WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on Roaring Fork, Little Snake River

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AUTHOR: Thomas C. Annear, Patrick Braaten and Paul Dey

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ABSTRACT

Instream flow data were collected in 1995 on the Roaring Fork, Little Snake River to determine flows needed to maintain or improve Colorado River cutthroat trout (CRC) habitat and populations. Studies were designed to complement ongoing management plans by the Wyoming Game and Fish Department (WGFD) and U.S. Forest Service (USFS).

Physical Habitat Simulation (PHABSIM) and Habitat Quality Index (HQI) models were used to develop instream flow recommendations. Recommendations are 1.6 cfs from October 1 to May 14, 4.4 cfs from May 15 to June 30 and 1.6 cfs from July 1 to September 30. These recommendations apply to a 3.2 mile of Roaring Fork extending downstream from the north section line of NE 1/4 of Section 13, Township 13 North, Range 86 North to the west section line of the NW 1/4 Section 22, Township 13 North, Range 86 North.

INTRODUCTION

Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) is the only trout species native to the Green River and Little Snake River drainages in Wyoming. Historically, this species enjoyed relatively wide distribution and abundance in most of the headwater streams of these drainages. However, habitat degradation, hybridization and competition with introduced trout species have led to serious population declines and decreases in geographical distribution. Binns (1977) reviewed the distribution, genetic purity, and habitat conditions for Colorado River cutthroat trout. His report concluded that habitat degradation was a major factor limiting recovery of the species.

In addition to Binns (1977), distribution and abundance of Colorado River cutthroat trout has been described by Oberholtzer (1987, 1990). Colorado River cutthroat trout are presently considered a "rare" species by the Wyoming Game and Fish Department (1977) and "sensitive" by the U.S. Forest Service (USFS) (1985). Management and monitoring responsibilities for populations in the Little Snake River drainage are coordinated by WGFD fisheries personnel in the Green River regional office.

Several strategies and agreements have been developed to guide CRC management and recovery. The WGFD developed the Comprehensive Management and Enhancement Plan for Colorado River Cutthroat Trout in Wyoming (1987) that outlines specific actions for increasing the range, habitat and numbers of the species. Obtaining adequate instream flows is one of the actions identified for addressing habitat needs. In 1987, the WGFD and U.S. Forest Service signed a memorandum of understanding that committed each agency to "protecting, maintaining, improving and managing Colorado River cutthroat trout populations" in ways that lead toward enhanced biological status. In 1994, the WGFD, USFS and Bureau of Land Management signed a cooperative agreement entitled "Conservation Plan for Colorado River Cutthroat Trout (*Oncorhynchus clarki pleuriticus*) for the Little Snake River Drainage, In Southeastern Wyoming". Pursuing opportunities to secure adequate instream flows is one of the tasks identified in that document. Habitat protection by acquiring instream flow water rights is consistent with the goals and objectives of each of these documents.

Fishery and other resource management practices could be significantly affected if actions are not taken to prevent listing Colorado River cutthroat trout as Threatened or Endangered. Acquiring adequate instream flow water rights on CRC streams is an important step to help avoid listing. In this regard, the WGFD has developed a management strategy of filing instream flow water rights on streams with populations or potential habitat for Colorado River cutthroat trout within their historic range. Studies in 1995 focused on Mill, North Fork Big Sandstone, Big Sandstone and East Fork Deep Creeks in addition to Roaring Fork Little Snake.

The specific objectives of this study were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Colorado River cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Colorado River cutthroat trout populations.

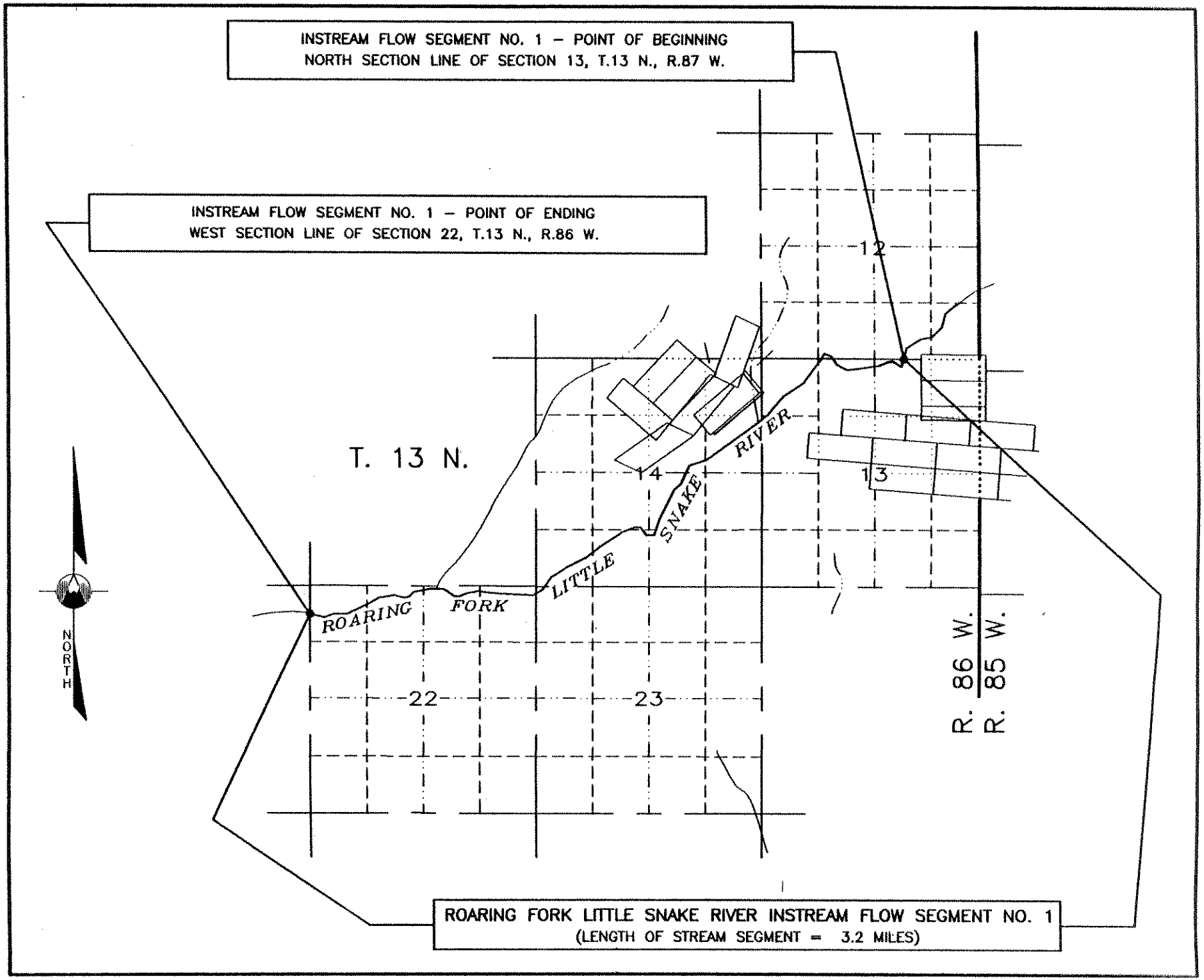
METHODS

Study Area

Roaring Fork is a tributary to the Little Snake River (Figure 1). The entire length of the instream flow segment is administered by the USFS and the majority of lands within the drainage basin are publicly owned. Mixed aspen and conifers predominate uplands throughout the reach. Willows and conifers are common in the riparian zone and beaver activity is evident in the drainage. Overall stream gradient is relatively steep (>3.5 %) and substrate is predominantly large cobble and boulder elements with occasional gravel patches in slower velocity areas. Very little fine sediment was observed in the channel. These characteristics are consistent with an A2 channel type as described by Rosgen (1985).

Fisheries

Observations by fisheries managers in Wyoming and other western states indicate that trout populations in small mountain streams typically fluctuate widely among consecutive years. In a western Oregon stream studied for 11 years, the density of age-0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m^2 and density of age-1 cutthroat trout (juveniles, 4-4.5 inches) ranged from 16 to 34 per


INSTREAM FLOW SEGMENT NO. 1 – POINT OF BEGINNING
NORTH SECTION LINE OF SECTION 13, T.13 N., R.87 W.
INSTREAM FLOW SEGMENT NO. 1 – POINT OF ENDING
WEST SECTION LINE OF SECTION 22, T.13 N., R.86 W.
T. 13 N.
12
13
14
22
23
R. 86 W.
R. 85 W.
ROARING FORK
LITTLE SNAKE RIVER
NORTH
ROARING FORK LITTLE SNAKE RIVER INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 3.2 MILES)

100 m^2 (House 1995). In this example, population fluctuations occurred despite the fact that structural habitat conditions and water quality were not degraded and relatively stable. The author suggested that changes in winter flows between years accounted for part or all of the observed variation in overwinter survival of the different age-classes.

In western Wyoming, Binns (1981) noted significant trout number declines in several Bonneville cutthroat trout streams following drought in 1977. Similar observations have been made by Remmick (1995, WGFD, personal communication) in more recent years. Department records for the Roaring Fork show that CRC populations (fish greater than 6 inches long) at a site within the instream flow segment have ranged from 86 per mile in 1986 to 896 in 1990 to 978 trout per mile in 1992.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without the benefit of periodic favorable flows, populations in some streams would decline or disappear and genetic diversity could be compromised. The WGFD instream flow strategy recognizes the inherent variability of trout populations as shown in Roaring Fork Creek and other streams throughout the state and Western U.S. (House 1995) and thus defines the "existing fishery" as a dynamic feature. This basic concept is incorporated into instream flow strategies developed for recovery of endangered fishes in the Colorado River system where high flows are recommended "when available" and lower flows are recommended during normal and below normal flow periods. Summarily, instream flow recommendations for the Roaring Fork are based on a goal of maintaining the existing dynamic trout population characteristics of a stream segment as affected by naturally variable flow conditions. Per W.S. 41-3-1001 through 41-3-1014, specific flow recommendations are for the lowest flow needed at various times of year to provide this beneficial use of water.

Habitat Modeling

After visually surveying approximately 2.0 stream miles, a study site was located in Range 86 West, Township 13 North, Section 22, NE1/4 at an elevation of about 8800 feet (Figure 1). The representative site had adult and juenile trout cover associated mostly with lateral scour pools and pocket pools caused by mid-channel boulders. Eight transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected between July 6 and August 29, 1995. Collection dates and corresponding discharges are listed in Table 1. Instream flow filing recommendations derived from data collected at this site were applied to a 3.2 mile-long reach extending downstream from the north section line of NE 1/4 of Section 13, Township 13 North, Range 86 North to the west section line of the NW 1/4 Section 22, Township 13 North, Range 86 North.

Table 1. Dates and discharges when instream flow data were collected on Roaring Fork Little Snake River in 1995.

Date	Discharge (cfs)

sensitive life stages and/or times of year. In many cases, habitat for young (fry and/or juvenile) and spawning life stages are significant "bottlenecks" (Nehring and Anderson 1993). As a consequence, the department's general approach to flow quantification includes ensuring adequate flows to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year. (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in Roaring Fork instream flow recommendations. Numbers indicate method used to determine flow requirements.

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

1 - Habitat Quality Index
2 - PHABSIM

Habitat Quality Index

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 trout standing stock gain or loss assessment associated with instream flow regime changes. 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 about 1 pound of trout. HQI results were used to identify the flow needed to maintain or improve existing levels of CRC 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 are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Roaring Fork habitat attributes were measured on the same dates 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. Average daily flow and peak flow estimates are based on elevation and basin area (Lowham 1976).

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability 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 widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (*sensu* Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.6 and 90 cfs. Precision declines outside this range; however, the modeled range accommodates typical Roaring Fork flows.

Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHABSIM modeling process. Suitability curves for adult, juvenile and spawning were developed by WGFD. Criteria for fry were obtained from studies by Bozek and Rahel (1992).

Observations by WGFD field biologists indicate spawning activity in most streams with CRC peaks between late May and mid June. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from May 15 to June 30. Even if spawning is completed prior to June 30, maintaining flows at the recommended level throughout June will benefit trout egg incubation by preventing dewatering.

RESULTS AND DISCUSSION

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. At the measured late summer flow of 1.6 cfs, HQI analysis indicates approximately 49 trout HU's (Figure 2). This level of habitat is maintained between late summer flows of 1.6 and 2.2 cfs. Maintaining higher late summer flows (up to 65 cfs) on a permanent basis would increase trout habitat units. Permanently reduced summer flows (to less than 1.6 cfs) would impact the fishery. Thus, the flow recommendation for the period of July 1 to September 30 is 1.6 cfs.

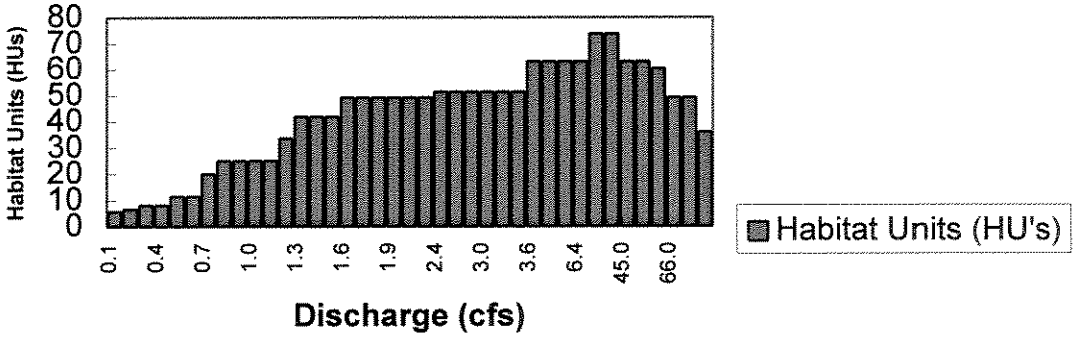


Figure 2. Trout habitat units at several late summer Roaring Fork flow levels. X-axis discharges are not to scale.

Based on HQI analysis and in consideration of the Colorado River cutthroat trout Management Plan's goals (Speas et al. 1994), an instream flow of 1.6 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective. Storage to achieve this flow on a permanent basis solely for instream flow purposes is likely not in the State's best interest.

PHABSIM Analyses

Peak spawning physical habitat occurs at 4.4 cfs (Figure 3). Normal spring flows are much higher - 70 cfs was measured in this study (Table 1). Such high flows might limit spawning activity near the study site or cause migration to more favorable (upstream) reaches. Though trout can usually find someplace to spawn whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 4.4 cfs. Therefore, an instream flow of 4.4 cfs is recommended for the period May 15 to June 30.

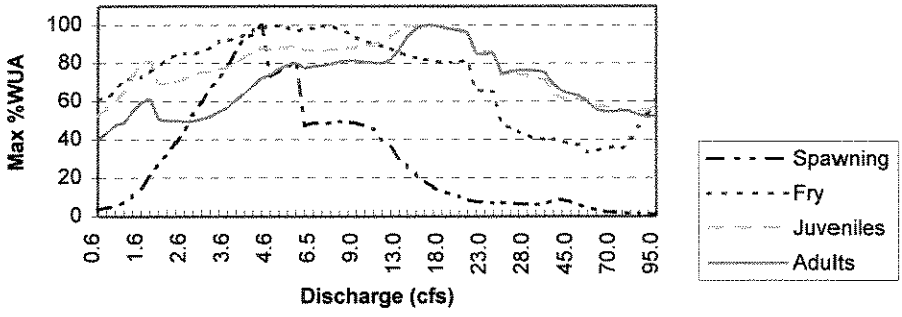


Figure 3. Weighted usable area (percent of maximum) for Colorado River Cutthroat trout life stages in Roaring Fork over a range of discharges.

Weighted usable area estimates for adult and juvenile CRC generally agree with HQI results (Figure 3). Adult and juvenile physical habitat show an initialpeak at about 1.8 cfs. At higher flow levels physical habitat declines somewhat and then increases with increasing flow to a higher peak at flows approximating 12 cfs. Adult WUA decreases rapidly as undercut bank and other habitat decrease at flows less than 1.6 cfs. The recommended late-summer flow of 1.6 cfs (based on the HQI model) will maintain about 80% of maximum adult and juvenile physical habitat. In consideration of this fact, and the fact that the HQI model cannot be used for determining instream flow needs outside the summer period, the flow recommendation from October 1 to May 14 is 1.6 cfs.

If approved, this flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level. 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 frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These mortality causes are all influenced by winter flows. Higher flows generally increase stream areas where trout can escape frazil 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 1.6 cfs recommended flow may not be present at all times of all years during the winter. Because the existing fishery is adapted to natural flow patterns (see above fisheries discussion), 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 stream flows, up to 1.6 cfs, to maintain existing trout survival rates.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 3 will maintain the existing Roaring Fork Colorado River cutthroat trout fishery. These recommendations apply to a 3.2 mile of Roaring Fork extending downstream from the north section line of NE 1/4 of Section 13, Township 13 North, Range 86 North to the west section line of the NW 1/4 Section 22, Township 13 North, Range 86 North. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 3. Instream flow recommendations to maintain or improve the existing Roaring Fork trout fishery.

Time Period	Instream Flow Recommendation (cfs)
May 15 to June 30	4.4
July 1 to September 30	1.6
October 1 to May 14	1.6

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 regulated in the future, additional studies and recommendations would be needed for establishing channel maintenance flow requirements.

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Appendix 1. Description of transects used for PHABSIM Analysis.

Transect	Total Length	Habitat Type
1	6.2	Riffle/Control
2	10.2	Run/Pool
3	4.0	Pool
4	3.7	Dropped from analysis
5	6.4	Run/Pool
6	3.0	Run/Pool
7	6.0	Riffle/Control
8	8.1	Pool