WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Tongue River Instream Flow Report

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Studies were conducted during the 1981 field season to obtain instream flow information from a portion of the Tongue River near the town of Dayton. The studies were 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 future water development activities.

METHODS

All of the field data used in this study were collected from a 326 foot long study site located on State property in the northeast corner of Section 10, Township 56 North, Range 87 West. 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 confluence of the North and South Forks of the Tongue River in the NW1/4 of S22 , T56N, R88W downstream to the east section line of Section 10, T56N, R87W. This is a distance of approximately 8.3 stream miles.

A physical habitat simulation (PHABSIM) model developed by the Instream Flow Service Group of the U. S. Fish and Wildlife Service (USFWS) (Bovee and Milhous 1978) was used to identify incremental changes in the amount of physical habitat (usable area) for rainbow trout spawning and incubation habitat with changes in flow. Data were collected at six transects which were placed across each habitat type within the study segment. Velocities and depths were measured at 1 to 2 foot intervals across each transect during 3 different flow events (Table 1). These data permitted simulation of physical habitat over a range of flows between 30 and 500 cfs.

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

Date	Discharge (cfs)
07-08-81	205
08-05-81	105
09-15-81	75

The Habitat Retention method (Nehring 1979) was used to identify a flow for maintaining adequate levels of aquatic insect production and fish passage through riffle areas. Data from single transects placed across three riffles within the study area were analyzed using the IFG-1 computer program (Milhous 1979). Flow data were collected on the same dates that PHABSIM data were collected (Table 1). The instream flow recommendation for this method was determined by identifying the discharge at which two of the three hydraulic criteria in Table 2 were met at all riffle cross sections in the study segment.

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

Category	Criteria
Average Depth (ft)	Top width * 0.01
Average Velocity (ft per sec)	1.00
Wetted Perimeter (percent)*	70

* - Compared to wetted perimeter at bank full conditions.

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1978) 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 as well as biological components of trout habitat. Results are expressed in habitat units (HU) per acre. Analyses obtained from this method apply primarily to the time of year that governs trout production. On the Tongue 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 Tongue were measured on the same dates and at the flow levels that data were collected for the PHABSIM and Habitat Retention models (Table 1). To better define the potential impact of other, lower late summer flow conditions on the existing stream fishery, some attributes were derived mathematically or obtained from existing gage data for flows lower than those which were measured. Gage data were

obtained from a U. S. Geological Survey gage located near the downstream end of the instream flow segment for the period of 1919 to 1980.

Results from the HQI and Habitat Retention models were combined to identify the flow needed to maintain existing levels of trout production between July 1 and September 30. Results from the Habitat Retention model were used to identify a flow from October 1 to March 31 which would maintain or improve trout survival. Results from the PHABSIM model for spawning and incubation life stages were used to identify flows which would improve rainbow trout reproductive success. Rainbow trout generally spawn in April and their eggs hatch in June. The spawning flow recommendation therefore applies to the period from April 1 to April 30 and the incubation flow recommendation applies to the period between May 1 and June 30.

RESULTS

Results from the Habitat Retention model showed that flows of 59, 52 and 48 cfs are necessary to maintain aquatic insect production and fish passage at riffles 1, 2 and 3 respectively (Appendix A). 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 59 cfs.

Results from the HQI analyses (Figure 1) indicate that trout densities in this portion of the Tongue would be maximized at an average late summer flow of approximately 100 cfs. Gage data from the U. S. Geological Survey gage near the study site show that the lowest average monthly flow for late summer occurs in September and is approximately 90 cfs. The trout fishery in this stream segment is adapted to this flow regime and the stream presently provides between 155 and 183 HU's per acre. The density of trout would be only slightly reduced at a flow of 60 cfs in late summer; however, at lower flows significant reductions in the fishery would likely occur. These reductions would largely be the result of lower critical period flow, higher annual flow variation and higher stream water temperatures.

Based on the results of the above two models, an instream flow of 60 cfs is recommended to maintain existing levels of trout production between July 1 and September 30.

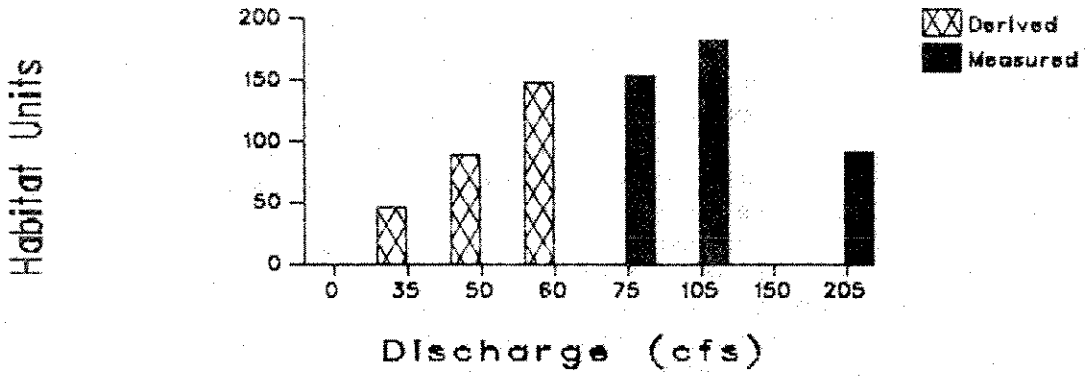

Figure 1. Number of potential trout habitat units at several late summer flow levels in the Tongue River.

It is a well documented fact that substantial losses of wild trout occur in the winter, particularly in relatively high elevation streams like the Tongue River. Kurtz (1980) found that the loss of winter habitat due to low flow conditions was an important factor affecting mortality rates of trout in the Green River in Wyoming. Needham et al. (1945) documented overwinter losses of brown trout ranging up to 85 percent and averaging over 60 percent in a California stream. Butler (1979) reported significant trout and aquatic insect losses caused by anchor ice formation. Reimers (1957) considered anchor ice, collapsing snow banks and fluctuating flows resulting from the periodic formation and breakup of ice dams to be the primary causes of trout winter mortality. These studies were all conducted on unregulated streams and illustrate the severe conditions that trout are exposed to naturally during the winter.

The causes of winter mortality discussed above are all greatly influenced by the quantity of winter flow in terms of its ability to minimize anchor ice formation (increased velocity and temperature loading) and dilute and prevent snow bank collapses and ice dam formation respectively. Any reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish that the stream could support. The fishery management objective for the time period from October 1 to March 31 is subsequently to protect all available natural stream flows in the instream flow segment.

The Habitat Retention method was developed to identify a flow that would provide adequate survival of aquatic insects in riffle areas and provide passage for trout between different habitat types in the stream. Maintenance of these features is important year round and as a consequence, the previously identified flow (60 cfs) that will maintain these features during

free-flowing conditions (when ice is not on the stream) also applies to the period between October 1 and March 31. Natural, undepleted flows during this time period that are less than 60 cfs will maintain trout survival at its current level since the existing trout population has evolved under these conditions. Stream flows greater than the winter survival maintenance flow will increase trout survival.

Preliminary analyses indicate that the recommended winter instream flow is not available naturally on occasion in the portion of the Tongue addressed by these studies. This does not indicate a need for storage to provide the recommended flow but instead shows that the entire available natural flow (up to 60 cfs) is needed through the winter to maintain trout survival at its present level.

Results from the PHABSIM model for rainbow trout spawning and incubation habitat (Figure 2) show that flows of 80 and 180 cfs respectively would provide the maximum amount of usable area for these life stages. Natural flows during the period when rainbow trout spawn are significantly greater than these flows under normal conditions. Although the present flow regime provides adequate recruitment to support the existing stream fishery, reductions in flow to 80 cfs from April 1 to April 30 and 180 cfs from May 1 to June 30 would improve spawning success and standing crop of rainbow trout in the stream.

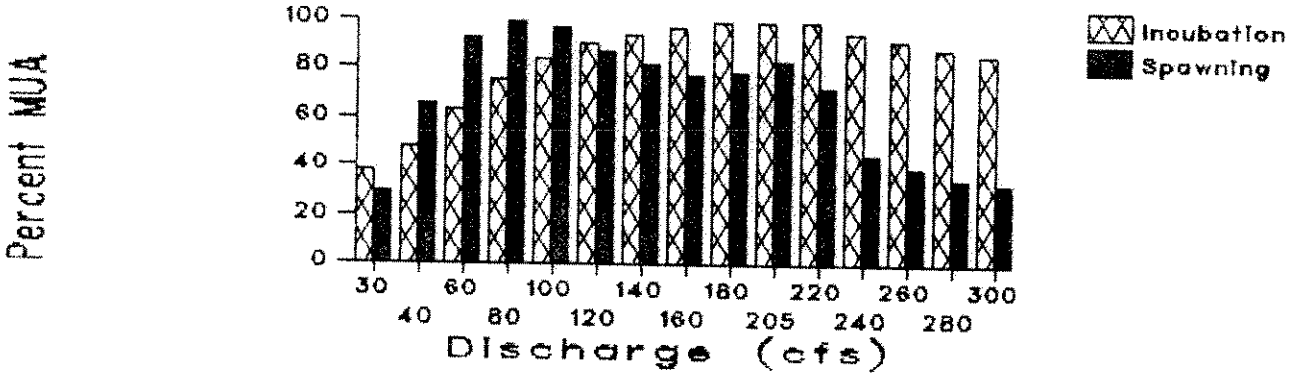

Figure 2. Percent of maximum usable area (MUA) for spawning and incubation life stages of rainbow trout.

CONCLUSIONS

Based on the analyses and results contained in this report, the instream flow recommendations in Table 3 apply to an 8.3 mile segment of the Tongue River extending downstream from the confluence of the North and South Forks of the Tongue River to the east section line of Section 10, T56N, R87W.

Table 3. Summary of instream flow recommendations for the Tongue River.

Time Period	Instream Flow Recommendation (cfs)
July 1 to September 30	60*
October 1 to March 31	60**
April 1 to April 30	80**
May 1 to June 30	180**

* - Feasibility determined by availability at least 50 percent of this time period

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

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APPENDIX A

Simulated hydraulic criteria for three riffles on the Tongue River.

Riffle 1

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (percent)	Discharge (cfs)
1.39*	0.47	67.2	27.8
1.47	0.55	68.2	34.8
1.51	0.59	68.6	38.8
1.56	0.64	68.9	43.2
1.60	0.64	69.3	47.9
1.68	0.79	70.0*	58.8**
1.77	0.91	70.7	71.7
1.85	1.04*	71.2	86.8

Riffle 2

0.75*	0.69	56.1	21.3
0.83	0.78	57.6	27.1
0.86	0.87	62.4	34.1
0.93	0.96	64.5	42.3
1.00	1.07*	66.5	52.0**
1.09	1.18	67.0	63.2
1.16	1.29	68.9	76.0
1.23	1.42	70.7*	90.6

Riffle 3

0.38	1.01*	35.2	10.3
0.55	1.18	47.4	22.8
0.61	1.24	50.8	28.4
0.65	1.29	56.3	34.7
0.72	1.34	59.1	41.8
0.77*	1.38	61.5	48.4**
0.84	1.45	65.0	58.4
0.98	1.57	70.0*	78.5

* - Minimum hydraulic criteria met
** - Maintenance flow