MAMMOTH CREEK 1994
FISH COMMUNITY SURVEY

Prepared for:
Mammoth County Water District
P.O. Box 597
Mammoth Lakes, California 93546

Prepared by:
Dennis J. Hood, Paul M. Bratovich
and David B. Christophel of

beak
consultants
incorporated

4600 Northgate Boulevard, Suite 215
Sacramento, California 95834

Draft Report
November 1994

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14 September 1994
Ref: 200.400

Mr. Dennis Erdman
Mammoth County Water District
P.O. Box 597
Mammoth Lakes, California 93546

Re: 1994 Mammoth Creek Fish Community Survey

Dear Mr. Erdman:

Pursuant to previous discussions with you and Mr. Kronick, please accept this letter and the attached cost estimate as a proposal to the Mammoth County Water District (District) by Beak Consultants Incorporated (Beak) to perform a fish community survey in Mammoth Creek in the fall of 1994. This survey is proposed as a means for continuing to monitor the fish population over time and under various hydrologic conditions.

As you are aware, Beak has conducted comprehensive, quantitative studies of instream flows, habitat availability, and the fish population in Mammoth Creek since 1988. Recommendations for a minimum flow maintenance schedule have been made as a result of these investigations. Results of the fish population monitoring were a major topic of discussion at the hearing and subsequent meeting with the State Water Resources Control Board regarding Preliminary Cease and Desist Order No. 9P. Thus, it is an important program, and we request that you consider its continuation.

Annual monitoring of the Mammoth Creek fishery will allow for assessment of the population to be made over a wide range of conditions. The specific objectives of the monitoring program are:

1) To estimate the total fish population among sampling sections;

2) To evaluate the size and age class structure of fish throughout Mammoth Creek and within each sampling section; and,

3) To compare the results of the proposed study with previous studies of Mammoth Creek under various hydrologic regimes.

December 5, 1994

Mr. Paul Bratovich
Regional Manager
Beak Consultants, Incorporated
4600 Northgate Boulevard, Suite 215
Sacramento, California 95834

Re: Mammoth Creek 1994 Fish Community Survey

Dear Paul:

I have reviewed the draft report of the Mammoth Creek 1994 Fish Community Survey and have only one comment. On page 2, under the description of the sampling site selection process, the procedure for determining the upstream boundary of the sampling section is described. It is stated that "a distance of 100 feet was measured in an upstream direction and served as the upstream boundary of the sampling section". Instead of 100 feet, should this figure be 300 feet instead?

Thank you for the opportunity to review this draft document. If you should have any questions, please feel free to contact either myself or Dennis Erdman at the District office at (619) 934-2596.

Sincerely,

MAMMOTH COUNTY WATER DISTRICT

Gary Sisson

GARY SISSON
Operations and Maintenance Manager

beak consultants incorporated

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GARY
PLEASE REVIEW
THANKS

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MAMMOTH COUNTY
WATER DISTRICT

November 28, 1994
Ref: 41308

Mr. Dennis Erdman
Mammoth County Water District
P.O. Box 597
Mammoth Lakes, CA 93546

RE: Fish Community Survey - 1994

Dear Mr. Erdman:

Please accept the enclosed draft report titled "Mammoth Creek 1994 Fish Community Survey" in fulfillment of our recent agreement to continue monitoring fish populations in Mammoth Creek.

We look forward to your review and comments on this draft report. We are also submitting a copy of this draft report to Mr. Kronick for his review and comment. If you have any questions regarding this draft or the work completed in its preparation, please do not hesitate to call either Dennis Hood or me at (916) 565-7900.

Sincerely,

Paul Bratovich
Regional Manager

PMB/nlb

enc:

cc: Mr. S. Kronick, w/ enc.

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MAMMOTH CREEK 1994 FISH COMMUNITY SURVEY

Prepared for the Mammoth County Water District

by Beak Consultants Incorporated

INTRODUCTION

Fishery resource needs and the establishment of instream flow requirements remain a significant issue for Mammoth Creek, Mono County, California. Mammoth County Water District (District) retained Beak Consultants Incorporated (Beak) in July of 1988 to evaluate the instream flow needs of the fishery in Mammoth Creek. Since that time, Beak has conducted comprehensive, quantitative studies of instream flows, habitat availability, and fish population estimation on Mammoth Creek. Annual sampling of the fish population of Mammoth Creek serves to evaluate instream flow effects and monitor the fishery of the creek. This study was designed and initiated as a method for comparison of population changes over time under various hydrologic conditions. Fish resource assessment surveys were conducted from October 4 through 11, 1994, in the Mammoth Creek study area to evaluate several aspects of species composition, abundance and distribution. Specific objectives were:

- To estimate the total fish population among sampling sections;
- To evaluate the size and age class structure of fish throughout Mammoth Creek and within each sampling section; and,
- To compare the results of similar studies of Mammoth Creek and other Sierra Nevada streams.

STUDY AREA

The Mammoth Creek study area extends from Lake Mary downstream to the confluence of Mammoth Creek and Hot Creek, a distance of approximately 10.4 miles. Five distinct reaches were identified in Mammoth Creek by Beak in 1988 (Bratovich et al. 1990), based upon analysis of topographic maps, calculation of gradient profiles, and visual inspection of the creek and associated morphological characteristics, tributaries, riparian vegetation and surrounding topography. Four of these reaches were located in the lower 8.9 miles (86.3 percent of the entire length) of the creek, and were characterized by gradients that range from 0.7 to 3.8 percent. By contrast, a fifth reach comprised of approximately the upper 1.4 miles (13.7 percent of the creek) was characterized by a gradient of approximately 12.3 percent. Habitat in this high-gradient reach typically consisted of cascade-plunge pool sequences in which the amount of usable fish habitat was not determined by stream discharge, but by sectional (streambed rock) hydraulic controls. Pursuant to concerns expressed by the California Department of Fish and Game (CDFG) and United States Forest Service (USFS) during the preliminary scoping meeting held in

1988 regarding the accuracy of modeling Reach A using the Instream Flow Incremental Methodology (IFIM), habitat characterization and all subsequent investigations were restricted to the remaining four study reaches (Bratovich et al. 1992). Therefore, for comparative purposes, the same four reaches were the focus of this 1994 investigation.

METHODS AND MATERIALS

Experimental Design

Distinct differences in the amount of riparian cover within each study reach were observed during the habitat mapping survey conducted by Beak in the fall of 1988 (Bratovich et al. 1990). To represent these distinct zones of riparian cover and to disperse sampling sections throughout the creek, fish sampling sections were located in both high and low zones of riparian cover within each study reach.

The experimental design and sampling site selection process were identical to those used in the 1993, 1992 and the 1988 surveys. The following is a description of the sampling site selection process established in 1988.

A traditional two-stage sampling design was used to assess fish resources in the Mammoth Creek study area. Within each of the four study reaches, two sampling sections (one each within designated high and low riparian cover zones) were chosen by the following formalized random selection procedure:

- The total thalweg length of both high and low riparian vegetation cover zones within each study reach was determined by summing the lengths of each primary habitat unit;
- A four digit number was selected with a random number generator and treated as a decimal fraction;
- The selected random number (treated as a fraction) was multiplied by the total length of the reach/cover stratum;
- The resultant product (Step 3, above) was measured (linear feet) from the downstream boundary of the study reach/cover stratum, and served as the downstream boundary of the sampling section; and,
- From the point identified in Step 4 (above), a distance of 100 feet was measured in an upstream direction and served as the upstream boundary of the sampling section.

The downstream boundary of each sampling section was identical between the 1988, 1992, 1993 and the present study, although the sampling section extended upstream 100-feet during the 1988 study and 300-feet during the 1992, 1993 and present study. The locations of the eight electrofishing sites are presented in **Figure 1**.

Data Acquisition

Fish resource assessment surveys were conducted by electrofishing. At least one day prior to electrofishing, selected sampling sections were located and the upstream and downstream boundaries marked with 0.5-inch diameter rebar driven into each bank. The rebar also served as anchors for block nets. Sampling sites were closed using block nets comprised of 0.125-inch stretched mesh, simultaneously placed across the upstream and downstream boundaries to preclude movement of fish into or out of the sampling section. Conductivity of the stream was measured and salt blocks were placed at the upstream boundary of

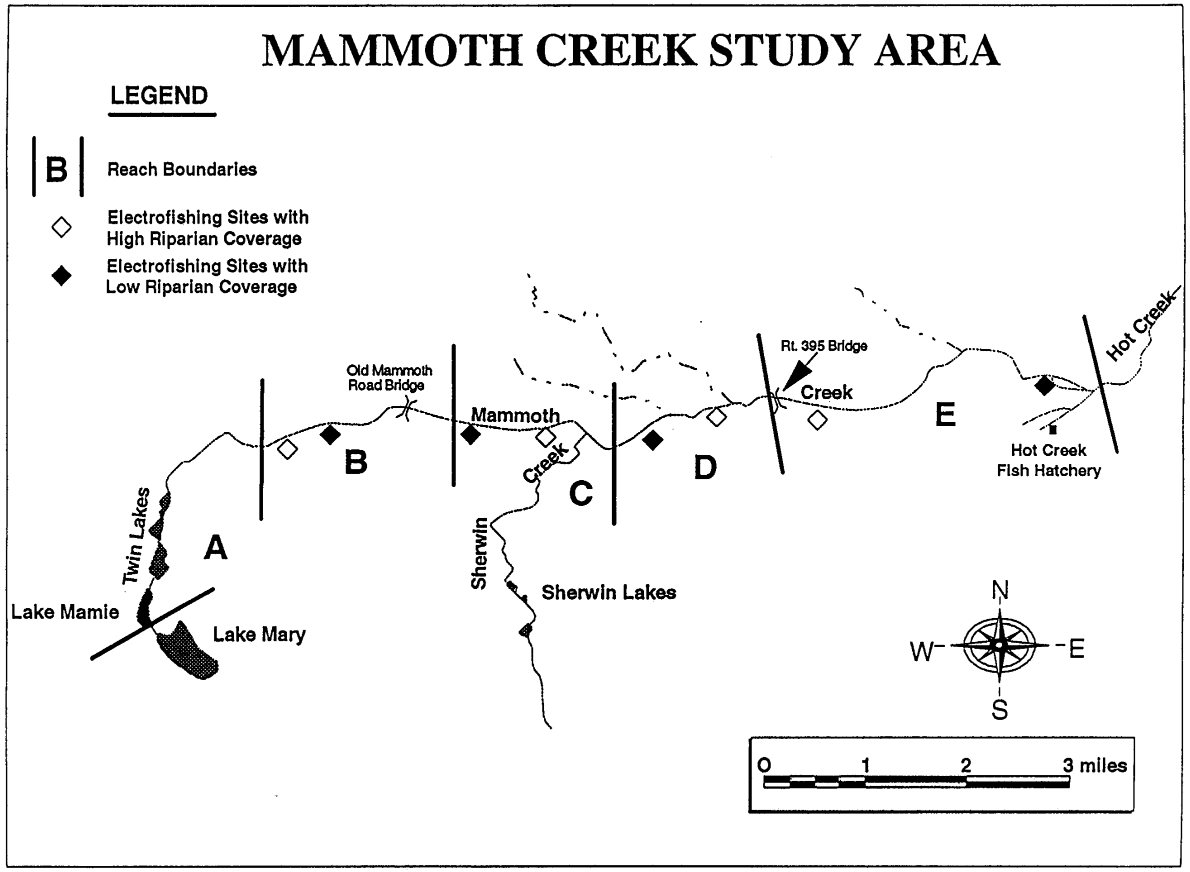

Figure 1. Locations of electrofishing sites sampled during October 1994 in Mammoth Creek, Mono County, California.

each sampling section to increase electrical conductivity and electrofishing effectiveness.

Electrofishing was conducted using a Smith-Root Model 15B generator powered backpack electrofisher. A four person crew was used to capture fish. One person operated the anode and two people, positioned at each side of the anode operator, netted fish. An additional person processed the catch while electrofishing continued.

A multiple-pass removal method of electrofishing was used for fish population estimation. A minimum of three complete passes were conducted at each sampling section. Each pass (or removal occasion) was conducted using a standardized technique to attain equal effort. The standardized technique included a systematic sampling approach that consisted of:

- electrofishing along the downstream block net;
- moving upstream in a recurring diagonal (acute angle) pattern from bank to bank, completely covering the area until encountering the upstream block net;
- electrofishing along the upstream block net; and,
- sampling along the downstream block net to collect any impinged fish.

Captured fish were placed in 5-gallon buckets and transferred to shore for processing. All captured fish were anesthetized using carbon dioxide (CO_2), identified to species, and enumerated. Captured trout were identified, measured (nearest 1 millimeter (mm) fork length, FL), and weighed (nearest 0.1 gram (g) up to 10.0g, nearest 1g over 10g). All possible precautions were taken to prevent stress and handling or holding mortality. Processed fish were held in a holding pen (2 ft. wide by 3 ft. tall by 4 ft. long) placed in the creek downstream of the sampling area. After the completion of all removal passes, fish were returned to the stream section from which they were captured.

Data Analysis

Population Estimation

Fish numbers occurring within each sampling section were estimated with a Maximum-Likelihood estimator (White et al. 1982), facilitated by use of the Microfish 2.3 software package (Van Deventer and Platts 1986). For each sampling section, the estimated total numbers of brown trout (and associated 95 percent confidence intervals) were calculated. Estimated brown trout totals were expressed as the number of fish per stream mile for comparison with surveys conducted by CDFG. Estimated numbers of brown trout per stream mile in Mammoth Creek were compared among data collected by CDFG in 1983 and 1984 (Deinstadt et al. 1985), the District in 1988 (Bratovich et al. 1990), CDFG in 1991 (unpublished data), the District in 1992 (Hood et al. 1992), the district in 1993 (Hood et al. 1993), and the District in 1994 (this study).

Length-Frequency

Length-frequency distributions were calculated to summarize body size information for fish captured in the Mammoth Creek study area. Length-frequency distributions of brown trout were calculated for the entire creek, and for each study reach. In addition, length-frequency distributions of rainbow trout were calculated for fish captured throughout the entire creek.

RESULTS

Species Composition and Relative Abundance

A total of 2,057 fish representing four species were captured by electrofishing in Mammoth Creek from October 4 through 11, 1994 (**Table 1**). Brown trout (*Salmo trutta*), comprised the largest portion of the total catch, 42.9 percent. Rainbow trout (*Oncorhynchus mykiss*), tui chub (*Gila bicolor*) and Owens sucker (*Catostomus fumeiventris*) accounted for the remaining 12.5, 19.1, and 25.5 percent of all fish caught, respectively.

Two hundred fifty-eight rainbow trout were captured in the entire study area. Eighty-one of these fish (31.4 percent) exhibited evidence that they were of hatchery origin by virtue of abraded dorsal fins. Only one rainbow trout was captured in the uppermost reach, Reach B. Most rainbow trout (67.4 percent) were captured in Reach C, followed by Reach D (22.5 percent) and Reach E (9.7 percent). More rainbow trout (176 fish or 68.2 percent) were caught in sampling sections characterized by low riparian cover than by high riparian cover. By contrast, all tui chub and Owens suckers captured during this study were caught in the sampling section located within the low riparian cover zone of the lowermost reach, Reach E. One rainbow trout was captured in the lowermost section of Reach E. No further population density analyses were conducted on species other than brown trout.

Brown Trout Population Estimation

The estimated number of brown trout in all sampling sections ranged from 23 fish at site EL to 251 fish at site DH (**Table 2**). Extrapolation of these numbers resulted in a range of 405 to 4,418 brown trout per mile. Brown trout population estimates in sites characterized by high riparian cover ranged from 810 brown trout/mile at site CH up to 4,418 brown trout/mile at site DH. The low riparian cover zone population estimates ranged from 405 brown trout/mile at site EL to 2,253 brown trout/mile at site BL. Maximum-Likelihood catch statistics for brown trout in each of the eight sampling sections are presented in **Appendix A**.

Length-Frequency Distribution

The length-frequency distribution calculated for all brown trout captured during this study exhibit a fairly distinct multimodal distribution (**Figure 2**). A pronounced peak (48 to 109 mm FL) in the distribution was apparent for the length groups likely representing young-of-year (YOY) fish. Additional age groups within the catch were also apparent, representing multiple age classes present in Mammoth Creek.

For the entire brown trout population captured in 1994, there were three readily discernable length groups. The lowest sized group was comprised of 609 fish ranging from 48 to 109 mm FL, with 91 percent of the fish in this group ranging from 60 to 100 mm FL. Brown trout within the lower size group are most likely YOY fish. The next group included 89 fish ranging from 110 to 159 mm FL and were probably Age I fish. The next group was comprised of 167 fish ranging from 160 to 259 mm FL, and most likely were Age II fish. Sixteen fish were in the 250 to 319 mm FL size range and may represent Age III fish. Two fish larger than 319 mm FL were captured during this study and may represent older fish; the largest fish captured measured 455 mm FL. Although ages of fish were not directly estimated in this study, the length groups of this study correlate well with previous investigations. Average length at annulus formation for brown trout in East Slope Sierra Nevada streams has

Table 1. Number of all fish captured by electrofishing Mammoth Creek, Mono County, California from October 4 through 11, 1994.

COMMON NAME	SCIENTIFIC NAME	REACH	Cover High	Cover Low	TOTAL
brown trout	(*Salmo trutta*)	B	219	127	346
		C	41	30	71
		D	242	86	328
		E	115	23	138
		TOTAL	617	266	883
rainbow trout (undetermined origin)	(*Oncorhynchus mykiss*)	B	1	0	1
		C	33	81	114
		D	22	35	57
		E	5	0	5
		TOTAL	61	116	177
rainbow trout (hatchery origin)	(*Oncorhynchus mykiss*)	B	0	0	0
		C	2	58	60
		D	0	1	1
		E	19	1	20
		TOTAL	21	60	81
tui chub	(*Gila bicolor*)	B	0	0	0
		C	0	0	0
		D	0	0	0
		E	0	392	392
		TOTAL	0	392	392
Owens sucker	(*Catostomus fumeiventris*)	B	0	0	0
		C	0	0	0
		D	0	0	0
		E	0	524	524
		TOTAL	0	524	524
				GRAND TOTAL	2057

Table 2. Estimated number[a] and density (trout/mile)[b] of all brown trout captured by electrofishing in Mammoth Creek, Mono County, California during October 1994.

Site	Number of brown trout	Brown trout per mile
BH	237	4171
BL	128	2253
CL	30	528
CH	46	810
DL	90	1584
DH	251	4418
EH	141	2482
EL	23	405

[a] Estimated number is generated by using a maximum-likelihood estimator based on actual catch.
[b] Trout number per stream mile extrapolated from population estimates.

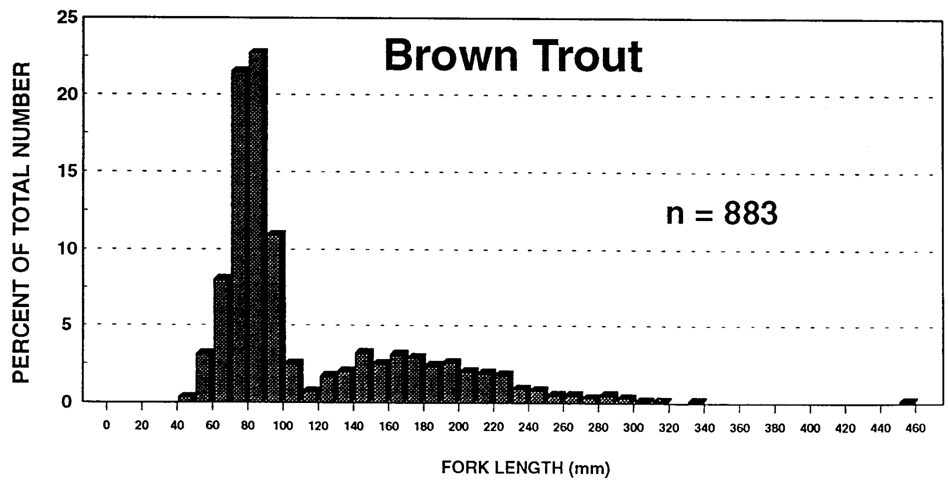

Figure 2. Length-frequency distribution of all brown trout captured at all electrofishing sites in the Mammoth Creek study area, October 4 through 11, 1994.

been reported to range from 84-139 mm FL (Age I), 160-257 mm FL (Age II), and 252-318 mm FL (Age III) (Snider and Linden 1981). In nearby Hot Creek, the average length at annulus formation for brown trout was reported to range from 133-157 mm FL (Age I), 227-243 mm FL (Age II), and 291-317 mm FL (Age III) (Snider and Linden 1981).

Brown trout length-frequency distributions differed among study reaches (**Figure 3**). Each of the distinct length modes were well represented only in Reach B. Distinct length groups for YOY brown trout were apparent in all four reaches. The YOY group of fish (≤ 109 mm FL) accounted for only 44 percent of the total catch in Reach B, but accounted for 62, 82 and 72 percent of the catch in Reaches C, D, and E, respectively. These results are consistent with those found during 1992 (Hood et al. 1992) and 1993 (Hood et al. 1993). Numbers of Age I fish (110-159mm) comprised 15 percent of the catch in Reach B. By contrast, numbers of Age I fish were low in Reaches D (4 percent) and E (7 percent), and virtually absent in Reach C. Large brown trout (159+ mm FL) were most abundant in Reaches B, C and E, accounting for 27, 37 and 21 percent of the total catch of brown trout in these reaches, respectively. The lowest proportion of large brown trout were captured in Reach D, comprising 14 percent of the total catch in this reach.

Of the 177 rainbow trout of undetermined origin, 77 percent ranged in length from 44 to 99 mm FL (**Figure 4**). Due to the fact that no fish in this size range have been planted in Mammoth Creek in the last 3 years (D. Redfern, CDFG, pers. comm.), it is believed that these trout were produced in the stream.

DISCUSSION

The overall objective of the 1988 Beak study was to develop flow recommendations that would maintain fish populations in Mammoth Creek in good condition. The objective of the 1992, 1993 and the present study is to continue to monitor the condition of the brown trout population in Mammoth Creek. Although the term "good condition" is not well defined, an inherent assumption of the habitat-based approach (IFIM) used in those studies is that fish populations are positively associated with available habitat.

Inferences regarding the "good condition" of the brown trout population in Mammoth Creek can be made by evaluation of available population density and size class structure information. During the past seven years, California has experienced dry hydrologic conditions, with the exception of a relatively wet year in 1993. Dry hydrologic conditions continue thus far for runoff year 1994. These consecutive dry years resulted in flow conditions in Mammoth Creek that were similar, and in some cases lower than, Beak's recommended minimum bypass flow levels (**Appendix B**). Comparison of the population estimates and size class structure based on data collected before and after these low flow conditions provides an opportunity to evaluate the adequacy of the recommended flows in Mammoth Creek for maintaining fish populations in good condition.

In the present study, brown trout densities (trout per mile) were lower than those found in 1988 in five of the eight sections sampled. However, brown trout densities in the present study (1994) were higher in six of the eight sections sampled in 1993, and higher than five of the eight sections sampled in 1992 (**Table 3 and Figure 5**). Averaged over all sampling sections in Mammoth

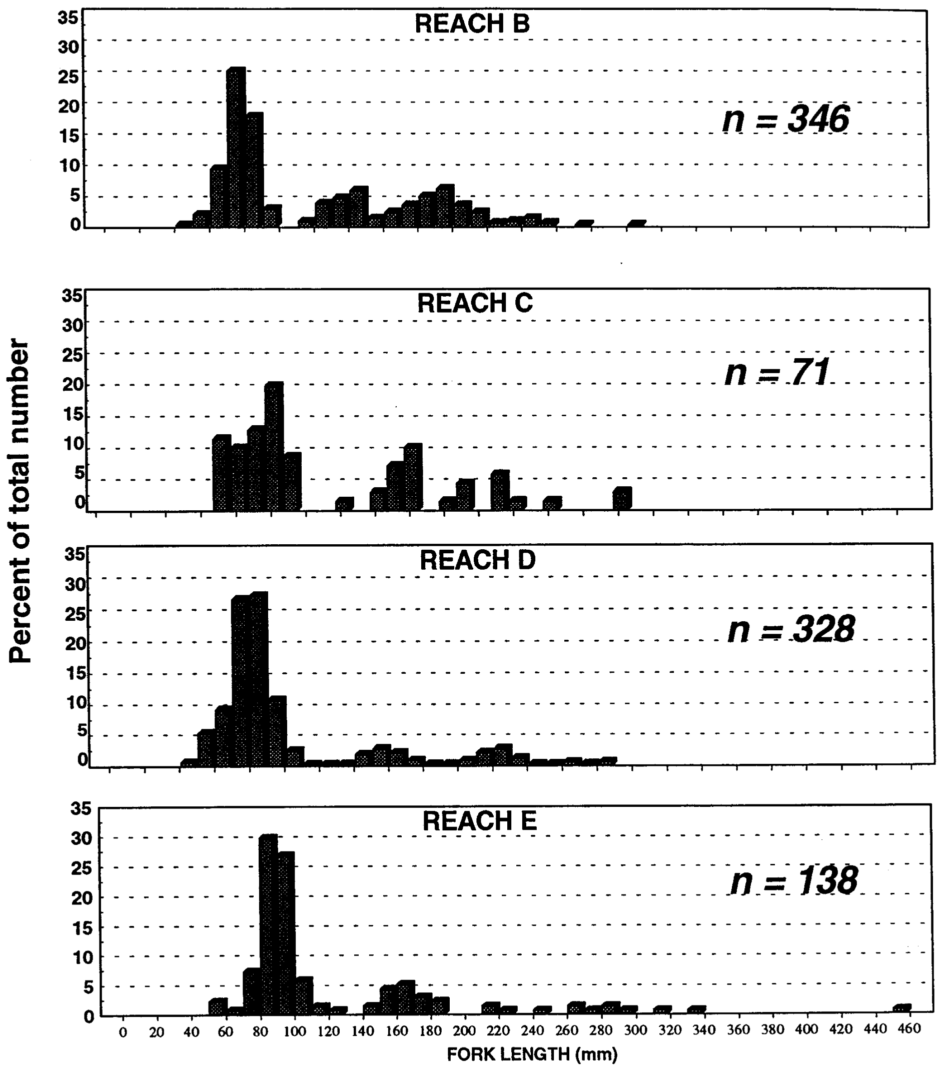

Figure 3. Length-frequency distributions of brown trout captured in Reaches B, C, D and E during early October 1994 in Mammoth Creek.

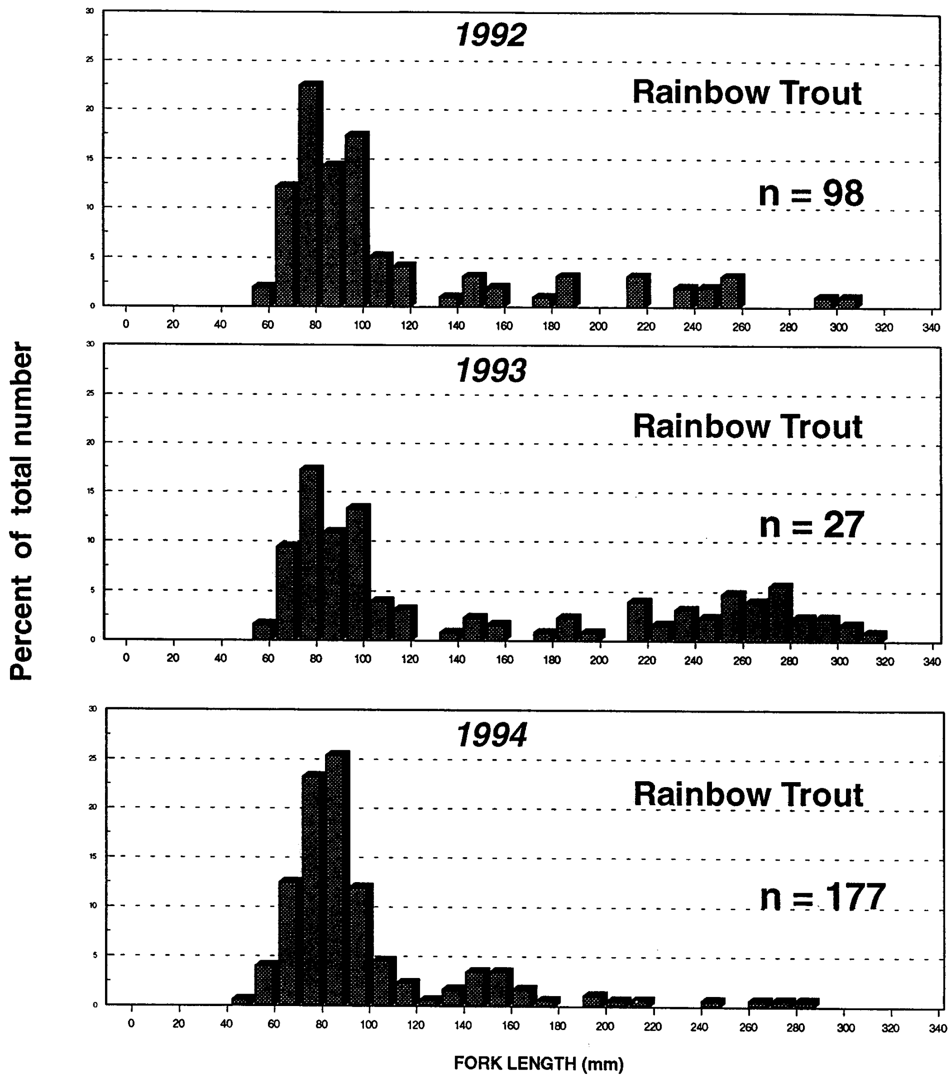

Figure 4. Length-frequency distribution of all rainbow trout (undetermined origin) captured at all electrofishing sites in the Mammoth Creek study area in mid October 1992, mid October 1993 and early October 1994.

Table 3. Population estimates (trout/mile)* and 95 percent confidence intervals for brown trout captured by electrofishing Mammoth Creek, Mono County, California from November 2 through 4, 1988, from October 21 through 28, 1992, from October 11 through 19, 1993 and from October 4 through 11, 1994.

Site	Year	Lower Confidence Boundary	Population Estimate	Upper Confidence Boundary
BH	1988	2904	3168	3617
	1992	2992	3045	3128
	1993	2582	3010	3437
	1994	3915	4171	4427
BL	1988	4488	4699	5028
	1992	1830	1848	1895
	1993	2570	2658	2770
	1994	2235	2253	2309
CL	1988	1848	1901	2069
	1992	827	845	906
	1993	1038	1232	1514
	1994	528	528	567
CH	1988	1109	1109	1202
	1992	546	563	621
	1993	475	510	609
	1994	722	810	980
DL	1988	1056	1056	1122
	1992	1584	1584	1611
	1993	510	510	551
	1994	1514	1584	1696
DH	1988	2006	2006	2124
	1992	1338	1390	1482
	1993	1056	1056	1089
	1994	4268	4418	4567
EH	1988	4171	4277	4493
	1992	3925	3978	4053
	1993	1197	1232	1305
	1994	2024	2482	2946
EL	1988	106	106	479
	1992	194	194	209
	1993	158	158	169
	1994	405	405	412

* Trout number per stream mile extrapolated from populations estimates

Creek, estimated brown trout densities for each year of sampling are as follows:

Year	Brown trout per mile
1994	2,081
1993	1,232
1992	1,681
1988	2,290

Comparison of trout densities by sampling site between the present study and the 1988, 1992 and 1993 investigations reveals generally the same pattern with two notable exceptions; reduced brown trout densities at sampling site CL, and increased brown trout densities at sampling site DH. The present study estimate of 528 trout per mile for site CL is 27.8% , 62.5% and 42.8% of the 1988, 1992 and 1993 population estimates, respectively.

One possible explanation for this decrease is related to a habitat change which has occurred between 1993 and 1994 within this area of Mammoth Creek. In 1993, alarge area of the stream within site CL was covered with overhanging willows and dammed with several log jams. Between the 1993 and 1994 surveys, several willow trees were cut and all of the log jams were removed. A large proportion of the fish captured in 1993 within this site were located within these areas. Given the assumption that the fish populations are positively associated with available habitat, this change in cover could explain the reduced brown trout density observed for site CL this year.

The large increase in brown trout density in 1994 at sampling site DH is not attributable to observable changes in habitat. This sampling site continues to be characterized by low accessibility, prevalent undercut banks and overhanging riparian vegetation, and several log jams.

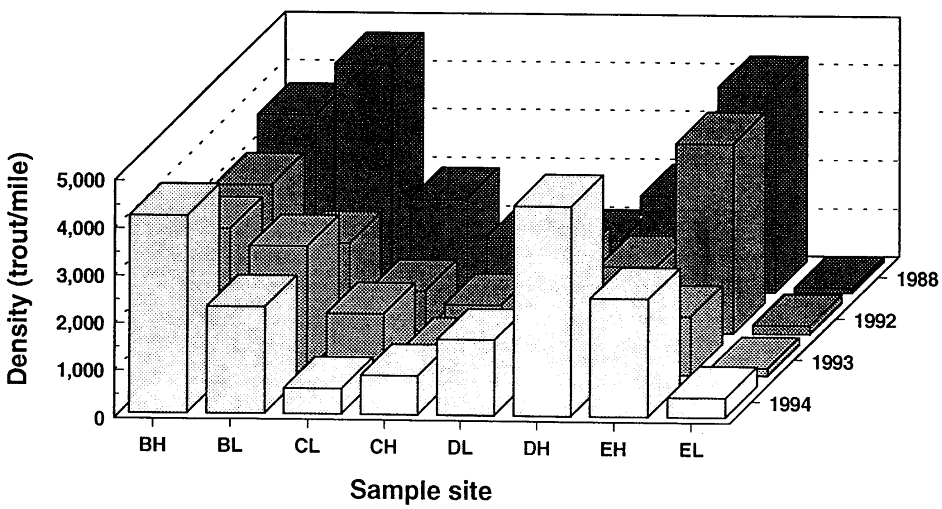

Figure 5. Population density (fish/mile) for brown trout captured by electrofishing Mammoth Creek, Mono County, California from November 2 through 4, 1988, from October 21 through 28, 1992, from October 12 through 19, 1993 from October 4 through 11, 1994.

Average densities for the entire study area in 1994 remain comparable to the results of previous CDFG investigations of Mammoth Creek. Fish population surveys of Mammoth Creek were conducted by CDFG in 1983 and 1984 (Deinstadt et al. 1985) as part of their general survey of streams of the Owens River drainage. These surveys were conducted during and following relatively wet years (sampling site locations are presented in **Figure 6**). Brown trout densities, expressed as number of trout per mile, were as follows:

Sampling Section	Brown trout per mile
1	1,109
2	493
3	2,798
4	704
5	1,707
Mean =	1,362

CDFG also conducted an electrofishing survey of fish populations in Mammoth Creek on October 24 and 25, 1991.

Sampling Section	Brown trout per mile
Behind Vons	443
At County Bldg.	2,123
Horse Pasture	2,321
Mid-Chance Ranch	1,091
Lowest	0
Mean =	1,196

Mean brown trout densities calculated from the present study (2,081 trout/mile) are much higher (1.5 to 1.7 times) than the CDFG findings during previous years. In addition to comparing favorably with 1983-84 and 1991 CDFG results in Mammoth Creek, the average brown trout densities obtained from Mammoth Creek during 1992, 1993 and 1994 compare well to other nearby creeks. CDFG estimated from 877 to 4,822 brown trout per mile for four sections in Convict Creek, and from 600 to 1,109 brown trout per mile in McGee Creek (Deinstadt et al. 1985).

In addition to population densities, the size class structure of a fish population can provide evidence of reproductive success and survival, and a general indication of a fish population's overall condition. To assess potential differences in the size class structure of the brown trout population in Mammoth Creek during the past few years, length-frequency data from the present survey were compared to CDFG's 1991 data and to Beak's 1988, 1992 and 1993 data (**Figure 7**).

The length-frequency distribution calculated for all brown trout captured during the present (1994) survey exhibited a length-frequency distribution similar to that calculated from the four previous surveys. At least three general size groups of fish were apparent and comprised the vast majority of the observations in all five distributions. The lower group in each distribution most likely represent YOY fish, the middle group represents Age I fish, and the upper group represents Age II fish. The YOY fish in all cases make up the highest proportion of the total catch for all five years. However, YOY fish represented approximately two/thirds of the total catch during 1988, 1992 and 1994, but only about one/half during 1991 and 1993. One possible interpretation of the lower percentage of YOY in 1991 is that the relatively low flows (i.e., flows lower than the recommended flows during the brown trout spawning and incubation period) that occurred during the fall and winter of 1990/91 (see Appendix B, runoff year 1990) may have resulted in brown trout spawning success and subsequent recruitment to the population lower than that which was observed in the catch during the 1988, 1992 and 1994 sampling periods. Similarly, relatively low flows which occurred during the spawning period of 1992/93 (see Appendix B, runoff year 1992) may have con-

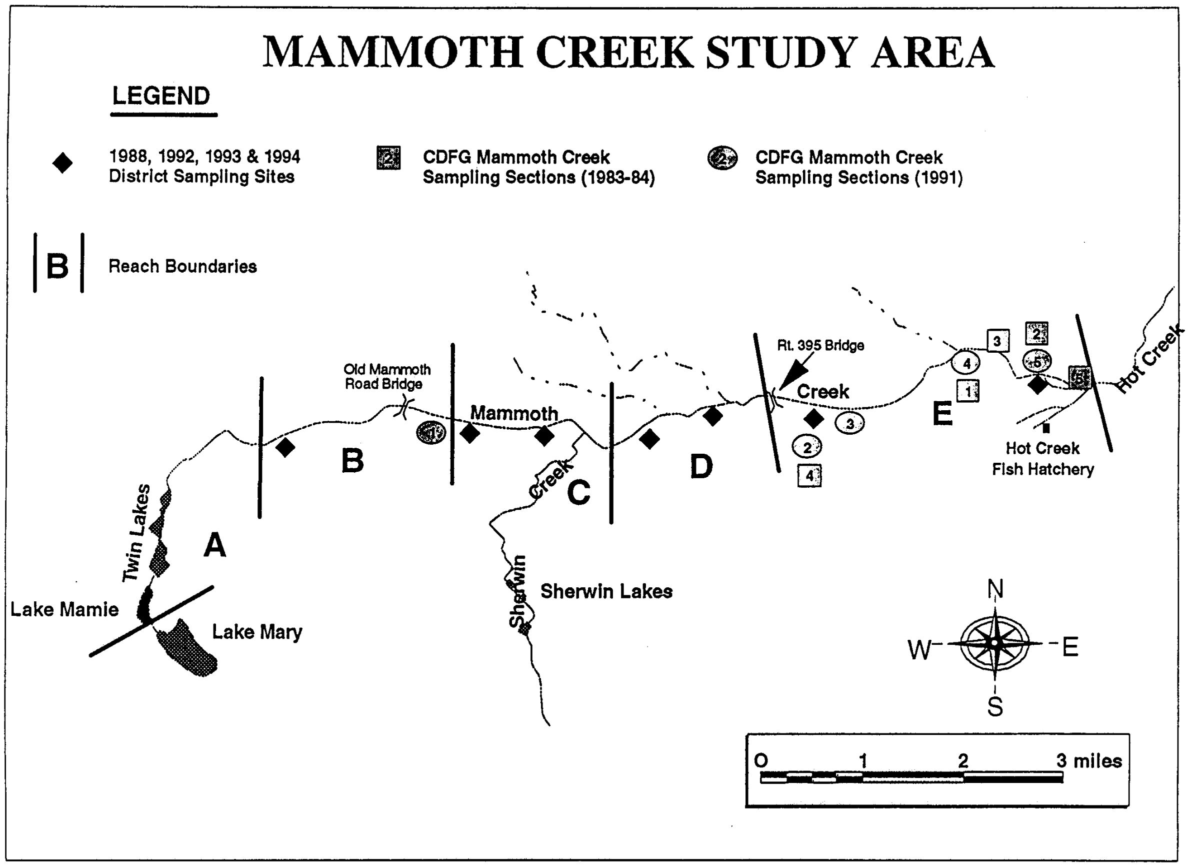

Figure 6. Locations of CDFG 1983-84 and 1991 electrofishing sites in Mammoth Creek, Mono County, California, and their relationship to electrofishing sites sampled by the District during November 1988, October 1992, October 1993 and October 1994.

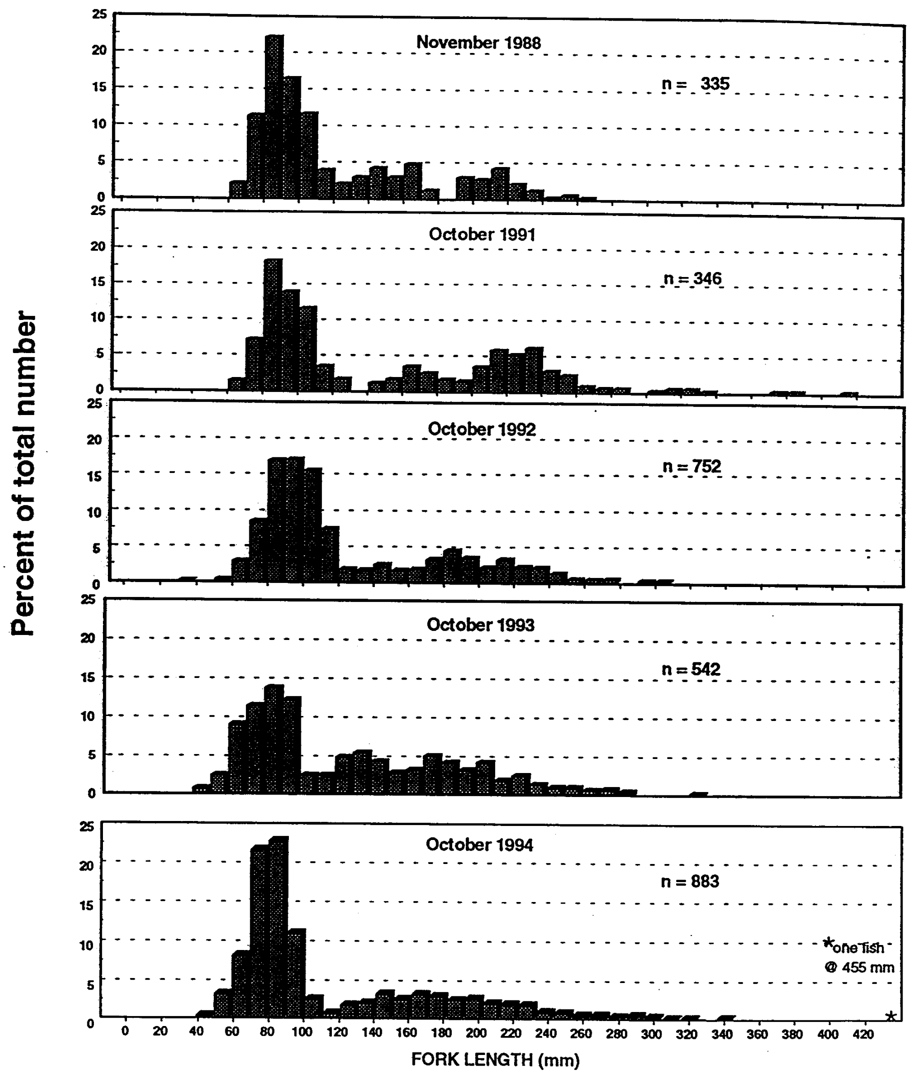

Figure 7. Comparison of brown trout length-frequency distributions from fish collected in Mammoth Creek by electrofishing during November 1988, October 1991, October 1992, October 1993 and October 1994.

tributed to the lower proportion of YOY fish captured during October 1993.

Another possible interpretation of the relatively low proportion of YOY fish captured in 1991 may be attributed to the habitat composition of the CDFG electrofishing sites. The brown trout length-frequency distribution for CDFG's 1991 data reveal a higher percentage of large fish than were caught in 1988, 1992 or 1994; this would suggest that the sites sampled in 1991 may have contained a greater proportion of habitat suitable for large fish than for YOY fish. The lower percentage of YOY fish observed in the 1993 study could be related to the high sustained flows which occurred between May and July of 1993. High spring snowmelt flows, in excess of 140 cfs, may have displaced the YOY fish into lower velocity portions of the creek or even into Hot Creek. This appears to be consistent with the results of the present (1994) study, which resulted in a high percentage of YOY brown trout following a spring of relatively low snowmelt flows. The length-frequency distributions (considered in conjunction with population density estimates) are suggestive of brown trout populations in good condition for all five years. In fact, data from the 1994 fish community survey exhibited the highest estimated brown trout density since 1988, successful reproduction and long-term survival.

In 1988, only 9 rainbow trout of undetermined origin were captured over the entire study area. CDFG's 1991 study resulted in the capture of only 14 rainbow trout. In 1992, 98 rainbow trout of undetermined origin were captured, 78 percent of which were considered YOY. In 1993, 27 rainbow trout of undetermined origin were captured within the study area. In 1994 (this study), 177 rainbow trout of undetermined origin were captured, 77 percent of which were considered YOY. The increases in the number of YOY captured in the present study (1994) supports the explanation for the dominance of brown trout in Mammoth Creek and the relationship of rainbow trout abundance as related to magnitude and timing of spring snowmelt flows. Kondolf et al. (1991) suggest that the spawning and incubation success of brown trout versus that of rainbow trout may be correlated to the annual spring snowmelt in high elevation Sierra streams. Rainbow trout eggs typically remain in the gravel of Owens River tributaries from March through late May or early June, when redds are susceptible to scouring by high snowmelt flows. Brown trout eggs, however, typically remain in the gravel from November until March, before high snowmelt scouring would occur. Therefore, rainbow trout spawning success in Mammoth Creek during 1992 and 1994 (as evidenced by the relatively high number of YOY rainbow trout captured) may be higher due to the low flow conditions associated with the 1992 and 1994 spring snowmelt period, and that the lower YOY recruitment to the population observed in 1993 may have resulted from the scouring flows of May, June, and July of 1993.

CONCLUSIONS

- Brown trout density and age structure (length-frequency) information obtained from the electrofishing survey conducted in October 1994 suggest that the brown trout population in Mammoth Creek remains in good condition. The results exhibit high densities of brown trout - the highest estimated density since the 1988 survey; successful reproduction and subsequent recruitment to the population; and long-term survival and habitat utilization opportunities for larger, older fish.
- Habitat changes as a result of hydrologic conditions may result in local fluctuations of population density and size class structure within a given sampling site.

- The low flow conditions during the spring of 1992 and 1994 may have improved rainbow trout spawning and incubation success, whereas high flow conditions in the spring of 1993 may have depressed YOY rainbow trout recruitment to the population.

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Appendix A

Maximum-Likelihood
Catch Statistics

Stream: MAMMOTH CREEK - SITE BH
Species: BROWN TROUT

Removal Pattern: 130 69 20
Total Catch = 219
Population Estimate = 237

Chi Square = 3.258
Pop Est Standard Err = 7.377
Lower Conf Interval = 222.468
Upper Conf Interval = 251.532

Capture Probability = 0.573
Capt Prob Standard Err = 0.042
Lower Conf Interval = 0.491
Upper Conf Interval = 0.656

Stream: MAMMOTH CREEK - SITE CH
Species: BROWN TROUT

Removal Pattern: 24 9 8
Total Catch = 41
Population Estimate = 46

Chi Square = 1.521
Pop Est Standard Err = 4.802
Lower Conf Interval = 41.000
Upper Conf Interval = 55.671

Capture Probability = 0.506
Capt Prob Standard Err = 0.107
Lower Conf Interval = 0.291
Upper Conf Interval = 0.722

The population estimate lower confidence interval was set equal to the total catch. Actual calculated lower CI was 36.3291 .

Stream: MAMMOTH CREEK - SITE BL
Species: BROWN TROUT

Removal Pattern: 97 23 7
Total Catch = 127
Population Estimate = 128

Chi Square = 0.369
Pop Est Standard Err = 1.604
Lower Conf Interval = 127.000
Upper Conf Interval = 131.176

Capture Probability = 0.760
Capt Prob Standard Err = 0.040
Lower Conf Interval = 0.682
Upper Conf Interval = 0.839

The population estimate lower confidence interval was set equal to the total catch. Actual calculated lower CI was 124.8237 .

Stream: MAMMOTH CREEK - SITE CL
Species: BROWN TROUT

Removal Pattern: 22 4 4
Total Catch = 30
Population Estimate = 30

Chi Square = 3.664
Pop Est Standard Err = 1.086
Lower Conf Interval = 30.000
Upper Conf Interval = 32.222

Capture Probability = 0.714
Capt Prob Standard Err = 0.091
Lower Conf Interval = 0.529
Upper Conf Interval = 0.899

The population estimate lower confidence interval was set equal to the total catch. Actual calculated lower CI was 27.77839 .

Stream: MAMMOTH CREEK - SITE DH
Species: BROWN TROUT

Removal Pattern: 167 56 19
Total Catch = 242
Population Estimate = 251

Chi Square = 0.011
Pop Est Standard Err = 4.306
Lower Conf Interval = 242.518
Upper Conf Interval = 259.482

Capture Probability = 0.667
Capt Prob Standard Err = 0.034
Lower Conf Interval = 0.599
Upper Conf Interval = 0.734

Stream: MAMMOTH CREEK - SITE EH
Species: BROWN TROUT

Removal Pattern: 58 38 19
Total Catch = 115
Population Estimate = 141

Chi Square = 0.470
Pop Est Standard Err = 13.336
Lower Conf Interval = 115.000
Upper Conf Interval = 167.406

Capture Probability = 0.428
Capt Prob Standard Err = 0.071
Lower Conf Interval = 0.288
Upper Conf Interval = 0.567

The population estimate lower confidence interval was set equal to the total catch. Actual calculated lower CI was 114.5944 .

Stream: MAMMOTH CREEK - SITE DL
Species: BROWN TROUT

Removal Pattern: 56 22 8
Total Catch = 86
Population Estimate = 90

Chi Square = 0.085
Pop Est Standard Err = 3.194
Lower Conf Interval = 86.000
Upper Conf Interval = 96.346

Capture Probability = 0.632
Capt Prob Standard Err = 0.061
Lower Conf Interval = 0.511
Upper Conf Interval = 0.754

The population estimate lower confidence interval was set equal to the total catch. Actual calculated lower CI was 83.65382 .

Stream: MAMMOTH CREEK - SITE EL
Species: BROWN TROUT

Removal Pattern: 21 1 1
Total Catch = 23
Population Estimate = 23

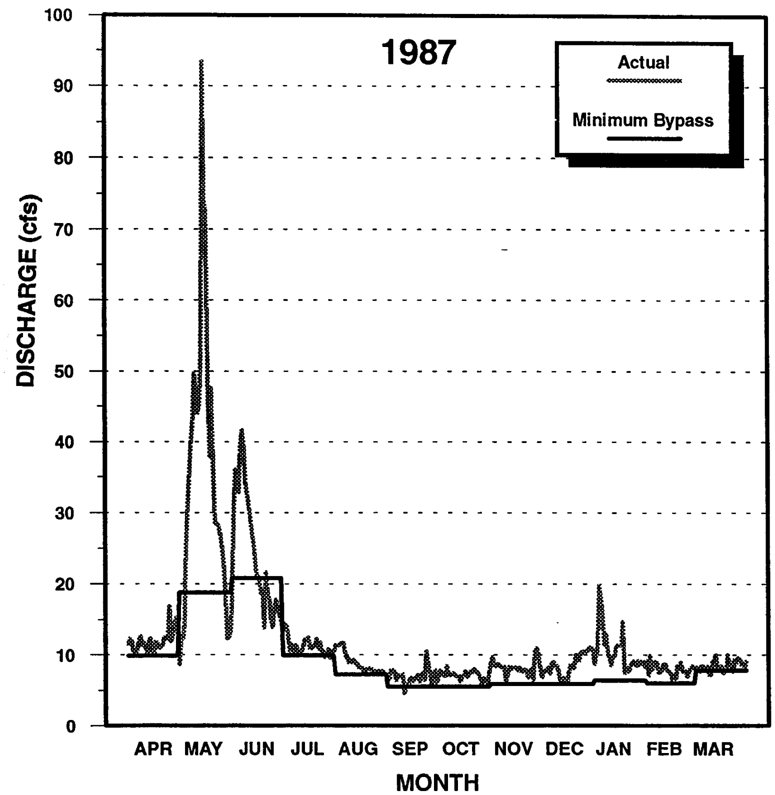
Chi Square = 2.757
Pop Est Standard Err = 0.198
Lower Conf Interval = 23.000
Upper Conf Interval = 23.410

Capture Probability = 0.885
Capt Prob Standard Err = 0.066
Lower Conf Interval = 0.748
Upper Conf Interval = 1.021

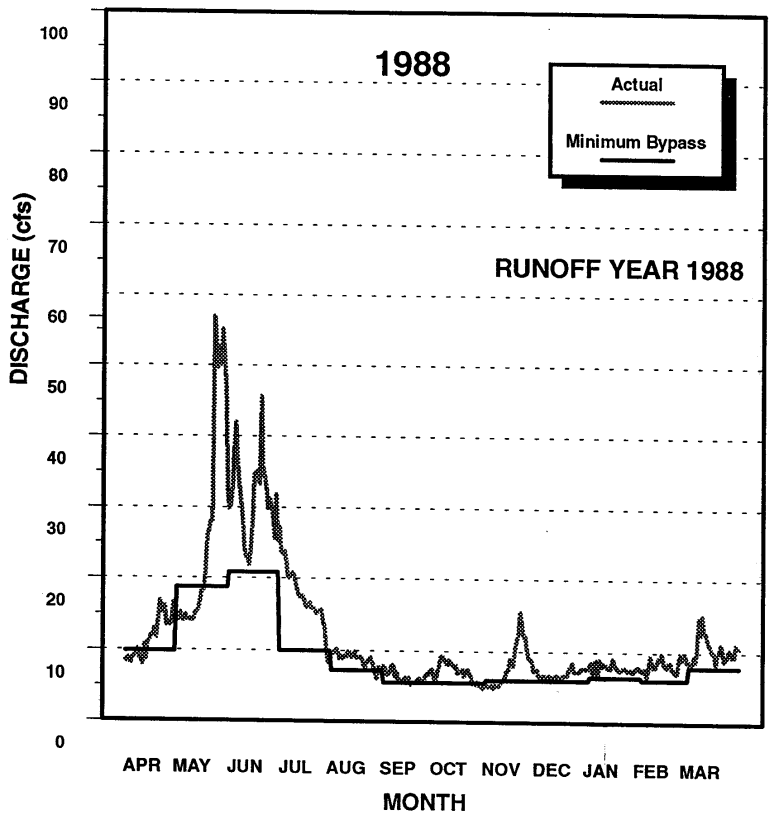
The population estimate lower confidence interval was set equal to the total catch. Actual calculated lower CI was 22.5901 .

Appendix B

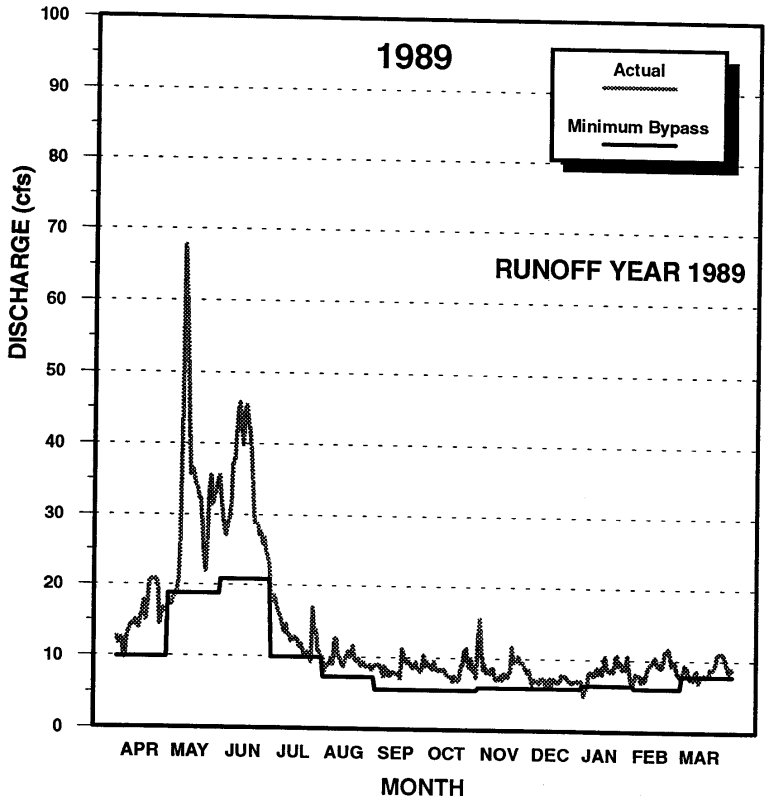
Mammoth Creek Hydrographs 1987-1994



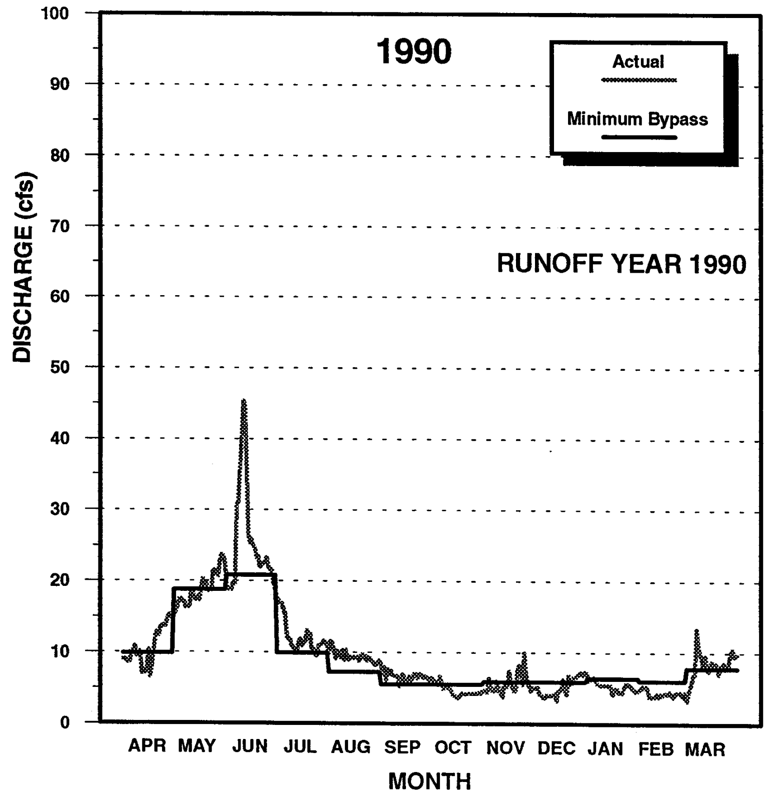
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1987 and the recommended operational minimum mean daily bypass flow regime.



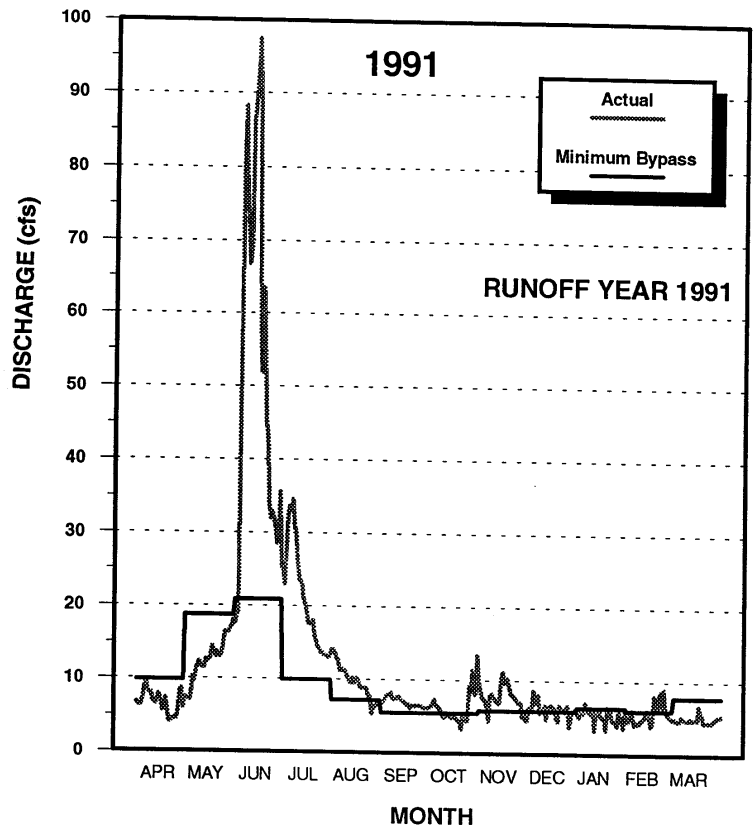
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1988 and the recommended operational minimum mean daily bypass flow regime.



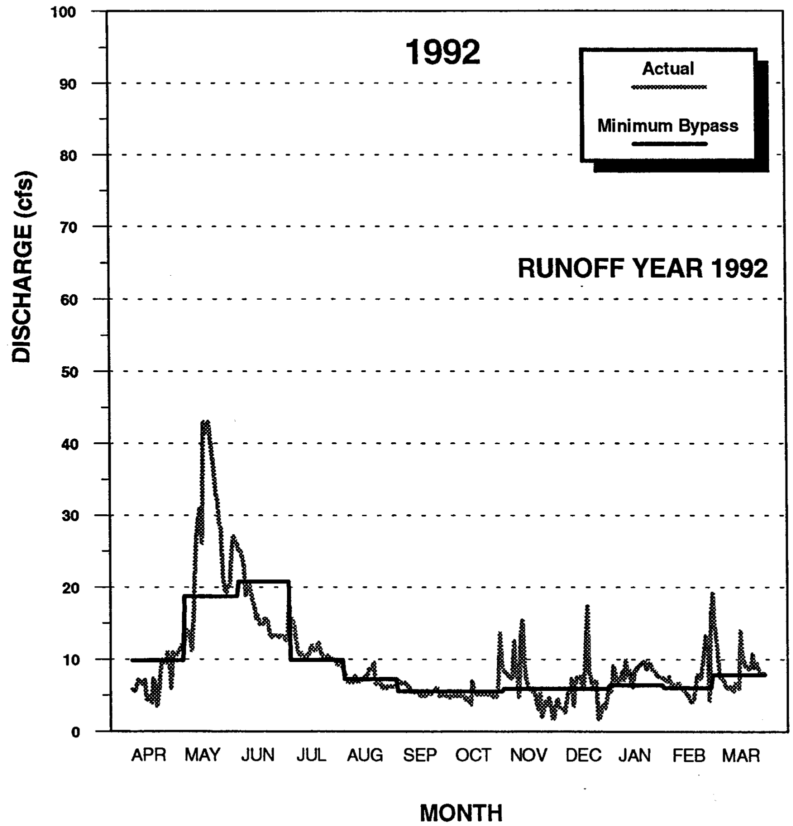
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1989 and the recommended operational minimum mean daily bypass flow regime.



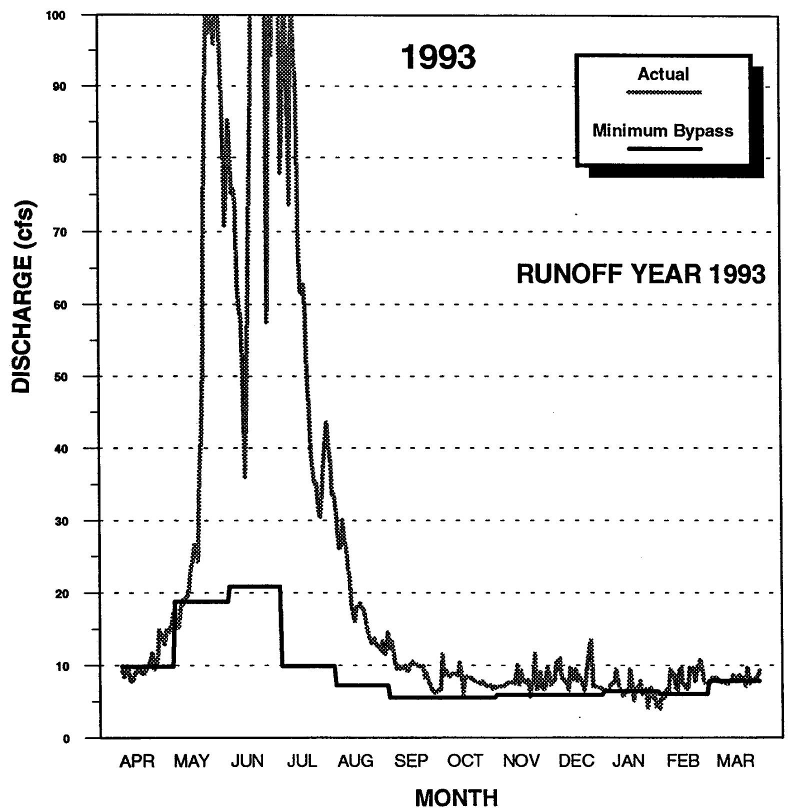
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1990 and the recommended operational minimum mean daily bypass flow regime.



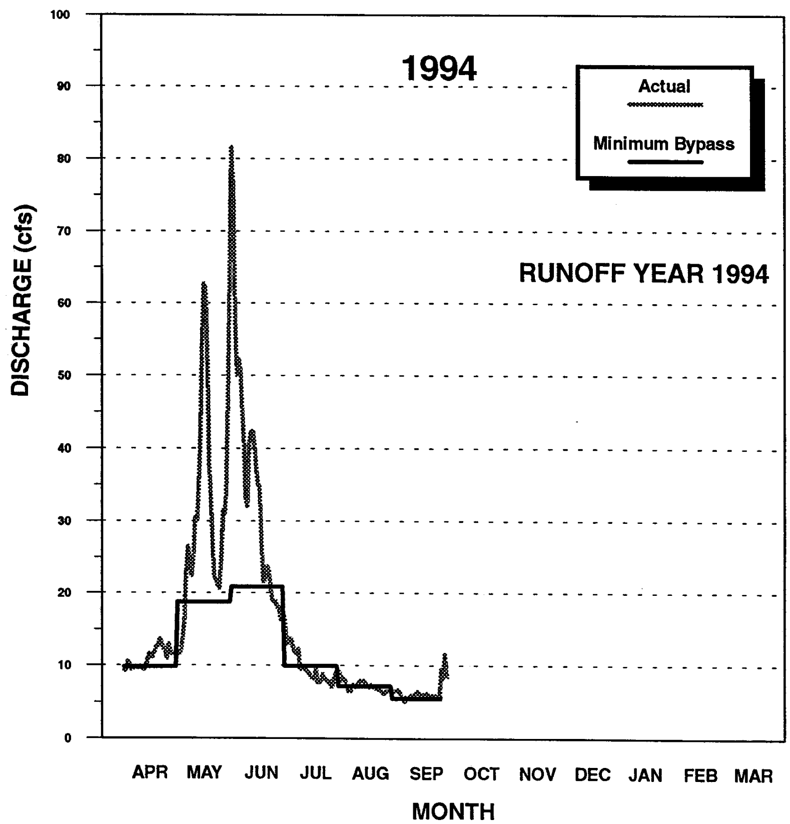
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1991 and the recommended operational minimum mean daily bypass flow regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1992 and the recommended operational minimum mean daily bypass flow regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1993 and the recommended operational minimum mean daily bypass flow regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1994 and the recommended operational minimum mean daily bypass flow regime.