

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on Porcupine Creek., a Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*) Stream.

PROJECT: IF-4094-07-9403

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ABSTRACT

Instream flow studies were initiated in 1994 on Porcupine Creek to determine instream flows needed to maintain or improve Bonneville cutthroat trout (BRC) populations. Studies were designed to complement ongoing monitoring of BRC index streams (Remmick et al. 1994).

Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and the Habitat Retention Method were used to derive instream flow recommendations. Recommendations are: October 1 - April 30 = 1.5 cfs, May 1 - June 30 = 7.5 cfs, and July 1 - September 30 = 2.6 cfs.

INTRODUCTION

Bonneville cutthroat trout (*Oncorhynchus clarki utah*) populations in Wyoming are restricted to tributaries of the Bear River - primarily the Thomas Fork and Smiths Fork watersheds. Physical, chemical, and biological characteristics of the Bear River drainage were inventoried between 1966 and 1977 (Miller 1977). Binns (1981) reviewed the distribution, genetic purity, and habitat conditions associated with populations of Bonneville cutthroat trout. Results of more recent population and habitat surveys are presented in Remmick (1981, 1987) and Remmick et al. (1994). In general, populations are limited by seasonally low flows, lack of riparian cover, thermal pollution arising in conjunction with low flows and reduced riparian vegetation, and silt pollution.

The Bonneville Cutthroat trout was recently petitioned for listing under the Endangered Species Act but is not listed at this time. Status review was initiated in response to concerns expressed by the Idaho Fish and Game Department, the Desert Fishes Council and the Utah Wilderness Association.

A 5-year management plan for Wyoming, developed by the Wyoming Game and Fish Department (WGFD) in coordination with the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM), outlines management goals and provides criteria for listing Bonneville cutthroat trout as threatened (Remmick et al. 1994). The plan's purpose is to outline management practices to prevent listing by moving toward wider distributions and higher populations. The plan recommends that status decisions be made after a five-year population and habitat monitoring period.

Fish management and other land management practices could be significantly affected by potential listing of Bonneville cutthroat trout as Threatened or Endangered. Identification and acquisition of instream flow water rights is a critical element identified in the management plan to avoid listing on all streams containing Bonneville cutthroat trout.

One objective outlined in the management plan is to "describe existing habitat conditions, establish habitat condition objectives, and determine the impacts of past, present or proposed land management activities for all index streams by 1997." Index streams include a range of stream types for which significant habitat information and data on Bonneville cutthroat trout populations exists. Consistent with this objective, the Instream Flow Crew initiated studies in 1993 on the following index streams: Huff Creek, Coal (Howland) Creek, and Hobble Creek. In 1994, studies were completed on Porcupine Creek, Smiths Fork River, and Raymond Creek. This report details the results of studies on Porcupine Creek.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Bonneville cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Bonneville cutthroat trout populations.

## METHODS

### Study Area

Porcupine Creek is a tributary to the Smiths Fork River (Figure 1). The headwaters flow south through mixed conifers (*Abies lasiocarpa*, *Pinus contorta latifolia*, and *Picea engelmannii*) and the stream curves west at lower elevations where riparian cover decreases and is composed primarily of grasses (*Poa* sp.) and shrubs (*Cornus stolonifera*, *Artemisia tridentata*, and *Prunus virginiana*). Overall stream gradient is 1.8% and the channel type was rated as B4 (Rosgen 1985). This rating indicates a deeply entrenched channel that is well confined by its valley and has bed material composed of very coarse gravel, cobble, mixed sand and fine material. The watershed is grazed yearly and is under management of the BLM at lower elevations and the Forest Service at higher elevations. Beaver are active in the drainage.

### Fisheries

Bonneville cutthroat trout populations in Porcupine Creek were assigned an "A" purity rating by Dr. Robert Behnke (Remmick et al. 1994). This rating indicates an essentially pure population. Population estimates in 1994 indicate an average of 931 trout/mile (ave. length = 4.5, range = 2.3-7.8 in.).

Though site-specific data for Porcupine Creek are limited, studies by Remmick (WGFD, pers. comm.) and other WGFD biologists indicate cutthroat trout exhibit fairly dynamic changes in population density in response to annual discharge fluctuations. Management theory is based on the phenomenon that fish populations in small streams are dependent on strong year classes produced in good flow years which occur every three to five years. Without benefit of periodic flows, populations in some streams would decline or disappear.

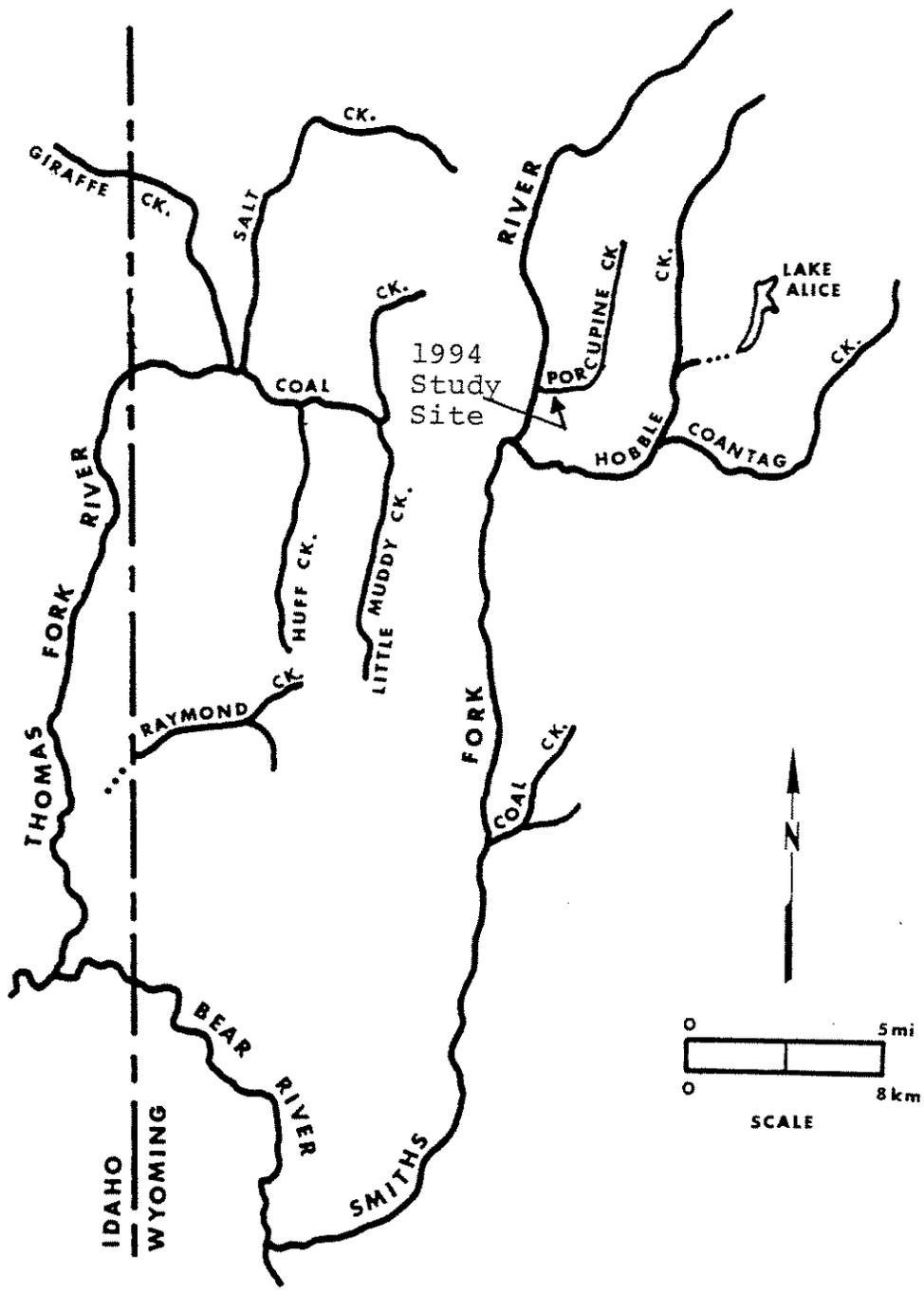


Figure 1. The Smiths Fork and Thomas Fork drainages.

## Habitat Modeling

After visually surveying approximately 1 mile of stream, a study site was located approximately 500 feet upstream from Porcupine Creek's confluence with the Smiths Fork River in Township 28N, Range 118W, Section 27 (Figure 1). This site was chosen because it is representative of habitat attributes in lower Porcupine Creek. Trout cover is associated mostly with pools and additional cover is provided by undercut banks and woody debris. Ten transects were distributed among pool, run, and riffle habitat types and an additional transect was established directly over a redd (trout egg nest) to evaluate physical habitat for spawning at a verified spawning site (Appendix 1).

Data were collected between May 26 and September 13, 1994. Collection dates and corresponding discharges are listed in Table 1. Instream flow filing recommendations derived from this site were applied to an approximately 1.5 mile-long reach extending downstream from the point Porcupine Creek crosses the boundary between sections 23 and 26 (T28N, R118W) to the confluence with the Smiths Fork River (T28N, R118W, S27, NW1/4). The land through which the proposed segment passes is under Bureau of Land Management and Forest Service administration.

Table 1. Dates and discharges at which instream flow data were collected from Porcupine Creek in 1994.

Date	Discharge (cfs)
May 26	5.7
June 20	3.9
September 13	1.7

Critical Bonneville cutthroat trout life stages in Porcupine Creek and time periods of importance are identified in Table 2. Critical life stages are those life stages most sensitive to environmental fluctuations. Population integrity is sustained by providing adequate flow for critical life stages. In many cases, Rocky Mountain stream populations are constrained by spawning and young (fry and juvenile) life stage habitat bottlenecks (Nehring and Anderson 1993). On Porcupine Creek, observations indicate that spawning habitat is likely a critical factor influencing trout populations.

Table 2. Methods used to determine instream flow recommendations at different times of year based on various life stages of Bonneville cutthroat trout.

LIFE STAGE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ADULT							1	1	1			
SPAWNING					2	2						
ALL	3	3	3	3						3	3	3

- 1 - Habitat Quality Index
- 2 - PHABSIM
- 3 - Habitat Retention

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from three riffle transects. A maintenance flow is defined as the continuous flow required to maintain minimum hydraulic criteria in riffle areas of a stream. Year-round maintenance of these criteria ensures passage between habitat types for all trout life stages. In addition, the criteria ensure adequate survival of benthic invertebrates. A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

Category	Criteria
Mean Depth (ft)	Top width <sup>a</sup> X 0.01
Mean Velocity (ft/s)	1.00
Wetted Perimeter (percent) <sup>b</sup>	50

a - At average daily flow. Minimum depth = 0.20.

b - Percent of bank full wetted perimeter

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for assessment of trout standing stock gains or losses associated with changes in instream flow regimes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HUs), where one HU is defined as the amount of habitat quality that will support 1 pound of trout. HQI results were used to identify the minimum flow needed to maintain or improve existing levels of Bonneville cutthroat trout production between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of mean late summer flow conditions. Under this assumption, HU estimates can be extrapolated through a range of potential late summer flows (Conder and Annear 1987). Porcupine Creek habitat attributes were measured on the same dates that PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout production at discharges other than those measured. The estimate of average daily flow (ADF; 4.6 cfs) is from Binns (1981) and is based on basin area and ADF at Smiths Fork gage #10032000. A maximum temperature of 74° F was determined with a max-min thermometer placed in Porcupine Creek between June 20 and September 13, 1994. An average peak flow for simulation of ASFV (34 cfs) was calculated by multiplying the peak/minimum flow ratio at Smiths Fork gage #10032000 (20.2) by the observed Porcupine Creek minimum flow of 1.7 cfs.

A Physical Habitat Simulation (PHABSIM) model was used to quantify physical habitat (depth and velocity) available over a range of discharges. This methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is the most widely used method for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

Depth, velocity, and substrate were measured along the above transects according to techniques outlined in Bovee and Milhous (1978). Measurements were taken on the dates listed in Table 1. Hydraulic calibration techniques and modeling options outlined in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.2 and 15.0 cfs. Precision declines outside this range; however, the modeled range easily accommodates the range of typical Porcupine Creek flows.

The PHABSIM model uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive an estimate of weighted usable area (WUA) at various flows. Suitability curves for spawning Bonneville cutthroat trout were developed from data collected in 1994 from Huff Creek (Appendix 2).

According to estimates by Binns (1981), spawning in Porcupine Creek (elevation 7100-7500 feet) peaks between May 12 and June 10. In 1994, redds were observed on May 26 and spawning appeared to be complete since no actively spawning trout were observed. Because the onset and duration of spawning varies between years due to differences in flow quantity and water temperature, the period for which spawning recommendations are applied should extend from May 1 to June 30. Even if spawning is completed by June 1, maintaining flows at a selected level throughout June will benefit incubation of deposited trout eggs. The PHABSIM model was used to obtain flow recommendations for spawning Bonneville cutthroat trout from May 1 to June 30 (Table 2).

## RESULTS AND DISCUSSION

### Habitat Retention Analysis

Habitat retention results indicate that a flow of 1.5 cfs is required to maintain hydraulic criteria at all riffles to provide passage for all life stages of trout between habitats (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year. Higher flows are often needed during May through September to support critical life stages (Table 2).

Table 4. Simulated hydraulic criteria for three riffles on Porcupine Creek. Average daily flow = 4.6 cfs. Bank full discharge = 30 cfs.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	0.65	4.28	11.6	30.0
	0.43	1.90	11.6	8.5
	0.36	1.39	10.8	5.1
	0.34	1.31	10.7	4.6
	0.31	1.12	10.6	3.5
	0.29	1.00 <sup>1</sup>	10.5	2.9
	0.25	0.84	10.4	2.1
	0.20 <sup>1</sup>	0.66	10.2	1.3 <sup>2</sup>
	0.18	0.58	10.1	1.0
	<.10	<.31	<6.4 <sup>1</sup>	<.2
Riffle 2	0.69	3.70	12.4	30.0
	0.55	2.60	11.0	15.0
	0.45	1.89	9.7	8.0
	0.38	1.44	8.7	4.6
	0.35	1.25	8.3	3.5
	0.29	1.00 <sup>1</sup>	7.7	2.2
	0.28	0.93	7.4	1.9
	0.30	0.83	6.2 <sup>1</sup>	1.5 <sup>2</sup>
	0.27	0.70	6.0	1.1
	0.20 <sup>1</sup>	0.46	5.5	0.5
Riffle 3	0.64	3.74	12.8	30.0
	0.52	2.61	11.2	15.0
	0.43	1.89	10.0	8.0
	0.36	1.42	9.1	4.6
	0.34	1.23	8.6	3.5
	0.29	0.99 <sup>1</sup>	8.3	2.3
	0.26	0.90	8.1	1.9
	0.20 <sup>1</sup>	0.70	7.8	1.1 <sup>2</sup>
	0.16	0.58	7.5	0.7
	0.13	0.47	6.4 <sup>1</sup>	0.4

1 - Minimum hydraulic criteria met

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

Based on habitat retention results, an instream flow equal to the lesser of 1.5 cfs or the natural discharge is recommended for the October 1 to April 30 time period. Such a recommendation will maintain the existing fishery because it maintains existing natural flow patterns up to the identified maintenance level. Higher flows during this time period may enhance the fishery although development of storage solely for fishery management is not practical or in the best interest of the State.

### Habitat Unit Analysis

The measured late summer stream flow of 1.7 cfs likely represents an absolute minimum late summer flow because 1994 flows in the Smiths Fork drainage during July through September were near historic lows (Appendix 3). Discharge at Smiths Fork gage #10032000 for the three month period was only 40% of the 20 year average flow for that period. Therefore, a better estimate of long-term average late-summer flow in Porcupine Creek is likely higher than 1.7 cfs. Porcupine Creek exhibits characteristics of a spring stream implying that year-to-year base flow levels are only moderately influenced by runoff. Consequently, average late summer flow is likely not considerably greater than the measured 1.7 cfs. A conservative estimate of a minimum instream flow that maintains or improves the fishery would be higher than 1.7 cfs.

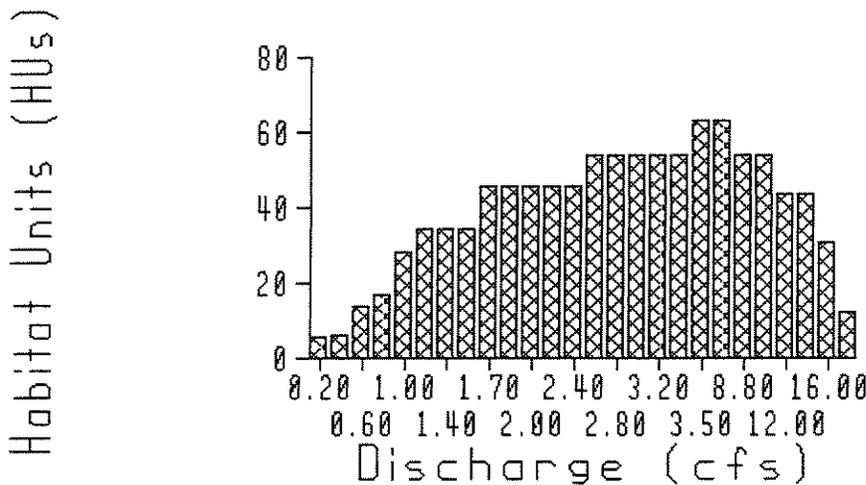


Figure 2. Trout habitat units at several late summer flow levels in Porcupine Creek. Discharges on the x-axis are not to scale.

The HQI analysis indicates that at average late summer flows between 1.7 and 2.5 cfs, Porcupine Creek supports approximately 46 trout HUs (Figure 2). Habitat Units are greater in years when average late summer discharge is between 2.6 and 3.4 cfs and maximized at an average late summer discharge between 3.5 and 8.7 cfs.

Maintenance of late summer flows of 2.6 cfs would improve trout habitat by 8 HUs over existing conditions (assuming late summer flow approximates 1.7 cfs). In light of the 5-year Management Plans' emphasis on increasing Bonneville cutthroat trout populations in areas where they are low (Remmick et al. 1994) and the dynamic nature of this species' populations in small streams, instream flow recommendations

should allow populations of Bonneville cutthroat trout to take advantage of favorable flow conditions whenever they are naturally available. This strategy is appropriate considering the species' Category II status and represents a legitimate effort to avoid listing of the species under the Threatened and Endangered Species Act.

Based on the results of the HQI analysis and in consideration of the goals of the Bonneville cutthroat trout Management Plan (Remmick et al. 1994), an instream flow equal to the lessor of natural discharge or 2.6 cfs is recommended to maintain or improve existing levels of trout production between July 1 and September 30. This flow represents the minimum stream flow that will accomplish this objective. Though naturally available less often than 1.7 cfs, a flow of 2.6 cfs would allow beneficial use of water in years when it is available. Management strategy is to take advantage of natural flow conditions when available and storage solely for instream flow purposes is likely not in the best interest of the State.

#### PHABSIM Analyses

Weighted usable area estimates for spawning Bonneville cutthroat trout are illustrated in Figure 3. PHABSIM analysis indicates that a flow of 7.5 cfs maximizes physical area for spawning. Spring flows are probably equal to or greater than 7.5 cfs and hence spawning physical habitat would be maintained or improved by a flow of 7.5 cfs. Therefore, an instream flow of 7.5 cfs is recommended for the period May 1 to June 30.

#### Anticipated Effects of Recommended Flows

The recommended instream flow of 1.5 cfs during the winter period (October 1 to April 30) would maintain trout survival at current levels. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival. Fish populations are influenced primarily through the effects of frazile ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These causes of winter mortality are all influenced by winter flows. Higher flows minimize temperature changes and subsequent trout mortality. They also increase areas in a stream where trout can escape frazile ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

The 1.5 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns, occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter streamflows, up to 1.5 cfs, to maintain existing survival rates of trout populations.

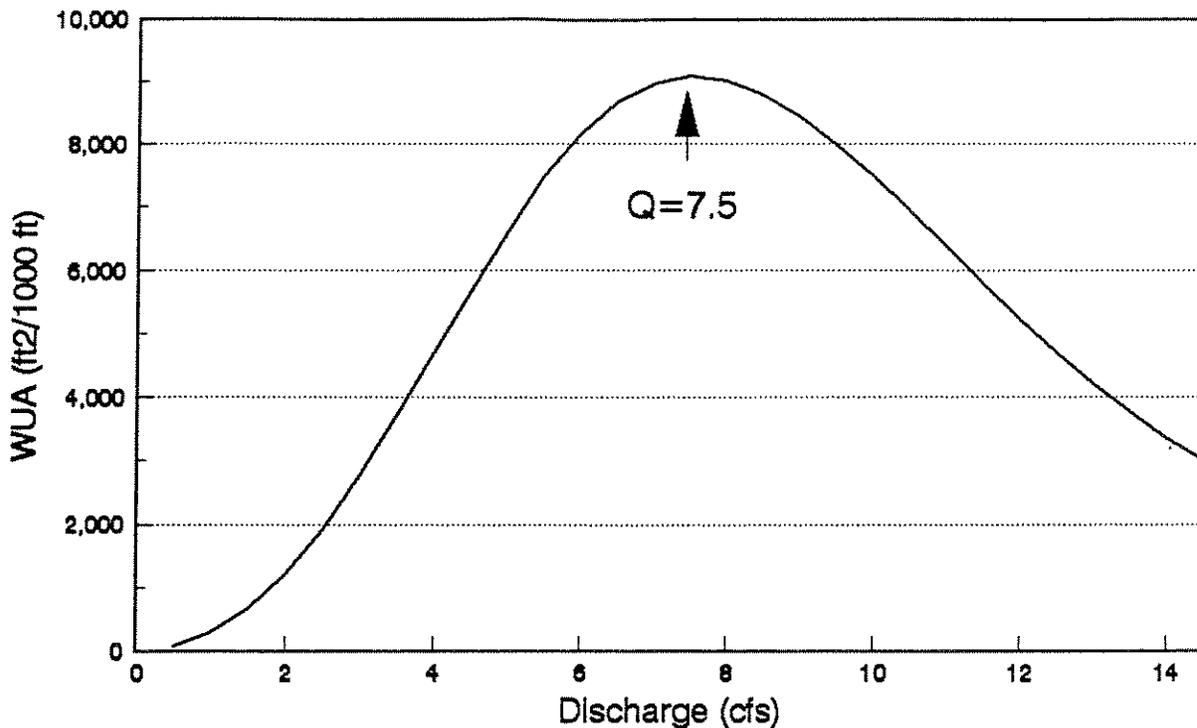


Figure 3. Spawning Weighted Usable Area (WUA) for Bonneville cutthroat trout over a range of discharges on Porcupine Creek.

#### INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain or improve the existing Porcupine Creek Bonneville cutthroat trout fishery. These recommendations apply to an approximately 1.5 mile segment of Porcupine Creek extending downstream from the point Porcupine Creek crosses the boundary between sections 23 and 26 (T28N, R118W) to the confluence with the Smiths Fork River (T28N, R118W, S27, NW1/4). Because data were collected from representative habitats and simulated over a wide range of flow levels, collection of additional data under different flow conditions would not significantly change these recommendations.

Table 5. Summary of instream flow recommendations to maintain or improve the existing trout fishery in Porcupine Creek.

Time Period	Instream Flow Recommendation (cfs)
May 1 to June 30	7.5
July 1 to September 30	2.6
October 1 to April 30	1.5 <sup>1</sup>

1 - To maintain existing natural stream flows

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If the stream is regulated in the future, additional studies and recommendations may be appropriate for establishing flow requirements for channel maintenance.

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Appendix 1. Reach weighting used for PHABSIM analysis.

STAIID	LENGTH	WEIGHT	PERCENT	HABITAT TYPE
0.00	3.25	1.00	3.85	RIFFLE
6.50	8.25	1.00	9.76	POOL
16.50	10.25	1.00	12.13	POOL
27.00	9.50	1.00	11.24	RIFFLE/RUN
35.50	7.00	1.00	8.28	RIFFLE
41.00	7.00	1.00	8.28	RUN/POOL
49.50	10.55	1.00	12.49	POOL
60.00	8.85	1.00	10.47	RUN
75.50	18.95	1.00	22.43	RIFFLE
84.50	0.90	1.00	1.07	RIFFLE
0.00	1.00	1.00	NA	Spawning Riffle

Appendix 2. Suitability index data used for PHABSIM analysis.  
 Spawning index data were developed by WGFD from 1994  
 observations in Huff Creek.

	VELOCITY	WEIGHT	DEPTH	WEIGHT	SUBSTRATE	WEIGHT
SPAWNING	0.00	0.00	0.00	0.00	0.00	0.00
	0.10	0.00	0.10	0.03	4.10	0.00
	0.20	0.01	0.15	0.08	4.20	1.00
	0.32	0.02	0.20	0.15	5.60	1.00
	0.45	0.03	0.25	0.30	5.70	0.00
	0.60	0.06	0.30	0.51	100.00	0.00
	0.76	0.11	0.35	0.70		
	0.91	0.19	0.40	0.90		
	1.01	0.25	0.45	1.00		
	1.10	0.32	0.50	1.00		
	1.22	0.44	0.55	0.82		
	1.32	0.54	0.60	0.64		
	1.41	0.64	0.65	0.41		
	1.50	0.74	0.70	0.23		
	1.60	0.83	0.75	0.12		
	1.72	0.93	0.80	0.05		
	1.81	0.98	1.00	0.01		
	1.91	1.00	1.50	0.00		
	1.97	1.00	100.00	0.00		
	2.09	0.96				
	2.19	0.91				
	2.31	0.80				
	2.41	0.71				
	2.50	0.60				
	2.62	0.47				
	2.72	0.38				
	3.20	0.00				
	100.00	0.00				

Appendix 3

Station #10032000 Smiths Fork near Border, WY

Discharge, Cubic Feet per Second

Daily Mean Values

WATER YEAR	JUL TOTAL	AUG TOTAL	SEP TOTAL	TOTAL JUL-SEP	ANNUAL TOTAL
1963	7743	4553	3262	15558	60870
1964	10232	4795	3100	18127	75382
1965	16525	6761	4477	27763	96025
1966	4817	3193	2665	10675	52958
1967	13043	5991	3747	22781	79268
1968	8486	4889	3359	16734	60690
1969	6659	4036	2998	13693	70952
1970	9036	4717	3347	17100	65596
1971	17160	7330	4530	29020	113858
1972	12553	6487	4177	23217	103980
1973	6550	3939	3082	13571	57713
1974	9596	5386	3316	18298	83343
1975	18654	6830	4124	29608	79707
1976	9978	5381	3410	18769	80803
1977	1903	1708	1562	5173	25956
1978	15005	6234	4107	25346	90025
1979	6689	3877	2637	13203	58331
1980	9728	5125	3434	18287	78976
1981	4665	3074	2166	9905	42865
1982	15268	6801	4754	26823	99070
1983	17402	7494	4642	29538	103973
1984	14192	7028	4562	25782	100691
1985	5954	4279	3427	13660	64001
1986	15580	6223	4978	26781	118171
1987	4164	3457	2441	10062	46016
1988	4603	2956	2372	9931	46437
1989	6589	3806	2916	13311	58537
1990	5188	3517	2399	11104	47635
1991	6779	4028	3013	13820	55431
1992	3480	2523	2053	8056	39684
1993	10661	5410	3490	19561	79291
AVERAGE (1973-1993) ----->				17912	72137
**1994	2831	2255	2094	7180	38166

\*\* Please note: All 1994 values are provisional.

Data Sources:

1963-1989 USGS ADAPS  
 1990-1993 USGS "Water Resources Data Reports"  
 1994 USGS Utah Office (personal comm.)

Exceptions:

1972 USGS "Water Resources Data Report"  
 (September and Annual only)

