

**Annie Spring Flow Response to Long-term Drought
and
Municipal Water Use Trends
At Crater Lake National Park.**

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Crater Lake National Park is currently experiencing a local long-term drought. The surface elevation of the lake itself has dropped from 6,178 ft in 1984 to less than 6,168 ft in 1992.

Water for park municipal use is drawn from Annie Spring, the headwater of Annie Creek. The U.S. Geological Survey has maintained a gauging station on Annie Creek since 1977, shortly after the park moved its water intake facility from Munson Creek to Annie Creek. The gauging station is located directly beneath the road crossing several hundred feet below Annie Spring. The water intake is located at the spring origin, there are no discharge data for the spring origin. The origin is not the sole source of water as stream discharge increases several fold between the spring and the road crossing. Table 1 lists mean discharge in cubic feet per second (cfs) for Annie Creek by water year (Oct 1 - Sept 30), by month. During the winter of 1993, Annie Creek discharge is expected to drop to its lowest level in the 16 year record period. A typical hydrograph or flow pattern for the creek shows flow decreasing through the fall and winter, reaching minimum values in March or April (Figure 1). Spring flow responds rapidly to snow melt increasing in April or May and peaking in June. Estimated flow values for December 1992 (.43 cfs) are 23% of the 1977-1987 mean for December (1.9 cfs). Discharge values for 1977 through 1991 are adjusted to include water withdrawal from the

spring. Values for 1992 and 1993 represent gauge recordings plus estimated water withdrawal rates based on preliminary data analysis.

Although discharge is currently low, this is not the first time low flows have been recorded. Minimum gauge values of .41 cfs and .39 cfs were recorded on March 18, 1989, and April 29, 1991, respectively. No water intake problems were noted during 1989 and 1991. Municipal water withdrawal has increased from approximately 9 million gallons in 1990 to over 13 million gallons in 1992 (Table 2) compounding trends in reduced spring discharge (Figure 2). Table 2 also indicates that water use increased in each development area that withdraws water from Annie Spring (Munson Valley, Rim Village, and Mazama Village). Table 3 itemizes water use for each development area by month for 1990 through 1993. There were no dramatic increases in water use in Munson Valley, Rim Village and Mazama Village during fall and winter 1990-1992. However, Mazama Village was open for the first time during the months of November and December in 1992. The most dramatic seasonal increases in water use occurred in Mazama Village and Munson Valley in June, July, and August. Water use increased in Mazama Village from approximately 500,000 gallons in July, 1990, to 1,100,000 gallons in July, 1992. In Munson Valley water use increased from approximately 370,000 gallons in August, 1990, to 990,000 gallons in August 1992. Table 4 lists total water withdrawal for Annie Spring by month from 1989 through December 1993. There is a trend toward increased water use during the winter months. This trend is expected to continue during the winter of 1993 (without water conservation) as Sleepy Hollow housing area is near full occupancy.

Water intake pipes have been lowered into the spring, and a timer has been installed on the water pumps to increase pumping efficiency. Reducing the pumping rate to more closely match spring recharge is recommended. A list of water conservation recommendations will be distributed to park and concession employees and to construction contractors. The park should be prepared with alternatives to meet water needs if these steps are not adequate.

Accumulated snow fall as of January 12, 1993, was above the long-term average for that date. If snow fall trends continue Annie Spring will recharge and attain average or higher flow rates corresponding closely in time with snow melt. The exact timing of snow melt can only be predicted as closely as predicting the weather.

In summary, during the winter of 1993, Annie Spring will likely reach the lowest recorded, discharge values since the gauge was installed in 1977. Compounding this problem is increased municipal water use and water withdrawal from the spring. The creek appears to have adequate flow to meet water demands; however, the current catchment and withdrawal system is probably not adequate to capture enough flow if current water use and spring flow trends continue. The design of the water system obviously warrants re-visiting especially with increased park development proposed and increased visitor use projected. In light of this new information, it is advisable to make new projections of future water use to determine if Annie Spring can support water withdrawal projections without violating water right allocations and instream flow requirements for channel processes and stream flora and fauna.

Table 1. Annie Creek Mean Discharge (cfs) by Water Year, by Month, for 1977-1987 and for 1988 through December 1993.

Month	1977-1987	1988	1989	1990	1991	1992*	1993*
Oct	1.9	1.23	1.30	2.41	1.17	1.27	.60
Nov	1.6	.98	1.04	2.33	.94	.96	.47
Dec	1.9	.89	.75	2.06	.65	1.00	.43
Jan	1.8	.76	.62	1.62	.53	.90	
Feb	1.6	.72	.51	1.15	.49	.78	
Mar	1.7	.83	.47	.74	.53	.71	
Apr	1.9	1.49	1.94	1.71	.46	1.62	
May	4.0	2.68	5.20	4.37	.85	3.14	
Jun	7.4	5.17	8.15	4.81	4.91	1.82	
Jul	6.3	3.80	6.71	2.98	4.88	1.50	
Aug	3.5	2.28	3.90	1.96	2.23	1.06	
Sep	2.4	1.70	2.63	1.45	1.51	.81	
Mean Annual	3.1	1.88	2.78	2.31	1.60	1.30	

* 1977-1991 values are adjusted for municipal water withdrawal. 1992-1993 values represent discharge plus estimates for withdrawal based on preliminary data.

Annie Creek Mean Monthly Discharge (cfs) By Water Year

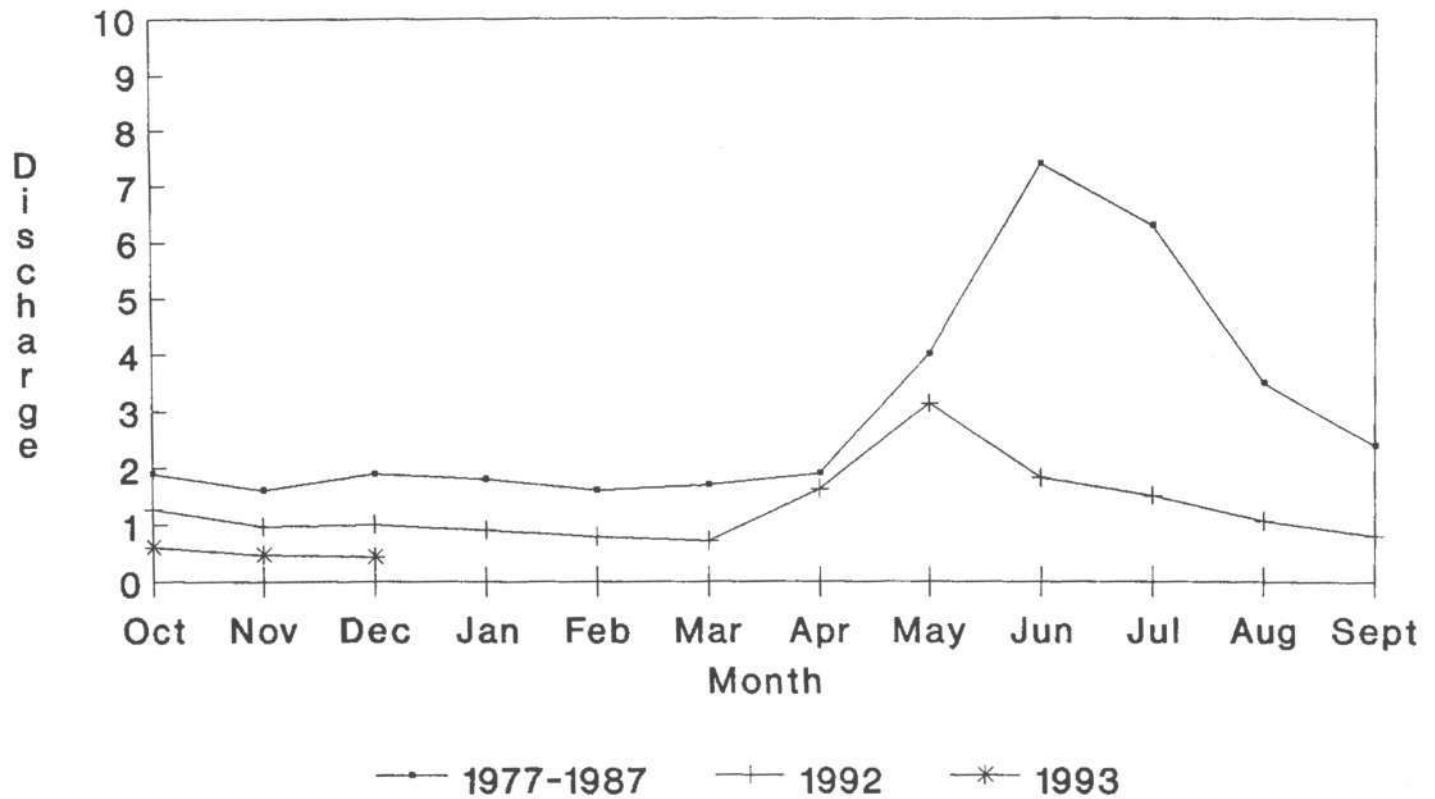


Figure 1. Annie Creek Mean Monthly Discharge, in Cubic Feet per Second, by Water Year.

Table 2. Annie Spring Municipal Water Withdrawal, in Gallons, for Calender Years 1990 Through 1992, for Munson Valley, Rim Village and Mazama Village.

Location	1990	1991	1992
Munson Valley	3,409,250	3,933,920	4,687,620
Rim Village	3,628,600	4,067,750	5,071,440
Mazama Village	1,894,800	3,132,700	3,623,800
Annie Spring Total	8,932,650	11,134,370	13,382,660

Annie Creek Mean Annual Discharge (cfs)
and Total Annual Municipal Water Use.
(gallons x 1 million)

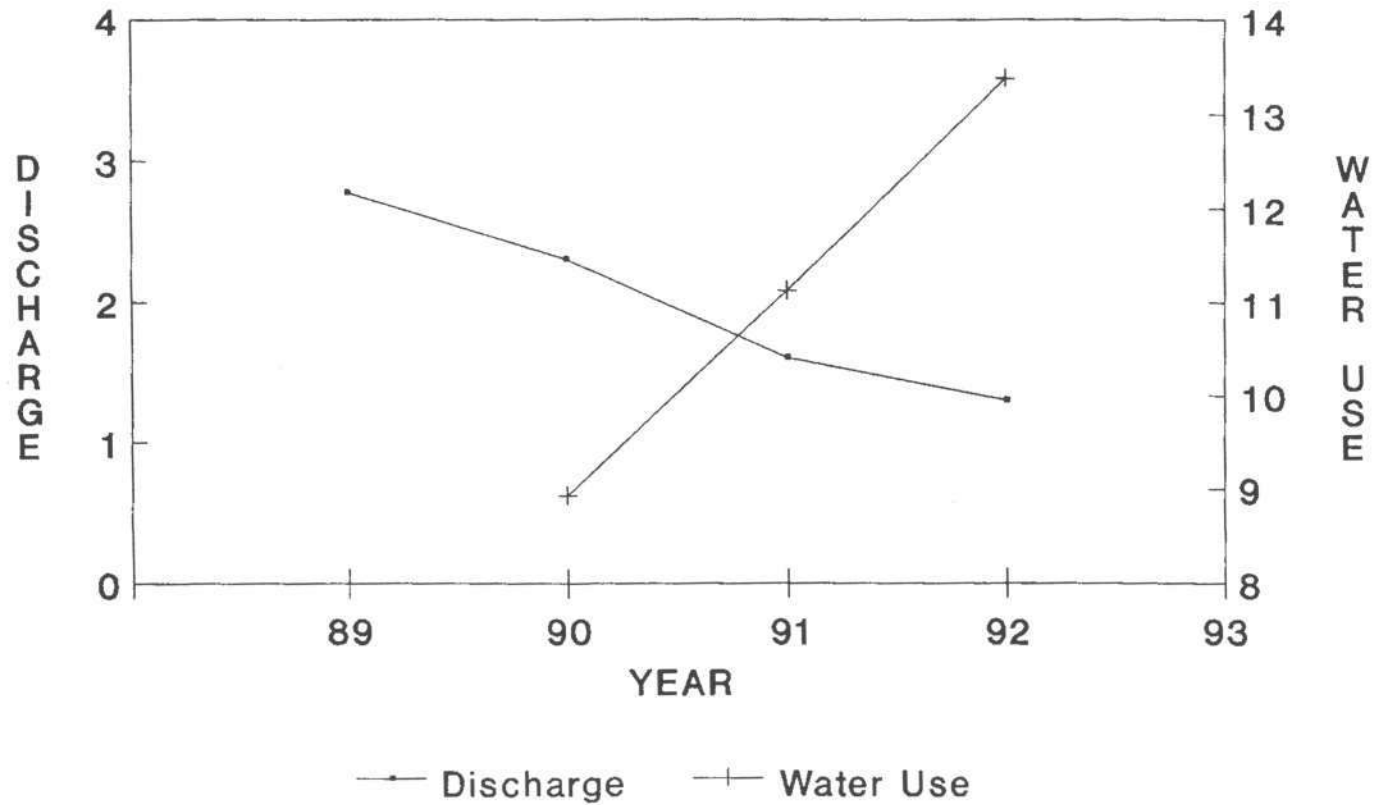


Figure 2. Annie Creek Mean Annual Discharge, in Cubic Feet per Second, and Total Annual Municipal Water Withdrawal from Annie Creek (gallons x 1 million).

Table 3. Annie Spring Municipal Water Withdrawal, in Gallons, by Water Year, by Month for Munson Valley, Rim Village and Mazama Village.

1990

Location	October	November	December	January	February	March	April	May	June	July	August	September
MUNSON	NA	NA	NA	220,430	371,420	193,780	219,360	215,210	354,160	369,650	373,240	324,580
RIM	NA	NA	NA	115,530	74,420	133,470	137,860	223,720	478,970	724,860	698,620	468,030
MAZAMA	closed	closed	closed	closed	closed	closed	23,100	259,900	235,000	504,500	500,100	261,100
TOTAL	NA	NA	NA	335,960	445,840	327,250	380,320	698,830	1,068,130	1,599,010	1,572,361	1,053,710

1991

Location	October	November	December	January	February	March	April	May	June	July	August	September
MUNSON	222,170	259,370	265,880	417,680	214,200	239,070	236,420	238,230	322,250	417,780	451,720	461,270
RIM	289,140	157,850	126,130	157,710	109,410	142,460	228,280	238,690	450,310	830,120	738,370	524,490
MAZAMA	82,100	closed	closed	closed	closed	closed	closed	354,000	239,700	766,700	976,000	633,200
TOTAL	593,410	417,220	392,010	575,390	323,610	381,530	464,700	830,920	1,012,260	2,014,600	2,166,090	1,618,960

1992

Location	October	November	December	January	February	March	April	May	June	July	August	September
MUNSON	431,930	243,680	252,050	273,100	257,870	283,650	237,350	301,510	444,320	693,880	989,700	289,930
RIM	406,890	121,280	117,730	104,950	107,590	134,060	172,500	284,980	490,590	843,250	755,440	898,560
MAZAMA	163,000	closed	closed	closed	closed	closed	119,000	133,900	411,900	839,600	1,107,600	764,600
TOTAL	1,001,920	364,960	369,780	378,050	365,400	417,710	528,850	720,390	1,346,810	2,376,730	2,852,740	1,953,090

1993

Location	October	November	December
MUNSON	375,690	292,880	247,800
RIM	732,000	389,000	158,520
MAZAMA	114,100	48,000	85,100
TOTAL	1,221,790	729,880	491,420

NA = Not Available

Table 4. Annie Spring Municipal Water Withdrawal, in Gallons, by Water Year, by Month, for 1989 Through December, 1993.

Year	October	November	December	January	February	March	April	May	June	July	August	September
1989	NA	NA	NA	NA	NA	NA	NA	NA	1,269,990	1,713,440	1,729,360	NA
1990	593,410	417,220	392,010	355,960	445,840	327,250	380,320	698,830	1,068,030	1,599,010	1,572,361	1,053,710
1991	1,001,920	364,960	369,780	575,390	323,610	381,530	464,700	830,920	1,012,260	1,599,010	2,166,090	1,618,960
1992	1,221,790	729,880	491,420	378,050	365,400	417,710	528,850	720,390	1,346,810	2,376,730	2,852,740	1,953,090
1993	1,107,690	681,880	406,320									

NA = Not Available