WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream flow studies on Douglas Creek, Carbon County

PROJECT: IF-4494-07-9403

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ABSTRACT

Instream flow studies were conducted on Douglas Creek in 1994 as part of an ongoing monitoring and enhancement program for Colorado River cutthroat trout in streams of the Little Snake River basin. The goal of this study was to determine instream flows necessary for maintaining or improving Colorado River cutthroat trout habitat in Douglas Creek.

Physical habitat modeling and the Habitat Quality Index were used to determine instream flows necessary for maintenance of Colorado River cutthroat trout habitat. Based on results from these methodologies, the instream flow recommendations are: October 1 to April 30, 0.3 cfs; May 1 to June 30, 3.6 cfs; July 1 to September 30, 0.5 cfs. The instream flow applies to a 1.0-mile stream reach extending from R87W, T14N, S3, SW1/4 downstream to the confluence of Douglas Creek with Big Sandstone Creek in R87W, T14N, S10, NW1/4.

INTRODUCTION

Colorado River cutthroat trout Oncorhynchus clarki pleuriticus are classified as Category 2 taxa by the U.S. Fish and Wildlife Service. Species in this category may be appropriate for listing as threatened or endangered if significant losses of habitat or declines in population size continue. Colorado River cutthroat trout are considered a species of special concern by the Wyoming Game and Fish Department (WGFD) and Region 2 of the U.S. Forest Service. Although Colorado River cutthroat trout were historically distributed throughout streams of the Colorado River drainage in Wyoming, Colorado, Utah, Arizona and New Mexico, they now occupy less than 1% of their historic range (Speas et al. 1994). In Wyoming, populations of Colorado River cutthroat trout occur predominantly in small headwater streams of the Green, Little Snake and Blacks Fork River watersheds. Several factors including poor land management practices,

limited stream flows, displacement by non-native trouts, fishing pressure and habitat fragmentation have contributed to the reduced distribution and abundance of Colorado River cutthroat trout throughout their native range (Trotter 1987).

In the Little Snake River watershed, water management activities pose the greatest threat to Colorado River cutthroat trout. Water quality violations and habitat fragmentation following completion of the City of Cheyenne's Stage I and Stage II water diversions have occurred in Colorado River cutthroat trout streams (Hipple 1986, Schmal 1986, Wilcox 1989). Additional flow diversions in other streams of the Little Snake River drainage (Savery Creek drainage) have been considered as part of the City of Cheyenne's Stage III water development plan which could further impact this species. Depending on the magnitude, these types of impacts could contribute to the listing of this species as threatened or endangered unless adequate protective measures are implemented. The potential effects of these flow diversions are discussed in Miller (1980) and Wyoming Game and Fish Department (1986). Appropriate protective measures such as acquisition of adequate instream flow water rights could help avoid the listing of Colorado River cutthroat trout as threatened or endangered and allow some development of water resources to proceed. The importance of protecting habitat and populations of Colorado River cutthroat trout was formally acknowledged by an April 22, 1987 Memorandum of Understanding between the Forest Sevice and the WGFD.

In 1994, a management plan for Colorado River cutthroat trout in the Little Snake River watershed was cooperatively prepared by the U.S. Forest Service, the WGFD, and the U.S. Bureau of Land Management (Speas et al. 1994). This plan calls for the protection, maintenance, and re-establishment of Colorado River cutthroat trout in streams of the Little Snake River drainage. Within this plan, the acquisition of instream flows water rights for maintenance and protection of critical Colorado River cutthroat trout habitat was listed as a primary objective.

The objectives of this study were 1) to examine relationships between discharge and physical habitat quantity and quality available to Colorado River cutthroat trout in Douglas Creek and 2) to determine an instream flow regime in Douglas Creek for the maintenance Colorado River cutthroat trout habitat.

STUDY AREA

Douglas Creek originates on the west slope of the Sierra Madre Mountains at elevations in excess of 9,600 feet above mean sea level. The channel has a total length of about 3.0 miles and terminates at its confluence with Big Sandstone Creek. The entire Douglas Creek watershed is located within the Medicine Bow National Forest.

Douglas Creek has an average slope of about 6.0%. The class A3 channel (Rosgen 1985) is relatively stable and substrates are comprised of small boulders, cobbles, and gravel. Beaver dams are present throughout the drainage and provide important habitat for adult trout.

Hydrology

Douglas Creek, like most small streams in the Medicine Bow National Forest, is ungaged; therefore, site-specific stream flow records for Douglas Creek are not available. Discharge records for Big Sandstone Creek do exist for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988. This USGS gage (# 09255900) was located 300 feet downstream from the Douglas Creek confluence with Big Sandstone Creek.

Big Sandstone flow data were used to estimate monthly flow patterns in Douglas Creek. Flow patterns in Douglas Creek were obtained by applying a monthly water yield to drainage area ratio from Big Sandstone Creek to Douglas Creek. For all watershed versus flow relationships, a watershed area of 9.85 square miles and gaged flows were used for Big Sandstone Creek. Flows were estimated in Douglas Creek using a watershed area of 2.13 square miles. Thus, flows in Douglas Creek are about 21.6% of Big Sandstone Creek flows.

Based on this hydrologic simulation technique and average flows of 15.89 cfs in Big Sandstone Creek, average daily flows in Douglas Creek are 3.52 cfs; greatest mean daily flows (18.03 cfs) would occur in June (Figure 1). In 1987 (period of lowest flows on record for Big Sandstone Creek), average daily flow in Douglas Creek would have been 2.13 cfs and greatest mean daily flows (13.46 cfs) would have occurred in May (Figure 1). The average daily minimum flow in Douglas Creek for the Big Sandstone Creek period of record was 0.31 cfs (range 0.24 cfs-0.39 cfs). These estimations indicate minimum base flows in Douglas Creek are relatively stable across years despite annual variability in precipitation levels.

Fisheries

Douglas Creek historically supported only Colorado River cutthroat trout and was classified as a "cutthroat trout sanctuary" by Kanaly et al. (1955). The pristine conditions in Douglas Creek offered abundant and diverse habitat. Since 1955, however, populations of Colorado River cutthroat trout have declined in Douglas Creek. Brook trout (Salvelinus fontinalis) emigrating upstream from Big Sandstone Creek have led to the decline of Colorado River cutthroat through mechanisms of competition and displacement.

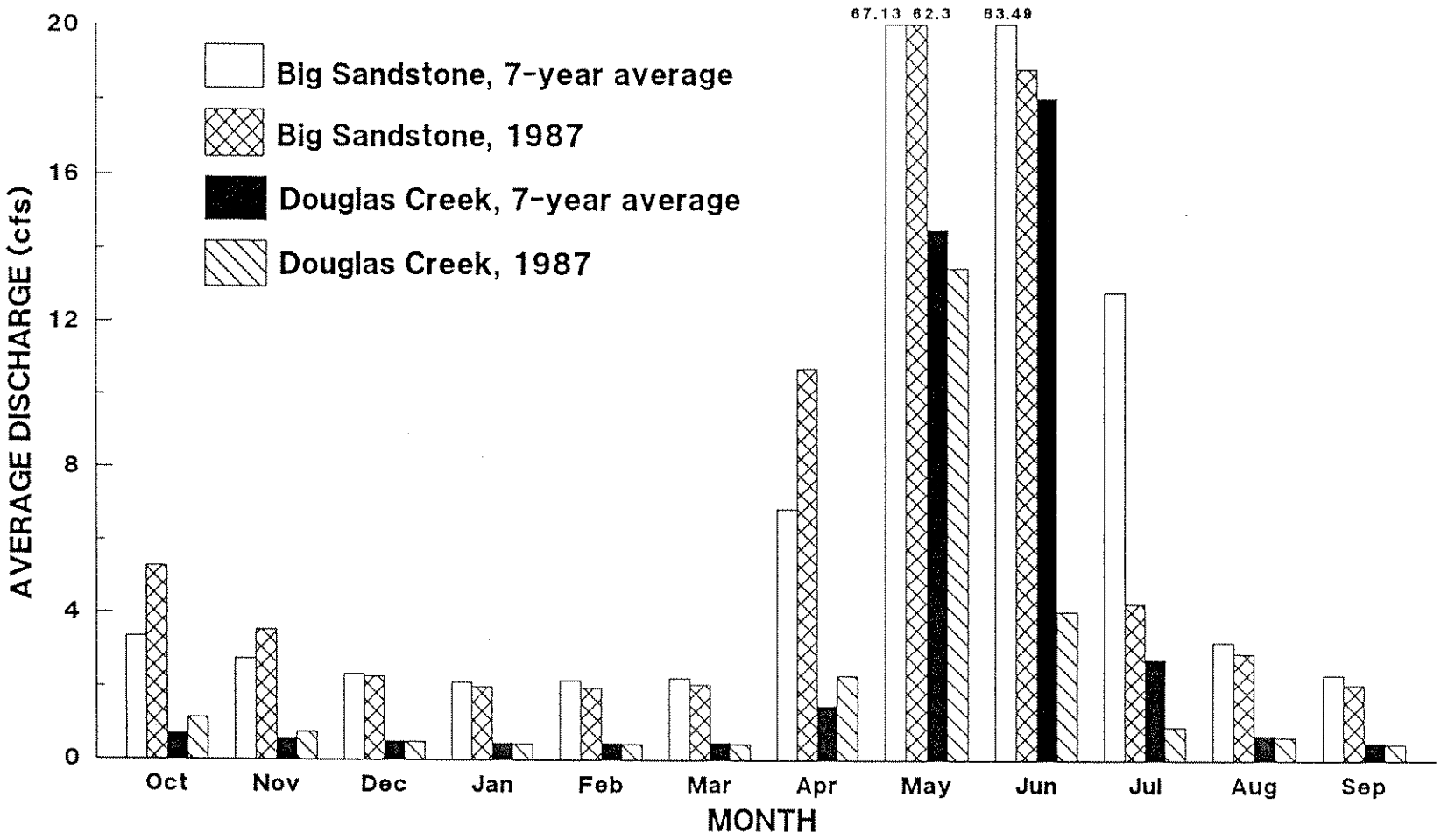

Figure 1. Mean daily flows in Big Sandstone Creek and Douglas Creek. Big Sandstone Creek data were compiled from USGS gage number 09255900 for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988. Discharge in Douglas Creek was estimated from Big Sandstone Creek data (see text for an explanation of methods).

Habitat for Colorado River cutthroat trout in Douglas Creek remains relatively pristine. Beaver ponds and several deep pools have the potential to provide quality habitat for adults; pocket pools for juvenile life stages are abundant throughout the stream. Numerous gravel-dominated areas are also present to provide adequate spawning for Colorado River cutthroat trout. Because Douglas Creek supports abundant habitat for all life stages, habitat protection through the maintenance of adequate instream flows is an important first-step toward re-establishing Colorado River cutthroat trout in this stream.

Though quantitative, site-specific data for Douglas Creek do not exist, observations by Remmick (WGFD, pers. comm.) indicate Colorado River cutthroat trout typically exhibit natural fluctuations in year-class strength and population density. The magnitude of these fluctuations is primarily influenced by seasonal variability in discharge which affects spawning success and physical habitat quality. Present 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 may occur every three to five years. Without the benefit of periodic high flows, populations in some streams would decline or cease to exist.

Study site

After surveying about 0.5 miles of stream. a study site on Douglas Creek was established about 1,200 feet upstream from Big Sandstone Creek in R87W, T14N, S10, NW1/4. The elevation of the study site is 8,350 feet above mean sea level. Within the 152-foot-long study site, ten transects were established in riffles, runs, pocket pools and plunge pools to represent habitat types, except beaver ponds, found throughout the upper reaches of Douglas Creek.

METHODS

Instream flow data were collected at the study site in Douglas Creek on the dates and discharge listed in Table 1. Instream flow information derived from the study site was applied to a 1.0-mile stream reach extending from R87W, T14N, S3, SW1/4 downstream to the confluence of Douglas Creek with Big Sandstone Creek in R87W, T14N, S10, NW1/4. The land through which the instream flow segment passes is administered by the U.S. Forest Service.

Table 1. Dates and discharges when hydraulic data were collected in Douglas Creek.

Date	Discharge (cfs)
June 8, 1994	5.3
June 29, 1994	0.7
September 21, 1994	0.3

A physical habitat simulation model (PHABSIM; Bovee 1982; Milhous et al. 1989) was used to quantify relationships between stream discharge and the amount of physical habitat available to spawning, fry, juvenile and adult life stages of Colorado River cutthroat trout. This model is the mostly widely used method for assessing relationships between instream flow and physical habitat for fish (Reiser et al. 1989). In PHABSIM, physical habitat is reported as weighted usable area (ft^2/1,000 feet of stream length).

The physical habitat model was calibrated for all ten transects using hydraulic characteristics of depth, velocity and substrate measured on the dates and discharges listed in Table 1. Based on these data, physical habitat simulations were conducted for flows ranging from 0.1 cfs to 10.0 cfs. Habitat suitability criteria from Bovee (1978) and Bozek and Rahel (1992) were used in the spawning and fry physical habitat simulations, respectively. Suitability criteria from Braaten et al. (in preparation) were used in juvenile and adult physical habitat simulations.

The Habitat Quality Index (HQI, Binns and Eiserman 1979; Binns 1982) was used to estimate trout production over a broad range of late summer flow conditions. The HQI was developed by the WGFD and has been reliably used in Wyoming to assess the effects of stream flows on production potential of trout. Nine attributes which address the biological, chemical and physical aspects of trout production are included in the HQI. Results are expressed in habitat units, where one habitat unit is defined as the amount habitat that will support about 1 pound of trout.

In the HQI analysis, habitat attributes measured at various flow events are assumed typical of mean late summer flow conditions. Under this assumption, habitat unit estimates may be extrapolated through a range of possible late summer flows (Conder and Annear 1987). Some attributes of the HQI were mathematically derived from habitat measurements collected on the dates and discharges listed in Table 1.

Jesperson (1979) and Quinlan (1980) studied the biology of Colorado River cutthroat trout in streams of the Little Snake River drainage. These authors found the majority of spawning by Colorado River cutthroat trout occurred on the descending limb of the

hydrograph during June, and in some instances spawning continued through the first week of July. Depending on flow and temperature conditions, spawning may begin in May. Suitable physical habitat for spawning is most critical during this time period. Following egg maturation through July, physical habitat for fry is important from early August through September. Most age-0 Colorado River cutthroat attain the juvenile life stage by September. Based on the biology of Colorado River cutthroat trout, Table 3 illustrates the biologically critical times of the year to which instream flow modeling methodologies apply in Douglas Creek.

Table 3. Methods used to determine instream flow recommendations at different times of the year for various life stages of Colorado River cutthroat trout.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning					1	1						
Fry								1	1			
Juvenile	1	1	1	1						1	1	1
Adult	1	1	1	1			2	2	2	1	1	1

1 - PHABSIM
2 - Habitat Quality Index

RESULTS

Spawning Physical Habitat

Physical spawning habitat is maximized at 3.6 cfs, and is maintained near maximum levels (> 60 ft^2/1,000 ft) at flows ranging from 3.0 cfs to 4.6 cfs (Figure 2). At flows less than 3.0 cfs or greater than 4.6 cfs, the amount of physical spawning habitat declines rapidly with relatively small changes in discharge.

Fry, Juvenile, and Adult Physical Habitat

Physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout exhibit similar relationships to discharge (Figure 3). The amount of physical habitat is relatively constant over the entire range of simulated flows, increasing gradually up to the highest flow simulated (10 cfs). The amount of physical habitat at low flows exhibits a threshold relationship to discharge whereby physical habitat declines greatly at flows less than 0.3 cfs (adult and juvenile) and less than 0.2 cfs (fry).

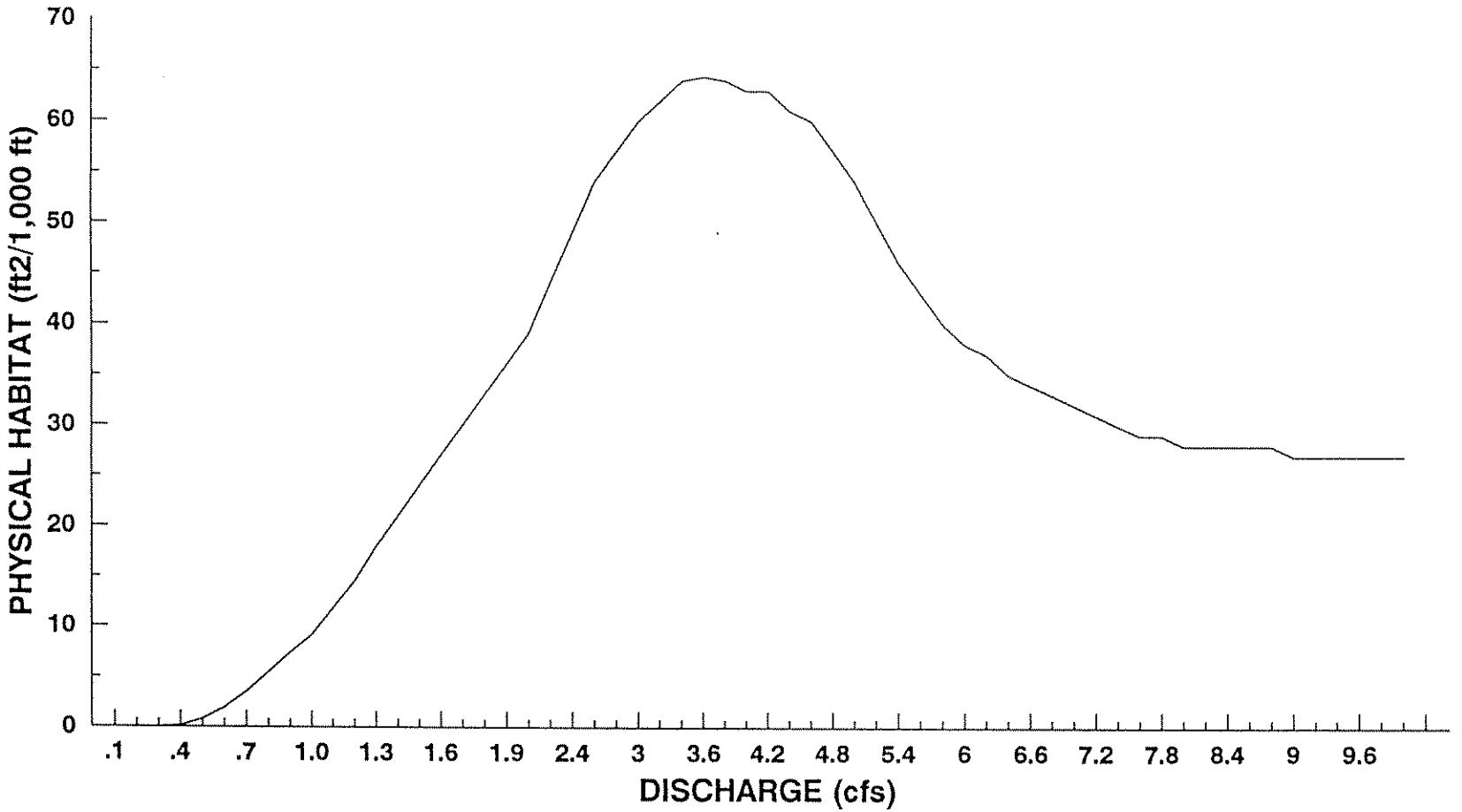

Figure 2. Relationship between discharge and physical spawning habitat for Colorado River cutthroat trout in Douglas Creek.

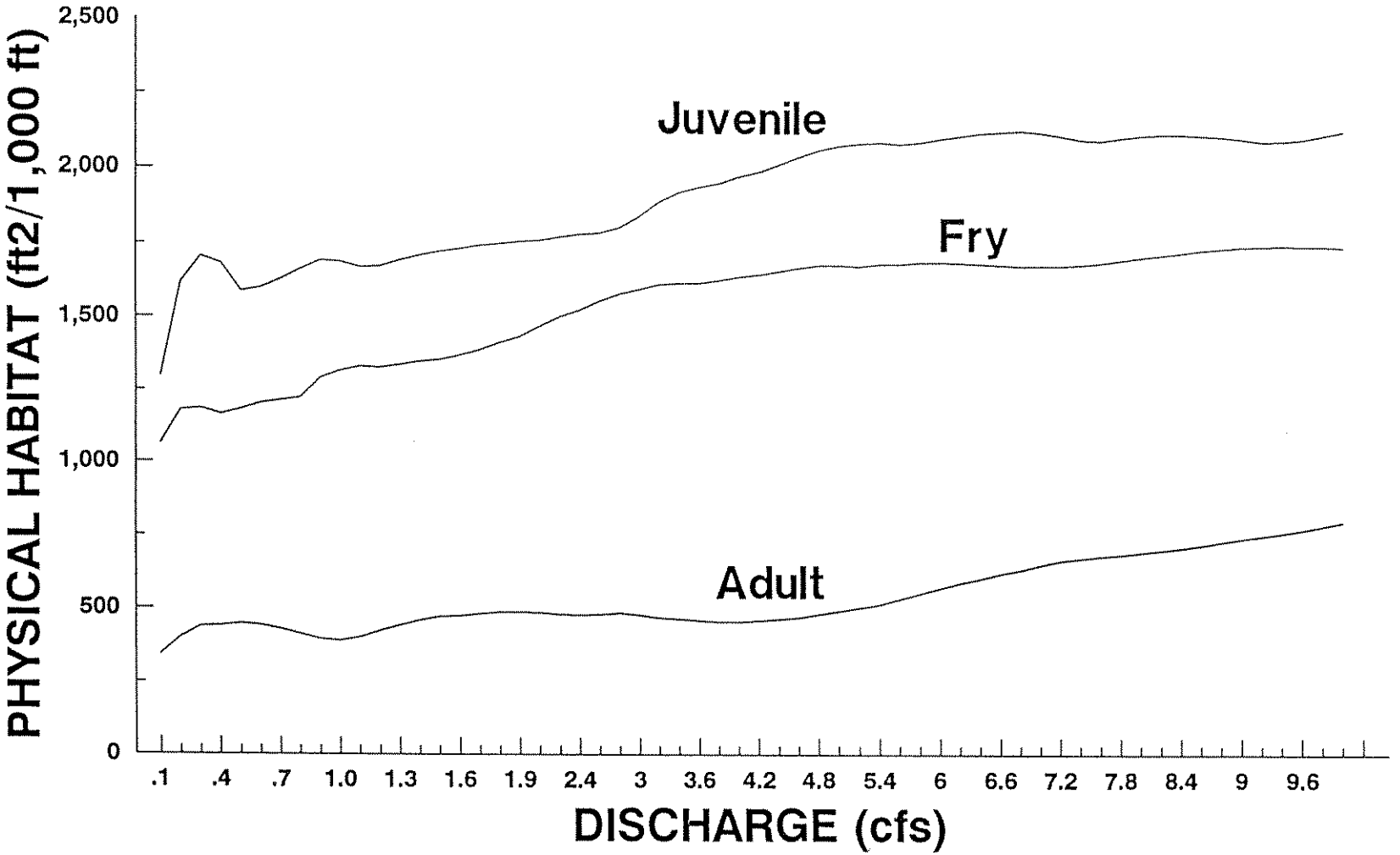

Figure 3. Relationships between discharge and physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout in Douglas Creek.

Habitat Quality Index

Douglas Creek supports 32.6 habitat units at the existing mean summer flow of 0.5 cfs (estimated from hydrologic relationships). At flows greater than 0.7 cfs, the number of habitat units increases through 7.5 cfs then declines (Figure 4). The number of habitat units is reduced 27%, 39%, and 62% as flows are reduced from 0.5 cfs to 0.4, 0.3 and 0.2 cfs, respectively.

DISCUSSION

Results from physical habitat simulations indicate physical habitat for spawning is maximized at 3.6 cfs, but near maximum levels are maintained through a broad range of flows (3.0 cfs to 4.6 cfs). Based on Douglas Creek hydrologic simulations, average daily flows during May and June are 14.5 cfs and 18.0 cfs, respectively. Mean daily flows of 13.5 cfs (May) and 4.1 cfs (June) occur in Douglas Creek during the driest year on record (1987). This preliminary analysis of flow patterns suggests a spring and early summer flow of 3.6 cfs should naturally be available for maximizing physical spawning habitat during average and below-average water years and would maintain or improve existing levels of physical habitat for spawning.

At the existing (estimated) mean summer flow of 0.5 cfs, Douglas Creek supports 32.6 habitat units and this level is maintained through 0.7 cfs. Significant reductions (up to 62%) in habitat units and production potential would occur if flows were reduced to less than 0.5 cfs. Although greater flows (e.g. greater than 0.7 cfs) would improve production potential in Douglas Creek, flows of this magnitude rarely occur in late summer. These results indicate a flow of at least 0.5 cfs during late summer is necessary to maintain or improve Colorado River cutthroat trout production in Douglas Creek.

The quantity of physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout is relatively high through the entire range of simulated flows; however, reductions in physical habitat for juveniles and adults occur as flow declines to less than 0.30 cfs. Reductions in physical habitat for fry did not occur until flow declined to less than 0.20 cfs. Based on hydrologic simulations, mean minimum flows in Douglas Creek from late summer through winter are about 0.30 cfs. These results suggest suitable physical habitat for juveniles and adults is maintained at or above the natural minimum base flow of 0.30 cfs and indicate that reductions of flow during the late summer, fall, and winter to less than 0.30 cfs would have negative impacts on juvenile and adult physical habitat. Because flows during these months average about 0.40 cfs, flows of 0.30 should naturally be available.

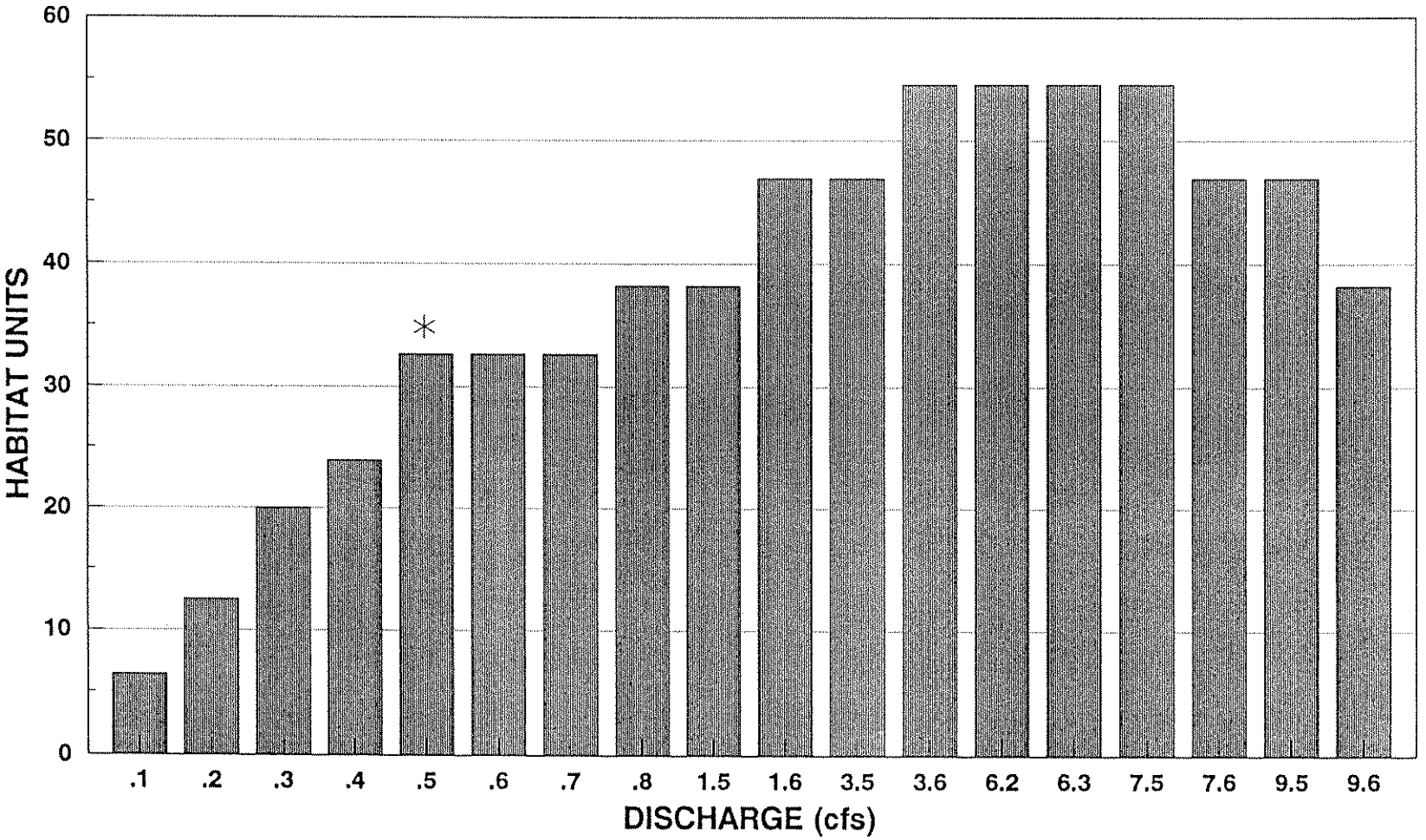

Figure 4. Relationship between discharge and trout habitat units in Douglas Creek. * = habitat units at existing conditions.

Based on results from this study, the instream flows listed in Table 5 are recommended for Douglas Creek. The spring and early summer flow of 3.6 cfs will maximize physical habitat for spawning. A summer flow of 0.5 cfs will maintain existing levels of trout production and provide suitable habitat for fry, juveniles and adults. A late summer, fall and winter flow of 0.3 cfs will maintain physical habitat at levels which naturally occur at existing base flows.

The limitation of flows strictly to the recommended flows may contribute to a decline in physical habitat quality over the long-term. For example, substrate fines may accumulate in spawning gravels due to a lack of cyclical major runoff events (e.g. bankful discharge) which could reduce spawning success. The absence of high natural runoff flows in the spring could also limit the recruitment of spawning gravels from the upper watershed. The lack of these channel maintenance flows may also lead to the encroachment of stream banks and a gradual narrowing of the stream channel. This process would reduce the total space available to trout, and in combination with the above processes, lead to reduced physical habitat suitability.

The WGFD does not presently have the expertise with methods used to determine appropriate channel maintenance flows. When this expertise is acquired, supplemental water rights for channel maintenance should be pursued.

Table 5. Summary of instream flow recommendations for Douglas Creek.

Time period	Discharge (cfs)
October 1 to April 30	0.3
May 1 to June 30	3.6
July 1 to September 30	0.5

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