Bulletin 69-84
March 1985

State of California
The Resources Agency

Department of
Water Resources

California High Water 1983-84

Gordon K. Van Vleck
Secretary for Resources
The Resources Agency

George Deukmejian
Governor
State of California

David N. Kennedy
Director
Department of Water Resources

ON THE COVER: Looking south across flooded Bradford Island in the Sacramento-San Joaquin Delta on December 4, 1983. The levee break is visible on the right-hand side of the photograph. (DWR #6324-10)

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FOREWORD

In terms of flood damage, water year 1983-84 ranked very low when compared to the events of recent years. There were a few flash floods, one Delta Island flooded, and the Sutter and Yolo Bypasses in the Sacramento River Flood Control Project were heavily flooded. Property damage, however, was relatively light.

Bulletin 69-84, is the seventeenth in a series of reports on high water in California. It presents information on storms, flooded areas, and flood damage during the period October 1, 1983 through September 30, 1984. Most of the data and information in this bulletin was provided by the Department of Water Resources, the National Weather Service, the U. S. Bureau of Reclamation, and the U. S. Army Corps of Engineers. Other public and private sources also furnished information for this bulletin. The assistance of these agencies and individuals is gratefully acknowledged.

The data received from these sources is reflected in the tables and graphs in Bulletin 69-84. These data are not the final and official records and must be considered preliminary and subject to revision. Also included are graphs showing weir overflow days and hydrographs of a number of streams and reservoirs.

Additional information concerning specific events can be obtained from your local Office of Emergency Services and from city and county police departments.

David N. Kennedy, Director
Department of Water Resources
The Resources Agency
State of California

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State of California
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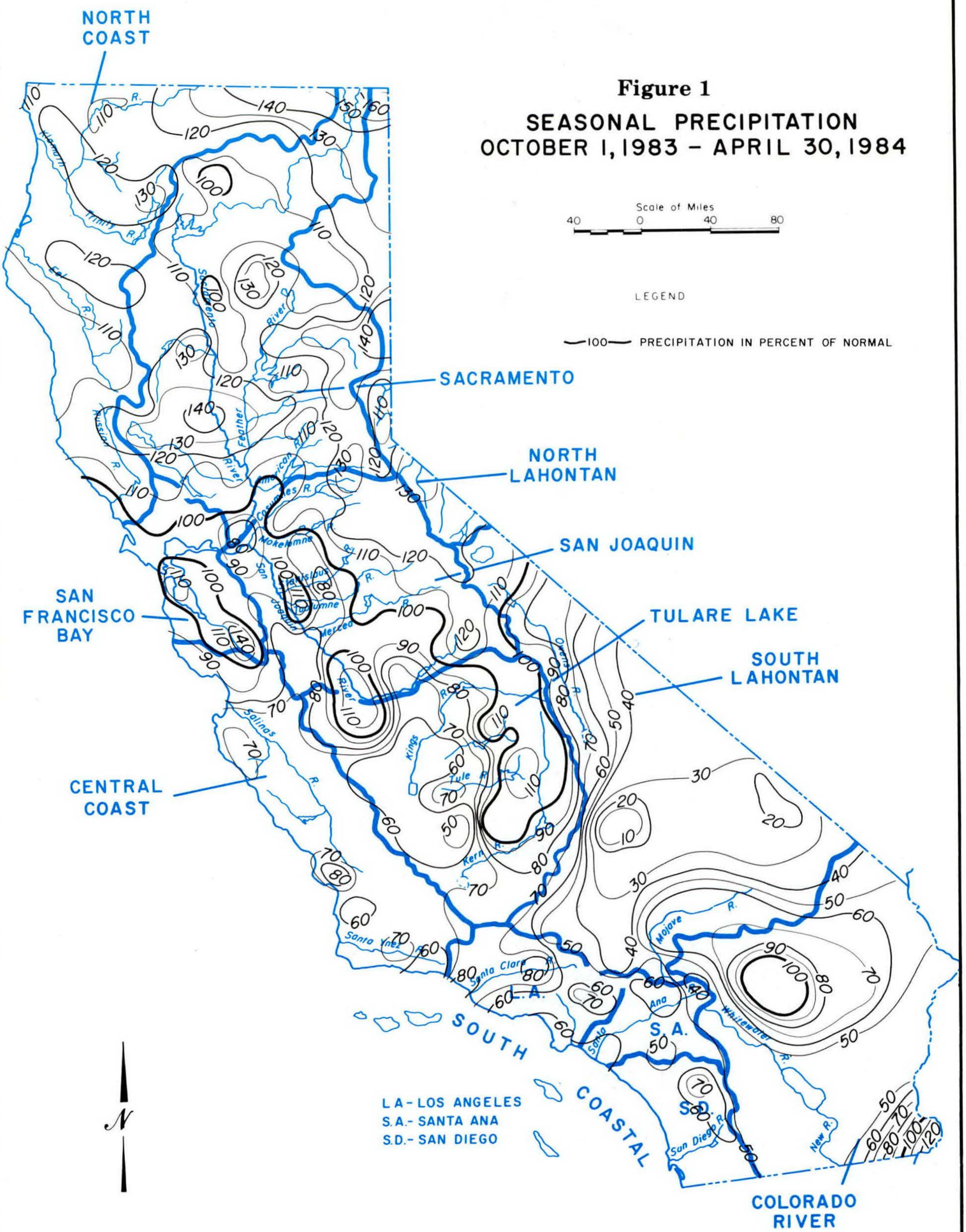
The California Water Commission serves as a policy advisory body to the Director of Water Resources on all California water resources matters. The nine-member citizen commission provides a water resources forum for the people of the State, acts as a liaison between the legislative and executive branches of State Government, and coordinates Federal, State, and local water resources efforts.

Figure 1

SEASONAL PRECIPITATION
OCTOBER 1, 1983 - APRIL 30, 1984



CALIFORNIA COOPERATIVE SNOW SURVEYS

FLOOD EVENTS OF WATER YEAR 1983-84

If the fall weather patterns of water year 1983-84 were an indication of what was to be in store for Californians for the rest of the year, water officials and residents were understandably concerned.

The fall quarter had closed with precipitation amounts ranging from 150 percent of normal in the north state to as high as 250 percent of normal in the south. Snow depths and water content were also keeping pace with the historic snowpack of the previous year. Major rivers were unseasonably high, and on November 11 the Sacramento River began overflowing into the Sutter Bypass at Colusa. This marked the earliest overflow of the Colusa Weir in more than two decades. In addition, many flood-storage reservoirs were near or above maximum allowable storage. A historically unprecendented surface-water carryover from the previous year accounted for much of the excess water.

California could not afford a repeat of the experience of the past two years, which had proven to be very costly in terms of flood damage and loss of life. The outlook, however, was bleak when considering that the normally wettest months of December, January, and February, which usually can be expected to produce 60 percent of the seasonal total, lay ahead.

Early in December, the central portion of the State also experienced near record drops in barometric pressure. This phenomenon, combined with a high-tide cycle and other conditions, sometimes spells disaster for levees of the Sacramento-San Joaquin Delta. Such was the case on December 3, 1983. See page 17 for details.

Then, the weather changed abruptly. January precipitation for all of California averaged only 5 percent of normal for the month, making January 1984 one of the driest Januarys of record.

Despite the meager yield of precipitation during January and below normal amounts in February, Californians were, nevertheless, assured of an adequate supply of water for the hot and demanding months ahead. Although snow water content measured only 75 percent of normal on April 1, reservoir storage was at least 15 percent above average. The near-record precipitation during October, November, and December was enough to offset the below-normal precipitation during the remainder of the winter and spring. The April 1 runoff forecast by the California Cooperative Snow Surveys indicated that April-July runoff would be about 95 percent of normal, but because of the heavy runoff during the fall and early winter, the total annual runoff for water year 1983-84 would approximate 130 percent of normal.

Flooding during water year 1983-84, in terms of property damage, was minimal, and no flood-related deaths were reported.

WEATHER PATTERNS OF 1983-84

Seldom is a summary of annual water conditions as ambiguous as this one for 1983-84. Figure 1 depicts the water year precipitation. Total precipitation has been recorded at 105 percent of normal statewide; however, chronologically and geographically, water year 1983-84 was anything but normal. By hydrologic area, precipitation ranged from a high of 115 percent on the North Coast and in the Sacramento Valley to a low of 60 percent on the South Coast.

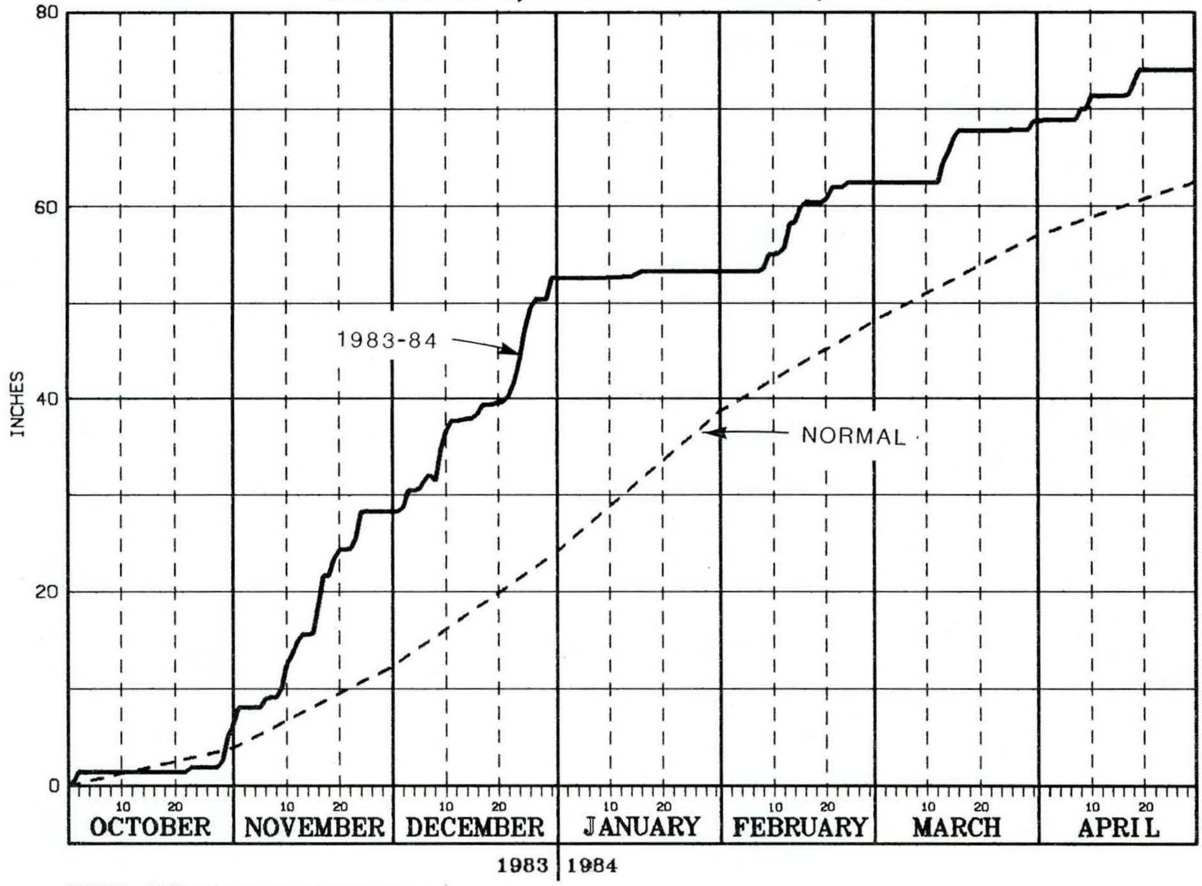
Yet, the most dramatic aspect of the season was the abrupt change from record wetness during November-December 1983 to record dryness in January 1984. In only one week--from December 28 through January 4--an intense storm track through California was totally displaced by a massive high-pressure area. This "blocking high" created an extended dry pattern of historic proportions during January and February in Southern California. Although the storm track through northern California revived somewhat after January, the remainder of winter and spring yielded less than normal precipitation over most of the State.

The unusual aspects of the water year are illustrated in Figure 2, which shows the accumulated precipitation at Blue Canyon in the American River Basin. The November-December precipitation total of 46.20 inches was exceeded only in 1955, 1964, and 1981. By contrast, the January total of 0.74 inches was the driest January of record at Blue Canyon. Table 1 summarizes the precipitation in percentage of normal for three prominent runoff regions of the State. The north includes the drainage basins of the Upper Sacramento and Feather rivers; the central covers the area from the Yuba to the Merced River; the south includes the area from the Upper San Joaquin to the Kern River.

Table 1. Precipitation in Percent of Normal

Season	North	Central	South
Fall 1983 (Sept., Oct., Nov.)	166	232	223
Winter 1983 (Dec., Jan., Feb.)	89	96	83
Spring 1984 (Mar., Apr., May)	78	64	45

Figure 2
ACCUMULATED PRECIPITATION AT BLUE CANYON, AMERICAN RIVER BASIN
OCTOBER 1, 1983 - APRIL 30, 1984



NOTE: ELEVATION OF STATION 5,280 FEET

October-December 1983

Heavy showers of subtropical origin drenched much of Southern California during the first two days of October. Many areas recorded 1 to 2 inches, with 3 to 5 inches in the mountains. Yet, the remainder of October was warm and dry in most of California until the last three days of the month. For example, the average Sacramento temperature of 69.5° made it the second warmest October on record; October precipitation of 0.53 inches was 59 percent of normal.

Subtropical moisture contributed to heavy rainfall in northern California beginning October 29. The final weather system in this series originated in the North Pacific, and produced thunderstorms, locally heavy showers, and funnel clouds in Southern California on November 1. Storm totals were generally 0.50 inches or less throughout the Central Valley and Bay Area, while the North Coastal mountains had at least 2 inches and the northern Sierra more than 3 inches. Heavier storm totals included Bucks Lake (Feather River Basin) with 7.32 inches and Blue Canyon 6.37 inches.

Rain in the northern third of California on November 6 left 1 to 2 inches in the Sierra from Blue Canyon northward and in the North Coastal mountains. Then, as the jet stream dropped into northern California, a series of four Pacific storms produced heavy precipitation between November 9 and 14. The second storm on November 10 carried subtropical moisture and energy from the remnants of Typhoon Marge, battering the North Coast with 60-70 mph winds; at least 5 to 7 inches of rain fell in the Russian, Eel, and Feather River basins. Wind gusts of 80 mph were reported at Mammoth Lake Village on the evening of November 10.

Six-day storm totals included 14.1 inches at Honeydew (Mattole River Basin); 13.6 inches at Bucks Lake; 10.8 inches at Yorkville (Russian River Basin); and 10.2 inches at Mining Ridge (near Big Sur). Precipitation totals included 3 inches at Sacramento and Huntington Lake, with heavy snow in the Sierra Nevada above 7,000 feet.

Wet Pacific storms continued to assault northern and central California during November 15-21; the North Coast basins received 3 to 6 inches, while the Sierra basins from the Upper San Joaquin northward received at least 5 inches. Heaviest totals were in the American River Basin, where 13 inches fell at Forni Ridge and 10.4 inches at Blue Canyon. In the Stanislaus River Basin, Calaveras Big Trees received 10.2 inches. Snow fell as low as 2,500 feet east of Sacramento, while new snowfall of at least 2 feet fell at ski resorts from Mammoth Mountain north to Lake Tahoe. The upper slopes of Squaw Valley were covered with 7 feet of snow by November 21. Through satellite imagery, Figure 3 portrays the active nature of the storm track on November 16.

A major Pacific storm swept down the State on Thanksgiving Day (November 24), producing moderate to heavy precipitation in most areas except the desert regions. North Coast and Sierra storm totals of 3 inches or more were common November 23 through 25. Some heavier totals included 6.20 inches at LaPorte (Feather River Basin) and 3.20 inches at Springville Tule Headworks (Tule River Basin). Sierra snowfall was 2 to 3 feet from this storm, while the Los Angeles area received about 1 inch of rain near the coast and 2 to 3 inches in the mountains.

Then on December 3, a deep low-pressure center moved rapidly across northern California, accompanied by extremely high winds and damaging tides in the Delta. Wind gusts from the west reached 68 mph at Venice Island, 82 mph at Angel Island, and 129 mph at Mt. Tamalpais (at 2,604 feet) in Marin County. The high winds forced the closing of the Golden Gate Bridge for only the third time in history. In Sacramento, the atmospheric pressure dropped to 29.28 inches of mercury at noon, only 0.05 inches above the record set in 1982. Precipitation ranged from less than 1 inch in the Central Valley to as much as 2.40 inches at Huntington Lake; more than 2 feet of snow fell in the Sierra Nevada above 7,000 feet.

Figure 3

November 16, 1983, 2345 GMT (1545PST) from GOES WEST. This infrared depiction shows an area of moderate to heavy rainfall moving into northern and central California, where Blue Canyon received 3.5 inches. The jet stream parallel to 40°N defines an active storm track stretching across the eastern Pacific Ocean.

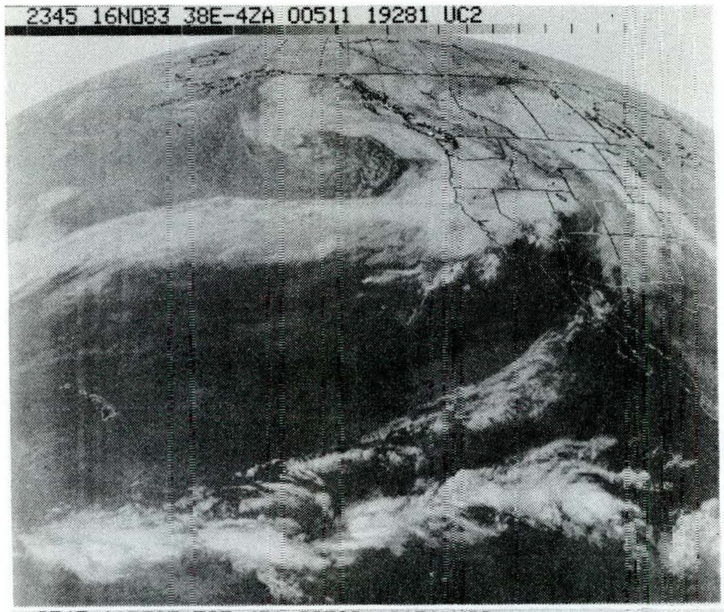


Figure 4

December 11, 1983, 0545 GMT (2145 PST December 10) from GOES WEST. This infrared satellite imagery depicts a good size storm pushing heavy precipitation into northern California, with Mt. Shasta receiving more than 5 inches of rainfall. Another storm is waiting in the wings at 150°W, between 35° and 40°N.

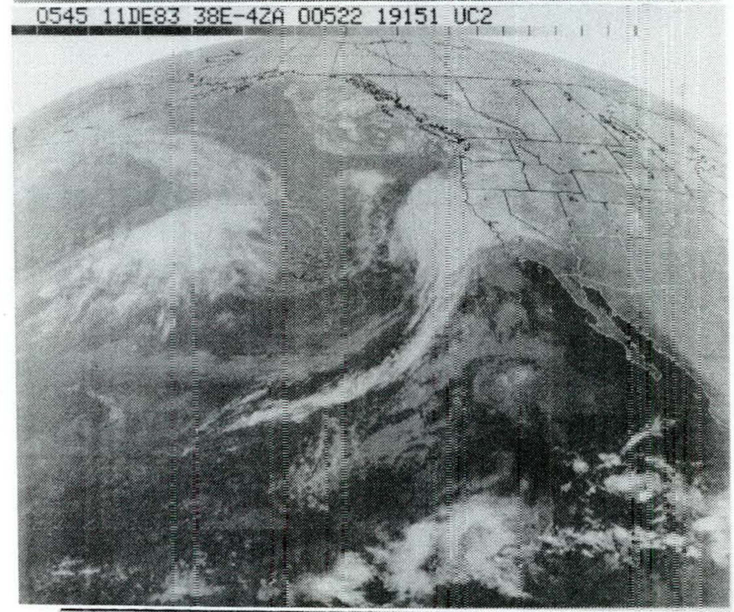
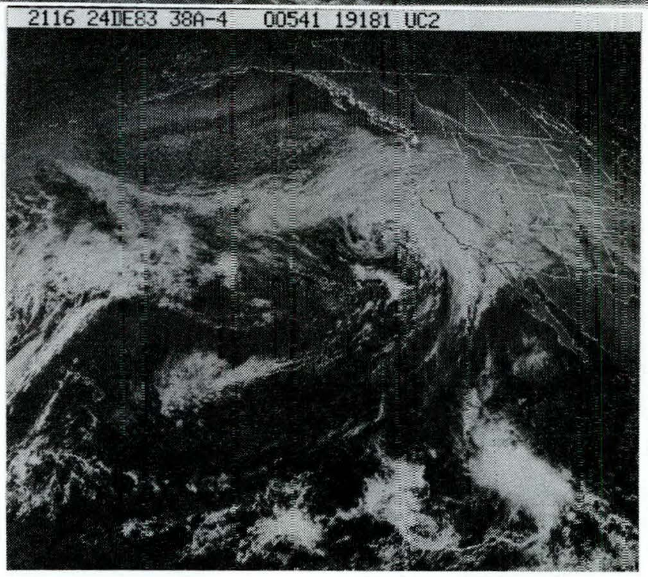


Figure 5

December 24, 1983, 2116 GMT (1316 PST) from GOES WEST. This visual imagery shows a very large storm, producing precipitation over almost the entire State. This storm produced 24-hour amounts of 5 inches in the Feather River Basin and in the mountains north of Los Angeles.



A series of Pacific storms between December 6 and 14 produced almost daily precipitation on the North Coast and in the northern Sierra Nevada. Two of these storms are depicted by satellite imagery (December 11) in Figure 4. The major precipitation-producing mechanism was orographic lifting, with as much as 19.61 inches falling at Gasquet in the Smith River Basin. Other totals included 11.29 inches at Shasta Dam, 6.31 inches at Blue Canyon, and 3.10 inches at Huntington Lake. The Bay area through the Sacramento Valley received 1.5 to 2 inches, while Southern California had generally less than an inch.

A strong surge of subtropical moisture moved northeast into California over the Christmas weekend. At the same time, cold polar air was still flowing into California from the north. The cooling and lifting of the moist, subtropical air mass produced very heavy rains on Christmas Eve in central and northern California, with 5 inches in some locations. The Christmas Eve storm is depicted by satellite in Figure 5. The greatest storm total during December 22 through 27 was 17.12 inches at Four Trees, at 5,120 feet in the Feather River Basin.

Other storms totals included 13.02 inches at Mining Ridge, 12.00 inches at Honeydew, 7.18 inches at Lodgepole (Kaweah River Basin), and 3.94 inches at Sacramento. The warm air mass caused the snow line in the Sierra to rise above 7,000 feet on Christmas Eve, and the heavy precipitation produced substantial runoff. In Southern California, Blythe received 0.24 inches, its first precipitation of the water year, and Lake Arrowhead was deluged with 7.20 inches during the storm.

November-December 1983 was the wettest in 40 years of record in the North Sierra drainage, and the third wettest in the central and southern drainage areas. New November monthly records were set at Calaveras Big Trees with 29.38 inches, Pacific House with 23.00 inches, and Sonora with 12.72 inches. New December monthly totals were recorded at Eureka, with 14.13 inches and at Red Bluff, where 10.29 inches fell.

January-February 1984

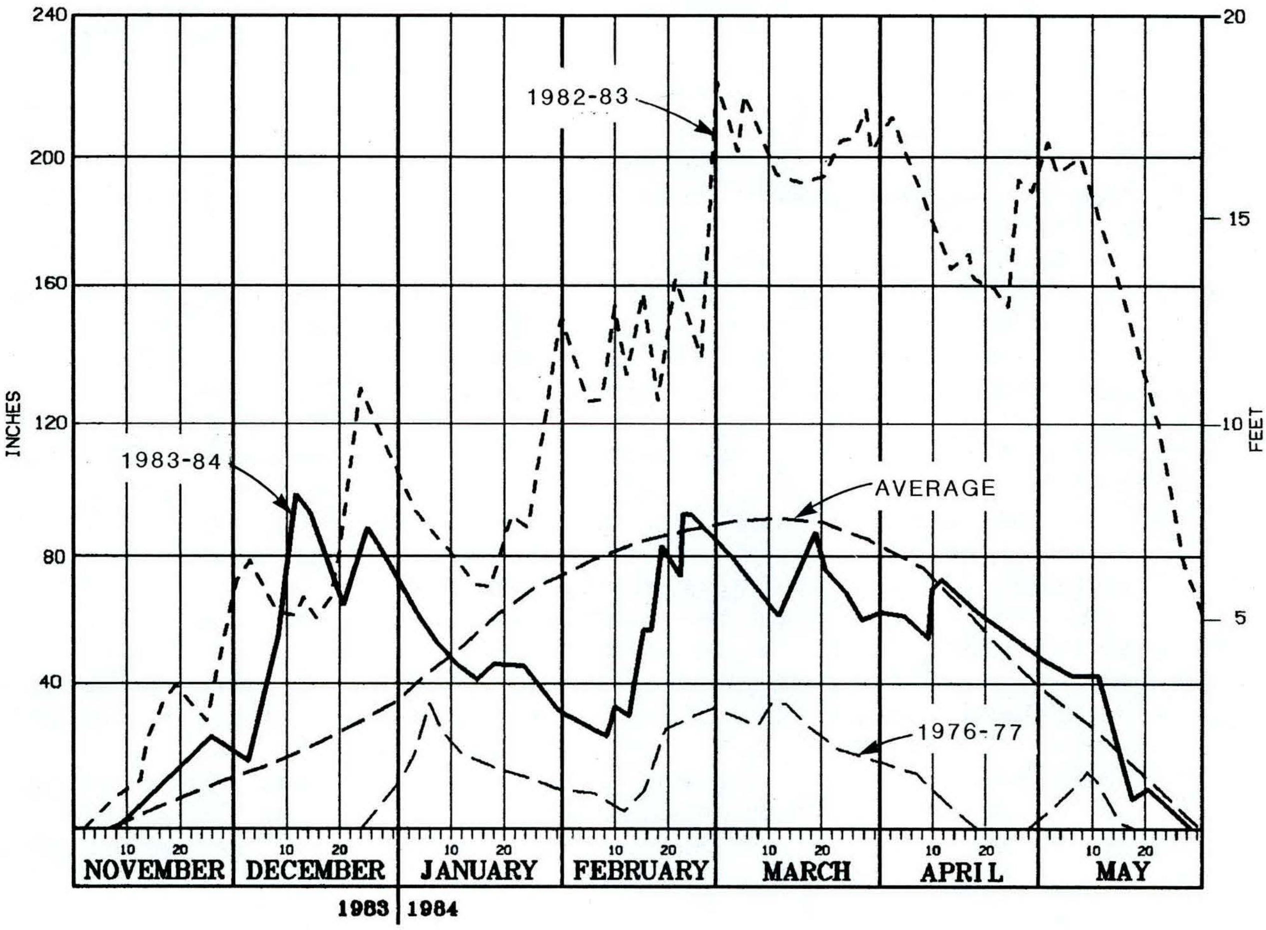
Abruptly, the storm track literally dried up in January as a huge mass of high pressure blocked out all but a few light showers. In fact, January 1984 will go down as the driest, or nearly driest, January of this century. Precipitation for the month averaged 5 percent of normal throughout California. Some January dry records include Bowman Dam, 0.46 inches; Redding, 0.35 inches; Santa Barbara, 0.21 inches; Mount Shasta City, 0.19 inches; Yosemite Park, 0.48 inches; Lodgepole, 0.03 inches; and Huntington Lake, none. On January 26, wind gusts of 50 to 80 mph caused damage in the Southern Sierra Nevada and in the Southern California mountains.

The extreme dryness continued in Southern California during February. Ventura and Oxnard during January through February were the driest in 100 years of records. Some areas in Ventura County reported no rain during both January and February. In the San Joaquin Valley, Bakersfield, with 0.10 inches, experienced its driest January-February of record.

In northern California, however, February brought another abrupt change. During the first week, the West Coast ridge began breaking down and drifting southward. On February 8, rain began falling on the North Coast and by February 13, two impressive Pacific storms had brought substantial moisture to central and northern California. Some of the larger totals for February 8 - 13 include 9.4 inches at Four Trees; 9.3 inches at Gasquet; and 3.4 inches at Grant Grove in the Kings River Basin. At least one-half inch of rain fell in the Central Valley from Fresno northward.

From February 9 through 25, Norden, near Donner Summit at 7,000 feet, received 84 inches of new snow. See Figure 6 for a profile of the snow depth at Donner Summit. February precipitation was 104 percent of normal at Huntington Lake, and 99 percent of normal at Blue Canyon in the Sierra Nevada. The only other normal area was on the North Coast, where Eureka was 100 percent of normal during February. By contrast, Sacramento and the Bay Area were only about 50 percent of normal.

Figure 6 SNOW DEPTH AT NORDEN



March-June 1984

March 1984, California's third dry month in a row, experienced above-normal wetness only on the North Coast from Eureka northward; Crescent City received 8.37 inches, 123 percent of normal. Precipitation generally measured less than 50 percent of normal in the San Joaquin Valley and along the coast from San Francisco southward. Most of Southern California received less than 10 percent of normal in March. Snowfall in the Sierra Nevada was 50 to 75 percent of normal; Norden, for example, had 31 inches of snow during March.

Most precipitation fell during a series of minor storms from March 13 - 17 and on March 31, when thunderstorms with small hailstones were active in the Central Valley. March was also unusually warm, with average temperatures as much as 7 degrees above normal at Los Angeles and Huntington Lake. Sacramento, with an average temperature of 60.6° (5.3° above normal), saw its second warmest March of record. On March 26, wind gusts of 50 mph reduced visibility to zero in some Southern California desert areas.

April 1984 was another dry month except for the far North Coast, where Crescent City received 6.06 inches, or 133 percent of normal, and in the Los Angeles Basin, where the International Airport recorded 1.16 inches of rain, 125 percent of normal; most of that precipitation fell on April 6, when 0.87 inches was measured. Nearby, Santa Barbara had only 10 percent of normal precipitation for the month. Precipitation in the Sierra Nevada ranged from 60 percent in the south to as high as 94 percent in Blue Canyon (5.24 inches); Norden received 40 inches of snow during the month.
Average April temperatures ranged from 4° above normal in Los Angeles and Bakersfield to 5° below normal at Yosemite and Bakersfield. At Bakersfield, the average April minimum temperature of 42.9° was the lowest on record; the low of 34° on April 27 was the coldest April temperature of record.

May 1984 was the fifth consecutive dry month. Above-normal precipitation was confined to just a few locations in the central Sierra Nevada and the North Coast. Deer Creek Forebay received 3.75 inches, or 149 percent of normal, and Eureka recorded 2.50 inches, 157 percent of normal. On the evening of May 14, Beale Air Force Base near Marysville was hit by an unusually intense thunderstorm; the storm produced a funnel cloud, hail 1/4 inch in diameter, and 1.15 inches of rain. On May 30, extensive high-level thunderstorm activity in Southern California produced very little rain, although lightning from the storm touched off some 60 wildfires. May was warm in most areas: Sacramento set a new May record with an average temperature of 73°. The Sacramento high of 107° on May 28 was the warmest May temperature ever recorded in the capital city.

Unseasonable shower activity occurred in central and northern California June 4 - 8. Blue Canyon received 2.43 inches of rain compared to a June normal of 0.86 inches. Manzanita Lake, where the normal is 1.66 inches for the entire month, received 3.36 inches during June. However, dry weather continued in the southern Sierra and in Southern California.

July-September 1984

A large, warm high-pressure area aloft over the "Four Corners" area of the southwestern desert controlled the weather in California from July through September of 1984. This clockwise circulation provided a southerly flow of unusual warmth and humidity, which, in turn, led to widespread record heat and above-normal thunderstorm activity across the Southern California interior.

July produced the warmest month ever recorded in Sacramento, with an average temperature of 80.7°, 4.1° above normal. Record average temperatures for July were also recorded at Santa Maria (67.4°, 5.1° above normal) and San Diego, where the average of 77.6° was 6.9° above normal. The average low temperature of 72.6° at San Diego also set a record, along with an extraordinary 24 days of record warm overnight low temperatures.

Flash-flood watches and warnings were frequent during July for the desert and adjacent mountain areas. On July 18, flash flooding occurred near Needles, Fort Irwin, and Big Bear Lake. One rain gauge at Big Bear Lake received 1.80 inches; 1.10 inches fell in less than 20 minutes. Mitchell Caverns in San Bernardino County was deluged with 5.66 inches of rain on July 27. Flash flooding was also reported on the South Fork of the Kern River on July 30; Onyx reported that 2.35 inches had fallen in 40 minutes.

The southern Sierra Nevada was also wet, with 2.60 inches at Huntington Lake establishing a new July record. Some desert and interior locations had monthly totals near or above the average annual rainfall. During July, Mitchell Caverns had 9.58 inches; the annual average is 8.60 inches. The total of 2.55 inches at Niland (Imperial County) exactly equalled its average for an entire year.

Heavy thunderstorms and local flash flooding impacted the Southern California interior several times during August, as the overactive monsoon pattern continued. On August 15, flash flooding occurred near Lake Isabella in Kern County, where Bodfish received 1.10 inches in one hour. On the same day, Wildrose Ranger Station in Inyo County received 5.02 inches; the August total there was 8.36 inches. In Kern County on August 22, Lake of the Woods had 1.75 inches in 40 minutes. On August 30, thundershowers occurred north of a line extending from San Francisco to Placerville, when an upper-level low-pressure center pulled up moisture from tropical storm Lowell; rainfall in the upper Feather River Basin and Mount Shasta area exceeded 1 inch.

Figure 7 LOCATION OF HYDROGRAPHS

● RESERVOIRS

7. Shasta Lake
8. Lake Oroville
9. Bullards Bar Reservoir
10. Folsom Lake
11. Camanche Reservoir
12. New Melones Reservoir
13. New Don Pedro Reservoir
14. Lake Mc Clure
15. Millerton Lake
16. Pine Flat Reservoir
17. Tulare Lake
18. Isabella Reservoir

▲ RIVER GAGING STATIONS

1. Smith River at Dr. Fine Bridge
2. Eel River at Fernbridge
3. Van Duzen River at Bridgeville
4. Sacramento River at Bend Bridge
5. Sacramento River at Rio Vista
6. San Joaquin River near Vernalis

■ PRECIPITATION GAGING STATIONS

1a. Smith River at Gasquet
2a. Eel River and Van Duzen Rivers at Bridgeville

The unusual heat and humidity continued as San Diego experienced its warmest August of record (average temperature of 76.6°, 4.4° above normal). Santa Maria had its second warmest August ever, with an average temperature of 68.4° (5.3° above normal).

September 1984 will go down as the warmest month of any month on record at San Diego (average temperature of 78.9°, 7.9° above normal); Santa Maria (71.9°, 8.9° above normal); and San Francisco (69.4°, 7.0° above normal). Fresno recorded its warmest September ever with an average of 81.0°, 6.9° above normal. Sacramento saw its warmest May--September period of record, with an average temperature of 76.2°. The previous record was 75.3° in 1981. Summer heat records in Sacramento included 110 days of 90° or higher, 38 days of 100° or higher, and 14 days with 105° or more.

Rainfall was spotty and generally not heavy during September as the summer monsoon pattern diminished in Southern California. Thundershowers on September 15-16 dumped an inch of rain on Mt. Wilson and 0.68 inches at Victorville in the Mojave Desert. On September 19, thundershowers created the most spectacular lightning display in years from the Bay Area to Sacramento; rainfall, however, was generally less than a quarter inch. A surprise Pacific weather system on September 30 left 0.50 inches at Eureka, 0.82 inches at Blue Canyon, and several inches of early snow above 7,000 feet in the Sierra Nevada.

SUMMARY OF FLOOD EVENTS

This section summarizes the significant flood events of water year 1983-84. A reference map to the hydrographs in this section is provided in Figure 7.

North Coast Hydrologic Area

The first blast of winter hit the North Coast on November 11, leaving in its wake downed power lines, damaged buildings, and blocked roads. The inaugural event was the tail end of tropical storm Marge, bringing with it wind gusts of 99 miles per hour in the Crescent City area. It also dumped 8 inches of rain on Honeydew and 7.6 inches in Petrolia. Many small streams overflowed their banks when accumulations of silt and debris clogged channels.

The wet weather pattern continued in the North Coast for the remainder of November and most of December. All-time seasonal precipitation records for the region were on the verge of being broken. Major rivers, however, were behaving surprisingly well despite the persistent rainfall. No flood stages were reached and only on a few occasions were warning levels recorded (see Figures 8 and 9).

The wet-weather regime changed dramatically in early January, and below-normal precipitation became the pattern for the remainder of the winter, spring, and summer.

North Bay-Central Coast Hydrologic Basins

Flood events of water year 1983-84 in the San Francisco Bay were centered mostly in the North Bay and, in particular, the Vallejo area. The flood-prone population centers along the Russian River went through the winter relatively unscathed, although warning stages were reached at Guerneville in late December. Warning stages were also recorded during this period at Oak Knoll and Napa on the Napa River.

Figure 8 HYDROGRAPH OF THE SMITH RIVER

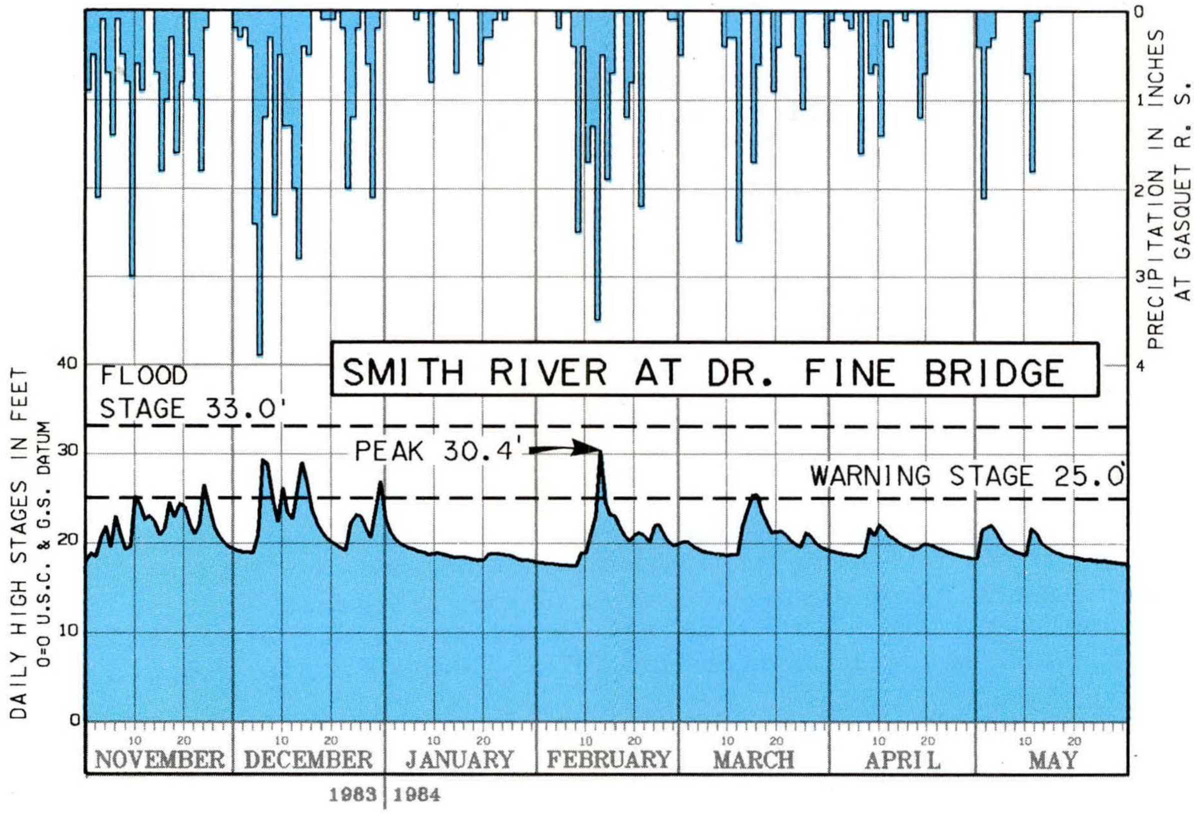
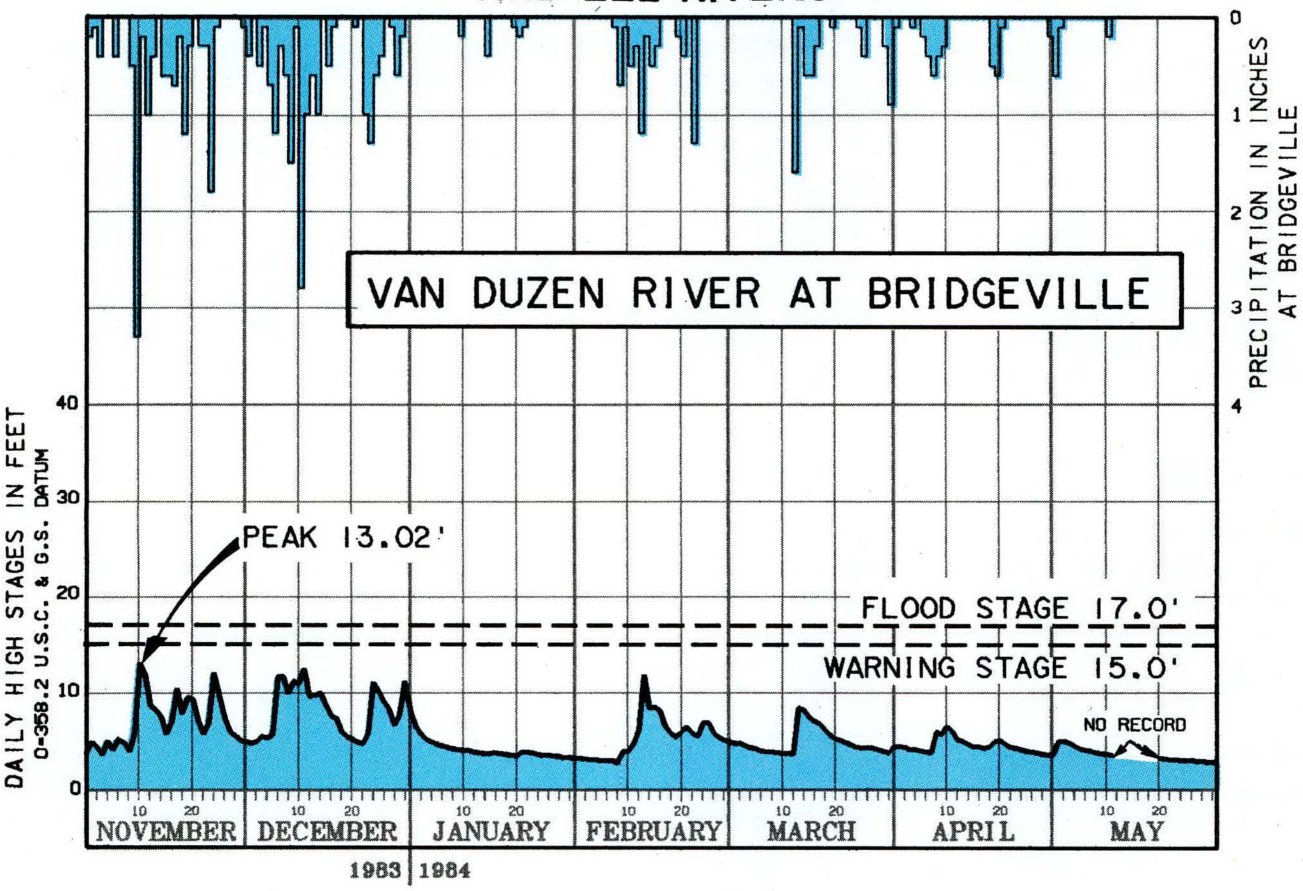
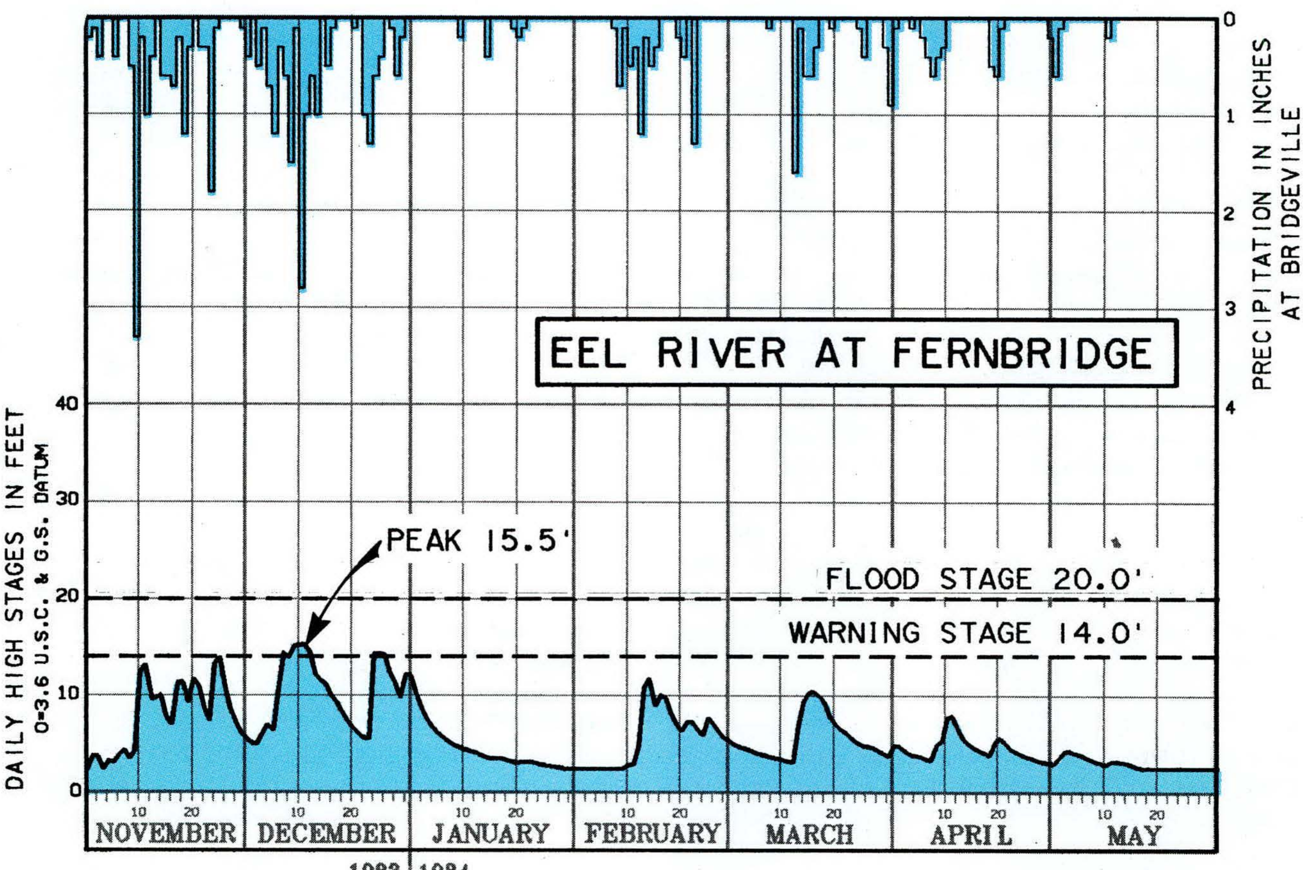


Figure 9 HYDROGRAPHS OF THE VAN DUZEN AND EEL RIVERS





The City of Vallejo was hard hit early in December, when heavy rain and violent wind with gusts to 70 miles per hour buffeted the area. The destructive winds were related to a near-record low barometric pressure of 29.22 inches of mercury recorded in the North Bay. The resulting steep pressure gradient instigated severe southwest winds as air flowed from the high-pressure area into the deep low.

Homes and businesses along the bay front at Sandy Beach took the brunt of the attack. Heavy losses were also reported in Vallejo along Sacramento Street and Sonoma Boulevard. At least 50 homes and 25 to 30 businesses were damaged, with losses reported in excess of $1 million.

Sacramento River Drainage Basin

Reservoirs of the Sacramento River Drainage basin began the water year with an average storage of 126 percent of normal. The Sacramento-San Joaquin Flood Control Project underwent a severe test during the previous 1982-83 water year, when more than four times the average volume of runoff passed through the system. During that period, the project performed as designed without major problems. However, the long-term high-water stages appreciably eroded river banks and weakened levees. Flood control officials were concerned that, in the event of another wet year, problems could develop in areas where repair work was limited by lack of time and funds.

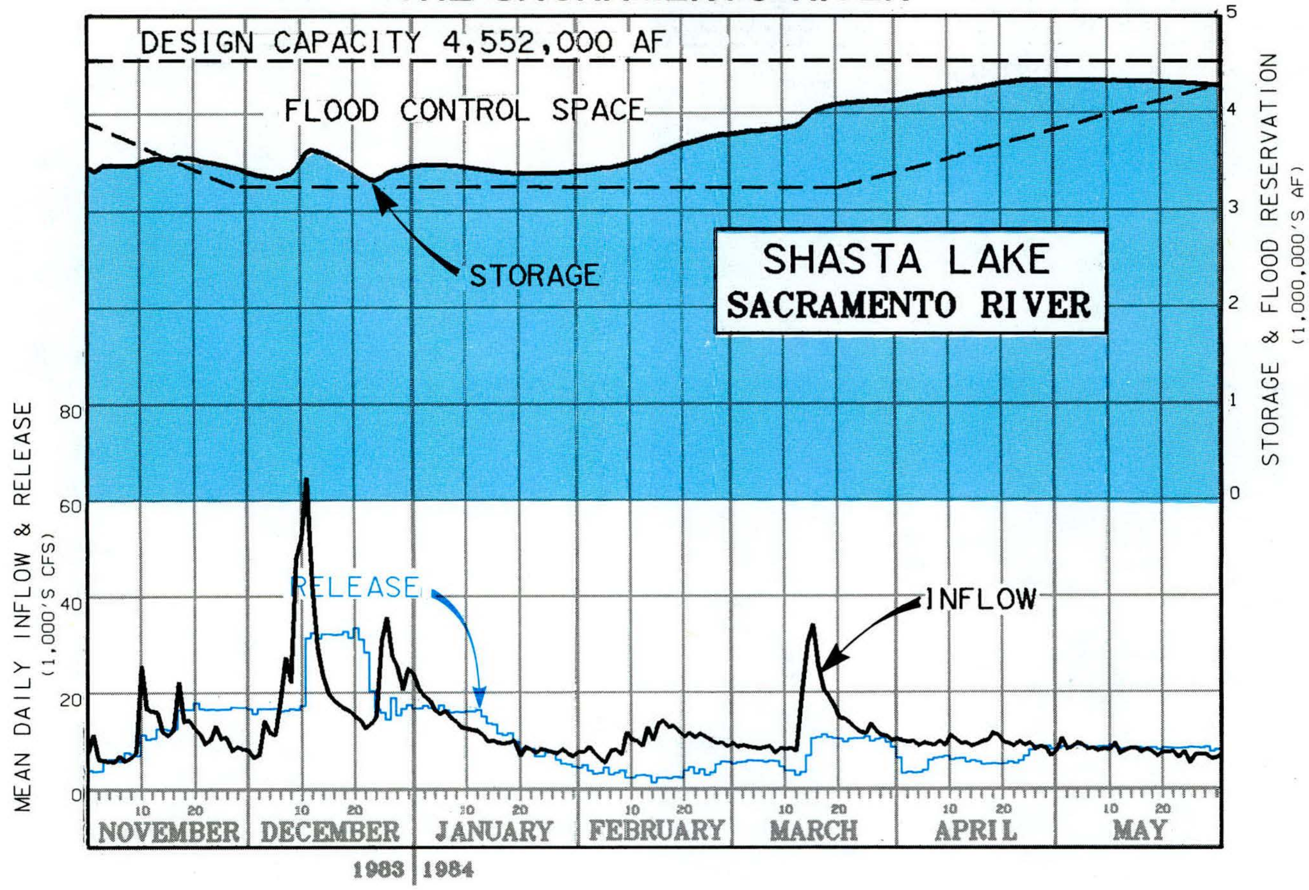
October was relatively dry, but the rainy season began in earnest in early November when 3 to 7 inches of rain dropped on the north and central State. There was little let-up in storms for the next two months. The November-December siege brought seasonal totals for the Sacramento Valley to as much as 225 percent of normal.

Local runoff and flood-control releases from reservoirs to accommodate heavy inflows created high water in major rivers. Warning-stage levels began to be common along the Sacramento Valley Flood Control Project, and flood stages were reached at Tehama Bridge, Vina Woodson Bridge and at Ord Ferry. On the evening of November 11, the Sacramento River rose to a stage of 60 feet at the Colusa Bridge. This marked the earliest date that water began pouring over the spillway at Colusa Weir since 1962, when overflow occurred during several days in October. See Appendix A for periods of weir overflows.

On the evening of December 26, 12 gates of the Sacramento Weir were opened to relieve pressure on levees near Sacramento. The total was increased to 23 gates the following day, allowing approximately 30,000 cfs to flow into the Yolo Bypass.

Hydrographs of Shasta Lake and the Sacramento River at Bend Bridge are shown in Figure 10. Hydrographs of Lake Oroville, Bullards Bar Reservoir, and Folsom Lake are presented in Figures 11 and 12.

Figure 10 HYDROGRAPHS OF SHASTA LAKE AND THE SACRAMENTO RIVER



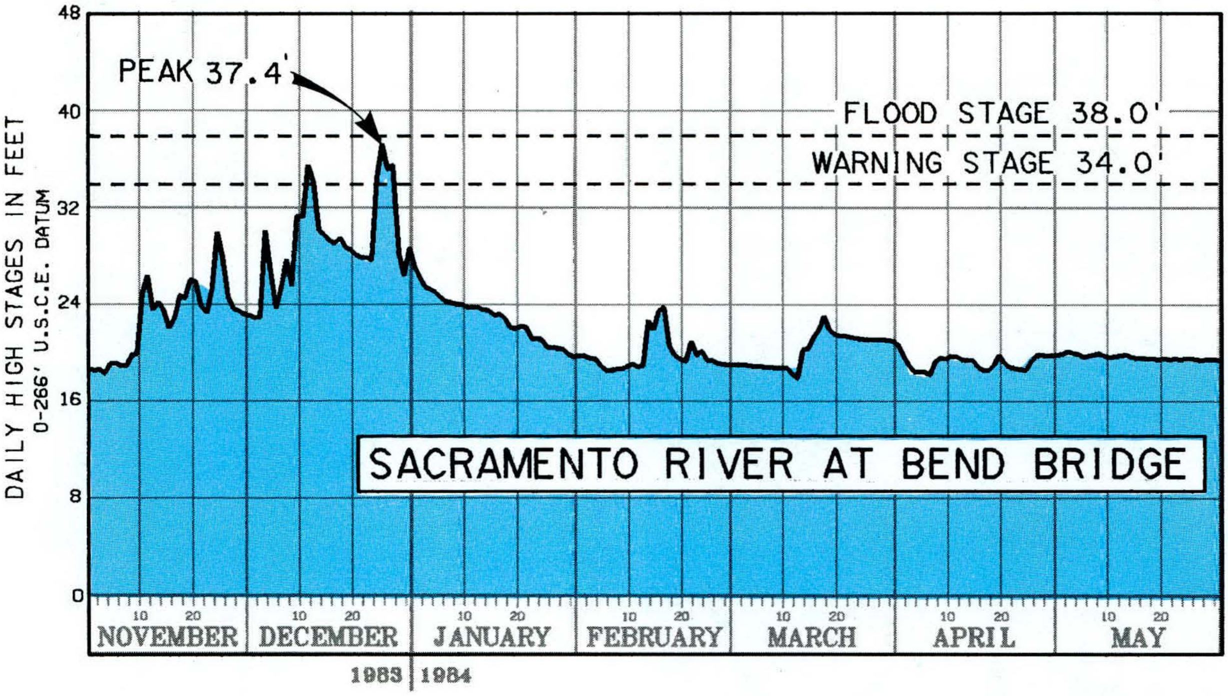
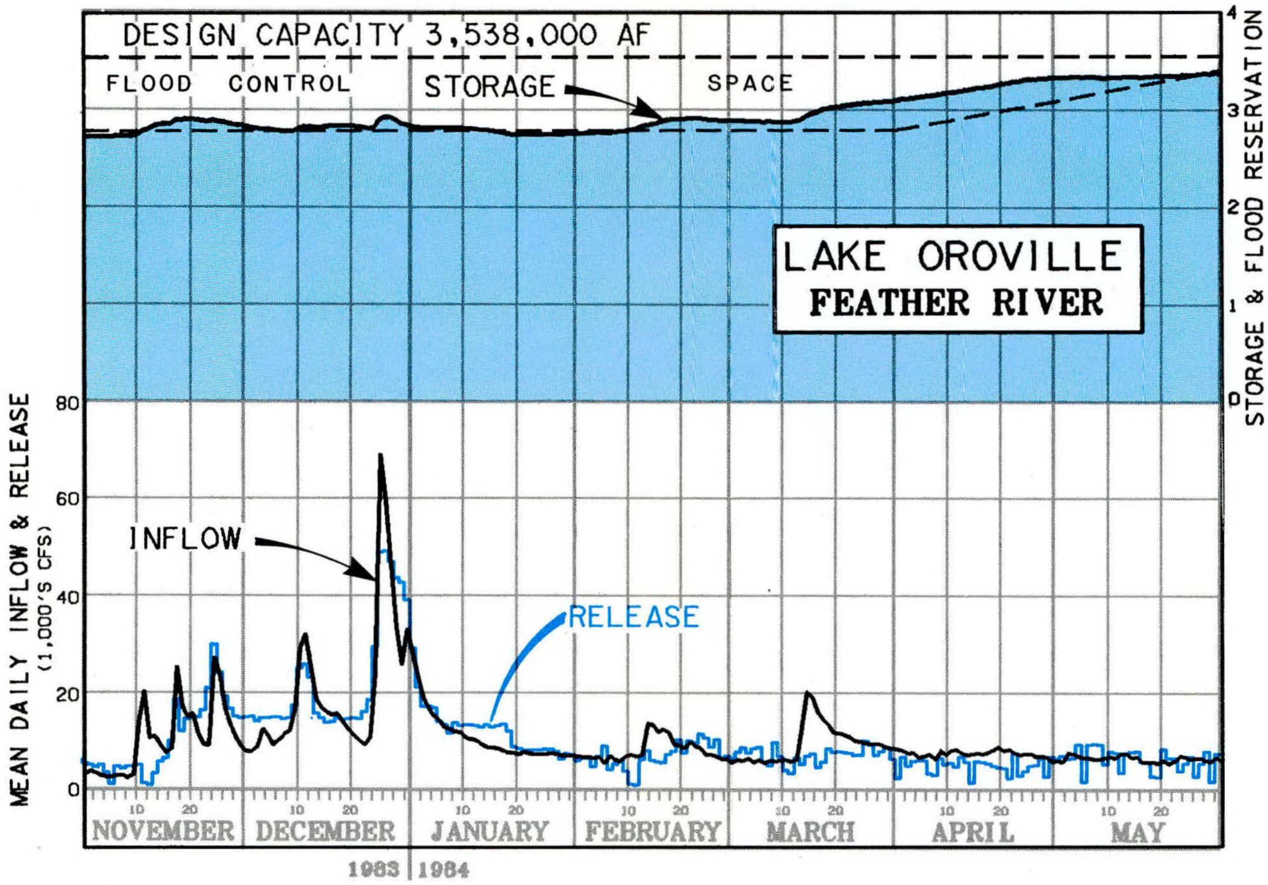


Figure 11 HYDROGRAPHS OF LAKE OROVILLE AND BULLARDS BAR RESERVOIR



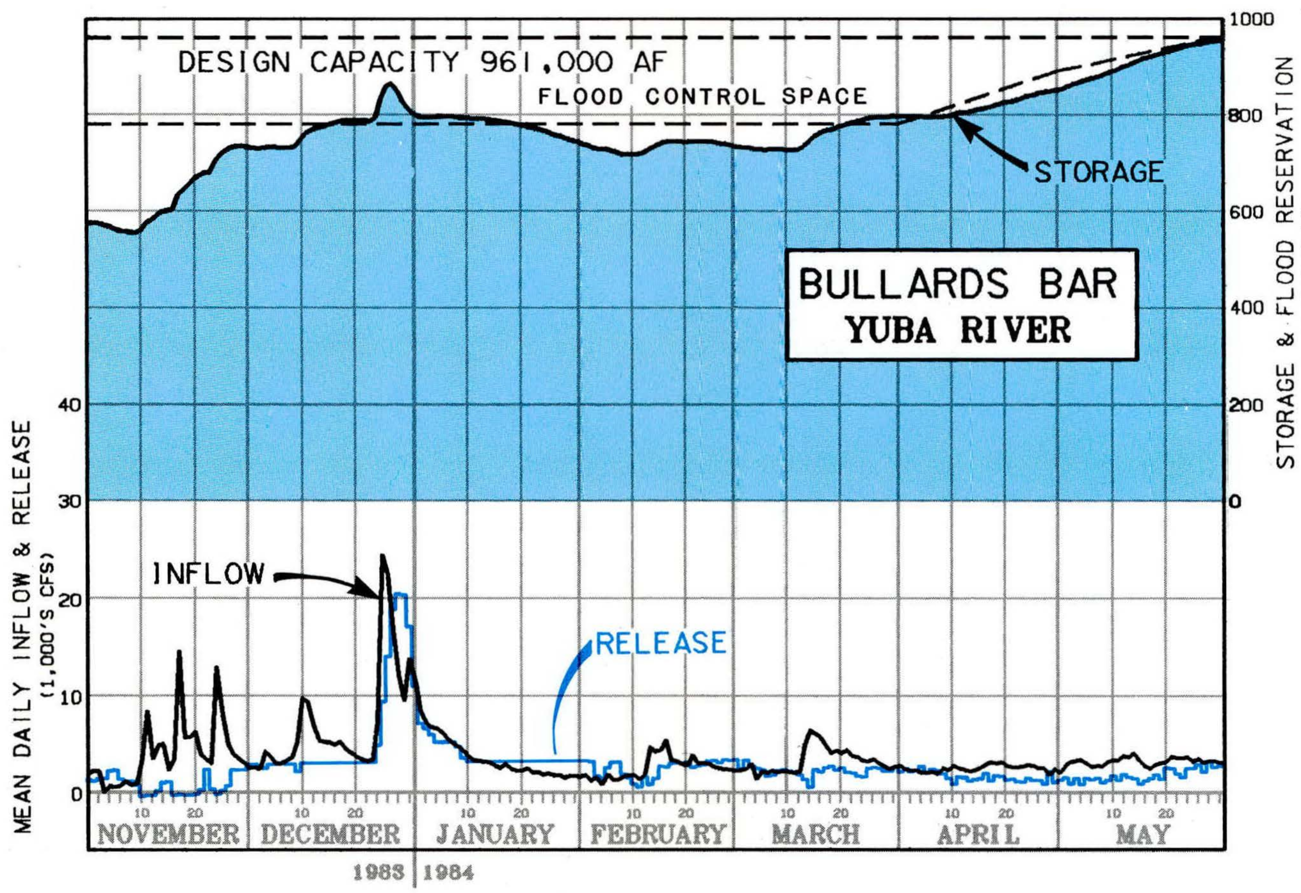
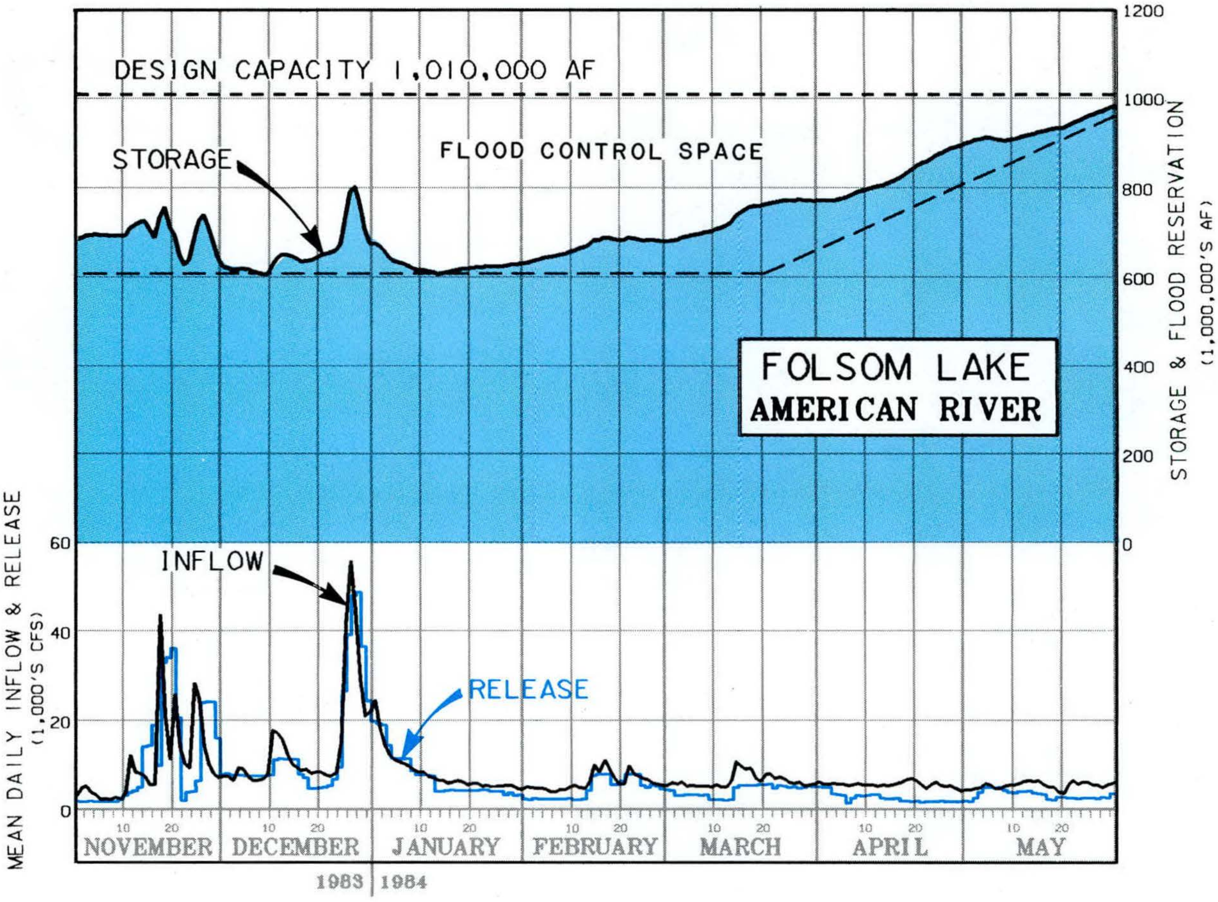


Figure 12 HYDROGRAPH OF FOLSOM LAKE



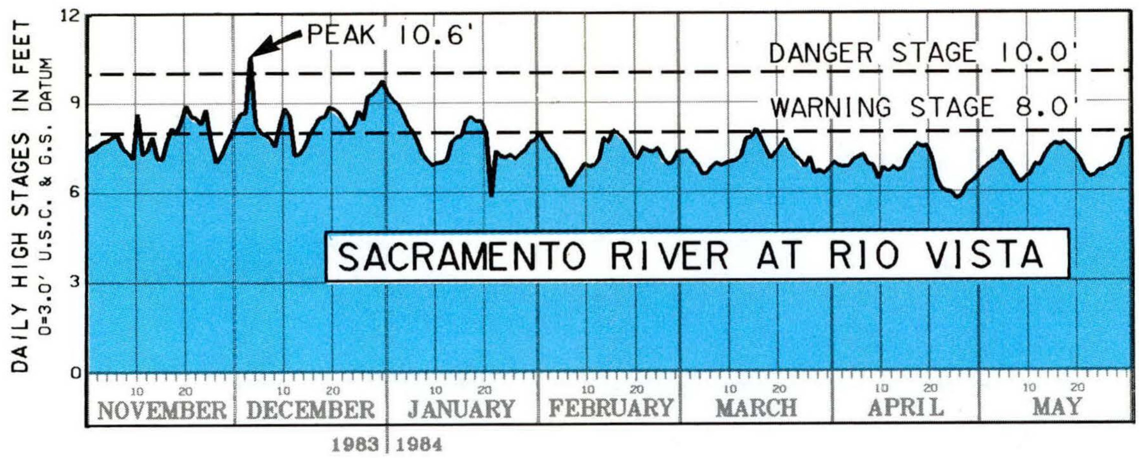
Sacramento-San Joaquin River Delta

During the summer of 1983, Reclamation District officials worked urgently to both restore Delta Islands and reinforce levees deteriorated by the persistent storms of 1982-83. Crises in the Delta are nothing new. However, on December 1, Federal and State river forecasters predicted that a series of high tides well above warning levels would prevail during the coming week, indicating that the fragile Delta levees would require close watching.

A strong Pacific storm, associated with a substantial drop in atmospheric pressure and moderate westerly winds, was expected to hit in full force at about the same time the highest tide was predicted to peak in the Delta.

The storm arrived on December 3 as forecast, but was stronger than predicted. The barometric pressure dropped to a reading in Sacramento of 29.28 inches of mercury, only 0.05 inches above the city's lowest all-time December record set in 1982. This phenomenon alone contributed to about a 10 inch additional rise in the tide stage. To further aggravate the situation, the predicted

Figure 13 HYDROGRAPH OF THE SACRAMENTO RIVER



moderately high winds proved to be of gale force, whipping the surface water of the hundreds of miles of Delta waterways into a frenzy and overtopping and eroding levees. The busy Golden Gate Bridge was closed for only the third time in history to prevent traffic accidents when the bridge deck began swaying in response to hurricane-force, on-shore winds.

At 1:45 p.m. on December 3 the Sacramento River reached 10.61 feet at Rio Vista, breaking the all-time record of 10.46 feet set on January 29, 1983. Two hours later the inevitable occurred. A hydrograph of the Sacramento River at Rio Vista is shown in Figure 13.

At about 4 p.m. the badly deteriorating west levee of Bradford Island finally succumbed to the high tide and relentless pounding waves. The initial breach of 40-50 feet gradually widened to 600 feet as the water surged through the gap, scouring a 40 to 50-foot deep channel. As the flood waters became stabilized, much of the 2,150 acre island was under 15 feet of water. Fortunately, the 30 to 60 island residents were evacuated without injury. A few head of livestock were lost, but most managed to find refuge on high ground or were barged to safety.

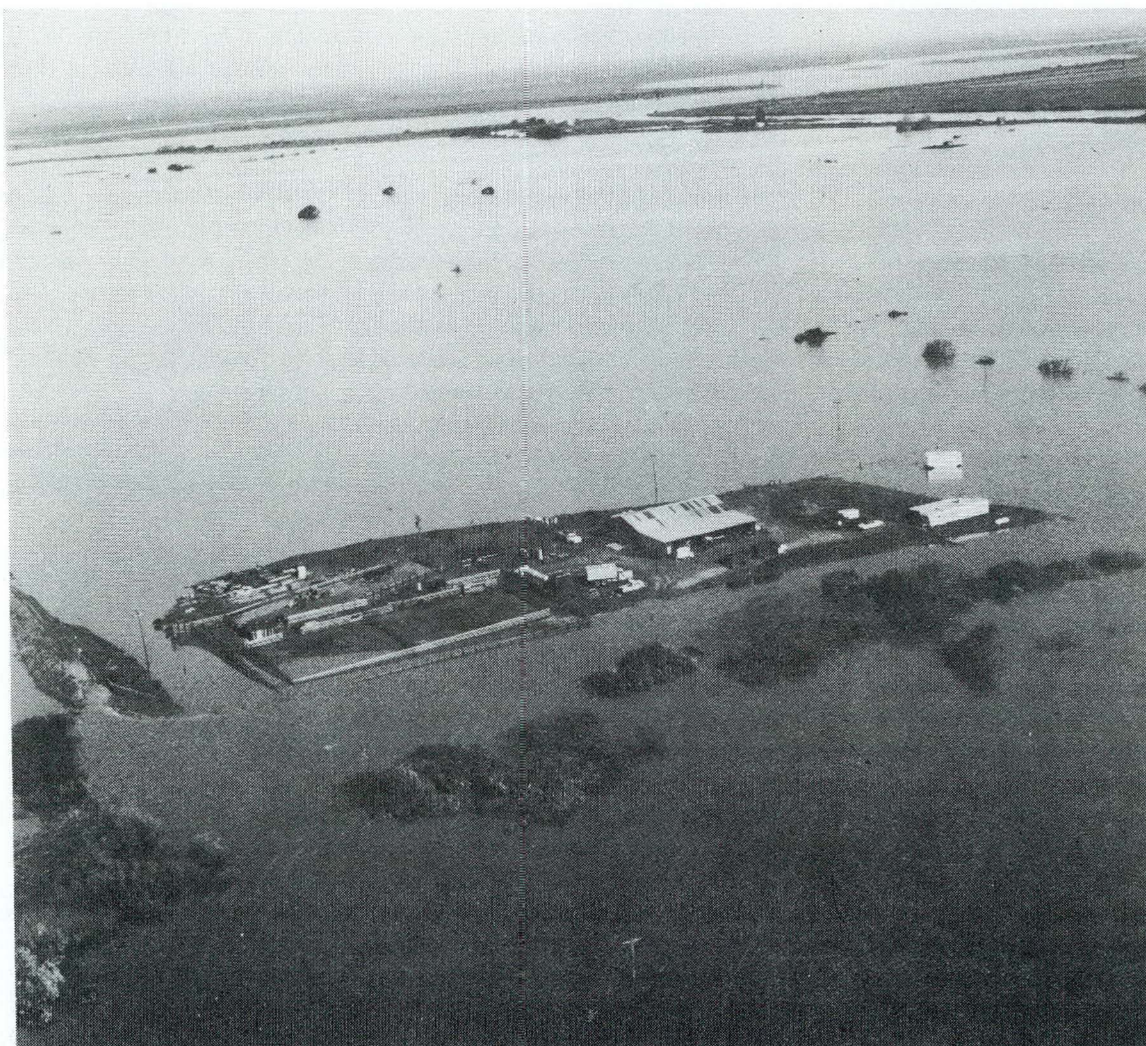
Because of the critical location of Bradford Island from a water quality and quantity standpoint, and its possible negative impact on surrounding islands should the island not be reclaimed, procedures for reclaiming the island began almost immediately following the break.

On December 9, the Governor declared Bradford Island a disaster area, making limited funds from the Natural Disaster Assistance Act available for flood damage compensation.

Once the island had filled with flood water, another problem developed that required immediate attention -- the interior levee slopes became vulnerable to wave wash action due to the incessant and strong winds. California Conservation Corps crews, directed by DWR Flood Operations personnel, were rushed in to place protective plastic on the exposed interior levee slope. During a four-day period, beginning December 8, CCC crews averaging 60 workers per day placed plastic sheeting on about 2,500 feet of the most vulnerable portions of the interior levee. In some areas where plastic and sandbags were not effective, rock was placed as a more stable reinforcement. Approximately 20,000 tons of rock were used for this purpose.

Closing the break required 145,000 tons of rock at a cost of $3,625,000. About 400,000 cubic yards of silt was combined with the rock to fill the voids and seal the break. The silt was dredged from the adjacent San Joaquin River channel as part of a channel cleaning program. The existing drain pumps on the island were damaged by the flooding, and additional pumping facilities had to be installed. The cost of the new facilities and the dewatering totaled $450,000.

Delta problems during early December were not limited to Bradford Island. At about the same time that the Bradford Island levee



The benefit of building on high ground shows up in this photo of Bradford Island, taken on December 4, 1983, the day following the west levee break (DWR 6324-81) failed, a "boil" of proportions rarely seen appeared on Bouldin Island. The boil was discovered on the Potato Slough levee on the south side of Bouldin Island. The boil broke out on the landward slope of the levee about 10 feet below the Potato Slough water surface at high tide. A horseshoe sandbag ring was quickly constructed around the perimeter of the boil to control the flow through the levee. At high tides, two 10-inch pipes were required to carry the boil's discharge. A dredge sealed the passageway from the waterside with mud, gravel and rock. This prompt action by experienced flood fighters prevented an almost certain levee failure.

San Joaquin River Drainage Basin

Reservoirs of the Southern Sierra were bulging at the seams at the onset of the new water year. Despite heavy and sustained releases that kept the lower San Joaquin River at above-warning stage through much of the summer of 1983, the drawdown was not sufficient to reduce reservoir storages to desirable levels. The October 1 survey showed reservoirs of the basin retaining 179 percent of the 10-year average. The million-acre-foot Pine Flat flood-control reservoir of the Kings River held 193 percent of average.

In late December the San Joaquin River near Vernalis rose above the 24.5-foot warning stage and continued rising until January 6, peaking at 27.9 feet (Figure 14). For the third year in a row, mobile home parks within the San Joaquin River floodplain were evacuated. On January 25 the river receded below warning stage, but the cautious evacuees did not return to the flood plain until later in February.

Figures 15 through 18 show hydrographs of Camanche, New Melones, and New Don Pedro reservoirs; Lake McClure and Millerton Lake; Pine Flat and Isabella Reservoirs; and Tulare Lake.

Figure 14 HYDROGRAPH OF THE SAN JOAQUIN RIVER

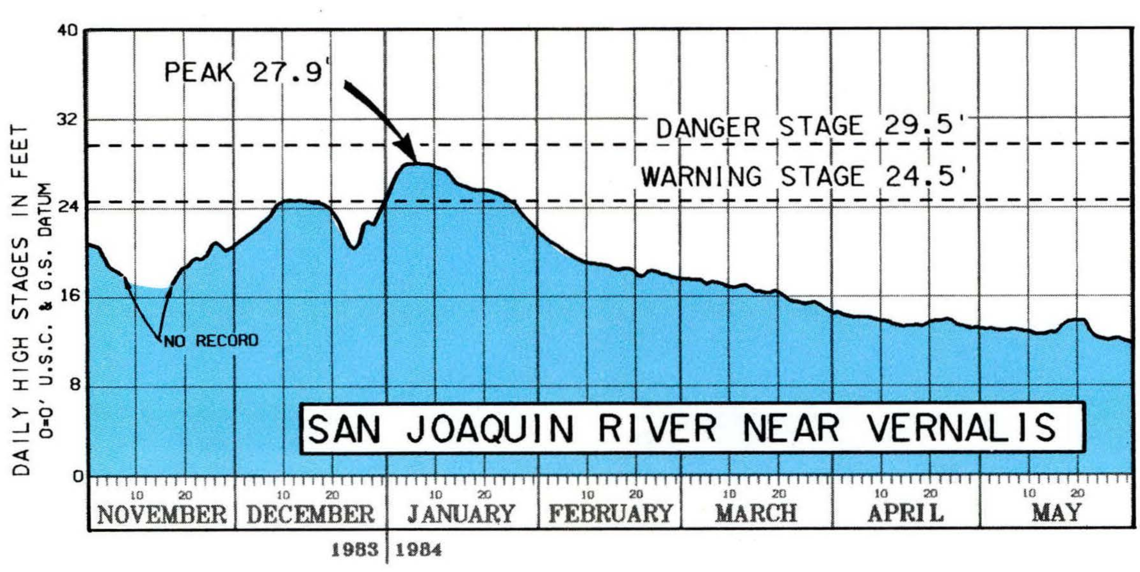
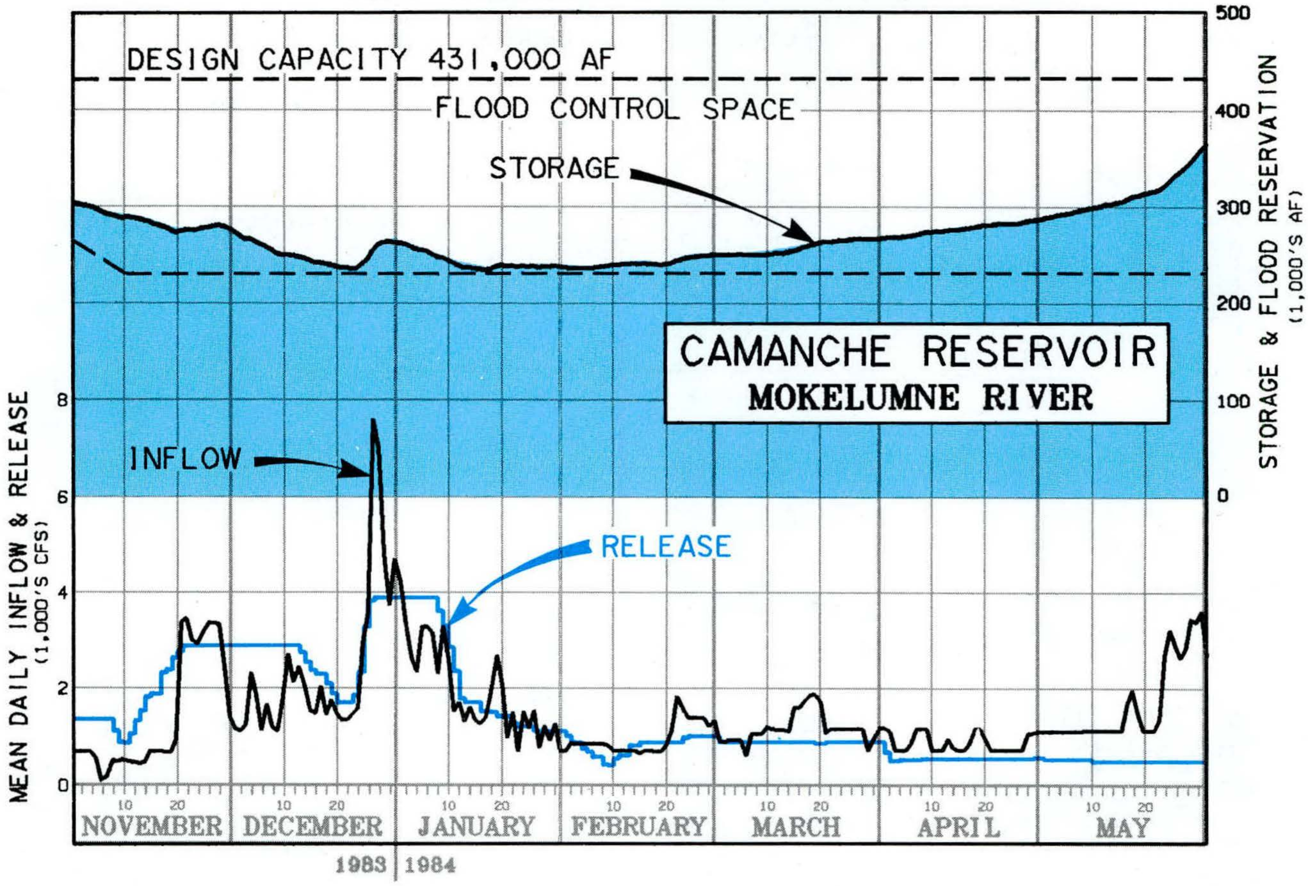


Figure 15 HYDROGRAPHS OF CAMANCHE AND NEW MELONES RESERVOIRS



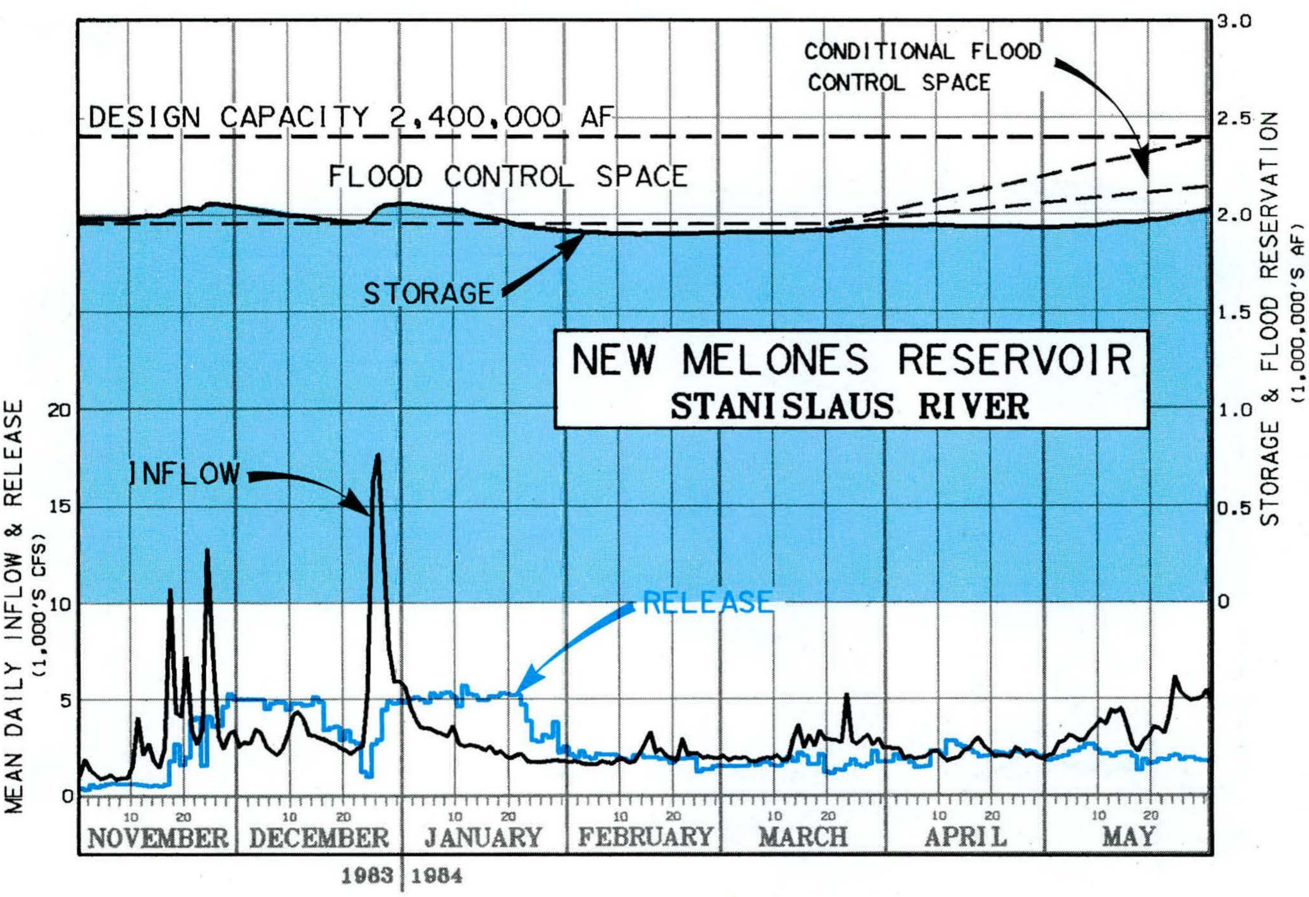


Figure 16 HYDROGRAPHS OF NEW DON PEDRO RESERVOIR AND LAKE MC CLURE

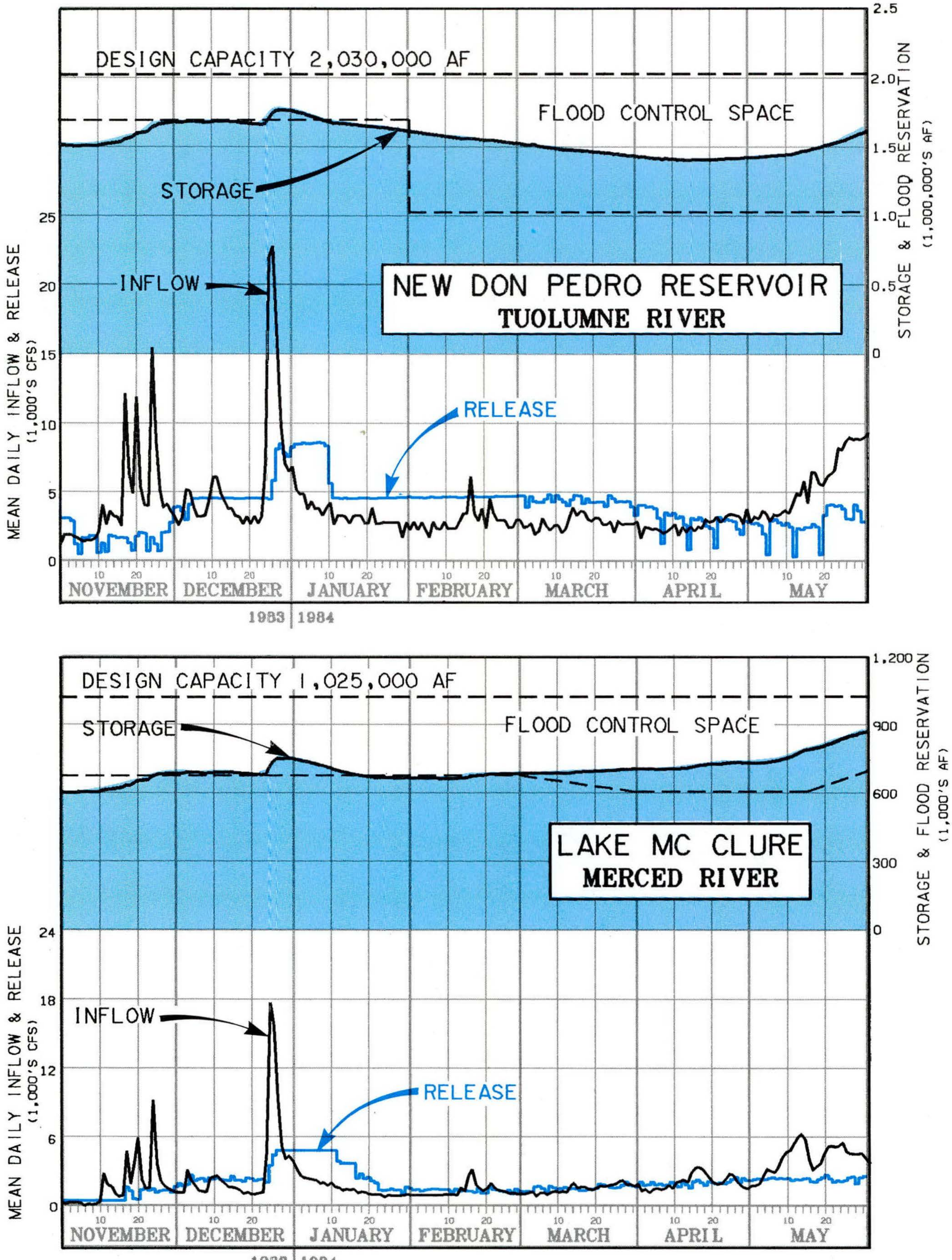


Figure 17 HYDROGRAPHS OF MILLERTON LAKE AND PINE FLAT RESERVOIR

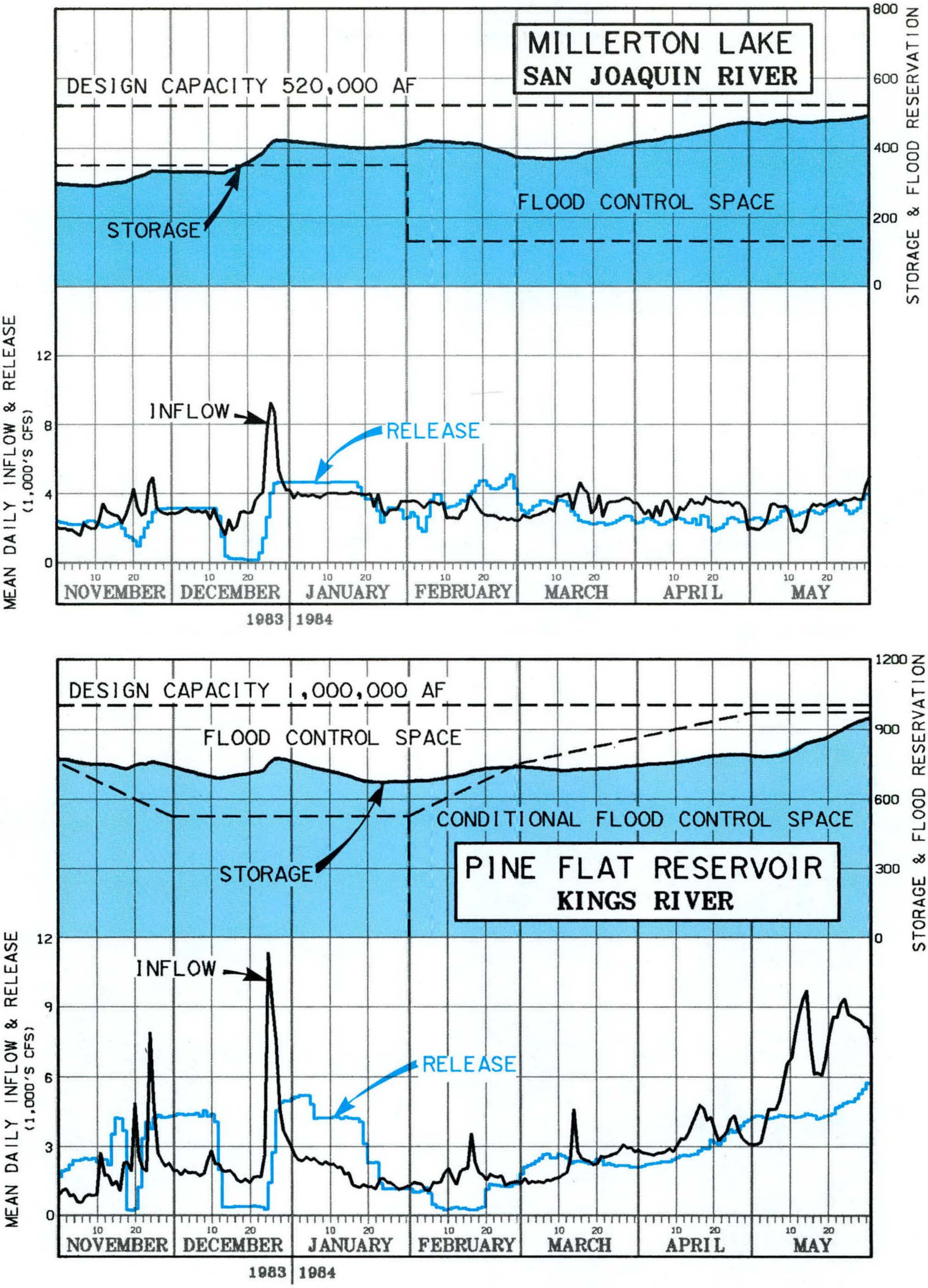
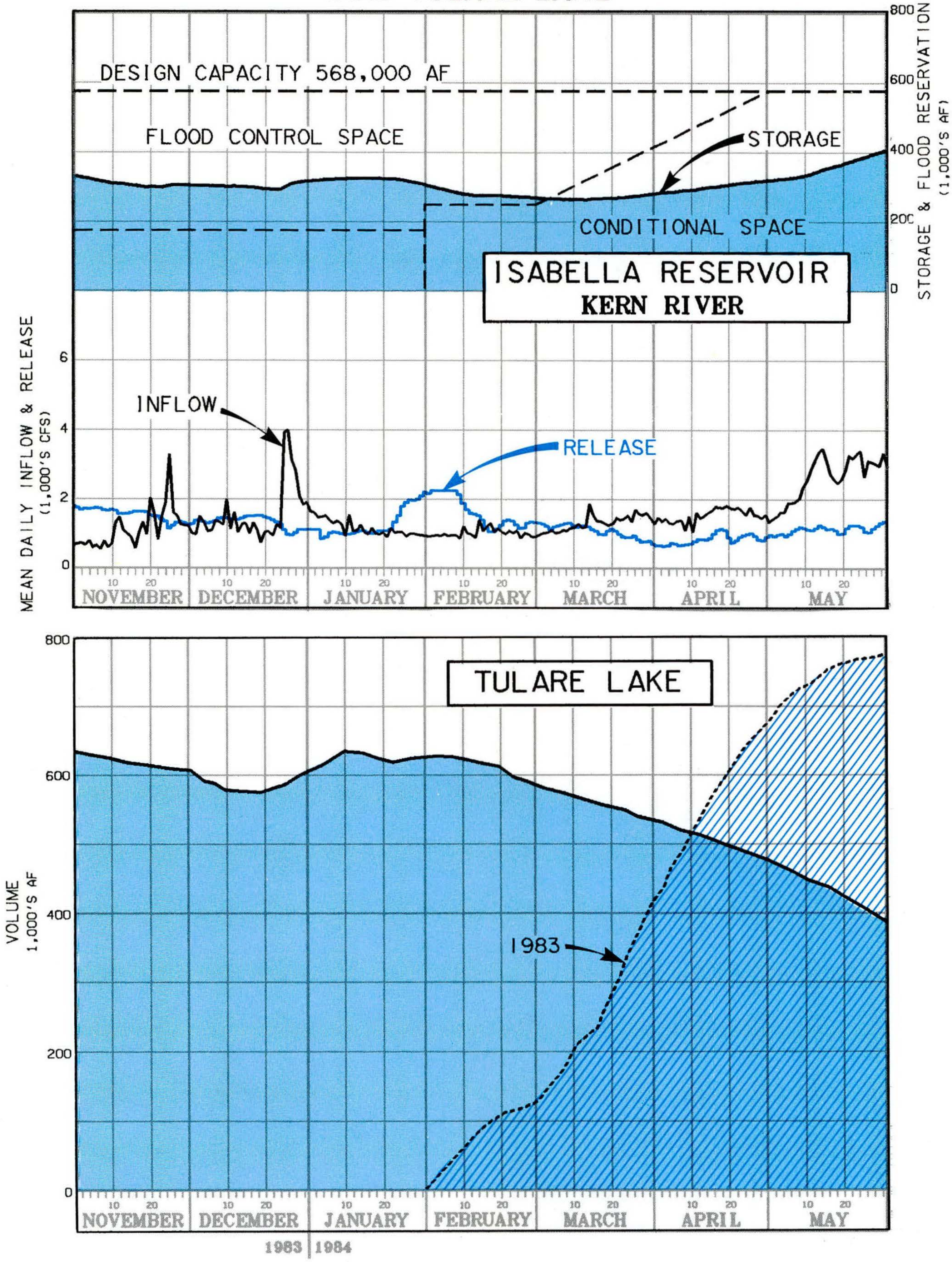


Figure 18 HYDROGRAPHS OF ISABELLA RESERVOIR AND TULARE LAKE

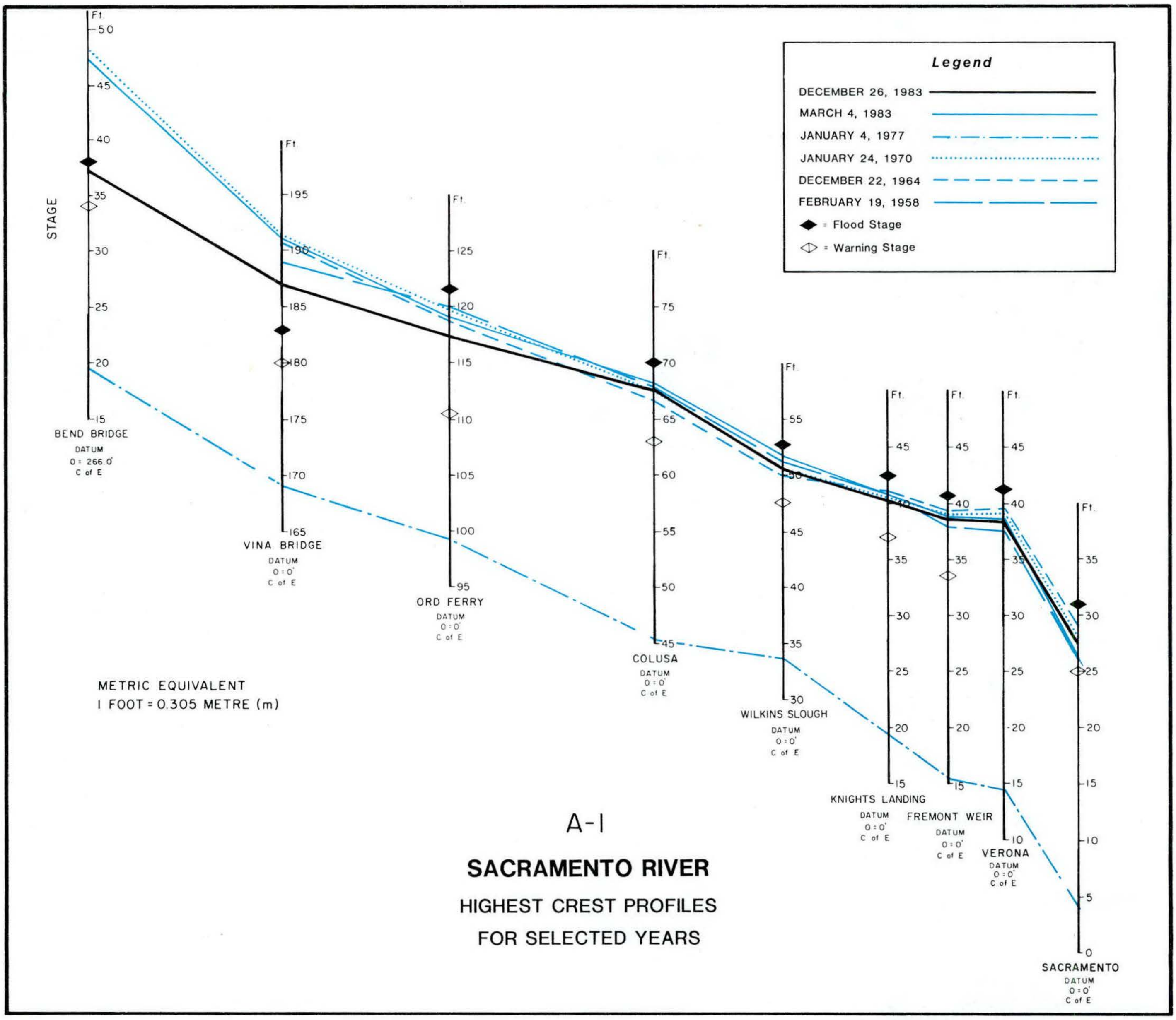


South Coastal Hydrologic Region

The first storm of the new water year struck Southern California on October 1 and knocked out power to more than 100,000 homes and businesses. The unseasonal downpour capped one of the strangest Septembers of record, when a series of storms in the latter part of the month ended a hot spell that was rapidly making September 1983 one of the warmest Septembers of record. In addition, the storms elevated this closing month of the 1982-83 water year to the third wettest in the region's history.

The earlier and later rains were not particularly destructive in terms of flood damage when compared to recent events; however, the storms reactivated landslides, created power outages, and caused numerous traffic problems. The storms also brought the serious deficiencies of storm-drain systems to the attention of public officials and residents in numerous and widespread areas. Many citizens complained that they must sandbag or take some action to protect their property from flooding every time it rains hard enough to generate runoff.

APPENDIX A
Sacramento River Crest and Weir Overflow Records

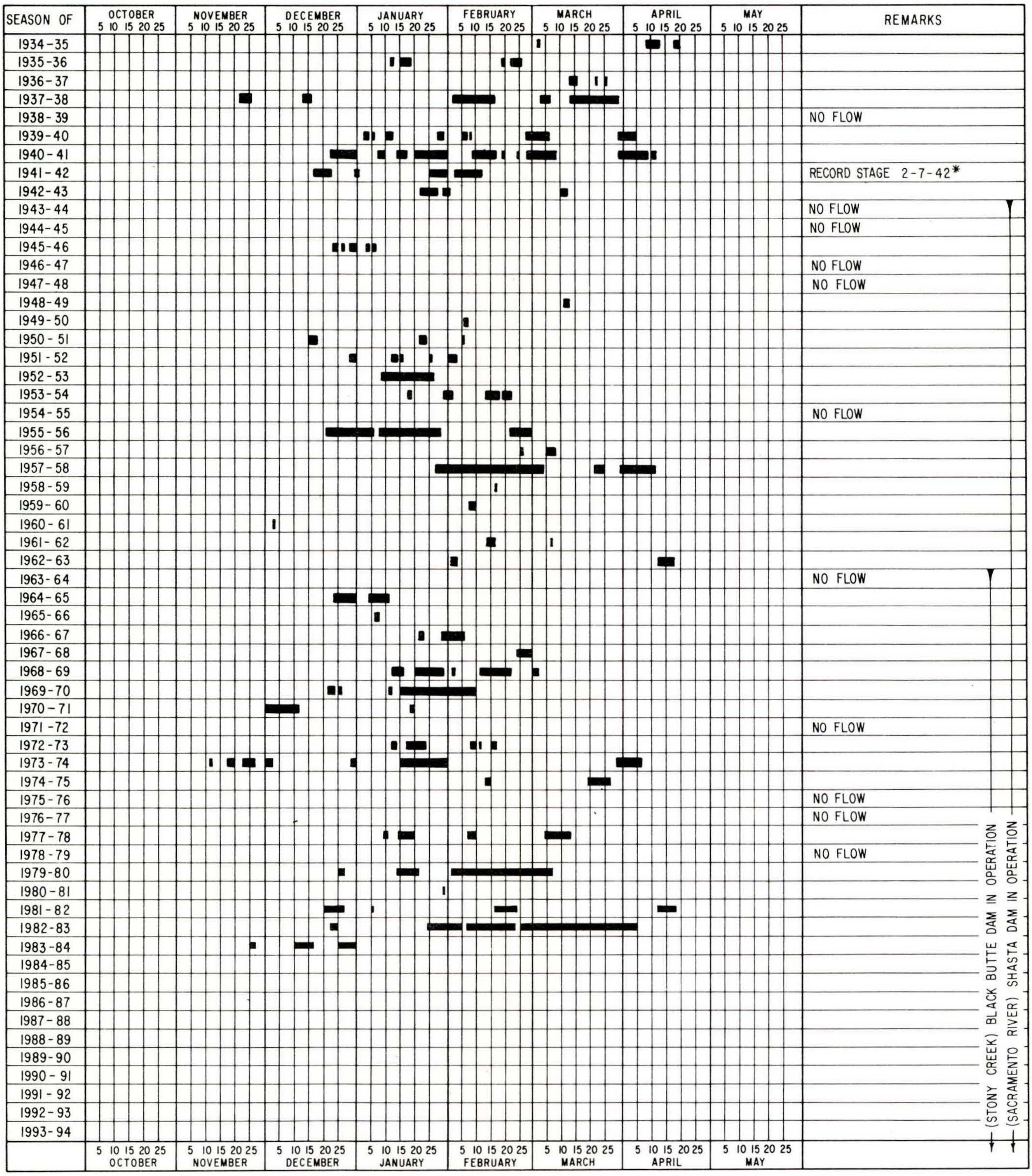


A-1

SACRAMENTO RIVER

HIGHEST CREST PROFILES FOR SELECTED YEARS

Figure A-2 PERIOD OF RECORD OF OVERFLOW OF THE MOULTON WEIR



NOTE:

Data compiled from records of D.W.R. stream gaging station "Sacramento River at Moulton Weir."

Datum: 0 = 0' U.S.E.D.

Period of record: 1935 to present

Crest elevation = 76.75 feet

LEGEND

▬ Designates periods of flow over weir

* 83.8 feet

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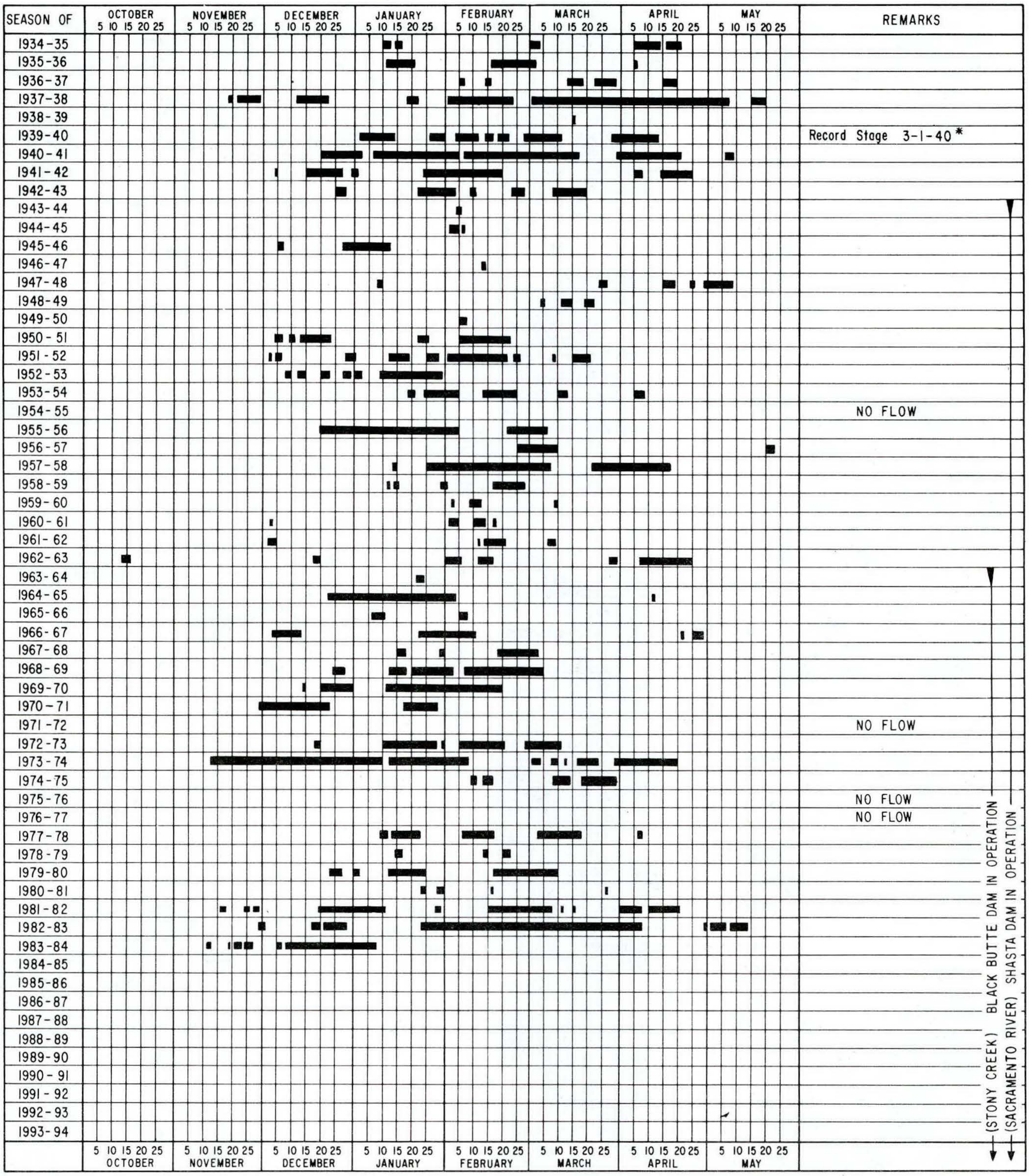
Figure A-3 PERIOD OF RECORD OF OVERFLOW OF THE COLUSA WEIR



NOTE:

Data compiled from records of D.W.R. stream gaging station Sacramento River at Colusa Weir

Datum: 0 = 0' U.S.E.D.

Period of record: 1935 to present

Crest elevation: 61.80 feet

LEGEND

Designates periods of flow over weir

* 70.6 feet

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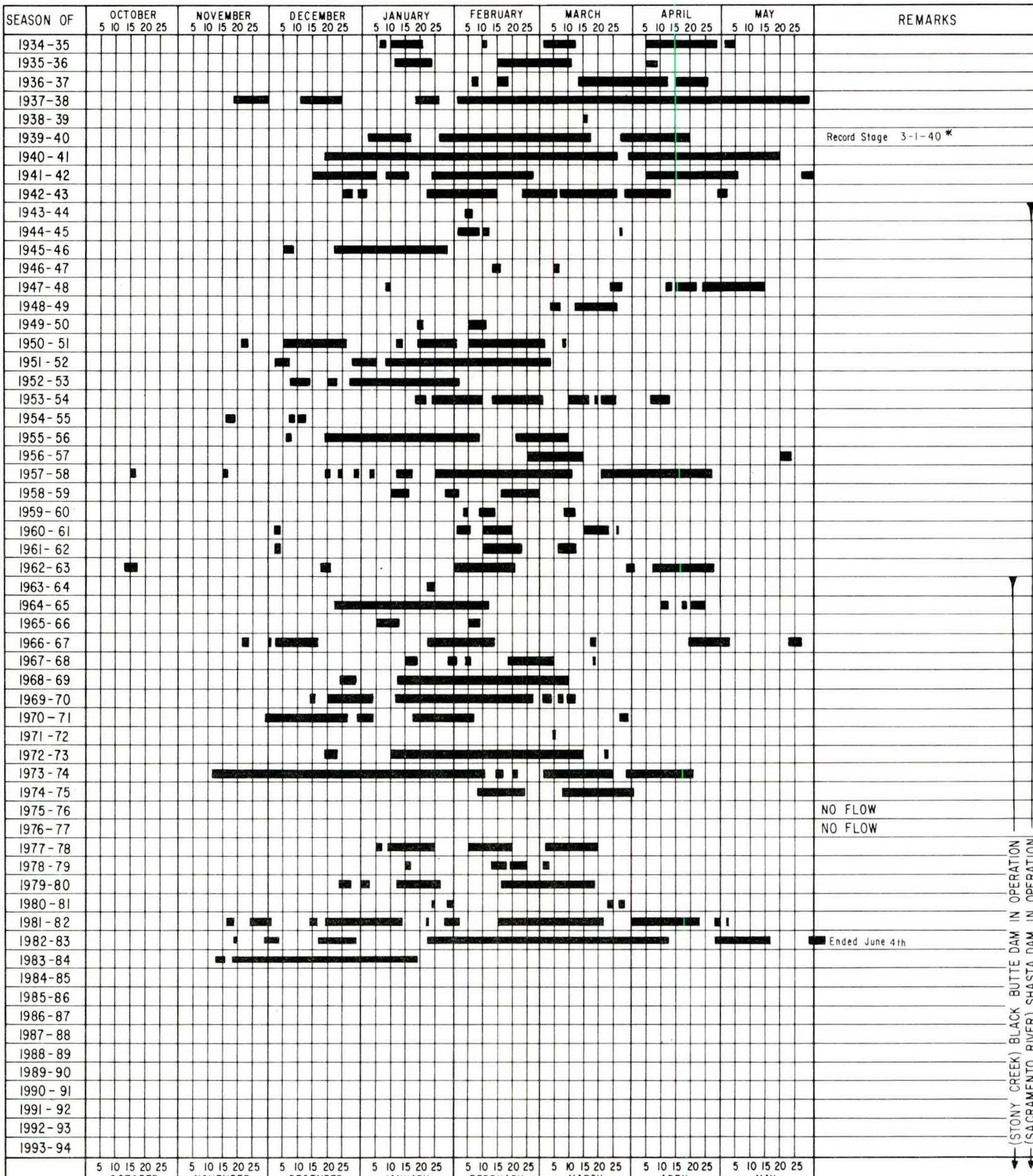
Figure A-4 PERIOD OF RECORD OF OVERFLOW OF THE TISDALE WEIR



NOTE:

Data compiled from records of D.W.R. stream gaging station "Sacramento River at Tisdale Weir"

Datum: 0=0' U.S.E.D.

Period of record: 1935 to present

Crest elevation = 45.45 feet

LEGEND

Designates periods of flow over weir

*53.3 feet

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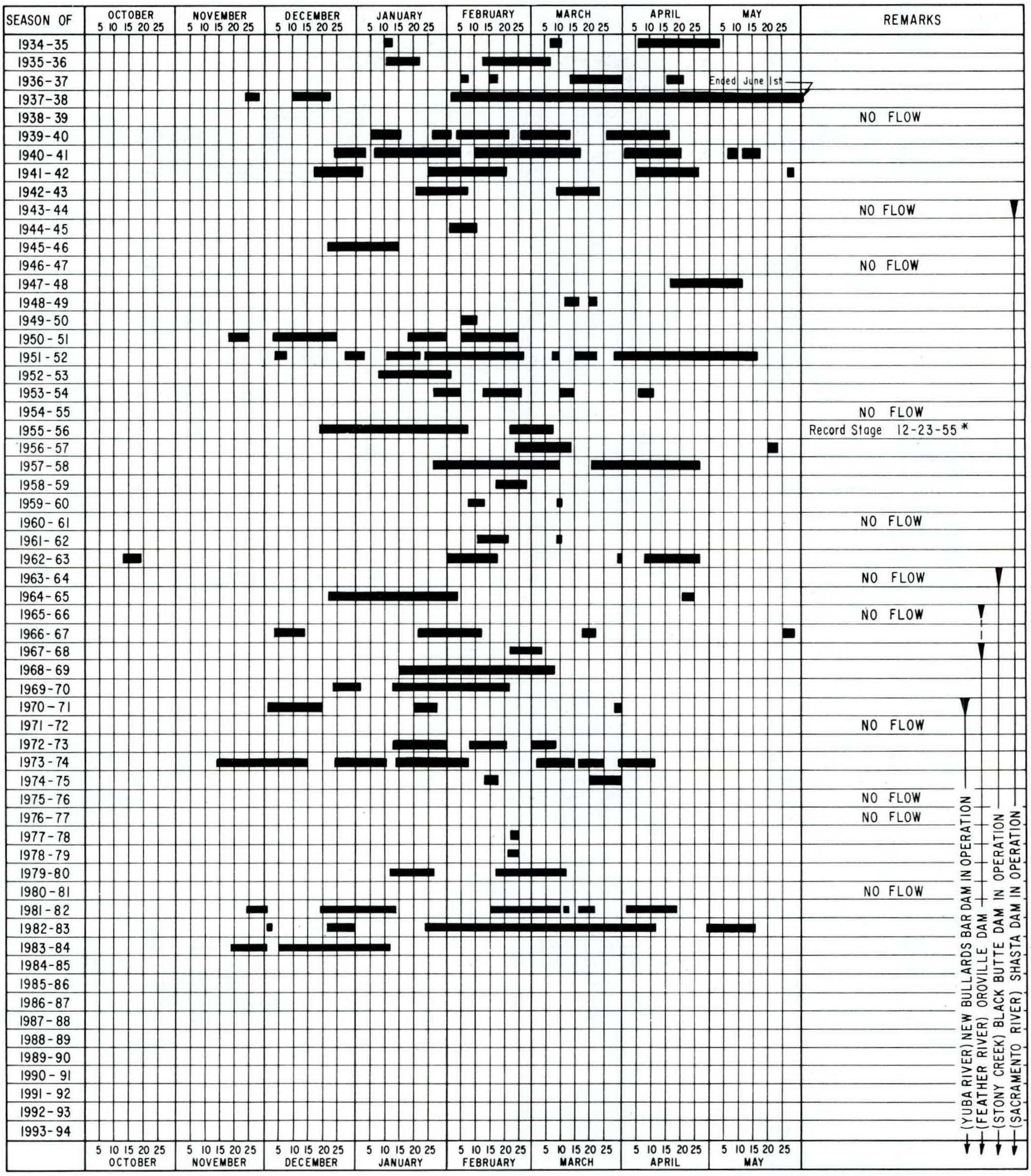
Figure A-5 PERIOD OF RECORD OVERFLOW OF THE FREMONT WEIR



NOTE:

Data compiled from records of D.W.R. stream gaging station "Sacramento River at Freemont Weir, West End"

Datum: 0 = 0' U.S.E.D.

Period of record: 1934 to present

Crest elevation = 33.50 feet

LEGEND

Designates periods of flow over weir

* 39.7 feet

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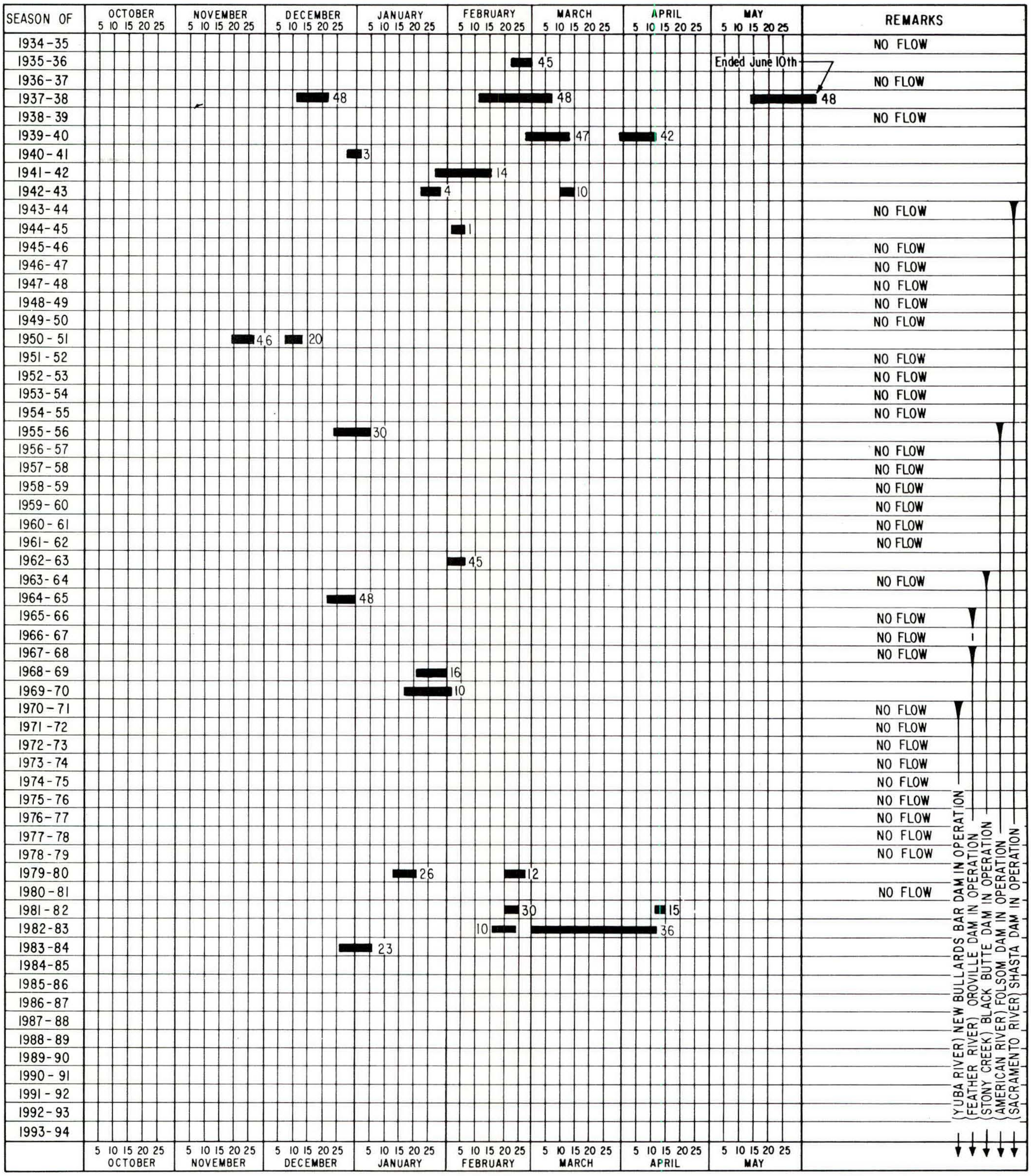
Figure A-6 PERIOD OF RECORD OF OVERFLOW OF THE SACRAMENTO WEIR



NOTE:

Data compiled from records of D.W.R. stream gaging station "Sacramento Weir Spill to Yolo Bypass, near Sacramento.

Datum: 0=0' U.S.E.D.

Period of record: 1926 to present

Crest elevation = 24.75 feet

Elevation of top of gates = 31.0 feet

LEGEND

▬ 5 Designates periods of flow over weir and total number of gates opened.

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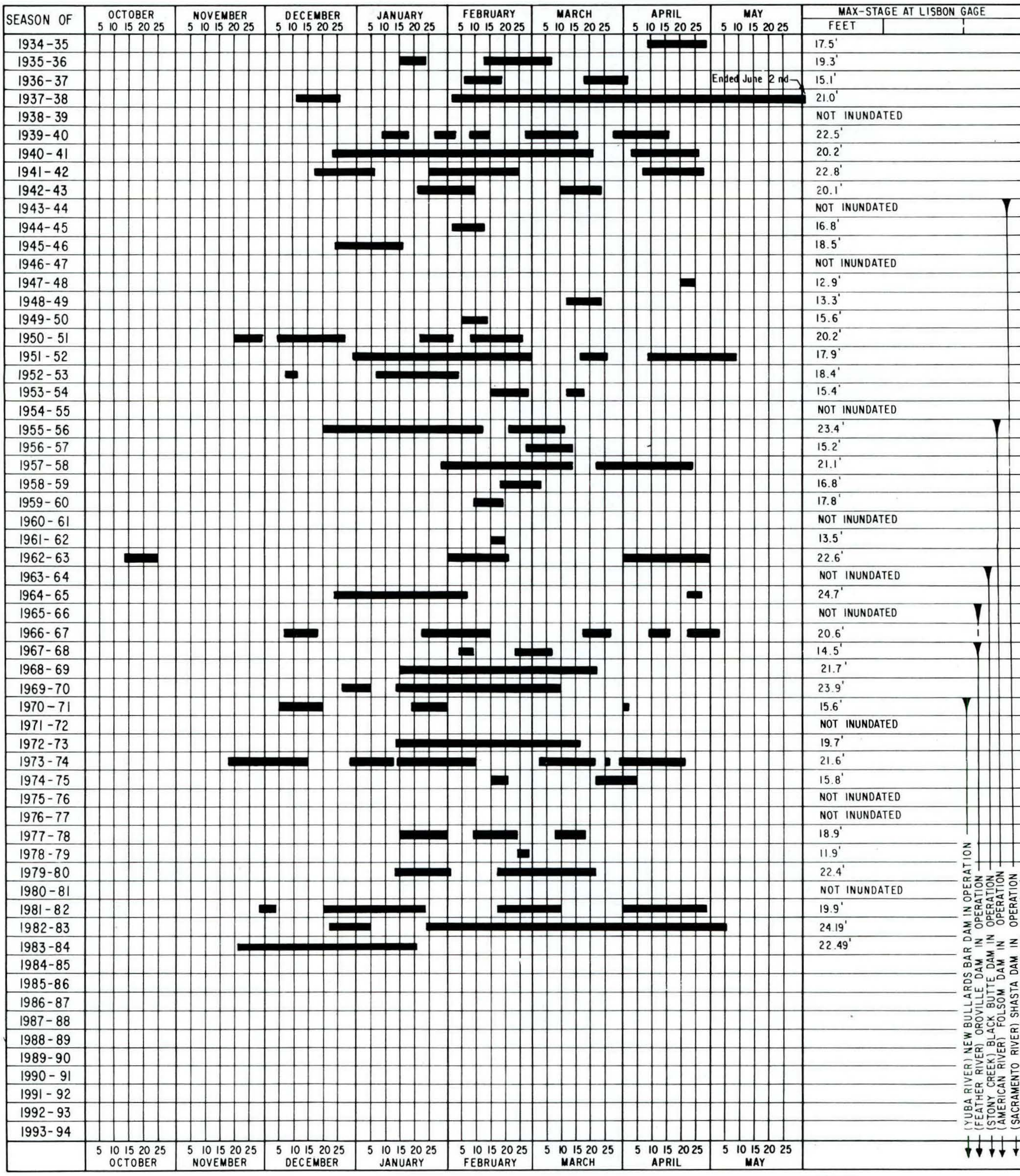
Figure A-7 PERIOD OF RECORD OF INUNDATION OF THE YOLO BYPASS



NOTE:

Data compiled from records of D.W.R. stream gaging station "Yolo Bypass near Lisbon."

Datum: 0=U.S.E.D. Datum

Period of Record: 1914 to Present

Assumed overflow of Bypass at stage above 11.5' on the Lisbon gage.

LEGEND

Designates period of inundation of Bypass.

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85 79721

CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C)+32	(°F−32)/1.8

State of California—Resources Agency
Department of Water Resources
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95802