KERN COUNTY WATER AGENCY

WATER SUPPLY REPORT
1996

THOMAS N. CLARK
GENERAL MANAGER

JULY 2000

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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.

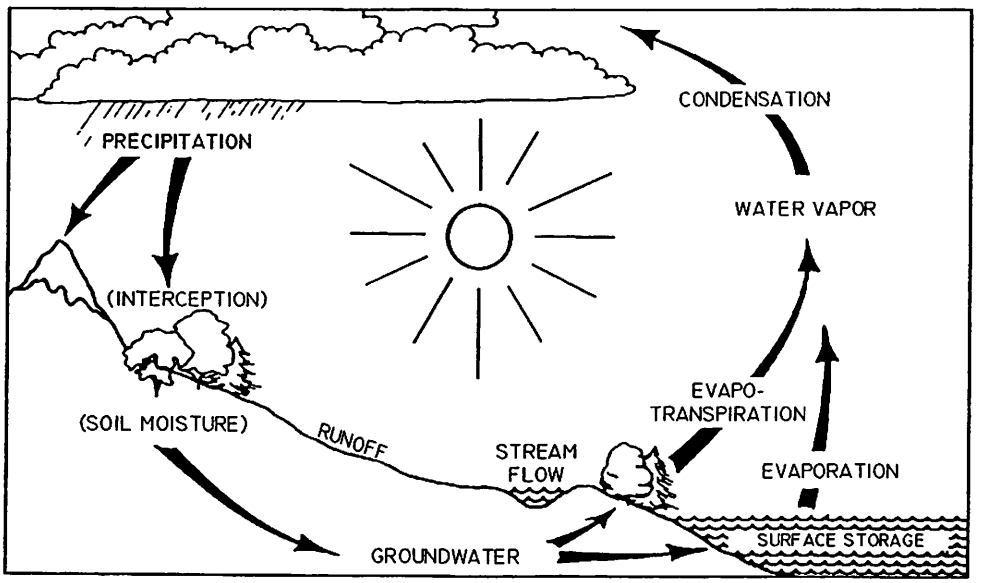
Since its beginning in 1961, the Agency has been building a base of information on the water supply and demand characteristics of the San Joaquin Valley portion of Kern County. Since 1977, the Agency has published the annual Water Supply Report in order to present these statistics in one document and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



1996: A WET YEAR STARTS DRY

While 1995 was classified as a wet year, conditions late in the year became dry, and 1996 thus started off dry. Initial allocations to State Water Project contractors were 75 percent, based on reservoir carryover storage. Pacific storms failed to materialize until mid-January, when a series of them began to move into California. By mid-February, conditions had done a turnaround. SWP allocations were raised to 90 percent early in March due to the increased precipitation and snowpack. Allocations were raised to 100 percent by late March. The water year finished with a Sacramento River Index (SRI) of 22.2 maf, and statewide snowpack at 85 percent of average. Table 1 is a history of Sacramento River indices; Figure 2 shows the same information as a graph.

Likewise for the Central Valley Project, initial dry conditions meant low initial allocations. The CVP allocation for south of Delta contractors started at only 40 percent. While Friant Unit contractors received an initial Class I water allocation of 100 percent, they were allocated no Class II water. By mid-May, south of Delta contractor allocations were raised to 95 percent and Friant Class II was raised to 55 percent.

Kern County surface water supplies from all sources during 1996 were about 3,041,100 acre-feet. Normal supplies are about 2,200,000 acre-feet. Therefore, water availability was about 138 percent of normal. SWP entitlement deliveries from all sources totaled 1,335,400 acre-feet, or about 120 percent of entitlement. Kern River supplies were 970,700 acre-feet, about 129 percent of average. Central Valley Project deliveries totaled 611,300 acre-feet, or 157 percent of the 1975-96 average. However, 1996 surface water supplies were less than in 1995, while both agricultural and municipal and industrial (M&I) demand increased. This therefore caused increases in groundwater pumping in areas with groundwater sources.

Because of the relatively good water supply conditions, about 903,100 acres of farm land was cropped. Total irrigated acreage was 880,600 acres, 32,200 more than in 1995.

Change in groundwater storage in 1996 was an increase of 241,700 acre-feet. Total direct recharge in 1996 was 1,298,800 acre-feet. Total withdrawals since 1970 have been about 13,100,000 acre-feet. Total additions to storage over the same period have been about 6,185,000 acre-feet. The net change in storage since 1970 has been a net loss of about 6,919,000 acre-feet, or about 256,000 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 5,390,000 acre-feet (about 898,000 acre-feet per year).

MONTEREY AMENDMENTS IMPLEMENTATION

The Monterey Agreement was signed on December 14, 1994 by representatives of the State Water Contractors and the California Department of Water Resources. During the course of 1995, state and local-level negotiations took place, which resulted in actual amendments to the Master Contracts between various water contractors and DWR, and to the contracts between water contractors and their member agencies. KCWA approved and signed the amendments on December 14, 1995.

During 1996, interim implementation of the various Master Contract amendments began. Of importance to KCWA, DWR began to allocate water based on contract entitlement (the Monterey amendments removed the "agriculture first" shortage provisions). KCWA Member Units combined to permanently retire 45,000 acre-feet of agricultural entitlement, as part of the process of transferring the Kern Water Bank to local entities. The Kern Water Bank Authority was formed, with KCWA Improvement District No. 4 and various Member Units as participants, to oversee the production of a Habitat Conservation Plan for the water bank property and to begin initial construction and operations of Kern Water Bank facilities. Transfer of the property was accomplished in September 1996. Certain KCWA Member Units that had a combined 130,000 acre-feet of entitlement available for permanent sale began to market it to willing buyers, with contract amendments to change their entitlements considered on a case-by-case basis (the first of these sales took place in October 1996). DWR and the SWP contractors began to make payments into the agricultural trust fund created by the Monterey Amendments.

BAY-DELTA ACCORD AND THE CALFED BAY-DELTA PROCESS

On December 15, 1994 the Bay-Delta Accord was signed by federal and state agencies that had been working to develop new water quality standards for the Sacramento-San Joaquin Delta, the hub of California's water supply system. The Accord was also signed by various "stakeholders:" environmental advocacy organizations, and agricultural and urban water agencies that rely upon Delta water. The Accord had an initial three-year term, and provides an average of 300,000 acre-feet of additional outflow for fish and wildlife, which could go as high as 1,100,000 acre-feet in a critically dry year. In exchange, water suppliers received assurances that federal Endangered Species Act (ESA) "take" limits would not further impact water supplies, a moratorium on new ESA listings was put in place, and a program for determining a long-term plan to fix the Delta's environmental and water supply problems was put in place. The CALFED Bay-Delta Program, as it is called, was in its second year of existence in 1996.

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

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

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

Descending Order by Year

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

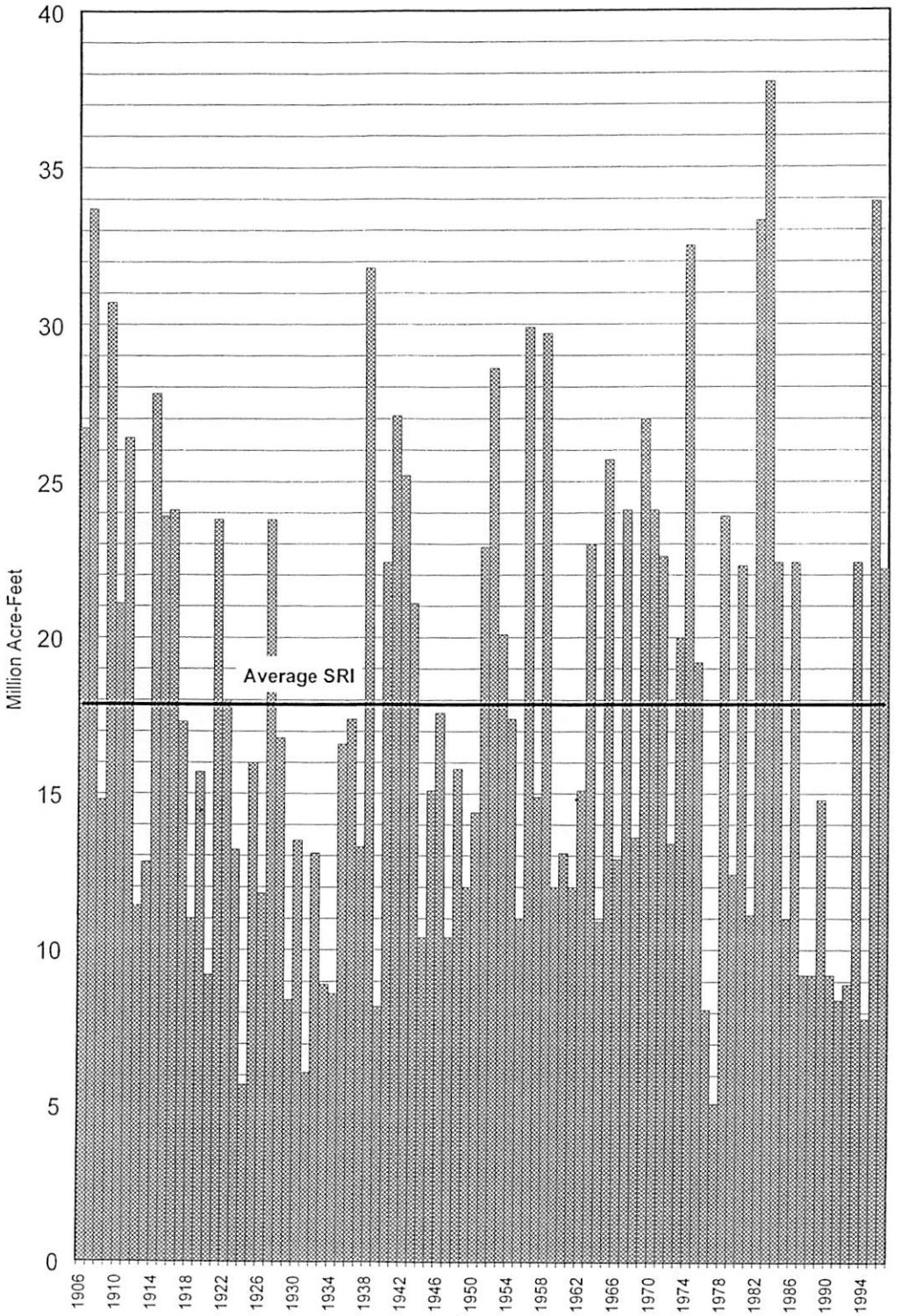
Ascending Order by Index

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

91 year average	17.9
91 year median	91.0
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



These common programs are the topic of much debate. The Water Use Efficiency Common Program in its original from was of particular interest and concern to Kern County, because it contained recommendations for the retirement of large areas of farmland (up to 800,000 acres) in the San Joaquin Valley. This recommendation was intended to free up water being used for irrigation purposes, with the added purpose of decreasing agricultural runoff into the San Joaquin River. While voluntary land retirement programs, such as that promulgated under the Central Valley Project Improvement Act, can be fairly administered, a very large program like that proposed by CALFED would have serious impacts on the economy of the San Joaquin Valley and the state of California. For this reason, the program does not appear to meet the solution principle of "no significant redirected impacts."

As part of its Phase I process, which was designed to result in a set of proposed alternative solutions for the problems of the Bay-Delta, CALFED conducted an extensive series of formal public hearings around the state in order to take comments on its initial program recommendations. These were devised by the CALFED agencies with input from BDAC. One such hearing was held in Fresno in January 1996, at which time a wide variety of different alternatives for solving the Delta's environmental and water-related problems were debated. By mid-March, CALFED's list of alternatives was pared down to ten, and a public hearing was held in Bakersfield during April. The main concern expressed by many Kern County water users related to water supply reliability, and the need for an increased and more reliable water storage and delivery system in California. This, coupled with concern about agricultural land retirement, was the focus of Kern County's input into the CALFED Bay-Delta Program.

By June, CALFED had selected its three "preliminary Phase II alternatives" for a Bay-Delta solution, which would be subjected to federal and state Environmental Impact Report/Statement processes. Each alternative is comprised of a different configuration of Delta conveyance, supported by the common programs and core actions. Water storage, in a variety of sizes and combinations, will be studied to determine the combination of conveyance and storage which meets the Program objectives at the highest and most cost-effective level for each alternative.

The alternatives are:

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

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

(3) Dual Delta Conveyance, where a combination of improved through-Delta conveyance, as well as conveyance isolated from Delta channels, is used. Benefits include improved operational flexibility, more flexibility to increase supply while avoiding fishery impacts, improved water quality, and possible improved quality of agricultural return flows to the San Joaquin River. Concerns include hydrologic and biologic studies required to identify quantity and timing win-

dows for water diversion into storage, construction of isolated conveyance facility affecting wetland and terrestrial habitats and land uses, significant technical challenges in designing an efficient fish screening system, and possible total Delta outflow reduction. CALFED indicates that evaluations for Alternative 3 will include extensive study of the isolated conveyance portion in order to find an optimal range of combined through-Delta and isolated conveyance for this alternative.

The three alternatives were the subject of a CALFED Technical Workshop, held in June. Area of origin concerns, water supply increases, land retirement issues (now associated with water quality components, rather than large-scale ag land retirement as a means of reducing Delta water demand, which had been removed from the program), and the development of an attainable Ecosystem Restoration Plan, were among the major topics mentioned by participants in their comments.

The three alternatives were evaluated in light of comments received, with varying levels of storage and conveyance, until they appeared in final form as the "Phase II Alternatives" in October. They will continue to be subjected to rigorous assessment, with a goal of producing a preferred alternative for the draft EIR/EIS by October 1997. The final EIR/EIS is expected in September 1998. Phase III will consist of implementation of the chosen "preferred alternative" and the four common programs. This phase is scheduled to begin in early 1999 and will last up to 30 years.

As a means of funding various ecosystem restoration and water management projects through the term of the CALFED Program, a general obligation water bond was proposed in the legislature. The bond act, Proposition 204 ("The Safe, Clean, Reliable Water Supply Act of 1996"), was passed by California voters in the November election. The bond provides a total of $1.9 billion in funding for various water conservation, recycling and recharge projects, flood control, the state's share of Central Valley Project Improvement Act requirements, and for ecosystem restoration projects such as fish screens.

WATER SUPPLIES

State Water Project (SWP)

Since the year began with a dry period, increased allocations were not announced by DWR until early March. Initial allocations to State Water Project contractors were 75 percent, based on reservoir carryover storage. This was raised to 90 percent in March, after precipitation began and the Sierra snowpack began to from. By late March, DWR increased allocations to 100 percent.

The chronology of 1996 allocations follows:

December 1, 1995	75% (initial allocation)
March 4, 1996	90%
March 8, 1996	100% (final allocation)

The low initial allocation, while improved from the initial allocation of 40 percent in 1995, caused concern among local water users. However, by the end of January the typical Pacific storm pattern began, and the year ended with a snowpack of 85 percent of average, and a Sacramento River eight-station index of 22.2 million acre-feet.

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 1,352,100 acre-feet was available during 1996, including 1,117,060 acre-feet of SWP entitlement, 52,300 acre-feet of 1995 entitlement carried forward into 1996, 32,400 acre-feet of "Interruptible Water," and 150,300 acre-feet of SWP water transferred into Kern County by other entities. A total of 1,335,400 acre-feet of SWP water was actually delivered during 1996. Since the first deliveries in 1968, more than 22 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 1996 SWP deliveries by contract type.

KCWA and its Member Units had planned to deliver some 104,855 acre-feet of SWP water for groundwater programs during 1996. However, increased delivery rates on the California Aqueduct caused resuspension of sediments deposited during the 1995 storm event that breached the California Aqueduct at Arroyo Pasajero. The high turbidity caused by these extremely fine-grained sediments made SWP water unsuitable for recharge, as it could cause plugging of pore spaces in Kern County's prime recharge areas. Exchanges were made for Central Valley Project Friant Unit and Kern River water to overcome this problem. Once turbidity levels began to lower later in the summer, SWP water became suitable for recharge. KCWA and its Member Units recharged a total of about 102,781 acre-feet of SWP water during 1996.

Kern River

The start of the year was one of the warmest and driest in recent history. By mid-January, Kern watershed snowpack water content had fallen to less than 25 percent of normal. But beginning on January 16, a series of strong Pacific storms began to barrage the Kern River watershed. By February 1, the Kern River runoff forecast had improved to 69 percent of normal. February precipitation approached 250 percent of normal throughout the watershed, with a near-record 24 hour rainfall total at Lake Isabella of 2.13 inches on February 19. April 1 snow survey measurements in the Kern River watershed indicated a basin-wide average water content of 21.4 inches, 124 percent of normal. A comparison of the snow pack in the Kern River watershed during 1994-96 with the historic average (inches of water content) is shown as follows:

	Apr 1 1994	Apr 1 1995	Apr 1 1996	Apr 1 Avg.	1996 % of Avg.
Upper Tyndall Cr.	15.5	34.0	29.9	27.7	108
Crabtree Meadow	10.3	27.7	19.0	19.8	96
Chagoopa	13.7	34.6	25.5	21.8	117
Pascoe	18.7	53.8	37.7	24.9	151
Wet Meadow	7.5	43.2	21.4	30.3	71
Tunnel Guard	4.4	27.1	14.0	15.6	89
Casa Vieja Meadows	10.5	29.5	17.8	20.9	85
Beach Meadows	0.4	13.2	4.1	11.0	37
Average	10.1	32.9	21.1	21.5	94

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

February, 1996	69% of average
March	100%
April	115%
May	117%
Final	126% (final runoff)

Table 5 shows historic Kern River runoff and cumulative runoff for the 103 years of complete record, including diversions above First Point. In 1996 a total of 968,036 acre-feet of Kern River water flowed past First Point of Measurement. An additional 2,465 acre-feet was diverted above First Point. Total 1996 Kern River flows were 970,500 acre-feet, about 136 percent of average. During the last 103 years, the Kern River has yielded more than 74 million acre-feet of runoff. Since Isabella Dam began regulating flows in 1954, nearly 31 million acre-feet of runoff has occurred. Figure 4 is a histograph of annual Kern River flows at First Point. Table 6 gives a summary of Kern River deliveries by entity in 1996. 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, initial dry conditions meant low initial allocations for the Central Valley Project. The allocation for south of Delta contractors started at only 40 percent. While Friant Unit contractors received an initial Class I water allocation of 100 percent, they were allocated no Class II water. By mid-May, south of Delta agricultural contractor allocations were raised to 95 percent and Friant Class II was raised to 55 percent.

Following is a chronology of CVP water allocations:

	Friant-Kern Supplies	CVP Delta Supplies
January 19, 1996 100%	Class I, no Class II	40% Class I
February 15, 1996	100% Class I, no Class II	60% Class I
February 22, 1996	100% Class I, 25% Class II	60% Class I
March 1996	100% Class I, 35% Class II	80% Class I
May 1996	100% Class I, 55% Class II	95% Class I (Urban 100%)

Table 2. Kern County Water Agency, Member Unit Contract Entitlements for 1996-2035

Member Unit	Firm	Surplus [1]	Former Table 1 Entitlement [2]	M&I	Ag	Total
Berrenda Mesa WD	155,100	8,100	163,200		155,100	155,100
Lost Hills WD	134,110	0	134,110	2,000 [3]	132,110	134,110
Belridge WSD	147,665	0	147,665	15,000 [3]	132,665	147,665
Buttonwillow ID	83,000	13,100	96,100		83,000	83,000
Pond Poso ID	67,000	11,100	78,100		67,000	67,000
Semitropic WSD	5,000	562	5,562		5,000	5,000
Cawelo WD	38,200	6,800	45,000		38,200	38,200
Improvement District No. 4	87,276	1,554	88,830	77,000	10,276	87,276
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	**1,117,060**	**97,894**	**1,214,954**	**136,000**	**981,060**	**1,117,060**

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.

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

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

Mean Deliveries	781,719 AF	Minimum Deliveries (1991)	34,886 AF
Median Deliveries	862,448 AF	Maximum Deliveries (1981)	1,386,641 AF
Mean Importations	749,046 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.

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

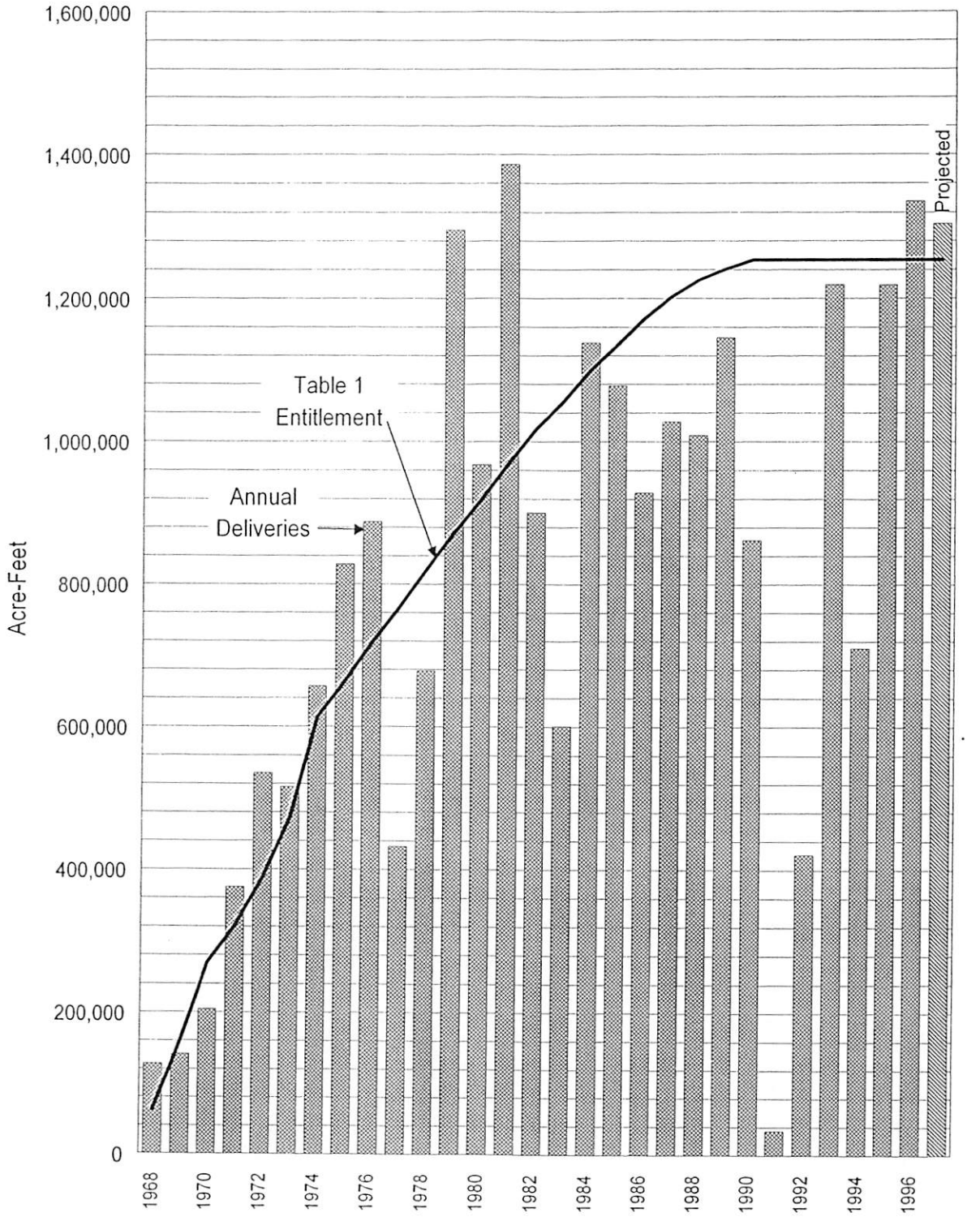


Table 4. 1996 State Water Project Deliveries by Contract (in acre-feet)

District	(1) Table 1 Entitlement	(2) Carryover of 1995 Entitlement into 1996	(3) Interruptable Water Program Allocation	(4) Total SWP Supply	(5) Long-Term M&I Pool	(6) Landowner Transfers Out of Kern County
			SWP Water Supplies			
Berrenda Mesa WD	155,100	7,679	(1)	162,779		(13,020) (2)
Lost Hills WD	134,110	8,920	16,064	159,094		(14,455) (3)
Belridge WSD	147,665	11,668		159,333		(7,412) (4)
Semitropic WSD	155,000	(529)		154,471		
Cawelo WD	38,200			38,200		
Improvement Dist. No. 4	87,276	2,011	16,337	105,624	11,100	
Rosedale-Rio Bravo WSD	29,900			29,900		
Buena Vista WSD	21,300			21,300		
Kern Delta WD	25,500			25,500		
Henry Miller WD	35,500			35,500		
West Kern WD	25,000			25,000		
Wheeler Ridge-Maricopa WSD	238,088	18,666		256,754		(9,200) (5)
Tehachapi-Cummings CWD Ag	4,300	1,961		6,261		
Tehachapi-Cummings CWD M&I	15,000	1,974		16,974	(11,100)	
Tejon-Castac WD AG	3,121			3,121		
Tejon-Castac WD M&I	2,000			2,000		
KCWA (ODC/Bank)				-		
Westside Mutual WC				-		
Westlands WD				-		42,632
Tulare Lake Basin WSD				-		
Dudley Ridge WD				-		1,455
Dudley Ridge WD (KWB)				-		
Total	1,117,060	52,350	32,400	1,201,811	0	0

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

(1) Includes 8,086 AF utilized in-district and 7,978 AF delivered to banking areas on behalf of Paramount Farming Company.
(2) Landowner transfer (13,020 AF) to Westlands WD (Vista Verde Farms = 1,520 AF; Woolf Enterprises = 11,500 AF).
(3) Includes 13,000 AF to Westland WD (Shannon = 5,000 AF (out of 10,000); Woolf Enterprises = 4,500 AF; Chevron = 3,500 AF);
Includes 1,455 AF to Dudley Ridge WD (Paramount = 755 AF; Ritchie = 700 AF).
(4) Landowner transfer (7,412 AF) to Westlands WD (Chevron = 2,500 AF; Woolf Enterprises =4,912 AF (out of 5,000)).
(5) Landowner transfer (9,200 AF) to Westlands WD (Chevron = 8,800 AF; Harris = 400 AF).
(6) Transfer of 24,000 AF to Westlands WD via WWD's purchase of a like quantity of BM's banked USBR 215 water.
(7) Transfer of 1,500 AF from Lost Hills WD to Tulare Lake Basin WSD to satisfy mitigation requirements associated with Lost Hills WD's evaporation basin.
(8) Includes 146,200 AF transferred to Semitropic WSD from Alameda County WD (6,200 AF),
Santa Clara Valley WD (45,000) and Metropolitan WD (95,000 AF);
Includes 10,000 AF transferred to Westlands WD per Hacienda exchange.
(9) SWP entitlement exchange payback to Westlands WD for Friant-Kern water delivered to ID4 during 1995 (2,287 AF).
(10) Includes 2,287 AF from ID4 as payback for Friant-Kern water to ID4 during 1995;
Includes 24,000 AF from BMWD (see footnote 6); includes 10,000 AF from Semitropic WSD per Hacienda exchange.

Table 4 (continued). 1996 State Water Project Deliveries by Contract (in acre-feet)

	(7)	(8)	(9)	(10)	(11)	(12)
			Approved Transfers			
District	Misc. Transfers Into/Out of Kern County	Misc. Transfers, Exchanges, Paybacks	BV Misc. & Simultaneous Exchanges	ID4 Misc. & Simultaneous Exchanges	Settlement Pool Per 1996 WMP	Friant-Kern For SWP Exchange
Berrenda Mesa WD	(24,000) (6)	7,708 (12)		5,400 (20)	(21,124)	
Lost Hills WD	(1,500) (7)	(5,846) (13)	3,000 (18)	255 (21)	6,500	
Belridge WSD				972 (22)	(35,477)	
Semitropic WSD	136,200 (8)	(1,862) (14)		1,534		(2,250)
Cawelo WD		(38,200) (15)				
Improvement Dist. No. 4	(2,287) (9)	3,600 (16)	(3,600) (19)	(43,471)		(2,250)
Rosedale-Rio Bravo WSD				3,701		(2,250)
Buena Vista WSD		88,700 (15)	(3,869)	31,000		
Kern Delta WD		(25,500) (15)				
Henry Miller WD			9,469		9,000	
West Kern WD		(25,000) (15)				
Wheeler Ridge-Maricopa WSD		406 (17)	(5,000) (19)	198 (23)	(35,685)	
Tehachapi-Cummings CWD Ag		(1,949) (16)			(550)	
Tehachapi-Cummings CWD M&I		(1,651) (16)			(1,650)	
Tejon-Castac WD AG		34 (17)		16 (23)		(2,121)
Tejon-Castac WD M&I						(1,938)
KCWA (ODC/Bank)		(1,254) (17)			78,986	(71,319)
Westside Mutual WC		814 (17)		395 (23)		
Westlands WD	36,287 (10)					82,128
Tulare Lake Basin WSD	1,500 (7)					
Dudley Ridge WD						
Dudley Ridge WD (Transfer in)	4,131 (11)					
Total	150,331	0	0	0	0	0

(11) Duddley Ridge WD transfer of Interruptible (1,752 AF) and Entitlement (2,379 AF) for storage in the Kern Water Bank.
(12) Includes landowner transfers of 5,708 AF from Lost Hills WD (Paramount = 2,250 AF; Blackwell = 3,158 AF; Chevron = 300 AF); Includes 2,000 AF from Semitropic WSD (Westside Mutual KWB groundwater exchange).
(13) Includes landowner transfers of 5,708 AF to Berrenda Mesa WD (Paramount = 2,250 AF; Blackwell = 3,158 AF; Chevron = 300 AF); Includes 138 AF landowner transfer to Semitropic WSD (LHUD).
(14) Includes 138 AF landowner transfer to Lost Hills WD (LHUD); includes 2,000 AF to Berrenda Mesa WD (Westside Mutual KWB groundwater exchange).
(15) Long term exchange amounts to Buena Vista WSD from Kern Delta WD (25,500 AF), West KernWD (25,000 AF) and Cawelo WD (38,200 AF).
(16) Sale of Tehachapi-Cummings County WD's 1995 SWP Carryover water to Improvement District No. 4.
(17) Transfer of 1,254 AF from KCWA to the Kern Water Bank Authority in exchange for a like quantity of Kern River Miscellaneous water (December).
(18) Transfer of 3,000 AF from BV to LH in exchange for a like quantity of future SWP water.
(19) Transfer of 8,600 AF to BV (WRM = 5,000 AF; ID4 = 3,600 AF) in exchange for a like quantity of future Kern River water.
(20) Includes 900 Af from ID4 exchanged for a like quantity of BM's banked water in the Pioneer facility; Includes 4,500 AF from ID4 exchanged for a like quantity of BM's (Westside Mutual) banked water in the KWB.
(21) Payback of LH's 1995 Friant-Kern exchange water delivered by ID4 during February of 1996 (255 AF).
(22) Includes 472 AF payback of BEL's 1995 Friant-Kern exchange water delivered by ID4 during February of 1996; Includes 500 AF from ID4 exchanged for a like quantity of BEL's (Westside Mutual) banked water in the KWB.
(23) Transfer of 609 AF from ID4 to the Kern Water Bank Authority in exchange for a like quantity of Kern River Miscellaneous water (December).

Table 4 (continued). 1996 State Water Project Deliveries by Contract (in acre-feet)

District	(13) Total SWP Water Available	(14) In-District Deliveries	(15) Recharge Deliveries	(16) Total Deliveries	(17) Balance to be Delivered
Berrenda Mesa WD	117,743	109,079	8,664	117,743	0
Lost Hills WD	147,048	136,774	10,274	147,048	0
Belridge WSD	117,416	111,444	5,972	117,416	0
Semitropic WSD	288,093	275,653	13,861	289,514	(1,421)
Cawelo WD				0	0
Improvement Dist. No. 4 Ag	68,716	20,969	47,747	68,716	0
Rosedale-Rio Bravo WSD	31,351	30,993	358	31,351	0
Buena Vista WSD	137,131	136,888		136,888	243
Kern Delta WD	0			0	0
Henry Miller WD	53,969	36,043		36,043	17,926
West Kern WD	0			0	0
Wheeler Ridge-Maricopa WSD	207,473	202,359	5,114	207,473	0
Tehachapi-Cummings CWD Ag	3,762	3,762		3,762	0
Tehachapi-Cummings CWD M&I	2,573	2,573		2,573	0
Tejon-Castac WD AG	1,050		1,050	1,050	0
Tejon-Castac WD M&I	62		62	62	0
KCWA (ODC/Bank)	6,413		6,413	6,413	0
Westside Mutual WC	1,209		1,209	1,209	0
Westlands WD	161,047	161,047		161,047	0
Tulare Lake Basin WSD	1,500	1,500		1,500	0
Dudley Ridge WD	1,455	1,455		1,455	0
Dudley Ridge WD (KWB)	4,131		4,131	4,131	0
Total	1,352,142	1,230,539	104,855	1,335,394	16,748

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

103 Year Mean Natural First Point Flow	728,000 AF	Minimum Natural First Point Flow (1961)	177,642 AF
103 Year Median Natural First Point Flow	564,600 AF	Maximum Natural First Point Flow (1916)	2,520,149 AF
43 Year Mean Regulated First Point Flow	709,800 AF	Mimimum Regulated First Point Flow (1961)	177,063 AF
43 Year Median Regulated First Point Flow	572,100 AF	Maximum Regulated First Point Flow (1983)	2,381,575 AF

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

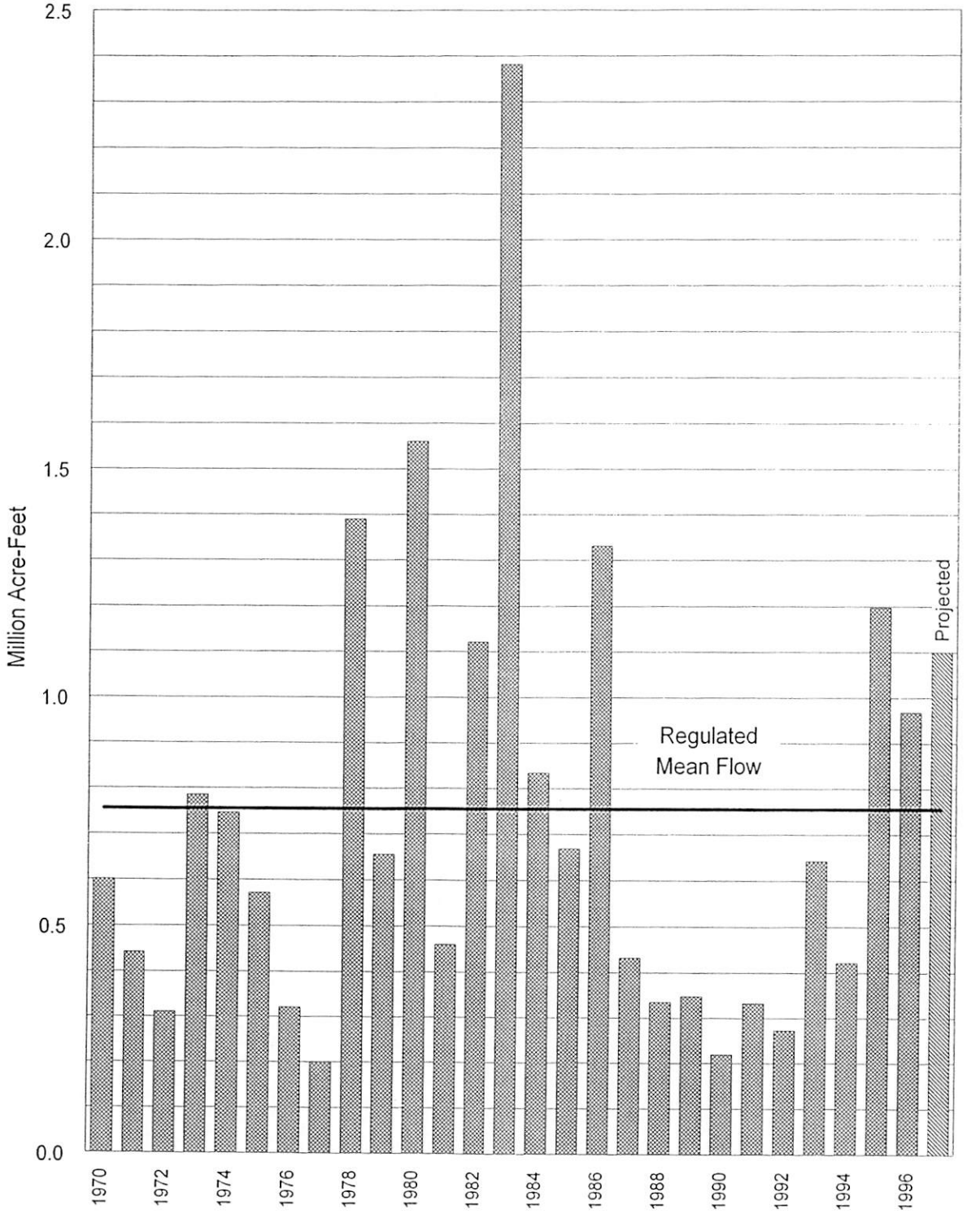


Table 6. 1996 Kern River Water Diversions by Entity (in acre-feet)

Area of Use	Diversions
Above First Point	
Kern Valley Golf Course (Kernville)	177
La Hacienda, Inc.	59
Lake Ming	790
Olcese WD	1,437
City of Bakersfield	2
Subtotal	**2,465**
Below First Point	
Arvin-Edison WSD	39,437
Buena Vista WSD	81,714
Cawelo WD	75,527
City of Bakersfield, Irrigation and Spreading [1]	93,516
County of Kern (at Second Point)	2,828
Hacienda WD/Paramount Farming Co.	10,542
Henry Miller WD	5,223
Improvement District No. 4	51,203
Kern County Water Agency	17,024
Kern Delta WD	245,628
Kern Water Bank Authority	21,417
North Kern WSD	253,696
Rosedale Ranch Improvement District	14,556
Rosedale-Rio Bravo WSD	55,004
South Fork	721
Subtotal	**968,036**
Total	**970,501**

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

Table 7 shows 1996 deliveries of CVP water by entity. As shown, 177,467 acre-feet of Class I entitlement and 235,656 acre-feet of Class II water was delivered. A total of 88,111 acre-feet of "Section 215" water was delivered in 1996, most of which was delivered to KCWA for groundwater recharge and banking programs. Also, 110,029 acre-feet of other CVP water was delivered to KCWA, mostly for groundwater programs.

Since SWP water in the California Aqueduct began to experience high turbidity during the spring, which made the water unsuitable for recharge and banking programs, KCWA arranged an exchange of SWP water for Friant-Kern water, which was low in turbidity. This exchange arrangement was first undertaken in 1995, immediately after the storm event that breached the aqueduct at Arroyo Pasajero. SWP water was delivered to CVP contractors north of the area of the aqueduct that contained the fine-grained sediments, while a like amount of Friant-Kern water was delivered through the Friant-Kern Canal into the Kern River channel, and from there into groundwater recharge areas. This type of exchange exemplifies the inherent flexibility of the two water systems in the San Joaquin Valley, as well as the ingenuity of water managers in the area.

Table 8 displays annual and cumulative deliveries of CVP water since 1950, when the first importations were made to Kern County. Figure 5 is a histograph of CVP deliveries since 1970. From 1950 to 1996, over 13 million acre-feet of CVP water was imported into Kern County.

Minor Streams

Local "minor stream" watersheds are the second largest local source of water, after the Kern River. Streams which yield measurable 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 unusually 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 1996 were estimated to be about 88,100 acre-feet as follows;

Stream Group	Acre-feet
Poso	53,400
Caliente	10,200
El Paso	4,700
San Emigdio	19,800
Total	88,100

Some minor stream water is used for irrigation by farmers in the North Kern Water Storage District and Semitropic WSD. Much of the remaining water percolates to the underlying aquifer. Some of this recharge probably contributes to the shallow groundwater in the Kern Lake Bed area and near the Kern National Wildlife Refuge. KCWA estimated that about 83,700 acre-feet of the minor stream flows during 1996 contributed to groundwater recharge. Table 9 shows annual minor stream runoff, along with cumulative runoff since 1970. The variability of minor stream flows is shown by the accompanying statistics, and shown graphically in Figure 6. Figure 7a shows the hydrograph for Poso Creek in 1996. Figure 7b shows cumulative runoff for Poso Creek for the year.

Effective Precipitation

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

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

Most urban storm runoff is captured in unlined sumps and allowed to percolate. This runoff is not usually measured. A small amount of storm runoff is diverted into the Kern River, where it becomes available for delivery or recharge. About 300 acre-feet of urban runoff was diverted into the Kern River system in 1996.

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 1996 contributed 192,500 acre-feet of effective precipitation, with 162,000 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 1996 was 140 percent of average, about 20 percent lower than 1995. Following is a tabulation of 1993-96 and average monthly rainfall (in inches) for Meadows Field. KCWA estimates that rainfall provided about 2.6 inches of useable water for crops grown during 1996.

Rainfall at Meadows Field, Bakersfield

	1993	1994	1995	1996	Avg.	1996 % of Avg
Jan	2.33	0.57	2.29	1.08	1.02	106
Feb	2.02	1.34	0.87	2.54	1.00	254
Mar	1.76	0.97	3.39	0.78	0.94	83
Apr	0	1.06	0.79	0.12	0.65	18
May	0	0.27	0.35	0.02	0.30	7
Jun	0.48	0	0.12	0	0.07	0
Jul	0	0	0	0	0.01	0
Aug	0	0.01	0	0	0.02	0
Sep	0.08	0.09	0	0	0.10	0
Oct	0.17	0.08	0	0.94	0.31	303
Nov	0.79	0.98	0	0.84	0.52	161
Dec	0.62	1.32	2.03	1.73	0.80	216
Total	**8.17**	**6.69**	**9.84**	**8.08**	**5.74**	**140**

Table 7. 1996 Central Valley Project Deliveries by Entity[1] (in acre-feet)

	Class I	Class II	215 Water	Other [3] Water	Total
Arvin-Edison WSD	38,431	101,860	7,596	24,140	172,027
Cawelo WD					
Delano-Earlimart ID	7,589	4,694	1,049	14,295	27,627
Kern County Water Agency		13,484	77,766	53,274	144,524
Kern-Tulare WD [2]	1,673	18,356		754	20,783
North Kern WSD		2,035			2,035
Rag Gulch WD [2]	107	1,733		54	1,894
Rosedale-Rio Bravo WSD		39,088		230	39,318
Semitropic WSD		2,307			2,307
Shafter-Wasco ID	37,441	23,099	1,700	14,278	76,518
So. San Joaquin MUD	92,226	29,000		3,004	124,230
Total	**177,467**	**235,656**	**88,111**	**110,029**	**611,262**

[1] Quantities for water year March 1996 - February 1997.
[2] Per exchange of Cross Valley Canal water with Arvin-Edison WSD.
[3] Includes M&I water, operational spill water and non-project water delivered via CVP.

Table 8. 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			
1968	206,499	3,151,722			
1969	372,826	3,524,548			
1970	351,392	3,875,940			
1971	348,865	4,224,805			
1972	238,475	4,463,280			
1973	412,178	4,875,458			
1974	480,575	5,356,033			
1975	442,130	5,798,163			
1976	226,512	6,024,675			
1977	121,469	6,146,144			
1978	357,847	6,503,991			
1979	462,526	6,966,517			
1980	462,772	7,429,289			

Mean Delivery	295,416 AF	Median Delivery 1975-96	391,609 AF
Median Delivery	245,482 AF	Min. Delivery 1975-96 (1977)	121,469 AF
Mean Delivery 1975-96	387,659 AF	Max. Delivery 1975-96 (1982)	656,608 AF

Figure 5. Central Valley Project Deliveries to Kern County

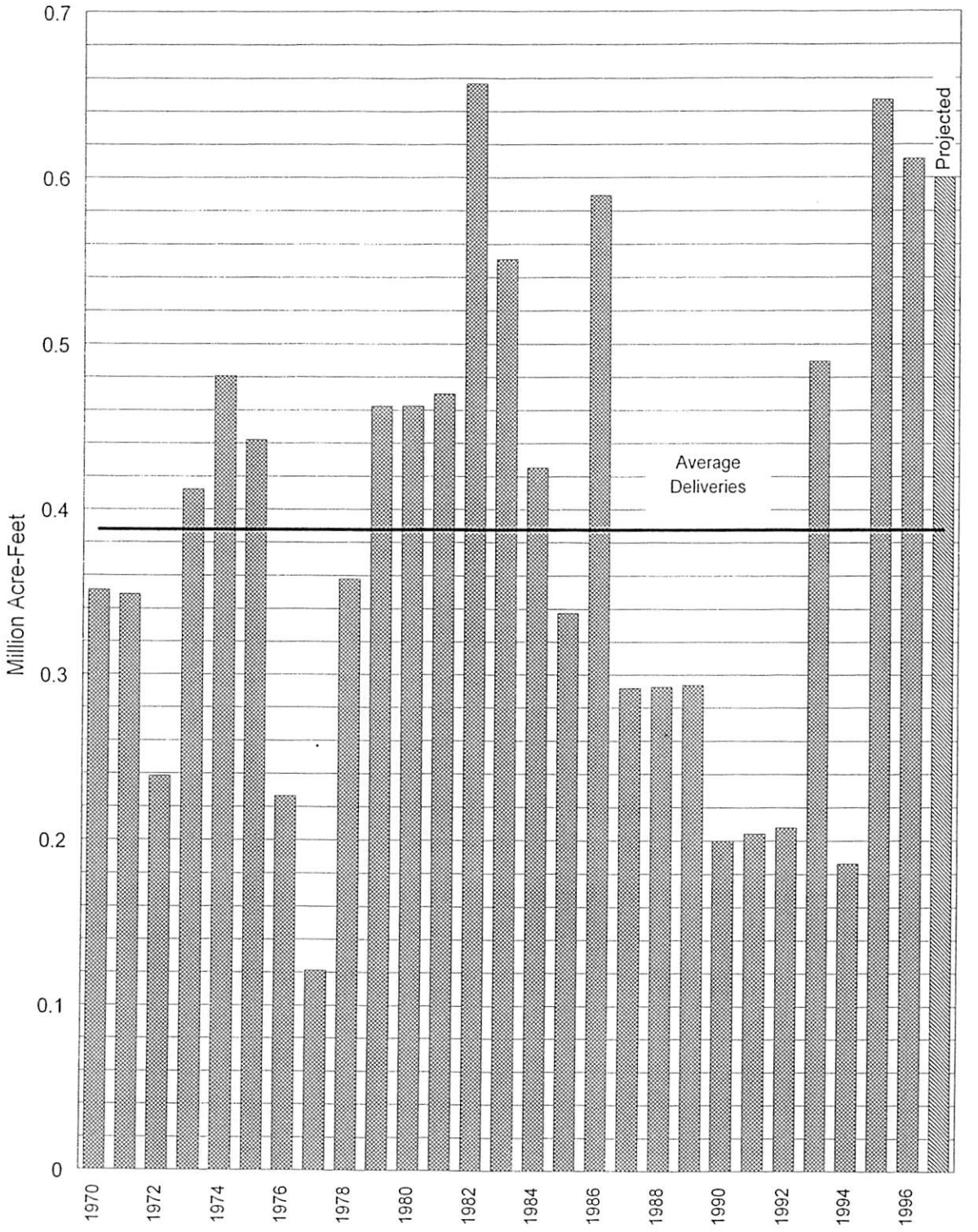


Table 9. Minor Stream Flows in the San Joaquin Valley Portion of Kern County (in acre-feet)

Year	Annual Stream Flows	Cumulative Stream Flows
1970	132,400	132,400
1971	63,200	195,600
1972	21,600	217,200
1973	22,900	240,100
1974	104,900	345,000
1975	39,400	384,400
1976	42,700	427,100
1977	32,900	460,000
1978	429,200	889,200
1979	96,700	985,900
1980	65,200	1,051,100
1981	63,600	1,114,700
1982	91,700	1,206,400
1983	273,300	1,479,700
1984	14,300	1,494,000
1985	20,200	1,514,200
1986	32,600	1,546,800
1987	28,600	1,575,400
1988	22,900	1,598,300
1989	26,300	1,624,600
1990	17,000	1,641,600
1991	34,600	1,676,200
1992	52,200	1,728,400
1993	72,900	1,801,300
1994	36,800	1,765,200
1995	161,900	1,963,200
1996	88,100	1,853,300

Mean Flow	77,300 AF
Median Flow	42,700 AF
Minimum Flow (1984)	14,300 AF
Maximum Flow (1978)	429,200 AF

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

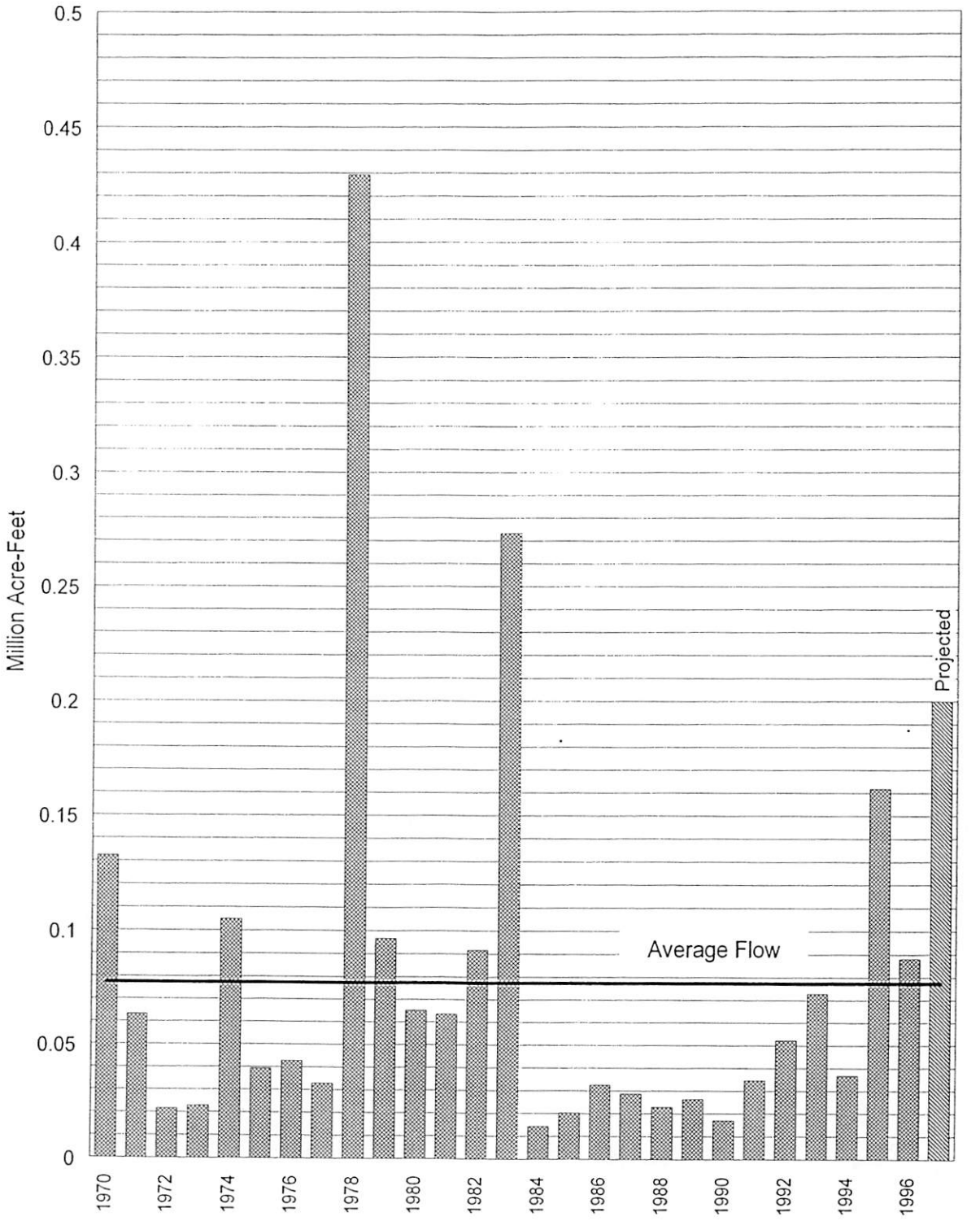
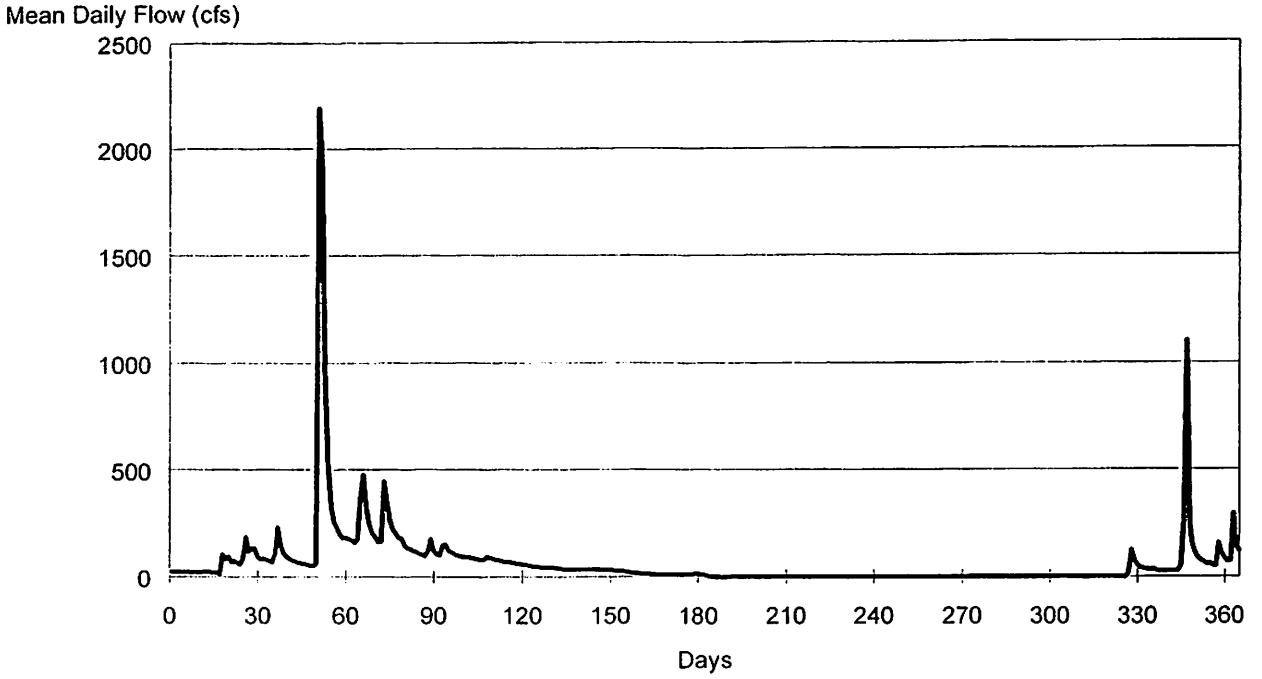
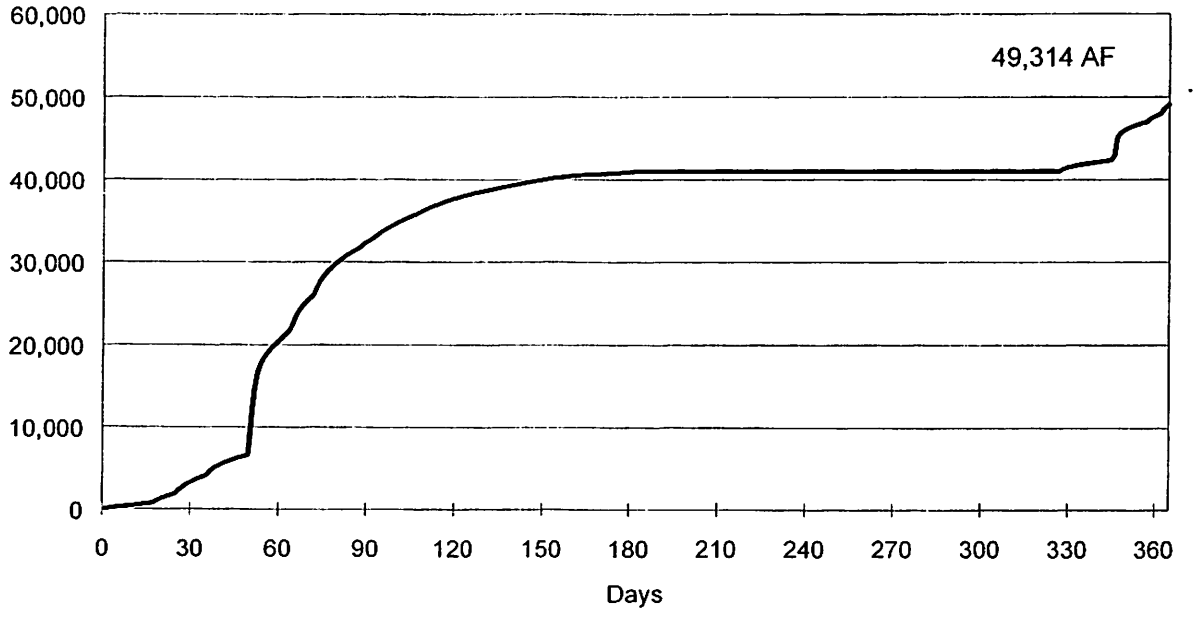


Figure 7a. Poso Creek Hydrograph, 1996



Note:
1. Hydrograph began 0000 hrs on 1/1/96 and ended at 2400 hrs on 12/31/1996.
2. Located at Lat.35 30' 49", Long. 118 54' 17", SW 1/4, SW 1/4, Sec. 6, T.28S., R.29E. Kern County.
3. Peak Discharge, 1,093 cfs, 3/12/95.

Figure 7b. Poso Creek Cumulative Volumes, 1996



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume (AF)	3426	17016	12142	5211	2303	859	19	0	0	0	884	7454
Cumulative Volume (AF)	3426	20442	32584	37795	40098	40957	40976	40976	40976	40976	41860	49314

Table 10. 1996 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	1.18	3.80	0.63	0.20	0.20	0	0	0	0	0.87	1.04	1.95	9.87
Sycamore	420	31S/30E-20	1.07	3.68	0.56	0.15	0.16	0	0	0	0	0.90	1.03	1.77	9.32
Tejon	480	32S/29E-15	1.15	3.04	0.54	0.13	0.12	0	0	0	0	1.07	0.90	1.59	8.54
CALIFORNIA DEPARTMENT OF WATER RESOURCES															
Bakersfield 14W	310	30S/25E-04R	0.97	3.11	0.28	0.05	0.03	0	0	0	0	0.72	1.67	0.74	7.57
Lost Hills O&M Center	300	27S/21E-03	0.44	3.40	0.68	0.37	0	0	0	0	0	1.32	1.14	3.23	10.58
Wind Gap O&M Center	780	11N/20W-26	m	m	m	0.10	0	0	0	0	0	1.23	0.83	0.82	m
J.G. BOSWELL COMPANY															
Buena Vista #4	300	32S/25E-06	0.64	3.22	0.16	0.06	0	0	0	0.05	0	0.82	1.02	0.92	6.89
Buena Vista Gin	300	32S/25E-12	0.52	3.37	0.24	0.02	0	0	0	0	0	0.81	1.11	1.10	7.17
Buena Vista Office	290	31S/25E-25	0.59	3.51	0.25	0.05	0	0	0.01	0	0	1.15	1.16	1.04	7.76
Kern Lake Shop	280	32S/28E-18	0.60	2.71	0.45	0.05	0	0	0.06	0	0	0.92	0.82	1.12	6.73
Kern Lake Time Room	280	32S/27E-16	0.61	2.83	0.56	0.07	0	0	0.08	0	0	1.00	0.83	1.41	7.39
Paloma	290	32S/24E-02	0.52	3.08	0.34	0.01	0	0	0.04	0	0	0.91	0.96	1.15	7.01
KERN COUNTY PLANNING DEPARTMENT															
Arvin Fire Station	450	31S/29E-28	0.96	2.39	0.63	0.18	0	0	0	0	0	0.81	0.89	1.33	7.19
Buena Vista Aquatic Rec Are:	300	31S/25E-15	0.59	2.74	0.09	0.02	0	0	0.01	0	0	0.77	0.62	0.75	5.59
Buttonwillow Fire Station	270	29S/23E-14	0.87	2.45	0.19	0.19	0.05	0	0.03	0	0	1.06	0.84	1.49	7.17
Communications Center	770	29S/28E-16	0.92	2.59	0.94	0.16	0.31	0	0.01	0	0	0.92	1.07	1.86	8.78
Edmonston Pump Station	1,310	10N/18W-17M	2.06	2.99	0.69	0.06	0	0	0	0	0	1.88	0.89	2.72	11.29
McFarland Fire Station	350	26S/25E-10	1.00	2.66	0.75	0.16	0.04	0	0.07	0	0	1.04	1.74	2.30	9.76
Pine Mountain	5,200	09N/21W-19	3.10	8.05	1.30	0.83	0.02	0	0.11	0.26	0	3.17	2.50	5.95	25.29
Rio Bravo Fire Station	610	29S/29E-04	1.19	2.84	1.03	0.13	0	0	0.04	0	0	0.76	1.61	2.22	9.82
NATIONAL WEATHER SERVICE															
Bakersfield NWS	380	30S/28E-08	1.08	2.54	0.78	0.12	0.02	0	0	0	0	0.94	0.84	1.73	8.05
Bear Valley	4,100	32S/31E-03	2.84	3.82	2.12	0.46	0	0.03	0	0	0	1.41	2.26	3.94	16.88
Delano	320	25S/25E-S11	0.62	0.70	0.60	0.24	0	0	0	0	0	0.99	1.44	2.93	7.52
Glennville	3,100	25S/30E-25	5.54	5.66	3.27	1.33	0.08	0	0	0	0	0.55	5.01	5.31	26.75
Keene	2,900	31S/32E-20	1.90	4.75	2.00	0.44	0	0	0	0	0	0.86	2.28	3.44	15.67
Lebec	3,600	09N/19W-26	0.79	1.75	0.51	0.18	0	0	0	0	0	1.53	0.58	2.06	7.40
Lost Hills	280	26S/21E-35	0.44	2.86	0.68	0.36	0	0	0.04	0	0	1.39	1.14	3.14	10.05
Maricopa	700	10N/24W-11	m	1.69	0.37	0.05	0	0.21	0	0	0	0.65	0.97	0.79	m
Piute	4,290	29S/33E-36	3.87	3.13	2.20	0.41	0	0	0	0	0	0.65	2.32	3.21	15.79
Tehachapi	3,980	32S/33E-21	2.37	3.28	1.05	0.36	0	0	0	0	0	1.53	0.97	2.24	11.80
Wasco	300	27S/24E-11	0.64	1.57	0.75	0.21	0.02	0	0	0	0	1.29	1.36	2.81	8.65
Woody	1,600	25S/29E-35	3.72	3.93	1.75	0.70	0.05	0	0	0	0	1.17	0.15	3.14	14.61
TEHACHAPI-CUMMINGS COUNTY WATER DISTRICT															
Station 6	4,890	12N/15W-01	2.75	3.35	1.45	0.50	0	0	0	0	0	1.20	1.30	2.05	12.60
Station 20	5,730	12N/15W-12	3.65	4.95	2.00	0	0	0	0	0	0	2.20	1.75	2.95	17.50
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT															
5P-P2	590	11N/22W-09	1.59	3.02	0.23	0.02	0	0	0	0	0	0.78	0.91	1.00	7.55
District Headquarters	480	11N/12W-11	1.07	2.70	0.39	0.06	0	0	0	0	0	1.13	0.81	1.29	7.45
Greenlee's Pasture	380	12N/21W-36	1.21	2.58	0.43	0.05	0	0	0	0	0	1.16	0.89	1.28	7.60
PA-2	960	11N/19W-30	1.36	2.48	0.51	0	0	0	0	0	0	1.05	0.81	0.71	6.92
Spill Basin	850	11N/18W-31	2.10	2.64	1.22	0.05	0	0	0	0	0	0.80	1.00	0.58	8.39
WRM-2	510	32S/24E-35	1.14	2.96	0.14	0	0	0	0	0	0	0.75	1.03	1.08	7.10
OTHER OPERATORS															
Belridge WSD Office	550	28S/21E-34	0.36	4.52	0.45	0.15	0	0	0.15	0	0	1.50	1.40	2.90	11.43
Blackwell's Corner (BMWD)	630	27S/20E-06	0.53	3.45	0.33	0.16	0.01	0	0	0	0	1.61	1.60	2.67	10.36
City of Bakersfield DWR Yd.	400	30S/27E-06	0.72	2.78	0.33	0.15	0	0	0	0	0	0.54	1.13	1.49	7.14
Del Kern Station (KDWD)	350	31S/28E-06C	0.72	3.25	0.52	0.09	0	0	0.06	0	0	1.05	0.84	1.47	8.00
Shafter Cotton Research Sta.	370	27S/25E-33J	0.96	2.88	0.76	0.18	0.15	0	0.01	0	0	0.82	1.07	2.47	9.30
So. Belridge (Cal Resources)	600	28S/21E-33	0.52	3.36	0.16	0.03	0	0	0	0	0	0.99	0.84	1.03	6.93

Note: Boxed numbers are estimated values. "m" indicates missing data.

Pacific storms failed to materialize until mid-January, when a series of them began to move into California. By mid-February, conditions had done a turnaround, and storms continued through mid-March. 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.

Wastewater Reuse

The reuse of municipal and industrial wastewater provides an irrigation water source for Kern County agriculture. There are 14 active wastewater sewage treatment plants in the San Joaquin Valley portion of Kern County. Wastewater treatment processes are classified as follows: "Primary" treatment removes most suspended matter from the sewage (usually via settling ponds), but removes little or no colloidal or dissolved matter. "Secondary" treatment provides some biological action or filtration to remove any remaining colloidal or dissolved substances from the sewage (nearly all wastewater 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 wastewater 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 1996 about 51,300 acre-feet of wastewater was treated (Table 12). KCWA estimated that about 47,800 acre-feet was used by agriculture, 100 acre-feet evaporated and 3,500 percolated to the underlying aquifer. Table 13 shows historic amounts of treated wastewater. Figure 10 shows the same information as a graph.

Another source of reusable wastewater 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 wastewater is as a byproduct of oil production. Unlike treated municipal effluent or tail water, oil field produced waters are a true addition to the hydrologic system, being drawn from deep, connate waters that are intermixed with oil deposits. In the Kern Front oil field, which lies astride the Kern River northeast of Bakersfield, substantial quantities of water are removed with each barrel of oil. The chemical quality of this water is generally within acceptable limits for agriculture. Thus, much of this water is discharged into irrigation canals. During 1996, Cawelo Water District and Texaco Exploration and Production, Inc. began a joint water conservation program to utilize oil field produced water as a source of irrigation water. This project required the construction of a central pump station in the Kern River field, along with 7.6 miles of

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

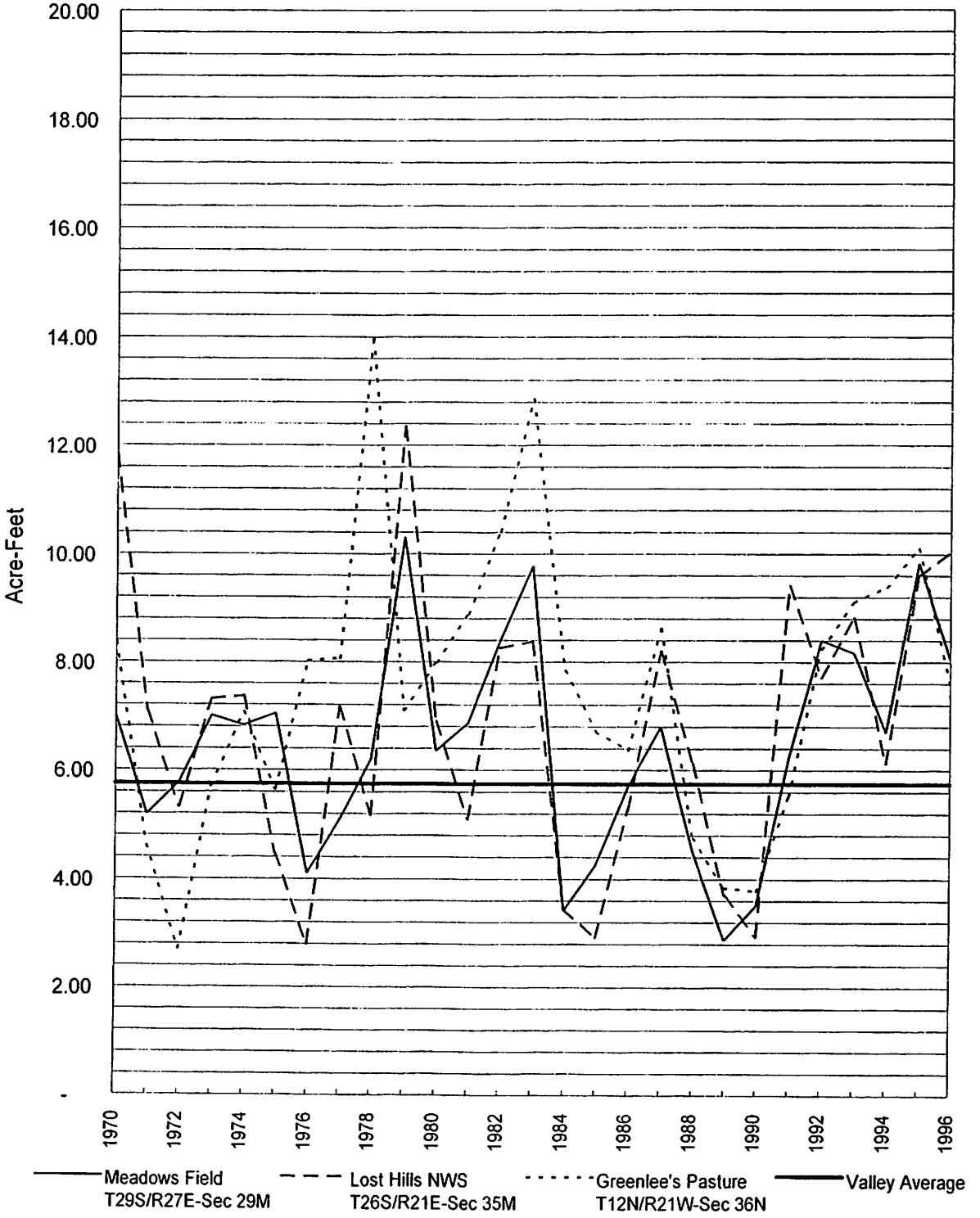


Table 11. Effective Precipitation in the San Joaquin Valley Portion of Kern County (in acre-feet)

	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

Mean EP (total)	216,300 AF
Median EP (total)	171,700 AF
Mean EP (per acre)	2.99 Inches/Acre
Median EP (per acre)	2.57 Inches/Acre

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

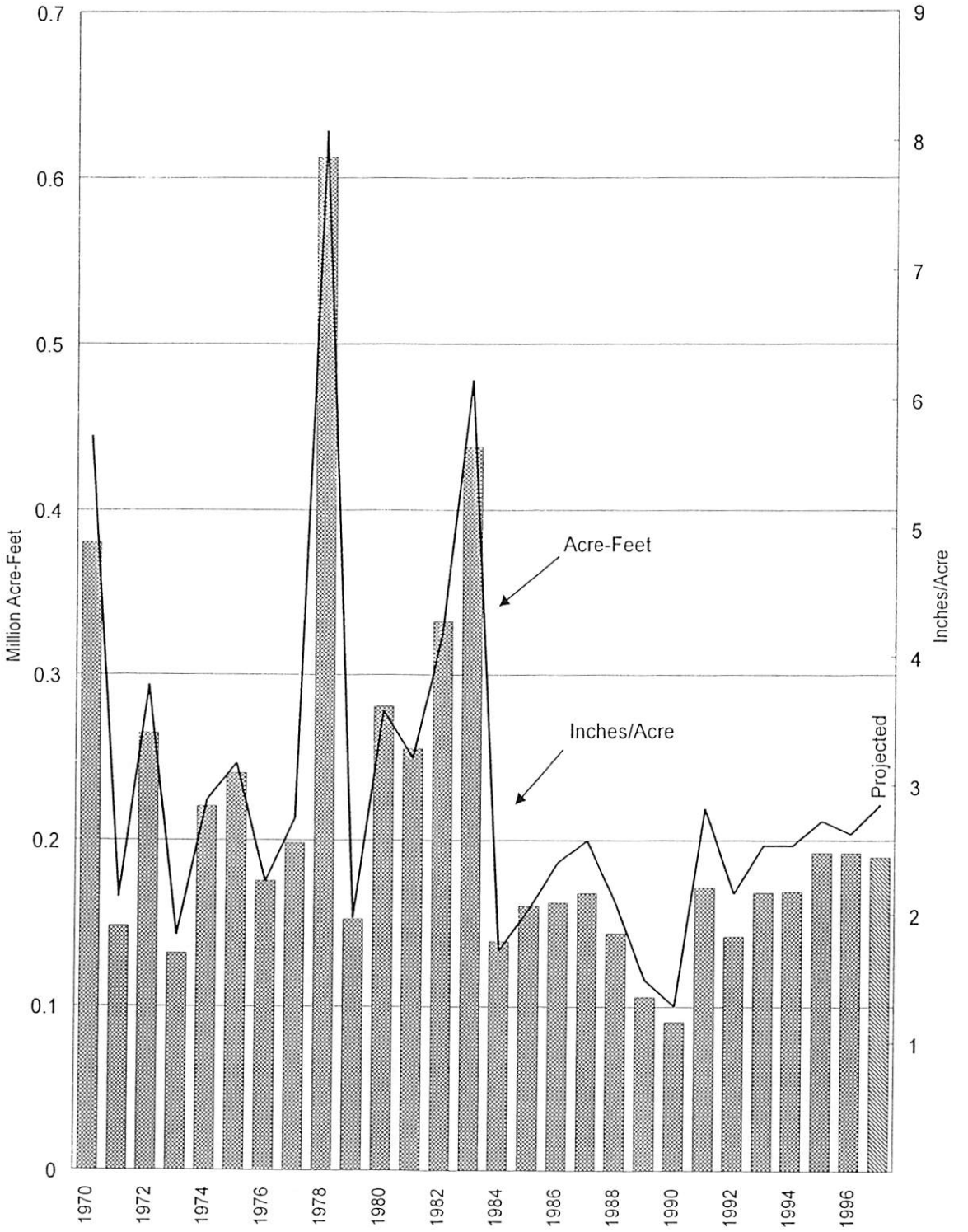


Table 12. 1996 Wastewater Treatment Plant Volumes

Facility	Volume (MG)	Volume (AF)	Influent Source	Treatment System	Effluent Use
City of Arvin	343	1,052	Dom	Secondary	Agriculture
City of Bakersfield					
#2	6,440	19,763	Dom/Ind	Secondary	Restricted Agriculture
#3	3,720	11,417	Dom/Ind	Secondary	Restricted Agriculture
Kern County Waste Management Department					
KSA (Mt. Vernon)	1,501	4,605	Dom	Secondary	Agriculture
BVARA [1]	.5	17	Agr	Secondary	Percolation
Sheriff's Lerdo Facility [1]	80	247	Dom	Secondary	Same
Reeder Tract [1]	11	33	Dom	Secondary	Same
NOR Sanitary District #1	1,205	3,698	Dom/Ind	Secondary	Restricted Agriculture Percolation
City of Delano	1,298	3,983	Dom	Secondary	Restricted Agriculture
Lamont Public Utilities District	655	2,011	Dom	Primary	Agriculture
City of McFarland	273	838	Dom	Secondary	Agriculture
City of Shafter	453	1,390	Dom/Ind	Secondary	Agriculture
Shafter Airport	62	192	Ind	Secondary	Percolation
City of Wasco	663	2,033	Dom/Ind	Secondary	Agriculture
Total	**16,710**	**51,279**			

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.

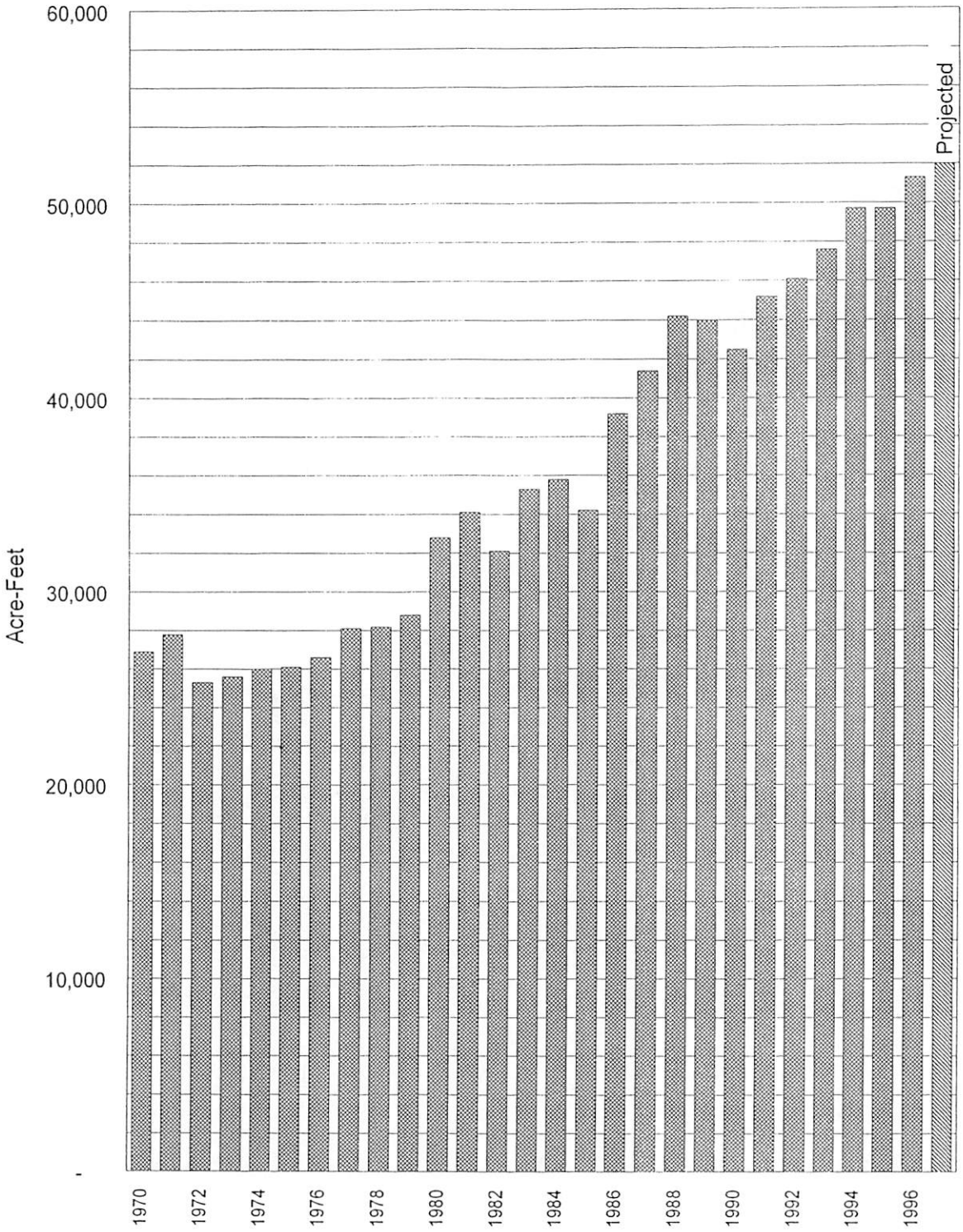
[1] No information available for 1996; 1994 data used as an estimation.

Table 13. Wastewater 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

Mean Water Reuse	36,100 AF
Median Water Reuse	34,200 AF
Minimum Water Reuse (1972)	25,300 AF
Maximum Water Reuse (1996)	51,300 AF

Figure 10. Wastewater Reuse in Kern County



pipeline to connect the field with Cawelo's distribution system. The project has the capacity to provide almost 4.5 acre-feet per day to Cawelo. It also includes a comprehensive water treatment and quality monitoring program. In November 1996 the joint program won the prestigious International Development Research Council Distinguished Service Award in Environmental Planning.

A total of 13,800 acre-feet of produced water from the Kern Front oil field was reused in 1996. 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 1996 were calculated to be about 1,609,000 acre-feet. This is about 215,100 acre-feet, or 14 percent more than was extracted in 1995. A lesser amount of surface water supplies plus an increase in irrigated acreage, are the reasons for this increase.

Groundwater is pumped for a variety of uses in the San Joaquin Valley portion of Kern County, with agriculture the largest user. In 1996 agriculture used about 1,450,300 acre-feet. Municipal and industrial uses were about 159,300 acre-feet.

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

WATER REQUIREMENTS

Agricultural

Gross irrigated acreage in the San Joaquin Valley portion of Kern County was about 848,400 acres in 1995. Since 19,100 acres were double-cropped, total gross cropped acreage in 1995 was 829,300 acres. Some 727,000 acres (including double cropping) were irrigated over the usable groundwater basin, and 121,400 acres were irrigated on lands outside the usable groundwater basin. Total irrigated acreage increased 5 percent over 1995.

Gross irrigated acreage in the San Joaquin Valley portion of Kern County was about 880,600 acres in 1996. Since 20,500 acres were double-cropped, total gross acreage in 1996 was 860,100 acres. Approximately 748,000 acres were irrigated over the usable groundwater basin, and 132,500 acres were irrigated on lands outside the usable groundwater basin. Total irrigated acreage increased 4 percent over 1995.

Kern County produces more than 30 percent of the nation's carrots. During 1996, carrot acreage increased by 4,700 acres. Cotton acreage decreased by 15,400 acres from 1995 to 1996, due to

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

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

Mean Oil Field Water	10,000 AF
Median Oil Field Water	9,600 AF
Minimum Oil Field Water (1990)	5,300 AF
Maximum Oil Field Water (1995)	19,800 AF

Figure 11. Oil Field Produced Water in Kern County

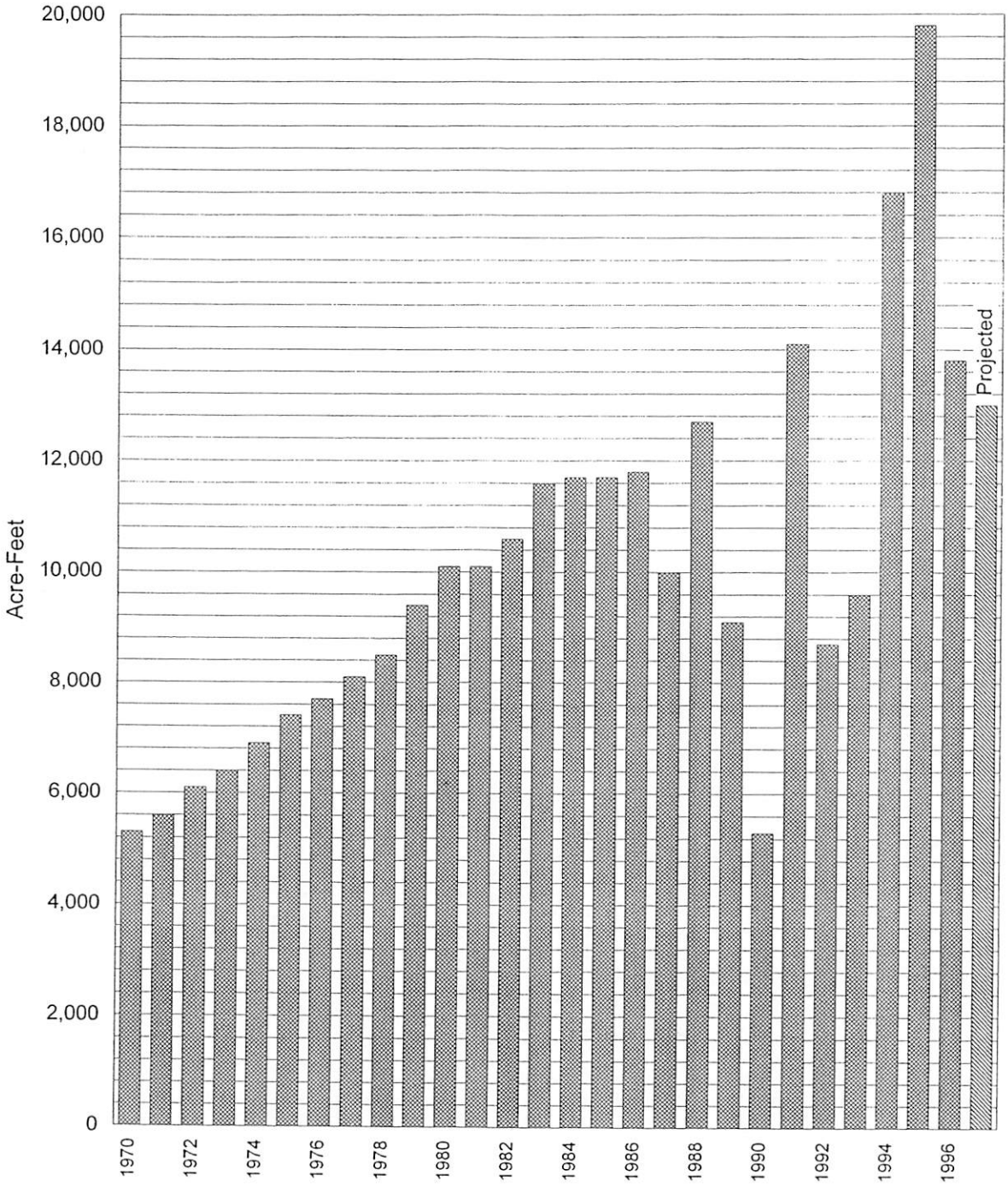
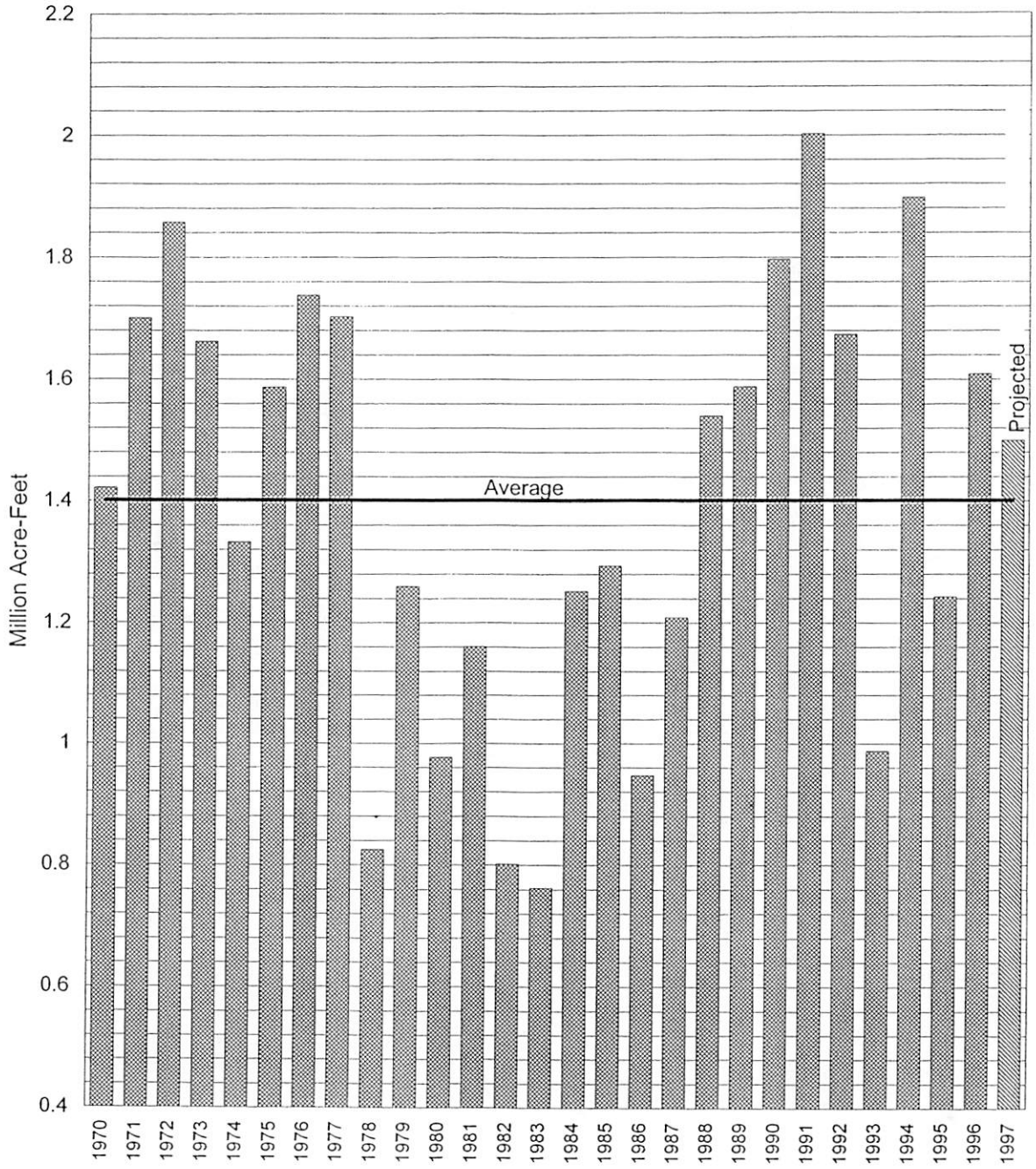


Table 15. Groundwater Pumping in the San Joaquin Valley Portion of Kern County (in acre-feet)

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

Mean Groundwater Pumping	1,401,200 AF
Median Groundwater Pumping	1,422,000 AF
Minimum Pumping (1983)	762,700 AF
Maximum Pumping (1991)	2,002,400 AF

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



the variability in water supply during the period. Grapes, including both wine and table grapes, increased by 7,100 acres. About 155,500 acres were idle in 1996.

A historical 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 32 percent of Kern County's total acreage. Cotton remains an important crop to Kern County's economy, and accounts for another 33 percent of the county's total acreage. Alfalfa and other green feeds accounted for about 10 percent of Kern County's total acreage, and are grown to support the dairy and cattle industries (milk and cream production are now California's number one crop), as well as for pleasure horses. Vegetables represent about another 9 percent of Kern County's agricultural acreage.

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

The Kern County Agricultural Commissioner's annual crop report for 1996 shows that Kern agricultural products reached a new high market value of $2,067,052,000. This is an increase of 4 percent from 1995, and is attributable to an increase in irrigated acreage related to abundant water supplies. A comparison of 1995 to 1996 gross crop values shows:

	1996	1995	Change
Trees and Vines	$977,834,000	$1,005,502,000	$-27,668,000
Cotton	346,812,000	296,764,000	50,048,000
Field crops	30,610,000	37,810,000	-7,200,000
Green Feeds	86,951,000	68,983,000.	17,968,000
Vegetables	343,463,000	329,777,000	13,686,000
Grains	36,660,000	20,387,000	16,273,000
Other	244,722,000	219,728,000	24,994,000
Total	$2,067,052,000	$1,978,951,000	$88,101,000

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

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

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

Source: 1992 Agricultural Statistics

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

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

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

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

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

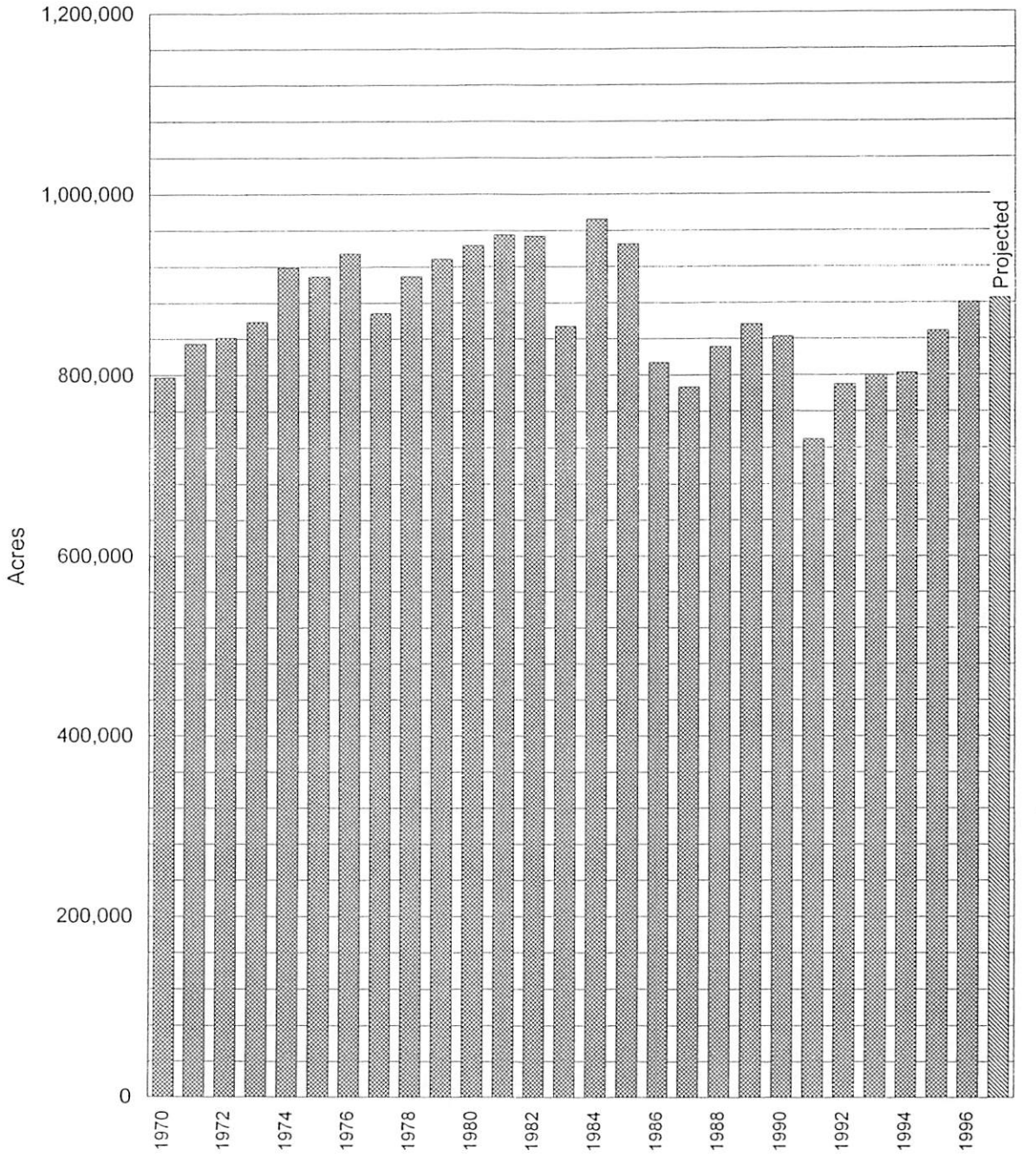
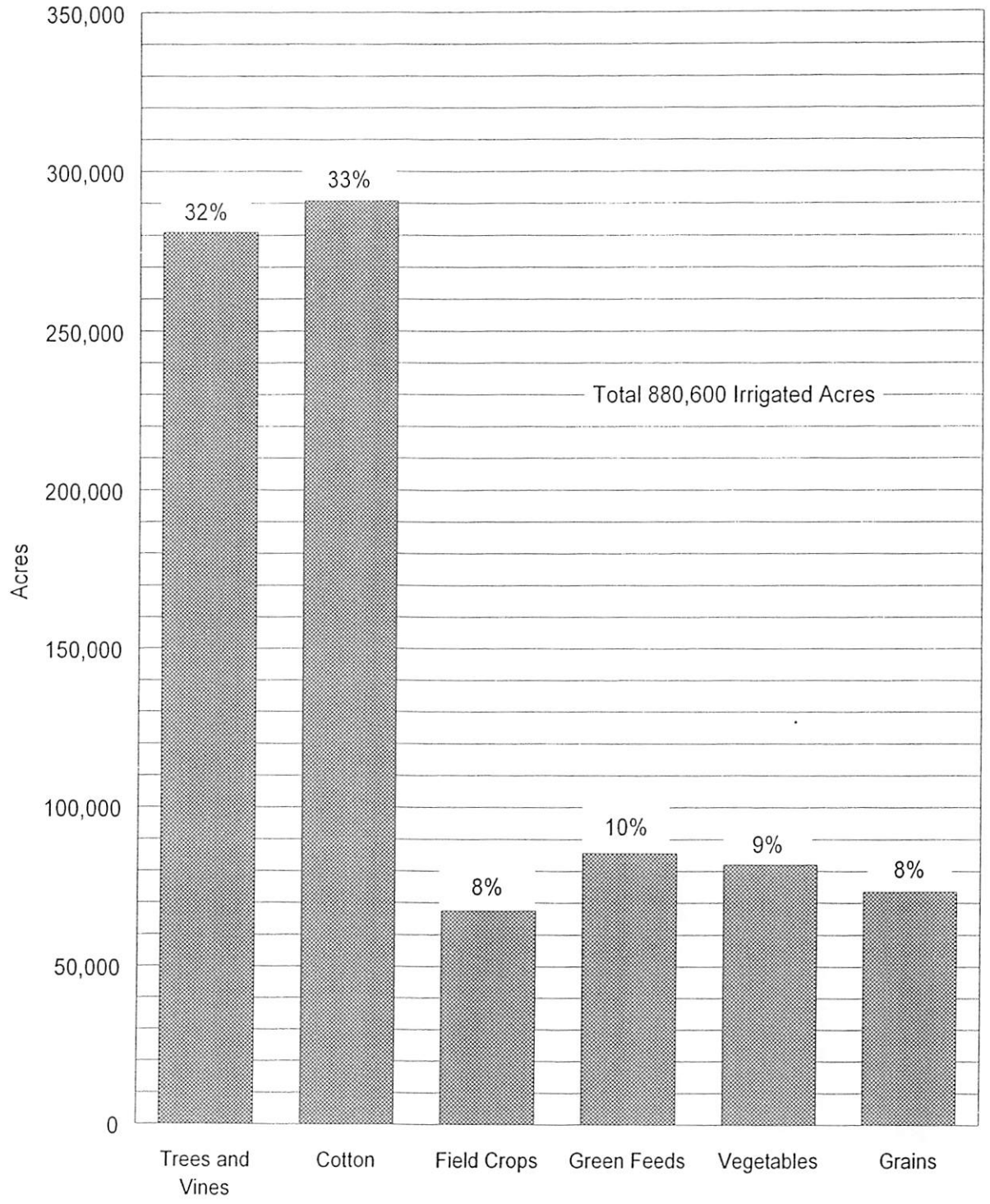


Figure 14. 1996 Summary of Irrigated Acreage



Per unit crop demands in 1996 were normal. Table 17 is a summary of monthly evaporation as measured at three climatic stations in the county. Evaporation is a key parameter for measuring crop water use. The Bakersfield 12S and 14W stations (operated by the Department of Water Resources) typify evaporation on the San Joaquin Valley floor. Figure 15 displays monthly evaporation for these stations as percent of normal.

Many crops experienced yield increases compared to 1995, with its extremely wet spring conditions. Almond yields increased by 13 percent, while cotton increased by 12 percent.

KCWA uses data from the California Irrigation Management 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 1996 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 1996 were estimated to be about 3,137,200 acre-feet with 2,748,100 acre-feet occurring over the usable groundwater basin. Net agricultural requirements in 1996 were about 2,523,900 acre-feet with about 1,298,800 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 113,700 acre-feet of water was lost to saline sinks during 1996, and about 21,500 acre-feet was lost to moisture-deficient soils. About 552,500 acre-feet of agricultural water applied in 1996 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 1996 were estimated to be about 193,500 acre-feet, with about 178,100 acre-feet required over the usable groundwater basin. Of this total, 29,900 acre-feet was supplied by KCWA's Henry C. Garnett Water Purification Plant. Olcese Water District served the Rio Bravo area with 870 acre-feet of treated Kern River water. East Niles Community Services

Table 17. 1996 Monthly Evaporation for San Joaquin Valley Climatic Station (in inches)

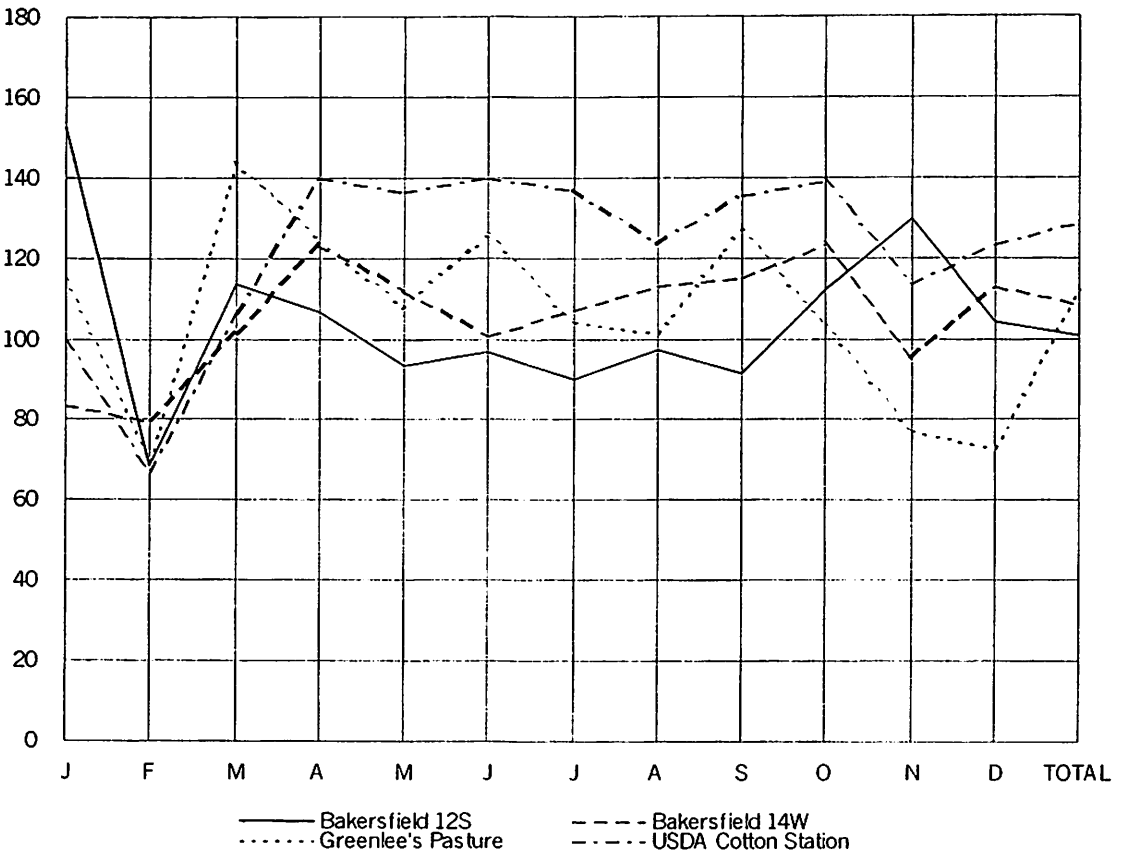
Table 17
1996 Monthly Evaporation for
San Joaquin Valley Climatic Stations
(in inches)

	Bakersfield 14W	USDA Cotton Station	Greenlee's Pasture	Avg. All Stations
January	1.18	1.33	1.42	1.26
February	1.75	1.87	1.61	1.81
March	4.02	4.17	5.74	4.10
April	7.16	8.13	7.71	7.65
May	9.28	10.85	9.26	10.07
June	9.62	11.61	11.31	10.62
July	10.37	11.7	9.64	11.04
August	9.62	9.71	8.38	9.67
September	7.36	8.18	8.1	7.77
October	5.33	5.97	4.7	5.65
November	2.04	2.56	1.71	2.30
December	1.37	1.61	0.98	1.49
Total	**69.10**	**77.69**	**70.56**	**73.40**
Percent of Normal	**109**	**128**	**111**	**116**

Station Locations

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

Figure 15. 1996 Percent of Normal Evaporation



Percent of Normal, Total:

Bakersfield 12S	**100.5**
Bakersfield 14W	**108.8**
Greenlee's Pasture	**111.3**
USDA Cotton Station	**128.5**

Bakersfield 12S

1996 observed monthly EP, Bakersfield 12S (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

Bakersfield 14W

1996 observed monthly EP, Bakersfield 14W (irrigated pasture) compared to long-term average for pasture pans in the San Joaquin Valley. This station is indicative of EP on the valley floor.

Greenlee's Pasture

1996 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

1996 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. 1996 Irrigated Acreage, San Joaquin Valley Portion of Kern County

Crop	Acres [1]	Percent of Total	Consumptive Water Use [2] (AF/Acre)
Alfalfa (including seed)	80,256	7.6	3.86
Almonds	81,812	7.7	3.64
Apples	5,268	0.5	3.46
Apricots	767	<0.1	3.44
Asparagus	393	<0.1	3.82
Avocado	5	<0.1	3.72
Barley	18,525	1.7	1.76
Beans	6,245	0.6	1.93
Broccoli	244	<0.1	0.53
Carrots	32,227	3.0	0.69
Citrus	43,949	4.2	3.28
Corn, Field & Sweet	17,362	1.6	2.83
Cotton	290,768	27.5	2.93
Dry Farmed Grains, Pasture	22,535	2.1	-
Figs	584	<0.1	3.53
Grapes	97,276	9.2	2.53
Guayale, Jojoba	209	<0.1	1.95
Idle, Fallow Lands	155,526	14.7	-
Kiwi	476	<0.1	2.66
Lettuce	2,888	0.3	0.17
Melons, Squash, Cucumbers	9,927	0.9	1.86
Misc. Deciduous Trees	9,847	0.9	3.53
Misc. Field Crops	1,375	0.1	2.50
Misc. Hay/Grain	11,165	1.1	1.67
Misc. Subtropical Trees	575	<0.1	2.90
Misc. Vegetables	2,985	0.3	1.60
Nursery	4,549	0.4	3.79
Oats	2,360	0.2	1.70
Olives	953	<0.1	3.44
Onions, Garlic	15,871	1.5	3.60
Pasture, Turf	5,394	0.5	4.76
Peaches, Nectarines	5,742	0.5	3.40
Pears	44	<0.1	3.64
Peas	320	<0.1	1.61
Peppers	1,653	0.2	2.09
Pistachios	29,153	2.8	3.43
Plums, Prunes	2,717	0.3	3.47
Potatoes	27,497	2.6	2.01
Rice	-	-	-
Safflower	9,712	0.9	2.65
Sorghum/Milo	1,140	0.1	2.29
Sudan Grass	155	<0.1	2.15
Sugar Beets	7,758	0.7	3.54
Tomatoes	7,292	0.7	2.55
Turnips	71	<0.1	1.60
Walnuts	1,666	0.2	2.84
Wheat	41,437	3.9	2.43
Total Irrigated Lands	**880,612**	**100.0**	**2.88**
Total Harvested Lands	**903,147**		
Double Cropped	**20,482**		

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

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

[2] Weighted average consumptive use of all crops.

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.

District used about 1,860 acre-feet of CVP water obtained from Arvin-Edison WSD. The remainder of M&I needs, 145,500 acre-feet, was supplied by groundwater. Table 20 gives a breakdown of urban water deliveries by water purveyor service area. The total production of the purveyors as shown on Table 20 is less than gross M&I requirements. This is because many rural families and businesses maintain their own water systems (wells), and their production volumes are not recorded. Gross M&I requirements include an estimate of the needs of these rural areas.

Average municipal and industrial water use over the groundwater basin was 332 gallons per capita per day (gpcd), slightly higher than 1995. This increase in water use in wet years such as 1996 is observed in urban areas throughout California. 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 1996 was about 185 gpcd.

Net M&I consumptive use in 1996 was about 52,500 acre-feet over the groundwater basin. Gross return flows from M&I uses were about 125,600 acre-feet. About 51,300 acre-feet were treated in wastewater treatment facilities and evaporated, percolated or reused for agriculture. The remaining 74,300 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 1996, 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. No water was exported from Kern County in this manner during 1996.

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 1996 about 67,500 acre-feet of evaporation losses occurred, with about 66,900 over the groundwater basin. This was substantially more than in 1995, and is probably due to the increase in wetted surface area over a longer period of time during wet year 1996.

CHANGE IN GROUNDWATER STORAGE

Figure 16 displays a gross total water demand for the San Joaquin Valley portion of Kern County of 4,650,700 acre-feet in 1996. About 4,291,900 acre-feet of this demand occurred over the

Table 20. 1996 Urban Water Use, San Joaquin Valley Portion of Kern County

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

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

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

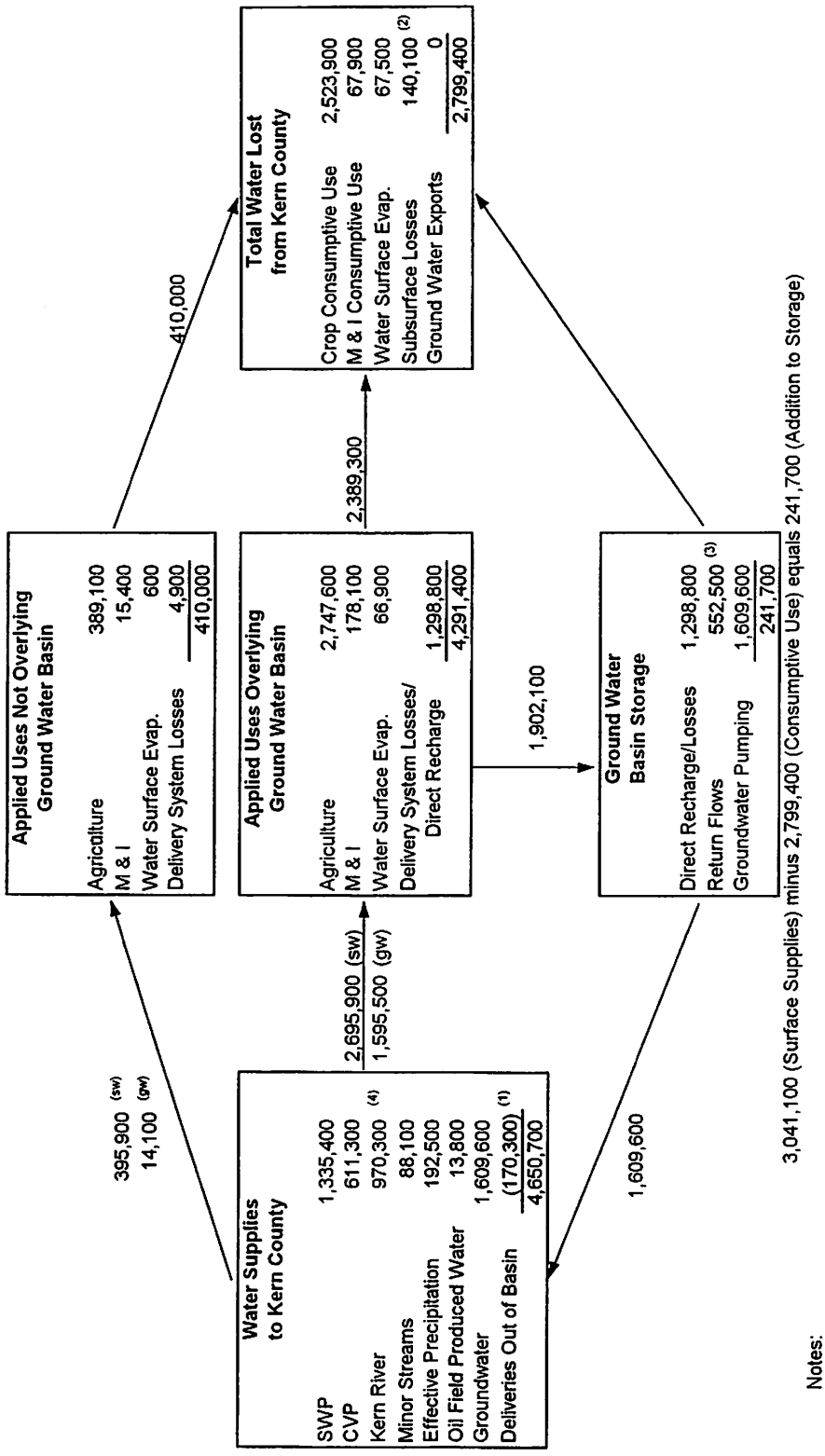
(3) Includes significant quantities of water used to irrigate a golf course.

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

(5) 1996 data not available; estimated using 1994 data.

(6) 1996 data not available; estimated using 1995 data.

Figure 16. 1996 Water Resources Inventory, San Joaquin Valley Portion of Kern County (acre-feet)



groundwater basin. A large amount of water, 1,298,800 acre-feet, was used for direct recharge or unlined delivery system losses. Total net water use was 2,799,400 acre-feet, with about 2,389,300 used over the groundwater basin. Gross available surface water supplies were about 3,041,100 acre-feet. While there was a net increase in groundwater storage of 241,700 acre-feet in 1996, this was considerably less than in the very wet year 1995.

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 1996, about 12,955,000 acre-feet was withdrawn from groundwater storage. During the same period the balance between additions and extractions has replenished about 6,919,000 acre-feet. The average change in storage since 1970 is about 256,000 acre-feet per year. Figure 18 shows the cumulative groundwater balance since 1970. In volume of groundwater storage, the basin still stands below 1977 levels, although a definite upward trend continues.

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

BASIN-WIDE WATER USE EFFICIENCY

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

Over the entire San Joaquin Valley portion of Kern County, gross water uses were about 4,650,100 acre-feet during 1996 (3,136,700 for agriculture, 193,500 for M&I use, 67,500 of evaporation losses, 1,298,800 for groundwater recharge, and 4,900 in unrecoverable delivery system losses). Total consumption of water was about 2,659,300 acre-feet (2,523,900 by agriculture, 67,900 by M&I, and 67,500 in evaporation losses). Effective precipitation was about 192,500 acre-feet. Agricultural irrigation efficiency was about 74 percent. A total of 51,200 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 743,800 acre-feet. However, about 118,600 acre-feet of deep percolation was intercepted by shallow

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

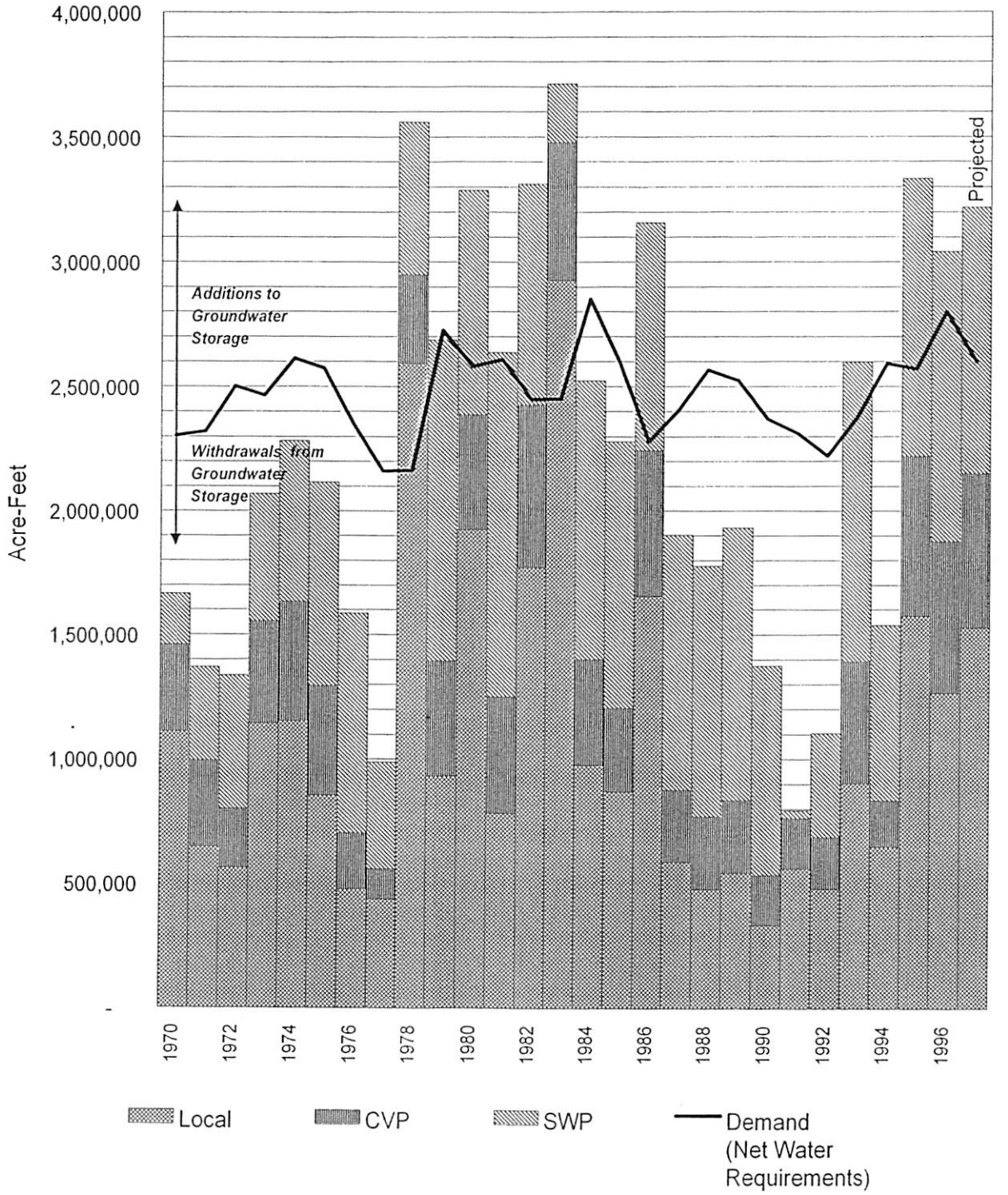


Figure 18. Cumulative Change in Groundwater Storage, San Joaquin Valley Portion of Kern County

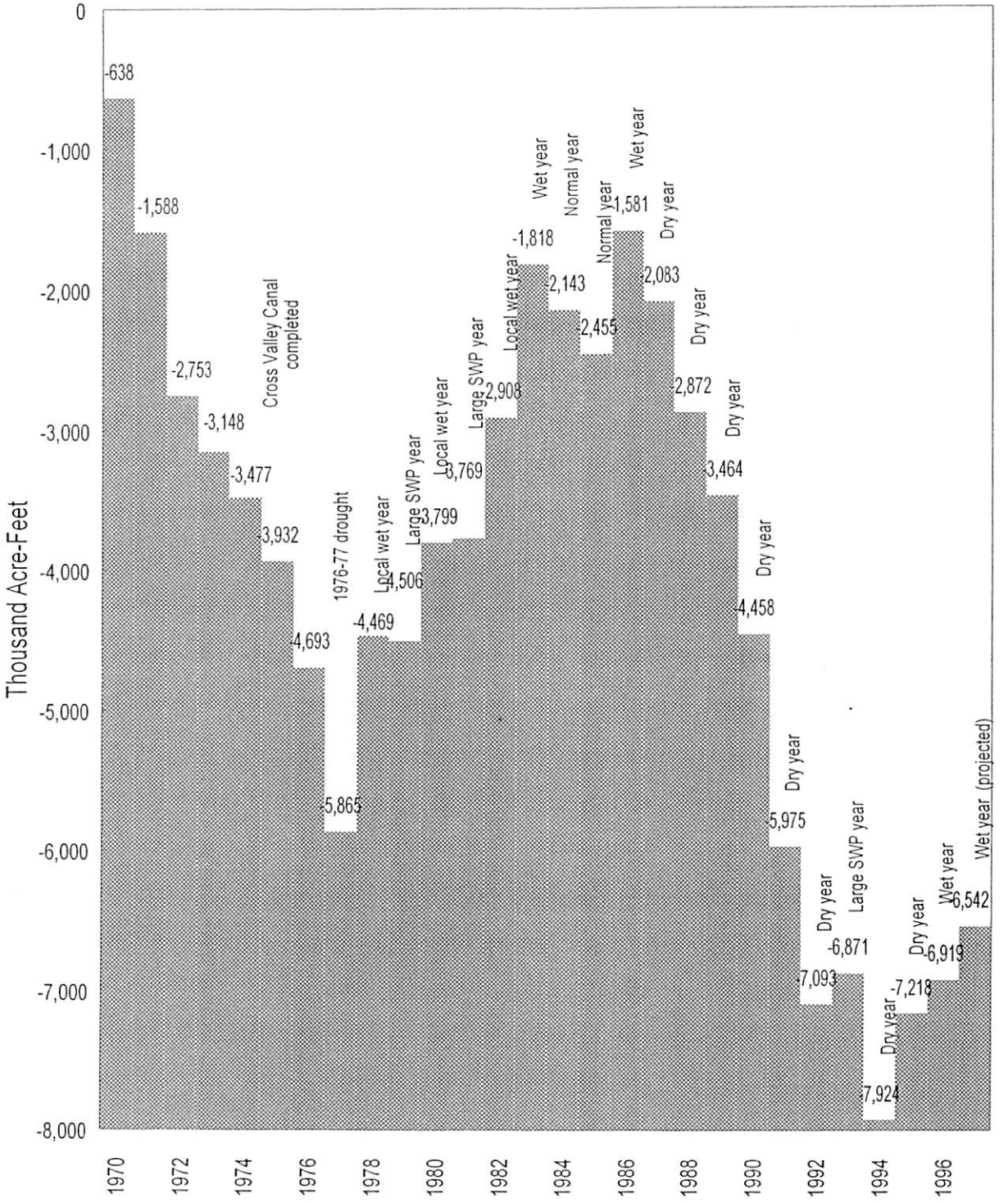


Table 21. Surface* and Groundwater Usage or Availability, San Joaquin Valley Portion of Kern County (in acre-feet)

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

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

groundwater, and another 21,500 acre-feet was absorbed by moisture-deficient soils. Therefore net groundwater returns were 552,500 acre-feet in 1996.

Of the 4,650,100 acre-feet in gross water demand during 1996, 4,493,900 acre-feet was beneficially used or was available for reuse via net deep percolation. This means that 97 percent of the water used in 1996 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-State Water Project Intertie was not operated during 1996. Table 22 displays data for years in which the Intertie was operated.

GROUNDWATER CONDITIONS

Groundwater Recharge

Numerous entities in Kern County are actively engaged in groundwater replenishment operations. The Semitropic ID, 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 channel. Central Valley Project water is recharged in spreading ponds operated by the Arvin-Edison Water Storage District or in the Kern River and Poso Creek channels, as well as recharge facilities on the Kern River Fan. State Water Project 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

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)
Total	**1,010,220**	**132,861**	**1,143,081**	(2)			**608,665**				**521,299**	(2)

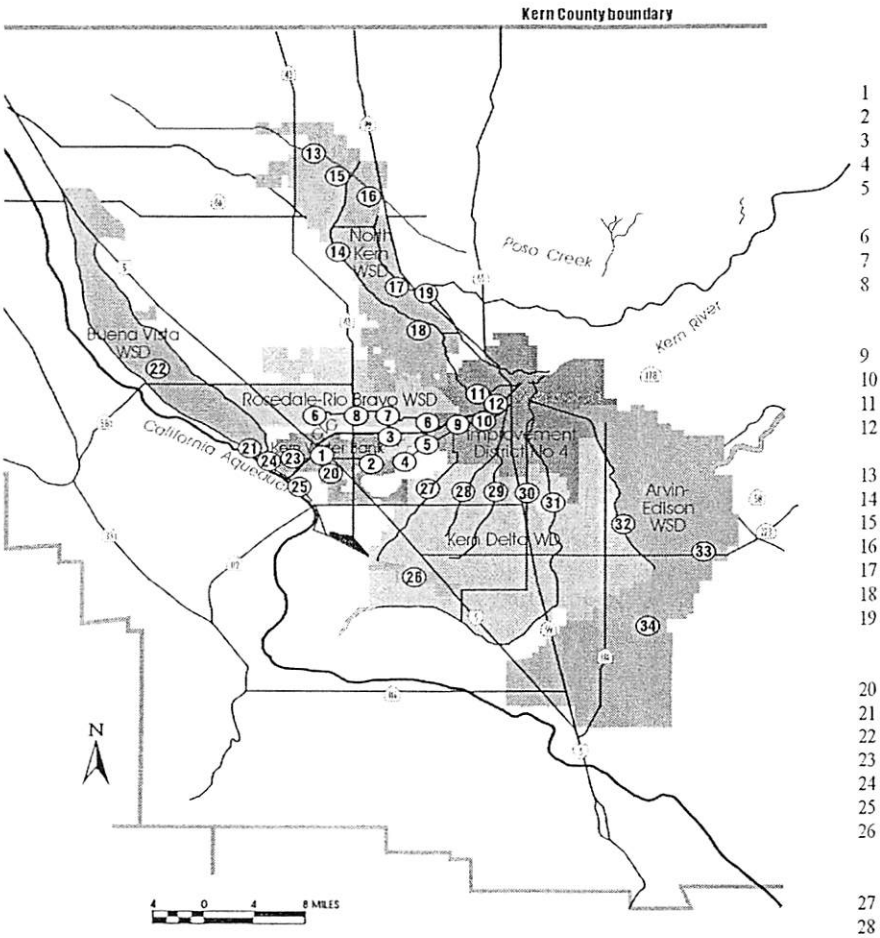
* A breakdown between sources was not available.

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

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

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

Figure 19. Groundwater Recharge Sites
1996 Summary
Southern San Joaquin Valley Portion of Kern County



	Location	Recharge (AF)
1	Kern Fan Element	174,000
2	COB 2800 Ac	61.000
3	Pioneer North	42,000
4	Pioneer South	16,000
5	Berrenda Mesa Spreading	10.000
6	Rosedale-Rio Bravo WSD	
7	Goose Lake Slough	
8	KFE/RRB	
	RRBWSD Total	125.000
9	Kern River	93,000
10	Truxtun Lakes	6.000
11	Calloway Canal and One Ditch	11.000
12	Cross Valley Canal extension	2,000
13	Poso Creek	
14	Calloway Canal	
15	Poso 27	
16	Switch Field	
17	Minter Field	
18	Rosedale Ponds	
19	Lerdo Canal	
	North Kern WSD Total	162,000
20	Kern River Bypass Channel	17,000
21	Kern River Flood Channel	0
22	Buttonwillow Canals	42,000
23	Main Canal	4.000
24	Outlet Elk Pen	1.000
25	Outlet Canal	10,000
26	Maples Canal	1,000
	Buena Vista WSD Total	75.000
27	Buena Vista Canal	
28	Stine Canal	
29	Farmers Canal	
30	Kern Island Canal	
31	Central Branch Canal	
32	Eastside Canal	
	Kern Delta WD Total	66.000
33	Sycamore Spreading Grounds	
34	Tejon Spreading Grounds	
	Arvin-Edison WSD Total	58.000
	Grand Total	**976,000**

of these programs. Table 23 shows major conjunctive use and banking programs since 1971, listing the amounts of water by source. About 1,298,800 acre-feet of water was recharged in 1996, deliberately and incidentally. Following is the approximate breakdown between sources:

Kern River	851,700	
SWP	139,000	
CVP	128,000	
Wastewater	4,100	
Minor Streams	83,700	
Combined	9,300	
Total	**1,298,800**	**Acre-feet**

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

Such recharge activities show the importance of reducing groundwater overdraft, as well as water conservation, in Kern County. Since 1970 about 15,200,000 acre-feet of water has been recharged (deliberately and incidentally) as part of groundwater replenishment programs and banking operations. The effectiveness of such recharge activities is apparent in Figure 17. KCWA estimates that the 15,200,000 acre-feet of recharged water results in a gross basin-wide groundwater pumping lift reduction of about 152 feet, or about one foot for every 100,000 acre-feet. Figure 20 shows historic groundwater recharge as a bar graph. It clearly shows that 1996, with its later rainfall and lag time in surface supplies, caused extractions to be higher than recharge.

Groundwater Banking

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

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

to reach an ultimate storage capacity of nearly 1,000,000 acre-feet. In 1996, the Kern Water Bank recharged a total of 161,684 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 1996 a total of 38,600 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 proposed "Pioneer Project" comprises two parcels on either side of the Kern River southwest of Bakersfield. When completed, the Pioneer Project will increase Kern County's groundwater recharge capacity by about 170,000 acre-feet a year. During 1996, about 52,370 acre-feet were recharged through the Pioneer Project.

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

Shallow Groundwater

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

The areas suffering from shallow groundwater in Kern County follow the historic lower-elevation trace of the Kern River channel. Increases in shallow groundwater area appear after a year of high Kern River runoff. Similarly, contractions seem to occur during years when runoff is low. In this sense, shallow groundwater seems to be a natural phenomenon.Table 25 lists historic areas with shallow groundwater problems, categorized into five-foot increments, along with the number of monitoring wells measured. At first glance, it may seem that an enormous increase in shallow 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 1996 water within five feet of the ground surface was found under an area of about 27,000 acres. This was a 72 percent decrease from the summer 1995 areal extent. The areal extent of shallow groundwater between 5-10 feet of the ground surface was about 157,400 acres, about 92 percent higher than 1995. The areal extent of shallow groundwater between 10-15 feet

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

Entity/Location	Source	1971-91	1992	1993	1994	1995	1996	Total
BANKING								
City of Bakersfield [2]								
2,800 Acre Spreading Area	Combined [1]	614,823	--	7,881	--	39,117	21,994	683,815
Kern County Water Agency								
Kern Water Bank	Combined [1]	--	--	--	--	688	18,069	18,757
Pioneer Property	Combined [1]	--	--	--	--	102,693	52,367	155,060
Berrenda Mesa Spreading Area	Combined [1]	33,960	--	7,563	2,333	34,280	9,554	87,690 [1]
Kern River Channel	Combined [1]	33,552	--	26,494	--	2,029	6,179	68,254
2,800 Acre Spreading Area	Combined [1]	82,733	--	125,734	20,551	73,337	16,612	318,967
Subtotal KCWA		150,245	--	159,791	22,884	213,027	102,781	648,728
Kern Water Bank Authority								
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	Combined [1]	--	--	--	--	230,938	143,615	374,553
2800 Acres	Combined [1]	--	--	--	--	--	--	--
Pioneer Property	Combined [1]	--	--	--	--	--	--	--
Subtotal KWBA		--	--	--	--	230,938	143,615	374,553
Total Banking		912,947	--	167,672	22,884	483,082	268,390	1,854,975
CONJUNCTIVE USE								
Arvin-Edison WSD	Friant-Kern	717,929	5,553	120,217	3,884	108,664	51,954	1,008,201
Buena Vista WSD Direct Rechg.	Combined (1)	1,313,714	34,308	76,743	47,161	128,203	81,156	1,681,285
Semitropic WSD Direct Rechg.	SWP	59,472	9,326	9,738	8,960	20,881	23,560	131,937
In-Lieu Rechg.	SWP	636,971	1,531	31,728	34,638	73,954	114,135	892,957
	Combined [1]	7,289	--	--	--	--	--	7,289 [1]
I.D. No. 4 Direct Rechg.	Kern River	420,975	4,437	30,319	15,250	30,692	64,753	566,426
	SWP	259,258	2,574	44,557	14,030	19,523	138	340,080
	Friant-Kern	18,835	--	8,084	193	7,098	9,754	43,964
Kern Delta WD Direct Rechg.	Combined [1]	1,100,768	37,740	57,428	47,675	61,252	65,301	1,370,164
North Kern WSD Direct Rechg.	Kern River	1,424,685	23,967	61,512	30,255	242,263	121,233	1,903,915
In-Lieu Rechg.	Kern River	2,259,110	26,739	133,785	86,402	124,873	140,781	2,771,690
Rosedale-Rio Bravo WSD Direct Rechg.	Kern River	517,980	1,041	26,890	--	102,307	44,293	692,511
	SWP	514,643	8,282	55,636	6,119	48,375	29,545	662,600
	Friant-Kern	161,869	--	6,859	--	8,470	25,919	203,117
	Combined [1]	279,800	--	--	--	--	--	279,800 [1]
In-Lieu Rechg.	SWP	--	--	--	2,657	--	--	2,657
Wheeler Ridge-Maricopa WSD								
In-Lieu Recharge	SWP	193,714	--	6,882	--	12,650	--	213,246
Total Conjunctive Use		9,887,012	155,498	670,378	297,224	989,205	772,522	12,771,839
OVERDRAFT CORRECTION								
Groundwater Replenishment Programs								
Direct Rechg.	Kern River	188,185	--	--	--	--	5,365	193,550
	SWP	257,920	--	521	--	--	38,795	297,236
	Friant-Kern	7,723	--	--	--	--	4,396	12,119
In Lieu Rechg.	Kern River	--	--	573	--	3,725	3,189	7,487
	SWP	96,871	--	1,194	--	--	--	98,065
Total Overdraft Correction		550,699	--	2,288	--	3,725	51,745	608,457
GRAND TOTALS	**Kern River**	4,810,935	56,184	253,079	131,907	503,860	379,614	6,135,579
	SWP	2,166,728	21,713	150,256	66,404	175,383	206,173	2,786,657
	Friant-Kern	906,356	5,553	135,160	4,077	124,232	92,023	1,267,401
	Combined [1]	3,466,639	72,048	301,843	117,720	672,537	414,847	5,045,634 [1]
	Total	11,350,658	155,498	840,338	320,108	1,476,012	1,092,657	15,235,271

[1] Breakdown between sources not available.

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

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

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

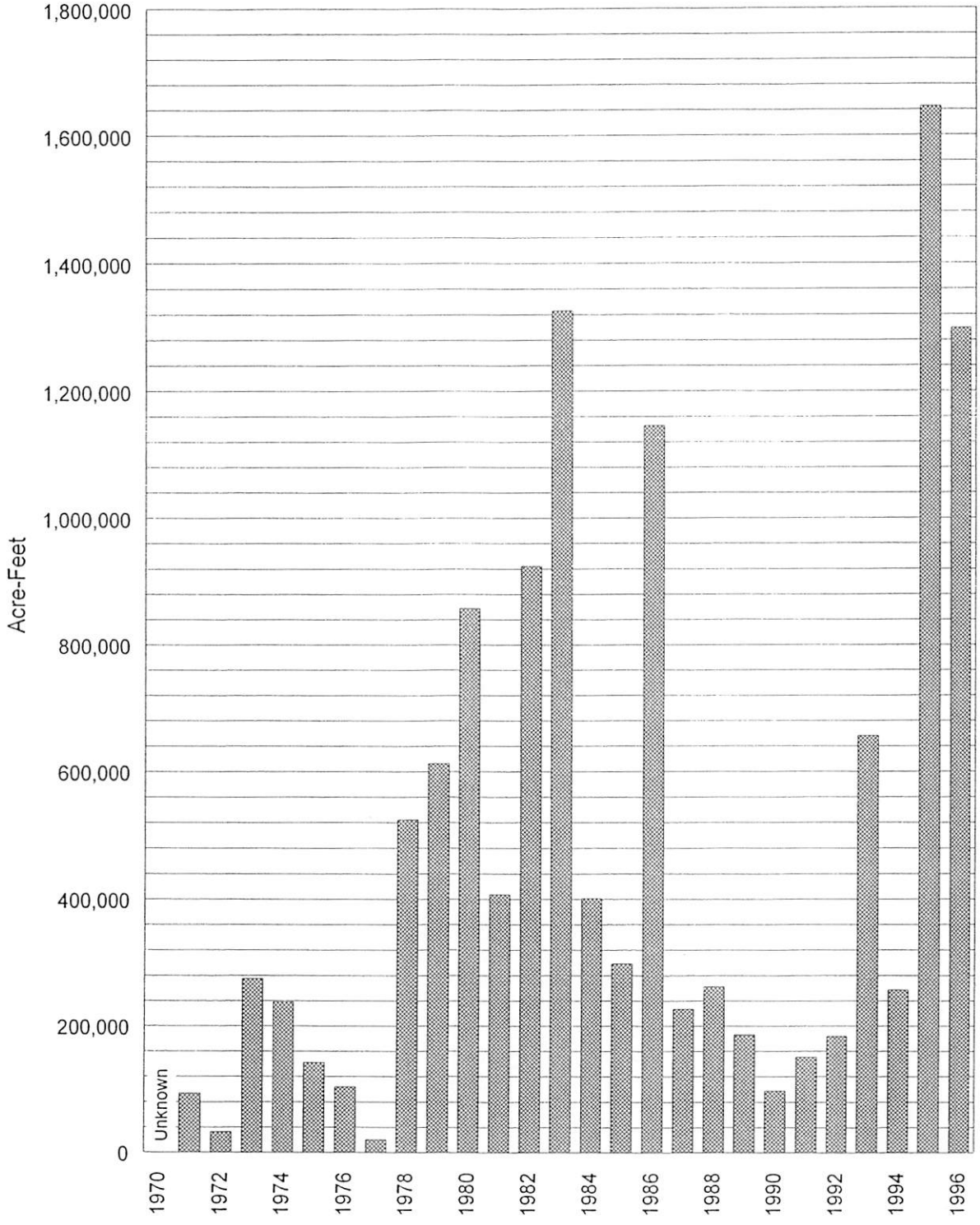


Table 24. Groundwater Banking Summary

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
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)
Storage Balance	6,056	15,969	15,969	15,969	40,434	40,434	40,434	40,434	50,434	44,434
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
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)
Storage Balance	104,587	109,092	164,124	65,890	103,803	217,183	232,769	231,556	295,724	295,177
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	
Recovery/Sale										
Storage Balance									12,766	12,766
Kern County Water Agency										
Recharge/Purchase				63,364		14,155	416	15,055	29,389	
Recovery/Sale										
Storage Balance				63,364	63,364	77,519	77,935	92,990	122,379	122,379
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
Recovery/Sale										
Storage Balance	24,328	24,328	76,932	81,397	95,663	95,663	95,663	95,663	151,860	157,204
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
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
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						
Recovery/Sale										
Storage Balance				5,600	5,600	5,600	5,600	5,600	5,600	5,600
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
Recovery/Sale			(13,772)	(100,837)			(472)	(1,615)		(6,656)
Storage Balance	134,971	149,389	257,025	241,720	318,364	445,899	461,901	475,743	648,263	654,439

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

Table 24 (continued). Groundwater Banking Summary

	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
Alameda County WD										
Recharge/Purchase									5,580	5,580
Recovery/Sale										
Storage Balance									5,580	5,580
Belridge WSD										
Recharge/Purchase						14,204	325	15,642	3,942	34,113
Recovery/Sale							(2,029)			(2,029)
Storage Balance						14,204	12,500	28,142	32,084	32,084
Buena Vista WSD										
Recharge/Purchase						7,849		27,535	20,000	105,818
Recovery/Sale	(5,000)	(3,138)	(2,242)	(4,410)	(4,004)					(24,794)
Storage Balance	39,434	36,296	34,054	29,644	25,640	33,489	33,489	61,024	81,024	81,024
Berrenda Mesa WD										
Recharge/Purchase				4,002		7,936	6,568	59,819	4,686	92,511
Recovery/Sale			(9,500)	(4,002)			(400)			(13,902)
Storage Balance	9,500	9,500				7,936	14,104	73,923	78,609	78,609
Cawelo WD										
Recharge/Purchase						14,068		3,245	2,000	19,313
Recovery/Sale							(44)			(44)
Storage Balance						14,068	14,024	17,269	19,269	19,269
City of Bakersfield										
Recharge/Purchase						32		13,089	300	425,950
Recovery/Sale	(5,432)	(2,859)	(23,318)	(57,159)	(30,266)		(8,311)	(1,297)	(1,781)	(247,775)
Storage Balance	289,745	286,886	263,568	206,409	176,143	176,175	167,864	179,656	178,175	178,175
Dudley Ridge WD										
Recharge/Purchase								1,587	20,748	22,335
Recovery/Sale										
Storage Balance								1,587	22,335	22,335
Henry Miller WD										
Recharge/Purchase								3,999	5,223	9,222
Recovery/Sale										
Storage Balance								3,999	9,222	9,222
Improvement District No. 4										
Recharge/Purchase		3,500				23,007	10,641	92,765	71,851	214,530
Recovery/Sale					(3,500)		(100)	(1,500)		(5,100)
Storage Balance	12,766	16,266	16,266	16,266	12,766	35,773	46,314	137,579	209,430	209,430
Kern County Water Agency										
Recharge/Purchase				42,096	6,450	5,542		28,999	45,069	250,535
Recovery/Sale		(16,105)		(66,775)	(22,684)					(105,564)
Storage Balance	122,379	106,274	106,274	81,595	65,361	70,903	70,903	99,902	144,971	144,971
Kern Delta WD										
Recharge/Purchase										
Recovery/Sale										
Storage Balance										
Lost Hills WD										
Recharge/Purchase				2,035		31,153	5,280	26,191	8,079	72,738
Recovery/Sale										
Storage Balance				2,035	2,035	33,188	38,468	64,659	72,738	72,738
Metropolitan WD of So. Calif.										
Recharge/Purchase						50,000		45,000	85,499	180,499
Recovery/Sale										
Storage Balance						50,000	50,000	95,000	180,499	180,499
OlceseWD/Hacienda WD										
Recharge/Purchase	3,214			22,096	6,450			6,028	1,694	196,686
Recovery/Sale		(873)	(104,305)	(23,496)	(6,450)		(1,160)			(136,284)
Storage Balance	160,418	159,545	55,240	53,840	53,840	53,840	52,680	58,708	60,402	60,402
Rosedale-Rio Bravo WSD										
Recharge/Purchase								6,355	14,342	20,697
Recovery/Sale									(12,265)	(12,265)
Storage Balance								6,355	8,432	8,432

Table 24 (continued). Groundwater Banking Summary

	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
Semitropic WSD										
Recharge/Purchase						19,972		1,100	29,945	51,017
Recovery/Sale							(181)			(181)
Storage Balance						19,972	19,791	20,891	50,836	50,836
Santa Clara Valley WD										
Recharge/Purchase									40,500	40,500
Recovery/Sale										
Storage Balance									40,500	40,500
State of California										
Recharge/Purchase			248,005							255,384
Recovery/Sale					(72,049)		(12,458)	(752)	(41,563)	(126,822)
Storage Balance	7,379	7,379	255,384	255,384	183,335	183,335	170,877	170,125	128,562	128,562
Tejon-Castac WD										
Recharge/Purchase							70	2,324	6,211	8,605
Recovery/Sale										
Storage Balance							70	2,394	8,605	8,605
Westside Mutual Water Co.										
Recharge/Purchase								134,517	65,321	199,838
Recovery/Sale									(5,000)	(5,000)
Storage Balance								134,517	194,838	194,838
Wheeler Ridge-Maricopa WSD										
Recharge/Purchase		15,019				58,290		61,387	27,807	168,103
Recovery/Sale							(7,551)			(7,551)
Storage Balance	5,600	20,619	20,619	20,619	20,619	78,909	71,358	132,745	160,552	160,552
Total of All Accounts										
Recharge/Purchase	**3,214**	**18,519**	**248,005**	**70,229**	**12,900**	**232,053**	**22,884**	**529,582**	**458,797**	**2,373,974**
Recovery/Sale	**(10,432)**	**(22,975)**	**(139,365)**	**(155,842)**	**(138,953)**		**(32,234)**	**(3,549)**	**(60,609)**	**(687,311)**
Storage Balance	647,221	642,765	751,405	665,792	539,739	771,792	762,442	1,288,475	1,686,663	1,686,663

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

	Summer Measurements						Winter Measurements					
Year	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezos	0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezos
1976	27,940	64,700	--	79,680 (1)	172,320	--	--	--	--	--	--	--
1977	19,320	68,980	--	95,960 (1)	184,260	180	16,930	52,530	--	67,300 (3)	136,760	143
1978	27,680	65,760	--	87,920 (1)	181,360	174	9,600	59,520	--	86,400 (3)	155,520	--
1979	30,270	67,310	--	95,870 (1)	193,450	--	15,320	83,200	--	80,640 (3)	179,160	126
1980	74,357	82,787	--	125,883 (1)	283,027	--	45,882	92,998	126,665	62,578	328,123	154
1981	62,002	85,556	--	128,323 (1)	275,881	178	46,746	75,318	36,736	104,200	263,000	168
1982	78,725	95,615	76,271	30,226	280,837	259	90,658	85,541	55,392	43,181	274,772	199
1983	109,915	90,090	63,510	48,980	312,495	227	--	--	--	--	--	--
1984	110,500	57,650	45,400	47,649	261,199	246	--	--	--	--	--	--
1985	49,396	120,396	123,776	90,323	383,891	290	--	--	--	--	--	--
1986	84,160	79,774	73,698	83,264	320,896	330	--	--	--	--	--	--
1987	57,600	84,864	89,816	76,672	308,952	261	90,800	74,100	61,200	72,200	298,300	--
1988	82,700	86,500	83,900	93,400	346,500	288	--	--	--	--	--	--
1989	65,536	95,949	83,558	85,760	330,803	328	--	--	--	--	--	--
1990	67,561	91,257	82,823	-- (2)	241,641 (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	--	--	--	--	--	--

(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.

-- 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 a more accurate map to be produced.

of the surface was 68,300 acres in 1996, a 19 percent increase over 1995. The probable cause for the decrease in areal extent for the 0-5 feet interval was relatively low precipitation in 1996. An examination of Table 25 shows that a large increase in area for the 0-5 feet interval 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 1996 (about 2,682,400 acre-feet), carried about 456,500 tons of new salts into the groundwater basin. This quantity of salt was somewhat less than the amount introduced in 1995, due to the comparatively lower availability of surface water in 1996.

Surface Water Salt Loads, 1996

Source	Volume (af)	Avg. TDS (ppm)	Salt Load (tons)
SWP Over G.W. Basin	847,600	223	257,000
Kern River	968,000	76	99,900
Minor Streams	88,100	413	49,500
Other Local Supplies*	167,400	70	15,900
CVP	611,300	41	34,200
Total	2,682,400	126	456,500

* 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.

Agricultural water well drilling decreased slightly during 1996 compared to activity in 1995. The Kern County Environmental Health Services Department issued 26 agricultural water well permits in 1996, in comparison to 30 permits issued during 1995. 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 1996, along with 83 wells for non-agricultural and non-domestic purposes (e.g., monitoring and cathodic protection wells). A total of 137 new agricultural and domestic water wells were drilled during 1996. Annular seals were required on three of the new wells to prevent degradation of lower groundwater zones (annular seals are plugs of cement between the well casing and the drilled hole near a regional stratum of low permeability to movement of water between two aquifer systems).

Groundwater Levels

Plate 4, "Depth to Groundwater, Spring 1996" was prepared by KCWA using hundreds of well measurements taken by KCWA and others. The 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 the basin. In areas north of Wasco water levels in confined wells are used for contouring because they best represent the aquifer most utilized. The "Depth to Groundwater" map shows the distances in feet from the ground surface to the water surface.

A "Groundwater Surface Elevation" map (Plate 5) was prepared based on the same measured wells as the "Depth to Groundwater" map. This map implies the horizontal movement of groundwater from higher to lower elevations. The major direction of groundwater movement is away from the sources of recharge.

Plate 5 shows what appears to be steep gradients between Semitropic Water Storage District and neighboring Buena Vista Water Storage District, Lost Hills Water District and Southern San Joaquin Municipal Utility District. Contours in these areas are based on both unconfined and confined wells. These apparent steep gradients are explained by the differences in water level between the unconfined and confined aquifers.

Historically, the Kern River has been the major groundwater recharge source. Mounding of water occurs along the Kern River channel, and groundwater moves away from this area. In this area, the rate of horizontal groundwater flow in the upper portions of the aquifer is estimated to be 70-500 feet per year. Another high area is along the northeastern edge of the valley. Also, some local mounding is attributed to local water districts' recharge efforts.

Generally, groundwater level lows are associated with areas of higher groundwater pumping. The largest of these areas is in the central portion of the valley (west/northwest of Wasco). Other low areas are in the extreme south end of the valley and in the Arvin area.

Plate 6 depicts groundwater level changes from Spring 1995 to Spring 1996. Differences were plotted and contoured to show areas of relative improvement or decline. Shading was added to emphasize significant level changes.

Unless the annual change exceeds 10 feet, little impact (either losses or gains) to storage can be inferred. The potential error related to the timing of groundwater level measurements and simple measuring errors preclude more precision.

In a dramatic change from 1994-95, very few areas within the basin showed water level declines. This is largely due to ample supplies of surface water, resulting in a corresponding lower demand for groundwater. Also, the large-scale groundwater recharge programs, begun in 1993, have contributed to the improved groundwater levels.

Areas that showed the greatest changes in water levels were near the Kern Water Bank, City of Bakersfield 2800 Acres Spreading Grounds and KCWA Pioneer Recharge Facility. Water levels near these recharge areas rose as much as 110 feet above the 1995 depth to water of 150 feet. Areas near the Arvin-Edison Water Storage District's recharge ponds (south of the City of Arvin) had water level increases between 20 and 60 feet. Even areas of the valley which normally show declines in water levels experienced either static conditions (no change) or water level rises between 10 and 20 feet.

Water level changes in eight key water wells are displayed on hydrographs asFigures 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 pair is between Shafter and Rosedale-Rio Bravo. A third pair of wells is southwest of Bakersfield. The fourth pair of wells is in the Arvin area.

The two wells in the Pond-Poso area represent the unconfined and confined aquifer systems in the area. The hydrographs are plotted together to compare water level changes in both aquifers. The unconfined well reflects an upward trend since the 1977 drought. This trend is probably a continuation of a long-term rise in water levels, caused by surface water deliveries from the Friant-Kern system. During 1990-92 drought conditions were more severe, with an increased dependence on groundwater. The recent decline in water levels reflects the expanded use of groundwater during the drought. The confined well shows a steady rise of water levels from the 1977 drought through 1987. This confined well shows a more rapid and marked response to the recent drought than did the unconfined well.

The Shafter/Rosedale-Rio Bravo area hydrographs represent the unconfined aquifer. The well (T29S/R26E-34Q01) is located between the Kern River channel and Rosedale-Rio Bravo WSD's recharge facilities. The hydrograph reflects a long-term decline in water levels from 1960 through the 1977 drought, with transient rises during years when Kern River flows were above average. Since these wells are situated close to the Kern River and recharge facilities, the hydrographs show rapid water level rises during the 1978-86 and 1993-96 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 a minimum of two aquifers exist in this area. The delivery of CVP water to Arvin-Edison in the mid-1960s caused groundwater levels to rise, as seen in the shallow well hydrograph. During the 1976-77 and 1978-86 droughts, groundwater levels declined. During the 1978-86 and current wet years, water levels rose.

INDIAN WELLS VALLEY

Indian Wells Valley is located in the northeast corner of Kern County. The extended valley floor encompasses about 450 square miles. The southern Sierra Nevada Mountains bound the valley 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. Surrounding mountains may reach 9,000 feet. The largest community in the valley is the city of Ridgecrest, with a population of about 29,000. The valley is an arid desert, with rainfall of only 3-4 inches per year. Little, if any, rainfall reaches the groundwater table; it is rapidly evaporated by high winds and high temperatures or transpired by desert plants. Presently, the only source of potable water is groundwater, much of which is of good to excellent quality. Groundwater recharge comes from the adjacent mountain ranges.

The "Cooperative Groundwater Management Plan for the Indian Wells Valley" was signed in September 1995. Participants include the U.S. Bureau of Land Management, Eastern Kern County Indian Wells Valley is located in the northeast corner of Kern County. The extended valley floor encompasses about 450 square miles. It is bounded by the Sierra Nevada Mountains on the west, the Coso Range on the north, the Argus Mountains on the east, the Rademacher Hills on the southeast and the El Paso Mountains on the south. Elevations on the valley floor range from 2,300 to 3,000 feet above sea level, and surrounding mountains may reach 9,000 feet. The largest community in the valley is the city of Ridgecrest, with a population of 29,000. The valley is an arid high desert, with rainfall of only 3-4 inches per year. Little rainfall reaches the groundwater table; it is rapidly evaporated by high winds and temperatures or transpired by desert plants. The only source of potable water is groundwater, much of which is of good to excellent quality, and is provided by recharge from the adjacent mountain ranges.

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

two ephemeral streams in the nearby Sierra Nevada. KCWA is also providing use of its groundwater database for storage of data generated by the technical subcommittee's projects.

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

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

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

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

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

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

Figure21a. Water Well Hydrograph
Pond-Poso Area

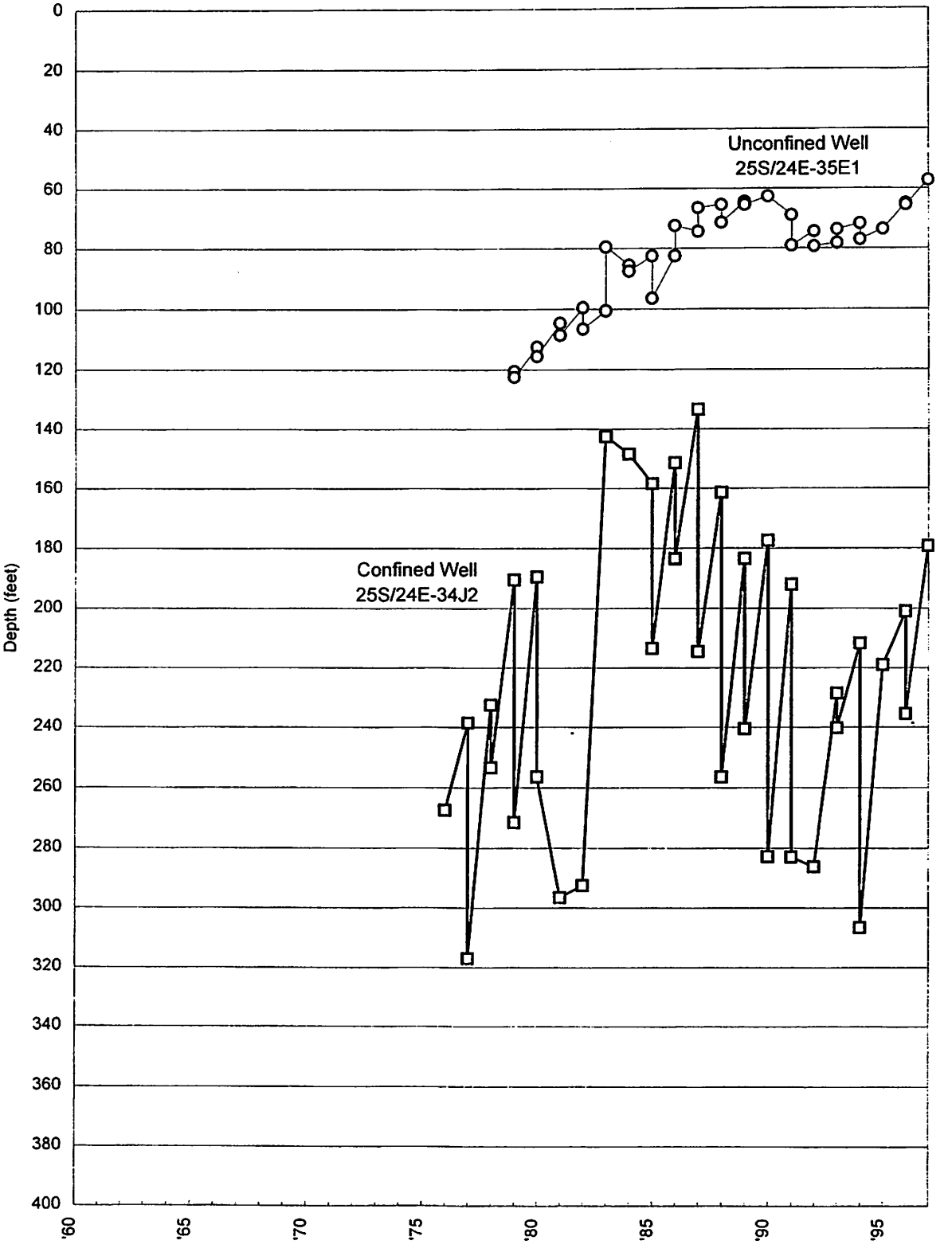


Figure21b. Water Well Hydrograph
Shafter/Rosedale-Rio Bravo Area

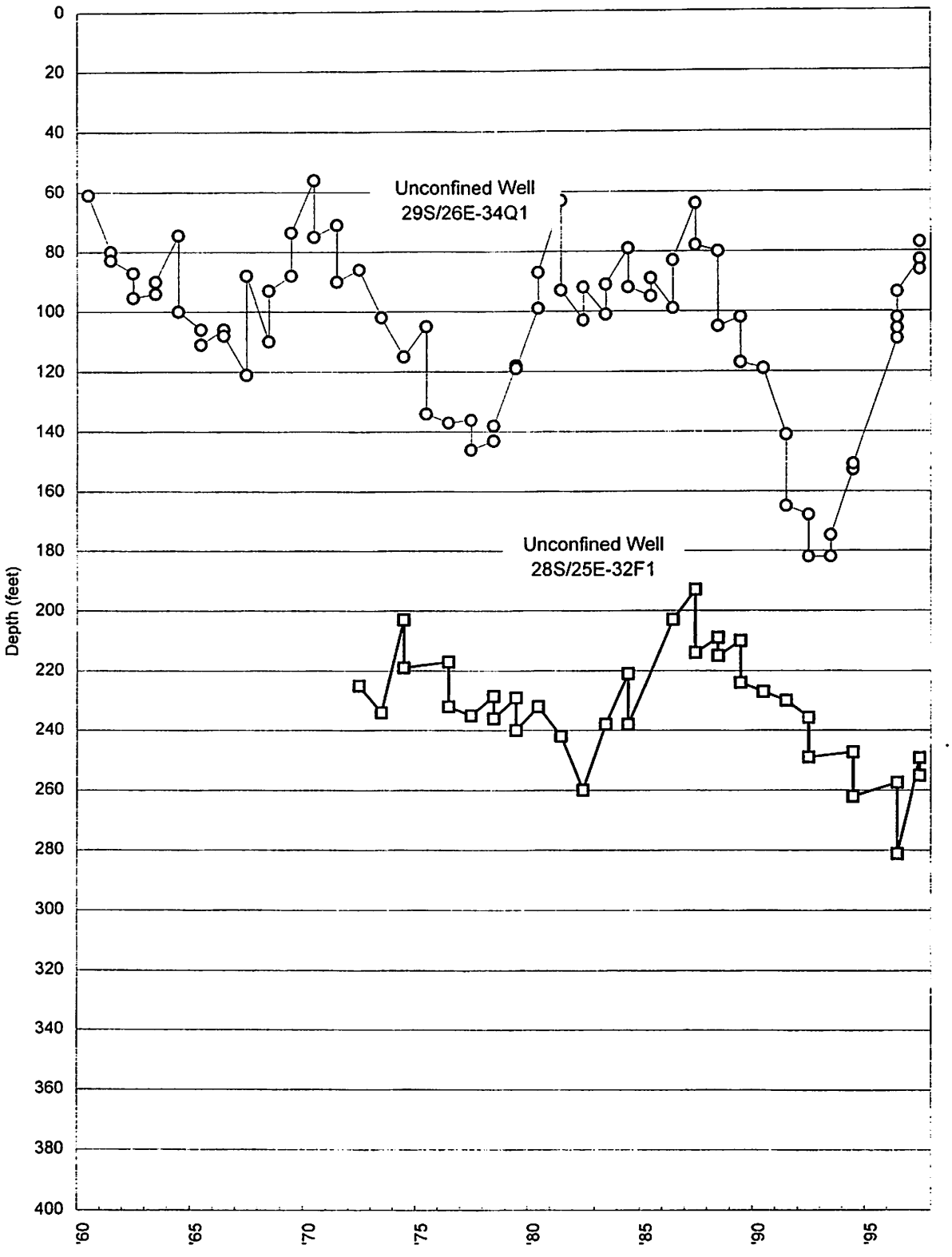


Figure21c. Water Well Hydrograph
Southwest Bakersfield Area

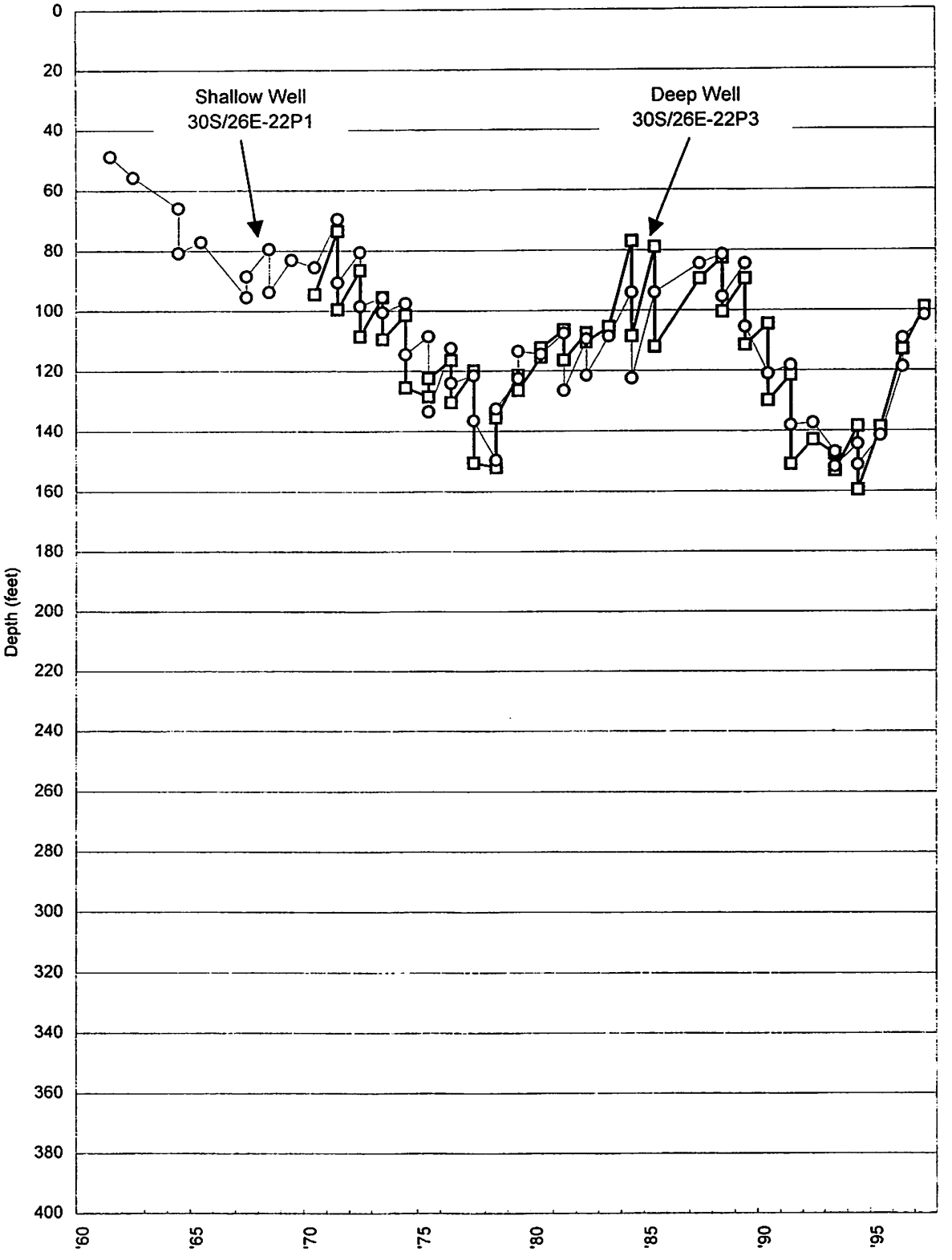


Figure21d. Water Well Hydrograph
Arvin-Edison Area

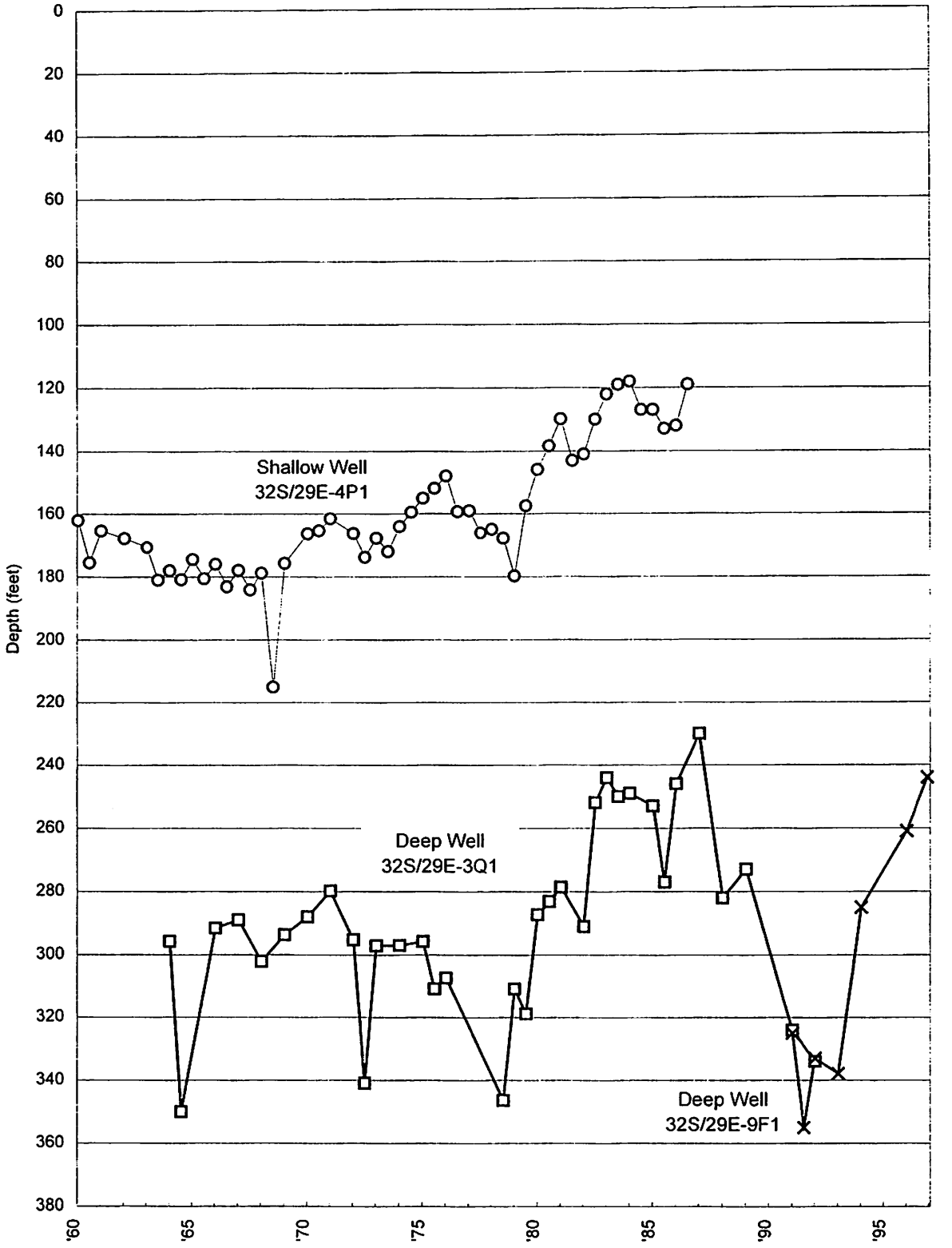


Figure21e. Water Well Hydrograph
Indian Wells Valley

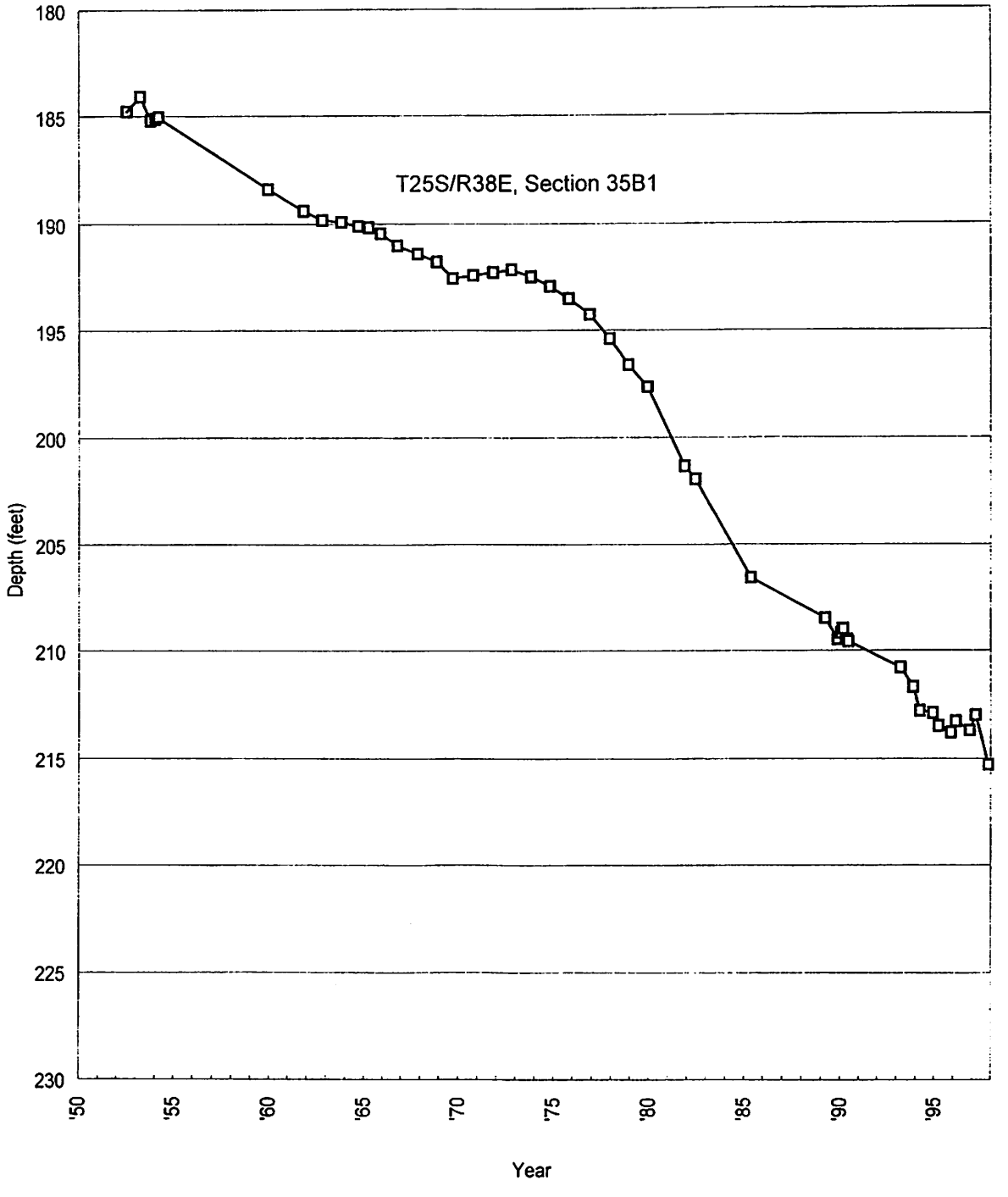


Figure21f. Water Well Hydrograph
Indian Wells Valley

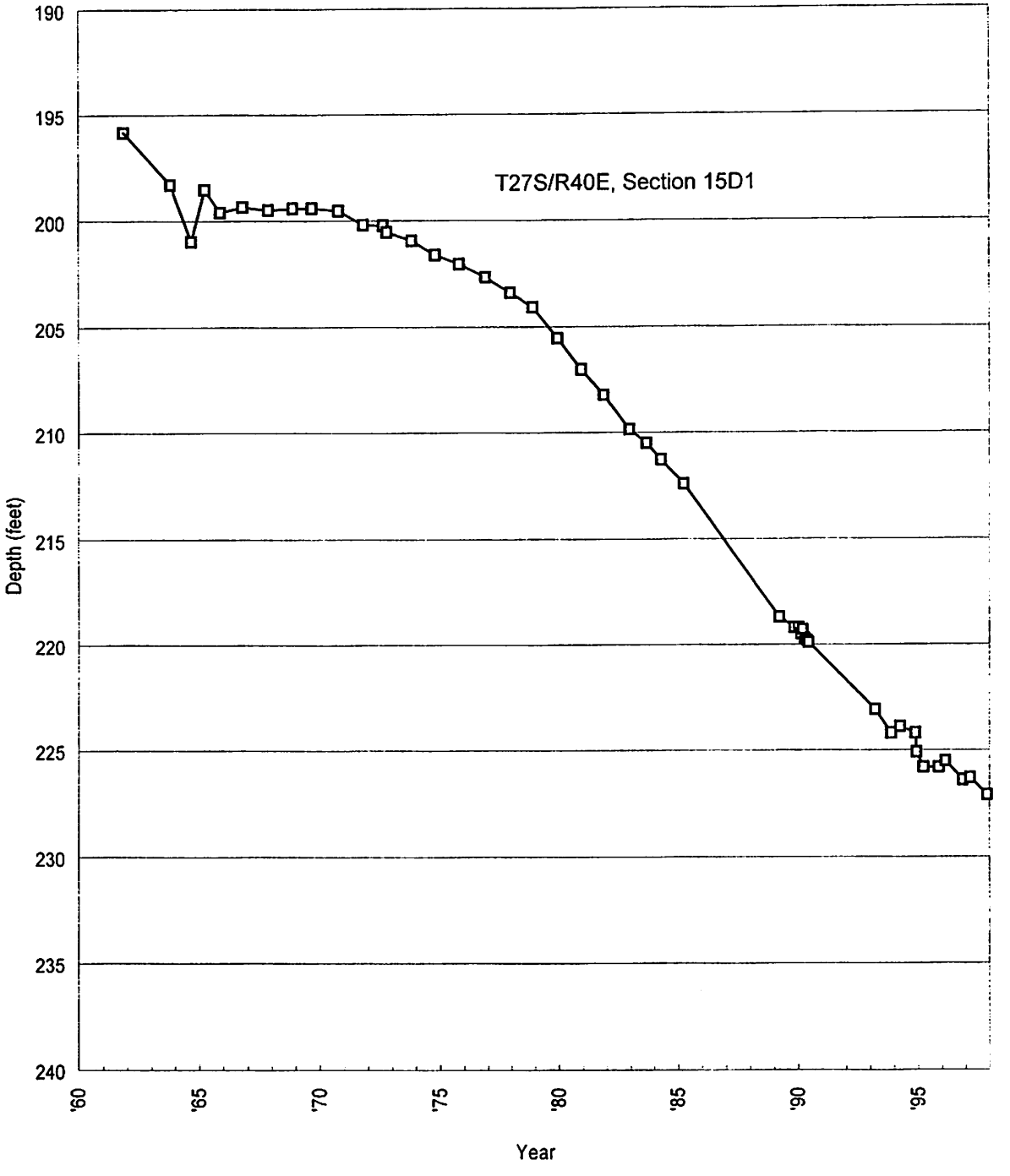
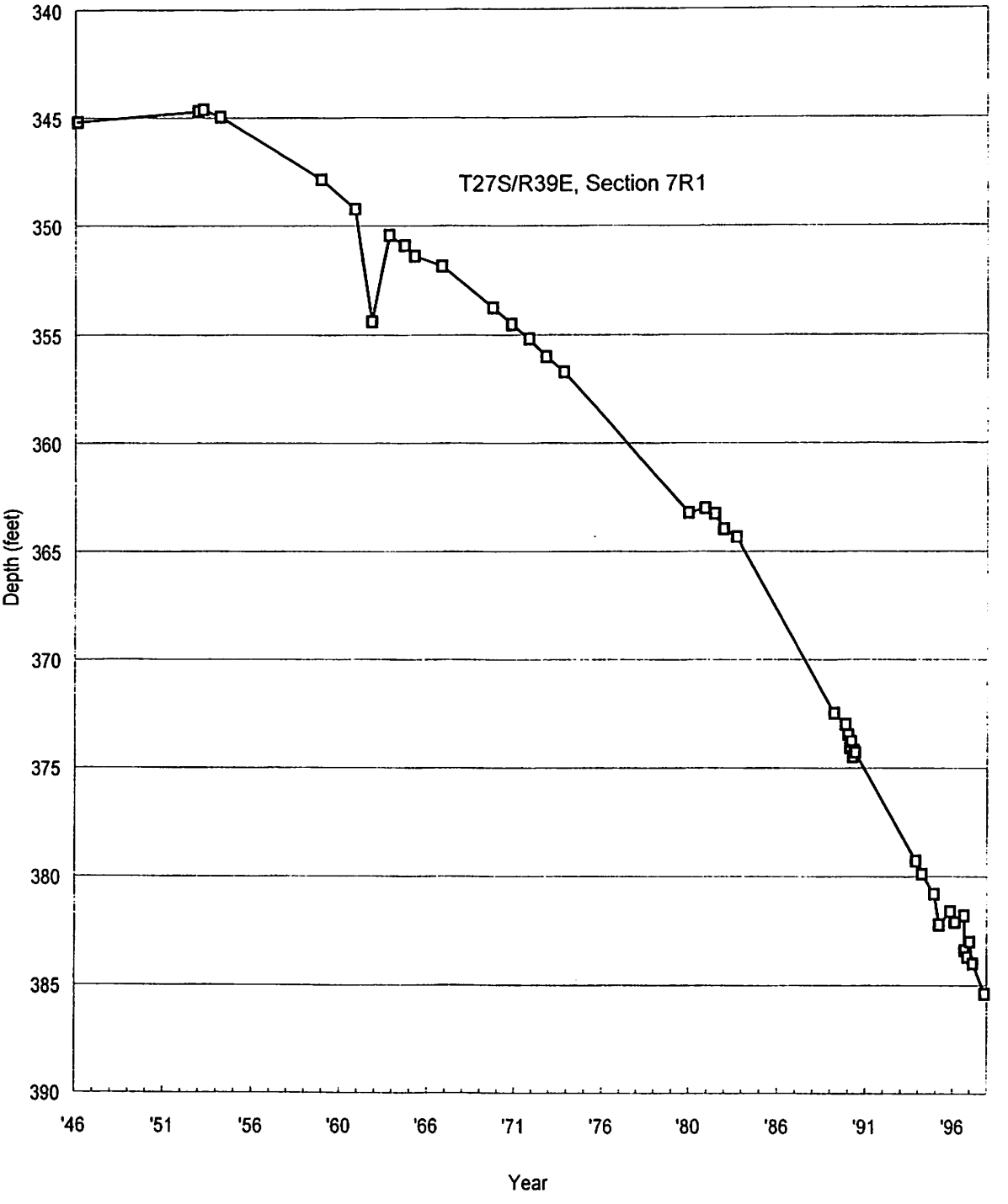


Figure21g. Water Well Hydrograph
Indian Wells Valley



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 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.

FOCUS: LOST HILLS WATER DISTRICT

Lost Hills Water District was formed in 1963 to provide a water supply for west side agriculture. The district is located along the Kern County-Kings County border, almost entirely north of state Highway 46. Interstate Highway 5 traverses through the center of the district.

The gross area of the district is 72,860 acres, all located in Kern County. In 1996, about 58,440 acres were under cultivation. Elevations within the district range from 500 feet above sea level in the west, sloping to 200 feet on the valley floor. Agriculture in the area requires an imported State Water Project supply, as the district is not located over the groundwater basin. The district's SWP entitlement is 134,110 acre-feet. Distribution facilities include 58 miles of canals, eight miles of which are lined, and 26 miles of which have interceptor lines used during normal to wet years to provide additional irrigation flexibility. There are also 44 miles of pipelines.

Soil fertility in the district is good, with 80 percent of the soil in the district classified as "prime" agricultural land according to the Storie Index. (The Storie Index results from the multiplication of four factors: the percentage rank of the soil in (a) soil profile - hardness of any clay layer and the deepness of the topsoil; (b) surface texture - low rating at any of the three extremes (clay, sand, silt), high rating at a good combination of the three (loamy soil); (c) slope - nearly level to very steep; (d) a multiplicative combination of several additional factors, such as drainage, alkalinity, fertility, acidity and erosion hazard. Since the factors are combined multiplicatively rather than additively, a high rating is difficult to obtain.) Using the cultivation suitability land classification, about 55 percent of the soils in the district are Class 1 (excellent) or Class 2 (good); 45 percent are Class 3 (fair). The district is well suited for field crops.

In 1996, the majority of the irrigated acreage (40,000 acres) in the district was planted in field crops such as cotton and grains. The most prevalent type of irrigation system is sprinklers (46 percent of irrigated acreage) row and border systems (30 percent) and low-volume systems such as drip or microsprinklers (24 percent). Crops utilizing low-volume systems include pistachios, grapes, almonds, melons and tomatoes. Overall irrigation efficiency within the district is estimated to be 85 percent.

Irrigated crops grown in Lost Hills are grouped as follows:

Field Crops	78%
Orchards	22%
Total	58,440 acres

Table 26 displays the various crops and acreage in the district. Much of the district's field crops, about 40,000 acres, are cotton and barley, as shown on Table 26. The majority of orchard crops are pistachios, at about 8,700 acres. The total gross value of the crops produced in Lost Hills Water District in 1996 was almost $104 million. This translates into about $311 million total economic value for Kern County via a multiplier effect.

Table 26. 1996 Irrigated Acreage in the Lost Hills Water District

Crop	Irrigated Acres
Annual Crops	
Alfalfa	160
Barley	14,710
Beans	920
Corn	400
Cotton	24,630
Melons	340
Safflower	2,040
Tomatoes	770
Wheat	1,360
Subtotal	45,330
Permanent Crops	
Almonds	1,550
Apples	-
Citrus	-
Figs	560
Grapes	2,160
Kiwis	-
Olives	60
Pistachios	8,780
Subtotal	13,110
Total Irrigated Acreage	**58,440**

OUTLOOK: 1997

The SWP share of San Luis Reservoir filled on Nov. 30, 1996. Wet conditions in 1996 carried over into 1997, with an initial State Water Project allocation of 70 percent in December. In January 1997, the year began to shape up as very wet. There were record-setting storm events all around California, particularly on January 1 and 2, during which DWR's eight-station precipitation index was at 226 percent of average. By mid-February 1997, SWP allocations were set at 100 percent, or 1,112,730 acre-feet. Central Valley Project allocations were also set at 100 percent of Class I, with 60 percent of Class II, or 545,000 acre-feet. The Kern River reached a record peak inflow of about 35,000 cfs to Lake Isabella during the early morning of January 3, and is forecast to yield 1,133,400 acre-feet. Effective precipitation is expected to be about 200,000 acre-feet; therefore, surface water supplies are estimated to be about 2,991,000. It is expected that the Kern River intertie with the California Aqueduct will be put into operation to manage flood waters.

The wet conditions indicate projected water demands on levels similar to 1996, approximately 3,100,000 acre feet. Irrigated acreage is expected to be about the same as in 1996 (approximately 850,000 acres) because of ample surface water supplies received early in the growing season. Consumption for all types of uses is estimated to be about 2,500,000 acre-feet. KCWA projects that a net increase in groundwater storage will occur in 1997, of about 500,000 acre feet. Such an increase would continue the pattern of wet-year storage programs begun in 1995 and continued in 1996.

PLATE 1

KERN COUNTY WATER AGENCY
Bakersfield, California

DEPTH TO SHALLOW GROUNDWATER

JULY 1996

J. GILLICK/Y. HASLEBACHER

DECEMBER 1997

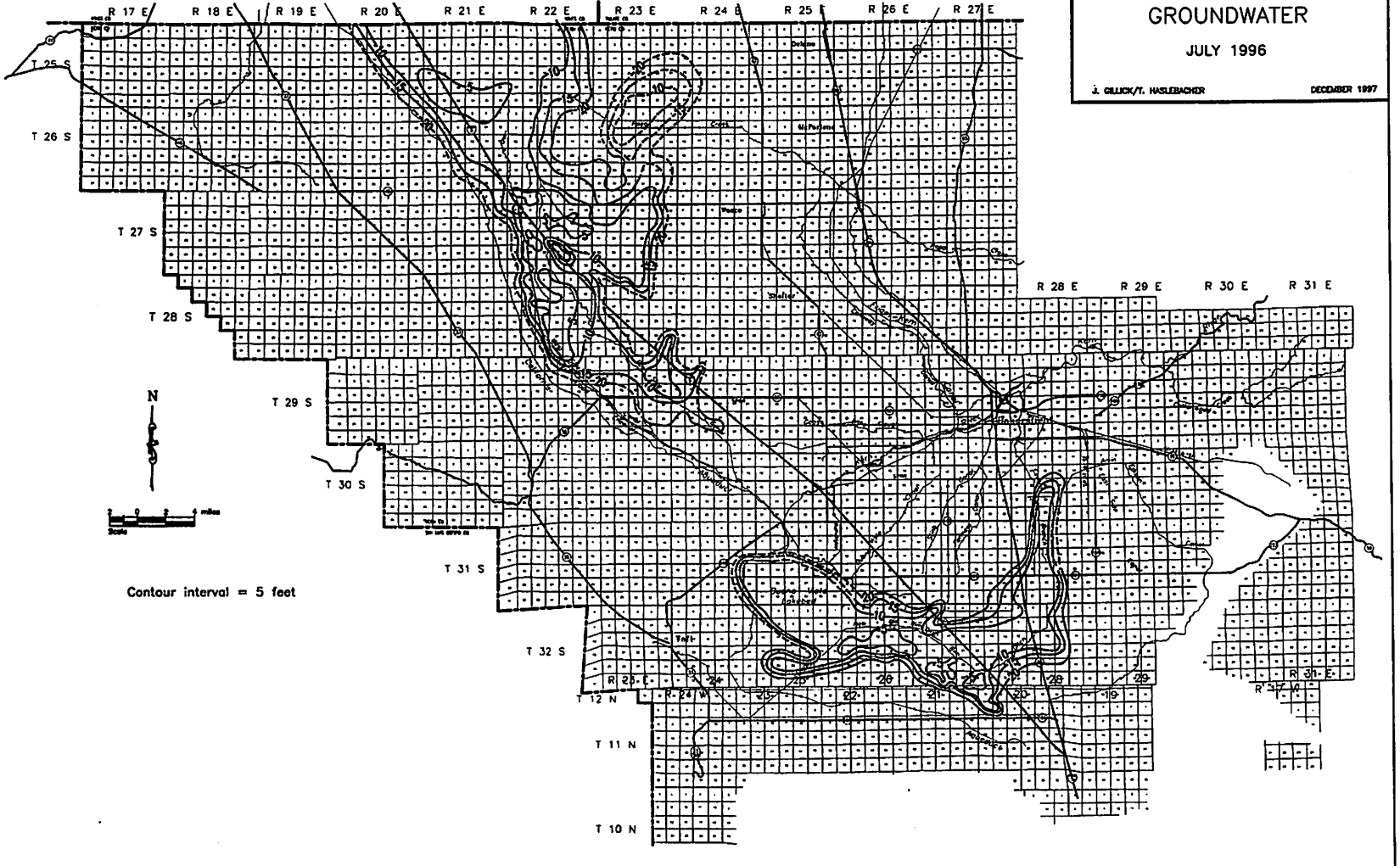
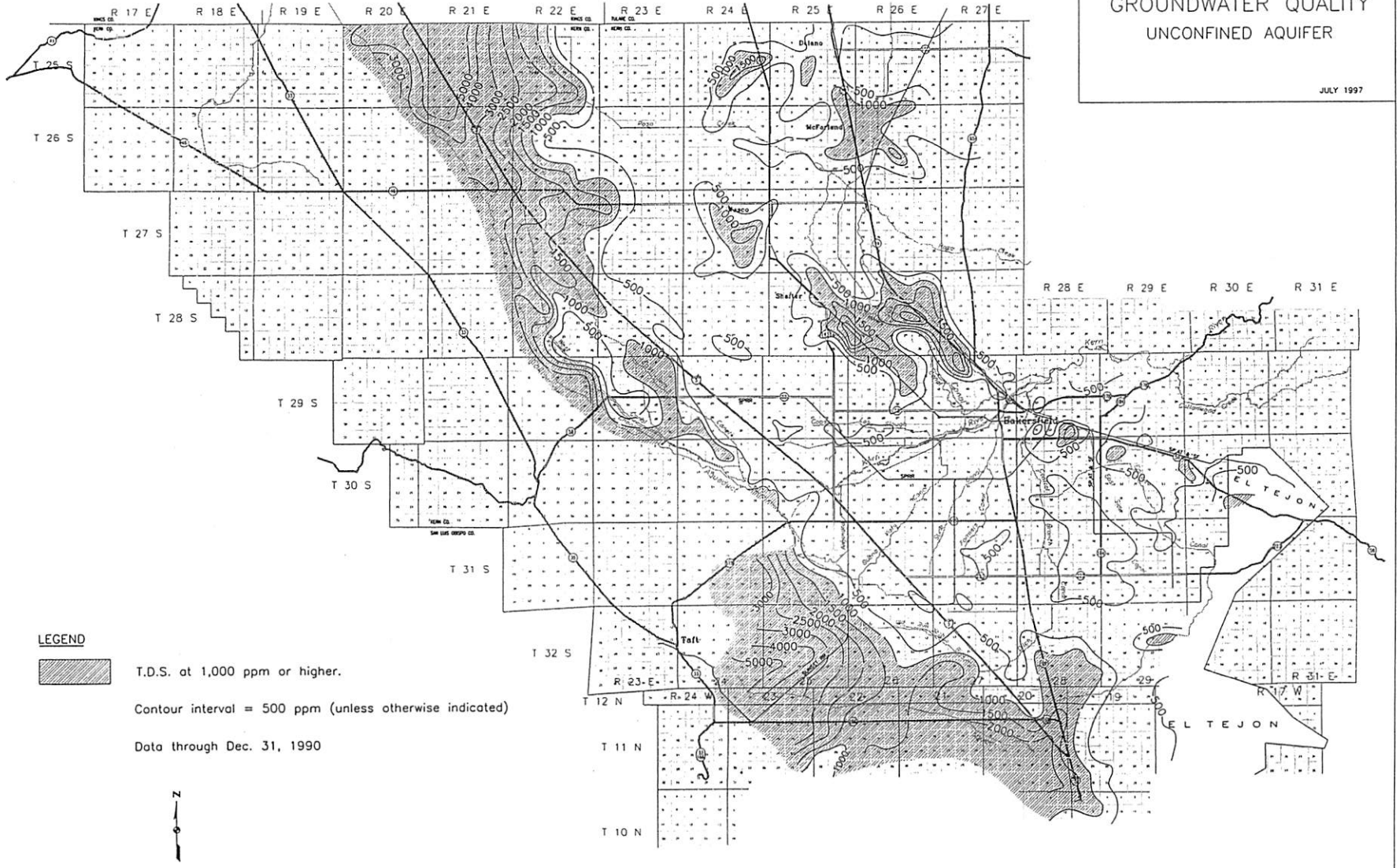


PLATE 2

KERN 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

N

2 0 2 4 miles
scale

PLATE 3

KERN COUNTY WATER AGENCY
Bakersfield, California

GROUNDWATER QUALITY
CONFINED AQUIFER

MARCH 1997

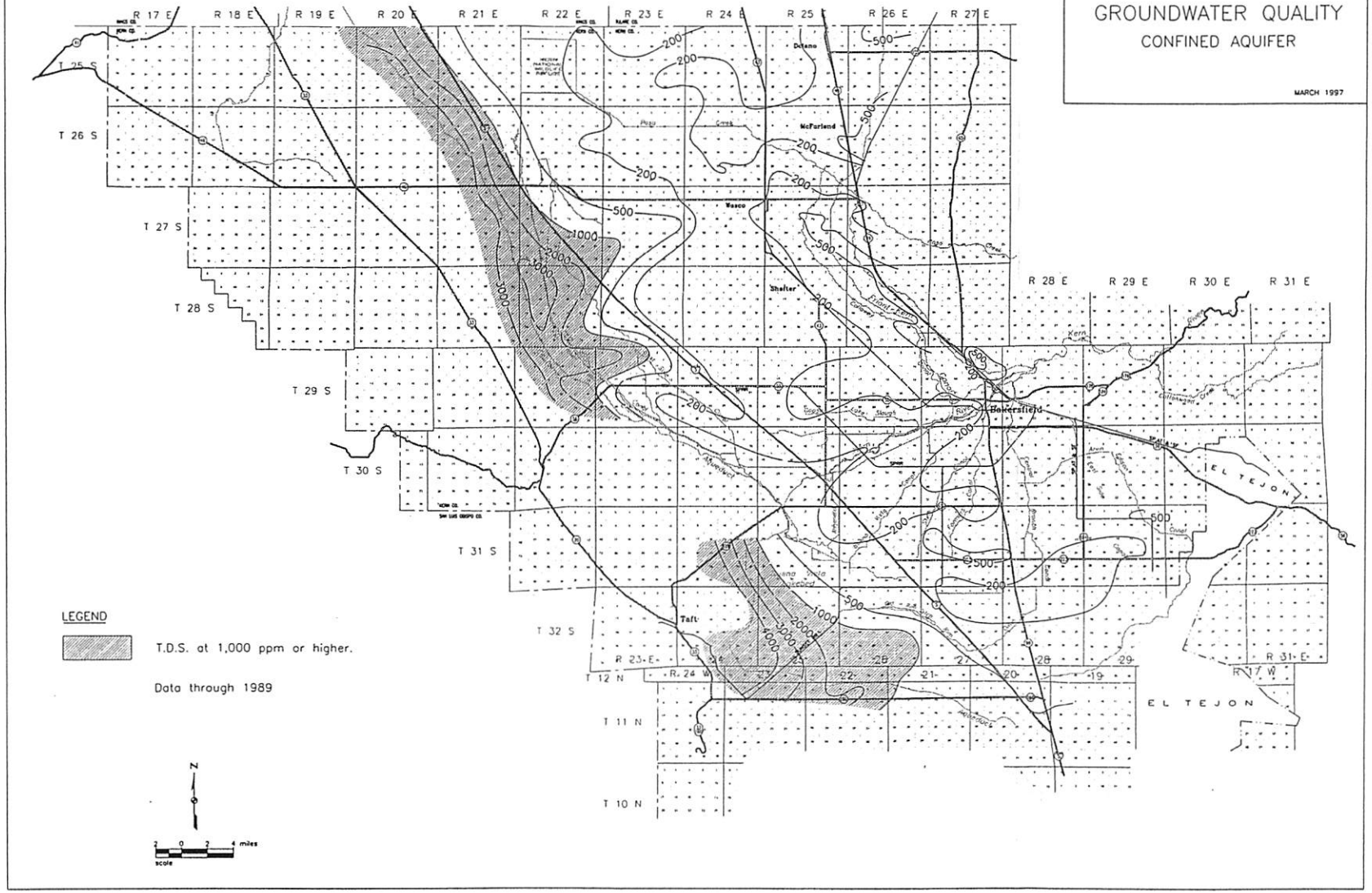


PLATE 4

KERN COUNTY WATER AGENCY
Bakersfield, California

DEPTH TO GROUNDWATER

SPRING 1997

J. CLUCK/T. HASLEBACHER DECEMBER 1997

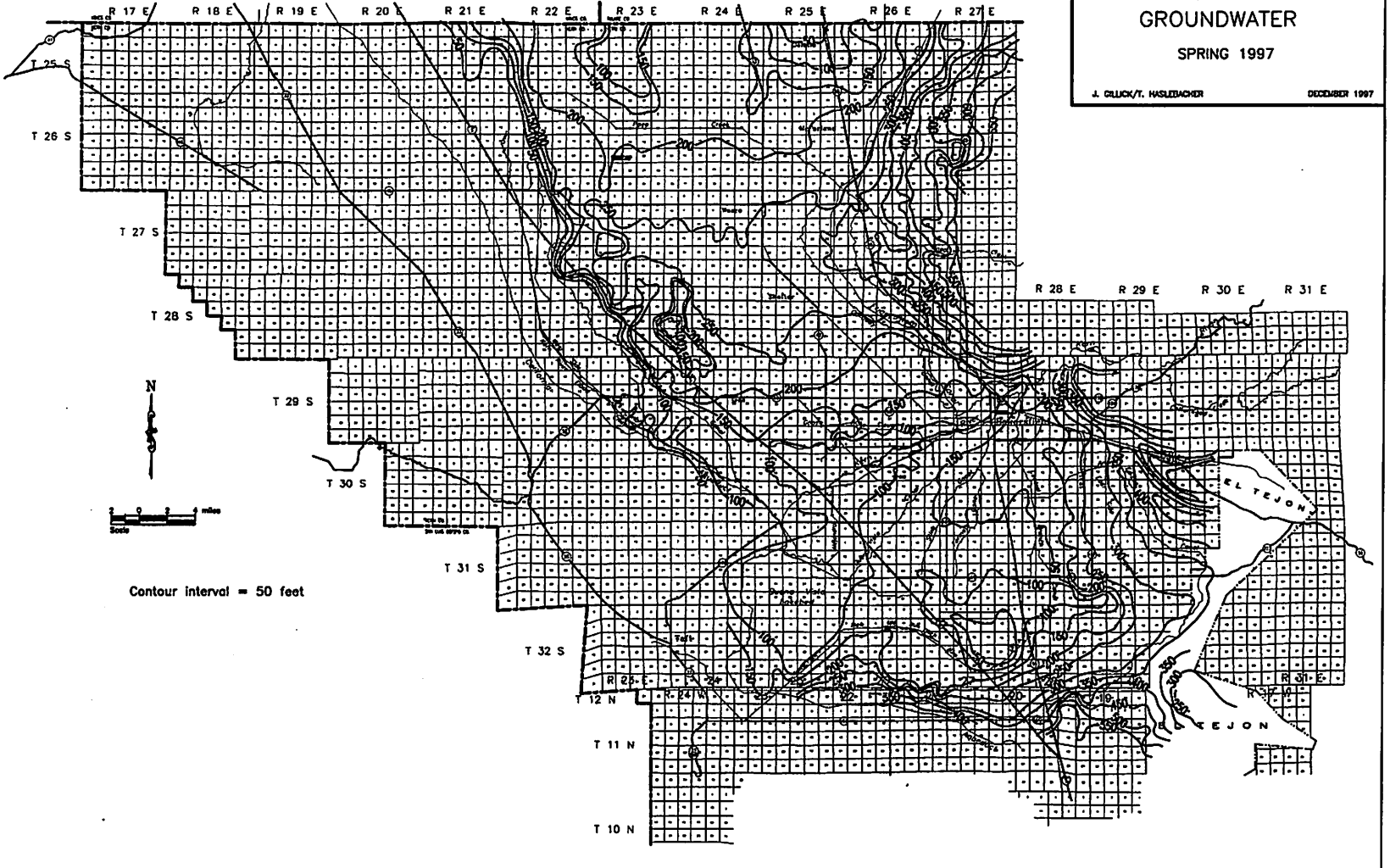


PLATE 5

KERN COUNTY WATER AGENCY
Bakersfield, California

GROUNDWATER SURFACE ELEVATION

SPRING 1997

J. GILLICK/T. HASLEBACHER

DECEMBER 1997

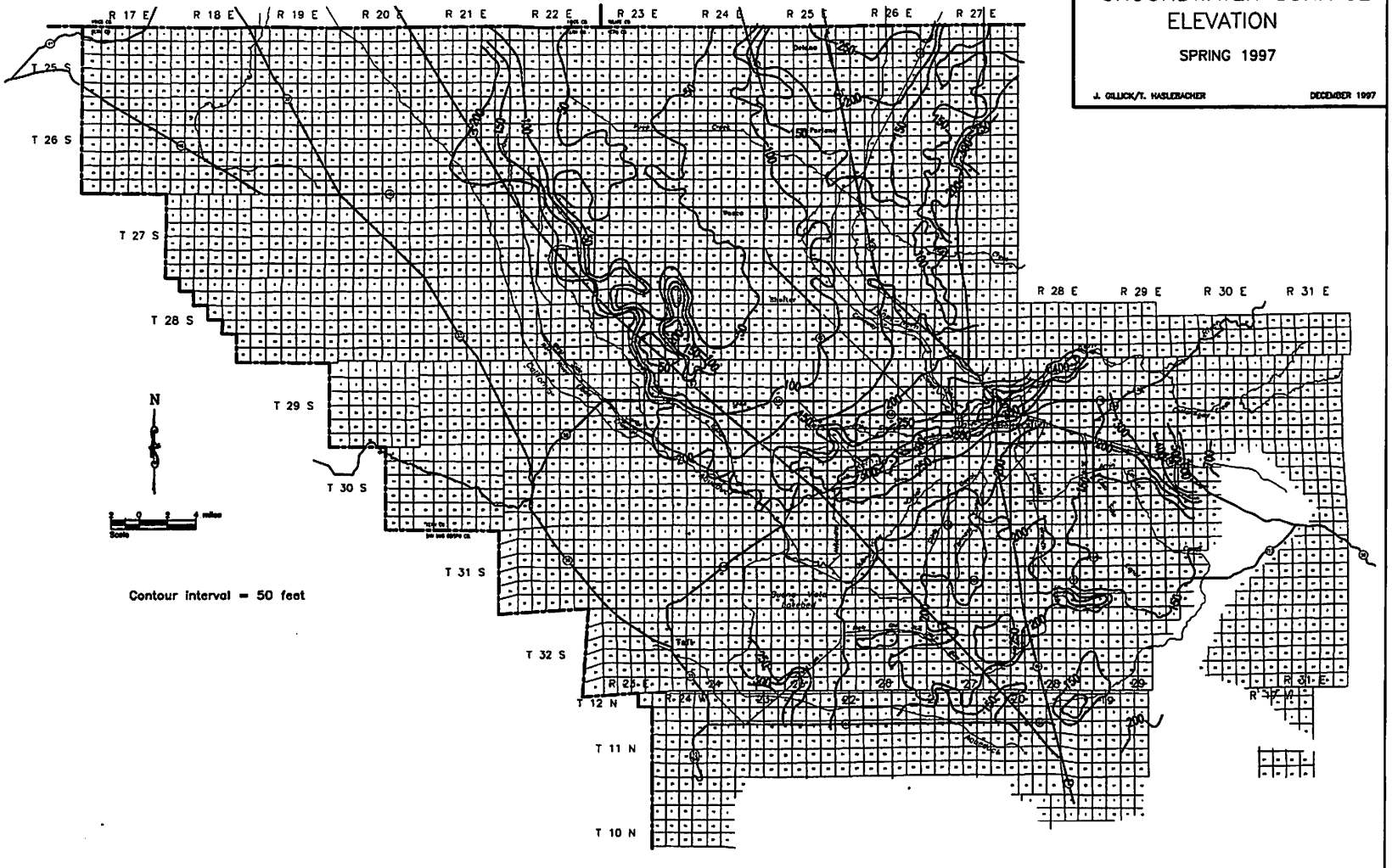


PLATE 6

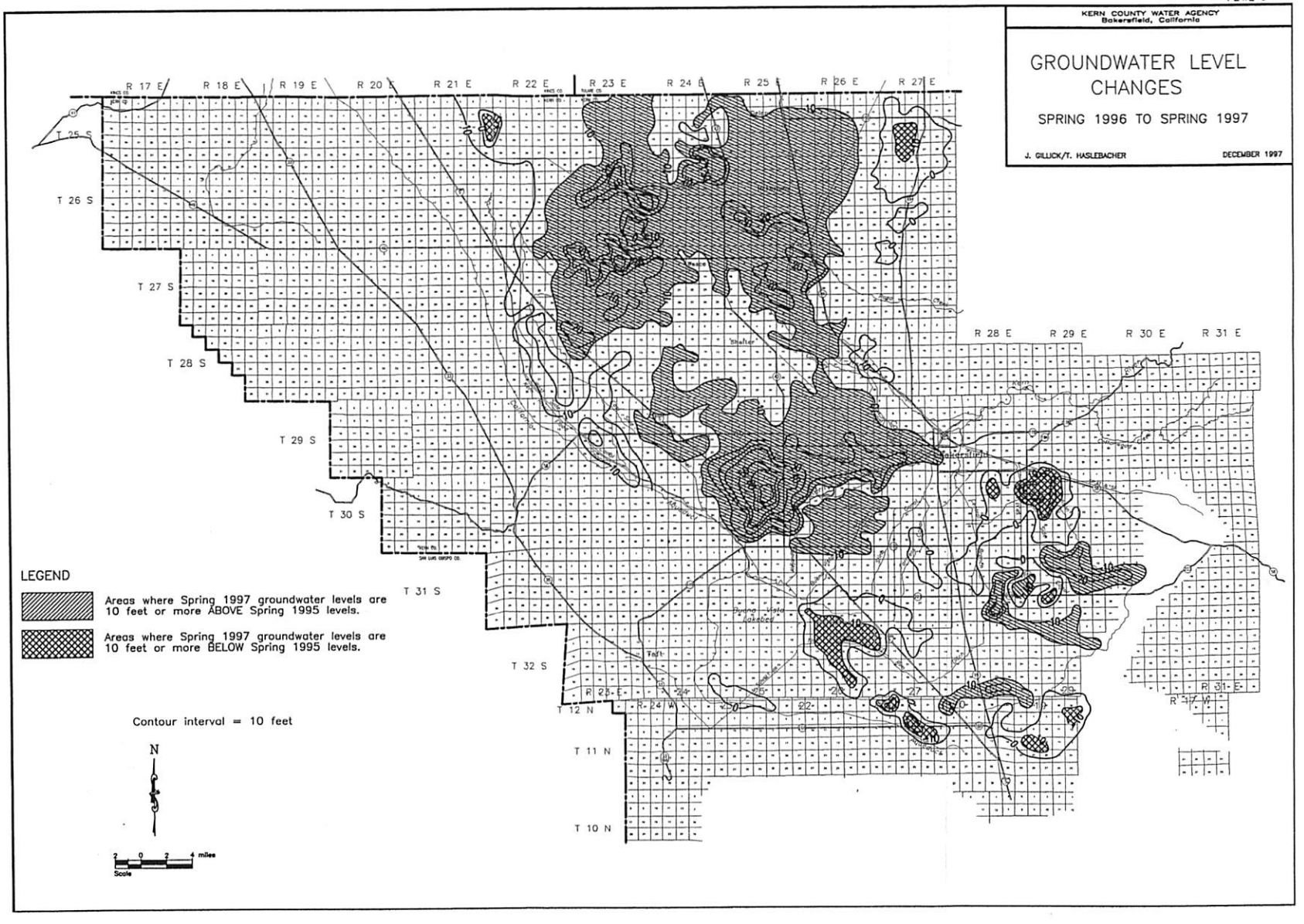
KERN COUNTY WATER AGENCY
Bakersfield, California

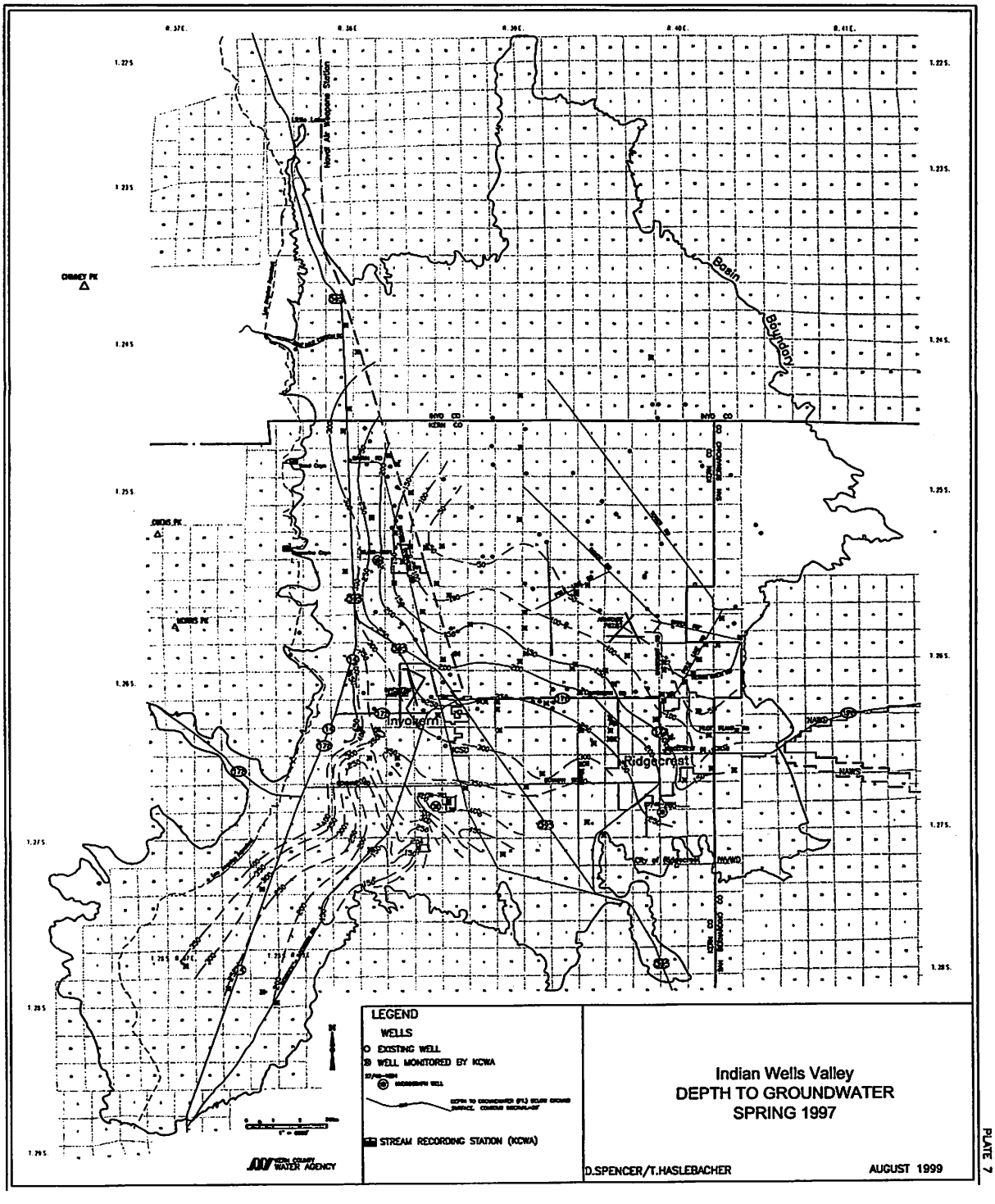
GROUNDWATER LEVEL CHANGES

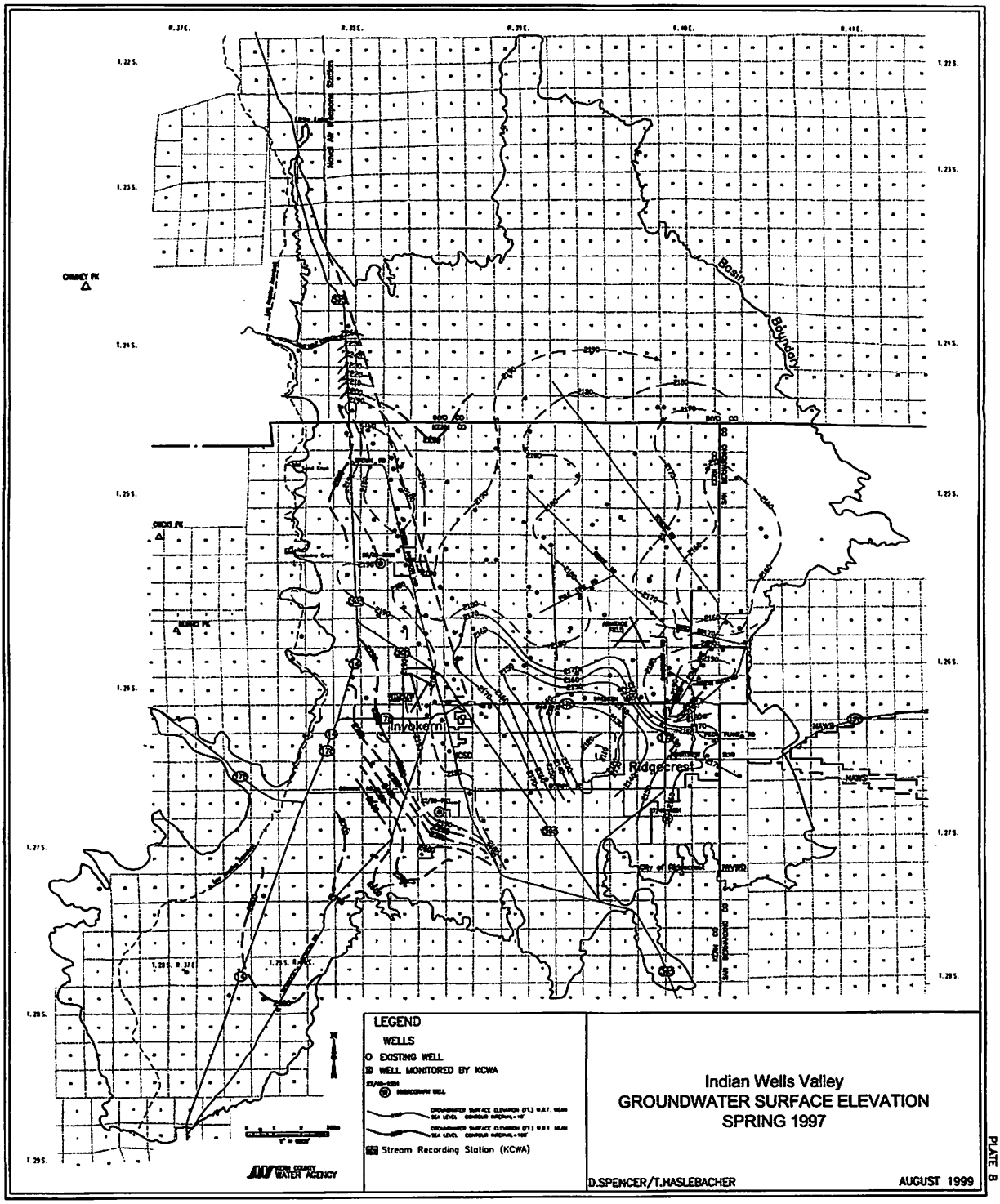
SPRING 1996 TO SPRING 1997

J. GILLICK/T. HASLEBACHER

DECEMBER 1997



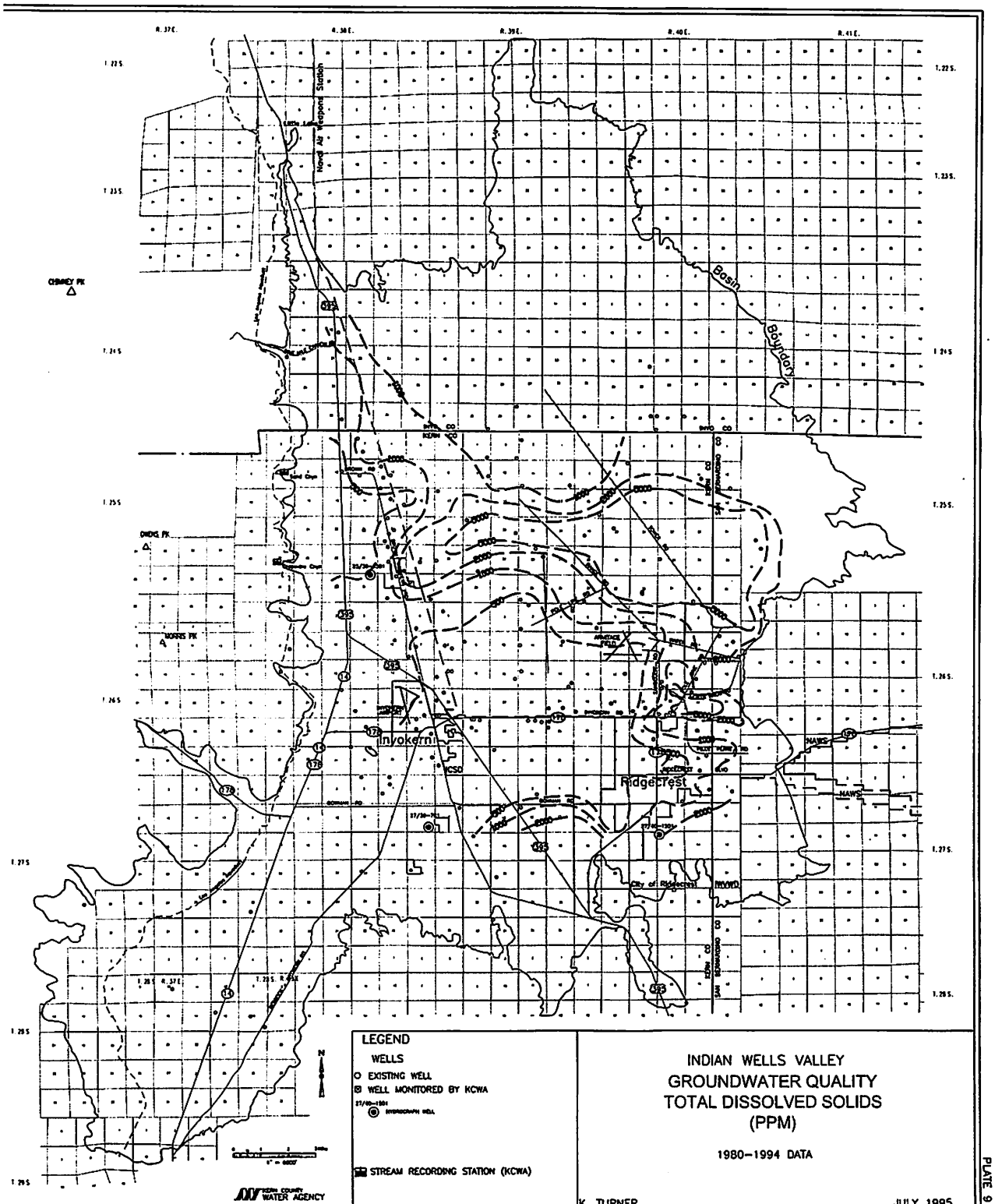

Indian Wells Valley
DEPTH TO GROUNDWATER
SPRING 1997
LEGEND
WELLS
EXISTING WELL
WELL MONITORED BY KCWA
STREAM RECORDING STATION (KCWA)
Basin
Boundary
Inyokern
Ridgecrest
D.SPENCER/T.HASLEBACHER
AUGUST 1999
PLATE 7

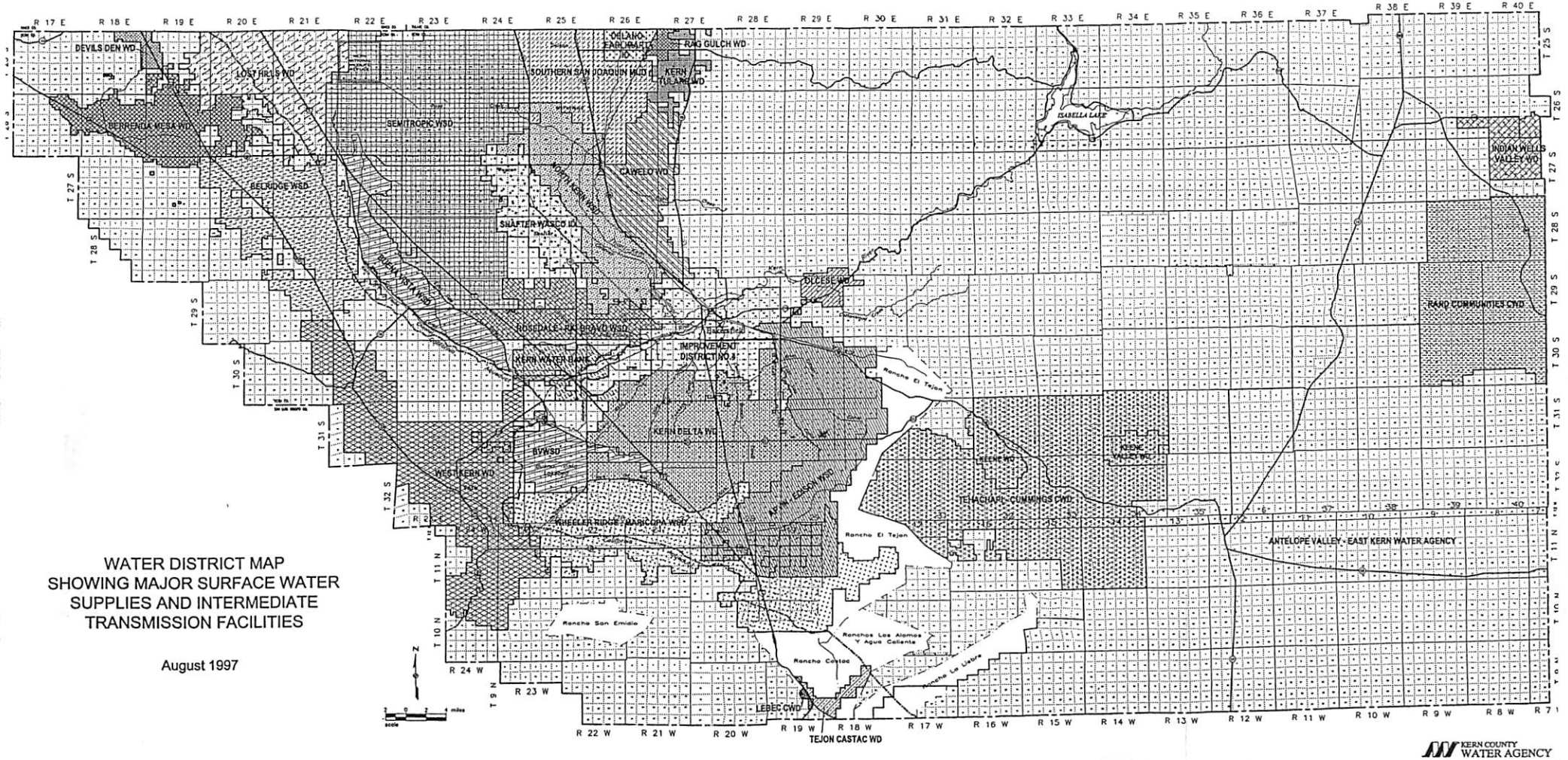


Indian Wells Valley
GROUNDWATER SURFACE ELEVATION
SPRING 1997

D.SPENCER/T.HASLEBACHER AUGUST 1999

PLATE 8


R.37E.
R.38E.
R.39E.
R.40E.
R.41E.
T.22S.
T.23S.
T.24S.
T.25S.
T.26S.
T.27S.
T.28S.
Naval Air Weapons Station
China Lake
CHINA LAKE BLVD
CHINEY PK
DIXON PK
MORRIS PK
Basin
Boundary
Inyokern
Ridgecrest
NAWS
City of Ridgecrest
RVWD
KCSD
KCWA
SAN BERNARDINO CO
INYO CO
LEGEND
WELLS
EXISTING WELL
WELL MONITORED BY KCWA
HYDROGRAPH WELL
STREAM RECORDING STATION (KCWA)
KERN COUNTY WATER AGENCY
INDIAN WELLS VALLEY
GROUNDWATER QUALITY
TOTAL DISSOLVED SOLIDS
(PPM)
1980–1994 DATA
K. TURNER
JULY 1995
PLATE 9



WATER DISTRICT MAP SHOWING MAJOR SURFACE WATER SUPPLIES AND INTERMEDIATE TRANSMISSION FACILITIES

August 1997

KERN COUNTY WATER AGENCY