MAMMOTH CREEK 1997 FISH COMMUNITY SURVEY

Prepared for:

Mammoth Community Water District
P.O. Box 597
Mammoth Lakes, California 93546

Prepared by:

KDH

P.O. Box 1107
West Point, California 95255

March 1998

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Dennis J. Hood

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INTRODUCTION

Instream flow needs for fish resources in Mammoth Creek, Mono County, California have been the focus of several investigations over the past twenty years. As a result of these investigations, mean monthly instream flow regimes have been recommended that are intended to maintain the trout fishery in Mammoth Creek in good condition. In addition to comprehensive, quantitative studies of instream flows and habitat availability conducted by Beak Consultants Incorporated (Beak) in 1988, Mammoth Community Water District (District) has continued to collect fish population data annually since 1992. These fish community surveys have allowed the District to monitor the condition of the trout fishery and compare population changes over time under various historical conditions.

This report documents the results of the 1997 fish resource assessment survey conducted from October 4 through 10, 1997. Specific objectives of this study were:

- To estimate the total fish population and evaluate the size and age class structure of fish throughout the Mammoth Creek study area and within each sampling section;
- To compare the results of this year's study with previous studies of Mammoth Creek and other similar Sierra Nevada streams; and
- To relate the results of this year's fish population dynamics with the hydrologic conditions of Mammoth Creek over the water year preceding the survey.

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 in 1988 (Bratovich *et al.* 1990), based upon analysis of topographic maps, calculation of gradient profiles, 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 a cascade-plunge pool sequence 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 1997 investigation.

METHODS AND MATERIALS

Experimental Design

The experimental design and rationale of sampling site selection are described in detail in Bratovich *et al.* 1990. Distinct differences in the amount of riparian cover within each study reach were observed during the habitat mapping survey conducted in 1988 (Bratovich *et al.* 1990). To ensure representation of riparian cover and dispersion of sampling sections, fish sampling sections were located within *zones* of "high" and "low" riparian cover within each study reach. However, discretion must be used when comparing and interpreting the results between "high" and "low" riparian cover sites. For example, Site EH represents a *zone* of "high" riparian cover within Reach E. However, in comparison with other "high" riparian cover sites, it is characterized by a relatively low amount of riparian cover. Conversely, Site DL was randomly selected within a "low" riparian *zone* for Reach D but in fact has a high amount of willow cover. Additionally, since the initiation of these fish community surveys in 1988, the riparian cover at Site BL has changed significantly, and although it remains in a "low" riparian cover *zone*, rapid willow tree growth at this site has resulted in high riparian cover at the sample site.

Consistent with the previous five surveys (1992-96), eight stream sections were sampled in 1997, with each 300-foot long sample site representing a "high" or "low" riparian vegetation cover *zone* within a study reach (Figure 1). The downstream boundary of the sampling sites remained the same for the and 1992-97 surveys with two exceptions. In 1995, the organization that conducted the 1995-96 surveys, Sierra Nevada Aquatic Research Laboratory (SNARL) was unable to access the lowermost site. SNARL established an alternate site extending 300 feet downstream from the boundary of U.S. Forest Service land, just upstream from the confluence of Mammoth and Hot Creeks (Jenkins and Dawson 1996) (Figure 1). The second sampling site change resulted from extreme high flow conditions experienced in the spring of 1995 which shifted the stream course at Site CH into a previously dewatered adjacent channel (J. Moynier, District, pers. comm.). It appears that this change went unreported and resulted in a slightly different site being sampled in 1995 and 1996. For this study we established the bottom of Site CH as being directly adjacent to the now dewatered site sampled in 1988 and 1992-94. The two CH sites are similarly characterized therefore no significant differences in the fish composition is likely. As requested by the District, we sampled the lowermost site sampled by SNARL personnel in 1995-96 as our eighth site in this study (1997).

Data Acquisition

Fish resource assessment surveys were conducted by electrofishing. At least one day prior to electrofishing, selected sampling sites were re-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. On the same day of sampling, sites were closed using block nets comprised of 0.25-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 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 and process fish. One person operated the electrofisher and two people, one positioned at each side of the operator, netted fish. The fourth 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 was conducted at each sampling section. Each pass (or removal occasion) was conducted using a standardized technique to ensure equal effort. The standardized technique included a systematic sampling approach that consisted of:

- electrofishing along the downstream block net;

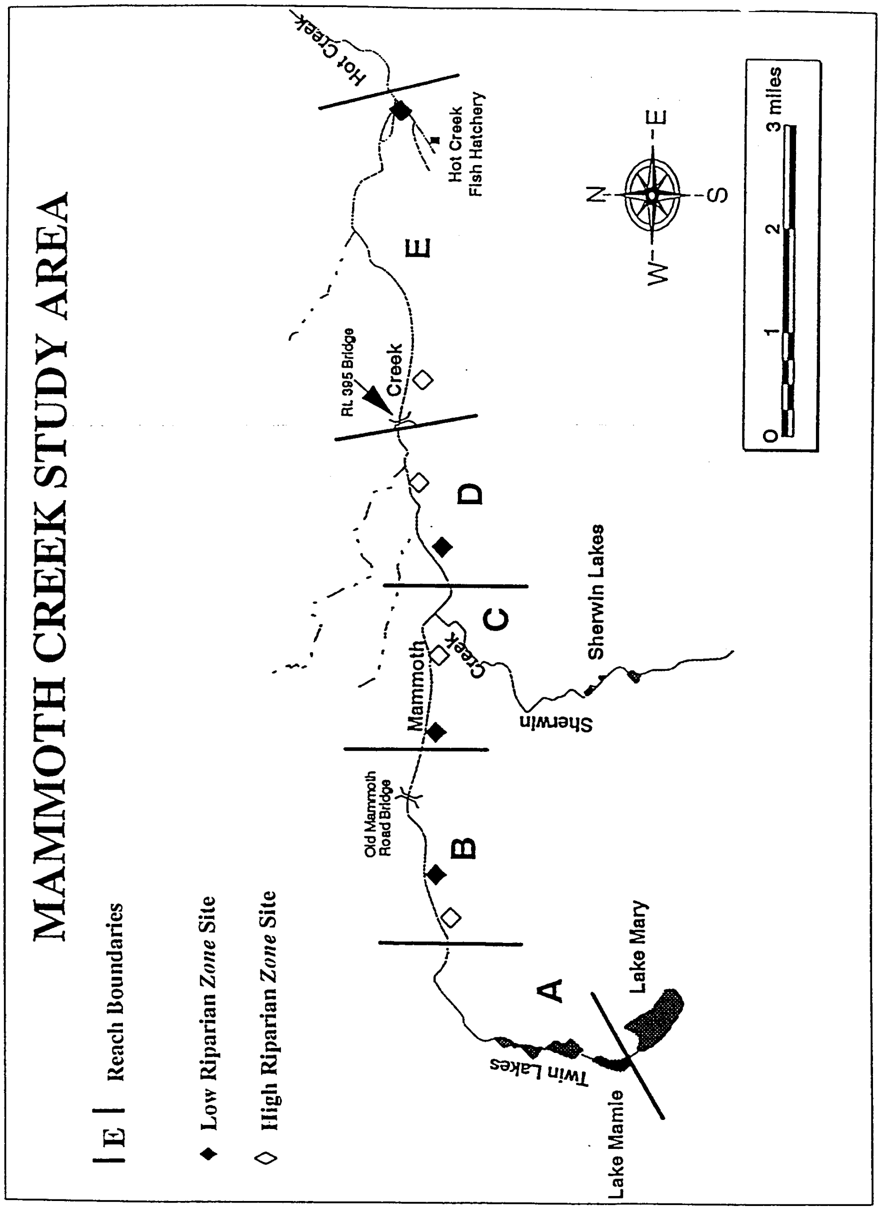

Figure 1. Locations of electrofishing sites sampled on Mammoth Creek, October 4 through 10, 1997 (modified from Hood *et al.* 1995).

- 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. Captured fish were anesthetized (as necessary) using carbon dioxide (CO_2), identified to species, measured (to the nearest 1 millimeter (mm) fork length (FL)), and weighed (to the nearest 0.1 gram (g) up to 10.0g, and to the nearest 1g over 10g). When possible, fish of hatchery origin were identified by typical deformed and abraded dorsal fins. All possible precautions were taken to prevent stress and handling or holding mortality. Anesthetized, processed fish were immediately revived in oxygen-rich water. Processed fish were held in a two-foot by three-foot by four-foot holding pen placed in the stream outside of the sampling area. After the completion of all removal passes, fish were returned to the general area of 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 and presumed "wild" rainbow trout (and associated 95 percent confidence intervals) were expressed as the number of fish per stream mile. Estimated brown trout totals and 95 percent confidence intervals, expressed as the number of fish per stream mile, were summarized in a tabular format for each sampling section and visually compared between the 1992-97 surveys.[1] In addition, the numbers of brown trout per stream mile in Mammoth Creek were calculated and compared among data collected by CDFG in 1983 and 1984 (Deinstadt *et al.* 1985), and the previous consecutive years surveys conducted by the District (Hood *et al.* 1993, 1994, 1995, and Jenkins and Dawson 1996, 1997). Numbers of presumed "wild" rainbow trout per stream mile in Mammoth Creek were calculated and compared among data collected in the previous consecutive years surveys conducted by the District (Hood *et al.* 1993, 1994, 1995, and Jenkins and Dawson 1996, 1997).

Size and Age Structure

Length-frequency distributions were calculated and graphed (using 10 mm size groups) on frequency histograms to summarize body size and *inferred* age class information for all trout captured in the Mammoth Creek study area in 1997 for comparison with previous years. Length-frequency (and inferred age) distributions of brown trout were calculated for the entire creek, and for each study reach. In addition, length-frequency distributions of presumed "wild" rainbow trout were calculated and graphed for fish captured throughout the entire creek.

RESULTS

Species Composition and Relative Abundance

A total of 1,346 fish representing four species were captured by electrofishing in Mammoth Creek from October 4 through 10, 1997 (Table 1). Brown trout (*Salmo trutta*), comprised 76.2% of the total catch; the highest percentage of all previous surveys. Rainbow trout (*Oncorhynchus mykiss*) accounted for 23.5% of the total catch

[1] Because of the differences in the lengths of sample sites between the 1988 survey (100 feet) and the 1992-97 surveys (300 feet), the quantity of habitat types sampled differs between the two data sets. Therefore, in this year's report we chose to exclude the 1988 survey data.

Table 1. Number of all fish captured by electrofishing Mammoth Creek, Mono County, California from October 4 through 10, 1997.

			[illegible]		
Common Name	Scientific Name	Reach	[illegible]	[illegible]	Total
Brown trout	(*Salmo trutta*)	B	448	38	486
		C	93	12	105
		D	31	92	123
		E	213	99	312
		TOTAL	785	241	1026
Rainbow trout (presumed "wild")	(*Oncorhynchus mykiss*)	B	7	7	14
		C	46	52	98
		D	40	57	97
		E	46	5	51
		TOTAL	139	121	260
Rainbow trout (hatchery origin)	(*Oncorhynchus mykiss*)	B	0	1	1
		C	9	32	41
		D	4	1	5
		E	9	0	9
		TOTAL	22	34	56
Tui chub	(*Gila bicolor*)	B	0	0	0
		C	0	0	0
		D	0	0	0
		E	1	1	2
		TOTAL	1	1	2
Owens sucker	(*Catostomus fumeiventris*)	B	0	0	0
		C	0	0	0
		D	0	0	0
		E	0	2	2
		TOTAL	0	2	2
GRAND TOTAL					1346

and tui chub (*Gila bicolor*) and Owens sucker (*Catostomus fumeiventris*) comprised only 0.15% each of the total catch.

Three hundred-sixteen rainbow trout were captured in the entire study area. Fifty-six of these fish (17.7 %) exhibited evidence that they were of hatchery origin by virtue of abraded dorsal fins. The remaining 82.3% of rainbow trout captured are presumed to be "wild". Brown and rainbow trout were captured in all four reaches and at each of the eight sample sites. Only two tui chub and two Owens suckers were captured over the entire study area. One tui chub was caught at site EH. The remaining tui chub and two Owens suckers were caught in the sampling section located within the "low" riparian cover *zone* of the lowermost reach, Reach E.

Trout Population Estimation

The number of brown trout captured in all sampling sections ranged from 12 fish at site CL to 448 fish at Site BH (Table 2). Extrapolation of these numbers resulted in a range of 211 to 8,589 trout/mile. Brown trout population estimates in sites characterized by "high" riparian cover ranged from 616 brown trout/mile at Site DH up to 8,589 brown trout/mile at Site BH. The "low" riparian cover *zone* population estimates ranged from 211 brown trout at Site CL to 1,795 brown trout/mile at Site EL. Maximum likelihood catch statistics for brown trout in each of the eight sampling sections are presented in Appendix A.

The number of presumed "wild" rainbow trout captured in all sampling sections ranged from 5 fish at Site EL to 58 fish at Site DL (Table 2). Extrapolation of these numbers resulted in a range of 88 to 1,021 rainbow trout/mile. Rainbow trout population estimates in sites characterized by "high" riparian cover ranged from 123 rainbow trout/mile at Site BH up to 810 rainbow trout/mile at sites CH and EH. The "low" riparian cover zone population estimates ranged from 88 rainbow trout/mile at Site EL to 1,021 rainbow trout/mile at Site DL. Maximum likelihood catch statistics for presumed "wild" rainbow trout in each of the eight sampling sections are presented in Appendix A.

Trout Length-Frequency Distribution

The length-frequency distribution calculated for all brown trout captured during this study exhibit a multimodal distribution similar to that observed

Table 2. Estimated abundance by sample site and extrapolated densities (trout/mile) of brown and presumed "wild" rainbow trout captured by electrofishing in Mammoth Creek, Mono County, California, from October 4 through 10, 1997.

Site	Number of Brown Trout	Brown Trout/mile	Number of Rainbow Trout	Rainbow Trout/mile
BH	488	8,589	7	123
BL	40	704	7	123
CH	96	1,690	46	810
CL	12	211	53	933
DH	35	616	41	722
DL	94	1,654	58	1,021
EH	217	3,819	46	810
EL	102	1,795	5	88

in previous years studies (Hood *et al.* 1993, 1994, 1995; Jenkins and Dawson 1996 and 1997) (Figure 2). A pronounced peak (52 to 120 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 readily apparent, representing multiple age classes present in Mammoth Creek.

For the entire brown trout population captured in 1997, we categorized fish into five distinct age groups similar to the groupings used in previous studies (Bratovich *et al.* 1990; Hood *et al.* 1993, 1994, 1995; Jenkins and Dawson 1996 and 1997). The group of the smallest sized fish was comprised of 826 fish ranging from 52 to 120 mm FL, with 96.6 percent of the fish in this group ranging from 61 to 110 mm FL. Brown trout within the lower size group are most likely YOY fish. The next group included 22 fish ranging from 121 to 160 mm FL and were probably Age I fish. The next group was comprised of 159 fish ranging from 161 to 259 mm FL, and most likely were Age II fish. Fourteen fish were in the 261 to 320 mm FL size range and may represent Age III fish. Five fish larger than 320 mm FL were captured during this study and likely represent older fish. Although ages of fish were not directly estimated in this study, the length groups of this study correlate well with previous investigations for brown trout in East Slope Sierra Nevada streams (Snider and Linden 1981).
Brown trout length-frequency distributions were similar among study reaches (Figure 3). Distinct length groups for YOY brown trout were dominant in all four reaches and were most abundant in Reach B. The YOY group of fish (≤120 mm FL) accounted for 90.3 percent of the total catch in Reach B and accounted for 66.7, 73.2 and 72.8 percent of the catch in Reaches C, D, and E, respectively. Numbers of Age I fish (>120 but ≤160mm) were low in Reaches B (1.4%), D (1.6%) and E (3.1%), and absent in Reach C. Large brown trout (>160 mm FL) were most abundant in Reaches C, D and E, accounting for 33.2, 25.3 and 24.1 percent of the total catch, respectively. By contrast, large brown trout comprised only 8.2 percent of the total catch in Reach B.

Of the 260 presumed "wild" rainbow trout captured, 80.8 percent fell into the YOY size class range (≤ 120 mm FL) (Figure 4). These results are very similar to the percentage of YOY captured during last years survey (77%) (Jenkins and Dawson 1997).

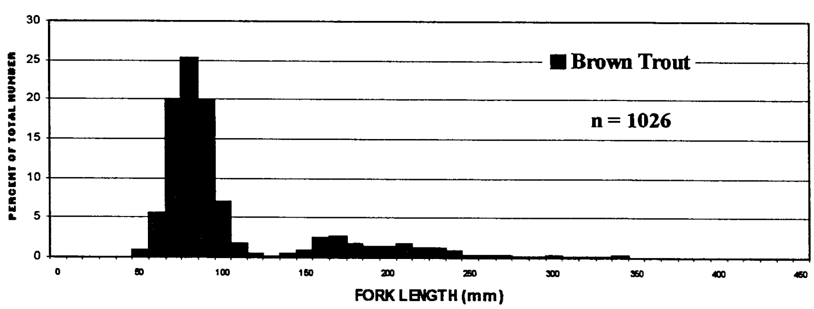

Figure 2. Length-frequency distribution of all brown trout captured at all electrofishing sites in the Mammoth Creek study area, October 4 through 10, 1997.

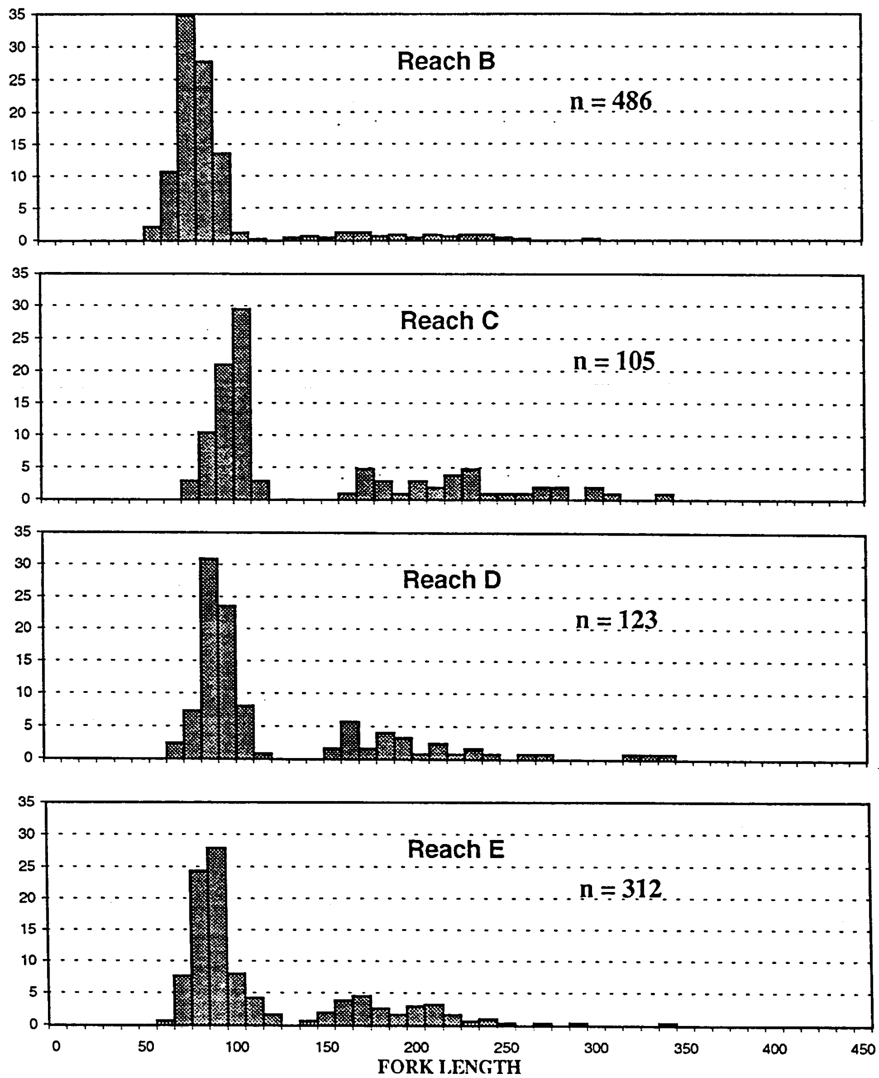

Figure 3. Length-frequency distribution of all brown trout captured in Reaches B, C, D and E in the Mammoth Creek study area, October 4 through 10, 1997.

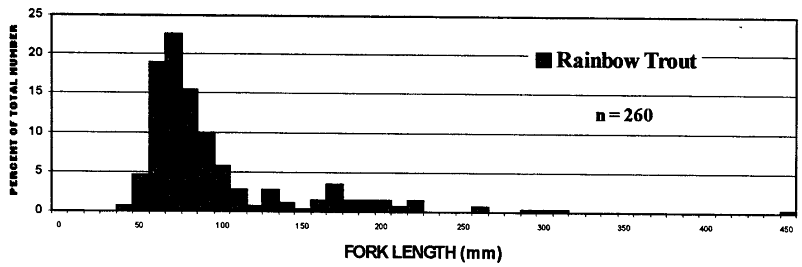

Figure 4. Length-frequency distribution of all presumed "wild" rainbow trout captured at all electrofishing sites in the Mammoth Creek study area, October 4 through 10, 1997.

Due to the fact that no fish in this size range were planted in Mammoth Creek in the last 2 years (C. Boone, CDFG, pers. comm.), it is believed that these trout were produced in the stream.

DISCUSSION

Sufficient instream flow is necessary for maintaining an aquatic environment that allows for a healthy fish population both in terms of population size and the ability to maintain successful reproduction (i.e. "good condition"). Over the past ten years there have been eight similar fish community surveys conducted within Mammoth Creek (1988, 1991-97). Trout abundance and length-frequency data collected from these studies allows us to compare the responses of the fish community to the various hydrologic conditions to which they were exposed over that same time period and make general inferences as to the "condition" of the Mammoth Creek fishery. Because of differences in sample site length for the 1988 study (Bratovich *et al.* 1990), and sample site locations for the CDFG 1991 study (Hood *et al.* 1995), as compared to surveys conducted from 1992-97, we felt that the 1992-97 data set was the most consistent and the most relevant for comparing with this year's results.

Relatively dry hydrologic conditions prevailed in Mammoth Creek from the late 1980's through 1992 and in 1994. In contrast, wetter conditions were predominant in 1993 and 1995-97 with the 1995 runoff year being the wettest of the past eleven years (Appendix B). Comparison of the population estimates and age structure, based on data collected before and after these flow conditions occurred in the creek, provides an opportunity to evaluate the adequacy of the historical flows for maintaining fish populations in "good condition".

Species Composition and Relative Abundance Estimates

Native Fishes

Native fishes (tui chub and Owens sucker) captured during this study were at an all-time low for the 1992-97 surveys. Only two fish of each species was caught representing only 0.3% of the total number of fish caught (n=1346) in 1997.

Rainbow Trout
Presumed "wild" rainbow trout estimates were very similar to the results of the 1996 survey, and were the second highest documented in the 1992-97 studies (579/mile) (Table 3).

Brown Trout
Brown trout abundance (estimated number of fish/mile) was the highest recorded (2,385/mile) for the 1992-97 survey period (Table 3). Brown trout population estimates (trout/mile) for each sampling site for the 1992-97 survey period are presented in Table 4. Average densities compare well with studies conducted previously in 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). Seven of the eight sites sampled in 1997 had higher brown trout densities than in 1996 (Table 5).

Table 3. Estimated average population densities (trout/mile) of brown and presumed "wild" rainbow trout captured by electrofishing in Mammoth Creek, Mono County, California, 1992-97. Numbers in parenthesis eliminate data from the sampling at Site EL for the 1995-97 surveys. (Data source: Jenkins and Dawson 1997 and this study).

Year	Brown trout per mile	Rainbow trout per mile
1997	2,385 (2,469)	579 (649)
1996	1,379 (1,413)	588 (591)
1995	592 (528)	78 (61)
1994	2,079	437
1993	1,289	57
1992	1,681	222

Comparison of brown trout densities by sampling site between the present study and the previous studies conducted in consecutive years (1992-96), reveals the highest densities ever recorded at five of the eight sections sampled[2] (Table 5). Brown trout densities remain relatively low (211 trout/mile) at Site CL. One possible explanation for this may be attributed to the high number of hatchery-reared rainbow trout planted by CDFG in this area. Thirty-two rainbow trout of hatchery origin were captured at sample Site CL during this survey (1997). As a result of the trout stocking in this area, in conjunction with easy public access to this area, recreational fishing pressure in this area appears to be higher than at any of the other seven sample sites. Brown trout at sample Site CL may be displaced by the larger hatchery fish, and/or, brown trout densities are being reduced by increased angler harvest in the area.

The results of this years survey suggest that the hydrologic conditions of Mammoth Creek between the 1996 and 1997 survey were favorable in terms of both brown and rainbow trout densities. Comparison of Mammoth Creek hydrology between this past water year and the same time periods for previous studies reveals similar conditions in two circumstances. The late-fall and early-winter hydrology of 1995-96 was similar to the same time period in 1996-97, and spring flow conditions in 1993 resembled the spring flow conditions in 1997 (Appendix B). Although, there are no obvious similarities in trout densities between the 1993 and 1996 survey results and this year, comparison of size class data between this year and previous studies may reveal similarities given the similar hydrologic conditions.

[2] Data from Site EL should be viewed as two separate data sets (1992-94 and 1995-97) by reason of the location change that occurred in 1995.

Trout Length-Frequency Distribution

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 age structure of the brown trout population in Mammoth Creek during the past six years, length-frequency data from the present study were compared to the 1992-96 data (Figure 5).

In general, the length-frequency distribution calculated for all brown trout captured during the present (1997) study exhibited a length-frequency distribution very similar to that calculated from previous studies. For the past six surveys, YOY fish make up the highest proportion of the total catch (Figure 6).

Table 4. Population estimates (trout/mile) and 95 percent confidence intervals for brown trout captured by electrofishing Mammoth Creek, Mono County, California, 21-28 October, 1992, 11-19 October, 1993, 4-11 October, 1994, 1-7 November, 1995, 3-8 October, 1996, and 4-10 October, 1997. (Data source: Jenkins and Dawson 1997, and this study).

Site	Year	Lower Confidence Boundary	Population Estimate	Upper Confidence Boundary
BH	1992	2992	3045	3128
	1993	2558	2957	3356
	1994	3915	4171	4427
	1995	1654	1760	1901
	1996	3942	4840	5738
	1997	8200	8589	8978
BL	1992	1830	1848	1895
	1993	2570	2658	2770
	1994	2235	2253	2309
	1995	528	546	616
	1996	158	158	158
	1997	669	704	788
CH	1992	546	563	621
	1993	475	510	609
	1994	722	810	980
	1995	299	334	453
	1996	1250	1302	1390
	1997	1637	1690	1785
CL	1992	827	845	906
	1993	1038	1232	1514
	1994	528	528	567
	1995	88	88	100
	1996	158	158	194
	1997	211	211	232

Table 4 (continued). Population estimates (trout/mile) and 95 percent confidence intervals for brown trout captured by electrofishing Mammoth Creek, Mono County, California, 21-28 October, 1992, 11-19 October, 1993, 4-11 October, 1994, 1-7 November, 1995, 3-8 October, 1996, and 4-10 October, 1997. (Data source: Jenkins and Dawson 1997, and this study).

Site	Year	Lower Confidence Boundary	Population Estimate	Upper Confidence Boundary
DH	1992	1338	1390	1482
	1993	1056	1056	1089
	1994	4268	4418	4567
	1995	563	616	737
	1996	1778	1901	2059
	1997	546	616	771
DL	1992	1584	1584	1611
	1993	510	510	551
	1994	1514	1584	1696
	1995	a	18	a
	1996	563	634	792
	1997	1619	1654	1725
EH	1992	3925	3978	4053
	1993	1197	1232	1302
	1994	2006	2464	2929
	1995	299	334	458
	1996	810	898	1056
	1997	3749	3819	3911
EL	1992	194	194	209
	1993	158	158	169
	1994	405	405	412
	1995	1038	1038	1062
	1996	1144	1144	1162
	1997	1742	1795	1880

[a] Due to a capture pattern of 1-0-0, estimate is assumed to be exactly correct, with no confidence limits.

Table 5. Population estimates (trout/mile) for brown trout captured by electrofishing Mammoth Creek, Mono County, California, 1992-97. Bold numbers indicate highest value for each site.

	Sample Site							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1997	**8589**	704	**1690**	211	616	**1654**	**3819**	**1795**[a]
1996	4840	158	1302	158	1901	634	898	1144[a]
1995	1760	546	334	88	616	18	334	1038[a]
1994	4171	2253	810	528	**4418**	1584	2464	405
1993	2957	**2658**	510	**1232**	1056	510	1232	158
1992	3045	1848	563	845	1390	1584	3978	194

[a] Different EL site locations were used for survey years 1992-94 and 1995-97.

Eighty-one percent of this years catch was comprised of YOY fish. The next highest YOY proportion was in the 1996 survey (73%) followed by 1994 (70%), 1992 (68%), 1993 (55%) and the lowest in 1995 (46%)[3].

In addition to the YOY age class, at least two or more brown trout age groups were present in every reach for every year (Figure 5). In comparison to the 1992-96 surveys, the overall length-frequency distribution for brown trout this year was most similar to 1994 (Figure 5).

As stated previously, spring flows in 1993 resembled the spring flow conditions of 1997 (Appendix B). Low YOY percentages in 1993 were suspected to be related either to high sustained flows between May and July that year or relatively low flows during the spawning period of 1992-93, or some combination of the two (Hood *et al.* 1994) (Appendix B and C). Strong YOY densities in all reaches this year, in conjunction with spring flow conditions similar to spring flows of 1993, suggest that flow conditions at some time other than spring snowmelt may have an influence on spawning/YOY recruitment success.

A closer examination of the late-fall, early-winter (November through February) hydrology for the 1991-97 period reveals low flow conditions in 1991-92 (Ave.=6.2cfs) and 1992-93 (Ave.=6.7cfs), moderately higher flow conditions in 1993-94 (Ave.=7.7cfs) and 1994-95 (Ave.=8.7cfs) and relatively high flow conditions in 1995-96 (Ave.=13.5cfs) and 1996-97 (Ave.=19.05cfs) (Appendix C). Perhaps the higher flows during the spawning period are aiding the spawning success of brown trout and the subsequent recruitment of YOY fish into the population. This is difficult to quantify however, because spawning and incubation success (and the subsequent recruitment of YOY fish) for brown trout also appears to be related to stream discharge from January through October (Jenkins and Dawson 1997). Nevertheless, the length-frequency distributions (considered in conjunction with population density estimates) are suggestive of brown trout populations in good condition in 1997. Furthermore the data reflects the highest YOY densities and overall brown trout abundance for all of the years surveyed.

Although brown trout continue to dominate the trout community in the study area, presumed "wild" rainbow trout accounted for approximately twenty percent of the trout captured in 1997. Trout per mile estimates were the second highest for all survey years and YOY fish comprised approximately 80 percent of the total rainbow trout catch (Table 3 and Figure 4). Therefore, it is

[3] YOY proportion estimates are approximated using the same size class grouping for all years (≤ 120 mm FL).

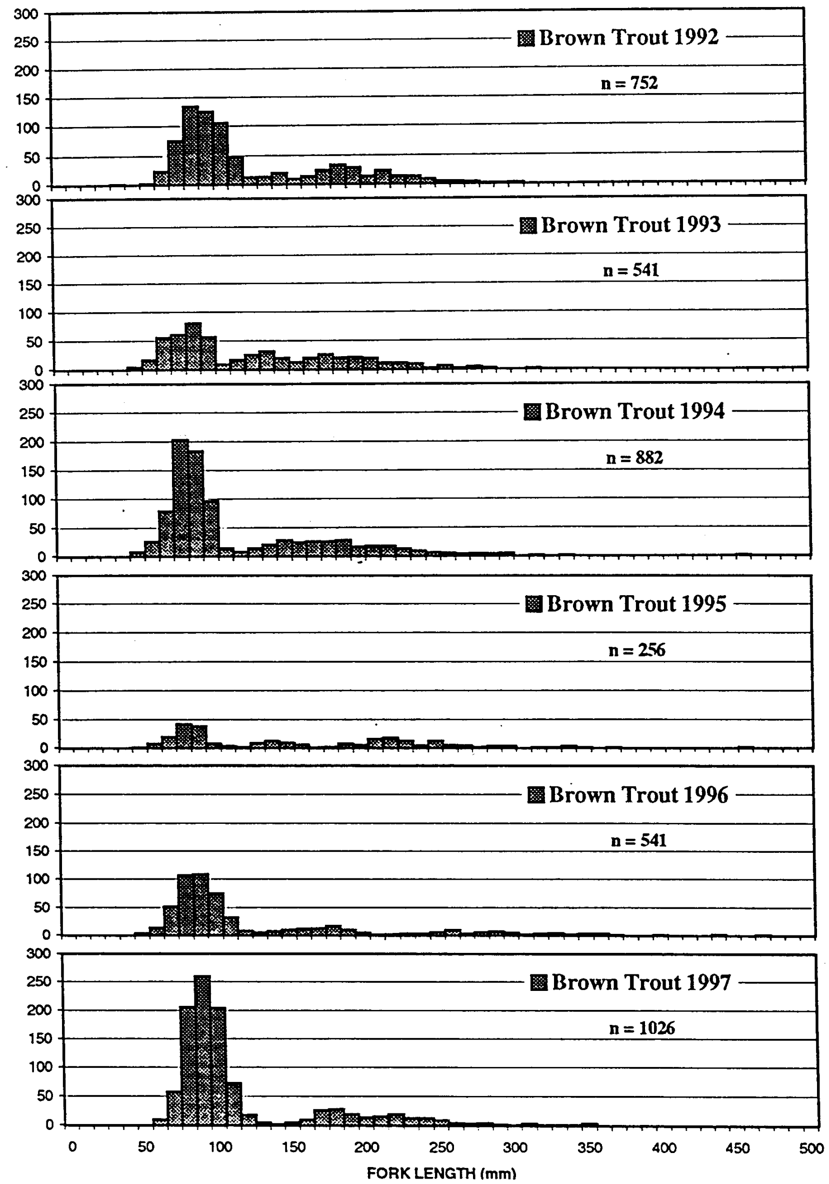

Figure 5. Length-frequency distribution of all brown trout captured in Mammoth Creek, 1992-97.

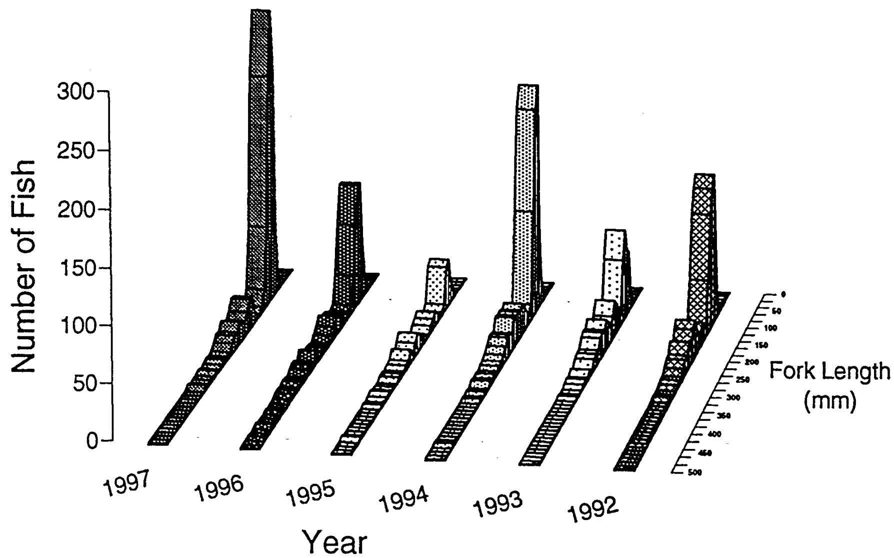

Figure 6. Comparison of brown trout length-frequency distributions from trout captured in the Mammoth Creek study area, 1992-97.

reasonable to believe that the conditions in Mammoth Creek between the 1996 survey and the 1997 survey were favorable as evidenced by the spawning success of the rainbow trout population.

CONCLUSIONS

- Trout density and age structure (length-frequency) information obtained from the electrofishing survey conducted in October 1997 suggest that both the brown and rainbow trout populations in Mammoth Creek remain in good condition. The results exhibit high densities of brown trout (the highest density of fish for the 1992-97 survey years) and presumed "wild" rainbow trout (the second-highest density of fish for the 1992-97 survey years); successful reproduction and subsequent recruitment to the population; and, long-term survival.

- It appears that the trout population in Mammoth Creek continues to endure natural annual population density variation as a result of the hydrologic conditions to which they are subjected. They have exhibited the ability to withstand and continue to recover from various uncontrollable environmental factors such as the extreme snowmelt conditions as experienced in 1995 and the drought induced low flow conditions of the early 90's.

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APPENDIX A
Maximum Likelihood Catch Statistics

Stream: **MAMMOTH CREEK - SITE BH**
Species: Brown Trout

Removal Pattern: 278 113 57

Total Catch	= 448
Population Estimate	= 488
Chi Square	= 0.851
Pop Est Standard Err	= 11.209
Lower Conf Interval	= 465.918
Upper Conf Interval	= 510.082
Capture Probability	= 0.564
Capt Prob Standard Err	= 0.030
Lower Conf Interval	= 0.505
Upper Conf Interval	= 0.622

Stream: **MAMMOTH CREEK - SITE BL**
Species: Brown Trout

Removal Pattern: 19 11 6 2

Total Catch	= 38
Population Estimate	= 40
Chi Square	= 0.491
Pop Est Standard Err	= 2.385
Lower Conf Interval	= 38.000
Upper Conf Interval	= 44.825
Capture Probability	= 0.507
Capt Prob Standard Err	= 0.087
Lower Conf Interval	= 0.330
Upper Conf Interval	= 0.683

Stream: **MAMMOTH CREEK - SITE CH**
Species: Brown Trout

Removal Pattern: 62 24 7

Total Catch	= 93
Population Estimate	= 96
Chi Square	= 0.372
Pop Est Standard Err	= 2.704
Lower Conf Interval	= 93.000
Upper Conf Interval	= 101.366
Capture Probability	= 0.664
Capt Prob Standard Err	= 0.056
Lower Conf Interval	= 0.554
Upper Conf Interval	= 0.775

Stream: **MAMMOTH CREEK - SITE CL**
Species: Brown Trout

Removal Pattern: 9 2 1

Total Catch	= 12
Population Estimate	= 12
Chi Square	= 0.371
Pop Est Standard Err	= 0.532
Lower Conf Interval	= 12.000
Upper Conf Interval	= 13.175
Capture Probability	= 0.750
Capt Prob Standard Err	= 0.133
Lower Conf Interval	= 0.456
Upper Conf Interval	= 1.044

Stream: **MAMMOTH CREEK - SITE DH**
Species: Brown Trout

Removal Pattern: 16 11 4

Total Catch	= 31
Population Estimate	= 35
Chi Square	= 0.744
Pop Est Standard Err	= 4.341
Lower Conf Interval	= 31.000
Upper Conf Interval	= 43.821
Capture Probability	= 0.500
Capt Prob Standard Err	= 0.124
Lower Conf Interval	= 0.248
Upper Conf Interval	= 0.752

Stream: **MAMMOTH CREEK - SITE DL**
Species: Brown Trout

Removal Pattern: 66 20 6

Total Catch	= 92
Population Estimate	= 94
Chi Square	= 0.039
Pop Est Standard Err	= 2.012
Lower Conf Interval	= 92.000
Upper Conf Interval	= 97.996
Capture Probability	= 0.708
Capt Prob Standard Err	= 0.052
Lower Conf Interval	= 0.605
Upper Conf Interval	= 0.811

Stream: **MAMMOTH CREEK - SITE EH**		Stream: **MAMMOTH CREEK -SITE EL**	
Species: Brown Trout		Species: Brown Trout	
Removal Pattern: 160 39 14		Removal Pattern: 61 20 14 4	
Total Catch	= 213	Total Catch	= 99
Population Estimate	= 217	Population Estimate	= 102
Chi Square	= 0.863	Chi Square	= 2.245
Pop Est Standard Err	= 2.627	Pop Est Standard Err	= 2.403
Lower Conf Interval	= 213.000	Lower Conf Interval	= 99.000
Upper Conf Interval	= 222.176	Upper Conf Interval	= 106.758
Capture Probability	= 0.729	Capture Probability	= 0.579
Capt Prob Standard Err	= 0.033	Capt Prob Standard Err	= 0.050
Lower Conf Interval	= 0.665	Lower Conf Interval	= 0.480
Upper Conf Interval	= 0.794	Upper Conf Interval	= 0.678

The population estimate lower confidence intervals for seven of the sites were set equal to the total catches. Actual calculated lower confidence intervals (LCI) were:

Site	Calculated LCI
BL	35.17532
CH	90.63351
CL	10.82469
DH	26.17865
DL	90.00442
EH	211.8244
EL	97.24238

Stream: **MAMMOTH CREEK - SITE BH**		Stream: **MAMMOTH CREEK - SITE CH**	
Species: Presumed "wild" rainbow trout		Species: Presumed "wild" rainbow trout	
Removal Pattern: 6 0 1		Removal Pattern: 35 8 3	
Total Catch	= 7	Total Catch	= 46
Population Estimate	= 7	Population Estimate	= 46
Chi Square	= 3.256	Chi Square	= 0.623
Pop Est Standard Err	= 0.327	Pop Est Standard Err	= 0.917
Lower Conf Interval	= 7.000	Lower Conf Interval	= 46.000
Upper Conf Interval	= 7.801	Upper Conf Interval	= 47.846
Capture Probability	= 0.778	Capture Probability	= 0.767
Capt Prob Standard Err	= 0.164	Capt Prob Standard Err	= 0.065
Lower Conf Interval	= 0.377	Lower Conf Interval	= 0.635
Upper Conf Interval	= 1.178	Upper Conf Interval	= 0.899

Stream: **MAMMOTH CREEK - SITE CL**
Species: Presumed "wild" rainbow trout

Removal Pattern: 37 12 3
Total Catch = 52
Population Estimate = 53

Chi Square = 0.141
Pop Est Standard Err = 1.464
Lower Conf Interval = 52.000
Upper Conf Interval = 55.937

Capture Probability = 0.712
Capt Prob Standard Err = 0.068
Lower Conf Interval = 0.575
Upper Conf Interval = 0.850

Stream: **MAMMOTH CREEK - SITE DL**
Species: Presumed "wild" rainbow trout

Removal Pattern: 37 20 0
Total Catch = 57
Population Estimate = 58

Chi Square = 9.419
Pop Est Standard Err = 1.529
Lower Conf Interval = 57.000
Upper Conf Interval = 61.061

Capture Probability = 0.712
Capt Prob Standard Err = 0.065
Lower Conf Interval = 0.582
Upper Conf Interval = 0.843

Stream: **MAMMOTH CREEK SITE DH**
Species: Presumed "wild" rainbow trout

Removal Pattern: 28 6 6
Total Catch = 40
Population Estimate = 41

Chi Square = 3.687
Pop Est Standard Err = 1.865
Lower Conf Interval = 40.000
Upper Conf Interval = 44.769

Capture Probability = 0.656
Capt Prob Standard Err = 0.087
Lower Conf Interval = 0.481
Upper Conf Interval = 0.831

Stream: **MAMMOTH CREEK - SITE EH**
Species: Presumed "wild" rainbow trout

Removal Pattern: 36 6 4
Total Catch = 46
Population Estimate = 46

Chi Square = 2.880
Pop Est Standard Err = 0.917
Lower Conf Interval = 46.000
Upper Conf Interval = 47.846

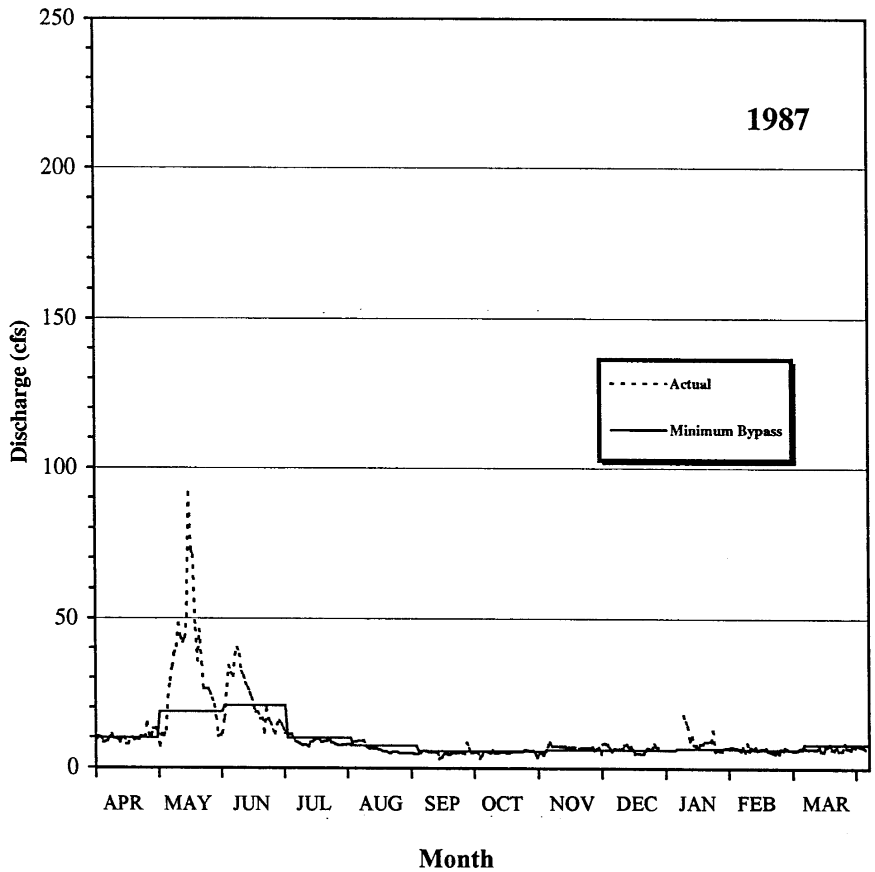
Capture Probability = 0.767
Capt Prob Standard Err = 0.065
Lower Conf Interval = 0.635
Upper Conf Interval = 0.899

The population estimate lower confidence intervals for six of the sites were set equal to the total catches. Actual calculated lower confidence intervals (LCI) were:

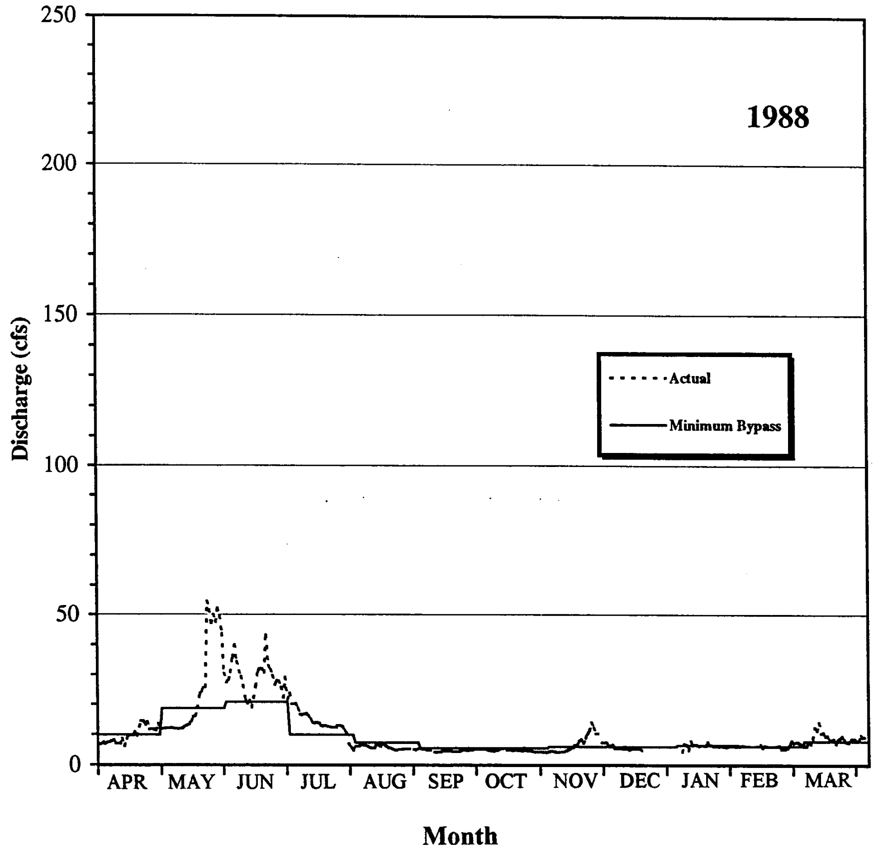
Site	Calculated LCI
BH	6.199153
CH	44.15401
CL	50.06269
DH	37.23121
DL	54.93852
EH	44.15401

At sample site BL the presumed "wild" rainbow trout removal pattern was 7-0-0-0 and at site EL was 5-0-0-0. Microfish software cannot calculate confidence intervals for these results. Therefore, the estimated populations are seven (BL) and five (EL).

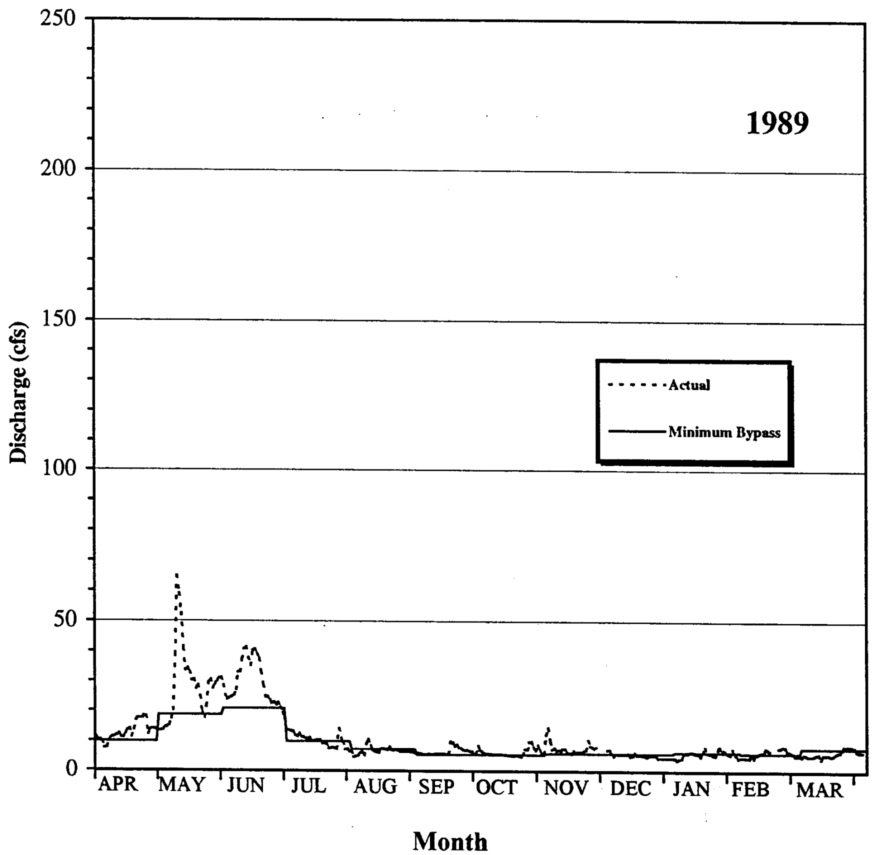
APPENDIX B
Mammoth Creek Hydrographs (1987-1997)



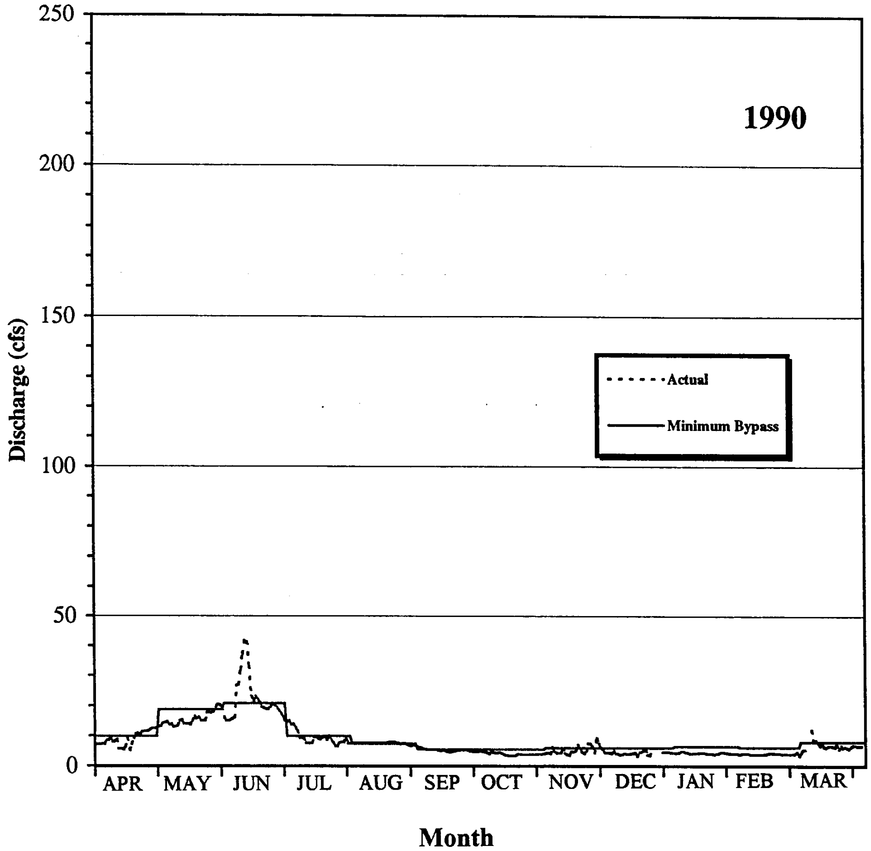
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1987, and the recommended operational minimum mean daily bypass regime.



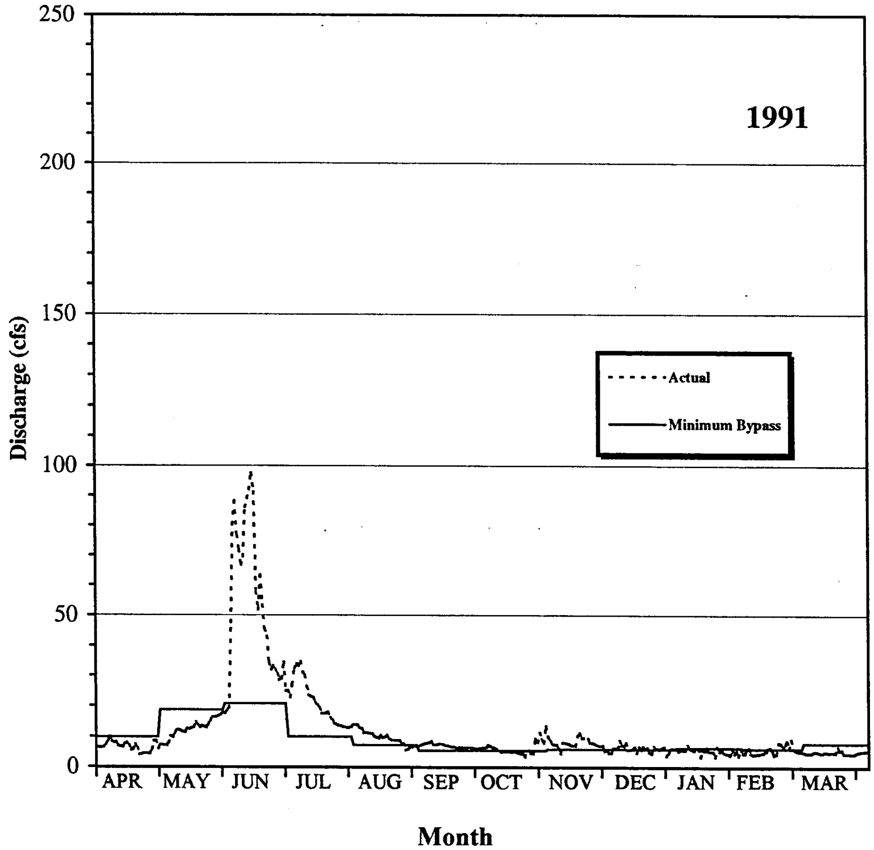
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1988, and the recommended operational minimum mean daily bypass regime.



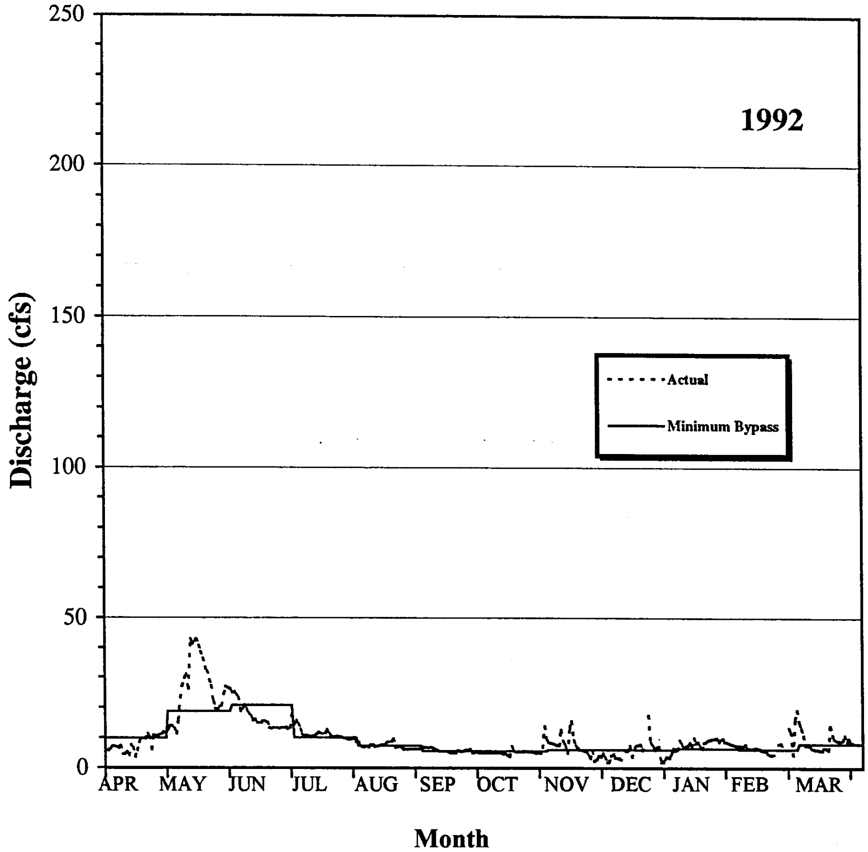
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1989, and the recommended operational minimum mean daily bypass regime.



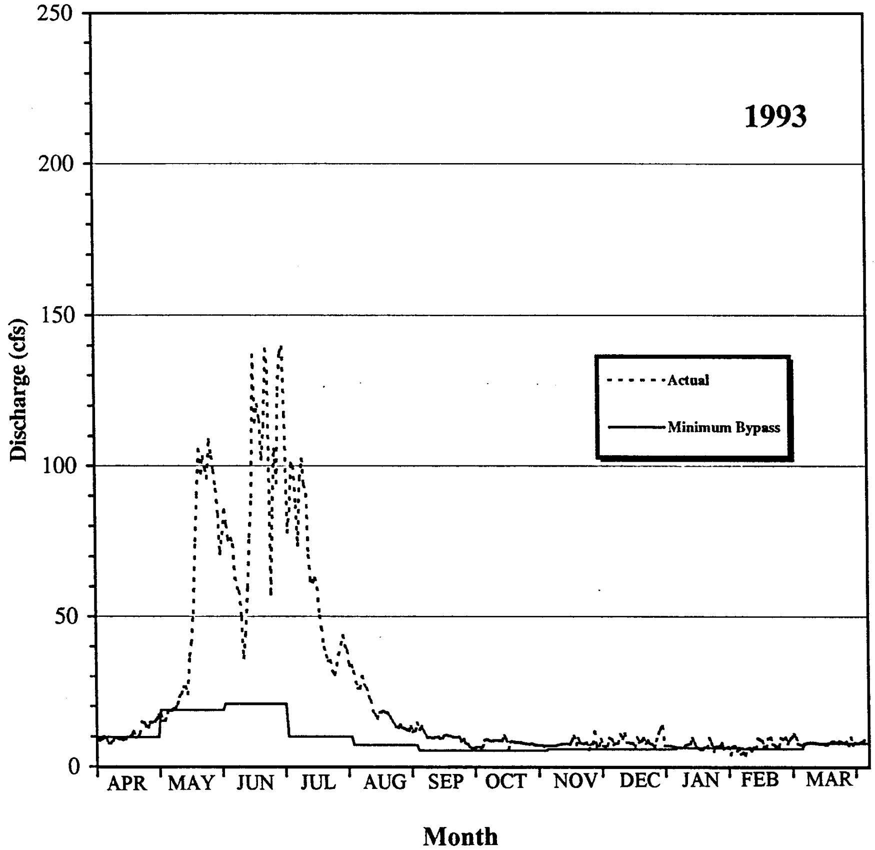
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1990, and the recommended operational minimum mean daily bypass regime.



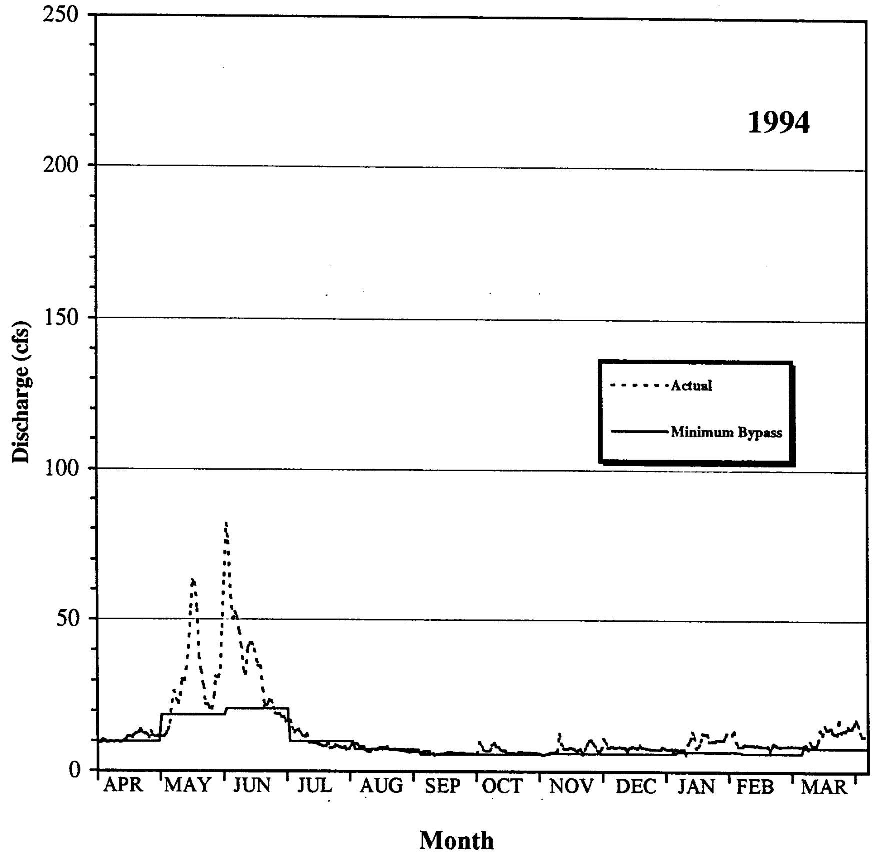
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1991, and the recommended operational minimum mean daily bypass regime.



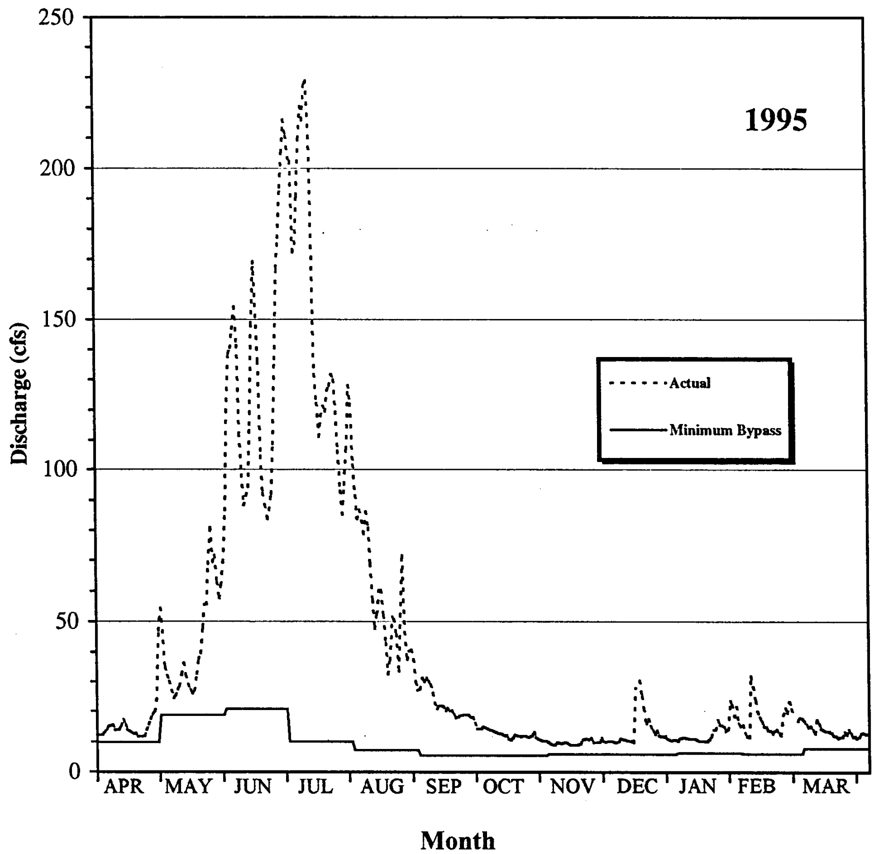
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1992, and the recommended operational minimum mean daily bypass regime.



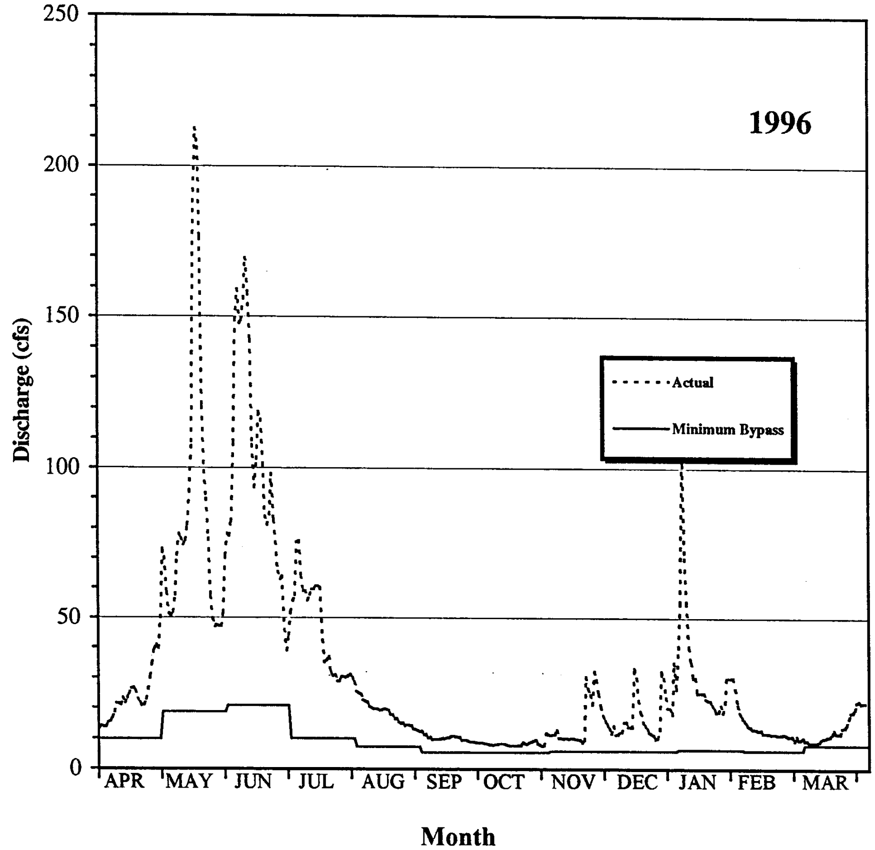
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1993, and the recommended operational minimum mean daily bypass regime.



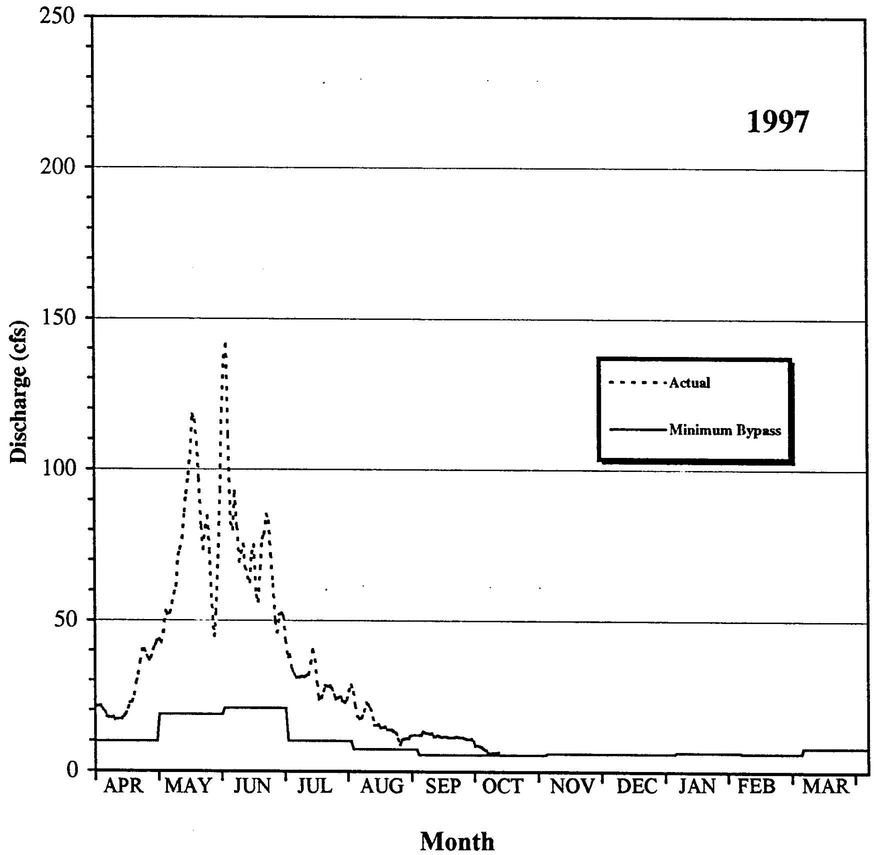
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1994, and the recommended operational minimum mean daily bypass regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1995, and the recommended operational minimum mean daily bypass regime.

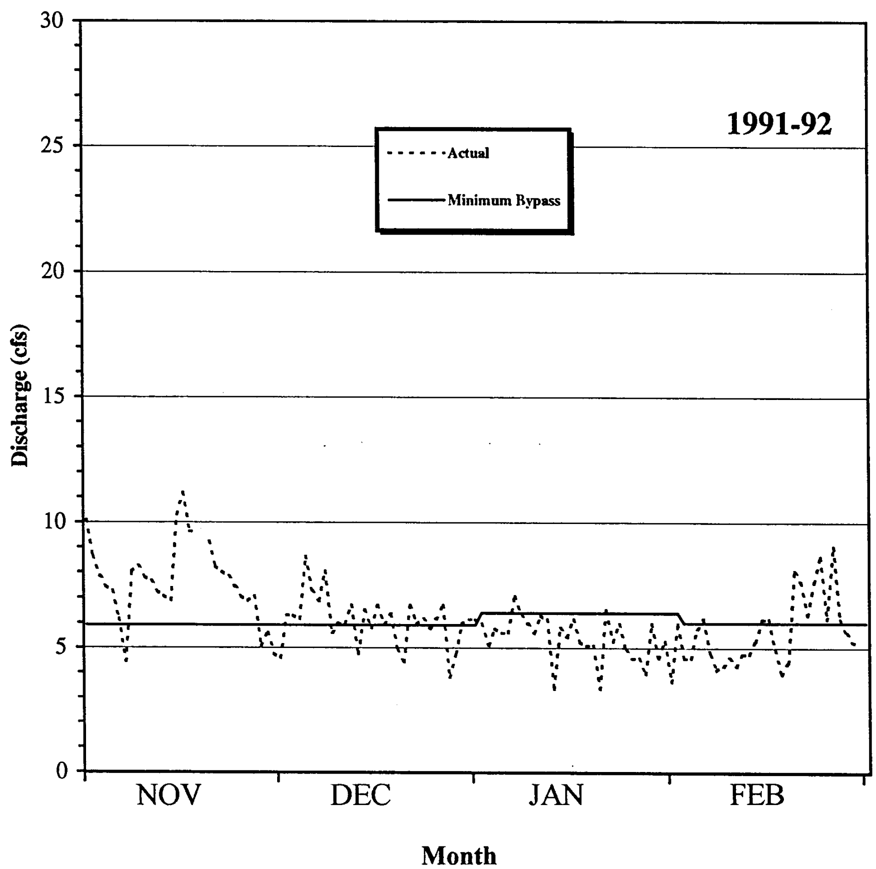


Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1996, and the recommended operational minimum mean daily bypass regime.

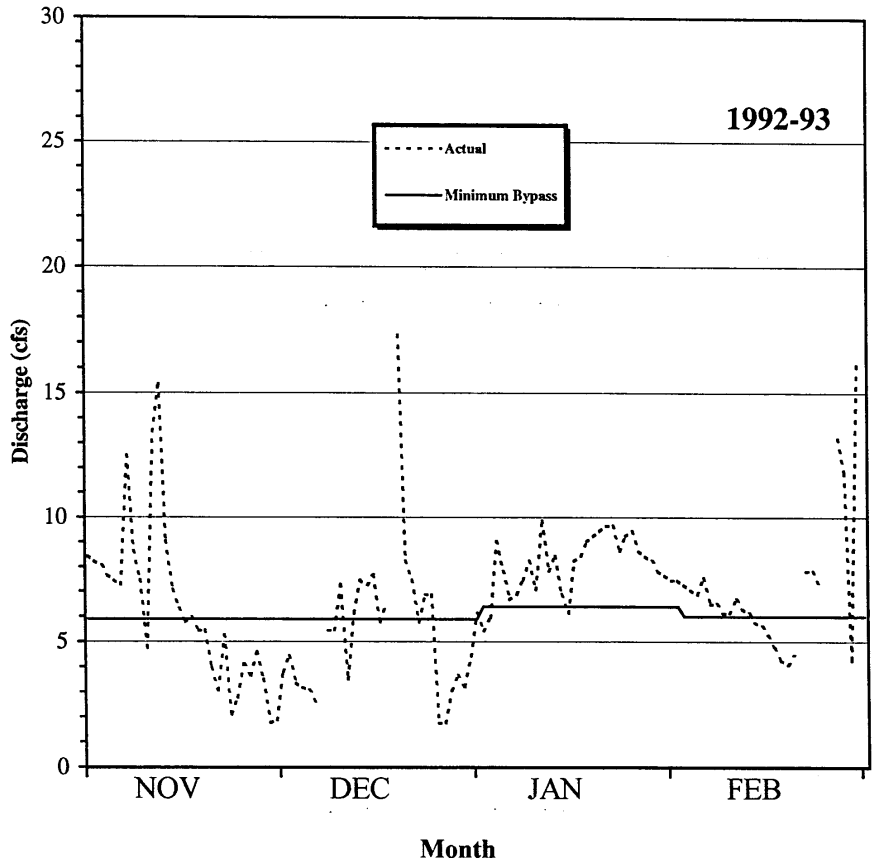


Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1997, and the recommended operational minimum mean daily bypass regime.

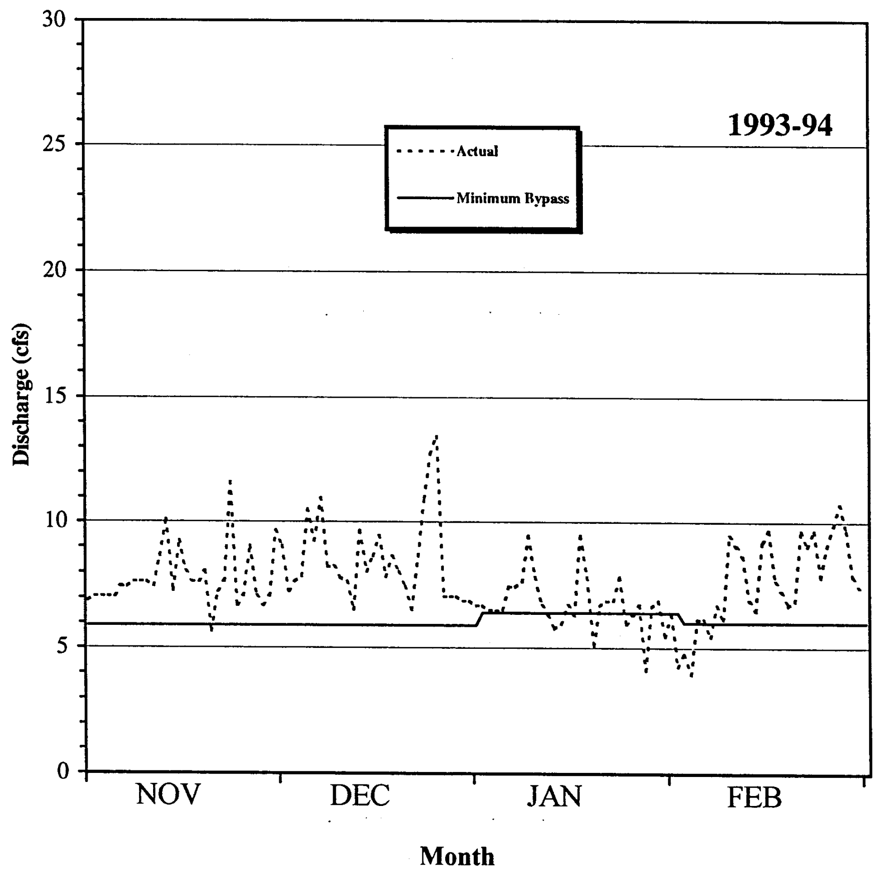
APPENDIX C
Mammoth Creek Hydrographs
(November through February, 1991-1997)



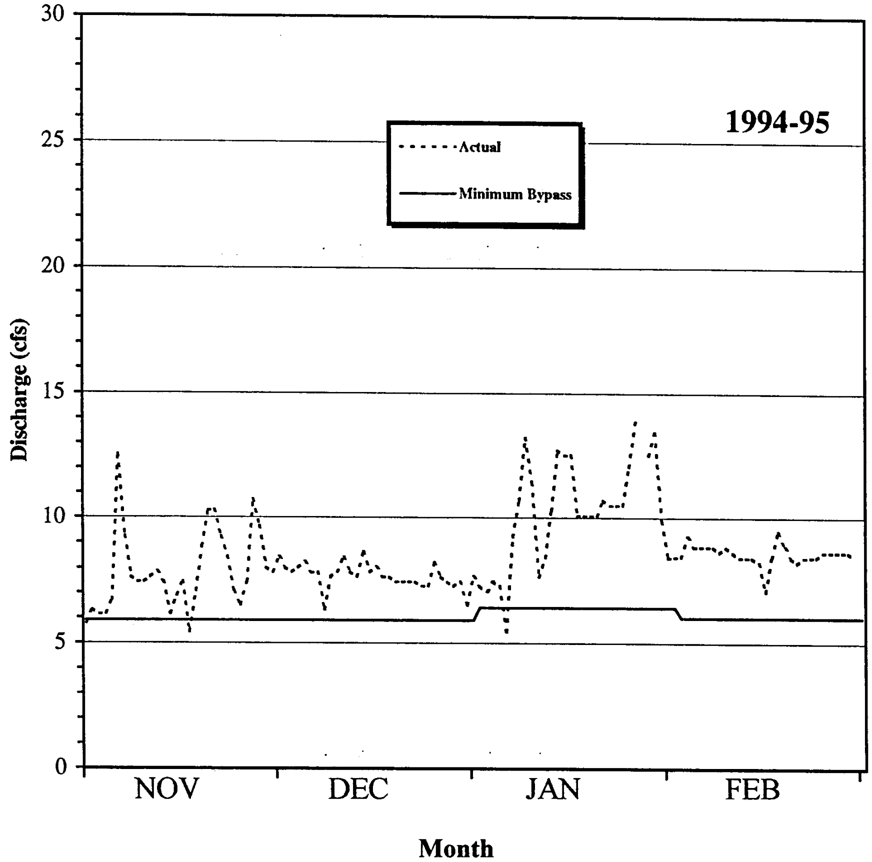
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1991 for the months November through February, and the recommended operational minimum mean daily bypass regime.



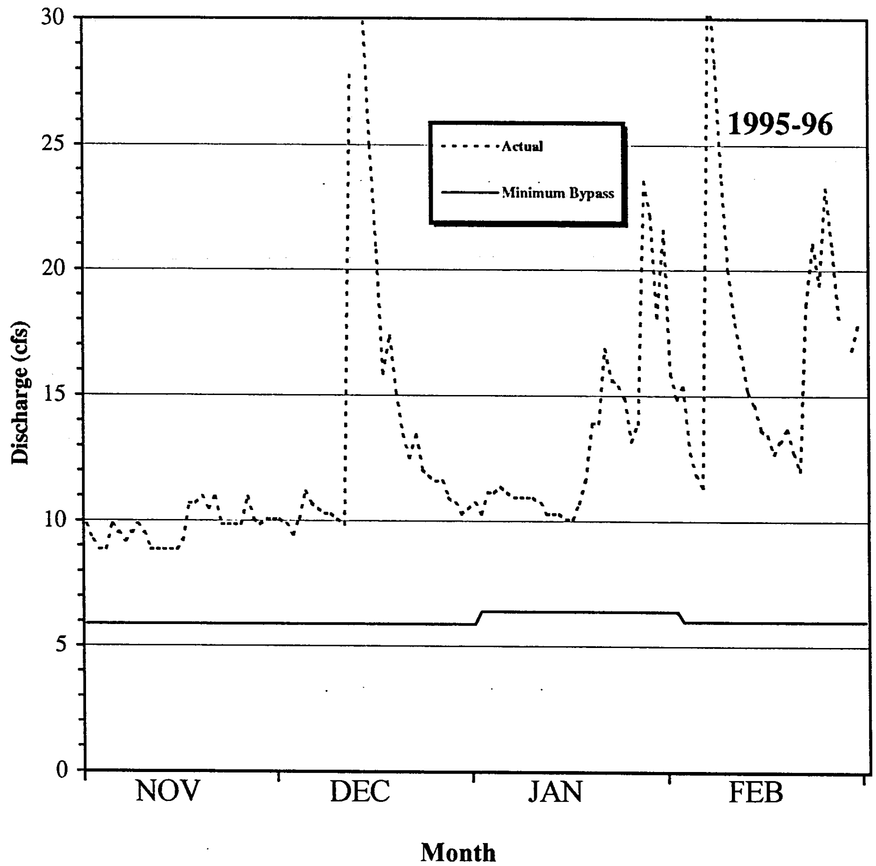
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1992 for the months November through February, and the recommended operational minimum mean daily bypass regime.



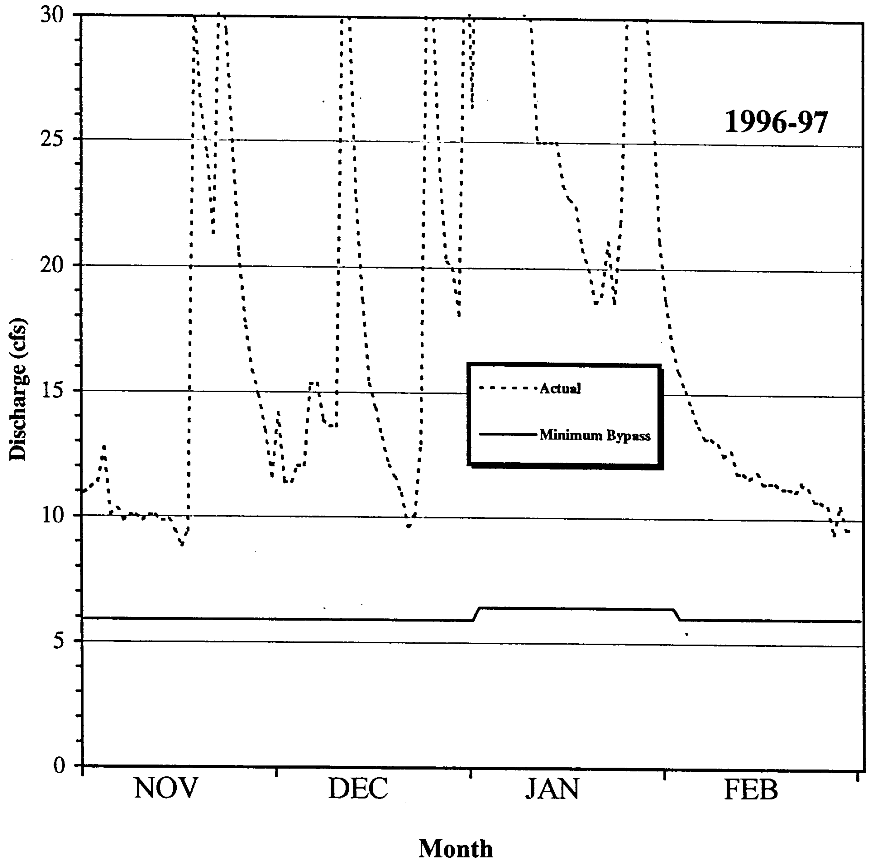
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1993 for the months November through February, and the recommended operational minimum mean daily bypass regime.



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



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1995 for the months November through February, and the recommended operational minimum mean daily bypass regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1996 for the months November through February, and the recommended operational minimum mean daily bypass regime.