STREAMFLOW LOSSES TO MADISON GROUP ROCKS IN THE LITTLE BELT AND BIG SNOWY MOUNTAINS, MONTANA

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 82-49

STREAMFLOW LOSSES TO MADISON GROUP ROCKS IN THE LITTLE BELT AND BIG SNOWY MOUNTAINS, MONTANA

By R. D. Feltis and Ronald R. Shields

U.S. Geological Survey

Water-Resources Investigations 82-49

Helena, Montana
August 1982

STREAMFLOW LOSSES TO MADISON GROUP ROCKS IN THE LITTLE BELT AND BIG SNOWY MOUNTAINS, MONTANA

By

R. D. Feltis and Ronald R. Shields

ABSTRACT

Four streams originating in the Little Belt and Big Snowy Mountains in central Montana were measured at various times from May 4 to October 1, 1975, to determine streamflow losses across outcrops of the Madison Group (Mississippian age). Based on the seepage measurements made during base-flow conditions, streamflow losses in the Middle Fork Judith River were 10.2 cubic feet per second. Based on streamflow data obtained for 39 months at two streamflow-gaging stations on the Middle Fork Judith River, the average daily loss was 9.1 cubic feet per second or about 6,600 acre-feet per year. Seepage measurements on other stream reaches indicated losses of 7.6 cubic feet per second on the South Fork Judith River, 9.2 cubic feet per second in Yogo Creek, as much as 64 cubic feet per second in Dry Wolf Creek, and about 60 cubic feet per second in Rock Creek.

INTRODUCTION

Rocks of the Madison Group underlie most of Montana east of the Rocky Mountains, which includes the eastern two-thirds of the State. The Madison Group, of Early and Late Mississippian age, includes, in ascending order, the Lodgepole Limestone, Mission Canyon Limestone, and Charles Formation. In the Little Belt and Big Snowy Mountains, the Charles Formation has not been recognized or mapped. Therefore, the Mission Canyon Limestone is considered to be the upper formation of the Madison Group in these areas. Although the contact between the Lodgepole and Mission Canyon Limestones also is unmapped, it can be determined by visual inspection of the bedding. Locally, the Madison Group is a source of water for municipal, irrigation, fish propagation, and industrial uses. It is a potential source of water for larger industrial use in most of Montana east of the Rocky Mountains.

The Madison Group was subjected to several periods of solution channeling by water prior to deposition of the overlying formations. After the mountains of central Montana were formed, the Madison Group rocks were exposed by erosion and water again circulated through the solution openings. Most of these openings occur in the upper part of the Mission Canyon Limestone.

Most streams in the interior of the Little Belt and Big Snowy Mountains are perennial, but where the streams flow across the Madison Group rocks, the water seeps into solution channels in the limestone. The volume of water that moves from the stream into the rock depends upon the size and number of solution channels

and the ability of the channels to transmit the water away from the mountains into the adjacent basins. Other factors that affect the volume of infiltration are the quantity of rain and snowmelt runoff, and the magnitude and duration of the streamflow.

The purpose of this investigation was to determine the rate of flow loss of selected streams crossing areas of outcrop of Madison Group rocks in the Little

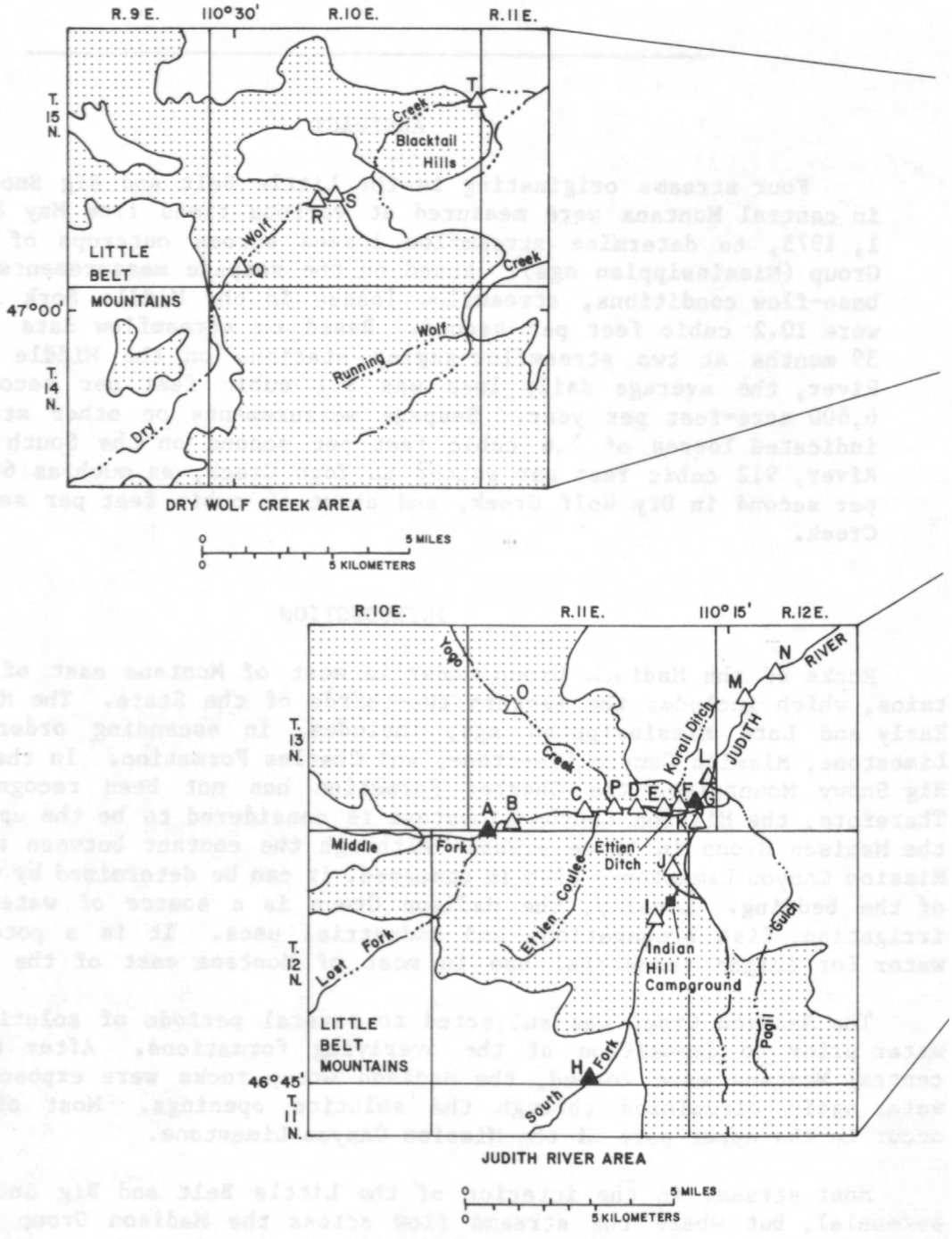
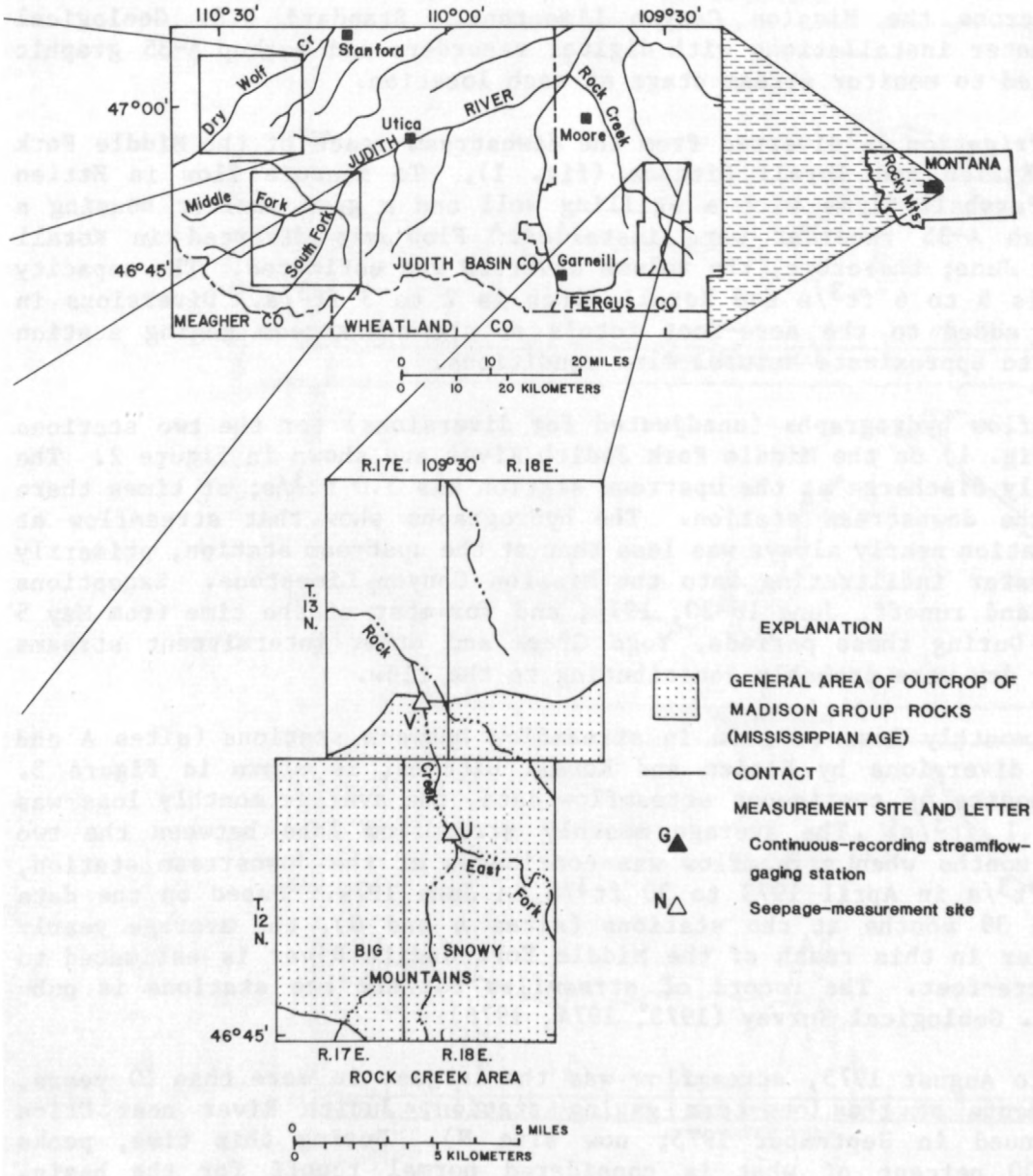


Figure 1.--Location of streamflow-gaging

Belt and Big Snowy Mountains. From July 1972 through September 1975 two streamflow-gaging-stations were operated on the Middle Fork Judith River in the Little Belt Mountains in Judith Basin County. Seepage measurements were made at various times from May 4 to October 1, 1975, on the Middle Fork, South Fork, and main stem of the Judith River; Yogo Creek; and Dry Wolf Creek in the Little Belt Mountains, and on Rock Creek in the Big Snowy Mountains. The location of the streamflow-gaging stations and seepage-measurement sites is shown in figure 1 and described in table 1.



stations and seepage-measurement sites.

Middle Fork Judith River

Gaging-station measurements

Two streamflow-gaging stations on the Middle Fork Judith River (sites A and G, fig. 1) were located upstream and downstream from the outcrop of the Mission Canyon Limestone. The stations were 6.1 stream miles apart, with 5.2 miles of the stream flowing across the Mission Canyon Limestone. Standard U.S. Geological Survey servomanometer installations with digital recorders and backup A-35 graphic recorders were used to monitor stream stage at each location.

Water for irrigation is diverted from the downstream reach of the Middle Fork Judith River by Ettien and Korall Ditches (fig. 1). To measure flow in Ettien Ditch, a 1-foot Parshall flume with a stilling well and a gage shelter housing a "totalizer" and an A-35 recorder were installed. Flow was diverted in Korall Ditch only during June; therefore, the volume diverted was estimated. The capacity of Ettien Ditch is 5 to 6 ft^3/s and Korall Ditch is 2 to 3 ft^3/s. Diversions in the ditches were added to the acre-foot totals at the downstream gaging station (site G, fig. 1) to approximate natural-flow conditions.

Daily streamflow hydrographs (unadjusted for diversions) for the two stations (sites A and G, fig. 1) on the Middle Fork Judith River are shown in figure 2. The smallest mean daily discharge at the upstream station was 3.0 ft^3/s; at times there was no flow at the downstream station. The hydrographs show that streamflow at the downstream station nearly always was less than at the upstream station, primarily as a result of water infiltrating into the Mission Canyon Limestone. Exceptions were during overland runoff, June 16-20, 1974, and for most of the time from May 5 to August 1975. During these periods, Yogo Creek and other intermittent streams that are normally dry were probably contributing to the flow.

The average monthly loss or gain in streamflow between stations (sites A and G), adjusted for diversions by Ettien and Korall Ditches, is shown in figure 3. Based on the 39 months of continuous streamflow data, the average monthly loss was computed to be 9.1 ft^3/s. The average monthly streamflow loss between the two stations, during months when streamflow was continuous at the downstream station, ranged from 6.7 ft^3/s in April 1973 to 30 ft^3/s in June 1974. Based on the data collected for the 39 months at the stations (sites A and G), the average yearly loss to the aquifer in this reach of the Middle Fork Judith River is estimated to be about 6,600 acre-feet. The record of streamflow for the two stations is published by the U.S. Geological Survey (1973, 1974, 1976).

From May 5 to August 1975, streamflow was the largest in more than 10 years, based on measurements at the long-term gaging station, Judith River near Utica (station discontinued in September 1975; now site N). During this time, peaks were more than 100 percent of what is considered normal runoff for the basin. The 1975 period of high flow, when a gain in streamflow was determined between gaging stations, is included in the computation of the average monthly loss. Although the gain may be associated directly with tributary inflow and some loss was occurring between sites A and G, the average discharge for the 39 months would

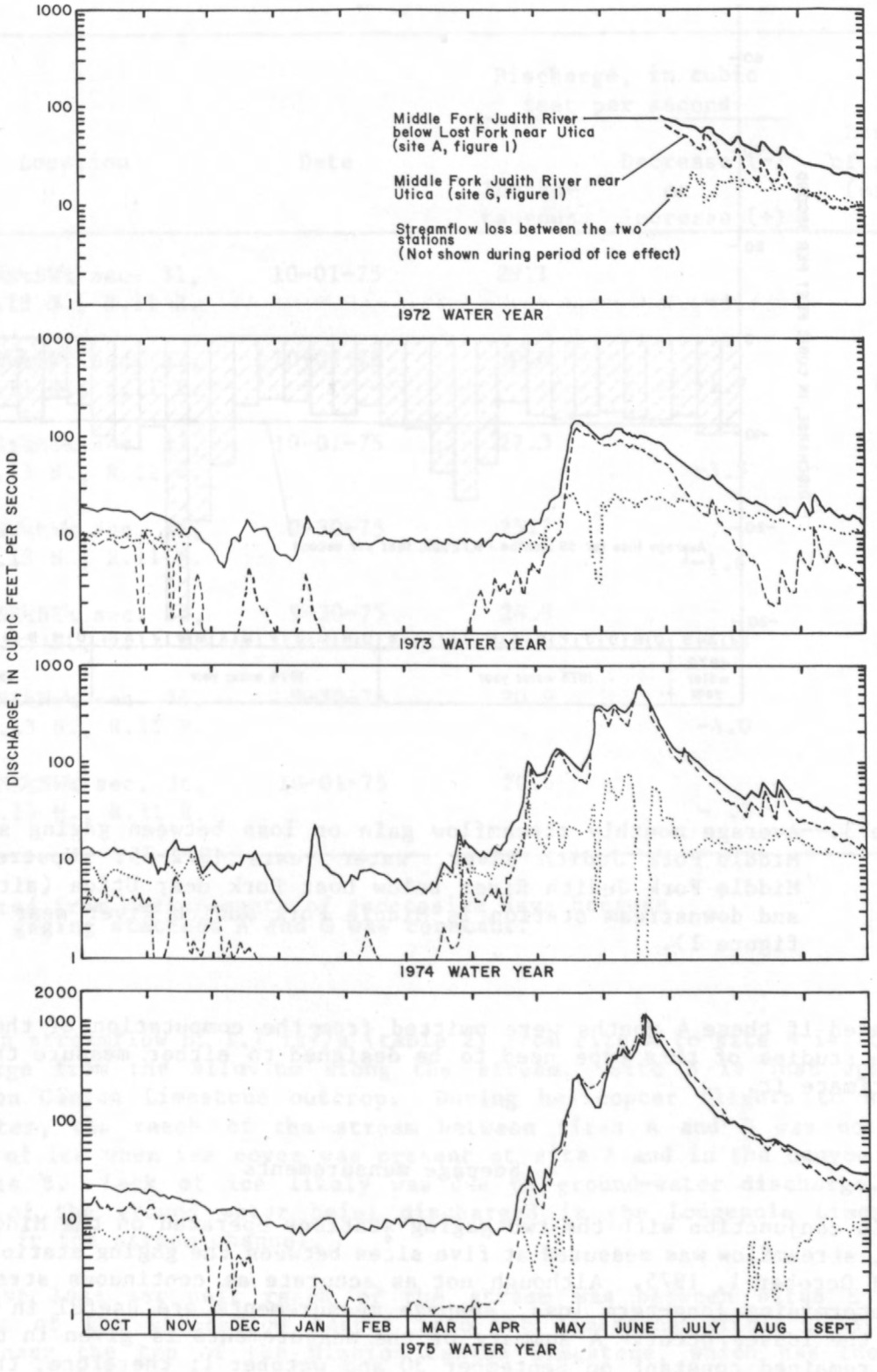


Figure 2.--Streamflow hydrographs at gaging stations on the Middle Fork Judith River, water years 1972-75.

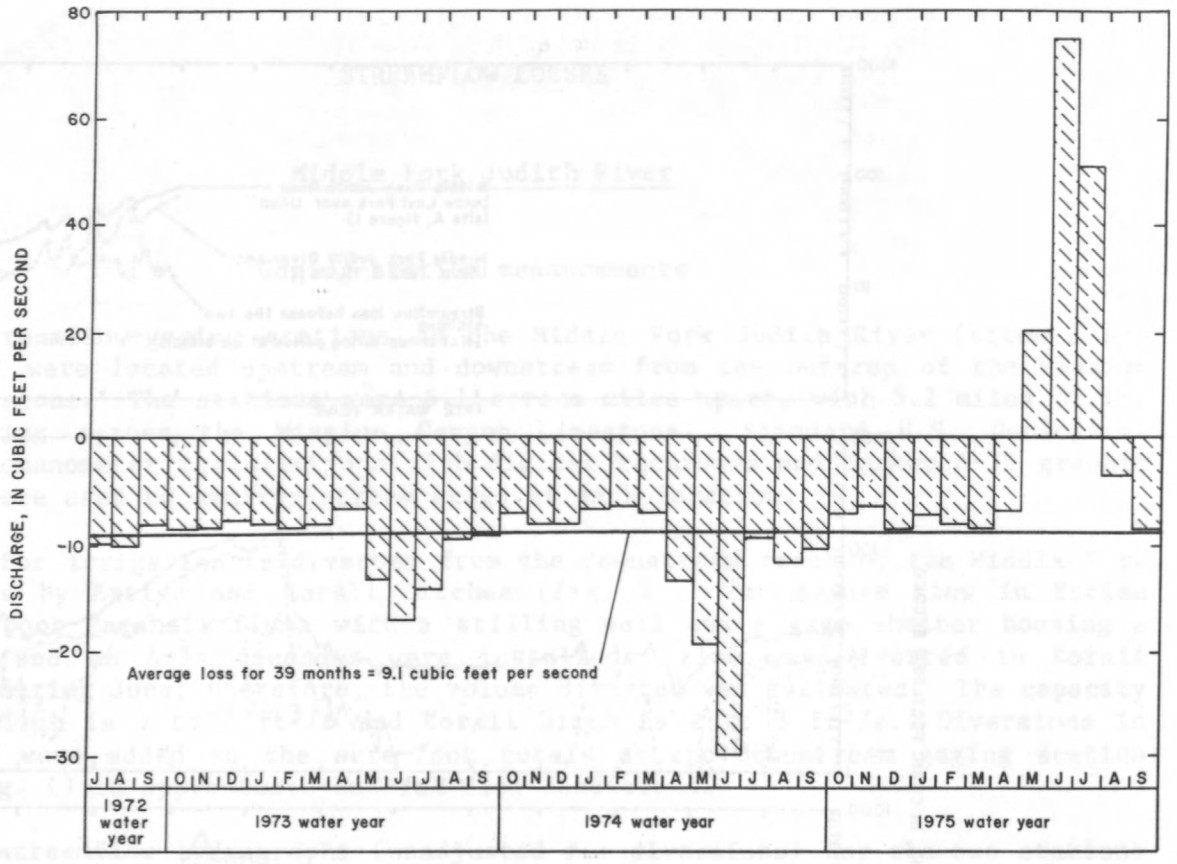


Figure 3.--Average monthly streamflow gain or loss between gaging stations on the Middle Fork Judith River, water years 1972-75. Upstream station is Middle Fork Judith River below Lost Fork near Utica (site A, figure 1) and downstream station is Middle Fork Judith River near Utica (site G, figure 1).

be biased if these 4 months were omitted from the computation of the average loss. Future studies of this type need to be designed to either measure tributary inflow or estimate it.

Seepage measurements

In conjunction with the two gaging stations operated on the Middle Fork Judith River, streamflow was measured at five sites between the gaging stations on September 30 and October 1, 1975. Although not as accurate as continuous streamflow records for determining long-term loss, seepage measurements are useful in defining areas where the losses occur. A summary of the measurements is given in table 2. River stage remained constant on September 30 and October 1; therefore, the loss between sites C and D (table 2) was computed using measurements made on successive days. No water was being diverted into Ettien Ditch. The loss in streamflow across the Mission Canyon Limestone from site B to the downstream gaging station (site G) was 10.2 ft^3/s (table 2). This loss during the seepage investigation compares favorably with the 9.1 ft^3/s average loss computed from the 39 months of streamflow record.

Table 2.--*Seepage measurements, Middle Fork Judith River*

Site identification (fig. 1)	Location	Date	Discharge, in cubic feet per second		Length of reach (miles)
			Instantaneous	Decrease (-) or increase (+)	
A	SE¼SE¼SW¼ sec. 31, T.13 N., R.11 E.	10-01-75	29.1	--	--
B	SW¼NW¼SW¼ sec. 32, T.13 N., R.11 E.	10-01-75	30.8	+1.7	0.85
C	NW¼SE¼NE¼ sec. 33, T.13 N., R.11 E.	10-01-75	27.3	-3.5	2.2
D	NE¼SW¼NW¼ sec. 35, T.13 N., R.11 E.	9-30-75	25.7	[1]-1.6	1.4
E	SW¼SE¼NE¼ sec. 35, T.13 N., R.11 E.	9-30-75	24.9	- .8	.82
F	NW¼SE¼NW¼ sec. 36, T.13 N., R.11 E.	9-30-75	20.9	-4.0	.53
G	SE¼NE¼NW¼ sec. 36, T.13 N., R.11 E.	10-01-75	20.6	- .3	.27

[1]Decrease computed from measurements of successive days because river stage at gaging stations A and G was constant.

The gain in streamflow of 1.7 ft^3/s (table 2) from site A to site B is attributed to discharge from the alluvium along the stream. Site B is just upstream from the Mission Canyon Limestone outcrop. During helicopter flights to site A during the winter, the reach of the stream between sites A and B was noted to always be free of ice when ice cover was present at site A and in the canyon downstream from site B. Lack of ice likely was due to ground-water discharge. The primary source of the ground water being discharged is the Lodgepole Limestone, which crops out in the stream channel.

The greatest loss per unit reach of the stream was between sites E and F where 4.0 ft^3/s of the streamflow seeped into the limestone within 0.53 mile. This reach is near the top of the Mission Canyon Limestone, which has the most solution cavities and fractures.

South Fork Judith River

The South Fork Judith River flows across the Mission Canyon Limestone for about 4 miles from the NE¼ sec. 14, T. 12 N., R. 11 E., to the mouth of the South Fork Canyon (site K, fig. 1). Streamflow measurements indicate progressive losses (table 3). The total loss measured was 7.6 ft^3/s.

Table 3.--*Seepage measurements, South Fork Judith River*

Site identification (fig. 1)	Location	Date	Discharge, in cubic feet per second		Length of reach (miles)
			Instantaneous	Decrease (-) or increase (+)	
H	SE¼NE¼SW¼ sec. 34, T.12 N., R.11 E.	10-01-75	9.4	--	--
I	NW¼NW¼SW¼ sec. 12, T.12 N., R.11 E.	10-01-75	6.9	-2.5	5.3
J	NW¼NE¼SW¼ sec. 1, T.12 N., R.11 E.	10-01-75	4.4	-2.5	1.4
K	NE¼SE¼NW¼ sec. 36, T.13 N., R.11 E.	10-01-75	1.8	-2.6	1.7

Open fractures and faults related to geologic structure at the junction of the main Little Belt Mountains and an eastward-trending salient are probably the principal factors affecting streamflow losses along the reach of the stream from sites I to J. This reach is in a transition zone between the steeply dipping beds of the Madison Group salient to the east of the South Fork Judith River and the more gently dipping beds to the west. About 1,100 feet northeast of the Indian Hill Campground (fig. 1), the flexure of the limestone has left open fractures. The South Fork Judith River generally is dry downstream from site I from the fall to the spring runoff period.

Main stem of Judith River

The confluence of the Middle and South Forks of the Judith River is on alluvial valley fill about 750 feet downstream from the outcrop of the Mission Canyon Limestone (site G; fig. 1). The alluvial valley fill is a thick lens of coarse gravel deposited by the narrowly confined South and Middle Forks during floods. Streamflow measurements made for a 4.3-mile reach of stream are given in table 4.

The seepage measurements indicate a loss and a subsequent gain in streamflow along the main stem of the Judith River. No tributary inflow is visible between sites G and N. The loss and subsequent gain in streamflow are attributed to infil-

Table 4.--*Seepage measurements, Judith River*

Site identification (fig. 1)	Location	Date	Discharge, in cubic feet per second		Length of reach (miles)
			Instantaneous	Decrease (-) or increase (+)	
G	SE¼NE¼NW¼ sec. 36, T.13 N., R.11 E.	9-30-75	20.8	--	--
K	NE¼SE¼NW¼ sec. 36, T.13 N., R.11 E.	9-30-75	1.9	--	--
--	Confluence of Middle and South Forks	9-30-75	22.7	--	--
L	SE¼SE¼NE¼ sec. 25, T.13 N., R.11 E.	9-30-75	12.4	-10.3	0.9
M	SW¼NE¼SE¼ sec. 18, T.13 N., R.12 E.	9-30-75	10.8	- 1.6	2.4
N	SW¼NE¼NW¼ sec. 17, T.13 N., R.12 E.	9-30-75	24.3	+13.5	1.0

tration into the alluvial valley fill and subsequent return of the water to the stream channel. The river gradient across the gravel lens from site G to site M, over which a 11.9 ft^3/s loss occurred, is 33 ft/mi. The gradient from sites M to N, where the 13.5 ft^3/s gain occurred, is 47 ft/mi. The net gain of 1.6 ft^3/s can be attributed to ground-water inflow from the sides of the valley along the stream reach.

Yogo Creek

Yogo Creek is generally dry at its confluence with the Middle Fork Judith River (site P, fig. 1). A seepage measurement (June 1964) showed that 42 ft^3/s of water infiltrated into the Mission Canyon Limestone along Yogo Creek from near site O to the mouth (Zimmerman, 1966, p. 15); the creek was dry at its mouth. On October 1, 1975, the discharge measured at site O was 9.2 ft^3/s, but at site P the stream was dry (table 5).

Streamflow of Yogo Creek reaches the Middle Fork Judith River only during periods of high flow when more water is flowing than can infiltrate into the limestone aquifer. The mean daily streamflow hydrographs (fig. 2) show that the discharge at downstream site G exceeded that of upstream site A from June 16 to 20, 1974. During this period it is assumed that the flow of Yogo Creek into the Middle Fork Judith River equaled or exceeded the volume of water that seeped into the Madison Group rocks along the Middle Fork Judith River.

Table 5.--*Seepage measurements, Yogo Creek*

Site identification (fig. 1)	Location	Date	Discharge, in cubic feet per second: Instantaneous	Discharge, in cubic feet per second: Decrease (-) or increase (+)	Length of reach (miles)
O	NE¼NW¼NW¼ sec. 20, T.13 N., R.11 E.	10-01-75	9.2	--	--
P	NE¼SW¼SE¼ sec. 34, T.13 N., R.11 E.	10-01-75	0	-9.2	3.8

Dry Wolf Creek

Dry Wolf Creek flows across the Mission Canyon Limestone twice; first in the Little Belt Mountains proper (sites Q-S, fig. 1), and then again about 1 mile from the mountain front where the creek has been superimposed on the limestone in Blacktail Hills, a small dome (upstream from site T, fig. 1). In the mountains, the stream crosses the Mission Canyon Limestone for about 3 miles, normal to the strike of the formation, but in Blacktail Hills the stream mostly parallels the strike of the formation in an arc-shaped trace for about 3 miles. The stream generally is dry where it leaves the Little Belt Mountains, except during spring runoff. A considerable volume of water infiltrates the Madison Group rocks from Dry Wolf Creek and only about once or twice in 10 years is the flow sufficient to exceed the infiltration capacity of the aquifer and flow across the entire outcrop of the Madison Group rocks in Blacktail Hills.

Seepage measurements (May 1964) indicated a loss of 90 ft^3/s to the limestone in the Little Belt Mountains from sites Q to R and 74 ft^3/s in the Blacktail Hills from sites S to T (Zimmerman, 1966, p. 15). On July 1 and 17, 1975, two attempts were made to conduct seepage measurements on Dry Wolf Creek. The flood of June 19-20, 1975, washed out bridge approaches to the mountain reach of the stream, making access impossible by road. Therefore, on July 1, measurements were made only in the Blacktail Hills area at sites S and T. The measured loss was 64 ft^3/s (table 6). On July 17 a loss of 14.9 ft^3/s was measured in the mountain reach from sites Q to R, and a loss of 41.4 ft^3/s was measured in the Blacktail Hills reach. On both dates water was flowing farther downstream than the location of the Madison Group contact in Blacktail Hills (site T).

Rock Creek

Rock Creek flows across the Mission Canyon Limestone for about 2 miles on the north side of the Big Snowy Mountains. The limestone dips to the north at about 10 degrees or less and the stream crosses the Mission Canyon Limestone about normal to the strike of the formation. Seepage measurements on June 5, 1968, indicated a water loss of 55.8 ft^3/s (Feltis, 1973, p. 23). On May 4, 1975, the water loss between sites U and V was 60.2 ft^3/s (table 7). Streamflow crossed the outcrop

on both of these measurements. During some years the streamflow is not sufficient to cross the outcrop of the limestone.

Table 6.--*Seepage measurements, Dry Wolf Creek*

Site identification (fig. 1)	Location	Date	Discharge, in cubic feet per second: Instantaneous	Discharge, in cubic feet per second: Decrease (-) or increase (+)	Length of reach (miles)
S[1]	SW¼NW¼NE¼ sec. 28, T.15 N., R.10 E.	7-01-75	181	--	--
T	NW¼SW¼SE¼ sec. 12, T.15 N., R.10 E.	7-01-75	117	-64	4.4
Q	NE¼SE¼SW¼ sec. 31, T.15 N., R.10 E.	7-17-75	74.2	--	--
R[2]	SW¼NW¼NE¼ sec. 28, T.15 N., R.10 E.	7-17-75	59.3	14.9	2.8
T	NW¼SW¼SE¼ sec. 12, T.15 N., R.10 E.	7-17-75	17.9	41.4	4.4

[1]Downstream side of bridge.
[2]Upstream side of bridge at canal diversion.

Table 7.--*Seepage measurements, Rock Creek*

Site identification (fig. 1)	Location	Date	Discharge, in cubic feet per second: Instantaneous	Discharge, in cubic feet per second: Decrease (-) or increase (+)	Length of reach (miles)
U	SW¼NE¼ sec. 7, T.12 N., R.18 E.	5-04-75	64.2	--	--
V	NE¼NE¼SW¼ sec. 25, T.13 N., R.17 E.	5-04-75	4.0	-60.2	3.0

SUMMARY

Streamflow losses across outcrops of the Mission Canyon Limestone were determined for several streams originating in the Little Belt and Big Snowy Mountains of central Montana. Continuous streamflow records were collected for 39 months during water years 1972-75 at stations on the Middle Fork Judith River upstream and downstream from the Mission Canyon Limestone. Based on the streamflow data, the average daily loss on the Middle Fork Judith River was 9.1 ft^3/s or about 6,600 acre-feet per year. Seepage measurements made on October 1, 1975, during base-flow conditions indicated a loss of 10.2 ft^3/s, as compared to the average monthly streamflow loss that ranged from 6.7 to 30 ft^3/s.

Seepage measurements made at various times from May 4 to October 1, 1975, in other streams indicated losses of 7.6 ft^3/s in the South Fork Judith River, 9.2 ft^3/s in Yogo Creek, as much as 64 ft^3/s in a downstream reach of Dry Wolf Creek, and about 60 ft^3/s in Rock Creek. Measurements on the main stem Judith River indicated a loss of 11.9 ft^3/s and a subsequent gain downstream of 13.5 ft^3/s; the gain was attributed to ground-water inflow along the stream reach.

Seepage measurements are useful in defining areas of water loss. However, for accurate estimates of long-term streamflow loss (recharge) to the Madison Group, continuous streamflow records are needed.

SELECTED REFERENCES

Feltis, R. D., 1973, Geology and water resources of the eastern Judith Basin, Montana: Montana Bureau of Mines and Geology Bulletin 87, 51 p.

_____1977, Geology and water resources of the northern part of the Judith Basin, Montana: Montana Bureau of Mines and Geology Bulletin 101, 65 p.

_____1980, Water resources of the Judith Basin, central Montana: Montana Bureau of Mines and Geology Hydrogeologic Map 1, 3 sheets.

U.S. Geological Survey, 1973, Water resources data for Montana, 1973, part 1, Surface water records: Helena, Mont., 242 p.

_____1974, Water resources data for Montana, 1974, part 1, Surface water records: Helena, Mont., 289 p.

_____1976, Water resources data for Montana, water year 1975: Helena, Mont., U.S. Geological Survey Water-Data Report MT-75-1, 604 p.

Zimmerman, E. A., 1966, Geology and ground-water resources of western and southern parts of Judith Basin, Montana: Montana Bureau of Mines and Geology Bulletin 50-A, 33 p.

Table 1.--*Measurement-site descriptions*

[Number in parentheses is formal U.S. Geological Survey station number (06109750) or site number based on latitude and longitude (4650301102148)]

Site identification (fig. 1)	Stream	Location and formal station or site number
A	Middle Fork Judith River	SE¼SE¼SW¼ sec. 31, T. 13 N., R. 11 E., Judith Basin County, on left bank about 200 feet downstream from Lost Fork, and about 16 miles southwest of Utica. Formal name and number are Middle Fork Judith River below Lost Fork near Utica (06109750).
B	Middle Fork Judith River	SW¼NW¼SW¼ sec. 32, T. 13 N., R. 11 E., Judith Basin County, 0.15 mile upstream from Arch Coulee, and 15.5 miles southwest of Utica (4650301102148).
C	Middle Fork Judith River	NW¼SE¼NE¼ sec. 33, T. 13 N., R. 11 E., Judith Basin County, 0.25 mile upstream from Ettien Coulee, and about 14 miles southwest of Utica (4650481101935).
D	Middle Fork Judith River	NE¼SW¼NW¼ sec. 35, T. 13 N., R. 11 E., Judith Basin County, 0.1 mile upstream from Ettien Ditch diversion, and 13.8 miles southwest of Utica (4650501101758).
E	Middle Fork Judith River	SW¼SE¼NE¼ sec. 35, T. 13 N., R. 11 E., Judith Basin County, at ranger station, 0.2 mile downstream from ford, and 13.2 miles southwest of Utica (4650471101708).
F	Middle Fork Judith River	NW¼SE¼NW¼ sec. 36, T. 13 N., R. 11 E., Judith Basin County, 0.2 mile upstream from station 06109780, just downstream from diversion, and 13 miles southwest of Utica (4650501101629).
G	Middle Fork Judith River	SE¼NE¼NW¼ sec. 36, T. 13 N., R. 11 E., Judith Basin County, on left bank 630 feet upstream from confluence with South Fork Judith River, 67 feet downstream from county highway bridge, and 12.8 miles southwest of Utica. Formal name and number are Middle Fork Judith River near Utica (06109780).

Table 1.--*Measurement-site descriptions*--Continued

Site identification (fig. 1)	Stream	Location and formal station or site number
H	South Fork Judith River	SE¼NE¼SW¼ sec. 34, T. 12 N., R. 11 E., Judith Basin County, Lewis and Clark National Forest, on right bank just downstream from Trask Gulch, 8 miles upstream from confluence with Middle Fork Judith River, and 18 miles southwest of Utica. Formal name and number are South Fork Judith River near Utica (06109800).
I	South Fork Judith River	NW¼NW¼SW¼ sec. 12, T. 12 N., R. 11 E., Judith Basin County, 0.3 mile upstream from Indian Hill Campground, 3 miles upstream from confluence with Middle Fork Judith River, and 15.8 miles southwest of Utica (4648451101724).
J	South Fork Judith River	NW¼NE¼SW¼ sec. 1, T. 12 N., R. 11 E., Judith Basin County, 0.3 mile downstream from Rocky Gulch, 1.7 miles upstream from confluence with Middle Fork Judith River, and 14.1 miles southwest of Utica (4649421101707).
K	South Fork Judith River	NE¼SE¼NW¼ sec. 36, T. 13 N., R. 11 E., Judith Basin County, just upstream from mouth, and 12.8 miles southwest of Utica (4650501101614).
L	Judith River	SE¼SE¼NE¼ sec. 25, T. 13 N., R. 11 E., Judith Basin County, at county bridge, 0.5 mile downstream from Pagil Gulch, and 12 miles southwest of Utica (4651341101544).
M	Judith River	SW¼NE¼SE¼ sec. 18, T. 13 N., R. 12 E., Judith Basin County, at farm bridge, 0.1 mile upstream from Missouri Coulee, and 9.8 miles southwest of Utica (4653051101435).
N	Judith River	SW¼NE¼NW¼ sec. 17, T. 13 N., R. 12 E., Judith Basin County, on left bank, 4 miles downstream from confluence of South and Middle Forks Judith River, and 9 miles southwest of Utica at mile 99.3. This site was operated as gaging station, Judith River near Utica (06110000), from 1919 to September 1975. Now operated as a site (4653301101354).

Table 1.--*Measurement-site descriptions*--Continued

Site identification (fig. 1)	Stream	Location and formal station or site number
O	Yogo Creek	NE¼NW¼NW¼ sec. 20, T. 13 N., R. 11 E., Judith Basin County, 3.9 miles upstream from mouth, and 14 miles southwest of Utica (4652481102145).
P	Yogo Creek	NE¼SW¼SE¼ sec. 34, T. 13 N., R. 11 E., Judith Basin County, 0.1 mile upstream from mouth, and about 13 miles southwest of Utica (4650471101837).
Q	Dry Wolf Creek	NE¼SE¼SW¼ sec. 31, T. 15 N., R. 10 E., Judith Basin County, 200 feet downstream from Butcherknife Creek, and 15 miles southwest of Stanford (4700501103015).
R	Dry Wolf Creek	SW¼NW¼NE¼ sec. 28, T. 15 N., R. 10 E., Judith Basin County, 100 feet upstream from bridge, and 12 miles southwest of Stanford (4702131102734).
S	Dry Wolf Creek	SW¼NW¼NE¼ sec. 28, T. 15 N., R. 10 E., Judith Basin County, 100 feet downstream from bridge, and 12 miles southwest of Stanford (4702151102730).
T	Dry Wolf Creek	NW¼SW¼SE¼ sec. 12, T. 15 N., R. 10 E., Judith Basin County, 0.2 mile downstream from county bridge, 1 mile downstream from Mud Spring Creek, and 10 miles southwest of Stanford (4704161102346).
U	Rock Creek	SW¼NE¼ sec. 7, T. 12 N., R. 18 E., Fergus County, 150 feet downstream from East Fork Rock Creek (Crystal Creek), and 12.5 miles northeast of Garneill (4649041092957).
V	Rock Creek	NE¼NE¼SW¼ sec. 25, T. 13 N., R. 17 E., Fergus County, 0.5 mile downstream from bridge at boundary of Lewis and Clark National Forest, and 11.5 miles southeast of Moore (4651311093034).

Table 1.--*Measurement-site descriptions*--Continued

Site identification (fig. 1)	Stream	Location and formal station or site number
--	Ettien Ditch	NW¼SE¼NW¼ sec. 35, T. 13 N., R. 11 E., Judith Basin County, 0.1 mile downstream from confluence with Middle Fork Judith River, and 13.7 miles southwest of Utica (4650481101745).
--	Korall Ditch	NW¼SW¼NW¼ sec. 36, T. 13 N., R. 11 E., Judith Basin County, 0.5 mile upstream from confluence with South Fork Judith River, and 13.5 miles southwest of Utica (4650531101630).