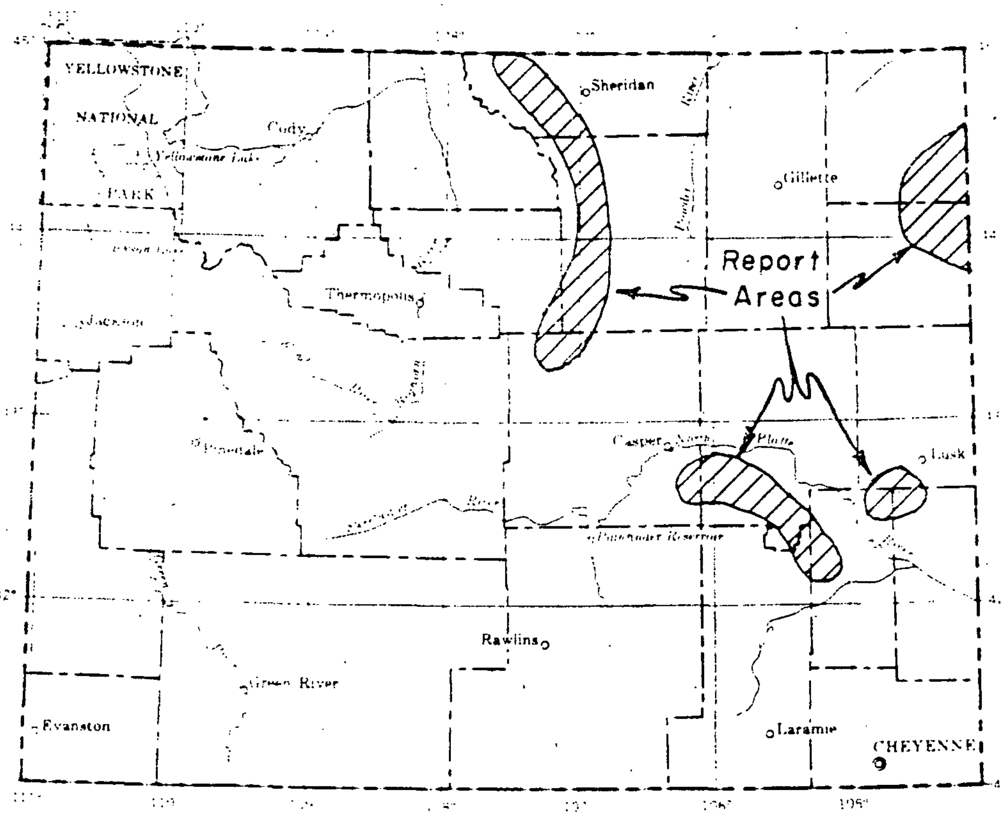
GEOHYDROLOGIC RECONNAISSANCE AND MEASUREMENT OF PERENNIAL STREAMS CROSSING OUTCROPS OF THE MADISON LIMESTONE, NORTHEASTERN WYOMING, 1974



U. S. GEOLOGICAL SURVEY

Open-File Report 75-614

Prepared in cooperation with the
Wyoming State Engineer and
The Old West Regional Commission

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOHYDROLOGIC RECONNAISSANCE AND MEASUREMENT OF PERENNIAL STREAMS CROSSING OUTCROPS OF THE MADISON LIMESTONE, NORTHEASTERN WYOMING, 1974

By F. C. Boner, G. C. Lines, M. E. Lowry, and J. E. Powell

Open-File Report 75-614

Prepared in cooperation with the
Wyoming State Engineer
and
The Old West Regional Commission

Cheyenne, Wyoming

January 1976

CONTENTS

ILLUSTRATIONS

TABLES

GEOHYDROLOGIC RECONNAISSANCE AND MEASUREMENT OF PERENNIAL STREAMS CROSSING OUTCROPS OF THE MADISON LIMESTONE, NORTHEASTERN WYOMING, 1974

By F. C. Boner, G. C. Lines, M. E. Lowry, and J. E. Powell

ABSTRACT

During the summer of 1974, a geohydrologic field reconnaissance was made of 55 perennial streams crossing outcrops of the Madison Limestone of Mississippian age in the Powder River structural basin in northeastern Wyoming. Areas investigated were the Laramie Mountains, the Bighorn Mountains, the Hartville Uplift, and the Black Hills Uplift. Following the reconnaissance, 32 gaging stations were established to monitor streamflow. Miscellaneous discharge measurements were obtained on ungaged streams three times during the summer and fall of 1974. The report summarizes the results of the geohydrologic reconnaissance, lists the discharge measurements made through early December 1974, and lists the locations of gaging station and miscellaneous discharge measurement sites.

INTRODUCTION

The need for new sources of water for expanding development of energy resources (mainly coal) in northeastern Wyoming has focused attention on the Madison Limestone aquifer. The Madison has been used for many years as a source of water for the oil industry and for a few municipal water supplies.

Generally, there are insufficient hydrologic data for the Madison Limestone to evaluate fully its potential as a water source. For example, little is known about recharge to the Madison. The principal objective of the investigation is to gage the flow of perennial streams across formation outcrops in the recharge areas, to determine the loss of streamflow to (or gain from) the Madison Limestone and associated rocks, and to ascertain the occurrence of geologic features in outcrops of the Madison Limestone that affect gains and losses of streams.

The study is being made by the U.S. Geological Survey in cooperation with the Wyoming State Engineer as described in a contract between the Old West Regional Commission and the Wyoming State Engineer. It began in late June 1974 and will end in June 1976.

The general areas under investigation are along the northern and northeastern flanks of the Laramie Mountains, the eastern slopes of the Bighorn Mountains, the western part of the Black Hills Uplift, and the Hartville Uplift near Jay Em, Wyoming.

In a separate but related study for the Wyoming State Engineer, the Wyoming Water Resources Research Institute of the University of Wyoming is making geologic field surveys in the eastern flanks of the Bighorn Mountains and the northern part of the Laramie Mountains. They are also investigating recharge from ephemeral streams and from overland flow to develop one or more acceptable methodologies to relate precipitation and infiltration to recharge.

Use of Metric Units

Because use of the metric system is increasing in the United States, values for units of measurement are given in metric as well as in English units in the text of this report. Metric equivalents are given in parentheses following the English units. Metric equivalents of English units used in this report may be determined by the following conversion factors:

From	Multiply by	To obtain
Feet (ft)	.3048	Metres (m)
Miles (mi)	1.609	Kilometres (km)
Cubic feet per second (ft^3/s)	.02832	Cubic metres per second (m^3/s)

Site Selection

Geologic and hydrologic field reconnaissance to locate possible recharge areas along perennial streams was begun in late June 1974 as soon as snowmelt runoff had ended. Teams consisting of a hydrogeologist and a surface-water hydrographer investigated each perennial stream that crossed the outcrop area of the Madison Limestone along the northern and northeastern flanks of the Laramie Mountains, the eastern slopes of the Bighorn Mountains, and the western flanks of the Black Hills Uplift. The hydrogeologist identified the geologic contacts and geologic features that might influence losses and gains along each stream. The hydrographer located potential stream-gage sites and measured the streamflow above and below the outcrop. Subsequent sections of this report describe site conditions as noted by the reconnaissance teams.

Upon completion of the field reconnaissance, stream-gaging sites were selected. Streams that indicated considerable loss across the recharge area were given first consideration when selecting gaging station sites. A further consideration was whether streamflow records of sufficient accuracy could be collected at specific sites. Areal coverage was also a criterion for gage selection because the financing of the study only allowed for about 30 gaging stations. Streams not selected for gaging stations were then considered as sites for miscellaneous discharge measurements.

Gaging stations were constructed as soon as an area had been investigated and sites had been selected. Selection of the type of gage at each of the 32 new gaging stations was based on individual site conditions. Graphic or digital water-stage recorders with stilling wells were installed at 6 sites, digital recorders with pressure-transducer systems were used at 4 sites, and graphic recorders with servo-manometer systems were used at 22 sites.

Gaging stations at six sites on four streams, currently in operation by the U.S. Geological Survey in cooperation with the Wyoming State Engineer and the Wyoming Department of Economic Planning and Development, were utilized in this study. These gages are: Highline ditch near Dayton; Tongue River near Dayton; South Piney Creek near Story; North Fork Crazy Woman Creek below Pole Creek, near Buffalo; North Fork Crazy Woman Creek near Buffalo; and North Fork Powder River below Pass Creek, near Mayoworth.

Following is a list of gaging stations, miscellaneous discharge measurement sites, and geologic reconnaissance sites where no measurements of streamflow were made--numbers identify the sites shown on plate 1:

1. Cottonwood Creek (southwest of Glendo), upper site
2. Cottonwood Creek (southwest of Glendo), lower site
3. Horseshoe Creek, upper site
4. Horseshoe Creek, lower site
5. La Bonte Creek, upper site
6. La Bonte Creek, lower site
7. West Fork La Bonte Creek, upper site
8. Mill Creek
9. West Fork La Bonte Creek, lower site
10. Wagon Hound Creek, upper site
11. Wagon Hound Creek, lower site
12. La Prele Creek (no discharge measurement)
13. Spring Canyon Creek, upper site
14. Spring Canyon Creek, lower site
15. Cottonwood Creek (south of Careyhurst), upper site
16. Cottonwood Creek (south of Careyhurst), lower site
17. Little Box Elder Creek, upper site
18. Little Box Elder Creek, lower site
19. Box Elder Creek, upper site
20. Box Elder Creek, lower site

21. Hunton Creek, upper site
22. West Fork Hunton Creek
23. Hunton Creek, lower site
24. Little Deer Creek, upper site
25. Little Deer Creek, lower site
26. Deer Creek (no discharge measurement)
27. Smith Creek, upper site
28. Smith Creek, lower site
29. Rawhide Creek (no discharge measurement)
30. South Fork West Pass Creek, upper site
31. South Fork West Pass Creek, lower site
32. West Fork Taffner Creek
33. East Pass Creek
34. Columbus Creek
35. Smith Creek
36. Tongue River, upper site
37. Highline Ditch
38. Tongue River, lower site
39. Little Tongue River, upper site
40. Little Tongue River, lower site
41. South Fork Little Tongue River, upper site
42. South Fork Little Tongue River, lower site
43. Wolf Creek, upper site
44. Wolf Creek, lower site
45. Soldier Creek, upper site
46. Soldier Creek, lower site
47. Big Goose Creek, upper site
48. Big Goose Creek, lower site
49. Rapid Creek, upper site
50. Rapid Creek, lower site
51. Little Goose Creek, upper site
52. Little Goose Creek, lower site
53. North Piney Creek, upper site
54. North Piney Creek, lower site
55. South Piney Creek, upper site
56. South Piney Creek, lower site
57. Mead-Coffeen Ditch, upper site
58. Mead-Coffeen Ditch, lower site
59. Spring Creek
60. North Rock Creek, upper site
61. North Rock Creek, lower site
62. South Rock Creek, upper site
63. South Rock Creek, lower site
64. North Fork Sayles Creek, upper site
65. North Fork Sayles Creek, lower site
66. Johnson Creek, upper site
67. Johnson Creek, lower site
68. French Creek, upper site
69. French Creek, lower site

70. Clear Creek, upper site
71. Clear Creek, lower site
72. Little North Fork Crazy Woman Creek, upper site
73. Little North Fork Crazy Woman Creek, lower site
74. North Fork Crazy Woman Creek tributary, upper site
75. North Fork Crazy Woman Creek tributary, lower site
76. North Fork Crazy Woman Creek, upper site
77. North Fork Crazy Woman Creek, lower site
78. Muddy Creek, upper site
79. Muddy Creek, lower site
80. Billy Creek, upper site
81. Billy Creek, lower site
82. Poison Creek, upper site
83. Poison Creek, lower site
84. Middle Fork Crazy Woman Creek, upper site
85. Middle Fork Crazy Woman Creek, lower site
86. Beaver Creek, upper site
87. Beaver Creek, lower site
88. North Fork Powder River, upper site
89. Gardner Creek
90. Pass Creek
91. North Fork Powder River, lower site
92. Beartrap Creek, upper site
93. Beartrap Creek, lower site
94. North Fork Red Fork Powder River, upper site
95. North Fork Red Fork Powder River, lower site
96. South Fork Red Fork Powder River, upper site
97. South Fork Red Fork Powder River, lower site
98. Beaver Creek, upper site
99. Beaver Creek, lower site
100. Middle Fork Powder River, upper site
101. Middle Fork Powder River, lower site
102. Pine Creek, upper site
103. Pine Creek, lower site
104. Buffalo Creek, upper site
105. North Fork Buffalo Creek
106. Buffalo Creek, lower site
107. Stockade Beaver Creek, upper site
108. Stockade Beaver Creek, lower site
109. Cold Springs Creek, upper site
110. Sand Creek, lower site
111. Inyan Kara Creek

Results of discharge measurements at the gaging stations through early December 1974 are tabulated in table 1, and the locations of the gage sites are tabulated in table 2. The results of discharge measurements at the miscellaneous sites are tabulated in table 3, and the locations of the sites are tabulated in table 4.

Considerations

Although the project is referred to as the "Madison study," the Paleozoic sequence, in general, is to some degree in hydraulic connection. Therefore, in the north and central part of the Bighorn Mountains, the flow of streams was measured as near as possible to the base of the Flathead Sandstone of Cambrian age and as near as possible to the top of the Tensleep Sandstone of Pennsylvanian age. This was not possible, or desirable, in all cases because of other overriding considerations.

In order to monitor changes in flow in a stream reach by measuring only an upper and lower site, tributary inflow and diversions between the two sites had to be measured along many streams.

The most important factor in selection of a miscellaneous or gage site is the quality of record that can be obtained. Poor stream gaging conditions at some of the geologic contacts required moving the gaging site either upstream or downstream. Due to rough channel conditions in mountain streams, most discharge measurements are rated as fair (measurement error could be as much as ±8 percent). Because of measurement errors, a single pair of measurements may not be sufficient to determine if a gain or loss occurs in a reach, especially if the gain or loss is a small percentage of the discharge.

Computation of Streamflow Records

Streamflow record computation is the process of converting a daily record of stage (gage height) to discharge. A continuous record of the gage height is obtained from the gaging stations. Charts are removed from the graphic and digital recorders monthly and are returned to the subdistrict offices for processing. Graphic charts are hand computed by personnel in the subdistrict offices. Digital punch-tapes are computer processed from the terminal in Cheyenne, Wyoming.

A rating curve must be developed for each gaging station to convert gage heights to discharge. The rating curve, a plot of gage height versus discharge, is based on measurements of discharge and stage. In order to define a rating curve, numerous discharge measurements must be available and must cover a range of gage height and discharge. Insufficient data will be available during the first year to define a rating curve. Rating curves will be developed at the gages after the May-June snowmelt and rain runoff period during which high discharges will be measured.

Once a rating curve is developed, the daily gage heights from the recorder charts can be converted to discharge. This will be done for all the gaging stations during the fall of 1975.

Rain Gages

Rain gages were installed during May and June 1975 near one of the gaging stations in each of the drainage basins listed below.

East Pass Creek	North Fork Powder River
Little Tongue River	Beaver Creek
Wolf Creek	Buffalo Creek
South Piney Creek	Smith Creek
South Rock Creek	Little Deer Creek
North Fork Crazy Woman Creek	Little Box Elder Creek
Poison Creek	Cottonwood Creek

The purpose of the rain gages is to obtain supplemental records of rainfall in the immediate proximity of the outcrop areas. The rainfall records collected by the U.S. Weather Service are not close to the outcrop areas and are not readily usable.

LARAMIE MOUNTAINS

General Geologic and Hydrologic Description

The Madison Limestone along the northern and northeastern flanks of the Laramie Mountains forms a narrow sinuous outcrop that seldom exceeds a mile (1.6 km) in width. The continuity of the Madison outcrop is often broken by a mantle of Tertiary rocks that laps onto the flanks of the mountains. The Madison in this area comprises a basal conglomeratic sandstone unit, a middle unit of massive limestone, and an upper unit of limestone with chert lenses. The basal sandstone unit and upper cherty unit are conformable with the middle unit of limestone. The Madison is underlain by Precambrian granite and metamorphic rocks and overlain by massive sandstone in the Casper Formation of Pennsylvanian and Permian age. Disconformities separate the Madison from these underlying and overlying rocks. The Madison is about 300 feet (90 m) thick in its outcrop area south of Casper but wedges out southward along the east flank of the Laramie Mountains. The Madison is 112 feet (34 m) thick in its outcrop area along Horseshoe Creek southwest of Glendo (Maughan, 1963, p. C25).

The basal sandstone of the Madison along the northern and northeastern flanks of the Laramie Mountains consists predominantly of rounded quartz and feldspar pebbles in a matrix of quartz sand and was derived from weathering of the underlying Precambrian granite. The sandstone is well cemented and probably has little intergrain or primary permeability. The sandstone has some secondary permeability in the form of fractures mainly along bedding planes. Hydraulic connection between the basal sandstone unit and underlying Precambrian rocks and the overlying middle unit of limestone is probably poor. The basal sandstone in its outcrop area is thickest along the northern flanks of the Laramie Mountains and seems to wedge out southward. The basal sandstone was not observed south of Wagon Hound Creek, however, Maughan (1963, p. C25) reports 1 foot (0.3 m) of basal sandstone along Horseshoe Creek.

The middle unit of the Madison consists predominantly of gray to pink massive partly sandy dolomitic limestone. The middle unit also contains minor amounts of tan to salmon finegrained thinbedded to massive sandstone. The middle unit has little primary permeability. However, fractures and fistsized solution openings along bedding planes are common. Where the fractures and solution openings cross bedding planes, the secondary permeability of the limestone is increased. Larger solution openings and caves are visible locally. The middle unit is at least 200 feet (60 m) thick along the northern flanks of the Laramie Mountains, however, it also wedges out southward. Along Cottonwood Creek southwest of Glendo, the middle unit is about 100 feet (30 m) thick.

The upper cherty unit of the Madison consists predominantly of gray thin-bedded to massive partly silty limestone interbedded with yellowish-gray thin-bedded chert. Fractures and fist-sized solution openings are common in the limestone, and the chert is usually extensively fractured. Hydraulic connection between the upper cherty unit and both the underlying middle unit of limestone and the overlying Casper Formation is probably good in most areas. The thickness of the upper cherty unit varies because of erosion before deposition of the overlying Casper Formation; however, the unit is seldom more than 50 feet (15 m) thick in its outcrop area along the northern and northeastern flanks of the Laramie Mountains.

The Casper Formation in its outcrop area along the northern and northeastern flanks of the Laramie Mountains consists predominantly of tan to pink fine-grained massive cross-bedded sandstone and limestone near the top and interbedded tan to salmon thick-bedded sandstone and limestone near the base. Locally, a conglomeratic sandstone was observed at the base of the formation. Sandstones in the Casper are usually poorly cemented and friable, and they have some intergrain or primary permeability. Limestones in the Casper have little primary permeability, but secondary permeability in the form of fractures and solution openings is common. The Casper Formation is about 850 feet (260 m) thick near La Prele Reservoir west of Douglas (Rapp, 1953, p. 11).

Cottonwood Creek (Southwest of Glendo)

The middle unit of the Madison is in fault contact with Precambrian granite along Cottonwood Creek in the NW¼SE¼NE¼ sec. 15, T. 27 N., R. 70 W. (fig. 1). The Madison near the fault is moderately fractured and has only small solution openings. Near the fault, the Madison strikes N. 60° E. and dips 8° SE. Stream discharge at the fault contact was 8.42 ft^3/s (0.238 m^3/s) during the reconnaissance on June 17, 1974. About 1,300 feet (400 m) downstream from the fault, the upper cherty unit of the Madison is exposed at creek level; bedding is horizontal. At this place, a tunnel has been constructed and, at one time, reportedly diverted water from the creek to bypass sinks further downstream. No water was being diverted into the tunnel at the time of the visit.

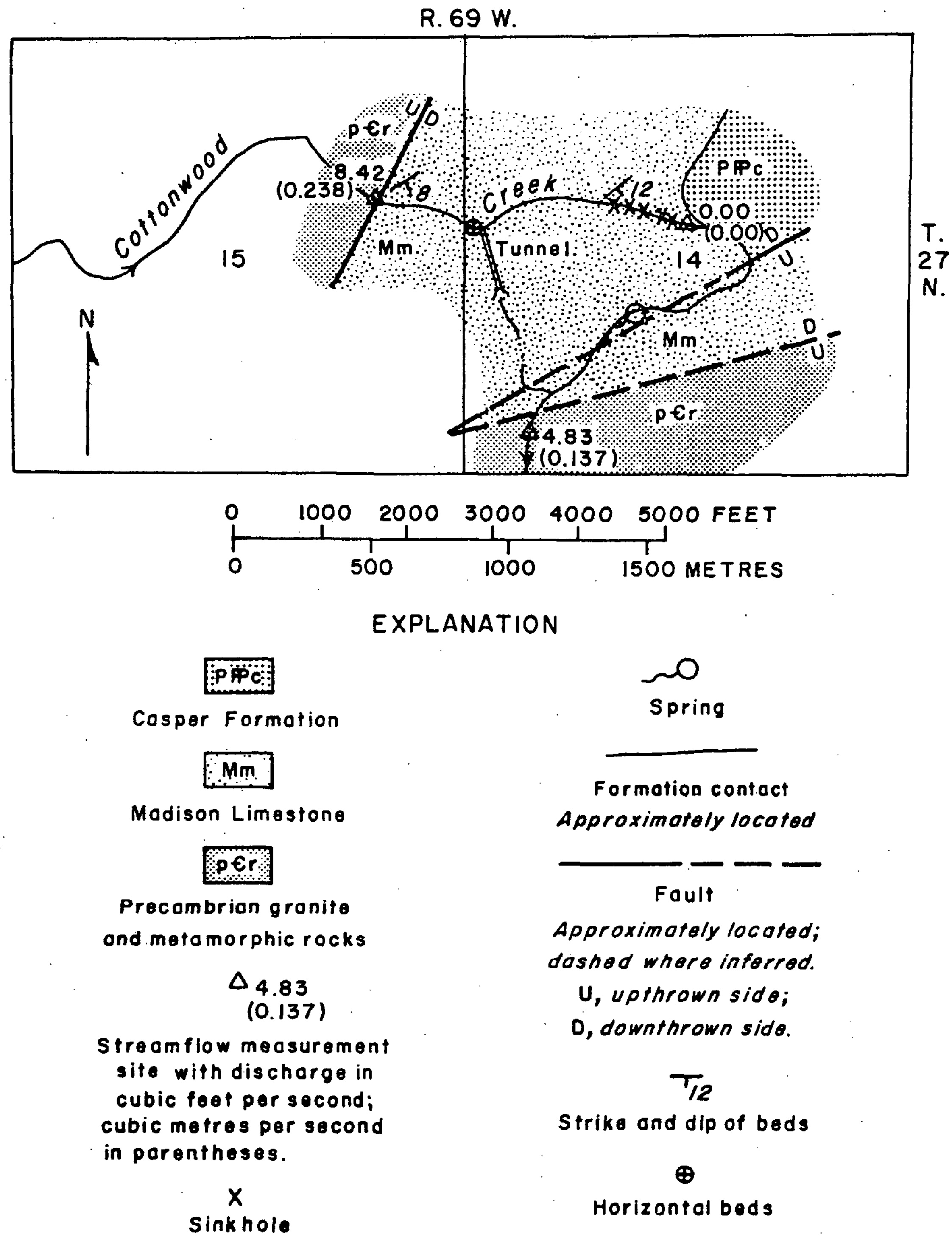


Figure 1.—Generalized geologic map and hydrologic conditions observed along Cottonwood Creek, June 17, 1974.

About 1,600 feet (490 m) downstream from the tunnel entrance, about one-third of the streamflow was lost to a large sinkhole along the right bank. The sinkhole occurs in the upper cherty unit of the Madison; bedding strikes N. 50° E. and dips 12° SE. At the sinkhole, the chert and limestone is extensively fractured, and the limestone has extensive solution openings along bedding planes. The remainder of the streamflow was lost to many smaller sinkholes in a distance of about 1,000 feet (300 m) downstream.

Sandstone and limestone in the basal part of the Casper Formation are exposed along the left bank for a distance of about 800 feet (240 m) downstream from where the stream went dry and are butted against limestone in the middle unit of the Madison by a northeast trending fault. The stream crosses the fault at this point, and the fault parallels the stream along the right bank. Where the stream crosses the fault again about 1,500 feet (460 m) further downstream, springs issue from the streambed apparently where the upper cherty unit of the Madison is butted against less permeable limestone in the middle unit. Exposures below the springs are poor, but it appears that the middle unit of the Madison is in fault contact with Precambrian granite and metamorphic rocks about 2,000 feet (610 m) further downstream in the SE¼SW¼SW¼ sec. 14, T. 27 N., R. 70 W. Stream discharge at this fault contact was 4.83 ft^3/s (0.137 m^3/s).

In summary, streamflow entering the Madison outcrop area along Cottonwood Creek was 8.42 ft^3/s (0.238 m^3/s). In a distance of 0.7 mile (1.1 km) all the flow had been lost to sinkholes in the upper cherty unit of the Madison. Where the creek crossed a fault that has butted the upper cherty unit against the middle unit of the Madison, 4.83 ft^3/s (0.137 m^3/s) returned to the stream from springs.

Horseshoe Creek

In the NW¼SW¼NE¼ sec. 13, T. 28 N., R. 71 W., Madison Limestone and underlying Precambrian granite are exposed along the right bank of Horseshoe Creek. Near the granite contact the Madison consists predominantly of gray to pink massive partly sandy limestone. Maughan (1963, p. C25) reports 1 foot (0.3 m) of basal sandstone in the Madison in this locality, but a typical exposure was not found during the reconnaissance of June 18, 1974. The Madison strikes N. 10° W. and dips 72° NE. near the granite contact. Stream discharge at the contact was 37.2 ft^3/s (1.05 m^3/s).

Sandstone in the basal Casper Formation and underlying Madison Limestone are exposed along the right bank of the creek in the NW¼NE¼NW¼ sec. 18, T. 28 N., R. 70 W. Exposures along this reach of the stream are poor because of a broad floodplain on the left bank and talus covered slopes on the right bank. Near the Casper contact, the Madison strikes N. 15° W. and dips 86° NE. The discharge of Horseshoe Creek was 34.7 ft^3/s (0.983 m^3/s) at the Madison and Casper contact.

Even though the discharge measurements show a 2.5 ft^3/s (0.071 m^3/s) loss across the Madison outcrop, no sinkholes or evidence of extensive solution were observed. Sinkholes could, however, be masked by a thick mantle of alluvium in the streambed and floodplain.

La Bonte Creek

Madison Limestone and underlying Precambrian metamorphic rock are exposed along La Bonte Creek in the SE¼SW¼NW¼ sec. 22, T. 29 N., R. 27 W. The Madison strikes N. 75° W. and dips 20° NE. Stream discharge at the contact was 29.8 ft^3/s (0.844 m^3/s) at the time of the reconnaissance on June 19, 1974.

Exposures of Madison along the creek further downstream are poor, and the Madison and Casper contact is not exposed. The Madison and Casper contact is covered by Tertiary rocks on hillsides on either side of the creek and covered with alluvium in the floodplain. However, in the NW¼SW¼SE¼ sec. 15, T. 29 N., R. 72 W., chert and limestone in the upper cherty unit of the Madison are exposed in the streambed. Stream discharge just below this exposure was 29.1 ft^3/s (0.824 m^3/s).

The discharge measurements showed a loss in streamflow of 0.7 ft^3/s (0.02 m^3/s) across the Madison outcrop, however, no sinkholes were observed.

West Fork La Bonte Creek

Madison Limestone and underlying Precambrian granite are exposed along West Fork La Bonte Creek in the SW¼NW¼NW¼ sec. 36, T. 30 N., R. 73 W., about 0.4 mile (0.6 km) upstream from Mill Creek. The Madison at the granite contact strikes N. 80° W. and dips 10° NE. Stream discharge at the contact was 10.3 ft^3/s (0.292 m^3/s) at the time of the reconnaissance on June 20, 1974. The Madison near the granite contact is extensively fractured and has some solution permeability primarily along bedding planes. No sinkholes were observed along the creek.

Mill Creek flows into West Fork La Bonte Creek about half way across the Madison outcrop. The discharge of Mill Creek at its mouth was 0.45 ft^3/s (0.013 m^3/s).

The Madison and Casper contact is not exposed along the creek but is covered by alluvium and Tertiary rocks. The contact is exposed on a hillside north of the creek. Along the strike of the Madison and Casper contact in the center of sec. 25, T. 30 N., R. 72½ W., the discharge of West Fork La Bonte was 11.3 ft^3/s (0.320 m^3/s).

In summary, 10.7 ft^3/s (0.303 m^3/s) entered the Madison outcrop area along West Fork La Bonte Creek and 11.3 ft^3/s (0.320 m^3/s) left the outcrop area, a gain of 0.6 ft^3/s (0.02 m^3/s).

Wagon Hound Creek

The basal sandstone unit of the Madison overlies Precambrian granite in the NE¼SW¼SW¼ sec. 9, T. 30 N., R. 73 W. The basal sandstone is about 20 feet (6 m) thick and is overlain by typical massive limestone in the middle unit of the Madison. The basal sandstone strikes N. 70° W. and dips 18° NE. Streamflow at the Madison-granite contact was 2.26 ft^3/s (0.064 m^3/s) at the time of the reconnaissance on June 21, 1974. Limestone is exposed along the creek for only about 100 feet (30 m) and is covered with alluvium downstream. No sinkholes in the Madison were observed.

The Madison and Casper contact is not exposed along the creek but is exposed on hillsides north and south of the creek. Along the strike of the Madison and Casper contact in the NE¼SW¼SW¼ sec. 10, T. 30 N., R. 73 W., stream discharge was 2.50 ft^3/s (0.071 m^3/s). Thus, the gain in streamflow across Madison outcrop was 0.24 ft^3/s (0.007 m^3/s).

La Prele Creek

The basal sandstone unit of the Madison and the underlying Precambrian granite are exposed along La Prele Creek in the SW¼NW¼ sec. 25, T. 31 N., R. 74 W. The basal sandstone is directly overlain by Tertiary rocks and no limestone is exposed along the creek for several miles downstream. No streamflow measurements were made.

The basal sandstone unit of the Madison is again exposed along the east side of La Prele Reservoir about half a mile (0.8 km) south of the dam. The Madison and Casper contact is exposed at the top of the dam on the left bank and is at creek level about 600 feet (180 m) north of the dam in the NE¼SE¼SW¼ sec. 21, T. 32 N., R. 73 W. No extensive solution activity in the Madison was observed. No streamflow measurements were made because most of the Madison outcrop is under the reservoir.

Spring Canyon Creek

The basal sandstone of the Madison and the underlying Precambrian granite are exposed along the right bank of Spring Canyon Creek in the SW¼SE¼SE¼ sec. 13, T. 32 N., R. 74 W. The sandstone at this point strikes N. 80° W. and dips 24° NE. Limestone in the middle and upper units of the Madison shows no sign of extensive solution activity and no sinkholes were observed. Stream discharge at the Madison and granite contact was 0.08 ft^3/s (0.002 m^3/s) at the time of the reconnaissance on June 28, 1974.

The Madison and Casper contact is exposed in the hillside east of the creek in the NE¼NW¼SE¼ sec. 13, T. 32 N., R. 74 W. Stream discharge at this location was also 0.08 ft^3/s (0.002 m^3/s). Thus, Spring Canyon Creek neither gained nor lost water where it crossed the Madison outcrop.

Cottonwood Creek (South of Careyhurst)

The basal sandstone of the Madison and the underlying Precambrian granite are exposed along Cottonwood Creek in the SW¼NW¼SW¼ sec. 13, T. 32 N., R. 74 W. The Madison near the contact strikes N. 70° W. and dips 20° NE. Stream discharge at the Madison and granite contact was 0.64 ft^3/s (0.018 m^3/s) at the time of the reconnaissance on July 30, 1974.

Cottonwood Creek gradually lost all of its flow as it crossed the Madison outcrop. The stream ceased to flow in the SE¼SE¼NE¼ sec. 14, T. 32 N., R. 74 W. Limestones in the middle and upper units of the Madison have extensive secondary permeability in the form of fist-sized and smaller solution openings. Bedrock in the streambed is covered with alluvium, and sinkholes are indicated by small depressions in the alluvium.

In the SW¼NW¼NW¼ sec. 13, T. 32 N., R. 74 W., the Madison and Casper contact is exposed along the creek. The Madison strikes N. 65° W. and dips 20° NE. at the Casper contact. The stream was dry at this point.

Little Box Elder Creek

The basal sandstone of the Madison and the underlying Precambrian granite are exposed along Little Box Elder Creek in the SE¼SW¼SE¼ sec. 8, T. 32 N., R. 74 W. The Madison near the contact strikes N. 85° W. and dips 16° NE. Stream discharge at the Madison and granite contact was 0.87 ft^3/s (0.025 m^3/s) at the time of the reconnaissance on July 29, 1974.

Little Box Elder Creek gradually lost all of its flow as it crossed the Madison outcrop. The stream ceased to flow in the SE¼SE¼NE¼ sec. 8, T. 32 N., R. 74 W. Here, as along Cottonwood Creek 4 miles (6 km) to the east, the limestones in the middle and upper units of the Madison have extensive secondary permeability in the form of fist-sized and smaller solution openings. Bedrock in the streambed is covered with alluvium and no sinkholes were observed.

In the NE¼SE¼NW¼ sec. 9, T. 32 N., R. 74 W., the Madison and Casper contact is exposed along the creek. The Madison strikes N. 80° W. and dips 10° NE. The stream was dry at this point.

Box Elder Creek

The basal sandstone of the Madison and the underlying Precambrian granite are exposed along Box Elder Creek in the SE¼ sec. 12, T. 32 N., R. 75 W. The Madison near the granite contact strikes N. 75° W. and dips 8° NE. Stream discharge at the Madison and granite contact was 24.4 ft^3/s (0.691 m^3/s) at the time of the reconnaissance on June 26, 1974.

Box Elder Creek gradually gained water as it crossed the Madison outcrop. Many small seeps and springs issued from limestones in the middle and upper units of the Madison just above the creek. The Madison Limestone, as a whole, has very little secondary permeability along Box Elder Creek. No sinkholes were observed.

In the SW¼ sec. 6, T. 32 N., R. 74 W., the Madison and Casper contact is exposed along the creek. The discharge of the creek at this contact was 30.9 ft^3/s (0.875 m^3/s), indicating a gain in streamflow of 6.5 ft^3/s (0.184 m^3/s) across the Madison outcrop.

On August 14, 1974, Box Elder Creek was visited again to see if a more accessible measuring site further upstream could be substituted for the site in the canyon at the Madison and granite contact. In the SW¼NE¼SE¼ sec. 23, T. 32 N., R. 75 W., Precambrian granite is exposed along the creek. The discharge of the creek at this site was 5.28 ft^3/s (0.150 m^3/s). Downstream about 2 miles (3 km) at the Madison and granite contact, the discharge was 5.36 ft^3/s (0.152 m^3/s). On the basis of these two measurements, it was concluded that the more accessible upper site could be used. Stream discharge at the Madison and Casper contact on the same day was 6.11 ft^3/s (0.173 m^3/s).

Hunton Creek

Both Hunton Creek and West Fork Hunton Creek are in an alluvial valley, and no bedrock is exposed along their banks. The basal sandstone of the Madison and the underlying Precambrian granite are exposed in a hillside 100 feet (30 m) east of Hunton Creek in the SW¼NE¼NE¼ sec. 10, T. 32 N., R. 75 W. The Madison near the contact strikes N. 80° W. and dips 38° NE. Stream discharge of Hunton Creek at this spot was 0.64 ft^3/s (0.018 m^3/s) at the time of the reconnaissance on June 27, 1974. The discharge of West Fork Hunton Creek, 1,200 feet (370 m) west of the Hunton Creek site, was 0.03 ft^3/s (0.001 m^3/s).

The Madison and Casper contact is exposed on hillsides a quarter of a mile (0.4 km) east and west of Hunton Creek. If bedrock were not covered by alluvium, the Madison and Casper contact would probably be exposed in the SE¼SE¼NE¼ sec. 3, T. 32 N., R. 75 W., 0.3 mile (0.5 km) below the mouth of West Fork Hunton Creek. The discharge of Hunton Creek at this site was 0.73 ft^3/s (0.021 m^3/s). A small irrigation ditch which diverts water out of Hunton Creek 0.1 mile (0.2 km) below the mouth of West Fork Hunton Creek had a flow of 0.12 ft^3/s (0.003 m^3/s). Thus, the total discharge leaving the area was 0.85 ft^3/s (0.024 m^3/s).

In summary, the combined discharge of Hunton Creek and West Fork Hunton Creek entering the Madison outcrop was 0.67 ft^3/s (0.019 m^3/s). The combined flow leaving the area was 0.85 ft^3/s (0.024 m^3/s), indicating a gain of 0.18 ft^3/s (0.005 m^3/s).

Little Deer Creek

The basal sandstone unit of the Madison and the underlying Precambrian granite are exposed along Little Deer Creek in the NW¼NW¼SW¼ sec. 28, T. 32 N., R. 76 W. The Madison strikes N. 85° E. and dips 19° NW. near the granite contact. Exposures of limestone are poor and the degree of secondary permeability could not be determined. The discharge of Little Deer Creek at the Madison and granite contact was 1.09 ft^3/s (0.031 m^3/s) at the time of the reconnaissance on July 31, 1974.

No sinkholes were observed further downstream, but the creek gradually lost water. In the NW¼NW¼NW¼ sec. 28, T. 32 N., R. 76 W., the Madison and Casper contact is exposed in the hillside east of the creek. Here the limestones in the Madison have a vuggy appearance and fist-sized solution openings are numerous. At the Madison and Casper contact, the discharge of the creek was 0.55 ft^3/s (0.016 m^3/s), indicating a loss in streamflow of 0.54 ft^3/s (0.015 m^3/s) across the Madison outcrop.

Little Deer Creek continued to lose water gradually downstream where it crossed the outcrop of the Casper Formation. In the SE¼NE¼NW¼ sec. 21, T. 32 N., R. 76 W., Little Deer Creek was dry.

Deer Creek

The basal sandstone unit of the Madison and the underlying Precambrian granite are exposed at the mouth of Deer Creek Canyon in the NW¼NE¼SE¼ sec. 26, T. 32 N., R. 77 W. About 300 feet (90 m) downstream the Madison is in fault contact with Mesozoic shales and sandstone. Near the fault, the Madison strikes N. 70° E. and dips 85° NW.

No sinkholes or apparent loss of streamflow was observed at the time of the reconnaissance on August 2, 1974. No discharge measurements were made.

Smith Creek

The basal sandstone unit of the Madison and the underlying Precambrian granite are exposed in the hillside north of Smith Creek in the SW¼SE¼NW¼ sec. 15, T. 31 N., R. 78 W. The Madison strikes N. 70° E. and dips 85° NW. The discharge of Smith Creek at the Madison and granite contact was 2.98 ft^3/s (0.084 m^3/s) at the time of the reconnaissance on August 1, 1974.

The width of the Madison outcrop is about 300 feet (90 m) because of the steeply dipping beds. However, the strike of the beds is nearly parallel to the creek, and the Madison outcrop area along the stream is nearly 1 mi (1.6 km) long. No sinkholes were observed, and limestones in the Madison have little secondary permeability.

Smith Creek crosses the Madison and Casper contact in the NE¼NW¼SW¼ sec. 14, T. 31 N., R. 78 W., about 0.2 mile (0.3 km) upstream from Otter Creek. The discharge of the creek at this site was 2.57 ft^3/s (0.074 m^3/s), indicating a loss of 0.41 ft^3/s (0.011 m^3/s) across the Madison outcrop.

HARTVILLE UPLIFT

Rawhide Creek

Rawhide Creek was the only stream in the Hartville Uplift that was visited during the reconnaissance. The headwaters of Rawhide Creek in sec. 31, T. 31 N., R. 64 W., are in the outcrop area of the Guernsey Limestone of Devonian and Mississippian age (the Madison Limestone equivalent in the Hartville Uplift area). The Guernsey consists of gray thin-bedded to massive sandy cherty limestone. Bedding in the Guernsey is horizontal in this area. The Guernsey unconformably overlies Precambrian granite which crops out downstream.

Rawhide Creek on the Guernsey outcrop is actually a complex series of many draws that were dry at the time of the reconnaissance on June 24, 1974. None of the draws showed any sign of recent flow.

BIGHORN MOUNTAINS

General Geologic and Hydrologic Description

The Paleozoic formations, which are the ones of primary interest, consist, in ascending order, of the Flathead Sandstone and the Gros Ventre and Gallatin Formations of Cambrian age, the Bighorn Dolomite of Ordovician age, the Jefferson Formation of Devonian age, the Madison Limestone of Mississippian age, the Amsden Formation of Mississippian and Pennsylvanian age, and the Tensleep Sandstone of Pennsylvanian and Permian age. The aggregate thickness of these formations in the northern part of the Bighorn Mountains in Wyoming is nearly 3,000 feet (900 m). The sections thin southward to less than 1,000 feet (300 m). The Bighorn Dolomite and the Jefferson Formation are not present in the southern part of the mountains.

Fractures, which would increase the permeability of the formations, are present throughout the area. The rocks are shattered at places in the areas of most intense deformation. Solution openings, or fractures enlarged by solution, can be seen in every canyon. Solution is most common in the Madison where there are extensive caves. Solution features were also observed in the Gallatin and Gros Ventre Formations, the Bighorn Dolomite, the Amsden Formation, and the Tensleep Sandstone.

Ground water, lakes and ponds, snowmelt, and direct runoff from precipitation are the principal sources of water in streams flowing off the Bighorn Mountains. In the central part of the mountains, the ground-water contribution to streamflow is derived from the Precambrian crystalline rocks, glacial deposits, and the White River Formation of Oligcene age. Of these, only the crystalline rocks are widespread. Crystalline rocks are not good aquifers; therefore, most of the streamflow is from sources other than ground water. In the northern and southern parts of the mountains, lakes and ponds are not as great a factor in sustaining low flows. In these areas, the Paleozoic aquifers occur in a much larger area and contribute much of the flow to the stream.

The shape of flow-duration curves for streams heading in the area of crystalline rocks usually contrasts with those for streams that derive much of their flow from ground water. The flow-duration curve of a stream heading in crystalline rocks is typically very steep because most of the snowmelt enters the stream directly rather than via the ground-water reservoir. In areas of more prolific aquifers, such as the Paleozoic formations, a large part of the snowmelt recharges the ground-water reservoir and this water is discharged over a much longer time to the streams. The flow-duration curves for these streams are much flatter than those of streams draining crystalline rocks.

This general relation is shown by flow-duration curves of Little Bighorn River, which drains an area consisting principally of Paleozoic rocks, and Clear Creek which drains an area consisting principally of crystalline rocks. (See fig. 2.)

South Fork West Pass Creek

The upper measurement site is in the NW¼SW¼NW¼ sec. 7, T. 57 N., R. 88 W. This site is along strike of the Gallatin and Gros Ventre Formations close to the base of the Bighorn Dolomite. The Bighorn is repeated upstream by faulting and approximately one-fourth of the flow of 2.97 ft^3/s (0.084 m^3/s) measured on August 29, 1974, flows from a cave in the Bighorn upstream from the site.

The lower measurement site is in the SE¼NW¼NW¼ sec. 5, T. 57 N., R. 88 W. The site is about on strike with the top of the Tensleep Sandstone. The discharge was 4.86 ft^3/s (0.138 m^3/s) on August 29, 1974.

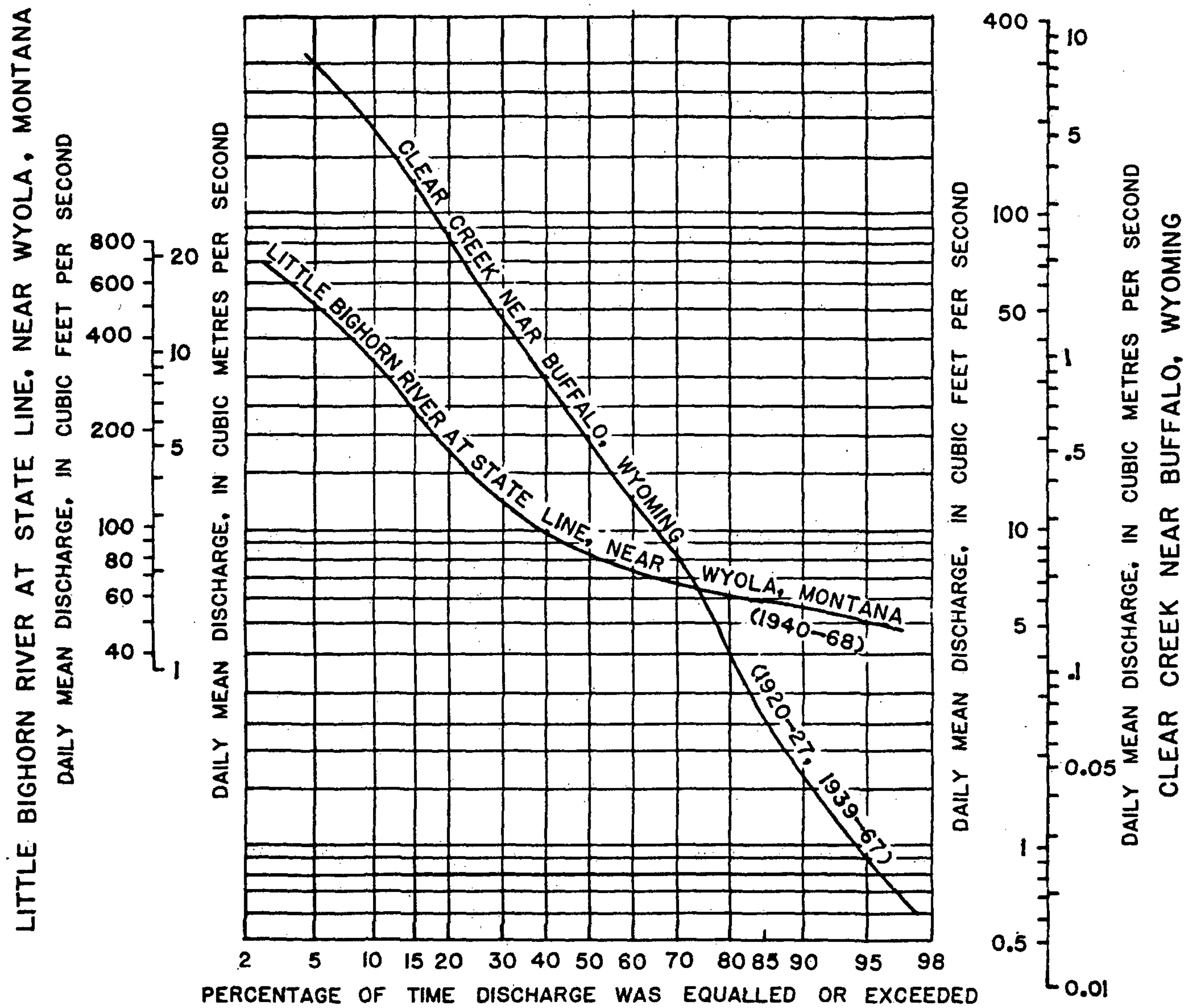


Figure 2.--Flow-duration curves for Little Bighorn River at State Line, near Wyola, Montana, and Clear Creek near Buffalo, Wyoming.

There is a diversion just below the upper site; however, the ditch parallels the creek and all but 0.1 to 0.2 ft^3/s (0.003 to 0.006 m^3/s) was lost by seepage between the point of diversion and the mouth of the canyon. No sudden, visible change in discharge was noted in the reach between the two sites. The measured increase in flow of 1.89 ft^3/s (0.054 m^3/s) is apparently gradual.

West Fork Taffner Creek

The measurement site is in the SE¼NW¼NE¼ sec. 8, T. 57 N., R. 88 W., near, and along strike with, the Tensleep and Amsden contact. Diversions occur downstream so a lower site could not be selected.

The flow of 1.05 ft^3/s (0.030 m^3/s) measured on September 24, 1974, is all discharged from rocks of Paleozoic age as the stream heads in rocks of Cambrian age. No upper site was measured nor was the stream channel walked.

East Pass Creek

The measurement site is in sec. 4, T. 57 N., R. 88 W., in the center of a small anticlinal ridge on which the Tensleep Sandstone is exposed. Discharge was not measured downstream because of irrigation diversions.

The stream heads in rocks of Paleozoic age; therefore, all the flow is attributed to ground water discharged from these rocks. The discharge was 9.10 ft^3/s (0.258 m^3/s) on September 4, 1974. The stream was not walked to specifically identify the gaining reaches.

Columbus Creek

The measurement site is in the SE¼NE¼SW¼ sec. 18, T. 57 N., R. 87 W. The site is on strike with the Tensleep Sandstone but about 50 feet (15 m) below the top. Small seeps issue from the Tensleep downstream from the site; however, the site was picked at the higher location because of a better measuring and control section.

Columbus Creek heads in the Madison Limestone but it is incised into rocks of Cambrian age between the head water and the mouth of the canyon. The flow of 3.39 ft^3/s (0.096 m^3/s) measured on September 4, 1974, is all derived from Paleozoic rocks. The stream channel was not walked to determine specific reaches where the creek gains water.

Smith Creek

The measurement site is in the NE¼NE¼NW¼ sec. 29, T. 57 N., R. 87 W. The site is on strike with, and at about the top of, the Tensleep Sandstone.

The creek heads in the Gallatin and Gros Ventre outcrop and the stream was dry in this area at the time of the reconnaissance. The flow of 0.96 ft^3/s (0.027 m^3/s) measured at the lower site on August 28, 1974, was all from ground water discharged from rocks of Paleozoic age. The stream channel was not walked.

Tongue River

The upper measurement site is in the SE¼NE¼NW¼ sec. 10, T. 56 N., R. 87 W. The site is on strike with, and near the top of, the Bighorn Dolomite. A suitable measuring section could not be found upstream and the presence of a bridge from which high-water measurements could be made strongly influenced the site selection. Flow at the site was 223 ft^3/s (6.32 m^3/s) on July 17, 1974.

The existing gage in the NE¼NE¼NE¼ sec. 11, T. 56 N., R. 87 W., is considered adequate for the lower measuring site. The site is on strike with the Amsden Formation, and the possible benefits of changing the location to a downstream site were not great enough to warrant the additional costs. Diversions for irrigation and municipal supply occur in the reach as does inflow from Cave Creek. Seeps issue from the Amsden Formation along the canyon walls north of the gage. Flow at the lower gage July 17, 1974, including the diversion for irrigation, was 225 ft^3/s (6.37 m^3/s).

Little Tongue River

The upper measurement site is in the SW¼SE¼SE¼ sec. 21, T. 56 N., R. 87 W. The site is on strike with Gallatin and Gros Ventre Formations and near the base of the Bighorn Dolomite. The flow of 6.43 ft^3/s (0.182 m^3/s) measured July 17, 1974, was all lost below the gage into the basal Bighorn and overlying talus. At least part of this loss crosses surface water drainage divides by flowing through the subsurface into the Tongue River.

A landslide has dammed Little Tongue River in the NW¼ sec. 26, T. 56 N., R. 87 W., forming a large, normally dry, lake bed. It is doubtful, therefore, that there is often continuous flow throughout the channel.

The lower measurement site is in the SW¼SE¼SW¼ sec. 24, T. 56 N., R. 87 W. The site is on strike with, and approximately at the top of, the Tensleep Sandstone. The discharge at the site was 4.40 ft^3/s (0.125 m^3/s) on July 17, 1974. The entire stream was not walked so the origin of this water is not known.

Dye Studies

It has been shown by dye studies that at least a part of the water lost in the upper reach of the Little Tongue River undergoes subterranean diversion beneath surface drainage divides to appear in the stream flowing through the rear portion of Tongue River Cave. The entrance to Tongue River Cave is in Tongue River Canyon in the NW¼SE¼NE¼ sec. 10, T. 56 N., R. 87 W., approximately 2.5 miles (4 km) north of the sinking reach of the Little Tongue River and 2,500 feet (760 m) lower in elevation. The stream enters the cave approximately 1,800 feet (550 m) south of the cave entrance, leaves the cave approximately 1,000 feet (300 m) downstream from where it enters, and is known to resurge beneath the surface of the Tongue River.

At 1630 hours on October 29, 1974, 389 millilitres of a 20 percent solution of Rhodamine WT dye was injected into the Little Tongue River approximately 300 feet (90 m) downstream from the upper measurement site and 200 feet (60 m) upstream from where water was last visible in the streambed. The discharge at the injection site at the time of the dye injection was 0.5 ft^3/s (0.014 m^3/s); while the discharge at the upper measurement site was estimated to be 2 ft^3/s (0.06 m^3/s). Recovery sampling from the stream in Tongue River Cave commenced at 1950 hours on October 30, 1974. The discharge at the sampling site in the cave was measured three times during the sampling period, and an average value of 1.76 ft^3/s (0.0498 m^3/s) was adopted in the subsequent analysis. Absolute dye concentrations were determined from fluorometer measurements of the samples, and the total dye recovered was calculated from the resulting sample concentration-versus-time curve. The total dye recovered in the cave was 35 percent of that injected into the Little Tongue River; while the stream discharge in the cave was 80 percent of the estimated discharge in the Little Tongue River above the sinking reach. It would thus appear that only a portion of the total discharge in the cave is diverted water lost from the Little Tongue River. The concentration-versus-time curve consisted of a single sharp peak, suggesting that the underground route from the Little Tongue River to the stream in the cave consists of a single conduit. The peak occurred 34 hours after injection of the dye into the Little Tongue River.

South Fork Little Tongue River

The upper measurement site is in the NW¼SE¼SW¼ sec. 35, T. 56 N., R. 87 W. The site is on strike of the Flathead Sandstone and downstream from a tributary entering from the south. The discharge was 0.60 ft^3/s (0.017 m^3/s) on August 27, 1974.

The lower measurement site is in the SE¼SE¼NW¼ sec. 25, T. 56 N., R. 87 W. The site is on strike, and near the base of, the Tensleep Sandstone. Diversions and absence of a good measuring section ruled measurement closer to the top of the Tensleep out of consideration.

The flow at the lower site was 1.26 ft^3/s (0.036 m^3/s) on August 27, 1974. The stream channel was not walked to determine where the increase in discharge occurs.

Wolf Creek

The upper site is in the SW¼NW¼NE¼ sec. 7, T. 55 N., R. 86 W. The site is on strike with, and at about the base of, the Bighorn Dolomite. Just below the site the Bighorn is repeated by faulting, and other small faults occur downstream. The discharge was 22.7 ft^3/s (0.643 m^3/s) on July 18, 1974.

The lower site is in the NE¼SE¼SW¼ sec. 5, T. 55 N., R. 86 W. The site is on strike with the Amsden Formation. There are diversions downstream in the reach where the Tensleep Sandstone crops out. The discharge was 21.9 ft^3/s (0.620 m^3/s) on July 18, 1974.

There was no noticable change in discharge in the reach between the two sites.

Soldier Creek

The upper site is in the NW¼NW¼SW¼ sec. 21, T. 55 N., R. 86 W. The site is on strike with the Gallatin and Gros Ventre Formations and just below the base of the Bighorn Dolomite. Seeps issue from the Gallatin and Gros Ventre upstream, but the site was selected below a small tributary in favor of an upstream location. The discharge was 0.29 ft^3/s (0.008 m^3/s) on September 5, 1974.

The lower measurement site is in the SW¼SW¼SW¼ sec. 15, T. 55 N., R. 86 W. The site is about on strike with the top of the Tensleep Sandstone. The discharge was 0.55 ft^3/s (0.016 m^3/s) on September 5, 1974.

Approximately the lower half of the reach was walked and there was no noticeable change in flow in the reach.

Big Goose Creek

The upper measuring site is in the NW¼SW¼NE¼ sec. 3, T. 54 N., R. 86 W. The site is on strike with the Flathead Sandstone. Flow at the site was 15.7 ft^3/s (0.445 m^3/s) on February 12, 1975.

The lower measuring site is at the existing gaging station in the NW¼NE¼ sec. 35, T. 55 N., R. 86 W. This gage is about on strike with the Cloverly Formation of Cretaceous age. Flow at this site was 10.0 ft^3/s (0.283 m /s) on February 11, 1975.

The city of Sheridan was diverting 5.3 ft^3/s (0.15 m^3/s) between the two sites at the time of the measurements. The lower site was accepted as the existing gage, rather than a stratigraphically lower position because of the location of the Sheridan water treatment plant.

Rapid Creek

The upper measuring site is in the NW¼NE¼NW¼ sec. 13, T. 54 N., R. 86 W. The site is on strike with the Gallatin and Gros Ventre Formations near the base of the Bighorn Dolomite. The discharge was 24.3 ft^3/s (0.688 m^3/s) on July 19, 1974.

The lower site is in the NE¼SW¼SE¼ sec. 12, T. 54 N., R. 86 W. The site is on strike with, and near the base of, the Tensleep Sandstone. A diversion above this site is measured with a parshall flume. The flow, including the diversion, was 22.6 ft^3/s (0.640 m^3/s) on July 19, 1974.

The entire reach of the channel was not walked to look for changes in discharge.

Little Goose Creek

The upper measuring site is in the SW¼NW¼NW¼ sec. 12, T. 53 N., R. 85 W. The site is on strike with the Gallatin and Gros Ventre Formations. Flow at the site was 5.16 ft^3/s (0.146 m^3/s) on February 12, 1975.

The lower measuring site is in the SE¼SW¼NE¼ sec. 1, T. 53 N., R. 85 W., at the site of an existing gaging station. The site is near the top of the Tensleep Sandstone. Discharge at the site was 7.58 ft^3/s (0.215 m^3/s) on February 12, 1975.

North Piney Creek

The upper measurement site is in the NW¼SE¼NW¼ sec. 11, T. 53 N., R. 84 W. The site is on strike with, and near the top of, the Gallatin and Gros Ventre Formations. Discharge was 20.3 ft^3/s (0.575 m^3/s) on July 21, 1974.

The lower measurement site is at an existing gage in the NW¼SW¼ sec. 12, T. 53 N., R. 84 W. The site is in the outcrop of the Wasatch Formation of Eocene age, however, the improvement that might be obtained in selecting an upstream site did not warrant the duplication, that for all practical purposes would have been done, by measuring an additional site. Discharge at the site was 22.5 ft^3/s (0.637 m^3/s) on July 21, 1974.

Springs were noted in the base of the Bighorn Dolomite and small seeps issue from the Wasatch above the gage.

South Piney Creek

The upper site is at an existing gage in the NW¼NE¼NE¼ sec. 23, T. 53 N., R. 84 W. This gage is on strike with, and near the top of, the Gallatin and Gros Ventre Formations. The flow at the site was 109 ft^3/s ($3.09 m^3/s$) on July 16, 1974.

The lower measurement site is in the SW¼SW¼SW¼ sec. 13, T. 53 N., R. 84 W. The site is on strike with the eastern-most outcrop of Paleozoic rocks (Madison Limestone) on the south side of the canyon. The Wasatch Formation occurs east of this outcrop. Discharge was 89.7 ft^3/s (2.54 m^3/s) on July 16, 1974.

Sinks near the base of the Bighorn Dolomite and diversions occur within the reach. The principal diversion (Mead-Coffeen ditch) and Spring Creek are also gaged. Water that sinks in the Bighorn Dolomite in the canyon of South Piney Creek is known to rise in Spring Creek (Don Dexter of the Wyoming Game and Fish Commission, oral commun., 1974).

North Rock Creek

The upper measurement site is in the NW¼SW¼SW¼ sec. 13, T. 52 N., R. 84 W. Precambrian rocks crop out in this area. The discharge was 15.4 ft^3/s (0.436 m^3/s) on September 6, 1974.

The lower measurement site is in the SW¼NE¼NW¼ sec. 24, T. 52 N., R. 84 W., just above Pheasant Creek. The discharge was 16.8 ft^3/s (0.476 m^3/s) on September 6, 1974. The area upstream to the mouth of the canyon is underlain by colluvium. The outcrop of the Paleozoic section is absent because of faulting.

South Rock Creek

The upper measurement site is in the SW¼SW¼SW¼ sec. 25, T. 52 N., R. 84 W. The site is on strike with the Gallatin and Gros Ventre Formations and near the base of the Bighorn Dolomite. The discharge was 10.0 ft^3/s (0.283 m^3/s) on September 6, 1974.

The lower measurement site is in the SW¼SW¼SE¼ sec. 25, T. 52 N., R. 84 W. The site is on strike with, and just upstream from, the top of the Tensleep Sandstone. Discharge at the site was 9.30 ft^3/s (0.263 m^3/s) September 6, 1974.

North Fork Sayles Creek

The upper measurement site is in the NE¼NE¼SE¼ sec. 12, T. 51 N., R. 84 W. The site is on strike with, and near the top of, the Gallatin and Gros Ventre Formations. The discharge was 0.04 ft^3/s (0.001 m^3/s) on September 7, 1974.

The lower measurement site is in the SE¼NE¼NW¼ sec. 7, T. 51 N., R. 83 W. The site is on strike with the Tensleep Sandstone and just below the top. The discharge was 0.15 ft^3/s (0.004 m^3/s) on September 7, 1974.

The upstream site is below the confluence of a small tributary and all the water at the upper site was coming from the tributary. The flow disappeared about 10 feet (3 m) below the measuring site. A similar discharge occurs upstream in North Fork Sayles Creek and this flow is lost several hundred yards above the measuring site into the upper part of the Gallatin and Gros Ventre Formations.

Ground-water discharge occurs in the upper part of the Bighorn or the lower part of the Madison. The complete stream reach was not walked.

Johnson Creek

The upper site was measured in the SE¼NE¼NW¼ sec. 29, T. 51 N., R. 83 W. The site is near the middle of the Flathead Sandstone. The discharge was 0.03 ft^3/s (0.001 m^3/s) on September 7, 1974.

The lower site is in the NE¼SE¼NE¼ sec. 29, T. 51 N., R. 83 W., in an area of talus and landslide deposits. The discharge at the site was 0.09 ft^3/s (0.003 m^3/s) on September 7, 1974.

Numerous small seeps issue from the talus and slide deposits. Many of the seeps are well above stream level and the water is probably lost by evaporation and transpiration rather than contributing to streamflow. The Paleozoic rocks younger than the Flathead Sandstone are absent along the stream course due to faulting.

French Creek

The upper measuring site is in the SW¼NE¼NE¼ sec. 32, T. 51 N., R. 83 W. The site is about on strike with the Bighorn and Madison contact. The discharge at the site was 1.43 ft^3/s (0.040 m^3/s) on September 9, 1974.

The lower site is in SE¼NE¼NE¼ sec. 32, T. 51 N., R. 83 W. This site is on strike with the top of the Paleozoic outcrop. The discharge at this site was 1.43 ft^3/s (0.040 m^3/s) on September 9, 1974.

The upper site is stratigraphically higher than that selected at most sites because of a tributary entering from the south. This tributary flow is probably less than 0.1 ft^3/s (0.003 m^3/s) but serves to illustrate the reach upstream from the measured site is not a losing reach.

Clear Creek

The upper site is in the NE¼SE¼NW¼ sec. 10, T. 50 N., R. 83 W. The site is near the Precambrian and Cambrian contact and the stream flows parallel to the contact at the site. The discharge was 76.0 ft^3/s (2.15 m^3/s) on August 6, 1974.

The lower site is in the NE¼NW¼NE¼ sec. 10, T. 50 N., R. 83 W. The site is on the Wasatch Formation outcrop. The discharge at the site was 72.7 ft^3/s (2.06 m^3/s) on August 6, 1974.

Most of the Paleozoic section is faulted out along the stream channel. The abrupt steepening of the stream gradient just downstream from the upper site is probably an expression of the fault.

Little North Fork Crazy Woman Creek

The upper measuring site is in the SW¼NW¼SE¼ sec. 10, T. 49 N., R. 83 W. The site is on strike with the Flathead Sandstone. The discharge at the site was 2.29 ft^3/s (0.065 m^3/s) on August 8, 1974.

The lower measuring site is in the NE¼SW¼SW¼ sec. 11, T. 49 N., R. 83 W. The site is along strike with the Tensleep Sandstone, but below the top because of irrigation diversions. The discharge was 1.40 ft^3/s (0.040 m^3/s) on August 8, 1974.

The entire reach was not walked. Water was noted, on one occasion after a rainstorm, to issue from solution openings in the Madison high above the stream level. These springs may flow for only a short duration in direct response to precipitation or change in stream stage in the upper reach.

North Fork Crazy Woman Creek Tributary

The upper measuring site is in the NE¼NE¼NW¼ sec. 22, T. 49 N., R. 83 W. The site is on strike with the Gallatin and Gros Ventre Formations near the base of the Bighorn Dolomite. Flow at the site was 0.07 ft^3/s (0.002 m^3/s) on August 27, 1974.

The lower measuring site is in the NW¼NE¼NE¼ sec. 22, T. 49 N., R. 83 W. This site is near the top of the Tensleep Sandstone.

Most of the flow at the time of the reconnaissance was piped from an area just below the upper measuring site to a stock tank at the mouth of the canyon. The water is piped because all the water at low flow is lost, but the zone of loss could not be observed.

North Fork Crazy Woman Creek

The upper measuring site is in the NW¼NE¼SW¼ sec. 28, T. 49 N., R. 83 W. The site is along strike of the Gallatin and Gros Ventre Formations and near the base of the Bighorn Dolomite. The discharge at the site was 23.8 ft^3/s (0.674 m^3/s) on July 8, 1974.

The lower measuring site is in the SW¼SW¼NE¼ sec. 27, T. 49 N., R. 83 W. The site is just upstream from, and on strike with, the top of the Tensleep Sandstone. The discharge was 22.6 ft^3/s (0.640 m^3/s) on July 8, 1974.

There are three zones of loss during low flow. The two principal zones are about 0.75 mile (1.2 km) and 0.90 mile (1.4 km) below the upper gage site. Loss of about equal amounts at the two sites nearly depletes streamflow and the small amount of water remaining is lost a few hundred feet downstream, possibly in talus deposits.

Most of the flow at the lower site enters the stream in a spring zone near the top of the Madison Limestone. Smaller springs occur just upstream.

Dye Studies

In September 1974, a known quantity of dye was injected into the stream at the upper measurement site and the amount of dye passing the lower gage site was measured. The dye did not come through the system as a single slug but as three separate peaks. The first and smallest peak was observed in the small flow that passes the two principal zones of loss. This water returned to the springs in the stream channel above the main area of springs at the top of the Madison. The relation of the other two peaks to the different sinks and springs was not observed.

The dye was injected into the stream at 0830 hours, September 25, 1974. Successive peaks arrived at the lower measurement site at 1200, 1515, and 1800 hours the same day. A total of 72.9 percent of the dye was recovered through 1100 hours, September 27, 1974.

The dye loss, nearly 30 percent, cannot be attributed to sorption and other loss in the 1.3-mile (2.1-km) reach between the two gages. A similar study, in a similar geologic environment, in the Wind River Canyon, showed essentially no dye loss from the injection site below Boysen Dam to the mouth of the canyon. This is a distance of 5.7 miles (9.2 km). It is concluded that there was a loss of nearly 30 percent of the water flowing past the upper measuring site. Water that had not previously been part of the stream discharge entered the stream to make the discharge at the lower site only about 5 percent less than that at the upper station.

Muddy Creek

The upper measuring site is in the SE¼SW¼NE¼ sec. 6, T. 48 N., R. 83 W. The site is on strike with the Gallatin and Gros Ventre Formations. The discharge was 0.85 ft^3/s (0.024 m^3/s) on August 6, 1974.

The lower measuring site is in the NE¼SE¼NW¼ sec. 3, T. 48 N., R. 83 W. The site is on strike with the top of the Tensleep Sandstone. The discharge at the site was 0.71 ft^3/s (0.020 m^3/s) on August 6, 1974.

Small seeps issue from the Flathead Sandstone just above the upper site. The entire reach between the two gages was not walked.

Billy Creek

The upper measurement site is in the NE¼NW¼SW¼ sec. 16, T. 48 N., R. 83 W. The site is on strike with the Gallatin and Gros Ventre Formations. The discharge at the site was 0.83 ft^3/s (0.024 m^3/s) on August 8, 1974.

The lower measurement site is in the SW¼NW¼NE¼ sec. 15, T. 48 N., R. 83 W. The site is on strike with the Tensleep Sandstone and just upstream from the top. Discharge at the site was 0.88 ft^3/s (0.025 m^3/s) on August 8, 1974.

The channel was walked from the lower site to about the base of the Madison Limestone and there was no noticeable change in discharge. The upper site is downstream from a large landslide deposit that may affect flow in the stream.

Poison Creek

The upper measurement site is in the SE¼NW¼NW¼ sec. 32, T. 48 N., R. 83 W. The site is probably along the strike of the Gallatin and Gros Ventre Formations but landslide deposits on either side of the valley conceal the bedrock. The discharge at the site was 2.58 ft^3/s (0.073 m^3/s) on September 8, 1974.

The lower measurement site is in the SW¼NE¼SW¼ sec. 3, T. 47 N., R. 83 W. The site is just upstream from the top of the Tensleep Sandstone. Discharge at the site was 2.95 ft^3/s (0.084 m^3/s) September 8, 1974.

The reach between the two sites was not walked.

Middle Fork Crazy Woman Creek

The upper measurement site is in the SW¼SW¼NW¼ sec. 8, T. 47 N., R. 83 W. The site is in an area where Precambrian rocks are exposed. Discharge at the site was 5.42 ft^3/s (0.153 m^3/s) on September 8, 1974.

The lower measurement site is in the SW¼SW¼NE¼ sec. 10, T. 47 N., R. 83 W. The site is upstream from a small diversion in an area where the Tensleep Sandstone crops out. The discharge at the site was 5.74 ft^3/s (0.163 m^3/s) on September 8, 1974.

The reach between the two sites was not walked.

Beaver Creek

The upper measurement site is in the NW¼SW¼NW¼ sec. 29, T. 47 N., R. 83 W. At this site the stream flows on the dip slope of the Flathead Sandstone. The discharge was 0.04 ft^3/s (0.001 m^3/s) on September 10, 1974.

The lower site is in the NE¼NW¼NE¼ sec. 28, T. 47 N., R. 83 W., at the top of the Tensleep Sandstone. There was no flow on September 10, 1974.

Flow at the time of the reconnaissance was lost into the Flathead Sandstone and resumed downstream near the base of the Bighorn Dolomite. The rest of the channel was not walked.

North Fork Powder River

The upper measurement site is in the NE¼SE¼SW¼ sec. 25, T. 47 N., R. 85 W., and the lower site is in the NW¼NE¼SE¼ sec. 36, T. 46 N., R. 84 W. The gage at the lower site was installed as the result of recommendations of a previous study of stream loss below Dullknife Reservoir. The results of this study, which was done in 1971, are abstracted below.

A traverse of the North Fork Powder River from Gardner Creek to the gage near Mayoworth, a distance of about 7.4 miles (12 km), was made on August 31 and September 1, 1971. Release from the reservoir had been shut off the previous day to cut back the amount of streamflow in the reach. An account of discharge measurements of the traverse follows.

Streamflow of the North Fork Powder River above Gardner Creek was 13.3 ft^3/s (0.377 m^3/s); streamflow of Gardner Creek was 3.90 ft^3/s (0.110 m^3/s). At this locality, the river flowed on the Bighorn Dolomite, and there was about 100 feet (30 m) of Bighorn above stream level.

Downstream from Gardner Creek, the stream flowed on the Bighorn Dolomite for about 1.1 miles (1.8 km) at which point the stream gradient increased noticeably, and the underlying Cambrian rocks (Gallatin Formation) were exposed along the stream channel. The stream flowed on the Cambrian rocks for about 0.8 mile (1.3 km), or 1.9 miles (3.1 km) below Gardner Creek, from which point the stream again flowed on the Bighorn Dolomite for about 0.2 mile (0.3 km) to a point about 2.1 miles (3.4 km) below Gardner Creek. At 2.1 miles (3.4 km) below Gardner Creek, the stream flowed on the Madison Limestone and a streamflow measurement of 18.5 ft^3/s (0.524 m^3/s) was made.

The stream continued to flow on the Madison Limestone for about 1.2 miles (1.9 km) to a point about 3.3 miles (5.3 km) downstream from Gardner Creek where the overlying Amsden Formation was exposed at stream level. About 0.7 mile (1.1 km) downstream from this contact, or about 4.0 miles (6.4 km) below Gardner Creek, a streamflow measurement of 16.2 ft^3/s (0.459 m^3/s) was made.

At a point about 4.2 miles (6.8 km) downstream from Gardner Creek, the stream gradient again steepened and the Madison Formation was exposed along the stream channel for about 0.2 mile (0.3 km), but no increase or decrease in streamflow along this reach was apparent. Downstream from this point the stream flowed on the Amsden Formation and the overlying Tensleep Sandstone to a point about 6.0 miles (9.7 km) below Gardner Creek. Downstream from this point, the stream flowed on red beds of Permian and Triassic age.

A streamflow measurement of 3.93 ft^3/s (0.111 m^3/s) was made at Pass Creek, about 5.3 miles (8.5 km) below Gardner Creek. Discharge at the gage near Mayoworth, about 7.4 miles (11.9 km) below Gardner Creek, determined from gage height, was 22.2 ft^3/s (0.629 m^3/s).

A traverse of the North Fork Powder River from the sinkholes near Bull Creek to the big spring below Johnson Creek, a distance of about 3.8 miles (6.1 km), was made September 16, 1971.

Release from the reservoir was 29.8 ft^3/s (0.844 m^3/s). Straw had been placed in the sinkholes near Bull Creek a few days earlier by a local rancher in an attempt to prevent water from going into the sinkholes. The straw was partially effective, about 20 ft^3/s (0.6 m^3/s) was flowing past the sinkholes and reaching that part of the stream underlain by sandstone about 600 feet (180 m) downstream from the sinkholes. From this point for a distance of about 2.1 miles (3.4 km) below Bull Creek the stream flowed on the Tensleep Sandstone or the Amsden Formation. No stream loss or gain was apparent in this reach. Downstream from this reach the stream flowed on the Madison Limestone. Within a quarter of a mile (0.4 km) downstream from the Amsden and Madison contact a loss in streamflow was noticeable. Within another quarter of a mile (0.4 km) all the streamflow, about 20 ft^3/s (0.6 m^3/s) had disappeared below the stream bed. Most of the water entered into apparent sinkholes in about a 600-foot (180-m) reach of the stream about 0.5 mile (0.8 km) upstream from Johnson Creek. At a distance of about 2.7 miles (4.3 km) below Bull Creek--about 0.4 mile (0.6 km) above Johnson Creek--all flow in the stream had disappeared and there was no flow between that point and the big spring about 0.7 mile (1.1 km) below Johnson Creek. It is probable that additional water would go underground if larger discharges were released from the reservoir.

The geology along the stream in the vicinity of and upstream from the sinkholes near Bull Creek was examined in an attempt to delineate the upstream extent of possible sinkhole development.

The area is extensively faulted. The main fault zone extends east-west along the North Fork Powder River in the vicinity of Bull Creek. Displacement of the fault is as much as 1,400 feet (430 m) in the vicinity of Bull Creek. The fault zone extends along the river channel about 0.4 mile (0.6 km) upstream from the mouth of Bull Creek. From this point, the fault zone continues westward, whereas the stream bends upstream in a more northwestward direction. Upstream from the point of divergence of the stream from the fault zone, the stream flows on either the Flathead Sandstone or Precambrian granitic rocks, neither of which are conducive to solution and sinkhole development. Downstream from this point, the stream flows along a fault zone where Tensleep Sandstone is faulted against Flathead Sandstone. Underlying the Tensleep Sandstone are several hundred feet of carbonate rocks that are conducive to solution and sinkhole development.

Beartrap Creek

Bighorn Dolomite and the underlying Cambrian rocks are exposed along Beartrap Creek in the SE¼SW¼NE¼ sec. 36, T. 45 N., R. 85 W. The discharge of the creek at this site was 5.96 ft^3/s (0.169 m^3/s) at the time of the reconnaissance on September 13, 1974.

Sandstone near the middle of the Tensleep is exposed in the NE¼NE¼NE¼ sec. 19, T. 44 N., R. 84 W., near the mouth of Beartrap Creek. The discharge of Beartrap Creek 100 feet (30 m) above its mouth was 6.51 ft^3/s (0.184 m^3/s).

These two measurements indicate that Beartrap Creek had a net gain in streamflow of 0.55 ft^3/s (0.016 m^3/s) across the outcrop area of the Bighorn Dolomite, Madison Limestone, Amsden Formation, and lower part of the Tensleep Sandstone.

North Fork Red Fork Powder River

Bighorn Dolomite and the underlying Cambrian rocks are exposed along North Fork Red Fork Powder River in the SE¼NE¼NW¼ sec. 10, T. 44 N., R. 85 W. The discharge of the creek at this site, 300 feet (90 m) below Baldwin Creek, was 2.08 ft^3/s (0.059 m^3/s) at the time of the reconnaissance on September 12, 1974.

Sandstone near the middle of the Tensleep is exposed in the NE¼NE¼NE¼ sec. 19, T. 44 N., R. 84 W., along North Fork Red Fork Powder River near the mouth of Beartrap Creek. The Tensleep in this area strikes N. 26° E. and dips 12° SE. The discharge of North Fork Red Fork Powder river about 100 feet (30 m) above Beartrap Creek was 2.52 ft^3/s (0.071 m^3/s).

These two measurements indicate that North Fork Red Fork Powder River had a net gain in streamflow of 0.44 ft^3/s (0.012 m^3/s) across the outcrop area of the Bighorn Dolomite, Madison Limestone, Amsden Formation, and lower part of the Tensleep Sandstone.

At the mouth of the canyon in the SW¼SE¼ sec. 20, T. 44 N., R. 84 W., the top of the Tensleep is exposed along North Fork Red Fork Powder River. The discharge of the river at this point was 9.40 ft^3/s (0.266 m^3/s). Taking into account the discharge of Beartrap Creek at its mouth, the North Fork Red Fork Powder River gained an additional 0.81 ft^3/s (0.023 m^3/s) where it flowed across the upper part of the Tensleep.

South Fork Red Fork Powder River

Bighorn Dolomite and underlying Cambrian rocks are exposed along South Fork Red Fork Powder River in the NE¼SW¼NE¼ sec. 26, T. 44 N., R. 85 W. The discharge of the river at this site was 5.21 ft^3/s (0.148 m^3/s) at the time of the reconnaissance on September 11, 1974.

The top of the Tensleep Sandstone is exposed at the mouth of the canyon in the NW¼NW¼NE¼ sec. 29, T. 44 N., R. 84 W. The discharge of South Fork Red Fork Powder River at this site was 7.19 ft^3/s (0.204 m^3/s).

These two measurements indicate that South Fork Red Fork Powder River has a net gain in streamflow of 1.98 ft^3/s (0.056 m^3/s) across the outcrop area of the Bighorn Dolomite, Madison Limestone, Amsden Formation, and Tensleep Sandstone.

Beaver Creek

Bighorn Dolomite(?) and the underlying Cambrian rocks are exposed in the hillside about 80 feet (24 m) above Beaver Creek in the SE¼SE¼NW¼ sec. 28, T. 43 N., R. 85 W. The discharge of Beaver Creek at this site was 1.94 ft^3/s (0.055 m^3/s) at the time of the reconnaissance on August 29, 1974.

The top of the Tensleep Sandstone is exposed at the mouth of the canyon in the SE¼SW¼NW¼ sec. 16, T. 43 N., R. 84 W. The Tensleep strikes N. 35° E. and dips 8° SE. The discharge of Beaver Creek at this site was 7.13 ft^3/s (0.202 m^3/s).

These two discharge measurements indicate that Beaver Creek had a net gain in streamflow of 5.19 ft^3/s (0.147 m^3/s) across the outcrop areas of the Bighorn Dolomite(?), Madison Limestone, Amsden Formation, and Tensleep Sandstone.

Middle Fork Powder River

Madison Limestone and underlying Cambrian rocks are exposed in the canyon walls along the Middle Fork Powder River in the NW¼NE¼NW¼ sec. 30, T. 42 N., R. 84 W. The Madison strikes N. 5° E. and dips 8° SE. The discharge of the river at this spot was 13.6 ft^3/s (0.385 m^3/s) at the time of the reconnaissance on September 10, 1974.

Downstream, the Madison has extensive solution openings just above river level, and many small seeps and springs issue from the limestone. "Outlaw Cave" is located along the left bank in NW¼SW¼ sec. 21, T. 42 N., R. 84 W. No sinkholes were observed.

The Madison and Amsden contact is exposed at river level in the SW¼NW¼ sec. 21, T. 42 N., R. 84 W. The Madison strikes N. 30° E. and dips 6° SE. The discharge of the river at the Madison and Amsden contact was 17.1 ft^3/s (0.484 m^3/s), indicating a gain in flow of 3.5 ft^3/s (0.099 m^3/s) across the Madison outcrop.

The top of the Tensleep Sandstone is exposed at the mouth of the canyon in the SE¼SW¼SW¼ sec. 14, T. 42 N., R. 84 W. The discharge of the Middle Fork Powder River was 16.6 ft3/s (0.470 m3/s) at this point. This measurement and the measurement made upstream at the Madison and Amsden contact indicate a 0.5 ft^3/s (0.014 m^3/s) loss across the Amsden and Tensleep outcrops. The difference in discharge, however, is well within the range of error in the measurements.

Pine Creek

Madison Limestone and the underlying Cambrian rocks are exposed in the hillside east of Pine Creek in the SE¼SW¼SW¼ sec. 10, T. 40 N., R. 86 W. The discharge of the creek at the contact was 0.44 ft^3/s (0.012 m^3/s) at the time of the reconnaissance on August 28, 1974.

Exposures of Madison Limestone are poor along the creek, and the degree of secondary permeability could not be determined. Pine Creek gradually lost all of its water in crossing the Madison outcrop, and in the SE¼SW¼NE¼ sec. 15, T. 40 N., R. 86 W., the creek was dry. No sinkholes were observed.

The Madison and Amsden contact is exposed along Pine Creek in the NW¼NW¼NW¼ sec. 23, T. 40 N., R. 86 W. Pine Creek was dry at this site.

Buffalo Creek

Madison Limestone and the underlying Cambrian rocks are exposed along Buffalo Creek in the SW¼NW¼NE¼ sec. 20, T. 40 N., R. 86 W., about 400 feet (120 m) below the mouth of Middle Fork Buffalo Creek. The Madison strikes N. 35° E. and dips 24° SE. The discharge at this spot was 0.11 ft^3/s (0.003 m^3/s) at the time of the reconnaissance on August 27, 1974.

The Madison Limestone along Buffalo Creek has some secondary permeability in the form of solution openings mainly along bedding planes. The creek gradually lost water, and in the SW¼NW¼NW¼ sec. 21, T. 40 N., R. 86 W., the stream was dry. The streambed is covered with a thin layer of alluvium, and no sinkholes were observed.

Along the North Fork Buffalo Creek, Madison Limestone and the underlying Cambrian rocks are exposed in the SE¼SE¼NE¼ sec. 17, T. 40 N., R. 86 W. The Madison strikes N. 30° E. and dips 20° SE. The discharge at this spot was 0.95 ft^3/s (0.027 m^3/s) at the time of the reconnaissance on August 28, 1974. All of the flow in the north fork was lost to a sinkhole in the SE¼NW¼SW¼ sec. 16, T. 40 N., R. 86 W. The streambed at the sinkhole is covered with a thin layer of alluvium and no Madison Limestone is exposed. The sinkhole appears as a small depression in the streambed.

The Madison and Amsden contact is exposed on hillsides on both sides of Buffalo Creek below the confluence of the North Fork and the South Fork. Exposures along the creek are poor, but the creek probably crosses the Madison and Amsden contact in the NE¼NW¼SE¼ sec. 21, T. 40 N., R. 86 W. Buffalo Creek was dry at this spot.

In summary, inflow to the Madison outcrop was 0.11 ft^3/s (0.003 m^3/s) on Buffalo Creek and 0.95 ft^3/s (0.027 m^3/s) on North Fork Buffalo Creek. All of the water was lost to the Madison in a short distance. At the Madison and Amsden contact below the mouth of the north fork, Buffalo Creek was dry, indicating a net loss of 1.06 ft^3/s (0.030 m^3/s).

BLACK HILLS UPLIFT

General Geologic and Hydrologic Description

The Black Hills Uplift is an elongate dome with approximate dimensions of 120 miles (190 km) north and south and as much as 60 miles (100 km) east and west. The core of the uplift consists predominantly of Precambrian igneous and metamorphic rocks. The Precambrian rocks are surrounded by concentric outcrops of successively younger Paleozoic rocks that dip away from the central area. The Paleozoic rocks are steeply inclined along the east side of the Black Hills Uplift and are gently dipping on the west side.

The Paleozoic formations, which are the ones of primary interest, consist in ascending order of the Deadwood Formation of Cambrian and Ordovician age, the Winnipeg Formation and Whitewood Dolomite of Ordovician age, the Englewood Formation of Devonian and Mississippian age, the Pahasapa Limestone (the Madison Limestone equivalent in the Black Hills Uplift area) of Mississippian age, the Minnelusa Formation of Pennsylvanian and Permian age, the Opeche Shale and Minnekahta Limestone of Permian age, and the Spearfish Formation of Permian and Triassic age.

The Pahasapa Limestone (the Madison Limestone equivalent) is over 600 feet (200 m) thick in Spearfish Canyon in the northern part of the Black Hills Uplift, and thins to about 300 feet (100 m) in the southern part.

The degree of hydraulic connection between the Pahasapa Limestone and both the underlying and overlying rocks is not known. However, in the western part of the Black Hills Uplift along Stockade Beaver Creek, the hydraulic connection between the Pahasapa Limestone and the overlying Minnelusa Formation, Opeche Shale, Minnekahta Limestone, and Spearfish Formation is probably good.

Stockade Beaver Creek

The upper measurement site is in the NE¼NE¼ sec. 4, T. 47 N., R. 60 W., where the canyon floor and walls are red to yellow sandstone of the Minnelusa Formation. An outcrop of the Minnekahta Limestone is a few hundred feet west of the canyon wall. The discharge was 1.77 ft^3/s (0.050 m^3/s) on September 6, 1974.

The stream originates from springs in the Madison Limestone in South Dakota about 3 miles (5 km) upstream from the upper measurement site. The stream gains water from numerous small seepage type springs along a reach about 1,200 feet (370 m) long. About 9 miles (14 km) downstream from the upper measurement site the stream disappears, probably into permeable zones in the Minnekahta and (or) solution channels in gypsum zones in the Spearfish Formation. Farther downstream, streamflow reappears as the Spearfish outcrop narrows.

The lower measurement site is in the SW¼SE¼ sec. 19, T. 45 N., R. 60 W. The discharge was 10.5 ft^3/s (0.30 m^3/s) on September 6, 1974. The valley floor at this site and for several miles upstream is Spearfish Formation. On the west the valley walls are Sundance Formation overlain by rocks of the Morrison Formation both of Jurassic age and the Inyan Kara Group of Cretaceous age. The eastern valley wall consists of Minnekahta Limestone underlain by Opeche Shale and Minnelusa Formation. Springs with extensive travertine deposits are on the eastern side of the valley about 140 feet (43 m) above the valley floor. This spring water probably originates from Stockade Beaver Creek where it flows along the Minnekahta, Opeche, and Minnelusa rocks several miles upstream.

Cold Springs and Sand Creeks

The upper measurement site on Cold Springs Creek is in the NW¼ sec. 9, T. 48 N., R. 60 W. The discharge was 3.82 ft^3/s (0.108 m^3/s) on September 5, 1974. Surface rocks are Minnelusa Formation and consist of yellow to red crossbedded sandstone, limestone, anhydrite, and shale. The stream originates from numerous springs issuing from the Madison Limestone in South Dakota about 3 miles (5 km) upstream. Downstream from the upper measurement site the creek flows along the Minnelusa, Opeche, and Minnekahta rocks for about 3.5 miles (5.6 km) and then over the Minnelusa outcrop to about 14 miles (23 km) north where it gradually disappears. No faults or other structures are evident in the vicinity of the upper measurement site or downstream (north) to the area where the streamflow disappears.

The lower measurement site on Sand Creek (Cold Springs Creek becomes Sand Creek downstream from Idol Gulch) is in the SW¼ sec. 18, T. 52 N., R. 60 W. Discharge at this site was 27.0 ft^3/s (0.765 m^3/s) on September 5, 1974. The perennial flow in Sand Creek begins from springs in the Madison Limestone near the Fish Genetics Laboratory, U.S. Fish and Wildlife Service. The springs are in a bog area about 0.5 mile (0.8 km) upstream from the lower measurement site and appear to consist of many small springs rather than a few large ones. The aggregate flow from the bog area averages about 24 ft^3/s (0.68 m^3/s). Part of the spring flow may be from Cold Springs Creek, which gradually seeps into the Minnelusa and ceases to flow perennially about 8 miles (13 km) upstream from the spring area.

At the lower measurement site, as in the spring area, the valley floor is Madison Limestone and the walls are red to yellow sandstone and limestone of the Minnelusa Formation. No faults or structure are visible in the vicinity of the spring area or in the reach of the stream where perennial flow occurs.

Inyan Kara Creek

The measurement site is at the bridge on State Highway 116 in the S½ sec. 17, T. 49 N., R. 63 W. Discharge was 1.14 ft^3/s (0.032 m^3/s) on September 5, 1974. Bedrock at this site is Sundance Formation, with higher areas of Spearfish Formation nearby.

The stream originates from a spring near the Spearfish and Minnekahta contact in the northeast corner of T. 49 N., R. 62 W. The dip of the Minnekahta at the spring is 7° W. The stream flows along the Spearfish and Minnekahta contact for about 5 miles (8 km) and gains water from additional contact springs.

No fractures, faults, or other structures are evident in the reach from the springs to the measurement site.

REFERENCES

Hodson, W. G., Pearl, R. H., and Druse, S. A., 1973, Water resources of the Powder River basin and adjacent areas, northeastern Wyoming: U.S. Geol. Survey Hydrol. Inv. Atlas HA-465.

Maughan, E. K., 1963, Mississippian rocks in the Laramie Range, Wyoming, and adjacent areas: U.S. Geol. Survey Prof Paper 475-C, p. C23-27.

Rapp, J. R., 1953, Reconnaissance of the geology and ground-water resources of the La Prele area, Converse County, Wyoming: U.S. Geol. Survey Circ. 243, 33 p.

Swenson, F. A., Miller, W. R., Hodson, W. G., and Visher, F. N., 1975, Water in the Madison Group, Wyoming and Montana: U.S. Geol. Survey open-file rept. 75-660, 26 p., 4 pl. [Also in press as U.S. Geol. Survey Misc. Inv. Map I-847-C.]

Table 1.--Results of discharge measurements at gaging stations

Stream	Upper Site Date	Upper Site Discharge (ft^3/s)	Lower Site Date	Lower Site Discharge (ft^3/s)
		LARAMIE MOUNTAINS		
Smith Creek	8- 1-74	2.98	8- 1-74	2.57
	10-16-74	2.42	10-17-74	1.86
	12- 4-74	1.90	12- 4-74	1.61
Little Box Elder Creek	7-29-74	.87	7-29-74	.00
	10-10-74	.95	10-10-74	.00
	12- 4-74	.74	12- 4-74	.00
Little Deer Creek	7-31-74	1.09	7-31-74	.55
	10-10-74	.68	10- 9-74	.35
	12- 3-74	.67	12- 3-74	.50
Cottonwood Creek	6-17-74	8.42	6-17-74	4.83
	7-25-74	.60	7-24-74	.00
	8- 5-74	.57	8- 5-74	.00
	9- 4-74	.26	9- 4-74	.00
	10- 1-74	.29	10- 1-74	.00
	11- 5-74	.28	11- 5-74	.00
		BIGHORN MOUNTAINS		
East Pass Creek			9- 4-74	9.10
			10-25-74	5.96
			11-12-74	7.06
Tongue River	7-17-74	223	7-17-74	*225
	9-25-74	99.7	9-25-74	*93.4
	10- 7-74	57.3	10- 7-74	*64.8
	11-12-74	61.0	11-12-74	*66
Little Tongue River	7-17-74	6.43	7-17-74	4.40
	9-25-74	1.52	9-25-74	.87
	10- 9-74	2.98	10- 9-74	1.42
	11-14-74	1.92	11-14-74	.90
Wolf Creek	7-18-74	22.7	7-18-74	21.9
	10-23-74	6.38	10-27-74	5.83
	11-12-74	6.79	11-12-74	7.03
South Piney Creek	7-16-74	109	7-16-74	89.7
	10-27-74	24.9	10-27-74	22.5
	11-11-74	24.4	11-11-74	20.6

* Total of flow in Tongue River and Highline ditch.

Table 1.--Results of discharge measurements at gaging stations--continued

Stream	Upper Site Date	Upper Site Discharge (ft^3/s)	Lower Site Date	Lower Site Discharge (ft^3/s)
		BIGHORN MOUNTAINS--continued		
Mead-Coffeen Ditch	7-16-74	21.3	10-27-74	2.54
	10-27-74	.94	11-13-74	2.27
	11-11-74	.95		
Spring Creek			10-27-74	2.52
			11-13-74	1.93
South Rock Creek	9- 6-74	10.0	9- 6-74	9.30
	10-24-74	5.81	10-22-74	6.04
	11-13-74	5.47	11-13-74	4.95
North Fork Crazy Woman Creek	7- 8-74	23.8	7- 8-74	22.6
	8- 8-74	27.6	8- 8-74	25.9
	9-10-74	10.1	9-10-74	9.68
	9-25-74	8.98	9-25-74	9.81
	10- 7-74	17.2	10- 7-74	15.7
	11-19-74	8.36	11-19-74	7.75
Poison Creek	9- 8-74	2.58	9- 8-74	2.95
	10-25-74	2.66	10-26-74	3.15
	11- 6-74	3.47	11-21-74	3.00
	12- 2-74	1.66		
North Fork Powder River	8-15-74	18.1	7-22-74	50.0
	9-10-74	8.45	11-21-74	19.2
	10- 7-74	4.14		
	11- 6-74	3.08		
	12- 3-74	1.65		
Gardner Creek (Miscellaneous measurements at mouth)			7-23-74	4.14
			11- 7-74	4.37
			12- 3-74	4.01
Pass Creek (miscellaneous measurements at mouth)			7-22-74	3.18
			11-21-74	3.87
Beaver Creek	8-29-74	1.94	8-30-74	7.13
	11- 7-74	2.04	11- 1-74	7.90
			11-21-74	8.06
Buffalo Creek	8-27-74	.11	8-27-74	.00
	11-12-74	.28	10-16-74	.00
	12- 5-74	.38	10-24-74	.00
			12- 5-74	.00

Table 1.--Results of discharge measurements at gaging stations--continued

Stream	Upper Site		Lower Site	
	Date	Discharge (ft^3/s)	Date	Discharge (ft^3/s)
BIGHORN MOUNTAINS--continued				
North Fork Buffalo Creek	8-28-74	.95		
	11-14-74	1.46		
	12- 3-74	1.01		
BLACK HILLS UPLIFT				
Stockade Beaver Creek	9- 6-74	1.77	9- 6-74	10.5
	10-22-74	1.84	10-24-74	14.1
	11-12-74	1.88	11-13-74	12.4
Cold Springs-Sand Creek	9- 5-74	3.82	9- 5-74	27.0
	10-23-74	2.43	9-18-74	26.6
	11-12-74	2.44	10- 3-74	25.7
			11-12-74	24.0

Table 2.--Location of gaging stations

Stream	Upper Site	Lower Site
	LARAMIE MOUNTAINS	
Smith Creek	Lat 42°39'00", long 106°10'39", in SW¼SE¼NW¼ sec.15, T.31 N., R.78 W., Natrona County, digital water-stage recorder with pressure-transducer system, 1.2 miles upstream from Otter Creek, and 16 miles southeast of Casper.	Lat 42°39'24", long 106°09'40", in NE¼NW¼SW¼ sec.14, T.31 N., R.78 W., Natrona County, digital water-stage recorder with pressure-transducer system, 0.2 mile upstream from Otter Creek, and 16 miles southeast of Casper.
Little Box Elder Creek	Lat 42°45'04", long 105°44'25", in SE¼SW¼SE¼ sec.8, T.32 N., R.74 W., Converse County, digital water-stage recorder with pressure-transducer system, 4.6 miles southwest of Barber Ranch, and 7.6 miles southwest of Careyhurst.	Lat 42°45'38", long 105°43'33", in NE¼SE¼NW¼ sec.9, T.32 N., R.74 W., Converse County, graphic water-stage recorder with stilling well, 0.3 mile southwest of Little Box Elder Cave, 3.6 miles southwest of Barber Ranch, and 6.6 miles southwest of Careyhurst.
Little Deer Creek	Lat 42°42'54", long 105°57'51", in NW¼NW¼SW¼ sec.28, T.32 N., R.76 W., Converse County, digital water-stage recorder with pressure-transducer system, 0.2 mile upstream from East Cart Creek, and 11.2 miles south of Glenrock.	Lat 42°43'17", long 105°57'57", in NW¼NW¼NW¼ sec.28, T.32 N., R.76 W., Converse County, graphic water-stage recorder with servo-manometer system, 0.2 mile downstream from East Cart Creek, and 10.8 miles south of Glenrock.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	LARAMIE MOUNTAINS--continued	
Cottonwood Creek	Lat 42°18'53", long 105°13'33", in NW¼SE¼NE¼ sec.15, T.27 N., R.70 W., Platte County, graphic water-stage recorder with servo-manometer system, 0.2 mile downstream from Dagley Creek, 0.2 mile upstream from diversion tunnel inlet, 1.1 miles downstream from Cottonwood Falls, 1.3 miles downstream from bridge on county road, and 7.0 miles southeast of Binford.	Lat 42°18'27", long 105°13'08", in SE¼SW¼SW¼ sec.14, T.27 N., R.70 W., Platte County, graphic water-stage recorder with servo-manometer system, 700 feet downstream from diversion tunnel outlet, 1.9 miles downstream from Dagley Creek, and 7.5 miles southeast of Binford.
	BIGHORN MOUNTAINS	
East Pass Creek		Lat 44°56'37", long 107°29'05", in sec.4, T.57 N., R.88 W. (unsurveyed), Sheridan County, graphic water-stage recorder with servo-manometer system, 0.6 mile upstream from Taffner Creek, 1.5 miles downstream from West Fork, and 7.7 miles southwest of Parkman.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BIGHORN MOUNTAINS--continued	
Tongue River	Lat 44°50'45", long 107°19'56", in SE¼NE¼NW¼ sec.10, T.56 N., R.87 W., Sheridan County, Bighorn National Forest, graphic water-stage recorder with servo-manometer system, at bridge on Forest Service trail, 0.2 mile upstream from Tongue Canyon Campground, 1.0 mile upstream from Highline ditch intake, 2.1 miles downstream from Sheep Creek, and 3.8 miles southwest of Dayton.	Lat 44°50'58", long 107°18'14", in NE¼NE¼NE¼ sec.11, T.56 N., R.87 W., Sheridan County, graphic water-stage recorder with stilling well, 0.5 mile upstream from Crystal Draw, 0.6 mile downstream from Highline ditch intake, and 2.5 miles southwest of Dayton. A graphic water-stage recorder with stilling well is also in operation on Highline ditch. These gaging stations are a part of the cooperative program with the Wyoming State Engineer.
Little Tongue River	Lat 44°48'25", long 107°20'47", in SW¼SE¼SE¼ sec.21, T.56 N., R.87 W., Sheridan County, Bighorn National Forest, graphic water-stage recorder with servo-manometer system, 0.4 mile downstream from unnamed tributary, 0.5 mile northeast of Fallen City, 0.6 mile east of Steamboat Point, 3.0 miles upstream from South Fork Little Tongue River, and 6.3 miles southwest of Dayton.	Lat 44°48'22", long 107°17'44", in SW¼SE¼SW¼ sec.24, T.56 N., R.87 W., Sheridan County, graphic water-stage recorder with servo-manometer system, 0.3 mile downstream from Bighorn National Forest boundary, 0.5 mile upstream from South Fork Little Tongue River, and 5.0 miles southwest of Dayton.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BIGHORN MOUNTAINS--continued	
Wolf Creek	Lat 44°45'36", long 107°15'53", in SW¼NW¼NE¼ sec.7, T.55 N., R.86 W., Sheridan County, Bighorn National Forest, graphic water-stage recorder with servo-manometer system, 0.5 mile upstream from forest boundary, 1.1 miles upstream from Red Canyon Creek, 1.2 miles west of Wolf, and 1.5 miles downstream from Alden Creek.	Lat 44°45'54", long 107°14'48", in NE¼SE¼SW¼ sec.5, T.55 N., R.86 W., Sheridan County, graphic water-stage recorder with servo-manometer system, 0.4 mile upstream from Red Canyon Creek, 0.5 mile downstream from Bighorn National Forest boundary, and 0.6 mile southwest of Wolf.
South Piney Creek	Lat 44°33'26", long 106°56'11", in NW¼NE¼NE¼ sec.23, T.53 N., R.84 W., Johnson County, Bighorn National Forest, graphic water-stage recorder with stilling well, 2.3 miles southwest of Story, and 3.3 miles upstream from confluence with North Piney Creek. This gaging station is a part of the cooperative program with the Wyoming State Engineer.	Lat 44°33'29", long 106°55'50", in SW¼SW¼SW¼ sec.13, T.53 N., R.84 W., Sheridan County, graphic water-stage recorder with servo-manometer system, 0.3 mile downstream from Mead-Coffeen ditch intake, 0.5 mile upstream from Big Piney ditch intake, and 2.1 miles southwest of Story.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BIGHORN MOUNTAINS--continued	
Mead-Coffeen Ditch (diversion from South Piney Creek)	Lat 44°33'41", long 106°55'45", in NE¼SW¼SW¼ sec.13, T.53 N., R.84 W., Sheridan County, graphic water-stage recorder with stilling well, at roadway 0.3 mile southwest of fish hatchery, 0.4 mile downstream from intake, and 1.9 miles southwest of Story.	Lat 44°34'07", long 106°55'29", in NE¼SE¼NW¼ sec.13, T.53 N., R.84 W., Sheridan County, graphic water-stage recorder with stilling well, at upstream side of county road, 0.3 mile northeast of fish hatchery, 1.1 miles downstream from intake, and 1.4 miles southwest of Story. Also Spring Creek at lat 44°34'07", long 106°55'23", in NE¼SE¼NW¼ sec.13, T.53 N., R.84 W., Sheridan County, graphic water-stage recorder with stilling well, at upstream side of county road, 0.3 mile northeast of fish hatchery, 1.4 miles upstream from mouth, and 1.4 miles southwest of Story.
South Rock Creek	Lat 44°26'37", long 106°55'12", in SW¼SW¼SW¼ sec.25, T.52 N., R.84 W., Johnson County, graphic water-stage recorder with servo-manometer system, just downstream from Bighorn National Forest boundary, 0.2 mile downstream from unnamed tributary, 0.7 mile upstream from Red Canyon, and 13 miles northwest of Buffalo.	Lat 44°26'36", long 106°54'36", in SW¼SW¼SE¼ sec.25, T.52 N., R.84 W., Johnson County, graphic water-stage recorder with servo-manometer system, 0.2 mile upstream from Red Canyon, and 13 miles northwest of Buffalo.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BIGHORN MOUNTAINS--continued	
North Fork Crazy Woman Creek	Lat 44°11'11", long 106°51'12", in NW¼NE¼SW¼ sec.28, T.49 N., R.83 W., Johnson County, Bighorn National Forest, graphic water-stage recorder with servo-manometer system, 8 feet upstream from bridge, 0.7 mile upstream from forest boundary, 3.4 miles downstream from Pole Creek, 4.0 miles west of Klondike Ranch, and 13 miles southwest of Buffalo. This gaging station is operated in cooperation with the Wyoming Department of Economic Planning and Development.	Lat 44°11'16", long 106°49'48", in SW¼SW¼NE¼ sec.27, T.49 N., R.83 W., Johnson County, graphic water-stage recorder with servo-manometer system, 70 feet upstream from bridge on county road, 2.1 miles upstream from Spring Draw, 3.0 miles west of Klondike Ranch, and 13 miles southwest of Buffalo. This gaging station is operated in cooperation with the Wyoming Department of Economic Planning and Development.
Poison Creek	Lat 44°05'29", long 106°51'47", in SE¼NW¼NW¼ sec.32, T.48 N., R.83 W., Johnson County, digital water-stage recorder with stilling well, 0.6 mile downstream from Tetley Spring, and 16 miles north of Mayoworth.	Lat 44°04'12", long 106°49'17", in SW¼NE¼SW¼ sec.3, T.47 N., R.83 W., Johnson County, graphic water-stage recorder with servo-manometer system, 1.1 miles upstream from mouth, and 18 miles north of Mayoworth.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BIGHORN MOUNTAINS--continued	
North Fork Powder River	Lat 44°00'29", long 107°01'08", in NE¼SE¼SW¼ sec.25, T.47 N., R.85 W., Johnson County, graphic water-stage recorder with servo-manometer system, 20 feet downstream from Bull Creek, 1.5 miles upstream from Gammon Creek, 2.1 miles downstream from Dullknife Reservoir, and 6.8 miles southwest of Hazelton. Monthly discharge measurements are also made on Gardner Creek at mouth, a tributary 6.0 miles downstream.	Lat 43°54'41", long 106°53'20", in NW¼NE¼SE¼ sec.36, T.46 N., R.84 W., Johnson County, graphic water-stage recorder with servo-manometer system, 0.8 mile downstream from Pass Creek, 1.0 mile northwest of the Hat Ranch, and 7.2 miles northwest of Mayoworth. This gaging station is a part of the cooperative program with the Wyoming State Engineer. Monthly discharge measurements are also made on Pass Creek at mouth, a tributary 0.8 mile upstream.
Beaver Creek	Lat 43°39'54", long 107°03'45", in SE¼SE¼NW¼ sec.28, T.43 N., R.85 W., Johnson County, graphic water-stage recorder with stilling well, 0.3 mile downstream from Bayer Creek, and 7.7 miles west of Barnum.	Lat 43°41'52", long 106°56'52", in SE¼SW¼NW¼ sec.16, T.43 N., R.84 W., Johnson County, graphic water-stage recorder with servo-manometer system, 0.1 mile upstream from White Panther Ditch diversion, and 3.0 miles northwest of Barnum.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BIGHORN MOUNTAINS--continued	
Buffalo Creek	Lat 43°25'33", long 107°11'18", in SW¼NW¼NE¼ sec.20, T.40 N., R.86 W., Natrona County, graphic water-stage recorder with servo-manometer system, 400 feet downstream from South Fork Buffalo Creek, 0.8 mile upstream from North Fork Buffalo Creek, and 17.5 miles north of Arminto. Also North Fork Buffalo Creek, at lat 43°26'11", long 107°10'58", in SE¼SE¼NE¼ sec.17, T.40 N., R.86 W., Natrona County, graphic water-stage recorder with servo-manometer system, 1.3 miles upstream from mouth, and 18 miles north of Arminto.	Lat 43°25'08", long 107°09'59", in NE¼NW¼SE¼ sec.21, T.40 N., R.86 W., Natrona County, graphic water-stage recorder with servo-manometer system, 0.3 mile downstream from North Fork Buffalo Creek, 1.8 miles upstream from Pine Creek, and 18 miles north of Barnum.

Table 2.--Location of gaging stations--continued

Stream	Upper Site	Lower Site
	BLACK HILLS UPLIFT	
Stockade Beaver Creek	Lat 44°05'04", long 104°03'41", in NE¼NE¼ sec.4, T.47 N., R.60 W., Weston County, graphic water-stage recorder with servo-manometer system, at Mallo Campground, 500 feet upstream from headquarters building, 800 feet upstream from dam, and 3.8 miles east of Four Corners.	Lat 43°51'30", long 104°06'23", in SW¼SE¼ sec.19, T.45 N., R.60 W., Weston County, graphic water-stage recorder with servo-manometer system, at downstream side of bridge on county road, 0.6 mile upstream from South Draw, 2.5 miles north of LAK Reservoir, and 4.7 miles east of Newcastle.
Cold Springs and Sand Creek	Lat 44°09'14", long 104°04'39", in NW¼ sec.9, T.48 N., R.60 W., Weston County, graphic water-stage recorder with servo-manometer system, 155 feet upstream from U.S. Highway 85, and 1.4 miles northeast of Buckhorn.	Lat 44°29'42", long 104°06'34", in SW¼ sec.18, T.52 N., R.60 W., Crook County, graphic water-stage recorder with servo-manometer system, 0.4 mile north of Fish Genetic Laboratory headquarters, 0.9 mile upstream from Hospital Gulch, and 3.6 miles south of Beulah.

Table 3.--Results of discharge measurements at miscellaneous sites

Stream	Date	Discharge entering outcrop area (ft^3/s)	Discharge leaving outcrop area (ft^3/s)	Gain (+) or loss (-) (ft^3/s)
		LARAMIE MOUNTAINS		
Hunton Creek	6-27-74	0.67	0.85	+.18
	10-10-74	.10	.00	-.10
	11- 6-74	.18	.00	-.18
Box Elder Creek	6-26-74	24.4	30.9	+6.5
	8-14-74	5.28	6.11	+.83
	10-18-74	4.53	4.93	+.40
	11- 6-74	6.04	6.72	+.68
Cottonwood Creek (south of Careyhurst)	7-30-74	.64	.00	-.64
	10-11-74	.67	.00	-.67
	11- 7-74	.61	.00	-.61
Spring Canyon Creek	6-28-74	.08	.08	.00
	10-11-74	.04	.03	-.01
	11- 6-74	.04	.04	.00
Wagon Hound Creek	6-21-74	2.26	2.50	+.24
	10- 3-74	.21	.10	-.11
	11- 5-74	.68	.21	-.47
West Fork LaBonte Creek	6-20-74	10.7	11.3	+.6
	10- 2-74	.64	.77	+.13
	11- 5-74	.79	1.01	+.22
LaBonte Creek	6-19-74	29.8	29.1	-.7
	10- 1-74	1.40	1.43	+.03
	11- 4-74	2.06	2.54	+.48
Horseshoe Creek	6-18-74	37.2	34.7	-2.5
	9-30-74	2.18	2.02	-.16
	11- 4-74	4.00	3.50	-.50
		BIGHORN MOUNTAINS		
South Fork West Pass Creek	8-29-74	2.97	4.86	+1.89
	10-23-74	2.48	4.13	+1.65
	11-17-74	2.56	4.76	+2.20

Table 3.--Results of discharge measurements at miscellaneous sites--continued

Stream	Date	Discharge entering outcrop area (ft^3/s)	Discharge leaving outcrop area (ft^3/s)	Gain (+) or loss (-) (ft^3/s)
		BIGHORN MOUNTAINS--continued		
West Fork Taffner Creek	9- 4-74	--	1.05	+1.05
	10-23-74	--	1.42	+1.42
	11-17-74	--	.89	+.89
Columbus Creek	9- 4-74	--	3.39	+3.39
	10-22-74	--	2.60	+2.60
	11-17-74	--	3.19	+3.19
Smith Creek (west of Dayton)	8-28-74	--	.96	+.96
	10-22-74	--	.99	+.99
	11-17-74	--	.84	+.84
South Fork Little Tongue River	8-27-74	.60	1.26	+.66
	10-22-74	.59	2.62	+2.03
	11-17-74	.84	1.38	+.54
Soldier Creek	9- 5-74	.29	.55	+.26
	10-22-74	.62	.52	-.10
	11-17-74	.38	.35	-.03
Big Goose Creek	2-11-75	15.7	15.3	-.4
Rapid Creek	7-19-74	24.3	22.6	-1.7
	10-22-74	.92	1.56	+.64
	11-17-74	1.00	1.61	+.61
Little Goose Creek	2-12-75	5.16	7.58	+2.42
North Piney Creek	7-21-74	20.3	22.5	+2.2
	10-21-74	12.0	9.9	-2.1
	11-16-74	7.17	8.67	+1.50
North Rock Creek	9- 6-74	15.4	16.8	+1.4
	10-21-74	1.77	1.52	-.25
	11-16-74	.50	1.01	+.51
North Fork Sayles Creek	9- 7-74	.04	.15	+.11
	10-21-74	.13	.18	+.05
	11-16-74	.02	.15	+.13

Table 3.--Results of discharge measurements at miscellaneous sites--continued

Stream	Date	Discharge entering outcrop area (ft^3/s)	Discharge leaving outcrop area (ft^3/s)	Gain (+) or loss (-) (ft^3/s)
		BIGHORN MOUNTAINS--continued		
Johnson Creek	9- 7-74	.03	.09	+.06
	10-21-74	.14	.19	+.05
	11-16-74	.19	.22	+.03
French Creek	9- 9-74	1.43	1.43	.00
	10-21-74	2.06	2.27	+.21
	11-16-74	2.73	2.02	-.71
Clear Creek	8- 6-74	76.0	72.7	-3.3
	10-20-74	52.9	44.2	-8.7
	11-16-74	22.8	27.1	+4.3
Little North Fork Crazy Woman Creek	8- 8-74	2.29	1.40	-.89
	10-20-74	(Not allowed access to sites)		
	11-16-74	1.06	1.52	+.46
Unnamed tributary to North Fork Crazy Woman Creek	8-27-74	.07	.00	-.07
	10-20-74	(Not allowed access to sites)		
	11-15-74	.07	.00	-.07
Muddy Creek	8- 6-74	.85	.71	-.14
	10-20-74	.61	.72	+.11
	11-16-74	.42	.61	+.19
Billy Creek	8- 8-74	.83	.88	+.05
	10-20-74	.80	1.38	+.58
	11-16-74	.91	1.16	+.25
Middle Fork Crazy Woman Creek	9- 8-74	5.42	5.74	+.32
	10-19-74	5.71	6.57	+.86
	11-15-74	4.78	6.51	+1.73
Beaver Creek (tributary to South Fork Crazy Woman Creek)	9-10-74	.04	.00	-.04
	10-19-74	.03	.00	-.03
	11-15-74	.03	.00	-.03
North Fork Red Fork	9-12-74	2.08	2.52	+.44
	10-18-74	1.81	2.14	+.33
	11-15-74	1.85	1.77	-.08

Table 3.--Results of discharge measurements at miscellaneous sites--continued

Stream	Date	Discharge entering outcrop area (ft^3/s)	Discharge leaving outcrop area (ft^3/s)	Gain (+) or loss (-) (ft^3/s)
		BIGHORN MOUNTAINS--continued		
South Fork Red Fork	9-11-74	5.21	7.19	+1.98
	10-19-74	4.98	7.95	+2.97
	11-15-74	4.78	6.39	+1.61
Beartrap Creek	9-13-74	5.96	6.51	+.55
	10-18-74	5.78	7.92	+2.14
	11-15-74	4.05	4.64	+.59
Middle Fork Powder River	9-10-74	13.6	17.1	+3.5
	10-17-74	14.6	18.2	+3.6
	11-15-74	12.6	17.6	+5.0
Pine Creek	8-28-74	.44	.00	-.44
	10-16-74	.42	.00	-.42
	11-15-74	.32	.00	-.32
		BLACK HILLS UPLIFT		
Inyan Kara Creek	9- 5-74	--	1.14	+1.14

Table 4.--Location of miscellaneous measurement sites

Stream	Upstream Location	Downstream Location
	LARAMIE MOUNTAINS	
Hunton Creek	Lat 42°45'43", long 105°48'54", in SE¼NE¼NE¼ sec.10, T.32 N., R.75 W., Converse County, 0.4 mile upstream from West Fork Hunton Creek, 0.8 mile upstream from bridge on Box-elder Road, and 7.1 miles southeast of Glenrock. Also included is flow of West Fork Hunton Creek at Lat 42°45'40", long 105°49'13", in NW¼SW¼NE¼ sec.10, T.32 N., R.75 W., Converse County, 50 feet upstream from cattle crossing, 0.6 mile up-stream from mouth, and 7.2 miles southeast of Glenrock.	Lat 42°46'20", long 105°48'47", in SE¼SE¼NE¼ sec.3, T.32 N., R.75 W., Converse County, at bridge on Box-elder Road, 0.4 mile downstream from West Fork Hunton Creek, and 6.6 miles southeast of Glenrock. Also included is flow diversion at Lat 42°46'10", long 105°48'53", in SE¼NE¼SE¼ sec.3, T.32 N., R.75 W., Converse County, 15 ft upstream from culvert in road to Cossart Ranch, and 6.8 miles southeast of Glenrock.
Box Elder Creek	Lat 42°43'34", long 105°47'45", in SW¼NE¼SE¼ sec.23, T.32 N., R.75 W., Converse County, 0.2 mile downstream from bridge on Boxelder Road, 0.4 mile downstream from Spring Creek, and 9.7 miles southeast of Glenrock.	Lat 42°46'01", long 105°46'37", in SW¼ sec.6, T.32 N., R.74 W., Converse County, 0.4 mile upstream from Con-verse County Park boundary, 0.5 mile upstream from diversion, and 8.0 miles southeast of Glenrock.
Cottonwood Creek	Lat 42°44'21", long 105°40'22", in SW¼NW¼SW¼ sec.13, T.32 N., R.74 W., Converse County, 0.5 mile upstream from unnamed tributary, 0.6 mile west of Spring Canyon Road, and 7.6 miles south of Careyhurst.	Lat 42°44'50", long 105°40'29", in SW¼NW¼NW¼ sec.13, T.32 N., R.74 W., Converse County, 0.1 mile upstream from canyon mouth, 0.2 mile upstream from unnamed tributary, 0.8 mile west of Spring Canyon Road, and 7.0 miles south of Careyhurst.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	LARAMIE MOUNTAINS--continued	
Spring Canyon Creek	Lat 42°44'09", long 105°39'32", in SW¼SE¼SE¼ sec.13, T.32 N., R.74 W., Converse County, 300 feet downstream from unnamed tributary, 0.4 mile upstream from reservoir, and 7.9 miles south of Careyhurst.	Lat 42°44'30", long 105°39'37", in NE¼NW¼SE¼ sec.13, T.32 N., R.74 W., Converse County, just upstream from reservoir, 100 feet upstream from unnamed tributary, and 7.5 miles south of Careyhurst.
Wagon Hound Creek	Lat 42°34'48", long 105°36'42", in NE¼SW¼SW¼ sec.9, T.30 N., R.73 W., Converse County, 0.1 mile upstream from unnamed diversion, 2.3 miles upstream from Nagle Ditch diversion, and 16 miles southwest of Douglas.	Lat 42°34'47", long 105°35'38", in NE¼SW¼SW¼ sec.10, T.30 N., R.73 W., Converse County, 1.3 miles upstream from Nagle Ditch diversion, and 15.5 miles southwest of Douglas. Also included is flow of unnamed diversion at Lat 42°34"52", long 105°36'36", in SW¼NE¼SW¼ sec.9, T.30 N., R.73 W., Converse County, at end of culvert 20 feet downstream from intake, and 16 miles southwest of Douglas.
West Fork LaBonte Creek	Lat 42°31'48", long 105°33'15", in SW¼NW¼NW¼ sec.36, T.30 N., R.73 W., Converse County, 0.5 mile upstream from Mill Creek, and 17 miles southwest of Douglas. Also included is flow of Mill Creek at the mouth.	Lat 42°32'25", long 105°32'12", in center sec.25, T.30 N., R.72½ W., Converse County, 0.5 mile upstream from Gooseberry Creek, 0.8 mile downstream from Mill Creek, and 16 miles southwest of Douglas.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	LARAMIE MOUNTAINS--continued	
LaBonte Creek	Lat 42°28'05", long 105°28'25", in SE¼SW¼NW¼ sec.22, T.29 N., R.72 W., Converse County, 100 feet upstream from unnamed diversion, 1.0 mile upstream from Rutherford Creek, and 6.9 miles northwest of Esterbrook.	Lat 42°28'32", long 105°27'58", in NW¼SW¼SE¼ sec.15, T.29 N., R.72 W., Converse County, 0.5 mile upstream from Indian Creek, and 6.9 miles northwest of Esterbrook. Also included is flow of unnamed diversion about 600 feet south on right bank.
Horseshoe Creek	Lat 42°24'08", long 105°18'38", in SW¼NW¼NE¼ sec.13, T.28 N., R.71 W., Albany County, Medicine Bow National Forest, 1.0 mile upstream from Three Cripples Creek, 1.8 miles downstream from Soldier Creek, and 2.7 miles east of Esterbrook.	Lat 42°24'17", long 105°17'47", in NW¼NE¼NW¼ sec.18, T.28 N., R.70 W., Albany County, Medicine Bow National Forest, 0.2 mile upstream from Three Cripples Creek, and 3.4 miles east of Esterbrook.
	BIGHORN MOUNTAINS	
South Fork West Pass Creek	Lat 44°56'01", long 107°32'32", in NW¼SW¼NW¼ sec.7, T.57 N., R.88 W., Sheridan County, at Bighorn National Forest boundary, and 11 miles west of Parkman.	Lat 44°56'52", long 107°31'05", in SE¼NW¼NW¼ sec.5, T.57 N., R.88 W. (unsurveyed), Sheridan County, 0.1 mile upstream from North Fork West Pass Creek, and 9 miles west of Parkman.
West Fork Taffner Creek		Lat 44°56'08", long 107°30'25", in SE¼NW¼NE¼ sec.8, T.57 N., R.88 W. (unsurveyed), Sheridan County, 1.0 mile downstream from Bighorn National Forest boundary, and 9 miles west of Parkman.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	BIGHORN MOUNTAINS--continued	
Columbus Creek		Lat 44°54'43", long 107°24'36", in SE¼NE¼SW¼ sec.18, T.57 N., R.87 W., Sheridan County, 0.8 mile downstream from Bighorn National Forest boundary, and 5.5 miles southwest of Parkman.
Smith Creek		Lat 44°53'29", long 107°23'26", in NE¼NE¼NW¼ sec.29, T.57 N., R.87 W., Sheridan County, 0.4 mile downstream from Bighorn National Forest boundary, 5.2 miles south of Parkman, and 5.6 miles west of Dayton.
South Fork Little Tongue River	Lat 44°46'13", long 107°18'53", in NW¼SE¼SW¼ sec.35, T.56 N., R.87 W., Sheridan County, Bighorn National Forest, 0.1 mile downstream from unnamed tributary, 2.2 miles southwest of Horseshoe Ranch, and 7.0 miles south of Dayton.	Lat 44°47'58", long 107°17'28", in SE¼SE¼NW¼ sec.25, T.56 N., R.87 W., Sheridan County, 0.4 mile south of Horseshoe Ranch, 0.8 mile downstream from Bighorn National Forest boundary, and 5.4 miles south of Dayton.
Soldier Creek	Lat 44°43'27", long 107°14'07", in NW¼NW¼SW¼ sec.21, T.55 N., R.86 W., Sheridan County, Bighorn National Forest, 0.6 mile downstream from south forest boundary, 1.0 mile upstream from north forest boundary, and 15 miles west of Sheridan.	Lat 44°44'04", long 107°12'59", in SW¼SW¼SW¼ sec.15, T.55 N., R.86 W., Sheridan County, 0.3 mile downstream from Bighorn National Forest boundary, and 13.5 miles west of Sheridan.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	BIGHORN MOUNTAINS--continued	
Big Goose Creek	Lat 44°41'08", long 107°12'07", in NW¼SW¼NE¼ sec.3, T.54 N., R.86 W., Sheridan County, Bighorn National Forest, 0.4 mile upstream from forest boundary, 1.4 miles upstream from Red Canyon, and 5.6 miles southwest of Beckton.	Lat 44°42'08", long 107°10'51", in NW¼NE¼ sec.35, T.55 N., R.86 W., Sheridan County, at gaging station, 0.4 mile upstream from Cave Creek, and 14 miles southwest of Sheridan.
Rapid Creek	Lat 44°39'37", long 107°10'01", in NW¼NE¼NW¼ sec.13, T.54 N., R.86 W., Sheridan County, at Bighorn National Forest boundary, 0.8 mile upstream from Big Goose and Beaver Ditch diversion, and 8.6 miles west of Big Horn.	Lat 44°39'47", long 107°09'40", in NE¼SW¼SE¼ sec.12, T.54 N., R.86 W., Sheridan County, 0.3 mile downstream from Bighorn National Forest boundary, 0.5 mile upstream from Big Goose and Beaver Ditch diversion, and 8.2 miles west of Big Horn. Included are two ditches that divert flow upstream from this site.
Little Goose Creek	Lat 44°35'07", long 107°03'02", in SW¼NW¼NW¼ sec.12, T.53 N., R.85 W., Sheridan County, 0.1 mile downstream from Bighorn National Forest boundary, and 7.3 miles southwest of Big Horn.	Lat 44°35'46", long 107°02'22", in SE¼SW¼NE¼ sec.1, T.53 N., R.85 W., Sheridan County, at gaging station, 100 ft upstream from headgate of Lower Peralta ditch, and 6.5 miles southwest of Big Horn.
North Piney Creek	Lat 44°34'57", long 106°56'50", in NW¼SE¼NW¼ sec.11, T.53 N., R.84 W., Sheridan County, 1.9 miles downstream from Gin Creek, and 3.0 miles west of Story.	Lat 44°34'50", long 106°55'55", in NW¼SW¼ sec.12, T.53 N., R.84 W., Sheridan County, at gaging station, 2.1 miles west of Story, and 3.2 miles upstream from confluence with South Piney Creek.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	BIGHORN MOUNTAINS--continued	
North Rock Creek	Lat 44°28'30", long 106°55'13", in NW¼SW¼SW¼ sec.13, T.52 N., R.84 W., Johnson County, at Bighorn National Forest boundary, 1.6 miles northwest of H F Bar Ranch, and 14 miles northwest of Buffalo.	Lat 44°28'08", long 106°54'46", in SW¼NE¼NW¼ sec.24, T.52 N., R.84 W., Johnson County, just upstream from Pheasant Creek, 1.0 mile northwest of H F Bar Ranch, and 13 miles northwest of Buffalo.
North Fork Sayles Creek	Lat 44°24'20", long 106°54'09", in NE¼NE¼SE¼ sec.12, T.51 N., R.84 W. (unsurveyed), Johnson County, Bighorn National Forest, 0.1 mile upstream from forest boundary, 3.6 miles south of H F Bar Ranch, and 11 miles northwest of Buffalo.	Lat 44°24'36", long 106°53'29", in SE¼NE¼NW¼ sec.7, T.51 N., R.83 W., Johnson County, 0.5 mile downstream from Bighorn National Forest boundary, 3.4 miles south of H F Bar Ranch, and 10 miles northwest of Buffalo.
Johnson Creek	Lat 44°21'53", long 106°52'17", in SE¼NE¼NW¼ sec.29, T.51 N., R.83 W., Johnson County, Bighorn National Forest, 0.6 mile upstream from Eagle Ditch, 0.6 mile upstream from forest boundary, and 8.7 miles west of Buffalo.	Lat 44°21'53", long 106°51'47", in NE¼SE¼NE¼ sec.29, T.51 N., R.83 W., Johnson County, Bighorn National Forest, just upstream from Eagle Ditch, 0.1 mile upstream from forest boundary, and 8.2 miles west of Buffalo.
French Creek	Lat 44°21'01", long 106°51'48", in SW¼NE¼NE¼ sec.32, T.51 N., R.83 W., Johnson County, Bighorn National Forest, 0.1 mile upstream from Eagle Ditch diversion, 0.2 mile upstream from forest boundary, 0.4 mile downstream from Willow Creek, and 8.3 miles west of Buffalo.	Lat 44°21'03", long 106°51'44", in SE¼NE¼NE¼ sec.32, T.51 N., R.83 W., Johnson County, Bighorn National Forest, 260 feet upstream from Eagle Ditch diversion, 0.1 mile upstream from forest boundary, 0.5 mile downstream from Willow Creek, and 8.2 miles west of Buffalo.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	BIGHORN MOUNTAINS--continued	
Clear Creek	Lat 44°19'15", long 106°49'52", in NE¼SE¼NW¼ sec.10, T.50 N., R.83 W., Johnson County, 0.5 mile east of Bighorn National Forest boundary, 1.3 miles downstream from Grommund Creek, and 7.2 miles west of Buffalo.	Lat 44°19'23", long 106°49'40", in NE¼NW¼NE¼ sec.10, T.50 N., R.83 W., Johnson County, 0.6 mile east of Bighorn National Forest boundary, 1.0 mile upstream from Mosier Gulch, and 7.0 miles west of Buffalo.
Little North Fork Crazy Woman Creek	Lat 44°13'43", long 106°49'49", in SW¼NW¼SE¼ sec.10, T.49 N., R.83 W., Johnson County, 3.7 miles northwest of Klondike Ranch, and 10 miles southwest of Buffalo.	Lat 44°13'34", long 106°49'00", in NE¼SW¼SW¼ sec.11, T.49 N., R.83 W., Johnson County, 3.0 miles northwest of Klondike Ranch, and 10.5 miles southwest of Buffalo.
North Fork Crazy Woman Creek tributary	Lat 44°12'33", long 106°49'52", in NE¼NE¼NW¼ sec.22, T.49 N., R.83 W., Johnson County, 0.6 mile downstream from Bighorn National Forest boundary, 3.2 miles west of Klondike Ranch, and 11.5 miles southwest of Buffalo.	Lat 44°2'29", long 106°49'26", in NW¼NE¼NE¼ sec.22, T.49 N., R.83 W., Johnson County, 1.0 mile downstream from Bighorn National Forest boundary, 3.6 miles west of Klondike Ranch, and 11.3 miles southwest of Buffalo.
Muddy Creek	Lat 44°09'36", long 106°52'24", in SE¼SW¼NE¼ sec.6, T.48 N., R.83 W., Johnson County, 6.0 miles southwest of Klondike Ranch, and 15.5 miles southwest of Buffalo.	Lat 44°09'45", long 106°49'10", in NE¼SE¼NW¼ sec.3, T.48 N., R.83 W., Johnson County, 3.5 miles southwest of Klondike Ranch, and 14 miles southwest of Buffalo.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	BIGHORN MOUNTAINS--continued	
Billy Creek	Lat 44°07'44", long 106°50'35", in NE¼NW¼SW¼ sec.16, T.48 N., R.83 W., Johnson County, 6.0 miles southwest of Klondike Ranch, and 16 miles southwest of Buffalo.	Lat 44°08'05", long 106°48'54", in SW¼NW¼NE¼ sec.15, T.48 N., R.83 W., Johnson County, 5.0 miles southwest of Klondike Ranch, and 15 miles southwest of Buffalo.
Middle Fork Crazy Woman Creek	Lat 44°03'33", long 106°51'58", in SW¼SW¼NW¼ sec.8, T.47 N., R.83 W., Johnson County, 100 feet downstream from Doyle Creek, 3.6 miles upstream from Poison Creek, and 16 miles north of Mayoworth.	Lat 44°03'33", long 106°49'01', in SW¼SW¼NE¼ sec.10, T.47 N., R.83 W., Johnson County, 0.6 mile upstream from Poison Creek, and 16 miles north of Mayoworth.
Beaver Creek	Lat 44°01'03", long 106°51'55", in NW¼SW¼NW¼ sec.29, T.47 N., R.83 W., Johnson County, 3.6 miles upstream from Corpe Creek, and 13 miles north of Mayoworth.	Lat 44°01'12", long 106°50'05", in NE¼NW¼NE¼ sec.28, T.47 N., R.83 W., Johnson County, 1.2 miles upstream from Corpe Creek, and 13 miles north of Mayoworth.
North Fork Red Fork Powder River	Lat 43°02'35", long 107°47'57", in SE¼NE¼NW¼ sec.10, T.44 N., R.85 W., Johnson County, 300 feet downstream from Baldwin Creek, 1.0 mile upstream from School Section Draw, and 12 miles northwest of Barnum.	Lat 43°46'18", long 106°58'24", in NE¼NE¼NE¼ sec.19, T.44 N., R.84 W., Johnson County, 100 feet upstream from Beartrap Creek, and 8.0 miles northwest of Barnum.
South Fork Red Fork Powder River	Lat 43°45'12", long 107°01'14", in NE¼SW¼NE¼ sec.26, T.44 N., R.85 W., Johnson County, 2.8 miles upstream from confluence with North Fork Red Fork, and 8.5 miles northwest of Barnum.	Lat 43°45'26", long 106°57'40", in NW¼NW¼NE¼ sec.29, T.44 N., R.84 W., Johnson County, 0.4 mile upstream from confluence with North Fork Red Fork, 1.0 mile downstream from unnamed tributary, and 6.9 miles northwest of Barnum.

Table 4.--Location of miscellaneous measurement sites--continued

Stream	Upstream Location	Downstream Location
	BIGHORN MOUNTAINS--continued	
Beartrap Creek	Lat 43°49'30", long 107°00'40", in SE¼SW¼NE¼ sec.36, T.45 N., R.85 W., Johnson County, 11 miles west of Mayoworth.	Lat 43°46'18", long 106°58'18", in NE¼NE¼NE¼ sec.19, T.44 N., R.84 W., Johnson County, 100 feet upstream from mouth, and 10 miles southwest of Mayoworth.
Middle Fork Powder River	Lat 43°34'59", long 106°59'10", in NW¼NE¼NW¼ sec.30, T.42 N., R.84 W., Johnson County, 2.7 miles downstream from Bachaus Creek, 4.1 miles upstream from Buffalo Creek, and 6.8 miles southwest of Barnum.	Lat 43°36'05", long 107°54'38", in SE¼SW¼SW¼ sec.14, T.42 N., R.84 W., Johnson County, 1.6 miles upstream from Buffalo Creek, and 4.3 miles south of Barnum.
Pine Creek	Lat 43°26'34", long 107°09'23", in SE¼SW¼SW¼ sec.10, T.40 N., R.86 W., Natrona County, 200 feet downstream from unnamed tributary, and 19 miles north of Arminto.	Lat 43°25'38", long 107°08'26", in NW¼NW¼NW¼ sec.23, T.40 N., R.86 W., Natrona County, 1.0 mile upstream from mouth, and 18 miles north of Arminto.
	BLACK HILLS UPLIFT	
Inyan Kara Creek		Lat 44°13'45", long 104°26'45", in S½ sec.17, T.49 N., R.63 W., Crook County, at bridge on State Highway 116, and 13.0 miles northeast of Upton.

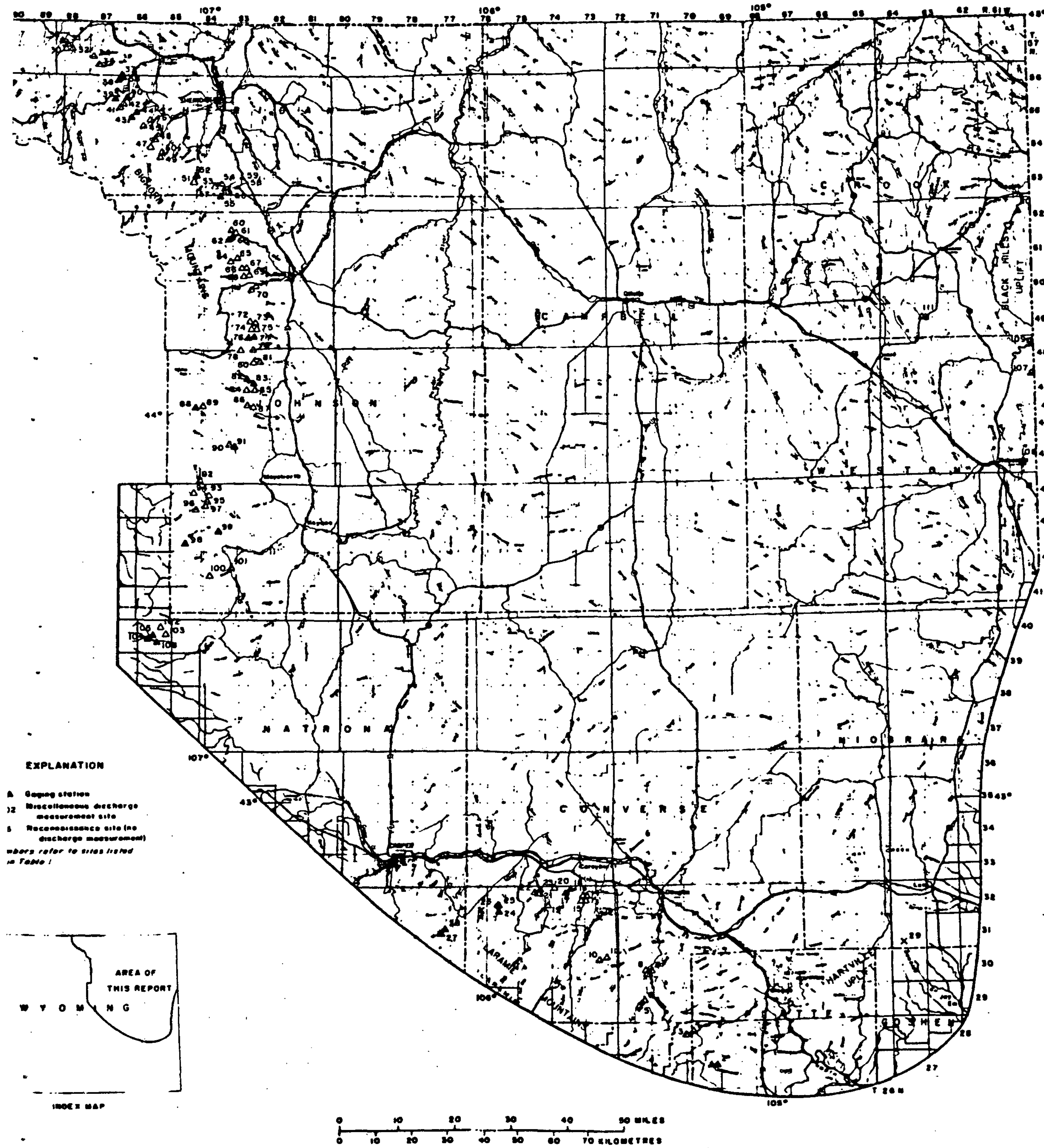


Plate I.—Map of northeastern Wyoming showing locations of gaging stations, miscellaneous discharge measurement sites, and geologic reconnaissance sites where no streamflow measurements were made.

U.S. GOVERNMENT PRINTING OFFICE: 1976—682-826/5 REGION NO. 8