FLOOD ESTIMATES FOR UNGAGED STREAMS IN GLACIER AND YELLOWSTONE NATIONAL PARKS, MONTANA

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CONVERSION FACTORS

To convert inch-pound units in this report to metric units, multiply by the following factors:

Multiply inch-pound unit	By	To obtain metric unit
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot	0.3048	meter
inch	25.40	millimeter
mile	1.609	kilometer
square mile	2.590	square kilometer

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

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ABSTRACT

Estimates of 100-year flood discharge were made at 59 sites in Glacier National Park and 21 sites in Yellowstone National Park to assist the National Park Service in quantifying stream inflow and outflow in the Parks. The estimates were made using regression equations previously developed for Montana. The resulting 100-year discharges are listed in tables; the discharges ranged from 260 to 62,700 cubic feet per second in Glacier National Park and from 110 to 27,900 cubic feet per second in Yellowstone National Park.

INTRODUCTION

Streamflow data are needed to quantify Federal reserved water rights. This study was made in cooperation with the National Park Service, Rocky Mountain Region, to establish stream inflow and outflow in Glacier and Yellowstone National Parks. Streams where water rights needed to be quantified were selected by the National Park Service. For Yellowstone National Park, only streams in the Montana part of the park were considered. The 100-year discharge is to be used by the National Park Service as the basis for negotiating the Federal reserved water right of a particular stream.

The purpose of this report is to provide estimates of 100-year flood discharges at selected sites in Glacier and Yellowstone National Parks. Estimates for streams with contributing drainage areas outside Glacier National Park were determined using only the contributing drainage area in the park. The estimates were determined by using techniques developed in a report by Parrett and Omang (1981). The techniques used required determination of drainage area, mean annual precipitation, and geographical factor for sites in Glacier National Park and drainage area, mean basin elevation, percentage of total basin area above 6,000 feet, and geographical factor for sites in Yellowstone National Park.

STUDY AREAS

Glacier National Park is in northwestern Montana (fig. 1). It is bounded on the north by the international boundary between the United States and Canada, on the east by the Blackfeet Indian Reservation, and on the west by the North Fork of the Flathead River. The southern boundary of the park corresponds essentially to the Middle Fork of the Flathead River and of its tributaries, Bear Creek and Summit Creek. Most of Glacier National Park west of the Continental Divide is in the drainage basin of the Flathead River. Most of Glacier National Park east of the divide drains into Canada through the Waterton, Belly, and Saint Mary Rivers. An area in its southern part is tributary to the Two Medicine River and Cut Bank Creek.

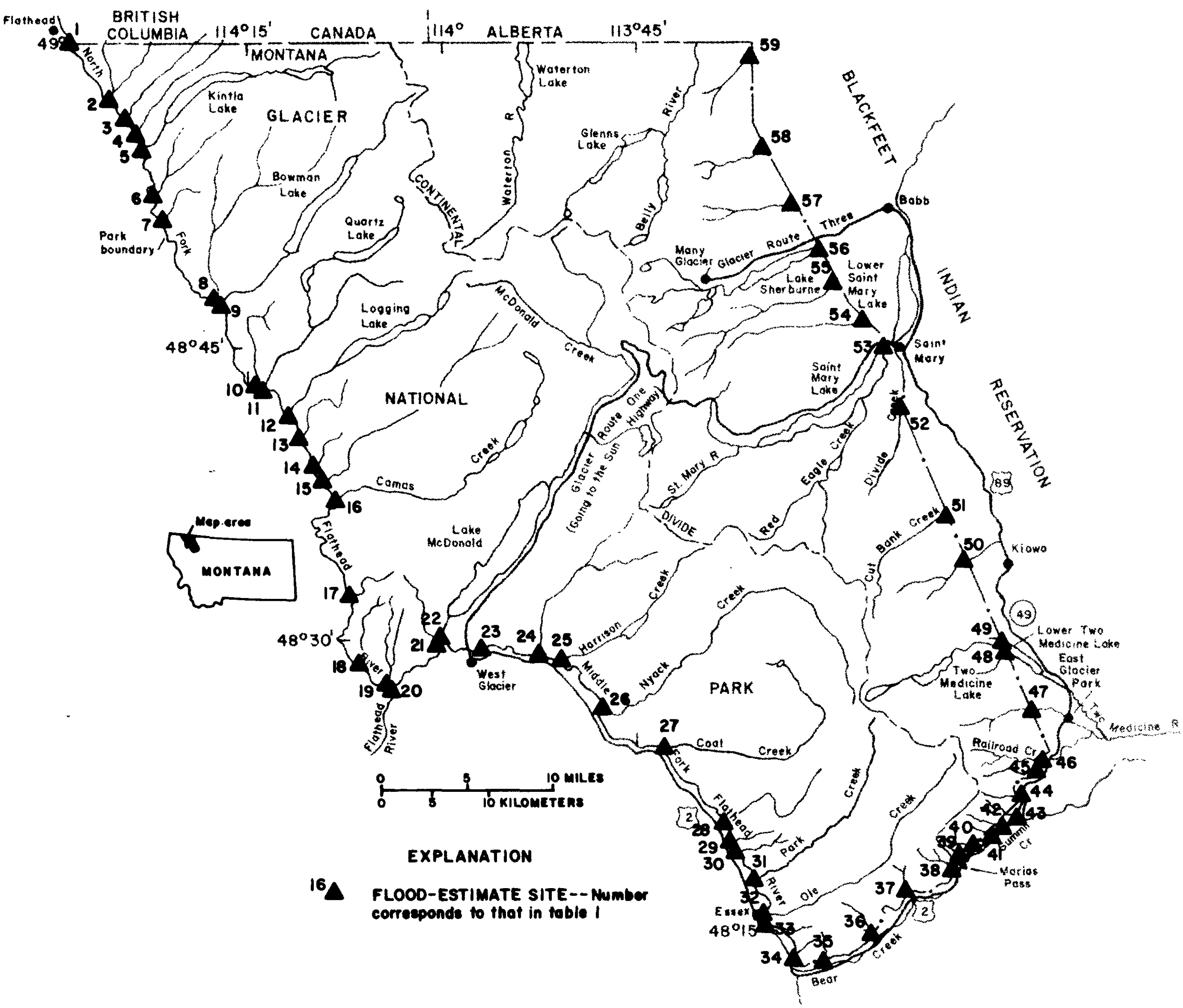

Figure 1.--Sites where flood estimates were made in Glacier National Park.

The climate is characterized by moderately cool weather throughout the year. The annual precipitation is in excess of 40 inches in the mountains and is about 20 to 30 inches in the lowlands. Although much of the precipitation is from winter snowfall, more precipitation is received in June than in any other month of the year. The precipitation in the mountains west of the divide is somewhat greater than that east of the divide.

The part of Yellowstone National Park studied consists only of the area located in Montana (fig. 2). This area consists of a strip about 2-1/2 miles wide on the north edge of the park and a narrower belt along the western side. Three large rivers drain this region. The Yellowstone River leaves the park at its northern boundary and the Madison and Gallatin Rivers leave the park at its western boundary.

The climate is unlike that found in the surrounding low country, with the amount of precipitation larger and the mean annual temperature lower. Rainstorms occur frequently throughout the summer, and snowfall is likely at any time between September and May. The annual precipitation in the mountains is 50 inches; that in the valleys is about 15 to 20 inches.

STREAMFLOW ESTIMATES

One-hundred-year flood estimates were made for 59 sites in Glacier National Park and 21 sites in Yellowstone National Park. Estimates were made for 57 sites in Glacier National Park where streams leave the park and for 2 sites where they enter the park. Estimates were made for 12 sites in Yellowstone National Park where streams leave the park and for 9 sites where they enter the park.

The 100-year flood discharge is the discharge that would be expected to occur, on the average, once in 100 years. Stated another way, there is 1 chance in 100, or a 1 percent chance, of the discharge being that magnitude or greater in any given year. These discharges were determined by using regression equations developed by Parrett and Omang (1981) for estimating 100-year flood magnitudes. The equations are based on an analysis in which 12 different basin characteristics were considered. Parrett and Omang (1981) divided the state into several regions and developed different predicting equations for each region. For this study, Glacier National Park was included in the Northwest Region and Yellowstone National Park was included in the Upper Yellowstone-Central Mountain and Southwest Regions.

Glacier National Park

One-hundred-year flood estimates for the sites in Glacier National Park were determined by using the following equation for the Northwest Region:

$$Q_{100}=23.4A^{0.77}P^{0.61}G_f \qquad (1)$$

where

Q_{100} = 100-year discharge,
A = drainage area,
P = mean annual precipitation, and
G_f = geographical factor.

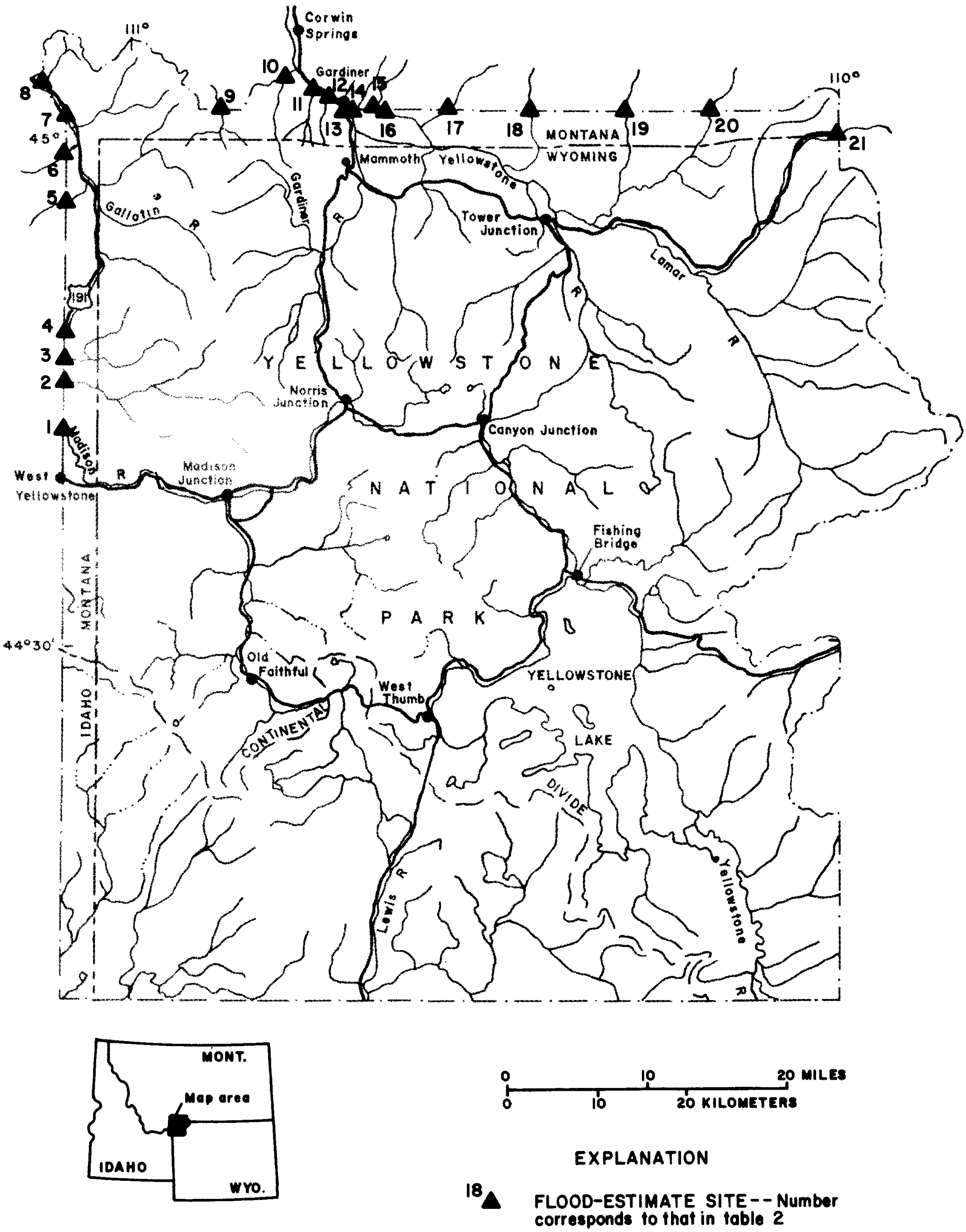

Figure 2.--Sites where flood estimates were made in Yellowstone National Park.

The drainage area, in square miles, was determined for all the sites by planimetering the area outlined on the largest scale topographic map available. Mean annual precipitation is the basin average, in inches, and was determined from an average annual precipitation map of Montana (U.S. Soil Conservation Service, 1977). The geographical factor was determined from a map of the State showing lines of equal geographical factors (Parrett and Omang, 1981). These lines were determined by plotting antilogarithms of regression residuals for the 100-year discharges. The estimated 100-year flood discharges, in cubic feet per second, are listed in table 1. Also listed are the basin characteristics used to determine the discharges.

For the two large streams, the North Fork of the Flathead River and the Middle Fork of the Flathead River, the 100-year discharge was determined differently. The discharge for the North Fork of the Flathead River at the upstream park boundary was that determined by Parrett and Omang for the gaging station at Flathead, British Columbia (station 1, fig. 1). The discharge for the North Fork of the Flathead River at the downstream park boundary was that determined by Parrett and Omang for the gaging station near Columbia Falls (station 20, fig. 1). Because Glacier National Park contributes only part of the runoff resulting in the 100-year discharge at the downstream boundary, the discharge at that station was estimated using only the contributing drainage area from Glacier National Park. The discharge was determined using the drainage area-transfer method based on the difference in drainage areas between two sites on the same stream.

The drainage area-transfer method formula is:

$$Q_u = (A_u/A_g)^a Q_g \qquad (2)$$

where Q_u = 100-year discharge estimated at the ungaged site,
A_u = drainage area at the ungaged site,
A_g = drainage area at the gaged site,
a = exponent of drainage area for the 100-year discharge for the region in which the stream is located, and
Q_g = 100-year discharge at the gaged site.

The discharge for the Middle Fork of the Flathead River at the upstream park boundary was that determined by Parrett and Omang for the gaging station at Essex (station 34, fig. 1). The discharge for the Middle Fork of the Flathead River at the downstream park boundary was that determined by Parrett and Omang for the gaging station near West Glacier (station 23, fig. 1). The discharge estimated using only the contributing drainage area from Glacier National Park was determined by the drainage area-transfer method. These discharges are listed in table 1.

Yellowstone National Park

Streamflow estimates for the sites in Yellowstone National Park were determined by using the equations for the Upper Yellowstone-Central Mountain Region and the Southwest Region. The Upper Yellowstone-Central Mountain Region equation used was:

$$Q_{100}=48.8\ A^{0.73}(E/1000)^{2.95}\ (HE+10)^{-1.24}G_f \quad (3)$$

where: Q_{100} = 100-year discharge,
A = drainage area,
E = mean basin elevation,
HE = percentage of total basin area above 6,000 feet, and
G_f = geographical factor.

Mean basin elevation, in feet above sea level, was determined by using a transparent grid overlay on a topographic map. The basin elevation at each grid intersection was determined, and the mean basin elevation was calculated by averaging. The percentage of basin area above 6,000 feet elevation was determined by planimetering the drainage area above the 6,000-foot contour on a topographic map, multiplying by 100, and dividing the result by the total drainage area. The other variables are as defined for equation 1.

The Southwest Region equation used was:

$$Q_{100}=1{,}890\ A^{0.72}(HE+10)^{-0.92}G_f \quad (4)$$

where Q_{100} = 100-year discharge,
A = drainage area,
HE = percentage of total basin area above 6,000 feet, and
G_f = geographical factor.

The 100-year discharges estimated and the basin characteristics used to determine these discharges are listed in table 2.

Discharges for the Madison River at the park boundary (site 1, fig. 2) and the Yellowstone River at the boundary (site 16, fig. 2) were determined by the drainage area-transfer method using gaging stations on the Madison and Yellowstone Rivers in the vicinity as the gaged sites. These discharges are listed in table 2.

SUMMARY

One-hundred-year flood estimates were determined for streams entering and leaving Glacier and Yellowstone National Parks in Montana for the purpose of negotiation of the Federal reserved water rights. The discharges were determined by using regression equations developed from a previous report to estimate magnitudes of floods. Drainage area, mean annual precipitation, and a geographical factor were the independent variables used in estimating flows for Glacier National Park. Drainage area, mean basin elevation, elevation above 6,000 feet, and a geographical factor were the independent variables used for Yellowstone National Park. The 100-year discharges ranged from 260 to 62,700 ft^3/s in Glacier National Park and from 110 to 27,900 ft^3/s in Yellowstone National Park.

SELECTED REFERENCES

Hague, Arnold, Weed, W. H., and Iddings, J. P., 1896, Yellowstone National Park, Wyoming: U.S. Geological Survey Geologic Atlas No. 30, 6 p.

Parrett, Charles, and Omang, R. J., 1981, Revised techniques for estimating magnitude and frequency of floods in Montana: U.S. Geological Survey Open-File Report 81-917, 66 p.

Ross, C. P., 1959, Geology of Glacier National Park and the Flathead region, northwest Montana: U.S. Geological Survey Professional Paper 296, 125 p.

U.S. Soil Conservation Service, 1977, Average annual precipitation, Montana, based on 1941-1970 base period: Department of Agriculture, 16 p.

U.S. Water Resources Council, 1981, Guidelines for determining flood flow frequency: Bulletin 17B, 28 p.

Table 1.--*Summary of flood estimates and basin characteristics for streams in Glacier National Park*

Site or station No. (fig. 1)	Site or station name	Drainage area (square miles)	Mean annual precipitation (inches)	Geographical factor (G_f)	100-year discharge (cubic feet per second)
1	North Fork Flathead River at upstream boundary (station 12355000)	450	55	1.0	19,000
2	Spruce Creek	16.8	55	1.0	2,370
3	Kishenenn Creek	79.4	65	1.0	8,670
4	Starvation Creek	16.3	65	1.0	2,560
5	Kintla Creek	56.4	77	1.0	7,390
6	Ford Creek	11.9	56	1.0	1,840
7	Mud Creek	2.34	30	1.0	360
8	Akokala Creek	40.7	57	1.0	4,780
9	Bowman Creek	56.7	73	1.0	7,180
10	Mud Lake Creek	8.85	30	1.0	1,000
11	Quartz Creek	52.6	72	1.0	6,720
12	Logging Creek	38.9	65	1.0	5,000
13	Sullivan Meadow Creek	4.22	27	1.0	530
14	North Fork Flathead River tributary	2.04	33	1.0	340
15	Anaconda Creek	32.0	57	1.0	3,970
16	Camas Creek	82.5	59	1.0	8,420
17	North Fork Flathead River tributary No. 2	3.37	26	1.0	440
18	North Fork Flathead River tributary No. 3	3.03	30	1.0	440
19	North Fork Flathead River tributary No. 4	4.81	30	1.0	620
20	North Fork Flathead River at downstream boundary (station 12355500)	1,550	26	1.0	[a]43,000
21	Rubideau Creek	6.16	36	1.0	840
22	McDonald Creek	178	70	1.0	16,900
23	Middle Fork Flathead River at downstream boundary (station 12358500)	1,130	59	1.0	[b]62,700
24	Lincoln Creek	37.8	65	1.0	4,900
25	Harrison Creek	27.2	75	1.0	4,150
26	Nyack Creek	85.2	76	1.0	10,100
27	Coal Creek	56.6	79	1.0	7,520
28	Muir Creek	13.8	70	1.0	2,360
29	Middle Fork Flathead River tributary No. 3	1.21	70	1.0	360
30	Middle Fork Flathead River triburary No. 2	2.00	55	1.0	460
31	Park Creek	40.1	77	1.0	5,680

Table 1.--*Summary of flood estimates and basin characteristics for streams in Glacier National Park*—Continued

Site or station No. (fig. 1)	Site or station name	Drainage area (square miles)	Mean annual precipitation (inches)	Geographical factor (G_f)	100-year discharge (cubic feet per second)
32	Ole Creek	47.0	75	1.0	6,320
33	Middle Fork Flathead River tributary	.96	65	1.0	290
34	Middle Fork Flathead River at upstream boundary (station 12357000)	510	52	1.0	31,700
35	Bear Creek tributary	1.40	60	1.0	370
36	Shields Creek	3.28	60	1.0	710
37	Autumn Creek	2.96	55	1.0	620
38	Bear Creek	3.20	62	1.0	710
39	Summit Creek tributary	.85	65	1.0	260
40	Summit Creek tributary No. 2	1.93	65	1.0	500
41	Summit Creek tributary No. 3	1.02	65	1.0	300
42	Summit Creek tributary No. 4	1.64	65	1.0	440
43	Summit Creek tributary No. 5	2.56	60	1.0	590
44	Coonsa Creek	1.24	60	1.0	340
45	Summit Creek tributary No. 6	2.03	60	1.0	490
46	Railroad Creek	7.65	67	1.0	1,460
47	Midvale Creek	9.37	79	1.0	1,880
48	Fortymile Creek	2.00	65	1.0	510
49	Two Medicine River	52.9	76	1.0	6,980
50	Lake Creek	6.64	92	1.0	1,590
51	North Fork Cut Bank Creek	30.2	92	1.0	5,090
52	Divide Creek	10.3	76	1.0	1,980
53	St. Mary Lake Outlet	146	75	1.0	15,100
54	Wild Creek	3.89	82	1.0	980
55	Boulder Creek	19.5	88	1.0	3,540
56	Lake Sherburne Outlet	64.6	85	1.0	8,710
57	Kennedy Creek	18.4	94	1.0	3,520
58	Otaso Creek	10.6	93	1.0	2,290
59	Lee Creek	9.71	68	1.0	1,770

[a] Contribution from Glacier National Park was 34,000 cubic feet per second.
[b] Contribution from Glacier National Park was 53,200 cubic feet per second.

Table 2.--*Summary of flood estimates and basin characteristics for streams in Yellowstone National Park*

Site No. (fig. 2)	Site name	Drainage area (square miles)	Mean basin elevation (feet above sea level)	Basin above 6,000 feet elevation (percent)	Geo-graphical factor (G_f)	100-year discharge (cubic feet per second)
1	Madison River	447	7,920	100	0.8	2,320
2	Couger Creek	81.6	7,560	100	1.0	600
3	Duck Creek	39.9	7,390	100	1.0	360
4	Grayling Creek	43.6	7,810	100	1.0	380
5	Bacon Rind Creek	14.2	8,740	100	.8	480
6	Snowslide Creek	8.79	8,560	100	.8	320
7	Gallatin River	146	7,990	100	.8	2,010
8	Daly Creek	9.66	7,860	100	.9	300
9	Mol Heron Creek	7.51	8,530	100	.9	310
10	Reese Creek	13.7	7,740	96	.9	380
11	Stephens Creek	3.71	7,560	88	.9	150
12	Landslide Creek	2.96	6,340	64	.9	110
13	Gardiner River	209	7,940	98	.9	2,950
14	Eagle Creek	5.02	7,230	91	1.0	180
15	Bear Creek	48.6	8,260	96	1.0	1,300
16	Yellowstone River	2,288	8,150	100	1.0	27,900
17	Crevice Creek	11.0	8,650	100	1.0	480
18	Hell Roaring Creek	126	8,640	100	1.1	3,120
19	Buffalo Creek	44.6	8,810	100	1.1	1,550
20	Slough Creek	103	8,510	100	1.1	2,580
21	Soda Butte Creek	28.5	8,890	100	1.1	1,150