

Historical Information on Klamath Watershed Hydrology and Water Quality in the Upper Klamath Basin

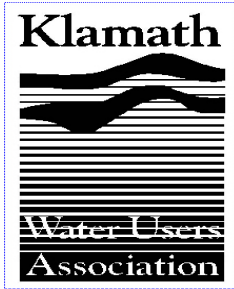
Presented to the National Research Council
Committee on Hydrology, Ecology, and Fishes
of the Klamath River Basin.

October 3, 2006
Yreka, CA

Submitted by the Klamath Water Users
Association



Prepared by Dr. Kenneth A. Rykbost



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About the Klamath Water Users Association

The Klamath Water Users Association (KWUA) is a non-profit corporation that has represented Klamath Irrigation Project farmers and ranchers since 1953. KWUA members include rural and suburban irrigation districts and other public agencies as well as private individuals who operate on both sides of the California-Oregon border. We represent over 1400 family farms and ranches that encompass over 200,000 of some of the best farm land in the West.

The mission of the organization is to preserve, protect and defend the water and power rights of the landowners of the Klamath Basin while promoting wise management of ecosystem resources.

The Klamath Water Users Association is governed by an 11 member board of directors who are representatives from Klamath Project districts. The association employs an Executive Director to execute the policy decisions made by the board.

About the Klamath Project

Irrigation and Drainage

The Klamath Project on the Oregon-California border was one of the earliest Federal reclamation projects. In addition to providing irrigation, a major aspect of the project was drainage – the ability to remove water from a closed basin. The project was authorized by the Reclamation act of 1902 and construction began in May of 1905. According to a 1998 study conducted by Davids Engineering ("Klamath Project Historical Water Use Analysis"), effective efficiency for the overall Project is 93 percent, making the Klamath Project one of the most efficient in the country.

Water Supply

There are two main sources of water supply for the Klamath Project. One consists of Upper Klamath Lake and the Klamath River, and the other consists of Clear Lake Reservoir, Gerber Reservoir, and the Lost River, which are part of a closed basin.

Power

Power has always been an integral component to the Klamath Project. In addition to numerous individual and district pumps, there are 5 major (drainage) pumping plants with power input ranging from 450 to 3,650 hp. In addition, there are 40 pumping plants of less than 1000 hp.

Member Districts

Ady District
Improvement Co.

Enterprise Irrigation
District

Klamath Basin
Improvement District

Klamath Drainage
District

Klamath Irrigation
District

Malin Irrigation District

Pine Grove Irrigation
District

Pioneer District
Improvement Co.

Poe Valley
Improvement District

Shasta View Irrigation
District

Sunnyside Irrigation
District

Tulelake Irrigation
District

Van Brimmer Ditch
Company

Warren Act
Contractors

Westside
Improvement District

Wocus Drainage
District

Principal Crops

Alfalfa Hay
Beef Cattle
Barley
Nursery Stock
Grass Hay
Horseradish
Mint
Onions
Oats
Potatoes
Strawberry Root-Stock
Wheat

Canals, Laterals and Drains

There are 18 canals with a total length of 185 miles. Laterals total 516 miles, and drains 728 miles.

Irrigation Season

The peak irrigation season normally extends from April through September, although diversions may begin in March in some areas and may be applied through October in others. The growing season varies considerably from year to year, but averages approximately 120 days. In certain areas of the Project, particularly Lower Klamath, winter irrigation practices are common.

Principal Crops

The primary crops grown in this area are alfalfa hay, beef cattle, irrigated pasture, cereal grains, onions, potatoes, mint, and horseradish. Dairy production is a major component of agriculture in the Basin. In recent years organic production of most of these crops has increased significantly and the market for organics appears to be strong. In addition, the Klamath Basin has shown tremendous potential for the development of crops for use in bio-fuels.

Homestead Lands

Oregon and California legislation, which relinquished state title to project lands, and congressional action which directed the project undertaking, provided for disposition of the reclaimed lands in accordance with the 1902 Reclamation Act. Under provisions of the Act, the reclaimed public lands were to be opened for homesteading. The first public lands were opened for homesteading in March of 1917. Much of the Klamath project went on to be homesteaded by both World War I and World War II veterans.

Watershed

The Klamath River Watershed represents a landmass of over 10 million acres. Annual flows at the mouth of the Klamath River average over 15 Million acre feet per year. There are over 100 tributaries to the Klamath River that are located downstream of the Klamath Reclamation Project.

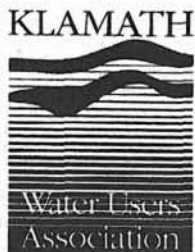
Habitat

The Upper Klamath Basin is home to 6 National Wildlife Refuges. Tulelake NWR and Lower Klamath NWR are two of the pre-eminent waterfowl refuges in the country. Water used by these refuges is delivered via the irrigation and drainage system of the Klamath Reclamation Project. Private lands in the Upper Basin are home to more than 400 species of fish and wildlife.

Conservation

In 2003 and 2004 the Klamath Water Users received the "Leadership in Conservation" award from the State of Oregon. The 2003 award recognized the organization for their continuing efforts and support of more than 250 conservation projects in the Basin since 1992. The 2004 award was given to KWUA for "exemplifying the spirit of the Oregon Plan for Salmon and Watersheds".

In addition to these awards, numerous individuals and irrigation districts within the Klamath Project have been recognized for their contributions to conservation and cooperation.



Klamath Water Users Association

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The Klamath Water Users Association is pleased to provide the attached historical information regarding hydrology and water quality in the Upper Klamath Basin. We believe that the enclosed information is pertinent to the charge of the NRC committee in its review the Bureau of Reclamation's Natural Flow Study and the Hardy Phase II Final Report.

The enclosed graphics are from the Power Point presentation "Klamath Watershed in Perspective: A Review of Historical Hydrology of Major Features of the Klamath River Watershed and Evaluation of Hardy Iron Gate Flow Requirements" prepared by K.A. Rykbost and R. Todd in 2003.

The full Power Point presentation may be viewed at:
<http://www.kwua.org/science/04watershedken032304.ppt>

Relevant information is presented in supplemental comments included as footnotes.

Data sources used are from the US Geological Survey streamflow records, U.S. Bureau of Reclamation, U.S. Weather Bureau and NOAA Fisheries, Hardy Phase I and Hardy Phase II draft reports.

Water Quality data presented are from "Nutrient Loading In the Klamath Basin: Agricultural and Natural Sources" by K.A. Rykbost and B.A. Charlton, Special Report 1023, Agricultural Experiment Station, Oregon State University. 2001.

We wish to thank the committee for the opportunity to participate in these proceedings and would like to reserve our right to provide additional relevant information.

(The following footnotes, numbered 1-11, correspond with attached graphics)

Footnotes

- 1. Cumulative Deviation from Mean Annual Inflow to Upper Klamath Lake.** This graph, included in the Balance Hydrologics Inc. review of the Klamath River hydrology, is derived from Bureau of Reclamation data on inflow to Upper Klamath Lake. It depicts very distinct patterns of long-term trends in wet or dry periods in the Upper Klamath Basin. From 1906 through 1914, inflow to the lake averaged about 400,000 AF/year above the long-term mean. This period has been used as a baseline for upper river flow estimates by Balance Hydrologics Inc, Hardy Phase I, and the Bureau of Reclamation's Natural Flow Study. The period from 1922 through 1950 was a period of sustained drought conditions during which inflows averaged about 300,000 AF/year below long-term means. From 1951 through 1958 inflows averaged over 500,000 AF/year above average. A third drought period occurred between 1987 and 1994, including the severe drought years of 1992 and 1994. Inflows averaged nearly 400,000 AF/year below long-term means during this period. Balance Hydrologics, Inc. adjusted flow estimates by 4 percent to compensate for the 1905-1912 period. Hardy Phase I followed this precedent. The Natural Flow Study used the relationship between Link River and Keno flows from 1905 through 1914 as the basis for estimating losses between Klamath Lake and Keno.
- 2. Precipitation in the Klamath Watershed.** NOAA precipitation records, complete for 1951 to the present at 5 locations in the watershed, are summarized for 4 periods through 2000. One reason for choice of periods for this analysis was the interest in evaluating flows in the Trinity River before and after construction of dams in the upper Trinity. A second reason was to attempt to identify any trends in flows during the 40 years following construction of Iron Gate Dam. Where possible, flow summaries were calculated for these same multi-year periods. As evident in this graph, precipitation was quite uniform for these 4 periods at each location. The wet period of 1950 to 1964 identified in the lake inflow graph is evident in Crater Lake and Klamath, CA data, but not noticeable at Klamath Falls, Keno, or Yreka.
- 3. Klamath River and Tributaries Streamflow.** Mean annual streamflows for Iron Gate Dam and the four major tributaries are summarized by decades from the era after Iron Gate Dam construction. Flows at the mouth of Klamath River are not available for 1994-1997 so this period was excluded for all sites. Differences in flows between periods are relatively small. Iron Gate flows account for about 12 percent of flows at the mouth of the Klamath. Combined flows for Shasta and Salmon rivers are similar to Iron Gate Flows.
- 4. Annual Klamath Water Volumes.** To put flows in perspective for comparison with diversions for irrigation in the Reclamation Project, this graph shows annual flows in thousand AF. Combined water use for irrigation and wildlife refuges (based on data from Jon Hicks – Bureau of Reclamation) in the Reclamation Project averages about 175,000 AF/year and represents less than 2 percent of the average flow at the mouth of the Klamath. Total upper basin and main tributary flows account for about 55 percent of flow at the mouth of the river. The remaining 45% can be attributed to other small tributaries, accretions and springs.

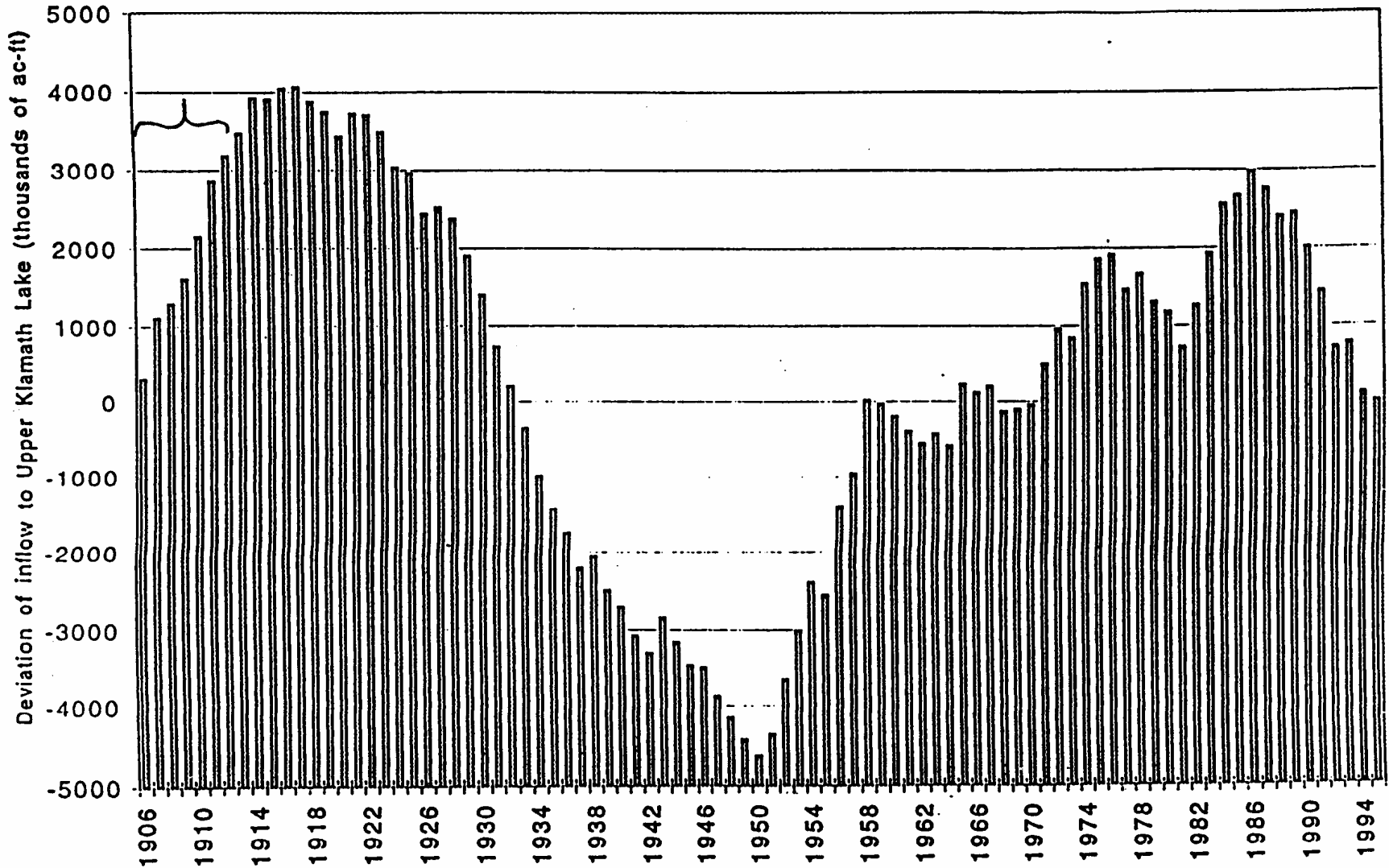
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- 5. Monthly Outflow at Klamath River Mouth.** All years of record are presented for flows at the mouth of the river. Highest flows were observed from 1998-2000. Lowest flows were recorded during drought periods of 1922-1925 and 1990-1993. During all periods, low flows were recorded from July through October.
- 6. Klamath River Flows at Keno.** All years of record are presented. Note the large difference in spring and summer flows between the 1905-1912 period and all other periods and the shift in the hydrograph to the right, indicating much higher flows from April through August and reduced flows in October and November. Flows for drought years from 1938-1950 and wet years from 1951-1963 are widely disparate. From 1905-1912, several factors contributed to higher than normal flows. A) a wet-year cycle as demonstrated by Klamath Lake inflows, B) damming of the Lost River Slough (1890) to stop flows from Klamath River going to the Lost River and Tulelake in years with high flows, C) reduction of flows to Lower Klamath Lake by construction of the railroad between Klamath River and Lower Klamath Lake, and D) efforts to drain Lower Klamath Lake and Tulelake to reclaim these areas for agricultural use. In sum, Flows at Keno from 1905-1912 are not an appropriate basis for modeling natural conditions existing before any modification of the upper basin hydrology.
- 7. Monthly Hardy Stream Flows at Iron Gate Dam.** Actual mean flows at Iron Gate dam for 1961-1996 are compared with flows from Hardy Phase I and Hardy Phase II draft reports. Although Hardy flows for an average year type were derived from different procedures in Phase I and II, the flow regimes are nearly the same. Compared to actual flows from 1961-1996, they represent significantly higher volumes and the same shift in timing as observed for Keno flows from 1905-1912. A comparison with Hardy Phase II Final Report flows from Table L-5 shows virtually the same monthly mean flows as those recommended in Phase I and Phase II draft reports. Implementation of Hardy recommended flows, in combination with reduced storage in the upper basin imposed by Klamath Lake minimum elevation requirements, would seriously reduce irrigation and wildlife refuge supplies for the Reclamation Project in a majority of years and preclude irrigation and refuge deliveries altogether in worst case scenarios such as 2001.
- 8. Williamson River Flows.** Williamson River, including its tributaries, accounts for about 50 percent of inflow to Upper Klamath Lake. The Natural Flow Study indicates this sub-basin has remained relatively stable compared to its unaltered state. A graph of flows for all periods of records shows similar trends with other segments of the watershed in relation to wet and drought cycles. Large differences between the wet years of 1951-1963 and drought years of 1938-1950 are similar to flows at Keno and the mouth of Klamath River during these cycles.

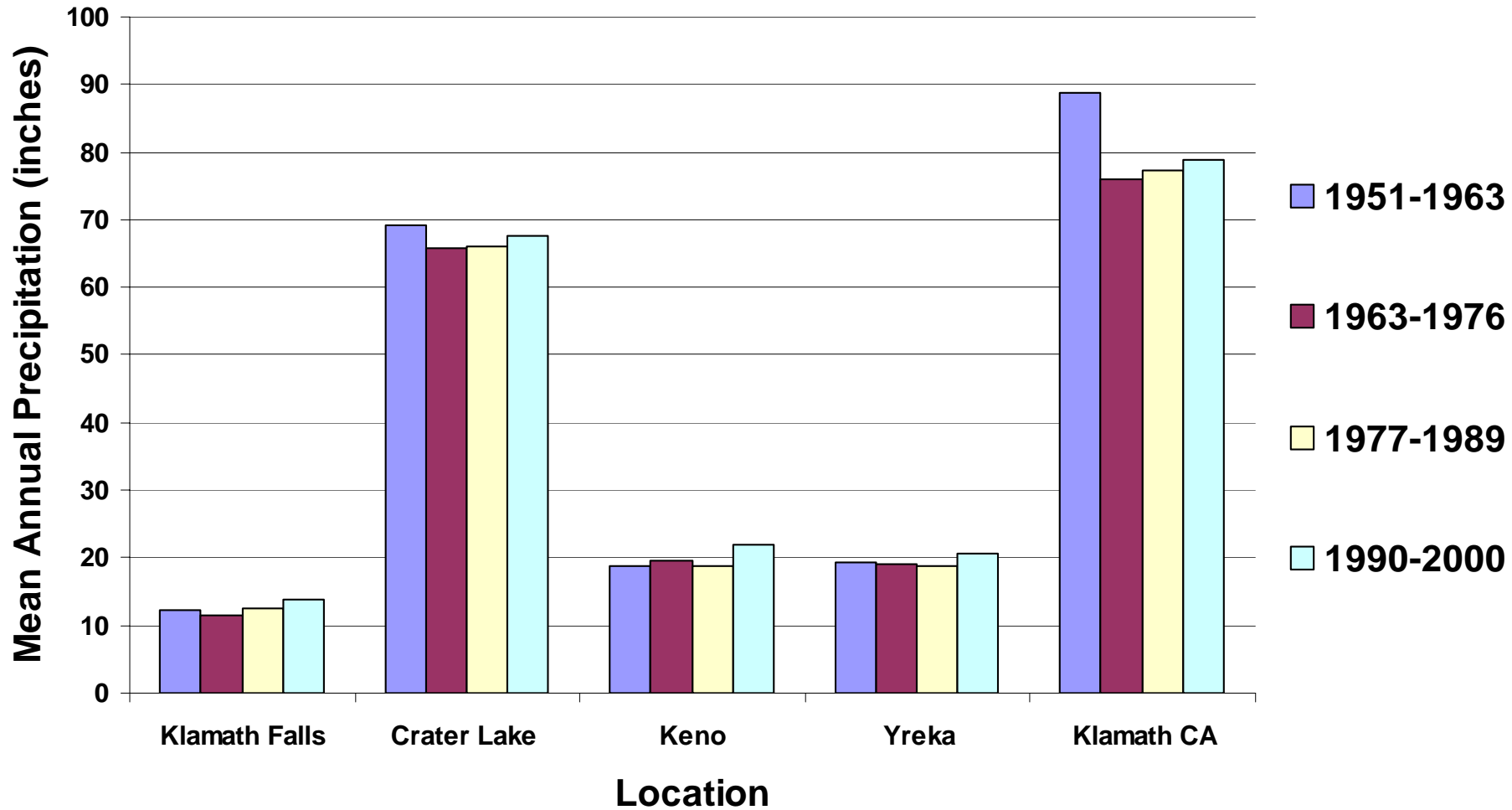
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- 9. Williamson River Yield per Inch of Precipitation.** Flows at Modoc Point, near the mouth of the river were calculated as yield per inch of precipitation observed at Klamath Falls and Crater Lake for the periods from 1951 to 2000. There appears to be a significant trend for declining yield in this sub-basin. Possible reasons include an increase in extent of wetlands in Klamath Marsh and Sycan Marsh, increased diversions for irrigation, juniper encroachment, and canopy interception of precipitation in dense forest stands common in the watershed. Data provided in the Natural Flow Study also indicates a trend for declining yield during this period.
- 10. Water Quality Problems in the Upper Klamath Basin.** Impairment of water quality in the Klamath River is partially a function of poor water quality in Upper Klamath Lake. Massive annual blue-green algae blooms in the lake contribute to high pH, low dissolved oxygen, high ammonia levels and high chlorophyll-a in discharges to Klamath River. High phosphorus content is a driving force for algae blooms. Numerous studies have attempted to quantify sources of P. The Oregon Department of Environmental Quality assimilated data and identified anthropogenic activities as responsible for about 40 percent of the P inflow to Klamath Lake in their TMDL report for the Klamath Headwaters. Earlier studies attribute about 60 percent of the P load in Klamath Lake to re-suspended solids from the lakebed. Table 4 is a compilation of data from the appendix of Kann and Walker, 1999 (a draft report of Klamath Tribe studies of water quality in Klamath Lake prepared for the Bureau of Reclamation). This 8-year data set from 9 sampling locations throughout the lake show mean monthly Total P concentrations ranging from 0.05 ppm to .22 ppm. Concentrations of 0.02-0.05 ppm P are reported as sufficient to support blue-green algae.
- 11. Phosphorous Content of Springs and Artesian Wells in the Wood River Valley.** The USGS report by Snyder and Morace in 1997 identified very high P content in three wells on the Wood River Ranch adjacent to Agency Lake. In 1998-2000 Klamath Experiment Station staff monitored P and N content in a number of artesian wells and several springs feeding streams in the region. Table 1 presents P concentrations identified in the study. Natural background sources reflect relatively high P content associated with the volcanic origin of the region. The springs monitored are the source of over 25 percent of the inflow to Klamath Lake. Spring Creek contributes about 50 percent of the Williamson River flows in late summer and early fall. Over 1500 artesian wells have been developed in the Wood River Valley and 800 are reported to be in use or uncapped. Clearly, natural background phosphorus sources are sufficient to support blue green algae in Klamath Lake, even if anthropogenic sources are eliminated.

Cumulative Deviation from Mean Annual Inflow to Upper Klamath Lake: Water Years 1906 through 1995

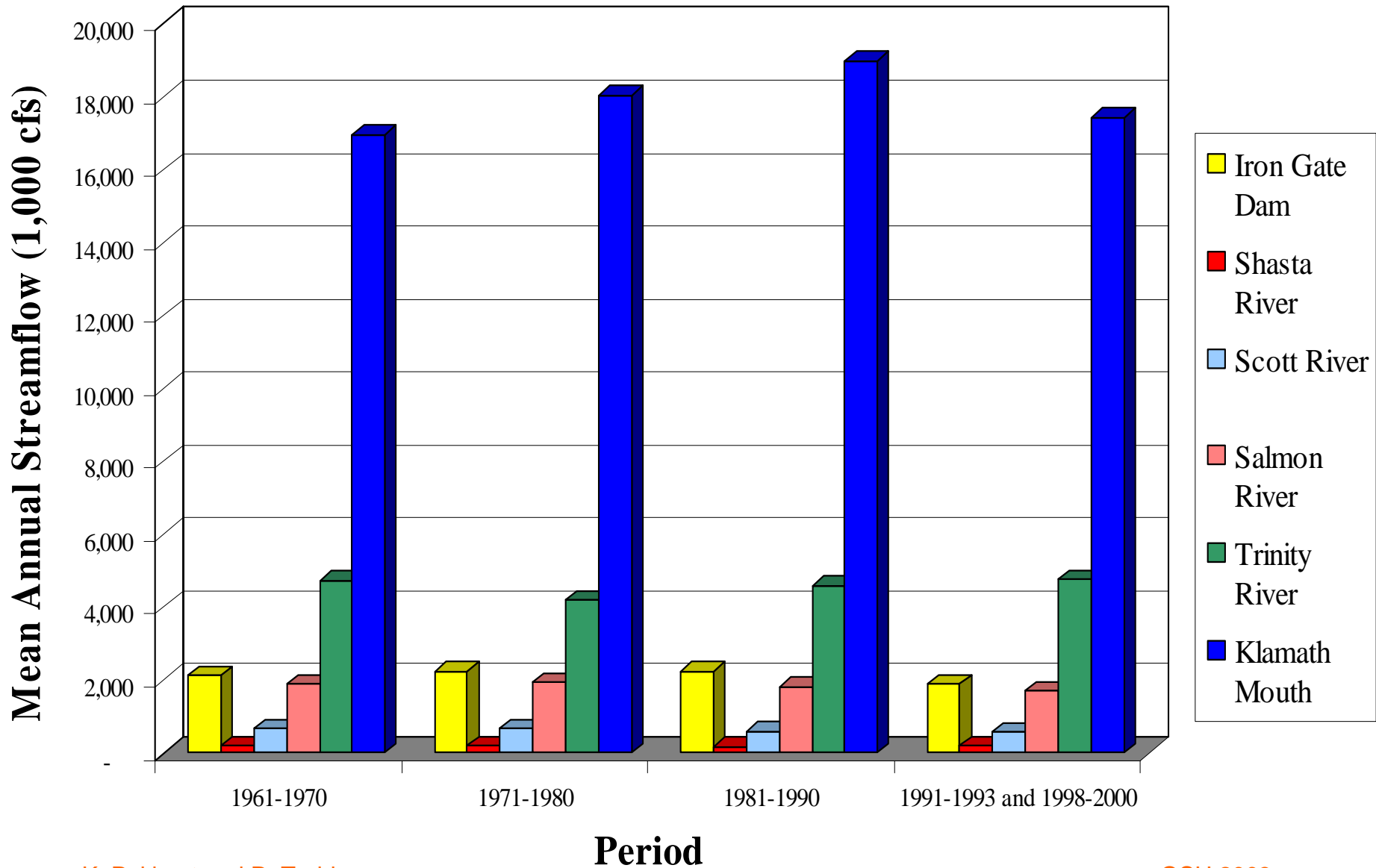


Mean Annual Precipitation in the Klamath Watershed

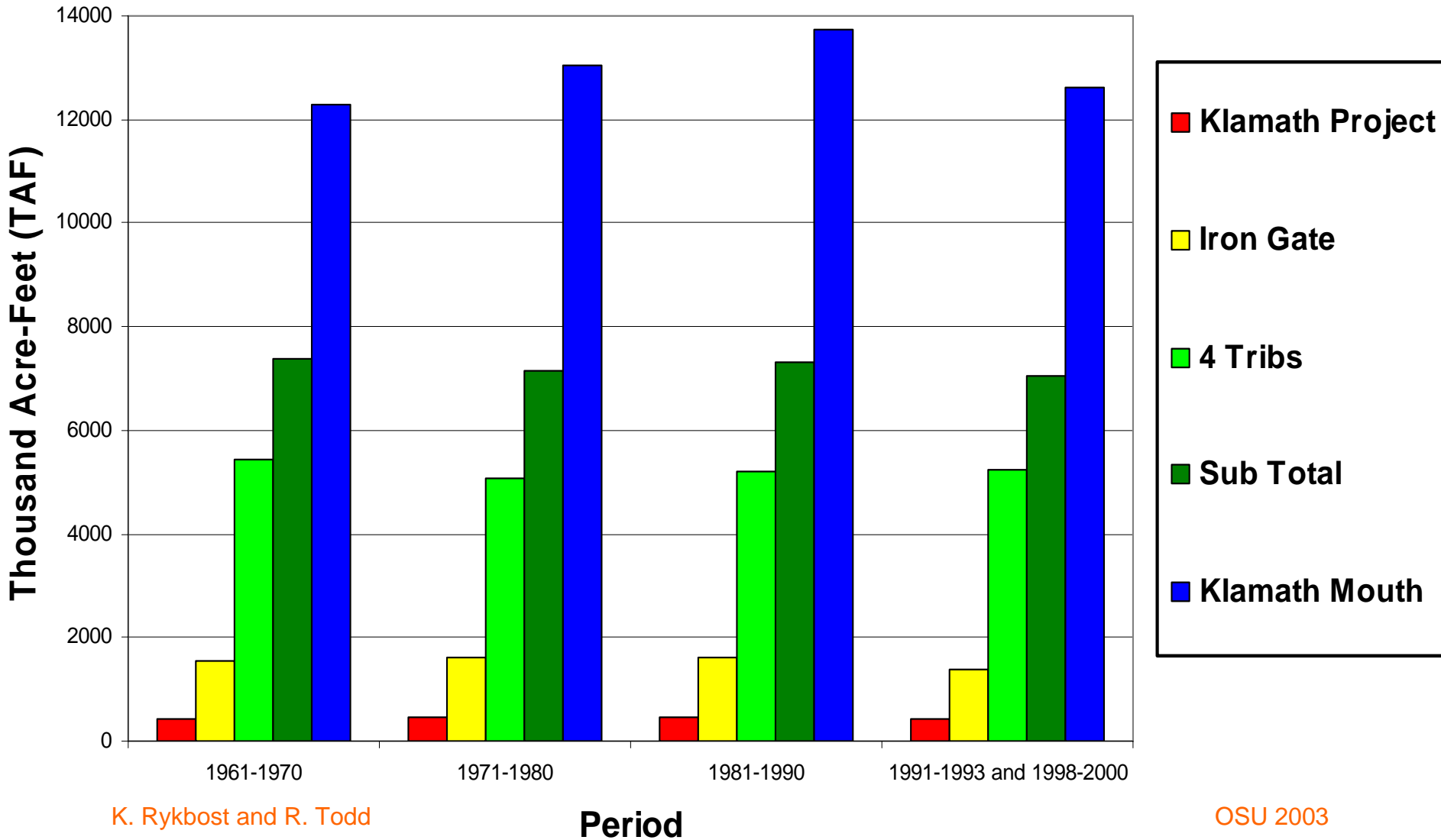


Klamath River and Tributaries Streamflow

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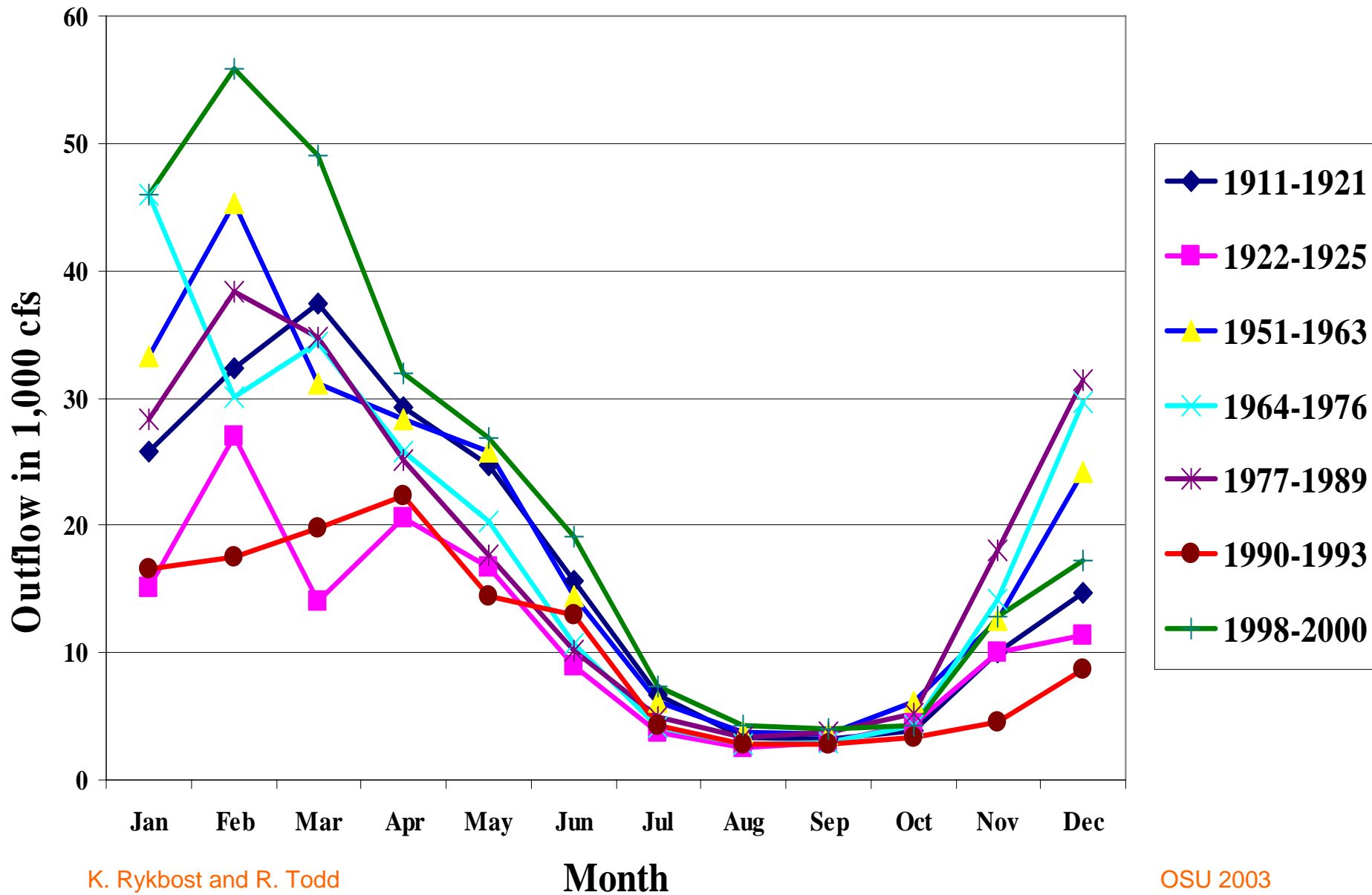


Annual Klamath Water Volumes

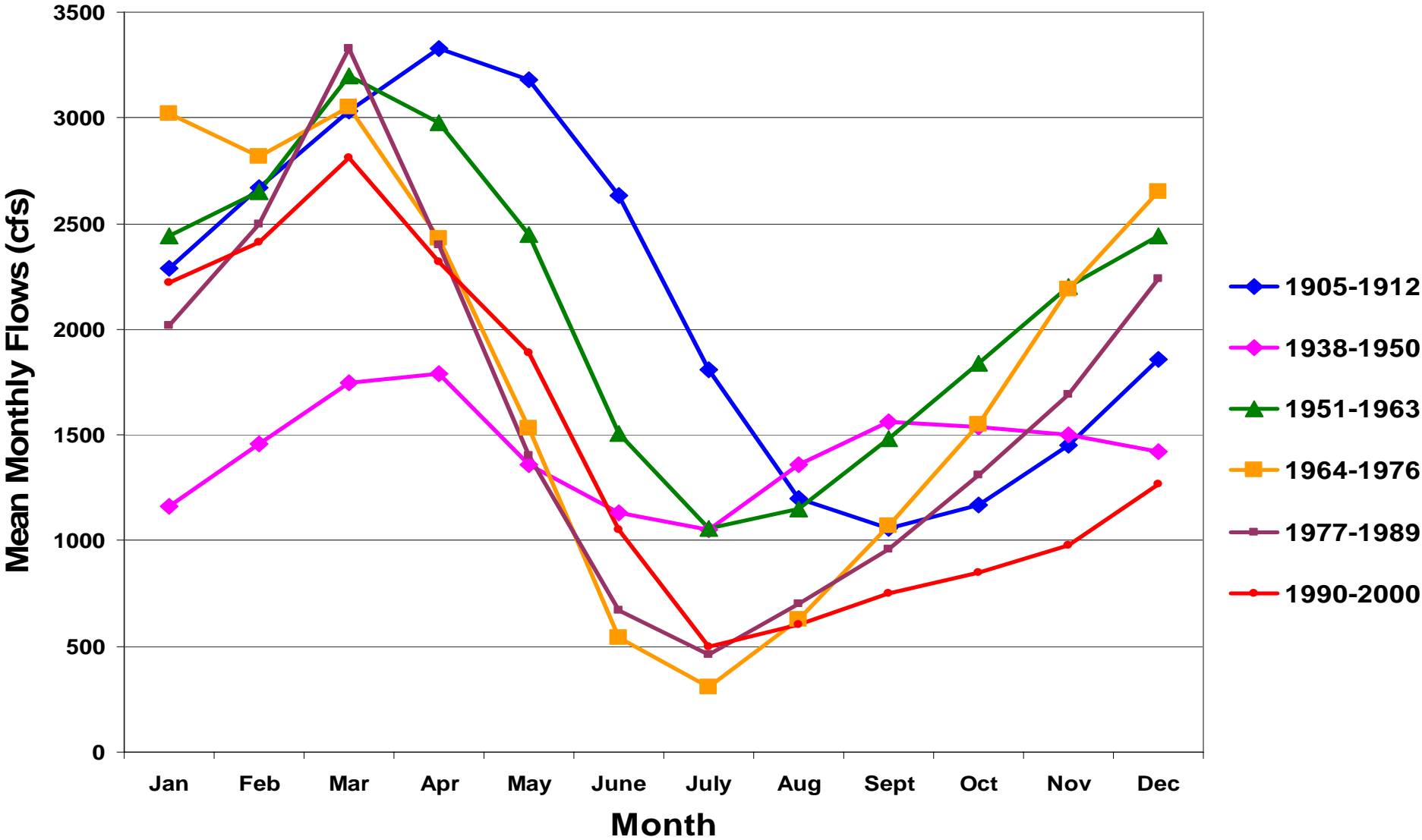


Mean Monthly Outflow at Klamath River Mouth

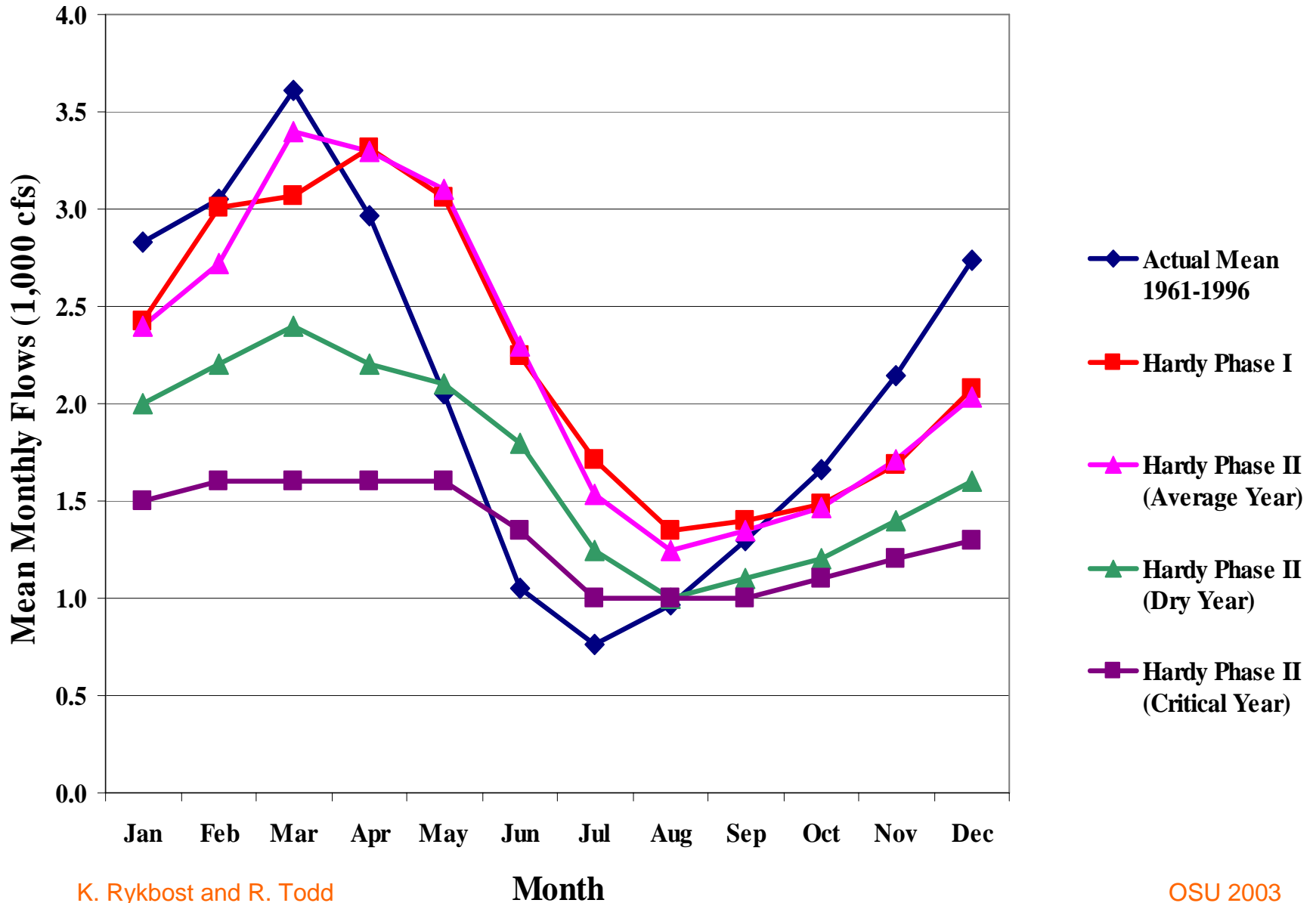
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Klamath River Flows at Keno, OR

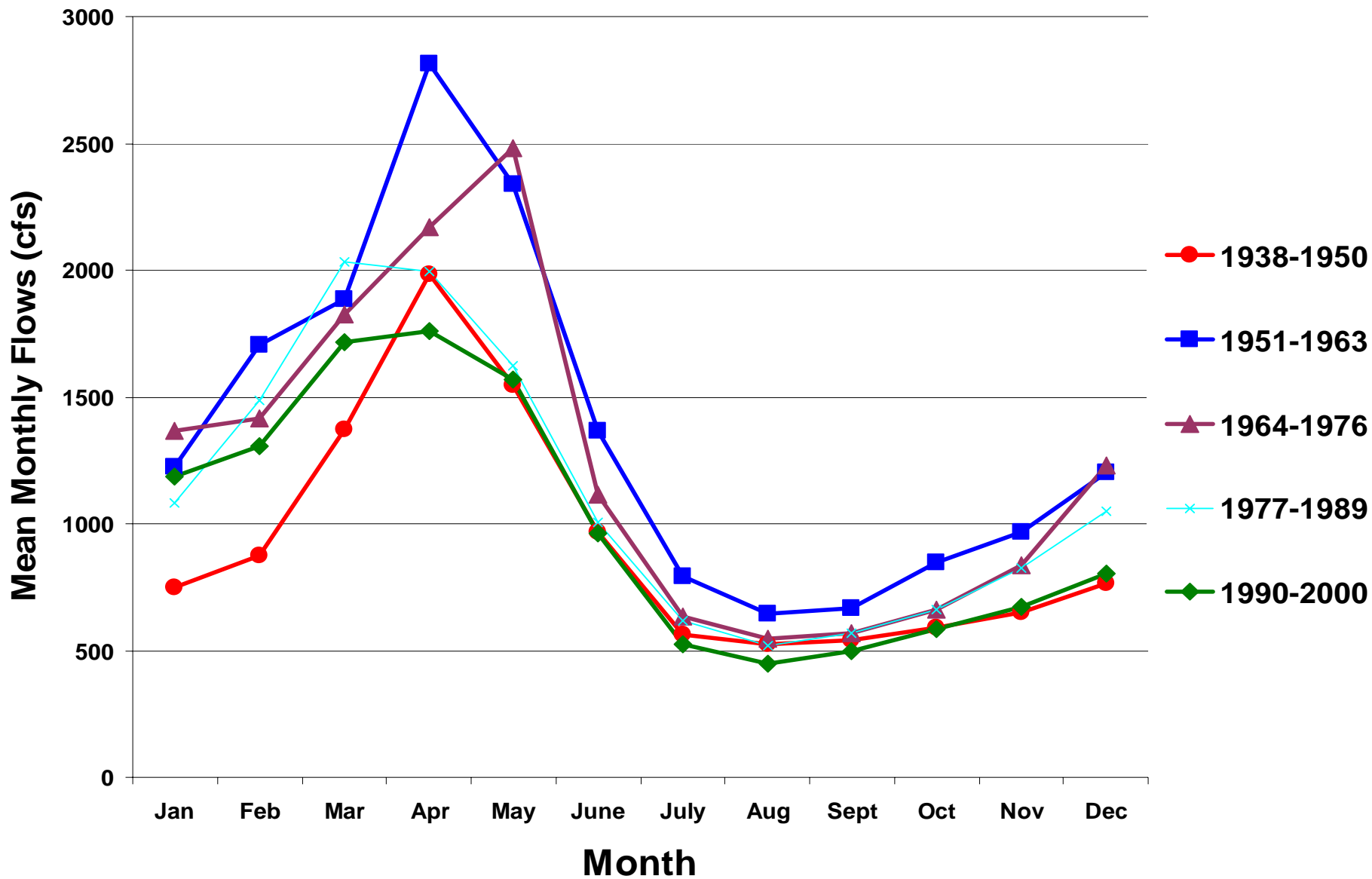


Monthly Hardy Stream Flows at Iron Gate Dam

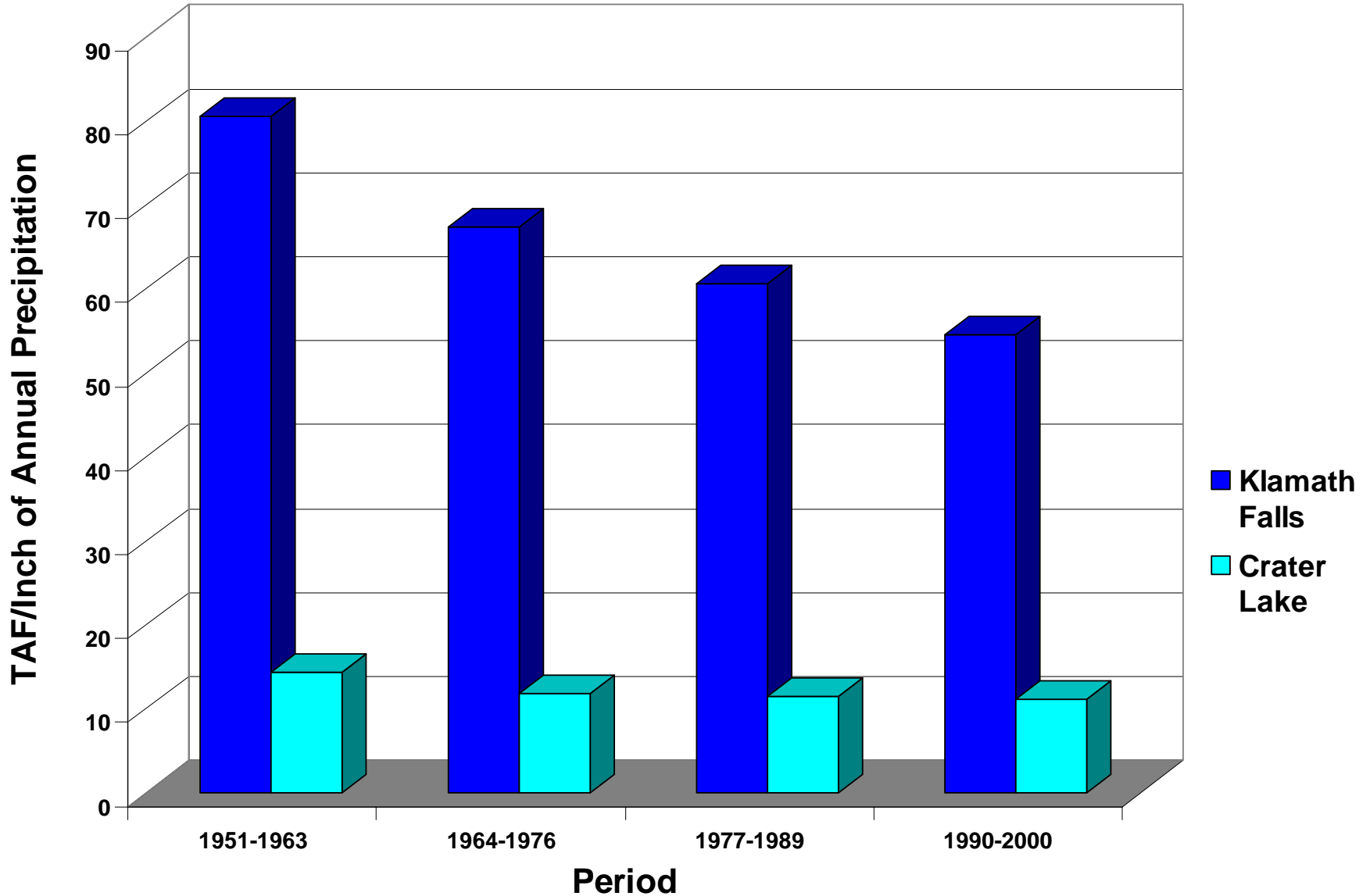


Williamson River Flows at Modoc Point Road

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9 of 11 **Williamson River Yield Per Inch of Precipitation**



KLAMATH BASIN NUTRIENT LOADING

Table 4. Lake-wide mean concentrations of total phosphorus (TP), total nitrogen (TN), and ammonia nitrogen, (NH₄-N) by month for Upper Klamath/Agency Lake, 1991-1998.¹

Month	No. samples	Total phosphorus (TP)	Total nitrogen (TN)	Ammonia nitrogen (NH₄-N)
		----- ppm -----		
January	6	0.09	1.42	0.48
February	22	0.07	0.95	0.08
March	40	0.05	0.60	0.08
April	84	0.06	0.72	0.04
May	105	0.06	0.67	0.05
June	142	0.12	1.67	0.14
July	149	0.22	2.25	0.35
August	146	0.19	2.03	0.21
September	127	0.19	1.88	0.27
October	118	0.14	1.73	0.23
November	34	0.09	1.21	0.26
December	1	0.09	2.42	0.84

¹Data from Appendix I, Kann and Walker, 1999.

KLAMATH BASIN NUTRIENT LOADING

Table 1. Nutrient concentrations in artesian wells and springs in the Upper Klamath Basin, OR.

Springs	Sample date	Total phosphorus	Total Kjeldahl nitrogen	Wells	Sample date	Total phosphorus	Total Kjeldahl nitrogen
		--- ppm ---				--- ppm ---	
Annie Creek Spring	09/03/99	0.03	< 0.2	Sevenmile	08/18/98	0.09	--
	09/03/99	0.04	< 0.2		09/30/98	0.10	0.2
Crystal Creek Spring	08/11/98	0.11	--	A. McAuliffe Ranch	08/18/98	0.09	--
	07/28/99	0.07	< 0.2		09/30/98	0.11	0.1
Mares Egg Spring	09/30/98	0.07	0.2	Fort Klamath Telephone Company	09/30/98	0.31	0.3
Blue Spring	09/30/98	0.06	0.1	Horseshoe Resort	09/30/98	0.69	0.5
					09/03/99	0.71	0.5
Kimball Park Spring (Wood River Source)	09/30/98	0.07	0.1	Church House	09/30/98	0.75	0.5
	09/03/99	0.06	< 0.2		09/03/99	0.73	0.6
Fort Creek Spring	09/30/99	0.09	0.1	Porter Residence	08/18/98	0.79	--
	09/03/99	0.06	< 0.2		09/30/98	0.75	0.5
					09/03/99	0.76	0.5
Spring Creek Spring	09/30/98	0.08	0.1	W. McAuliffe Residence	08/18/98	1.20	--
	09/03/99	0.09	< 0.2		09/30/98	1.13	1.3
	09/03/99	0.09	< 0.2				
Barkley Spring	11/04/98	0.08	< 0.2	McNeary Residence	09/30/98	1.56	1.9
Malone Spring	07/28/99	0.06	0.4	Wood River Ranch Northwest	11/04/98	2.58	9.1
					12/30/98	1.86	8.7
Odessa Spring	09/30/98	0.04	0.19		04/06/99	2.77	6.0
					03/15/00	2.28	8.5
Harriman Spring	09/30/98	0.04	0.20				
Threemile Creek Spring	09/30/98	0.02	0.19	Wood River Ranch Corral	11/04/98	5.87	5.8
					12/30/98	6.10	5.8
					04/06/99	5.90	7.3
					03/15/00	3.23	5.7