000097

Kern County Water Agency
Water Supply Report
1988

May 1989

Kern County Water Agency
WATER SUPPLY REPORT
1988

Stuart T. Pyle
General Manager

George E. Ribble
Assistant Engineer-Manager

May 1989

Table of Contents

Tables

Figures

Plates

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 five during a one-year period for residential use.

Agency Kern County Water Agency (KCWA).

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

cfs Cubic feet per second, a rate of flow.

1 cfs = 450 gallons per minute
= 646,360 gallons per day
= 1.983 acre-feet per day

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

Confined Aquifer The ground water bearing strata located below (confined by) the Corcoran Clay.

Corcoran Clay A thick, impermeable layer of clay which lies under much of the San Joaquin Valley. This clay layer separates the ground water 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.

Four-Basin 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 Folsum Reservoir.

Ground Water 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.

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

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) .0012335 = cubic hectometers
Feet (x) .0348 = meters
Inches (x) 2.54 = centimeters
Million gallons per day (x) .043813 = cubic meters per second

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

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 The ground water-bearing strata located above the Corcoran 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, and to conduct investigations relative to water resources. The Agency serves as a master contractor with the State Department of Water Resources for water service via the State Water Project (SWP). The Agency administers 17 subcontracts for such water with 15 local water districts. In addition to its SWP contract administration duties, a 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 fund 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 facilitate water leaders and users in making water management decisions.

Agriculture has long played an important part in our local, and state, economy. Agricultural products grown in Kern County generate over $1 billion annually in revenues, and provide jobs for about 26,000 people. While accounting for nearly 85 percent of our total water use, agriculture in Kern County is both efficient and progressive. Kern County serves as a laboratory for the development and dissemination of new irrigation technologies and farming practices. Mining and manufacturing, while accounting for much less of our total water use, nevertheless are vitally important to our economy. For instance, nearly 37,000 producing oilwells in Kern County account for over 50 percent of the total oil production in the entire state. All of these activities require water, about 3 million acre-feet annually for Kern County.

The Water Supply Report attempts to identify and quantify the interrelationships of the hydrologic cycle (see Figure 1) with the water-intensive activities in the San Joaquin Valley portion of Kern County. While local surface storage facilities and contracts for imported surface supplies have lessened our dependence upon ground water supplies, a condition of overdraft persists. Coordinated water recharge and management efforts have had a positive effect upon ground water storage, raising ground water levels by as much as 50 feet since 1977. The net result of the interactions between the available water supplies and the various demands for that water is a change in ground water storage and ground water 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.

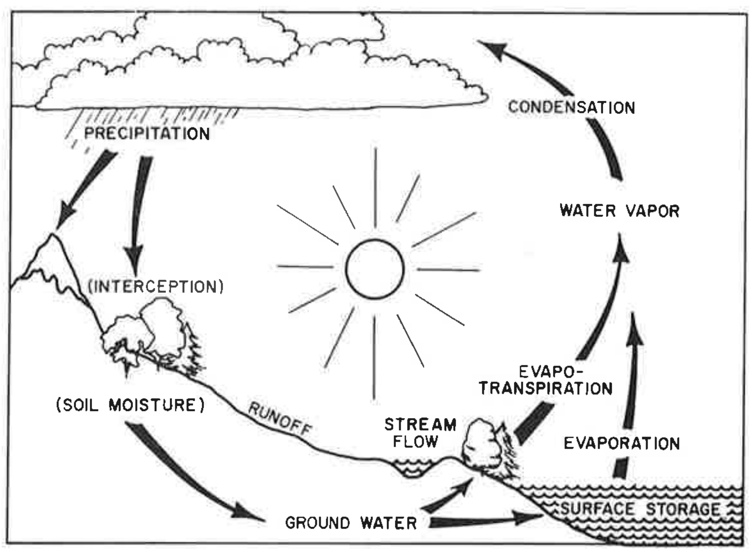


Figure 1. The Hydrologic Cycle

1988: More of the Same

Hydrologically, the year 1988 was nearly a mirror image of the previous year. The local Kern River provided only 338,458 acre-feet during 1988 (about 52 percent of normal) compared to 434,715 acre-feet the previous year. The Sacramento River Index, used by the State Department of Water Resources (DWR) as an indicator of available SWP supplies, was only 9.2 million acre-feet during 1988 (tied for the 9th driest of record), exactly the same as during 1987. The period of runoff record stretches back to 1906.

A total of 1,009,520 acre-feet of SWP water was delivered during 1988. This was only slightly less than the amount delivered in 1987, and was one of the few bright spots in our 1988 water supply. Total CVP imports were 292,825 acre-feet, compared to 291,981 acre-feet during 1987. Local Kern River supplies were abysmally low, with only 338,458 acre-feet being available. This was only about 45 percent of normal. Comparatively, 1987 Kern River supplies were 434,715 acre-feet. This marks the second consecutive critically dry year on the Kern River system.

Total irrigated acreage in 1988 was about 831,100 acres, compared with 787,800 acres in 1987. Measured pan evaporation on the valley floor was about 108 percent of normal, primarily due to a long, hot spring. Crop water use, which is related to pan evaporation, was therefore slightly higher than normal. Comparatively, evaporation during 1987 was about 117 percent of normal.

The change in ground water storage in 1988 was a withdrawal of about 703,800 acre-feet, the fifth time since the 1976-77 drought that a withdrawal has occurred. The total extractions since 1970 (when SWP water was first delivered over the Kern County ground water basin) have been about 7,640,000 acre-feet. The total additions to storage over the same period have been about 4,957,000 acre-feet. Hence, the net change in storage since 1970 has been a reduction of about 2,683,000 acre-feet, or about 141,000 acre-feet per year. Since the 1976-77 drought (the years of worst overdraft since 1970) the ground water basin has recovered to 1972 levels, in volume of water stored.

Water Supplies

State Water Project

The year 1987 was officially designated as critical according to the State Department of Water Resources "Rule Curve" criteria. The Four-Basin Index for the SWP was only 9.2 million acre-feet, exactly the same as the previous year. The last time that two critical years occurred back-to-back was the 1976-77 drought. However, the 1987-88 drought was not as severe as the 1976-77 period. The historic record of the Sacramento River Index (SRI) is given in Table 1 both in natural order and sorted by size. Figure 2 is a histograph of the historic Index. Generally, when the index is above 19.6 the year is classified as wet. When the index is between 15.7 and 19.6 the year is above normal. Between 12.5 and 15.7 is below normal. From 10.2 to 12.5 is considered dry. When the index is below 10.2 the year is classified as critical. While the SRI for 1988 was nearly twice what it was in 1977, the severity of the water supply situation is illustrated by both years being "critical". When critical years follow each other, reservoir storage facilities are severely depleted. This was the case during 1988. The SWP reservoirs in the northern portion of the state started their water year with only 42-64 percent of normal carryover storage.

A total of 1,009,520 acre-feet of SWP water was delivered during 1988, consisting of 939,051 acre-feet of Member Unit Table 1 entitlement, 56,634 acre-feet of 1987 entitlement carried over to 1988, and 13,835 acre-feet of Emergency Relief Water. The amount of SWP water delivered in the San Joaquin Valley portion of Kern County amounted to 1,006,213 acre-feet.

Agency annual entitlements to SWP water are according to a build-up schedule in the master contract. The build-up provides for increasing amounts of "firm" water and decreasing amounts of "surplus" water. Maximum entitlement will be reached in 1990. Agency member unit contract entitlements for 1988 and 1990 are shown on Table 2. The Agency's actual contracted entitlement with the DWR is the total firm entitlement shown on Table 2.

Since the first deliveries in 1968, a total of over 15.1 million acre-feet of SWP water has been imported into Kern County. A histogram of historic SWP deliveries is provided in Figure 3. Table 3 provides a numerical history of SWP deliveries, with both annual and cumulative deliveries shown. Table 4 shows 1988 SWP deliveries by contract type.

Kern River

Kern River regulated flows in 1988 were only 335,473 acre-feet. In addition, a total of 2,985 acre-feet of Kern River water was diverted above First Point in 1988, for a total Kern River flow of 338,458 acre-feet. This was about 47 percent of the 94-year mean flow of 723,722 acre-feet, and about 45 percent of the mean regulated flow (1954 to present) of 746,919 acre-feet. Comparatively, a total of 434,715 acre-feet of Kern River water was available in 1987.

The Kern River watershed experienced extended dry periods during the snowpack accumulation period of November-March. Notably, from January 18, 1988 to February 26, 1988 (a 40 day period), no precipitation occurred over the entire Kern River watershed. Normally, a large portion of snowpack accumulation occurs during January-February. Snowmelt began early due to unseasonably warm weather during February-March, 1988. Several snow sensor sites were virtually bare by late March, when snowmelt is normally just beginning. The severity of the local drought is illustrated by the following readings in inches of water content for snow sensor sites within the Kern River basin:

	April 1, 1988	April 1 Average	Percent of Normal
Upper Tyndall Creek	18.6	27.7	67.1
Crabtree Meadow	8.9	19.8	44.9
Chagoopa Plateau	9.0	21.8	4.1
Pascoe	12.2	24.9	49.0
Wet Meadow	0.4	30.3	1.3
Tunnel Guard	0.0	15.6	--
Casa Vieja Meadows	3.9	20.9	18.7
Beach Meadows	0.0	11.0	--

Table 5 gives historic Kern River First Point runoff and cumulative runoff for the 95 years of complete

Table 1
Historic Sacramento River Indexes *
(in million acre-feet)

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

Figure 2
Historic Sacramento River Indexes

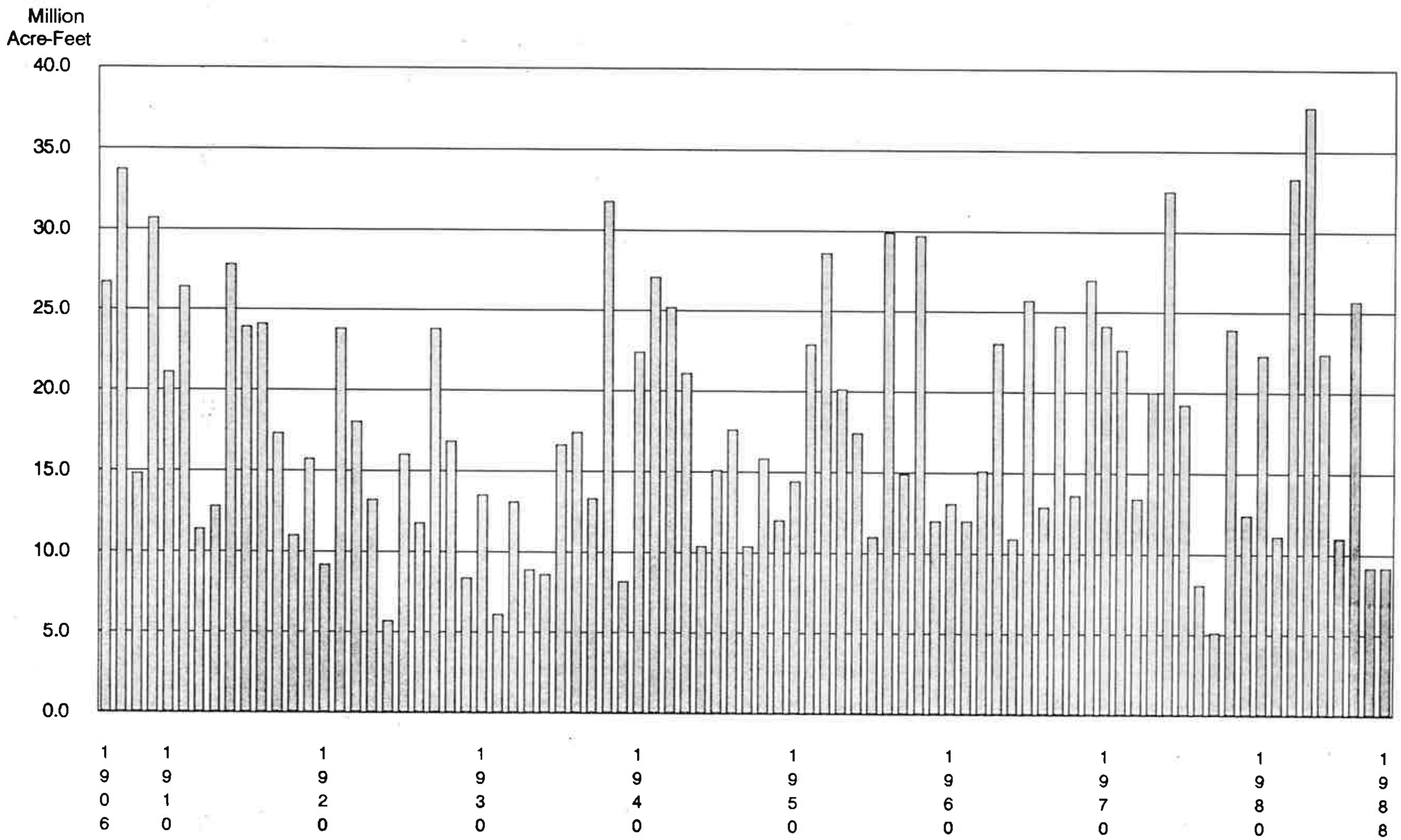


Table 2
Kern County Water Agency
Member Unit Contract Entitlements
for 1988 and 1990*

	Table 1 Entitlements (in acre-feet)					
	1988			1990		
Member Unit	**Firm**	**Surplus**	**Total**	**Firm**	**Surplus**	**Total**
Berrenda Mesa WD	148,800	13,100	161,900	155,100	8,100	163,200
Lost Hills WD	138,800	0	138,800	140,400	0	140,400
Belridge WSD	161,000	0	161,000	163,000	0	163,000
Buttonwillow ID	72,500	21,300	93,800	83,000	13,100	96,100
Pond Poso ID	58,500	17,600	76,100	67,000	11,100	78,100
Semitropic WSD	6,600	1,400	8,000	8,000	900	8,900
Cawelo WD	34,400	10,100	44,500	38,200	6,800	45,000
Improvement District No. 4	71,200	0	71,200	77,000	0	77,000
Rosedale-Rio Bravo WSD	26,700	7,500	34,200	29,900	5,100	35,000
Buena Vista WSD	19,125	5,625	24,750	21,300	3,750	25,050
Kern Delta WD	22,900	6,700	29,600	25,500	4,500	30,000
Henry Miller WD	31,875	9,375	41,250	35,500	6,250	41,750
West Kern WD	23,500	0	23,500	25,000	0	25,000
Wheeler Ridge-Maricopa WSD	241,600	57,700	299,300	263,200	39,700	302,900
Tehachapi-Cummings CWD Ag	2,900	900	3,800	4,300	700	5,000
M&I	12,300	0	12,300	15,000	0	15,000
Tejon-Castac WD	1,900	0	1,900	2,000	0	2,000
Total	**1,074,600**	**151,300**	**1,225,900**	**1,153,400**	**100,000**	**1,253,400**

* Maximum annual entitlement is reached in 1990.

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

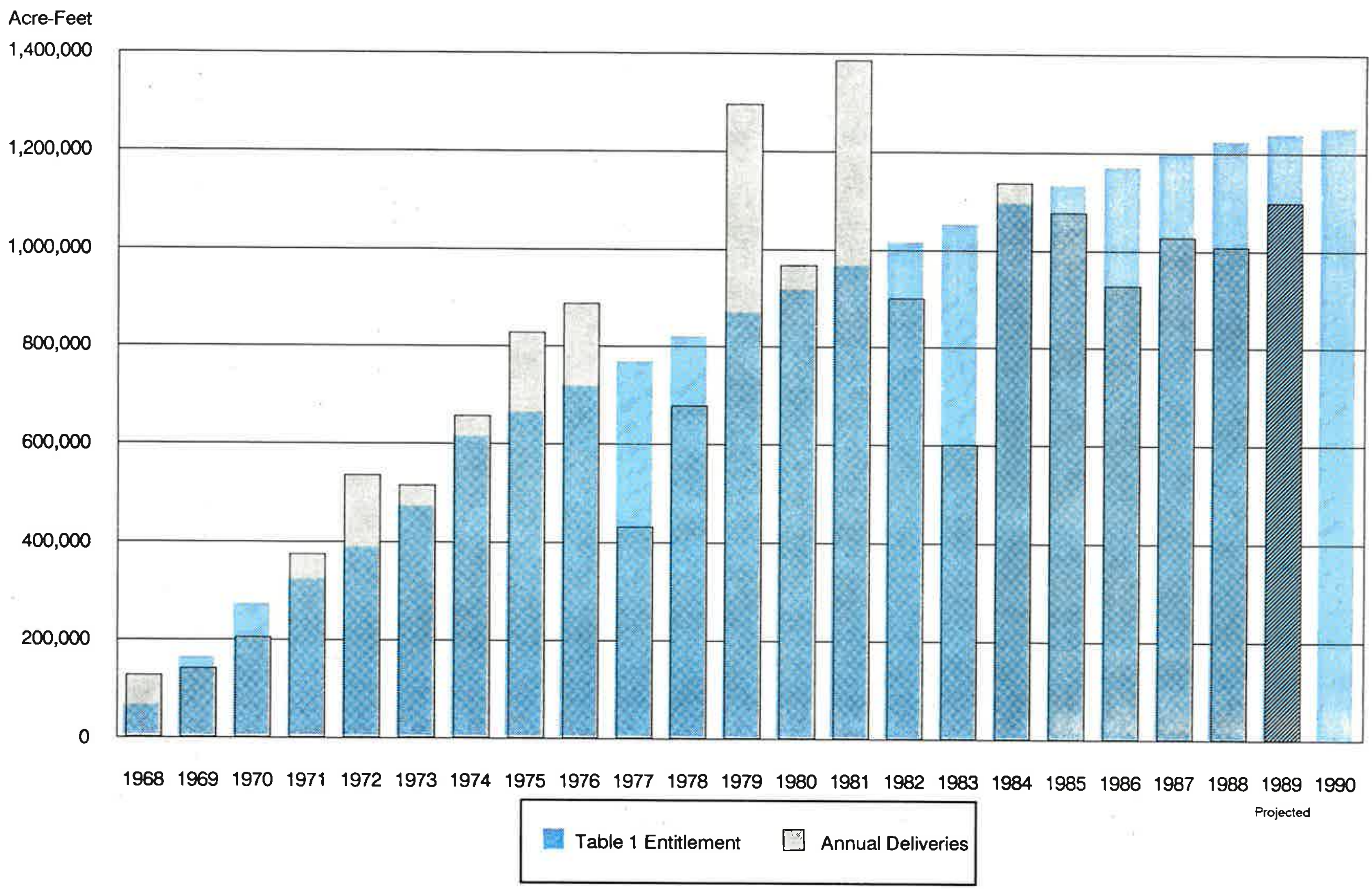


Table 3
SWP* Water Deliveries to the
San Joaquin Valley Portion of Kern County
(in acre-feet)

Year	Annual Deliveries	Cumulative Deliveries	Intertie Deliveries	Deliveries** 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	362,292	724	238,167	9,997,076
1984	1,138,040	11,674,783	13,639	1,360	1,123,041	11,120,117
1985	1,078,147	12,752,930		4,015	1,074,132	12,194,249
1986	929,178	13,682,108	12,701	2,916	913,561	13,107,810
1987	1,028,124	14,710,232		2,217	1,025,907	14,133,717
1988	1,009,520	15,719,752		3,307	1,006,213	15,139,930

Mean Deliveries	748,560 AF
Median Deliveries	828,437 AF
Mean Importations	720,949 AF
Median Importations	821,738 AF

* Includes Pre-consolidation water deliveries.

** Includes Tehachapi-Cummings CWD and other deliveries outside the San Joaquin Valley portion of Kern County.

Table 4
1988 State Water Project
Deliveries by Contract
(in acre-feet)

Member Unit	Table 1 Entitlement	1988 Ag Pool	1987 Carryover Entitlement	Lost Hills Emergency Relief Water Exchange Paypack	Lost Hills Emergency Relief Water Sale to Cawelo	Long-Term, Annual M&I Supplemental Pools	Landowner Transfers	Total 1) Delivery
Berrenda Mesa WD	103,026		7,087					110,113
Lost Hills WD	102,951		6,785	7,169				116,905
Belridge WSD	131,596		9,146					140,742
Buttonwillow ID	62,860	23,041						85,901
Pond Poso ID	54,620	19,014					1,000	74,634
Semitropic WSD	5,052	1,548						6,600
Cawelo WD	30,478	7,345	4,249		6,666		4,300	53,038
Improvement District No. 4 Ag	3,204		620					3,824
M&I	65,100					4,750		69,850
Rosedale-Rio Bravo WSD	18,849		94					18,943
Buena Vista WSD	17,634	2,652	5,042					25,328
Kern Delta WD	22,900	7,251	4,000					34,151
Henry Miller WD	31,875	10,555	2,891					45,321
West Kern WD	20,565					4,750		25,315
Wheeler Ridge-Maricopa WSD	178,828		16,720					195,548
Tehachapi-Cummings CWD Ag	1,394							1,394
M&I	1,913							1,913
Total	**852,845**	**71,406**	**56,634**	**7,169**	**6,666**	**9,500**	**5,300**	**1,009,520**

1) Excludes 118,675 AF of 1988 entitlement delivered in Jan-Mar 1989.

Note: This table shows contracted deliveries for calendar 1988. For each district, physical deliveries may vary from amounts shown due to:

a) Current year SWP/Kern River exchanges.
b) Payback of SWP water from prior year exchanges.
c) Conjunctive use agreements.

Table 5
Historic Kern River Flows at First Point of Measurement *
(in acre-feet)

Calendar Year	Annual Flows	Cumulative Flows	Calendar Year	Annual Flows	Cumulative Flows	Regulated Flows
1894	533,326	533,326				
1895	1,023,052	1,556,378				
1896	620,192	2,176,570	1931	185,644	25,991,148	
1897	893,488	3,070,058	1932	847,378	26,838,526	
1898	252,007	3,322,065	1933	441,086	27,279,612	
1899	338,872	3,660,937	1934	227,665	27,507,277	
1900	332,373	3,993,310	1935	474,128	27,981,405	
1901	910,426	4,903,736	1936	796,447	28,777,852	
1902	552,449	5,456,185	1937	1,260,187	30,038,039	
1903	546,395	6,002,580	1938	1,582,613	31,620,652	
1904	492,403	6,494,983	1939	461,073	32,081,725	
1905	531,809	7,026,792	1940	789,098	32,870,823	
1906	1,900,540	8,927,332	1941	1,401,076	34,271,899	
1907	1,070,000 **	9,997,332	1942	771,966	35,043,865	
1908	506,000 **	10,503,332	1943	1,220,827	36,264,692	
1909	1,838,643	12,341,975	1944	625,537	36,890,229	
1910	659,066	13,001,041	1945	938,055	37,828,284	
1911	1,013,384	14,014,425	1946	650,683	38,478,967	
1912	387,432	14,401,857	1947	406,698	38,885,665	
1913	380,242	14,782,099	1948	329,506	39,215,171	
1914	911,837	15,693,936	1949	302,870	39,518,041	
1915	646,287	16,340,223	1950	601,360	40,119,401	
1916	2,520,149	18,860,372	1951	442,222	40,561,623	
1917	823,082	19,683,454	1952	1,500,999	42,062,622	
1918	538,593	20,222,047	1953	548,833	42,611,455	
1919	499,124	20,721,171	1954	528,357 ***	43,139,812	528,357
1920	632,188	21,353,359	1955	367,783	43,507,595	896,140
1921	509,519	21,862,878	1956	755,500	44,263,095	1,651,640
1922	643,426	22,506,304	1957	445,859	44,708,954	2,097,499
1923	500,515	23,006,819	1958	967,511	45,676,465	3,065,010
1924	187,727	23,194,546	1959	353,165	46,029,630	3,418,175
1925	465,913	23,660,459	1960	324,088	46,353,718	3,742,263
1926	366,706	24,027,165	1961	177,063	46,530,781	3,919,326
1927	792,580	24,819,745	1962	607,848	47,138,629	4,527,174
1928	312,828	25,132,573	1963	676,237	47,814,866	5,203,411
1929	322,958	25,455,531	1964	361,624	48,176,490	5,565,035
1930	349,973	25,805,504	1965	634,303	48,810,793	6,199,338

* Includes Second Point deliveries above First Point.
** Data incomplete. Flow extrapolated from available data.
*** Isabella Dam in operation. All subsequent flows are controlled releases.

Table 5 (continued)
Historic Kern River Flows at First Point of Measurement *
(in acre-feet)

Calendar Year	Annual Flows	Cumulative Flows	Regulated Flows
1966	504,506	49,315,299	6,703,844
1967	1,465,855	50,781,154	8,169,699
1968	497,026	51,278,180	8,666,725
1969	2,313,769	53,591,949	10,980,494
1970	601,254	54,193,203	11,581,748
1971	442,651	54,635,854	12,024,399
1972	311,292	54,947,146	12,335,691
1973	785,133	55,732,279	13,120,824
1974	745,903	56,478,182	13,866,727
1975	572,091	57,050,273	14,438,818
1976	320,784	57,371,057	14,759,602
1977	200,702	57,571,759	14,960,304
1978	1,385,780	58,957,539	16,346,084
1979	656,068	59,613,607	17,002,152
1980	1,560,652	61,174,259	18,562,804
1981	460,469	61,634,728	19,023,273
1982	1,121,088	62,755,816	20,144,361
1983	2,381,575	65,137,391	22,525,936
1984	836,541	65,973,932	23,362,477
1985	671,959	66,645,891	24,034,436
1986	1,334,546	67,980,437	25,368,982
1987	434,715	68,415,152	25,803,697
1988	338,458	68,753,610	26,142,155

95 Year Mean First Point Flow	723,722 AF
95 Year Median First Point Flow	572,091 AF
Regulated Mean First Point Flow	746,919 AF
Regulated Median First Point Flow	601,254 AF

record. During the last 95 years, nearly 69 million acre-feet of Kern River runoff have occurred. Since Isabella Dam began regulating flows in 1954, over 26 million acre-feet of Kern River runoff has occurred. Figure 4 is a histograph of annual Kern River flows at First Point.

Entitlements to Kern River water are determined according to formulae established in the "Miller-Haggin Agreement" of 1888 and the "Shaw Decree," a judicial decree set in 1900 by Judge Lucien Shaw. Later amendments to these agreements have been adopted as circumstances warranted. Essentially, these agreements establish diversion rights to Kern River water based on unimpaired flows at First Point of Measurement. Most of these diversion rights are now held by public water districts. Hence, entitlements to Kern River water are diverted into district delivery facilities, and subsequently to farmers within the district. Table 6 gives a summary of Kern River deliveries in 1988. Plate 9 shows the major canal distribution facilities operated by the Kern River group.

Central Valley Project (CVP)

Deliveries of federal CVP water to Kern County in 1988 were 292,825 acre-feet. Comparatively, 1987 deliveries of CVP water were 291,981 acre-feet. Supplies in 1988 were about 103 percent of average, and about 119 percent of the median. These statistics seem to portray the year 1988 as somewhat wet. However, the areas in Kern County that receive CVP water were not fully developed until about 1975. Therefore, a more reasonable mean delivery is computed using 1975 to 1988 as the period of record. For 1975 to 1988, the mean delivery is 406,261 acre-feet, and the median is 438,751 acre-feet. Comparing 1988 CVP deliveries to these new statistics shows that it was only 72 percent of the mean and 67 percent of the median. Also, the fact that no Class 2 entitlement was available in 1988 helps to put the year in proper perspective. Since 1966, Class 2 entitlements have been unavailable in only 5 years (1976-77 and 1987-88). Table 7 shows 1988 deliveries of CVP water by entity. As is shown, 265,472 acre-feet of Class 1 entitlement and 27,353

Figure 4
Kern River Flows
at First Point of Measurement

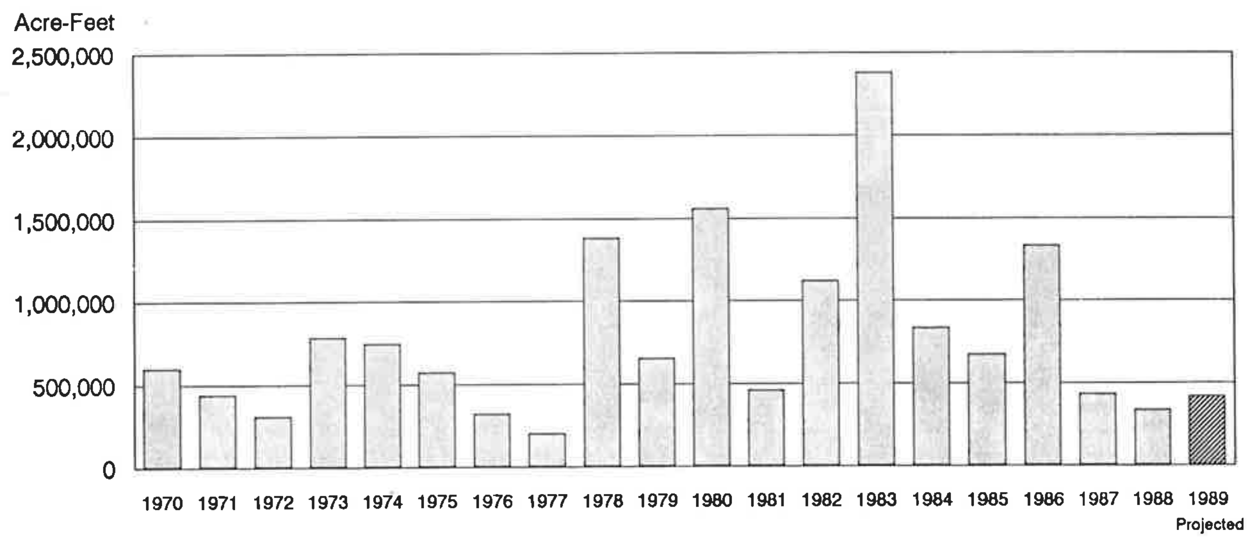


Table 6
1988 Summary of Kern River Water*
Diversions by Entity**
(in acre-feet)

Area of Use	Deliveries
Arvin-Edison WSD	2,700 1)
Buena Vista WSD	7,000 1)
Cawelo WD	15,600 1)
City of Bakersfield, Irrigation and Spreading	26,600 2)
Olcese WD	2,200 3)
Improvement District No. 4	26,400 1)
Kern Delta WD	163,200 4)
Kern River Channel, Losses and Spreading	8,000
Rag Gulch WD	1,400 1)
Kern-Tulare WD	9,400 1)
North Kern WSD	75,700
Rosedale-Rio Bravo WSD	300 1)
Total	**338,500**

* Includes the following sources:

Kern River (regulated)	335,500
Above First Point	3,000
Total	**338,500**

These sources become intermixed due to various indirect exchanges and spills.

**Deliveries include system losses.

1) Does not include direct deliveries of SWP or CVP water.
2) Includes 800 acre-feet diverted above First Point to Lake Ming.
3) Diverted above First Point.
4) Includes water delivered via Second Point facilities. Excludes SWP water delivered via exchange.

Table 7
1988 Central Valley Project
Deliveries by Entity
(in acre-feet)

		Cross Valley Canal 4)	
	Class 1	Pumped into F.K. Canal	Total
Arvin-Edison WSD 1)	101,322		101,322
Cawelo WD 2)		494	494
Delano-Earlimart ID	9,093	6,154	15,247
Kern National Wildlife Refuge 2)	8,200		8,200
Kern-Tulare WD 3)	10,670	9,414	20,084
Rag Gulch WD 3)	7,257	818	8,075
Shafter-Wasco ID	42,455	3,200	45,655
So. San Joaquin MUD	86,475	7,276	93,751
Total	**265,472**	**27,356**	**292,828**

1) Includes 88,970 AF delivered via the Cross Valley Canal.
2) Delivered via the San Luis Canal.
3) Per exchange of Cross Valley Canal water with Arvin-Edison WSD.
4) Pump-in pursuant to USBR authorized Exchange/Transfer Agreements during 1988.

Note: No Class 2 allotments for 1988.

acre-feet of other CVP water was delivered. Table 8 gives 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 1950. At the end of 1988, over 11 million acre-feet of CVP water have been imported into Kern County.

Minor Streams

Secondary to the Kern River water supply is runoff from local "minor streams." Streams which yield measurable runoff are grouped into three watershed areas; the northeast stream group (most significant of which is Poso Creek), the southeast stream group (most significant of which are Caliente and Tehachapi Creeks) and the southern stream group (most significant of which are San Emigdio and El Paso Creeks). Total yields from minor streams can be substantial during above-average precipitation years, such as 1982, 1983 and 1986. A large portion of these flows percolate into the underground aquifers before reaching the valley floor. Minor stream flows in 1988 were estimated to be about 22,900 acre-feet as follows:

Northeast stream group	15,400 acre-feet
Southeast stream group	2,000 acre-feet
Southern stream group	5,500 acre-feet

Some of this water evaporated. During most years, some is used for irrigation by farmers in the North Kern Water Storage District and Pond-Poso Improvement District. Much of the water percolated to the underlying aquifers. Some of this recharge probably contributes to perched water in the Kern Lake Bed area and near the Kern National Wildlife Refuge. The Agency estimated that about 21,700 acre-feet of the minor stream flows during 1988 contributed to ground water recharge. Table 9 shows annual minor stream runoff by stream group, along with cumulative runoff. The variability of minor stream flows is shown by the accompanying statistics. Figure 6 charts annual minor stream flows.

The Agency, in cooperation with local water districts, monitors stream flows on Poso, Tehachapi Creeks. Figures 7a, 7b, 7c and 7d are hydrographs for these creeks showing runoff during 1988.

Effective Precipitation

Rainfall that occurs during the growing season of a crop, or is otherwise stored in the soil for later use, provides water that would otherwise be applied by the farmer. By reducing the total crop water needs that the farmer must fulfill, rainfall can reduce the total volume of water that needs to be imported or withdrawn from ground water supplies. So, rainfall provides an alternative water supply, referred to as "effective precipitation."

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

Most urban storm runoff is captured in unlined sumps and allowed to percolate. It 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 100 acre-feet of rainfall was diverted into the Kern River system in 1988.

The Agency gathers monthly rainfall data for 45 measuring stations in the San Joaquin Valley portion of Kern County. This rainfall data is subsequently used to compute effective precipitation. Slightly less than normal rainfall in 1988 contributed 144,200 acre-feet of effective precipitation, with 14,700 acre-feet occurring over the useable ground water basin. This includes the urban storm water diverted into the Kern River. Rainfall in 1988 was about 91 percent of normal. Following is a tabulation of 1988 versus average monthly rainfall for the San Joaquin Valley portion of Kern County. The Agency estimates that rainfall provided about 1.9 inches of useable water for crops grown during 1988.

Table 8
Annual and Cumulative
Central Valley Project Deliveries
to Kern County
(in acre-feet)

Year	Annual Delivery	Cumulative Delivery
1950	762	762
1951	27,005	27,767
1952	49,500	77,267
1953	83,558	160,825
1954	112,093	272,918
1955	126,238	399,156
1956	279,134	678,290
1957	141,684	819,974
1958	223,830	1,043,804
1959	166,099	1,209,903
1960	156,978	1,366,881
1961	126,412	1,493,293
1962	231,045	1,724,338
1963	234,283	1,958,621
1964	189,330	2,147,951
1965	245,482	2,393,433
1966	232,084	2,625,517
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
1981	469,966	7,899,255
1982	656,608	8,555,863
1983	550,874	9,106,737
1984	425,371	9,532,108
1985	337,514	9,869,622
1986	589,262	10,458,884
1987	291,981	10,750,865
1988	286,674	11,037,539

Mean Delivery	283,014 AF
Median Delivery	245,842 AF

Figure 5
Central Valley Project
Deliveries to Kern County

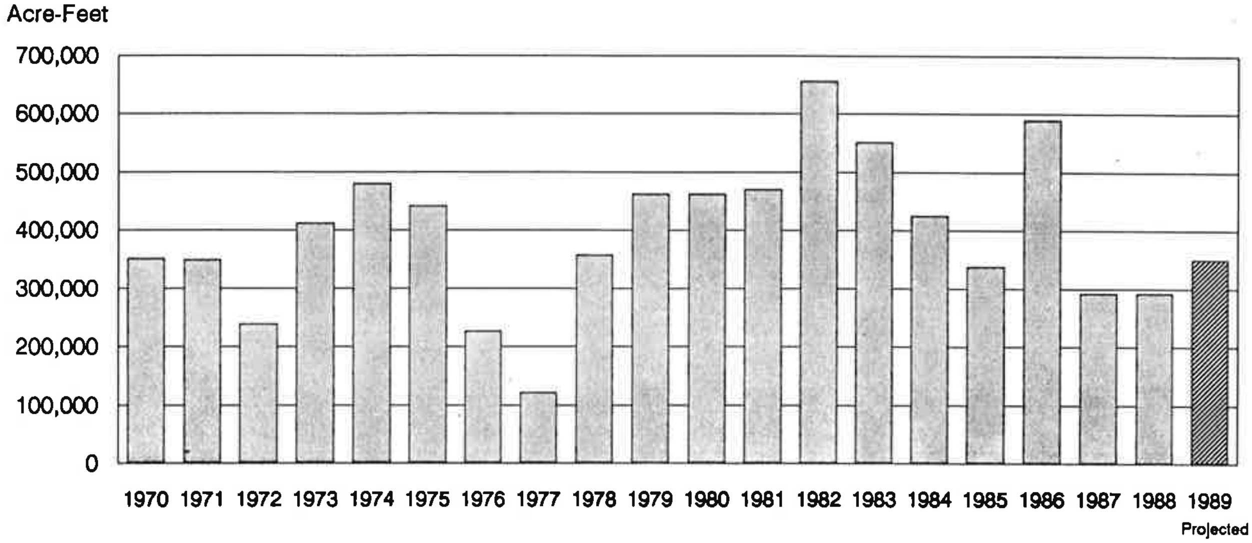


Figure 6
Minor Stream Flows
in Kern County

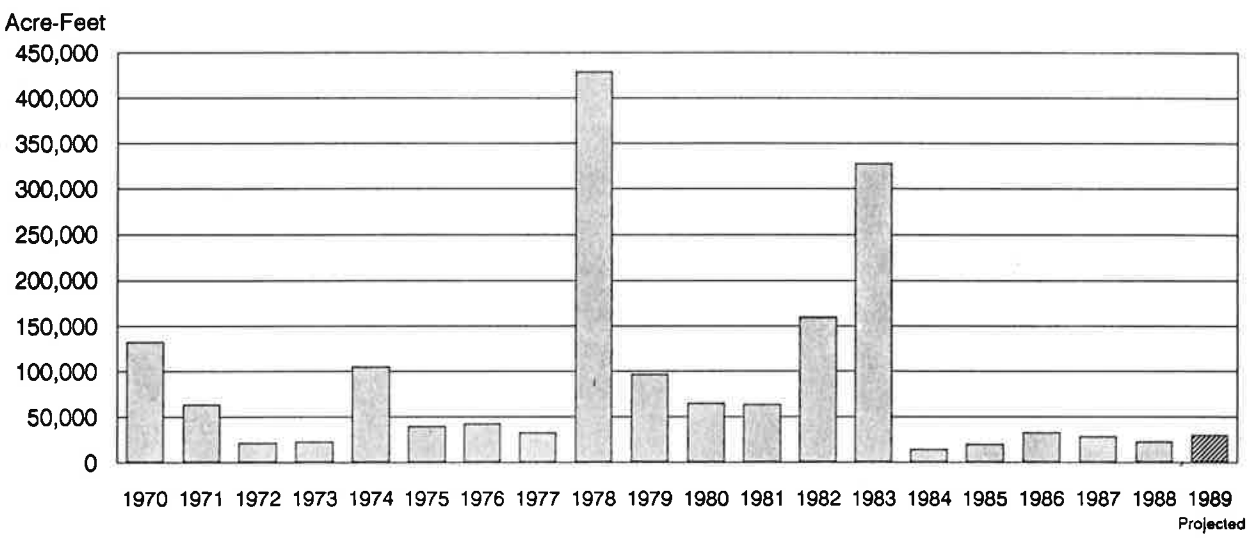
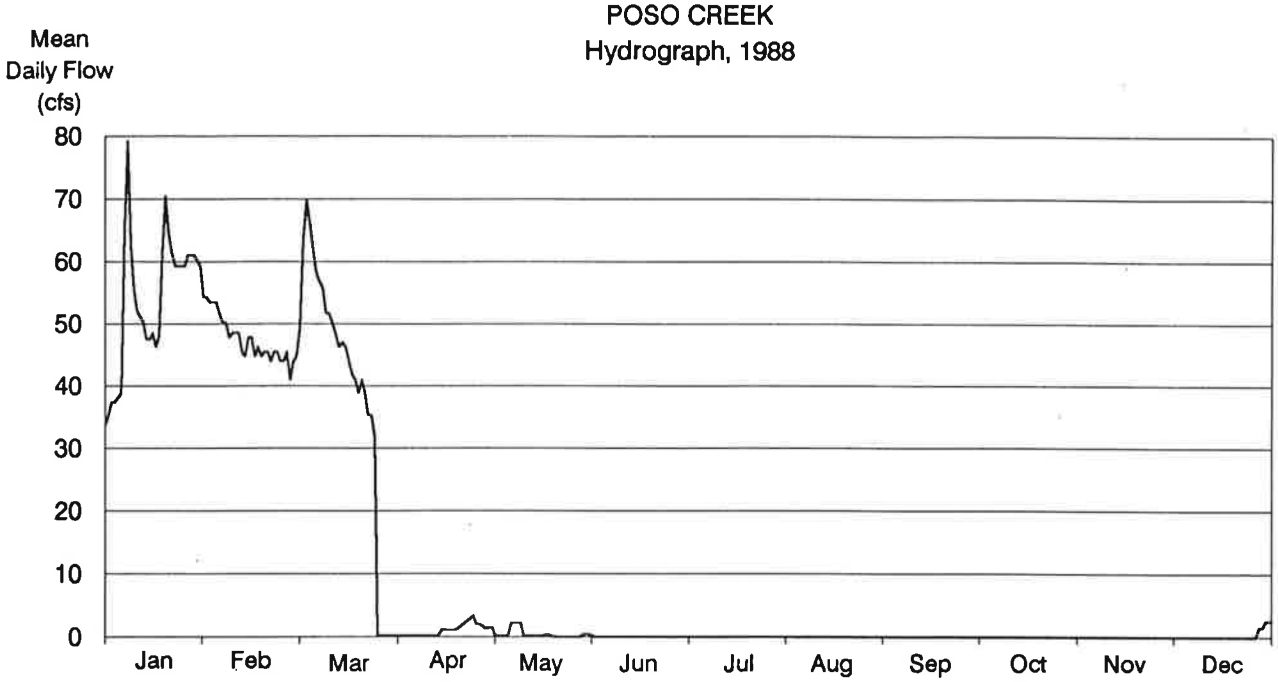


Table 9
Annual and Cumulative
Minor Stream Flows in the
San Joaquin Valley Portion of Kern County

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	159,900	1,274,600
1983	327,700	1,602,300
1984	14,300	1,616,600
1985	20,200	1,636,800
1986	32,600	1,669,400
1987	28,600	1,698,000
1988	22,900	1,720,900

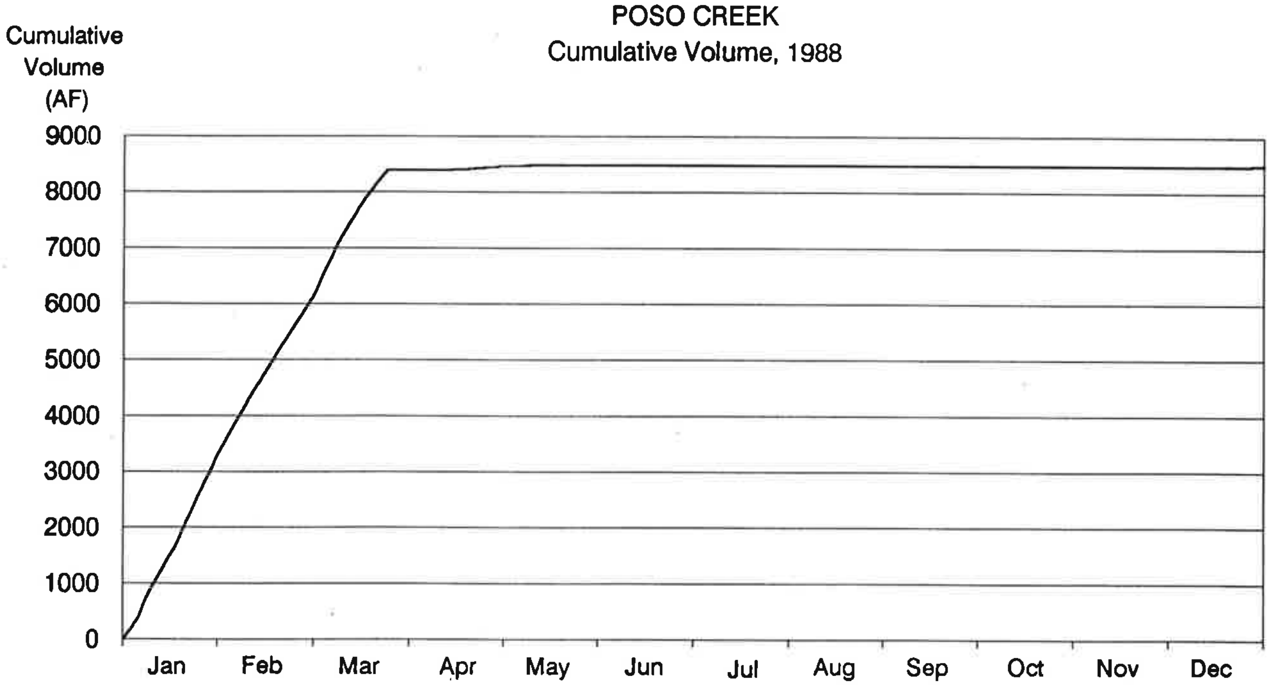
Mean Flow	90,600 AF
Median Flow	42,700 AF

Figure 7a
POSO CREEK
Hydrograph, 1988



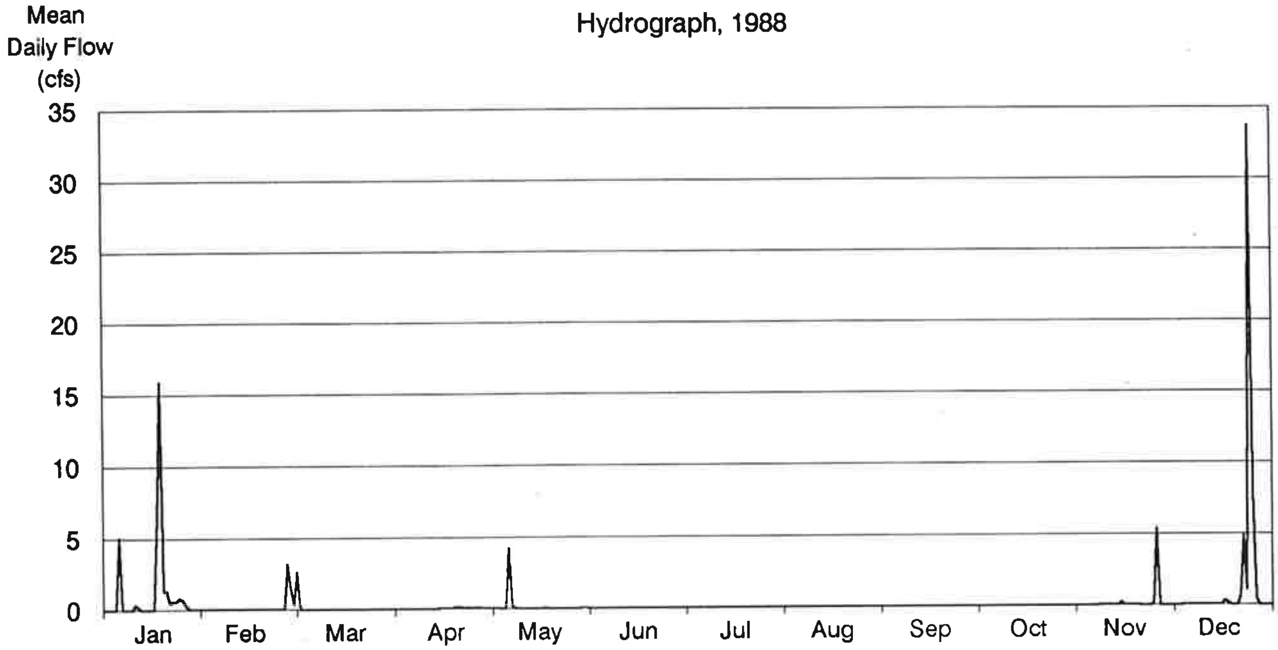
NOTE: 1. Hydrograph began 0000 hrs on 1-1-88 and ended at 2400 hrs on 12-31-88.
2. Located at Lat. 35 30'49", Long. 118 54'17", SW 1/4, SW 1/4, Sec.6, T.28S., R.29E., Kern County.
3. Peak discharge, 79.2 cfs, Jan. 7, 1988.

Figure 7b
POSO CREEK
Cumulative Volume, 1988



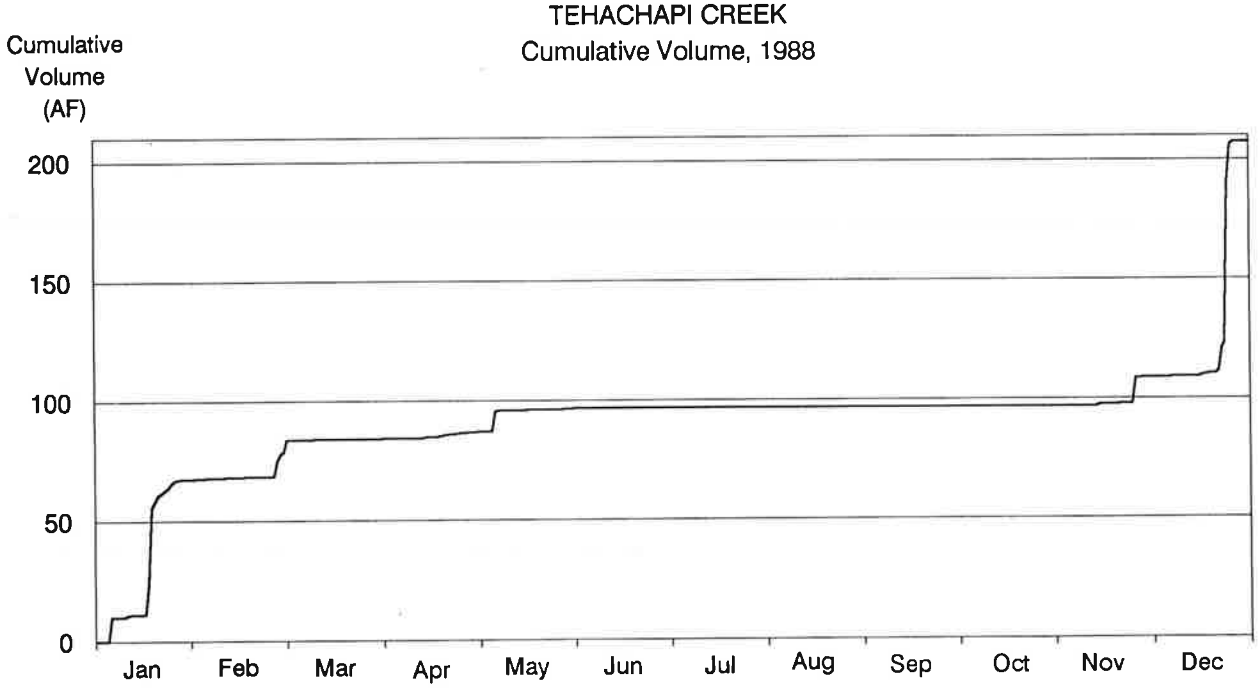
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume (AF)	3353.1	2716.6	2323.8	68.7	27.3	0.3	0	0	0	0	0	21.1
Cumulative Volume (AF)	3353.1	6069.7	8393.5	8462.2	8489.5	8489.8	8489.8	8489.8	8489.8	8489.8	8489.8	8510.9

Figure 7c
TEHACHAPI CREEK
Hydrograph, 1988



NOTE:
1. Hydrograph began 0000 hrs on 1-1-88 and ended at 2400 hrs on 12-31-88.
2. Located at Lat. 35 10'26", Long. 118 28'43", NE 1/4, SW 1/4, Sec.6, T.32S., R.33E., Kern County.
3. Flat portions reflect low flow conditions. Q is calculated using Broad-Crested Weir Method.
4. Peak discharge, 33.7 cfs, Dec. 22, 1988.

Figure 7d
TEHACHAPI CREEK
Cumulative Volume, 1988



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Volume (AF)	67.7	11	5.8	2.5	9.5	0.2	0	0	0	0	12	98.6
Cumulative Volume (AF)	67.7	78.7	84.5	87	96.5	96.7	96.7	96.7	96.7	96.7	108.7	207.3

	1988 Rainfall	Meadows Field Ave.Rainfall	% of Average
January	1.16	1.02	88
February	0.36	1.00	36
March	0.40	0.94	43
April	1.36	0.65	209
May	0.15	0.30	50
June	0.16	0.07	229
July	--	0.01	--
August	--	0.02	--
September	--	0.10	--
October	--	0.31	--
November	0.58	0.52	112
December	1.04	0.80	130
Total	5.23	5.74	91

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. This is due to the effects of orographic uplift associated with the mountains at the southern end of the valley. Table 10 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 a minor source of water for Kern County agriculture. There are 13 active wastewater sewage treatment plants in the valley portion of Kern County. Wastewater treatment processes are classified as primary, secondary or tertiary. Primary treatment removes most of the suspended matter from the sewage (usually via settling ponds), but little or no colloidal or dissolved matter. Secondary treatment provides some biological action or filtration to remove any remaining organic matter from the sewage. Tertiary treatment removes harmful chemicals (such as heavy metals) and nutrients. Nearly all of the wastewater treatment facilities in Kern County provide secondary treatment of sewage. About half of the effluent from these treatment plants is used to irrigate several salt-tolerant crops on bordering lands, such as cotton, pasture and some grains. A small amount is directly recharged to the ground water basin. The remainder is evaporated. In 1988, about 44,200 acre-feet of wastewater was treated (see Table 11).

Another source of wastewater is a by-product of oilfield production. Oilfield wastewater is a new source of surface water for Kern County, being drawn from deep, connate waters which are intermixed with oil deposits. In the Kern Front oilfield, which lies astride the Kern River east of Bakersfield, substantial quantities of water are removed with each barrel of oil. The chemical quality of this water is generally within acceptable limits for agriculture. Thus, much of this water is discharged into irrigation canals. A total of 12,700 acre-feet of production water from the Kern Front oilfield was reused in 1988.

In other areas, some oil companies discharge their waste waters into lined and unlined sumps, where much of it recharges the underlying aquifer, probably degrading it in the process. These amounts cannot be quantified, however, since accurate records of such discharges are seldom kept.

Another source of wastewater reuse 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, or would otherwise be lost as ground water return flows. This recovered water is either transported back to the main irrigation system or it is applied on an adjacent field (from the foot of one field to the head of another). On the average, about 5-10 percent of applied water is recovered and reused. Tail water return systems are widely used on fields which 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.

Total wastewater reuse was estimated to be about 56,900 acre-feet in 1988, excluding any tailwater reuse, which were not estimated. Table 12 gives a historical summary of wastewater reuse in the San Joaquin Valley portion of Kern County since 1970.

Ground Water Extractions

Ground water extractions in Kern County are not recorded. In the past, agricultural power records from the utility companies were matched with calculated numbers for ground water production. In this report, ground water extractions are estimated

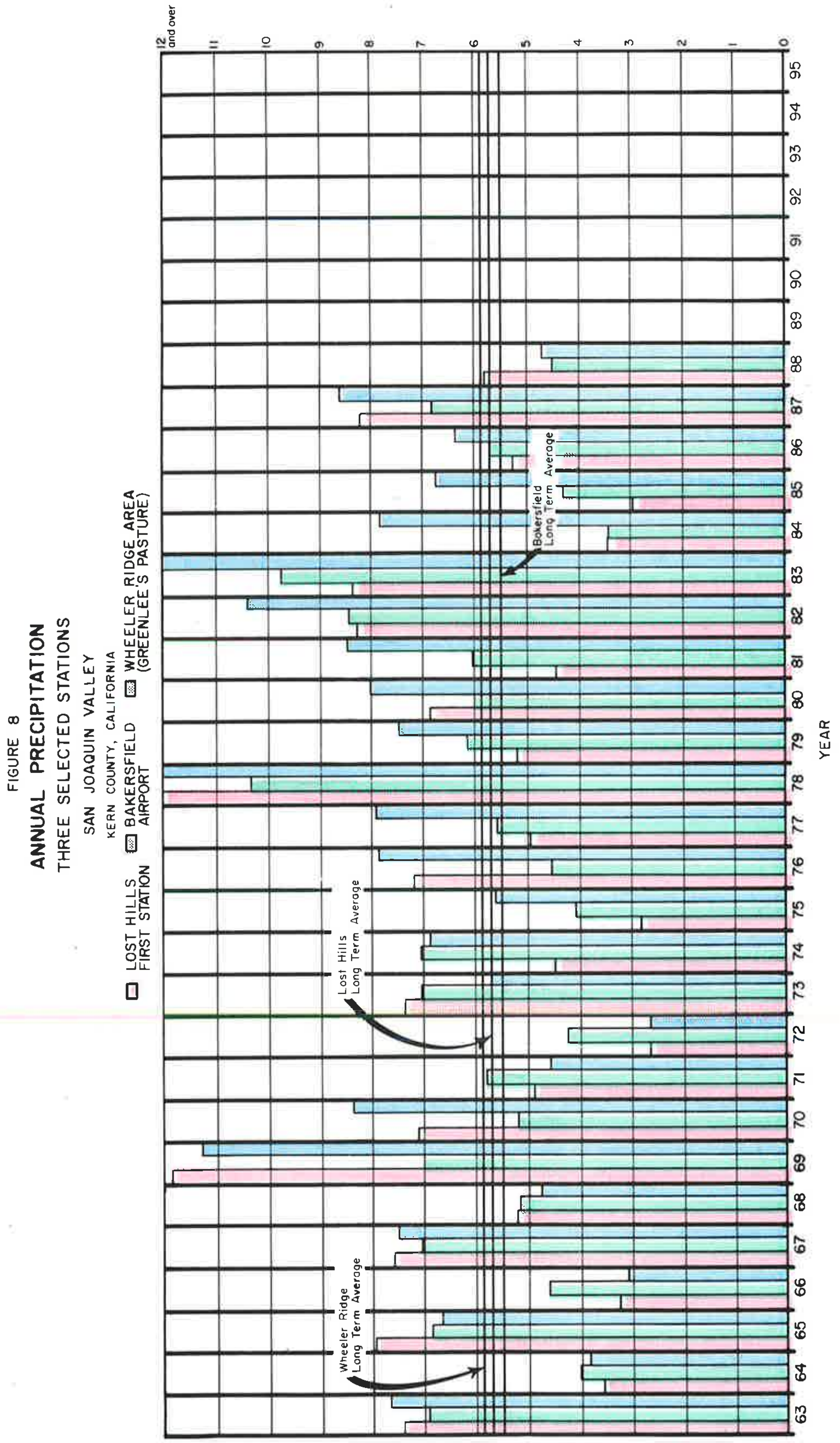


FIGURE 8
ANNUAL PRECIPITATION
THREE SELECTED STATIONS
SAN JOAQUIN VALLEY
KERN COUNTY, CALIFORNIA
LOST HILLS FIRST STATION
BAKERSFIELD AIRPORT
WHEELER RIDGE AREA (GREENLEE'S PASTURE)
Wheeler Ridge Long Term Average
Lost Hills Long Term Average
Bakersfield Long Term Average
12 and over
11
10
9
8
7
6
5
4
3
2
1
0
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
YEAR

Table 10
Annual and Cumulative
Effective Precipitation
in the San Joaquin Valley Portion
of Kern County
(in acre-feet)

	Annual Effective Precipitation	Unit Rate AF/Acre)	Cumulative Effective Precipitation
1970	380,200	0.48	380,200
1971	148,300	0.18	528,500
1972	264,900	0.31	793,400
1973	131,900	0.15	925,300
1974	220,200	0.24	1,145,500
1975	240,500	0.26	1,386,000
1976	175,300	0.19	1,561,300
1977	198,400	0.23	1,759,700
1978	612,500	0.67	2,372,200
1979	152,600	0.16	2,524,800
1980	281,200	0.30	2,806,000
1981	255,400	0.27	3,061,400
1982	332,300	0.35	3,393,700
1983	438,100	0.51	3,831,800
1984	139,300	0.14	3,971,100
1985	160,700	0.17	4,131,800
1986	162,600	0.20	4,294,400
1987	168,200	0.21	4,462,600
1988	144,200	0.17	4,606,800

Mean EP (total)	242,500 AF
Median EP (total)	209,300 AF
Mean EP (per acre	0.27 AF/Acre
Median EP (per ac	0.24 AF/Acre

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

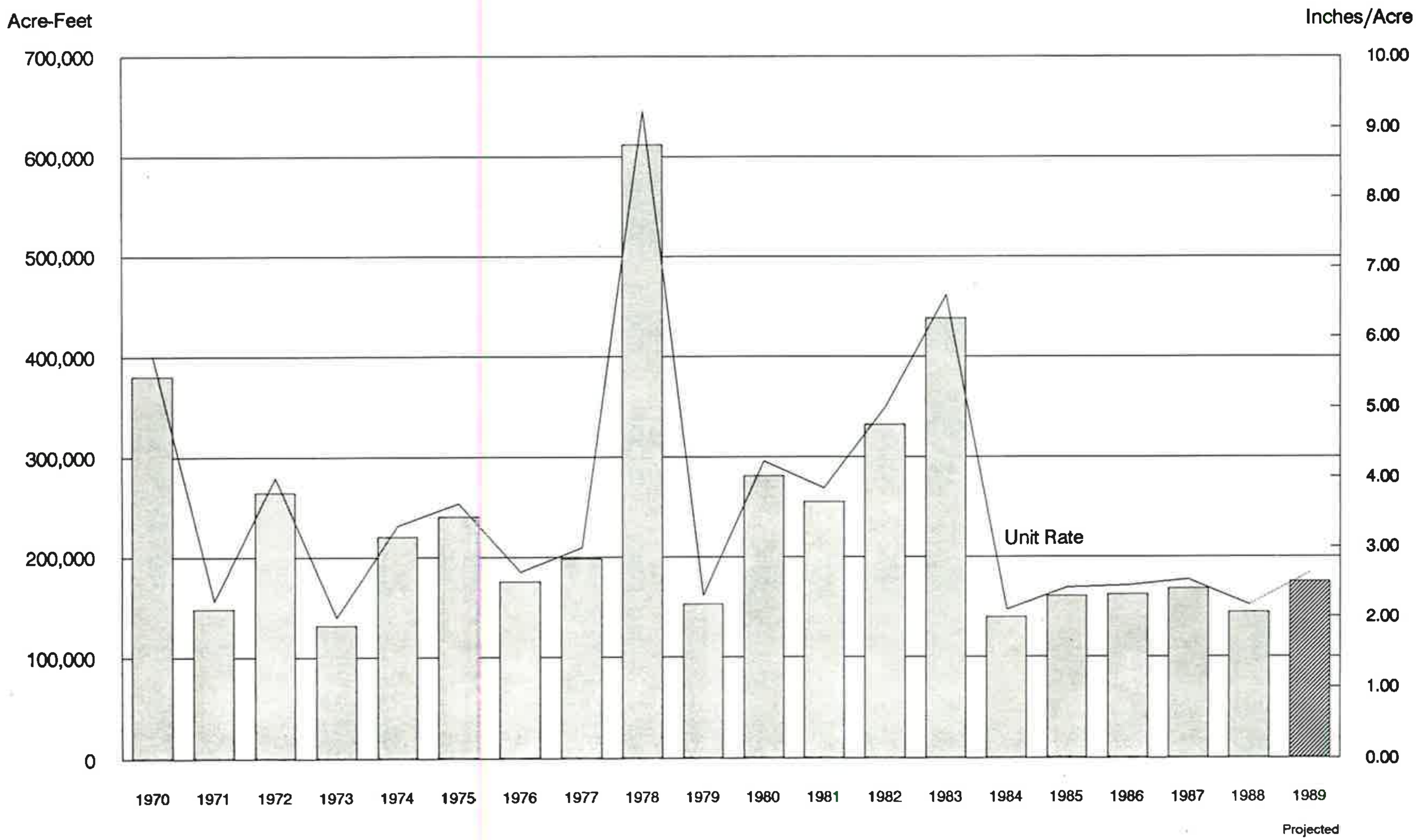


Table 11
1988 Wastewater Treatment Plant Volumes

Facility	Volume (AF) *	Influent Source	Treatment System	Effluent Use
City of Arvin	891	Dom	Secondary	Agriculture
City of Bakersfield				
#2	18,162	Dom/Ind	Secondary	Restricted Agriculture
#3	8,317	Dom/Ind	Secondary	Restricted Agriculture
Kern County Public Works				
Mt. Vernon	4,354	Dom	1/2 Primary, 1/2 Secondary	Agriculture
BVARA	18	Agr	Secondary	Evaporation
Sheriff's Lerdo Facility	360	Dom	Secondary	Percolation
NOR Sanitary District #1	3,757	Dom/Ind	Secondary	Restricted Agriculture, Percolation
City of Delano	3,210	Dom	Secondary	Restricted Agriculture
Lamont Public Utilities District	1,690	Dom	Primary	Agriculture
City of McFarland	599	Dom	Secondary	Agriculture
City of Shafter	898	Dom/Ind	Secondary	Agriculture
Shafter Airport	337	Ind	Secondary	Percolation
City of Wasco	1,620	Dom/Ind	Secondary	Agriculture
Total	**44,213**			

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

* Based on daily average flow.

Table 12
Historic Waste Water Reuse
(in acre-feet)

Year	Waste Water 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

Mean Waste Water Flows	31,500 AF
Median Waste Water Flows	28,500 AF

by "backing in," or solving for the missing number in the ground water change-in-storage equation (see Figure 13).

Total ground water extractions in 1988 were calculated to be about 1,504,200 acre-feet. This is about 331,500 acre-feet more than was extracted in 1987. Likely, the reason for this increase was the jump in irrigated acreage during a critically-dry year.

Ground water is pumped for a variety of uses in the valley. Agriculture, the largest user of ground water over the basin, used about 1,432,000 acre-feet in 1988. Municipal and industrial uses of ground water over the basin were about 85,700 acre-feet. An additional 22,500 acre-feet of ground water was exported out of the ground water basin by West Kern Water District, Lost Hills Water Company and some small agricultural operations on the west side of the valley. The exported water was used for crop irrigation, oilfield steaming and for meeting the needs of west side towns, such as Taft, Maricopa and Lost Hills.

Since 1977 it has become apparent that ground water pumping is very sensitive to available surface water supplies. During years when abundant surface water is available at a price commensurate with the price of pumping, farmers use the surface water. Hence, ground water pumping is reduced. However, when surface water supplies are reduced, the opposite is true and farmers are forced to rely more heavily on their ground water pumps in order to grow their crops. Hence, the development of additional water storage facilities capable of supplying a firm yield at a reasonable cost would benefit Kern County's ground water basin.

Timing is another factor affecting ground water pumping. Although surface water may be available during the early spring months, it may not be available during the peak irrigation season (typically during the hot summer months). Hence, absent a storage facility (like Lake Isabella) or a conjunctive use program to normalize the availability of surface water, farmers would have no choice but to pump the additional water to meet peak demands. Table 13 gives historic ground water pumping in the San Joaquin Valley portion of Kern County since 1970. Both annual and cumulative amounts are tabulated, along with descriptive statistics. Figure 10 provides a histograph of ground water pumping, graphically displaying the relative "ups and downs".

Subsurface Inflow

Many geologists believe that subsurface inflow, particularly from the west side of the valley, provides a substantial source of natural recharge to the ground water basin. Possibly, as much as 200,000 acre-feet per year is added to the useable ground water basin from subsurface movement of water. However, it is generally believed that such subsurface inflow is also a significant source of quality degradation to the ground water basin. The ground water of the west side, being marine in nature, is very saline. So the migration of this marine water into the fresh water aquifers degrades our useable ground water supply. This report does not include an estimate of subsurface inflow, because enough data does not now exist to substantiate a volume.

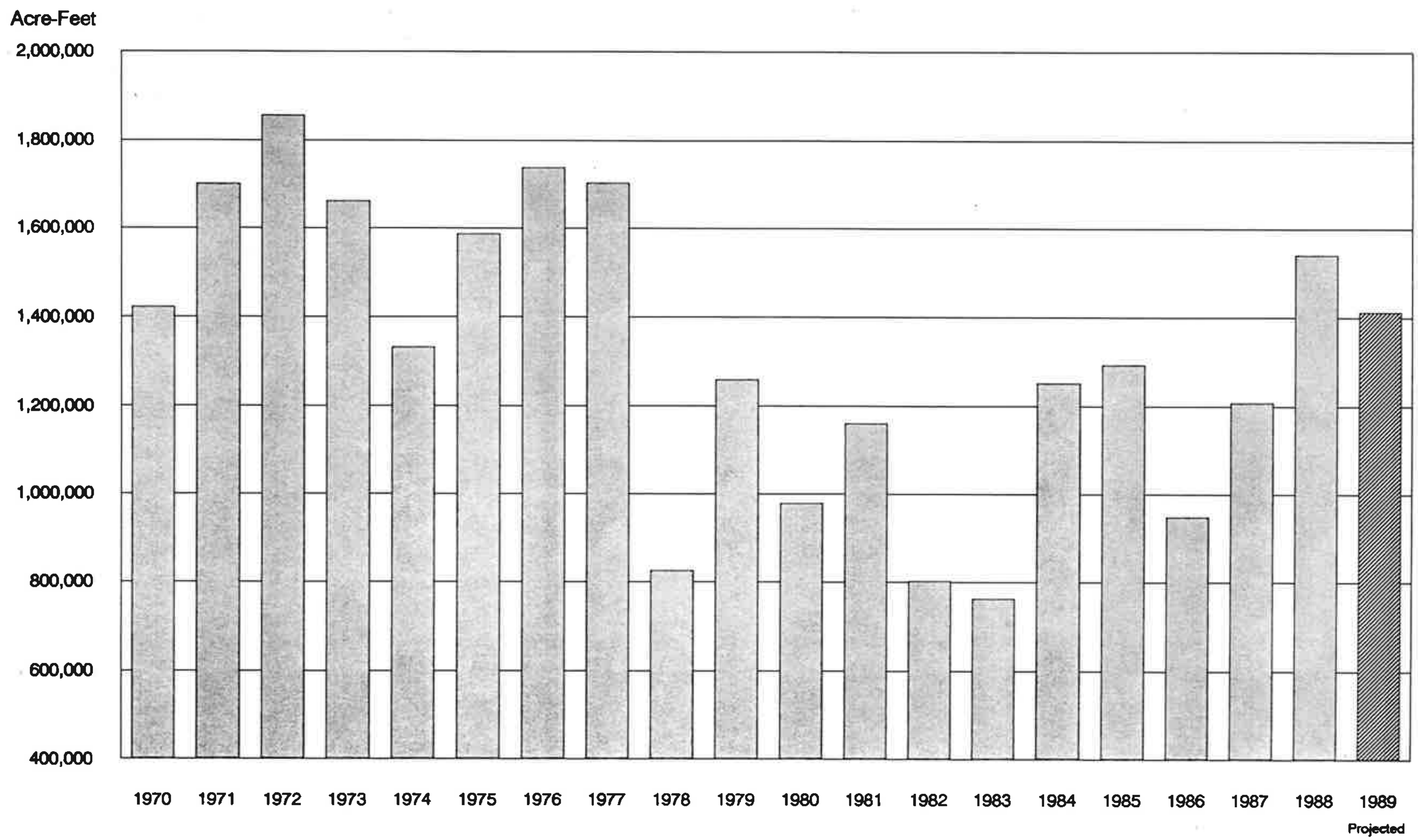
Table 13

Historic Ground Water Pumping
(in acre-feet)

Year	Annual Ground Water Pumped	Cumulative Ground Water Pumped
1970	1,422,000	1,422,000
1971	1,700,000	3,122,000
1972	1,857,000	1,857,000
1973	1,662,000	4,784,000
1974	1,333,000	3,190,000
1975	1,587,000	6,371,000
1976	1,738,000	8,109,000
1977	1,703,000	9,812,000
1978	825,000	10,637,000
1979	1,260,000	11,897,000
1980	977,000	12,874,000
1981	1,161,000	14,035,000
1982	802,200	14,837,200
1983	762,700	15,599,900
1984	1,252,200	16,852,100
1985	1,293,800	18,145,900
1986	947,600	19,093,500
1987	1,208,700	20,302,200
1988	1,540,200	21,842,400

Mean Ground Water Pumping	1,317,500 AF
Median Ground Water Pumping	1,293,800 AF
Minimum Pumping in 1983	762,700 AF
Maximum Pumping in 1972	1,857,000 AF

Figure 10
Ground Water Pumping
in the San Joaquin Valley Portion of Kern County



Water Requirements

Agricultural

Gross irrigated acreage in the San Joaquin valley portion of Kern County was about 831,100 acres in 1988, about 43,300 acres more than in 1987. This marks a turnaround in the general decline in irrigated acreage that has occurred since 1984. Since about 5,000 acres were double-cropped, total gross cropped acreage in 1988 was about 826,100 acres. About 709,300 acres (including double-cropping) were irrigated over the useable ground water basin (about 41,000 acres more than in 1987). About 121,800 acres were irrigated on lands outside the useable ground water basin (about 2,300 acres more than in 1987). Acreage planted to cotton increased about 27,300 acres over 1987. Likewise, small grains increased in acreage over 1987 by about 16,700 acres. Potatoes also showed a 3,000 acre increase over 1987. Alfalfa acreage, however, decreased by nearly 9,000 acres over 1987. Carrots were reduced by about 3,000 acres. Melons saw a 1,800 acre decrease from 1987. Likely, some of the alfalfa acreage was planted to cotton during 1988 (alfalfa is a common rotation crop with cotton). In addition, some idle lands were brought back into production.

A historical summary of irrigated acreage is provided on Table 14, along with descriptive statistics. Figure 11 shows historic irrigated acreage plotted as a bar graph.

Per unit crop water demands in 1988 were slightly higher than normal. Evaporation, which corresponds to crop water use, was about 8 percent higher than normal. Table 15 is a summary of monthly evaporation as measured at three climatic stations in the County. The Bakersfield 10NW station (operated by the State Department of Water Resources) is representative of evaporation on the valley floor. Figure 12 displays monthly evaporation for these stations as a percent of normal. Overall, 1988 was a good growing season, marked by a long, warm summer and dry harvest season. Some problems were experienced with cotton, however. Normally, cotton is planted in late March to early April, after the rainy season. Usually, not much rainfall occurs during April (normally about 0.6 inches). However, April, 1988 saw rainfall over 200 percent of normal. Measuring stations throughout the valley received from 1.00 to 2.56 inches of precipitation during April. As a consequence, some newly-emerged cotton seedlings were washed out. Perhaps as much as 5 to

Figure 11
Irrigated Acreage in the
San Joaquin Valley Portion of Kern County

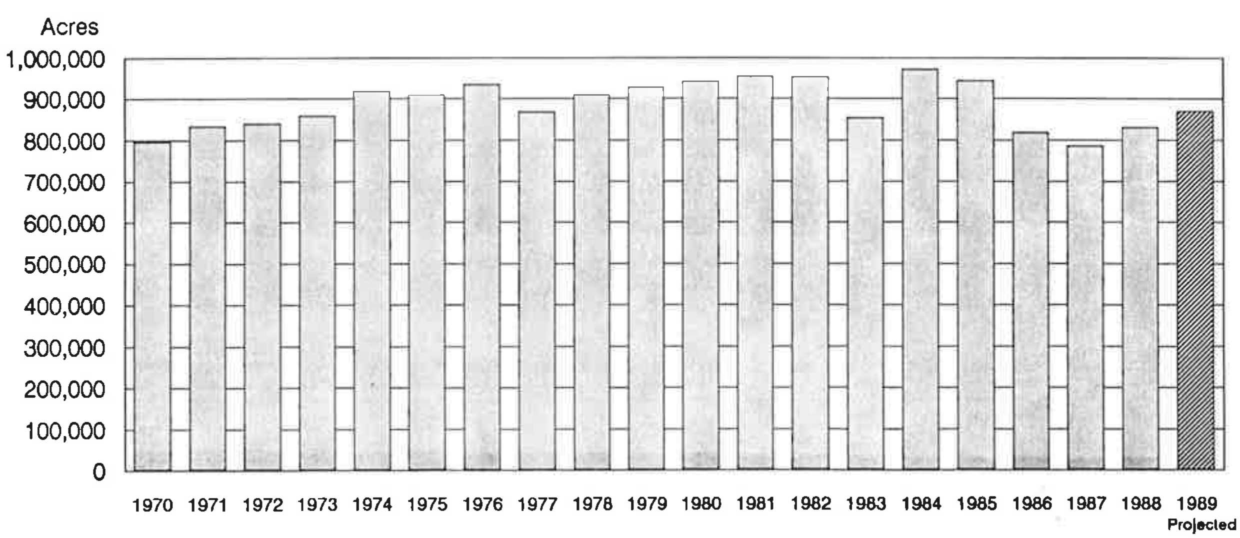


Table 14
Historic Irrigated Acreage *
(in Acres)

Year	Total Irrigated Acreage
1970	797,300
1971	834,800
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	819,500
1987	786,800
1988	831,100

Mean Irrigated Acreage	887,600
Maximum Irrigated Acreage in 1984	972,800
Minimum Irrigated Acreage in 1987	786,800

* 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 5,000 to 8,000 acres annually.

Table 15
1988 Monthly Evaporation for
Three San Joaquin Valley Climatic Stations
(in inches)

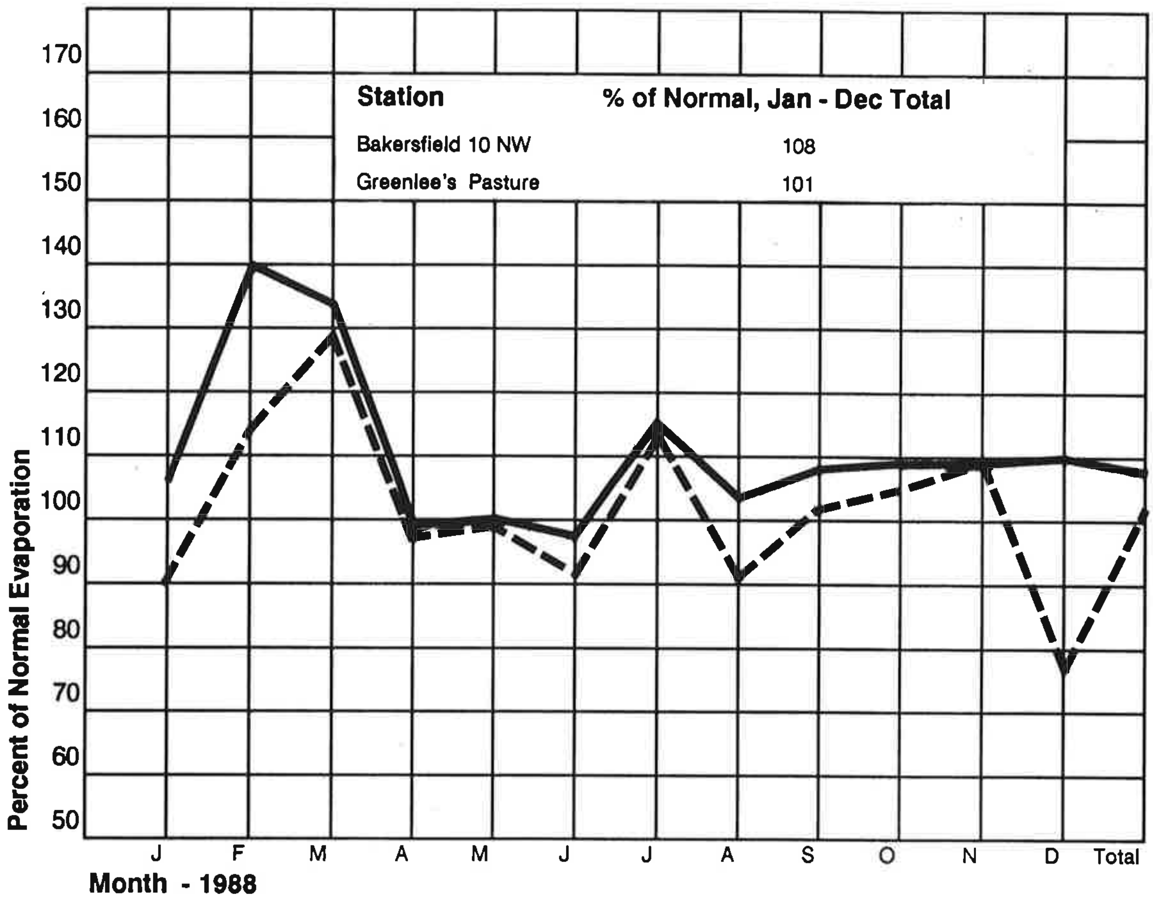
	Bakersfield 10NW	USDA Cotton Station	Greenlee's Pasture	Average
January	1.50	1.35	1.10	1.32
February	3.07	2.79	2.70	2.85
March	5.31	4.74	5.16	5.07
April	5.77	6.40	5.74	5.97
May	8.28	9.90	8.40	8.86
June	9.40	10.80	7.97	9.39
July	11.13	11.77	10.30	11.07
August	8.85	10.04	7.35	8.75
September	6.90	8.57	6.19	7.22
October	4.70	5.54	4.53	4.92
November	2.34	2.80	2.36	2.50
December	1.32	1.32	1.08	1.24
Total	**68.57**	**76.02**	**62.88**	**69.16**
Percent of Normal	**108**	**126**	**101**	**112**

Station Locations

Bakersfield 10NW	NE1/4, NW1/4, Section 18, T28S, R27E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.
Greenlee's Pasture	SW1/4, SW1/4, Section 36, T12N, R21W, SBB&M. Equipment: USWB Class "A" evaporation pan in an irrigated pasture environment.
USDA Cotton Station	NW1/4, SE1/4, Section 33, T27S, R25E, MDB&M. Equipment: USWB Class "A" evaporation pan in an irrigated grass turf environment.

Figure 12

1988
Percent of Normal Evaporation



Bakersfield 10 NW
1988 observed monthly EP, Bakersfield 10 NW (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 (Wheeler Ridge)
1988 observed monthly EP, Greenlee's Pasture (irrigated pasture - Wheeler ridge area) compared to 8 year average for that station. This is indicative of EP at higher foothill elevations.

10 percent of the crop was replanted. Adding to the problem was the cold and windy weather during late April and early May. During April, 1988 cotton fields received only 75 heat units (a measurement of warmth) compared with a normal of 150 and nearly 250 during April, 1987. A warm April is desirable, since the heat encourages strong seedling growth in cotton. Ideally, farmers like the bolls to be set before the July-August heat, which can stunt fruit set. Fruit set in those fields not well established before the early rains experienced unusually small boll sizes, which contributed to a substantial yield drop over 1987. On the positive side, however, cotton quality during 1988 was excellent. Some have characterized the 1988 cotton crop as of better grade than any in the past 10 years. Staple length (a measurement of the length of the cotton fiber) was longer than in past years. Apparently, the same hot summer that caused low yields also contributed to the excellent quality. Since most plants had fewer fruits to support, they were able to grow to their full potential.

One farmer's problems are another farmer's blessings, however. Grape growers, particularly table grapes, were benefitted by the cool May temperatures. Harvest was delayed by about a week, which allowed for larger berry sizes. Like cotton, 1987 was the premier year for grape quality. Likewise, market prices for grapes were excellent during 1988, with table grape prices averaging 27 percent more than 1987, and wine grapes fetching 32 percent more than 1987.

The Kern County Agricultural Commissioner's annual crop report shows that, in 1988, the agricultural products of Kern County had a market value of more than $1,511,800,000, nearly 9 percent more than 1987. Some 30 crops fetched higher per unit prices than they did in 1987 and 17 other crops returned lower per unit prices than they did in 1987. In particular, the average market price for barley rose from $98 per ton in 1987 to about $117 per ton in 1988. Wheat showed similar increases. Alfalfa prices rose from about $81 per ton to $91 per ton, perhaps aided by the reduction in planted acreage. Stone fruits nearly all experienced substantial price increases over 1987, excepting nectarines, which saw prices slip about 57 percent. Prices for melons were much increased over 1987, probably due to a strong market generated by the hot summer. Lettuce, which historically has experienced extreme variations in price, saw prices fall from $423 per ton in 1987 to $208 per ton in 1988. Potatoes also experienced a price drop of about 40 percent from 1987.

The Agency uses data from the California Irrigation Management and Information Service (CIMIS) to compute crop consumptive use on a district-by-district and crop-by-crop basis. CIMIS is a statewide computerized irrigation scheduling system that can help farmers to schedule their irrigations based upon soil moisture budgets, and hence, possibly reduce their total applied water requirements. There are four CIMIS weather stations in Kern County. CIMIS is funded and operated by the State Office of Water Conservation. Approximate crop water use, as computed using the CIMIS data for 1988, is summarized on Table 16, along with total irrigated acreage.

It is difficult to quantify applied water requirements over the valley. Areal differences, soil differences, cultural practices, leaching requirements (typically 5-10 percent) and irrigation technologies employed across the valley result in very different applied water rates on specific crops. For instance, farmers in areas suffering from perched water will usually apply less water on their crops than they would if the soil were well-drained. The intent is to manage the perched water problem. In addition, the crop may consumptively use some of the perched water, reducing the amount the farmer needs to apply. Also, sprinkler or low-volume irrigation typically requires somewhat less water than furrow or flood irrigation. Many factors govern the type of irrigation system chosen by a farmer. Furrow or flood irrigation systems are not necessarily less efficient than other systems. Under some conditions (such as level slopes and heavy soils), furrow irrigation may be as efficient as sprinklers.

Gross agricultural applied water requirements in 1988 were estimated to be about 2,990,100 acre-feet with 2,623,100 acre-feet occurring over the useable ground water basin. This was some 88,500 acre-feet more than was applied in 1987. Likely, this increase reflects the increase in irrigated acreage during 1988. Net agricultural requirements in 1988 were about 2,306,600 acre-feet with about 1,986,000 acre-feet occurring over the ground water basin. This was about 102,100 acre-feet more than was consumptively used in 1987, reflecting the increase in irrigated acreage. The difference between gross and

Table 16
1988 Irrigated Acreage
in the San Joaquin Valley Portion
of Kern County, California

Crop	Acres	Percent of Total	Consumptive Water Use (AF/Acre)	Crop	Acres	Percent of Total	Consumptive Water Use (AF/Acre)
Alfalfa (including seed)	88,485	10.6	4.05	Misc. Truck Crop	1,385	0.2	2.39
Almonds	83,121	10.0	3.27	Nursery	4,288	0.5	2.74
Apples	3,821	0.5	3.29	Oats	677	0.1	1.26
Apricots	509	0.1	3.47	Olives	3,230	0.4	2.72
Asparagus	1,273	0.2	2.00	Onions, Garlic	10,903	1.3	3.47
Avocado	300	--	3.94	Pasture, Turf	6,288	0.8	4.72
Barley	20,228	2.4	1.68	Peaches, Nectarines	4,814	0.6	3.42
Beans	8,030	1.0	1.66	Pears	455	0.1	2.92
Broccoli	675	0.1	0.79	Peas	2,493	0.3	1.72
Carrots	5,686	0.7	0.80	Peppers	898	0.1	1.64
Citrus	34,182	4.1	3.37	Pistachios	19,823	2.4	3.00
Corn, Field	6,808	0.8	2.62	Plums, Prunes	4,006	0.5	3.30
Cotton	326,390	39.3	2.76	Potatoes	24,216	2.9	1.82
Figs	515	0.1	2.81	Rice	675	0.1	4.75
Grapes	89,676	10.8	2.46	Safflower	4,778	0.6	2.67
Guayale and Jojoaba	1,316	0.2	0.97	Sorghum/Milo	2,000	0.2	2.31
Kiwi	628	0.1	2.42	Sudan Grass	1,454	0.2	1.83
Lettuce	5,896	0.7	0.73	Sugar Beets	8,539	1.0	3.40
Melons, Squash, Cucumber	5,700	0.7	1.70	Tomatoes	2,857	0.3	2.40
Misc. Deciduous Trees	2,892	0.3	3.27	Turnips	307	--	0.79
Misc. Field Crop	4,095	0.5	2.73	Walnuts	1,824	0.2	2.95
Misc. Hay/Grain	5,566	0.7	0.75	Wheat	29,079	3.5	1.82
Misc. Subtropical Trees	322	--	3.48				
				Total	**831,103**	**100.0**	**2.78***

Note: Double-cropped acreage is counted twice, since it is irrigated twice.
* Weighted average consumptive use of all crops.

net water requirements over the basin is an estimate of agricultural return flows to ground water. Not all return flows return to useable ground water. Some is irrecoverably lost to saline sinks (such as perched water areas). Over moisture-deficient soils, return flows are absorbed by the soils and are irrecoverably lost. About 94,500 acre-feet of water was lost to saline sinks during 1988, and about 45,300 acre-feet was lost to moisture-deficient soils. About 542,100 acre-feet of agricultural applied water in 1988 returned to the useable ground water basin.

Quite a large amount of applied water data has been collected over the years by many entities. The Agency and the State Department of Water Resources both have programs of applied water data collection. The amount of water applied on a crop is affected by several factors: the slope and texture of the soil, the type of irrigation system being used and the age of the crop (for trees and vines). Table 17 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 1988 were estimated to be about 148,700 acre-feet, with about 117,000 acre-feet required over the useable ground water basin. The total water used outside of the basin, about 31,600 acre-feet, includes the ground water that was exported from the basin and used for M&I purposes. Of the total amount used over the useable basin, 27,200 acre-feet was supplied by the Agency's water treatment plant, and 1,200 acre-feet was supplied by Arvin-Edison Water Storage District to East Niles Community Services District. The Olcese Water District, which serves the Rio Bravo area, used about 1,000 acre-feet of Kern River water. The remainder, about 87,500 acre-feet, was likely drawn from ground water. Table 18 gives a breakdown of urban water deliveries by water purveyor service area. The total production of these purveyors, as listed on Table 18, is somewhat less than the gross M&I requirements. The reason for this is that many rural families and businesses maintain their own water systems, and as such, their volumes of production are not recorded. In addition, some small water companies do not keep accurate records of their water production. The gross M&I requirements reflect this fact and include an estimate of what these rural areas and small water companies used.

The average municipal and industrial water use over the ground water basin in 1988 was estimated to be about 270 gallons per capita per day (gpcd), about 13 percent less than in 1987. On the average, M&I water use is about 250 gpcd. Probably, the decrease in 1988 was a reflection of the less severe weather during 1988. The previous year was marked by an unusually hot summer. Net M&I consumptive use in 1988 was about 42,000 acre-feet over the ground water basin. Gross return flows from M&I uses over the ground water basin were about 75,000 acre-feet. About 44,200 acre-feet of M&I return flows were treated in sewage treatment facilities and evaporated, percolated or reused for agriculture. The remaining 30,800 acre-feet returned to ground water supplies. Since virtually all of the M&I water used outside the ground water basin is for oilfield operations (only about 16 percent was used domestically), it is all consumptively used. Any water not consumptively used is lost to moisture deficient soils.

Exports

Several entities export water out of the Kern County portion of the ground water basin for a variety of reasons. In addition, during periods of high runoff, some water may be introduced into the California Aqueduct via the Kern River-California Aqueduct Intertie and exported over the Tehachapi Mountains, or spilled into the Kern River Flood Channel, where it may flow north into Tulare Lake in Kings County. Essentially, this is not a useable surface supply. The dry-year conditions precluded any water being exported in this manner during 1988.

West Kern Water District exported about 16,400 acre-feet of ground water in 1988. About 3,800 acre-feet was used to supply the domestic needs of the towns and cities within the district, including Taft, McKittrick and Maricopa. Oilfield recovery operations accounted for the balance of about 12,600 acre-feet. It should be noted that West Kern Water District replaces its ground water extractions with SWP water. About 25,300 acre-feet of SWP water was directly recharged by Buena Vista Water Storage District for West Kern during 1988.

Lost Hills Water Company exported about 400

Table 17
Average Applied Water Requirements
For Various Crops
in Kern County
(in acre-feet per acre)

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

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

Table 18
1988 Urban Water Use
San Joaquin Valley Portion of Kern County

Water Purveyor Service area	Metered Connections	Non-metered Connections	Annual Water Use Million Gals.	 Acre Feet	Permanent Population	GPCD 1)
Arvin						
Arvin CSD	1,769	0	626	1,922	7,800	220
Bakersfield Metro Area						
Airport Mutual WC	--	--	18	56	--	--
Bakersfield Municipal Water System	--	--	3,028	9,292	--	--
California Water Service	12,321	38,606	19,970	61,282	203,600	269
Casa Loma WC	--	267	119	364	1,500	217
East Niles CSD	5,834	--	2,480	7,610	20,419	333
Fairfax WC	--	--	1	3	--	--
Greenfield CWD	428	366	288	884	5,384	147
North of the River MUD	192	1,482	3,058	9,384	30,000	279
Oildale MWC	356	6,007	2,150	6,598	24,000	245
Rancho Verdugo WC	--	--	109	333	--	--
Stockdale MWC	--	--	78	239	--	--
Stockdale Annex MWC	--	--	79	243	--	--
Vaughn WC	1,173	1,268	1,440	4,419	2,441	1,616
Victory MWC	--	--	62	191	--	--
Buttonwillow						
Buttonwillow CWD	406	--	--	--	1,250	-- 5)
Delano						
City of Delano	1,073	4,052	3,140	9,636	20,090	428
Lamont						
Lamont PUD and ID#1	594	2,997	800	2,455	12,560	175 5)
Lost Hills						
Lost Hills WC	201	--	133	408	201	1,813 5)
McFarland						
McFarland MWC	1,534	16	470	1,442	8,500	151
Rio Bravo						
Olcese WD	185	--	340	1,042	500	1,861 3)
Shafter						
City of Shafter	14	2,646	905	2,778	7,545	329 5)
Taft-Maricopa-McKittrick						
West Kern WD	6,881	--	5,356	16,436	22,660	648 2)
Wasco						
Wasco PUD	124	2,669	1,204	3,695	11,200	295
Total			**45,854**	**140,711**		**280** 4)

1) Gallons per capita per day.
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, Vaughn Water Company.
5) Information not available. Estimated from 1987.

acre-feet of ground water to satisfy the domestic needs of the town of Lost Hills and for oilfield recovery operations. Water is transported to the town of Lost Hills via a 13-mile pipeline.

It should be noted that domestic water use by these west side towns is quite low when compared to the average domestic water use over the ground water basin. The average domestic water use over the basin in 1988 was about 270 gallons per capita per day, compared to about 151 gallons per capita per day for the west side towns.

Some farmers on the west side of the valley export small amounts of ground water for irrigation. About 5,700 acre-feet was likely used by these farmers in 1988.

A total of about 22,500 acre-feet of ground water was exported from the useable ground water basin in 1988.

Water Surface Evaporation

Water surface evaporation normally accounts for a small amount of water lost from the valley portion of Kern County. In 1988, about 41,800 acre-feet of evaporation losses occurred, with about 38,900 acre-feet occurring over the ground water basin. This was slightly less than was lost in 1987, due to a slightly lower evaporation rate and a smaller water surface area. Ground water spreading programs were severely curtailed during 1988. Any water lost in this manner is lost from this regional hydrologic system.

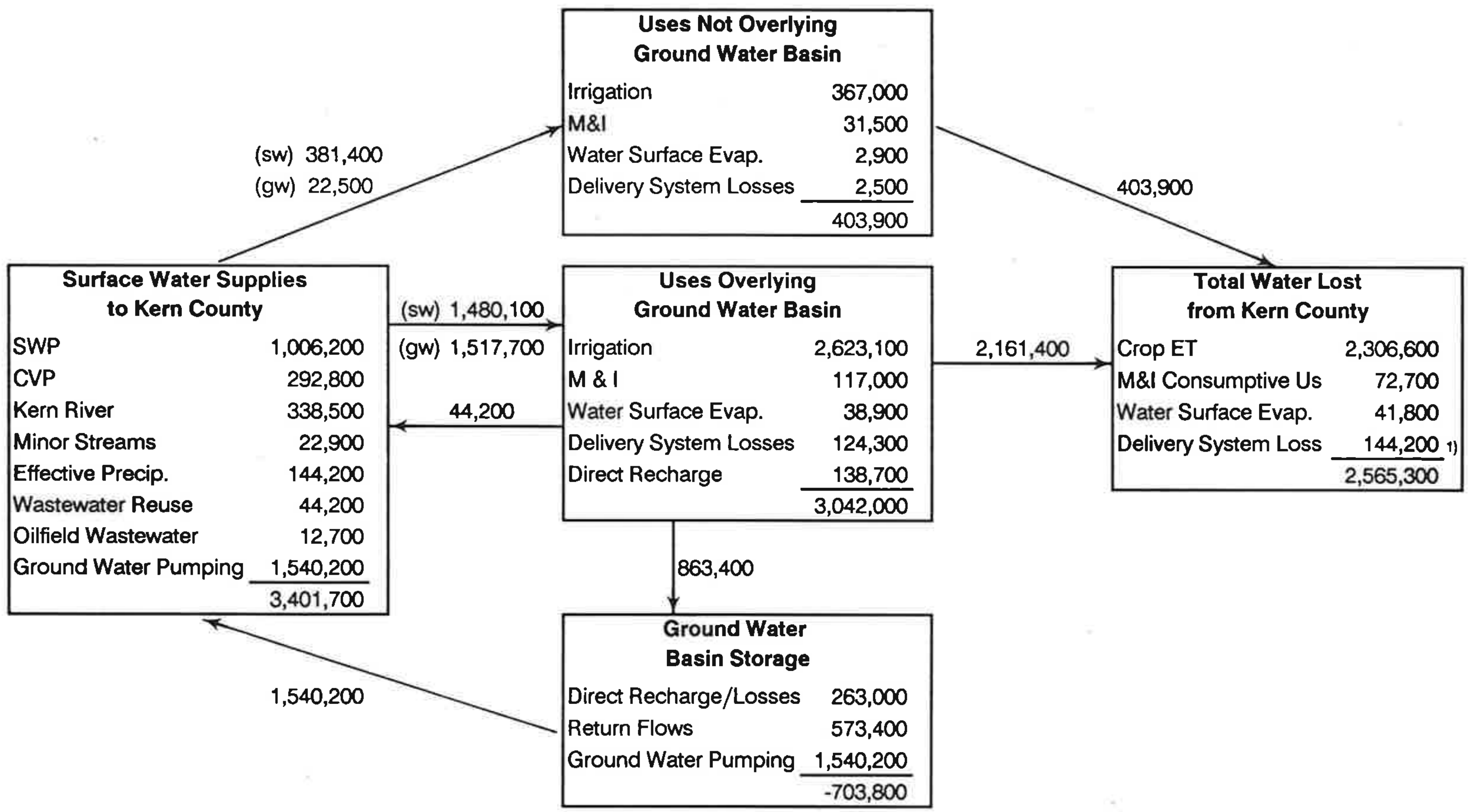
Change In Ground Water Storage

Water supplies and demands for the San Joaquin Valley portion of Kern County, as shown by Figure 13, show a total gross water demand of about 3,445,900 acre-feet in 1988. About 3,042,000 acre-feet occurred over the ground water basin, including 263,000 acre-feet of water used for direct recharge or delivery system losses. Total net water demand was about 2,565,300 acre-feet, with about 2,161,400 acre-feet over the ground water basin. Gross available surface water supplies were about 1,861,500 acre-feet. Hence, there was a net withdrawal from ground water storage of about 703,800 acre-feet. This was consistent with the fact that 1988 was the second critically-dry year in a row. However, the 1987-88 drought was not nearly as severe as the 1976-77 drought, in terms of water lost from ground water storage. During the 1976-77 period, 1,794,000 acre-feet of water was lost from underground storage. The 1987-88 period saw 1,115,000 acre-feet of water lost from storage.

Figure 14 graphically displays the water supplies and demands of the San Joaquin Valley portion of Kern County since 1970 (when SWP water was first introduced over the ground water basin). During 1970 to 1975, delivery systems were being developed, and the Cross Valley Canal had not been completed, therefore State Project deliveries were relatively low. During 1976 and 1977, not much water was available because of the drought. However, this graphic shows that, since the 1976-77 drought, a net reduction in storage has only occurred five times; in 1981, 1984, 1985, 1987 and 1988. During 1970 to 1988, when about 7,631,000 acre-feet of water was withdrawn from ground water storage, the balance of additions over extractions has replenished about 4,957,000 acre-feet. Figure 15 shows the cumulative ground water balance since 1970 when SWP water was first introduced over the Kern County ground water basin. In volume of ground water storage, the basin stands at 1972 levels, about the time when SWP deliveries began over the ground water basin. The increasing water levels, as shown on the water well hydrographs on pages xx-xx, corroborate this fact.

It has become apparent that Kern County's ground water 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 upon the ground water basin. Table 19, which provides a summary of supplies from these sources, shows this relative dependence. The dependence is especially illustrated by comparing supplies for the year 1986 with 1987. During 1986, surface water supplies were ample. Hence, ground water comprised only 25 percent of the total water supply. But in 1987 the reverse was true. Ground water pumping increased to make up for the dry-year conditions.

Figure 13
1988 Hydrologic Balance
San Joaquin Valley Portion of Kern County
(in acre-feet)



1,861,500 (Surface Supplies) minus 2,565,300 (Consumption) equals -703,800 (Change in Storage)

1) Includes 47,200 AF return flows, 2,500 AF delivery losses lost to moisture deficient soils.

(sw) Surface Water
(gw) Ground Water

Figure 14

GROSS WATER SUPPLIES AND NET WATER REQUIREMENTS

SAN JOAQUIN VALLEY, KERN COUNTY, CALIFORNIA

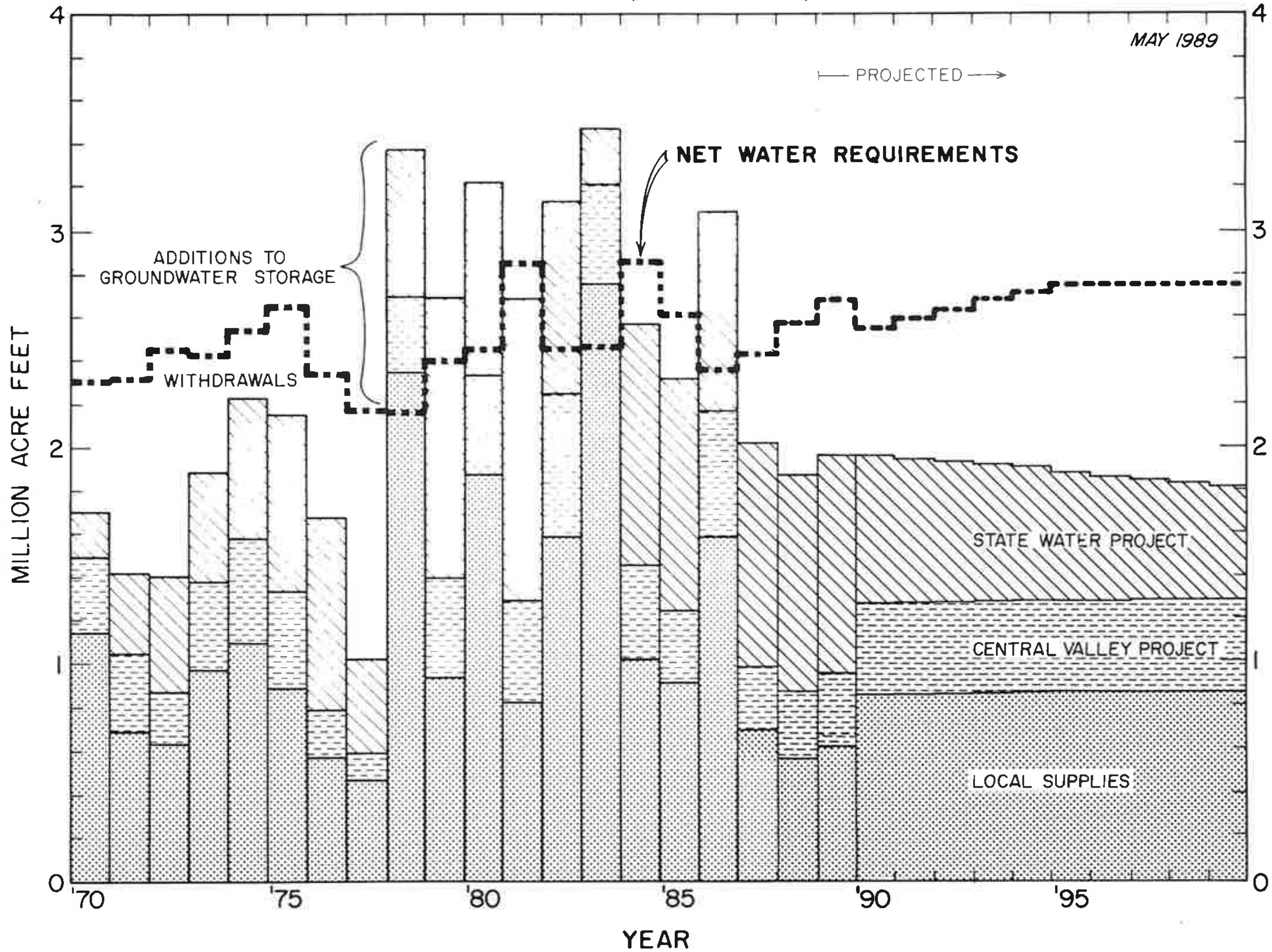
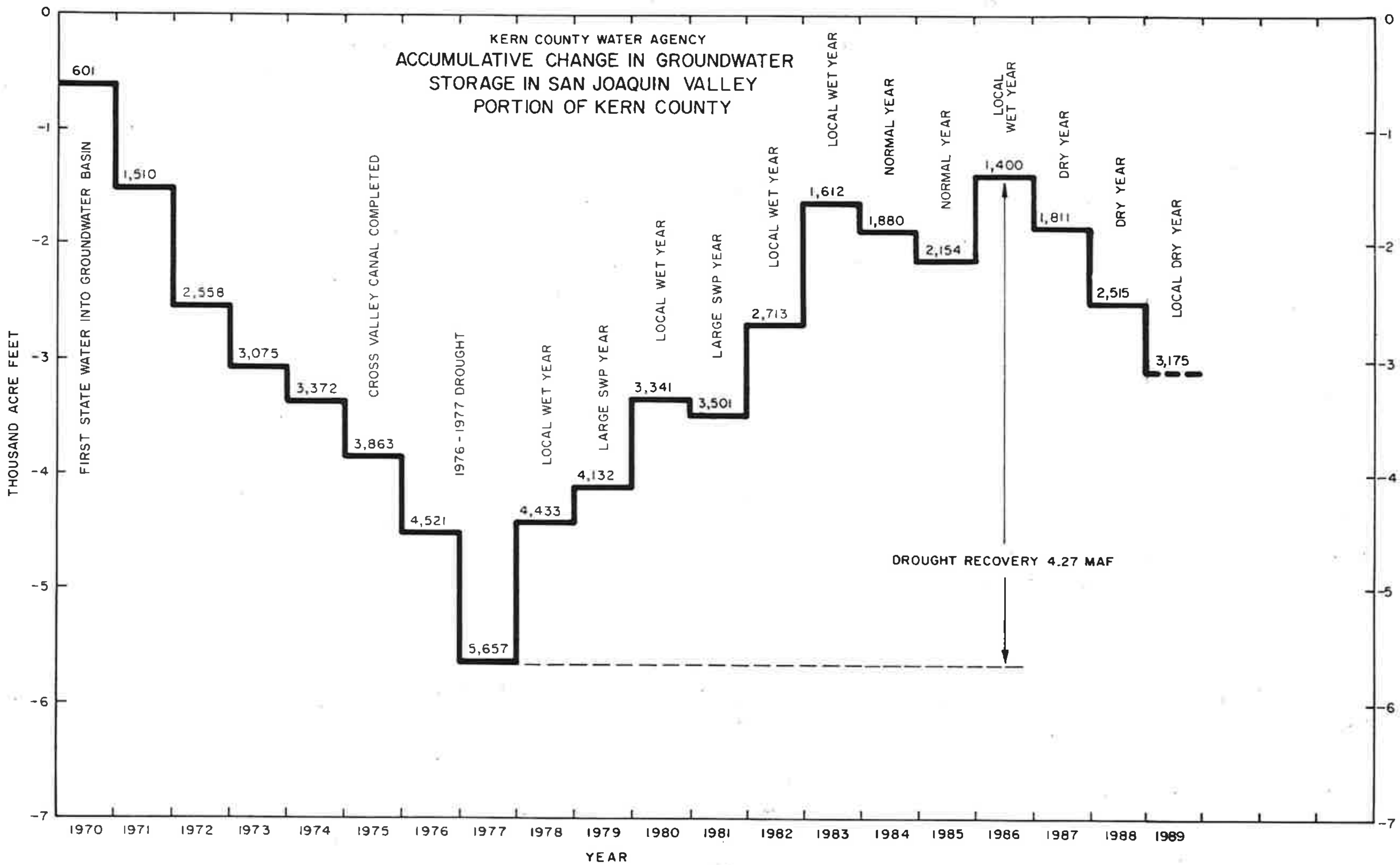


Figure 15



KERN COUNTY WATER AGENCY
ACCUMULATIVE CHANGE IN GROUNDWATER STORAGE IN SAN JOAQUIN VALLEY PORTION OF KERN COUNTY
THOUSAND ACRE FEET
0
-1
-2
-3
-4
-5
-6
-7
YEAR
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
601
FIRST STATE WATER INTO GROUNDWATER BASIN
1,510
2,558
3,075
3,372
CROSS VALLEY CANAL COMPLETED
3,863
4,521
1976 - 1977 DROUGHT
5,657
LOCAL WET YEAR
4,433
LARGE SWP YEAR
4,132
LOCAL WET YEAR
3,341
LARGE SWP YEAR
3,501
LOCAL WET YEAR
2,713
LOCAL WET YEAR
1,612
NORMAL YEAR
1,880
NORMAL YEAR
2,154
LOCAL WET YEAR
1,400
DRY YEAR
1,811
DRY YEAR
2,515
LOCAL DRY YEAR
3,175
DROUGHT RECOVERY 4.27 MAF

Table 19
Historic Deliveries of Surface* and Ground Water Supplies in the San Joaquin Valley Portion of Kern County
(in acre-feet)

	Kern River		Other Local Supplies		Central Valley Project		State Water Project		Ground Water		Total
	Supply	% of Total	Supply	% of Total	Supply	% of Total	Supply	% of Total	Supply	% of Total	Supplies
1970	601,300	19.3	543,000	17.4	351,400	11.3	204,600	6.6	1,422,000	45.5	3,122,300
1971	442,700	14.2	243,400	7.8	348,900	11.2	375,500	12.1	1,700,000	54.7	3,110,500
1972	311,300	9.6	316,500	9.7	238,500	7.3	535,600	16.4	1,857,000	57.0	3,258,900
1973	785,100	22.1	185,400	5.2	412,200	11.6	515,500	14.5	1,662,000	46.7	3,560,200
1974	745,900	20.9	356,400	10.0	480,600	13.5	651,800	18.3	1,333,000	37.4	3,567,700
1975	572,100	15.3	311,600	8.3	442,100	11.8	821,700	22.0	1,587,000	42.5	3,734,500
1976	320,800	9.4	250,500	7.3	226,500	6.6	883,400	25.8	1,738,000	50.8	3,419,200
1977	200,700	7.4	265,600	9.8	121,500	4.5	429,400	15.8	1,703,000	62.6	2,720,200
1978	1,217,000	29.4	1,076,400	26.0	348,700	8.4	675,600	16.3	825,000	19.9	4,142,700
1979	656,100	16.6	284,900	7.2	462,500	11.7	1,291,800	32.7	1,260,000	31.9	3,955,300
1980	1,421,800	33.7	386,100	9.2	462,800	11.0	965,100	22.9	977,000	23.2	4,212,800
1981	460,500	12.0	360,900	9.4	470,000	12.2	1,384,700	36.1	1,161,000	30.3	3,837,100
1982	1,110,700	28.3	468,700	11.9	644,600	16.4	898,200	22.9	802,200	20.4	3,924,400
1983	1,597,600	37.8	812,700	19.2	454,700	10.8	600,500	14.2	762,700	18.0	4,228,200
1984	809,000	21.2	201,100	5.3	425,400	11.1	1,136,700	29.7	1,252,200	32.7	3,824,400
1985	672,000	18.6	226,800	6.3	337,500	9.4	1,074,100	29.8	1,293,800	35.9	3,604,200
1986	1,332,700	32.9	265,000	6.6	573,700	14.2	926,300	22.9	947,600	23.4	4,045,300
1987	434,700	13.5	248,200	7.7	292,000	9.1	1,025,900	32.0	1,208,700	37.7	3,209,500
1988	338,500	10.0	224,000	6.6	286,700	8.4	1,006,200	29.6	1,540,200	45.4	3,395,600
Avg.	**738,400**	**22.7**	**369,900**	**11.4**	**388,400**	**11.9**	**810,700**	**24.9**	**1,317,500**	**40.5**	**3,255,000**

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

Basin-Wide Water Use Efficiency

Water applied to a crop that is in excess of it's ET requirements percolates past the root zone and usually returns to ground water supplies, where it is available for reuse. Most of this "deep percolation" returns to ground water within two years. Sometimes the deep percolation is intercepted by shallow clay lenses in the soil (this condition is referred to as "perched water"). In some areas the deep percolation may return to unusable saline ground water. In the western portion of Kern County, most of the soils are "moisture-deficient." That is, the water held in the soil is less than the amount of water a soil would normally retain after gravity drainage. Any deep percolation occurring over these moisture-deficient soils will be absorbed until the water holding capacity of the soils is satisfied. Hydrologists estimate it would take over 3 million acre-feet of water to satisfy these moisture-deficient soils.

Over the entire San Joaquin Valley portion of Kern County, gross applied water use was about 3,141,100 acre-feet during 1988 (2,990,100 for agriculture, 148,500 for M&I, 2,500 for delivery system losses). The total consumption of water was about 2,379,300 acre-feet (2,306,600 by agriculture, 72,700 by M&I). The agricultural irrigation efficiency, therefore, was about 77 percent. A total of 44,200 acre-feet of M&I water was treated and reused, mostly by agriculture. The difference between gross and net requirements (adjusted for wastewater reuse) is deep percolation, which amounted to 715,100 acre-feet. However, about 94,500 acre-feet of deep percolation was intercepted by perched water and about 49,700 acre-feet was absorbed by moisture-deficient soils. Therefore, net deep percolation was 573,400 acre-feet in 1988. Expressed another way, of the 3,141,100 acre-feet of water applied during 1988, 2,996,900 acre-feet was beneficially used or available for reuse (via net deep percolation). As a percent, 95 percent of the total applied water during 1988 was beneficially used or available for reuse. This percentage is termed "basin-wide water use efficiency." Kern County is one of the most efficient areas of the state in terms of basin-wide water use efficiency.

Intertie Activity

The Kern River-California Aqueduct Intertie has proven to be a blessing to Kern and Kings Counties. The Intertie was completed in 1977 as a flood control structure. Flows into the California Aqueduct through the Intertie may contain water from the Kern, Kaweah, San Joaquin or Tule Rivers, or a combination of these. Generally, Kern River flows must exceed about 200 percent of normal before the Intertie gates need to be opened. The water first passes through a sedimentation basin to remove sand and silt. The Intertie structure has a capacity of 3,500 cfs. However, downstream aqueduct demands can become the limiting factor. The structure allows Kern River and Friant-Kern (northern streams) flood water to be diverted from flood damage areas for beneficial use in Kern County. Since its completion, the Intertie has operated in all but five years. Through the end of 1988, a total cumulative flow of 1,143,081 acre-feet of water has passed through its gates into the California Aqueduct. About 47 percent of this was used in Kern County, the remainder went to southern California.

The Intertie did not operate during 1988. Table 20 is a historical summary of Intertie activity to date, showing the inflow by source, as well as amounts exported and retained in the County.

Water that enters the California Aqueduct from the Intertie becomes the property of the State Department of Water Resources, and is used to meet SWP system needs south of the Intertie. Occasionally, during periods of extremely heavy runoff, temporary pumps may be installed to pump the water to aqueduct reaches north of the Intertie as well. Such Intertie water displaces an equal amount of SWP water that would have been pumped from the Sacramento-San Joaquin Delta, producing a power savings for the SWP.

Table 20
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
Total	**1,010,220**	**132,861**	**1,143,081**			**608,665**			**534,416**

* A breakdown between sources was not available.

Ground Water Conditions

Ground Water Recharge

Several entities in Kern County are actively engaged in ground water replenishment operations. Kern River water is recharged to ground water 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 works operated by the Arvin-Edison Water Storage District or in the Kern River and Poso Creek channels. State Water Project water is recharged by the Agency and several water districts in the Kern River channel via the Cross Valley Canal, in unlined irrigation canals, or in district operated recharge sites. During wet periods, every effort is made to deliver water through unlined canals, so that incidental seepage will occur. This maximizes the recharge that occurs during such wet times.

Many of the water districts in Kern County use conjunctive use and banking programs to help balance their supplies. A correctly managed conjunctive use or banking program is an effective ground water management tool that allows a district to "smooth over" periods when surface water is unavailable. The intent is to store water during times when the available supply exceeds demand, and recover the water when the opposite is true. Also, a correctly managed program puts limits to the amount of water that can be withdrawn in any year, so adverse regional effects are minimized. A tremendous amount of ground water recharge in Kern County is accomplished as part of these programs. Table 21 outlines major conjunctive use and banking programs since 1971, listing the amounts of water by source. About 263,000 acre-feet of water was spread in 1988, both deliberately and incidentally. The approximate breakdown between sources was:

Kern River	141,600 AF
SWP	74,600
CVP	21,600
Wastewater	3,500
Minor Streams	21,700
Total	**263,000 AF**

These numbers should only be considered as best estimates since many times the supplies are intermixed in the same canal systems. Hence, any differentiation becomes impossible. The amount of recharge shown on Table 21 is less than the amount of recharge listed here. This is because Table 21 does not include incidental seepage losses or minor stream flows that have naturally recharged the ground water basin.

Such recharge efforts, from whatever source, show the importance attached to reducing ground water overdraft in Kern County, as well as water conservation. Since the 1976-77 drought, a total of about 7,338,700 acre-feet of water has been recharged (both deliberately and incidentally) to replenish ground water supplies. The effectiveness of such recharge activities are apparent in Figure 15. The Agency estimates that the 7,338,700 acre-feet of recharged water results in a gross basin-wide ground water elevation change of about 73 feet, or about 1 foot for every 100,000 acre-feet.

Ground Water Banking

Ground water banking is a concept that has picked up momentum in recent years. The state DWR's ability to provide a dependable water supply is less than its contractual obligations. Since few suitable above-ground storage sites remain in California, DWR is expanding its below-ground storage capacity. The intent of banking programs is to store surface water in the underground during times of surplus and extract it during times of need. Hence, available surface water supplies are used conjunctively with ground water. This cooperative process is known as "conjunctive use". While conjunctive use has been practiced for many years by local water managers, it is a new approach for the SWP. Recently, the state Department of Water Resources purchased about 19,600 acres of land to be used for the Kern Water Bank. The Kern Water Bank is a banking/extraction program which will ultimately provide as much as 100,000 acre-feet of annual yield for the State Water Project. On the local level, the City of Bakersfield has maintained its 2,800 acre recharge area as a banking site for many years,

Table 21
Summary of
Ground Water Recharge Activities *
(in acre-feet)

Entity/Location	Source	1971-84	1985	1986	1987	1988	Total
BANKING							
City of Bakersfield **							
2,800 Acre Spreading Area	Kern 2)	445,899	331	93,573	0	0	539,803
	SWP	21,010	0	0	0	0	21,010
	F-K	33,498	71	36,792	0	0	70,361
Subtotal COB		500,407	402	130,365	0	0	631,174
Kern County Water Agency							
Berrenda Mesa Spreading Area	Combined	14,987 1)	0	19,389 1)	0	0	34,376 1)
Kern River Channel (in ID4)	SWP	33,552	0	0	0		33,552
2,800 Acre Spreading Area	SWP	59,967	15,055	22,766	0	0	97,788
Subtotal KCWA		108,506	15,055	42,155	0	0	165,716
DWR-Kern Water Bank							
2800 Acre Spreading Area	SWP				7,379	0	7,379
Subtotal Banking		608,913	15,457	172,520	7,379	0	804,269
CONJUNCTIVE USE							
Arvin-Edison WSD	F-K	660,135	13,319	69,149	6,386	3,334	752,323
Buena Vista WSD	Kern	196,900	2,700	39,760	3,086	0	242,446
	SWP	8,400	0	0	0	20,500	28,900
Semitropic WSD Direct Rechg.	SWP	0	0	0	0	17618	17,618
In-Lieu Rechg.	SWP	377,302	49,777	46,622	51,624	15,328	540,653
	Combined	993 1)	993 1)	4,317 1)	986 1)	--	7,289 1)
I.D. No. 4 Direct Rechg.	Kern	226,620	7,980	68,000	18,199	29,850	350,649
	SWP	286,610	32,280	22,530	13,999	5,210	360,629
	F-K	17,770	940	2,220	535	0	21,465
Kern Delta WD Direct Rechg.	Kern	83,954	0	19,081	47,747	38,341	189,123
	SWP	1,351	0	0	0	0	1,351
North Kern WSD Direct Rechg.	Kern	1,151,260	19,200	149,900	23,000	22,109	1,365,469
In-Lieu Rechg.	Kern	348,300	36,500	36,900	15,908	15,135	452,743
Rosedale-Rio Bravo WSD	Kern	406,779	--	82,625	6,000	6,000	501,404
	SWP	406,235	--	30,220	21,888	23,600	481,943
	F-K	156,482	--	5,325	0	0	161,807
	Combined	221,500 1)	58,300 1)	--	--	--	279,800 1)
Wheeler Ridge-Maricopa WSD							
In-Lieu Recharge	SWP	76,073	7,751	2,362	377	0	86,563
Subtotal Conjunctive Use		4,626,664	229,740	579,011	209,735	197,025	5,842,175
OVERDRAFT CORRECTION							
Ground Water Replenishment							
Program (GRP) In-Lieu Rechg.	SWP	96,871	0	0	0	0	96,871
Direct Rechg.	SWP	257,920	17,755	0	0	0	275,675
	Kern	52,940	0	4,290	0	0	57,230
	F-K	7,723	0	0	0	0	7,723
Idle Lands Spreading	Kern	130,955	0	0	0	0	130,955
Subtotal Overdraft Correciton		546,409	17,755	4,290	0	0	568,454
Total	**Kern**	3,043,607	66,711	494,129	113,940	111,435	3,829,822
	SWP	1,625,291	122,618	124,500	95,267	82,256	2,049,932
	F-K	875,608	14,330	113,486	6,921	3,334	1,013,679
	Combined	237,480 1)	59,293 1)	23,706 1)	986 1)	0	321,465 1)
	Total	5,781,986	262,952	755,821	217,114	197,025	7,214,898

* Includes direct and in-lieu recharge.
** Includes banking by Olcese WD, Hacienda WD, Buena Vista WSD, City of Bakersfield; for breakdown between districts see Table 23.
1) Breakdown between sources not available.
2) Includes urban storm runoff.
Note: For a breakdown of 1971 to 1984, see prior Water Supply Reports.

Table 22
Ground Water Banking Summaries
(in acre-feet)

Kern County Water Agency
Ground Water Banking Summary, Water in COB 2,800 Acre Spreading Area
Recharge or Purchase / (Extraction or Sale)*

Calendar Year	Contracting Entity: Berrenda Mesa WD	Wheeler Ridge-Maricopa WSD	KCWA General	KCWA ID #4	Total	Storage Balance
1981	9,500	5,600	29,812		44,912	44,912
1985			15,055		15,055	59,967
1986			10,000	12,766	22,766	82,733
1988				3,500 **	3,500	86,233
Total	**9,500**	**5,600**	**54,867**	**16,266**	**86,233**	**86,233**

* No extractions or sales to date.
** Assignment of 3,500 AF from City of Bakersfield ground water storage to ID #4 on behalf of Kern-Tulare WD (2,800 AF) and Rag Gulch WD (700 AF).

Department of Water Resources, Kern Water Bank
Recharge or Purchase/(Extraction or Sale)*

Calendar Year	Contracting Entity or Location: Buena Vista WSD	City of Bakersfield 2,800 Acres	KCWA ID #4	Kern Delta WD	Kern Fan Element	North Kern WSD	Rosedale-Rio Bravo WSD	Semitropic WSD	West Kern WD	Total
1987	0	7,379	0	0	0	0	0	0	0	**7,379**
1988	0	0	0	0	0	0	0	0	0	**0**
Total	**0**	**7,379**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7,379**

* No extractions or sales to date.

City of Bakersfield - 2,800 Acre Recharge Facility*
Contracting Entities Other Than KCWA or DWR
Recharge or Purchase/(Extraction or Sale)

Calendar Year	City of Bakersfield Recharge	City of Bakersfield Extraction	Olcese/Hacienda WD Recharge	Olcese/Hacienda WD Extraction	Buena Vista WSD Recharge	Buena Vista WSD Extraction	Total Banking Recharge	Total Banking Extraction	Storage Balance
1978	104,587		24,328		6,056		134,971	0	134,971
1979	4,505				9,913		14,418	0	149,389
1980	68,804	(13,772)	52,604				121,408	(13,772)	257,025
1981	2,603	(100,837)	4,465				7,068	(100,837)	163,256
1982	37,913		14,266		24,465		76,644	0	239,900
1983	113,380						113,380	0	353,280
1984	16,058	(472)					16,058	(472)	368,866
1985	402	(1,615)					402	(1,615)	367,653
1986	64,168		56,197		10,000		130,365	0	498,018
1987	109	(656)	5,344			(6,000)	5,453	(6,656)	496,815
1988		(5,432)	3,214			(5,000)	3,214	(10,432)	489,597
Total	**412,529**	**(122,784)**	**160,418**	**0**	**50,434**	**(11,000)**	**623,381**	**(133,784)**	**489,597**

* A more detailed breakdown is provided in the City of Bakersfield 2,800 Acre Recharge Facility Report.

where KCWA and others have "deposited" water. Table 22 outlines the banking account balances for those entities who are involved in various banking programs. Table 22 is an in-depth breakdown of the banking portion of Table 21.

Perched Ground Water

When deep percolation of applied waters are intercepted by shallow clay beds, "perched water" accumulations result. These accumulations are generally much saltier than the ground water underneath, making them undesirable in farming operations when the water reaches the crop root zone. The loss of crop yields, build-up of salts in the soils and farm equipment "bogging" in poorly drained fields are symptoms associated with perched water problems.

Depth to perched water, as measured in shallow monitoring wells, is contoured on Plate 1. Water within 5 feet of the surface was found under an area of about 82,700 acres in the summer of 1988. This was slightly decreased over the summer of 1987 acreage. It is difficult to characterize the changes that occur in perched water areas. Generally, the areas suffering from perched water in Kern County follow the historic trace of the Kern River channel, including the old Kern Lake and Buena Vista Lake beds (where Kern River flows ponded). Generally, increases in perched water area seem to occur after a year of high Kern River runoff. Likewise, contractions seem to occur during years when runoff is reduced. In this sense, perched water should be considered a naturally occurring phenomenon. Table 23 lists historic areas with perched water problems, categorized into five feet increments, along with the number of monitoring wells measured. At first glance, it would seem that an enormous increase in perched water area occurred between 1979 and 1980. Probably, the increase is not "real", in the sense that KCWA and cooperating water districts have been constantly expanding the monitoring grid. Hence, this large increase was more likely the result of better monitoring as the grid was expanded. Table 23 clearly shows the continuing expansion of the monitoring grid. Expanding the monitoring grid has now allowed the eastern and western edges of the perched water areas to be fairly well defined. Piezometers located in these areas are consistently reading dry.

Efforts to statistically link changes in perched water areas with available water supplies or irrigated acreage have failed. Simply, not enough is known about the perched water phenomena to allow for a reliable analysis. In 1986, KCWA began a pilot program to systematically measure perched water levels on a monthly basis, along with associated information. The intent is to provide a long-term, consistent data set on which to base a reliable analysis. The program has been in effect for two years. An analysis of the data thus far seems to suggest that perched water levels are not static, but can change considerably from month to month or year to year. In addition, in some areas the electrical conductivity (EC) of perched water seems to vary with depth. Much more study is needed before relationships can be well understood.

Ground Water Quality

The ground water basin in the Kern County portion of the San Joaquin Valley has no outflow, except in extremely wet years. Therefore, new salts introduced into the basin with imported water supplies are retained in the basin. The ground water is the recipient of these salts in the form of recharge waters or return flows from irrigation, municipal and industrial users.

Surface water supplies over the useable ground water basin in 1988, some 1,474,200 acre-feet, carried about 429,400 tons of new salts into the ground water basin. This volume of salt is about the same as was introduced in 1986. However, surface water supplies over the useable ground water basin were about 129,100 acre-feet less than in 1987. This indicates that surface water supplies carried lower salt concentrations (were of better quality) than in 1987. It should be noted that SWP water carries about twice as much salt as local supplies. Following is a table of salt loads by surface water source:

Source	Volume (AF)	Avg. TDS (ppm)	SaltLoad (Tons)
SWP Over G.W. Basin	639,700	312	271,300
Kern River	338,500	121	55,700
Minor Streams	22,900	132	11,300
Other Local Supplies	186,400	198	41,000
CVP	286,700	128	50,100
Total	**1,474,300**		**429,400**

Table 23
Areal Extent of Shallow Ground Water
(in acres)

Year	Summer Measurements 0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezo's.	Winter Measurements 0-5 ft.	5-10 ft.	10-15 ft.	15-20 ft.	Total Within 20 ft.	No. of Piezo's.
1976	27,940	64,700	--	79,680 *	172,320	--	--	--	--	--	--	--
1977	19,320	68,980	--	95,960 *	184,260	180	16,930	52,530	--	67,300 *	136,760	143
1978	27,680	65,760	--	87,920 *	181,360	174	9,600	59,520	--	86,400 *	155,520	--
1979	30,270	67,310	--	95,870 *	193,450	--	15,320	83,200	--	80,640 *	179,160	126
1980	74,357	82,787	--	125,883 *	283,027	--	45,882	92,998	126,665	62,578	328,123	154
1981	62,002	85,556	--	128,323 *	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	--	--	--	--	--	--

* 10-20 ft. measurement.
-- Data not available.

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

Ground water pumped and used for irrigation will become degraded as salts are leached from the crop root zones. A portion (averaging 20 to 30 percent in this basin) of applied water percolates through the soil profile to the ground water. This smaller volume of water carries most of the salts once held by the total volume applied, resulting in a concentration of the salts. The introduction of local drainage projects would help reduce this build-up of salts by removing some near-surface accumulations in the perched water areas. In any area which is dependent upon supplemental water supplies, sustained large-scale importation of water and large-scale agriculture will eventually result in the degradation of ground water supplies. This phenomena is likely occurring in the unconfined ground water aquifers of Kern County by the introduction of additional salts from applied waters and fertilizers. It should be noted that this is a normal by-product of water use, whether for agricultural, municipal or industrial purposes. The challenge of water leaders is to relieve the destruction of our precious ground water by improved water management, including salt management.

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

Plate 3 is a compilation of data from ground water wells producing from the confined or lower aquifer system. This lower system is partially protected from surface contaminants by the Corcoran Clay (outlined on Plates 2 and 3). Contours on this map show the overall quality of this supply to be superior to that of the unconfined zone.

In November, 1981 the Kern County Board of Supervisors adopted and agricultural water well ordinance to help deal with the problem of deteriorating ground water quality conditions. The ordinance, originally administered by the Agency, is aimed at reducing further degradation of the confined aquifer by setting standards for construction and abandonment of wells to prevent poor quality unconfined ground water (waters above the Corcoran Clay) from moving into fairly high quality confined waters (below the Corcoran Clay). The ordinance requires close monitoring of new well construction and abandonment of old wells in order to ensure that degradation of ground water quality is avoided. Recently, some problems have surfaced regarding the implementation of the agricultural well ordinance. A separate municipal well ordinance was administered entirely by the County of Kern Department of Environmental Health. Conflicts between the municipal and agricultural well ordinances forced a re-thinking of the ordinance altogether. A committee was established to study the possibility of a combined municipal and agricultural well ordinance. After much discussion, a combined ordinance was adopted by the Board of Supervisors in April, 1989. The new ordinance spells out the respective duties of KCWA and County Department of Environmental Health, as well as appeal procedures, much more clearly than before. A complement to the revised ordinance is a confining clay map of the San Joaquin Valley portion of Kern County being prepared for KCWA by a ground water consultant. The map is slated for completion in late 1989, and should provide a solid basis for the design and placement of annular seals.

A total of 38 agricultural wells were constructed during 1988, 13 of which required annular seals to prevent degradation of the confined aquifer. An annular seal is a plug of cement between the well conductor pipe or casing and the drilled hole. A total of 16 permits were issued during 1988 for the abandonment of wells. Likely, the increased drilling activity during the last two years was in response to the dry-year conditions. From its implementation to the end of 1988, a total of 266 agricultural wells have been constructed, 90 of which required annular seals.

Ground Water Levels

Plate 4, "Depth to Ground Water, Spring 1989" was prepared by the Agency using hundreds of well measurements taken by the Agency and others on a semi-annual basis. The water depths and elevations are plotted and contoured to aid in the evaluation of ground water trends. Control wells include unconfined and a few composite aquifer wells from areas where the two levels are compatible. The Depth to

Ground Water map shows the distances in feet from the ground surface to the water surface.

The highest pumping lifts occur on the extreme eastern edge of the valley, areas south and east of the community of Arvin and in the White Wolf basin area. These areas have deeper water levels which are associated with higher elevations, being on foothill regions of the valley.

Areas of lesser pumping lifts appear in the west central valley area, Lost Hills area, west of Delano, Buena Vista Lake area and near the Kern River channel (especially near Bakersfield). Some of the very shallow lifts, less than 50 feet, are probably linked to the shallow perched water problem. However, the shallow area west of Delano is probably related to heavy dependence on surface water, while the Kern River channel shallow area is due to natural and artificial recharge efforts in the Kern River channel.

A "Ground Water Surface Elevation" map (Plate 5) was prepared, based on the same measured wells as the "Depth to Ground Water" map. This map exhibits movement of ground water from higher to lower elevations. The directions of flow are perpendicular to the contour lines. The contours emphasize the relative highs and lows of ground water elevation.

The major direction of ground water movement is away from the sources of recharge. Historically, the Kern River has been the major ground water recharge source. Mounding of water occurs longitudinally along the Kern River channel, and ground water is shown as moving away from this area. Other high areas are along the northeastern edge of the valley, and some local mounding is attributed to recharge efforts of local districts.

The north-south ground water mound, which extends from the northeastern corner of Township 25 South, Range 26 East (about five miles east of Delano) into the northwestern corner of Township 29 South, Range 27 East (about six miles northwest of Bakersfield), is now thought to reflect the eastern margin of the Corcoran or "E" Clay.

Ground water lows are often areas of higher ground water pumping. The largest of these areas is in the central portion of the valley where the most intensive pumping occurs. Other low areas are in the extreme south end of the valley and in the Edison-Lamont area.

Plate 6 depicts ground water level changes from the Spring of 1988 to the Spring of 1989. Computed differences were plotted and contoured to show areas of relative improvement or decline. Color has been added to this map to emphasize significant changes. The 1988 to 1989 change map reflects increases in unconfined water levels associated with areas with perched water. In general, the areas of high pumping show continued decline, associated with the drought conditions.

Of the well measurements used to produce the "Depth to Ground Water" map (Plate 4), the "Ground Water Surface Elevations" map (Plate 5) and the "Ground Water Level Changes" map (Plate 6) the average level change per unconfined well and confined well from 1988 to 1989 were -3.4 feet and -6.1 feet respectively.

Water level changes in six key water wells are displayed on hydrographs as Figures 16a, 16b and 16c. Two wells are located in the Kern National Wildlife Refuge area, two wells are west of Wasco and two are located southwest of Bakersfield. In each case, one well is representative of the unconfined aquifer water levels and one is an example of the confined aquifer water levels. Both hydrographs are plotted on the same graph to observe and compare water level changes in both aquifers. In the Kern National Wildlife area, the unconfined water levels are likely affected by recharge from perched water accumulations. The confined well was showing a continual decline until the sharp rise in 1978, resulting from surface water deliveries to the area. The Wasco area hydrographs show the unconfined well dropping in early years, but coming up in the early 1980's. Now it appears to be falling off somewhat. The confined well is recovering and now exceeds prior levels, probably in response to imported surface water deliveries (hence, less pumping) to the area. The southwest Bakersfield graphs show the continual decline in water levels until 1978. Since that time, the effects of recharge efforts in the Kern River channel and increases in surface water deliveries in the area have produced a marked recovery. These wells are at a point comparable to water levels of about sixteen years ago.

Figure 16a
Water Well Hydrograph
Wildlife Refuge Area

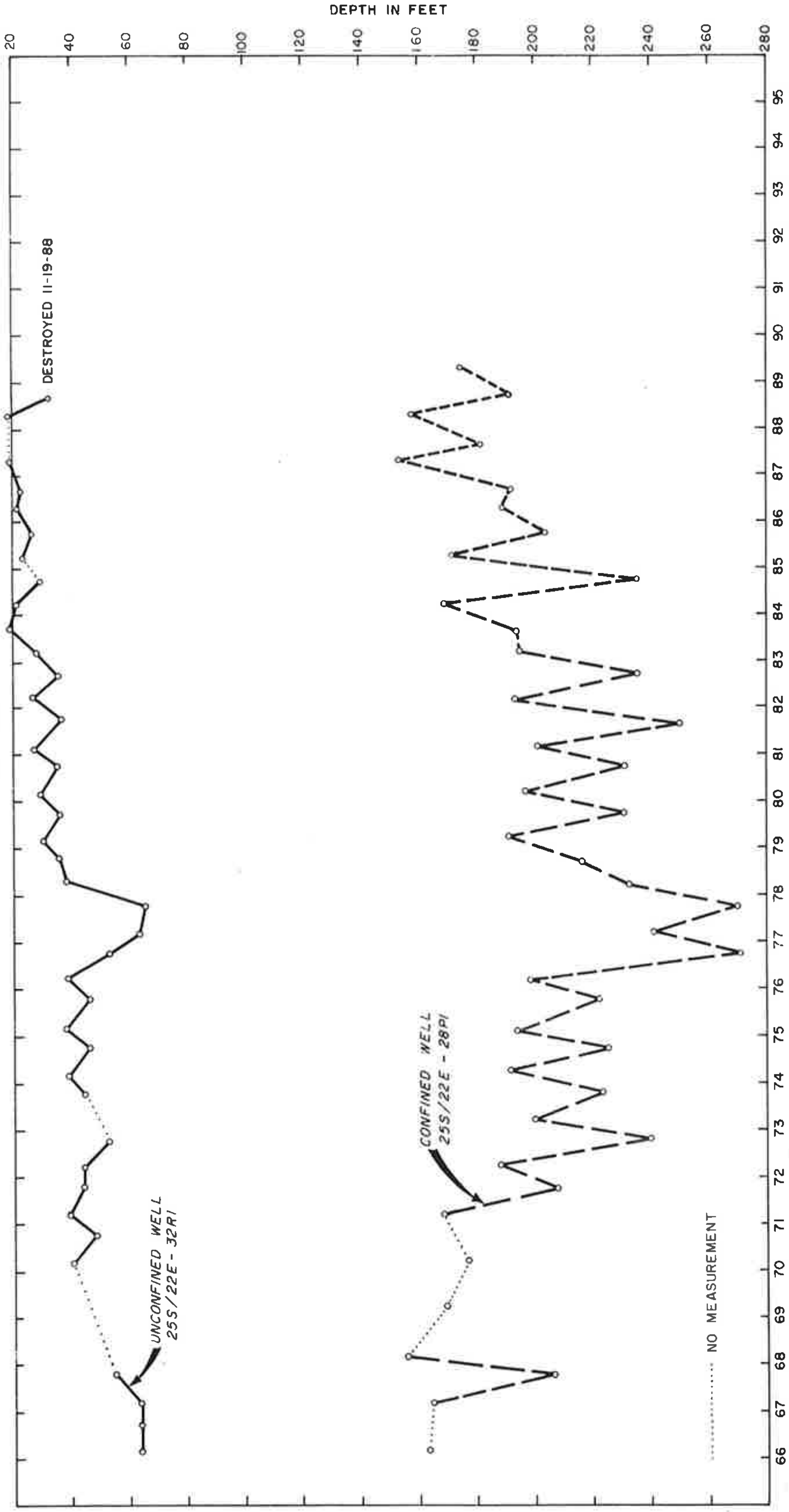


Figure 16b
Water Well Hydrograph
Wasco Area

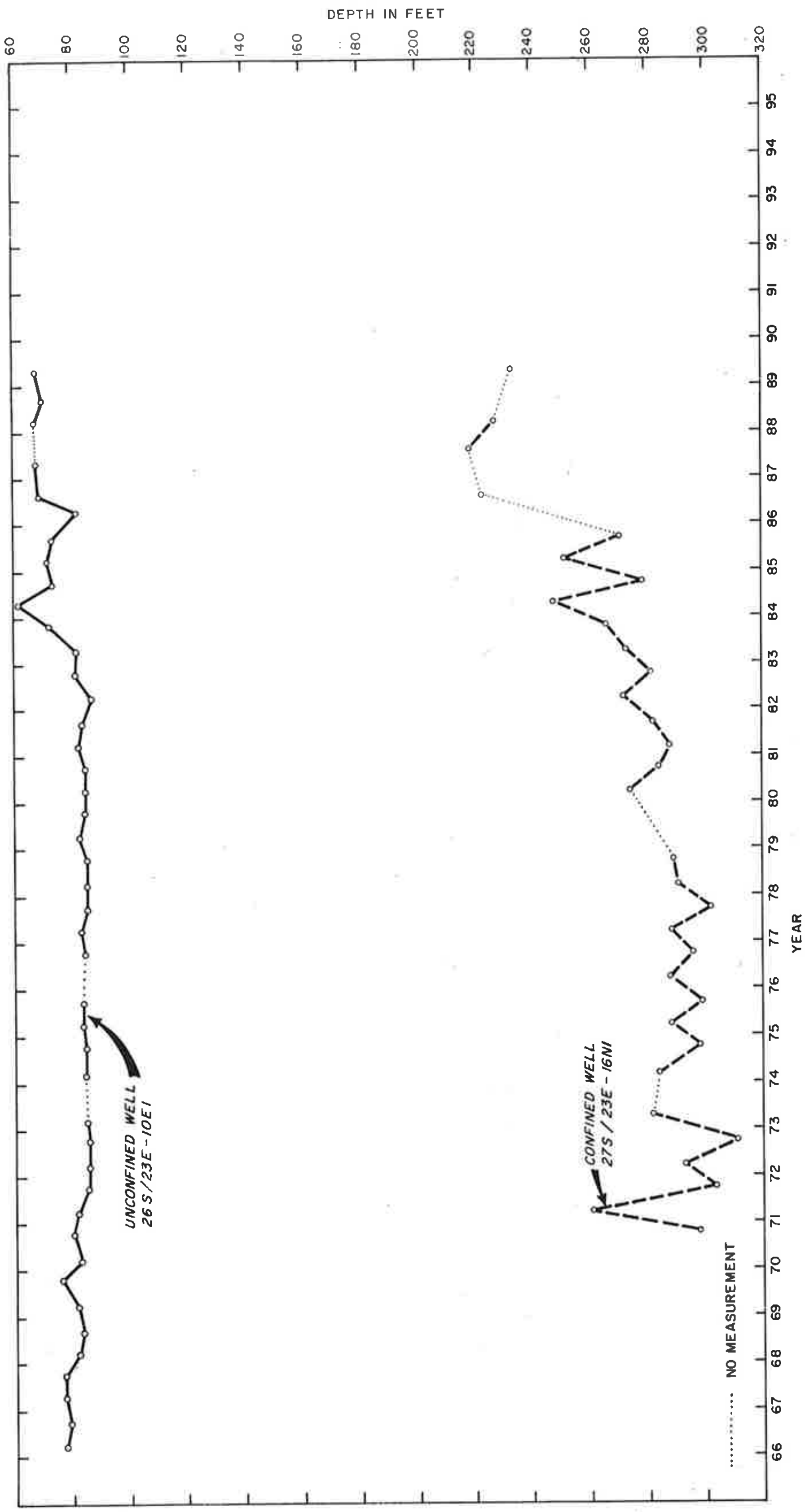
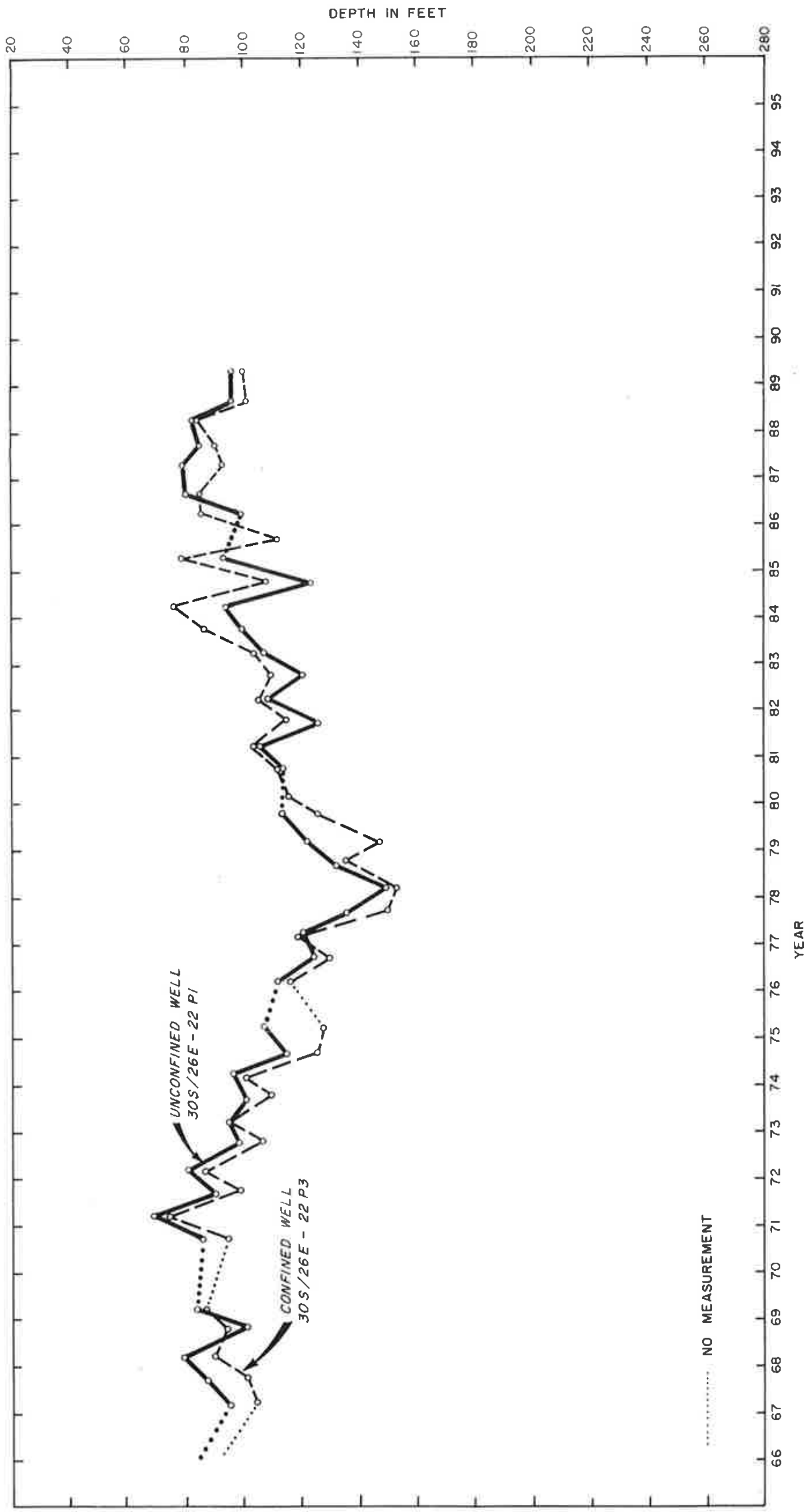


Figure 16c
Water Well Hydrograph
Southwest Bakersfield



Indian Wells Valley

Indian Wells Valley is located in the northeast corner of the county. The valley encompasses about 480 square miles, extending about 35 miles in a north-south direction and 25 miles in an east-west direction. The valley is surrounded by the southern Sierra Nevada Mountains on the west, the Coso Range on the north, the Argus Mountains on the east, and the El Paso Mountains on the south. Elevations on the valley floor are around 2,300 feet above sea level, while surrounding mountains may reach 9,000 feet. The largest community in the valley is the city of Ridgecrest, with a population of about 25,400, making it the second largest city in Kern County. Total population in the valley is about 63,000, most of which is centered in the Ridgecrest/ China Lake community. The valley is an arid desert, with rainfall of only 5-6 inches per year. Little rainfall reaches the ground water table; it is rapidly evaporated by the high winds or transpired by desert plants. Presently, the only source of water is ground water.

In October, 1987 a group of concerned citizens founded the Indian Wells Valley Water Coordinating Committee to address the ground water management needs of the valley. The committee's charge is to ensure that future water supplies are developed in a coordinated manner. The underground geology of the valley is quite complex. The U.S. Geological Survey and others have studied the area in recent years, but consensus has not been reached on the ground water conditions of the valley. Recognizing this, the committee suggested that an independent review of available hydrologic data be done. A subsequent study funded by the state DWR, Indian Wells Valley Water District, East Kern Resource Conservation District and KCWA released "Hydrologic Conditions in Indian Wells Valley and Vicinity" in February, 1989. The USGS has been studying the area for about 10 years, under a cost sharing arrangement with US Navy, KCWA and local entities. The USGS is developing a ground water quality computer model, scheduled for completion in November, 1989. Recently, KCWA began a ground water monitoring program in the valley. Measurements from 72 wells were the basis for Plate 7, "Depth to Ground Water, Indian Wells Valley" and Plate 8, "Ground Water Surface Elevations, Indian Wells Valley". The ground water mound (Plate 8) located northeast of Ridgecrest may be partially explained by migrating sewage effluent being recharged nearby. It could be that these elevations represent pressure heads of confined zones at relatively shallow depths. Plate 8 shows a large pumping depression extending from Ridgecrest to Inyokern, which is where most of the population is centered. The areal extent of the depression has expanded by about 21,000 acres since 1946. Comparatively, the population of the valley was about 15,000 in 1946, most of which was at China Lake Naval Weapons Center.

Focus: Berrenda Mesa Water District

The Berrenda Mesa Water District was organized in 1963 under the name "Antelope Plains Water District". The name was changed to "Berrenda Mesa Water District in 1965. The formation of the district was to provide a vehicle to contract for an imported water supply from the California State Water Project. Ultimately, the district obtained a contract for a maximum entitlement of 105,100 acre-feet of SWP water, to be delivered via the Coastal Branch of the California Aqueduct. Subsequently, Berrenda Mesa was able to purchase additional entitlement from Semitropic Water Storage District, thus providing for a maximum entitlement of 163,200 acre-feet (including 8,100 acre-feet of regulated surplus water). The district encompasses 55,440 gross acres located in the northwestern corner of Kern County. Soils in the district are excellent for agriculture. About 68 percent of the soils are Class I, 28 percent are Class II and 4 percent are Class III. A full 90 percent of the soils are considered prime and are well-drained. Elevations within the district range from 480 feet on the eastern edge to about 1,200 feet on the west (on the slopes of the Temblor Mountains). Most of the district is fairly flat to gently rolling terrain. The district's delivery system consists of about 15 miles of lined canals, about 50 miles of pipeline and 13 pumping plants. About 49,000 acres are capable of receiving surface water via the delivery system.

Prior to the delivery of SWP water beginning in 1968, agriculture in Berrenda Mesa was limited to a few localized aquifers supporting about 3,200 acres of crops (mostly cotton and barley). Depletion of these small aquifers left the area virtually waterless. Hence, nearly the entire district remained undeveloped, even though the lands were of excellent quality for agricultural use. Presently, the crops grown in the district can be grouped as follows:

Field Crops	1	percent
Orchards	79	"
Vegetables	5	"
Vineyards	15	"
Total	**32,279 acres**	

A breakdown of crops grown in the Berrenda Mesa Water District during 1988 is given on Table 24. The total market value of these crops was estimated to be about $98,541,000 and accounted for about 6 percent of the total value of all irrigated crops grown in Kern County during 1988. It is of interest to note that nearly 20 percent of the almonds grown in Kern County, and about 44 percent of the pistachios grown in Kern County are located in Berrenda Mesa Water District. On a statewide level, Berrenda Mesa grows about 3 percent of the almonds and about 16 percent of the pistachios in the entire state.

Virtually all crops grown in the district are irrigated with low volume and sprinkler systems. Half of the orchard crops have low volume systems installed. The other half are irrigated with various forms of sprinklers. Of special interest, all of the pistachios in the district have low volume systems installed. Because no alternative water supply is available, agriculture in Berrenda Mesa is extremely efficient. The Agency estimates that Berrenda Mesa's irrigation efficiency during 1988 was about 84 percent, without consideration for salt leaching requirements. This is one of the highest efficiencies in Kern County, and reflects the large investment in "state of the art" irrigation systems by the farmers in the district.

Table 24
1988 Irrigated Acreage in the Berrenda Mesa Water District

Crop	Acres
Almonds	16,024
Apples	335
Beans (Garbonza)	100
Cotton	160
Grain	300
Grapes	4,902
Lettuce	748
Onions, Garlic	620
Pecans	55
Pistachios	8,945
Potatoes	50
Test Plot	40
Total	**32,279**

Outlook: 1989

A series of late-season storms moved across the state during late March, 1989. These storms brought much-needed relief from the previous two years of drought. The effectiveness of the storms is demonstrated by the fact that the Sacramento River Index rose from 7.0 (before the storms) to 13.6 (after the storms). As such, 1989 will not be classified as a critically dry year. Reservoirs in the northern portion of the state experienced rapid increases in storage during March-April, 1989. However, The southern portion of the state was not so blessed; the central and southern San Joaquin Valley areas still face drought conditions. As of May, 1989 the California Cooperative Snow Survey showed that the major river systems in the state can expect water-year (October-September) runoff of 35-95 percent of normal. The following tabulation demonstrates the uneven distribution of the runoff:

	1,000 AF	% of Average
Sacramento River Basin Expected Runoff		
Sacramento River	6,600	75
Feather River	3,800	80
Yuba River	2,330	95
American River	2,280	80
San Joaquin River Basin Expected Runoff		
Cosumnes River	205	50
Mokelumne River	570	73
Stanislaus River	810	68
Tuolumne River	1,270	65
Merced River	530	52
San Joaquin River	940	51
Tulare Lake Basin Expected Runoff		
Kings River	930	53
Kaweah River	222	47
Tule River	56	35
Kern River	370	49

For the Tulare Lake Basin, this is an improvement from 1988, but is still far from normal.

Total deliveries of SWP water in 1989 were expected to be about 1,100,000 acre-feet over the San Joaquin Valley portion of Kern County. Federal CVP contractors are to receive their full Class 1 entitlements, although none of their Class 2 entitlements are expected to be fulfilled. About 350,000 acre-feet of CVP water is projected to be delivered in Kern County. Kern River runoff for the calendar year is projected to be about 350,000 acre-feet. Local minor stream flows are expected to be slightly more than in 1988, or about 30,000 acre-feet. Wastewater reuse does not fluctuate much, and is expected to be about the same as in 1988. Effective precipitation is expected to be about 175,000 acre-feet, only slightly more than in 1988. Accordingly, total surface water supplies in 1989 are expected to be about 2,017,000 acre-feet, about 225,000 acre-feet more than was available in 1988.

Total irrigated acreage in 1989 is estimated to be about 870,000 acres, about 40,000 acres more than in 1988. Most of the additional acreage is expected to be planted in cotton, which has done well for the last few years. Crop water demands are estimated to be about the same as in 1988. As a result, net irrigation demands are projected to be 2,410,000 acre-feet in 1989. Consumption by all types of uses are estimated to be about 2,680,000 acre-feet. Thus, the Agency projects that there will be a net decrease in ground water storage in 1989, possibly as much as 660,000 acre-feet. This would mark the sixth time since the 1976-77 drought that a net decrease in ground water storage has occurred, and the third year in a row.

PLATE I

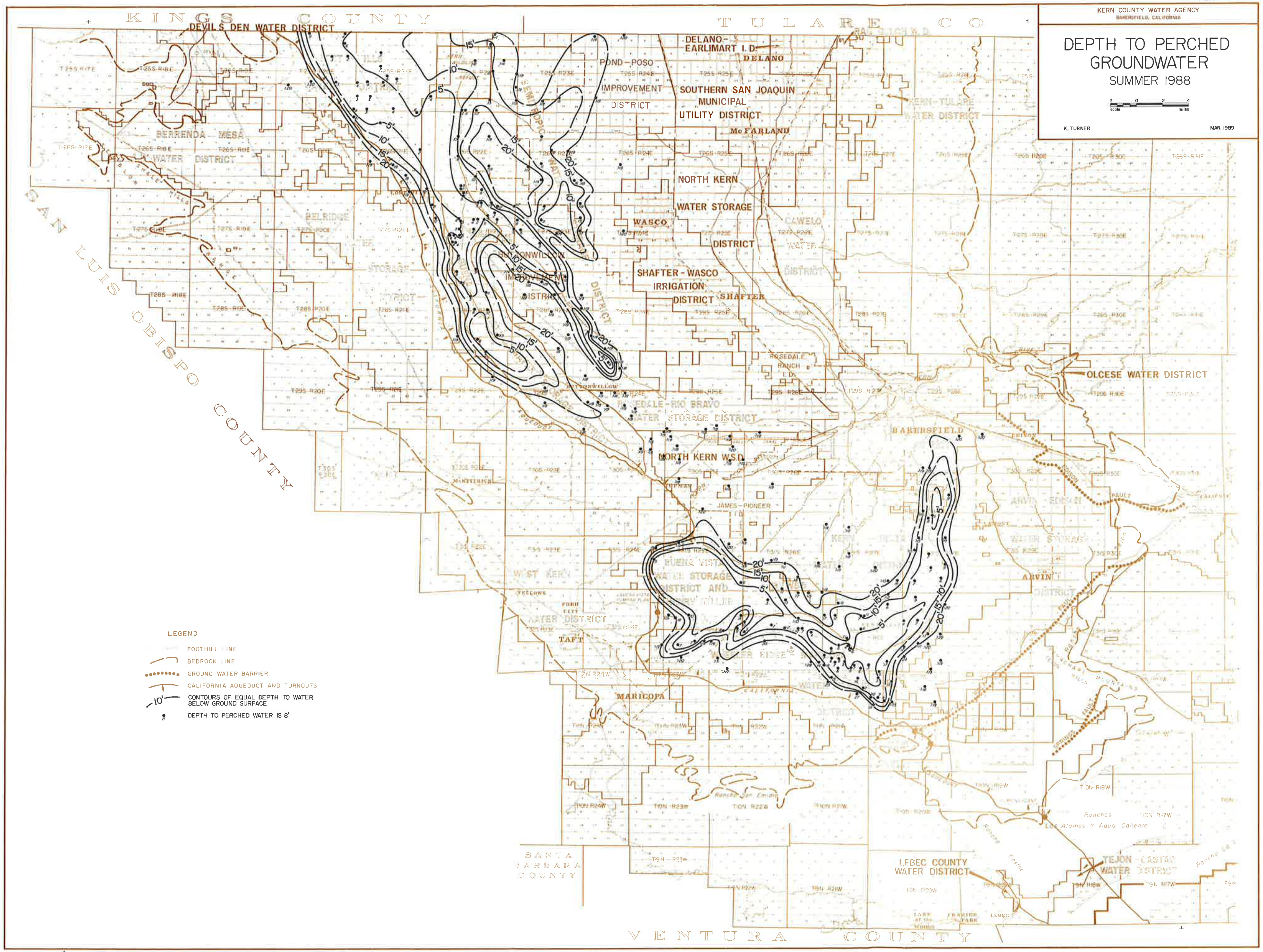
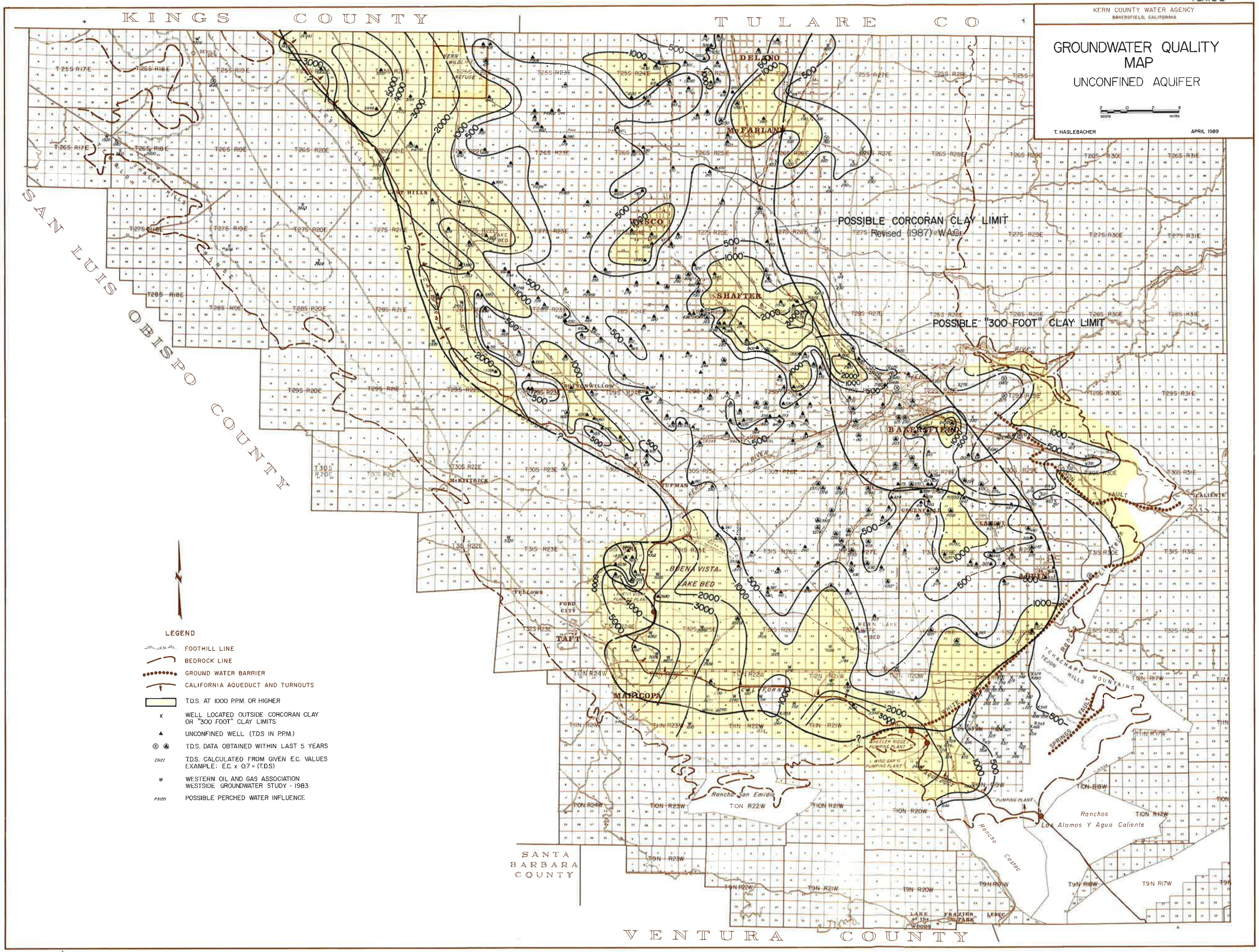

KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
DEPTH TO PERCHED GROUNDWATER
SUMMER 1988
K. TURNER
MAR 1989
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
DEVILS DEN WATER DISTRICT
BERRENDA MESA WATER DISTRICT
DELANO-EARLIMART I.D.
DELANO
POND-POSO IMPROVEMENT DISTRICT
SOUTHERN SAN JOAQUIN MUNICIPAL UTILITY DISTRICT
McFARLAND
KERN-TULARE WATER DISTRICT
NORTH KERN WATER STORAGE DISTRICT
WASCO
SHAFTER-WASCO IRRIGATION DISTRICT
SHAFTER
CAWELO WATER DISTRICT
BELRIDGE
ROSEDALE RANCH I.D.
OLCESE WATER DISTRICT
ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT
BAKERSFIELD
NORTH KERN W.S.D.
JAMES-PIONEER
BUENA VISTA WATER STORAGE DISTRICT AND
ARVIN-EDISON WATER STORAGE
ARVIN
TAFT
MARICOPA
LEBEC COUNTY WATER DISTRICT
TEJON-CASTAC WATER DISTRICT
Rancho San Emidio
Ranchos Los Alamos Y Agua Caliente
LEGEND
FOOTHILL LINE
BEDROCK LINE
GROUND WATER BARRIER
CALIFORNIA AQUEDUCT AND TURNOUTS
CONTOURS OF EQUAL DEPTH TO WATER BELOW GROUND SURFACE
DEPTH TO PERCHED WATER IS 8'

PLATE 2


KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER QUALITY MAP
UNCONFINED AQUIFER
T. HASLEBACHER
APRIL 1989
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
POSSIBLE CORCORAN CLAY LIMIT
Revised (1987) W.A.G.
POSSIBLE "300 FOOT" CLAY LIMIT
DELANO
McFARLAND
WASCO
SHAFTER
BAKERSFIELD
BUENA VISTA LAKE BED
KERN LAKE BED
MARICOPA
TAFT
LAMONT
ARVIN
TEHACHAPI MOUNTAINS
TEJON HILLS
Ranchos Los Alamos Y Agua Caliente
Rancho San Emidio
LEGEND
FOOTHILL LINE
BEDROCK LINE
GROUND WATER BARRIER
CALIFORNIA AQUEDUCT AND TURNOUTS
T.D.S. AT 1000 P.P.M. OR HIGHER
WELL LOCATED OUTSIDE CORCORAN CLAY OR "300 FOOT" CLAY LIMITS
UNCONFINED WELL (T.D.S. IN P.P.M.)
T.D.S. DATA OBTAINED WITHIN LAST 5 YEARS
T.D.S. CALCULATED FROM GIVEN E.C. VALUES EXAMPLE: E.C. x 0.7 = (T.D.S)
WESTERN OIL AND GAS ASSOCIATION WESTSIDE GROUNDWATER STUDY - 1983
POSSIBLE PERCHED WATER INFLUENCE

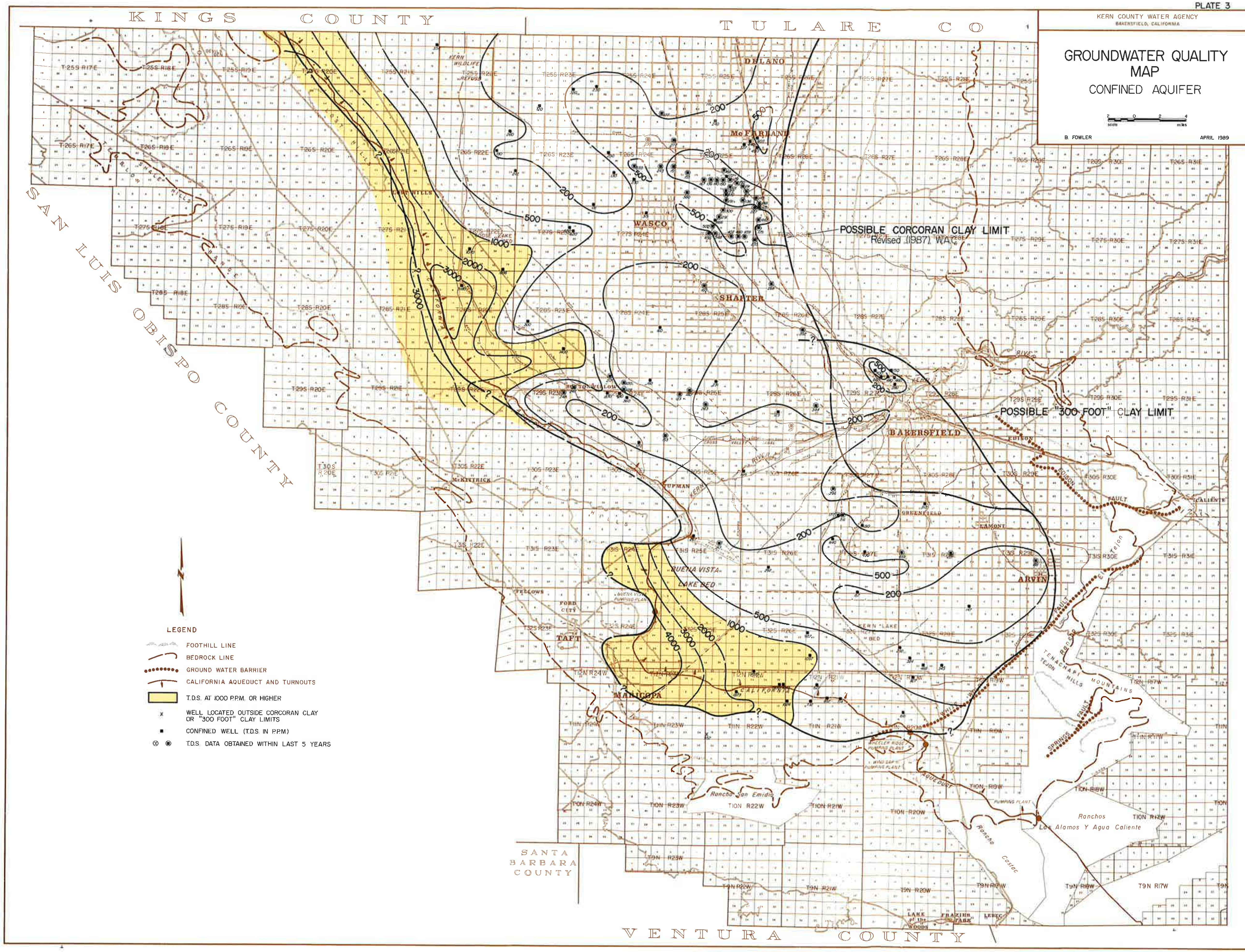
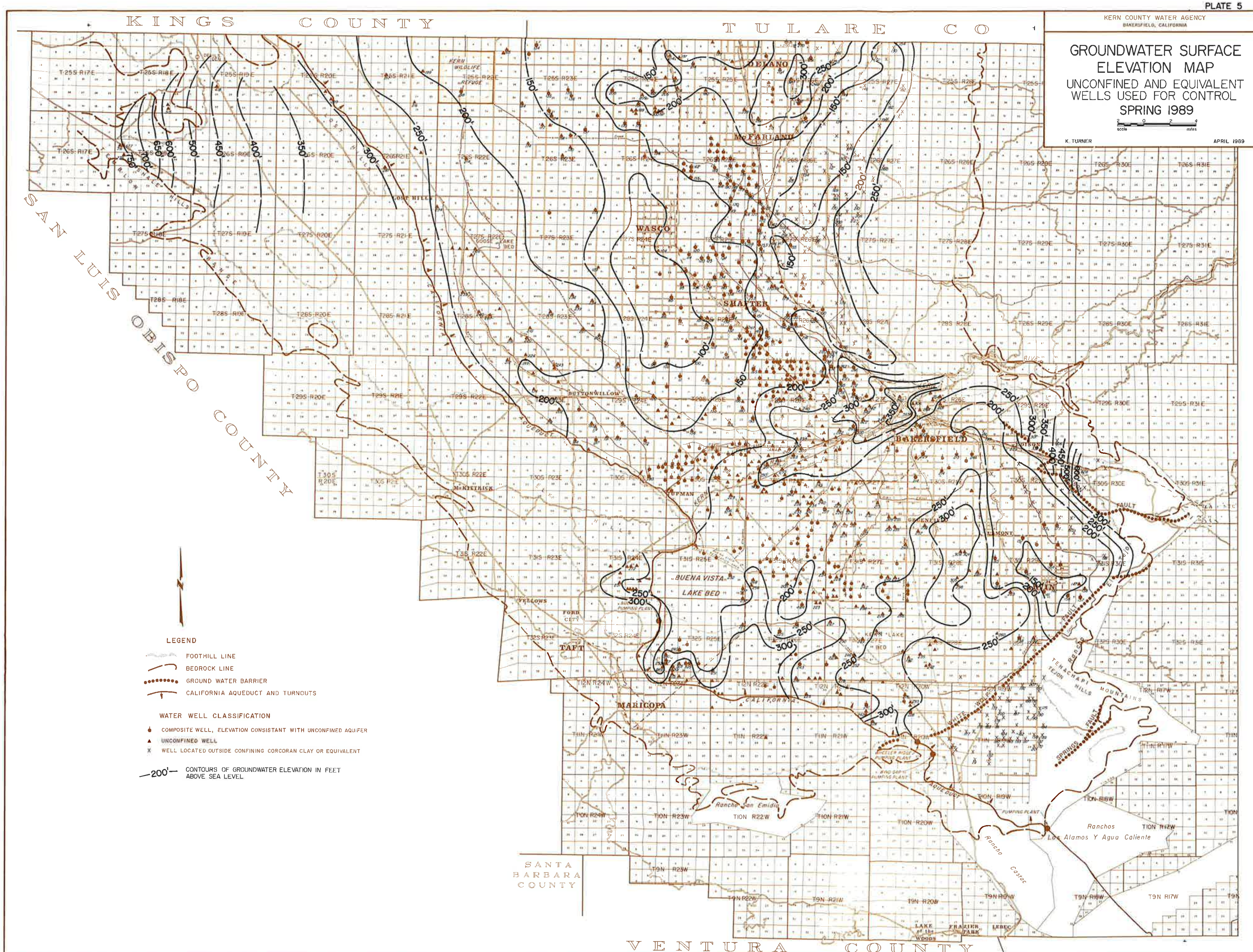


PLATE 3
KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER QUALITY MAP
CONFINED AQUIFER
B. FOWLER
APRIL 1989
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
POSSIBLE CORCORAN CLAY LIMIT
Revised (1987) WA
POSSIBLE "300 FOOT" CLAY LIMIT
DELANO
McFARLAND
WASCO
SHAFTER
BAKERSFIELD
GREENFIELD
LAMONT
ARVIN
TUPMAN
McKITTRICK
FELLOWS
FORD CITY
TAFT
MARICOPA
BUENA VISTA LAKE BED
KERN LAKE BED
EDISON
TEHACHAPI MOUNTAINS
TEJON HILLS
Rancho San Emidio
Ranchos Los Alamos Y Agua Caliente
LEGEND
FOOTHILL LINE
BEDROCK LINE
GROUND WATER BARRIER
CALIFORNIA AQUEDUCT AND TURNOUTS
T.D.S. AT 1000 P.P.M. OR HIGHER
WELL LOCATED OUTSIDE CORCORAN CLAY OR "300 FOOT" CLAY LIMITS
CONFINED WELL (T.D.S. IN P.P.M.)
T.D.S. DATA OBTAINED WITHIN LAST 5 YEARS


KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
DEPTH TO GROUNDWATER
UNCONFINED AND EQUIVALENT
WELLS USED FOR CONTROL
SPRING 1989
2 0 2 4
scale miles
K. TURNER
APRIL 1989
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
DELANO
McFARLAND
WASCO
SHAFTER
BUTTONWILLOW
BAKERSFIELD
ARVIN
MARICOPA
TAFT
McKITTRICK
BUENA VISTA LAKE BED
KERN LAKE BED
LEGEND
FOOTHILL LINE
BEDROCK LINE
GROUND WATER BARRIER
CALIFORNIA AQUEDUCT AND TURNOUTS
WATER WELL CLASSIFICATION
COMPOSITE WELL, ELEVATION CONSISTANT WITH UNCONFINED AQUIFER
UNCONFINED WELL
WELL LOCATED OUTSIDE CONFINING CORCORAN CLAY OR EQUIVALENT

PLATE 5


KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER SURFACE ELEVATION MAP
UNCONFINED AND EQUIVALENT WELLS USED FOR CONTROL
SPRING 1989
K. TURNER
APRIL 1989
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
DELANO
McFARLAND
WASCO
SHAFTER
BUTTONWILLOW
BAKERSFIELD
McKITTRICK
TAFT
MARICOPA
BUENA VISTA LAKE BED
LEGEND
FOOTHILL LINE
BEDROCK LINE
GROUND WATER BARRIER
CALIFORNIA AQUEDUCT AND TURNOUTS
WATER WELL CLASSIFICATION
COMPOSITE WELL, ELEVATION CONSISTANT WITH UNCONFINED AQUIFER
UNCONFINED WELL
WELL LOCATED OUTSIDE CONFINING CORCORAN CLAY OR EQUIVALENT
200' CONTOURS OF GROUNDWATER ELEVATION IN FEET ABOVE SEA LEVEL

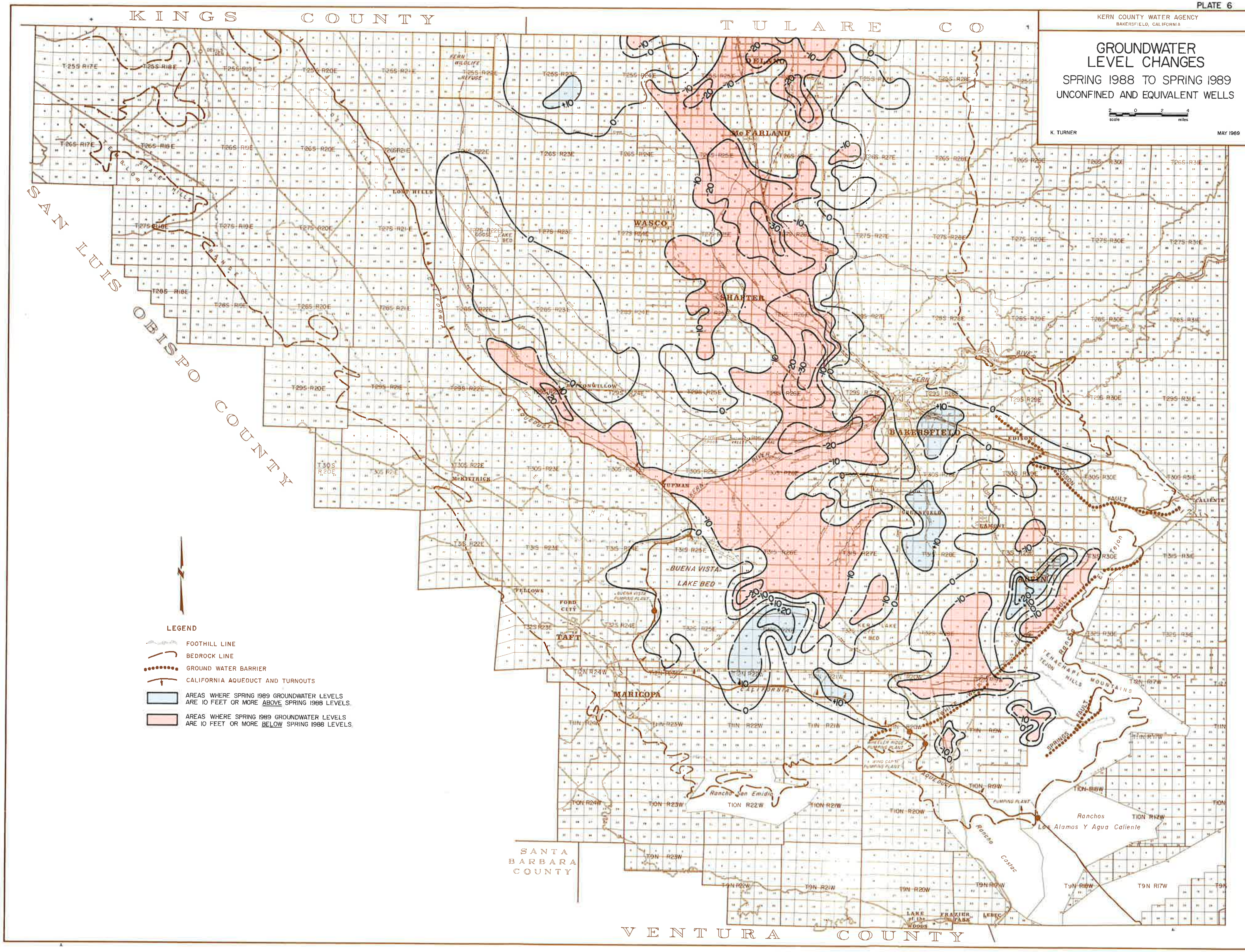


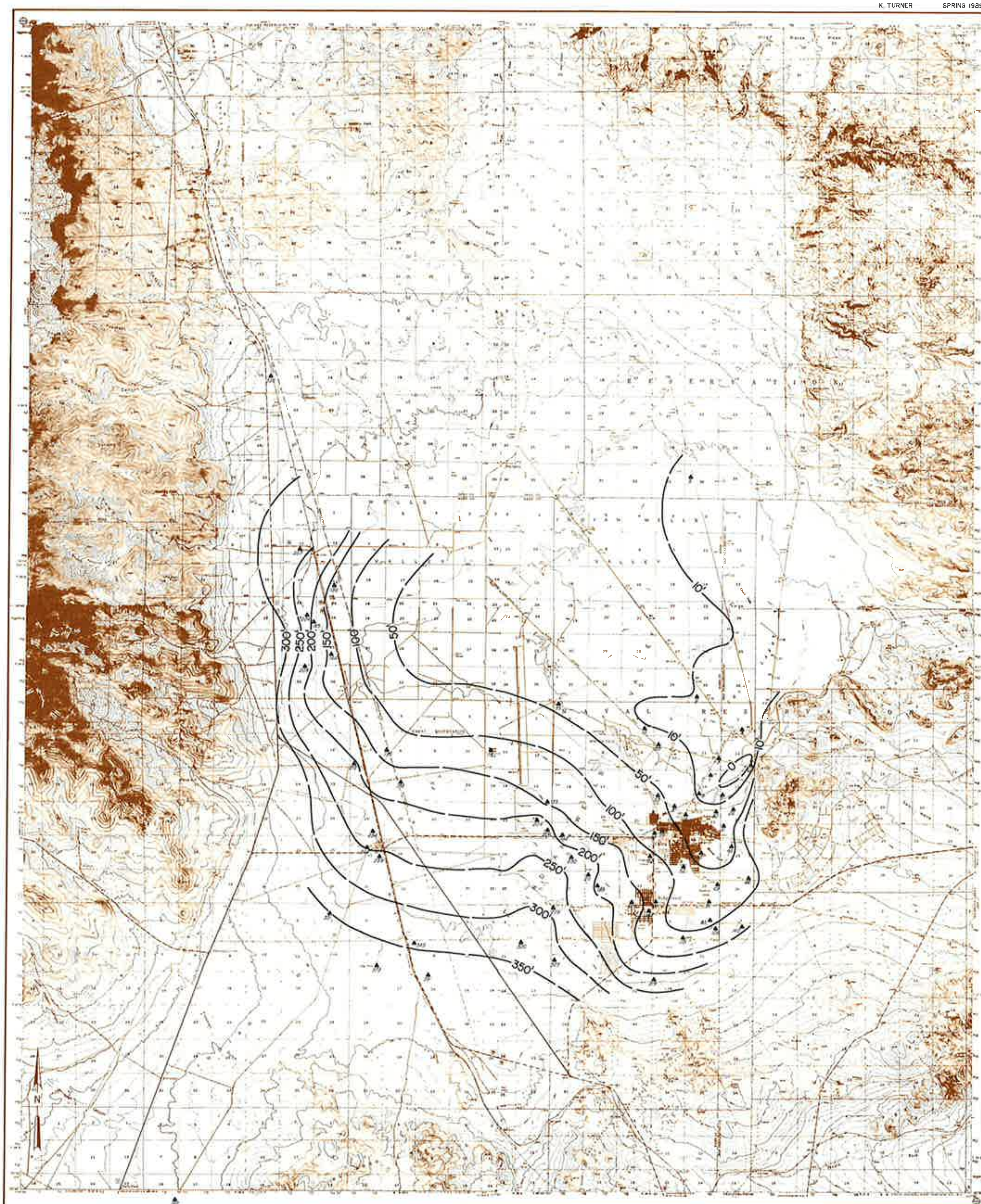
PLATE 6
KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA
GROUNDWATER LEVEL CHANGES
SPRING 1988 TO SPRING 1989
UNCONFINED AND EQUIVALENT WELLS
scale
miles
K. TURNER
MAY 1989
LEGEND
FOOTHILL LINE
BEDROCK LINE
GROUND WATER BARRIER
CALIFORNIA AQUEDUCT AND TURNOUTS
AREAS WHERE SPRING 1989 GROUNDWATER LEVELS ARE 10 FEET OR MORE ABOVE SPRING 1988 LEVELS.
AREAS WHERE SPRING 1989 GROUNDWATER LEVELS ARE 10 FEET OR MORE BELOW SPRING 1988 LEVELS.
KINGS COUNTY
TULARE CO
SAN LUIS OBISPO COUNTY
SANTA BARBARA COUNTY
VENTURA COUNTY
DELANO
McFARLAND
WASCO
SHAFTER
LOST HILLS
BUTTONWILLOW
BAKERSFIELD
TUPMAN
McKITTRICK
BUENA VISTA LAKE BED
FELLOWS
FORD CITY
TAFT
MARICOPA
EDISON
LAMONT
ARVIN
CALIENTE
TEHACHAPI MOUNTAINS
TEJON HILLS
Rancho San Emidio
Ranchos Los Alamos Y Agua Caliente
Rancho Castac
LEBEC

KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA

PLATE 7

INDIAN WELLS VALLEY
DEPTH TO GROUNDWATER
UNCONFINED WELLS

K. TURNER SPRING 1989



CONTOURS OF DEPTH TO GROUNDWATER IN FEET ABOVE SEA LEVEL.

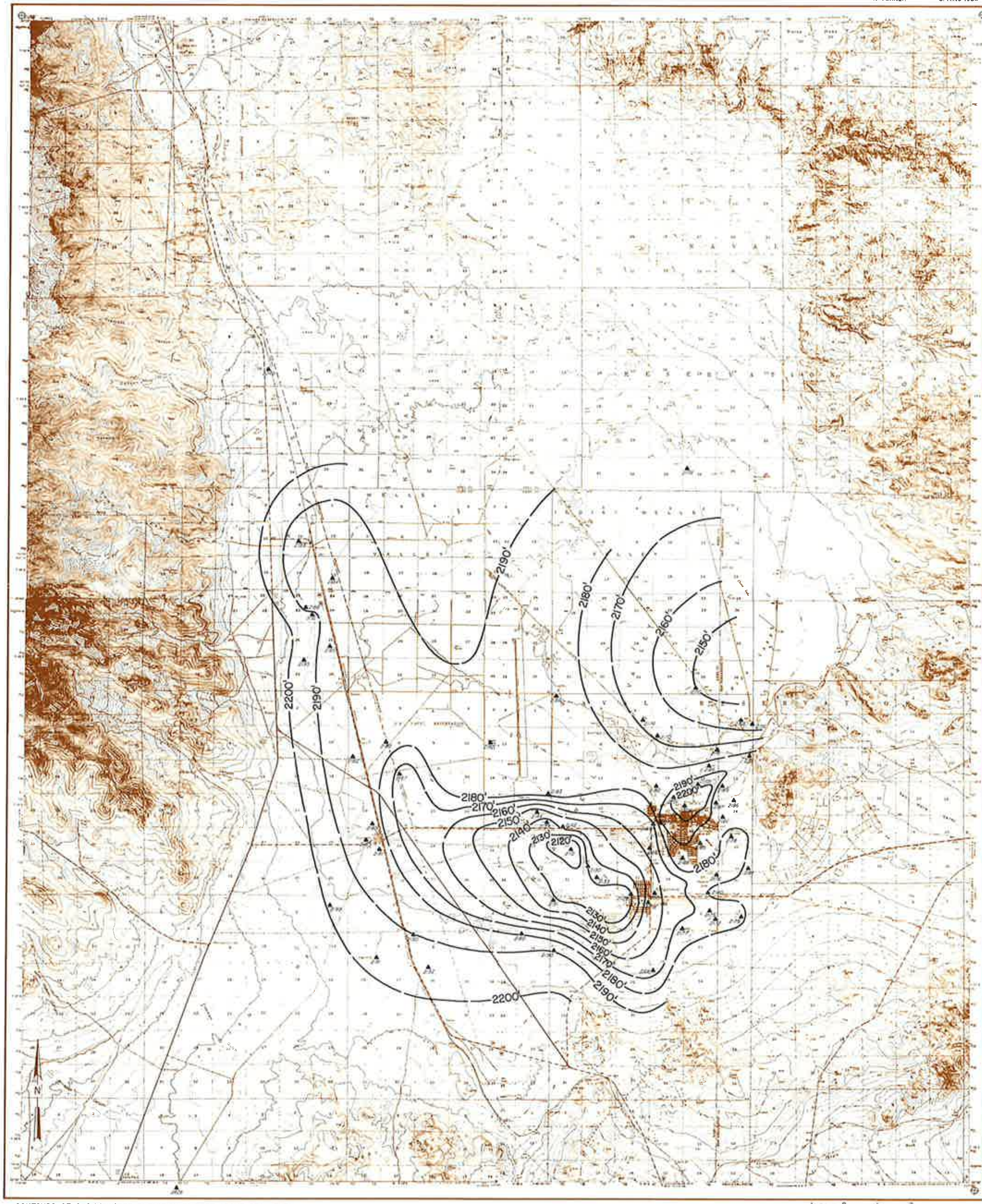
KERN COUNTY WATER AGENCY
BAKERSFIELD, CALIFORNIA

PLATE 8

INDIAN WELLS VALLEY GROUNDWATER SURFACE ELEVATION

UNCONFINED WELLS

K TURNER SPRING 1989



CONTOURS OF GROUNDWATER ELEVATION IN FEET ABOVE SEA LEVEL