

Kern County Water Agency

**Water Supply Report
1998**

THOMAS N. CLARK
GENERAL MANAGER

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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.

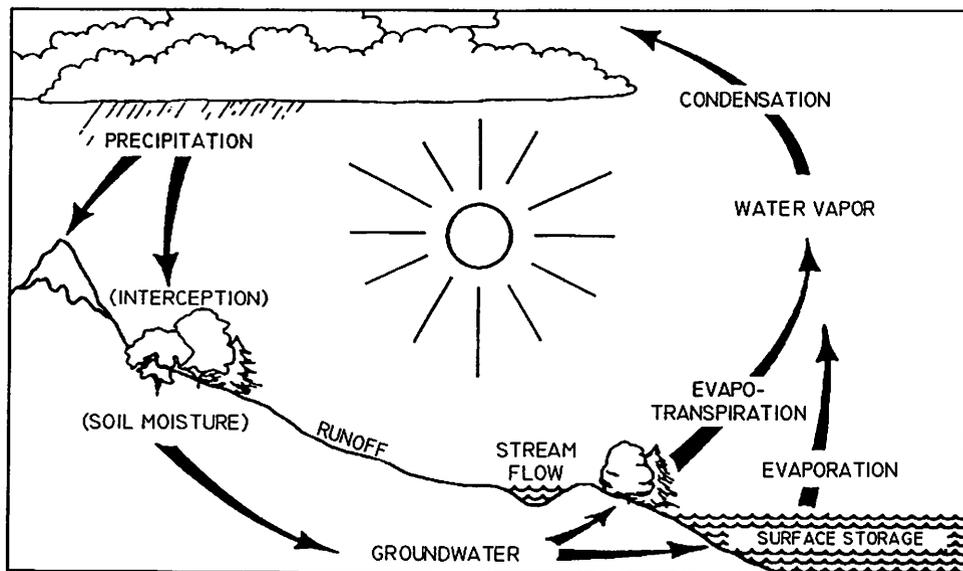
Since its beginning in 1961, the Agency has been building a base of information on the water supply and demand characteristics of the San Joaquin Valley portion of Kern County. Since 1977, the Agency has published the annual Water Supply Report in order to present these statistics in one document and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



1998 El Niño Brings in the Year with a Splash

Coming out of an extremely wet, record-setting El Niño year in 1997, early 1998 weather continued to deluge Kern County with record-setting precipitation. Kern County water supplies were in good shape, with state and federal reservoirs filled by early January and state water allocations at 80 percent. The unusually broad pool of warm water that characterizes an El Niño condition was seen in late January, measuring almost twice the size of the United States at its peak. This allowed severe storms to form more closely to the California coastline than is normal. An active southern branch of the jet stream pushed these raging Pacific storms into the southern Sierra Nevada mountain range, soaking them with record-breaking precipitation. El Niño related storms during February 1998 resulted in 10.60 inches of precipitation at Isabella Dam, an all-time record for the month and roughly 92 percent of the annual average of 11.49 inches. The Kern River yielded 1,717,967 acre-feet of natural runoff as measured at First Point during 1998. That was the sixth largest volume of runoff on record and the first time in history the river generated over one million acre-feet of runoff in four consecutive years.

According to the Department of Water Resources, the northern California eight-station precipitation index, which registered only 58 percent of average in December 1997, rose dramatically to 212 percent in January, and to 265 percent in February. The mid-February Sacramento River Runoff Forecast pegged the 1998 runoff to be 18.3 million acre-feet at the 99th percentile probability of exceedence. By March that estimate climbed to 23.4 million acre-feet.

Oroville Reservoir storage in early February stood at almost three million acre-feet which was 57,800 acre-feet below the flood control diagram. Unlike 1997 when early, heavy precipitation gave way to extremely dry months, 1998 evolved very differently and the Feather River April-July runoff at the 90th percentile was estimated to be in excess of two million acre-feet. State Water Project allocations were raised to 100 percent in mid-March 1998.

By March the federal share of San Luis Reservoir was full. Allocations for south Delta agricultural contractors were at 80 percent of contract amounts at the 90th percentile probability of exceedence. CVP Friant contractors reached 100 percent of Class I and 25 percent of Class II by April.

On March 24 Oroville Reservoir stood at 45,000 acre-feet above the flood control diagram. Over 120,000 acre-feet of storage was added in just three days.

By April, above normal precipitation continued in northern California watersheds but the frequency and intensity diminished from earlier in the year. By April 20, 1998 total precipitation in that area was 160 percent of average.

The water year finished with a Sacramento River Index (SRI) of 31.4 million acre-feet, one of the highest on record. Table 1 is a history of Sacramento River indices; Figure 2 shows the same information as a graph.

Kern County surface water supplies from all sources during 1998 were about 3,980,700

acre-feet. Normal supplies are about 2,200,000 acre-feet. Therefore, water availability was about 181 percent of normal. SWP entitlement deliveries from all sources totaled 987,299 acre-feet, or about 91 percent of entitlement. While full SWP entitlement was available, wet local conditions precluded its full use. Kern River supplies were 1,665,420 acre-feet, about 223 percent of average. Central Valley Project deliveries totaled 466,500 acre-feet, or 116 percent of the 1975-98 average.

Because of the excellent water supply conditions, about 895,000 acres of farm land was cropped. Total irrigated acreage was 861,500 acres, about 25,000 less than in 1997.

Change in groundwater storage in 1998 was an increase of 867,800 acre-feet. Total direct recharge in 1998 was 1,653,100 acre-feet. Total withdrawals since 1970 have been about 15,200,000 acre-feet. Total additions to storage over the same period have been about 5,777,000 acre-feet. The net change in storage since 1970 has been a net loss of about 14,623,000 acre-feet, or about 325,000 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 5,788,000 acre-feet (about 965,000 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 in order 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 enacted, and a program to determine a long-term plan to fix the Delta's environmental and water supply problems was activated. The CALFED Bay-Delta Program, as it is called, was in its fourth year of existence in 1998.

CALFED is made up of 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. 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.

After extensive hearings, CALFED devised three common programs:

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.

In early 1997 it became clear that CALFED was having difficulties developing a Preferred Alternative as it 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.

By 1998 CALFED buckled down to produce a draft Programmatic Environmental Impact Statement (PEIS), outlining its long-term solution to the problems of the Delta. This draft PEIS identified a through-Delta option as its preferred alternative. The alternative

identified only minimal changes to the existing Delta channel configuration, only vaguely referenced new surface and groundwater storage, laid out a water quality program primarily aimed at improving ecosystem quality, strongly emphasized water use efficiency as the primary method by which water supply reliability would be achieved, and yet contained a detailed ecosystem restoration program. This didn't sit well with the water user community, who viewed the plan as unbalanced and unworkable.

CALFED's own studies strongly indicated that an isolated facility offered the greatest benefits to fisheries, and that a partially isolated "dual facility" offered the greatest flexibility for both fisheries and water supply. Yet the identified preferred alternative was the worst performer in terms of fisheries, water supply and source water quality. The sense of the urban and agricultural water users was that CALFED had caved in to politics in choosing a through-Delta alternative, and had abandoned the "getting better together" maxim.

The 1998 PEIS was widely criticized by stakeholder groups for its lack of specificity, lack of attention to increasing water supplies for all stakeholders (including the environment), and its heightened focus on water use efficiency as a primary means for generating additional water for the ecosystem. Agricultural and urban water users weren't "getting better together" with the environment. Rather, the plan outlined in the PEIS would result in the environment "getting better" at the expense of agricultural and urban water users.

Subsequently, CALFED produced a "Revised Phase II Report" in November 1998, which provided a brief overview of what the reconstituted preferred alternative would look like. The report continued to identify a through Delta option as its preferred alternative. However a trigger was inserted whereby an isolated facility would be built if drinking water quality goals or fishery recovery goals could not be met with the through-Delta system. Water storage facilities were elevated to the status of a "common program," although the revised report stated that CALFED would not pursue new on-stream storage.

State water users also suffered a setback when a \$1.7 billion water management bond proposed by the Governor failed to pass in the state Senate. The bond had included funding for the implementation of Stage 1 of the CALFED solution, groundwater storage programs, water conservation measures, water recycling facilities, watershed management, non-point source pollution controls, flood control projects and water conservation projects contained within the water transfer between San Diego County Water Authority and the Imperial Irrigation District.

At the heart of the defeat of the bond was an effort to add over \$150 million for planning studies for new water storage facilities. A 350-page CALFED draft outline for developing the first stage of a Delta solutions package became a flashpoint for stakeholders late in 1998, as the debate continued to rage on whether the state needed additional water storage.

By December 1998 Interior Secretary Bruce Babbitt indicated he would like to see a package of preferred Delta solution actions. Of particular focus was the initial stage of the CALFED program, which will form the finalization of an environmental impact statement/report at the end of 1999 through 2006. This first stage consisted of an array of

actions intended to move the Delta ecosystem toward fuller recovery, improve water quality, shore up water supplies and improve the estuary's disaster preparedness.

The program's water management strategies included water transfers, conservation, reuse, storage, water quality, diversion management, watershed management and ecosystem monitoring.

Other significant issues in 1998

Also of note in 1998 was a historic series of agreements designed to share responsibility for Bay-Delta water quality standards for the first time between northern and southern water users. The centerpiece of the various settlements was the San Joaquin River Agreement, which settled long standing disputes among a variety of water users over the need for additional flows and water project diversion restrictions. The agreement included the Vernalis Adaptive Management Program, a 12-year effort to scientifically evaluate salmon survival on this major tributary to the Sacramento-San Joaquin Delta.

In late 1998 it came to light that the federal Endangered Species Act was being selectively enforced in the Delta. Pacific Gas and Electric Company (PG&E) operated two power plants in the southern Delta. As part of relicensing these plants, PG&E developed a habitat conservation plan which indicated that the two power plants "take" quantities of Delta Smelt that are comparable in magnitude to the combined Delta Smelt take at the SWP and CVP pumping plants. Yet PG&E's environmental assessment recommended a finding of no significant impact was appropriate for the pumping plants. Comparatively, the SWP and CVP projects faced significant ESA-imposed operational restrictions in order to protect Delta Smelt. This selective enforcement of the federal ESA is being legally challenged by the SWP and CVP water users.

In December 1998, DWR released the final draft of Bulletin 160-98, the California Water Plan. This planning document, updated and released every five years, is intended to provide the statewide assumptions for projecting California's future water supply needs. Based on state population forecasts, the final document identified a shortage of 2.4 million acre-feet in average years by 2020. Many environmental interests took exception to the forecast shortage, on the grounds that the CALFED process would result in significant water supply reliability improvements and that water use efficiency was not given equal weight as supply-side water management tools.

Water Supplies

State Water Project (SWP)

The extraordinarily wet months at the end of 1997 were enough to prompt DWR to approve an 80 percent allocation of state water by the end of January. In March the allocation reached 100 percent and many water suppliers were dealing with an overabundance of water.

The chronology of 1998 allocations follows:

January 31, 1998	80% allocation
February 28, 1998	100% 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 1,218,123 acre-feet was available during 1998, including 1,087,730 acre-feet of SWP entitlement, 1,684 acre-feet of "carryover water," and 128,709 acre-feet of SWP water transferred into Kern County by other entities. A total of 987,299 acre-feet of SWP water was actually delivered during 1998. Since the first deliveries in 1968, nearly 25 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 1998 SWP deliveries by contract type.

Kern River

It was early in 1998 when the continuing El Niño pattern brought record-setting precipitation to the Kern River watershed. A February storm produced 10.6 inches of precipitation at Isabella Dam, setting a record for the month and roughly 92 percent of the annual average of 11.49 inches. The Kern River yielded 1,717,967 acre-feet of natural runoff as measured at First Point during the 1998 calendar year, the sixth largest volume of runoff on record and the first time in history the river generated over one million acre-feet of runoff for four consecutive years.

The final tally for Kern River 1998 regulated snowmelt runoff at First Point of measurement was 1,662,556 acre-feet.

	<u>Apr 1</u> <u>1996</u>	<u>Apr 1</u> <u>1997</u>	<u>Apr 1</u> <u>1998</u>	<u>Apr 1</u> <u>Avg</u>	<u>1998%</u> <u>of Avg</u>
Upper Tyndall Cr.	29.90	40.80	46.70	27.70	169
Crabtree Meadow	19.00	21.60	29.80	19.80	150
Chagoopa	25.50	29.20	35.10	21.80	161
Pascoe	37.70	37.70	55.90	24.90	224
Wet Meadow	21.40	19.00	44.60	30.30	147
Tunnel Guard	14.00	12.70	27.10	15.60	174
Casa Vieja Meadow	17.80	17.60	34.60	20.90	165
Beach Meadows	4.10	0.30	24.90	11.00	226
Average	21.10	22.40	37.30	21.50	173%

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

February, 1998	158% of average
March	199%
April	224%
May	235%
Final	242% (final runoff)

Table 5 shows historic Kern River runoff and cumulative runoff for the 105 years of complete record, including diversions above First Point. In calendar year 1998 a total of 1,662,556 acre-feet of regulated Kern River water flowed past First Point of measurement. That was 225 percent of the 1954-98 long-term average regulated flow at First Point of measurement of 740,300 acre-feet and 276 percent of the historical median of 601,300 acre-feet. An additional 2,864 acre-feet was diverted above First Point. Total 1998 Kern River flows were 1,665,420 acre-feet, about 224 percent of average. During the last 105 years, the Kern River has yielded nearly 77 million acre-feet of runoff. Since Isabella Dam began regulating flows in 1954, over 32 million acre-feet of runoff has occurred. Figure 4 is a histogram of annual Kern River flows at First Point. Table 6 gives a summary of Kern River deliveries by entity in 1998. 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 of 1998 meant initial, almost-full allocations for the Central Valley Project. Early in the year the allocation for south of Delta contractors started at 65 percent. Friant CVP contractors were approved for 100 percent of Class I supplies and 25 percent of Class II supplies. By May, south of Delta ag contractors were at 100 percent of normal water supplies and Friant was at 100 percent for both Class I and Class II supplies.

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
1998	31.4			1977	5.1		
1997	25.2			1924	5.7		
1996	22.2			1931	6.1		
1995	33.9	1950	14.4	1994	7.8	1917	17.3
1994	7.8	1949	12	1976	8.1	1954	17.4
1993	22.4	1948	15.8	1939	8.2	1936	17.4
1992	8.9	1947	10.4	1929	8.4	1946	17.6
1991	8.4	1946	17.6	1991	8.4	1922	18.0
1990	9.2	1945	15.1	1934	8.6	1975	19.2
1989	14.8	1944	10.4	1992	8.9	1973	20.0
1988	9.2	1943	21.1	1933	8.9	1953	20.1
1987	9.2	1942	25.2	1990	9.2	1943	21.1
1986	22.4	1941	27.1	1988	9.2	1910	21.1
1985	11	1940	22.4	1987	9.2	1996	22.2
1984	22.4	1939	8.2	1920	9.2	1980	22.3
1983	37.7	1938	31.8	1947	10.4	1993	22.4
1982	33.3	1937	13.3	1944	10.4	1986	22.4
1981	11.1	1936	17.4	1964	10.9	1984	22.4
1980	22.3	1935	16.6	1985	11.0	1940	22.4
1979	12.4	1934	8.6	1955	11.0	1971	22.6
1978	23.9	1933	8.9	1918	11.0	1951	22.9
1977	5.1	1932	13.1	1981	11.1	1963	23.0
1976	8.1	1931	6.1	1912	11.4	1927	23.8
1975	19.2	1930	13.5	1926	11.8	1921	23.8
1974	32.5	1929	8.4	1961	12.0	1978	23.9
1973	20	1928	16.8	1959	12.0	1915	23.9
1972	13.4	1927	23.8	1949	12.0	1970	24.1
1971	22.6	1926	11.8	1979	12.4	1967	24.1
1970	24.1	1925	16	1913	12.8	1916	24.1
1969	27	1924	5.7	1966	12.9	1942	25.2
1968	13.6	1923	13.2	1960	13.1	1997	25.2
1967	24.1	1922	18	1932	13.1	1965	25.7
1966	12.9	1921	23.8	1923	13.2	1911	26.4
1965	25.7	1920	9.2	1937	13.3	1906	26.7
1964	10.9	1919	15.7	1972	13.4	1969	27.0
1963	23	1918	11	1930	13.5	1941	27.1
1962	15.1	1917	17.3	1968	13.6	1914	27.8
1961	12	1916	24.1	1950	14.4	1952	28.6
1960	13.1	1915	23.9	1989	14.8	1958	29.7
1959	12	1914	27.8	1908	14.8	1956	29.9
1958	29.7	1913	12.8	1957	14.9	1909	30.7
1957	14.9	1912	11.4	1962	15.1	1998	31.4
1956	29.9	1911	26.4	1945	15.1	1938	31.8
1955	11	1910	21.1	1919	15.7	1974	32.5
1954	17.4	1909	30.7	1948	15.8	1982	33.3
1953	20.1	1908	14.8	1925	16.0	1907	33.7
1952	28.6	1907	33.7	1935	16.6	1995	33.9
1951	22.9	1906	26.7	1928	16.8	1983	37.7
93 year average		18.1					
93 year median		93.0					
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

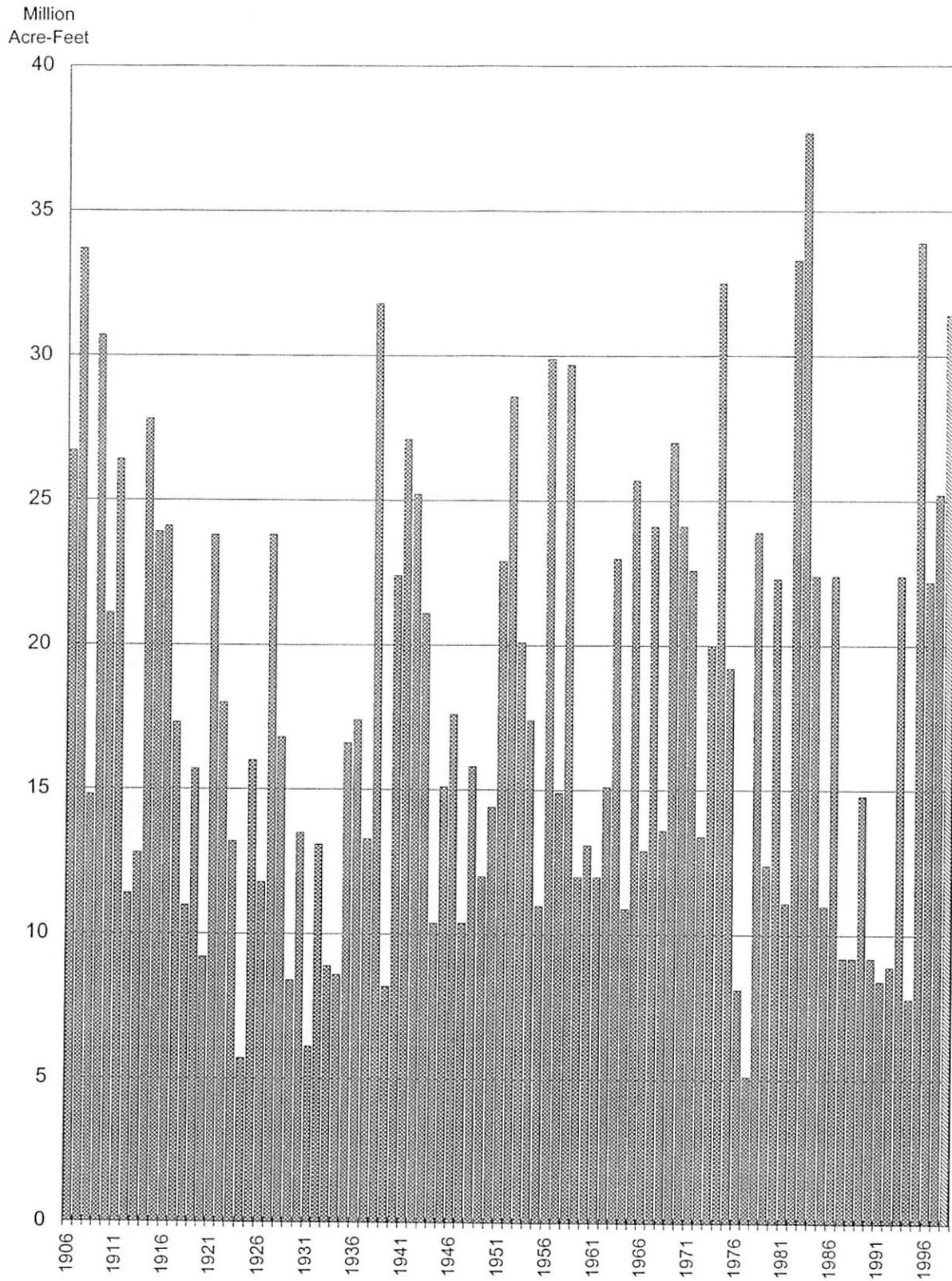


Table 2. Kern County Water Agency, Member Unit Contract Entitlements for 1998-2035 (in acre-feet)

Member Unit	Firm	Surplus ⁽¹⁾	Former Table 1 Entitlement ⁽²⁾	Firm Entitlement		
				M&I	Ag	Total
Berrenda Mesa WD	130,100	6,976	137,076		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	1,087,730	96,115	1,183,845	136,000	951,330	1,087,730

Note: Maximum annual entitlement is 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.

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

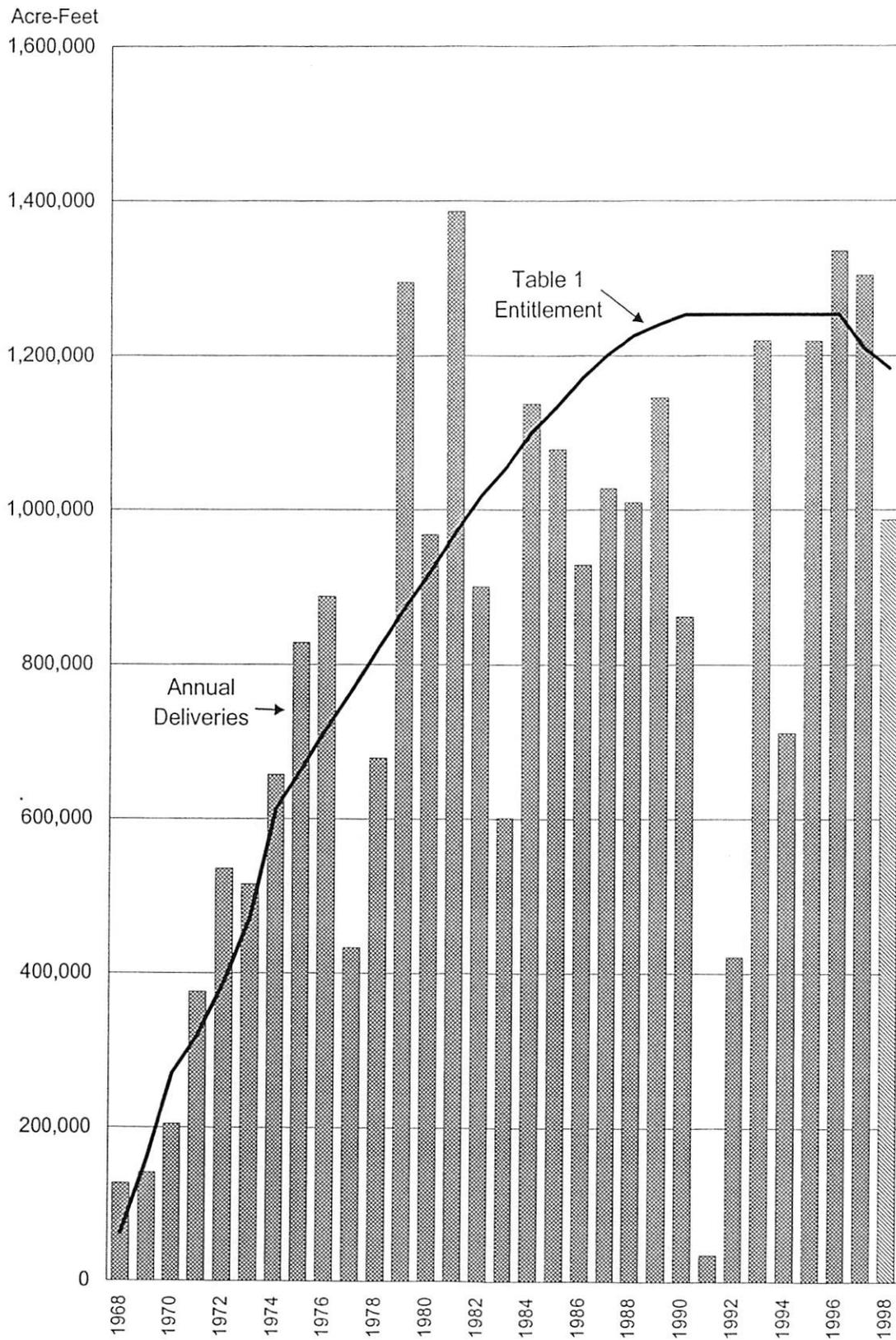


Table 3. SWP Deliveries to the San Joaquin Valley Portion of Kern County (in acre-feet)

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	34,886	17,763,148		2,213	32,673	17,107,424
1992	421,520	18,184,668		3,508	418,012	17,525,436
1993	1,219,653	19,404,321		14,139	1,205,514	18,730,950
1994	711,002	20,115,323		15,616	695,386	19,426,336
1995	1,219,146	21,334,469		107,950	1,111,196	20,537,532
1996	1,335,394	22,669,863		88,209	1,247,185	21,784,717
1997	1,303,900	23,973,763		290,523	1,013,377	22,798,094
1998	987,299	24,961,062		148,101	839,198	23,637,292

Mean Deliveries	805,196 AF	Minimum Deliveries (1991)	34,886 AF
Median Deliveries	888,112 AF	Maximum Deliveries (1981)	1,386,641 AF
Mean Importations	765,029 AF	Minimum Importations (1991)	32,673 AF
Median Importations	857,336 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.

Table 4. 1998 State Water Project Deliveries by Contract (in acre-feet)

District	(1)	(2)	(3)	(4)	(5)	(6)
	SWP Water Supplies		Total SWP Supply	Landowner Transfers Out of Kern County	Misc. Transfers Out of Kern County	Westlands (7) Exchange Out of Kern County
Table 1 Entitlement	Carryover of 1997 Entitlement into 1998					
Berrenda Mesa WD	130,100		130,100	(17,873) (1)		(5,707)
Lost Hills WD	134,110		134,110	(9,658) (2)	(9,620) (5)	
Belridge WSD	147,665		147,665	(4,904) (3)	(11,380) (4)	(6,478)
Semitropic WSD	155,000		155,000			
Cawelo WD	38,200		38,200			(1,616)
Improvement Dist. No. 4	82,946		82,946		(1,000) (6)	
Rosedale-Rio Bravo WSD	29,900		29,900			
Buena Vista WSD	21,300		21,300			(1,309)
Kern Delta WD	25,500		25,500			(1,308)
Henry Miller WD	35,500		35,500			(1,985)
West Kern WD	25,000		25,000			(1,398)
Wheeler Ridge-Maricopa WSD	238,088		238,088			(10,445)
Tehachapi-Cummings CWD A ₁	4,300		4,300			(1,079)
Tehachapi-Cummings CWD M	15,000		15,000			
Tejon-Castac WD Ag	3,121		3,121			(225)
Tejon-Castac WD M&I	2,000		2,000			
MWD (AEWSD)			0			
Westside Mutual WC			0			
Westlands WD		1,684	1,684	32,435		31,550
Tulare Lake Basin WSD			0		21,000	
Tulare Lake Basin WSD/MWD			0		1,000 (6)	
Dudley Ridge WD (KWB)			0			
Others			0			
Total	1,087,730	1,684	1,089,414	0	0	0

Note: This table shows contracted deliveries for calendar year 1998. 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) Landowner transfer (17,873 AF) to Westlands WD (Woolf = 16,853 AF; Vista Verde = 1,020 AF).
- (2) Landowner transfer (9,658 AF) to Westlands WD (Woolf = 7,658 AF; Shannon = 2,000 F).
- (3) Landowner transfer (4,904 AF) to Westlands WD (Woolf).
- (4) Transfer of 20,000 AF to TLBWSD in exchange for a like quantity of banked Friant-Kern water (KWB) purchased by Harris Ranch from Westside Mutual WC; Lost Hills WD=8,620 AF and Belridge WSD=11,380 AF.
- (5) Includes 1,000 AF to Tulare Lake Basin WSD for mitigation purposes; includes 8,620 AF to Tulare Lake Basin WSD.
- (6) Exchange of ID4's SWP entitlement for a like amount of TLBWSD's Kern River water; Nickel's lower Kern River water made available to TLBWSD and subsequently sold to Western Water Company, which in turn sold to a buyer in MWD.
- (7) Transfer of 31,550 AF to Westlands WD in exchange for a like quantity of Friant-Kern water returned to the exchange participants within 10 years.

Table 4 (continued). 1998 State Water Project Deliveries by Contract (in acre-feet)

District	(7) Misc. Transfers Into Kern County	(8) Misc. Transfers, Exchanges Other	(9) Misc. and Simultaneous Exchanges, Other	(10) Kern River for SWP Exchange	(11) Friant- Kern for SWP Exchange
Berrenda Mesa WD			(1,443)		
Lost Hills WD		(130) (12)	(870)	(3,797) (16)	
Belridge WSD		(157) (13)	(1,179)		
Semitropic WSD	73,050 (8)	130 (12)	166		
Cawelo WD		(36,584) (14)			
Improvement Dist. No. 4		10,800 (15)	(36,372)	(20,400) (16)	(2,600) (17)
Rosedale-Rio Bravo WSD			6,406	(7,353) (16)	
Buena Vista WSD	6,500 (9)	84,378 (14)	28,446		
Kern Delta WD		(24,192) (14)			
Henry Miller WD					
West Kern WD		(23,602) (14)			
Wheeler Ridge-Maricopa WSD			1,596		
Tehachapi-Cummings CWD Ag					
Tehachapi-Cummings CWD M&I		(10,800) (15)			
Tejon-Castac WD Ag		157 (13)	132		
Tejon-Castac WD M&I					
MWD (AEWSD)	23,234 (10)		(690)		
Westside Mutual WC			3,039		
Westlands WD		20,000		31,550	2,600
Tulare Lake Basin WSD					
Tulare Lake Basin WSD/MWD					
Dudley Ridge WD (KWB)	5,925 (11)		239		
DWR (KWB/Demo)			530		
Total	108,709	20,000	0	0	0

Note: This table shows contracted deliveries for calendar year 1998. 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) Includes storage transfers from MWD (39,500 AF), Santa Clara Valley WD (23,800 AF), Alameda County WD (3,780 AF) and Alameda County -Zone 7 (5,970 AF).
- (9) MWD entitlement destined for storage in Arvin-Edison WSD; delivered to Buena Vista WSD in exchange for a like amount of BV's Kern River water delivered to Arvin-Edison WSD on behalf of MWD.
- (10) MWD entitlement to be stored in Arvin-Edison WSD (see footnote #8).
- (11) Dudley Ridge WD transfer of entitlement (4,941 AF) and Interruptible water (984 AF) for storage in Kern Water Bank.
- (12) Landowner transfer from Lost Hills WD to Semitropic WSD on behalf of Lost Hills Utility District.
- (13) Permanent transfer of 157 AF from Belridge WSD to Tejon-Castac WD; associated SWP costs administered within Belridge WSD contract in 1998.
- (14) Long-term exchange amounts to Buena Vista WSD from Kern Delta WD (24,192 AF), West Kern WD (23,602 AF) and Cawelo WD (36,584 AF).
- (15) Long-term M&I Pool quantity (10,800 AF) to Improvement District No. 4.
- (16) Transfer of 31,550 AF to Westlands WD in exchange for a like amount of Kern River water purchased by Westlands WD from La Hacienda, Inc; LHWB = 3,797 AF; ID4 = 20,400 AF; RRBWSD = 7,353 AF.
- (17) Transfer of 2,600 AF to Westlands WD in exchange for a like quantity of Friant-Kern (MID) water.

Table 4 (continued). 1998 State Water Project Deliveries by Contract (in acre-feet)

District	(12) (Col 3..11) Total SWP Water Available	(15) In-District Deliveries	(16) Recharge Deliveries	(17) (Col 15..16) Total Deliveries	(18) (Col 14-17) Balance to be Delivered
Berrenda Mesa WD	105,077	86,879	6,706	93,585	11,492
Lost Hills WD	110,035	88,037	5,216	93,253	16,782
Belridge WSD	123,567	82,968	10,312	93,280	30,287
Semitropic WSD	228,346	199,272	5,222	204,494	23,852
Cawelo WD	0	0	0	0	0
Improvement Dist. No. 4	33,374	2,798	16,749	19,547	13,827
Rosedale-Rio Bravo WSD	28,953	28,953	0	28,953	0
Buena Vista WSD	139,315	96,255	0	96,255	43,060
Kern Delta WD	0	0	0	0	0
Henry Miller WD	33,515	21,310	0	21,310	12,205
West Kern WD	0	0	0	0	0
Wheeler Ridge-Maricopa WSD	229,239	147,880	8,106	155,986	73,253
Tehachapi-Cummings CWD A ₁	3,221	2,531	0	2,531	690
Tehachapi-Cummings CWD M	4,200	3,751	0	3,751	449
Tejon-Castac WD A _g	3,185	0	0	0	3,185
Tejon-Castac WDM & I	2,000	0	258	258	1,742
MWD (AEWSD)	22,544	22,544	0	22,544	0
Westside Mutual WC	3,039	0	3,039	3,039	0
Westlands WD	119,819	119,819	0	119,819	0
Tulare Lake Basin WSD	21,000	21,000	0	21,000	0
Tulare Lake Basin WSD/MWD	1,000	1,000	0	1,000	0
Dudley Ridge WD (KWB)	6,164	0	6,164	6,164	0
DWR (KWB/Demo)	530	530	0	530	0
Total	1,218,123	925,527	61,772	987,299	230,824

Note: This table shows contracted deliveries for calendar year 1998. 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.

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	75,124,462	30,684,996
1998	1,717,967	1,662,556	76,698,721	32,182,125

105 Year Mean Natural First Point Flow	741,700 AF	Minimum Natural First Point Flow (1961)	177,642 AF
105 Year Median Natural First Point Flow	589,500 AF	Maximum Natural First Point Flow (1916)	2,520,149 AF
45 Year Mean Regulated First Point Flow	740,300 AF	Minimum Regulated First Point Flow (1961)	177,063 AF
45 Year Median Regulated First Point Flow	601,300 AF	Maximum Regulated First Point Flow (1983)	2,381,575 AF

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

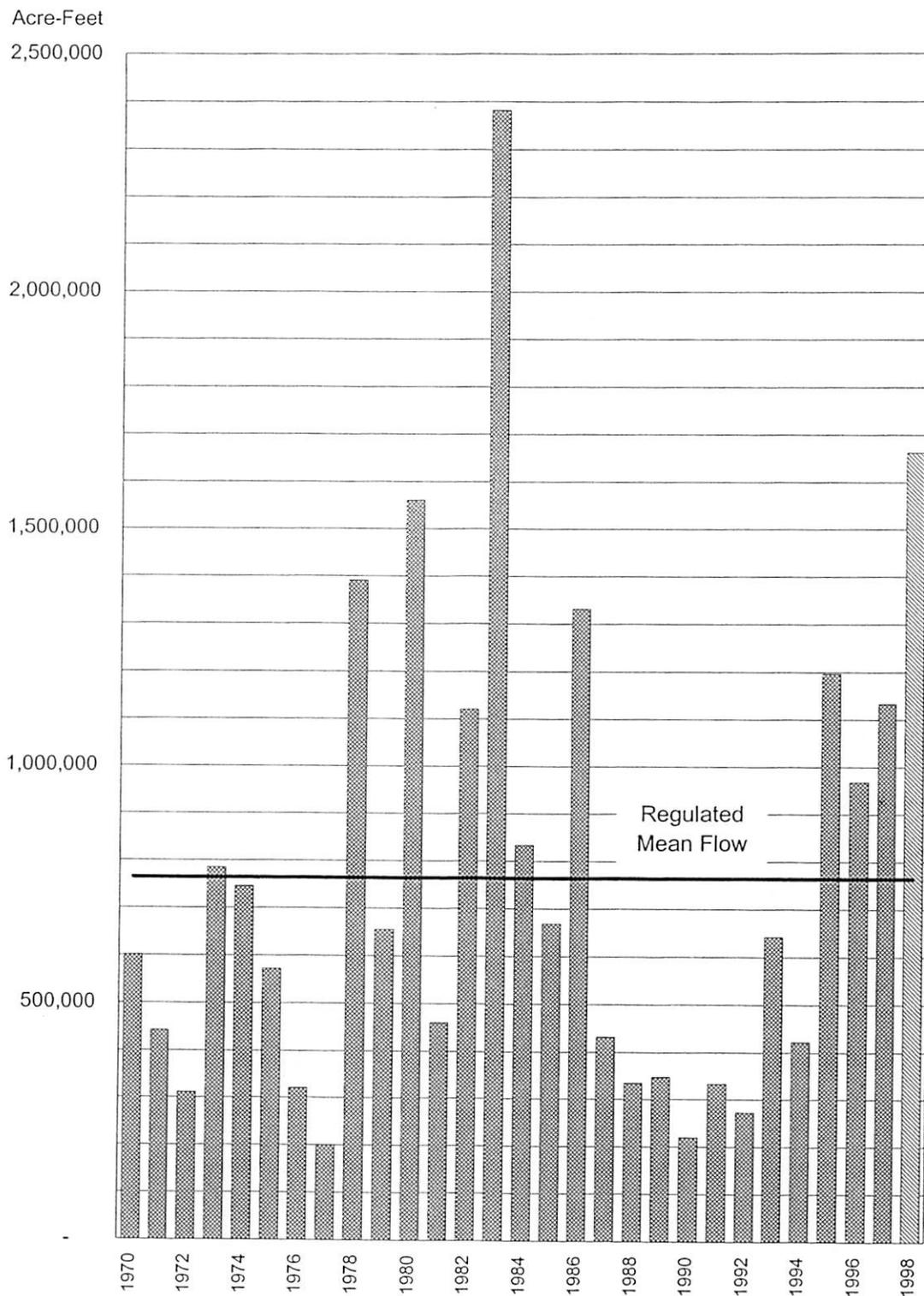


Table 6. 1998 Kern River Water Diversions by Entity (in acre-feet)

Area of Use	Diversions
Above First Point	
City of Bakersfield	2
Kern Valley Golf Course (Kernville)	145
La Hacienda, Inc.	661
Lake Ming	790
Olcese WD	1,266
Subtotal	2,864
Below First Point	
Arvin-Edison WSD	35,869
Buena Vista WSD	355,667
Cawelo WD	61,613
City of Bakersfield, Irrigation and Spreading ⁽¹⁾	112,180
Henry Miller WD	7,300
Improvement District No. 4	83,874
Kern County Water Agency (Pioneer Property)	129,112
Kern Delta WD	193,646
Kern -Tulare WD	10,866
Kern Water Bank Authority	194,590
North Kern WSD	346,844
Rag Gulch WD	1,628
Rosedale Ranch Improvement District	15,053
Rosedale-Rio Bravo WSD	113,863
South Fork	451
Subtotal	1,662,556
Total	1,665,420

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

Following is a chronology of CVP water allocations:

	<u>Friant-Kern Supplies</u>	<u>CVP Delta Supplies</u>
February 13, 1998	100% Class I, 25% Class II	65% Class I
March 26, 1998	100% Class I, 25% Class II	80% Class I
April 1998	100% Class I, 100% Class II	85% Class I (Urban 100%)
May 28, 1998	100% Class I, 100% Class II	100% Class I

Table 7 shows 1998 deliveries of CVP water by entity. As shown, 201,020 acre-feet of Class I entitlement and 252,231 acre-feet of Class II water was delivered. A total of 11,365 acre-feet of "Section 215" water was delivered in 1998, most of which was delivered to KCWA for groundwater recharge and banking programs. Also, 1,875 acre-feet of other CVP water was delivered, mostly to KCWA, for groundwater programs.

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 histogram of CVP deliveries since 1970. From 1950 to 1998, almost 15 million acre-feet of CVP water was imported into Kern County.

Minor Streams

Local "minor stream" watersheds are the second largest local source of surface water, after the Kern River. Streams which yield measurable 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 1998 were estimated to be about 286,400 acre-feet as follows:

<u>Stream Group</u>	<u>Acre-feet</u>
Poso	163,100
Caliente	50,100
El Paso	25,500
San Emigdio	47,700
Total	286,400

Table 7. 1998 Central Valley Project Deliveries by Entity ⁽¹⁾(in acre-feet)

	Class I	Class II	215 Water	Other ⁽³⁾ Water	Total
Arvin-Edison WSD	36,152	124,830	854	606	162,442
Delano-Earlimart ID	19,908	9,085	355	55	29,402
Kern County Water Agency	2,269		10,156		12,425
Kern-Tulare WD ⁽²⁾	1,617	21,974			23,591
North Kern WSD	6,056	2,024			8,080
Rosedale-Rio Bravo WSD	3,417	35,440			38,857
Shafter-Wasco ID	38,144	28,878		947	67,969
So. San Joaquin MUD	93,457	30,000		267	123,724
Total	201,020	252,231	11,365	1,874	466,490

⁽¹⁾ Quantities for water year March 1997 - February 1998.

⁽²⁾ Per exchange of Cross Valley Canal water with Arvin-Edison WSD.

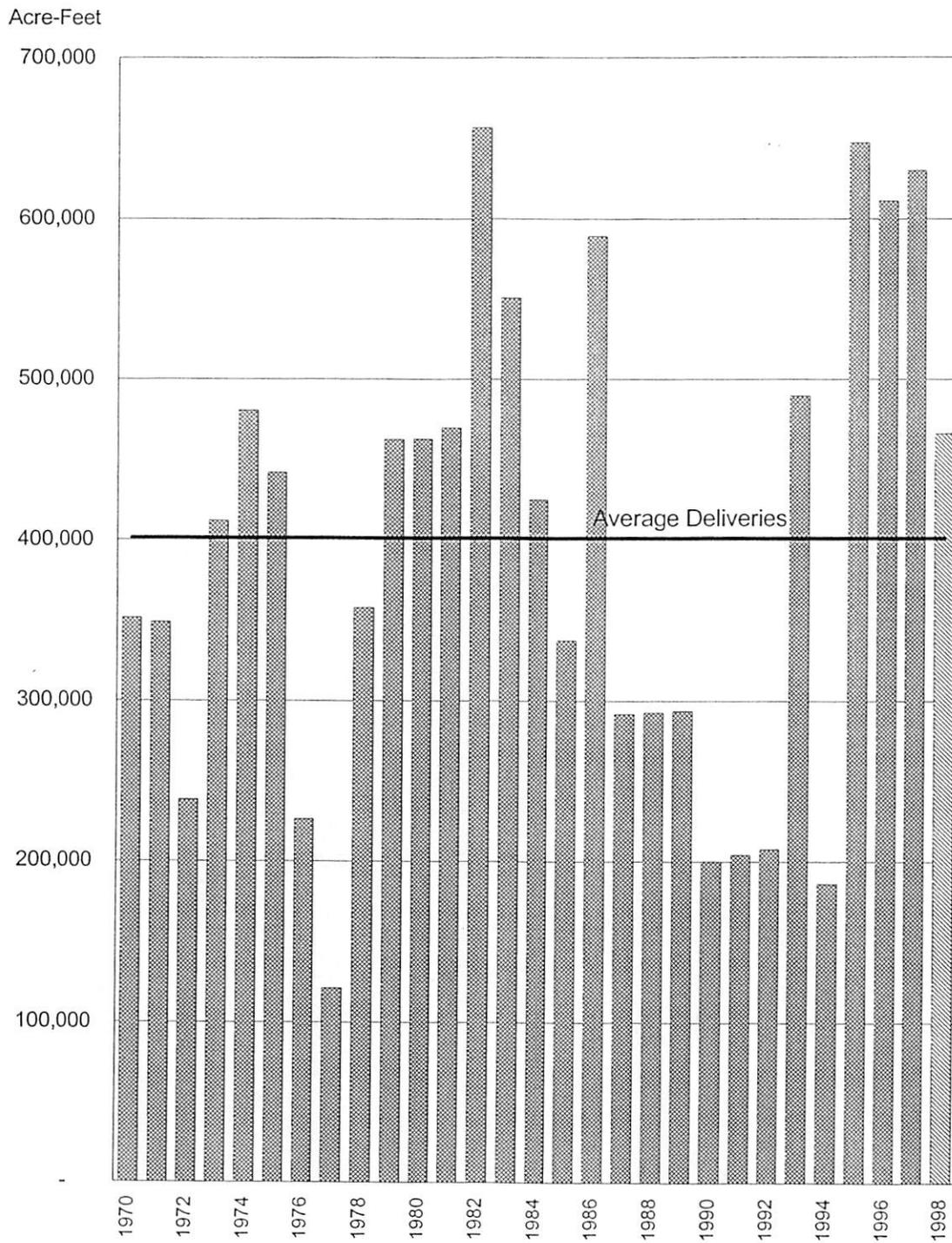
⁽³⁾ Includes M&I water, operational spill water and non-project water delivered via CVP.

Table 8. 1998 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	1998	466,490	14,981,057
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	305,736 AF	Median Delivery	1975-98	433,751 AF
Median Delivery	279,134 AF	Min. Delivery	1975-98 (1977)	121,469 AF
Mean Delivery 1975-1998	401,043 AF	Max. Delivery	1975-98 (1982)	656,608 AF

Figure 5. Central Valley Project Deliveries to Kern County



Some minor stream water is used for irrigation by farmers in the North Kern Water Storage District and Semitropic Water Storage District. 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 268,500 acre-feet of the minor stream flows during 1998 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 Tehachapi in 1998. Figure 7b shows cumulative runoff for Tehachapi 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 1998.

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 1998 contributed 575,200 acre-feet of effective precipitation, with 502,200 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 1998 was 214 percent of average, about 120 percent higher than 1997. Following is a tabulation of 1995-98 and average monthly rainfall (in inches) for Meadows Field. KCWA estimates that rainfall provided about 8.0 inches of useable water for crops grown during 1998.

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 (1989)		6,900 AF
Maximum Flow (1978)		429,200 AF

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

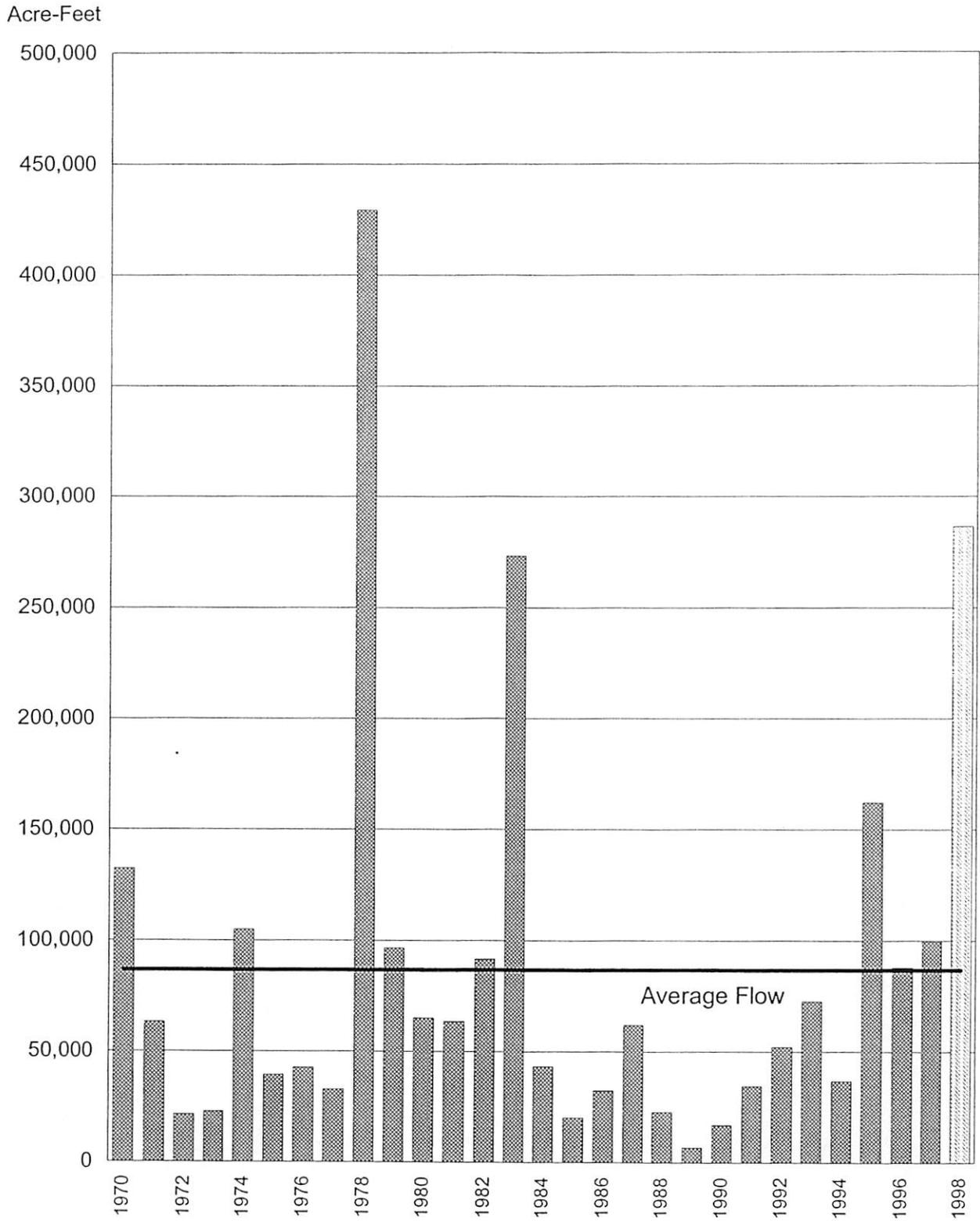
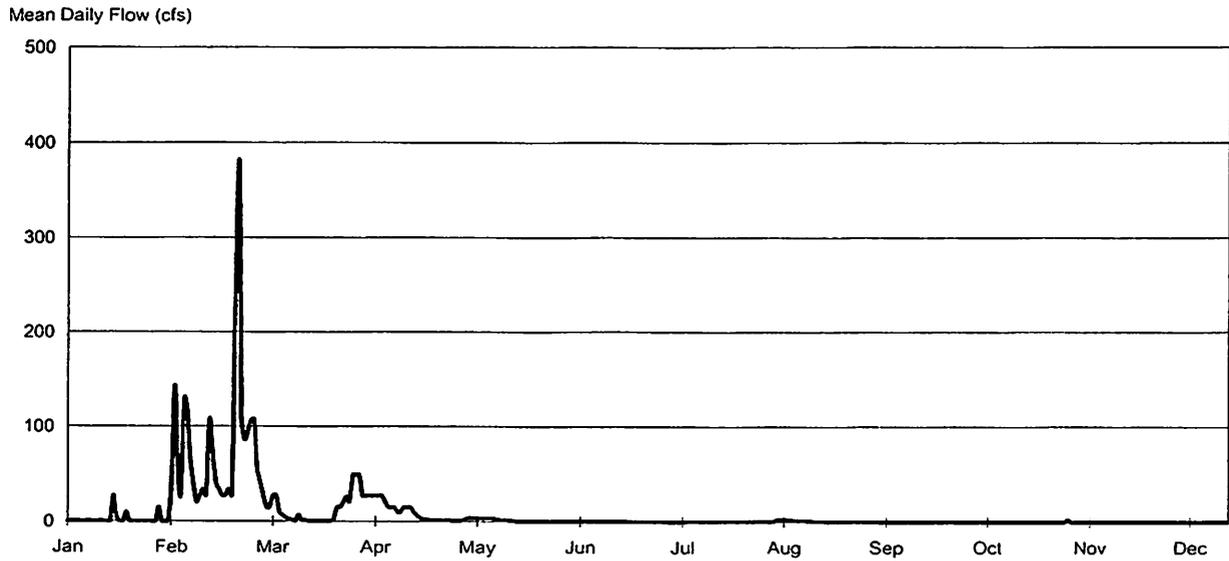
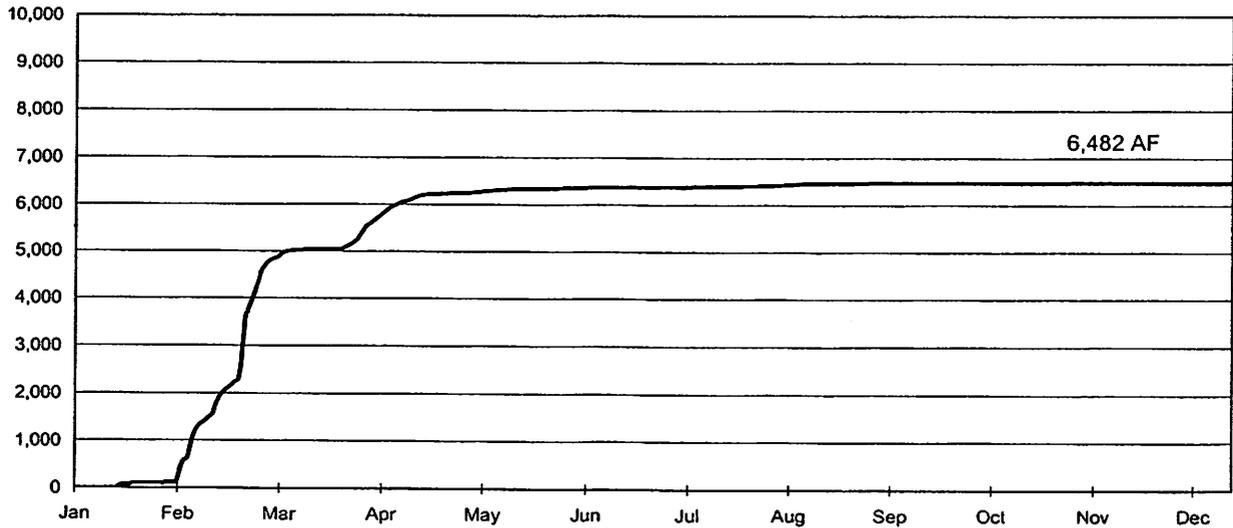


Figure 7a. Tehachapi Creek Hydrograph (cfs), 1998



- Note:
1. Hydrograph began 0000 hrs on 1/1/98 and ended at 2400 hrs on 12/31/98.
 2. Located at Lat. 35 10' 26", Long. 118 28' 43"; NE 1/4, SW 1/4, Sec. 6, T32S, R33E, Kern County.
 3. Peak discharge, 705 cfs, 2/23/98.

Figure 7b. Tehachapi Creek Cumulative Volumes (acre-feet), 1998



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume (AF)	120	4,437	783	900	110	29	31	63	3	0	5	0
Cumulative Volume (AF)	120	4,557	5,340	6,240	6,350	6,379	6,410	6,474	6,477	6,477	6,482	6,482

Rainfall at Meadows Field, Bakersfield						
	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>	<u>Avg.</u>	<u>1998</u> <u>% of Avg</u>
Jan	2.29	1.08	1.87	1.32	1.07	123
Feb	0.87	2.54	0.80	5.36	1.16	462
Mar	3.39	0.78	0.21	2.51	1.18	213
Apr	0.79	0.12	0	0.87	0.66	132
May	0.35	0.02	0	1.33	0.22	605
Jun	0.12	0	0	0.37	0.08	463
Jul	0	0	0	0	0.01	0
Aug	0	0	0	0	0.04	0
Sep	0	0	0.05	0.31	0.12	258
Oct	0.08	0	0.25	0.24	0.29	83
Nov	0.98	0	1.70	0.46	0.61	75
Dec	2.03	1.73	0.97	0.55	0.77	71
Total	9.84	8.08	5.85	13.32	6.22	214

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.

Recycled Water

The reuse of municipal and industrial waste water provides an irrigation water source for Kern County agriculture. There are 14 active waste water recycling treatment plants in the San Joaquin Valley portion of Kern County. Recycling 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 recycling 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 recycling 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 1998 about 48,800 acre-feet of waste water was recycled (Table 12). KCWA estimated that about 45,100 acre-feet was used by agriculture, 100 acre-feet evaporated and 3,600 percolated to the underlying aquifer. Table 13 shows historic amounts of recycled water. 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.

Oil Field Produced Water

Another source of waste water 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. Thus, much of this water is discharged into irrigation canals.

A total of 2,000 acre-feet of produced water from the Kern Front oil field was reused in 1998. 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 1998 were calculated to be about 1,290,200 acre-feet. This is about 200,000 acre-feet more than was extracted in 1997 and likely reflects the large amount of surface water used for direct recharge.

Groundwater is pumped for a variety of uses in the San Joaquin Valley portion of Kern County, with agriculture the largest user. In 1998 agriculture used about 1,123,800 acre-feet. Municipal and industrial uses were about 166,400 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 histogram of groundwater pumping, a graphic display of relative variations.

Table 10. 1998 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	1.96	5.22	4.85	3.03	1.15	0.26	0	0	0.52	0.46	1.12	1.12	19.69
Sycamore	420	31S/30E-20	1.86	4.95	4.57	3.02	1.10	0.22	0	0	0.52	0.48	1.01	0.96	18.69
Tejon	480	32S/29E-15	1.79	4.21	3.44	1.62	1.22	0.05	0	0	1.00	0.57	1.31	0.89	16.10
CALIFORNIA DEPARTMENT OF WATER RESOURCES															
Lost Hills O&M Center	300	27S/21E-03	1.02	5.88	2.31	0.98	2.93	0	0	0	0.15	0.84	0.91	0.32	15.34
Wasco 7E	410	27S/26E-06	1.41	6.29	2.99	1.21	1.61	0.95	0	0	0	0.48	0.60	0.70	16.24
Wind Gap O&M Center	780	11N/20W-26	2.38	6.22	2.45	1.97	1.67	0.24	0	0	0.48	0.41	1.02	0.75	17.59
J.G. BOSWELL COMPANY															
Buena Vista #4	300	32S/25E-06	0.92	5.57	2.77	1.13	1.96	0.09	0	0	1.57	0.15	0.42	0.49	15.07
Buena Vista Gin	300	32S/25E-12	1.27	5.16	2.45	1.01	1.78	0.13	0	0	0.53	0.11	0.51	0.42	13.37
Buena Vista Office	290	31S/25E-25	1.48	5.08	2.60	1.14	2.06	0.56	0	0	0.47	0.17	0.62	0.40	14.58
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	1.42	4.57	3.43	1.64	1.93	0.22	0	0	0.59	0.10	0.86	0.52	15.28
Paloma	290	32S/24E-02	1.60	4.62	3.08	1.29	1.88	0.14	0	0	0.40	0.11	0.78	0.45	14.35
KERN COUNTY PLANNING DEPARTMENT															
Arvin Fire Station	450	31S/29E-28	1.38	4.30	3.43	2.06	0.60	0.20	0	0	0.22	0.18	1.05	0.10	13.52
Buena Vista Aquatic Rec Area	300	31S/25E-15	0.71	4.12	2.61	0.48	1.55	0.32	0	0	0.42	0.16	0.35	0.36	11.08
Buttonwillow Fire Station	270	29S/23E-14	0.73	6.64	3.45	0.73	2.40	0.46	0	0	0.07	0.51	0.82	0.27	16.08
Communications Center	770	29S/28E-16	1.39	5.14	2.66	0.88	2.53	0.06	0	0.09	1.06	0	0.34	0.27	14.42
Edmonston Pump Station	1,310	10N/18W-17M	3.10	9.29	4.14	3.50	1.89	0.61	0	0	1.16	0.50	2.31	2.28	28.78
McFarland Fire Station	350	26S/25E-10	1.09	5.52	2.97	0.80	1.79	1.05	0	0	0	0.51	0.88	0.10	14.71
Pine Mountain	5,200	09N/21W-19	3.55	14.85	4.03	1.28	1.64	0.02	0	0	0.93	0.26	1.29	1.05	28.90
Rio Bravo Fire Station	610	29S/29E-04	1.41	6.70	3.12	0.88	2.17	0	0	0	2.34	0.16	0.36	0.36	17.50
NATIONAL WEATHER SERVICE															
Bakersfield	380	30S/28E-08	1.32	5.36	2.51	0.87	1.33	0.37	0	0	0.31	0.24	0.46	0.55	13.32
Bear Valley	4,100	32S/31E-03	6.75	10.80	6.29	2.84	1.74	0.46	0	0.09	0.76	0.69	2.04	2.01	34.47
Delano	320	25S/25E-S11	1.29	3.86	2.39	0.83	1.74	0.80	0	0	0.02	0.44	0.61	0.59	12.57
Glennville	3,100	25S/30E-25	7.17	12.01	5.61	3.25	4.92	1.45	0	0	0.48	0.57	1.95	1.36	38.77
Keene	2,900	31S/32E-20	4.79	9.49	3.61	3.36	1.00	0.03	0	0	0.07	0.57	1.17	1.55	25.64
Lebec	3,600	09N/19W-26	----- Incomplete data -----												
Lost Hills	280	26S/21E-35	1.12	4.96	2.28	1.17	2.73	0	0	0	0.15	0.48	0.55	0.47	13.91
Maricopa	700	10N/24W-11	0.22	5.35	2.86	1.00	3.69	0.02	0	0	0	0	0.43	0.57	14.14
Piute	4,290	29S/33E-36	3.40	9.79	2.82	0.48	1.25	0.07	0	0.04	0.46	0.09	1.45	0.20	20.05
Tehachapi	3,980	32S/33E-21	----- Incomplete data -----												
Wasco	300	27S/24E-11	0.98	5.44	2.30	1.26	1.81	1.98	0	0	0	0.52	0	0.89	15.18
Woody	1,600	25S/29E-35	3.57	7.90	3.37	2.68	4.24	0.65	0	0	0.08	0.52	1.04	0.63	24.68
TEHACHAPI-CUMMINGS COUNTY WATER DISTRICT															
Station 6	4,890	12N/15W-01	3.50	10.87	2.65	3.55	1.85	0.30	0	0.90	1.05	1.25	1.50	0.55	27.97
Station 20	5,730	12N/15W-12	4.25	12.70	2.85	4.55	2.63	0.45	0	1.10	1.20	1.55	1.90	0.80	33.98
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT															
5P-P2	590	11N/22W-09	1.40	5.36	2.72	1.08	2.16	0.18	0	0	0.70	0.14	1.35	0.48	15.57
District Headquarters	480	11N/12W-11	1.46	6.09	3.63	1.83	1.21	0.10	0	0	0.59	0.17	1.22	0.80	17.10
Greenlee's Pasture	380	12N/21W-36	1.22	5.32	3.30	1.83	1.34	0.10	0	0	0.58	0.16	1.34	0.68	15.87
PA-2	960	11N/19W-30	2.21	5.19	3.60	1.92	1.28	0.17	0	0	0.52	0.46	1.45	0.78	17.58
Spill Basin	850	11N/18W-31	2.25	6.30	3.50	2.41	1.29	0.08	0	0	0.72	0.48	2.16	1.21	20.40
WRM-2	510	32S-24E-35	1.08	5.82	2.78	0.61	1.74	0.04	0	0	0.63	0.08	1.22	0.22	14.22

Table 10 (continued). 1998 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 Comer (BMWD)	630	27S/20E-06	1.34	7.39	2.69	1.32	2.58	0	0	0	0.14	0.46	1.09	0.31	17.32
City of Bakersfield DWR Yd.	400	30S/27E-06	1.46	5.08	2.93	1.03	1.91	0.39	0	0	0.34	0.18	0.61	0.17	14.10
Del Kern Station (KDWD)	350	31S/28E-06C	1.72	4.53	3.12	1.45	2.13	0.33	0	0	0.81	0.16	0.69	0.43	15.37
Shafter Cotton Research Sta.	370	27S/25E-33J	1.25	6.15	3.17	0.75	1.77	0.74	0	0	0.08	0.45	0.62	0.74	15.72
So. Belridge (Cal Resources)	600	28S/21E-33	1.93	6.37	2.39	0.78	2.45	0.20	0	0	0.02	1.00	0.82	0.46	16.42
Approximate Average For All Stations			2.06	6.31	3.07	1.58	1.88	0.33	0	0.05	0.50	0.38	1.00	0.70	17.87

Note: Boxed numbers are estimated values

"m" indicates missing data

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

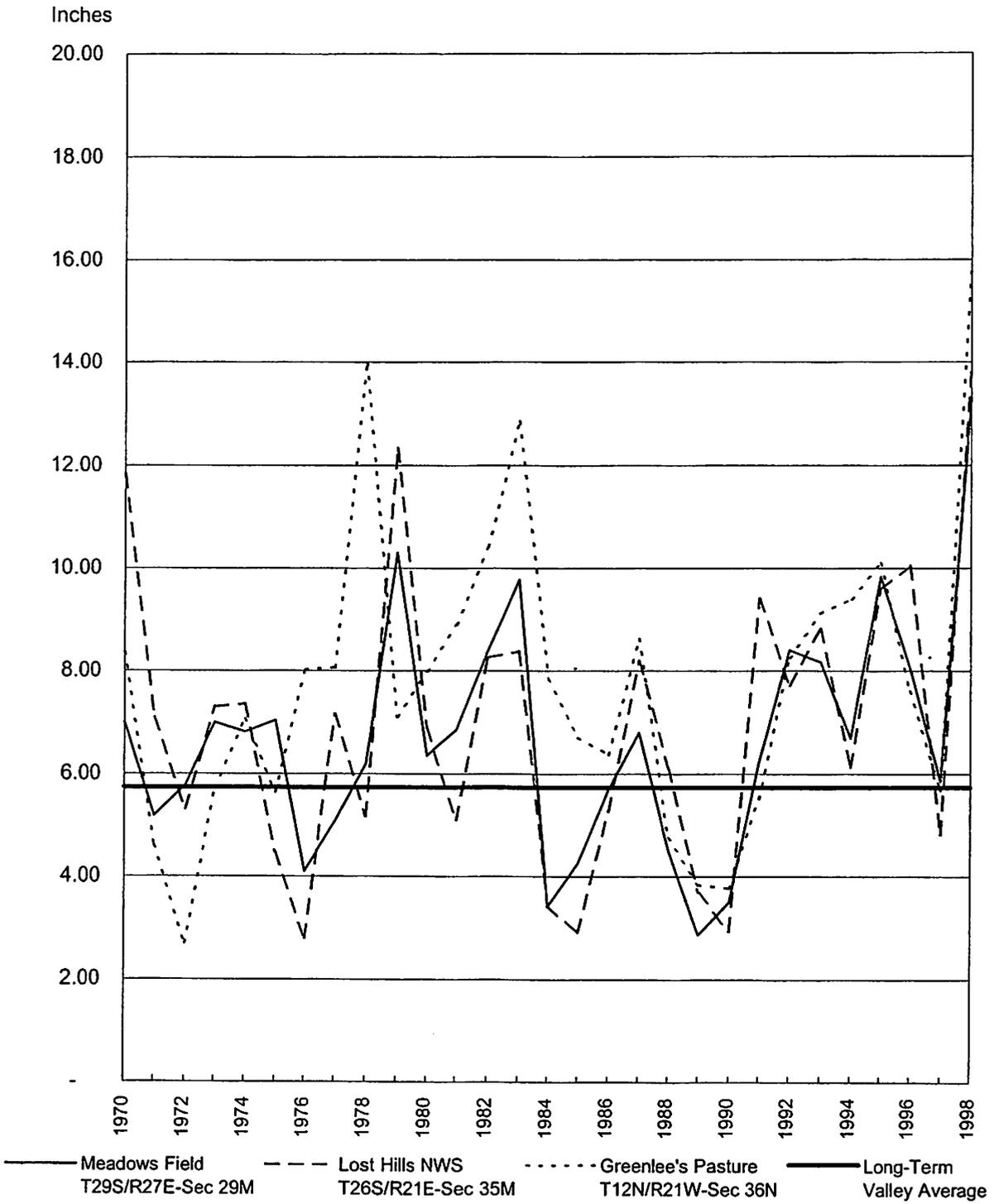


Table 11. Effective Precipitation in the San Joaquin Valley Portion of Kern County (in acre-feet)

	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
1998	575,200	8.01	6,520,900

Mean EP (total)	224,900 AF
Median EP (total)	171,700 AF
Mean EP (per acre)	3.11 Inches/Acre
Median EP (per acre)	2.57 Inches/Acre

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

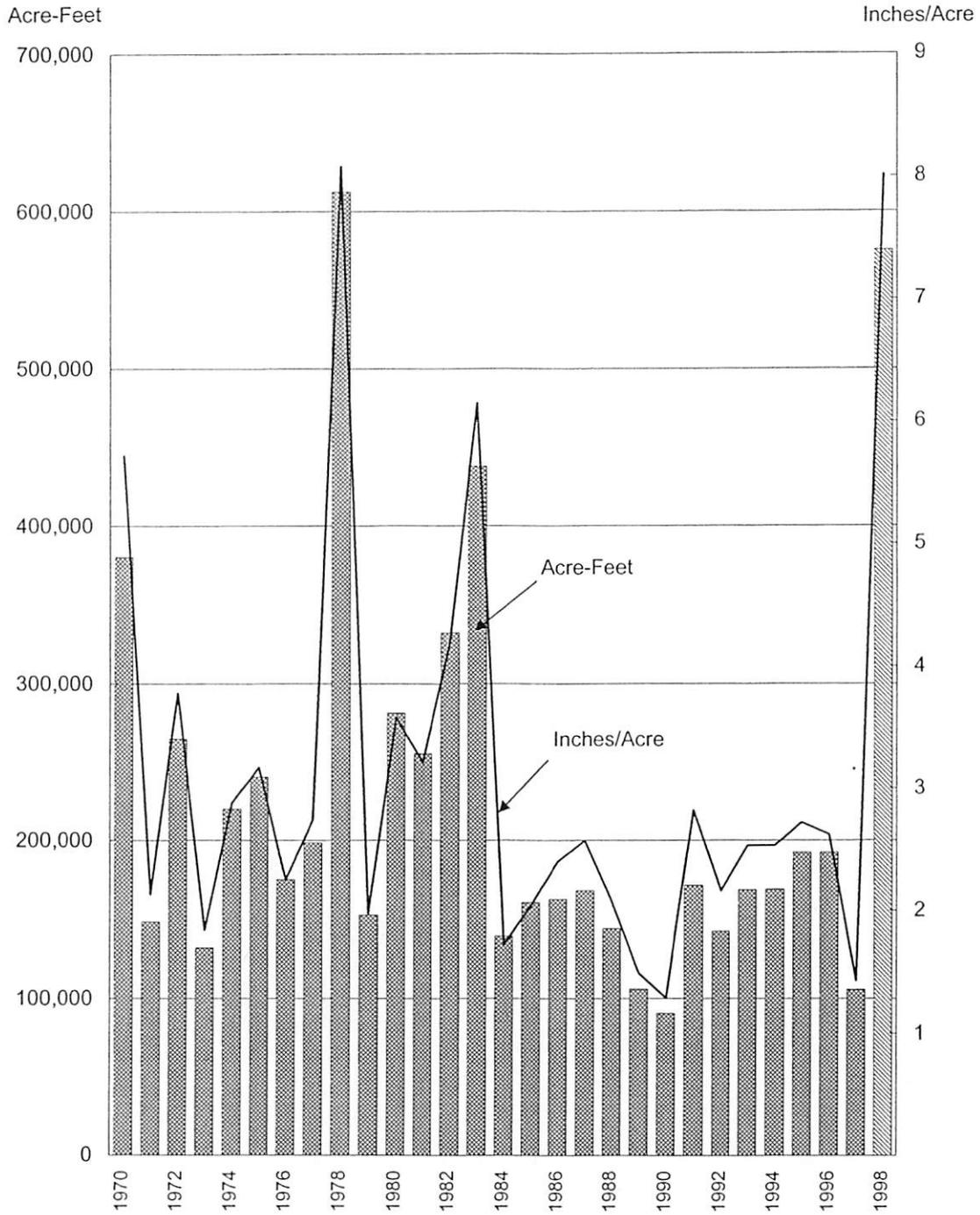


Table 12. 1998 Waste Water Treatment Plant Volumes

Facility	Volume		Influent Source	Treatment System	Effluent Use
	(MG)	(AF)			
City of Arvin	377	1,157	Dom	Secondary	Agriculture
City of Bakersfield					
#2	5,931	18,201	Dom/Ind	Secondary	Restricted Agriculture
#3	3,748	11,501	Dom/Ind	Secondary	Restricted Agriculture
Kern County Waste Management Department					
KSA (Mt. Vernon)	1,536	4,714	Dom	Secondary	Agriculture
BVARA ⁽¹⁾	8	24	Agr	Secondary	Percolation
Sheriff's Lerdo Facility ⁽¹⁾	93	285	Dom	Secondary	Same
Reeder Tract ⁽¹⁾	11	35	Dom	Secondary	Same
NOR Sanitary District #1	1,278	3,920	Dom/Ind	Secondary	Restricted Agriculture Percolation
City of Delano	1,389	4,264	Dom	Secondary	Restricted Agriculture
Lamont Public Utilities District		0	Dom	Primary	Agriculture
City of McFarland	274	840	Dom	Secondary	Agriculture
City of Shafter	515	1,581	Dom/Ind	Secondary	Agriculture
Shafter Airport	74	226	Ind	Secondary	Percolation
City of Wasco	665	2,041	Dom/Ind	Secondary	Agriculture
Total	15,899	48,789			

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.

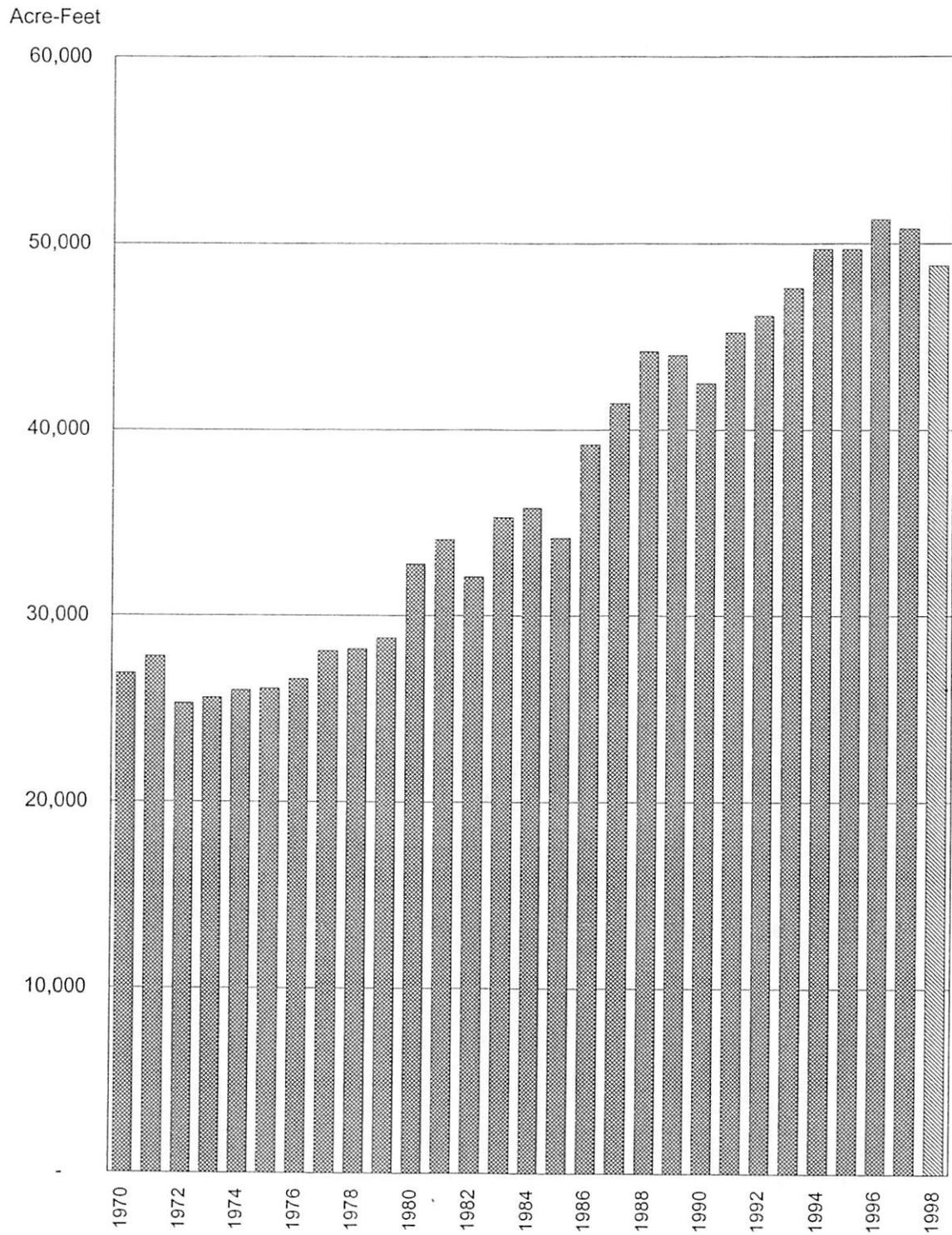
⁽¹⁾ No information available for 1998; 1994 data used as an estimation.

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
1998	48,800	1,074,200

Mean Water Reuse	37,000 AF
Median Water Reuse	35,300 AF
Minimum Water Reuse (1972)	25,300 AF
Maximum Water Reuse (1996)	51,300 AF

Figure 10. Waste Water Reuse in Kern County



Water Requirements

Agricultural

Gross irrigated acreage in the San Joaquin Valley portion of Kern County was about 861,500 acres in 1998. Since 23,100 acres were double-cropped, total net acreage in 1998 was 838,400 acres. Approximately 733,000 acres were irrigated over the usable ground-water basin, and 128,400 acres were irrigated on lands outside the usable groundwater basin.

A historic summary of irrigated acreage is provided in Table 16, along with descriptive statistics. Figure 13 shows historic irrigated acreage plotted as a bar graph. Figure 14 categorizes irrigated acreage by crop. Permanent crops (trees and vines) make up 37 percent of Kern County's total acreage. Cotton remains an important crop to Kern County's economy and encompasses 23 percent of the county's total acreage. Alfalfa and other green feeds accounted for about 14 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 nine 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 1998 shows that all Kern agricultural products had a combined market value of \$2,068,032,200. This is a decline of over \$172 million from 1997 which is attributed to the devastations of the El Niño weather patterns that destroyed acreage of trees, vines and other crops. A comparison of 1997 to 1998 gross crop values shows:

	<u>1997</u>	<u>1998</u>	<u>Change</u>
Fruit and nut crops	\$1,169,373,000	\$1,073,140,000	-\$93,233,000
Field crops & rangeland	453,915,000	300,487,000	-153,428,000
Vegetable crops	286,516,000	325,576,500	39,060,500
Nursery crops	79,629,000	82,636,000	3,007,000
Seed crops	5,678,000	4,449,000	-1,229,000
Other*	245,428,000	281,743,700	36,315,700
Total	\$2,240,559,000	\$2,068,032,000	-172,527,000

*Includes industrial and wood crops, livestock and poultry, livestock and poultry products and apiary products.

Trees and vines account for over half of Kern County's gross agricultural value, reflecting the importance of these crops to the local economy. In 1998, production of bell peppers,

tomatoes, garlic and cantaloupes increased, primarily as a replacement for cotton which saw a reduction in acreage from 1997 of about 75,000 acres. The drop in cotton acreage stemmed from its continual downturn in price.

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:

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 1998 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.

KCWA uses data from the California Irrigation Management and Information Service (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 1998 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 1998 were estimated to be about 2,985,600 acre-feet with 2,667,700 acre-feet occurring over the usable groundwater basin. Net agricultural requirements in 1998 were about 2,523,800 acre-feet with about 2,195,200 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. In moisture deficient soils, return flows are absorbed by the soils and are irrecoverable. About 398,300 acre-feet of water was lost to saline sinks during 1998. About 409,000 acre-feet of agricultural water applied in 1998 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 1998 were estimated to be about 197,500 acre-feet, with about 182,100 acre-feet required over the usable groundwater basin. Of this total, 26,500 acre-feet was supplied by KCWA's Henry C. Garnett Water Purification Plant. Olcese Water District served the Rio Bravo area with 900 acre-feet of treated Kern River water. East Niles Community Services District used about 1,900 acre-feet of CVP water obtained from Arvin-Edison Water Storage District. The remainder of M&I needs over the groundwater basin, 152,900 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 292 gallons per capita per day, a drop of 40 gpcd. 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 1998 was about 185 gpcd.

Net M&I consumptive use in 1998 was about 53,700 acre-feet over the groundwater basin. Gross return flows from M&I uses were about 128,400 acre-feet. About 48,800 acre-feet were treated in wastewater recycling facilities and evaporated, percolated or reused for agriculture. The remaining 79,600 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.

Exports

During periods of high runoff, such as occurred during parts of the year in 1998, 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. In 1998 188,000 acre-feet of water was exported from Kern County in this manner.

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 1998 about 70,000 acre-feet of evaporation losses occurred, with about 69,500 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 4,929,900 acre-feet in 1998. About 4,552,400 acre-feet of this demand occurred over the groundwater basin. A large amount of water, 1,673,100 acre-feet, was used for direct recharge or unlined delivery system losses. Total net consumptive water use was 2,778,800 acre-feet, with about 2,401,400 used over the groundwater basin. Gross available surface water supplies were about 3,832,600 acre-feet. There was a net increase in groundwater storage of 867,800 acre-feet in 1998.

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 1998, about 15,200,000 acre-feet was withdrawn from groundwater storage. During the same period the balance between additions and extractions has replenished about 5,777,000 acre-feet. The average withdrawal from storage since 1970 is about 325,000 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.

Table 14. Oil Field Produced Water (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
1998	1,290,200	40,212,800

Mean Groundwater Pumping	1,386,600 AF
Median Groundwater Pumping	1,333,000 AF
Minimum Pumping (1983)	762,700 AF
Maximum Pumping (1991)	2,002,400 AF

Figure 11. Oil Field Produced Water in Kern County

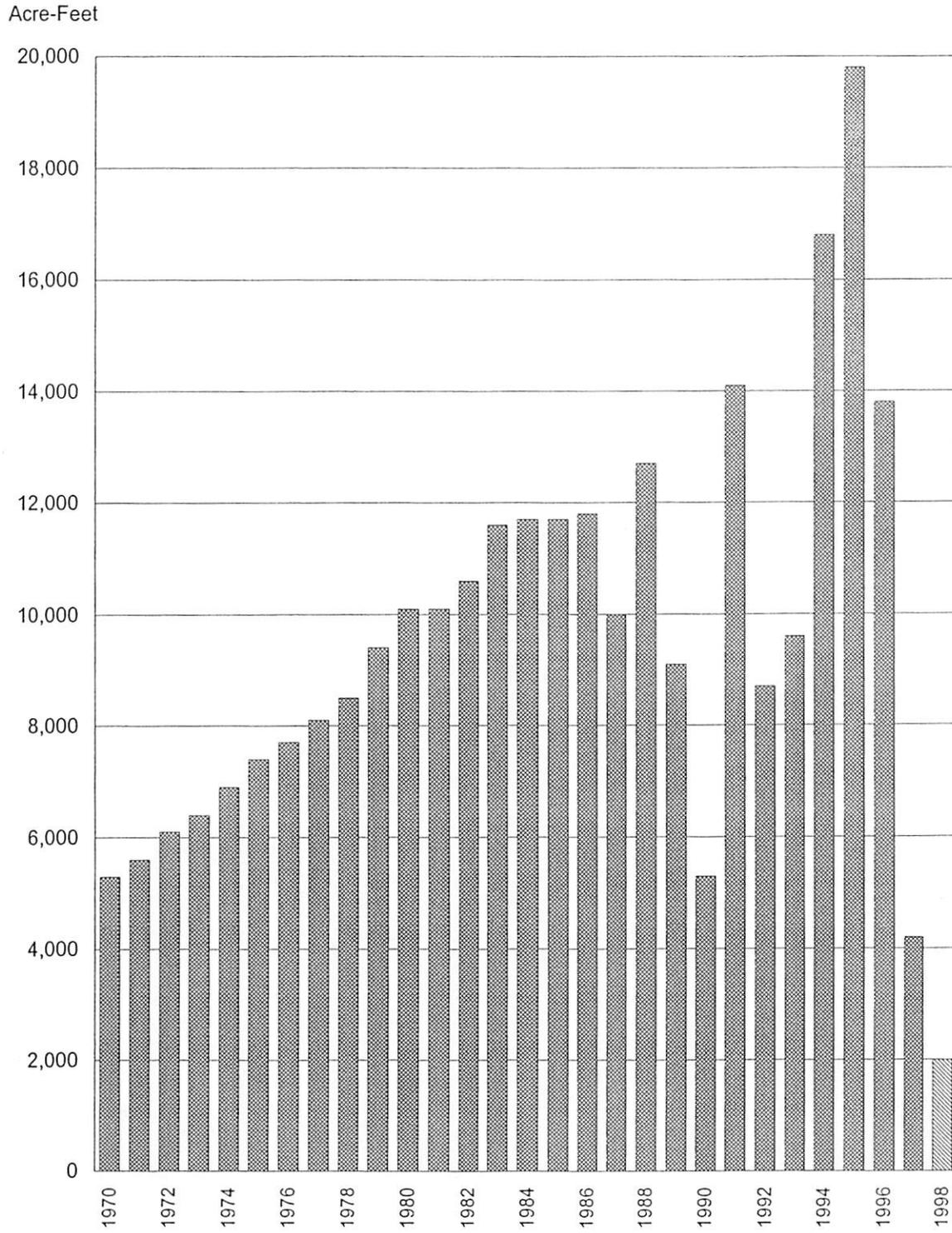


Table 15. Groundwater Pumping in the San Joaquin Valley Portion of Kern County (in acre-feet)

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
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1975	1,587,000	9,561,000
1976	1,738,000	11,299,000
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1996	1,609,600	37,831,200
1997	1,091,400	38,922,600
1998	1,290,200	40,212,800

Mean Groundwater Pumping	1,386,600 AF
Median Groundwater Pumping	1,333,000 AF
Minimum Pumping (1983)	762,700 AF
Maxim Pumping 1991	2,002,400 AF

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	1998	861,500
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	867,400 Acres
Minimum Irrigated Acreage (1991)	729,400 Acres
Maximum Irrigated Acreage (1984)	972,800 Acres

⁽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

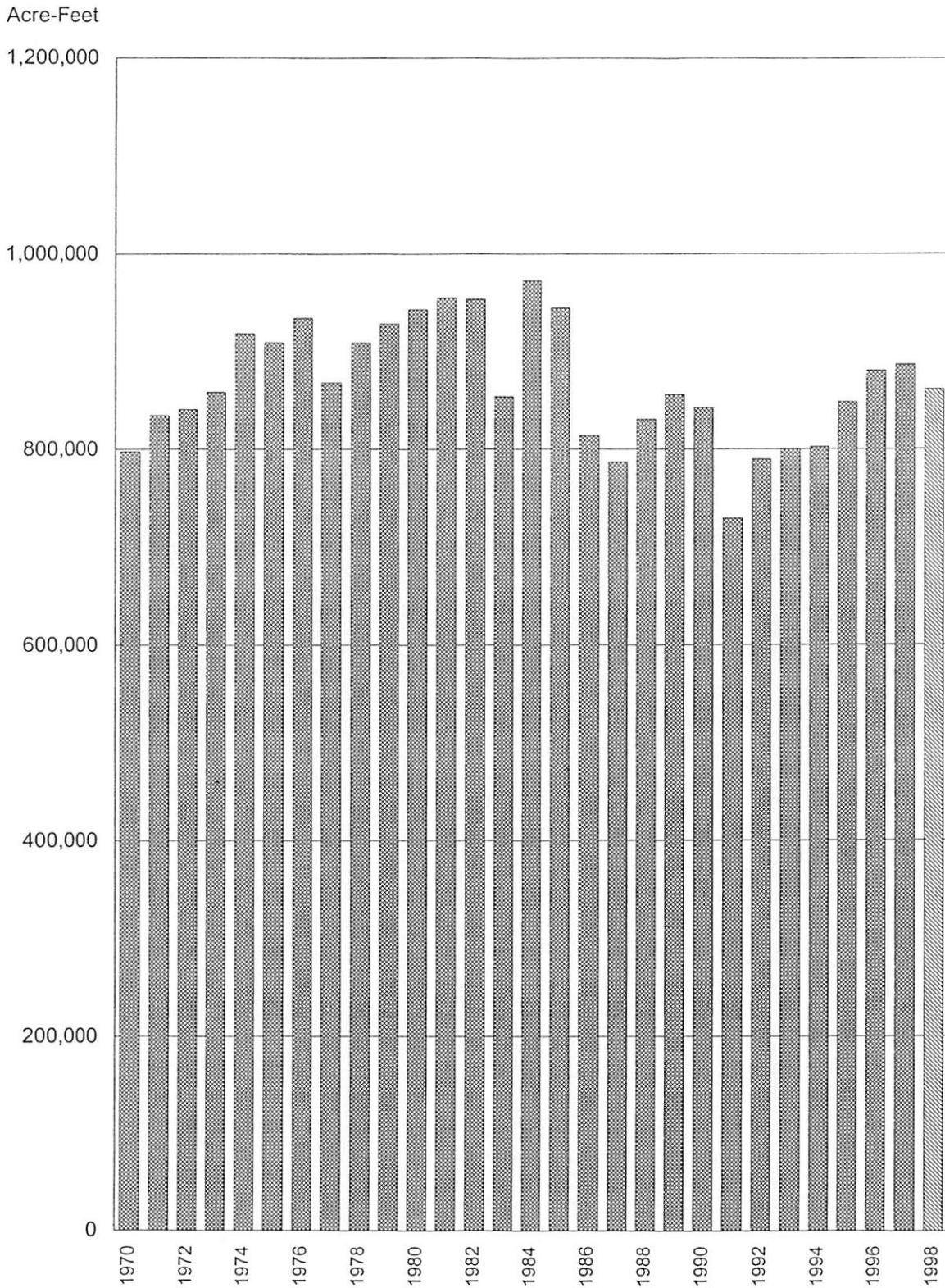


Figure 14. 1998 Summary of Irrigated Acreage

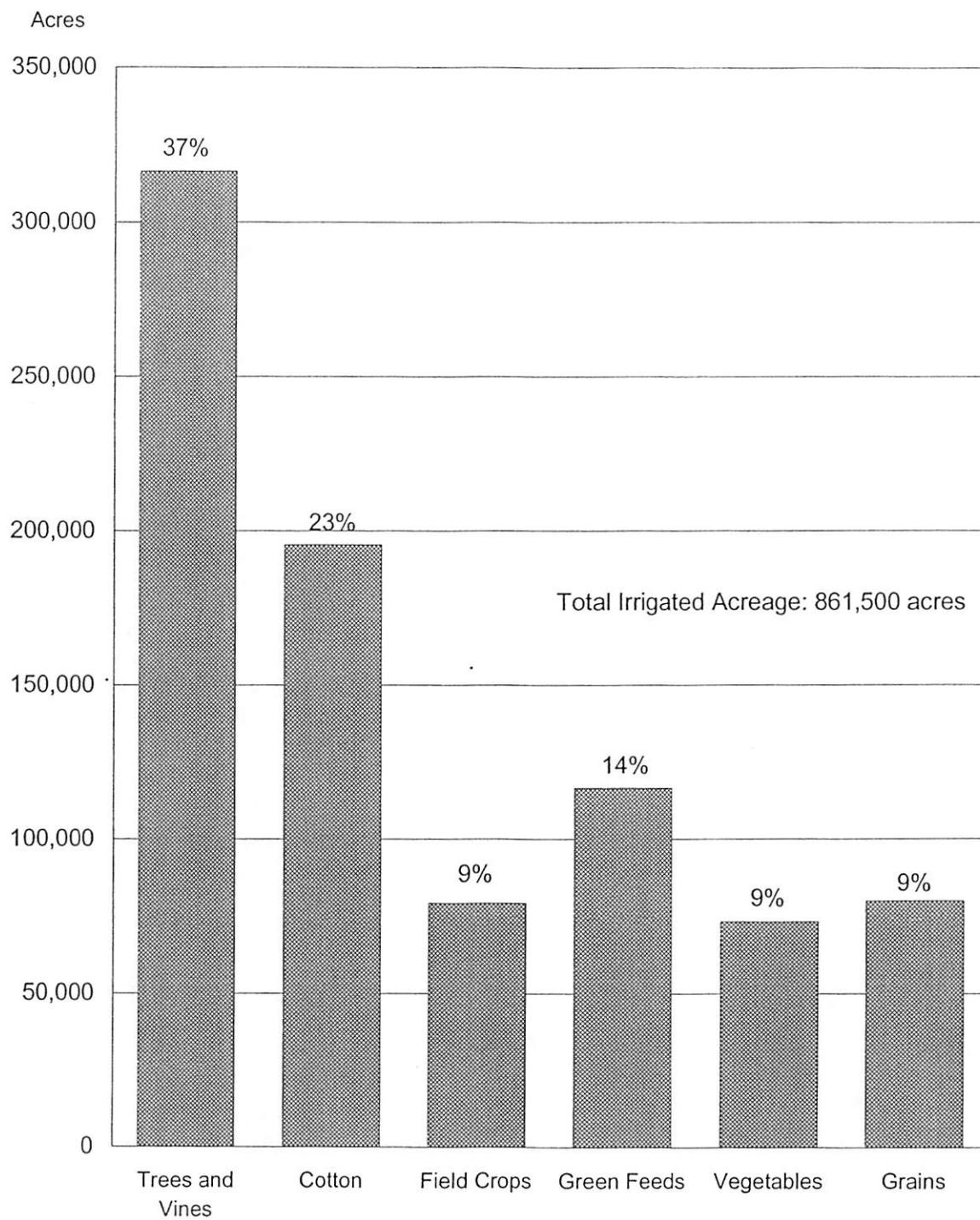


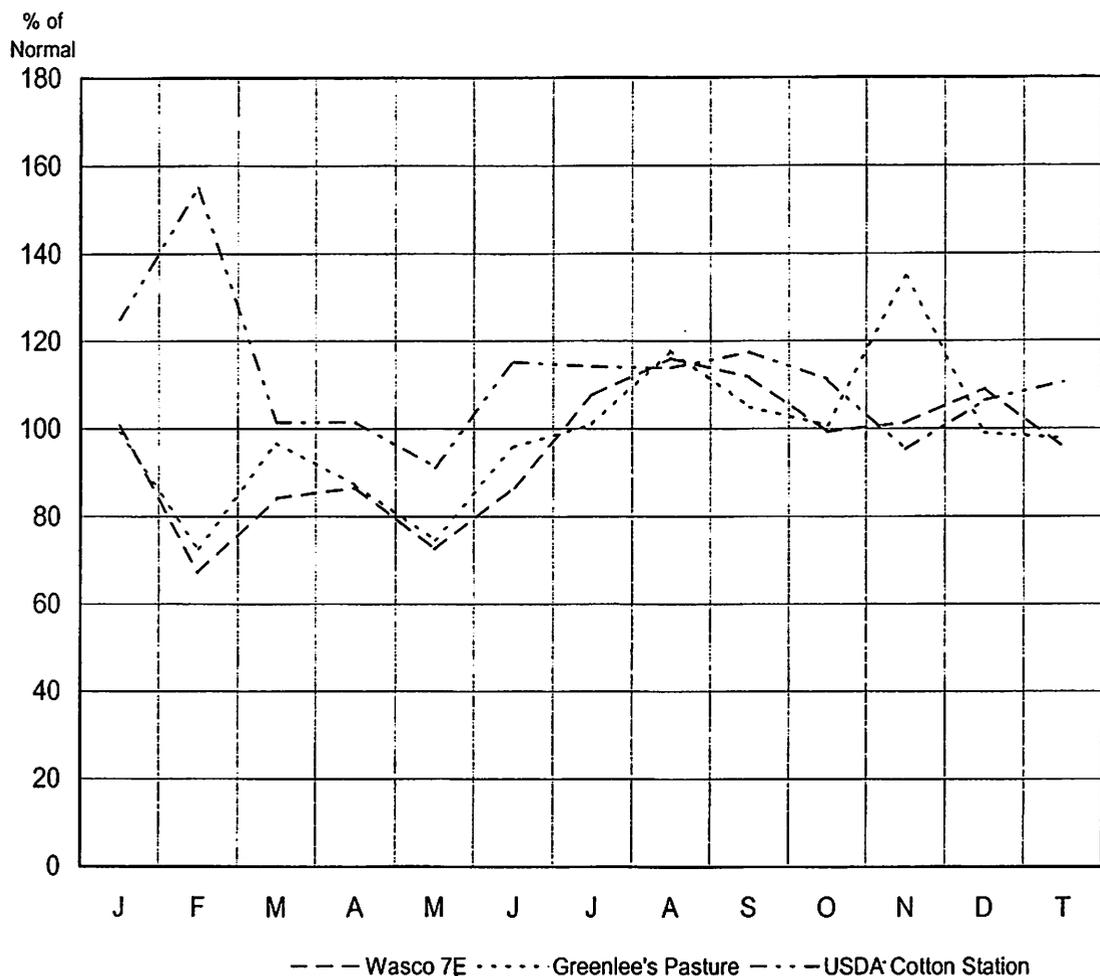
Table 17. 1998 Monthly Evaporation for San Joaquin Valley Climatic Station (in inches)

	Wasco 7E	USDA Cotton Station	Greenlee's Pasture	Avg. All Stations
January	1.42	1.68	1.22	1.44
February	1.47	4.32	1.67	2.49
March	3.34	3.99	3.93	3.75
April	5.03	5.9	5.41	5.45
May	6.02	7.26	6.38	6.55
June	8.28	9.57	8.64	8.83
July	10.42	9.77	9.42	9.87
August	9.88	8.98	9.89	9.58
September	7.14	7.09	6.77	7.00
October	4.29	4.78	4.62	4.56
November	2.18	2.15	3.03	2.45
December	1.32	1.39	1.33	1.35
Total	60.79	66.88	62.31	63.33
Percent of Normal	96	111	98	101

Station Locations

Wasco 7E	Section 6Q, T27S, R26E, 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. 1998 Percent of Normal Evaporation



Percent of Normal, Total:

Wasco 7E	95.7
Greenlee's Pasture	97.8
USDA Cotton Station	110.6

Wasco 7E

1998 observed monthly EP, Wasco 7E (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

1998 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

1998 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. 1998 Irrigated Acreage, San Joaquin Valley Portion of Kern County

Crop	Acres ⁽²⁾	Percent of Total	Consumptive Water Use ⁽¹⁾ (AF/Acre)
Alfalfa (including seed)	101,740	10.1	7.92
Almonds	101,779	10.1	5.58
Apples	4,646	0.5	5.31
Apricots	595	-	5.31
Asparagus	656	-	3.84
Avocado	54	-	3.81
Barley	2,672	0.3	1.59
Beans	5,817	0.6	4.06
Broccoli	384	-	0.57
Carrots	26,694	2.6	1.26
Citrus	46,762	4.6	5.03
Corn, Field & Sweet	28,003	2.8	5.70
Cotton	195,449	19.3	3.18
Dry Farmed Grains, Pasture	33,566	3.3	-
Figs	814	-	3.53
Grapes	100,949	10.0	3.90
Guayale, Jojoba	192	-	2.01
Idle, Fallow Lands	117,126	11.6	-
Kiwi	416	-	2.72
Lettuce	2,892	0.3	0.34
Melons, Squash, Cucumbers	7,179	0.7	1.69
Misc. Deciduous Trees	15,988	1.6	5.30
Misc. Field Crops	1,861	0.2	2.65
Misc. Hay/Grain	13,536	1.3	1.73
Misc. Subtropical Trees	360	-	6.34
Misc. Vegetables	3,407	0.3	5.20
Nursery	6,038	0.6	4.02
Oats	2,382	0.2	1.54
Olives	1,091	0.1	3.57
Onions, Garlic	15,802	1.6	3.50
Pasture, Turf	14,903	1.5	4.89
Peaches, Nectarines	5,918	0.6	5.27
Pears	72	-	3.72
Peas	116	-	1.48
Peppers	2,831	0.3	2.13
Pistachios	32,780	3.2	5.36
Plums, Prunes	2,753	0.3	5.36
Potatoes	28,744	2.8	3.64
Rice	-	-	-
Safflower	4,798	0.5	2.55
Sorghum/Milo	6,554	0.6	2.49
Sudan Grass	1,225	0.1	2.20
Sugar Beets	4,932	0.5	3.60
Tomatoes	5,854	0.6	2.63
Turnips	29	-	1.70
Walnuts	1,551	0.2	4.58
Wheat	60,247	6.0	2.21
Total Irrigated Lands	861,465	100.0	3.00
Total Harvested Lands	895,031		
Double Cropped	23,086		

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.

Table 20. 1998 Urban Water Use, San Joaquin Valley Portion of Kern County

Water Purveyor Service area	Metered Connections	Non-metered Connections	Annual Water Use		Permanent Population	GPCD ⁽¹⁾
			Million Gals.	Acre Feet		
Arvin						
Arvin CSD ⁽⁵⁾	2,247	-	597	1,832	11,249	145
Bakersfield Metro Area						
Airport Mutual WC	Unknown	Unknown	19	50	Unknown	-
California Water Service						
Bakersfield Division	18,660	36,390	20,560	63,092	186,290	302
Ashe Water Division	22,862	-	7,900	24,243	68,820	314
Casa Loma WC ⁽⁵⁾	-	215 ⁽⁵⁾	401 ⁽⁵⁾	1,231	2,000 ⁽⁵⁾	549 ⁽⁵⁾
East Niles CSD	6,476	-	3,900	11,968	24,097	443
Greenfield CWD	728	350	365	1,120	6,500	154
North of the River MWD	470	1,430	770	2,362	7,000	301
Oildale MWC	490	6,022	2,074	6,364	22,000	258
Rancho Verdugo WC	289	-	79	241	920	234
Stockdale MWC	-	80	24	254	200	325
Stockdale Annex MWC	-	140	52	159	300	476
Vaughn WC	4,937	828	2,294	7,039	16,200	388
Victory MWC ⁽⁵⁾	-	150	57	170	600	262
Metro Area Subtotal	54,912	45,605	38,495	118,293	334,927	320
Buttonwillow						
Buttonwillow CWD	-	463	154	473	1,500	281
Delano						
City of Delano	3,360	3,536	2,500	7,672	34,150	201
Lamont						
Lamont PUD and ID# 1	307	3,171	1,604	4,922	14,677	299
Lost Hills						
Lost Hills Utility District	273	20	98	302	720	374 ⁽²⁾
McFarland						
McFarland MWC	1,778	-	443	1,360	8,000	152
Rio Bravo						
Olcese WD	418	-	258	793	1,320	536 ⁽³⁾
Shafter						
City of Shafter	-	4,029	1,185	3,636	11,227	289
Taft-Maricopa-McKittrick						
West Kern WD	6,989	-	4,403	13,511	17,500	689 ⁽⁴⁾
Wasco						
City of Wasco	138	3,100	1,260	3,867	20,143	171
Wasco State Prison	-	-	270	829	5,949	124
Total	70,422	59,924	51,268	157,489	461,362	292 ⁽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) 1998 data not available; estimated using 1995 data.

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.

Over the entire San Joaquin Valley portion of Kern County, gross water uses were about 4,929,900 acre-feet during 1998 (2,985,600 for agriculture, 197,500 for M&I use, 70,000 of evaporation losses, 1,673,100 for groundwater recharge, and 3,700 in unrecoverable delivery system losses). Total consumption of water was about 2,665,900 acre-feet (2,526,800 by agriculture, 69,100 by M&I, and 70,000 in evaporation losses). Effective precipitation was about 575,200 acre-feet. Agricultural irrigation efficiency was about 65 percent. A total of 48,800 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 590,900 acre-feet. However, about 112,900 acre-feet of deep percolation was lost by saline sinks. Therefore, net groundwater returns were 429,200 acre-feet in 1998.

Of the 4,929,900 acre-feet in gross water demand during 1998, 4,817,000 acre-feet was beneficially used or was available for reuse via net deep percolation. This means that 98 percent of the water used in 1998 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 opened in 1998 to receive Friant-Kern flood flows entering the Kern River channel. During the wet, early part of the year some 57,822 acre-feet of Friant-Kern water flowed into the Aqueduct via the Intertie. Another 130,226 acre-feet of Kern River water flowed into the aqueduct. None of the water inflowing into the Intertie was retained in the county.

Through the end of 1998, a total cumulative flow of 1,370,860 acre-feet of water has passed through the Intertie gates into the California Aqueduct. About 38 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.

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 1,673,100 acre-feet of water was recharged in 1998, deliberately and incidentally. Following is the approximate breakdown between sources:

<u>Source</u>	<u>Acre-feet</u>
Kern River	556,000
SWP	147,400
CVP	59,400
Wastewater	3,600
Minor Streams	268,500
Combined	638,200
Total	1,673,100

These numbers should be considered as “best estimates,” since supplies are often inter-mixed 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.

Such recharge activities show the importance of reducing groundwater overdraft, as well as water conservation, in Kern County. Since 1970 about 17,615,300 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 17,615,300 acre-feet of recharged water results in a gross basin-wide groundwater pumping lift reduction of about 176 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 1,230

acre-feet per day. It expects the Water Bank to reach an ultimate storage capacity of nearly 1,000,000 acre-feet. In 1998, the Kern Water Bank recharged a total of 306,641 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 1998 a total of 38,649 acre-feet were recharged in the 2800 Acres.

In 1992 KCWA purchased 2,400 acres of land to develop additional water recharge and banking facilities. The "Pioneer Project" comprises two parcels on either side of the Kern River southwest of Bakersfield. The Pioneer Property has an annual groundwater recharge capacity by about 146,000 acre-feet. During 1998, 61,667 acre-feet were recharged on 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 398 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 1998 water within five feet of the ground surface was found under an area of about 27,100 acres. This was a 9 percent increase from the summer 1997 areal extent. The areal extent of shallow groundwater between 5-10 feet of the ground surface was about 157,500 acres, about 8 percent lower than 1997. The areal extent of shallow groundwater between 10-15 feet of the surface was 68,300 acres in 1998, a 16 percent increase over 1997. An examination of Table 25 shows that a large increase in shallow groundwater area commonly occurs in wet years, while constrictions 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 1998 (about 3,290,700 acre-feet), carried about 504,100 tons of new salts into the groundwater basin.

<u>Source</u>	<u>Surface Water Salt Loads, 1998</u>		
	<u>Volume</u> (af)	<u>Avg. TDS</u> (ppm)	<u>Salt Load</u> (tons)
SWP over gw basin	561,500	207	158,100
Kern River	1,665,300	76	172,100
Minor Streams	286,400	325	126,600
Other Local Supplies*	166,200	65	14,700
CVP	611,300	39	32,600
Total	3,290,700	113	504,100

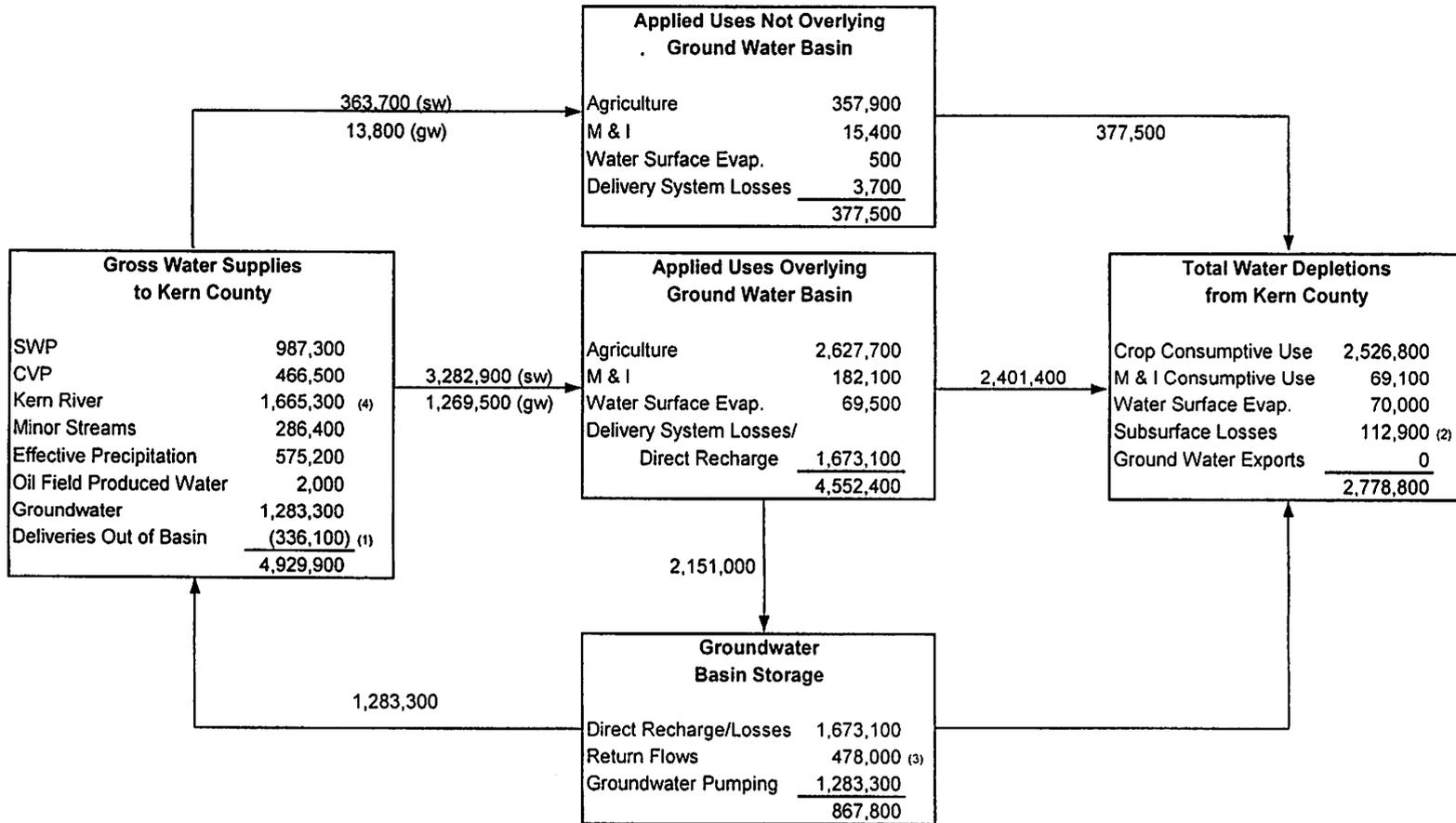
*includes effective rainfall, oil field produced water

Groundwater pumped and used for irrigation becomes degraded as salts are leached from the crop root zone. A portion of applied water (averaging about 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.

Figure 16. 1998 Water Resources Inventory, San Joaquin Valley Portion of Kern County (acre-feet)



3,646,600 (Surface Supplies) minus 2,778,800 (Consumptive Use) equals 867,800 (Addition to Storage)

Notes:

- ⁽¹⁾ Delivered to Tulare Lake Basin WSD (22,000 AF), Westlands WD (119,819 AF) and Tehachapi-Cummings WD (6,282 AF). Also includes 188,048 AF that flowed into the California Aqueduct/Kern River Intertie which ultimately was exported out of Kern County via the A.D. Edmunston Pumping Plant.
- ⁽²⁾ Includes 81,900 AF to saline sinks, and 31,000 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 145 AF delivered to Kern Valley Golf Course (Kernville).

(sw) Surface Water
(gw) Ground Water

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

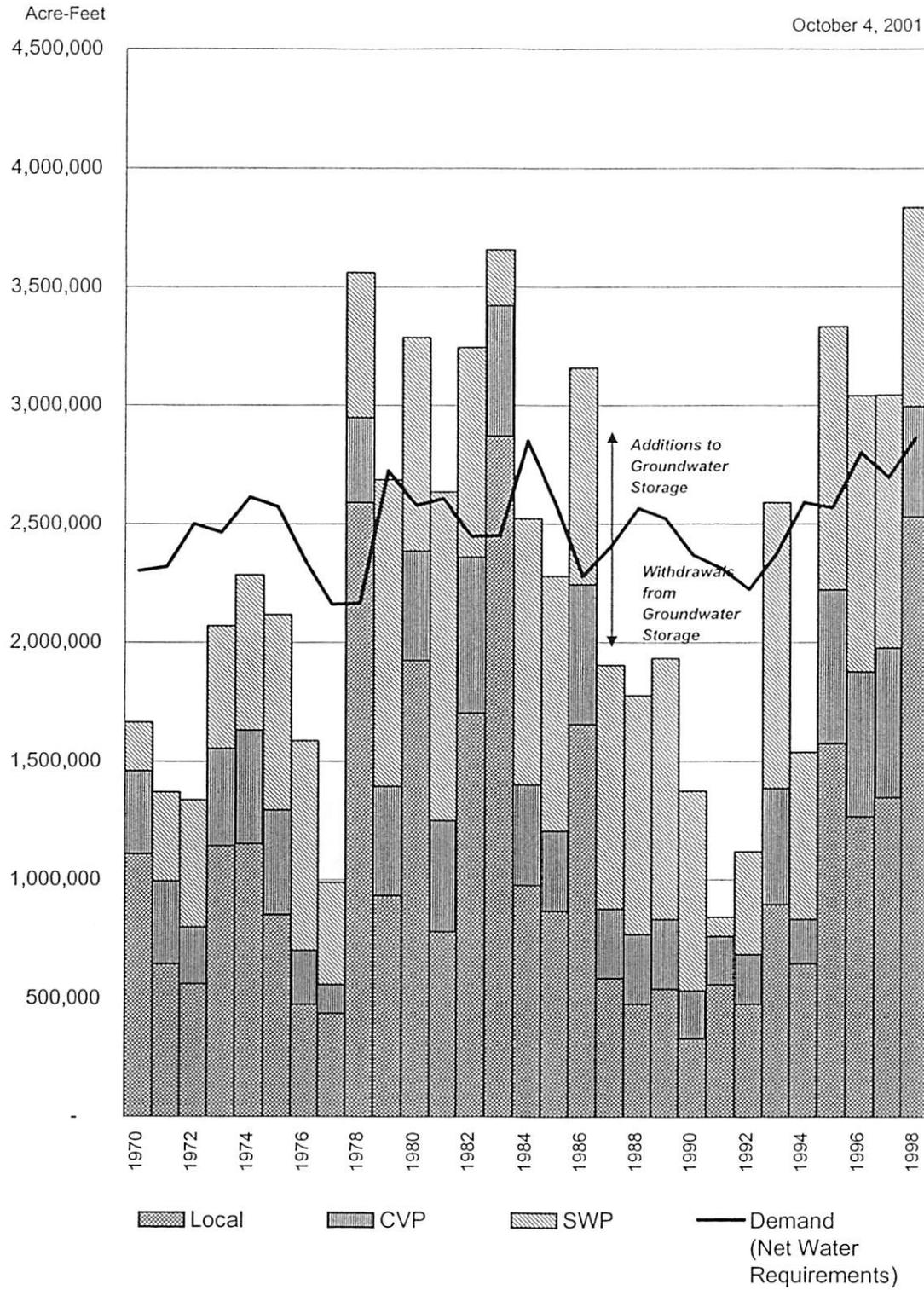
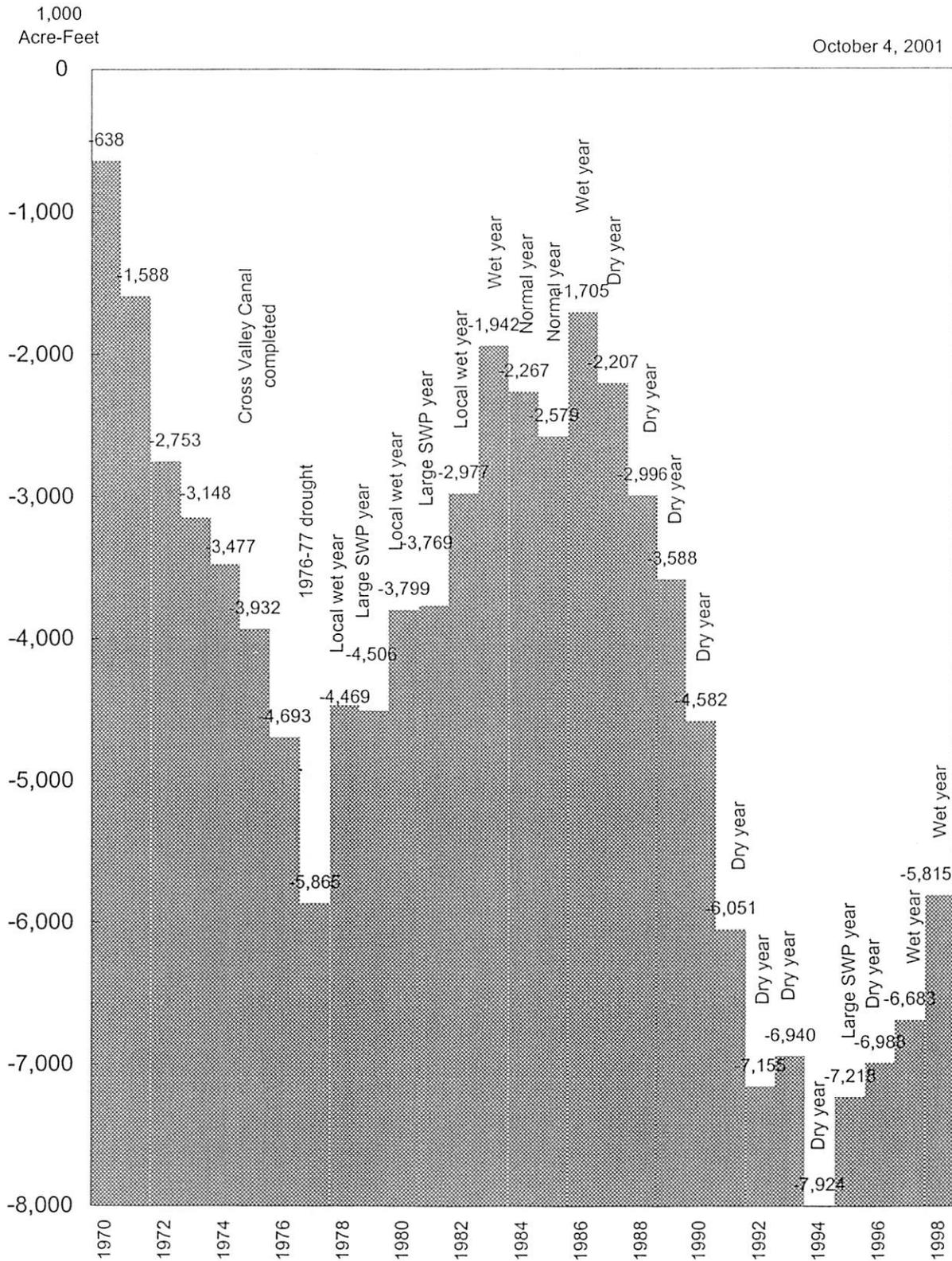


Figure 18. Cumulative Change in Groundwater Storage, San Joaquin Valley Portion of Kern County



October 4, 2001

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		Total Supplies
	Available	% of Total	Available	% of Total	Usage	% of Total	Usage	% of Total	Usage	% of Total	
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	21.5	194,200	5.1	425,400	11.1	1,123,000	29.4	1,252,200	32.8	3,816,600
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	12.0	240,100	7.6	292,000	9.3	1,025,900	32.6	1,208,700	38.5	3,142,600
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	122,100	3.5	293,900	8.4	1,097,200	31.4	1,588,500	45.4	3,498,700
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	374,300	7.9	647,100	13.6	1,111,200	23.3	1,242,800	26.1	4,760,600
1996	1,038,300	21.6	294,400	6.1	611,300	12.7	1,247,200	26.0	1,609,600	33.5	4,800,800
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
1998	1,718,000	33.2	863,600	16.7	466,500	9.0	839,200	16.2	1,290,200	24.9	5,177,500
Avg.	817,200	21.9	321,200	8.6	395,100	10.6	808,500	21.7	1,386,600	37.2	3,728,500

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

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	47,496	49,289	0	5,352	5,352 ⁽¹⁾
1998	130,226	57,822	188,048	130,226	57,822	188,048	0	0	0
Total	1,129,122	241,738	1,370,860 ⁽²⁾			846,002			526,651 ⁽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.

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

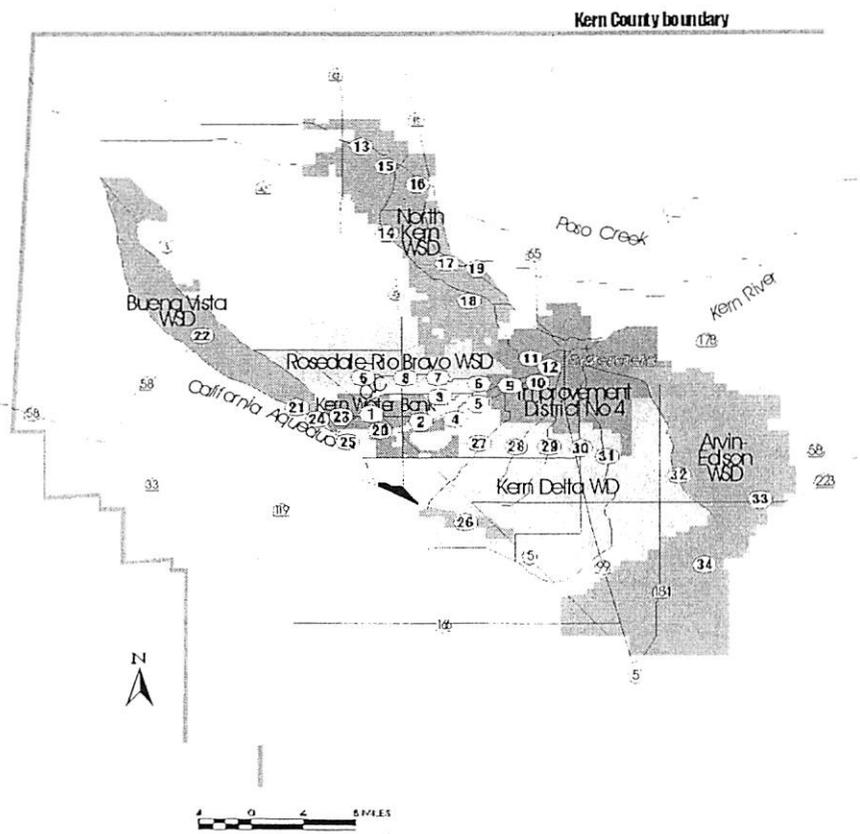
Entity/Location	Source	1971-93	1994	1995	1996	1997	1998	Total
BANKING								
City of Bakersfield ⁽¹⁾								
2,800 Acre Spreading Area	Combined ⁽¹⁾	622,704	--	39,117	21,994	31,500	38,649	753,964
Kern County Water Agency								
Kern Water Bank	Combined ⁽¹⁾	--	--	688	18,069	--	--	18,757
Pioneer Property	Combined ⁽¹⁾	--	--	102,693	52,367	13,235	61,667	229,962
Berrenda Mesa Spreading Area	Combined ⁽¹⁾	41,523	2,333	34,280	9,554	6,565	20,349	114,604 ⁽¹⁾
Kern River Channel	Combined ⁽¹⁾	60,046	--	2,029	6,179	5,883	458	74,595
2,800 Acre Spreading Area	Combined ⁽¹⁾	208,467	20,551	73,337	16,612	875	--	319,842
Subtotal KCWA		310,036	22,884	213,027	102,781	26,558	82,474	757,760
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	306,641	796,784
2800 Acres	Combined ⁽¹⁾	--	--	--	--	--	--	--
Pioneer Property	Combined ⁽¹⁾	--	--	--	--	--	--	--
Subtotal KWBA		--	--	230,938	143,615	115,590	306,641	796,784
Total Banking		1,080,619	22,884	483,082	268,390	173,648	427,764	2,456,387
CONJUNCTIVE USE								
Arvin-Edison WSD	F-K	843,699	3,884	108,664	51,954	73,151	49,000	1,130,352
Buena Vista WSD Direct Rechg.	Combined (1)	1,424,765	47,161	128,203	81,156	52,831	89,321	1,823,437
Semitropic WSD Direct Rechg.	SWP	78,536	8,960	20,881	23,560	21,997	103,596	257,530
In-Lieu Rechg.	SWP	670,230	34,638	73,954	114,135	110,995	13,736	1,017,688
	Combined ⁽¹⁾	7,289	--	--	--	--	69,040	76,329 ⁽¹⁾
I.D. No. 4 Direct Rechg.	Kern	455,731	15,250	30,692	64,753	60,224	26,345	652,995
	SWP	306,389	14,030	19,523	138	--	--	340,080
	F-K	26,919	193	7,098	9,754	2,629	2,547	49,140
Kern Delta WD Direct Rechg.	Combined ⁽¹⁾	1,195,936	47,675	61,252	65,301	69,016	52,034	1,491,214
North Kern WSD Direct Rechg.	Kern	1,510,164	30,255	242,263	121,233	137,340	264,694	2,305,949
In-Lieu Rechg.	Kern	2,419,634	86,402	124,873	140,781	135,657	95,135	3,002,482
Rosedale-Rio Bravo WSD Direct Rechg.	Kern	545,911	--	102,307	44,293	72,875	104,879	870,265
	SWP	578,561	6,119	48,375	29,545	17,080	26,923	706,603
	F-K	168,728	--	8,470	25,919	31,843	4,660	239,620
	Combined ⁽¹⁾	279,800	--	--	--	--	--	279,800 ⁽¹⁾
In-Lieu Rechg.	SWP	--	2,657	--	--	--	--	2,657
Wheeler Ridge-Maricopa WSD								
In-Lieu Recharge	SWP	200,596	--	12,650	--	--	--	213,246
Total Conjunctive Use		10,712,888	297,224	989,205	772,522	785,638	901,910	14,459,387
OVERDRAFT CORRECTION								
Groundwater Replenishment Programs								
Direct Rechg.	Kern	188,185	--	--	5,365	10,084	58,321	261,955
	SWP	258,441	--	--	38,795	1,912	3,129	302,277
	F-K	7,723	--	--	4,396	6,969	3,144	22,232
In Lieu Rechg.	Kern	573	--	3,725	3,189	889	6,631	15,007
	SWP	98,065	--	--	--	--	--	98,065
Total Overdraft Correction		552,987	--	3,725	51,745	19,854	71,225	699,536
GRAND TOTALS								
	Kern	5,120,198	131,907	503,860	379,614	417,069	556,005	7,108,653
	SWP	2,338,697	66,404	175,383	206,173	151,984	147,384	3,086,025
	F-K	1,047,069	4,077	124,232	92,023	114,592	59,351	1,441,344
	Combined ⁽¹⁾	3,840,530	117,720	672,537	414,847	295,495	638,159	5,979,288 ⁽¹⁾
Total		12,346,494	320,108	1,476,012	1,092,657	979,140	1,400,899	17,615,310

⁽¹⁾ Breakdown between sources not available.

⁽²⁾ Includes banking by Ocese WD, Hacienda WD, Buena Vista WSD, City of Bakersfield; for breakdown between districts see Tables 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 19. Groundwater Recharge Sites, 1998 Summary, Southern San Joaquin Valley Portion of Kern County



Location	Recharge (AF)	Location	Recharge (AF)
1 Kern Water Bank	306,600	20 Kern River Bypass/Channel	26,000
2 COB 2800 Ac	38,600	21 Kern River Flood Channel	16,700
3 Pioneer North and South	62,000	22 Buttonwillow Canals	35,700
4 Pioneer South		23 Main Canal	0
5 Berrenda Mesa Spreading	20,300	24 Outlet Elk Pen	36,700
		25 Outlet Canal	24,100
6 Rosedale-Rio Bravo WSD		26 Maples Canal	1,000
7 Goose Lake Slough		Buena Vista WSD Total	140,200
8 KFE/RRB			
RRBWSO Total	136,500	27 Buena Vista Canal	
		28 Stine Canal	
9 Kern River	90,700	29 Farmers Canal	
10 Truxton Lakes	6,400	30 Kern Island Canal	
11 Calloway Canal and One Ditch	22,900	31 Central Branch Canal	
12 Coross Valley Canal Extension	3,200	32 Eastside Canal	
		Kern Delta WD Total	52,000
13 Poso Creek			
14 Calloway Canal and One Ditch		33 Sycamore Spreading Grounds	
15 Poso 27		34 Tejon Spreading Grounds	
16 Switch Field		Arvin-Edison WSD Total	138,300
17 Minter Field			
18 Rosedale Ponds		Grand Total	1,282,400
19 Lerdo Canal			
North Kern WSD Total	264,700		

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	1998	Total
Alameda County WD										
Recharge/Purchase							5,580	10,000	9,750	25,330
Recovery/Sale										
Storage Balance							5,580	10,000	9,750	25,330
Belridge WSD										
Recharge/Purchase				14,204	325	15,642	3,942	2,196	13,204	49,513
Recovery/Sale					(2,029)					(2,029)
Storage Balance				14,204	12,500	28,142	18,146	14,696	41,346	47,484
Buena Vista WSD										
Recharge/Purchase				7,849		27,535	20,000	215	15,875	121,908
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	33,704	76,899	97,114
Berrenda Mesa WD										
Recharge/Purchase		4,002		7,936	6,568	59,819	4,686	7,125	29,065	128,701
Recovery/Sale	(9,500)	(4,002)			(400)					(13,902)
Storage Balance				7,936	14,104	73,923	12,622	21,229	102,988	114,799
Cawelo WD										
Recharge/Purchase				14,068		3,245	2,000			19,313
Recovery/Sale					(44)					(44)
Storage Balance				14,068	14,024	17,269	16,068	14,024	17,269	19,269
City of Bakersfield										
Recharge/Purchase				32		13,089	300	16,635	52,606	495,191
Recovery/Sale	(23,318)	(57,159)	(30,266)		(8,311)	(1,297)	(1,781)	(618)	(30,269)	(278,662)
Storage Balance	263,568	206,409	176,143	176,175	167,864	179,656	174,694	183,881	201,993	216,529
Dudley Ridge WD										
Recharge/Purchase						1,587	20,748	10,246	22,721	55,302
Recovery/Sale										
Storage Balance						1,587	20,748	10,246	24,308	55,302
Henry Miller WD										
Recharge/Purchase						3,999	5,223	664	1,885	11,771
Recovery/Sale										
Storage Balance						3,999	5,223	664	5,884	11,771
Improvement District No. 4										
Recharge/Purchase				23,007	10,641	92,765	71,851	6,720	39,373	260,623
Recovery/Sale			(3,500)		(100)	(1,500)				(5,100)
Storage Balance	16,266	16,266	12,766	35,773	46,314	137,579	107,624	53,034	176,952	255,523
Kern County Water Agency										
Recharge/Purchase		42,096	6,450	5,542		28,999	45,069		6,690	257,225
Recovery/Sale		(66,775)	(22,684)							(105,564)
Storage Balance	106,274	81,595	65,361	70,903	70,903	99,902	115,972	70,903	106,592	151,661
Kern Delta WD										
Recharge/Purchase									647	647
Recovery/Sale										
Storage Balance									647	647
Lost Hills WD										
Recharge/Purchase		2,035		31,153	5,280	26,191	8,079	10,898	18,633	102,269
Recovery/Sale										
Storage Balance		2,035	2,035	33,188	38,468	64,659	41,267	49,366	83,292	102,269
Metropolitan WD of So. Calif.										
Recharge/Purchase				50,000		45,000	85,499	156,220	39,500	376,219
Recovery/Sale										
Storage Balance				50,000	50,000	95,000	135,499	206,220	134,500	376,219
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	55,534	62,080	58,708	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	2,288	6,355	10,720

Table 24 (continued). Groundwater Banking Summary

	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Semitropic WSD										
Recharge/Purchase				19,972		1,100	29,945	35,310	16,458	102,785
Recovery/Sale					(181)					(181)
Storage Balance				19,972	19,791	20,891	49,917	55,101	37,349	102,604
Santa Clara County FC&WD										
Recharge/Purchase							40,500	35,000	23,800	99,300
Recovery/Sale										
Storage Balance							40,500	35,000	23,800	99,300
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	141,772	170,877	170,125	128,562
Tejon-Castac W/D										
Recharge/Purchase					70	2,324	6,211	1,675	5,795	16,075
Recovery/Sale										
Storage Balance					70	2,394	6,211	1,745	8,189	16,075
Westside Mutual Water Co.										
Recharge/Purchase						134,517	65,321	51,183	150,920	401,941
Recovery/Sale							(5,000)			(5,000)
Storage Balance						134,517	60,321	51,183	285,437	396,941
Wheeler Ridge-Maricopa WSD										
Recharge/Purchase				58,290		61,387	27,807	14,232	83,634	265,969
Recovery/Sale					(7,551)					(7,551)
Storage Balance	20,619	20,619	20,619	78,909	71,358	132,745	106,716	85,590	216,379	258,418
Total of All Accounts										
Recharge/Purchase	248,005	70,229	12,900	232,053	22,884	529,582	458,797	370,007	530,556	3,274,537
Recovery/Sale	(139,365)	(155,842)	(138,953)		(32,234)	(3,549)	(60,609)	(618)	(30,269)	(718,198)
Storage Balance	751,405	665,792	539,739	771,792	762,442	1,288,475	1,169,980	1,131,831	1,788,762	2,556,339

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

Year	Summer Measurements					No. of Piezo's	Winter Measurements				
	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.		0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.
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 ⁽²⁾	136,760
1978	27,680	65,760	--	87,920 ⁽¹⁾	181,360	174	9,600	59,520	--	86,400 ⁽²⁾	155,520
1979	30,270	67,310	--	95,870 ⁽¹⁾	193,450	--	15,320	83,200	--	80,640 ⁽²⁾	179,160
1980	74,357	82,787	--	125,883 ⁽¹⁾	283,027	--	45,882	92,998	126,665	62,578	328,123
1981	62,002	85,556	--	128,323 ⁽¹⁾	275,881	178	46,746	75,318	36,736	104,200	263,000
1982	78,725	95,615	76,271	30,226	280,837	259	90,658	85,541	55,392	43,181	274,772
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 ⁽³⁾	350	--	--	--	--	--
1991	40,363	101,888	45,141	-- ⁽²⁾	187,392 ⁽³⁾	351	--	--	--	--	--
1992	9,954	102,114	46,287	-- ⁽²⁾	158,355 ⁽³⁾	344	--	--	--	--	--
1993	25,184	97,357	46,893	-- ⁽²⁾	169,434 ⁽³⁾	518	--	--	--	--	--
1994	19,176	106,506	69,362	-- ⁽²⁾	195,044 ⁽³⁾	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 ⁽⁴⁾	--	--	--	--	--
1998	27,117	157,484	68,300	65,176	318,077	398	--	--	--	--	--

⁽¹⁾ 10-20 ft. measurement.

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

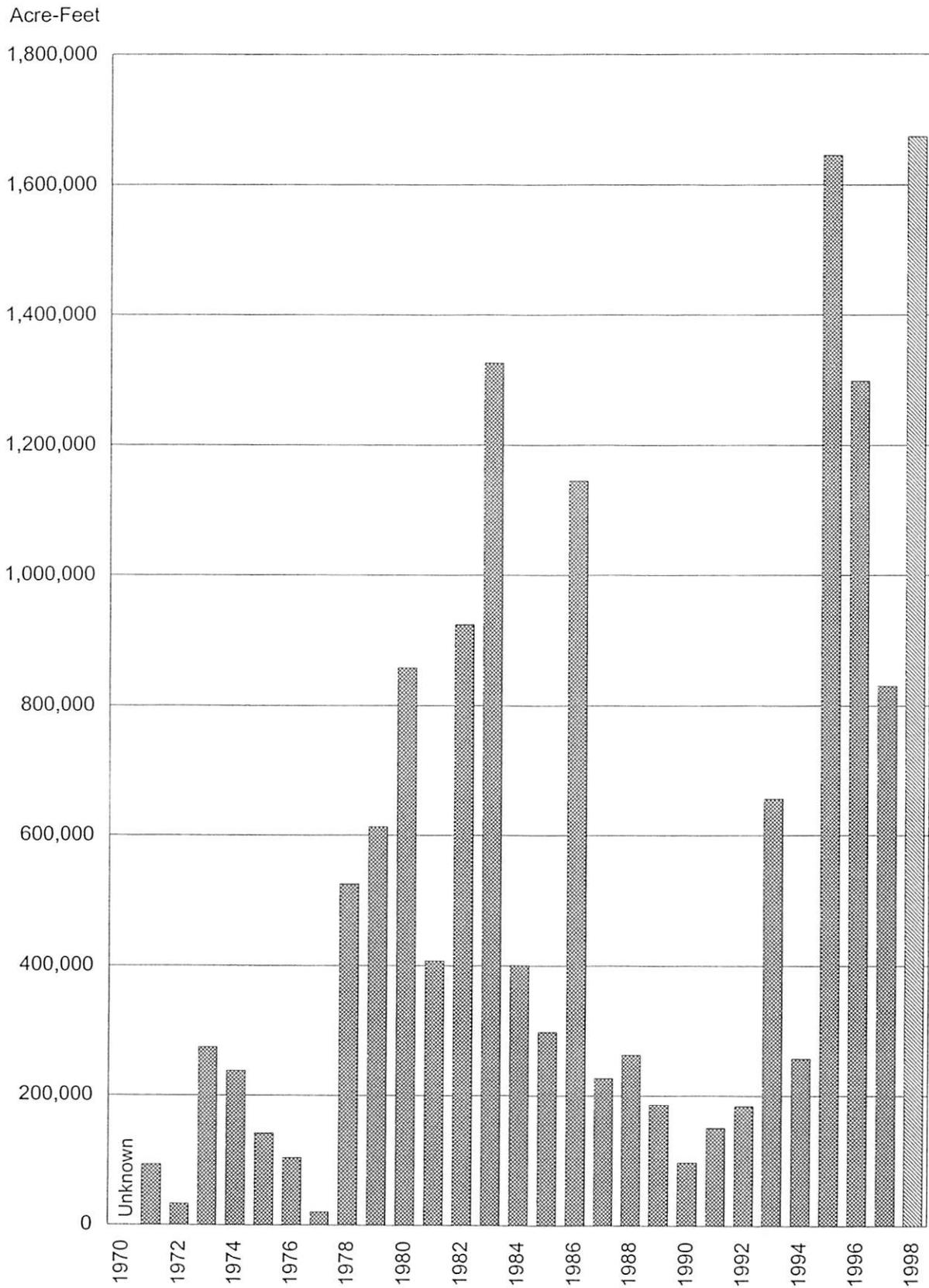
⁽³⁾ No 15 foot contour established. Total is within 20 feet.

⁽⁴⁾ Some cooperators did not report shallow groundwater data in 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 20. Groundwater Recharge, San Joaquin Valley Portion of Kern County



Agricultural water well drilling decreased slightly during 1998 compared to activity in 1997. The Kern County Environmental Health Services Department issued 28 agricultural water well permits in 1998, in comparison to 26 permits issued during 1997. The decrease in drilling activity was due to the fact that two wet years in a row made plenty of surface water available. An additional 107 domestic wells were permitted and drilled during 1998, along with 38 wells for non-agricultural and non-domestic purposes (e.g., monitoring and cathodic protection wells). A total of 135 new agricultural and domestic water wells were drilled during 1998. Annular seals were required on two of the new wells to prevent degradation of lower 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 movement of water between two aquifer systems).

Groundwater Levels

Plate 4, "Depth to Groundwater, Spring 1998," was prepared using over 1,400 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 Water Storage District and neighboring Buena Vista Water Storage District. 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 1998 to spring 1999. 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 1998 to 1999 change map shows four very small areas 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 to 50 feet above the 1998 depth to groundwater of less than 100 feet. Areas of the central and eastern portions of the valley which normally show declines in water levels or static conditions (no change), experienced rises of 10 to 50 feet.

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 Water Storage District, 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 wells are 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 1993-98 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 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 two or more aquifers may 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 over 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, 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 acre-feet per year, as follows:

	<u>Acre-feet</u>
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 feet 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

Figure 21a. Water Well Hydrograph Pond-Poso Area

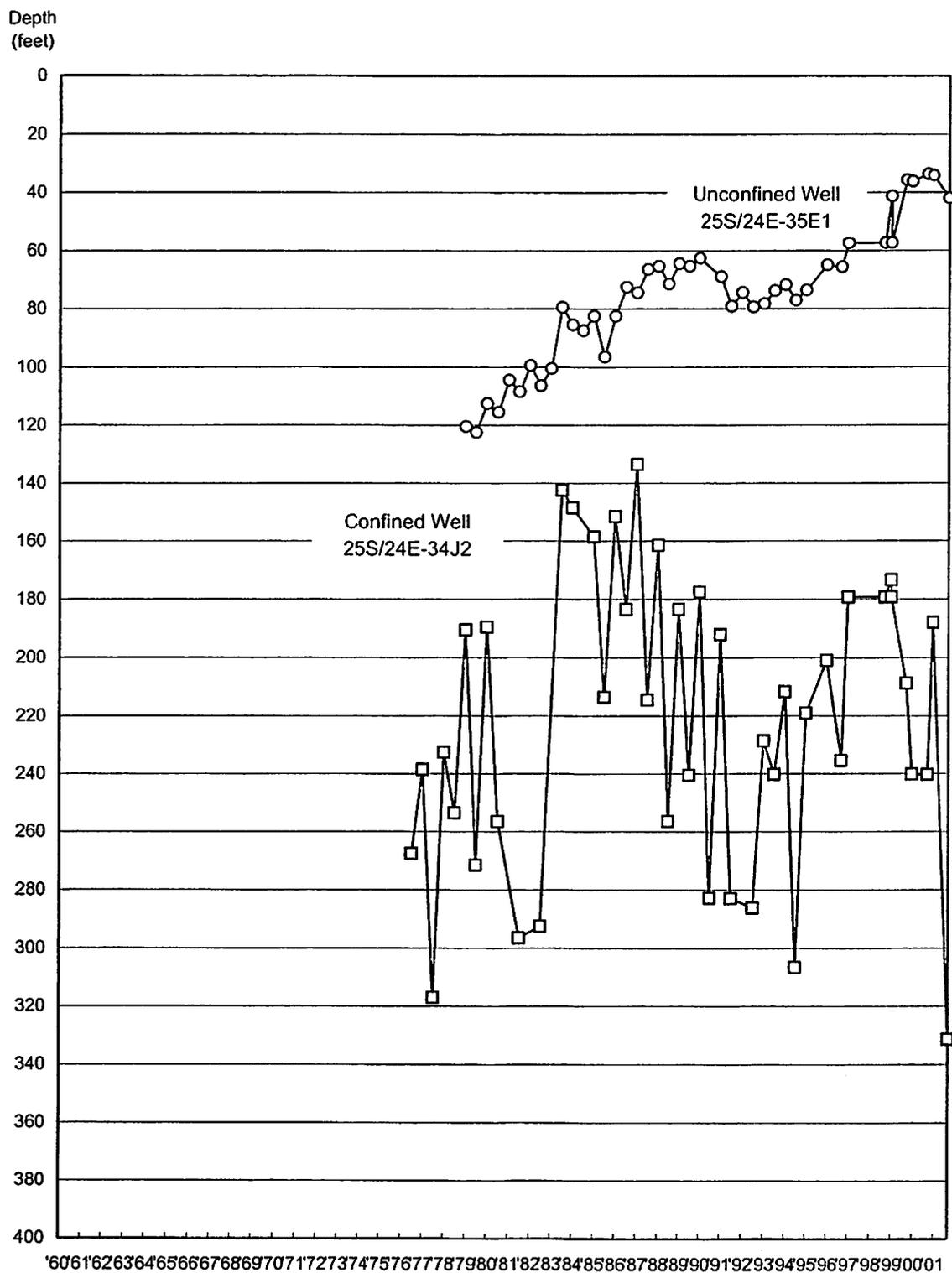


Figure 21b. Water Well Hydrograph Shafter/Rosedale-Rio Bravo Area

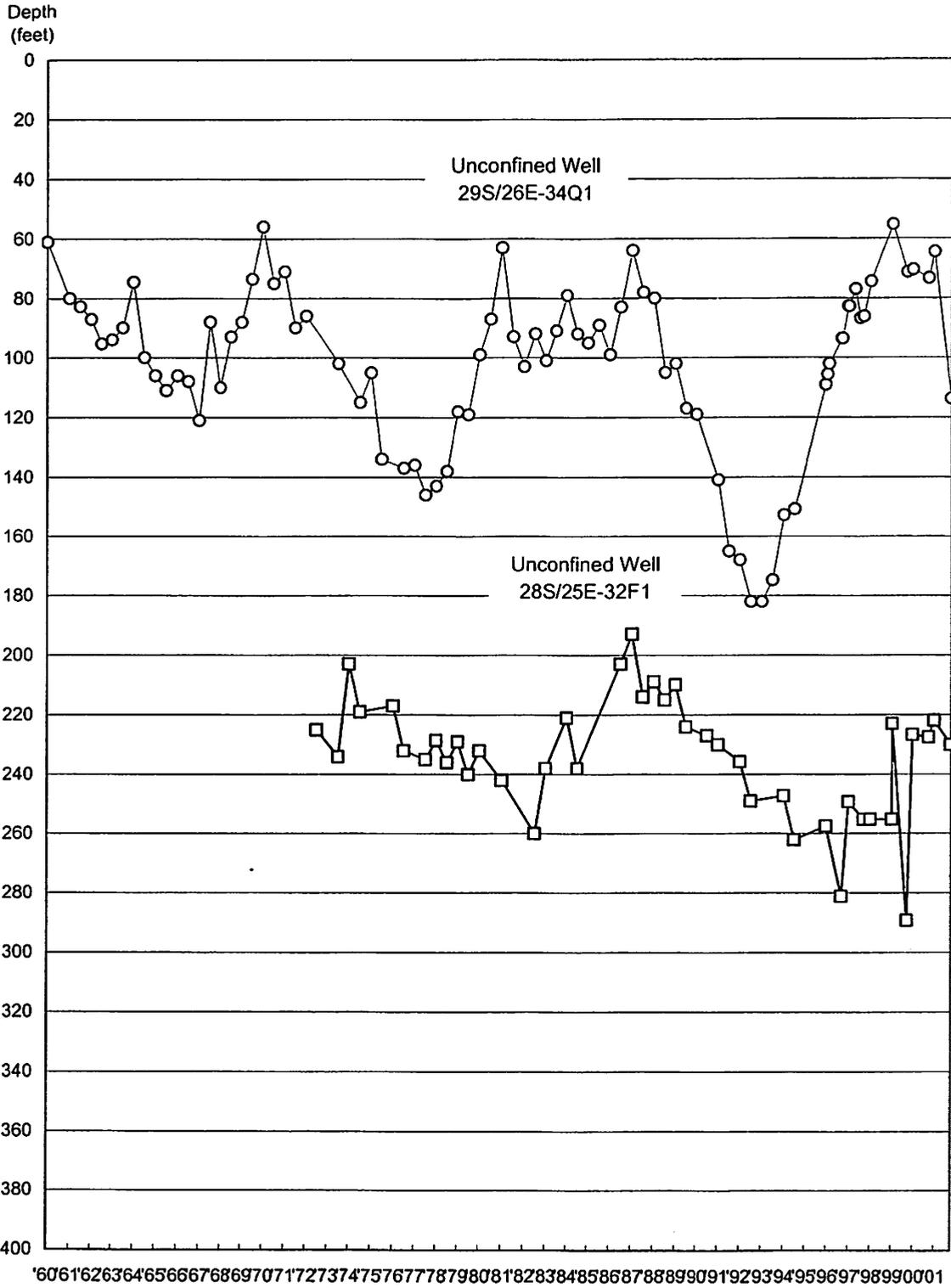


Figure 21c. Water Well Hydrograph Southwest Bakersfield Area

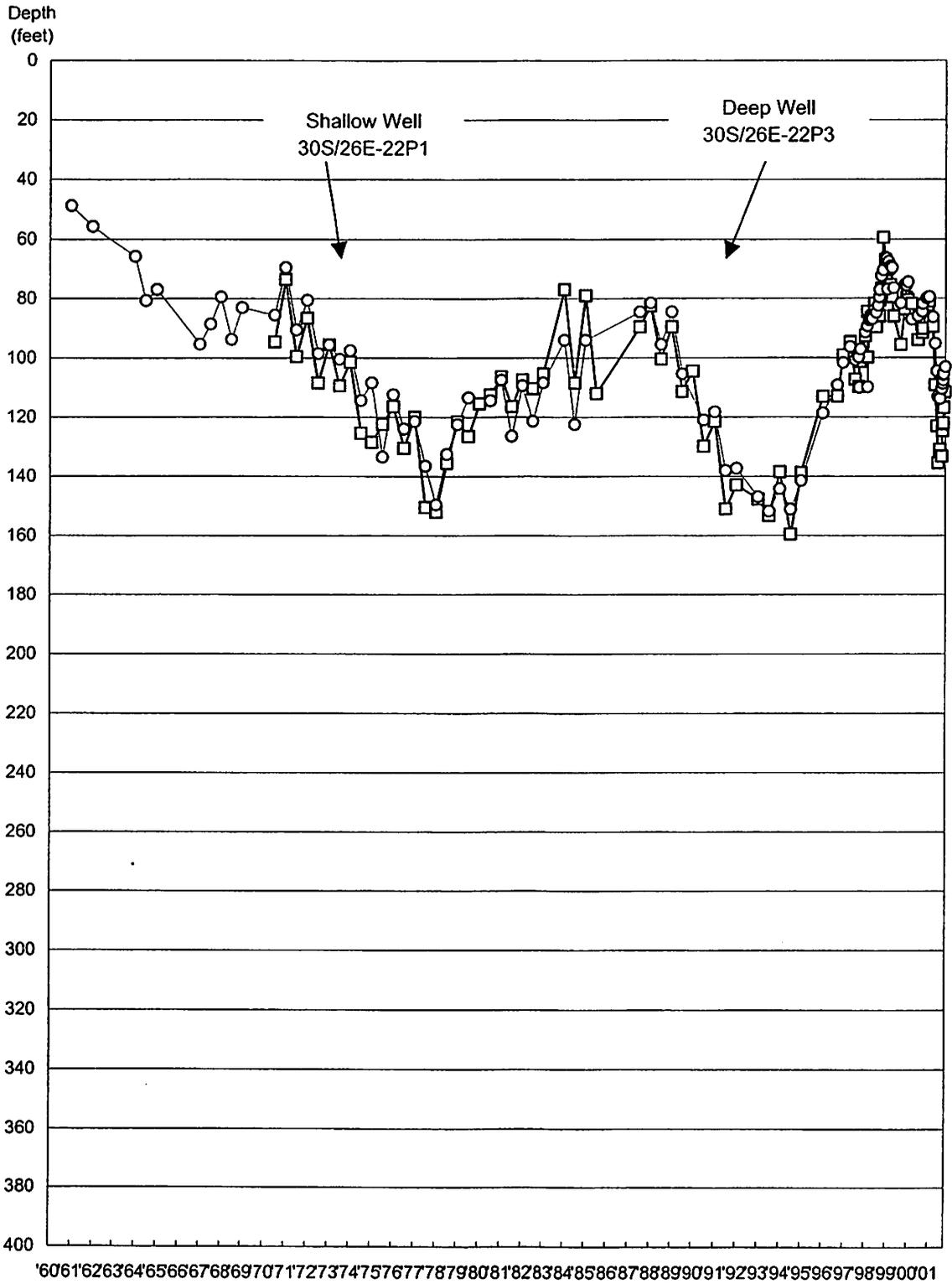


Figure 21d. Water Well Hydrograph Arvin-Edison Area

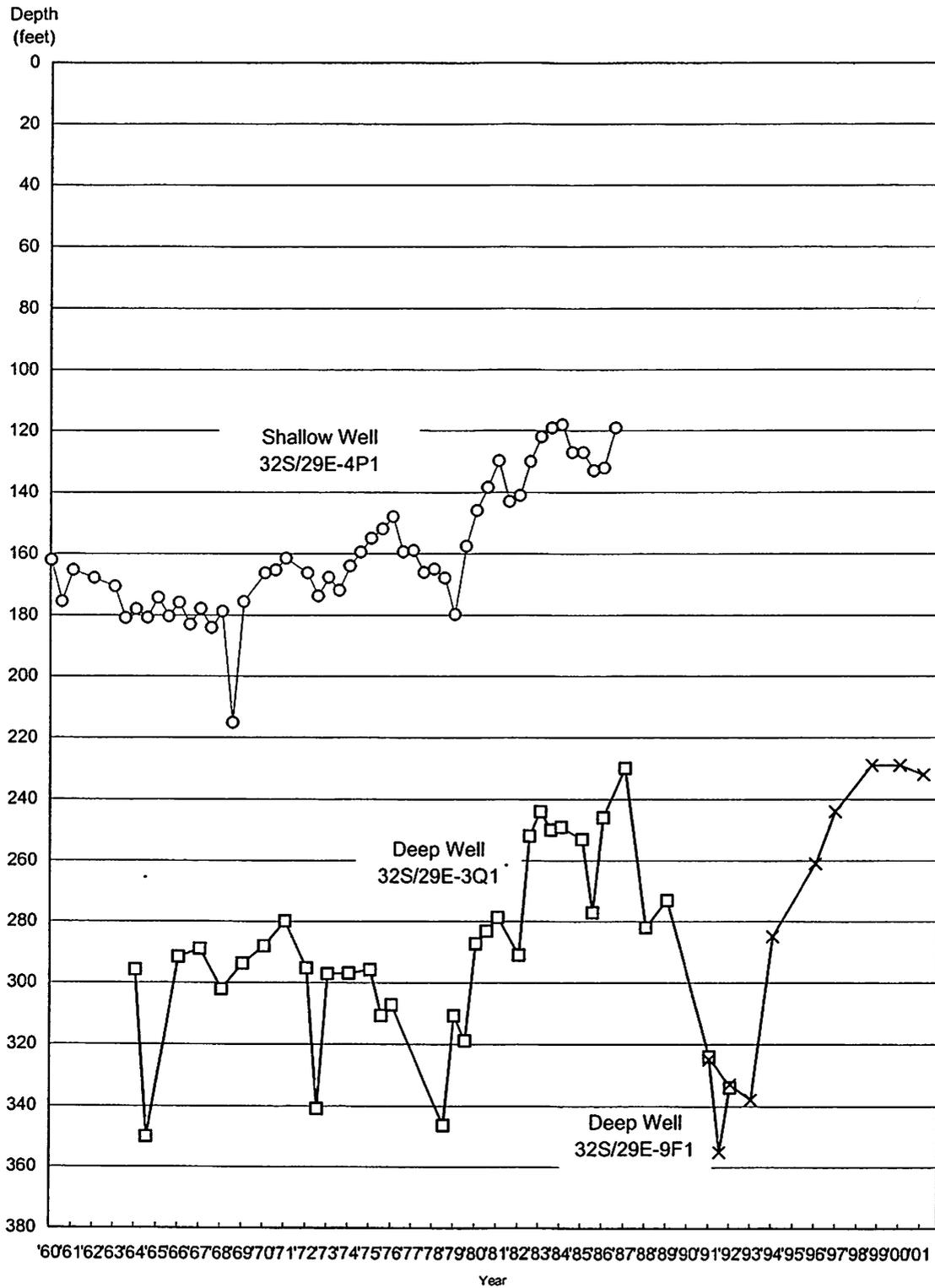


Figure 21d. Water Well Hydrograph Indian Wells Valley

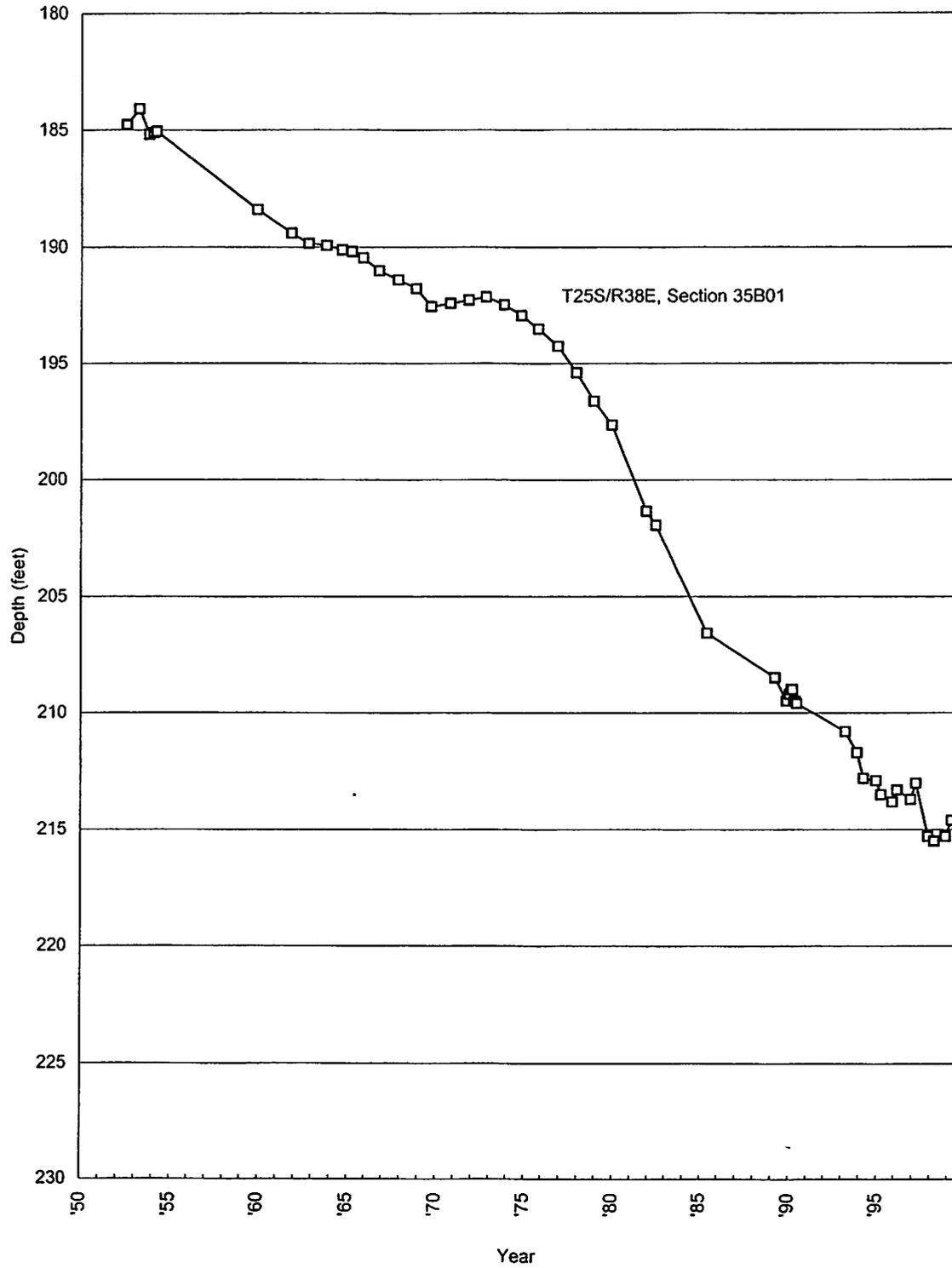


Figure 21f . Water Well Hydrograph Indian Wells Valley

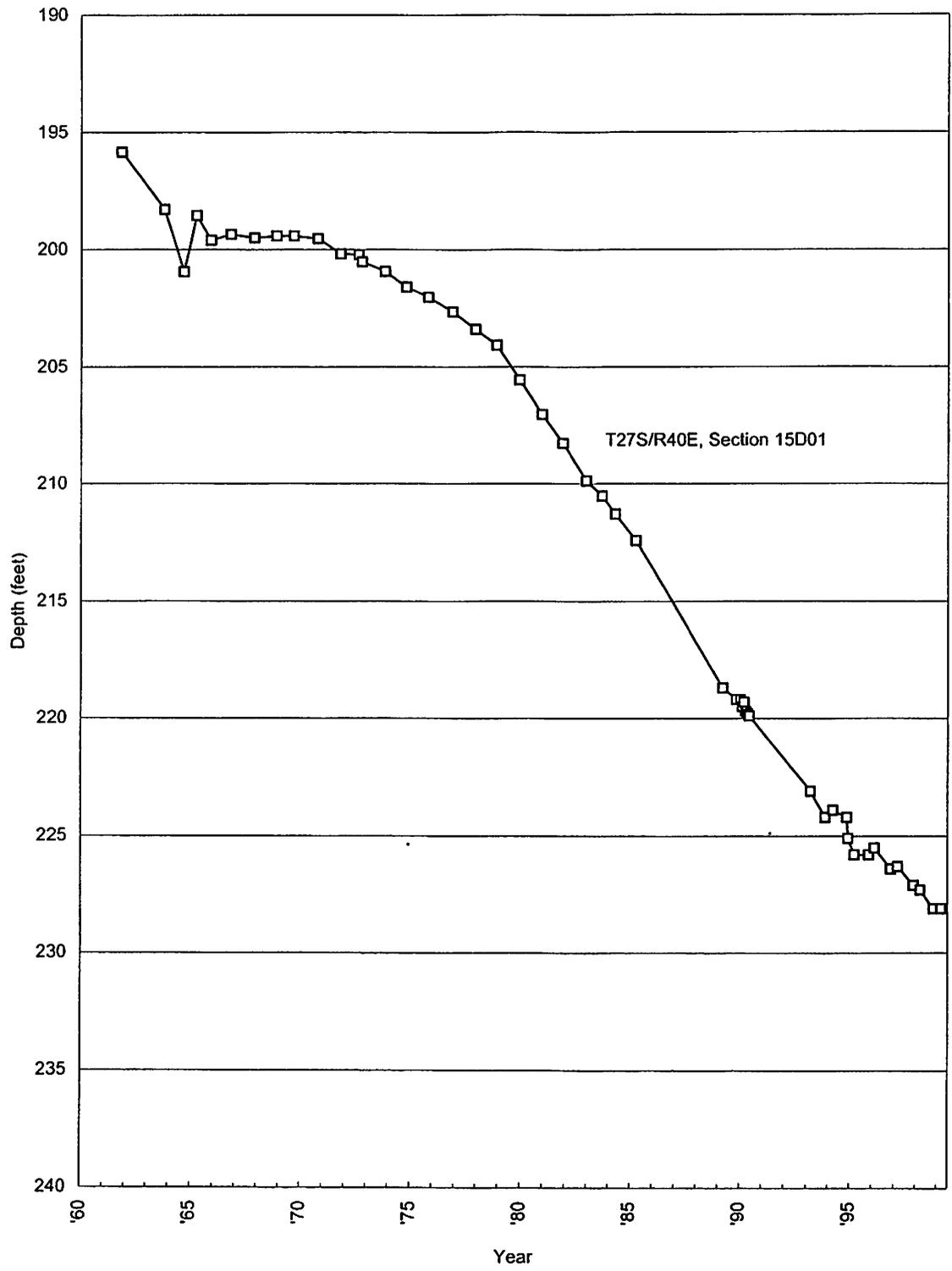
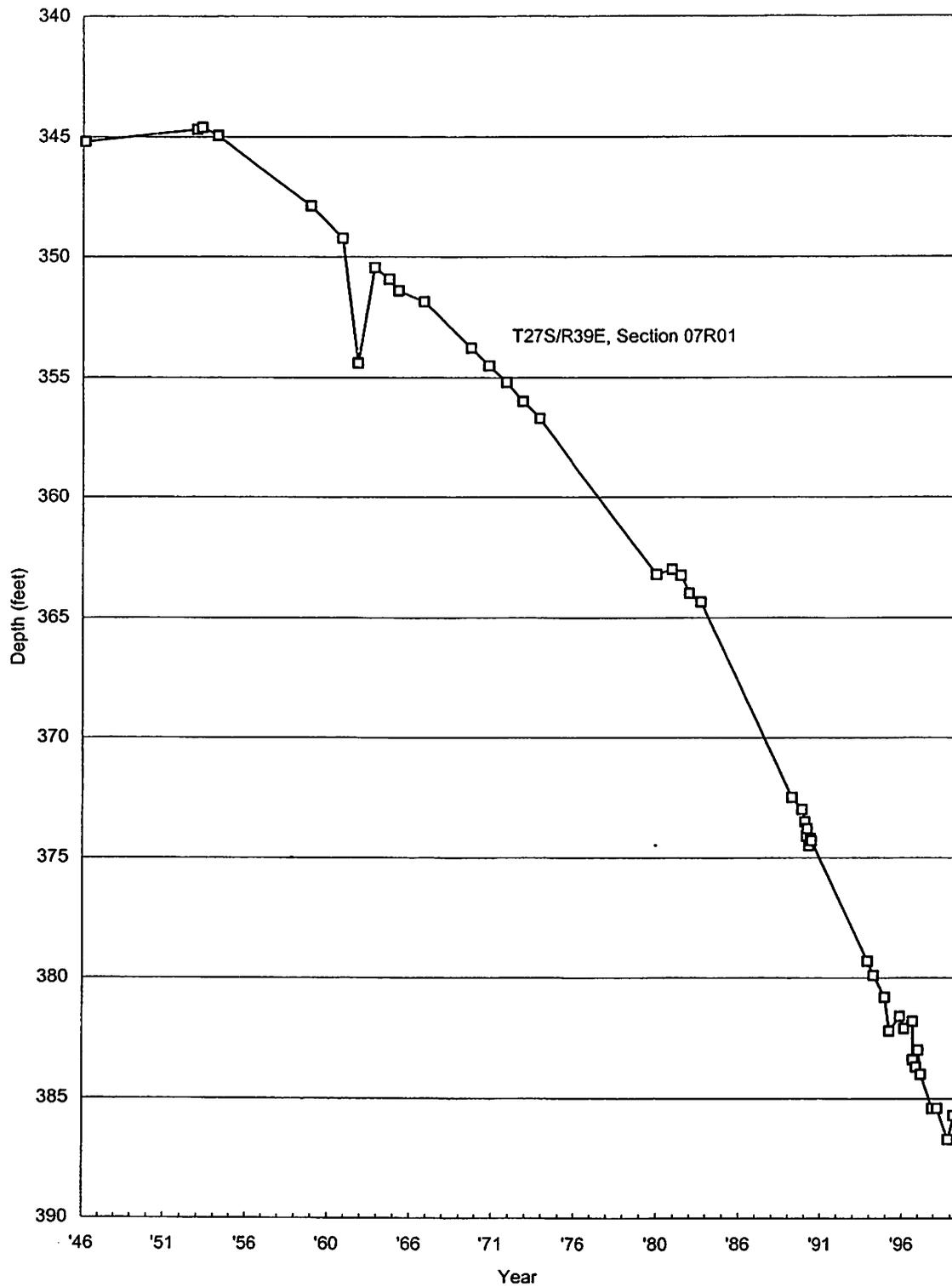


Figure 21g. Water Well Hydrograph Indian Wells Valley



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 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.

Outlook: 1999

1998 was a year that will forever be remembered as being one of incredible precipitation throughout not only California, but in many parts of the world. The year presented many challenges for water managers as well as water policy experts. But as is common after an El Niño weather year, a La Niña effect frequently follows and 1999 appeared to be following suit. Late in 1998 weather forecasters were predicting that the upcoming La Niña would bring minimal rainfall, drying out the state, and ushering in a cold winter. Water suppliers geared up for what proposed to be a water-short year in 1999.

SEVEN COUNTY WATER AGENCY
Gaberrieta, California

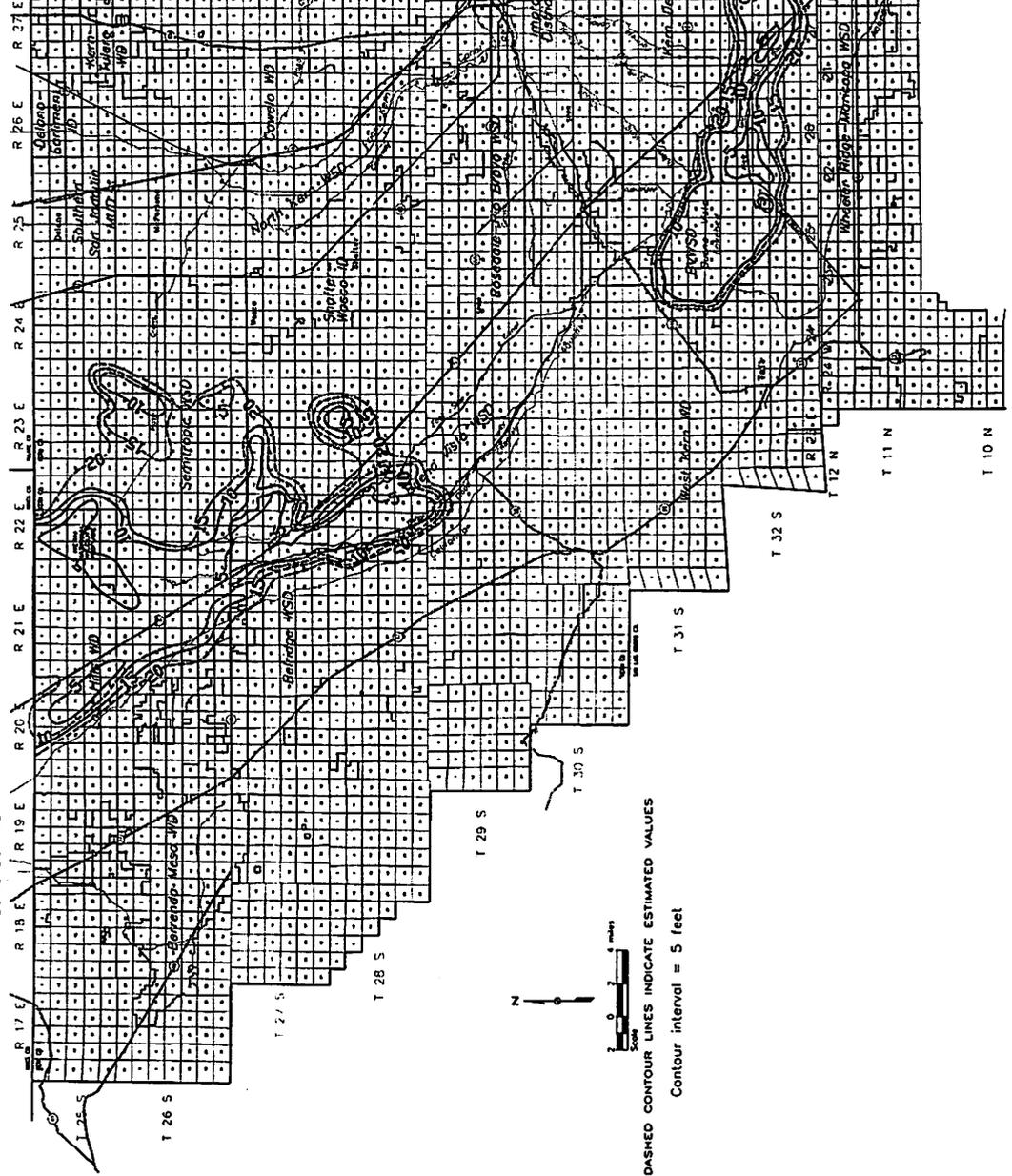
DEPTH TO SHALLOW GROUNDWATER

JULY 1998

T. MASTERDOPE
FEBRUARY 2002

Reg Gulch WD

Devils Den WD

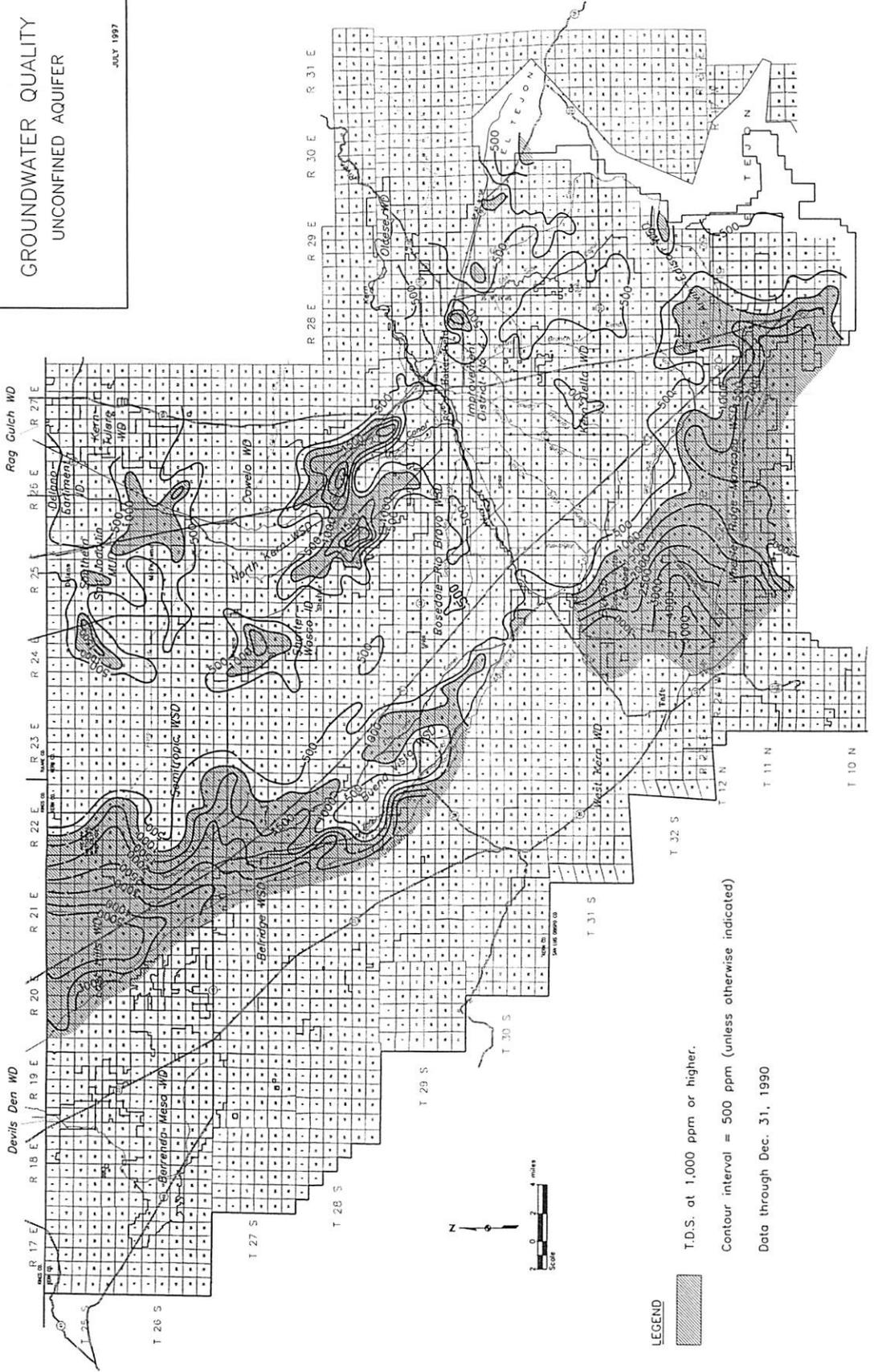


DASHED CONTOUR LINES INDICATE ESTIMATED VALUES
Contour interval = 5 feet

HERN COUNTY WATER AGENCY
Bakersfield, California

GROUNDWATER QUALITY UNCONFINED AQUIFER

JULY 1997



LEGEND



T.D.S. at 1,000 ppm or higher.

Contour interval = 500 ppm (unless otherwise indicated)

Data through Dec. 31, 1990

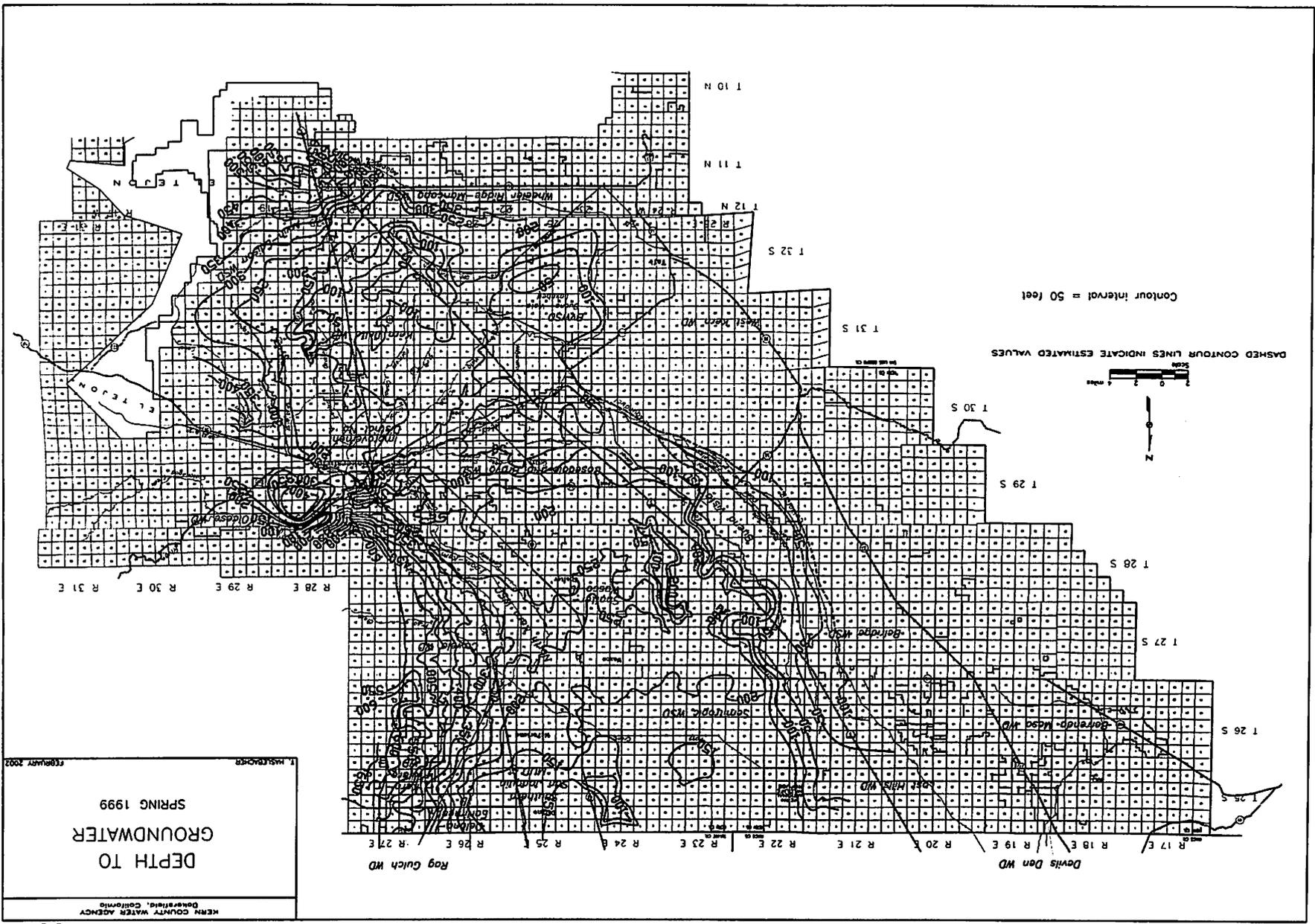
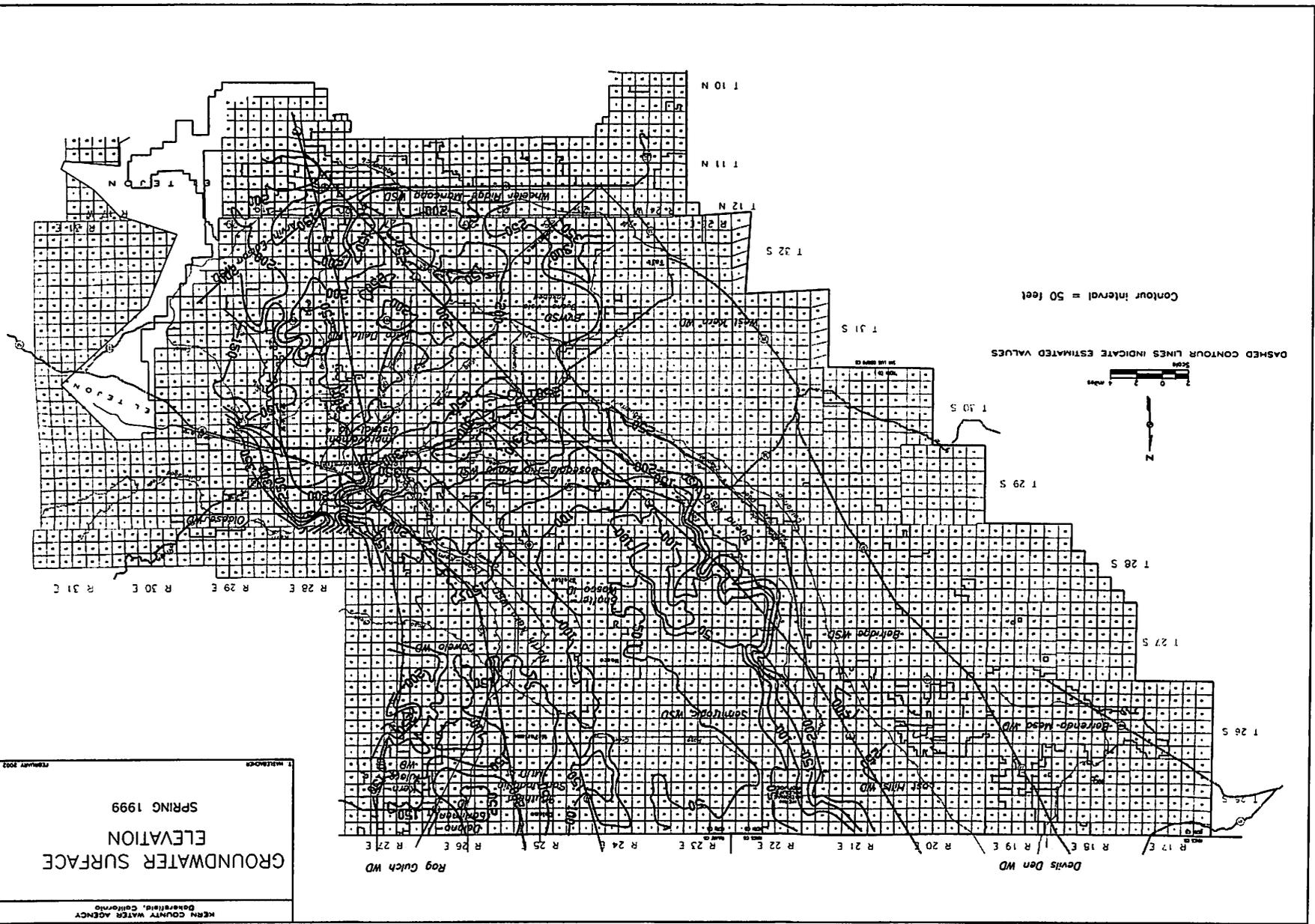
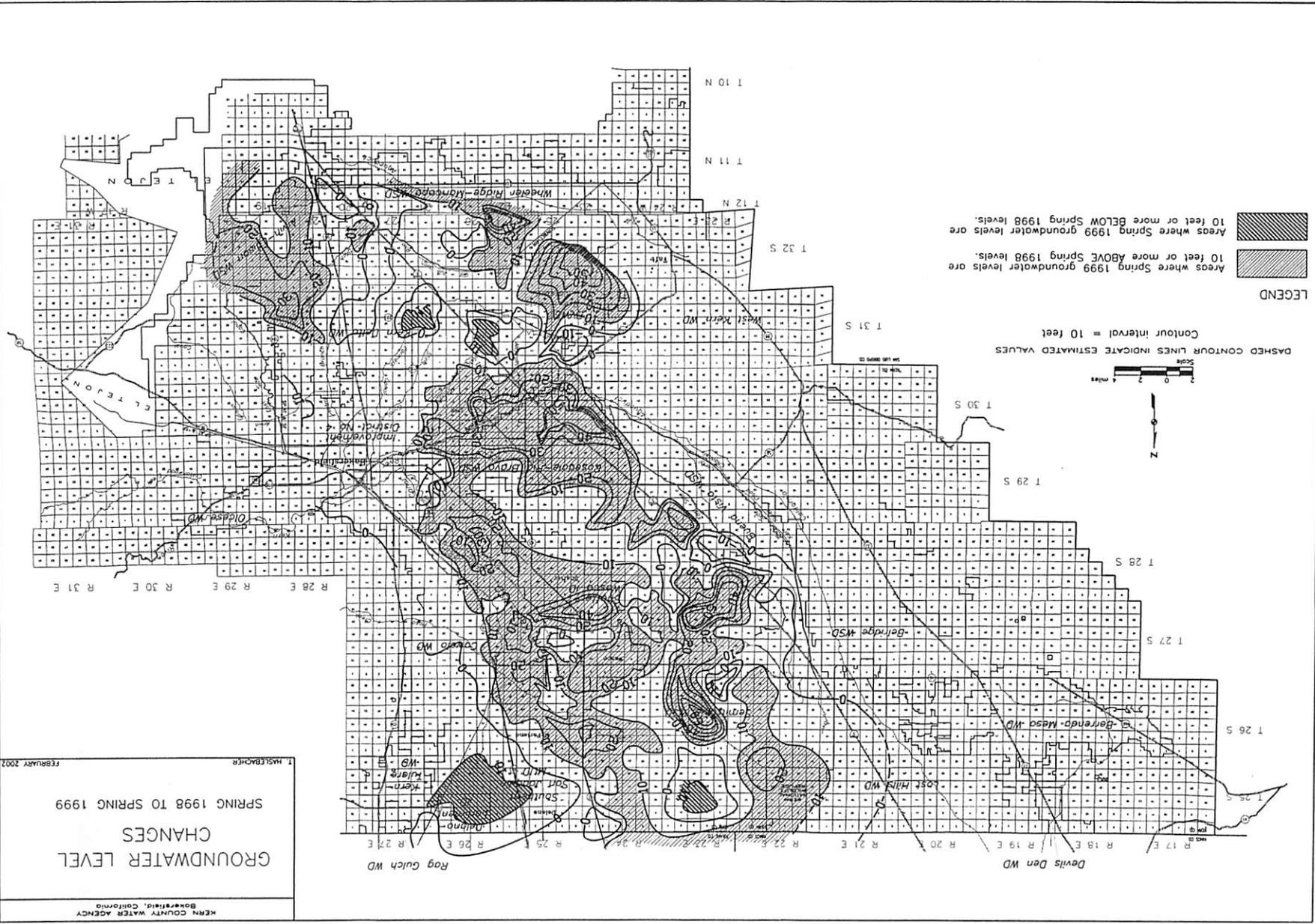


PLATE 4
 KERN COUNTY WATER AGENCY
 DUKERFIELD, CALIFORNIA
 HASZBACHER
 FEBRUARY 2002



MERRICKS
 REMANENT 2003
 KERN COUNTY WATER AGENCY
 Bakersfield, California
**GROUNDWATER SURFACE
 ELEVATION**
 SPRING 1999



LEGEND

Areas where Spring 1999 groundwater levels are 10 feet or more ABOVE Spring 1998 levels.

Areas where Spring 1999 groundwater levels are 10 feet or more BELOW Spring 1998 levels.

DASHED CONTOUR LINES INDICATE ESTIMATED VALUES
 Contour interval = 10 feet

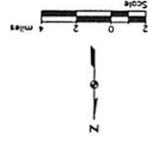


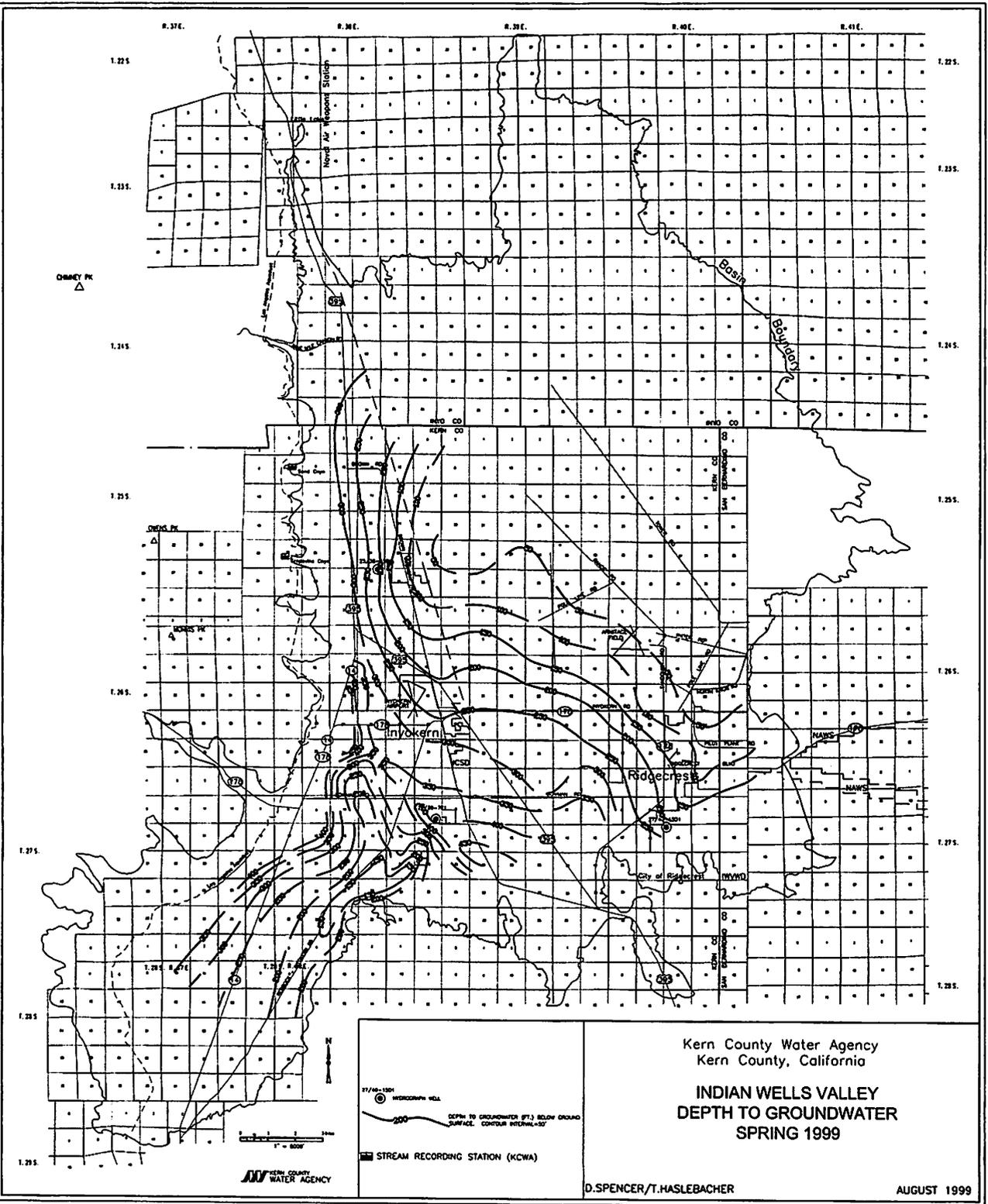
PLATE 6

KERN COUNTY WATER AGENCY
 BAKERSFIELD, CALIFORNIA

GROUNDWATER LEVEL
 CHANGES
 SPRING 1998 TO SPRING 1999

MASTERBACHE

FEBRUARY 2002



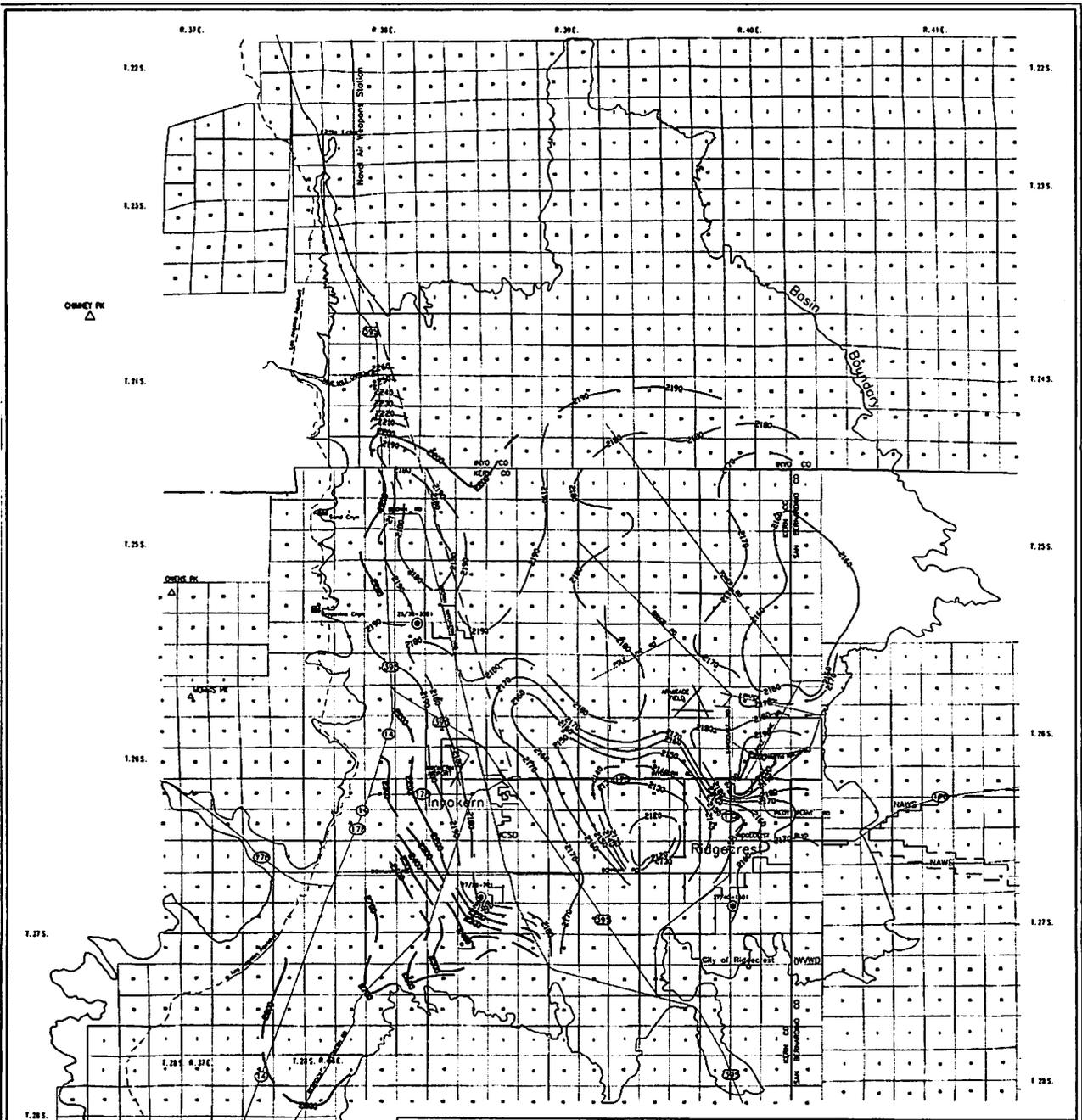
Kern County Water Agency
 Kern County, California

**INDIAN WELLS VALLEY
 DEPTH TO GROUNDWATER
 SPRING 1999**

D.SPENCER/T.HASLEBACHER

AUGUST 1999

PLATE 7



Kern County Water Agency
 Kern County, California
INDIAN WELLS VALLEY
GROUNDWATER SURFACE ELEVATION
SPRING 1999

- 22746-1201
- ① HYDROGRAPH WELL
- 2150 — GROUNDWATER SURFACE ELEVATION (FT) W.R.T. MEAN SEA LEVEL. CONTOUR INTERVAL=10'
- 2200 — GROUNDWATER SURFACE ELEVATION (FT) W.R.T. MEAN SEA LEVEL. CONTOUR INTERVAL=100'
- STREAM RECORDING STATION (KCWA)

D.SPENCER/T.HASLEBACHER

AUGUST 1999

PLATE 8

