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HYDROGEOLOGIC FEATURES OF THE ALLUVIAL DEPOSITS IN THE NOWOOD RIVER DRAINAGE AREA, BIGHORN BASIN, WYOMING

By M. E. Cooley and W. J. Head

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ABSTRACT

The Nowood River and its principal tributaries, Tensleep and Paint Rock Creeks, flow in open valleys formed along the lower western flank of the Bighorn Mountains. Chemical analyses of the Nowood River and its principal tributaries indicate that the dissolved solids during the late spring high runoff are less than 200 milligrams per liter and, during the low flows of early autumn, the dissolved solids are as much as 900 milligrams per liter. Chemical analyses and specific conductances also show downstream increases in the amount of dissolved solids. Inflow of ground water to Tensleep Creek is indicated near the town of Ten Sleep where in a reach less than 1 mile long the dissolved solids and sulfate contents increase from 213 to 472 and 58 to 230 milligrams per liter, respectively.

The principal deposits mapped include the terrace, flood plain, younger (generally undissected) alluvial fan, older (disected) alluvial fan, boulder-fan deposits, and pediment deposits. Remnants of terrace deposits occur at 30-40 feet, 120-150 feet, 200-260 feet, and 280-330 feet above the Nowood River, but the most conspicuous terrace remnants border the flood plain 50-100 feet above the river. Coarse boulder-fan deposits, containing many boulders slightly more than 4 feet in diameter, are near Paint Rock Creek. The flood-plain alluvium, the younger alluvial-fan deposits, and the boulder-fan deposits comprise the alluvial aquifer. The flood-plain alluvium along the Nowood River is mainly fine grained containing minor amounts of pebbles and cobbles; water production from wells is lower here than in the gravelly alluvium along Tensleep and Paint Rock Creeks.

Owing to the sparcity of well-log data, 42 surface-resistivity measurements were made at 10 sites to obtain information on the thickness of the alluvial aquifer. Thickness is indicated to be 25-50 feet along the Nowood River, nearly 80 feet in a buried channel along Tensleep Creek, and 28 to possibly 95 feet along Paint Rock Creek. The surface resistivity also revealed a buried bedrock ridge between Paint Rock and Medicine Lodge Creeks 30-40 feet beneath the top of the boulder-fan deposits. The buried channels along Tensleep and Paint Rock Creeks may be, in part, collapse features resulting from solution from the underlying gypsum beds.

The dissolved solids content of the water from wells completed in the alluvial aquifer along the Nowood River and the lower reaches of Tensleep and Paint Rock Creeks ranges from 225 to 2,600 milligrams per liter. The amount of dissolved solids is less than 300 milligrams per liter only in the water in the flood-plain alluvium in Tensleep Canyon and in the boulder-fan deposits and adjacent flood-plain alluvium along Paint Rock and Medicine Lodge Creeks.

Wells completed in the alluvial aquifer have been tested at rates of nearly 40 gallons per minute, but maximum yields may exceed 100 gallons per minute from the flood-plain alluvium along Tensleep Creek and from the boulder-fan deposits. Therefore, the most favorable areas for development of ground water are from the flood-plain alluvium along Tensleep Creek and from the boulder-fan deposits and adjoining flood-plain alluvium between Paint Rock and Medicine Lodge Creeks. Along the Nowood River the flood-plain alluvium, although the yields may be small (less than 25 gallons per minute), has potential for ground-water development.

Low lands, displaying solution-collapse features, are eroded principally into the Goose Egg and Chugwater Formations near the Bighorn Mountains. Deposits associated with the solution-collapse features include reprecipitated gypsum from the Goose Egg Formation, platy siliceous material, and a few beds of volcanic ash believed to be correlative with the Pearlette ash beds of early Pleistocene age and younger ash eruptions. Numerous springs, which help maintain the perennial flows of small streams, issue in the low lands.

INTRODUCTION

Alluvial deposits, comprising an alluvial aquifer, furnish water to many stock and domestic wells along the Nowood River and its principal tributaries Tensleep and Paint Rock Creeks. In late 1974, the U.S. Geological Survey, in cooperation with the Wyoming State Engineer, began a study of the hydrology and geology, including the geomorphology, of the lower part of the Nowood River drainage basin (fig. 1) to determine possible favorable areas for obtaining ground water for irrigation and other uses. The area investigated is along the Nowood River and its main tributaries between its confluence with the Bighorn River at Manderson to the locality called Big Trails, 20 miles south of Ten Sleep.

Field Work and Acquisition of Data

The principal investigative proceedures included collection of hydrologic and chemical data, geologic mapping of the several alluvial deposits, surface-resistivity soundings to obtain information on the thickness and character of the deposits, and evaluation of the well-log information. The well-log data are sparse and provide little information in determining thickness and lithology of the alluvial deposits.

Mapping of the alluvial deposits in the bottom land along the Nowood River and its main tributaries determined their areal extent (pl. 1) and identified the deposits that have the best potential for ground-water development. The mapping was done on aerial photographs and on 7½-minute quadrangle maps (scale: 1:24,000 with contour intervals of 20 or 40 ft). All data were plotted on the 7½-minute quadrangle maps which subsequently were reduced photographically to the scale 1:62,500.

Direct-current (surface) resistivity measurements were made in the alluvial deposits to define the thickness of the deposits at 10 locations (pl. 2). Five locations are along the Nowood River, two along both Tensleep and Paint Rock Creeks, and one along Medicine Lodge Creek. These measurements provided the main source of the subsurface information in lieu of the meager well-log data. The field technique utilized the Schlumberger array. Interpretations were made using Hummel's curve matching methods (Keller and Frischknecht, 1966) and a computerized interpretation method based on modified Dar Zarrouk functions (Zohdy, 1975). The resistivity data were not refined for lithologic and porosity interpretations.

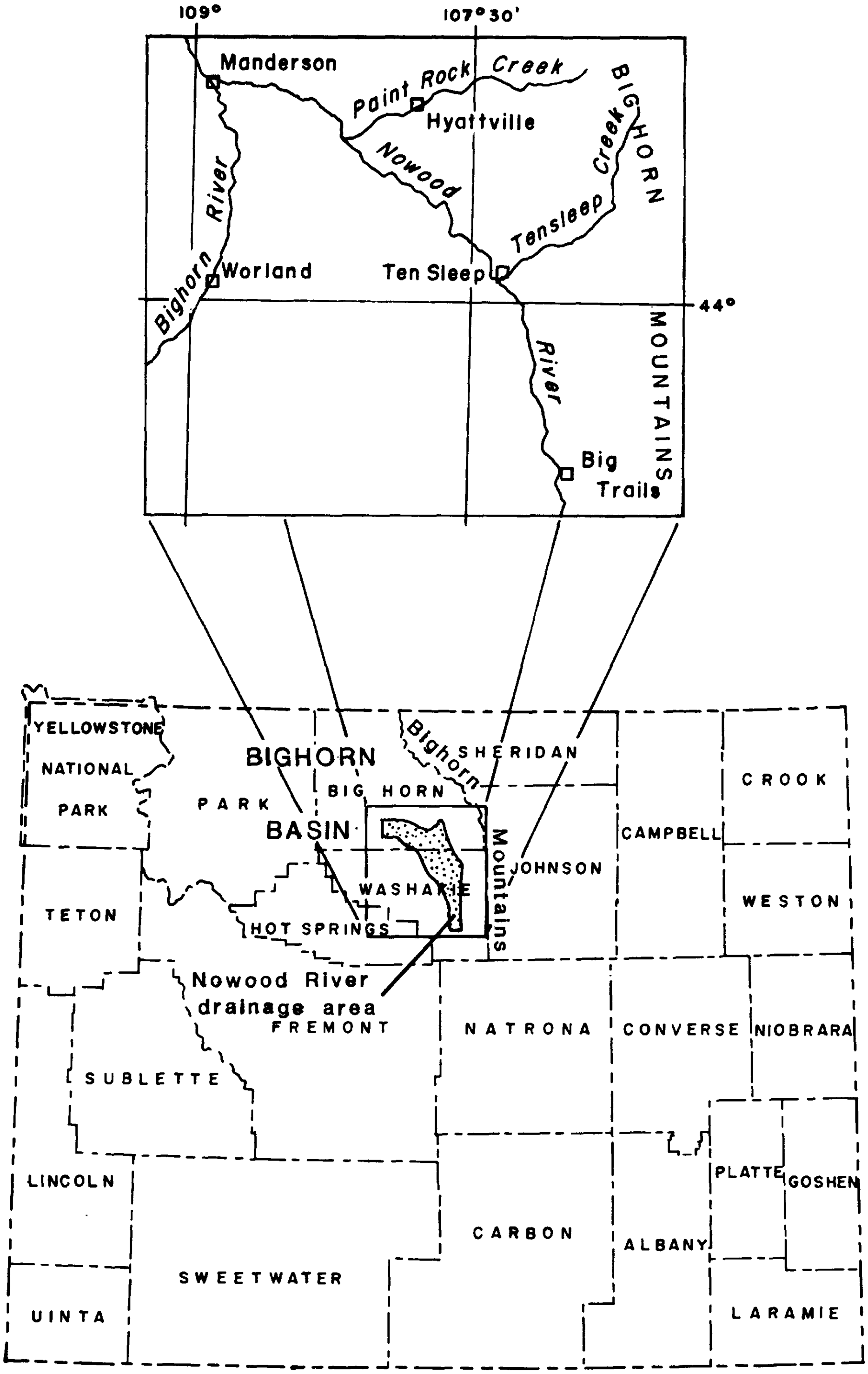


Figure 1.--Map of Wyoming showing location of the Nowood River drainage area

Previous Investigations and Acknowledgments

The principal previous geologic and hydrologic investigations pertaining in part to the alluvial aquifer were in the northern part of the area; these include geomorphic and structural studies by Andrews and others (1947) and Rogers and others (1948), and a water-resources study of the Manderson-Hyattville area by Swenson and Bach (1951). Well-log data and well-yield information were obtained from the files of the Wyoming State Engineer, Cheyenne, and from Swenson and Bach (1951). Chemical analyses of water samples from wells, springs, and streams collected in 1975-76 were done in the State Laboratories, Wyoming Department of Agriculture, Laramie. The authors acknowledge and thank the many ranchers who contributed information concerning their water wells and irrigation-water supplies.

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 denotes 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 counterclockwise 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 of well 47-90-29cab is in the NW¼ of the NE¼ of the SW¼ of sec. 29, T. 47 N., R. 90 W.

As a means of identification, the Geological Survey assigns an eight-digit station number (such as 06270000) 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.

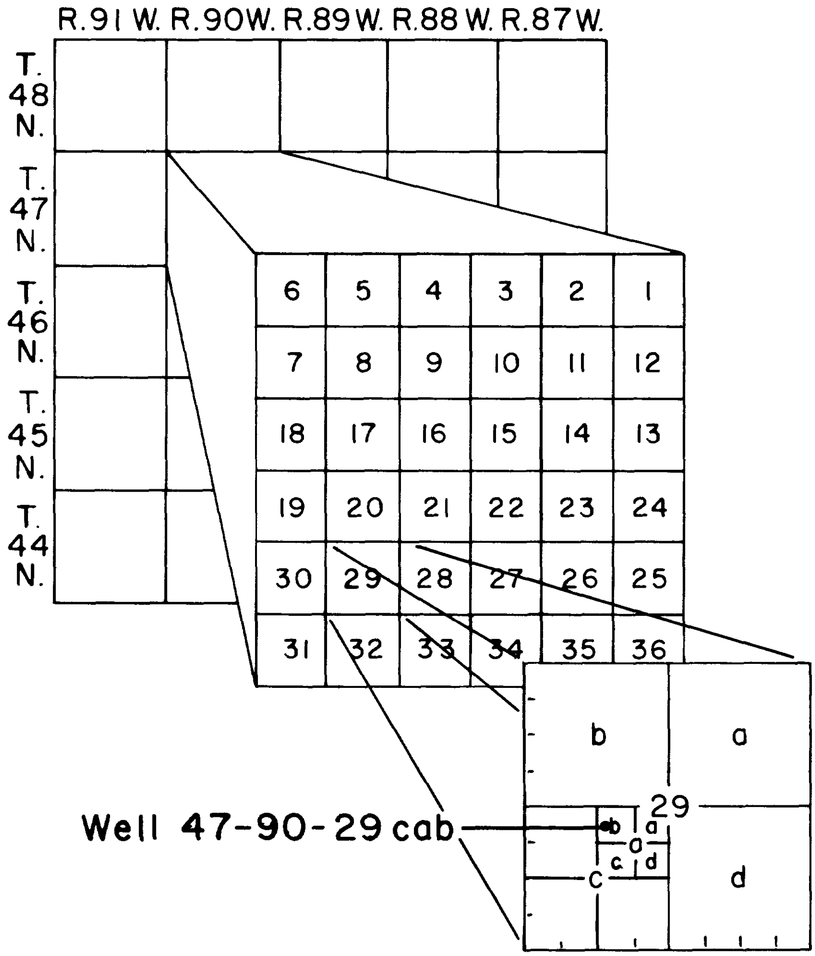


Figure 2.--Well-numbering system

Metric Units

For those readers interested in using the metric system, the following table may be used to convert the inch-pound units of measurement used in this report to metric units:

inch-pound units	multiply by	metric units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
acre	4047.	square meter (m^2)
	0.4047	hectare (ha)
gallon per minute (gal/min)	3.78543	liter per minute (L/min)
acre-foot (acre-ft)	1233.	cubic meter (m^3)
	0.001233	cubic hectometer (hm^3)
	0.000001233	cubic kilometer (km^3)
pound-force per square inch (lbf/in^2)	6.8948	kilopascal (kPa)

STREAMFLOW, INCLUDING CHEMICAL QUALITY

The Nowood River flows in an open valley throughout its course downstream from Big Trails at the south edge of the area investigated to its confluence with the Bighorn River to the northwest. From Big Trails to its mouth, the altitude of the Nowood River decreases from 4,760 to 3,380 feet, an average gradient of the valley of about 15.5 ft/mi. The main tributaries of the Nowood River are perennial streams that flow through nearly vertical-walled canyons cut into the western flank of the Bighorn Mountains before debouching into valleys along the eastern margin of the Bighorn Basin (fig. 3).

Short-term streamflow records are available for the principal streams of the Nowood River basin (table 1). The annual discharge for the Nowood River near the town of Ten Sleep, as indicated by sporadic stream-flow measurements between 1938 and 1977, ranged from 42,520 to 129,100 acre-ft. The annual discharge of Tensleep Creek during 1944-72 ranged from 61,860 to 138,500 acre-ft and discharge of Medicine Lodge Creek during 1943-73 ranged from 15,250 to 34,220 acre-ft. However, the runoff in August and September during the late part of the growing season has been as low as 4,900 acre-ft for Tensleep Creek and 1,234 acre-ft for Medicine Lodge Creek. Some short-term records are also available for Paint Rock and Canyon Creeks (table 1). The runoff for September usually is lower than that for August. Generally, peak flows derived from snowmelt are in May or June, which in some years may be as much as 10 times the amount of the August-September flows. At present (1978), storage reservoirs have not been built,

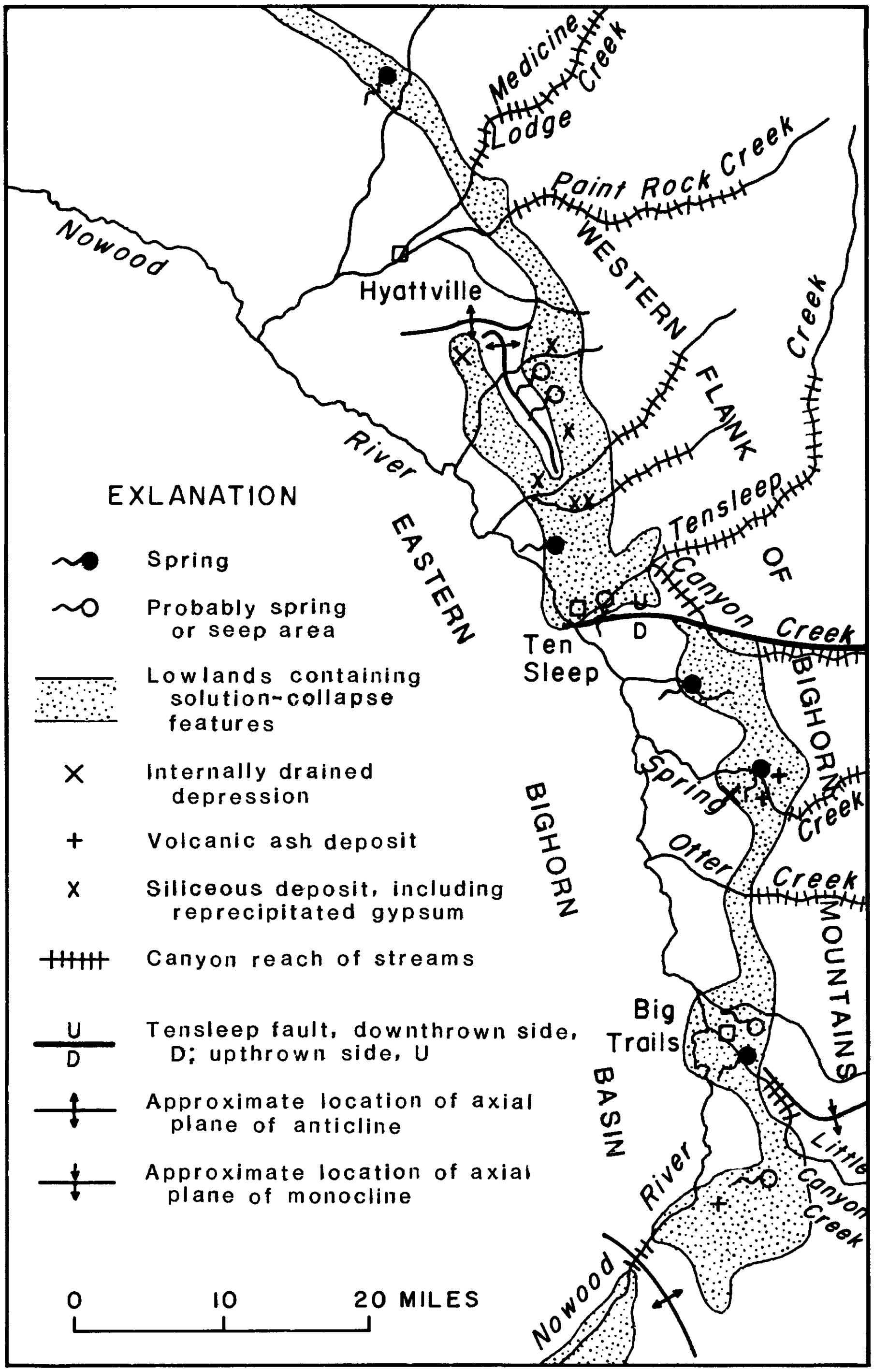


Figure 3.--Lowlands containing solution-collapse features

Table 1.--Records of streamflow for the Nowood River and its principal tributaries.

Water year	Selected monthly and annual runoff, in acre-feet					
	May	June	July	Aug.	Sept.	Water year
			CANYON CREEK NEAR TEN SLEEP			
1939	-----	1,620	1,220	1,280	1,550	------
1940	2,580	1,630	1,350	1,120	1,240	18,200
1941	7,880	1,660	1,130	1,270	1,390	23,330
1942	3,810	1,760	1,130	1,230	1,340	21,880
1943	4,690	5,570	1,970	1,160	1,330	26,250
1944	6,460	5,160	2,060	1,320	1,410	26,820
1969	2,270	1,330	958	415	322	------
1970	4,170	2,170	776	449	454	10,580
1971	4,060	2,870	489	493	439	11,190
			TENSLEEP CREEK NEAR TEN SLEEP			
1911	17,700	32,000	6,460	3,940	3,050	87,100
1912	14,600	62,500	26,800	14,300	6,370	145,000
1915	23,200	40,800	30,200	10,200	7,800	155,000
1916	21,500	51,500	20,100	7,260	4,360	141,000
1917	18,700	52,200	32,600	6,640	5,220	142,000
1918	20,200	55,900	12,500	5,720	4,650	123,000
1919	30,200	11,500	3,620	3,010	3,450	78,800
1920	17,800	56,900	24,700	8,550	7,440	137,000
1921	27,000	33,500	7,070	3,540	3,310	98,000
1922	23,200	35,700	14,400	4,910	3,060	101,000
1923	22,400	47,100	20,800	8,180	10,100	126,000
1942	34,700	60,100	18,800	5,080	6,900	164,000
1944	28,620	42,480	18,350	3,920	3,140	116,000
1945	16,010	36,720	25,820	5,770	6,380	110,700
1946	19,010	37,010	12,870	4,290	5,790	110,800
1947	30,670	29,270	20,540	5,680	3,780	114,800
1948	30,100	27,930	11,870	5,220	3,220	103,800
1949	24,670	33,770	9,280	3,370	4,240	96,140
1950	12,470	40,430	16,070	4,870	4,840	99,580
1951	20,510	19,440	15,950	5,540	3,620	88,630

Table 1.--Records of streamflow for the Nowood River--Continued

Water year	Selected monthly and annual runoff, in acre-feet					
	May	June	July	Aug.	Sept.	Water year
			TENSLEEP CREEK NEAR TEN SLEEP--Continued			
1952	27,800	30,690	13,350	5,720	3,660	107,800
1953	9,910	47,760	10,700	4,720	3,040	95,630
1954	22,870	14,520	7,120	4,870	2,120	70,330
1955	20,620	35,770	10,300	2,690	2,210	88,790
1956	24,130	24,210	5,400	2,750	2,500	77,770
1957	14,080	36,340	14,660	4,020	5,950	91,680
1958	27,950	14,440	9,370	4,240	2,770	79,800
1959	12,270	43,750	11,300	4,020	3,100	93,650
1960	14,020	17,650	4,890	2,520	2,680	61,860
1961	17,500	18,110	3,890	2,490	6,270	65,860
1962	22,550	40,720	14,000	5,970	4,410	114,500
1963	20,090	43,140	9,850	3,480	3,490	97,950
1964	22,770	34,280	12,530	3,600	3,450	95,010
1965	12,120	54,510	17,790	5,470	4,330	112,400
1966	21,150	15,010	6,630	3,470	2,900	71,390
1967	22,330	56,590	26,750	6,380	6,380	136,400
1968	12,190	68,010	17,870	10,670	7,580	138,500
1969	26,960	18,260	13,460	3,730	2,330	90,050
1970	21,660	31,250	11,190	3,170	2,640	90,860
1971	20,510	46,990	9.760	5,080	3,330	104,400
1972	23,490	43,630	11,560	8,780	6,770	-------
			NOWOOD RIVER NEAR TEN SLEEP 06270000			
1938	------	6,440	1,650	982	2,310	-------
1939	9,710	7,270	455	937	1,960	57,710
1940	13,110	4,990	1,210	799	2,800	47,890
1941	46,940	6,910	1,420	5,140	5,840	100,400
1942	44,240	9,610	2,180	1,480	2,860	126,600

Table 1.--Records of streamflow for the Nowood River--Continued

Water year	Selected monthly and annual runoff, in acre-feet					
	May	June	July	Aug.	Sept.	Water year
	NOWOOD RIVER NEAR TEN SLEEP 06270000--Continued					
1943	14,970	13,030	2,590	1,480	3,400	96,340
1950	13,330	4,480	1,290	1,570	3,970	-------
1951	9,460	2,590	1,770	1,150	3,550	49,760
1952	11,110	3,830	1,380	1,520	2,010	51,910
1953	11,990	7,470	967	1,330	1,560	52,970
1954	9,020	2,410	360	810	983	42,520
1955	31,940	16,170	2,220	1,220	1,640	89,440
1973	55,820	21,720	5,620	2,670	5,350	129,100
1974	13,580	4,020	1,970	1,650	3,020	72,020
1975	40,770	29.900	7,740	2,390	2,870	125,300
1976	9,056	3,158	927	1,368	1,845	72,480
1977	20,579	3,528	1,068	1,586	1,545	104,800
	PAINT ROCK CREEK NEAR HYATTVILLE					
1920	------	------	------	6,210	3,950	-------
1921	27,100	42,100	6,700	3,000	2,120	91,300
1922	23,500	50,200	13,800	5,810	1,920	106,000
1923	21,400	49,700	29,300	9,280	7,860	128,000
1924	37,500	71,400	24,100	5,410	4,160	170,000
1925	40,300	35,600	18,000	7,930	4,390	129,000
1926	37,000	28,000	18,000	7,750	6,600	121,000
1941	28,230	21,500	7,170	7,950	7,910	-------
1942	19,070	26,840	11,780	2,310	1,950	79,760
1943	12,780	48,230	19,170	4,440	2,310	100,600
1944	24,520	42,680	20,960	4,010	2,750	103,400
1945	12,930	44,070	31,060	6,240	5,930	109,600
1946	17,470	39,030	14,890	3,900	5,250	100,700
1947	24,060	34,400	24,510	4,980	3,210	104,000
1948	33,840	28,010	10,490	4,520	2,170	90,710
1949	26,610	36,190	10,250	2,550	2,690	88,780
1950	10,390	52,400	17,590	4,390	3,720	98,210
1951	22,840	24,750	19,800	6,510	2,700	88,220
1952	26,110	32,220	14,360	4,510	2,370	94,430
1953	7,950	59,020	16,280	4,760	2,270	98,290

Table 1.--Records of streamflow for the Nowood River--Continued

Water year	Selected monthly and annual runoff, in acre-feet					
	May	June	July	Aug.	Sept.	Water year
			Medicine Lodge Creek near Hyattville			
1943	4,040	13,540	3,680	1,020	776	29,370
1944	6,590	12,340	4,460	1,090	910	29,830
1945	3,330	10,230	5,990	1,360	1,340	26,930
1946	5,830	10,400	3,050	986	1,320	28,780
1947	7,550	9,320	4,620	1,230	1,010	29,880
1948	7,110	5,660	1,840	988	722	22,000
1949	6,590	9.280	2,150	863	831	24,520
1950	3,250	10,570	3,070	1,100	899	23,560
1951	6,210	6,950	3,180	1,280	980	23,780
1952	7,240	7,360	3,210	1,310	823	25,450
1953	1,480	13,990	3,110	1,200	847	25,060
1954	5,520	4,420	1,370	691	584	17,320
1955	4,620	11,510	2,650	968	746	24,510
1956	8,070	7,580	1,350	799	706	23,320
1957	3,100	8,500	2,480	924	986	20,140
1958	7,530	3,990	1,740	1,190	694	19,680
1959	2,340	13,720	2,420	902	716	24,380
1960	4,220	5,250	1,160	772	680	16,510
1961	5,690	4,560	996	726	942	16,750
1962	6,010	10,180	2,470	1,130	930	26,790
1963	5,900	12,030	1,700	797	710	25,410
1964	5,070	16,920	5,590	1,250	1,140	34,220
1965	2,590	17,790	4,520	1,260	952	31,810
1966	5,240	3,260	964	682	552	15,250
1967	4,130	17,680	5,490	1,340	1,220	33,420
1968	2,150	11,920	4,760	2,570	2,370	29,390
1969	8,770	5,800	4,200	1,270	904	27,890
1970	4,970	11,090	2,660	1,120	855	25,420
1971	5,080	10,930	2,270	1,210	857	24,790
1972	5,330	10,290	2,970	1,770	1,410	26,930
1973	4,870	8,840	2,680	1,260	1,310	24,120

and spring to early summer high flows, except the part evaporated or used for irrigation, flow through the drainage basin. Tensleep Creek is the only stream in the area that has streamflow records extending back to before 1920. During 1911-24 (excluding the 1913-14 records, which are incomplete), the August-September flows were substantially higher than those during 1944-72. Records of Paint Rock Creek also indicate that the August-September flows for 1921-26 were slightly higher than those for 1941-53.

Chemical analyses of samples from the Nowood River and its principal tributaries indicate that in 1975 the amount of dissolved solids during the late spring and early summer high runoff period was less than 200 mg/L and that during the low flows of early autumn the dissolved-solids concentration was as much as 1,050 mg/L (table 2). The flow of the Nowood River also shows a downstream increase in the amount of dissolved solids.

A series of measurements of the specific conductance was made to obtain additional information on the dissolved-solids concentration in the waters of the major streams. In the Nowood River and Tensleep, Paint Rock, and Medicine Lodge Creeks, there was a progressive downstream increase in the specific-conductance values (table 3). Other measurements made in September 1976 of the flows of Crooked, Otter, Spring, and Brokenback Creeks also show a downstream increase in the specific conductance (table 2, pl. 2).

Much of the increase of the specific conductance is due to the return flows of irrigation water that had been diverted from the streams. In places in the lower reaches of the Nowood River and Paint Rock Creek, white alkali encrustation can be seen in fields and near irrigation ditches. In addition, it was found that the flows of tributaries of the Nowood River and Tensleep and Paint Rock Creeks show wide differences in the specific conductance, ranging from less than 200 µmho/cm to about 3,800 µmho/cm. (See section "Solution-Collapse Features and Spring Flow. These flows furnish some of the recharge to the alluvial aquifer.

SEDIMENTARY BEDROCK

Consolidated sedimentary rocks ranging from the Bighorn Dolomite (Ordovician) to the Fort Union Formation (Paleocene) (table 4) are exposed in the part of the Nowood River drainage area investigated. These rocks dip regionally westward across the area from the Bighorn Mountains to the center of Bighorn Basin. A distinctive low-land area containing solution-collapse features is developed on the Chugwater (Triassic) and Goose Egg (Permian) Formations. These low lands are generally east of the Nowood River and are crossed by all the tributaries of the river that head in the Bighorn Mountains (fig. 3).

Table 2.--Chemical analyses of surface water in the Nowood River drainage area

[Analytical results in milligrams per liter (mg/L), except as indicated. Analyses by State Laboratories, Wyoming Department of Agriculture and U.S. Geological Survey]

Stream	Station No. (table 3 and plate 2)	Approximate flow	Date of collection	Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (sum of constituents)	Hardness (Ca, Mg)	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)	Remarks
Little Canyon Creek near Big Trails----------------	2	high	6-12-75	11	27	11	2.1	0.2	110	0	15	1.8	0.1	0 9	124	110	0.1	203	8.0	
----------Do----------------	2	low	9- 8-75	12	94	28	4.7	1.9	220	3	180	1.8	.3	1.2	430	350	.1	641	8 4	
Spring Creek----------------	51	low	9-15-76	11	47	23	1.2	.9	240	6	8.2	1.8	.2	3.0	218	210	0	382	8.5	Location SW¼ sec. 26, T. 46 N., R. 87 W.
Alkali Creek near Ten Sleep	8	----	9-12-76	16	350	130	130	11	160	0	1,500	25	1.3	0	2,210	1,400	1.5	2,270	7.9	Thin white alkali encrustations along Creek.
Tensleep Creek--------------	22	low	9- 9-76	7.7	15	7.3	1.8	.5	81	0	2.5	3.3	.1	.2	78	68	.1	138	8.1	
Tensleep Creek at Wigwam Fish Rearing Station------	24	high	6-12-75	6.4	6.8	2.4	1.1	.7	33	0	3.3	1.8	.1	.3	39	27	1	58	7.3	
----------Do----------------	24	low	9- 8-75	9.3	24	10	2.9	.9	120	3	1.6	1.8	.1	.5	112	100	.1	195	8.4	
Canyon Creek at mouth-------	26	high	6-11-75	9.3	26	8.8	1.6	1.4	98	0	24	1.8	.1	.6	122	100	.1	205	7.9	
----------Do----------------	26	low	9- 8-75	11	53	24	2.9	1.2	220	6	40	1.8	.2	1.6	245	230	.1	419	8.5	
Tensleep Creek--------------	29	low	9- 9-76	10	45	17	2.9	1.2	150	6	58	0	.3	.7	213	180	.1	361	8.4	
----------Do----------------	31	low	9- 9-76	12	110	25	4.7	2.1	190	0	230	0	.3	1.3	472	370	.1	671	8.2	
Nowood River near Ten Sleep	9A	high	6- 2-75	11	37	10	5.9	2.1	110	0	58	3.6	.2	1.2	181	130	.2	277	7.9	Station 06270000, monthly samples taken for chemical analysis.
----------Do----------------	9A	low	8-30-75	11	140	44	38	3.3	240	0	420	3.6	.2	.1	775	530	.7	1,010	8.1	Do.
----------Do----------------	9A	high	5-21-76	11	52	15	7.6	1.6	130	0	98	1.8	.2	1.2	252	190	2	410	7.9	Do.
----------Do----------------	9A	low	9- 4-76	9.1	130	43	39	2.8	230	0	390	4.7	.5	.1	729	500	.8	1,060	8.1	Do.
Tributary of Brokenback Creek	52	low	11- 5-76	9.6	39	28	4.1	1.6	260	0	4.1	1.5	.3	2.4	217	210	.1	404	8.0	Location in Salt Trough, NE¼ sec. 9, T. 48 N., R. 88 W.
Brokenback Creek------------	53	low	9-10-76	11	54	31	1.8	1.2	280	6	17	.9	.3	1.7	262	260	0	456	8.4	Location SE¼ sec. 20, T. 48 N., R. 88 W.
Paint Rock Creek at Hyattville----------------	39	high	6-11-75	6.2	17	5.4	1.6	3.0	67	0	13	1.8	.1	.1	81	65	.5	132	7.7	
----------Do----------------	39	low	9- 9-75	16	140	31	27	2.1	200	0	370	1.8	.4	.2	688	480	.5	932	8.2	
Paint Rock Creek near mouth below Hyattville----	17	high	6- 3-75	.1	27	8.9	7.0	.7	92	0	40	.0	.1	.3	137	100	.3	219	7.6	Station 06273500, monthly samples taken for chemical analysis.
----------Do----------------	17	low	8-30-75	14	160	42	60	3.3	270	0	470	3.6	.5	.0	884	560	1.1	1,110	8.1	Do.
----------Do----------------	17	high	6- 4-76	4.2	16	3.8	4.7	1.6	55	0	21	1.9	.1	.2	81	56	.3	143	7.5	Do.
----------Do----------------	17	low	9- 4-76	13	150	42	67	3.0	280	0	450	3.6	.7	.1	869	550	1.2	1,240	8.2	Do.
Nowood River at Manderson--	21	high	6- 3-75	10	34	11	8.6	.9	100	0	63	1.8	.3	.8	180	130	3	287	7.9	Station 06274220, monthly samples taken for chemical analysis.
----------Do----------------	21	low	8-30-75	7.3	140	57	86	4.0	210	0	570	9.0	.4	.0	974	580	1.5	1,200	8.1	Do.
----------Do----------------	21	high	6-11-76	5.4	24	6.2	6.4	1.2	64	0	42	0	.1	.4	117	84	.3	200	8.3	Do.
----------Do----------------	21	low	9- 4-76	6.5	140	57	110	4.2	220	0	610	8.0	.7	.1	1,050	580	.8	1,450	8.2	Do.

Table 2.--Chemical analyses of surface water--Continued

Ponds	Station No. (pl. 2)	Approximate stage	Date of collection	Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (sum of constituents)	Hardness (Ca, Mg)	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)	Remarks
Unnamed ephemeral pond near Spring Creek NE¼ sec. 34, T. 46 N., R. 87 W.	P1	low	9-12-76	36	71	13	5.9	23	120	0	150	12	0.4	2.3	372	230	4.0	535	7.1	Pond occupied small area in internally drained depression.
Oxbow Lake in abandoned meander of Tensleep Creek SE¼ sec. 16, T. 47 N., R. 88 W.	P2	high	9- 9-76	28	490	110	20	9.1	240	0	1,500	2.7	1.0	2.5	2,310	1,700	.2	2,360	7.8	
Small reservoir below spring, NE¼ sec. 1, T. 47 N., R. 89 W.	P3	high	9-10-76	21	410	120	85	3.7	45	3	1,500	38	1.4	.5	2,240	1,500	.9	2,410	8.4	Smith Lake, sampled by spillway.
Carothers Lake, Brokenback Creek drainage area	P4	high	9-10-76	26	90	47	5.3	2.3	95	0	340	1.9	.6	.9	563	420	.1	779	7.6	Sampled on east shore, NW¼ sec. 16, T. 48 N., R. 88 W. Flow of stream in Salt Trough diverted into lake.
Unnamed reservoir, Buffalo Creek drainage area	P5	medium low	9-10-76	.7	490	250	77	1.4	92	0	2,200	15	1.4	.1	3,120	2,300	.7	3,070	8.1	Sampled at dam, SE¼ sec. 1, T. 48 N., R. 89 W.
Renner Reservoir, Buffalo Creek	P6	high	9-10-76	16	540	160	120	11	69	0	2,200	16	1.2	1.9	3,090	2,000	1.2	3,010	7.4	Sampled at dam in east-central sec. 35, T. 49 N., R. 89 W.

Table 3.--Specific conductance of streamflow at selected sites in the Nowood River drainage area

Station No.[1]	Specific conductance[2] (µmho/cm at 25°C) 5-13-76	9-10, 13-76 [3]	Drainage and remarks
			NOWOOD RIVER
1	315M	950C	Nowood River above mouth of Little Canyon Creek.
2	220SM	690C	Little Canyon Creek near Big Trails.
	255SM	860C	Little Canyon Creek at mouth.
3	1,200SM	3,000C	Crooked Creek.
4	315SM	940C	Nowood River.
5	195SM	1,500C	Otter Creek.
6	290M	828C	Nowood River.
7	840M	1,020SM	Spring Creek.
8	3,800C	2,270C	Alkali Creek (near Ten Sleep).
9	310M	964C	Nowood River.
10	245SM	608C	Tensleep Creek near mouth.
11	295M	----	Nowood River.
12	1,260M	843C	Brokenback Creek; measurement taken 1½ miles upstream from Nowood River.
13	320M	849C	Nowood River.
14	2,800C	3,020C	Tributary, right bank.
15	595M	1,280C	Nowood River.

Table 3.--Specific conductance of streamflow at selected sites--Continued

Station No.[1]	Specific conductance[2] (µmho/cm at 25°C) 5-13-76	9-10, 13-76 [3]	Drainage and remarks
	NOWOOD RIVER--continued		
16	315M	940C	Nowood River.
17	580SM	1,100C	Paint Rock Creek near mouth.
18	2,875C	2,360C	Tributary, left bank; flow from oil field.
19	390M	1,200C	Nowood River.
20	445M	1,120C	Do.
21	450M	1,120C	Nowood River at mouth.

Table 3.--Specific conductance of streamflow at selected sites--Continued

Station No.[1]	Specific conductance[2] (µmho/cm at 25°C) 5-16-76	9- 8-76	11- 7-76	Drainage and remarks
		TENSLEEP CREEK		
22	72C	92C	137C	Tensleep Creek.
23	93C	121C	165C	Do.
24	105C	135C	169C	Tensleep Creek near Wigwam Fish Rearing Station.
25	----	405C	372C	Canyon Creek.
26	220M	405C	406C	Canyon Creek at mouth.
27	175M	245C	301C	Tensleep Creek.
28	----	335C	334C	Do.
29	----	345C	326C	Do.
30	----	520C	390C	Do.
31	----	610C	551C	Tensleep Creek at east edge of Ten Sleep.
10	315SM	645C	540C	Tensleep Creek near mouth.

Table 3.--Specific conductance of streamflow at selected sites--Continued

Station No.[1]	Specific conductance[2] (µmho/cm at 25°C) 5-14-76	9-12-76	Drainage and remarks
			PAINT ROCK CREEK
32	130C	------	Paint Rock Creek; measurement made of water in diversion ditch.
33	160C	235C	Paint Rock Creek.
34	198C	519C	Do.
35	270C	730C	Paint Rock Creek at Hyattville.
36	175C	241C	Medicine Lodge Creek.
37	220C	239C	Do.
38	230C	254C	Do.
39	390C	392C	Do.
40	365C	671C	Medicine Lodge Creek at Hyattville.
41	2,800VM	2,420C	Alkali Creek (near Hyattville).
42	790M	1,130C	Paint Rock Creek.
17	600M	1,130C	Paint Rock Creek near mouth.

[1] Locations shown on plate 2.

[2] Brief description of condition of flow:

C - Clear
SM - Slightly muddy
M - Muddy
VM - Very muddy.

[3] Stations 1-5 measured 9-10-76 and stations 6-21 measured 9-13-76. Precipitation did not occur during September 9-13, 1976.

Table 4.--Summary of geohydrologic information of the sedimentary rocks in the Nowood River drainage area

[Data principally from Lowry and others, 1976, and Swenson and Bach, 1951]

Erathem	System	Stratigraphic unit	Brief lithologic description	Brief hydrologic description
Cenozoic	Tertiary	Fort Union Formation	Sandstone, shale, and some coal. Thickness is 1,000-1,500 feet.	Sandstone and possible coal beds yield small amounts of water to wells. Chemical quality generally is fair.
Mesozoic	Cretaceous	Cretaceous rocks	Consists of an alternating sequence of thick shale and thin sandstone units, which in descending order consists of the Lance Formation, Meeteetse Formation, Mesaverde Formation, Cody Shale, Frontier Formation, Mowry Shale, Thermopolis Shale, and Cloverly Formation. Total thickness is 6,600-7,500 feet.	Sandstone beds and at places coal beds yield small amounts of water to wells from the Lance Formation, Meeteetse Formation, Mesaverde Formation, Frontier Formation, Muddy Sandstone Member of Thermopolis Shale, and Cloverly Formation. Chemical quality ranges from fair to poor.
	Jurassic	Jurassic rocks	Consists of variegated shale, some sandstone, and minor limestone and gypsum, which in decending order consists of the Morrison, Sundance, and Gypsum Spring Formations. Total thickness is 700-800 feet.	Sandstone beds yield less than 25 gal/min of water to wells. Solution of gypsum in Gypsum Spring Formation detrimentally affects the chemical quality of the water.
	Triassic	Chugwater Formation	Reddish-brown shale to sandstone. Thickness is 700-800 feet.	Not a source of water to wells. Few springs discharge from the formation from water that probably originated in the Tensleep Sandstone.
Paleozoic	Permian	Goose Egg Formation	Reddish-brown shale and silty sandstone and gypsum. Thickness is 160 feet.	Yields a few gallons per minute of water to wells drilled near Ten Sleep. Most of the wells flow at the land surface. Many springs discharge from the formation from water that probably originated in the Tensleep Sandstone. Solution of the gypsum detrimentally affects the chemical quality of the water, and has caused the formation of solution-collapse features locally.
		Park City Formation	Limestone and dolomite. Thickness is less than 100 feet.	Yields a few gallons per minute to a few wells in southern part of area.
	Permian / Pennsylvanian	Tensleep Sandstone	Light cross-stratified sandstone. Thickness is 130-300 feet.	Yields as much as 300 gal/min of water to wells. Most wells flow at the land surface, with shut in pressures of as much as 150 lbf/in^2. Spring discharge from the sandstone helps maintain perennial flow of many streams. Chemical quality of water satisfactory for domestic, irrigation, and most industrial uses.
	Pennsylvanian	Amsden Formation	Reddish-brown shale and sand- Thickness is 300 feet.	Yields some of water to a few wells. Chemical quality of water satisfactory for domestic, municipal, irrigation, and most industrial uses.
	Mississippian and Devonian	Madison Limestone	Light-gray limestone. Thickness is 500-700 feet.	Yields generally more than 1,000 gal/min of water to wells. Wells flow at the land surface with shut-in pressures mainly between 150 and 250 lbf/in^2. Chemical quality of water satisfactory for domestic, municipal, irrigation and most industrial uses. High hardness may limit use of water for some industrial purposes.
	Ordovician	Bighorn Dolomite	Light-gray limestone and dolomite. Thickness is 300 feet.	
	Cambrian	Gallatin and Gros Ventre Formations, undivided	Mainly greenish-gray shale.	Formations are not known to yield water in the Nowood River area.
		Flathead Sandstone	Brown quartzitic arkosic sandstone.	Yields more than 400 gal/min of water to wells. Wells flow at the land surface with shut-in pressures of as much as 450 lbf/in^2. Chemical quality of water satisfactory for domestic, irrigation, and most industrial uses.

The Paleozoic rocks (table 4) crop out east of this strike valley and along the western flank of the Bighorn Mountains. Part of the Goose Egg Formation and the Tensleep Sandstone (Permian and Pennsylvanian) are exposed along the eastern margin of the low lands, but the Amsden Formation (Pennsylvanian), Madison Limestone (Mississippian and Devonian), and the Bighorn Dolomite are displayed only in spectacular Tensleep Canyon and other canyons trenched into the western flank of the Bighorn Mountains (fig. 3). The Jurassic, Cretaceous, and lower Tertiary formations are present in the broad expanse of the Bighorn Basin to the west of the low lands.

Most of the Nowood River flood plain overlies rocks of Cretaceous age. However, the Chugwater Formation and the Jurassic formations underlie the flood plain near Big Trails and Ten Sleep, and the Fort Union Formation is present at the mouth of the river at Manderson.

Ground Water, Including Chemical Quality

Only small amounts of water are withdrawn by wells completed in the sedimentary rocks above the Tensleep Sandstone. These rocks furnish a dependable supply of water to stock wells and, in places, to domestic wells, but the amount of water that can be withdrawn by wells is insufficient for irrigation. However, quantities of water adequate for irrigation can be obtained at places from the Tensleep Sandstone and throughout the area from the Madison Limestone, Bighorn Dolomite, and Flathead Sandstone (table 4). Most of the flowing wells in the Nowood River are completed in the Tensleep Sandstone or older rocks.

Ground water of poor chemical quality has long been a problem to the residents in the Nowood River valley. Generally, very hard water containing large amounts of dissolved solids is present in the Triassic to Cretaceous sedimentary rocks and in the alluvial deposits that crop out in the river valley. The main constituents and the hardness, as shown in table 5, of water in these rocks are indicated in the following tabulation:

Number of analyses	Water yielding unit	Range of constituents			Range of dissolved solids (mg/L)	Range of hardness Ca, Mg (mg/L)
		Dissolved calcium (mg/L)	Dissolved sodium (mg/L)	Dissolved sulfate (mg/L)		
1	Fort Union Formation	3.0	307	7.7	776	13
10	Cretaceous rocks	8.8-368	36-1,600	476-2,700	926-6,120	28-1,590
2	Jurassic rocks	45-428	250-794	460-3,000	994-4,590	250-1,680
1	Chugwater Formation	300	130	960	1,730	1,100
4	Goose Egg Formation	54-85	2.3-120	16-230	309-607	210-340
22	Paleozoic rocks	20-54	1.2-15	1.8-54	148-261	110-240

The amount of fluoride is greater than 1.0 mg/L in more than half of the analyses. Four of the 10 analyses of water from the Cretaceous rocks show fluoride to be more than 1.4 mg/L--more than 1.5 mg/L of fluoride may cause mottling of children's teeth (U.S. Public Health Service, 1962). The analysis of well 46-88-24bbc (pl. 2, table 5) indicates 4.1 mg/L of fluoride, which is one of the highest concentrations of fluoride reported from water wells in the southeastern part of the Bighorn Basin.

Table 5.--Chemical analyses of ground water in the Nowood River drainage area

[Analytical results in milligrams per liter (mg/L) except as indicated. Analyses by State Laboratories, Wyoming Department of Agriculture and U.S. Geological Survey]

Water yielding unit: Qf, flood-plain alluvium; Qa, alluvial-fan deposits; Qab, Boulder-fan deposit; Tfu, Fort Union Formation; Kc, Cody Shale; Kmt, Mowry and Thermopolis Shales, undivided; Kcv, Cloverly Formation; Jm, Morrison Formation;

T c, Chugwater Formation; Pg, Goose Egg Formation; P Pt, Tensleep Sandstone; Pa, Amsden Formation; Mm, Madison Limestone; Ob, Bighorn Dolomite; Єf, Flathead Sandstone.

Location	Depth of well (ft)	Water yielding unit	Date of collection	Temperature (°C)	Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (sum of constituents)	Hardness (Ca, Mg)	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)	Remarks
44-87- 8dcd	---	P Pt	7-15-75	-----	9.2	42	16	2.9	1.2	170	0	35	1.8	0.3	0.2	193	170	0.1	321	8.2	
9abd	---	Pg	5- 9-76	12.0	10	60	31	7.0	1.2	250	0	86	2.5	.5	.1	322	280	.2	552	7.9	Spring.
9bbc	1,820	Mm,Ob	5-13-75	15.5	9.5	46	23	3.2	1.2	230	0	34	1.8	.3	0	231	210	.1	400	9.7	Dual-completion well.
17ddc	575	P Pt	9- 8-75	15	10	50	20	2.3	1.4	200	0	49	1.8	.2	.7	231	210	.1	389	8.1	
21bdd	---	---	11- 7-76	-----	9.1	53	24	2.9	1.4	210	0	48	10	.4	1.6	252	230	.1	413	7.7	Big Spring. Orifice in Goose Egg Formation near fault. Flow derived from Tensleep Sandstone and (or) underlying formations.
44-88- 1bda	<100	Jm(?)	9-10-76	-----	9	45	32	250	2.6	370	0	460	6.5	.7	1.2	994	250	7.0	1,500	8.1	
1bbd	25±	Qf	5-13-76	-----	11	200	80	220	3.7	390	0	960	14	1.0	19	1,700	830	3.3	2,170	7.6	
45-87- 7add	20±	Qf	9-10-76	-----	19	120	34	16	1.9	370	0	180	1.0	.4	5.8	561	450	.3	837	7.7	
30abc	170	Kcv(?)	9-10-76	-----	7.9	270	85	450	6.1	43	0	1,800	17	1.0	0	2,680	1,000	6.1	3,020	6.5	
30acb	75	Kcv(?)	9-10-76	-----	11	150	57	670	4.4	340	0	1,800	17	1.2	0	2,830	610	20	3,400	7 7	
46-87-10acb	1,410	A,M	9- 8-75	14	9.8	46	23	1.2	.7	230	0	19	0	.2	.5	214	210	0	385	8.1	
21acd	1,100(?)	P Pt	5-13-75	-----	10	54	26	2.7	.9	280	0	21	1.8	.2	.6	257	240	.1	444	7.8	Deepened 1960.
22add	---	---	9-12-76	12 0	20	420	67	11	2.3	230	0	1,100	2.2	.8	5.2	1,770	1,300	.1	1,930	8.0	Spring. Orifice in flood-plain alluvium, flow probably from Goose Egg Formation.
22daa	---	---	9-12-76	-----	24	350	75	11	2.1	240	0	970	2 2	.9	6.1	1,560	1,200	.1	1,870	7 7	Do.
23acd	---	Pg	9-13-76	-----	11	59	30	1.2	.9	260	0	61	.5	3	2.9	295	270	0	501	7.9	Spring.
26dbd	---	Pg	9-15-76	-----	11	53	27	2.9	1.2	270	0	20	1.8	.3	3.2	254	240	.1	444	8.0	Do.
46-88-14aac	40±	Qa	9-10-76	-----	9.2	26	8.8	350	1.4	440	0	490	1.8	.8	3.9	1,110	100	15	1,560	8.0	
24bbc	60	Kmt	9-10-76	-----	7.6	8.8	1.4	1,000	2.1	640	0	1,500	71	4.1	7.2	2,930	28	82	3,900	8.3	
47-87- 6daa	---	Qf	7-17-76	-----	9.3	25	12	3.5	.7	140	0	5.8	0	.1	.7	126	110	0	227	7.9	
28bbc	---	G(?)	9- 9-76		18	68	42	2.9	1.4	380	0	16	.8	.2	12	353	340	.1	592	8.0	Depth of well 34 or 62 feet.
33bdb1	2,708	Mm,Ob,Єf	9- 8-75	25.0	10	66	31	3.5	1.6	290	0	64	2.5	.2	1.0	324	290	.9	529	7.8	
33bdb2	---	Pg	9- 8-75	15.5	11	54	17	120	12	150	0	230	84	2.2	.5	607	210	3.6	961	8.2	
47-88- 1cda and 1dbc	---	Mm, Pa	9- 8-75	10.5	10	38	20	1.8	.9	220	0	5.8	.0	.2	2.5	185	170	.1	314	8.0	Combined flow of well 47-88-1cda and East Spring 47-88-1dbc.
1cdb	---	Mm, Pa	9- 8-75	9.0	9.9	34	16	1.8	1.6	170	0	4.8	1.1	.1	1.7	156	150	.1	274	8.1	West Spring.
2bcb	540	Pg,P Pt(?)	6-11-75	-----	9.5	49	26	1.6	3.0	260	0	6.7	16	.2	2.4	243	230	0	403	7.7	
5baa	1,682	Mm,Ob	9- 9-75	14.5	10	47	26	1.2	.9	260	0	3.3	0	.2	2.2	220	220	0	400	7.9	
8dab	2,960	Mm,Ob,Єf	9- 9-75	23.5	11	20	14	15	5.4	140	0	19	2.2	.4	.5	158	110	.6	273	8.1	
11cdb	20	Qf	9-15-76	-----	10	47	23	4.1	.5	230	0	25	.6	.1	0	224	210	.1	391	8.3	
15cbc	---	Qf	6-11-75	-----	19	280	71	43	4 9	280	0	820	3.6	.5	3.7	1,380	1,000	.6	1,610	7.3	
16aba	2,700	Єf,Ob(?),Mm(?)	9- 8-75	23.0	11	25	15	9.9	5.1	160	0	14	1.8	3	7	163	120	.4	276	8.2	

Table 5.--Chemical analyses of ground water in the Nowood River drainage area--Continued

Location	Depth of well (ft)	Water yielding unit	Date of collection	Temperature (°C)	Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (sum of constituents)	Hardness (Ca, Mg)	Sodium-adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)	Remarks
47-88-16cca	1,050	Mm, ℙa	6-13-75	-----	8.9	49	24	3.2	4.2	260	0	19	1.8	0.3	0.3	237	220	0.1	411	7.6	Ten Sleep town well.
16daa	227	Pg	9- 8-75	14	11	85	32	2.3	1.2	200	0	180	.7	.3	1.1	410	340	.1	620	7.7	
20aad	758	Pℙt,Pg(?)	10-31-53	-----	7.3	50	21	12	3.6	217	0	56	3.0	.6	0	262	212	.4	444	7.7	
21aba	280	Pg	11- 6-75	-----	9.7	61	27	3.5	1.2	220	0	97	1.8	.4	0	309	260	.1	507	7.9	
27dbd	<20	Qf	5-17-76	-----	13	440	100	220	21	480	0	1,500	15	1.0	.1	2,570	1,500	2.5	2,930	7.6	
47-89- 3aad	20	Qf	9-15-76	-----	13	200	68	31	3.0	340	0	540	2.2	.7	0	1,020	780	.5	1,300	7.6	
12bdc	40	Qf	9-15-76	-----	27	300	76	46	2.6	370	0	820	1.8	.8	4.4	1,460	1,100	.6	1,730	7.7	
13aab	901	Pℙt, ℙa	9- 8-75	13.0	9.2	49	26	2.9	1.9	260	0	16	1.1	.4	.8	234	230	.1	417	7.9	
13abd	---	Pℙt(?)	5-17-76	-----	26	300	82	130	3.7	410	0	960	11	.9	11	1,730	1,100	1.7	2,080	7.5	
48-89- 4acd	1,362	Mm	9- 9-75	13.5	9.4	44	23	2.3	.9	240	0	5.8	1.4	.2	2.2	206	200	.1	366	8.0	
6dcb	3,933	Mm,Ob,Ꞓf	5-23-75	-----	11	29	12	12	8.6	160	0	25	1.8	.4	0	179	120	.5	321	8.1	
25acb	400	Pℙt, Others(?)	9- 9-75	11.5	8.5	56	34	8.2	3.3	230	0	100	1.8	1.1	2.5	232	280	.2	547	7.8	Deepened to 600 feet after 1962(?); repaired hole in casing in 1974.
25ada	2,287	Ꞓf,Ob(?),Mm(?)	9- 9-75	20.5	9.4	26	16	9 9	5.4	160	3	12	1.8	.3	.4	165	130	.4	291	8.4	
34cbc	32	Qa	5-17-76	-----	15	190	73	21	3.7	420	0	450	4.3	.8	.4	957	760	.3	1,343	7.7	
48-90-11dba	35±	Qf(?)	9-15-76	-----	13	200	82	120	2.3	520	0	670	9.1	.6	6.1	1,350	840	1.8	1,770	7.8	
49-88-29dac	2,287	Ꞓf,Ob(?),Mm(?)	5-14-75	-----	11	24	16	3.7	2.3	150	0	14	1.8	.3	.4	148	130	.1	255	8.0	
49-89- 5bda	2,214	Mm	9- 9-75	18.5	10	39	21	2.3	1.2	210	0	6.6	1.8	.2	1.5	188	180	.1	332	7.9	
6bcb	2,895	ℙa,Mm	6-12-75	-----	9.8	50	25	4.8	2.3	230	0	54	1.8	.4	2.2	261	230	.1	452	7.8	Hyattville town well.
29abb	960	Mm, Others	5-15-75	-----	7.1	84	23	7.5	1.2	200	0	160	0	.3	.1	383	310	.2	613	8.1	
34dca	300±	Pℙt	9- 9-75	14.5	8.3	46	25	5.9	3.0	230	0	38	1.8	.8	4.0	244	220	.2	422	8.0	
49-90- 1aaa	140	Kcv	9-11-47	-----	5.0	17	8.5	827	12	270	0	1,550	35	1.0	4.9	2,590	78	41	3,540	7.6	
1aaa	140	Kcv	6- 5-67	10.5	3.4	12	5.2	695	3.2	271	17	1,250	37	1.6	1.3	2,180	50	42	3,180	8.7	
1acd	50	Qf	5-14-76	-----	20	150	38	21	2.6	380	0	270	1.8	.7	1.6	692	530	.4	1,010	7.8	
1ccc	8	Qf	9-13-76	-----	21	120	45	25	2.3	420	0	180	1.8	.8	0	605	470	.5	881	7.9	
1dbd	---	Qf	5-14-76	-----	11	60	21	7.0	1.9	230	0	67	1.8	.3	.6	283	230	.2	475	8.1	Spring.
3aaa	40	Jm	9-11-47	-----	20	428	149	794	14	334	--	3,000	14	1.4	6.5	4,590	1,680	8.4	5,190	7.6	
17acd	---	Qa	5-14-76	-----	14	200	65	100	4.4	390	0	680	0	.6	.2	1,260	760	1.6	1,640	7.5	
18ddb	1,965±	--	5-13-75	13	10	410	170	1,800	7.2	80	0	5,500	57	4.0	.1	8,000	1,700	19	8,090	7.6	Converted oil-test well.
20ccb	2,800	--	5-13-75	-----	6.7	380	270	2,300	8.4	79	0	6,900	70	4.3	.1	9,980	2,000	23	9,970	7.9	Do.
30dda	---	Qa	8- 5-68	-----	13	199	55	55	2.6	315	0	548	2.0	.2	.1	1,030	723	.9	1,360	7.9	
32abd	80	Kmt(?)	9-15-76	-----	6.5	25	5.0	1,400	3.0	450	0	2,700	24	1.8	11	4,400	83	69	5,360	8.3	

Table 5.--Chemical analyses of ground water in the Nowood River drainage area--Continued

Location	Depth of well (ft)	Water yielding unit	Date of collection	Temperature (°C)	Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (sum of constituents)	Hardness (Ca, Mg)	Sodium adsorption ratio	Specific conductance (µmho/cm at 25°C)	pH (units)	Remarks
49-91- 4acb	38(?)	Kc	9-13-76	-----	8.0	11	1.1	640	1.4	450	0	880	66	1.0	0.6	1,830	32	50	2,410	7.8	
6aab	60(?)	Kc	9-13-76	-----	15	180	140	1,600	4.9	580	0	3,700	160	1.5	27	6,120	1,000	22	6,680	8.1	
14daa	100	Qf(?)	5-14-76	-----	9.0	220	85	110	2.3	240	0	910	16	.6	.1	1,470	890	1.7	1,800	8.0	
50-89-26cad2	160	P PPt	5-12-76	-----	10	44	18	2.9	1.6	230	0	5.8	.7	.3	1.1	197	180	.1	362	8.1	
27cdc	25	Qab	5-12-76	-----	7.0	53	11	2.3	2.3	220	0	8.2	1.8	.2	.6	195	180	.1	360	7.8	
28cbc	---	Qab	5-12-76		13	71	26	4.7	2.1	330	0	23	1.8	.3	.8	306	290	.1	541	7.8	
31bab	3,995	Є,Ob(?),Mm(?)	9-10-75	25.5	11	25	17	6.4	4.7	150	0	18	1.8	.2	.6	161	130	.2	281	8.1	
32dbb	20	Qa	9-10-76	-----	15	78	18	4.1	2.1	260	0	64	0	.5	1.2	312	270	.1	501	7.8	
50-90-23cad	2,500	Mm,Ob	9-10-75	15	9.4	39	19	2.9	.9	210	0	4.1	1.8	1	2.5	180	170	.1	322	8.2	
50-92-31bba	104	Tfu	9-12-47	-----	7.0	3.0	1.3	307	6.4	642	--	7.7	101	3.2	3.5	776	13	97	1,280	8.4	
33baa	40	Qa	9-13-76	-----	8.2	40	12	320	3.5	370	0	520	7.5	1 4	3	1,100	150	12	1,580	7.3	
35aca	76	Kmv	9-12-47	-----	9.0	368	163	36	11	324	--	1,320	28	0	2.5	2,100	1,590	.3	2,490	7.5	
35bbb	---	Qf	9-13-76	-----	12	230	100	150	2.8	520	0	850	23	.6	.1	1,630	1,000	2.1	2,120	7.8	Depth 40 or 60 feet.
36bda	122	Kmv	9-12-47	-----	10	60	28	204	8.4	256	--	476	6.0	.6	4.2	926	264	5.4	1,330	7.8	

In the part of the river valley near Spring and Otter Creeks, the lack of potable water causes ranchers to haul water or use river water for domestic purposes. In contrast, relatively large supplies of potable well or spring water are easily obtained in the area east of the Nowood River valley from the Tensleep Sandstone, Goose Egg Formation, and, in places, the alluvial deposits.

The chemical quality of water in the Paleozoic rocks generally is excellent for domestic and other purposes (table 5). Most of the water in the Tensleep Sandstone and older rocks contains less than 250 mg/L of dissolved solids. Much of the water from wells completed in the Goose Egg Formation contains between 250 and 500 mg/L of dissolved solids and as much as 230 mg/L of sulfate. The presence of the sulfate is caused by the water being in contact with gypsum (calcium sulfate) beds in the formation.

Solution-Collapse Features and Spring Flow

Solution-collapse features formed principally from solution of gypsum in the Goose Egg Formation are displayed in conspicuous low lands eroded into the Goose Egg and Chugwater Formations near the Bighorn Mountains, particularly east of Big Trails, near Brokenback Creek, and east of Brokenback anticline (fig. 3). Large, deep cavities formed by solution, some of which are 75 feet in diameter, are also present in thick gypsum beds of the Goose Egg Formation near the crest of Brokenback anticline. Distribution of the alluvial deposits and bottom land also show the general location of the low lands in the eastern part of plates 1 and 2. The above average thickness of alluvial deposits, believed to be the fillings of buried collapse features, were interpreted from surface-resistivity surveys along Tensleep Creek and along Paint Rock and Medicine Lodge Creeks northeast of Hyattville. (See section, Thickness of Alluvial Aquifer.)

Two small internally drained depressions possibly caused in part from solution of the gypsum in the Goose Egg Formation are in sec. 20, T. 49 N., R. 89 W., west of Zeisman dome, and the other in sec. 34, T. 46 N., R. 87 W., near Spring Creek. The depression near Spring Creek contained a small pond during 1974-76 (table 2), but the depression near Zeisman dome is covered by a mature stand of grass, indicating that ponding has not occurred during the past few years.

At places affected by the collapse movements, the sedimentary rocks dip as much as 25° and in different directions; some of the beds are tilted in a direction opposite the true dip of the area. Part of the strata affected by the collapse movements have been offset by very small normal faults. Locally, the alluvial deposits associated with the features are tilted and also involved in the collapse movements. The deformation probably has resulted from solution of gypsum in the Goose Egg Formation and resultant collapse of the upper beds of this formation and the basal part of the Chugwater Formation.

Water discharged from well 49-88-29dac, completed in the Flathead Sandstone about 1966, also caused some subsidence and formed generally circular, vertical-walled depressions as much as 30 feet across and earth cracks in the channel and adjoining flood-plain alluvial deposits of Cottonwood Creek downstream from the well. Some of the depressions were present in 1970 when M. E. Lowry (oral commun., 1974) visited the area. In this reach, Cottonwood Creek flows on the Goose Egg Formation and the depressions resulted in part from solution of gypsum in that formation and resultant subsidence of the overlying alluvium.

Springs issue from the Goose Egg Formation, the lower part of the Chugwater Formation, or alluvial deposits overlying these formations in the low lands (pl. 2, fig. 3). Spring and permanent seep areas are present in the strata of the lower part of the Chugwater Formation in sec. 1, T. 47 N., R. 89 W. (Mark Carter, oral commun., 1975) and in the southern part of sec. 9, T. 44 N., R. 87 W. These areas contain concentrations of linear structural features that probably represent large joints; faults were not recognized at either locality. Another seep area is reported to be present in the low lands along the steep-dipping northeast limb of Brokenback anticline (Homer Renner, oral commun., 1976). The Renner Reservoir and an unnamed reservoir were built in the low lands to take advantage of the seepage as well as to impound runoff.

The spring flow is derived mainly from ground water under artesian pressure that moves upward from the Tensleep Sandstone to the alluvial deposits (if present) at the land surface, principally by means of fractures and solution channels through the Goose Egg Formation. Thus, the chemical quality of water in ponds, springs, and some streams that receive considerable spring flow are chemically similar, but the concentrations differ widely because much of the water has been in contact with gypsum beds in the Goose Egg Formation, or with soluble material in the alluvial deposits. In most analyses, calcium, sulfate, and sometimes magnesium are high as indicated by the chemical analyses of water from six springs (excluding springs at the Wigwam Fish Rearing Station) that have dissolved-solids concentration ranging from about 370 to 1,800 mg/L, calcium from about 50 to 400 mg/L, and sulfate from about 50 to 1,100 mg/L (table 5). The only ground water that contains high amounts of calcium and sulfate in the consolidated sedimentary rocks underlying the low lands occurs in the Goose Egg Formation. Water in the Tensleep Sandstone and underlying artesian aquifers contain only small amounts of sulfate, although calcium and magnesium may be comparatively high (table 5).

An increase in the sulfate and dissolved solids in Tensleep Creek occurs near Ten Sleep between stations 29 and 31 (pl. 2); this increase may be attributed to inflow of water that has moved upward from the Tensleep Sandstone, through the Goose Egg Formation and adjacent flood-plain alluvium and seeping into the creek. The specific conductance of the water in Tensleep Creek increased in a distance of about 0.8 mile from 345 µmho/cm to 610 µmho/cm between stations 29 and 31 in September 1976 and from 326 to 551 µmho/cm between these stations in November 1976 (table 3). Chemical analyses of Tensleep Creek taken at stations 29 and 31 in September 1976 indicated an increase in the dissolved-solids concentration from 213 to 472 mg/L, calcium concentration from 45 to 110 mg/L, and sulfate concentration from 58 to 230 mg/L, (table 2); only a slight increase was noted for sodium and most of the other constituents. Calcium and sulfate are also high and sodium is low in chemical analyses of waters in a small pond (SW¼ sec. 16, T. 47 N., R. 88 W.), in an abandoned meander of Tensleep Creek near station 30, and in well 47-88-15cbc completed in the flood-plain alluvium near the creek (tables 2).

Much of the flow of Alkali Creek near Ten Sleep and Crooked Creek near Big Trails are also from springs that occur in the low lands. The spring-fed Alkali Creek south of Ten Sleep contained about 2,200 mg/L of dissolved solids and 1,500 mg/L of sulfate in September 1976 (table 2); values of specific conductance taken in May 1976 also were high (table 3). Comparatively high values of the specific conductance were also obtained for the water in Crooked Creek (pl.2).

The water of most ponds in the low lands is derived from springs or from runoff that occurs mainly on the gypsiferous Goose Egg Formation or lower part of the Chugwater Formation. Dissolved solids of the ponds that obtain a considerable part of their water from seepage ranges from about 2,000 to more than 3,000 mg/L and have large concentrations of calcium and sulfate (table 2). In contrast, at the time of sampling, water in the pond in sec. 34, T. 46 N., R. 87 W. contains 372 mg/L of dissolved solids, and is of better quality than the other ponds because drainage into the pond is only over the Chugwater Formation, which does not contain gypsum.

DESCRIPTION OF SURFICIAL DEPOSITS

Only the principal surficial deposits were mapped and described during this investigation (pl. 1; table 6). For convenience of mapping, the deposits were grouped as terrace deposits (Qt1 to Qt5); flood-plain alluvium (Qf) along the Nowood River and its principal tributaries--Paint Rock, Tensleep, Canyon, Spring, Otter, and Little Canyon Creeks; alluvial deposits along the minor tributaries (Qs, Qk, Qfc); the younger (virtually undissected) alluvial-fan deposits (Qay); the older (dissected) alluvial-fan deposits (Qao); boulder-fan deposits (Qab) (present only northeast of Hyattville); and pediment deposits (Qp). The flood-plain alluvium, the younger alluvial-fan deposits, and the coarse boulder-fan deposits (Qab) (present only northeast of Hyattville) comprise the alluvial aquifer along the Nowood River and its principal tributaries. (See section on Alluvial Aquifer.) The other deposits generally are thin and discontinuous and, for the most part, are not considered to be significant sources of ground water.

Terrace Deposits

Terrace remnants, designated as terraces Qt1 through Qt5, occur between 30 and 350 feet above the present flood plain. The most widespread and conspicuous terrace remnants are of terrace Qt2. The height of the terraces along the different drainages is shown in table 7.

Andrews and others (1947) mapped terraces along the Bighorn River and along the lower 8-mile long reach of the Nowood River. In this area they designated four terrace levels, which they called terraces Qt1 to Qt4. The following short tabulation shows the terrace terminologies used in the present report and that used by Andrews and others (1947):

This report	Andrews and others (1947)
Terrace Qt1	Not present in part of area mapped by Andrews and others (1947).
Terrace Qt2 (Qt2a and Qt2b)	Qt1
Terrace Qt3	Qt2
Terrace Qt4	Qt3 and Qt4
Terrade Qt5	Not present in part of area mapped by Andrews and others (1947).

Table 6.--Lithologic and hydrologic description of the surficial deposits in the Nowood River drainage basin

Geologic unit	Lithologic description and thickness	Hydrology	Remarks concerning chemistry and use of water
Terrace deposits (Qt1, Qt2a, Qt2b, Qt2, Qt3, Qt4, and Qt5)	Coarse deposits along the Nowood River, Paint Rock Creek, and Tensleep Creek consist principally of well-rounded to rounded pebbles to small cobbles composed of dense siliceous rock types. Pebbles and cobbles are generally a minor portion of the deposits along the other streams. In most remnants of terraces Qt2a and Qt2b, the pebbles and cobbles are overlain by a layer of buff silt to sandy silt that is a combination of sheet-wash deposits, loess, and old soils. Generally, this layer is 1 to 4 feet thick but, locally, the thickness is more than 10 feet. Thickness of the terrace deposits along the Nowood River, Paint Rock Creek, and Tensleep Creek is mostly less than 20 feet; whereas, the thickness of the deposits along tributaries to these streams range from 10 to more than 30 feet.	Seepage derived from infiltration of irrigation water occurs along the base of some of the terrace Qt2a and Qt2b deposits, particularly near Hyattville. The areal extent of most of the other terrace deposits is too small to store an appreciable amount of water.	Because of their limited areal extent and because only the basal part of few (terraces Qt2a and Qt2b) of the deposits are saturated, none of the terrace deposits are favorable for development of ground water by wells.
Flood-plain alluvium (Qf)	Clay to cobbles. Coarsest alluvium is along Tensleep, Paint Rock, and Medicine Lodge Creeks. Thickness is less than 50 feet along the Nowood River and locally as much as about 80 feet along Tensleep and Paint Rock Creeks and about 90 feet along Medicine Lodge Creek.	Deposits are a major part of the alluvial aquifer. Well yields probably are less than 50 gal/min along the Nowood River. Locally, well yields may be more than 100 gal/min along Tensleep, Paint Rock, and Medicine Lodge Creeks.	Low yields and poor chemical quality preclude development for irrigation and industrial purposes along Nowood River and lower reaches of Paint Rock Creek. Alluvium furnishes water for stock and, in places, for domestic use. Chemical quality of water in the alluvium along Nowood River in area near the mouth of Spring Creek is so poor that the water is not used for domestic purposes. Wells drilled in thickest part of the alluvium along Paint Rock and Medicine Lodge Creeks northeast of Hyattville may obtain enough water for some industrial uses and possibly for irrigation. In this area the chemical quality of water is good to fair.
Main alluvium in tributary valleys (Qs)	Chiefly of reddish-brown silt to sand derived from the nearby Triassic and Permian rocks. Grey to greyish-brown silt beds containing considerable amounts of organic material are exposed along much of Brokenback Creek and near Spring Creek in sec. 22, T. 46 N., R. 87 W. Also along Brokenback Creek in sec. 26, T. 48 N., R. 88 W., is a 3- to 4-foot thick bed of earthy gypsum is interbedded with alluvium and presumably was deposited in a small lake. The minor quantity of gravel that represents the fills of small channels occurs in lenses mainly in the lower part of the alluvial exposures. Thickness ranges from about 10 to more than 30 feet.	Few wells penetrate the alluvium and virtually no hydrologic information is available. Along some drainages the alluvium is recharged from water moving upward from the sedimentary bedrock and from small streams.	The alluvium along Alkali Creek (north of Hyattville) and Buffalo, Brokenback, and Crooked Creeks probably are of sufficient permeability and thickness to yield small amounts of water to wells, although much of this water is not suitable chemically for domestic purposes. The alluvium in the other drainages contain insufficient water to be considered for development by wells.
Alluvium in undissected low areas (Qk)	Clay to silt. Thickness is unknown.	Numerous seeps and a few springs are present. The seepage and spring flow is water that discharges into the alluvium from Paleozoic aquifers.	At least six reservoirs, including the Renner Reservoir, have been built to take advantage of the spring flow and seepage. The few wells penetrating this alluvium were completed in the underlying Paleozoic aquifers.
Flood-plain alluvium in abandoned valley near Big Trails (Qfc)	Consists of poorly formed lenticular layers of light-reddish brown silt, silty sand, and sand. Beds of gravel not noted in the exposures. Thickness is unknown.	Wells do not penetrate the unit, but its water-yielding characteristics may be similar to that of the flood-plain alluvium of the nearby Nowood River and Little Canyon Creek.	
Younger (generally undissected) alluvial-fan deposits (Qay)	Consist mainly of poorly sorted mixtures of silty sand to silt in lenticular layers less than 1.5 feet thick. Gravel, containing considerable silt, is present only as fills of small channels. Fan material is derived chiefly from the generally shaly Triassic to Cretaceous rocks, which contribute little coarse detritus from erosion. Sediment derived from the Triassic rocks is light brown to light-reddish brown; whereas, sediment from the other rocks generally is a light gray to buff. Thickness of most deposits range from about 20 to more than 30 feet.	Deposits are a minor part of the alluvial aquifer. Deposits yield less than 20 gal/min to wells because of low permeability caused by the high percentage of silt in the sand and gravel beds.	Used for stock and locally for domestic purposes. In places, the deposits may not yield sufficient water for completion of wells, or the poor chemical quality of the water precludes its use for domestic purposes.
Older (dissected) alluvial-fan deposits (Qao)	Lithologic descriptions of the deposits are same as for the younger alluvial-fan deposits, except the older fan deposits generally are slightly darker brown or more reddish brown than the younger fan deposits. Most deposits are more than 30 feet thick.	In few exposures where the deposits may contain some water, their hydrologic characteristics probably are the same as the younger alluvial-fan deposits.	Deposits are not known to yield water to wells. Their limited distribution and general thinness indicates that they are not a likely source for ground-water supplies.
Boulder-fan deposits (Qab)	Consists of coarse detritus containing some boulders more than 4 feet in diameter. Thickness is between about 30 to 80 feet as determined from surface resistivity measurements	Deposits are part of the alluvial aquifer. Well yields may be more than 100 gal/min in thick sections of the deposits.	Used for stock and domestic purposes. Water of good to fair chemical quality. Deposits probably will yield enough water for some industrial and irrigation uses
Pediment deposits (Qp)	Consists of sand to silt with minor amounts of gravel. The gravel is concentrated in lenses and contain much silt. Thickness is mainly less than 15 feet.	Deposits do not contain water, except in places where deposits are recharged from irrigation. Locally, seepage from infiltration of the irrigation water emerges along the base of the deposits.	Development of ground water is not feasible owing to the thinness, silty composition, and limited extent of the deposits.
Landslide deposits (Qls)	Consists of jumbled masses of debris derived mainly as slumps from the Mowry Shale and Frontier Formation (Cretaceous). Thickness is unknown.	Deposits probably do not transmit appreciable amounts of ground water.	

Table 7.--Height of terraces in the Nowood River drainage area

Terrace	Height of terraces, in feet, above streambed									
	Bighorn River near Manderson	Nowood River throughout area	Paint Rock Creek	Buffalo Creek		Broken-back Creek	Tensleep Creek	Spring Creek	Otter Creek	Crooked Creek
				Lower reach	Upper reach					
Qt1	-------	30- 40	------	-------	-------	-------	-------	35- 40	-------	-------
Qt2	80	50-100	50-60	60- 70	40- 50	70	40- 50	60- 70	-------	-------
Qt3	-------	120-150	130	130	100	100	-------	100	120	-------
Qt4	200-250	200-260	220	-------	200±	-------	180	250	200	120-140
Qt5	300-350	280-300	-------	-------	300-320	300-340	330	200-250	320-340	250

Terrace deposits Qtl through Qt5 along the Nowood River, Bighorn River, Paint Rock Creek, and Tensleep Creek (pl. 1; table 6) consist of pebbles to cobbles; whereas, the deposits along the other streams contain mixtures of sand to sandy silt that include various amounts of coarse materials. In the area where the tributary creeks leave the canyons of the Bighorn Mountains, some pebbly and cobbly deposits are present. In most remnants of the relatively widespread terraces Qt2a and Qt2b, the pebbles and cobbles are overlain by a layer of silt to sandy silt. Due to the rather wide distribution of the silt layer, some of the terraces are farmed and others could be cleared for cultivation.

Flood-Plain Alluvium

The flood-plain alluvium (mapped as Qf), including the modern channel deposits, is present as a narrow band that adjoins the channels of the main streams. The width of the valley floor of the Nowood River underlain by the flood-plain alluvium ranges from only about 0.1 mile near Big Trails to 0.75 mile downstream of Paint Rock Creek. Locally, the alluvium is as much as 0.75 mile wide along Tensleep Creek and 0.5 mile wide near the confluence of Paint Rock and Medicine Lodge Creeks at Hyattville.

Along the Nowood River, the flood-plain alluvium represents at least two periods of alluviation separated by at least one period of erosion and channeling that occurred prior to the formation of the modern channel. The older deposit forms the bulk of the alluvium and is preserved as a terrace about 6-12 feet above river level (pl. 2) and 18-34 feet below terrace Qtl. Generally, this terrace is capped by an immature soil as much as a foot thick and considerable organic matter. The younger deposits, forming local 3- to 5-foot high terraces, commonly are flooded by the river. The terraces are modified by numerous scarplets that indicate the presence of abandoned channels and meanders. Many of the abandoned channels contain swamps and are filled by silty to clayey sediments.

The flood-plain alluvium along the Nowood River generally is similar in lithology at most localities . Most exposures display thin layers of silty sand to clay that contain considerable amounts of organic material. At places, dark-gray, fine-grained, partly carbonaceous, lenticular layers suggest accumulation of sediment in shallow ponds or abandoned channels. Lenses of rounded pebbles to small cobbles are not common in the upper part of the deposits but some can be seen in clear exposures near river level. The pebbles and cobbles consist mainly of chert, quartzite, and other dense siliceous rocks derived from older deposits and from the Bighorn Mountains.

The few logs of wells drilled through the flood-plain alluvium along the Nowood River also indicate that the alluvium is rather fine grained and that gravel occurs only in the bottom-most few feet (table 8). Except for well 49-91-24ba, thicknesses of the gravel reported by drillers' logs range from only 5 to 11 feet. The small amount of gravel limits the quantity of ground water that can be obtained from wells completed in the alluvium.

The alluvium along Tensleep, Paint Rock, and Medicine Lodge Creeks occurs as broad, multiple fill terraces generally 3 to 8 feet above stream level. The low terraces may be modified by abandoned and modern flood channels. In general, the alluvium consist mainly of pebbles to small boulders. In the few logs that are available of wells along Tensleep and Paint Rock Creeks, well drillers also reported considerable gravel in the alluvial deposits (table 8). Many of the terraces have a capping layer of sandy silt to silty sand that is sufficiently thick to permit cultivation.

The flood-plain alluvium along Spring and Otter Creeks is not as coarse as the alluvium along Tensleep and Paint Rock Creeks but is coarser than the alluvium along the Nowood River. Exposures of the alluvium are limited because the channels of Spring and Otter Creeks are only 5-7 feet deep. In these creek-bank exposures, the alluvium consists mainly of sand to silt, with pebbles and cobbles in the lower part. Only near the mouths of the canyons where these streams leave the Bighorn Mountains is the alluvium composed principally of rounded pebbles and cobbles.

Alluvium in Small Tributary Valleys

Alluvium (mapped as Qs and Qk) consists of narrow belts of flood-plain alluvium along the stream channels and of alluvial-fan, pediment, and colluvial deposits on the adjoining relatively wide valley slopes. The alluvium mapped as Qs is widely exposed in low terraces along the many tributary drainages of the area, particularly along reaches of streams in the low lands (fig. 3) which are carved from the Chugwater and Goose Egg Formations. The alluvium mapped as Qk occupies only undissected low areas in the bottom land where seepage occurs and several reservoirs have been built. The deposits consisting mainly of clay to sand are generally similar in composition, with only local differences noted as to the amounts of organic material, silt, or clay present.

Table 8.--Driller's logs of wells showing description of the alluvial deposits.

(Except for well 44-88-1bd, all the wells penetrate the entire thickness of the alluvial deposits.)

Well no.	Depth (ft)	Thick-ness (ft)	Description	Drainage and remarks
44-88-1bd	1	1	Sandy red soil	Nowood River.
	3	2	Gray sand and silt	
	14	11	Gray sand--silt and clay, hard	
	25	11	Gravel	
47-87-6	12	12	Dirt and broken rock	Tensleep Creek.
	23	11	Boulders, sand	
47-88-1cda	82	82	Valley fill	Tensleep Creek. Well drilled on a low terrace about 15 feet above general level of the valley floor.
47-88-15cbc	36	34	Gravel	Tensleep Creek.
47-88-16cca	14	14	Surface gravel	Tensleep Creek.
47-88-16daa	2	2	Top soil	Tensleep Creek.
	52	50	Boulders and valley fill	
47-88-20aad	9	9	Sand and gravel	Tensleep Creek.
47-88-21aba	23	23	Soil and boulders	Tensleep Creek.
49-90-1ac	2	2	Dirt	Paint Rock Creek.
	45	43	Boulders and sand	
49-91-4ab	20	20	Clay	Nowood River.
	25	5	Gravel	
49-91-4ac	20	20	Clay	Nowood River.
	30	10	Gravel	
49-91-14da	27	27	Dirt and quick sand	Nowood River.
	33	6	Gravel and sand	
49-91-24ba	26	26	Sand and gravel	Nowood River.

A mile-long remnant of flood-plain alluvium (mapped as Qfc) is preserved in an abandoned valley near Big Trails. The abandoned valley is about 200 feet deep and has an average width of about 800 feet. Antecedent Little Canyon Creek probably alternately occupied this valley and its present valley downstream of Big Trails. The flood-plain remnant in the valley forms a 15- to 20-foot bank above the modern flood-plain alluvium along Little Canyon Creek and the Nowood River. This alluvium is older than the flood-plain alluvium (Qf) and the younger alluvial-fan deposits along the Nowood River and Little Canyon Creek. Possibly, it may be the only remnant of a flood-plain alluvial deposit near the Nowood River that was associated with the formation of the older alluvial-fan deposits.

Episodes of accelerated deepening of channels during the past century and at earlier time have dissected the alluvial deposits (principally Qs) in the tributary valleys. This channel dissection along parts of Buffalo and Brokenback Creeks and locally other drainages has formed two main alluvial terraces, which are younger than gravel-capped terraces Qtl through Qt5. The higher terrace is as much as 36 feet high and was formed at least a few centuries ago. The lower terrace, generally less than 15 feet above the stream channel, represents the level of the valley floor before the deepening of the channels that began during the past century (pl. 2). In many valleys headward-cutting gullys associated with this channel trenching have destroyed valuable crop and grazing land. Continued deepening of stream channels during historic time has progressively lowered the ground-water table and, therefore, decreased the amount of water stored or drained the alluvial deposits.

Younger Alluvial-Fan Deposits

The younger, generally undissected, alluvial-fan deposits (mapped as Qay) merge with and are the lateral equivalents of the flood-plain alluvium. They occupy discontinuous exposures along the margins of the valley floor. These deposits are formed of detritus brought in by tributaries of the Nowood River and Tensleep, Paint Rock, Medicine Lodge, Canyon and Little Canyon Creeks.

The largest alluvial fans occur at the mouths of tributary streams and extend for slightly more than 2 miles along the main drainages. However, most fans occupy relatively small areas. Due partly to the gentle slopes, the fan deposits along the valley floors of the Nowood River and Tensleep and Paint Rock Creeks have been subjected to only slight erosion, which only in a few localities has been sufficiently severe to hamper cultivation.

Older Alluvial-Fan Deposits

Exposures of the older, dissected alluvial-fan deposits (mapped as Qao) are present only at scattered localities (pl. 1). All the older fan deposits are dissected, some severely, and occur as small isolated outcrops. In some localities, the base of the fan deposits is higher than the general level of the nearby valley floor. Thus, small exposures of the sedimentary rocks may be present along stream channels that cross the fan deposits.

Boulder-Fan Deposits

Coarse boulder-fan deposits (mapped as Qab), the coarsest part of the alluvial aquifer, cover much of the broad confluent valleys of Paint Rock and Medicine Lodge Creeks about 4 miles northeast of Hyattville where these creeks cross the low lands containing solution-collapse features. These deposits include mostly gneiss and granite boulders, of which some are slightly more than 4 feet in diameter. The granite and gneiss boulders probably are derived from the Precambrian rocks in the Bighorn Mountains that are exposed in the upper Paint Rock Creek drainage area. Although Medicine Lodge Creek drains a small area of granite and gneiss, these rock types were not found during a brief inspection of deposits along this creek upstream of the boulder-fan deposits. The eroded summit of the boulder-fan deposits slopes gently westward to northwestward and is between 20 and 40 feet above the nearby creekbeds. The fan is transsected by several northwest-trending swales and channel-like features that are interpreted to be old drainage courses of Paint Rock Creek. A series of surface-resistivity measurements revealed that a bedrock ridge is concealed beneath the central part of the fan deposits.

Remnants of the boulder and the older alluvial-fan deposits are lower than remnants of terrace Qtl and higher than the terraces formed from the flood-plain alluvium. As best determined, these fan remnants are about 20 feet above the present channel of the Nowood River, which is also the height of the alluvium in the abandoned valley near Big Trails.

Pediment Deposits

Gentle slopes of the area are overlain by a thin, discontinuous surficial mantle, consisting of colluvium, loess, slope wash, alluvial-fan, and some terrace deposits. Collectively, these deposits--mainly the upslope equivalents of terraces Qt2a and Qt2b deposits--are referred to as pediment deposits (mapped as Qp). Only the principal deposits are shown on plate 1. The pediment deposits are generally fine grained--principally composed of mixtures of sand and silt locally containing lenticular beds of gravel. Some of these deposits recently have been cultivated for alfalfa or grain crops.

Landslide Deposits

Two small landslides (mapped as Qls) are present in sec. 19, T. 48 N., R. 89 W. and in secs. 13 and 14, T. 48 N., R. 90 W., along the southwest side of the flood plain of the Nowood River. They outline small areas of hummucky topography at the base of cliffs eroded from the Cretaceous formations.

Deposits Associated with Solution-Collapse Features

Deposits associated with or deposited in some of the solution-collapse features and not known to occur in the other parts of the Nowood River drainage basin include a cemented gravel deposit, reprecipitated gypsum, siliceous material, and a few beds of volcanic ash (fig. 3; table 9). Except possibly for the cemented gravel near Spring Creek, these deposits are dry. Small springs, two of which were sampled for chemical analysis (table 5), issue from the alluvium adjoining the cemented gravel. Although part of this spring flow may be from the cemented gravel, most of the flow probably is from the Goose Egg Formation, which is exposed nearby.

ALLUVIAL AQUIFER

The flood-plain alluvium and younger alluvial-fan deposits are hydraulically connected and form the principal units of the alluvial aquifer. Upstream from Hyattville, the alluvial aquifer also includes the boulder-fan deposits. The flood-plain alluvium, however, is the most widespread unit of the alluvial aquifer. The alluvial aquifer is best developed along the Nowood River and its main tributaries including Paint Rock, Tensleep, Spring, Otter, and Little Canyon Creeks. Hydrology of the other alluvial deposits (table 7) is not discussed in this section.

Thickness

In general, the alluvial aquifer is thin throughout the Nowood River drainage area. Due to the sparcity of the well-log data, surface-resistivity measurements were made to obtain additional thickness information. All available thickness data are shown on plate 2.

Table 9.--Brief description of deposits associated with solution-collapse features

Deposit	Description and remarks
Cemented gravel sec. 23, T. 46 N., R. 87 W.	Light-gray cemented sand and gravel that includes some large cobbles. Pebbles and cobbles are well-rounded to subrounded and consist mainly of sandstone, limestone, and chert. Deposit displays conspicuous medium-scale cross strata. The base of the deposits are not exposed, but the thickness is at least 60 feet. Yields water to springs.
Earthy gypsum deposits in Brokenback Creek valley	Deposits consist of poorly to well-formed layers of silty gypsum and gypsum, locally as much as 70 feet thick. The gypsum rests on an irregular surface formed from solution-collapse of the Goose Egg and Chugwater Formations. The gypsum beds may dip as much as 20 degrees. At places the gypsum underlies deposits of terraces Qt2 and Qt3. The gypsum is derived from leaching and reprecipitation of the gypsum in the Goose Egg Formation.
Siliceous material in Brokenback and Buffalo Creek drainage areas.	Deposits consist of very hard, platy, white, generally thinbedded layers. Absence of calcareous cement is indicated from the virtual lack of effervescence when hydrochloric acid is applied. Some of the deposits are more than 10 feet thick and overlie earthy gypsum deposits. The deposits are resistent to erosion and, at places, form the cap rock on low bluffs 100 to 180 feet above South Fork of Brokenback Creek.
Volcanic ash beds and associated deposits	The ash bed in sec. 23, T. 46 N., R. 87 W., is exposed in a borrow pit and overlies the cemented gravel described above. The ash bed is about 1 foot thick and occurs near the top of a 5-foot thick sequence that consists of layers of sandy silt and silty sand. The fine-grained sequence is interpreted to represent deposition in a shallow pond or depression that may be associated with solution-collapse features. A similar ash bed occurs in the strike valley about 6½ miles south of Big Trails. This ash bed is about 4 feet thick and is present in the lower part of an exposure that displays reddish-brown silty and sandy sediments. The sediments are more than 50 feet thick. Both ash beds are very fine grained in contrast with the Pearlette ash beds, which are coarse grained; they probably represent volcanic eruptions from the Yellowstone National Park area, younger than the eruptions that produced the Pearlette ash beds (K. L. Pierce, oral commun., 1976). An older coarse-grained ash bed, tentatively identified by Pierce (oral commun., 1976) as one of the younger Pearlette ash beds, forms the basal part of terrace Qt4 deposits about 250-feet above Spring Creek in sec. 26, T. 46 N., R. 87 W. The ash bed is 10-12 feet thick and underlies a 15-foot thick layer of pebbles and cobbles.

Forty-two surface-resistivity measurements were made at 10 locations to determine the thickness of the alluvial deposits. Many geoelectric horizons--indicating some change in electrical resistivity of the earth--reported from the resistivity data are depths to the base of the alluvial deposits, which is considered to be the contact between the unconsolidated alluvium deposits and the underlying consolidated sedimentary rocks. Most of these depth determinations compare favorably with available depth to bedrock information from well logs. In a few localities, geoelectric values are deeper than expected, which apparently are due to the conductive properties of the pore fluids in the rocks that underlie the alluvium at those locations. These values probably indicate depths to the base of sandstone beds that are present in the upper part of the underlying sedimentary rocks (table 10).

Based on the results of the surface-resistivity measurements and the well-log information, the alluvial aquifer along the Nowood River is less than 50 feet thick. Near Big Trails the alluvium is 25 to 30 feet thick. Downstream near the mouth of Tensleep Creek the thickness ranges between 23 and possibly 46 feet. Farther downstream at the narrows in sec. 33, T. 48 N., R. 89 W., two geoelectric horizons are indicated. The shallow horizon at a depth of 41 feet is probably the base of the alluvium and the deeper horizon at a depth of 82 feet may represent a sandstone bed in the Morrison Formation, which underlies the alluvium at this locality. Near the mouth of Paint Rock Creek where the flood plain of the Nowood River is wide, the thickness of the alluvium ranges from 25 to 45 feet. (See cover.) Two electrical-resistivity measurements made 4 miles upstream of the river mouth indicated distinct geoelectric horizons at depths of 34 and 39 feet, which are believed to be the base of the flood-plain alluvium. From the wells correlated and listed by Swenson and Bach (1951, table 7), the thickness of the alluvium near the mouth of the Nowood River probably is not more than 50 feet. Additional information concerning the geologic interpretation of the geoelectric horizons obtained from the surface-resistivity measurements is in table 10.

Two profiles comprising 16 surface-resistivity measurements were made across the wide valley of Tensleep Creek near Ten Sleep. From the resistivity measurements, the maximum thickness of the alluvium in a buried channel or channel-like feature was determined to be nearly 80 feet about 1 mile east of Ten Sleep and about 50 feet 3 miles east of the town. (See cover.) Two driller's logs of water wells show that the depths of the alluvium are more than 50 feet at a location 1 mile east of Ten Sleep and at the Wigwam Fish Rearing Station 4 miles northeast of Ten Sleep. The surface-resistivity measurements along both profiles and the well logs indicate a shallow bedrock platform overlain by less than 25 feet of deposits extending upstream from Ten Sleep along the base of cliffs at the southern border of the valley. The resistivity measurements and the log of well 47-88-16cca also determined that the pediment deposits on the gentle valley slopes north of Ten Sleep are only about 15 feet thick.

Table 10.--Geologic interpretation of the geoelectric horizons indicated from surface resistivity measurements.

[Resistivity field crew or data processing personnel: D. M. Hudson, T. O. McGowan, D. S. Barker, and K. T. Kilty]

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		NOWOOD RIVER
Sec. 18, T. 44 N., R. 87 W.	15	Base of alluvium; depths of a few wells penetrating the alluvium in this area range from 15 to 30 feet.
	26	Base of alluvium; depths of a few wells penetrating the alluvium in this area range from 15 to 30 feet.
Sec. 24, T. 47 N., R. 89 W.	26	Base of alluvium; driller's log of well 47-88-16daa 1½ miles to the east (along Tensleep Creek) indicates an alluvial thickness of 52 feet.
	24	Base of alluvium; driller's log of well 47-88-16daa 1½ miles to the east (along Tensleep Creek) indicates an alluvial thickness of 52 feet.
	46	Probably base of alluvium.
	27	Base of alluvium.
	39	Probably base of alluvium.
	30±	Probably base of alluvium; measurement was taken across Tensleep fault.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		NOWOOD RIVER--Continued
Sec. 33, T. 48 N., R. 89 W.	41	Probably base of alluvium; a nearby well that withdraws water from the alluvium has a depth of 32 feet.
	82	Probably base of a sandstone bed in the Morrison Formation that underlie the alluvium in this area.
Secs. 13, 14, T. 49 N., R. 91 W.	43	Base of alluvium; driller's logs of nearby wells indicate alluvial thickness of 26 and 33 feet.
	45	Base of alluvium; driller's logs of nearby wells indicate alluvial thickness of 26 and 33 feet.
	25	Base of alluvium; driller's logs of nearby wells indicate alluvial thickness of 26 and 33 feet.
	25	Base of alluvium; driller's logs of nearby wells indicate alluvial thickness of 26 and 33 feet.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks [1]
		NOWOOD-RIVER--Continued
Sec. 34, T. 50 N., R. 92 W.	5	Geoelectric horizon in flood-plain alluvium.
	10	Do.
	12	Do.
	34	Probably base of flood-plain alluvium.
	56	Sandstone bed in Mesaverde Formation or possibly base of flood-plain alluvium; depth of water wells in the lower reach of Nowood River completed in the sedimentary rocks underlying the alluvium range from 37 to 76 feet.
	7	Geoelectric horizon in flood-plain alluvium.
	9	Do.
	39	Probably base of flood-plain alluvium.
	121	Sandstone bed in Mesaverde Formation.
	194	Do.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		TENSLEEP CREEK
Secs. 11, 14, T. 47 N., R. 88 W.[2]	22	Base of alluvium; measurement made near exposure of Chugwater Formation along north side of valley.
	54	Base of alluvium in deep part of buried channel of Tensleep Creek; driller's logs of wells 47-88-1cda and 16daa indicate alluvial thicknesses of 82 and 52 feet, respectively.
	44	Base of alluvium in deep part of buried channel of Tensleep Creek; driller's logs of wells 47-88-1cda and 16daa indicate alluvial thicknesses of 82 and 52 feet, respectively.
	20	Base of alluvium in southeastern part of valley underlain by a shallow buried bedrock platform; driller's log of well 47-88-21abb indicates an alluvial thickness of 23 feet.
	8	Base of alluvium in southeastern part of valley underlain by a shallow buried bedrock platform; driller's log of well 47-88-21abb indicates an alluvial thickness of 23 feet.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		TENSLEEP CREEK--Continued
Secs. 15, 16, 21, T. 47 N., R. 88 W.[2]	7	Base of pediment deposits; driller's log of well 47-88-16cca indicates 14 feet of pediment deposits.
	10	Base of pediment deposits; driller's log of well 47-88-16cca indicates 14 feet of pediment deposits.
	33	Base of alluvium; drillers' log of nearby well 47-88-16daa indicate an alluvial thickness of 52 feet.
	38	Base of alluvium; drillers' log of nearby well 47-88-16daa indicate an alluvial thickness of 52 feet.
	38	Base of alluvium; drillers' log of nearby well 47-88-16daa indicate an alluvial thickness of 52 feet.
	79	Base of alluvium in deep part of buried channel of Tensleep Creek; driller's logs of wells 47-88-1cda and 16daa indicate alluvial thicknesses of 82 and 52 feet, respectively.
	13	Base of alluvium on shallow buried bedrock platform; driller's log of wells 47-88-20aad and 21abb indicate alluvial thicknesses of 9 and 23 feet, respectively.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		PAINT ROCK CREEK
Sec. 16, T. 50 N., R. 89 W.	7	Base of alluvium; Tensleep Sandstone is exposed in nearby channel of Medicine Lodge Creek; about 12 feet of alluvium at archaeological excavation to the west (G. C. Frison, oral commun., 1976).
Secs. 27, 28, 34, T. 50 N., R. 89 W.[2]	5	Geoelectric horizon in the flood-plain alluvium.
	8	Geoelectric horizon in the flood-plain alluvium.
	95	Probably base of alluvial deposits; extreme depth may be due to the filling of the alluvium of a large collapse feature caused by solution of gypsum in the Goose Egg Formation. Generally, the base of the alluvium under the flood plain does not not exceed 50 feet as determined from well-log information near Hyattville, other resistivity measurements, and bedrock outcrops in the channel of Medicine Lodge Creek about 1½ miles upstream.
	30	Probably base of boulder-fan deposits along sides and crest of a buried ridge that occurs between Paint Rock and Medicine Lodge Creeks.
	28	Probably base of boulder-fan deposits along sides and crest of a buried ridge that occurs between Paint Rock and Medicine Lodge Creeks.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		PAINT ROCK CREEK--Continued
Secs. 27, 28, 34, T. 50 N., R. 89 W.[2]--Continued		
	39	Probably base of boulder-fan deposits along sides and crest of a buried ridge that occurs between Paint Rock and Medicine Lodge Creeks.
	3	Geoelectric horizon in boulder-fan deposits.
	12	Geoelectric horizon in boulder-fan deposits.
	65	Base of boulder-fan deposits in deep part of buried channel of Paint Rock Creek; elevation of measurement is about 20 feet above Paint Rock Creek.
	2.5	Geoelectric horizon in boulder-fan deposits.
	12	Do.
	20	Do.
	80	Probably base of boulder fan deposits in deep part of buried channel of Paint Rock Creek; elevation of measurement is about 20 feet above Paint Rock Creek.

Table 10.--Geologic interpretation of the geoelectric horizons--Continued

Location	Depth to geoelectric horizon at each measurement horizon [1] (ft)	Interpretation of geoelectric horizon relating to the alluvial bedrock contact and remarks
		PAINT ROCK CREEK
Sec. 17, T. 49 N., R. 90 W.	38	Base of Frontier Formation or base of alluvium; measurements are near southwestern edge of the Frontier Formation. A nearby well completed in the Frontier Formation indicates the alluvium is less than 27 feet thick and driller's logs of two wells 2½ miles to the west (along Nowood River) indicate alluvial thicknesses of 26 and 33 feet.
	44	Base of Frontier Formation or base of alluvium; measurements are near southwestern edge of the Frontier Formation. A nearby well completed in the Frontier Formation indicates the alluvium is less than 27 feet thick and driller's logs of two wells 2½ miles to the west (along Nowood River) indicate alluvial thicknesses of 26 and 33 feet.
	40	Base of Frontier Formation or base of alluvium; measurements are near southwestern edge of the Frontier Formation. A nearby well completed in the Frontier Formation indicates the alluvium is less than 27 feet thick and driller's logs of two wells 2½ miles to the west (along Nowood River) indicate alluvial thicknesses of 26 and 33 feet.

[1] Figure underlined is the value shown on plate 2 for the base of the alluvial deposits.

[2] Measurement locations are arranged from north to south.

Seven surface-resistivity measurements were made across the wide area underlain by the boulder-fan deposits between Paint Rock and Medicine Lodge Creeks 4 miles northeast of Hyattville. Results of the measurements indicate that a low, presumably westward-trending, buried bedrock ridge lies between these two creeks. Depths of the geoelectric horizons that probably represent the base of the boulder-fan deposits are between 28 and 40 feet below the land surface along the buried ridge, as much as 80 feet near Paint Rock Creek and 95 feet near Medicine Lodge Creek. The large, seemingly excessive, thickness of more than 70 feet of alluvial deposits along parts of Tensleep, Paint Rock, and Medicine Lodge Creeks have only local distribution and may represent the fills of large solution-collapse features. (See section Solution-Collapse Features and Spring Flow.)

The thickness of the alluvial aquifer is not known along Canyon, Spring, Otter or Little Canyon Creeks. The only available information along these creeks is from well 45-87-7add, which has a depth of 20 feet and is completed in the flood-plain alluvium along Otter Creek.

Well Yields

The meager well-yield information in table 11 indicates that only low yields can be expected from the alluvial aquifer. Along the Nowood River, the average yield is not known but maximum yields of more than about 25 gal/min may be possible in only a few areas, such as at the narrows in sec. 33, T. 48 N., R. 89 W. and at the mouths of the large creeks such as Tensleep or Paint Rock Creeks.

Well yields should be higher in the gravelly deposits along Tensleep and Paint Rock Creeks than in the deposits along the Nowood River. However, the only information about well yields is from several shallow water wells in lower Tensleep Canyon (sec. 6, T. 47 N., R. 87 W.) and from one well near Hyattville. The wells in Tensleep Canyon were tested briefly at rates of 10 to 40 gal/min. The well tested at 40 gal/min was reported to have no drawdown; the gravel here is considerably coarser than the gravel in the wide valley of Tensleep Creek below Tensleep Canyon. If the yields of the wells in Tensleep Canyon are representative for the alluvial aquifer along Tensleep Creek, then the maximum yields of properly constructed wells penetrating large thicknesses of the gravelly deposits between the canyon and Ten Sleep may exceed 100 gal/min.

Table 11.--Records of wells that withdraw water from the alluvial aquifer.

[Data obtained from the files of the Wyoming State Engineer, Cheyenne, Wyo., as reported by the owners at the completion of the wells]

Well no.	Depth of well (ft)	Static water level (ft)	Alluvial aquifer: Depth to base (ft)	Alluvial aquifer: Saturated thickness (ft)	Yield (gal/min)	Drawdown (ft)	Length of test (hrs)
47-87-6	28	6	23	17	20	([1])	2
6	28	9	28+	19+	40	0	3/4
6	22	10	22+	12+	10	([2])	3
6	20	16	--	--	25	--	---
6	30	21	--	--	20	1/2	1/2
6	35	25	--	--	20	1½	1/2
49-90-1acd	50	13	45	32	20	30	1
49-91-4abb	38	16	25	9	5	([3])	1/3
4acb	[4]110	--	30	--	20	([5])	1/3

[1] Reported drawdown is below base of alluvial aquifer.

[2] Reported drawdown is below depth of well.

[3] Reported drawdown is below base of alluvial aquifer and equal to depth of well.

[4] Water from alluvial aquifer and rocks of Cretaceous(?) age.

[5] Reported drawdown is below base of alluvial aquifer.

Information is not available on the maximum well yields of the boulder-fan deposits northeast of Hyattville; only a few small domestic and stock wells withdraw water from the deposits. These deposits, are the coarsest in the Nowood River basin and should have the highest permeability and yield of the alluvial deposits. However, a well drilled near Hyattville in the gravelly flood-plain alluvium downstream of this fan deposit is reported to yield only 20 gal/min. This well was drilled near the contact between the younger alluvial-fan deposits and the flood-plain alluvium. Its yield is probably low and not fully representative for the alluvial aquifer along Paint Rock Creek downstream from the boulder-fan deposits.

Chemical Quality

The chemical quality of water in the alluvial aquifer differs widely throughout the area. Dissolved-solids concentration generally is more than 1,000 mg/L, except near Tensleep Canyon and along Paint Rock and Medicine Lodge Creeks upstream from Hyattville where the amounts of dissolved solids are less than 300 mg/L (table 5). The concentrations of most individual constituents, particularly calcium, magnesium, sodium, and sulfate in the water analyzed also range widely as shown in the tabulation below:

	Mg/L
Calcium	25 - 440
Magnesium	8.8 - 100
Sodium	2.3 - 350
Sulfate	5.8 - 1,500

Chloride is low and bicarbonate is high in all the chemical analyses. Fluoride is commonly more than 0.5 mg/L, but less than 1.5 mg/L. Two analyses of well water along the Nowood River show a fluoride concentration of 1.0 mg/L, and an analysis of well 50-92-33baa lists 1.4 mg/L of fluoride. All the water is very hard; many analyses indicate a hardness, calculated as calcium carbonate, of more than 700 mg/L, and only a few analyses show a hardness of less than 200 mg/L.

In the alluvial aquifer along the Nowood River, the dissolved solids, as determined from 10 of 11 analyses, have a range from 957 to 1,700 mg/L; the remaining analysis indicates the amount of dissolved solids to be 2,570 mg/L. Near the mouths of Spring and Otter Creeks, as reported by ranchers, the water in the alluvial aquifer, as well as the water in the underlying sedimentary rocks, seem to be unfit for drinking and domestic purposes. In general, the chemical quality of the water in the alluvial aquifer seems to be affected mainly by: (1) The quality of the water discharged to the deposits from the adjacent sedimentary bedrock, (2) the quality of water that enters the deposits along the Nowood River from deposits along the main tributary streams, and (3) the amount of interchange between the generally better quality water of the Nowood River and the water in the adjacent alluvial deposits.

In the alluvial aquifer along Tensleep Creek, there is a progressive increase in the amount of dissolved solids and constituents, especially calcium and sulfate, in the downstream direction as shown in the following tabulation:

Well number and general location	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved solids (sum of constituents) (mg/L)
47-87-6daa Tensleep Canyon	25	12	3.5	5.8	126
47-88-11cdb 2.3 mi east of Ten Sleep	47	23	4.1	25	224
47-88-15cbc	280	71	43	820	1,380

The values of specific conductance of the water of Tensleep Creek also increases markedly in the downstream direction (table 3). Much of the increase in dissolved solids and constituents probably is due to water moving upward from the Tensleep Sandstone and other bedrock aquifers through the gypsum-bearing Goose Egg Formation and into the alluvial deposits. (See section Solution-Collapse Features and Spring Flow.)

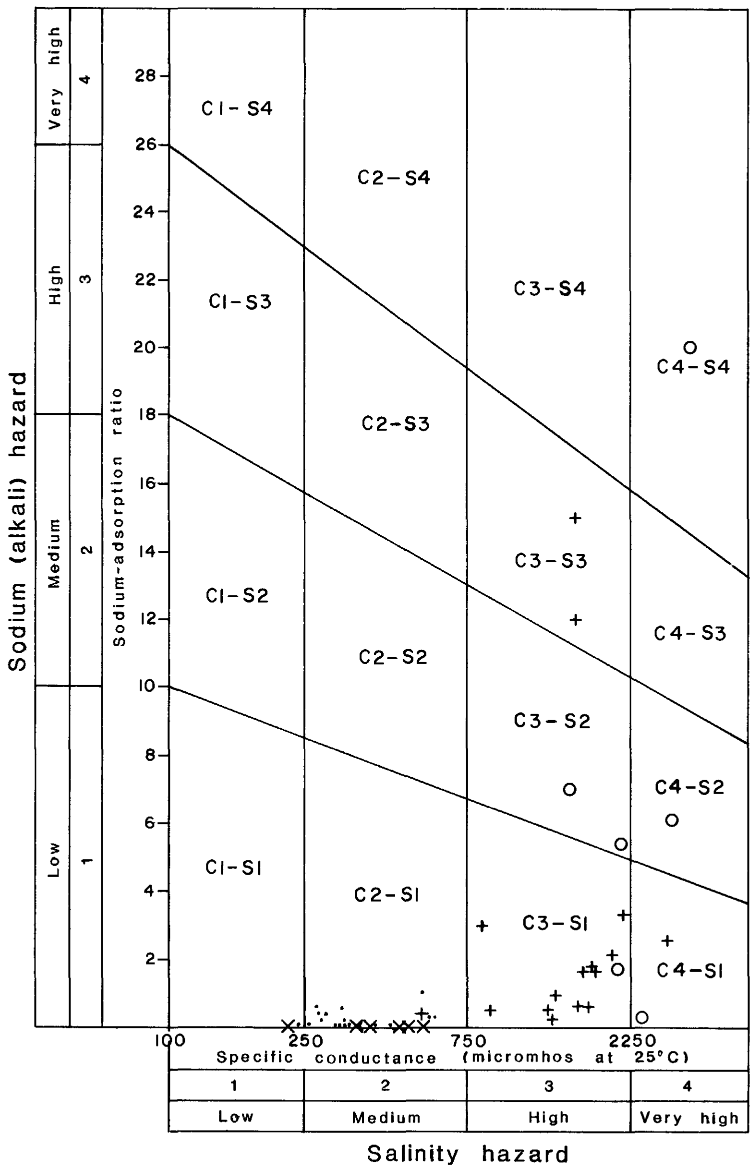
Similarly, an increase in the downstream direction in dissolved solids and constituents takes place in the water of the alluvial aquifer along Paint Rock Creek. In the area of the boulder fan deposits 4 miles northeast of Hyattville, the dissolved-solids concentration in the alluvial deposits is less than 200 mg/L. Near Hyattville, the amount of dissolved solids is about 700 mg/L and sulfate about 270 mg/L. Near the mouth of Paint Rock Creek the amount of dissolved solids increases to about 1,200 mg/L and sulfate to about 700 mg/L (table 5).

Figure 4 shows graphically the classification of well water for irrigation (U.S. Salinity Laboratory Staff, 1954, p. 79-81) in the alluvial deposits and in the sedimentary rocks. Only the water in the boulder-fan deposits and in the nearby alluvial deposits along Paint Rock Creek and along Tensleep Creek near the western border of the Bighorn Mountains has a low sodium hazard and a low to medium salinity hazard. Elsewhere, the water in the alluvial deposits show wide differences in the sodium and salinity hazards. The salinity hazard generally is high to very high with the sodium hazard ranging from low to high. The high salinity and (or) sodium hazard makes much of the water in the alluvial aquifer along the Nowood River and in the lower reach of Paint Rock Creek below Hyattville unfit for irrigation. However, figure 4 also indicates that water in the Paleozoic aquifers is the best water in the area for irrigation.

Areas of Water-Producing Potential

Ground water is obtained from wells completed in most of the sedimentary rocks and from the alluvial deposits. Water having excellent chemical quality that can be used for nearly all types of development is from the deeply buried artesian aquifers, notably the Flathead Sandstone, Bighorn Dolomite, Madison Limestone, and Tensleep Sandstone (table 4). Many wells completed in these formations flow at the land surface. Most of the water in the Jurassic to Cretaceous sedimentary rocks is suitable only for the watering of stock owing to the small well yields and poor chemical quality. Locally, the Jurassic formations yield some water that is used for domestic purposes. Near Manderson, the Fort Union Formation furnishes a dependable source of water for domestic wells.

Alluvial deposits, forming the alluvial aquifer, extend throughout the Nowood River valley and along the lower reaches of Paint Rock, Tensleep, Spring, and Otter Creeks. Table 7 contains a summary of the hydrologic characteristics that affect water development of the alluvial deposits. The parts of the alluvial aquifer most favorable for the development of ground water by wells are the flood-plain alluvium and the boulder-fan deposit northeast of Hyattville. Although the younger alluvial-fan deposits are part of the alluvial aquifer, these deposits yield less than 20 gal/min of water to wells. In places, water in the alluvial aquifer along the Nowood River contains more than 1,500 mg/L of dissolved solids. Water having less than 200 mg/L is in Tensleep Canyon and along Paint Rock and Medicine Lodge Creeks near and upstream from Hyattville.



EXPLANATION

\+ Samples from flood-plain alluvium along Nowood River and lower reaches of Paint Rock and Tensleep Creek.

× Boulder-fan deposits and flood-plain alluvium and alluvial-fan deposits along Paint Rock Creek upstream of Hyattville and along Tensleep Creek in Tensleep Canyon and near the western flank of the Bighorn Mountains.

· Paleozoic aquifers, not including the Goose Egg Formation.

○ Lower Tertiary to Triassic sedimentary rocks. In other analyses, the sodium-adsorption ratio is greater than 30 or the specific conductance is more than 5,000 µmho/cm at 25°C.

Figure 4.--Classification of irrigation waters in the alluvial deposits and bedrock formations in the Nowood River drainage area

The largest yields of wells completed in the flood-plain alluvium along the Nowood River and along Paint Rock Creek downstream from the boulder-fan deposits generally would be obtained in the central part of the alluvial area shown in plate 1. Smaller yields, less than 25 gal/min and in places less than 5 gal/min, would be expected in the peripheral areas where the flood-plain alluvium generally is finer grained and thinner than it is in the central areas. The alluvium may be thicker and coarser (with corresponding higher yields) along sharp bends where the flow of the streams has been directed against the sides of the valley and in the narrower parts of the valley floor such as at sec. 33, T. 48 N., R. 89 W. However, all yields from the flood-plain alluvium along the Nowood River are low, probably less than 50 gal/min, and insufficient for irrigation.

The coarse-grained flood-plain alluvium in the valley of Tensleep Creek upstream from Ten Sleep should give relatively high yields, possibly more than 100 gal/min. In the south side of the valley, however, a bedrock platform underlies the alluvial deposits at a shallow depth, and along the north side of the valley, fine-grained alluvial-fan or pediment deposits border the flood-plain alluvium. The greatest thickness of the flood-plain alluvium is in the central part of the valley in the buried channel of Tensleep Creek. This central part of the valley and the adjoining lower part of Tensleep Canyon are the most favorable areas for the development of ground water from the alluvial aquifer along Tensleep Creek (pl. 2, inset 2).

Other areas possible for ground-water development from the alluvial aquifer are the boulder-fan deposits and the adjacent flood-plain alluvium of Paint Rock and Medicine Lodge Creeks northeast of Hyattville. The most favorable place for development is near Paint Rock and Medicine Lodge Creeks, where yields should be greater than the well yields along Tensleep Creek. The presence of a buried bedrock ridge between these creeks precludes the development of much ground water in the central part of the boulder-fan deposits.

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