WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Snake River Instream Flow Studies

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INTRODUCTION

Case History

Stream flows in the Snake River through Jackson Hole have been a public issue since construction of the first log crib dam on the lake in 1906. Since that time the dam has been enlarged or improved on several occasions to control runoff by capturing spring flows for downstream irrigators. During the 1940's, excessive releases made for irrigators caused Jackson residents to request more gradual releases to reduce flooding and bank erosion.

In more recent times, concerns have focused on protecting the increasingly valuable Snake River cutthroat trout fishery in the river. Over the past 20 years, winter releases from Jackson Lake Dam have on several occasions been reduced to levels that limited the survival of trout and other aquatic organisms. As recently as 1987, releases from the dam were lowered to 100 cfs for a portion of the non-irrigation season. At these flow levels, short term impacts occur when aquatic insects and sculpins are stranded and die in dewatered riffle areas and side channels. Prolonged low flows can cause impacts by 1) permitting formation of frazile ice (suspended ice crystals) which can plug fish's gills, 2) causing fish to emmigrate to more desirable habitats and 3) by limiting production of aquatic insects in riffle areas.

Study Area

The Snake River is one of the premier rivers in Wyoming as well as in the nation. It is presently rated a blue ribbon or Class I fishery by the Game and Fish Department. Recent estimates indicate that the river receives approximately 250,000 days of use by recreationists annually.

The river fishery near the dam is made up primarily of native fishes including Snake River cutthroat trout, mountain whitefish and several species of nongame fish. Non-native game fish species found here comprise a smaller part of the fish community and include brown and rainbow trout. The Snake River cutthroat is the most sought after species by river fishermen and the Department's objective for the river is to improve the quality of this fishery.

In recent years, the Department has taken several steps to accomplish this objective. Since spawning habitat for cutthroat trout is limited in the river proper, spawning areas have been created and/or improved in some of the many tributaries and spring creeks feeding the river. More recently, the Department has implemented special regulations to regulate the harvest of fish from the river. The adult fish which reside in the river year round are periodically impacted by low winter flows. Maintenance of a continuous, adequate flow will further improve survival and growth of the native fishery.

When flows from Jackson Lake Dam are restricted, the most seriously impacted portion of the river is the 4.3 mile long segment from the dam to the mouth of Pacific Creek (Figure 1). This stream segment is characterized by a single well defined channel with occasional deep pools and a series of long runs. At Pacific Creek and beyond, several tributaries contribute flow to the river which help maintain the river fishery further downstream. These tributaries contribute a large amount of bed load material (gravels) which causes the habitat to change significantly. This is evidenced by the extensive gravel bars and channel braiding in this portion of the system.

METHODS

Data Collection

The primary concern at present deals with maintaining an adequate amount of physical habitat for adult Snake River cutthroat trout in the river segment between the dam and Pacific Creek during the non-irrigation season. This time period extends from approximately October 1 to March 31. To determine the stream flow needed to protect the fishery during this time period, two different computer models were used.

A physical habitat simulation (PHABSIM) model developed by the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) was used to incrementally identify trade offs in physical habitat over a range of stream flows. Both multiple and single flow calibration techniques were used to obtain the best hydraulic simulation for this model. Suitability indices developed specifically for adult

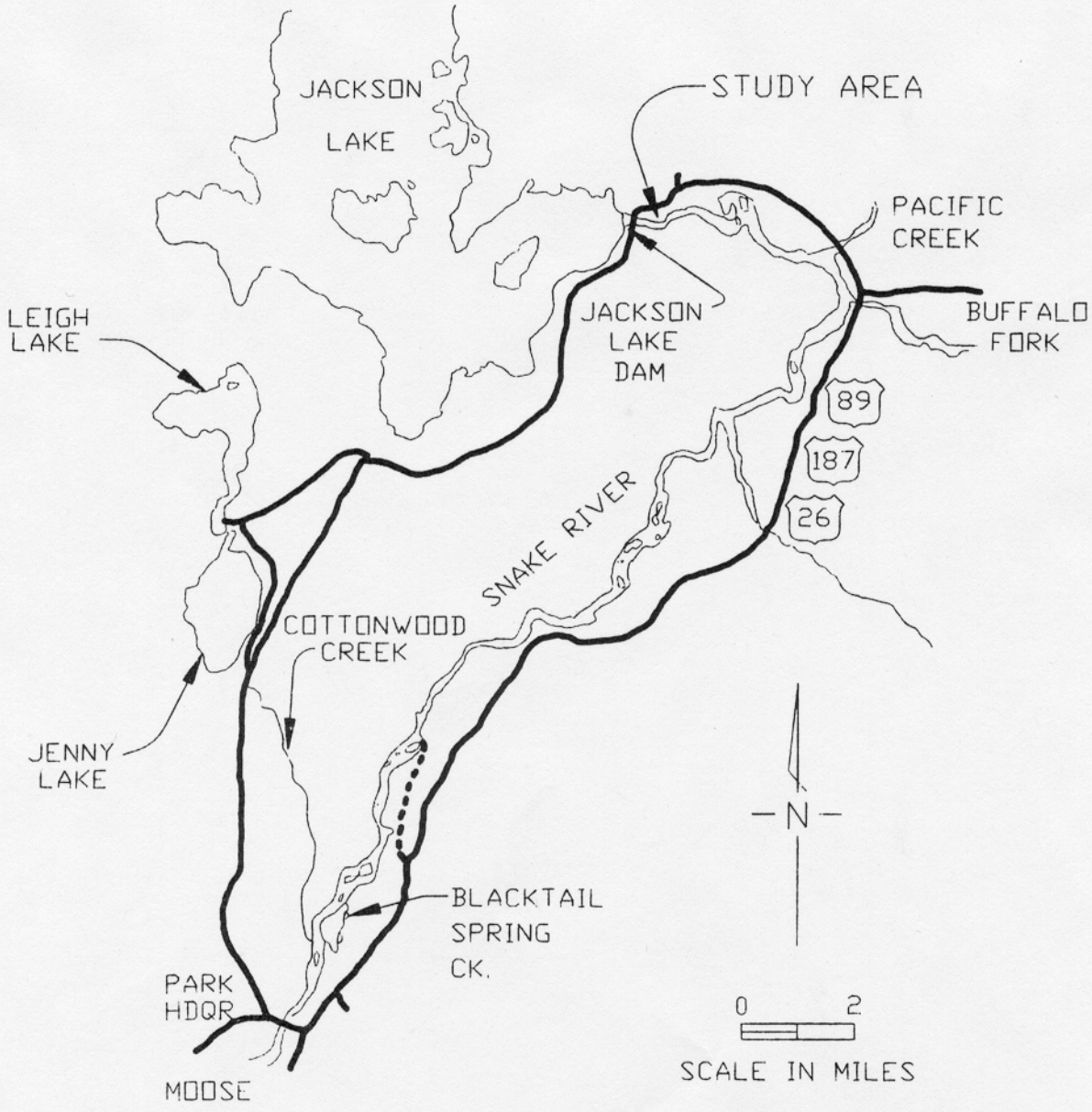

Figure 1. Location of the study area.

Snake River cutthroat winter habitat preferences were used to identify the amount of weighted usable area or physical habitat over the specified range of flows. (Johnson et al. 1987).

A Habitat Retention method (Nehring 1979) was used to identify a maintenance flow. A maintenance flow is defined here 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 adequate survival of aquatic macroinvertebrates. The maintenance flow is identified as the discharge at which two of the three criteria in Table 1 are met.

Table 1. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention method.

Category	Criteria
Average Depth (ft)[1]	Top width X 0.01
Average Velocity (ft per sec)	1.00
Wetted Perimeter (percent)[2]	70

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

Instream flow data were collected at a representative part of the river segment between the dam and Pacific Creek. The study site was located approximately 1/2 mile downstream from the dam in section 17, T45N, R114W. Five transects were used to define the physical habitat in this segment. Stream flows were originally measured at three different discharges (Table 2). Several days after collecting these data, it was discovered that releases from the dam were not stable when the higher discharge measurements were made. Since the PHABSIM method requires that flows be stable during the time that data are collected, another set of data was obtained in late December.

A trend was noted where our measured discharges were consistently about 10 percent less than discharges reported by the gage at the dam. Possible explanations for this discrepancy include loss of water to bank storage, error in our measurements or error in gage estimates. It seems unlikely that 20 cfs or more would be lost to bank storage in the short distance between our study site and the dam. In fact, a slight accrual would be logical considering seepage from the reservoir. As our flow meters were calibrated and at least some of our estimates reflected an average of two or more cross sections, the gage readings at the dam may be over estimating the actual releases from the dam. This situation may require additional study in the future.

Table 2. Dates and discharges when instream flow data were collected in the Snake River below Jackson Lake Dam.

Date	Measured Discharge	Reported Gage Discharge
October 5	170	189
October 6	413-475	438-500
October 7	690	723-746
December 22	411	510

RESULTS

PHABSIM Analysis

Of the various calibration techniques used with the PHABSIM model, the approach using the measured stage-discharge relationship with one set of cell velocities (measured at 170 cfs) provided the best hydraulic simulation. When combined with the suitability indices for adult Snake River cutthroat trout, this model indicated that weighted usable area is maximized at 400 cfs in the study area over the range of flows for which simulations were made (Figure 2). The amount of usable area decreases slightly at higher flows and also shows relatively slight decreases at lower flows to a point. However, at flows of 250 cfs and less, the amount of usable area for trout decreases at an increasingly rapid rate.

Habitat Retention Method

Two of the five transects used for the PHABSIM analysis were riffle areas which were appropriate to use with the Habitat Retention method. Since this is a single transect technique, all of the discharges and water surface elevations measured in October could be used at each transect for calibrating the model. With this method, the maintenance flow is defined as that discharge at which two of the three defined hydraulic criteria in Table 1 are met for all riffles in the study area. For this stream segment, a discharge of 280 cfs is needed to meet these criteria (Tables 3 and 4).

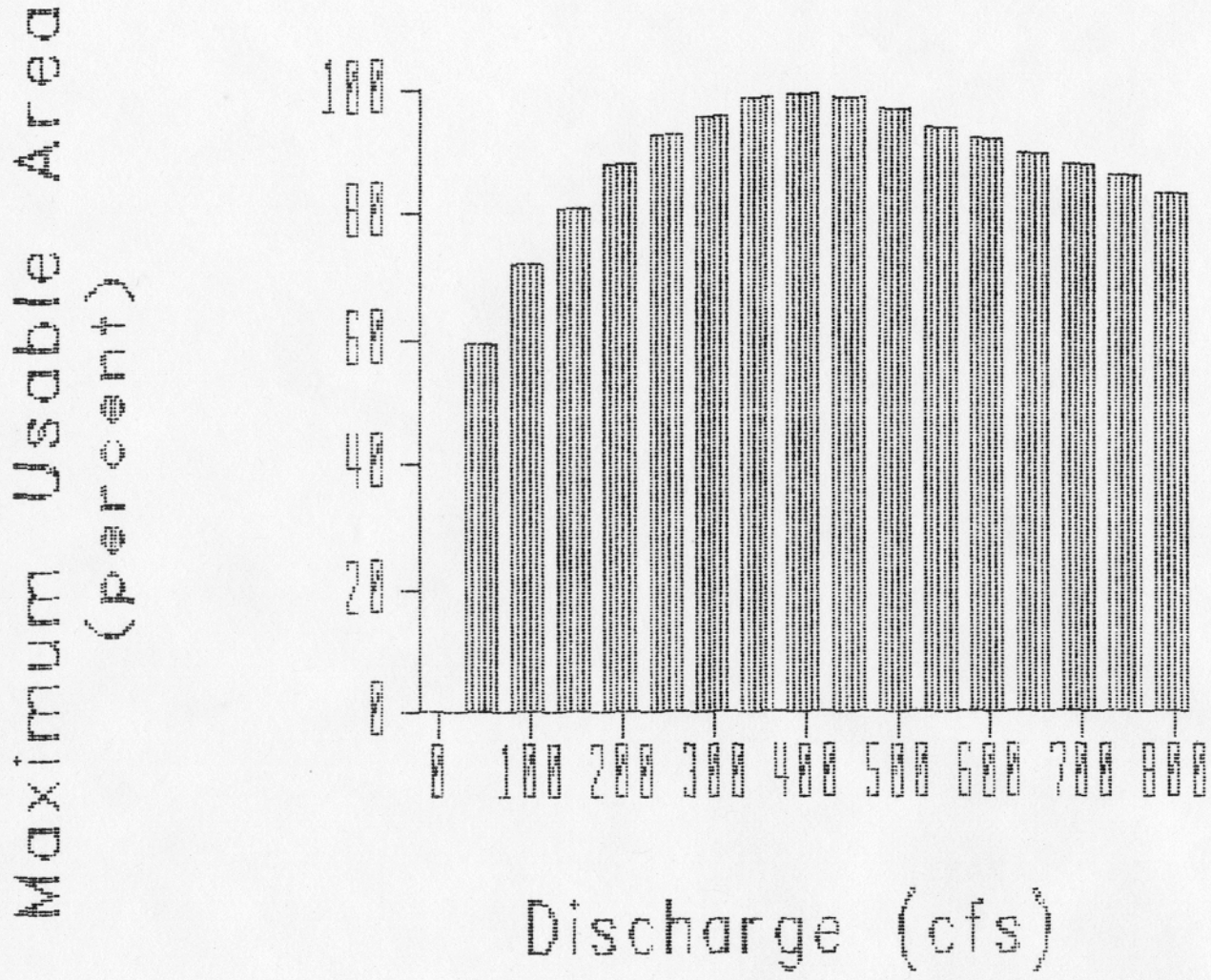

Figure 2. Percent change in maximum weighted usable area (MWUA) during the winter with change in discharge for adult Snake River cutthroat trout in the Snake River.

Table 3. Simulated hydraulic criteria at riffle number 1 in the Snake River below Jackson Lake dam.

Riffle Number 1			
Discharge (cfs)	Average Velocity (fps)	Average Depth (ft)	Wetted Perimeter (feet)
42	0.77	0.34	161
75	0.84	0.48	185
108	0.91	0.59	199
148[2]	1.00[1]	0.71	209[1]
170	1.04	0.77	213
215	1.12	0.87	221
276	1.22	0.98	231
346	1.33	1.11	235
584	1.64	1.47	243
1204	2.27	2.09[1]	254

1 - Point at which minimum hydraulic criterion is met.
2 - Maintenance flow for this transect.

Table 4. Simulated hydraulic criteria at riffle number 2 in the Snake River below Jackson Lake dam.

Riffle Number 2			
Discharge (cfs)	Average Velocity (fps)	Average Depth (ft)	Wetted Perimeter (feet)
45	0.45	0.58	172[1]
74	0.55	0.76	178
102	0.63	0.89	181
134	0.71	1.02	185
173	0.80	1.16	188
218	0.89	1.28	191
269	0.98	1.41	269
281[2]	1.00[1]	1.44	195
347	1.11	1.59	197
569	1.42	1.98[1]	204
1564	2.34	3.04	220

1 - Point at which minimum hydraulic criterion is met.
2 - Maintenance flow for this transect.

CONCLUSIONS

The primary objectives of this study were to 1) identify potential impacts to adult Snake River cutthroat trout over a range of flows during the winter between Jackson Lake dam and the mouth of Pacific Creek and 2) develop an instream flow recommendation which would maintain or improve physical habitat for this fishery. A PHABSIM model and Habitat Retention method were used to obtain this information. Studies were conducted at a representative portion of the stream segment immediately below the dam.

Results from the PHABSIM model indicated that the amount of physical habitat for adult trout during the winter changes

relatively little over a range of flows from about 300 cfs to 650 cfs. The change in percent of maximum weighted usable area is about 10 percent over this range (Figure 2). The relatively "flat" shape of the curve is indicative of the fact that most of the physical habitat in the river is found in deep pools and that velocities and depths change relatively little over this range of flows. At flows less than 300 cfs, the amount of usable area in pools (primarily associated with areas of preferred depth) begins to decline fairly rapidly. Decreases in physical habitat at flows above 400 cfs are a result of increased velocities in the river.

The PHABSIM model provides information regarding only the amount of physical habitat for the target species in the study area. It does not accurately assess impacts to habitats or organisms (riffles, aquatic macroinvertebrates) outside of the study area. These impacts are more appropriately addressed by the Habitat Retention method. Results from this method indicate that impacts to aquatic insect production and trout passage will result at flows less than 280 cfs.

Though not directly shown by either of these models, flows that are significantly less than 280 cfs cause waters to recede at an increasingly rapid rate from the oxbow below the dam and from side channels further downstream (Jon Erickson, personal communication). As these areas dry up, habitat for all aquatic organisms is lost.

The Snake River fishery is an extremely important resource to both the state and local community. Because of this status, water management strategies which maximize this resource should be pursued. As the PHABSIM data indicate, the winter release which provides the maximum amount of physical habitat is 400 cfs.

This discharge approximates the natural inflow to the reservoir during normal water years according to gage records. As a result, a continuous release of this amount would normally have little impact on storage volumes in the reservoir. During low water years, however, a release of this magnitude could lower storage levels considerably over the entire winter period. Depending on the extent of this reduction, impacts could occur to lake trout recruitment in the reservoir by dewatering areas where these fish have deposited eggs in early winter.

To minimize this potential impact while still providing protection to the river fishery, releases should be made which are equal to 400 cfs or the natural inflow whichever is less. However, at flows less than 280 cfs, potential impacts to trout and aquatic insect survival are significantly greater. Therefore, we recommend that releases not fall to less than 280 cfs at any time between October 1 and March 31.

Excessive flows in the river also result in a reduction of physical habitat for adult trout. Reductions are gradual at

increasingly greater flows in the study area; however, and exceed 10 percent at flows greater than 650 cfs. Although a reliable method does not presently exist to relate reduction in physical habitat with a precise loss of fish, these physical habitat losses are a real concern. Releases greater than 650 cfs should be coordinated with the Game and Fish Department, the Bureau of Reclamation and other interested parties. Table 5 contains a summary of instream flow recommendations for the Snake River between the dam and the mouth of Pacific Creek.

Table 5. Summary of instream flow recommendations for the Snake River between Pacific Creek and Jackson Lake dam for the period of October 1 to March 31.

Preferred flow[1]	400 cfs
Maintenance flow	280 cfs
Maximum flow	650 cfs

1 - Or the natural inflow to the reservoir, whichever is less but not less than 280 cfs.

These recommendations apply only to that portion of the river between the dam and the mouth of Pacific Creek. More comprehensive studies, if and when they are conducted, may in the future reveal that a different release schedule would better serve the entire river fishery between Jackson Lake and Palisades Reservoir. Until this time, implementation of the above recommendations will provide the maximum amount of physical habitat for Snake River cutthroat trout in the most seriously impacted portion of the river. It will at the same time maintain approximate historical flow patterns in further downstream segments of the river and protect the lake trout fishery in Jackson Lake.

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