INSTREAM FLOW REQUIREMENTS FOR
DINKEY CREEK, FRESNO COUNTY

Dennis P. Lee
Associate Fishery Biologist
Inland Fisheries Branch
1234 East Shaw Avenue
Fresno, CA 93710

ABSTRACT.

Instream flow requirements for fish were determined for Dinkey Creek in 1979, using methodology developed by the Cooperative Instream Flow Service Group of the U.S. Fish and Wildlife Service. The information was needed to establish minimum flow releases from a postponed hydroelectric project on Dinkey Creek.

Estimates of habitat available for brown and rainbow trout at several life stages and evaluation of natural flows in Dinkey Creek provided the opportunity to predict flows necessary to maintain trout populations at historical levels. Flow schedules developed (in cfs) were as follows:

Normal Water Year

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
14	36	36	36	36	36	36	36	36	20	8.0	5.4

Dry Water Year (less than 60% of normal)

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
7.0	18	25	25	36	36	36	36	36	9.0	3.0	3.0

Wet Water Year (greater than 135% of normal)

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
6	36	36	36	36	36	36	36	36	36	23	10

INTRODUCTION

Dinkey Creek is located in Fresno County on the west slope of the Sierra Nevada in Central California. It supports populations of trout and nongame fish. It is a part of the Kings River watershed and is currently being studied for hydroelectric development. The Kings River Conservation District (KRCD) has applied for a license to construct a dam near Dinkey Creek Meadow plus several diversions on downstream tributaries, for the purpose of storing water for power generation. The California Department of Fish and Game (DFG) initiated studies in the fall of 1978 to determine instream flow requirements for trout downstream from the proposed dam. The KRCD and DFG agreed to utilize methodology developed by the Cooperative Instream Flow Service Group (IFG) of the U.S. Fish and Wildlife Service for determining these needs. Field data were collected from July 1979 through October 1979 and computer analyses were completed in early 1980.

This report summarizes these studies and presents instream flow recommendations necessary to maintain trout populations in Dinkey Creek.

DESCRIPTION OF THE STUDY AREAS

Three study areas were selected in the 12 miles of Dinkey Creek between the proposed Dinkey Creek dam site and the confluence of the creek with the North Fork Kings River (Figure 1). Selection was based on typicalness to the overall stream area and relationship to incremental flows. Only that portion of stream necessary to represent the overall stream habitat was included in the study area. The uppermost study area was located downstream from the dam site and immediately upstream from the confluence with Bear Creek and included 787 ft of stream. The second study area was located both immediately upstream and downstream from the U.S. Forest Service (USFS) bridge crossing at Ross Crossing and was 1,683 ft in length. The final study area was located approximately 0.5 miles above the mouth of Dinkey Creek and was 353 ft in length.

All stations represented typical stream habitat comprised of pool and riffle areas of moderate gradient. Cover for trout was abundant in the form of deep pools, pocket water riffles, and instream boulders.

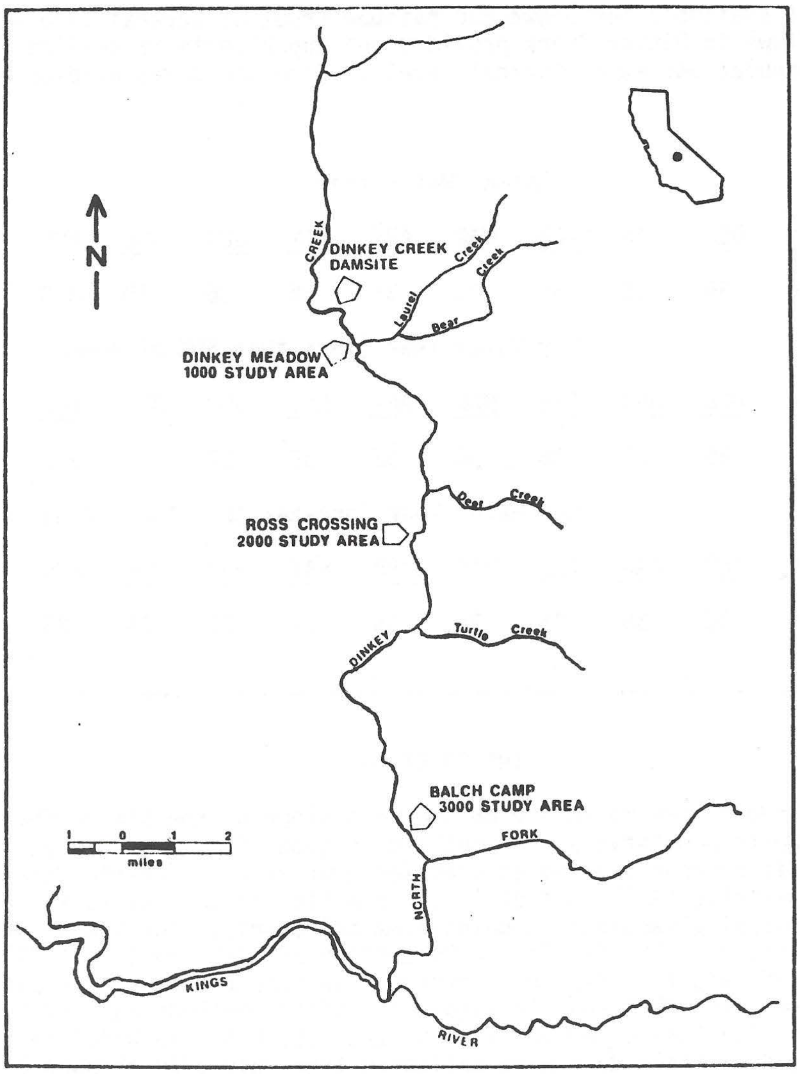

Figure 1. Dinkey Creek instream flow study area.

METHODS

The instream flow assessment method employed for this study was patterned after that developed by the IFG (Bovee and Milhous 1978). This methodology predicts the suitability of stream habitat for fish of a given species and life stage as defined by combinations of depth, velocity, and substrate occurring within a range of specified stream discharges. The applicability of the IFG methodology is predicated on several important assumptions:

A. Physical variables of depth, velocity, temperature, and substrate are important quantifiable parameters affecting fish production which change with streamflow. Important parameters affecting fish production such as water chemistry, light, and temperature were assumed constant for the Dinkey Creek study.

B. The probability that fish will choose to live in association with any particular stream condition of depth, velocity, or substrate can be described independently.

C. There is a direct relationship between the availability and actual use of the habitat by fish.

D. Habitat changes over a range of flows within a homogeneous reach of a river will correspond to the changes observed by study of a chosen representative segment (area) within the reach.

E. The hydraulic force of the selected flow regime will not alter the stream channel.

Based on a review of topographic maps and knowledge of the area, a total of 10 study stations (transects) were established for each of the 3 study areas during October 1978. Assistance with these efforts was provided by the U.S. Fish and Wildlife Service (USFWS), USFS and KRCD during on-site inspections of each candidate study area. Transect stations were established to cover habitat types (riffles, runs, pools) and major hydraulic controls (channel confinements which affected upstream water levels).

The downstream transect in each study area was located at a hydraulic control to improve simulation of riverflow movement and to provide a good estimate of river discharge during each period of field data collection. In one instance, an alternate location within the study area was used to provide an accurate estimate of river discharge.

From late July through November 1979, field data were collected at each station a minimum of three times as runoff flows decreased from slightly over 100 cfs to approximatley 5 cfs (Table 1). (Actual flows at each study area varied depending on snow melt and tributary inflow).

A steel tape was stretched across the river, perpendicular to the flow of the river at each study station. Permanently drilled eye bolts for tape attachment were placed on each river bank above the estimated high flow level and a reference zero point was established at one of the end stakes. Water velocity and depth measurements were taken along the tape every 2 ft between the banks.

Velocities were measured as mean column velocity with one measurement taken at 0.6 total depth (from surface) if the depth was 2 ft or less, or the average of two measurements taken at 0.2 and 0.8 total depth, if the depth exceeded 2 ft. All velocity measurements were taken using Price-Gurley current meters. Depths were measured to the nearest 0.1 ft using hand held top-setting wading rods where depth permitted. In pools deeper than 6 ft, measurements were taken from a small pram.

During measurements at low flows, substrate conditions were evaluated at each established measurement interval either visually or by physically scraping the riverbed to estimate sizes and mixtures of substrate materials. Substrate values were recorded using a graduated modified Wentworth scale of 1 to 8 (Table 2).

TABLE 1

Streamflows Measured at Three Study Areas of Dinkey Creek During the Instream Flow Study

Study Area	Date	Flows Measured (cfs)
1000 (Dinkey Meadow)[1/]	9-4-79	5.5
	7-16-79	26.8
	7-5-79	47.5
2000 (Ross Crossing)	10-4-79	11.7
	8-3-79	31.2
	7-25-79	48.2
	7-6-79	91.2
3000 (Balch Camp)	10-10-79	13.5
	8-16-79	28.2
	7-26-79	55.1
	7-7-79	105.0

1/ Arbitrary values were assigned to the various study areas for computer identification.

TABLE 2

Dinkey Creek Instream Flow Study
Substrate Evaluation Scale[1/]

Scale Value	Substrate Type	Approximate Size Range (mm)
1	Plant detritus	-
2	Mud	.06 (deep layer)
3	Silt	.06 (shallow layer)
4	Sand	.06-4
5	Gravel	4-130
6	Rubble	130-220
7	Boulder	220-4000
8	Bedrock	4000

1/ Size ranges are approximate as used for this study. Substrate conditions were ranked qualitatively as being either within or as mixtures of these categories based on visual and touch observations made during the low flow period of the study.

Relative water surface elevations at each transect within the study area were referenced to an arbitrary datum (benchmark) using an engineer's level and a stadia rod. Water surface elevations were shot each time velocity and depth measurements were taken at the study stations.

Habitat preference curves for use in calculating usable habitat were developed by the IFG and reviewed by DFG fishery biologists (Bovee 1978). The habitat curves were based on the likelihood of use of a range of velocity, depth, or substrate conditions for a particular life stage of a species.

Data coding for computer processing was completed in 1979, using procedures outlined in draft Instream Flow Group User Manuals (Main 1978a, 1978b). Data processing services were provided by the U.S. Water and Power Resources Service, Sacramento, with a link to a main frame computer in Denver, Colorado. Hydraulic simulation of river flows through the study reaches was undertaken using the USFWS's IFG-4 Program to establish stage (water level) versus discharge (flow volume) relationships (Appendix 1).

Usable habitat projections within each study reach were made for a series of simulated flows ranging from 5.5 cfs to 105 cfs using the IFG HABITAT Program (Appendix 2) and data input from the IFG-4 Program. Primary output from the HABITAT Program was available habitat area per 1000 ft of river for each life stage of each species of interest.

Recommended flow releases for various portions of Dinkey Creek downstream from the proposed dam were based on considerations of habitat/flow relationships developed with the IFG-4 and HABITAT Programs, the seasonal occurence and importance of salmonid life stages in Dinkey Creek, the historic availability of water under natural conditions, and the estimated "base flow" accretions from tributaries which could be expected to increase the riverflow within each of the study reaches.

The tributary flow estimates were developed by the KRCD using stream gauge data where available and standardized procedures for computing discharges in unguaged streams.

RESULTS

Weighted usable habitat estimates were expressed as the square feet of usable habitat per 1000 feet of stream for the various life stages of rainbow and brown trout. These estimates are presented by study area at arbitrarily selected flows in Appendix 3. The data are also presented in graphic form within this report on a species life-stage basis (as straight line plots between analysis points).

For rainbow trout, no spawning habitat was predicted at the 1000 study area and only very small amounts (less than 2% of the gross area) at the two lower study areas. Adult rainbow trout habitat increased directly with flows at all stations except the 2000 study area (Figures 2, 3, and 4). At the 2000 study area, the amount of habitat available to adults at 91.7 cfs was slightly reduced from that at 75 cfs. At the 1000 study area, usable juvenile rainbow trout habitat was greatest at flows of 47.5 cfs (Figure 2). Juvenile habitat was maximized at flows of 36 and 45 cfs at the 2000 and 3000 study areas respectively (Figures 3, 4). The amount of rainbow trout fry habitat varied at different flows at all study areas and was maximized at flows of 20, 31, and 28.2 cfs at the 1000, 2000, and 3000 study areas respectively (Figures 2, 3, and 4).

No habitat was available for brown trout spawning at the 1000 study area and, like rainbow trout spawning habitat, was very limited in the lower two study areas. Adult brown trout habitat was maximized at 36 cfs at the 1000 study area and at 48 cfs and 75 cfs at the 2000 and 3000 study areas, respectively (Figures 2, 3, and 4). Significant increases (more than 5%), however, in usable adult habitat were not noted above 36 and 40 cfs at the 2000 and 3000 stations respectively. Fry and juvenile habitat follow similar increases as streamflows increased (Figures 2, 3, and 4). Both habitat types appeared to be maximized at flows greater than 15 cfs with some decrease in the amount of usable habitat as flows exceeded approximately 25 cfs.

DISCUSSION AND CONCLUSIONS

The instream flow assessment method used on Dinkey Creek worked well for simulation of

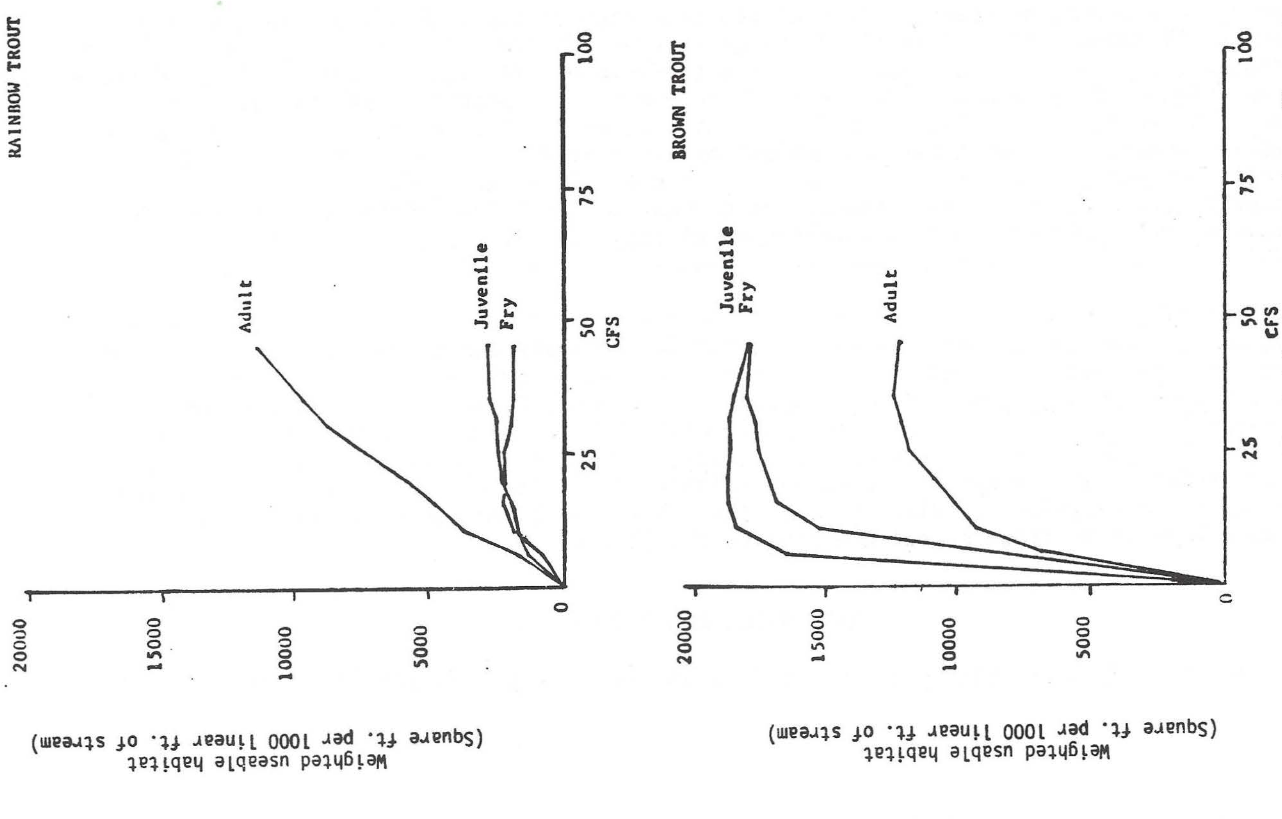

Figure 2. Weighted useable habitat versus streamflow at Study Area 1000, Dinkey Meadow, Dinkey Creek.

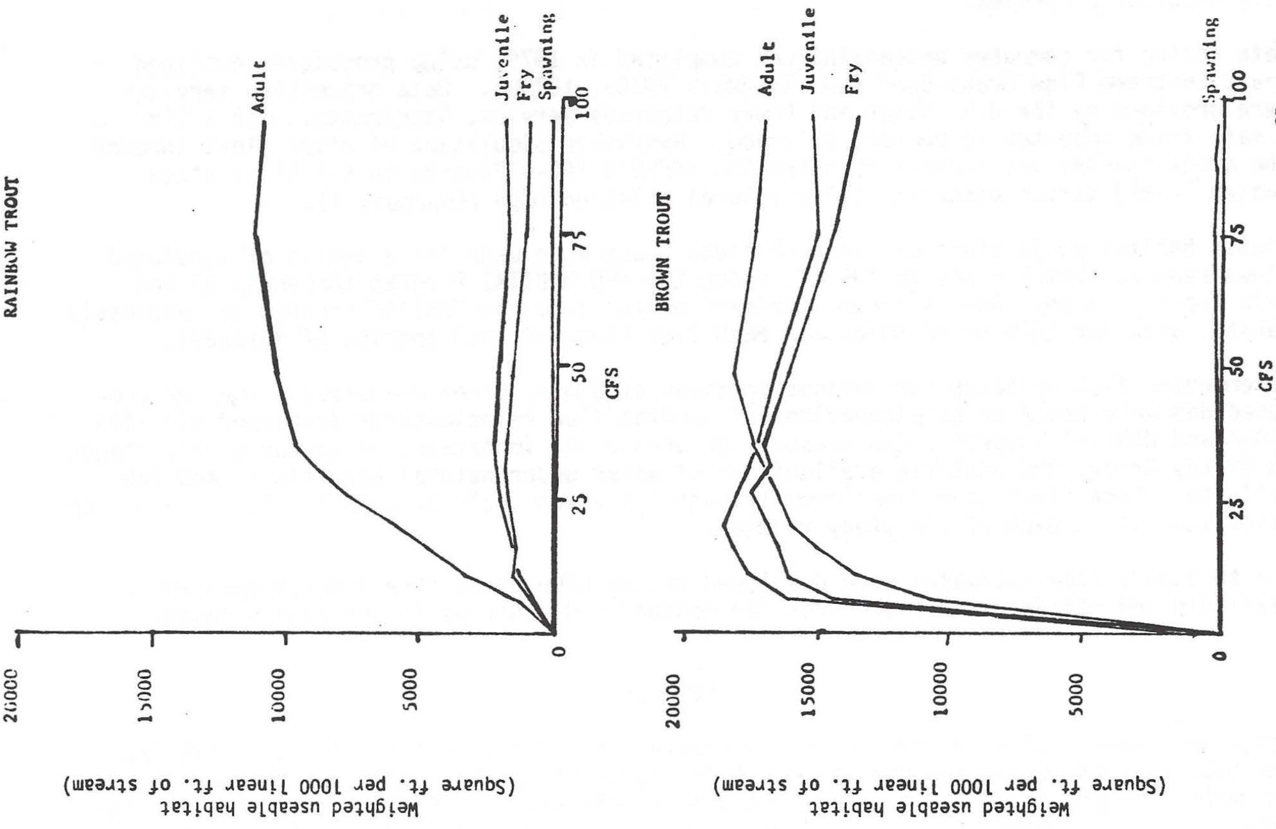

Figure 3. Weighted useable habitat versus streamflow at Study Area 2000, Ross Crossing, Dinkey Creek.

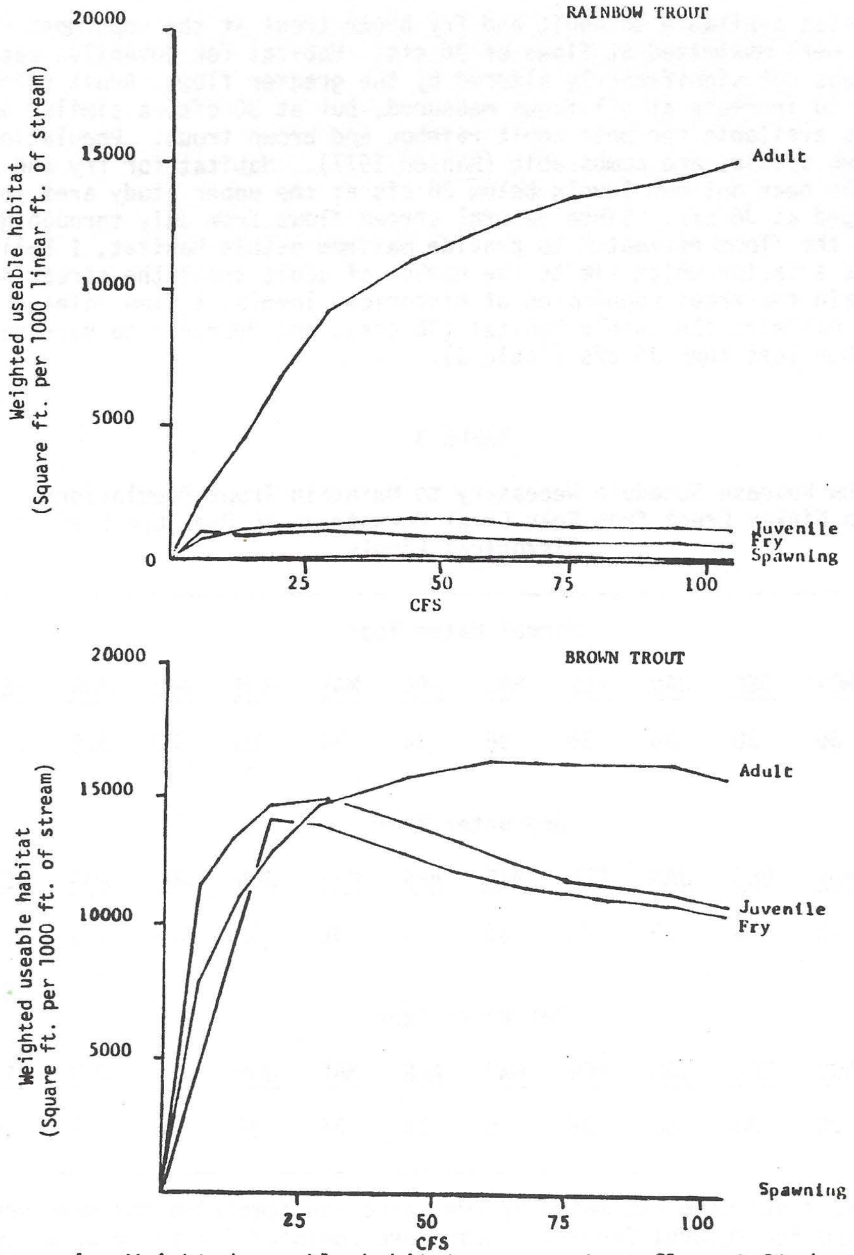

Figure 4. Weighted useable habitat versus streamflow at Study Area 3000, Balch Camp, Dinkey Creek.

flows within the desired range of 5 to 50 cfs. The additional or fourth flow measured at the two lowermost study areas provided additional data for plotting the weighted usable habitat versus stream flow curves. Difficulties were encountered at one transect located at the 2000 study area where velocities were not measurable in a very wide and deep pool at the lowest stream flow measured. It was necessary to predict velocities at that station in order to complete the hydraulic stream simulation of the stream. Difficulties were also encountered with flow calibration at all stations where negative velocities associated with the occurrence of eddies were recorded. In all instances, it was necessary to assign absolute values to the negative velocity measurements. Although the negative flows were small compared to the dominant channel, the reversal of values caused the corresponding discharge estimates for the affected sections to increase proportionately to the velocity reversals. Eddies were encountered at one or more stations in each of the study areas resulting in a tendency to slightly overestimate the corresponding flow and alter the estimated habitat. This occurred because flow directions (either upstream or downstream) was not a concern in determining usable habitat.

The amount of habitat available to adult and fry brown trout at the uppermost study area (1000 study area) were maximized at flows of 36 cfs. Habitat for juveniles was maximized below 36 cfs but was not significantly altered by the greater flow. Adult rainbow trout habitat continued to increase at all flows measured, but at 36 cfs, a similar amount of usable habitat was available for both adult rainbow and brown trout. Population composition of the two species are comparable (Hansen 1977). Habitat for fry and juvenile brown trout reaches near optimum levels below 36 cfs at the upper study area, but is not dramatically changed at 36 cfs. Since natural stream flows from July through November are usually below the flows estimated to provide maximum usable habitat, I believe this low flow period is a factor which limits the number of adult trout the stream can hold. In order to maintain the trout population at historical levels, a flow release is required which will maximize the usable habitat (36 cfs), and decrease to near natural flow conditions when less than 36 cfs (Table 3).

TABLE 3

Flow Release Schedule Necessary to Maintain Trout Populations in Dinkey Creek from Bear Creek Downstream to Deer Creek at Historical Levels

Normal Water Year

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
14	36	36	36	36	36	36	36	36	20	8.0	5.4

Dry Water Year

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
7.0	18	25	25	36	36	36	36	36	9.0	3.0	3.0

Wet Water Year

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
6	36	36	36	36	36	36	36	36	36	23	10

Naturally occurring flows were estimated by averaging and combining the mean monthly flows for Dinkey and Bear/Laurel Creeks. These were computed for three water year types based on the following criteria:

Normal water year - Stream flows range from 60-135% of the mean historical value.
Dry water year - Stream flows are equal to or less than 60% of the mean historical value.
Wet water year - Stream flows are equal to or greater than 135% of the mean historical value.

Fifty nine years of records were used in the computation of which 33 were classified as normal, 13 as dry, and 13 as wet water years (Appendix 4).

During a normal year, the flow release schedule provides two transition months (July and October) for the maintenance flows to decrease (July) and increase (October) from the late summer, low flow period. Since stream flows normally drop dramatically during a dry water year, the July transition month is not as significant as during a normal water year, and November becomes the fall transition month. Conversely, July stream flows are significantly above the maintenance flow during a wet water year and August is a transition month. Mean natural monthly flows during October under the 135% or greater wet year criteria present an unusual situation. Flows are significantly less than a normal year and are comparable to a dry year average. This is due to the fact that early season rainfall and/or snow melt is delayed to a later time in the water year. During the months of December and January, the dry year schedule provides flows which reduce habitat for adult rainbow trout by 33% and adult brown trout habitat by 10% as compared to normal water years.

"Base Flow" accretions from tributaries in the reach from Deer Creek to Turtle Creek were computed as 5 cfs and represent the minimum flow release for Deer Creek as provided in the Dinkey Creek Hydroelectric License. The Deer Creek accretion flow of 5 cfs and the recommended flow schedule as measured below the confluence of Bear and Laurel Creeks will provide the following estimated flows (cfs) at the 2000 study area (Ross Crossing) during normal years:

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
19	41	41	41	41	41	41	41	41	25	13	10.4

The November through June mean monthly flows result in a 12% decrease in adult rainbow trout habitat from the maximum potential habitat available at 75 cfs, and 1 and 6% reductions in maximum potential habitat available for juvenile and fry, respectively. Late summer stream flows reduce habitat proportionally but approximate the historical natural flows at that time of the year. At flows above 36 cfs, there exists up to 5 times more usable habitat for adults than for fry or juvenile rainbow trout, however, as flows decrease, the proportion of adult habitat is reduced accordingly. This again suggests that late summer adult habitat probably limits the number of rainbow trout in this study area.

Usable habitat for brown trout shows a trend similar to rainbow trout habitat at the 2000 study area (Ross Crossing). Adult and fry habitat at 41 cfs is reduced only 2% and 4%, respectively below the potential optimum habitat available. Habitat for juvenile brown trout is similarly decreased 7%. Comparison of the amount habitat available for juvenile and fry with habitat available for adults suggests that adult brown trout habitat does not reach as near optimum levels as the other life histories during late summer stream flows.

Accretion flows in the reach of Dinkey Creek from Ross Crossing downstream to the 3000 study area (Balch Camp) plus the stream flows released below Ross Crossing will result in the following estimated mean monthly flow (cfs) pattern at the 3000 study area (Balch Camp):

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
24	50	55	53	68	68	91	97	74	41	16	14.4

This flow pattern is less than the natural mean monthly flows at the mouth of Dinkey Creek with the exception of September (20% increase). The flow pattern appears to provide a sufficient amount of usable adult rainbow and brown trout habitat as compared with the other study areas with the exception of the late summer stream flows for rainbow trout. Although the rainbow trout adult habitat is not optimized at the range of flows measured, 15 cfs provides approximately one-third of the usable habitat provided by the winter flows. Adult brown trout habitat, however, is maximized at 75 cfs. The 14-16 cfs summer flow decreases the habitat by only 25%. Fry and juvenile rainbow trout habitat appears to be limited at all flows examined but did not show any significant increase or decrease above a flow of 5.5 cfs. Fry and juvenile brown trout habitat was maximized at flows of 20 and 28.2 cfs respective but did not significantly change over the predicted range of stream flows.

In conclusion, I believe that if the minimum instream flow releases are maintained in Dinkey Creek as outlined in the recommended flow schedule, the historical population size of trout in Dinkey Creek will not be significantly altered. If the late summer period is in reality a limiting factor in determining the trout population size, some increase in the carryover capabilities of the stream may be realized in extreme dry years.

LITERATURE CITED

Bovee, K.D. 1978. Probability-of-use criteria for the family salmonidae. Instream Flow Information Paper No. 4. U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

Bovee, K.D. and Robert Milhous 1978. Hydraulic simulation in instream flow studies: theory and techniques. Instream Flow Information Paper No. 5. U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

Hansen, P. 1977. Field notes to the Files, California Department of Fish and Game, Region 4, 1234 E. Shaw, Fresno.

Kings River Conservation District 1978. Kings River Hydroelectric Project, Unit 3 - Dinkey Creek Project, Environmental Report, Exhibit W, Vol. 1, pages II-126 - II-129.

Main, R. 1978 a. Habitat program user manual. U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

1978 b. IFG4 Program user manual. U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

NOTE: APPENDICES NOT INDLUCED IN THIS PUBLICATION - TO OBTAIN COPY OF APPENDIX 1-4 PLEASE CONTACT AUTHOR.