----	6	5,506	Qsa	-----	-----	Do.	
17cdb2	Bain and McKiernan	H	13	30	13	-----	2.2	5,510	Qsa	-----	-----	Do.	
17cdb3	P. Bramman	H	22	-----	-----	-----	+	5,515	Qsa	-----	-----	Do.	
18dba	F. Harvard	S	15	-----	-----	-----	4.40	5,550	Qsa	-----	-----		
D2-3-3bbe	E-Y Cattle Co.	H, S	140	-----	-----	-----	-----	5,095	TW	-----	-----	K 7-16-65	
4bbb	D. Booth	H, S	-----	-----	-----	-----	-----	5,080	(?)	-----	-----	Do.	
4cab	H. Titus	U	150	7	105	X	65	5,110	TW	5	55	LD	
5dac	G. Dougherty	H, S	60	-----	40	X	40	5,070	TW	-----	-----	K 7-16-65	
5dba	do	H	40	-----	-----	-----	-----	5,050	Qa	-----	-----	Do.	
7aaa	J. Majdae	H, S	140	8	140	P	15	5,070	TW	-----	-----	K 7-16-65, LD	
7aab	do	H	408	8	408	P	+	5,070	TW(?)	4	-----	LD	
11aca	G. Griffin	S	123	-----	-----	-----	-----	5,235	TW	-----	-----		
D2-4-7ac	do	S	300	-----	-----	-----	-----	5,240	TW	-----	-----		

TABLE 4.—*Drillers' logs of wells*

[Yields in gallons per minute, and dissolved solids, in parts per million, are given in parentheses where available]

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A1-1-27ddd</b>					
Sand, gravel, and boulders.....	20	20	(1½ gpm sulfur water at 40 ft).....	10	45
Shale, dark, soft.....	5	25	Shale, sandy, dark.....	5	50
Shale, light-gray, sticky.....	10	35	Sandstone, dark (water).....	4	54
Shale, sandy, medium-dark					
<b>Well A1-1-33bbb</b>					
Soil, heavy clay.....	2	2	Mud, dark, soft (with bad odor).....	3	543
Sand, gravel (alaskali water).....	20	22	Sand, soft, black and white (with sulfur water).....	7	550
Shale, sandy, dark-gray (3 gpm at 30 ft, 6 gpm at 60 ft).....	366	388	Sandstone, hard and soft layers.....	50	600
Shale, black (gas).....	12	400	Limestone, hard (5 hr drilling).....	2	602
Shale, sandy, gray.....	30	430	Sandstone, gray.....	18	620
Shale, dark, sticky.....	30	460	Shell, hard.....	1	621
Shale, dark, hard.....	10	470	Bentonite.....	1	622
Bentonite and sandstone.....	5	475	Rock, hard.....	2	624
Shale, dark, hard.....	65	540	Shale, sandy, gray, hard.....	88	712
<b>Well A1-1-35adc</b>					
Surface.....	2	2	Shale, dark-gray.....	3	21
Gravel and sand.....	16	18			
<b>Well A1-1-35ccb</b>					
Silt, sandy.....	20	20	Mud, blue.....	2	32
Gravel and sand.....	10	30			
<b>Well A1-3-11bcd</b>					
Soil.....	3	3	Shale, hard, blue.....	423	458
Sandstone, soft.....	4	7	Sandstone, hard.....	10	468
Shale, sandy.....	25	32	Shale.....	287	755
Sandstone, hard.....	3	35	Water sand, coarse.....	15	770
<b>Well A1-3-34dac</b>					
Topsoil, sandy.....	4	4	Shale, sandy, hard, blue.....	10	100
Gravel.....	18	22	Shale, sandy, gray.....	2	102
Shale, gray.....	6	28	Sand, gray.....	5	107
Shale, gray, sandy.....	55	83	Shale, sandy, hard, blue.....	8	115
Sandrock, gray.....	7	90			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A1-4-21ddd</b>					
Topsoil, sandy.....	6	6	Shale, sandy, gray.....	10	111
Sand and gravel.....	20	26	Shale, sandy, blue.....	3	114
Shale, yellowish-gray.....	12	38	Shale, sandy, gray.....	21	135
Sandrock, yellow (hard water).....	14	52	Shale, sandy, blue.....	11	146
Shale, sandy, gray.....	16	68	Shale, sandy, gray.....	32	178
Shale, sandy, blue.....	5	73	Sand, gray (water).....	12	190
Shale, sandy, gray.....	19	92	Shale, sandy, blue, hard.....	10	200
Shale, blue, hard.....	9	101			
<b>Well A1-4-26caa</b>					
Soil, sandy.....	3	3	Shale, brown and blue, hard and sticky.....	69	424
Gravel.....	17	20	Hard-rock layer.....	3	427
Shale, cavey, blue.....	10	30	Water sand.....	10	437
Shale, sandy, gray.....	5	35	Shale, hard, blue and dark- gray.....	18	455
Shale, sandy, blue.....	10	45	Shale, hard, dark-gray.....	23	478
Shale, blue and brown.....	25	70	Water sand.....	12	490
Shale, sandy, blue.....	10	80	Shale, dark-brown, sticky.....	20	510
Shale, sandy, gray.....	3	83	Water sand.....	15	525
Water sand.....	7	90	Shale, blue and brown.....	15	540
Shale, brown.....	28	118	Shale, red-brown.....	15	555
Shale, sandy, blue.....	17	135	Shale, sandy, blue.....	12	567
Water sand.....	10	145	Shale, red-brown.....	13	580
Shale, sandy, blue and brown.....	15	160	Shale, sandy, gray.....	10	590
Shale, sandy, gray.....	8	168	Water sand.....	7	597
Water sand.....	25	193	Shale, sandy, gray, hard.....	9	606
Shale, sandy, blue.....	3	196	Sand.....	1	607
Water sand.....	24	220	Shale, sandy, hard, gray.....	12	619
Shale, sandy, blue.....	5	225	Shale, brown.....	15	634
Water sand.....	30	255	Shale, sandy, blue.....	10	644
Shale, brown and blue.....	25	280	Water sand.....	12	656
Shale, sandy, gray, very hard.....	10	290	Shale, sandy, hard, blue.....	14	670
Shale, cavey, brown, yellow, gray.....	30	320	Shale, sandy, hard, gray.....	10	680
Shale, blue, sandy.....	15	335	Shale, dark-gray.....	5	685
Shale, gray, and hard shells.....	20	355	Shale, brown.....	15	700
<b>Well A1-4-27aca</b>					
Soil, sandy (surface water).....	18	18	Shale, gray, and hard shells o' f rock.....	5	110
Gravel (hard water).....	9	27	Shale, gray, sticky, hard.....	5	115
Sandstone, light-brown and yellow.....	34	61	Shale, sandy, hard, gray.....	6	121
Sandstone, blue and gray.....	13	74	Shale, blue and gray, sticky, soft.....	4	125
Shale, gray.....	9	83	Shale, gray, with blue streaks.....	50	175
Sandrock, hard.....	2	85	Shale, sandy, gray.....	10	185
Shale, gray.....	1	86	Shale, blue, sticky.....	5	190
Sandstone, hard.....	4	90	Shale, hard, gray.....	18	208
Shale, sandy, hard, gray.....	6	96	Sand (water).....	4	212
Shale, gray, sticky.....	4	100	Shale, sandy, blue, hard.....	3	215
Shale, sandy, hard, gray.....	5	105			

TABLE 4.—*Drillers' logs of wells—Continued*

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A1-4-27aca—Continued</b>					
Sand (water).....	7	222	Shale, sticky, brown.....	11	460
Shale, gray, sticky.....	3	225	Shale, sandy, gray.....	5	465
Shale, brown.....	5	230	Shale, brown, and hard shells..	47	512
Shale, gray.....	12	242	Shale, brown and blue.....	13	525
Shale, blue.....	8	250	Shale, sandy, gray, hard.....	10	535
Shale, brown.....	10	260	Shale, sticky, brown and blue..	7	542
Shale, gray.....	5	265	Shale, sandy, gray, hard.....	3	545
Water sand and hard shells.....	20	285	Sand (water).....	5	550
Shale, gray, hard.....	15	300	Shale, gray, hard.....	5	555
Sand (water).....	5	305	Shale, sticky, brown and blue..	5	560
Shale, sandy, hard, gray.....	9	314	Shale, gray, hard.....	5	565
Shale, blue, hard.....	2	316	Shale, sticky, light-brown.....	25	590
Shale, gray, and hard shells.....	19	335	Shale, gray, hard.....	10	600
Shale, brown and blue.....	5	340	Shale, sticky, blue and brown..	18	618
Shale, sandy, light-brown.....	10	350	Sand (water).....	22	640
Sand and hard shells.....	15	365	Shale, brown.....	10	650
Shale, gray and blue, hard.....	30	395	Sandstone, brown.....	5	655
Shale, brown and blue, sticky and hard.....	5	400	Sandstone, gray, hard.....	5	660
Shale, medium-gray.....	15	415	Shale, brown and blue.....	20	680
Shale, blue and brown.....	25	440	Sand (water).....	45	725
Shale, sandy, hard, gray.....	9	449	Shale, yellow.....	5	730
<b>Well A1-4-29dcb</b>					
Soil, sandy, and gravel.....	10	10	Shale, very sandy, gray, hard..	7	257
Sand, fine.....	3	13	Shale, sandy, blue, hard.....	3	260
Gravel.....	5	18	Shale, gray, sandy, hard.....	25	285
Sand and gravel.....	6	24	Shale, gray; some gray sand- rock.....	8	293
Sand, fine.....	7	31	Sandrock, gray; trace of shale; red and black specks.....	53	346
Sand and gravel.....	9	40	Shale, sandy, gray, hard, sticky.....	64	410
Shale and sand.....	3	43	Shale, blue, sticky.....	3	413
Sand, fine.....	7	50	Shale, dark-gray, sticky.....	7	420
Gravel.....	25	75	Shale, sandy, blue, sticky.....	1	421
Shale, variegated yellow and blue.....	5	80	Shale, sandy, gray, sticky.....	9	430
Shale, sandy, blue.....	7	87	Shale, blue; some purple and brown.....	17	447
Shale, sandy, gray.....	6	93	Sand, white, sharp (water, 445 ppm).....	13	460
Shale, blue and green.....	11	104	Shale, brown; some yellow and gray; hard, sticky.....	40	500
Shale, blue, red, brown.....	5	109	Sand shell, hard.....	4	504
Shale, sandy, blue.....	8	117	Shale, brown and blue.....	41	545
Shale, sandy, gray, hard.....	9	126	Sand, grayish-white (water)....	15	560
Shale, soft, gray.....	3	129	Shale, gray.....	5	565
Shale, gray, hard.....	17	146	Sand, fine, white and flecked (water).....	20	585
Sandstone, gray, soft.....	2	148	Shale, blue.....	6	591
Sandrock, gray, hard.....	3	151	Sand, white and flecked (water)..	17	608
Shale, gray, hard.....	8	159	Shale, brown and light-blue....	22	630
Shale, sandy, gray, medium- hard.....	12	171	Sand, flecked (water).....	10	640
Sandrock, gray, soft.....	9	180			
Shale, sandy, gray, medium- soft.....	22	202			
Shale, sandy, blue and gray, sticky.....	48	250			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A1-4-29deb—Continued</b>					
Shale, blue-gray, hard.....	12	652	Shale, dark-brown, hard		
Sand, white and flecked (water) ..	3	655	(drilled 1 ft per hr).....	7	825
Shale, blue and brown, sticky ..	15	670	Sand shells, hard.....	18	843
Sand (water, gas bubbles).....	4	674	Shale, brown, sticky, hard,		
Shale, blue and brown.....	11	685	some blue shale.....	10	853
Sand (water).....	10	695	Sand shells, hard.....	17	870
Shale, blue.....	3	698	Shale, brown; some blue (gas,		
Sand (water).....	6	704	oily).....	17	887
Sand shells, hard.....	19	723	Shale, sandy, dark-gray		
Sand (water).....	10	733	(drilled 2 ft per hr).....	11	898
Hard rock and sand (drilled 1			Shale, dark-gray, sticky.....	17	915
ft per hr).....	5	738	Shale, gray, hard.....	13	928
Shale, blue and brown, hard,			Sandstone, very soft.....	12	940
sticky.....	17	755	Sand shells, hard.....	20	960
Sand shells, gray, hard.....	21	776	Sandstone, soft.....	4	964
Shale, light-brown, sticky.....	24	800	Shale, gray, hard.....	6	970
Shale, light-gray (gas, oily			Sandstone.....	12	982
rancid odor).....	18	818	Shale, brown and blue.....	12	994
<b>Well A1-4-31ad</b>					
Gravel.....	30	30	Sandstone.....	10	250
Shale.....	170	200	Shale.....	105	355
Shale and sandstone.....	10	210	Sandstone (water).....	30	385
Shale.....	30	240	Shale, red, brown, green.....	15	400
<b>Well A1-4-33aab</b>					
Soil.....	7	7	Sandstone, coarse, hard.....	13	233
Sand and gravel.....	10	17	Shale, gray.....	42	275
Sandstone, yellow.....	27	44	Sandstone, red and white		
Shale, yellow, gray, green.....	21	65	(coarse 295-300).....	35	310
Sandstone, gray and red.....	21	86	Shale, gray, brown, and blue...	56	366
Shale, blue and gray.....	87	173	Sandstone, hard.....	19	385
Sandstone, gray, black, red.....	30	203	Shale, blue, gray, brown.....	85	470
Shale.....	5	208	Sandstone and hard shells.....	28	498
Sandstone, coarse, hard.....	7	215	Shale, sandy, gray.....	2	500
Shale, gray.....	5	220			
<b>Well A1-4-34ac</b>					
Topsoil, sandy.....	1	1	Shale, sandy, gray.....	29	112
Gravel.....	4	5	Water sand (15 gpm, 3,540		
Shale, yellow-blue.....	19	24	ppm).....	14	126
Sandstone, yellow.....	26	50	Shale, blue.....	12	138
Shale, sandy, blue (seep of			Shale, sandy, gray.....	11	149
water at 60 ft, 2,240 ppm).....	17	67	Shale, blue.....	3	152
Shale, sandy, gray.....	11	78	Shale, sandy, dark-gray.....	6	158
Shale, sandy, blue.....	5	83	Shale, sticky, blue.....	6	164

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A1-4-3fac—Continued</b>					
Shale, brown; with coal streak..	6	170	Shale, sandy, light-blue.....	13	365
Shale, blue.....	11	181	Shale, sandy, gray.....	5	370
Shale, sandy, gray.....	97	278	Sandstone, very coarse.....	25	395
Shale, sandy, light-blue.....	9	287	Water sand, coarse (10 gpm, 910 ppm).....	8	403
Shale, gray, and hard shells.....	43	330	Shale, sandy, hard, blue.....	3	406
Shale, sandy, gray.....	22	352			
<b>Well A2-2-4ddd</b>					
Shale, sandy, blue and yellow- brown.....	12	12	Shale, sticky, blue.....	4	242
Shale, sandy, blue; mixed with light-green shale (water at 18-30 ft).....	28	40	Shale, sticky, gray.....	24	266
Shale, sandy, gray, hard.....	48	88	Shale, sticky, blue; mixed with brown shale.....	9	275
Shale, sandy, blue.....	12	100	Sandstone, bluish-red.....	25	300
Shale, sandy; gray with red specks.....	30	130	Shale, sandy, gray.....	18	318
Shale, sandy, gray, sticky.....	10	140	Shale, sandy, blue.....	8	326
Shale, sandy; gray with red specks.....	36	176	Shale, sandy; gray with red specks.....	38	364
Shale, sandy, sticky, gray.....	24	200	Shale, sandy, dark-gray.....	2	366
Shale, sandy; gray with red sand.....	6	206	Shale, sticky, hard, blue.....	7	373
Shale, sticky, blue.....	3	209	Sandrock, hard, gray.....	1	374
Shale, sandy, gray, hard.....	5	214	Shale, sandy, gray.....	12	386
Shale, sticky, blue.....	3	217	Shale, brown and blue, hard...	3	389
Shale, sandy, gray.....	21	238	Water sand, white (12 gpm).....	11	400
			Shale, sticky, blue; mixed with brown shale.....	30	430
			Water sand, white.....	20	450
			Shale, sandy, blue.....	10	460
<b>Well A2-2-16cdb</b>					
Soil.....	2	2	Sandstone, reddish-brown (water, 4 gpm).....	33	75
Sandstone.....	28	30	Shale, sandy, gray.....	5	80
Shale, light-gray and yellow....	12	42			
<b>Well A2-2-18ada2</b>					
Soil.....	6	6	Sandstone, gray.....	19	381
Sandstone, yellow and blue....	44	50	Shale, blue.....	31	412
Shale, sandy, gray.....	26	76	Sandstone, white (water).....	18	430
Sandstone, gray (little water) ..	14	90	Shale.....	5	435
Shale, gray and blue.....	272	362			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A2-2-3ladd1</b>					
Sand, gravel (hard water).....	25	25	Shale, blue.....	5	135
Shale, blue.....	10	35	Sand with blue shale, very streaked (water).....	25	160
Sandstone, soft, blue (hard water).....	15	50	Shale, blue.....	3	163
Shale, blue.....	17	67	Sand (hard water).....	12	175
Sand (hard water).....	6	73	Shale, blue and gray.....	22	197
Shale, blue.....	9	82	Sand and blue shale.....	4	201
Shale, brown.....	8	90	Shale, blue.....	11	212
Shale, gray and blue.....	14	104	Sandstone, coarse.....	4	216
Sand, white (hard water).....	21	125	Shale, brown; sandy blue shale.....	9	225
Shale, blue.....	3	128	Water sand (385 ppm).....	5	230
Shale, brown.....	2	130			
<b>Well A3-1-24cca</b>					
No log.....	105	105	Sandstone.....	25	381
Shale, blue and gray.....	69	174	Shale, blue and gray.....	108	489
Sandstone, gray.....	51	225	Sandstone, silty, gray.....	25	514
Shale, sandy, gray.....	19	244	Shale, gray, blue and brown.... (no water)	46	560
Sandstone, gray.....	36	280			
Shale, blue and gray.....	76	356			
<b>Well A3-2-3bdb</b>					
Topsoil.....	3	3	Shale, sandy, gray.....	2	143
Sand and gravel.....	5	8	Shale, blue, light-green and brown.....	14	157
Shale, sandy, gray.....	12	20	Shale, sandy, gray (smells like crude oil).....	20	177
Shale, sandy, blue.....	7	27	Sandstone, gray.....	9	186
Shale, sandy, gray.....	11	38	Shale, sandy, gray.....	21	207
Shale, blue and yellow.....	7	45	Sandstone, gray.....	9	216
Water sand (15 gpm, 5,200 ppm).....	1	46	Water sand (5 gpm, 700 ppm).....	20	236
Sandstone, yellow.....	21	67	Shale, sandy, blue.....	2	238
Shale, sandy, gray.....	28	95			
Water sand (10 gpm, 3,850 ppm).....	16	111			
Shale, blue.....	30	141			
<b>Well A3-2-7cda</b>					
Topsoil, sandy (water).....	27	27	Shale, sandy, hard, gray.....	2	164
Sandrock, soft, yellow.....	6	33	Shale, sandy, soft, blue; with brown shale.....	12	176
Shale, sandy, soft, gray.....	4	37	Rock, hard, gray.....	18	194
Sandstone, soft, yellow.....	37	74	Shale, sandy, medium-gray.....	20	214
Shale, sticky, blue.....	12	86	Shale, sandy, soft, blue.....	12	226
Shale, sandy, hard, light-blue.....	5	91	Shale, sandy, hard, gray.....	28	254
Shale, sandy, soft, gray.....	6	97	Shale, blue, soft.....	6	260
Shale, sandy, soft, blue.....	6	103	Shale, sandy, medium-blue.....	19	279
Shale, sandy, gray, medium- hard.....	14	117	Shale, sandy, blue, coarse and muddy.....	3	282
Shale, sandy, soft, blue.....	2	119	Shale, sandy, sticky, blue.....	5	287
Shale, sandy, soft, gray.....	7	126	Shale, soft, blue and brown.....	15	302
Shale, sandy, gray, hard.....	30	156	Shale, soft, gray.....	5	307
Shale, sandy, soft, blue.....	6	162			

TABLE 4.—*Drillers' logs of wells—Continued*

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A3-2-7cda—Continued</b>					
Shale, sandy, hard, gray.....	11	318	Shale, sandy, medium-hard gray.....	38	449
Shale, sandy, medium-hard, gray.....	32	350	Shale, sandy, hard, blue.....	3	452
Sandstone, soft, red and gray...	48	398	Sand, coarse, gray (water).....	11	463
Shale, sandy, sticky, soft, gray..	2	400	Sandstone, fine.....	9	472
Sandstone, soft, gray and red (small amount of water).....	11	411	Sand, coarse, and hard shells...	22	494
			Rock, hard, gray.....	2	496
			Shale, sticky, gray.....	4	500
<b>Well A3-2-32cbb</b>					
Clay, sandy.....	10	10	Sandstone.....	40	165
Sandstone and shale.....	25	35	Shale, hard, with hard stringers..	150	315
Sandstone.....	30	65	Shale, hard.....	140	455
Shale.....	15	80	Sandstone (water).....	18	473
Sandstone and shale.....	45	125	Shale.....	12	485
<b>Well A3-6-15bcb</b>					
Clay, fine gravel, and cobbles...	12	12	Sandstone, gray.....	8	306
Sandstone, broken.....	15	27	Sandstone, siltstone, and shale..	40	346
Siltstone, sandstone, and shale..	20	47	Sandstone, gray, coarse, white..	14	360
Sandstone, brown.....	30	77	Sandstone, medium, white.....	25	385
Shale, siltstone, fine sandstone..	18	95	Siltstone, sandstone, and shale..	28	413
Sandstone, gray.....	53	148	Sandstone and blue shale.....	22	435
Siltstone, sandstone, and shale..	60	208	Sandstone, medium, white.....	16	451
Sandstone, gray.....	7	215	Sandstone, coarse, white (water).....	44	495
Siltstone, very hard and bluish..	83	298			
<b>Well A4-2-12ddd</b>					
Topsoil, sandy.....	2	2	Shale, blue and brown.....	4	207
Shale, sandy, gray.....	2	4	Shale, sandy, gray.....	8	215
Shale, sandy, dark-gray.....	11	15	Shale, brown.....	5	220
Shale, sandy, gray (10 gpm at 40 ft, 5,950 ppm at 50 ft).....	46	61	Shale, sandy, red-brown.....	8	228
Sandstone, yellow (90 gpm at 61-73 ft).....	12	73	Shale, sandy, gray, hard.....	67	295
Shale, sandy, gray (4,200 ppm at 80 ft).....	53	126	Shale, brown.....	3	298
Shale, sandy, blue.....	6	132	Shale, sandy, gray, hard.....	20	318
Shale, sandy, gray (12 gal/hr, 132 ft-150 ft).....	18	150	Shale, sandy, dark-gray.....	14	332
Shale, sandy, brown.....	10	160	Shale, sandy, gray, medium- gray.....	26	358
Shale, sandy, gray.....	3	163	Shale, blue and brown, cavey...	6	364
Shale, sandy, red-brown.....	5	168	Shale, sandy, brown.....	11	375
Shale, sandy, gray.....	35	203	Shale, brown.....	6	381
			Shale, sandy, gray, hard.....	5	386
			Shale, brown and blue.....	12	398
			Shale, sandy, gray, hard.....	2	400

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well A4-3-5dcb</b>					
Sandstone, yellow and gray (hard water).....	41	41	Shale, gray.....	10	150
Shale, gray, brown, green, yellow.....	22	63	Sandstone, soft (water, 2 gpm) ..	40	190
Sandstone, gray.....	32	95	Shale, gray.....	5	195
Shale, gray.....	25	120	Sandstone, gray.....	12	207
Sandstone with lime shells.....	20	140	Shale, gray and brown.....	63	270
			Sandstone, gray.....	5	275
			Shale, gray and brown.....	50	325
<b>Well A4-3-11acd</b>					
Sand and gravel.....	10	10	Sandstone, soft.....	16	178
Shale, sandy, gray.....	30	40	Coal shale.....	2	180
Sandstone.....	20	60	Shale, blue.....	9	189
Shale, gray, sandy.....	27	87	Shale, brown.....	8	197
Sandstone, gray.....	3	90	Shale, sticky, light-gray.....	18	215
Shale, gray.....	21	111	Sandstone, gray (water, 2,300 ppm).....	75	290
Hard shell of rock.....	2	113	Sand, soft (water, 1,890 ppm)....	34	324
Sandstone, gray, soft.....	17	130	Limestone, hard.....	3	327
Shale, gray, hard.....	2	132	Shale, very sandy (water).....	18	345
Water sand (2,800 ppm).....	8	140	Shale, sandy, gray.....	2	347
Sandstone, hard.....	22	162			
<b>Well A4-3-20abc</b>					
Soil, sandy.....	25	25	Shale, sandy, gray.....	8	98
Sandstone, yellow.....	32	57	Hard rock.....	1	99
Sandstone, gray.....	11	68	Shale, sandy, blue and gray.....	2	101
Shale, brown.....	5	73	Sandstone, gray.....	4	105
Shale, sandy, gray.....	13	86	Shale, sandy, gray.....	9	114
Shale, brown.....	4	90	Water sand.....	8	122
<b>Well A4-3-21bbc</b>					
Soil.....	7	7	Shale, sandy, gray, blue, brown.....	57	348
Shale, sandy, gray.....	24	31	Sandstone, gray.....	23	371
Sandstone, yellow.....	55	86	Shale, sandy, gray, blue, brown.....	64	435
Shale, sandy, gray, blue, brown.	32	118	Sandstone, coarse.....	4	439
Sandstone (water).....	6	124	Shale, sandy, gray, blue, brown.....	351	790
Shale, sandy, gray, blue, brown.....	159	283			
Sandstone, gray.....	8	291			
<b>Well A4-3-35adc</b>					
Soil, sandy.....	6	6	Sandstone, gray.....	23	195
Sand and gravel.....	5	11	Shale, blue.....	19	214
Shale, sandy, blue.....	29	40	Sandstone (softer water).....	9	223
Sandstone, yellow.....	30	70	Shale, gray, blue and brown....	64	287
Shale, sandy, gray and blue....	30	100	Sandstone (water).....	25	312
Sandstone (water).....	12	112	Shale, sandy, gray.....	3	315
Shale, sandy, blue and gray....	60	172			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well B1-1-5acb1</b>					
Surface .....	7	7	Sand and gravel .....	1	35
Quicksand .....	13	20	Shale .....	5	40
Clay, broken .....	14	34			
<b>Well B1-1-31add</b>					
Surface .....	2	2	Broken shale (water) .....	13	50
Rock and clay .....	10	12	Shale .....	32	82
Shale .....	25	37	Broken shale .....	8	90
<b>Well B1-2-26add</b>					
Surface .....	1	1	Sand and boulders (water) .....	13	28
Boulders .....	14	15			
<b>Well B1-2-26cbd</b>					
Surface .....	1	1	Quicksand .....	5	26
Rock and clay .....	20	21	Gravel (water) .....	2	28
<b>Well B1-2-35baa</b>					
Surface .....	1	1	Sand and gravel .....	3	22
Rock and clay .....	16	17	Clay, brown .....	2	24
Rock and gravel .....	2	19	Shale .....	10	34
<b>Well B1-2-36cbb</b>					
Surface .....	3	3	Clay, yellow .....	13	31
Clay, brown .....	12	15	Boulders .....	2	33
Boulders .....	3	18	Gravel (water) .....	3	36
<b>Well B2-2-26aca</b>					
Gravel .....	12	12	Sand (water) .....	10	35
Clay, yellow .....	3	15	Sand, muddy .....	5	40
Sandstone .....	10	25			
<b>Well B2-2-28bca</b>					
Surface .....	3	3	Shale, brown .....	4	64
Gravel .....	7	10	Sand rock (water) .....	4	68
Clay, yellow .....	25	35	Shale, blue .....	49	117
Sand rock .....	6	41	Sand (water) .....	19	127
Shale, blue .....	19	60			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well B2-2-31cda2</b>					
Surface.....	2	2	Gravel (water).....	6	36
Clay, brown.....	18	20	Shale.....	3	39
Clay, yellow.....	10	30			
<b>Well B4-3-32dcd</b>					
Topsoil with a few rocks.....	12	12	Shale, sandy, gray.....	25	75
Shale, sandy, light-blue.....	6	18	Shale, sandy, light-blue.....	5	80
Shale, sandy, gray.....	29	47	Sand.....	15	95
Shale, sandy, light-brown.....	3	50	Shale, sandy, gray.....	5	100
<b>Well B4-4-14ccb</b>					
Gravel.....	54	54	Shale, sandy, light-blue.....	15	226
Shale, sandy, light-brown.....	33	87	Shale, sandy, gray.....	22	248
Shale, sandy, gray (2 gpm at 95 ft).....	13	100	Water sand (4 gpm).....	8	256
Shale, sandy, brown.....	10	110	Shale, sandy, gray.....	27	283
Shale, sandy, gray.....	19	129	Shale, blue and brown.....	32	315
Water sand (2 gpm).....	19	148	Shale, sandy, gray.....	7	322
Shale, blue and brown.....	29	177	Water sand (main water, soft) ..	7	329
Shale, sandy, blue.....	7	184	Shale, sandy, hard, gray.....	30	359
Shale, sandy, gray.....	22	206	Shale, light-brown.....	6	365
Shale, brown and blue.....	5	211	Shale, sandy, hard, gray; with lime mixed.....	35	400
<b>Well B4-4-16ada</b>					
Soil, sandy, and rocks.....	30	30	Shale, gray.....	8	65
Boulders, sand (small amount of water).....	12	42	Shale, blue and brown.....	15	80
Shale, blue.....	3	45	Sandstone, gray.....	30	110
Sandstone, light-brown.....	12	57	Water sand, coarse.....	20	130
<b>Well B4-4-24cbc</b>					
Rocks, sand, and gravel (water from 20-30 ft).....	30	30	Sandroek, red-brown.....	6	46
Sandroek, brown.....	10	40	Sandroek, light-brown.....	4	50
<b>Well B5-6-35ada</b>					
Gravel, boulders, sandy clay, with streaks of shale; very unconsolidated material.....	75	75	Sandstone with hard stringers (water increased slightly on hard stringers).....	125	200

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well C1-1-4abd</b>					
Surface.....	1	1	Sand and gravel (water).....	3	20
Boulders.....	13	14	Shale.....	3	23
Sand.....	3	17			
<b>Well C1-1-4adc</b>					
Surface.....	1	1	Quicksand.....	1	21
Gravel and clay.....	19	20	Gravel (water).....	3	24
<b>Well C1-1-5dab</b>					
Surface.....	2	2	Shale.....	13	41
Clay and rock.....	20	22	Shale, sandy (1 gpm).....	2	43
Quicksand (water).....	6	28	Shale.....	107	150
<b>Well C1-1-5dba</b>					
Surface.....	1	1	Boulders, hard.....	3	27
Rock.....	17	18	Sand (water).....	3	30
Quicksand.....	4	22	Shale.....	12	42
Gravel and clay.....	2	24			
<b>Well C1-1-6cdd</b>					
Surface.....	3	3	Shale and gravel.....	2	27
Rock and clay.....	15	18	Shale, black.....	11	38
Gravel (dry).....	7	25	Shale, sandy, blue (water).....	24	62
<b>Well C1-1-6ddc</b>					
Surface.....	3	3	Clay and gravel.....	7	20
Rock and gravel.....	7	10	Sand and gravel (water).....	3	23
Gravel.....	3	13			
<b>Well C1-1-7dcb</b>					
Clay, brown.....	20	20	Sand and gravel.....	7	40
Gravel and clay.....	13	33	Shale.....	3	43
<b>Well C1-1-8aab</b>					
Surface.....	2	2	Shale.....	21	54
Rock and clay.....	20	22	Shale (water).....	12	66
Quicksand.....	11	33			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well C1-1-8ada</b>					
Surface.....	1	1	Clay, red, and rock (water).....	8	13
Clay.....	4	5	Gravel.....	7	20
<b>Well C1-1-8ccb</b>					
Topsoil.....	3	3	Shale, gray.....	19	260
Gravel.....	31.5	34.5	Shale, black.....	35	295
Shale, dark.....	29.5	64	Shale, sandy, gray.....	5	300
Sand, soft.....	13	77	Limestone, hard, white.....	5	305
Sand (carrying water).....	6	83	Shale, gray.....	17	322
Sand.....	20	103	Shale, hard, gray.....	28	350
Shale, blue.....	67	170	Shale, hard, light-gray.....	50	400
Shale, gray.....	31	201	Shale, hard, black.....	92	492
Bentonite.....	1	202	Shale, sandy, gray.....	5	497
Shale, blue.....	2	204	Sand, gray, fine (water).....	17	514
Coal and sand.....	3	207	Sand, gray.....	29	543
Shale, gray.....	20	227	Shale, gray.....	5	548
Shale, black.....	14	241			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well C1-2-13ddd</b>					
Clay.....	5	5	Shale, blue.....	21	56
Rock and gravel.....	15	20	Shale, red.....	6	62
Clay, pink.....	15	35	Shale, blue.....	8	70
<b>Well C1-2-24ada</b>					
Rock and clay.....	7	7	Shale, sandy (water, 2 gpm)....	5	26
Shale, brown.....	11	18	Shale, gray.....	10	36
Shale, gray.....	3	21	Shale, sandy (water, 40 gpm)...	5	41
<b>Well C1-2-24dcb</b>					
Rock and clay.....	17	17	Rock, sandy, red (water).....	15	40
Rock, red.....	8	25			
<b>Well C1-2-26ada</b>					

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-1-15add</b>					
Clay .....	20	20	Gravel and sand .....	5	28
Clay, sandy .....	3	23	Shale, blue .....	3	31
<b>Well D1-1-15ccc</b>					
Clay, brown .....	13	13	Shale, black .....	1	39
Sand and gravel .....	25	38			
<b>Well D1-1-16acb</b>					
Surface .....	5	5	Shale, light-gray .....	25	60
Clay .....	20	25	Shale, blue .....	20	80
Shale, sandy .....	10	35			
<b>Well D1-1-21add</b>					
Surface .....	3	3	Gravel and sand .....	18	21
<b>Well D1-1-22bce</b>					
Surface .....	8	8	Gravel and sand .....	15	23
<b>Well D1-1-30dba</b>					
Clay .....	10	10	Shale .....	330	715
Sand and gravel .....	10	20	Shale with bentonite .....	140	855
Shale .....	185	205	Shale with sandstone stringers..	160	1,015
Shale with sandstone stringers..	180	385			
<b>Well D1-2-9bbb1</b>					
No log .....	160	160	Coal and dark sandy shale .....	7	349
Shale, sandy, brown, soft .....	25	185	Shale, sandy, gray, soft .....	13	362
Shale, sandy, gray, soft .....	55	240	Hard layer of rock .....	3	365
Shale, sandy, brown .....	47	287	Sandstone, gray, with red specks (soft water) .....	47	412
Coal .....	1	288	Shale, sandy, brown, soft .....	8	420
Shale, sandy, brown, dark .....	7	295	Shale, sandy, gray, soft .....	10	430
Shale, sandy, gray, soft .....	38	333			
Shale, sandy, coarse (no water) ..	9	342			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-2-10-dcc</b>					
Soil, sandy.....	4	4	Shale, soft, light-gray.....	40	291
Sand, gravel (water).....	26	30	Shale, brown.....	4	295
Sandstone, yellow.....	35	65	Shale, yellow.....	5	300
Shale, yellow.....	6	71	Shale, soft, light-gray.....	14	314
Shale, gray.....	12	83	Shale, yellow.....	8	322
Shale, blue.....	5	88	Shale, sandy, light-gray.....	14	336
Shale, gray.....	30	118	Shale, brown.....	11	347
Shale, brown and blue.....	7	125	Shale, sandy, light-gray (seep of water).....	36	383
Shale, soft, light-gray.....	10	135	Sandstone, hard.....	6	389
Shale, sandy, soft, gray.....	10	145	Shale, yellow-gray.....	17	406
Shale, soft, light-gray.....	15	160	Sandstone, gray.....	6	412
Shale, sandy, hard, gray.....	20	180	Water sand (very soft water but a very small amount, 1 gpm).....	6	418
Shale, soft, brown and gray.....	20	200	Shale, sandy, gray.....	37	455
Shale, soft, brown and blue.....	9	209	Shale, soft, gray, very cavey.....	18	473
Shale, sandy, gray.....	5	214			
Shale, brown.....	2	216			
Shale, sandy, soft, gray.....	32	248			
Shale, brown.....	3	251			
<b>Well D1-3-10cca</b>					
Topsoil, sandy.....	20	20	Shale, sandy, blue.....	8	244
Gravel.....	10	30	Sand, gray (water, 20 gpm, 446 ppm).....	9	253
Shale, sandy, yellowish-gray (water, 4 gpm at 47 ft, 542 ppm).....	28	58	Shale, sandy, blue and brown..	11	264
Shale, sandy, gray.....	68	126	Shale, sandy, bluish-gray.....	36	300
Shale, sandy, blue.....	30	156	Shale, sandy, blue.....	14	314
Shale, sandy, gray.....	6	162	Shale, sandy, bluish-gray.....	16	330
Shale, sandy, blue.....	10	172	Sandstone, gray, very fine sand..	20	350
Shale, sandy, gray.....	11	183	Shale, sandy, blue and brown..	25	375
Shale, sandy, blue.....	21	204	Sand, gray (principal water bed, 434 ppm).....	15	390
Shale, sandy, gray.....	32	236			
<b>Well D1-3-12dba</b>					
Topsoil and dirt, rocks.....	6	6	Sand, brown.....	5	40
Shale, blue.....	9	15	Shale, sandy, brown.....	5	45
Sandstone, yellow, very shaly..	8	23	Shale, sandy, gray.....	5	50
Sandstone, brown.....	12	35	Shale, gray, and bentonite.....	5	55
<b>Well D1-3-13dad</b>					
Topsoil, sandy.....	3	3	Shale, sandy, gray.....	29	55
Gravel and water.....	8	11	Sand, fine, gray (water).....	10	65
Shale, red-brown.....	9	20	Shale, sandy, gray.....	15	80
Bentonite.....	6	26			

TABLE 4.—*Drillers' logs of wells—Continued*

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-3-14abb</b>					
Soil, sandy, and gravel.....	5	5	Sand.....	10	30
Shale, yellowish-gray.....	15	20	Shale, reddish-gray.....	10	40
<b>Well D1-3-23bcc</b>					
Topsoil, sandy.....	6	6	Shale, sandy, gray.....	16	97
Sand, gravel (hard water).....	14	20	Sand, gray (good water).....	20	117
Shale, sandy, gray.....	40	60	Shale, sticky, brown and gray..	3	120
Shale, blue.....	21	81			
<b>Well D1-3-23bdd2</b>					
Soil, sandy.....	8	8	Shale, sandy, gray.....	10	100
Gravel.....	5	13	Shale, sticky, gray.....	50	150
Shale, gray, soft.....	5	18	Shale, brown.....	10	160
Sandstone, yellow.....	4	22	Shale, sticky, gray.....	15	175
Shale, gray.....	8	30	Shale, sandy, gray, hard.....	31	206
Sandstone, gray.....	60	90	Water sand and hard shells.....	44	250
<b>Well D1-3-24cbb</b>					
Soil.....	5	5	Sandstone, gray.....	19	212
Gravel (water).....	11	16	Shale, sandy, blue.....	6	218
Shale, sandy, blue, gray, brown.	154	170	Sandstone, white (water).....	12	230
Sandstone, gray.....	15	185	Shale, blue.....	2	232
Shale, sandy, blue.....	8	193			
<b>Well 1-3-21cbd</b>					
Topsoil, sandy.....	4	4	Shale, sandy, gray.....	6	131
Gravel.....	8	12	Shale, sandy, blue.....	11	142
Sandrock, yellow (veins of hard water).....	12	24	Shale, blue and brown.....	2	144
Shale, blue.....	3	27	Shale, sandy, gray.....	5	149
Shale, sandy, gray (water at 55 ft. Fairly hard and tastes bitter).....	58	85	Shale, blue and brown.....	31	180
Shale, blue.....	6	91	Shale, sandy, gray.....	20	200
Shale, gray.....	31	122	Sandrock, gray; with hard shells.....	20	220
Shale, blue.....	3	125	Sand, white (water).....	10	230
			Shale, sandy, blue.....	5	235
<b>Well D1-3-24cda</b>					
Soil, sandy.....	8	8	Shale, blue.....	6	238
Gravel.....	9	17	Sandstone, bluish-white.....	8	246
Shale, sandy; alternating gray, blue, brown, yellow.....	200	217	Sandstone, brown.....	8	254
Sandstone, coarse (small flow)..	15	232	Sandstone, white (main flow)...	11	265
			Shale, brown.....	2	267

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-3-2fcd</b>					
Topsoil, sandy.....	23	23	Water sand (good for 60 gpm or better).....	10	50
Gravel (no water).....	3	26			
Shale, sandy, gray.....	14	40			
<b>Well D1-4-2cab</b>					
Topsoil, sandy.....	6	6	Sand, fine, white.....	12	49
Gravel.....	10	16	Shale, blue.....	4	53
Shale, gray.....	15	31	Shale, sandy, gray.....	12	65
Shale, sandy, gray.....	6	37			
<b>Well D1-4-3deb</b>					
Topsoil, sandy.....	3	3	Shale, sandy, blue.....	15	98
Gravel.....	11	14	Shale, sandy, gray.....	14	112
Shale, sandy, blue.....	9	23	Shale, sandy, blue, very hard....	8	120
Shale, sandy, gray, hard.....	30	53	Sand (water).....	10	130
Shale, blue.....	4	57	Shale, sandy, gray.....	7	137
Shale, sandy, gray.....	26	83			
<b>Well D1-4-4ccd</b>					
Gravel.....	9	9	Shale, sandy, blue.....	3	41
Sandstone, hard layers.....	3	12	Sandstone, gray (water).....	14	55
Shale, bluish-gray.....	8	20	Shale, sandy, gray.....	8	63
Sandstone, gray (water).....	18	38			
<b>Well D1-4-4cdd</b>					
Topsoil, sandy.....	6	6	Shale, gray, sandy.....	18	198
Gravel (water bearing).....	9	15	Shale, sandy, blue.....	2	200
Sandstone, hard.....	1	16	Shale, sandy, gray.....	3	203
Shale, sandy, soft, gray.....	1	17	Shale, soft, blue.....	6	209
Sandstone, hard.....	1	18	Shale, sandy, gray.....	9	218
Shale, sandy, gray.....	14	32	Shale, sandy gray, red and brown sand.....	18	236
Shale, blue.....	5	37	Shale, soft, blue.....	4	240
Shale, sandy, gray.....	8	45	Shale, sandy, soft, gray.....	8	248
Sand (water bearing).....	12	57	Shale, very sandy, gray.....	7	255
Shale, sandy, gray.....	30	87	Shale, soft, blue.....	4	259
Shale, sandy, sticky, gray.....	21	108	Shale, sandy, soft, gray.....	7	266
Shale, sandy, gray.....	12	120	Shale, soft, blue.....	2	268
Rock, hard, white.....	2	122	Shale, sandy, gray.....	5	273
Shale, sandy, gray.....	23	145	Shale, sandy, blue.....	8	281
Shale, sandy, blue.....	8	153	Shale, soft, dark-brownish-blue..	2	283
Shale, sandy, gray.....	3	156	Shale, soft, reddish-brown.....	9	292
Shale, soft, sticky, blue.....	3	159	Shale, sandy, blue.....	5	297
Shale, sandy, gray.....	18	177	Shale, soft, reddish-brown.....	13	310
Shale, soft, blue.....	3	180			

TABLE 4.—*Drillers' logs of wells—Continued*

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-4-1cdd—Continued</b>					
Shale, sandy, blue.....	4	314	Shale, sandy, hard, blue.....	5	385
Shale, sandy, gray.....	6	320	Sand, gray (water bearing, flow increased to 100 gpm)....	35	420
Sand, gray (water bearing, well flowed 9 gpm).....	18	338	Shale, sandy, hard, blue.....	3	423
Shale, hard, brown.....	8	346	Sand, gray (water bearing).....	7	430
Sandstone, hard, brown.....	5	351	Shale, sandy, hard, blue.....	5	435
Shale, hard, reddish-brown.....	9	360	Sand, gray (water bearing).....	3	438
Shale, hard, blue.....	4	364	Sandstone, gray.....	8	446
Shale, hard, reddish-brown....	14	378	Sand and blue medium-hard shale.....	4	450
Shale, blue and brown mixed...	2	380			
<b>Well D1-4-1ddd</b>					
Topsoil, sandy.....	3	3	2 gpm).....	50	170
Gravel.....	14	17	Shale, sandy, gray.....	20	190
Shale, sandy, gray.....	63	80	Sandrock.....	58	248
Shale, sticky, gray.....	40	120	Water sand (flow).....	17	265
Sandrock (water at 150 ft,					
<b>Well D1-4-5bbb</b>					
Topsoil, sandy.....	6	6	Sand, gray (water).....	10	50
Gravel.....	8	14	Shale, sandy, blue.....	10	60
Shale, sandy, gray.....	26	40			
<b>Well D1-4-7bbb</b>					
Gravel.....	15	15	Sandstone, gray (water, 3 gpm) ..	17	180
Sandstone, reddish-brown (seep of hard water at 29 ft).....	35	50	Shale, alternating gray and blue..	50	230
Shale, gray and blue.....	76	126	Sandstone, gray.....	16	246
Sandstone, gray, very coarse....	17	143	Shale, alternating gray and blue..	121	367
Shale, sandy, gray.....	20	163	Sandstone, gray(water).....	15	382
			Shale, blue.....	8	390
<b>Well D1-4-7dcb</b>					
Topsoil, sandy.....	1	1	Shale, sandy, gray (water at 40 ft, 5 gpm).....	23	65
Gravel.....	14	15	Sandrock, gray (water at 75 ft, 5 gpm, very hard).....	10	75
Shale, yellow-brown.....	8	23	Shale, sandy, gray.....	7	82
Shale, sandy, brown.....	17	40	Shale, blue.....	3	85
Shale, pink.....	3	43			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-4-9aad</b>					
Gravel and water .....	14	14	Shale, sandy, hard, gray .....	45	180
Shale, sandy, gray, very coarse ..	43	57	Sandstone, gray (small amount of water at 185 ft) .....	32	212
Shale, sandy, blue .....	6	63	Shale, sandy, blue .....	6	218
Shale, gray .....	32	95	Shale, sandy, gray .....	17	235
Shale, blue .....	22	117	Sandrook, gray .....	15	250
Sandstone, gray, with red streaks .....	13	130	Water sand .....	15	265
Shale, sandy, hard, blue .....	5	135	Shale, brown and blue .....	2	267
<b>Well D1-4-9cdc2</b>					
Sand and gravel (water) .....	17	17	Sandstone (soft water) .....	13	339
Sand, yellow (water) .....	13	30	Shale, gray and blue .....	136	475
Sandstone, gray, soft .....	30	60	Sandstone (soft water) .....	39	514
Sandstone, gray, hard .....	18	78	Shale, brown .....	1	515
Shale, blue and gray .....	248	326			
<b>Well D1-4-9cdc3</b>					
Soil .....	3	3	Sandstone, yellow (water) .....	39	57
Gravel (water) .....	15	18			
<b>Well D1-4-18baa</b>					
Sand, yellowish, and gravel .....	8	8	Shale, sandy, blue .....	25	190
Shale, brown and blue .....	24	32	Shale, blue .....	10	200
Bentonite .....	8	40	Shale, sandy, blue .....	40	240
Shale, sandy, blue .....	8	48	Sandstone, light-gray .....	25	265
Shale, sandy, gray (water at 60 ft, hard) .....	49	97	Shale, sandy, light-blue .....	17	282
Shale, sandy, blue .....	5	102	Shale, sandy, light-gray .....	11	293
Shale, sandy, gray .....	30	132	Shale, sandy, blue, hard .....	13	306
Sand, blue, and coal shale .....	3	135	Sand (main water) .....	10	316
Shale, blue .....	30	165	Shale, sandy, blue .....	4	320
<b>Well D1-4-18bba</b>					
Topsoil, sandy .....	2	2	Shale, streaks of blue and brown .....	5	119
Gravel .....	11	13	Shale, sandy, gray .....	13	132
Shale, brown .....	11	24	Shale, gray .....	12	144
Shale, sandy, gray .....	5	29	Shale, blue, and coal .....	3	147
Bentonite (0-35 very soft and cavey) .....	6	35	Shale, sandy, gray .....	19	166
Shale, sandy, gray .....	22	57	Shale, sandy, blue .....	11	177
Shale, sandy, coarse, gray (water at 57 ft, 3,312 ppm) .....	19	76	Shale, sandy, gray .....	6	183
Shale, sandy, blue .....	7	83	Shale, sandy, blue .....	6	189
Shale, sandy, gray .....	19	102	Shale, sandy, gray .....	3	192
Shale, sandy, blue .....	7	109	Shale, sandy, gray (114-198 ft, soft and sticky) .....	6	198
Shale, sandy, gray .....	5	114	Shale, sandy, hard, gray .....	11	209

TABLE 4.—*Drillers' logs of wells—Continued*

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-4-18bba—Continued</b>					
Shale, blue.....	11	220	Shale, sandy, gray, hard.....	5	311
Shale, sandy, gray.....	17	237	Shale, sandy, blue, hard.....	3	314
Shale, sandy, blue.....	5	242	Sand, gray (378 ppm).....	10	324
Shale, sandy, gray.....	47	289	Shale, sandy, blue, hard.....	6	330
Shale, sandy, blue.....	17	306			
<b>Well D1-4-18bbd</b>					
Topsoil, sandy.....	8	8	Shale, sandy, gray.....	4	40
Gravel.....	10	18	Sand, gray (hard water).....	5	45
Shale, sandy, brown, very soft..	6	24	Shale, sandy, gray.....	15	60
Shale, yellowish-gray, very soft.....	12	36			
<b>Well D1-4-18daa</b>					
Soil.....	1	1	Shale, gray, blue and green.....	129	217
Gravel.....	15	16	Sandstone (water, 2 gpm).....	18	235
Shale, yellow and gray.....	56	72	Shale, sandy, gray.....	15	250
Sandstone (bad water).....	16	88	Sandstone (water).....	20	270
<b>Well D1-5-11acc</b>					
Topsoil.....	3	3	Sand, good, coarse (third water at 146 ft).....	4	153
Sand.....	2	5	Clay, blue.....	1	154
Clay, red.....	15	20	Sand (fourth water at 154 ft)....	2	156
Sandstone.....	7	27	Clay, blue.....	2	158
Clay, blue.....	32	59	Sand (fifth water).....	8	166
Clay, red and blue.....	59	118	Clay, red and blue.....	25	191
Shale, sandy (first water at 118 ft).....	7	125	Clay, sandy.....	10	201
Sandstone.....	1	126	Sand (sixth water at 191 ft).....	7	208
Sand, good, coarse (second water at 126 ft).....	6	132	Clay, blue.....	2	210
Clay, blue.....	14	146	Sand (seventh water at 210 ft) ..	1	211
Clay, sandy (carries water).....	3	149	Clay, blue.....	1	212
			Sand (eighth water at 212 ft)....	3	215
			Clay, blue.....	10	225
<b>Well D1-6-7bcd</b>					
No log.....	60	60	Sandstone, fine to coarse, light- gray, greenish-gray, uncon- solidated, soft (water).....	120	680
Sandstone, fine to coarse, green to olive, soft.....	60	120	Claystone, sandy, greenish- gray.....	10	690
Claystone, sandy, green, yellow, red.....	100	220	Sandstone, medium to coarse, light-gray, soft (water).....	10	700
Sandstone, fine to coarse, green to light-gray, soft (water).....	120	340	Claystone, sandy, greenish- gray.....	20	720
Claystone, sandy, greenish- gray; bentonite.....	220	560			

TABLE 4.—*Drillers' logs of wells*—Continued

Material	Thick- ness (feet)	Depth (feet)	Material	Thick- ness (feet)	Depth (feet)
<b>Well D1-6-7bcd—Continued</b>					
Sand and claystone, greenish-gray.....	20	740	Claystone, sandy, green, yellow, red.....	60	830
Sandstone, very fine to medium, light-gray, clayey, soft (water).....	30	770	Siltstone, light-gray, clayey.....	70	900
			Shale, variegated, silty, sandy; some chert.....	60	960
<b>Well D2-3-4cab</b>					
Shale, blue and brown.....	14	14	Shale, sandy, blue.....	32	120
Shale, sandy, reddish-brown.....	34	48	Sand, coarse (water).....	22	142
Sandrock, yellow (bad water).....	40	88	Shale, sandy, gray.....	8	150
<b>Well D2-3-7aaa</b>					
Soil.....	20	20	Shale, blue, gray, yellow, brown.....	31	116
Sand and gravel.....	18	38	Sandstone, coarse, with shale.....	9	125
Sandstone, yellow.....	8	46	Sandstone, dirty.....	5	130
Shale, blue, gray, pink.....	23	69	Sandstone (soft water, 2 gpm).....	8	138
Sandstone (water, soft, 5 gpm).....	11	80	Shale, sandy, gray.....	2	140
Shale, gray and pink.....	4	84			
Sandstone (no water).....	1	85			
<b>Well D2-3-7aab</b>					
Soil, sandy.....	17	17	Sandstone, coarse (water, 1 gpm).....	3	298
Sand and gravel (water).....	23	40	Shale, variegated.....	20	318
Shale, sandy, blue, pink, gray, yellow.....	68	108	Sandrock, gray (water, 1 gpm).....	9	327
Sandstone (good water, 1½ gpm).....	14	122	Shale, sandy, gray.....	43	370
Shale, blue.....	1	123	Shale, blue and brown.....	4	374
Sandstone, silty, coarse.....	12	135	Shale, sandy, sticky, gray.....	23	397
Shale, variegated.....	160	295	Sand, white (water, 3 gpm).....	7	404
			Shale, sandy, gray.....	4	408

TABLE 5.—Logs of test holes and test wells

[Altitudes given in table of well records (table 3)]

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>A1-1-34beb</b>							
Alluvium:				Alluvium—Continued			
Clay and silt, dark-brown to black.....	6	6	some finer sand and coarser gravel.....	22	28		
Sand and gravel; mostly coarse sand to fine gravel:			Cody Shale:				
			Shale, dark-gray.....	3	31		
<b>A1-2-6aaa</b>							
Slope wash and alluvium:				Wind River Formation:			
Clay, silt, and sand, tan; very fine to coarse sand and some very fine gravel.	37	37	Conglomerate and very coarse sandstone, loosely cemented (takes drilling mud, no returns).....	6	50		
Gravel and sand.....	7	44					
<b>A1-2-6adb</b>							
Slope wash:				Wind River Formation—Con.			
Sand and silt, clayey; some very fine gravel; brown...	5	5	Sandstone, medium-grained to very coarse grained, dark-brown, loosely cemented; thin interbeds of siltstone.....	5	81		
Sand, very fine, and silt, tan.....	5	10	Siltstone, dark-gray.....	5	86		
Wind River Formation:			Sandstone, coarse-grained to very coarse grained, very well sorted, light-gray, loosely cemented, clean (damp).....	5	91		
Siltstone, dark-gray.....	10	20	Sandstone, very coarse grained, to very fine grained conglomerate; very well sorted, light-gray, loosely cemented (damp, water at 101 ft)...	15	106		
Sandstone, very fine grained to medium-grained, slightly silty, light-brown, fairly well sorted, loosely cemented.....	12	32	Siltstone(?), poor samples...	5	111		
Siltstone, dark-greenish-gray.....	6	38	Conglomerate, very fine grained, and very coarse grained sandstone; well-sorted, loosely cemented (water, specific conductance 1,200 micromhos).....	21	132		
Sandstone, very fine grained to medium-grained, light-bluish-gray, loosely cemented.....	4	42	Sandstone, very fine grained, tan, and green and gray siltstone; interbedded.....	4	136		
Siltstone, dark-gray.....	4	46	Sandstone, very fine grained to coarse-grained sandstone, poorly sorted, tan, loosely cemented.....	6	142		
Sandstone, very fine grained to fine-grained, light-bluish-gray, cemented.....	5	51					
Siltstone, dark-gray.....	10	61					
Sandstone, very fine grained to medium-grained, light-bluish-gray, loosely cemented....	9	70					
Siltstone, dark-brownish-gray, and dark-brown medium- to coarse-grained sandstone, loosely cemented; interbedded.....	6	76					

TABLE 5.—Logs of test holes and test wells—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
<b>A1-2-6adb—Continued</b>					
Wind River Formation—Con.			Wind River Formation—Con.		
Siltstone, red.....	1	143	tan and brown, loosely		
Siltstone(?), light color,			cemented (specific con-		
poor samples.....	3	146	ductance of water jetted		
Sandstone(?), poorly sorted,			from hole, when at total		
poor samples.....	5	151	depth, was 1,300		
Sandstone, very fine			micromhos).....	10	161
grained to coarse-grained,					
<b>A1-2-21bbb</b>					
Slope wash and alluvium (not			Wind River Formation—Con		
mapped):			Sandstone, medium- to		
Sand and silt, brown.....	7	7	coarse-grained, light-gray,		
Gravel, very fine, and			clean (dry).....	5	135
brown sand.....	3	10	Siltstone, sandy, and very		
Wind River Formation:			fine grained to medium-		
Siltstone, greenish-gray.....	5	15	grained sandstone; bluish-		
Marlstone(?), grayish-white,			gray and gray; some		
very hard; powdery			coarser sand.....	55	190
returns.....	1	16	Sandstone, very fine grained		
Siltstone, tan.....	4	20	to medium-grained, silty,		
Siltstone, very fine grained			gray; some coarser sand..	20	210
sandy, greenish-gray.....	15	35	Sandstone, coarse-grained		
Siltstone, purplish-gray and			to very coarse grained,		
olive.....	23	58	well-sorted, light-gray,		
Siltstone, bluish-gray.....	3	61	clean (dry).....	10	220
Sandstone, very fine grained			Sandstone, medium-		
to medium-grained, blu-			grained to very coarse		
ish-gray (damp).....	9	70	grained, silty, gray (dry) ..	20	240
Siltstone, very fine grained,			Sandstone, very fine		
sandy, bluish-gray.....	5	75	grained to coarse		
Sandstone, very fine grained			grained, silty, gray (dry) ..	15	255
to medium-grained, silty,			Siltstone, sandy, brown....	5	260
bluish-gray.....	5	80	Sandstone, very fine		
Siltstone, very fine grained,			grained to coarse-grained,		
sandy, bluish-gray; hard			silty, gray (water).....	10	270
streaks at 84, 88, and 91 ft.	11	91	Sandstone and very fine		
Sandstone, very fine grained,			conglomerate; poor sam-		
silty, bluish-gray (damp) ..	9	100	ples (water, noticeable		
Sandstone, very fine grained			increase in water 280-285		
to medium-grained, blu-			ft; specific conductance		
ish-gray.....	10	110	730 micromhos).....	27	297
Siltstone, very fine grained,			Siltstone, sandy, gray.....	3	300
sandy, bluish-gray.....	5	115			
Sandstone, very fine grained					
to medium-grained, blu-					
ish-gray and gray (dry)...	15	130			

TABLE 5.—*Logs of test holes and test wells—Continued*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
<b>A1-2-26cbb</b>					
Slope wash (not mapped):			Wind River Formation—Con.		
Sand, silty, clayey, brown..	3	3	Siltstone, sandy, and very		
Wind River Formation:			fine-grained silty sand-		
Sandstone, medium to very			stone; dark-gray (slightly		
coarse grained; mostly			damp about 205 ft).....	44	210
fair sorting; tan and yel-			Siltstone or shale, dark-		
low; rusty zones; loosely			reddish-brown.....	10	220
cemented; thin streak of			Siltstone, very fine grained		
very fine grained and			sandy, greenish-gray.....	5	225
fine-grained conglomerate			Siltstone, dark-gray.....	10	235
at 17 ft.....	17	20	Marlstone(?), grayish-white,		
Siltstone, very fine grained,			very hard; powdery		
sandy, green.....	5	25	returns.....	2	237
Sandstone, very fine			Sandstone, very fine grained		
grained to coarse-grained,			to medium grained, silty,		
green, poorly sorted;			light-gray.....	3	240
green siltstone.....	5	30	Siltstone, dark-gray.....	15	255
Sandstone, medium-			Siltstone and silty very fine		
grained, yellow, well-			grained to fine-grained		
sorted.....	13	43	sandstone, dark-brownish-		
Siltstone, very fine grained,			gray.....	10	265
sandy, green.....	5	48	Sandstone, medium- to		
Sandstone, very fine grained			coarse-grained; some finer		
to medium-grained,			sand and silt; fair sorting;		
bluish-gray, poorly			dark brownish gray.....	19	275
sorted; few hard streaks..	32	80	Sandstone, very fine grained		
Sandstone, mostly fine- to			to medium grained; some		
medium-grained, bluish-			coarse sand and silt; dark		
gray; fair sorting.....	55	135	brownish gray.....	10	285
Siltstone, very fine grained,			Siltstone, dark-gray; some		
sandy, dark-gray.....	5	140	sandy siltstone.....	20	305
Sandstone, mostly fine- to			Sandstone, coarse-grained		
medium-grained, bluish-			to fine-grained conglom-		
gray; fair sorting.....	10	150	erate (water, specific		
Siltstone, dark-gray, and			conductance 750 micro-		
bluish-gray very fine			mhos).....	30	335
grained sandstone.....	5	155	Siltstone, dark-gray.....	10	345
Siltstone, dark-gray.....	9	164			
Marlstone(?), grayish-white,					
very hard; powdery					
returns.....	2	166			
<b>A1-5-15aab</b>					
Slope wash and alluvium:			Slope wash and alluvium—Con.		
Silt and very fine sand, tan..	5	5	Sand, mostly coarse; fair		
Clay, silty, sand, tan.....	6	11	sorting; tan (water in-		
Sand, very fine and fine,			creased at 42 ft)....	8	50
and clay, tan (damp)....	4	15	Wind River Formation:		
Sand, mostly fine, tan			Sandstone, fine- to medium-		
(wet).....	10	25	grained, bluish-gray....	5	55
Sand, mostly coarse, and					
clay, tan (wet).....	17	42			

TABLE 5.—Logs of test holes and test wells—Continued

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>A2-1-27bcb</b>							
<b>Wind River Formation:</b>				<b>Wind River Formation—Con.</b>			
Sandstone, coarse-grained, and very fine grained conglomerate; yellow, clean.....	22	22	Sandstone, very fine to medium, bluish-gray.....	7	112		
Siltstone, very fine grained, sandy, bluish-gray.....	5	27	Siltstone, dark-brownish- red.....	8	120		
Sandstone, medium- grained to very coarse grained; some fine sand and very fine gravel; yellow.....	18	45	Sandstone, fine to very coarse grained, bluish- gray.....	10	130		
Sandstone, very fine to very coarse grained, yellow and rusty-brown...	16	61	Siltstone, dark-brownish- red, partly sandy.....	15	145		
Sandstone, very fine grained to coarse-grained, very silty; sandy silt- stone; bluish-gray.....	14	75	Sandstone, mostly very fine to fine-grained, silty; sandy siltstone; brown and gray (little water 150 to 170 ft).....	54	199		
Sandstone, fine to very coarse grained, yellow and very light brown.....	11	86	Sandstone, very fine grained to medium- grained, silty; some sandy siltstone; hard (little water at 210 ft).....	16	215		
Siltstone, sandy, bluish- gray.....	6	92	Sandstone, very fine to very coarse grained, silty, gray and light- gray, partly hard; poor samples (little water 255 to 320 ft).....	114	329		
Sandstone, very fine to very coarse grained, bluish-gray (damp at 92 ft).....	3	95	Sandstone; no sample, no circulation with water or air, probably well-sorted permeable sandstone (water).....	3	332		
Sandstone, medium- grained to very coarse grained, well-sorted, bluish-gray.....	10	105					
<b>A2-2-32cbc</b>							
<b>Alluvium:</b>				<b>Wind River Formation:</b>			
Clay or silt, sandy, tan.....	4	4	Sand and gravel; some cobbles or boulders; mostly medium sand to very fine gravel in sam- ples; mostly dark-colored grains; better sorting 26- 30 ft.....	10	30		
Sand, mostly very fine; clay and silt; dark brown.....	4	8	Sandstone, very fine grained, silty, dark-olive- green.....	3	33		
Sand and gravel; mostly coarse sand to fine gravel; mostly dark-colored grains.....	9	17	Siltstone, light-bluish-gray..	3	36		
Sand, very fine to coarse; mostly dark-colored grains.....	3	20					

TABLE 5.—Logs of test holes and test wells—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
<b>A3-1-9cda</b>					
Slope wash and alluvium:			Wind River Formation—Con.		
Sand, very fine to coarse, tan.....	5	5	Sandstone, very fine grained to coarse-grained, gray; layer of dark-gray siltstone at 120 ft (damp 125-130 ft).....	20	130
Gravel, very fine to fine; coarse to very coarse sand; very well sorted; tan.....	3	8	Siltstone, dark-gray.....	2	132
Wind River Formation:			Sandstone, very fine grained to coarse-grained, silty, dark-gray; some sandy siltstone.....	13	145
Siltstone, green and tan, and very fine grained sandy siltstone.....	7	15	Sandstone, mostly me- dium-grained to very coarse grained (little wa- ter at 150 ft).....	9	154
Sandstone, very fine grained, very silty, tan and light-gray.....	5	20	Siltstone, dark-gray.....	3	157
Siltstone or shale, olive- brown and green.....	20	40	Sandstone, fine- to coarse- grained, gray; less finer grains 157-160 ft (water)..	13	170
Siltstone, very fine grained and fine-grained, sandy; silty sandstone; gray and green.....	7	47	Bentonite streak.....		170
Siltstone, dark-gray.....	18	65	Sandstone, medium- grained to very coarse grained; some very fine grained conglomerate (water).....	12	182
Sandstone, fine- to medi- um-grained; some coarser sand; fair sorting; green- ish tan and gray.....	18	83	Sandstone, very fine grained to coarse-grained; sandy gray siltstone.....	5	187
Siltstone, very fine grained, sandy, dark-gray.....	3	86	Sandstone, medium grained to very coarse grained (water).....	19	206
Sandstone, fine- to coarse- grained, yellow; hard cemented zones inter- bedded with loose mostly medium- to coarse- grained sandstone.....	12	98	Siltstone, very fine grained, sandy, dark- gray.....	1	207
Siltstone, dark-gray.....	7	105			
Sandstone, very fine grained and fine-grained, dark-gray.....	5	110			

**A4-1-11bdd**

Dune(?) sand or alluvium (not mapped):			Wind River Formation—Con.		
Sand, very fine to coarse, silty; contains a little gravel, poorly sorted; tan.....	5	5	Siltstone or shale, greenish- gray.....	5	30
Wind River Formation:			Siltstone or shale, dark- reddish-brown, green, and dark-gray.....	10	40
Sandstone, very fine grained to coarse-grained, very silty; some sandy siltstone; poorly sorted, greenish-tan.....	13	18	Sandstone, very fine grained to medium- grained, silty, gray (damp).....	1^	50
Sandstone, mostly fine- to coarse-grained; fair sorting; tan.....	7	25	Sandstone, very fine grained to fine-grained, well-cemented, light- whitish-gray, very hard..	1	51

TABLE 5.—*Logs of test holes and test wells*—Continued

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>A4-1-11bbd—Continued</b>							
Wind River Formation—Con. Sandstone, fine- to coarse- grained, gray; thin layer of dark-gray siltstone at about 60 ft; well sorted 65-80 ft (damp, little water at 79 ft).....		29	80	Wind River Formation—Con. Sandstone, very fine grained to medium- grained, very silty; very fine grained sandy silt- stone; gray.....		40	150
Siltstone, gray, hard, and sandy siltstone.....		10	90	Sandstone, very fine grained to medium- grained gray; stringers of very coarse grained sand- stone containing fine gravel; streaks of light- gray shale (probably a little water).....		25	175
Sandstone; mostly very coarse grained to very fine grained conglomer- ate; very silty and clayey; fairly tight (little water at 110 ft).....		20	110	Shale, dark-gray.....		10	185
<b>A4-1-18dbc</b>							
Terrace deposits (not mapped): Sand and some gravel, poorly sorted.....		18	18	Wind River Formation—Con. Siltstone, dark-gray, green, and dark-reddish-brown; streak of very hard light- gray marlstone(?) at about 166 ft.....		13	173
Wind River Formation: Sandstone, mostly medium- to coarse-grained, rusty- yellow.....		49	67	Sandstone, mostly very fine grained to medium- grained, very silty, dark- gray; streaks of dark-gray siltstone; thin bed of hard greenish-gray shale at about 197 ft.....		27	200
Siltstone or shale, olive- green and dark-gray.....		21	88	Siltstone, dark-gray.....		5	205
Sandstone, very fine grained to medium-grained, very silty, gray.....		2	90	Sandstone, very fine grained to coarse grained, partly silty, gray and dark-gray; fair sorting 215-225 ft (damp).....		20	225
Siltstone, dark-gray.....		4	94	Siltstone, sandy, gray.....		1	226
Sandstone, very fine grained to medium-grained, silty, gray.....		16	110	Sandstone, mostly coarse grained to very coarse grained, very well sorted, light-gray (water at 230 ft).....		4	230
Siltstone, dark-gray.....		8	118	Sandstone, fine- to coarse-grained; fair sort- ing; light-gray; hard streak at 247 ft (water)....		17	247
Sandstone, very fine grained to medium-grained, silty, gray; streak of very hard whitish-gray marlstone(?) at 122 ft; powdery re- turns.....		7	125	Sandstone, medium grained to very coarse grained, well-sorted, light-gray (water).....		24	271
Bentonite(?) streak, gray.....			125	Shale, dark gray.....		1	272
Sandstone, fine grained to very coarse grained, fairly well sorted, gray and dark-gray.....		10	135				
Sandstone, medium- to coarse-grained, well- sorted, dark-gray.....		7	142				
Shale, dark-gray.....		10	152				
Siltstone, very fine grained, sandy, gray, hard; streak of silty coarse-grained sandstone at 160 ft.....		8	160				

TABLE 5.—Logs of test holes and test wells—Continued

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>A5-3-32bcb</b>							
Wind River Formation:				Wind River Formation—Con.			
Siltstone, dark-gray and green; contains some very fine grained sand	25	25		Siltstone, very sandy, and silty; very fine grained to fine-grained sandstone; gray	5	245	
Siltstone, very fine grained, sandy; silty very fine to fine-grained sandstone; gray; streak of very hard white material at 40 ft	35	60		Siltstone, dark-gray; some very fine grained sandy siltstone	15	260	
Siltstone or shale, dark-reddish-brown	12	72		Sandstone, very fine grained, very silty, gray and light-gray	14	274	
Siltstone, and very fine grained silty sandstone, gray	11	83		Siltstone, reddish-brown	1	275	
Siltstone, dark-brown and green	7	90		Siltstone, very fine grained, sandy, gray and dark-gray	15	290	
Sandstone, very fine-grained to fine-grained, silty; sandy siltstone; gray	9	99		Siltstone, dark-reddish-brown, dark-gray, and green	17	307	
Sandstone, fine- to medium-grained, silty; fair shorting; gray	6	105		Siltstone, very fine grained, sandy, and very silty; very fine grained sandstone; light-gray and gray	8	315	
Siltstone, dark-gray	5	110		Siltstone or shale, dark-reddish-brown, green, and dark-gray; some very fine grained sandy siltstone	10	325	
Siltstone, dark-brown and green	5	115		Siltstone, very fine grained, sandy; silty sandstone; gray	7	332	
Siltstone, very fine grained, sandy, dark-gray and green, hard	15	130		Siltstone or shale, dark-reddish-brown, green and dark-gray	13	345	
Siltstone or shale, dark-reddish-brown, green, and dark-gray	15	145		Siltstone, sandy, light-gray very hard	3	348	
Sandstone, very fine grained to medium-grained, silty; poor sorting; gray	5	150		Limestone, very hard (or very fine grained calcareous well-cemented sandstone), mostly gray, some tau; some cherty(?) material of other colors	6	354	
Siltstone, dark-gray and green	10	160		Siltstone or shale, dark-reddish-brown, green, and dark-gray	11	365	
Sandstone, very fine grained to medium-grained, very silty, gray and dark-brown	15	215		Siltstone, very fine grained, sandy, gray and light-gray; streak of reddish-brown shale at 368 ft	9	374	
Siltstone, dark-gray	5	220		Siltstone, dark-gray; some brown	6	380	
Sandstone, very fine grained and fine-grained, very silty, gray	10	230		Siltstone, very fine grained, sandy, light-gray	5	385	
Sandstone, very fine grained to coarse-grained, gray	10	240		Sandstone, very fine grained to fine-grained, silty, light-gray	4	389	

TABLE 5.—Logs of test holes and test wells—Continued

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>A5-3-32bcb—Continued</b>							
Wind River Formation—Con.				Wind River Formation—Con.			
Siltstone or shale, dark-reddish-brown, green, and dark-gray; some gray very fine grained sandy siltstone below 395 ft. ....				41	430	Sandstone, very fine to fine-grained, silty, light-gray. .... 5 520	
Siltstone or shale, dark-reddish-brown, green, and dark-gray; thin beds of gray very fine grained sandy siltstone and silty sandstone at about 432, 448, 469, and 482 ft. ....				60	490	Siltstone or shale, dark-reddish-brown; some green. .... 13 533	
Sandstone, very fine grained to medium-grained, slightly silty; fair sorting; light-gray. ....				5	495	Sandstone, very fine grained to medium-grained, silty, light-gray, hard. .... 3 536	
Siltstone or shale, dark-reddish-brown, green, and dark-gray; hard streak at 512 ft. ....				20	515	Siltstone or shale, dark-reddish-brown; some green. .... 9 545	
						Siltstone, very fine grained, sandy, light-gray, hard. .... 7 552	
						Siltstone or shale, dark-reddish-brown; some green (dry hole to total depth) ..... 8 560	
<b>A5-4-21ccd</b>							
Terrace deposits:				Wind River Formation—Con.			
Gravel and sand, angular fragments, silty, poorly sorted. ....				5	5	Sandstone, fine- to medium-grained, well-sorted, blue-gray; streak of very hard white material at 94 ft. .... 6 96	
Wind River Formation:				Siltstone or shale, dark-gray and dark-reddish-brown. .... 4 100			
Sandstone, very fine grained to fine-grained, silty, fairly well sorted, olive-tan, soft, loosely cemented. ....				22	27	Siltstone or shale, dark-gray; streaks of light-gray very fine grained to fine-grained silty sandstone at 120, 140, and 150 ft. .... 55 155	
Siltstone, black, rusty-brown, and green. ....				3	30	Sandstone, very fine grained to medium-grained, silty, gray; coarser and better sorted 160-165 ft. .... 15 170	
Siltstone, green, few streaks of green; rusty very fine grained silty sandstone. ....				12	42	Siltstone, very fine grained, sandy; some silty sandstone; gray. .... 12 182	
Sandstone, very fine grained and fine-grained, rusty, olive-tan. ....				7	49	Marlstone(?), white, very hard; powdery returns. .... 3 185	
Marlstone(?), white, very hard. ....				2	51	Siltstone, dark-gray. .... 38 223	
Siltstone, gray and green; contains very fine sand. ....				6	57	Sandstone, very fine grained to fine-grained, silty, gray. .... 12 235	
Sandstone, very fine grained to medium-grained, olive-tan. ....				5	62		
Siltstone, bluish-gray and green; layers of very fine grained silty sandstone. ....				28	90		

TABLE 5.—*Logs of test holes and test wells—Continued*

Thickness (feet)		Depth (feet)		Thickness (feet)		Depth (feet)	
<b>A5-1-21ced</b>							
<b>Wind River Formation—Con.</b>				<b>Wind River Formation—Con.</b>			
Siltstone, dark-gray.....	10	245		Sandstone, coarse-grained to very coarse grained, very well sorted (water started at 279 ft; specific conductance 3,900 micro- mhos).....	20	295	
Sandstone, very fine grained to fine-grained, silty, gray.....	5	250		Siltstone, very fine grained, sandy, dark-gray.....	1	296	
Siltstone, dark-gray.....	5	255					
Sandstone, very fine grained to medium- grained, gray.....	5	260					
Sandstone, medium- grained, very well sorted, gray; hard streak at 266 ft (damp).....	15	275					
<b>A5-5-33aba</b>							
<b>Terrace deposits:</b>				<b>Wind River Formation—Con.</b>			
Gravel, sand, and clay, poorly sorted; gravel is angular and largely of sedimentary rocks.....	7	7		Siltstone, dark-gray and green, partly sandy.....	17	112	
<b>Wind River Formation:</b>				Siltstone, sandy, and very fine to fine-grained silty sandstone; gray.....	8	120	
Siltstone, very fine grained, sandy; silty very fine to medium-grained sand- stone; green.....	28	35		Sandstone, very fine grained to medium- grained; fair sorting; dark-gray (dry).....	10	130	
Siltstone, green and olive	15	50		Siltstone, dark-gray, streak of very fine to fine- grained silty sandstone at 150 ft.....	30	160	
Sandstone, very fine grained, light-gray and green; hard cemented streaks.....	5	55		Sandstone, very fine to fine-grained; siltstone; dark-gray; streaks of hard white material.....	7	167	
Sandstone, fine to coarse- grained, very well sorted, light-gray and green (damp).....	12	67		Siltstone, dark-gray.....	4	171	
Siltstone or shale, dark- gray.....	8	75		Marlstone(?), white, very hard.....	2	173	
Sandstone, very fine grained, silty, dark-gray; dark-gray and green sandy siltstone.....	5	80		Sandstone, fine to medium- grained, well-sorted, gray (water at 182 ft).....	13	186	
Siltstone or shale, dark- gray and green.....	10	90		Shale, dark-gray, oil stain..	1	187	
Sandstone, very fine grained to medium- grained, silty, gray.....	5	95		Sandstone, very fine grained, silty, gray.....	1	188	
				Shale, very dark gray.....	2	190	

TABLE 5.—*Logs of test holes and test wells—Continued*

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)	
<b>B4-1-4cbb</b>								
Wind River Formation:				Wind River Formation—Con.				
Siltstone, partly sandy, and silty very fine grained to medium- grained sandstone; olive and gray.....	80	80	Sandstone, fine- to coarse- grained, silty, gray; streaks of olive-gray silt- stone.....	15	135	Siltstone, olive-gray.....	5	140
Sandstone, very fine grained to medium- grained, silty, gray.....	15	95	Sandstone, medium- grained to very coarse grained, gray.....	15	155	Sandstone, very coarse grained, and very fine grained conglomerate; very well sorted (water, specific conductance 1,350 micromhos).....	10	165
Sandstone, very fine grained to coarse-grained, silty, gray.....	20	115	Siltstone or shale, reddish- brown.....	1	166			
Sandstone, very fine to very coarse, gray; con- tains some very fine gravel.....	5	120						
<b>B4-2-6add</b>								
Wind River Formation:				Wind River Formation—Con.				
Siltstone, sandy, and very fine grained silty sand- stone; light-gray.....	13	13	Sandstone, fine- to coarse- grained; fair sorting; gray; some very coarse sand 115-120 ft.....	12	120	Siltstone, sandy, dark-gray..	5	125
Sandstone, fine- to coarse- grained; fair sorting; tan and light-gray; mostly firmly cemented.....	37	50	Conglomerate, very fine grained, and very coarse sand, very well sorted, gray (still dry).....	6	131	Sandstone, mostly coarse- grained to very coarse grained, well-sorted, gray (wet at 136 ft).....	5	136
Sandstone, very fine grained to fine-grained, silty, tan, loosely cemented.....	10	60	Siltstone, sandy, gray.....	3	139	Sandstone, mostly medium- to coarse- grained; fair sorting; gray (dry).....	16	155
Sandstone, medium- to coarse-grained, well- sorted, tan, loosely cemented.....	7	67	Sandstone, mostly very fine grained to medium- grained, well-sorted, gray..	10	165	Siltstone, gray, partly sandy, very fine grained..	55	220
Marlstone(?), very light gray, very hard.....	2	69	Sandstone, very fine grained to medium-grained, silty, light-gray.....	13	233	Siltstone, reddish-brown....	24	257
Sandstone, coarse-grained and very coarse grained; very fine grained con- glomerate.....	6	75	Sandstone, very fine grained to fine-grained, silty, light-gray.....	18	275	Sandstone, very fine grained to fine-grained, silty, light-gray.....	18	275
Sandstone, medium- to coarse-grained, cemented, very hard.....	2	77	Siltstone, red and green, and some very fine grained silty sandstone...	26	301			
Conglomerate, mostly very fine to fine gravel.....	9	86						
Siltstone, green and tan....	4	90						
Marlstone(?), light-gray, very hard.....	1	91						
Conglomerate, mostly very fine to fine gravel, light- gray and tan.....	17	108						

TABLE 5.—Logs of test holes and test wells—Continued

Thickness (feet)		Depth (feet)		Thickness (feet)		Depth (feet)	
<b>B4-2-33daa</b>							
Slope wash and alluvium:				Wind River Formation—Con.			
Sand, very fine and fine, silty, brown.....				4	4	(water at about 60 ft)..... 7 62	
Wind River Formation:				Sandstone, very fine			
Siltstone, sandy, brown....				7	11	grained to coarse-grained, silty, green..... 6 68	
Sandstone, very fine grained to medium-grained, tan, loosely cemented.....				4	15	Siltstone, very fine grained, sandy, greenish- gray..... 16 84	
Sandstone, very fine grained to fine-grained, silty, green, and reddish-brown; green siltstone.....				5	20	Sandstone, very fine grained to fine-grained, well-sorted, gray (water)..... 24 108	
Siltstone, reddish-brown....				5	25	Siltstone, sandy, gray and green..... 9 117	
Siltstone, reddish-brown and greenish-gray.....				5	30	Sandstone, fine- to medium-grained, well- sorted, gray, loosely cemented (water)..... 5 122	
Siltstone, and very fine grained to medium- grained silty sandstone; green.....				12	42	Siltstone, greenish-gray.... 2 124	
Sandstone, very fine grained to medium-grained, well- sorted, olive, clean (damp).....				13	55	Sandstone, as above..... 1 125	
Sandstone, medium- to coarse-grained, well-						Siltstone, gray and greenish-gray, partly sandy..... 6 131	
<b>B4-4-2cda</b>							
[Log of test hole 50 ft west of well]							
Alluvium:				Alluvium—Con.			
Clay and silt, dark-brown and tan.....				6	6	Sand and gravel..... 4 40	
Sand and gravel; some cobbles.....				20	26	Clay..... 1 41	
Sand, gravel, and cobbles; some boulders.....				10	36	Gravel..... 3 44	
				Wind River Formation:			
				Siltstone, gray..... 2 46			
				Sandstone..... 1 47			
<b>B4-4-22aba</b>							
Terrace deposits:				Terrace deposits—Con.			
Soil, dark-brown, sandy, gravelly.....				1	1	Sand, gravel, and cobbles; some boulders..... 8 35	
Sand and silt, clayey, gravelly, tan.....				7	8	Wind River Formation:	
Sand, gravel, and cobbles...				12	20	Siltstone or shale, reddish- brown..... 2 37	
Sand and gravel.....				7	27		

TABLE 5.—Logs of test holes and test wells—Continued

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>B1-1-26abb</b>							
Terrace deposits:				Terrace deposits—Con.			
	Cobbles, gravel, and sand, clayey, silty, brown.....	1	1		Sand and fine gravel; some coarser gravel.....	10	26
	Cobbles, gravel, and sand; poorly cemented with white calcareous cement..	5	6		Sand, very fine to coarse; streaks of brown clay.....	5	31
	Cobbles, gravel, and coarse sand, angular; boulder at 8 ft.....	3	9		Sand and fine gravel; streaks of brown clay and coarser gravel.....	7	38
	Sand and fine gravel; some coarser rock.....	3	12	Wind River Formation:			
	Sand, clay, and fine gravel; some coarser rock; rusty- yellow water.....	4	16		Siltstone, and very fine grained sandstone; blue gray; poor samples.....	6	44
					Siltstone(?), red; water color changed to reddish-orange; no samples.....	2	46
<b>B5-3-32dda</b>							
Slope wash and alluvium:				Wind River Formation—Con.			
	Gravel veneer on surface.....				grained, silty; siltstone; greenish-gray and reddish-brown (water)....	15	60
	Silt, sandy, clayey, brown..	7	7		Siltstone, greenish-gray and light-purple.....	5	65
Wind River Formation:					Sandstone and siltstone, gray and light-purple (water from 70-75 ft)....	10	75
	Siltstone, greenish-gray.....	8	15		Sandstone, fine- to medium-grained, well- sorted, black and white grains, clean (water)....	14	89
	Siltstone, reddish-brown and greenish-gray.....	20	35		Siltstone, gray.....	2	91
	Siltstone, very fine grained, sandy, greenish-gray and brownish-gray (wet at 35 ft).....	5	40				
	Sandstone, very fine grained, silty, greenish- gray (little water).....	5	45				
	Sandstone, mostly very fine grained to fine-						
<b>B5-4-10abc</b>							
Alluvium:				Wind River Formation—Con.			
	Sand, clayey, poorly sorted, brown.....	4	4		Siltstone, red; some green; some greenish-gray very fine grained silty sand- stone 45-50 ft.....	16	50
Wind River Formation:					Siltstone, red.....	15	65
	Siltstone, dark-greenish- gray, light-gray, and very light maroon.....	11	15		Siltstone, greenish-gray and dark-gray; some very fine grained silty sandstone...	15	80
	Siltstone, and some very fine grained silty sand- stone; greenish-gray.....	10	25		Sandstone, very fine grained to medium-grained, green- ish-gray; very hard ma- terial at 92 ft (water at 83 ft).....	12	92
	Sandstone, mostly very fine grained to medium- grained, greenish-gray....	9	34				



TABLE 5.—Logs of test holes and test wells—Continued

		Thickness (feet)	Depth (feet)			Thickness (feet)	Depth (feet)
<b>B6-3-33ccd—Continued</b>							
Wind River Formation—Con.				Wind River Formation—Con.			
Siltstone, reddish-brown, dark-gray and green, partly hard.....	21	61		sorted (little water).....	6	71	
Sandstone, very fine grained to coarse-grained, very silty, poorly sorted; some sandy siltstone; green and gray (little water)....	4	65		Sandstone, very fine grained to coarse-grained, silty, very poorly sorted.....	19	90	
Sandstone, coarse grained to very coarse grained, well-				Sandstone, fine to coarse, gray (water).....	5	95	
				Siltstone, reddish-brown and green.....	1	96	
<b>B6-4-36cdb</b>							
Ayeross and Wind River Formations:				Ayeross and Wind River Formation:—Con.			
Sandstone, fine- to coarse- grained, green and greenish-tan; hard cemented layers and streaks of very fine grained and fine-grained conglomerate.....	35	35		Sandstone, fine- to coarse- grained, very light gray...	21	140	
Sandstone, fine- to coarse- grained, blue-gray and olive-brown; streak of green siltstone at about 40 ft.....	25	60		Sandstone, coarse-grained to very coarse grained, very light gray.....	5	145	
Siltstone, very fine grained, sandy, dark-green and dark greenish-gray, very hard.....	5	65		Sandstone, very fine grained to medium- grained, very light gray and brown.....	10	155	
Sandstone, medium- to coarse-grained; fair sorting (damp).....	10	75		Siltstone, dark-reddish- brown.....	5	160	
Siltstone, dark-gray and greenish-gray.....	32	107		Sandstone, mostly very fine grained to medium- grained, gray.....	12	172	
Sandstone, very fine grained to fine-grained, silty, gray.....	8	115		Siltstone, dark-reddish- brown, and some brown sandstone.....	3	175	
Siltstone, gray.....	4	119		Sandstone, very fine grained to medium- grained, gray (trace of water 195-200 ft).....	25	200	
				Sandstone, fine- to coarse- grained, gray (damp).....	10	210	
				Siltstone(?); no samples....	2	212	
<b>C1-1-1dac</b>							
Alluvium:				Alluvium—Continued			
Soil, sand, gravel, and cobbles.....	1	1		Cobbles, gravel, sand, and some boulders; contains streaks of light-brown clay.....	30	38	
Cobbles, gravel, and sand; contains some tan and light-brown clay.....	7	8		Cody Shale:			
				Shale, dark-gray; oil odor...	8	46	

TABLE 5.—*Logs of test holes and test wells—Continued*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
<b>D1-1-14aaa</b>					
Slope wash and alluvium:			Slope wash and alluvium—Con.		
Silt, slightly sandy, brown	7	7	Gravel, fine to medium, and coarse sand	3	17
Gravel and coarse sand	3	10	Cody Shale:		
Gravel, fine to medium, clean	4	14	Shale, dark-gray	9	26
<b>D1-1-16ddd</b>					
Slope wash and alluvium:			Slope wash and alluvium—Con.		
Silt, sandy, tan	3	3	Gravel, fine to coarse	9	31
Silt, heavy, tan	12	15	Sand, fine to coarse	7	38
Gravel, fine to medium, and coarse sand	7	22	Frontier(?) Formation:		
			Shale, dark-gray	3	41
<b>D1-1-21dda</b>					
Slope wash and alluvium:			Slope wash and alluvium—Con.		
Clay and sand, brown	5	5	Sand and gravel; mostly coarse sand to me- dium gravel; some clay; layer of sand and of gravel	26	52
Clay and sand, mostly very fine to fine, tan	16	21	Wind River Formation:		
Sand and gravel; mostly very coarse sand to fine gravel; layers of clay; not loose, may be lightly cemented or bound with clay	5	26	Sandstone; no sample	3	55
			Siltstone, sandy, light-gray	1	56
<b>D1-1-22bcb</b>					
Slope wash and alluvium:			Cody Shale:		
Clay, silty, yellow-green to tan; soil at top	8	8	Clay(?) and shale, dark- gray (clay zone may be present above Cody Shale)	15	47
Gravel, sand, and clay	7	15	Shale, dark-gray	4	51
Gravel and sand	14	29			
Clay, sandy, brown	3	32			
<b>D1-1-23ada</b>					
Slope wash and alluvium:			Slope wash and alluvium—Con.		
Clay and sand; some very coarse sand; tan	5	5	Gravel and sand; mostly coarse sand to fine gravel	3	36
Clay, sandy; mostly very fine sand; brown to tan	11	16	Clay, sandy, tan	4	40
Sand and clay; very fine to coarse sand	10	26	Cody shale:		
Sand, clayey; mostly coarse sand	7	33	Shale	1	41

TABLE 5.—Logs of test holes and test wells—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
<b>D1-3-7dcd</b>					
Terrace deposits:			Wind River Formation—Con.		
Soil, brown.....	1	1	Sandstone, fine-grained, well-sorted, yellowish- green and gray (damp)...	6	89
Sand, some gravel, silty, tan.....	13	14	Sandstone, coarse-grained, very well sorted (water at 94 ft).....	10	99
Wind River Formation:			Siltstone and very fine grain- ed silty sandstone.....	5	104
Siltstone, very fine grained, sandy, green.....	16	30	Sandstone, medium-grained to very coarse grained; some fine gravel (water) ..	17	121
Sandstone, very fine grained to medium grained; fair sorting; tan..	2	32	Siltstone and very fine grained silty sandstone, dark-gray.....	3	124
Siltstone, green.....	9	41	Sandstone, very coarse, and very fine grained conglomerate (water).....	4	128
Sandstone, medium- to coarse-grained, well- sorted, tan.....	20	61	Siltstone, and very fine grained silty sandstone; yellow and yellowish- green.....	2	130
Bentonite(?) or blue-gray clay streak.....		61			
Siltstone, gray, and very fine grained silty sand- stone.....	19	80			
Sandstone, very fine grained, silty, light-gray..	3	83			
<b>D1-3-29ccc</b>					
Slope wash and alluvium (not mapped):			Wind River Formation—Con.		
Silt, sandy, reddish-brown..	4	4	Sandstone, medium- grained to very fine grained conglomerate; tan, clean, loosely ce- mented.....	12	65
Wind River Formation:			Sandstone, fine-grained to very fine grained con- glomerate; tan, loosely cemented.....	16	81
Siltstone, red.....	4	8	Siltstone, sandy, and very fine-grained to medium- grained silty sandstone; greenish-gray.....	4	85
Sandstone, very fine to very coarse grained, silty, white to tan, loosely cemented.....	9	17	Sandstone, very fine grained to coarse-grained, silty, poorly sorted, greenish-gray.....	4	89
Siltstone, very fine grained sandy, purple and dark- gray.....	3	20	Siltstone, very fine grained, sandy, brown and dark brownish-gray.....	18	10'
Siltstone, very fine grained sandy, tan and dark-gray	5	25	Sandstone, medium-grained to very coarse grained; some very fine gravel; well-sorted; bluish-gray; loosely cemented.....	20	127
Sandstone, very fine grained to coarse-grained, silty; siltstone; tan, gray, and brown.....	10	35	Siltstone, dark-gray.....	8	135
Siltstone, gray, purple, and red.....	5	40			
Sandstone, fine-grained to very coarse grained; some very fine gravel; fair sorting; tan; loosely cemented; clean.....	7	47			
Siltstone, very fine grained, sandy, rusty and green- ish-gray.....	6	53			

TABLE 5.—Logs of test holes and test wells—Continued

Thickness (feet)		Depth (feet)		Thickness (feet)		Depth (feet)	
<b>D1-3-29ccc—Continued</b>							
Wind River Formation—Con. Sandstone, fine- to coarse- grained; fair sorting; bluish-gray . . . . .				8	143	Wind River Formation—Con. poor returns below 150 ft; some thin siltstone layers (damp at 150 ft, no water noted above 150 ft; water at 165 ft; specific conduc- tance 2,000 micromhos) . . .	
Sandstone, medium- grained to very fine grained conglomerate; well-sorted; greenish- gray to 195 ft; tan below;						60	203
						7	210
<b>D1-4-2bca</b>							
Alluvium:						Wind River Formation:	
Sand, fine, silty . . . . .				4	4	Siltstone, gray . . . . .	
Sand, fine to medium . . . . .				5	9		
Gravel, fine to coarse . . . . .				5	14		
<b>D1-4-11bba</b>							
Alluvium:						Wind River Formation:	
Soil and silt, sandy, brown . . . . .				6	6	Sandstone, very fine grained to medium- grained, tan . . . . .	
Gravel and sand; mostly coarse sand to medium gravel . . . . .				7	13	2	15
						1	16
<b>D1-4-11cac</b>							
Slope wash (not mapped):						Wind River Formation—Con.	
Silt, sandy . . . . .				2	2	Siltstone, gray . . . . .	
Wind River Formation:						Siltstone, sandy, gray . . . . .	
Siltstone, gray . . . . .				6	8	Siltstone, gray, hard . . . . .	
Siltstone, sandy, gray and brown . . . . .				3	11	Siltstone, sandy, gray . . . . .	
Siltstone, gray . . . . .				10	21	Sandstone, fine- to medium-grained (water) . . . . .	
Sandstone, fine-grained, silty . . . . .				5	26		

TABLE 5.—*Logs of test holes and test wells—Continued*

Thickness (feet)		Depth (feet)		Thickness (feet)		Depth (feet)	
<b>D1-4-33daa</b>							
Slope wash and alluvium:				Slope wash and alluvium—Cor.			
Clay and soil.....	2	2		Sand, as above except less clay and generally coarser (water).....	3	25	
Sand, mostly medium to very coarse, clayey; fair sorting; tan (water).....	10	12		Wind River Formation:			
Sand, as above except more clay and grayer color (less water).....	10	22		Siltstone, sandy, gray.....	2	27	

TABLE 5.—*Logs of test holes and test wells—Continued*

Thickness (feet)		Depth (feet)		Thickness (feet)		Depth (feet)	
<b>D1-5-11bdd</b>							
Slope wash and alluvium:				Slope wash and alluvium—Con.			
Sand, very fine to medium, tan; dune sand.....		12	12	Sand, very coarse, fairly well sorted (water).....		9	36
Sand and silt, tan.....		3	15	Sand, mostly very coarse; some very fine gravel; very well sorted; tan (water).....		7	43
Sand, fine to very coarse; some fine gravel; poorly sorted; some coarser gravel 22-27 ft (water at 25 ft).....		12	27	Wind River Formation: Siltstone, bluish-gray.....		20	63

TABLE 6.—*Chemical analyses of ground-water*

[Analytical results in parts per million, except as indicated.]

Location	Depth of well (feet)	Production interval (feet)	Date of collection	Temperature (° F)	Silica (Si O <sub>2</sub> )	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )
<b>Madison Limestone and Bighorn Dolomite</b>												
B2-1-18ccc	4,222		12-13-62				178	34	46		293	
<b>Tensleep Sandstone</b>												
C1-1-2aad <sup>1</sup>	Spring		5-18-45	116			162	41	49		290	0
2aad <sup>1</sup>	Spring		8-18-53	103	34				49		280	0
<b>Permian rocks and (or) Dinwoody Formation</b>												
B5-6-14dad	980	At 980	9-30-64	51	9.4	0.29	409	68	557	18	734	0
35ada	290	75-200	10-1-65	48	14	.44	447	171	469	7.6	367	0
<b>Jurassic, Jurassic(?), and Triassic(?) rocks</b>												
B3-1-5ba	5,306		10-31-55		0.23		4,380	93	4,320		379	0
<b>Frontier Formation</b>												
A1-1-33bbb <sup>3</sup>	712	543-620(?)	10-30-57				0.4	0.3	772	3.5	951	117
A8-4-7 cab <sup>1</sup>	440		7-22-46			0.20	10	8.1	1,510		516	33
B4-4-14ccb	400	329-359	11-4-65		7.4	.21	33	11	680	2.4	166	0
C1-1-8ccb	548	497-543(?)	5-19-45				1.0	1.3	435		430	70
D2-1-7daa <sup>3</sup>	350		5-10-63						680			
<b>Cody Shale</b>												
A1-1-36cb <sup>13</sup>	>300		5-18-45				15	12	59 <sup>R</sup>		390	23
B4-1-31dab <sup>1</sup>	384		11-14-51		7.4	0.06	71	4.1	716		138	0
<b>Fort Union Formation</b>												
D1-2-9bbbl	430	365-412	11-6-64		6.9	0.60	8.3	1.8	387	3.1	561	16
10dec <sup>3</sup>	473	412-418	11-19-66				6	3	400	3	522	33

See footnotes at end of table.

samples, Wind River Indian Reservation, Wyo.

Analyses by U.S. Geological Survey, except as indicated]

Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids		Hardness as CaCO <sub>3</sub>		Sodium-ad- sorption- ratio (SAR)	Specific con- ductance (micro- mhos at 25° C)	pH	Remarks
					Resi- due on evapo- ration at 180° C	Sum	Cal- cium mag- nesi- um	Non- car- bon- ate				
<b>Madison Limestone and Bighorn Dolomite—Continued</b>												
360	50					930			0.7		7.4	
<b>Tensleep Sandstone—Continued</b>												
362	41	2.6	0.1			801	573	336	0.9	1,180		
358	43						556	326	.9	1,170	7.3	
<b>Permian rocks and (or) Dinwoody Formation—Continued</b>												
1,560	219	2.1	0.0	0.48	3,240	3,210	1,300	698	6.7	3,920		
2,320	76	1.1	.1	.06	4,030	3,690	1,820	1,520	4.8	4,230	8.2	Mn 0.59 ppm.
<b>Jurassic, Jurassic(?), and Triassic(?) rocks—Continued</b>												
11,100	6,260	1.0	0.3		27,200	26,300	11,300	11,000		31,700	7.2	
<b>Frontier Formation—Continued</b>												
500	57			3.8	1,800					2,530	9.1	
2,700	52	2.8	10		4,600		58	0		5,660	8.4	
1,230	116	1.6	1.0	2.0	2,220	2,170	126	0	6	3,170	7.9	
430	20	3.8	.0			1,170	8	0		1,800		
		.95			2,350		25				8.6	
<b>Cody Shale—Continued</b>												
730	182	1.2	4.3			1,750	87	0	36	2,660		
1,520	37	1.2	1.0	0.21	2,450	2,430	194	81	16	3,380	7.5	
<b>Fort Union Formation—Continued</b>												
1.5	291	2.6	0.0	0.18	1,010	995	28	0	32	1,760	8.4	Mn 0.09 ppm.
1	270	1.8	0	.10	992		30		30	1,720	8.6	

TABLE 6.—*Chemical analyses of ground-water samples,*

Location	Depth of well (feet)	Production interval (feet)	Date of collection	Temperature (° F)	Silica (Si O <sub>2</sub> )	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )
<b>Wind River Formation</b>												
A1-1-3bbb	579	559(?)—579	8-31-66	53	1.8	-----	16	9.7	96	2.5	204	0
A1-3-16cca	103	-----	10-19-48	50	15	0.02	81	8.2	171	4.0	157	0
17add	285	246-280	11- 8-65	-----	11	.36	4.2	.4	148	.4	52	2
A1-4-3ddd	124	-----	10-20-48	52	26	3.0	64	15	98	.8	388	0
12ecc	64	-----	10-21-48	51	19	.32	42	14	21	.8	145	3.9
24caa	70	-----	10-21-48	50	12	1.4	5.0	2.2	226	.8	85	4.9
27cda	645	255-645	10-21-60	57	13	.13	1.6	1.0	126	1.6	184	10
27ddd	600	353-600	10-22-48	55	13	.03	6.5	.3	142	.4	191	7
27ddd	600	353-600	9-23-54	54	11	.00	1.5	.1	142	1.7	185	12
27ddd	600	353-600	12- 3-65	-----	12	.00	.8	.2	136	.9	204	0
A1-4-32bda	367	-----	10-15-48	50	9.5	2.4	8.5	.2	155	2.8	131	1
34add	609	345-609	10-27-51	56	11	.01	2.9	.1	160	.5	192	9
34add	609	345-609	12- 2-65	50	7.5	.00	1.2	1.7	165	1.4	187	10
34bac	535	440-535	12- 2-65	50	8.3	.00	.8	.1	132	.9	165	21
34bbd	660	460-660	10-26-51	-----	12	.06	23	1.1	125	.7	191	8
A2-1-24ced	180	-----	9-15-65	55	26	.13	94	14	15	3.1	334	0
A2-2-41cd	40	-----	9-17-49	49	10	2.0	370	70	403	6.4	236	0
15dea	22	-----	10-18-48	50	14	.08	37	5.9	167	18	386	0
17aaa	500	486-500	10-18-48	50	25	2.8	34	1.5	148	1.2	186	0
18ada	485	-----	11- 1-60	-----	20	.00	59	7.8	72	2.0	190	0
A2-3-10bce	85	60-65	10-19-48	49	11	.16	23	3.4	250	3.6	152	0
19dda	228	202-228	9-17-49	50	10	2.0	14	.6	235	4.0	35	0
26dea	80	35-55	9-17-49	49	10	2.4	62	.5	579	4.8	28	0
A2-4-2cbe	50	-----	10-20-48	50	16	1.1	13	1.7	343	2.4	561	0
10dec	350	330-350	9-17-49	52	10	.54	16	.4	260	4.8	34	0
17ada	40	-----	10-20-48	49	12	.26	12	1.3	350	21	625	14
A2-5-2aba	306	275-300	10-20-48	50	16	.16	14	1.5	261	.8	34	0
30cdd	177	165-167	10-21-48	52	10	1.9	10	.1	248	.4	163	0
7cda	128	108-125	9-17-49	52	8.8	.96	8.0	10	235	4.8	138	0
A2-6-19dab	360	300-353	10-20-48	55	13	2.0	26	4.6	284	.8	126	6
A3-1-9cda	207	150-206	11- 1-66	-----	18	-----	201	20	759	2.8	445	0
21add	226	183-225	10-14-48	52	13	.60	46	2.0	458	4.4	85	0
21bab	40	-----	9-17-49	51	14	1.1	81	24	86	3.2	284	0
21ddd	75	-----	10-14-48	50	28	4.0	282	73	414	2.4	414	0
25bed	223	66(?)	9-17-49	49	14	8.0	230	59	966	6.4	512	0
36ada	77	-----	10-14-48	50	13	2.2	450	167	748	5.6	342	0
A3-2-5bcb	100	70-100	8-14-50	58	10	-----	33	.5	459	1.3	78	0
6acc	41	-----	6-18-51	50	-----	-----	-----	-----	253	2.6	134	0
6acc	41	-----	6-19-51	49	-----	-----	-----	-----	362	3.7	164	0
7cca	398	300-398	10-29-60	-----	16	.30	8.0	0	210	.4	88	2
10acc	482	466-482	10-18-48	50	14	1.6	6.0	.6	174	5.2	44	0
26adc	321	296-321	10-18-48	53	13	2.0	46	.1	445	7.6	22	0

See footnotes at end of table.

## Wind River Indian Reservation, Wyo.—Continued

Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids		Hardness as CaCO <sub>3</sub>		Sodium-ad- sorption- ratio (SAR)	Specific conduct- ance (micro- mhos at 25° C)	pH	Remarks
					Resi- due on evapo- ration at 180° C	Sum	Cal- cium mag- nesi- um	Non- car- bon- ate				
<b>Wind River Formation—Continued</b>												
103	20	0.6	0.2	0.19	358	350	100	0	4.7	610	8.0	
426	17	.3	1.2	.12	830	802	236	107	4.8	1,200	7.5	
251	15	2.4	0	.33	474	461	12	0	19	743	8.4	Mn 0.08 ppm.
84	7.0	.6	19	.20	500	508	221	0	2.6	784	7.9	
68	20	.4	.5	.30	247	249	162	37	.7	385	8.3	
368	39	2.0	.4	.38	698	703	22	0	21	1,090	8.3	
107	9.0	.6	.6	-----	335	360	8	0	19	574	8.5	PO <sub>4</sub> 0.04 ppm, Li 0.04 ppm.
125	9.9	.4	.8	.22	394	401	17	0	15	664	8.6	
117	9.0	.4	.0	-----	378	386	4	0	31	613	8.9	
122	11	.6	.0	.10	400	384	3	0	34	627	8.2	
220	16	3.6	.2	.34	510	482	22	0	12	768	8.2	
161	13	.4	.6	.16	472	453	7	0	25	725	8.7	Pumped 22 hr 10 min.
174	11	.8	.0	.13	486	465	10	0	22	769	8.5	
99	8.9	.7	.0	.07	354	353	2	0	41	470	8.7	
96	10	.6	.5	.24	355	351	10	0	6.9	562	8.6	Pumped 32 hr 2 min.
47	3.0	.4	1.7	.05	373	368	293	19	.4	586	8.0	Mn 0.06 ppm.
1,780	20	.2	17	.30	2,930	2,790	1,210	1,020	2.6	3,140	7.3	
140	23	1.0	.6	.08	618	600	116	0	6.7	916	7.9	
232	6.5	.5	.0	.12	548	542	91	0	6.7	825	7.7	
170	4.0	.8	.7	-----	448	429	179	24	2.3	658	8.0	Al 0.2 ppm.
448	7.6	1.4	.0	.25	864	824	72	0	13	1,240	7.4	
456	41	1.2	.6	.48	800	782	38	9	17	1,130	7.3	
1,250	82	1.2	41	.52	2,050	2,050	157	134	20	2,770	6.9	
3.2	258	2.8	.4	.66	933	926	40	0	24	1,610	7.9	
456	92	1.2	.3	.46	878	858	42	14	15	1,280	6.8	
224	20	1.0	4.4	.24	984	972	36	0	25	1,470	8.3	
444	97	2.8	.2	.43	872	854	41	13	18	1,360	7.7	
376	28	1.2	.8	.40	734	756	25	0	-----	1,210	8.0	
400	18	.8	.3	.24	752	754	61	0	13	1,090	7.2	
440	94	1.6	1.4	.22	953	934	84	0	13	1,480	8.2	
1,770	67	.4	.1	.16	2,980	3,060	582	217	12	3,800	7.9	
1,000	12	.7	.3	.08	1,590	1,580	123	53	18	2,060	7.5	
196	21	1.2	34	.28	606	601	301	68	2.6	867	7.8	
1,380	46	1.4	9.8	.22	2,570	2,440	1,000	661	18	3,030	7.2	
2,120	163	2.4	92	.33	4,090	3,910	817	397	15	4,840	7.8	
2,760	158	.7	.3	.18	4,700	4,470	1,810	1,530	7.6	4,790	7.7	
990	8.5	.8	.8	.10	1,550	1,540	85	21	22	2,180	7.5	
400	290	-----	-----	.12	1,220	-----	391	281	-----	1,830	7.8	Pumped 36 min.
945	330	-----	-----	.30	2,150	-----	808	674	-----	2,810	7.7	Pumped 23 hr 50 min.
345	21	2.0	0	-----	608	647	20	0	20	974	8.5	
320	26	1.4	.4	.10	612	570	18	0	18	913	7.5	
988	18	.7	.2	.22	1,560	1,530	116	98	18	2,160	7.1	

TABLE 6.—*Chemical analyses of ground-water samples,*

Location	Depth of well (feet)	Production interval (feet)	Date of collection	Temperature (° F)	Silica (Si O <sub>2</sub> )	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )
<b>Wind River Formation—Continued</b>												
A3-2-27baa	57		12- 5-50 <sup>1</sup>	49	12	0.08	488	167	282	5.3	256	0
30ddb	582	215-230	10-18-48	52	15	.03	70	2.6	579	7.2	119	0
A3-3-6ccc	270	240-270	10-26-51	52	21		.9	.1	97	.2	74	33
16cbc	360	340-360	10-18-48	50	17	.60	12	.1	217	1.2	34	0
24ccc	50	37-50	10-20-48	48	16	2.1	460	179	714	10	175	0
26aba	244	228-244	10-19-48	49	11	.28	27	.1	332	4.0	23	0
A3-4-29cdd	76		9-17-49 <sup>1</sup>	49	9.2	3.0	74	7.9	473	4.8	416	0
A3-5-33dcc	35		10-16-48	47	19	.06	206	41	735	3.2	330	0
A3-6-15beb	495	451-495	10-27-60		10	.08	4.8	1.0	179	.6	168	2
A4-1-11bbd	185	110-175	11- 2-66		6.9		149	15	1,500	6.3	212	0
18dbe	272	230-271	11- 2-66		11		36	2.9	582	.2	131	0
A4-2-20dba	266	248-258	8-14-50	50	12		31	.1	548	1.8	64	0
A4-3-13dcb	465	425-436	10-26-51	51	10	.25	5.5	.1	256	.6	32	16
34ada	305	278-302	10-26-51	50	12		7.5	.1	264	.2	43	0
36dbb	120		10-29-60		28	.13	320	224	520	8.2	254	0
A4-4-20dad	234	170-210	10-26-51	52	8.0	1.6	31	.9	556	.9	34	0
23dbd <sup>1</sup>	621	411-590	6-26-51	53	6.8	.08	14	.7	380	.6	78	0
28cdc	>87		10-19-48	48	13	.30	186	69	354	6.0	285	0
A5-4-21ccd	296	279-295	10-26-66		5.7		34	8.0	819	3.0	72	0
A5-5-33aba	190	182-188	10-26-66		4.9		52	7.9	1,070	3.0	76	0
B3-1-24cda <sup>1</sup>	40		9-17-49		32	.01	70	29	124	3.2	405	15
B3-3-4aba	55	30-55	11- 4-65		23	.05	39	17	6.6	.8	190	0
B4-1-4cbb	166	155-165	10-31-66		5.4		9.6	1.9	261	1.0	140	2
25daa	487		12-19-66		1.8		32	3.2	342	1.8	50	4
B6-3-33ccd	96	90-95	10-31-66		6.2		11	.1	294	.4	90	0
D1-3-2aba <sup>3</sup>	60		11- 4-64				27	5	80	1	211	0
7ded	130	94-128	11- 3-66		12		102	15	56	2.0	180	0
10cca <sup>3</sup>	390	244-253	10-29-64				1	2	175	1	211	21
10cca <sup>3</sup>	390	375-390	10-27-64				3	3	155	0	153	24
13aab <sup>3</sup>	300		11-12-64				28	4	190	1	211	6
13dad <sup>3</sup>	80	55-65	11-19-64				148	16	310	3	241	0
14bbd <sup>3</sup>	108	91-108	11-19-64				163	5	580	1	85	0
D1-3-17beb	150	95-140	11- 3-65		17	.17	59	12	73	2.1	162	0
23adc <sup>3</sup>	60		11-19-64				146	39	130	1	226	0
23eba	550		5-18-45				1.5	2.2	150		166	12
24cbd <sup>3</sup>	235	220-230	11-19-64				5	2	175	1	122	15
D1-4-4cdd	450	320-450	9-30-64		7.0	.06	2.0	1.0	139	1.0	223	
18bba <sup>3</sup>	330	At 57	10-16-64				424	58	521	3	305	0
18bba <sup>3</sup>	330	314-325	10-26-64				4	2	150	1	156	18
D1-5-11acc	225	118-215	11- 5-65	55	16	.26	150	39	340	7.4	469	0
12db	800	300-800	12- 3-65		19	.03	51	22	92	5.4	177	0
<b>Glacial deposits</b>												
B3-2-17acb	45	At 45	11- 4-65		19	0.10	46	10	18	2.4	170	0

See footnotes at end of table.

Wind River Indian Reservation, Wyo.—Continued

Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids		Hardness as CaCO <sub>3</sub>		Sodium-adsorption-ratio (SAR)	Specific conductance (microhos at 25° C)	pH	Remarks
					Residue on evaporation at 180° C	Sum	Calcium magnesium	Non-carbonate				

Wind River Formation—Continued

2,190	24	0.7	13	0.15	3,660	3,310	1,910	1,700	28	3,500	7.1	
1,290	15	.6	.3	.04	2,040	2,040	185	87	18	2,720	7.5	
42	38	1.6	.4	.21	272	270	3	0	30	446	9.7	
394	36	2.0	.0	.27	716	696	30	2	17	1,100	8.0	
2,980	69	1.2	.8	.98	4,940	4,520	1,880	1,740	-----	5,160	7.9	
664	59	1.0	.3	.12	1,130	1,110	68	49	18	1,660	7.1	
848	17	1.1	.7	.28	1,670	1,640	217	0	14	2,190	7.8	
1,760	58	1.1	44	.34	3,130	3,030	682	411	-----	3,830	7.6	
234	12	3.0	.7	-----	565	530	16	0	19	847	8.3	Li 0.08 ppm.
3,250	77	1.2	.1	.07	5,000	5,110	435	261	31	6,300	7.8	
1,190	14	.4	.1	.05	1,870	1,910	102	0	25	2,670	8.0	
1,090	48	1.1	.3	.10	1,810	1,770	78	26	32	2,560	8.2	
435	49	2.0	.4	.35	802	791	14	0	26	1,270	9.5	
500	35	1.8	.4	.24	866	842	19	0	24	1,320	7.2	
2,510	56	1.0	0	-----	4,040	3,790	1,720	1,510	-----	6,180	7.7	
1,020	160	3.2	.3	.22	1,820	1,800	81	53	27	2,740	7.2	
415	260	4.0	.3	.15	1,130	1,120	38	0	27	1,870	7.5	
1,150	34	.8	.0	.14	2,050	1,960	748	514	5.6	2,490	7.5	
1,370	335	2.2	.1	.19	2,580	2,610	118	59	33	3,810	7.5	
1,800	416	3.8	.1	.23	3,310	3,390	162	100	37	4,730	7.9	
175	16	1.4	15	.31	696	680	294	0	3.1	964	8.2	
23	1.0	.5	.7	.01	203	205	168	12	.2	340	7.8	
406	51	1.4	.1	.09	828	808	32	0	20	1,280	8.3	
763	15	.5	.5	.03	1,190	1,190	93	45	15	1,770	8.5	
438	86	3.4	.1	.17	880	883	28	0	24	1,380	8.0	
58	0	-----	-----	2	336	-----	-----	-----	3.5	540	7.3	
258	8.6	.7	.9	.06	550	543	315	167	1.4	797	7.8	
125	14	-----	0	.12	434	-----	-----	-----	17	569	8.8	
157	11	1	0	.18	466	-----	-----	-----	11.4	569	8.2	
285	12	-----	0	.12	644	-----	88	-----	8.8	983	8.2	
873	37	1.0	8	.12	1,630	-----	438	-----	6.5	2,210	7.9	
1,640	36	.8	.7	.09	2,560	-----	430	-----	12	3,380	7.8	
208	8.2	.9	.3	.10	492	461	196	63	2.3	696	7.8	
501	57	.4	0	.05	1,010	-----	525	-----	2.5	1,350	7.7	
155	9	.5	.0	-----	-----	416	12	0	19	688	-----	
239	14	1.1	0	.09	540	-----	23	-----	12	879	8.6	
139	4.0	1.1	.04	-----	388	426	-----	8	20	670	8.5	Commercial analysis.
1,960	43	-----	0	.36	3,310	-----	2,590	-----	4.5	3,730	7.6	
132	11	1.2	0	.14	378	-----	19	-----	10.5	697	8.8	
782	77	1.2	.3	.33	1,710	1,650	534	149	6.4	2,320	8.0	
270	7.1	1.6	.0	.10	590	555	219	74	2.7	869	8.1	

Glacial deposits—Continued

52	4.0	0.2	0.2	0.03	240	236	157	18	0.6	380	7.7	
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TABLE 6.—*Chemical analyses of ground-water samples,*

Location	Depth of well (feet)	Production interval (feet)	Date of collection	Temperature (° F)	Silica (Si O <sub>2</sub> )	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )
<b>Terrace deposits near Wind River</b>												
A1-4-32adb	12	-----	10-15-48	54	38	0.34	87	13	56	6.4	368	0
B4-3-32baa	41	-----	4-28-66	-----	30	.04	35	19	24	1.0	223	0
B4-4-22aba	33	21-33	10-26-66	50	31	-----	64	12	86	1.6	392	0
23adc	30	-----	4-28-66	-----	24	.00	47	42	144	2.0	566	0
<b>Terrace deposits near Muddy Creek</b>												
A4-4-23acd	23	11-19	6-26-51	-----	-----	-----	-----	-----	-----	175	334	7
23dbd2	20	8-15	10-26-51	-----	-----	-----	-----	-----	-----	240	294	14
<b>Alluvium of Mill Creek valley</b>												
D1-1-15ccc	38	16-38	10-25-66	52	17	-----	358	94	258	5.4	342	0
22bba1	30	-----	8-13-65	-----	17	0.05	238	121	226	4.6	313	0
22bba1	30	-----	4-28-66	-----	16	.00	223	127	235	5.0	342	0
22beb	21	19-21	10-5-65	53	19	.45	227	156	316	6.0	329	0
31dda	45	-----	10-6-65	49	18	.46	63	26	15	2.3	284	0
32acd	45	-----	10-5-65	-----	19	.07	49	31	11	2.1	284	0
<b>Alluvium of Kirby Draw</b>												
A1-5-15aab	29	-----	9-28-65	51	12	0.80	42	8.0	461	1.9	417	0
D1-5-11bdd	34	32-34	10-6-65	52	14	.34	168	55	1,100	4.7	409	0
<b>Alluvium of Beaver Creek valley</b>												
D1-4-33daa	22	20-22	9-28-65	52	18	1.3	184	48	169	7.4	271	0
<b>Alluvium of Crow Creek valley</b>												
B4-3-8bbd	30	-----	11-4-65	50	29	0.37	104	17	89	3.6	526	0
<b>Alluvium of Owl Creek valley</b>												
A8-4-16aaa	50	-----	7-23-46	-----	-----	0.05	114	41	-----	-----	332	-----
A9-2-35aaa	47	-----	7-22-46	-----	-----	.80	285	121	-----	65	300	-----

See footnotes at end of table.

## Wind River Indian Reservation, Wyo.—Continued

Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids		Hardness as CaCO <sub>3</sub>		Sodium-ad- sorption- ratio (SAR)	Specific conduct- ance (micro- mhos at 25° C)	pH	Remarks
					Resi- due on evapo- ration at 180° C	Sum	Cal- cium mag- nesi- um	Non- car- bon- ate				
<b>Terrace deposits near Wind River—Continued</b>												
86	7.0	1.2	0.6	0.16	494	479	270	0	1.5	738	7.5	
20	5.3	.6	1.9	.04	268	247	165	0	.8	397	7.9	
71	7.2	1.3	.7	.34	446	468	210	0	2.6	705	7.6	
115	17	1.3	0	.02	714	670	289	0	3.7	1,100	8.0	
<b>Terrace deposits near Muddy Creek—Continued</b>												
122	17	-----	17	-----	606	-----	68	0	-----	897	8.4	
273	27	-----	15	-----	796	-----	76	0	-----	1,210	8.7	
<b>Alluvium of Mill Creek valley—Continued</b>												
1,470	21	1.4	8.5	0.44	2,540	2,400	1,280	1,000	3.1	2,740	7.6	
1,220	17	1.0	6.0	.47	2,230	2,010	1,090	833	3.0	2,500	8.2	
1,210	22	.9	7.1	.39	2,150	2,010	1,080	800	3.1	2,600	7.9	
1,470	24	.9	4.0	.63	2,640	2,390	1,210	940	4.0	2,890	8.0	Mn 0.45 ppm.
59	1.9	.9	1.4	.08	329	328	264	31	.4	543	8.1	Mn 0.03 ppm.
38	2.6	.9	2.5	.05	293	296	250	17	.3	492	8.1	Mn 0.03 ppm.
<b>Alluvium of Kirby Draw—Continued</b>												
695	31	1.5	0.00	0.27	1,490	1,460	138	0	17	2,140	8.2	Mn 0.54 ppm.
2,450	95	.8	.1	.49	4,600	4,090	646	311	19	5,650	8.2	Mn 0.12 ppm.
<b>Alluvium of Beaver Creek valley—Continued</b>												
648	88	1.0	0.1	0.22	1,380	1,300	656	434	2.9	1,780	8.1	Mn 1.1 ppm.
<b>Alluvium of Crow Creek valley—Continued</b>												
84	10	0.3	0.3	0.02	601	597	331	0	2.1	911	7.9	Mn 0.26 ppm.
<b>Alluvium of Owl Creek valley—Continued</b>												
1,060	30	0.8	1.6	-----	1,930	-----	453	181	9.1	2,440	8.0	
1,040	16	.2	.0	-----	1,960	-----	1,210	964	.8	2,010	7.3	

TABLE 6.—Chemical analyses of ground-water samples,

Location	Depth of well (feet)	Production interval (feet)	Date of collection	Temperature (° F)	Silica (Si O <sub>2</sub> )	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )	
<b>Alluvium of Little Wind River valley</b>													
A1-1-34bec	28	0-28	11- 2-66		15		157	63	223	9.9	404	0	
C1-1-4adc	24	At 24	11- 3-65		10	0.00	53	22	14	3.1	220	0	
4ccc <sup>2</sup>	42	At 41	5-10-63						110				
5dba <sup>2</sup>	42		5-10-63						36				
6dde <sup>2</sup>	23	20-23	5-10-63						64				
8ada <sup>2</sup>	20	5-20(?)	5-10-63						18				
8dda <sup>2</sup>	43	3-12	5-10-63						7				
9aab <sup>2</sup>	30	28-30	5-10-63						93				
9bdc <sup>1 2</sup>	36	26-29	5-10-63						115				
10cbd1	60	33-40	11- 3-65	47	7.9	1.3	40	18	200	2.4	343	0	
18hab <sup>2</sup>	32	23-32	5-10-63						24				
C1-2-1ded <sup>2</sup>	20		5-10-63						72				
D1-2-9bbb2	20		11- 3-65	54	20	.01	168	80	161	4.6	395	0	
9bbb2	20		4-28-66	45	17	.00	128	68	122	3.0	317	0	
D1-3-18dda	12		11- 3-65		68	.19	162	58	226	1.0	268	0	
24cba	10	5-10	10- 5-65	57	16	.18	168	73	181	3.9	344	0	
<b>Alluvium of Wind River valley</b>													
A1-1-3daa	41		10-15-48	49	24	0.14	48	11	28	2.0	202	0	
A1-3-35cde <sup>2</sup>	40		11-19-64				69	12	28	1.5	238	0	
A1-4-31dec	9		11- 6-65	53	24	.50	128	33	243	3.9	488	0	
A2-1-13ccc	60		9-15-65		13	.10	56	9.4	25	1.6	188	0	
B4-4-2cda	33	21-33	10-26-66		15		92	14	24	2.8	286	0	
2deb <sup>1</sup>			4-28-66		16	2.02	74	21	19	3.5	262	0	
<b>Water-bearing formation unknown</b>													
A5-6-21aa	600-800		8-23-46		65	14	0.03	76	37	19		275	
A7-1-19cca			4-28-65		54	11	.00	52	28	5.0	2.2	224	0
C1-1-6cdd <sup>2</sup>	62	38-62	5-10-63						250				
8aab <sup>2</sup>	66	54-66	5-10-63						160				
18bcc <sup>2</sup>	33	20-24	5-10-63						16				
C1-2-24ada <sup>2</sup>	41	36-41	5-10-63						6				
24dab <sup>2</sup>	90		11-10-64				110	71	117	4	366	0	

<sup>1</sup> Geologic source is questionable.<sup>2</sup> In solution at time of analysis.<sup>3</sup> Analysis by Wyoming State Department of Agriculture, Laramie, Wyo.<sup>4</sup> Riverton city well.

## Wind River Indian Reservation, Wyo.—Continued

Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids		Hardness as CaCO <sub>3</sub>		Sodium-ad- sorption- ratio (SAR)	Specific con- ductance (micro- mhos at 25° C)	pH	Remarks
					Resi- due on evapo- ration at 180° C	Sum	Cal- cium mag- nesi- um	Non- car- bon- ate				

## Alluvium of Little Wind River valley—Continued

732	20	1.0	0.3	0.66	1,460	1,420	650	319	3.8	1,860	7.8	
63	5.7	.3	1.2	.10	292	280	222	42	.4	476	7.6	
		.85			730		340				8.2	
		.28			420		209				7.9	
		.95			540		230				7.8	
		.9			1,160		655				7.8	
		.82			550		347				7.4	
		.58			1,160		525				7.6	
		.72			750		275				7.7	
306	7.2	.5	3.4	.96	772	757	173	0	6.6	1,170	7.8	Mn 0.16 ppm.
		.62			930		415				7.7	
		1.32			450		195				7.7	
694	18	.9	3.6	.32	1,450	1,340	746	422	2.6	1,780	8.2	
558	18	.8	2.7	.02	1,140	1,070	598	338	2.2	1,480	7.9	
845	13	1.6	8.5	.42	1,570	1,520	641	421	3.9	1,930	7.7	
736	28	.6	2.7	.20	1,500	1,380	720	438	2.9	1,810	8.1	Mn 0.77 ppm.

## Alluvium of Wind River valley—Continued

47	5.0	0.3	0.8	0.07	256	267	165	0	0.9	435	8.0	
99	9	.2	10	.04	354		223		.8	541	7.6	
495	64	.6	.1	.17	1,270	1,230	456	56	4.9	1,790	7.7	Mn 0.20 ppm.
68	6.2	.2	.0	.02	284	272	178	24	.8	447	7.8	
103	3.4	.1	1.4	.06	378	397	286	51	.6	635	7.6	
80	7.4	.2	.0	.05	392	355	272	57	.5	603	8.0	

## Water-bearing formation unknown—Continued

143	5.0	0.8				430	342	116	14	696	7.5	Paleozoic(?) rocks.
67	5.0	.7	0.8	0.03	280	282	245	61	.1	479	6.8	Do.
		1.15			780		37				8.6	Alluvium(?), Cody(?) Shale.
		1.25			550		35				9	Do.
		.95			1,630		1,000				7.1	Alluvium(?), Thermopolis (?) Shale.
		.78			420		305				7.4	Cloverly and Morrison(?) Formations, Sundance(?) Formation.
490	11		0	.46	1,070		568			1,460	7.4	Do.

TABLE 7.—*Chemical analyses*

[Analytical results in parts per million, except as

Date of collection	Discharge (cfs) <sup>1</sup>	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)
<b>INDIVIDUAL SAMPLES</b>											
<b>6-2185 <sup>2</sup> Wind River near Dubois, Wyo.</b>											
<i>1965</i>											
July 19.....	632	20	0.11	13	1.9	2.9	1.5	57	0	0	0
Aug. 26.....	188	22	<sup>3</sup> .02	14	6.0	4.5	1.8	78	0	2.5	1.1
Sept. 27.....	175	26	.05	15	5.7	10	2.1	88	0	11	1.8
Nov. 1.....	87	24	.05	22	5.5	6.7	2.2	101	0	8.2	0
Dec. 10.....	86	23	.05	23	5.7	7.4	2.6	102	2	17	0
<i>1966</i>											
Jan. 17.....	63	27	<sup>3</sup> .00	23	7.4	9.0	2.5	113	0	13	.7
Feb. 2.....	65	27	.05	22	6.4	8.0	3.0	107	0	12	1.1
Mar. 23.....	74	27	.00	24	7.1	9.0	2.8	115	0	13	1.1
Apr. 5.....	61	26	.05	25	6.8	9.0	2.0	119	0	14	0
May 6.....	368	17	.19	13	7.2	7.0	2.5	67	0	14	5.0
June 6.....	328	21	.....	10	4.9	6.0	1.6	67	0	2.9	1.1
July 5.....	230	23	.10	16	3.2	7.3	1.9	71	0	6.4	0
Aug. 1.....	131	25	.11	20	3.5	7.0	2.4	88	0	8.2	.7
Sept. 6.....	84	24	.15	21	6.7	7.9	1.5	95	0	14	3.5
Oct. 3.....	73	25	.06	17	8.6	7.7	1.5	110	0	6.6	4.3
<b>6-2310 <sup>2</sup> Little Wind River above Arapahoe, Wyo.</b>											
<i>1966</i>											
Aug. 1.....	7.9	16	0.18	103	54	144	3.6	243	0	532	23
Sept. 6.....	15	11	.08	128	71	206	6.2	265	0	802	33
Sept. 30.....	36	9.6	.11	100	43	131	2.4	244	0	447	25
<b>6-2336 <sup>2</sup> Pop Agie River at Hudson, Wyo.</b>											
<i>1966</i>											
Aug. 1.....	73	12	0.18	103	43	71	3.6	267	0	346	6.4
Sept. 6.....	159	8.0	.00	57	52	64	2.2	204	0	302	7.1
Sept. 30.....	123	5.4	<sup>3</sup> .04	80	37	64	2.4	210	0	305	8.9

See footnotes at end of table.

*of surface-water samples*

indicated. Analyses by U.S. Geological Survey]

Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Calculated	Dissolved solids			Hardness as CaCO <sub>3</sub>	Noncarbonate hardness as CaCO <sub>3</sub>	Percent sodium	Sodium- adsorption- ratio	Specific conductance (micro- mhos per cm at 25° C)	pH
				Residue at 180° C	Parts per million	Tons per acre- foot						
<b>INDIVIDUAL SAMPLES—Continued</b>												
<b>6-2185<sup>2</sup> Wind River near Dubois, Wyo.—Continued</b>												
0	0	0	67	72	0.10	-----	40	0	13	0.2	100	7.7
.2	.3	0	90	112	.15	-----	60	0	14	.3	146	7.8
.1	0	0	115	102	.14	-----	60	0	26	.6	148	7.4
.3	.1	0	119	156	.21	-----	77	0	15	.3	179	7.8
.2	.1	0	133	172	.23	-----	80	0	16	.4	195	8.3
.2	0	0	139	136	.18	-----	88	0	18	.4	208	8.2
.2	0	0	133	142	.19	-----	82	0	17	.4	197	7.6
.2	0	.04	141	164	.22	-----	88	0	17	.4	209	7.8
.2	0	.01	142	170	.23	-----	90	0	17	.4	236	7.6
.1	.6	0	100	114	.16	-----	62	7	19	.4	128	7.1
.2	0	.02	81	100	.14	-----	45	0	22	.4	117	7.5
.2	.3	.01	93	94	.13	-----	52	0	23	.4	133	7.1
.2	.0	0	110	116	.16	-----	65	0	18	.4	157	7.3
.2	.0	.01	126	122	.17	-----	81	3	17	.4	171	7.6
.2	.3	.02	125	122	.17	-----	78	0	17	.4	185	7.8
<b>6-2310<sup>2</sup> Little Wind River above Arapahoe, Wyo.—Continued</b>												
0.9	2.1	0.19	999	1,050	1.43	-----	478	279	39	1.9	1,400	7.8
.9	.0	.24	1,390	1,420	1.93	-----	610	393	42	3.6	1,810	8.0
.7	1.9	.16	881	924	1.26	-----	425	225	40	2.7	1,260	8.0
<b>6-2336<sup>2</sup> Pop Agie River at Hudson, Wyo.—Continued</b>												
0.6	0.9	0.12	718	764	1.04	-----	435	216	26	1.5	1,050	7.6
.5	.0	.00	593	662	.90	-----	356	189	28	1.5	881	7.7
.5	.0	.13	606	638	.87	-----	350	178	28	1.5	900	8.1

TABLE 7.—*Chemical analyses of*

Date of collection	Dis-charge (cfs) <sup>1</sup>	Silica (SiO <sub>2</sub> )	Iron (Fe)	Cal-cium (Ca)	Mag-nesium (Mg)	Sodi-um (Na)	Potas-sium (K)	Bicar-bonate (HCO <sub>3</sub> )	Car-bonate (CO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chlo-ride (Cl)
<b>COMPOSITE SAMPLES</b>											
6-2280 <sup>2</sup> Wind River at Riverton, Wyo.											
<i>1965</i>											
Oct. 1-10 .....	768	18	-----	33	8.3	19	2.3	135	0	46	5.7
Oct. 11-27 .....	861	21	-----	37	10	20	2.9	156	0	51	3.5
Oct. 28-Nov. 3 .....	1,460	10	-----	31	13	17	2.0	113	0	71	5.3
Nov. 4-16 .....	529	14	-----	44	16	24	2.8	165	0	88	5.3
Nov. 17-30 .....	506	17	-----	44	15	23	2.8	186	0	71	7.1
Dec. 1-9 .....	479	16	-----	45	16	25	2.9	192	0	71	5.3
Dec. 10-18 .....	417	15	-----	49	19	28	2.9	195	0	103	5.3
Dec. 19-31 .....	395	15	-----	44	18	24	2.9	189	0	77	7.1
<i>1966</i>											
Jan. 1-15 .....	438	16	-----	47	12	24	3.5	183	0	56	5.3
Jan. 16-31 .....	414	15	-----	46	18	28	3.3	183	0	87	5.3
Feb. 1-12 .....	448	14	-----	45	13	23	3.1	171	0	64	4.3
Feb. 13-19 .....	401	15	-----	47	13	23	3.1	177	0	69	5.3
Feb. 20-28 .....	474	15	-----	44	13	24	3.1	168	0	67	3.5
Mar. 1-13 .....	415	18	-----	43	13	24	2.0	159	0	63	7.1
Mar. 14-31 .....	376	15	-----	43	13	32	2.0	171	0	76	7.1
Apr. 1-7 .....	533	15	-----	34	14	26	1.4	155	0	60	4.6
Apr. 8-14 .....	141	14	-----	48	17	43	1.5	186	0	114	5.3
Apr. 15-30 .....	236	13	-----	37	16	33	1.0	165	0	82	4.6
May 1-7 .....	341	19	-----	40	13	24	2.5	165	0	68	3.5
May 8-14 .....	1,250	15	-----	24	8.9	12	1.7	113	0	31	1.8
May 15-31 .....	246	15	-----	26	9.8	19	1.3	122	0	45	2.8
June 1-10 .....	280	12	-----	28	6.0	22	1.5	107	0	52	2.5
June 11-19 .....	246	13	-----	30	6.4	23	1.5	116	1	48	4.3
June 20-30 .....	445	14	-----	27	6.4	17	1.3	110	0	37	3.5
July 1-9 .....	171	13	-----	36	10	38	2.3	149	0	65	14
July 10-Aug. 9 .....	346	11	-----	27	7.8	24	1.7	122	0	38	7.1
Aug. 10-Sept. 14 .....	190	10	-----	49	8.1	43	2.2	162	0	109	6.7
Sept. 15-30 .....	308	16	-----	49	7.9	43	2.9	179	0	95	5.3

See footnotes at end of table.

*surface-water samples*—Continued

Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids			Hardness as CaCO <sub>3</sub>	Noncarbonate hardness as CaCO <sub>3</sub>	Percent sodium	Sodium adsorption- ratio	Specific conductance (micro- mhos per cm at 25° C)	pH	
			Calculated	Residue at 180° C								
				Parts per million	Tons per acre- foot							Tons per day
<b>COMPOSITE SAMPLES—Continued</b>												
<b>6-2280<sup>2</sup> Wind River at Riverton, Wyo.—Continued</b>												
0.4	0.0	0.06	199	220	0.30	457	118	7	26	0.8	320	8.1
.4	.0	.06	223	246	.33	564	135	7	24	.8	356	8.1
.3	.0	.04	206	240	.33	956	130	37	22	.6	339	7.7
.4	.0	.09	276	316	.43	451	174	39	23	.8	455	7.8
.4	.0	.06	271	316	.43	432	174	21	22	.8	444	7.6
.3	.0	.08	276	284	.39	371	178	21	23	.8	448	8.1
.4	.0	.04	319	320	.44	364	201	41	23	.9	508	8.1
.3	.0	.07	280	272	.37	290	182	27	22	.8	442	8.0
.3	.7	.04	255	242	.33	287	167	17	23	.8	434	7.6
.3	.7	.04	294	284	.39	320	188	38	24	.9	474	7.9
.4	.1	.17	251	234	.32	284	166	26	23	.8	414	8.0
.4	.4	.07	263	226	.31	247	170	25	22	.8	417	8.0
.3	.3	.10	253	232	.32	301	162	24	24	.8	411	8.1
.2	.6	.04	249	258	.35	288	160	30	24	.8	414	8.2
.3	.0	.07	272	290	.39	291	162	22	30	1.1	449	8.2
.3	.2	.11	232	232	.32	338	143	15	28	.9	386	7.2
.4	.2	.05	334	358	.49	137	190	37	33	1.4	544	7.7
.3	.2	.11	268	280	.38	178	158	23	31	1.1	446	7.7
.4	.7	.04	252	292	.40	271	152	17	25	.8	413	7.9
.3	.5	.02	151	196	.27	669	97	4	21	.5	253	7.4
.3	.0	.06	179	190	.26	127	105	5	28	.8	295	7.6
.3	.2	.04	178	186	.25	139	95	7	33	1.0	270	8.2
.5	.0	.02	185	194	.26	127	102	5	32	1.0	302	8.3
.3	.0	.00	160	156	.21	185	93	3	28	.7	258	8.2
.4	.2	.10	252	264	.36	122	130	8	38	1.4	406	8.1
.3	.1	.09	177	194	.26	178	100	0	34	1.0	300	8.0
.4	.1	.06	309	298	.41	155	156	23	37	1.5	490	7.6
.4	.0	.06	308	290	.39	238	155	8	37	1.5	470	7.8

TABLE 7.—*Chemical analyses of*

Date of collection	Discharge (cfs) <sup>1</sup>	Silica (SiO <sub>2</sub> )	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO <sub>3</sub> )	Calcium carbonate (CO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)
<b>6-2355 <sup>2</sup> Little Wind River near Riverton, Wyo.</b>											
<i>1965</i>											
Oct. 1-20 .....	503	8.5 .....	62	31	50	2.8	159	0	249	9.9	
Oct. 21-31 .....	387	6.3 .....	63	35	48	2.9	171	0	253	8.5	
Nov. 1-15 .....	338	5.5 .....	74	33	55	3.5	190	0	259	9.9	
Nov. 16-30 .....	301	7.2 .....	78	36	59	3.6	196	0	293	10	
Dec. 1-13 .....	222	8.7 .....	69	37	55	3.1	186	0	267	8.9	
Dec. 14-18 .....	197	10 .....	76	36	66	3.8	210	0	283	11	
Dec. 19-31 .....	234	12 .....	74	39	61	3.2	210	0	291	8.9	
<i>1966</i>											
Jan. 1-10 .....	233	11 .....	68	38	58	3.3	192	0	274	11	
Jan. 11-27 .....	198	12 .....	73	32	52	3.0	192	0	249	11	
Jan. 28-Feb. 5 ..	193	11 .....	70	29	47	3.5	186	0	218	8.9	
Feb. 2-20 .....	189	11 .....	76	35	56	3.2	198	0	260	11	
Feb. 21-28 .....	214	11 .....	76	32	54	3.5	186	0	255	12	
Mar. 1-10 .....	198	11 .....	76	38	62	2.5	186	0	294	16	
Mar. 11-18 .....	272	12 .....	78	49	110	5.5	165	0	455	18	
Mar. 19-31 .....	264	11 .....	80	45	79	3.5	189	0	361	16	
Apr. 1-16 .....	298	11 .....	75	33	68	4.0	188	0	294	18	
Apr. 17-30 .....	304	9.2 .....	85	47	116	4.0	198	0	463	19	
May 1-7 .....	337	7.2 .....	61	27	54	1.4	162	0	230	13	
May 8-15 .....	805	7.8 .....	42	12	30	1.0	116	0	116	6.4	
May 16-31 .....	475	4.8 .....	46	16	33	1.1	123	0	138	6.7	
June 1-10 .....	612	8.5 .....	54	18	41	.6	128	0	183	7.1	
June 11-30 .....	659	8.0 .....	54	23	40	1.5	134	0	186	7.1	
July 1-15 .....	297	8.8 .....	77	33	68	1.4	192	6	289	11	
July 16-31 .....	115	12 .....	95	37	94	2.0	222	0	384	16	
Aug. 1-20 .....	102	12 .....	99	42	99	3.0	238	0	411	17	
Aug. 21-Sept. 10	182	9.2 .....	98	40	95	2.6	226	0	397	15	
Sept. 11-30 .....	219	8.9 .....	90	36	89	2.7	203	0	363	17	

<sup>1</sup> Discharge subject to revision.<sup>2</sup> Official station number.<sup>3</sup> In solution at time of analysis.

## surface-water samples—Continued

Fluoride (F)	Nitrate (NO <sub>3</sub> )	Boron (B)	Dissolved solids				Hardness as CaCO <sub>3</sub>	Noncarbonate hardness as CaCO <sub>3</sub>	Percent sodium	Sodium- adsorption- ratio	Specific conductance (micro- mhos per cm at 25° C)	pH
			Calculated	Residue at 180° C								
				Parts per million	Tons per acre- foot	Tons per day						
<b>6-2355 <sup>2</sup> Little Wind River near Riverton, Wyo.—Continued</b>												
0.6	0.0	0.12	492	544	0.74	738	284	154	27	1.3	743	8.0
.4	.7	.09	502	500	.68	522	301	161	26	1.2	762	8.2
.7	.2	.10	534	572	.78	523	320	164	27	1.3	800	7.9
.7	.6	.11	584	602	.82	490	340	179	27	1.4	862	7.9
.5	.0	.10	534	570	.78	343	322	169	27	1.3	836	7.8
.5	.1	.11	589	628	.85	332	340	168	29	1.6	897	7.9
.5	.2	.10	594	624	.85	395	344	172	28	1.4	874	7.8
.5	1.4	.04	559	600	.82	379	328	171	28	1.4	838	8.0
.5	1.0	.00	528	544	.74	291	312	155	26	1.3	804	8.0
.5	1.1	.10	480	502	.68	260	295	142	25	1.2	754	7.9
.5	1.1	.11	551	582	.79	296	331	169	27	1.3	844	7.7
.5	2.0	.10	537	564	.77	327	320	168	27	1.3	825	7.8
.5	1.1	.09	592	634	.86	338	345	193	28	1.5	894	8.0
.5	8.2	.11	817	874	1.19	642	396	261	37	2.4	1,180	7.8
.5	1.8	.10	691	762	1.04	545	386	231	31	1.7	1,040	8.0
1.0	.0	.06	596	604	.82	485	323	169	31	1.6	872	8.0
.7	2.5	.08	843	872	1.19	718	405	243	38	2.5	1,180	8.0
.5	.1	.03	474	498	.68	455	265	132	31	1.4	726	7.3
.3	.1	.05	273	290	.39	623	156	61	29	1.0	445	7.5
.3	.1	.04	307	340	.46	433	181	80	28	1.1	509	7.3
.3	.9	.07	376	394	.54	655	208	103	30	1.2	588	7.0
.3	.5	.10	386	406	.55	719	228	118	27	1.1	604	6.9
.5	.8	.12	590	616	.84	495	330	163	31	1.6	876	8.3
.6	.8	.14	751	780	1.06	242	390	208	34	2.0	1,090	8.0
.6	.5	.18	801	842	1.15	233	420	223	34	2.1	1,100	8.2
.6	.5	.20	769	716	.97	350	410	225	33	2.0	1,070	8.1
.6	.6	.18	708	748	1.02	443	372	206	34	2.0	997	8.2

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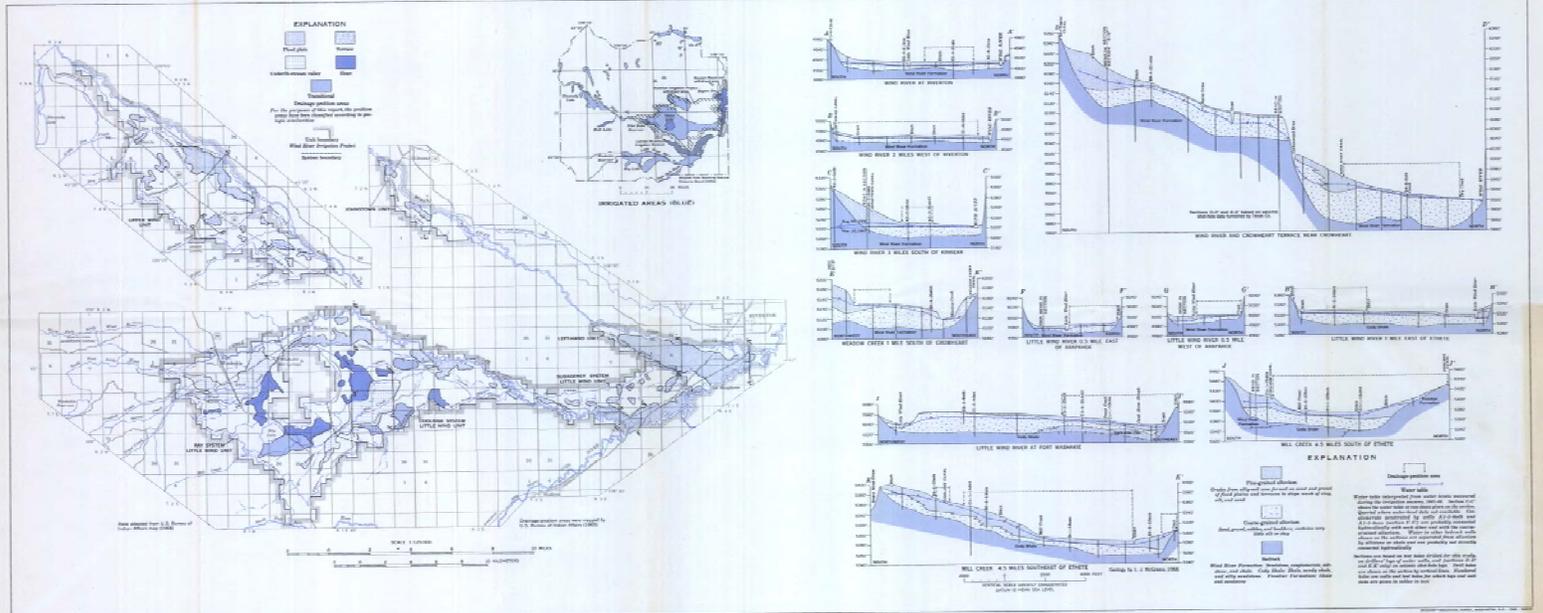
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MAP AND SECTIONS SHOWING DRAINAGE-PROBLEM AREAS IN THE WIND RIVER IRRIGATION PROJECT, WIND RIVER INDIAN RESERVATION, WYOMING