WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Little Bighorn River Instream Flow Report

PROJECT: IF-3088-07-8703

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DATE: February 1989

INTRODUCTION

Data were collected during the 1988 field season to conduct instream flow analyses for a segment of the Little Bighorn River located in the Bighorn National Forest. The study was designed to provide results which could be used to determine instream flow needs for trout as well as to evaluate potential flow related impacts of possible future water development activities. This study does not address recommendations for flushing flows for channel maintenance.

METHODS

Study Area

The Little Bighorn River is considered a Class 2 stream by the Wyoming Game and Fish Department (WGFD). Stream classifications throughout Wyoming range from Class 1 (highest rating) to Class 5 (lowest rating). Class 2 streams are generally considered important trout fisheries on a statewide basis. Less than 6% of all streams in the state are Class 2 streams.

The Little Bighorn River contains naturally reproducing populations of rainbow trout, brown trout, and mountain whitefish. Brook and cutthroat trout occur incidentally. The stream below the mouth of Dry Fork Creek is primarily managed as a wild fishery for rainbow trout and secondarily for brown trout; therefore no fish are stocked in this section by the WGFD. The entire study reach is located within National Forest land and is accessible to the public. Because this section of the Little Bighorn River supports an important trout fishery and has public access, this segment was identified as a critical reach.

Data Collection

All of the field data used in this study were collected from a 519 foot long study site located in the southeast quarter of Section 25, Township 58 North, Range 90 West. This site is located approximately 3.5 miles upstream from the

Wyoming-Montana border (Figure 1). This site contained a combination of pool and riffle habitat for trout that was representative of trout habitat features found throughout this portion of the stream. Results and recommendations were applied to a portion of the stream extending from the north boundary of the SW1/4 SW1/4 of Section 20, Township 58 North, Range 89 West to the mouth of Dry Fork Creek at the east boundary of the NW1/4 NW1/4 of Section 12, Township 57 North, Range 90 West. This is a distance of approximately 4.4 stream miles.

In accordance with the 1986 Instream Flow legislation, the goal of this study was to determine instream flows necessary to maintain or improve the existing trout fishery in the above segment of the Little Bighorn River. The specific objectives of this study were to determine instream flows necessary to 1) maintain or improve physical habitat for rainbow trout spawning and incubation during the spring, 2) maintain or improve physical habitat for brown trout spawning and incubation during the fall, 3) maintain or improve hydraulic characteristics in the winter that are important for survival of trout, fish passage and aquatic insect production and, 4) maintain or improve adult trout production during the late summer months. Three habitat models were used to make these determinations.

Models

A physical habitat simulation model (PHABSIM) developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) was used to quantify incremental changes in the amount of physical habitat available for rainbow and brown trout spawning and incubation at various discharge rates. The amount of physical habitat available at a given discharge is expressed in terms of weighted usable area (WUA) and reflects the composite suitability of depth, velocity and substrate at a given flow. Depth, velocity and substrate data were collected at eight transects as described in Bovee and Milhous (1978). Dates and discharge rates when data were collected are given in Table 1. The WUA for various life stages of rainbow and brown trout was simulated for flows ranging from 10 to 300 cubic feet per second (cfs) using calibration and modeling techniques outlined in Milhous et al. (1984).

Table 1. Dates and discharges when instream flow data were collected.

Date	Discharge (cfs)
06-17-88	230
07-16-88	111
09-13-88	68

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow. A maintenance flow is defined as a continuous flow that is needed to maintain minimum hydraulic criteria at riffle areas in a stream segment. These criteria are needed to provide passage for all life stages of trout between different habitat types and maintain existing survival rates of trout and aquatic macroinvertebrates.

Data from single transects placed across three riffles within the study area were analyzed with the IFG-1 computer program (Milhous 1978). Flow data were collected

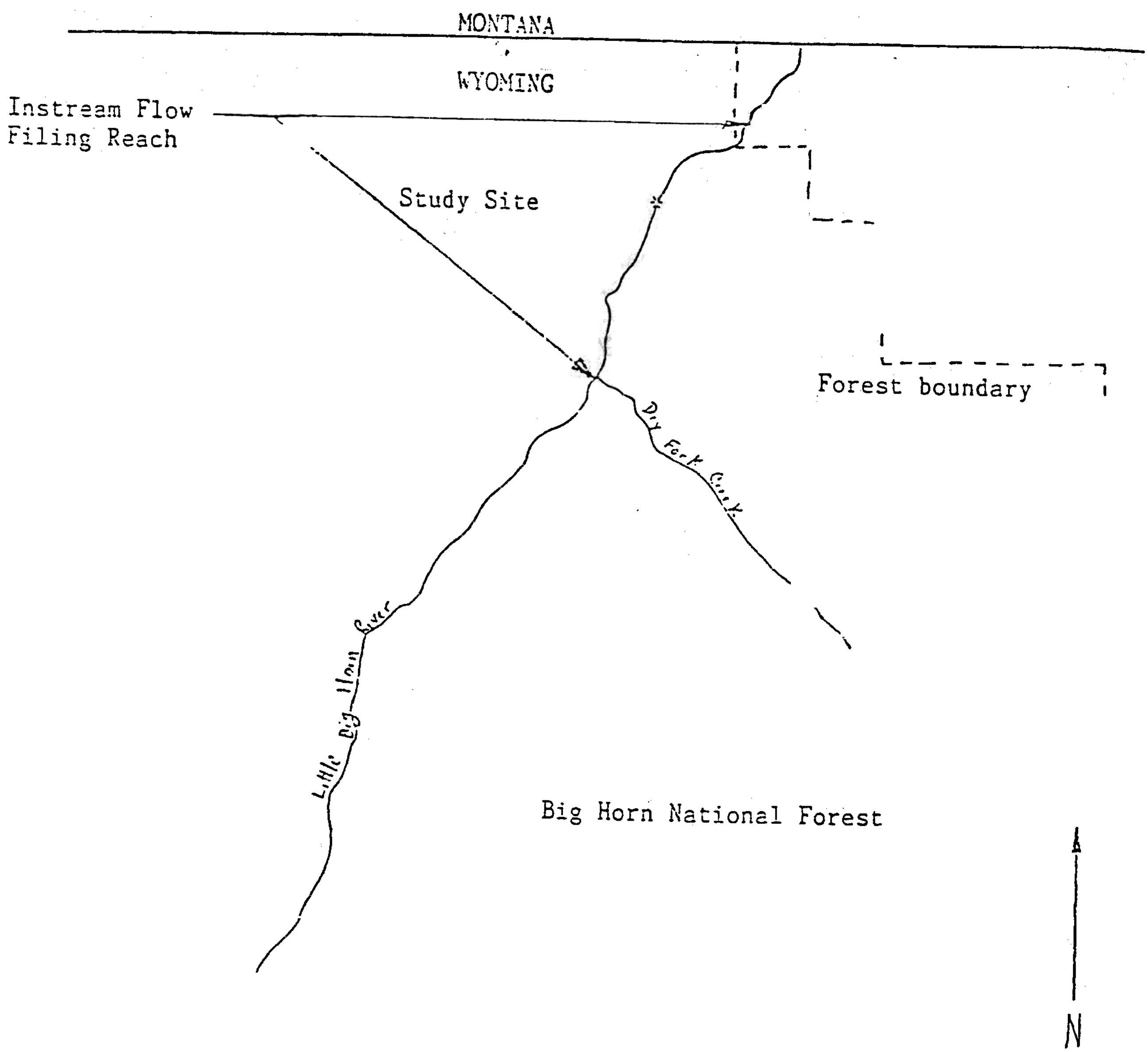

Figure 1. Map of study area on the Little Bighorn River

during three different flow events (Table 1). The maintenance flow is identified as the discharge at which two of the three criteria in Table 2 are met for all riffles in the study area.

Table 2. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention method.

Category	Criteria
Average Depth (ft)	Top width[1] x 0.01
Average Velocity (ft per sec)	1.00
Wetted Perimeter (percent)[2]	60

1 - At average daily flow
2 - Compared to wetted perimeter at bank full conditions

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1979) was used to estimate potential changes in trout standing crops over a range of late summer flow conditions. This model incorporates seven attributes that address chemical, physical and biological components of trout habitat. Results are expressed in habitat units (HU). One HU is defined as the amount of habitat quality which will support one pound of trout. Analyses obtained from this method apply to the time of year that governs trout production. On the Little Bighorn River, this time period is between July 1 and September 30.

By measuring habitat attributes at various flow events as if associated habitat features were typical of late summer flow conditions, HU estimates can be made for a range of theoretical summer flows. Habitat attributes on the Little Bighorn River were measured on the same dates and flow levels that data were collected for the PHABSIM and Habitat Retention models (Table 1). To better define the potential impact of other late summer flow levels on trout production, some attributes were derived mathematically or obtained from existing gage data. Gage data were obtained from a U.S. Geological Survey gage located on the Little Bighorn River near the Wyoming-Montana border for the period 1939 to 1986. A regression equation was developed to relate the discharges at the U.S.G.S. gage with discharges measured at the study site. This relationship was used to determine the annual stream flow variation and critical period stream flow, two variables of the HQI, at the study site.

Results from the PHABSIM analysis were used to evaluate the relationship between discharge and physical habitat for rainbow trout spawning and incubation. Rainbow trout generally spawn in April and May and their eggs incubate in the stream gravels until late June. Results from this model were applied to the stream for the period between April 1 and June 30.

PHABSIM results were also used to identify stream flows necessary to maintain or improve physical habitat for brown trout. This species normally spawns in October and November and the eggs incubate until late March. Spawning and incubation results were subsequently used to address the relationship between these life stages and discharge from October 1 to March 31. Results from the Habitat Retention model were combined with the results of the PHABSIM model for brown trout to identify a flow from October 1 to March 31 which would meet the dual objectives of maintaining trout survival and passage and aquatic insect survival as well as maintaining brown trout reproductive success.

Results from the HQI model were used to identify the flow needed to maintain existing levels of trout production between July 1 and September 30.

RESULTS

An analysis of gage records indicated that existing flow conditions at the study site approximate 60 cfs during the month of April. Results of the PHABSIM analysis indicate that at this discharge, physical habitat for rainbow trout spawning is approximately 80% of the maximum amount available, which occurs at a discharge of 90 cfs (Figure 2). Reductions in existing physical habitat for spawning occur at flows lower than 60 cfs, while flows between 70 and 125 cfs result in relatively large increases in physical habitat for spawning.

Gage records indicate that existing flows during May and June approximate 300 cfs. PHABSIM results indicate that a flow of 300 cfs provides approximately 40% of the maximum amount of physical habitat for incubation, which occurs at a discharge of 20 cfs. Flows between 20 and 300 cfs will therefore maintain or improve the existing physical habitat for rainbow trout incubation. However, flows less than 60 cfs will reduce the existing amount of physical habitat for trout that may still be spawning during May and June. Such reductions would also dewater some rainbow trout eggs that were deposited at this flow level and consequently cause a reduction in spawning success.

To maintain or improve physical habitat available to rainbow trout for both spawning and incubation, an instream flow of 60 cfs is recommended for the period of April 1 to June 30. This discharge will maintain the existing amount of physical habitat for spawning during the period April 1 to April 30. In addition this discharge will improve existing physical habitat for incubation between May 1 and June 30 while also maintaining physical habitat for late spawning fish during these months.

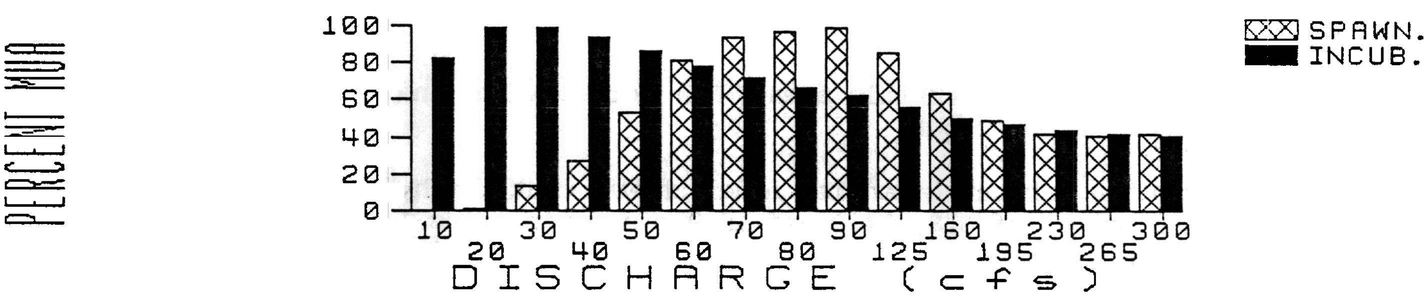

Figure 2. Percent of maximum usable area (MUA) for spawning and incubation life stages of rainbow trout.

PHABSIM results for brown trout spawning and incubation were nearly identical to those for rainbow trout. Results of the PHABSIM analysis indicate that under existing average flow conditions during the month of October (approximately 60 cfs), physical habitat for brown trout spawning is approximately 80% of the maximum amount available, which occurs at a discharge of 90 cfs (Figure 3). Reductions in existing physical habitat for spawning occur at flows lower than 60 cfs, while flows between 70 and 125 cfs result in relatively large increases in physical habitat for spawning.

The hydrologic analysis showed that existing average flows during the brown trout incubation period (November through March) approximate 50 cfs. A discharge of 50 cfs provides about 85% of the maximum usable area for incubation, which occurs at a discharge of 20 cfs. Flows of between 20 and 50 cfs will maintain or improve the existing physical habitat for brown trout incubation. However, flows less than 60 cfs will reduce physical habitat for trout that may still be spawning in early November. In addition, reductions in flows below 50 cfs from late November to March 31 would also dewater some brown trout eggs that were deposited during October and early November and consequently cause a reduction in spawning success.

To maintain or improve physical habitat available to brown trout for spawning, an instream flow of 60 cfs is recommended for the period of October 1 to November 15. A discharge of 50 cfs during the period November 16 to March 31 is the minimum flow that will maintain existing physical habitat for incubation while preventing the dewatering of eggs that were deposited at higher discharges in October and early November.

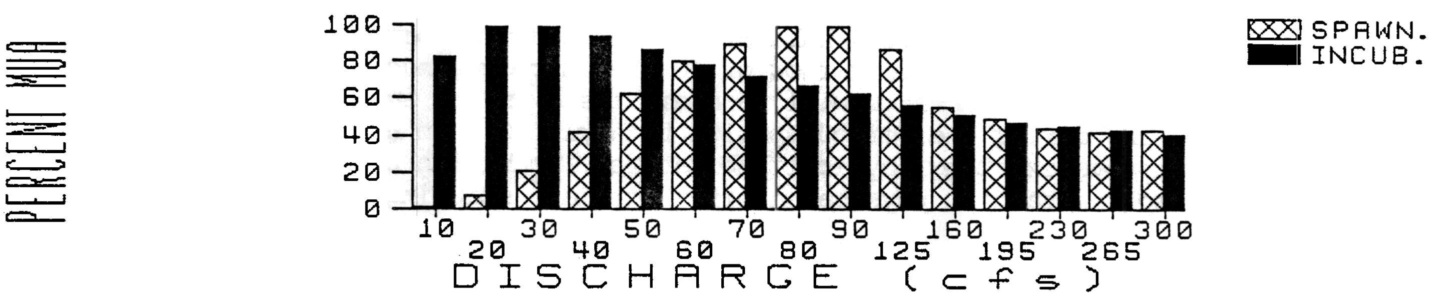

Figure 3. Percent of maximum usable area (MUA) for spawning and incubation life stages of brown trout.

Results from the Habitat Retention model showed that the hydraulic criteria in Table 2 are met at flows of 8.8, 14.0 and 15.9 cfs for riffles 1, 2, and 3, respectively (Table 3). The maintenance flow derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site which in this case is 15.9 cfs.

Table 3. Simulated hydraulic criteria for three riffles on the Little Bighorn River. Average daily flow = 110 cfs. Bank full discharge = 712.0 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1			
2.49	5.84	50.3	712.0
2.42	5.49	49.5	636.9
2.23	4.77	48.0	497.4
2.04	4.11	46.8	380.7
1.84	3.49	45.5	284.5
1.34	2.06	40.4	110.0
1.08	1.52	38.7	61.9
0.81	1.00 [1]	34.7	28.3
0.51	0.57	30.2 [1]	8.8 [2]
0.39 [1]	0.46	28.2	5.4
Riffle 2			
1.95	7.12	52.4	712.0
1.85	6.63	51.8	619.1
1.71	5.65	48.5	458.8
1.53	4.72	46.5	328.8
1.31	3.87	45.2	226.0
0.96	2.67	42.7	110.0
0.68	1.84	39.8	48.8
0.42 [1]	1.16	33.1	17.1
0.39	1.07	31.5 [1]	14.0 [2]
0.36	1.00 [1]	30.3	11.7
Riffle 3			
2.80	5.05	53.6	712.0
2.53	4.69	52.5	583.1
2.26	4.14	47.8	416.3
1.85	3.58	45.6	281.7
1.42	3.06	43.5	177.1
1.10	2.66	39.8	110.0
0.93	2.37	34.2	70.6
0.81	2.22	32.2 [1]	55.5
0.37 [1]	1.84	24.1	15.9 [2]
0.12	1.00 [1]	3.5	0.0

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

Based on the results of the Habitat Retention method, an instream flow of 15.9 cfs was identified as the flow that would maintain minimum hydraulic criteria at riffles to provide passage for all life stages of trout between different habitat types and maintain existing survival rates of trout and aquatic macroinvertebrates. However, a flow of 15.9 cfs during the fall and winter would result in significant reductions in physical habitat for brown trout spawning. The results of the PHABSIM analysis indicate that physical habitat for brown trout spawning would be reduced to approximately 5 percent of the maximum amount available. As a result, the recommended instream flow for the period October 1 to November 15 is 60 cfs and for the period November 16 to March 31 the recommended flow is 50 cfs. These recommendations will maintain the existing levels of spawning and incubation for brown trout and also meet or exceed the hydraulic criteria used in the Habitat Retention method for providing fish passage, and maintaining survival rates of trout and aquatic macroinvertebrates.

Results from the HQI analyses (Figure 4) indicate that trout HU's in this portion of the Little Bighorn River would be maximized at an average late summer flow of approximately 85 cfs. Under existing conditions, the stream presently supports 248 HUs which is equal to the maximum potential indicated by the HQI model. A flow of 62 cfs is the minimum flow that will maintain the existing number of habitat units. At lower average late summer flows, the model indicates that reductions in the fishery would occur. These reductions would largely be the result of lower velocities, lower critical period flow and higher annual flow variation. Significant increases in stream flow above 85 cfs would result in increasingly rapid reductions in trout HUs, as would small reductions in discharge below 62 cfs (Figure 4).

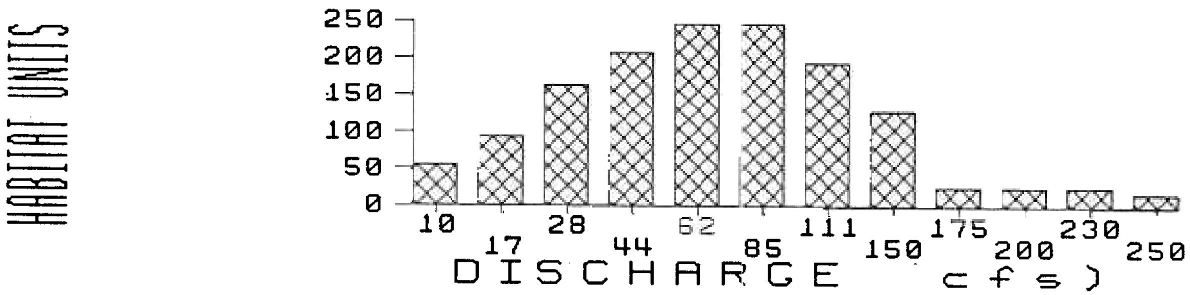

Figure 4. Number of potential trout habitat units at several late summer flow levels in the Little Bighorn River.

Based on the results from the HQI analysis, an instream flow of 62 cfs is recommended to maintain existing levels of trout production between July 1 and September 30.

CONCLUSIONS

Based on the analyses and results contained in this report, the instream flow recommendations in Table 4 will maintain or improve the existing fishery of the Little Bighorn River. These recommendations apply to a 4.4 mile segment of the river extending from the north boundary of the SW1/4 SW1/4 of Section 20, Township 58 North, Range 89 West to the mouth of Dry Fork Creek at the east boundary of the NW1/4 NW1/4 of Section 12, Township 57 North, Range 90 West.

Table 4. Summary of instream flow recommendations to maintain the existing trout fishery in the Little Bighorn River.

Time Period	Instream Flow Recommendation (cfs)
April 1 to June 30	60
July 1 to September 30	62 [1]
October 1 to November 15	60 [2]
November 16 to March 31	50 [2]

1 - Feasibility determined by availability at the 50% exceedence level during the specified time period

2 - To maintain the existing natural flows up to the specified amount

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