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FLOODS IN NORTHERN CALIFORNIA, JANUARY 1997

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Photo by John Trotter, Jan.4, 1997/Sacramento Bee

Photo: The community of Olivehurst was inundated with water after a levee failed on the Feather River

INTRODUCTION

Flooding in California in recent years has been attributed mostly to climate conditions referred to as the "El Niño" effect. However, floods in California also have been associated with other climate conditions (table 1). The flood of January 1997 occurred during a weak "La Niña" or near-normal (average) climate condition (U.S. Department of Commerce, 1997). These climate conditions are based on sea-surface water temperatures and trade-wind velocities in the Pacific Ocean. Precipitation from storms during any climate condition generally increases with orographic uplift as the storms move easterly across the mountains of California. During El Niño, trade winds diminish, and upwelling of colder water in the ocean is inhibited along the Pacific Coast of the United States. Precipitation is enhanced by increased evaporation from the warmer surface water. The result is an increase in the number and intensity of storms. La Niña, characterized by colder than average ocean temperatures, does not entirely prevent storms of sufficient precipitation to cause flooding in California.

Precipitation in the Sierra Nevada mountain range produced an above-normal snowpack and saturated soils during November and December 1996. A series of storms from December 29, 1996, through January 4, 1997, brought heavy and relatively warm precipitation across much of California. Precipitation totals of up to 24 inches were recorded for the week. Virtually all of this precipitation was rain because temperatures were above freezing at elevations as high as about 9,000 feet. Rainfall on snow and saturated soils caused rapid runoff

Photo by Laura Chun, Jan. 2, 1997/Sacramento Bee

Photo: Water from the Cosumnes River surges through a broken levee

and widespread flooding in the major drainage basins.

Because California is a large state with a varied climate, storms and floods did not occur statewide. Floods in the Sacramento and San Joaquin Valleys resulted from local runoff and flows from rivers that originate in the central Sierra Nevada. Most flooding occurred near the tributaries and main channels of the Sacramento and San Joaquin Rivers (fig. 1). Localized flooding from intense rainfall was widespread throughout northern California. Flooding in coastal regions of California was less extensive and magnitudes of peak flows were lower than those during the 1986 flood (Hunrichs and others, 1998). Total flood damages in 1997, including damage to flood-control structures, were estimated at nearly 2 billion dollars. This was the highest amount of flood damage in the state's history (Flood Emergency Action Team, 1997). Disaster areas were declared in 48 of California's 58 counties.

DATA COLLECTION

The U.S. Geological Survey (USGS) has compiled flood data in California for more than 100 years. Most of these data were collected at and near streamflow-gaging stations operated by the USGS and the California Department of Water Resources (DWR). As a fact-finding agency, the USGS provides objective and consistent data in publications and data bases (Hammond and Harmon, 1998) that are available to government agencies and the public. Near real-time (hourly) stage data from stations operated by the USGS and DWR are available by satellite transmission for a flood-warning system developed by DWR, Division of Flood Management.

USGS personnel in California and Nevada, trained in flood-data collection techniques, made more than 200 floodflow (discharge) measurements during January 1997. These and other measurements are required to determine peak (maximum) discharges. Other measurements and calculations include hydraulic equations applied to elevations of high-water marks, surveyed cross sections, and slopes of river channels (Benson and Dalrymple, 1967). Data for the flood of January 1997 show that the highest flows on record occurred at 37 of 41 gaging stations where the 100-year flood was exceeded (table 2). The first eight stations listed show data for rivers in California that flow into west-central Nevada, where flooding also was widespread (Hammond and Harmon, 1998).

FLOOD FREQUENCY

Floods occur more frequently than other natural hazards; the earth generates about 10,000 floods each year (U.S. Geological Survey Fact Sheet FS-061-95). Flood stage in the Sacramento River, for example, has an exceedence probability of 0.50 (formerly referred to as an average recurrence interval of two years) or a 50 percent chance to occur during each year. Flood frequency (exceedence probability) is defined as the frequency (exceedence probability) is defined as the average interval of time within which a flood of given magnitude will be equalled or exceeded once. The chance that a flood with a 0.01 exceedence probability will occur in a given year is 1 in 100 (the "100-year flood"). The magnitude of a "100-year flood" at a selected site normally is considered in the design of bridges and other structures at or near river channels. Long-term operation of a streamflow-gaging station is required to produce reliable flood-frequency data for that site. The reliability of the flood frequency improves as the length of the record increases. Each additional flood usually changes computed frequency values; therefore, updating and improving flood-frequency estimates is a

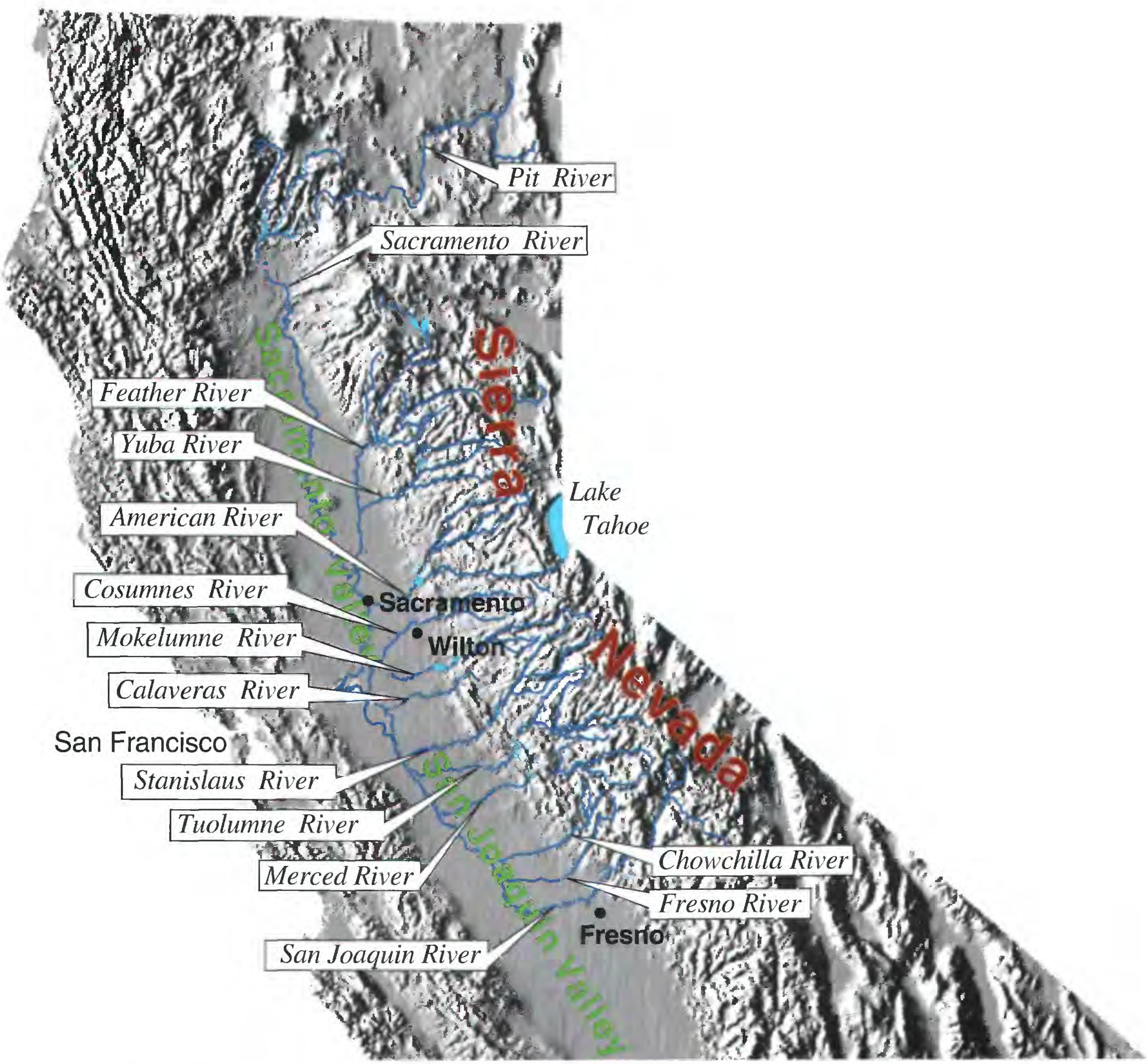

Figure 1. Major rivers associated with significant flood damage in northern California during January 1997

Table 2. Flood peaks exceeding the 100-year flood at streamflow gaging stations in California, January 1997

[R, regulated station; mi², square mile; ft, ft; ft/s, ft per second; ft³/s, cubic feet per second. N.A., not available. Asterisk(*), 1997 water year discharge exceeds peak of record. Stage is the level of the water surface above an arbitrary, fixed datum. Water year 1963, for example, is October 1, 1962, to September 30, 1963]

Station number/name	Drainage area (mi^2)	Previous peak of record			1997 water year	
		Water year	Stage (ft)	Discharge (ft^3s)	Stage (ft)	Discharge (ft/s)
10293000 East Walker River near Bridgeport (R)	359	1963	N.A.	1,390	6.74	1,910*
10295500 Little Walker River near Bridgeport	63.1	1963	N.A.	1,510	5.70	2,540*
10296000 West Walker River below Little Walker River, near Coleville (R)	181	1950	N.A.	6,620	10.11	12,300*
10296500 West Walker River near Coleville (R)	250	1937	N.A.	6,500	10.23	12,500*
10310000 West Fork Carson River at Woodfords (R)	65.4	1963	N.A.	4,890	15.36	8,100*
10336610 Upper Truckee River at South Lake Tahoe	54.9	1986	9.08	2,740	9.95	5,480*
10336660 Blackwood Creek near Tahoe City	11.2	1964	9.90	2,100	9.82	2,940*
11234760 San Joaquin River above Shakeflat Creek near Big Creek (R)	1,003	1996	20.44	24,700	32.00	80,000*
11242000 San Joaquin River above Willow Creek near Auberry (R)	1,295	1955	54.2	73,200	65.17	99,200*
11251000 San Joaquin River below Friant (R)	1,676	1937	23.8	77,200	22.97	60,300
11276900 Tuolumne River below Early Intake near Mather (R)	487	1995	11.33	13,800	12.33	18,200*
11278000 Eleanor Creek near Hetch Hetchy (R)	78.4	1950	14.95	11,700	26.74	19,500*
11278300 Cherry Creek near Early Intake (R)	226	1963	14.50	16,500	18.46	33,200*
11278400 Cherry Creek below Dion R. Holm power plant near Mather (R)	234	1982	15.36	16,300	25.40	33,500*
11282000 Middle Tuolumne River at Oakland recreation camp	73.5	1955	11.75	4,920	13.02	6,300*
11283500 Clavey River near Buck Meadows	144	1980	21.47	19,400	28.66	47,000*
11290000 Tuolmune River at Modesto (R)	1,884	1950	69.19	57,000	71.21	55,800
11292000 Middle Fork Stanislaus River at Kennedy Meadows near Dardanelle (R)	47.5	1996	8.37	3,310	7.99	2,890
11296500 South Fork Stanislaus River at Strawberry (R)	44.8	1950	9.25	3,900	12.34	7,820*
11298000 South Fork Stanislaus River near Long Barn (R)	66.9	1950	9.3	4,900	13.03	12,900*
11319500 Mokelumne River near Mokelumne Hill (R)	544	1950	23.5	33,700	25.60	41,300*
11333000 Camp Creek near Somerset (R)	62.6	1982	14.50	8,680	20.30	22,400*
11333500 North Fork Cosumnes River near El Dorado (R)	205	1955	14.8	15,800	21.40	42,000*
11334200 Middle Fork Cosumnes River near Somerset	107	1958	16.20	11,800	22.00	29,800*
11335000 Cosumnes River at Michigan Bar (R)	536	1986	14.76	45,100	18.54	93,000*
11384000 Big Chico Creek near Chico	72.4	1986	14.0	10,600	15.67	13,100*

continuing process. Magnitudes of flood peaks were determined by records and measurements at 292 streamflow-gaging stations in California during and after the floods of January 1997. Frequencies (exceedence probabilities) of flood peaks were computed by the log-Pearson type III method (U.S. Water Resources Council Bulletin 17B, 1981) and a graphical method described by Hunrichs and others, 1998. Flood peaks for January 1997 at sites where the 100-year flood was exceeded are listed in table 2, with previous peaks of record included for comparison. Periods of record range from 13 to 90 years at the stations selected for table 2. Flood data for this report are provided by Hunrichs and others, 1998.

POST-FLOOD INVESTIGATIONS

Many special investigations (studies) have been completed by the USGS following floods in California. These studies contribute to mitigation tasks that may prevent or minimize damage from future floods. An investigation of flooding in the Cosumnes River near Sacramento is selected as an example for the following reasons:

- The magnitude of flooding in January 1997 was unprecedented during the period of continuous stage and streamflow data collection that was initiated in 1907 at Michigan Bar. These data are published on an annual basis for the Cosumnes River at Michigan Bar station (Anderson and others, 1997). This station has one of the longest periods of record in California.
- During the 1997 flood, levee failures occurred at more than 20 locations, and floodflows inundated parts of State Highway 99 and Interstate Highway 5.
- The river is essentially uncontrolled (the only dams are small diversion structures).
- The river and a tributary (Deer Creek) combine to form a common floodplain. The two streams generally flow parallel to each other through about 14 miles of the valley.
- The area has been considered for residential development.

Methods for this study include a step-backwater analysis based on channel geometry and magnitude of the 100-year floodflow. Channel geometry was defined by ground surveys at selected transect sites across the channels and floodplain of the river and Deer Creek. Results of the study are water-surface elevations at surveyed transects and a flood-inundation map showing boundaries of the 100-year flood (Guay and others, 1998). This study, completed in cooperation with the Federal Emergency Management Agency (FEMA), indicates a need to update topographic maps of the area.

Table 1. Climate conditions during times of flood peaks in the Sacramento River, northern California, 1980-98

Date of flood	Climate condition in Pacific Ocean
February 1980	El Niño
December 1981	Near normal (average)
January 1983	El Niño
March 1983	El Niño
December 1983	La Niña
February 1986	Near normal (average)
January 1995	El Niño
January 1997	Near normal (average)
February 1998	El Niño

REFERENCES

Anderson, S.W., Rockwell, G.L., and Hayes, P.D., 1998, Water resources data, California, water year 1997, volume 3: U.S. Geological Survey Water-Data Report CA-97-3, 479 p.

Benson, M.A., and Dalrymple, Tate, 1967, General field and office procedures for indirect discharge measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A1, 30 p.

Flood Emergency Action Team, 1997, Final report of the Flood Emergency Action Team: Sacramento, California, The Resources Agency of California, 279 p.

Guay, J.R., Harmon, J.G., and McPherson, K.R., 1998, Flood-inundation map and water-surface profiles for floods of selected frequencies, Cosumnes River and Deer Creek, Sacramento County, California: U.S. Geological Survey Open-File Report 98-283, one plate.

Hammond, S.E., and Harmon, J.G., 1998, Publications document floods of January 1997 in California and Nevada: U.S. Geological Survey Fact Sheet FS-093-98, 4 p.

Hunrichs, R.A., Pratt, D.A., and Meyer, R.W., 1998, Magnitude and frequency of the floods of January 1997 in Northern and Central California--Preliminary Determinations: U.S. Geological Survey Open-File Report 98-626, 120 p.

U.S. Department of Commerce, 1997, NOAA La Niña page: National Oceanic and Atmospheric Adminstration (Accessed Oct. 7, 1998, on the World Wide Web at URL http://www.noaa.gov/lanina.html; last update Oct. 6, 1998).

U.S. Water Resources Council, 1981, Guidelines for determining flood flow frequency: Bulletin 17B, 27p.

Table 2. Flood peaks exceeding the 100-year flood at streamflow gaging stations in California, January 1997—Continued

Station number/name	Drainage area (mi^2)	Previous peak of record			1997 water year	
		Water year	Stage (ft)	Discharge (ft^3s)	Stage (ft)	Discharge (ft/s)
11396000 Lost Creek near Clipper Mills (R)	30.0	1955	6.90	5,000	13.50	5,760*
11396200 South Fork Feather River below Forbestown Dam (R)	87.5	1986	16.07	15,400	17.64	21,800*
11396350 South Fork Feather River at Ponderosa Dam (R)	108	1986	N.A.	21,000	69.78	27,800*
11402000 Spanish Creek above Blackhawk Creek at Keddie	184	1986	14.88	19,600	15.68	22,100*
11403000 East Branch of North Fork Feather River near Rich Bar (R)	1,025	1964	16.56	48,300	N.A.	88,800*
11404300 Grizzly Creek below diversion dam near Storrie	14.4	1986	9.54	5,870	7.33	6,300*
11404330 North Fork Feather River below Grizzly Creek (R)	1,914	1986	N.A.	86,000	29.97	115,000*
11433300 Middle Fork American River near Forrest Hill (R)	524	1964	69.0	310,000	29.56	123,000
11435100 Pyramid Creek at Twin Bridges (R)	8.76	1996	5.73	1,190	7.22	2,920*
11439500 South Fork American River near Kyburz (R)	193	1964	10.92	17,400	14.26	25,000*
11443500 South Fork American River near Camino (R)	493	1955	32.6	49,800	N.A.	62,300*
11444500 South Fork American River near Placerville (R)	598	1964	17.4	47,300	N.A.	71,000*
11445500 South Fork American River near Lotus (R)	673	1955	21.37	71,800	26.90	90,000*
11448500 Adobe Creek near Kelseyville	6.36	1974	8.92	1,570	10.23	2,320*
11463170 Big Sulfur Creek at Geysers Resort near Cloverdale	13.1	1995	9.63	7,550	9.78	8,010*

USGS PUBLICATIONS

Descriptions of USGS programs, activities, and reports on previous floods are available in the following publications:

Open-File Report 93-411, "Southern California Storms and Floods of January-February 1993," by James C. Bowers.

Fact Sheet FS-059-95, "Water--Managing a Natural Resource"

Fact Sheet FS-061-95, "Natural Hazards Programs--Lessons Learned for Reducing Risk"

Fact Sheet FS-062-95, "Northern California Storms and Floods of January 1995"

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