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KERN COUNTY WATER AGENCY

Water Supply Report 1997

Thomas N. Clark
General Manager
August 2001

Kern County Water Agency

WATER SUPPLY REPORT
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DEFINITIONS

Acre-Foot (AF) The quantity of water required to cover one acre of land to a depth of one foot (325,872 gallons). This amount of water is normally used by a family of four during a one-year period for residential use (not including water used for food or clothing).

Agency Kern County Water Agency (KCWA).

Aquifer Geologic formations or parts of formations containing sufficient saturated permeable material able to yield sufficient quantities of water.

cfs Cubic feet per second, a rate of flow.
1 cfs = 450 gallons per minute
1 cfs = 646,360 gallons per day
1 cfs = 1.983 acre-feet per day

Change in Groundwater Storage The change in volume of water retained by subsurface aquifers within the groundwater basin. A negative change reflects the fact that extractions have exceeded recharge.

Confined Aquifer A groundwater-bearing stratum constrained at its upper surface by an impervious unit, such as a regional clay.

Corcoran Clay A thick, impermeable layer of clay which lies under much of the San Joaquin Valley. This clay layer separates the groundwater basin into two distinct aquifers. One region, referred to as the "unconfined" aquifer, lies above the Corcoran Clay. The other region, referred to as the "confined" aquifer, lies entirely below the Corcoran Clay.

CVC The Cross Valley Canal.

CVP The federal Central Valley Project. The Friant-Kern Canal is its major feature in Kern County.

DWR California Department of Water Resources. The operators of the State Water Project (California Aqueduct).

Electrical Conductance (EC) A measure of the ability of water to conduct an electrical current, which can be related to the concentration of total dissolved solids. The normal unit of measurement is micromhos per centimeter.

Groundwater Basin An area underlain by one or more permeable formations (aquifers) capable of furnishing a substantial and beneficial water supply. The basin referred to in this report is within the San Joaquin Valley portion of Kern County but is connected hydrologically and geologically to a larger basin.

Groundwater Recharge Any act of nature or man which replenishes or adds water to that supply which is stored within the natural subsurface aquifer system.

In-lieu Recharge The process of recharging groundwater supplies by substituting surface water for groundwater that would otherwise be extracted.

Irrigation Efficiency The amount of applied irrigation water that actually goes to satisfy net crop water demands, expressed as a percent.

Metric Conversions

Acre-feet (x) 1233.5 = cubic meters
Acre-feet (x) 0.0012335 = cubic hectometers
Feet (x) 0.0348 = meters
Inches (x) 2.54 = centimeters
Million gallons per day (x) 0.043813 = cubic meters per second

Overdraft A long-term condition in which groundwater extractions exceed groundwater recharge.

Sacramento River Index An index used by the California Department of Water Resources to forecast available water supplies and SWP delivery capabilities. The index consists of the forecasted or computed unimpaired flows of the Sacramento River near Red Bluff, Feather River at Oroville Reservoir, Yuba River at Smartville and American River at Folsom Reservoir.

SWP The State Water Project. In Kern County, its major feature is the Edmund G. Brown California Aqueduct.

TDS Total dissolved solids. A measurement of the dissolved matter in water, consisting mainly of inorganic salts, and small amounts of organic matter and gases. Usually measured in parts per million (ppm).

Unconfined Aquifer A groundwater bearing stratum that is not constrained at its upper surface by an impervious or semi-impervious unit, such as a regional clay.

USBR United States Bureau of Reclamation. The operators of the Federal Central Valley Project.

INTRODUCTION

The Kern County Water Agency was created by the California Legislature in July 1961 and ratified by the electorate of Kern County in September 1961. The Agency was granted the primary power to acquire and contract for water supplies for Kern County, with additional powers to control flood and storm waters, to drain and reclaim land, to store and reclaim water, to protect the quality of underground waters, and to conduct investigations relative to water resources. The primary focus of the Agency, working with other water entities, is to coordinate management of the water supplies of Kern County, with particular emphasis on State Water Project supplies, in order to enhance our local economy.

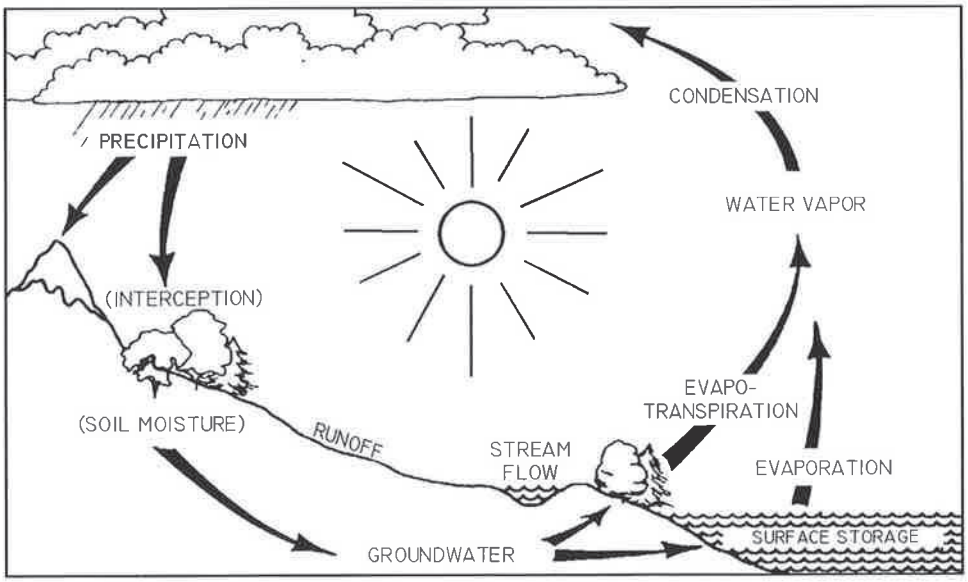
Since its beginning in 1961, the Agency has been building a base of information on the water supply and demand characteristics of the San Joaquin Valley portion of Kern County. Since 1977, the Agency has published the annual Water Supply Report in order to present these statistics in one document and to assist water leaders and users in making water management decisions.

The Water Supply Report attempts to identify and quantify the interrelationships of the hydrologic cycle (see Figure 1) with human activities in Kern County. For instance, the planting and harvesting of crops has altered the natural pattern of evapotranspiration. Groundwater storage has been affected by the groundwater pumping and recharge, as the agricultural, municipal and industrial sectors attempt to meet their expanding needs. Local surface storage facilities and contracts for imported surface supplies have lessened our dependence upon groundwater supplies. Also, coordinated groundwater recharge efforts have had a positive effect on groundwater.

The net result of the interactions between the available water supplies and the various demands for that water is a change in groundwater storage and groundwater quality. The Water Supply Report documents these changes and their causes.

All supporting data and calculations used to prepare this report are on file at the Agency and are open to public review.

Figure 1. The Hydrologic Cycle



1997: A WET, WET START AND FINISH

1997 started with a blast of precipitation. Initial State Water Project (SWP) allocations in December 1996 were only 70 percent, but due to a slight eastern Pacific El Niño condition, January's weather patterns set records. January 1997 saw precipitation at 226 percent of average and on January 2 peak inflow to Lake Oroville set a record of 320,000 cubic feet per second. DWR estimated that about three million acre-feet of water flowed out through the Sacramento-San Joaquin Delta during the first seven days of 1997. This is enough water to fill Lake Isabella over five times.

During early 1997 Tulare Lake bed (north of Kern County) flooded to such an extent that 41,000 acres of farmland were covered by 248,000 acre-feet of water from Sierra runoff. By mid-February, SWP allocations were raised to 100 percent, making 1997 the third straight year of 100 percent SWP supplies.

April, May and June, however, were very dry, causing snowpack to melt rapidly. Thus, while water users had more than enough water earlier in the year, by summer runoff was at record lows. This negatively impacted the operational flexibility of the SWP and Central Valley Project (CVP) due to federal Endangered Species Act pumping restrictions.

By fall, one of the largest El Niño conditions ever observed had formed in the eastern equatorial Pacific Ocean. Weather forecasters accurately predicted that water year 1997-98 would have "wetter than normal" conditions over most of the southern U.S. Those predictions materialized into fact in late September when an El Niño-derived hurricane moved north from Mexico and drenched southern California and Kern County.

The water year finished with a Sacramento River Index (SRI) of 25.2 million acre-feet, and statewide snowpack at 85 percent of average. Table 1 is a history of Sacramento River indices; Figure 2 shows the same information as a graph.

By February 1997 Central Valley Project allocations were at 100 percent for south of Delta ag contractors. Friant CVP contractors were approved for 100 percent of Class I supplies and 60 percent of Class II supplies. By May, south of Delta ag contractors were reduced to 90 percent of normal water supplies while Friant dropped to 100 percent Class I and 30 percent Class II allocation.

Kern County surface water supplies from all sources during 1997 were about 3,170,200 acre-feet. Normal supplies are about 2,200,000 acre-feet. Therefore, water availability was about 144 percent of normal. SWP entitlement deliveries from all sources totaled 1,303,900 acre-feet, or about 117 percent of entitlement. Kern River supplies were 1,136,441 acre-feet, about 157 percent of average. Central Valley Project deliveries totaled 630,026 acre-feet, or 158 percent of the 1975-97 average. However, 1997 surface water supplies were less than in 1995, while both agricultural and municipal and industrial (M&I) demand increased. This therefore caused increases in groundwater pumping in areas with groundwater sources.

Because of the relatively good water supply conditions, about 906,800 acres of farm land was cropped. Total irrigated acreage was 886,700 acres, just 6,000 acres more than in 1996.

Change in groundwater storage in 1997 was an increase of 305,300 acre-feet. Total direct recharge in 1997 was 830,300 acre-feet. Total withdrawals since 1970 have been about 15,100,000 acre-feet. Total additions to storage over the same period have been about 4,800,000 acre-feet. The

net change in storage since 1970 has been a net loss of about 10,300,000 acre-feet, or about 368,000 acre-feet per year. In terms of the volume of water stored, the groundwater basin is at a level lower than the last drought in 1976-77. During the six years of the 1987-92 drought, groundwater storage was reduced by about 5,5120,000 acre-feet (about 919,000 acre-feet per year).

BAY-DELTA ACCORD AND THE CALFED BAY-DELTA PROCESS

On December 15, 1994 the Bay-Delta Accord was signed by federal and state agencies that had been working to develop new water quality standards for the Sacramento-San Joaquin Delta, the hub of California's water supply system. The Accord was also signed by various "stakeholders:" environmental advocacy organizations, and agricultural and urban water agencies that rely upon Delta water. The Accord had an initial three-year term, and provided an average of 300,000 acre-feet of additional outflow for fish and wildlife, which could go as high as 1,100,000 acre-feet in a critically dry year. In exchange, water suppliers received assurances that federal Endangered Species Act (ESA) "take" limits would not further impact water supplies, a moratorium on new ESA listings was put in place, and a program for determining a long-term plan to fix the Delta's environmental and water supply problems was put in place. The CALFED Bay-Delta Program, as it is called, was in its third year of existence in 1997.

CALFED is made up of the staffs of the state and federal agencies that signed the Bay-Delta Accord. State agencies include the Department of Water Resources, Fish and Game, California Environmental Protection Agency and the State Water Resources Control Board. Federal agencies include the Environmental Protection Agency, the U.S. Fish and Wildlife Service, the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Natural Resources Conservation Service and National Marine Fisheries Service. In addition, a federally chartered citizens advisory committee, the Bay-Delta Advisory Council (BDAC) was formed to provide input to CALFED staff throughout the process. Kern County has two representatives on the council, one representing KCWA and one representing the Friant Water Users Authority and Arvin-Edison Water Storage District.

The CALFED Program is guided by four "solution principles": the Delta solution must be affordable, equitable, implementable, and have no significant redirected impacts. The solution must meet the needs of four fundamental problems in the Delta: water supply reliability, water quality, ecosystem quality and levee system vulnerability. While any proposed solution is being considered and weighed against these principles during CALFED's public review process, the "Preferred Alternative" Delta solution will contain four "Common Programs": Ecosystem Restoration, Water Use Efficiency, Water Quality and System Vulnerability. These four common program elements will be implemented regardless of what final preferred alternative is chosen to solve the Delta's problems.

These common programs are the topic of much debate. The Water Use Efficiency Common Program in its original form was of particular interest and concern to Kern County, because it contained recommendations for the retirement of large areas of farmland (up to 800,000 acres) in the San Joaquin Valley. This recommendation was intended to free up water being used for irrigation purposes, with the added purpose of decreasing agricultural runoff into the San Joaquin River. While voluntary land retirement programs, such as that promulgated under the Central Valley Project Improvement Act, can be fairly administered, a very large program like that proposed by CALFED would have serious impacts on the economy of the San Joaquin Valley and

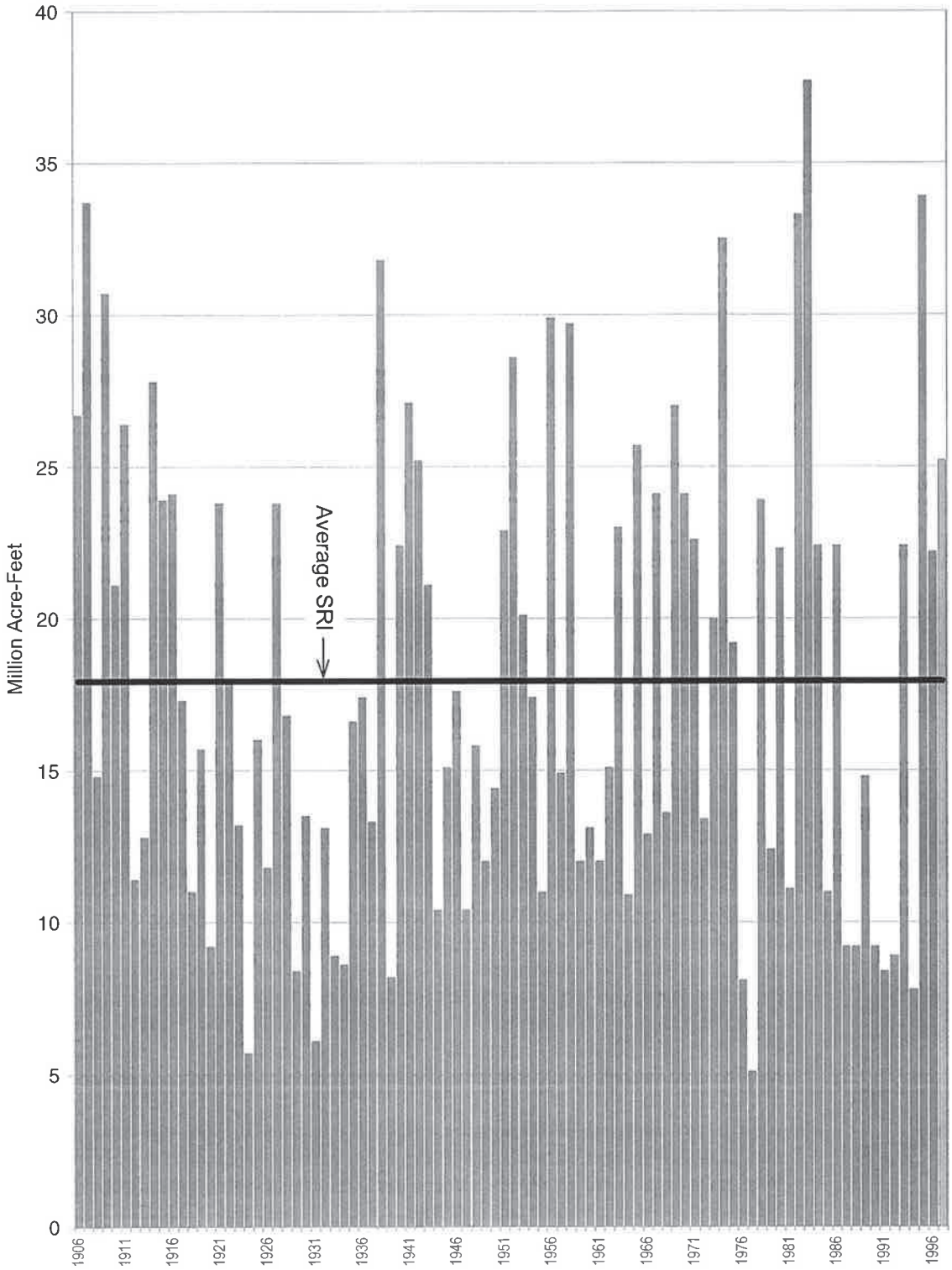
Table 1. Sacramento River Indices* (in million acre-feet)

Descending Order by Year				Ascending Order by Index			
Year	Index	Year	Index	Year	Index	Year	Index
1997	25.2	1951	22.9	1977	5.1	1935	16.6
1996	22.2	1950	14.4	1924	5.7	1928	16.8
1995	33.9	1949	12.0	1931	6.1	1917	17.3
1994	7.8	1948	15.8	1994	7.8	1954	17.4
1993	22.4	1947	10.4	1976	8.1	1936	17.4
1992	8.9	1946	17.6	1939	8.2	1946	17.6
1991	8.4	1945	15.1	1929	8.4	1922	18.0
1990	9.2	1944	10.4	1991	8.4	1975	19.2
1989	14.8	1943	21.1	1934	8.6	1973	20.0
1988	9.2	1942	25.2	1992	8.9	1953	20.1
1987	9.2	1941	27.1	1933	8.9	1943	21.1
1986	22.4	1940	22.4	1990	9.2	1910	21.1
1985	11.0	1939	8.2	1988	9.2	1996	22.2
1984	22.4	1938	31.8	1987	9.2	1980	22.3
1983	37.7	1937	13.3	1920	9.2	1993	22.4
1982	33.3	1936	17.4	1947	10.4	1986	22.4
1981	11.1	1935	16.6	1944	10.4	1984	22.4
1980	22.3	1934	8.6	1964	10.9	1940	22.4
1979	12.4	1933	8.9	1985	11.0	1971	22.6
1978	23.9	1932	13.1	1955	11.0	1951	22.9
1977	5.1	1931	6.1	1918	11.0	1963	23.0
1976	8.1	1930	13.5	1981	11.1	1927	23.8
1975	19.2	1929	8.4	1912	11.4	1921	23.8
1974	32.5	1928	16.8	1926	11.8	1978	23.9
1973	20.0	1927	23.8	1961	12.0	1915	23.9
1972	13.4	1926	11.8	1959	12.0	1970	24.1
1971	22.6	1925	16.0	1949	12.0	1967	24.1
1970	24.1	1924	5.7	1979	12.4	1916	24.1
1969	27.0	1923	13.2	1913	12.8	1942	25.2
1968	13.6	1922	18.0	1966	12.9	1997	25.2
1967	24.1	1921	23.8	1960	13.1	1965	25.7
1966	12.9	1920	9.2	1932	13.1	1911	26.4
1965	25.7	1919	15.7	1923	13.2	1906	26.7
1964	10.9	1918	11.0	1937	13.3	1969	27.0
1963	23.0	1917	17.3	1972	13.4	1941	27.1
1962	15.1	1916	24.1	1930	13.5	1914	27.8
1961	12.0	1915	23.9	1968	13.6	1952	28.6
1960	13.1	1914	27.8	1950	14.4	1958	29.7
1959	12.0	1913	12.8	1989	14.8	1956	29.9
1958	29.7	1912	11.4	1908	14.8	1909	30.7
1957	14.9	1911	26.4	1957	14.9	1938	31.8
1956	29.9	1910	21.1	1962	15.1	1974	32.5
1955	11.0	1909	30.7	1945	15.1	1982	33.3
1954	17.4	1908	14.8	1919	15.7	1907	33.7
1953	20.1	1907	33.7	1948	15.8	1995	33.9
1952	28.6	1906	26.7	1925	16.0	1983	37.7

92 year average	17.9
92 year median	16.3
Minimum (1977)	5.1
Maximum (1983)	37.7

* An index used by the California Department of Water Resources to forecast available water supplies and SWP delivery capabilities. The index consists of the forecasted or computed unimpaired flows of the Sacramento River near Red Bluff, Feather River at Oroville Reservoir, Yuba River at Smartville and American River at Folsom Reservoir.

Figure 2. Sacramento River Indices



the state of California. For this reason, the program does not appear to meet the solution principle of "no significant redirected impacts."

As part of its Phase I process, which was designed to result in a set of proposed alternative solutions for the problems of the Bay-Delta, CALFED conducted an extensive series of formal public hearings around the state in 1996 in order to take comments on its initial program recommendations. These were devised by the CALFED agencies with input from BDAC. After extensive hearing around the state, CALFED had devised three preferred alternatives.

The alternatives are:
1) Reoperation of Existing System Conveyance, where little or no modifications are made to the flow capacity of existing Delta channels. Benefits include improved operational flexibility, continued use of existing conveyance system, and less disturbance of habitat in and adjacent to existing channels, as well as to existing land uses. Concerns include continued fish entrainment at pumps, no improvement in Delta water quality, and continued high salinity of agricultural return flows to the San Joaquin River.

2) Through-Delta Conveyance, where a variety of modifications to Delta channels could be made to increase the conveyance efficiency. Benefits include improved operational flexibility, improved fishery habitat, and creation of a more efficient method of transferring water to pumps. Concerns include habitat corridors combined with conveyance channels adversely impacting fish entrainment, temporary construction impacts on aquatic environments due to dredging, significant technical challenges in designing an efficient fish screening system, in-Delta land use impacts, and possible total Delta outflow reduction.

3) Dual Delta Conveyance, where a combination of improved through-Delta conveyance, as well as conveyance isolated from Delta channels, is used. Benefits include improved operational flexibility, more flexibility to increase supply while avoiding fishery impacts, improved water quality, and possible improved quality of agricultural return flows to the San Joaquin River. Concerns include hydrologic and biologic studies required to identify quantity and timing windows for water diversion into storage, construction of isolated conveyance facility affecting wetland and terrestrial habitats and land uses, significant technical challenges in designing an efficient fish screening system, and possible total Delta outflow reduction. CALFED indicates that evaluations for Alternative 3 will include extensive study of the isolated conveyance portion in order to find an optimal range of combined through-Delta and isolated conveyance for this alternative.

In early 1997 it became clear that CALFED was having difficulties developing a Preferred Alternative. By March CALFED was in the Phase II process to subject the three alternatives to rigorous assessment with the goal of producing a preferred alternative for a draft PEIS/R by October. CALFED staff and consultants, augmented by stakeholders' staff, refined specific components of the alternatives, primarily the "Common Elements" (those elements which will be the same regardless of final alternative analyzed in the PEIS/R. The Bay-Delta Advisory Council (BDAC) had workgroups analyzing efficient water use, water quality, ecosystem restoration, assurances and financing. Staff and consultants analyzed storage and conveyance options.

During the late spring and early summer CALFED examined the inter-relationships between the Delta solution components, the Common Programs and the alternatives. Public workshops were held to gather comments on the three alternatives, facility operations concepts, adaptive management strategies for environmental restoration, financing strategies and assurances. Area of origin concerns, water supply increases, land retirement issues, and the development of an attainable

Ecosystem Restoration Plan were among the major topics mentioned by participants in their comments.

This same year, the Environmental Water Caucus sent a letter to CALFED outlining their position on how the Bay-Delta should be fixed. Their position was that structural solutions were unacceptable, assurances must be provided that extensive ecosystem restoration will take place and that diversions of water from the Bay-Delta watershed must be reduced. This extreme position seemed to indicate that the EWC would support CALFED's water supply component only if it resulted in a reduced water supply.

In May 1997 a real flap occurred regarding water project operations. The CALFED Ops Group recommended a 1997 spring export reduction and pulse flows to benefit out-migrating San Joaquin River salmon, a step beyond the requirements of the Bay-Delta Accord. However, the Accord does contain a provision allowing for operations to protect listed species which are outside the Accord, provided that such operations result in no-net-loss of water to the projects.

What created concern was a proposal by the U.S. Bureau of Reclamation to make up the water using CVPIA (B) (2) water. Water users sent a letter to CALFED objecting to this, mainly because it could result in lower water allocations to CVP contractors.

Environmentalists maintained that the no-net-loss provision should not apply, since CVPIA (B)(2) water could be used to make up the lost water. They also suggested that the no-net-loss provision in the Accord was not meant to guarantee that water needed for environmental purposes would not impact water user deliveries. The CALFED Ops Groups outlined a solution where USBR and DWR could make up the water in several ways, including relaxing Delta water quality standards and CVPIA actions. Environmentalists voiced opposition to those solutions, so the CALFED Ops Group eventually outlined a plan which did not relax water criteria but depended on reservoir re-operations and MWD shifting its demand schedule.

The situation worsened in July when the U.S. Fish and Wildlife Service (FWS) decided that portions of the 800,000 acre-feet of (B) (2) water could be applied above and beyond the Bay-Delta Accord. This ran counter to the "deal is a deal" principles of the Accord that no additional water above those quantities was required to meet the Accord's standards for federal regulatory actions. Environmentalists said no such deal existed.

FWS maintained that the 800,000 acre-feet of (B)(2) water should be used for additional Delta fishery benefits, above the Accord. Water users were deeply troubled at the prospect of losing significantly more than the 1.1 million acre feet agreed to in the Accord.

The fact that FWS wanted to give the 800,000 acre-feet preferential treatment above CVP contractor deliveries and only share shortages in critically dry years could only worsen the impact on CVP water users in almost all years.

Another troubling principal was that FWS intended to establish a "water reserve account" whereby (B)(2) water not used in a year could be carried over and used at a later time at the complete discretion of FWS. In a wet year FWS could argue that none of the (B)(2) water was needed and hold the entire 800,000 acre-feet in reserve. If there were following dry years, FWS could then operate as if it had 1.6 million acre-feet of (B)(2) water to work with. This would create major problems for CVP contractors.

This apparent reneging prompted water users to consider the FWS proposals a serious threat to the Bay-Delta Accord and the CALFED program. Letters were written to all levels of federal government, pointing out the critical need to maintain federal-state relations in the CALFED process.

WATER SUPPLIES

State Water Project (SWP)

The year began with three exceptionally wet months which resulted in DWR granting a 100 percent allocation by February 1997. However, three very dry months followed. The combined February through May precipitation totals for northern California watersheds placed them as the driest on record for the past 70 years.

This unique hydrology resulted in project operations being impacted by Delta Smelt. Since the water year was technically classified as a wet year, the combined smelt take in May at the state and federal export facilities was about 29,000, which exceeded the wet year May take limit of 9,000. Pumping restrictions were extended past the May 15 deadline. Export pumping was reduced by 1,000 cfs for five days. Later measures were taken to make up for the shortfall and DWR was able to pump additional water during June.

The chronology of 1997 allocations follow:

December 1, 1996	70% (initial allocation)
February 11, 1997	100%
March 8, 1997	100% (final allocation)

Member Units' contract entitlements for 1990 and after are shown on Table 2. The table also breaks out entitlement between municipal and industrial (M&I) and agricultural uses. While the M&I entitlement is small compared to the agricultural, KCWA is the third largest M&I contractor with the SWP, and is the largest agricultural contractor.

A total SWP supply of 1,339,911 acre-feet was available during 1997, including 1,112,730 acre-feet of SWP entitlement, 26,088 acre-feet of "Interruptible Water," and 185,298 acre-feet of SWP water transferred into Kern County by other entities. A total of 1,303,900 acre-feet of SWP water was actually delivered during 1997. Since the first deliveries in 1968, over 24 million acre-feet of SWP water has been brought into Kern County. A graph of historic SWP deliveries is provided in Figure 3. Table 3 provides a history of SWP deliveries, with annual and cumulative deliveries and imports. Table 4 shows 1997 SWP deliveries by contract type.

Kern River

The new year had just begun when a warm, subtropical stormtrack, having deluged northern and central California for much of the previous week, moved south into the Kern River Basin. The result was extreme rainfall in the higher elevations of the watershed. By the early morning of January 3, 1997 the North Fork of the Kern River had amassed flood flows in excess of 32,000 cubic feet per second, threatening the banks upstream from Lake Isabella. Full natural flow for January 3 was 19,794 cubic feet per second, the third highest Kern River flow this century, exceeded only by the great rains in December 1966 and January 1969.

Kern River runoff during January 1997 reached 246,022 acre feet, maximum of record, nearly 700 percent of normal January runoff.

By the first of February, all had changed and a dry spring followed. The final tally for Kern River 1997 April-July snowmelt runoff at First Point of measurement was 571,476 AF, 122 percent of normal.

Kern River Snow Pack (in inches of water content)

	Apr 1 1995	Apr 1 1996	Apr 1 1997	Apr 1 Avg	1997% of Avg
Upper Tyndall Cr.	34.0	29.9	40.8	27.7	147
Crabtree Meadow	27.7	19.0	21.6	19.8	110
Chagoopa	34.6	25.5	29.2	21.8	134
Pascoe	53.8	37.7	37.7	24.9	151
Wet Meadow	43.2	21.4	19.0	30.3	63
Tunnel Guard	27.1	14.0	12.7	15.6	81
Casa Vieja Meadow	29.5	17.8	17.6	20.9	84
Beach Meadows	13.2	4.1	0.3	11.0	3
Average	**32.9"**	**21.1"**	**22.4"**	**21.5"**	**104% of Avg**

The outlook for Kern River supplies improved during the April-July snowmelt period as the water year progressed, as shown below:

February, 1997	69% of average
March	100%
April	115%
May	117%
Final	126% (final runoff)

Table 5 shows historic Kern River runoff and cumulative runoff for the 104 years of complete record, including diversions above First Point. In 1997 a total of 1,133,463 acre-feet of Kern River water flowed past First Point of Measurement. An additional 2,978 acre-feet was diverted above First Point. Total 1997 Kern River flows were1,136,441 acre-feet, about 157 percent of average. During the last 104 years, the Kern River has yielded more than 76 million acre-feet of runoff. Since Isabella Dam began regulating flows in 1954, nearly 32 million acre-feet of runoff has occurred. Figure 4 is a histograph of annual Kern River flows at First Point. Table 6 gives a summary of Kern River deliveries by entity in 1997. Plate 10 shows major canal distribution facilities operated by water districts that receive Kern River entitlement.

In November 1996, KCWA and the City of Bakersfield agreed to develop a joint operating agreement for flows in the Kern River. This landmark cooperative program will allow the Kern River to flow during periods of upstream demand when the river would normally be dry. Under the terms of the agreement, KCWA will not have to pay incremental costs above the cost to recharge water in its own Pioneer Project spreading ponds, which will encourage spreading and banking in the Kern River channel instead. KCWA Improvement District No. 4 and the City are developing an operations plan, which aims toward providing additional flows in the river between May and September, even during years when conditions are very dry. It is expected that this agreement will enhance recreational uses of the Kern River, as well as improve aesthetics of the river channel area.

Central Valley Project (CVP)

Just as for the SWP, the downpours in January meant initial, almost-full allocations for the Central Valley Project. The allocation for south of Delta contractors started at 100 percent. Friant CVP contractors were approved for 100 percent of Class I supplies and 60 percent of Class II supplies. By May, south of Delta Ag Contractors were reduced to 90 percent of normal water supplies while Friant dropped to a 30 percent allocation for Class II supplies.

Following is a chronology of CVP water allocations:

	Friant-Kern Supplies	CVP Delta Supplies
January 17, 1997	100% Class I, 60% Class II	75% Class I
February 14, 1997	100% Class I, 52% Class II	100% Class I
April 17, 1997	100% Class I, 25% Class II	90% Class I
May 1997	100% Class I, 30% Class II	90% Class I (Urban 100%)

Table 7 shows 1997 deliveries of CVP water by entity. As shown, 106,073 acre-feet of Class I entitlement and 369,697 acre-feet of Class II water was delivered. A total of 12,034 acre-feet of "Section 215" water was delivered in 1997, most of which was delivered to KCWA for groundwater recharge and banking programs. Also, 142,223 acre-feet of other CVP water was imported into Kern County becuase of lack of recharge capacity, much of which entered the Kern River-California Aqueduct Intertie.

Table 8 displays annual and cumulative deliveries of CVP water since 1950, when the first importations were made to Kern County. Figure 5 is a histograph of CVP deliveries since 1970. From 1950 to 1997, over 14 million acre-feet of CVP water was imported into Kern County.

Minor Streams

Local "minor stream" watersheds are the second largest local source of water, after the Kern River. Streams which yield measurable surface runoff are grouped into four watershed areas: the Poso group (including Poso Creek), the Caliente group (including Caliente and Tehachapi Creeks), the El Paso group (including El Paso Creek), and the San Emigdio group (including San Emigdio Creek). Grouping of minor streams is based upon hydrologic similarity of the watersheds and representative gauging records. Minor stream flows can be substantial during above-average precipitation years, such as 1982, 1983 and 1986.

Runoff for ungauged streams is estimated by statistical methods based on historic relationships of the watershed area, precipitation and runoff for similar gauged streams. Gauges are in place on Poso and Tehachapi Creeks, and therefore actual measurements can usually be used for these watersheds. (KCWA, in cooperation with local water districts, monitors stream flows on Poso and Tehachapi Creeks). However, in very dry years the flow on Tehachapi Creek is too small for the gauge to record. In this report, flows are assumed to occur at the foothill line before they disappear into the valley alluvium. Total minor stream volumes in 1997 were estimated to be about 100,000 acre-feet as follows:

Stream Group	Acre-feet
Poso	75,400
Caliente	8,300
El Paso	4,100
San Emigdio	12,200
Total	**100,000**

The amount computed for minor stream volumes only reflect surface flows. There may also be subsurface flows in minor streams which add to basin storage. These subsurface flows may be significant but as yet their volume is unknown.

Some minor stream water is used for irrigation by farmers in the North Kern Water Storage District and Semitropic WSD. Much of the remaining water percolates to the underlying aquifer. Some of this recharge probably contributes to the shallow groundwater in the Kern Lake Bed area and near the Kern National Wildlife Refuge. KCWA estimated that about 95,000 acre-feet of the minor stream flows during 1997 contributed to groundwater recharge. Table 9 shows annual minor stream runoff, along with cumulative runoff since 1970. The variability of minor stream flows is shown by the accompanying statistics, and shown graphically in Figure 6. Figure 7a shows the hydrograph for Poso Creek in 1997. Figure 7b shows cumulative runoff for Poso Creek for the year.

Effective Precipitation

Rainfall that occurs during the growing season of a crop or that is stored in the soil for later use can reduce the total volume of water that needs to be imported or withdrawn from groundwater supplies. Rainfall can provide an alternate water supply called "effective precipitation."

Only that portion of rainfall that satisfies crop water requirements can properly be called effective precipitation. A large portion of rainfall evaporates from the soil surface and the soil profile before the crop can use it. Timing of rainfall is also an important factor in determining its effectiveness. During years of extremely heavy rainfall a small amount may percolate past the crop root zone and recharge the underlying aquifer, particularly during early stages of crop growth, thus becoming unavailable to the crop. In addition, heavy rain immediately after an irrigation cycle may not be useable by a crop.

Most urban storm runoff is captured in unlined sumps and allowed to percolate. This runoff is not usually measured. A small amount of storm runoff is diverted into the Kern River, where it becomes available for delivery or recharge. About 300 acre-feet of urban runoff was diverted into the Kern River system in 1997.

KCWA gathers monthly rainfall data for most of the measuring stations in the San Joaquin Valley portion of Kern County, along with data for some mountain stations. This rainfall data is used to compute effective precipitation and minor stream runoff. Table 10 gives monthly rainfall for every measuring station gathered by KCWA. Rainfall in 1997 contributed 105,600 acre-feet of effective precipitation, with 94,100 acre-feet occurring over the useable groundwater basin. This excludes urban storm water diverted into the Kern River. Rainfall at Meadows Field Airport near Bakersfield in 1997 was 102 percent of average, about 27 percent lower than 1996. Following is a tabulation of 1994-97 and average monthly rainfall (in inches) for Meadows Field. KCWA estimates that rainfall provided about 1.4 inches of useable water for crops grown during 1997.

Table 2. Kern County Water Agency, Member Unit Contract Entitlements for 1997-2035 (in acre-feet)

Member Unit	Firm	Surplus [1]	Former Table 1 Entitlement [2]	Firm Entitlement		
				M&I	Ag	Total
Berrenda Mesa WD	155,100	8,100	163,200		155,100	155,100
Lost Hills WD	134,110	0	134,110	2,000 [3]	132,110	134,110
Belridge WSD	147,665	0	147,665	15,000 [3]	132,665	147,665
Buttonwillow ID	83,000	13,100	96,100		83,000	83,000
Pond Poso ID	67,000	11,100	78,100		67,000	67,000
Semitropic WSD	5,000	562	5,562		5,000	5,000
Cawelo WD	38,200	6,800	45,000		38,200	38,200
Improvement District No. 4	82,946	899	83,845	77,000	5,946	82,946
Rosedale-Rio Bravo WSD	29,900	5,100	35,000		29,900	29,900
Buena Vista WSD	21,300	3,750	25,050		21,300	21,300
Kern Delta WD	25,500	4,500	30,000		25,500	25,500
Henry Miller WD	35,500	6,250	41,750		35,500	35,500
West Kern WD	25,000	0	25,000	25,000		25,000
Wheeler Ridge-Maricopa WSD	238,088	35,907	273,995		238,088	238,088
Tehachapi-Cummings CWD	19,300	700	20,000	15,000	4,300	19,300
Tejon-Castac WD	5,121	471	5,592	2,000	3,121	5,121
Total	**1,112,730**	**97,239**	**1,209,969**	**136,000**	**976,730**	**1,112,730**

Note: Maximum annual entitlement was reached in 1990.

[1] Per the Monterey Agreement surplus water was removed from the Member Unit contracts. Surplus water entitlements are still used in the allocation of interruptible water in proportion to the Member Unit's Former Table 1 Entitlements, if demands for interruptible water are greater than the supply of interruptible water (see footnote 2).

[2] Former Table 1 Entitlement is the Member Unit's contract entitlement plus the amount of surplus water (see footnote 1).

[3] Agricultural entitlement converted to M&I use.

Table 3. SWP Deliveries to the San Joaquin Valley Portion of Kern County (in acre-feet)

Year	Annual [1] Deliveries	Cumulative Deliveries	Intertie Deliveries	Deliveries [2] Outside SJV	Annual Importations	Cumulative Importations
1968	127,384	127,384			127,384	127,384
1969	141,265	268,649			141,265	268,649
1970	204,634	473,283			204,634	473,283
1971	375,505	848,788			375,505	848,788
1972	535,573	1,384,361			535,573	1,384,361
1973	515,546	1,899,907		25	515,521	1,899,882
1974	656,773	2,556,680		4,992	651,781	2,551,663
1975	828,437	3,385,117		6,699	821,738	3,373,401
1976	888,112	4,273,229		4,755	883,357	4,256,758
1977	432,837	4,706,066		3,424	429,413	4,686,171
1978	678,400	5,384,466	64,100	2,826	611,474	5,297,645
1979	1,295,388	6,679,854		3,630	1,291,758	6,589,403
1980	968,092	7,647,946	64,792	3,041	900,259	7,489,662
1981	1,386,641	9,034,587		1,897	1,384,744	8,874,406
1982	900,973	9,935,560	13,679	2,791	884,503	9,758,909
1983	601,183	10,536,743	365,505	724	234,954	9,993,863
1984	1,138,040	11,674,783	13,639	1,360	1,123,041	11,116,904
1985	1,078,147	12,752,930		4,015	1,074,132	12,191,036
1986	929,178	13,682,108	12,701	2,916	913,561	13,104,597
1987	1,028,124	14,710,232		2,217	1,025,907	14,130,504
1988	1,009,520	15,719,752		3,307	1,006,213	15,136,717
1989	1,146,062	16,865,814		48,833	1,097,229	16,233,946
1990	862,448	17,728,262		21,643	840,805	17,074,751
1991	34,865	17,763,127		2,213	32,652	17,107,403
1992	421,520	18,184,647		3,508	418,012	17,525,415
1993	1,219,653	19,404,300		14,139	1,205,514	18,730,929
1994	711,002	20,115,302		15,616	695,386	19,426,315
1995	1,219,146	21,334,448		107,950	1,111,196	20,537,511
1996	1,335,394	22,669,842		88,209	1,247,185	21,784,696
1997	1,303,900	23,973,742		231,659	1,072,241	22,856,937

Mean Deliveries	781,719 AF	Minimum Deliveries (1991)	34,886 AF
Median Deliveries	875,280 AF	Maximum Deliveries (1981)	1,386,641 AF
Mean Importations	759,819 AF	Minimum Importations (1991)	32,673 AF
Median Importations	870,347 AF	Maximum Importations (1981)	1,384,744 AF

[1] Includes Pre-consolidation water deliveries, 1977 Dry Year Pool, 1991 State Bank water.

[2] Includes Tehachapi-Cummings CWD and other deliveries outside the San Joaquin Valley portion of Kern County. Beginning in 1990, also includes local groundwater programs.

Figure 3. State Water Project Deliveries to Kern County Water Agency

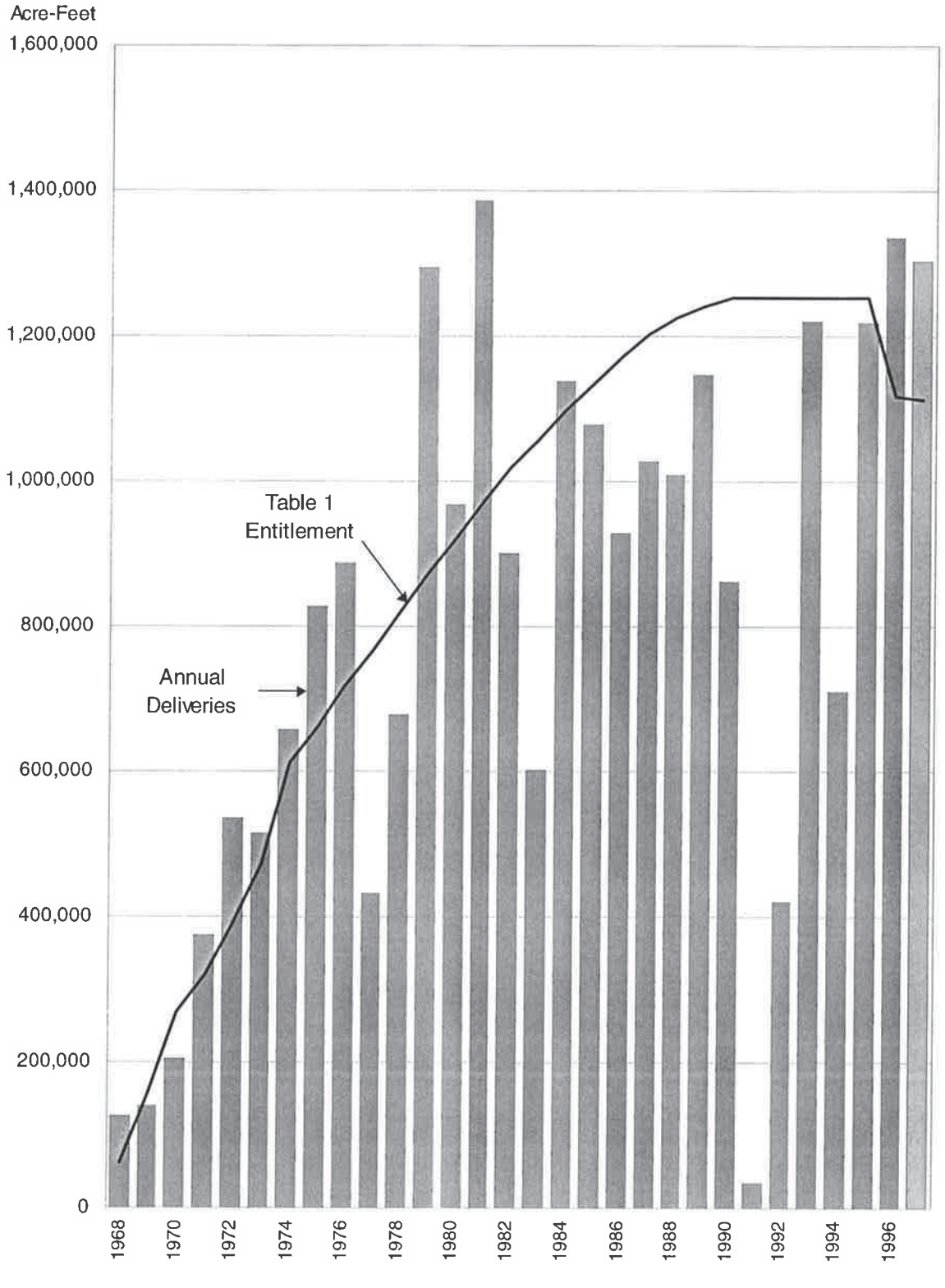


Table 4. 1997 State Water Project Deliveries by Contract (in acre-feet)

	(1)	(2)	(3)	(4)	(4)	(5)
	SWP Water Supplies					
District	Table 1 Entitlement	Interruptable Water Program Allocation	Total SWP Supply	Kern River Intertie Flood Water (1) (no charge)	Landowner Transfers Out of Kern County	Misc. Transfers Out of Kern County
Berrenda Mesa WD	155,100	3,213	158,313		(13,020) (2)	
Lost Hills WD	134,110	15,912	150,022		(13,500) (3)	(1,500) (6)
Belridge WSD	147,665	6,963	154,628		(7,500) (4)	
Semitropic WSD	155,000		155,000	282		
Cawelo WD	38,200		38,200			
Improvement Dist. No. 4	82,946		82,946	406		(2,500) (7)
Rosedale-Rio Bravo WSD	29,900		29,900			
Buena Vista WSD	21,300		21,300	891		
Kern Delta WD	25,500		25,500			
Henry Miller WD	35,500		35,500	231		
West Kern WD	25,000		25,000			
Wheeler Ridge-Maricopa WSD	238,088		238,088	1,018	(5,000) (5)	
Tehachapi-Cummings CWD Ag	4,300		4,300			
Tehachapi-Cummings CWD M&	15,000		15,000			
Tejon-Castac WD AG	3,121		3,121	84		
Tejon-Castac WD M&I	2,000		2,000			
MWD (AEWSD)						
Westside Mutual WC				2,034		
Westlands WD			0		39,020	2,500 (7)
Tulare Lake Basin WSD			0			1,500 (6)
Dudley Ridge WD			0			
Dudley Ridge WD (KWB)			0	406		
DWR (KWB/Demo)			0			
Total	**1,112,730**	**26,088**	**1,138,818**	**5,352**	**0**	**0**

Note: This table shows contracted deliveries for calendar year 1997. District deliveries may vary from amounts shown, due to: (a) current year SWP/Kern River exchanges, (b) payback of SWP water from prior year exchanges, and (c) conjunctive use agreements.

(1) Kern River Intertie flood flows into the California Aqueduct and authorized for delivery via the Cross Valley Canal, Buena Vista Turnout No. 2 and No. 4.
(2) Landowner transfer (13,020 AF) to Westlands WD (Vista Verde = 1,520 AF; Woolf = 11,500 AF).
(3) Landowner transfer (13,500 AF) to Westlands WD (Shannon = 4,000 AF; Chevron = 5,000 AF; Woolf = 4,500 AF).
(4) Landowner transfer (7,500 AF) to Westlands WD (Chevron = 2,500 AF; Woolf = 5,000 AF).
(5) Landowner transfer (5,000 AF) to Westlands WD (Chevron).
(6) Transfer of 1,500 AF from Lost Hills WD to Tulare Lake Basin WSD to satisfy mitigation requirements associated with Lost Hills WD's evaporation basin.
(7) Transfer of 2,500 AF from ID4 to Westlands WD as repayment of a 1996 exchange whereby ID4 received a like quantity of Friant-Kern water (Dresick).

Table 4 (continued). 1997 State Water Project Deliveries by Contract (in acre-feet)

	(6)	(7)	(8)	(9)	(10)
District	**Westlands (8) Exchange Out of Kern County**	**Misc. Transfers Into Kern County**	**Misc. Transfers, Exchanges Other**	**ID4 Misc. & Simultaneous Exchanges**	**Kern River for SWP Exchange**
Berrenda Mesa WD	(43,000)		2,366 (12)		
Lost Hills WD		5,800 (9)	6,986 (13)		
Belridge WSD	(27,000)		867 (14)		
Semitropic WSD		170,000 (10)	(9,653) (15)		(2,124) (22)
Cawelo WD			(38,200) (16)		
Improvement Dist. No. 4			3,000 (17)	(50,331)	(18,542) (23)
Rosedale-Rio Bravo WSD	(9,140)		8,000 (18)	65	(9,334) (24)
Buena Vista WSD	(7,080)		57,375 (19)	50,000	
Kern Delta WD			(21,255) (16)		
Henry Miller WD			20,000		
West Kern WD	(7,080)		(17,920) (16)		
Wheeler Ridge-Maricopa WSD	(26,000)			86	
Tehachapi-Cummings CWD Ag	(1,700)				
Tehachapi-Cummings CWD M&I			(11,000) (20)		
Tejon-Castac WD AG	(2,000)		(566) (21)		
Tejon-Castac WD M&I	(2,000)			7	
MWD (AEWSD)		1,486			
Westside Mutual WC				173	
Westlands WD	125,000		10,443		30,000 (25)
Tulare Lake Basin WSD					
Dudley Ridge WD		2,670			
Dudley Ridge WD (KWB)		5,342 (11)			
DWR (KWB/Demo)					
Total	**0**	**185,298**	**10,443**	**0**	**0**

Note: This table shows contracted deliveries for calendar year 1996. District deliveries may vary from amounts shown, due to: (a) current year SWP/Kern River exchanges, (b) payback of SWP water from prior year exchanges, and (c) conjunctive use agreements.

(8) Transfer of 125,000 AF to Westlands WD in exchange for a like quantity of Friant-Kern water returned to the exchange participants within the next 10 years.
(9) Transfer from Dudley Ridge WD to Lost Hills WD on behalf of Paramount Farming Company.
(10) Includes storage transfers from Metropolitan Water District (125,000 AF), Santa Clara Valley WD (35,000 AF) and Alameda County WD (10,000 AF).
(11) Dudley Ridge WD transfer of entitlement (900 AF) and Interruptible water (4,442 AF) for storage in Kern Water Bank.
(12) Includes 566 AF from Tejon-Castac WD and 1,800 AF from Semitropic WSD in exchange for like quantities of KWB groundwater (from account of WMWC
(13) Includes 8,000 AF from Semitropic WSD in exchange for a like quantity of Interruptible water to ST during 1998 or 1999;
Includes 147 AF landowner transfer to Semitropic (LHUD); includes 867 AF landowner transfer to Belridge (Ritchie Farms).
(14) Includes landowner transfer (867 AF) from Lost Hills WD on behalf of C. J. Ritchie Farms.

Table 4 (continued). 1997 State Water Project Deliveries by Contract (in acre-feet)

District	(11) Friant-Kern for SWP Exchange	(12) Kern Water Bank Recovery	(13) Demo Program Water	(14) (Col 3..13) Total SWP Water Available
Berrenda Mesa WD	(1,200)			103,459
Lost Hills WD	(3,000) (26)	(11,338)		133,470
Belridge WSD		(2,000)		118,995
Semitropic WSD	(2,504) (26)	(1,851)	(10,033)	299,117
Cawelo WD				0
Improvement Dist. No. 4	(11,579)	(2,670)		730
Rosedale-Rio Bravo WSD			(3,558)	15,933
Buena Vista WSD			(9,300)	113,186
Kern Delta WD			(4,245)	0
Henry Miller WD				55,731
West Kern WD				0
Wheeler Ridge-Maricopa WSD		(6,671)		201,521
Tehachapi-Cummings CWD Ag				2,600
Tehachapi-Cummings CWD M&I				4,000
Tejon-Castac WD AG		(555)		84
Tejon-Castac WD M&I				7
MWD (AEWSD)				1,486
Westside Mutual WC				2,207
Westlands WD	18,283			225,246
Tulare Lake Basin WSD				1,500
Dudley Ridge WD		(2,670)		0
Dudley Ridge WD (KWB)				5,748
DWR (KWB/Demo)		27,755	27,136	54,891
Total	**0**	**0**	**0**	**1,339,911**

Note: This table shows contracted deliveries for calendar year 1997. District deliveries may vary from amounts shown, due to: (a) current year SWP/Kern River exchanges, (b) payback of SWP water from prior year exchanges, and (c) conjunctive use agreements.

(15) Includes 8,000 AF to Lost Hills WD (exchange of SWP entitlement for future Interruptible water); includes 147 AF landowner transfer from Lost Hills WD (LHUD); includes 1,800 AF to Berrenda Mesa WD (exchange of SWP entitlement for groundwater).

(16) Long-term exchange amounts to Buena Vista WSD from Kern Delta WD (21,255 AF), West Kern WD (17,920 AF) and Cawelo WD (38,200 AF).

(17) Includes 11,000 AF from Tehachapi-Cummings CWD per long-term M&I pool agreement; includes 8,000 AF to Rosedale-Rio Bravo WSD.

(18) Transfer of 8,000 AF from Improvement District No. 4 in exchange for a like quantity of Rosedale-Rio Bravo WSD's Kern River water.

(19) Includes long-term exchange amounts from Kern Delta WD (21,255 AF), West Kern WD (17920 AF) and Cawelo WD (38,200 AF); excludes 20,000 AF of Cawelo WD long-term exchange water delivered to Henry Miller WD.

(20) Long-term M&I pool quantity (11,000 AF) to Improvement District No. 4.

(21) Transfer of 566 AF to Berrenda Mesa WD (exchange of SWP entitlement for groundwater).

(22) Transfer of 2,124 AF to Rosedale-Rio Bravo WSD in exchange for a like quantity of Kern River water delivered to Semitropic WSD via North Kern WSD.

(23) Includes 13,000 AF to Westlands WD for a like amount of Kern River water to ID4 (Nickel/Westlands purchase); includes 2,588 AF (Nov) and 2,954 AF (Dec) to RRB for a like amount of Kern River water to ID4.

(24) Includes 17,000 AF to Westlands WD for a like amount of Kern River water to RRB (Nickel/Westlands purchase); includes 2,124 AF from Semitropic WSD, 2,588 AF (Nov) and 2,954 AF (Dec) from ID4 for a like amount of Kern River water to Semitropic WSD and ID4.

Table 4 (continued). 1997 State Water Project Deliveries by Contract (in acre-feet)

	(15)	(16)	(17)	(18)
District	**In-District Deliveries**	**Recharge Deliveries**	**(Col 15..16) Total Deliveries**	**(Col 14-17) Balance to be Delivered**
Berrenda Mesa WD	97,307	4,687	101,994	1,465
Lost Hills WD	121,913	6,736	128,649	4,821
Belridge WSD	114,882	850	115,732	3,263
Semitropic WSD	266,711	28,576	295,287	3,830
Cawelo WD	0	0	0	0
Improvement Dist. No. 4	67	663	730	0
Rosedale-Rio Bravo WSD	15,933	0	15,933	0
Buena Vista WSD	112,153	0	112,153	1,033
Kern Delta WD	0	0	0	0
Henry Miller WD	40,343	0	40,343	15,388
West Kern WD	0	0	0	0
Wheeler Ridge-Maricopa WSD	195,893	1,104	196,997	4,524
Tehachapi-Cummings CWD Ag	2,600	0	2,600	0
Tehachapi-Cummings CWD M&	3,997	0	3,997	3
Tejon-Castac WD AG	0	91	91	(7)
Tejon-Castac WD M&I	0	0	0	7
MWD (AEWSD)	1,486	0	1,486	0
Westside Mutual WC	0	2,207	2,207	0
Westlands WD	223,562	0	223,562	1,684
Tulare Lake Basin WSD	1,500	0	1,500	0
Dudley Ridge WD	0	0	0	0
Dudley Ridge WD (KWB)	0	5,748	5,748	0
DWR (KWB/Demo)	54,891	0	54,891	0
Total	**1,253,238**	**50,662**	**1,303,900**	**36,011**

Note: This table shows contracted deliveries for calendar year 1997. District deliveries may vary from amounts shown, due to: (a) current year SWP/Kern River exchanges, (b) payback of SWP water from prior year exchanges, and (c) conjunctive use agreements.

(25) Transfer of 30,000 AF (RRB = 17,000 AF, ID4 = 13,000 AF) to Westlands WD in exchange for a like quantity of Kern River water (Nickel/Westlands purchase).

(26) Semitropic WSD assigned 447 AF of their exchange allocation to Lost Hills WD for an exchange fee; cost savings on behalf of both districts.

Table 5 . Kern River Flows (in acre-feet)

Calendar Year	Natural Flows	Cumulative Natural Flows	Calendar Year	Natural Flows	Regulated Flows [1]	Cumulative Flows	
						Natural	Regulated
1894	533,326	533,326					
1895	1,023,052	1,556,378					
1896	619,692	2,176,070	1931	185,645		26,249,601	
1897	893,434	3,069,504	1932	737,727		26,987,328	
1898	251,827	3,321,331	1933	441,086		27,428,414	
1899	338,872	3,660,203	1934	227,665		27,656,079	
1900	332,373	3,992,576	1935	474,128		28,130,207	
1901	880,089	4,872,665	1936	796,447		28,926,654	
1902	552,539	5,425,204	1937	1,260,182		30,186,836	
1903	546,395	5,971,599	1938	1,358,685		31,545,521	
1904	492,949	6,464,548	1939	461,073		32,006,594	
1905	531,809	6,996,357	1940	789,098		32,795,692	
1906	1,900,540	8,896,897	1941	1,401,076		34,196,768	
1907	990,900	9,887,797	1942	771,966		34,968,734	
1908	498,503	10,386,300	1943	1,220,827		36,189,561	
1909	1,838,643	12,224,943	1944	625,537		36,815,098	
1910	658,911	12,883,854	1945	938,055		37,753,153	
1911	1,013,384	13,897,238	1946	650,683		38,403,836	
1912	387,432	14,284,670	1947	406,698		38,810,534	
1913	367,840	14,652,510	1948	329,506		39,140,040	
1914	1,113,513	15,766,023	1949	302,870		39,442,910	
1915	646,287	16,412,310	1950	601,360		40,044,270	
1916	2,520,149	18,932,459	1951	442,222		40,486,492	
1917	823,082	19,755,541	1952	1,500,999		41,987,491	
1918	538,503	20,294,044	1953	548,833		42,536,324	
1919	499,124	20,793,168	1954	528,357	510,320 [2]	43,064,681	510,320
1920	600,643	21,393,811	1955	444,300	367,783	43,508,981	878,103
1921	509,519	21,903,330	1956	840,862	755,500	44,349,843	1,633,603
1922	861,426	22,764,756	1957	444,338	445,859	44,794,181	2,079,462
1923	500,515	23,265,271	1958	1,104,730	967,511	45,898,911	3,046,973
1924	187,727	23,452,998	1959	257,978	353,165	46,156,889	3,400,138
1925	465,913	23,918,911	1960	300,037	324,088	46,456,926	3,724,226
1926	366,706	24,285,617	1961	177,642	177,063	46,634,568	3,901,289
1927	792,580	25,078,197	1962	697,704	607,848	47,332,272	4,509,137
1928	312,828	25,391,025	1963	801,450	676,237	48,133,722	5,185,374
1929	322,958	25,713,983	1964	339,266	361,624	48,472,988	5,546,998
1930	349,973	26,063,956	1965	720,362	634,303	49,193,350	6,181,301

(1) Regulated flows do not include deliveries above First Point.

(2) Isabella Dam in operation. All subsequent flows are controlled releases.

Table 5 (continued) Kern River Flows (in acre-feet)

Calendar Year	Natural Flows	Regulated Flows [1]	Cumulative Flows	
			Natural	Regulated
1966	678,595	504,506	49,871,945	6,685,807
1967	1,396,227	1,465,855	51,268,172	8,151,662
1968	453,760	497,026	51,721,932	8,648,688
1969	2,461,370	2,313,769	54,183,302	10,962,457
1970	589,474	601,254	54,772,776	11,563,711
1971	427,454	442,651	55,200,230	12,006,362
1972	268,427	311,291	55,468,657	12,317,653
1973	979,652	785,133	56,448,309	13,102,786
1974	818,608	745,903	57,266,917	13,848,689
1975	564,567	572,091	57,831,484	14,420,780
1976	249,468	320,784	58,080,952	14,741,564
1977	196,998	200,702	58,277,950	14,942,266
1978	1,653,505	1,390,675	59,931,455	16,332,941
1979	672,661	656,068	60,604,116	16,989,009
1980	1,639,957	1,560,652	62,244,073	18,549,661
1981	449,263	460,469	62,693,336	19,010,130
1982	1,271,139	1,121,088	63,964,475	20,131,218
1983	2,489,128	2,381,575	66,453,603	22,512,793
1984	821,797	834,036	67,275,400	23,346,829
1985	672,431	668,971	67,947,831	24,015,800
1986	1,444,939	1,331,561	69,392,770	25,347,361
1987	375,935	432,309	69,768,705	25,779,670
1988	294,685	335,473	70,063,390	26,115,143
1989	397,038	348,773	70,460,428	26,463,916
1990	203,571	219,501	70,663,999	26,683,417
1991	406,289	333,494	71,070,288	27,016,911
1992	296,829	272,822	71,367,117	27,289,733
1993	853,760	642,339	72,220,877	27,932,072
1994	336,456	422,361	72,557,333	28,354,433
1995	1,385,160	1,197,100	73,942,493	29,551,533
1996	1,038,261	968,036	74,980,754	30,519,569
1997	1,181,969	1,133,463	76,162,723	31,653,032

104 Year Mean Natural First Point Flow	732,300 AF	Minimum Natural First Point Flow (1961)	177,642 AF
104 Year Median Natural First Point Flow	577,000 AF	Maximum Natural First Point Flow (1916)	2,520,149 AF
44 Year Mean Regulated First Point Flow	719,400 AF	Mimimum Regulated First Point Flow (1961)	177,063 AF
44 Year Median Regulated First Point Flow	586,700 AF	Maximum Regulated First Point Flow (1983)	2,381,575 AF

Figure 4. Kern River Regulated Flows at First Point of Measurement

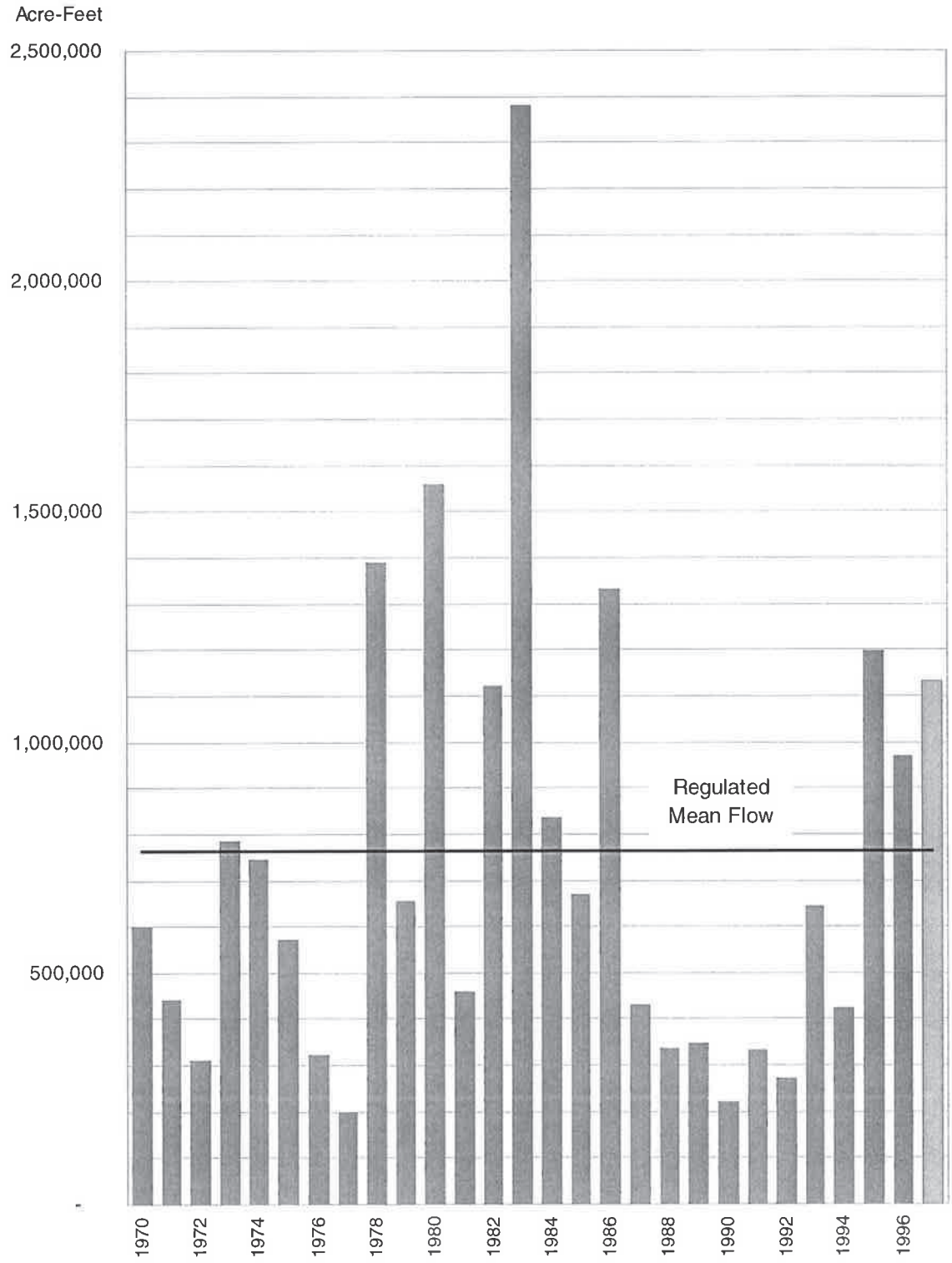


Table 6. 1997 Kern River Water Diversions by Entity (in acre-feet)

Area of Use	Diversions
Above First Point	
Kern Valley Golf Course (Kernville)	181
La Hacienda, Inc.	469
Lake Ming	790
Olcese WD	1,538
City of Bakersfield	0
Subtotal	**2,978**
Below First Point	
Arvin-Edison WSD	23,405
Buena Vista WSD	149,795
Cawelo WD	74,660
City of Bakersfield, Irrigation and Spreading [1]	79,571
Henry Miller WD	2,731
Improvement District No. 4	107,133
Kern County Water Agency (Pioneer Property)	9,182
Kern Delta WD	254,420
Kern -Tulare WD	10,945
Kern Water Bank Authority	42,057
North Kern WSD	262,024
Olcese WD/La Hacienda	10,000
Rag Gulch WD	1,641
Rosedale Ranch Improvement District	17,379
Rosedale-Rio Bravo WSD	87,926
South Fork	594
Subtotal	**1,133,463**
Total	**1,136,441**

[1] Includes Kern River Canal & Irrigating Company deliveries, Truxtun Lakes deliveries, Carrier Canal losses and percolation, Kern River channel losses and percolation.

Table 7. 1997 Central Valley Project Deliveries by Entity[1] (in acre-feet)

	Class I	Class II	215 Water	Other [3] Water	Total
Arvin-Edison WSD	39,671	200,839	829	935	242,274
Delano-Earlimart ID	7,589	4,694	1,049	14,295	27,627
Kern County Water Agency	2,269		10,156		12,425
Kern-Tulare WD [2]	1,617	21,974		23	23,615
North Kern WSD	6,056	2,024			8,080
Rag Gulch WD [2]		1,847		300	2,147
Rosedale-Rio Bravo WSD	3,417	35,440		230	39,087
Shafter-Wasco ID	37,317	28,083		1,376	66,776
So. San Joaquin MUD	8,137	74,795		267	83,199
Kern River Inflow [4]				124,796	124,796
Total	**106,073**	**369,697**	**12,034**	**142,223**	**630,026**

[1] Quantities for water year March 1996 - February 1997.

[2] Per exchange of Cross Valley Canal water with Arvin-Edison WSD.

[3] Includes M&I water, operational spill water and non-project water delivered via CVP.

[4] Of this amount, 51,055 acre-feet entered the California Aqueduct via the Kern River-California Aqueduct Intertie.

Table 8. 1997 Central Valley Project Deliveries to Kern County (in acre-feet)

Year	Annual Delivery	Cumulative Delivery	Year	Annual Delivery	Cumulative Delivery
1950	762	762			
1951	27,005	27,767	1981	469,966	7,899,255
1952	49,500	77,267	1982	656,608	8,555,863
1953	83,558	160,825	1983	550,874	9,106,737
1954	112,093	272,918	1984	425,371	9,532,108
1955	126,238	399,156	1985	337,514	9,869,622
1956	279,134	678,290	1986	589,262	10,458,884
1957	141,684	819,974	1987	291,981	10,750,865
1958	223,830	1,043,804	1988	292,828	11,043,693
1959	166,099	1,209,903	1989	293,865	11,337,558
1960	156,978	1,366,881	1990	200,141	11,537,699
1961	126,412	1,493,293	1991	204,396	11,742,095
1962	231,045	1,724,338	1992	208,021	11,950,116
1963	234,283	1,958,621	1993	489,783	12,439,899
1964	189,330	2,147,951	1994	186,303	12,626,202
1965	245,482	2,393,433	1995	647,077	13,273,279
1966	232,084	2,625,517	1996	611,262	13,884,541
1967	319,706	2,945,223	1997	630,026	14,514,567
1968	206,499	3,151,722			
1969	372,826	3,524,548			
1970	351,392	3,875,940			
1971	348,865	4,224,805			
1972	238,475	4,463,280			
1973	412,178	4,875,458			
1974	480,575	5,356,033			
1975	442,130	5,798,163			
1976	226,512	6,024,675			
1977	121,469	6,146,144			
1978	357,847	6,503,991			
1979	462,526	6,966,517			
1980	462,772	7,429,289			

Mean Delivery	302,387 AF	Median Delivery 1975-97	425,371 AF
Median Delivery	262,308 AF	Min. Delivery 1975-97 (1977)	121,469 AF
Mean Delivery 1975-97	398,197 AF	Max. Delivery 1975-97 (1982)	656,608 AF

Figure 5. Central Valley Project Deliveries to Kern County

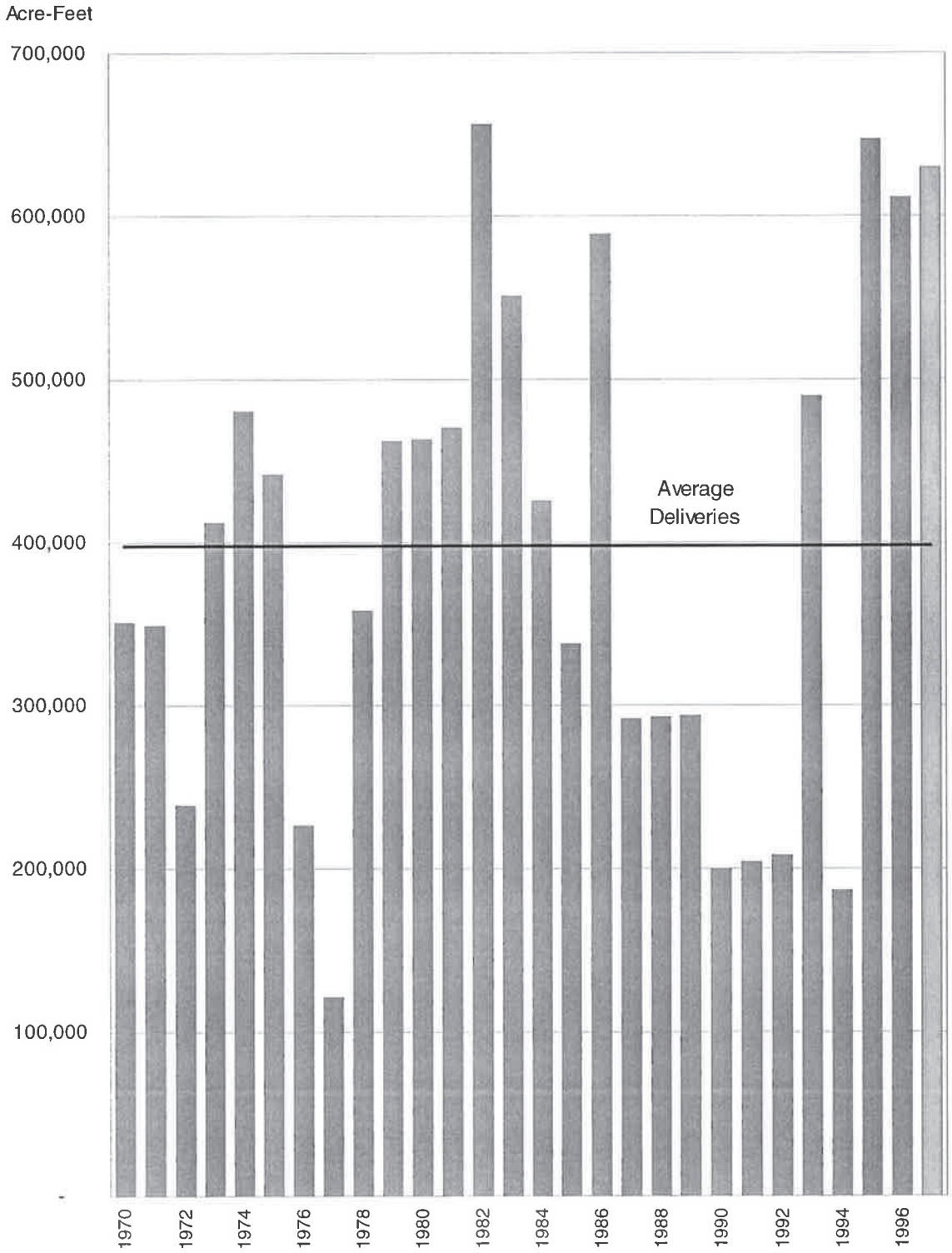


Table 9. Minor Stream Flows in the San Joaquin Valley Portion of Kern County (in acre-feet)

Year	Annual Stream Flows	Cumulative Stream Flows
1970	132,400	132,400
1971	63,200	195,600
1972	21,600	217,200
1973	22,900	240,100
1974	104,900	345,000
1975	39,400	384,400
1976	42,700	427,100
1977	32,900	460,000
1978	429,200	889,200
1979	96,700	985,900
1980	65,200	1,051,100
1981	63,600	1,114,700
1982	91,700	1,206,400
1983	273,300	1,479,700
1984	43,200	1,522,900
1985	20,200	1,543,100
1986	32,600	1,575,700
1987	61,900	1,637,600
1988	22,900	1,660,500
1989	6,900	1,667,400
1990	17,000	1,684,400
1991	34,600	1,719,000
1992	52,200	1,771,200
1993	72,900	1,844,100
1994	36,800	1,880,900
1995	162,100	2,043,000
1996	88,100	2,131,100
1997	100,000	2,231,100
1998	286,400	2,517,500

Mean Flow	86,800 AF
Median Flow	61,900 AF
Minimum Flow (1984)	6,900 AF
Maximum Flow (1978)	429,200 AF

Figure 6. Minor Stream Flows in the San Joaquin Valley Portion of Kern County

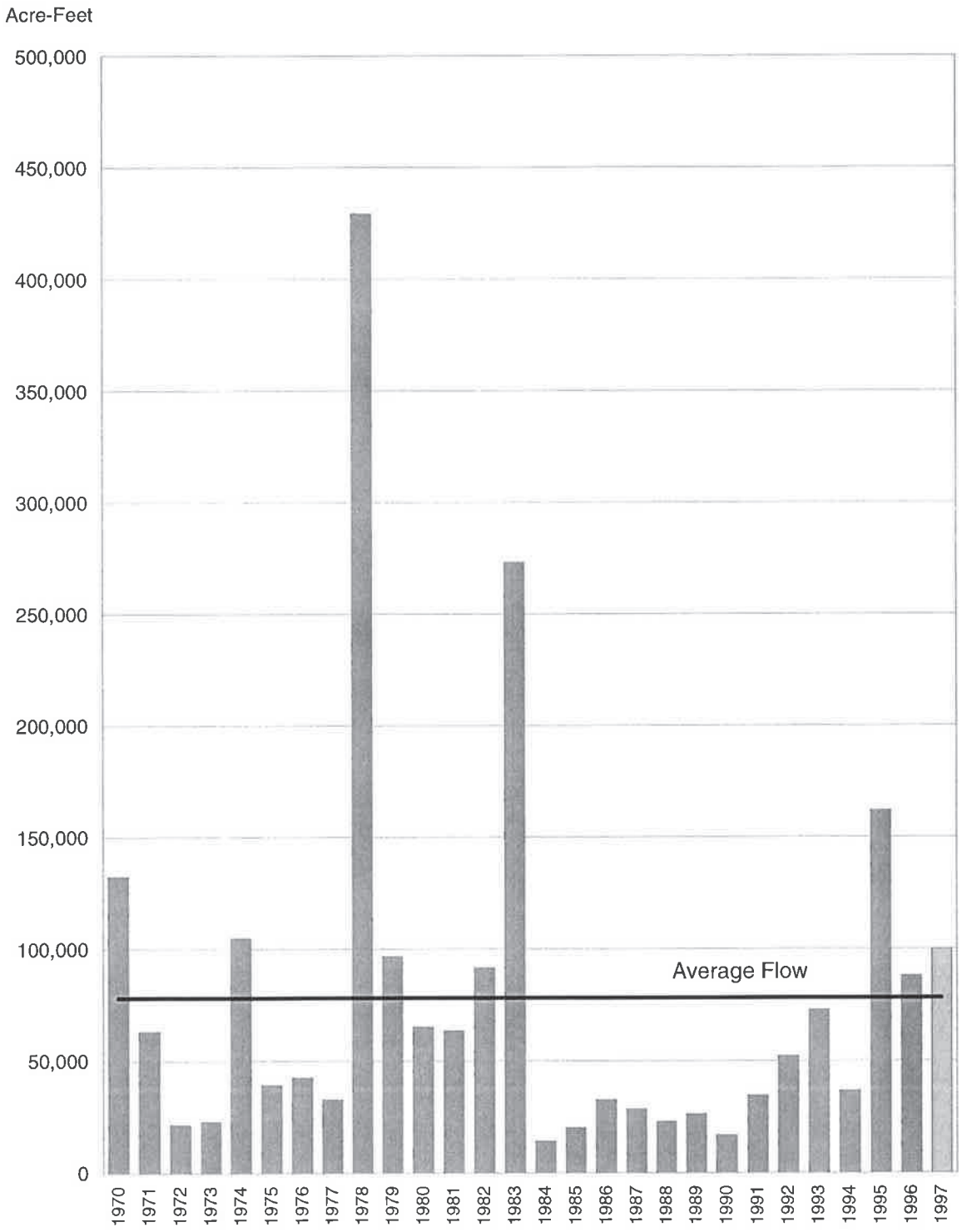
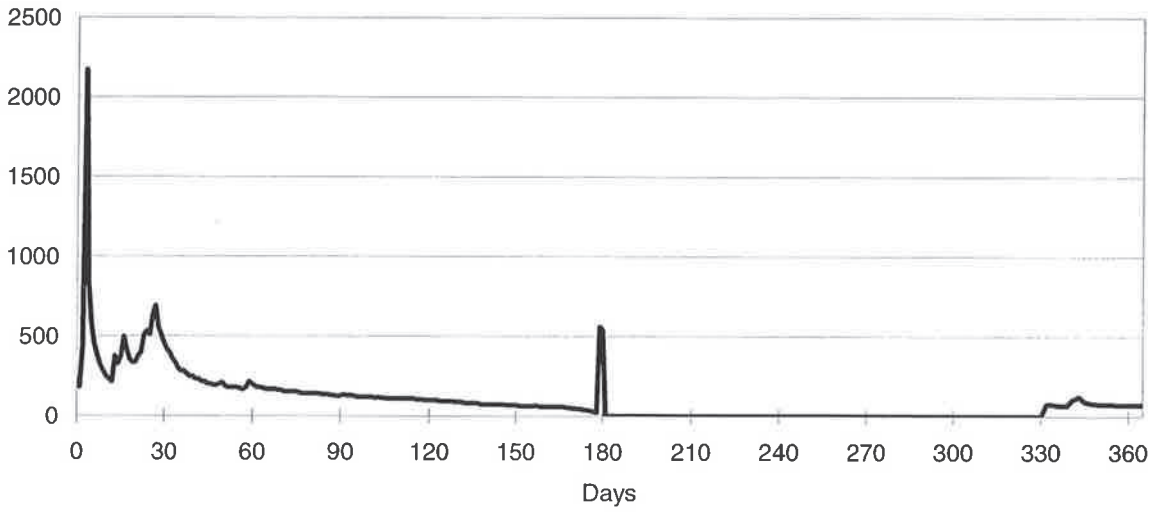
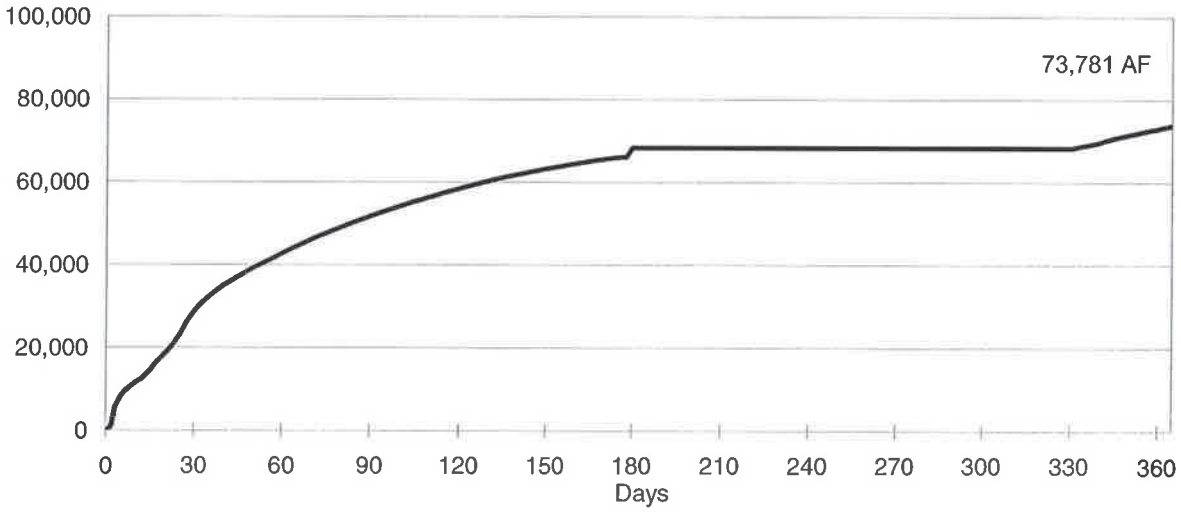


Figure7a. Poso Creek Hydrograph Mean Daily Flow (cfs), 1997



1. Hydrograph began 0000 hrs on 1/1/97 and ended at 2400 hrs on 12/31/1997.
2. Located at Lat.35 30' 49", Long. 118 54' 17", SW 1/4, SW 1/4, Sec. 6, T.28S., R.29E. Kern County.
3. Peak Discharge, 2,170 cfs, 1/3/97.

Figure7b. Poso Creek Cumulative Volumes (acre-feet), 1997



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly ttl	29,591	12,744	9,344	6,736	4,949	4,963	0	0	0	0	520	4,935
Cumulative ttl	29,591	42,335	51,679	58,415	63,364	68,327	68,327	68,327	68,327	68,327	68,846	73,781

Table 10. 1997 Monthly Rainfall at Selected Stations (in inches)

OPERATOR/Station	Elev. (ft)	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ARVIN-EDISON WATER STORAGE DISTRICT															
District Headquarters	500	31S/30E-29	2.92	0.98	0.06	0	0	0	0	0	0.15	0.05	1.61	0.43	6.20
Sycamore	**420**	31S/30E-20	2.80	0.95	0.05	0	0	0	0	0	0.12	0.04	1.61	0.41	5.98
Tejon	480	32S/29E-15	2.56	1.38	0.06	0	0	0	0	0	0.10	0.05	1.18	0.45	5.78
CALIFORNIA DEPARTMENT OF WATER RESOURCES															
Lost Hills O&M Center	300	27S/21E-03	1.88	0.02	0.20	0	0	0	0	0	0	0.11	m	2.24	4.45
Bakersfield 14W	310	30S/25E-04R	0.97	3.11	0.28	0.05	0.03	0	0	0	0	0.72	1.67	0.74	7.57
Wasco 7E	410	27S/26E-06	1.78	0.18	0.04	0	0	0	0	0	0.01	0.16	1.61	3.86	7.64
Wind Gap O&M Center	780	11N/20W-26	3.13	1.14	0	0	0	0	0	0	0.04	0.78	0.77	0.97	6.83
J.G. BOSWELL COMPANY															
Buena Vista #4	300	32S/25E-06	1.44	0.40	0.12	0	0	0	0	0	0	0.04	0.68	1.60	4.28
Buena Vista Gin	300	32S/25E-12	1.25	0.40	0.13	0	0	0	0	0	0	0.06	0.77	1.55	4.16
Buena Vista Office	290	31S/25E-25	1.52	0.34	0.30	0	0	0	0	0	0	0.05	0.80	1.59	4.60
Kern Lake Shop	280	32S/28E-18	2.25	0.97	0.17	0	0	0	0	0	0.03	0.03	0.70	0.70	4.85
Kern Lake Time Room	280	32S/27E-16	2.00	0.71	0.01	0	0	0	0	0	0.03	0.05	0.72	0.72	4.24
Paloma	290	32S/24E-02	1.62	0.70	0.05	0	0	0	0	0	0	0.06	0.87	1.16	4.46
KERN COUNTY PLANNING DEPARTMENT															
Arvin Fire Station	450	31S/29E-28	1.83	0.79	0.02	0	0	0	0	0	m	m	m	0.13	2.77
Buena Vista Aquatic Rec Area	300	31S/25E-15	1.09	0.19	0.05	0	0	0	0	0	0.01	0	0.76	1.11	3.21
Buttonwillow Fire Station	270	29S/23E-14	1.36	0.11	0.05	0	0	0	0	0	0	0.45	1.18	1.02	4.17
Communications Center	770	29S/28E-16	2.09	0.60	0.35	0.02	0	0	0	0	0.14	0.09	1.74	0.64	5.67
Edmonston Pump Station	1,310	10N/18W-17M	3.37	2.25	0.24	0.07	0	0	0	0	0.10	1.30	1.60	3.36	12.29
McFarland Fire Station	350	26S/25E-10	1.89	0.37	0.05	0	0	0	0	0	0.03	0	2.33	1.08	5.75
Pine Mountain	5,200	09N/21W-19	3.91	2.43	0.42	0.05	0.12	0.03	0.07	0	0.08	0.48	3.11	11.32	22.02
Rio Bravo Fire Station	610	29S/29E-04	1.84	0.50	0.08	0.02	0	0	0	0	0.23	0.12	1.78	0.30	4.87
NATIONAL WEATHER SERVICE															
Bakersfield	380	30S/28E-08	1.87	0.80	0.21	0	0	0	0	0	0.05	0.25	1.70	0.97	5.85
Bear Valley	4,100	32S/31E-03	7.04	2.18	0.42	0.26	0.07	0	0.08	0	0.37	1.01	3.16	1.76	16.35
Delano	320	25S/25E-S11	2.04	0.22	0	0	0	0	0	0	0.04	0.15	1.30	1.54	5.29
Glennville	3,100	25S/30E-25	8.40	1.25	0.04	0	0	0	0.07	0	0.56	0.60	3.62	2.18	16.72
Keene	2,900	31S/32E-20	5.67	0.43	0.06	0.13	0	0	0	0	0.07	0.72	1.40	1.62	10.10
Lebec	3,600	09N/19W-26	1.85	1.51	0.10	0	0.02	0	0	0	0.13	0.99	1.08	6.39	12.07
Lost Hills	280	26S/21E-35	1.17	0.05	0.17	0	0	0	0	0	0	0.02	1.36	2.05	4.82
Maricopa	700	10N/24W-11	---------- Incomplete data ----------												
Piute	4,290	29S/33E-36	4.83	0.50	0.02	0	0	0	0.51	0	1.31	0.30	2.37	1.57	11.41
Tehachapi	3,980	32S/33E-21	---------- Incomplete data ----------												
Wasco	300	27S/24E-11	1.39	0	0.13	0	0	0	0	0	0.05	0.15	1.25	1.48	4.45
Woody	1,600	25S/29E-35	4.35	1.00	0	0.01	0	0	0.03	0	0.11	0.55	3.05	1.17	10.27
TEHACHAPI-CUMMINGS COUNTY WATER DISTRICT															
Station 6	4,890	12N/15W-01	5.13	1.78	0.10	0	0	0	0	0	1.30	0.75	2.60	2.05	13.71
Station 20	5,730	12N/15W-12	5.90	2.40	0.10	0	0	0	0	0	1.55	1.20	3.50	2.40	17.05
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT															
5P-P2	590	11N/22W-09	1.89	0.80	0.11	0	0	0	0	0	0	0.07	0.77	2.51	6.15
District Headquarters	480	11N/12W-11	2.54	1.94	0.11	0	0	0	0	0	0.03	0.10	0.80	0.67	6.19
Greenlee's Pasture	380	12N/21W-36	2.29	1.90	0.04	0	0	0	0	0	0	0.04	0.76	0.65	5.68
PA-2	960	11N/19W-30	2.88	1.17	0.10	0	0	0	0	0	0	1.30	1.02	1.57	8.04
Spill Basin	850	11N/18W-31	2.28	1.31	0.06	0	0	0	0	0	0	1.27	1.45	1.28	7.65
WRM-2	510	32S-24E-35	1.03	0.40	0.45	0	0	0	0	0	0	0	1.06	2.74	5.68

Table 10 continued. 1997 Monthly Rainfall at Selected Stations (in inches)

OPERATOR/Station	Elev. (ft)	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTHER OPERATORS															
Belridge WSD Office	550	28S/21E-34	2.34	0.25	0	0	0	0	0	0	0	0	1.20	1.85	5.64
Blackwell's Corner (BMWD)	630	27S/20E-06	1.98	0.11	0.22	0	0	0	0	0	0.03	0.33	1.69	1.93	6.29
City of Bakersfield DWR Yd.	400	30S/27E-06	1.74	0.58	0.19	0	0	0	0	0	0.04	0.17	1.76	1.26	5.74
Del Kern Station (KDWD)	350	31S/28E-06C	1.94	0.81	0.09	0.03	0	0	0	0	0.07	0.06	1.18	1.16	5.34
Shafter Cotton Research Sta.	370	27S/25E-33J	2.09	0.24	0.03	0	0	0	0	0	0	0.25	2.24	1.53	6.38
So. Belridge (Cal Resources)	600	28S/21E-33	1.42	0.25	0	0	0	0	0	0	0.01	0	1.38	2.34	5.40

Note: Boxed numbers are estimated values

"m" indicates missing data

Rainfall at Meadows Field, Bakersfield

	1994	1995	1996	1997	Avg.	1997 % of Avg
Jan	0.57	2.29	1.08	1.87	1.02	183
Feb	1.34	0.87	2.54	0.80	1.00	80
Mar	0.97	3.39	0.78	0.21	0.94	22
Apr	1.06	0.79	0.12	0	0.65	0
May	0.27	0.35	0.02	0	0.30	0
Jun	0	0.12	0	0	0.07	0
Jul	0	0	0	0	0.01	0
Aug	0.01	0	0	0	0.02	0
Sep	0.09	0	0	0.05	0.10	50
Oct	0.17	0.08	0	0.25	0.31	81
Nov	0.79	0.98	0	1.70	0.52	327
Dec	1.32	2.03	1.73	0.97	0.80	121
Total	**6.69**	**9.84**	**8.08**	**5.85**	**5.74**	**102**

Figure 8 shows annual rainfall recorded at three selected climatic stations in Kern County. Rainfall in the Wheeler Ridge area is normally higher than on the valley floor. Orographic uplift associated with the mountains at the southern end of the valley account for the higher rainfall in this area. Table 11 lists the annual amounts of effective precipitation expressed as total acre-feet and inches per acre, along with cumulative amounts and descriptive statistics. Figure 9 is a graphic depiction of the same information.

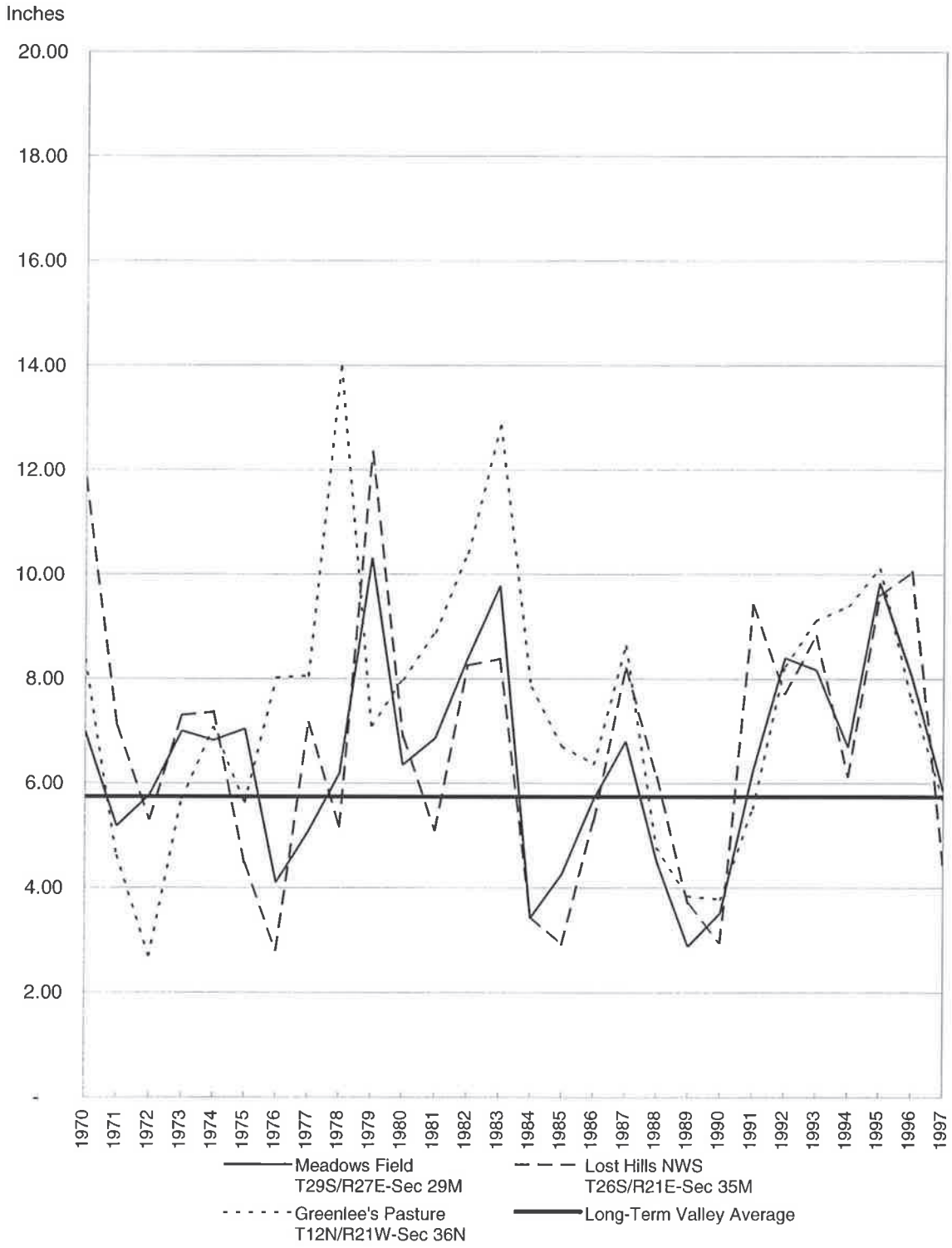
Waste Water Reuse

The reuse of municipal and industrial waste water provides an irrigation water source for Kern County agriculture. There are 14 active waste water sewage treatment plants in the San Joaquin Valley portion of Kern County. Waste water treatment processes are classified as follows: "Primary" treatment removes most suspended matter from the sewage (usually via settling ponds), but removes little or no colloidal or dissolved matter. "Secondary" treatment provides some biological action or filtration to remove any remaining colloidal or dissolved substances from the sewage (nearly all waste water treatment facilities in Kern County provide secondary treatment of sewage). "Tertiary" treatment involves further filtration and disinfection to inactivate pathogens.

Most of the effluent from waste water treatment plants in Kern County is used to irrigate salt-tolerant crops on bordering lands, such as cotton, pasture and some grains. A small amount percolates directly to the groundwater basin; the remainder is evaporated. In 1997 about 50,800 acre-feet of waste water was treated (Table 12). KCWA estimated that about 47,000 acre-feet was used by agriculture, 100 acre-feet evaporated, and 3,700 percolated to the underlying aquifer. Table 13 shows historic amounts of treated wastewater. Figure 10 shows the same information as a graph.

Another source of reusable waste water results from agricultural tail water return systems. Many farming operations have installed these systems to intercept water that would normally run off the field during irrigation. This recovered water is either transported back to the main irrigation system or is applied on an adjacent field (from the foot of one field to head of another). Tail water return systems are widely used on fields that are furrow or border irrigated. Their efficiency lies in the saving of energy required to recover the water from wells, or by reducing the need to import additional surface supplies. From a basin balance standpoint these two water reuse activities are internal and do not add to the hydrologic system.

Figure 8. Annual Precipitation at Three Stations in the San Joaquin Valley Portion of Kern County



Note: Valley average is over a greater period than shown on graph.

Table 11. Effective Precipitation in the San Joaquin Valley Portion of Kern County (in acre-feet)

	Annual Effective Precipitation	Unit Rate (inches per acre)	Cumulative Effective Precipitation
1970	380,200	5.72	380,200
1971	148,300	2.13	528,500
1972	264,900	3.78	793,400
1973	131,900	1.84	925,300
1974	220,200	2.88	1,145,500
1975	240,500	3.17	1,386,000
1976	175,300	2.25	1,561,300
1977	198,400	2.74	1,759,700
1978	612,500	8.08	2,372,200
1979	152,600	1.97	2,524,800
1980	281,200	3.58	2,806,000
1981	255,400	3.21	3,061,400
1982	332,300	4.18	3,393,700
1983	438,100	6.15	3,831,800
1984	139,300	1.72	3,971,100
1985	160,700	2.04	4,131,800
1986	162,600	2.40	4,294,400
1987	168,200	2.57	4,462,600
1988	144,200	2.08	4,606,800
1989	106,100	1.49	4,712,900
1990	90,500	1.29	4,803,400
1991	171,700	2.82	4,975,100
1992	142,300	2.16	5,117,400
1993	168,700	2.53	5,286,100
1994	169,100	2.53	5,455,200
1995	192,400	2.72	5,647,600
1996	192,500	2.62	5,840,100
1997	105,600	1.43	5,945,700

Mean EP (total)	212,300	AF
Median EP (total)	170,400	AF
Mean EP (per acre)	2.93	Inches/Acre
Median EP (per acre)	2.55	Inches/Acre

Figure 9. Effective Precipitation in the San Joaquin Valley Portion of Kern County

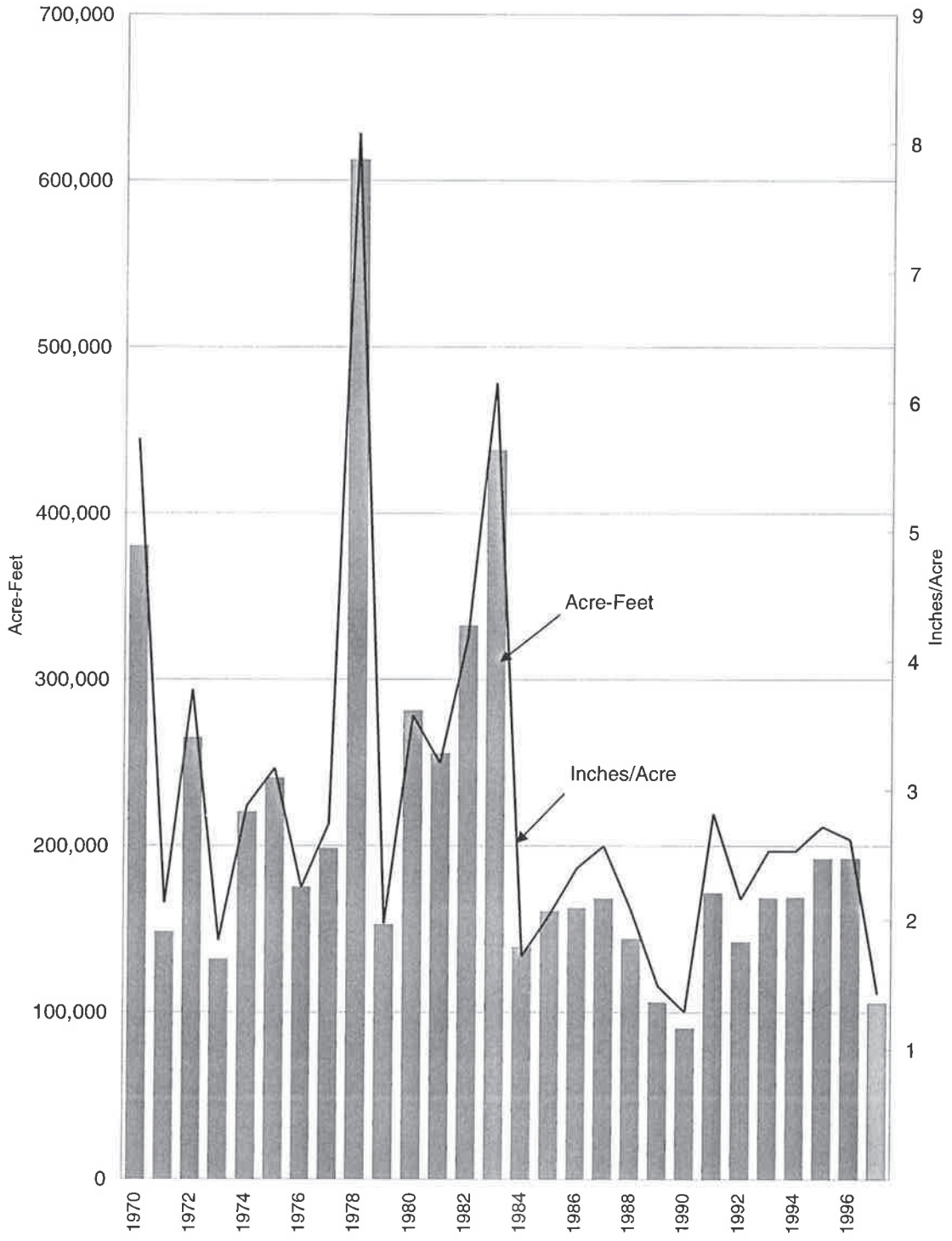


Table 12. 1997 Waste Water Treatment Plant Volumes

Facility	Volume (MG)	Volume (AF)	Influent Source	Treatment System	Effluent Use
City of Arvin	397	1,219	Dom	Secondary	Agriculture
City of Bakersfield					
#2	5,953	18,267	Dom/Ind	Secondary	Restricted Agriculture
#3	3,786	11,619	Dom/Ind	Secondary	Restricted Agriculture
Kern County Waste Management Department					
KSA (Mt. Vernon)	1,570	4,819	Dom	Secondary	Agriculture
BVARA	9	27	Agr	Secondary	Percolation
Sheriff's Lerdo Facility	80	246	Dom	Secondary	Same
Reeder Tract	11	34	Dom	Secondary	Same
NOR Sanitary District #1	1,278	3,922	Dom/Ind	Secondary	Restricted Agriculture Percolation
City of Delano	1,341	4,116	Dom	Secondary	Restricted Agriculture
Lamont Public Utilities District	694	2,128	Dom	Primary	Agriculture
City of McFarland	255	783	Dom	Secondary	Agriculture
City of Shafter	528	1,620	Dom/Ind	Secondary	Agriculture
Shafter Airport	73	224	Ind	Secondary	Percolation
City of Wasco	580	1,780	Dom/Ind	Secondary	Agriculture
Total	**16,555**	**50,804**			

For influent source:
- Dom - domestic
- Ind - industrial
- Agr - agricultural

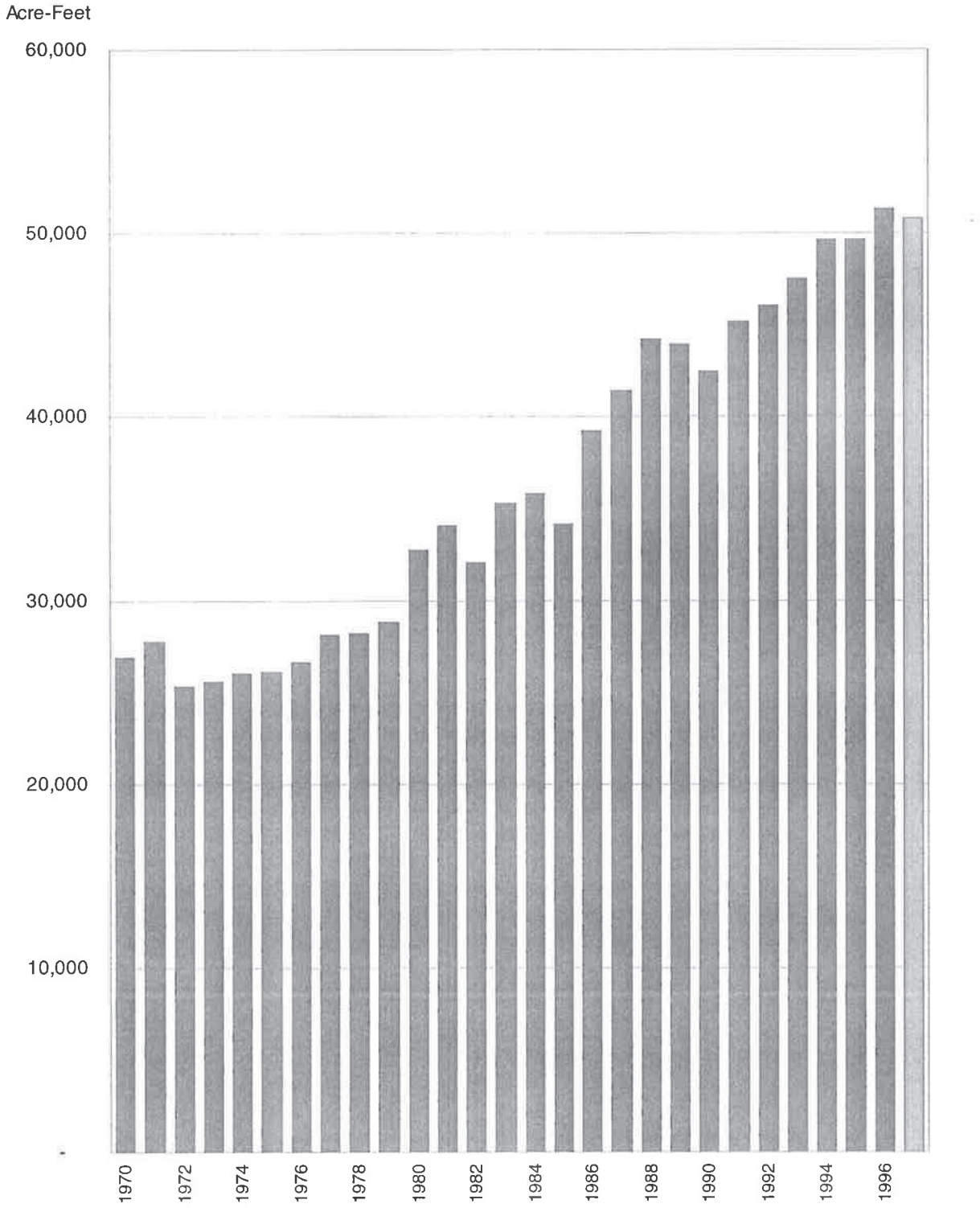
Primary treatment removes settleable solids.
Secondary treatment involves further oxidation of waste water to remove dissolved and biologically degradable substances.
Tertiary treatment involves further filtration and disinfection to inactivate pathogens.

Table 13. Waste Water Reuse (in acre-feet)

Year	Annual Flows	Cumulative Flows
1970	26,900	26,900
1971	27,800	54,700
1972	25,300	80,000
1973	25,600	105,600
1974	26,000	131,600
1975	26,100	157,700
1976	26,600	184,300
1977	28,100	212,400
1978	28,200	240,600
1979	28,800	269,400
1980	32,800	302,200
1981	34,100	336,300
1982	32,100	368,400
1983	35,300	403,700
1984	35,800	439,500
1985	34,200	473,700
1986	39,200	512,900
1987	41,400	554,300
1988	44,200	598,500
1989	44,000	642,500
1990	42,500	685,000
1991	45,200	730,200
1992	46,100	776,300
1993	47,600	823,900
1994	49,700	873,600
1995	49,700	923,300
1996	51,300	974,600
1997	50,800	1,025,400

Mean Water Reuse	36,600 AF
Median Water Reuse	34,800 AF
Minimum Water Reuse (1972)	25,300 AF
Maximum Water Reuse (1996)	51,300 AF

Figure 10. Waste Water Reuse in Kern County



Oil Field Produced Water

Another source of wastewater is as a byproduct of oil production. Unlike treated municipal effluent or tail water, oil field produced waters are a true addition to the hydrologic system, being drawn from deep, connate waters that are intermixed with oil deposits. In the Kern Front oil field, which lies astride the Kern River northeast of Bakersfield, substantial quantities of water are removed with each barrel of oil. The chemical quality of this water is generally within acceptable limits for agriculture when blended with canal water. Thus, much of this water is discharged into irrigation canals.

A total of 4,200 acre-feet of produced water from the Kern Front oil field was reused in 1997. Table 14 shows historic oil field produced water flows. Figure 11 shows the same information as a graph.

Groundwater Extractions

Most of the groundwater extractions in Kern County are not recorded. In the past, agricultural and urban power records from utility companies were matched with calculations for groundwater production. However, the accuracy of such power record calculations was unsatisfactory. In this report groundwater extractions are estimated by solving for the missing number in the groundwater change-in-storage equation.

Total groundwater extractions in 1997 were calculated to be about 1,091,400 acre-feet. This is about 518,200 or one-third less than was extracted in 1996. A continued abundance of surface water supplies plus a dramatically cooler summer are important reasons for this decrease. During 1996 May-September evaporation was from 100-115 percent of normal. Comparatively, during 1997 May-September evaporation patterns were very normal. This translates into much lower water requirements in 1997 during this peak crop water use period. Also, in 1996 nearly 1,300,000 acre-feet of surface water was recharged to groundwater. This was 42 percent of the total available surface water supply of 3,041,100 acre-feet. In 1997 830,300 acre-feet was recharged, or about 26 percent of the available surface water supply of 3,170,200 acre-feet. This strongly suggests that in 1996 less surface water was available for delivery to end users, which required a corresponding increase in groundwater pumping with all other things being equal.

Groundwater is pumped for a variety of uses in the San Joaquin Valley portion of Kern County, with agriculture the largest user. In 1997 agriculture used about 935,400 acre-feet. Municipal and industrial uses were about 156,000 acre-feet.

Table 15 shows historic groundwater pumping in the San Joaquin Valley portion of Kern County since 1970. Both annual and cumulative amounts are tabulated, along with descriptive statistics. Figure 12 is a histograph of groundwater pumping, a graphical display of relative variations.

WATER REQUIREMENTS

Agricultural

Gross irrigated acreage in the San Joaquin Valley portion of Kern County was about 886,700 acres in 1997. Since 12,100 acres were double-cropped, total net acreage in 1997 was 874,600 acres.

Approximately 760,400 acres were irrigated over the usable groundwater basin, and 125,300 acres were irrigated on lands outside the usable groundwater basin.

Kern County produces more than 30 percent of the nation's carrots. During 1996, carrot acreage increased by 4,700 acres but decreased by 6,260 acres in 1997. Production of grains including wheat, hay, oats, alfalfa and others increased in 1997. Cotton acreage continued to decline and the crop slipped to ranking third in Kern County's commodity list. Tomato production declined by almost half. Almost 104,000 acres were idle in 1997.

A historical summary of irrigated acreage is provided in Table 16, along with descriptive statistics. Figure 14 shows historic irrigated acreage plotted as a bar graph. Figure 14 categorizes irrigated acreage by crop. Permanent crops (trees and vines) make up 32 percent of Kern County's total acreage. Cotton remains an important crop to Kern County's economy but dropped to encompassing 33 percent of the county's total acreage. Alfalfa and other green feeds accounted for about 10 percent of Kern County's total acreage, and are grown to support the dairy and cattle industries (milk and cream production are now California's number one crop), as well as for pleasure horses. Vegetables represent about another 9 percent of Kern County's agricultural acreage.

Crops grown in Kern County are consumed throughout the United States. Kern County grows 60 percent of the country's pistachios, 30 percent of its carrots, 17 percent of its almonds and 16 percent of its grapes. Kern's agricultural commodities are also exported to countries around the world. The top ten export crops are almonds, carrots, cotton, grapes, nursery stock, oranges, pistachios, plums and potatoes. Countries receiving products from Kern County include Canada, Mexico, countries in Central and South America, Africa, Europe, the Middle East, Japan, China, southeast Asia, and Australia.

The Kern County Agricultural Commissioner's annual crop report for 1997 shows that Kern agricultural products reached a new high market value of $2,192,923,000. This is an increase of 5 percent from 1996, and is attributable to an increase in irrigated acreage related to abundant water supplies. A comparison of 1996 to 1997 gross crop values shows:

Gross Crop Values, Kern County

	1997	1996	Change
Trees and Vines	$1,176,311,000	$1,009,989,000	$166,322,000
Cotton	304,206,000	346,812,00	-42,606,000
Field Crops	23,008,000	25,882,000	-2,874,000
Green Feeds	84,637,000	72,056,000	12,581,000
Vegetables	229,993,000	259,960,000	-29,967,000
Grains	31,317,000	39,377,000	-8,060,000
Other	343,451,000	333,748,000	9,703,000
Total	**$2,192,923,000**	**$2,087,824,000**	**$105,099,000**

Trees and vines account for more than half of Kern County's gross agricultural value, reflecting the importance of these crops to the local economy.

Agriculture is an important source of employment in Kern County. About 25 percent of all jobs in the county are agriculture-related. For some smaller communities, agriculture is nearly the sole source of employment:

Table 14. Oil Field Produced Water (in acre-feet)

Year	Annual Flows	Cumulative Flows
1970	5,300	5,300
1971	5,600	10,900
1972	6,100	17,000
1973	6,400	23,400
1974	6,900	30,300
1975	7,400	37,700
1976	7,700	45,400
1977	8,100	53,500
1978	8,500	62,000
1979	9,400	71,400
1980	10,100	81,500
1981	10,100	91,600
1982	10,600	102,200
1983	11,600	113,800
1984	11,700	125,500
1985	11,700	137,200
1986	11,800	149,000
1987	10,000	159,000
1988	12,700	171,700
1989	9,100	180,800
1990	5,300	186,100
1991	14,100	200,200
1992	8,700	208,900
1993	9,600	218,500
1994	16,800	235,300
1995	19,800	255,100
1996	13,800	268,900
1997	4,200	273,100

Mean Oil Field Water	9,800 AF
Median Oil Field Water	9,500 AF
Minimum Oil Field Water (1997)	4,200 AF
Maximum Oil Field Water (1995)	19,800 AF

Figure 11. Oil Field Produced Water in Kern County

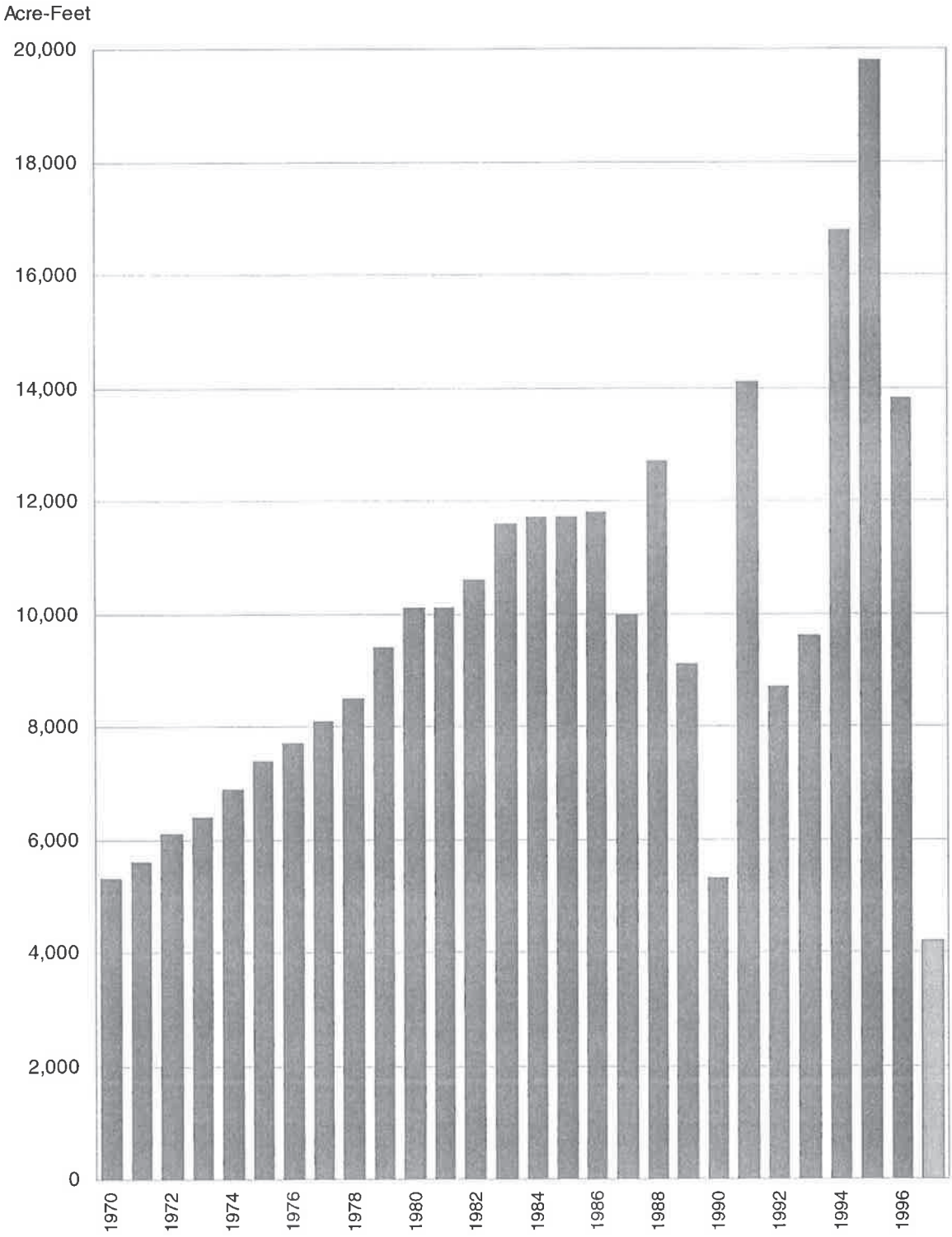


Table 15. Groundwater Pumping in the San Joaquin Valley Portion of Kern County (in acre-feet)

Year	Annual Groundwater Pumped	Cumulative Groundwater Pumped
1970	1,422,000	1,422,000
1971	1,700,000	3,122,000
1972	1,857,000	4,979,000
1973	1,662,000	6,641,000
1974	1,333,000	7,974,000
1975	1,587,000	9,561,000
1976	1,738,000	11,299,000
1977	1,703,000	13,002,000
1978	825,000	13,827,000
1979	1,260,000	15,087,000
1980	977,000	16,064,000
1981	1,161,000	17,225,000
1982	802,200	18,027,200
1983	762,700	18,789,900
1984	1,252,200	20,042,100
1985	1,293,800	21,335,900
1986	947,600	22,283,500
1987	1,208,700	23,492,200
1988	1,540,200	25,032,400
1989	1,588,500	26,620,900
1990	1,796,500	28,417,400
1991	2,002,400	30,419,800
1992	1,673,600	32,093,400
1993	987,700	33,081,100
1994	1,897,700	34,978,800
1995	1,242,800	36,221,600
1996	1,609,600	37,831,200
1997	1,091,400	38,922,600

Mean Groundwater Pumping	1,401,200 AF
Median Groundwater Pumping	1,377,500 AF
Minimum Pumping (1983)	762,700 AF
Maximum Pumping (1991)	2,002,400 AF

Figure 12. Groundwater Pumping in the San Joaquin Valley Portion of Kern County

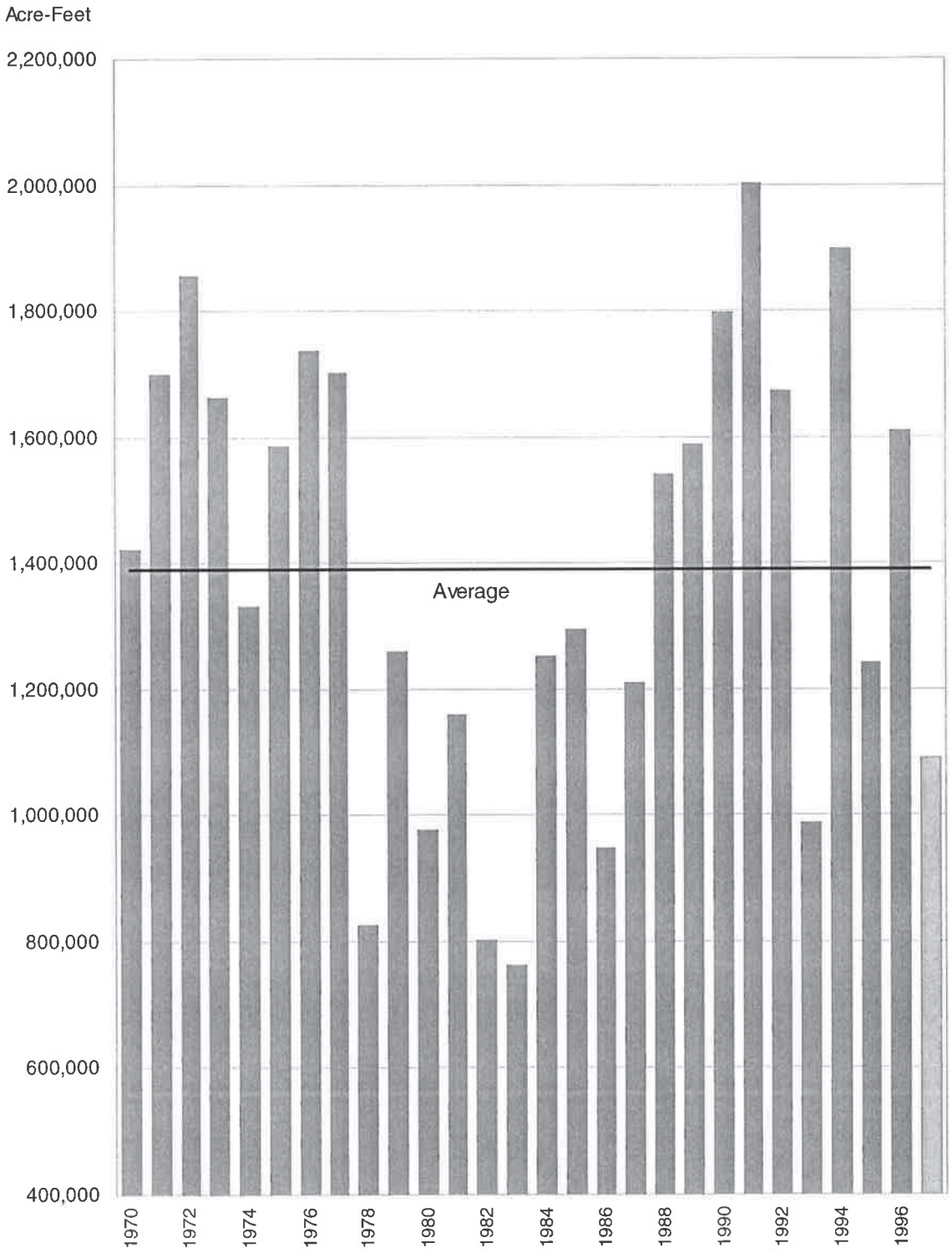


Table 16. Irrigated Acreage[1] in the San Joaquin Valley Portion of Kern County

Year	Total Irrigated Acreage	Year	Total Irrigated Acreage
1970	797,300		
1971	834,800	1996	880,600
1972	841,000	1997	886,700
1973	858,700		
1974	919,000		
1975	909,600		
1976	934,800		
1977	868,100		
1978	909,400		
1979	928,700		
1980	943,500		
1981	955,400		
1982	954,100		
1983	854,200		
1984	972,800		
1985	945,100		
1986	813,900		
1987	786,800		
1988	831,100		
1989	856,100		
1990	842,400		
1991	729,400		
1992	789,600		
1993	800,100		
1994	802,400		
1995	848,400		

Mean Irrigated Acreage	866,900 AF
Minimum Irrigated Acreage (1991)	729,400 AF
Maximum Irrigated Acreage (1984)	972,800 AF

[1] Double-cropped acreage is counted twice, since it is irrigated twice. Double-cropping is generally a small percentage of total irrigated acreage, in the order of 10,000 to 20,000 acres annually.

Figure 13. Irrigated Acreage in the San Joaquin Valley Portion of Kern County

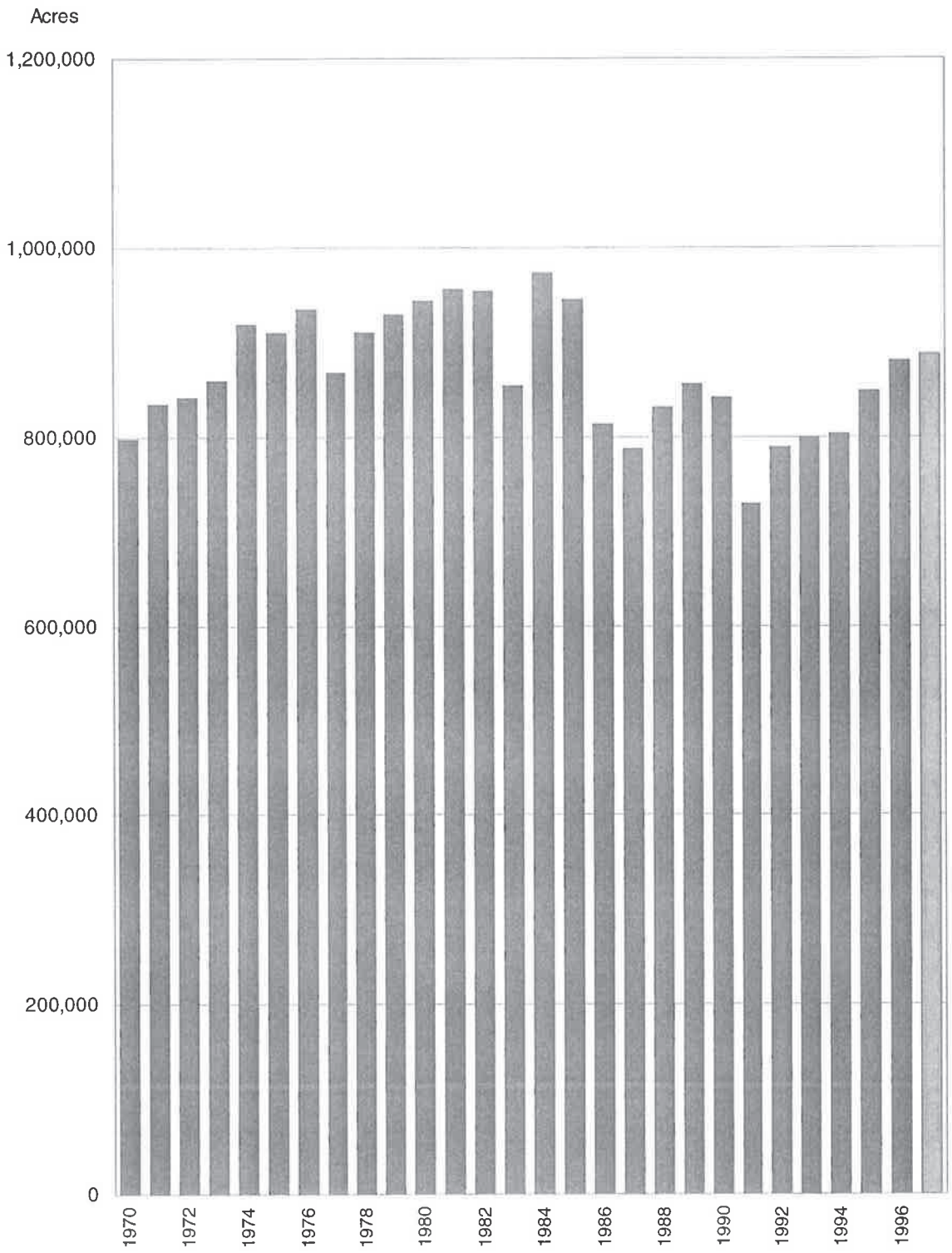
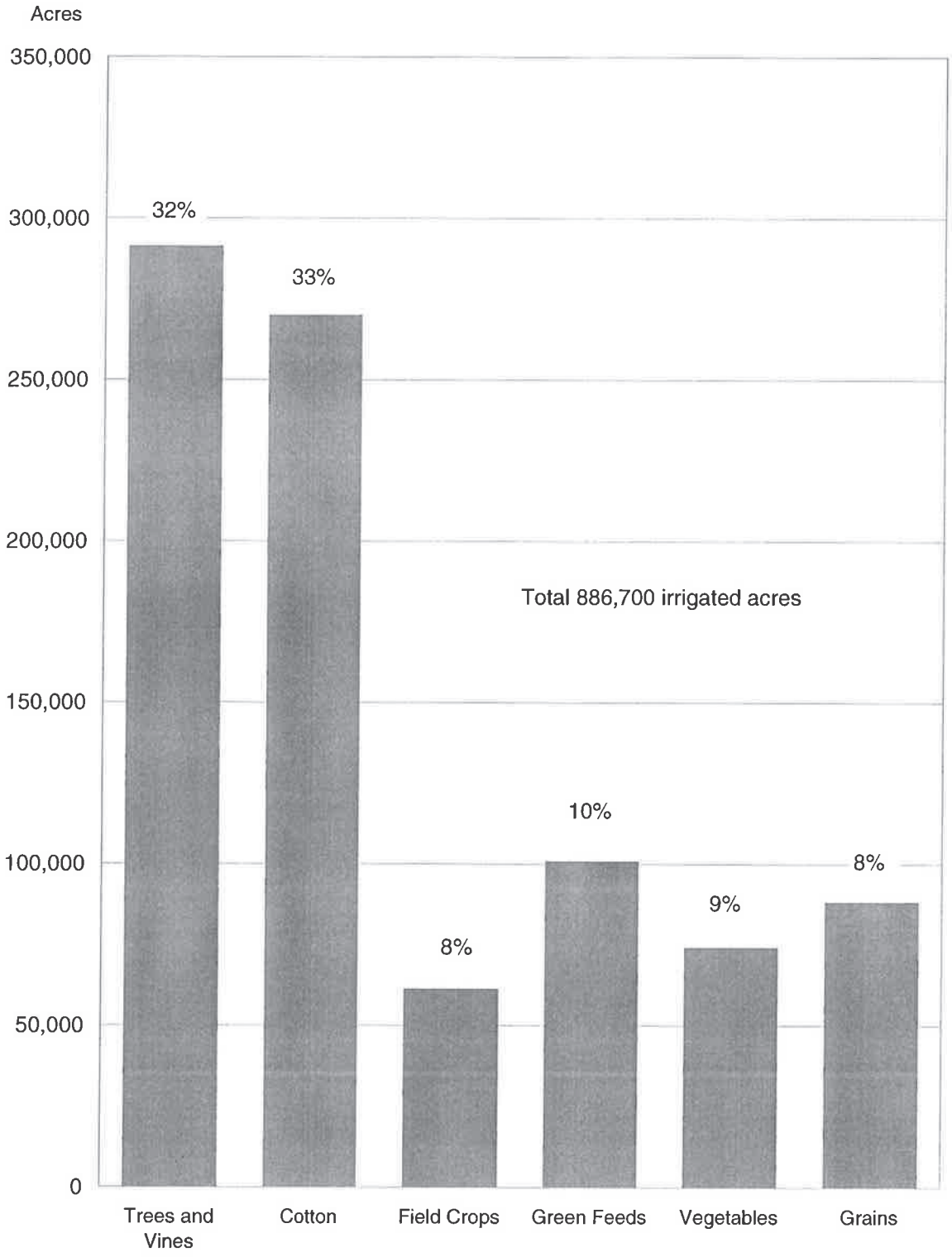


Figure 14. 1997 Summary of Irrigated Acreage



	Agriculture's Share of Employment
Arvin	92%
Buttonwillow	77%
Delano	80%
Lost Hills	94%
Shafter	64%
Wasco	75%

Source: US Census Bureau, 1990

Per unit crop demands in 1997 were slightly higher than normal. Table 17 is a summary of monthly evaporation as measured at three climatic stations in the county. Evaporation is a key parameter for measuring crop water use. The Bakersfield 12S and 14W stations (operated by the Department of Water Resources) typify evaporation on the San Joaquin Valley floor. Figure 15 displays monthly evaporation for these stations as percent of normal.

Many crops experienced yield increases compared to 1996, with its extremely wet spring conditions. Almond yields increased by 13 percent, while cotton increased by 12 percent.
KCWA uses data from the California Irrigation Management Information System (CIMIS) to compute crop consumptive use. CIMIS is a statewide computerized irrigation scheduling system, funded and operated by the DWR Division of Local Assistance. The program helps farmers to schedule their irrigation based upon soil moisture budgets, which can help reduce total applied water requirements. There are four CIMIS weather stations in Kern County. Approximate crop water use as computed using CIMIS data for 1997 is summarized on Table 18, along with total irrigated acreage.

It is difficult to quantify applied water requirements for the San Joaquin Valley portion of Kern County. Areal differences, such as soil type, cultural practices, leaching requirements (typically five to 10 percent) and irrigation technologies employed around the valley result in different applied water rates on specific crops. Farmers in areas suffering from shallow groundwater will usually apply less water on their crops than they would if the soil were well drained, because their intent is to manage the shallow groundwater problem. In addition, a crop may consumptively use some shallow groundwater, thus reducing the amount the farmer needs to apply. Also, sprinkler or low volume irrigation typically requires less water than flood or furrow irrigation, although furrow or flood systems are not necessarily less efficient than other systems. Many factors govern the type of irrigation system chosen by a farmer. Under some conditions (such as level slopes and heavy soils), furrow irrigation may be as efficient as sprinklers or low volume systems. The efficiency of any given irrigation system is largely determined by how well the system is managed.

Gross agricultural requirements in 1997 were estimated to be about 3,044,700 acre-feet with 2,703,700 acre-feet occurring over the usable groundwater basin and 341,000 acre-feet over the non groundwater area. Return flows in the non groundwater area may be lost to moisture deficient soils or saline groundwater. It is generally not available for reuse and does not add to basin storage. About 13,400 acre-feet was estimated to be lost to moisture-deficient soils in 1997.

Net agricultural requirements in 1997 were about 2,425,900 acre-feet with about 2,105,500 acre-feet occurring over the groundwater basin. The difference between gross and net water requirements over the basin is an estimate of agricultural return flows to groundwater. Not all return flows return to usable groundwater; some is lost to saline sinks such as shallow groundwater areas. About /w125,500 acre-feet of water was lost to saline sinks during 1997, and another 13,400 acre-feet was lost to moisture deficient soils. About 616,700 acre-feet of agricultural water applied in 1997 returned to usable groundwater storage.

A large amount of applied water data has been collected over the years by many entities. Table 19 provides a basin-wide average applied water requirement for some major crops grown in Kern County.

Municipal and Industrial (M&I)

Gross M&I requirements in 1997 were estimated to be about 193,700 acre-feet, with about 178,300 acre-feet required over the usable groundwater basin. Of this total, 33,400 acre-feet was supplied by KCWA's Henry C. Garnett Water Purification Plant. Olcese Water District served the Rio Bravo area with 870 acre-feet of treated Kern River water. East Niles Community Services District used about 1,860 acre-feet of CVP water obtained from Arvin-Edison WSD. The remainder of M&I needs, 156,000 acre-feet, was supplied by groundwater. Table 20 gives a breakdown of urban water deliveries by water purveyor service area. The total production of the purveyors as shown on Table 20 is less than gross M&I requirements. This is because many rural families and businesses maintain their own water systems (wells), and their production volumes are not recorded. Gross M&I requirements include an estimate of the needs of these rural areas.

Average municipal and industrial water use over the groundwater basin was 332 gallons per capita per day (gpcd), the same as in 1996. Local long-term average M&I water use is in the range of about 250-300 gpcd. Residential water use is about 200 gpcd. Commercial, industrial and institutional use accounts for the difference. Domestic water use by west side towns (Taft, Maricopa, Lost Hills) are quite low in comparison to domestic use over the groundwater basin. The average domestic water use in these towns during 1997 was about 185 gpcd.

Net M&I consumptive use in 1997 was about 52,300 acre-feet over the groundwater basin. Gross return flows from M&I uses were about 126,000 acre-feet. About 50,800 acre-feet were treated in wastewater treatment facilities and evaporated, percolated or reused for agriculture. The remaining 75,200 acre-feet were returned to the usable groundwater basin. Most of the M&I water used outside the groundwater basin is for oil field operations (only about 30 percent is used for residential purposes), and is all consumptively used. Return flows from water used for residential purposes is lost to moisture deficient soils or saline groundwater.

Exports

During periods of high runoff, such as occurred during parts of the year in 1997, some water may be introduced into the California Aqueduct via the Kern River-California Aqueduct Intertie and exported over the Tehachapi mountains into southern California. Some water may spill into the Kern River flood channel, where it can flow north into Tulare Lake in Kings County. This type of water is not a usable supply. A total of 47,496 acre-feet of Friant-Kern flood water was exported from Kern County in this manner during 1997. All of this water was pumped south out of the county via the A. D. Edmunston pumping plant.

A potential source of water available for export exists in the ability to move banked water supplies out of the groundwater basin to out-of-county interests. Many water districts not located in Kern County have expressed interest in storing water via water banking programs that have been proposed as a result of the Monterey Amendments. When banked water is exported out-of-county in the future, the annual calculation of groundwater storage must reflect those exports.

Water Surface Evaporation

Water surface evaporation accounts for a small portion of water lost from the San Joaquin Valley portion of Kern County. Open canals, ditches and recharge ponds all lose water via evaporation. In 1997 about 69,700 acre-feet of evaporation losses occurred, with about 69,100 over the groundwater basin.

CHANGE IN GROUNDWATER STORAGE

Figure 16 displays a gross total water demand for the San Joaquin Valley portion of Kern County of 4,143,000 acre-feet in 1997. About 3,781,400 acre-feet of this demand occurred over the groundwater basin. A large amount of water, 830,300 acre-feet, was used for direct recharge or unlined delivery system losses. Total net consumptive water use was 2,695,500 acre-feet, with about 2,334,000 used over the groundwater basin. Gross available surface water supplies were about 3,170,200 acre-feet. There was a net increase in groundwater storage of 305,300 acre-feet in 1997.

Figure 17 is a graph displaying the water supplies and demands of the San Joaquin Valley portion of Kern County since 1970, when SWP water was first introduced over the groundwater basin. During 1970-75, delivery systems were being developed, and the Cross Valley Canal had not been completed. During 1976-77, drought conditions restricted surface water supplies.

Between 1970 and 1997, about 15,100,000 acre-feet was withdrawn from groundwater storage. During the same period the balance between additions and extractions has replenished about 4,800,000 acre-feet. The average change in storage since 1970 is about 368,000 acre-feet per year. Figure 18 shows the cumulative groundwater balance since 1970. In volume of groundwater storage, the basin still stands below 1977 levels, although a definite upward trend continues.

Kern County's groundwater management plans depend upon the sustained delivery of surface water from all three major sources: Kern River, State Water Project and Central Valley Project. A reduction in one supply, unless accompanied by an increase in another, can have a serious impact on the groundwater basin. Table 21 provides a summary of supplies from these sources and shows their interdependence. An excellent example is the comparison of 1986 with 1987. During 1986 surface water supplies were ample, while in 1987 they were scarce. Groundwater pumping increased in 1987 to make up for the dry-year conditions. Conditions during the most recent drought also showed this dependence as reduced surface water supplies were replaced by groundwater pumping.

BASIN-WIDE WATER USE EFFICIENCY

Water applied to a crop in excess of its evapotranspiration requirements percolates past the root zone and enters groundwater supplies, where it is available for reuse. Sometimes shallow clay layers in the soil can intercept this deep percolation, resulting in a condition called "shallow groundwater." In some areas deep percolation may enter unusable saline groundwater. In the western portion of Kern County, most soils are moisture-deficient (the water held in the soil is less than the amount of water the soil would normally retain after drainage via gravity). Any deep percolation occurring in these moisture-deficient soils will be absorbed until the water-holding capacity of the soils is reached.

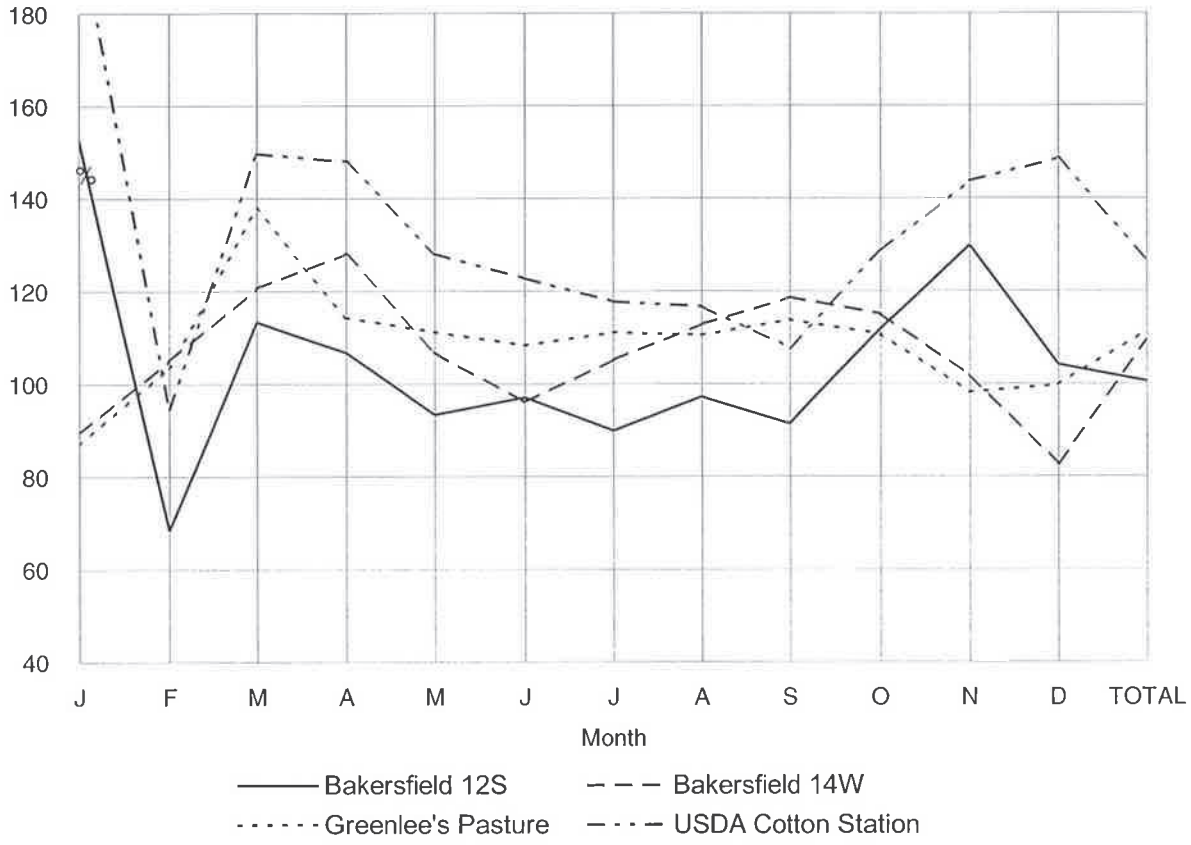
Table 17. 1997 Monthly Evaporation for San Joaquin Valley Climatic Station (in inches)

	Bakersfield 12S [1]	Bakersfield 14W	USDA Cotton Station	Greenlee's Pasture	Avg. All Stations
January	2.15	1.18	1.33	1.42	1.55
February	1.5	1.75	1.87	1.61	1.71
March	4.5	4.02	4.17	5.74	4.23
April	6.2	7.16	8.13	7.71	7.16
May	7.75	9.28	10.85	9.26	9.29
June	9.28	9.62	11.61	11.31	10.17
July	8.7	10.37	11.7	9.64	10.26
August	8.27	9.62	9.71	8.38	9.20
September	5.84	7.36	8.18	8.1	7.13
October	4.83	5.33	5.97	4.7	5.38
November	2.79	2.04	2.56	1.71	2.46
December	1.26	1.37	1.61	0.98	1.41
Total	**63.07**	**69.10**	**77.69**	**70.56**	**69.95**
Percent of Normal	**101**	**109**	**128**	**111**	**112**

Station Locations

Bakersfield 12S	Section 36D, T31S, R27E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.
Bakersfield 14W	Section 4R, T30S, R25E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.
USDA Cotton Station	Section 33F, T27S, R25E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated grass turf environment.
Greenlee's Pasture	Section 36N, T12N, R21W, SBB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.

Figure 15. 1997 Percent of Normal Evaporation



Percent of Normal, Total:	
Bakersfield 12S	**100.5**
Bakersfield 14W	**109.2**
Greenlee's Pasture	**111.5**
USDA Cotton Station	**126.8**

Bakersfield 12S

1997 observed monthly EP, Bakersfield 12S (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

Bakersfield 14W

1997 observed monthly EP, Bakersfield 14W (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

Greenlee's Pasture

1997 observed monthly EP, Greenlee's Pasture (irrigated pasture - Wheeler Ridge area) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP in the foothill regions of the valley.

USDA Cotton Station

1997 observed monthly EP, USDA Cotton Station (irrigated turf) compared to long-term average for long-term average for USDA Cotton Station in the San Joaquin Valley. This station is indicative of EP for cotton in Kern County.

Table 18. 1997 Irrigated Acreage, San Joaquin Valley Portion of Kern County

Crop	Acres [2]	Percent of Total	Consumptive Water Use [1] (AF/Acre)
Alfalfa (including seed)	88,490	8.8	7.30
Almonds	91,780	9.1	5.21
Apples	4,862	0.5	4.89
Apricots	679	-	4.89
Asparagus	698	-	3.56
Avocado	54	-	5.39
Barley	9,882	1.0	1.81
Beans	5,715	0.6	3.54
Broccoli	152	-	1.04
Carrots	25,967	2.6	1.44
Citrus	45,135	4.5	4.77
Corn, Field & Sweet	11,342	1.1	5.34
Cotton	269,952	26.7	2.71
Dry Farmed Grains, Pasture	20,125	2.0	-
Figs	584	-	5.30
Grapes	97,660	9.7	3.60
Guayale, Jojoaba	192	-	2.01
Idle, Fallow Lands	103,694	10.3	-
Kiwi	293	-	3.78
Lettuce	2,639	0.3	0.34
Melons, Squash, Cucumbers	7,142	0.7	1.83
Misc. Deciduous Trees	9,053	0.9	5.30
Misc. Field Crops	14,665	1.5	2.65
Misc. Hay/Grain	27,700	2.7	1.73
Misc. Subtropical Trees	142	-	4.77
Misc. Vegetables	12,396	1.2	6.17
Nursery	5,607	0.6	4.02
Oats	1,219	0.1	1.75
Olives	1,040	0.1	4.97
Onions, Garlic	12,869	1.3	3.51
Pasture, Turf	12,301	1.2	4.60
Peaches, Nectarines	5,695	0.6	4.83
Pears	-	-	5.21
Peas	1,091	0.1	1.65
Peppers	2,088	0.2	1.95
Pistachios	30,098	3.0	4.82
Plums, Prunes	2,626	0.3	4.94
Potatoes	19,575	1.9	4.04
Rice	-	-	3.50
Safflower	5,280	0.5	2.55
Sorghum/Milo	262	-	2.11
Sudan Grass	2,306	0.2	2.20
Sugar Beets	4,364	0.4	3.34
Tomatoes	3,430	0.3	2.39
Turnips	-	-	3.40
Walnuts	1,550	0.2	3.96
Wheat	47,124	4.7	2.42
Total Irrigated Lands	**885,699**	**100.0**	**2.34**
Total Harvested Lands	**905,824**		
Double Cropped	**12,138**		

Note: Double-cropped acreage is counted twice, since it is irrigated twice.

[1] Weighted average consumptive use of all crops.

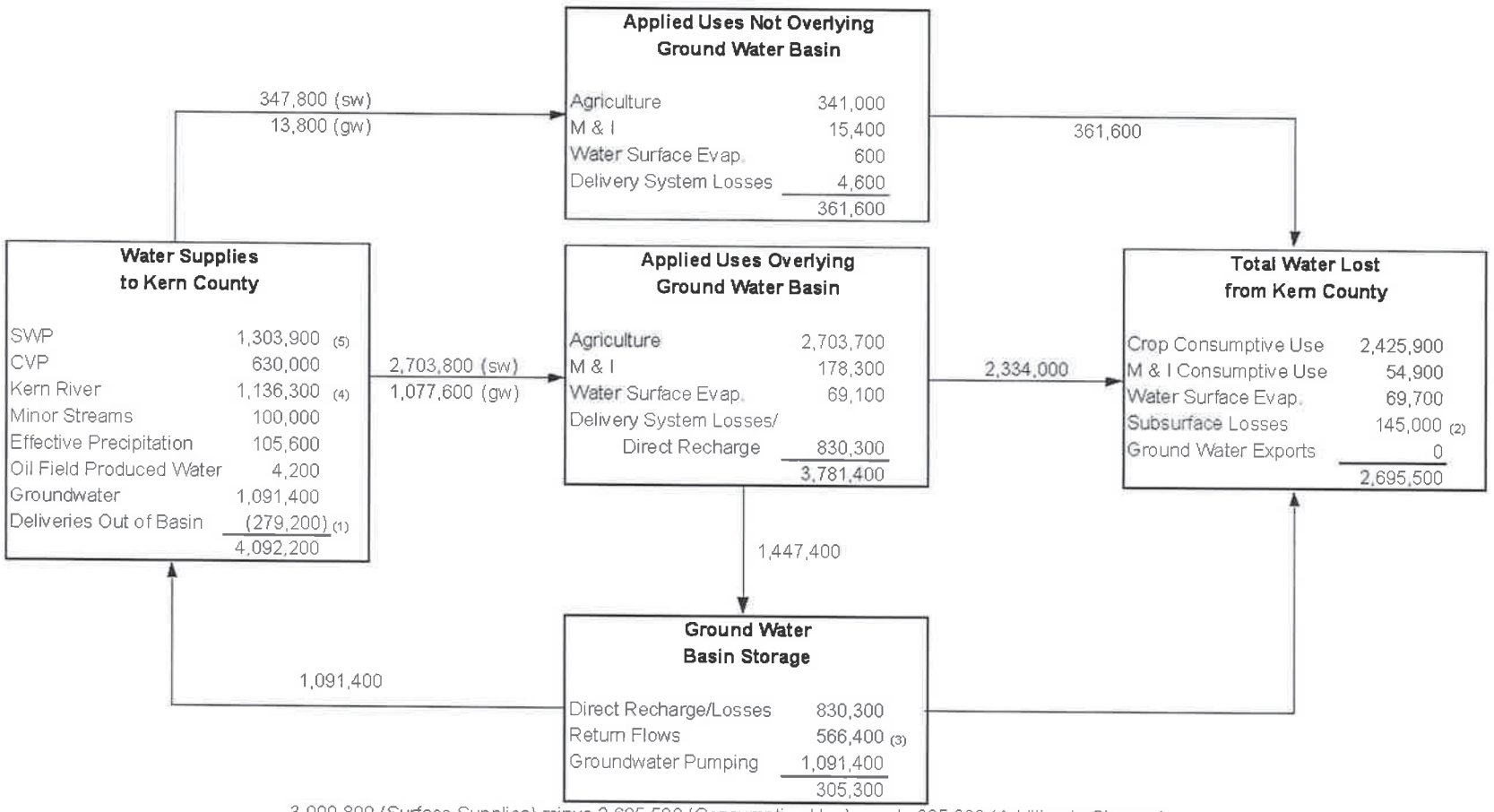
[2] Excludes acreage in Arvin-Edison WSD/Wheeler Ridge-Maricopa WSD overlap area.

Table 19. Average Applied Water Requirements for Various Crops, San Joaquin Valley Portion of Kern County (in acre-feet per acre)

Crop	Drip [1]	Sprinkler [2]	Row/Border [3]
Alfalfa		3.45-4.35	3.5-5.15
Almonds	2.85-4.10	2.85-4.50	2.85-4.50
Apples	1.95-3.80	3.40-4.75	
Beans (dry)			2.00-2.75
Carrots		1.75-2.45	
Citrus	2.05-3.75	2.75-4.40	3.50-4.50
Corn (field)			3.00-5.00
Cotton		2.25-3.75	2.45-3.75
Grapes	2.00-4.00	2.15-4.50	2.35-4.85
Lettuce			1.50-2.50
Onions, Garlic		1.00-2.65	1.25-4.25
Melons, Squash, Cucumbers			2.00-3.40
Misc. Deciduous Trees	2.75-3.35	3.00-4.00	3.00-4.50
Nursery			2.25-3.50
Pasture, Irrigated		3.50-4.50	3.50-6.00
Pistachios	2.65-4.40	2.35-3.35	3.00-3.50
Potatoes		1.10-2.30	
Small Grains		1.00-2.50	1.00-2.50
Tomatoes			2.50-3.50
Walnuts			3.50-5.00

[1] Includes emitters, misters, mini-sprinklers and fan jets.
[2] Includes portables, solid-sets, linear moves, sprinkler guns.
[3] Border includes border strip, level basin, contour strip.
Note: A blank entry indicates that an irrigation system is generally not utilized on a crop.

Figure 16. 1997 Water Resources Inventory, San Joaquin Valley Portion of Kern County (acre-feet)



3,000,800 (Surface Supplies) minus 2,695,500 (Consumptive Use) equals 305,300 (Addition to Storage)

Notes:

(1) Delivered to Tulare Lake Basin WSD (1,500 AF), Westlands WD (223,562 AF), Tehachapi-Cummings WD (6,597 AF). An additional 47,496 acre-feet of CVP water entered the California Aqueduct via the Kern River-California Aqueduct Intertie and was exported.

(2) Includes 125,500 AF to saline sinks, and 19,500 AF losses to moisture deficient soils.

(3) A total of 50,800 AF of municipal waste water was treated and reused. The reuse is not included here.

(4) Total excludes 177 AF delivered to Kern Valley Golf Course (Kernville). Includes 29,788 AF delivered above First Point.

(5) Not all of this water is delivered into Kern County.

(sw) Surface Water
(gw) Ground Water

Figure 17. Gross Water Supplies and Net Water Requirements, San Joaquin Valley Portion of Kern County, California.

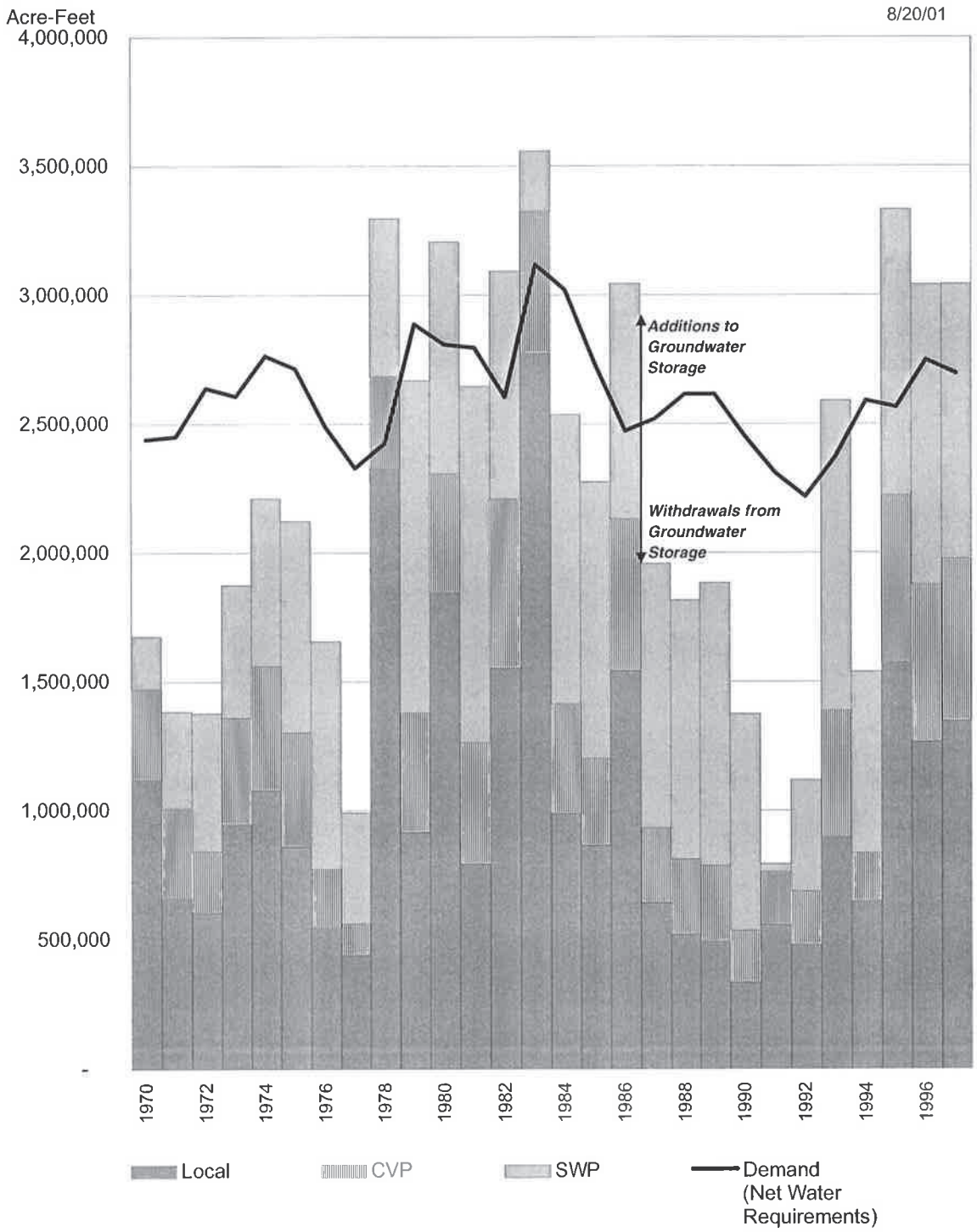


Figure 18. Cumulative Change in Groundwater Storage, San Jaoquin Valley Portion of Kern County

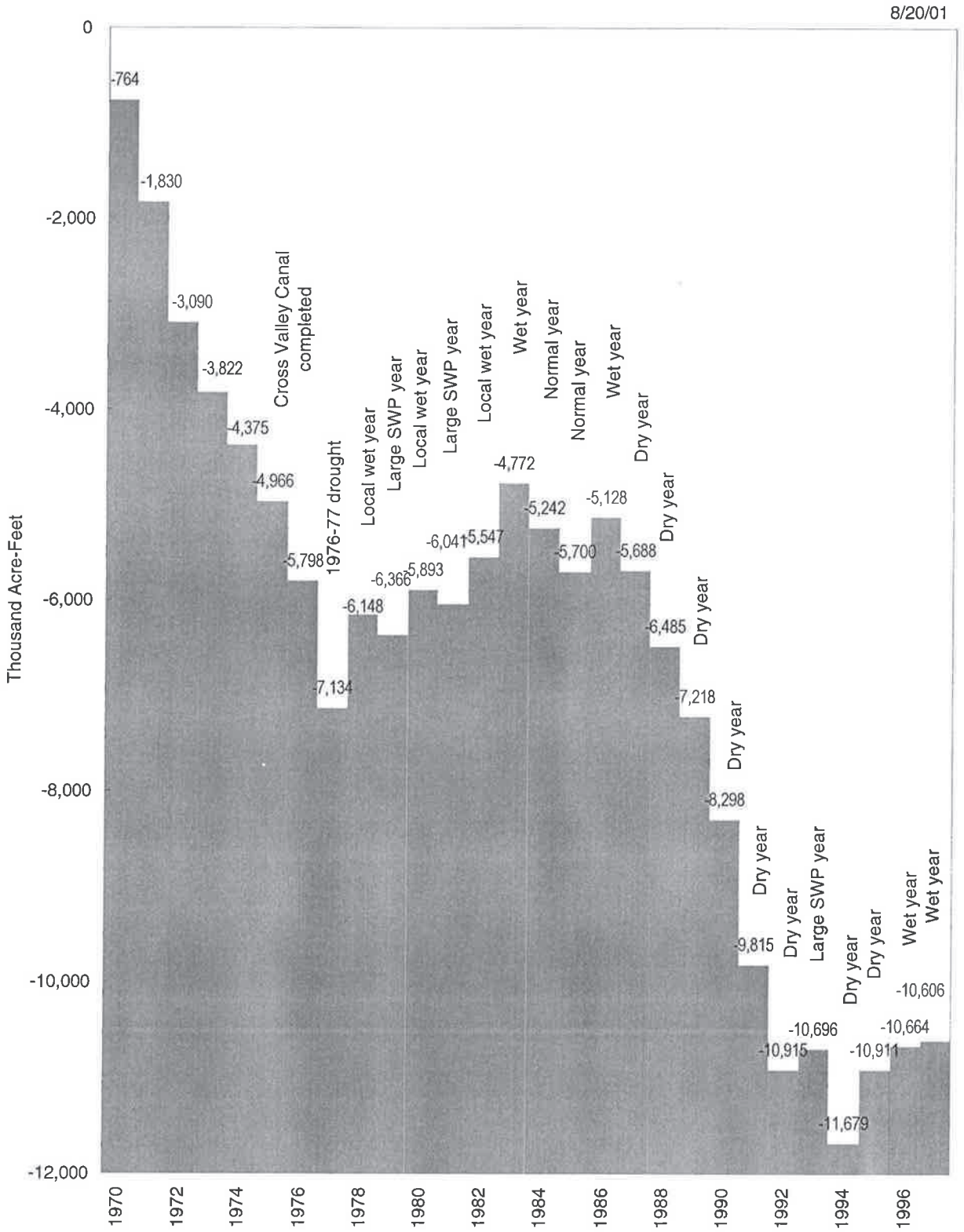


Table 20. 1997 Urban Water Use, San Joaquin Valley Portion of Kern County

Water Purveyor Service area	Metered Connections	Non-metered Connections	Annual Water Use: Million Gals.	Annual Water Use: Acre Feet	Permanent Population	GPCD [1]
Arvin						
Arvin CSD [6]	2,265	-	638	1,959	10,700	163
Bakersfield Metro Area						
Airport Mutual WC	Unknown	Unknown	16	50	Unknown	-
California Water Service						
Bakersfield Division	16,645	37,985	23,867	73,240	184,040	355
Ashe Water Division	20,229	176	8,129	24,945	60,720	367
Casa Loma WC [6]	-	215	401	1,231	2,000	550
East Niles CSD	6,342	-	3,437	10,547	21,900	430
Greenfield CWD	712	368	385	1,181	6,000	176
North of the River MWD	425	1,471	2,335	7,165	6,295	1,016
Oildale MWC	429	5,776	2,289	7,024	22,000	285
Rancho Verdugo WC	288	-	93	287	540	474
Stockdale MWC	-	80	71	254	200	966
Stockdale Annex MWC	-	138 [6]	52 [6]	159	250	568
Vaughn WC	4,113	862	2,458	7,544	13,980	482
Victory MWC [6]	-	155	55	170	620	245
Metro Area Subtotal	**49,183**	**47,226**	**43,589**	**133,799**	**329,245**	**368**
Buttonwillow						
Buttonwillow CWD [5]	-	415	158	486	1,278	340
Delano						
City of Delano	2,945	3,587	2,500	7,672	31,443	218
Lamont						
Lamont PUD and ID#1	277	3,181	1,853 [6]	5,685	14,677	346
Lost Hills						
Lost Hills Utility District [5]	223	-	105	322	800	360 [2]
McFarland						
McFarland MWC	1,748	-	470	1,442	11,000	117
Rio Bravo						
Olcese WD	369	-	285	874	850	**918** [3]
Shafter						
City of Shafter [6]	26	3,318	917	2,814	11,000	228
Taft-Maricopa-McKittrick						
West Kern WD	7,038	-	4,407	13,523	16,500	732 [2]
Wasco						
City of Wasco	673	3,230	1,392	4,271	18,067	211
Wasco State Prison	2	-	221	679	4,500 [6]	135
Total	**64,749**	**60,957**	**56,535**	**173,527**	**450,060**	**332** [4]

(1) Gallons per capita per day. Note that the computed GPCD on this table includes residential, commercial, industrial and public authority water use. Residential use is about 200 GPCD.

(2) Includes significant quantities of water used by oil companies.

(3) Includes significant quantities of water used to irrigate a golf course.

(4) Weighted average gpcd, excluding Rio Bravo, Lost Hills and Taft-Maricopa-McKittrick.

(5) 1997 data not available; estimated using 1994 data.

(6) 1997 data not available; estimated using 1995 data.

Table 21. Surface* and Groundwater Usage or Availability, San Joaquin Valley Portion of Kern County (in acre-feet)

	Kern River		Other Local Water		Central Valley Project		State Water Project		Groundwater		
	Available	% of Total	Available	% of Total	Usage	% of Total	Usage	% of Total	Usage	% of Total	Total Supplies
1970	589,500	19.1	517,900	16.8	351,400	11.4	204,600	6.6	1,422,000	46.1	3,085,400
1971	427,500	13.9	217,100	7.1	348,900	11.4	375,500	12.2	1,700,000	55.4	3,069,000
1972	268,400	8.4	292,600	9.2	238,500	7.5	535,600	16.8	1,857,000	58.2	3,192,100
1973	979,700	26.3	161,200	4.3	412,200	11.0	515,500	13.8	1,662,000	44.6	3,730,600
1974	818,600	22.6	332,000	9.2	480,600	13.3	651,800	18.0	1,333,000	36.9	3,616,000
1975	564,600	15.2	287,300	7.8	442,100	11.9	821,700	22.2	1,587,000	42.9	3,702,700
1976	249,500	7.5	225,700	6.8	226,500	6.8	883,400	26.6	1,738,000	52.3	3,323,100
1977	197,000	7.3	239,400	8.9	121,500	4.5	429,400	16.0	1,703,000	63.3	2,690,300
1978	1,653,500	36.8	1,050,200	23.3	357,800	8.0	611,500	13.6	825,000	18.3	4,498,000
1979	672,700	17.0	258,700	6.6	462,500	11.7	1,291,800	32.7	1,260,000	31.9	3,945,700
1980	1,640,000	37.8	356,500	8.2	462,800	10.7	900,300	20.8	977,000	22.5	4,336,600
1981	449,300	11.8	329,100	8.7	470,000	12.4	1,384,700	36.5	1,161,000	30.6	3,794,100
1982	1,271,100	31.4	434,600	10.7	656,600	16.2	884,500	21.8	802,200	19.8	4,049,000
1983	2,489,100	52.2	723,000	15.2	550,900	11.6	238,200	5.0	762,700	16.0	4,763,900
1984	821,800	21.7	165,300	4.4	425,400	11.2	1,123,000	29.6	1,252,200	33.1	3,787,700
1985	672,400	18.8	192,600	5.4	337,500	9.5	1,074,100	30.1	1,293,800	36.2	3,570,400
1986	1,444,900	35.2	207,000	5.0	589,300	14.4	913,600	22.3	947,600	23.1	4,102,400
1987	375,900	12.1	206,800	6.7	292,000	9.4	1,025,900	33.0	1,208,700	38.9	3,109,300
1988	294,700	8.9	179,800	5.4	292,800	8.8	1,006,200	30.4	1,540,200	46.5	3,313,700
1989	397,000	11.3	141,500	4.0	293,900	8.4	1,097,200	31.2	1,588,500	45.2	3,518,100
1990	203,600	6.4	112,800	3.6	200,100	6.3	857,300	27.0	1,796,500	56.7	3,170,300
1991	406,300	14.2	220,400	7.7	204,400	7.1	32,700	1.1	2,002,400	69.9	2,866,200
1992	296,800	10.6	203,200	7.3	208,000	7.4	418,000	14.9	1,673,600	59.8	2,799,600
1993	853,800	22.5	251,200	6.6	489,800	12.9	1,205,500	31.8	987,700	26.1	3,788,000
1994	336,500	10.1	222,700	6.7	186,300	5.6	695,400	20.8	1,897,700	56.8	3,338,600
1995	1,385,200	29.1	374,100	7.9	647,100	13.6	1,111,200	23.3	1,242,800	26.1	4,760,400
1996	1,038,300	22.0	294,400	6.2	611,300	13.0	1,165,100	24.7	1,609,600	34.1	4,718,700
1997	1,182,000	28.2	209,800	5.0	630,000	15.1	**1,072,200**	25.6	1,091,400	26.1	4,185,400
Avg.	**770,300**	**21.1**	**303,600**	**8.3**	**383,700**	**10.5**	**794,600**	**21.8**	**1,401,200**	**38.4**	**3,653,300**

* Adjusted for deliveries within Kern County. SWP includes Intertie deliveries.

830,300 for groundwater recharge, and 4,600 in unrecoverable delivery system losses). Total consumption of water was about 2,550,500 acre-feet (2,425,900 by agriculture, 54,900 by M&I, and 69,700 in evaporation losses). Effective Precipitation was about 105,600 acre-feet. Agricultural irrigation efficiency was about 76 percent. A total of 50,800 acre-feet of M&I water was treated and reused, mostly by agriculture. The difference between gross and net requirements is an estimate of groundwater returns, which amounted to 762,200 acre-feet. However, about 131,600 acre-feet of deep percolation was intercepted by shallow groundwater, and another 13,400 acre-feet was absorbed by moisture-deficient soils. Therefore net groundwater returns were 566,400 acre-feet in 1997.

Of the 4,143,000 acre-feet in gross water demand during 1997, 3,947,200 acre-feet was beneficially used or was available for reuse via net deep percolation. This means that 95 percent of the water used in 1997 was put to beneficial use or was available for reuse. This percentage is termed "basin-wide water use efficiency." Kern County is among the most water-efficient areas in the state.

INTERTIE ACTIVITY

The Kern River-California Aqueduct Intertie is a structure connecting the Kern River to the California Aqueduct near Tupman. Its basic purpose is to dispose of flood water, preventing damages downstream of the Kern River flood plain. Flows into the California Aqueduct through the Intertie may contain water from the Kern, Kaweah, Kings, San Joaquin or Tule Rivers, or a combination of these. Generally, Kern River flows must exceed about 200 percent of normal before the Intertie gates need to be opened. The structure has a capacity of 3,500 cfs. However, downstream Aqueduct demands can become the limiting factor in wet years when demands are low.

Generally, when Intertie water enters the California Aqueduct it becomes the property of the state Department of Water Resources, and is used to meet SWP system needs. During periods of extremely heavy runoff (such as in 1983), temporary pumps may be installed to pump the water to Aqueduct reaches north (upstream) of the Intertie.

The Intertie gates opened on January 9, 1997 to receive Friant-Kern flood flows entering the Kern River channel. During January and February 1997, 51,055 acre-feet of Friant-Kern water flowed into the Aqueduct via the Intertie, plus 1,793 acre-feet of Kern River water because of mandatory release operations at Isabella Reservoir.

Through the end of 1997, a total cumulative flow of 1,195,929 acre-feet of water has passed through the Intertie gates into the California Aqueduct. About 45 percent of this was used in Kern County; the remainder went to southern California. Table 22 is a historical summary of Intertie activity to date, showing the inflow by source, and amounts exported from and retained in the County for years in which the Intertie was operated. The Intertie only operates when all other local uses or demands have been exhausted.

Over the entire San Joaquin Valley portionof Kern County, gross water uses were about 4,650,100 acre-feet during 1997 (3,136,700 for agriculture, 193,500 for M&I use, 67,500 of evaporation losses,

GROUNDWATER CONDITIONS

Groundwater Recharge

Many entities in Kern County are engaged in groundwater replenishment. Semitropic WSD, Rosedale-Rio Bravo WSD, North Kern WSD, Arvin-Edison WSD, City of Bakersfield, Kern Water Bank Authority and KCWA all operate recharge facilities. Kern River water is recharged by a combination of deliberate spreading in recharge areas, by losses in unlined canals, or by percolation in the Kern River's channel. Central Valley Project water is recharged in spreading ponds operated by Arvin-Edison WSD or in the channels of the Kern River and Poso Creek, as well as in recharge facilities on the Kern River alluvial fan. State Water Project water is recharged by KCWA and several other water districts in the Kern River channel (via the Cross Valley Canal), in unlined irrigation canals, and in district or KCWA operated recharge sites. During wet periods, every effort is made to deliver water through unlined canals to maximize groundwater recharge.

Many water districts in Kern County utilize conjunctive use and banking programs to help balance their supplies, as shown on Figure 19. A well-managed conjunctive use or banking program is an effective groundwater management tool that allows a district to maintain an adequate supply during periods when sufficient surface water is unavailable. The intent is to store surface water during times when available supply exceeds demand, and recover groundwater during periods when the opposite occurs. A correctly managed program monitors the effects of water recharge and withdrawals in any year, to help understand and anticipate local and regional groundwater impacts. A tremendous amount of groundwater recharge in Kern County is accomplished as part of these programs. Table 23 shows major conjunctive use and banking programs since 1971, listing the amounts of water by source. About 830,300 acre-feet of water was recharged in 1997, both deliberately and incidentally. Following is the approximate breakdown between sources:

Source	Acre-feet
Kern River	80,500
SWP	41,000
CVP	114,600
Wastewater	3,700
Minor Streams	95,000
Combined	295,500
Total	**830,300**

Note: These numbers include direct and incidental recharge. Sources are often intermixed in the same conveyance or recharge facilities.

These numbers should be considered as "best estimates," since supplies are often intermixed in the same canal systems, making differentiation impossible. The amount of recharge shown in Table 23 is less than the amount of recharge listed here. This is because Table 23 also includes in-lieu recharge, and excludes incidental recharge and minor stream flows, which naturally recharged the groundwater basin. In-lieu recharge is accomplished by delivering surface water to users who would normally pump groundwater.

Table 22. Summary of Kern River-California Aqueduct Intertie Activity (in acre-feet)

	Intertie Inflow				Amount Exported				Retained in County			
	Kern River	Friant-Kern	Total		Kern River	Friant-Kern	Total		Kern River	Friant-Kern	Total	
1978	168,818	9,113	177,931		n/a*	n/a*	113,831		n/a*	n/a*	64,100	
1980	138,816	0	138,816		74,024	0	74,024		64,792	0	64,792	
1982	10,339	11,968	22,307		5,928	2,700	8,628		4,411	9,268	13,679	
1983	662,856	96,200	759,056		n/a*	n/a*	393,551		n/a*	n/a*	365,505	
1984	27,524	0	27,524		13,885	0	13,885		13,639	0	13,639	
1986	1,867	15,580	17,447		0	4,746	4,746		1,867	10,834	12,701	
1995	(13,117)	0	(13,117)	(1)	0	0	0		(13,117)	0	(13,117)	(1)
1997	1,793	51,055	52,848		1,793	45,703	47,496		0	5,352	5,352	(1)
Total	**1,012,013**	**183,916**	**1,195,929**	(2)			**656,161**				**539,768**	(2)

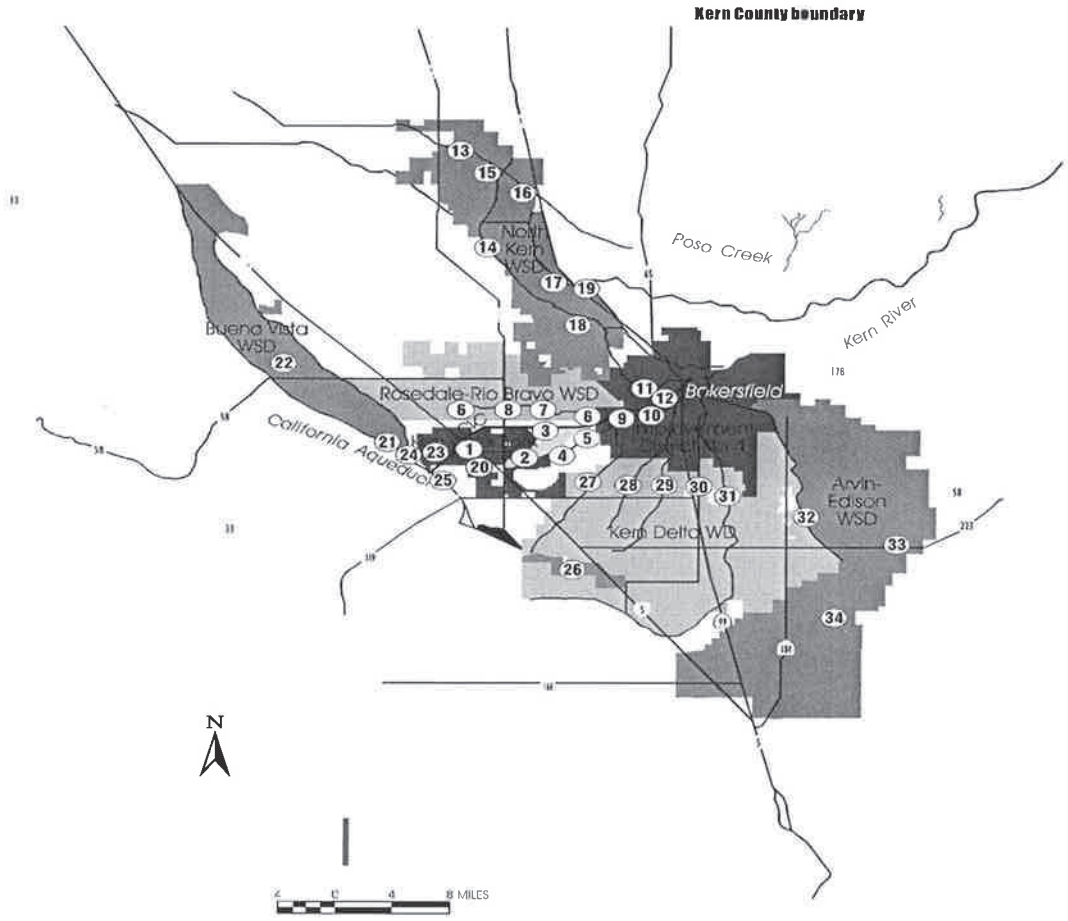
* A breakdown between sources was not available.

(1) A major flood event north of Kern County caused SWP water to be reverse flowed into the Kern River flood channel. This is the opposite operation for which the Intertie was designed and constructed.

(2) The year 1995 is not included in totals.

Source: State Department of Water Resources and City of Bakersfield Kern River Annual Reports.

Figure 19. Groundwater Recharge Sites, 1997 Summary, Southern San Joaquin Valley Portion of Kern County



	Location	Recharge (AF)
1	Kern Water Bank	115,600
2	COB 2800 Ac	31,400
3	Pioneer North and South	13,200
4	Pioneer South	
5	Berrenda Mesa Spreading	6,600
6	Rosedale-Rio Bravo WSD	
7	Goose Lake Slough	
8	KFE/RRB	
	RRBWSD Total	121,700
9	Kern River	89,500
10	Truxtun Lakes	6,000
11	Calloway Canal and One Ditch	30,400
12	Cross Valley Canal extension	2,400
13	Poso Creek	
14	Calloway Canal	
15	Poso 27	
16	Switch Field	
17	Minter Field	
18	Rosedale Ponds	
19	Lerdo Canal	
	North Kern WSD Total	137,300

	Location	Recharge (AF)
20	Kern River Bypass/Channel	16,200
21	Kern River Flood Channel	3,900
22	Buttonwillow Canals	51,500
23	Main Canal	2,200
24	Outlet Elk Pen	13,800
25	Outlet Canal	16,700
26	Maples Canal	1,900
	Buena Vista WSD Total	106,200
27	Buena Vista Canal	
28	Stine Canal	
29	Farmers Canal	
30	Kern Island Canal	
31	Central Branch Canal	
32	Eastside Canal	
	Kern Delta WD Total	69,000
33	Sycamore Spreading Grounds	
34	Tejon Spreading Grounds	
	Arvin-Edison WSD Total	73,200
	Grand Total	**802,500**

Table 23. Summary of Groundwater Recharge Activities (in acre-feet)

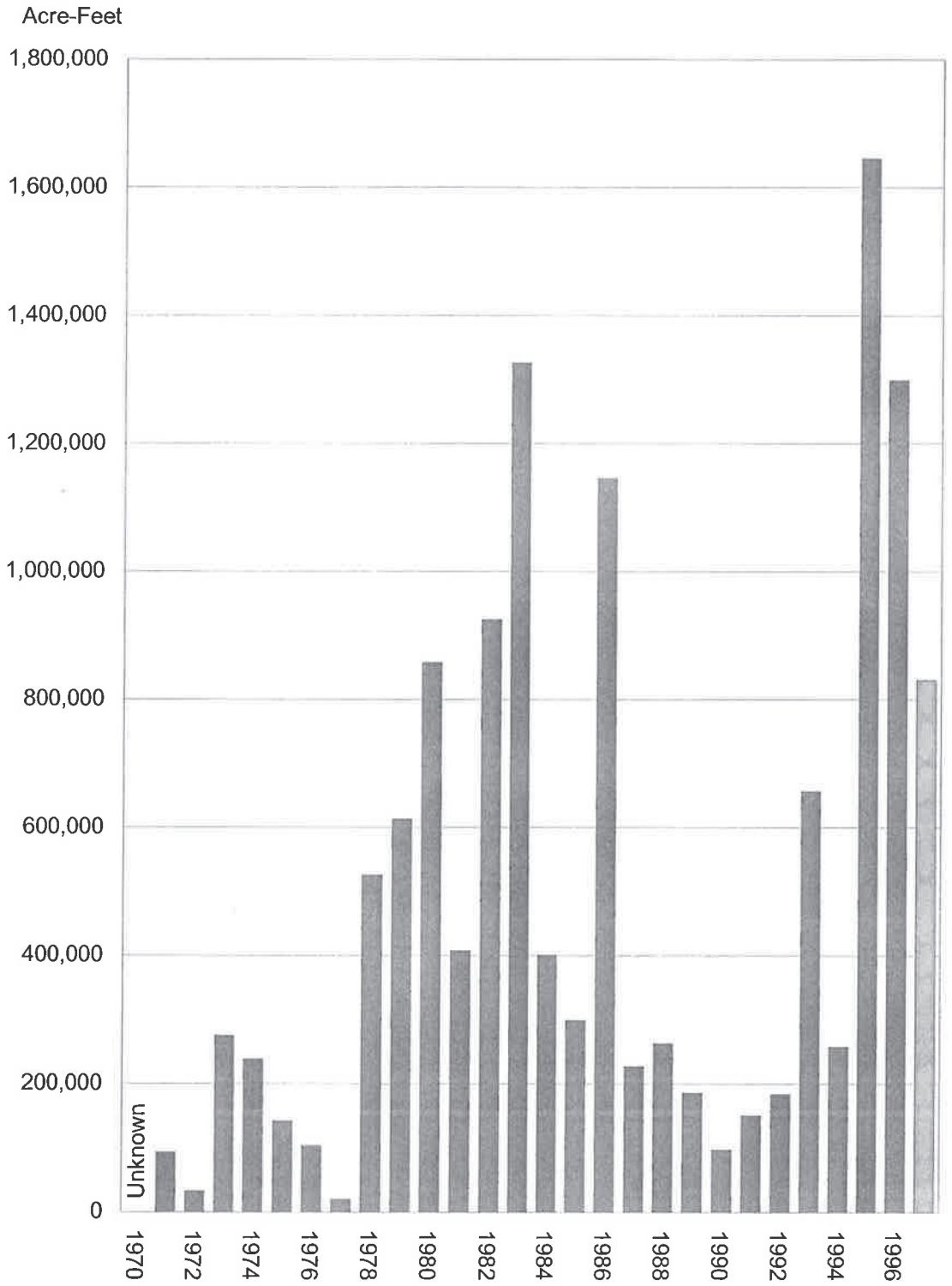
Entity/Location	Source	1971-91	1993	1994	1995	1996	1997	Total
BANKING								
City of Bakersfield[2]								
2,800 Acre Spreading Area	Combined[1]	614,823	7,881	--	39,117	21,994	31,500	715,315
Kern County Water Agency								
Kern Water Bank	Combined[1]	--	--	--	688	18,069	--	18,757
Pioneer Property	Combined[1]	--	--	--	102,693	52,367	13,235	168,295
Berrenda Mesa Spreading Area	Combined[1]	33,960	7,563	2,333	34,280	9,554	6,565	94,255 [1]
Kern River Channel	Combined[1]	33,552	26,494	--	2,029	6,179	5,883	74,137
2,800 Acre Spreading Area	Combined[1]	82,733	125,734	20,551	73,337	16,612	875	319,842
Subtotal KCWA		**150,245**	**159,791**	**22,884**	**213,027**	**102,781**	**26,558**	**675,286**
DWR-Kern Water Bank								
2800 Acre Spreading Area	SWP	7,379	--	--	--	--	--	7,379
Local Elements In-lieu Rechg.	SWP	136,300	--	--	--	--	--	136,300
Local Elements Direct Rechg.	SWP	4,200	--	--	--	--	--	4,200
Subtotal DWR		**147,879**	--	--	--	--	--	**147,879**
Kern Water Bank Authority								
Kern Water Bank	Combined[1]	--	--	--	230,938	143,615	115,590	490,143
2800 Acres	Combined[1]	--	--	--	--	--	--	--
Pioneer Property	Combined[1]	--	--	--	--	--	--	--
Subtotal KWBA		--	--	--	**230,938**	**143,615**	**115,590**	**490,143**
Total Banking		**912,947**	**167,672**	**22,884**	**483,082**	**268,390**	**173,648**	**2,028,623**
CONJUNCTIVE USE								
Arvin-Edison WSD	F-K	723,482	120,217	3,884	108,664	51,954	73,151	1,081,352
Buena Vista WSD Direct Rechg.	Combined[1]	1,348,022	76,743	47,161	128,203	81,156	52,831	1,734,116
Semitropic WSD Direct Rechg.	SWP	68,798	9,738	8,960	20,881	23,560	21,997	153,934
In-Lieu Rechg.	SWP	638,502	31,728	34,638	73,954	114,135	110,995	1,003,952
	Combined[1]	7,289	--	--	--	--	--	7,289 [1]
I.D. No. 4 Direct Rechg.	Kern	425,412	30,319	15,250	**30,692**	64,753	60,224	626,650
	SWP	261,832	44,557	14,030	19,523	138	--	340,080
	F-K	18,835	8,084	193	7,098	9,754	2,629	46,593
Kern Delta WD Direct Rechg.	Combined[1]	1,138,508	57,428	47,675	61,252	65,301	69,016	1,439,180
North Kern WSD Direct Rechg.	Kern	1,448,652	61,512	30,255	242,263	121,233	137,340	2,041,255
In-Lieu Rechg.	Kern	2,285,849	133,785	86,402	124,873	140,781	135,657	2,907,347
Rosedale-Rio Bravo WSD Direct Rechg.	Kern	519,021	26,890	--	102,307	44,293	72,875	765,386
	SWP	522,925	55,636	6,119	48,375	29,545	17,080	679,680
	F-K	161,869	6,859	--	8,470	25,919	31,843	234,960
	Combined[1]	279,800	--	--	--	--	--	279,800 [1]
In-Lieu Rechg.	SWP	--	--	2,657	--	--	--	2,657
Wheeler Ridge-Maricopa WSD		--						
In-Lieu Recharge	SWP	193,714	6,882	--	12,650	--	--	213,246
Total Conjunctive Use		**10,042,510**	**670,378**	**297,224**	**989,205**	**772,522**	**785,638**	**13,557,477**
OVERDRAFT CORRECTION								
Groundwater Replenishment Programs								
Direct Rechg.	Kern	188,185	--	--	--	5,365	10,084	203,634
	SWP	257,920	521	--	--	38,795	1,912	299,148
	F-K	7,723	--	--	--	4,396	6,969	19,088
In Lieu Rechg.	Kern	--	573	--	3,725	3,189	889	8,376
	SWP	96,871	1,194	--	--	--	--	98,065
Total Overdraft Correction		**550,699**	**2,288**	--	**3,725**	**51,745**	**19,854**	**628,311**
GRAND TOTALS	**Kern**	**4,867,119**	**253,079**	**131,907**	**503,860**	**379,614**	**417,069**	**6,552,648**
	SWP	**2,188,441**	**150,256**	**66,404**	**175,383**	**206,173**	**151,984**	**2,938,641**
	F-K	**911,909**	**135,160**	**4,077**	**124,232**	**92,023**	**114,592**	**1,381,993**
	Combined[1]	**3,538,687**	**301,843**	**117,720**	**672,537**	**414,847**	**295,495**	**5,341,129 [1]**
	Total	**11,506,156**	**840,338**	**320,108**	**1,476,012**	**1,092,657**	**979,140**	**16,214,411**

[1] Breakdown between sources not available.

[2] Includes banking by Olcese WD, Hacienda WD, Buena Vista WSD, City of Bakersfield; for breakdown between districts see Table 24.

Note: For a breakdown of 1971 to 1991, see prior Water Supply Reports. These numbers may be revised from previous years Water Supply Reports.

Figure 20. Groundwater Recharge, San Joaquin Valley Portion of Kern County



Such recharge activities show the importance of reducing groundwater overdraft, as well as water conservation, in Kern County. Since 1970 about 16,200,000 acre-feet of water has been recharged (deliberately and incidentally) as part of groundwater replenishment programs and banking operations. The effectiveness of such recharge activities is apparent in Figure 17. KCWA estimates that the 16,200,000 acre-feet of recharged water results in a gross basin-wide groundwater pumping lift reduction of about 162 feet, or about one foot for every 100,000 acre-feet. Figure 20 shows historic groundwater recharge as a bar graph.

Groundwater Banking

Groundwater banking is a water management tool that has increased in use in recent years, and is directly related to the decreasing ability of the SWP and CVP to provide a reliable water supply. Because of limitations of existing surface water storage and conveyance facilities, coupled with regulatory restraints, DWR and USBR cannot meet their contractual obligations. Since groundwater storage is now more environmentally acceptable and economically feasible, KCWA and local water districts are expanding the development of water banking programs. The purpose of banking programs is to store surface water underground when it is available and recover it in times when it is not available. Available surface water supplies are used in conjunction with groundwater.

The Kern Water Bank was originally planned as a banking/recovery program that would have provided as much as 100,000 acre-feet of annual dry-year yield for the State Water Project. Through the terms of the Monterey Amendments, ownership and operation of the Kern Water Bank was transferred to local districts, which formed the Kern Water Bank Authority late in 1995. The Kern Water Bank property was actually transferred to KCWA by DWR, then conveyed to the Authority, in August 1996. The Authority is planning for the construction of approximately 6,800 acres of recharge ponds with a recharge rate of 3,000 acre-feet per day. It expects the Water Bank to reach an ultimate storage capacity of nearly 1,000,000 acre-feet. In 1997, the Kern Water Bank recharged a total of 115,590 acre-feet.

Another local project, the City of Bakersfield 2800 Acre recharge facility, has been maintained as a banking and recovery facility for many years, and KCWA and other districts have deposited water. During 1997 a total of 31,500 acre-feet were recharged in the 2800 Acres.

In 1992 KCWA purchased 2,253 acres of land to develop additional water recharge and banking facilities. The proposed "Pioneer Project" comprises two parcels on either side of the Kern River southwest of Bakersfield. When completed, the Pioneer Project will increase Kern County's groundwater recharge capacity by about 170,000 acre-feet a year. During 1997, about 26,558 acre-feet were recharged through the Pioneer Project.

Table 24 summarizes banking account balances for those entities involved as bankers in various banking programs. It displays in detail the banking portion of the information on Table 23, and includes recharge, extractions and transfers/sales of banking accounts. Recharge and recoverable balances shown have not been reduced to reflect evaporation or other losses.

Shallow Groundwater

When the downward movement of groundwater is interrupted by shallow clay or other strata of low permeability, shallow groundwater accumulations result. These are generally undesirable for farming operations if the water reaches the crop root zone. Poor crop yield, soil salt buildup and poorly-drained fields are symptoms of shallow groundwater problems.

Kern County areas suffering from shallow groundwater tend to follow the historic lower-elevation trace of the Kern River channel, and increases in shallow groundwater area appear after a year of high Kern River runoff. Conversely, contractions in shallow groundwater area occur during years when runoff is low. Thus, shallow groundwater appears to be a natural phenomenon. Table 25 lists areas with historic shallow groundwater problems, categorized into five-foot increments, along with the number of monitoring wells measured. While the number of data points (monitoring wells) has increased and decreased through time, the current data set incorporates 240 wells, covering the historic drainage of the Kern River.

Depth to shallow groundwater as measured in shallow monitoring wells is contoured on Plate 1. In the summer of 1997 water within five feet of the ground surface was found under an area of about 30,000 acres. This was a 9 percent increase from the summer 1996 areal extent. The areal extent of shallow groundwater between 5-10 feet of the ground surface was about 146,400 acres, about 7 percent lower than 1996. The areal extent of shallow groundwater between 10-15 feet of the surface was 58,700 acres in 1997, a 14 percent decrease from 1996. The probable cause for the increase in areal extent for the 0-5 feet interval was the increased rainfall in 1997. An examination of Table 25 shows that a large increase in area for the 0-5 feet interval commonly occurs in wet years, while contractions occur in relatively drier years.

Groundwater Quality

The groundwater basin of the Kern County portion of the San Joaquin Valley is a basin of interior drainage. It has no appreciable surface or subsurface outflow, except in extremely wet years. Therefore, new salts introduced into the basin with imported surface water supplies are retained in the basin. Groundwater is the recipient of these salts via recharge water or return flows from irrigation and urban users.

Surface water supplies over the usable groundwater basin in 1997 (about 2,536,400 acre-feet), carried about 379,000 tons of new salts into the groundwater basin.

Surface Water Salt Loads, 1997

Source	Volume (af)	Avg. TDS (ppm)	Salt Load (tons)
SWP over gw basin	703,000	197	188,000
Kern River	968,000	76	99,900
Minor Streams	88,100	368	44,100
Other Local Supplies*	166,000	66	14,800
CVP	611,300	38	31,900
Total	**2,536,400**	**110**	**379,000**

*includes effective rainfall, oil field produced water

Groundwater pumped and used for irrigation becomes degraded as salts are leached from the crop root zone. These salts return to groundwater via subsurface flows. This is a natural byproduct of human uses. A portion of applied water (averaging 25 percent in this basin) percolates through the soil profile to the groundwater. This smaller volume of water carries the salts once held by the total volume applied, and the result is a concentration of salts. The construction of local drainage projects helps reduce this buildup of salts by removing some near-surface accumulations in shallow groundwater areas. In areas of interior drainage like Kern County, the sustained importation of water, with large-scale agriculture, unless properly managed, will eventually result in the degradation of groundwater supplies. This is a normal by-product of water use by humans, whether for

agricultural or urban purposes. A great challenge for water managers is to relieve the contamination of precious groundwater by improved management, including salt management.

Chemical analyses of well water samples collected through the years have been used as a basis for drafting the water quality maps in this report. Plate 2 illustrates the variations in groundwater quality samples taken from the unconfined (upper) water system, as revealed by the total dissolved solids (TDS) data obtained. TDS are shown in parts per million (ppm). These are generally more shallow areas, usually less than 400 feet below ground surface level. Higher salt contents are prevalent on the west side of the southern San Joaquin Valley and in an area west of Delano.

Plate 3 is a compilation of data from water wells producing from the confined (lower) aquifer system. This lower system is partially protected from surface contaminants by the Corcoran Clay. Contours on this map show the groundwater quality of the lower aquifer to be superior to that of the unconfined zone.

Agricultural water well drilling decreased slightly during 1997 compared to activity in 1996. The Kern County Environmental Health Services Department issued 26 agricultural water well permits in 1997, in comparison to 32 permits issued during 1996. The decrease in drilling activity was due to the fact that three wet years in a row made plenty of surface water available. An additional 107 domestic wells were permitted and drilled during 1997, along with 83 wells for non-agricultural and non-domestic purposes (e.g., monitoring and cathodic protection wells). A total of 133 new agricultural and domestic water wells were drilled during 1997. Annular seals were required on three of the new wells to prevent degradation of separated groundwater zones (annular seals are plugs of concrete between the well casing and the drilled hole near a regional stratum of low permeability to prevent the movement of water between two aquifer systems).

Groundwater Levels

Plate 4, "Depth to Groundwater, Spring 1998," was prepared using hundreds of well measurements taken by KCWA and others. Water depths are plotted and contoured to aid in the evaluation of groundwater trends. Control wells include unconfined and select composite aquifer wells throughout most of the basin. In areas north of Wasco, water levels in confined wells are used for contouring because they best represent the most utilized aquifer. The "Depth to Groundwater" map shows the distance in feet from the ground surface to the groundwater surface.

Plate 5, "Groundwater Surface Elevation" map, was prepared based on the same measured wells as the "Depth to Groundwater" map. It displays the horizontal movement of groundwater from higher to lower elevations. The major direction of groundwater movement is away from sources of recharge. Plate 5 also shows what appear to be steep gradients between Semitropic WSD and neighboring Buena Vista WSD. Contours in these areas are based on well data from both unconfined and confined aquifers.

Historically, the Kern River has been the major groundwater recharge source in the basin. Mounding of groundwater occurs along the river channel, and groundwater moves away from this area. The rate of horizontal flow in the upper portions of the aquifer is estimated to range from 70 to 500 feet per year. Also, some mounding is attributed to various water districts' local recharge efforts.

Plate 6 depicts groundwater level changes from spring 1997 to spring 1998. Differences were plotted and contoured to show areas of relative improvement or decline. Shading was added to emphasize significant changes. Unless the annual change exceeds 10 feet, little impact to storage (as either losses or gains) can be inferred. The potential error related to the timing of groundwater level measurements, along with simple measuring errors preclude more precision.

Continuing a trend that began in 1995, the 1997-1998 change map shows only one area within the basin with water level declines. This is largely due to ample supplies of surface water. Also, large-scale groundwater recharge programs, begun in 1993, have contributed to improved groundwater levels.

Areas that showed the greatest changes in water levels were near the Kern Water Bank and the KCWA Pioneer Project recharge facility. Water levels near these recharge areas rose 30 feet above the 1997 depth to groundwater of 50-100 feet. Areas of the valley which normally show declines in water levels experienced static conditions (no change) during this period.

Water level changes in eight key water wells are displayed on hydrographs as Figures 21a, 21b, 21c and 21d. Each hydrograph represents water levels for a pair of wells, one unconfined and the other confined. One well pair is located in the Pond-Poso area, another between the city of Shafter and Rosedale-Rio Bravo WSD, a third pair southwest of Bakersfield, and the fourth pair in the Arvin area.

The two wells in the Pond-Poso area represent the confined and unconfined aquifer systems in that region. The hydrographs are plotted together to compare water level changes in both aquifers. The unconfined well reflects an upward trend since the 1977 drought, probably a continuation of a long-term rise in water levels caused by surface water deliveries via the Friant-Kern system. During 1990-92 drought conditions were more severe, with an increased dependence on groundwater; this is reflected by the decline in water levels during that period. The confined well shows a variable pattern of rises and falls from year to year. Since 1994 there has been an upward trend, corresponding to the recent wet years.

The Shafter/Rosedale-Rio Bravo area hydrographs represent the unconfined aquifer. The well (T29S/R26E-34Q01) is located between the Kern River channel and Rosedale-Rio Bravo WSD's recharge facilities. The hydrograph reflects a long-term decline in water levels from 1960 through the 1977 drought, with transient rises during years when Kern River flows were above average. Since these wells are situated close to the Kern River and recharge facilities, the hydrographs show rapid water level rises during the 1978-86 and 1993-97 wet periods, and declines during the 1987-92 drought.

The more moderate groundwater level changes in the Shafter well (T28S/R25E-32F01) reflect the greater distance from the main areas of groundwater recharge. This well appears to be at the southeastern terminus of the Corcoran Clay. Present groundwater level data suggests that no confined aquifer exists east and south of this location. Deep wells in these areas show annual groundwater levels and fluctuations that are consistent with the shallow wells. Confined and unconfined aquifers usually exhibit characteristic differences in seasonal groundwater level changes.

The southwest Bakersfield hydrographs show continual declines until 1978. The wet period 1978-86 appears as a rise in groundwater level. The 1987-92 drought shows another period of decline. Levels are coming back up as a result of the recent series of wet years. In the past, these two wells (T30S/R26E-22P1 and T30S/R26E-22P3) were classified as unconfined and confined, respectively. However, similar groundwater levels in both wells over a long period of time suggest that a confined aquifer may not exist in this area.

The Arvin-Edison area wells are designated as shallow (T32S/R29E-04P1) and deep (T32S/R29E-03Q1). The Arvin-Edison deep well may be in a confined aquifer, since it has shown annual

Table 24. Groundwater Banking Summary

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Alameda County WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Belridge WSD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Buena Vista WSD												
Recharge/Purchase	6,056	9,913			24,465				10,000			
Recovery/Sale										(6,000)	(5,000)	(3,138)
Storage Balance	6,056	15,969	15,969	15,969	40,434	40,434	40,434	40,434	50,434	44,434	39,434	36,296
Berrenda Mesa WD												
Recharge/Purchase				9,500								
Recovery/Sale												
Storage Balance				9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500	9,500
Cawelo WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
City of Bakersfield												
Recharge/Purchase	104,587	4,505	68,804	2,603	37,913	113,380	16,058	402	64,168	109		
Recovery/Sale			(13,772)	(100,837)			(472)	(1,615)		(656)	(5,432)	(2,859)
Storage Balance	104,587	109,092	164,124	65,890	103,803	217,183	232,769	231,556	295,724	295,177	289,745	286,886
Dudley Ridge WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Henry Miller WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Improvement District No. 4												
Recharge/Purchase									12,766			3,500
Recovery/Sale												
Storage Balance									12,766	12,766	12,766	16,266
Kern County Water Agency												
Recharge/Purchase				63,364		14,155	416	15,055	29,389			
Recovery/Sale												(16,105)
Storage Balance				63,364	63,364	77,519	77,935	92,990	122,379	122,379	122,379	106,274
Kern Delta WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Lost Hills WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Metropolitan WD of So. Calif.												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
OlceseWD/Hacienda WD												
Recharge/Purchase	24,328		52,604	4,465	14,266				56,197	5,344	3,214	
Recovery/Sale												(873)
Storage Balance	24,328	24,328	76,932	81,397	95,663	95,663	95,663	95,663	151,860	157,204	160,418	159,545
Rosedale-Rio Bravo WSD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												

Table 24 (continued). Groundwater Banking Summary

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Semitropic WSD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Santa Clara Valley WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
State of California												
Recharge/Purchase										7,379		
Recovery/Sale												
Storage Balance										7,379	7,379	7,379
Tejon-Castac WD												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Westside Mutual Water Co.												
Recharge/Purchase												
Recovery/Sale												
Storage Balance												
Wheeler Ridge-Maricopa WSD												
Recharge/Purchase				5,600								15,019
Recovery/Sale												
Storage Balance				5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	20,619
Total of All Accounts												
Recharge/Purchase	**134,971**	**14,418**	**121,408**	**85,532**	**76,644**	**127,535**	**16,474**	**15,457**	**172,520**	**12,832**	**3,214**	**18,519**
Recovery/Sale			**(13,772)**	**(100,837)**			**(472)**	**(1,615)**		**(6,656)**	**(10,432)**	**(22,975)**
Storage Balance	**134,971**	**149,389**	**257,025**	**241,720**	**318,364**	**445,899**	**461,901**	**475,743**	**648,263**	**654,439**	**647,221**	**642,765**

Note: Storage balances have not been adjusted to reflect evaporation or other losses.
Some numbers may have been revised from previous years Water Supply Report.

Table 24 (continued). Groundwater Banking Summary

	1990	1991	1992	1993	1994	1995	1996	1997	Total
Alameda County WD									
Recharge/Purchase							5,580	10,000	15,580
Recovery/Sale									
Storage Balance							5,580	10,000	15,580
Belridge WSD									
Recharge/Purchase				14,204	325	15,642	3,942	2,196	36,309
Recovery/Sale					(2,029)				(2,029)
Storage Balance				14,204	12,500	28,142	16,442	30,338	34,280
Buena Vista WSD									
Recharge/Purchase				7,849		27,535	20,000	215	106,033
Recovery/Sale	(2,242)	(4,410)	(4,004)						(24,794)
Storage Balance	34,054	29,644	25,640	33,489	33,489	61,024	53,489	61,239	81,239
Berrenda Mesa WD									
Recharge/Purchase		4,002		7,936	6,568	59,819	4,686	7,125	99,636
Recovery/Sale	(9,500)	(4,002)			(400)				(13,902)
Storage Balance				7,936	14,104	73,923	18,790	81,048	85,734
Cawelo WD									
Recharge/Purchase				14,068		3,245	2,000		19,313
Recovery/Sale					(44)				(44)
Storage Balance				14,068	14,024	17,269	16,024	17,269	19,269
City of Bakersfield									
Recharge/Purchase				32		13,089	300	16,635	442,585
Recovery/Sale	(23,318)	(57,159)	(30,266)		(8,311)	(1,297)	(1,781)	(618)	(248,393)
Storage Balance	263,568	206,409	176,143	176,175	167,864	179,656	166,383	195,673	194,192
Dudley Ridge WD									
Recharge/Purchase						1,587	20,748	10,246	32,581
Recovery/Sale									
Storage Balance						1,587	20,748	11,833	32,581
Henry Miller WD									
Recharge/Purchase						3,999	5,223	664	9,886
Recovery/Sale									
Storage Balance						3,999	5,223	4,663	9,886
Improvement District No. 4									
Recharge/Purchase				23,007	10,641	92,765	71,851	6,720	221,250
Recovery/Sale			(3,500)		(100)	(1,500)			(5,100)
Storage Balance	16,266	16,266	12,766	35,773	46,314	137,579	118,165	144,299	216,150
Kern County Water Agency									
Recharge/Purchase		42,096	6,450	5,542		28,999	45,069		250,535
Recovery/Sale		(66,775)	(22,684)						(105,564)
Storage Balance	106,274	81,595	65,361	70,903	70,903	99,902	115,972	99,902	144,971
Kern Delta WD									
Recharge/Purchase									
Recovery/Sale									
Storage Balance									
Lost Hills WD									
Recharge/Purchase		2,035		31,153	5,280	26,191	8,079	10,898	83,636
Recovery/Sale									
Storage Balance		2,035	2,035	33,188	38,468	64,659	46,547	75,557	83,636
Metropolitan WD of So. Calif.									
Recharge/Purchase				50,000		45,000	85,499	156,220	336,719
Recovery/Sale									
Storage Balance				50,000	50,000	95,000	135,499	251,220	336,719
OlceseWD/Hacienda WD									
Recharge/Purchase		22,096	6,450			6,028	1,694	9,400	206,086
Recovery/Sale	(104,305)	(23,496)	(6,450)		(1,160)				(136,284)
Storage Balance	55,240	53,840	53,840	53,840	52,680	58,708	54,374	68,108	69,802
Rosedale-Rio Bravo WSD									
Recharge/Purchase						6,355	14,342	2,288	22,985
Recovery/Sale							(12,265)		(12,265)
Storage Balance						6,355	2,077	8,643	10,720

Table 24 (continued). Groundwater Banking Summary

	1990	1991	1992	1993	1994	1995	1996	1997	Total
Semitropic WSD									
Recharge/Purchase				19,972		1,100	29,945	35,310	86,327
Recovery/Sale					(181)				(181)
Storage Balance				19,972	19,791	20,891	49,736	56,201	86,146
Santa Clara County FC&WD									
Recharge/Purchase							40,500	35,000	75,500
Recovery/Sale									
Storage Balance							40,500	35,000	75,500
State of California									
Recharge/Purchase	248,005								255,384
Recovery/Sale			(72,049)		(12,458)	(752)	(41,563)		(126,822)
Storage Balance	255,384	255,384	183,335	183,335	170,877	170,125	129,314	170,125	128,562
Tejon-Castac WD									
Recharge/Purchase					70	2,324	6,211	1,675	10,280
Recovery/Sale									
Storage Balance					70	2,394	6,281	4,069	10,280
Westside Mutual Water Co.									
Recharge/Purchase						134,517	65,321	51,183	251,021
Recovery/Sale							(5,000)		(5,000)
Storage Balance						134,517	60,321	185,700	246,021
Wheeler Ridge-Maricopa WSD									
Recharge/Purchase				58,290		61,387	27,807	14,232	182,335
Recovery/Sale					(7,551)				(7,551)
Storage Balance	20,619	20,619	20,619	78,909	71,358	132,745	99,165	146,977	174,784
Total of All Accounts									
Recharge/Purchase	**248,005**	**70,229**	**12,900**	**232,053**	**22,884**	**529,582**	**458,797**	**370,007**	**2,743,981**
Recovery/Sale	**(139,365)**	**(155,842)**	**(138,953)**		**(32,234)**	**(3,549)**	**(60,609)**	**(618)**	**(687,929)**
Storage Balance	**751,405**	**665,792**	**539,739**	**771,792**	**762,442**	**1,288,475**	**1,160,630**	**1,657,864**	**2,056,052**

Table 25. Areal Extent of Shallow Groundwater, San Joaquin Valley Portion of Kern County (in acres)

	Summer Measurements						Winter Measurements					
Year	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezo's	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezo's
1976	27,940	64,700	--	79,680 [1]	172,320	--	--	--	--	--	--	--
1977	19,320	68,980	--	95,960 [1]	184,260	180	16,930	52,530	--	67,300 [3]	136,760	143
1978	27,680	65,760	--	87,920 [1]	181,360	174	9,600	59,520	--	86,400 [3]	155,520	--
1979	30,270	67,310	--	95,870 [1]	193,450	--	15,320	83,200	--	80,640 [3]	179,160	126
1980	74,357	82,787	--	125,883 [1]	283,027	--	45,882	92,998	126,665	62,578	328,123	154
1981	62,002	85,556	--	128,323 [1]	275,881	178	46,746	75,318	36,736	104,200	263,000	168
1982	78,725	95,615	76,271	30,226	280,837	259	90,658	85,541	55,392	43,181	274,772	199
1983	109,915	90,090	63,510	48,980	312,495	227	--	--	--	--	--	--
1984	110,500	57,650	45,400	47,649	261,199	246	--	--	--	--	--	--
1985	49,396	120,396	123,776	90,323	383,891	290	--	--	--	--	--	--
1986	84,160	79,774	73,698	83,264	320,896	330	--	--	--	--	--	--
1987	57,600	84,864	89,816	76,672	308,952	261	90,800	74,100	61,200	72,200	298,300	--
1988	82,700	86,500	83,900	93,400	346,500	288	--	--	--	--	--	--
1989	65,536	95,949	83,558	85,760	330,803	328	--	--	--	--	--	--
1990	67,561	91,257	82,823	-- [2]	241,641 [2]	350	--	--	--	--	--	--
1991	40,363	101,888	45,141	-- [2]	187,392 [2]	351	--	--	--	--	--	--
1992	9,954	102,114	46,287	-- [2]	158,355 [2]	344	--	--	--	--	--	--
1993	25,184	97,357	46,893	-- [2]	169,434 [2]	518	--	--	--	--	--	--
1994	19,176	106,506	69,362	-- [2]	195,044 [2]	422	--	--	--	--	--	--
1995	96,431	82,231	57,427	55,416	291,505	377	--	--	--	--	--	--
1996	27,117	157,484	68,300	65,176	318,077	398	--	--	--	--	--	--
1997	29,597	146,439	58,702	62,982	297,720	240 [3]	--	--	--	--	--	--

[1] 10-20 ft. measurement.

[2] Data insufficient to establish a 20 foot contour. Total is area within 15 feet.

[3] No 15 foot contour established. Total is within 20 feet.

[3] Some cooperators did not report shallow groundwater data for 1997.

-- Data not available.

Note: Annual changes in shallow Groundwater area may be perceived rather than real, due to increases in the number of monitoring wells used to prepare the maps. More monitoring wells may have provided better coverage, allowing for a more accurate map to be produced.

Figure 21a. Water Well Hydrograph Pond-Poso Area

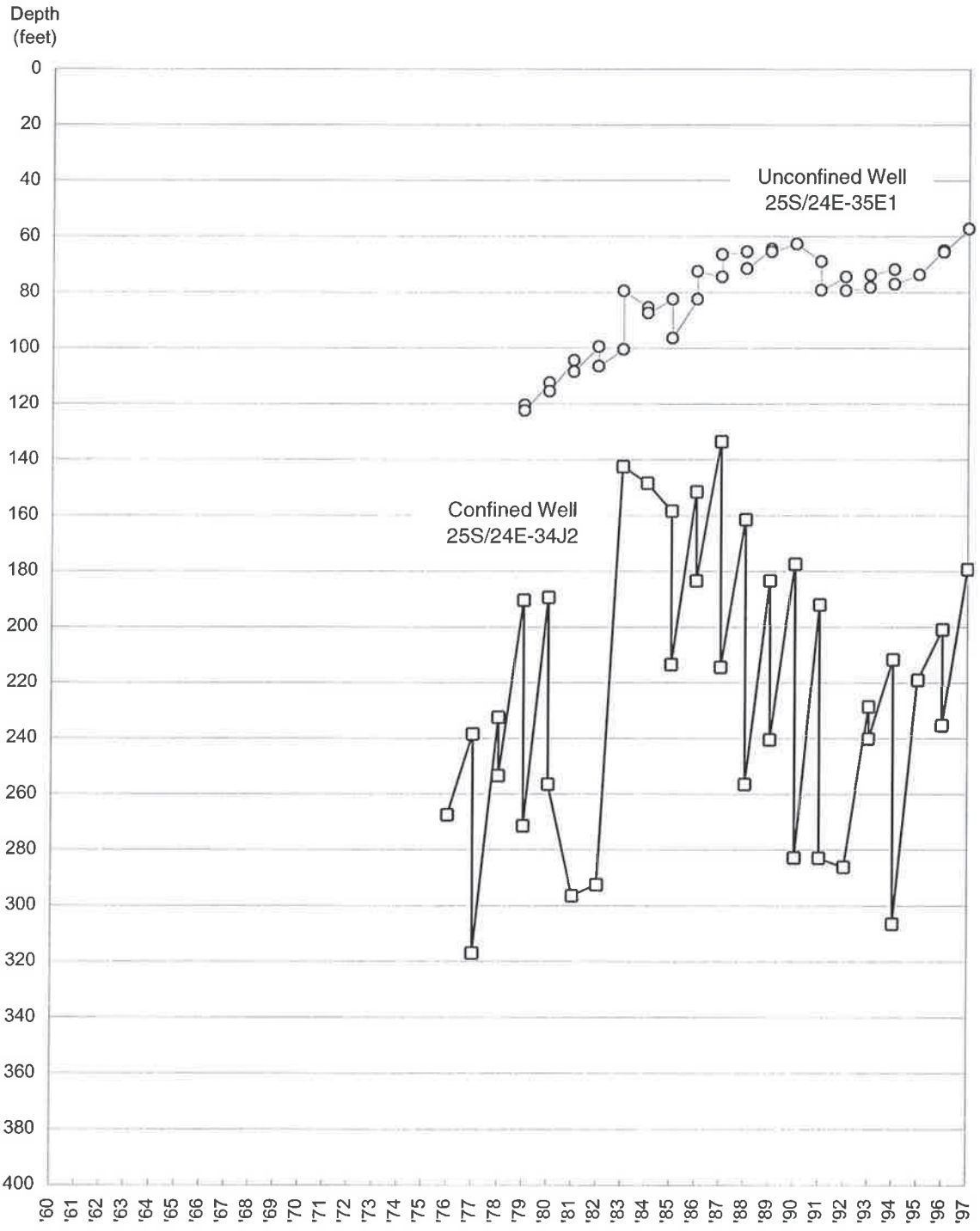


Figure 21b. Water Well Hydrograph Shafter/Rosedale-Rio Bravo Area

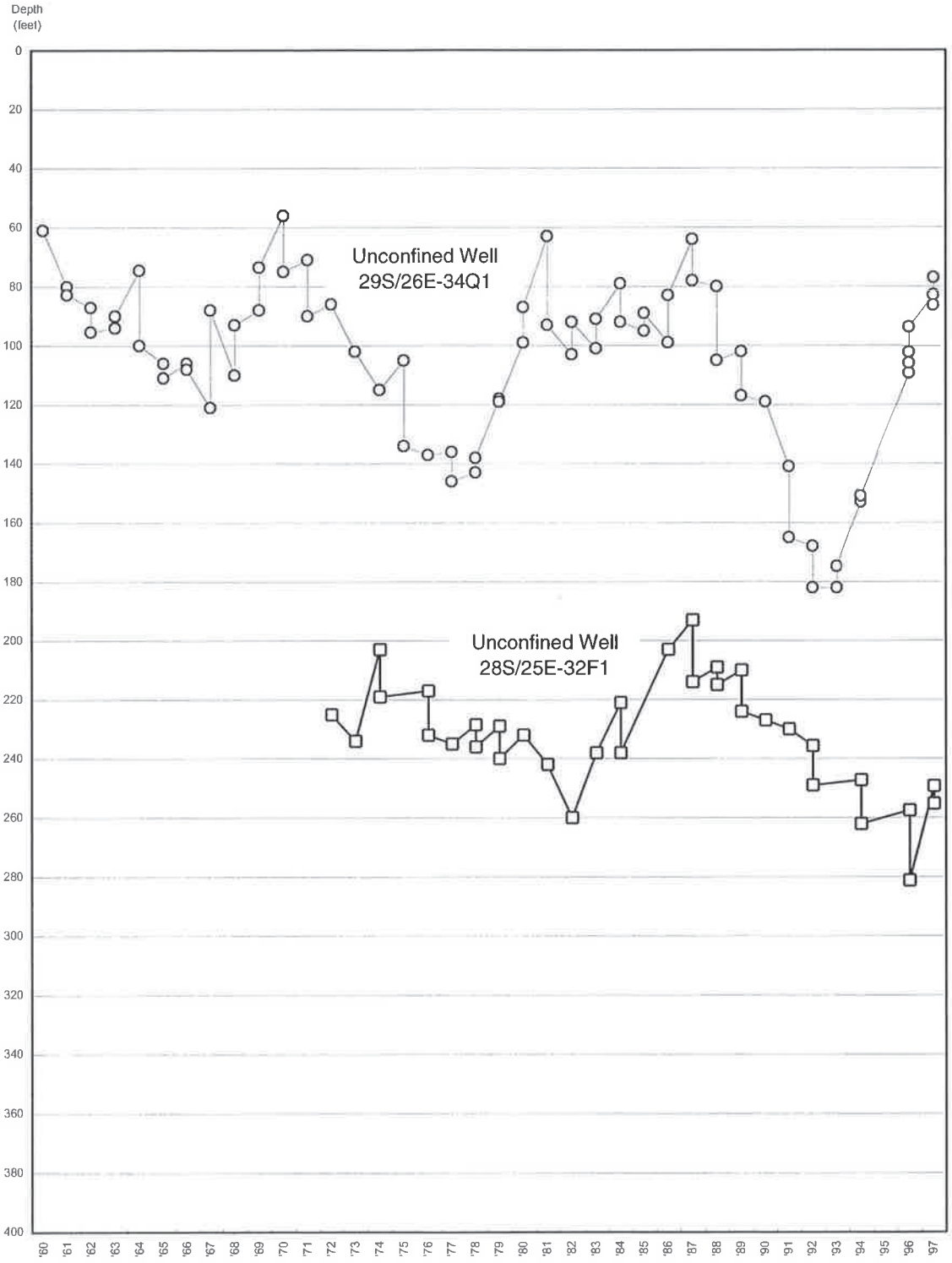


Figure 21c. Water Well Hydrograph Southwest Bakersfield Area

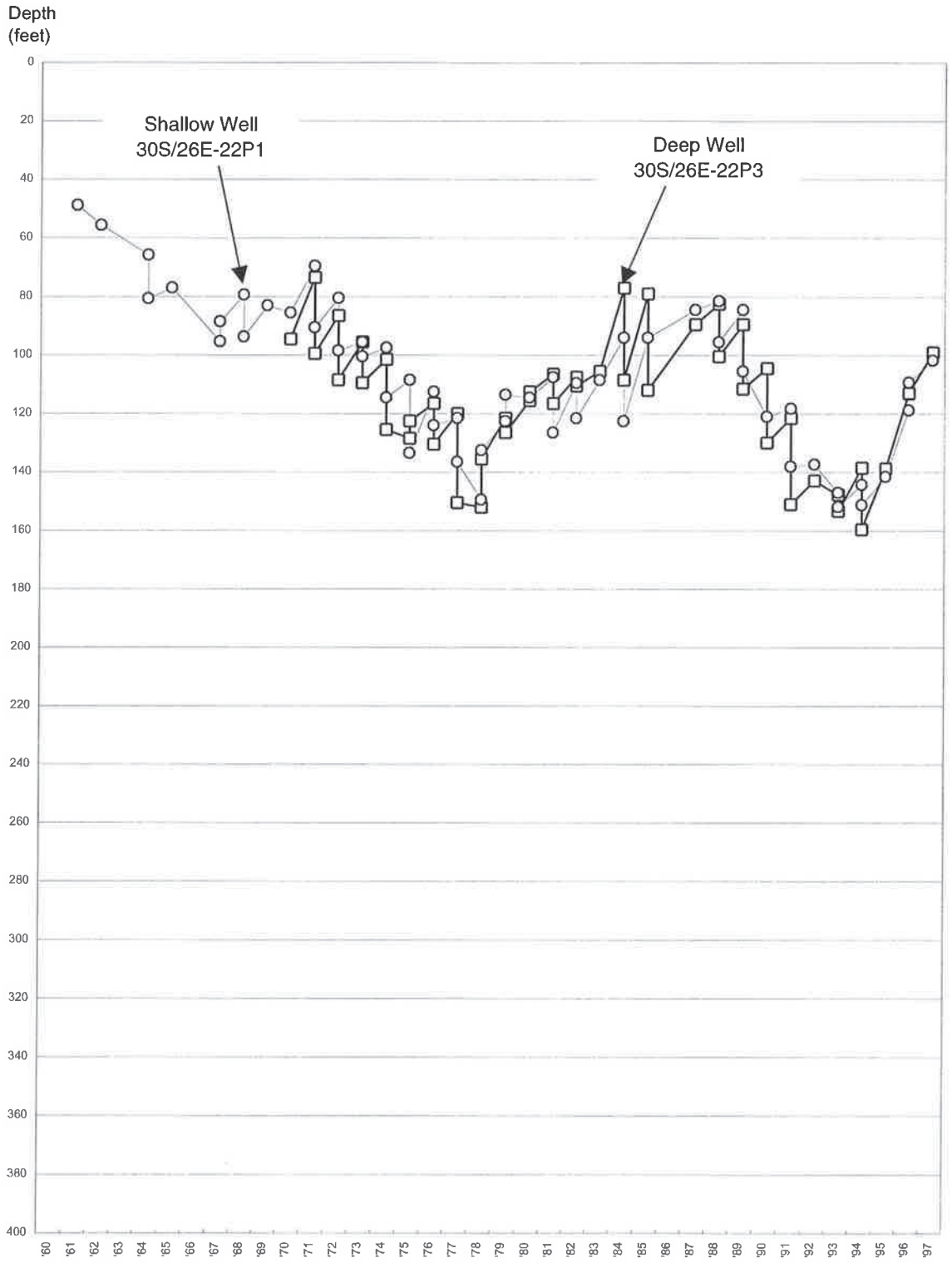
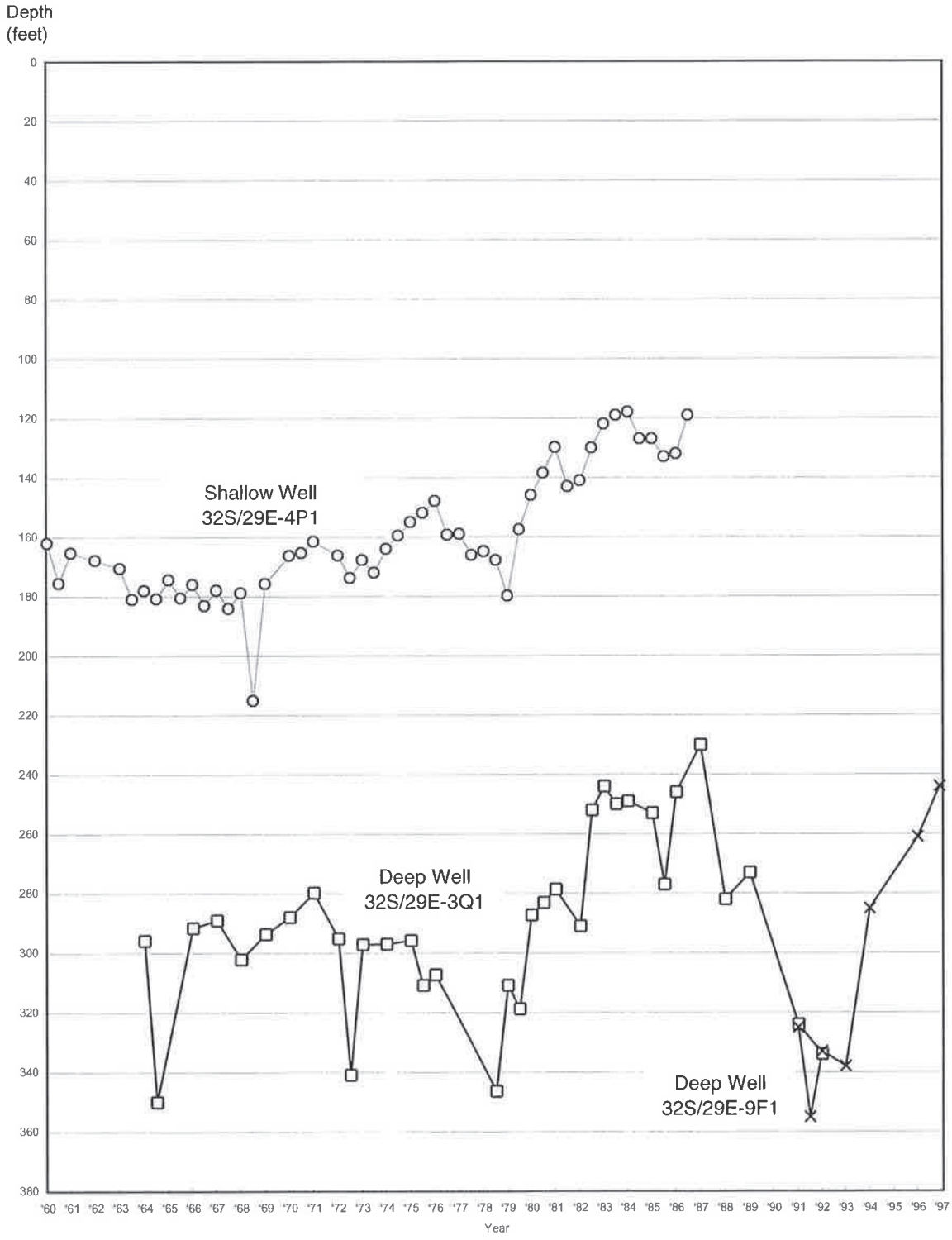


Figure 21d. Water Well Hydrograph Arvin-Edison Area



variability in groundwater levels more consistent with the behavior of a confined aquifer. The large difference in groundwater levels between the two wells also suggest that a minimum of two aquifers exist in this area. The delivery of CVP water to Arvin-Edison in the mid-1960s caused groundwater levels to rise, as seen in the shallow well hydrograph. During the 1976-77 and 1978-86 droughts, groundwater levels declined. During the 1978-86 and current wet years, water levels rose.

INDIAN WELLS VALLEY

Indian Wells Valley is located in the northeast corner of Kern County. The extended valley floor encompasses about 450 square miles. It is bounded by the Sierra Nevada Mountains on the west, the Coso Range on the north, the Argus Mountains on the east, the Rademacher Hills on the southeast and the El Paso Mountains on the south. Elevations on the valley floor range from 2,300 to 3,000 feet above sea level, and surrounding mountains may reach 9,000 feet. The largest community in the valley is the city of Ridgecrest, with a population of 29,000. The valley is an arid high desert, with rainfall of only 3-4 inches per year. Little rainfall reaches the groundwater table; it is rapidly evaporated by high winds and temperatures or transpired by desert plants. The only source of potable water is groundwater, much of which is of good to excellent quality, and is provided by recharge from the adjacent mountain ranges.

The Indian Wells Valley Water Management Steering Committee was established in 1995 as part of the "Cooperative Groundwater Management Plan for Indian Wells Valley." The committee's goal is to coordinate operations in a manner that meets ongoing water supply demands while ensuring the availability of good quality groundwater for future generations. Additionally, a technical subcommittee was formed to address technical issue requests from the water management committee. The committee is made up of hydrogeologists, engineers and representatives from KCWA and various groundwater users in the valley. Among the issues being studied by the technical subcommittee are: development of a groundwater quality monitoring program, review of groundwater data, review of weather station data, and installation of stream gauges in two ephemeral streams in the nearby Sierra Nevada. KCWA is also providing use of its groundwater database for storage of data generated by the technical subcommittee's projects.

Indian Wells Valley Water District (IWVWD), Brown Road Farming Company, China Lake Naval Air Weapons Station (NAWS) and North American Chemical Company (NACC) are the major groundwater pumpers within the valley. Inyokern Community Services District (ICSD) meets most of the water demands for the City of Inyokern. The City of Ridgecrest pumps a small amount of groundwater to meet landscaping needs. Independent well owners (9,000-10,000 residents within the valley) account for additional pumping in the range of 3,000-6,000 acre-feet per year.

Based on past studies total pumping in the valley is from 25,000 to 29,000 per year, as follows:

	Acre-feet
Brown Road Farming	7,500
IWVWD	8,000
NAWS	4,400
NACC	2,500
ICSD	300
Independent well owners	3,000-6,000
City of Ridgecrest	100
Total	**25,800 - 28,800**

Several technical investigations have attempted to determine the hydrologic balance for the valley. Results have varied considerably, due to differing assumptions of natural annual recharge to and discharge from the valley. Long-term average annual recharge has been estimated from a conservative low of 3,000 acre-feet to more than 43,000 acre-feet. Determining the hydrologic balance for Indian Wells Valley is much more difficult than for the San Joaquin Valley portion of Kern County. The San Joaquin Valley is heavily influenced by large amounts of imported surface water and Kern River flows, while Indian Wells Valley's water balance is entirely related to natural groundwater recharge.

Water level measurements for wells throughout the valley are the basis for Plate 7, "Depth to Groundwater, Indian Wells Valley" and Plate 8, "Groundwater Elevation, Indian Wells Valley." Plate 8 shows three sinks for groundwater flow in the valley. The first is naturally occurring and represents the discharge of groundwater (via evaporation) within the China Lake playa, located about 5 miles northeast of Ridgecrest. The second sink is associated with large-scale agricultural pumping along Brown Road, about 8 miles north of Inyokern. The third sink is a regional pumping depression extending from southeast Ridgecrest to north of Inyokern, called the Ridgecrest-Inyokern pumping corridor. This depression is the most important from a basin-wide groundwater management perspective, as it has expanded by about 30,000 acres since 1946. This extensive pumping depression is a response to increased population in the valley, from about 15,000 in 1946 to about 38,000 today.

Hydrographs for key wells are shown in Figures 21e, 21f and 21g. These hydrographs reflect the consistent decline in water levels over broad portions of the valley. They represent water levels in wells located along the perimeter of the valley, at sufficient distance from large pumping capacity wells as to avoid their influence. Figure 21e charts a well in the northwest portion of the basin (about 5 miles northwest of Inyokern) near the foot of the Sierra Nevada (26S/38E-35B1). Figure 21f shows a well in the southeast portion of the basin, about 1.5 miles north of Cerro Coso College in southern Ridgecrest (27S/39E-7R11). Figure 21g shows a well in the southwest portion of the basin, about 3 miles south of Inyokern and within the Little Dixie Wash (27S/40E-15D1).

In general, water levels have been declining from 0.5 to 1.0 foot per year in areas outside the Ridgecrest-Inyokern pumping corridor. In the center of the pumping area water levels have declined by an average of 1.5 feet annually. In this central area, water levels declined only 15 feet between 1920 and 1953, while between 1953 and 1993 they declined 60 to 70 feet. More recently, water levels have stabilized, due to the Indian Wells Valley Water District redistributing pumping further to the west. In Figure 21f recent water levels have declined from 1.0 to 1.5 feet per year, a matter of interest since groundwater pumping in this area is limited.

The accelerated decline of groundwater levels in the southwest area is probably linked to a dramatic change in subsurface geology. Plate 8, "Groundwater Surface Elevations," presents an anomalous steep hydraulic gradient in the southwest portion of the valley. A series of studies suggests that these extreme water level differences might be the manifestation of complex structural geology or stratigraphic relationships. The interpretation of continuity of groundwater flow along this steep gradient is tentative at best. It is presented to convey the existence of extreme differences in water levels in the southwest area and does not infer that continuous groundwater flow exists there. Additional work is needed to address whether such continuous flow exists.

Plate 8 shows an apparent steep hydraulic gradient in the two to three mile-wide zone trending southeast from Armitage Field to Ridgecrest Blvd. This trend parallels the Little Lake Fault Zone. In this area, wells and piezometers perforated at various depths show significant water level differences. The degree of hydraulic communication across the Little Lake Fault Zone needs

Figure 21e. Water Well Hydrograph Indian Wells Valley

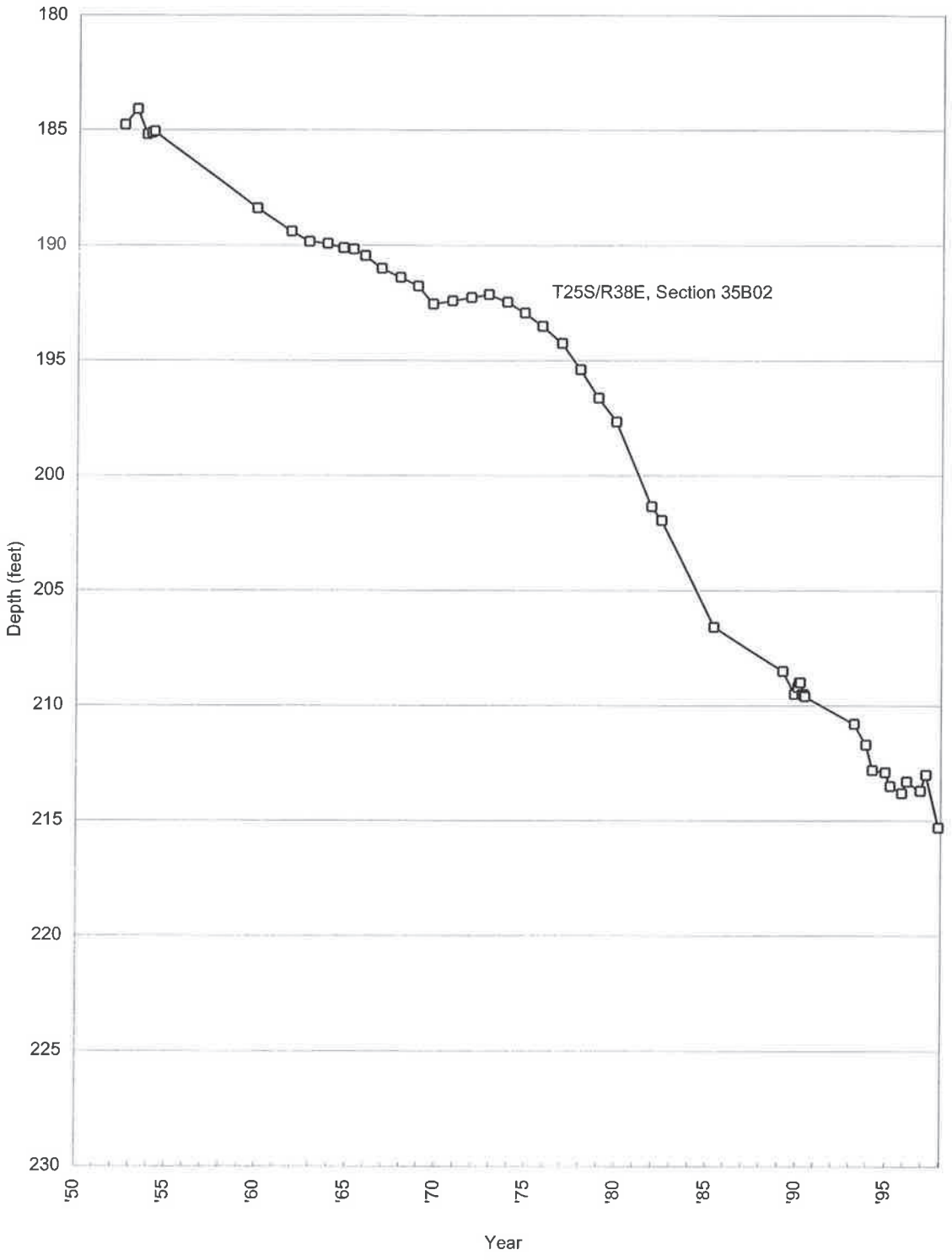


Figure 21f. Water Well Hydrograph Indian Wells Valley

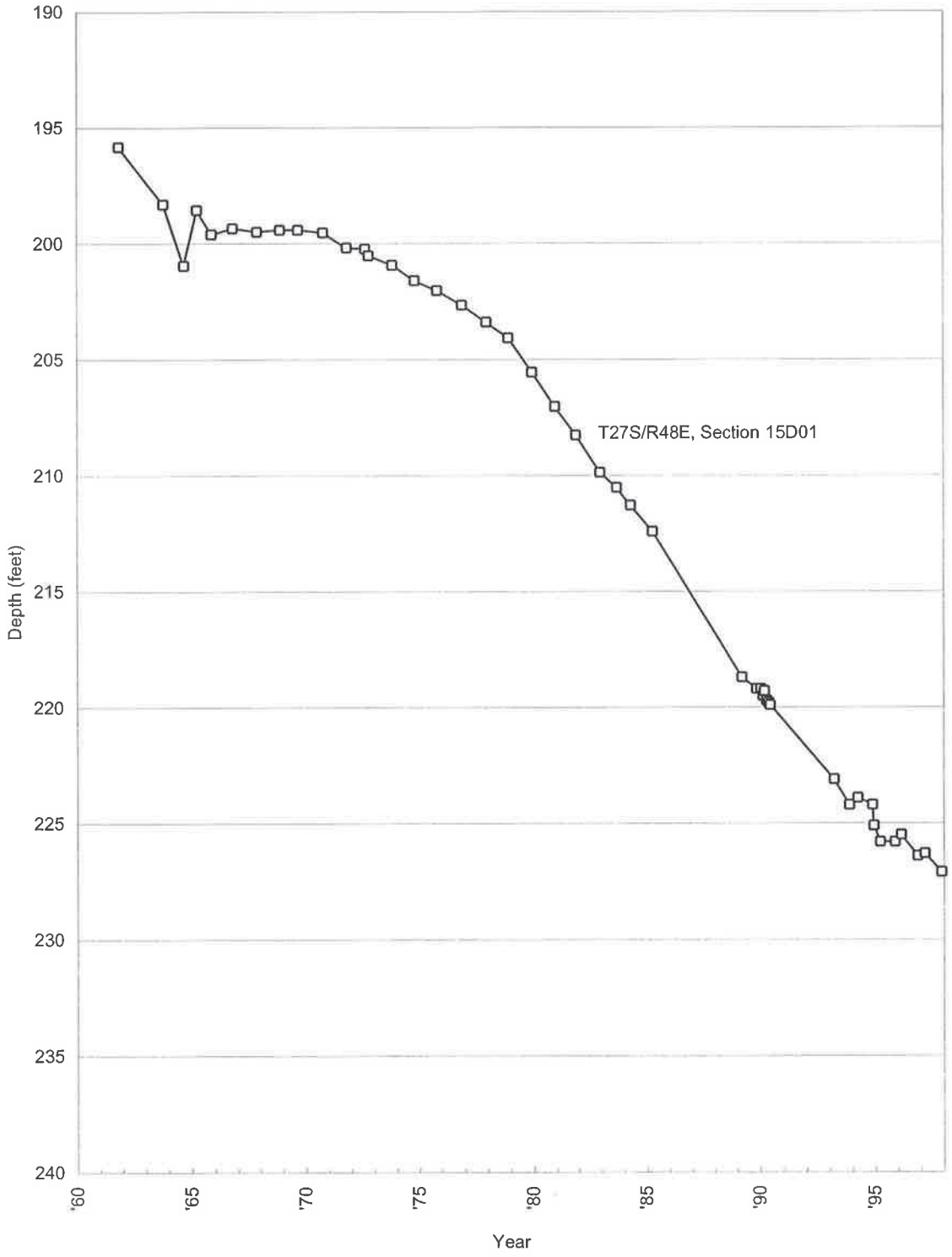
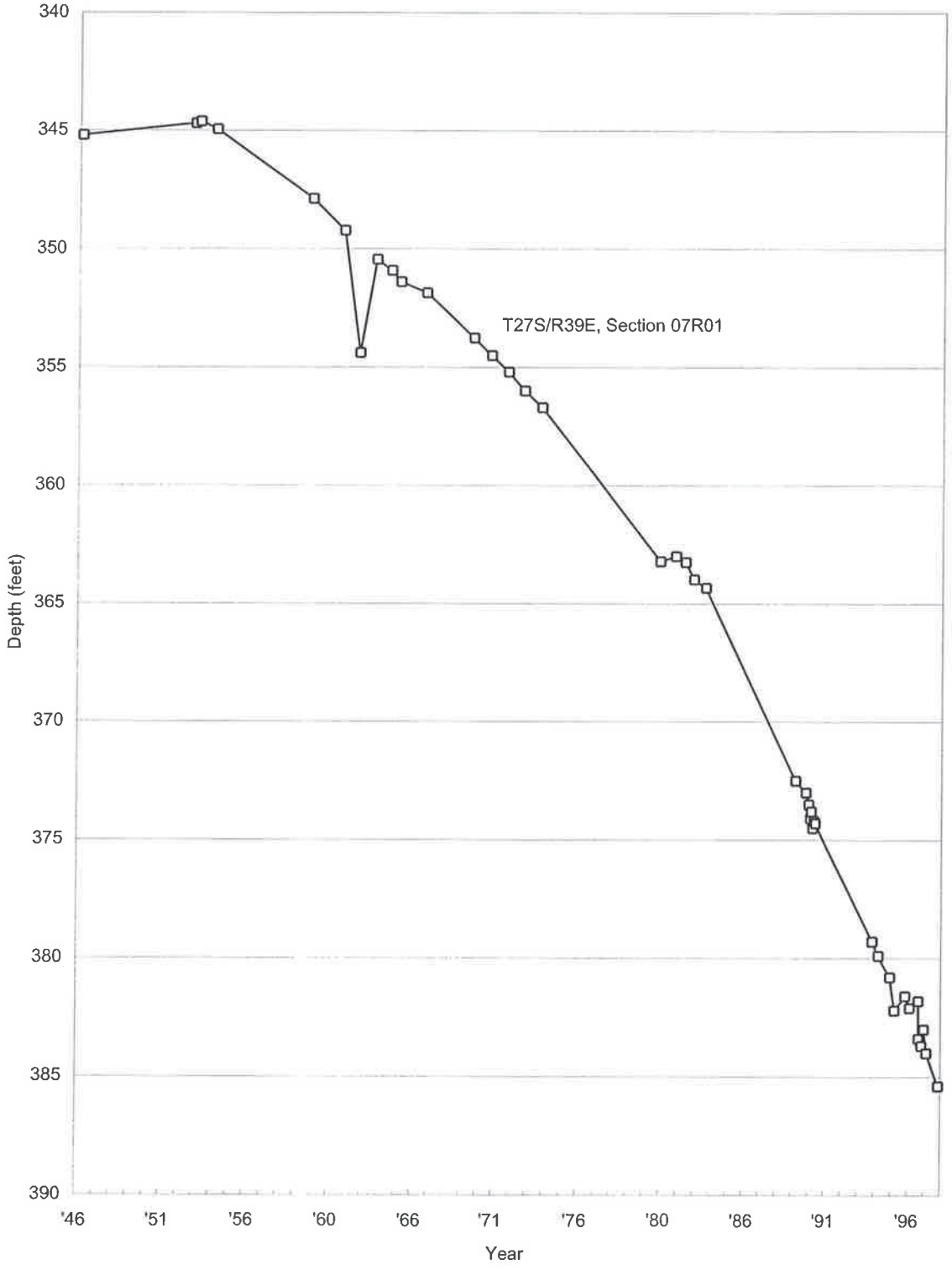


Figure 21g. Water Well Hydrograph Indian Wells Valley



evaluation to determine whether pumping in the Ridgecrest-Inyokern pumping corridor influences the lateral or vertical migration of poor-quality groundwater.

Plate 9, "Groundwater Quality, Indian Wells Valley," shows the distribution of total dissolved solids (TDS) throughout the basin. The map represents a compilation of data acquired between 1980 and 1994 by the U.S. Geological Survey, KCWA, U.S. Bureau of Reclamation, IWVWD and private well owners. The distribution of relatively good quality water (TDS less than 500 parts per million, ppm) reflects areas that probably benefit from recharge via adjacent mountain ranges. The map displays the distribution of very poor quality groundwater (TDS greater than 2,000 ppm) in large portions of T25S/R39E and T25S/R40E, and in the eastern portion of T26S/R40E. To the southeast, south and southwest of Ridgecrest there is poor quality groundwater (TDS greater than 1,000 ppm).

Participants in the Indian Wells Valley Groundwater Management Plan recognize that acquisition of additional hydrologic and geologic data is required to develop sound management practices for the valley. A multi-agency technical committee is developing programs to acquire and analyze needed data, to propose prudent water management practices, and to serve as a consultant to the Management Steering Committee. The principle long-term goal is to produce a more accurate hydrologic balance for the valley.

FOCUS: NORTH KERN WATER STORAGE DISTRICT

North Kern Water Storage District was formed in 1950, making it one of the oldest water districts in Kern County. Kern River water supplies have been delivered to the district's area (north of the Kern River) since about 1874. Its establishment in 1950 formalized and aggregated its First Point appropriative water rights. The district is located just west of Freeway 99, bounded on the south by Seventh Standard Road and stretching as far north as the city of McFarland, in a swath about six miles wide.

The gross area of the district is 61,050 acres. In 1997, about 50,700 acres were under cultivation. An additional 4,900 acres were either idle or transitioning to permanent crops. Elevations within the district range from 450 feet above sea level on the eastern edge, sloping to 270 feet to the west. Agriculture in the area is supported by the oldest organized conjunctive use project in Kern County. Average Kern River supplies are about 163,000 acre-feet annually. Distribution facilities include 154 miles of canals, 20 miles of which are lined, 20 miles of pipelines, and 1,500 acres of groundwater recharge ponds. The district also operates 70 wells located near its distribution canals, which recover groundwater during dry years for delivery to its customers.

Soil fertility in the district is good, with 85 percent of the soil in the district classified as "prime" agricultural land according to the Storie Index. (The Storie Index results from the multiplication of four factors: the percentage rank of the soil in (a) soil profile - hardness of any clay layer and the deepness of the topsoil; (b) surface texture - low rating at any of the three extremes (clay, sand, silt), high rating at a good combination of the three (loamy soil); (c) slope - nearly level to very steep; (d) a multiplicative combination of several additional factors, such as drainage, alkalinity, fertility, acidity and erosion hazard. Since the factors are combined multiplicatively rather than additively, a high rating is difficult to obtain.) Using the cultivation suiutability land classification, about 55 percent of the soils in the district are Class 1 (excellent) or Class 2 (good); 45 percent are Class 3 (fair). The district is well suited for field crops.

Table 26 displays the various crops and acreage in the district. Much of the district's field crops (about 19,000 acres) are cotton, wheat and alfalfa, as shown on Table 26. Nursery crops, comprising 17

Table 26. 1997 Irrigated Acreage in North Kern Water Storage District

Annual Crops	Irrigated Acres
Alfalfa	3,428
Beans	602
Carrots	759
Corn	176
Cotton	5,508
Lettuce	39
Nursery	3,276
Melons	123
Onions	245
Peppers	241
Potatoes	945
Sugar Beets	657
Wheat	2,814
Subtotal	18,813
Permanent Crops	
Almonds	16,076
Apples	1,104
Grapes	11,517
Olives	80
Peaches	1,237
Pecans	188
Pistachios	1,597
Subtotal	31,799
Total Irrigated Acreage	**50,612**

percent of the field crop acreage, derives 80 percent of the farm value attributed to annual crops. The majority of orchard crops are almonds with 16,100 acres, and grapes with 11,500 acres. The total gross value of the crops produced in North Kern Water Storage District in 1997 was over $216 million. This translates into about $650 million total economic value for Kern County via a multiplier effect.

OUTLOOK: 1998

The Department of Water Resources' December allocation for 1998 SWP supplies was 40 percent. Precipitation through December 15 was nearly average, but forecasters were predicting that 1998 would be a banner precipitation year with a particularly strong El Niño pattern likely.

Initial CVP water supply outlook was also conservative, with supplies estimated at 75-85 percent of allocations in January 1998. The Kern River was already shaping up to be wetter than normal. In January 1998 water year runoff was estimated to be about 122 percent of average.

The expected El Niño pattern did develop. By the end of February 1998 northern California precipitation had reached 168 percent of average. Reservoir storages throughout the state began to fill and spill. DWR raised SWP allocations to 80 percent of requests in February.

On March 11, 1998 DWR announced that SWP allocations would be 100 percent of contractor requests for the year, or about 1,000,000 acre-feet for Kern County. Also in March 1998, the U.S. Bureau of Reclamation announced 85 percent allocations for agricultural contractors south of the Delta, and allocations to Friant Division contractors of 100 percent of both Class I and Class II. Total CVP supplies to Kern County should be about 500,000 acre-feet.

By the end of March northern California precipitation had risen to 168 percent of average. By April 1, 1998 the April-July unimpaired snowmelt runoff forecast had risen to 215 percent of normal for the Kern River watershed, or 1,300,000 acre-feet.

Fed by El Niño, total surface water supplies should reach about 3,000,000 acre-feet in 1998. Total net demands are estimated to be 2,900,000 acre-feet. Thus, KCWA projects that a net increase in groundwater storage of about 250,000 acre-feet. This would mark the fourth consecutive year that an increase in storage occurred.