WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Trout Creek Instream Flow Studies

PROJECT: FX-GR-3ES-511

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DATE: November 1999

ABSTRACT

Studies conducted during 1997 determined instream flows necessary for maintaining Colorado River cutthroat trout (CRC) habitat and populations. Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and the Habitat Retention Method were used in developing instream flow water right recommendations of: October 1 - April 15 = 1.5, April 16 - June 30 = 13, and July 1 - September 30 = 2.7 cfs.

INTRODUCTION

Wyoming's instream flow law (W.S.41-3-1001) defines the Wyoming Game and Fish Department's (WGFD) role in identifying instream flow levels necessary to maintain important fisheries. According to the law, unappropriated flowing water "may be appropriated for instream flows to maintain or improve existing fisheries..." (W.S.41-3-1001(b)). WGFD instream flow recommendations must be for specific stream segments and seasons. These recommendations are incorporated into an instream flow water right application and, as provided by statute, may become an instream flow water right held by the state of Wyoming. This process ensures that adequate stream flow is protected when it is available in priority so that important fisheries will persist.

Since the law was passed in 1986 and through 1997, 76 instream flow water right applications have been filed, 7 approved by the state engineer, and 2 formally adjudicated. Initially, efforts focused on WGFD class 1 and 2 waters, which are highly productive and provide popular recreational opportunities. More recently, efforts have shifted toward small headwater streams supporting native cutthroat trout.

Wyoming has historic ranges for Bonneville cutthroat trout (*Oncorhynchus clarki utah,* sometimes locally referred to as "Bear River" cutthroat trout), Colorado River cutthroat trout (*O.clarki pleuriticus*), and Yellowstone cutthroat trout (*O.clarki bouvieri*). A variant of Yellowstone cutthroat trout, the Snake River cutthroat trout, also occurs in the northwest portion of the state. Since the early 1990s, instream flow studies have been done on many stream segments throughout the native range of Bonneville and Colorado River cutthroat trout. This report includes results and recommendations from studies on Trout Creek, a Colorado River cutthroat trout stream.

The historic distribution and conservation status of Colorado River cutthroat trout is reviewed in Young (1996) and Nesler et al. (1999). In Wyoming, historic range includes streams tributary to the Green River: the Little Snake River drainage on the west side of the Sierra Madre mountains, Green River tributaries draining the east face of the Wyoming Range mountains, the Blacks Fork River and its tributaries arising in the Uinta mountains, and a few tributaries like Trout Creek that flow directly into the Green River from the east. Prior to 1997, instream flow studies were conducted in the major drainages of the Wyoming Range and Sierra Madre mountains. During 1997, additional studies were performed in remaining streams such as Trout Creek, an east-side tributary to Flaming Gorge reservoir, which combines with Sage Creek before entering the reservoir.

A conservation plan was developed by Wyoming, Colorado, and Utah state wildlife agencies, in coordination with the U.S. Fish and Wildlife Service, to guide conservation efforts in the tri-state area through three primary activities: protecting existing and restored ecosystems, restoring degraded ecosystems, and planning (Nesler et al. 1999). The process of acquiring and maintaining suitable instream flows is listed as a strategy for restoration. Obtaining instream flow water rights to be held by the state of Wyoming will provide assurance that available water will be reserved when it is available in priority for providing CRC habitat. Such efforts do not increase habitat from present levels or ensure that adequate habitat is available; instead, they act to avoid future water depletions up to the limits established by instream flow water rights. Instream flow water right acquisition is just one step in a comprehensive process of protecting and conserving native cutthroat trout habitat and populations.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Colorado River cutthroat trout in Trout Creek and, 2) determine an instream flow regime that will help maintain the Trout Creek Colorado River cutthroat trout fishery.

METHODS

Study Area

Trout Creek is located in southwest Wyoming in Sweetwater County, south of Rock Springs. It flows north and then westerly before entering Flaming Gorge Reservoir (Figure 1). Land ownership in the Trout Creek basin is primarily Bureau of Land Management (BLM) but most parcels abutting the proposed instream flow segment are State administered. The upper boundary of the proposed instream flow segment is at about elevation 8,045 feet and is marked by the confluence of the east and west forks of Trout Creek in the southwest quarter of section 5, Range 105W, Township 13N. This point marks a location where the creek is fully formed from its primary springs. The downstream boundary for the proposed instream flow segment is the irrigation diverting point located in the northeast quarter of Section 20, Range 105W, Township 14N at an elevation of about 7,280 feet.

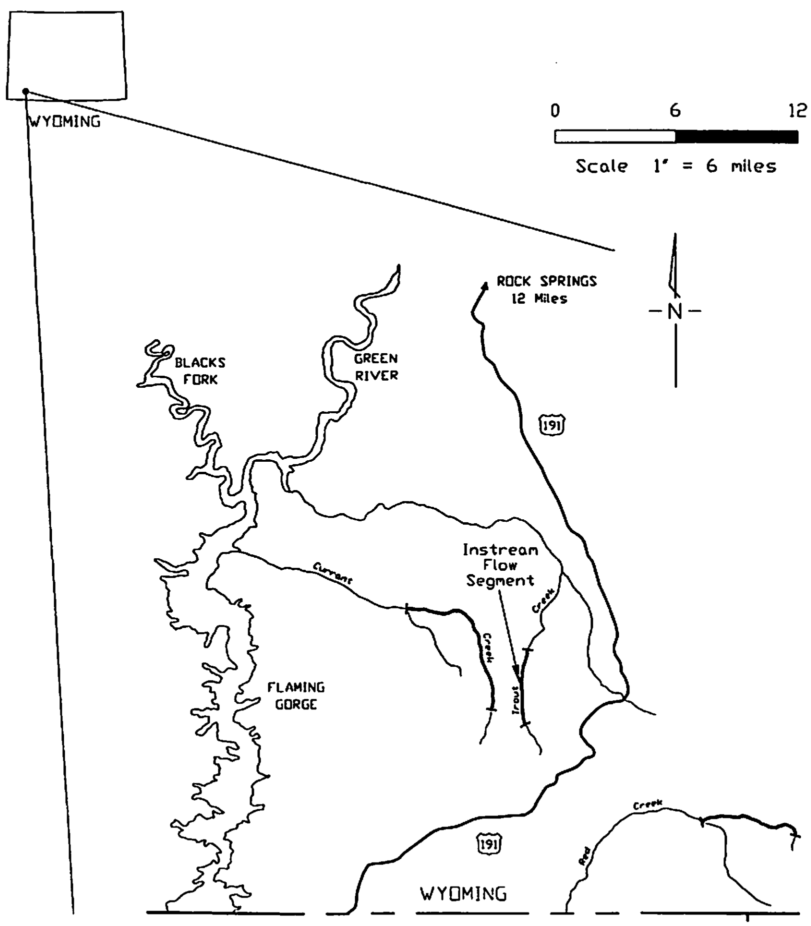

Figure 1. Trout Creek instream flow segment and surrounding area.

Trout Creek originates from springs and small headwater tributaries on Pine Mountain with elevations of over 9,000 feet in the basin. Watershed climate is semi-arid with 10-14 inches of annual precipitation in the headwaters and lesser amounts at lower elevations. Snowmelt run-off typically occurs in May while springs sustain baseflow the rest of the year. Stream aspect is north facing throughout the proposed instream flow segment. A steep-walled canyon, loosely called the "narrows", occurs near the upper end of the proposed segment. The stream is in a region of highly dissected and steep fluvial slopes (Valley Type

VII under *Rosgen and Silvey 1998)*. Downstream of the narrows several large slumps have occurred on the east side of the valley. Stream type downstream of the narrows was characterized as G4, reflecting the following conditions: instability due to high sediment supply from both upslope and channel derived sources, moderate gradient, low width to depth ratio, and gravel dominated channel with mixtures of sand and some cobble (Rosgen and Silvey 1998). In the narrows, stream type can be classified as B4 reflecting a gradient of 2-4% and more channel stability than downstream.

Headwaters are dominated by subalpine fir (*Abies lasiocarpa*) with some lodgepole pine (*Pinus contorta*) and scattered aspen (*Tremuloides* spp.). This likely represents a climax community resulting from fire suppression during most of this century. Upland vegetation at the confluence of the two forks is mostly sagebrush grassland with aspen, douglas fir (*Pseudotsuga menziesii*) and limber pine (*Pinus flexus)* patches often associated with draws. A large stand of douglas fir occurs in the narrows. Representative shrubs include mountain mahogany (*Cercocarpus montanus*), snowberry (*Symphoricarpos albus*), antelope bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), sagebrush (*Artemesia* spp.), chokecherry (*Prunus* spp), serviceberry (*Anelanchier* spp.), and currant (*Ribes* spp.). Riparian woody species are more abundant, diverse, and exhibit greater age class diversity than on any other Little Mountain or Pine Mountain watershed. These species include willow (*Salix* spp), currant, rose (*Rosa* spp.), water birch (*Betula occidentalis*), chokecherry, and aspen.

Ramsey Ranch operates throughout the basin and has been the historical lessee for cattle operations on BLM and State administered lands. Operation involves traditional cow/calf season-long use. Watershed management actions by Department and BLM personnel include prescribed burning and encouraging beaver expansion. A burn was conducted in April of 1992 in which approximately 1,500 acres were burned in a mosaic form. Regenerating decadent riparian woody vegetation and enhancing watershed function by regenerating mixed mountain shrub communities were the primary goals. In addition, the increased vegetational diversity improves wildlife habitat. Additional burns are planned for the future.

Beaver are being encouraged through supplementation with large woody materials to support solid dam construction. A goal of beaver enhancement is an elevated water table thereby encouraging the establishment of additional woody species. Additional benefits include stabilized banks, reduced sediment sources from banks, and deep pools for overwintering trout. Another management activity included installing cross-timber large woody debris structures (n=57) in 1996 to trap sediment, retain water, create pool habitat and provide overhead cover (WGFD Annual Progress Report on the 1997 Work Schedule, page 452).

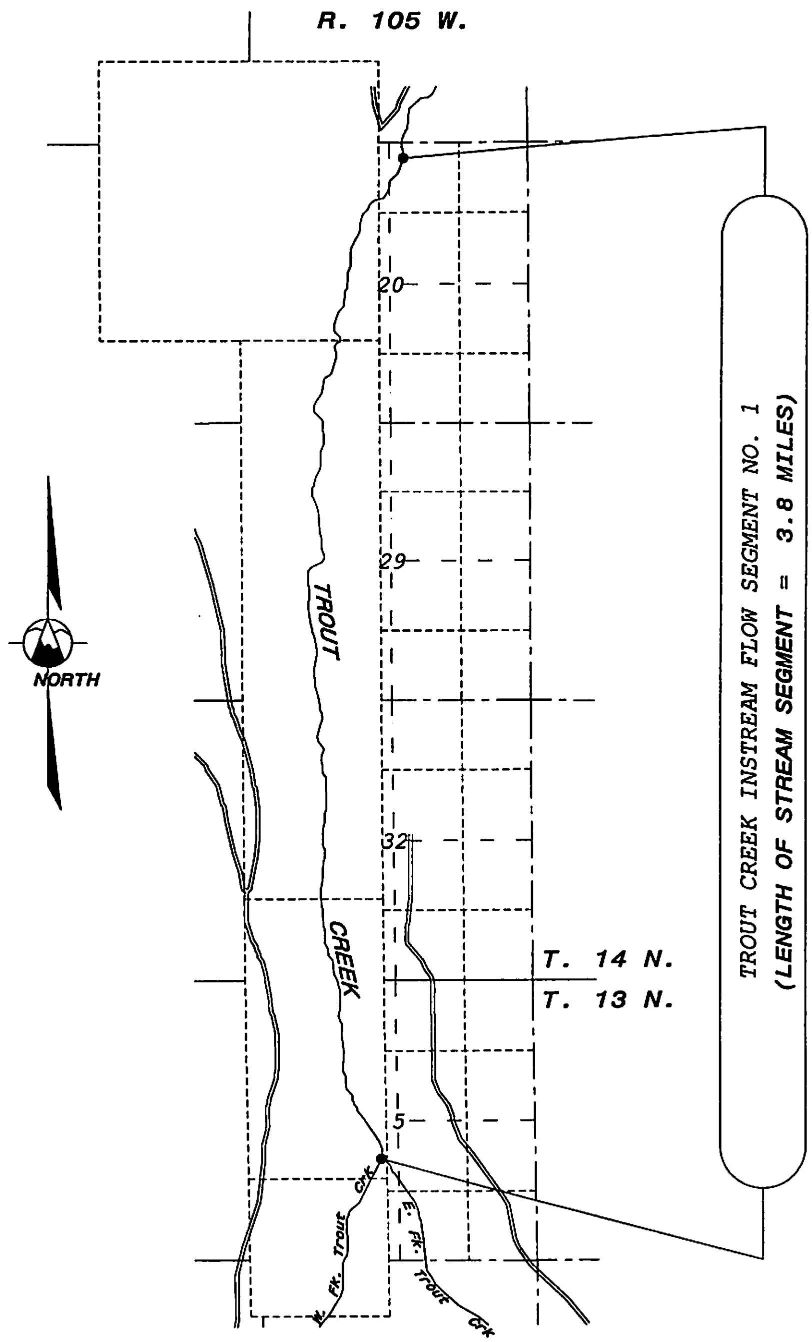

Figure 2. Detailed schematic of the Trout Creek instream flow segment and land ownership.

Fisheries

Earliest Trout Creek records show 10,000 brook trout were stocked in 1900 on the Ramsey Ranch. However, subsequent stocking records indicate that Snake River and Yellowstone cutthroat trout were the only species stocked through the early 1980's. In addition, brook trout have not shown up in subsequent surveys conducted periodically by fisheries workers. Colorado River cutthroat trout have been stocked 4 times between 1988 and 1996. A population estimate conducted at the instream flow study site in 1997 showed a density of 254 CRC per mile (64 lbs/acre).

It is commonly found that trout population density in small mountain streams fluctuates annually (House 1995, Mueller 1987). Such changes in abundance are related to natural variation in environmental factors like flow level and timing, temperature, and abundance of predators and competitors. If adequate habitat exists, populations survive during periods of hardship such as drought and flourish during periods with optimal conditions. In Trout Creek, steps are being taken to increase the minimum and maximum population potential by improving the watershed and channel. This will decrease the chances of CRC extinction during a low point in their population cycle. Under this framework, long-term trout population maintenance depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations might decline or disappear. The WGFD instream flow strategy recognizes the inherent variability of trout populations and thus defines the "existing fishery" as a dynamic feature. Instream flow recommendations are based on a goal of maintaining habitat conditions that provide the opportunity for trout numbers to fluctuate within existing natural levels.

Habitat Modeling

A representative study site was located at Township 14N, Range 105W, Section 20, NW1/4 on May 22, 1997 (Figure 1). The site contained trout cover associated mostly with lateral scour pools and grassy banks. Nine transects were distributed among pool, deep run, run and riffle habitat types (Appendix 1). Data for calibrating simulations were collected between May 22 and August 28, 1997 (Table 1).

Table 1. Data collection dates for Trout Creek instream flow data and discharge.

Date	Discharge (cfs)
Instream flow data	
May 22, 1997	6.3
June 26, 1997	5.6
August 28, 1997	3.2
Flow measurement only	
August 10, 1989	2.3
July 12, 1994	3.2
August 21, 1996	2.6
May 5, 1998	8.3
October 7, 1998	4.0

Determining critical trout life stages (fry, juvenile, adult, etc.) for a particular time period is necessary for determining flow recommendations. Critical life stages are those most sensitive to environmental stresses. Annual population integrity is sustained by providing adequate flow for critical life stages. In many cases, trout populations are constrained by spawning and young (fry and juvenile) life stage habitat "bottlenecks" (Nehring and Anderson 1993). Therefore, our general approach includes ensuring that adequate flows are provided to maintain spawning habitat in the spring was well as juvenile and adult habitat throughout the year (Table 2).

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

Life Stage	Jan	Feb	Mar	Apr 1 to Apr 15	Apr 16 to Apr 30	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult								1	1	1			
Spawning					2	2	2						
All	3	3	3	3	3	3	3	3	3	3	3	3	3

1 = Habitat Quality Index; 2 = PHABSIM; 3 = Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from hydraulic control riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Maintaining criteria in riffles at all times of year when flows are available in priority ensures that habitat is also maintained in other habitat types such as runs or pools (Nehring 1979). In addition, maintenance of identified flow levels may facilitate passage between habitat types for all trout life stages and maintain adequate benthic invertebrate survival.

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
Percent Wetted Perimeter[b]	50

a - At average daily flow or mean depth = 0.20, whichever is greater
b - Percent of bank full wetted perimeter

Simulation tools and calibration techniques used for hydraulic simulation in PHABSIM (Physical Habitat Simulation) are also used with this technique. 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 1,000 ft of stream length) at various flows. The habitat retention method involves analysis of hydraulic characteristics at control riffles. The AVPERM model within the PHABSIM methodology is used to simulate cross section depth, wetted perimeter and velocity for a range of flows. The flow that maintains 2 out of 3 criteria for all three transects is then identified.

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eiserman 1979; Binns 1982) was used to determine trout habitat levels over a range of late summer flow conditions. Most of the annual trout production in mountain streams occurs during the late summer, following peak runoff, when longer days and warmer water temperatures stimulate growth at all trophic levels. The HQI was developed by the WGFD to measure trout production in terms of habitat. It has been reliably used in Wyoming for habitat 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 existing levels of Colorado River 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 late summer flow conditions. For example, stream widths measured in June under high flow conditions are considered a fair estimate of the stream width that would occur if the same flow level occurred in the month of September. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Trout Creek 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 habitat at discharges other than those measured.

Average daily flow (ADF; 4.8 cfs) and peak flow (67 cfs) estimates for determining critical period stream flow and annual stream flow variation are based on elevation and basin area for mountainous regions in Wyoming (Lowham 1988).

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability for life stages over a range of discharges. The 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 1,000 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 1.0 and 10 cfs.

Usable spawning area was modeled individually for four riffle transects. Physical habitat for other life stages was modeled by combining simulated habitat from a single deep run transect with physical habitat in a continuous segment represented by 7 transects (Appendix 2). The spawning simulations were used in developing instream flow recommendations while the remaining simulations were used to validate the recommendations from the Habitat Retention and Habitat Quality Index models and provide incremental analyses of changes in physical habitat with flow.

Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHAMSIM modeling process. The spawning suitability curves used for deriving instream flow recommendations are listed in Appendix 2. Curves for fry are from Bozek and Rahel (1992) while those for adults and juveniles were developed from bank observations of Colorado River cutthroat trout in Dirtyman Creek, tributary to Savery Creek.

Observations by WGFD biologists indicate spawning activity in Trout Creek likely peaks in May during most years. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning flow recommendations should extend from April 16 to June 30. Even if spawning is completed before the end of this period, maintaining flows at a selected level throughout June will benefit trout egg incubation by preventing dewatering. The PHABSIM model was used in making flow recommendations for maintaining spawning habitat from April 16 to June 30 (Table 2).

RESULTS AND DISCUSSION

Trout populations are naturally limited by extreme conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988, Cunjak 1996, Annear et al. 1999). Frazil ice (suspended ice crystals formed when water is chilled below 0°C) in high gradient stream reaches can be both a direct mortality source through gill abrasion and subsequent suffocation or an indirect mortality source when resultant anchor ice limits habitat, causes localized de-watering, and exerts excessive metabolic demands on fish forced to seek ice-free habitats (Brown et. al 1994). Pools downstream from high gradient frazil ice-forming areas can accumulate anchor ice (Brown et. al 1994, Cunjak and Caissie 1994). Such accumulations may result in mortalities if low winter flows or ice dams block emigration.

Super-cooled water (<0° C) can also physiologically stress fish. As temperatures decrease below 4° C, fish gradually lose ion exchange abilities. At water temperatures near 0° C, fish have limited ability to assimilate oxygen or rid cells of carbon dioxide and other waste products. If fish are forced to be active near 0°C, such as to avoid frazil ice, direct mortalities can occur. The extent of impacts depends on the magnitude, frequency and duration of frazil events and the availability of escape habitats (Jakober et al. 1998). Juvenile and fry life stages tend to be impacted more than larger fish because younger fish inhabit shallower habitats and stream margins where frazil ice accumulates. Larger fish that inhabit deep pools may endure frazil events if they are not displaced.

Refuge from frazil ice occurs in groundwater influx areas, ice covered pools not close to frazil ice sources, and where heavy snow cover and stream bridging reduces frazil formation (Brown et al. 1994). Lower gradient streams and narrow streams are more likely to have insulating surface ice cover or at higher elevations, heavy snow cover and bridging. Trout Creek's high elevation, relatively narrow width and moderate slope suggest that snow bridging occurs in the headwaters. However, department personnel observed frazil ice formation and resultant anchor ice in October 1996 in the Narrows (Kevin Spence, personal communication). This is consistent with other streams where frazil events occur in early winter before sufficient insulating snow is present or in late winter when snow melt becomes superchilled by flowing over snow and ice before entering the stream. Therefore, natural winter flow levels up to the identified 1.5 cfs should be maintained to maximize access to and availability of frazil-ice-free refugia. Any artificial reduction of natural winter stream flows could increase trout mortality, reduce the number of fish the stream could support, and degrade the existing fishery.

Habitat Retention Analysis

Maintenance of naturally occurring flows up to 1.5 cfs is necessary at all times of the year (Table 4). On riffle 1, 2 of 3 criteria were met at a discharge of 1.1 cfs. On riffle 2 the discharge that satisfied 2 of 3 criteria was 1.5 cfs. And on riffle 3 the discharge that met 2 of 3 criteria was 1.3

cfs. Therefore, the discharge that meets 2 of 3 criteria for all riffles is 1.5 cfs.

Table 4. Simulated hydraulic criteria for three Trout Creek riffles. Average daily flow = 4.8 cfs. Bank full discharge estimated at 10 cfs.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	0.36	2.56	11.1	10
	0.42	1.91	6.4	5.0
	0.30	1.46	5.7	2.4
	0.26	1.31	**5.5**[a]	1.8
	0.23	1.22	5.5	1.5
	0.22	1.19	5.4	1.4
	0.22	1.16	5.4	1.3
	0.21	1.13	5.3	1.2
	0.20[a]	1.10	5.3	**1.1**[b]
	<0.19	**<1.06**[a]	<5.2	<1.0
Riffle 2	0.36	1.88	14.8	10
	0.30	2.41	**7.4**[a]	5.1
	0.28	1.41	6.1	2.4
	0.27	1.06	5.9	1.6
	0.27	**1.01**[a]	5.9	**1.5**[b]
	0.26	0.96	5.8	1.4
	0.26	0.91	5.8	1.3
	0.25	0.86	5.7	1.2
	0.25	0.81	5.6	1.1
	<0.25[a]	<0.76	<5.5	<1.0
Riffle 3	0.38	2.42	11.2	10
	0.30	2.37	7.4	5.0
	0.26	1.59	**5.6**[a]	2.2
	0.24	1.52	5.6	2.0
	0.22	1.35	5.5	1.6
	0.21	1.27	5.5	1.4
	0.20[a]	1.22	5.5	**1.3**[b]
	0.19	1.17	5.5	1.2
	0.19	1.12	5.5	1.1
	0.18	**<1.07**[a]	5.4	1.0

a - Hydraulic criteria met
b - Discharge at which 2 of 3 hydraulic criteria are met

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 shortfalls during the winter do not imply any degree of infeasibility or a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 1.5 cfs, to maintain existing trout survival rates. Results from the HQI and PHABSIM methods below indicate that higher flows are needed during April through September to support spawning and adult life stages.

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". One way to define "existing fishery" is by the number of habitat units that occur under normal July through September flow conditions. Since there is no stream flow gage on Trout Creek, an estimate for discharge over the July through September period can be derived from point measurements collected during instream flow studies (Table 1) or gathered during the course of regular fishery and habitat surveys. In addition to those data shown in Table 1, flows of 2.6, 3.2, and 4.0 cfs were measured on August 21, 1996; July 12, 1994; and October 10, 1998. Therefore, late late-summer flow normally ranges between about 2.6 and 5.6 cfs. Two habitat peaks occur in this range; one at discharges of 2.7 to 2.8 cfs peaks at 130 habitat units while the other at 3.2 to 5.6 cfs peaks slightly higher at 145 habitat units (Figure 3). The decrease between these peaks is due to increasingly unsuitable (high) velocities. For the purpose of maintaining existing fishery values, the term "minimum" means the lowest amount of flow that will provide the identified fishery benefits, whenever it is naturally available. Since both 2.7 and 3.2 cfs fall within the range of normal estimated late summer flows, the minimum flow to maintain the existing fishery during late summer is 2.7 cfs.

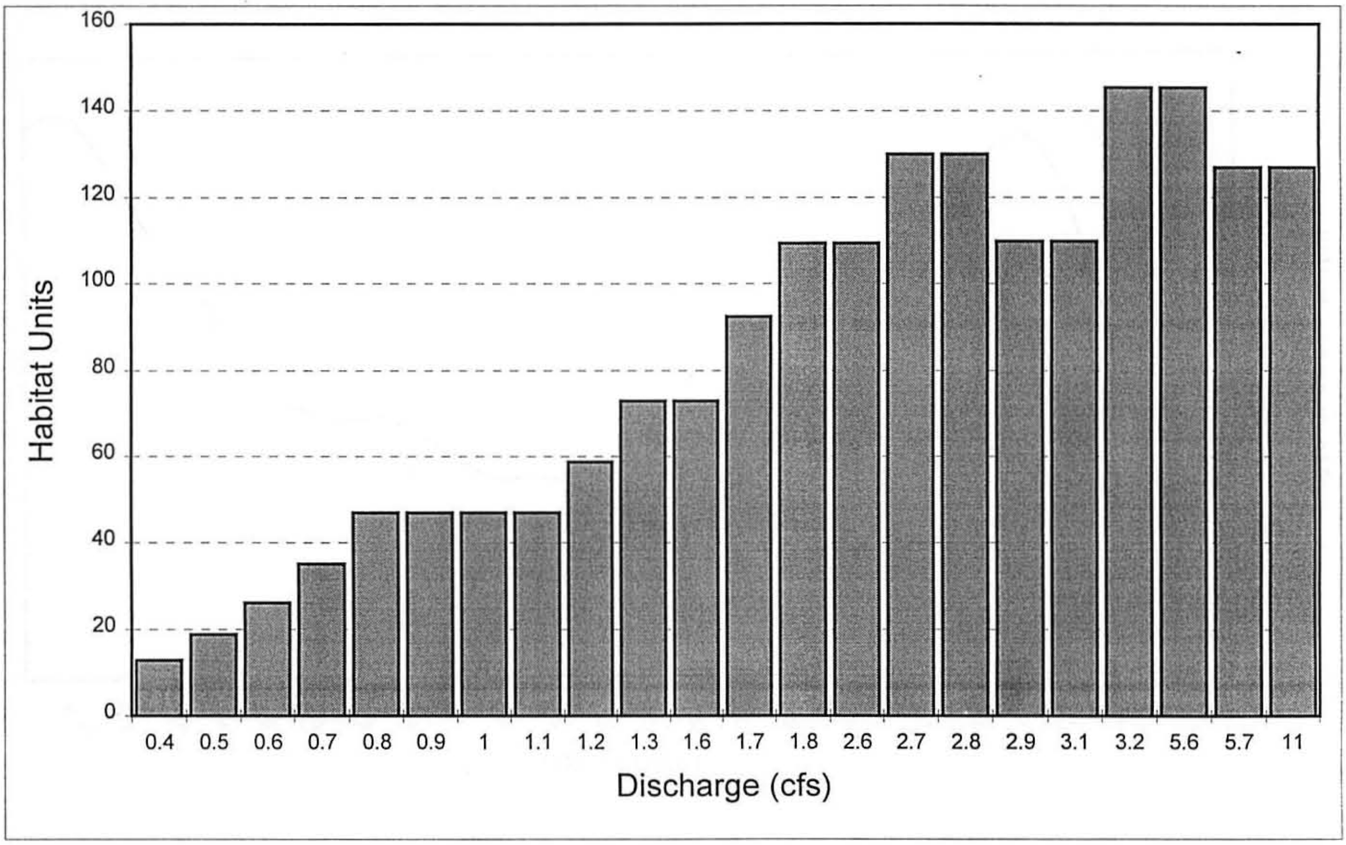

Figure 3. Trout habitat units at several late summer Trout Creek flow levels. X-axis discharges are not to scale.

Based on this analysis, an instream flow of 2.7 cfs between July 1 and September 30 would maintain existing trout habitat quality. This flow represents the lowest stream flow that will accomplish this objective if all other habitat attributes remain unchanged. The existing fishery is naturally dynamic as a function of stream flow availability. In years when stream flow is naturally less than 2.7 cfs in late summer the fishery declines. Likewise, in years when late summer flow is 2.7 cfs or more, it expands. As noted above, maintaining this existing fishery simply means maintaining existing natural stream flows up to the recommended amount in order to maintain the existing natural habitat and fish population fluctuations.

PHABSIM Analyses

Spawning was identified as a critical life stage. The amount of physical area suitable for spawning showed a bimodal pattern with peaks at 2.8 cfs and 13 cfs (Figure 4). To decide whether the lower or higher flow level offered better spawning habitat, the suitability of individual cells on transects was examined. The peak at 2.8 cfs comes from the sum of several cells with low spawning suitability. The peak at 13 cfs reflects high quality spawning habitat on fewer cells. Since normal flows during spawning are likely to be higher and such high flows create quality habitat, a flow of 13 cfs is recommended to maintain spawning habitat. The instream flow recommendation for the period from April 16 to June 30 is 13 cfs to maintain spawning habitat.

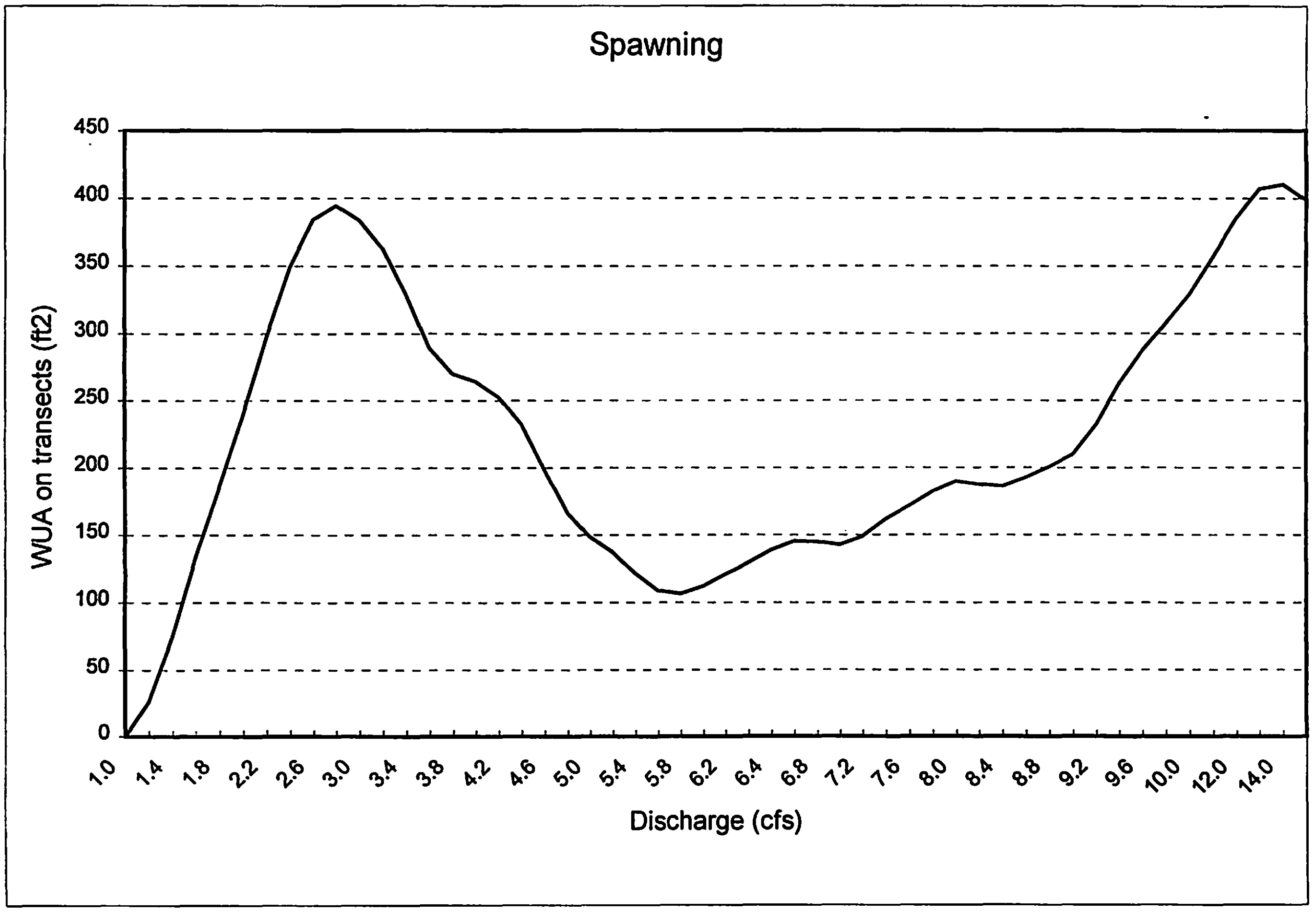

Figure 4. Relationship between stream flow and spawning habitat averaged over four Trout Creek riffles.

Physical habitat levels for adults, juveniles and fry are at relatively low levels until flows increase above 5 to 7 cfs (Figure 5). The recommended winter flow of 1.5 cfs from Habitat Retention results appears to offer a low but stable level of weighted useable area. Furthermore, the late-summer recommendation of 2.7 cfs from HQI results maintains a low but stable level of physical habitat for fry, juveniles, and adults.

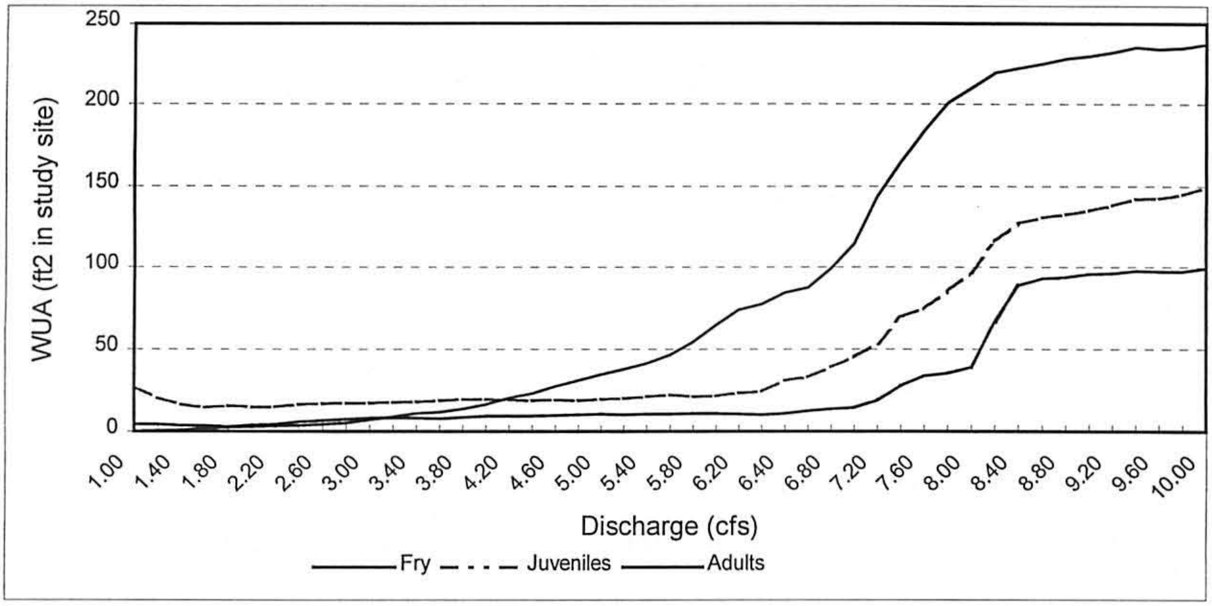

Figure 5. Weighted usable area for Colorado River cutthroat trout in Trout Creek over a range of discharges. X-axis discharges are not to scale.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain the existing Trout Creek Colorado River cutthroat trout fishery. These recommendations apply to an approximately 3.8 mile Trout Creek segment extending downstream from confluence of East and West Forks Trout Creek at Range 105W, Township 13N and section 5 to the diversion ditch located in Range 105W, Township 14N, Section 20. The instream flow reach is on lands under BLM and State administration. 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 5. Instream flow recommendations to maintain the existing Trout Creek trout fishery.

Time Period	Instream Flow Recommendation (cfs)
October 1 to April 14	1.5
April 15 to June 30	13
July 1 to September 30	2.7

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 are necessary for establishing channel maintenance flow requirements.

LITERATURE CITED

Annear, T.C. and A.L. Conder. 1984. Relative bias of several fisheries instream flow methods. North American Journal of Fisheries Management 4:531-539.

Annear, T. C., W. Hubert, D. Simpkins and L. Hebdon. In Press. Behavioral and physiological response of trout to winter habitat in Wyoming, USA. Hydrological Processes.

Binns, N.A. 1982. Habitat Quality Index Procedures Manual. WDFG Publication

Binns, N.A. and F. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.

Bovee, K. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and technique. Instream Flow Information Paper 5, FWS/OBS-78/33, Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service. Fort Collins, Colorado.

Bozek, M.A. and F.J. Rahel. 1992. Generality of microhabitat suitability models of young Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) across site and among years in Wyoming streams. Canadian Journal of Fisheries and Aquatic Science 49:552-564.

Brown, R.S., S.S. Stanislawski, and W.C. Mackay. 1994. Effects of frazil ice on fish. *In* Proceedings of the Workshop on the Environmental Aspects of River Ice, Saskatoon, Sask., 18-20 August 1993. *Edited by* T.D. Prowse. NHRI Symp. Ser. No.12. National Hydrology Research Institute, Saskatoon, Sask. pp.261-278.

Butler, R. 1979. Anchor ice, its formation and effects on aquatic life. Science in Agriculture, Vol XXVI, Number 2, Winter, 1979.

Conder, A.L. and T.C. Annear. 1987. Test of weighted usable area estimates derived from a PHABSIM model for instream flow studies on trout streams. North American Journal of Fisheries Management 7:339-350.

Cunjak, R.A. 1988. Physiological consequences of overwintering in streams; the cost of acclimatization? Canadian Journal of Fisheries and Aquatic Sciences 45:443-452.

Cunjak, R.A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of fisheries and Aquatic Sciences 53(Suppl.1):267-282.

Cunjak, R.A. and D. Caissie. 1994. Frazil ice accumulation in a large salmon pool in the Miramichi River, New Brunswick: ecological implications for overwintering fishes. *In* Proceedings of the Workshop on the Environmental Aspects of River Ice, Saskatoon, Sask., 18-20 August 1993. *Edited by* T.D. Prowse. NHRI Symp. Ser. No.12. National Hydrology Research Institute, Saskatoon, Sask. pp.261-278.

House, R. 1995. Temporal variation in abundance of an isolated population of cutthroat trout in western Oregon, 1981-1991. North American Journal of Fisheries Management 15:33-41.

Jakober, M.E., T.E. McMahon, R.F. Thurow, and C.G. Clancy. 1998. Role of stream ice on Fall and Winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society 127:223-235.

Kurtz, J. 1980. Fishery management investigations. - a study of the upper Green River fishery, Sublette County, Wyoming (1975-1979). Completion Report. Wyoming Game and Fish Department, Fish Division, Cheyenne.

Lowham, H.W. 1988. Streamflows in Wyoming. USGS Water Resources Investigations Report 88-4045.

Milhous, R.T., D.L. Wegner, and T. Waddle. 1984. User's guide to the physical habitat simulation system. Instream Flow Paper 11, FWS/OBS-81/43, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Milhous, R.T., M.A. Updike, and D.M. Schneider. 1989. Physical habitat simulation system reference manual - version II. Instream Flow Information Paper No. 26. U.S. Fish and Wildlife Service, Biol. Rep. 89(16).

Mueller, J.W. 1987. Electrofishing results in Sand Creek, Hospital Gulch Station, Sand Creek Country Club, 1986. Wyoming Game and Fish Department Administrative Report.

Needham, P., J. Moffett, and D. Slater. 1945. Fluctuations in wild brown trout populations in Convict Creek, California. Journal of Wildlife Management 9:9-25.

Nehring, R. 1979. Evaluation of instream flow methods and determination of water quantity needs for streams in the state of Colorado. Colorado Division of Wildlife, Fort Collins.

Nehring, B.R. and R.M. Anderson. 1993. Determination of population-limiting critical salmonid habitats in Colorado streams using the Physical Habitat Simulation System. Rivers 4:1-19.

Nesler, T., M. McAfee, R. Remmick, B. Rosenblund, and R. Radant. 1999. Draft conservation agreement and strategy for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming.

Reimers, N. 1957. Some aspects of the relation between stream foods and trout survival. California Fish and Game 43:43-69.

Reiser, D.W., T.A. Wesche, and C. Estes. 1989. Status of instream flow legislation and practices in North America. Fisheries 14(2):22-29.

Rosgen, D. and L. Silvey. 1998. Field guide for stream classification. Wildland Hydrology, Pagosa Springs, CO.

Thurow, R.F. and J.G. King. 1994. Attributes of Yellowstone cutthroat trout redds in a tributary of the Snake River, Idaho. Transactions of the American Fisheries Society 123:37-50.

Young, M.K., N.R. Schmal, T.W. Kohley, and V.G. Leonard. 1996. Conservation status of Colorado River cutthroat trout. General Technical Report RM-GTR-282. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky mountain Forest and Range Experiment Station. 32 p.

Appendix 1. Reach weighting used for PHABSIM analysis of fry, juvenile and adult physical habitat.

Transect	Reach Length (ft)	Percent	Habitat Type
1	5.5	9.0	Stand-alone deep run
2	---	---	Stand-alone habitat retention & spawning riffle
3	1.5	2.5	Control and spawning riffle
4	9.7	15.9	Run
5	3.6	5.9	Run and pool
6	15.1	24.7	Control, habitat retention, spawning riffle
7	11.7	19.2	Run with undercut bank
8	10.7	17.5	Run
9	3.2	5.2	Control, habitat retention, spawning riffle

Appendix 2. Spawning suitability index data used in PHABSIM analysis. Index data are from Thurow and King, 1994.

Velocity	Weight	Depth	Weight	Substrate	Weight
0.00	0.00	0.00	0.00	0.00	0.00
0.59	0.00	0.32	0.00	4.00	0.00
0.69	0.10	0.34	0.10	4.10	0.10
0.94	0.20	0.37	0.20	4.20	0.20
1.10	0.50	0.45	0.50	4.30	0.50
1.12	1.00	0.52	1.00	4.40	1.00
1.72	1.00	0.82	1.00	5.60	1.00
1.82	0.50	0.97	0.50	5.70	0.50
2.06	0.20	1.27	0.20	5.80	0.20
2.26	0.10	1.58	0.10	5.90	0.10
2.31	0.00	1.75	0.00	6.00	0.00