FISH DIVISION

ADMINISTRATIVE REPORT

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

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ABSTRACT

Instream flow studies were initiated in 1994 on Raymond 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).

The Habitat Quality Index (HQI) and the Habitat Retention Method were used to derive flow recommendations. Recommendations are: October 1 - June 30 = 1.4 cfs and July 1 - September 30 = 1.9 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 Raymond Creek, Smiths Fork River, and Porcupine Creek. This report details the results of studies on Raymond 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

Raymond Creek, in the Thomas Fork watershed, originates from two forks in the Sublette Range of southwest Wyoming. The creek flows west through a narrow canyon with steep, rocky hillsides and becomes intermittent at low elevation due to the effects of irrigation withdrawal (Figure 1). Stream gradient is steep (6.4%) and the channel type was rated A-3 (Rosgen 1985). This rating indicates a deeply entrenched channel that is very well confined by its valley and has bed material composed of sand, gravel, cobble, and boulder. Riparian vegetation is generally well developed and consists primarily of deciduous shrubs. Cattle are trailed through the canyon and the upper watershed is grazed yearly and is under management of the BLM. Beaver are active in the drainage.

Soils in the upper drainage are poorly consolidated and subject to erosion. Grazing impacts exacerbate the inherent erodability of the soils with the result that extreme episodes of channel downcutting occur in the upper basin (Vern Phinney, BLM, pers. comm.). Silt and fine shale are then deposited downstream in the canyon section, reducing habitat by filling beaver ponds and pools.

Fisheries

Bonneville cutthroat trout populations in Raymond Creek were assigned an "A" purity rating by Dr. Robert Behnke (Remmick et al. 1994). This indicates an essentially pure population. The original brood stock for Wyoming's Bonneville Cutthroat trout culture efforts were collected from Raymond Creek. Population estimates in 1994 indicate an average of 269 trout/mile (ave. length = 6.0, range = 2.0-10.5 in.). Population estimates in 1987 indicated an average of 380 trout/mile.

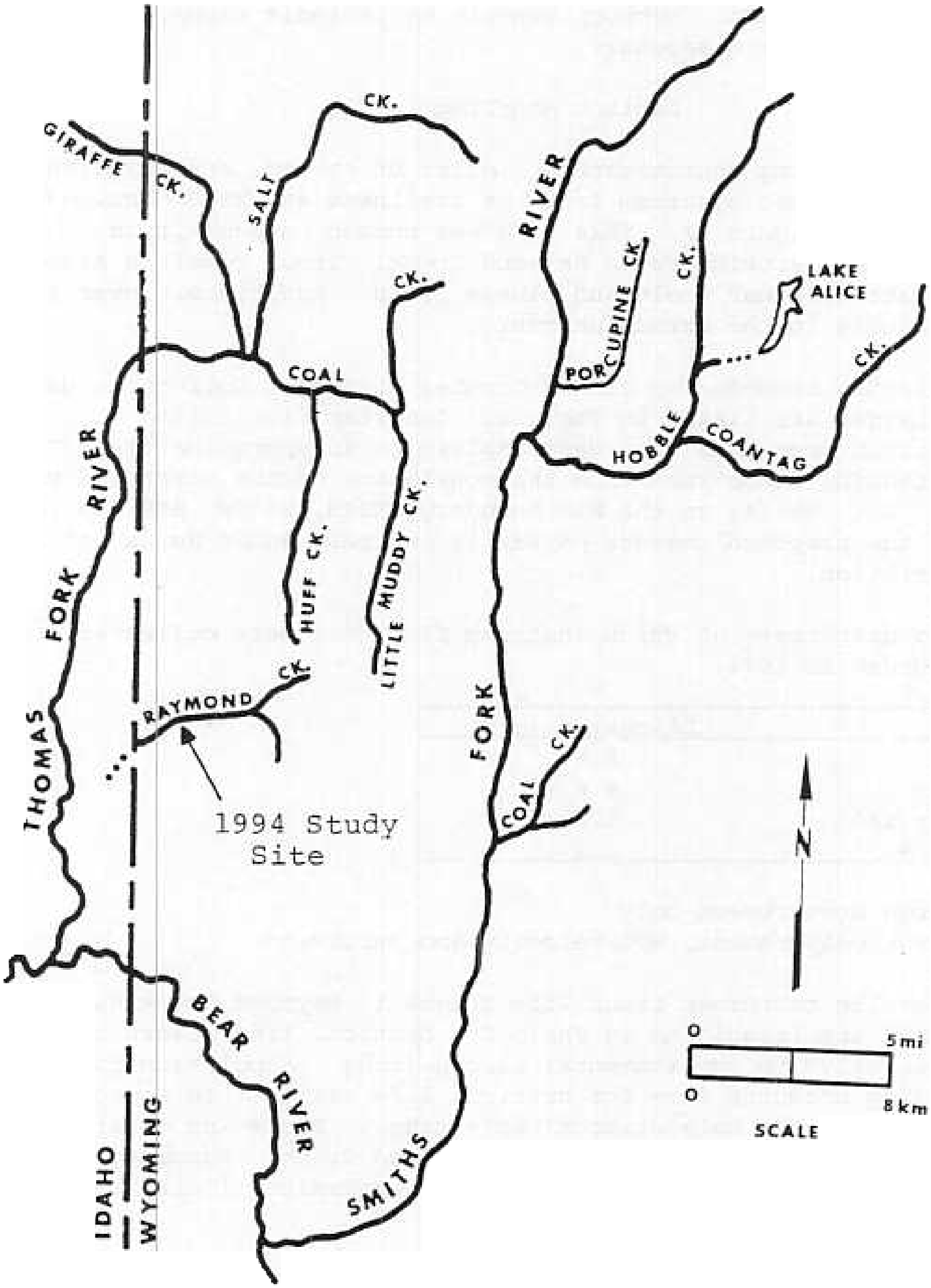

Figure 1. The Smiths Fork and Thomas Fork drainages.

Though site-specific data for Raymond Creek do not exist, 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.

Habitat Modeling

After visually surveying approximately 2 miles of stream, a study site was located approximately 50 feet upstream from the trailhead at the BLM boundary in T26N, R119W, S06, NE1/4 (Figure 1). This site was chosen because it is representative of habitat attributes in Raymond Creek. Trout cover is associated mostly with small lateral scour pools and plunge pools. Additional cover is provided by woody debris in the stream channel.

Data were collected between May 12 and October 3, 1994. Collection dates and corresponding discharges are listed in Table 1. Instream flow filing recommendations derived from this site were applied to an approximately 1.7 mile-long reach extending downstream from the confluence of the north and south forks (T26N, R119W, S04, NW1/4) to the BLM boundary (T26N, R119W, S06, NE1/4). The land through which the proposed segment passes is entirely under Bureau of Land Management administration.

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

Date	Discharge (cfs)
May 12	5.6
June 22	4.6
September 14[1]	1.8
October 3[2]	2.3

[1] discharge measurement only

[2] discharge measurement, HQI velocity and substrate.

Critical Bonneville cutthroat trout life stages in Raymond 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 Raymond Creek, adults were identified as the sole critical life stage. Pools and other deep, slow water habitat types are relatively uncommon in Raymond Creek. Assuming adequate recruitment is occurring (see below) these habitat constraints limit the potential size and number of adult BRC's.

In many cases, Rocky Mountain stream populations are constrained by spawning and young (fry and juvenile) life stage habitat bottlenecks (Nehring and Anderson 1993). However, Raymond Creek population sampling indicated that all life stages were well represented. In addition, significant spawning areas are not evident in Raymond Creek. Rather, spawning likely occurs in small, isolated patches throughout the basin. For instance, small (2-6 inch diameter) patches of habitat with the appropriate substrate were observed below plunge pools. Modeling changes in quantity of such small habitats in response to various flows is problematic. For these reasons, the spawning life stage was not selected as a critical life stage. It was assumed that flows appropriate for adults would be adequate for other life stages.

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			
ALL	2	2	2	2	2	2				2	2	2

1 - Habitat Quality Index
2 - 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[a] X 0.01
Mean Velocity (ft/s)	1.00
Wetted Perimeter (percent)[b]	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 existing levels of Bonneville cutthroat trout production between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes are measured at various flow events as if they are typical of mean late summer flow conditions. Under this approach, HU estimates can be extrapolated through a range of potential late summer flows (Conder and Annear 1987). Raymond Creek habitat attributes were measured on the same dates that PHABSIM data were collected (Table 1). A maximum temperature of 56° F was observed by Binns (1981). 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;3.3 cfs) is from the equation $Q_a=0.06 * (W)^{1.9}$ where Q_a is mean annual flow and W is channel width (8.3 ft; Lowman 1976).

RESULTS AND DISCUSSION

Habitat Retention Analysis

Habitat retention results indicate that a flow of 1.4 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 July through September to support critical life stages (Table 2).

Based on habitat retention results, an instream flow equal to the lessor of 1.4 cfs or the natural discharge is recommended for the October 1 to June 30 time period. Such a recommendation will maintain the current existing fishery because it maintains existing natural flow patterns up to the identified maintenance level. Higher flows during this time may enhance the fishery although development of storage solely for fishery management is not practical or in the best interest of the State.

Table 4. Simulated hydraulic criteria for three riffles on Raymond Creek Average daily flow = 3.3 cfs. Bank full discharge = 21 cfs.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	0.60	2.98	11.6	20.0
	0.43	1.85	10.3	8.0
	0.41	1.51	8.9	5.4
	0.40	1.38	8.6	4.6
	0.35	1.13	8.3	3.2
	0.32	1.01[1]	8.2	2.6
	0.26	0.76	7.8	1.5
	0.20[1]	0.52	7.0	0.7[2]
	0.17	0.45	6.8	0.5
	<.11	<.31	<6.2[1]	<.2
Riffle 2	0.67	2.72	11.6	20.0
	0.48	1.75	10.0	8.0
	0.43	1.44	9.1	5.4
	0.40	1.34	8.9	4.6
	0.34	1.13	8.6	3.2
	0.30	0.99[1]	8.4	2.4
	0.25	0.81	7.6	1.5
	0.23	0.74	7.4	1.2
	0.20[1]	0.66	7.1	0.9[2]
	0.18	0.52	5.7[1]	0.5
Riffle 3	0.43	4.20	11.4	20.0
	0.35	2.46	9.6	8.0
	0.31	1.97	9.2	5.4
	0.29	1.80	9.0	4.6
	0.26	1.48	8.7	3.2
	0.24	1.27	8.3	2.4
	0.20	0.99[1]	7.7	1.5
	0.20[1]	0.96	7.6	1.4[2]
	0.17	0.77	7.2	0.9
	0.16	0.58	5.5[1]	0.5

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

Habitat Unit Analysis

A discharge of 1.8 cfs was measured on September 14, 1994 (Table 1). However, average late summer flow is likely higher because of the drought conditions experienced in 1994 in the region. For example, flows in the nearby Smiths Fork drainage during July through September were near historic lows (Appendix 1). Discharge at Smiths Fork gage #10032000 for the three month period was only 40% of the 20 year average flow for that period. Therefore, average late-summer flow in Raymond Creek is likely slightly higher than 1.8 cfs. Since Raymond Creek has numerous springs sustaining base flow, average late summer flow is probably not reduced as much as observed in the Smiths Fork drainage. Field observations and channel characteristics suggest average late summer flow is probably between 1.9 and 2.8 cfs.

HQI analysis indicates that at average late summer flow conditions Raymond Creek supports approximately 102 trout HUs (Figure 2). This number of HUs is maintained at a range of average late summer flows between 1.9 and 2.8 cfs. Habitat Units are less in years when average late summer discharge is less than 1.9 cfs and maximized at an average late summer discharge between 2.9 and 9.0 cfs.

Maintenance of late summer flows of 1.9 cfs would maintain present trout habitat. 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.

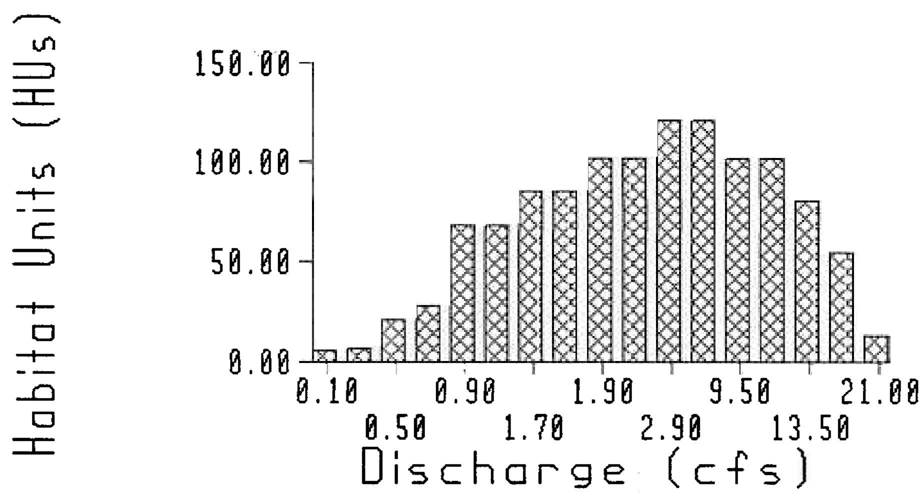

Figure 2. Trout habitat units at several late summer flow levels in Raymond Creek. Discharges on the x-axis are not to scale.

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 1.9 cfs is recommended to maintain existing levels of trout production between July 1 and September 30. This flow represents the minimum stream flow that will accomplish this objective.

Anticipated Effects of Recommended Flows

The recommended late summer flow of 1.9 cfs would maintain BRC populations by providing adequate habitat for adult trout. The recommended instream flow of 1.4 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 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 1.4 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 1.4 cfs, to maintain existing survival rates of trout populations.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain the existing Raymond Creek Bonneville cutthroat trout fishery. These recommendations apply to an approximately 1.7 mile-long reach extending downstream from the confluence of the north and south forks (T26N, R119W, S04, NW1/4) to the BLM boundary (T26N, R119W, S06, NE1/4). 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 the existing trout fishery in Raymond Creek.

Time Period	Instream Flow Recommendation (cfs)
July 1 to September 30	1.9
October 1 to June 30	1.4[1]

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

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)