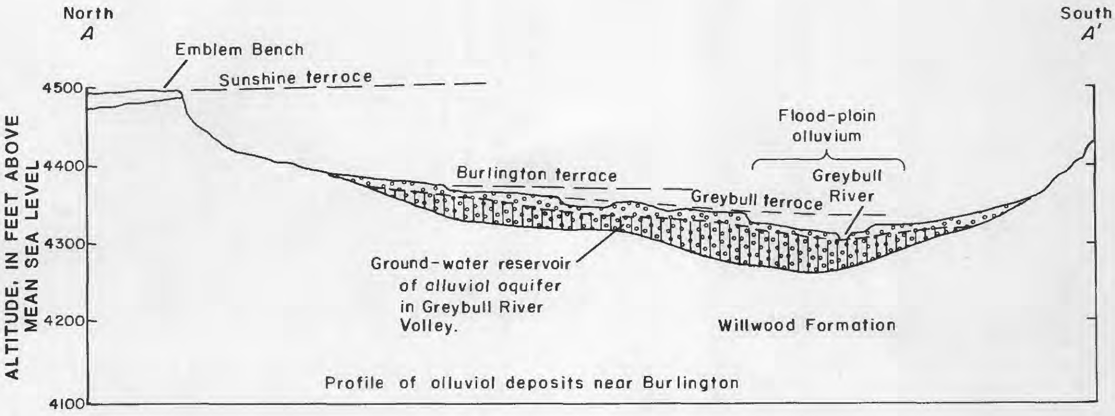
HYDROGEOLOGIC FEATURES OF THE ALLUVIAL DEPOSITS IN THE GREYBULL RIVER VALLEY, BIGHORN BASIN, WYOMING

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 79-6



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WYOMING STATE ENGINEER

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16. Abstracts The alluvial aquifer along the Greybull River consists principally of the Greybull terrace deposits and the flood-plain alluvium but also includes the Burlington terrace deposits east of Burlington, the McKinnie terrace, and the younger, generally undissected alluvial-fan deposits. Well-log data and 18 surface-resistivity measurements at four localities indicate that the thickness of the alluvial aquifer is as much as 60 feet thick only near Burlington and Otto. The most favorable area for development of ground water from the alluvial aquifer is near Burlington and Otto where relatively large amounts of water can be obtained from the Greybull terrace deposits and the flood-plain alluvium. Elsewhere, the deposits of the alluvial aquifer yield only small amounts of water to wells.

17. Key Words and Document Analysis. 17a. Descriptors

*Ground water/ *water resources/ *Wyoming/ *Rocky Mountain Region/ terraces/ *flood-plain alluvium/ *geomorphology/ chemical analysis.

17b. Identifiers/Open-Ended Terms

Thickness of alluvium/ *surface resistivity/ Greybull terrace/ *alluvial aquifer/ alluvial fan/ Bighorn Basin/ *surficial geology.

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1979

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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Open-File Report

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U.S. Geological Survey
2120 Capitol Avenue
P.O. Box 1125
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United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
2120 Capitol Avenue
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Cheyenne, Wyoming 82001

Dear Sir/Madam:

I am pleased to enclose for your information a copy/copies of U.S. Geological Survey Water Resources Investigations 79-6, "Hydrogeologic features of the alluvial deposits in the Greybull River Valley, Bighorn Basin, Wyoming," by M. E. Cooley and W. J. Head.

Sincerely yours,

W. W. Dudley, Jr.

William W. Dudley, Jr.
District Chief

Enclosure
ERC:ej

HYDROGEOLOGIC FEATURES OF THE ALLUVIAL DEPOSITS IN THE GREYBULL RIVER VALLEY, BIGHORN BASIN, WYOMING

by Maurice E. Cooley and William J. Head

ABSTRACT

Conspicuous gravel-floored benches and terraces, including the Rim, Sunshine, Burlington, Greybull, and McKinnie terraces, alluvial fans, pediments, and flood plains, are displayed in the Greybull River Valley. The Greybull terrace is redefined and the Burlington and McKinnie terraces are named in this report. The distribution of the deposits control the occurrence of the shallow ground-water reservoir near the Greybull River. This ground-water reservoir is called the alluvial aquifer and consists principally of the Greybull terrace deposits, the flood-plain alluvium, and, subordinately, the deposits of the Burlington terrace east of Burlington, the McKinnie terrace, and the younger alluvial fans. The other alluvial deposits are virtually nonwater-yielding, except for remnants of terrace Qt2 deposits that locally yield some water to wells.

Available well-log and surface-resistivity measurements at four localities indicate that the thickness of the alluvial deposits is as much as 60 feet thick only between Burlington and Otto. Upstream from Burlington, the thickness of the part of the alluvial aquifer that extends below the level of the Greybull River probably does not exceed 15 feet. In the lowermost part of the Greybull River Valley downstream from Otto, the deposits may not be more than about 30 feet thick.

The water in the alluvial aquifer generally is very hard. The dissolved solids in water of the Greybull terrace deposits range from 385 to 887 milligrams per liter; whereas, the dissolved-solids concentration of water in other deposits of the alluvial aquifer ranges from about 400 to 2,200 milligrams per liter. Locally, water in the alluvial aquifer and in the underlying Willwood Formation contains more than 1.5 milligrams per liter of fluoride. Use of the chemical analyses in conjunction with specific conductance helped determine inflow of moderately mineralized ground water from the alluvial aquifer to the Greybull River near Otto.

The most favorable area for development of ground water from the alluvial aquifer along the Greybull River is between Burlington and Otto where relatively large quantities of water can be obtained from the Greybull terrace deposits and the flood-plain alluvium. The Greybull terrace deposits have the best possibilities for development of ground water because (1) they consist mainly of pebbles and cobbles, (2) they range in thickness from 30 to 56 feet throughout much of their extent, and (3) they have known yields of more than 250 gallons per minute, the highest yields of any unit of the alluvial aquifer.

INTRODUCTION

The alluvial deposits are the principal aquifer in the Greybull River Valley and the source of water to many stock and domestic wells and to a few irrigation wells. In 1975, the U.S. Geological Survey, in cooperation with the Wyoming State Engineer, began an investigation of the hydrology and geology, including the geomorphology, of the Greybull River Valley (fig. 1) to determine the most favorable areas for obtaining ground water for irrigation. The part of the Greybull River Basin investigated extends from the mouth of the Wood River, southwest of Meeteetse, downstream to the mouth of the river at Greybull. The study, however, was concerned chiefly with the area between the abandoned Fenton School and the town of Greybull (pl. 1).

Field Work and Acquisition of Data

The main investigative proceedures utilized were (1) geologic mapping of the alluvial deposits (pl. 1) to determine the lithology and extent of the water-yielding deposits that form the alluvial aquifer, (2) surface-resistivity measurements at four locations to determine the thickness and character of the alluvial deposits, (3) evaluation of well records and well-log data from the files of the Wyoming State Engineer and from a report by Robinove and Langford (1963), (4) collection of water samples from wells and the Greybull River for chemical analysis, and (5) measurements of the specific conductance of the Greybull River at low flow to determine the downstream increase in dissolved solids. All locations of the surface-resistivity measurements, wells, springs, and stream-sampling sites are shown on plate 2.

Eighteen surface-resistivity measurements were made at the Fenton School (abandoned), at Burlington, at Otto, and in the narrows 3 miles southwest of Greybull to help determine the thickness of the alluvial deposits. The field technique utilized the Schlumberger array. Interpretations were based on Hummel's curve matching methods (Keller and Frishknecht, 1960), and a computerized interpretation method based on modified Dar Zarrouk functions (Zohdy, 1975). The resistivity data obtained were not refined for lithologic and porosity interpretations.

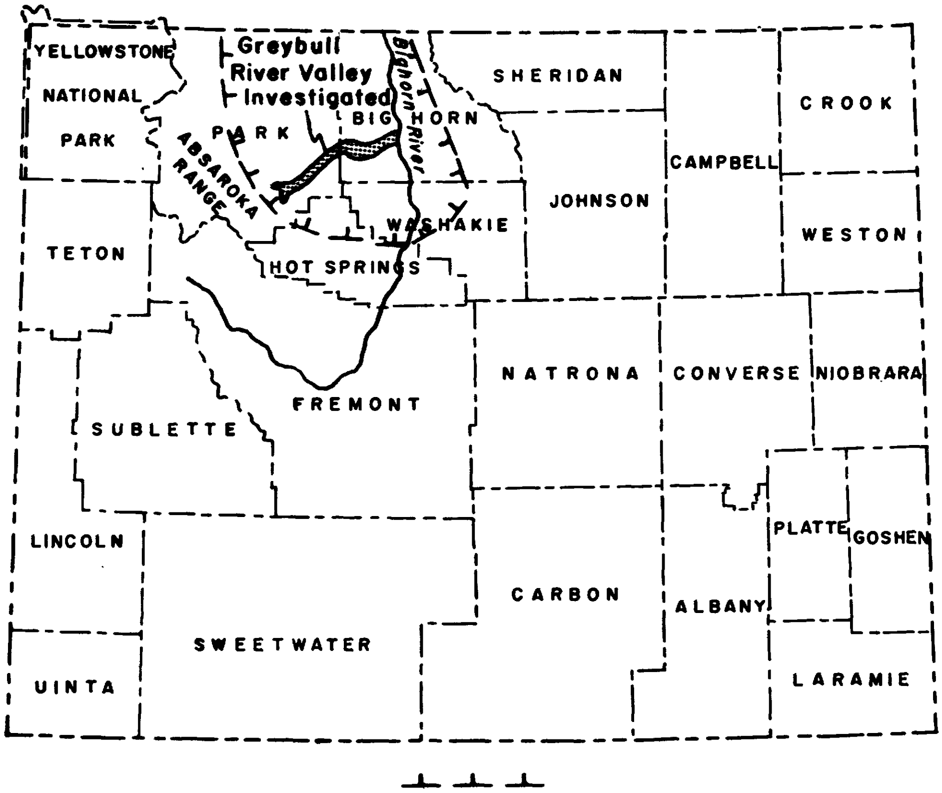

Figure 1.--Map of Wyoming showing location of the part of Greybull River Valley investigated.

Previous Investigations and Acknowledgments

The earliest comprehensive geomorphic investigation of the area was by Andrews and others (1947) who mapped the alluvial deposits and terraces for most of the Bighorn Basin. Macklin (1936, 1937, and 1947) and Merrill (1974) mapped some of the higher terraces and in the Greybull River Valley and other drainage basins. Robinove and Langford (1963) described the ground-water conditions, including chemical quality, of the lower Greybull River area. A hydrologic reconnaissance of the Bighorn Basin was made by Lowry and others (1976).

The authors gratefully acknowledge the assistance of personnel of the Wyoming State Engineer's office, Cheyenne, in obtaining well data and other information from their files, and cooperation of the many ranchers in the area who provided information concerning their wells and use of water. Samples of water from wells and from some streams collected in 1976 were analysed in the State laboratories, Wyoming Department of Agriculture, Laramie. Special thanks are given to K. L. Pierce (geologist, U.S. Geological Survey) for his assistance in defining the geomorphic relationships of the terraces and deposits.

Location-Numbering System

The location of a well is designated by a numbering system based on the Federal system of land subdivision. The first number denotes the township, the second number denoted the range, and the third number denotes the section. One or more letters follow the section number and denote the location within the section. The section is divided into four quarters (160 acres) and lettered a, b, c, and d in a counter-clockwise direction, beginning in the northeast quarter. Similarly, each quarter may be further divided into quarters (40 acres) and again into 10-acre tracts and lettered as before. The first letter following the section number denotes the quarter section; the second letter, if shown, denotes the quarter-quarter section; and the third letter denotes the quarter-quarter-quarter section, or 10-acre tract. For example in figure 2, the location 51-98-29cab is in the NW¼ of the NE¼ of the SW¼ of sec. 29, T. 51 N., R. 98 W.

As a means of identification, the Geological Survey assigns an eight-digit station number (such as 06277500) to most sites where surface-water data are collected. Where assigned, station numbers are used in this report. The station numbers increase in downstream order. Stations on tributaries are assigned numbers between upstream and downstream stations on main stems. Gaps are left in the numbering system to allow for new stations that may be established. The first two digits of the station number denote the drainage basin. Station numbers beginning with "06" are in Missouri River drainage.

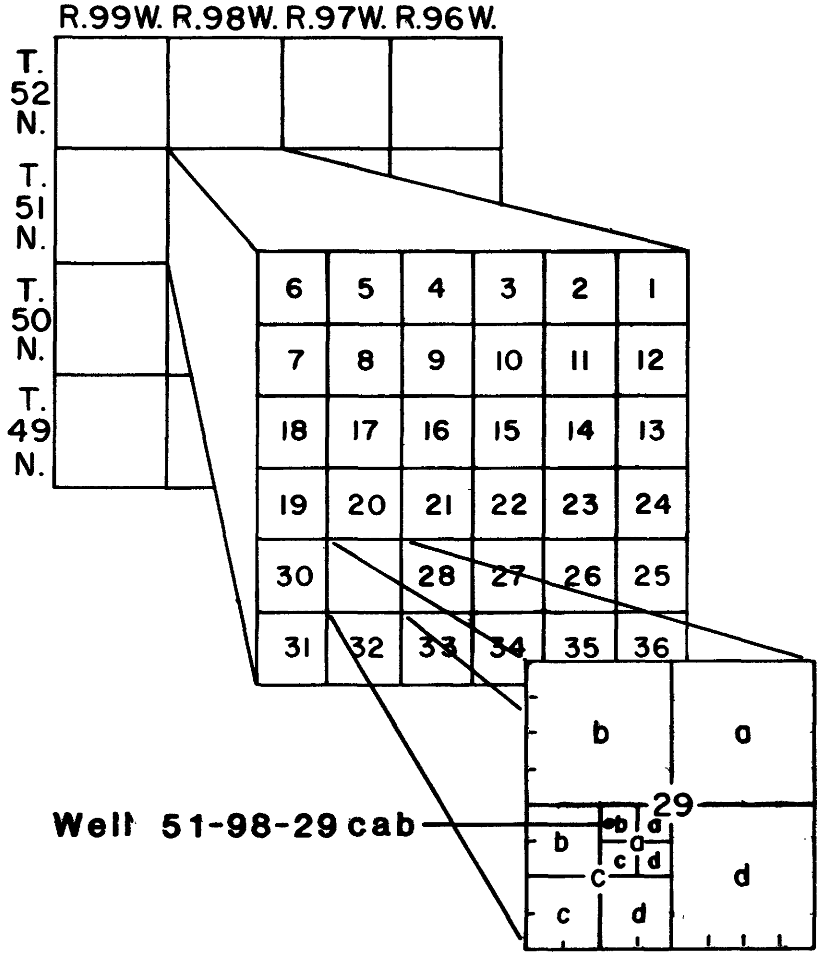

Figure 2.--System of numbering wells.

Metric Units

Inch-pound units used in this report may be converted to metric equivalents by the following conversion factors:

Inch-pound units	Multiply by	Metric units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometers (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
acre	0.4047	hectare (ha)
gallon per minute (gal/min)	3.78543	liter per minute (L/min)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
acre-foot (acre-ft)	1,233	cubic meter (m^3)

STREAMFLOW

Most of the flow of the Greybull River is from the Absaroka Range and adjacent uplands southwest of Meeteetse at altitudes of 6,500 to more than 9,000 feet. Only a minor part is obtained from the low altitude and low rainfall belt (below 4,500 ft) of the central Bighorn Basin where most of the water is used for irrigation. The average discharge of the river at Meeteetse for 51 years (1921-71) was 251,400 acre-ft/yr. The flow is mainly from snowmelt that occurs from April to June and in some years in July. The flows during August and September are the two lowest months of the May to September growing season (table 1); water demand for irrigation may be high or even critical during these two months. Due to freezing temperatures, the flows during the winter generally are less than those for August or September. For the years of record, the flow at Meeteetse during August ranged from 2,230 to 104,800 acre-ft and for September from 5,010 to 39,390 acre-ft. A grouping of years during 1921-75 having low flows are as follows:

Number of-years	Month	Amount of flow (acre-ft)
4	August	<10,000
12	August	10,000-20,000
10	September	<10,000
25	September	10,000-20,000

Below Meeteetse, part of the flow of the Greybull River is diverted to irrigate more than 53,000 acres of crop and hay land. Some of the irrigated acreage is on Emblem Bench outside the area investigated. Excess irrigation water--including leakage from unlined canals and ditches that were excavated in gravel--is a principal source of recharge to the underlying alluvial deposits. Locally, this recharge has caused waterlogging of the deposits and has resulted in considerable land taken out of cultivation, particularly near the Greybull River between Burlington and Otto.

Table 1.--Records of streamflow for gaging station 06277500 Greybull River at Meeteetse, Wyo.

[Records poor. Some regulation by Sunshine Reservoir beginning May 1940, capacity 52,990 acre-ft; and Lower Sunshine Reservoir beginning December 1972, capacity 58,900 acre-ft. Diversions for irrigation of about 10,600 acres above station. Several diversions above station for irrigation below station.]

Water year	Selected monthly and annual discharge, in acre-feet					Total water year
	May	June	July	Aug.	Sept.	
1897	------	------	31,500	18,400	6,190	--------
1898	------	------	------	------	-----	--------
1920	------	------	------	------	9,400	--------
1921	52,600	121,000	28,600	18,500	10,700	#270,000
1922	44,000	102,000	49,200	23,900	13,000	#275,000
1923	47,700	88,100	82,400	27,700	21,200	#315,000
1924	*94,100	*158,000	70,100	17,800	11,800	#439,000
1925	41,600	67,800	49,600	27,700	14,800	#268,000
1926	55,500	50,100	52,400	22,600	15,100	#249,000
1927	24,400	71,400	40,400	33,500	22,400	#255,000
1928	62,700	77,400	#67,600	#21,500	16,000	#307,000
1929	71,300	117,000	35,300	14,300	9,640	#298,000
1930	37,800	52,100	37,100	65,200	18,400	#254,000
1931	81,200	107,000	17,900	17,000	9,880	304,000
1932	54,500	90,400	36,200	11,300	7,320	241,000
1933	39,200	131,000	29,600	12,700	9,940	260,000
1934	32,940	16,880	11,580	8,910	6,690	123,900
1935	24,000	131,600	47,280	13,170	6,770	265,900
1936	24,290	48,370	26,030	27,210	7,280	172,600
1937	42,240	131,500	47,570	13,030	8,510	287,900
1938	27,210	68,410	50,580	16,330	14,430	217,900
1939	23,850	26,160	20,630	8,890	5,010	131,900
1940	14,990	20,390	15,200	8,390	8,580	94,620
1941	38,200	76,800	55,660	104,800	39,390	353,400
1942	66,920	85,010	51,230	29,430	12,500	328,600
1943	34,560	77,740	80,270	38,640	13,970	300,800
1944	54,990	109,400	64,850	33,550	9,700	317,700
1945	33,170	79,660	75,900	37,720	21,010	291,300

Table 1.--Records of streamflow--Continued

Water year	Selected monthly and annual discharge, in acre-feet					Total water year
	May	June	July	Aug.	Sept.	
1946	27,810	48,330	45,970	29,700	12,200	226,700
1947	45,260	68,030	72,780	38,920	18,330	285,100
1948	32,040	63,180	53,070	32,870	17,030	243,600
1949	33,410	58,400	43,580	28,330	12,430	222,000
1950	21,380	53,480	47,540	33,360	18,070	209,800
1951	37,480	58,470	87,330	40,550	17,870	280,600
1952	63,320	91,210	48,910	32,730	15,690	319,000
1953	22,570	55,320	39,630	22,590	11,670	185,700
1954	28,910	37,640	34,210	21,010	7,970	165,800
1955	13,130	28,060	23,600	13,960	5,870	112,200
1956	28,670	48,870	40,240	30,410	15,420	191,200
1957	40,970	189,500	87,560	44,070	16,130	410,000
1958	64,510	50,780	39,230	35,680	17,540	247,800
1959	21,030	39,630	34,350	30,000	12,910	168,900
1960	21,400	28,900	21,500	14,490	7,690	128,400
1961	20,950	48,890	27,530	21,380	14,210	162,700
1962	28,930	70,890	49,210	32,150	13,420	247,500
1963	39,690	125,400	56,090	35,740	17,930	308,800
1964	27,570	90,870	74,800	36,900	16,070	278,600
1965	30,760	100,900	136,400	56,750	17,240	372,300
1966	20,950	27,260	31,620	26,430	16,240	162,900
1967	26,140	139,000	104,900	34,440	15,630	348,700
1968	26,320	63,700	45,900	24,660	16,160	215,800
1969	32,460	45,910	42,000	30,100	15,580	208,800
1970	26,720	72,170	40,540	30,880	15,760	212,400
1971	30,970	124,100	53,830	34,320	11,940	283,700
1972	30,570	76,490	36,600	19,820	13,200	-------
1973	27,890	12,170	7,890	2,320	18,910	120,500
1974	49,590	95,110	53,160	35,890	19,130	-------
1975	6,098	34,540	48,116	19,688	11,380	-------

* Revised.

\# Partly estimated on basis of record for nearby stations and adjacent record.

Chemical data of water listed in tables 2 and 3 were obtained for the Greybull River and from water wells to learn of possible relations between the flow and the return water from irrigated fields and ground-water discharge from the alluvial deposits adjoining the river. Depending on the amount of streamflow, the dissolved-solids content at Meeteetse ranges from about 100 to 250 mg/L. The river picks up dissolved solids enroute downstream. At station 12, the chemical-measurement station 06277500 Greybull River near Basin east of Otto, the dissolved solids during 1974 to 1976 ranged from 142 to 741 mg/L (table 2). Relations of the specific conductance to the discharge of the Greybull River were derived by Robinove and Langford (1963, fig. 18) at Meeteetse and at the chemical-measurement station Greybull River near Basin. A series of measurements of the specific conductance made in September 1976 during the low-flow period of the river in the late irrigation season (table 4) indicated an increase of only 2.4 µmho/cm per mile between station 3 at Meeteetse and station 10 south of Burlington. However, an increase of 30.2 µmho/cm per mile occurred between station 10 and station 11 south of Otto and 51.2 µmho/cm per mile between station 11 and station 12, about 4.2 miles east of Otto. The return flow to the Greybull River from the irrigated areas occurs mainly between stations 10 and 11. Aerial and ground inspections revealed the presence of small temporary ponds and marsh-like areas on the flood plain in this area.

Overland return irrigation water seems to be insufficient to cause all the increase in the specific conductance between stations 10 and 12, particularly between stations 11 and 12; instead, this increase may be due to discharge of ground water from the alluvial deposits. Water from the alluvial deposits west of the meridian 108°22'30", about half way between Burlington and Otto, contains less than 700 mg/L of dissolved solids, but water in the alluvial deposits east of this meridian contains more than 1,000 mg/L (as much as 2,160 mg/L) of dissolved solids with high amounts of sulfate, sodium, and bicarbonate (table 3). The large amounts of dissolved solids, particularly the sulfate and sodium content of the low flows of the Greybull River at station 12 (table 2), indicate some inflow to the river from the nearby alluvial deposits. West of meridian 108°22'30" the inflow of water having relatively low dissolved solids from the alluvial deposits seems to only slightly affect the chemical quality of the river.

Table 2.--Selected chemical analyses of surface water in the Greybull River valley

[Chemical analyses before 1960 from Robinove and Langford, 1963, table 5.

Analytical results in milligrams per liter (mg/L), except as indicated.]

Instantaneous discharge (ft^3/sec)	General flow condition	Date of collection	Dissolved silica (SiO_2) (mg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrate (NO_3) (mg/L)	Dissolved solids Sum of constituents (mg/L)	Hardness as $CaCO_3$ (Ca, Mg) (mg/L)	Hardness as $CaCO_3$ Noncarbonate	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)
Near gaging station 06276500 Greybull River at Meeteetse (station 3 of table 4)																			
820	high	7-24-55	--	28	10	18	2.4	-----	--	-----	---	---	----	213	112	---	0.7	308	---
1,530	high	6- 4-56	16	16	4.2	8.3	.9	70	0	20	0	0	0.9	101	57	0	.5	158	7.7
670	high	7-24-56	13	23	7.0	13	1.1	91	0	38	0	.1	.7	144	86	11	.6	233	8.0
947	high	8- 9-57	--	33	11	17	---	134	0	52	0	---	----	-----	128	28	.7	322	8.0
420	low	9-14-76	11	37	15	27	1.9	150	0	85	2.3	.3	.3	252	150	---	.93	405	8.2
Intake of Farmers Canal (station 8 of table 4)																			
	low	9-14-76	13	39	19	35	4.2	180	0	100	2.1	.3	.3	302	180	---	1.2	483	8.2
Greybull River at chemical-measurement station 06277500 Greybull River near Basin (station 12 of table 4)																			
500	high	6- 5-56	17	31	7.9	24	1.6	121	0	61	0	0	1.5	204	110	11	1.0	334	7.6
15	low	7-24-56	18	86	31	164	3.4	312	0	425	17	.5	1.7	925	340	84	3.9	1,330	8.0
2,210	high	6-21-74	12	26	3.2	17	1.9	98	0	33	0	.3	.14	142	78	0	.8	228	8.0
46	low	9- 3-74	18	72	39	120	4.2	330	3	310	9.1	.6	.66	741	340	64	2.8	1,090	8.4
1,140	high	6-30-75	16	26	7.4	23	1.6	110	0	51	3.6	.2	.09	185	95	5	1.0	-----	---
33	low	8- 5-75	18	67	33	120	4.2	280	9	290	12	.6	.45	693	300	55	3.0	-----	---
493	high	6-30-76	16	26	7.4	23	1.6	110	0	51	3.6	.2	.09	185	95	5	1.0	-----	---
69	low	9- 4-76	18	60	24	110	5.1	280	9	230	7.3	.9	.8	603	250	---	3.0	903	8.5

Table 3.--Selected chemical analyses of ground water in the Greybull River valley

[Chemical analyses before 1960 from Robinove and Langford, 1963, table 5.

Analytical results in milligrams per liter (mg/L), except as indicated.]

Location	Depth of well (ft)	Date of collection	Dissolved silica (SiO_2) (mg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrate (NO_3) (mg/L)	Dissolved solids Sum of constituents (mg/L)	Hardness as $CaCO_3$ (Ca, Mg) (mg/L)	Hardness as $CaCO_3$ Noncarbonate	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°)	pH (units)
Alluvial-fan deposits																			
49-100-13bdc	17	9-16-76	26	100	39	38	4.2	490	0	95	2.1	.5	6.5	552	420	---	0.8	878	7.7
51- 94- 5bdd	---	9-15-76	16	200	62	340	5.3	510	0	1,000	18	.9	38	1,950	760	---	5.3	2,430	8.1
Flood-plain alluvium																			
50-99-14bac[1]	---	8- 9-57	31	83	43	65	8.1	447	0	153	3.5	.6	2.7	610	384	17	1.4	921	7.5
51-94- 2bbd	15	8-10-57	30	188	50	380	3.0	577	0	950	30	.5	3.4	1,920	675	202	6.4	2,560	7.5
51-95-15ccb1	24	8-10-57	30	203	54	236	3.7	516	0	770	30	.3	4.1	1,590	730	307	3.8	2,050	7.8
15ccb1	24	5-19-76	22	130	35	210	2.6	400	0	520	20	.7	1.3	1,140	480	---	4.2	1,680	7.7
21aca	10	9-15-76	3.5	100	29	300	3.5	350	0	700	27	1.0	1.4	1,340	380	---	6.7	1,810	8.1
51-96- 7dda	12	5-19-76	21	100	26	52	3.0	410	0	130	4.3	.4	1.4	546	360	---	1.2	848	7.6
8cba	39	5-19-76	25	73	17	41	1.6	290	0	99	1.8	.3	1.6	404	250	---	1.1	641	7.6
24bab1[2]	25	9-15-76	29	93	32	530	3.5	710	0	850	17	.9	17	1,930	360	---	12	2,510	8.1
24bab2[3]	25	9-15-76	23	90	30	520	3.7	690	0	810	16	.8	7.3	1,840	350	---	12	2,450	7.8
51-97-12abc2	16	8-10-57	32	96	25	70	1.7	443	0	123	.1	.4	4.8	571	341	0	1.7	872	7.5
12abc2	16	9-15-76	25	91	22	48	1.9	410	0	90	1.7	.5	1.2	483	320	---	1.2	761	7.9
51-98-23aaa	9	8- 9-57	28	115	29	74	11	464	0	186	4.5	.4	1.2	677	408	28	1.6	1,020	7.2
52-93-19bda	32	9-15-76	28	150	61	360	2.8	590	0	860	24	.9	21	1,800	630	---	6.1	2,430	7.7
20abc	7	-57	--	---	---	---	----	---	--	---	----	---	----	-----	---	---	---	1,450	---
20acb	8	-57	--	---	---	---	----	---	--	---	----	---	----	-----	---	---	---	2,300	---
52-94-24dda	8	8-10-57	29	235	53	290	5.0	614	0	880	36	.4	5.5	1,840	804	---	4.4	2,390	7.4

Table 3.--Selected chemical analyses of ground water--Continued

Location	Depth of well (ft)	Date of collection	Dis-solved silica (SiO_2) (mg/L)	Dis-solved calcium (Ca) (mg/L)	Dis-solved mag-nesium (Mg) (mg/L)	Dis-solved sodium (Na) (mg/L)	Dis-solved potas-sium (K) (mg/L)	Bicar-bonate (HCO_3) (mg/L)	Car-bonate (CO_3) (mg/L)	Dis-solved sulfate (SO_4) (mg/L)	Dis-solved chloride (Cl) (mg/L)	Dis-solved fluo-ride (F) (mg/L)	Dis-solved nitrate (NO_3) (mg/L)	Dissolved solids Sum of con-stituents (mg/L)	Hardness as $CaCO_3$ (Ca, Mg) (mg/L)	Hardness as $CaCO_3$ Noncar-bonate	Sodium-adsorp-tion ratio	Specific conduct-ance (µmho/cm at 25°C)	pH (units)
								McKinnie terrace deposits											
51-94- 7adc	---	9-15-76	28	96	45	550	3.5	610	0	1,100	30	1.1	30	2,160	430	---	12	2,800	8.1
								Greybull terrace deposits											
51-96- 3cda	25	8-10-57	32	85	19	115	3.1	374	0	233	4.5	.6	6.8	683	291	0	2.9	988	7.7
3cda	25	4-11-58	--	---	---	---	----	370	0	---	----	---	----	-----	294	0	---	960	7.8
3cda	25	5-16-66	28	81	25	90	3.2	352	0	202	5.3	.6	5.2	613	302	---	2.2	920	7.3
3cda	25	8-12-66	--	75	17	92	----	353	0	---	----	---	----	-----	259	---	2.5	884	7.5
51-96- 5dbd	56	5-19-76	28	86	19	88	3.0	370	0	180	5.4	.4	3.5	600	290	---	2.2	892	7.7
51-97- 2bdd	17±	9-15-76	23	63	17	40	3.5	260	0	110	3.4	.4	4.2	385	230	---	1.2	600	7.7
52-96-32ccb1	30	8- 9-57	28	72	19	128	3.9	334	0	238	6.4	.7	13	673	258	0	3.5	982	7.7
32ccb2	40	9-10-70	25	72	20	89	5.2	318	0	168	6.5	.6	9.8	552	262	---	2.4	838	7.9
32ccc	26	5-19-76	24	89	24	77	3.0	320	0	210	5.4	.6	21	615	320	---	1.9	907	7.8
33dcb	22	8- 9-57	28	59	18	130	3.7	363	0	187	2.7	.8	4.6	612	222	0	3.8	915	7.8
52-97-25dbc	19	8- 9-57	31	50	14	247	3.7	386	0	355	6.8	2.0	34	933	184	0	7.9	1,360	7.8
25dbc	19	8- 9-57	31	102	26	130	2.9	439	0	268	5.8	1.4	3.4	786	362	2	3.0	1,140	7.6
								Burlington terrace deposits											
52-96-28cbc	70	5-19-76	25	120	35	130	3.0	410	0	360	3.6	1.4	11	887	430	---	2.7	1,300	7.8
52-97-26dbb	16	8- 9-57	31	102	26	130	2.9	439	0	268	5.8	1.4	3.4	787	362	---	2.9	1,140	7.6
26dbb	16	4-11-58	--	122	37	176	----	388	0	482	11	---	3.6	-----	458	140	3.6	1,470	7.7
								Pediment deposits											
51-98-13aad	---	8- 9-57	23	178	50	74	4.4	392	0	468	5.0	.9	13	1,010	648	327	1.3	1,340	7.6
13aad	---	4-11-58	--	---	---	---	----	414	0	---	----	---	----	-----	686	347	---	1,370	7.8
								Terrace Qt2 deposits											
51-94- 8dbb	40	8-10-57	29	145	22	109	3.8	316	0	410	8.5	1.0	21	900	452	193	2.2	1,220	7.8

Table 3.--Selected chemical analyses of ground water--Continued

Location	Depth of well (ft)	Date of collection	Dissolved silica (SiO_2) (mg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrate (NO_3) (mg/L)	Dissolved solids Sum of constituents (mg/L)	Hardness as $CaCO_3$ (Ca, Mg) (mg/L)	Hardness as $CaCO_3$ Noncarbonate	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)
									Willwood Formation										
50-98- 5aac	42	8- 9-57	2.8	9.0	6.2	276	2.1	193	0	472	9.5	.5	.2	873	48	0	17	1,340	8.0
50-99-21adc	97	8-10-57	15	120	139	72	5.5	546	0	538	15	.6	5.7	1,180	870	422	1.1	1,640	7.4
32cab	80	9-16-76	8.2	9.0	3.3	340	1.9	470	0	370	8.0	3.0	2.3	979	36	---	25	1,480	8.2
51-95- 6cdb	---	9-15-76	17	180	59	550	4.2	490	0	1,400	59	1.4	.4	2,460	700	---	13	3,300	7.8
12dbc	>100	9-15-76	6.9	33	8.6	200	2.6	240	0	290	20	1.1	0	683	120	---	7.8	1,020	7.8
15ccb2	124	10- 9-57	6.8	22	4.4	610	3.3	268	0	974	135	2.5	3.4	1,890	73	0	31	2,790	7.8
15ccb2	124	5-19-76	6.4	21	5.0	630	3.5	270	0	1,000	130	2.5	.2	1,940	72	---	32	2,790	8.3
15ddc	130	5-19-76	6.5	8.7	2.0	250	1.9	270	3	260	60	1.6	1.7	726	30	---	20	1,170	8.4
51-98-13aad	100	8- 9-57	8.9	13	6.7	532	2.7	541	10	740	12	1.5	2.3	1,600	60	0	30	2,360	8.4
21dcd	>100	9-15-76	7.9	25	9.9	390	3.7	530	0	450	10	.8	3.1	1,160	100	---	16	1,650	8.2
28cbb	200-300	9-15-76	7.0	6.7	2.7	450	2.1	570	0	510	9.3	1.3	3.6	1,270	28	---	38	1,970	8.2
51-99-26ddd	564	7-27-70	8.8	39	20	198	3.6	289	0	271	62	1.9	.6	747	180	---	6.4	1,190	8.2
52-96-29bba	65	5-19-76	4.7	24	6.1	640	2.8	230	0	1,200	69	.2	1.2	2,060	86	---	30	2,830	8.3
32dcb	132	9-10-70	6.4	17	4.0	450	2.8	258	4	705	52	2.4	2.6	1,370	59	---	25	2,100	8.3
52-97-26cad	180	8- 9-57	8.9	4.0	0	245	1.3	476	16	50	47	4.3	1.2	612	10	0	34	1,030	8.6
									Fort Union Formation										
49-100-13baa1	150±	9-16-76	6.3	61	34	140	6.5	380	0	300	5.0	.4	14	748	290	---	3.6	1,130	7.7
13baa2	80	9-16-76	6.5	86	43	130	6.5	390	0	350	6.0	.6	14	834	390	---	2.9	1,230	7.7
14ddb	60	9-16-76	6.6	39	19	200	4.9	500	0	180	6.6	.4	6.0	708	180	---	6.6	1,090	7.9
52-94-25acc	---	5-19-76	12	190	68	1,000	6.3	960	0	1,600	410	1.3	7.4	3,760	750	---	16	4,720	7.8
25caa	---	5-19-76	11	62	15	180	3.7	400	0	210	58	.9	0	733	220	---	5.2	1,180	8.2
							Lance and Meeteetse Formations, undifferentiated												
48-100-10bbd	---	7- 8-68	2.1	7.5	11	330	11	688	5	207	7.2	.1	10	899	64	---	7.3	1,510	9.0
49-100-34bdb	90	9-16-76	15	90	40	130	4.6	460	0	280	8.1	.5	1.0	798	390	---	2.8	1,210	7.8

1 Spring.
2 Well at house.
3 Well at corral.
4 Part of water probably from alluvium.
5 Water probably from Fort Union Formation.

Table 4.--Specific conductance of the water in the Greybull and Wood Rivers

Station no.	Specific conductance[1] (µmho/cm at 25°C) 9-14-76	Drainage and remarks
1	322C	Greybull River 7.5 miles southwest of Meeteetse.
2	270C	Wood River near mouth.
3	403C	Greybull River at Meeteetse.
4	395C	Greybull River 5 miles northeast of Meeteetse.
5	446C	Greybull River 8.5 miles northeast of Meeteetse.
6	418C	Greybull River at Sheets Flat.
7	470C	Greybull River at Fenton School.
8	471C	Greybull River at intake of Farmers Canal 1.5 miles downstream of Fenton School.
9	502C	Greybull River at Advent School.
10	483C	Greybull River south of Burlington.
11	725C	Greybull River south of Otto.
12	1,040C	Greybull River 4.2 miles east of Otto at chemical-measurement station 6277500 Greybull River near Basin.
13	956SM	Greybull River near mouth. Reason for decrease of specific conductance between stations 12 and 13 is not known.

[1] Appearance of flow: C, clean; SM, slightly muddy.

GEOHYDROLOGY OF THE SEDIMENTARY BEDROCK

Older sedimentary rocks ranging from the Mowry Shale of Cretaceous age to the Willwood Formation of Eocene age are exposed and comprise the bedrock in the part of the Greybull River Valley investigated. In the central part of the Bighorn Basin, the strata are nearly horizontal. A few gently dipping lenticular sandstone beds in the Willwood Formation indicate that a broad synclinal area, containing the thickest accumulation of alluvial deposits near the Greybull River, is present near Burlington and Otto. However, only the approximate position of the axial plane of the syncline was determined because dips could be measured only at a few scattered localities. East of the outcrop of the Willwood Formation, near Greybull, the sedimentary rocks are tilted along the west-dipping flank of a structural platform that borders the central part of the Bighorn Basin. Here dips are more than 30 degrees and some faulting is visible. In western Bighorn Basin, southwestward from the YU Bench, the strata are displayed in a series of folds including the Oregon Basin and Spring Creek anticlines and associated synclines.

Sandstone beds are the chief water-yielding units in all the older sedimentary rocks exposed near the Greybull River. The principal water-yielding units are sandstone beds in the Frontier, Mesaverde, Lance, and Meeteetse Formations of Cretaceous age and the Fort Union Formation of Paleocene age. Areas where these formations underlie the bottom land along the Greybull River are shown on plate 2. Generally, small yields, less than 25 gal/min (gallons per minute), of ground water can be obtained by wells from these formations (Robinove and Langford, 1963, table 8) although, locally, well yields of 200 gal/min have been reported from the Frontier Formation and 48 gal/min from the Mesaverde Formation. Yield data are lacking from the Fort Union Formation, but sandstone beds of this unit probably yield as much or more water to wells than the Cretaceous formations. In contrast, most wells completed in the Willwood Formation yield less than 10 gal/min (table 5) and many yield only 2 to 5 gal/min. The water in the older sedimentary rocks is artesian, but only a few wells in a small area north to northeast of Meeteetse flow at the land surface (pl. 2).

The dissolved-solids concentration of water in the Willwood Formation from 14 wells ranges from 621 to 2,060 mg/L (milligrams per liter). Generally, sulfate is the principal anion. Fluoride ranges from 0.2 to 4.3 mg/L, but in 6 wells the amount of fluoride is more than 1.5 mg/L. In general, water in the Willwood Formation is not as hard as the water in the overlying alluvial deposits or in the underlying Fort Union Formation.

Table 5.--Yields, depths, and other hydrologic information of selected wells in the Greybull River basin

[Data from files of the Wyoming State Engineer, Cheyenne; and from Robinove and Langford (1963, table 8).]

Well number	Depth (ft)	Yield (gal/min)[1]	Drawdown (ft)[1]	Specific capacity (gal/min per ft of drawdown)	Geologic unit and remarks
48-100-19bb	90	3R	4R	0.75	Mesaverde Formation; ½-hour test.
48-101-27aa	40	48R	0	----	Mesaverde Formation; ½-hour test.
49-100-13bcc	80±	¼R	--	----	Fort Union Formation; well flows at land surface.
51-94-4bca	50	5R	5R	1.0	Willwood Formation; 24-hour test.
8dbb	39	240R	26R	9.2	Terrace Qt2a deposits.
10bbc	20	25R	6R	4.2	Alluvial-fan deposits.
11bba	18	175R	0	----	Terrace Qt2a deposits.
11bda	70	10R	--	----	Willwood Formation; ½-hour test.
51-95-5bb	60	1-3R	--	----	Willwood Formation; 24-hour test.
5bdc	20	15+R	--	----	Alluvial-fan deposits; 24-hour test.
13bab	80	100R	--	----	Flood plain alluvium and Willwood Formation· yield mainly from flood-plain alluvium.
15ccb1	24	141	9.5	14.8	Flood plain alluvium; ¼-hour test.

See footnote at end of table.

Table 5.--Yields, depths, and other hydrologic information of selected wells in the Greybull River basin--Continued

Well number	Depth (ft)	Yield (gal/min)[1]	Drawdown (ft)[1]	Specific capacity (gal/min per ft of drawdown)	Geologic unit and remarks
51-95-19bdc	80	50R	--	----	Flood-plain alluvium and Willwood Formation; yield mainly from flood-plain alluvium.
20daa	80	20R	6R	3.3	Willwood Formation; 24-hour test.
22ddc	130	5R	106R	.05	Willwood Formation; 1¼-hour test.
51-96-3ba	22	670R	--	----	Greybull terrace deposits.
4bb	37	---	--	----	Greybull terrace deposits; yield is unknown but well was tested with a pump powered by a 55-horsepower motor.
51-96-4dcc1	65	10R	20R	.5	Willwood Formation; 1/6-hour test.
4dcc2	25	30R	8R	3.8	Greybull terrace deposits; 36-hour test.
5bb	39	900R	--	----	Greybull terrace deposits.
51-97-1bcb	56	250	--	----	Greybull terrace deposits.
51-98-1bdb	530	5R	110R	.05	Willwood Formation; 4-hour test.
13aad	--	30R	--	----	Flood-plain alluvium(?).
52-93-7ad	14	20R	2R	10	Terrace Qtl deposits; 12-hour test.
8ad	20	25R	--	----	Flood-plain alluvium.
8dd	20	600R	3R	200	Flood-plain alluvium; 6-hour test.

See footnote at end of table.

Table 5.--Yields, depths, and other hydrologic information of selected wells in the Greybull River basin--Continued

Well number	Depth (ft)	Yield (gal/min)[1]	Drawdown (ft)[1]	Specific capacity (gal/min per ft of draw-down)	Geologic unit and remarks
52-93-9adc	76	200R	--	----	Frontier Formation; 7-day test.
9da	100	25R	40R	.6	Frontier Formation; 24-hour test.
16bc	18	50R	--	----	Flood-plain alluvium; dug well.
17aa	20	180R	--	----	Flood-plain alluvium; thickness of alluvium is 18 ft; 1-hour test.
52-96-20bcc	22	20R	3R	6.7	Lower Sunshine terrace deposit on Emblem Bench; 3-hour test.
30cbb	35-40	20R	--	----	Greybull terrace deposit; 10-hour test.
30da	28	12-14	-	----	Burlington terrace deposit; four wells at the Burlington School.
31aad	50	10R	--	----	Willwood Formation; 4-hour test.
31dca	47	590	10.4	57	Greybull terrace deposit.
33cdd	27	10R	3R	3.3	Greybull terrace deposit; 2-hour test.
33cdd	20	10R	2R	5	Greybull terrace deposit; ½-hour test.
36cc	120	10R	40	.25	Willwood Formation; 5-hour test.

[1] R, reported.

TERMINOLOGY AND RELATIONS OF THE TERRACES

As shown by a geologic map (Andrews and others, 1947), the principal terraces in the Greybull River Valley are the Rim, Sunshine, and Greybull terraces. These names are retained in this report. The Rim terrace, (YU surface of Macklin, 1937, p. 861), named by Hewett (1926, p.58), is the highest terrace near the Greybull River. The Sunshine terrace (Emblem surface of Macklin, 1937, p. 861) includes the surface on Emblem Bench and many remnants upstream to Meeteetse. Field mapping indicated that the Sunshine terrace on Emblem Bench consists of two levels herein called the upper and lower Sunshine terrace.

The Greybull terrace, as shown on maps of Andrews and others (1947) and Robinove and Langford (1963, pl. 1), was found to be a multiple feature that is divisible into two distinct terraces. West of Burlington the upper terrace is as much as 40 feet above the lower terrace. The lower terrace covers a broad area in the wide valley of the Greybull River at Burlington; consequently, in this report the name Greybull terrace is retained for the lower terrace, but the upper terrace on which Burlington is located is named the Burlington terrace. Only a few small remnants of the Burlington or Greybull terraces were recognized in other parts of the Greybull River Valley.

The Greybull terrace deposits are divided into two parts, the virtually undissected part (Qtg) and the dissected part (Qtgd). The dissected part is characterized by a ridge-and-swale topography that has a local relief of about 7 feet. Field inspection and study of aerial photographs disclose that some of the swales represent two old channels of the Greybull River (pl. 1). Topographic maps indicate that the summits of the low ridges and the level of the undissected part of the terrace are at the same altitude--approximately 20 feet above the Greybull River. The ridge-and-swale topography may have influenced Andrews and others (1947) and Robinove and Langford (1963, pl. 1) to include the dissected part of the Greybull terrace deposits (as defined in this report) with the alluvium (flood-plain alluvium undifferentiated of this report).

The youngest terrace along the Greybull River is named the McKinnie terrace in his report from excellent exposures of the terrace along State Highway 30 near McKinnie Creek east of Otto. The McKinnie terrace deposits (shown as Qtk) were mapped separately downstream from the Advent School. The terrace deposits were recognized as far upstream as Meeteetse, but there the deposits are included with the pediment deposits or the older alluvial-fan deposits.

Remnants of numbered terrace deposits occur at four main levels along the Bighorn River between Greybull and Basin. These are referred to from lowest to highest as terraces Qt1 to Qt4 (pl. 1). Near Greybull, the numerical designation of terraces Qt1 to Qt4 is the same as used by Andrews and others (1947). In the area south of the Greybull River, however, terrace Qt2 as used in this report corresponds with Terrace Qt1 of Andrews and others (1947). Remnants of terrace Qt3 extend for 8 miles from the Bighorn River upstream along Dry Creek. The upper Sunshine terrace on Emblem Bench may be the upstream continuation of terrace Qt3, or it represents a terrace level formed slightly below terrace Qt3. The lower Sunshine terrace extends along Dry Creek to the Bighorn River where it is about 60 feet below terrace Qt3.

The gradient of the Burlington terrace deposits (shown as Qtb, pl. 1) and terrace Qt2 deposits are steeper than the gradients of the Greybull terrace deposits and the Greybull River. The Burlington terrace deposits are 40 feet above the Greybull terrace deposits and 60 feet above the Greybull River 2½ miles west of Burlington. Eastward from this point the distance between the heights of the two terraces decreases gradually to about 15 feet near Burlington and to 5 feet 1 mile east of Burlington. East of sec. 33, T. 52 N., R. 96 W. the Burlington terrace deposits are overlain by the thick Greybull terrace deposits and alluvial-fan deposits, which have accumulated in a broad synclinal area near Burlington and Otto. In a small exposure along an irrigation ditch near the northwest corner of sec. 34, T. 52 N., R. 96 W., pebbly to cobbly sediments that probably form the topmost beds in the Burlington terrace deposits are buried by about 3 feet of younger alluvium. Remnants of terrace Qt2 deposits indicate a decrease in height above the Greybull River from 70 feet near its mouth to 40 feet near Dorsey Creek east of Otto. Projection of the level of terrace Qt2 deposits upstream from Dorsey Creek indicate this level would also be below the top of the Greybull terrace deposits in the synclinal area between Burlington and Otto. The Burlington terrace and terrace Qt2 deposits may be lateral equivalents because of their similar heights above the Greybull River and similar decreases in height above river level in the Burlington and Otto area. If the Burlington terrace and terrace Qt2 deposits are lateral equivalents, then the structural movement that formed the synclinal area between Burlington and Otto also downwarped slightly both terrace deposits and caused the accumulation of the thick Greybull terrace deposits in that area.

DESCRIPTION OF THE TERRACE DEPOSITS AND ALLUVIAL DEPOSITS

The distribution and lithology of the alluvial deposits associated with terraces, alluvial fans, pediments, and flood plains (pl. 1) control the occurrence and yield of shallow ground-water reservoirs in the Greybull River valley. (See illustration on cover.) The alluvial aquifer, as defined in this report, consists principally of the Greybull terrace deposits and the flood-plain alluvium and subordinately of the Burlington terrace, McKinnie terrace, and the alluvial-fan deposits. Hydrology of the alluvial deposits is presented in table 6 and in section Alluvial Aquifer.

Table 6.--Lithologic and hydrologic description of the surficial deposits in the Greybull River Basin

Geologic unit	Description and thickness	Hydrology	Remarks concerning chemistry and use of water
Rim terrace deposits (Qtr)	Principally pebbles to cobbles. Maximum thickness of 62 ft on YU Banch, as determined from test holes drilled by the U.S. Bureau of Reclamation (Robinove and Langford, 1963, p. 28-29, table 8), and 45 ft on Table Mountain.	Deposits are dry. If terrace remnants of YU Bench and Table Mountain were farmed, excess irrigation water would recharge the deposits. Deposits are sufficiently permeable to yield water to wells.	If deposits on Table Mountain were recharged from irrigation, the water probably would contain a large amount of sulfate because of considerable gypsum (calcium sulfate) in the terrace deposits.
Sunshine terrace deposits (Qts, Qtsu, Qtsl)	Principally pebbles to cobbles. Maximum thickness of 50 ft on Emblem Bench, elsewhere, thickness is less than 15 ft. On Emblem Bench, the upper terrace is 15 to 30 ft above the lower terrace.	Due to their small areal extent, deposits are dry except on Emblem Bench. Deposits on Emblem Bench are recharged by irrigation water and, at places, yield more than 200 gal/min to wells (Robinove and Langford, 1963, table 8). Absence of springs along the southern escarpment of Emblem Bench indicates that ground water in the deposits moves north to northeastward away from the Greybull River Valley toward Dry Creek.	Water is suitable for most purposes (Robinove and Langford, 1963).
Deposits of terraces (Qt1 to Qt4)	Principally pebbles to small cobbles; thickness generally less than 20 ft.	Except for a remnant of terrace Qt1 north of Greybull and some remnants of terrace Qt2, remnants of the terraces are too small to store sufficient ground water for development of wells. Where farmed, the deposits are recharged chiefly from irrigation. A few wells near Dorsey Creek and between Greybull and Basin withdraw water from terrace Qt2 deposits. Well 51-94-8dbb, penetrating less than 16 ft of coarse-grained material, was tested at a rate of 240 gal/min (Robinove and Langford, 1963, table 8).	Single analysis of water from well 51-94-8dbb indicates water from terrace Qt2a deposits near Dorsey Creek is suitable for stock, most domestic, irrigation, and some industrial uses. Development of water for irrigation and industrial uses is limited because water storage in the deposits is dependent on recharge from continued application of surface-diverted irrigation water.
Burlington terrace deposits (Qtb)	Principally pebbles to small cobbles; maximum known thickness is 32 ft east of Burlington. Thickness is generally less than 15 ft west of Burlington.	In area east of Burlington, the terrace deposits are part of the alluvial aquifer. Well yields are not known but deposits are similar to the deposits of terrace Qt2 and Sunshine terrace deposits where yields of more than 200 gal/min were reported (Robinove and Langford, 1963, table 8). West of Burlington the base of the terrace deposits is separated from the deposits of the alluvial aquifer by bedrock thereby reducing the saturated thickness and the yield of ground water in the deposits. At Burlington, wells completed in the terrace deposits yield between 3 and 20 gal/min.	Three analyses indicate the water in the Burlington terrace deposits is similar chemically to the water in the Greybull terrace deposits. Because of high hardness, water in the deposits is cased out of some domestic wells completed in the underlying Willwood Formation. Quality of the water may limit use of water for some irrigation and industrial purposes.
Greybull terrace deposits, virtually undissected part (Qtgd)	Principally pebbles to small cobbles. Coarse material overlain by 1 to 3 ft of silt to silty sand. Maximum thickness is nearly 60 ft. Much of deposit is more than 35 ft thick.	Deposits form principal unit of the alluvial aquifer. Unit occurs only near Burlington. Deposits yield more than 300 gal/min to wells.	Chemical quality of water in deposits is best for all of the Greybull River Valley. Chemical quality and well yields are adequate for development of irrigation, stock, and domestic wells. High hardness may limit use for some industrial purposes. Two chemical analyses show flouride to be 1.4 mg/L or more.
Greybull terrace deposits, dissected part (Qtgd)	Principally pebbles to small cobbles. Coarse-grained material is at the surface and along the summits and sides of low ridges; whereas, the swales are underlain by a thin discontinuous mantle of pebbly sandy silt to silty sand.		

Table 6.--Lithologic and hydrologic description of the surficial deposits in the Greybull River Basin--Continued

Geologic unit	Description and thickness	Hydrology	Remarks concerning chemistry and use of water
McKinnie terrace deposits (Qtk)	Clay and silt to cobbles. Most beds consist of poorly sorted mixtures of nearly inconsolidated clay to silty sand, are lenticular, and range in thickness from a few inches to about 2 ft. Few well-sorted sand beds were observed. Discontinuous beds of rounded pebbles and cobbles are at the base of the exposures. At one place, a buried channel about 10 ft deep and 100 ft wide contains thin to thick dark-gray clayey beds containing considerable organic material. Thickness is 20 to about 50 ft.	Deposits are a minor part of the alluvium aquifer. Hydrologic characteristics are not known, owing to the lack of information of wells completed in the deposits.	Probably main use of water is for the watering of stock.
Flood-plain alluvium (Qty, Qfo, and Qfu)	Clay to small boulders. Maximum thickness in combination with other deposits is about 60 ft. Elsewhere thickness is generally less than 20 ft.	Deposits are a major part of the alluvial aquifer only near Burlington and Otto where they may yield more than 200 gal/min to wells. Elsewhere yields probably are less than 100 gal/min.	Six of 14 chemical analyses indicate water contains less than 1,000 mg/L of dissolved solids. Only one analysis indicates a hardness less than 300 mg/L. Water of best chemical quality in the deposits is in the Burlington-Otto area. At many places, chemical quality is not suitable for domestic, irrigation, or industrial use.
Younger (generally undissected) alluvial-fan deposits (Qay)	Clay to silty sand with minor pebbles. Maximum thickness is about 50 ft.	Deposits are a minor part of the alluvial aquifer. Most well yields are probably less than 20 gal/min.	Low well yields sufficient for only stock and domestic use. In places, poor chemical quality precludes use of water for domestic purposes.
Older (dissected) alluvial-fan deposits (Qao)	Clay to silty sand with minor pebbles. Thickness is more than 20 ft in many exposures.	Deposits are virtually nonwater-bearing.	
Pediment deposits (Qp)	Clay to boulders upstream from Fenton School. Mainly clay to silty sand downstream from Fenton School. Thickness is less than 25 ft.	Deposits are virtually nonwater-bearing.	

Terrace Deposits

Except for the McKinnie terrace deposits, the terrace deposits along the Greybull River (pl. 1) consist predominantly of well-rounded to rounded pebbles to small cobbles ranging in composition from basalt to dark andesite transported from the volcanic rocks capping the Absaroka Range. In contrast, the McKinnie terrace deposits consist mostly of mixtures of clay to silty sand (table 6). Only the Rim terrace deposits near the eastern tip of Table Mountain are composed mainly of quartzite and chert derived from Paleozoic formations and quartzite, granite, and other light-colored siliceous types derived from Precambrian basement terrane. The pebbly to cobbly terrace deposits along the Bighorn River consist of a mixture of all types of siliceous types of sedimentary and igneous rocks. All the pebbly to cobbly deposits generally are overlain by a mantle of silty to sandy sediments, which in part represent old soils. The thickness of the fine-grained sediments is known only along the edges of the terraces and irrigation ditches where they generally are 1 to 3 feet thick. However, these fine-grained sediments are sufficiently widespread to allow the terraces to be cultivated.

Flood-Plain Alluvium

The flood-plain alluvium consists of two mappable units--the older flood-plain alluvium (shown as Qfo) and the younger flood-plain alluvium (shown as Qfy)--between Fenton School and the mouth of the Greybull River. In this area the units are separated by low terraces 4 to 8 feet high. The area occupied by the flood-plain alluvium is as much as 2 miles wide downstream from the Fenton School, 500 feet to half a mile wide between the Fenton School and Meeteetse, and not much wider than the river channel at most places upstream from Meeteetse. Upstream from the Fenton School, the flood-plain alluvium is undifferentiated (shown as Qfu) and consists principally of pebbles to small boulders, in places overlain by 1 to 3 feet of sand and silt. Older sedimentary rocks commonly crop out along the edge of the flood plain or in a few places from low rapids in the river channel near the Fenton School and upstream. Downstream from the Fenton School, the older and younger flood-plain alluvial deposits consist of sand, silty sand, and silt, 1 to more than 6 feet thick, that overlies rounded pebbly to small cobbly deposits similar to the modern channel deposits of the river.

Coarse deposits composed mainly of volcanic debris from the Absaroka Range are present along the entire length of the Greybull River channel. The widespread distribution of the gravel allows for easy interchange of water between the river and the adjacent deposits. In general, the channel of the Greybull River is characterized by large pebble to cobble bars. Large amounts of detritus accumulate in the channel upstream of some of the highway bridges. This material is removed by the Highway Department periodically to insure unrestricted flow through the bridge openings.

Alluvial-Fan Deposits

The alluvial-fan deposits are divided into younger, virtually undissected (shown as Qay), and older dissected (shown as Qao) deposits, which were laid down by tributaries of the Greybull River. The younger fan deposits, are upslope equivalents of the flood-plain alluvium. Most of the channels on these fans have been obliterated by cultivation, but a few are more than 5 feet deep. In general, the alluvial-fan deposits consist of light gray to buff, thin to thick lenticular layers containing mixtures of sandy clay to silty sand. A few lenses consist of poorly sorted pebbles encased in a matrix of silt and sand. Silt and clay beds are predominant throughout the drainage basin--particularly in the part underlain by the Willwood Formation. The older fan deposits are roughly contemporaneous with the Greybull and McKinnie terraces. Except for being slightly darker brown, the older alluvial-fan deposits are similar in lithology to the younger alluvial-fan deposits. Exposures of older sedimentary rocks commonly are along the borders of or along stream channels entrenched in the older fans.

Pediment Deposits

Pediment deposits (shown as Qp) are a heterogenous assemblage of slope-wash, alluvial-fan, and colluvial deposits that occur in discontinuous outcrops. In the area upstream of YU Bench, remnants of the Burlington, Greybull, and McKinnie terrace deposits, the alluvial-fan deposits, and some flood-plain alluvium were mapped with the pediment deposits. Only the pediment deposits younger than the lower Sunshine terrace deposits are shown on plate 1, and they comprise the lateral equivalents of the McKinnie to Burlington terrace deposits and the older alluvial-fan deposits. Small exposures of the older sedimentary rocks occur within or along the lower border of most pediments. The composition of the pediment deposits differs locally, ranging from sand and silt to coarse boulders. Coarse deposits usually occur along the sides of the river valley upstream from YU Bench whereas silt to silty sand deposits are prevalent on broad slopes near Burlington and Otto.

ALLUVIAL AQUIFER

The alluvial aquifer is the chief aquifer in the Greybull River Valley and consists primarily of the Greybull terrace deposits and the flood-plain alluvium (Qfy, Qfo, Qfu), and secondarily of the deposits of the Burlington and McKinnie terraces and of the younger alluvial-fan deposits. The alluvial aquifer extends throughout the Greybull River Valley, but it is most widespread and productive between Burlington and Otto where it is 2 to 4 miles wide and composed mostly of the Greybull terrace deposits and the flood-plain alluvium. Downstream from Otto, the flood-plain alluvium and, where present, the McKinnie terrace deposits and younger alluvial-fan deposits comprise the alluvial aquifer. Upstream from the Fenton School, the alluvial aquifer includes only the flood-plain alluvium and, locally, the younger alluvial-fan deposits.

Thickness

The available well-log data and the surface-resistivity measurements indicate that the thickness of the alluvial deposits comprising the alluvial aquifer varies widely and is as much as 60 feet. In the narrow valley upstream from YU Bench, the thickness of the deposits that are below the level of the Greybull River probably does not exceed 15 feet. Three surface-resistivity measurements near the Fenton School indicate that the base of the alluvial aquifer is only a few feet below river level (table 7; inset 1 of pl. 2). Throughout much of the Burlington-Otto area, the alluvial aquifer is more than 35 feet thick, with a known maximum thickness of nearly 60 feet. The thickest part occurs mainly north of the Greybull River and extends as a 1- to 2½-mile wide lens-shaped zone from near the Advent School to south of Otto. Little thickness information is available east of Otto except in the lowermost part of the Greybull River valley. In the narrowest part of the valley 3 miles upstream from the mouth of the river, two surface-resistivity measurements indicate only 16 feet of alluvial deposits. Log data of a few wells near the mouth of the river indicate that the maximum thickness of the deposits is 20 to perhaps 30 feet. Logs of wells drilled through the flood-plain alluvium along the Bighorn River at Greybull show only a thickness of about 20 feet.

Buried ridges are known to affect the thickness of the alluvial deposits south and southeast of Table Mountain and at the Advent School. In much of the area north of the Greybull River near Table Mountain, buried extensions of south to southeastward trending bedrock ridges flanking the mountain underlie the alluvium. However, specific information is only available at one place south of Otto. As reported by the owner, who is also a well driller (Merlin Wardell, oral commun., 1976), well 51-95-15ccb2 was dug 24 feet deep to below the base of coarse-grained alluvial deposits. The driller's logs of nearby wells 51-95-15ccb1 and 51-95-15ddc show that the alluvium is only 24 and 23 feet thick, respectively. A series of surface-resistivity measurements indicate that these wells penetrated the summit of a buried ridge. Geoelectric horizons interpreted to represent the base of the alluvium are somewhat deeper to the north and south of this location (table 7). Another buried ridge at the Advent School is indicated by well logs and by a small exposure of the Willwood Formation along the north bank of the Greybull River a quarter of a mile southwest of the school. Driller's logs of two wells drilled three-fourths of a mile east and southeast of the school indicate only 17 to 18(?) feet of alluvial deposits; whereas, farther to the east and southeast the deposits are more than 35 feet thick.

Table 7.--Relation of the geoelectric horizons obtained from surface-resistivity measurement to the geology

Depth to geoelectric horizon at each measurement location[1] (ft)	Interpretation of geoelectric horizon and remarks
Profile near abandoned Fenton school sec. 13, T.51 N., R.98 W.	
3	Base of flood-plain alluvium; sandstone bed of Willwood Formation forms low rapids in nearby channel of Greybull River; some lateral effects are present in electrical measurements.
27	Base of alluvial deposits; measurement made on an alluvial fan 20 to 25 feet above river level.
115	Base of a sandstone bed in the Willwood Formation.
39	Probably contact between silty to sandy alluvial-fan deposits and coarse-grained material; measurement made 40 to 50 feet above river level.
49	Base of alluvial deposits.
129	Probably base of same sandstone bed in the Willwood Formation indicated above at 115 feet.

See footnote at end of table.

Table 7.--Relation of the geoelectric horizons--Continued

Depth to geoelectric horizon at each measurement location[1] (ft)	Interpretation of geoelectric horizon and remarks
Profile near Burlington[2], secs. 5, 7, 8, 17, and 18, T. 51 N. R. 96 W.; and secs. 29, 31, and 32, T. 52 N., R. 96 W.	
1	Probably base of a soil that overlies coarse-grained material of the Burlington terrace deposits.
9	Geoelectric horizon in the Burlington terrace deposits.
14	Probably the base of the Burlington terrace deposits; nearby well 52-96-19cdd indicates 16± feet of deposits overlying the Willwood formation; strong lateral effects 42 feet from center of measurement.
13	Geoelectric horizon in the Greybull terrace deposits; logs of wells indicate that the thickness of the Greybull terrace deposits along the Burlington terrace may be as much as 31 feet.
45	Probably base of the Greybull terrace deposits.
61	Sandstone bed in the Willwood Formation.
28	Geoelectric horizon in the Greybull terrace deposits.
42	Base of the Greybull terrace deposits; logs of nearby wells indicate that the base of the Greybull terrace deposits is between 30 and 47 feet.
56	Sandstone bed in the Willwood Formation.

See footnotes at end of table.

Table 7.--Relation of the geoelectric horizons--Continued

Depth to geoelectric horizon at each measurement location[1] (ft)	Interpretation of geoelectric horizon and remarks
Profile near Burlington[2], secs. 5, 7, 8, 17, and 18, T. 51 N., R. 96 W.; and secs. 29, 31, and 32, T. 52 N., R. 96 W.--Continued	
9	Geoelectric horizon in the Greybull terrace deposits.
13	Geoelectric horizon in the Greybull terrace deposits.
16	Geoelectric horizon in the Greybull terrace deposits.
37	Base of the Greybull terrace deposits.
37	Base of flood-plain alluvium; geoelectric horizon is in agreement with depths indicated by logs of wells drilled through the nearby Greybull terrace deposits.
55	Geoelectric horizon in the Willwood Formation.
6	Contact between fine and coarse-grained layers in the flood-plain alluvium or the water table, which is about 5 feet (Robinove and Langford, 1963) below the land surface.
16	Geoelectric horizon in the flood-plain alluvium.
39	Base of the flood-plain alluvium.
17	Probably the base of the flood-plain alluvium.
139	Base(?) of a sandstone bed in the Willwood Formation.

See footnotes at end of table.

Table 7.--Relation of the geoelectric horizons--Continued

Depth to geoelectric horizon at each measurement location[1] (ft)	Interpretation of geoelectric horizon and remarks
Profile near Otto[2], secs. 15, 16, and 21, T. 51 N., R. 95 W.	
26	Base of the McKinnie terrace deposits.
42	Sandstone bed in the Willwood Formation; nearby exposures of the Willwood Formation display lenticular sandstone beds.
61	Do.
36	Probably base of flood-plain alluvium; depth may be slightly excessive.
5	Contact between fine and coarse-grained layers in the flood-plain alluvium.
19	Geoelectric horizon in the flood-plain alluvium.
38	Base of flood-plain alluvium.
131	Base(?) of sandstone bed in the Willwood Formation.
6	Depth to the water table in the flood-plain alluvium.
21	Geoelectric horizon in the flood-plain alluvium.
32	Base of the flood-plain alluvium; logs of nearby wells indicate base of flood-plain alluvium is at 24 feet; one well, 51-95-15ccb2, was dug below the base of the alluvium.
75	Sandstone bed in the Willwood Formation.

See footnotes at end of table.

Table 7.--Relation of the geoelectric horizons--Continued

Depth to geoelectric horizon at each measurement location[1] (ft)	Interpretation of geoelectric horizon and remarks
Profile near Otto[2], secs. 15, 16, and 21, T. 51 N., R. 95 W.--Cont'd	
18	Geoelectric horizon in the flood-plain alluvium.
59	Probably base of flood-plain alluvium; depth may be excessive because maximum depth of flood-plain alluvium from logs of nearby wells is 40 or 60(?) feet.
87	Sandstone bed in the Willwood Formation.
114	Do.
6	Depth to the water table in the flood-plain alluvium.
8	Geoelectric horizon in the flood-plain alluvium.
26	Probably geoelectric horizon in the flood-plain alluvium or possibly the base of the flood-plain alluvium.
39	Probably the base of the flood-plain alluvium; records of a nearby well indicates thickness of flood-plain alluvium is less than 40 feet.
51	Sandstone bed in the Willwood Formation.

See footnotes at end of table.

Table 7.--Relation of the geoelectric horizons--Continued

Depth to geoelectric horizon at each measurement location[1] (ft)	Interpretation of geoelectric horizon and remarks
Profile in narrows, 3 miles upstream from mouth of Greybull River, sec. 25, T. 52 N., R. 94 W.	
16	Probably base of flood-plain alluvium logs of most wells completed in the flood-plain alluvium between this site and mouth of Greybull River indicate only about 20 feet of alluvium.
70±	Probably sandstone bed near contact of Lance and Fort Union Formations; sedimentary rocks dip as much as 40 degrees in the area.
16	Probably base of flood-plain alluvium.
52	Probably sandstone bed near contact of Lance and Fort Union Formations.

[1] Measurement location is listed from north to south. Figure underlined is the value shown on plate 2 for the base of the alluvial deposits.

[2] Near Burlington and Otto multiple geoelectric horizons are indicated from the computed resistance-depth curves. Many geoelectric horizons obtained are considerably deeper than the base of the alluvial deposits as shown by logs of nearby wells; this presented problems in determining which geoelectric value indicated the base of the alluvial deposits. This difficulity is due mainly to the conductive properties of the ground water in the Willwood Formation known to underlie the alluvial deposits at these locations. The points on the resistance-depth curve where changes in the resistance (from high to low resistance) occur were selected as representing the contact between the alluvial deposits and the Willwood Formation; most of these values compare favorably with the available depth to the base of the alluvial deposits obtained from well data. The deep geoelectric values indicate the probable depths to lenticular sandstone beds in the Willwood Formation.

Occurrence and Chemical Quality of Ground Water

The depth to water in the alluvial aquifer ranges from 3 to 10 feet below the land surface (Robinove and Langford, 1963, pl. 1). The Greybull River is the main control on the altitude of the water table. The depth to water also is influenced by the proximity of canals, laterals, and irrigated fields and by the 3- to 25-foot high terraces cut into the alluvial deposits. At many places, but particularly west of Otto, recharge from irrigation has caused the water table in the flood-plain alluvium to rise too close to the land surface for crops.

Recharging the alluvial deposits from irrigation has modified the natural ground-water gradient in the wide valley near Burlington and Otto. Flow lines showing direction of ground-water movement were constructed from depth-to-water data listed by Robinove and Langford (1963, pl. 1). The flow lines indicate that ground water near the Farmers Canal and associated laterals moves eastward to southeastward subparallel to the Greybull River rather than taking a more direct route to the river (pl. 2). Part of this water may emerge at the surface in a broad low area of the flood-plain west of Otto. Tail water from nearby irrigated fields also collects on the surface in this low area.

Principally during the irrigation season, water accumulates in small, shallow depressions along the terraces eroded from the alluvial deposits throughout the Greybull River Valley and in the swales formed in the dissected part of the Greybull terrace deposits. The presence of these ponds and adjoining wet areas caused some difficulty in the selection of sites for surface-resistivity soundings. This water is derived from seepage from the shallow water table in the alluvial deposits and from irrigation tail water. The depressions adjacent to the terraces probably were moist during the natural conditions present before the onset of agricultural practices in the valley because many ranch and farm buildings and the town of Burlington are located in the well-drained areas along the rims of the terraces.

Data concerning potential yields of wells (table 5) are meager because only a few irrigation wells have been completed in the alluvial aquifer. As best determined, in 1975-76 none of the irrigation wells were in operation and all irrigation water was diverted from the Greybull River. Yields of wells are reported to be as much as 670 gal/min from the Greybull terrace deposits and 141 gal/min from the flood-plain alluvium along the Greybull River. The flood-plain alluvium along the Bighorn River at Greybull is reported to yield as much as 600 gal/min to one well. Two wells, each completed with horizontal galleries, about 1½ miles north of Greybull are reported to yield more than 900 gal/min.

Ground water in the deposits comprising the alluvial aquifer is very hard, and ranges in dissolved solids from 385 to about 2,200 mg/L (table 3). Most of the water analyzed contains high concentrations of calcium, bicarbonate, and sulfate; some analyses also indicate a high amount of sodium. About half of the analyses show less than 0.7 mg/L fluoride but, in some, the fluoride is as much as 2.0 mg/L--more than 1.5 mg/L of fluoride may cause mottling of children's teeth (U.S. Public Health Service, 1962). The available analyses indicate that the dissolved solids in the water in the Greybull terrace deposits range from 385 to 887 mg/L; whereas, the dissolved solids and individual constituents in the water in the flood-plain alluvium have greater ranges. Due to the high hardness, water in the alluvial aquifer is cased out of some domestic wells and the wells are completed in the Willwood Formation, which contains much softer water (table 3).

Downstream from Otto, much of the water in the alluvial aquifer contains 1,800 to 2,200 mg/L of dissolved solids. Upstream from Burlington, even where considerable interchange of water takes place between the flood-plain alluvium and the Greybull River, water in the alluvium is very hard and few wells are completed in the deposits. In this area most of the wells are completed in the Tertiary Willwood or Fort Union Formations or in the Cretaceous rocks.

A diagram (fig. 3) portrays graphically the classification of water for irrigation (U.S. Salinity Laboratory Staff, 1954, p. 79-81) in the main alluvial deposits and in the Fort Union and Willwood Formations. The best water is in the Greybull and Burlington terrace deposits and in part of the flood-plain alluvium, particularly in the Burlington-Otto area. Robinove and Langford (1963, p. 2) state that in general the classification of water for irrigation "shows that ground water from deposits of Quaternary age [including the deposits of the alluvial aquifer] has a high to very high salinity hazard and a low to medium sodium hazard.****Despite the salinity hazard, the ground water from Quaternary deposits is suitable for irrigating most crops grown in the area, provided drainage is good so that soil salinity can be controlled." Much of the water in the generally low-yielding Willwood and Fort Union Formations is the least desirable for irrigation purposes, owing to its high to very high sodium (alkali) hazard.

Favorable Areas for Ground-Water Development

The Greybull terrace deposits and the flood-plain alluvium in the Burlington-Otto area have the best potential for ground-water development. Elsewhere, water in the alluvial deposits and bedrock formations may be of poor chemical quality or yields of wells are insufficient for irrigation or industrial use. Table 6 contains a synopsis of the hydrology and use of ground water of the alluvial water-yielding units in the Greybull River Valley.

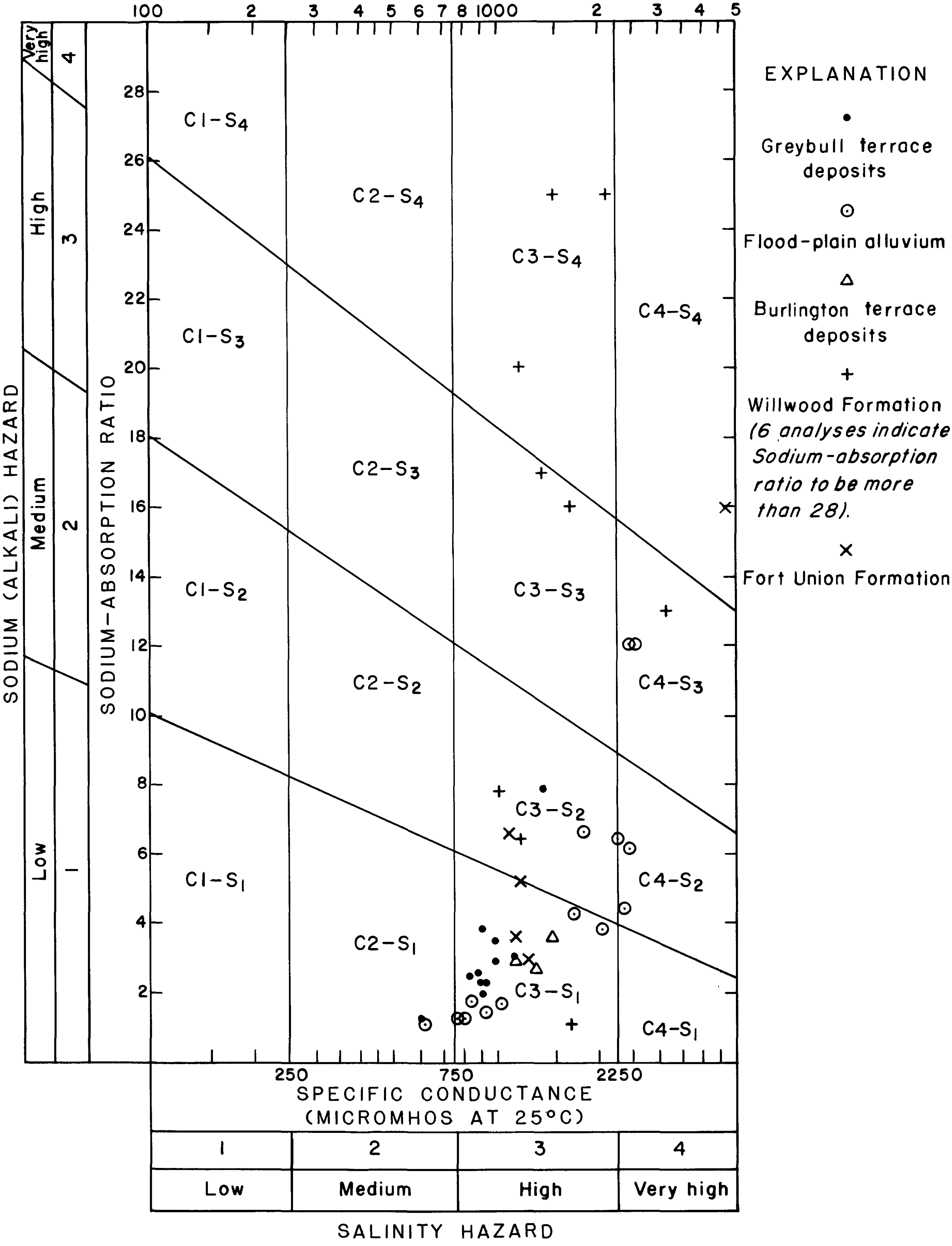

Figure 3.—Diagram showing classification of irrigation waters of the main alluvial deposits and bedrock formations in the Greybull River Valley.

By far, the Greybull terrace deposits have the best potential for the development of ground water for irrigation and other uses because (1) they have known yields of more than 250 gal/min, (2) they consist chiefly of permeable deposits of pebbles and cobbles, and (3) the thickness generally ranges from 30 to as much as 56 feet (saturated thickness generally from 20 to more than 45 feet). In addition, the water in the deposits has the best chemical quality, ranging from about 400 to 850 mg/L dissolved solids, of any unit of the alluvial aquifer (table 2). The main area for development of ground water from the Greybull terrace deposits is between Burlington and the Greybull River in Tps. 51 and 52 N., Rs. 96 and 97 W.

The flood-plain alluvium in the Burlington and Otto area also has a high potential for development, but probably not as great as that of the Greybull terrace deposits. Well 51-95-15ccbl was tested at a rate of 141 gal/min from a saturated thickness of less than 24 feet of coarse-grained alluvium. Information is not available from wells penetrating greater thickness of coarse alluvium, but yields should be more than 200 gal/min. Buried extensions of the bedrock ridges near Otto and at the Advent School may limit, locally, the amount of water that can be developed from the flood-plain alluvium in those areas. Small yields, ranging to only a few gallons per minute, can be expected also near the margins of the flood-plain alluvium, particularly where bordered by the fine-grained alluvial-fan and McKinnie terrace deposits.

In the area near Burlington and Otto the Greybull terrace deposits and flood-plain alluvium can be utilized by wells developed for irrigation without depleting the flow of the Greybull River. The deposits--from recharge of river-diverted irrigation water--probably have reached maximum saturation because the water available from irrigation recharge is much greater than the amount of water withdrawn by the small yielding domestic and stock wells. At present, much of the excess irrigation water is ponded and evaporated. Wells completed in the alluvial deposits and utilized for irrigation during years having low surface flow would lower the water table somewhat, but the water withdrawn would be replenished during years of adequate flow--with the resulting decrease in the amount of excess irrigation water lost to evaporation.

At other places away from the Burlington and Otto area, the flood-plain alluvium along the Greybull River is thin and may yield only relatively small amounts, probably less than 100 gal/min, of water to wells. Well 52-93-19bda was drilled for irrigation and, for reasons unknown, was later abandoned. Although sufficient water is present for stock or domestic purposes, the generally high hardness and, in places, the relatively high concentration of dissolved solids make the water undesirable for domestic use in the area downstream from Otto and at most places upstream from the YU Bench. Throughout the area studied, water having lower amounts of dissolved solids generally is found near the Greybull River, where interchange of water takes place between the river and the flood-plain alluvium, than in areas away from the river.

The part of the Burlington terrace deposits lying adjacent to and east of Burlington is known to yield some water to wells. In this area, most of the deposits are saturated and are included with the alluvial aquifer. East of Burlington, the Burlington terrace deposits are similar to the deposits overlying the gravels of the upper and lower Sunshine terraces on Emblem Bench and should yield comparable amounts--possibly more than 200 gal/min--of water to wells.

Locally, some water is obtained for domestic and stock use from the fine-grained younger alluvial-fan deposits and the McKinnie terrace deposits, particularly where these deposits border the flood-plain alluvium. The chemical quality of the water in these deposits varies widely, but probably it is similar to the chemical quality of the water in the flood-plain alluvium (table 3). Throughout much of the area upstream from the Fenton School, the altitude of the base of the alluvial-fan deposits is above the level of the Greybull River, which causes the deposits to be drained or to contain an insufficent saturated zone for development by wells.

SUMMARY

The alluvial deposits comprise the principal aquifer in the Greybull River Valley and the source of water to many stock and domestic wells and to a few irrigation wells. Geomorphic and geologic mapping, coupled with surface-resistivity measurements and well-log data, was essential to determining the lithology, thickness, and extent of the water-yielding terrace and flood-plain deposits that comprise the alluvial aquifer. The alluvial aquifer consists principally of the Greybull terrace deposits and the flood-plain alluvium and, subordinately, of the Burlington terrace, McKinnie terrace, and the alluvial-fan deposits.

The thickness forms a major control on the amount of water that can be obtained from the alluvial deposits. Well-log data and surface-resistivity measurements indicate that the thickness of the alluvial deposits is as much as 60 feet only in the Burlington-Otto area. In most of this area the deposits are at least 35 feet thick. Throughout much of the remaining part of the Greybull River Valley the deposits are less than 20 feet thick. Buried bedrock ridges were found to be present beneath the alluvial deposits at the Advent School and along the southern flanks of Table Mountain in the vicinity of Otto.

Ground water in the deposits forming the alluvial aquifer is very hard and contains between 385 to about 2,200 mg/L of dissolved solids. Water in the Greybull terrace deposits ranges from 385 to 887 mg/L. Due to the high hardness, water in the alluvial aquifer is cased out of some domestic wells and the wells are completed in the underlying Willwood Formation that contains softer water. Downstream from Otto, much of the water in the alluvial aquifer contains 1,800 to 2,200 mg/L of dissolved solids. Most of the water in the alluvial deposits has a high to very high salinity hazard and a low- to medium-sodium hazard--conditions that are suitable for irrigation of most crops grown in the river valley.

The Greybull terrace deposits and the flood-plain alluvium in the Burlington-Otto area have the best potential for ground-water development. Elsewhere, water is of poor chemical quality or yields of wells are insufficient for irrigation use. Yields of wells are reported to be as much as 670 gal/min from the Greybull terrace deposits and 141 gal/min from the flood-plain alluvium. The yield of 141 gal/min was from a well that penetrated less than 24 feet of coarse-grained flood-plain alluvium. Yields of wells penetrating greater thicknesses of coarse-grained alluvium should be more than 200 gal/min.

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