INSTREAM FLOW REQUIREMENTS FOR RAINBOW AND BROWN TROUT IN THE TUOLUMNE RIVER BETWEEN O'SHAUGHNESSY DAM AND EARLY INTAKE

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INTRODUCTION

The Hetch Hetchy water and power system, an integrated system of water supply and hydroelectric facilities, was constructed by the City and County of San Francisco under terms of easements issued by the United States Department of the Interior pursuant to legislation enacted by the U. S. Congress in 1913 (the Raker Act, 38 Stat. 242).

Staged construction of project facilities within the Hetch Hetchy system has taken place since 1913. First, O'Shaughnessy Dam was built at the lower end of Hetch Hetchy Valley in Yosemite National Park. Storage in Hetch Hetchy Reservoir, formed behind the dam, began in April 1923. A diversion dam and tunnel entrance (known as Early Intake) was also constructed 12.1 river miles downstream in the Stanislaus National Forest. From 1925 to 1967, water released from Hetch Hetchy Reservoir was diverted from the river at Early Intake and transported, by tunnel, 20 miles to a powerhouse on Moccasin Creek, a tributary to the Tuolumne River further downstream. At Moccasin Creek, Hetch Hetchy water enters the Hetch Hetchy Aqueduct and is conveyed 120 miles to San Francisco.

Subsequently, the Canyon Power Project was constructed as part of the Hetch Hetchy System, and was completed in 1967. Its principle features include a

diversion facility at O'Shaughnessy Dam, a 12 mile conveyance tunnel along the north canyon wall of the Tuolumne River, and the Robert C. Kirkwood powerhouse, constructed just upstream of the Early Intake diversion. This project was approved by the Secretary of the Interior on April 27, 1961 provided that "[t]he interests of sport fishery and recreation can be protected by requiring continuing releases of water from O'Shaughnessy Dam to maintain the Tuolumne as a **live** [emphasis added] stream between the dam and Early Intake." Included within this approval were stipulations for: 1) minimum instream flows between O'Shaughnessy Dam and Early Intake; and 2) a two year study to determine the adequacy of the prescribed minimum instream flows for the resident fishery, recreational use, and aesthetics.

In August 1967 the U. S. Fish and Wildlife Service completed a report describing the interagency study conducted pursuant to the Secretary's 1961 approval and presented a recommended release schedule to protect the fishery, recreational use, and aesthetic value of the affected reach of the Tuolumne River. Negotiations subsequent to completion of the fishery and recreation study resulted in instream flow schedules providing 59,235 acre-feet, 49,994 acre-feet, or 35,197 acre-feet of water for fishery flows, depending on rainfall and reservoir storage within the Hetch Hetchy basin.

In 1985 the City and County of San Francisco was granted approval by the Secretary of the Interior to install a third generator at the Kirkwood powerhouse. This approval was predicated on an agreement between San

Francisco, California Trout, Friends of the River, the Sierra Club, and the Tuolumne River Preservation Trust, which provided additional river flows of 15,000 acre-feet, 6,500 acre-feet, or 4,400 acre-feet, to mitigate any deficiencies in the existing fishery flow releases. This agreement also included an additional 4 year study to document flow needs and habitat affects.

In 1987 the City and County and the Department of the Interior reached agreement regarding a study to be completed to determine the affect of operation of the new generator on the Tuolumne River fishery resources between O'Shaughnessy Dam and the diversion dam at Early Intake. This study is generally called the Hetch Hetchy Fishery Investigation and includes four major elements. These are: 1) a detailed instream flow analysis, using the Service's instream flow incremental methodology (IFIM); 2) development of habitat suitability curves for rainbow and brown trout within the affected reach of the Tuolumne River; 3) a population survey of adult and juvenile rainbow and brown trout within the affected reach; and, 4) a review of existing temperature data and development of a temperature model for the affected reach.

This report describes results of efforts undertaken by Service personnel under study element 1 of the Hetch Hetchy Fishery Investigation and provides recommendations regarding instream flows to be released from O'Shaughnessy Dam to protect the fishery resource.

DESCRIPTION OF STUDY AREA

General Setting

The Tuolumne River originates at an elevation of 13,000 feet above mean sea level on the western slope of the southern Sierra Nevada mountains of California. It flows approximately 185 miles in a westerly direction, eventually joining the San Joaquin River and flowing into the Pacific Ocean (Figure 1). Of glacial origin the Tuolumne flows westerly across the Tuolumne meadows area of Yosemite National Park, over the falls and cascades of the "Grand Canyon of the Tuolumne" and into the 8 mile long Hetch Hetchy Valley. Since O'Shaughnessy Dam was completed in 1923, Hetch Hetchy Valley has been submerged below Hetch Hetchy Reservoir. Below O'Shaughnessy Dam the river drops from pool to pool over cascades, riffles, and pocket waters until it reaches Poopenaut Valley. Leaving Poopenaut Valley the Tuolumne River flows through an extremely deep gorge characterized by sheer granite walls 1,000 feet tall. Exiting the gorge area, the river passes through Mather Pool, over Preston falls, and courses through Preston Meadow and on into Indian Meadow. Below Indian Meadow and before the River reaches the confluence of Cherry Creek it encounters the Early Intake diversion dam where, prior to 1967, much of the river flow was diverted into a tunnel where it begins the 140 mile journey to San Francisco. Below Early Intake, the Tuolumne continues westerly into Don Pedro Reservoir below which it finally leaves the Sierra Nevada and

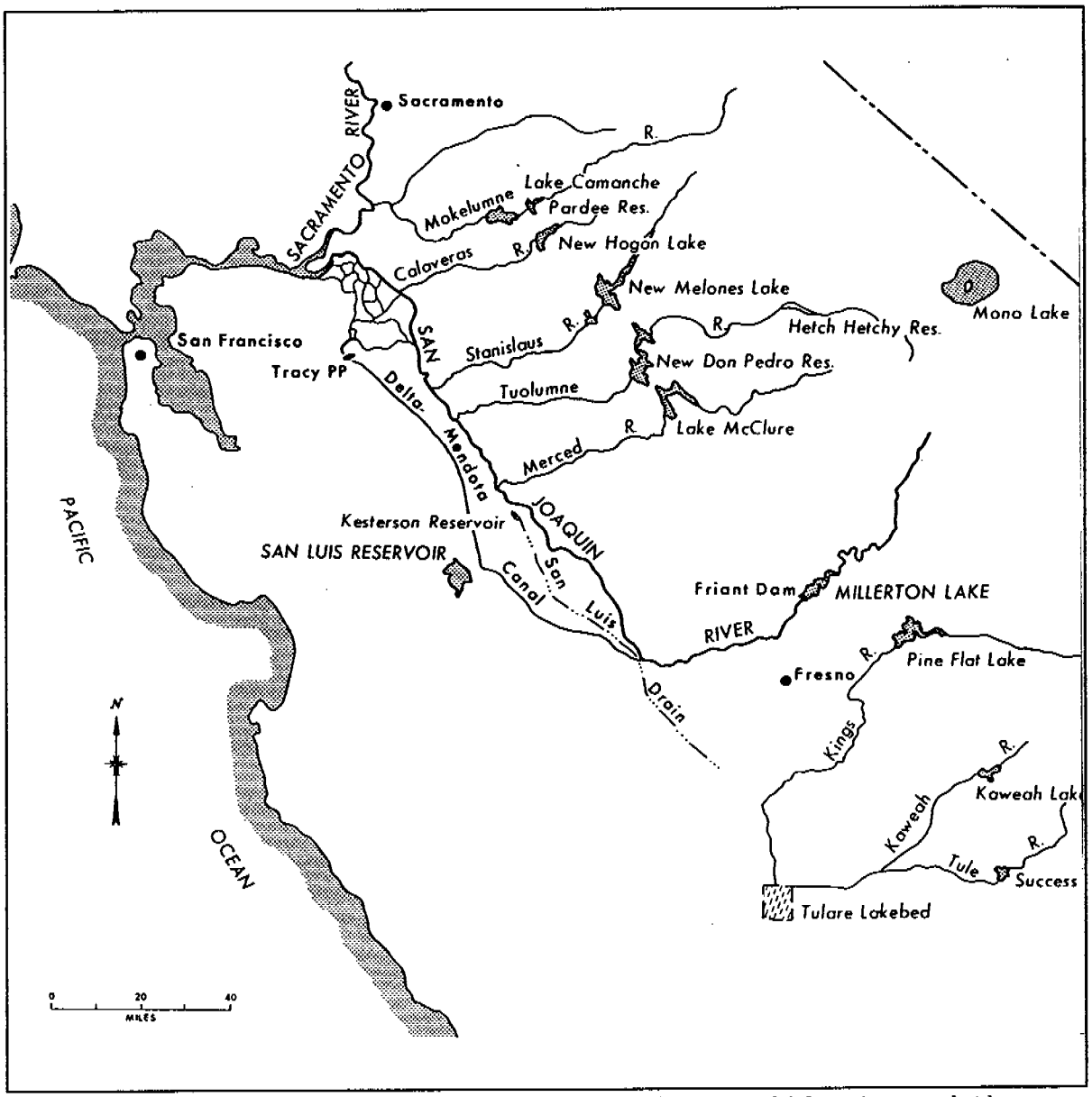


Figure 1. General location of the Tuolumne River, California, and the Hetch Hetchy Fishery Investigation Study Area.

its foothills, crosses the eastern floor of the San Joaquin Valley and ultimately flows into the San Joaquin River near the town of Modesto, California. Eventually, the waters of the Tuolumne River flow into the Sacramento-San Joaquin River Delta, through the San Pablo Bay-San Francisco

Bay complex and into the Pacific Ocean, passing beneath San Francisco's famous Golden Gate.

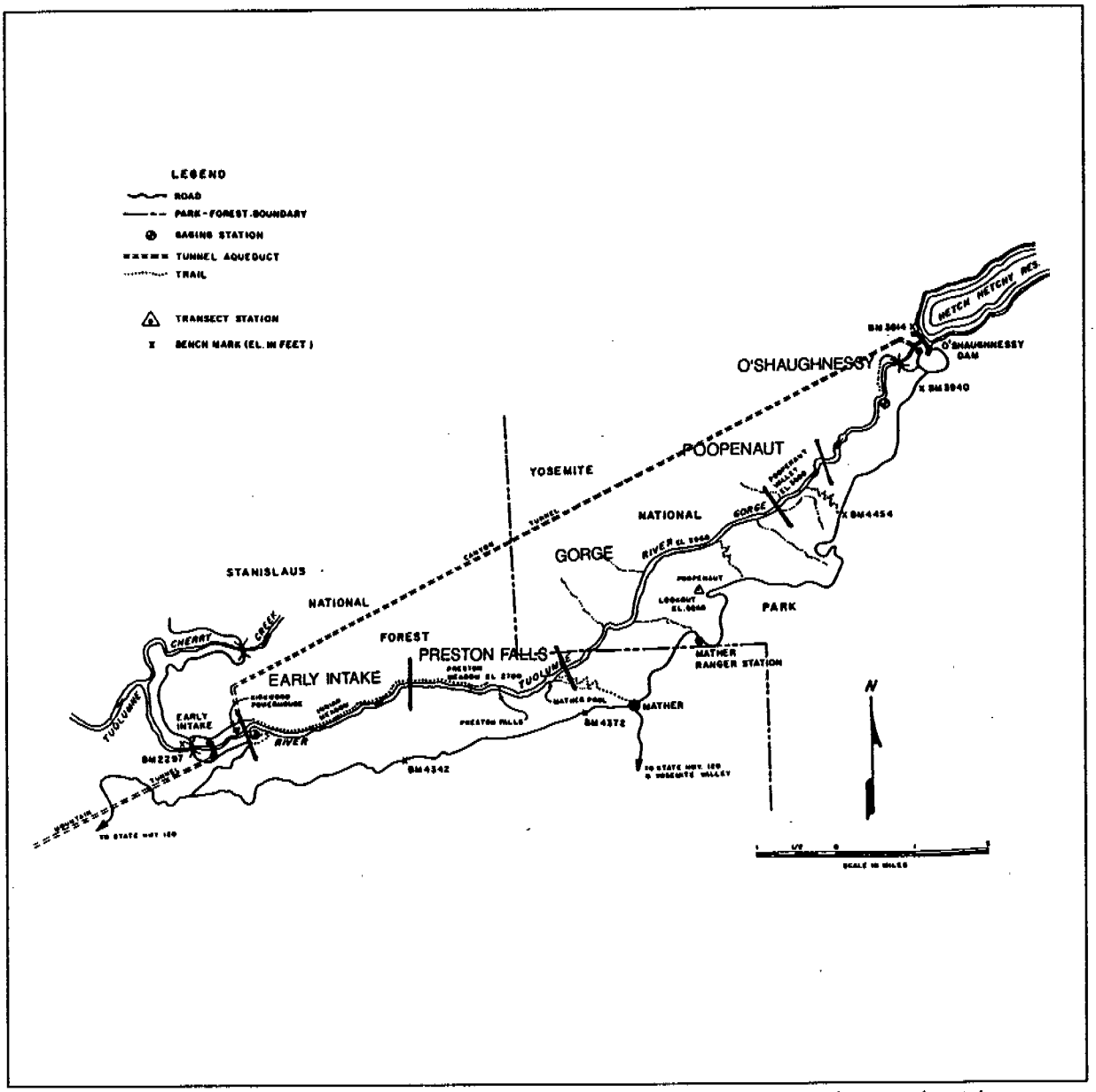


Figure 2. Detailed map of the Hetch Hetchy Instream Flow investigation study area.

The study reach for this investigation begins at O'Shaughnessy Dam, at an elevation of 3,814 feet above mean sea level, in the northwestern corner of Yosemite National Park, and extends to Early Intake 12.1 miles downstream at an elevation of 2,297 feet above mean sea level. About half the study reach falls within the National Park, the other half falls within the Stanislaus National Forest. Between O'Shaughnessy Dam and Early Intake, 12.1 miles of trout habitat is available in the Tuolumne River. Within the study reach no tributaries enter the Tuolumne, although there are a number both above and below the area. A detailed map of the study reach is provided in Figure 2.

Hydrology

Historical flow records for the Tuolumne River exist only for the years 1911 through 1916. These records were taken at the lower Hetch Hetchy Valley and are illustrated in Figure 3.

Since storage began in Hetch Hetchy Reservoir in April 1923, Tuolumne River flows below O'Shaughnessy Dam have been controlled by the City and County of San Francisco through operation of the Hetch Hetchy Water and Power Project. Until 1967 water was released from Hetch Hetchy Reservoir at O'Shaughnessy Dam into the Tuolumne River. It was diverted 12.1 miles downstream at Early Intake into the Hetch Hetchy Aqueduct. For the most part flow patterns seemed to remain as they had been prior to 1923 expect that the magnitude of high flows was significantly reduced (Figure 4). Flow reductions, however, were

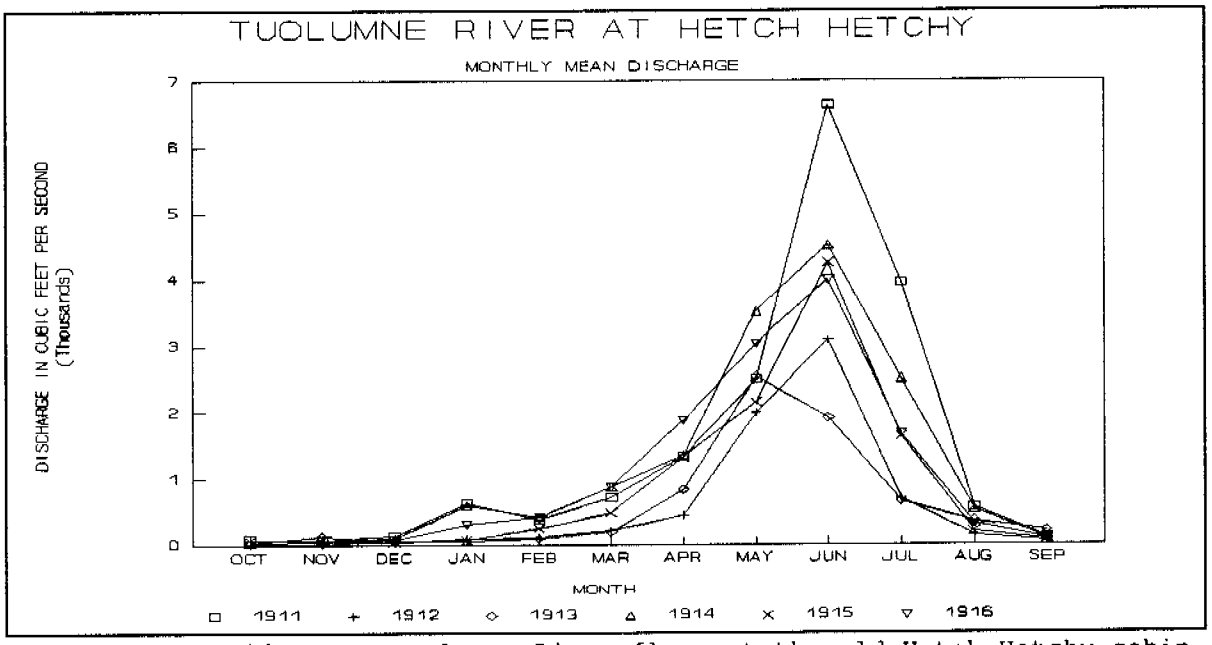


Figure 3. Monthly mean Tuolumne River flows at the old Hetch Hetchy cabin site and near the future O'Shaughnessy Dam site for the years 1911 through 1916.

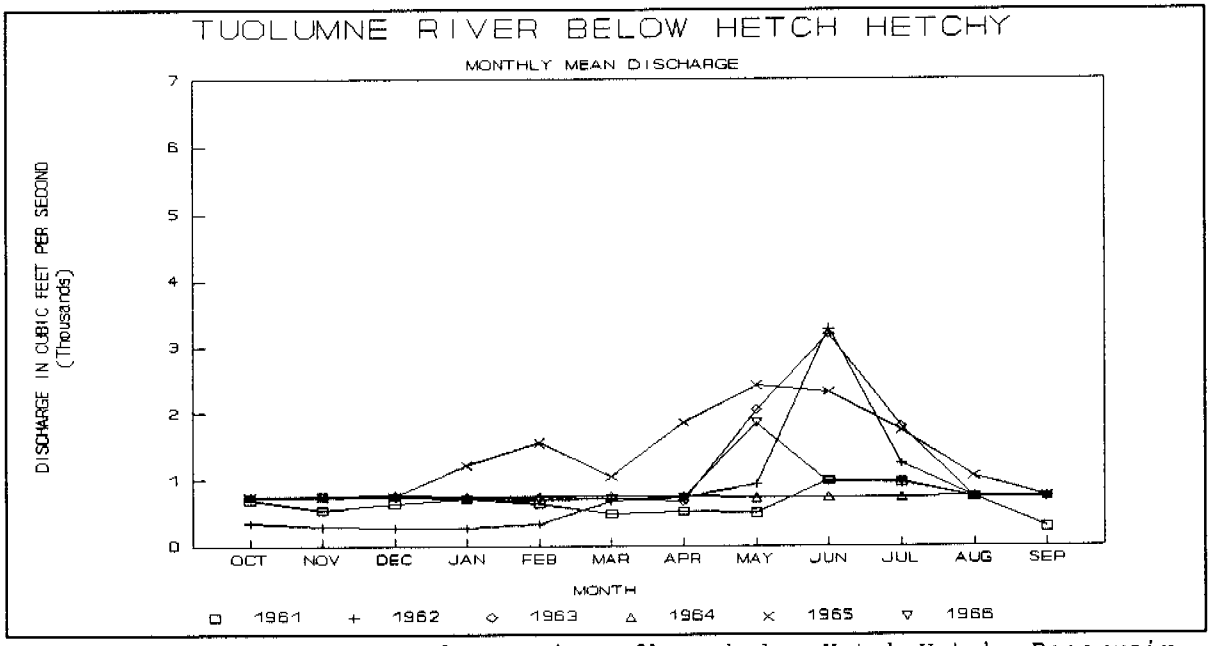


Figure 4. Monthly mean Tuolumne River flows below Hetch Hetchy Reservoir for the water years 1961 through 1966.

most significant during the spring and summer months.

Through an agreement between the City and County of San Francisco, the Department of the Interior, the Department of Agriculture, and the State of California between 39,597 acre-feet and 74,207 acre-feet of water is currently

Table I. The minimum amounts of water to be released from Hetch Hetchy Reservoir to the Tuolumne River at O'Shaughnessy Dam by water year schedule along with additional "mitigation" water provided under agreement in 1985.

	Minimum Monthly Release Schedule (CFS)			Cumm. Precip.(in.) or runoff (AF)	
Month	A	B	C	A >	B > C
January	50	40	35	8.8	6.1
February	60	50	35	14.0	9.5
March	60	50	35	18.6	14.2
April	75	65	35	23.0	18.0
May	100	80	50	26.6	19.5
June	125	110	75	28.5	21.3
July	125	110	75	575,000	390,000
August	125	110	75	640,000	400,000
September 1-15	100	80	75	---	---
September 16-30	80	65	50	---	---
October	60	50	35	---	---
November	60	50	35	---	---
December	50	40	35	---	---
MINIMUM RELEASE (AF)	59,207	49,994	35,197		
Added "mitigation" release for water year (AF)	15,000	6,500	4,400		
TOTAL ANNUAL FISHERY ALLOCATION (AF)	74,207	56,494	39,597		

available to protect the fishery resources between O'Shaughnessy Dam and Early Intake. The actual annual volume of water is based on cumulative rainfall from January through June and on reservoir storage criteria for the months of July and August. The current annual water allocation schedules for fishery flows into the Tuolumne River below O'Shaughnessy Dam, along with rainfall and storage criteria, are provided in Table I.

Additional mitigation water has also been provided since 1985 and varies with water year flow schedule. This mitigation water is used to increase instream flows, as necessary, and is provided according to schedules provided by the Fish and Wildlife Service.

Mean monthly Tuolumne River flows below O'Shaughnessy Dam for the past twenty years are illustrated in Figure 5.

Fishery Resources

The fishery resources of the Tuolumne River are significant. Rainbow trout (*Onchorhynchus mykiss*) and brown trout (*Salmo trutta*) inhabit the reach of the river between Hetch Hetchy Reservoir and Early Intake. In 1976 the Service estimated that the 12.1 mile reach of the Tuolumne River between O'Shaughnessy Dam and Early Intake supported about 8,000 wild rainbow and brown trout 6.5 inches in length or larger (USFWS, 1976). More recently, population estimates

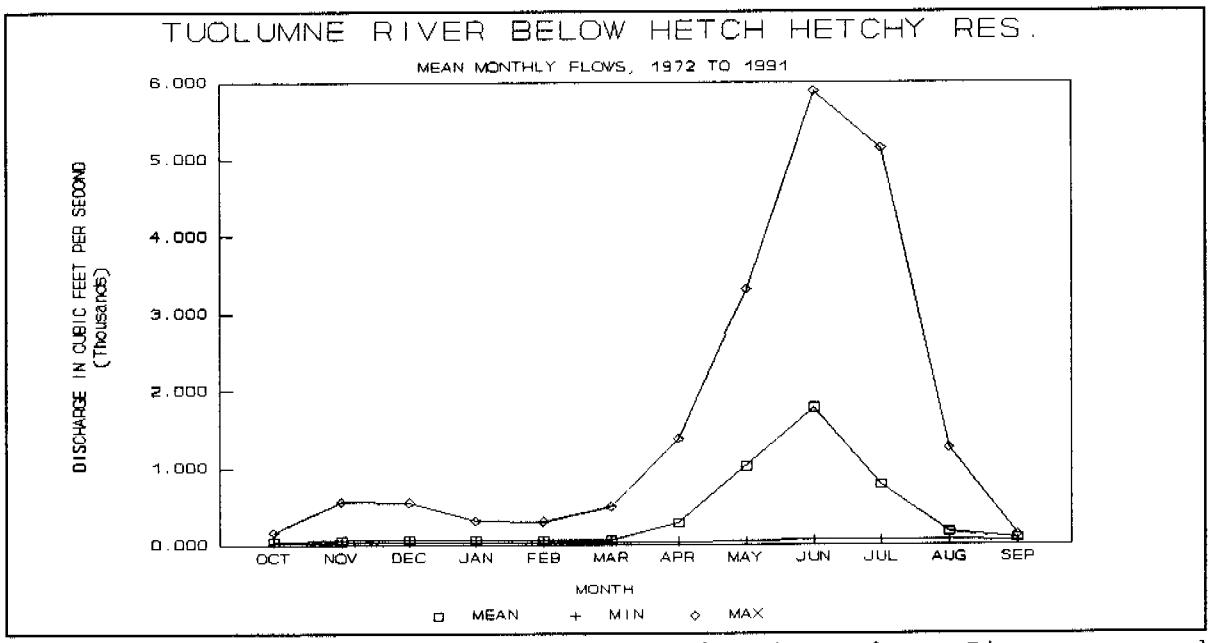


Figure 5. Monthly discharges (streamflow) for the Tuolumne River, measured just below O'Shaughnessy Dam for the years 1972 through 1991.

conducted as part of the Hetch Hetchy Fishery Investigation have estimated approximately 7,000 adult trout for the study reach (USFWS 1990). Other fish species are also found within the study reach and include California roach (*Hesperoleucus symmetricus*), sculpin (*Cottus* spp.), and suckers (*Catostomidae* spp.).

At one time the Tuolumne River supported annual runs of chinook salmon numbering upward of 100,000 or more. Many of these fish are believed to have migrated upstream into the study area as far as Preston Falls, about half way between O'Shaughnessy Dam and Early Intake.

Steelhead trout were also thought to occur within the Tuolumne River and may, in fact, have migrated well past Preston Falls and Hetch Hetchy Meadow, currently submerged below Hetch Hetchy Reservoir, in Yosemite National Park.

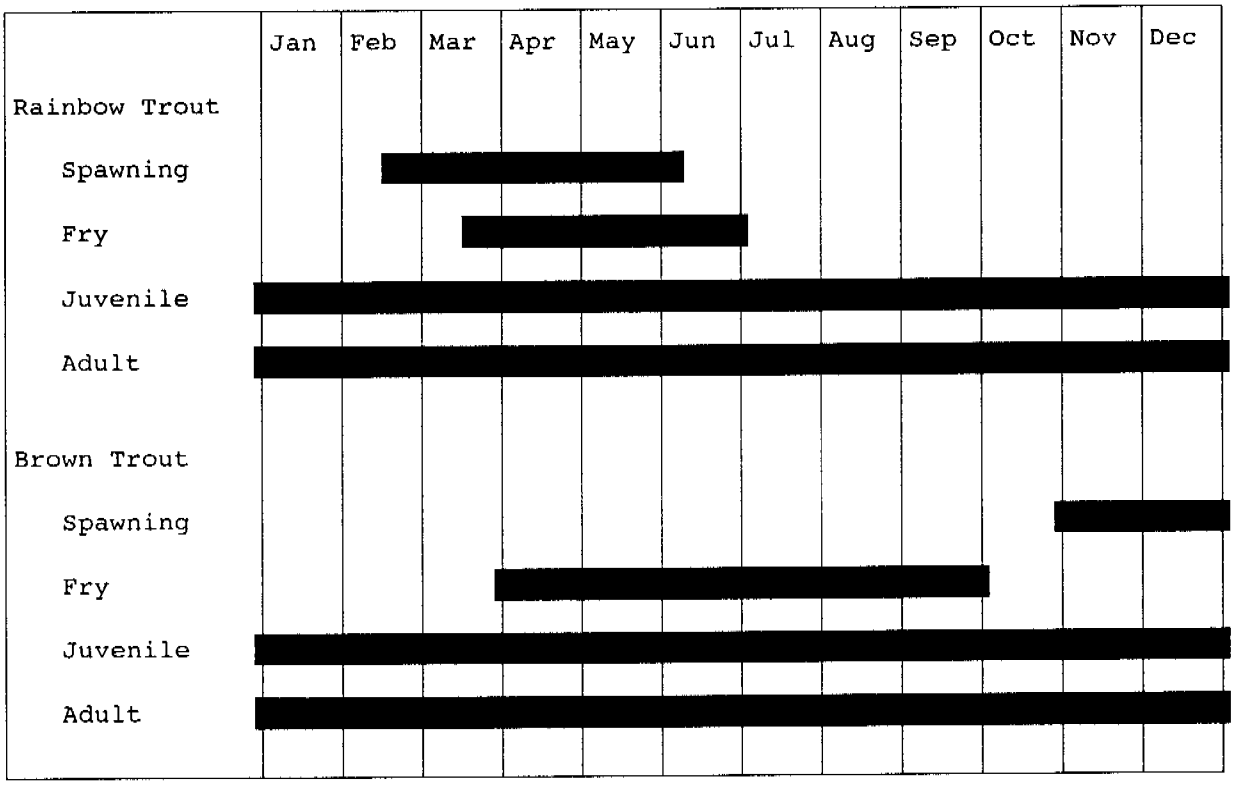
The existence of anadromous fishes within the study area was eliminated following construction of LaGrange Dam in 1915. This dam is located on the Tuolumne River near the town of LaGrange, California.

Rainbow trout and brown trout are the target species for this study. All lifestages (spawning, fry, juvenile, and adults) have been observed within the study reach. Table II is a lifestage periodicity chart for trout in the Tuolumne River between O'Shaughnessy Dam and Early Intake.

IFIM Study Sites

The Tuolumne River between O'Shaughnessy Dam and Early Intake was first surveyed by air and then on foot (except for that reach between Poopenaut Valley and Mather Pool). The study reach was subsequently divided into 5 river sections. These sections were determined based on general stream channel configuration, aquatic habitat types, overall gradient, and fish population assemblage and are identified as: 1) the Early Intake reach ; 2) the Preston Falls reach; 3) the Gorge reach; 4) the Poopenaut Valley reach; and, 5) the O'Shaughnessy reach.

Table II. life stage periodicity chart for rainbow trout and brown trout inhabiting the Tuolumne River between O'Shaughnessy Dam and Early Intake.



During the spring of 1988 aquatic habitat mapping was completed for the entire study reach. Twelve habitat types were described. These are: deep pools, shallow pools, pocket water, cascades, cascade/deep pool, cascade/pocket water, chutes, riffles, runs, glides, side channels, and backwaters.

Complete descriptions of the 5 river sections, measured lengths and areas of each habitat type within these sections, along with habitat maps are provided in Appendix A.

Of the 12 habitat types identified and mapped we found that 6 (deep pools, shallow pools, pocket water, run, riffle, and cascade/pocket water) made up 93.9 percent of the total habitat available between O'Shaughnessy Dam and Early Intake. Steep gradient, high velocity cascade and chute habitats, and a combination of cascade/deep pool habitats made up 4.6 percent of the remaining habitat area, while low gradient glides, side channel, and backwater habitats were found to amount to only 1.5 percent of the total available habitat within the study area. Therefore, we decided that stream hydraulic data (velocities and depths) along with substrate and cover data necessary to describe the physical habitat available at various flows would be gathered mainly within the 6 main habitat types for use in the instream flow evaluation. A total of 29 transects were eventually selected.

METHODS

The Service's Instream Flow Incremental Methodology (IFIM) (Bovee and Milhouse 1978; Milhouse et al. 1981; Bovee 1982) was used for this evaluation. The IFIM was developed to facilitate water resource development, evaluation, and effective stream management. Basically, the methodology uses a computer-based physical habitat simulation model (PHABSIM) to combine stream hydraulic and physical parameters with fish habitat requirements. The product of the PHABSIM allows investigators to relate changes in streamflow to physical

habitat availability. Important components of this technique are the development of a calibrated hydraulic stream model and knowledge of the suitability of specific habitat conditions (i.e., water depths, velocity, and substrate or cover) for individual fish species and life stages.

Field Techniques

Transects were placed within each study site so as to provide a representation of the predominant habitats found within that reach. Permanent markers (pins) were placed at the ends of each transect and a benchmark established as reference points within each study site. For each transect, water velocities, depths, and substrate were measured and recorded at vertical points distributed across the wetted width of the river for each of three "calibration" flows. Generally, the distance between each measuring point was kept constant. As needed, however, additional measuring points were added at gradient breaks in bottom profile or where significant changes in water velocities or substrate were observed. A rule of thumb was established that no more than 10 percent of the total measured streamflow for any one transect would occur within any given "cell" (i.e., the area between vertical measuring points). As a result, the number of vertical points across each transect where measurements were recorded varied from transect to transect depending on stream hydrology and streambed morphology. Generally, the number ranged between 20 and 30 per transect.

Water depths and velocities were measured at each transect for three release flows from O'Shaughnessy Dam. These "calibration" flows were 250 cubic feet per second (cfs), 125 cfs, and 25 cfs. Water velocity and depth data collected for each calibration flow was subsequently used to establish the water surface elevation (stage) versus streamflow (discharge) relationship and to calibrate the hydraulic simulation incorporated within the physical habitat simulation program. The measured flow for each transect was calculated using standard techniques. In calibrating the model, measured discharges at the Hetch Hetchy stream gage was used as the mean discharge for each study site.

Mean water column velocities were measured at 0.6 of the total depth (measured from the water surface) for water depths less than or equal to 2.5 feet. At depths greater than 2.5 feet but less than or equal to 5.0 feet, velocities were measured at 0.2 and 0.8 of the total water depth. For water depths greater than 5.0 feet, velocities were measured at 0.2, 0.6 and 0.8 of the total water depth. Water velocity measurements were made with either a Price AA or Gurley water velocity meter. In extremely slow velocity areas, with water depths of less than 1 foot, a Pygmy water velocity meter was used. Mean water column velocities were calculated using standard formulas.

Water depths were measured to the nearest 0.1 foot with a top-setting wading rod in areas less than 8 feet deep. For depths greater than 8 feet a raft mounted sounding reel system with a cable and 15-pound sounding weight was used.

Substrate composition and fish cover were assessed in each observation cell. An observation cell is defined as having a width equal to the horizontal distance between midpoints of adjacent vertical measuring points and a length

Table III. Substrate composition categories used in the Hetch Hetchy instream flow study, 1988.

Code	Substrate Type	Size Range (mm)
1	Organic Debris	---
2	Mud/Soft Clay	---
3	Silt	<.062
4	Sand	.062 - 2
5	Course Sand	2 - 4
6	Small Gravel	4 - 25
7	Medium Gravel	25 - 50
8	Large Gravel	50 - 75
9	Small Cobble	75 - 150
10	Medium Cobble	150 - 225
11	Large Cobble	225 - 300
12	Small Boulder	300 - 600
13	Medium Boulder	600 - 2000
14	Large Boulder	> 2000
15	Bedrock	---

upstream and downstream to a point representing the "transition" point to the next habitat type. Substrate composition was described using a modified Brusven index system. Substrate categories and their respective codes are listed in Table III. An index was used, composed of a 6-digit substrate descripter based on dominant and subdominant substrate types and percent embeddedness of the substrate. It is coded as xXyY.%E (where xX = dominant substrate, yY = subdominant substrate, %E = percent embeddedness).

Table IV. Cover categories used in the Hetch Hetchy instream flow study, 1988.

Object Cover	Overhead Cover	Cover Quality
0 = None	0 = None	0 = None
1 = Objects < 6 inches	1 = Instream Overhead (undercut banks, rootwads, logs, etc.)	1 = Poor (<25%)
2 = Objects 6 to 12 inches	2 = Overhanging Overhead (within 18" of waters surface)	2 = Fair (25-50%)
3 = Objects > 12 inches	3 = Instream & Overhanging (both code 1 and 2)	3 = Good (50-75%)
------	-------	4 = Excellent (75-100%)

Cover was described using a three-digit code. The first digit of the code defines the size of the largest object(s) seen within the observation cell. The second digit defines any overhead cover which provides protection from predators, sunlight, etc., within the observation cell. The third digit, which follows a decimal, describes the quality of the cover as poor, fair, good, or excellent. Cover codes and descriptions are listed in Table IV. The cover index is coded as XY.Z (where X = object cover, Y = overhead cover, and Z = cover quality).

If no overhead cover was present in the observation cell, the linear distance to the nearest overhead cover was estimated to the nearest foot.

General information recorded for each field day included sampling date and time, river reach and site, estimated stream discharge, air and water temperature, name of observer and recorder, observation method, water visibility, weather conditions, total length of study area and equipment used.

Water depth, velocity, and substrate suitability criteria used in this investigation were determined through field measurements of habitat use by rainbow and brown trout adults (both spawning and non-spawning), fry, and juveniles within the study reach of the Tuolumne River. These data were collected between October 20, 1987 and June 14, 1990. Results of the habitat criteria development phase of this study are described in the 1990 Progress Report on the Hetch Hetchy Fishery Investigation (USFWS 1991). Habitat suitability indexes used in the Hetch Hetchy IFIM are provided in Appendix B.

Data Analysis

Field data gathered was initially transcribed from the field data forms into microcomputer database files using dBASE II (Ashton-Tate, dBASE II, IBM PC-DOS, Version 2.43). These files were checked for errors and corrected where necessary. They then became the "raw" database files from which all subsequent data analyses were conducted. The edited dBASE files where then transcribed to LOTUS 1-2-3 spreadsheets (1-2-3, release 2.01, LOTUS Development Corp.) for further analysis, including mean column water velocity calculations and conversion of substrate and cover codes to appropriate index

values. These data were then formatted to input data decks needed for the hydraulic simulation (IFG4) program by using FLOSORT, a program developed by Andrew Hamilton of the Service's Lewiston Suboffice, Lewiston, California. All files were checked for accuracy using the RCKI4 microcomputer program provided by the Service's National Ecology Research Center, Aquatic Systems Modeling Section (NERC).

Individual input data decks were built for each flow and study site using the 3 sets of water surface elevations and velocity data collected during the calibration flows.

The product of the physical habitat simulation (PHABSIM) is an index of the habitat potential for each study site, called the weighted usable area (WUA). For each study site and each computation flow the WUA is equal to the suitability index for the combined characteristics measured (water velocity, water depth, and substrate or cover) and the total surface area represented by that study site. The WUA is unique to the streamflow, the transect, and the target species and life stage to which it applies. The term "weighted" refers to the influence of the habitat suitability criteria applied to the physical habitat simulation and is provided as a separate input data set.

The fish habitat versus streamflow relationship determined through the physical habitat simulation model is expressed in terms of square feet of weighted usable area of habitat per 1,000 linear feet of stream. Since the

study sections on the Tuolumne River are not the same length, the total weighted usable habitat area for each study section (represented by a study site) was calculated. The study section totals were than combined for a total estimate of weighted usable area of habitat for the entire 12 mile study reach between O'Shaughnessy Dam and Early Intake.

RESULTS

During 1988 data describing the water surface elevations at each transect, water velocity across the transect, substrate, and cover were collected at each of the 29 transects during 3 "calibration" flows, measured as releases from O'Shaughnessy Dam. The calibration flows were 250 cubic feet per second (cfs), 125 cfs, and 25 cfs. These data were used to calibrate the hydraulic simulation portion of the PHABSIM model. Table V summarizes dates and flow conditions during transect data collection.

The streamflow versus total weighted usable area of habitat relationship for rainbow trout and brown trout in the Tuolumne River between Hetch Hetchy Reservoir and Early Intake are illustrated in Figures 6 and 7, respectively.

The weighted usable area estimates used to generate these figures are provided in Appendix C.

Table V. Dates and Stream discharges during transect data collection for the Hetch Hetchy Instream FLow Investigation.

Reach	Number Transects	Date(s) Data Gathered	Discharge at O'Shaughnessy Dam
1. Early Intake	6	July 21-22	250
		Sept. 13-15	125
		Oct. 13	25
2. Preston Falls	7	July 21	250
		Sept. 15	125
		Oct. 13	25
3. Gorge	0	inaccessible, no data gathered	
4. Poopenaut	4	July 20	250
		Sept. 14	125
		Oct. 12	25
5. O'Shaughnessy	12	July 18-19	250
		Sept. 12-13	125
		Oct. 11-12	25

DISCUSSION

Developing a flow recommendation for the Tuolumne River between Hetch Hetchy Reservoir and Early Intake is a difficult task. It is important to balance the habitat needs for the target species and life stages. These needs include not only the availability of physical habitat but also adequate water quality to provide for survival and growth. The model developed for this study resulted in the estimated total weighted usable area of habitat for rainbow and brown trout within the Tuolumne River study reach as shown in Figures 6

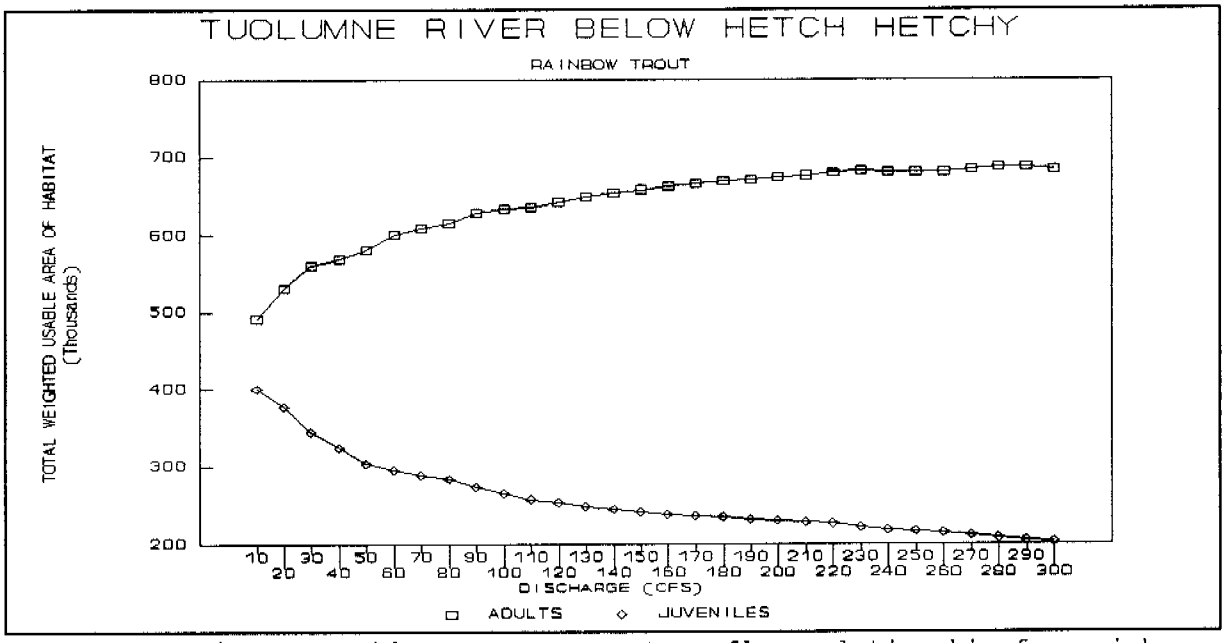


Figure 6. Weighted usable area versus streamflow relationship for rainbow trout in the Tuolumne River, between Hetch Hetchy Reservoir and Early Intake.

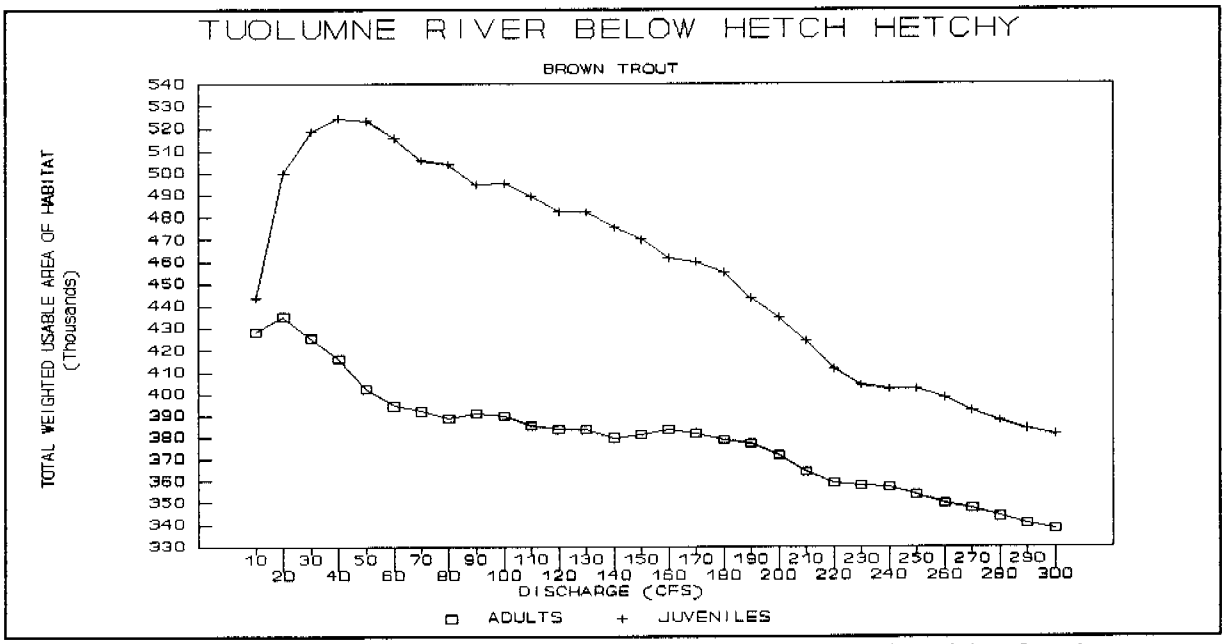


Figure 7. Weighted usable area versus streamflow relationship for brown trout in the Tuolumne river between Hetch Hetchy Reservoir and Early Intake.

and 7. Considering the overall percentage of the maximum predicted amount of available habitat, flows as low as 80 cfs would provide at least 90 percent of the maximum predicted area of adult trout habitat within the study reach. Flows as low as 20 to 30 cfs would provide at least 90 percent of the maximum habitat area predicted for juvenile rainbow and brown trout.

However, caution should be used and the availability of physical habitat alone should not be used to establish flow needs. An examination of the water temperature records gathered by the U.S. Geological Survey within the study reach since August 1987 suggests that this may be the most critical habitat parameter influencing the trout population below Hetch Hetchy Reservoir. Water temperature records for the years 1988 through 1991 are discussed in the 1990 Annual Report for the Hetch Hetchy Fishery Investigation (USFWS, 1991) and are also provided in Appendix D.

Generally, rainbow and brown trout can survive water temperatures between 0^{o} and 28^{o} C, although the optimal range for growth is between 13^{o} and 21^{o} C, and the best range for egg incubation is between 8^{o} and 15^{o} C (Moyle 1976, Bovee 1978).

The data illustrated in Appendix D indicate that the months of June and July are typically those months where high water temperatures (i.e. > 21^{o} C) occur, except when river flows exceed about 125 cfs. In addition, by reviewing the

winter water temperature data it is evident that water temperatures during the months of November and March may be low enough to limit development of brown trout eggs which are incubating in the river gravel during this time.

While water temperatures generally increase between O'Shaughnessy Dam and Early Intake during the summer months, they can decrease during the winter months. This is due to the warming or cooling effect of the ambient air temperature during these months.

Therefore, a balance between optimizing the availability of physical habitat for rainbow and brown trout, and providing suitable water temperatures for growth and development has been taken into account when conceiving the recommended instream flow schedules which follow.

RECOMMENDED FLOW SCHEDULES

Based on the results of this instream flow study, and considering the importance of water temperature to the survival, growth, development and condition of rainbow and brown trout inhabiting the river, an annual instream flow allocation of 59,207 acre-feet to 75,363 acre-feet is recommended for the Tuolumne River below Hetch Hetchy Reservoir. Recommended annual flow schedules are provided in Table VI.

Table VI. Annual instream flow schedule recommended for the maintenance of rainbow and brown trout within the Tuolumne River Between O'Shaughnessy Dam and Early Intake.

		Minimum Instream Flow Schedules					
		A		B		C	
Month	Days	cfs	Ac-Ft	cfs	Ac-Ft	cfs	Ac-Ft
January	31	85	5,227	70	4,304	50	3,074
February	28	85	4,721	70	3,888	60	3,332
March	31	85	5,227	70	4,304	60	3,689
April	30	100	5,951	70	4,165	75	4,463
May	31	100	6,149	70	4,304	100	6,149
June	30	125	7,438	125	7,438	125	7,438
July	31	150	9,223	135	8,301	125	7,686
August	31	150	9,223	135	8,301	125	7,686
September 1-15	15	125	3,719	100	2,975	100	2,975
September 16-30	15	100	2,975	70	2,083	80	2,380
October	31	85	5,227	70	4,304	60	3,689
November	30	85	5,058	70	4,165	60	3,570
December	31	85	5,227	70	4,304	50	3,074

Three schedules are maintained because of the uncertainty of sustaining appropriate water temperatures, during the summer and winter months under the recommended flows. Rainfall and water storage criteria, currently being used to determine the instream flow schedule for the Tuolumne below Hetch Hetchy, should also be maintained. Water temperature records should continue to be collected, both near Hetch Hetchy and above Early Intake, to verify that appropriate levels can be maintained to support a healthy trout population within the Tuolumne River below Hetch Hetchy Reservoir.

It is recommended that these schedules be applied beginning in water year 1993 and that a period of validation follow. During the validation period water temperature data, currently being gathered just below O'Shaughnessy Dam and above Early Intake, should continue to be recorded and that these data be

reviewed annually. This would document the adequacy of recommended schedules in meeting river water temperatures necessary to improve trout growth and development. Periodic trout population surveys should also be continued to develop estimates of total adult population size and to monitor condition of the fish.

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APPENDIX

APPENDIX A: Description of Hetch Hetchy IFIM study sections, distribution of habitat types and habitat maps of the Tuolumne River between O'Shaughnessy Dam and Early Intake.

STUDY SECTIONS

SECTION 1 - EARLY INTAKE.

This reach extends from Kirkwood Powerhouse (0.5 river mile upstream from Early Intake) to Lower Preston Falls a distance of 2.5 river miles. It is moderately steep, as the 12 mile study reach goes, with a gradient of 1.8%. The stream bed is composed primarily of boulders 2 to 6 feet in diameter. Nearly half of this reach is pocket water (45%). The next most common habitat type is deep pool at 26% of the length of the study section. Deep pools in this section are located where bedrock ridges extend into the stream causing scour holes. Nineteen percent of the section is cascade/pocket water, this is located just above the powerhouse where larger boulders have fallen into the channel. The other habitat types represented here are shallow pool (3%), run (4%), a single 302 foot side channel (2%), and chute and backwater both less than 1%.

SECTION 2 - PRESTON FALLS.

This section is from Lower Preston Falls to the Mather Pool, a distance of 2 river miles.In this section the most abundant habitat type changes from pocket water to deep pool. Deep pool makes up 66% of the study section. Shallow pool habitat is 9% of the section length for a total of 75% of this section as pool habitat. The pools here have a different character from the rest of the study reach, they are mostly long pools with fine sand substrate. Many trees have fallen in from the eroding banks providing abundant woody debris (however we haven't found any fish specifically associated with this wood). The rest of the length of this section is spread among the other habitat types. Pocket water 9%, cascade/pocket water 2%, cascade/deep pool 2%, cascade 5%, chute 1%, riffle 1%, run 3%, and side channel 2%. the overall gradient, 1.5% is similar to section 1 but much of this area is composed of two relatively flat meadows.

SECTION 3 - GORGE

From Mather Pool to the lower end of Poopenaut Valley this study section is 4.3 river miles long. Above Mather Pool the canyon walls become almost vertical and are close together. This section is the longest, 4.3 miles, and steepest, 2.2% gradient. The stream bed which is almost always adjacent to the sheer canyon walls is choked with boulders. Pocket water and cascade/pocket water make up almost half of the length, 23% and 24% respectively. Deep pool intersperses these boulder areas with 44% of the length. Shallow pool, riffle and run compose 1, 3 and 3% of the length. These last three types are primarily in the lowest 1.5 miles of the study section.

SECTION 4 - POOPENAUT VALLEY

This section extends from the lower end of Poopenaut Valley to the upper end of Poopenaut Meadow at a pool called "big pool". The reach is 0.9 river miles long. Poopenaut Meadow is the largest meadow in the study reach. A wide grass covered bench extends on either side of the river with a dense thicket of willows along the bank. The stream bed is all sand. The gentle gradient of the section, 0.8% slope, is reflected in that 70% of the length is classified as run or glide (62% and 8% respectively). At bedrock outcrops deep pools (22% of the length) are scoured out. Shallow pools make up 7% of the length and riffles 1%.

SECTION 5 - O'SHAUGHNESSY

Section 5 extends from the upper end of Poopenaut Meadow to O'Shaughnessy Dam, 2.7 river miles.The section below the dam is in a relatively wide valley. The valley floor is mostly bedrock with pockets of alluvium. The gradient of this section in 1.2%. Sixty percent of the section length is deep pools, 14% shallow pool and the rest spread between the other habitat types. Six percent is pocket water, 3% cascade/pocket water, 4% cascade/deep pool, cascade 6%, chute 1%, riffle 5%, side channel <1%, backwater 1%.

Table A-1. Lengths and areas of each habitat type in study section 1, Early Intake to Lower Preston Falls (2.5 miles).

Habitat Type	Distance(ft)	Percent of Total	Area(Acres)	Percent of Total
Deep Pool	3355	26	4.87	28
Shallow Pool	436	3	0.66	4
Pocket Water	5943	45	7.81	46
Cascade/Pocket Water	2423	19	2.77	16
Cascade/Deep Pool	0	0	0	0
Cascade	0	0	0	0
Chute	4	<1	0.01	<1
Riffle	0	0	0	0
Run	557	4	0.78	5
Glide	0	0	0	0
Side Channel	302	2	0.19	1
Backwater	78	<1	0.05	0

Table A-2. Lengths and areas of each habitat type in study section 2, Lower Preston Falls to Mather Pool.

Habitat Type	Distance(ft)	Percent of Total	Area(acres)	Percent of Total
Deep Pool	8109	66	18.42	74
Shallow Pool	1052	9	2.90	12
Pocket Water	1092	9	1.30	5
Cascade/Pocket Water	374	2	0.41	2
Cascade/Deep Pool	283	2	0.31	1
Cascade	560	5	0.54	2
Chute	73	1	0.07	<1
Riffle	174	1	0.15	1
Run	427	3	0.59	2
Glide	0	0	0	0
Side Channel	200	2	0.07	<1
Backwater	0	0	0	0

Table A-3. Lengths and areas of each habitat type in study area 3, Mather Pool to the lower end of Poopenaut Valley.

Habitat Type	Distance(ft)	Percent of Total	Area(acres)	Percent of Total
Deep Pool	9780	44	17.39	53
Shallow Pool	171	1	0.22	1
Pocket Water	5088	23	5.15	16
Cascade/Pocket Water	5379	24	8.09	25
Cascade/Deep Pool	0	0	0	0
Cascade	406	2	0.35	1
Chute	0	0	0	0
Riffle	687	3	0.44	1
Run	777	3	0.85	3
Glide	0	0	0	0
Side Channel	0	0	0	0
Backwater	0	0	0	0

Table A-4. Lengths and areas of habitat types in study section 4, lower end of Poopenaut Meadow to Study Reach Mile 9.7 "Big Pool".

Habitat Type	Distance(ft) Total	Percent of	Area(acres) Total	Percent of
Deep Pool	886	22	3.19	46
Shallow Pool	278	7	0.53	7
Pocket Water	0	0	0	0
Cascade/Pocket Water	0	0	0	0
Cascade/Deep Pool	0	0	0	0
Cascade	0	0	0	0
Chute	0	0	0	0
Riffle	33	1	0.05	1
Run	2498	62	2.78	40
Glide	331	8	0.42	6
Side Channel	0	0	0	0
Backwater	0	0	0	0

Table A-5. Lengths and areas of habitat types in study section 5, upper end of Poopenaut Meadow to O'Shaughnessy Dam.

Habitat Type	Distance(ft) Total	Percent of	Area(acres) Total	Percent of
Deep Pool	10803	60	16.11	70
Shallow Pool	2489	14	2.56	11
Pocket Water	1159	6	1.24	5
Cascade/Pocket Water	480	3	0.74	3
Cascade/Deep Pool	676	4	0.40	2
Cascade	1056	6	0.95	4
Chute	133	1	0.07	<1
Riffle	917	5	0.65	3
Run	0	0	0	0
Glide	0	0	0	0
Side Channel	42	<1	0.08	<1
Backwater	94	1	0.09	<1

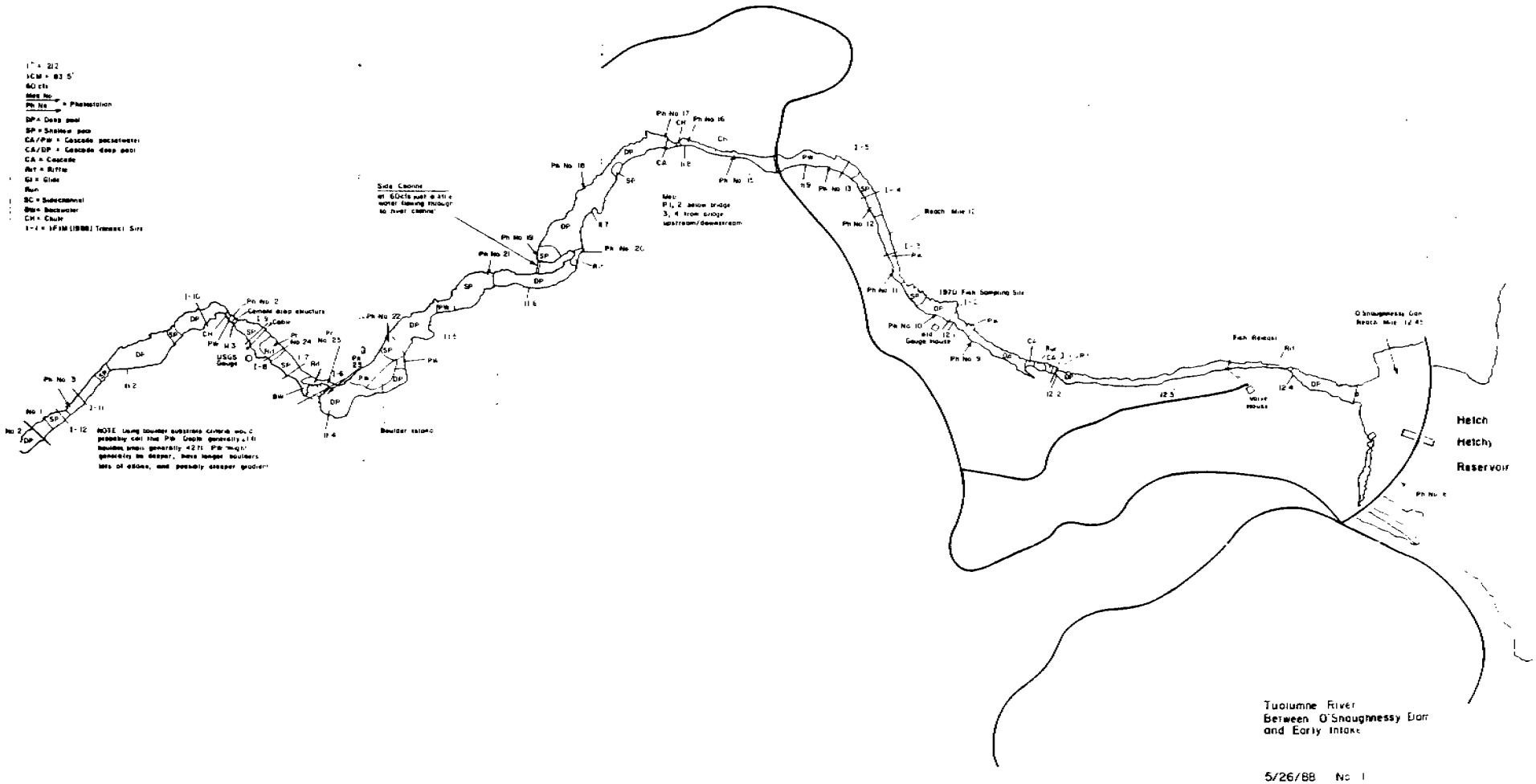
Table A-6. Length in feet of each habitat type contained within each study section and the total study area.

Section / Habitat Type	1	2	3	4	5	Total	Percent
Deep Pool	3355	8109	9780	886	10803	32933	51
Shallow Pool	436	1052	171	278	2489	4426	7
Pocket Water	5943	1092	5088	0	1159	13282	13
Cscde/Pckt Water	2423	374	5379	0	480	8656	13
Cscde/Deep Pool	0	283	0	0	676	959	1
Cascade	0	560	406	0	1056	2022	3
Chute	4	73	0	0	133	210	<1
Riffle	0	174	687	33	917	1811	3
Run	557	427	777	2498	0	4259	7
Glide	0	0	0	331	0	331	<1
Side Channel	302	200	0	0	42	544	<1
Backwater	78	0	0	0	94	172	<1
Total	13098	12344	21588	4026	17849	68902	100

Table A-7. A comparison of lengths and areas of each habitat type within the total study reach, between Kirkwood Powerhouse and O'Shaughnessy Dam.

Habitat	Length(ft)	Percent	Area(acres)	Percent	
Deep Pool	32933	51	59.98	67	
Shallow Pool	2489	7	6.87	8	
Pocket Water	13282	13	1.24	1	
Cscde/Pckt Water	8656	13	12.01	13	
Cscde/Deep Pool	959	1	0.71	1	
Cascade	2022	3	1.84	2	
Chute	210	<1 (.3)	0.15	<1 (.2)	
Riffle	1811	3	1.29	1	
Run	4259	7	5.00	6	
Glide	331	<1 (.5)	0.42	<1 (.5)	
Side Channel	544	<1 (.8)	0.34	<1 (.4)	Backwater
172	<1 (.3)	0.14	<1 (.2)		
Total	67668*	100	89.99	100	

*The sum of the lengths may be longer than the study reach length because some habitat types overlap in the river channel.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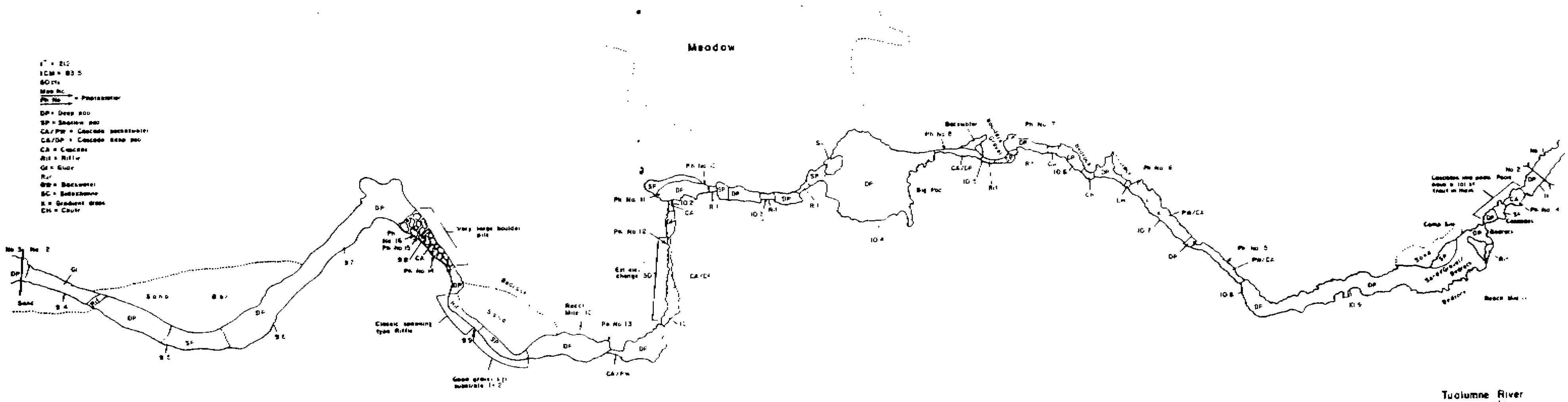
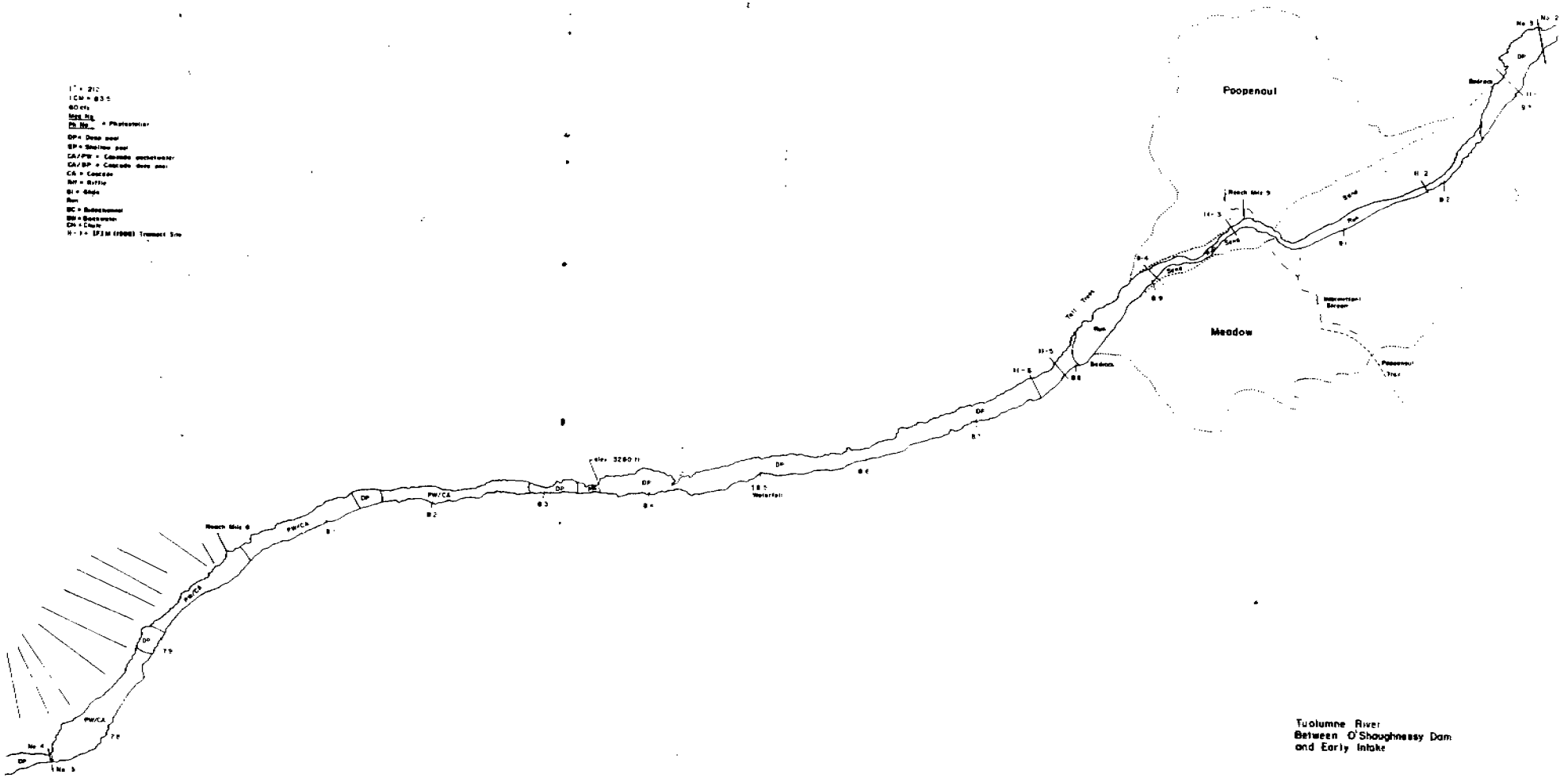
Between O'Shaughnessy Dam
and Early Intake
5/26/88 No. 1
Hetch
Hetchy
Reservoir



Tuolumne River
Between O'Shaughnessy Dam
and Early Intake

5/26/88 No 2



Tuolumne River
Between O'Shaughnessy Dam
and Early Intake

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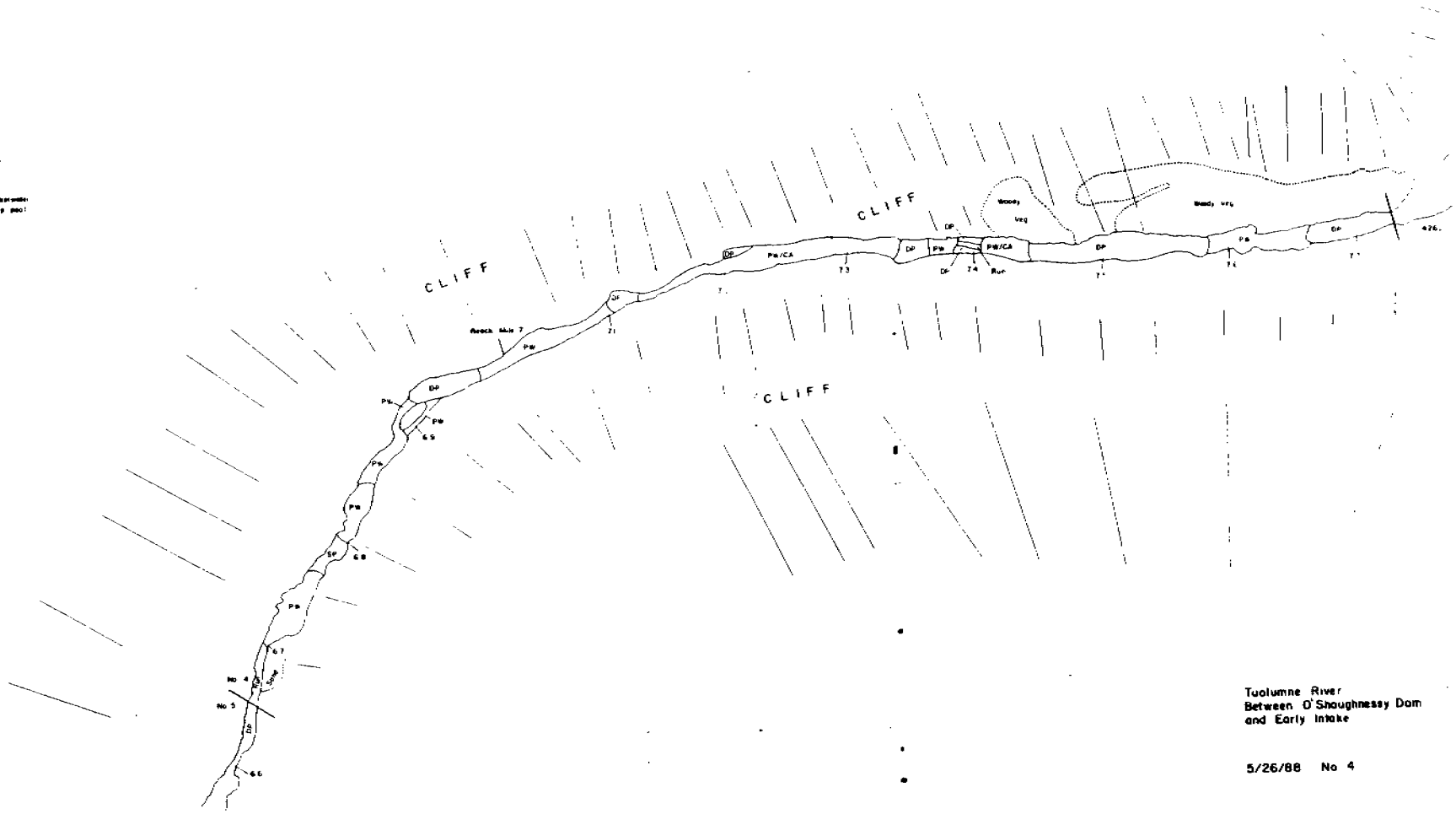
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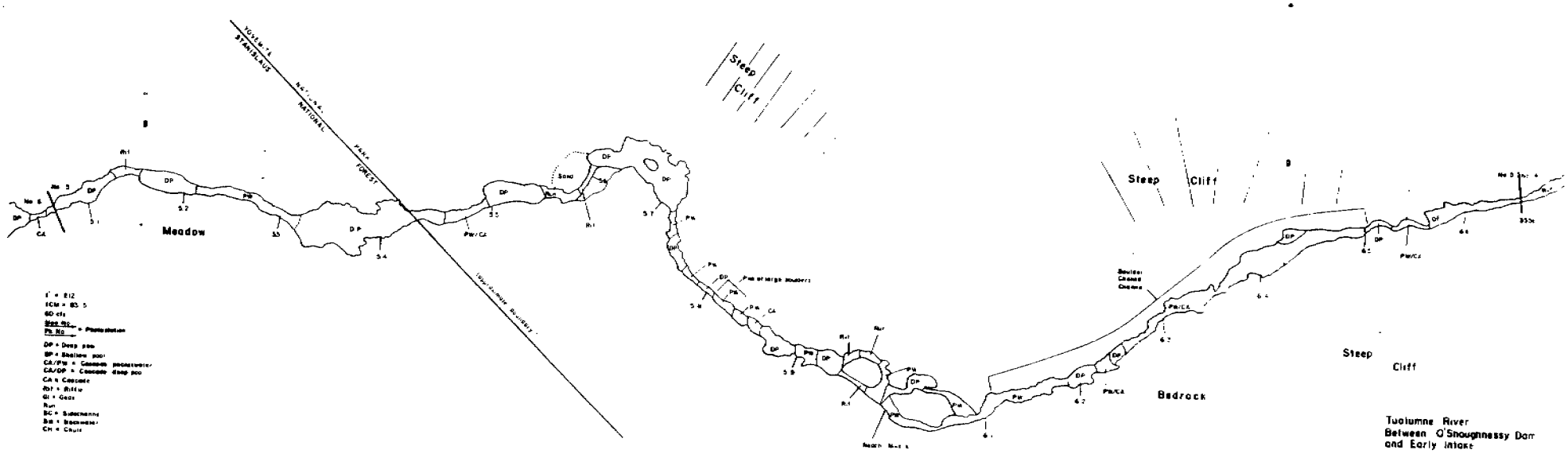
CLIFF
CLIFF
Woody Veg
Woody Veg
DP
Pw/CA
Pw
SP
Run
T3
T4
T5
T6
T7
426.
Rock Mile 7
7.1
6.9
6.8
6.7
6.6
No. 4
No. 5
Dam
Tuolumne River
Between O'Shaughnessy Dam
and Early Intake
5/26/88 No 4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Meadow
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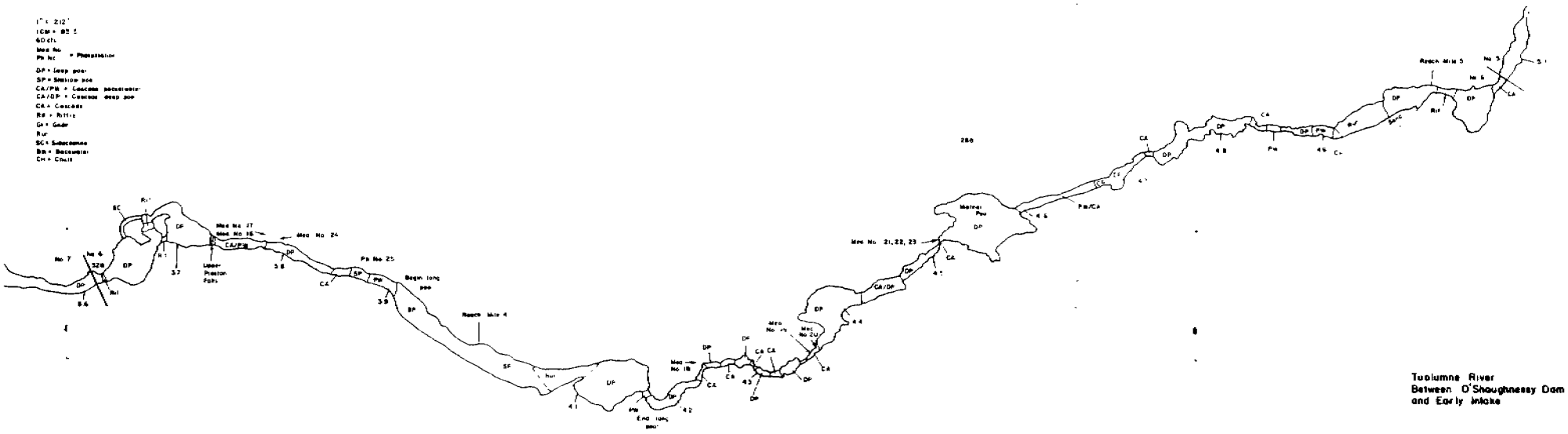
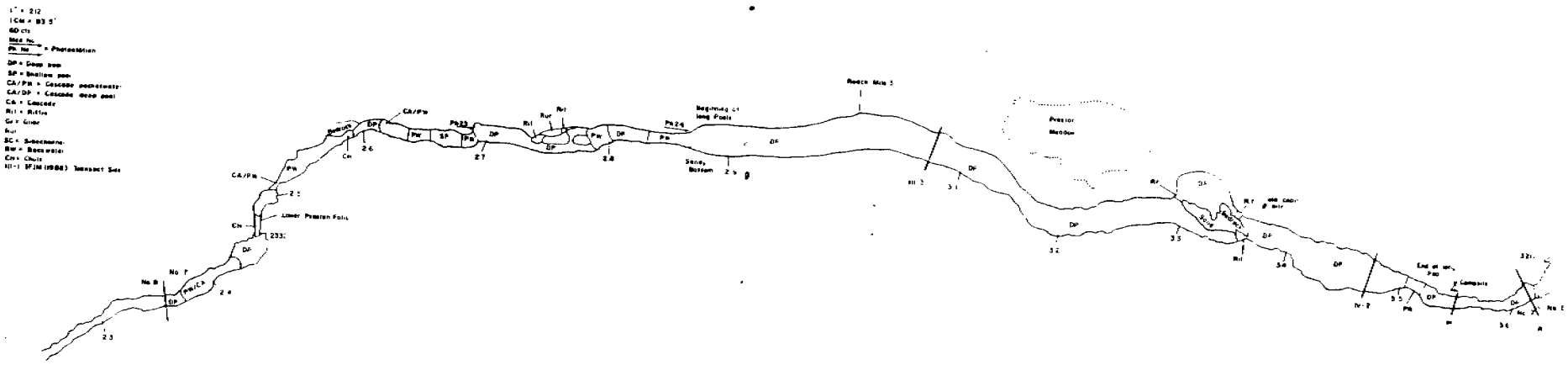


Tuolumne River
Between O'Shaughnessy Dam
and Early Intake

5/26/88 No 6



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Between O'Shaughnessy Dam
and Early Intake

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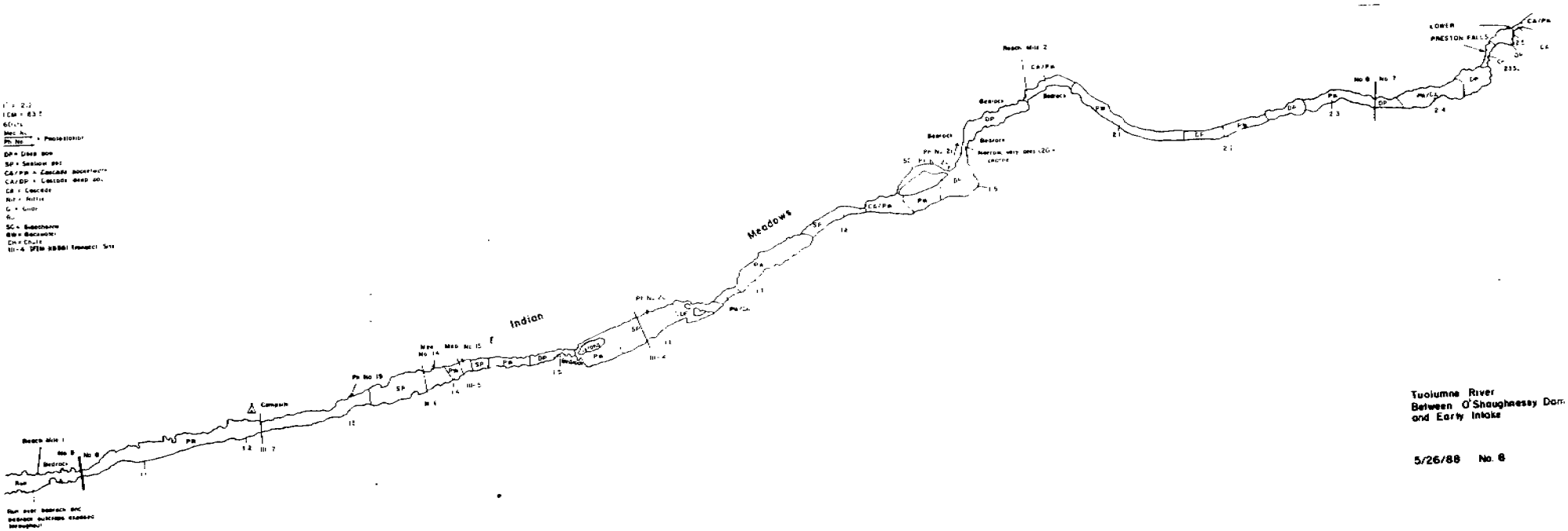
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Tuolumne River
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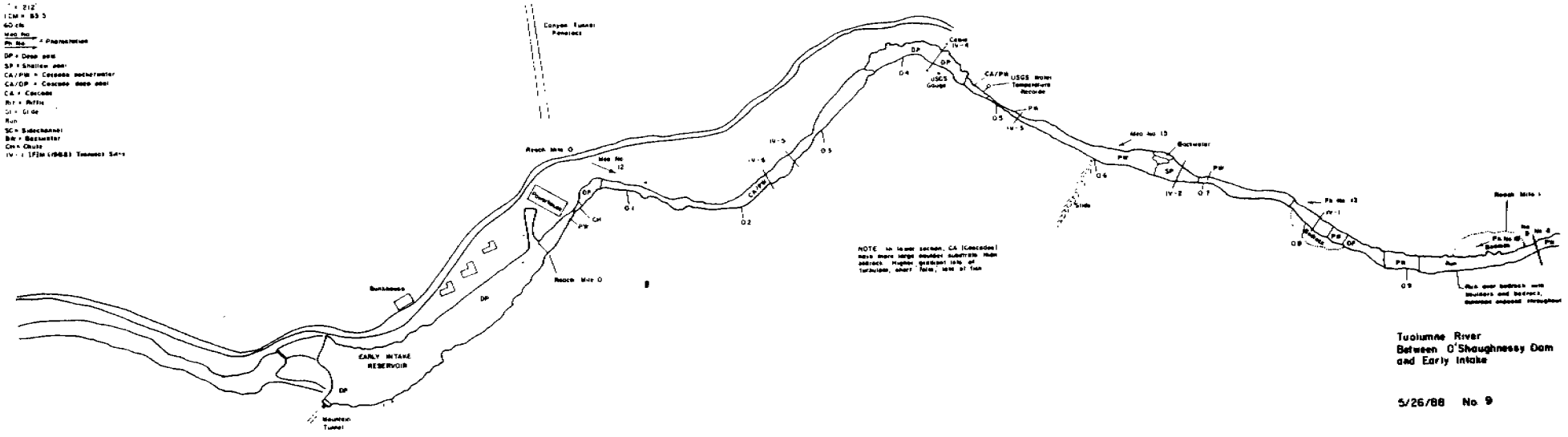
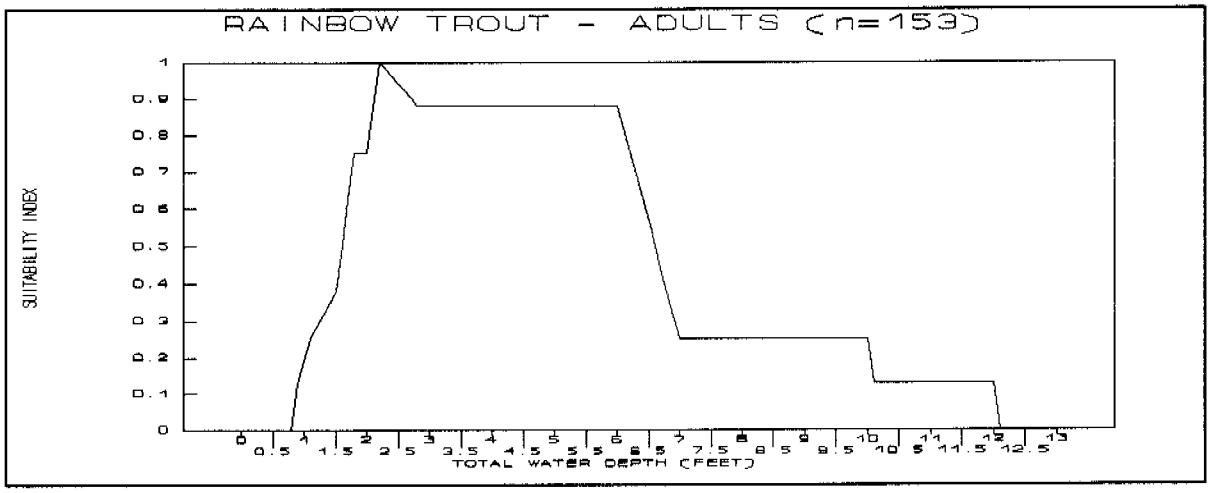


Tuolumne River
Between O'Shaughnessy Dam and Early Intake

5/26/88 No. 9

APPENDIX B: Habitat Suitability Indexes for Rainbow Trout and Brown Trout inhabiting the Tuolumne River between O'Shaughnessy Dam and Early Intake.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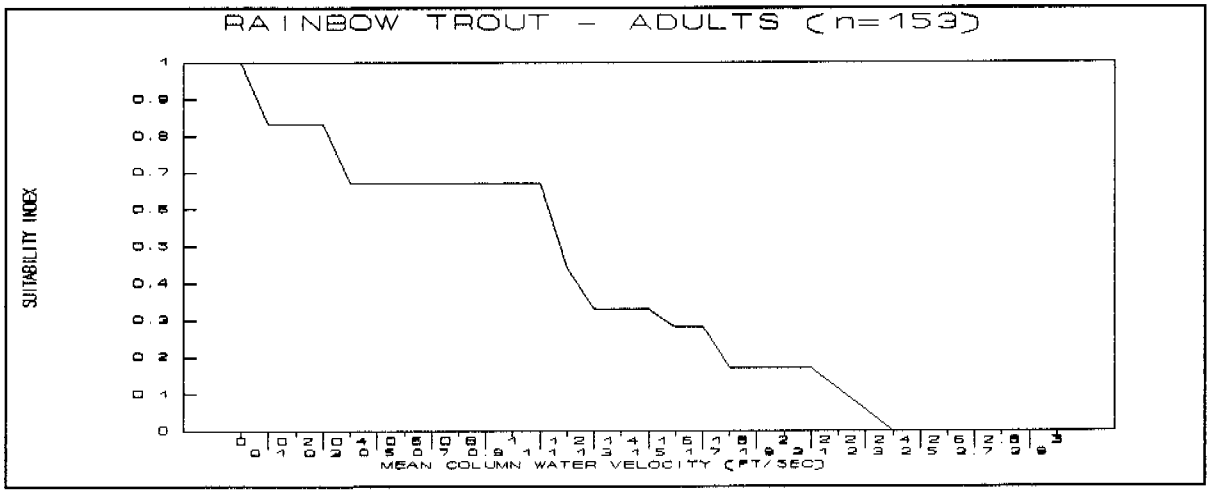
TOTAL WATER DEPTH (FEET)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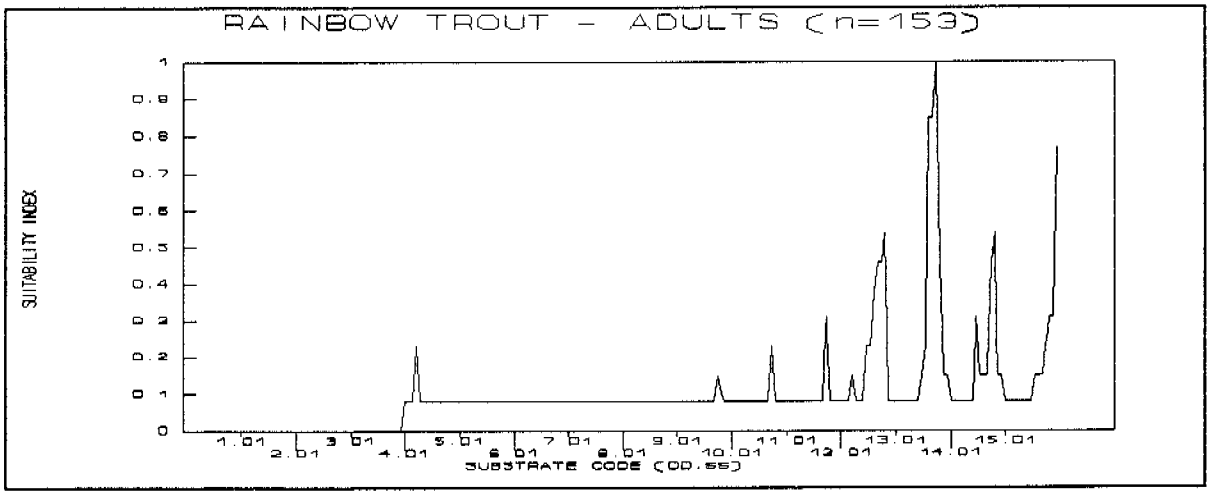
SUITABILITY INDEX
MEAN COLUMN WATER VELOCITY (FT/SEC)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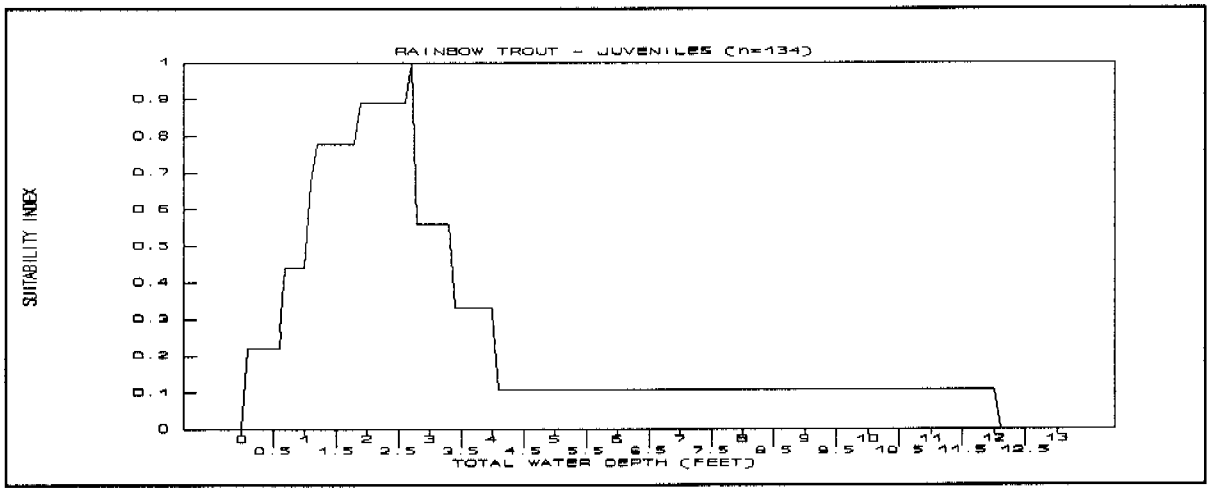
SUITABILITY INDEX
SUBSTRATE CODE (OD.SS)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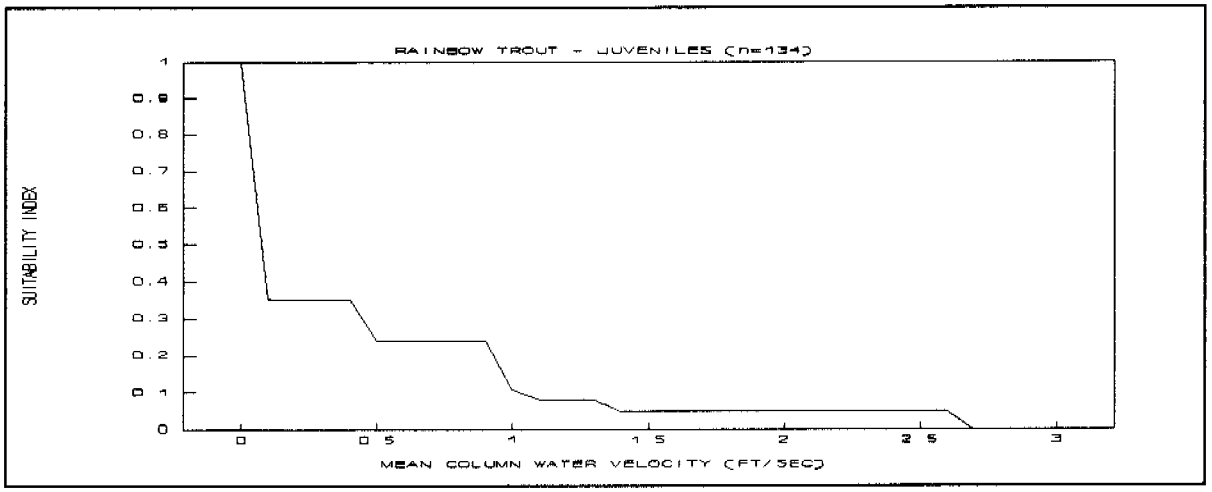
SUITABILITY INDEX
TOTAL WATER DEPTH (FEET)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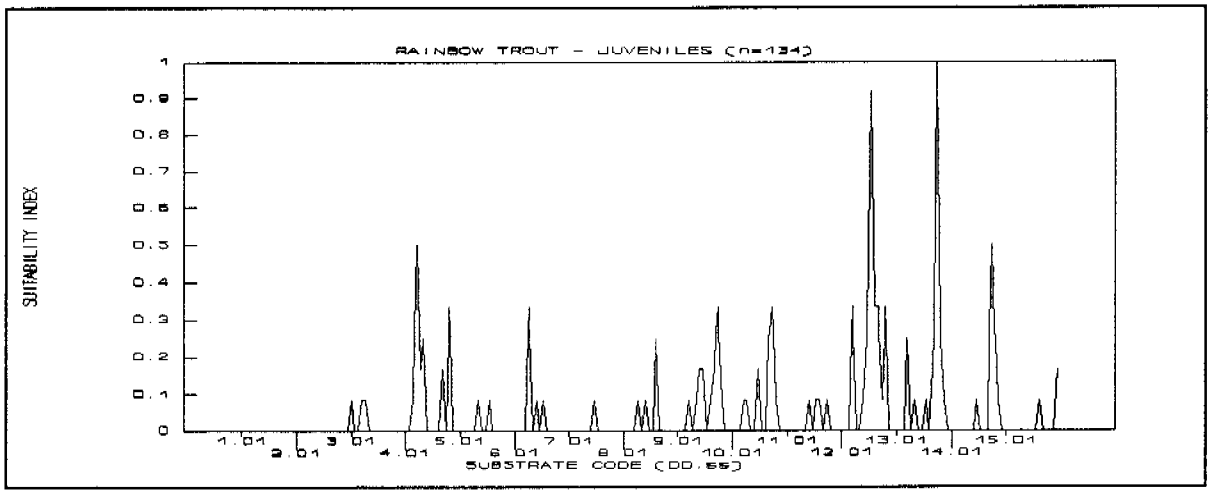
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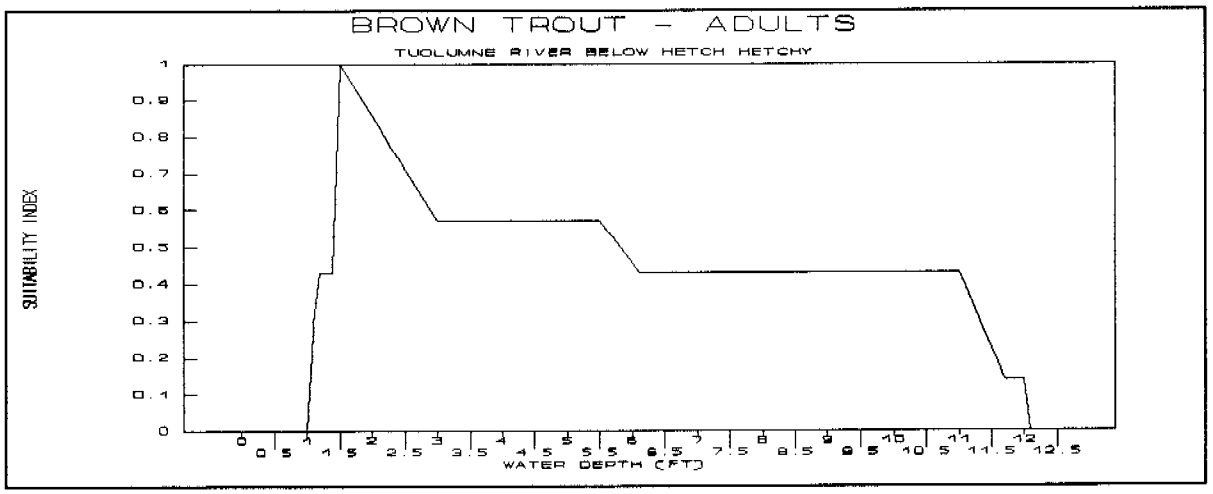
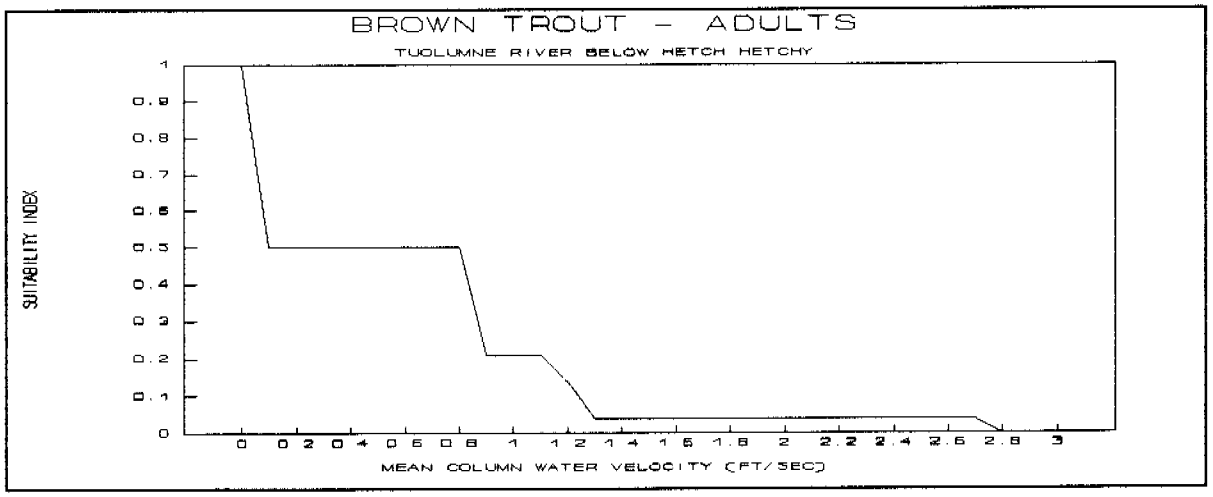

BROWN TROUT - ADULTS
TUOLUMNE RIVER BELOW HETCH HETCHY
SUITABILITY INDEX
WATER DEPTH (FT)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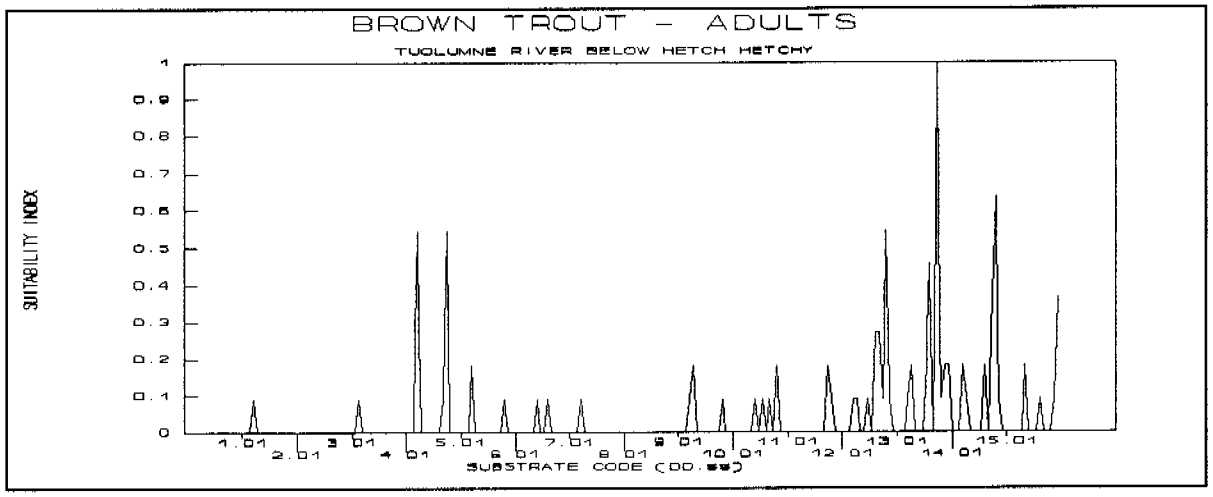
TUOLUMNE RIVER BELOW HETCH HETCHY
SUITABILITY INDEX
MEAN COLUMN WATER VELOCITY (FT/SEC)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TUOLUMNE RIVER BELOW HETCH HETCHY
SUITABILITY INDEX
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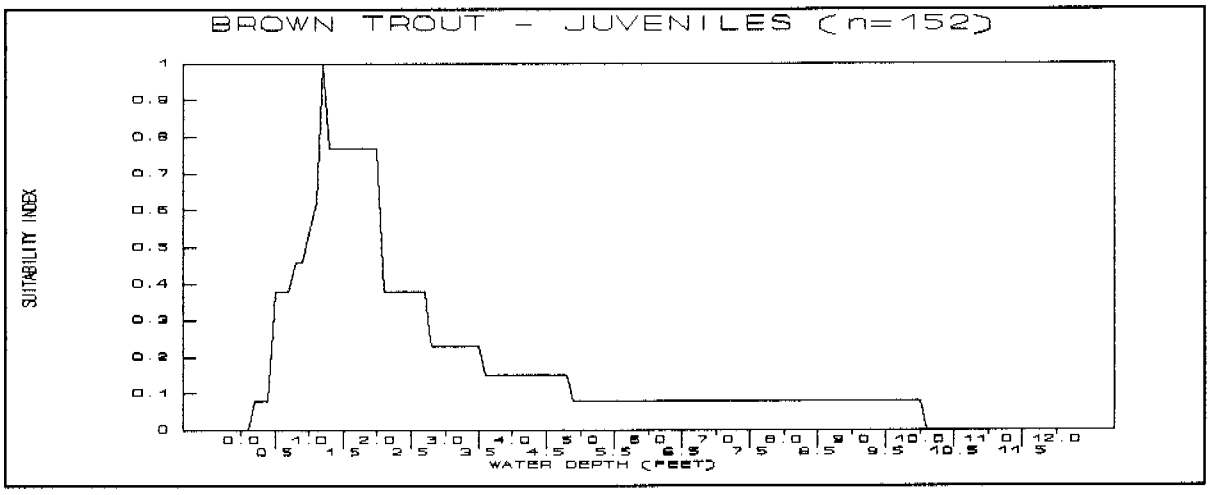
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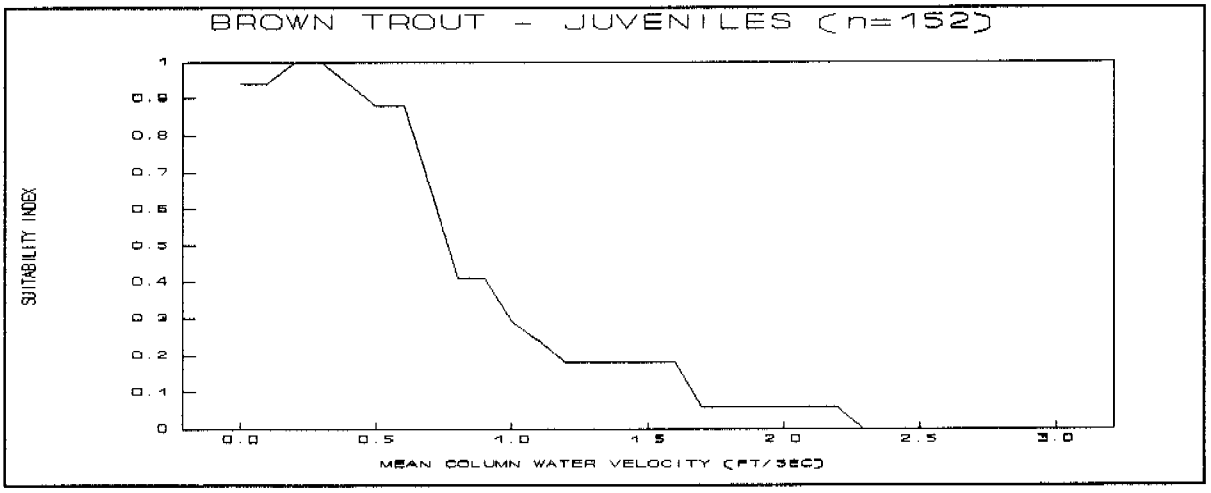
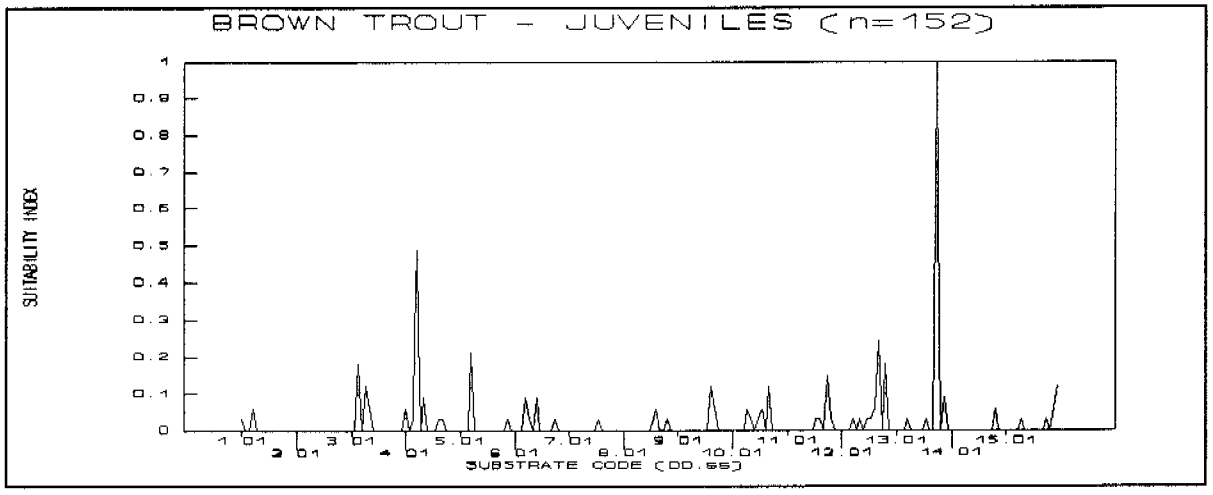
WATER DEPTH (FEET)


BROWN TROUT - JUVENILES (n=152)
SUITABILITY INDEX
MEAN COLUMN WATER VELOCITY (FT/SEC)


BROWN TROUT - JUVENILES (n=152)
SUITABILITY INDEX
SUBSTRATE CODE (DD.SS)

HETCH HETCHY TROUT HABITAT USE OBSERVATIONS
OCTOBER 20, 1987 THROUGH JUNE 14, 1990
FREQUENCY DISTRIBUTIONS (FQ) & SUITABILITY INDEX (SI)

WATER DEPTH

	RAINBOW TROUT						BROWN TROUT					
	Adults			Juveniles			Adults			Juveniles		
INTERVAL	#	FQ	SI	#	FQ	SI	#	FQ	SI	#	FQ	SI
0	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
0.1	0	0.00	0.00	2	0.22	0.22	0	0.00	0.00	0	0.00	0.00
0.2	0	0.00	0.00	0	0.00	0.22	0	0.00	0.00	1	0.08	0.08
0.3	0	0.00	0.00	0	0.00	0.22	0	0.00	0.00	1	0.08	0.08
0.4	0	0.00	0.00	0	0.00	0.22	0	0.00	0.00	0	0.00	0.08
0.5	0	0.00	0.00	1	0.11	0.22	0	0.00	0.00	5	0.38	0.38
0.6	0	0.00	0.00	1	0.11	0.22	0	0.00	0.00	4	0.31	0.38
0.7	0	0.00	0.00	4	0.44	0.44	0	0.00	0.00	3	0.23	0.38
0.8	0	0.00	0.00	3	0.33	0.44	0	0.00	0.00	6	0.46	0.46
0.9	1	0.13	0.13	2	0.22	0.44	0	0.00	0.00	1	0.08	0.46
1	0	0.00	0.19	4	0.44	0.44	0	0.00	0.00	7	0.54	0.54
1.1	2	0.25	0.25	6	0.67	0.67	2	0.29	0.29	8	0.62	0.62
1.2	1	0.13	0.28	7	0.78	0.78	3	0.43	0.43	13	1.00	1.00
1.3	1	0.13	0.32	1	0.11	0.78	2	0.29	0.43	8	0.62	0.77
1.4	0	0.00	0.35	6	0.67	0.78	3	0.43	0.43	7	0.54	0.77
1.5	3	0.38	0.38	7	0.78	0.78	7	1.00	1.00	8	0.62	0.77
1.6	2	0.25	0.50	5	0.56	0.78	2	0.29	0.97	8	0.62	0.77
1.7	1	0.13	0.63	7	0.78	0.78	1	0.14	0.94	4	0.31	0.77
1.8	6	0.75	0.75	3	0.33	0.78	2	0.29	0.92	3	0.23	0.77
1.9	3	0.38	0.75	8	0.89	0.89	3	0.43	0.89	6	0.46	0.77
2	6	0.75	0.75	2	0.22	0.89	6	0.86	0.86	10	0.77	0.77
2.1	1	0.13	0.88	4	0.44	0.89	2	0.29	0.83	5	0.38	0.38
2.2	8	1.00	1.00	3	0.33	0.89	2	0.29	0.80	3	0.23	0.38
2.3	5	0.63	0.98	5	0.56	0.89	0	0.00	0.77	2	0.15	0.38
2.4	2	0.25	0.96	4	0.44	0.89	0	0.00	0.74	5	0.38	0.38
2.5	4	0.50	0.94	5	0.56	0.89	5	0.71	0.71	4	0.31	0.38
2.6	3	0.38	0.92	2	0.22	0.89	3	0.43	0.68	2	0.15	0.38
2.7	4	0.50	0.90	9	1.00	1.00	1	0.14	0.65	5	0.38	0.38
2.8	7	0.88	0.88	3	0.33	0.56	0	0.00	0.63	3	0.23	0.23
2.9	4	0.50	0.88	3	0.33	0.56	2	0.29	0.60	2	0.15	0.23
3	5	0.63	0.88	2	0.22	0.56	4	0.57	0.57	3	0.23	0.23
3.1	2	0.25	0.88	0	0.00	0.56	2	0.29	0.57	0	0.00	0.23
3.2	6	0.75	0.88	4	0.44	0.56	0	0.00	0.57	1	0.08	0.23
3.3	3	0.38	0.88	5	0.56	0.56	1	0.14	0.57	0	0.00	0.23
3.4	4	0.50	0.88	1	0.11	0.33	0	0.00	0.57	1	0.08	0.23
3.5	2	0.25	0.88	1	0.11	0.33	2	0.29	0.57	3	0.23	0.23
3.6	3	0.38	0.88	1	0.11	0.33	0	0.00	0.57	0	0.00	0.15
3.7	3	0.38	0.88	0	0.00	0.33	0	0.00	0.57	0	0.00	0.15
3.8	1	0.13	0.88	1	0.11	0.33	1	0.14	0.57	1	0.08	0.15
3.9	3	0.38	0.88	2	0.22	0.33	3	0.43	0.57	2	0.15	0.15
4	4	0.50	0.88	3	0.33	0.33	1	0.14	0.57	0	0.00	0.15

4.1	2	0.25	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.15
4.2	2	0.25	0.88	1	0.11	0.11	3	0.43	0.57	1	0.08	0.15
4.3	3	0.38	0.88	0	0.00	0.11	2	0.29	0.57	0	0.00	0.15
4.4	3	0.38	0.88	0	0.00	0.11	1	0.14	0.57	0	0.00	0.15
4.5	4	0.50	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.15
4.6	2	0.25	0.88	1	0.11	0.11	0	0.00	0.57	0	0.00	0.15
4.7	0	0.00	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.15
4.8	7	0.88	0.88	1	0.11	0.11	1	0.14	0.57	2	0.15	0.15
4.9	1	0.13	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.08
5	1	0.13	0.88	1	0.11	0.11	0	0.00	0.57	1	0.08	0.08
5.1				0	0.00	0.11	0	0.00	0.57	0	0.00	0.08
5.2	1	0.13	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.08
5.3	1	0.13	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.08
5.4	0	0.00	0.88	0	0.00	0.11	0	0.00	0.57	0	0.00	0.08
5.5	2	0.25	0.88	0	0.00	0.11	4	0.57	0.57	1	0.08	0.08
5.6	0	0.00	0.88	0	0.00	0.11	0	0.00	0.55	0	0.00	0.08
5.7	0	0.00	0.88	0	0.00	0.11	1	0.14	0.52	0	0.00	0.08
5.8	0	0.00	0.88	0	0.00	0.11	0	0.00	0.50	0	0.00	0.08
5.9	1	0.13	0.88	0	0.00	0.11	0	0.00	0.48	0	0.00	0.08
6	7	0.88	0.88	0	0.00	0.11	2	0.29	0.45	0	0.00	0.08
6.1	0	0.00	0.82	0	0.00	0.11	3	0.43	0.43	0	0.00	0.08
6.2	0	0.00	0.75	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
6.3	0	0.00	0.69	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
6.4	0	0.00	0.63	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
6.5	1	0.13	0.57	1	0.11	0.11	3	0.43	0.43	0	0.00	0.08
6.6	0	0.00	0.50	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
6.7	0	0.00	0.44	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
6.8	1	0.13	0.38	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
6.9	1	0.13	0.31	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7	2	0.25	0.25	0	0.00	0.11	1	0.14	0.43	1	0.08	0.08
7.1	1	0.13	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7.2	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7.3	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7.4	0	0.00	0.25	0	0.00	0.11	2	0.29	0.43	0	0.00	0.08
7.5	0	0.00	0.25	0	0.00	0.11	3	0.43	0.43	0	0.00	0.08
7.6	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7.7	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7.8	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
7.9	1	0.13	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
8	1	0.13	0.25	0	0.00	0.11	1	0.14	0.43	0	0.00	0.08
8.1	1	0.13	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
8.2	0	0.00	0.25	0	0.00	0.11	2	0.29	0.43	0	0.00	0.08
8.3	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
8.4	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
8.5	0	0.00	0.25	1	0.11	0.11	1	0.14	0.43	0	0.00	0.08
8.6	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
8.7	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
8.8	1	0.13	0.25	0	0.00	0.11	1	0.14	0.43	0	0.00	0.08
8.9	0	0.00	0.25	0	0.00	0.11	2	0.29	0.43	0	0.00	0.08
9	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08

9.1	1	0.13	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.2	1	0.13	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.3	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.4	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.5	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.6	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.7	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.8	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
9.9	0	0.00	0.25	0	0.00	0.11	0	0.00	0.43	0	0.00	0.08
10	2	0.25	0.25	0	0.00	0.11	3	0.43	0.43	1	0.08	0.08
10.1	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.2	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.3	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.4	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.5	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.6	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.7	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.8	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
10.9	0	0.00	0.13	0	0.00	0.11	0	0.00	0.43	0	0.00	0.00
11	0	0.00	0.13	0	0.00	0.11	3	0.43	0.43	0	0.00	0.00
11.1	0	0.00	0.13	0	0.00	0.11	0	0.00	0.39	0	0.00	0.00
11.2	0	0.00	0.13	0	0.00	0.11	0	0.00	0.35	0	0.00	0.00
11.3	0	0.00	0.13	0	0.00	0.11	0	0.00	0.31	0	0.00	0.00
11.4	0	0.00	0.13	0	0.00	0.11	0	0.00	0.27	0	0.00	0.00
11.5	0	0.00	0.13	0	0.00	0.11	0	0.00	0.23	0	0.00	0.00
11.6	0	0.00	0.13	0	0.00	0.11	0	0.00	0.18	0	0.00	0.00
11.7	0	0.00	0.13	0	0.00	0.11	1	0.14	0.14	0	0.00	0.00
11.8	0	0.00	0.13	0	0.00	0.11	0	0.00	0.14	0	0.00	0.00
11.9	0	0.00	0.13	0	0.00	0.11	0	0.00	0.14	0	0.00	0.00
12	1	0.13	0.13	1	0.11	0.11	1	0.14	0.14	0	0.00	0.00
12.1	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0		
12.2	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0		
12.3	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0		
12.4	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0		
12.5	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0		
12.6	0	0.00	0.00	0	0.00	0.00	0	0.00		0		
12.7	0	0.00	0.00	0	0.00	0.00	0	0.00		0		
12.8	0	0.00	0.00	0	0.00	0.00	0	0.00		0		
12.9	0	0.00	0.00	0	0.00	0.00	0	0.00		0		
13	0	0.00	0.00	0	0.00	0.00	0	0.00		0		

HETCH HETCHY TROUT HABITAT USE OBSERVATIONS
OCTOBER 20, 1987 THROUGH JUNE 14, 1990
FREQUENCY DISTRIBUTIONS (FQ) & SUITABILITY INDEX (SI)

MEAN COLUMN WATER VELOCITY

	RAINBOW TROUT						BROWN TROUT					
	Adults			Juveniles			Adults			Juveniles		
INTERVAL	#	FQ	SI	#	FQ	SI	#	FQ	SI	#	FQ	SI
0	18	1.00	1.00	37	1.00	1.00	28	1.00	1.00	16	0.94	0.94
0.1	6	0.33	0.83	3 10	0.27	0.35	6	0.21	0.50	12	0.71	0.94
0.2	12	0.67	0.83	8 13	0.35	0.35	8	0.29	0.50	17	1.00	1.00
0.3	15	0.83	0.83	0 12	0.32	0.35	3	0.11	0.50	17	1.00	1.00
0.4	11	0.61	0.67	0 13	0.35	0.35	6	0.21	0.50	16	0.94	0.94
0.5	8	0.44	0.67	0 9	0.24	0.24	7	0.25	0.50	12	0.71	0.88
0.6	11	0.61	0.67	0 8	0.22	0.24	5	0.18	0.50	15	0.88	0.88
0.7	9	0.50	0.67	0 2	0.05	0.24	6	0.21	0.50	11	0.65	0.65
0.8	6	0.33	0.67	0 5	0.14	0.24	14	0.50	0.50	5	0.29	0.41
0.9	4	0.22	0.67	0 9	0.24	0.24	3	0.11	0.21	7	0.41	0.41
1	8	0.44	0.67	0 4	0.11	0.11	0	0.00	0.21	5	0.29	0.29
1.1	12	0.67	0.67	0 3	0.08	0.08	6	0.21	0.21	4	0.24	0.24
1.2	8	0.44	0.44	0 3	0.08	0.08	4	0.14	0.14	1	0.06	0.18
1.3	6	0.33	0.33	0 0	0.00	0.08	0	0.00	0.04	3	0.18	0.18
1.4	2	0.11	0.33	0 2	0.05	0.05	1	0.04	0.04	3	0.18	0.18
1.5	6	0.33	0.33	3 1	0.03	0.05	0	0.00	0.04	1	0.06	0.18
1.6	1	0.06	0.28	0 0	0.00	0.05	0	0.00	0.04	3	0.18	0.18
1.7	5	0.28	0.28	0 1	0.03	0.05	1	0.04	0.04	0	0.00	0.06
1.8	0	0.00	0.17	9 0	0.00	0.05	0	0.00	0.04	1	0.06	0.06
1.9	0	0.00	0.17	6 0	0.00	0.05	1	0.04	0.04	1	0.06	0.06
2	1	0.06	0.17	0 0	0.00	0.05	0	0.00	0.04	0	0.00	0.06
2.1	3	0.17	0.17	0 0	0.00	0.05	0	0.00	0.04	1	0.06	0.06
2.2	0	0.00	0.12	0 0	0.00	0.05	0	0.00	0.04	1	0.06	0.06
2.3	1	0.06	0.06	8 1	0.03	0.05	0	0.00	0.04	0	0.00	0.00
2.4	0	0.00	0.00	0 0	0.00	0.05	0	0.00	0.04	0	0.00	0.00
2.5	0	0.00	0.00	0 0	0.00	0.05	1	0.04	0.04	0	0.00	0.00
2.6	0	0.00	0.00	0 1	0.03	0.05	1	0.04	0.04	0	0.00	0.00
2.7	0	0.00	0.00	0 0	0.00	0.00	0	0.00	0.04	0	0.00	0.00
2.8	0	0.00	0.00	0 0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
2.9	0	0.00	0.00	0 0	0.00	0.00	0	0.00		0	0.00	0.00
3	0	0.00	0.00	0 0	0.00	0.00	0	0.00		0	0.00	0.00

HETCH HETCHY TROUT HABITAT USE OBSERVATIONS
OCTOBER 20, 1987 THROUGH JUNE 14, 1990
FREQUENCY DISTRIBUTIONS (FQ) & SUITABILITY INDEX (SI)

SUBSTRATE CATEGORY

	RAINBOW TROUT				BROWN TROUT			
	Adults		Juveniles		Adults		Juveniles	
CATEGORY	# FQ	SI	# FQ	SI	# FQ	SI	# FQ	SI
1.01	0 0.00	0.00	0 0.00		0 0.00		1 0.03	
1.02	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.03	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.04	0 0.00	0.00	0 0.00		1 0.09		2 0.06	
1.05	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.06	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.07	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.08	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.09	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.10	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.11	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.12	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.13	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.14	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
1.15	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.01	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.02	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.03	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.04	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.05	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.06	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.07	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.08	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.09	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.10	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.11	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.12	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.13	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.14	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
2.15	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
3.01	0 0.00	0.00	1 0.08		0 0.00		0 0.00	
3.02	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
3.03	0 0.00	0.00	0 0.00		1 0.09		6 0.18	
3.04	0 0.00	0.00	1 0.08		0 0.00		0 0.00	
3.05	0 0.00	0.00	1 0.08		0 0.00		4 0.12	
3.06	0 0.00	0.00	0 0.00		0 0.00		2 0.06	
3.07	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
3.08	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
3.09	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
3.10	0 0.00	0.00	0 0.00		0 0.00		0 0.00	
3.11	0 0.00	0.00	0 0.00		0 0.00		0 0.00	

3.12	0 0.00	0.00	0 0.00	0 0.00	0 0.00
3.13	0 0.00	0.00	0 0.00	0 0.00	0 0.00
3.14	0 0.00	0.00	0 0.00	0 0.00	0 0.00
3.15	0 0.00	0.00	0 0.00	0 0.00	0 0.00
4.01	1 0.08	0.08	0 0.00	0 0.00	2 0.06
4.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
4.03	0 0.00	0.08	1 0.08	0 0.00	1 0.03
4.04	3 0.23	0.23	6 0.50	6 0.55	6 0.48
4.05	0 0.00	0.08	2 0.17	0 0.00	0 0.00
			3 0.25	0 0.00	3 0.09
4.07	0 0.00	0.08	0 0.00	0 0.00	0 0.00
4.08	0 0.00	0.08	0 0.00	0 0.00	0 0.00
4.09	0 0.00	0.08	0 0.00	0 0.00	0 0.00
4.10	1 0.08	0.08	0 0.00	0 0.00	1 0.03
4.11	1 0.08	0.08	2 0.17	1 0.09	1 0.03
4.12	1 0.08	0.08	0 0.00	6 0.55	0 0.00
4.13	0 0.00	0.08	4 0.33	0 0.00	0 0.00
4.14	0 0.00	0.08	0 0.00	0 0.00	0 0.00
4.15	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.01	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.03	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.04	0 0.00	0.08	0 0.00	2 0.18	7 0.21
5.05	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.06	1 0.08	0.08	1 0.08	0 0.00	0 0.00
5.07	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.08	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.09	0 0.00	0.08	1 0.08	0 0.00	0 0.00
5.10	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.11	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.12	0 0.00	0.08	0 0.00	0 0.00	0 0.00
5.13	0 0.00	0.08	0 0.00	1 0.09	0 0.00
5.14	0 0.00	0.08	0 0.00	0 0.00	1 0.03
5.15	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.01	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.03	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.04	0 0.00	0.08	0 0.00	0 0.00	3 0.09
6.05	0 0.00	0.08	4 0.33	0 0.00	1 0.03
6.06	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.07	1 0.08	0.08	1 0.08	1 0.09	3 0.09
6.08	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.09	0 0.00	0.08	1 0.08	0 0.00	0 0.00
6.10	0 0.00	0.08	0 0.00	1 0.09	0 0.00
6.11	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.12	1 0.08	0.08	0 0.00	0 0.00	1 0.03
6.13	0 0.00	0.08	0 0.00	0 0.00	0 0.00
6.14	1 0.08	0.08	0 0.00	0 0.00	0 0.00
6.15	1 0.08	0.08	0 0.00	0 0.00	0 0.00
7.01	0 0.00	0.08	0 0.00	0 0.00	0 0.00

7.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.03	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.04	0 0.00	0.08	0 0.00	1 0.09	0 0.00
7.05	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.06	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.07	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.08	0 0.00	0.08	1 0.08	0 0.00	0 0.00
7.09	0 0.00	0.08	0 0.00	0 0.00	1 0.03
7.10	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.11	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.12	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.13	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.14	0 0.00	0.08	0 0.00	0 0.00	0 0.00
7.15	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.01	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.03	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.04	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.05	0 0.00	0.08	1 0.08	0 0.00	0 0.00
8.06	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.07	0 0.00	0.08	1 0.08	0 0.00	0 0.00
8.08	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.09	0 0.00	0.08	0 0.00	0 0.00	1 0.03
8.10	0 0.00	0.08	3 0.25	0 0.00	2 0.06
8.11	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.12	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.13	0 0.00	0.08	0 0.00	0 0.00	1 0.03
8.14	0 0.00	0.08	0 0.00	0 0.00	0 0.00
8.15	0 0.00	0.08	0 0.00	0 0.00	0 0.00
9.01	0 0.00	0.08	0 0.00	0 0.00	0 0.00
9.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
9.03	0 0.00	0.08	0 0.00	0 0.00	0 0.00
9.04	0 0.00	0.08	1 0.08	1 0.09	0 0.00
9.05	0 0.00	0.08	0 0.00	2 0.18	0 0.00
9.06	0 0.00	0.08	1 0.08	0 0.00	0 0.00
9.07	0 0.00	0.08	2 0.17	0 0.00	0 0.00
9.08	0 0.00	0.08	2 0.17	0 0.00	0 0.00
9.09	0 0.00	0.08	0 0.00	0 0.00	0 0.00
9.10	1 0.08	0.08	1 0.08	0 0.00	4 0.12
9.11	1 0.08	0.08	2 0.17	0 0.00	2 0.06
9.12	2 0.15	0.15	4 0.33	0 0.00	0 0.00
9.13	1 0.08	0.10	1 0.08	1 0.09	0 0.00
9.14	1 0.08	0.08	0 0.00	0 0.00	0 0.00
9.15	1 0.08	0.08	0 0.00	0 0.00	0 0.00
10.01	0 0.00	0.08	0 0.00	0 0.00	0 0.00
10.02	0 0.00	0.08	0 0.00	0 0.00	0 0.00
10.03	0 0.00	0.08	0 0.00	0 0.00	0 0.00
10.04	0 0.00	0.08	1 0.08	0 0.00	0 0.00
10.05	0 0.00	0.08	1 0.08	0 0.00	2 0.06
10.06	1 0.08	0.08	0 0.00	0 0.00	1 0.03

10.07	0	0.00	0.08	0	0.00	1	0.09	0	0.00
10.08	0	0.00	0.08	2	0.17	0	0.00	1	0.03
10.09	0	0.00	0.08	0	0.00	1	0.09	2	0.06
10.10	0	0.00	0.08	0	0.00	0	0.00	0	0.00
10.11	1	0.08	0.08	3	0.25	1	0.09	4	0.12
10.12	3	0.23	0.23	4	0.33	0	0.00	0	0.00
10.13	0	0.00	0.08	1	0.08	2	0.18	0	0.00
10.14	0	0.00	0.08	0	0.00	0	0.00	0	0.00
10.15	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.01	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.02	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.03	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.04	1	0.08	0.08	0	0.00	0	0.00	0	0.00
11.05	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.06	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.07	1	0.08	0.08	1	0.08	0	0.00	0	0.00
11.08	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.09	0	0.00	0.08	1	0.08	0	0.00	1	0.03
11.10	0	0.00	0.08	1	0.08	0	0.00	1	0.03
11.11	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.12	4	0.31	0.31	1	0.08	2	0.18	5	0.15
11.13	1	0.08	0.08	0	0.00	1	0.09	1	0.03
11.14	0	0.00	0.08	0	0.00	0	0.00	0	0.00
11.15	0	0.00	0.08	0	0.00	0	0.00	0	0.00
12.01	0	0.00	0.08	0	0.00	0	0.00	0	0.00
12.02	0	0.00	0.08	0	0.00	0	0.00	0	0.00
12.03	0	0.00	0.08	0	0.00	0	0.00	0	0.00
12.04	2	0.15	0.15	4	0.33	1	0.09	1	0.03
12.05	0	0.00	0.08	0	0.00	1	0.09	0	0.00
12.06	0	0.00	0.08	0	0.00	0	0.00	1	0.03
12.07	0	0.00	0.08	1	0.08	0	0.00	0	0.00
12.08	3	0.23	0.23	3	0.25	1	0.09	1	0.03
12.09	1	0.08	0.23	1	0.92	0	0.00	1	0.03
12.10	5	0.38	0.38	4	0.33	3	0.27	2	0.06
12.11	6	0.46	0.46	4	0.33	3	0.27	8	0.24
12.12	1	0.08	0.46	1	0.08	1	0.09	0	0.00
12.13	7	0.54	0.54	4	0.33	6	0.55	6	0.18
12.14	1	0.08	0.08	0	0.00	1	0.09	0	0.00
12.15	0	0.00	0.08	0	0.00	0	0.00	0	0.00
13.01	0	0.00	0.08	0	0.00	0	0.00	0	0.00
13.02	0	0.00	0.08	0	0.00	0	0.00	0	0.00
13.03	0	0.00	0.08	0	0.00	0	0.00	0	0.00
13.04	1	0.08	0.08	3	0.25	1	0.09	1	0.03
13.05	0	0.00	0.08	0	0.00	2	0.18	0	0.00
13.06	1	0.08	0.08	1	0.08	0	0.00	0	0.00
13.07	1	0.08	0.08	0	0.00	0	0.00	0	0.00
13.08	2	0.15	0.15	0	0.00	0	0.00	0	0.00
13.09	3	0.23	0.23	1	0.08	2	0.18	1	0.03
13.10	11	0.85	0.85	0	0.00	5	0.45	0	0.00
13.11	2	0.15	0.85	2	0.17	0	0.00	0	0.00

13.12	13	1.00	1	2	1.00	1	1.00	3	1.00
13.13	6	0.46	0.46	3	0.25	1	0.09	0	0.00
13.14	2	0.15	0.15	1	0.08	2	0.18	3	0.09
13.15	2	0.15	0.15	0	0.00	2	0.18	0	0.00
14.01	0	0.00	0.08	0	0.00	0	0.00	0	0.00
14.02	0	0.00	0.08	0	0.00	0	0.00	0	0.00
14.03	0	0.00	0.08	0	0.00	0	0.00	0	0.00
14.04	1	0.08	0.08	0	0.00	2	0.18	0	0.00
14.05	1	0.08	0.08	0	0.00	1	0.09	0	0.00
14.06	0	0.00	0.08	0	0.00	0	0.00	0	0.00
14.07	0	0.00	0.08	0	0.00	0	0.00	0	0.00
14.08	4	0.31	0.31	1	0.08	0	0.00	0	0.00
14.09	2	0.15	0.15	0	0.00	0	0.00	0	0.00
14.10	2	0.15	0.15	0	0.00	2	0.18	0	0.00
14.11	0	0.00	0.15	0	0.00	0	0.00	0	0.00
14.12	6	0.46	0.46	6	0.50	4	0.36	0	0.00
14.13	7	0.54	0.54	3	0.25	7	0.64	2	0.06
14.14	2	0.15	0.15	1	0.08	1	0.09	0	0.00
14.15	2	0.15	0.15	0	0.00	0	0.00	0	0.00
15.01	0	0.00	0.08	0	0.00	0	0.00	0	0.00
15.02	0	0.00	0.08	0	0.00	0	0.00	0	0.00
15.03	0	0.00	0.08	0	0.00	0	0.00	0	0.00
15.04	0	0.00	0.08	0	0.00	0	0.00	0	0.00
15.05	0	0.00	0.08	0	0.00	0	0.00	1	0.03
15.06	1	0.08	0.08	0	0.00	2	0.18	0	0.00
15.07	0	0.00	0.08	0	0.00	0	0.00	0	0.00
15.08	0	0.00	0.08	0	0.00	0	0.00	0	0.00
15.09	2	0.15	0.15	0	0.00	0	0.00	0	0.00
15.10	2	0.15	0.15	1	0.08	1	0.09	0	0.00
15.11	0	0.00	0.15	0	0.00	0	0.00	0	0.00
15.12	3	0.23	0.23	0	0.00	0	0.00	1	0.03
15.13	4	0.31	0.31	0	0.00	0	0.00	0	0.00
15.14	3	0.23	0.31	0	0.00	1	0.09	2	0.06
15.15	10	0.77	0.77	2	0.17	4	0.36	4	0.12

APPENDIX C: Estimated weighted usable area of habitat for rainbow trout and brown trout in the Tuolumne River between Hetch Hetchy Reservoir and Early Intake.

WEIGHTED USABLE AREA PER 1000 LINEAR FEET OF STREAM FOR FOUR STUDY SITES IN THE TUOLUMNE RIVER ALONG WITH THE ESTIMABED TOTAL COMBINED WEIGHTED USABLE AREA OF HABITAT FOR RAINBOW AND BROWN TROUT IN THE REACH BETWEEN O'SHAUGHNESSY DAM AND EARLY INTAKE.

TOTAL AREA

	DISCHARGE	EARLY INTAKE	INDIAN MEADOW	O'SHAUGHNESSY LOWER	O'SHAUGHNESSY UPPER	COMBINED TOTAL
1	10	46,614	70,696	51,600	55,780	1,596,619
2	20	53,086	78,738	54,887	59,166	1,741,760
3	30	58,654	83,161	56,856	61,965	1,843,058
4	40	62,847	88,397	58,534	64,356	1,935,244
5	50	66,295	92,172	60,106	65,992	2,006,579
6	60	69,190	95,584	61,112	67,217	2,064,347
7	70	72,076	97,356	62,145	68,349	2,111,121
8	80	74,271	98,432	63,044	69,402	2,147,377
9	90	76,047	99,682	64,307	70,324	2,183,924
10	100	77,140	100,821	65,041	71,099	2,210,075
11	110	78,407	101,561	66,237	71,733	2,237,330
12	120	79,159	102,198	66,652	72,294	2,253,893
13	130	79,724	102,704	67,042	72,744	2,267,355
14	140	80,138	103,183	67,437	73,171	2,279,545
15	150	80,521	103,866	67,825	73,657	2,293,251
16	160	82,406	104,577	68,239	74,036	2,316,040
17	170	84,305	105,259	68,818	74,399	2,339,905
18	180	84,593	105,915	69,881	74,763	2,357,212
19	190	84,863	106,417	70,533	75,137	2,370,259
20	200	85,173	106,884	71,167	75,497	2,383,068
21	210	85,671	107,100	71,850	76,773	2,403,131
22	220	85,976	107,233	72,450	77,051	2,412,876
23	230	86,274	107,361	73,036	77,513	2,423,889
24	240	86,564	107,486	74,564	77,997	2,442,464
25	250	86,859	107,607	75,167	78,446	2,453,453
26	260	87,181	107,711	75,729	78,766	2,463,140
27	270	87,544	107,810	76,254	79,005	2,472,134
28	280	87,838	107,906	76,731	79,240	2,480,254
29	290	88,068	108,068	77,137	79,471	2,487,807
30	300	88,294	108,299	77,538	79,673	2,495,478

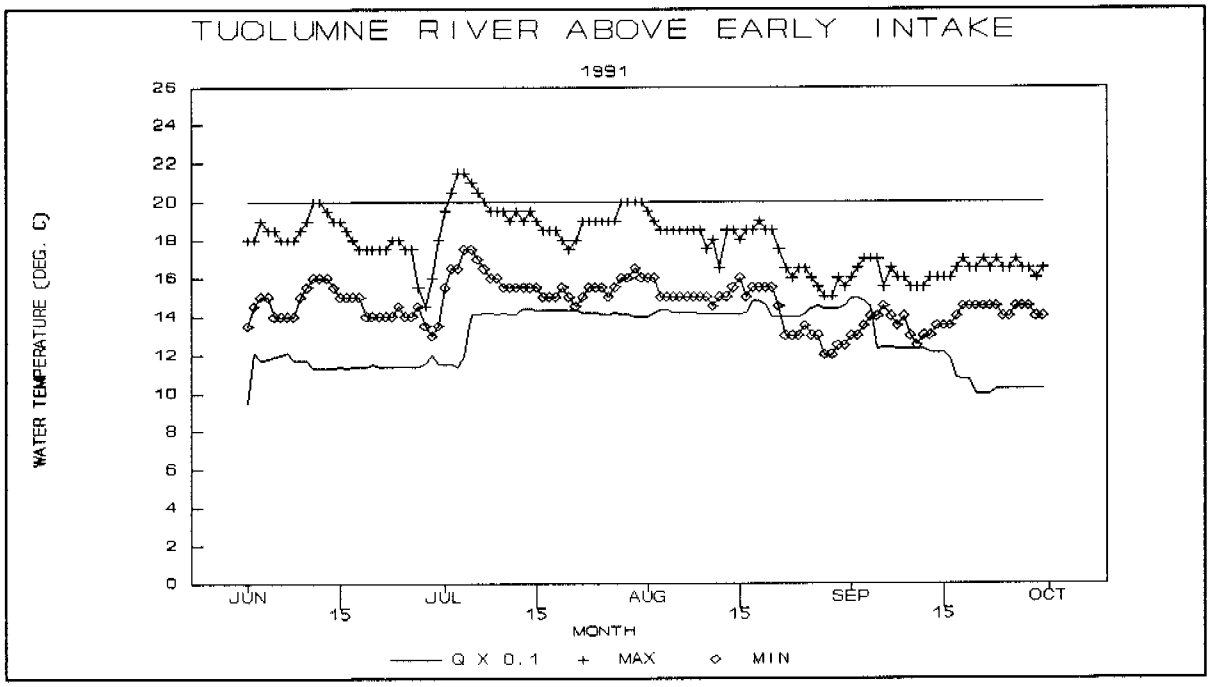
RAINBOW TROUT

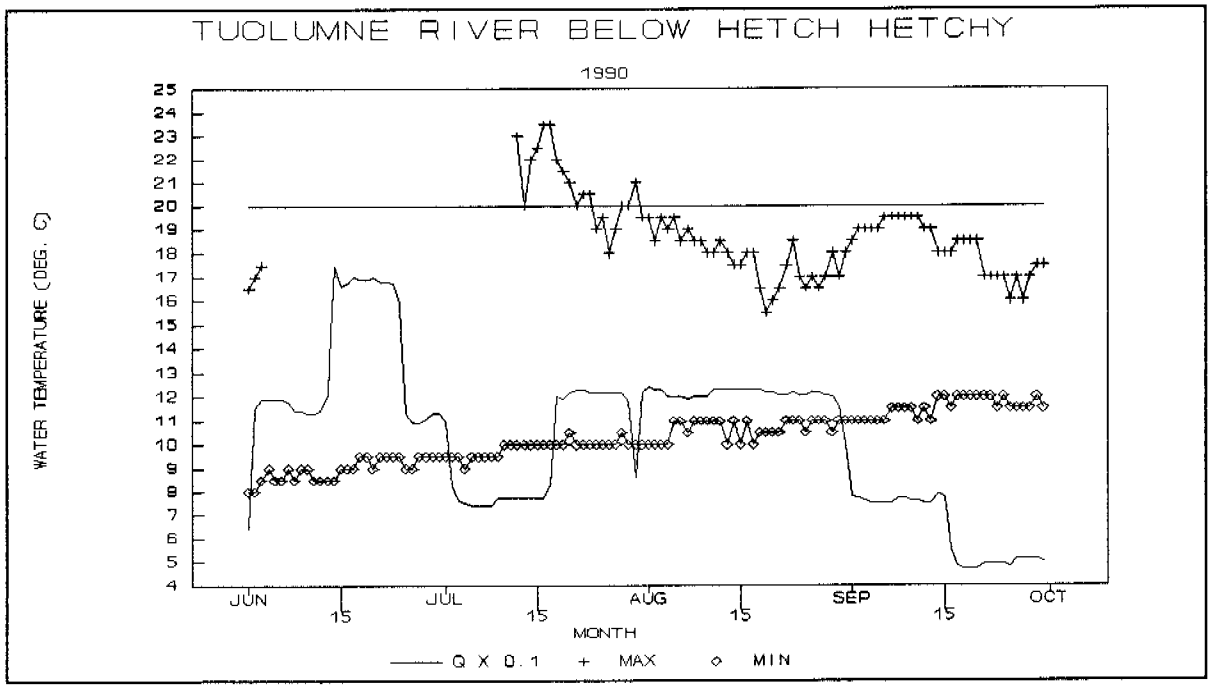
	DISCHARGE	EARLY INTAKE		INDIAN MEADOW		LOWER O'SHAUGHNESSY		UPPER O'SHAUGHNESSY		COMBINED
		ADULT	JUVENILE	ADULT	JUVENILE	ADULT	JUVENILE	ADULT	JUVENILE	ADULT
1	10	24,817	13,926	14,075	18,908	12,280	12,519	18,430	11,758	490,590
2	20	24,996	10,703	16,233	17,629	14,182	13,935	19,837	11,018	531,660
3	30	24,957	9,118	17,847	15,177	15,883	13,583	20,498	10,370	560,381
4	40	23,732	8,471	19,423	14,684	16,576	12,291	20,666	10,042	569,449
5	50	23,296	8,081	20,947	14,725	16,869	10,203	21,017	9,732	581,460
6	60	23,873	7,864	22,224	14,785	17,352	9,582	21,441	9,384	600,436
7	70	23,857	7,787	23,225	14,493	17,857	9,240	21,225	9,128	608,985
8	80	23,922	7,767	23,995	14,641	17,936	8,914	21,328	8,792	615,737
9	90	24,502	7,531	24,911	14,647	18,325	8,493	21,334	8,123	628,375
10	100	24,606	7,420	25,663	14,369	18,836	8,170	20,848	7,709	634,024
11	110	24,799	7,270	26,276	14,209	19,243	7,975	19,920	7,219	635,009
12	120	24,992	7,130	26,969	14,227	19,398	7,922	19,934	6,776	641,989
13	130	25,179	7,084	27,533	14,197	19,473	7,845	20,078	6,430	648,501
14	140	25,516	7,169	28,017	14,072	19,549	7,735	20,049	6,039	654,085
15	150	25,788	7,164	28,513	13,887	19,585	7,556	19,868	5,990	657,818
16	160	25,917	7,152	29,043	13,772	19,655	7,306	19,794	5,977	661,974
17	170	25,938	7,212	29,658	13,602	19,713	7,137	19,675	5,911	665,540
18	180	25,889	7,352	30,212	13,441	19,691	7,009	19,694	5,909	668,725
19	190	25,894	7,193	30,552	13,128	19,698	7,010	19,641	5,859	670,550
20	200	25,994	7,092	30,819	12,937	19,699	7,041	19,693	5,865	673,295
21	210	26,192	7,015	30,992	12,738	19,636	6,986	19,822	5,885	676,179
22	220	26,336	7,046	31,213	12,468	19,623	6,888	19,958	5,919	679,474
23	230	26,425	7,059	31,320	12,114	19,635	6,748	20,062	5,896	681,650
24	240	26,396	7,110	31,185	11,752	19,709	6,540	19,994	5,880	680,651
25	250	26,503	7,227	31,054	11,498	19,680	6,441	19,966	5,870	680,039
26	260	26,788	7,306	30,938	11,159	19,617	6,340	19,978	5,887	680,720
27	270	27,177	7,303	30,909	10,687	19,557	6,260	20,099	5,913	683,485
28	280	27,482	7,281	30,863	10,195	19,522	6,216	20,263	5,932	686,155
29	290	27,639	7,252	30,741	9,795	19,528	6,193	20,300	5,960	686,714
30	300	27,692	7,267	30,528	9,495	19,481	6,158	20,088	5,974	683,651

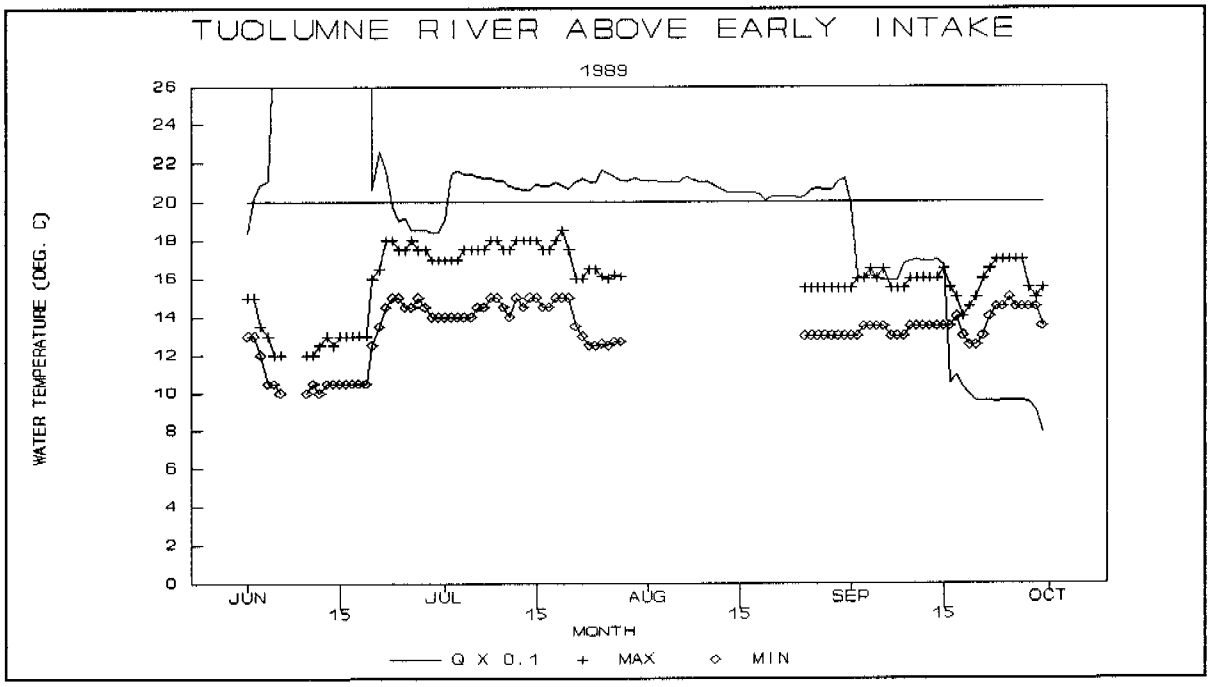
BROWN TROUT

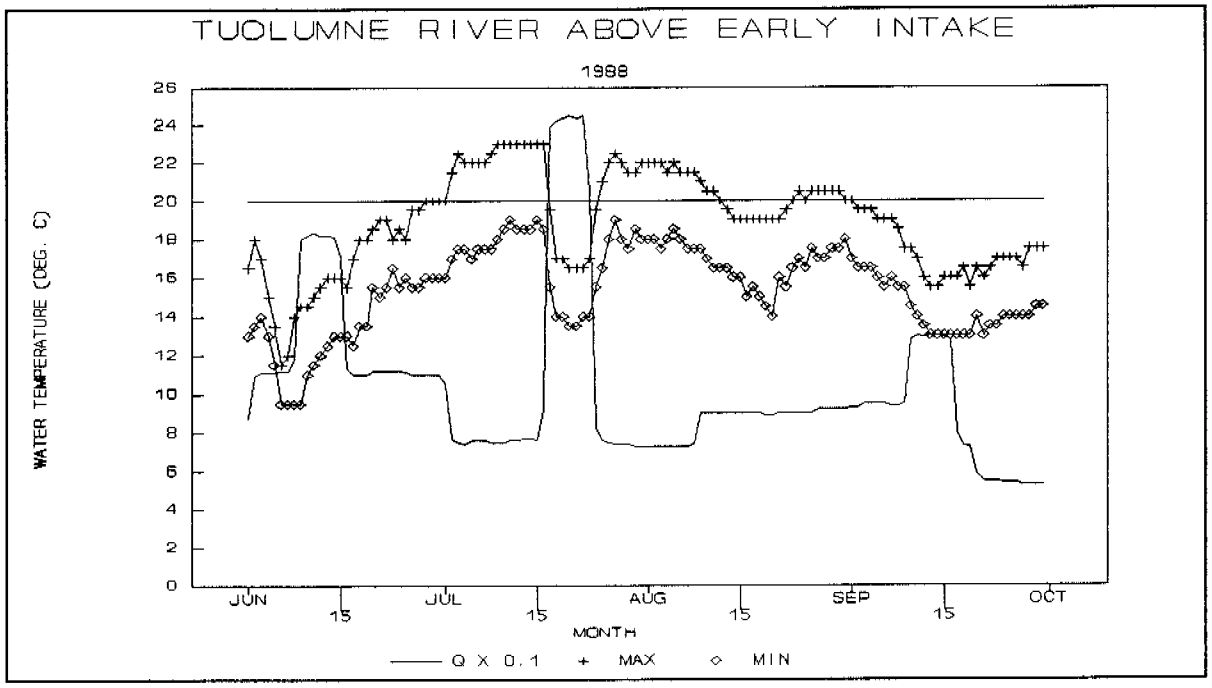
	DISCHARGE	EARLY INTAKE		INDIAN MEADOW		LOWER O'SHAUGHNESSY		UPPER O'SHAUGHNESSY		COMBINED
		ADULT	JUVENILE	ADULT	JUVENILE	ADULT	JUVENILE	ADULT	JUVENILE	ADULT
1	10	16,397	12,818	12,322	23,923	12,412	14,451	18,589	12,033	428,222
2	20	14,204	13,459	13,159	28,911	14,720	15,869	18,281	13,239	435,452
3	30	12,614	14,105	13,379	31,240	15,371	15,656	17,451	13,424	425,323
4	40	11,666	13,822	13,783	33,483	15,353	15,431	16,785	12,805	416,440
5	50	11,804	13,553	13,687	33,407	13,876	15,635	16,445	12,748	402,303
6	60	11,742	13,699	13,629	33,278	13,164	15,110	16,245	12,319	394,320
7	70	11,729	13,886	14,120	32,858	12,827	14,164	15,908	12,181	392,012
8	80	11,883	14,176	14,317	33,194	12,651	13,425	15,397	12,184	388,811
9	90	12,103	14,378	14,819	33,289	12,320	12,637	15,464	11,558	391,304
10	100	11,968	14,480	15,165	33,467	12,251	12,502	15,167	11,569	389,738
11	110	12,037	14,248	15,110	33,225	12,128	12,498	14,702	11,211	385,170
12	120	12,240	14,435	15,317	32,530	11,916	12,238	14,395	10,967	383,664
13	130	12,370	14,530	15,490	32,312	11,845	12,291	14,209	10,988	383,562
14	140	12,462	14,600	15,406	31,434	11,747	11,980	13,824	11,079	379,781
15	150	12,585	15,033	15,894	30,373	11,504	11,517	13,738	11,375	381,049
16	160	12,632	15,099	16,516	29,440	11,235	11,112	13,790	11,431	383,594
17	170	12,654	15,269	16,691	28,798	10,998	10,798	13,630	11,856	381,704
18	180	12,644	15,773	16,844	28,072	10,722	10,521	13,448	11,744	378,977
19	190	12,685	15,741	16,967	27,288	10,445	10,349	13,336	11,101	376,940
20	200	12,474	15,389	16,925	26,483	10,136	10,350	13,187	10,936	371,705
21	210	12,246	14,951	16,708	25,536	9,782	10,280	12,955	10,771	364,226
22	220	12,313	14,702	16,483	24,447	9,476	9,897	12,771	10,603	359,339
23	230	12,477	14,806	16,035	23,720	9,352	9,528	12,899	10,542	357,560
24	240	12,948	14,996	15,503	23,278	9,275	9,437	12,997	10,625	357,342
25	250	13,077	14,976	14,931	22,849	9,194	9,598	12,950	10,792	353,521
26	260	13,030	14,672	14,440	22,243	9,182	9,705	12,888	10,937	349,511
27	270	13,044	14,696	14,197	21,231	9,092	9,596	12,890	11,092	347,356
28	280	13,037	14,722	13,760	20,299	8,981	9,550	12,878	11,280	343,562
29	290	13,070	14,511	13,433	19,501	8,867	9,566	12,829	11,589	340,395
30	300	13,141	14,218	13,162	18,998	8,805	9,621	12,783	11,803	338,269

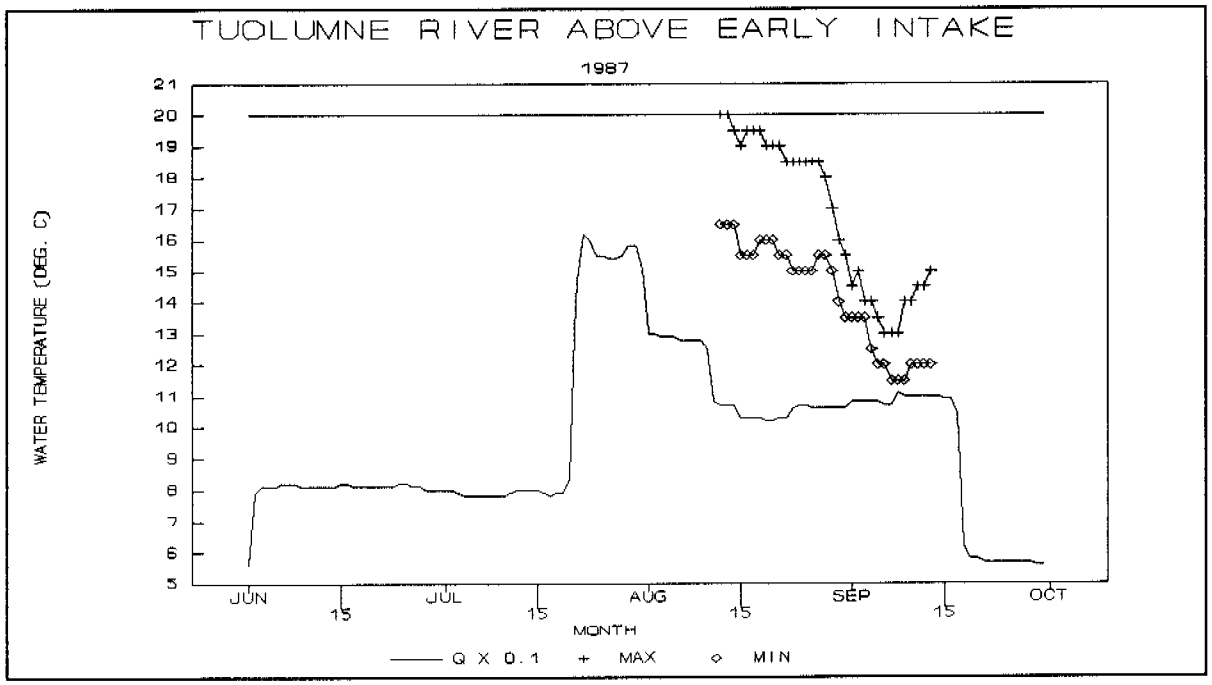
APPENDIX D: Water temperature records for the months of June through October during water years 1988 through 1991 for the Tuolumne River above Early Intake.


TUOLUMNE RIVER ABOVE EARLY INTAKE
1991
WATER TEMPERATURE (DEG. C)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
JUN
15
JUL
15
AUG
15
SEP
15
OCT
MONTH
Q X 0.1
+ MAX
◇ MIN


TUOLUMNE RIVER BELOW HETCH HETCHY
1990
WATER TEMPERATURE (DEG. C)
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
JUN
15
JUL
15
AUG
15
SEP
15
OCT
MONTH
Q X 0.1
+ MAX
◇ MIN


TUOLUMNE RIVER ABOVE EARLY INTAKE
1989
WATER TEMPERATURE (DEG. C)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
JUN
15
JUL
15
AUG
15
SEP
15
OCT
MONTH
Q X 0.1
MAX
MIN


TUOLUMNE RIVER ABOVE EARLY INTAKE
1988
WATER TEMPERATURE (DEG. C)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
JUN
15
JUL
15
AUG
15
SEP
15
OCT
MONTH
Q X 0.1
MAX
MIN


TUOLUMNE RIVER ABOVE EARLY INTAKE
1987
WATER TEMPERATURE (DEG. C)
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
JUN
15
JUL
15
AUG
15
SEP
15
OCT
MONTH
Q X 0.1
+ MAX
◇ MIN